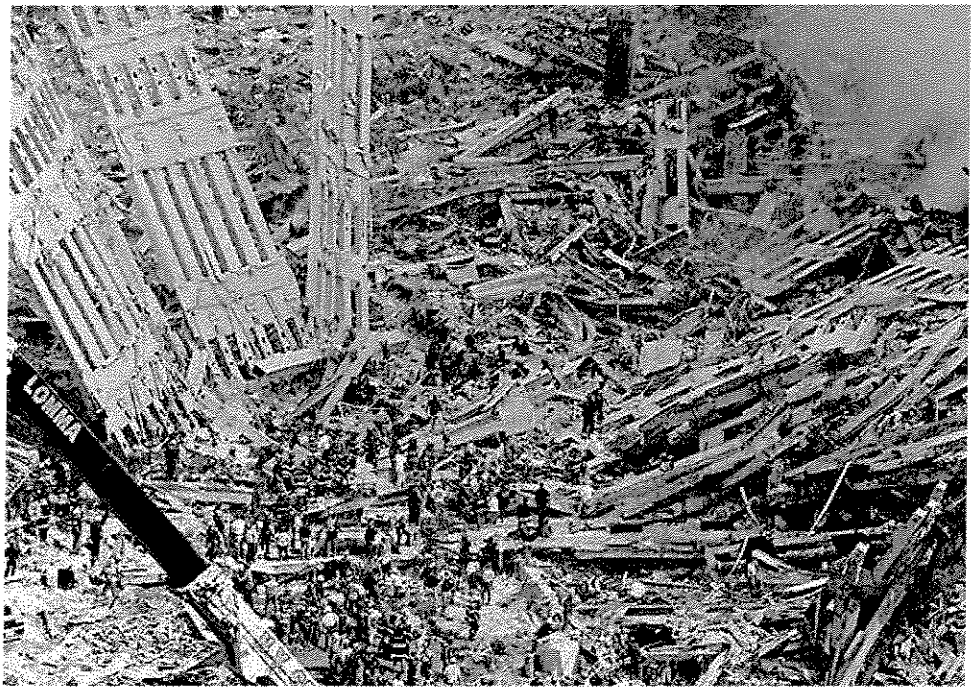
A Homeland Security Issue:
Tandem Diversity and the Public Switched Telephone Network



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Executive Summary

Much has been written recently about the inability of our nation's telecommunications infrastructure to absorb the blows dealt by man-made and natural disasters. Despite the growth of new, competitive telecommunications networks, such networks are often highly dependent on the incumbent local exchange carriers' ("LEC") infrastructure. The nexus of interdependence between these competitive carriers and the incumbent LEC networks are LEC tandem switches; the tandem switches is where the networks connect. Given that over half of the nation's voice traffic is now routed via competitive carriers, this dependency on legacy LEC tandems creates a critical choke point in our nation's telecommunications infrastructure, exposing the public to serious risks that have recently been identified as a homeland security issue. Hardening the country's telecommunications network by introducing independent tandem infrastructure is essential to homeland security: it reduces significantly the risk of network failure in times of national disasters and can contribute measurably to rapid disaster recovery. Given that such a solution is available to the public at no cost to taxpayers, this public policy should be adopted and implemented immediately.

Homeland Security and the Lessons Learned from 9/11 and Hurricane Katrina

On September 11th, 2001, a terrorist attack destroyed the World Trade Center Towers and a significant and critical part of the network infrastructure serving New York City. Verizon switching hubs and transmission facilities throughout the financial district were destroyed.

A special report written in the aftermath of the tragedy concluded[1]:

> "...In an effort to build systems that are easy to use, readily accessible, and have broad activity, telecommunications companies (under the jurisdiction of federal regulatory agencies) have built systems that are vulnerable to deliberate attack. To decrease that vulnerability, significant changes must be made to both systems hardware and software...Network plant vulnerabilities primarily arise out of physical proximity. Switching and routing equipment that provide the telecommunications backbone for a geographic area often are located in just a few buildings, making an easy target for attack. That fact was underscored on September 11th when the World Trade Center collapse knocked out a telecommunications facility in Lower Manhattan that supplied 80 percent of the New York Stock Exchange's communications capacity...As for Bell's (ILEC) rivals, one study shows that less than 10 percent of competing carriers have facilities fully separate from Bell networks..."

Despite heroic efforts by hundreds (if not thousands) of telecommunications employees to restore service in the area - the current Public Switches Telephone Network (PSTN) failed the people of New York for days, weeks, and months. Hurricane Katrina was a much different disaster, affecting a much broader area with sustained damage over a much longer period of time. Despite these differences, the resulting failures of the PSTN were identical.

The FCC found:

> "...more than 3 million customer phone lines were knocked out in Louisiana, Mississippi, and Alabama area following Hurricane Katrina. The wireline telephone network sustained significant damage both to the switching centers that route calls and to the lines used to connect buildings and customers on the network. **Katrina highlighted the dependence on tandems and tandem access to SS7 switches. The high volume routes from tandem switches,** especially in and around New Orleans **were especially critical and vulnerable.** Katrina highlighted the need for diversity of call routing and avoiding strict reliance upon a single routing solution...**The switches that failed, especially tandems, had widespread effects on a broad variety of communications in and out of the Katrina region. As an example, a major tandem switch in New Orleans was isolated, which meant that no communications from parts of New Orleans to outside the region could occur."** [2]

FCC Commissioner Michael J. Copps stated,

> "Measured in these terms, this report is a shocking indictment of the disaster readiness of our existing communications networks...In light of these sobering conclusions, I think **the central question raised by the report is how - and not whether- the communications industry should begin to incorporate more rigorous standards into how it constructs and maintains networks."** [3]

With respect to the PSTN, the lessons learned from 9/11 and Hurricane Katrina are similar. Reliability, resiliency and survivability are dependent on the availability of diverse transmission facilities and switching, especially tandems.

The current PSTN architecture and LEC tandem network no longer serves the public's best interest.

The LEC tandem networks were designed to provide a level of survivability at a time when the preponderance of voice traffic originated and terminated on their own network. With the increasing migration of traffic to competitive carriers, a serious and threatening single point of failure has evolved in the interconnection of these networks. This single point of failure is the LEC tandem switch.

Built and managed almost exclusively by the old AT&T monopoly (and its LEC heirs), tandem switches perform the role of handing off traffic between multiple subtended end office switches. If one or more LEC tandem switch becomes incapacitated, those subtended interconnected end office switches, even with some overflow capacity, experience an increased risk of being isolated and the entire Public Switched Telephone Network (PSTN) impacted.

In the case of Hurricane Katrina, the failure of BellSouth tandem switches crippled communications across entire regions of the southeast precisely when those areas needed communications the most. On 9/11, the Verizon West Street central office, a major switching hub where scores of competitive carriers collocated and interconnected, was severely

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[1] Special report after 9/11, dated October 2001; John Wohsletter, Discovery Institute.

[2] Recommendations of the Independent panel Reviewing the Impact of Hurricane Katrina on Communications Networks, Effect of Hurricane Katrina on Various Types of Communications Networks FCC Docket No. 116-19, Released June 19, 2006 at __(emphasis added)("Hurricane Katrina Report").

[3] Statement of Michael J. Copps, Re: Report and Recommendations to the Federal Communications Commission, from the independent Panel Reviewing the Impact of Hurricane Katrina on the Communications Networks at __ (emphasis added).

damaged; thus triggering a catastrophic ripple throughout the industry as many competitive carriers lacked alternative facilities to serve customers in the Wall Street market, again isolating subtended switches and leaving end users without service.

The impact of the recent disasters included:

- Inability for long distance calls to enter or leave areas served by the tandem.
- Hampered communications for first responders.
- Isolation of the public from emergency information and assistance.
- Inability of local carriers, including wireless and wireline, to exchange traffic and complete calls.

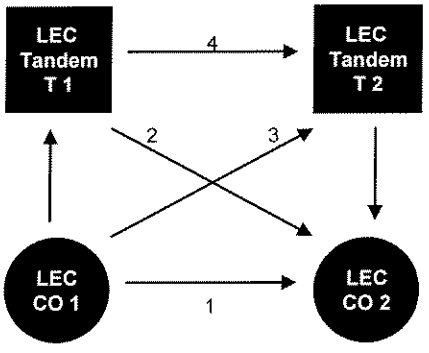
The explosive growth of new carriers that rely predominately on LEC tandem switches to exchange traffic with other carriers has exacerbated the need for LEC tandem diversity. Wireless carriers, cable telephony, VoIP providers, and Competitive Local Exchange Carriers all rely principally on LEC tandem switches to exchange traffic with one another.

Original Route Diversity Has Eroded with Competition

The PSTN was originally planned and engineered as a single network under the concepts of the regulated AT&T monopoly. Serving central offices were woven together as a network by being direct connected with other central offices as well as being interconnected with primary and often secondary tandems, which enabled indirect interconnection with other switches and alternative routes for overflowing traffic when direct connections were unavailable due to capacity or service interruptions. For example, a call needing to be connected between one central office (CO 1) to another central office (CO 2) could have four routes for termination:

1. Direct connections between CO 1 and CO 2
2. Indirect connection between CO 1 through its primary tandem (T 1) and then to CO 2
3. Indirect connection between CO 1 through its secondary tandem (T 2) and then to CO 2
4. Indirect connection between CO 1 through T 1 to T 2 and then to CO 2

Figure 1



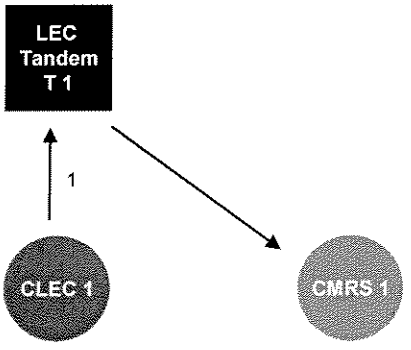
This diversity of alternative routing was made possible by the integrated engineering and interconnection of the Bell System.[4]

[4] Obviously, not all end offices have this topology. Routing topology is a function of traffic patterns and demand. There are various configurations on routings within LATAs. The one shown in the above diagram is, however, the final building block and can be extensively found within the PSTN for ILEC networks.

As the competitive landscape evolved, the LEC tandems became a natural interconnection point for the new long distance, wireless, cable telephony, and competitive local exchange carriers to exchange calls with each other (i.e., "transit" calls). But this proliferation of diversely managed competitive switches subtended to the LEC tandems made centralized network planning and system redundancy more difficult.

Today, for example, competitive local carriers principally exchange traffic by routing traffic indirectly to each other through the LEC tandems. On a relative basis, there is very little direct connection of competitive switches. Yet, it is estimated that over half of the nation's voice traffic is originated by these competitive carriers.[5] Also, the LECs traditionally prohibit inter-tandem routing of traffic or assess significant charges.[6] Thus, there is principally one call path for completion of traffic between, for example, one CLEC central office (CLEC 1) and a wireless' carrier's switch (CMRS 2) and that is through the LEC tandem. Thus, a call is sent by CLEC 1 to the LEC tandem (T 1) that the CMRS 2 switch homed (or subtended) to, as shown in Figure 2 below.

Figure 2



Being "single-threaded" to LEC tandems creates a single point-of-failure architecture exposing the public to significant risks. As noted above, these risks were recently identified as a Homeland security issue by the FCC Hurricane Katrina Report. This finding confirms the finding of the New York Department of Public Service investigation after the terror attack in September 2001:

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[5] According to the FCC report "Local Telephone Competition: Status as of December 31, 2005", CLECs had 31.6M access lines and ILECs had 143.8M access lines. Based on an assumption of 900 MOUs per access line per month, this equates to 28.44B MOUs per month for CLECs and 129.42B MOUs for ILECS. The CTIA 2005 semi-annual survey for 2006 reported 1.5T MOUs which equates to 125B MOUs per month. Thus, for 2005, competitive carriers represented 54% of total MOUs (153.44M/282.86M); this figure is projected to reach 57% in 2007.

[6] See, e.g., Verizon Wireless Interconnection Services, http://www22.verizon.com/wholesale/solution/?_solId=300061&catId=100012 ("Verizon will not inter-tandem switch cellular/PCS traffic.").

> "After the September 11 attack, we found that the wireless industry may have consistently undersized trunks interconnecting their services to wireline facilities. While this practice may make sense from a purely economic standpoint, the danger is that it can result in network "choke points" that may easily become swamped in emergency or catastrophic situations."[7]make sense from a purely economic standpoint, the danger is that it can result in network "choke points" that may easily become swamped in emergency or catastrophic situations."[8]

Despite safeguards such as emergency generators and battery back-up power, redundant processors, and diverse facilities to minimize the impact of catastrophic events, tandem switches and major switching hubs have a history of becoming isolated or incapacitated. The fires at New York Telephone Second Avenue Central Office and the Illinois Bell Hinsdale, Illinois office together with the destruction caused by Hurricane Katrina and 9/11 are such examples.

While direct connections between competitive carriers (for example, CLEC 1 to CMRS 2) to bypass the LEC tandem would add diversity, this arrangement is not practical for connecting all competitive carrier switches with one another:

- In order to complete a direct connect network, a carrier with multiple switches needs connections from each of their switches to every other competitive switch. This could require hundreds of circuits. (For example, if there are 100 switches in a market, it would take 9,900 connections to direct connect all the switches.)
- Carriers seeking direct connections often have to negotiate with their competitors the initial connectivity as well as continue to communicate and work together cooperatively to ensure adequate capacity exists.
- Due to economics, many direct connections are not efficient (cost savings below the fixed cost to interconnect) and these circuits are normally only engineered to handle existing traffic, not increases tied to industry growth, let alone increased volumes expected in emergency situations.

Thus, in reality, tandems act as concentrators for sparsely trafficked routes and provide an economical alternative to uneconomical direct connections.

A more effective and more rapid means to add much-needed switch and route redundancy and diversity, particularly for competitive switches, would be to have a diverse, independent second tandem network to the PSTN. This would provide immediate resiliency and alternate routing for competitive carriers. This second alternate tandem network would ideally provide:

- Separate physical switch locations from existing tandems.
- Complete diversity from a facility perspective.
- Diverse transport
- Standard safeguards such as generator and battery back up, etc.

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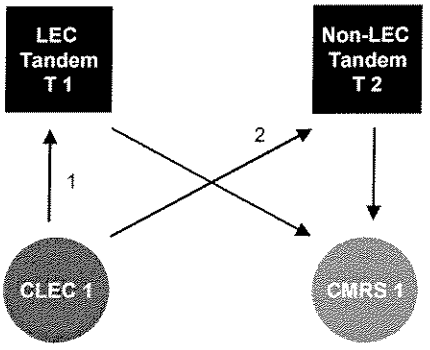
[7] Reply Comments of New York Department of Public Service, FCC Docket No. 06-159, September 25, 2006 at 3.

[8] Reply Comments of New York Department of Public Service, FCC Docket No. 06-159, September 25, 2006 at 3.

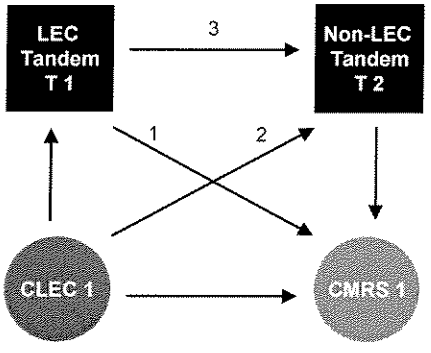
Adding a second tandem (Non-LEC T), particularly one completely diverse to the LEC tandem (LEC T), immediately doubles the termination paths between interconnected competitive switches (CLEC 1 and CMRS 2)(see Figure 3). The second non-LEC tandem also provides a more practical solution for a competitive carrier to interconnect with all other competitive carrier switches through just one connection instead of multiple direct connects.

Figure 3



The redundancy benefits of the competitive tandem can be further leveraged by interconnecting the competitive tandem with the LEC tandem, thus enabling the LEC tandem to overflow and re-route traffic through the competitive tandem for indirect termination to the terminating central office when the LEC tandem's connections to the terminating central office are unavailable. (See Figure 4) Interconnecting LEC tandems with independent tandems while allowing competitive carriers to designate the independent tandem as their "homing" tandem enables one tandem to leverage the other tandem's connectivity for overflow and back up routing.

Figure 4



This interconnection between LEC and Non-LEC tandems enables, as shown above, four diversely owned and operated switches to route traffic between themselves efficiently and helps restore the robust route diversity originally engineered into the PSTN when it was principally managed as the closed Bell System. (see Figure 1).

Neutral Tandem: An Independent Solution for Tandem Diversity

Neutral Tandem is the first alternate tandem service provider facilitating the interchange of traffic between wireless carriers, cable telephony service providers, CLEC, and VoIP providers. Its first-of-its-kind network already currently connects over 600 switches owned by over 50 carriers and allows diverse tandem terminations to over 130 million telephone numbers in over 50 markets in the US.

Neutral Tandem provides the following diversity and network survivability features to the PSTN:

- Diverse tandem switching facilities located in separate buildings from existing ILEC tandems.
- Multiple competitive access provider facilities for physically diverse transmission.
- An alternate route for carriers to exchange local and long distance calls.
- A comprehensive disaster recovery alternative.
- A neutral (non-competitive) solution for carriers.
- Reduced risk of network failure in times of Homeland disasters (natural or man-made).
- Tandem and diverse routing engineering services for the other carriers.

The tandem overlay network designed and built by Neutral Tandem allows competitive carriers to exchange local and long distance traffic over diverse transmission and switching facilities. By reducing everyday reliance on the ILEC tandems, competitive carriers advance their disaster recovery plans. Moreover, Neutral Tandem can provide a valuable service by representing its interconnected carriers in disaster recovery planning. Many carriers do not have the network management skills required to do extensive disaster recovery planning which come with managing a highly interconnected tandem network.

The addition of a *neutral* tandem to a geographic area provides significant second routing choice and significant advancement of network survivability and resiliency. Interconnection of Neutral Tandem with the LEC tandem further enhances that capability. As the Neutral Tandem network continues to grow connections among switches in a market, the PSTN strengthens its ability to complete calls in the event of network outage.

Carriers connecting only to LEC tandems risk isolating their switches if the route between their switch and the tandem or the tandem switch itself is severed or incapacitated.[9] Experience has shown that isolated switches have a cascading effect on all other carriers acting rationally and taking advantage of redundant interconnections.

[9] See, e.g., Petition of Neutral Tandem, Inc. for Interconnection with Verizon Wireless, Inc. Pursuant to Sections 201(a) and 332(c)(1)(B) of the Communications Act of 1934, as Amended Docket No. 06-159.

Conclusion

The lessons of 9/11 and Hurricane Katrina highlight that the nation's telecommunications infrastructure is extremely vulnerable to failure exactly when it is needed the most. Resiliency, redundancy, and survivability of the Public Switched Telephone Network are critical to public safety and Homeland security.

Reports from both of these disasters, although very different in nature, each identify the reliance on LEC switches and tandems as a severe weakness in the nation's telephony network. Reducing this risk is simply a function of redundancy and diversity of the network.

An independent, non-LEC tandem solution such as Neutral Tandem provides a second, separate network for routing traffic--particularly between competitive carriers highly dependent on LEC tandems for inter-carrier routing--using diverse switching and transmission completely independent of the LEC tandem network. Interconnecting the LEC tandems with Neutral Tandem furthers the restoration of the original diversity engineered into the Bell System network. From a survivability perspective, this *neutral tandem* network can only be seen as a positive step for the United States in this era of terrorism and increasing risks tied to natural disasters.