



Z H O N E®

*White Paper*

## **END OFFICE ACCESS**



*A Near-Term and A Long-Term Strategy for  
Migrating to An Integrated Access Network*

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## EXECUTIVE SUMMARY

Today incumbent service providers are facing serious challenges. Cable companies and other new competitors are encroaching on their telephone business. At the same time incumbent telecom service providers are entering the video business. Given the major paradigm shifts that are occurring, it is our opinion that a successful access strategy can be judged by the following critical success factors:

- The access network architecture MUST NOT be disruptive to legacy services
- The access network architecture MUST allow for easy rollout of new services
- The access network architecture MUST lower on-going OPEX

This paper presents a near-term and a long-term strategy for migrating to an integrated access network that will satisfy these critical success factors.

In the near term the access network can be broadband enabled by replacing DLC's and DSLAM's with Zhone MALC's. The MALC's integrate cleanly into the existing TDM network using GR-303 interfaces to PSTN switches, provide ATM and gigabit ethernet interfaces to core routers, and provide POTS, DSL, and B-PON access for triple play services. In the longer term the Zhone MALC's can replace class 5 switches in end offices providing integrated access, switching, and transport. The Zhone strategy makes the access network ready for current and future broadband service offerings, while minimizing change of legacy services and network operations.

Our results show that an 82% savings in operations expenses can be made by retiring class 5 switches and using MALC's as local switches. In this analysis the following operations expenses are considered:

- Environmental
- Capacity Planning
- NOC Support
- Service Provisioning & Configuration
- Equipment Maintenance
- Network Administration
- Field Support

The substantial OPEX savings associated with migrating the access network to a common infrastructure will result in a rapid pay back of the CAPX investment required to roll out the Zhone MALC's.

In summary, the Zhone MALC simplifies network operations by delivering all services over a single, common infrastructure.

## CHALLENGES FACING SERVICE PROVIDERS

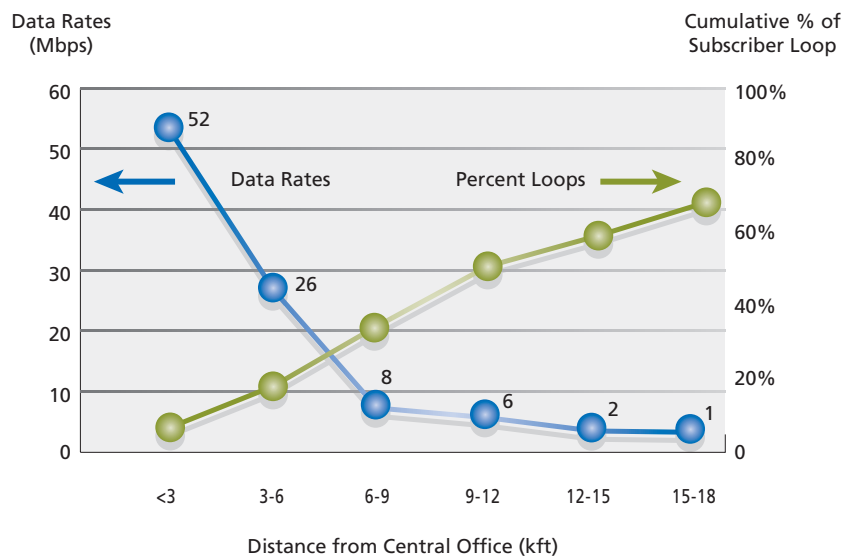
Today the telecommunications industry is in the early stages of a major paradigm shift created by new wireline and wireless technologies and emerging competition. Voice over IP, new mobile and fixed wireless technologies, and IP transport has created an opportunity for emerging service providers to enter iLEC markets with a diverse portfolio of services and an infrastructure with lower operational expenses than incumbent service providers. Among the new entrants to the traditional iLEC markets are:

- Service Provisioning & Configuration
- Cable companies with triple play service offerings of voice, broadcast video, video-on-demand, and high speed internet
- New VoIP service providers offering fixed price, unlimited telephone service to customers with broadband internet service
- Cellular carriers with family rate and fixed pricing plans that encourage customers to reduce or eliminate minutes on wireline voice services
- Wireless Internet Service Providers (WISP's) making use of low cost, high performance WiMax technology to deliver broadband service
- Electric power companies using low cost, high performance power-line carrier technology to deliver broadband service

While there is a diverse array of technical approaches used by new companies, the unifying theme is that most new entrants are basing their networks on IP packet technology. As a result, competitors enjoy a network with lower operational costs than iLECs operating multiple networks for voice, data, and video. For example, cable companies have made massive investments in their digital HFC networks to enable triple play services over IP networks. As a result many cable networks use distributed packet and video distribution systems in outside plant backhauling traffic to centralized Head-ends. This allows for cost effective operations and maintenance of equipment.

In contrast, most telephone companies are struggling to deploy triple play services on networks that were constructed over the last century. The telephone network was designed to carry voice services. It is a hierarchical model with a large number of end offices interconnected to interchange offices. These networks were originally designed such that the distance from a customer to an end office was less than

18,000 feet. Over the last thirty years DLC equipment and remote terminals have been deployed to more effectively aggregate telephone service and reduce the number of copper loops required in end offices. However, DLC's were designed for POTS aggregation, not for high speed data and video and many networks are still saddled with old copper pairs and long loop lengths.



**Figure 1**

The graph presented in Figure 1 compares loop lengths to DSL data rates. Clearly, a large percentage of copper loops are not suitable for delivering triple play services. As a result many service providers have been investing in fiber and remote terminals to shorten copper loops to enable universal broadband service deployment.

As DSL networks are deployed, incumbents have the additional burden of operating multiple networks for voice, video, and high speed data. The legacy voice networks have resulted in a large number of end offices with access, switching, and transport equipment that takes up valuable space and is expensive to operate and maintain. DSL data networks are separate and require additional capital and operational expenditures. The maintenance of separate networks for separate services puts incumbents at a disadvantage to emerging service providers. An analogy to this situation is the emergence of JetBlue and other low cost operators in the airline industry. Incumbent airline carriers have much higher operational costs and, as a result, are having trouble competing with low cost airlines.

In summary, incumbent service providers are facing new threats created by multiple technological advances. Unless service providers take bold steps to modernize their networks, they will have difficulty offering diverse services at competitive prices.

## **CRITICAL SUCCESS FACTORS**

An important step in formulating a good strategy is determining the critical success factors. These are the necessary conditions for an incumbent service provider's on-going success in the telecommunications business. In the access network the critical success factors are:

- *The access network architecture MUST NOT be disruptive to legacy services*
- *The access network architecture MUST allow for easy rollout of new services*
- *The access network architecture MUST lower on-going OPEX*

Each of these critical success factors will be discussed in the following sections.

### **ACCESS NETWORK ARCHITECTURE *MUST NOT BE* DISRUPTIVE TO LEGACY SERVICES**

While the rush to provide new services is critical to future success, it is clear that revenues from POTS and other legacy services still constitute the lion's share of the incumbent's revenue stream. Therefore, it is critical that any network strategy provide a graceful migration path from the current TDM network to the future integrated IP network. This migration path must minimize disruption to on-going legacy services. In order to minimize the transition from the TDM network to a packet network, access network equipment should be able to effectively operate in either the legacy TDM network or the future integrated packet network. Furthermore, access equipment **MUST** provide cost effective support for POTS and other legacy services.

## **ACCESS NETWORK ARCHITECTURE *MUST ALLOW FOR EASY ROLLOUT OF NEW SERVICES***

The ability to easily rollout new network services will be imperative to an incumbent operator's continued success. To effectively compete with emerging service providers, incumbents must have the flexibility to offer a full range of broadband services:

- Voice
- High Speed Internet
- Broadcast TV
- Video-on-demand
- Emerging broadband services (Internet games, custom video packages, integrated wireless & wireline voice packages, etc.)

This implies that the access network infrastructure must:

- Have the scalability to support internet, broadcast video, and video-on-demand services
- Support a wide variety of user and network side interfaces
- Deliver residential broadband services over copper or fiber

Service rollout must not be limited by the network architecture. Service providers must be free to rollout services in response to market demand.

## **ACCESS NETWORK ARCHITECTURE *MUST LOWER ON-GOING OPEX***

In order to compete with Cable companies and other emerging broadband carriers, incumbents must lower on-going network operations expenses.

Examples of operations expenses are:

- vendor maintenance expenses
- Environmental expenses (floorspace, power, cooling, battery & generator backup)
- NOC support expenses
- Field support expenses
- Service provisioning expenses
- Capacity planning expenses

This implies that service providers must

- Consolidate their networks
- Reduce the number of central offices requiring on-site operations staff
- Deploy network equipment that can be remotely managed

If service provider's operating costs are not in line with the competition, they could be facing a future scenario similar to that faced by incumbent airlines competing with JetBlue.

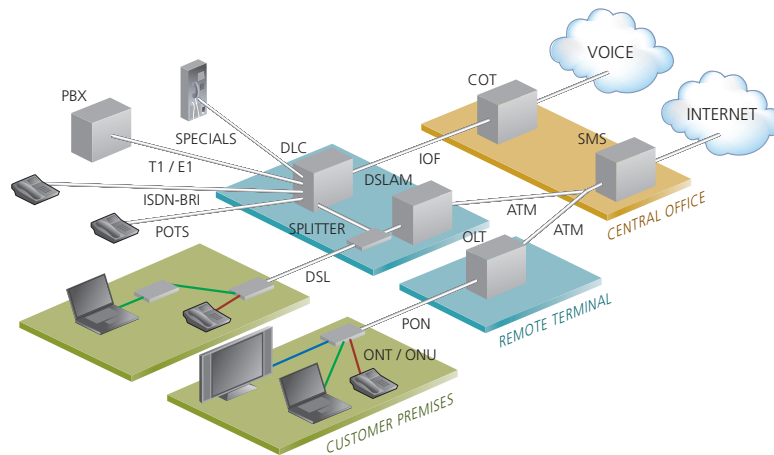
## **ZHONE'S ACCESS STRATEGY**

Zhone Technologies is dedicated to simplifying access networks starting with a simple principal: deliver all services over a single, common infrastructure. The Zhone access solution is flexible and scalable allowing easy integration with legacy TDM networks and next generation packet networks. Multiple subscriber interfaces enable the delivery of a wide variety of narrowband and broadband services.

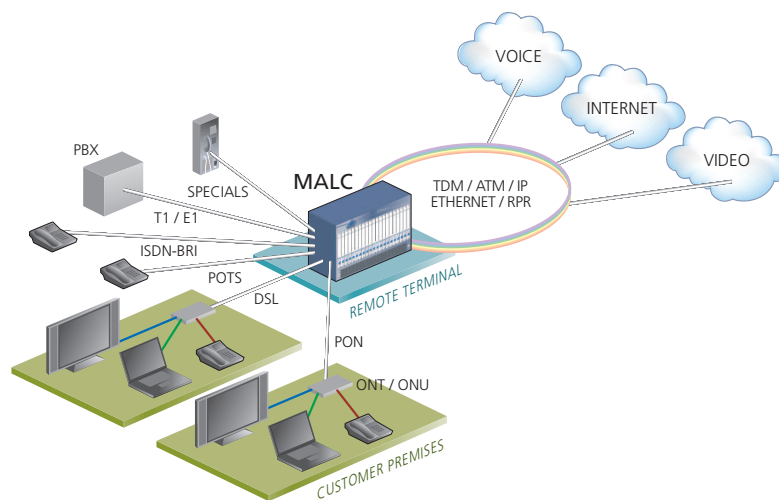
In this section both near term and long term access strategies for migrating to next generation networks are discussed and the operational benefits and economics of these approaches are presented.

### **NEAR TERM STRATEGY**

The strategy for migrating to the next generation network must provide a graceful migration path. Therefore, in the near term it is important to convert the access network to a broadband, packet-ready infrastructure with minimal disruption of legacy network operations. An important objective is the consolidation of access services on a single platform that can seamlessly interoperate with both the existing PSTN and the IP data network.



Traditional - Separate Access Networks



Today - Full Service Voice, Data and Video on One Platform

Figure 2

Zhone's solution for access consolidation is depicted in Figure 2. The Zhone MALC (Multi-Access Line Concentrator) consolidates access by terminating multiple types of access lines on a single, integrated platform:

- POTS
- T1/E1
- G.SHDSL
- POTS Specials
- ADSL
- VDSL
- ISDN BRI
- ADSL2
- B-PON

Figure 2 also depicts how many legacy networks use a separate access terminals for POTS, DSL, and PON. In order to simplify access and therefore reduce OPEX, a first step in the network migration strategy is replacing existing DLC's and DSLAM's with MALC's in the access network.

In this first step the MALC's can be interconnected to the existing network infrastructure with minimal disruption to network services and operations. The MALC connects voice services to the PSTN using standard GR-303 interfaces to class 5 voice switches in central offices. DSL and PON internet services are connected to the IP network over standard ATM interfaces or ethernet. This strategy allows service providers to consolidate access on the front end of the network without making major changes in the core of their network.

The graceful migration strategy also allows mandated services such as Emergency 911 (E911) and Emergency Stand Alone capability (ESA) to continue without interruption. A complete migration to VoIP complicates emergency services. The graceful migration strategy allows service providers to implement a broadband packet ready access network before dealing with all the complexities associated a complete migration to a VoIP network.

### LONGER TERM STRATEGY

To remain competitive over the longer term, incumbent service providers should move towards a consolidated broadband packet network for all services. This network will support multiple types of narrowband and broadband access lines, packet transport, routers, and a VoIP network. Another important part of the consolidation strategy is the retirement of class 5 switches from the end offices and consolidation of switching and service delivery in a smaller group of Super-POP's. This network architecture is outlined in Figure 3. The Zhone MALC is used as an integrated access, switching, and transport platform operating in both remote terminals and end offices.

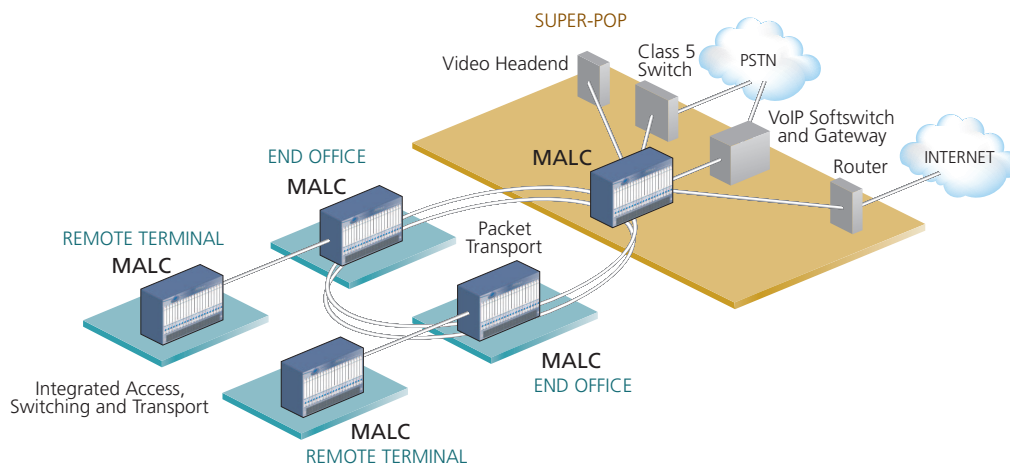


Figure 3

As an access platform the MALC has a wide variety of interfaces fully supporting triple play services. Voice service is provisioned with POTS, POTS specials, ISDN, T1, or carried as VoIP payloads over broadband interfaces. At the MALC voice is converted to VoIP using G.711 encoding with G.168 echo cancellation combined with SIP, MGCP, or VoATM signaling. The MALC uses VoIP signaling protocols to communicate with the Softswitch in the Super-POP and then transmits the payload across the IP packet network. The MALC can also backhaul voice traffic to a legacy class 5 switch using GR-303 interfaces.

Video service is provided over DSL or B-PON access interfaces and uses IP packet transport to distribute video from the Head-End in the Super-POP. The MALC implements IGMP IP multicast to improve network scalability for broadcast video. Multicast technology allows a single IP video stream to be broadcast across the core network and branched to different subscribers at the MALC.

High speed internet service uses DSL or B-PON access interfaces and can use either ATM or Ethernet transport to connect to core routers in the super-POP. The MALC provides integrated transport for services over either ATM or Gigabit Ethernet optical links. RPR ring capability could also be used for resiliency and 50 msec recovery from link failures.

The Super-POP architecture allows service providers to consolidate the operations and management of their core network in a centralized, controlled facility. The Super-POP hosts the video Head-End with satellite down links, off air down links, video-on-demand servers, and video application servers. Core routers connecting to the service provider's backbone IP network and the internet are also located in the Super-POP. These routers carry IP VPN, internet, and VoIP traffic. The MALC connects to high speed routers in the video Head-End and the IP network using gigabit ethernet. Voice switching is also centralized in the Super-POP. VoIP switching is carried out in the Super-POP by a VoIP Softswitch and gateway. VoIP traffic will either traverse the IP network via the router or connect directly to the PSTN via a gateway. Additionally, legacy class 5 switches are maintained in the Super-POP. The MALC's connect to the class 5 switches via GR-303 interfaces.

Using the MALC as an integrated access, transport, and switching system in end offices and remote terminals will result in a network that:

- Will minimize disruption to legacy services
- Enable the rollout of triple play services
- Lower operations costs by retiring class 5 switches and integrating access, transport, and switching
- Improve network survivability by distributing switching to end offices and remote terminals
- Support ESA and E911 emergency services
- Allow for the construction of new remote terminals with a common architecture for all services

## BUSINESS CASE

One of the key critical success factors defined earlier is that the access network architecture MUST lower on-going OPEX. This section will provide an analysis of the operations cost savings that can be achieved by retiring class 5 switches in end offices and using the MALC as an integrated platform for access, transport, and switching. The areas of operations expenses we will consider are:

- Environmental
- Capacity Planning
- NOC Support
- Service Provisioning & Configuration
- Equipment Maintenance
- Network Administration
- Field Support

These expenses are calculated for an end office with 5000 lines. However, the results of this study can be easily extended to multiple end offices with an arbitrary number of lines.

Annual OPEX for 5000 Lines	MALC 723	Class 5 Switch	Savings
Environmental Cost	\$ 18,583	\$ 196,448	91%
Equipment Maintenance	\$ 67,500	\$ 363,718	81%
Capacity Planning	\$ 225	\$ 727	69%
Network Administration	\$ 450	\$ 1,212	63%
Service Provisioning & Configuration	\$ 2,250	\$ 4,850	54%
NOC Support	\$ 4,500	\$ 12,124	63%
Field Support	\$ 22,500	\$ 72,744	69%
<b>TOTAL</b>	<b>\$ 116,008</b>	<b>\$ 651,822</b>	<b>82%</b>

Figure 4

The table in Figure 4 presents the annual operations expenses (5000 lines) for the MALC 723 and a class 5 switch. The environmental expenses are broken out further in Figure 5. Because of increased port densities, integrated access, transport, and switching, the MALC results in an overall OPEX savings of 82%. This amounts to an annual savings of \$535,815 for a 5000 line end office. With cost savings of this magnitude the service provider can quickly payback the MALC capital investment while positioning the access network for the future. In the following sections the assumptions for each of the expense categories will be discussed.

Annual Environmental Expense	MALC 723	Class 5 Switch
Floorspace	\$ 5,309	\$ 37,162
Power	\$ 1,800	\$ 21,600
Cooling	\$ 5,377	\$ 64,523
Battery & Generator Backup	\$ 6,097	\$ 73,164
<b>Total</b>	<b>\$ 18,582.65</b>	<b>\$ 196,447.78</b>

**Figure 5**

## **ENVIRONMENTAL**

The environmental expenses are:

- Floor space expenses
- Power expenses
- Cooling expenses
- Battery and generator backup expenses

Floor space expenses are calculated assuming a cost of \$40.00 per square foot. The area of one rack plus clearances equates to \$442.40 in floor space per rack. Note that no side clearances are included, as they would only apply to the end racks. A typical rack has about 42 RU (1.5” per Rack Unit). Each RU then costs \$10.53. Power expenses are calculated assuming a cost of \$.07 per Kilowatt hour. Power is calculated based on the configurations required for the MALC and the class 5 switch to support 5000 lines. Cooling costs are estimated to be \$1.50 per 10,000 BTU. The BTU generated is calculated from the power dissipation of each system. Battery and generator backup expenses are estimated to be \$.29 per Kilowatt hour. The total cost of battery and generator backup is calculated using the power estimates for the MALC and the class 5 switch.

## **EQUIPMENT MAINTENANCE**

Software upgrades contribute significantly to the ongoing operations of a telecommunications network. Switch manufacturers typically have multiple releases per year that need to be installed on switches. In addition to software upgrades, maintenance also includes manufacturer site visits, technical support, and equipment replacements for technical problem resolution. Maintenance is usually priced at 15% to 20% of the cost of the equipment. Because the MALC integrated platform costs less, maintenance is subsequently cheaper.

## **CAPACITY PLANNING**

Network capacity planning is an engineering function. It involves analyzing measured statistical data and using capacity planning tools to estimate the need for more transmission bandwidth, switches, line cards, and physical capacity. Because the MALC integrates access, transport, and switching the complexity and therefore the cost of capacity planning is reduced.

## **NETWORK ADMINISTRATION**

Network Administration is a process associated with maintaining switches and routers with the correct software revisions and the correct configurations. Administration also includes performance and fault monitoring. Network consolidation and improvements in element network management systems result in lower network administration costs in the MALC network.

## **SERVICE PROVISIONING & CONFIGURATION**

As customers order new services the operations group needs to provision circuits and configure routers. This is the process of provisioning and configuration to add new customers and services to the network. Network consolidation and improvements in element network management systems result in lower provisioning and configuration costs in the MALC network.

## **NOC SUPPORT**

NOC support represents the operations costs associated with running a Network Operations Center (NOC). The NOC is a 24 X 7 call center that deals with level 1 and level 2 support. Level 3 support is usually escalated outside the NOC. NOC support includes both technician level and engineering level staff. Network consolidation and improvements in element network management systems result in lower NOC support costs in the MALC network.



## **FIELD SUPPORT**

Field support costs are associated with truck rolls. These costs include field technicians as well as field engineers providing service to remote central offices. The combination of improved remote management capabilities in the MALC and reduction of equipment in remote terminals and end offices leads to reductions in field support costs.

## CASE STUDY

The following case study demonstrates how retiring class 5 switches can save space and reduce complexity in the end offices. This is an example of an iLEC that has a large installed base of Nortel DMS switches. This Zhone customer had DMS 100's in a large central office connected to Remote Line Concentrating Modules (RLCM's) in a small end office. The RLCM's were terminating POTS lines and backhauling the voice traffic to the DMS 100 using GR-303 over T1 lines. They had decided to rollout high speed internet service over DSL and, therefore, needed to install DSLAM's in the end office.

This customer decided to deploy Zhone MALC's for the following reasons:

- Provision high speed internet DSL service
- Reduce operations cost and complexity by retiring the RLCM's and consolidating access, transport, and switching on the MALC

This iLEC replaced 14 Bays of Nortel RLCM's with 2 Bays of Zhone MALC's. The MALC was connected to the DMS 100 in the central office using GR-303 over T1 lines. By integrating cleanly into the existing TDM network, the addition of the MALC caused very little disruption to the network. This service provider successfully reduced environmental and maintenance expenses while providing DSL service. In addition their end office is now ready to offer a full range of triple play services. The old configuration and new configuration is highlighted in Figure 6.

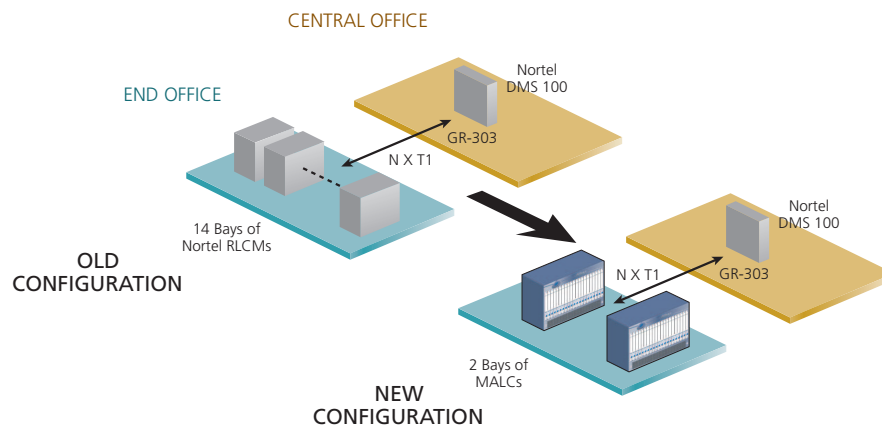


Figure 6

## CONCLUSION

Incumbent service providers today are facing serious threats from emerging competitors. Given this competitive environment, we believe that the critical success factors for profitability are:

- The access network architecture **MUST NOT** be disruptive to legacy services
- The access network architecture **MUST** allow for easy rollout of new services
- The access network architecture **MUST** lower on-going OPEX

Zhone's solution provides a minimally disruptive migration path to the next generation network. As MALC's replace legacy technology in the access network, operations costs are reduced and new service capability is added. In the longer term, MALC's can replace many class 5 switches in end offices with significant reductions in OPEX.

In summary, the Zhone MALC simplifies network operations by delivering all services over a single, common infrastructure.



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**About Zhone Technologies, Inc. (Zhone)**

Zhone Technologies, Inc. (Nasdaq: ZHNE) is the first company dedicated solely to delivering the full spectrum of next-generation wireline infrastructure equipment. Zhone's Single-Line Multi-Service architecture (SLMS™), allows carriers to concurrently deliver voice, new premium data and video services over copper or fiber access lines. Zhone provides carriers with an elegant migration from legacy circuit-based technology to packet based networks while substantially reducing operating costs. With deployments at over 300 carriers including among some of the world's largest networks, Zhone has enabled carriers to reinvent their businesses. For more information, please visit <http://www.zhone.com>

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