ORIGINAL

RECEIVED-FPSC

00 OCT 27 PM 4:36

RECORDS AND REPORTING

Legal Department

E. EARL EDENFIELD, JR.
General Attorney

BellSouth Telecommunications, Inc.
150 South Monroe Street
Room 400
Tallahassee, Florida 32301
(305) 347-5561

October 27, 2000

Mrs. Blanca S. Bayó
Director, Division of Records and Reporting
Florida Public Service Commission
2540 Shumard Oak Boulevard
Tallahassee, FL 32399-0850

Re: 000084-TP (US LEC Arbitration)

Dear Ms. Bayó:

Enclosed is an original and fifteen copies of BellSouth Telecommunications, Inc.'s Rebuttal Testimony of Cynthia K. Cox, which we ask that you file in the captioned docket.

A copy of this letter is enclosed. Please mark it to indicate that the original was filed and return the copy to me. Copies have been served to the parties shown on the attached Certificate of Service.

Sincerely,

E. Earl Edenfield Jr.
(AM)

E. Earl Edenfield, Jr.

Enclosures

cc: All Parties of Record
Marshall M. Criser III
R. Douglas Lackey
Nancy B. White

APP ____
CAF ____
CMP ____
COM 3 + org
CTR ____
ECR ____
LEG 1
OPC ____
PAI ____
RGO *
SEC 1
SER ____
OTH ____

RECEIVED & FILED
FPSC-BUREAU OF RECORDS

DOCUMENT NUMBER-DATE
13855 OCT 27 8
FPSC-RECORDS/REPORTING

CERTIFICATE OF SERVICE
Docket No. 000084-TP

I HEREBY CERTIFY that a true and correct copy of the foregoing was served via U.S. Mail this 27th day of October, 2000 to the following:

Diana Caldwell
Staff Counsel
Florida Public Service
Commission
Division of Legal Services
2540 Shumard Oak Boulevard
Tallahassee, FL 32399-0850

Aaron Cowell
Executive Vice President and
General Counsel
US LEC Corporation
Transamerica Square
401 N. Tryon Street, Suite 1000
Charlotte, N.C. 28202
Tel. No. (704) 319-1117
Fax. No. (704) 319-0069

Kenneth A. Hoffman, Esq.
John R. Ellis, Esq.
Rutledge, Ecenia, Purnell & Hoffman
P.O. Box 551
Tallahassee, FL 32302
Tel. No.: (850) 681-6788
Fax. No. (850) 681-6515

E. Earl Edenfield Jr.

E. EARL EDENFIELD, JR (pw)

BELLSOUTH TELECOMMUNICATIONS, INC.
REBUTTAL TESTIMONY OF CYNTHIA K. COX
BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION
DOCKET NO. 000084-TP
OCTOBER 27, 2000

Q. PLEASE STATE YOUR NAME, YOUR POSITION WITH BELLSOUTH TELECOMMUNICATIONS, INC. ("BELLSOUTH") AND YOUR BUSINESS ADDRESS.

A. My name is Cynthia K. Cox. I am employed by BellSouth as Senior Director for State Regulatory for the nine-state BellSouth region. My business address is 675 West Peachtree Street, Atlanta, Georgia 30375.

Q. HAVE YOU PREVIOUSLY FILED TESTIMONY IN THIS DOCKET?

A. Yes. I filed direct testimony on September 21, 2000.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. My testimony rebuts the direct testimony filed by US LEC of Florida, Inc. ("US LEC"), witnesses Wanda Montano and Timothy J. Gates, on October 13, 2000.

DOCUMENT NUMBER-DATE
13855 OCT 27 8
FPSC-RECORDS/REPORTING

*Issue 1: **Should BellSouth be required to include US LEC's logo on the cover of BellSouth's White Page and Yellow Page directories?***

Q. MS. MONTANO STATES, ON PAGE 2 OF HER TESTIMONY, THAT THE REQUIREMENT FOR NONDISCRIMINATORY ACCESS TO DIRECTORY LISTINGS INCLUDES A REQUIREMENT THAT AN ALEC'S LOGO BE PLACED ON THE COVER OF BELLSOUTH'S DIRECTORIES. . PLEASE COMMENT.

A. As stated in my direct testimony, BellSouth agrees that Section 251(b)(3) of the 1996 Act requires that BellSouth permit ALECs to have nondiscriminatory access to directory listings. There is nothing in Section 251 or Section 271 which indicates that the term "directory listings" includes printing of an ALEC's logo on the cover of the ILEC's directory. In fact, in the FCC's Order 98-271, CC Docket No. 98-121, dated October 13, 1998 (BellSouth's Application for Provision of In-Region, InterLATA Services in Louisiana – "Louisiana II"), states at ¶252:

Section 271(c)(2)(B)(viii) requires a BOC to provide "[w]hite pages directory listings for customers of the other carrier's telephone exchange service" We note that section 251(b)(3) obligates all LECs to permit competitive providers of telephone exchange service to have nondiscriminatory access to directory listings. Given the similarity of the language in these two sections of the Act, we believe it reasonable to conclude that the term "directory listing" as used in section 251(b)(3) is comparable to "white pages directory listings" as used *in section 271(c)(2)(B)(viii). In the Local Competition Second Report and Order, the Commission determined that, "[a]s a minimum standard... the term 'directory listing' as used in section 251(b)(3) is synonymous with the definition of 'subscriber list information' in section 222(f)(3)." In addition, the Commission has previously stated that "[a] white pages directory is a compilation of the individual white pages listings.*

Thus, the only applicable requirement is that BellSouth include US LEC's subscriber listings in BellSouth's white pages directory listings. There is no mention of a requirement to include the ALEC's logo on the cover of the directory. The Public Service Commissions in Louisiana and South Carolina and the FCC found BellSouth to have satisfied the white pages checklist requirement - checklist item (viii). In addition, the Florida Public Service Commission found BellSouth to be compliant as to Checklist Item 8 as follows:

> *"ORDERED that BellSouth is providing white page directory listings in accordance with Section 271(c)(2)(B)(viii), of the Telecommunications Act of 1996, as discussed in Section VI.H. of this Order." Order No. PSC-97-1459-FOF-TL, dated November 19, 1997.*

There is no additional requirement of either the FCC or this Commission that BellSouth must include ALEC logos on its directory covers.

Q. IN US LEC WITNESS MONTANO'S TESTIMONY (P. 3), SHE SAYS "IN REFUSING TO INCLUDE US LEC'S LOGO ON ITS DIRECTORIES,

BELLSOUTH HAS ATTEMPTED TO SHIELD ITSELF BEHIND ITS UNREGULATED AFFILIATE, BAPCO, THE PUBLISHER OF BELLSOUTH'S DIRECTORY LISTINGS." PLEASE COMMENT.

A. USLEC is incorrect by asserting that BellSouth is "shielding itself" through BAPCO. The only question that needs to be answered is whether placing US LEC's logo on a directory published by BellSouth is a requirement under Checklist Item 8. This commission and every other one faced with the question, including Tennessee, has found that there is no such requirement on BellSouth or on its affiliate BAPCO. In Tennessee (as my testimony makes clear elsewhere), the TRA established a separate docket in reply to a subsequent request from AT&T. The TRA was prevented by the Tennessee Court of Appeals from enforcing that decision, and that stay remains in effect, pending a final decision by the court.

Q. FURTHER ON PAGE 3, MS. MONTANO STATES, "BAPCO's REFUSAL TO INCLUDE US LEC'S LOGO ON THE COVER OF ITS WHITE PAGES AND YELLOW PAGES, WHILE INCLUDING BELLSOUTH'S LOGO, VIOLATES SEC. 251(b)(3) OF THE ACT, FOR THE SAME REASON THAT BELLSOUTH ITSELF WOULD VIOLATE THE ACT FOR THE SAME CONDUCT." WHAT IS YOUR RESPONSE?

A. Both Section 271(B) (viii) [Checklist Item 8] and Section 251(b)(3) call for "access" and/or "interconnection" related to directory listings. The Act elsewhere specifically defines what subscriber list information means in Section

222(f)(3). In no place does the Act place any other directory requirements on BellSouth. US LEC's argument that BellSouth's conduct, in BAPCO's use of the BellSouth name, violates the Act is incorrect.

BAPCO publishes White Pages directories for BellSouth. BAPCO also publishes directories on behalf of other local service providers. Having directories published through a separate entity serves many useful purposes, not the least of which is the focus it provides in offering listings, advertising and other services to local service providers like US LEC. We offer customer guide pages to LECs, listing related training and other services to LECs. The fact is, however, that the directory business is in another BellSouth entity, because it is different and appropriately separate from the regulated telephone business, and not because BellSouth would avoid any obligation placed by the Commission separate and apart from this more narrow proceeding.

Q. IN HER TESTIMONY ON PAGE 4, MS. MONTANO STATES THAT ICG AND NEXTLINK WERE INCLUDED ON THE NASHVILLE, TENNESSEE DIRECTORY COVER, WHILE US LEC WAS NOT INCLUDED. PLEASE EXPLAIN.

A. Both ICG and Nextlink were on the cover of the Nashville directory for one book and only one time. That one instance was the result of a temporary settlement with the Commission and parties to the special docket pending appeal. We are no longer required to include any other local service provider's name or logo on our directory covers by order of the Court of Appeals, by virtue of the stay issued by the court. In fact, subsequent White Pages directories have been published for Nashville and other Tennessee cities since that time, without any ALECs' names on the cover.

Issue 2: Should BellSouth be required to provide US LEC's Subscriber Listing Information ("SLI") to third party publishers? If so, under what terms?

Q. ON PAGE 5, MS. MONTANO SAYS THAT BELLSOUTH INACCURATELY STATES THAT THE DISPUTE UNDER ISSUE 2 IS WHETHER "BELLSOUTH [IS] REQUIRED TO PROVIDE US LEC'S SUBSCRIBER LISTING INFORMATION ('SLI') TO THIRD PARTY PUBLISHERS." PLEASE EXPLAIN.

A. BellSouth is asking this Commission to confirm that there is no <u>requirement</u> under the Act or the FCC's rules for BellSouth to provide US LEC's SLI to third party publishers. Since there is no such requirement under the Act or the FCC's rules, it would be inappropriate for this Commission to either require BellSouth to provide US LEC's SLI to third party publishers, or to mandate the terms under which BellSouth might provide such listings. In fact, BellSouth has agreed to provide US LEC's SLI to third party publishers as a voluntary, negotiated agreement, outside the requirements of the Act or the FCC's rules. The dispute between the parties is whether BellSouth should be required to pay US LEC a proportionate share of any revenues BellSouth may receive for providing US LEC's customer lists to third parties. BellSouth's position is that it is not appropriate for this Commission to require any such sharing of revenues or to mandate any terms for a voluntary offer that is not an obligation of BellSouth. If US LEC wants to receive compensation for its own SLI, it can provide the information to third party publishers itself, as, in fact, other ALECs have chosen to do.

Q. ON PAGE 7, MS. MONTANO CITES FCC RULE 51.217(c)(3)(i) AS REQUIRING BELLSOUTH TO PROVIDE US LEC'S SLI TO THIRD PARTY PUBLISHERS. DOES THE RULE MAKE SUCH A REQUIREMENT?

A. No. FCC Rule 51.217(c)(3)(i) states: "A LEC shall permit competing providers to have access to its directory assistance services so that any customer of a competing provider can obtain directory listings, except as provided in paragraph (c)(3)(iii) of this section, on a nondiscriminatory basis, notwithstanding the identity of the customer's local service provider, or the identity of the provider for the customer whose listing is requested." This is a requirement that customers of competing providers be able to obtain Directory Assistance listings. Clearly, this rule does not require BellSouth to provide US LEC's or any other ALEC's listings to directory publishers.

Q. DOES BELLSOUTH HAVE AGREEMENTS WITH OTHER ALECS TO PROVIDE COMPENSATION AS A RESULT OF PROVIDING THE ALEC'S SUBSCRIBER LIST TO THIRD PARTIES?

A. No. BellSouth does not have any agreements with ALECs or Independent

Companies (ICOs) to share any compensation received from third party publishers as a result of providing other companies' subscriber listings. In the past, we compensated ICOs for provision of their listings. However, in the Fall of 1999, through renegotiation of ICO agreements, we specified in all the contracts that compensation for such listings would not apply. We are not currently paying any ICOs for these listings.

Issue 3: Should BellSouth be permitted to designate more than one Point of Interface in the same LATA for BellSouth originated traffic to be delivered to US LEC? If so, under what conditions?

Issue 5: Should parties be required to provide facilities for the transport of traffic from a Point of Interface (POI) to their own end users?

Q. WHAT IS THE ESSENCE OF THE DISPUTE BETWEEN THE PARTIES ON THESE ISSUES?

A. As I stated in my direct testimony, in a nutshell, these issues are about whose customers should pay for the costs that US LEC creates as a result of its network design decisions. US LEC wants BellSouth's customers to bear those costs. Not surprisingly, BellSouth's position is that US LEC's customers should bear the costs of US LEC's decisions. All of the discussion concerning who gets to establish points of interconnection, how many points there will be, when reciprocal compensation applies to the facilities, etc. are simply a means to an end. And that end is whether customers that US LEC does <u>not</u> serve should bear the additional costs that result from US LEC's network design or whether US LEC's own customers should bear those costs. Although the processes required to implement the parties' positions concerning network interconnection are very complicated, the Commission only has to decide whether US LEC should bear the full costs of its network design.

Q. BEGINNING AT PAGE 10, MR. GATES' TESTIMONY IMPLIES THAT US LEC'S NETWORK DESIGN REPRESENTS AN EFFICIENT NETWORK ARCHITECTURE. PLEASE RESPOND.

A. US LEC equates efficiency with what is cheapest for US LEC. As explained in my direct testimony (pages 18-19), to measure efficiency, the cost to every carrier involved should be considered. A principal reason that US LEC's choice is more economical for US LEC is that it expects BellSouth's customers to bear substantially increased costs that US LEC causes by its network design. As I described in detail in my direct testimony, it simply doesn't make any sense for BellSouth to incur the cost of hauling a local Lake City call outside the local calling area with no compensation just because US LEC wants us to do so. If US LEC bought these facilities from anyone else, US LEC would pay for the facilities. However, US LEC doesn't want to pay BellSouth for the same capability.

US LEC's method of transporting local traffic is clearly more costly to BellSouth, but US LEC blithely ignores the additional costs they want BellSouth to incur. (Exhibit CKC-1 of my direct testimony includes diagrams which illustrate the additional costs caused by US LEC.) Of course, these increased costs will ultimately be borne by customers. If US LEC has its way, these costs will be borne by BellSouth's customers. I submit that competition should reduce costs to customers, not increase them. Competition certainly is not an excuse for enabling a carrier to pass increased costs that it causes to customers it doesn't serve. BellSouth requests that this Commission require US LEC to bear the cost of hauling local calls outside BellSouth's local calling areas.

Q. PLEASE RESPOND TO MR. GATES' STATEMENT, AT PAGE 25, THAT "EACH LEC BEARS THE RESPONSIBILITY OF OPERATING AND MAINTAINING THE FACILITIES USED TO TRANSPORT AND DELIVER TRAFFIC ON ITS SIDE OF THE POI. ... LIKEWISE, AN INTERCONNECTING TERMINATING LEC WILL BEAR RESPONSIBILITY FOR THE FACILITIES ON ITS SIDE OF THE POI, BUT THEN RECOVER THE COSTS OF TRANSPORTING AND TERMINATING TRAFFIC OVER THOSE FACILITIES FROM THE ORIGINATING LEC, IN THE FORM OF RECIPROCAL COMPENSATION."

A. Mr. Gates is wrong. As I described in my direct testimony, the facilities discussed in this issue facilitate interconnection. These are not transport and termination facilities. In paragraph 176 of FCC Order 96-325, the FCC clearly stated that interconnection does not include transport and termination. Indeed, reciprocal compensation charges for transport and termination apply only to facilities used for transporting and terminating traffic, not for interconnection of the parties' networks.

Q. ON PAGES 24-25, MR. GATES CITES THE JUNE 21, 2000 FCC ORDER IN THE TSR WIRELESS COMPLAINT CASE AGAINST US WEST AS EVIDENCE THAT "EACH LEC BEARS THE RESPONSIBILITY OF OPERATING AND MAINTAINING THE FACILITIES USED TO TRANSPORT AND DELIVER TRAFFIC ON ITS SIDE OF THE POI. THIS RESPONSIBILITY EXTENDS TO BOTH THE TRUNKS AND FACILITIES AS WELL AS THE TRAFFIC THAT TRANSITS THOSE TRUNKS AND FACILITIES."

FURTHER, MR. GATES STATES, "US LEC SHOULD NOT HAVE TO PAY BELLSOUTH FOR THE INTERCONNECTION TRUNKS AND FACILITIES THAT TRANSPORT BELLSOUTH-ORIGINATED TRAFFIC TO US LEC FOR TERMINATION." (PAGE 26) PLEASE RESPOND.

A. I think the case Mr. Gates relies upon is very important and does provide clear direction on this point. It does not, however, make the point that Mr. Gates asserts, that is, that BellSouth is required to haul traffic from a remote local calling area to US LEC's single point of interconnection in a LATA, if that is what Mr. Gates actually believes.

To the contrary, the Order Mr. Gates cites is completely consistent with BellSouth's position in this case. In the TSR Order, the FCC determined a couple of things. First, the FCC identified the MTA as the local calling area for telecommunications traffic between a LEC and a CMRS provider as defined in 47 CFR Section 51.701(b)(2). That really isn't in dispute and wasn't in dispute in the TSR case. The MTA has been defined, for CMRS purposes, as a local calling area. Second, the FCC determined that this rule, when read in conjunction with 51.703(b) requires LECs to deliver, without charge, traffic to CMRS providers anywhere within the local calling area, or MTA, in which the call originated. This point is really important and the FCC order deserves quoting. The FCC in the TSR order, at page 22, said that local exchange carriers are required "to deliver, without charge, traffic to CMRS providers anywhere within the MTA in which the call originated, with the exception of RBOCs...." The FCC did not say, in this case, that local exchange carriers were required to deliver calls to CMRS providers to points outside the MTA in which the call originated, but rather only had to deliver such traffic at no charge within the MTA where the call originated.

With regard to traffic that originates on the incumbent local exchange carrier's network, the relevant area in which the traffic has to be delivered free of charge is defined in Section 51.701(b)(1) as the "local service area established by the state commission." To clarify, Section 51.701(b) provides as follows:

> *(b) <u>Local telecommunications traffic</u>. For purposes of this subpart, local telecommunications traffic means:*
>
> *<u>(1)</u> telecommunications traffic between a LEC and a telecommunications carrier other than a CMRS provider that*

> *originates and terminates within a local service area established by the state commission; or*
>
> *(2) telecommunications traffic between a LEC and a CMRS provider that, at the beginning of the call originates and terminates within the same Major Trading Area, as defined in § 24.202(a) of this chapter."*

Therefore, BellSouth is not required, with regard to LEC to ALEC traffic to deliver the traffic without charge to US LEC to any point outside of the "local service area established by the state commission." This is entirely consistent with BellSouth's position. We are only obligated to deliver local calls to US LEC at a point within the local calling area where the call originates. The portion of the FCC order quoted on pages 25 and 26 of Mr. Gates' testimony must be read in the complete context of this order, which clearly limits BellSouth's obligation to deliver traffic to US LEC at no charge to only within the local calling area.

Q. HOW DOES THE FCC ADDRESS THE ISSUE OF ADDITIONAL COSTS CAUSED BY AN ALEC'S CHOSEN FORM OF INTERCONNECTION?

A. As stated in my direct testimony (page 19) in its First Report and Order (Order No. 96-325) in Docket 96-98, the FCC states that the ALEC must bear those costs. Paragraph 199 of the Order states that "a requesting carrier that wishes a 'technically feasible' but expensive interconnection would, pursuant to section

252(d)(1), be required to bear the cost of that interconnection, including a reasonable profit." Further, at paragraph 209, the FCC states that:

> *Section 251(c)(2) lowers barriers to competitive entry for carriers that have not deployed ubiquitous networks by permitting them to select the points in an incumbent LEC's network at which they wish to deliver traffic. Moreover, because competing carriers must usually compensate incumbent LECs for the additional costs incurred by providing interconnection, competitors have an incentive to make economically efficient decisions about where to interconnect."* (emphasis added)

BellSouth's position on this issue is consistent with the FCC's Order.

Q. ON PAGE 11, MR. GATES CITES FPSC ORDER NO. PSC-97-0122-FOF-TP (FEBRUARY 3, 1997) AND THE FCC ORDER APPROVING SOUTHWESTERN BELL'S ENTRY INTO THE TEXAS LONG DISTANCE MARKET AS EVIDENCE THAT AN ALEC HAS THE OPTION TO INTERCONNECT AT ONLY ONE TECHNICALLY FEASIBLE POINT IN EACH LATA. PLEASE COMMENT.

A. We agree that the FCC Order No. 00-238 (CC Docket No. 00-65, Released June 30, 2000 at paragraph 78) states that an ALEC has the option to interconnect at only one technically feasible point in each LATA. As stated in my direct testimony, US LEC can pick any POI in the LATA that is technically feasible. It can choose one or more POIs in the LATA. However, US LEC still has financial responsibility for getting to the local network where it wishes to serve customers; and BellSouth is not obligated to deliver at no charge its originating traffic to US LEC's POI outside the local calling area where the calls originate.

Q. PLEASE COMMENT ON MR. GATES' CLAIM, AT PAGE 14, THAT ALECS HAVE THE RIGHT TO DESIGNATE POIS, BUT ILECS SUCH AS BELLSOUTH DO NOT.

A. Mr. Gates is incorrect. As explained in my direct testimony (pages 22-25), the FCC permits ALECs to designate a POI on the ILEC's network for traffic originated by the ALEC. It does not allow the ALEC to specify a POI for traffic originated on the ILEC's network. (See discussion in my direct testimony on pages 22-24, quoting the FCC's Local Competition Order.) The POI for BellSouth's originated traffic is a single point in a local calling area to which BellSouth will deliver all of its customers' traffic to the ALEC. The traffic originated by all BellSouth customers in a local calling area would be transported by BellSouth to a single point in that local calling area at no charge to the ALEC. This point represents the highest degree of aggregation for the local calling area that BellSouth can provide to US LEC. Assuming there is more than one wire center in the local calling area, US LEC can then pick up all of BellSouth's traffic that originates in that local calling area at a single point rather than having to pick up the traffic at each individual wire center.

Mr. Gates complains that BellSouth doesn't have the authority to deliver its originated traffic in this manner. I disagree. As stated in my direct testimony, BellSouth has the right to establish a single POI in each local calling area for its originating traffic. If BellSouth didn't aggregate the traffic in this way, the cost to US LEC likely would be higher. However, if US LEC wants to pick up the traffic at each of BellSouth's end offices instead of using the BellSouth designated POI, it certainly is free to do so.

Q. PLEASE COMMENT ON MR. GATES' IMPLICATION AT PAGE 14 THAT US LEC'S ABILITY TO COMPETE WOULD BE HAMPERED BY US LEC'S INABILITY TO OBTAIN FREE FACILITIES FROM BELLSOUTH.

A. Mr. Gates is incorrect. I addressed this thoroughly in my direct testimony at pages 21-22. As I have already stated, all carriers must bear their own costs of interconnection. Therefore, US LEC is in the same competitive position as other carriers. Apparently, what US LEC believes is that instead of bearing its own costs, it should be able to have BellSouth's customers subsidize its interconnection in a way that, in fact, would give it an unfair advantage.

Issue 4: What is the appropriate definition of "serving wire center" for purposes of defining transport of the parties' respective traffic?

Q. WHAT HAS US LEC PROPOSED AS THE DEFINITION OF A SERVING WIRE CENTER?

A. On page 16 of the testimony of Mr. Gates, US LEC states that generally, "a serving wire center is synonymous with a central office." Mr. Gates goes on to say that by central office, he is referring "to a 'class 5' central office where the local exchange company terminates the subscriber outside plant...Essentially, a serving wire center is the central office with entrance facilities for the ALEC." As I explained in my direct testimony, BellSouth's proposed definition of serving wire center is "the wire center owned by one Party from which the other Party would normally obtain dial tone for its Point of Presence." A serving wire center is not synonymous with central office. Instead, a serving wire center is a specific central office determined by the location of the ALEC's point of presence. Mr. Gates seems to acknowledge this by recognizing that a switch would have entrance facilities for the ALEC. BellSouth agrees, and the entrance facilities are in fact local channels as proposed by BellSouth.

Q. ON PAGES 17-19 OF HIS TESTIMONY, MR. GATES ILLUSTRATES AN EXAMPLE WHICH "HIGHLIGHTS THE ANTICOMPETITIVE IMPACT OF BELLSOUTH'S PROPOSAL TO UNILATERALLY DESIGNATE POIS FOR BELLSOUTH-ORIGINATED TRAFFIC. IF BELLSOUTH DESIGNATES POIS AT END OFFICES SOME DISTANCE FROM US LEC'S POI, THE INTERCARRIER COMPENSATION WILL NOT BE SYMMETRICAL." (PAGE 19) DO YOU AGREE?

A. No, BellSouth does not agree that US LEC or any other ALEC is, or will be, disadvantaged by BellSouth's placement of POIs. The issue here is not whether or not US LEC will be disadvantaged through a proposed definition of serving wire center. US LEC plainly seeks to receive Dedicated Interoffice Channel Transport rates when it is not performing the function that entitles an ALEC to such compensation. Dedicated Interoffice Channel Transport is charged for transport between two Bellsouth wire centers or two US LEC wire centers. As Mr. Gates' diagrams show, US LEC has only one wire center and therefore is not providing interoffice transport. However, BellSouth has two wire centers, and is entitled to charge for the interoffice transport when it provides this function.

Issue 6a: Which rates should apply for the transport and termination of local traffic: composite or elemental?

Issue 6b: If elemental rates apply, should US LEC be compensated for the tandem switching elemental rates for purposes of reciprocal compensation?

Q. ON PAGE 31, MR. GATES STATES THAT RECIPROCAL COMPENSATION RATES THAT US LEC CHARGES BELLSOUTH MUST BE SYMMETRICAL WITH THE RECIPROCAL COMPENSATION RATES THAT BELLSOUTH CHARGES US LEC. IS BELLSOUTH PROPOSING SOMETHING DIFFERENT?

A. No. BellSouth is proposing that symmetrical reciprocal compensation rates apply to the extent that both parties are serving a comparable geographic area and are performing the same function. Mr. Gates even states that US LEC's proposed composite rate is the sum of the individual rate elements for tandem switching, tandem transport termination, tandem transport mileage and end office switching. To the extent that both parties are performing the same functions, and that tandem switching is applicable, reciprocal compensation is symmetrical for this function. The difference in the parties' positions is that US LEC's composite rate would result in US LEC being compensated for tandem switching and transport, regardless of whether it provides these services or serves a comparable geographic area.

Q. ON PAGE 31, MR. GATES SAYS THAT THE APPROPRIATE RATES FOR RECIPROCAL COMPENSATION ARE BELLSOUTH'S *TARIFFED* RATES FOR TANDEM SWITCHING, TANDEM TRANSPORT TERMINATION, TANDEM TRANSPORT MILEAGE AND END OFFICE SWITCHING. DO YOU AGREE?

A. No. As stated in my direct testimony (page 30), the appropriate rates are the UNE reciprocal compensation rates as previously approved by this Commission, with the distinction that all of the rates apply only if the applicable facilities are actually used to transport or terminate the local call within the local calling area.

Q. MS. MONTANO HAS LISTED THE GEOGRAPHIC AREA SERVED BY US LEC'S SWITCHES IN FLORIDA ON PAGE 11 OF HER TESTIMONY. BASED ON THIS TESTIMONY, DO US LEC'S SWITCHES IN FLORIDA SERVE A GEOGRAPHIC AREA COMPARABLE TO BELLSOUTH'S TANDEM SWITCHES?

A. No. Based on the number of customers served, I do not believe that US LEC is serving a comparable geographic area. Based on Ms. Montano's testimony, it is impossible to determine where US LEC's customers are located. For example, in Orlando, US LEC has 337 customers throughout 12 wire centers. This could mean that US LEC has 11 wire centers with one customer each and one wire center with 326 customers. This would not demonstrate that US LEC is serving a comparable geographic scope.

Q. WHAT EVIDENCE DOES BELLSOUTH HAVE TO DEMONSTRATE ITS TANDEM SWITCH COVERAGE?

A. Attached to this testimony as Exhibit CKC-3 are BellSouth's maps indicating the areas served by BellSouth's Local Tandems in the Orlando, Jacksonville and Southeast LATAs in Florida. BellSouth's local tandems serve wire centers as shown on the maps in various colors as noted in the legend on each map. These various colored wire centers are only those that home on the applicable local tandem for completion of calls in their basic local calling areas. Note that the independent wire centers have an X in the 7th character position.

R. DO YOU AGREE WITH MR. GATES' CLAIM (PAGE 33) THAT WHEN THE ALEC'S SWITCH SERVES AN AREA COMPARABLE TO THE AREA SERVED BY BELLSOUTH'S TANDEM SWITCH THAT THE ALEC HAS MET THE "SINGLE CRITERION" TO ALLOW THE ALEC TO CHARGE THE TANDEM SWITCHING RATE?

A. No. As discussed in my direct testimony (pages 37-38), clearly, the FCC has a two-part test to determine if a carrier is eligible for tandem switching; an ALEC's switch must serve the same geographic area as the ILEC's tandem switch, and an ALEC's switch must perform <u>local</u> tandem switching functions. This position was reiterated by the U.S. District Court in <u>MCI Telecommunication Corp. v. Illinois Bell Telephone</u>, and the Ninth Circuit Court of Appeals in <u>U.S. West Communications v. MFS Intelenet, Inc., et. al.</u> as cited in my direct testimony.

Q. WHAT WAS THE STATUS OF THE FCC'S RULE 51.711 AT THE TIME OF THESE RULINGS?

A. At the time of both rulings, the Eighth Circuit had reinstated Rule 51.711. Also, the FCC's Rule 51.711 was in effect at the time that the Illinois Commerce Commission and the Washington Utilities and Transportation Commission made their original rulings in these cases.

Q. ON PAGES 32-33, MR. GATES QUOTES FCC RULE 51.711(a), PLACING EMPHASIS ON SUBPART (3) OF THE RULE AND IGNORING SUBPART (1). IN YOUR OPINION, HAS MR. GATES ACCURATELY INTERPRETED THIS RULE?

A. Absolutely not. Mr. Gates self-servingly ignores subpart (1) of this rule. Subpart (1) clearly states that symmetrical rates assessed by an ALEC upon an

ILEC for transport and termination of local traffic are equal to the rates "that the incumbent LEC assesses upon the other carrier for the same services." (emphasis added) "Same services" equates to the same functions that the ILEC performs to transport and terminate the ALEC's originating local traffic. US LEC is only entitled to assess tandem switching charges upon BellSouth when US LEC actually performs the tandem switching function for local calls and actually serves an area geographically comparable to the area served by Bellsouth's tandem switch to terminate a local call originating from a BellSouth end user. Similarly, BellSouth may only seek recovery of tandem switching charges from US LEC when BellSouth performs the tandem switching function to terminate a local call originating from a US LEC end user.

Q. HAS THE COMMISSION PREVIOUSLY DECIDED ON THIS ISSUE?

A. Yes. In my direct testimony I discussed several decisions by the Commission addressing both the geographic coverage and functionality criteria that an ALEC must meet to be eligible to charge for tandem switching. Just as in the Intermedia arbitration case, US LEC has failed to demonstrate that it meets the geographic and functionality criteria required before US LEC is eligible for tandem switching compensation.

Issue 7: Should ISP-bound traffic be treated as local traffic for the purposes of reciprocal compensation, or should it be otherwise compensated?

Q. MR. GATES EXPOUNDS AT LENGTH (PAGES 35-61 ON US LEC'S

POSITION THAT ISP-BOUND TRAFFIC SHOULD BE TREATED AS LOCAL TRAFFIC FOR THE PURPOSES OF RECIPROCAL COMPENSATION. PLEASE RESPOND.

A. BellSouth's position on this issue is that ISP-bound traffic is <u>not</u> local traffic eligible for reciprocal compensation. Our position has been presented to this Commission at length in three recent arbitration proceedings: arbitrations between BellSouth and ITC^DeltaCom, Intermedia and Global NAPS. As stated in my direct testimony, BellSouth agrees to apply the Commission's Order in the Intermedia Arbitration proceeding (Order No. PSC-00-1519-FOF-TP, dated August 22, 2000) to this case, as an interim mechanism. However, BellSouth contends that the interim mechanism must be subject to true-up, pending an order from the FCC on inter-carrier compensation for ISP-bound traffic. BellSouth agrees to this as a conciliatory offer that avoids requiring the Commission to rehear this issue. BellSouth reserves the right, however, to appeal or seek judicial review on this issue.

Q. IF THIS COMMISSION DETERMINES THAT COMPENSATION SHOULD BE PAID FOR ISP-BOUND TRAFFIC, WHAT SHOULD BE THE RATES?

A. BellSouth's position is that a minute of use (MOU) compensation arrangement should not be applied to ISP-bound traffic. However, if this Commission considers a MOU compensation arrangement, at a minimum it should consider the characteristics of ISP calls as distinguished from local calls, as this

Commission found in its order in the Global NAPs arbitration with BellSouth (Order No. PSC-00-1680-FPF-TP, dated September 19, 2000).

Local exchange rates do not take into account and compensate for access service such as ISP-bound traffic or traffic sent to IXCs. Access service characteristics were never considered when local rates were established. Further, ISP-bound traffic bears little resemblance to local traffic. Indeed, for BellSouth the typical call duration for a local call is between three and four minutes. On the other hand, an Internet call session generally lasts much longer than three to four minutes and may last several hours. As additional evidence, attached to my testimony as Exhibit CKC-4 is a Report of the NARUC Internet Working Group (March, 1998), and two supporting Bellcore studies which state that an average ISP-bound call is 20 minutes as opposed to an average voice call of three minutes.

Q. HOW DO COSTS SUPPORTING COMMISSION APPROVED RECIPROCAL COMPENSATION RATES FOR LOCAL CALLS COMPARE TO COSTS FOR ISP CALLS?

A. Costs per minute for ISP calls are lower than such costs for local calls. The cost for local calls is a combination of call set-up cost and a per minute cost. In the cost support for reciprocal compensation, the cost of call set-up is spread over the average duration of a local call, which is around 3 minutes. Assuming that the average duration of ISP calls is 20-25 minutes, using the same reciprocal compensation rate for local and ISP calls means that call set up cost would be over recovered. Therefore, any per minute reciprocal compensation rate, if applied to ISP-bound traffic, should be a lower per minute rate to account for the longer call duration.

Q. WHAT IMPACT WOULD THE DIFFERENCE IN HOLDING TIMES HAVE ON THE COMMISSION'S PREVIOUSLY APPROVED RATES?

A. The Commission's previously approved reciprocal compensation rates are clearly overstated for a carrier, such as US LEC, that is predominately, if not entirely, serving ISPs. The effect is reflected most in the costs for end office switching. The Commission approved a rate of $.002 per minute to recover end office switching. The cost study for that rate included call setup costs to be recovered on a per minute of use basis; the more minutes that a call takes, the lower the per minute setup cost. The cost of $.002 per minute was based on local calls only with an average call duration of 2.708 minutes per call. Using an average call duration of 20 minutes, which more closely resembles ISP calls, would reduce costs by 36%. This reduction would result in a cost of $.00128 for ISP calls using the Commission's approved methodology. The Commission's approved reciprocal compensation rates for tandem switching and common transport would also overstate cost; however, the magnitude would be much less than the impact on end office switching costs. Again, BellSouth is not proposing to apply reciprocal compensation to ISP traffic. This analysis is provided to show that the previously adopted rates for reciprocal compensation would overstate costs of ISP traffic.

Issue 8: Should US LEC be allowed to establish its own local calling areas and assign its NPA/NXX for local use anywhere within such areas, consistent with applicable law, so long as it can provide information permitting BellSouth as the originating carrier to determine whether reciprocal compensation or access charges are due for any particular call?

Q. MR. GATES, AT PAGE 62, STATES "BELLSOUTH DOES NOT INCUR ANY ADDITIONAL COSTS IN DELIVERING TRAFFIC TO US LEC'S SWITCH BASED ON THE LOCATION OF US LEC'S CUSTOMERS." PLEASE COMMENT.

A. US LEC, based on the testimony of Mr. Gates, is missing the point. Reciprocal compensation is to cover the cost of transporting and terminating local calls. It is the terminating carrier that incurs these costs, and, therefore, collects the money. Second, the end points of a call determine whether or not a call is local. Clearly, when a BellSouth customer calls a US LEC customer in a different local calling area, it is not a local call, regardless of where US LEC's switch is located, and what cost BellSouth incurs to get the call to that switch. US LEC is not entitled to reciprocal compensation for these calls.

Q. BEGINNING ON PAGE 63 OF HIS TESTIMONY, MR. GATES DISCUSSES THREE ALLEGED "SIGNIFICANT NEGATIVE IMPACTS" OF BELLSOUTH'S PROPOSED LANGUAGE WITH RESPECT TO ASSIGNMENT OF CODES. PLEASE ADDRESS EACH OF THESE ALLEGATIONS.

A. Mr. Gates makes the following three allegations that occur with BellSouth's proposed language:

- BellSouth would be able to evade its reciprocal compensation obligations under the 1996 Act;
- Contrary to one of the fundamental goals of the 1996 Act, the language would have a negative impact on the competitive deployment of affordable dial-up Internet services; and
- BellSouth would have a competitive advantage over US LEC in the ISP market.

BellSouth disagrees. BellSouth would not be evading any reciprocal compensation obligations under the Act. The Act requires reciprocal compensation for the transportation and termination of local traffic. The traffic under discussion, as shown above, is <u>not</u> local.

BellSouth's position has no impact on US LEC's ability to serve ISPs. US LEC is free to target and select customers, and assign telephone numbers as it chooses. BellSouth is only saying that calls originate and terminate with customers in <u>different</u> local calling areas are <u>not local</u> and, therefore, <u>are not</u> subject to reciprocal compensation.

Furthermore, BellSouth's proposed language would not grant us an advantage in the ISP market. Due to the FCC's exemption of ISP-bound traffic from access charges, BellSouth is limited to charging its ISP customers the tariffed business local exchange rate. ALECs like US LEC generally have more flexibility in their pricing.

Q. ON PAGE 64, MR. GATES STATES THAT "PLACING LIMITATIONS ON RECIPROCAL COMPENSATION BY REFERRING TO A CUSTOMER'S PHYSICAL LOCATION WOULD GIVE BELLSOUTH THE ABILITY TO RECLASSIFY LOCAL CALLS AS TOLL CALLS." IS THIS A VALID STATEMENT?

A. Absolutely not. US LEC is the party attempting to reclassify the nature of the call, from toll to local. An FX call or Virtual NXX call that crosses local calling area boundaries is a toll call, which should not be subject to reciprocal compensation. If the provider of the FX or Virtual NXX service chooses not to bill its customer for toll service, that is its choice; however, the billing alternative does not change the nature of the call. An example of this is FX service. In this instance, the call originates and terminates in two different local calling areas. While the originating party may be charged as if this is a local call, in reality the terminating party is paying for the call through FX charges.

Q. ON PAGES 70-75, MR. GATES PRESENTS DIAGRAMS CLAIMING TO DEMONSTRATE THAT ISP-BOUND CALLS SERVED THROUGH A VIRTUAL NXX ARRANGEMENT ARE NO DIFFERENT THAN "OTHER LOCAL CALLS." DO YOU AGREE WITH HIS CHARACTERIZATION?

A. No. I disagree. First, BellSouth agrees with the FCC's determination that ISP-bound calls are interstate. However, this issue is not an ISP issue. I will therefore respond to Mr. Gates diagrams by assuming that the US LEC customer is not an ISP. Given this fact, BellSouth would agree that Diagrams 5 and 7 represent local calls. We also agree that our obligation for delivering our originating traffic is the same in both diagrams. However, our obligation is not as described by Mr. Gates. Our obligation is as I described earlier in my testimony. That is, BellSouth must deliver its originating traffic, at no charge, to a point in the local calling area (LCA) where the call originates. In Diagram 5, that could be at the POI as shown by Mr. Gates. However, in Diagram 7, it would be at a point in LCA2, not the POI in LCA 1. BellSouth does not agree that Diagrams 6 and 8 represent local calls. In both of these diagrams, the originating party is in one LCA and the terminating party is in a different LCA. Reciprocal compensation would not apply to these cases. BellSouth's obligation to deliver the originating traffic is still limited to a point within LCA 1 in both diagrams.

Q. IS US LEC'S POSITION ON THIS ISSUE CONSISTENT WITH THE ARGUMENTS THAT ALECS HAVE USED AS RATIONALE THAT ISP-BOUND CALLS ARE LOCAL?

A. No. The argument by ALECs that ISP-bound calls are local has been that there are really two calls. ALECs have argued that the first call terminates at the ISP server, which was portrayed as a local call. The second call then left the ISP server in the local calling area and went to the Internet. While BellSouth disagrees with this argument, it is important to note that in the context of this issue, the "first" call as described by the ALECs is not even a local call, and by their own argument, would not be subject to reciprocal compensation.

Q. ON PAGES 79 AND 80, MR. GATES STATES THAT "THE COSTS ASSOCIATED WITH ACCESSING THE INTERNET WOULD INCREASE" IF BELLSOUTH RESTRICTS ALECS' USE OF NXX CODES. PLEASE COMMENT.

A. First, let me reiterate, BellSouth is not attempting to restrict US LEC's use of NXX codes. Second, as I have already stated, reciprocal compensation is designed to compensate a carrier for transporting and terminating a local call. Long distance calls have different compensation mechanisms that apply and would continue to apply in the cases we have been discussing. In the FX example I described earlier, BellSouth charges the FX customer appropriate charges to cover BellSouth's costs. US LEC should do the same. For example, the rate elements of BellSouth's FX service include local channel, interoffice channel, bridging equipment charge, exchange access, and usage charges (See BellSouth General Subscriber Service Tariff, Section A9.) When US LEC assigns telephone numbers to a customer in a way that allows people to make a long distance call to that customer but not be charged for a long distance call, US LEC should recover its costs from the customer who is benefiting – not try to recover those costs from BellSouth.

Issue 9: Should ISP-bound traffic be considered local traffic for the purposes of

calculating Percent Local Usage("PLU")?

Q. MR. GATES STATES US LEC'S POSITION (PAGE 82) THAT ISP-BOUND TRAFFIC IS LOCAL AND, THEREFORE, SHOULD BE INCLUDED IN THE PLU CALCULATION. PLEASE RESPOND.

A. BellSouth's position is the same as stated in my direct testimony: The PLU factor should be developed on the same basis upon which it is applied; that is, if the PLU is multiplied to a minutes of use total to determine minutes for application of reciprocal compensation, then only minutes of local traffic subject to reciprocal compensation should be included in calculating the factor. BellSouth's position is that ISP-bound traffic calls are not local, are not subject to reciprocal compensation, and should not be included in the PLU factor.

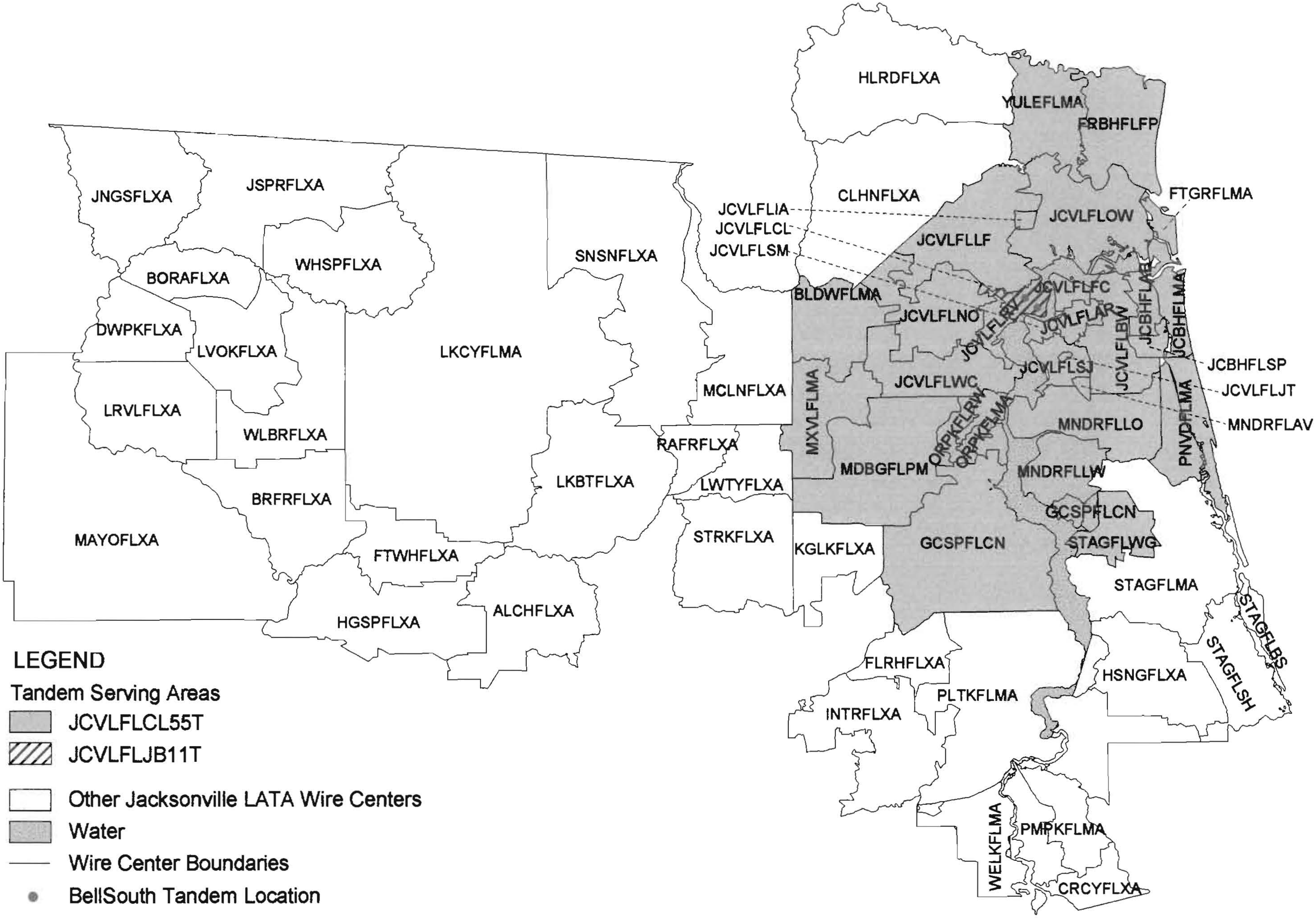
Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

233371

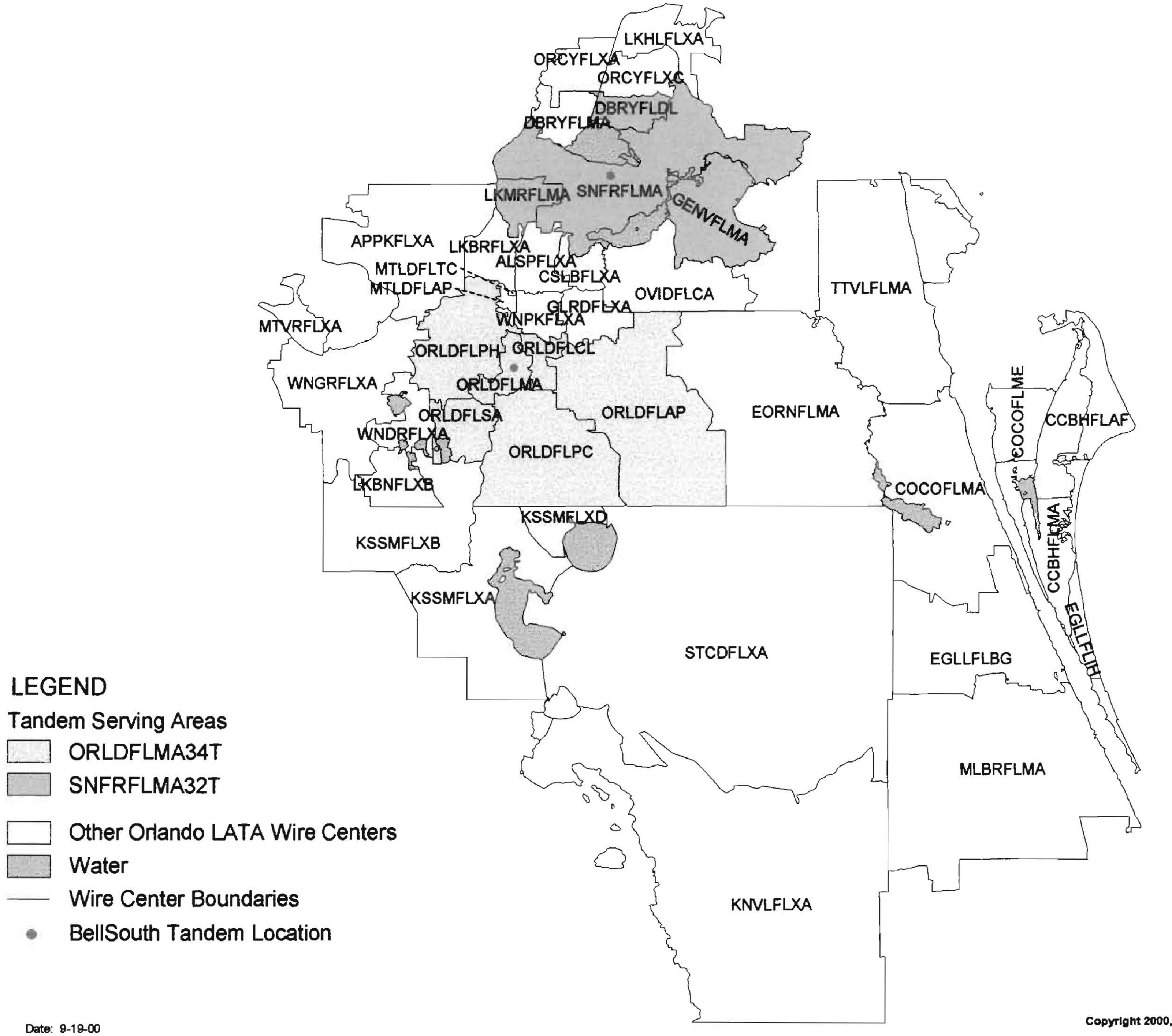
BELLSOUTH TELECOMMUNICATIONS, INC.
FPSC DOCKET NO. 000084-TP
EXHIBIT CKC-3
PAGES 1 – 3
OCTOBER 27, 2000

BellSouth Jacksonville LATA - Local Tandem Serving Area



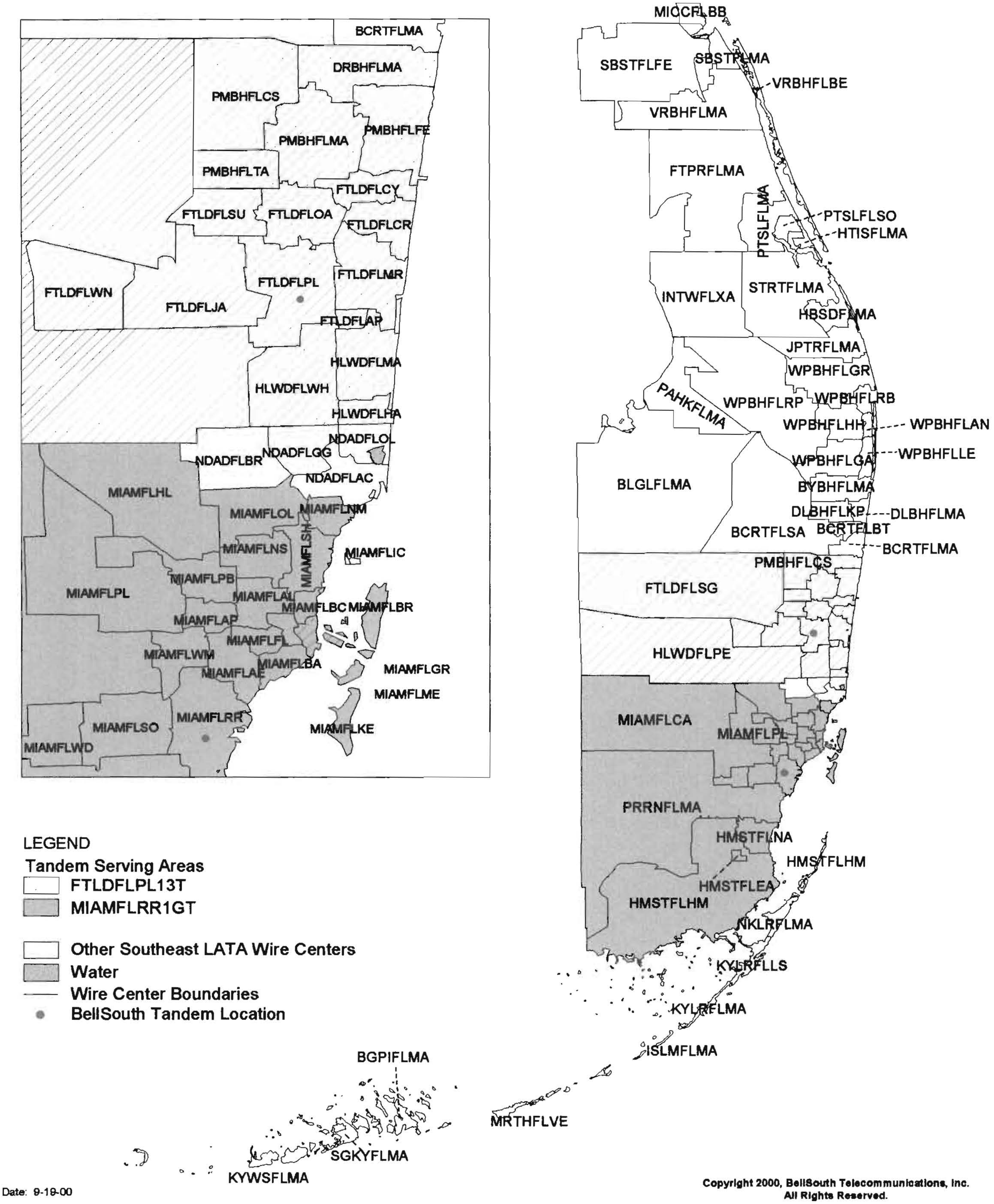
Date: 9-19-00

BellSouth Orlando LATA - Local Tandem Serving Area



Date: 9-19-00

BellSouth Southeast LATA - Local Tandem Serving Area



LEGEND

Tandem Serving Areas

☐ FTLDFLPL13T

▨ MIAMFLRR1GT

☐ Other Southeast LATA Wire Centers

▨ Water

—— Wire Center Boundaries

● BellSouth Tandem Location

Date: 9-19-00

BELLSOUTH TELECOMMUNICATIONS, INC.
FPSC DOCKET NO. 000084-TP
EXHIBIT CKC-4
PAGES 1 – 60
OCTOBER 27, 2000

PRICING AND POLICIES FOR INTERNET TRAFFIC ON THE PUBLIC SWITCHED NETWORK

REPORT OF THE NARUC INTERNET WORKING GROUP

Contributors

Jeff Richter (Wisconsin) – Co-Chair	Doris McCarter (Ohio) – Co-Chair
Mark Long (Florida)	Tom Solt (Missouri)
Vivian Witkind-Davis (NRRI)	Joel Shifman (Maine)
John Hoag (NRRI)	Barbara Combs (Oregon)
Terry Reid (Florida)	

Acknowledgements

Sandy Ibaugh (Indiana)
Michael Dorrian (Ohio)
Linda Schmidt (NRRI)

FINAL DRAFT
Submitted to the Committee on Communications at the
NARUC Winter Meetings, Washington, D.C., March 1998

I. Introduction

Growing use of the public switched telephone network (PSN)[1] to access the Internet presents new, difficult policy concerns for regulators. Promotion of Internet use is consensus public policy nationally and even worldwide. But snowballing Internet growth has costs and allocative implications for Internet relayers (including providers of both the backbone network and access), for intermediate telecommunications carriers, and for end users, including both individuals and businesses.

This report is the product of efforts by members of the National Association of Regulatory Commissioners (NARUC) Communications Committee and Communications Staff Subcommittee to address current public policy issues on use of the PSN to access Internet services to exchange messages and information, transfer data, and conduct transactions. Some of the issues were first formally raised before the Staff Subcommittee in a provocative panel discussion at the NARUC Winter Meetings in Washington, D.C., in February 1997. The Internet Working Group was formed at the winter meetings and sent a questionnaire to industry players in mid-April 1997. The Working Group reviewed responses to its questionnaire, comments filed at the FCC Notice of Proposed Rulemaking (NPRM) on Access Charges,[2] and comments filed in response to the FCC Notice of Inquiry (NOI) regarding use of the PSN by Internet service providers.[3] A follow-up panel presented further discussion of the issues before the NARUC Communications Committee at its summer meetings in San Francisco in July 1997. The first draft of this paper was presented along with a request for comment at the NARUC Annual Meeting in Boston in November 1997.

AT&T reports that there will be 30 million Internet accounts for 43.2 million households and 2.1 million businesses by the year 2000. This growth will help people to do such things as pay bills, improve themselves through education, and work at home. Demands will also be made of the network to provide greater and greater bandwidth as multimedia, voice and other Internet applications become more commonplace. Intermediate telecommunications carriers (the ones that connect Internet end users to the Internet) are concerned that these increasing costs are not being borne by those causing the investments, thus straining the capabilities of some telecommunications resources previously deployed for other public and private purposes. The

---

[1] The FCC has begun to use the term public switched network, or PSN, in place of the public switched telephone network, or PSTN. The term PSN applies to "any common carrier network that provides circuit switching between public users." *Newton's Telecom Dictionary*, 9th edition (New York: Flatiron, 1995), 914.

[2] FCC 96-488, released December 4, 1996, Access Charge Reform, CC Docket 96-262.

[3] FCC 96-488, released December 4, 1996, Usage of the Public Switched Network by Information Service and Internet Access Providers, CC Docket 96-263.

FCC's exemption of Internet service providers (ISPs) from access charges may be hindering migration of Internet use to more appropriate technology than the existing PSN, which is currently designed to handle voice traffic rather than data.

The Internet is first being deployed to large businesses and wealthier, more urban residential users. Schools, libraries and rural health care facilities nationwide are receiving subsidies for Internet investments under the Telecommunications Act of 1996, but there is no promise that other rural and low-income customers will receive Internet access any time soon. Planning for universal service has not addressed the means to support a ubiquitous national rollout of advanced telecommunications services maintained at affordable rates.

In this report, we analyze issues of PSN congestion, local access pricing, and universal service from the perspective of public service commissions concerned for the public interest, including the preferences of U.S. customers of telecommunications and Internet services and the broad range of providers of those services. Internet issues have also been addressed at the national level by the Federal Communications Commission (FCC), the Clinton administration, the National Telecommunications and Information Administration (NTIA) — the Administration's policy advisory arm — and the Rural Utility Service (RUS) in the Department of Agriculture.

We first address, in a qualitative way, the technical impact of the Internet on the PSN. We limit our analysis to consideration of calls dialed to *reach* the Internet. Some of this congestion is due to ISP failure to provide a sufficient number of connections for their users, so the users experience busy signals when they attempt to dial in.[4] We do not address a second problem, the phenomenon known as the "worldwide wait," named because of slow responses to user requests while they are online to the Internet. Nor do we address congestion problems that may arise as a result of dial-ups to computers that do not involve connections with the Internet.

In Section II we review technical solutions for the problems posed to the PSN and some other vehicles for access to the Internet. The question is posed as to whether the PSN is the appropriate vehicle in the long term for carrying this traffic or whether some other network is better suited. We discuss the various technologies that may be used to provide access to the Internet, and their suitability and likelihood of becoming the preferred method of access in the short term and long term. We provide an initial, broad analysis of the costs of migrating the PSN to a data environment and relate this to currently available technology and emerging technologies.

Section III attempts to bridge the gap between the current regime of ISP exemption from access charges and appropriate pricing for the future. We examine the effects of the exemption,

---

[4] Many software programs allow the user to instruct the computer to continue to dial until it successfully connects with the other computer. In the worst cases, repeated dialing may last an hour or more when the ISP has insufficient capacity for its customers. If many callers are engaged in repeated redialing, their combined calls could make a large contribution to busying out a switch

exploring the positive and negative results of the exemption up to now and into the future for Internet use and the PSN. We discuss pricing options that may be suitable for high bandwidth data users as the PSN migrates toward a data environment.

Section IV is a discussion of some universal service issues raised by deployment of Internet services. The burden may fall on states to fund any early diffusion of advanced telecommunications services to high-cost and low-income areas. We examine possible state and federal policies for making Internet service available and affordable throughout the United States.

Having explored all of the issues and provided an analysis of the various dynamics and viewpoints we summarize the Working Group's conclusions and recommendations in Section V.

II. Technical Sources and Engineering Solutions to Possible Internet Congestion

The Internet is a packet-switched backbone network designed for data transfer, delivery, and retrieval. An important difference between packet-based and circuit-based networks (that is, the traditional, analog, circuit, local portion of the telephone network or PSN) is that the public switched circuit network relies on a continuous connection through the switching and transport networks to transfer voice or data, while the packet network is active only when delivering packets. In a circuit network, a channel is established for communications between the end users, and that channel is maintained until the connection is terminated. In addition, packets can be stored off-network for later access, delivery, or retrieval by an individual or group of users and need not be transported in sequence or over the same pathway. Thus a continuous packet connection to the Internet does not tie up the Internet work as an analog circuit connection would.

Because a continuous connection is maintained, using the analog voice network for data communications over the Internet is much less efficient than using a packet-switched network. In an Internet call, the Internet Service Provider (ISP) as well as the ISP's customer may be considered end users. ISPs are often connected both to a packet network over high speed dedicated facilities on one side for communication with the Internet and to the PSN through local business lines on the other side to provide access for end user customers. When an ISP bridges the circuit-switched PSN and its packet-switched network, the mismatch of technology is only partially mitigated by modems. Modems (modulator/demodulators) convert digital data for transmission over the local (or toll) analog network to the interconnection point of an ISP where it is packeted for delivery over the Internet network.

There is little doubt that the Internet has caused changes in the capacity used for some PSN calls and in the average duration and number of calls. The Internet has also affected the patterns of local use among and within LECs. LEC data show that the average duration of Internet calls is considerably longer than that of local voice calls. The LECs claim that the growth in number and duration of Internet calls has caused facility congestion problems in interoffice trunking common in multi-office exchanges and extended area service (EAS) arrangements. ISPs, on the other hand, allege that empirical data do not prove the existence of congestion on the Internet. They and other observers believe the PSN, if properly managed, will be able to accommodate the growth with little problem. While many organizations debate the locus, frequency, and severity of Internet access congestion using the PSN, the technical community is preparing short-, medium- and long-term solutions. This section examines some possible directions that PSN access to the Internet network may take.

The long-term scenario foreseen by all respondents to the Working Group survey is the relocation of interoffice data services from the PSN to a digital packet network. Access to the packet "cloud" could be achieved through many means, including improved resource management, residential Integrated Services Digital Networks (ISDNs), digital subscriber loops (DSLs), or displacement of dial-up over analog modems with cable modems or wireless.

Respondents to the NARUC survey and to the FCC's NOI regarding Usage of the Public Switched Network by Information Service and Internet Access Providers (Docket 96-263) provided valuable insight into specific mechanisms of the congestion problem but not its scope. The primary problem is excessive blocking of calls at originating end offices due to resources in use by calls to Internet service providers (ISPs). Sub-problems include:

1. Quantities and configuration of (inbound) line control modules (LCMs)
2. Insufficient interoffice trunking
3. Lack of sufficient terminating CPE (for example, ISP modems) as blocked users persistently re-dial

ISPs must work to avoid the third type of problem above, where their modem banks are oversubscribed and caller retries "busy out" the switch. The same "first order" statistics developed by telcos can assist ISPs in designing the capacity of their trunks and modem banks.

Two fundamental premises must be presented as background. The first is that all communications networks are designed to meet probabilistic demand calculated at the busiest hour of the day, week, month, and year — and are not designed to provide service to all customers simultaneously. The second is that this busy hour exists during the work day and consists mostly of voice calls. While it is true that, on average, call durations ("holding times") by modem to ISPs are longer than voice calls (Bellcore: 20 minutes compared to three minutes, respectively), it is the total traffic offered in centum-call-seconds (CCS) that is the center of the congestion problem. While many respondents could identify PSN usage attributable to Internet calls, no telephone company contended that the Internet has *in general* caused shifts in the busy hours. At face value, this would indicate (falsely) that the existing voice network is sufficient for Internet callers and that no additional capital equipment is required. Rather, situations arise where additional equipment has been required to maintain quality of service. In their survey responses, PacBell and Bell Atlantic cited examples of congestion in their Santa Clara and Herndon end offices, respectively.

Short Term: Improved Resource Management

The primary reaction to congestion on the access side of the switch is to reconfigure line units. Bellcore viewed the problem of congestion as separate issues of trunking and access and provided different solutions for each.[5] In the short term, Bellcore noted that the present mode of operations can be managed better, reducing switch stress by de-loading switches and routing Internet calls more intelligently.

A moderately complex task is to rebalance subscribers across existing line concentrators (there is a range of lines which can share a single line unit based on the number of minutes at any given time the lines are experiencing). A more interventionist (and costly) step, if rebalancing is unsuccessful, is to regroom the switch by adding line units and reassigning customers.

Interoffice trunking congestion may still occur even in the absence of access line overload. One telco that has extensive ISP subscribership on primary rate interface (PRI) digital trunks has still had to utilize foreign exchange (FX) trunking to process these calls over the interoffice network. While FX-type trunking can be used to alleviate congestion on the voice trunk groups, it can still result in a less efficient use of the trunks themselves.

One solution recommended by Bellcore is the installation of equipment "upstream" of the switch that would divert, based on dial number, ISP calls from switch line concentrators used by voice customers. This "pre-switch adjunct" equipment is already being sold by Lucent and Nortel, manufacturers of the dominant Class 5 switch models. Each of these product solutions has characteristics or limitations that make them less than attractive in all situations.

The Internet Access Coalition, which contends that the Internet access congestion issues arise from poor resource management within switches, notes that digital trunking by ISPs is technically feasible but is not economical. Dial-up calls to ISPs that have T-1 or Primary Rate ISDN would bypass the switch components that are subject to access congestion. Their analysis, however, showed that, in many regions, an ISP would find it cheaper to operate analog lines (prone to congestion) than equivalent ISDN-PRI or T-1 service that is non-blocking.

---

[5] Amir Atari and James Gordon. *Impact of Internet Traffic on LEC Networks and Switching Systems* (Red Bank, NJ: Bellcore). 1996.

Medium Term: Technological Solutions

Some emerging products and services have the potential to operate without congestion to the PSN. We will briefly introduce options for digital subscriber loops (DSLs), ISDN, and Internet routers. While each of these is technically attractive, each also has economic or locational impediments to deployment.

1. Digital Subscriber Loop

Digital Subscriber Loop (xDSL) technology is a potential long-term access technology that would use existing copper pairs to connect customers directly to the packet "cloud." The particular variant of xDSL to consider, according to vendor ADC, is based on speed, operating distance, upstream and downstream speed differential, and suitable applications. xDSL will someday be a high-performance (T-1 or higher) access solution for the 80 percent of customers within 18,000 feet of an end office, but currently it is not generally available. Similarly, cable modems offer local area network (LAN) style Internet connections to customers, but existing cable infrastructure is suitable only for 15 percent to 20 percent of potential users. Other potential Internet access media include powerline carrier (Norweb) and satellite downlink.

2. ISDN

Both Primary Rate and Basic Rate ISDN (PRI and BRI) are viable technical solutions for alleviating access congestion. ISDN pricing, however, has been inconsistent, and some respondents, including AT&T, believe that the associated network and customer premises costs and technical limitations mean that widespread deployment is years away, while others, such as Bell Atlantic and U S West) noted that ISDN is an affordable option that will meet the needs of the market for years to come.

Digital trunks such as Primary Rate ISDN and T-1 can link ISP points of presence (POPs) with ISP modems and alleviate load on switches, but current tariffs are higher than for equivalent POTS lines. Bellcore notes that the packet ("D") channel of Basic Rate or Residential ISDN could be used by customers to connect to existing telco packet networks. Residential ISDN connections bypass switch components prone to congestion.

3. Router Development

Internet routers could potentially be the bridge between the current voice telephony and the data network of tomorrow. In the short run, traffic could be routed over a dual network. There is even debate that the dual network may continue in the long run due to the sheer expense of converting the PSN to a data friendly network. Under the dual network concept, voice would be processed according to one set of parameters and traffic destined for an ISP could be routed onto data facilities. In the long run, the Working Group envisions that all data (including voice) could be processed in a uniform manner. Right now, it appears that packets may be the most likely method for backbone networks, with a variety of digital solutions for local access. Some parties advocate that a more efficient configuration would be for routers to be placed at all switches, therefore, the originating switch could determine if a call is addressed to or from an ISP and thus route its traffic onto a data network.

The location of routers is a function of cost. The basic assumption with using a router system is that there would be new costs associated with processing traffic over these facilities. If transport is charged for traffic from the router, then ISPs have a much greater incentive to build their own facilities to the office with a router than to pay the ILEC to transport the traffic. Of course, the placement of its own facilities to a router would require a higher profit threshold for the ISP, so whether it would go into a rural area using its own facilities is unknown. In other words, rural areas may still have difficulty obtaining Internet service either due to having to make a toll call (or pay a higher transport cost) because the ISP server is in a distant area or because providing transport to a closer office with a router involves more facilities placement cost on the part of the ISP. Requiring ILECs to provide the transport from the routers to the ISP does not solve the bandwidth problem unless hi-cap facilities are placed and then priced close to cost. Then the matter simply becomes one for the ISP of revenues versus cost.

Routers could be placed in tandem, however, this does not stop Internet traffic from entering the PSN. Tandem router placement may be an acceptable solution but once bandwidth requirements increase, congestion could become a problem for both the ILEC and the end users' requirements. Tandem placement of a router could be very useful if there is terminating end office switch congestion. Tandems are typically designed to carry significant traffic flows. However, there has been no contradictory evidence to the ISP contention that the switch congestion problem most often spoken of is with the terminating switch. It is before this switch that traffic must be diverted. Therefore, locating the router at the tandem and then providing hi-cap transport between the router and the ISP server could solve many problems for the terminating switch.

Long Term: Network Evolution of the Internet and Internet Access

The Internet, beginning at backbone level, has begun the transition to packet technology. The backbone technology chosen by MCI, UUNET, and others is Asynchronous Transfer Mode (ATM). ATM is similar to frame relay (FR) and X.25 networks in that it is a shared resource, gaining efficiency by multiplexing many streams together to provide virtual private services.

Bell Atlantic and U S West, in their survey responses, anticipated the full spectrum of ATM and frame relay networks, using xDSL and cable modems as well as improved analog dial for access.

BellSouth, in comments in CC Docket No. 96-263, outlined a proposed network which the company said would be suitable in the long term. BellSouth stated that the Commission's current rules regarding protocol conversion would make it impossible for it to implement such a network, however. Dial-up connections would be routed to the network access server that would, in turn, be connected to a "radius" or routing server. In other words, based on the number dialed by the Internet subscriber, the radius server would identify the Internet provider to which the network access server should establish a data connection. The network access server would then make the connection to the underlying ATM/Frame Relay network to which the Internet provider would also be connected.

The possible paths discussed here for long-term Internet evolution are based upon developing technology and media. Given the rapid progress in the fields of communications and electronics, in just a few years the Internet may well use as yet unheard-of technology to speed the transport of data to and from the end user. The trend seems clear: as we move ahead in time, the capability of higher speeds of data transport will move closer and closer to the end user.

Costs of Reducing Congestion

Many levels of solutions can be applied to the general problem of PSN congestion, the ultimate being relocation of data services to broadband packet networks. While the costs of this solution have not been estimated, the costs of some solutions are more easily calculated. We have figures for the cost of labor to reconfigure switches but lack cost data on line cards themselves and the new category of pre-switch adjuncts, as deployed. Cost data are available for some ways for ISPs to mitigate congestion, including digital T-1 or ISDN PRI. Regulators must use the information they have and obtain the further information they need to develop pricing strategies to encourage the use of data-friendly infrastructure. Because competition is in a nascent stage and the Internet is growing so rapidly, it may not be sufficient to wait for new providers to place their facilities.

III. Appropriate Structure and Charges for Local Network Access

Access Charges

Although several avenues are open for evolution to networks that support data better than the existing PSN, the current exemption of ISPs from access charges inhibits that transition. The number of people subscribing to the Internet keeps growing, but unless the Internet acquires more bandwidth it may encounter an application constraint both on its own backbone and on the PSN. The comparative price of compatible CPE and local lines with packet switching capability versus current analog modems and circuit switching is a disincentive for Internet users to migrate to "data-friendly" technology. The exemption of ISPs from access charges distorts prices and sends incorrect economic signals to end users and Internet service providers. Until end user demands for bandwidth force ISPs to use what are probably more expensive data networks, ISPs will continue to purchase analog lines and use modems to change digital messages to analog and back to digital packets for delivery over the packet network. So, to some unknown extent, the exemption is helping to keep the Internet from growing into a mature multimedia network.

The ISP exemption grew out of the FCC's Computer II proceedings in the 1970s, in which the

Commission introduced a distinction between basic and enhanced communication services. Enhanced services include access to the Internet and other interactive computer networks. In a 1983 access charge order the FCC decided that even though enhanced service providers (ESPs) may use the facilities of local exchange carriers to originate and terminate interstate calls, they should not be required to pay interstate access charges.[6] In its 1997 access charge decision, the FCC decided to maintain the exemption. The Commission noted that the term "information services" in the 1996 Telecommunications Act appears to be similar in meaning to "enhanced services."[7] The Act establishes a policy "to preserve the vibrant and competitive free market that presently exists for the Internet and other interactive computer services, unfettered by federal or state regulation."[8]

The FCC decision means ESPs (including ISPs) may purchase services from incumbent local exchange carriers under the same intrastate tariffs available to end users. They pay business line rates and the appropriate subscriber line charge rather than interstate access rates. Business line rates are significantly lower than equivalent interstate access charges because of separations allocations, pervasive flat and message rates for local business service, and the per-minute rate structure of access charges.[9] On the other hand, interexchange carriers (IXCs) at least for now must pay access charges for similar connections to the PSN.

Most ISPs purchase analog business lines from the LEC at a fixed cost per month. Most households and businesses can purchase access to the Internet through a flat monthly charge from an ISP. The local usage on the lines over which they place calls to access the Internet is generally priced on a flat monthly or message (per-call) basis. These rates are based on local usage rates. The lack of true time-related charges on either end of these calls encourages long call durations. The ILECs claim that the long holding times associated with Internet calls burden the PSN and have caused, and may continue to cause, network congestion and blocked calls. If the ESP exemption were discontinued, the LECs argue, a more accurate pricing signal would be sent which would encourage ISPs to seek more efficient methods of serving their end users.

The access charge exemption is a preference for a certain class of users of the public switched network, just like the home mortgage payment exemption is a tax preference in the federal income tax system. A preference acts like a subsidy to a certain group or function, foregoing funds that would otherwise go to common use. It is as an active policy preference that the exemption has been supported — something that will encourage development of the Internet and the many benefits we can see from having this new means of information exchange, plus

---

[6] FCC 1997 Access Charge NPRM, para. 284.

[7] Ibid., para. 284.

[8] 47 USC, para. 230(b)(2).

[9] FCC 1997 Access Charge NPRM, para. 285.

innovations yet to come. There is a strong public interest argument for government promotion of the Internet. The Internet User Coalition, for example, commented to the Working Group that the Internet provides citizens a venue for political speech and access to information, lifelong learning, communications and commerce.

ISPs argue that exemptions were justified in the first place and continue to be needed now to support a nascent industry. Many commenters in FCC dockets and the Working Group's survey argued that applying any extra charges to the ISPs would stymie the Internet's growth. ISPs argue that the access charge exemption is an incentive for investment and innovation in information services and thus serves U.S. industrial policy. The ISPs and their supporters say that even though the Internet business has grown, it is still volatile and prospects for success are uncertain.

Another argument for keeping the exemption is that the existing access charge system is inappropriate. BellSouth maintains that it is better to keep the current access charge exemption than to apply an access charge regime that was designed for circuit-switched voice telephony. Most telecommunications industry analysts agree that access charges are too high. The FCC said it saw no reason to extend the existing imperfect access charge regime to an additional class of users, when it could have detrimental effects on the growth of the information service industry and the existing structure.[10]

Those who continue to be opposed to the access charge exemption for ISPs now and in the immediate future claim that Internet use is already causing congestion, particularly in the switch from which the ISP is served. The Alliance for Public Technology, in comments on the FCC access charge NPRM, said ISPs are thus paying less for using the local network than other businesses, even though some claim they impose greater demand for ports, switches, lines and other network elements. Bell Atlantic suggested the exemption creates a financial disincentive to switch to data networks where they are available, encouraging ISPs to purchase circuit-switched services instead of packet-based. The general exemption of ISPs may also ignore differences in traffic patterns among ESPs and even in Internet uses, another commenter suggested. Some of these providers may pose a larger immediate burden on the network than others.

Rural Utilities Services (RUS) told the NARUC Internet Working Group that the ISP exemption means rural telephone companies are losing toll support they would otherwise receive because many calls made to access the Internet are toll calls. Because the rural carriers do not have access to the toll revenues by virtue of the exemption, local rates are forced up as plant must be put into place to handle the increased "local" traffic, and revenues must be generated to recover the cost of this plant. (This issue is discussed further below, in section IV. on universal service.)

Whether or not ISPs are causing congestion now on the public switched network, the access

---

[10] FCC 96-488, para. 288.

charge exemption encourages growth of Internet use that can lead to overloading a network designed for voice communications. Asked whether the exemption influences network deployment decisions all respondents to the working group survey who answered the question said it does. AT&T said the exemption discourages CLECs and ILECs from developing new service offerings that have to compete with below-cost access services used by ISPs. The company said neither CLECs nor ILECs are receiving accurate economic signals that would encourage them to upgrade networks or engineer existing ones more efficiently because they are being denied the revenue streams to pay for the upgrades or transition activities. BellSouth and U S West made similar arguments.

The access charge exemption has an influence on who will win and who will lose in the marketplace for telecommunications services. Interestingly, many ISPs no longer argue for the exemption on nascent industry grounds, but on competitive grounds. They suggest that independent ISPs are now battling ISPs affiliated with other carriers so the independents need a price break to level the playing field. Some ISPs also suggest that since they have no adequate widespread technological alternative to ILEC networks, to continue the exemption will force ILECs to upgrade. Until that happens, they claim the exemption is a monetary recognition of the PSN's shortcomings for data transmission. ISPs and others also allege that the revenue from the second line which computer users tend to order has not been considered as an offset to any additional PSN costs. They further point out that many ISPs are phone companies themselves and argue that those ISPs would not be providing Internet service if it imposed unrecoverable costs.

Other telecommunications companies see the exemption as giving unfair competitive advantage to ISPs. AT&T commented that the IXCs are paying "artificially high non-economic subsidy laden charges" and ISPs are paying below costs. AT&T maintained that IXCs are at a competitive disadvantage since ISP services (voice over net, faxes) are cross elastic. Bell Atlantic and U S West advanced similar arguments from the perspective of the ILECs. Bell Atlantic suggested that if IXCs moved voice traffic onto the Internet, and the exemption continued, LEC costs would increase without an adequate cost recovery mechanism. Resellers agreed that preferential treatment of ESPs over other telecommunications service providers gives "unwarranted competitive advantage." The Telecommunications Resellers Association said ISPs should be brought under the access charge regime.

Jurisdictional Issues

Any discussion of the appropriate pricing for network access to the Internet must include jurisdiction. While it is the Internet Working Group's strong hope that any pricing options advanced herein would be applied on both the interstate and intrastate level, should that not be the case, the Internet Working Group would offer its analysis and conclusions for consideration by the states.

The FCC's finding that ISP traffic is exempt from interstate access charges is not readily interpreted as a decision regarding the jurisdictional nature of the traffic. It does not make it any less an interexchange, and ultimately an interstate and international, connection. BellSouth commented that the exemption should not and does not change the underlying jurisdiction of the traffic. The FCC decision leaves state regulators with jurisdiction for local rate and policy applications. It is reasonable for them to interpret this traffic as local by default. Yet the reason the FCC can apply its exemption to interstate access in the first place is that at least some of the traffic traverses state and national boundaries. In general, only the local phone dial-up number makes it appear local. This was true with call traffic into many early toll resale enterprises. If the incoming ISP traffic is on a toll call or 800 number, intra- or interstate access charges are being applied today.

If ISP traffic is interstate, as the FCC's assertion of jurisdiction to apply the ESP exemption indicates, then this issue is ripe for reevaluation under jurisdictional separations. Comprehensive jurisdictional separations reform is currently under investigation and assigned for resolution to the Federal-State Joint Board on Separations.[11] The NPRM does not refer specifically to ISP traffic, but to data traffic generically, in its request for comments on these issues.

If the traffic is interstate, a workable solution was suggested by several parties to apply to ISP traffic only the traffic-sensitive portion of access charges without any common line component. This is the intended ultimate goal of the access reform ordered by the FCC for Tier A LECs' interstate access charges[12], and a solution recommended by several parties in the FCC's NOI on the Internet.[13]

If ISP traffic can, due to the exemption, be interpreted as jurisdictionally local, states do have options for solving the problems associated with this rapidly growing segment of local traffic. The solutions then would have to be with regard to local service pricing. If the jurisdiction of the traffic is split, identification of the local traffic that is Internet directed would be necessary. This could necessitate the imposition of considerable registration and reporting requirements.

Changes in pattern of use, call duration and number of calls may make the existing separations (Part 36 methodologies) process inappropriate due to resulting large separations shifts for some companies. Under Part 36 many portions of the network are allocated based on jurisdictional minutes-of-use (MOUs) or weighted jurisdictional MOUs. An increase in usage caused by the Internet calls could vastly increase the allocation of cost to the intrastate jurisdiction due to the ESP exemption. This is because the exemption causes LECs to treat the costs of serving ESPs

---

[11] CC Docket No. 86-280, Jurisdictional Separations Reform and Referral to the Federal-State Joint Board, released October 7, 1997.

[12] Access Charge Reform, First Report and Order, FCC 97-158.

[13] Usage of the Public Switched Network by Information Providers, FCC 96-488.

(which include ISPs) as a cost of serving local end users.

In general, LECs claim the Internet causes their revenue requirement to increase because they may need to install more inter-office and switching facilities to handle the vast increase in traffic caused by the Internet, while a lower percentage of the total cost is allocated to the interstate jurisdiction due to the ESP exemption. Compounding this problem is that the Internet may cause the need for network upgrades all the way to the end users as essential service requirements under universal service programs expand to meet basic end user demands. This separations problem causes the company's intrastate jurisdictional allocations to increase, which may result in requests by some companies for intrastate rate increases claimed to cover costs primarily incurred for a jurisdictionally mixed or interstate service.

At this time the Working Group agrees that Internet traffic is indiscernible. However, the Working Group believes that this is because no one is attempting to record the traffic. Much as 800 traffic was originally viewed as indiscernible and later able to be tracked, so too could be the case with Internet traffic.

Options for Pricing Internet Access

Most interested parties agree that government should not establish a social goal with respect to which technology or network is used to deliver Internet services. However, many parties fail to acknowledge that government already has influenced the growth of the Internet by extending the ESP exemption to ISPs. While in the past Internet traffic was not of such a magnitude or sophistication to affect the PSN, its continuing growth leads one to question whether the time has come to reconsider how Internet traffic is priced. Should government continue the preferential rates for ISPs, apply traditional access charges to them, or design a new pricing mechanism? As we discuss the various dynamics associated with pricing PSN access to the Internet, we must keep sight of the overall fundamental network change — whether the result is a data-friendly PSN or a dual PSN composed of one network (route) for voice and one for data.

In regard to the standard argument of whether ISPs should pay traditional access charges, some parties concede that if the Universal Service Fund is designed to recover all needed local revenues, typical interstate access rates could decline sharply and then ISPs could pay the new access rates. By doing this, the rates would be close to cost and that would send the correct market signals to ISPs as to whether or not they should obtain another method of access which would give them the data capabilities that their users need or desire.

However, current access charges are based on voice technology. Given the growing data usage of the network, the Working Group is concerned that the traditional rate structure for access charges may not reflect future network usage. Therefore, we have explored rate structures which may be more suited to data traffic. We recognize that this leap in rate structures from the current regime may produce a "gap" between rate structure and actual network deployment of technology, but we believe, at this juncture, that regulators must begin to prepare for the fundamental change the network will undergo. Most commenters did not offer any pricing options for Internet usage. Basically there were two viewpoints: continuation of the ISP exemption and an access rate that is lower than current access rates.

All the commenters to the working group survey agreed that end users should not be required to pay for the ISPs' use of the PSN. If any increased charges are to be paid, the commenters suggested, they should be paid by the ISP directly. However, all parties also recognized that any increased costs to the ISPs will be passed along to end users.

Alternatives to a voice-based pricing scheme were not advanced, although several ISP commenters expressed concern about usage-sensitive pricing. Some sort of flat rate, cost based, block rate pricing might alleviate some ISPs' concerns over their cost volatility. Moreover, many ISPs want the ability to purchase UNEs, without being designated a carrier.

One suggestion offered by the Working Group was that wireless interconnection rates be used as a surrogate for ISPs' access to the PSN. Only one party commented on this suggestion. It argued that wireless interconnection rates should not be assessed on ISP providers because while an Internet call is roughly 20 minutes in duration, a wireless call is 2 ½ minutes for cellular and 5 seconds for paging. Therefore, wireless service is not analogous to Internet service and the rate should not be transferred. In short, whereas a wireless customer may view a $0.20 call to be affordable (based on a rate of $0.08 a minute for a 2.5-minute call) an ISP user would not view a $1.60 call to be reasonable (based on $0.08 a minute for 20 minutes).

The Working Group also explored the possible development of a special category of end user (if the exemption continues) whereby outgoing call volumes above a certain level would require the end user to be migrated onto a service which is priced and engineered to recover and account for the high call volume. However, the Working Group is mindful that the application of some sort of per minute local measured service (LMS), in many states and localities, is either statutorily forbidden or politically obstructed. Also, if a pricing scheme were applied to Internet traffic only, it could be challenged as discriminatory and subject to litigation. Another solution could be to charge all customers in markets without LMS for all incoming local calls above a certain level. This could eliminate the need to separately identify the traffic as Internet directed. If a high enough set amount of incoming traffic were free each month, ISPs would likely be the primary recipients of this charge.

Another idea put forth by the Working Group was the use of the Signaling System 7 (SS7) network and rates to process Internet calls. All carrier commenters rejected the idea of using the SS7 network. They argue that the SS7 network is designed and maintained as a signaling network and could not handle Internet traffic, even though it is similar to packet technology. Also, many commenters are concerned that the implementation of local number portability (LNP) will consume the spare capacity of the SS7 network. Consequently, there is little spare bandwidth on the SS7 network for other traffic. No commenter addressed the question of whether the SS7 network could be expanded to fulfill this function.[14]

Most commenters to the survey argue that there should be only one access charge structure since the network is performing the same function regardless of whether voice (analog) or data (packet) is being transmitted. However, if access charges are not brought down to cost and government feels the need to keep the cost of access to the Internet low, care should be taken to at least price the services and/or facilities close to cost. This pricing policy would have the effect of incenting the providers of the PSN to deploy a more data-friendly network and of encouraging the use of more data-friendly facilities on the part of end users and ISPs.

Reciprocal Compensation

In addition to general concerns about the appropriate pricing for access to the Internet, regulators have recently been faced with the question of what compensation should be paid between carriers for the exchange of this traffic. It should first be noted that although the battle over pricing access to the Internet has spilled over into reciprocal compensation, the general pricing and costing dynamics mentioned earlier in this paper have not changed. What we now address is the question of cost recovery/revenue generation when some ILECs bypass the end user and ISPs and instead focus on intermediate carriers as their revenue source. This section will discuss the various options for resolving the reciprocal compensation question should a state commission assert its jurisdiction in resolving a dispute on this issue, as a number of commissions already have.

The basic allegation in the reciprocal compensation disputes is that all calls to ISPs are long distance. To support this conclusion some carriers are claiming that in order for the FCC to have exempted ISPs from access charges, it must have assumed that the nature of ISP traffic, both to and from the ISP, is long distance, perhaps even interstate. The Internet Working Group asked participants in the group's survey whether the ESP exemption creates an incentive for CLECs to want ISP servers at their end offices in order to recover the terminating unbundled local switched rates. AT&T replied that the exemption perpetuates uneconomic behavior in many forms, but that Internet traffic is interstate, not local, so the reciprocal compensation portions of interconnection agreements are inapplicable.[15] We have already discussed the pragmatic matters associated with identifying traffic destined to ISPs or large terminating users. We will assume that these end users are somehow identifiable. With that caveat, there are four basic avenues to resolve the compensation issue.

ISP ①

The first avenue would be to agree with the carriers who assert that some or all calls to the ISPs

---

[14] Bellcore did advance this viewpoint in its paper, "Architectural Solutions to Internet Congestion Based on SS7 and Intelligent Network Capabilities," Atai and Gordon: Bellcore, 1997.

[15] See U S West, 7.

are long distance calls. By reaching this conclusion the commission could simply acknowledge that there is a massive amount of traffic which does not originate and terminate within an ILEC's local calling area. Given that neither the Telecommunications Act nor the FCC has eliminated the distinction between local and non-local, this could be a solution. However, one would first need to examine whether all of the calls, or at least a majority of them, can be traced to their termination points. After this measurement is done, one could employ the use of PIUs (percentage of interexchange use) to assess charges. The difficulty associated with this solution is that regulators would have to undertake a task that they have not typically done. They would have to look behind an end user's private network to determine where traffic is ultimately terminating. Furthermore, regulators may find that such a determination is used to support an ILEC's claim that all end users should be paying access charges since the existence of the intermediate carrier does not change the nature of the end user's call to the ISP. If a state believes that the service provided by ISPs is a carrier-type (and non-local) service, and the FCC agrees, then a state commission may find this solution a desirable means to correct a perceived incongruity in the treatment of ISPs vis-à-vis IXCs.

[illegible]

② Another option is not to look behind an end user's private network, regardless of whether it is open or closed to the general public, and continue to treat such traffic as local, including the non-application of access charges. While the Telecommunications Act did continue the distinction between local and non-local service, one can assert that this distinction lies primarily in the nature of traffic which carriers are processing. Therefore, if traffic processed within only one network would be considered local, then the same traffic processed within two networks covering the same local calling area should still be considered local. Furthermore, if a state determines that the flat rate usage packages which are currently being subscribed to by its end users are cost compensatory of all the minutes the end users are generating, this option is further supported. It may be inappropriate from a public interest viewpoint to assess access charges to a private network for traffic which terminates to it, especially when it has been determined that end users are fully compensating the LEC for traffic which they are generating. If a state were to allow access charges to be assessed in this situation, it may wish to develop an understanding with the ILEC concerning the adequacy of the ILEC's network in processing data transmissions and further steps which may need to be taken to develop that network. Lastly, this option would continue to provide CLECs with a revenue stream to finance the building of their networks.

PSC motivation

11: keep 1st [illegible]

③ A third avenue to resolve this dispute is that there be no compensation exchanged between carriers for traffic to an ISP. The argument for this option is that so long as no carrier is receiving compensation for calls to ISPs, each will have the same perspective on ISPs. For example, right now many ILECs have a very large majority of their residential customers subscribed to low flat rate usage service. As such, it is very difficult to obtain additional revenues from their customers for the large amounts of traffic they generate once they start subscribing to the Internet. So, as alluded to earlier in this paper, the ILECs arguably are not being compensated for the usage of their networks. With the existence of an intermediate carrier, not only are the ILECs perhaps not compensated, but they must pay carriers for termination on the other carriers' networks. By not allowing compensation to flow between the carriers, neither carrier would be compensated for this traffic. This is how both carriers would come to view ISPs in a similar manner. The revenue which they could generate from the ISPs would be the charges they directly assess to the ISP. The only complexity in this argument would be those ILECs and their associated end users who subscribe to local minutes-of-use service. In this scenario the ILEC is being compensated by the end user for the use of its network, so the dynamic of the non-recovery of costs through flat rate end user charges does not exist. The difficulty of distinguishing between Internet minutes that are subject to flat rates and those subject to minutes-of-use charges may render this solution unworkable. Another potential adverse effect of this scenario may be that, once CLECs are no longer compensated for ISP traffic, their traffic imbalances become so great that they are unable to sustain themselves financially. This dynamic would be very difficult to assess currently because if a CLEC is marketing mostly to ISPs, they will intentionally have few other customers. Therefore, assessing whether they can be financially sustainable in the long run may not be readily achievable today.

④ ixx approach

The fourth avenue open to regulators is more complex. This solution requires that ISPs be assessed a "termination surcharge" when calls to it attain a certain level. In this manner, non-ISP end users do not have to have any of their rates adjusted. It would be the ISP who would pay for the traffic terminating to it. The complexity in this solution is when the end user resides on a carrier's network different from the carrier network on which the ISP is located. This is because, technically speaking, the carrier which is owed money from the ISP is the end user's carrier. In this situation it may be that the ISP's carrier becomes the collection agent for the originating carrier. In this scenario, the terminating carrier could still be paid the terminating charges owed to it. The result could be a sort of netting.

IV. Relationship of Internet Access and Universal Service

Universal service is a complex issue with a seeming myriad of ongoing controversies. The issue involves setting and achieving objectives for telecommunications infrastructure and subscription levels. In terms directly relevant to the Internet, the issue is the degree to which advanced telecommunications infrastructure should be ubiquitously available and which services should be included as universal service offerings?

Many businesses and institutions have turned to virtual private networks to meet their computer and telecommunications needs. This trend is fostered by the technological availability of virtual channels within the PSN providing bandwidth or capacity reservation at flat rates. Higher-speed PSN offerings are based on an access line charge with usage priced on a per-unit basis. Further, video transmissions are handled by the PSN as data. Because of these dynamics, questions arise regarding the appropriateness of differentiating data and video transmissions on the PSN and what type of rates to charge for potentially bursty and voluminous transmissions, particularly in relation to the pricing of voice traffic. Currently, because one can obtain bandwidth at a flat rate and because video-dedicated channels appear more reliable, they are more attractive than typical switched or derived video channels on the PSN. As a result carriers have an incentive to invest in adjunct networks that carry high speed, high volume data and video transmissions but do not have the incentive to invest in advanced infrastructure placed in the PSN itself. This has the undesirable effect of denying or delaying the general offering on the PSN, to residential and small business customers, of a reasonably priced high speed form of access to the Internet.

Universal service planning should address the means to support the concomitantly necessary investments for designated advanced telecommunications services for which customer demand will not garner sufficient revenue to support facility placement. Such concerns would encompass the need to subsidize, in some areas, infrastructure necessary to provide advanced services or to facilitate Internet access. Even the current USF rules may inadvertently be slowing the roll out of advanced telecommunications to the general public. This is because, in some cases, the diversion of educational, health care and library institutions' usage, and attendant revenues, from the PSN to private two-way video and data networks has and will continue to exacerbate the need for support funding to keep the rates for advanced telecommunications services low enough to be considered affordable. This problem is particularly acute in rural and low income areas.

In addition, there are overlapping and conflicting aspects to the drive for a ubiquitous national roll out of advanced telecommunications services and the need to define, and maintain at affordable rates, "basic" or "essential" telecommunications services. In this debate, regulators must be careful not to over-plan the deployment of advanced services. Where regulators believe companies are making significant infrastructure inroads, or are trending to this, caution should be employed so that one does not fund infrastructure investments that would have occurred anyway. Many rural and low-income markets often experience a lag in such investment. The question becomes, "When is such a lag intolerably long?"

Of course universal service is only one of many public policy goals for telecommunications industries, some of which conflict in real world applications. Additional goals include: (1) development of competitive markets, (2) placement of telecommunications infrastructure in all markets, (3) encouragement of technological innovation, (4) use of deregulation, lesser regulation and/or non-regulation, and (5) affordable access for essential public institutions.

Many of these often conflicting goals are directly incorporated into Section 706 of the Telecommunications Act, "Advanced Telecommunications Incentives." Congress allowed a period of time to see whether or not the competitive market can provide the needed facilities to all Americans in a timely and reasonable fashion. If after three years under the Act the FCC finds that the market mechanisms have failed, it is authorized to remove barriers to investment and promote competition.[16] No funding remedies are authorized in this section.

---

[16] On January 26, 1998, Bell Atlantic filed a petition with the FCC requesting that the deregulatory steps authorized under Section 706 of the Act be taken at this time due to the slow deployment of the advanced network features like high-speed broadband capacity over packet switched networks. This petition attempts to sidestep the review procedure contemplated in the law and foreshortens the period envisioned by Congress for the provisions that foster local competition to take effect. Many RBOCs seem to be looking for novel routes through which to provide in-region services before they receive FCC approvals under Section 271 of the 1996 Act.

In Section 254(h), on the other hand, the provision of advanced telecommunications services is allowed to be subsidized, and that subsidy is limited to specified schools, libraries and health care institutions. Other ratepayers may not directly benefit in their homes and businesses from this subsidy for higher capacity services to these institutions. There currently is no provision for direct subsidy for the general public of the higher capacity services when provided to their homes and small businesses. In fact there are price disincentives built into accessing the Internet at low speeds such as an increase in the subscriber line charge for subscription to a second line for modem connections. While this higher subscriber line charge is based on cost and is a means to limit the size of the support funding for basic lines, it is nonetheless an example of how the Universal service goals for basic and advanced services can operate in conflict.

Network traffic directed to use ISP services is currently exempt from application of interstate access charges regardless of its jurisdictional pattern. Practically, this policy results in the assignment of most ISP traffic to local usage, thereby shifting the relative usage and jurisdictional costs of this traffic to the states. A more meaningful jurisdictional assignment of Internet traffic should reflect the realities of the shared network facility. Lacking that, there appears to be an implicit subsidy from intrastate service for some ISP traffic when one compares it to treatment of similar IXC traffic. If the FCC continues to exempt ISP traffic from explicit interstate access charges, it must develop an explicit interstate subsidy mechanism, as required under the 1996 Act, to replace the current implicit subsidy based on a jurisdictional shift of the traffic to local.

Consideration of universal service objectives and access charge reform objectives must go hand-in-hand if regulators are to prevent the opportunity for arbitrage inherent in the current melange of historical pricing policy and forward-looking market objectives. What we find today in the Internet and its access providers is a hybrid of services and technologies that frustrate application of traditional regulatory paradigms. The Internet and its interplay with local telecommunications networks displays carrier, enhanced service provider, and broadcast media attributes. Therefore, the categorization of ISPs as a distinct class of customers from traditional IXCs may be a necessary interim step to achieving a compensation model that is acceptable today for application to Internet access over the PSN — and possibly, soon thereafter, to all interconnects with the local network for origination and termination of telecommunications transmissions.

Under the 1996 Act, subsidy for advanced telecommunications and information service capabilities is allowed only when they are being deployed in the networks of telecommunications carriers and the services are being subscribed to by a substantial majority of residential customers. Such a subscription level would make these services eligible for consideration for inclusion in the definition of services supported by the federal USF. The demand of the institutions eligible for support under Section 254(h) for such advanced telecommunications services over the PSN is being diverted to private connections that have been made more affordable by the subsidies under that section. This leaves a smaller total demand on the PSN over which to spread the costs of such services. This results in higher prices which further reduce residential demand for the PSN-based services. Therefore, to the extent that demand for advanced telecommunications services is diverted away from the PSN by private connections, the inclusion of advanced services in the definition of universal service will be delayed. In some rural and low-income or high cost areas this may delay the delivery of access to information technologies and services.

Lastly, states are authorized under Section 254(f) to develop additional definitions and standards to advance universal service within a state as long as they are funded so as not to rely on the federal USF mechanisms. Advancement of Internet accessibility through higher speed connections to homes would require greater bandwidth than is supported under current FCC USF rules. This appears to leave states to fund any general advancement in data speed connectivity on the PSN from in-state sources. This burden is exacerbated because states have to bear the cost of infrastructure necessary to process Internet traffic which in turn has been encouraged by the implicit subsidy inherent in the ISP exemption.

Should ISPs Contribute to the Universal Service Fund?

There is a continuing controversy over using universal service funding to make advanced services for Internet access and information services ubiquitously available at affordable prices. That controversy also spills over into the issue of whether ISPs can and should contribute as "telecommunications carriers" to federal universal service programs. USF funding therefore ties back to the ongoing policy debate regarding the intent of the Act and the effect of the FCC's exemption of the ISPs from access charges, effectively declaring them end users rather than telecommunications carriers. Definitions are evolving regarding what is an end user, a service, a facility, and a carrier. Regardless, ISPs benefit from the subsidies for advanced services to the institutions designated in the Act when those subsidies make it possible for those institutions to use their services. In addition there is a blurring of the definitions of data, voice, and video when it comes to telecommunications applications. The Internet is capable of carrying voice transmissions and entrepreneurs are attempting to fully tap that capability and that market. As beneficiaries of subsidies to institutions accessing the Internet, and due to their public offering characteristiecs, it can be argued that ISPs should share in the cost of subsidizing services that are deployed to access the ISPs' services.

The Telecommunications Act states in Section 254(d) that every interstate telecommunications carrier shall contribute to the fund with equity and nondiscrimination. The FCC's previous exemption of Internet service providers from the "telecommunications carrier" designation for public policy reasons made sense at that time, but may prove inconsistent with the application of the Act's principles of explicit rather than implicit subsidization for universal service. Redefinition of ISPs as a distinct class of carriers and application of some form of economically based access charges and assessment for USF purposes could end this historical subsidy to ISPs and make them contributors to the explicit subsidies that promote use of their services. If the legal distinction between carriers cannot be made for purposes of applying access charges, another alternative may be to go ahead and assess ISPs and provide universal service funds directly to the ISPs to offset the charges.

V. Conclusions

At its inception and for many years thereafter, the PSN carried only voice communications. Growth in data transmission in recent years has resulted in a network that is heavily used for different types of communications. The current technology used for transmission of voice does not appear to be optimal for data. It is imperative that all participants in the telecommunications market, including regulators, have a clear understanding of how the PSN interrelates to the data network and how voice and data telephony are converging.

From a technical point of view, it is important that the PSN start migrating to a network which is data friendly. While it is understood that the PSN of today needs to undergo some fundamental changes to achieve this goal, we should also understand that all of the necessary changes do not have to occur on what is typically termed "the PSN." For instance, data traffic could be diverted onto a separate, data-friendly network for delivery to the Internet backbone by adding switch adjuncts into the network. Technology such as xDSL could also be employed in the loop to provide the premises connections which would permit high transmission speeds, thus keeping the last mile from being the choke point in data transmission. Many technologies could and will be used to provide quality data transmission capabilities in the future.

To make the transition to the data-friendly network will involve capital outlays. It is not enough that the Internet be able to process data. The loops and switches of the PSN must also be capable of doing so. Given that there is little compensation today for the increased traffic already traversing the network, due at least in part to the ISP access charge exemption, carriers may not be willing to make the investments needed to upgrade the network without a reasonable expectation of capital recovery. Because the FCC has determined that this investment for network upgrades will not be recovered through access charges paid by the ISPs, it is important that we devise some means to fund transformation of the PSN from primarily a voice network into one which can process any type of traffic desired, whether it be voice, data, or video. This funding could come from the end users who call the ISPs, the ISPs themselves, or the universal service fund. Of course we must always be careful not to fund technological and pricing developments which will occur naturally. However, we must weigh this concern against whether the pace of technology development is acceptable when a large segment of society may not be provided timely access to advanced telecommunications technologies.

[illegible]

PSN traffic and advanced telecommunications infrastructure are evolving symbiotically. In recognition of this, costs imposed on the PSN by those accessing the Internet should be equitably shared among the originators, conveyors and recipients of these communications in a manner that promotes technological innovation, network reliability and service quality, infrastructure investment, competitive markets, and ultimately, universal service. Numerous controversies have arisen regarding jurisdictional cost allocations, application of access charges or other local pricing options, payment of reciprocal compensation, and receipt of and assessment for universal service funding for PSN facilities. These controversies may be resolved equitably, vis-à-vis all telecommunications carriers and end users, if they are addressed systemically with recognition for their interplay. By seeing these controversies in focus in this paper, regulators and public policy makers may be able to avoid the perpetuation of some of the seemingly endless applications to the evolving PSN of inadequate and piecemeal fixes to often outmoded pricing and policy models. Such refreshed vision may engender innovative options and perspectives that otherwise might not be considered.

In summary, the telecommunications network is undergoing a transformation. It is imperative that the public continue to perceive the network as seamless. While it may be that several networks will be used to deliver the telecommunications services of tomorrow, all of them will have to interact to connect all users. Viewing the networks separately, without taking into account how they relate to each other in a unified communications system, would jeopardize the potential they hold to provide benefits for all consumers and to society as a whole.

References

"Internet Telephony: A Sound Investment," d.Comm (Data Communications supplement to The Economist), June, 1997.

"Comments of Cincinnati Bell Telephone Company" in re Federal Communications Commission Docket Number 96-263, Usage of the Public Switched Network by Information Service and Internet Access Providers, 1997.

"The Need for Speed," ADC Telecommunications, website http://www.kentrox.com/product/cellworx/nspeed/xdslprimer.intro.html, accessed 10/27/97.

AT&T, Comments to Internet Working Group.

Atari, Amir, and James Gordon, *Impacts of Internet Traffic on LEC Networks and Switching Systems*, Red Bank, NJ: Bellcore, 1996.

Bell Atlantic/Nynex, Comments to Internet Working Group.

BellSouth, Comments to the FCC.

Goldstein, Fred, testimony to the Maryland Public Service Commission on the ISDN Tariff, November 11, 1996.

Internet Access Coalition, Comments to the Internet Working Group.

National Cooperative Telephone Association, *Passage to the Internet*.

Rural Utilities Service, Comments to Internet Working Group.

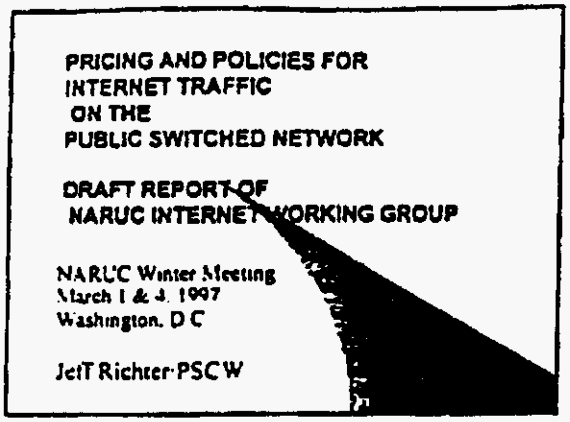
Selwyn, Lee, and Joseph Laszlo, "The Effect of Internet Use on the Nation's Telephone Network," Boston: Economics and Technology, Inc., 1997.

TCG, Comments to Internet Working Group.

Telecommunications Resellers Association, Comments to Internet Working Group.

U S West, Comments to Internet Working Group.

Werbach, Kevin, "Digital Tornado: The Internet and Telecommunications Policy," Washington, DC: Federal Communications Commission, 1997.

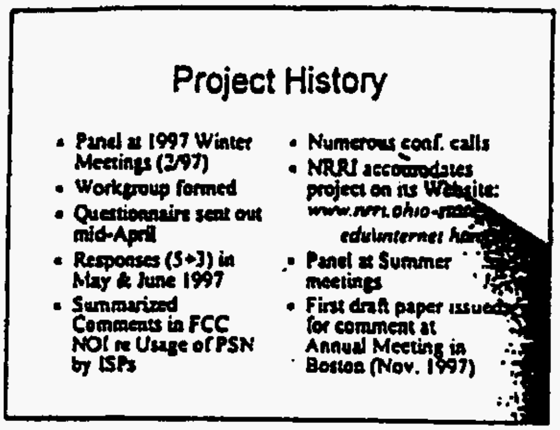


PRICING AND POLICIES FOR
INTERNET TRAFFIC
ON THE
PUBLIC SWITCHED NETWORK

DRAFT REPORT OF
NARUC INTERNET WORKING GROUP

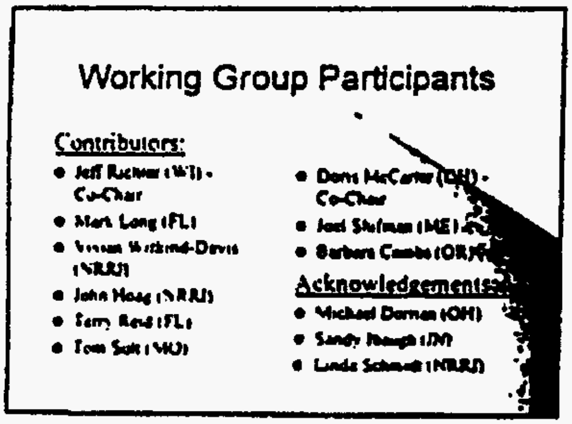
NARUC Winter Meeting
March 1 & 4, 1997
Washington, D.C.

Jeff Richter PSCW



Project History

- Panel at 1997 Winter Meetings (2/97)
- Workgroup formed
- Questionnaire sent out mid-April
- Responses (5+3) in May & June 1997
- Summarized Comments in FCC NOI re Usage of PSN by ISPs
- Numerous conf. calls
- NRRI accommodates project on its Website: *www.nrri.ohio-state.edu/internet.htm*
- Panel at Summer meetings
- First draft paper issued for comment at Annual Meeting in Boston (Nov. 1997)



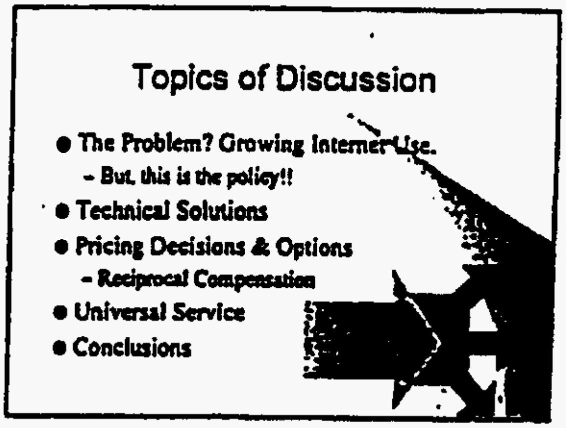
Working Group Participants

Contributors:

- Jeff Richter (WI) - Co-Chair
- Mark Long (FL)
- Vivian Witkind-Davis (NRRI)
- John Hoag (NRRI)
- Terry Reid (FL)
- Tom Solt (MO)
- Doris McCarter (OH) - Co-Chair
- Joel Shifman (ME)
- Barbara Combs (OR)

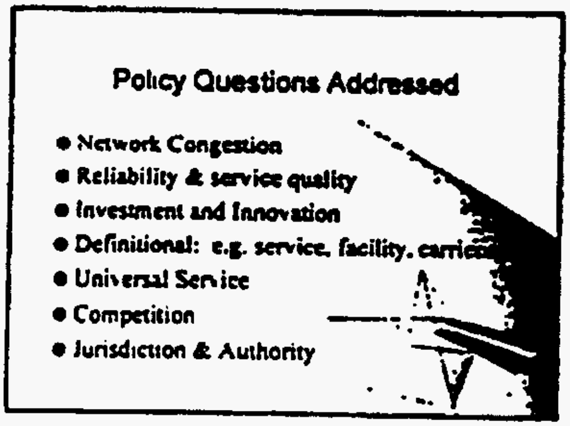
Acknowledgements:

- Michael Dorman (OH)
- Sandy Ibaugh (IN)
- Linda Schmidt (NRRI)



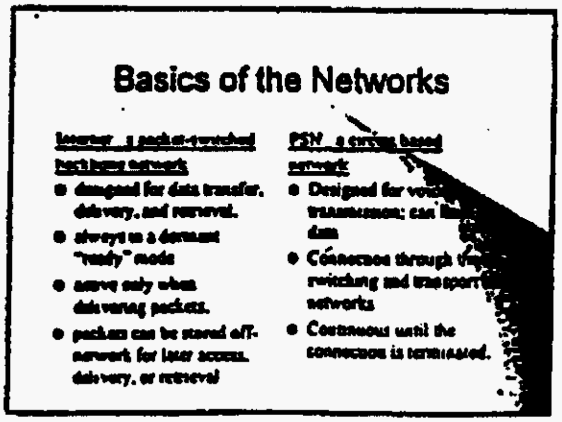
Topics of Discussion

- The Problem? Growing Internet Use.
  - But, this is the policy!!
- Technical Solutions
- Pricing Decisions & Options
  - Reciprocal Compensation
- Universal Service
- Conclusions



Policy Questions Addressed

- Network Congestion
- Reliability & service quality
- Investment and Innovation
- Definitional: e.g. service, facility, carrier
- Universal Service
- Competition
- Jurisdiction & Authority



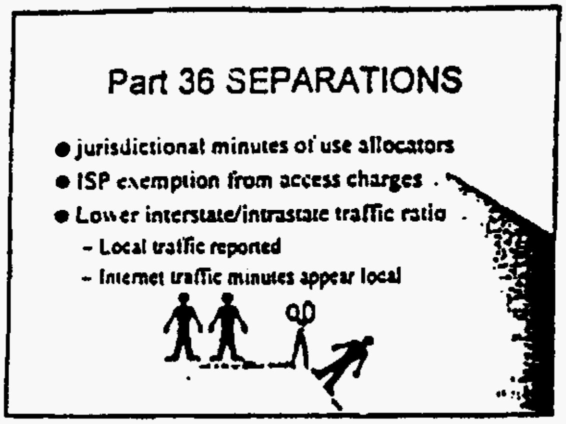
Basics of the Networks

Internet - a packet-switched backbone network

- designed for data transfer, delivery, and retrieval.
- always in a dormant "ready" mode
- active only when delivering packets.
- packets can be stored off-network for later access, delivery, or retrieval

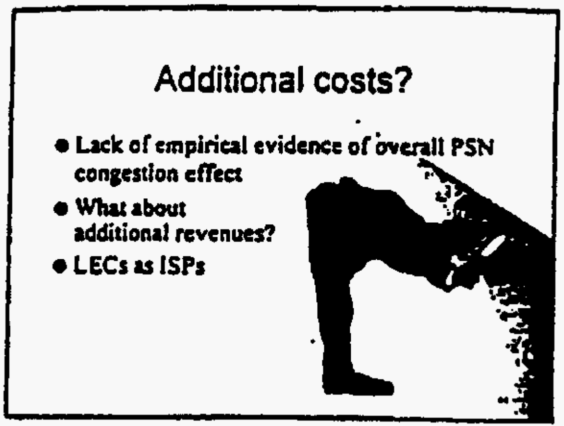
PSN - a circuit based network

- Designed for vo transmission; can data
- Connection through the switching and transport networks
- Continuous until the connection is terminated.



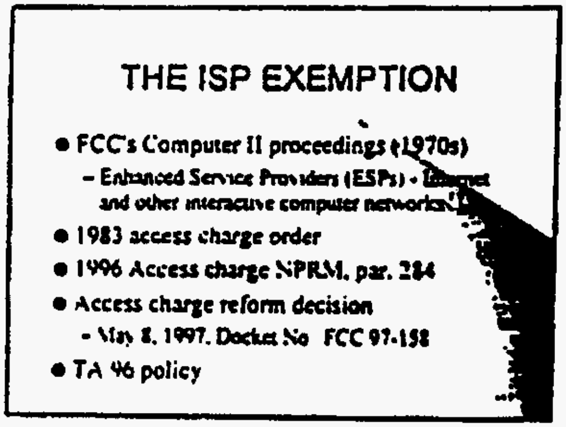
Part 36 SEPARATIONS

- jurisdictional minutes of use allocators
- ISP exemption from access charges
- Lower interstate/intrastate traffic ratio
  - Local traffic reported
  - Internet traffic minutes appear local



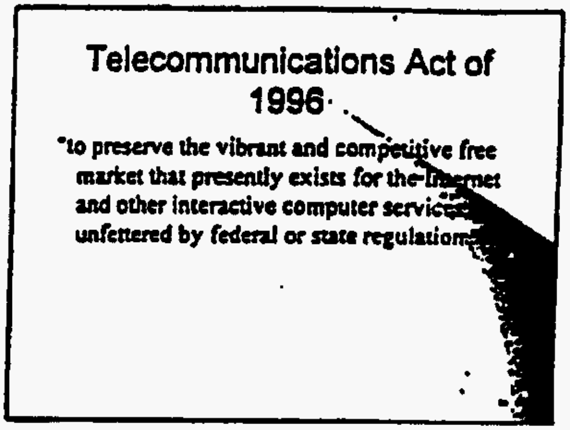
Additional costs?

- Lack of empirical evidence of overall PSN congestion effect
- What about additional revenues?
- LECs as ISPs



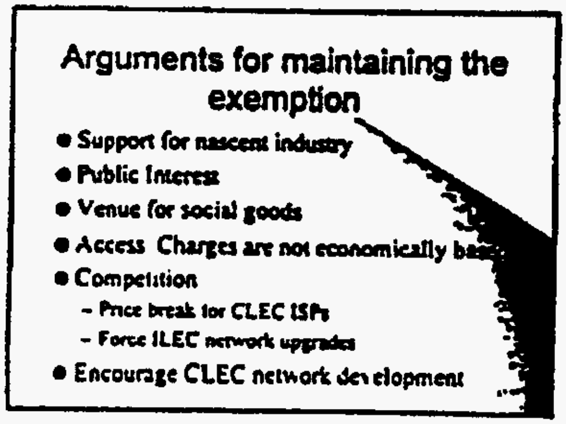
THE ISP EXEMPTION

- FCC's Computer II proceedings (1970s)
  - Enhanced Service Providers (ESPs) - Internet and other interactive computer networks
- 1983 access charge order
- 1996 Access charge NPRM, par. 284
- Access charge reform decision
  - May 8, 1997, Docket No FCC 97-158
- TA 96 policy



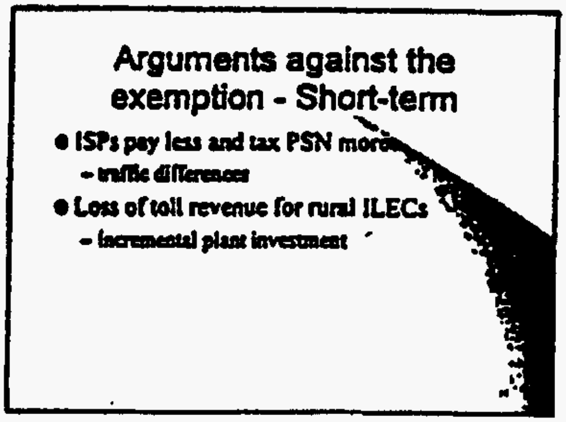
Telecommunications Act of 1996

"to preserve the vibrant and competitive free market that presently exists for the Internet and other interactive computer services unfettered by federal or state regulation



Arguments for maintaining the exemption

- Support for nascent industry
- Public Interest
- Venue for social goods
- Access Charges are not economically bas
- Competition
  - Price break for CLEC ISPs
  - Force ILEC network upgrades
- Encourage CLEC network development



Arguments against the exemption - Short-term

- ISPs pay less and tax PSN more
  - traffic differences
- Loss of toll revenue for rural ILECs
  - incremental plant investment

SO WHAT?

- In an Internet call, the two end users are the Internet Service Provider (ISP) and the ISP's customer.
- Internet service providers (ISPs) are connected to both networks:
  - the packet network over high speed dedicated facilities for exchange with the Internet, and
  - the PSN through local business lines to provide dial-in access for end users.

ESP Exemption

Why local connections for dial-in?

- The FCC exempts Enhanced Service Provider (ESP) traffic from access charg
- the FCC has interpreted that ISPs are ESP
- Therefore, ISPs not required to pay access charges
  - On the other hand interexchange carriers (IXCs) must pay access charges for similar connections to the PSN.

So basic PSN service less efficient BUT more attractive

- cheaper for end users
- modems bridge gap
- flat or per-call local prices

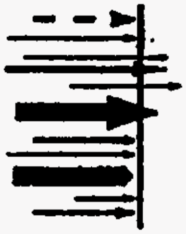
PSN CONGESTION??

- Call durations
  - Voice ~ 4 minutes, Internet ~20 minu
- Second busy hour in the evening
- Exacerbated by flat rate pricing
- Could result in congestion of several PSN components

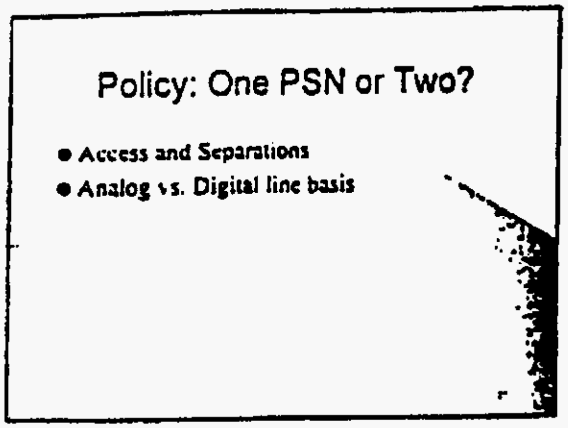
Locus of Congestion

- Access Line Congestion
  - Increase blocking, dial tone delay
  - Line units added or reconfigured
- Trunk Side Congestion
- ISP termination - not enough modems
- NOT to be confused with Internet slowness

Jurisdictional Nature of traffic:



- Local or Interexchange
- Inter- or Intra-State
- Inter-Net

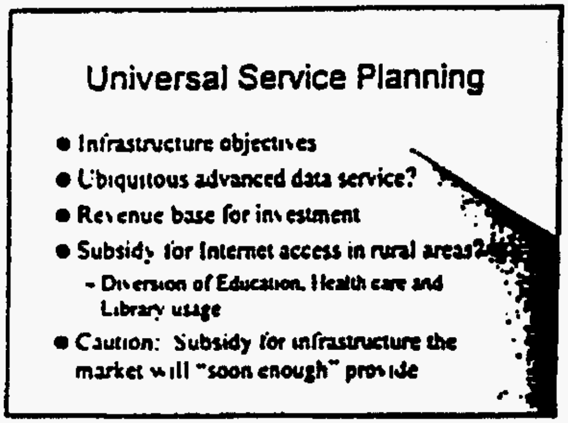


Policy: One PSN or Two?

- Access and Separations
- Analog vs. Digital line basis

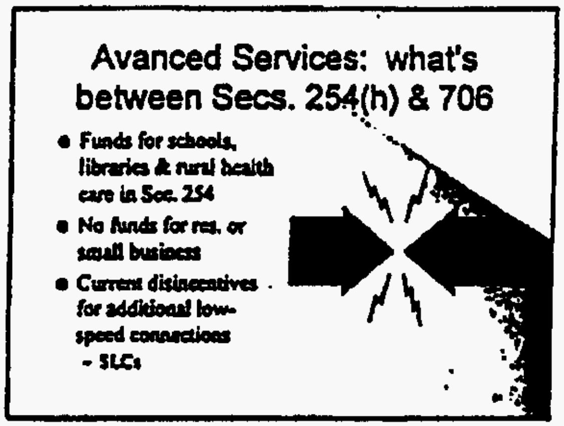
Government Policy Goals

- Development of competitive markets
- Ubiquitous Infrastructure
- Encourage technological innovation
- Use of de-/lesser/non-regulation
- Affordable access for essential institutions
- Universal Service
  - basic/essential service
  - rural issues



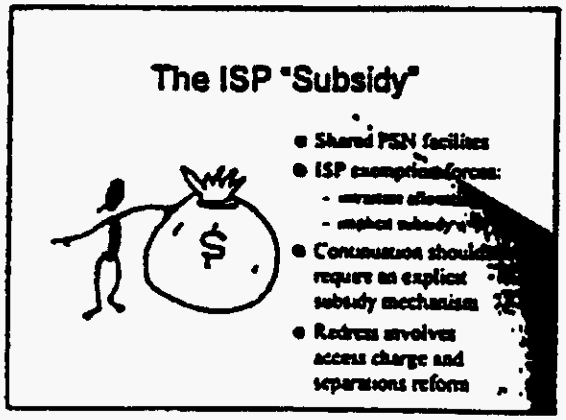
Universal Service Planning

- Infrastructure objectives
- Ubiquitous advanced data service?
- Revenue base for investment
- Subsidy for Internet access in rural areas?
  - Diversion of Education, Health care and Library usage
- Caution: Subsidy for infrastructure the market will "soon enough" provide



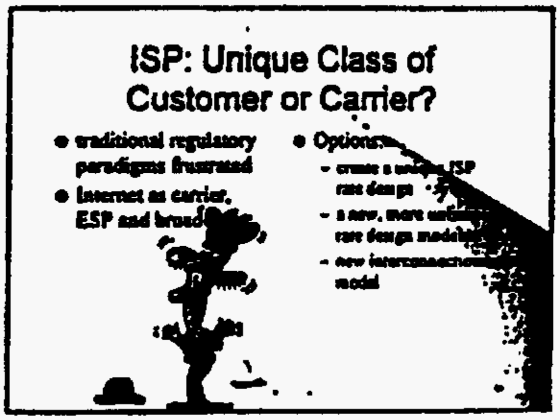
Avanced Services: what's between Secs. 254(h) & 706

- Funds for schools, libraries & rural health care in Sec. 254
- No funds for res. or small business
- Current disincentives for additional low-speed connections
  - SLCs



The ISP "Subsidy"

- Shared PSN facilities
- ISP exemption/forces:
  - [illegible]
  - implicit subsidy [illegible]
- Continuation should require an explicit subsidy mechanism
- Redress involves access charge and separations reform



ISP: Unique Class of Customer or Carrier?

- traditional regulatory paradigms frustrated
- Internet as carrier, ESP and broad
- Options:
  - create a unique ISP rate design
  - a new, more unif rate design model
  - new interconnection model

Arguments against the exemption - Long-term

- Network overload encouraged
- Discourages new competitive offering
- Harms IXC entry
  - Cost imposition of Access
  - Loss of revenue

What is the short-term evolution of Internet access?

Two schools of thought:

- PSN management
  - Sufficient revenue?
- Migration to data networks
  - Sufficient incentives?
  - Business - PL, Centrex, ISDN
  - Residence - ISDN

Bellcore

Internet Traffic Engineering Solutions Forum

- SS7-based solutions, 10/97
  - Line-side Redirect: pre-switch
    - route calls directly to ISP, i.e., via PRI, T-1
  - Trunk-side Redirect: post-switch
    - divert traffic to packet 'cloud' for transport
- Improve "Present Mode of Operation" 6/96
  - Add, reconfigure line units

Is ISDN a short-term mass solution?

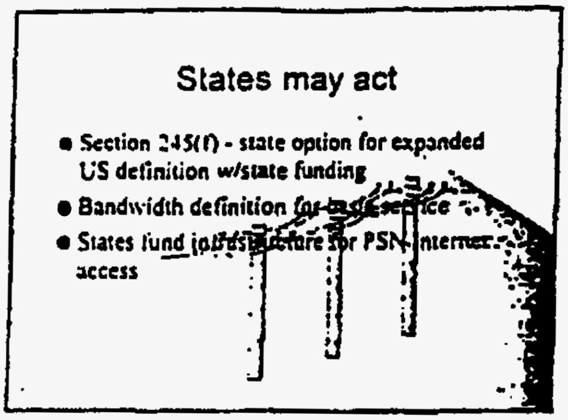
- PRI for ISP's prevents line-side congestion
- Debate on consumer BRI use continu
  - already passed over by the market for the generation of digital lines?
- Affordability
- Technical limits
  - speed, distance

Long-term Evolution of the Internet and Internet access?

- Internet has gone packet
  - ATM backbones, Frame Relay
- Last Mile
  - xDSL
  - cable modems
  - improved analog?
- LECs as protocol converters
  - LEC modem banks?

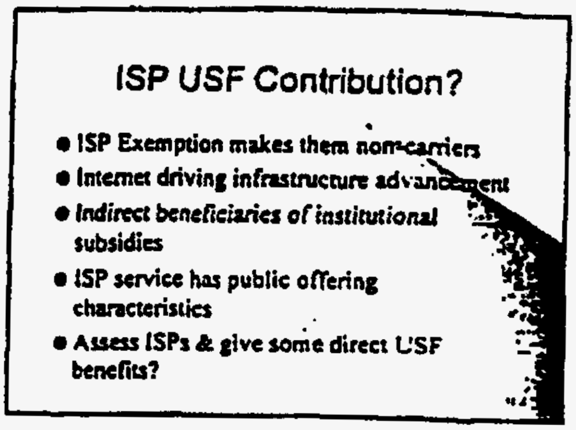
Structure and Charges for Local PSN Internet Access

- Government should not establish a specific technology as a social goal.
- Continue the preferential rates?
  - This may be affecting technological advanc
- If charged for PSN, it should be:
  - forward looking
  - to ISP, not end user



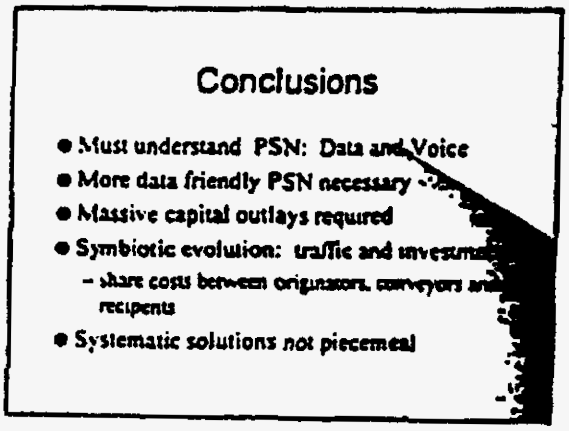
States may act

- Section 245(f) - state option for expanded US definition w/state funding
- Bandwidth definition for basic service
- States fund infrastructure for PSN-internet access



ISP USF Contribution?

- ISP Exemption makes them non-carriers
- Internet driving infrastructure advancement
- *Indirect beneficiaries of institutional subsidies*
- ISP service has public offering characteristics
- Assess ISPs & give some direct USF benefits?



Conclusions

- Must understand PSN: Data and Voice
- More data friendly PSN necessary
- Massive capital outlays required
- Symbiotic evolution: traffic and investm
  - share costs between originators, conveyors an recipents
- Systematic solutions *not* piecemeal

Bellcore
Bell Communications Research

Impacts of Internet Traffic on LEC Networks and Switching Systems

Amir Atai, Ph.D., James Gordon, Ph.D.

Bellcore, Red Bank, New Jersey, U.S.A.

Impacts of Internet Traffic on LEC Networks and Switching Systems

Amir Atai, Ph.D., James Gordon, Ph.D.

Bellcore, Red Bank, New Jersey, U.S.A.

Abstract: *The past year has seen explosive growth in internet traffic. Currently, the most common way of accessing the internet is via the switching systems and the interoffice trunk facilities of the Public Switched Telephone Network (PSTN). The PSTN was designed to carry voice calls that have an average call holding time of about 3 minutes. The nominal 3 minute call assumption pervades all aspects of telco equipment design such as switch engineering, line concentration ratios, and trunk group sizes. However, internet calls violate this fundamental assumption and have a mean holding time of the order of 20 minutes with some calls lasting for many hours.*

This long holding time traffic severely taxes the PSTN. It requires additional equipment to be provisioned, without compensating revenues, and potentially affects service performance for all users. Internet traffic, which is packet data in nature, can in principle be carried much more efficiently on data networks. However, since the PSTN currently represents the only near-universal access method, any long term solution necessarily involves a staged migration from the present mode of operation towards some packet network solution.

This paper reviews the impacts of internet traffic on the PSTN. It summarizes the impact of internet traffic on transmission and switching equipment, the need for comprehensive revisions to existing engineering and planning algorithms, and the implications of these issues for operational practices and operations support systems. It also provides analysis of the cost of supporting internet traffic on the PSTN. Finally, it describes a number of possible solutions. In each case the current barriers to implementing the solution are discussed.

I. INTRODUCTION

The past year has seen explosive growth in internet related telephone traffic – specifically, calls from residential and business subscribers across the public switched telephone network (PSTN) to internet service providers (ISPs).[1] Although there are alternative methods of accessing the internet (to be discussed later in this paper), the only near-universal access currently available to the public is via modem calls across the PSTN. After reaching an ISP, such calls are converted back into data format so that they can be piped directly into a local internet gateway, or transmitted across a packet network to a remote gateway. This network architecture is illustrated in Figure 1.

The rapid growth in internet traffic has been stimulated by a number of developments, including: (i) the increased power and availability of personal computers (PCs), (ii) the growth in commercial uses of the internet, and (iii) the popularity and increased ease of access to the world wide web (WWW) via web browsers such as Netscape. In addition, the growth in corporate telecommuting and work-at-home (WAH) employment has created an environment in which users are more comfortable with on-line services and are more likely to use PCs for work and leisure.

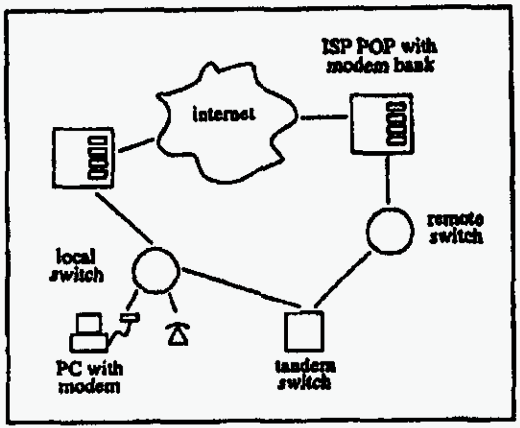


Figure 1: Internet Access via the PSTN

The rise in internet traffic provides an important indication that the center of mass in telecommunications is shifting towards data applications and services. Although the PSTN is currently used to carry internet calls in circuit switched mode, these calls are essentially data calls. They are generated in packet data format by PCs, and can in principle be carried far more efficiently and cost effectively over data networks. Suitable data networks exist today. However, due to cost and equipment limitations, access to these networks is largely limited to high volume business users. As access to data networks becomes universally available, the volume of data traffic generated by applications such as point of sale transactions, electronic commerce, video telephony, etc., will dwarf the traffic currently carried by the PSTN.

The trend towards data will challenge telecommunications network and service providers in a number of significant ways. In general, it will be necessary to develop engineering, planning, operational and business procedures to cope with new networks and services. The first major challenge is being met by local exchange carriers (LECs) in the form of internet traffic. This traffic has significantly increased the load on LEC net-

---

[1] For the purposes of this discussion internet traffic may be taken to include internet, work at home (WAH), telecommuting and on-line services calls, all of which appear to have similar characteristics.

works, while providing very little compensating revenue. While its volume poses an immediate threat to the capacity of the PSTN, at a more fundamental level its qualitatively new characteristics are challenging the engineering, forecasting, planning and operational procedures established by the Bell System over the past 80 years.

At present, a number of LECs are analyzing the internet phenomenon, and debating the best path forward. Since the PSTN currently represents the only near-universal access method, any long term solution necessarily involves a staged migration from the present mode of operation towards some packet network solution. The principal requirements of the migration strategy are that it be *cost effective* (i.e., provide the desired capabilities for reasonable investment), and that it be sufficiently flexible to evolve towards future technologies (e.g., ATM). Confusing the issue are a host of uncertainties associated with tariffing, time to market of new technologies, demand forecasts, etc. Notwithstanding the complexity of the problem, solutions need to be put in place quickly in order to protect the integrity of the PSTN.

The object of this paper is to review in more detail the various impacts of internet traffic on the PSTN, and provide a high level summary of possible solutions. In particular, based on analysis of traffic data, it summarizes the impact of internet traffic on transmission and switching equipment, the need for comprehensive revisions to existing engineering algorithms, and the implications of these issues for operational practices and operations support systems (OSSs). The paper also provides analysis of the cost of supporting internet traffic on the PSTN. Finally, it describes possible solutions, including more efficient use of existing PSTN equipment, as well as solutions based on packet networks (ISDN, Frame Relay, ATM). In each case the current barriers to implementing the solution are summarized.

II. GROWTH IN INTERNET AND RELATED TRAFFIC

As noted above, growth in internet traffic is tied to a number of factors including: PC penetration (percent of U.S. households with PCs), modem penetration (percent of PCs with modems), growth in corporate telecommuting and WAH employment (these users tend to be high volume users), and a range of less easily quantifiable factors such as time to market of new technologies (e.g., ADSL) and customers' willingness to pay for 'hot' new applications. Based on Bellcore's market analysis, Figure 2 shows conservative demand projections for internet access out to the year 2001. The demand is broken down into two categories: dialup access via the PSTN using POTS and ISDN lines (lower part of Figure 2), and alternative 'dedicated' access methods such as ADSL, which effectively bypass the PSTN (upper part of Figure 2). Note that the y-axis in Figure 2 has no units. Figure 2 illustrates anticipated average relative growth in U.S. internet traffic over the next 5 years. More detailed assumptions and information are required in order to be precise about growth in particular LEC markets.

The demand forecasts in Figure 2 are conservative, in the sense that conservative assumptions were made regarding the rollout of new technology. They suggest that by 2001, internet traffic will approximately double relative to its present value. If more aggressive assumptions are made, the demand could be significantly higher – as much as 5 times its present value by 2001. In fact, these estimates may well be too low, since they are based on analysis of numbers of households. No accounting is made for growth in per household internet traffic, which itself could be quite significant. In brief, the figures indicate that while new technologies such as ADSL and cable modems will grab a segment of the internet access market, the PSTN will support most internet access traffic for at least the next 5 years.

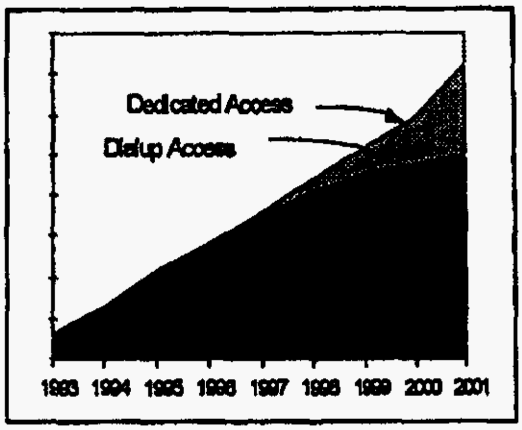


Figure 2: Forecast Demand for Internet Access

III. CHARACTERISTICS OF INTERNET TRAFFIC

Today's PSTN has evolved over the past 80 years to become a very efficient carrier of voice telephony. This evolution has occurred in a carefully planned fashion based on detailed understanding of the characteristics of voice traffic. The well established engineering model for voice calls assumes that: (i) the average call holding time is around 3 minutes, (ii) the statistical call holding time distribution is well approximated by an exponential distribution, and (iii) call arrivals are Poisson. These mathematical assumptions have been validated via analysis of measured data. In conjunction with appropriate demand forecasting models, they are used to engineer the PSTN. For example, the operations support systems (OSSs) that monitor trunk usage in the PSTN, utilize the above model to decide when and where additional trunking capacity should be provided. The large scale economics of the PSTN – e.g., its return on capital investment – are largely determined by how efficiently it can carry traffic across shared switching and transmission resources. Appropriate traffic models quantify what efficiencies can be achieved for a given grade of service (GOS).

Traditional models of voice telephony are embodied in a range of widely used standards, engineering procedures, OSSs, and cost models [1]. They underlie the traffic, measurement and engineering sections of Bellcore's LATA Switching Systems Generic Requirements (LSSGR) [2], that for many years have provided a benchmark for the functionality and performance expected of LEC switches in the U.S. They are likewise embedded in Bell System OSSs such as TNDS and COER [1], as well as in vendor supplied planning and engineering systems for specific switches. Finally, they are incorporated in tools used by the RBOCs for estimating the cost of the network switching and transmission equipment required to meet projected growth, based on detailed breakdowns of capital costs, etc.

Internet traffic is qualitatively different from traditional voice traffic. Based on current data analysis, internet calls have a mean holding time of the order of 20 minutes, and their distribution is not exponential.[1] Instead, the holding times of internet calls are statistically distributed according to a power law distribution. This means that with non-negligible probability, one can encounter calls with very long durations – e.g., 12 hours, 24 hours or longer. Traditional and internet call holding time distributions are illustrated in Figure 3. The plots in this figure give the probability that a call holding time will be greater than the time value on the *x*-axis. The 'flatter' shape of the internet distribution indicates that internet call durations vary widely from a few seconds to many hours. In contrast, the probability that a traditional voice call will last longer than a 10 minutes is very low, and the probability that it will exceed one hour is virtually zero. Traditional call holding times tend to be clustered far more closely around the average value of 3 minutes.

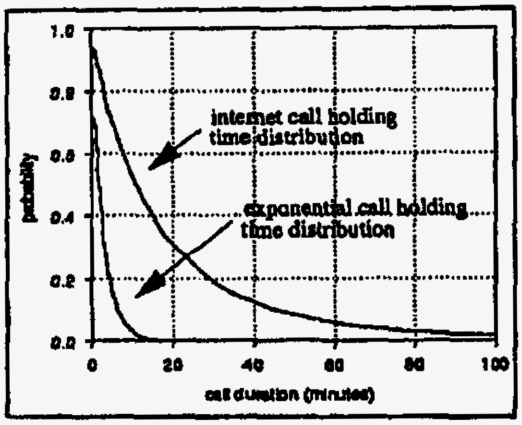


Figure 3: Call Holding Time Distributions

In addition to qualitative differences, internet traffic is also quantitatively different from traditional voice traffic. PSTN traffic loads are typically measured in units of centum call seconds (ccs), representing one hundred seconds of connect time. For example, a subscriber line which generates an average of 2 calls per hour with an average call holding time of 3 minutes is said to generate 2x(3x60)/100 = 3.6 ccs load, where the maximum possible load per line is 36 ccs. Historically, residential and business subscriber lines are expected to generate 3 - 6 ccs, with residential lines at the lower end of this scale and business lines at the higher end. The PSTN is engineered around this expectation. If a subscriber now starts using the same line to carry internet calls, as well as regular voice calls, the average load generated per line can rise to 10 ccs or higher. In this case, the network is suddenly required to handle about 3 times the load for which it is engineered.

IV. IMPACTS ON THE PSTN

The nature of internet traffic creates a number of issues for network engineering. The most immediate impact is due to the much higher loads generated by internet users. When significant number of subscriber lines suddenly generate 3 times their engineered load, one can expect significant congestion to occur in several parts of the PSTN: the local access switch, the backbone trunk and tandem network, and at the terminating switch which is connected to the ISP. Since internet traffic from a wide geographic area is typically funneled into the terminating switch, acute congestion is most likely to occur first at the terminating switch. In such cases, lines between the terminating switch and the ISP have been observed to be loaded to 30 ccs or more. Under these conditions, only a fraction of calls can successfully complete. That is, most calls are blocked due to lines not being available.

The congestion that has been observed in other parts of the PSTN – the access switches and trunking network – is partly due to elevated loads, and partly due to other less obvious causes. Line peripheral units in LEC switches are engineered to traditional traffic levels i.e., 3 - 6 ccs per line. In particular, line concentration ratios (LCRs) – the ratio of lines to trunks – are matched to these loads, so as to provide a uniformly good grade of service to subscribers e.g., <1% calls blocked. Internet usage can increase the load generated per subscriber line to 10 or more ccs, resulting in excessive blocking of call attempts, dialtone delay, and related problems. In summary, internet traffic can result in dramatic degradation of service quality.

The occurrence of excessive blocking is illustrated in a heuristic way in Figure 4. Figure 4 shows two blocking curves derived from traditional traffic models. One curve is for a scenario in which a group of lines is offered traditional exponential calls. The other is for a scenario in which 4% of the lines are effectively blocked out (i.e., continuously occupied) by long holding time internet calls. In the latter case, the presence of the internet calls produces a sixty-fold increase in the blocking experienced by the exponential traffic (from 0.05% to approximately 3%). Figure 4 shows that a small percentage of internet traffic can have a dramatic impact on network performance.

---

[1] Based on preliminary analysis of recently collected data. More work is underway to refine internet traffic models.

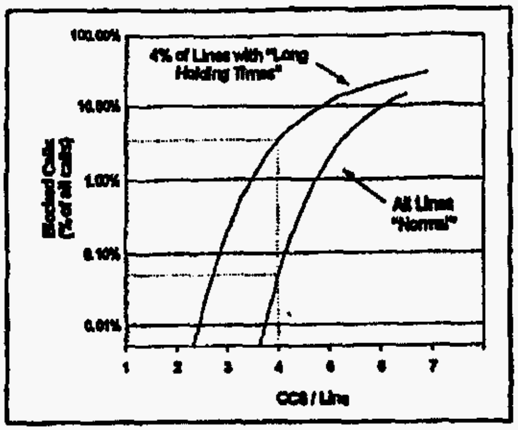


Figure 4: Blocking Scenarios

Within the PSTN, the only answer to this problem is to reduce LCRs i.e., to provide more trunks (and other switch resources) per subscriber line. In this way one regains the established grade of service, at the cost of providing additional network equipment. Since line terminating equipment is the largest capital component of switch cost, internet traffic has the potential to cost LECs large sums of money in 'out of cycle' capital expenditure. First cut estimates suggest that this cost will exceed $35M per region per year. However, this estimate is based on incomplete analysis, and the actual cost is expected to be much higher. Further studies are underway in Bellcore to produce more accurate estimates of this cost. Figure 5 shows Bellcore's analysis of a hypothetical scenario, which involves 30 central offices (COs) providing internet access, several tandem switches, and two internet 'hub' COs (i.e., terminating switches). For the purposes of this study, Bellcore's SCIS tool was used to estimate incremental capital and operational costs on a per switch basis.

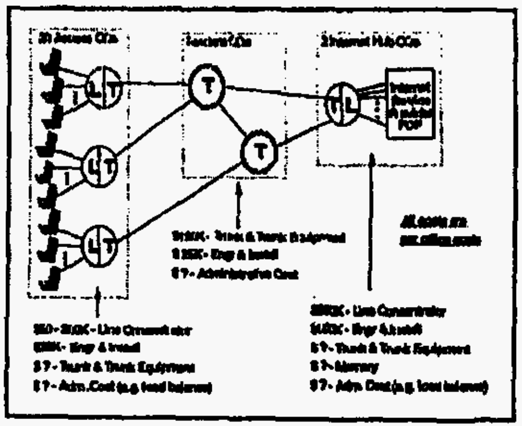


Figure 5: Cost of Supporting Internet Access

The largest cost components in all switches were associated with line terminating equipment. Note that trunk and administrative costs were not included in this study. Based on extremely conservative assumptions, the annual cost of supporting internet access in an ISP point-of-presence (POP) serving area was estimated to be in the range $2.7M to $4.2M+. (Costs vary according to factors such as vendor specific capital and operational costs.) A typical LEC will contain many such POP service areas. Note that this expenditure is likely to generate little compensating revenue for the LEC. Many subscribers will simply use their existing flat rate lines for internet access, resulting in zero additional revenues to the LEC. Others may purchase a second line – second line sales have risen substantially recently – however, the additional revenue from this source is unlikely to offset capital expenditure.

For more accurate estimates of the additional cost to LECs of supporting internet traffic on the PSTN, it is natural to turn to traditional traffic models. These models have been used in the past to engineer such quantities as LCRs, switch resources, trunk groups, etc. However, the qualitatively new characteristics of internet traffic imply that the traditional models are no longer valid. For example, it is not sufficient to simply plug the new elevated subscriber line loads into traditional traffic models, and recalculate line concentration ratios. The traditional models are overly optimistic and will tend to under-estimate the internet impact. New models are required, which account for the much greater variability in internet call holding times. This point is illustrated in Figure 6 below.

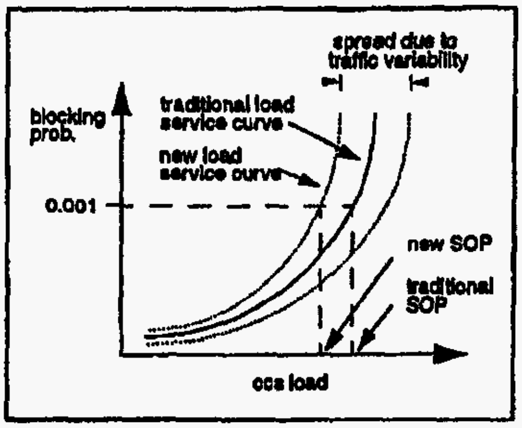


Figure 6: New Engineering Models

Figure 6 shows a traditional 'load-service' curve (solid line), for example, one that might be generated using an Erlang B or Poisson formula. For a given grade of service (i.e., blocking probability), such a curve is used to calculate a 'safe operating point' (SOP) for the relevant equipment. The SOP is the largest load that can be carried by the equipment while still meeting the GOS criterion. In the presence of internet traffic, switches and trunks can no longer be assumed to operate on the solid curve in Figure 6. Instead, they will tend to operate in some band around this curve, indicated by the dashed lines. It follows that in the presence of internet traffic, one must engineer the network more conservatively, according to the left-most dashed line. The overall impact of this effect is to de-load network equipment.

and reduce network efficiency. The magnitude of this effect – i.e., the additional cost to the network associated with new engineering criteria – is yet to be fully quantified. However, work is underway in Bellcore to address this issue, and to provide suitable new engineering models in the near future. These models will replace the traditional models developed in the Bell System over the past 80 years.

Going beyond fundamental traffic models and capital costs, the increased variability of internet traffic will impact the operation of LEC networks in a variety of ways. In the area of operations and facility management, current procedures for load balancing and monitoring switch performance may prove inadequate for internet traffic. Severe difficulties have already been encountered in load balancing switches carrying significant levels of internet traffic. This problem is presently being studied by Bellcore to determine what changes are required to current procedures, and what new switch measurements may be needed. As noted in section 3, a number of the large scale OSSs and support tools used by LECs are based on traditional traffic models. These OSSs need to be updated to accommodate internet traffic. If they are not, the tendency will be for these tools to underestimate network resources, potentially resulting in poor service to subscribers, and sub-optimal network planning.

Finally, from the LEC perspective, it is important that equipment vendors, particularly switch vendors, be aware of these issues, and take necessary steps to incorporate new traffic models and engineering algorithms into their engineering, provisioning and planning tools. Switch vendors also need to consider whether new traffic measurements should be provided by switches, so that their customers can better track and respond to changing traffic profiles.

V. NETWORK SOLUTIONS

As noted above, the most common internet access arrangement at present is for ISPs to be connected to the local 'terminating' PSTN switch via large multiline hunt groups, consisting of hundreds or perhaps thousands of lines. No special actions are taken within the PSTN to identify or route internet access traffic separately, or at a different grade of service, from regular voice traffic – internet traffic uses exactly the same switches, trunk groups etc. This situation will be referred to below as the *present mode of operation* (PMO).

Sections I - IV discussed various PSTN impacts of internet access traffic in the PMO. It was noted that since the PSTN currently represents the only near-universal access method, any long term solution to these problems necessarily involves a staged migration from the PMO towards some packet network solution. This section describes a number of solutions that will relieve pressure on the PSTN, and ultimately allow internet traffic to be carried in an efficient, economical fashion. These solutions may be characterized as short term (ST), medium term (MT) and long term (LT). In each case the current barriers to implementing the solution are discussed.

As shown in Figure 7, internet solutions may be broadly characterized according to whether they are implemented in the access switches of the PSTN, or in the inter-office trunking network. Trunking solutions generally attempt to reduce stress on the PSTN by de-loading the switches as far as possible, and by trunking internet traffic more intelligently. ***Trunking solutions, however, do not address the central problem of internet traffic, which is that the PSTN is not designed to efficiently carry packet data traffic. Access solutions do address this problem. They attempt to siphon off internet traffic at the edge of the PSTN, before it enters PSTN switch and trunk facilities.*** Once the internet traffic is separated from voice traffic, it is then routed onto data networks, where it can be carried very efficiently. Access solutions have far more long term potential to reduce the cost of carrying internet traffic, and for this reason are likely to form the basis for any long term network solution.

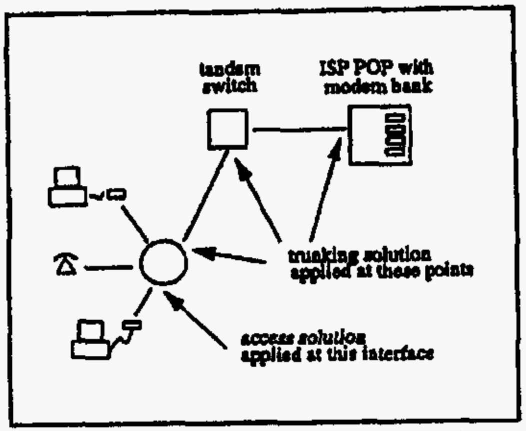


Figure 7: Access versus Trunking Solutions

It is possible to take advantage of both broadband technologies such as B-ISDN, Frame Relay, and ATM to provide a more efficient interface to ISPs as well as narrowband technologies such as Advanced Intelligent Network (AIN) or Local Number Portability (LNP) to more efficiently route the data calls within PSTN to switching systems that can better handle the data calls. While the underlying technology for these solutions is largely in place, a network planning assessment is needed to select the most promising and cost effective of these technologies to implement.

The trunking and access solutions discussed in this section are listed below, together with their characterization as short term, medium term or long term:

<u>TRUNKING</u>

- managed PMO (ST)
- numbering solution (ST)
- modem pool in CO (ST)
- post-switch adjunct (ST)

<u>ACCESS</u>

- managed PMO (ST)
- packet mode ISDN (MT)
- pre-switch adjunct (MT)
- ADSL (MT/LT)
- cable modems (MT/LT)
- packet radio (LT)

Managed PMO Trunking Solution

Trunking solutions address the problem of congestion in the trunking network and terminating switch. Although trunking solutions are technically feasible, they may not be within the full control of LEC for a number of reasons. First, an ISP buys only as many lines as it deems necessary to the terminating switch. For the most part, ISPs are content to provide a much poorer grade of service than in the PSTN. Internet traffic is growing so fast that customer retention is not an issue (at least in the near term), and customers themselves generally expect many calls to be blocked. Consequently, with too few lines to accommodate the offered load, congestion is likely to be a chronic problem on ISP lines.

This congestion can be contained by putting ISP lines on separate peripherals so that other customers are not affected. It could also be ameliorated by: (i) connecting the ISP to the terminating switch via trunk or primary rate ISDN (PRI) interfaces, (ii) connecting the ISP directly to tandem switches via trunk or PRI interfaces, so that switches are de-loaded, and (iii) connecting the ISP to remote integrated digital loop carrier (IDLC) interfaces, which could be engineered to an appropriate grade of service. The latter three actions would improve the LEC operations and facilities aspects of this problem.

However, ISPs currently perceive little incentive (e.g., in terms of cost) to move away from basic line side connections, and so they typically opt to be connected to the switch via multiline hunt groups. In some cases this choice may be made in ignorance of other options, or through failure to recognize the potential cost / performance advantages of more efficient interfaces. The competitive cost of basic line side connections is undoubtedly attractive to ISPs. However, line side connections are more expensive to maintain operationally, and as multiline hunt group sizes grow, there may be some cost incentive for ISPs to move towards trunk or PRI interfaces.

This issue highlights the role of tariffing in influencing practical network solutions. The tariffs applied to various line types by public utilities commissions (PUCs) in many cases reflect a traditional view of how subscribers utilize network equipment. Tariffs are set in part so that different classes of customers pay in proportion to their usage of network resources. However, internet traffic has distorted traditional patterns of network usage, and undermined the LECs' ability to recover costs in proportion to usage. Bellcore is currently helping the LECs address this issue through data studies in support of tariff changes.

AIN Routing / Numbering Solution

The main idea in this solution is to assign switched based dialed number (DN) triggers to pre-advertised internet or online telephone numbers. Once the originating switch recognizes that the call is destined to an ISP (based on the defined trigger), it can then either route these calls to a tandem or a large switching system that has sufficient capacity to carry the data calls (e.g., an inner-city switch which is under-utilized at night), or decide to route them out of the PSTN entirely and use a packet network to concentrate the data traffic for transport to the ISP. In either case, the first step in this solution would be to detect the data calls using the defined trigger, and segregate them from voice calls for more efficient transport and routing. The office-based DN trigger is available in most modern switching systems.

One implication of this approach is that every call through the switch must be screened for this trigger, which will typically require additional processor capacity. In the case of equivalent AIN triggers, there may be a substantial hit on switch processors, which translates into a substantial reduction in switch capacity, due to this potentially non-revenue producing internet traffic. A potential advantage of the AIN / numbering solution is that it concentrates internet traffic in relatively few places (e.g., designated trunk groups) and thereby achieves economic efficiencies in the engineering of CO equipment, as well as minimizing capital expenditure for high performance interfaces between selected tandems and ISPs.

Once a data call has been detected, it can then either use translations and routing tables in the switching systems to route the calls to pre-selected switches or alternatively launch a routing query to an AIN Service Control Point (SCP). The advantage of using SCPs is that switches do not need to store large routing tables that are subject to frequent change. SCPs permit intelligent routing based on availability of modem ports or routes, time-of-day and day-of-week routing, and other criteria that LEC and ISP can agree upon. Additionally, the LNP architecture offers the advantage of maintaining the same access numbers while routing the calls in way that is most cost effective for the LEC or ISP. Thus end-users always dial the same number to access the ISP. However, the network routes the call based on paths that are most suitable from a network capacity and cost point of view.

Modem Pool in Central Office / Post-Switch Adjunct

Instead of providing 1MB line interfaces to the ISP, in which case the ISP maintains its own modem pool, the LEC, as a value added service, could maintain a modem pool (or equivalent equipment) on its own premises, concentrate the output of this modem pool into high speed digital pipes (DS1/DS3) either at end offices or tandems, and then transport the aggregated data stream to the ISP across a data network (e.g., Frame Relay). This implementation may provide a more attractive interface for the ISPs – maintenance of large modem pools is an acknowledged problem – while providing the LEC with the opportunity to engineer the network so as to avoid the LHT related problems. One business driver for this solution is that ISPs desire to extend their local calling areas as far as possible, so that customers benefit from local calling rates. Widely deployed modem pools / adjuncts effectively achieve this objective. The business case, and deployment, implementation and engineering guidelines for this solution need to be more fully analyzed.

Managed PMO Access Solution

Within the local access switch, it is possible to take some actions to reduce or manage the impact of internet traffic. For example, if it is possible to identify heavy internet users, one can provide IDLC interfaces for these users, which are engineered independently of other lines to provide the required grade of service. Educated management of access switches will provide limited relief from internet problems – if nothing else, it is better for operations staff to understand the problem than to operate in a blind fashion. However, managed operation of access switches within the PMO will result in significant 'out of cycle' equipment expenses, and will not provide any substantial long term relief from internet problems.

Packet Mode ISDN

Data transmission only uses a fraction of the 64 kbps circuit switched bandwidth which is held up for the duration of internet calls. Specifically, data packets are sent back and forth across the circuit in rapid bursts followed by relatively long idle periods, and thus the bandwidth remains unused for most of the call. The inefficiency of carrying packet data over circuit switched networks was the main driver for developing packet switched networks such as X.25, Frame Relay, etc.

Ideally, one needs a simple method of identifying internet calls as data calls, and routing them to a data network before they enter the PSTN. In its packet mode services, ISDN provides such a method. Circuit mode ISDN calls operate in much the same way as traditional analog POTS calls. They seize a 64 kbps circuit and retain it for the duration of the call, regardless of whether the bandwidth is used or not. In contrast, packet mode ISDN calls do not reserve any fixed amount of bandwidth – they use bandwidth only as required. In packet mode calls, packets are sent as the subscriber generates them, and the switch is engineered to multiplex multiple packet streams together onto shared communication channels, so that bandwidth is utilized effectively, and all users receive an acceptable level of packet delay performance.

Packet mode services constitute a different paradigm for communications. They were included in ISDN for the purpose of carrying packet data traffic, but for a variety of reasons have not been made generally available to the public. Some of these reasons are possibly connected to questions concerning the capacity of ISDN packet handlers (which siphon off packet data traffic at the access side of the switch), and some may be related to lack of (pre-internet) applications and positioning of these products within the market place.

Although there are issues concerning the capacity, engineering and cost of ISDN peripherals, packet mode ISDN in principle constitutes the most attractive solution for identifying and segregating data calls at the access side of the switch. Implementation of ISDN as a practical solution may require interactions with switch suppliers to understand current limitations of packet handlers, and possibly increase their capacity in line with projected demand for packet mode services. Interaction may also be required to investigate appropriate engineering algorithms for ISDN switches. These same issues are currently arising through the use of packet mode ISDN services for point of sale (POS) transaction traffic.

Pre-Switch Adjunct

The idea of a pre-switch adjunct is to put some equipment with switching and modem capabilities between the subscriber and the local access switch. This adjunct equipment would perform some sort of table lookup on each call origination, to determine whether the call is destined to an ISP, or whether it is a regular voice call. In the first case, the adjunct equipment would route the call to a data network (via a modem function) and totally bypass the LEC switch. In the case of a voice call, the adjunct would simply pass the call to the LEC switch, and call setup and billing would proceed normally.

The idea behind the access node is valid – to siphon off data calls before they hit the LEC switching network. However, there are a variety of technical and business issues which need to be resolved with this approach, including the engineering and operations issues surrounding support of the adjunct, the cost of the additional equipment versus other solutions, implementation of billing, etc. In addition, since the adjunct resides between the subscriber and the local access switch, which is the subscriber's primary point of contact to the network, the pre-switch adjunct solution raises sensitivities to issues such as reliability, priority for emergency calls, recovery from failures, overload control, etc.

Asymmetric Digital Subscriber Loop (ADSL)

ADSL is an emerging technology that would replace or supplement the existing POTS or ISDN line between the subscriber and the local access switch. ADSL provides more bandwidth from the switch to the subscriber than in the reverse direction, from the subscriber to the switch. This arrangement is based on the expectation that subscribers will typically want to receive more information (e.g., video images) than they send. ADSL also provides the capability to siphon off data calls on the access side of the switch, before they enter the PSTN. These calls could then be routed to a packet network for efficient transport. Although it represents a potential solution, the timeframe and economics of ADSL rollout and acceptance are not clear.

Cable Modems

Cable modems utilize a shared hybrid fiber coax (HFC) medium and a media access control (MAC) scheme to share bandwidth among a subset of customers from a cable head-end. Cable modem technology has the potential to provide attractive high speed data access to cable-equipped subscribers. However the implementation details of this technology are still being explored. Since most, if not all, cable modem technology is implemented with a MAC scheme that allows for collisions and retransmissions, many details of the modem architecture, MAC scheme, traffic characteristics, line length (i.e. propagation time), deployment topologies, etc. will affect the real-world throughput of these devices. Vendor claims of 100 times narrowband ISDN bandwidth may greatly overstate their realizable throughput in realistic deployment scenarios. The aggregation of the upstream bandwidth of these devices is also dependent on traffic characteristics, as the upstream bandwidth is limited.

As with packet mode ISDN and ADSL, cable modems represent a solution in which internet traffic would be carried over data networks rather than the PSTN. Since cable lines are owned by cable companies, cable modems represent a potential competitor to the LECs. In order to retain market share, the LECs either need to team with cable companies, or deploy alternative solutions that are competitive with cable modems in terms of access speed, ease of installation, etc. As with ADSL, the timeframe and economics of cable modem rollout and acceptance are not clear.

VI. CONCLUSIONS

Due to a variety of market drivers, including wider availability of personal computers, the popularity of web browsers, and the rapid increase in internet service providers, internet traffic on the PSTN has experienced explosive growth in the past 6 to 12 months, and is projected to continue this growth for at least the next 5 years. The public switched telephone network (PSTN) will be the main carrier of internet access traffic for the foreseeable future. The PSTN is already struggling under the increased volume of this traffic, and network problems such as congestion, excessive blocking of subscriber calls, and exhaustion of switch capacity point to the danger of network failures unless effective short term and long term network solutions are identified and implemented soon.

Internet traffic is essentially data traffic, and can be carried most effectively on data networks. However, since the PSTN is currently the only near-universal method of access, any long term solution will necessarily involve a staged migration from the present mode of operation to some data network solution. The burning issue for LECs is how to engineer this migration in a cost effective and timely manner, given current technological constraints. This paper has identified a range of actions that can be taken to orchestrate a satisfactory long term solution. The final solution for each LEC may include a number of these actions, and could well be influenced by the unique business strategies and network plans of that LEC.

Regardless of the ultimate solution selected by an LEC, there is a substantial amount of work required in order to cost out the alternatives, perform interoperability testing of various supplier equipment, formulate appropriate engineering and operations plans for the network, and translate these technical advances into attractive products and marketing strategies. In parallel with this activity, it may be desirable for the LECs to jointly support the industry in formulating common equipment / interface standards and functional requirements, to facilitate service offering and interworking within the U.S. market.

REFERENCES

[1] *Engineering and Operations in the Bell System*. Bell Telephone Laboratories, 1983.
[2] *LATA Switching Systems Generic Requirements*. Bellcore Document TR-TSY-000064.

LIST OF ACRONYMS

ADSL	asymmetric digital subscriber loop
AIN	advanced intelligent network
ATM	asynchronous transfer mode
B-ISDN	broadband ISDN
CO	central office
COER	Bell System OSS (see reference [1])
DN	dialed number
GOS	grade of service
HFC	hybrid fiber coax
IDLC	integrated digital loop carrier
ISDN	integrated services digital network
ISP	internet service provider
LATA	local access and transport area
LCR	line concentration ratio
LEC	local exchange carrier
LHT	long holding time
LNP	local number portability
LSSGR	LATA Switching Systems Generic Requirements
MAC	media access control
OSS	operations support system
PC	personal computer
PMO	present mode of operation
POP	point of presence
POTS	plain old telephone service
PSTN	public switched telephone network
PUC	public utilities commission
RBOC	Regional Bell Operating Company
TNDS	Bell System OSS (see reference [1])
WAH	work at home
WWW	world wide web

Bellcore

Architectural Solutions to Internet Congestion Based on SS7 and Intelligent Network Capabilities

A Bellcore White Paper by Dr. Amir Atai and Dr. James Gordon

Abstract: The explosive growth of the internet has created problems for the Public Switched Telephone Network (PSTN), which for the foreseeable future will provide the majority of users with internet access via dialup modems. Based on current growth rates, the volume of 'internet' traffic on the PSTN is forecasted to rival or overtake 'regular' telephone or fax traffic in the next few years. This represents an enormous shift in the volume and nature of the PSTN traffic.

All of the solutions proposed to date recognize that it is necessary to off-load internet traffic from the PSTN. The PSTN is optimized for circuit-switched voice traffic, whereas internet traffic is most efficiently carried by packet-switched networks. In the search for effective off-load strategies, the first impulse has been to look for technological answers, i.e., to employ a new class of equipment to siphon traffic off the PSTN.

However, it is equally important, and perhaps more cost effective, to explore the use of existing features and capabilities in the voice network to develop efficient strategies to carry internet traffic. Intelligent Network capabilities, and those provided by Signaling System No. 7 (SS7) infrastructure, can be used to construct off-load architectures with flexible routing and call control. This report describes a number of such architectures.

1. Introduction

Reed Hundt, outgoing chairman of the FCC, recently voiced the need for a "... high speed, congestion-free, always reliable, friction-free, packet-switched, big band-width, data friendly network that is universally available, competitively priced, and capable of driving our economy to new heights. .. If we build it, the wonders will come." [A]

The authors of this paper are in agreement with Chairman Hundt's desire for ready public access to high speed data networks and the internet. The center of mass in the telecommunications industry is shifting away from traditional voice technology to data networking. High speed public data networks are needed to support a range of advanced telecommunications and information services that will become available in the near future, including commerce over the web, multimedia applications, and internet telephony.

However, while data networks will be a key ingredient of the future, the existing voice network (the PSTN [1]) will not become obsolete overnight, or even for many years. For one thing, there is a huge investment in the PSTN which cannot simply be discarded. Furthermore, the PSTN is a sophisticated system that offers an array of advanced features that cannot be matched by data networks in their present stage of maturity. With intelligent planning and packaging of services, voice and data networks should in fact complement and augment one another, for the greater benefit of subscribers.

The integration of voice and data services was planned well in advance by the 'minders' of the telecommunications infrastructure. For example, work began as early as twenty years ago on an Integrated Services Digital Network (ISDN), that would combine voice and data services. While ISDN has enjoyed a recent surge in popularity due to the growth in internet traffic, its penetration is still very small.[2] Efforts to simplify ISDN or-

---

[1] Public Switched Telephone Network.

[2] According to references in a recent FCC report (reference D), approximately 70% of subscriber lines can in principle support ISDN. However, only 1% of access lines actually have ISDN equipment deployed. And only 1.4% of internet users employ ISDN service.

dering and provisioning are currently underway, with the goal of increasing ISDN penetration. However, support for ISDN may be eroded by competition from newer technologies such as high speed analog modems and Asymmetric Digital Subscriber Loop (ADSL).

In principle, ISDN should have provided a 'data pipe' into residential homes, to supplement the existing 'voice pipe'. As always, access is one of the main barriers to the growth of data services – the famous 'last mile' problem. In the absence of widely available data access to residential homes, data services will tend to remain niche products, available to limited segments of the population. The need for 'universal' high speed data access might be satisfied in the future by technologies such as ADSL and cable modems. In the near term, however, these products are unlikely to achieve widespread deployment, due to immaturity of the technology and the initial expense of equipment.

Over the next few years, the PSTN will provide the vast majority of residential users with access to the internet and other data networks. Using voice circuits or 'pipes' to access data networks is not an ideal solution. However, it is the only alternative that is feasible in the short term. Ironically, in spite of the failure to deploy large scale residential data access, internet traffic may well drive the first widespread integration of voice and data networks. Due to popularity of the World Wide Web, etc., dialup internet traffic on the PSTN has experienced dramatic growth over the past two years. This in turn has created problems for the PSTN, leading network operators and equipment vendors to seek ways of offloading internet traffic from the PSTN onto data networks.

At present, the pros and cons of various internet offload strategies are being debated, and subject to marketplace evaluation. For example, carrier meetings such as Bellcore's Internet Traffic Engineering Solutions Forum (ITESF)[3] are actively exploring architectural solutions for the internet congestion problem.

In the search for solutions, the first impulse has been to look for technological answers – i.e., to employ some new class of equipment to siphon traffic off the PSTN. However, it is equally important to explore the potential for using existing features and intelligence in the voice network to develop efficient strategies for carrying internet traffic. In particular, the Signaling System No. 7 (SS7) and Intelligent Network (IN) capabilities of the PSTN have the potential to enhance the management, and streamline the transport of internet traffic, whatever technology and network equipment is employed.

This paper reviews a number of network architectures that facilitate the inter-working of the PSTN and data networks and, in particular, that allow internet traffic to be off-loaded from the PSTN onto data networks for more efficient transport. The pros and cons of these architectures are discussed. A particular emphasis of the paper is on the possible role of IN and SS7 capabilities in supporting the flexible transport and management of internet traffic. The main conclusion of the paper is that SS7 and IN capabilities can significantly improve the attractiveness of both pre-switch and post-switch offload architectures.

2. Problem Statement

Internet traffic creates a number of problems for the PSTN, but ultimately the most critical problem is that it upsets the PSTN's established economics. Internet traffic increases the load on PSTN resources, requiring the purchase and deployment of additional PSTN equipment, in order to carry the excess traffic. It follows that internet traffic increases the costs experienced by network operators. In contrast, it results in little or no compensating revenue. Or, as in the case of second lines, the revenue is outweighed by the increased costs.[a]

At present, many local exchange carriers (LECs) are in a holding pattern with regard to internet traffic, while potential solutions are evaluated. Although sufficient equipment has been added to cope with current demands, there is a clear recognition that better solutions are required. Furthermore, practical workable solutions are needed soon, since there appears to be no slowdown in the rate of growth of internet traffic.
One example of internet growth concerns the recent introduction of flat-rate pricing for some popular on-line services. Bellcore measurements suggest that under flat-

---

[3] The ITESF was created in 1997 and meets quarterly. At the time of writing, membership includes 8 carriers from the U.S., Canada, and Australia. Its goal is to understand the impact of internet traffic on LEC networks, share best practices, and identify architectural solutions. Equipment suppliers are also invited by the ITESF to discuss relevant current and future products.

rate pricing plans, users will stay on-line up to twice as long (on average) as under metered rate plans. Understandably, given the number of online users, this doubling of call duration can result in significantly higher loads for the PSTN. Internet growth forecasts from several sources all point to continued rapid growth. For example, by the year 2000 it is estimated that 30% of US households will be on-line, compared to 15% in 1997.

The continued growth of internet traffic adds to the costs of network operators. Since tariff relief is unlikely in the near term, the only solution to this problem is to proactively reduce costs by carrying internet traffic more efficiently. There are many proposed architectures for doing this, and the challenge for carriers is to identify the best off-load strategies, and synthesize the one(s) that are most cost effective, and that are consistent with network evolution. The final solution may well make use of many different elements, including new types of equipment, and the use of IN capabilities in creative and novel ways.

For a brief description of internet-related problems on the PSTN, and a survey of architectural solutions, the reader is referred to an earlier Bellcore white paper on this subject.[C] The impact of internet traffic has been documented in more detail in studies by Bell Atlantic, NYNEX, Pacific Bell and US WEST (see the web pages for these companies), and a comprehensive overview is provided by a recent FCC paper.[D] In addition, internet congestion has been discussed in numerous technical magazines and mass media articles and a more general perspective on how internet traffic affects PSTN engineering is given by the Bellcore article.[E] Many suppliers have developed, or are in the process of developing, products aimed at alleviating or solving internet congestion on the PSTN.

3. Key Issues

3.1 Why off-load?

The root cause of internet congestion is that internet calls have a much longer duration than the voice calls for which the PSTN was designed. Typical internet calls have an average duration of 20 minutes or longer, while average voice calls last 3-5 minutes. In addition, a segment of internet users stay online for many hours at a time. The probability of a voice call exceeding one hour's duration is less than 1%. In contrast, more than 10% of internet calls will exceed one hour.

In a circuit-switched network such as the PSTN, these long holding time (LHT) calls tie up both switch resources and interoffice trunks, and cause congestion that affects all users. Bellcore traffic modeling, supported by field measurements, shows that small increases in the amount of internet / LHT traffic can significantly increase the probability of call blocking (the main quality of service measure in the PSTN). For example, if 4% of users generate internet calls with 45 minute call holding time, then the probability of blocking increases from 1% to 7% (assuming no additional network equipment is deployed).

Even though an internet call lasts much longer (on average) than a voice call, the line is not actively used during the entire call. It is estimated that internet users utilize only 1/5 to 1/6 of a voice circuit's bandwidth. The on-off nature of internet traffic makes it ideal for packet switching, which 'multiplexes' (i.e., combines) several users' traffic onto a single channel. It is anticipated that multiplexing gains of 300% to 500% can be achieved by transporting internet access traffic on packet-switched versus circuit-switched networks. The efficiencies obtained through statistical multiplexing result in lower capital and operational costs, provided the traffic is of sufficient volume, and assuming that a data network infrastructure is in place. These reduced costs are a principal motivation for off-loading internet traffic from the PSTN onto data networks.

3.2 Present Mode of Operation

Before discussing off-load architectures, it is useful to understand the present mode of operation (PMO). Presently, most Internet Service Providers (ISPs) interface to local exchange carrier (LEC) networks via multi-line hunt groups or Primary Rate ISDN (PRI) (see Figure 1). Typically, the switches that ISPs connect to are chosen (by the ISPs) in order to maximize the free calling area. Often they are residential switches that were not designed to handle high volumes of traffic, particularly LHT traffic.

As shown in Figure 1, calls from many originating (or ingress) switches are routed through tandems or direct trunk groups to the terminating (or egress) switch, where they gain access to the ISP modem pool. This network topology funnels traffic into the egress switch, and can easily lead to congestion unless carefully engineered by the LEC. Routine operation of switches includes the task of provisioning new lines, and load balancing new and existing lines across line peripherals, so that uniformly good service is provided to all customers.

The fact that LECs often do not know what lines are used for internet access makes provisioning and switch load balancing a non-trivial and laborious task. It is estimated that internet-related load balancing costs a large LEC on the order of $30 million dollars a year in additional operations costs. Nevertheless, it is an important function. If allowed to occur, traffic imbalances on switches will cause non-uniform blocking for users, leading to poor service for subscribers, and other capacity management problems for the LEC.

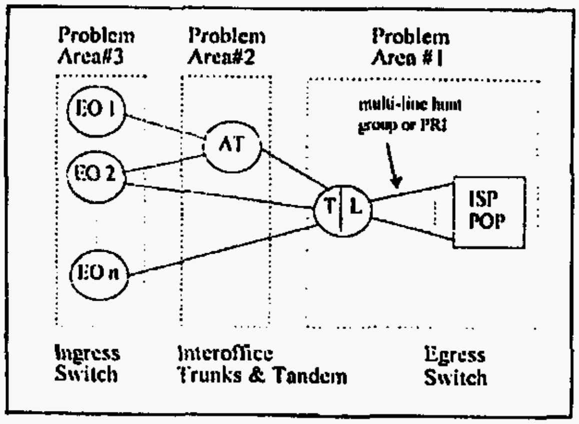


Figure 1: PMO Problem Areas

In Figure 1, the switches most likely to experience congestion problems are the egress switches which serve ISPs (Problem Area #1). As noted above, multi-line hunt groups (1MB lines) are a common method of connection between the egress switch and ISP. However, there is a significant movement on the part of LECs and ISPs towards primary rate ISDN (PRI) for the following reasons. For LECs, PRI has the advantage of being a trunk-side rather than a line-side connection. Since there is no concentration on trunk-side connections, PRI connections reduce the likelihood of switch congestion. (Specifically, they eliminate the problem of congestion in switch line modules.)

For ISPs, PRI connections have several advantages, though they are more expensive than 1MB lines. First, 1MB lines make it difficult to achieve high modem densities due to wiring constraints. By virtue of simpler physical wiring, PRI connections support higher modem densities. Second, digital carriers (such as PRI and D-4) provide better transmission quality, which is important for recently introduced 56kb modems. Finally, ISPs can obtain network management information via the PRI (signaling) D-channel. This information is valuable to ISPs, since it allows them to track calling numbers, customer usage patterns, etc.

In Figure 1, the second segment of the network that is impacted by LHT traffic comprises the interoffice trunks and access tandems (Problem Area #2). Since under normal circumstances trunks carry both voice and internet traffic, additional internet traffic requires the provisioning of additional trunks to ensure adequate service for both voice and data users. The least congested elements in Figure 1 are likely to be the originating or ingress switches (Problem Area #3). Initially, ingress switches are unlikely to experience congestion, since only a fraction of all subscribers are internet users. However, as internet penetration grows, internet-related congestion will progressively occur in more and more ingress switches, causing similar problems to those in egress switches.

Understanding internet congestion from a network perspective is critical in designing cost-effective solutions. At current internet penetrations, it is estimated that 25% to 33% of all switches can be categorized as egress switches. Based on the above discussion, the most immediate network segments to de-load are Problem Areas #1 and #2. However, ingress switches (Problem Area 3) may also be congested in certain high-penetration areas, and addressing congestion in ingress switches will become more important as time goes on. Effective internet off-load architectures need to address all three problem areas, and be capable of reducing congestion where it is most acute, as determined by internet penetration levels, varying traffic patterns and communities of interest.

3.3 Off-Load Architectures

Faced with the growth of internet traffic, carriers have a fundamental choice. They can continue to add equipment to the PSTN in order to maintain service quality for all customers, while carrying internet calls on the same facilities as regular voice calls. Alternatively, they can adopt some new network architecture – referred to here as an off-load architecture – which effectively segregates internet traffic from regular voice traffic, and allows internet traffic to be carried more efficiently over dedicated facilities or a packet network.

If the first course is adopted, there are several short term engineering approaches which can be used to fine tune the PSTN for internet traffic. One such approach is to identify heavy internet users (by some means), and terminate their lines on digital switch modules that are more flexible in term of line concentration ratios. For example, new classes of line modules and 'Next Generation' Digital Loop Carrier systems can be used to support line concentration ratios as low as 1:1, potentially eliminating blocking at the line concentration level of the switch.

In this approach, heavy internet users would be carried on the same facilities (i.e., switch modules and trunks) as voice customers. However, the engineering rules for both switches and trunks would be modified (i.e., made more conservative), in order to provide acceptable service to all customers. Apart from its higher cost, this approach raises a number of practical issues, including: (i) the development of new engineering procedures, (ii) the development of provisioning and load balancing procedures for shared switch modules, and (iii) planning and managing network capacity in the presence of several distinct classes of traffic.

While the above approach undoubtedly provides immediate relief for network operators, and is appropriate in the short term, it fails to address the fundamentally different nature of internet traffic. If dialup internet traffic continues to grow at forecast rates, its volume will soon rival that of regular voice traffic on the PSTN. In this situation it no longer suffices to adopt makeshift solutions to internet congestion. Instead, it becomes desirable to treat internet traffic as a distinct class of traffic with its own requirements, and to develop network architectures that can transport internet traffic efficiently, and provide the features required by end-users.

A simple form of internet off-load architecture would be to segregate internet traffic within the PSTN. According to this strategy, one would identify internet calls (e.g., by means of intelligent network capabilities), and route them over dedicated switch modules and trunks within the PSTN. This strategy may well prove to be cost-effective in the medium term, and provide an intermediate step towards a full data off-load architecture. It could be implemented using existing SS7 and IN capabilities, and avoids a number of evolution issues associated with data networks and protocols (see section 3.6).

Ultimately, however, data networks will provide the most efficient means of carrying internet traffic. By taking advantage of statistical multiplexing gains, data networks can efficiently transport internet calls. Furthermore, data networks will in time provide the features and services that are most closely aligned with internet (and other data) applications. If the decision is made to migrate towards a full data off-load architecture, the question arises as to how best to achieve this goal. As noted above, for the foreseeable future the PSTN will provide the majority of users with access to the internet and other data networks. It follows that a key element of any data off-load strategy is to decide at what point within the PSTN one should re-direct internet calls onto a data network. There are two basic options:

1. Post-Switch (Trunk-Side Redirect) – In a post-switch architecture, internet calls are allowed to pass through the ingress switch, before being redirected out of the PSTN and onto a packet network for final delivery to an ISP. The main benefit of this approach is that internet calls by-pass the PSTN's interoffice trunks and the egress switches, and are instead transported by a packet network. However, the ingress switches are still involved in both the signaling and transport phases of internet calls.

2. Pre-Switch (Line-Side Redirect) – In a pre-switch architecture, internet calls are intercepted and redirected onto a packet network on the line side of the ingress switch. The goal is to by-pass all PSTN elements (ingress switch, trunks, and egress switch). Note that although the ingress switch is no longer involved in internet call transport, it may still be involved to some extent in call–related sig-

naling. However, its involvement is minimal in comparison to a post-switch architecture.

Sections 4 - 6 provide examples of these two classes of off-load architecture. They also describe the features and capabilities needed to make post-switch and pre-switch architectures effective, flexible and robust. And they comment on the pros and cons of the architectures from a technological and cost perspective.

3.4 Internet Call Identification, Routing

A problem common to all internet off-load architectures is how to identify and route internet versus voice calls. The most straightforward approach to this problem is to provide full 10-digit number translations (i.e., routing instructions) within every switch in the PSTN. However, this solution could be an administrative nightmare, and would not provide as much flexibility as other alternatives. The following discussion describes several other methods for internet call identification and routing.

IN Office-Based Triggers – One option is to obtain all ISP and on-line service provider (OSP) telephone numbers, and configure office-based 'triggers' for these numbers. Every call entering the switch would be screened against the list of numbers. Internet calls would 'hit the trigger' (i.e., be positively matched against a known ISP / OSP number), causing the switch to issue a query for routing instructions. Advantages of this scheme are that there is no need to alter dialing plans (i.e., ISP / OSP numbers), and this type of trigger should be available on all modern switching systems, since it is required by many basic IN and SS7 type services. Disadvantages are that ISP / OSP numbers are not always known in advance, and office-based triggers consume additional switch processing power, since every originating call (both voice and internet) must be screened against the trigger.

LNP Routing of ISP Numbers – Since LNP will soon be widely deployed (under regulatory mandate), the option exists of configuring ISP / OSP numbers as LNP ported numbers, and using LNP queries to obtain routing information for internet calls. In LNP, inter-switch intra-LATA calls to a ported NPA-NXX hit an LNP trigger, causing routing queries to be sent to an LNP database. With modifications, the same mechanism could possibly be used to route internet calls. For instance, the Location Routing Number (LRN) returned by an LNP query could point to an Internet Call Routing (ICR) node (see sections 4 and 5), rather than a 'ported-to' switch as is the case in LNP. This strategy has at least two advantages. First, there is no need to alter dialing plans. Second, it gives ISPs the flexibility of moving location and / or carrier, in a way that is completely transparent to their customers. ISP customers would continue to dial the same access numbers, and the network would ensure that calls got routed to the ISP's new location or carrier. Of course, this use of LNP raises a number of protocol and administration issues, which would need to be addressed before it can be implemented in the network.

IN Single Number Service – Currently, ISPs advertise many access numbers to their customers. For example, different numbers may be used for different calling areas, different modem banks (i.e., different speed modems) within the same calling area, etc. Single Number Service is an intelligent service within the PSTN, that allows calls to a single number to be routed to different locations based on various criteria. For example, calls can be routed to the nearest ISP point of presence (POP) during business hours, and to a remote central location outside of business hours. Different 'single' numbers could be used for 28.8 versus 56kb modems, or the network itself could route calls to the correct modems based on stored customer information. For ISPs, Single Number Service can greatly simplify the administration of access numbers and technical support call centers. Note that in future internet off-load architectures, the location of modem functionality may shift from the ISP POP to some other location (e.g., access server). Single Number Service would make such changes transparent to ISP customers.

***XX Service Code** – A final method is to assign a special service code to internet calls, such as the 800 service code used for toll free calls. The advantage of the service code approach is that it makes it easy for switches to determine that an originating call is an internet call. This detection would occur early in the switch's digit analysis, in contrast to an office-based trigger where the switch must wait for the user to finish dialing all digits and then compare the results with the trigger list. An obvious disadvantage of the service code approach is that it changes the user dialing plan.

3.5 Access Server and ICR Node

The assumption underlying all off-load architectures is that, once an internet call has been identified, it can be routed to some transport facilities outside of the normal PSTN. These facilities could be dedicated point-to-point links to an ISP, or they could be a packet network. In either case, there is typically a need for some intermediate network element that will act as an interface between the PSTN and the non-PSTN internet transport facilities.

We refer to this element as an access server (AS). Note that the term AS is a loose one, that could describe several types of equipment with different functionality. For example, the AS could take incoming calls from SS7 trunks in the PSTN, and forward them over PRI to ISPs. In this case, no data transport is involved. However, the AS is required to be capable of SS7 signaling. Alternatively, the access server could incorporate modem bank functionality. In this case, the AS would terminate incoming PSTN calls, convert them to packet format, and forward them to ISPs over a packet network. In all cases, the common feature of the AS is that it acts as a *transport* interface between the PSTN and internet facilities.

Several of the off-load architectures discussed below utilize a new type of SS7 *signaling* node, which we refer to as an Internet Call Routing (ICR) node. The ICR node contains the routing intelligence for internet calls. It is a central network element, that controls internet call routing via instructions to ingress switches and / or access servers. Signaling between the ICR node and switches is via SS7. Signaling between the ICR node and access servers will probably be via some other (possibly proprietary) protocol.

We emphasize that access servers and ICR nodes (Bellcore's terms) are relatively new elements in the PSTN (though they have precedent in existing adjunct equipment such as intelligent peripherals and voicemail systems). Functionally, access servers and ICR nodes are not well-defined, and can be expected to evolve according to market demand, changes in internet protocols, etc. The functions of access servers and ICR nodes are described in more detail in sections 4 and 5 below.

3.6 ISP Issues

While LECs have some latitude within the present mode of operation (PMO) to improve the handling of internet traffic within their own networks, significant efficiencies will only be achieved by moving to off-load architectures. This in turn requires the participation or cooperation of other parties, chiefly ISPs. In order to be attractive to ISPs (and their customers), off-load architectures must provide a number of key capabilities. These can be summarized under the three headings of administration, authorization and authentication (AAA).

ISPs are extremely sensitive about relinquishing the administration of modems (or modem functionality) to third parties such as LECs. One reason is that they have 'grown up' with existing modem technology, and have become very efficient at maintaining it. A more fundamental reason is that retaining control of modems allows ISPs to directly manage their own customer bases, without relying on third parties, and without having third parties intrude on this relationship. Sensitivities regarding customer access are heightened by the fact that some LECs have ISP subsidiaries.

A key element of many off-load architectures is to move modem functionality away from ISPs and closer to end users, so that internet calls can be converted to packet format as early as possible, to take advantage of multiplexing gains. As a pre-condition for the successful implementation of off-load architectures, it is therefore critical that LECs address the ISP concerns regarding access to, and security of, ISP customer information. (Note that LECs are not necessarily enthusiastic about taking over modem maintenance. However, they recognize that it may be a necessary step in obtaining the benefits of off-load strategies.)

Similarly, ISPs do not want to give up authorization and authentication functions. They want to maintain their own private databases of customers in good standing, and regulate access to their facilities via their own authentication procedures. Currently, internet protocols will not easily support joint authentication by the network provider and ISP. Joint authentication requires that one separate the physical event of a modem answering a call from the user authentication process. Achieving joint authentication would allow the LEC to regulate access to its transport network, and the ISP to separately regulate access to its own facilities.

Given the ISPs' concerns, the capability to perform joint authentication is another pre-requisite for moving modems away from ISPs and closer to end users. Tunneling protocols may provide an answer to this problem, as well as providing better capabilities for encryption, and performance guarantees for traffic streams carried by shared internet facilities. In fact, satisfying the ISPs' technical and business requirements may depend more on the future evolution of internet protocols than it does on the LECs' service offerings.

4. Post-Switch Architectures

Post-switch architectures, which intercept calls on the network side of access switches, provide a solution for internet congestion that is potentially more integrated with existing PSTN functionality. PSTN ingress switches are currently the main repository for call processing logic, routing intelligence and subscriber line features. By relying on ingress switches to identify and route internet calls, post-switch architectures can potentially take full advantage of IN and SS7 signaling capabilities to efficiently transport and manage internet traffic.

4.1 Description of Architectures

This section describes three post-switch architectures. Note that all three architectures utilize the same technique to identify internet versus non-internet calls. As described in Section 3.4, an ingress switch has the option of identifying internet calls by means of 10-digit dialed number translations, or by means of IN triggers and SCP query / responses. Beyond this common element, the three architectures use different strategies to achieve efficient signaling and transport.

Architecture A: Line / PRI Interface

Architecture A is illustrated in Figure 2. It shows a simple arrangement in which the ingress switch routes internet calls to an Access Server (AS). The AS acts as an interface between the PSTN and a data network. Note that in this architecture, the AS and switch are connected by a regular telephone line (e.g., multi-line hunt group) or Primary Rate ISDN (PRI). At present, these two methods are the most prevalent means of connecting switches to adjunct equipment.

There are disadvantages to both line and PRI interfaces. The line interface is difficult to manage at a switch level, due to the size of multi-line hunt groups, and the present lack of Operations Support Systems (OSS) capabilities for non-standard engineering, tracking, measurements, etc. In addition, the line interface is likely to be expensive, given that line unit costs are predicated on 'traditional' subscriber usage patterns and line-concentration ratios. Internet lines tend to be more heavily utilized than regular lines, requiring more investment in switch equipment per subscriber line. Finally, the line interface provides no capability for intelligent signaling, which could be used for example to monitor subscriber usage and identify heavy users. On the plus side, by relying on the ingress switch, architecture A can provide dynamic routing (e.g., in case of modem congestion), but only if the modems are directly adjacent to the ingress switch (i.e., are located in the AS).

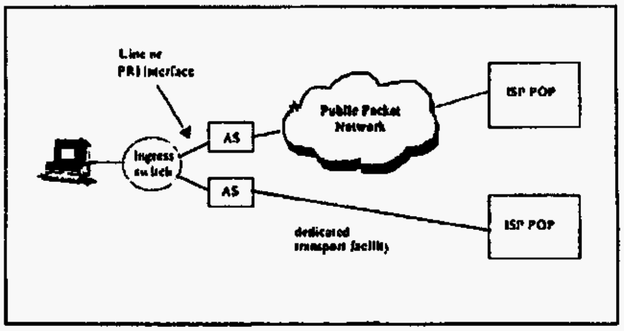


Figure 2: Post-Switch Architecture A (line / PRI)

In comparison, the PRI interface is functionally attractive, since it supports out-of-band signaling that can potentially be customized to the internet application. PRI is also easier to manage than multi-line hunt groups, as described in section 3.2. However, for reasons associated with current switch architectures and provisioning limitations, PRI may be unsuitable for large scale deployment in the network. In effect, there may be insufficient capacity for PRI terminations in the PSTN to support large scale use.

Architecture B. SS7 Trunk Interface & ICR Node

There are strong practical motivations for requiring the interface between the ingress switch and AS to be an SS7 trunk. SS7 trunks are the basic means of transporting calls between switches inside the PSTN, and are readily provisionable on almost all switches in the network. Due to their availability, and also their streamlined support in existing OSSs, SS7 trunk architectures offer the best hope of providing a widely deployed, scaleable architecture for internet traffic.
However, current access servers do not support an SS7 trunk interface. The use of SS7 trunks implies that calls are setup using the SS7 protocol and the Common Channel Signaling network. This in turn implies that call setup signaling for internet calls must be processed by an SS7 capable node. At present, access servers are relatively simple devices, which perform the functions of a modem bank, without any call processing or SS7 intelligence. It is probably not economical to implement SS7 capabilities in the AS. This strategy would make the AS too expensive to deploy on a large scale. Also, individual access servers would not handle sufficient traffic to warrant the expense of a dedicated SS7 link.[4]

One approach which solves this problem is illustrated in Figure 3. The architecture in Figure 3 features: (i) a new type of SS7 node (an Internet Call Routing (ICR) node) which can perform SS7 call setup signaling with ingress switches, and (ii) an upgraded AS that has a non-SS7 signaling interface to the ICR node. While implementing a non-SS7 signaling interface is likely to increase the cost of AS, its advantage is that it can be less sophisticated than the standardized SS7 protocol, and can utilize existing capabilities within commercially available access servers for Q.931 based signaling. Consequently, the AS in Figure 3 has the potential to cost less than a fully SS7 capable AS.

The ICR node in Figure 3 is critical to call setup, since the AS cannot cut-through an SS7 trunk connection by itself. Instead, it relies on signaling from the ICR node to tell it which circuit the call is coming in on, and to complete the connection. Note that the ICR node will monitor AS ports / modems to determine whether it has free modems that can be used to answer the incoming call. If not, the ICR will use standard SS7 signaling to release the call, and provide busy tone at the ingress switch. Although we have described the ICR node as a new type of SS7 node, it may in fact be an existing SS7 node running an Internet Call Routing application. The ICR node also has the potential to perform intelligent functions, beyond simple call setup and teardown.

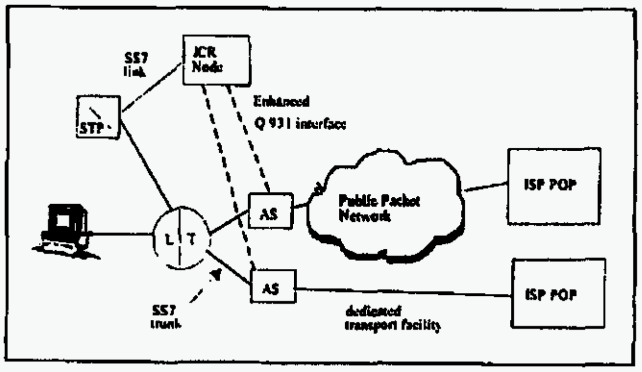


Figure 3: Post-Switch Architecture B

As discussed above, the immediate advantage of Architecture B is that it utilizes SS7 supported trunks to connect ingress switches to access servers. This can facilitate its wide-spread deployment throughout the PSTN, and make it easier to scale up as internet traffic grows. However, Architecture B also has a number of other advantages. The ICR node can be owned and operated either by the LEC or by an ISP. Also modem bank functionality can be situated either in the AS itself, or in the ISP box in Figure 3. In the first case packet transport could take advantage of multiplexing gains. In the latter case, transport would be via circuit emulation, and would not realize any multiplexing gain. However, these options for modem locations may make the architecture more flexible in addressing the future business needs of ISPs.

---

[4] A single SS7 link has the capacity to handle many thousands of Access Server ports. Access servers typically have from several hundred up to 700 ports. A single SS7 link can therefore handle 40 plus access servers at typical engineered loads.

Note that having modems located on the ISP premises is closer to the present mode of operation (PMO). In this case, the AS simply provides an SS7 supported trunk termination co-located with the ingress switch, and internet calls are transported in circuit-switched or circuit emulation mode to the ISP. In future, as data protocols evolve, ISPs may find it desirable to have the LEC maintain modems at the AS, and have internet calls delivered to them in data format, to take advantage of multiplexing gains on data networks. Architecture B facilitates both options.

Architecture C. SS7 Trunk Interface & Gateway Node

Finally, Figure 4 – Architecture C – shows a more evolved version of Architecture B. In this architecture, the ICR node handles both call signaling and call transport. Calls are routed from access servers to the ICR using PRI trunks, for example. The ICR node acts as a hub, providing a common platform where a variety of access technologies such as T1, ISDN PRI, Frame Relay, modem pools and routers can be made available to both ISPs and corporations. Consolidating access from numerous egress switches into this type of hub is anticipated to provide operational efficiencies for LECs and ISPs. As the internet continues to expand and evolve, it can make it easier for ISPs to upgrade and stay current with new equipment, and also to gain faster access to new markets with smaller up-front capital cost.

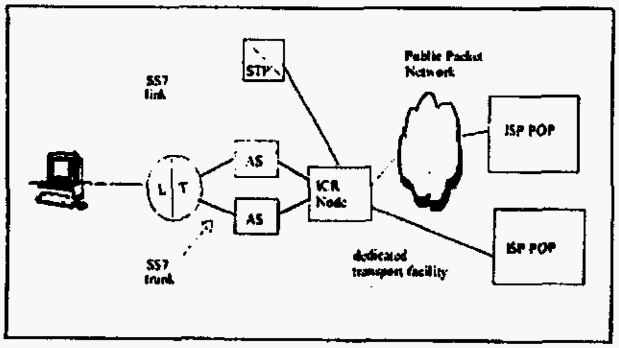


Figure 4: Post-Switch Architecture C

4.2 Post-Switch Issues

The advantage of post-switch architectures is that they take advantage of the intelligence that resides in network switches and SCPs, to better route and manage internet traffic inside the PSTN. For example, they can utilize sophisticated SS7 and IN triggers, routing functionality and traffic controls. Of course, post-switch architectures are based on the assumption that one would want to allow internet calls inside the PSTN. There are reasons why this may be the case.

It is possible to view internet traffic as merely a problem for the PSTN, that should be banished to external data networks as soon as possible. Alternatively, it is possible to imagine internet traffic as requiring the first true large scale integration of the PSTN and data networks. In the latter view, internet traffic is not so much a problem as an opportunity. By bringing this traffic into the PSTN, and managing it intelligently, the opportunity exists to offer a range of new internet-related features and services that packet networks, in their present stage of maturity, cannot support. Post-switch architectures may therefore constitute a longer term goal for network operators.

The immediate challenge for post-switch architectures is to justify the cost of burdening ingress switches with the triggers and additional signaling required to support internet call routing. This additional burden could be significant. For example, deploying office-based triggers in order to identify internet versus voice calls could increase call processing times in the switch. This translates into a corresponding reduction in switch capacity, and the possible need for processor upgrades in some switches. The capacity impact will vary based on switch technology and the type of triggers or translations used (e.g., 6 vs. 10 digit).

Although post-switch architectures do not off-load internet traffic from ingress switches, they can conceivably improve the situation of these switches by intelligently managing internet traffic. For instance, although the situation is improving, many ISP facilities are under-engineered in comparison to the PSTN, resulting in very high levels of blocking in the ISP busy hour. Ineffective call attempts utilize trunk and switch resources only for very short periods of time (e.g., 0.9 - 1.5 seconds). However, taken across a network, their cumulative effect can be significant. In certain cases it is possible that they could inflate the load on switch processor by a non-negligible amount and result in significant increase in the load on trunks. Both of these effects necessitate the addition of more switching and trunk capacity to the network, if the established level of service is to be maintained.

However, SS7 and IN traffic monitoring capabilities can be used to block internet calls at the ingress switch if the target ISP facility is known to be congested. By using these capabilities, the ingress switch does not waste time processing calls that are bound to fail once they reach the ISP. Similarly, inter-office trunk resources are not tied up on calls that cannot be served. This type of call throttling can ensure that ingress switches and trunk resources are used efficiently.

Finally, we note that intelligent routing inside the PSTN can be used to route internet calls to alternate facilities, in the event that the primary facility (e.g., modem bank) is congested. And more generally, intelligent routing can be used to route internet calls flexibly, based on time of day or other appropriate criteria. This can allow ISPs to efficiently manage their own resources, schedule upgrades, etc. Similarly, from the LEC perspective, flexible routing can be used to route internet traffic through facilities (e.g., downtown offices) that are not heavily utilized during the 9-11 PM internet busy hour. This will help to maximize the efficiency of PSTN resources.

5. Pre-Switch Architectures

As described in Section 4, post switch architectures reduce internet congestion on interoffice trunks and egress switches. However, ingress switches are still involved in transport. Pre-switch architectures, which intercept calls on the line side of ingress switches, have the advantage of totally by-passing the PSTN, including ingress switches. (However, note that PSTN elements may still be involved to some extent in call-related signaling).

The common element of pre-switch architectures is an adjunct box that resides in front of the switch and has the capability to re-direct calls (e.g., onto a data network). The intelligence to re-direct internet vs. voice calls can reside in the adjunct box, ingress switch, or in another network element. Calls that are identified as voice calls are passed through the adjunct to the ingress switch for normal processing through the PSTN. Internet calls are intercepted and re-directed onto dedicated transport facilities for delivery to ISPs.

Although adjunct boxes are conceptually simple – they merely act as a call re-direct mechanism – they raise a number of issues. For instance, once an adjunct redirects a call and takes the switch out of the call path, the switch still needs to know how to handle incoming calls to the busy line, in order to support features such as call forwarding, call waiting and voicemail. Less obviously, the switch needs to retain the capability for operator interrupt, access to calling party information by law enforcement agencies, wire tapping and billing, for / during internet calls.

It follows that pre-switch adjuncts cannot act independently of the switch. Instead there needs to be a mechanism to maintain a consistent view of call and line states between the switch and adjunct. Additionally, in cases where per-call billing is required, billing information for the redirected call needs to be collected (somewhere). These problems are not necessarily difficult to solve. However, they require advance thought and planning. A final issue with pre-switch architectures is that they may not be able to support ISDN customers. To date, pre-switch mechanisms for re-directing ISDN calls have not been proposed.

5.1 Description of Architectures

Proposed pre-switch adjunct architectures make use of an embedded base of Integrated Digital Loop Carrier (IDLC) technology. In an IDLC configuration, a Remote Data Terminal (RDT) is used to terminate a group of customer lines at a location that is (nominally) remote from the switch. The RDT is connected to a digital switching system via a DS1 or OC-3 carrier which, by multiplexing many customer lines onto a single carrier, provides efficiency in the local loop and enhanced operations capabilities.

Note that there are several standard protocols that can operate over the RDT-switch interface, including TR-57, TR-8 and GR-303. Of these, GR-303 is the most recent and the most powerful in terms of its signaling capabilities and ability to support new (e.g., internet) applications. At present, however, GR-303 is not widely deployed in the network. It follows that IDLC-based pre-switch adjuncts which are capable of working with TR-57 and TR-8 (as well as GR-303) will have wider applicability within the network. On the other hand, GR-303 provides a standardized interface that can be implemented on multiple vendors' equipment. Non-GR-303-based adjuncts rely on a signaling interface (between the RDT and ICR node, see below) that is currently not standardized (i.e., is proprietary to individual vendors).

As suggested above, there are at least two approaches for re-directing internet calls in pre-switch adjuncts, namely non-GR-303-based and GR-303-based solutions. These are described in more detail below.

D. SS7 Based Line Side Call Redirect

The first approach for pre-switch architectures is to use the ingress switch for digit collection and trigger assignment, but to place call routing intelligence in a separate network element. This approach is illustrated in Figure 5. In this scenario, an Internet Call Routing (ICR) node controls the RDT via a signaling interface that could be proprietary, or that could conceivably be developed into a standard interface to facilitate the mixing and matching of equipment from different vendors. The ICR node is SS7 capable and utilizes SS7 (ISUP) signaling to control the setup and teardown of circuits through the switch.

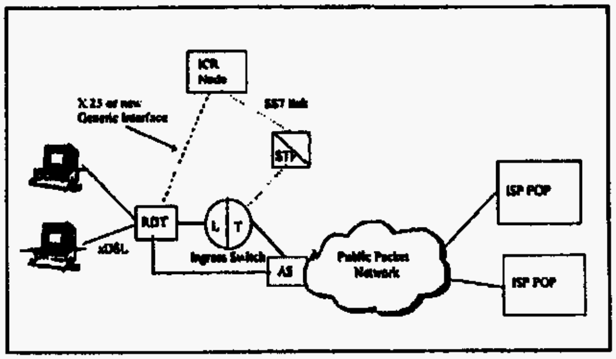


Figure 5: SS7 Based Line Side Off-load Architecture

In Figure 5, incoming internet calls hit a trigger in the switch, which causes the switch to issue a query for routing instructions (to an SCP). When routing information is received, an SS7 call setup message is sent to the ICR. The ICR informs the RDT to re-direct the call to a data network, and at the same time sends an SS7 release message back to the switch, forcing the switch out of the call path. A final step is for the RDT to signal the switch that the subscriber line is busy (off-hook), so that calls arriving from the network do not interfere with the ongoing internet call.

The philosophy behind this approach is to put internet call routing intelligence in a central network element (the ICR node) rather than a simple, unintelligent element (the RDT) on the edge of the network. This can make it easier to implement changes to internet call routing, since only the ICR nodes must be upgraded, rather than a large number of RDTs, which do not necessarily have the operations support for frequent changes or upgrades to internet call routing functionality.

Note that by placing internet call routing intelligence in the ICR node, rather than the RDT, this architecture can potentially work with TR-57 and TR-58, as well as GR-303. Also note that the ICR node in Figure 5 is similar in functionality to the one employed in post-switch architecture B. In fact, the same ICR node could conceivably control both pre-switch adjuncts and post-switch access servers. This type of combined ICR node would support very flexible off-load architectures.

E. Non-SS7 Line Side Call Redirect

The second approach, illustrated in Figure 6, is based on enhancements to the GR-303 standard. In this approach, RDTs may be co-located with ingress switches, and the GR-303 interface is used to support the signaling required to re-direct and manage internet calls. Incoming internet calls can be identified (via a trigger) and routed (via a table lookup) in either the switch itself, or in the RDT. In the first case, the switch is responsible for normal call processing, including dialtone generation. If an internet call is detected, the switch signals the RDT via GR-303 to re-route the call onto a data network. In this case, internet call filtering can be provisioned on a per-line basis, and the potential exists to overflow internet calls onto the PSTN if the data network is unavailable. It does, however, involve a real-time hit on the ingress switch, to support the call filtering, routing and signaling functions.

The second case is again based on GR-303, but relies on internet calls being identified and routed in the RDT rather than the switch. In this case the RDT is provisioned with DTMF receivers so that it can register dialed digits. (The RDT may or may not provide dialtone.) It is also provisioned with the routing information for internet calls. When an internet call is detected in the RDT, the RDT itself re-routes the call to a data network, and informs the switch of this action. This case minimizes the impact of internet traffic on the ingress switch, but requires some non-standard functionality in RDTs, and new call flows between the RDT and switch.

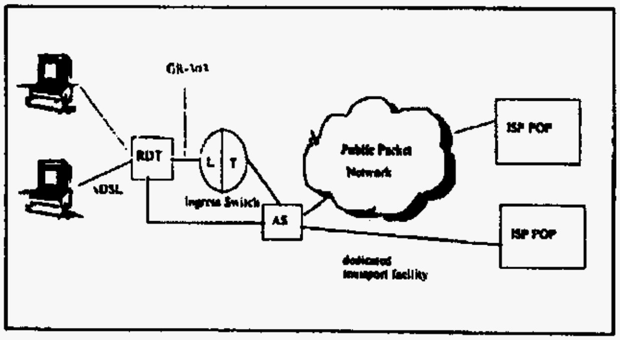


Figure 6: Non-SS7 Based Line Side Off-load Architecture

5.2 Pre-Switch Issues

The pre-switch architectures described above are attractive because they de-load internet traffic from the ingress switches, as well as from inter-office trunks and egress switches. They do, however, involve a tradeoff. Deploying equipment at the edge of the network, particularly if it involves significant complexity or intelligence, can be an expensive proposition, due to the amount of equipment and the operational effort involved in installing and maintaining the equipment. It also leaves one vulnerable to stranded investment, if technology changes.

One strategy for obtaining the benefits of pre-switch architectures, while avoiding the pitfall of stranded investment, is to place internet call routing intelligence in an ICR node, as in Figure 5. Placing intelligence in the ICR node, rather than the RDTs, has the potential to make RDTs simpler, less expensive and, consequently, less vulnerable to the risk of stranded investment. The ICR node could also be used to implement intelligent functions beyond simple call setup and teardown, and could potentially be used to support both pre- and post-switch architectures (see Figures 4 and 5). Finally, the ICR node can work with all IDLC technology (not just GR-303), though it currently depends on a proprietary signaling interface to the RDT.

More generally, the key to the effective use of pre-switch architectures is to balance the amount of equipment deployed, versus the amount of internet traffic off-loaded from the PSTN. Measurements of internet usage show that internet users will vary from heavy to light. In general, a small percentage of heavy users can generate a large percentage of the total internet traffic. A much larger number of light users generate the balance of the traffic. For example, it is not unusual to find that 20% of internet users generate about 55% of the total load, and that 40% of users generate more than 80% of the total load.

The best strategy for a pre-switch architecture is to deploy only as many adjuncts as are required to terminate the lines of identified heavy users. This strategy minimizes the line-related costs associated with deploying adjuncts, while maximizing the traffic-related benefit that one obtains by off-loading internet calls onto data networks. The key question is what percentage of subscriber lines should be moved onto pre-switch adjuncts. Even supposing that one has an effective strategy for identifying heavy users (which may itself be problematical), one still needs a formula for where to draw the line between heavy and light users.

As one moves lines onto pre-switch adjunct terminations, the per-line equipment costs will steadily rise. However, the same is not true of the traffic-related savings. Initially, one will obtain great savings by moving a core of heavy users onto adjuncts. As one continues, however, progressively smaller savings are obtained, since one is capturing only light users. In general, there will be an optimal operating point, where total savings (traffic-related cost savings minus equipment costs) are maximized. Identifying this optimal operating point – which may vary from switch to switch, and would also vary over time as traffic patterns change – is a critical issue for pre-switch architectures.

The problem of identifying heavy users in the first place, as a prior step to moving them onto adjuncts, is likewise important. Specifically, one needs the capability to reliably measure and rank order subscribers' internet usage, via statistically valid sampling. Currently, there are several methods for identifying heavy users. Off-line processing of SS7 data, collected by means of some portable SS7 collection system or device, can provide a snapshot of heavy users as well as other useful information. This approach has been used in the absence of permanently deployed SS7 data collection systems. As permanent systems come on-line, it will be preferable to analyze data using automated systems and filters.

One alternative to an external measurements system is to utilize switch traffic and provisioning systems to measure subscriber usage, and manage heavy users. An advantage of this approach is that the measurements can be integrated into the switch provisioning flow, in order to load balance heavy users across line peripherals. A possible disadvantage is that existing switch systems may not capture full call data, or may present aggregate data in a way that is not useful for the identification of heavy users. This issue is being addressed in Bellcore's switch provisioning systems.

Another alternative that avoids external measurements systems is to use the capabilities of the Intelligent Network architecture to identify the heavy users. This function can be implemented in the ICR node or in SCPs.

Beyond the immediate problem of identifying and managing heavy internet users, a further benefit of collecting internet traffic usage measurements is to provide traffic data and performance measurements concerning ISPs. As internet connection services evolve, traffic data will become valuable to ISPs, for purposes of marketing and service differentiation. In addition, there is a market for third party validation of ISP performance. Other applications of traffic / performance measurements are to provide network traffic and usage measurements for ISPs so that modem pools can be engineered optimally for a given Quality of Service. Finally, LECs can also use traffic reports to size and engineer the DS1/ISDN trunk groups between switches and access servers, and to support engineering of the Frame Relay or ATM transport network.

Lastly, note that once heavy users have been identified using PSTN / SS7 measurements, and are moved onto pre-switch adjuncts, the task of monitoring their usage and grooming users on a continuing basis may need to be performed by the pre-switch adjuncts themselves, or by the ICR node. Once users are moved onto adjuncts, they will no longer have visibility through SCP or switch-based measurements, unless this capability is specifically implemented in the switches and SCPs.

6. Other Feature Capabilities

In this section we briefly describe some SS7 and IN-based features to improve internet call control and routing.

A. Alternate Routing on Busy Modem Pools

A common and widespread problem with current internet access is that calls are often blocked due to busy modems. Furthermore, when users are not successful in connecting to a modem pool on the first attempt, they often retry. Measurements show that internet calls have a much higher re-attempt rate than voice calls (an average of 5 re-attempts for each blocked internet call).

These re-attempts further increase the load on the network and can actually decrease the call completion rate (snow ball effect).

It is possible that when a particular modem pool is busy, there are other modem pools with available capacity. To implement alternate routing for calls that encounter a busy signal (i.e., busy modem), the network needs to monitor the status of internet access lines. Also in certain scenarios where the number of re-attempts are high, it may be beneficial to invoke a call throttling mechanism to stop some of the calls from entering the network. SS7 and IN capabilities can be used to implement alternate routing and call throttling mechanisms. These advanced routing features will ensure that modems at various locations are utilized in an optimal manner, and can also increase call completion rates for customers.

B. Multiple Trunk Groups Routing on Busy Trunks

Another advanced routing feature that can be useful in the internet access network is the capability of supporting three or more alternate trunk groups as choices for routing the call. If the first trunk group is busy, then an attempt to terminate on the second trunk group will automatically be made, and if all trunks in the second trunk groups are busy, the third trunk group will be used. Using this feature, if there are some temporal variations in internet traffic, multiple routes are available for forwarding the call to an AS. This will result in cost effective engineering, as one does not have to over engineer a particular trunk group and the corresponding number of modems in a particular AS.

C. Decision Based Routing

Other decision based and flexible routing can be used in these architectures. Examples include routing based on time of day, or based on NPA-NXX of the calling party, or possibly even routing some calls to less congested AS for the most preferred customers, etc.

D. Internet Call Throttling

Current blocking levels for accessing ISPs are much higher than the traditional performance levels for which PSTN switches and trunks are engineered for (typically 1% blocking or less). The amount of blocking varies among ISPs, also depends on particular locations, and time of day, etc. Ineffective attempts impact the PSTN in two ways. The first impact is on switch processors. A re-attempt call uses about the same amount of switch processor resources to setup and clear the call as a successful (answered) call. The second impact is that an ineffective (busy) call also uses the inter-office trunks for a small (but non-negligible) duration. A busy call ties up the direct trunks for about 1.3-1.8 seconds, and tandem trunks for 0.9 to 1.4 seconds.

Clearly the amount of re-attempt traffic generated depends on the ISP probability of blocking. If ISPs improve call completion rate, the majority of ineffective traffic will disappear. However, at current marginal performance levels the network resources wasted due to ineffective attempts is not negligible. Thus, it may be justified to design a call throttling scheme to control ineffective attempt at the originating switches. A cost / performance study is needed to determine the cost of deploying such control schemes vs. the savings obtained by blocking some calls at the edge of the network.

7. Discussion

This paper has outlined five architectures for off-loading internet traffic from the PSTN onto data networks. Three of these are post-switch architectures, and two are pre-switch architectures. These architectures can be compared and evaluated under three main headings:

1. *Technical issues* — What are the technical issues that need to be resolved before the architecture can be implemented, and what is the timeframe for resolving them? These issues include such items as protocol interworking, tunneling, feature support, additional OSS capabilities, etc.

2. *Cost / business issues* — What are the cost/benefits of adopting a particular architecture? To what extent will it reduce the costs associated with carrying internet traffic on the PSTN? By virtue of new technology (e.g., ADSL), can a solution architecture not only reduce current costs, but also result in new services and revenues?

3. *Strategic issues* — Finally, what are the strategic implications of adopting a particular architecture? How does the architecture fit with other service offerings, and the general evolution of the network?

> Will it facilitate potential new services such as internet telephony, and support sophisticated signaling interfaces between voice and data networks (e.g., marriage of SS7 and TCP/IP)?

We conclude with some general observations on the pros and cons of the proposed off-load architectures. Leaving aside strategic issues, the intent of off-load architectures is to reduce PSTN costs by carrying internet traffic more efficiently. Additional benefits may include better service to internet users, and the potential to support new internet or data oriented services for residential subscribers, business subscribers and ISPs. However, in the short term, the focus is on reducing PSTN costs.

The effectiveness of the above architectures depends on the usage patterns of internet users, and on how costs are distributed throughout the PSTN. Pre-switch architectures capture internet traffic before it enters the PSTN. Because of this, they eliminate or reduce the costs associated with ingress switches, which constitute a significant portion of the total network costs. Pre-switch architectures also have the potential to capture internet traffic very efficiently, provided one can solve the problem of identifying heavy internet users. If this problem is solved, pre-switch adjuncts can be targeted specifically at a relatively small number of heavy users, resulting in maximum impact for minimum expenditure.

One problem with pre-switch architectures is that they move the onus of identifying heavy users onto other systems, such as OSSs, external measurement systems, etc. Unless pre-switch architectures are supported with systems necessary to identify and groom heavy users on an on-going basis (which may itself involve some cost), these architectures are likely to be ineffective, and may even result in increased costs. Identifying the optimal percentage of subscriber lines to move onto pre-switch adjuncts (possibly on a switch-by-switch basis), and ensuring that switches are maintained at the optimal operating point, requires fairly sophisticated data collection systems, and provisioning / work order processes.

Finally, an additional risk factor associated with pre-switch architectures is that they operate at the edge of the network. Capturing traffic at the edge of the network, where it is diffuse, can potentially result in significant cost savings as described above, but may also result in stranded capital investment if technology or subscriber usage patterns begin to change. Dealing with aggregated (internet) traffic streams inside the PSTN, would be a safer strategy, since one then obtains efficiencies of scale in deploying and operating off-load equipment. The risk of stranded investment can be addressed by providing a plausible evolution strategy for pre-switch equipment.

SS7 and IN capabilities have the potential to be effectively integrated with pre-switch architectures, so as to address the above concerns. As described briefly in sections 5, SS7 and IN capabilities can be used to identify heavy users prior to their being moved onto pre-switch adjuncts. (Once they are moved, their usage may need to be monitored by alternative means.) Furthermore, use of SS7 signaling to support internet call routing, as in Architecture D, permits routing intelligence to be controlled from inside the network. This in turn reduces the risk of stranded investment in adjuncts, and makes it easier to upgrade and manage routing databases, etc.

However, at present the integration of pre-switch adjuncts with SS7 signaling requires some novel network arrangements and non-standard signaling. These issues need to be addressed by the industry. Some have raised fundamental concerns regarding the pre-switch adjunct architecture. Critics of this architecture argue that it may not be a good idea to put triggers and call processing capabilities in another box in front of the switch. The argument is that this strategy gradually results in having another substantial switch (the adjunct) standing in front of the Class 5 switch.

In contrast to pre-switch architectures, the post-switch architectures described in Section 4 make it unnecessary to explicitly identify and manage heavy internet users. By default, ingress switches are used to route all internet calls to AS, by means of 10-digit number translations or IN-based routing. This constitutes an advantage for post-switch architectures since, as discussed above, the identification and management of heavy internet users is a non-trivial problem.

By capturing internet traffic on the network side of ingress switches, post-switch architectures can take advantage of economies of scale in the deployment of off-load equipment. Architecture C (Section 4) takes this idea to its logical conclusion, by routing all internet calls and signaling through a hub ICR facility. If internet traffic grows into a high penetration, large scale service as has been forecasted, this type of hub facility can be used to provide economical connectivity between LECs and ISPs.

As the market evolves towards more sophisticated, value-added internet services, the hub arrangement may well prove to be very attractive to ISPs and corporations, since they can avoid owning and operating their own AS equipment. Instead, the hub facility could be operated by an LEC or third party, and the ISP or corporation could simply subscribe to new equipment according to their own customers' or employees' needs. The hub operator would manage a variety of AS equipment from multiple vendors, achieving economies of scale by serving many ISPs and corporations.

A major disadvantage of post-switch architectures, at least in the simplest implementations, is that they do not address ingress switch costs. In addition, they potentially incur some additional costs through the deployment of IN capabilities on switches, SCPs, ICR node, and the implementation of IN triggers on switches. However, it should be noted that SS7 and IN nodes are already widely deployed. Thus there may only be some incremental cost associated with carrying or processing the signaling required for off-load function.

As with pre-switch architectures, SS7 and IN capabilities can address the weaknesses of post-switch architectures, by means of flexible call routing, and a number of traffic flow control features that can be custom designed for internet traffic management.

8. Conclusions

In conclusion, there are pros and cons to both pre- and post-switch architectures. These two classes of architecture have strengths in different areas. In reality, an optimal strategy could utilize both types of architecture, depending on traffic volumes, congestion levels in ingress switches, and overall economics.

Many of the technical issues associated with the implementation of off-load architectures are now reasonably well understood. Work programs in these areas (e.g., requirements / standards development) are mapped out, and are waiting for expressions of interest from the industry. Business case and cost analysis efforts is not as well advanced. Information to evaluate the cost effectiveness of various architectures certainly exists, but needs to be assembled and synthesized into a coherent picture.

In this paper, various internet off-load architectures have been described with somewhat of a near term focus in mind. It may be advantageous for network providers and equipment suppliers to also rethink the overall network evolution to better understand the direction of the PSTN in terms of incorporating new technologies that would facilitate the support of all traffic types including voice, data, and video applications.

A principal contribution of this paper is to highlight the potential use of SS7 and IN capabilities not only to enhance the effectiveness of both pre- and post-switch architectures from a technical point of view, but also improve their economics by providing the flexibility to adapt to a rapidly changing internet traffic patterns.

Acknowledgments

The main objective of this paper was to stimulate industry debate and discussion on the solutions for the internet congestion problem. The views expressed here are those of the authors, and do not represent the views of Bellcore. The authors gratefully acknowledge discussion with many industry members including members of the ITESF, and the following Bellcore subject matter experts: Michelle Baughman, Rob Bond, Faad Ghoraishi, Gail Linnell, Maria Pontones, Ann Merrell, John Mulligan, Fred Russell, Janet Quinlan, Mike Terner, Janice Warner, and Stan Wainberg.

References

[A] The Internet: From Here to Ubiquity, Speech by FCC Chairman Reed E. Hundt, August 26, 1997 (obtainable from the FCC home page, http://www.fcc.gov).

[B] Pacific Bell White Paper on Internet Congestion (can be obtained from the Pacific Bell web page).

[C] Amir Atai, James Gordon, "Impacts of Internet Traffic on LEC Networks and Switching Systems", Bellcore, June 1996

[D] Digital Tornado: The Internet and telecommunications Policy, FCC OPP Working Paper Series no. 29 (can be obtained from the FCC web page, http://www.fcc. gov/Bureaus/OPP/working_ papers /oppwp29.pdf).

[8] Amir Atai, James Gordon, "Internet, Fractals and PSTN Engineering", Convergence Magazine, November 1996.

NOTICE OF DISCLAIMER AND LIMITATION OF LIABILITY

The information provided is directed solely to professionals who have the appropriate degree of experience to understand and interpret its contents in accordance with generally applicable regulations. No recommendations as to products or vendors is made or should be implied.

While the information contained herein has been prepared from sources deemed to be reliable, Bellcore reserves the right to revise the information without notice, but has no obligation to do so. Use of this information is at your sole discretion.

BELLCORE MAKES NO REPRESENTATION OR WARRANTY THAT THE INFORMATION IS TECHNICALLY ACCURATE OR SUFFICIENT OR CONFORMS TO ANY STATUTE, GOVERNMENT RULE OR REGULATION, AND MAKES NO REPRESENTATION OR WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE OR AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. BELLCORE, ITS OWNERS AND AFFILIATES SHALL NOT BE LIABLE BEYOND THE AMOUNT OF ANY SUM RECEIVED IN PAYMENT BY BELLCORE FOR INFORMATION WITH RESPECT TO ANY CLAIM, AND IN NO EVENT SHALL BELLCORE, ITS OWNERS OR AFFILIATES BE LIABLE FOR LOST PROFITS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES. ANY AND ALL USE OF OR RELIANCE UPON SUCH INFORMATION IS SOLELY YOUR RESPONSIBILITY AND YOU ASSUME ALL RISKS AND LIABILITIES, IF ANY, WITH RESPECT THERETO.

In considering any decision to build or implement any proposed solution disclosed in this Bellcore white paper, the applicability, if any, of US Patents 5,423,003 and 5,602,991 should be considered.

Bellcore has a distinguished history of providing communications consulting, engineering, software development, training, and research. Over the years, Bellcore has solved some of the world's greatest communications challenges; pioneered some of the most advanced communications technologies; and written industry-wide communications standards. Our client list includes more than 800 communications companies, corporations, equipment manufacturers, and governments all over the globe.

Dr. Amir Atai is the Director of Bellcore's Network Traffic & Performance area. His group does research on traffic and performance impacts of various technologies on clients networks, develops new engineering algorithms, builds analytical and simulation models in support of the above activities.

Dr. James Gordon is a consultant to Bellcore, in the area of capacity and performance analysis, analyzing the performance of switching systems, SS7 nodes and other network elements. Dr. Gordon's experience ranges from 'hands on' auditing of vendor equipment to forward-looking traffic modeling and simulation studies.

1-800-521-CORE (U.S. and Canada)
+1-732-699-5800 (in all other countries)

Or visit Bellcore on the Internet:
http://www.bellcore.com

Bellcore

OOA-1019W