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NDC4

**REPORT ON THE INSTITUTIONAL NETWORK TECHNICAL
REVIEW AND NEEDS ASSESSMENT
FOR THE
NORTHERN DAKOTA COUNTY CABLE COMMUNICATIONS
COMMISSION**

By

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INTRODUCTION

CBG Communications, Inc. (CBG) has conducted a cable-related Needs and Interest Assessment and Technical Review of the institutional network (I-Net) serving the seven member jurisdictions of the Northern Dakota County Cable Communications Commission (NDC4) franchise area. The NDC4 I-Net is a requirement of the cable television franchise agreement with Comcast, as described in Section 7 and Exhibits D. and G. NDC4 and the public Institutions (Cities, School Districts, Dakota County, Inver Hills Community College and Dakota County Library) currently utilizing the I-Net (I-Net Users or Users) financed the construction of the I-Net under the terms of the franchise. Over \$820,000 was provided by I-Net Users in capital payments to the cable operator.

CBG's I-Net Needs and Interests Assessment and system Technical Review have been performed as part of the overall cable-related community needs and interests ascertainment as part of franchise renewal activities with Comcast. As part of the CBG study, we gathered a substantial amount of information from I-Net Users through a variety of methodologies described in the next section of this report. We also developed a detailed Request for Information (RFI) as described in the I-Net Technical Overview section. The information contained in the RFI response received from Comcast was reviewed, as well as information from the independent technical evaluation conducted by CBG.

The results of our review and analysis have allowed us to provide findings, conclusions and recommendations concerning a variety of project elements, including:

- Development of an updated list of technical and administrative contacts for each I-Net User (Attachment 1)
- Review of as-built network diagrams and other technical information to verify construction, design and technical standards
- Confirmation of network design changes and User site additions since 2002, including interconnects
- Descriptions of how I-Net Users have utilized the NDC4 I-Net
- Analysis of current and future needs related to the I-Net fiber ring and star connections

- Determination of a number of needs and interests for I-Net design changes, updates and additional User locations
- Analysis of the economic/budgetary value and savings realized by NDC4 I-Net Users and the need for continued value in the next 10-15 years

The full results of the I-Net Needs and Interests Assessment and Technical Review are presented in the report that follows and provide information for the NDC4 regarding issues of significance to I-Net Users and the ability of the I-Net and Comcast to meet the demonstrated needs and interests of those Users. The findings, conclusions and recommendations detailed in the report and the attachment that follows, provide documented community needs information to assist the NDC4 in franchise renewal proceedings.

STUDY METHODOLOGY

CBG used a variety of research methodologies to perform the I-Net technical review and needs assessment study. These included:

- Key interviews with NDC4 staff and others who oversee the development, implementation and operation of the network so that it functions properly for I-Net Users;
- Detailed focused discussions with I-Net Users, including one group discussion focused on K-12 and higher educational Users and one group discussion focused on local government Users and allied organizations;
- Preparation of, and review of the response to, a detailed Request for Information (RFI) from Comcast concerning the implementation and operation of the network from the company's perspective and according to its franchise requirements; and
- An on-line institutional network Users survey which, asked Users to provide their experiences, attitudes and opinions concerning current and prior uses of the I-Net and their needs and interests concerning the current and future operation of the I-Net.

Additionally, follow-up information was obtained as needed to clarify and to provide additional information to that gathered in the focused discussions, RFI, interviews and survey.

The information gathered was used to analyze a variety of different attributes of past, current and future I-Net utilization, including:

- Voice, video, data, Internet, LAN and WAN applications;
- Past experience and current and future needs related to fiber ring and star connection-related issues including:
 - network management, repair and maintenance
 - implementation of hardware and transport electronics
 - network speeds and transfer rates
 - network reliability and security
 - Internet connections
- Determination of needs and interests related to additional sites and potential network design alterations and enhancements; and
- Assessment of the economic/budgetary value and cost effectiveness of the I-Net to the Users.

Once analyzed, the information resulted in the conclusions and recommendations embodied at the end of this report.

INSTITUTIONAL NETWORK TECHNICAL REVIEW

From 1999 – 2002, CBG’s principals were instrumental in designing, building and proof testing the existing I-Net to best serve the many entities connected to the network. To ensure we had an accurate understanding of the current design and operation of the I-Net, NDC4 sent a Request For Information (“RFI”) to Comcast in mid-October, 2013. The RFI asked Comcast for current information related to network design, site lists showing all sites currently connected to the I-Net, fiber counts and architectures employed.

Comcast provided information on November 15, 2013 including a site list, maps of the network and cutsheets showing the routing of fibers and the number of fibers throughout their network available for the NDC4 I-Net. Much of the information is labeled “Confidential” and required that a Non-Disclosure Agreement be signed by CBG. Such “Confidential” information is not

disclosed in this Report. CBG has reviewed this documentation and provides the following findings:

There are currently 38 facilities connected to the NDC4 I-Net (not including Comcast’s hub location). Of these 38 facilities, the following nine (9) facilities, plus Comcast’s hub location, are connected in a ring topology:

Facility Name	Facility Address	City
Comcast Hub	Babcock Trail	IGH
Henry Sibley High School	1897 Delaware Avenue	MH
West St. Paul City Hall	1616 Wentworth Avenue	WSP
Inver Hills Community College	2500 80 th Street	IGH
Inver Grove Heights City Hall	8150 Barbara Avenue	IGH
Dakota County Northern Service Center	1 Mendota Road	WSP
Inver Glen Library	8098 Blaine Avenue	IGH
Simley High School	2920 80 th Street E	IGH
South St. Paul Senior High	104 5 th Avenue E	SSP
Wentworth Library	199 Wentworth Avenue E	WSP

In addition to the above nine facilities connected via a ring topology, the following 29 facilities are connected via a star topology:

Facility Name	Facility Address	
Convent of the Visitation	2455 Visitation Drive	MH
Friendly Hills Middle School	701 Mendota Heights Road	MH
Garlough Elementary School	1740 Charlton Road	WSP
Mendota Elementary School	1979 Summit Lane	MH
Mendota Heights City Hall	1101 Victoria Curve	MH
Moreland Elementary School	217 Moreland Avenue	WSP
Somerset Elementary School	1355 Dodd Road	MH
South St. Paul City Hall	125 3 rd Avenue N	SSP
Inver Grove Heights Fire Department Station #1	7015 Clayton Avenue E	IGH

Inver Grove Heights Fire Department Station #3	2059 Upper 55 th Street E	IGH
Inver Grove Heights Water Treatment	Babcock Trail	IGH
Inver Wood Golf Course	1850 70 th Street E	IGH
Salem Elementary School	5899 Babcock Trail	IGH
District #197 Transportation Garage	1145 Medallion Drive	MH
Mendota Heights Fire Department	2107 Dodd Road	MH
Mendota Public Works Garage	2431 Lexington Avenue S	MH
NDC4 Studio Location	5845 Blaine Avenue	IGH
Pine Bend Elementary School	9875 Inver Grove Trail	IGH
South Grove Elementary School (Building is gone. Fiber is cut at the property line near the road)	7560 Clayton Avenue	IGH
Hilltop Elementary School	321 68 th Street E	IGH
Family Connections	1515 5 th Avenue S	SSP
Kaposia Elementary School	1225 1 st Avenue N	SSP
Lincoln Center	357 9 th Avenue N	SSP
South St. Paul District Center	104 5 th Avenue S	SSP
ALC (known today as CLC)	151 6 th Street E	SSP
Heritage Middle School	121 Butler Avenue	WSP
Thompson Oaks Golf Course	1555 Oakdale Avenue	WSP
Thompson Park Activity Center (TPAC)	1200 Stassen Lane	WSP
West St. Paul Ice Arena	60 Emerson Avenue W	WSP
West St. Paul Pool	92 Orme Street	WSP

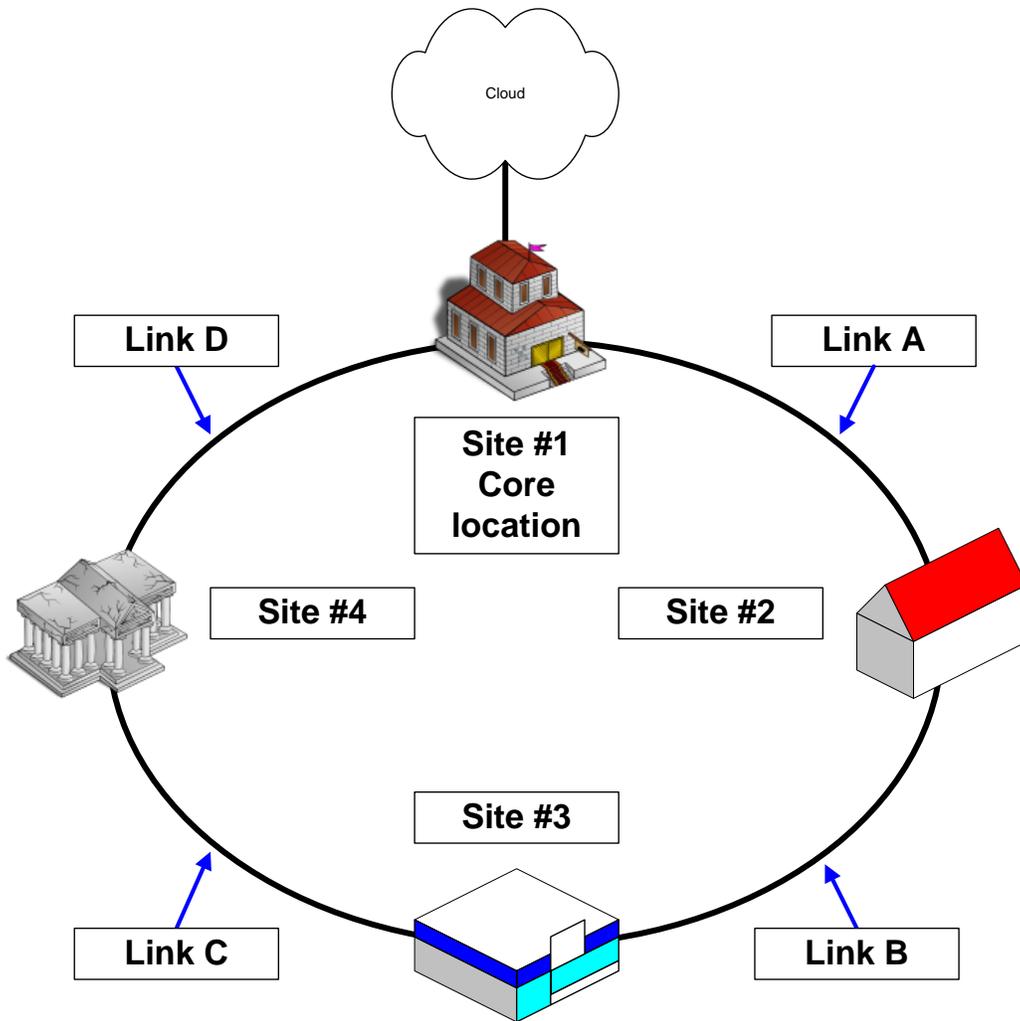
Architecture

As stated above, the NDC4 I-Net is currently connected to 38 locations throughout the NDC4 area, plus the Comcast Hub in Inver Grove Heights. All of the links between sites, both on the ring and star portions of the network, have 6 dark fibers that are designated to be I-Net fibers for use by the entities connected to the network. The only exceptions are the NDC4 location which has 18 fibers routed in a star back to the Comcast hub location and an 8 count fiber from the Inver Grove Heights Fire Station #1 to the Inver Grove Heights City Hall. It should be noted that the core locations have 6 fibers into the facility and 6 fibers out of the facility. In addition,

some of the core locations also have fibers entering them from locations that star out from the core location.

By way of background, there are two types of connections or links that are utilized to make connectivity on the NDC4 I-Net between 2 or more facilities. The first is a ring topology or design. This is created by having fiber optic cables enter each facility and a separate set of fiber optic cables leave the facility to connect to the next location on the ring. This design, by default, provides a higher level of redundancy whereby if the fiber feeding a facility is cut, or otherwise compromised, the fiber leaving the facility can replace the path that has been compromised (Essentially, communications are routed in the other direction around the ring). Therefore, connectivity can be restored in a relatively rapid manner. A simplistic description of this is as follows:

In the diagram below all forward traffic is running around the network from Site #1 to Site #2 to Site #3 to Site #4 and then continuing on to Site #1, etc.

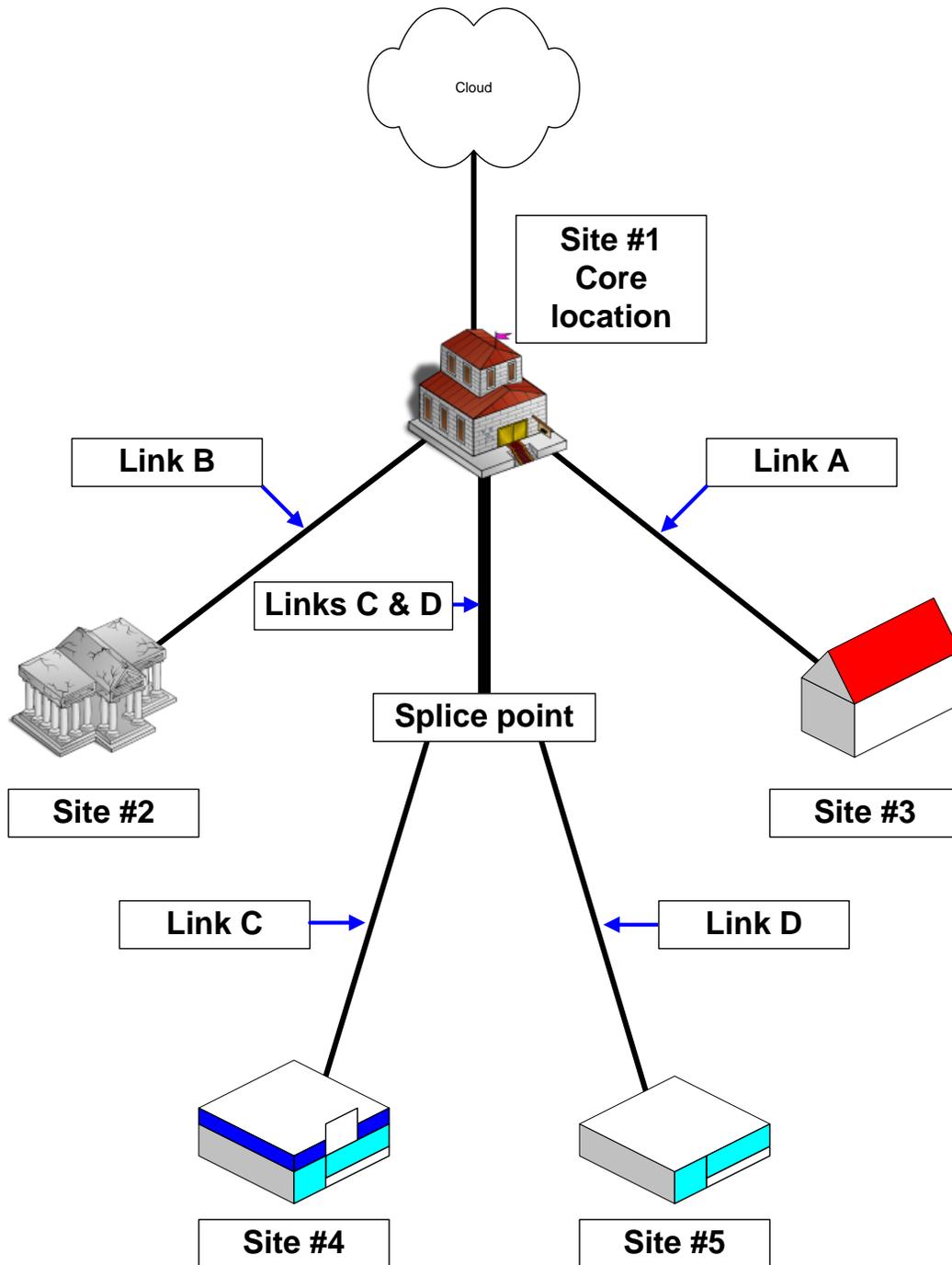


To most simply explain how reliability is improved by this architecture, assume traffic is routed around the network as explained above. However, if link A is cut, effectively removing it from the network, all traffic that normally runs from site #1 to site #2 would now be routed via links D, C and B to get to site #2. Therefore all traffic on the network continues to reach all locations on the ring.

The effectiveness of this redundancy is increased by connecting equipment that automatically switches the direction of network traffic in order to bypass the link that has experienced a problem. Without this equipment in place, manual switching of fiber routes would need to occur, which would increase the amount of downtime in the event of a failure on one of the links. This equipment automatically switches the routing of traffic with no interruption in service.

Depending on the location of the network sites, their proximity to each other and other routing factors, a ring architecture can be more costly to build because two separate paths are required. This also requires more construction to occur for placement of the fiber optic cables as well as additional maintenance of the infrastructure. Therefore, not all connections may be able to be cost effectively built as ring connections.

The second, often more cost effective, architecture or design employed on the NDC4 I-Net is known as a star configuration, providing star connections or spurs back to a core location located on the above ring network. This design provides a single fiber path (multiple fibers) between locations. Star designs are largely as functional as ring designs, however, there is a lower level of redundancy because there is only a single link, and therefore single points of failure, between facilities. Where reliability is less critical, a star architecture may be desired because of the often lower cost to construct links between facilities. This architecture is shown in the diagram below:



Reliability on a star-configured network can be further explained in the following manner: In the above diagram, each star or spur connection has a single path back to a core location (Site #1 in this diagram). If Link C were cut, continuity or connectivity from Site #1 to Site #4 would be lost until the fiber is repaired. Furthermore, if the fiber were cut between the splice point and Site #1, connectivity to Sites #4 & #5 would be lost until the fiber was repaired.

Network Management

Each of the governmental, educational and library Users of the network are ultimately responsible for lighting or activating the network to fulfill their needs as well as for maintaining the network. However, it was found early in the network design phase in the late 1990s and early 2000s, that a single entity could more effectively manage the network. It was determined that the State of Minnesota, which needed to connect to many of the government facilities served by the I-Net, could apply their expertise across the I-Net to most effectively activate the network and manage it for most connections. This group is currently known as MN.IT.

MN.IT has deployed and maintained equipment on the ring portion of the network to act as a backbone between core locations and as aggregation points for traffic entering the ring via star connections. This ring is currently designed with a capacity of 1 gigabits per second (Gbps) shared capacity among all entities using the I-Net. This capacity has been sufficient to allow the aggregation of the traffic from the Star locations, which are each provisioned up to 100 megabits per second (Mbps) capacity. Because the star locations do not regularly utilize their maximum capacity, the 1 Gbps backbone can accommodate many more than 10 100Mbps connections.

Comcast is responsible for maintaining the existing fiber optic cable infrastructure, including rerouting of fiber when necessary, locating the fiber prior to construction near the fiber, expanding to new or relocated facilities, etc. MN.IT is responsible for lighting the fiber provided by Comcast, managing the network and troubleshooting problems that occur on the network. In addition, MN.IT is responsible for scaling or upgrading the equipment at star locations and on the ring as needs for capacity increase over time.

FINDINGS

Technical Review

After review of the documentation provided by Comcast, meetings with the I-Net Users, discussions with NDC4 and Town Square Television staff, analysis of the surveys as described further below and interviews of I-Net Users, our findings indicate that the current NDC4 I-Net is constructed and maintained as envisioned in the existing Franchise Agreement with Comcast.

The I-Net currently has 9 facilities connected via a ring architecture (core facilities) throughout the NDC4 geographical area. Furthermore, there are currently 29 facilities connected to the NDC4 I-Net in a star configuration with spurs or links back to a facility on the ring.

The fiber optic I-Net has been highly reliable over the time period since its completion and activation over 10 years ago. Comcast has been responsive to the Users' needs with prompt reaction and resolution of problems when they have occurred. Furthermore, network certification testing was performed to prove the network was built to specification prior to activation and based on Users' feedback, regarding network operation and reliability we surmise that the network continues to function as designed.

Needs Assessment

As indicated above, two focused discussions were held with I-Net Users, one focusing on local government I-Net use and current and future needs; and one focusing on K-12 and higher educational use of the I-Net and needs going forward. The findings from both focus groups are profiled below.

Focused Discussions

The focused discussions were set-up as "work groups" to ensure that the participants knew that they were designed to be highly interactive and discuss the existing I-Net from a very detailed "hands-on" use of the network perspective, and future I-Net needs from a detailed planning and visioning perspective.

The specific discussion topics included:

- A brief overview of the cable franchising and renewal process
- A discussion of the existing I-Net, including the utility of the existing system focusing on fiber infrastructure, transport equipment, system capacity, applications enabled and system performance parameters; and
- A discussion of current and future I-Net needs to be pursued and negotiated in a renewed franchise, centering on network architecture, infrastructure, connectivity, applications and resolution of any existing issues.

The key findings from each focused discussion are detailed below.

Local Government Focused Discussion

A focused discussion was held on October 9, 2013 that was well attended by the cities and Dakota County utilizing the I-Net, as well as a consortium of Minnesota local governments called the Local Government Information Systems (LOGIS) and the State of Minnesota's IT (MN.IT) department. The following entities were represented at the meeting:

- NDC4
- Mendota Heights
- South St. Paul
- Inver Grove Heights
- West St. Paul
- Dakota County
- Dakota County Libraries
- MN.IT
- LOGIS

The focused discussion allowed participants to contribute to the discussion and share their current and future needs related to networking in general and specifically as they relate to the current and future NDC4 I-Net. Key findings include:

- **The existing fiber optic I-Net has proven to be highly valuable and has fulfilled many of the NDC4 member local governments' network connectivity needs.** Each of the entities represented have facilities connected via the existing I-Net. The I-Net enables video, voice and data communications that facilitate many governmental functions, which ultimately provide benefits to the residents of each of the entities. Examples of capabilities and applications enabled by the I-Net include:
 - Enabling expensive software programs to be utilized enterprise wide, including at remote locations
 - Providing Internet access at libraries, for the general public, who cannot afford high speed Internet at home

- Connecting video surveillance cameras for public safety and traffic management and enabling public safety entities to monitor school video surveillance
- Uploading remote video from police cars
- Providing flexibility for moving servers as needs change
- Connecting voice (phone) systems
- Facilitation of video applications which to date include, video conferencing, Skype conferencing, backhaul for PEG productions, as well as video training and sharing of training and informational video

The fiber optic I-Net has been provisioned at 1 Gbps aggregate around the ring and then 100 Mbps connections for each of the Users starrng into the ring. Participants indicated that utilization of the network and capacity needs continue to grow with more Users being added over time, the expansion of current applications and the deployment of new applications. Therefore, MN.IT is continually monitoring the utilization of available capacity and will be upgrading the equipment on the network as needs dictate.

- **Governmental Users find the affordability of the existing I-Net to be incomparable to other options for connectivity.** As evidence of this, Governmental Users have eliminated T-1s that were very costly. One specific example was the elimination of 36 T-1s that averaged approximately \$1,500 per month for each connection. These connections were provisioned on the I-Net at higher speeds at significantly lower costs. The investment that the Users made in the network back in 2002 has proven to be extremely cost effective. The term “priceless” was used to describe the flexibility and cost effectiveness of the network.
- **Governmental Users are extremely satisfied with the existing I-Net’s reliability.** Users are satisfied with the reliability of the I-Net. Most often problems are related to the equipment on the network rather than Comcast’s fiber optic infrastructure. Each organization troubleshoots and repairs problems at all star locations. If the problem is found to be on the ring, the User calls MN.IT who troubleshoots the problem and notifies Comcast if the problem may be fiber optic cable related. MN.IT is typically the first

responder when there are issues with ring or core I-Net connections and most often MN.IT is working with Comcast to diagnose and fix problems before the Users are aware of a problem. Problems have been resolved quickly.

Users, including MN.IT, responded that Comcast has been very cooperative and responsive when problems arise.

The ring or core connections have provided a very high level of reliability. The star connections into each core facility, creating single points of failure, have also been highly reliable with few problems over the course of time.

Regarding, future needs and interests, participants discussed a number of enhancements that need to be made going forward. Specifically:

- **Governmental entities cited a need to expand the number of sites that have connectivity via the ring.** There is a need for redundancy that would be provided by a ring architecture rather than the existing star architecture currently in place for some entities. For instance, the City of Mendota Heights spurs back to Henry Sibley High School. This spur made economic sense when the network was initially designed. However, with the I-Net evolving from an ancillary benefit to cities to a critical communication platform, this is no longer a desirable network architecture for this location. This creates single points of failure for the City that can become problematic if the fiber spur is cut or otherwise compromised.
- **Bandwidth, both on the ring and for remaining star connections, will need to continue to increase at rapidly increasing levels. Bandwidth scalability is critical.** Users stated that in the past the network's designed capacity limits were projected to be sufficient for several years to come. However, these limits were exceeded. Some Users were hesitant to try to project exact future capacity requirements, but are all in agreement that capacity needs will continue to increase rapidly. Bandwidth needs will increase as new applications are developed and deployed. For instance, a few years ago license plate readers were not used. Today these are increasingly used by some of the cities. Video needs will also continue to expand. More and more video security and surveillance will continue to drive the need for more capacity throughout the network. This will include

applications that do not exist today, or have not been deployed yet. Enhancements of video quality to HD and future versions of HD will drive capacity needs, as will real-time video conferencing, video training and informational services sharing between buildings and cities, County, schools, libraries, etc. In addition, increases in the use of portable devices by city employees and the public in the case of the libraries, drive the need for more capacity.

- **Interconnections need to continue and be expanded.** The existing interconnect to St. Paul is currently utilized to provide public safety, governmental and educational connectivity to the State of Minnesota, TIES and LOGIS. These entities provide services and applications to the various governmental and educational entities on the NDC4 I-Net. These interconnections need to be maintained and be scalable over the course of any renewed franchise term.
- **The NDC4 I-Net is affordable and scalable in its current configuration. The I-Net needs to continue to be affordable and scalable in the future.** As detailed above, the existing I-Net has been very cost effective. In addition, group participants indicated that the I-Net has provided a level of flexibility and scalability not readily available over other managed networks. MN.IT can make changes, in a timely manner, as the needs of individual entities change. This cost effectiveness, high level of scalability and flexibility is not attainable on other networks that are currently commercially available.
- **Network upgrades and expansion.** The governmental focus group indicated a need to continue their ability to expand the existing network to new or additional locations in the future. Specific instances for needed expansion today include:
 - South St. Paul City Hall (needs to be a ring site rather than a star site. Ring fiber goes through the City Hall today as a splice-through)
 - South St. Paul Airport
 - South St. Paul Public Works building

- South St. Paul Wakota Arena (need a direct connection to the South St. Paul City Hall in addition to the connection to the South St. Paul High School)
- South St. Paul Central Square Community Center
- West St. Paul Golf Course (expand from current connection at the Garage)

Educational Focused Discussion

A variety of educational representatives participated in a focused discussion held on October 10, 2013, including representatives from:

- Inver Hills Community College
- ISD 197, West St. Paul/Mendota Heights/Eagan Schools
- ISD 199, Inver Grove Heights Community Schools
- South St. Paul Public Schools
- St. Croix Lutheran High School
- TIES – (originally known as “Technology Information Educational Systems”)

Participants engaged in a wide-ranging, in-depth and interactive conversation during the focused discussion group, which resulted in the following key findings:

- **Educational Users find that the existing fiber optic I-Net has been highly beneficial in providing network connectivity.** Specifically, the current I-Net provides the connectivity that each school district and Inver Hills Community College need between their facilities. The I-Net enables high capacity video, voice and data communications for the benefit of administrators, faculty and students. Specific examples of beneficial I-Net utilization include:
 - Enterprise networks that enable many client/server applications
 - Internet access for classroom, student and administrative use
 - Both PBX and Voice over IP (VoIP) phone systems

- Video applications, to date including telepresence for distance learning, as well as access to YouTube and Vimeo

In the same manner as the governmental agencies use of the network, the fiber optic I-Net has been provisioned at 1 Gbps aggregate around the ring and then 100 Mbps connections for each of the Users starrng into the ring. Participants indicated that on average about 60% of each connection is utilized currently and this percentage is growing exponentially as applications increase.

- **The interconnections between the institutional network and other fiber infrastructure have been extremely valuable to Educational Users.** For example, the transport equipment for ring sites is provisioned by MN.IT and all star connections are provided by each of the entities using these star links and TIES utilizes these connections to provision its services to the schools. It is through interconnections with other I-Nets and fiber infrastructure that TIES (located in St Paul) is able to provision the school districts' services on the NDC4 I-Net. Other interconnects include:
 - Connection from Pilot Knob Elementary in Eagan through City of Eagan I-Net fiber and then Comcast's metropolitan area institutional network interconnection known as the PRISMA system (PRISMA) at 30 Mbps connection speed
 - Interconnection between TIES and the State of Minnesota's Information Technology group (MN.IT) in the Minnesota Technology Center, most often referred to as the 511 Building, in Minneapolis. This interconnect is also made through the PRISMA system that is further leveraged by the NDC4 I-Net Users.
 - Redundant connections for Internet access to TIES through an intertie to the gigapop that connects the University of Minnesota's Internet backbone into Chicago and then a secondary connection via Time Warner Telecom that connects the Internet connection to Kansas City's Internet hub. The main Internet trunk is a 10 Gbps connection coming into the (511 Building) via Level 3.

Participants noted that what all this means is that the Educational Users of the NDC4 I-Net have high reliability concerning Internet access because of the

multiple high capacity paths that are providing Internet service into the NDC4 I-Net.

- Two interconnections providing 100 Mbps Internet into the NDC4 ring for Inver Hills Community College.
- **Educational Users have found that the existing I-Net is very reliable.** The Users are responsible for their star connections and the equipment utilized to activate the star locations. If a problem is believed to exist on the fiber to a star location, the Users contact Comcast directly. Regarding the ring sites, when there has been a problem, MN.IT and TIES handle the trouble calls. Any that are fiber-related are then passed on to Comcast. Participants indicated that Comcast has responded quickly in the two fiber cut instances that were discussed. There are star connections into each core facility (meaning single points of failure) but these have also been largely reliable. School districts have been involved in the trouble call process when there have been problems with the star connections, although there have been very few.
- **Educational Users find the existing I-Net to be an extremely affordable network.** Educational Users noted that the investment in the I-Net by the school districts and Inver Hills Community College in the long term has been very cost effective. They note that, for example, other providers of gigabit Ethernet circuits would charge them approximately \$1,500 per month, when the provisioning of such around the ring and the 100 Mbps connections to sites have ended up costing substantially less than that.

Regarding future needs and interests, participants discussed a number of enhancements that need to be made going forward. Specifically:

- **Educational entities cited a need to expand the number of sites that have access to the ring.** For example, South St. Paul Schools are served by star connections through South St. Paul High School which then are routed to its District Office (HQ) facility. They note that it will be important to reconfigure the existing ring infrastructure so that the District Office HQ is on the ring. They would also like to create more redundant pathways to lessen the single points of failure.

West St. Paul Schools would like to see all of its sites connected in a ring fashion. They are now involved in a pilot project using state funds for a leasing model to interconnect their sites with full ring infrastructure (the pilot is at around 50% completion). Regardless of how the pilot proceeds, they noted that the I-Net will continue to be needed and it is important, again, to reduce single points of failure.

Consistent with this, it will be important to increase redundancy within the overall network, either through physical redundancy or provider redundancy. Again, participants noted that this is why the I-Net will continue to be needed regardless of how individual educational entity networks move forward, either as the primary source of network communications or as a redundant source.

- **Bandwidth, both on the ring and for remaining star connections, will need to be increased.** All the educational entities noted applications and overall network use that are driving the need for higher bandwidth at an increasing pace. These include such applications and uses as:
 - The increase in the use of portable devices within the schools and on campus by students, faculty and administrators alike. Additionally, Inver Hills Community College notes a growing number of wireless Users that have a growing need for high capacity access. They note that their current network now has 3500 unique devices on it.
 - The increase in cloud applications requiring a greater amount of information to be both uploaded to, and downloaded from, the Internet. Participants noted that, in some cases, 60% of their applications are cloud-based now, and in every case are increasing.
 - Increased use of telepresence. Inver Hills Community College noted that telepresence is already using 5 to 6 gigabits of their total network capacity and will increase, placing a higher demand on their ring and Internet connections. In fact, they see a point at which, during a 5-10 year planning horizon, they will need a 10 Gbps aggregate connection just for their own use. This means that even if the ring is upgraded from 1 Gbps to 10 Gbps as is contemplated in the near future

during the planning horizon, there will potentially be a need for multiple 10 Gbps connections around the I-Net ring.

- Greater use of real-time services noted by school districts such as VoIP and access to and provision of video services, like increased access to YouTube and Vimeo, and the uploading of high definition video content. They also note increased bandwidth needs due to K-12 telepresence requirements.
 - The need for more on-line collaborations noted by school districts, increasing the capacity needed for interactive Internet access.
 - An increase in teleconferencing. It's always been extremely useful in more remote areas of the state and is growing in popularity in denser areas of the state, such as the NDC4 jurisdictions.
 - An around the clock office and learning environment, which is increasing workload generally to 365 days a year, which in turn is increasing the number of enterprise applications that need simultaneous capacity on the network.
- **Existing interconnects need to continue and be expanded.** All of the existing interconnects are critical to effective educational use of the NDC4 I-Net. Additionally, new interconnects such as establishing one across Dakota County to connect Inver Hills Community College with Dakota Technical College, would be significantly useful.
 - **Use of the I-Net is affordable now and needs to continue to be affordable in the future.** Every educational participant noted that the affordability of the I-Net was critical in helping make effective use of the applications that are currently on the I-Net and that this affordability needs to continue at present or even better levels.
 - **The existing foundation of the network is flexible and scalable and should continue, with the addition of more fiber infrastructure and additional ring configuration, in order to meet the growing needs of educational entities in the future.** Participants noted that the existing dark fiber network has significant capacity that could continue to be leveraged simply by changing out cards in transport equipment. They also noted that in cases where they have sought their own network infrastructure, they have determined

that developing dark fiber similar to the NDC4 I-Net was the most cost effective, flexible and scalable solution to meet their needs. Accordingly, dark fiber continues to be the preferred solution for meeting the educational entities' needs.

It would be helpful to have more fiber strands available on the network to enable the provision of both aggregate services across the ring as well as specific targeted services from point to point. Accordingly, adding dark fiber strands to the existing network would be beneficial.

Participants indicated that they had leased some connections in the past, but had not experienced the same high reliability, the same flexibility, nor the highly affordable cost.

NDC4 Institutional Network Users Survey

Introduction

During October and November of 2013, an on-line survey of NDC4 I-Net Users and stakeholders was performed. The survey was designed to collect information both operational and technical in nature. Stakeholders were asked questions aimed at building an understanding of the I-Net's current functionality as well as visionary projections, plans and needs in the future. The key findings from the I-Net Needs Assessment survey are as follows:

Responding Organizations

Both government and educational organizations responded to the survey, including:

Local Government

Dakota County

Dakota County Libraries

City of Inver Grove Heights

City of Mendota Heights

City of South St. Paul

City of West St. Paul

LOGIS (Application provider to local governments)

MN.IT (Application provider and ring network manager)

Educational

ISD 197 - West St. Paul, Mendota Heights, Eagan Area Schools

ISD 199 - Inver Grove Heights Community Schools

South St. Paul Public Schools

Intermediate School District 917

TIES (Application and transport system provider to school districts)

Inver Hills Community College

St. Croix Lutheran High School

Non-Profit/PEG Access Provider

Town Square Television

Representatives

Representatives of the organizations were all familiar with the use and operation of the I-Net and included IT Managers, Directors of Technology and Technical Services, Network Engineers and Architects, Technology Coordinators and Specialists, and City Administrators.

Sites Connected

Both local government and educational respondents listed multiple sites connected to the institutional network core sites that are on the I-Net ring or star sites connecting into the ring. These sites varied in connection speed from 100 Mbps (primarily star connections) to 1 Gbps (primarily ring connections).

Other connections were listed by I-Net Users that were provided by other means that were interconnected into, and leveraged the capacity of, the I-Net. This included leased connections such as a T1 from the South St. Paul maintenance center back to City Hall, a 5 Mbps point to point microwave connection from Fleming Field back to South St. Paul's core network, a

connection for South St. Paul Schools using district-owned fiber to the Central Square community center, a multimode fiber connection from the Inver Grove City Hall to the public works maintenance shop, a 30 Mbps connection routed through the City of Eagan's I-Net to the NDC4 I-Net for Pilot Knob Elementary and other similar connections.

Application and network service providers such as MN.IT, LOGIS and TIES indicated that a connection into the NDC4 ring was key to connecting government and educational entities to their services. Similarly, Town Square Television discussed how it utilized not only I-Net fibers to transport video for live city meetings and other PEG channel purposes, but also interconnects through the PRISMA system to send PEG video and other files to other PEG studios outside the NDC4 area.

Future I-Net Connections

Respondents to the survey noted the need for continuation of existing connections, and also noted a number of additional sites that need to be connected in the future. For example, St. Croix Lutheran indicated that it would like a number of I-Net connections, including its main campus building, future dormitory and the press box at the football field/track.

Town Square Television indicated a number of connection needs beyond existing connections to other PEG Access centers, including new connections to organizations such as Lakeville TV, Farmington TV and Hastings TV, all within the next three years. Furthermore, Town Square Television is currently utilizing all 18 fibers it has back to the Comcast hub. Additional fibers will be needed in the future. Additional capacity may be made available by re-purposing the existing fibers via utilization of additional colors of light. MN.IT also noted the possibility of using multiple wavelengths on the fiber I-Net

Other new connections noted by existing Users included:

- City parks
- Lift stations
- Public WiFi points
- A new fire station
- Pool locations

- Golf courses (maintenance buildings)
- Surveillance cameras in different parts of the City

Other general comments included the need for increased bandwidth up to 10 Gbps in the future, as well as more redundant paths. For example, South St. Paul public schools indicated that they need to create redundancy for all their major sites, whether creating a ring for those sites or using the I-Net as part of a total redundancy strategy.

Current and Future Redundancy

Survey respondents noted several redundant pathways that they currently utilize. For example, Intermediate School District 917 noted redundant paths that they have to TIES. Similarly, TIES noted that they have several rings around the Twin Cities in order to provide redundant links to most of the school districts. They also noted that they have multiple connections to Tier 1 national backbone providers for Internet access and other applications.

ISD 197 noted that they have a 100 Mbps Comcast connection as well as a 200 Mbps CenturyLink connection. Also Dakota County indicated that the state provides a 10 Gbps redundant backbone into their Northern Service Center.

Significant needs were noted for new redundant connections, including:

- Expansion of the ring topology to more sites where economically viable. Specifically noted by MN.IT were the Mendota Heights and South St. Paul City Hall locations.
- Adding a physically redundant path for Inver Hills Community College
- Adding a full fail-over location for the City of Inver Grove Heights Water Treatment Plant, and
- Exploring opportunities for duplicate facilities through partnering agencies.

Additionally, Dakota County indicated that it is moving forward with plans to build redundant connections and South St. Paul Public Schools has developed an RFP to create a redundant ring architecture.

Some I-Net Users indicated that they already have redundant connections to their Internet service provider (ISP), however others indicated that there is a need but the cost is a barrier.

Network Monitoring

Survey respondents indicated a variety of network monitoring tools, approaches and capabilities. Some indicated they have limited monitoring, while others indicated that they rely on service providers such as LOGIS, TIES, MN.IT and Dakota County IT.

Regarding other information that they would like to have available, some said that the current system is good and nothing further is needed at this time. Others indicated that they would like to have more proactive notification of outages and other issues as well as better analytics tools.

Wide Area Network (WAN)

Many respondents indicated that their wide area networks, including those portions provisioned over the I-Net, are connected to sites owned or shared by other agencies, especially the State of Minnesota network and the Dakota County network. The libraries also indicated that they are connected to other libraries and TIES is connected to the University of Minnesota. Inver Hills Community College is also connected to the state of Minnesota through a connection via the St. Paul I-Net. South St. Paul Public Schools are connected into the City of South St. Paul's network and vice versa. Town Square Television is connected into a number of high school building networks for live IP video feeds.

The majority of respondents indicated that their current WAN architecture is meeting their immediate or near term needs. Those that indicated "No" noted a lack of bandwidth, a need for additional strands of fiber, and the expensive cost of leased lines.

Most respondents noted that their WAN requirements would change over the foreseeable future based on new applications and the need for additional bandwidth. For example, LOGIS indicated that for some of their cities, they are migrating to 10 Gbps connections, but could not do this for those on the NDC4 ring because of current bandwidth limitations.

TIES indicated that they are deploying 10 Gbps links and they expect this to grow, especially as school districts deploy more personal devices that need to access the network. Inver Hills Community College needs QOS on the network for increasing use of telepresence. The City of

West St. Paul indicates that it will be important to not be “handicapped” by network limitations in order to implement new technology and that expansion of fiber networks, including the I-Net, would be key to preventing this type of limitation.

Two respondents indicated a need for reduced bandwidth WAN service, at a lower cost. Specifically, Dakota County indicated that traffic signals and other small sites could use reduced bandwidth. Similarly, the City of Mendota Heights said that the golf course, lift stations and water towers could potentially use reduced bandwidth.

Internet Service Provider Access

Respondents indicated a variety of current connections to Internet service providers including everything from MN.IT’s multiple 10 Gbps connections to multiple Tier 1 ISPs and then 10 Gbps backbone links from MN.IT to Dakota County to a number of 100 Mbps connections for various Users.

The vast majority of Users indicated that their current Internet service is meeting their immediate or near term needs. Regarding those that said “No”, the City of South St. Paul indicated that the bandwidth is too limited for mass data movement and offsite backups and South St. Paul Public Schools indicated that they have a concern that there is no redundancy to major educational sites.

Most I-Net Users noted an increase in the need for Internet access in the foreseeable future, including the need for more bandwidth as more services are delivered online, including both applications and storage. Also, increased use of wireless devices and streaming audio and video will require greater Internet access. Overall, Users see increases from 100 Mbps to 300+ Mbps, 1 Gbps to 10 Gbps and then to multiple 10 Gbps links over time.

Voice Connectivity

Respondents note both the use of organization wide PBX systems for their voice applications, as well as VoIP systems. A number of respondents use the I-Net for their voice connections. For example, South St. Paul Public Schools uses the I-Net for a hybrid/digital/VoIP with T1 emulation system and will be looking to move to a full VoIP solution sometime during this fiscal year. The City of South St. Paul currently connects three sites with T1s not on the I-Net, but plans to add VoIP in the future somewhere in the 2016 to 2020 timeframe. While many manage their systems internally, some use external management and some like the City of South St. Paul

will be looking to have an externally managed system when it implements VoIP. Nearly every entity that uses VoIP applications over the I-Net has been satisfied with the performance of the I-Net for that application. While some are unsure of whether they will increase use of VoIP in the future (primarily based on unknown budgetary requirements), several indicated that they would like to expand their use based on the need for more phones or the need to expand it to more sites. Some, such as Dakota County and Inver Hills Community College, indicated the desire to work with other agencies and pursue shared VoIP infrastructures.

Use of Video Communications

Survey respondents indicated a variety of video communications uses of their network including video conferencing, live video streaming, on demand video and PEG channel signal delivery. The majority of respondents were using the Internet for accessing and providing such video, and the majority was using the I-Net for at least a portion of the transport.

Specifically, Town Square Television is using the I-Net for transporting live video of city meetings from four fixed sites as well as live video from sporting events at all 6 area high schools. TIES' video applications include remote meetings and remote class hosting. The City of South St. Paul uses video for video conference training and streaming video reception. ISD 197 uses a variety of Internet video such as YouTube, Skype and Google hangouts. MN.IT uses H.323 and Cisco Telepresence applications.

Regarding future video transport needs, a variety were noted including increases in HD video at all I-Net sites for Town Square Television. South St. Paul Public Schools noted the need for live event streaming as well as High Definition and on demand video for classrooms. The City of South St. Paul noted the need for additional staff training and other video conferences. Dakota County indicated that the implementation of virtual desktop infrastructure would enable more desktop video to be acquired. Inver Hills Community College noted an increase in telepresence requirements. ISD 197 noted a need for more robust video conferencing.

I-Net Availability and Reliability

The vast majority of respondents have not had problems with I-Net uptime. Those that had indicated that they had either minor interruptions or storm related interruptions.

Most respondents also did not have any connectivity problems and those that did indicated that they were related to cut cables or configuration bottlenecks and problems. Most respondents also indicated that response time for problem resolution had been acceptable in that Comcast employees have been available within a reasonable amount of time. TIES noted that the response time had exceeded the time allowed by the franchise, but that it has to go through MN.IT so this elongates the time. In fact, several respondents noted that the state handles these issues and so the state would need to weigh in on this question (MN.IT noted in its response that there have been times when they needed to escalate service response at Comcast, but that generally fiber repair occurs in a reasonable timeframe). About 1/3 of respondents indicated that they have not received at least a 7 day advanced notice of a scheduled network outage. They indicated that they either get no notification of fiber work on the I-Net or that they are not on the notice list (such notices go to the State's MN.IT group).

No respondent indicated a decrease in reliability when comparing the use of the I-Net to service provided by their previous service provider. Six in ten respondents indicated the same reliability, and four in ten indicated an increase in reliability.

Respondents noted a number of sites that require 24x7 uptime and more than half of respondents noted future plans that would require 24x7 uptime. Specifically, South St. Paul Public Schools noted that online learning and teacher on demand video requirements would enhance the need for 24x7 uptime. The city of Mendota Heights noted such requirements for police and fire, Dakota County noted 24x7 uptime needed for their disaster recovery site at the Northern Service Center and the City of West St. Paul noted the need for 24x7 uptime at their public works building when it acts as a hot site. MN.IT noted that PSAP and 911 related services would require 24 x 7 uptime.

In the longer term, entities such as ISD 197 noted that increased bandwidth (for increased applications) would continue to require 24x7 reliability.

Current I-Net Management and Operational Structure

Most respondents indicated that the current I-Net management and operational structure has met their needs. They noted that the State provides good support, the service has been very transparent, edge devices are upgraded as needed, the connectivity is secure and they are able to

meet their performance objectives. Those that indicated that the management and operational structure needs to change indicated that more communication was needed, there have been too many changes without original stakeholder input or decision making, and that the dual layer of operation can slow down restoration of service.

Cost of I-Net Connection

Respondents were asked to compare monthly connection costs over the I-Net to their previous service provider. The largest number of respondents indicated a decrease in cost with others indicating that the cost stayed the same. Two in ten respondents indicated that the cost had increased.

Overall Satisfaction with Existing I-Net Services

Nearly all respondents indicated that they were highly satisfied with existing I-Net services indicating that it has been very reliable, stable, a great value, and “exceeded expectations in reliability, performance and cost.” They also discussed how it was flexible for continuing to adapt to service needs.

Future Bandwidth Increases

Respondents noted a variety of bandwidth increases needed in the near future, including moving from 100 Mbps to 1Gbps connections, moving to 10 Gbps ring transport and individual 10 Gbps connections for Dakota County. Respondents noted continuing needs for higher bandwidth beyond the near term including, moving to 10 Gbps connections for such entities as ISD 199 and multiple 10 Gbps connections for Dakota County. A variety of applications were cited to support the need for such bandwidth increases, including more public safety related video, a higher degree of telepresence, more connections to offsite backups and hosted software solutions, increasing live video feeds and streaming services, and expansion of other existing applications. Dakota County even noted a need for 100 Gbps beyond 5 years. MN.IT notes that dark fiber or wavelength services will allow them to continue to support required bandwidth needs well into the future.

Additional Services and Capabilities

Respondents noted other services and capabilities that were needed in the future, including the ability for Town Square Television to have connectivity to all Dakota County sites, ubiquitous

broadband wireless connectivity throughout the community to help bridge the digital divide, more sharing of training between agencies in Dakota County, and more connectivity between various cities and agencies to increase shared resources and more opportunities for internetworking with other fiber networks and fiber infrastructure.

CONCLUSIONS AND RECOMMENDATIONS

After review of the findings from the workgroup discussions, NDC4 I-Net Users survey, analysis of the information provided by Comcast in response to the RFI, other technical review activities, interviews and follow-up discussions, the following summary of major conclusions and recommendations is evident:

- 1. The existing I-Net is highly beneficial in providing network connectivity for the I-Net User organizations.** Each entity utilizing the NDC4 I-Net has been able to implement a high capacity connection to all of its major organizational sites, as well as to application service providers and network service managers for myriad video, voice and data applications. As such, the I-Net forms the core of each of the I-Net User organization's wide area network infrastructure (in the case of Dakota County it forms the core of the portion of its WAN that serves the northern part of Dakota County).
- 2. The existing I-Net enables multiple network applications.** I-Net Users in both the focused discussions and the survey indicated many and varied network applications that utilize the I-Net for transport, including, but not limited to: enterprise network and associated client/server applications; high speed access to the Internet for government operations and educational classroom, student and administrative use; telephone and other voice applications; and video training, video conferencing, telepresence, distance learning, and other video applications.
- 3. Interconnects between the NDC4 I-Net and other fiber and institutional network infrastructure in other jurisdictions in the region are critical to enabling necessary applications.** I-Net Users indicated that while connectivity between their core sites and their remote locations was critical, equally critical are the interconnections that provide a range of applications and services to those organizations. These applications and services are provided by entities based around the region, but not within the seven member jurisdiction NDC4 area, and include such large application service providers and network

system managers as MN.IT, TIES and LOGIS. Many of the network operations that are critical to the I-Net User organizations would not be possible without the interconnects between the NDC4 I-Net and fiber and other institutional network infrastructure in other regional jurisdictions.

- 4. Current I-Net reliability and availability is high.** I-Net Users noted that high reliability and high network uptime were critical to their network operations and that the I-Net currently provides this high level of connectivity. Some problems were noted around the time to restore service when fiber cables were cut, but such problems were often described as being more a function of the process for notifying Comcast and that a more direct interface, or quicker interface through network managers, would help to decrease the mean time to repair.
- 5. Use of the I-Net is very affordable.** I-Net Users noted that the investment that they made in funding the I-Net infrastructure had been a highly beneficial one that has resulted in very affordable, high capacity communications over a number of years. I-Net Users noted that other alternatives are much costlier and they also noted, in nearly half of the cases that their cost had gone down and in most other cases that even as their costs had stayed the same, their capabilities had increased.
- 6. Going forward, the ability to add locations to the network needs to remain.** There are currently additional sites that need to be connected to the NDC4 dark fiber I-Net and the ability to add sites in the future needs to remain in place. The sites where connectivity is needed in the near term include:
 - a. South St. Paul Airport
 - b. South St. Paul Public Works building
 - c. South St. Paul Wakota Arena (need a direct connection to the South St. Paul City Hall in addition to the connection to South St. Paul High School)
 - d. South St. Paul Central Square Community Center
 - e. West St. Paul Golf Course (expand from current connection at the Garage)
- 7. Going forward, the NDC4 I-Net ring needs some reconfiguration.** There are adjustments that need to be made to the NDC4 I-Net ring going forward including:

- a. Placement of all critical sites on the core or ring, including the South St. Paul District Center (in fact the District desires a ring configuration for all of their sites).
- b. The Mendota Heights and South St. Paul City Halls need to be placed on the ring rather than connection via the current star configuration.
- c. Beyond this, a reconfiguration of star sites to place all, or as many as are feasible, into a ring configuration. This may require development of an architecture that includes a master ring connecting to multiple subrings.

8. More redundancy for I-Net Users' network connections is needed. I-Net Users noted that they needed more redundancy, including redundancy for their core sites as well as creating redundant paths for their remote locations. Reconfiguration of the ring, as described above, would provide an extra level of redundancy, especially for remote locations and for core sites not on the ring. Additional redundant mechanisms would include: additional fiber pathways that are part of the I-Net; additional fiber pathways from other entities, such as Dakota County; and additional connectivity that might be provided through cost-effective, shared infrastructure, including high capacity leased lines.

9. Bandwidth increases for the NDC4 I-Net connections are needed. Users noted an escalating need in the coming years for higher capacity connections. Consistent with the current management and operation of the network, these would most likely occur based on change-out in both core network equipment and remote site network equipment (potentially only requiring the change out of cards in current edge and core devices). Specifically, an immediate need has been demonstrated to take the NDC4 I-Net ring from 1 Gbps aggregate transport to 10 Gbps aggregate transport. Near future needs will include taking remote site connections from 100 Mbps to 1 Gbps. In the longer term, the 1 Gbps connections will need to escalate to 10 Gbps and ring infrastructure will need to migrate to multiple 10 Gbps aggregate connectivity or even 100 Gbps aggregate connectivity.

10. Additional strands of fiber are needed as part of the I-Net going forward. I-Net Users noted that the current limitation of 6 strands around the ring may need to be increased, in order to provide more dedicated (point-to-point) connections, especially between high capacity sites and for HD video origination sites. Additionally, NDC4 and

Town Square Television have utilized all 18 fibers currently available from its location to the Comcast hub. The majority of these fibers are used for video origination, video transport to Comcast for insertion on the subscriber system and sharing video with other Access entities throughout the Twin Cities area. Town Square Television needs to increase its capacity by adding fiber optic strands or deployment of wavelength division multiplexing on the existing fibers. MN.IT also notes that adding multiple wavelengths would increase capacity.

- 11. The I-Net must remain a very affordable network option for the I-Net Users.** I-Net Users noted that while the I-Net demonstrates significant high reliability and availability and high capacity transport capability, it is also the affordability of these types of connections that is critical to their ability to continue to operate in a highly effective manner, as well as expand connectivity over time. This means that the network needs to remain the most highly affordable option for the I-Net Users, including providing high capacity connectivity at well below commercial market rates. I-Net Users also noted that they had spent a substantial sum initially funding the network and that part of the rationale was to continue to have access to a base asset, such as the dark fiber I-Net, that would allow them to cost effectively continue to expand connectivity using significantly higher capacity in the future while only seeing very affordable increases in network equipment costs.
- 12. There needs to be an expansion of interconnects between the I-Net and additional infrastructure.** As described above, the interconnects between the I-Net and other infrastructure around the region are critical to successful utilization of the I-Net by the I-Net Users. Expanding these interconnects beyond the current ones is important, including such interconnects as: HD video and FTP data transport for Town Square Television to and from other PEG Access centers in the region and high capacity interconnects between Inver Hills Community College and Dakota County Technical College.
- 13. The current management and operational structure has worked well but needs some modification, including more communication, greater involvement of the I-Net Users in its operation and faster response pathways for service issues.** I-Net Users noted that while the current management and operational structure, where many

applications and network equipment are provisioned, monitored and managed by state entities such as MN.IT, LOGIS and TIES is beneficial, there needs to be a higher level of communication to, and a greater involvement in the ongoing operation of the I-Net by the Users. This should also lead to quicker response to network outages by both Comcast (when it is a fiber cable related issue) and the network management organizations MN.IT and TIES (when it's a network equipment issue). One recommendation that has proven effective in other instances with multi-jurisdictional I-Net Users, would be an I-Net Users group that would meet on a monthly or quarterly basis to continue to share information. Also, having an electronic means of communication quickly in the case of both cable outages and network outages, where not only the network manager but Comcast would be notified directly, would serve to improve communications and response time.

14. Overall, based on all the needs going forward, I-Net Users prefer a network with the same dark fiber foundation as is currently provided. Based on all of the above, including but not limited to, the need for continued high network reliability and availability, superlative affordability, the ability to be flexible and scalable in the provision and utilization of network capacity, the ability for high capacity communications both within and between organizations and the ability to grow the network over time, effectively, quickly and affordably, I-Net Users prefer that the network continue with the same dark fiber foundation that is currently provided. Again, I-Net Users noted that they had invested directly in the funding of the I-Net infrastructure and consequently have an investment in a going concern that has served them well.