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Strategies for Unbundling Remote Access Terminals

By David Ehreth

Background

In the last decade, large numbers of Next Generation Digital Loop Carriers (NGDLC) were deployed throughout the country. NGDLCs are part of a larger plan to deliver voice services with a high degree of efficiency and economy. The purpose of an NGDLC is to act as an "extension cord" for a Class 5 central office voice switch. By multiplexing up to 2,000 voice paths on a fiber optic connection, a large amount of money was saved on copper and other outside plant facilities. Thus, the savings in facility costs that were realized justified the cost of NGDLC.

NGDLCs have two terminals, one located in the central office and one located in a remote location near a community of users. Some NGDLCs can be configured in rings or in chains that have facility cost or reliability benefits. The remote terminal of an NGDLC has a number of circuit cards that are connected to end user devices such as telephones and PBXs. The remote terminal is "hardened", meaning that it will work in harsh environments of heat, cold and humidity. The remote terminal is located on street corners, sidewalks, telephone poles or in remote "huts" near end users.

An important protocol was developed in the late 1980s and early 1990s that facilitated the use of NGDLCs. This protocol, today known as GR-303, was used to connect the NGDLC to the Class 5 switch. To gain even greater economies, a technique known as "concentration" was used in GR-303. Concentration is a technique that enables some number of telephone users to employ a smaller number of trunk paths to the switch. The principle is that not everybody uses his or her telephone at the same time. By taking advantage of this fact, a reduction in actual size of the Class 5 switch could be realized by concentration at the remote terminal of the NGDLC. As an example, 2,000 telephones could be served by as few as 400 trunk paths to the switch without any noticeable degradation of the quality of service.

Concentration brought with it a basic change in Digital Loop Carriers (DLC) that separated the traditional DLC from the NGDLC. Because NGDLCs could perform concentration, they have a primitive level of switching as part of their inherent make up. The Class 5 switch that is connected to an NGDLC controls the switching (concentration) function at the NGDLC through a control link defined in GR-303.

Because an NGDLC could map (or switch) a subscriber to a trunk path, another capability became inherent to the design of a GR-303-based NGDLC. This was the capability to host multiple GR 303 "virtual" groups inside of a single physical platform. This capability is particularly useful for load balancing traffic in order to achieve the optimum concentration ratio. Each virtual GR 303 group requires a data link for control, the Time Slot Management Channel (TMC) and a provisioning link known as an Embedded Operations Channel (EOC). System provisioning commands pass through the EOC that allow the NGDLC to be configured by Operations Support Systems (OSS) that interface to the switch. By administering a system through the switch, the OSS didn't need to have a great deal of knowledge about the NGDLC. This reduced the overall complexity of OSS procedures and leveraged the switch as an agent in the provisioning process.

The Impact of Increased Data Traffic on Access

During the decade of the 1990's when NGDLCs were being installed, consumers were learning how to use the Internet and new demand for data services emerged. Network operators who owned NGDLCs saw an opportunity to use these platforms as delivery vehicles for advanced services such as data communications. As a result, most of the NGDLC vendors equipped their products with the ability to handle one or more data protocols. Further, the NGDLCs were designed or enhanced to offer digital subscriber line services or fiber optic services.

In 1996, the Telecommunications Reform Act (TR-96) opened the local service market to competition. Competitive Local Exchange Carriers (CLEC) were allowed to sell services over "unbundled" facilities. In the case of copper wire facilities, the process is fairly straightforward. A CLEC sells a service to a customer, notifies the Incumbent Local Exchange Carrier (ILEC) that he has made the sale, and the ILEC is required to locate the copper wire that serves that customer and deliver it to the CLEC at the central office. This simple process becomes somewhat more complicated when the customer is served from an NGDLC over what is called an "electronically-derived loop." The actual practice of unbundling electronically-derived loops was left by the TR-96 Telecom Act to be clarified later after the matter had been studied and a "technically feasible" solution found. It was left to each of the states to develop a satisfactory policy on electronic loop unbundling. In spite of this, work is ongoing at the Federal Communications Commission to find technically feasible solutions to electronic loop unbundling.

As part of the opening of competition in the communications markets, Congress and the FCC have ruled that ILECs who have in the past been beneficiaries of local telephone monopolies may not, themselves, provide data communications services. However, ILECs have been allowed to operate unregulated subsidiary businesses that may provide data services. Meanwhile, a large number of CLECs and Data Local Exchange Carriers (DLEC) have begun to offer data services.

Because there has been no general clarification on the issue of unbundling electronically-derived loops and because the ILEC operators have been restricted from providing data services, remote terminals of NGDLCs have not been extensively used for delivery of data services. This is unfortunate for two reasons. First, NGDLCs are the ideal location to launch data services because they are located a short distance from end users. Second, there are alternatives to unbundling remote terminal facilities that, while fair to CLECs, allow ILEC owners to retain a significant ability to provide all network service providers, subsidiaries and CLECs alike, with high value services.

GR-303: Limitations on Scalability, Limitations of Shared Databases

At a glance, it might seem as if GR-303 provided a good solution for unbundling services from an NGDLC remote terminal (RT). Virtual GR-303 groups could be created for each CLEC that wanted to have virtual access to the RT. These groups are defined in the GR-303 standard as "Interface Groups." Each interface group is logically portioned so that it behaves as a separate resource. These groups could be delivered to the CLEC point of presence (POP) in the ILEC central office near the central office terminal (COT) of the NGDLC. Each CLEC could then transport its GR-303 group along with TMC and EOC to its remote switch center where it would connect to its own Class 5 switch. At a glance, this would seem to give the CLEC the ability to control both feature offerings and switch resources. However, on closer examination, GR-303 presents some significant challenges when used as a multi-tenant solution for unbundling.

A summary of the issues with using GR-303 as an unbundling tool reveals two major problems. First is the issue that GR-303 is not scalable for unbundling. Second, there are significant operational issues concerning shared databases that could lead to catastrophic system failures. The following will examine these two issues.

Load Balancing Using Interface Groups

It should be noted that the original intent of the interface groups was to perform a function known as "load balancing." Since GR-303 is a concentrating interface, high-traffic customers can potentially upset the concentration ratio between line resources and trunk resources. A high-traffic user can congest a system that has allocated one trunk resource to every four line appearances. To solve this potential problem and to get the best economics out of concentration, GR-303 offered the possibility of multiple interface groups being created on a single RT. This would enable a network operator to virtually gather his high-traffic users together on a single interface group with a low concentration ratio, let's say 2:1, while leaving the low-traffic users (usually the majority) on high concentration ratio interface groups, say 4:1. GR-303 allows for eight interface groups, maximum. The most commonly deployed digital loop carrier systems, the Alcatel Litespan 2000 and the Advanced Fibre Communications UMC 1000 allow for 4 and 6 interface groups per RT, respectively.

Each interface group uses a redundant TMC. Each TMC occupies one 64Kb/s channel in a T1 trunk. The GR-303 TMC uses the ISDN call processing protocol Q.931. The use of Q.931 is ideal for the original intent of GR-303: to perform concentration on the remote terminal. However, as a means of unbundling a remote terminal, the use of individual protocol stacks for each interface group presents an additional problem. Specifically, this architecture is not scalable beyond certain practical limits. There are several reasons for this.

First, the amount of computing resource to manage the Q.931 resource is not infinitely expandable within a given RT. The second reason is that both of the two TMCs on each interface group require a physical link to terminate the High-Level Data Link Protocol (HDLC) used as the link-layer transport methodology. Each HDLC termination requires an allocation of physical space which reaches certain practical limits within the constraints of the RT and the COT. For example, if a COT were to service a chain of four remote terminals and each of these terminals was equipped with four interface groups, the

COT would be required to manage 16 active and 16 stand-by data links to support 16 different service providers.

Note, however, that if a provider had subscribers on all of the RTs (such as an incumbent carrier), it would consume four of the 16 interface groups on the COT, leaving only 12 for other providers.

If a second provider (say, CLEC-A) also had subscribers on all of the RTs, it would consume four more interface groups on the COT as well. That would leave only eight interface groups. If CLEC-B and DLEC-1 have subscribers on all the RTs, these four providers would consume all 32 data links.

If there were subscribers to a fifth service provider, these stranded subscribers could only be made available on a "universal interface." A universal interface has a 1:1 mapping or connection between a subscriber terminal and a trunk circuit in an "always connected" mode. This defeats the purpose of GR-303 which is to eliminate the high cost and low efficiency of the universal mode.

Having a GR-303 interface available to a small number of network operators and a universal interface available to other operators would create a fundamentally unbalanced system of costs for RT unbundling. On the other hand, forcing everyone to the universal interface would set the clock back significantly in terms of cost and architecture.

Flawless Master/Flawless Slave?

Another issue with the use of multiple GR-303 interface groups for the purpose of RT unbundling is the general database architecture of GR-303. There exists a "master/slave" relationship between the LDS and the NGDLC where the LDS is the master and the NGDLC is the slave.

The master/slave relationship in GR-303 architecture provides a very efficient method for the LDS to control the resources of the NGDLC. GR-303 was created with the assumption that, while there may be several interface groups, there would be only one network operator and only one provisioning system. Thus, the LDS could be certain that it knows what resources exist within an RT. Also, the LDS can manage the different interface groups created by a single provisioning system, each with its own database. If there were an error in the provisioning (for example, one interface group claimed resources within another interface group), a significant malfunction would occur. This malfunction could include symptoms as minor as the loss of a call to the loss of an entire interface group. It is possible for a system to be brought down by such a database error. Because of this, a great deal of caution is used when building system databases. Even when in use, a system of database "auditors" runs in the background to cross-check the integrity of the databases. Database integrity is one of the most complex elements of system design for a GR-303 system. Failure of database integrity can cause catastrophic results.

When an RT has been unbundled and is a slave to many switches, it must be presumed that one of these switches is the database master and that the other switches are database slaves. If each switch (representing different service providers) were free to provision the RT, it would not be possible to use GR-303 because no one would be able to insure what resources belonged where.

Theoretically, problem of database integrity can be solved by making one of the switches the master of the system database. The master switch would then be responsible for passing that database information to each of the other switches in a carefully coordinated manner. Although this method is theoretically possible, coordination between the switches and their respective owners would be difficult, if not altogether impossible, to achieve. The operations support systems for each of the switches would need to be electronically bonded in a way that would make the owner of a "slave" switch subject to the commands of a master switch. In practical terms, the owner of the master switch would most probably be the ILEC and the owner of the slave switch would be the CLEC. The ability of the CLEC to operate his network would depend entirely on the flawless performance of the operations support systems and the ability of the ILEC to provision the system flawlessly. The ILEC would depend on the flawless performance of the CLEC's operations support system to insure that the "real" database information was activated in the slave switch at some predetermined time across all of the slave switches.

Coordinating Operating Support Systems (OSS)

Further complicating the master/slave switch approach would be the need to coordinate the operations support systems themselves. There are many different approaches in the industry to operations support systems, and there are many different vendors of products in this area. These operations support systems need to be fully inter-operable, but, the practicality of such an arrangement is small. The probability that competing business interests could find an agreeable common solution that is both technically acceptable and highly robust is slim.

To summarize, there are two major problems with using GR-303 as an unbundling tool. First, GR-303 does not scale well for unbundling. Second, sharing critical databases between master and slave switches could lead to catastrophic failures. At best, it would be highly problematic. Both of these issues highlight the fact that GR-303 was not designed to solve the unbundling problem.

The Access Switch Approach

Another approach that has been developed for unbundling RTs is the concept of "access switching." Access switching solves both the scalability problem and the shared database problems outlined above. Access switching is a new technology that has evolved from many of the standards bodies that have been studying the evolution of the network from a single-owner, single-service network to a multi-owner, multi-service network. Access switching was, in fact, designed specifically for the need to unbundle RTs, while preserving the fundamental physical architecture of RTs and leveraging some of their latent capabilities.

There are two important principles to access switching. First is the idea of making the control intelligence separate from the physical service delivery layer of the network. Second is the idea of "virtualizing" both services and ownership.

Separation of Control and Physical Layers

The best example of the first principle, separation of the control layer from the physical layer, is in the computer industry where this principle is commonly applied. In the computer field, it is common that the control layer (the operating system) is separated from the hardware (the physical computer). This independence allows services to continue to evolve on the same physical platform without having to change the actual hardware. The access switch provides this kind of capability to existing RTs, thus enabling new kinds of services to appear without having to change existing hardware.

Virtualization of Services and Ownership

Again, the computer industry has provided a model for the second principle; "virtualizing" services and ownership. Many of us work in corporate LAN (local area network) environments. In this mode, we share resources such as printers and file servers. When we look at these resources through our desktop computers, they appear to be resources that we own, but in fact, they are resources that are physically shared amongst many users on the LAN. In this way, we have "virtual" ownership of these resources. We use them as if they were ours, but they are, in fact, shared.

An access switch creates this ability to share the resources of an RT in much the same way, through the use of the independent control layer. An access switch creates the ability to have unlimited "virtual" owners who functionally control the RT resources, even though the physical RT resources are shared.

The most significant aspect of this architecture compared to the GR-303 architecture is that the access switch architecture is designed with unbundling in mind so that it solves both the scalability issue and the shared database issue.

In the access switched architecture, the actual physical connections to end-users are made at the RT as done today by ILECs. This layer of the architecture, the service delivery or media layer, is in place today and carries the actual "bearer" traffic.

Control of the service delivery or media layer is done at the control layer by an access switch. An access switch is a body of software running on a dedicated computer that provides control and signaling to the service delivery device, typically an NGDLC RT. An access switch enables switching and routing to be done at the NGDLC RT. The access switch's database enables virtual subdivision of the physical RT resources. The access switch, in turn, interfaces to the applications layer. At the applications layer are devices known as feature servers. The feature servers are like the access switch in that they are bodies of software that run on dedicated computers. The feature servers provide the applications and features for end-users who are connected to the service delivery layer to use.

To understand how this architecture is actually implemented in a network, it is important to understand several points. First, a single access switch controls many service delivery devices such as RTs. One access switch can control up to 100,000 subscribers connected to many RTs. Second, an access switch can be connected to a large number of feature servers. Finally, a single feature server can be connected to many access switches simultaneously.

The network configuration shown in Figure 4 creates the ability to unbundle the NGDLC RT down to the individual service circuit level without imposing any limitations on the number of virtual owner/operators that can operate resources in the RT. In addition, it provides the owner of the physical system with the ability to wholesale an extensive range of services over and above the basic unbundling requirements. While providing many value-added opportunities to the owner of the physical system, the access-switching strategy provides profound functional and cost advantages to the virtual owners.

There are two broad categories of unbundling contained within the single subject of RT unbundling. They are the unbundling of regular POTS and the unbundling of digital services, most notably DSL. The access switching architecture addresses both of these classes of service. Before examining these two branches, it would be good to build an understanding of the operational theory of access switched architecture.

Capabilities of the Access Switched Architecture

The access switched architecture gets its name from the fact that switching, the "dialtone function," is done at the RT, the access point of the network. This differs from the traditional monolithic Class 5 switch model. The benefits of unbundling of the access switch architecture come from "disaggregation" of the network architecture. In the present method of operation, switching, features and hardware are locked together in a single, inaccessible Class 5 switch package. By separating these three functions into three layers, it becomes possible to create "virtual" ownership of network resources. As discussed earlier, it is helpful to think of the corporate LAN environment of shared virtual resources to understand the impact of the access switched network architecture.

The access switch itself creates dialtone, performs call processing and network signaling for voice traffic and performs connection control and signaling for packet-based traffic. The access switch contains a database that holds an image of the physical system. The call or connection processing depends on this databasebecause it holds information that tells the system what resources are available and which have been assigned to virtual owners.

Feature servers interconnect to the access switch over a packet network, such as an IP network. The access switch itself performs control functions but has no internal ability to provide features. When a subscriber invokes a feature, either by a sequence of keys or by generating a data message, the access switch consults a database that tells it which virtual owner is associated with the subscriber. Once the owner is determined, the access switch locates another database where the virtual owner's "feature table" is kept. The feature table correlates subscriber keystrokes or messages to feature servers where the feature software is physically located. The virtual owner can configure the feature table according to his business interests. The feature table provides the access switch with the address of the virtual operator's feature server. The access switch contacts the feature server and executes the feature server's directions such as:

- give tone
- collect digits
- set up a session
- any other features required

When a feature sequence is complete, the call control returns to the access switch. Because they are connected over a packet network, there is no limit to the number of feature servers that can provide features to the access switch and to the subscribers.

Network signaling can be done for voice and data by an access switch. For voice, the access switch provides a convenient aggregation point for Signaling System 7 (SS7). One SS7 A-Link connected to an access switch will service a highly physically distributed group of RTs.

Using SVCs to Release "Stranded Bandwith" in PVCs and to Add Scalability

For DSL served from an RT, an access switch can serve as a "proxy signaling agent." Most DSL configurations today rely upon ATM transport. An access switch can serve as the ATM proxy signaling agent. Proxy signaling uses ATM Forum UNI 4.0 signaling between subscriber terminals and the proxy signaling agent in the access switch. When the subscriber signals for a connection, the access switch call agent works with the feature server of the subscriber's virtual owner to find the service. Once the network location for the service has been determined, the call agent acts as an ATM proxy signaling agent to establish the virtual connection. This enables DSL to have virtual ownership at the RT and to be switched, giving DSL a level of scalability that it does not have when used in permanent virtual circuit mode (PVC).

When DSL is used to provide voice over DSL (VoDSL), the access switch manages calls either as ATM connections or as TDM connections. In either case, the access switch provides capability to manage the subscriber end of the call as ATM or TDM and the trunk side of the call as TDM, ATM or IP. In each case, the trunk protocol choice is made on a call-by-call basis by the virtual owner of the subscriber.

An access switch can control all or part of an RT. If an RT is connected to a Class 5 switch over TR-08 or GR-303, that connection can remain while other parts of the RT can be controlled by an access switch. Thus, an RT can be unbundled progressively without disturbing the configuration of the original owner or operator.

Inter-machine trunks (IMT) connect the time division multiplexed (TDM) voice traffic coming from the NGDLC to the network. IMTs are the traditional trunk type that connects today's Class 5 switches to the network. These trunks can be segregated as to ownership or can carry mixed traffic. IMTs can be connected directly to Class 4 Tandem switches or pre-sorted and aggregated through cross connects.

Optical connections are available to carry high-speed data traffic from the NGDLC into the network. These connections can be engineered to meet the needs of the services that they carry such as asynchronous transfer mode (ATM), Internet protocol (IP) or others.

Because the access switch is separated from the network service delivery hardware, it is not dedicated to a particular type of connection management or switching. Rather, the access switch readily adapts to new network protocols. Thus, an access switch can be useful to voice switching, and at the same time, can manage switched virtual circuits (SVCs) for ATM.

Connecting Feature Servers to Access Switches

Feature servers do not particularly care how many access switches are connected to them. Their only real limitation is how much feature traffic their computer can handle at any one time. They use any of several protocols to communicate with access switches, and rely on packet networks to carry instructions back and forth between the feature server and the access switch. Because of this, a network operator can have a single feature server connected to unbundled RTs and at the same time, can use this feature server with co-located access devices under the control of an access switch. The co-located access device is used by CLECs to electronically gather unbundled loops inside an ILEC wire center. Most often, the access device is an NGDLC of the type used as an RT. This creates the potential for a uniform feature delivery system for a CLEC, even though the physical circumstances may vary widely.

The service delivery or media layer of the network, the NGDLC RT, is a widely-deployed technology. Most NGDLCs have powerful, latent capabilities that enable them to perform voice switching and ATM routing. Many are able to serve a plethora of services ranging from POTS to DSL. Most RTs can be upgraded easily to manage DSL and ATM. To upgrade an NGDLC RT to work with an access switch only requires a little additional hardware for decoding tone dialing and for generating tones. Most of the work required to upgrade an NGDLC to work with an access switch is at the COT where trunk groups are formed. Little, if any, new hardware is required at the RT.

Using the Access Switch Architecture to Unbundle DSL in RTs

Using network elements and signaling paths to unbundle DSL circuits in an RT accomplishes two purposes. First, it provides a robust method for unbundling the DSL facility. Ownership of the physical platform remains intact. Virtual division of the RT facility is aided by the use of an external OSS system that can receive orders for circuits from many CLECs and translate those orders into specific provisioning commands for configuring the access switch's database. The database synchronization problem is eliminated by having only one facility database per switch.

Second, because this configuration is inherently capable of proxy signaling, each DSL circuit can be switched according to service needs. This makes DSL using ATM transport scalable. Use of PVCs has left large amounts of bandwidth stranded because there has been no way to turn a connection off and on. Proxy signaling solves this problem. When implemented in the access switch architecture, proxy signaling also solves the problem of creating scalable virtual ownership. Each DSL circuit in an RT can be assigned to a different virtual owner. No special data links are required to add virtual owners.

A summary of benefits for using access switch architecture to unbundle DSL circuits:

1. Provides equal access to an indefinite number of virtual owner/operators
2. Provides scalable bandwidth, an advantage over PVCs
3. Provides unified database management which eliminates synchronization errors
4. Allows each virtual owner/operator to run their features and feature servers
5. Allows the owner of the physical system to sell value-added services to virtual owner/operators

Using the Access Switch Architecture to Unbundle POTS in RTs

The same general criteria that apply to DSL also apply to POTS. Each circuit in an RT can be identified as to virtual ownership. The individual circuits can then be associated with the feature server of the owner/operator. Switching of POTS circuits can result either in circuits being terminated on the RT for inter-RT calls, or on circuits terminated on an IMT towards the network. SS7 signaling is performed on behalf of the distributed system by the access switch.

The access switched architecture can also be used to unbundle POTS circuits in an RT. In this mode, the RT can use the access switch to perform the proxy signaling for DSL described in the previous section while processing voice calls on behalf of many virtual owners. The assumption in this configuration is that there is a single physical owner of the RT and the access switch. The operator of these facilities employs a multi-client provisioning system that enables work orders to be processed through the physical system operator.

The feature tables that are used to correlate feature invocation to feature servers are built through the multi-client OAM&P system at the time that the virtual owner initiates service on the RT. These tables will have a template form that can be easily downloaded. The feature tables themselves are small data structures making the number of feature tables present at any one time practically unlimited. The feature tables can be modified without affecting operation of any other service provider. The dialing plans for initiating a feature are contained in these tables. Corresponding to any feature entry is the network address of the feature server that provides the service. The access switch, depending on which feature server-to-access switch protocol is being used, supplies necessary information so that the feature server can take control of the call during the feature sequence.

The access switch is able to provide all of the usual information regarding traffic, call peg counts, status and alarm information. It is a relatively easy matter to sort this information by owner so that each owner/operator can get access to the kind of information that would be expected from a traditional switch.

It should be noted that GR-303 interface groups can work alongside the access switched portion of the RT. This would enable incumbent operators who rely on GR-303 today to continue operation in the current mode without disruption of their business model. It allows some small number of other operators to use GR-303 interface groups subject to the same limitations noted in the section on unbundling with GR-303.

A summary of the benefits of using the access switch architecture to unbundle RTs:

1. Scales to an unlimited number of owner operators.
2. Eliminates database synchronization issues presented by GR-303.
3. Allows an operator to continue their current business model ininteruppted.
4. Provides dialtone at a fraction of the cost of traditional Class 5 alternatives.
5. Eliminates the need for complicated physical arrangements to be made, such as space sharing.
6. Provides new operators the ability to provide services and features of their choosing.
7. Leverages current infrastructure for the benefit of all.
8. Retains the physical system operator's ability to sell value-added capabilities beyond those of basic unbundled loops.
9. Simplifies the problems associated with loop testing in a multi-owner, electronic loop environment.
10. Requires a minimum modification of existing network facilities and can be done quickly.
11. Positions the network for continued evolution to advanced services while not disadvantaging any one network service provider.

Other Features of the Access Switched Architecture

The access switch is fundamentally a media gateway controller. As such, it is assumed that a variety of transport methodologies will be employed on both the line and trunk sides of the RT. The line-side technologies might include all forms of DSL, fiber optics, wireless and just POTS. Each of these line technologies might use transport protocols such as TDM, IP or ATM. The transport protocols are executed at the media gateway (physically, the RT). Control of the protocols is executed at the media gateway controller (the access switch).

Using this architecture then enables choices of protocol technologies to be associated with line-side technologies on demand. As was discussed in the example of ATM proxy signaling for DSL, the access switch makes an ideal location for matching service characteristics to media characteristics, thus insuring the greatest possible flexibility in providing advanced features.

Each virtual owner/operator has equal access to resources, thereby fostering both services and competition. The kinds of services that will be available with access-switched architecture include:

1. Voice over TDM.
2. Voice over IP.
3. Voice over ATM.
4. Voice over DSL (using TDM, IP or ATM)
5. ATM proxy signaling.
6. Dialtone for data calls.

Summary

The access switching architecture provides a match for the current need to address competitive issues and RT unbundling. It not only provides a simple answer that provides benefits to all network users, it provides a major step in the direction of the next generation network architecture, in which multi-owner, multi-service issues will be the predominant drivers.

For more information on access switching, its capabilities and applications to network opportunities, please contact Westwave Communications.

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463 Aviation Blvd., Santa Rosa, CA 95403 707.591-9378