BELLSOUTH REPLY COMMENTS

CC Docket No. 01-338

July 17, 2002

ATTACHMENT 4

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Review of the Section 251 Unbundling	)	
Obligations of Incumbent Local	)	CC Docket No. 01-338
Exchange Carriers	)	
	)	
Implementation of the Local Competition	)	
Provisions in the Telecommunications	)	CC Docket No. 96-98
Act of 1996	)	
	)	
Deployment of Wireline Services	)	
Offering Advanced Telecommunications	)	CC Docket No. 98-147
Capability	)	

UNE-P AND INVESTMENT

Prepared for and Submitted by

BellSouth, SBC, and Verizon

July 2002

UNE-P AND INVESTMENT

The facts on the ground show that facilities-based investment by CLECs is *lower* in states with high volumes of UNE-P than in states with low volumes of UNE-P. The facts also show that AT&T's claim that there is a correlation between high volumes of UNE-P and ILEC investment is wrong. AT&T supports its contrary arguments with data from just a few hand-picked states, and in some cases with data regarding only AT&T's own investments, rather than those of CLECs as a whole.

A. Real-World Experience Confirms That UNE-P Impedes CLEC Facilities-Based Investment.

AT&T claims that CLECs need the UNE-P in order to "develop[] a sufficiently large customer base" to make it economical "to transfer . . . customers off the ILECs' switches entirely onto" the CLECs' own switches.[1] AT&T asserts that, as a result, "facilities-investment is highest where UNEs are most available."[2] The facts show otherwise.

1. Data from all states with significant CLEC entry demonstrate that the availability of the UNE-P decreases the level of facilities-based competition.

To support its theory that UNE-P leads to facilities-based competition, AT&T points to its own business plan in just two states, California and New York. But the data from all states with significant CLEC entry refute this theory. As demonstrated in Figure 1, a simple regression analysis shows that facilities-based competition within a state decreases as UNE-P penetration within that state increases. In statistical terms, there is a strong *negative* correlation between facilities-based competition and UNE-P usage.[3]

Figure 1 is based on data from the 26 states where, as of year-end 2001, total CLEC facilities-based and UNE-P lines represented at least 10 percent or more of the BOC access lines within those states.[4] These 26 states represent 87 percent of all facilities-based CLEC lines and 91 percent of all UNE-P lines.[5] These states account for 76 percent of all CLEC switches. They

---

[1] AT&T Brief at 61.

[2] AT&T Brief at vi.

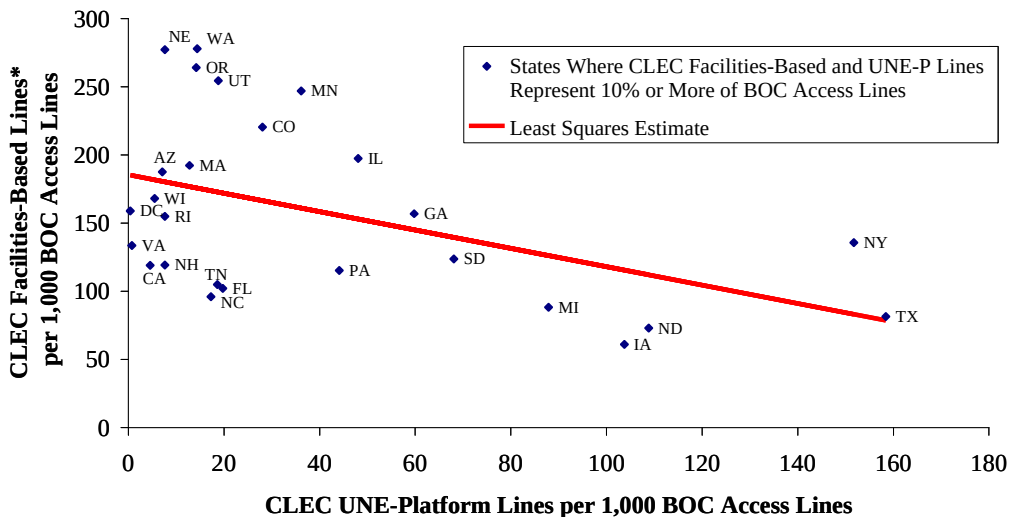
[3] Appendix A contains the results of the statistical analysis. It demonstrates that, to a 95-percent level of confidence, there is a statistically significant *negative* correlation between these two variables.

[4] We have normalized CLEC lines against the BOC access lines within a state, rather than all ILEC lines within that state, because data are not available for CLEC lines in non-BOC territory (including in the former GTE territory). This permits an apples-to-apples comparison of the CLEC lines within a BOC's territory in a given state to the BOC's own lines within that state.

[5] States where total CLEC lines represent less than 10 percent of BOC access lines were properly excluded from this analysis. These states typically have relatively low volumes of both facilities-based lines and UNE-P, which produces a close to 1:1 correlation between these two variables that, given the relatively small volumes involved, is not meaningful as a statistical matter. The 10-percent threshold applied in Figure 1 removes those states that merely add statistical noise to the analysis. In any event, including these states does not produce a statistically significant positive correlation, but rather a statistically insignificant correlation. Thus, this analysis of all states also does not support AT&T's claims.

also contain nearly three-quarters of all BOC access lines. They include all of the states in which, as of year-end 2001, AT&T was providing UNE-P to residential consumers.[6]

Figure 1. Facilities-Based Competition Decreases as UNE-P Penetration Increases



*Facilities-based lines are based on CLEC E911 listings as of year-end 2001.

The inverse relationship between facilities-based competition and UNE-P usage is particularly striking in the business market.[7] As of year-end 2001, CLECs served at least 13 million, and more likely closer to 20 million business lines using their own switches, compared to only 1.6 million business lines through UNE-P.[8] Nearly all of these lines were originally acquired and continue to be served by CLECs using their own switches; only a negligible amount of facilities-based lines have been migrated from UNE-P. Thus, the pattern is just the opposite of what AT&T claims: relatively low UNE-P volumes are associated with relatively high facilities-based volumes.

This relationship also is evident in residential markets. UNE-P usage is heavily concentrated in residential markets: approximately 70 percent of all UNE-P lines serve residential customers. But the states in which facilities-based residential competition is most

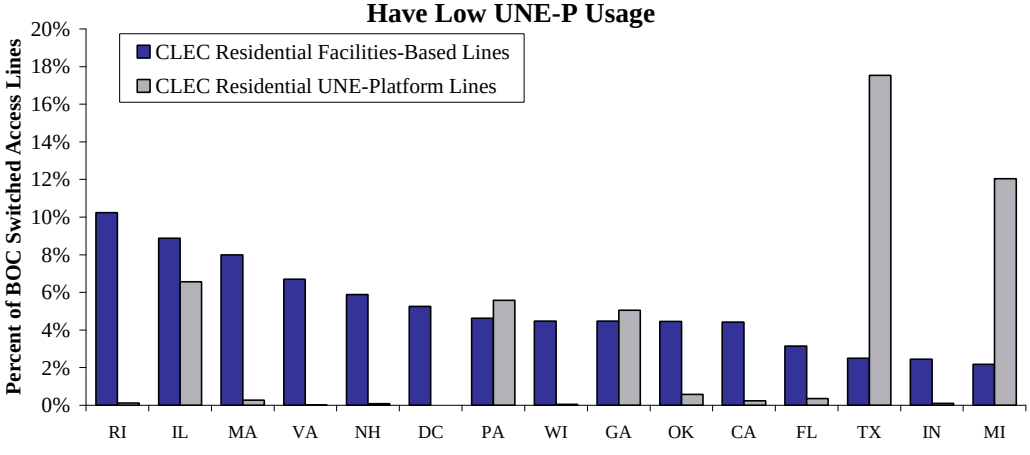
[6] AT&T is providing local residential service using UNEs in New York, Texas, Michigan, Georgia, Illinois, and Ohio, and has announced plans to begin providing service in New Jersey and California later this year. *See* AT&T Press Release, *AT&T Says It's Eager to Compete in PA. Local Phone Market, Hopeful That Regulatory Judge's Opinion Today Will Pave the Way* (May 7, 2002); AT&T Press Release, *AT&T Enters Illinois Residential Local Phone Market* (June 5, 2002); AT&T Press Release, *AT&T Enters Ohio Residential Local Phone Market* (June 11, 2002); AT&T Press Release, *AT&T To Offer Residential Local Service in New Jersey Later This Summer* (July 15, 2002).

[7] The fact that UNE-P volumes have recently begun to increase significantly in certain states with substantial facilities-based competition, such as Michigan and California, in no way suggests a positive correlation between facilities-based competition and UNE-P usage in those states. The recent increase in UNE-P usage in those and other states is a result of recent decreases in UNE-P rates and is occurring *despite*, not because of, the substantial facilities that were previously deployed.

[8] *See UNE Fact Report 2002* at II-4.

advanced tend to have very low levels of residential UNE-P. For example, the five states with the most facilities-based residential lines in proportion to the BOC access lines in each state are Rhode Island, Illinois, Massachusetts, Virginia, and New Hampshire.[9] In each of these states except Illinois, residential UNE-P represents less than 1 percent of the BOC access lines in the state. *See* Figure 2. This same is true with respect to all but five of the 15 states with the highest level of facilities-based residential competition. *See id.*

Figure 2. Most States with High Levels of Facilities-Based Residential Competition Have Low UNE-P Usage



Conversely, the level of residential UNE-P is highest in those residential markets where levels of facilities-based residential competition are relatively low. The three states with the highest residential UNE-P penetration (by far) are New York, Texas, and Michigan, where residential UNE-P lines represent 26 percent, 18 percent, and 12 percent of the BOC residential lines in those states, respectively. By comparison, facilities-based residential lines represent only 2.5 percent or less of the BOC access lines in each of those states. Indeed, New York – the state championed as the gold-standard in AT&T's analysis – has proportionately more residential UNE-P than any other state, but its level of facilities-based residential competition does not even place it among the top-15 states. And there is no evidence to suggest that AT&T or any other CLEC has actually migrated residential lines from UNE-P to their own switches. As these facts demonstrate, UNE-P does not stimulate facilities-based competition in residential markets, but impedes it.

Most facilities-based residential competition is provided through cable telephony (and to an increasing degree through wireless).[10] Quite obviously, UNE-P does nothing to facilitate the deployment of cable telephony, because cable telephony is provided over an entirely separate network. But UNE-P can discourage the investment in cable telephony from ever occurring, and the facts indicate that is exactly what is occurring. As noted above, the states with the highest levels of residential UNE-P all have low levels of facilities-based residential competition through cable telephony. This is why one of the nation's two largest cable telephony providers – Cox –

[9] The analysis of competition in residential markets excludes the states served by Qwest in the analysis because residential E911 listings for Qwest were not available.

[10] *See UNE Fact Report 2002* at II-11 & IV-10.

has stated that "instead of promoting local competition, the current broad availability of UNEs and the Commission's pricing methodology actually jeopardize the development of facilities-based competition."[11] Likewise, analyst Legg Mason has recently stated with respect to WorldCom's plan to expand its UNE-P offerings, "the more successful the plan is, the more it will reduce the attractiveness of the telephony opportunity for cable."[12] And "[g]iven how the . . . plan affects the attractiveness of telephony to new facilities-based providers," state regulators may be forced to modify state rates "if they want to encourage new facilities-based competitors, such as cable."[13]

2. Even the more limited comparison of New York to California proves the negative influence of UNE-P on facilities-based competition.

The evidence AT&T submits to support its claims fails to prove its theory that access to the UNE-P leads to greater facilities-based investment. In the first place, rather than analyze the full range of relevant data, or even some reasonable subset, AT&T supplies an essentially anecdotal discussion of its own business plan in just two states – New York and California. AT&T reports that it has deployed more circuit switches in New York, where UNE-P is widespread, than in California, where it isn't – and claims that this proves its thesis that more UNE-P leads to more facilities-based investment.[14]

This is just brazen data dredging. And it fails even on its own terms. More importantly, the proliferation of UNE-P customers in New York, and not in California, has *not* in fact resulted in proportionately more competitive facilities-based investment or proportionately more facilities-based competition in New York.

In the analysis of "cause" and "effect," timing matters – the cause has to come first, the effect has to follow. AT&T and other CLECs deployed most of their circuit switches in New York *before* the rise of UNE-P.[15] AT&T did not begin providing UNE-P service in New York until August 1999, and did not do so in large volumes until late 1999 at the earliest.[16] Yet AT&T deployed far *more* circuit switches in New York *before* year-end 1999 (15 switches) than it has deployed since (2 switches).[17] CLECs as a whole in New York likewise deployed most of their switches (55 of 73) before the rise of UNE-P in that state.

---

[11] Comments of Cox Communications, Inc. at 12, *Implementation of the Local Competition Provisions of the Telecommunications Act of 1996*, CC Docket No. 96-98 (FCC filed May 26, 1999).

[12] Legg Mason, *WorldCom/MCI Bundled Phone Offer Challenges Rivals, Regulators* at 2 (Apr. 23, 2002).

[13] *Id.* at 4.

[14] *See* AT&T Brief at 49-50; AT&T Willig Decl. ¶ 107.

[15] Appendix B provides the dates on which CLEC switches in New York and California were deployed.

[16] By December 1999, when AT&T began offering residential service through UNE-P statewide, the company had signed up 50,000 customers in New York. *See* AT&T Press Release, *AT&T Offers New Yorkers a New Choice for Local Residential Phone Service* (Dec. 1, 1999).

[17] The same is true for WorldCom, the CLEC that is most comparable to AT&T. WorldCom began providing UNE-P service in New York a few months before AT&T, and also had acquired a large volume of platforms by late 1999. But like AT&T, WorldCom deployed most of its switches (8 of 9) prior to that time. *See* Figure 3.

Nor is it even appropriate to attribute the few switches that AT&T and other CLECs have deployed since year-end 1999 in New York to the rise of UNE-P. As noted above, CLECs that have obtained UNE-P are not migrating those UNE-P customers to their own switches in any significant numbers. In New York, for example, AT&T and WorldCom together provide UNE-P service to well over one million residential customers[18] – enough customers, in other words, to fill five to ten large switches (or an even larger number of smaller ones). Even though AT&T and WorldCom also operate 26 local circuit switches in New York state,[19] neither appears to have converted any residential customers in New York to their own switches.[20]

Moreover, since the end of 1999 – which is to say, since the time that UNE-P competition supposedly began to spur facilities-based competition in *New York* – AT&T, WorldCom, and all CLECs collectively, have actually been deploying more of their new switches in *California*, where AT&T claims that UNE-P has been less viable than in New York. *See* Figure 3. In fact, since 1999, CLECs have deployed more than twice as many switches in California as in New York, despite the fact that New York's demographics make it a more likely target for facilities-based competition than California.[21] *See id.* Today, despite far higher volumes of UNE-P in New York than in California, CLEC circuit-switch deployment in California is roughly equal to CLEC switch deployment in New York – hardly the result one would expect if AT&T's theory were correct. *See* Figure 4.

---

[18] S. Alexander, *Judge Recommends Qwest Be Fined for Impeding Local Service by AT&T; But AT&T Says It Won't Enter Market*, Star Trib. (Feb. 26, 2002) (AT&T vice president Tom Pelto said that AT&T uses the UNE-Platform to provide local residential phone service to about 1 million people in New York.); M. McDonald, *Local Phone Fight Gets Put on Hold*, Crain's N.Y. Bus. at 1 (Mar. 5, 2001) (WorldCom accumulated 400,000 customers in New York).

[19] *See* Appendix B; *see also UNE Fact Report 2002* at Appendix B.

[20] *See* Declaration of Vijetha Huffman ¶ 5, *attached to* Comments of WorldCom, Inc., *Application of Verizon New Jersey, Inc., Bell Atlantic Communications, Inc. (d/b/a Verizon Long Distance), NYNEX Long Distance Company (d/b/a Verizon Enterprise Solutions), Verizon Global Networks Inc. and Verizon Select Services Inc. for Authorization To Provide In-Region, InterLATA Services in New Jersey*, CC Docket No. 01-347 (FCC filed Jan. 14, 2002) ("UNE-P . . . is the only service-entry vehicle that WorldCom uses to offer local residential service, and it is the only service-delivery option that WorldCom currently views as even potentially viable."); Supplemental Declaration of Michael Lieberman on Behalf of AT&T Corp. ¶ 20, *attached to* Ex Parte Letter of Peter Keisler, Sidley Austin Brown & Wood (representing AT&T), to William F. Caton, FCC, CC Docket No. 01-324 (Feb. 8, 2002) (AT&T has recently stated that it has not pursued a strategy of converting platform customers to its own facilities "to provide basic local residential service to customers anywhere in the country.").

[21] For example, population density is nearly twice as high in New York as it is in California. *See* Netstate.com, *Census 2000 State Population Information*, http://www.netstate.com/states/tables/st_population.htm (population per square mile: California – 207, New York – 348). New York also has a much higher percentage of its population living in large cities than California. For example, 50 percent of the New York population lives in the state's 15 largest cities, compared to 30 percent in California. *See* United States Census Bureau, *Census 2000 Redistricting Data*, http://www.census.gov/clo/www/redistricting.html.

Figure 3. Despite the Rise of UNE-P in New York, CLECs Have Deployed More Switches in California

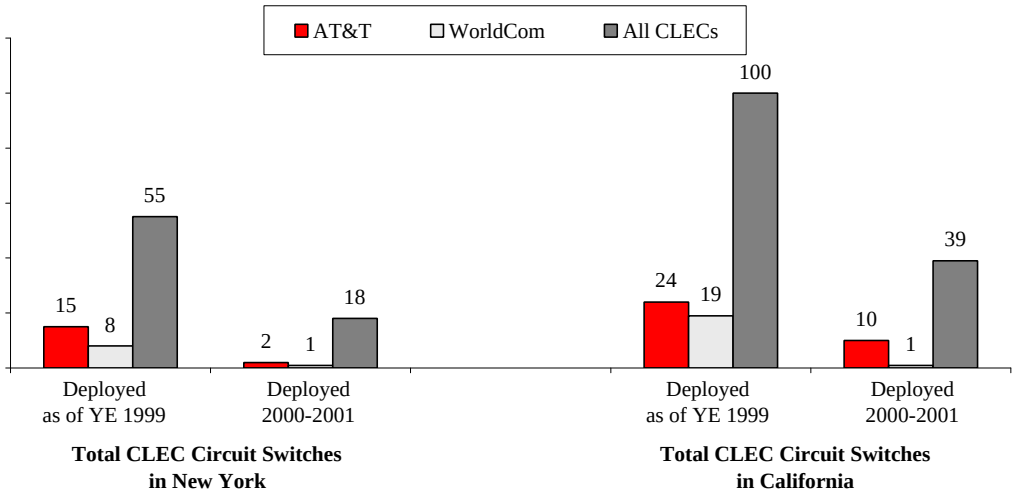
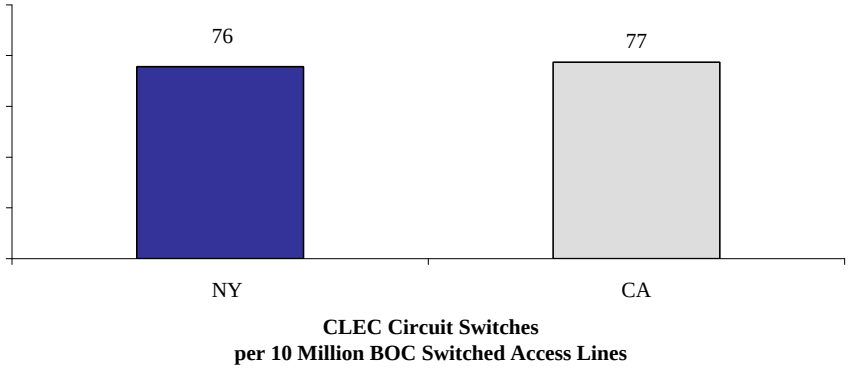
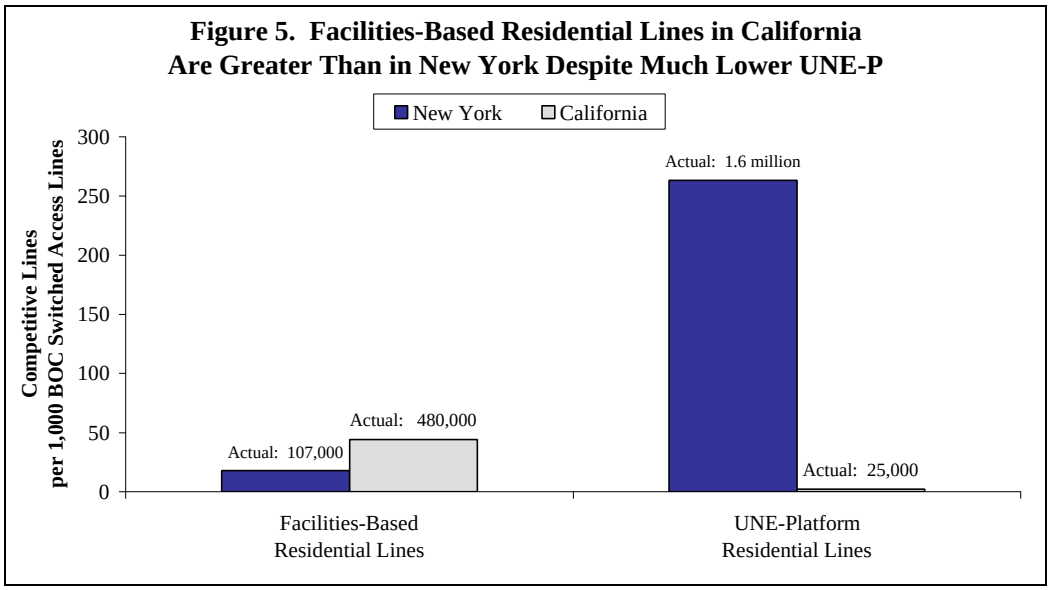


Figure 4. CLEC Switch Deployment in California Is Comparable to New York Despite Much Lower UNE-P



California also has much higher levels of facilities-based residential competition than New York, despite far lower levels of UNE-P in California. As of year-end 2001, CLECs were serving approximately 1.6 million residential lines through UNE-P in New York – roughly 26 percent of the number of BOC access lines in the state. As of that same date, CLECs were serving only 25,000 residential lines through UNE-P in California – less than 1 percent of the number of BOC access lines in the state. Despite this enormous disparity, the number of facilities-based residential lines is proportionately *higher* in California – more than double – than the number in New York. *See* Figure 5.[22]

[22] There is likely an even greater number of facilities-based residential lines in California than this analysis indicates because it does not include competitive lines located in Verizon's service area, which includes approximately 4 million switched access lines in Los Angeles and surrounding MSAs. There are numerous competitors providing facilities-based service in Verizon's territory, however. For example, as discussed below, Cox provides cable telephony in Orange County.



Facilities-based residential competition also is much more widely *available* in California than in New York. In New York, only one cable operator – Cablevision – has deployed cable telephony on an extremely limited basis (to fewer than 15,000 homes).[23] Despite original plans to deploy its service more broadly,[24] Cablevision stopped marketing its service in late 2000,[25] when residential UNE-P volumes in NY had already exceeded 1 million lines. In California, by contrast, cable telephony is now available to several million homes and growing. AT&T's cable network in the Bay Area passes 2.7 million homes,[26] at least one-third of which already "can get cable telephony today."[27] AT&T claims that among such homes there already is "19% telephony penetration" and "many communities in high 20s."[28] Moreover, the "backbone and headend segments of rebuilds [are] nearly complete,"[29] which will enable AT&T to provide cable telephony to those homes served by its San Francisco network that can not already receive it. In addition to AT&T, Cox offers cable telephony to nearly 700,000 homes in Orange County and

[23] *See* Cablevision Systems Corp., Form 10-K (SEC filed Apr. 1, 2002) (As of YE 2001, Cablevision provided residential telephone service to approximately 13,400 subscribers in Long Island and parts of southern Connecticut).

[24] *See, e.g.*, P. Joshi, *All This and Cable, Too*, Newsday at C08 (Sept. 14, 1998) ("Right now, [Cablevision] has offered telephone service to about 6,000 homes in nine Nassau County communities. The company plans to aggressively roll out throughout metropolitan New York over the next several years.").

[25] *See, e.g.*, J. Reif-Cohen, *et al.*, Merrill Lynch Capital Markets, Investext Rpt. No. 8305280, Cablevision Systems Corp. – Company Report at *5 (Dec. 17, 2001) ("For the past year, Cablevision has stopped marketing its telephone service and will not add anymore telephone homes to its universe.").

[26] Dan Somers, President and CEO, AT&T Broadband, *Operational Overview*, AT&T Broadband, Investor Presentation at 18 (July 2001).

[27] *Comcast Purchase of AT&T Means More Services*, Silicon Valley/San Jose Bus. J. at 11 (Jan. 4, 2002).

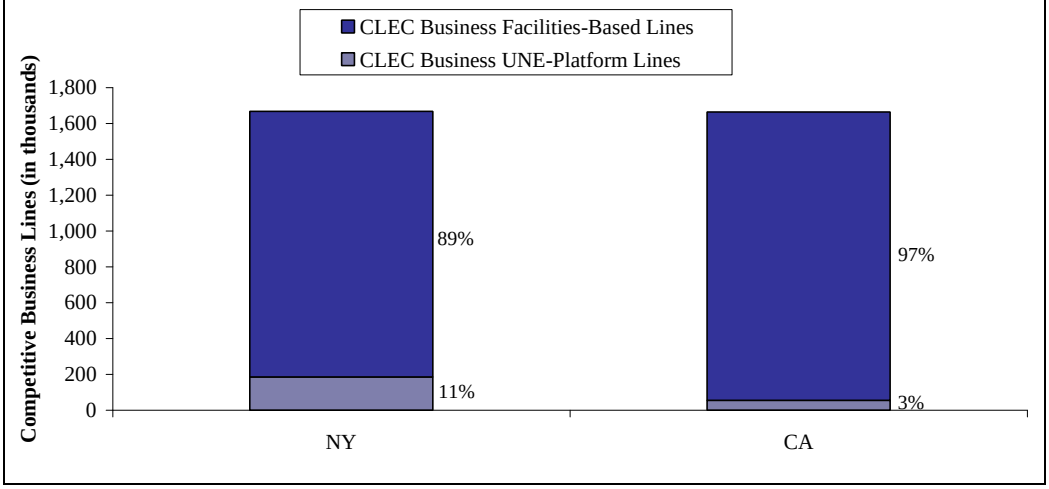
[28] Dan Somers, President and CEO, AT&T Broadband, *Operational Overview*, AT&T Broadband, Investor Presentation at 18 (July 2001).

[29] *Id.*

San Diego.[30] Cox makes this service available to 97 percent of the homes it passes in Orange County, and 77 percent of the homes it passes in San Diego.[31]

Finally, the inverse relationship between facilities-based competition and UNE-P penetration is particularly evident in comparing business markets in New York and California. Both AT&T and WorldCom use UNE-P to serve some business customers in New York, but these numbers are dwarfed by the number of business lines that AT&T and WorldCom serve over their own facilities. This also is true generally for all CLECs, not just AT&T and WorldCom. New York CLECs collectively serve at least 1.5 million business lines using their own switches, compared to only 186,000 lines through UNE-P. *See* Figure 6. California CLECs collectively serve at least 1.6 million business lines using their own switches, compared to only 54,000 lines through UNE-P. Again, virtually all of these lines have always been served using CLEC switches; the number of lines migrated from UNE-P to CLEC switches is minuscule. Thus, contrary to AT&T's claims, facilities-based business competition in both states has evolved prior to the availability of the UNE-P, or despite its availability, not because of it. *See id.*

Figure 6. Facilities-Based Business Competition in New York and California Is Not Attributable to UNE-P



[30] *Top 100 Systems*, Cablevision Magazine (Oct. 22, 2001); Cox Communications, *Presentation before the Lehman Brothers Telecom Trends and Technology Conference* (Dec. 7, 2001), http://www.corporate-ir.net/ireye/ir_site.zhtml?ticker=cox&script=1200 (Cox offers cable telephony to approximately 257,000 customers in Orange County, and approximately 406,000 customers in San Diego).

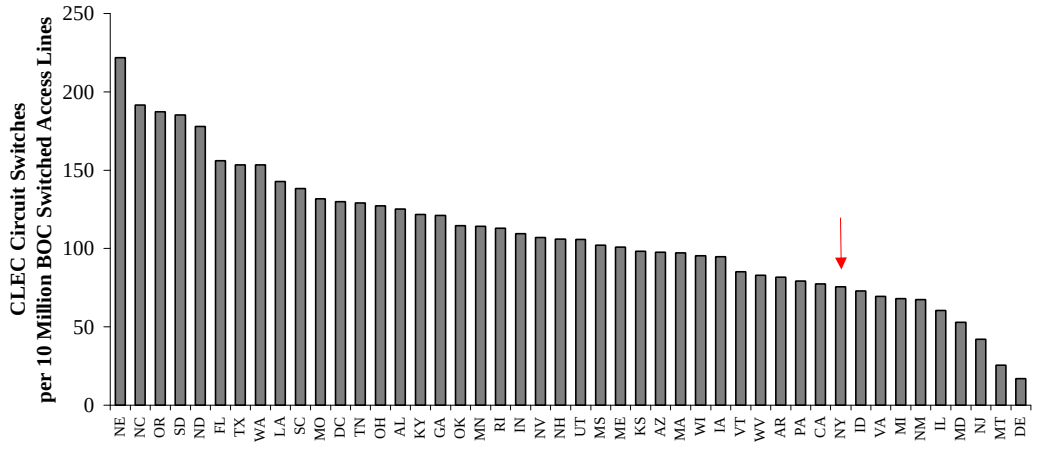
[31] Cox Communications, *Presentation before the Lehman Brothers Telecom Trends and Technology Conference* (Dec. 7, 2001), http://www.corporate-ir.net/ireye/ir_site.zhtml?ticker=cox&script=1200 (Cox offers cable telephony to approximately 257,000 customers in Orange County, and approximately 406,000 customers in San Diego).

3. AT&T's theory fares no better when New York is compared to other states.

UNE-P penetration is far greater in New York than in any other state. CLECs in New York also serve a large number of lines with their own switches. But when the numbers are normalized against the number of BOC access lines in each state, the number of facilities-based CLEC lines is found to be proportionately higher in many other states. And this is all the more striking given that New York's demographic characteristics – particularly its high overall population density and the massive concentration of telecommunications revenues in New York City – make it a far more attractive candidate for facilities-based competition than most other states.

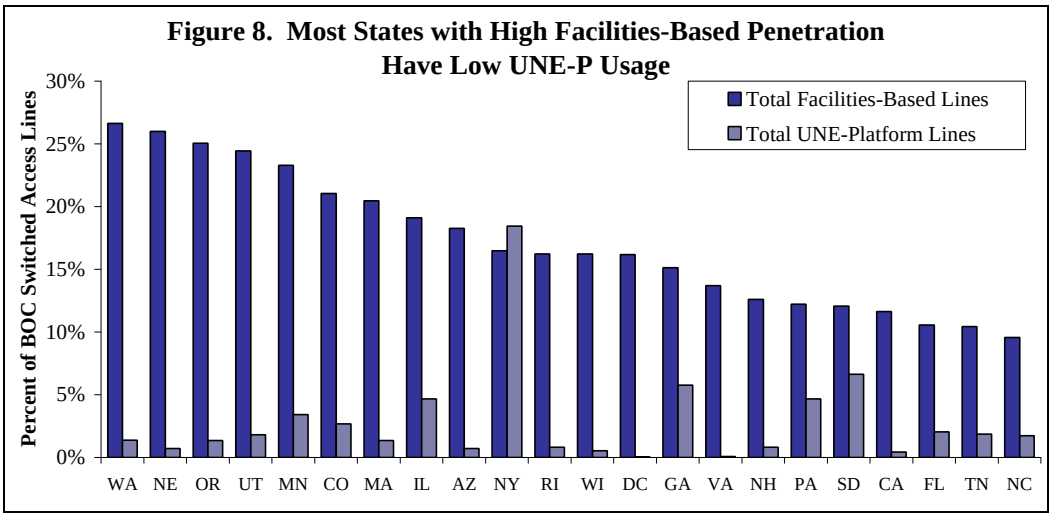
For example, among the 48 contiguous states,[32] New York ranks only 37th in terms of the number of CLEC *switches* deployed per BOC access lines in the state. *See* Figure 7.

Figure 7. High UNE-P in New York Has Not Led to High CLEC Switch Deployment



Moreover, New York ranks only tenth in terms of the number of facilities-based CLEC *lines*. *See* Figure 8. Significantly, *all* of the nine states that have proportionately more facilities-based lines than New York also have much lower volumes of UNE-P. *See id.*

[32] Data for the 48 contiguous states exclude Connecticut but include the District of Columbia.



Even within the former Bell Atlantic region, New York does not stand out in terms of facilities-based competition. Six states within the former Bell Atlantic region have more facilities-based residential competition than New York.[33]

Finally, data from three of the largest states in Verizon's region – New York, Massachusetts, and Pennsylvania – suggest a direct relationship between high levels of residential UNE-P and low levels of facilities-based residential competition.[34] New York has the most residential UNE-P (26 percent of BOC lines), but the least facilities-based residential competition (2 percent of BOC lines); Massachusetts has the least residential UNE-P (less than 1 percent of BOC lines), and the most facilities-based residential competition (8 percent of BOC lines); and Pennsylvania falls in the middle in terms of both residential UNE-P (6 percent of BOC lines) and facilities-based residential lines (5 percent of BOC lines). Significantly, while WorldCom has decided to provide residential UNE-P in both Massachusetts and Pennsylvania, AT&T has declined to do so. AT&T has instead made cable telephony its exclusive means of serving residential customers in both states.

B. The Data Do Not Support AT&T's Claims that UNE-P Encourages ILEC Investment.

Limiting its analysis to the 13 states that have already been granted section 271 approval, or for which an application is pending, AT&T asserts that the "availability of UNE-P increases *ILEC* incentives to build because UNE-P is a precursor to facilities entry by CLECs."[35] AT&T claims that, among these states, the three with the highest ILEC investment rates in 1999 and

[33] Rhode Island, Massachusetts, New Hampshire, District of Columbia, Pennsylvania, and Virginia. This is based on internal company data collected for the *UNE Fact Report 2002*.

[34] The data in this paragraph is based on internal company data collected for the *UNE Fact Report 2002*.

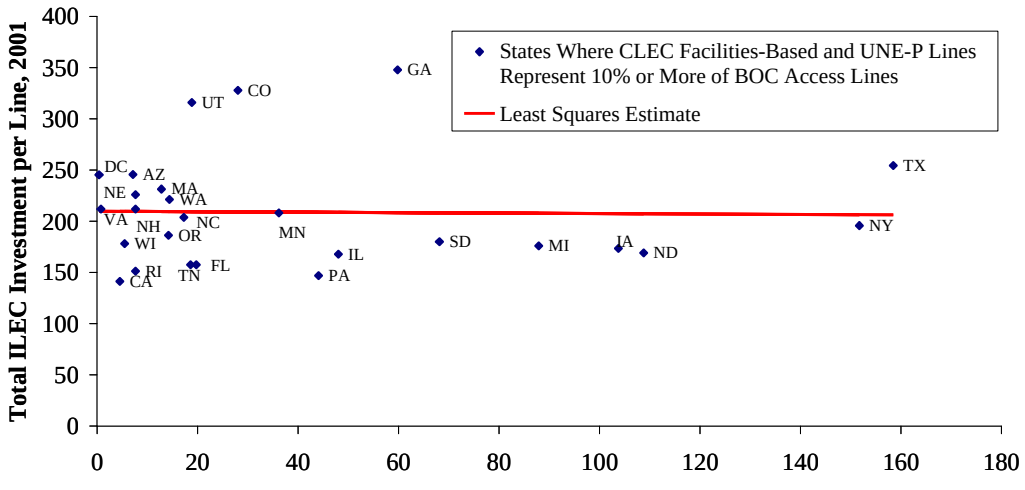
[35] AT&T Brief at 66.

2000 were Georgia, Texas, and New York, which it claims also are the states with the highest levels of UNE-P entry.[36]

As an initial matter, fails to explain why it should limit its analysis to these 13 states, and there is no logical basis for doing so. Many states that have not yet received section 271 approval have significant levels of local competition, provided both through CLECs' own facilities and through UNE-P. Conversely, some of the states that have received 271 approval still have relatively low levels of competition, even though those markets have been fully opened, as the FCC has found.

As explained above, however, there are 26 states in which CLECs have captured 10 percent or more of the BOC access lines in those states. To the extent that UNE-P usage is, as AT&T claims, increasing ILEC investment, it should be evident in a comparison of the data from these states. But, as demonstrated in Figure 9, there is no statistically significant correlation between UNE-P levels and ILEC investment in these 26 states.[37] Figure 9 is a simple regression analysis that compares the levels of ILEC investment within a state with the level of UNE-P penetration in that state. It demonstrates that there is no relationship between these two variables. Thus, the evidence fails to support AT&T's assertion of a relationship between UNE-P and ILEC investment

Figure 9. ILEC Investment Does *Not* Increase as UNE-P Increases



AT&T's analysis is further flawed because it is limited to just two years, 1999 and 2000. But some states have historically received proportionately more ILEC investment than others, with the record stretching back into the years preceding the advent of UNE-P usage. For example, AT&T claims that, in both 1999 and 2000, there was much larger ILEC investment in

[36] *See* AT&T Brief at 66; AT&T Willig Decl. ¶ 108.

[37] Appendix C contains the results of the statistical analysis. It demonstrates that, to a 95-percent level of confidence, there is no statistically significant correlation between these two variables.

Georgia (where there is relatively high UNE-P) than in Massachusetts (where there is relatively low UNE-P).[38] But that was also so in 1996, 1997, and 1998.[39] AT&T likewise claims that ILEC investment in California in 2000 was far lower than in New York, Texas, and all other 271 states. Here, too, however, that simply continues a longstanding historical pattern.[40] Here again, the data fail to support AT&T's theory that the UNE-P promotes ILEC investment.

The only relevant measure of what impact, if any, UNE-P has had in a particular state is the relative *change* in ILEC investment that has occurred since the advent of UNE-P. The data show that, even among the 13 states chosen by AT&T, there is no correlation between the volume of UNE-P in the state and the average increase in ILEC investment in that state.

For example, focusing on the two states – Georgia and Massachusetts – on which AT&T anchors its analysis, the average annual increase in ILEC investment per line over the last two years was in fact higher in Massachusetts than in Georgia, despite the fact that UNE-P penetration in Georgia is six times higher than in Massachusetts.[41] In fact, during this period the average increase in ILEC investment was higher in Massachusetts than in *any* other 271-approved state.[42] And among the Verizon states, the second highest increase in ILEC investment during this period was Rhode Island, where, as in Massachusetts, there is extensive facilities-based competition but only modest UNE-P usage. AT&T's other two main examples – New York and Texas – ranked only 5th and 10th, respectively, among the fourteen 271-approved states in terms of *growth* of ILEC investment over the past two years.

---

[38] AT&T Willig Decl. ¶ 109.

[39] During 1996, 1997, and 1998, ILEC investment per line in Massachusetts was $144, $151, and $153, respectively, compared to $227, $171, and $183 in Georgia. *See* FCC, *ARMIS Data Retrieval System*, http://www.fcc.gov/wcb/armis/db ("*ARMIS Database*"). In calculating ILEC investment per line, the methodology used is the same as that used by AT&T. *See* AT&T Willig Decl. ¶ 108, fn.23.

AT&T's claim that the rise of UNE-P in Georgia correlates with higher BellSouth investment in 1999 and 2000 also fails for another reason: UNE-P was not commercially available in Georgia until February 2000, and was not ordered in significant volumes until later that year. Thus, the rise of UNE-P in Georgia could not possibly have had any correlation with BellSouth investment in 1999, and any correlation with BellSouth investment in 2000 is highly unlikely.

[40] During 1996, 1997, and 1998, ILEC investment per line in California was $112, $125, and $118, respectively. This produces an average per-line investment of $118 during those years. The average per-line investment of the 14 states with an approved or pending section 271 application during those same three years was as follows: Arkansas, $157; Georgia, $194; Kansas, $141; Louisiana, $114; Maine, $128; Massachusetts, $149; Missouri, $156; New Jersey, $141; New York, $139; Oklahoma, $122; Pennsylvania, $101; Rhode Island, $92; Texas, $186; Vermont, $140. *See ARMIS Database.*

[41] In 2000 and 2001, ILEC investment per line increased by 7 and 50 percent, respectively, in Massachusetts (an average of 28 percent), compared to 22 and 30 percent, respectively, in Georgia (an average of 26 percent). *See ARMIS Database*.

[42] The average growth in rates of ILEC investment over the past two years in the 271-approved states were as follows: Arkansas, 26%; Georgia, 26%; Kansas, 11%; Louisiana, 6%; Maine, 16%; Massachusetts, 28%; Missouri, 21%; New Jersey, 1%; New York, 13%; Oklahoma, 17%; Pennsylvania, 6%; Rhode Island, 17%; Texas, 20%; Vermont, 20%. *See ARMIS Database*.

APPENDIX A. REGRESSION STATISTICS FOR FIGURE 1

Regression Statistics	
Multiple R	0.468664202
R Square	0.219646135
Adjusted R Square	0.18713139
Standard Error	59.50012169
Observations	26

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	23915.47043	23915.47043	6.755277908	0.015736696
Residual	24	84966.34754	3540.264481		
Total	25	108881.818			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	185.4032671	15.68746366	11.81856233	1.71219E-11	153.0259401	217.7805941	153.0259401	217.7805941
X Variable 1	-0.673618956	0.259174751	-2.599091747	0.015736696	-1.208529241	-0.138708671	-1.208529241	-0.138708671

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	180.6044122	6.905939381
2	182.337845	-63.21654081
3	166.5051474	54.00558292
4	185.1371276	-26.16290469
5	172.1167124	-69.88739742
6	145.1336051	11.87031769
7	153.047791	44.27183746
8	115.5301059	-54.37010294
9	176.7735875	15.56286116
10	126.1968694	-37.93628646
11	161.0429272	85.9474555
12	180.2891146	97.02851692
13	180.2643091	-60.84169231
14	83.17953903	52.47516256
15	173.7671997	-77.73334964
16	112.1112315	-39.07491477
17	175.8588531	88.36664056
18	155.6945439	-40.48412761
19	180.2587223	-25.36378541
20	139.5179939	-15.69243439
21	172.8737062	-67.83797457
22	78.66648786	2.914796534
23	172.7077562	81.75518014
24	184.8972561	-51.14385667
25	175.7211714	102.1846702
26	181.7213168	-13.54359336

APPENDIX B. DEPLOYMENT OF CLEC CIRCUIT SWITCHES IN CALIFORNIA AND NEW YORK

The list of switches in this appendix is based on information contained in Telcordia's *Local Exchange Routing Guide*. The deployment date for these switches is based on information contained in Telcordia's Business Integrated Rating/Routing Database System.

CLEC Circuit Switches Serving BOC Rate Centers in California and New York					
State	**Type**	**CLEC**	**City**	**Street**	**Year Deployed**
CA	DS	ADVANCED TELCOM GROUP	CONCORD	2041 EAST ST	2001
CA	5E	ADVANCED TELCOM GROUP	SAN RAFAEL	1009 E ST	2000
CA	5E	ALLEGIANCE TELECOM	LOS ANGELES	818 W 7TH ST. SUITE 320	1998
CA	5E	ALLEGIANCE TELECOM	RANCHO CORDOVA	10995 GOLD CENTER DR	2000
CA	5E	ALLEGIANCE TELECOM	SAN DIEGO	5761 COPLEY DR	1999
CA	5E	ALLEGIANCE TELECOM	SAN FRANCISCO	651 BRANNAN STREET, 3RD FLOOR	1998
CA	5E	ALLEGIANCE TELECOM	SANTA ANA	1251 E DYER RD	1999
CA	5E2	ALLEGIANCE TELECOM	SUNNYVALE	677 PALOMAR AVE	2000
CA	DS	ARRIVAL COMMUNICATIONS	BAKERSFIELD	1800 19TH ST	2001
CA	5E	AT&T	ANAHEIM	217 N LEMON ST	1999
CA	4E	AT&T	ANAHEIM	217 N LEMON ST	1997
CA	4E	AT&T	DUNNIGAN	INTER YOLO CNTY	1998
CA	5E	AT&T	DUNNIGAN	INTER YOLO COUNTY & ROADS 6 AND 86	2000
CA	4E	AT&T	GARDENA	17200 S VERMONT AVE	1997
CA	5E	AT&T	LOS ANGELES	700 S FLOWER ST	1997
CA	4E	AT&T	LOS ANGELES	420 S GRAND AVE	1998
CA	NT5	AT&T	LOS ANGELES	420 S GRAND AVE	1999
CA	5E	AT&T	MOJAVE	N-O HWY 58 & 9 MI E-O MOJAVE INDEX D	2000
CA	5E	AT&T	OAKLAND	1587 FRANKLIN ST	2000
CA	4E	AT&T	OAKLAND	1601 FRANKLIN ST	1998
CA	NT5	AT&T	OAKLAND	1601 FRANKLIN ST	2000
CA	5E	AT&T	OAKLAND	344 20TH ST	1997
CA	4E	AT&T	OXNARD	1050 S C ST	1997
CA	5E	AT&T	SACRAMENTO	603 S ST	1998
CA	4E	AT&T	SACRAMENTO	DONOT USE SEE SCRMCA01	1998
CA	4E	AT&T	SAN BERNARDINO	455 2ND ST	1998
CA	5E	AT&T	SAN BERNARDINO	455 W 2ND ST	2000
CA	5E	AT&T	SAN DIEGO	5464 MOREHOUSE DR	1997
CA	NT5	AT&T	SAN DIEGO	650 ROBINSON AVE	2000
CA	4E	AT&T	SAN DIEGO	650 ROBINSON AVE	1998
CA	5E	AT&T	SAN FRANCISCO	1 BUSH ST	1997
CA	NT5	AT&T	SAN FRANCISCO	360 SPEAR ST	2000
CA	5E	AT&T	SAN FRANCISCO	555 PINE ST	1999
CA	4E	AT&T	SAN FRANCISCO	611 FOLSOM ST	1997
CA	5E	AT&T	SAN FRANCISCO	360 SPEAR ST	2001
CA	NT5	AT&T	SAN JOSE	95 ALMADEN AVE	1999
CA	4E	AT&T	SAN JOSE	95 ALMADEN AV	1997
CA	5E	AT&T	SAN JOSE	95 ALMADEN AV	1999
CA	5E	AT&T	SHERMAN OAKS	14800 VENTURA BLVD	2000
CA	4E	AT&T	SHERMAN OAKS	14800 VENTURA BLVD	1997
CA	5E	AT&T	SHERMAN OAKS	14800 VENTURA BLVD	2000
CA	5E	AT&T	STOCKTON	345 N SAN JOAQUIN AV	1992
CA	4E	AT&T	STOCKTON	344 N HUNTER ST	1998
CA	D12	CITIZENS	ELK GROVE	820 ELK GROVE FLORIN RD	1991

CLEC Circuit Switches Serving BOC Rate Centers in California and New York					
State	**Type**	**CLEC**	**City**	**Street**	**Year Deployed**
CA	5E	COX	ALISO VEIJO	17 JOURNEY ST	1997
CA	D12	COX	EL CAJON	1175 N. CUYAMUCA ST.	2000
CA	DMS	COX	RANCHO SANTA MARGARITA	29947 AVENIDA DE LAS BANDERAS	2001
CA	D12	COX	SAN DIEGO	1441 EUCLID AVE	1997
CA	D12	ELECTRIC LIGHTWAVE	RANCHO CORDOVA	3224 LUYUNG DR.	1996
CA	NT5	FIRST WORLD COMMUNICATIONS	ANAHEIM	1520 S LEWIS ST	1997
CA	NT5	FOCAL COMMUNICATIONS	LOS ANGELES	1200 W 7TH ST	1998
CA	DM5	FOCAL COMMUNICATIONS	SAN FRANCISCO	650 TOWNSEND ST	1998
CA	NT5	FOCAL COMMUNICATIONS	SAN JOSE	1741 TECHNOLOGY DR	2000
CA	DS	GLOBAL CROSSING	ANAHEIM	2461 W LA PALMA AVE 2ND FLR	1997
CA	NT5	GLOBAL CROSSING	CALIFORNIA	SAN DIEGO	2001
CA	NT5	GLOBAL CROSSING	SACRAMENTO	1303 J ST	1999
CA	5E	ICG COMMUNICATIONS	ALHAMBRA	2300 W VALLEY BLVD	1999
CA	5E	ICG COMMUNICATIONS	IRVINE	2968 WHITE RD., SUITE 200	1996
CA	5E	ICG COMMUNICATIONS	LAKEWOOD	4007 PARAMOUNT BLVD	1997
CA	5E	ICG COMMUNICATIONS	LOS ANGELES	1905 ARMACOST AVE	1997
CA	5E2	ICG COMMUNICATIONS	LOS ANGELES	600 W 7TH ST	2000
CA	5E2	ICG COMMUNICATIONS	MILPITAS	1175 MONTAGUE EXPRESSWAY	2000
CA	5E	ICG COMMUNICATIONS	OAKLAND	180 GRAND AVE	1996
CA	5E	ICG COMMUNICATIONS	ONTARIO	1471 VALENCIA PL	1999
CA	5E	ICG COMMUNICATIONS	SACRAMENTO	1414 K ST	2000
CA	5E	ICG COMMUNICATIONS	SACRAMENTO	770 L ST	1996
CA	5E	ICG COMMUNICATIONS	SAN DIEGO	8951 COMPLEX DR	1996
CA	5E	ICG COMMUNICATIONS	SAN FRANCISCO	620 3RD ST	1998
CA	5E	ICG COMMUNICATIONS	SAN JOSE	190 PARK CENTER PLAZA	1997
CA	5E	KCINDUR COMM	SAN LUIS OBISPO	872 MORRO ST	1990
CA	DS	LEVEL 3	FRESNO	305 W NAPA AVE	2001
CA	DS	LEVEL 3	WEST SACRAMENTO	1075 TRIANGLE CT	2000
CA	DMS	MPOWER	BELLFLOWER	16730 BELLFLOWER BLVD	1998
CA	DS	MPOWER	EMERYVILLE	1400 65TH ST	2000
CA	NT5	MPOWER	LA MESA	4695 PALM AVE	1998
CA	DMS	MPOWER	POMONA	362 E 4TH ST	1997
CA	DS	MPOWER	SACRAMENTO	9332 TECH CENTER DR	2000
CA	NT5	MPOWER	SAN JOSE	560 CHARCOT AVE	2000
CA	DM5	NET-TEL CORP.	LOS ANGELES	530 W 6TH ST	1999
CA	NT5	NET-TEL CORP.	SAN FRANCISCO	200 PAUL AVE	2000
CA	DMH	NORTH COUNTY COMMUNICATIONS	LOS ANGELES	624 SOUTH GRAND	1999
CA	DMH	NORTH COUNTY COMMUNICATIONS	SACRAMENTO	926 J ST	1999
CA	DMH	NORTH COUNTY COMMUNICATIONS	SAN DIEGO	4008 TAYLOR ST	1999
CA	DMH	NORTH COUNTY COMMUNICATIONS	SAN FRANCISCO	98 BATTERY ST	1999
CA	VCD	PAETEC	LOS ANGELES	530 W 6TH ST	1999
CA	NT5	POINTE COMM INC	EL MONTE	11025 VALLEY BLVD	2000
CA	NT5	POINTE COMM INC	SAN DIEGO	3949 RUFFIN RD	2000
CA	5E	RCN	CARSON	1059 E BEDMAR ST	2000
CA	5E	RCN	SAN FRANCISCO	200 PAUL AVE	1999
CA	D12	SIERRA TELEPHONE CO.	OAKHURST	41950 ROAD 426	1989

CLEC Circuit Switches Serving BOC Rate Centers in California and New York					
State	**Type**	**CLEC**	**City**	**Street**	**Year Deployed**
CA	5E	SUREWEST COMMUNICATIONS	ROSEVILLE	224 LINCOLN ST	2001
CA	NT5	TELIGENT	LOS ANGELES	1200 W 7TH ST	1998
CA	NT5	TELIGENT	OAKLAND	1111 BROADWAY	1998
CA	DS	TIME WARNER TELECOM	BAKERSFIELD	1918 M ST	1998
CA	DM5	TIME WARNER TELECOM	FRESNO	7576 N DEL MAR AVE	1997
CA	5ESS	TIME WARNER TELECOM	IRVINE	7 MASON	2000
CA	DM5	TIME WARNER TELECOM	LOS ANGELES	3700 WILSHIRE BLVD	1997
CA	DM5	TIME WARNER TELECOM	RIVERSIDE	1110 PALMYRITA AVE	1996
CA	DMS	TIME WARNER TELECOM	SAN DIEGO	1125 NINTH ST	1999
CA	5E	TIME WARNER TELECOM	SAN DIEGO	8925 WARE CT	1996
CA	DM5	TIME WARNER TELECOM	SAN FRANCISCO	501 2ND ST	1997
CA	DM5	TIME WARNER TELECOM	SAN LUIS OBISPO	3050 BROAD ST	1997
CA	DMS	TIME WARNER TELECOM	WALNUT CREEK	1340 TREAT BLVD	1996
CA	5E	U.S. TELEPACIFIC	LOS ANGELES	800 W 6TH ST SUITE 300 3RD FLOOR	1998
CA	5E	U.S. TELEPACIFIC	SAN DIEGO	6134 NANCY RIDGE DR	2000
CA	5E	U.S. TELEPACIFIC	SAN JOSE	55 NICHOLSON LN	2000
CA	DM5	URJET BACKBONE NETWORK	LOS ANGELES	624 S GRAND AVE 11TH FLOOR	2000
CA	5E	WESTERN INTEGRATED NETWORKS	NORTH HIGHLANDS	5411 LUCE AVE	2000
CA	DE4	WORLDCOM	ANAHEIM	905 EAST DISCOVERY LANE	1998
CA	5E	WORLDCOM	BAKERSFIELD	1415 18TH ST	1999
CA	5E	WORLDCOM	BAKERSFIELD	1415 18TH ST	1996
CA	5E	WORLDCOM	FRESNO	1315 VAN NESS	NA
CA	5E	WORLDCOM	FRESNO	1315 VAN NESS AVE	1996
CA	DMH	WORLDCOM	HAYWARD	21350 CABOT BLVD	2000
CA	NT5	WORLDCOM	IRVINE	17642 ARMSTRONG AVE	1997
CA	DE4	WORLDCOM	LOS ANGELES	609 W 7TH AVE	1996
CA	AXT	WORLDCOM	LOS ANGELES	1149 SOUTH BROADWAY	1996
CA	AXT	WORLDCOM	LOS ANGELES	1149 S BROADWAY ST	1996
CA	5E	WORLDCOM	REDWOOD CITY	2700 SPRING ST	1998
CA	DE4	WORLDCOM	SAN DIEGO	707 BROADWAY	1996
CA	DMH	WORLDCOM	SAN DIEGO	8806 COMPLEX DR	1998
CA	NT5	WORLDCOM	SAN DIEGO	8806 COMPLEX DR	1997
CA	DE4	WORLDCOM	SAN FRANCISCO	274 BRANNAN ST	1996
CA	AXT	WORLDCOM	SAN FRANCISCO	525 MARKET ST	1996
CA	AXT	WORLDCOM	SAN FRANCISCO	525 MARKET ST	1995
CA	NT5	WORLDCOM	SAN JOSE	611 RIVER OAKS PKY	1998
CA	5E	WORLDCOM	STOCKTON	400 E MAIN ST	1996
CA	5E	WORLDCOM	SUNNYVALE	464 OAKMEAD PKY	1996
CA	5E	WORLDCOM	WEST SACRAMENTO	2820 KOVR DR	1999
CA	NT5	XO	FREMONT	855 MISSION CT	1998
CA	DMS	XO	LONG BEACH	200 PINE AVE	1997
CA	DS	XO	LONG BEACH	200 PINE AVE	2000
CA	DMS	XO	LOS ANGELES	624 S GRAND	1997
CA	DMS	XO	LOS ANGELES	624 S GRAND	1997
CA	DM5	XO	ROSEVILLE	1390 LEAD HILL BLVD	1999
CA	DMS	XO	SAN DIEGO	5771 COPLEY DR	1998
CA	NT5	XO	SANTA ANA	1924 E DEERE AVE	1997
CA	DMS	XO	SANTA ANA	1924 E DEERE AVE	1997
CA	DMS	XO	SANTA ANA	1924 E DEERE AVE	1997
NY	5E	ADELPHIA	BUFFALO	101 LASALLE AVE	1994

CLEC Circuit Switches Serving BOC Rate Centers in California and New York					
State	**Type**	**CLEC**	**City**	**Street**	**Year Deployed**
NY	5E	ADELPHIA	SYRACUSE	6007 FAIRLAKES RD	1994
NY	5E	ALLEGIANCE TELECOM	NEW YORK	111 8TH AVENUE 14TH FLOOR	1999
NY	5E	ALLEGIANCE TELECOM	NEW YORK	60 HUDSON ST	1996
NY	5E	AT&T	ALBANY	158 STATE ST.	1999
NY	4E	AT&T	BUFFALO	65 FRANKLIN ST	1997
NY	5E	AT&T	BUFFALO	325 DELAWARE AVE	1999
NY	NT5	AT&T	HUNTINGTON	1444 E JERICHO TPKE	1999
NY	5E	AT&T	MANHATTAN	811 10TH AVE	1999
NY	4E	AT&T	MANHATTAN	811 10TH AVE	1997
NY	5E	AT&T	MANHATTAN	33 THOMAS ST	1996
NY	4E	AT&T	MANHATTAN	33 THOMAS ST	2001
NY	NT5	AT&T	MANHATTAN	33 THOMAS ST	1999
NY	5E	AT&T	MANHATTAN	67 BROAD ST	1998
NY	5E	AT&T	MANHATTAN	1 WORLD FINANCIAL (TOWER B) CTR	1997
NY	5E	AT&T	MANHATTAN	250 VESEY ST	1997
NY	5E	AT&T	MANHATTAN	216 E 45TH ST	1997
NY	5E	AT&T	QUEENS	9403 QUEENS BLVD	2000
NY	4E	AT&T	SYRACUSE	201 S STATE ST	1997
NY	NT5	AT&T	WHITE PLAINS	400 HAMILTON AVE.	1999
NY	4E	AT&T	WHITE PLAINS	360 HAMILTON AVE	1997
NY	NT5	BROADVIEW	QUEENS	3718 NORTHERN BLVD	1999
NY	NT5	BROADVIEW	SYRACUSE	224 HARRISON ST	1999
NY	5E	CABLEVISION LIGHTPATH	BETHPAGE	1111 STEWART AVE	1999
NY	5E	CABLEVISION LIGHTPATH	HICKSVILLE	111 NEW SOUTH RD	1994
NY	5E	CABLEVISION LIGHTPATH	WHITE PLAINS	151 FULTON AVE	2001
NY	5E	CHOICE ONE	ALBANY	80 STATE ST	1999
NY	5E	CHOICE ONE	BUFFALO	350 MAIN ST	1999
NY	5E	CHOICE ONE	SYRACUSE	110 W FAYETTE ST	1999
NY	EWSD	COMAV	BROOKLYN	25 CHAPEL ST	1998
NY	5E	CONVERSENT	MELVILLE	201 OLD COUNTRY RD	2000
NY	5E	CORE COMMUNICATIONS	MANHATTAN	67 BROAD ST	2000
NY	DMH	CTSI	SYRACUSE	201 S STATE ST	2000
NY	5E	E.SPIRE	NEW YORK	75 BROAD STREET 3RD FLOOR	1999
NY	5E	EAGLE COMMUNICATIONS	MANHATTAN	60 E 56TH ST	2000
NY	5E	EAGLE COMMUNICATIONS	MANHATTAN	601 W 26TH ST	1999
NY	D12	FAIRPOINT	CHATHAM	19 RAILROAD AV	1992
NY	NT5	FOCAL COMMUNICATIONS	MANHATTAN	325 HUDSON ST	2000
NY	NT5	GLOBAL CROSSING	ALBANY	11 N PAERL ST SUITE 2000	1999
NY	NT5	GLOBAL NAPS	MANHATTAN	1 FINANCIAL SQ	2000
NY	DS	ICG COMMUNICATIONS	MANHATTAN	67 BROAD ST	1999
NY	NT5	INTERMEDIA COMMUNICATIONS	MANHATTAN	160 W BROADWAY	1997
NY	DM5	INTERNATIONAL TELCOM	MANHATTAN	160 W BROADWAY	1999
NY	DS	LEVEL 3	ALBANY	314 N PEARL ST	2001
NY	DS	LEVEL 3	BUFFALO	240 SCOTT ST	2001
NY	DCO	METROPOLITAN TELECOMMUNICATIONS	MANHATTAN	67 BROAD ST	2000
NY	DE4	METTEL	HEMPSTEAD	875 MERRICK AVE	1998
NY	D12	MIDHUDSON_COMM	ALBANY	11 N PEARL ST	1999
NY	DMS10	NECLEC LLC	NEW YORK CITY	32 OLD SLIP 4TH FLOOR	2000
NY	NT5	NET2000	MANHATTAN	325 HUDSON ST	1999
NY	DM5	NET-TEL CORP.	MANHATTAN	67 BROAD ST	1999

CLEC Circuit Switches Serving BOC Rate Centers in California and New York					
State	**Type**	**CLEC**	**City**	**Street**	**Year Deployed**
NY	NT5	NORTHLAND NETWORKS	SYRACUSE	500 S SALINA ST	1998
NY	MFS	NORTHLAND NETWORKS	UTICA	258 GENESEE ST	2000
NY	VCD	PAETEC	ALBANY	1 COMMERCE PLZ	1999
NY	5E	PAETEC	MANHATTAN	111 8TH AVE.	1999
NY	5E	RCN	MANHATTAN	333 W. HOUSTON ST	1997
NY	5E	RCN	QUEENS	3316 WOODSIDE AVE	1999
NY	NT5	TELIGENT	MANHATTAN	111 8TH AVE	1998
NY	NT5	THOUSAND ISLANDS COMMUNICATIONS	WATERTOWN	130 PARK PL	2000
NY	5E	TIME WARNER TELECOM	COLONIE	10 AIRLINE DR	1999
NY	DMT	WARWICK VALLEY TELEPHONE COMPANY	MIDDLETOWN	24 JOHN ST	1999
NY	DS	WESTELCOM NETWORKS	PLATTSBURGH	24 MARGARET ST	2000
NY	AXT	WORLDCOM	BUFFALO	325 DELAWARE - 1ST F	1994
NY	5E	WORLDCOM	BUFFALO	325 DELAWARE AVE	2000
NY	DMH	WORLDCOM	GARDEN CITY	845 STEWART AVE	1998
NY	DMS	WORLDCOM	NEW YORK	111 8TH AVE	1996
NY	AXT	WORLDCOM	NEW YORK	111 8TH AVE	1996
NY	NT5	WORLDCOM	NEW YORK	60 HUDSON ST	1995
NY	NT5	WORLDCOM	NEW YORK	560 WASHINGTON ST	1997
NY	5E	WORLDCOM	WESTBURY (NASSAU)	48 SWALM ST	1997
NY	5E	WORLDCOM	WHITE PLAINS	20 CHURCH ST @ MAIN ST	1997
NY	NT5	XO	MANHATTAN	111 8TH AVE	1998
NY	DMS	XO	NEW YORK	75 BROAD ST	2000

APPENDIX C. REGRESSION STATISTICS FOR FIGURE 9

Regression Statistics	
Multiple R	0.018943218
R Square	0.000358846
Adjusted R Square	-0.041292869
Standard Error	56.14694118
Observations	26

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	27.15981654	27.15981654	0.008615384	0.926817767
Residual	24	75659.49611	3152.479004		
Total	25	75686.65592			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	209.8146645	14.80338316	14.17342659	3.70534E-13	179.2619895	240.3673394	179.2619895	240.3673394
X Variable 1	-0.022700648	0.244568735	-0.092819092	0.926817767	-0.527465604	0.482064309	-0.527465604	0.482064309

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	209.6529453	35.98208499
2	209.7113612	-68.37899611
3	209.1778066	118.5399595
4	209.8056957	35.46994284
5	209.3669137	-51.98752384
6	208.4575955	139.3033201
7	208.7242999	-40.85967442
8	207.4599712	-34.0627992
9	209.5238483	21.85584432
10	207.8194362	-31.89292248
11	208.9937323	-0.961809023
12	209.6423199	16.27995673
13	209.641484	2.405122565
14	206.369772	-10.67938401
15	209.4225344	-5.819058164
16	207.3447567	-38.21400877
17	209.4930221	-23.33881879
18	208.8134942	-61.76747334
19	209.6412957	-58.29928461
20	208.2683519	-28.35850641
21	209.3924241	-52.00711209
22	206.2176843	47.94713452
23	209.3868316	106.6086299
24	209.7976121	2.150691122
25	209.4883823	11.62491737
26	209.6905844	-31.54023269

BELLSOUTH REPLY COMMENTS

CC Docket No. 01-338

July 17, 2002

ATTACHMENT 5

CLECs' Choices for Local Switching

By Charles L. Jackson

July 2002

A study prepared for BellSouth

Table of Contents

1 Executive Summary 1

2 Switching Needs: CLECs versus ILECs 3
- 2.1 Background 3
- 2.2 Traditional Cost Structure 5
- 2.3 ILEC and CLEC Network Architectures 5
- 2.4 Modern Electronics Lowers Costs of CLECs' Next-Generation Switches 6
- 2.5 Service Providers 10
- 2.6 Observations and Conclusions 10

3 Hardware Solutions 10
- 3.1 Traditional Switches 10
  - 3.1.1 Lucent 11
  - 3.1.2 Nortel 12
  - 3.1.3 Others 13
- 3.2 Remote Switching and Backhaul 14
- 3.3 New-Technology Voice Switches 15
- 3.4 New Technology Vendors and Products 17

4 Service Provider Solutions 21

5 eBay 24

6 Switching in Context 26

7 Conclusions 27

Appendix A: Eastern Management Group Study 29

1 Executive Summary

Although the tasks to be performed by their switches are similar or identical, ILECs and CLECs have vastly different needs for switching capabilities. ILECs need switching equipment that is compatible with their legacy network—including cable routes and operations support systems. CLECs, lacking these legacy constraints, have more freedom when shopping for switches. CLECs, building new systems covering large areas benefit from technologies that permit easy entry with lower fixed costs than traditional systems.[1]

New microelectronic and switch technologies, along with the entry of new suppliers, have lowered the cost of switches—especially the new technology switches and the switches from new entrants—have reduced the minimum efficient size of switches, and have made it possible for switches to serve telephone lines hundreds of miles distant from the switch. All these changes expanded the alternatives available to CLECs.

In addition to the option of purchasing switching hardware, CLECs have the alternative of purchasing switching services—both CLECs and ILECs offer wholesale switching services.

Given the facts, CLECs are not competitively impaired without access to unbundled switching. Indeed, the sheer deployment of alternative switches precludes any reasonable claim of impairment. As detailed in the UNE Fact Report 2002, filed as an attachment to BellSouth's Comments in this proceeding, the number of CLEC voice switches has increased from 700 to 1,300 in the three years since the UNE Remand record was compiled, and the number of CLEC data switches has grown from 860 to 1,700.[2] (Data switches can be used both for data and, increasingly, for voice and thus substitute directly for circuit switches.) Moreover, non-ILEC alternative switches serve customers in wire centers accounting for 86 percent of all BOC switched access lines—and 97 percent of BOC switched access lines in the top 100 MSAs,[3] demonstrating effective geographic ubiquity. And these

---

[1] This paper does not consider the market for packet switching, other than to note that CLECs have deployed a large number of packet switches, which may be used to switch both data and voice traffic.

[2] *UNE Fact Report 2002*, Section I, Table 1.

[3] *Id.*, at p. II-6

switches are being used to serve at least an estimated 13 million business lines and 3 million residential lines.[4] Finally, as discussed later in this paper, CLECs can and do use their switches to serve customers located in different MSAs or even different states, so that they can greatly expand their customer base without deploying a large number of new switches.

I performed a simple study that confirms the general results of the Fact Report cited above. Universal Access provides a product called C.O. Finder, which permits inquiries to a central office switch database developed by NECA. The November 1998 version of the database listed 58 switch entities serving the District of Columbia, with 49 of those associated with area code 202 in the District. The switches are listed as being owned by Bell Atlantic, Nextel, AT&T Wireless, SWB Mobile, and several other firms. The February 2002 version of the database listed 500 switch entities serving the District with 115 of them associated with area code 202. There has been a significant change in the reported data on non-ILEC switches in the District over a period of a little more than two years.

Considering CLEC access to switching in the context of the FCC's five criteria for impairment—cost, ubiquity, quality, timeliness, and operational impediments—it is clear that the CLECs would not be impaired by being required to deploy their own switches or purchase switching in the marketplace.

About the Author

I began my career as a computer programmer and worked as both a system programmer and a digital designer. I received my PhD in electrical engineering from MIT. I have worked for both the FCC and the House Commerce Committee. Currently, I work as a consultant and a professor. I have written extensively on technology and public policy. I am also an adjunct professor of electrical engineering and computer science at George Washington University, where I have taught graduate courses on mobile communications, wireless networks, and the Internet. I am a member of the FCC's Technological Advisory Council. My full biography is available at www.jacksons.net.

---

[4] *Id*., at Section II, Table 2

2 Switching Needs: CLECs versus ILECs

ILECs and CLECs have different needs for switching capabilities because their networks differ. ILECs need switching equipment that is compatible with their legacy network—including cable routes and operations support systems. Many of the ILECs have extensive operations support systems that they use to manage switch configuration. An ILEC cannot easily install a new switch if that switch is not compatible with the existing operations support system. CLECs, lacking these legacy constraints, have more freedom when shopping for switches. Start-up CLECs benefit from switching systems with lower fixed costs because their scale of operations in the first few years will be far smaller than those of most ILECs.

As a general proposition, the cost of deploying alternative switches is declining dramatically. Bob Lucky, Corporate Vice President of Applied Research at Telcordia Technologies and chairman of the FCC's Technological Advisory Committee, wrote,

> A recent study at Telcordia of the economics of packet networks showed a cost advantage of 20-40% for the equipment costs in packet technology relative to circuit technology. However, it is important to realize that this advantage is fast increasing because of the exponentially-declining costs of packet routers. While circuit switching costs are also decreasing, they are doing so at a much slower pace. *One estimate is that routers are doubling their cost effectiveness every 20 months, as compared with a very slow 80 months for circuit switches.* The point is very simple, but profound—the world is working on packet technology and not circuit technology. In technology today it is necessary to "ride the wave" of popularity, because that is where the economics will be most advantageous. Because of the growth of the Internet, that wave today is with packets.[5]

2.1 Background

Telecommunications switching lies at the heart of most local exchange carrier (LEC) services, including plain old telephone service (POTS). The basic idea of a telecommunications switch is

---

[5] "NGN and the Packetizing of Telecommunications," by Robert W. Lucky, *Exchange*, Spring 1999, Telcordia Technologies. Emphasis added.

simple. Instead of running wires between every pair of houses in a town, the LEC runs wires to a central point and connects the wires together as needed. This economizes enormously on the cost of wire, but at the expense of having the central connecting point.

At first, a human operator performed the central connecting function. However, mechanization or automation of this task reduced costs. The mechanical systems that performed this function were called switches—perhaps analogous to railroad switching systems or to electrical light switches or perhaps because the earlier manual systems were called switchboards.

To implement equal access and to provide other advanced services, LECs in the United States upgraded their switches in the 1980s and 1990s to modern digital switches such as the Lucent 5ESS and Nortel DMS series switches. These switches were large, relatively expensive (up to several million dollars) systems that included a central computer controlling the system, specialized modules for connecting incoming and outgoing signals, and various auxiliary equipment. Because speech signals are represented internally as digital quantities in these switches, it is common usage in the industry to call these *digital switches*. Digital switches have the advantages of connecting efficiently to digital transmission facilities, such as long-distance fiber networks or digital loop carrier systems, and of using the latest digital electronic technologies to reduce costs. Of course, these digital switches can also connect to analog telephone lines. The connection is made using a *line card* that contains the electronics needed to convert the analog voice signal to a digital signal.[6]

Switches are often categorized as either local or toll switches (also called tandem switches). *Local switches* connect to the user's telephone and need many more capabilities, such as call forwarding and accounting features, that are not needed on toll switches. Local switches are also often called Class 5 switches.

Remote switches or remote switching modules also exist. A *remote switch* is a partial switch, with some of its control logic or administrative features located in a second switch—often called the *host switch*.

2.2 Traditional Cost Structure

Historically, local telephone switches have been expensive. The costs of traditional switches reflect several factors including (1) the fact that much of the manufacturer's costs are software development costs—so the marginal production costs are much lower than the average cost; (2) the fact that there were few competitors in the local switching market until recently; and (3) the fact that, once a carrier bought a switch from a manufacturer, that manufacturer had a monopoly on hardware and software upgrades to the switch. This last factor, the fact that the owners of current switches are locked-in to their suppliers for hardware and software needed for growth and upgrades, creates incentives for the manufacturers not to lower the price of their traditional equipment. Klemperer and Varian provide excellent discussions of these incentives.[7,8] Given these incentives, we should not expect to see the same decline in the cost of traditional switches as will be the case for new-technology switches.

2.3 ILEC and CLEC Network Architectures

Telephone outside plant—the wires, cables, conduits, and poles that carry the signals—and switches evolved together. But, as a telephone company's network became mature, the company could no longer easily trade off outside plant capabilities against switching capabilities. Rather, when the company needed a new switch to replace an existing switch, that new switch had to be compatible with the existing network of cable and wires—it would be inefficient and disruptive to replace or rework the outside wiring. Consequently, ILEC switches in urban areas tend to be in buildings that have held switches for many years, and the scale of the switches made for the ILECs reflects this pattern—an ILEC can use multiple switches, located in buildings where wires congregate, to serve

---

[6] All modern switching equipment can connect to analog telephone instruments—either directly through a line card or indirectly through equipment containing a line card.

[7] Paul Klemperer, "Competition when Consumers Have Switching Costs: An Overview with Application to Industrial Organization, Macroeconomics, and International Trade," *Review of Economic Studies*, Vol. 62, pp. 515-539 at 519. Note, in the context of this paper, the title of Professor Klemperer's paper may be confusing—in that title *switching costs* refers to the cost to consumers of changing suppliers, not to the costs of devices that connect and route telephone calls (telephone switches).

[8] Hal Varian, Raffaele Mattioli Lecture, Bocconi University, Milano, Italy, on November 15-16, 2001, revised text of December 16, 2001.

an urban area. The switch manufacturers designed their switches to meet the ILECs' need for switches fitting their networks.

In contrast, CLEC networks can take advantage of the economies made possible by modern transmission capabilities. Rather than installing many switches in an urban area, CLECs install a single switch in a city or state and then haul the calls back to the switch for processing. Before the development of low-cost optical transmission systems, it was rarely economically feasible to carry telephone calls back to remote locations for switching. The growth of optical digital transmission, however, has changed this limitation. Currently, the signal from a modern digital loop carrier can be transmitted to a switch many miles away at relatively low cost. Similarly, modern communications permits the switching function to be fragmented, with equipment at the central office performing some functions and equipment at distant locations performing other functions.

Today CLEC networks are built with only a few switching nodes—one switch serves a city or an entire region. Correspondingly, the number of switches in the ILEC networks has been falling in recent years—the number of ILEC switches reported by the FCC in its annual report *Statistics of the Common Carriers* declined from 24,000 in 1995 to 18,000 in 2000.[9] However, the size of the ILEC networks, the utility of existing plant, and the cost of rearrangement limit the rate at which ILECs can consolidate and combine switches. In fact, these restrictions minimize the opportunities for consolidation of ILEC switches. CLECs, on the other hand, are not constrained by these factors.

2.4 Modern Electronics Lowers Costs of CLECs' Next-Generation Switches

The continuing process of innovation in microelectronics has produced amazing products. Today's Intel Pentium 4 has more than 50 million transistors. A typical modern desktop computer has far more memory or processing power than a central office switching machine of a decade ago. Unfortunately, neither the hardware nor the software of a desktop system is anywhere as reliable as

---

[9] FCC, Statistics of Communications Common Carriers, 1995 Table 2.10 and Statistics of Communications Common Carriers, 2000, Table 2.6. The ILECs had 7,978 full switches and 15,708 remotes in 1995 but only 6,429 full switches and 11,267 remotes at year end 2000.

the central office switch—so one cannot just load the software for a telephone switch into a new computer from Dell and have a telephone switch that costs $800.[10]

At the same time that microelectronics have progressed, the computer industry has poured enormous resources into the development and perfection of various forms of data communications equipment to support networking both in the office and in the larger Internet. One consequence of this work on data communications has been the development of new technologies that compete with the traditional voice switching technologies and new firms that compete with the traditional suppliers of central office switches. For example, Cisco—a leading data networking firm—has sales roughly the same as those of Lucent or Nortel. Investor expectations for Cisco are more optimistic than for Lucent or Nortel—Cisco's market valuation is more than three times that of Lucent and Nortel combined.[11] Cisco's leading products are called switches and routers—these products are designed to switch data traffic rather than voice traffic.

Over the last few years, products and technologies from the data communications or the Internet world have begun to appear in the telephone switching market. One feature of the new designs is that the minimum efficient scale of a switching machine is much smaller than in the traditional telecommunications world. Industry uses a mix of terminology to describe these new devices—including terms such as softswitch, media gateway, and multiservice access switch. I refer to these as *new-technology switches*—but it is important to understand that no term perfectly describes this new category of switches. A key feature of many of the new-technology switches is that the program logic controlling call setup and call features (such as call forward on busy/don't answer) runs on a general purpose computing platform—not on a special processor built only by the switch vendor. A second feature, seen in many new-technology switches, is that the voice signal is transferred using data communications technologies, such as Internet Protocol, Ethernet, or frame relay, rather than the traditional signal formats used in the telephone industry. The softswitch

---

[10] There are other technical issues that make the use of a PC as a telephone switch problematic.

[11] Data taken from Yahoo Finance, February 19, 2002. Market capitalizations: Lucent $18 billion, Nortel $17.5 billion, and Cisco $122.4 billion, ratio [122.4/(18 + 17.5)] = 3.45.

industry has created its own industry association—the International Softswitch Consortium—with more than 100 member firms.[12]

A recent study by John Malone of the Eastern Management Group (EMG) titled *Trends in Switching Prices, 1996—2002* reviewed these technological changes and concluded,

> Since a voice oriented next generation Class 5 Switching System for CLECs is different than that required by ILECs, which must incorporate products into a legacy network, a CLEC's costs for switching are substantially less than that of an ILEC.

That Eastern Management Study is attached to this report as Appendix A. The following are some of its key points:

- **Technology Has Changed Since UNE Remand Order**

  At the time the UNE Remand Order took effect (November 1999), integrated multiservice access platforms did not exist. Costly digital access cross connect systems (DACS), digital loop carriers (DLC), and frame relay switches had to be individually purchased by carriers to transmit customer data traffic. Recently, manufacturers have begun to develop and sell integrated multi-service access platforms (IMAP), also referred to as aggregators or converged switches. Since the UNE Remand Order, several new firms have developed Class 5 switch products.

- **Costs for CLECs Have Declined**

  Since a voice oriented next generation Class 5 Switching System for CLECs is different than that required by ILECs, which must incorporate products into a legacy network, a CLEC's costs for switching are substantially less than that of an ILEC. Operating expenses for a Class 5 Switching System include personnel, power, air conditioning, and space. Next generation Class 5 Switching System operating expenses may be 75% less per year than those of legacy systems.

- **CLEC Network Architecture Has Evolved**

---

[12] For information, see their website at www.softswitch.org.

Figure 1 below, taken from the Eastern Management Group study, shows the network architecture of a modern CLEC—using IMAPs for remote access, the concentration of traffic in each city, and high capacity backhaul to a switching system.

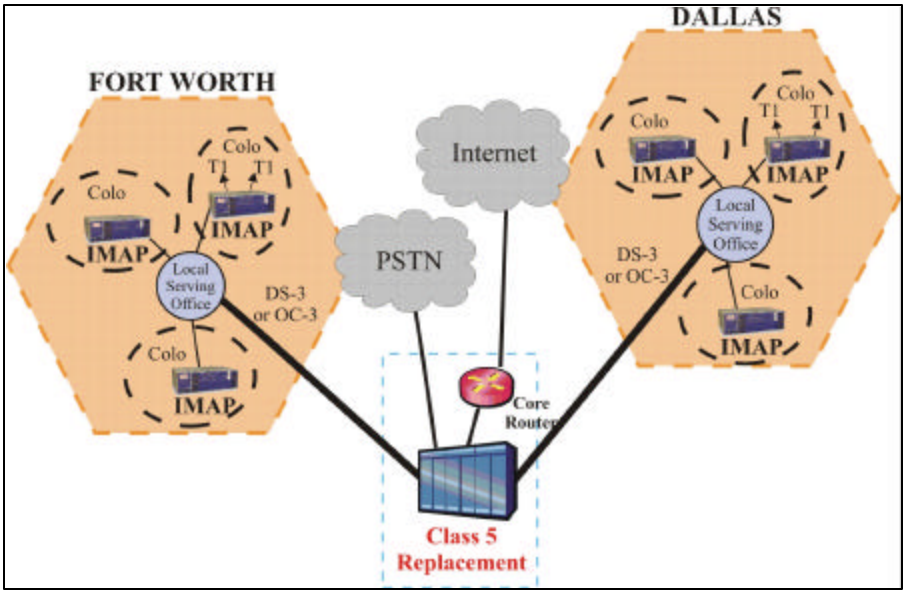


Figure 1. CLEC Network Architecture.

A filing by Taqua, Inc., a switch manufacturer, complements the EMG study.[13] Taqua, a relatively young firm, manufactures a modular central office switch—the OCX. At its smallest configuration, the Taqua OCX supports only 80 access lines. But, the same box can support up to 100,000 subscribers in a single rack.[14] Systems, such as the OCX, that are (1) designed for efficient operation even if connected to relatively few loops and (2) are manufactured using the most recent semiconductor and software technologies drastically reduce or eliminate the economies of scale in switching.

---

[13] See Comments of Taqua, Inc., in CC Docket No. 01-338, CC Docket No. 96-98, and CC Docket No. 98-147, April 5, 2002.

[14] Taqua filing at p. 5.

2.5 Service Providers

The changes in industry structure have created a new source of supply of telecommunications switching—vendors of switching services. A CLEC with a 5ESS switch can sell switching capacity to other CLECs—and, as I show below, some CLECs do so. Also, at least one ILEC continues to sell unbundled switching to CLECs in situations in which the FCC's UNE switching carve-out applies and market-priced switching rates are in the interconnection agreements pertinent to the ILEC and those CLECs.

2.6 Observations and Conclusions

CLECs and ILECs use switches to perform similar functions in their networks. ILECs, however, are constrained in their choice of switching technology by their legacy networks—whereas CLECs are not constrained in the same fashion. The cost of switches, especially switches based on packet switching technologies, continues to fall and the new technology switches are economically efficient at a smaller scale than the traditional switches. Furthermore, the current generation of traditional switches can serve telephone lines many hundreds of miles from the switch.

3 Hardware Solutions

In this section, I look at the supply of local switches in more detail. I consider first the suppliers of the traditional switches and then address the softswitch suppliers.

3.1 Traditional Switches

The industry that produces the traditional local switches used by most carriers in North America reflects the history of the telephone industry. The two major producers are Lucent and Nortel.

3.1.1 Lucent

Lucent's traditional local switch offering is formally known as the 5ESS but is often called the 5E. In recent years, Lucent has developed variations on the 5ESS design. One important variation is the remote unit that allows the capabilities of a 5ESS switch to be delivered using smaller modules located at distant locations from a host 5ESS system. Figure 2, taken from Lucent marketing literature, illustrates the concept.[15]

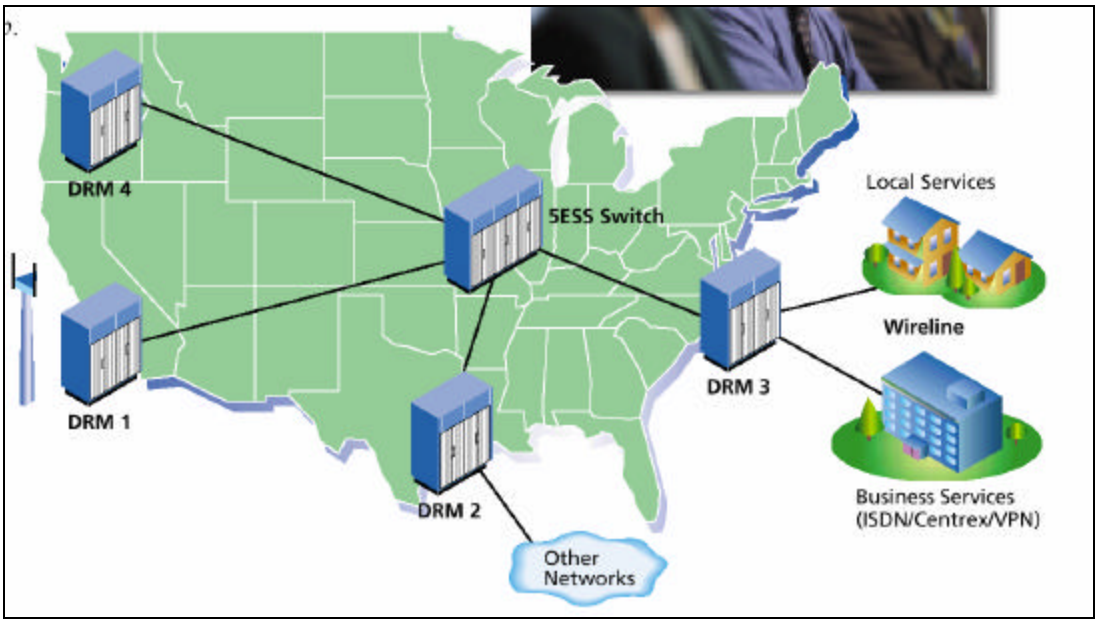


Figure 2. Lucent 5ESS Remote Capabilities

Lucent claims that the DRM remote unit illustrated here can be located up to 2,000 miles from the host 5ESS switch. CLECs use Lucent DRMs to provide service in cities hundreds of miles from their 5ESS. See, for example, the press release from Integra Telecom (a CLEC) at http://www.integratelecom.com/news/press/corp/091100_pr.shtml.

A second important variation on the traditional 5ESS design was the development of smaller versions of the 5ESS. One such smaller unit was the CDX (standing for compact digital exchange), now replaced by the VCDX (very compact digital exchange). Of course, the meaning of "very compact" depends on the context—a VCXD is 90 inches wide and about 7 feet tall. Lucent

---

15 Source, Distinctive Remote Module (DRM), Lucent, August 1999. 4 pages.

characterizes the VCDX as "the smallest configuration of the 5ESS family," but a VCDX can support up to 28,000 telephone lines.

Nevertheless, the Lucent VCXD, together with the backhaul option discussed below, provides a more reasonable scale of entry (lower fixed cost but lower capacity) for CLECs than did the older 5ESS designs. Lucent says of its VCDX,

> The VCDX provide the same dependable features of a full 5ESS® switch in a much smaller footprint, allowing your customers to offer the same broad array of services that a larger switch could offer. Ideal for residential, rural, and suburban markets, the VCDX is also fully scalable to a full 5ESS switch, letting your customers preserve their investment when their capacity demands increase.
>
> Minimum Footprint
>
> Compact size
>
> Housed in three cabinets that are 6 feet high, 29.9 inches wide, and 23.6 inches deep
>
> Ideal for locations with small-line-size applications
>
> 20,875 lines
>
> 25 Primary Rate Interfaces (PRIs)
>
> 4,080 Trunks.[16]

Lucent also manufactures several new-technology switching systems. I discuss those products below in the section on new-technology switches.

3.1.2 Nortel

Nortel's pioneering digital switch line, the DMS series, began shipping in 1980—two years ahead of Lucent's 5ESS. The early availability of the DMS product line, together with the changes in the U.S. telephone industry at divestiture, led to widespread use of the DMS switching products in the United States. The Nortel DMS product line encompasses a range of products—the DMS-10, DMS 100/200, DMS 250, and DMS-500. The DMS 100/200 is a traditional local switch; the DMS 10 is a

small local switch, somewhat comparable to the Lucent VCDX; the DMS 250 is a long-distance switch; and the DMS-500 is a combined local/long distance switch. Nortel promotes its DMS-10 to the CLEC market emphasizing the DMS-10's low initial cost and support for remote modules.[17]

The DMS family of switches supports remote units. The DMS remote units include a single cabinet version for start-up applications. Figure 3, taken from Nortel marketing materials, shows the size and capabilities of a standard DMS remote unit.[18] These DMS remotes can be separated from the host switch by as much as 650 miles.

Figure 3. DMS Remote

3.1.3 Others

Lucent and Nortel are not the only switch manufacturers—Alcatel, Ericsson, Siemens, and NEC also manufacture local switches. However, relatively few of their switches have been installed in the networks of the LECs in the United States. In terms of competitive impact in the United States, these firms are more important as sources of proven knowledge and expertise on telecommunications switching—resources that can be used to support the development of new technology switches—rather than as suppliers of traditional switches.

---

16 http://www.lucent.com.au/intl/au/en/products/solution/0,,CTID+2003-STID+10055-SOID+563-LOCL+1,00.html

17 "DMS-10 CLEC Switching Solutions," Nortel Product Brief, May 1999.

18 http://www.nortelnetworks.com/products/01/ndc/ntnb70.html.

3.2 Remote Switching and Backhaul

Carriers use two methods to provide switching efficiently at distant locations. The first is to locate a small switching unit at the distant location. These switching units are called *remotes* or *remote switches*. Remotes depend on some of the capabilities of a *host switch* to provide the full spectrum of call processing capabilities. Above, I provided a description of some of the remote capabilities of the Lucent and Nortel switches.

The second method is simply to haul the calls from the remote location back to the switch; process the calls at the switch; and, if necessary, haul the traffic back to the original location for termination. Until recently, such backhaul would have been uneconomical in most circumstances. However, the cost of transmission over modern fiber optic facilities has fallen so low that backhaul can now be economical in many situations. In many cases, carriers haul traffic hundreds of miles to switches. Backhaul is not just a theoretical possibility but rather is a market reality.

In traditional backhaul, the standard voice signal (a 64,000 bit-per-second stream of bits) is carried over traditional telephone transmission facilities, such as DS-1 or OC-1 circuits. Of course, the backhaul need not be done over traditional telecommunications networks. Data communications technologies, such as networks based upon the Internet's IP protocol, can also be used to do the backhaul. For example, Lucent sells a product, the *i*Merge CFG, that provides such a backhaul capability over IP networks.[19] Use of this box requires use of an access gateway to connect to analog phones.[20]

---

[19] The *i*Merge is manufactured by AG Communications Systems, a Lucent subsidiary.

[20] An access gateway converts the analog phone signal to an IP packet, and vice versa. Access gateways are made by many firms, including Lucent, Cisco, and Nortel.

Figure 4 shows the use of an *i*Merge box to extend the functions of a local switch to a remote access gateway.

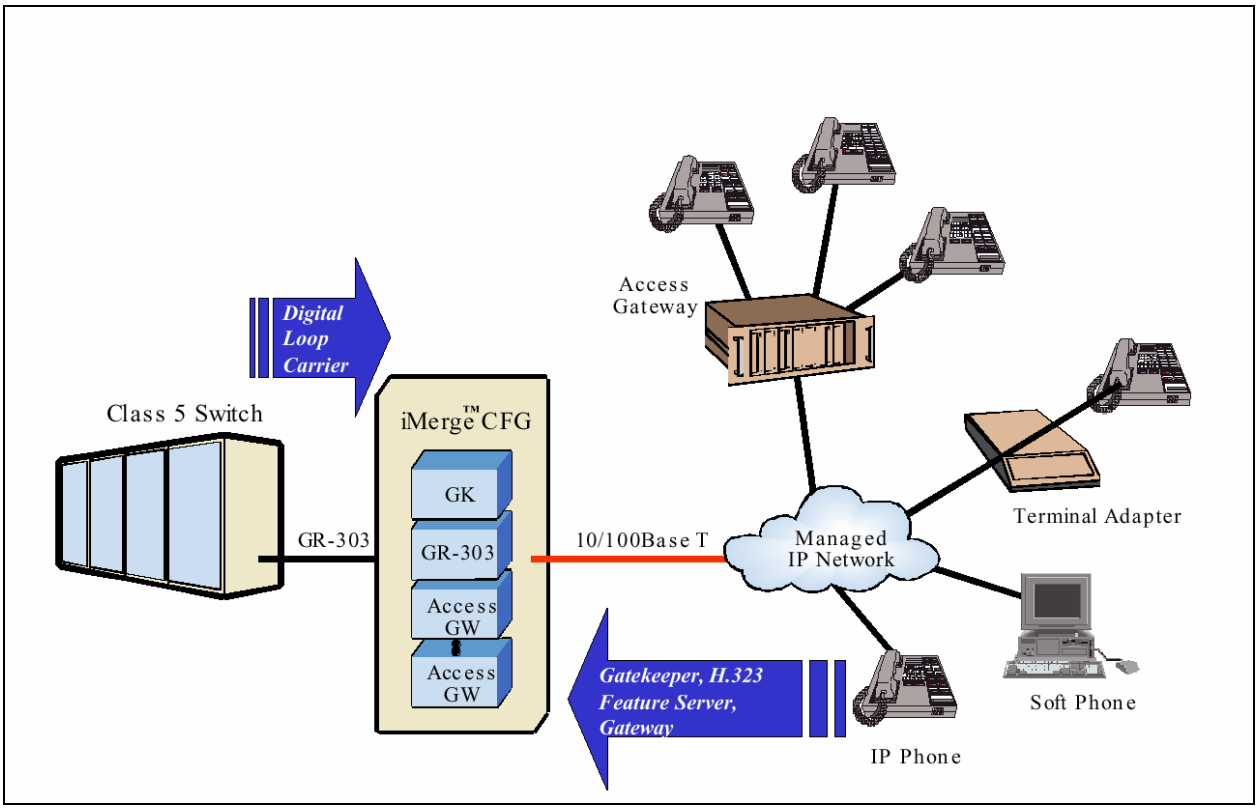


Figure 4. Lucent *i*Merge Remote Capability

Lucent is not the only firm that supplies a unit that permits traditional local switches to connect to remote loop terminations using an IP-based network—CopperCom, CableCom, General Bandwidth, Terayon, and others offer systems with similar capabilities.

3.3 New-Technology Voice Switches

Probably the most interesting switches for LECs are the switches built around data communications technologies. These systems can provide the same services as do traditional switches, but the new-technology switches do so in a quite different fashion. In traditional switches, a voice signal is represented as a stream of bits flowing at an even rate. The new-technology systems break a voice signal up into packets and send the packets over a packet-switching network—in same fashion that packets are used to carry web pages or radio broadcasts over the Internet.

The remote units described above illustrate one element of such network switching solutions. But, in those systems, the telephone calls are converted to packets at a gateway, carried back to a unit such as the Lucent *i*Merge over a packet network, converted by the IMerge box to a traditional telephone bit stream, and passed on to a traditional telephone switch for switching. But, of course, the middleman of the traditional switch is not necessary. The packetized voice signal could be sent over the data network directly to a second gateway connected to the telephone terminating the call or even to a telephone with built-in packet voice capabilities—an alternative sometimes called *pure IP telephony*.

Such a pure IP telephony arrangement might be useful inside an organization today, but most telephone calls must terminate on more traditional telephones—either analog wireline instruments or wireless phones. Thus, systems such as the *i*Merge and other forms of gateways between the analog telephones and the packet network will be needed for some time to come.

New-technology switches have been evolving over the last few years. One evolutionary path has been from telecommunications applications. Capability-limited, but low-cost switches, based on computers with cards that can connect the computer to T1 lines, were developed for applications such as international callback and office PBXs. Over time, the manufacturers have added additional capabilities, both hardware and software, to these systems. I believe that this path will ultimately turn out to be a dead end because of the likely success of the alternative approach described next.

A second evolutionary path grew from the Internet and data communications world. The original Arpanet/Internet researchers were always aware that telephone calls were one possible type of traffic that could go over the systems they were designing. The Department of Defense's Advanced Research Projects Agency (ARPA) sponsored research and experiments involving packet voice in the 1970s. Indeed, in 1978, Larry Roberts, now acknowledged as an Internet pioneer, wrote,

> In short, packet switching seems ideally suited to both voice and data transmissions. The transition to packet switching for the public data network has taken a decade, and still is not complete; many PTT's and carriers have not accepted its viability. Given the huge fixed investment in voice equipment in place today, the transition to voice switching may be

> considerably slower and more difficult. There is no way, however, to stop it from happening.[21]

Over the last few years, packet voice has moved from specialty market applications to moderately widespread use—widespread in the sense that there are millions of devices capable of generating packet voice installed, although not always carrying voice traffic. Packet voice, often called voice over internet protocol (VoIP), has become an object of intense research and product development. Last summer, the Office of Engineering and Technology (OET) sponsored a tutorial on this subject.[22] The speaker at that tutorial, Niel Ransom of Alcatel, described three trends for VoIP—first, bypassing the traditional telephone network; second, replacing the traditional telephone network; and third, enabling new applications.[23]

I believe that Roberts and Ransom are correct and that as VoIP and similar technologies evolve, they will supplant the traditional telephone network architecture.

3.4 New Technology Vendors and Products

The market for equipment capable of transmitting and switching voice over data networks is changing rapidly and is far from settled. Unlike the situation for traditional central office switches, there are dozens—perhaps hundreds—of suppliers fighting to define exactly what the products will be and to claim market share. A good discussion of the impact—or disruption as the author calls it—that the new technology switches will have on the switch manufacturing industry is given in Frank Ohrtman's master's thesis.[24] He identifies the "ability to scale down rather than up" to be "of great advantage in the converging market."[25] A recent study for investors reached much the same conclusion, saying,

> The deployments of Voice over Packet (VoP) technologies are quickly reaching an inflection point. The industry has moved from low-scale toll bypass deployments to large-scale competitive carrier deployments.

---

21 "The Evolution of Packet Switching," by Lawrence G. Roberts, *Proceedings of the IEEE*, November 1978.

22 Available at http://www.fcc.gov/oet/tutorial/tutorial.html.

23 Ransom tutorial, slide 14.

24 Supra, note 1.

25 Ibid, p. 42.

> Within the next year, we expect to see large-scale deployment by incumbents worldwide.[26]

A comprehensive survey of the new-technology switch market would be far too large for this paper. The International Softswitch Consortium lists 141 members on their website. Several of those, such as Time Warner Telecom and Verizon, are carriers but most appear to be equipment manufacturers.

Below, I briefly discuss a few new-technology switch suppliers that together illustrate the nature of the industry. These firms are:

- Cisco,
- Nortel and Lucent,
- Sonus, and
- Telcordia.

Cisco is the giant of computer networking, with 38,000 employees and sales of about $20 billion per year. Cisco sells several products that permit voice communications over data networks including telephone instruments, gateways that convert analog voice signals into data packets, systems for controlling telephone call setup over data networks, and its traditional data switching and routing products.

Nortel has developed a softswitch that it offers as an alternative to its traditional switches. Qwest has used the Nortel switch to carry live ILEC traffic.[27]

Lucent's strength in the telecommunications industry is, of course, its traditional switching product line the 5ESS. However, Lucent also has a variety of new-technology voice communications products. To build its expertise in this area, Lucent acquired Ascend and Excel, two firms in the

---

[26] See "The Metamorphosis of the Telephony Network," by Michael R. Brown and Stephanie Roscoe, RBC Capital Markets, December 10, 2001, at p. 1.

[27] See, "Nortel Networks Deploying Voice, Data Network for Qwest Using Internet Technology—Qwest First Local Carrier to Serve Customers Using Voice Over Packet Network Architecture," Nortel press release, October 11, 2001.

new-technology switch industry. The Ascend EXS switch is now the Lucent EXS switch. Lucent states,

> Lucent's new EXS® Converged Services Platform is an "any-gen" platform designed to seamlessly and cost-effectively bridge the gap between revenue-generating network services in today's Public Switched Telephone Network (PSTN) environment and packet-based network solutions of the future. From unified messaging and automatic speech recognition to web-initiated voice services and voice portal solutions, the EXS® Converged Services Platform is the ideal solution for your carrier-class needs.[28]

Previously, I described Lucent's *i*Merge product that extends the reach of a traditional switch over a data network.

Lucent is a significant competitor in the new-technology voice systems marketplace. Figure 5—taken from a recent Lucent presentation to investors—shows Lucent with the largest market share for universal port cards (cards that are installed in devices such as the EXS and that can support either telephone or data dial in—that is, they combine a voice digitizing function with a modem function).[29]

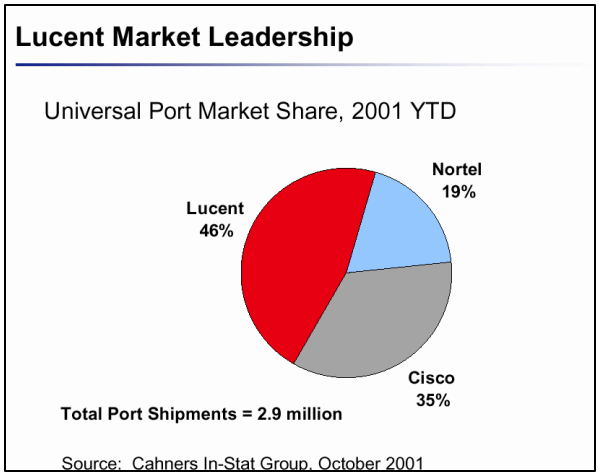


Figure 5. Universal Port Sales in 2001

---

[28] http://www.lucent.com/products/solution/0,,CTID+2002-STID+10153-SOID+1022-LOCL+1,00.html

[29] Presentation by Joe Sigrist, Lucent, "Voice-over-Packet Solutions," CSFB Annual Technology Conference, November 2001, slide 15.

With respect to market share, Sonus lies at the opposite pole from Lucent. Sonus was founded in late 1998 and had its initial public offering at the end of May 2000. Yahoo reports that a diverse range of carriers, including BellSouth, Time Warner Telecom, Level 3, Touch America (Montana Power), Qwest, China Netcom, and Fusion Communications Corporation (Japan), use Sonus switches in their networks.[30] Sonus's newest product is the Insignus Softswitch. Sonus emphasizes that their product can be economically used for small installations. They claim:

> **Seamless Scalability**
>
> The Insignus Softswitch can scale from the smallest single Point of Presence (POP) to the largest global configuration. The Insignus Softswitch and appropriate gateways can be deployed as a one-rack next-generation local switch. However, each module can also work with multiple gateways or other softswitch elements, allowing you to optimize network operation by sharing resources.[31]

Telcordia (formerly Bellcore) is not a hardware manufacturer but is a major provider of software for ILECs. Telcordia has developed a software package for new-technology switching (Telcordia calls its product *Call Agent*) and Telcordia sells that software package to both carriers and equipment suppliers.

Like the other vendors, Telcordia makes strong claims for its product:

> **The Call Agent's features make it the most advanced softswitch in the industry.**
>
> The Call Agent provides primary line VoIP without the need for a Class 5 circuit switch. The Call Agent is a "softswitch" that works with our associate-provided IP or ATM gateways to perform call control functions and deliver revenue-generating services running over IP and ATM networks. In addition, the Call Agent is based on an open architecture that eliminates dependence on switch suppliers for new products, services, and proprietary software upgrades. Telcordia has engineered the Call Agent to include:
>
> **CLASS(sm) Features** - revenue-driving services such as Call Waiting, Caller ID, and Call Forwarding

---

30 http://yahoo.marketguide.com, checked February 26, 2002.

31 "**Insignus ™ Softswitch** *An Open Services Architecture™ Component,"* Sonus Corporation brochure, 4 pages, 2002.

Regulatory Features - all the features necessary to become a licensed carrier, including 411, 911, Wiretap/Calea, and Telecommunications Relay Service (TRS)

Platform Features - features that support 24x7 operation of the Call Agent, including live system retrofits, live system growth, and overload detection (e.g., guaranteed 911 service); the Call Agent handles network congestion situations both with Automatic Congestion Control (ACC) procedures and alternate routing when trunk groups no longer have available trunks

Telcordia™ Accounting Gateway - a billing interface that converts IP billing records to the Automatic Message Accounting (AMA) format

Telcordia™ Announcement Server - a server that routes network announcements (e.g., "the phone line has been disconnected") to specified destinations

Highly Available Platform - the ability to run on commercially available computing platforms with an "n+1" redundancy scheme; it allows the Call Agent to handle thousands of simultaneous calls without ever going down

Scalability - the Call Agent brings next-generation call management to both small and large, single-site configurations as well as configurations that link Call Agent sites to networks of unlimited size

Network-Independent Architecture - its open architecture allows the Call Agent to function over virtually all access mediums and networks, including copper pair, fiber, Hybrid Fiber Coax (HFC), and IP and ATM networks.[32]

Telcordia's Call Agent runs on Sun computers, and Telcordia claims that Call Agent was the first product in its class to switch live traffic. Telcordia also states that Call Agent is being used by both cable companies and CLECs.[33]

4 Service Provider Solutions

Another important alternative supply of switching for LECs is to buy switching services from other carriers. As described previously, modern switches are flexible systems that can economically provide switching services to locations many hundreds of miles away. Thus, a carrier with a switch

---

32 http://www.telcordia.com/products_services/networksystems/softswitch/description.html

33 http://www.telcordia.com/products_services/networksystems/softswitch/references.html

in Miami could provide switching services for a start-up carrier in Orlando as well as to other providers in Miami.

In fact, carriers do buy and sell switching services as a normal part of doing business. Some CLECs advertise that they offer wholesale services. For example, Grande Communications in Texas offers wholesale CLEC services. The table below, taken from their website, shows how Grande Communications promotes its wholesale services.[34]

> WHOLESALE CLEC
>
> Grande Networks provides telephony services that enable CLECs to compete against local telephone providers.
>
> Our core service consists of the following components:
>
> - Local Dial Tone and Long Distance Service
> - 911 Database Update
> - Telephone Number Assignment
> - Local Number Portability
> - Local Telephone Features
> - Directory Listing Services
> - Calling Card
> - National Directory Assistance .

Grande Communications website also contains a map showing the location of their switching centers—reproduced below as Figure 6.

Figure 6. Grande Communications National Switching Network

Grande offers switching services to other carriers in Atlanta from the Grande switch in Atlanta—indeed, the Grande switch in Atlanta can provide service to carriers throughout the state of Georgia

and probably to some of the carriers in adjacent states. Grande says, "Grande's wholesale service division, Grande Networks, serves the integrated communications needs of other service providers and carriers by providing the underlying network products, services and professional support staff for carriers, ISPs, CLECs, VoIPs, ESPs and ASPs through Grande's ATM, voice and data switching platforms and SONET/fiber networks."[35]

KMCTelecom, also a CLEC, promotes its offering of port wholesale services that they call ClearPort.[36] KMCTelecom claims to actively market to CLECs.[37]

CLECs also actively search for wholesale switching suppliers. For example, the following message appeared on an Internet mailing list:

> I have a cable client with about 80,000 subs in various locations, with plant already largely configured for 2-way service that wants to explore using that plant as telephone loop plant. They are already doing this in at least one location so they know that it technically works.
>
> However, they don't want to buy their own switches for their various systems if they don't have to; instead, it seems to them (and to me) that a CLEC with a switch that has excess capacity should be interested in selling some of that capacity to my cable op client.
>
> States of particular interest: Georgia Alabama Florida Tennessee Louisiana Texas Oklahoma Wyoming
>
> Any CLECs out there who might want to make a few bucks on the side selling switching capacity, respond privately to me at <<address omitted>>[38]

Carrier hotels provide more evidence of such sales of switching capacity. Carrier hotels are locations where many carriers have located their switching and transmission facilities—thus permitting easy interconnection. Probably the most well-known carrier hotel in the industry is 60 Hudson Street in New York City—formerly the site of Western Union's headquarters. Switch and

---

34 Source: http://www.grandecom.com/ProductsServices/wholesale_clec.jsp.

35 "Grande Communications Receives Franchises to Offer Bundled Internet, Phone and Cable Services in Four New Central Texas Cities," press release, Grande Communications, Austin, TX, November 29, 2001. http://www.grandecom.com/About/pressroom_release.jsp?PR_ID=_PR215.

36 See http://www.kmctelecom.com/services/carrierhotel.cfm.

37 See http://www.kmctelecom.com/investor/MSDW_files/frame.htm, slide 14.

Data, a firm in that market, actively promotes the benefits of capacity sales among the carriers located in its space, saying,

> As Switch and Data's locations populate, a marketplace forms that yields an instant synergy. We encourage business-to-business within our sites, and by assuring our customers that we won't compete with them, this marketplace becomes an important reason to do business with Switch and Data.[39]

According to BellSouth, CLECs continue to purchase unbundled switching when serving customers that meet the current FCC UNE switching carve-out criteria—evidence of a wholesale market for ILEC switching at market (i.e., not TELRIC) prices.

5 eBay

And, as with most other products, eBay is also a possible source. More generally, the used equipment market can supply products needed by a firm interested in small-scale entry. Below are two pages that I took off of eBay. The first is for a traditional Nortel DMS switch—which had not received any bids at the time I downloaded the page. The second is for a Cisco gateway device that can be used to connect analog telephones to an IP network. Not only is the Cisco unit cheaper and capable of supporting far fewer lines, but bidding has passed any reserve price.

---

38 http://lists.robotics.net/archives/cleclist/1999-July/000445.html

39 http://www.switchanddata.com/products/marketplace.html

Figure 7. eBay auction of Nortel DMS 500.

Figure 8. Cisco Gateway on eBay

These eBay examples are offered slightly tongue-in-cheek. But, the eBay offerings demonstrate an important truth: as wireless usage expands and other local alternatives substitute for traditional telephone lines, the ILECs will see a decline in the number of access lines they sell. In fact, ILECs

have already begun to report such declines. The Common Carrier Bureau's Industry Analysis Division reported that the number of ILEC switched access lines went from 179.8 million in June 2000 to 174.5 million in June 2001—a decline of 5.3 million lines. This decline frees up equipment, such as line-cards and other switch subassemblies, which the ILEC can resell. Of course, such sales by the ILECs will put downward pressure on the price of switching equipment generally, including the switching equipment available to CLECs.

6 Switching in Context

The 1996 Act requires the FCC to consider whether requesting carriers would be impaired without access to a particular network element. The FCC's UNE Remand Order set forth five criteria that the FCC would consider in determining that lack of access to a network element would impair a CLEC— cost, ubiquity, quality, timeliness, and operational impediments.[40] Without conceding that these criteria are properly employed in the impairment analysis, it is clear that, even if they are, CLECs are not impaired without unbundled access to ILEC switching.

Cost—both new-technology switches and backhaul arrangements are cost effective.

Ubiquity—backhaul is a ubiquitous option in the contiguous 48 states. Furthermore, the smaller minimum efficient scale of new-technology switches and the separation of switch functions in new-technology switches between gateway functions and call control functions also make a ubiquitous presence easier to achieve.

Timeliness—historically, the lead time for procurement of traditional switches has been fairly long. However, the lead time for backhaul arrangements should be short and the smaller, new-technology switches can be deployed quickly. Thus, timeliness should not be an issue with the alternatives to ILEC switching.

---

[40] In the Matter of Implementation of the Local Competition Provisions of the Telecommunications Act of 1996, Third Report and Order and Fourth Further Notice of Proposed Rulemaking in CC Docket 96-98, FCC 99-238, at para. 23.

Quality—backhaul to traditional switches will provide the same service features as those switches have always provided. The fact that established ILECs, such as Qwest, use new-technology switches to carry live traffic shows that such switches provide quality equivalent to that of traditional ILEC switches.[41]

Operational Impediments—using a switch owned and controlled by the CLEC would provide better operational control and flexibility. Such a switch can be integrated into the CLEC's operations support systems. The CLEC can reconfigure and upgrade such a switch on its own timetable.

In summary, examining the backhaul and new-technology switch options for CLECs in the context of the FCC's five criteria for impairment demonstrates that these two technological options meet the criteria. Further, the other alternatives that I have discussed, that is, the purchase of switching at market prices from ILECs or other CLECs, appear to meet all five of the FCC's aforementioned criteria based on the fact that some CLECs have elected to utilize these options in the provision of service to their customers.

7 Conclusions

CLECs have multiple alternative sources of supply for switching. Those alternatives are affordable, are available, and have the necessary technical features. These alternatives are not theoretical. CLECs are using both the old-technology and the new-technology switches. CLECs buy switching capacity from ILECs and from other CLECs.

Two important factors that expanded the supply of switching alternatives to CLECs are (1) the availability of switches with small minimum efficient scale and (2) the economic and technical feasibility of backhaul. A key feature of the new-technology switches is that they have been packaged for smaller scale firms—they are economically efficient at far smaller line counts than are

---

[41] Indeed, unbundled access to an ILEC switch might well be access to a new-technology switch.

the old-technology switches. Backhaul and remote switching capabilities allow a switch to provide service in cities hundreds of miles away.

Given these facts, access to unbundled switching elements is not necessary to the operation of any CLEC with a reasonable business plan. Considering CLEC access to switching in the context of the FCC's five criteria for impairment—cost, ubiquity, quality, timeliness, and operational impediments—it is clear that the CLECs would not be impaired by being required to purchase switching in the marketplace.[42] The wireless and competitive long-distance industry did not have access to unbundled switching, but they grew relatively rapidly.

---

[42] There is one possible exception to this conclusion: fiber networks do not extend everywhere, and my analysis may not apply as strongly outside the 48 contiguous states. Conditions in Alaska and some of the more isolated islands within the FCC's jurisdiction may be sufficiently different that backhaul is uneconomic, and thus, the support for my conclusion would be weaker in those situations.

Appendix A: Eastern Management Group Study

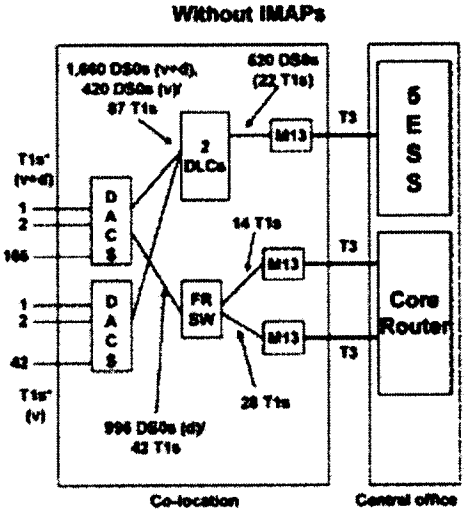
Trends in Switching Prices, 1996—2002

The Eastern Management Group

© The Eastern Management Group and The BellSouth Corporation 2002

Technology Has Changed Since UNE Remand Order
At the time the UNE Remand Order took effect (November 1999), integrated multi service access platforms did not exist. Costly digital access cross connect systems (DACS), digital loop carriers (DLC) and frame relay switches had to be individually purchased by carriers to transmit customer data traffic.

Figure 1: CLEC Network Architecture Before UNE Remand Order



Recently, manufacturers have begun to develop and sell integrated multi service access platforms (IMAP), also referred to as aggregators or converged switches. IMAPs concentrate the functions of DACS, DLS and frame relay switches into a single device. Some IMAP manufacturers are listed below.

Table 1: IMAP Manufacturers

Manufacturer	Founded
Advanced Fiber Communications	1992
Mainsail Communications	1998
Occam Networks	1999
Vina Technologies	1997
Zhone Technologies	1999

Since the UNE Remand Order, several Class 5 switch manufacturers have developed products. Some of these companies are identified in Table 2.

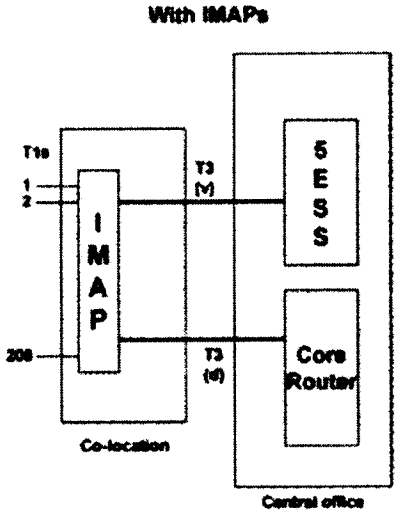
© The Eastern Management Group and The BellSouth Corporation 2002

Table 2: Class 5 Switching System Manufacturers

Manufacturer	Founded
Gluon Networks	1999
Santera Systems	1998
Taqua Systems	1998
Telica	1998

Traffic from IMAPs is transmitted using high-speed communications links to a Class 5 Switching System.

Figure 2: CLEC Network Architecture Today



Since a voice oriented next generation Class 5 Switching System for CLECs is different than that required by ILECs, which must incorporate products into a legacy network, a CLECs' costs for switching are substantially less than that of an ILEC.

© The Eastern Management Group and The BellSouth Corporation 2002

Table 3: Cost Comparison Next Generation Versus Legacy Class 5 Switching Systems [1]

	Next Generation Voice Oriented Switch	Legacy Switch
Initial Price	$100 Thousand	$1 Million
Price Per Port	$75	$250
Operating Expense	Low	High

Operating expenses for a Class 5 Switching System include personnel, power, air conditioning and space. Next generation Class 5 Switching System operating expenses may be 75% /year less than legacy.

Many residential customers as well as some small businesses have little requirement for data communications. As such, an inexpensive voice oriented Class 5 Switching System such as the example in Table 3 can meet the CLECs needs. However many CLECs have a mix of customers with many requiring extensive voice and data communications support. Before the UNE Remand Order, a CLEC would purchase frame relay switches, digital access cross connect systems (DACS), and digital loop carriers (DLC) to handle customers' voice and data traffic.

Recently, since the UNE Remand Order, manufacturers have begun to develop and sell integrated multi service access platforms (IMAP), also referred to as aggregators or converged switches. IMAPs concentrate the functions of DACS, DLC and frame switches into a single device. Voice and data traffic from an IMAP moves on to the Class 5 Switching System. IMAPs are small and require little space. They are scaleable, so a large up-front investment is not required by the CLEC.

Table 4: Typical IMAP [2]

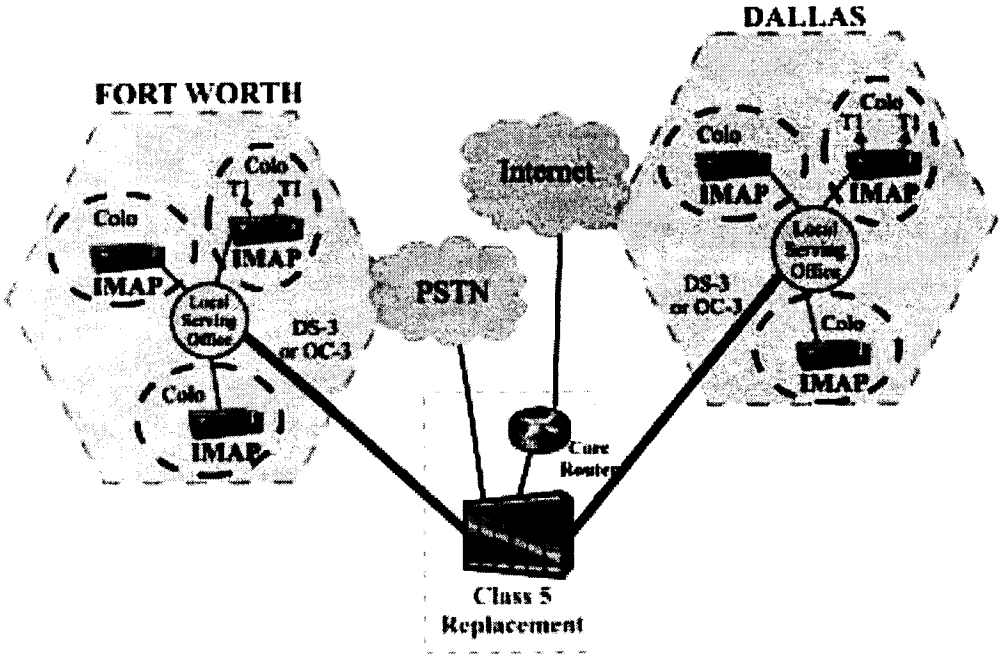
Capacity	96 T-1 or 2304 DSO equivalents
Cost	$30 Thousand

Voice as well as data traffic switched through IMAPs can be back hauled over broadband facilities to a Class 5 Switching System, reducing the number of Class 5 Switching Systems that a CLEC must purchase as the business builds-out its network. Figure 3 depicts a CLEC network employing just one Class 5 Switching System while serving 1200 customers with voice and data communication requirements in two Texas cities, Dallas and Fort Worth.

[1] Source: Taqua Systems
[2] Source: Vina Technologies

© The Eastern Management Group and The BellSouth Corporation 2002

Figure 3: Constructing a Multiple City Network Using Just 1 Class 5 Switching System



For the network depicted in Figure 3 we have priced out the CLEC investment for sufficient IMAPs and a Class 5 Switching System to serve 1200 customers, served by T-1 lines. Information relating to the network as well as the capital expenditure cost is shown in Table 5

Table 5: Capital Expenditure For A Two-City Network[3]

Customers Served	1200 via T-1 or 29,000 DSO equivalents
IMAPs	20 at $30 Thousand each
Class 5 Switching System	1 at $700 Thousand
Total Investment IMAP and Class 5 Switching System	$1.3 Million

[3] Source: Taqua Systems and Vina Technologies

© The Eastern Management Group and The BellSouth Corporation 2002