NETWORK PLAN EVALUATION

for

Upgrade of Loop Plant, Interexchange Transport, and Switching

Iowa Telecom

Newton, Iowa

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IOWA TELECOM
NETWORK DESIGN EVALUATION

Iowa Telecom asked GVNW to evaluate the Network Plan and Capital Expenditures Plan for service improvements to its network in the State of Iowa.

Background

Iowa Telecom was created on July 1, 2000 to acquire the Verizon (GTE) properties in Iowa. The service area purchased consisted of exchanges formerly operated by three ILECs in the State of Iowa. At year end 2001, there were   access lines in service in 296 exchanges. The exchanges range in size from 12,257 to 16 access lines, with most exchanges falling in the 100 to 1,000 access line size. These exchanges are scattered geographically over almost the entire state.

Unfortunately, some of the plant purchased had not been modernized at the same rate as that of some of the more progressive rural ILECs. For example, there are still currently analog carrier systems in the loop plant, and most switches are not at or near the current generic operating software version. There is, however, significant fiber cable between COs in place. The current network has several design issues that restrict Iowa Telecom's ability to offer new services customers want. In addition, the current network could be upgraded to significantly reduce ongoing operating costs.

Iowa Telecom has prepared a plan to modernize the current network. This Design Evaluation examines the current network and Iowa Telecom's plan to upgrade the network in light of:

Required and projected improvements in service quality
New services delivered
Reliability and redundancy of the network proposed
Conformance with industry best practices for design
Current status and future migration capability to new technologies
Financial prudence from a high level

GVNW Credentials

GVNW Consulting, Inc. is a business and technical consulting firm with approximately 200 small ILECs as clients nationwide. GVNW provides consulting to small ILECs on cost studies, business planning, network planning, and provides various administrative services to small ILECs, including 800 RESPORG, filings for the LERG, and filing of ASR and LSR information. GVNW also provides regulatory consulting, and has provided comments and testimony before the FCC and numerous state regulatory and legislative bodies regarding rate filings, cost recovery issues, depreciation, and network planning as it relates to cost recovery and rate levels. GVNW was an active participant in the Rural Task Force at the federal level over the past few years. GVNW was instrumental in the founding of Associated Network Partners, Inc. (ANPI), a toll reseller that now counts approximately 160 ILECs as customers. GVNW currently manages ANPI under contract.

The author of this report is Jack Pendleton. Mr. Pendleton is a Consultant Supervisor at GVNW with responsibilities for traffic factor development, network planning, and engineering. He has over 30 years experience in the telecommunications industry. He started his telecommunications career at the Bell System as a switching equipment engineer, were he worked on the introduction of then-new electronic switching technology to the Virginia operating company. He also worked in traffic engineering for all long distance and operator equipment for Virginia, where he engineered one of the first electronic operator systems in the Bell System. He served as a current (5 year) planner, outside plant engineer, outside plant planner, where he implemented the first CSA designs in Virginia, and in revenue requirements in Washington DC, preparing cost studies for filing in the ENFIA proceedings.

He then served as headquarters staff engineer at Citizens Utilities, and also performed cost studies. Mr. Pendleton then served as chief engineer of a small ILEC in Oregon, and later as assistant manager of a second small ILEC, where he also managed a large CATV build.

After that, Mr. Pendleton started his own consulting business, where he worked with Illuminet on the initial design and implementation of their SS7 network, and for Alcatel on introduction of new equipment into the ILEC market.

Mr. Pendleton joined GVNW in 1989. While there, he implemented SS7 for many small ILECs, and has performed numerous switch upgrade/replacement studies, CSA designs, and network fundamental plans. Mr. Pendleton served as a consultant to Myrio during the early stages of development of the video-over DSL product in business and technology development.

Mr. Pendleton has a BSEE in engineering from University of Miami, and is a member of IEEE, National Association of Radio and Telecommunications Engineers and Society of Cable TV Engineers. He is a registered Professional Engineer in Oregon and Idaho.

Current Network

The current network served access lines at year-end 2001. These were spread through 296 exchanges ranging in size from 12,257 to 16 access lines. These exchanges are scattered throughout much of the State of Iowa. Many exchanges are not contiguous. As a matter of comparison, the 18 exchanges in the metropolitan Des Moines area contain approximately access lines.

Significant portions of the current plant have not been modernized for some time, and there are several key issues that are impeding new service offerings, affecting current service, and causing high ongoing operating costs.

1.) Although efforts have commenced to reduce analog carrier, there is still substantial analog carrier in the outside plant. This carrier has not been deployed new by ILECs for approximately 15 years, and most manufacturers no longer produce analog carriers. Because of high costs and inadequate service quality characteristic of this obsolete equipment, most ILECs have replaced it with Digital Loop Carriers (DLC) over the years. This evaluation will address Iowa Telecom's approach to elimination of the analog loop carrier.

2.) The current network has very limited capability to offer customers broadband access to the Internet. While the embedded twisted pair copper cable deployed by Iowa Telecom and all ILECs does not have the inherent capability to provide broadband services, there are several technologies that can be used to accomplish this. By far the most common is Digital Subscriber Line (DSL). This Report will evaluate Iowa Telecom's plans for deployment of DSL.

3.) In order to provide the bandwidth necessary for broadband service, it is necessary to deploy fiber optic cable between exchanges and to some extent in the loop plant. Fortunately, there is already substantial fiber deployed between exchanges. However, some Iowa Telecom offices currently do not connect to the Iowa Telecom offices by fiber. In order to route traffic economically, and to be able to maintain the geographically diverse network, as many exchanges as possible should be connected to Iowa Telecom's fiber network. This will allow greater operational efficiencies, including centralizing Network Management, and Operations, Administration, Maintenance, and Provisioning (OAM&P). At this time, 44 exchanges are not connected by fiber cable to other Iowa Telecom exchanges.

4.) In order to provide redundancy, fiber should be deployed in a ring configuration that offers a second path in case of failure in one path. Currently, there is fiber that could be used to deploy several rings. Additional rings can be constructed by closing various gaps between exchanges with new fiber cable. This will need to be accomplished in order to provide redundancy and capacity for new features.

5.) Iowa Telecom currently has 85 stand-alone voice switches throughout the 296 exchanges. The remaining 211 exchanges are served by remotes from the hosts. This arrangement requires separate monitoring and administration of all hosts. In addition, when new operating software (often referred to as "generic software") is required, it must be purchased for each switch. Since the switch vendors charge for most generic software on a "per-switch" basis, this can be very uneconomical when the software is deployed over many small switches, as is the case with Iowa Telecom. The trend in the telecommunications industry has been to serve many small exchanges with remote switches, and consolidate these many remote switches into a few hosts. Thus, software upgrade costs per customer are optimized, as are OAM&P costs.

6.) The switches currently deployed in Iowa Telecom's network are inherited from three different previous network owners. Thus, there is a large variety of switch types represented. Switches from four manufacturers with five types of switches are deployed. One vendor is currently out of business, and support is minimal on this switch. Such diversity makes it difficult to offer the same mix of services across the network, or, in some cases, to deploy services that operate in the same way. For example, CLASS services are not currently available from the 4 Vidar switches deployed, as the manufacturer is no longer in business. Most ILECs the size of Iowa Telecom have standardized on one or at most two types of switches to minimize spare parts inventories and learning curves of technicians, and to maximize volume discounts available by concentrating purchases with one vendor.

Iowa Telecom's network upgrade plan should address these deficiencies with the aim of providing a modern network that can provide services as required by customers. The planned network should minimize troubles and outages by having a high degree of reliability and redundancy.

Current Industry Best Practices

In planning for the network upgrades required, Iowa Telecom should strive to conform to telecommunications industry "best practices". Iowa Telecom's plan should provide a modern network that provides services as required by customers and minimizes ongoing operating cost per customer. To do this, the Iowa Telecom plan must balance several seemingly opposite design goals:

1.) Iowa Telecom must balance new technology against proven technology. It is often tempting to deploy the most modern technology that can offer the service. In the current atmosphere of rapidly changing technology, where the only sure thing is change, this can put the ILEC ahead on the curve, and minimize upgrades. However, getting too far ahead of the curve can prove risky if the technology deployed, or the company selling it, is not successful. The last five years has shown both extremes of this issue. In 1999, with new products and new capabilities being announced at a breakneck pace, and with a seemingly limitless market for bandwidth created by the growth of the Internet, it appeared for a while that there was room for most new products to secure a market and thrive. For a few years, this was the case. However, in the last two years, many of these products have disappeared. In many cases, it was not due to inherent weakness of the product or underlying technology, but due to the vendor going bankrupt. Prudent ILECs had to pick not only the successful technologies and products, but also the successful vendors. From this fallout has emerged somewhat of a consensus in the ILEC industry as to what configurations offer the best balance of new vs. proven technology.

2.) Iowa Telecom must balance robustness against cost per customer. In just about all cases, the more robust a product is (reliable and feature rich), the higher the cost. While advances in technology continually improve reliability and features vs. cost, the network designer must carefully weigh reliability vs. cost to avoid either a network that is not reliable enough to satisfy customer demand or one that the customers cannot afford. Like the tradeoff between newness and proven technology, an ILEC industry consensus has emerged that balances reliability, features, and cost.

This report will evaluate the balances from a rural ILEC perspective at the current point in time. The tradeoffs and balances for rural ILECs are somewhat different from the large metropolitan ILEC and CLEC markets, both of which often receive substantially more attention than the rural ILEC market segment. Large metropolitan carriers have several key differences from small ILECs that move the balance point of the various tradeoffs to a different point than that for rural ILECs. First, large metropolitan ILECs typically have many large business customers with sophisticated communications needs. These often require that the metropolitan ILEC offer services on a scale that would not be economical on a cost-per-customer basis in rural areas. In addition, the metropolitan business market may demand services and features earlier than the rural market, requiring the metropolitan ILEC to purchase products earlier on the curve, before performance is proven in live traffic situations. However, because of the large size of most urban ILECs, (usually RBOCs), a mistaken choice can be replaced quickly with little effect on the urban ILEC's financial results due to the large size over which to spread the costs of premature retirement. Rural ILECs, being smaller in size, do not have the large customer base to spread cost of early retirements over, and thus must be somewhat more cautious when choosing new technology. This evaluation chooses a rural ILEC approach.

The Competitive LEC (CLEC) market is sometimes compared to the small ILEC market because both groups of companies are small relative to the large RBOC ILECs. However, there are several key differences here also that will affect technology choices. CLECs are usually start-ups, and thus do not have an embedded plant base that must be included in network design considerations. Thus, completely new technologies that are not necessarily compatible with the embedded ILEC plant base may be deployed. In addition, CLECs need to set themselves apart from the ILEC they compete with. Many have chosen to do this by offering more 'state-of-the-art" technologies than the ILEC. In some cases, this has worked well, providing more economical service that at least meets the performance of the ILEC network and sometimes exceeds it. ATM transport in long-haul fiber networks is a good example of this. In other cases, the technology may be more modern or economical, but performance may suffer, as evidenced by some of the early challenges experienced in deployment of Voice over Internet Protocol (VoIP) technology. Rural ILECs have to consider their embedded base of plant and their customers' expectations of service quality in their planning decisions. This often precludes technology deployed by CLECs as too far ahead of the curve at a given time.

Due to the ongoing change inherent in technology, today's "bleeding edge" is tomorrow's "best practice" and next week's "dinosaur". This evaluation will examine Iowa Telecom's network plan against industry best practices from a rural ILEC perspective at the current point in time. All plans for the next five years are expressed in terms of today's technology, costs, and trade-offs, with consideration to what are currently seen as the migration paths of the technologies and products available today. Current technology and migration paths will change over time. Remember that 1991 was the "Year of ATM", and the migration path at that time showed all data and most voice traveling over ATM to the desktop within 5 years. New developments like the Internet and Internet protocol changed that migration path drastically. It is expected that Iowa Telecom's plan will be a living document that will evolve over time to reflect future changes in then current technology and migration paths as they become evident.

Loop Design

Iowa Telecom has planned to eliminate analog carrier in the subscriber loop plant by deploying Digital Loop Carriers (DLC) in a Carrier Serving Area (CSA) design scheme. The Digital Loop Carriers will offer voice service to replace the analog carrier. Digital Subscriber Line Access Multiplexers (DSLAMs) will be deployed at the DLC sites to offer broadband service as demand dictates.

Elimination of Analog Carrier

ILECs deployed analog subscriber carrier aggressively in the 1970's and early 1980's. At that time, analog carrier was modern technology far superior to earlier electromechanical and vacuum tube based technologies that allowed multiple customers to be served on one cable pair. Analog carrier offered a cost effective alternative to cable reinforcement, especially in areas that were either rural with large distances between customers and the CO or in areas that were being upgraded to one-party service. At that time, RUS Rural Utilities Service (RUS), the US government agency that lends money to many rural telephone companies, encouraged deployment of analog carrier as a low cost way to offer one-party service in rural areas. (RUS policies are referred to in this report several times because, over the years, RUS, formerly REA, has provided network design guidelines that are tailored to rural areas. The other major provider of network design guidelines over the year, Bell Labs, later Bellcore, and currently Telcordia, has focused on areas served by the Bell System, and later RBOCs, typically urban areas.)

The shortcomings of analog carrier started to become evident in the late 1970's. Analog carrier tends to be troublesome, resulting in customer complaints and high maintenance costs. Troubleshooting is not automated, and often requires field visits to isolate and correct even minor problems. Moves and changes almost always require a field visit. All this adds up to high cost and poor service. The final nail in analog carrier's coffin became obvious with introduction of Internet service. Data rates on analog carrier are limited to below 30 Kilobits per second (Kb), thus restricting customers from utilizing the full capacity of 56 Kb modems to access the Internet.

Since the 1980's, and gaining force in the 1990's, ILECs have initiated programs to replace their analog subscriber carrier. During the early 90's, GVNW, and many other consultants, prepared numerous outside plant plans to eliminate analog carrier. Almost all analog carrier has been eliminated, although small amounts remain at some companies. In all cases that GVNW is aware of, ILECs have plans to replace all remaining analog carrier in the next few years.

Iowa Telecom's decision to eliminate analog carrier is prudent and in keeping with industry practices. Based on experience, this will result in improvements in service quality, lower costs per customer, and the capability to access the Internet at faster data rates.

Carrier Serving Area (CSA) Design

Analog carrier can be replaced in several ways. Physical copper cables can be reinforced to serve all customers on cable pairs. In some trial cases, fiber cable can be placed to each customer premises. Almost all ILECs are now building loop plant to the CSA design. CSA design is defined as:

1.) DLCs in the loop cable plant

2.) Copper cables between the DLC site and the customer premises with a defined maximum cable loop length

3.) Usually fiber between the DLC and the CO (Some very rural areas use copper cables plus T-1 carrier to connect the DLC to the CO. This design is becoming less common as demand develops for broadband services due to the lower cost of fiber vs. copper and the greater reliability of fiber vs. T-1 carrier over copper.)

CSA architecture is recommended by the RUS. CSA design is required of all new RUS construction so that new cable plant can support data rates up to 1.5 MB with the appropriate electronics.

Many studies have been conducted over the years by RUS, the RBOCs, GVNW, and others to determine the appropriate architecture for loop plant. CSA has emerged the winning architecture for several reasons:

1.) Lower first cost – In most cases, it is more economical to place a DLC unit and fiber cable between the DLC site and the CO to provide for additional access lines than it is to place a large copper cable between the field location where the DLC would be placed and the CO. There are several reasons for this:

   a.) Copper cable in large sizes is substantially more expensive per foot than fiber cable.

b.) Large copper cables are heavy and bulky, and cost more to install than fiber. For example, when placing large size copper cables, a trench is usually required. In contrast, fiber cable can be direct plowed for much lower cost than trenching. (Plowing usually costs less than half the cost of a comparable length of trench. For very large copper cables, conduit and manholes are required, adding significantly to cost.)

2.) Lower life cycle cost – Once fiber plus DLCs are placed, access line growth can be accommodated by adding DLC line circuits. Because of the very large capacity of fiber, additional physical cable is not required between the CO and the DLC site. With copper cable, additional access lines require that a second or third copper cable be placed to the CO.

3.) Increased capabilities – Copper cable can only transport voice and data at speeds up to a maximum of 56 KB. Copper cable over 12,000 feet in length requires load coils to provide for good quality voice transmission. (Note: some load schemes use 18,000 feet as the maximum length of non-loaded cable.) The maximum data rate that can be supported by cable with load coils is nominally 56 KB, but actual rates are usually lower.

Copper cable with no load coils using DSL technology can provide transport at 8 MB for up to 9,000 - 12,000 feet. At greater distances, the data rate drops off quickly to less than 0.5 MB at 20,000 feet. Thus, CSA design with no load coils can provide much greater data rate capabilities than copper alone.

Since much of the future growth in ILEC revenues are forecasted to be from transport of data for advanced services (a new, fast-growing market) rather than voice (a mature, slow-growing market), it is prudent to maximize future capability for data transport.

Fiber to the subscriber, often referred to as Fiber to the Home (FTTH), has been deployed in some field trial cases as a way to provide broadband service. FTTH will ultimately be required for the very large bandwidths of future services. In some cases, where all construction is new, and subscribers are close together, as in new platted subdevelopments, FTTH is price-competitive with CSA design if broadband customer demand is very high. However, FTTH is not widely deployed in the rural areas now for several reasons:

a.) FTTH is not cost effective compared to CSA where existing customers are served. FTTH requires that fiber be placed to each customer premises, where CSA allows existing copper cable to remain in service from the DLC to the customer. The high cost of construction in built-up areas drives the cost of FTTH up to the point where there can be no cost justification.

b.) FTTH is not yet tested in commercial deployments to the extent that a rural ILEC can take the risk that either the technology or the vendor will not be successful.

FTTH needs to be tested further in commercial service and in the marketplace before it should be deployed in rural applications.

c.) FTTH does not currently have an adequate means to provide dial tone in the event commercial power fails, a fairly common occurrence in many rural areas. Since the transport for FTTH is fiber, powering the customer premises equipment from the ILECs facilities (CO or DLC) is not possible unless a separate copper cable is run to each house. This adds to cost. A second alternative is to provide backup batteries at each customer premises. However, batteries add to first cost, require ongoing maintenance, and are not as reliable as the CO power that ILEC customers have come to expect as part of their service.

Thus, Iowa Telecom's use of CSA design is entirely in keeping with industry best practices for rural areas. Iowa Telecom would be remiss if it did not utilize CSA design in its cable loop plant design.

Broadband Service

At the current time, there are four possible ways that Iowa Telecom could consider to deliver broadband service to its customers:

Digital Subscriber Line (DSL)
Cable Modem
Fiber to the Home (FTTH)
Wireless

Iowa Telecom has chosen to use DSL technology. This will allow the use of embedded copper cable plant between the CO or DLC site and the customer.

Cable modem service is optimized for coaxial cable as deployed by CATV companies. Since Iowa Telecom does not currently have a coax cable network, using cable modem service would require deploying all new cable to the customer premises. The existing embedded plant would not be utilized. Due to cost, this is not a valid option for Iowa Telecom.

FTTH architecture is discussed earlier in the report. While Iowa Telecom should plan for future migration to FTTH when the demand for bandwidth requires this, FTTH is not cost effective at the current time. As FTTH technology matures, Iowa Telecom can include this in their customer plant plans using then current technology and costs.

Wireless technology for broadband Internet access to rural customers is just now reaching performance and price points where deployment can be justified in some cases. Performance is limited in some cases to line-of-sight, and thus may require extensive construction of towers to cover all the customers in a given area. A year ago, GVNW evaluated several rural wireless broadband deployments for technology and business case, and found the technology to have questionable performance and to not be cost effective. Recently GVNW has evaluated several systems that have adequate performance, yet, to date, we have not been able to obtain a profitable business case due to cost of wireless systems. However, as with almost all technology, performance continues to increase, while cost continues to decrease. GVNW anticipates that cost will reach a level where a positive business case can be achieved in the next year. GVNW also feels that, if wireless technology can be made to function using small structures (utility poles or similar structures) rather than large, costly towers, such as required for cellular service, there is a use for wireless on a migration path strategy. Here wireless broadband may be deployed beginning in a larger town until market penetration reaches a certain level. At that time, DSL can be deployed, and the wireless equipment reused in another location. This may reduce costs, and should be considered by Iowa Telecom as a way to deploy broadband service rapidly. Iowa Telecom has not presently considered wireless broadband, but should begin to evaluate this technology as part of the ongoing evolution of their network plan.

Demand for Data Transport and Bandwidth

In providing CSA and DSL, Iowa Telecom is forecasting that demand for data transport bandwidth will continue to grow. This is a valid assumption based on past history. Demand for dial up access to the Internet, currently the largest demand in the residential market for data transport, has shown increased demand for bandwidth per connection. This was reflected in growth in modem speed from 9.6 KB to 56 KB over the last 10 years. Unfortunately, due to the electrical characteristics of cable, 56 KB is the maximum data rate that can be economically transmitted over copper cable using analog modem technology. Further growth in bandwidth required a new technology. There have been several attempts at this, including DSL on existing copper cable plant, Cable Modem on existing CATV facilities, and wireless technologies. Because all these technologies are very different from the analog transmission over copper cable that dial-up Internet access uses, new technology is required. Like all new technologies, infrastructure had to be created, and there has been a substantial investment required from all providers. Because of this, all high-speed data transport has experienced spotty coverage and growing pains over the last few years. Content providers that could offer meaningful content that customers would be willing to pay for have been reluctant to invest large sums until the infrastructure was in place. Customers could see only higher speed to existing Internet services as a basis for paying more, and many could not justify this.

The various technologies for high-speed data transport to the customer stand at a critical point in their development. The old chicken-or-egg scenario here is a three-way standoff; which comes first, content, infrastructure, or customer demand (revenue).

> "Before consumers start downloading symphonies or watching pay-per-view events online, they need a high-speed connection to the Internet. But in the U.S., fewer than 10% of all homes have one. There may be a data fire hose running

from coast to coast, but the typical consumer is still connecting through a straw. Many consumers are unwilling to pay the extra cost of a high-speed line because, in their view, the Internet is not compelling or important enough to justify it. The entertainment companies that could make the Net more appealing to consumers, including most movie studios and TV networks, are staying on the sidelines until more homes have high-speed connections".[1]

Added to the uncertainty in early broadband deployment, the current economic slowdown has also reduced near term demand.

However, it is currently expected that ongoing deployment of infrastructure, advances in provision of secure content, and greater customer awareness will break the current deadlock in the next few years. After that, rapid growth of broadband services is forecasted.

Added to this, the current broadband initiatives being considered by the US Government (Congress and Executive Branch) will further speed deployment. The national position on broadband deployment is summed up by the following quotes by Michael Powell, Chairman of the FCC, in a recent proceeding regarding the Appropriate Framework for Broadband Access to the Internet:

> "As policymakers, we are all quick to acknowledge broadband deployment is the central communications policy objective in America...As is often the case under the legal and policy framework governing regulation of communications and related industries, the FCC does not hold all the tools necessary to promote broadband deployment in its toolkit...There needs to be a clear and productive regulatory environment at the state and federal level."[2]

The US broadband initiative is driven by a need to keep the US competitive in world markets vs. Europe and Japan, where government pays a part of the cost of broadband infrastructure. In the future, availability of ubiquitous broadband service is seen as just as necessary as electricity, good roads, and water for a given location to be competitive in the marketplace. As FCC Commissioner Kevin Martin stated:

> "Broadband deployment is vitally important to our nation, as new, advanced services hold the promise of unprecedented business, educational, and healthcare opportunities for all Americans."[3]

The demand for broadband is coming, and Iowa Telecom is prudent to be planning for it in their current network plan.

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[1] Jon Healey, *Telecom's Fiber Pipe Dream,* Los Angeles Times - April 1, 2002

[2] Notice of Proposed Rulemaking, FCC CC Docket No. 02-33, released Feb. 15, 2002, Separate Statement of Chairman Michael K. Powell

[3] Notice of Proposed Rulemaking, FCC CC Docket No. 02-33, released Feb. 15, 2002, Separate Statement of Commissioner Kevin J. Martin

Interexchange Transport Design

As Iowa Telecom begins to offer broadband services to its customers, adequate capacity will be required between exchanges to connect the broadband and Internet access equipment in each exchange to the Internet backbone. Adequate capacity will also be required for existing voice traffic. Iowa Telecom has chosen to provide this with fiber optic systems. The Iowa Telecom network currently has significant fiber deployed between exchanges. Of the 296 exchanges, 248 are connected to other Iowa Telecom exchanges by fiber. An additional 38 exchanges are connected to other ILECs by fiber. Only 10 exchanges are not connected by fiber, but use copper based facilities. This can provide adequate capacity for broadband service. However, in design of fiber, there are other considerations that must be addressed as well.

A span of fiber between two exchanges is vulnerable to outage if the fiber is cut due to such occurrences as dig-ups or trees falling on aerial fiber. In addition, fiber optic terminal equipment can experience failure of the electronic components that can cause the span to become non-functional;. The most common solution for this vulnerability is to provide two paths between the exchanges. This is accomplished by constructing fiber rings. Studies by RUS and RBOCs have proved that reliability is dramatically increased by using ring architecture, because the likelihood of both fiber paths being disabled at the same time is very much less than the likelihood of failure of a single path. Iowa Telecom plans to deploy 12 fiber rings statewide with full redundancy to serve 187 of their 296 exchanges. Additional exchanges will be served with collapsed rings as dictated by economical deployment of fiber cable. Some rings will be composed completely of fiber owned by Iowa Telecom. Others will be composed of fiber belonging to Iowa Telecom and other ILECs or network owners, where capacity and redundancy can be achieved by trading capacity on various fiber routes to form a complete ring.

There are several different configurations of rings. In all rings, signals travel around the ring in both directions (east-west, and west-east). Thus, there are two paths from each signal for each transmitting location to each receiving location. Some ring architectures use two fibers in each direction for a total of four, some use one in each direction for a total of two. The ring design must balance cost of fibers in the cable sheaths vs. the costs in the fiber optic terminals for each configuration to determine which configuration provides the most economical transport of a unit of data. This configuration can differ depending on plant costs, distance, and amount of traffic to be carried. It is often best to make this decision when the ring is designed on a detailed basis to take into account then-current technological capabilities and costs.

All current migration strategies to broadband, packet based transport architectures for future services, such as digital video, utilize ring technology (including rings switched at the optic level) in the interexchange transport design. Thus, this architecture provides a good basis for migration to services of the foreseeable future.

The only disadvantage to ring architecture is that Iowa Telecom will incur some additional costs that would not be required if rings were not deployed. In some cases, Iowa Telecom will have to build additional fiber cables between some exchanges that would not be required if a point-to-point fiber architecture was used, and Iowa Telecom may have to upgrade or replace some fiber optic terminals that are not currently capable of ring operation. In addition, to utilize the full capability of a ring, such as being able to access any terminal on the ring from any other terminal for maintenance and administration, all terminals have to be from the same vendor. This may require replacement of some terminals that do not fit the overall design scheme. Fiber optic terminal costs can be minimized by purchasing all terminals on one contract with staged delivery as the ring is completed. With customers demanding ever more reliable service, almost all ILECs and other carriers feel that the additional first cost of rings is more than outweighed by ongoing customer satisfaction. Thus, ring topology is deployed wherever possible today.

There are some exchanges that are small and remote from the remainder of the Iowa Telecom network where connection to the network via rings is not planned in the next five years. Iowa Telecom should evaluate these on an ongoing basis to determine the most economical way to connect the exchanges to the Iowa Telecom network. This could be accomplished by leased capacity, or these exchanges could be provided with fiber transport to other ILECs, and connectivity purchased as necessary. Each exchange will have to be evaluated on an individual case basis to determine the most cost effective method of providing transport.

GVNW feels the Iowa Telecom plan conforms to the best industry practices of fiber ring design. This provides broadband capacity and greatly increased reliability to customers in the affected Iowa Telecom exchanges with provision for migration to future architectures.

Switching Network Design

Iowa Telecom plans to consolidate the many types of switches and large number of stand alone host switches into a small number of host switches, replacing many of the current host switches with remote switches or DLCs off the few hosts. This is sometimes referred to as "few hosts, many remotes". Many companies with multiple switch locations have adopted this architecture over the last 5-10 years. This section will examine some of the reason for this, and evaluate whether Iowa Telecom's plan is prudent.

Iowa Telecom's current switching network can best be described as a conglomeration of various inherited brands, types, and configurations that were deployed by three predecessors over time. This includes:

- 296 exchanges
  - 211 remote switches of
    - 12 different types from
      - 4 different switch manufacturers
  - 85 stand-alone host switches of
    - 5 different types from
      - 4 different switch manufacturers

The switch host types are:

- 4 Vidar
- 2 Siemens Stromberg-Carlson DCO
- 55 Nortel DMS 10
- 7 Nortel DMS 100
- 17 AGCS GTD-5

Almost all the switches are not at or near the current operating software generic load. None of the switches are compliant with the Communications Assistance to Law Enforcement Act (CALEA), although waiver requests have been filed as required by the FBI.

Switch Type	Quantity of Hosts	Current Generic	Generic Deployed at Iowa Telecom	CALEA Compliant	Manufacturer Support
Vidar	4	N/A (2)	N/A (2)	No (2)	No (2)
SSC DCO	2	23	16	No	Limited (1)
Nortel DMS 10	55	502	410	No	Yes
Nortel DMS 100	7	15	NA015 on 2 switches NA008 on 5 switches	Yes on 2 No on 5	Yes Limited (1)
AGCS GTD-5	17	4007	4004	No	Limited (1)

Notes:

1.) Manufacturer support is not robust on most generics older than 2 or 3 versions from the current generic.

2.) Manufacturer is out of business due to bankruptcy. There is no current support for new generic software for this switch.

Based on the information above, Iowa Telecom cannot continue to operate in the current configuration with its switches so far out of date. Iowa Telecom is not compliant with several important mandates, including CALEA and LNP in many switches. Generic upgrade will be required over the next few years.

Software upgrades

It is standard operating practice in the ILEC industry to operate switches at the current generic software release or 1 to 2 versions earlier. Software versions older than 2 versions back from the current version are not deployed by most ILECs. This policy assures that support is available from the manufacturer, and that the switch can offer new features and functions as required. It is important to note that generic upgrades are often required by regulatory rulings. In the last decade, such requirements as IntraLATA competition (2-PIC), 800 Number Expansion (8XX), Local Number Portability (LNP), and CALEA, come to mind. All these mandates required a generic upgrade on the switches. Features, functions, and person/machine interfaces differ between generics, sometimes significantly. If all the switches are at the same release or just a few generic releases, ILEC personnel do not have to maintain expertise on many different versions. This optimizes learning curves and deployment of expertise, minimizing operating costs.

The Vidar switch was last manufactured in the early 1980's, at which time, the original manufacturer, TRW-Vidar left the business. The owners of Vidar switches created American Digital Switch Corp. (ADS) to support and upgrade the Vidar switches in place. However, there were not enough Vidar switches in place to justify a business that supported these switches, and upgrades to new services were slow coming to market and sometimes not full-featured. Over the years, ILECs replaced Vidar switches as new services were not available when required from ADS. The number of Vidar switches dwindled. ADS went bankrupt several years ago. It is currently very difficult to obtain parts, even in the used equipment market, for these switches because there are so few left that it is not economical for used equipment dealers to stock parts. Iowa Telecom currently maintains a stock of parts from decommissioned switches as spares. Technical support for problems beyond the capabilities of Iowa Telecom personnel is provided on a contract basis by several retired personnel of another ILEC who had extensive experience with the Vidar switches in the past. This situation leaves Iowa Telecom vulnerable to a catastrophic failure where either parts cannot be obtained or technical help is not available due to retirements or vacations by the few individuals that still have expertise on the Vidar switch. The Vidar switches should be replaced as soon as possible to avoid such a situation. Most ILECs replaced these switches many years ago.

The SSC DCOs are running obsolete software. It is GVNW's experience that the cost to upgrade a DCO runs approximately $30,000 to $75,000 per generic upgrade. In order to upgrade the DCOs to the current generic, the minimum cost to be expected would be approximately $350,000 for software only. Additional hardware would also be required, increasing the price of an upgrade to the point where it would be more economical to replace the DCO switches.

The DMS 10 switches will require a generic upgrade to the 502 generic to provide new features. GVNW has found in various switch bids that this cost averages over $100,000 per switch for hardware and software. Since most of the DMS 10s are small, the cost of the upgrades per customer is large. This makes the DMS 10s candidates for replacement.

The DMS 100 switches are the largest in the Iowa Telecom network. Although they must be upgraded, the cost per customer will be lower than with the DMS 10s because of the larger number of customers over which to spread the cost.

The GTD-5 switches are also not a current generic. The GTD-5 was built by a division of the old General Telephone Company, and widely deployed by the GTE operating companies in the 1980's. After that time, GTE sold the GTD-5 to AT&T (later Lucent), which formed the AGCS company to support the GTD-5. Unlike the Vidar switch, a substantial base of switches and almost 10,000,000 access lines in service of GTD-5 switches provide a viable ongoing business in support of the GTD-5. However, no new GTD-5s have been deployed in recent years, and the number of switches has begun to decrease as they are replaced by newer switches. Thus, there does not appear to be a long-term future with the GTD-5 product line, and further upgrades may not be prudent. These switches are candidates for replacement.

Many generic upgrades will be required to get all the host switches in Iowa Telecom's current network up to the current level. Ongoing upgrades will be required each 1-2 years to remain close to the current version. Since switch software is priced on a per-host-switch basis, the more host switches owned, the more upgrades will have to be purchased. Generic upgrades to the hosts are applicable to all remotes attached to that host, generic upgrades are not required for remotes. Iowa Telecom's plan to replace many of the host switches remotes off a few hosts will minimize ongoing generic upgrade costs.

Upgrade vs. Replace

It has been industry experience, especially in the small switches under approximately 2,500 access lines such as many of those deployed by Iowa Telecom, that if the switch is more than 3-5 generic software versions out of date, it is more cost effective to replace the switch than to upgrade to the current generic. Based on industry experience, this is probably true with many of Iowa Telecom's small host switches.

If these switches will be replaced in any case, a new remote switch is almost always less expensive than a stand alone switch, as there is less intelligence at the remote. Thus, given that the older, small stand-alone switches will be replaced rather than upgraded, it would be prudent to replace these with remotes off other hosts where connectivity between host and remote is in place. The decision to do so would have to be evaluated based on firm quotes for each case when the decision to move to a newer version of generic software is made. This is in keeping with Iowa Telecom's current plan.

GR-303

The existing subscriber carriers, both analog and digital, interface with Iowa Telecom's switches on an analog basis. Since analog carriers will be replaced in the near future, the analog interfaces can be retained for these and phased out over time. However, for digital loop carriers (DLCs), the analog interface requires that there be three analog/digital conversions in the path from the customer to the network. One occurs at the DLC remote unit where analog voice and modem tones are converted to digital for transport on the DLC. At the CO, the DLC CO unit converts the signal to an analog format. The analog line is connected to an analog line circuit on the digital switch. The switch line circuit converts the path back to digital format for switching and transport on the network. This configuration has been used since the introduction of DLCs in the mid 1970's, and continues to function well for voice traffic. However, for modem traffic, such as dial-up Internet access, this arrangement slows data transmission rates to a maximum of approximately 32 Kb (this rate is dependent on the make, model and vintage of the switch and DLC equipment involved). Customers that have purchased 56 Kb modems feel they are getting inferior service, resulting in customer dissatisfaction and complaints. This is especially true when DLCs are introduced into the loop plant to replace physical cable, causing the customer to experience a slow-down in data throughput.

GR 303 technology was introduced to alleviate analog/digital conversion issues by connecting the DLC directly to the switch on a digital basis. In theory, GR 303 should be less expensive than an analog interface between the DLC and switch at the CO because two pieces of equipment that perform analog/digital conversion are eliminated. However, some switch vendors, sensing a threat to their market share, have deliberately priced their GR 303 interface capability feature very high in order to discourage GR 303 deployment and encourage purchase of their own remote switch units. In addition, some older switch designs, such as the Vidar and SSC DCO, do not offer GR 303 at all. Iowa Telecom has, for these reasons, not deployed GR 303 widely in the past. However, in the future, GR 303 will be required to eliminate analog carrier and migrate to CSA design while allowing Internet traffic to be transported at speeds near 56 Kb.

The GR 303 feature is normally sold on a per-host- switch plus per-port basis. Thus, it would be economical for Iowa Telecom to consolidate its existing host switches into fewer switches to minimize per-switch costs for GR 303.

Packet Architecture and Softswitch Migration

Current public switched telecom network switches all utilize a circuit-switched architecture. Each call has a separate path from source to destination that is not shared with any other call. This applies to analog voice signals and digital paths. All Iowa Telecom switches currently utilize circuit based architecture.

Circuit based architecture is a holdover from the earliest days of telegraph (before telephone) technology, and is based on the economics that were prevalent at the time that a path (wires) was cheaper than intelligence (operators). This architecture persisted until today because it is very well suited to voice traffic, which is normally steady in nature and can tolerate very little delay.

With the emergence of computers, and communications between computers, both premises of circuit switched architecture were reversed. Computers provide very inexpensive intelligence relative to placing more wires, and data traffic can tolerate significant delay in most cases. The best model for data traffic uses architecture far older than telegraph, a road. On a road, many travelers share the same path. The same is true with packet technology, where each data message "call" is broken into parts and transmitted. Many different sources and destinations share a single path. Each packet waits for a clear space and enters the path. The source must have adequate intelligence to mark each packet with the sequence it left the source, and the destination must have adequate intelligence to put the packets back together in the same sequence to recreate the original message. This proves to be very easy and fast with computers.

As computers became faster and more sophisticated, it was possible to split digital voice signals into packets, send them over a packet network, and reconstruct them fast enough so that humans involved could not detect any delay. While this is a very simplistic expression of the issues involved, and actual technology to do this is complicated, in the last 3-5 years, computers have become fast enough to do this well, and voice traffic can now be transmitted over packet networks.

The economic goal of the telecom industry since early days has always been to move information at the most economical cost per unit. This goal drives all networks toward packet architecture. In a circuit network, each call has a separate path. If there is no traffic on the path at a given time, no other party can use the path. At the very high speeds of computers, spaces between words, and the time when a person is listening, rather than talking, are huge empty spaces. In a packet network, this space could be used to transmit other information. The resulting economics are such that, depending on traffic mix, a given bandwidth can carry at least twice the data, and sometimes 10 times as much data, using packet architecture as circuit architecture. As data traffic becomes a larger portion of the total traffic on the PSTN every year, the economics of packet architecture are very attractive for telecommunications networks.

Current voice switches such as deployed by Iowa Telecom were introduced in the early 1970's, when computers were primitive, and not very reliable. In order for a computer controlled switch to function at the level of reliability needed in the telecommunications network, the switch manufacturers had to write their own proprietary software, as then available commercial software was not optimized for call processing, and did not achieve adequate reliability. Like circuit architecture, this situation has persisted until today, mainly held in place by the many features required on a voice switch that are built on the old basic call processing software (currently about 3,000 features are listed in the Telcordia spec for voice switches). It is more cost effective to add one feature than to replace the software. This has resulted in a monopoly of software by switch vendors. Currently, due to complexity of the existing programs, new software features are costly and have long lead times. Recently, commercially available software has achieved reliability and performance necessary to operate a telecommunications switch. Since this is commercially available software, new features can be added, much as new applications can be written to run on the Windows operating system for PCs. All the applications writer has to know is how to interface the applications program with the operating program. New features can be written in well-known software languages, rather than the proprietary languages used by current circuit switches. This new model is referred to as "open" in that the operating system and language is open to anyone with adequate knowledge to write new programs. In the current proprietary systems, only the owner can change the program, the program is closed to all other parties. New open systems promise lower costs, faster times to market, and more features available, as many parties can write software, and perhaps compete in providing new features.

The convergence of packet technology and open systems has been broadly labeled "softswitch". Currently, GVNW is monitoring field trials of three softswitches in the Class 5 switch market.[4] Based on progress here, softswitches will be commercially available by year-end 2002. The pricing we have received indicates that softswitches will be very economical, especially in deploying the GR 303 interfaces required for DLCs.

Some current circuit switches can be migrated to softswitch architecture by replacing some of the components with new softswitch functionality. In most cases, the line circuits and GR 303 interfaces are retained for POTS, while the switching network and central processor are replaced with packet based softswitch components. In cases where current switches are deployed, this may be economical vs. replacement depending on relative pricing. Only one of the switch types currently deployed by Iowa Telecom, the Nortel DMS 100, has announced a demonstrated migration path to softswitch architecture. The others either have no path to softswitch, or while they have issued press releases saying they will migrate, have not shown a clear migration path.

Remote switches are basically line circuits with limited processing power located away from the host switch. Centralized processing is done at the host. These line circuits may be retained in a softswitch migration. Economics of softswitch will drive Iowa Telecom to replace many of its switches in the future. The current Iowa Telecom plan of connecting all switches with fiber and replacing stand alone switches with remotes will position Iowa Telecom to move to a softswitch architecture when economical.

Maintenance Issues

Currently in Iowa Telecom, there are five different types of switches with several versions of software in some types. Human/machine interfaces (how craft personnel operate the switch for maintenance and administration) are very different between

[4] Class 5 switches are those that have lines that connect to customers, as opposed to Class 1-4, that have only trunk circuits connecting to other switches. The Class designations are old Bell System terminology that referred to the old hierarchical toll network. The Class designations may not be applicable today, but have persisted.

switches types, and even differ slightly between different software versions on the same switch type. This requires Iowa Telecom personnel to have expertise on many different interfaces. Expertise is costly in terms of training and limits flexibility in assigning personnel to perform work functions based on which switches they have expertise on.

Access to a switch is at the host. Terminals may be located remotely to centralize network monitoring and troubleshooting, however, many troubles require a visit to the host switch to repair faulty hardware or perform certain maintenance functions. Visits to remotes, that typically do not have much local intelligence, tend to be less frequent than to hosts, as there is less equipment and software a the remote, and thus less to go wrong.

Consolidation of many stand alone host switches into a few hosts and many remotes should result in lower overall maintenance costs per customer over time.

Few Hosts-Many Remotes

Iowa Telecom's planned deployment of fiber ring architecture (See "Interexchange Transport Design"), will provide a robust platform for host-remote connection in most cases. As mentioned in the Interexchange Transport section, there are some Iowa Telecom offices that will not be connected by fiber to the Iowa Telecom network. In order to implement a host-remote configuration, there has to be adequate transport bandwidth between the host and remote. Iowa Telecom will need to examine, as part of their ongoing network plan, how to best upgrade the switches in these isolated exchanges. Options such as leased transport, or homing off another company's host where connectivity exists, could be explored. The second option here would require a close arrangement between companies for operating and administration procedures to function properly, and to safeguard the security of each company's service and records.

Conclusion

The Iowa Telecom network plan conforms well to current industry best practices to provide ILEC quality service for rural areas. The plan will upgrade service by providing higher speed dial-up Internet connections, broadband data service, and greatly increased reliability and redundancy. At a high level, all proposed upgrades are in keeping with now current cost-effective industry practices, however, Iowa Telecom must evaluate each deployment in light of then-current technology and pricing.

Two areas still under preliminary investigation should be evaluated in greater detail prior to beginning deployment. Iowa Telecom should consider how to provide interexchange transport and host-remote service to those exchanges that are not currently connected to the Iowa Telecom network. Iowa Telecom should evaluate cost and service issues related to deploying DLCs with GR 303 vs. remote switches in smaller exchanges served by the planned fiber rings.

Exhibit C

Planned Infrastructure Investments
(based upon 2002 Network Improvement Plan)

<u>Loop Costs</u>

Analog Carrier Replacement	$4,713,000
Air Core Cable Replacement	$4,500,000
Lead-Sheathed Cable Replacement	$5,123,000
Replace Obsolete DLCs	$3,800,000
Total Loop Costs	**$18,136,000**

<u>Switch-Related Costs (excluding LNP costs)</u>

DSL from Central Office [redacted]	$5,448,000
DSL from DLC [redacted]	$3,320,000
DLC Direct Interface Capabilities [redacted]	$930,000
Replace Obsolete Line Cards [redacted]	$2,600,000
CALEA Upgrade [redacted]	$2,050,000
Siemens DCO Switch Replacement [redacted]	$759,000
Generic Upgrades (immediate) [redacted]	$1,798,000
Generic Upgrades (future) [redacted]	$2,000,000
New Vertical Services [redacted]	$400,000
VIDAR Switch Replacement [redacted]	$2,408,000
Building Upgrades [redacted]	$1,600,000
Establish "Core" Host Switches [redacted]	$2,350,000
Host Switch Reduction [redacted]	$39,311,000
Total Switch-Related Costs	**$64,974,000**
Local Number Portability [redacted]	**$1,600,000**

<u>Transport-Related Costs</u>

Fiber/Terminals -- Host-Remote Links [redacted]	$9,200,000
Fiber -- Establish Rings [redacted]	$4,250,000
Fiber Optic Terminals -- Establish Rings [redacted]	$4,500,000
Growth [redacted]	$1,945,000
Replace Obsolete Fiber Terminals	$1,900,000
Total Transport-Related Costs	**$21,795,000**
Voicemail Hosts [redacted]	**$3,850,000**
Total Planned Infrastructure Investment	**$110,355,000**