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1.0 Executive Summary

As part of the definition of the software development process to be used by BellSouth Science and Technology (BST S&T) to develop services for the Advanced Intelligent Network (AIN), this document provides additional detail and focus on the project management aspect introduced in the "Software Development Process Overview" [1].

The purpose of project management is to coordinate and focus the planning, control and assessment of project activities. To address this purpose, methods and procedures must be established for a variety of aspects of the development process. This document will describe suggested methods and procedures which can be used to effectively manage the phases and aspects of software development.

The terms "project" and "project manager" in the context of this document assume a limited scope in an overall service or product development effort. For the purpose of this document, "project" refers to the work done by the Advanced Technology Development Center, ATDC, to transform requirements into a software product. A broader view of product development encompasses additional activities such as platform definition and selection, service concept evaluation, requirement specification, deployment activities, ongoing operations, field support, etc.

One major emphasis of project management is planning. Project planning is very important prior to beginning a development project but must continue throughout the project. It is necessary to assess project status periodically to determine whether or not modifications are needed in the current project plan. Typically, as the project progresses the increasing level of available information will allow the project plan to become more detailed. In addition, some basic plans may require change to efficiently guide and coordinate the project.

Project assessment drives project planning and keeps the project on schedule by measuring progress and by identifying problems which may require redirection of effort. The methods to be used in ongoing project assessment therefore constitute an important topic in the definition of a project management process.

Measurements of things such as project complexity, project status, and project quality are essential to successful project management. These and other measurements allow the project participants to quantify the current situation and to predict future results. They also provide for improvements to the development process by identifying, with accurate data, areas which require special attention in future planning.

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2.0 Introduction

2.1 Purpose

This document will describe the more important aspects of software project management and how they relate to the methods and procedures to be used by the Advanced Technology Development Center, ATDC, during software development projects. Additional study and experience will be required to further detail and refine the methods and procedures described. It is intended that this document will provide a starting point from which a very efficient process will evolve.

2.2 Scope

This document concentrates on ATDC's part in a larger process. ATDC has the goal of defining a process that interfaces effectively with all other existing processes.

2.3 Audience

This document is intended to be used by ATDC in software development projects. It may also prove to be of interest to other organizations interfacing with ATDC such as the Product Evaluation Center (PEC) and the Strategic Advanced Network Architecture Center (SANAC).

2.4 Document Organization

The document contains the following:

Section 1.0 - an executive summary.

Section 2.0 - the purpose, scope, intended audience, and document organization.

Section 3.0 - an overview of project management.

Section 4.0 - a discussion of project planning.

Section 5.0 - a discussion of project assessment (tracking).

Section 6.0 - a description of metrics to be taken and their purpose.

Section 7.0 - a summary of responsibilities by phase.

Section 8.0 - a conclusion highlighting project management deliverables.

Section 9.0 - a wrap-up.

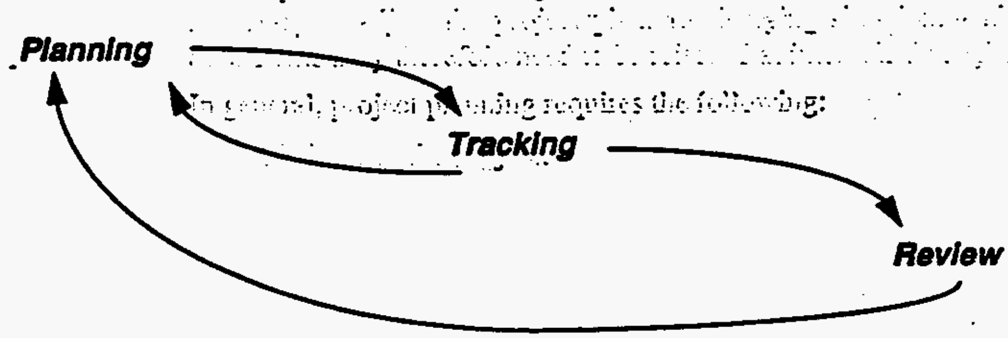
Section 10.0 - references.

Section 11.0 - a list of common acronyms.

Section 12.0 - a glossary of terms.

3.0 Overview

Project management focuses on three primary project aspects. Planning, tracking, and review encompass most of the activities associated with managing a project.



Planning is essential prior to the start of a project. It is also important to continue the planning process throughout the entire project. Project plans consider questions such as: "What is the definition of the project?", "Who will participate?", "How will the work be divided?", and "What process will be used?".

Continuous tracking of the project is necessary to ensure that the project is proceeding as planned and that mid-course corrections can be taken as required at appropriate times. As the need arises the plans must be adjusted. Tracking provides information on the effectiveness of past plans, the current status, and a prognosis for the remainder of the project.

The process of review takes place throughout the project and is associated with tracking. It is a required activity which concentrates on determining "what went right" and "what went wrong." It relies heavily on the collection of project metrics and its results are fed back into the process to support the goal of progressive process refinement.

Project management is an activity and a responsibility which is intended to speed the development process. It provides coordination of effort, maintains a focus on the project goals, and provides a mechanism by which the development process can improve.

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4.0 Planning

The planning aspect of project management can be broken into two parts, initial planning and ongoing planning. The initial project plans define the scope, schedule, costs and baseline approach for the project. Typical documents used to describe the initial project plan include: the Software Development Plan, the Integration Plan and the System Testing Plan. Ongoing planning is always necessary to adjust the project plans to changing situations and updated information. Planning documents may therefore need to be reissued at intervals throughout the project.

In general, project planning requires the following:

- Definition of the project.
- Establishment of the process to be followed.
- Evaluation and estimation of project complexity and required resources.
- Definition of work breakdown structures.
- Establishment of milestones.
- Determination of schedules.

The basic definition of the project is stated in the Software Development Plan. The Software Development Plan will reference and rely on other documents such as service specification documents to provide greater detail.

Process documents, such as this one, establish the normal process to be used throughout the project. During initial project planning the process is reviewed to determine whether or not modifications to this process are required. The Software Development Plan will address this issue.

Estimates, work breakdown structures, milestones and schedules are all considered and reconsidered during initial and ongoing planning. Progressive refinement of each of these items is a major part of project management.

4.1 The Software Development Plan

The Software Development Plan is used to lay the foundation for the software development organization's involvement in the project. This plan may be used as input to business cases or to explain the need for resources.It is essential that sponsorship by upper management and buy-in by all project participants be obtained at the beginning of the project. These agreements should be based on a clearly defined and mutually understood project definition and preliminary schedule having realistic and attainable goals. The Software Development Plan serves this purpose.

The Software Development Plan should therefore have the following characteristics:

- It should be understandable.
- It should have a modular and hierarchical structure.
- The highest level view should be brief (e.g. it may contain an executive summary).
- It should tell what the job is, how it will be done and what resources are needed.

- The risks and open issues should be clearly stated.
- It should allow for contingency (the goals should be attainable in less than ideal situations)

The Software Development Plan will contain the following:

- Project goals and objectives
- Organizational structure.
- Process to be used (changes required to the standard process should be noted, special attention should be given to the subject of quality).
- Laboratory facility requirements (initial view).
- Responsibilities of other organizations as they relate to software development.
- High level work breakdown structure.
- Schedule (including a start date).
- Risks and contingencies.

A typical outline for the Software Development Plan might be:

1. Purpose
2. Overview
3. Organizations & Roles
4. Requirements
5. ATDC Software Development Work Plan
6. Schedules and Milestones
7. Risks

The Software Development Plan is used primarily at the early stages of a project. Adjustments to the project, such as schedule modification and minor changes to the work breakdown structure, will be reflected in other project artifacts. However, it may be useful to update and reissue the Software Development Plan as situations change and additional information becomes available.

4.2 Development Estimates

Before beginning a development project the complexity and cost of the project must be estimated. This kind of evaluation comes in varying degrees of accuracy. The accuracy is directly related to the quantity of information available on the project which is in turn directly related to the amount of effort invested in the project.

The process of estimation is fairly simple in concept. The complexity of the project is examined, a reference is made to similar past projects, and a conclusion is drawn by scaling past experience to the current problem. However, it is usually the case that each new project differs in some important ways from all previous projects. Variance in the project content as well as the personnel working on the project can make it difficult to draw detailed conclusions from past experience. Estimates will however become better and better with each successive ATDC development effort.

At the beginning of a project a very preliminary evaluation must take place to decide whether or not a project should be undertaken. This kind of evaluation may be used as input to a business case or may take the form of a preliminary service evaluation used to prioritize candidate services and to determine required staffing levels.

Increasingly more detailed and accurate evaluations and estimates of project difficulty will be required for various purposes throughout the project cycle. The project manager will arrange for the delivery of such evaluations and estimates as required and will limit their use to the intended purposes.

Development estimates typically show units of engineer-weeks (or months). Estimates of the number of new and changed source modules or the number of new and changed lines of code are also sometimes useful. These are especially useful when used with metrics taken from previous development estimates. For example, the number of expected problems and required duration of the system testing phase can be extrapolated from this type of estimate.

4.2.1 Platform Development

Software not directly related to the implementation of any specific service can be referred to as platform software. This category includes functional elements used to support the implementation of many services (e.g. operations interfaces, database subsystems and SS7 interfaces). Platform software also includes the tools used to develop and maintain services.

Prior to the first service offering on a particular platform the current and future software requirements for the platform should be determined. These requirements will anticipate the functional needs of the platform in supporting a broad range of services.

The first platform software development estimates can be made when enough information is available on the vendor provided platform to make an intelligent assessment of required additional functionality. The vendor's RFP response will provide some of this information. When a final agreement is made with a platform vendor, additional information will become available and preliminary platform development estimates can be made.

4.2.2 Service Development

Service development estimates refer to the effort required to develop the software to implement a service on a particular platform. Underlying software needed to support more than one service is usually not considered to be part of the service development estimate. Service development estimates therefore provide information on the incremental costs associated with developing individual services.

A very preliminary service development estimate for a particular service can be provided soon after a draft version of the Service Concept[6] is available. An evaluation of the major issues associated with the implementation of the service is usually presented with the estimate. Due to the preliminary nature of this type of estimate, required effort will be presented as "high, medium,

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low" or perhaps as a number from "1" to "5" representing "easy" to "very difficult."

When the Feature Specification [6] is published a second preliminary service development estimate will be provided. This estimate is based on a detailed knowledge of the service requirements but not on a complete examination of the implementation issues. The development effort required for the service may be presented as a range of "engineer weeks" in this estimate.

When the feature design for a service has been completed a formal development estimate will be published. This estimate will give a number of required "engineer weeks" and a tentative schedule. The availability of a schedule assumes that all of the committed activities of the development group involved are known.

Development estimates will be provided at the conclusion of the requirements review, feature design, and feature subsystem design and as needed to adjust schedules as required.

4.3 Schedules and Structure Charts

Schedules and other charts may be used to present plans in an easily understood form. ATDC has selected the Viewpoint project management software tool to assist in the generation and maintenance of schedules and work breakdown structure charts. Copies of charts taken from ViewPoint will be attached to planning documents such as the Software Development Plan, the Integration Plan and the System Testing Plan.

Viewpoint allows the project to be defined in a hierarchy of project decomposition. The tool presents this hierarchy as a tree of nodes each having a particular function and level of detail. Underlying each node is a "timeline" chart showing activities or summaries of activities defined in lower nodes of the tree. The tool can therefore represent as much or as little detail as desired for a particular purpose.

Viewpoint will be used to plan and monitor the status of a project. The "timeline" charts can be of several forms including Gant, Network Gant and Pert. Dependencies between activities and events can be represented to ensure that the impact of schedule slips is fully anticipated and tracked.

During the initial planning phase the project and its supported activities will be modeled in the network tree chart. This tree will constitute the initial work breakdown structure. Known target dates and fixed events such as the availability of platforms will be input to the tool. The dependencies between activities will then be defined.

When the project has been divided into areas of responsibility, detailed levels of the network tree (sub-trees) can be stored as separately modifiable Viewpoint files. The detailed activities within these sub-trees will then be defined by the individuals responsible for these tasks. Viewpoint can then import all of the sub-trees to form a complete project schedule.

4.4 Integration Plan

A familiar model of the software development process shows the progressive decomposition of a project into small pieces during the first half of the process followed by the integration of completed modules during the latter half. Individually constructed units or modules can be combined in many ways to form a completed product. However, a carefully constructed scenario for the sequence of the integration will make this task easier and result in better quality. The Integration Plan documents the sequence to be followed in combining software units into a fully functional system. It also defines the method of testing to be used during the integration process to debug and verify the combined software at each integration step.

The Integration Plan document will include:

- Network Gant charts showing the timing and dependencies of the integration phase.
- A high level test strategy plan for each integration step.
- An explanation of the considerations which were made in arriving at the plan.

A configuration management system will be used to maintain the combined "verification" load which is built during the integration phase [9]. Modules to be added to this load must meet certain criteria with regard to quality[8]. The requirements for design and code reviews as well as for test planning and test results are addressed in companion process documents [10][11][12].

4.5 System Testing Plan

During the system testing phase a broad range of tests are performed to verify the quality of the software and to locate and fix problems to further improve the software's quality. This requires a broad range of tests including new feature tests, regression tests, stress tests and continuous running tests. The System Testing Plan describes the strategies to be used in system testing. It also provides schedules for testing activities to be carried out during the phase.

The System Testing Plan is not a collection of system test plans. System test plans are detailed test suites which will be used during system testing. The System Testing Plan describes when and how these test suites will be used.

New feature system test plans are typically written during system design. These test plans may however be updated or added to at anytime during the development process. The System Testing Plan is finalized when the strategy and schedule for the system testing phase can be determined.

Criteria exist for entrance to and exit from the system test phase [9][12]. It is a crucial part of the project management process to be able to use available information to predict the starting date, completion date, and resources needed for the system testing interval.

To summarize, the System Testing Plan must contain the following:

- A start date.
- An estimation of the resources required.
- A testing strategy.
- An assignment of responsibilities.
- A schedule.

4.6 Interfaces with Other Organizations

ATDC will work with many organizations to assist in conceptualizing, development and introduction of new services. Of primary importance, however, is ATDC's relationship with organizations providing requirement specifications and with the service verification organization.

Service Concepts are evaluated according to the Service Concepts and Requirements Process [6]. As previously described, ATDC will provide preliminary evaluations and estimates for candidate services to assist in this process. ATDC will also prototype certain services. This will provide an early opportunity to preview a service so that better decisions can be made with regard to service viability as well as functionality.

When a service has been approved for development, ATDC will work closely with the requirement specification group to form a clear and detailed understanding of the service to be developed. In fact, this interactive and iterative process of determining service requirements begins prior to service approval due to the fact that the business case must be based on the knowledge that the service is technically feasible.

The Network Integration Test group, NIT, will verify the quality of service software developed by ATDC. Following the successful completion of the system testing phase, ATDC will provide NIT with the verification version of a software release and all necessary documentation. However, prior to this, preliminary versions of the software and documentation will be made available to NIT to assist in preparation for the verification activity.NIT will also perform a "probe" or sampling of preliminary versions of the software to give an unbiased assessment of software quality. This probe may also (or alternately) be performed by a selected team from ATDC.

Following service deployment, ATDC will assist in the ongoing support of software in the field. The Switching Technical Assessment group, STAC, will work with operations groups such as ESAC to evaluate and track field problems. If STAC determines that a problem exists in ATDC software or requires assistance in locating the source of a problem, ATDC will be notified. ATDC will share a problem tracking database with STAC to guarantee satisfactory resolution of problems.

5.0 Project Assessment

During the course of a project, periodic assessment must take place to track progress and to reevaluate the current plan. To accurately gauge progress, a defined set of measurable items must exist for each project activity or phase. Project status and progress as well as predictions of the amount of work remaining are all based on these measurements.

5.1 The Project File

A project file should be maintained throughout the course of the project to collect all artifacts associated with the project. This file will provide a central source of information on the current status and plans for the project. It will also provide a history having a set of project snapshots (e.g. successive versions of planning documents and schedules) and metrics which can be used to improve the process to be used in future projects.

Some of the tools used to produce project deliverables such as specification documents, design documents, source code, test plans, test results and schedules support multiple versions or "snapshots" which can be used to maintain a project history. However, it may be desirable to store hard copies of these snapshots taken on perhaps a weekly basis in a physical project file. This is probably desirable until a fully integrated development and tracking environment is implemented electronically.

The project file will contain the following:

- The service feature specifications.
- The software development plans.
- The integration testing plan.
- The system testing plan.
- All design documents.
- Results from design reviews.
- Results from code reviews.
- Results from testing reviews.
- Test plans and test results.
- Project schedules.
- Problem report summaries.
- Meeting minutes for meetings related to the project.

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The project file will be updated as new versions of documents become available and as snapshots of progress are taken. Older versions of these artifacts are kept in the file to form a project history.

5.2 Progress Tracking and Reporting

As a project proceeds, it is important to determine the current status relative to the plan. Typically, work to be performed in pursuit of a particular milestone is modeled as a time line having a start date and an end date. To show the current state of the activity depicted by the time line a point on the line is chosen based on the percentage of work done compared with the work required to complete the activity. By maintaining time lines of this type, marked periodically, a project activity can be tracked in a useful way.

This method of project tracking seems to be simple enough and fairly accurate. However, in practice, the implementation of this project tracking method requires some additional complexity. Consider the following questions:

- How will "percent complete" be determined?
- What happens when an activity takes longer than expected?
- Why is the last "five percent" of an activity the hardest?

5.2.1 "Percent Complete"

Time lines are based on calendar time. The length of an activity time line is determined by the estimated calendar duration of the activity. However, activity status cannot be determined by looking for today's date on a calendar. Activity status depends on how much work has been completed and how much work remains. To address this problem, activities must be clearly defined and have quantifiable deliverables. For example, a particular coding activity can be defined to consist of the coding and successful review of a listed set of modules each having a stated purpose and planned design. In this case "percent complete" can be the percentage of completed modules to the total number of modules listed for the activity. When a "percent complete" calculated in this way is applied to the activity time line, the point drawn may or may not match the current date. Although this seems obvious, many individuals stay "on schedule" by watching their calendars during the planned activity interval only to stay "behind schedule" for a significant period after the final deliverable is due.

5.2.2 "What happens when the activity takes longer than expected?"

This question brings up an important issue. It is important because it occurs in almost every project. Activities normally take longer (more calendar time is required) than expected because there is more work to be done and less available time to do the work than originally anticipated.

Related to the coding activity example, consider a situation in which it is planned that fifty code modules will be written and reviewed for a particular activity time line. This activity line is expected to span five weeks of the calendar. The individual responsible expects to work an average of one half day five days a week on this particular activity (the five weeks of calendar time was derived from this fact and the estimate that 2.5 engineer weeks are required for the activity). The original activity time line would appear as shown below.

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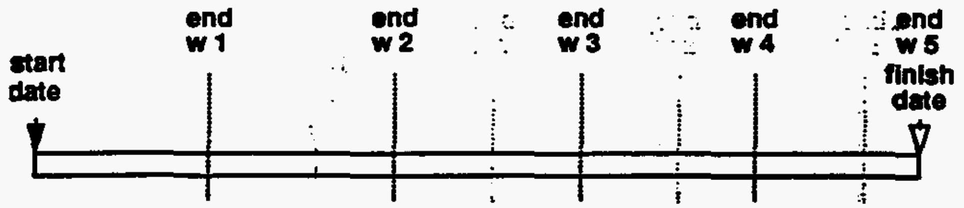
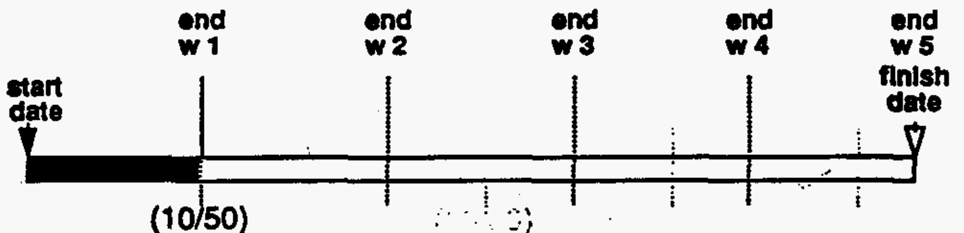


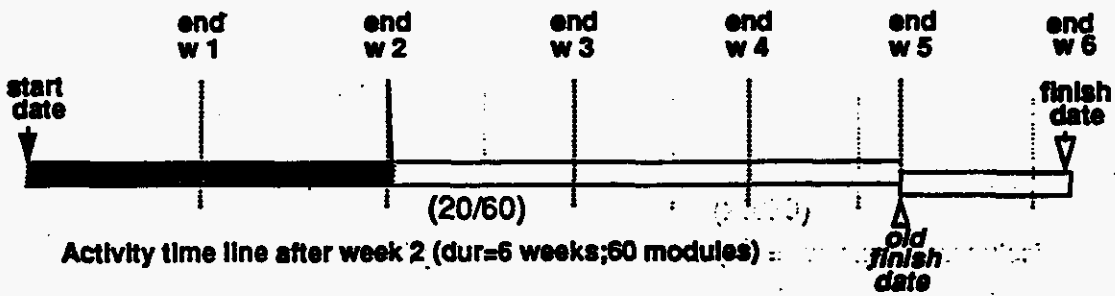
Activity time line as originally planned (dur=5 weeks; 50 modules)

Assume that at the end of the first week 10 modules were completed. The activity is on schedule. The snapshot for the end of week one would therefore be:



Activity time line after week 1 (dur=5 weeks; 50 modules)

At the end of two weeks it has been determined that more code modules than planned are needed to complete the functional unit covered in this activity time line. At this time 10 modules have been completed but a total of 60 modules are needed. The question is now, "how will the plan revision be illustrated in the time line representation?". The chart below is one solution.



Activity time line after week 2 (dur=6 weeks;60 modules)

This approach shows the schedule extension and bases current status on the revised estimate for the activity duration. Had it been unacceptable to extend the finish date more resources could be applied to allow the completion of the remaining 40 modules in the available three weeks. The chart would then appear as below but the assumption would be that 13.3 modules can be completed per average week and therefore the lagging schedule can be improved.

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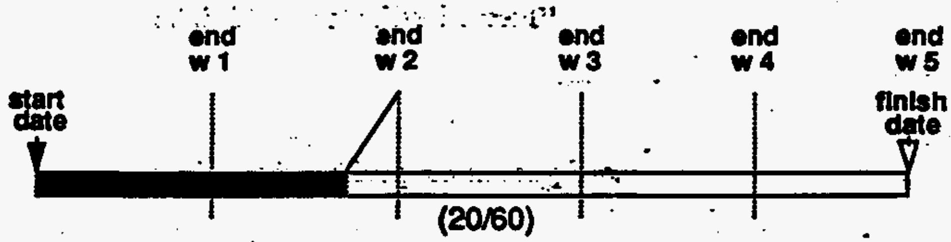
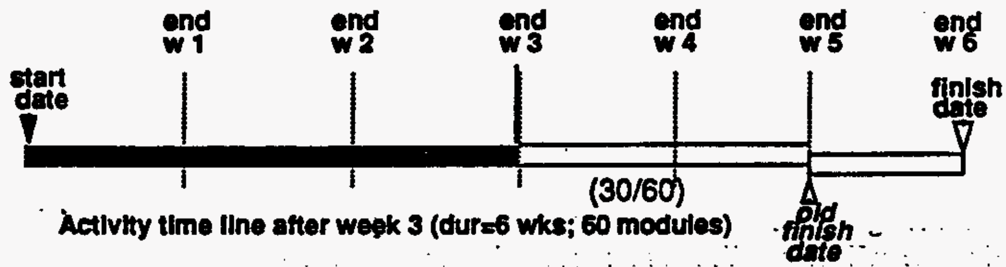


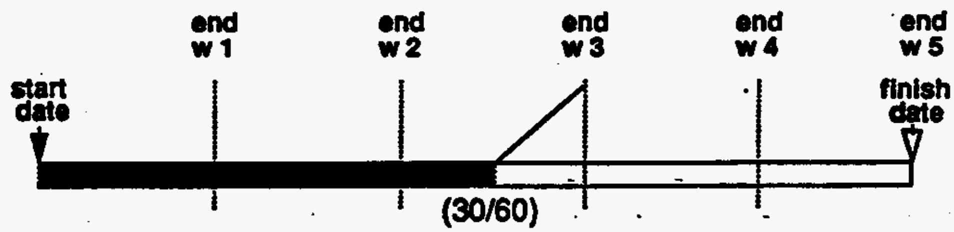
Activity time line after week 2 (dur=5 weeks;60 modules)

At the end of three weeks only 30 modules have been completed even though the resources for this activity have been increased. It has been determined that the remaining modules are more difficult than the previously completed ones. It is estimated that only 10 modules can be completed each week for the remainder of this activity. Given this situation the activity could be extended to span six weeks. The current status and the finish date slip would be shown as below.



Activity time line after week 3 (dur=6 wks; 60 modules)

If the schedule is not extended, a lag would be shown due to the fact that only 50% of the work was complete when 60% of the scheduled calendar time had been used up. It may be desirable to keep the original finish date throughout the activity and show the severity of the progress lags as below.



Activity time line after week 3(dur=5 weeks;60 modules)

Altering the plan during the course of a project is necessary at times to apply the best solution to changing problems. However, it is usually desirable to remain committed to target "finish" dates in tracking the project as long as practical considering the overall situation. This approach motivates effort to increase the rate of progress in areas showing slips.

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5.2.3 The Last "Five Percent"

As mentioned previously, it is typically the case that activity progress is reported to be "on schedule" until the deliverable is due and then reported to be "very nearly" complete for sometime thereafter. As the due date for the activity deliverable becomes near, activity progress seems to stall at about ninety five percent complete.

One obvious reason for this situation is that when status reports are not based on clearly measurable progress, individuals tend to give optimistic reports showing that their activities are proceeding on schedule until the deliverable is due. Even when individuals attempt to accurately estimate progress, a lack of "measurables" can result in overly optimistic reporting.

When a defined method of progress measurement exists, progress reporting becomes far less biased and significantly more accurate. However, care must be taken to avoid delays at the end of a project activity.

One hazard to avoid occurs when the more difficult parts of an activity are "saved" for last. If the method of measuring progress during a coding phase is to count completed modules, each module would ideally require the same amount of effort. However, this is usually not the case. As a result, individuals may delay the coding of the more time consuming modules in an effort to report favorable results hoping to catch up at the end.

Another problem occurs when the method of progress measurement overlooks certain tasks which must be completed to support the deliverable. For example, documentation and review meetings may be required as exit criteria for an activity but may not be required at any point prior to the end point. These tasks are likely to prolong the duration of the final "five percent" of an activity.

To avoid these problems, the method for determining activity status must accurately assess the total effort for the activity and the amount of effort needed for completion. To adequately meet this requirement, measurements must include all tasks and must take into account the relative difficulty of each task.

5.2.4 Tracking and Reporting Tools

Project management tools such as Viewpoint greatly simplify the periodic tracking and reporting of project status. In addition to providing an automated approach to the job of collecting status information, these tools prepare quality status reports of varying levels of detail.

As mentioned earlier, Viewpoint allows a project to be broken down into many parts and modeled as charts of related activity time lines. This modeling of the project is normally done during the project planning phase and is updated in a controlled manner by the project manager (e.g. changes to end dates).

Viewpoint will be used at intervals throughout the project to assess progress over time and to monitor critical path activities as well as to determine the overall impact of schedule delays. Viewpoint operates in either "plan" mode or "track" mode depending on whether the user wants to adjust the plan or to view current status. In "track" mode Viewpoint allows the user to input the desired assessment date. This would normally be the current date but could be set to a future date to view selected scenarios for the purpose of risk assessment.

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During the planning phase the project network diagram is created to model the project work breakdown structure (WBS). Viewpoint allows each team member or group of team members to maintain their own "sub-tree" of the project network diagram. These "sub-trees" can be stored in separate DOS files. Project team members will input status details related to their particular activities using Viewpoint on their individual project activity files. This will require determining and inputting the "percent complete" for each activity time line. Viewpoint can consolidate this information to form appropriate summary views of the project status.

Dependencies between various project activities can be modeled using the project management tool. As individual activities lead or lag the project plan the impact of these occurrences can be graphically shown by the tool. This will allow resources to be shifted to the critical path activities as needed.

5.3 Periodic Group Meetings

Meetings will be held periodically to review group progress and to identify important issues pertaining to the project. These meetings will in most cases occur weekly and will be attended by the members of an RM (Research Manager) group.

The typical agenda for this meeting will be as follows:

- Review of previous meeting's project status highlighting problem areas.
- High level view of current project status.
- Discussion of how well previous problem areas were addressed.
- Detailed views of current status.
- Identification of new problem areas and open issues.
- Discussion of new action plan including assignment of action items.

At the beginning of each group meeting the project status as it was presented in the previous meeting will be summarized. This will form a baseline for assessing recent progress. Problems that were identified in the previous meeting will be emphasized and the proposed methods for dealing with them will be restated.

A person will be responsible for estimating the status of each project activity prior to the weekly group meeting. This information will be given to the appropriate RM so that it can be used to update the project status in Viewpoint.

At the group meetings current progress will be summarized by the RM using summary views from the Viewpoint tool. Special attention will be paid to continuing lags and to improving situations. A comparison will be made between the previously proposed strategies for solving problems and the progress achieved.

Detailed views of individual activity progress will be presented by the individuals responsible. Efforts made to improve lagging areas will also be discussed in greater detail at this point.

Action items due since last meeting will be reviewed. New problems will be identified by the group. Strategies for addressing these problems will be formed and new action items will be

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assigned.

Viewpoint will probably be used extensively at the periodic group meetings. Critical path activities are automatically highlighted by the tool. Milestone slips and lags are highlighted. These features will provide for efficient identification of the high priority areas and problems. Alternatives for redirecting resources to solve problems can be explored using Viewpoint in an interactive group discussion.

5.4 Other Project Meetings

Using a project management tool such as Viewpoint to plan and track a project will provide a simple mechanism for project reporting to a variety of audiences. Viewpoint can build summary views of the project to suit almost any purpose.

The overall AIN project management team will use Viewpoint to plan and monitor higher level aspects of the project. Status updates from ATDC can be provided to the project management team in electronic form and "uploaded" into the high level project model. Viewpoint can then produce current status views of the project reflecting ATDC's contributions.

The AIN project management team will probably conduct periodic meetings (perhaps monthly) to discuss the overall project status using a form similar to that of the ATDC RM group meetings. ATDC's contributions to the project will appear as summary activities which span the service development work.

As ATDC grows it will become useful to divide project work into several RM teams. Each RM monitors a portion of a larger project conducting periodic group meetings as described above. Periodic Director meetings will take place to consolidate the results of these group meetings. The ATDC Director and the Research Managers will meet to discuss current status, problems and strategies to overcome problems. Interactions among the project "pieces" will be examined using the Viewpoint tool as appropriate.

5.5 Measuring Progress

It was mentioned previously that clearly defined measurements for project status must exist in order to obtain a meaningful assessment during project tracking. Each phase of development may have a different method of measurement. The objective is to use a measurement that is uniform during the course of a particular development phase and across all participants in the phase.

Some project activities are more accurately measured than others. Activities that consist of a number of clearly identifiable tasks, for example the coding of a set of defined modules, are ideally suited to measurement. Progress in phases such as high-level design is however more difficult to measure. Guidelines on how to determine progress during each of the typical development phases is provided below.

5.5.1 Requirements Review

When a service requirement specification document is issued an activity line should be established for the review of the document. The end date for the activity should be the date of the document review meeting. The numbered requirements in each document will be divided among the development team members. Each requirement will be reviewed to: determine whether or not it is appropriate in a general sense, determine whether or not the requirement is supported by platform capabilities, and whether or not the requirement is testable during a system test.

Progress toward completing the requirements review can be measured by counting completed requirements since the number of total requirements is known in advance.

5.5.2 System and Subsystem Design Phases

The high level design phase is perhaps the most difficult phase to quantify. The first step toward doing this is to attempt to gauge the overall size of the design effort. Since the deliverable from this design phase is a document, the size of the document should be estimated and an outline generated. Progress toward completing this phase will be measured in pages or sections completed in the document.

Another activity that takes place during or prior to System Design is the writing of test cases. A test or set of tests must be defined for each requirement in the requirements specification. These test cases will be used during system testing to prove that each requirement has been met. Progress during this activity will be measured by calculating the percentage of test cases written to the total expected.

5.5.3 Module Design, Coding, and Unit Testing

Service development will require the use of Decision Graphs, SLL, and C++. The C++ environment allows many small modules associated with a single subsystem to be coded and tested independently. In contrast, SLL may require the development of a large single source program file for each service. Decision graphs typically exist on a "per subscriber per service" basis and are relatively small.

C++ module development activities can be tracked by comparing the number of modules completed (designed, coded, or tested) to the number planned. Larger modules can be weighted more heavily than smaller ones where appropriate.For SLL, the number of planned modules may be only one. Therefore the size of the planned activities should be measured in "states", "events", or lines of SLL code. Decision Graphs will be built by or on behalf of customers. Typical sample Decision Graphs will be created during development for testing purposes. Required effort associated with the input and testing of representative Decision Graphs should be estimated in terms of the number and size (small/medium/large) of graphs needed for testing.

Completion of the design, coding, or unit test of a module or other "chunk" should imply that a review has taken place. Procedures for the review process are described in another ATDC document[11].

5.5.4 Integration and System Testing

Progress achieved during testing activities is also difficult to gauge. A great deal of literature exists on software testing and how progress can be measured during testing phases [2][3][12]. Progress in any development phase is most often determined by comparing the amount of work completed to the total amount of work required. As the literature points out, it is usually not possible to accurately estimate the amount of work required in a testing effort. It is therefore unlikely that testing progress can be accurately measured.

The situation is not hopeless however. The ability of an organization to estimate the amount of testing required for a given project improves with experience. If an organization has completed many projects of a similar nature, estimates of testing effort can be relatively accurate. Scaling factors can also be applied to adjust for differences in project complexity, staff and other variables. Parameters such as "number of lines of code", "number of modules", "number of requirements", etc. can be used. Regardless of accuracy, estimates for a testing interval usually consist of the quantity of tests which are expected to be run and a time duration.

One somewhat optimistic objective in test planning is to provide total coverage of system functionality. If it is possible to write and execute a complete test plan then progress can be measured by calculating the percentage of tests successfully completed. For a large software system consisting of several release levels this approach is usually not practical. Aside from the volume of tests required to completely test a system it is difficult to anticipate all of the required tests in advance. For this reason it is useful to track the rate of the discovery of defects as a function of the rate of test execution. By monitoring the trend of "bug" detection an estimate can be made on the number of remaining tests required to reach the desired level of quality.

During unit and integration testing the emphasis is on "new feature testing". Progress during these phases will be calculated based on the percentage of planned test cases successfully completed. In system testing, which is much broader in scope, this method will also be used but will be tempered with conclusions drawn from analysis of the defect detection statistics.

6.0 Metrics

Progressive refinement and improvement of the development process is a primary goal for ATDC. Essential to meeting this goal is the gathering of project related data during each development cycle. This data will be used to improve the accuracy of estimates, to avoid pitfalls, and to point out methods that should be improved.

It is important to gather the "right" metrics however. Gathering metrics is time consuming and can be considered intrusive in certain cases. Misuse or misinterpretation of metrics can be detrimental to a project and to the organization. The purpose of collecting project metrics should be to improve overall project predictability and efficiency. Project metrics should never be used to evaluate the work of individuals.

Automation of the metric collection process saves time, improves accuracy, and lessens any intrusive effects. Examples of automated metrics include mechanisms to count new or changed lines of source code and tools for tabulating and presenting occurrences of defects.

ATDC will probably err in favor of initially collecting more metrics than are probably necessary. As experience dictates some metrics may be deleted and some may be added. The following list is a first pass attempt at a useful set of metrics for ATDC:

- Personnel resources dedicated to the project (e.g. person weeks.)
- The number of source lines added or modified.
- The number of modules added.
- The number of modules modified.
- The number of elemental requirements.
- The number of test cases written.
- The number of test cases added after the start of testing.
- The amount of time spent in each project phase.
- The amount of time spent in each of several categories of project meetings.
- The amount of time spent on non-project related activities during the project.
- The number of defects found (per phase, per week, per test case, etc.)
- The number of defects caused in each phase.
- The amount of time spent "reworking" in each phase.

By taking measurements such as these at frequent intervals and maintaining a history of metric snapshots many other meaningful metrics and trends can be derived. The usefulness of these metrics is described below.

6.1 Resource Metrics

One of the most useful aspects of collecting project metrics is that the estimation process is based on past history. Having an extensive set of metrics collected over a number of previous projects can transform project estimation from guess work to a reliable planning activity.

Every software project is unique from every other software project in at least one way. Project situations differ in basic technical nature, development environment, size, complexity, personnel skills and attitudes, the level of familiarity that the organization has with similar projects, and a range of other factors. Project metrics can be used to determine the relative impact of these factors.

Project resource estimation usually requires a base metric such as "number of expected modules," "number of requirements," or "number of expected lines of code." Past resource requirements can then be scaled to the current project using the base metric. Additional scaling can then be used to adjust for other project variances.[5]

6.2 Productivity Metrics

Some metrics provide information on how well certain methods work in achieving desired results. Metrics can be used to identify the activities that are most time consuming. The productivity during these activities can then be compared across several past projects.

An example of a productivity metric is the number of lines of source code produced per unit time. This of course is an often misused metric sometimes used to gauge individual personnel performance. For this metric to be an accurate indicator of productivity the variance of style, program type, quality, etc. must be considered. Further, as previously mentioned, the purpose for this metric in ATDC is to improve the estimation process and to gauge the effectiveness of the development environment not to rate individual performance.

6.3 Quality Metrics

Metrics can be used to gauge quality in each development phase. This type of metric usually compares the number of defects found in a deliverable to the amount of effort spent trying to find defects. Defects can exist in requirements documents, software designs, programs and test plans. The effort required to find defects can be measured in the duration of a review, the number of test cases executed, or the amount of time spent in testing. The ratios formed by comparing defects to detection effort can be very effective in assessing the quality of the development process and in determining the status of project phases. Quality metrics are essential to the goal of progressive refinement of the development process[8].

6.4 Contingency

A common pitfall in project planning is to ignore the possibility that time consuming activities and situations unrelated to the project may occur. In fact, they invariably do occur and are often significant. Examples include: unexpected demands from other projects, illness, vacation and downsizing of staff.

Another pitfall is that if an estimate proves to be incorrect it is almost always too small. Even

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ATTACHMENT B
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without the unexpected occurrences described above most tasks take longer than expected. As described previously, metrics can be used to improve the estimation process and to minimize underestimating. However, overruns must be planned for.

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Both of these pitfalls can be avoided by scheduling for contingency. The amount of contingency required can be estimated based on past experience. It is therefore very useful to collect metrics on the frequency and magnitude of unexpected events and schedule overruns.

6.5 Metric Tools

Tools for automating the collection of metrics and for tabulating and presenting metric data are now under study in ATDC. The most obvious examples include problem tracking and test plan databases and spreadsheet programs. These and other tools will be integrated into the development environment to make the process as efficient and non-intrusive as possible.

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7.0 Responsibility by Phase

7.1 Preliminary Requirements Review

- When requirement specification work begins for a new service the RM assigned to the service will designate at least one developer to act as the primary contact from ATDC for a particular service.
- The designated developer will seek out preliminary service requirements documentation, attend related meetings, provide written and verbal feedback to the authors, and begin evaluating the required capabilities of the platforms.
- As soon as the service is well enough defined to begin system level design the appropriate RM will form a service development team

Deliverables:

Preliminary comments to authors.
Rough estimate of required number of service developers.

Metrics:

Time spent in this activity.

7.2 System Design and Feature Design

- In most cases the service is well enough defined to begin system level design when the first draft of the Service Mapping document is issued. At this point the service development team will divide the numbered requirements among themselves. The RM will appoint a team member to do this.
- Each developer will evaluate her/his assigned requirements against three basic criteria. (1) Does the requirement make sense? (2) Is the requirement testable? (3) Can the specified platform support the requirement. Exceptions will be reported to the requirement authors in writing. This evaluation is done for each of the three service requirement documents (Service Concept, Service Mapping, Feature Specification Document).
- Each developer will write a Capabilities Mapping Document describing how the specified platform can or cannot support each requirement assigned. This is initially done using the Service Mapping Document and updated when the FSD is finalized. If the specified platform cannot support a requirement with its current capabilities and analysis will be done to determine how new capabilities could be provided. The team should make a recommendation to the RM on whether the capability should be developed by ATDC, the vendor, or not at all. In the latter case associated requirement must be negotiated out of the service specification. The RM has the ultimate responsibility of resolving such situations.
- The RM will assign one service development team member to coordinate system testing. This individual (test coordinator) will see that a test abstract (a brief description of the required test strategy) exists for each service requirement. Responsibility for writing test abstracts lies on

each team member according to the partitioning of requirements as described above. A preliminary document containing the test abstracts and appropriate additional explanations will be issued when the Service Mapping document has been reviewed by the development team. Another version will be issued when the FSD is finalized.

- The service development team will write a Feature Design document and if necessary a System Design Addendum document. The RM will assign one person to be the editor for this document. Preliminary versions of these documents will be issued and reviewed at intervals mutually agreed upon by the RM and the team.

Deliverables:

Written comments on requirements documents.
Capability Mapping documents.
Test Abstract documents.
Feature Design documents (and perhaps System Design Addendum).

Metrics:

Time spent in this phase (further broken down as appropriate).
Number of requirements.
Size of Feature Design documents at each issue.
Results from design reviews.

7.3 Subsystem Design and Feature Subsystem Design

- During System and Feature Design the development team will decide how to break the design into definable pieces. The team and/or the RM will assign responsibility to each piece. In most cases the work breakdown will correspond to the architectural subsystems. A Subsystem design or Feature Subsystem design will be carried out by the assigned individuals. The culmination of this effort is a set of SSD or FSSD documents [10].
- The Capability Mapping documents and the System Test Abstract documents will be reviewed by each person responsible for these documents as described above.
- A subsystem design review will be held to review each document.

Deliverables:

Subsystem Design documents (if new subsystems are added).
Feature Subsystem Design documents.
Updated Capability Mapping documents.
Updated System Testing Abstracts.

Metrics:

Time spent in this phase (further broken down as appropriate).
Size of Feature Subsystem Design documents at each issue.
Results from design reviews.

PROPRIETARY

7.4 Unit Design, Code, and Test

- All (or at least almost all) of the required code "modules" (the definition of code modules in this context varies from C, C++, SLL, and Decision Graphs) will have been defined prior to beginning the "Unit" phase. Prior to the coding of each module, the detailed objectives and implementation plan for the module should be defined in the module header according to the Coding Standards and Reviews document [11].
- Before considering a module complete in the sense of unit design and coding each module must have passed a review [11].
- Unit test also requires a review as defined in the Software Testing Procedures document [12].

Deliverables:

Reviewed source code containing completed headers.
Reviewed unit test plans.

Metrics:

Time spent in this phase (further broken down as appropriate).
Size of code in lines per language.
Number of C/C++ modules.
Number of SLL FSM's.
Number of SLL states.
Number of SLL event handlers.
Number of test cases.
Results from design reviews.

7.5 Integration Test

- If more than one RM group is involved in a single integration effort, one RM will be designated to plan and manage the phase.
- An Integration Plan showing the strategy for the integration and testing of code segments will be written prior to the beginning of the Integration Test phase. This document will be authored by a member of the team designated by the managing RM. The plan should be reviewed.
- Detailed test cases must be completed prior to beginning System Test. During Integration Test these test cases should be developed and refined. The designated coordinator for the service team's System Test activity is responsible for orchestrating the teams preparation of the overall System Test Plan. This plan must be reviewed prior to the beginning of System Test.
- Integration Test is complete when all required functionality has been added to a common software load and successfully tested. A subset of the System Test Plan cases will be used as the criteria for determining that full functionality exists. This subset will include all tests which can be carried out under the limitations of the Integration Test configuration and which verify

functionality as specified in the requirements. Examples of System Test cases not used during Integration Test include stress testing and performance testing. The required set of Integration Test cases will be specified and added to the Integration Plan.

- A final review of the Integration Plan, the Integration Test cases, and the results of testing will be reviewed prior to completing this phase. "Bug curves" will be plotted from the DDTS problem tracking data base. These curves will show the rate of defect detection as a function of real time, time spent in testing, and number of test cases run. The RM and the team must agree that the criteria for moving to System Testing has been met.

Deliverables:

Reviewed Integration Test Plan at the beginning of the phase.
Reviewed System Test Plan including detailed test cases by the completion of the phase.
Reviewed Integration Test cases.
Reviewed final version of the Integration Test Plan and test cases with results.

Metrics:

Time spent in this phase (further broken down as appropriate).
Number of Integration Test cases.
Number of defects discovered. (broken down by cause type).
Updated metrics on software load size as specified earlier.
Bug curves.

7.6 System Test

- A single RM will be designated to manage the System Test phase.
- The System Test Plan will be updated as necessary (test cases will probably be added). A final review of the plan must be held prior to completing the phase. Intermediate reviews of the plan should be held to insure that it is appropriate in meeting the objectives of the System Test phase.
- Bug curves started during integration testing will continue.
- Weekly status meetings will be held to report progress during System Test. The managing RM will chair the meeting.
- The Network Integration Test group will perform one or more quality probes during System Testing. The NIT group's manager will be responsible for collecting appropriate metrics and writing a Quality Probe Report.
- A Release Package containing all required documentation and software will be prepared. All documents included (design documents and results from testing) must complete a final review. Outlines and descriptions of the required design documents are provided in the "Software Design Process" document [10].
- The director of ATDC, the designated representative from the NIT group, and the ATDC System Test manager will determine when the exit criteria for System Test has been met.

Deliverables:

Updated and reviewed System Test Plan and test cases with results.
Updated and reviewed final documentation.
NIT Quality Probe Report.

Metrics:

Time spent in this phase (further broken down as appropriate).
Test and defect metrics.
Bug curves.

7.7 Network Integration Test

- Assistance must given to the NIT group on a continuing basis to answer questions during the NIT phase. An RM will be designated as the primary contact for ATDC.
- Suspected problems will be reported via E-mail to the DDTS database by NIT. ATDC will adhere to a problem analysis and resolution process to be mutually agreed to. The process will require that an ATDC RM assign problem reports and track progress toward resolution. Verification/Concurrence of problem resolution must be attained by NIT.

Deliverables:

List of open problem reports on a weekly basis.
Status update on each open problem when available (automatic via E-mail).

Metrics:

Time spent in this phase (further broken down as appropriate).
Test and defect metrics.

8.0 Conclusion

As a brief summary of the highlights of the project management process described in this document, consider the following:

- A project file will be opened at the beginning of each project and maintained throughout the product life cycle.
- A "Software Development Plan" will be issued at the beginning of the project and reissued as needed.
- Development estimates will be prepared and issued at various times and for various purposes. The Software Development Plan will include development estimates.

- Schedules and charts will be prepared and maintained on the Viewpoint tool and will be used to plan and track project activities. These schedules and charts will be attached to the Software Development Plan.
- An "Integration Plan" will be written prior to the beginning of integration testing and hopefully prior to the beginning of module design.
- A "System Testing Plan" will be written prior to system testing and will describe the approach to be used in the system testing phase.
- Periodic group meetings will be held to review project status.
- Methods for assessing progress during each project phase will be well defined.
- Analysis of metrics will be used to support the goal of progressive refinement. The collection of metrics will be made as efficient as possible.

Southern Bell Tel. & Tel. Co.
FPSC Docket No. 920260
Audit
Date: 05-11-93
Amended Response to
Item No. 1-031.A
Page 1 of 1

Request: Provide the work programs/packages, as discussed by John Mast in our April 26, 1993 interview, for each project performed in the S&T organization for 1992.

Response: The Company stated on May 19, 1993 that the requested information would be mailed in overnight mail on May 20, 1993. The Company amends the response as follows:

The requested information is proprietary and is being sent in overnight mail on May 20, 1993.

This material constitutes confidential proprietary business information and is the subject of a "Notice of Intent to Request Specified Confidential Classification."

COPY

CONFIDENTIAL

Date Provided: May 20, 1993

[redacted] WORK PACKAGE

PROJECT NAME: ADVANCED INTELLIGENT NETWORK ARCHITECTURE RELEASES 1&2

RESPONSIBLE RM: [redacted]

CUSTOMERS:
Bellcore, Various Network Element Vendors such as AT&T, NTI, Siemens; Advanced Technology Development Center, Strategic Market Planning, Regulatory Planning

PROJECT OVERVIEW:
This project provides an analysis of the future [redacted] new service and revenue enhancement opportunities favored by BellSouth Marketing personnel. It formulates and analyzes network architectural alternatives for providing those services. The result of these formulations are requirements and specifications for network elements and operations systems that insure support, technically, for BellSouth's business plans.

DESCRIPTION OF [redacted] WORK:
This project will formulate various scenarios for new services in the [redacted] time frame and will assist the marketing organizations in an analysis of the various opportunities. Based on the priorities established by the marketing groups, the opportunities will be analyzed for optimum network architectural implementations. Requirements for network nodes (SSP, SCP, SN, STP, etc.) and operations systems will be published and consultations will be conducted with vendor systems engineering organizations to ensure that appropriate features supporting BellSouth's priorities are included in vendor development plans.

DELIVERABLES:
1. Requirements for AIN 0.2 SCP releases in the late [redacted] - early [redacted] time frame.
2. Requirements for ASPIN releases in the late [redacted] - early [redacted] time frame.
3. Requirements for "AIN 0.3" switch features to be implemented in the late 1995 time frame.
4. Detailed analysis of "Equal Access AIN" features for [redacted] implementation.
5. AIN 0.2 Architectural Overview Document to support training of staff and line personnel who have to work with AIN elements and services.

TO/FROM DEPENDENCIES:
This package is not dependent on others. However, this package supports development of market plans for new features on AIN and supports future strategic planning activities in a number of "downstream" organizations, including strategic market planning, and regulatory planning.

1993 WORK PACKAGE

PROJECT NAME: ADVANCED INTELLIGENT NETWORK ARCHITECTURE RELEASES 1&2

RESPONSIBLE RM: [redacted]

BUSINESS IMPACT:
The Business Case for AIN indicates substantial profits during the mid-to-late 1990's from services supported by the architecture. The cost of this package is included in that business case. This package supports one of the Corporate strategic thrusts, i.e., AIN Deployment.

HEADCOUNT:

SME [redacted]

PROPOSED BUDGET:

$

RELATED BELLCORE PROJECTS:

1R4111 AIN Planning and Requirements

	INDIVIDUALS WORKING ON THIS PROJECT	% OF TIME
2	[redacted]	100
3		100
4		100
5		100
6		100
7		100
8		100

[redacted] WORK PACKAGE

PROJECT NAME: AIN RLS 0.1 and 0.2 IMPLEMENTATION SUPPORT

RESPONSIBLE RM: [redacted]

CUSTOMERS:
Planning & Engineering, Operations Planning, INSAC Operations, Switching Operations, Advanced Technology Development Center, and others.

PROJECT OVERVIEW:
This project provides consulting services on AIN technical issues and support of Operations Staff, Engineering Staff, and development personnel for the implementation of AIN Release 0.1 and 0.2.

DESCRIPTION OF [redacted] WORK:
This project will conduct performance analyses of the SS7 network and various network nodes (SSPs, STPs, and SCPs) in an AIN environment. It will measure actual performance of the nodes in the laboratory environment under AIN services loads. From this information, engineering algorithms and design recommendations will be formulated for use by line traffic engineering personnel in deploying the AIN network. This project will also develop plans for new operations functionality needed to support the distributed control paradigm of AIN 0.2. These plans will be documented in an Operations Technical Plan, Issue 2, and will be used to develop requirements for Network Nodes (SSP, SCP, SN, etc., and will be used to drive the requirements effort for SMS and other operations systems development.

DELIVERABLES:
1. An Operations Technical Plan for AIN 0.2 outlining new operations functionality that must be implemented to support a distributed service control paradigm.
2. Specifications of features for vendor development of the SCP and Service Nodes, specifically those supporting engineering measurements, repair and operations, and surveillance.
3. Technical Memorandum outlining engineering rules for SCP deployment and Service Node Deployment for AIN services.
4. Long term analysis of the operations needs to be supported by the Service Management System, with the goal of recommending an architecture for the hardware and software of that system.
5. Consulting and training to various staffs on the details in the AIN Operations Technical Plan.

5

2 [redacted]WORK PACKAGE

PROJECT NAME: AIN RLS 0.1 and 0.2 IMPLEMENTATION SUPPORT

4 **RESPONSIBLE RM:** [redacted]

TO/FROM DEPENDENCIES:
This package is not dependent on others. However, this package supports development of methods and procedures for AIN deployment in a number of "downstream" organizations.

BUSINESS IMPACT:
The Business Case for AIN indicates substantial profits during the mid-to-late 1990's from services supported by the architecture. The cost of this package is included in that business case. This package supports one of the Corporate strategic thrusts, i.e., deployment of AIN.

HEADCOUNT:

16 SME [redacted]

PROPOSED BUDGET:

$

RELATED BELLCORE PROJECTS:

1R4111 AIN Planning and Requirements

6

INDIVIDUALS WORKING ON THIS PROJECT	% OF TIME
2 3 4 5 6 [redacted]	100
	100
	100
	100
	100

RELATED BELLCORE PROJECTS: AIN Planning and Requirements -- 1R4111

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[redacted] WORK PACKAGE

PROJECT NAME: SERVICE CONCEPTS DEVELOPMENT

RESPONSIBLE RM/DIR: [redacted]

CUSTOMERS:

Market Research, Marketing, AIN Architecture, Requirements & Development; Advanced Technology Development Center, Network Planning

PROJECT OVERVIEW:

This project supports simulation and prototyping of potential services for analysis and market research. As such, it provides tools to be used by Marketing personnel for establishing the BellSouth's mid-term and long-term business strategies. It also supports participation in the CASP group at Bellcore and concept development at BellSouth, efforts which lead to discovery of new services opportunities.

DESCRIPTION OF [redacted] WORK:

During [redacted] this project will support development of detailed service concepts for display services, personal services, multimedia services, mobile services and various applications that might utilize the AIN platforms. A number of these service concepts will be refined through market research that is supported by simulations and prototypes that are developed as part of this effort.

DELIVERABLES:

1. Service concept document for Phases II & III Customer Programmability.
2. Service concept description of Display based Voice Messaging Services.
3. Quality Function Deployment (QFD) analysis of Personal Number Service.
4. [redacted]
5. Service concept document for next phase of Personal Services.

[redacted]ORK PACKAGE

PROJECT NAME: SERVICE CONCEPTS DEVELOPMENT

RESPONSIBLE RM/DIR: [redacted]

TO/FROM DEPENDENCIES:

This package is not dependent on others. However, this package supports development of market plans for new features on AIN, ISDN, SS7 and other network capabilities and supports future strategic planning activities in a number of "downstream" organizations.

BUSINESS IMPACT:

This work is not directed toward any specific business case. Therefore, the specific business impact is not quantifiable. Rather, the work is directed toward finding new business opportunities for BellSouth Telecommunications to support growth in the business in the second half of the decade and focuses at the conceptual OP and OA stages of formulation and screening.

INDIVIDUALS WORKING ON THIS PROJECT	% OF TIME
[redacted]	100%
	100%
	100%
	100%
	100%
	100%

[redacted]

RELATED BELLCORE PROJECTS:

3Y6511 Product Concepts and Opportunity Analysis
2Y2311 Advanced Screen-Based Telephony Services & Requirements

PROPRIETAR

9

1 [redacted] WORK PACKAGE

PROJECT NAME: COMMUNITY LAB SERVICE CONCEPT DEVELOPMENT

3 **RESPONSIBLE RM/DIR:** [redacted]

CUSTOMERS:

Market Research, Marketing, AIN Architecture, Requirements & Development; Advanced Technology Development Center

PROJECT OVERVIEW:

This project supports simulation and prototyping of potential services for analysis and market research in a real customer environment. As such, it provides tools to be used by Marketing personnel for testing new service concepts in live marketing trials. Market research developed in such an environment should provide much more accurate data on which to base BellSouth's business cases, advertising plans, etc.

15 **DESCRIPTION OF [redacted] WORK:**

This project will develop service concepts and requirements documents for services to be tested in the Community Lab environment. Results of market research coming from the Community Lab will be documented and analyzed to ensure appropriate utilization in the development of final service concepts that will be a part of the formal service development and delivery process.

DELIVERABLES:

1. Continuation of testing for PNC Services
   - 24 [redacted]
   - 25 [redacted]
2. Voice Recognition Interface testing
3. ADSI Service testing
4. Integrated Service Test - PNC, ESSX, MemoryCall

TO/FROM DEPENDENCIES:
This package is not dependent on others. However, this package supports development of market plans for new features on AIN, ISDN, SS7 and other network capabilities and supports future strategic planning activities in a number of "downstream" organizations.

2 [redacted] WORK PACKAGE

PROJECT NAME: COMMUNITY LAB SERVICE CONCEPT DEVELOPMENT

4 **RESPONSIBLE RM/DIR:** [redacted]

BUSINESS IMPACT:

This work is not directed toward any specific business case. Therefore, the specific business impact is not quantifiable. Rather, the work is directed toward finding new business opportunities for BellSouth Telecommunications to support growth in the business in the second half of the decade and focus at the conceptual opportunity proposal (OP) and Opportunity Analysis (OA).

INDIVIDUALS WORKING ON THIS PROJECT	% OF TIME
13 [redacted]	100%
14	100%

15 [redacted] Headcount

RELATED BELLCORE PROJECTS:

None

[redacted] WORK PACKAGE

PROJECT NAME: FIBER DISTRIBUTION NETWORKS

RESPONSIBLE OM/RM/DIR: [redacted]

CUSTOMERS:
Marketing - Business Services

PROJECT OVERVIEW:
As [redacted] technologies develop to the point of [redacted] will continue to run into potential bottlenecks that have not been satisfactorily resolved. These include: [redacted] Using theoretical technical models, laboratory prototype devices and systems, vendor discussions, and limited field trials of experimental systems, [redacted]

DESCRIPTION OF [redacted] WORK:
[redacted]. We will work with [redacted] and others, giving them our inputs on: generic system requirements for [redacted] Field trials of experimental [redacted] services will be structured in cooperation with Marketing to obtain user data. We will continue [redacted], as appropriate. [redacted]

DELIVERABLES:
1. [redacted]
2. [redacted]
3. [redacted]
4. [redacted]

TO/FROM DEPENDENCIES:
[redacted]

PROPRIETARY

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[redacted] WORK PACKAGE

PROJECT NAME: FIBER DISTRIBUTION NETWORKS

RESPONSIBLE OM/RM/DIR: [redacted]

BUSINESS IMPACT:

[redacted]

HEADCOUNT: Authorized

[redacted]

INDIVIDUALS WORKING ON THIS PROJECT

[redacted] 100%
100%

RELATED BELLCORE PROJECTS:

13

[redacted] WORK PACKAGE

PROJECT NAME: ADVANCED INTELLIGENT NETWORK RELEASE 0

RESPONSIBLE OM/RM/DIR: [redacted]

CUSTOMERS:
Network Operations, Network Planning, Marketing, Science & Technology, Information Systems

PROJECT OVERVIEW:
This effort produces the detailed specifications required to permit [redacted] as applications on the [redacted]

DESCRIPTION OF [redacted] WORK:
AIN Services Specifications for:
1. [redacted]
2. [redacted]
3. [redacted]
4. [redacted] (not yet defined by Marketing)
5. [redacted]
6. [redacted]
7. [redacted]

PROPRIETARY

DELIVERABLES:

[redacted]

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[redacted] WORK PACKAGE

PROJECT NAME: ADVANCED INTELLIGENT NETWORK RELEASE 0

RESPONSIBLE OM/RM/DIR: [redacted]

TO/FROM DEPENDENCIES:
TO: See Customer list
FROM: Market Research, Marketing Product Management, Advanced Services Concept Group, Advanced Network Architecture Group

BUSINESS IMPACT:
This work is required to support [redacted]

HEADCOUNT: Authorized
[redacted]

[redacted]

RELATED BELLCORE PROJECTS:

15

[redacted]ORK PACKAGE

PROJECT NAME: ADVANCED DATA SERVICES

3 **RESPONSIBLE OM/RM/DIR:** [redacted]

CUSTOMERS:
Marketing - Business Services, Data Services Organization

PROJECT OVERVIEW:
Advanced data communications technologies such as: Switched Multi-megabit Data Services (SMDS), Frame Relay (FR), Fiber Distributed Data Interface (FDDI), Internetworking and the Network Management of these technologies have been identified as important to existing and prospective users of the BellSouth networks. Development and demonstration work in prior years has let to the planned deployment of new advanced data services based on these technologies in 1993.

DESCRIPTION OF 1992 WORK:
Laboratory systems and field trials will be cooperatively developed ad tested with network equipment and customer premise equipment (CPE) vendors to effectively support the initial roll out of three new data services, SMDS, FR and Native Mode LAN.

DELIVERABLES:
1. Support to be provided to Marketing for the 1993 roll out of three new data services; SMDS, Frame Relay, and Native Mode LAN (FDDI).
2. Support to be provided to Marketing for the roll out of special assembly SMDS services in conjunction with the proposed NC broadband network.
3. A specific exploratory development program to be carried out on a broadband network "RNET" jointly being developed with IBM and to be deployed in Tennessee (ORNL/UT).
4. Continuing support of an experimental SMDS network between BST Science and Technology locations in Atlanta and Birmingham. Other users will be placed on the prototype SMDS network.
5. Overview and management of ongoing Bellcore projects: AD/NMS, SMDS Phase 2, Frame Relay PVCs, High Speed Networking, Internetworking, Network Operating Systems, Computer Systems and Networks, Information Systems.
6. Development of network management capability for Native Mode LAN service.

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F01K01W 00/93/

17

1993 WORK PACKAGE

PROJECT NAME: WIRELESS ACCESS PCS SERVICES

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3 **RESPONSIBLE OM/RM/DIR:** [redacted]

CUSTOMERS:
Marketing - Business Services

PROJECT OVERVIEW:
Our work in the wireless PCS services area encompasses a wide range of activities related to the implementation of low-power radio technologies and AIN access services in the public switched network. Our work explores the application of AIN based access services and low-power radio technology in the local loop. A key component of our work is to evaluate the use of low-power radio technology in BellSouth's ESSX product line. In-building wireless access services for voice and data are expected to make up a significant portion of the future PCS market since business customers are often early adapters.

DESCRIPTION OF 1992 WORK:
We will work to identify and resolve network interface issues jointly with Bellcore and other Regions to facilitate the integration of wireless and wireline services. Tradeoffs associated with various methods of providing wireless PCS services such as channel rates, multiplexing/access methods, costs, security and complexity will be analyzed with the intent of contributing to current industry efforts to develop PCS services. We will also work closely with marketing to set up internal and customer trials to evaluate the efficiency of wireless access services in the workplace.

DELIVERABLES:
1. Conduct an internal trial of wireless ESSX at the BellSouth Colonnade facility.
2. Provide trial radio systems and technical support for customer wireless access trials as requested by Marketing.
3. Contribute to current industry effort to define early PCS services via a multi-regional trial of a Personal Number Service.
4. Provide technical consulting to others in BellSouth (e.g., Network Planning, Standards, Corporate, and Regulatory) as needed on radio topics (e.g., satellites, PCS, Microwave radio, etc.)
5. Provide reports to the FCC on the use of experimental licenses.
6. Jointly with Bellcore and the other Regions define network services which could be offered to PCS providers, and issue documents describing specifications and requirements for proposed PCS systems.

TO/FORM DEPENDENCIES:
Availability of trial radio system technology is assumed. Also, a strong push from BellSouth Telecommunications Marketing is needed to set up and evaluate customer trial situations. Continued RBOC support for Bellcore's PCS work plan is assumed.

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1993 WORK PACKAGE

PROJECT NAME: ADVANCED DATA SERVICES

RESPONSIBLE OM/RM/DIR: [redacted]

TO/FROM DEPENDENCIES:
Many of our activities depend critically on the timely execution and deliveries by our vendors, and joint partners. Network interface disclosures, tariff applications and approvals may also affect our deliverables.

BUSINESS IMPACT:
The first corporate revenues from the introduction of Advanced Data Services should be seen in 1993.

HEADCOUNT: Authorized

[redacted]

[redacted]

RELATED BELLCORE PROJECTS:

1993 WORK PACKAGE

PROJECT NAME: **WIRELESS ACCESS PCS SERVICES**

RESPONSIBLE OM/RM/DIR: [redacted]

BUSINESS IMPACT:
Emerging PCS services have the potential to revolutionize the telecommunications industry. Market researchers have estimated the total market value at almost [redacted] Most studies agree that tremendous demand exists for wireless access services and have projected a very large number of potential users of mature radio PCS systems. [redacted]

HEADCOUNT: **Authorized**

[redacted]

[redacted]

RELATED BELLCORE PROJECTS:

321302 Wireless Access
321408 Personal Communications Applications

PROPRIETARY

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1993 WORK PACKAGE

PROJECT NAME: NETWORK EVOLUTION

3 **RESPONSIBLE OM/RM/DIR:** [redacted]

CUSTOMERS:
Network Planning, Marketing, Bellcore, Vendors

PROJECT OVERVIEW:
New technologies, including Broadband ISDN (BISDN), Advanced Intelligent Network (AIN), and Personal Communications Services (PCS), will be deployed in BellSouth's network over the next decade. These technologies are synergistic with each other and overlap in a number of areas. The relationship between these new technologies must be clearly understood, a target architecture must be developed which weaves these technologies together in a cost-effective way to maximize the benefits to BellSouth, and a realistic plan must be developed to introduce these technologies economically and to maximize the benefits to BellSouth. If these technologies are developed independently, opportunities to reduce cost by taking advantage of the synergies will be missed, resources will be wasted in reinventing similar concepts for different technologies, and the cost to operate the network will be higher than if a proactive approach is taken to combine the best aspects of these technologies in a unified evolution plan. This project addresses the relationship of new technologies in the target network architecture and the evolution issues associated with the introduction of new technologies in BellSouth's network.

DESCRIPTION OF 1993 WORK:
1. Address technical issues associated with the introduction of new technologies in BellSouth's network, particularly in the areas of overlap between different technologies to ensure that the technologies work well together (e.g., BISDN, AIN, and PCS).
2. Work closely with equipment vendors to understand their plans for evolving their switching and transmission products and give them feedback to align their products with the needs of BellSouth.
3. Support Network Planning and Marketing in their network evolution studies.
4. Work proactively with Bellcore and the equipment vendors in defining a target network and evolution plan that meets the needs of BellSouth customers.

DELIVERABLES:
1. Write technical Memoranda documenting the vendor's product evolution plans and the role that these products would play in BellSouth's network.
2. Update BellSouth's Network Evolution Plan based on an analysis of the impact of new technologies.

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1993 WORK PACKAGE

PROJECT NAME: FIBER DISTRIBUTION NETWORKS

RESPONSIBLE OM/RM/DIR: [redacted]

TO/FROM DEPENDENCIES:

BUSINESS IMPACT:
As new technology becomes available, BellSouth's network must be evolved wisely to ensure that BellSouth is best positioned to generate revenue from new services and to benefit from more cost-effective ways of providing existing services. Effective network evolution is dependent on having a realistic target network architecture and a plan for evolving the network toward that target. This supports the Corporate strategic thrust for switch replacement.

HEADCOUNT:	Authorized
	[redacted]
[redacted]	50%
	50%

B 50

1993 WORK PACKAGE

PROJECT NAME: VIDEO SERVICES TRANSPORT

3 **RESPONSIBLE OM/RM/DIR:** [redacted]

CUSTOMERS:
Marketing - Business Services

PROJECT OVERVIEW:
Video communications services are already a rapidly growing market. The advent of Broadband ATM transmission and switching technologies and products have begun to accelerate the development of video communications technologies in view of the increased flexibility of ATM transport. The recent interest of the FCC in promoting Video Dial Tone services has also begun to accelerate the development of video communications. Important video communications applications such as Distance Learning and government telecommunications are currently being developed to meet the requirements of several large BellSouth customers. To perform research in support of meeting these customer needs, we need to utilize image coding theory, computer simulation, high-speed digital processing, and prototyping of various critical systems required for video telecommunications. Early lab and field prototype fiber systems require analysis and testing, to determine their usefulness and applicability in the BellSouth network. Transfer of video research concepts to potential user environments in local applications will be emphasized, such as video-conferencing, multipoint video conferencing, and video on fiber distribution. Behavioral science aspects, i.e., subjective testing will be assessed to the extent practicable.

27 **DESCRIPTION OF [redacted] WORK:**
Exploratory development will be performed using prototype video network service capabilities to evaluate and demonstrate user scenarios for possible applications, especially those already requested by certain BellSouth customers. These include: experimental evaluation of switched video and multipoint video conference bridging technologies in support of Distant Learning and government telecommunications applications, demonstration of video transmission using various video coding and compression technologies, demonstration of technologies for multimedia teleconferencing and Distant Learning applications, and other similar work. Qualitative evaluation and advice will continue to be given on proposals being made for advanced Television (ATV), video coding standards development in CCITT And ISO/MPEG, and EIA subcommittee work on digital video communications technologies.

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1993 WORK PACKAGE

PROJECT NAME: VIDEO SERVICES TRANSPORT

3 **RESPONSIBLE OM/RM/DIR:** [redacted]

DELIVERABLES:

1. Prototype broadband switched video and multipoint video systems applicable to Distant Learning and business video communications will be set up and demonstrated.
2. Both large-screen and desktop multimedia teleconferencing prototypes will be demonstrated using the research platform established in 1992.
3. Systems proposals will be developed for video delivery capabilities, as appropriate.
4. Continued assistance will be given to the ATV Advisory Committee on Advanced Television Service.
5. Periodic reports will be made on the status of ATV in the United States and its strategic significance to BellSouth.

TO/FROM DEPENDENCIES:
The experimental video facility will use corporate communications network facilities between Atlanta and Birmingham.

BUSINESS IMPACT:
Successful video services will be key elements in corporate revenue growth. The total available opportunity is expected to expand significantly as more competitors enter the market.

25 **HEADCOUNT:** Authorized [redacted]

26 27 [redacted]

1 [redacted] WORK PACKAGE 23

PROJECT NAME: BROADBAND ISDN

3 **RESPONSIBLE OM/RM/DIR:** [redacted]

CUSTOMERS:
Network Planning, Marketing, Bellcore, Vendors

PROJECT OVERVIEW:
BISDN, based on Synchronous Optical NETwork (SONET) transmission and asynchronous transfer Mode (ATM) multiplexing and switching, is the switching and transport infrastructure for BellSouth's target network architecture. BISDN will support many services with widely differing bit rates over a common platform to minimize the capital and operations costs and to maximize the flexibility of the network. SONET transmission equipment currently being installed for narrowband services will form the transmission infrastructure for BISDN. SMDS, Frame Relay, and switched DS-1 are three early availability broadband services being planned for BISDN. BellSouth's BISDN technology trial (VISTAnet) began in 1991. It is expected that commercial deployment of a broadband multiservices platform to support SMDS, Frame Relay, and ATM services will begin in 1993.

20 **DESCRIPTION OF [redacted] WORK:**
1. Address technical issues associated with BISDN and BISDN services.
2. Take a proactive role in standards bodies to ensure that CCITT recommendations (SONET, ATM, adaptation layer, and signaling) for initial commercial deployment of BISDN are consistent with BellSouth's business interests.
3. Take a proactive role with Bellcore to ensure that Bellcore technical advisories on BISDN and BISDN services are consistent with BellSouth's business interests.
4. Work closely with equipment vendors to understand their plans for broadband products and give them feedback to align their products with the needs of BellSouth.
5. Support Network Planning and Marketing in their studies of BISDN.
6. Develop proatotypical hardware and software for BellSouth BISDN trials.

DELIVERABLES:
1. Submit technical contributions to T1S1 and CCITT as required to resolve critical standards issues that could obstruct the completion of signaling standards required for the commercial deployment of BISDN.
2. Support the deployment of broadband switches for SMDS, Frame Relay and ATM services for the North Carolina state network.

PROPRIETARY

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[redacted] WORK PACKAGE

PROJECT NAME: BROADBAND ISDN

RESPONSIBLE OM/RM/DIR: [redacted]

3. Ensure that CCITT recommendations on BISDN signaling are completed for 1993 approval.
5. Ensure that Bellcore Technical Advisories on BISDN are completed.

TO/FROM DEPENDENCIES:

BUSINESS IMPACT:
Broadband ISDN is recognized throughout BellSouth as being an essential element of BellSouth's target network architecture. Specifications for BISDN are now being developed nationally and internationally, and both network and CPE vendors are now developing BISDN products. It is essential that the decisions now being made on BISDN are in BellSouth's business interests and that standards and requirements are completed in a timely manner. This can only be accomplished by having direct involvement in these decisions and taking a proactive role to ensure that critical issues are resolved before they become obstructions and delay the introduction of BISDN services.

HEADCOUNT: Authorized [redacted]

[redacted]	100%
	100%
	100%
	50%
	50%

1993 WORK PACKAGE

PROJECT NAME: AIN RELEASE 0 SOFTWARE DEVELOPMENT

RESPONSIBLE RM/DIR: [redacted]

CUSTOMERS:
Advanced Services Concepts, Transmission/Switching Product Evaluation, Switching Technical Methods, Information Systems

PROJECT OVERVIEW:
This work will provide the service creation environment and the lab testing environment for the [redacted] Field support for the [redacted] service will be provided. It also includes the [redacted] software for [redacted] and [redacted] Development of the customer programmability [redacted] of the AIN will be continued through joint efforts with AT&T and [redacted] Development of the [redacted] will be jointly developed between [redacted] In addition, [redacted] testing and [redacted] testing will be provided to evaluate the capabilities of these platforms for the development of new services. In addition, work will begin on some technologies required for future services, an example might be [redacted]

DESCRIPTION OF 1993 WORK:
1. Enhance the software development environment and lab facilities as required for the [redacted]
2. Resolve problems associated with the installation, [redacted]
3. Complete the software development of [redacted]
4. Continue the development of the software required for [redacted]
5. Complete the [redacted] required to support [redacted]
6. [redacted] required to support [redacted] first office application trials.
7. Plan and execute tests of the [redacted]
8. Provide software for an [redacted]

DELIVERABLES:
1. Enhanced software development environment, lab facilities, and computing facilities.
2. Software & design documentation for [redacted]
3. [redacted]
4. [redacted]
5. Evaluation reports of the [redacted]
6. Software to support a [redacted]

1993 WORK PACKAGE

PROJECT NAME: AIN RELEASE 0 SOFTWARE DEVELOPMENT

4 **RESPONSIBLE RM/DIR:** [redacted]

TO/FROM DEPENDENCIES:

FROM:

7 1. [redacted]
2. Service requirements from S&T technical specifications and requirements.
3. Service concepts from S&T Advanced Services Concepts.

TO:

1. Software design documentation to Switching Technical Methods.
2. Software & design documentation to Network Integration and Test.

BUSINESS IMPACT:

The AIN Business Case is well documented in many forms. This supports
16 [redacted]

INDIVIDUALS WORKING ON THIS PROJECT **% OF TIME**

18 [redacted] - 100% SME Headcount = [redacted]

RELATED BELLCORE PROJECTS: none

MRS - Tallahassee

Southern Bell Tel. & Tel. Co.
FPSC Docket No. 920260 - TL
Audit
Date: 10-26-92
Item No. 1-004
Page 1 of 1

Request: Provide all planning documents relating to PCN and wireless developed or obtained in 1991 and 1992.

Response: Attached is the March 30, 1992 BellSouth Standards Strategic Plans.

PROPRIETARY

B-92

MRS - Tallahassee

Request: Provide all planning documents relating to PCN and wireless developed or obtained in 1991 and 1992.

Response: Attached is the March 30, 1992 BellSouth Standards Strategic Plans.

PROPRIETARY

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Science and Technology

Subject: **Standards Strategy to Support Personal Communications Services**

Date: March 30, 1992

EXECUTIVE SUMMARY

This document is intended to provide an overview of the BellSouth standards strategy to support the present vision for BellSouth network deployment of Personal Communications Services (PCS). To facilitate the convergence of understanding within BellSouth of PCS concepts, included herein is a fundamental description of PCS from an industry standards perspective. The section describes PCS principles, required capabilities, and high-level service descriptions. Included for clarification of many terms used is a glossary of industry standards accepted terms. The BellSouth Corporate Strategy regarding PCS is outlined and gives current direction to BST and BSE subsidiaries in pursuing the development of BellSouth's PCS business. Consistent with other BellSouth strategies, the development of PCS architectures is discussed herein, and suggests that a near-term architecture employing AIN elements be employed which would later be evolved to the strategic BST target network architecture, also discussed. These architectures will support project deployment scenarios for wired and wireless end-user PCS as well as access services, all based on BST network evolution plans. A standards strategy section discusses unresolved PCS issues which will impact the network and how these issues should be developed within industry standards fora. The extent to which BellSouth can influence the outcome of these standards issues is dependent on BellSouth resources applied to standardization efforts. The current level of BellSouth representation within national and international standards fora is furnished and further resource requirements are discussed.

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FIGURES

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1. INTRODUCTION

1.1 Purpose

It has been determined that Personal Communications Services (PCS) are of strategic importance to BellSouth. The purpose of this document is to develop a plan for managing BellSouth's participation in national and international telecommunications industry standards fora to support BellSouth's goals and objectives. Facilitating the development of national and international industry standards concerning Personal Communications will permit BellSouth to most effectively execute its corporate strategy.

1.2 Document Overview

The following information is contained within this document.

- PCS fundamentals are described, including the goal of Personal Communications, the capabilities required to provide PCS, high-level end-user and access service descriptions of PCS, and a set of service objectives as envisioned by national industry standards bodies.
- The BellSouth Corporate strategy regarding PCS and wireless services is briefly discussed to provide a perspective on how Personal Communications may fit into the evolving telecommunications and information industry.
- Potential architectures and deployment schedules are presented to indicate how BellSouth may participate in providing PCS.
- Broad technical issues surrounding the implementation of PCS are discussed, as well as some standards management strategies for these issues.
- Resource requirements which will permit the realization of this standards strategy are discussed.
- A glossary of PCS terminology accepted by national industry standards bodies is included for clarity.

Because PCS is at a very early stage of development, it is envisioned that this document will require periodic revisions as PCS development matures.

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2. PCS FUNDAMENTALS

2.1 PCS Principles

It is generally understood that the goal of Personal Communications is to provide end-users with greater flexibility in their use of telecommunications services in terms of mobility and control[1]. *Mobility* addresses the ability of users to use any available terminal for network access. It also allows the use of a portable terminal which provides network access at different locations and while in motion. *Control* addresses the ability of the user to control access to services and associated service parameters and to have control over the completion of calls to the user.

2.2 Capabilities Required to Support PCS Principles

The mobility and control aspects of PCS can be defined in terms of personal mobility, terminal mobility, and service profile management capabilities. ANSI Technical Subcommittee T1P1 has defined a Personal Communications Service as a set of capabilities that allows some combination of terminal mobility, personal mobility, and service profile management.

Personal mobility allows a user to access services (e.g. make and receive calls) at any terminal in accordance with the user's service profile and to accept incoming calls at the user's current terminal or direct the calls to some other destination. This requires a unique user identifier which the network can use to identify and locate users. In addition, billing records for services should also be associated with the user.

Terminal mobility allows the user's terminal to access the network at different locations, while stationary or in motion. This requires a unique terminal identifier which the network can use to identify and locate terminals. Note that terminal mobility consists of two distinct attributes: access at different locations, and access while stationary or in motion. The latter is specifically associated with wireless terminals.

Service profile management allows a user to review and modify the user's service profile. Since the service profile controls the services provided to the user, the ability to control this profile gives the user a customized telecommunications environment not available in today's networks. This capability of PCS will offer the user the ability to configure telecommunications services in a manner which best meets the user's individual needs at any time or location.

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2.3 End-user Service Objectives

It is envisioned by industry standards committees that PCS should fulfill the following end-user service objectives:

- Services can be selected using a "cafeteria plan" and are uniquely configurable by and for each user.
- Services should be fully transparent, regardless of location and time, across multiple networks, public and private, wired and wireless.
- Services should be available to the user at any access point, through wired or wireless access.
- Services should be provided with ubiquitous coverage and connectivity to the public network.
- Services should utilize Intelligent Network capabilities.
- Services should have quality comparable to those provided over wireline.[1]
- Services should have low-cost potential.
- Services should be provided with sufficient privacy.
- Services access should be secure.

Personal communications encompasses services and features that offer various degrees of terminal and personal mobility. These services range from voice access using a portable, pocket-sized communicator (terminal mobility concept) to feature transportability (e.g. speed-calling list) from the user's primary network access point (wireline-based or wireless-based service provider) to an alternate network access point (personal mobility concept). The services offered will be limited by the capabilities of the network provider, service provider, and regulatory considerations.

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[1]These quality aspects are [redacted]

2.4 High-level PCS End-user Service Descriptions

Two broad categories of Personal Communications Services are envisioned for end-users within T1P1: Wireless-Access Mobility Services Conferring Terminal Mobility (WAMS) and Universal Personal Telecommunications (UPT) Services. WAMS is based on the CCITT/CCIR recommendations on Future Public Land Mobile Telecommunications Systems (FPLMTS). UPT services are based within CCITT recommendations of the same name.

2.4.1 Wireless-Access Mobility Services Conferring Terminal Mobility (WAMS)

These services allow users to originate and terminate calls from small, lightweight portable devices, regardless of location within a service provider's coverage area. WAMS, as an end-to-end service, uses emerging digital wireless technologies to enable a user to communicate while in motion. WAMS will allow users to access voice-grade services, be simple and easy to use (e.g. automatic registration), and utilize wireless access technology to serve small, lightweight handsets. WAMS will also offer security and quality comparable to wireline services. From an end-user's perspective the small, lightweight, shirt-pocket-sized terminal (SPT) will be the focal point of WAMS. By definition, the SPT will have low-power radio access to microcellular sites that will have full connectivity with the PSTN and Intelligent Network capabilities.

WAMS allows a user, while within a WAMS service provider's coverage area, to make and receive calls with a SPT. The SPT automatically registers with the network so that a user is not required to perform any manual tasks to register. The user can dial anywhere that is currently accessible by wireline networks.

The user will be able to move at pedestrian speeds while maintaining a conversation. As the user moves from location to location, alternative WAMS providers may be offering originating and terminating services. The user should be able to request the identification of (and to select) the WAMS service provider while at visited locations.

Voice services available via WAMS include exchange and access services and commonly available capabilities, such as dual-tone multi-frequency (DTMF), and Interexchange Carrier (IC) selection and pre-selection.

2.4.2 Universal Personal Telecommunications (UPT) Services

These services allow users access to a variety of telecommunications services. UPT enables users to originate and terminate calls based on a user-defined profile and a UPT number.

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UPT will allow users to access voice-grade services, enable users to be reached through their UPT number regardless of location, be simple and easy to use, and be access technology independent. UPT will also enable portability of vertical services and transparency across networks. UPT security and quality will be comparable to those offered over wireline.

UPT allows the user access to telecommunications services as defined in their user-defined service profile related to their UPT number. This profile will contain information regarding the services available to the user and the screening of calls destined to the user.

This service will include portability of some vertical services and features. Regardless of the location of the user's subscribed UPT service provider, a user should be able to have access to some common set of vertical features including portability of billing information and calling party number information. Calling party number information is needed for screening (by the user or by the network) of calls.

Users should be able to access their profiles and invoke vertical services in a uniform manner regardless of location, serving equipment, or UPT service provider.

Voice services available via UPT include exchange and access services and commonly available capabilities, for example dual-tone multi-frequency (DTMF) and Interexchange Carrier (IC) selection and pre-selection. While at visited locations, users should be able to identify the default UPT service provider and to select the UPT service provider of their choice.

2.5 High-level PCS "Wholesale" Access Services Description

Personal Communications access services, or "wholesale" services, are being designed to be typically offered by the regulated, wireline-based local exchange carriers to PCS service providers (PSPs)[2]. These PSPs include PCS Wireless Providers (PWPs) and PCS Database Providers (PDPs). PSPs, depending upon regulation, may be independent companies, or RBOC subsidiaries. In this scenario, the PSP's are the "customers" for the access services; the PCS users are the "customers" of the PSP. Five potential access services will be discussed here. The provision of multiple access services are necessary for a number of reasons:

- Multiple access service configurations allow for a staged entry into PCS rather than a "flash cut."
- Multiple services will accommodate a variety of network architectures and the inevitable evolution of those architectures.

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- Multiple access services will provide BST flexibility in establishing business relationships with PSPs.

A high-level diagram depicting access services and providers in relationship to end-to-end services in shown in Figure 1. Figure 2 shows the personal communications system physical architecture from which these access services were developed. Figure 3 shows the architecture of Figure 2 implemented using Advanced Intelligent Network (AIN) elements. Similar access services are certainly possible for other architectures as well.

Each access service provides functionalities across a specific interface to support several PCS end-to-end events, which will further support the end-to-end services such as WAMS. The particular events which have been identified as necessary in providing PCS end-to-end services are

- Terminal Registration,
- Personal Registration,
- Terminal Authentication and Privacy,
- User Authentication and Validation,
- Automatic Link Transfer, and
- Alerting and Call Delivery

The five access services which support combinations of the above events are listed below.

2.5.1 PCS Access Service for Networks (PASN)

This is a connection service that provides signalling and transport to a PWP with switching capabilities. BST provides translation (UPT number-to-TID, TID-to-RN[2]) and routing functions, so that calls for UPT subscribers are delivered to the appropriate PWP network over the PASN interface(s).

[2]TID: Terminal Identifier. RN: Routing Number. See glossary.

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2.5.2 PCS Access Service for Controllers (PASC)

This is a service intended for PWPs with radio channel control and some level of automatic link transfer capability. In addition to providing the translation and routing functions of PASN, this service also provides call delivery and call control (e.g. "dial tone") functions.

2.5.3 PCS Access Service for Ports (PASP)

This service is intended for PWPs with a minimum amount of PWP network functionality. Such a PWP would own the radio license and radio ports, but most functions would be handled by BST, including the functions provided by PASN and PASC.

2.5.4 PCS Access Service for Databases (PASD)

This access service is actually a collection of database functions from which the desired, or necessary functions can be selected. This service will include the exchange of both "persistent" (subscribed) and "transient" (call-related) data. Every PCS provider who will support the end-to-end services such as WAMS will require some of the functions in this access service. Those which serve as PCS hosts (providers whose databases store persistent data) will require most or all of these functions.

2.5.5 PCS Access Service for Enhanced Service Providers (PASE)

This access service provides functionalities to accommodate PCS providers wishing to supply PCS support services (e.g. high-speed paging for alerting, specialized voice mail) for other service providers.

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3. BELLSOUTH CORPORATE STRATEGY REGARDING PCS AND WIRELESS SERVICES

A BellSouth Wireless Vision is currently being developed which will provide new insights into the strategy for PCS and wireless services. At this point in time, BellSouth should proceed with the strategy for PCS as set forth for 1991[3]:

3.1 BellSouth should aggressively pursue the development and delivery of PCS in [redacted] markets:

- [redacted]

NOTE: Limited mobility is characterized by a degree of freedom experienced by pedestrians, and for the duration of a call, may possibly include further limitation to the service area of one base station. Full mobility is characterized by a degree of freedom afforded to a vehicular user.

3.2 BellSouth should immediately establish experiments and trials to enhance its leadership position in PCS.

3.3 BellSouth Enterprises (BSE) should pursue the development of [redacted]s. (End-user services)

3.4 BellSouth Telecommunications (BST) should pursue the development of [redacted] (End-user services)

3.5 BellSouth should closely coordinate its internal business activities associated with PCS.

3.6 BellSouth should develop large-scale intelligent network plans to support other providers of limited and full mobility services. (Access services)

3.7 BellSouth should aim for some degree of operational compatibility in the future for terminal devices used in all the markets it will pursue.

It is uncertain whether the FCC will allow BellSouth to offer wireless PCS, and if BellSouth is permitted to offer wireless PCS, the question arises as to whether wireless PCS business would be ruled as regulated or unregulated. Further more, uncertainty as to which aspects of PCS would be best served by BST and which would best be served by BSE is an issue which requires further attention.

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4. ARCHITECTURES FOR PROVIDING PCS

4.1 Strategic Architecture

Over the next decade, BellSouth Telecommunication will be evolving its present network toward the target BellSouth Information Networking Architecture (B-INA) shown in Figure 4.[redacted] in that feasibility and practicality of evolution are primary objectives of BellSouth's approach. This approach uses the embedded network foundation, integrating into that foundation flexible capabilities which support information network services, thereby utilizing the embedded infrastructure as much as is practical. B-INA is also founded upon comprehensive discussions with vendors to ensure that our evolution plans are aligned with vendor's product development plans.

Four platforms and their Operations Systems form the foundation for this B-INA target architecture[4]:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

Key attributes of this target architecture which relate directly to PCS are as follows:

4.1.1 Supports multiple services on a common platform.

4.1.2 [redacted]

4.1.3 [redacted]

4.1.4 [redacted]

4.1.5 [redacted]

4.1.6 [redacted]

4.1.7 [redacted]

4.1.8 [redacted]

4.1.9 [redacted]

4.1.10 [redacted]

4.1.11 [redacted]

These attributes are all aimed at the objective of providing services that customers need at affordable prices. The cost effectiveness or providing these services is maximized by supporting multiple services on a common platform, making use of appropriate standard interfaces to benefit from volume deployment, integrating operations systems with network elements, and reducing redundancy in corporate databases.

Joint efforts have been underway within the standards fora T1P1 and TIA TR45 to identify reference models for PCS. TR45 has already developed a reference model for cellular systems, and T1P1 should complete work on their PCS reference models in mid 1992. The two groups are working together in developing an agreed upon architecture which should meet the needs of users represented by both T1P1 constituents and TR45 constituents.

As the development of PCS matures, BellSouth should strive to insure that the above listed attributes are also those of the industry standardized PCS architectures, so as to be consistent with BST evolution toward its target B-INA.

4.2 Near-Term Architecture

Looking more toward the 1995-1996 window when wireless PCS will initially be deployed, the AIN architecture of Figure 3 is capable of providing end-user wireless services and access services as described in Section 2.4 and is evolvable to the target B-INA. Bellcore

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research has determined additional capabilities beyond that specified in AIN Release 1, Issue 1, which are required to provide PCS access services. The five access services identified within Section 2.5 were the basis of this analysis and are being used in determining AIN Release 1, Issue 2 requirements. The access service events which have been analyzed in support of PCS Access Services are [redacted] of the impact which PCS has upon the AIN Release 1, Issue 1 requirements, this analysis has identified new AIN functionality required for PCS access services in the following areas:

- [redacted]

5. PROJECT DEPLOYMENT SCHEDULE

Until regulatory uncertainties surrounding PCS subside, project deployment plans are subject to change. The events contained herein are closely linked to these PCS events in the BellSouth Report on Network Evolution[6].

BST will probably offer [redacted] which are now available and continue to be developed. BST is also well-positioned to offer infrastructure support for other PCS providers, such as wireline facilities to radio equipment and Advanced Intelligent Network (AIN) services from BellSouth ASPIN[3] nodes and SCPs[4].

5.1 End-user Services

5.1.1 Wireless Services

At this point in time, these services are characterized by their ability to allow the portable terminal which provides network access at different locations and while st or in motion *(terminal mobility)*.

Request Details of Gainesville Test

During 1991, BST began trials [redacted] at the University of Georgia in Athens and is conducting a PCN market trial in the area.

[redacted]

In 1993, standards will likely become finalized for PCS system architectures, port-to-portable interfaces, and network interfaces. Also, [redacted]

[redacted]

[4]Service Control Point (SCP) is an AIN network element which can perform centralized routing and database access services.

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place. Depending on FCC actions, service may have to be provided under FCC Rules and Regulations Part 15 using spread spectrum technology. Handsets and radio ports will be ~~classified as CPE. Handsets used in the office will be compatible with residential base stations available for use at the user's residence.~~

In the 1994-1995 time frame, it is expected that the FCC will have made available a sufficient amount of spectrum with which to begin deployment of a pervasive PCS offering. The deployment of such a system is estimated to require one to two years.

5.1.2 Wired Services

These services are typically characterized by their ability to allow the user to access services from any terminal (*personal mobility*) and to control access to services and associated service parameters and to have control over the completion of calls (*service profile management*).

[redacted]

5.2 "Wholesale" Access Services

During the 1994-1995 timeframe, AIN-based services will be sufficiently developed for offering to the cellular industry through intelligent interconnection. An integral part of the design of intelligent interconnection services will be the utilization of CCS7 signalling links between wireline and wireless carriers.

An industry SS7 interconnection trial involving Bellcore, BellSouth Cellular, Southern Bell, McCaw Cellular Communications, and an interexchange carrier has been undertaken in the southern Florida area[7]. The trial is the first to test the feasibility of interconnecting wireless and wireline networks using SS7 signalling links, and to determine the completeness of existing documentation regarding SS7 interconnection (there is presently no [redacted] networks). [redacted]

The following services, under concept development at Bellcore, are intended to be made available in the [redacted] but may vary somewhat depending on business plans within BellSouth. Refer to the high-level description in Section 2.5, Figure 1 for a high-level diagram depicting access services and providers in relationship to end-to-end services, Figure 2 for the PCS physical architecture from which these access services were derived, and Figure 3 for an AIN implementation of the Figure 2 Architecture. Once again, similar access services are certainly possible for other architectures as well.

5.2.1 [redacted]

[redacted]

5.2.2 [redacted]

[redacted]

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[redacted]

5.2.3 [redacted]

[redacted]

5.2.4 [redacted]

[redacted]

5.2.5 [redacted]

[redacted]

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6. ENHANCEMENT OBJECTIVES

PLACEHOLDER

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7. STANDARDS MANAGEMENT STRATEGIES FOR OPEN PCS ISSUES

7.1 Objectives

BellSouth standards management strategies should facilitate the development of PCS industry standards in a timely manner and which are consistent with BellSouth plans for service deployment as given in Section 5. These strategies should also ensure that the PCS industry standards developed affecting BellSouth will exhibit attributes compatible with those for the target BellSouth Information Networking Architecture (B-INA) described in Section 4.1.

7.2 PCS Open Issues

7.2.1 Spectrum Reallocations

On June 28, 1990, the FCC initiated Docket 90-314 which issued a Notice of Inquiry (NOI) requesting industry information of the development of Personal Communications Services (PCS). Among the topics, the FCC inquired about where spectrum should be allocated for PCS and how much spectrum would be needed. In its comments to the NOI, BellSouth recommended an initial amount of 30 to 40 Mhz of bandwidth, and ultimately 100 Mhz. On February 7, 1992, the FCC released a Notice of Proposed Rulemaking proposing to establish new areas of spectrum to be used for emerging telecommunications technologies. These new frequency bands will come from 220 MHz of spectrum between 1850 MHz and 2200 MHz, more specifically 1850-1990 MHz, 2110-2150 MHz, and 2160-2200 MHz. The FCC has identified emerging technologies such as PCS, data PCS, generic mobile-satellite services, digital audio broadcasting, and low-earth orbit satellites for applications within these bands, with PCS probably being the first application. *BellSouth should encourage the development of architecture and interface standards which best utilize this spectrum while also supporting BellSouth's positions for spectrum allocation and spectrum sharing with existing users.*

7.2.2 PCS Numbering Impacts

There are many technical issues concerning PCS numbering. Personal numbering has a significant impact upon the [redacted] Bellcore has analyzed the impact of the above items on the PSTN and documented preliminary results in [8]. BellSouth recommendations will be documented as the implications of these issues are clarified.

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7.2.2.1 Numbering Plan

It is envisioned that every end-user may be assigned a unique Universal Personal Telecommunications (UPT) number from their service provider when subscribing to PCS services. This number gives the user *personal mobility*, as described in Section 2.2. In addition to this UPT number associated with the user, there may also be a unique station number associated with the user's terminal which may be stationary or mobile. This station/terminal number allows for terminal mobility, also discussed in Section 2.2. It is possible that more than one user may be assigned to the same terminal, therefore multiple UPT numbers will be associated with one terminal number. Herein lies the need for a two-layer numbering scheme, the first, a UPT number which supports *personal mobility*, and a second number which supports *terminal mobility*[9].

It is BellSouth's position, as well as that of Bellcore and the TIA Microcell/PCS Ad-Hoc Committee, [redacted]. It has also been recognized that the North American Numbering Plan (NANP), the numbering plan which is a subset of CCITT Recommendation E.164 numbering plan, is rapidly exhausting, but can be expanded by five billion numbers, if interchangeable Numbering Plan Area (NPA) codes are implemented in 1995. BellSouth supports the position that interchangeable NPAs should be implemented, and also that the numbering plan for UPT and station numbers should maintain compatibility with E.164[10]. *BellSouth should develop a position on number portability*, the ability of the UPT number to be provided by multiple service providers, *and support this position in standards and numbering fora.*

7.2.3 Quality and Performance

Overall, PCS should provide service performance levels which meet the expectations of our customers. It is no longer desirable nor justifiable to "gold plate" our facilities to achieve customer satisfaction, but neither should we under-design our network elements to the point where capital conservation is outweighed by lost market share, because the services are not what the customer expects. It is important that we are dedicated to quality and "delight" customers with our products and services. The best way to determine our customer's service expectations is through market research and trials. Therefore, *BellSouth should support the development of performance standards which sustain service levels consistent with those determined through our market research and trials.*

7.2.3.1 Performance Models

There is a need for new performance modeling techniques for wireless access systems. Speech telephony performance models have been traditionally based on fixed network

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configurations assuming wired channels. Many PCS end-user services will be provided over wireless channels, the characteristics of which vary dynamically over millisecond time periods. These variations are ~~largely caused by the mobility of the user and create a range of received signal levels larger than those found on wired channels. Impairments that cause~~ such channel variations must be taken into account by performance models. *BellSouth should encourage the development of performance model standards for the wireless environment which will provide the level of service quality our customers expect.*

7.2.3.2 Wireless Access System Performance

Because the overall operational performance of a PCS system is dependent on the performance of the radio link, minimum performance criteria for wireless access systems should be established so that end-to-end wireless service quality is to be maintained comparable to that for wired services. Radio system performance criteria includes items such as system gain, receiver sensitivity to thermal noise and time delay spread, receiver interference ratios, maximum radio channel word error ratios, and maximum allowable transmitted spurious emissions. Note that establishing these criteria will influence wireless access interface radio parameters such as channel modulation, channel access scheme, duplexing scheme, channel management scheme, diversity scheme, codec rates/delays, error detection/correction, and maximum channel bit rates. *BellSouth should support the development of wireless access system standards which will ensure that our customers receive end-to-end service quality comparable to wireline services.*

7.2.3.3 Speech Codec Performance

Speech codecs (coders/decoders) used for PCS applications should be designed to operate well in a wireless environment, where channel impairments unique to radio propagation will severely affect system performance. A desirable codec design should ideally exhibit low throughput delay where possible to eliminate the need for echo cancellation and operate at low bit rates to achieve higher spectral efficiency on the wireless interface, thus providing higher traffic density per MHz of spectrum. The codec should also achieve a Mean Opinion Score (MOS) rating as close to toll quality as possible, so as to support high quality end-to-end service objectives. *BellSouth should support the development of a speech codec algorithm standard which exhibits the above qualities.*

7.2.3.4 Non-speech Applications Performance

This is for further study, dependent upon the position BellSouth develops on the role of PCS mobile data services and other non-speech services.

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7.2.4 PCS Services and Capabilities

The services being considered for PCS are basically described by WAMS and UPT in Section 2.4, and more specifically are being described within T1P1, being based on the CCITT and CCIR work. Because the subject of PCS mobile data is receiving increasingly more attention within T1 and TR-45, *BellSouth should develop positions on the role of mobile data services within PCS and support the development of standards. Also, BellSouth should encourage the development of marketable services and associated capabilities in the regulated and non-regulated networks to ensure the timely deployment of end-user and access services.*

7.2.5 PCS Architectures

There are many different architectures being investigated for PCS applications. *BellSouth* [redacted]

7.2.6 Interoperability

The extent to which a network which offers PCS interoperates with other networks will affect the complexity of the interworking function which is required to successfully interface the two networks. The interworking complexity can range from adjusting a physical layer difference, such as an optical to electrical conversion between networks, to a situation where the physical, data link, and network layers differ completely in their specifications. The latter extreme makes interconnection very difficult and expensive, especially where access services are concerned. *BellSouth should determine the level of interoperability its networks require to minimize the cost of interworking with other networks at various interfaces and support the development of industry standards in this regard.*

7.2.7 Signalling Network

SS7 signalling network capacities (STPs, databases, signalling link loads) should be examined under specific scenarios of mobile carrier interconnection for impact of large service penetration. The impact will be largely dependent on the interconnection scenario, the mobility characteristics of mobile users, the number of mobile users, and the implementation

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of the mobile network. Possible protocol enhancements may be required to increase message transfer speed needed to process the high volume of TCAP messages and Global Title Translations (GTT)[11].

7.2.8 Wireless Access Interfaces

The radio technologies selected to operate over these interfaces will have a significant effect on the network architecture and related functional elements offered by BellSouth, as well as the deployment economics. In general, the number of air interfaces should be minimized to a reasonable extent, and the performance/cost ratio for the radio technology used should be optimized for the environments (indoor/outdoor, pedestrian/vehicular, urban/suburban/rural, shared/set-aside spectrum, etc.) under which a given service will be provided.

A major technology issue currently under discussion is centered around determining the more appropriate channel access scheme, Time Division Multiple Access (TDMA) or Code Division Multiple Access (CDMA). The choice of radio channel access schemes affects various characteristics of PCS architectures as shown in Appendix 3[12]. Also, the choice of interface parameters such as duplexing (Time Division Duplexing [TDD] vs. Frequency Division Duplexing [FDD]), multiple vs. single channel access (TDMA vs. Time Division Multiplex [TDM]), and frequency assignment methods (Dynamic Channel Allocation [DCA] vs. Quasi-Static Autonomous Frequency Assignment [QSAFA]) may vary based on serving area environment, as shown in [13]. *BellSouth should encourage development of an air interface which considers PCS environments and is consistent with our regulated and non-regulated network evolution plans for PCS.*

7.2.9 Network Interfaces

Network interfaces which have the potential to provide the "wholesale" access services listed in Section 5.2 should be standardized. Just as the five interfaces identified in Figure 5 through Figure 9 are applicable to the specific architecture of Figures 2 and 3, *BellSouth should encourage the development of similar interface standards which are compatible with those interfaces of existing cellular providers as well as future PCS wired, wireless, and database service providers.*

7.2.10 Division of Industry Standards Work

A joint working agreement was reached between T1P1 and TIA TR-45 at the July 1991 T1P1 meeting. The meeting resulted in joint working sessions to identify areas of standardization required for Personal Communications. In January 1992, the two groups

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began to identify methods by which standards work on the identified areas could be jointly progressed. Open industry participation must be encouraged at all levels during the standardization process. [redacted] *BellSouth's regulated and non-regulated interests.*

7.2.11 Other Issues

- Real time charging and message accounting should be analyzed for feasibility of providing cost control and rating indication information to users.

- Operations, Administration, Maintenance, and Provisioning (OAM&P) issues need to be addressed.

- Security and privacy issues must be addressed concerning communications over the wireless access link.

- Database requirements should be determined, as many networks will be accessing location and service data necessary for proper call completion.

- Environmental requirements needing investigation pertain to the impact of new network elements, such as radio ports, on existing infrastructures, and concern such things as electromagnetic compatibility, electrical grounding, power systems, and physical parameters of network elements.

8. RESOURCE REQUIREMENTS

Resource requirements for the proper PCS standards coverage are expected to increase as high-level work in CCITT, CCIR, T1P1, and TIA TR-45 progresses into T1 and TIA fora concerned with more detailed aspects of UPT, FPLMTS, and PCS. Managers across BellSouth companies involved with various aspects of PCS should consider the importance of BellSouth participation within the following standards fora. Those managers who have expertise concerning the open PCS issues in Section 7.2 will be identified and may be asked to serve as Issue Managers, analyzing and making recommendations concerning open PCS issues which impact BellSouth.

8.1 International Fora

8.1.1 CCITT

There is a present need for one or more associates to be involved with CCITT UPT activities, such as WP I/1 Draft Recommendation F.851 "UPT Service Principles and Operational Provisions," WP II/1 Draft Recommendation E.168 "Application of E.164 Numbering Plan for UPT," and WP XVIII/5 Recommendation I.39x "Network Capabilities to Support UPT," and Draft Recommendation I.39x "Vocabulary of Terms for UPT." These recommendations have been very useful within T1P1.3 in developing U.S. positions for PCS service descriptions.

8.1.2 CCIR

One associate is currently participating within CCIR TG 8/1 developing the FPLMTS family of recommendations and monitoring technological advancements which will impact BellSouth's effectiveness in providing wireless services. These recommendations have been very useful within T1P1.2 in developing PCS concepts such as functional models, architectures, and the complex issues associated with the impact of a wireless interface within the distribution portion upon a telecommunications infrastructure.

8.2 National Fora

8.2.1 Committee T1

8.2.1.1 T1A1

A reorganization within the Committee has resulted in the reassignment of the performance and coding standards development within T1A1. Participation within this group, especially concerning performance is required.

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8.2.1.2 T1E1

[redacted] T1E1 also is now responsible for environmental requirements, therefore this area should be monitored for future developments.

8.2.1.3 T1M1

Participation within T1M1 may also be required to encourage the development of OAM&P standards compatible with those necessary for evolution toward the target BellSouth Information Networking Architecture (B-INA).

8.2.1.4 T1P1

Two associates are committed in leadership positions within T1P1.2 and T1P1.3, managing, contributing, and monitoring high-level systems engineering work for PCS. As this work is moved into other T1 Technical Subcommittees (TSC), it would be valuable to have one associate participate in T1P1.1 "Standards Planning and Program Management" and for that person to perform similar functions within BellSouth, managing BellSouth standards planning and participation in CCITT, CCIR, T1 TSCs and TIA fora, as required.

8.2.1.5 T1S1

One associate is needed to participate within T1S1 to develop (A)IN capabilities, and protocols needed to support PCS end-user and access services. The same may also contribute to CCITT WP XI/4.

8.2.1.6 T1X1

Some work concerning network synchronization is expected to be performed here, and it is not clear if BellSouth participation will be required.

8.2.2 Telecommunications Industry Association (TIA)

8.2.2.1 TIA TR-41

BellSouth participation may also be required within TR-41 for the development of wireless PBX standards to encourage compatibility with standards developed for wireless ESSX applications. [redacted]

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8.2.2.2 TIA TR-45.2

BellSouth participation is also needed to cover the development of cellular network interface standards within TR-45.2 "Intersystem Operations" and TR-45.1 "Network Interfaces." Development of the access services interfaces is expected to be performed in these fora.

8.2.2.3 TIA TR-45.4

As T1P1 and TR-45 have arranged a working agreement for the coequal development of PCS standards, one associate is also required to represent BellSouth's Non-regulated PCS interests within the TR-45.4 Subcommittee "Microcell/PCS."

Table 1 provides a visual indication of areas requiring national PCS standardization and the BellSouth participation in those fora where PCS issues will be addressed.

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Table 1

~~Areas Requiring Standardization for Personal Communications~~

BellSouth Standards Forum Representation

Standards Area	National Forum	Current BellSouth Representation
Internode Signaling (SS7)	T1S1.3	1
ISDN Access Signaling	T1S1.2	2
Intelligent Network	T1S1.1	3
Network Architecture		
Service Descriptions		
Systems Engineering[5]	T1P1.3	1
	T1P1.2	1
Performance	(T1Q1.1)[6]T1A1	1
Coding	(T1Y1.2) T1A1	1
Network Interfaces	T1E1.4	1
Access Interfaces (wired & wireless)	TIA TR-45.4	1
Wireless LANs	IEEE 802.11	
Synchronization	T1X1.3	1
Terminal Standards	TIA TR-41	1
Database Requirements	?	
Environmental Requirements	(T1Y1.4) T1E1.4	3
Charging/Message Accounting	?	
OAM&P	T1M1	5
TOTAL		22

[5] Includes terminology, service descriptions, service/system objectives, functional requirements/models, architectures, and numbering/addressing.

[6] Forums in parentheses have been discontinued. Work will be progressed in adjacently listed forum.

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9. GLOSSARY

Automatic Link Transfer (ALT) [T1P1] -
A process, initiated for reasons of signal quality, traffic management, or other reasons, of rerouting the radio portion of a call without interrupting the call.

Future Public Land Mobile Telecommunications Systems (FPLMTS) [F.FPLMTS] -
FPLMTS are systems which provide telecommunications services to mobile or stationary users by means of one or more radio links. This mobility will be unrestricted in terms of location within a radio coverage area. FPLMTS will extend the telecommunications services of fixed network to these users over wide geographic areas, subject to constraints imposed by spectrum allocation and radio propagation, and in addition, will support a range of service particular to mobile radio systems. (CCIR Rec 687 and Reports 1153 and 1155)

Personal Communications Service [T1P1] -
A set of capabilities that allows some combination of terminal mobility, personal mobility, and service profile management.

> Clarification: The acronym PCS should be taken to refer to Personal Communications Service unless specifically identified otherwise.

Personal Communications System [T1P1] -
A collection of facilities which provide some combination of terminal mobility, personal mobility, and service profile management.

> Clarification: The term facilities should be understood to include hardware, software, and network components.

personal mobility [I.11x] -
The ability of a user to access telecommunications services at any terminal on the basis of a unique personal identifier, and the capability of the network to provide those services according to the user's service profile.

> Clarification: The word "access" is intended to convey the concepts of both originating and terminating services. Management of the service profile by the user is not part of personal mobility.

Routing Number (RN) [Bellcore] -
An address used to deliver calls and information to a specific physical location. The RN is used in conjunction with the UPT number in order to provide service to a user. The RN is an E.164 number.

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service profile [I.11x] -
A record containing all the information related to a UPT user in order to provide the UPT service.

Note: Each UPT number has an associated UPT service profile.

Clarification: The service profile is the information relative to one particular UPT number which is needed for the network to be able to provide the UPT service involved with that particular number. The possibility exists for various interactions between UPT service profiles and other network profiles or discriminations. Such interactions should be studied and undesirable interactions resolved.

service profile management [I.11x] -
The ability to access and manipulate the UPT service profile.

Note: UPT service profile management can be performed by the UPT user, UPT customer, or the UPT service provider.

Terminal Identifier (TID) [Bellcore] -
A code which is stored in a user terminal, and by which a network can identify a specific terminal. The format includes a country code, a code identifying the provider of the terminal profile information, and the terminal identification code itself.

terminal mobility [I.11x] -
The ability of a terminal to access telecommunications services from different locations and while in motion, and the capability of the network to identify and locate that terminal.

Clarification: This ability implies the availability of telecommunications services throughout a spacial volume and ideally at all times.

Universal Personal Telecommunications (UPT) [I.11x] -
A service which provides personal mobility and service profile management. Note: This involves the network capability of uniquely identifying a UPT user by means of a UPT number.

Clarification: UPT enables each UPT user to initiate and receive calls on the basis of a unique, network-transparent UPT number across multiple networks at any terminal, fixed, movable, or mobile, irrespective of geographic location, limited only by terminal and network capabilities and restrictions imposed by the network provider. "Network-transparent" implies that the user does not need to know the location of the UPT database. Transparency includes the case where network-independent user identification is used.

UPT Customer (UPT subscriber) [I.11x] -
A person or entity who, or which, obtains a UPT service from a UPT service provider on behalf of one or more UPT users and is responsible for the payment of charges due to that service provider.

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UPT number [I.11x] -
A number that uniquely identifies a UPT user and is used to reach that user.

> Clarification: A UPT user may have more than one UPT number. The UPT number is a CCITT E.164 number.

UPT routing address [I.11x] -
A number used by the network to direct a call according to the user's UPT service profile.

> Clarification: The only differentiation with a (non-UPT) network routing address is that the UPT routing address is used for delivery of UPT calls.

UPT user [I.11x] -
A person who has access to universal personal telecommunications (UPT) services and has been assigned a UPT number.

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10. REFERENCES

[1] *System Engineering Working Document for Personal Communications, Draft 3*; ~~Technical Subcommittee T1P1; October 1991.~~

[2] TM-TSV-020257; *PCS Access Service Alternatives;* Bellcore; BCC/BCR PCS Access Service Alternatives Team; October 31, 1991.

[3] Viewgraphs; *Personal Communications Service Recommended Strategies*; Bill Pruett; January 1991.

[4] TM-ATSEC-08-91-033; *Report on BellSouth Network Evolution*; BellSouth; September 15, 1991.

[5] TM-TSV-020370; *AIN Platform Analysis II;* Bellcore; January 15, 1992.

[6] TM-ATSEC-08-91-033; *Report on BellSouth Network Evolution*; BellSouth; September 15, 1991.

[7] Memo; *BellSouth/McCaw Wireless SS7 Trial*; Jerry Breed; September 10, 1991.

[8] TM-INS-020228; *Technical Impacts of Personal Communications Numbering;* Bellcore; February 1, 1992.

[9] *Standardization Task Force Final Report*, TIA Microcell/PCS Ad-Hoc Committee, March 27, 1991.

[10] *PCS Numbering Plan Meeting Minutes*, Leonard Strickland, May 7, 1991.

[11] TM-NWT-020139; *Signalling System Number 7 Network Interconnection Impacts in Support of Mobile Communications Services*; Bellcore; October 31, 1991.

[12] TM-NWT-017426; *Preliminary Survey on Technical Issues Between Two Alternative Wireless Access Technologies, CDMA and TDMA, for PCS Applications;* Bellcore; S. Lin, T. Noerpel, J. Weise, July 18, 1991.

[13] TM-NWT-020320; *An Assessment of Alternative Access Technologies for PCS Applications;* Bellcore; November 5, 1991.

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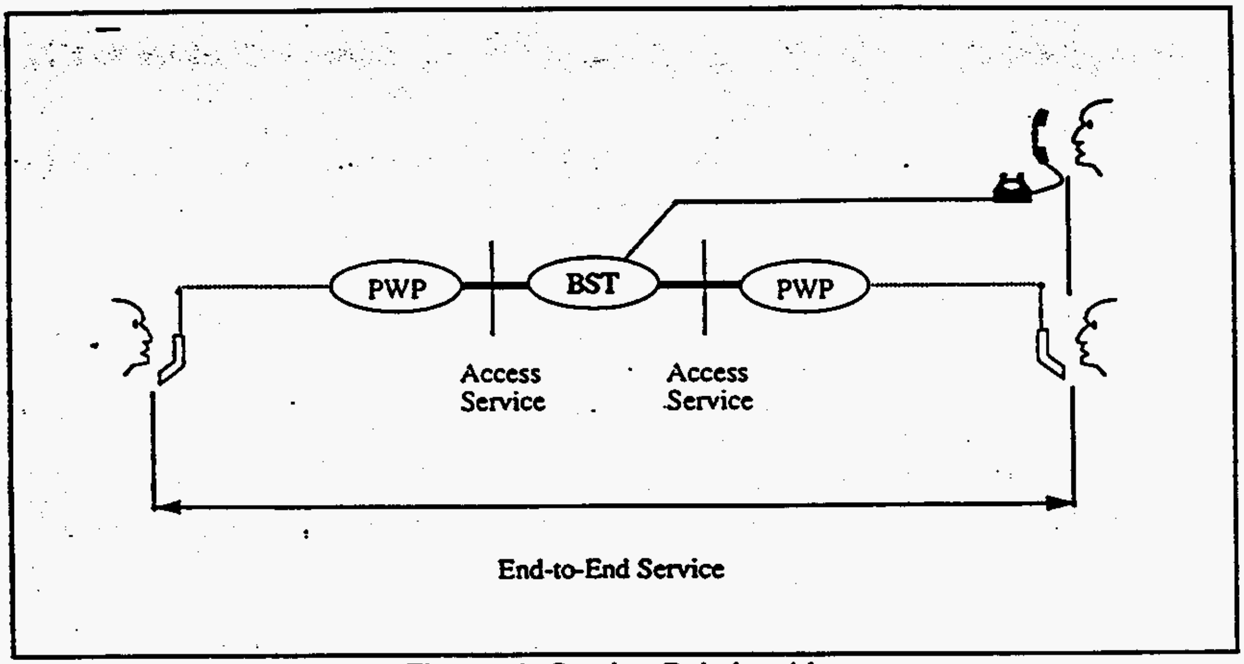

Figure 1. Service Relationships

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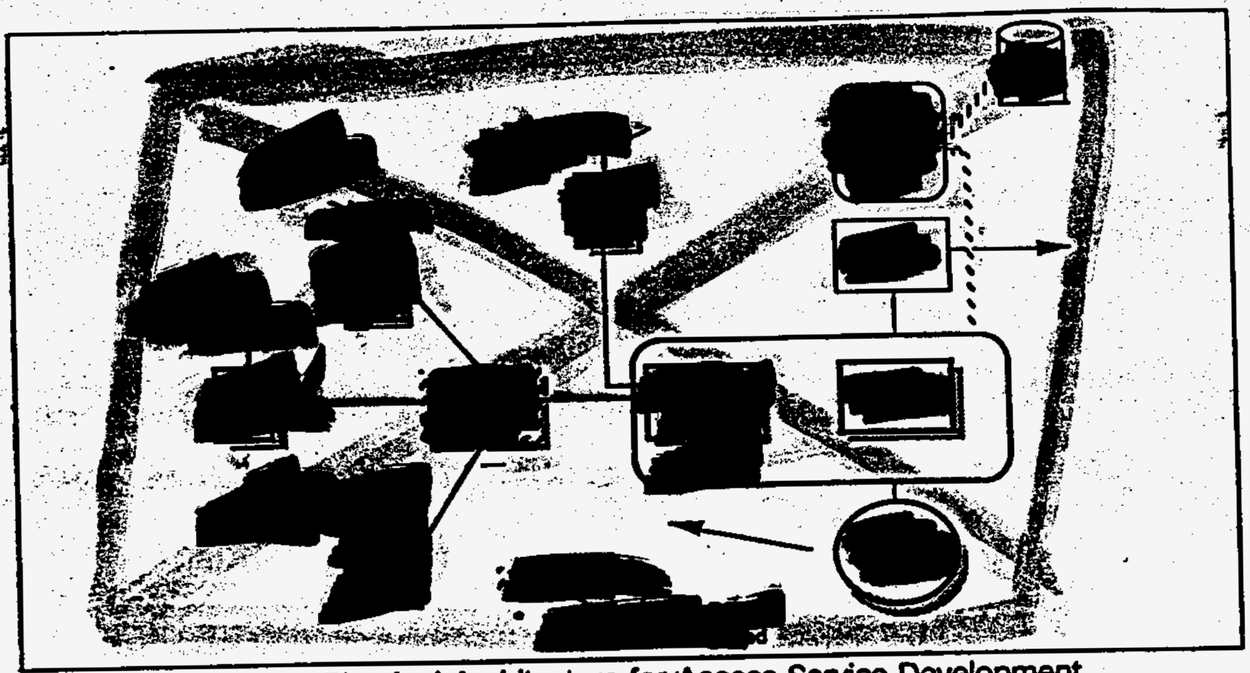

Figure 2. Physical Architecture for Access Service Development

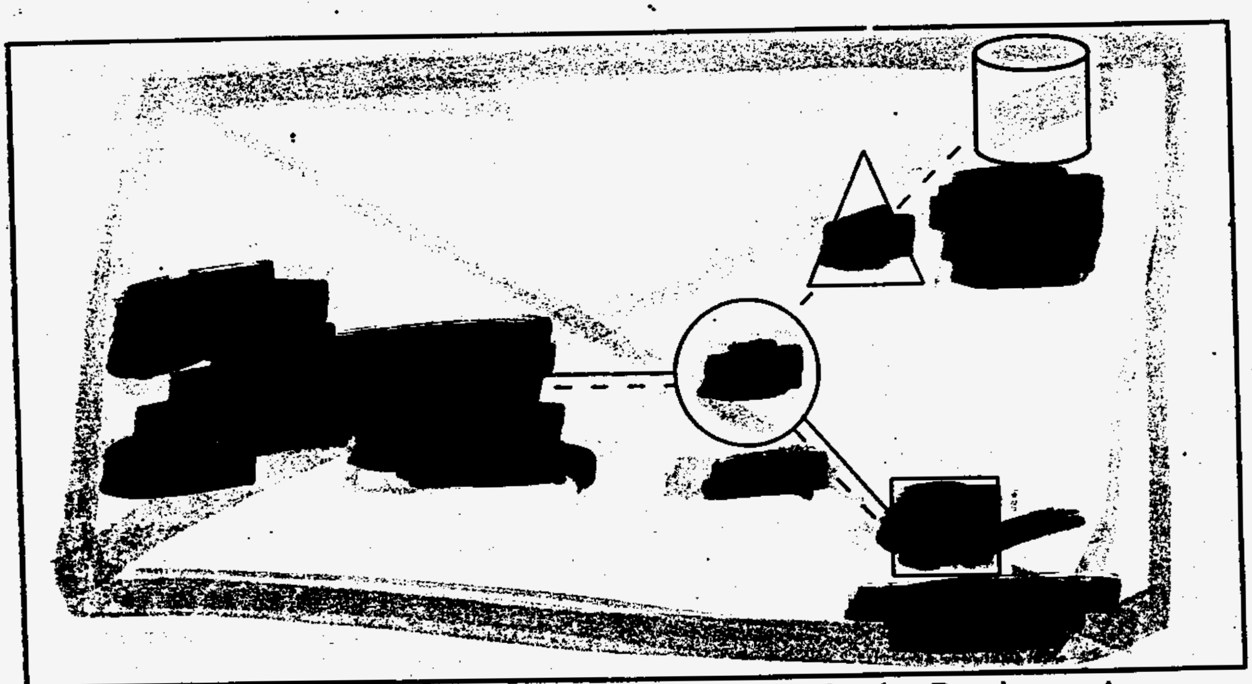

Figure 3. AIN Physical Architecture for Access Service Development

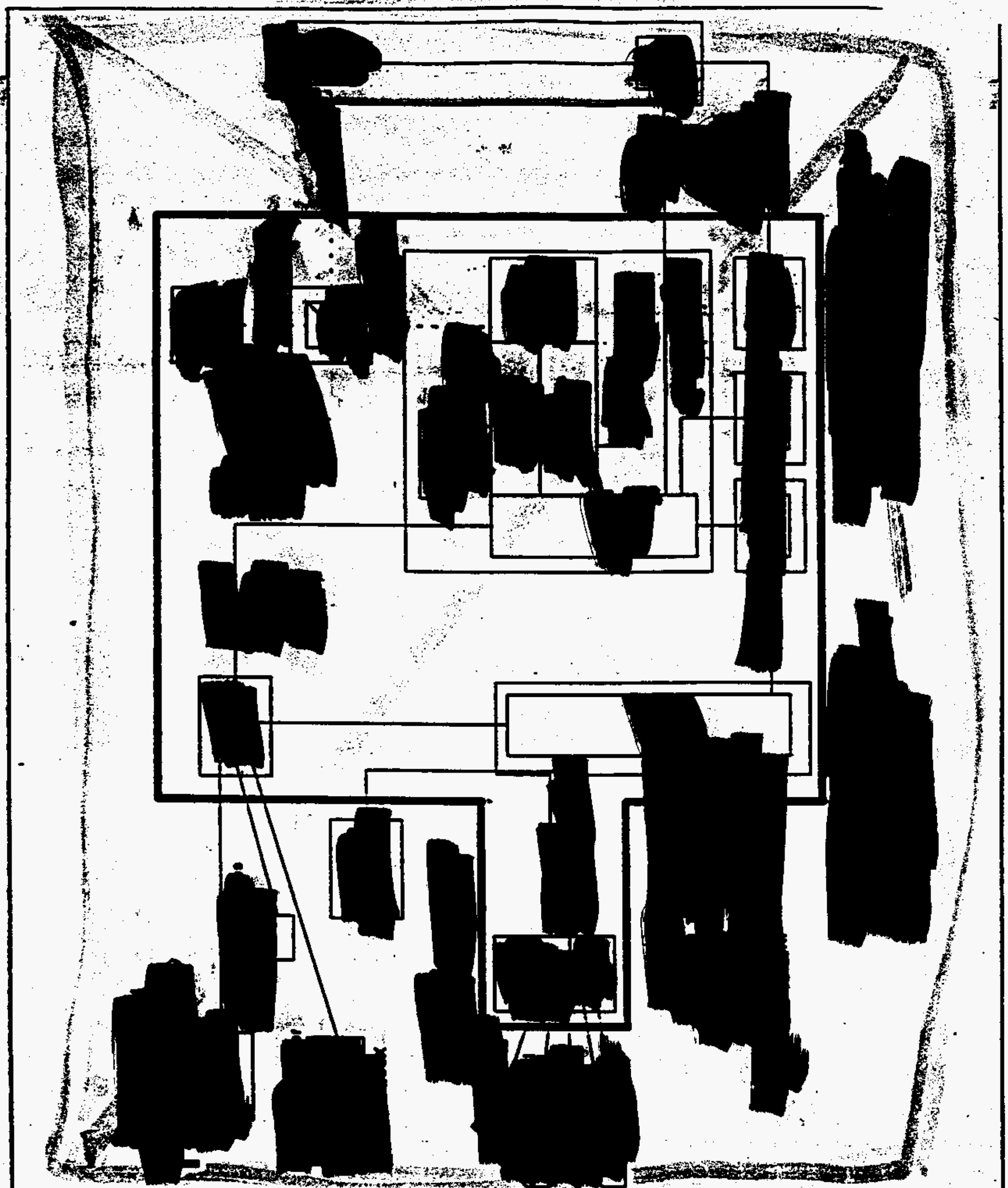

Figure 4. BellSouth Telecommunications Target Information Network

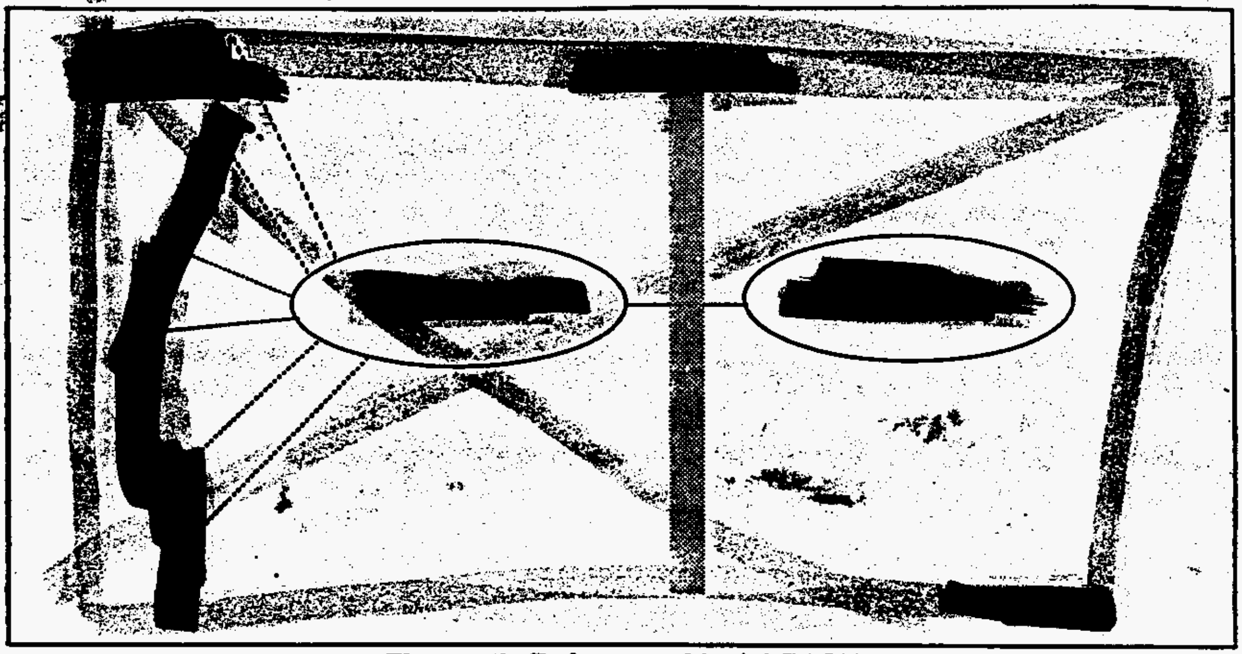

Figure 5. Reference Model PASN

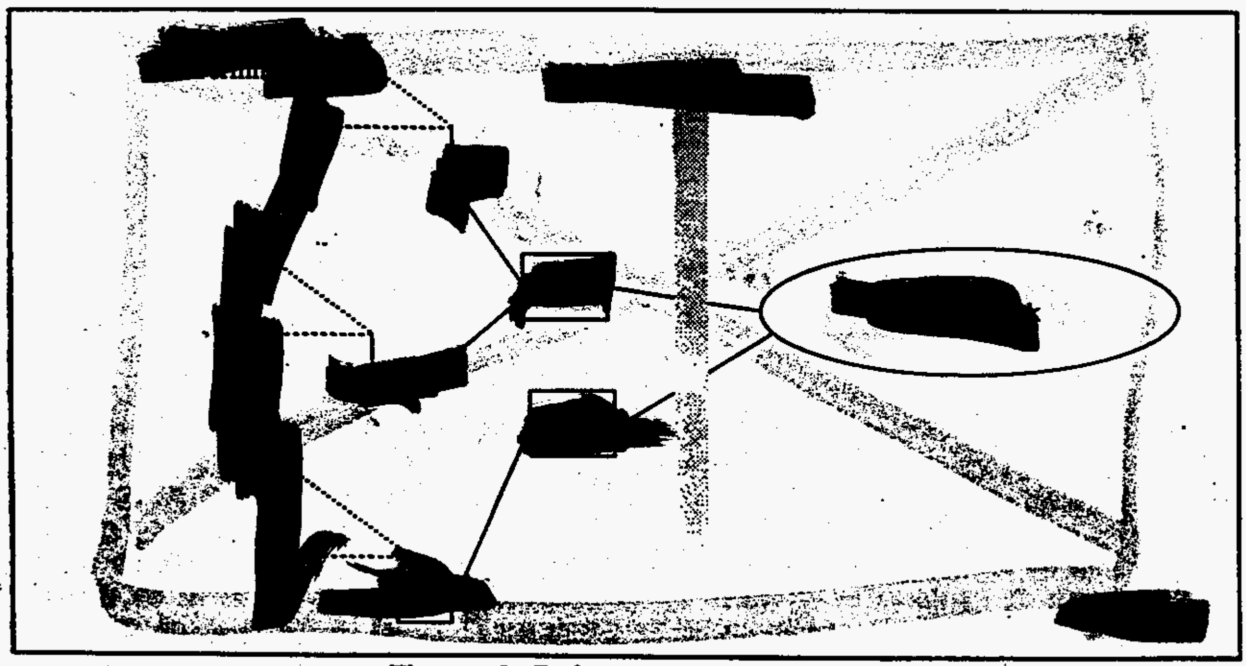

Figure 6. Reference Model PASC

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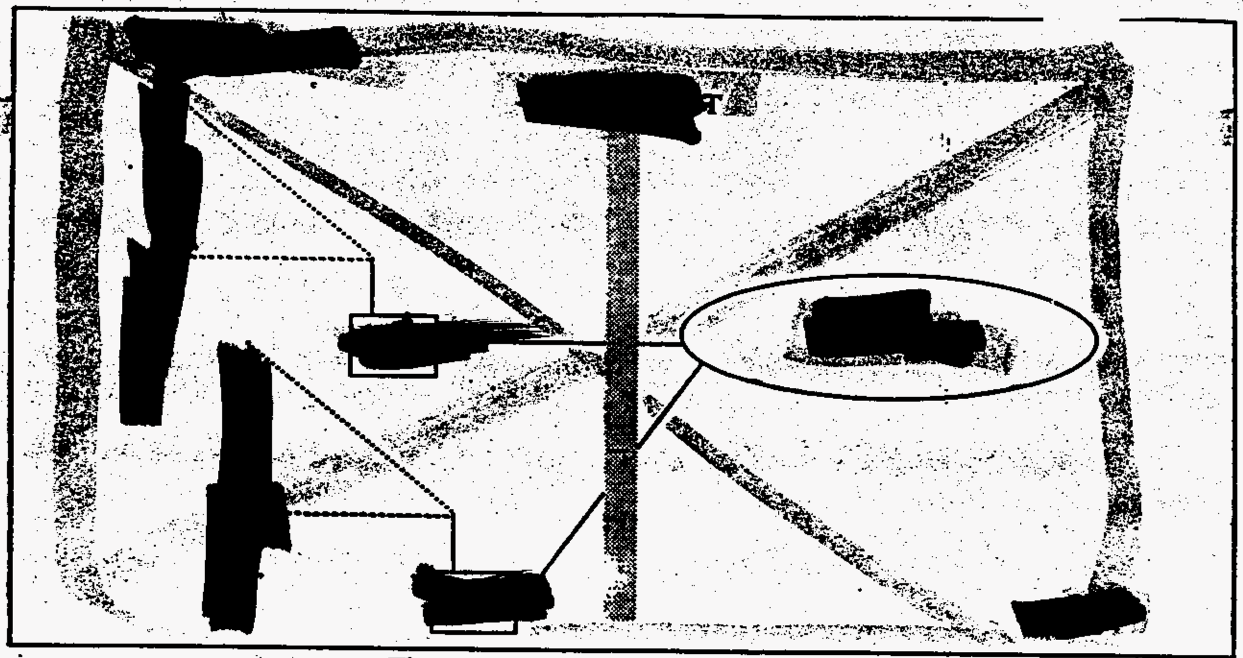

Figure 7. Reference Model PASP

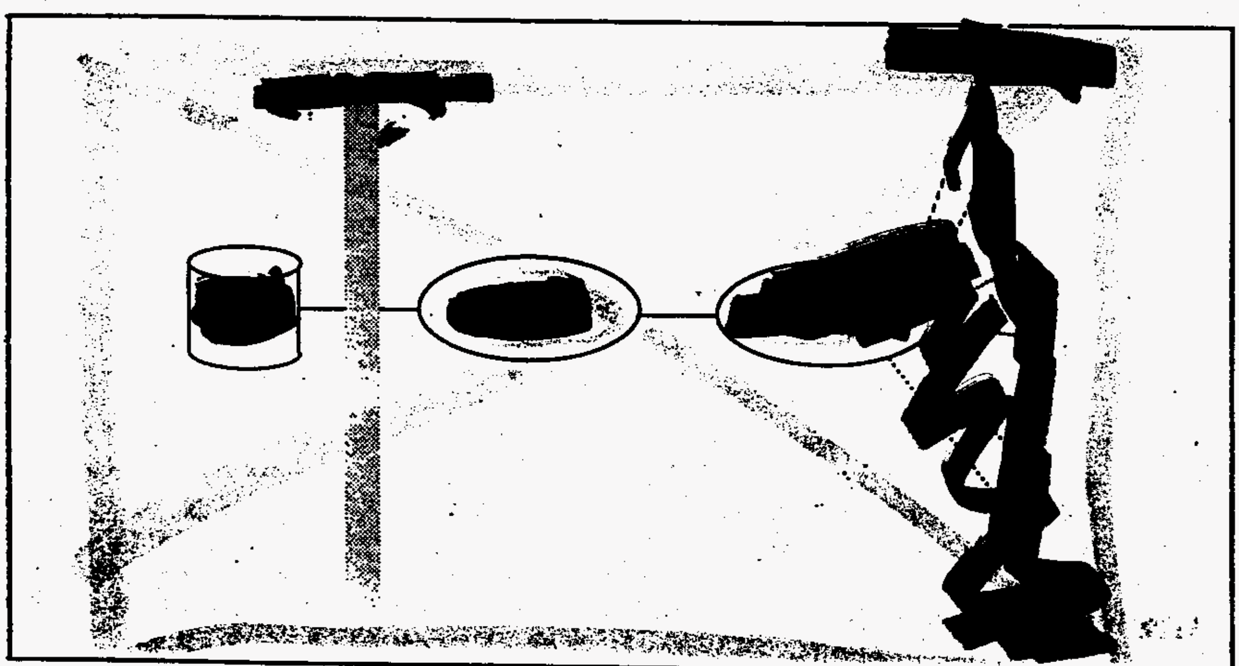

Figure 8. Reference Model PASD

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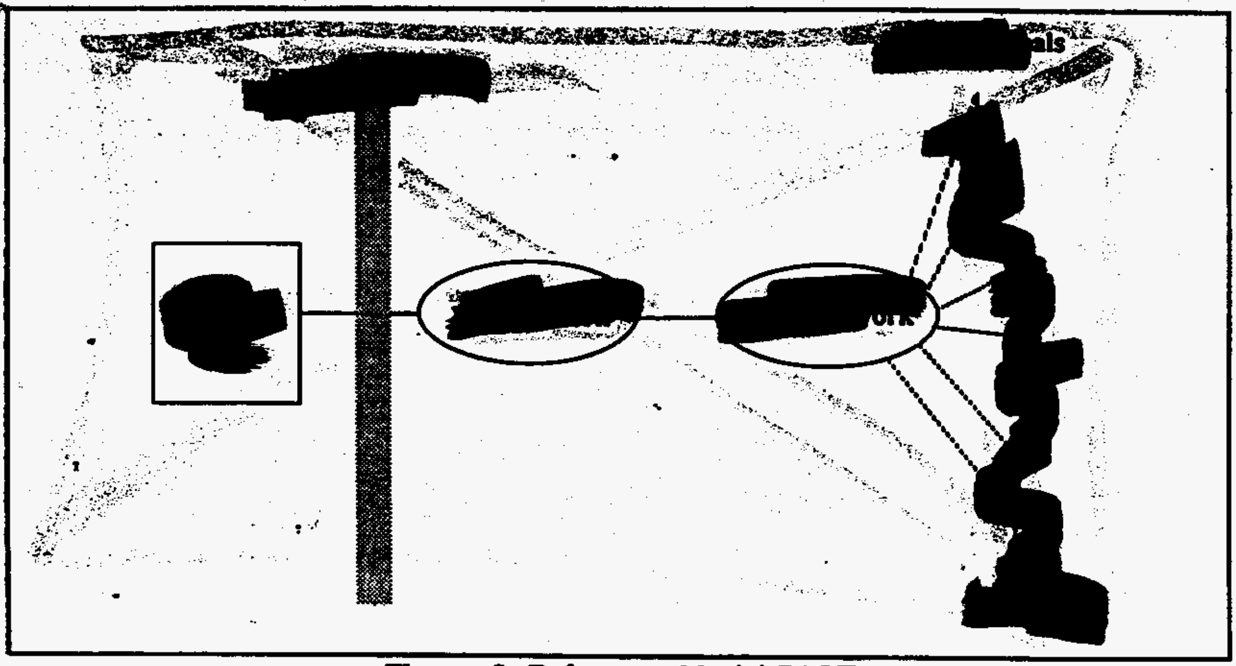

Figure 9. Reference Model PASE

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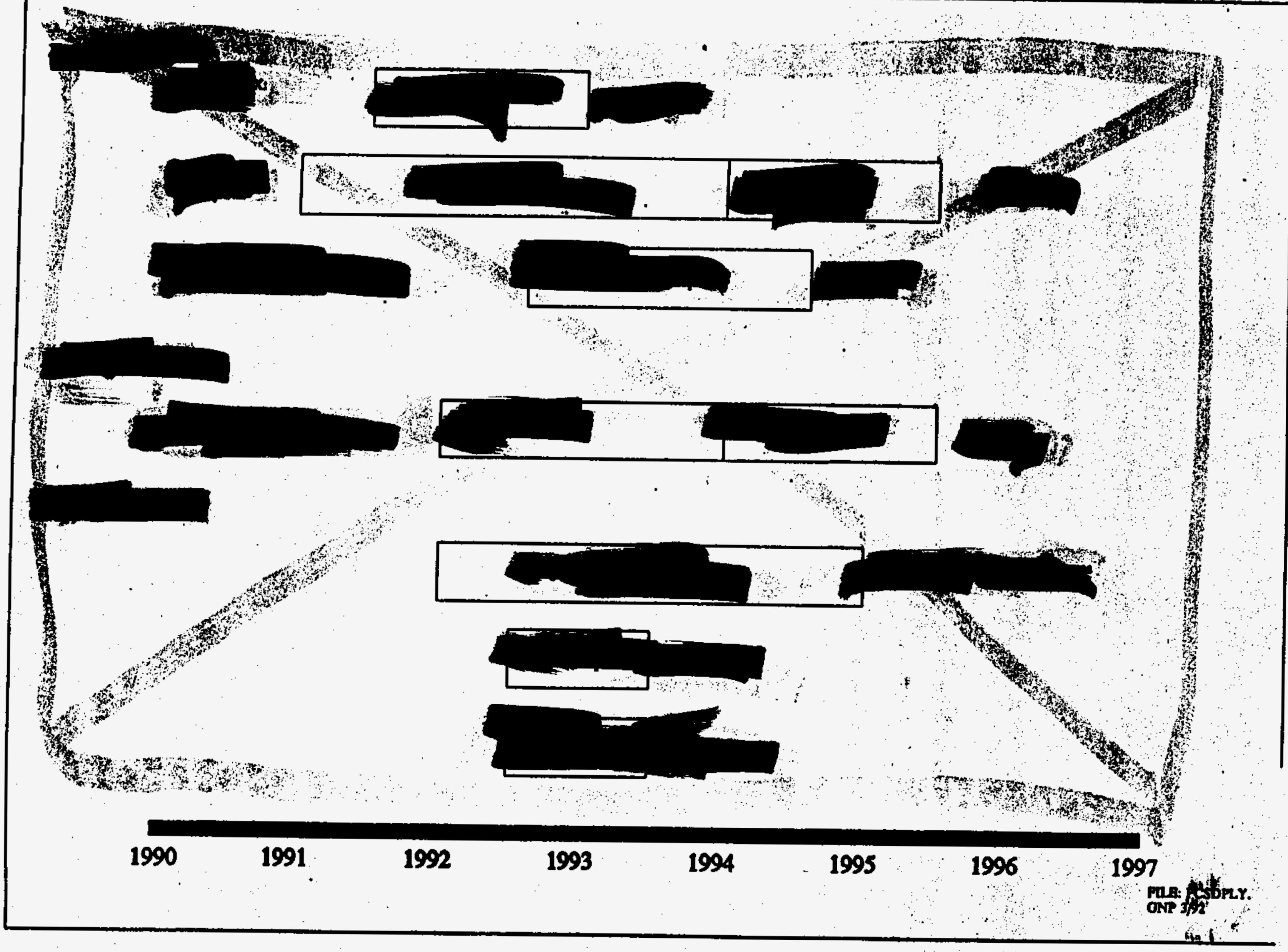
PROPRIETARY

APPENDIX 1 -

PERSONAL COMMUNICATIONS STANDARDS, REQUIREMENTS, AND DEPLOYMENT TIMELINE



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APPENDIX 2 -

Dissimilar Characteristics Between Architectures Employing CDMA and TDMA

CDMA/TDMA Dissimilar Characteristics with Network and Portable Terminal Implications:

- Complexity of Voice Activity Gating
- Ease of accommodating various user bit rates
- Intraport timing and synchronization requirements
- Ability to utilize vacant narrowband channels
- Multipath dispersive fading protection complexity
- Complexity of methods to protect system against malfunctioning transmitters
- Risk of unfamiliar technology with yet unknown problems
- Radio link Transfer implementation complexity
- Complexity of overall architecture

CDMA/TDMA Dissimilar Characteristics with Only Network Implications:

- Capacity is hard limited vs. soft limited
- Interport coordination requirements for pilot, Automatic Power Control, and blocking of excess calls
- Interport synchronization requirements

CDMA/TDMA Dissimilar Characteristics with Only Portable Terminal Implications:

- Automatic Power Control (APC) requirements
- Duplexer requirements
- Heat sink requirements
- Power requirements
- Usage time between recharges

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Tab 5

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Science & Technology

Date: November 18, 1991

Subject: Project Management Process

Author: H. E. Smalley

ABSTRACT

This document provides a description of proposed methods and procedures to be used by the Advanced Technology Development Center during the development of application software to implement services for the Advanced Intelligent Network (AIN). The subjects of project planning, tracking, and review are treated in detail. In addition, a definition of individual responsibilities for each development phase is provided

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Project Management Process

Rod Smalley

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9.0 Epilogue

The methods and procedures described in this document are intended to provide a basis for discussion and further definition of the project management process. Companion documents [8][9][10][11][12][13] providing additional details to certain related aspects of this process are also available. As ATDC begins to use the procedures described in these documents the need for changes will certainly occur. These documents are therefore "living" documents in the sense that they welcome comments and suggestions for change.

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10.0 References

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[13] Deployment and Field Support, BSS S&T Memorandum for File, to be written.

11.0 Acronyms

AIN	Advanced Intelligent Network
ATDC	Advanced Technology Development Center
BSS	BellSouth Services
S&T	Science and Technology
STAC	Switching Technology Assessment Center
PEC	Product Evaluation Center
SANAC	Strategic Advanced Network Architecture Center
WBS	Work Breakdown Structure
DOS	Disk Operating System

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12.0 Glossary

feature	A unique capability resident on a single network element.
phase	Used in this document to refer to the individual activities which are performed during the software development and testing process. Each phase has a clearly distinguishable entry and exit point, although phases may overlap and feed back into each other.
platform	A combination of hardware and software, normally purchased from a vendor, which provides the systems on which the software development is performed and tested.
project	In this document, the word "project" refers to a complete software development effort. The software lifecycle is defined for a project. Examples of projects include the development for an AIN Architectural Entity, or the development of a service or defined set of services for an existing AIN Architectural Entity. Planning is done on a project basis. Each aspect defined in the document addresses itself to a complete project.
service	One or more features on the network which may be sold to an end customer or used internally in BellSouth. A service may consist of features which reside in different AIN architectural entities.
service concept	An end user view of a service which BellSouth can sell to its customers or use internally.

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REPORT ON BELLSOUTH NETWORK EVOLUTION

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Proprietary Status

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Abstract

BellSouth's network will evolve over the next decade to a target Information Networking Architecture that serves the total information networking needs for voice, data, video, and image communications of BellSouth's customers. The target architecture and the evolution steps documented in this report are the result of a joint effort of Science and Technology, Network Planning, Marketing, CO Operations Support, Planning and Engineering, and Information Systems.

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REPORT ON

BELLSOUTH NETWORK EVOLUTION

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Attachments:

1. Introduction

"Why can't I use the same portable phone at home, in my car, and at my office?"

"Why can't I monitor my Georgia Tech class remotely at my home or office?"

"Why can't I view my patients' X-rays electronically at my office?"

"Why can't all my customers just dial "D-O-M-I-N-O-S" and be connected automatically to my nearest Domino's pizza store?"

"Why can't I connect my video codec to a dial-up T1 line and use it only when I need it?"

"Why can't I just press '8' to reply to *anyone* leaving a VMS message?"

"Why can't I integrate voice, video, and data on my workstation and create multi-media communications?"

"Why can't I spread calls across my attendants in Atlanta and Birmingham during the day, and send all calls to Atlanta at night?"

"Why can't my services survive, even when individual components of the network fail?"

These questions express some of the evolving needs of BellSouth's customers that cannot be totally satisfied by BellSouth's current network architecture. BellSouth faces increasing competition from bypass carriers who are positioning their networks to attract our most desirable customers. If BellSouth is to place its "customers first" and "respond positively to change", we must aggressively evolve our network to meet these challenges.

BellSouth's network has changed dramatically over the past decade, due in part to divestiture and increased competition from alternative service providers. Several recent events that will impact BellSouth's future network evolution are listed below.

- Common Channel Signaling 7 (CCS7) has been deployed to 50% of BellSouth offices, and it will reach 66% by year end.
- 121 BellSouth offices will be equipped for Integrated Services Digital Network (ISDN) by year-end 1991, giving ISDN access to 3.1 million lines.
- Tariffs for basic rate ISDN are being filed.
- The major switch vendors have committed to the National ISDN-1 Platform in 1992.
- An RFQ for replacement vehicles for 1AESS switches has been issued.
- An organization has been formed within BellSouth to develop Advanced Intelligent Network (AIN) services.
- An RFP for fiber in the loop equipment has been issued, and several trials are underway.
- Internal trials of Switched Multimegabit Data Service (SMDS) have begun, and an RFP is forthcoming.
- Thirteen CCITT Recommendations on Broadband ISDN (B-ISDN) have received unanimous international approval.
- Synchronous Optical NETwork (SONET) product evaluation trials have begun.
- A field trial of a B-ISDN Asynchronous Transfer Mode (ATM) switch has begun.
- Internal wireless trials have begun, and wireless ESSX field trials are being planned.

BellSouth is well positioned to achieve the goal of evolving its network over the next decade to a flexible and cost-effective Information Networking Architecture (INA) that can respond rapidly to satisfy emerging customer needs. To achieve this goal, a clear vision of BellSouth's target network architecture, as well as a realistic and cost-effective evolution path toward that target, is imperative.

This report presents the current view of the evolution of BellSouth's network over the next decade to a target Information Networking Architecture that serves the total information networking needs for voice, video, data, and image communications of BellSouth's customers. The primary focus of this report is on the technology aspects; while some regulatory, marketing, and economic aspects are identified and briefly discussed, they are not analyzed in detail. The target architecture and the evolution steps described in this report have been discussed extensively with many different organizations in BellSouth, and they represent a broad consensus.

Section 2 of this report presents several key attributes that have guided the formulation of BellSouth's target Information Networking Architecture. Section 3 describes recent developments that have fundamentally changed BellSouth's paradigm for network evolution. This new approach will enable BellSouth to satisfy its customers' needs in a cost-effective and timely manner and place BellSouth in a strong position with respect to alternative service providers. Section 4 presents BellSouth's target Information Network Architecture and relates this architecture to the attributes presented in Section 2. Section 5 is a summary of the steps needed to evolve cost-effectively to the target. Attachments to this report provide additional details of these evolution steps.

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2. Attributes of BellSouth's Target Network Architecture

Before developing a target network architecture, it is essential to understand the drivers that are forcing changes to the current network and to develop a set of attributes for measuring the suitability of the target architecture. This section identifies several attributes that are critical requirements for BellSouth's Information Networking Architecture.

- Supports Multiple Services on a Common Platform

  BellSouth must be able to take advantage of new service opportunities as they arise. However, much uncertainty surrounds the demand, timing, and cross-elasticity of new services now being planned by LECs, ICs, and ESPs. Massive investment in a new service whose success is uncertain entails much risk; however, failure to offer a new service until its success is assured may result in losing customers to competitors while we strive to catch up. BellSouth's target architecture must have the flexibility to support many services over a common platform in order to spread the cost of common network resources over multiple services and to maximize the service opportunities while minimizing the risk of service-specific investments.

- Enables Rapid Service Delivery

  The ability to provision services rapidly is a critical attribute of BellSouth's target architecture. Our customers are no longer willing to wait weeks, or even days, for BellSouth to provision new services, since private networks provide them with immediate responses to reconfiguration requests. A fundamental change must occur in the BellSouth network if we expect to be able to compete with private networks and alternative service providers. BellSouth's target architecture must move the creation, modification, and provisioning of new services closer to the customer.

- Enables BellSouth to Introduce New Services in a Timely Manner

  BellSouth's ability to introduce new services in a timely manner has been hampered by our dependence on switch vendors for the development of new services. The target architecture must allow us to develop our own services and to schedule the availability of new services based on our own assessment of our customers' needs.

- Preserves Customer Investments Through Service Continuity

  BellSouth's customers have made substantial investments in customer premises and private network equipment, and a network architecture that ignores this fact is doomed to failure. BellSouth's target architecture must provide for the cost-effective continuity of existing services and capabilities, while at the same time providing the new services required to satisfy our customers' emerging communications needs. Interworking of existing services and capabilities with emerging services is also critical to the success of new services.

- Uses Appropriate Open Standard Interfaces

The use of open standard interfaces 1) encourages the development of common VLSI components to reduce equipment costs, 2) facilitates ~~a multi-vendor environment to allow BellSouth to benefit from the competitive pricing of equipment, and~~ 3) encourages increased use of BellSouth's network by ESPs who can use BellSouth's services as a platform for their enhanced services. However, standards also inhibit vendor innovation and are costly and time-consuming to develop, so care must be taken to standardize only those interfaces necessary to meet BellSouth's strategic needs. BellSouth's target architecture must be based on the use of appropriate standard interfaces required for the timely introduction of new services.

- Provides High Reliability and Survivability

Service outage can have a devastating effect on customers, who have become increasingly dependent on their communications services. BellSouth's reputation for reliable and survivable communications has taken years to build; this reputation is invaluable as competition becomes increasingly fierce. Providing service survivability when individual components of the network fail is a key attribute of BellSouth's target architecture and will be critical in attracting and retaining our most important customers.

- Networks Other Networks

Networks are proliferating: business customers are building their own premises networks, cellular and wireless networks are on the rise, and IC networks are essential for interLATA communications. Enterprise networks are increasingly needing to interconnect with many different types of networks. As this occurs, the LEC's networks must undergo fundamental changes to assume the role of networking other networks together. BellSouth's target network must provide a seamless integration of services across various wireless, wireline, premises, ESP, and IC networks if we are to satisfy the customers' needs and be their provider of choice.

- Integrates Network Elements and Operations Systems into a Common Platform

The distinction between Network Elements (NEs) and Operations Systems (OSs) continues to blur. Using a common architectural platform and common standards for OSs and NEs will allow shared access to data and will enable BellSouth to migrate data and functionality between the two environments as appropriate to meet business and technical needs.

- Provides Independence from Regulatory Decisions

Regulatory issues, such as whether Personal Communications Services (PCS) and residential video services will be classified as basic or enhanced, often take many years to resolve. Wireless networks are expected to grow significantly in the future, but BellSouth's regulated entity may or may not be a wireless service provider. Providing wireless services would be a tremendous opportunity for BellSouth; however, even if this service is classified as enhanced, opportunities still exist to provide complementary services to the enhanced service providers. In particular, BellSouth's use of AIN capabilities to offer advanced services to enhanced service providers represents a tremendous opportunity for BellSouth. BellSouth's target network architecture must be able to offer new services that are classified as basic and also to offer complementary services to support enhanced services.

- Supports a Wide Range of Communications Bandwidth

Customers' bandwidth requirements have increased drastically over the past decade as their communications have begun to include data, video, and image information, in addition to voice. BellSouth must evolve its network from one optimized for voice communications to one optimized for information networking. Information networks, which carry voice, video, data, and image information, require bandwidths spanning a wide range from a few bits/s for telemetry applications to several hundred Mbit/s for supercomputer interconnection. BellSouth's target information networking architecture must be capable of supporting communications over this entire range in a cost-effective manner.

- Supports Multi-media Communications

Multi-media applications for personal computers and workstations are expected to emerge over the next few years. Companies such as Sun Microsystems and Apple are already developing systems for multi-media communications, and are planning LANs based on Asynchronous Transfer Mode (ATM) to support these applications. Support for multi-media communications is a critical attribute for BellSouth's target architecture. The ability to support multiple communications with a wide range of bit rates over an integrated customer access interface will be key to our success in this area.

- Provides Private and Secure Communications

The current telephone network is perceived as being both private and secure, but these attributes may be threatened in the future. BellSouth's target network architecture must ensure that our customers' communications and control of their communications are protected by building appropriate firewalls into the network architecture.

- Increases Customer Control of Services

Private networks are providing increased control and management capabilities that allow services to be tailored to meet the needs of the enterprise, and customers are becoming increasingly dependent on these capabilities. BellSouth's target architecture must provide similar capabilities to attract customers to public network services, which must integrate the control capabilities needed to provide for the transparent networking of networks.

- Reduces Redundancy in Corporate Databases

BellSouth's OSs currently require that some information be entered into multiple databases; this redundancy results in additional labor and computer storage costs. Furthermore, it results in inconsistent databases, which create additional labor costs to resolve. BellSouth's target architecture must minimize the redundancy of corporate databases in order to provide cost-effective services to compete with other service providers. In some cases, this redundancy can be minimized by integrating the data with the network elements themselves.

- Provides Needed Services at Affordable Prices

The attributes listed above are all aimed at the objective of providing the services that customers need at affordable prices. This is the ultimate measure of the success of the target network architecture. The ability to provide rapid service delivery, introduction of new services in a timely manner, service continuity, high reliability and survivability, seamless integration of services across multiple networks, services with a wide range of communications bandwidths, multi-media communications, privacy, security, and customer control of services are essential to satisfying the communications needs of our customers. The cost effectiveness of providing these services is maximized by supporting multiple services on a common platform, making use of appropriate standard interfaces to benefit from volume deployment, integrating operations systems with network elements, and reducing redundancy in corporate databases.

3. BellSouth's Network Evolution Directions

BellSouth has evolved its network in the past by replacing entire systems with new systems, as illustrated in Fig. 1, since there was no cost-effective evolution path that allowed earlier-generation systems to evolve into later-generation systems.

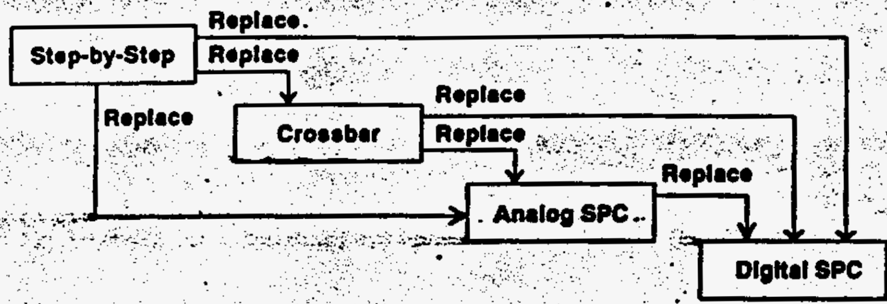

Fig. 1. Past network evolution characterized by replacement of entire systems.

Two key enabling technologies, end-to-end digital systems and Stored Program Control (SPC) systems, have now made it possible to evolve BellSouth's network on an incremental basis. In the future, existing systems will not be totally replaced; instead, new services and capabilities will be integrated into existing systems, as illustrated in Fig. 2. Some subsystems may be replaced as new capabilities are integrated until, over time, little or none of the original system remains. This represents a fundamental change in BellSouth's approach to network evolution, and one that will be of utmost importance in introducing future services in a timely and cost-effective manner.

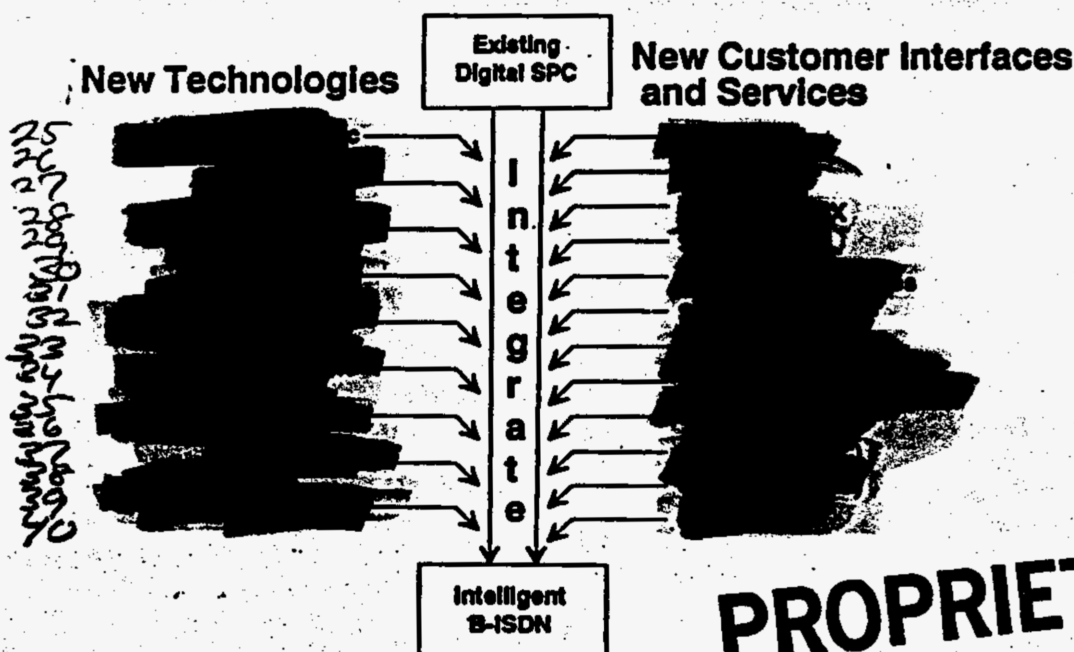

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Fig. 2. Future network evolution characterized by integration of new capabilities and services.

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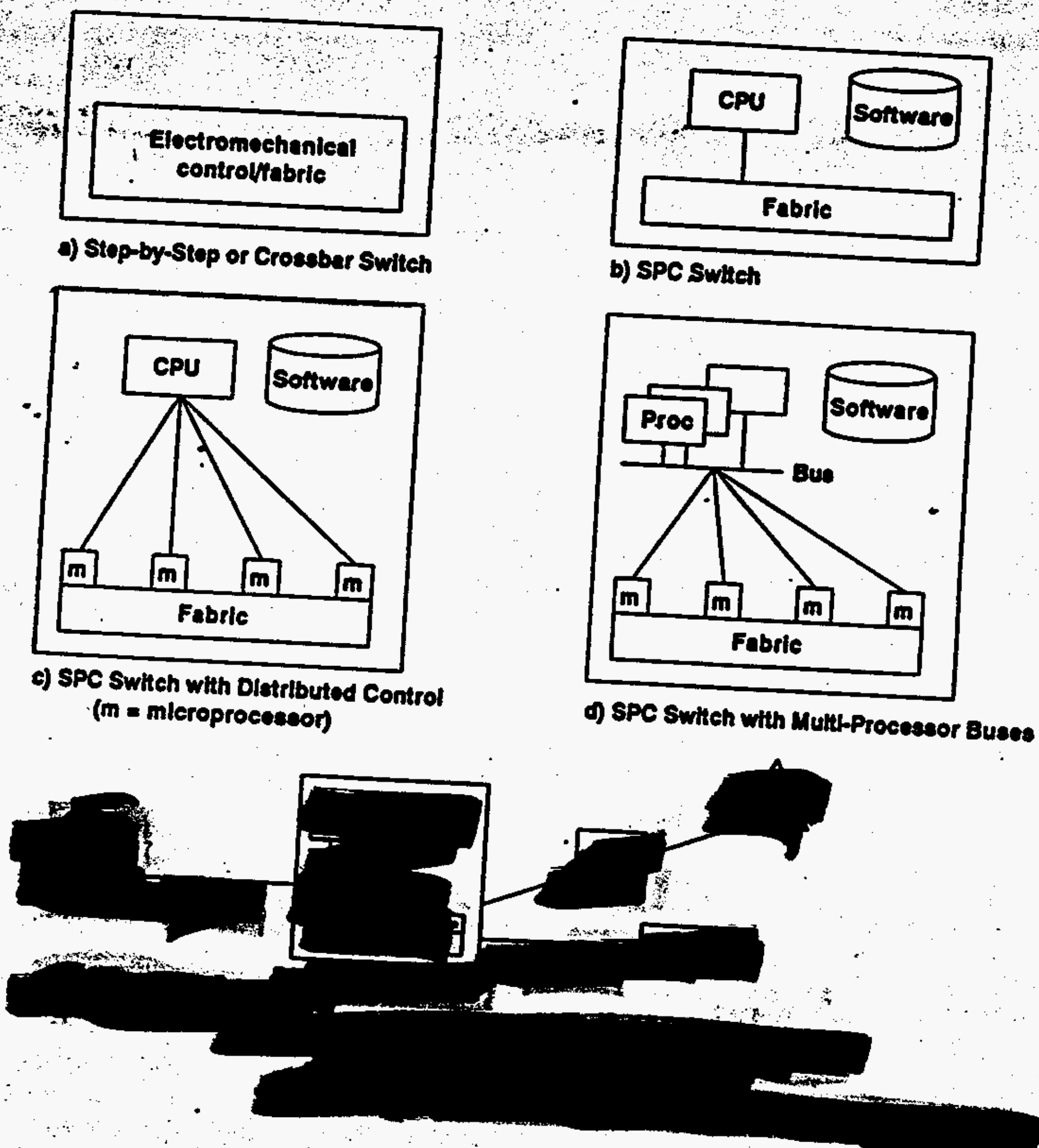
3.1. Call Processing Evolution

Processing elements in the network have evolved considerably over the past century, and they continue to evolve today, providing the increased flexibility needed to introduce new network services in a timely manner. Step-by-step switches (Fig. 3a) were directly controlled by customers' dial pulses, but crossbar switches introduced a common control capability to enable alternate routing, which increased the efficiency of the network. SPC switches (Fig. 3b) introduced an electronic Central Processing Unit (CPU), which enabled new features to be added easily by upgrading the software, while leaving the rest of the switch unchanged.



[redacted]

Fig. 3. Evolution of call processing.

As new features were added to SPC switches, greater demands were placed on the CPU. To cope with these increased demands, slower processors were replaced with faster processors, microprocessors were introduced to distribute the processing functions throughout the switch (Fig. 3c), and, now, architectures with multi-processors interconnected by high-speed buses are being introduced to increase the processing capacity even further (Fig. 3d). The multiple processor architectures provide much flexibility, allowing a few processors to be used initially for a low getting-started cost and additional processors to be added as the call processing demands increase.

Although SPC switches made it possible to introduce new services by simply upgrading the switch software, the implementations and availability dates of services and features differed from vendor to vendor, thus complicating operations and confusing customers. The Advanced Intelligent Network (AIN), shown in Fig. 3e, migrates some service control logic from the switch to other nodes. The Service Control Point (SCP) affects the processing of calls in the switch based on the contents of the SCP database. [redacted]. Service software in SCP and ASPIN nodes can be programmed by telephone companies, allowing new services to be prioritized based on customers' needs and made available in a uniform manner throughout the region on any vendor's switch.

Some service logic can also reside in computers owned by customers; a Switch-Computer Applications Interface (SCAI) will allow customers to request services and provide routing information to the network on a call-by-call basis for applications such as inbound and outbound telemarketing. AIN is a key component of the target information networking architecture, enabling it to satisfy many of the required attributes.

3.2. Transport and Switching Evolution

The data communications needs of business customers have changed considerably over the past two decades. In 1970, a 0.11 kbit/s teletypewriter was typical; by 1980, a 0.3 kbit/s or 1.2 kbit/s terminal was more common; today, high-performance personal computers and workstations are becoming ubiquitous, and many are connected to LANs operating at 10 Mbit/s Ethernet rates or 100 Mbit/s FDDI rates. In addition, there are indications that business customers will have an increased need for video communications over the coming decade.

Today's digital SPC switches contain 64 kbit/s digital switch fabrics, which provide synergies with interoffice digital transmission systems and digital loop carrier systems by eliminating the need for analog-to-digital conversion in integrated line and trunk switch interfaces. However, the 3 kHz bandwidth of analog telephone loops still limits the data rate that modems can transmit over most loops to a maximum of 2.4 or 9.6 kbit/s.

ISDN extends digital communications and out-of-band signaling to end users, thus enabling switched 64 kbit/s digital communications and more sophisticated control. This provides customers with an order of magnitude more bandwidth than was available over POTS-based data connections. However, ISDN still provides two to three orders of magnitude less bandwidth than that available on business customers' LANs.

New switching fabrics can be added to existing digital SPC switches to support higher-speed communications. For example, some switch vendors are now introducing new n x 64 kbit/s (n = 1, 6, 12, 24) switch fabrics to replace their existing 64 kbit/s switch fabrics, and others are modifying their 1.5 Mbit/s digital cross-connect systems to allow them to be controlled by the switch software, as shown in Fig. 4. Either of these fabrics will enable a Switched DS1 service, which will allow customers to establish 1.5 Mbit/s calls to other customers on a real-time basis using a T1 line and an associated POTS line for signaling. The n x 64 kbit/s fabrics will also enable a Switched Fractional DS1 service, which will allow customers to establish 384 kbit/s, 768 kbit/s, or 1.5 Mbit/s calls to other customers on a real-time basis using an ISDN Primary Rate Interface (PRI) and ISDN signaling.

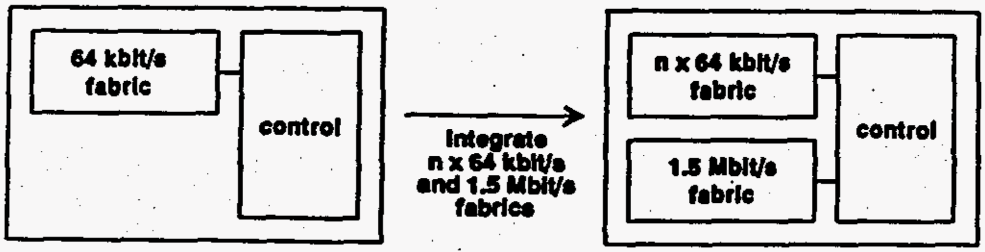


Fig. 4. Integration of new switch fabrics into Digital SPC switches

Today's public telecommunications network is optimized for connection-oriented services, which are characterized by a call setup phase, a communications phase, and a call disconnect phase. However, data customers typically use connectionless data protocols, such as Ethernet and the Internet Protocol (IP), which do not have traditional call setup or disconnect phases. Instead, each data packet is treated as a self-contained unit that carries not only the data to be transported, but also an address used to route the packet to the destination. Switched Multimegabit Data Service (SMDS) has been proposed by Bellcore as a public connectionless data service designed to provide networking between connectionless LANs. The initial introduction of SMDS on an early-availability basis is expected to use a stand-alone Metropolitan Area Network (MAN) switching fabric, which will provide SMDS initially over a new service-specific interface using service-specific technology.

Providing a new switching fabric for each new service introduced (e.g., an n x 64 kbit/s fabric for Switched DS1 and a MAN fabric for SMDS) results in high capital and operations costs, as well as long development intervals for new interface standards and products. Broadband ISDN (B-ISDN) will solve this problem by introducing a single switching fabric that supports many different types of communications, including both Constant Bit Rate (CBR) and Variable Bit Rate (VBR) communications at virtually any bandwidth desired, over a single standardized user interface. This fabric is based on a concept called Asynchronous Transfer Mode (ATM), in which information is carried in fixed-size cells along with a header that contains an explicit channel identification to simplify the multiplexing of different virtual channels with different bit-rates.

The ATM switching fabrics of B-ISDN will be connected by high-bandwidth optical fibers, using the SONET transmission format, which will provide a cost-effective and survivable transmission infrastructure that is extensible to Gbit/s rates and beyond. The use of SONET for B-ISDN transmission is another example of the fundamental change from evolution-by-replacement to evolution-by-integration. SONET, which is being deployed now to carry DS1 and DS3 channels, has been selected as the transmission infrastructure for B-ISDN to preserve the value of SONET equipment when ATM switches are deployed in the 1994 time-frame. ATM cells will be carried in some SONET payloads, while DS1s and DS3s are carried in others, thus ensuring a smooth and cost-effective evolution to B-ISDN.

4. BellSouth's Target Information Networking Architecture

[redacted]

- CCS7 provides highly reliable out-of-band message-based network signaling to support existing and future switched narrowband, wideband, and broadband services.
- ISDN extends digital communications and out-of-band message-based signaling capabilities to end users to enable new switched services.
- AIN places the development of new services under BellSouth's control, enabling the rapid introduction of new network services.
- B-ISDN extends ISDN to offer new high-bandwidth communications services to end users and provides them over an integrated platform to minimize capital and operations costs.
- PCS offers new services which give users freedom of movement and increased control from any terminal and to any network.

The public telecommunications network is expected to move from today's POTS-based architecture to a future Information Networking Architecture (INA) that supports information services, including not only voice, but also data, video, and image communications.

There are many different views on the structure and the timing of INA. For example, Bellcore views INA as a "desert-start" research project, which defines the target without being concerned about the feasibility or practicality of evolving to that target[1].

[redacted]

[1] Recently, however, an evolutionary path from AIN Release 0.1 to INA has been discussed.

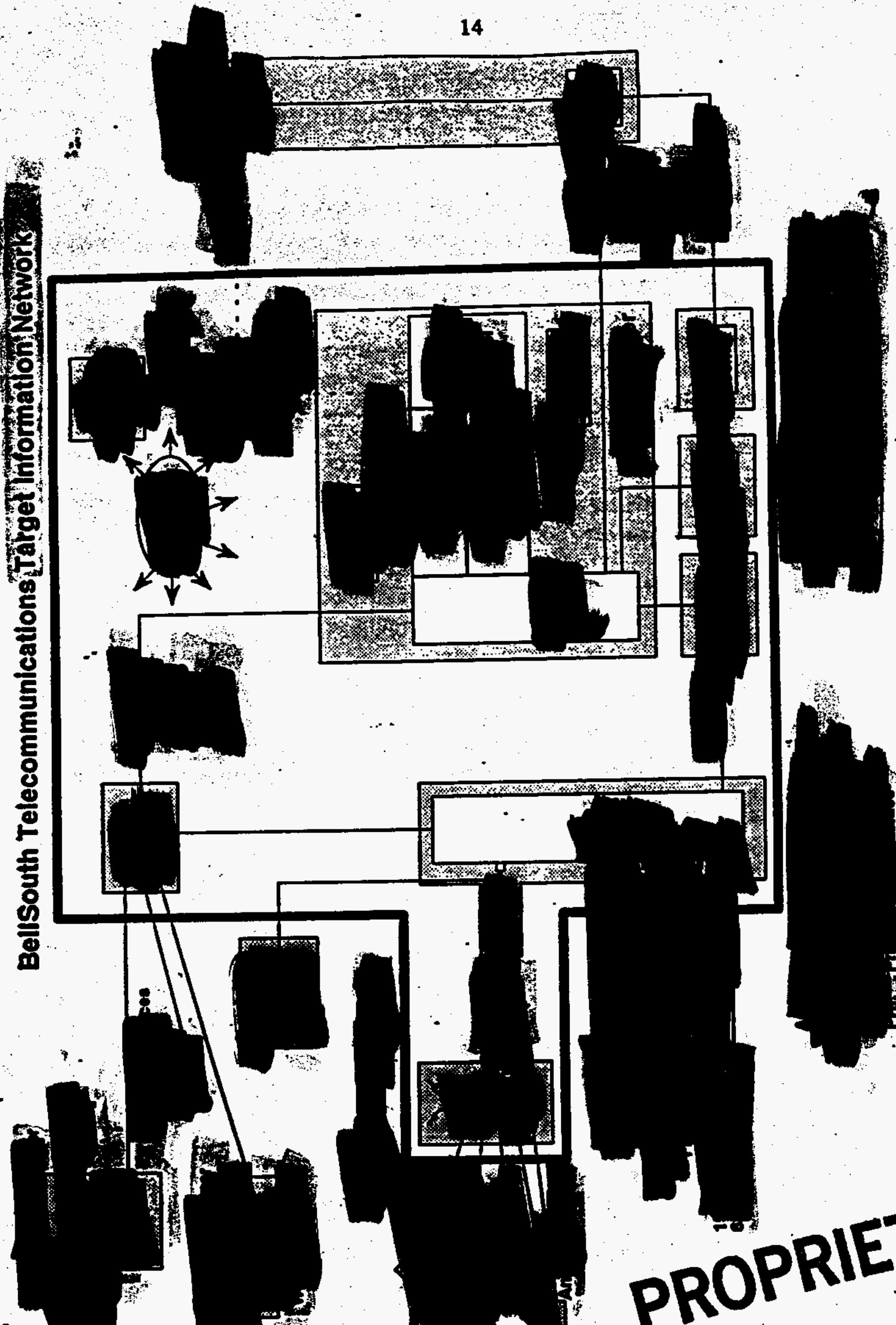


Fig. 5. BellSouth Telecommunications Target Information Networking Architecture

Network signaling for all components of the target architecture is based on the standard open interfaces of the highly-survivable CCS7 network. This critical underpinning for all other components of the target architecture not only enables many new AIN and B-ISDN services for which interprocessor communications are critical, but also makes possible interconnection to many other networks, including independent companies, cellular carriers, ICs, and private networks. Thus, BellSouth will be positioned to provide advanced services to those networks as well.

Call processing in the target architecture is based on the growable, distributed processing capability of existing digital SPC switching systems and is supplemented by AIN capabilities located in SCPs and [redacted] AIN will give BellSouth control over the features and timing of new services offered to our customers and enable us to introduce new services expeditiously and in a uniform manner throughout BellSouth. The architecture will allow provisioning organizations, marketing organizations, and customers to create, change, and provision their services instantaneously and electronically to meet individual customer needs. The operations capabilities required to manage and control the network will be essential to the success of these services.

The optical fiber transmission infrastructure of the target architecture provides the vast bandwidth required to support information networking services, including voice, data, video, and image. SONET survivable rings operating at Gbit/s rates interconnect the Fiber Centers with each other and with ATM access nodes. These nodes provide a common access platform supporting a wide variety of customer interfaces ranging from POTS to ISDN, Switched DS1, Switched DS3, Frame Relay, SMDS, and B-ISDN. A simple line card changeout, or a software download to the line card, is all that is required to provision a new customer interface. This common access platform not only expedites the introduction of new services, thus maximizing our new service opportunities, but also minimizes risk since the incremental investment required to introduce a new service is small.

Optical fiber can extend beyond the access nodes to remote multiplexer nodes, located very near the customer. Video from a CATV headend or an enhanced services provider is wavelength-division-multiplexed onto the fiber at the access node and carried to the remote multiplexer node for delivery to the customer over copper, fiber, or coax facilities. The remote multiplexer node can provide the same variety of customer interfaces as the access node; in addition, [redacted]

5. Evolution to BellSouth's Target Network Architecture

Each of the platforms comprising BellSouth's Information Networking Architecture must evolve on an incremental basis toward the target, and each evolution step must be justified economically. This section presents a roadmap for the cost-effective and timely evolution of these platforms. Background information and further details of the evolution steps are contained in Attachments to this report.

5.1. Evolution to CCS7

The network signaling for BellSouth's INA is based on the out-of-band signaling capabilities of the CCS7 network, which is currently deployed to 50% of BellSouth's offices and will reach 66% by year-end 1991. CCS7 will become even more valuable over the next few years as the following events occur.

- **STP Pass-through (1991):** STP pass-through will allow telephone companies (e.g., independent telephone companies) to access various database services through BellSouth Signaling Transfer Points (STP).

- **CCS7 Interconnection to ICs (CCSAC) (1992):** CCSAC will allow an Interexchange Carrier (IC) to connect to BellSouth's CCS7 network, enabling features such as Charge Number and Calling Party Identification to be provided on an interLATA basis. CCSAC will also lay the foundation for interLATA services such as TOUCHSTAR.

- **CCS7 Interconnection to Private Networks (1992):** Several private network owners have inquired about connecting to BellSouth's CCS7 network. Ultimately, this could extend TOUCHSTAR and AIN services between our network and private networks.

- **CCS7 Interconnection to Cellular Carriers (1992):** Interconnection to cellular carriers will allow expanded service areas for TOUCHSTAR and AIN services, thereby enhancing their value to our customers. BellSouth, McCaw, and Bellcore have selected southern Florida as the site for a trial interconnection in 1992.

As the demand for AIN services increases the load on the CCS7 network, the speed of the CCS7 signaling links will need to be increased from the current 56 kbit/s to 384 kbit/s, 1.5 Mbit/s, or even to the 155 Mbit/s rates of B-ISDN. This will likely be more than just a simple replacement of the physical level; the entire interface will need to be evaluated to determine whether changes will be required in higher levels.

5.2. Evolution to ISDN

ISDN is the next evolutionary step in providing end-to-end digital connectivity. Both AT&T ~~and NTI have committed to provide the capabilities of National ISDN-1 in 1992; this first~~ step toward service uniformity will lead to lower-cost CPE and network services, which will make ISDN more appealing to the mass market.

BellSouth plans to tariff the ISDN Basic Rate Interface (BRI), which provides two 64 kbit/s B-channels and one 16 kbit/s D-channel, in 1991. This service will be offered initially to large businesses and later extended to "single-line" applications for small businesses and residences. By 1993, several issues that make ISDN less-than-desirable to the residence market should be resolved:

- **Terminal Powering:** Presently, ISDN CPE is powered from a customer-provided power source (typically AC commercial power). Unless customer-provided power backup is available, the ISDN CPE will not function during a commercial power outage.

- **Extension Capability:** Typically, only one ISDN terminal is allowed to control a B-channel during a call. Therefore, traditional extension service, common to residence service, is not available with ISDN.

- **Premises Wiring:** Some residential premises wiring is probably not suitable for ISDN service, and determining whether ISDN will work with a residential customer's premises wiring may be time-consuming. If it is not acceptable, significant rewiring may be required.

- **CPE Terminal Portability:** The relative expense of ISDN CPE and the mobility of residential customers make it important that the CPE will function on multiple central office switch types. If CPE is not portable, the customer may have to replace it to move to a new residence supported by a different type of switch.

BellSouth also plans to tariff the ISDN Primary Rate Interface (PRI) in 1991, with volume deployment beginning in 1992. BellSouth's PRI tariff will be aimed at providing network access for PBXs. By 1997, ISDN will be receiving wide acceptance from both business and residential customers.

Many ISDN issues, such as terminal powering and extension capability, are fundamental issues for B-ISDN as well. Resolving these issues for ISDN will also resolve them for B-ISDN and enable us to introduce B-ISDN more effectively. ISDN also provides much of the infrastructure for B-ISDN. For example, [redacted]

5.3. Evolution to AIN

Call processing for BellSouth's target INA is provided by the growable, distributed processing capabilities of digital SPC switches and supplemented by AIN software in either an SCP or an [redacted]

The occurrence of certain trigger conditions while processing a call will cause the switch to suspend call processing and transmit information about the call through the CCS7 signaling network to an SCP. AIN service software in the SCP then sends control information back to the CO switch to affect how the call is processed.

AIN software can also reside in an [redacted]

[redacted]

AIN gives BellSouth control over the specification and development of new network services and avoids the need to negotiate a service description and a schedule for service development with switch vendors. An additional advantage of an AIN service is that all customers see a uniform service, unlike switch-based services which often differ across vendors' implementations.

BellSouth has formed a team to specify and develop AIN services with the following objectives for 1991 and 1992.

- Develop and install the essential Software Development Environment (SDE) required for the development of the first AIN services,
- Test the [redacted] and SCP platforms,
- Develop Calling Name Delivery service for 1993 deployment an [redacted]

Calling Name Delivery (CNAM) is similar to Calling Number Delivery; however, the network delivers the name rather than the number of the calling party. The name of the caller is expected to be more valuable to the customer receiving the call than the number. In addition, it avoids some legal questions that have arisen with Calling Number Delivery, since the call can only be returned if the customer has the calling party's number. Calling Name Delivery promises to be a mass market service that will be attractive to residential customers as much as to business customers.

[redacted] geographic location of the caller, and potentially on one or more of the following criteria specified by the customer: [redacted]

AIN operations will be supported by a Service Management System (SMS) that provides the ability to maintain AIN services on an SCP or an [redacted]

Initially, only the provisioning and maintenance organizations will be provided with some capabilities to modify services. As these tools mature, they will be enhanced and made accessible to BellSouth personnel outside the provisioning and maintenance organizations to provide more rapid response to customer requests. At the same time, the provisioning organization will be provided with more powerful tools to allow greater flexibility and capability. Ultimately, customers themselves will have the ability to create, modify and provision their own services.

[redacted]

[redacted]

[redacted]

5.4. Evolution to B-ISDN

5.4.1. Optical Fiber

BellSouth has been placing optical fiber in the interoffice and feeder environment since the early 1980's to increase the capacity and reduce the cost of transmission systems. Significant advances in optical technology have now resulted in an effort to make economical the extension of optical fiber directly to customers or to a small pedestal located very near the customer.

We have already realized tremendous cost savings by using optical fiber to carry voice information, but we will reap even greater benefits from our optical fiber infrastructure as we evolve to the target Information Networking Architecture. Optical fiber has a vast bandwidth capacity that far exceeds that required to carry voice information; thus, it positions BellSouth to offer other information networking services, including data, video, and image, which require much higher bandwidths than voice services alone.

5.4.2. SONET

BellSouth has been deploying optical transmission systems since the early 1980's; however, since no standards existed, each vendor developed equipment with proprietary interfaces, thus making optical interconnection of these systems impossible. A substantial set of national and international standards for optical interconnection, called the Synchronous Optical NETwork (SONET), has been issued, and SONET multiplexer products are now becoming available. All transport relief projects planned for 1992 and beyond will evaluate new SONET alternatives. The initial SONET deployments are expected to be primarily driven by growth requirements, with only very limited replacement of existing asynchronous equipment during the early deployment stages.

Two major benefits of SONET are its self-healing capabilities and its ability to provide more economical add/drop multiplexing (ADM). In the loop, 155 Mbit/s systems are expected to predominate, with point-to-point systems initially, followed by add/drop, followed by ADM rings. The unidirectional self-healing ring (USHR) architecture is expected to be more applicable in the loop than the bidirectional self-healing ring (BSHR). In the interoffice, the standard BSHR is expected to be favored when it becomes available in late 1992 or early 1993.

5.4.3. Early-Availability Broadband Services

Without a position in the marketplace, BellSouth cannot expect to be the future provider-of- [redacted] early-availability broadband services in the 1991 - 92 time-frame, while planning for the migration of these services to a future B-ISDN platform, is essential to our succes [redacted]

SMDS:

Switched Multimegabit Data Service (SMDS) is a 1.5 Mbit/s to 45 Mbit/s connectionless data service designed to support LAN interconnection and imaging applications. SMDS uses the 802.6 cell structure, which has been closely aligned with the ATM cell structure to facilitate a smooth evolution of SMDS to B-ISDN.

Frame Relay:

Frame Relay is a 64 kbit/s to 1.5 Mbit/s (and possibly higher) connection-oriented data service designed to support LAN interconnection and terminal-to-host applications. The Frame Relay protocol and procedures are similar to LAPD, so it is relatively easy for CPE and switch vendors to add Frame Relay interfaces to existing equipment.

Switched DS1:

Switched DS1 gives customers the ability to place 1.5 Mbit/s calls to other customers on a real-time basis for applications such as video conferencing. Switched DS1 requires that existing digital cross-connect systems and narrowband switches be enhanced, but allows customers to use existing CPE. Switched Fractional DS1 service may also become important; this allows a customer to place calls with a bandwidth of n x 64 kbit/s to other customers on a real-time basis.

5.4.4. Integration of Services on a B-ISDN Platform

B-ISDN will allow BellSouth to integrate many different broadband and narrowband services on a common transmission/switching platform to avoid the cost of building, operating, and maintaining many different service-specific platforms.

B-ISDN is based on a new concept called Asynchronous Transfer Mode (ATM), in which all information is packaged into small 48-byte cells. Each cell contains a 5-byte header, which carries an explicit channel identification that simplifies the multiplexing and switching of all types of information, including voice, data, video, and image. With ATM, cells are generated as required by the application. For example, a 64 kbit/s voice application would generate about one cell for every 2000 cells on a 155 Mbit/s interface, and a 45 Mbit/s video application would generate about one cell for every three cells. Data communications, which tend to be bursty in nature, can also be supported by ATM, and cells are generated only when the application has information to send. Therefore, an additional feature of ATM is that the network can use statistical multiplexing to achieve increased network efficiency.

ATM will also enable the installation portion of provisioning to be simplified. For example, an ATM access node can support many different types of customer interfaces, such as POTS, ISDN BRI, ISDN PRI, SMDS, or Switched DS1, simply by inserting the appropriate line card. The line card converts information on the interface to ATM cells, which are carried within the SONET transmission payload to the Fiber Center, where the cells are switched to the appropriate destination based on the channel identification in the header. The ATM switch in the Fiber Center handles all cells identically, independent of the service interface at the access node.

5.4.5. Introduction of B-ISDN Customer Interfaces

B-ISDN also provides a new integrated User-Network Interface (UNI), which will allow a customer to multiplex many different types of information, including multi-media communications, on their premises and to connect to the public network over a single ATM-based interface that supports the full range of communications required. The ability to establish ATM virtual channels on demand will stimulate the introduction of many new user applications integrating voice, video, data, and image communications for both business and residential customers.

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5.5. Evolution to PCS

BellSouth's interest in PCS is the result of recent growth trends in wireless telecommunications, including paging, cellular telephones, private mobile radio, and cordless telephones. [redacted]

A personal communications service with a small hand-held phone would ideally facilitate all of the following:

- Receiving a call anywhere and anytime,
- Having one phone that accommodates both business and personal calls,
- Having one phone number, and
- Implementing personal call-handling preferences, such as automatic call screening and automatically returning calls at a more convenient time.

There is currently a high degree of regulatory uncertainty regarding the role BellSouth and the other RBOCs will have in the upcoming PCS marketplace. [redacted]

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The architecture for wireless ESSX consists of various radio ports distributed on each floor of the customer's building according to traffic requirements and radio propagation characteristics. Users will be able to send and receive calls throughout the building. An ~~active call will be handed off from one radio port to another as the user moves around the~~ building. Each radio port will support multiple connections according to traffic needs and will be connected via ISDN BRI or PRI facilities to a radio port controller. New ISDN D-channel messages will be defined for such functions as handset registration and handoff between cells. The radio port controller will be connected to ISDN lines from a digital central office. A function of the radio port controller is to make the user's handset appear to be hardwired to the switch port. Switching is performed in the radio port controller to perform handoff and to connect the user to his or her assigned switch port. Eventually, the function of the radio port controller could be integrated into the digital switching system.

Three wireless ESSX trials are planned for 1991 to establish the concept of wireless ESSX in different environments with heterogeneous equipment. The goals of the trials are to:

– [redacted]

– [redacted]

– [redacted]

[redacted]

FCC spectrum allocation decisions are likely in the 1994-95 time-frame. [redacted]

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6. Conclusions

The general industry consensus is that the public telecommunications network will move [redacted] supports information services, including not only voice, but also data, video, and image communications. BellSouth is well positioned to evolve its network over the next decade to a flexible and cost-effective target architecture that can respond rapidly to emerging customer needs.

BellSouth's target Information Networking Architecture embodies the key attributes listed below.

- Supports Multiple Services on a Common Platform
- Enables Rapid Service Delivery
- Enables BellSouth to Control the Timing of Service Introduction
- Preserves Customer Investments Through Service Continuity
- Uses Appropriate Open Standard Interfaces
- Provides High Reliability and Survivability
- Networks Other Networks
- Integrates Network Elements and Operations Systems into a Common Platform
- Provides Independence from Regulatory Decisions
- Supports a Wide Range of Communications Bandwidth
- Supports Multi-media Communications
- Provides Private and Secure Communications
- Increases Customer Control of Services
- Reduces Redundancy in Corporate Databases

The feasibility and practicality of evolving BellSouth's current network to the target Information Networking Architecture are of paramount importance. In the past, new capabilities have been added to BellSouth's network by replacing older systems with newer systems. Two enabling technologies, end-to-end digital systems and Stored Program Control (SPC), now make it possible to evolve the current network by integrating new services and capabilities.

Five platforms and their Operations Systems form the foundation for BellSouth's target Information Networking Architecture.

- CCS7 provides highly reliable out-of-band message-based network signaling to support existing and future switched narrowband, wideband, and broadband services.
- ISDN extends digital communications and out-of-band message-based signaling capabilities to end users to enable new switched services.
- AIN places the development of new services under BellSouth's control, enabling the rapid introduction of new network services.
- B-ISDN extends ISDN to offer new high-bandwidth communications services to end users and provides them over an integrated platform to minimize capital and operations costs.
- PCS offers new services which give users freedom of movement and increased control from any terminal and to any network.

Section 5 has presented a summary of the steps needed to evolve BellSouth's network to the target Information Networking Architecture. The attachments to this report provide a more detailed description of these steps and discuss some of the issues associated with this evolution.

Attachments:
A - Evolution to CCS7
B - Evolution to ISDN
C - Evolution to AIN
D - Evolution to B-ISDN
E - Evolution to PCS
F - Evolution of OSs
G - Evolution to INA
H - Glossary

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A-1. Background

[redacted] were used for both access and network signaling [1]. Common control switching systems, such as the No. 5 Crossbar, while still accepting dial pulses on both customer loops and interoffice trunks, could also use Multi-Frequency (MF) signals to speed up interoffice signaling. Later, the introduction of Dual Tone MF (DTMF) or *TOUCH-TONE*[1] signaling extended this concept to access signaling.

Dial pulse and MF signaling are called "in-band" because the signaling information is carried within the voice communications channel. Stored Program Control (SPC) switching systems with intelligent processors made it possible for signaling information to be carried "out-of-band" over a common signaling channel that is separate from the voice communications channels. Furthermore, in this merger of computers and data communications, the signaling information carried over the common signaling channel could be functional data messages rather than tones or pulses. The advantages of "out-of-band" common channel signaling include:

- Signaling does not interfere with an active communications channel (e.g., talkoff, the erroneous interpretation of user information as signaling, is eliminated),
- Shortening of interoffice signaling delays results in increased utilization of transmission and switching facilities,
- The capability for transmitting functional data messages enables new services such as calling party identification, and
- The capability for transmitting functional data messages between a CO and an SCP enables the development of Intelligent Network services.

In 1976, Common Channel Interoffice Signaling (CCIS) was introduced in 4ESS toll switches. In the first major application of packet switching in the Bell System, signaling messages were carried from switching offices over 2.4 kbit/s signaling links to Signaling Transfer Points (STP), which routed the signaling messages to other switching offices [2] using a variant of a protocol called CCITT Signaling System No. 6 (CCIS6).

The BellSouth Common Channel Signaling Project began in early 1982. Common Channel Signaling (CCS), under the direction of AT&T, was primarily being used in the toll network at that time. Migration of CCS to the local network, while seeming to be the appropriate long-term strategy, had no real driver or economic justification. It was apparent that network savings alone would not pay for local common channel signaling, so BellSouth began to identify potential revenue-producing services that could utilize a CCS network.

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[1] Trademark of AT&T.

A team was formed in April, 1983, to study service and technical alternatives, as well as requirements. Two protocols were considered. CCIS6 was already being used in AT&T's toll network to support trunk signaling and database services. While CCIS6 was already available on some switching systems and some services had already been developed, it was limited in scope and was already outdated. Implementing CCIS6 would make the inevitable transition to a more sophisticated protocol more difficult. CCITT Signaling System No. 7 (SS7) offered several advantages over CCIS6 including:

- Public standards which made a multi-vendor environment much easier to implement,
- A more modern design which incorporated more modularity and flexibility,
- A forward-looking digital environment with the potential to accommodate ISDN messages and features, and
- An administration much simpler than CCIS6.

The major concern with SS7 was its availability, i.e., when the protocol would be sufficiently defined to support the services BellSouth was interested in deploying and when the vendor market would support the technology. Based on research and consultation with Bellcore, it was determined that sufficient protocol specifications to cover the initial BellSouth requirements would be available in 1986. Further, based on interactions with vendors, it was apparent that most of them were already incorporating the SS7 protocol into their product lines. All this led BellSouth to conclude that SS7 could be deployed in late 1987, only one year later than CCIS6 could be deployed.

BellSouth decided to use a two-tier CCS7 network. The first phase in 1987, shown in Figure 1, consisted of a pair of Service Control Points (SCPs) and Regional STPs (RSTPs) split between Atlanta and Birmingham, and a pair of Local STPs (LSTPs) located in Atlanta. The initial STPs were AT&T products, and the SCPs were developed by Bellcore. The initial Service Switching Points (SSPs) included 4ESS, 1AESS, and DMS 100/200 LATA/Access Tandem switches throughout the region. Initially, these tandems were homed primarily on the RSTPs, with some homed on the Atlanta LSTP pair[2]. The databases for the two initial services, 800 database service and credit card validation service, were contained in the SCP pair, which homed on the regional STP pair. As the initial services were database only, no trunk signaling was required.

[2] The target is to home SSP's on LSTP's only; this will occur by the end of 1991.

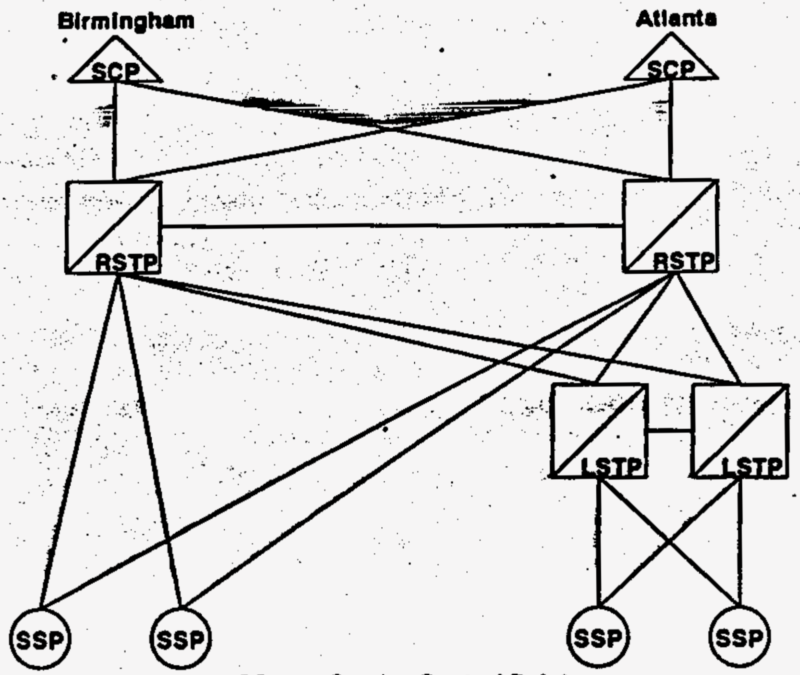

Fig. 1. Initial BellSouth CCS7 network.

Beginning in 1988, LSTPs began to be deployed to support local trunk signaling for *TOUCHSTAR*™ services. The first major location to deploy *TOUCHSTAR* was Memphis in October, 1988, using Ericsson LSTPs and both AT&T and NTI end offices. By the end of 1991, LSTPs from AT&T, Ericsson, or NTI will be deployed in all but two BellSouth LATAs. Fifty percent of BellSouth end offices and tandems now have local SS7 and *TOUCHSTAR* deployed; this will rise to 66 percent and will include all major metro areas within BellSouth by year-end 1991, providing CCS7 access to over 78 percent of BellSouth's main stations, as shown in Fig. 2. CCS7 access is planned for all switches, except 2BESSs, by year-end 1995.

The extensive backbone CCS7 network provides the long term signaling transport and database access mechanism needed to support existing and future services, including intraLATA and interLATA functionality, for the ISDN, AIN, B-ISDN, and PCS platforms.

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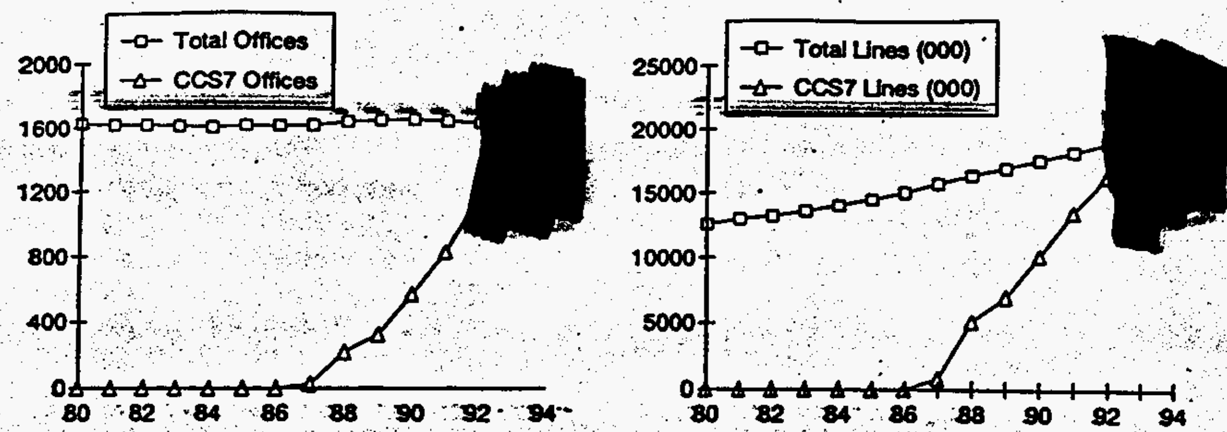


Fig. 2. Evolution to CCS7 in BellSouth [3].

A-1.1. CCS7 Architecture

A-1.1.1. CCS7 Physical Archite[redacted]e

Signaling Transfer Points (STP) are [redacted]t switches that interconnect the various nodes [redacted] the CCS7 network. The types of signaling links used in the CCS7 network are illustrated in Fig. 3 [4].

- A (Access) Links connect a Signaling Point (e.g., SSP or SCP) to an STP pair.
- B (Bridge) Links connect mated pairs of STPs at the same hierarchical level.
- C (Cross) Links connect two STPs that comprise a mated pair.
- D (Diagonal) Links connect an LSTP mated pair to an RSTP mated pair.
- E (Extended Access) Links connect a Signaling Point to an STP pair other than the home STP.
- F Links directly connect two Signaling Points.

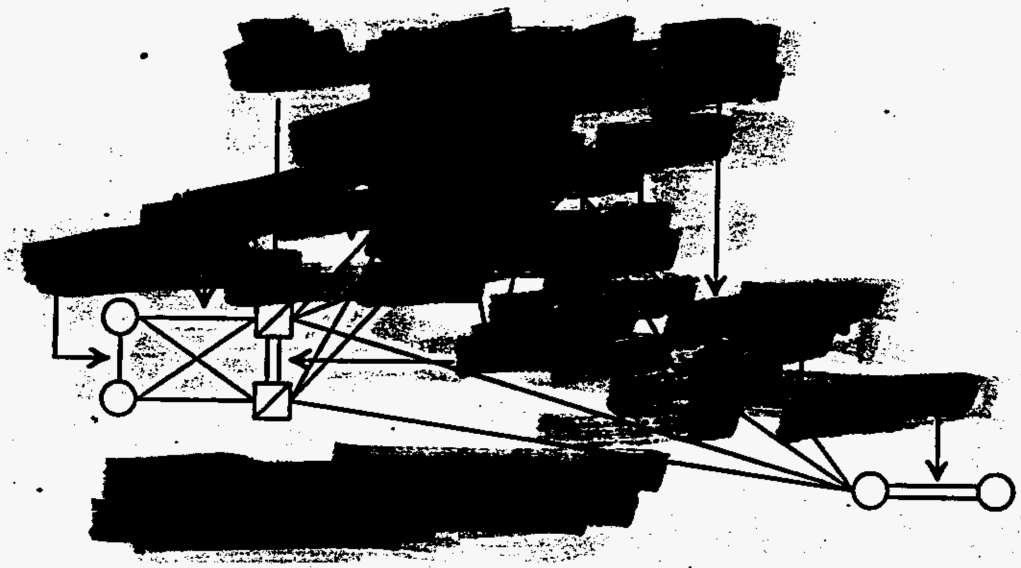
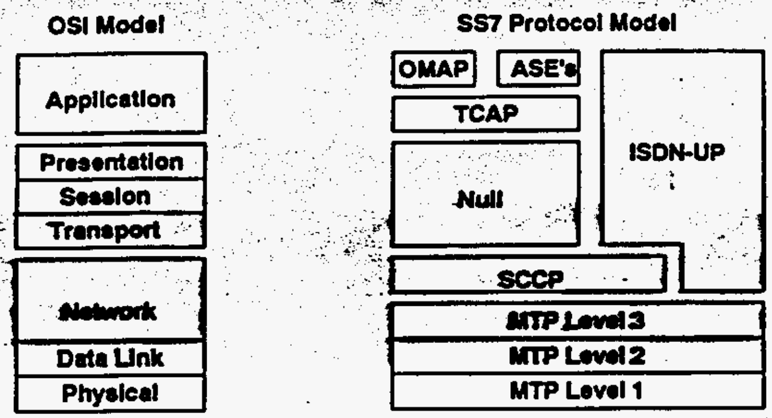


Fig. 3. CCS7 physical architecture.

A-1.1.2. CCS7 Protocol Architecture

The Signaling System No. 7 (SS7) protocol is used in the CCS7 network. The protocol architecture of SS7 is illustrated in Fig. 4 [5, 6, 7].



OMAP:	Operations Maintenance and Administration Part
ASE:	Application Service Element
TCAP:	Transaction Capabilities Application Part
ISDN-UP:	ISDN User Part
SCCP:	Signaling Connection Control Part
MTP:	Message Transfer Part

Fig. 4. SS7 protocol architecture.

The Message Transfer Part (MTP) provides reliable transfer of signaling messages. Level 1 provides a connection to the transmission medium. Level 2 ensures reliable data transport on a link. Level 3 provides message routing functions and network management functions needed to reconfigure the signaling network in the event of signaling link or signaling point failure or to control traffic in the event of congestion. The routing label used by MTP Level 3 to route a Message Signal Unit (MSU) toward its destination consists of a Destination Point Code (DPC), an Originating Point Code (OPC), and a Signaling Link Selection (SLS).

The Signaling Connection Control Part (SCCP) provides (1) specialized routing called Global Title Translation, (2) SCCP management to reroute or throttle signaling traffic in the event of failure or congestion in the signaling network, and (3) connectionless service. Global Title Translation is required when an "indirect" address is provided for an SS7 packet; this address must be translated to a DPC to route the message to its destination. Global Title Translation is typically performed at an STP. Connectionless service allows a user of the SCCP (e.g., TCAP) to request a transfer of up to 255 octets of user data without first requesting the establishment of a signaling connection. The user data is included in a unitdata (UDT) message, which contains the address used for routing within the message.

The Transaction Capabilities Application Part (TCAP) supports non-circuit-related services. It uses the connectionless service of the SCCP to carry messages between exchanges, between exchanges and databases, or between an exchange and the interworking point to an ISDN customer.

Application Service Elements (ASEs) provide the specific information that a particular application needs, e.g., information for querying a remote database to convert an 800 number into a network-routable telephone number.

The Operations Maintenance and Administration Part (OMAP) uses TCAP to monitor the protocol after it is deployment in the CCS7 network. Specifically, OMAP provides routing verification tests for the MTP and SCCP, determines if there are far-end equipment failures, performs circuit validation tests on exchanges, and collects measurements at signaling nodes.
13 Currently, [redacted]
14

The ISDN User Part (ISDN-UP or ISUP) controls the setup and tear-down of calls between switches in the CCS7 network. This information consists of trunk signaling and any additional service-related data (e.g., for *TOUCHSTAR*, AIN Release 0, Carrier Access). After an ISUP message is transported from a node to the next node, a trunk is established between the nodes, and the message is sent to the next switch. This process is repeated until the destination switch is reached. Work is proceeding on the extension of the ISUP to support the establishment of ATM virtual connections for Broadband ISDN.

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A-2. 1991 Events

A-2.1. STP Pass-Through

STP pass-through allows other telephone companies to access databases through BellSouth's STPs to provide various database services. Independent Telephone Companies (ITC) within the BellSouth region currently access our intraLATA 800 database in two ways - through direct connection to our LSTPs via "A" links and indirectly through BellSouth SSPs. We also provide operator services for a large number of independent companies, and while we currently send all independent company credit card validations for intraLATA calls to the AT&T Billing Validation Application (BVA), this is expected to change for many of these validations on 12/31/91, when the AT&T BVA is scheduled to be terminated.

We have filed a waiver with Judge Greene requesting authority to perform database inquiries for 800 and LIDB service for ITCs where the signaling crosses LATA boundaries. The DOJ has already agreed with the waiver request and if Judge Greene does not ask for additional information, a ruling could be expected during 1991. If we lose the capability to provide this type of pass-through, the independents must find another method of gaining access to these databases; this could then, in turn, cause them to have to find another means to connect to our network for local non-database services such as *TOUCHSTAR*. This would necessitate changes to our network, since some independents and other network providers currently connect to our network via "A" links for intercompany *TOUCHSTAR*.

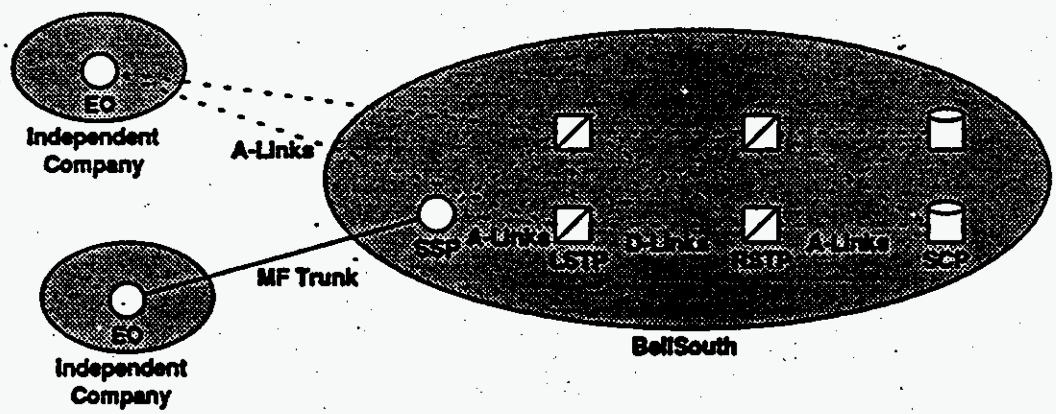

Fig. 5. STP Pass-Through.

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A-3. 1992 Events

A-3.1. CCS7 Interconnection to IC's (CCSAC)

CCSAC is the capability to set up an interLATA call over a Feature Group D trunk using SS7, and will allow Interexchange Carriers (IC's) to interconnect to the BellSouth CCS7 network. Once CCSAC is deployed down to the end office level, much faster call setup and teardown of connections will be possible. Optional features offered with CCSAC are Charge Number, Calling Party Identification, and Carrier Selection Parameter.

Since CCSAC will be offered as an option to Switched Access Feature Group D, CCS7 adds value to BellSouth's network and offers incentives for IC's to use our network to reach their customers, thereby diminishing the threat of bypass.

The architectural alternatives for CCSAC consist of either a BellSouth STP pair interconnecting to an IC STP pair via a quad of Bridge (B) links, or a BellSouth STP pair interfacing to a Signaling Point (SP) in the interconnecting network via a pair of Access (A) links. CCSAC service was deployed in Greensboro and Memphis in 2Q91. Seven more metropolitan areas are planned for 1991, 13 for 1992, and 15 for 1993.

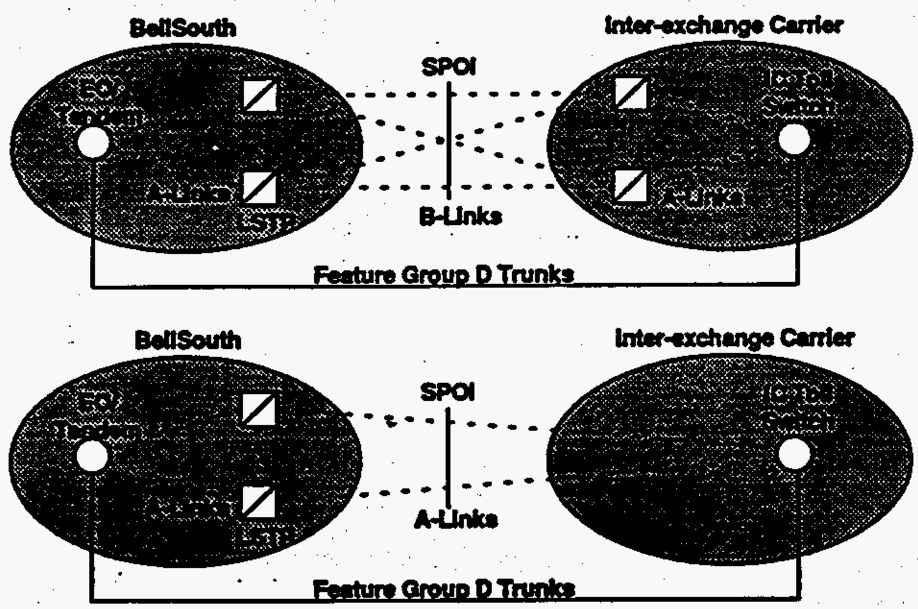

Fig. 6. CCS7 Interconnection to IC's

A-3.2. CCS7 Interconnection to Private Networks

BellSouth has received inquiries from several owners of private networks for interconnection to our CCS7 network to provide improved network connection, as well as to deliver the calling number to the private network. Ultimately, this connection could extend *TOUCHSTAR* and AIN services between our network and private networks. The demand for this appears to be something that will increase greatly over time, particularly as ICs begin to make this type of connection to private networks, bypassing our network. At this point, however, requirements are not expected to be completed until 12/91 for this type of interconnection, and very few PBXs are capable of connecting directly to a CCS7 network.

A-3.3. CCS7 Interconnection to Cellular Carriers

Interconnection to cellular carriers will expand the service areas for *TOUCHSTAR* and AIN services, thereby enhancing their value to our customers, while also giving a cellular carrier the opportunity to generate new revenues from the sale of services similar to *TOUCHSTAR*. National standards are now being developed for interconnection between a cellular network and an LEC network.

BellSouth Corp., McCaw Cellular Communications, and Bellcore have selected southern Florida as the site for a trial interconnecting the BellSouth network and the switches of wireless carriers using SS7. The 1992 trial will include four phases over 12 to 18 months. During the first phase, the Transaction Capabilities Application Part (TCAP) of SS7 will be transmitted on an interLATA basis. Phase two will test the call setup portion of the CCS7 network. Phases three and four will expand these trials to include processing network functions on an interLATA basis with interexchange carriers.

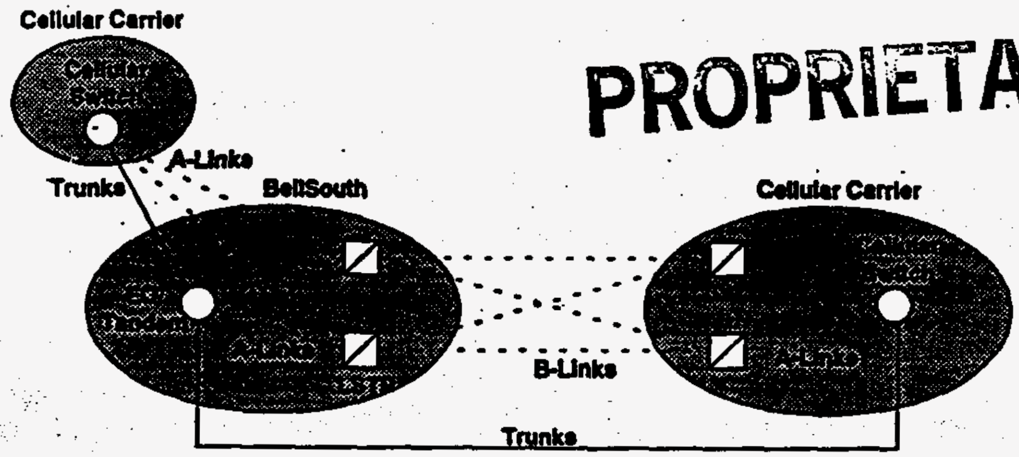

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Fig. 7. CCS7 Interconnection to Cellular Carriers.

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A-4. 1995+ Events

A-4.1. Increase Capacity of CCS7 Network

CCS7 signaling links currently operate at 56 kbit/s, and the most heavily-loaded STP pair currently uses only two of the eight possible link pairs. However, as the demand for AIN services increases, the amount of signaling traffic will increase. Furthermore, some AIN services may place stringent constraints on the allowable delay in passing an SS7 message between an SSP and an SCP. The queueing delay at a node as a function of traffic load and link speed is illustrated in Fig. 8. As AIN is introduced, both capacity and delay requirements may result in the need to increase the transmission rate of CCS7 links to 384 kbit/s or 1.5 Mbit/s, and possibly to B-ISDN rates eventually. In the U.S. we expect that the need for B-ISDN rates for signaling will occur well after the year 2000, if ever; however, Nippon Telephone and Telegraph (NTT) of Japan believes that the transport of network signaling traffic will actually be one of the major drivers, along with new services revenue and network integration cost reductions, for the deployment of B-ISDN switching technology in their network [9].

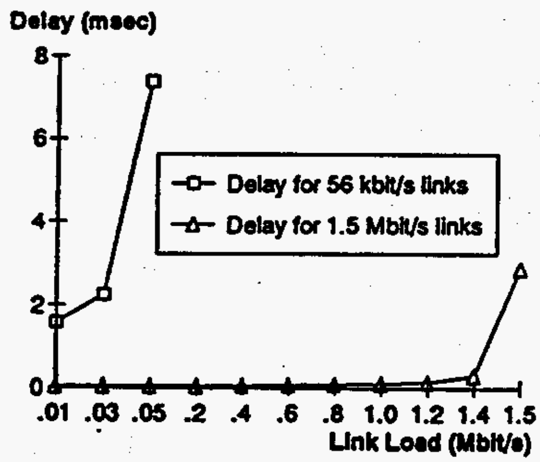

Fig. 8. Effect of Link Speed on Queueing Delays at a Node.

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A-5. Critical CCS7 Issues

- Standards

  Standards, as well as technical guidelines for interconnection to other networks, including private networks and cellular carriers, are not mature.

- Regulatory Issues

  Many regulatory issues are still unresolved regarding specific services being planned or provided using the CCS7 network, and resolution of some of these issues will impact how and when we expand our existing network and make widespread connection to other networks.

- OAM&P

  Necessary operations, maintenance, administration, and provisioning interactions must be established on an inter-company basis.

- Business Relationships

  A major hurdle in progressing to "national CCS7" is the initiation and maturing of business relationships with potential interconnecting networks.

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B-1. Background

B-1.1. Digital Transmission

Early trunks between offices used voice-frequency cable pairs. As the number of trunks increased, carrier systems were introduced to carry multiple trunks over a physical transmission medium and reduce the per-trunk cost. Early carrier systems used analog frequency-division multiplexing techniques, while later systems used digital time-division multiplexing techniques, as shown in Table I.

Carrier System	Medium	Channels	Multiplexing	Bandwidth/Bit Rate
O	Open Wire	16	Analog	2 - 256 kHz
ON	Cable Pairs	24	Analog	36 - 132 kHz
N1, N2	Cable Pairs	12	Analog	36 - 268 kHz
N3	Cable Pairs	24	Analog	36 - 268 kHz
L	Coax, Radio	600	Analog	60 - 2788 kHz
T1	Cable Pairs	24	Digital	1.544 Mbit/s
T1C	Cable Pairs	48	Digital	3.088 Mbit/s
T3	Fiber, Radio	672	Digital	44.736 Mbit/s
T4	Fiber	2016	Digital	139.264 Mbit/s
SONET OC-1	Fiber	672	Digital	51.84 Mbit/s
SONET OC-3	Fiber	2016	Digital	155.52 Mbit/s
SONET OC-12	Fiber	8064	Digital	622.08 Mbit/s
SONET OC-48	Fiber	32256	Digital	2.4 Gbit/s

Table I. Evolution of Carrier Systems [2].

The first commercial T1 digital carrier system was introduced in the Bell System in 1962. Digital transmission systems provide several advantages including:

- higher capacity and lower cost,
- higher quality voice transmission, and
- enabling of transport of data communications.

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Digital carrier systems at the DS3 rate or higher require coax, digital radio, or optical fiber as a transmission medium. Initial optical fiber systems used proprietary optical signal formats; however, since divestiture, an optical transmission signal format called SONET has been standardized internationally in the CCITT [3, 4, 5] and nationally in ANSI [6, 7]. Some SONET multiplexer products are now available and are currently undergoing evaluation in BellSouth field trials. Fig. 1 illustrates the evolution from analog to digital carrier systems in BellSouth.

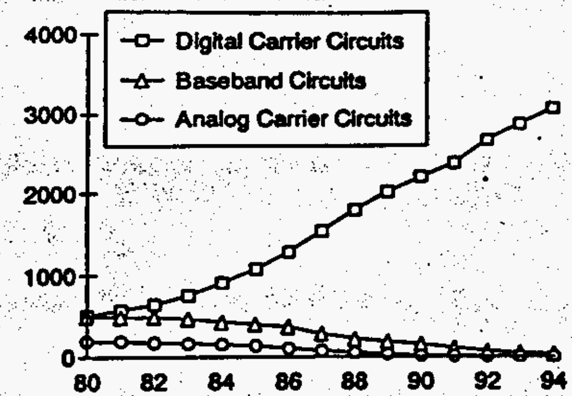


Fig. 1. Evolution of BellSouth Carrier Systems [1].

B-1.2. Digital Switching

The step-by-step, crossbar, and early SPC (1ESS, 1AESS, 2ESS, 2BESS, 3ESS, and RSS) switches used analog switching techniques. The AT&T 4ESS, introduced for toll switching in 1976, contained a digital time-slot interchange (TSI)/time-multiplexed switch (TMS). Analog trunks that terminated on the 4ESS were converted to a digital format for switching. However, digital trunks did not require conversion, thus providing an efficient termination that reduced the overall cost of transmission and switching, as shown in Fig. 1.

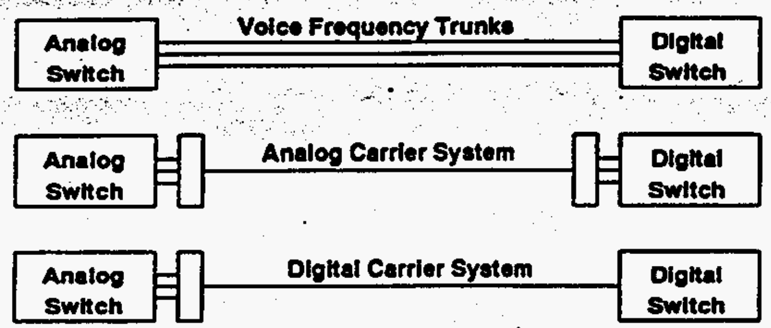


Fig. 1. Synergies of Digital Carrier Systems and Digital Switching Systems.

The NTI DMS-10 switch, first installed in 1981, was a digital time-division switching system designed for local offices serving from 200 to 6000 lines. The AT&T 5ESS, first introduced in 1982, was a digital time-division switching system designed for local offices serving from 1000 to 100,000 lines. Fig. 2 shows the evolution from analog to digital switching systems in BellSouth.

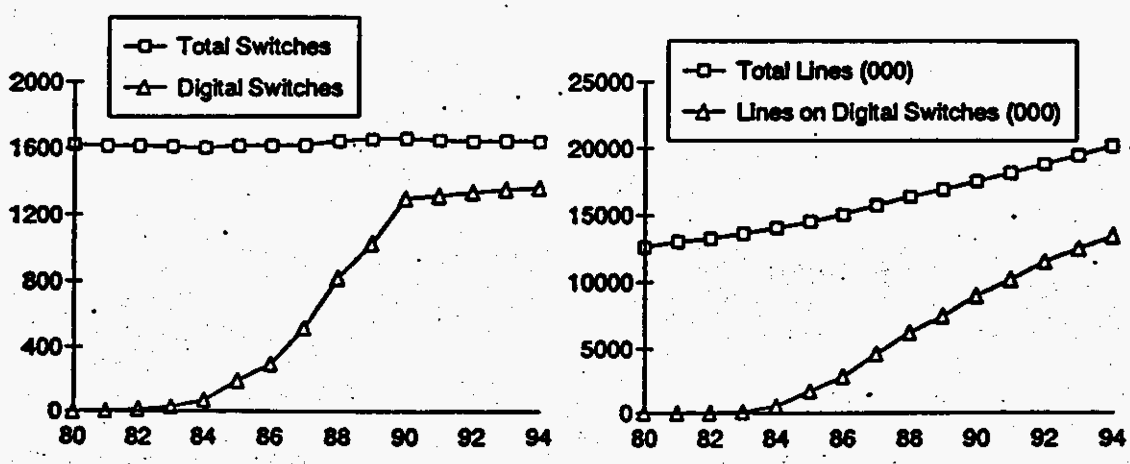
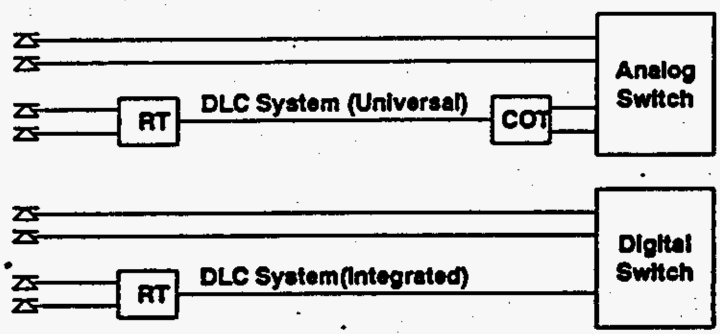


Fig. 2. Evolution of BellSouth Switching Systems [1].

B-1.3. Digital Loop Carrier Systems

The AT&T *SLC*[1]-40 digital loop carrier (DLC) system, introduced in the mid-1970's, used Adaptive Differential Pulse Code Modulation (ADPCM) voice coding to multiplex 40 POTS channels onto a single T1 carrier line. The AT&T *SLC*-96 DLC system, introduced in the late 1970's, while making less efficient use of bandwidth by multiplexing only 96 POTS channels onto four T1 carrier lines, was compatible with the PCM voice coding used in digital switches and interoffice carrier systems. A Central Office Terminal (COT), as illustrated in Fig. 2, was required to connect a DLC system to an analog switch in a configuration referred to as Universal DLC (UDLC). However, since the voice coding of the *SLC*-96 is compatible with that of a digital switch, its T1 carrier line can be connected directly to a digital switch in a configuration referred to as Integrated DLC (IDLC) [8]. This provides additional synergies between digital switches and digital loop carrier systems.



DLC: Digital Loop Carrier
RT: Remote Terminal
COT: Central Office Terminal

Fig. 2. Synergies of Digital Loop Carrier Systems and Digital Switches.

B-1.4. ISDN

ISDN is the next evolutionary step in providing end-to-end digital connectivity. The idea of an integrated all-digital network was first proposed to the CCITT in 1972 [9]. By the early 1980s, the last remaining network component to digitize was the local loop, and by 1984, the first technical standards for implementing ISDN had been ratified.

[1] Trademark of Western Electric Co.

B-1.5. ISDN Architecture

Basic Rate Interface (BRI) ISDN, shown in Fig. 3, is analogous to the telephone loop currently in use. However, it provides the equivalent of 144 kbit/s bandwidth instead of a single 3 kHz analog audio channel. BRI provides two B-channels and one D-channel in a configuration commonly referred to as 2B+D. A B-channel is a 64 kbit/s bidirectional information channel that can carry any digital information such as digitized voice or data. A D-channel is a 16 kbit/s packet channel that can carry low-speed packet data, feature activation information, and "out-of-band" signaling messages for controlling the B-channels. This "out-of-band" signaling capability is analogous to that provided by CCS7 within the network, and enables new revenue-producing services.

Primary Rate Interface (PRI) ISDN carries 23B+D channels over a digital 1.5 Mbit/s facility, and it is designed to meet the network access needs of a PBX or main-frame computer. The PRI D-channel differs from the BRI D-channel in that it has a data rate of 64 kbit/s, but it does not support data service.

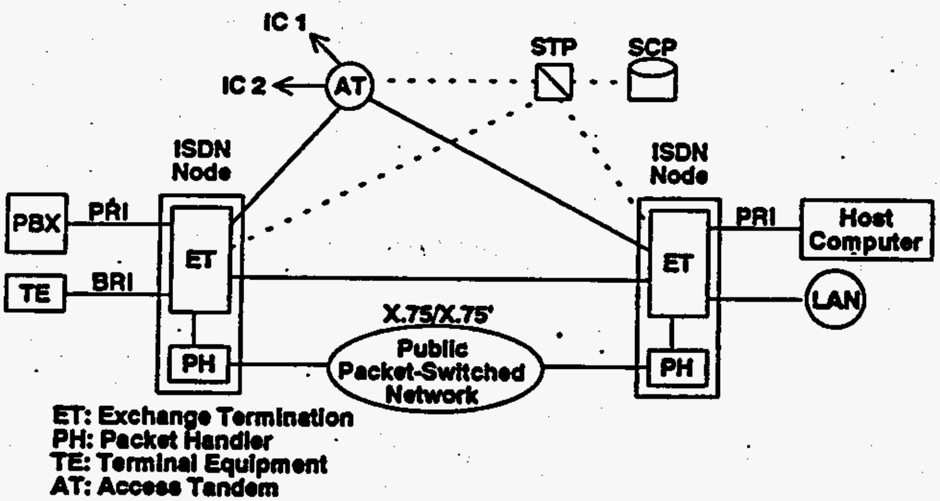


Fig. 3. ISDN Architecture.

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B-1.6. ISDN Status

In addition to the international Recommendations promulgated by the CCITT, Bellcore and the regional BOCs have also been developing standards and requirements for ISDN in the United States network; these are summarized in Table II.

		Bellcore TRs	ANSI Standards	CCITT Rec.
Network Layer	Common Supplementary Service Signaling	TR 847 TR 861	ANSI T1.610	Q.932
	Packet Mode Call Control	TR 301	ANSI T1.608 X3.100	X.25
	Circuit Mode Call Control	TR 268	ANSI T1.607	Q.931
Data Link Layer	PRI/BRI Circuit Mode	TR 793	ANSI T1.602	Q.920, Q.921
	BRI Packet Mode	TR 301	X3.100	X.25
Physical Layer (S/T/U interface)	Primary Rate Interface (PRI)	TR 754	ANSI T1.408	I.431
	Basic Rate Interface (BRI)	TR 393 TR 397	ANSI T1.601 (U) ANSI T1.605 (S/T)	I.430

Table II. ISDN Recommendations, Standards, and Requirements.

BellSouth began to deploy vendor-specific ISDN on a very limited basis in 1988, but intentionally sought to limit ISDN deployment until standard ISDN products were available before beginning volume deployment. The regional companies agreed that a phased development would be the most realistic approach, and they agreed on a set of capabilities to be included in the initial phase, entitled Phase 1.1 ISDN. In early 1988, Bellcore began developing the Technical Requirements necessary for the switch vendors to provide the first phase of ISDN, and by 1989, the Technical Requirements for Phase 1.1 ISDN were complete and available to the switch vendors.

In late 1989, AT&T and NTI announced that they would deliver products in full compliance with the Phase 1.1 TRs by year-end 1991. However, by May, 1990, both vendors indicated that they would not be able to deliver Phase 1.1 ISDN in the agreed-upon time-frame.

In light of the vendor non-compliance, a national task force, with representation from Bellcore and all of the regional companies, was established to assess the near-term viability of ISDN. The task force analyzed the capabilities defined in Phase 1.1 from a target market perspective to determine what subset of the Phase 1.1 capabilities was necessary to make ISDN attractive to various market segments. In February, 1991, Bellcore issued a Special Report entitled "National ISDN-1" [10], which specified a set of features for 1991-92 availability that is expected to be attractive to the initial set of customers, primarily large businesses. The goals have not changed; all the regional companies still want full vendor compliance with Phase 1.1 TRs. However, the reality is that Phase 1.1 ISDN, initially intended to be the first phase in standardized ISDN, will itself have to be achieved in phases.

In the second quarter of 1991, BellSouth began tariffing basic rate ISDN service, provided in conjunction with ESSX service.

B-2. 1992 Events

B-2.1. National ISDN-1

Both NTI and AT&T have committed to provide the capabilities described in the National ISDN-1 (NI-1) document in the first half of 1992. NI-1 is the first step toward service uniformity, which is important because of the high cost of enlarging the embedded base of pre-standard ISDN CPE and network arrangements. Service uniformity will lead to lower cost ISDN CPE and network services, which will, in turn, make ISDN more appealing to the mass market.

NI-1 recognizes the fact that it will be necessary to continue with some vendor-specific arrangements for a while. However, our initial target market, large business ESSX, will be the least affected by the absence of total service uniformity.

B-2.2. Lower Cost and More Capable CPE

Low cost CPE is key to mass acceptance of ISDN. To promote volume production of ISDN CPE, Bellcore and the regional companies have issued a guideline document for CPE vendors, which examines the NI-1 call control and supplementary services for circuit-mode and packet-mode calls from the terminal's perspective. Terminals that comply with these guidelines are expected to be portable, i.e., be able to function on multiple vendor switches that comply with the NI-1 capabilities. In 1992, CPE terminals designed to follow these guidelines should begin to appear in greater volumes and at lower costs, thus increasing the demand for ISDN.

The CPE guidelines also include recommendations for the support of future capabilities like display-based softkeys. Because of the stable NI-1 platform, CPE manufacturers will be encouraged to continue to build additional capabilities into ISDN CPE, such as the ability to do low-cost desktop video conferencing and image transfer. These new applications could further spur the demand for ISDN.

B-2.3. Primary Rate ISDN

BellSouth plans to tariff PRI ISDN in late 1991, and volume deployment should begin in 1992. Standards development for PRI is lagging behind that of BRI; however, because of the nature of the service and its intended market, lack of standardization for PRI should not be as significant. BellSouth's PRI tariff will be aimed at providing network access for PBXs and mainframe computers.

B-2.4. Single Line Business ISDN

BellSouth plans to offer BRI ISDN to single line (non-ESSX) customers in 1992. Several technical issues must be resolved before ISDN becomes attractive to the residential market. However, many single line business customers are expected to be interested in purchasing ISDN before those problems are totally resolved.

B-3. 1993 Events

B-3.1. National ISDN-2

The national ISDN Planning Group has formed a NI-2 Steering Committee to determine which features and capabilities should be included in the next phase of ISDN enhancements following NI-1. The switch vendors have indicated that their work program for NI-2 is already set. NI-2 will build on NI-1 capabilities and will provide a) additional uniformity of customer interfaces and services, b) improved data capabilities, c) improved billing, and d) improved PRI capabilities.

The increased standardization brought about by compliance with NI-2 will help decrease the cost of ISDN and increase the portability of ISDN CPE, thus making ISDN more attractive to the residence market.

B-3.2. Single Line Residence ISDN

Several issues that make ISDN less-than-desirable to the residence market should be resolved by 1993.

- **Terminal Powering:** Presently, ISDN CPE is powered from a customer-provided power source (typically AC commercial power). Unless customer provided power backup is available, the ISDN CPE will not function during a commercial power outage.
- **Extension Capability:** Typically, only one ISDN terminal is allowed to control a B-channel during a call. Therefore, traditional extension service, common to residence service, is not available with ISDN.
- **Premises Wiring:** Some residential premises wiring is probably not suitable for ISDN service, and determining whether ISDN will work with a residential customer's premises wiring may be time consuming. If it is not acceptable, significant rewiring may be required.
- **CPE Terminal Portability:** The relative expense of ISDN CPE and the mobility of residential customers make it important that the CPE will function on multiple central office switch types. If CPE is not portable, the customer may have to replace it to move to a new residence supported by a different type of switch.
- **Interworking with Existing Services:** ISDN CPE must be able to interwork with existing services, such as *TOUCHSTAR*, to be attractive to many customers.

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B-3.3. Increased OS Support

Many of the OSs necessary for the automatic provisioning and maintaining of ISDN service will not be available until 1993. Until these systems are available, many ISDN functions will have to be performed manually. Availability of the ISDN OSs will help decrease the cost of ISDN and may also add some customer network management capabilities that will enhance the sales of ISDN.

B-4. 1994-95 Events

B-4.1. National ISDN-3

NI-1 and NI-2 deal primarily with the voice capabilities of ISDN; NI-3 will focus more on the data capabilities. Increased data functionality will help move the demand for ISDN beyond those users who are only seeking access integration and make it attractive to users with new data applications.

The direction of NI-3 is to provide the following:

- Additional uniformity in customer interfaces and services
- Additional PRI capabilities and services
- Additional data capabilities
- Support of AIN services and capabilities.

B-5. 1997+ Events

B-5.1. Increased Acceptance of ISDN vs. POTS

ISDN will continue to receive wider acceptance from both business and residential customers in the latter half of the 1990s. The Single Line Service ISDN BRA forecast of BellSouth Telecommunications Marketing Analysis and Planning is shown in Fig. 4.

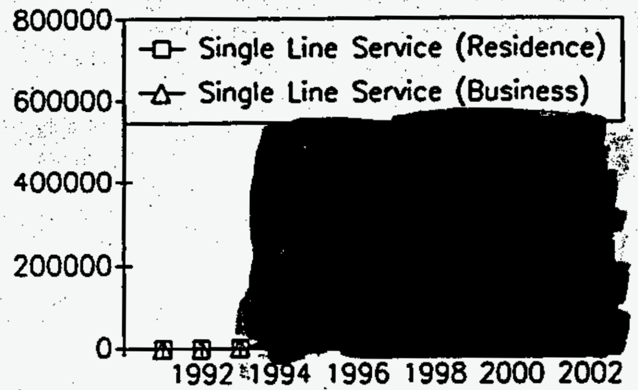

Fig. 4. ISDN Single Line Service Forecast.

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B-6. Critical ISDN Issues

- OAM&P

  Necessary operations, maintenance, administration, and provisioning interactions must be established on an inter-company basis.

- Terminal Powering

  CPE backup powering issues must be resolved to allow ISDN CPE to function during a commercial power outage.

- Extension Capability

  The capability to allow extension ISDN terminals to control a B-channel during a call is needed to provide the extension capability common in residential POTS service.

- Premises Wiring

  Issues related to the suitability of residential customer premises wiring for ISDN need to be resolved.

- CPE Portability

  CPE must be able to function on multiple central office switch types; otherwise customers may have to replace their CPE to move to a new residence supported by a different type of switch.

- Interworking with Existing Services

- Extension of Application Base (e.g. multimedia)

- Carrier Interworking with End-to-End InterLATA ISDN Capabilities

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C-1. Background

C-1.1. Switch Processor Evolution

The call control logic of step-by-step switches was distributed over the electromechanical switching elements, which were directly controlled on a progressive basis by the customer's dial pulses; since each digit controlled only one stage of switching, alternate routing was not possible. The call control logic of crossbar switches was centralized in an electromechanical marker frame; this centralization allowed alternate routing, which increased the efficiency of the network. The 1ESS introduced an electronic Central Processor Unit (CPU), which executed call control logic contained in program stores; this allowed new features to be added simply by changing the generic program software.

As new features were added to Stored Program Control (SPC) switching machines, greater demands were placed on the CPU. The DMS-100 and 5ESS coped with these increased demands by introducing microprocessors, working cooperatively, throughout the switch to distribute the call control logic [1]. While this architecture increased the call processing capacity, it still retained the possibility for processing capacity bottlenecks, i.e., a processor in one part of the switch may be idle, while another processor is overloaded.

In 1987, the DMS SuperNode architecture introduced a high speed processor bus, which provided communications among the DMS-core processor, application processors, peripheral modules and I/O devices. This allowed processors to be added as required to handle the increased processing demands. Most switch vendors either have multiprocessor architectures now, or are moving in that direction. Descriptions of the call processing architectures and evolution plans of the AT&T 5ESS, Ericsson AXE, Fujitsu FETEX-150, NEC NEAX 61E, NTI DMS SuperNode, and Siemens EWSD are contained in a separate BellSouth document [2].

C-1.2. Evolution to AIN

Intelligent Network (IN) concepts are based on the capability of CO switches to exchange data with an external database in a device called a Service Control Point (SCP) and to affect the processing of calls based on the contents of that database.

The service-specific logic for IN/1, first deployed in 1986 for 800 service, resided in the switch software, thus making service implementations dependent on new switching system software generic releases. SCPs based on IN/1 were developed and deployed. The Call Management Services Data Base (CMSDB) and Line Information Data Base (LIDB) applications currently execute on these SCPs.

In 1986, Bellcore released a plan for the second generation of the Intelligent Network (IN/2) [3]; however, an analysis revealed that IN/2 would not be achievable in the 1991 time-frame as required. In 1988, Bellcore described a subset of IN/2, called IN/1+ [4], but availability of IN/1+ capabilities by 1991 was also questionable. Vendor unwillingness to commit to 1991 availability, coupled with delays at Bellcore, pushed [redacted] In mid-1988, Bellcore recombined the IN/1+ and IN/2 concepts into a single concept called the Advanced Intelligent Network (AIN) with phased releases of switch software planned as follows:

[redacted]

As these releases were planned, the availability shifted at least two years, resulting in a need for the regions to define an AIN "Release 0", based on Bellcore's TR-402, which was issued in November, 1987, to define a public-network-based method of providing private network features [5].

[redacted]

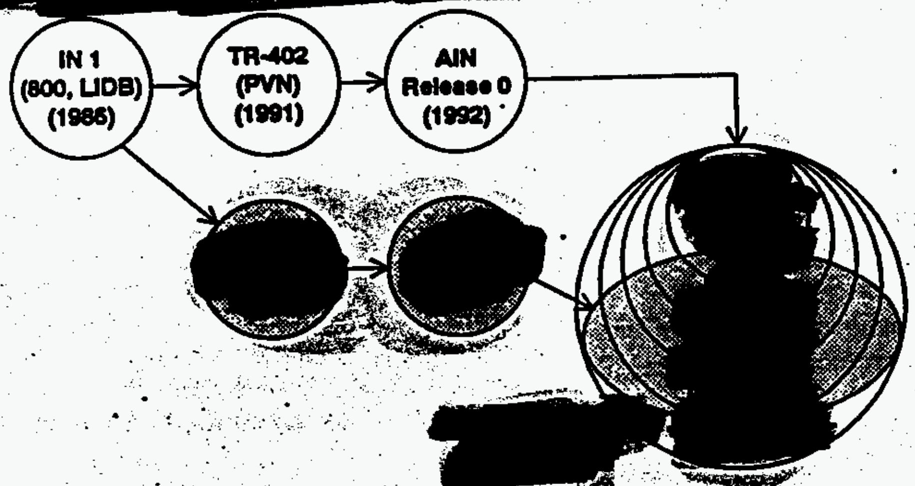

Fig. 1. Probable Evolution Path for AIN.

C-1.3. AIN Architecture

The AIN architecture relies heavily on the CCS7 network to provide communications among the various AIN network elements. The relationship between these elements is illustrated in Fig. 2.

- **Service Switching Point (SSP):** An SSP is a CO switch that is equipped with the software that allows it to communicate with an SCP using the AIN protocol. This allows the CO switch to suspend the processing of a call, query an SCP for instructions, and respond to a set of instructions that the SCP may return (e.g. route a call to a specified telephone number).

- **Service Control Point (SCP):** An SCP performs centralized routing and database access services for AIN. The SCP is comprised of a fault tolerant computer and a set of communications hardware and software that allow it to connect to the CCS7 network. In Release 0, the SCP can only get involved in the call prior to the completion of call routing.

- **Signal Transfer Point (STP):** An STP is a CCS7 packet switch whose sole responsibility is to route SS7 messages between two switches or between a switch and an SCP.

- [redacted]

- **Service Management System (SMS):** An SMS is a new AIN-specific OS. It includes operations functions to maintain services, initiate and control customer SCP data involving these services, and collect and report information on the usage of the services.

- **Software Development Environment (SDE):** The SDE comprises the [redacted]

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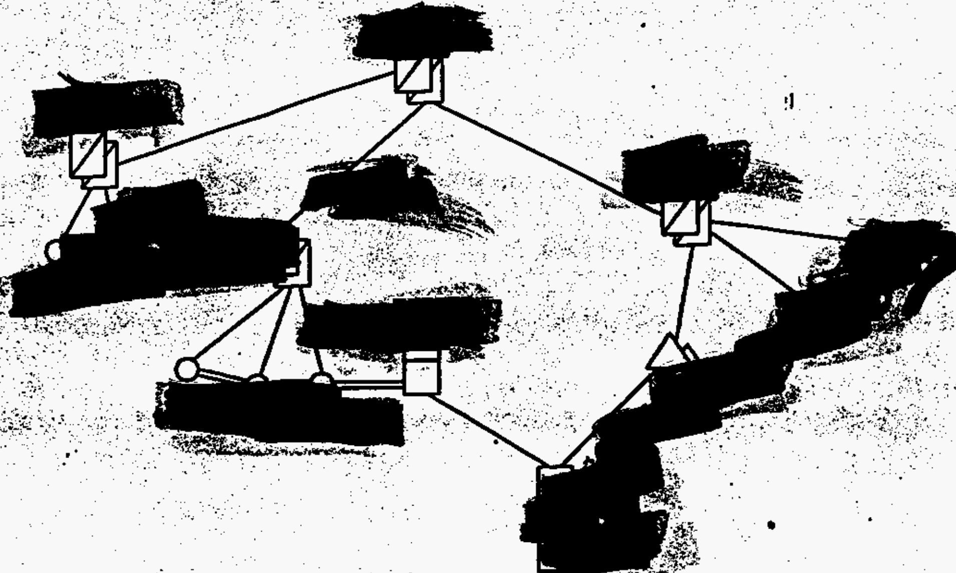

[redacted]

Fig. 2. AIN Architecture.

The SDE and the [redacted] provide a set of tools that allow the distribution of the service creation and modification process. The layering of the [redacted] is shown in Fig. 3. The decision graph tools from the SDE provide one layer of service creation and modification capability. [redacted]

The initial tools will be made available to the provisioning and maintenance organizations. [redacted]

Fig. 3. [redacted]

C-1.4. AIN Status

[redacted]

SCP: BellSouth issued a combined STP/SCP RFP in 1989, and several responses were reviewed; however, no SCP proposal was acceptable. BellSouth issued another SCP RFP in June, 1990, that did not require an integrated STP/SCP. The AT&T SCP was selected in August, and a [redacted]ontract with AT&T was completed in December, 1990. [redacted]

SSP: BellSouth released requirements for Release 0 [6, 7] based on the TR-402 paradigm in August, 1990. AT&T plans to comply with these requirements in generic 5E6.1 (December, 1991), and NTI plans to comply in generic BCS35 (April, 1992).

[redacted] The compliance date for NTI is unknown at present.

SMS: BellSouth agreed in principle in 1988 that Information Systems would develop software for the SMS, while S&T would develop software for network elements. High-level requirements for the SMS were completed in April, 1990, [redacted]. An RFP for the SMS was issued in December, 1990, and a vendor was selected in April, 1991, to develop specifications for the SMS. These specifications are due to be completed in [redacted]

SDE: The architecture for the SDE is shown in Fig. 4. Three levels of programming will be used in the SDE. The software layering in the [redacted] is illustrated in Fig. 3.

- **Decision Graphs:** Decision graphs provide the highest level of programming, but the least scope and flexibility. Decision graphs are applicable to routing logic and feature customization.
- [redacted]
- [redacted]

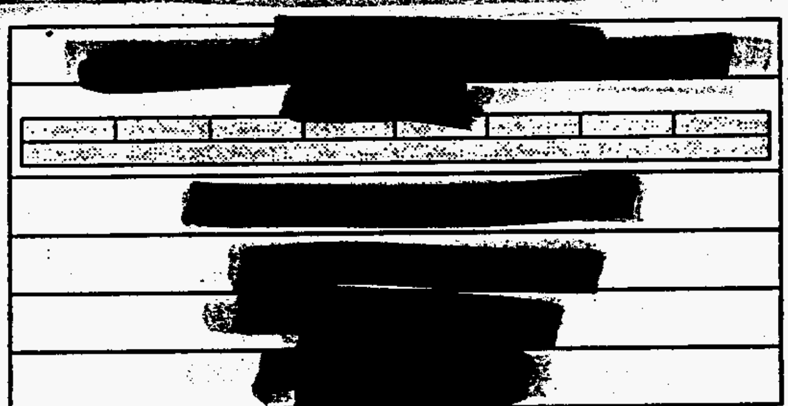

Fig. 4. Software Development Environment (SDE) Architecture.

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C-2. 1991 Events

C-2.1. Specification and Development of Initial AIN Services

The AIN objectives for 1991 and 1992 are listed below:

- [redacted]
- [redacted]
- Develop Calling Name Delivery service for 1993 deployment and [redacted]

The initial service development will be consistent with the following longer term goals:

- Prepare and position BellSouth to deliver many AIN services rapidly in the future.
- Enhance the software development environment to provide productivity and usability for ATDC and to make it available to other BellSouth users and BellSouth customers.

Calling Name Delivery (CNAM) is similar to Calling Number Delivery; however, the network delivers the name rather than the number of the calling party. The name of the caller is expected to be more valuable to the customer receiving the call than the number. In addition, it avoids some legal questions that have arisen with Calling Number Delivery, since the call can only be returned if the customer has the calling party's number. Calling Name Delivery promises to be a mass market service that will be attractive to residential customers as much as to business customers.

[redacted]

AIN architecture documents [11, 12] and the AIN Operations Technical Plan [13] were completed in July 1991. AIN Planning Guidelines [14] were issued in April 1990. These guidelines are scheduled to be updated in 1991. Table I lists several other potential AIN services for the future; these will be evaluated and prioritized based on the expected revenues and the cost of development.

[redacted]

Table I. Potential Future AIN Services.

C-3. 1992 Events

C-3.1. First SCP Service Using Release 0 Capabilities

Tariffs will be filed for the first SCP service making use of Release 0 capabilities in all nine BellSouth states in 1992. That service, Calling Name Delivery (CNAM), will allow a customer to receive the name of the calling party.

[redacted] Access Point (NAP) software, which supports only originating triggers, is planned for all 1AESS switches.

C-3.2. Early SMS Supporting Operations

[redacted]

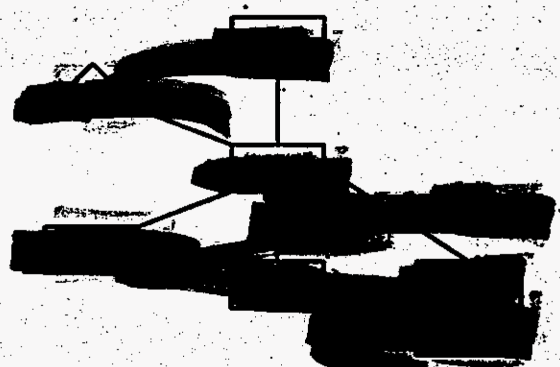

Fig. 5. AIN Service Management System (SMS).

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C-4. 1993 Events

C-4.1. First AIN Release 0.1 Service

[redacted]

C-4.2. First ASPIN Applications

[redacted]

This service is primarily designed to allow a customer to register so that calls can be routed to the registered locations. Thus, it is primarily a call routing capability. Registration is performed by the customer accessing the [redacted] and telling the [redacted] where to route the calls in order to reach the customer. Screening is performed via call announcer and what has been termed VMS Monitoring. Call Announcer uses a database lookup to determine the calling party's name and announces it to the customer. [redacted]

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[redacted]ill ensure routing to the proper voice mailbox, which may be MemoryCall or other voice mail offering. The voice mail feature should provide a message waiting indicator.

An example of an [redacted]pplication is [redacted] Calls to a customer's [redacted] are answered by a [redacted] The [redacted]ay screen the incoming call based on the calling number and then may route the call to an announcement, to a voice messaging service, to a temporary number provided by the customer [redacted]N may attempt to locate the customer. The location process might involve either simultaneous or sequential placement of calls to the customer's home, office, or mobile telephone. If one of the locations answers, the [redacted]

C-5. 1994 Events

C-5.1. First AIN Release 0.2 Service

[redacted]

An example of a [redacted] Upon receipt of an incoming call for a [redacted] would send a query over an ISDN D-channel to its local switch. The switch would convert the ISDN message to an SS7 TCAP query and place it on the SS7 network. An SCP containing a reverse white pages directory would convert the calling number to a [redacted]

C-5.2. Increased OS Support

Much still needs to be learned about the OS support that will be required for AIN. [redacted]

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C-6. 1996 Events

C-6.1. AIN Control of B-ISDN Services

[redacted]

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C-7. Critical AIN Issues

- **BellSouth Culture Change**

  To be successful in AIN, a culture change is needed to orient BellSouth more towards invention rather than reaction, and more towards creative problem solving rather than following pre-defined procedures.

- **Service Prioritization Process**

  Agreement is needed on an efficient and timely process for prioritizing the development of AIN services. This prioritization should take into account not only the projected revenues for a service, but also the relative time and cost of developing it.

- **Operations Procedures/Architecture**

  New operations procedures need to be developed to support distributed services control.

- **Service Management Capabilities**

  The development and deployment of service management capabilities will be critical to the success of AIN.

- **Industry Agreement on "Marketable and Maintainable" AIN Feature Set**

  Some level of industry agreement on the AIN feature set will be necessary for vendors to develop SSP software that can be used across multiple regions, while still allowing each region to develop software to offer services customized for that region.

- **Service Deployment Process**

  The entire process for developing new services, including filtering through raw ideas, market research, software development, and integration must continue to be optimized.

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D-1. Customers' Needs and Expectations are Changing

D-1.1. Business Customers

The data communications rates of business customers have exploded over the past 20 years. In 1970, a 0.11 kbit/s Model 33 teletypewriter was a typical terminal, but by 1980, a 0.3 kbit/s teletypewriter or a 1.2 kbit/s terminal was more common, and IBM 3270 terminals and IBM SNA networks were coming into widespread use.

Today, high-performance personal computers and workstations have become ubiquitous, many of which connect to LANs operating from 10 Mbit/s Ethernet rates up to 100 Mbit/s FDDI rates in order to communicate with each other and with file servers. Business customers would like to migrate from proprietary communications networks such as IBM's SNA and DEC's DECNET to industry standard communications networks such as ISO OSI. As customer applications move from a centralized to a distributed environment, TCP/IP and UNIX are becoming more popular than IBM's SNA.

Communications rates are expected to continue to increase. Hitachi has already introduced a 622 Mbit/s LAN product based on ATM cells in Japan to support future multimedia communications, and both Sun Microsystems and Apple Computer have joined a consortium planning B-ISDN interfaces for their computers for multimedia communications. As software tools are developed that allow more user-friendly communications involving integrated voice, data, video, and image information, the need for high-speed interpremises communications is expected to increase.

In 1964, AT&T introduced *PICTUREPHONE*[1] visual telephone service, which was highly unsuccessful due to insufficient voice and picture quality, the need for extreme lighting conditions, the low penetration of customers, and the high price of the service [1]. In 1975, AT&T introduced *PICTUREPHONE* meeting service (PMS), which required that customers either travel to expensive conference rooms or install an expensive conference room on their premises.

Although both *PICTUREPHONE* and PMS were unsuccessful because they did not adequately meet the customers' needs, the demand for video communications by business customers continues to be reaffirmed. Several large companies have installed private video communications facilities. [redacted]

[1] Registered Service mark of AT&T.

The communication needs of business customers are currently provided primarily by private network solutions; computer vendors dominate this market, and the business customers only lease private line transport from the telcos.

The 1982 Institute for the Future (IFTF) study [2] found that the item causing the most difficulty to communications and computer users was that systems were not integrated with each other. The three most valuable potential benefits that users expect from new communications systems are:

- better access to information resources,
- better information dissemination within the company, and
- integration of communications and computing capabilities.

This study shows that customers are not really satisfied with the communications that they currently obtain. This represents an opportunity for BellSouth to offer future services that will better satisfy their needs. For example, the capabilities provided by future workstations from Apple, Sun, and others are likely to stimulate the demand for multimedia communications to the desktop.

D-1.2. Residential Customers

Residential customers are demanding more freedom of choice in video entertainment, evidenced by the increasing number of channels demanded on cable television systems and the large numbers of rentals of video cassettes. As a result, cable television companies are now using optical fiber in their backbones to increase the capacity of their systems; for example, Time Warner just announced plans to serve 10,000 customers with a 150 channel system that will provide two-way data and voice communications in addition to video.

[redacted]

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BellSouth's optical fiber infrastructure positions it to provide new high-bandwidth services such as switched access television, pay-per-view, and video-on-demand to residential customers. Several value-added services, such as remote learning, encyclopedia look-up, and services similar to Prodigy, may become increasingly important in the future. However, while such services represent a large potential market for BellSouth, entering this market entails significant risks. Large investments will be required to upgrade our switching systems and access networks to support these services. Furthermore, to attract customers, these services must provide either significant added-value or cost reductions over competing networks' services. Success is further complicated by the fact that low-cost service is only possible if high customer volumes can be achieved, an unlikely occurrence in the first several years after offering a new service. Finally, the most significant impediment may be the regulatory aspects.

Regulatory issues continue to be addressed. The National Telecommunications and Information Administration (NTIA) issued a Notice of Inquiry (NOI) into all aspects of the telecommunications infrastructure in early 1990 to assist in the debate on a number of policy issues. For purposes of the inquiry the NTIA favored a broad definition of the term infrastructure to include the wide range of other telecommunications facilities and serving arrangements that can be employed to satisfy users' needs, such as value-added networks, cellular radio systems, paging networks, shared tenant services, metropolitan area networks, teleports, cable television systems and private networks. The NTIA wants to examine the view that, as the U.S. economy becomes more dependent on the provision of services requiring efficient dissemination and distribution of information, the telecommunications infrastructure will be as important to U.S. productivity as the transportation infrastructure was to the industrial economy.

The CATV/telco portion of the NOI included a section on the telco provisioning of video programming and/or video processing services. In a 1988 study, the NTIA suggested that telcos be limited to providing only a "video dial tone" for common carrier transport to others' cable TV programming; however, the NOI suggested that even if LECs are precluded from directly providing video programming, they nonetheless could conceivably offer a range of "video processing" services or capabilities that would afford viewers greater control over the programs they watch. These services, while not providing content, would involve the LECs in manipulating or repackaging content provided by others.

For example, LECs could develop video gateway menus tailored to the viewing preferences of individual customers. Alternatively, customers could program their own viewing preferences so that programs fitting those profiles would appear first on menus, or LECs could program their switches to "learn" customer preferences on the basis of actual viewing patterns. Moreover, viewers could selectively choose portions of a number of programs to watch, and the gateway could sort through the specific programs and deliver the selected segments to the viewer. Debates on these types of policy issues are likely to continue for several years, particularly if these types of services appear to be profitable.

D-2. B-ISDN Infrastructure Building Blocks

D-2.1. Optical Fiber

In the early 80's, BellSouth began placing optical fiber in the interoffice environment to increase the capacity and reduce the cost of interoffice transmission systems. By 1984, BellSouth studies found optical fiber to be economical in the feeder portion of the local loop, and began placing fiber for DLC systems. Significant advances in optical technology over the past decade have resulted in an effort to make economical the extension of optical fiber directly to the customer, or to a small pedestal located very near the customer [5].

The vast bandwidth capacity of optical fiber far exceeds the bandwidth required to carry voice communications. Thus, optical fiber is an enabling technology that positions BellSouth to offer future services, such as data, video, and image communications, which require much higher bandwidths than voice services.

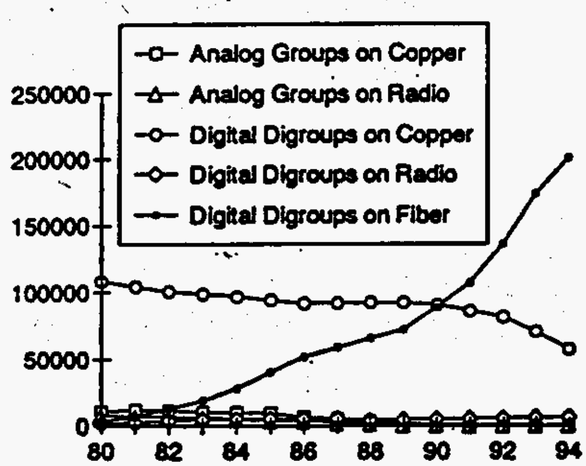

Fig. 1. Optical Fiber in BellSouth's Interoffice Network.

An economic study of Fiber-in-the-Loop (FITL) local access systems [6] was completed in March, 1989, and an RFQ for Fiber-to-the-Home (FTTH) systems was issued in April 1989. Responses to this RFQ indicated that FTTH systems were not affordable. The RFQ also specified a single Fiber-to-the-Curb (FTTC) cost target for systems of four-living-unit pedestals, and several responses approached this target. As a result, BellSouth's direction shifted from FTTH to four-living-unit FTTC deployments, and Bellcore activities were focused in that direction as well.

Several fiber in the loop trials are now underway in BellSouth, as shown in Table I, to enable us to gain experience and validate the assumptions used in our economic studies of architecture and product alternatives.

Project	Technology	Type Trial	Services	Lines in Service	Ultimate Homes	Service Date	Fibers Per ONU
Hunter's Creek I Orlando, FL	FTTH, AT&T	Concept	Sw. Dig. Video	215	250	11/86	2
Hunter's Creek II Orlando, FL	FTTH, AT&T	Tech. Eval.	POTS	116	117	8/89	1
Hunter's Creek III Orlando, FL	FTTC, AT&T	Tech. Eval.	POTS		83	3/91	2
Heathrow Orlando, FL	FTTH, NTI	Concept	POTS, ISDN, Sw. Dig. Video	90	256	6/88 11/88 7/89	2
Coco Plum Miami, FL	FTTH, AT&T	FOA	POTS	17	200	8/89	1
The Landings Savannah, GA	FTTH, AT&T	Tech. Eval.	POTS	10	216	9/89	1
Riverhill I Marietta, GA	FTTC, Raynet	Tech. Eval.	POTS	24	19	12/90	>1
Riverhill II Marietta, GA	FTTC, Raynet	Tech. Eval.	POTS		169	11/91	2
Governor's Island Asheville, NC	FTTH, AT&T	FOA	POTS	2	42	9/89	1
Morrowcroft Charlotte, NC	FTTH, AT&T	FOA	POTS	5	126	1/90	1
Lakeview Terrace Charleston, SC	FTTH, AT&T	FOA	POTS	2	85	4/90	1
The Summit Columbia, SC	FTTH, AT&T	Tech. Eval.	POTS	15	285	6/90	1
Dunes West Charleston, SC	FTTC, R-TEC	FOA	POTS		150	6/91	4
Springhurst Louisville, KY	FTTC, R-TEC	Tech. Eval.	POTS	16	64	1/91	4
Council Fire Chattanooga, TN	FTTC, BBT	Tech. Eval.	POTS	1	163	6/91	2
Grove of Riveredge Memphis, TN	FTTH, AT&T	Concept	POTS	90	99	11/88	1

Table I. BellSouth Fiber-in-the-Loop Trials.

FITL video deployment assumes that fiber is being placed on a cost parity with copper for POTS. Even under this assumption, a video transport service offer by an RBOC is difficult because of the fully-allocated costs requirements imposed by the FCC, which does not allow incremental pricing.

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BellSouth has proposed numerous FITL transport systems that include the following technologies:

- AM and digital video transport over fiber to a node,
- AM broadcast video transport over fiber to a pedestal, and
- switched digital video transport over fiber to a pedestal.

The first FITL video trials used switched digital technology to transport CATV signals from a CATV service provider's location to the customer. The early trials proved the feasibility of a switched digital video fiber-to-the-home system. However, the costs associated with these early systems were orders of magnitude higher than the costs associated with the AM coaxial transport systems used by the CATV industry. Since no new services were being offered over the switched digital system, it was difficult to justify the significantly higher cost.

The CATV industry, faced with the realization that an alternative method of transport was possible and that fiber offers a superior broadband transport medium, has begun a dedicated effort to find ways to justify the use of fiber in the CATV network. After initial trials with digital video, the CATV industry decided to pursue AM fiber transport because of the potentially low component and network cost. The CATV industry has now successfully developed AM fiber transport technology and is presently deploying fiber star architectures to replace coaxial tree-and-branch networks that have in the past been the characteristic CATV network architecture.

Since the primary customer for telco fiber transport was the CATV operator and the only significant service was CATV entertainment video, it appeared that telco early entry into broadband transport would be successful only if it could accommodate AM analog fiber video. As a result, telco FITL efforts shifted from a switched digital direction to an analog fiber transport service to accommodate the existing potential customer and existing predominant service. Unfortunately, FITL proved more costly than the equivalent hybrid fiber/coax networks of the CATV industry, and this cost combined with regulatory pricing and CATV concerns over competition have not resulted in significant success for telco analog AM fiber transport. In addition, telco analog AM fiber transport does not offer functional or performance advantages over the equivalent network that can be provided by the CATV industry.

In recent months, switched digital video has reappeared primarily due to the significant advances being made in digital video compression. The capabilities offered by low-bit-rate, high-performance video delivered over a broadband medium such as fiber, satellite broadcast, or coax, has created new revenue possibilities that could make a switched digital video system feasible. Major consumer electronics manufacturers are planning to build digital interfaces into next-generation television sets, making set-top converter boxes unnecessary with digital transport and new digital televisions. These possibilities have generated significant interest in switched digital video networks by a number of players, such as the satellite broadcast industry, the CATV industry, the telcos, and the video entertainment industry. This renewed interest in digital video and the limited [redacted]

[redacted]

The initial consensus of the study group seems to be that a switched digital video approach, which will support multiple services and service providers, is the proper path for the RBOCs. An RBOC analog AM broadcast transport service does not provide added value over an existing CATV service, does not easily provide for multiple services or service providers, and does not offer sufficient revenue potential from simple broadcast transport to justify today's FITL cost of an analog broadcast system. The final report from the study group is scheduled to be complete by the end of 1991. This "video services" report will be used by the FITL architecture group to write the video network requirements to be included in TA-909.

[redacted]is effort involves applying recent market research data and system technology, architectures, and cost to determine the most feasible residential broadband services to purs[redacted] In addition, by the time such a "catch-up" system is developed and ubiquitously deployed, other industries will have developed and deployed switched systems with greater performance and functional capability.[redacted] A final report from the residential broadband services study team is scheduled to be completed in 1991.

PROPRIETARY

D-2.1.1. Issue Fiber in the Loop RFP (1991)

An RFP for Fiber in the Loop (FITL) equipment, based primarily on Bellcore's TA-909 [7], was issued in June, 1991, to provide the vendor community with BellSouth's view of architecture and product directions. It is expected that some vendors may meet the cost targets provided in this RFP, and that two to three vendors may be approved for general deployment where economical [8].

The FITL architecture alternatives are shown in Fig. 2. The star architecture dedicates a fiber from the Host Digital Terminal (HDT) to each Optical Network Unit (ONU). The Passive Optical Network (PON) architecture uses passive splitters to split the optical signal over multiple ONUs.

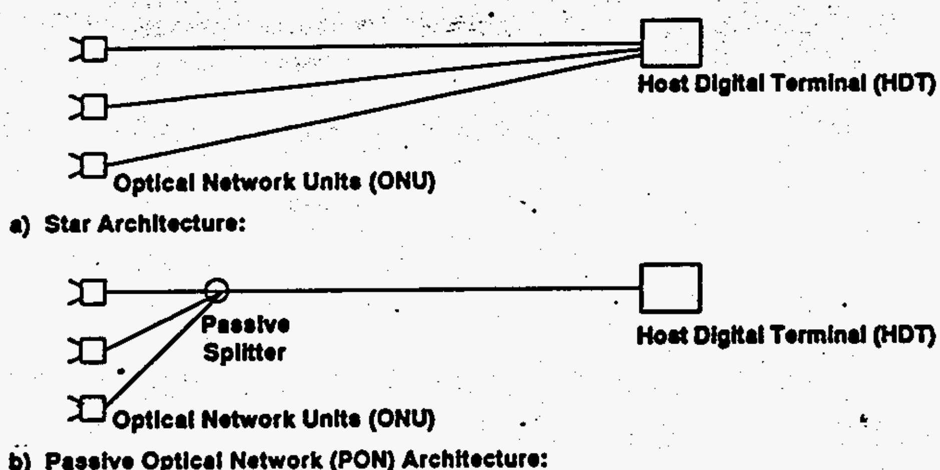

Fig. 2. Fiber in the Loop Architectures.

One issue is the number of fibers to be placed to each ONU. Two fibers can be placed, one for transmit and one for receive, or a single fiber can be placed, using directional couplers to separate the transmit and receive directions. The single fiber alternative may provide the optimal solution for BellSouth, since the cabling savings are expected to more than offset the increased cost of the vendors' electronics. Both alternatives are expected to be upgradeable to provide broadband services. Another issue is the number of living units to be served by an ONU. TA-909 specifies four living units as the maximum number of living units served by an ONU. However, greater sharing may be more economical, at least in the near term. The number of fibers dedicated to each ONU, and the number of living units served from each ONU, must be weighed against the cost and timing of future upgrades.

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D-2.2. SONET

Optical transmission systems have been used in BellSouth since the early 80's. However, since no standards existed for optical transmission systems, each vendor developed equipment with proprietary interfaces. This made optical interconnection of these systems impossible, and it required the use of separate Fiber Optic Terminals (FOT) for connecting digital equipment to optical fiber. The need for standard optical interfaces was recognized in the early 80's, and work began on a standard called the Synchronous Optical NETwork (SONET). A substantial set of CCITT Recommendations[2] [9, 10, 11], ANSI Standards [12, 13], and Bellcore Technical Advisories/Requirements [14, 15, 16, 17, 18] have been issued, and SONET multiplexer products are now becoming available. Fig. 3 illustrates the simplifications and economies resulting from the integration of SONET interfaces into add/drop multiplexers.

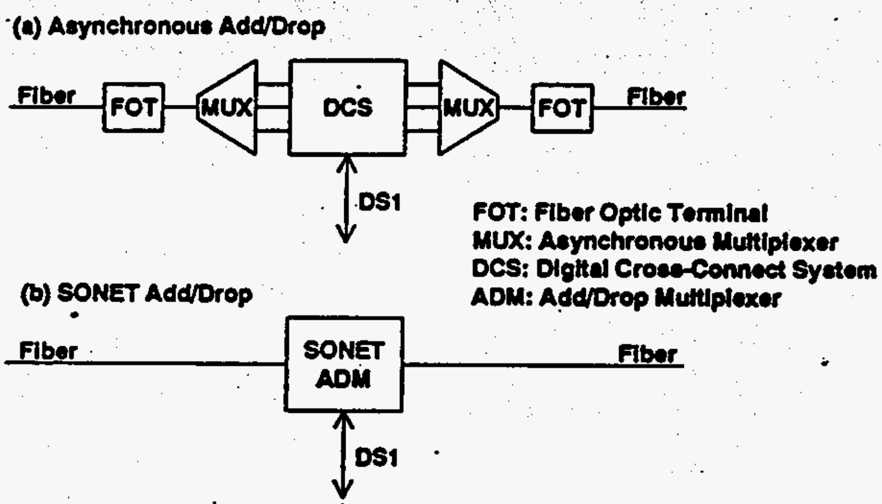

Fig. 3. Simplification and Economy of SONET for Add/Drop.

SONET was designed to be not only an optical transmission standard, but also a multiplexing standard, which supports existing multiplexing hierarchies. SONET rates are multiples of the fundamental rate of 51.84 Mbit/s, which is called STS-1 or OC-1[3]. The most important multiples are expected to be the OC-3 (155.52 Mbit/s), OC-12 (622.08 Mbit/s), and OC-48 (2.4 Gbit/s). Each STS-1 container can carry a single DS-3 signal, or 28 DS-1 signals carried as Virtual Tributaries (VT). SONET also supports other multiplexing hierarchies, such as the CEPT hierarchy used in Europe.

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[2] SONET is referred to as the Synchronous Digital Hierarchy (SDH) internationally.

[3] The Synchronous Transport Signal (STS) is the signal format for the Optical Carrier (OC).

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In December, 1990, BellSouth issued a planning Recommendation Letter for SONET multiplexers [19], which recommended SONET for use in all transport relief projects planned for 1992 or beyond wherever it is economically equivalent to asynchronous alternatives.

When the standardization of B-ISDN began in 1986, the U.S. advocated, and obtained international agreement on, the use of SONET for the B-ISDN physical layer. Thus, SONET deployment beginning in 1992 will form the underlying transmission infrastructure for B-ISDN, resulting in a smooth evolution to B-ISDN in the mid-90's [20].

D-2.2.1. Product Evaluation Trials (1991)

Currently, only fiber optic systems using proprietary transmission protocols are on the BellSouth Approved Products List. However, commercial SONET products from several vendors are now undergoing product evaluations. The lab evaluation of AT&T's DDM-2000 multiplexer is now in progress, and a unit has been installed in Memphis. The lab evaluation of Fujitsu's FLM-150 multiplexer is complete, and a unit has been installed in Alpharetta. The lab evaluation of NTI's OC-48 Transport Node is complete, and a unit has been installed in Gainesville.

The expected availability of SONET equipment is shown in Table II, and the expected date of SONET automation is shown in Table III.

Product	Availability
[redacted]	

Table II. Expected Availability of SONET Equipment.

Application	[redacted]	[redacted]	[redacted]
[redacted]			

Table III. Expected Availability of SONET Automation.

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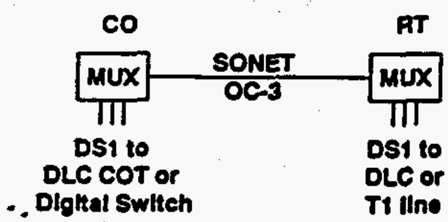
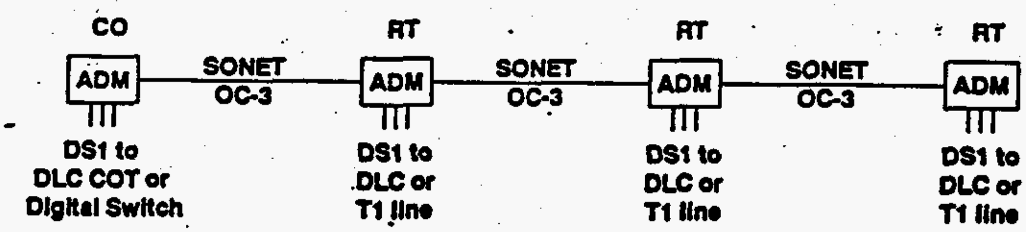
D-2.2.2. SONET Deployment in Interoffice and Feeder (1992)

All transport relief projects planned for 1992 and beyond should evaluate new SONET alternatives using the prices and planning assumptions contained in the SONET Multiplexer Planning Recommendations [19]. Initial SONET deployments are expected to be primarily driven by growth requirements, with only very limited replacement of existing asynchronous equipment during the early deployment stages.

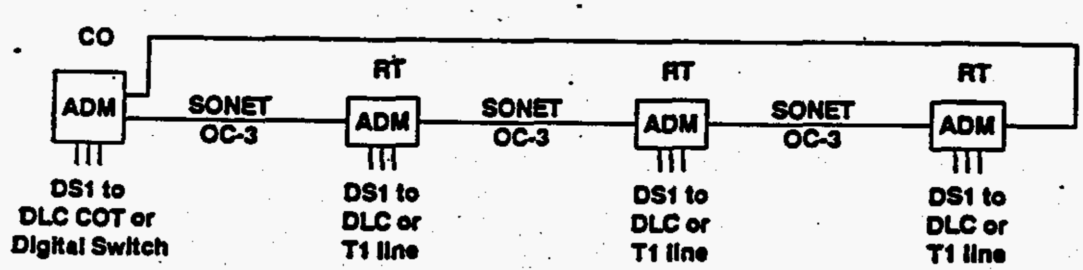
In the loop, OC-3 systems are expected to predominate, with point-to-point systems initially, followed by add/drop multiplexer (ADM) chains, and finally by ADM rings, as shown in Fig. 4. The unidirectional self-healing ring (USHR) architecture (Fig. 5) is expected to be more applicable in the loop than the bidirectional self-healing ring (BSHR) architecture (Fig. 6); since all traffic in the loop converges on the CO, no significant survivability or cost advantages result from the increased complexity of BSHR. Generally, multiple OC-3 systems are expected to be more economical than OC-12 systems in the loop.



(a) Point-to-point configuration



(b) Linear add/drop chain configuration



(c) Add/drop ring configuration

Fig. 4. Evolution of SONET architectures in the loop.

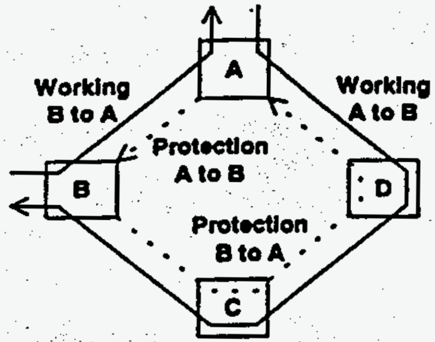


Fig. 5. Unidirectional Self-Healing Ring (USHR) configuration.

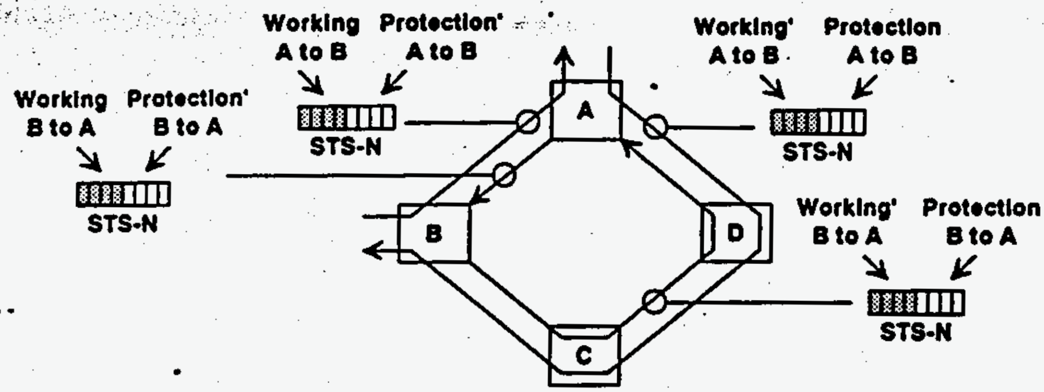


Fig. 6. Bidirectional Self-Healing Ring (BSHR) configuration.

In interoffice applications, the USHR configuration will be preferred over non-standard BSHR, except in cases where the capacity benefits of non-standard bidirectional rings can justify the risk of increased complexity due to their proprietary nature. However, recent progress has been made on standards for bidirectional rings, and it is probable that a thorough bidirectional ring algorithm will be established as a standard in late 1991 or early 1992. [redacted]

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D-3. Early-Availability Wideband and Broadband Services

Without a position in the marketplace, BellSouth cannot expect to be the future provider of choice for switched high-bandwidth services. BellSouth's participation in market trials of pre-B-ISDN services in the 1991 - 92 time-frame, while planning for migration to a future B-ISDN platform, is essential to our success. SMDS, Switched DS1, and Frame Relay are three early-availability services that could allow BellSouth to capture the emerging demand while positioning the corporation for the future.

SMDS:

Switched Multi-megabit Data Service (SMDS) is a 1.5 Mbit/s to 45 Mbit/s connectionless data service designed to serve applications such as LAN interconnection. SMDS uses the IEEE 802.6 cell structure, which has been closely aligned with the ATM cell structure to allow a smooth evolution to B-ISDN.

Frame Relay:

Frame Relay is a 64 kbit/s to 1.5 Mbit/s connection-oriented data service designed to provide traffic aggregation and switching capabilities for terminal-to-host and LAN interconnection applications. Frame Relay is based on the X.25 LAPD standard, so it is relatively easy for CPE and switch vendors to add Frame Relay interfaces to existing equipment.

Switched DS1:

Switched DS1 gives customers the ability to place 1.5 Mbit/s calls to other customers on a real-time basis for applications such as video conferencing. Switched DS1 requires that existing digital cross-connect systems and narrowband switches be enhanced, but allows customers to use existing CPE. Switched Fractional DS1 service may also become important; this allows a customer to place calls with a bandwidth of n x 64 kbit/s to other customers on a real-time basis.

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D-3.1. SMDS

Between 1989 and 1991, Bellcore released several Technical Advisories on SMDS, a high speed connectionless data service for B-ISDN [21, 22, 23, 24, 25, 26, 27, 28]. The requirements for the SMDS Subscriber Network Interface (SNI), Interexchange Carrier Interface (ICI), OAM&P, Operations Systems, and billing are fairly mature. SMDS is planned for initial deployment on a stand-alone MAN platform, based on the IEEE 802.6 standard; however, the 802.6 and ATM cell structures have been closely aligned to facilitate the migration of this service to a B-ISDN platform. Vendors including AT&T, NEC, Siemens, cisco Systems, Sun Microsystems, and Hewlett Packard (HP), Alcatel, and Wellfleet have demonstrated interoperability and some products are now becoming available.

D-3.1.1. Internal Service Trials on MAN Platforms (1991)

BellSouth has been working actively with other regions to demonstrate SMDS to generate interest from switching and CPE vendors, ICs, and customers. In October, 1990, a nationwide SMDS network involving BellSouth, Pacific Bell, Southwestern Bell, NYNEX, AT&T, Sun, cisco, and HP was demonstrated at INTEROP '90 in San Jose, California. In March, 1991, SMDS was also demonstrated at the AT&T Executive Conference on Data Networking in Jacksonville and at SUPERCOMM '91 in Houston.

[redacted] these trials, the team will determine how well the service supports the application, whether the service is indeed transparent to the end user, and analyze the economics of SMDS. [redacted] will determine how the service will be offered, what methods and procedures are needed to implement the service, and how the service will be supported.

[redacted] the AT&T Datakit™ II, which has an 8 Mbit/s internal backplane bus, and the prototype AT&T BNS-2000, which has a 200 Mbit/s internal backplane bus. [redacted]

Fig. 7. Science and Technology [redacted]

[redacted] which is split between Atlanta and Birmingham. This organization often conducts studies that require transferring large [redacted] between locations and accessing information stored in [redacted] including one in Nashville. Currently, company mail and shared 128 kbit/s data links are used for data communications between Atlanta and Birmingham, so many of the file transfers take hours and can only be done during restricted times because of the high traffic load. The SMDS capabilities were ideal for interconnecting the PCs, [redacted] workstations, and minicomputers serving the 310 users. T [redacted] after six months, when t [redacted]

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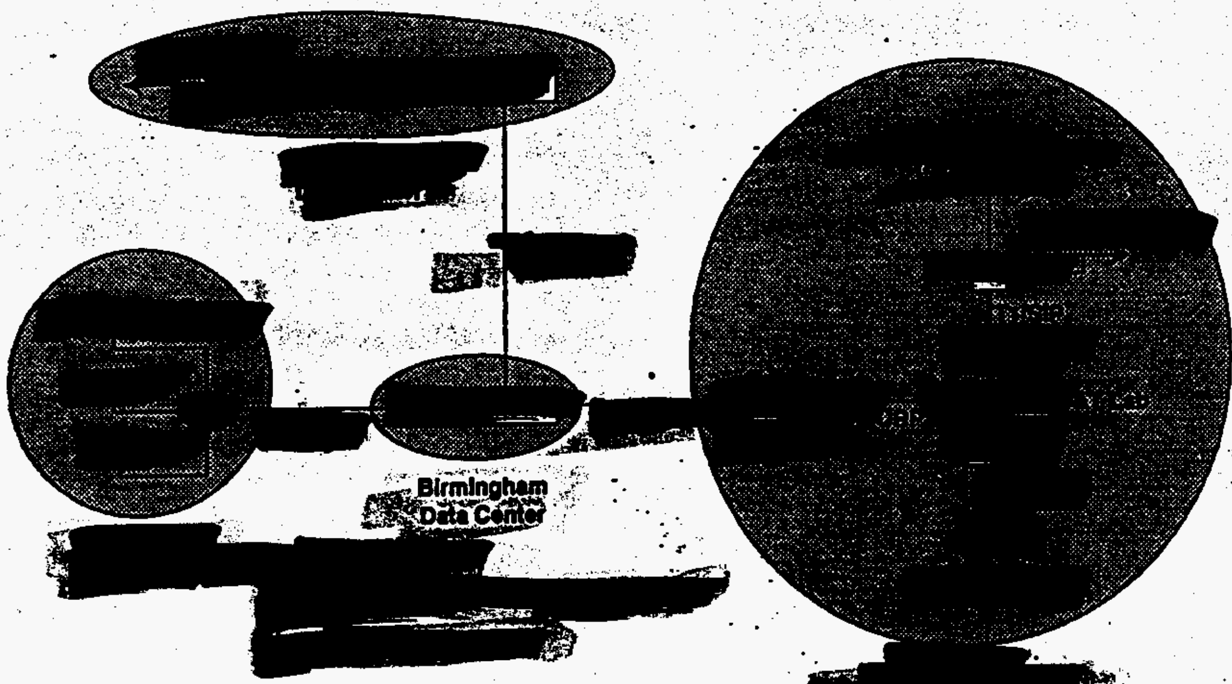

Fig. 8. [redacted]

An RFP for SMDS is scheduled to be issued in 1991. Responses to this RFP will provide additional information about the cost and availability of SMDS switching systems to be used in the SMDS business case, planning letter, and market trial proposal, all planned for completion in 1991.

If SMDS proves to be reliable and cost-effective, more applications will be added, spanning a larger geographical area. [redacted]

[redacted]

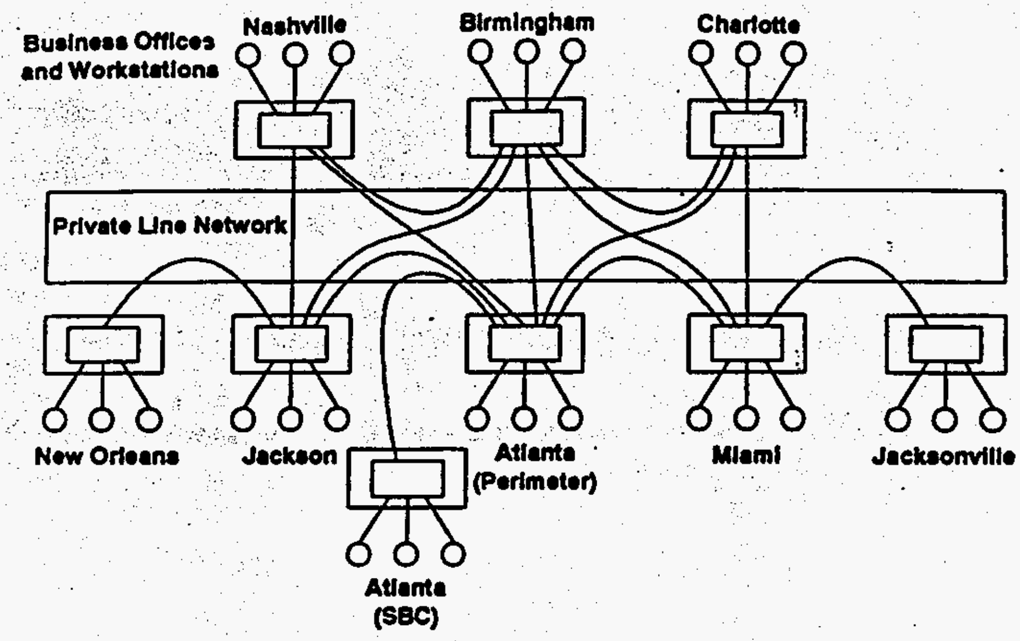

Fig. 9. Current architecture based on private lines.

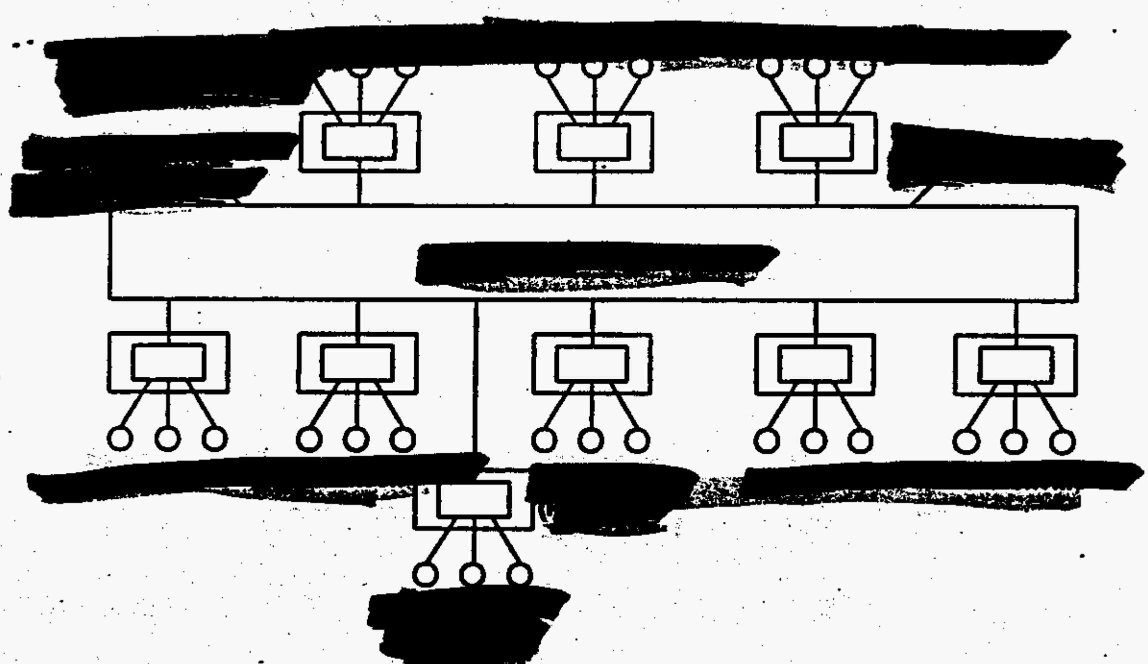

Fig. 1[redacted]

D-3.1.2. Market Trials on MAN Platforms (1992)

Assuming a successful outcome of internal SMDS trials in 1991, [redacted] again using MAN platforms for SMDS switching systems in the architecture shown in Fig. 11. Marketing trials will allow the testing of some of the facets of SMDS that are not addressed in concept or internal customer trials including the following:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

In addition, development will also take place in the following areas:

- [redacted]
- [redacted]
- [redacted]

A marketing trial provides a key type of valuable market research: direct, external customer feedback that can be used to fine-tune a BellSouth service offering prior to general tariff and deployment. The marketing trial will help to determine customer acceptance of existing SMDS capabilities and provide direction for further feature development.

Additionally, a marketing trial will continue BellSouth efforts to promote SMDS to the industry, including CPE and switch vendors, ICs, application developers, and the end customers. Since a marketing trial is usually conducted with larger customers, it will also help to promote public high-speed data networking as a viable networking alternative for other large customers in our region.

[redacted]

Fig. 11. Architecture for early-availability SMDS market trials.

D-3.2. Switched DS1

In today's telecommunication network, switched access for customers is typically restricted to services using less than 64 kbit/s of bandwidth. Public Switched DS1 service will give customers the ability to establish calls with other customers at the DS1 rate on a real-time basis. Switched DS1 is a constant-bit-rate connection-oriented service, and it is therefore appropriate for applications that have a longer holding time, relatively constant bandwidth requirements, and stringent delay requirements.

Video and workstation teleconferencing is likely to be the largest early application for Switched DS1. Currently there are several services that can be used for video conferencing, some of which are moderately successful, but none of them offer dialable real-time call setup. Another potential application is disaster recovery; a large user may choose to use Switched DS1 to temporarily replace failed links in a private line network. Other secondary applications might include high speed data transfer, LAN interconnection, and new versions of Customer Control Management (CCM) services.

Switched DS1 allows the customer to establish a digital call at 1.5 Mbit/s in real-time. Initially, the signaling will be provided over an associated POTS line, as shown in Fig. 12. The architecture provides compatibility with existing CPE, such as video codecs, and requires no additional equipment on the customer's premises other than a POTS telephone. The customer uses the POTS telephone to dial a special access code, such as "*T1", followed by the destination phone number. When the call is connected, the users may place the telephones on hook without disconnecting the DS1 call. To disconnect the DS1 call, one of the users goes off-hook and dials a termination code, such as "*T2". When the telephone is not being used for control of the Switched DS1 service, it can be used for POTS calls and other services.

Bellcore has issued two Technical Advisories for Switched DS-1 service. One is based on the use of an associated POTS line for control [29], and the other is based on the use of ISDN PRI [30]. The switched DS1 ISDN-based service provides initially for switched 384 kbit/s rates and eventually full n x 64 kbit/s services.

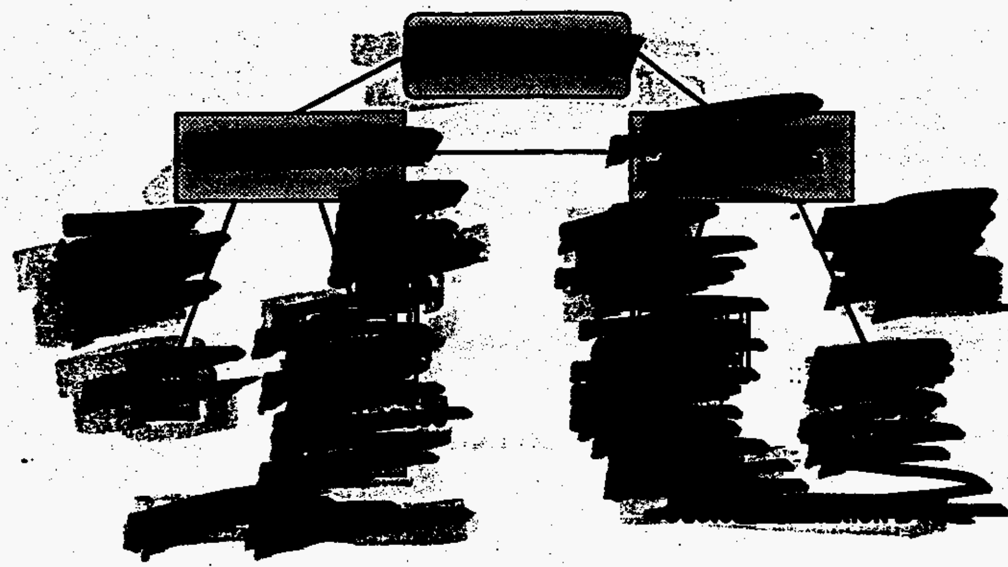

Fig. 12. Architecture for early-availability Switched DS1 market trials.

D-3.2.1. Market Trials (1991)

Given the major switch vendors' plans, [redacted] Both AT&T and NTI plan to support Switched DS1, and also switched fractional DS1, within their long-term switch architectures. AT&T also plans to support early-availability of Switched DS1 by using a digital cross-connect system, which is administered by the end office.

Switched DS1 service could evolve in a phased manner. [redacted] ities, along with switched fractional DS1 capabilities, will also be introduced on ISDN PRI using ISDN signaling.

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- If approached properly, switched DS1 can be positioned as an extension to basic telephony. Because this service uses well-known technologies and closely resembles the POTS model, it should be easier to develop and deploy than other network-intensive services. In addition, switched DS1 capabilities provide a connection-oriented capability, which bridges the gap between the switched data services offered today and the switched services at greater than the DS1 rate that will be offered in the near future. It is becoming clear that customers' communications needs are very heterogeneous and that no single solution will meet all their needs. If BellSouth does not offer a service that handles wideband Constant-Bit-Rate (CBR) applications prior to the widespread availability of B-ISDN in the mid-1990s and beyond, customers will continue to seek solutions outside the public network.

D-3.3. Frame Relay

Frame Relay is a 64 kbit/s to 1.5 Mbit/s connection-oriented data service designed to serve such applications as LAN interconnection. The Permanent Virtual Circuit (PVC) service is similar to a value-added private line. It is appropriate for connections with long holding-time characteristics. The Switched Virtual Channel (SVC) service is setup on a per-call basis similar to conventional circuit switching and it is appropriate for connections with relatively short holding-time characteristics.

Sufficient standards have been completed on the customer network interface for Frame Relay to allow preliminary deployment of a PVC Frame Relay service. Two other standards are in draft form and should become standards during 1991. The major CPE and switch vendors have embraced the initial PVC frame relay standard. Several of these vendors have published a document that outlines enhancements, which go beyond the initial standards and may result in a de facto enhanced frame relay definition.

A single-vendor implementation of PVCs could be accomplished in the 1991 - 92 time-frame, but a multi-vendor PVC implementation is unlikely unless the vendors agree to use one of the proprietary methods available for switch-to-switch connectivity; a proprietary ATM or 802.6 protocol seems to be the front runner for this interface. A
19 single vendor implementation of SVCs is unlikely before [redacted] if SVCs are ever developed.

BellSouth could provide an early-availability PVC Frame Relay service using one of the following alternatives:

- NTI's DPN-100, which currently provides PulseLink service
- NTI's LPP, which is a new attached processor for the DMS SuperNode
- AT&T's BNS-2000, which can also provide SMDS
- StrataCom IPX CPE, interconnected by private lines

There appears to be significant confusion in the marketplace regarding the capabilities available with Frame Relay. Despite the press and vendor hype, it is not clear how other RBOCs, ICs, and CPE vendors plan to achieve a uniform PVC frame relay service, although there is growing interest in resolving the remaining standards issues.

The cost savings and implied added-value to the customer are not evident, because of the unknown cost of the frame relay switching equipment and software, the limitations of our operations and provisioning systems, and the potential for cross-elasticity with
34 existing private line offerings. Current [redacted]
35 Attempts are being made to obtain accurate cost information from vendors for both CPE and switch equipment for frame relay.

D-4. Evolution to B-ISDN

B-ISDN is intended to provide the ability to offer high-bandwidth communications services to end users and to integrate many different broadband and narrowband services over a common transmission/switching platform to avoid the cost of building, operating, and maintaining many different service-specific networks.

D-4.1. Early B-ISDN Research

Early research leading to B-ISDN began at Bell Labs in the early 1980s, where prototypes of self-routing Banyan fast-packet switches with external links of 1.5 Mbit/s were developed for use in early trials in California [31]. Researchers at Bell Labs further extended this fast-packet switching concept by placing a Batcher sorting network ahead of the Banyan routing network to improve the traffic handling characteristics of the switch [32]. Bellcore designed and fabricated VLSI for a Batcher-Banyan switch in 1986; these switching elements were used in the development of the Experimental Research Prototype (ERP) B-ISDN network [33] and in experimental investigations of B-ISDN services [34]. Simultaneously, a research prototype based on a concept called Asynchronous Time Division (ATD) was under development in Europe [35].

Several objectives were common to these research activities:

- Support multiple communications services (voice, video, data, image) over a common switching platform.
- Support a range of communications bandwidths from very low to very high bit rates.
- Support both constant bit rate and variable bit rate services.

D-4.2. B-ISDN Specifications

By 1986, the need for broadband capabilities in ISDN was recognized internationally, and standardization of a B-ISDN User-Network Interface (UNI) and a Network Node Interface (NNI) began in CCITT. The first CCITT Recommendation on B-ISDN [36] was approved in 1988. It recommended a new packet-oriented transfer mode called Asynchronous Transfer Mode (ATM), based on fixed-size cells, as the target transfer mode for B-ISDN. At the June 1989 CCITT meeting, agreement was reached on the structure of the ATM cell and its mapping into the payload of the SONET transmission stream.

In November 1990, the CCITT gave unanimous approval to thirteen CCITT Recommendations on B-ISDN in Matsuyama, Japan [37]. While these Recommendations are far from being a complete specification for B-ISDN, they do cover most of the critical issues required for manufacturers to begin development efforts on a large scale. The CCITT SG XVIII plans to complete a much more comprehensive set of B-ISDN recommendations in 1992.

Work is also proceeding on B-ISDN signaling Recommendations in CCITT SG XI. Agreement was reached in the April 1991 meeting to proceed with signaling Recommendations for CCITT Release 1 B-ISDN services based on extensions to the existing Q.931 access and SS7 network signaling protocols. It is an objective to complete these Recommendations in 1992. Work on a new longer-term signaling protocol called the ISDN Signaling Control Part (ISCP), which is based on the separation of call and connection control, will proceed in parallel; the ISCP protocol may be completed in 1994.

In December 1989, Bellcore issued a Broadband Architecture and Evolution Plan [38], which described a set of steps for evolving the current network to B-ISDN. In December 1990, Bellcore issued two Framework Technical Advisories [39, 40] on B-ISDN switching systems and transport network elements, and two Special Reports [41, 42] one on B-ISDN transfer protocols and one on a network and operations plan. Final Bellcore Technical Requirements on B-ISDN are planned for 1992 - 93, in anticipation of complying commercial products in 1994 - 95.

D-4.3. B-ISDN Product Developments

All major switch vendors, including AT&T, NTI, Siemens, Fujitsu, NEC, Ericsson, and Hitachi, have developed prototype B-ISDN switching systems [43, 44, 45, 46, 47]. The first field trial of a B-ISDN switch was the BERKOM trial in Berlin in 1989 using the Siemens ATM switch [48]. This switch was based on the 5+64 cell structure, as proposed by the United States prior to the international agreement on the 5+48 cell structure in June, 1989. Fujitsu is currently leading in B-ISDN development. They demonstrated a second generation B-ISDN prototype switch at ICC90 in Atlanta, and

31 [redacted] This switch provides full switched capabilities over User-Network Interfaces of 155 and 622 Mbit/s, and it is consistent with the CCITT Recommendations approved in 1990.

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Some switch vendors plan to make commercial B-ISDN switch products available as early as 1993 (NEC, Fujitsu, NTI), others as late as 1996 (Ericsson and AT&T). NTI's ATM switch product will provide Permanent Virtual Connection (PVC) capabilities in late 1993 and can be used as an integrated platform to provide access to SMDS, Frame Relay, and ATM Cell Relay services. NTI plans to add Switched Virtual Connection (SVC) capability later, probably in the 1995 time frame. AT&T plans to extend the life of their DataKit platform (BNS-2000) by incorporating SMDS and Frame Relay interfaces and by increasing the speed of the backplane. They are currently focusing on 802.6 interfaces for the BNS-2000, however we are asking them to explore the possibility of introducing ATM interfaces in 1993 to support an ATM Cell Relay service. They plan to introduce a higher-capacity fabric based on the Eng/Karol architecture in the 1995-96 time frame.

CPE vendors are interested in B-ISDN because of its ability to support multimedia communications. Sun Microsystems and Apple are members of a consortium planning ATM interfaces for their workstations to support multimedia communications. Hitachi already produces a commercial ATM-based LAN product that is available in Japan [49, 50]. Stratacom plans to evolve their Frame Relay products to use a public ATM backbone. Toshiba plans to introduce a premises-based ATM switch in 1992.

D-4.4. BellSouth B-ISDN Planning Efforts

In March, 1990, BellSouth released Phase I of the Broadband Plan [51], which focused on the market, network evolution, and strategic issues associated with the deployment of broadband technology. In December 1990, BellSouth released Issue 2 of the B-ISDN Technical Plan [52], which addressed the technical issues associated with B-ISDN services and applications, network architecture, evolution, performance, signaling, traffic management, and operations.

D-4.5. B-ISDN Architecture

The B-ISDN physical architecture is shown in Fig. 13. The Local Exchange Node (LEN) serves various types of customer interfaces including B-ISDN User-Network Interfaces (UNI), which support a variety of customer services, as well as service-specific interfaces such as SMDS, Frame Relay, and Switched DS1. The LEN provides the ISDN call processing functions needed to establish ATM virtual channels over the B-ISDN UNI.

The Access Node (AN) serves the same types of customer interfaces as the LEN. However, it serves fewer interfaces, thus shortening the length of dedicated fiber required to customers. The AN may provide some call processing functions, but would likely be dependent on a host LEN to provide these functions.

The Remote Multiplexer Node (RMN) serves the same types of customer interfaces as the LEN and the AN, but it serves still fewer interfaces. It may be located at a pedestal serving fewer than a dozen customers to provide concentration and reduce the amount of dedicated fiber required to serve customers. The RMN is equivalent to the Optical Network Unit (ONU) in Fiber in the Loop terminology. Depending on the outcome of regulatory decisions, the RMN may also contain radio equipment used to provide wireless communications services to nearby customers.

The Transit Exchange Node (TEN) provides tandem functions to interconnect LENs. A TEN may or may not provide LEN functions as well.

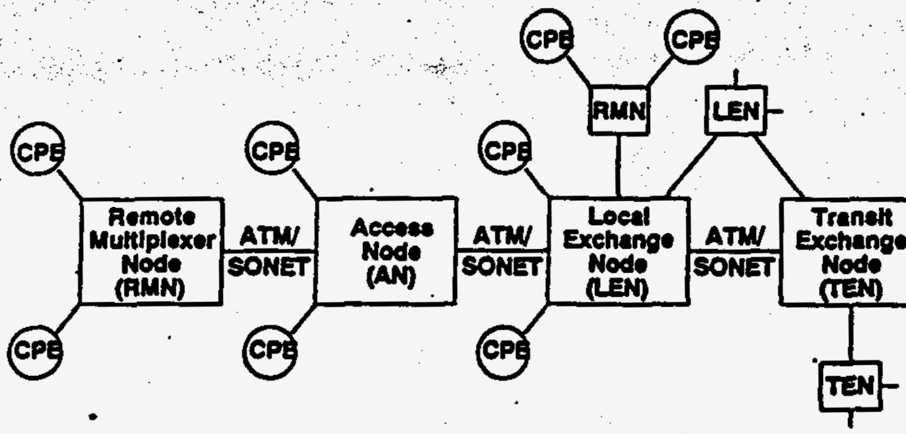

Fig. 13. B-ISDN physical architecture.

The B-ISDN protocol reference model is shown in Fig. 14. SONET provides the underlying transmission infrastructure for B-ISDN. ATM provides the multiplexing and switching to support multiple ATM virtual channels, each with its own specified bandwidth. The ATM Adaptation Layer (AAL) maps individual services, such as SMDS, Frame Relay, DS1, ISDN, etc., into the ATM payload.

SMDS	DS1/3	ISDN	PVC Frame Relay	SVC Frame Relay	PVC Cell Relay	SVC Cell Relay	etc.
ATM Adaptation Layer (AAL)							
ATM Multiplexing and Switching							
SONET Transmission							

Fig. 14. B-ISDN protocol reference model.

D-5. 1991 Events

D-5.1. Research Trial of Pre-Production B-ISDN Switch

In the fourth quarter of 1991, a pre-production version of a Fujitsu FETEX-150 B-ISDN switch will go into service in the VISTAnet testbed [53], which is a jóint project involving the University of North Carolina (UNC), MCNC, GTE, and BellSouth. VISTAnet is one of five national research testbeds organized by the Corporation of National Research Initiatives (CNRI) to advance technology and knowledge in networks operating at rates on the order of a gigabit per second. These testbeds are funded partly by the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA), and partly by private corporations taking part in these projects. Work on these testbeds is expected to contribute significantly to the establishment of the proposed National Research and Education Network (NREN), which is intended to link together government, industry, and higher education communities.

The VISTAnet architecture is shown in Fig. 15. The B-ISDN switch will connect together a Cray Y-MP supercomputer at MCNC, a medical workstation at the UNC Radiation Oncology Lab, and two highly parallel image processing systems at UNC. User-Network Interfaces (UNI) to these sites will be based on OC-12c (622.08 Mbit/s) ATM/SONET access interfaces consistent with the approved 1990 CCITT Recommendations on B-ISDN. The ATM host switch and a broadband remote switch module will be located in the BellSouth central office in Chapel Hill; a second remote ATM switch module will be located in the GTE office in Durham.

A second project referred to as the Medical Information Communications Applications (MICA) will broaden the study of medical applications and allow BellSouth to gain a better understanding of the market applications and opportunities for B-ISDN. The B-ISDN switch of VISTAnet will interconnect an X-ray archive system and high-resolution displays over OC-3c (155.52 Mbit/s) B-ISDN UNIs, allowing a family physician to get expert consultation from a remotely-located radiologist.

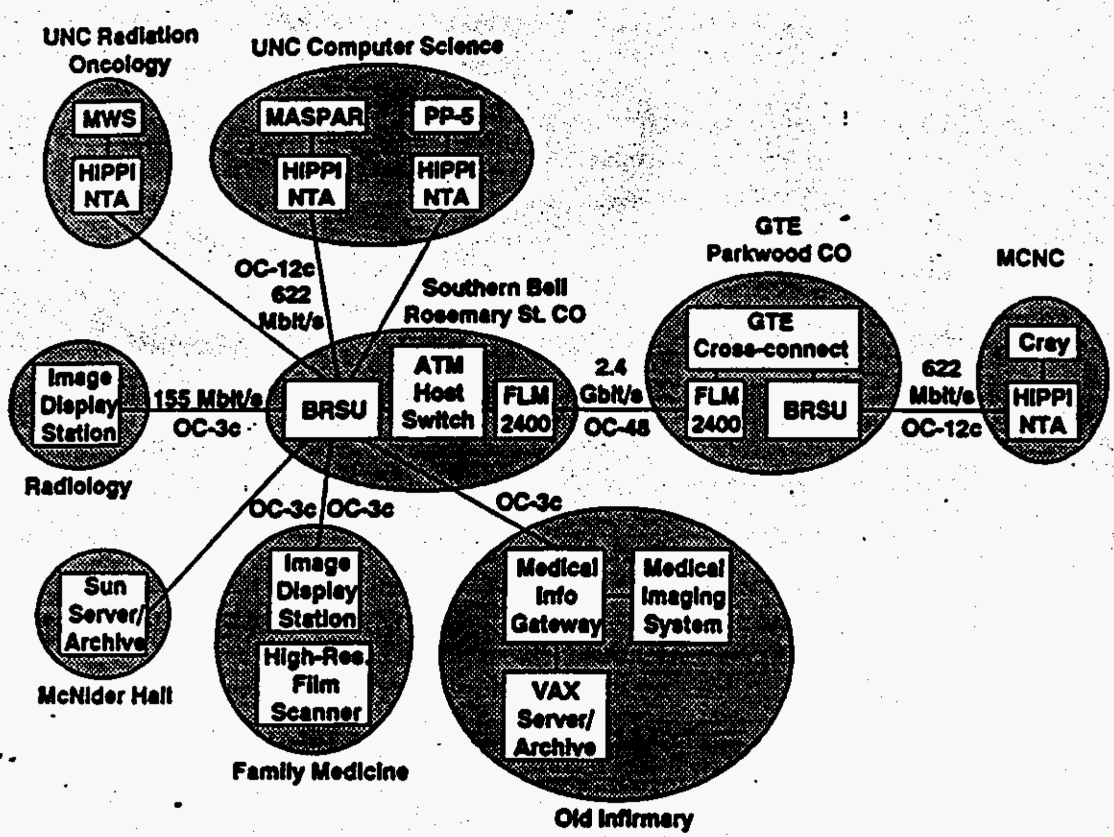

Fig. 15. VISTAnet and MICA B-ISDN Trial Architecture.

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D-6. 1992 Events

D-6.1. CCITT Standards for Initial B-ISDN Services

CCITT Recommendations sufficient for the following Release 1 B-ISDN services are expected to be completed in 1992:

- Provisioned ATM Virtual Path (VP) and Virtual Channel (VC) connection service, including both Constant Bit Rate (CBR) and Variable Bit Rate (VBR) connections.
- Switched ATM VP and VC virtual connection service, including both CBR and VBR connections.
- Connectionless data service (called SMDS in the U.S.).
- Interworking with certain narrowband services.

In order to complete these Recommendations, the following issues are now being given urgent attention:

- ATM issues including Generic Flow Control (GFC) and congestion control.
- ATM adaptation layers for CBR and VBR services.
- DSS1 and SS7 extensions for B-ISDN.

D-7. 1993 Events

D-7.1. ATM for Internal Network Integration of Services

Service-specific networks, as shown in Fig. 16, are sometimes the only alternative in the introduction phase of a new service, but they create costly inefficiencies. For example, separate OSs may be required to support different networks; separate engineering of trunk facilities may result in low trunk utilization; getting-started costs of network elements have to be borne by each individual service; and each service-specific network requires separate training, operations, administration, and maintenance.

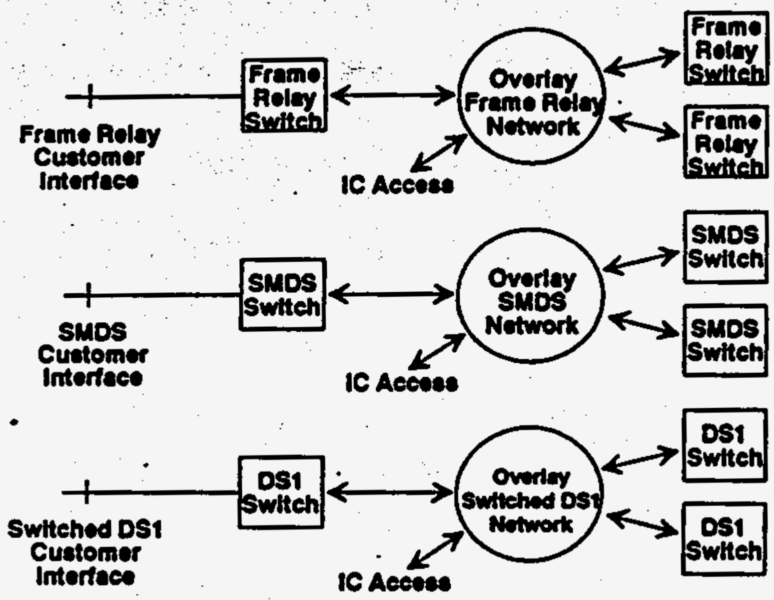

Fig. 16. Service-specific networks.

[redacted] Since ATM is designed to carry multiple services over a common switching platform, it can be used to provide a tandem function for the integrated transport of services, as shown in Fig. 17.

ATM Permanent Virtual Connections (PVC) are sufficient to support the ATM tandem function. ATM switches supporting the PVC capability [redacted] in 1993. [redacted]

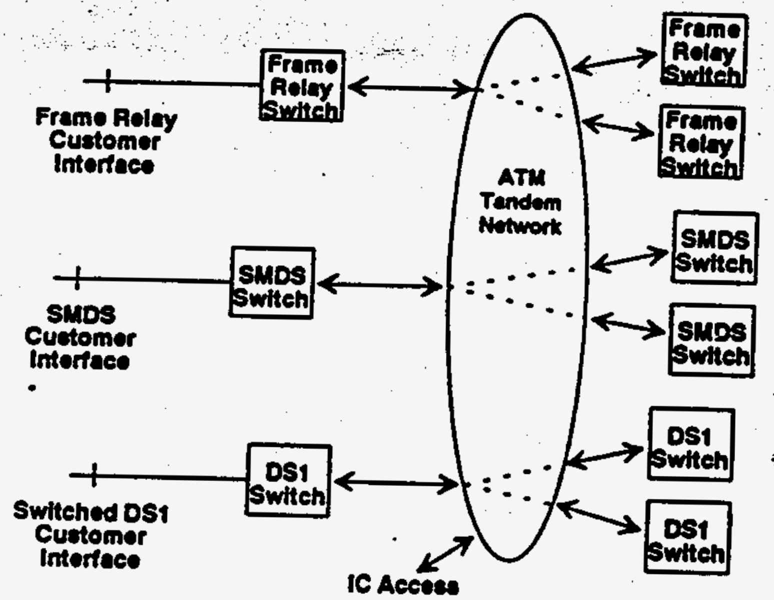

Fig. 17. ATM used for internal network integration.

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Using ATM to integrate the access network, as shown in Fig. 18, can result in further cost reductions. ATM allows flexibility in service provisioning since services can be offered from a common access shelf by plugging in the appropriate type of service interface card. This concept is analogous to the Metallic Facility Terminal concept used in the mid-70's to provide special service circuits from a common shelf of equipment.

Each service-specific access card converts information on the service-specific customer interface to ATM cells. The cells are multiplexed with cells from other access cards and routed to a module that provides higher layer functions. For example, for SMDS, the access card will translate the header of the 802.6-based cells to the ATM format and route the cells to an SMDS server, which will provide the Level 3 functions such as routing, address screening, and source address validation. The similar format of 802.6 and ATM cells simplifies the conversion process.

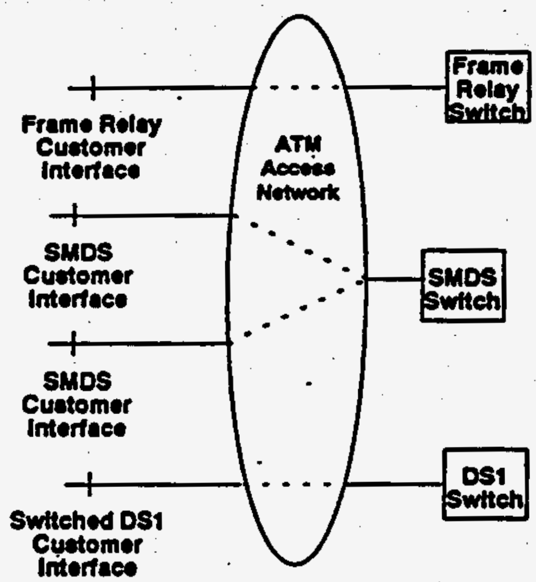

Fig. 18. ATM used for integrated access.

Extended service access through ATM allows the common costs of the access network elements to be shared over multiple services. It also increases the utilization of the transmission interfaces. This makes it economical to offer new services from offices where the services could be economically justified otherwise. For example, the demand for SMDS in the early years will likely be small, so only one or two SMDS switches may be placed within a LATA. Requiring a dedicated DS1 or DS3 facility between the customer and this SMDS switch may increase the cost of the service beyond the user's affordability. On the other hand, if the dedicated facility extends only to an ATM access shelf in the local Central Office, then the SMDS traffic can be multiplexed with other traffic to reduce the access cost.

The advantage of ATM extended access for SMDS is illustrated in Fig. 19. In the upper portion of the figure, the DS3 interfaces of four customers served from a CO are trunked over dedicated DS3s to the CO where the SMDS switch is located. In the lower portion of the figure, the customers' DS3s terminate at the ATM access shelf. Only Level 2 processing is done in the access card, so the cost is small, and the Level 3 processing is done at the SMDS switch. In addition to saving the cost of three DS3 trunks, three SMDS ports on the SMDS switch are also saved. The cost of these ports is significant because they provide all the Level 3 SMDS functions required to process the SMDS packets.

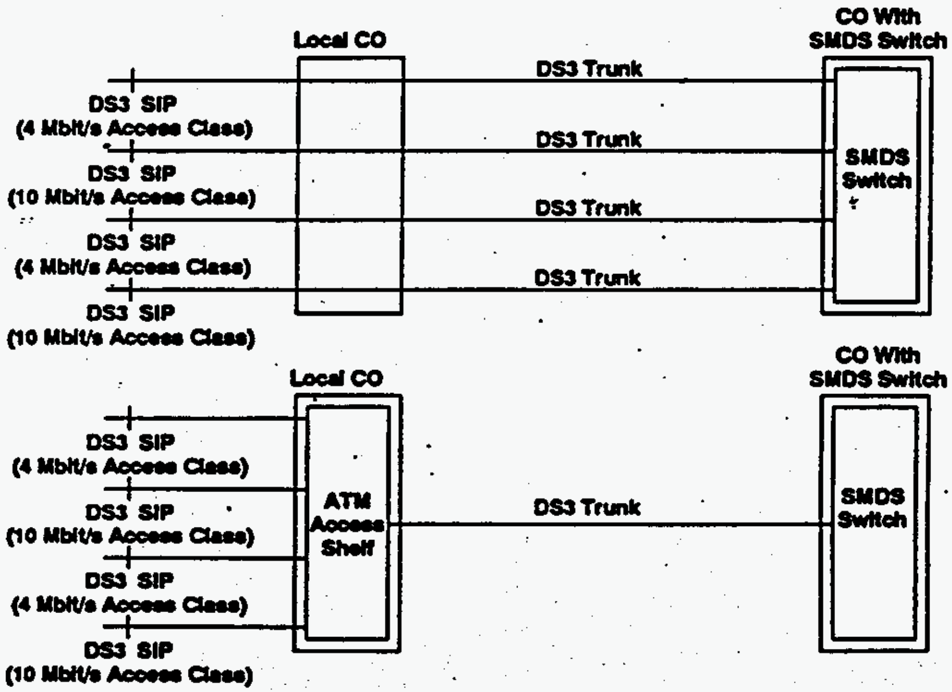

Fig. 19. ATM extended access to an SMDS switch.

NTI plans to introduce low-cost ATM access shelves in late 1993 to support extended access for SMDS and for other services. These access shelves can be connected in a ring configuration, as shown in Fig. 20. [redacted]

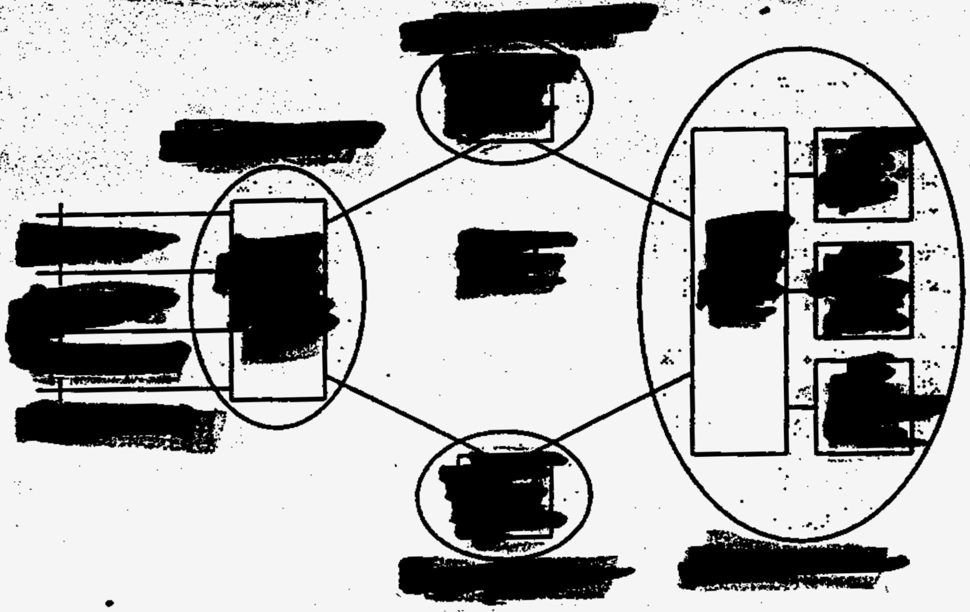

Fig. 20. SONET ring of ATM access shelves.

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D-7.2. Market Trials of ATM Cell Relay (PVC) Customer Services

The ATM access shelves can also be used to provide a new Cell Relay service to end users, as shown in Fig. 21. The customer interface would likely be a DS3 initially supporting a Permanent Virtual Connection (PVC) version of Cell Relay. Each PVC provisioned on the interface would have a bandwidth specified by the customer. One application of Cell Relay service is to support the communications needed by the next generation of multimedia workstations now being planned by Apple, Sun, and others.

ATM PVCs can be provisioned to other locations of the customer to implement private virtual networks. Multiple ATM Virtual Channel connections can be provisioned between the various locations, or alternatively Virtual Path connections can be provisioned between the various locations, with the end user allocating Virtual Channel connections within the Virtual Path as required.

ATM PVCs can also be provisioned to network elements, such as to an SMDS server to support SMDS connectionless data service. ATM PVCs could also be provisioned to other network elements such as video bridges to support multimedia teleconferencing.

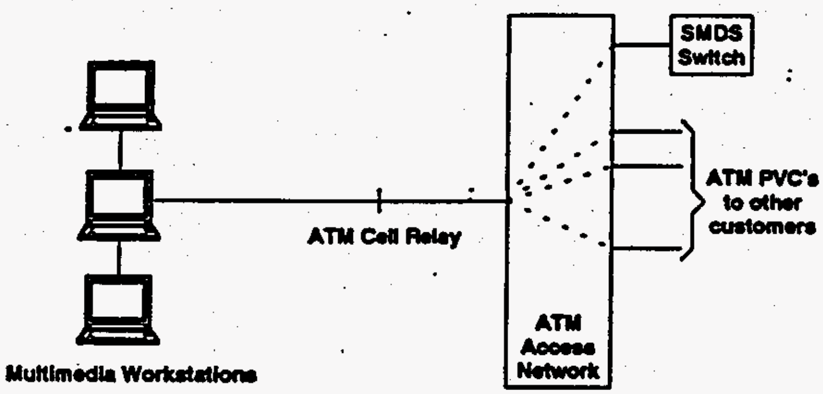

Fig. 21. ATM Cell Relay service.

D-8. 1994 Events

D-8.1. Market Trials of ATM Cell Relay (SVC) Customer Services

Some vendors (Fujitsu in particular) are expected to have commercial products supporting a switched ATM Cell Relay service by 1994. Other vendors plan to offer the switched capability in 1995 or 1996. [redacted]

[redacted]

D-8.2. CCITT Standards for Multimedia Signaling

CCITT SG XI is pursuing two parallel paths for B-ISDN signaling, one based on extensions to the existing ISDN User Part (ISUP) of the SS7 protocol for early B-ISDN introduction, and a longer-term signaling protocol called the ISDN Signaling Control Part (ISCP). ISCP was started by the Europeans around 1988 as an offshoot of work on call and connection separation. Two reasons for separating call and connection control are listed below.

- To allow association queries with databases while a call is in the active state.
- To allow look-ahead procedures to send messages between the originating exchange and the terminating exchange prior to proceeding with the connection setup.

In addition, there existed a need to allow for the control of multimedia (multi-connection) calls, which was not currently allowed for with the monolithic ISUP. ISUP would require that the CPE establish an independent connection for each media and integrate the communications within the CPE. CCITT Recommendations for ISCP may be completed in 1994.

D-9. 1996 Events

D-9.1. Increased OS Support

As B-ISDN capabilities are added to more switching nodes, and the number of customers increases in the 1995 - 96 time-frame, increased OS support will be required.

D-9.2. AIN Control of B-ISDN Services

In 1996, AIN capabilities are expected to be applied to B-ISDN to provide supplementary services, thus realizing synergies between AIN and B-ISDN.

D-9.3. Market Trials of Multimedia Services

B-ISDN systems with extended signaling capabilities based on ISCP are expected to become available in 1996.

D-10. 1998+ Events

D-10.1. Use B-ISDN in CCS7 Network

As demands on the CCS7 network increase due to increased demand for AIN services, the capacity of the CCS7 network may need to be expanded. In the 1998+ time-frame, the CCS7 network may be extended to take advantage of ATM switching technology.

D-10.2. Residential B-ISDN Services

As the cost of ATM technology declines as the volume deployment increases, it is likely to begin to be deployed to DLC systems to carry POTS, ISDN, and new services that are offered to residential customers.

D-11. Critical B-ISDN Issues

- Powering of FITL Pedestals
- Maintenance of FITL Pedestals
- ICI and ISSI Interfaces for SMDS and other Broadband Services
- Numbering for SMDS, and Other Broadband Services
- Availability of B-ISDN CPE
- Economics of Broadband Services
- OAM&P

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PROPRIETARY

E-1. Background

E-1.1. Pre-Cellular Systems

In the early 1930s, two-way mobile radio systems began to be used for police dispatch [1]. By 1934, 194 municipal police radio systems and 58 state police radio stations serving more than 5,000 radio-equipped police cars created the first spectrum crisis for the recently established Federal Communications Commission. In 1937, after extensive hearings, the FCC increased the number of channels allocated for police use from 11 to 40. During the 1940s, requests for spectrum for two-way mobile radio increased dramatically for a wide range of private sector uses: police, fire departments, forestry services, electric, gas, and water utilities, and transportation services, including railroads, buses, streetcars, trucks, and taxis. The number of mobile radio users exploded from a few thousand in 1940 to 86,000 by 1948; 695,000 by 1958; and almost 1.4 million by 1963, the vast majority of which were *not* interconnected to the telephone network.

Mobile Telephone Service (MTS), the interconnection of mobile users to the public telephone landline network to allow telephone calls from fixed stations to mobile users, was introduced in 1946 in St. Louis [1]. In less than a year, MTS was being offered in more that 25 U.S. cities, using operators who manually patched the radio call to the wireline network. In 1948, the first fully automatic mobile telephone system was turned up in Richmond, Indiana, but manual systems remained the dominant mode of operation for many years. From 1962 to 1964, an Improved Mobile Telephone Service (IMTS) field trial, which featured automatic trunking, direct dialing, and full-duplex operation (instead of push-to-talk), was conducted in Harrisburg, Pennsylvania.

E-1.2. Cellular Systems

The radio links of cellular systems do not differ significantly from IMTS, but the problem of spectrum congestion is alleviated by restructuring the coverage areas of mobile radio systems [1]. The traditional approach was to setup a high-power transmitter on top of the highest point in the area and blast out the signal 40 to 50 miles to the horizon. This provided coverage over a large area, but also tied up the relatively small number of RF channels.

Cellular uses many low-power transmitters, each designed to serve only a small area, called a cell. By reducing coverage areas, the frequencies can be reused in different cells, as shown in Fig. 1. To avoid interference, the same frequency is not reused in adjacent cells, but rather several cells are skipped before reusing a frequency. Since interference is dependent on the ratio of the cell radius to the distance between co-channel cells, cells can be split into smaller cells to increase the capacity in dense, high-traffic areas, as shown in Fig. 2.

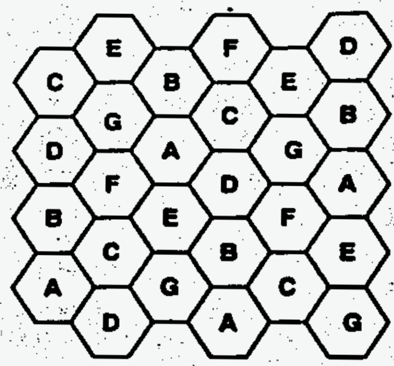


Fig. 1. Cell Pattern With No Frequencies in Adjacent Cells [1].

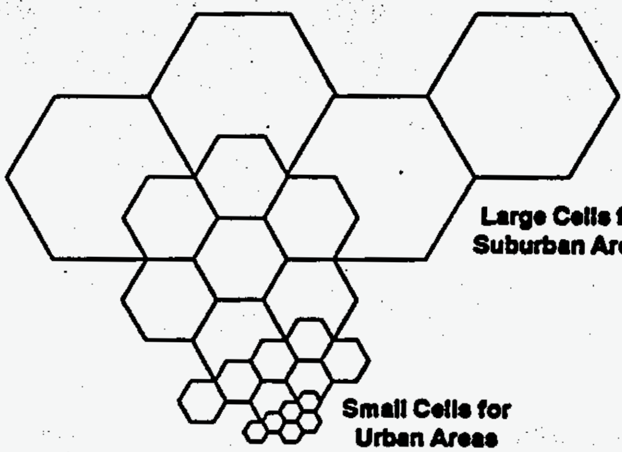


Fig. 2. Splitting of cells for denser areas [1].

The cellular architecture is based on four key principles:

- low power transmitters and small coverage zones as cells,
- frequency reuse,
- cell splitting to increase capacity, and
- hand-off from one cell to another without dropping or disrupting the call.

The first proposal for a large-capacity mobile telephone systems was in 1947, only a year after the introduction of mobile telephone service [1]. AT&T proposed to the FCC that 150 two-way channels be created, but the proposal was not acted on. Two years later, AT&T proposed a more elaborate plan to the FCC, which was in the process of allocating additional spectrum for UHF television. AT&T argued that mobile services were also entitled to additional spectrum, and should not be squeezed out by broadcasters. Each TV channel required 6 MHz of spectrum, enough for more than 100 mobile telephone channels, and each TV channel represented three times the total spectrum for all the pre-cellular mobile telephone frequencies. But, each TV channel benefited millions of people while a mobile telephone channel benefited only an elite few. In the Commission's decision on the 1949 docket, they rejected AT&T's ideas, and refused to allocate any portion of the spectrum to mobile telephony, while allocating 70 channels for UHF TV.

After 20 years of struggle between TV and mobile telephone, the decision on Docket 18262 in 1970 allocated 115 MHz in the 800 MHz band to mobile service, including 75 MHz to common carrier systems, of which 40 MHz was available for immediate allocation and the remainder was held in reserve [1]. After the first Report and Order on Docket 18262 in 1970, cellular radio passed through 12 years of further inquiries, petitions, comments, judgments, challenges, reconsiderations, and lawsuits before the decision on Docket 79-318 was rendered in March 1982, which established the licensing procedures.

In 1970, it was assumed by almost everyone that the new mobile telephone service would be operated as an extension of AT&T's wireline telephone monopoly [1]. Indeed, Motorola, the major supplier of mobile radio systems, a business it had "inherited" when AT&T was forced to get out of the radio manufacturing business by the 1956 Consent Decree, sided with AT&T against the Radio Common Carriers (RCC) in court battles until AT&T made a tactical error in 1975 by not including Motorola as a supplier for the planned cellular test system in Chicago. Motorola was outraged by its exclusion and changed its position in the court appeal, attacking the cellular allocation, and urging the court to set it aside. In 1977, Motorola teamed up with one of the larger RCCs to file an application for a second cellular developmental system in the Washington area. By this time, RCCs were beginning to develop into substantial businesses mainly on the strength of the rapidly growing paging business, which went from 50,000 customers nationwide in 1970 to more than 600,000 in 1978.

AT&T recommended a unified 40 MHz allocation for cellular, while the Justice Department recommended "open entry" with allocations as small as 5 MHz per operator [1]. The FCC accepted AT&T's arguments that smaller systems are less efficient and more costly, but decided to split the total into two operating licenses with each to receive 20 MHz (333 channels). One license in each area would be set aside for the wireline telephone company, while the other would be reserved for a nonwireline carrier.

The Chicago cellular system began operation on October 13, 1983, 79 days before divestiture, when AT&T withdrew from the operating business and the Chicago system was taken over by Ameritech [1]. By the end of 1984, cellular service was available in 25 American cities. However, costs were high, service was flawed, customers were reluctant, and profits were thin or non-existent. Cellular radio was by nature a system with a much higher fixed cost upfront than IMTS. A 5-channel IMTS system could be started for as little as $200,000; however, a cellular system for a major metropolitan area could easily cost $500,000 to $1 million per cell, for a total cost of $10 to $20 million before the first revenue producing call is placed. This made it necessary to attract a critical mass of customers, and be able to survive the relatively long start-up period before reaching this critical mass.

Technical problems also plagued cellular [1]. Operators found that dead spots appeared in unexpected locations. Hand-off was found to be more difficult than expected, and dropped calls and crosstalk problems occurred. Furthermore, these problems increase as the cells are split; some calculations indicate that a reduction in cell radius by a factor of four will produce more than a tenfold increase in the hand-off rate per customer. Privacy became an issue, and Bell Atlantic offered an encryption box for $2,500 plus $65 per month, a solution that was not particularly attractive for a service already in trouble due to its high cost. Finally, wireline operators in Chicago, Los Angeles, and New York City found that cell splitting, a fundamental principle of cellular, was about 50% more costly than adding capacity by acquiring more spectrum, and within one year of turning up service they petitioned the FCC for additional bandwidth.

After extensive debate, the FCC allocated an additional 5 MHz to the wireline and non-wireline cellular carriers. This added an additional 83 channels to each system. However, the addition was given with the stipulation that there would be no more frequencies allocated to cellular in the future.

The cellular industry realized that the new allocation would not be sufficient for service in the near future. To prepare for that time, the cellular industry moved to start the development of a digital system for the cellular industry. This system would be designed to fit into the existing channel bandwidths and to allow for the coexistence of both the existing analog FM system and the new digital system. Although there has been much controversy in the development of standards for the new digital system, it is presently scheduled for deployment in the 1992 time-frame. The new system will initially provide three channels for each existing channel.

E-1.3. Cordless Telephones

The roots of cellular technology extend earlier in history than cordless telephone's roots; however, the impact of cordless telephones has been just as great and its growth rate just as strong as cellular. Cordless telephone technology was developed in the 70's, and it is licensed to operate under Part 15 of the FCC Rules. A cordless telephone uses an analog frequency modulation scheme on the radio link similar to other existing radio systems and consists of a single base unit and a single handset. The base unit communicates with one and only one handset. Access to the telephone network is via an RJ-11 jack and inside wire to the Network Interface. A cordless telephone is, in essence, a cordless extension of the telephone network. RF channel selection is solely the task of each cordless telephone. The simplest cordless telephone has access to only one channel. More expensive products have multichannel capability, usually with the ability to select a good channel; however, the user can choose another channel if desired.

Cordless telephones under Part 15 of the Rules do not require an FCC license to operate. Under the FCC's low power operation rules, cordless telephones operate on ten channel pairs at 47 and 49 MHz. Cordless telephone transmit power is limited by the Rules, and Rules require the base unit antenna to be an integral part of the unit. These requirements limit the coverage of each cordless telephone. Even with these limitations, the sales of cordless telephones have increased 20% annually.

Cordless telephone manufacturers through the Telecommunications Industry Association (TIA) have petitioned the FCC to increase the current channel capacity significantly to meet the growing market. In 1985, Part 15 of the FCC Rules was changed to provide three bands of frequencies for low-power unlicensed use. These bands are located at 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz. The maximum transmit power in these bands can be as high as one watt if spread spectrum technology is employed.

Spread spectrum communications systems use special modulation techniques that spread the energy of the transmitted signal over a very wide bandwidth. Since the transmission rate through a radio channel is a function of the channel bandwidth and the signal-to-noise ratio of the radio system, conventional radio strategy fixes the bandwidth of the channel (set by the FCC) and allows the designer to select a modulation scheme that will allow the desired channel throughput. However, another approach is to fix the modulation scheme and increase the bandwidth used to transmit the signal. This increase in bandwidth is equivalent to increasing the data rate through the channel.

In spread spectrum, the bandwidth of the information to be transmitted is deliberately widened by means of a spreading function and then modulated onto an RF carrier. The spreading technique used in the transmitter is duplicated in the receiver to enable detection and decoding of the signal. Each user of the channel has a different spreading function. The spreading function produces the code to receive that signal and thus the name Code Division Multiple Access (CDMA). Spreading accomplishes two key characteristics of spread spectrum. First, spreading reduces the power density of the signal at any frequency within the transmitted bandwidth, thereby reducing the probability of causing interference to other signals occupying the same spectrum. Second, the signal processing tends to suppress undesired signals, thereby enabling such systems to tolerate strong interfering signals. Since these changes in Part 15 of the Rules to allow for spread spectrum use, many manufacturers have started developing spread spectrum systems which can operate in the Part 15 bands.

E-1.4. Personal Communications Services

Personal Communications Services (PCS) have been proposed to evolve from a marriage of two wireless technologies - cordless telephone technology and cellular technology. PCS offer a potential level of convenience and control over communications never before possible. To help visualize PCS, think of a very small telephone that will fit into a pocket or purse. At the airport, the phone is flipped out to call the office, while avoiding the lines at the credit card phones. In the office, the conventional phone may be chosen for its larger display, with the personal phone resting in a charging cradle, informing the network where the user is so calls can be forwarded there. At home, the personal phone can be carried in a pocket during a stroll around the neighborhood, to avoid missing calls. For those times when you prefer not to be disturbed, an automated message system can log the calls, providing convenient access to messages from anywhere that the phone can be used. Such a system offers unprecedented user control over telecommunications services. Personal Communications is based on several elements:

- A Personal Terminal, probably with a small display, which can be used at home, in the neighborhood, in the office, in the car, in public area (e.g., malls, transportation terminals);
- A Personal Access Number which will allow a person to be reached at any time or place desired, and will allow for privacy when preferred; and
- A *Personal Service Profile* across all communications networks, allowing for simplified billing and a common access to subscribed services and features such as three-way calling.

Personal Communications Networks (PCN) provide what is known as "terminal mobility". PCNs deal primarily with the radio access part of personal communications. Depending on the outcome of regulatory decisions, there will probably be multiple PCN providers in a specific geographic area. These may include a variety of PCNs, from simple public base stations ("wireless coin telephones") to satellite-based international PCNs (e.g., Motorola's proposed Iridium system).

With the combination of radio experience and a significant local exchange infrastructure, [redacted] Depending on traffic and switching requirements, and the development of interface standards, th[redacted]

Personal Communications Services include a number of services of interest to PCN users as well as non-PCN users. [redacted]

[redacted]

[redacted]

There are other Personal Communications Services under discussion: [redacted]

[redacted]

There are widespread coordinated efforts throughout Europe and Japan to develop personal communication systems for use and for sale. In the UK, two efforts are in progress. The first is the development and field trial of the second generation Cordless Telephone (CT2). CT2 is a digital, low-power cordless telephone system that operates on 40 FDMA channels around 865 MHz. The two applications of CT2 are as a private cordless telephone for business and residence use, and as a public cordless pay telephone system. In the public applications, CT2 systems will be strategically placed at shopping centers, airports, train stations, etc., where customers can originate calls. The CT2 system in the public mode cannot terminate calls and does not have the capability to handoff between base stations.

In addition to CT2 development, another effort in the UK has addressed Personal Communications Networks. Proposals have been accepted for a network comprising radio base stations with small service areas which would provide access to very small, light-weight, pocket radio-telephones capable of relatively long periods of use without the need to recharge batteries. The technology suggested was that proposed for the new digital European cellular system for availability in the mid-1990s, but in a different frequency band (between 1.7 and 2.3 GHz).

In another activity in Europe, the European Telecommunications Standards Institute (ETSI) is developing another digital cordless telephone system called the Digital European Cordless Telephone (DECT). Unlike CT2, DECT can both originate and terminate calls, uses TDMA, and will operate around 1.7 GHz.

In Japan, NTT has done extensive work in developing a multi-channel analog cordless telephone, called the Enhanced Services Cordless Telephone (ESCORT), which is integrated into a PBX system. Recently, the Japanese also announced an effort to develop a digital portable telephone system, which is scheduled for availability around 1995.

In the U.S. during the mid-80's, the only interest in personal communications was at Bellcore. In 1984, Bellcore started a small research project called Universal Digital Portable Communications (UDPC) [2, 3, 4], which is a digital, low-power, TDMA portable telephone system that uses small cell sizes of about 1000 foot radius. Access to the public switched network would be via radio ports strategically placed approximately 20 - 30 feet high in a square grid. The radio ports would be connected to a central office switch either on copper or fiber DLC systems. Prototypes of the radio links are operating in the laboratory; however, no work has been done in implementing the switch/processor function or the DLC line functions. Another problem area for UDPC is the lack of a frequency allocation in the U.S. for this service.

On June 28, 1990, the FCC issued a Notice of Inquiry (NOI) to consider whether to allocate frequencies for PCS, the particular PCS offerings to authorize, the technical standards that licensees should follow, and the regulatory policies that should govern PCS operations, including who may be eligible for PCS licenses. The NOI was triggered by the following:

- The FCC had received requests for authorization to provide PCS type services,
- The FCC had received petitions for Rule-making for PCS spectrum allocation,
- The FCC had received requests for allocations and reallocations of spectrum for PCS use, and
- The RF spectrum in the area of interest for PCS was under the FCC's control and was already allocated for other services.

During the course of the FCC's NOI, the technical characteristics and potential marketplace applications of PCS will be carefully studied. PCS experiments will be conducted by a broad range of companies including BellSouth, Bell Atlantic, NYNEX, Motorola, Ericsson, McCaw, and Millicom. The feasibility of different transmission technologies, such as TDMA and CDMA, will be investigated.

PCS advocates differ considerably in their recommendations concerning the amount of spectrum that the FCC should allocate in the 900 to 3,000 MHz range [5]. AT&T and Ericsson suggest that the FCC allocate approximately 180 to 230 MHz of bandwidth; BellSouth recommends 30 to 40 MHz initially and eventually 100 MHz; Ameritech suggests 50 to 200 MHz; US West and Motorola propose 200 to 300 MHz; and Southwestern Bell and Northern Telecom believe that 60 MHz would be adequate.

Although the FCC has not formally committed to a PCS allocation, it is exploring two approaches for a spectrum allocation [6]. The first approach, and the one which would permit deployment of some type of PCS service in a timely manner, is spectrum sharing. With spectrum sharing, two licensees use the same spectrum for different services. To do this, the services must coexist in the same spectrum without causing each other problems. One proposed method for spectrum-sharing requires that PCS licensees use spread spectrum techniques. As of yet, neither the FCC nor most other interested parties believe that sharing can be accomplishe[redacted]

The second approach is to dedicate spectrum for PCS service. If dedicated spectrum is required, existing users of the chosen band will have to be relocated to another band at a substantial cost. Because of this and the FCC process to accomplish the new allocation, PCS service may not begin in some areas with a dedicated spectrum until the 1998-99 time-frame.

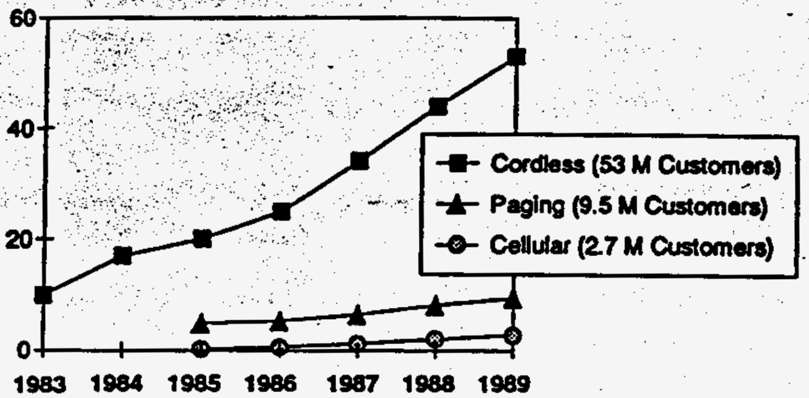
In either case, a PCS system would consist of a radio part and a network part. The radio part would include the handsets and the base stations, and the network part would include the distribution facility, the radio management system, and the network transport. The size and complexity of these components will be a function of the type of PCS service offered, i.e., limited mobility or full mobility. Since the antenna height at the base station will be low, landline distribution facilities are expected to be the facility of choice; these could be either copper-based or fiber-based. The radio management system and network transport could be as simple as 1FB lines from the telco connected into a remotely located centralized administrative and billing computer, or as complex as copper/fiber distribution facilities leased from the telco or from a CATV operator into switching centers connected by a common channel signaling network.

Potential providers of the components of PCS service include cellular operators, new PCS entrants, LECs, ICs, CATV operators, private radio operators, and equipment manufacturers. Since the issuing of the NOI, the FCC has received over 60 applications for experimental licenses for PCS trials. These applicants include RBOCs, cellular operators, PCS start-up companies, equipment manufacturers, and CATV companies. It is impossible at this time to determine either the outcome of the spectrum debate or who will be the PCS licensees.

PROPRIETARY

E-1.5. BellSouth PCS Planning Efforts

BellSouth's interest in Personal Communications is the result of a number of growth trends in wireless telecommunications areas. In particular, the areas of paging, cellular telephones, private mobile radio, and cordless telephones have all shown significant growth as shown in the following chart.



Sources: Cellular – CTIA Data Survey
Cordless – U.S. Department of Commerce
Paging – LINK Resources, Inc. 1988

There is currently a high degree of regulatory uncertainty as to what role BellSouth and the other RBOCs will have in the upcoming PCS marketplace. [redacted] Through its recent "pioneer's preference" order, the FCC has indicated that those companies which enable new wireless services through investments in innovative technology and trials will be ensured a future license in the area where they carried out the trial.

[redacted]

A Wireless/Wireline Planning Committee was formed in 1990 to identify business opportunities for wireline support of wireless networks (both cellular and PCS). In its initial report, the Wireless/Wireline Planning Committee examined the current state of interconnections between local exchange carriers and cellular mobile carriers, and described some possible services the wireline company might offer to wireless service providers and their customers. An interconnected architecture was proposed, and technical considerations including standards issues were briefly addressed.

A Wireless ESSX trial committee was formed in 1990 to define the concept of a wireless ESSX service and to perform laboratory and field trials of such a service. On February 6, 1991, the FCC granted BSS an experimental license to conduct trials in the 864-868 MHz band in Atlanta and in Birmingha[redacted] Active negotiations are underway with Motorola on a possible customer trial of wireless ESSX at the University of Florida in Gainesville, Florida.

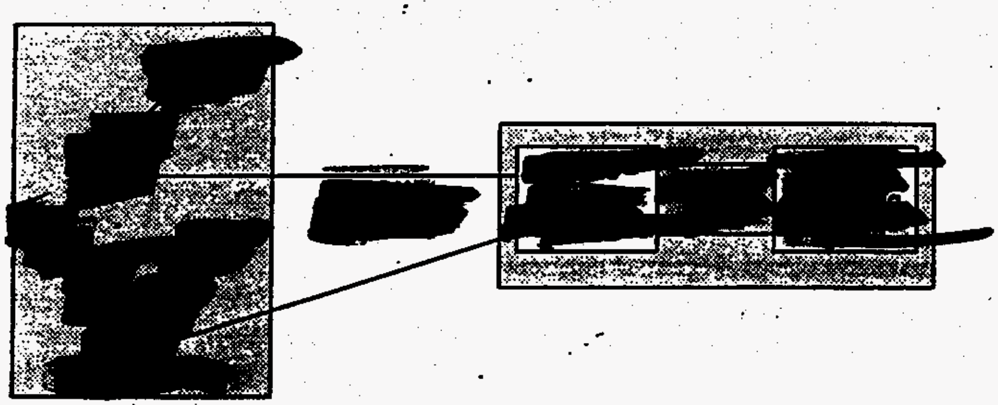


Fig. 3. Wireless ESSX Architecture.

The envisioned architecture for a wireless ESSX service is shown in Fig. 3[redacted]ers will also be able to send and receive calls throughout the building. An active call will be handed off from one radio port to another as the user moves around the building. Each radio port would support multiple connections according to traffic needs, and will be connected via ISDN BRI or PRI facilities to a radio port controller. New ISDN D-channel messages will be defined for such functions as handset registration and handoff between cells. The radio port controller will be connected via ISDN BRI facilities to the digital central office. A function of the radio port controller is to make the user's handset appear to be hardwired to the switch port. Switching is performed in the radio port controller to perform handoff and to connect the user to his or her assigned switch port. Eventually the function of the radio port controller could be integrated into the digital switching system.

E-2. 1991 Events

E-2.1. BellSouth Wireless Lab Trials

[redacted]

The goals of these trials are:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

E-2.2. Organization of T1P1

T1P1 is a Technical Sub-Committee operating under the auspices of Committee T1 - Telecommunications as an ANSI-accredited standards body. T1P1 was formed to address complex standards work requiring significant project management and systems engineering. The first project being addressed by T1P1 is Personal Communications.

T1P1 has formed three working groups. T1P1.1 is the project management group. They are responsible for general coordination of T1P1 projects. T1P1.2 deals with the wireless aspects of personal communications; they are concerned with the air interface and related issues. T1P1.3 addresses network aspects of personal communications; this includes switching, routing, and network services in support of personal communications.

In relation to personal communications, T1P1 is expected to perform systems engineering and project management resulting in high-level standards documents, reports, and other appropriate output. One key component of T1P1's work is that of working with other standards organizations to exchange information and expertise towards the goal of uniform personal communications standards. In particular, T1P1 will work with other T1 Sub-Committees to ensure that standards (e.g., signaling, network interconnections, performance) are being developed by the appropriate Sub-Committee. In addition T1P1 will make use of, and contribute to, work being done internationally and nationally. International work includes the Future Public Land Mobile Telecommunications Systems (FPLMTS) work of CCIR, and the Universal Personal Telecommunications (UPT) work of CCITT. National organizations include TIA's TR-45 and IEEE 802.11 wireless LAN group.

T1P1 meets quarterly; membership is open and includes manufacturers, service providers (e.g., RBOCs), consultants, and others.

E-2.3. Initial Service Description for Personal Number Calling AIN Service

[redacted] a number of service development mechanisms, including the use of market research to refine service concepts dynamically. [redacted]

[redacted] describes how the service combinations work together, and provides the common operations procedures for the services.

[redacted]

1. [redacted]

2. [redacted]

E-2.3.1. Personal Registration

[redacted]

Registration allows for three basic registration choices:

- Send my calls here;
- Send my calls there;
- Send my calls to default routing;

and one optional registration feature (if subscribed to):

- Send my calls to Anywhere Call Pickup.

[redacted] Anywhere Call Pickup allows a caller to get through to a customer in these situations, by allowing the caller to wait while the customer comes to pick up their call. The customer is informed of the waiting/parked call via a page to their pager. The customer can then find a phone, dial in, and connect to the caller. At any time while they are waiting, the caller can request to go to voice mail.

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E-2.3.2. Audio Call Screening

Audio Call Screening is a screening service that allows the customer to screen calls and determine whether to answer them. The service is based on the identification of the line that the caller is calling from by announcing the name associated with the calling number in-band to the customer (e.g., "Call from the phone of Cathy Addison for Boris Yeltsin"). The customer (Boris) can then choose from two basic choices:

- Accept the call;
- Hang up;

and one further screening feature if the customer also subscribes to Personal Voice Mail:

- Send the call to voice mail and allow me to listen in on the line.

The last option allows the customer to screen calls when callers who may or may not be known to them are calling from unrecognized line numbers. This provides a more comprehensive and reliable screening capability than with screening methods that rely purely on calling line identification.

E-2.3.3. Personal Voice Mail

[redacted] some simple administrative options, namely:

- Pick up their message(s);
- Request the "envelope" information for messages. This consists of the date and the time the message was left, the calling number (if available), and the calling name (if available); and
- Perform ring administration (i.e., the user can set the number of rings that will occur before voice mail will pick up the call.

E-2.4. SS7/MTSO Interconnection Trial in South Florida

In the present cellular environment, MTSOs are interconnected via inband signaling, and intersystem calls are established via trunks through the local telephone company or through an interexchange carrier or both. With the advent of CCS7, calls will be set up faster and new services can be implemented sooner. [redacted] An integral part of these services will be the use of CCS7. [redacted]

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E-3. 1992 Events

E-3.1. Standardization of Digital Personal Communication Networks

It is generally accepted within the telecommunications industry that voluntary standards greatly enhance the overall customer acceptability of communications services and equipment. Whichever technology is used to provide personal communications services, standards for (1) the radio, (2) the spectrum access mode and other physical parameters, and (3) the signaling protocols at all levels are critical. Given a spectrum allocation for personal communications in the U.S., national standards for the radio port-to-portable interface, radio port-to-network interface, and the system architecture for the access technology will present special challenges.

In the 1992 time-frame, decisions over the access standard will be made driven by this standards work. Field trials of CDMA will have progressed to the point where a decision can be made about its viability in a shared environment. Work will continue on the interface standards, and it is possible that such interface standards could be approved in this time-frame.

E-3.2. BellSouth Wireless ESSX Field Trials

Two Wireless ESSX trials are planned for 1992 to establish the concept of wireless ESSX in different environments with heterogeneous equipment.

- Gainesville, FL (University of Florida), a university campus with several campus locations covered.
- Birmingham (Colonnade), a typical suburban office development.

[redacted] Information on user registration, handoff, and call forwarding will reside in a system server. The radio architecture will be that of CT2. Radio ports will be placed inside a building to provide service to occupants of the building. Radio ports will also be strategically placed around the campus to provide service to occupants of the trial building requiring mobility and to students and professors.

[redacted]

PROPRIETARY

G-1. Background

A number of developments within the telecommunications and computer industries have been fundamental drivers behind the need to evolve an originally telephony-focused network into an information network. The following sections discuss recent developments in Open Systems Interconnection (OSI), network management, distributed processing, broadband communications, computing systems architecture, and their effect on BellSouth's network evolution plans. These driving forces lead us to the target network architecture described in Section G-2.

G-1.1. OSI

The Reference Model for Open Systems Interconnection, approved by CCITT and ISO in 1983, has been an influential description of how communication takes place between different computing systems. The model specifies a seven-layer architecture for communications between open systems, as shown in Fig. 1.

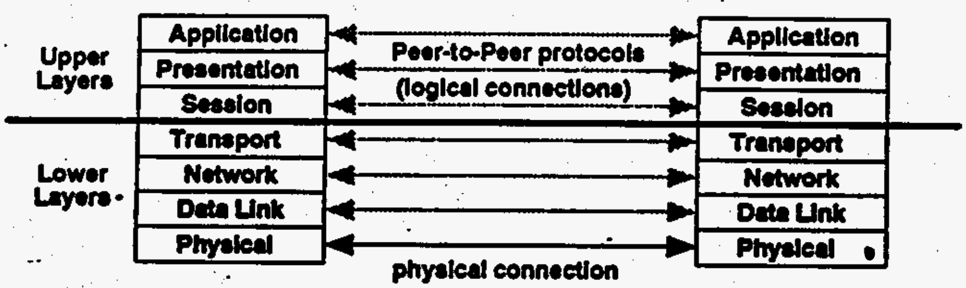

Fig. 1. Open Systems Interconnection (OSI) model.

Protocols, such as X.25 and Ethernet, and physical transmission specifications, such as SONET, reside in the lower layers of the model. More detail has been added in the past several years on the upper layers of the OSI model, especially the Application Layer. A number of Service Elements have been defined for the Application Layer, which provide generic services such as common management information, association control, and remote operations. These will allow applications developed independently on different systems to interact.

G-1.2. Network Management

Network management is an area of growing interest throughout the telecommunications and computing industries. Network management applies to all sizes of systems from small, localized systems such as a LAN on one floor of an office building to a nationwide system such as the CCS7 network. Major telecommunications vendors as well as major computer vendors have announced network management products, and many network management standards documents are being drafted in ISO.

ISO has several foundation documents which describe the OSI approach to Network Management. The Structure of Management Information document describes how information is handled using the object-oriented paradigm and how network management protocols are used to access information in the objects. Another fundamental OSI Network Management document is the Systems Management Overview, which describes the model for managing Open Systems. It describes the mechanisms for managing network resources and the OSI protocol standards for communicating information related to network resources.

The OSI Systems Management Overview (SMO) divides the task of network management into five Systems Management Functional Areas (SMFAs):

- Fault Management
- Configuration Management
- Accounting Management
- Performance Management
- Security Management

Each SMFA is supported by one or more Systems Management Functions (SMFs), such as Object Management Function, Event Report Function, Accounting Meter Function, and Log Control Function [1]. For example, the Accounting Management functional area uses the Accounting Meter SMF to gather accounting information and the Log Control SMF to store records of accounting information.

The Application Layer of OSI plays a key role in network management of OSI networks [2, 3]. The Systems Management Functions use the services and protocols provided by the Application Layer to communicate between managing and agent processes. The SMFs access the Common Management Information Service Element (CMISE) that handles the Common Management Information Protocol (CMIP). CMISE in turn calls upon the services of Association Control Service Element (ACSE) and the Remote Operations Service Element (ROSE). All of these service elements reside in the Application Layer.

Managed elements or resources in the network are modeled as Managed Objects. The Management Information Base is the conceptual repository for managed object instances, and it is accessed through an Agent process. The Agent performs all management operations on managed objects, at the request of the Manager. The Agent also receives and processes notifications spontaneously emitted by the managed objects. Fig. 2 illustrates the relationship between Managers, Agents, and managed Objects.

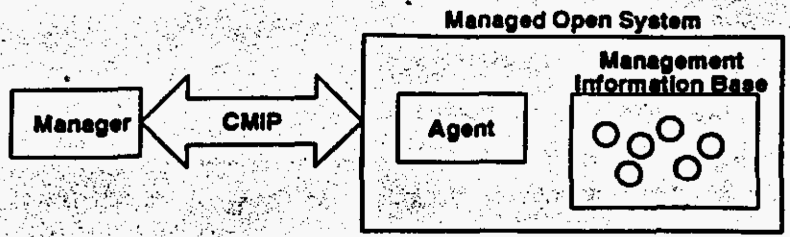

Fig. 2. Systems Management Model.

Although OSI Systems Management is being developed in the standards arena, few commercial products exist. In 1989, the Internet community developed a new protocol, Simple Network Management Protocol (SNMP), from the Simple Gateway Management Protocol used in Internet. In 1990, widespread commercial availability was achieved for SNMP. SNMP is targeted for the Internet network, but it can be used on any system that has an underlying User Datagram Protocol/Internet Protocol (UDP/IP) transport. Although it has fewer capabilities than OSI, it is more easily implemented. Internet documentation describes SNMP as an interim step for network management until OSI Network Management solutions are available. In the telephony environment, OSI CMISE will be used in operations support systems where Transaction Language 1 (TL1) is currently used.

G-1.3. Distributed Processing

The previous sections discussed how to connect two systems for communication, but systems can also be interconnected in order to run applications or processes. Several dispersed machines running a single application form a distributed processing environment. Open Distributed Processing (ODP) is one of several closely related projects that have begun recently to standardize a distributed computing environment. ODP, an ISO effort, is closely aligned with work on a Distributed Applications Framework (DAF), which is occurring in the CCITT [4]. Both draw heavily on the Advanced Networked Systems Architecture (ANSA) developed under the European Commission ESPRIT project and currently handled by the Architecture Projects Management Ltd. independent laboratory at Cambridge, England [5].

ODP breaks the problem of specifying its distributed processing environment into viewpoints. Each viewpoint addresses different facets of distributed processing. No hierarchy or priority exists among the viewpoints; they are simply different views. The five viewpoints are listed below.

- The *Enterprise viewpoint* considers issues such as how the enterprise uses an information system, what business processes and information are automated, and what security and management policies will be applied to the information system.
- The *Information viewpoint* is concerned with the definition of the information or data required in the distributed process. This viewpoint is similar to the

Management Information Base (MIB) in OSI's Common Management Information Protocol (CMIP).

- The *Computational viewpoint* shows which processes are present and how they are interrelated. It is a model of application processes.

- The *Engineering viewpoint* extends the Computational viewpoint to show the mechanisms for achieving distribution such as location transparency. It defines the support architecture upon which the applications of the Computational viewpoint are built.

- The *Technology viewpoint* is concerned with the actual hardware and software components implementing the distributed system.

The Computational viewpoint of the ODP infrastructure consists of application-specific functions, common functions, and the kernel. The fact that functions are distributed is transparent to the Computational viewpoint; only the existence of functions is seen. Examples of common functions are directory, naming, trading, and object management. Applications-specific functions are those needed specifically for the purpose of the enterprise, such as an airline reservation system for a travel agency. The functions are considered computational objects in the Computational viewpoint. In the Engineering viewpoint, the structure of the kernel is seen to consist of engineering objects and a nucleus. The engineering objects are the run-time representations of computational objects.

In addition to viewpoints, ODP also defines a number of aspects of information systems (storage, process, user access, communications, identification, management, and security).

Although ODP and DAF are standards documents and not products, they are based on the software workbench called ANSAware, developed by the ANSA project.

G-1.4. Broadband Communications Systems

Broadband communications systems - all systems that operate at bit rates higher than DS1 (1.5 Mbit/s) - are necessary to support the performance demands of the many communications systems. For example, an Ethernet operates at 10 Mbit/s, and DS3
31 private line services are used in private networks. On the horizon, [redacted]
32

The ability to interconnect end systems at such high bandwidths opens a vast area of new applications beyond voice transport or computer interconnection at modem speeds. Broadband communications systems allow image, high-speed data, and video information exchange. The new transport capability affects other areas of networking such as signaling and maintenance.

G-1.5. Computing Architectures

Over the past two decades, more and more tasks performed by the operating companies have become mechanized. The August, 1989, issue of the BellSouth Mechanization Digest included nearly 400 computer-based systems used within BellSouth for handling technical and procedural work. While these systems are very useful for their intended task, they have often been planned and implemented independently. The Open Systems Computing Architecture (OSCA™) was proposed by Bellcore in the late 1980's to address the independence among operations systems.

OSCA is an architecture designed to allow interoperability among operations systems. The OSCA architecture [6] is composed of three types of communicating Building Blocks. The User Layer Building Block provides the functionality for human users to access the system. The Processing Layer Building Blocks perform all processing done within OSCA systems. The Data Layer Building Blocks are the stewards of corporate data, ensuring semantic integrity of the data throughout the OSCA system. The Processing Layer Building Block can have local data used by that Processing Layer Building Block, but it cannot steward corporate data. Fig. 3 shows the OSCA target architecture.

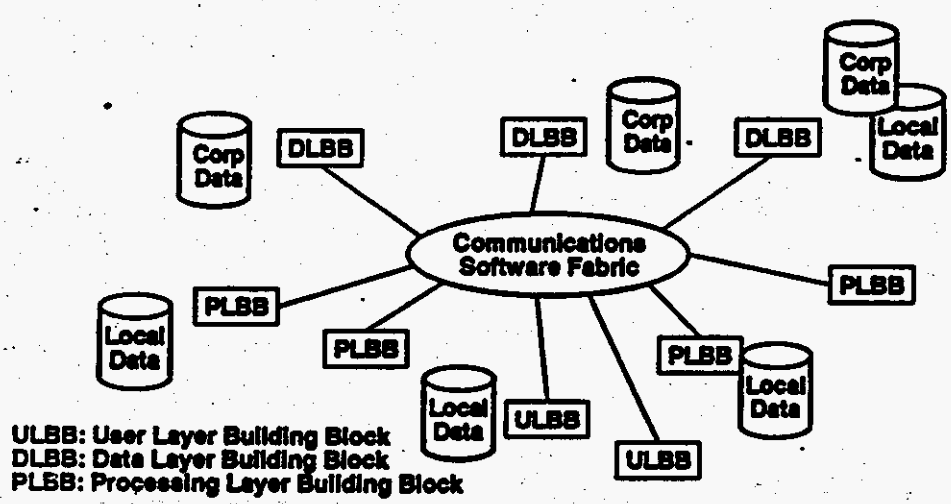

Fig. 3. OSCA Target Architecture.

All building blocks communicate through well-defined interfaces called contracts. Any functionality that a building block provides to other building blocks must be declared in the contract; functionality not defined in a contract is unavailable outside the building block.

[redacted]

The Presentation Interface is closely related to the Application Environment, but it is treated and documented separately due to the complexities of the presentation interface technology.

404.1

G-1.6. Industry Efforts on Information Networking Architectures

Each of the previously discussed developments has been important in driving the need for an information networking architecture. OSI has had a profound influence on how telecommunications is viewed. It has opened vendor-proprietary solutions to allow OSI-compliant systems to exchange information and makes it possible to build large, heterogeneous networks. The need to manage the networked open systems quickly arises, and the opportunity to distribute processing as well as information also becomes evident. The emergence of broadband communications systems with the capability for high-speed transport and multi-media applications adds further power to the open systems network. Clearly, networked open systems have the capability for providing a very desirable *information network*. It is strategically important for BellSouth to exploit the communications power available through this series of developments. However, harnessing the power of the developments is not done automatically. Just as the interoperability in computing applications drove the need for computing architectures (OSCA and BSCA), using these developments will require an information networking architecture.

An Information Networking Architecture (INA) project started at Bellcore in 1988. Similar projects to integrate the network and operation systems were underway in several regions (i.e., Pacific's NetSys, US West's #1Net, and Southwestern's DOCINA) [redacted] at would integrate the computing power of network elements and operations systems into a flexible information network [9]. This information network would support both internal users needs for administering the network and external customers' needs to access robust services and to perform customer network management. An INA Task Force of Regional Subject Matter Experts and Bellcore produced a list of INA Attributes. Since the most pressing concern for the regions among all the INA attributes was the management of data redundancy, a special project on data redundancy management was initiated [10].

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Bellcore and the INA Task Force developed a set of INA attributes and a two-segment INA Model, shown in Fig. 4, which were presented to the industry in mid-1990 [11].

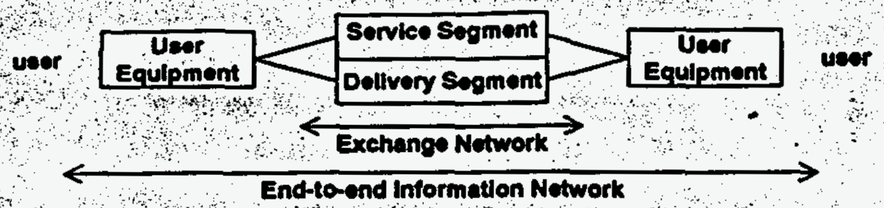

Fig. 4. Bellcore's Two-Segment Model of INA.

The Model divides INA into a Service Segment and a Delivery Segment, instead of today's division between Network Elements and Operations Systems. In INA the Delivery Segment contains hardware and low-level, technology-dependent software for both Network Elements and Operations Systems. The technology-independent components of INA, which provide services, are in the Service Segment.

The regional Task Force representatives stressed the need to use relevant work in industry and international standards in the specification of INA. A thorough document was written to assess the relevance of the standards work and vendor products[12]. Among the standards addressed were ODP, DAF, ANSA, OSI CMISE, B-ISDN, and OSCA. The document concludes that a number of standards are applicable to particular areas of the INA, and they should be used in forming the definition of INA.

A significant effort towards defining INA during 1990 was the Enterprise Architecture work of the Integration Focus Group made of regional company subject matter experts and Bellcore. The Enterprise Architecture [13] is a model of the functions, the data, and the interactions between them in a regional company environment. The Enterprise Architecture models the enterprise of the regions, modeling all activities using information engineering methodology as described by James Martin [14]. The Enterprise Architecture will be further decomposed in the Business Area Analysis process. The Enterprise Architecture will also lead to the Object Architecture for INA.

In the fall of 1990, the INA work program changed direction in response to an INA Task Force proposal for more tangible and practical deliverables. A three-cycle field trial called the INA Field Experiment was proposed by Bellcore. The INA Field Experiment will proceed in three overlapping cycles to allow simultaneous refinement of specifications while testing specifications at the current cycle's level of detail in regional company testbeds. Several regions have offered to sponsor an INA Field Experiment. Although not a sponsoring region, BellSouth is participating by working with Bellcore to write the initial service architecture specifications.

There are a number of technical guidelines currently in place for the Field Experiment. First, the Delivery Segment transport and switching will be done with B-ISDN Asynchronous Transfer Mode. Connections will be switched based on Virtual Path and Virtual Channel Identifiers. Operations and network management functions will be performed on physical equipment in the Delivery Segment or CMISE objects representing the equipment. The INA Architecture will specify a distributed computing environment that Service Segment objects use to access Delivery Segment resources. The Distributed Processing Environment (DPE) provides logical-to-physical address translation, allowing Service Segment objects to access Delivery Segment resources and other applications. The DPE also enhances more efficient and widespread use of Delivery Segment resources. The Data, User, and Processing Layer Building Block concepts from OSCA will be used to design Service Segment applications. Fig. 5 illustrates Bellcore's INA target architecture [15] with these guidelines added.

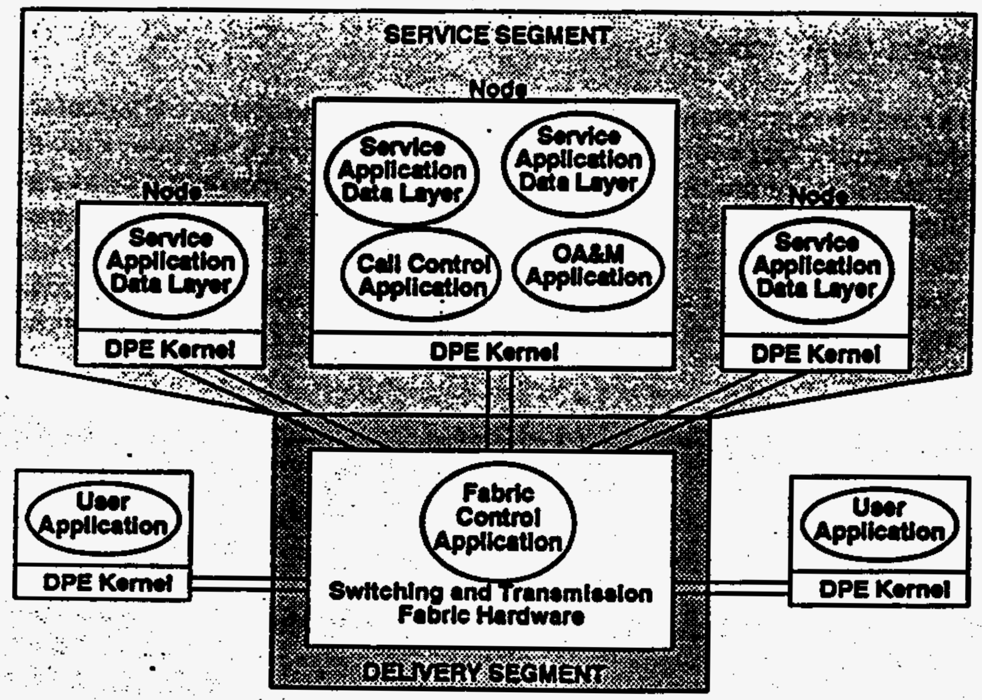

Fig. 5. Bellcore's INA Technical Architecture Concepts.

G-2. BellSouth's Target Information Networking Architecture

G-2.1. Attributes

Before developing a target network architecture, it is essential to understand the drivers that are forcing changes to the current network and to develop a set of attributes for measuring the suitability of the target architecture. This section identifies several attributes that are critical requirements for BellSouth's Information Networking Architecture.

- Supports Multiple Services on a Common Platform

  BellSouth must be able to take advantage of new service opportunities as they arise. However, much uncertainty surrounds the demand, timing, and cross-elasticity of new services now being planned by LECs, ICs, and ESPs. Massive investment in a new service whose success is uncertain entails much risk; however, failure to offer a new service until its success is assured may result in losing customers to competitors while we strive to catch up. BellSouth's target architecture must have the flexibility to support many services over a common platform in order to spread the cost of common network resources over multiple services and to maximize the service opportunities while minimizing the risk of service-specific investments.

- Enables Rapid Service Delivery

  The ability to provision services rapidly is a critical attribute of BellSouth's target architecture. Our customers are no longer willing to wait weeks, or even days, for BellSouth to provision new services, since private networks provide them with immediate responses to reconfiguration requests. A fundamental change must occur in the BellSouth network if we expect to be able to compete with private networks and alternative service providers. BellSouth's target architecture must move the creation, modification, and provisioning of new services closer to the customer.

- Enables BellSouth to Introduce New Service in a Timely Manner

  BellSouth's ability to introduce new services in a timely manner has been hampered by our dependence on switch vendors for the development of new services. The target architecture must allow us to develop our own services and to schedule the availability of new services based on our own assessment of our customers' needs.

- Preserves Customer Investments Through Service Continuity

BellSouth's customers have made substantial investments in customer premises and private network equipment, and a network architecture that ignores this fact is doomed to failure. BellSouth's target architecture must provide for the cost-effective continuity of existing services and capabilities, while at the same time providing the new services required to satisfy our customers' emerging communications needs. Interworking of existing services and capabilities with emerging services is also critical to the success of new services.

- Uses Appropriate Open Standard Interfaces

The use of open standard interfaces 1) encourages the development of common VLSI components to reduce equipment costs, 2) facilitates a multi-vendor environment to allow BellSouth to benefit from the competitive pricing of equipment, and 3) encourages increased use of BellSouth's network by ESPs who can use BellSouth's services as a platform for their enhanced services. However, standards also inhibit vendor innovation and are costly and time-consuming to develop, so care must be taken to standardize only those interfaces necessary to meet BellSouth's strategic needs. BellSouth's target architecture must be based on the use of appropriate standard interfaces required for the timely introduction of new services.

- Provides High Reliability and Survivability

Service outage can have a devastating effect on customers, who have become increasingly dependent on their communications services. BellSouth's reputation for reliable and survivable communications has taken years to build; this reputation is invaluable as competition becomes increasingly fierce. Providing service survivability when individual components of the network fail is a key attribute of BellSouth's target architecture and will be critical in attracting and retaining our most important customers.

- Networks Other Networks

Networks are proliferating: business customers are building their own premises networks, cellular and wireless networks are on the rise, and IC networks are essential for interLATA communications. Enterprise networks are increasingly needing to interconnect with many different types of networks. As this occurs, the LEC's networks must undergo fundamental changes to assume the role of networking other networks together. BellSouth's target network must provide a seamless integration of services across various wireless, wireline, premises, ESP, and IC networks if we are to satisfy the customers' needs and be their provider of choice.

- Integrates Network Elements and Operations Systems into a Common Platform

The distinction between Network Elements (NEs) and Operations Systems (OSs) continues to blur. Using a common architectural platform and common standards for OSs and NEs will allow shared access to data and will enable BellSouth to migrate data and functionality between the two environments as appropriate to meet business and technical needs.

- Provides Independence from Regulatory Decisions

Regulatory issues, such as whether Personal Communications Services (PCS) and residential video services will be classified as basic or enhanced, often take many years to resolve. Wireless networks are expected to grow significantly in the future, but BellSouth's regulated entity may or may not be a wireless service provider. Providing wireless services would be a tremendous opportunity for BellSouth; however, even if this service is classified as enhanced, opportunities still exist to provide complementary services to the enhanced service providers.
16 In particular [redacted]
17
BellSouth's target network architecture must be able to offer new services that are classified as basic and also to offer complementary services to support enhanced services.

- Supports a Wide Range of Communications Bandwidth

Customers' bandwidth requirements have increased markedly over the past decade as their communications have begun to include data, video, and image information, in addition to voice. BellSouth must evolve its network from one optimized for voice communications to one optimized for information networking. Information networks, which carry voice, video, data, and image information, require bandwidths spanning a wide range from a few bits/s for telemetry applications to several hundred Mbit/s for supercomputer interconnection. BellSouth's target information networking architecture must be capable of supporting communications over this entire range in a cost-effective manner.

- Supports Multi-media Communications

Multi-media applications for personal computers and workstations are expected to emerge over the next few years. Companies such as Sun Microsystems and Apple are already developing systems for multi-media communications and are planning LANs based on Asynchronous Transfer Mode (ATM) to support these applications. Support for multi-media communications is a critical attribute for BellSouth's target architecture. [redacted]

- Provides Private and Secure Communications

The current telephone network is perceived as being both private and secure, but these attributes may be threatened in the future. BellSouth's target network architecture must ensure that our customers' communications and control of their communications are protected by building appropriate firewalls into the network architecture.

- Increases Customer Control of Services

Private networks are providing increased control and management capabilities that allow services to be tailored to meet the needs of the enterprise, and customers are becoming increasingly dependent on these capabilities. BellSouth's target architecture must provide similar capabilities to attract customers to public network services, which must integrate the control capabilities needed to provide for the transparent networking of networks.

- Reduce Redundancy in Corporate Databases

BellSouth's OSs currently require that some information be entered into multiple databases; this redundancy results in additional labor and computer storage costs. Furthermore, it results in inconsistent databases, which create additional labor costs to resolve. [redacted]

G-2.2. Description

3 BellSouth's target [redacted] Fig. 6, has been developed to satisfy several key attributes and to provide direction for the near-term
5 evolution of BellSouth's network. [redacted]

- CCS7 provides highly reliable out-of-band message-based network signaling to support existing and future switched narrowband, wideband, and broadband services.
- ISDN extends digital communications and out-of-band message-based signaling capabilities to end users to enable new switched services.
- AIN places the development of new services under BellSouth's control, enabling the rapid introduction of new network services.
- B-ISDN extends ISDN to offer new high-bandwidth communications services to end users and provides them over an integrated platform to minimize capital and operations costs.
- PCS offers new services which give users freedom of movement and increased control from any terminal and to any network.

The public telecommunications network is expected to move from today's POTS-based architecture to a future Information Networking Architecture (INA) that supports information services, including not only voice, but also data, video, and image communications.

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There are many different views on the structure and the timing of INA. For example, Bellcore views INA as a "desert-start" research project, which defines the target without being concerned about the feasibility or practicality of evolving to that target[1]. [redacted]easibility and practicality of evolution are paramount objectives of BellSouth's approach, which starts with the embedded network and integrates flexible capabilities to support information network services, while making use of the embedded infrastructure as much as practical. BellSouth's INA is also based on extensive discussion with vendors to ensure that our evolution plans are aligned with vendors' product development plans.

Fig. 6. BellSouth's Information Networking Architecture.

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[redacted]

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Network signaling for all components of the target architecture is based on the standard open interfaces of the highly-survivable CCS7 network. [redacted] so makes possible interconnection to many other networks, including independent companies, cellular carriers, ICs, and private networks. Thus, [redacted]

Call processing in the target architecture is based on the growable, distributed processing capability of existing digital SPC switching systems and is supplemented by AIN capabilities located in SCPs and ASPINs. [redacted] he operations capabilities required to manage and control the network will be essential to the success of these services.

The optical fiber transmission infrastructure of the target architecture provides the vast bandwidth required to support information networking services, including voice, data, video, and image. SONET survivable rings operating at Gbit/s rates interconnect the Fiber Centers with each other and with ATM access nodes. These nodes provide a common access platform supporting a wide variety of customer interfaces ranging from POTS to ISDN, Switched DS1, Switched DS3, Frame Relay, SMDS, and B-ISDN. A simple line card changeout, or a software download to the line card, is all that is required to provision a new customer interface. This common access platform not only expedites the introduction of new services, thus maximizing our new service opportunities, but also minimizes risk since the incremental investment required to introduce a new service is small.

Optical fiber can extend beyond the access nodes to remote multiplexer nodes, located very near the customer. Video from a CATV headend or an enhanced services provider is wavelength-division-multiplexed onto the fiber at the access node and carried to the remote multiplexer node for delivery to the customer over copper, fiber, or coax facilities. The remote multiplexer node can provide the same variety of customer interfaces as the access node; in addition, if PCS is classified as a basic service, a PCS card can provide wireless access, [redacted]

G-3. 1991 Events

During 1991, the INA Field Experiment Cycle 1 documentation will be written. This includes several types of documents. First, a Framework Architecture is being developed, which outlines the architectural separations, key interfaces and applications for INA Cycle 1. Concurrently, the Service Architecture is being written to describe the INA services according to the five OSI Network Management functional areas (Fault, Configuration, Accounting, Performance, and Security), and an area dealing with call control and customer access to services. Detailed specifications will be written based on each area. Objects will be defined, then grouped into OSCA Building Blocks. Other foundation documents will be written covering related Cycle 1 issues such as Distributed Processing Environment, Data Management, and OSCA Contract Specifications. Service Specifications for Cycle 1 INA services will be developed for each Field Experiment site. The vendor community will be invited to participate by building trial equipment for the Field Experiment. By the end of 1991, the first set of documents on the INA Field Experiment Cycle 1 will be complete.

G-4. 1992 Events

In 1992, the INA architecture from the 1991 documents will be constructed in a lab *prototype*. The lab prototype will be constructed at Bellcore, but the regions will contribute technical expertise and technical direction. Vendors who have chosen to participate may be contributing prototype INA-compliant equipment. Through the lab prototype process, new ideas will be trialed and performance will be verified for the Field Experiment. The documents will be modified to reflect what is learned from the lab prototype. *This stage of the Cycle 1 Field Experiment* will be completed in 1992.

At the same time, documentation for the Cycle 2 of the Field Experiment will be started. Cycle 2 will reflect what has been learned while prototyping and what technologies will be available in the Cycle 2 time-frame.

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G-5. 1993 Events

The INA Field Experiment Cycle 1 specifications verified in the lab prototype will be deployed in several regional company networks. The INA platform (DPE, objects modeling resources, Network Management facilities, call processing, etc.) will be the same in each site, but the services trialed will be different. The results will be incorporated as much as possible into the documentation and prototyping occurring at this time for INA Cycle 2.

G-6. Critical INA Issues

The work of INA should be closely coordinated with the work of the CCS7, ISDN, AIN, B-ISDN, and PCS platforms. In particular,

- How do the distributed processing environment and OSCA coordinate with other platforms?
- What problems arise from an object-oriented view of the network?
- Will platforms that are not compliant with the OSCA architecture be supportable in INA?

Bellcore's working premise for INA is that the existing network can be ignored. In other words, INA is a desert-start model. Clearly, INA must evolve to be part of the network, not a clean replacement. What issues in addition to those above must be taken into account to evolve existing networks to INA?

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GLOSSARY

ACD	Automatic Call Distributor
ACSE	Association Control Service Element
ADM	Add/Drop Multiplexer
ADPCM	Adaptive Differential Pulse Code Modulation
AIN	Advanced Intelligent Network
AN	Access Node
ANC	Area Number Calling
ANSA	Advanced Networked Systems Architecture
ASE	Application Service Element
ASN.1	Abstract Syntax Notation 1
ASPIN	Advanced Services Platform for the Intelligent Network
AT	Access Tandem
ATD	Asynchronous Time Division
ATM	Asynchronous Transfer Mode
B-DCS	Broadband Digital Cross-connect System
B-ISDN	Broadband ISDN
BOSIP	BellSouth Open Systems Interconnection Platform
BRI	Basic Rate Interface
BRSU	Fujitsu Broadband Remote Switch Unit
BSCA	BellSouth Computing Architecture
BSHR	Bidirectional Self-Healing Ring
BVA	Billing Validation Application
CAR	Carrier Access Restriction
CATV	Community Antenna Television
CBR	Constant Bit Rate
CCIS	Common Channel Interoffice Signaling
CCITT	Comité Consultatif International Télégraphique et Téléphonique
CCM	Customer Control Management
CCS	Common Channel Signaling
CCSAC	Common Channel Signaling Access
CDMA	Code Division Multiple Access
CLASS	Custom Local Area Signaling Services
CMISE	Common Management Information Service Element
CMSDB	Call Management Services Data Base
CNRI	Corporation of National Research Initiatives
CO	Central Office
COT	Central Office Terminal
CPE	Customer Premises Equipment
CPU	Central Processor Unit
CRIS	Customer Records Information System
CSCANS	Customer Services Computer Access Network Standards
CT	Cordless Telephone

DAF	Distributed Applications Framework
DARPA	Defense Advanced Research Projects Agency
DCOS	Data Collection Operations System
DCS	Digital Cross-connect System
DECT	Digital European Cordless Telephone
DLBB	Data Layer Building Block
DLC	Digital Loop Carrier
DMS	Digital Multiplex Switch
DOJ	Department of Justice
DPC	Destination Point Code
DPE	Distributed Processing Environment
DQDB	Distributed Queue Dual Bus
DS-n	Digital Signal - Level n
DSS1	Digital Signaling System 1
DTMF	Dual Tone Multifrequency
EADAS	Engineering and Data Acquisition System
EADAS/NM	Engineering and Data Acquisition System/Network Management
ERP	Experimental Research Prototype
ESCORT	Enhanced Services Cordless Telephone
ESP	Enhanced Service Provider
ESS	Electronic Switching System
ETSI	European Telecommunication Standards Institute
FCC	Federal Communications Commission
FDDI	Fiber Distributed Data Interface
FDM	Frequency Division Multiplexing
FITL	FIber in the Loop
FOT	Fiber Optic Terminal
FTAM	File Transfer and Management
FTTC	Fiber to the Curb
FTTH	Fiber to the Home
GFC	Generic Flow Control
HDT	Host Digital Terminal
IC	Interexchange Carrier
IDLC	Integrated Digital Loop Carrier
IEEE	Institute of Electrical and Electronic Engineers
IFTF	Institute For The Future
IMTS	Improved Mobile Telephone Service
IN	Intelligent Network
INA	Information Networking Architecture
IOTP	Integrated Operations Transition Plan
IP	Intelligent Peripheral
IP	Internet Protocol
ISCP	ISDN Signaling Control Part
ISDN	Integrated Services Digital Network

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ISDN-UP	Integrated Services Digital Network - User Part
ISO	International Standards Organization
ISP	Information Strategy Plan
ISUP	Integrated Services Digital Network - User Part
LAN	Local Area Network
LAPD	Link Access Protocol D
LATA	Local Access Transport Area
LEC	Local Exchange Carrier
LEN	Local Exchange Node
LIDB	Line Information Data Base
LSTP	Local Signaling Transfer Point
MAN	Metropolitan Area Network
MBG	Multilocation Business Group
MCNC	formerly Microelectronics Center of North Carolina
MF	Multifrequency
MIB	Management Information Base
MICA	Medical Information Communications Applications
MSU	Message Signal Unit
MTP	Message Transfer Part
MTS	Mobile Telephone Service
MTSO	Mobile Telephone Service Operator
NE	Network Element
NI	National ISDN
NMA	Network Monitoring Analysis
NNI	Network Node Interface
NOC	Network Operations Center
NOI	Notice of Inquiry
NREN	National Research and Education Network
NSDB	Network and Services Data Base
NSF	National Science Foundation
NTI	Northern Telecom, Inc.
NTIA	National Telecommunications Information Administration
NTMOS	Network Traffic Management Operations System
NTT	Nippon Telephone and Telegraph
OA&M	Operations, Administration, and Maintenance
OC-n	Optical Carrier - Level n
ODP	Open Distributed Processing
OMAP	Operations Maintenance and Administration Part
ONU	Optical Network Unit
OPC	Originating Point Code
OS	Operations System
OSCA™	Operations Systems Computing Architecture
OSF	Open Software Foundation
OSI	Open Systems Interconnection

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OTGR	Operations Technology Generic Requirements
PBX	Private Branch Exchange
PCM	Pulse Code Modulation
PCN	Personal Communications Network
PCS	Personal Communications Services
PICS	Plug-in Inventory Control System
PLBB	Processing Layer Building Block
PMS	*PICTUREPHONE* Meeting Service
PNC	Personal Number Calling
PNS	Personal Number Service
PON	Passive Optical Network
POTS	Plain Old Telephone Service
PRA	Primary Rate Access
PRI	Primary Rate Interface
PTN	Personal Telephone Number
PVC	Permanent Virtual Circuit
Q.931	Access Signaling Protocol for ISDN
Q.932	Supplementary Services Signaling Protocol for ISDN
RBOC	Regional Bell Operating Company
RCC	Radio Common Carrier
RCMAC	Recent Change Network Administration Center
RFI	Request for Information
RFP	Request for Proposal
RFQ	Request for Quotation
RMAS	Remote Memory Administration System
RMN	Remote Multiplexer Node
RNS	Regional Negotiation System
ROSE	Remote Operations Service Element
RR	Record Retrieval
RSM	Remote Switch Module
RSTP	Regional Signaling Transfer Point
RT	Remote Terminal
SAS	Service Administration System
SBC	Southern Bell Center
SCCP	Signaling Connection Control Part
SCCS	Switching Center Control System
SCIA	Switch-Computer Applications Interface
SCP	Service Control Point
SDE	Software Development Environment
SEAS	Signaling and Engineering Administrative System
SIP	Subscriber Interface Protocol
SLS	Signaling Link Selection
SMDS	Switched Multimegabit Data Service
SMF	Systems Management Functions

SMFA	Systems Management Functional Areas
SMO	Systems Management Overview
SMS	Service Management System
SN	Services Node
SNA	Systems Network Architecture
SNI	Subscriber Network Interface
SNMP	Simplified Network Management Protocol
SOAC	Service Order Analysis and Control
SONET	Synchronous Optical NETwork
SPC	Stored Program Control
SS7	Signaling System No. 7
SSP	Service Switching Point
STM	Synchronous Transfer Mode
STP	Signaling Transfer Point
STS-n	Synchronous Transport Signal - Level n
SVC	Switched Virtual Circuit
TA	Terminal Adapter
TA	Technical Advisory
TCAP	Transaction Capabilities Application Part
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TEN	Transit Exchange Node
TIRKS	Trunk Integrated Records Keeping System
TL-1	Transaction Language 1
TNS	Total Network Surveillance
TR	Technical Reference
UDLC	Universal Digital Loop Carrier
UDP	User Datagram Protocol
UDPC	Universal Digital Portable Communications
UHF	Ultra High Frequency
ULBB	Upper Layer Building Block
UNC	University of North Carolina
UNI	User-Network Interface
URP	Universal Receiver Protocol
USHR	Unidirectional Self-Healing Ring
VBR	Variable Bit Rate
VC	Virtual Channel
VCC	Virtual Channel Connection
VLSI	Very Large Scale Integration
VMS	Voice Mail System
VP	Virtual Path
VPC	Virtual Path Connection
VPX	Virtual Path Cross-connect

VT	Virtual Tributary
W-DCS	Wideband Digital Cross-connect System
WDM	Wavelength Division Multiplexing
WFA	Work and Force Administration
WFA/C	WFA/Control
WFA/DI	WFA/Dispatch In
WFA/DO	WFA/Dispatch Out

Confidential

Southern Bell Tel. & Tel. Co.
FPSC Docket No. 920260-TL
Audit
Date: 4-9-93
Item No. 1-012.1
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Request: Provide Attachment F, Evolution of OS's, which was missing from the "Network Evolution Plan" provided in response to item 1.12.

Response: Attached is Attachment F, Evolution of OS's, which was inadvertently omitted when the "Network Evolution Plan" was provided on January 21, 1993.

This material constitutes proprietary confidential business information and is covered by the "Notice of Intent to Request Specified Confidential Classification" dated January 21, 1993.

Date Provided: April 16, 1993

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F-1. Background

BellSouth is moving from a predominantly AT&T OS environment to a multi-vendor OS environment, using many Bellcore OSs, some from AT&T, some developed by BellSouth, and a few from other vendors. This evolution is motivated by:

- Economics,
- Need to support multi-vendor network elements,
- Compliance with requirements, and
- Need for automated flow-through with service orders untouched by human hands; this is a major goal of OSs for POTS and for all new architectures.

Fundamental changes will be occurring in OSs over the next decade, as summarized below.

- New platforms such as ISDN, AIN, and B-ISDN will provide the potential for increased operations capabilities. These will create new opportunities for BellSouth to offer increased capabilities to customers.
- OS functions will be increasingly integrated into network elements. For example, the Plug-in Inventory Control System (PICS) is a database that contains information about the type and location of plug-in units. Whenever a plug-in is received, relocated, or removed, a data record of that change must be made in the PICS system. Future plug-ins will eventually contain identifying numbers, and the network elements can be queried from OSs to obtain accurate information about the type and location of plug-ins, thus eliminating the need to maintain a separate database.
- The Transaction Language 1 (TL1) protocol is currently used for OS/NE interfaces. Over the next decade these will migrate to OSI protocols, specifically CMISE and ASN.1. This will allow for OS/OS communications as well as OS/NE communications. OSI standards and requirements for operations technology, transport, and service are listed in Table I [1].

OSI Requirements Plans					
Draft Specification	Formal Product	Completed/Projected Time Frame			Products
		1989	1990	1991	
Alarm Surveillance	ANSI Standard TA-1030 TR	V1 LB Issue 1	V1 Issue 2	Issue 3 Issue 1	NMA
Performance Monitoring	ANSI Standard TA-1030 TR-1014 TR-1014	Issue 1	V1 for LB Issue 2	Issue 1	NMA
Switch Memory Administration (incl. ISDN)	ANSI Standard TA-981 FA-1078 TR	Issue 1	Issue 2 Issue 1	Issue 3 Issue 1	MIZAR CCRS
Transport Memory Administration	ANSI Standard TA-1014 TR	Issue 1	Issue 2	Issue 3 Issue 1	OSP/INE
Network Data Collection	TA-376 TR	Issue 2		Issue 3	DCOS
Network Traffic Management	TA-495 TR	Issue 2		Issue 3	NPMS
Test Access	ANSI Standard TA-1031 TA-1038	Issue 1 Issue 1	Issue 2	Issue 2	
Test Management	FA-1102 TA TR			Issue 1	ITS
SONET	ANSI Standard TA-1042 TR	Issue 1	Issue 2	V1 for LB Issue 1	NMA OPS/INE LINC
ISDN Performance Monitoring	TA-1041TR	Issue 1			NMA
ISDN Testing	TA-1057		Issue 1		ITS
IDLC	TA-303 TR-303	Issue 5	Issue 1 S. 3		NMA OPS/INE
SMDS	TA-774		Issue 2	Issue 3	NMA

Table I. OSI Requirements Plans.

BellSouth and Bellcore have produced guiding documents that discuss operations from a global perspective. Bellcore has consolidated its views into the Operations Technology Generic Requirements (OTRG) [2], a single Technical Reference consisting of many modules. The modules address operations functions such as memory and system administration, network maintenance, message accounting, and network traffic management. There are also modules on the user system interface, the generic operations interface, the embedded operations interfaces, and operations application messages. The modules of the OTGR are continually updated and reissued to reflect new changes in the network and its operations.

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Bellcore has also produced the Integrated Operations Transition Plan (IOTP) [3], which focuses on significant transition steps in operations support systems developed by Bellcore. The IOTP describes the target operations environment in the mid-90's timeframe, including the business and technical drivers that will result increasingly in shared corporate data and end-to-end process automation. After describing the Enterprise Model, the document focuses on the operations processes of Service Activation, Service Assurance, and Network Capacity Provisioning.

[redacted]

It also recommends future support for OSs in each of these categories.

The Bellcore work on Information Networking Architecture is also related to the evolution of OSs. The INA Overview [5] does not partition the network into NEs and OSs. Instead, it proposes a new separation of functionality into a Service Segment and a Delivery Segment, as described in Attachment G, Evolution to INA. The INA Model stresses that as computers are networked and as switching and transmission systems have more sophisticated diagnostics, the functionality of NEs and OSs becomes more and more similar. Thus, the distinction between OSs and NEs is diminished to a distinction, not of functionality, but of characteristics such as the real-time and reliability constraints.

In addition to the overall operations planning, considerable attention has been focused on how to manage the data used by OSs. Some data is useful only within a limited work area, and it is owned and maintained by a single group. Other data is shared among many areas of the company and is used in many functions. This is referred to as Corporate Data. The Corporate Data Position Paper [6] defines Corporate Data in the following way:

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Corporate data is a record of business facts that are necessary to the operation of the corporation, impact its ability to do business, and are potentially shared across work group boundaries.

The distinguishing characteristic of corporate data is that it has meaning outside of a specific work group or mechanized application.

There is no specified owner of corporate data. Therefore, there must be consensus among all involved parties as to the relevant data factors (key characteristics) such as definition, properties, and business rules governing the interactions of function and data.

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F-2. OS Support for CCS7

The OSs supporting CCS 7 are listed below and illustrated in Fig. 1.

- The Signaling and Engineering Administrative System (SEAS) is a multi-function network support system for CCS7. SEAS maintains a network configuration record base, collects and processes data from each STP and SCP, displays network critical event messages, and provides access to STPs for users to enter translations information. SEAS also collects traffic engineering and network management data.

- The Switching Center Control System (SCCS) provides remote monitoring, alarm surveillance and analysis functionality for CO switches, STPs, and SCPs. SCCS collects status and event data from multiple network nodes for display in the centralized Network Operations Center (NOC). It also provides analysis programs that operate on the collected data to assist in localizing troubles. SCCS is being replaced with Network Monitoring Analysis (NMA) beginning in 2Q91.

- The Total Network Surveillance (TNS) is being deployed to integrate multiple SEAS and SCCS outputs for a network view of CCS7 links and nodes. BellSouth's long term maintenance will be handled by NMA. NMA is currently deployed throughout BellSouth to support facility maintenance. The NMA-SWITCH module will eventually surpass SCCS capabilities.

- The Service Management System (SMS) provides administration support for SCPs. BellSouth currently uses the Bellcore SMS for 800 service control and report thresholding. A new BellSouth SMS will handle AIN requirements.

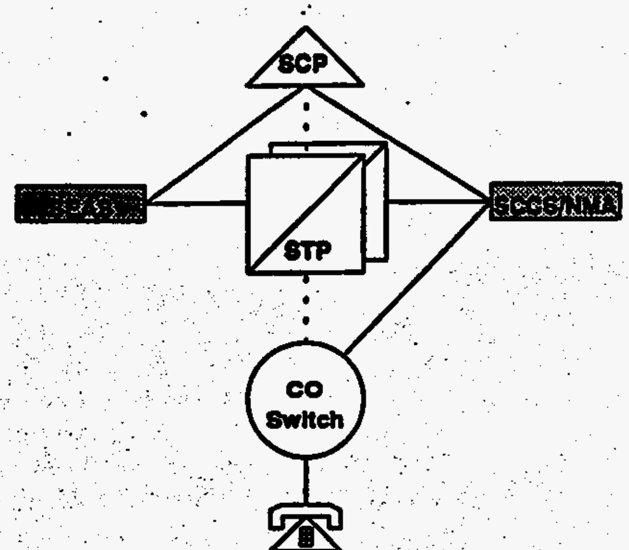

Fig. 1. BellSouth Target OS Support for CCS7.

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F-3. OS Support for ISDN

ISDN will provide the potential for additional operations capabilities, such as performance monitoring of the local loop. This will allow us to identify and correct potential problems even before the customer is aware that the problem exists.

One innovation planned by at least one vendor is a line card that can function as either a POTS or an ISDN line access card under software-downloadable control. This is consistent with the target architecture attribute of being able to support multiple services over a common platform and has the potential to significantly simplify provisioning by eliminating the need to send a craftsperson out to change a plug-in. It will also result in the reduction of maintenance spare plug-in inventory levels.

Enhancements are now being made to several OSs to support the new operations capabilities of ISDN. These OSs will be extensions of existing OSs as much as practical from an economic perspective. Fig. 2 shows the OSs that are planned to support ISDN.

The Service Order Analysis and Control (SOAC) receives service orders from the service order processor for ISDN as well as other services. The Memory Administration Systems (MAS) load and update the recent change memory in switching systems, and they support the Recent Change Memory Administration Centers (RCMAC) and Network Operations Center (NOC). The MAS systems that are currently in use in BellSouth are the Remote Memory Administration System (RMAS) and (MIZAR).

The Network and Services Data Base (NSDB) is a Bellcore-developed application designed to provide a common data source for OSs. NSDB receives data from Trunk Integrated Records Keeping System (TIRKS) and Work and Force Administration/Control (WFA/C). SOAC will provide NSDB with service order data needed to support ISDN. NSDB provides the carrier, circuit, and ISDN database for the Integrated Test System (ITS). NSDB also provides real-time facility and equipment data to Network Monitoring and Analysis (NMA).

ITS is a Bellcore-developed application that serves as the testing and analysis OS for the installation and maintenance of multiple services, such as analog and digital special services and ISDN BRI. ITS also contains "flow-through" software that will automatically test and hand-off problems without human intervention. Future enhancements being considered are support for FITL, SONET transport, AIN, and POTS.

WFA provides the basic functionality for the provisioning and maintenance of non-designed and designed services. Initially, support for the installation of ISDN basic service will be provided within WFA Control (WFA/C) and WFA Dispatch Out (WFA/DO). Maintenance support will include WFA/C, WFA/DO, and , in addition, WFA Dispatch In (WFA/DI). Trouble reports are entered into WFA/C and handed off to either WFA/DO or WFA/DI.

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Fig. 2. BellSouth Target OS Support for ISDN.

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