

# **The Case for Creating a Telecom Institutional Network**

**A Proposal for the Fullerton City Council**

**Prepared for the**

**Fullerton Technology Working Group**

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# The Case for Creating a Telecom Institutional Network (I-Net)

## A Proposal for the Fullerton City Council

### Executive Summary

The Technology Working Group (TWG) performed extensive research and analysis of the telecommunications needs of Fullerton institutions and how best to satisfy them. The TWG concurs with the recommendation of its predecessor commission, the Technology Infrastructure Task Force, which recommended that the City of Fullerton and its institutions form a consortium to create an I-Net that will link participants to a customer-owned or controlled, open access, open architecture, fiber-optic network. The telecom requirements of the potential participants have only increased since the original recommendation was made five years ago.

Working with a consultant, Lee Afflerbach, who designed institutional networks (I-Nets) for Santa Monica and Ventura, the TWG prepared a conceptual design for an I-Net that consists of fiber-optic laterals connecting facilities to hubs at six fire stations and city hall that are linked by a central loop of fiber. **In addition to serving schools, government facilities and other institutions, the central loop of the I-net is critical to the implementation of wireless infrastructure to support public safety/public works applications and traffic management and video surveillance systems.**

The TWG also developed this case for creating the I-Net, obtained cost estimates for building and activating an I-Net linking 55 sites, presented this information to City and school district decision makers at an I-Net forum, and successfully enlisted their support for preparing an RFP. This information is documented in this report.

Corning Cable Systems and Packet Front provided estimates of the cost to build and activate the I-Net. Broadband Associates and Paxio both made estimates of the cost to operate maintain and monitor the I-Net. If additional analysis is desired, the TWG has identified consultants who have the expertise to evaluate this I-Net case.

It is estimated that it will cost \$2-2.5 million to build the whole I-Net and cost an undiscounted rate of about \$500-600 per month per site to provide connectivity of 100-1000 Mbps at 55 sites. Most if not all of the cost to connect the schools to the central loop qualifies for funding through the Federal Communication Commission's E-rate program. Depending upon how the I-Net is funded, the monthly cost per site can range from \$205-270 for the Fullerton School District, from \$393-430 for the Fullerton Joint Union High School District and from \$360-1376 for the City of Fullerton. These monthly costs include voice service and most compare very favorably with the current monthly costs for much less bandwidth. In addition the monthly costs may decrease significantly over 5 years as more institutions begin to share the I-Net.

Massive increases in bandwidth that are possible with fiber-optic cable not only greatly lower the cost per bit of data-rate, but lead to significant cost efficiencies in the operation of IT departments. Fiber also makes feasible applications that are not practical at lower bandwidths. Consequently, the cost/benefit of fiber is significant, but hard to measure quantitatively. Many institutions that have moved to fiber report payback periods of 2-5 years.

## Introduction/History

In 1980 the original franchise agreement between the City of Fullerton and the cableco called for 18 city-owned sites to be connected with cable. Unfortunately this institutional network (I-Net, see Appendix 1, Glossary of terms) was never constructed. Only city hall was connected to the cableco's system in order that City Council meetings could be broadcast over the public access channel. Because the terms of the franchise agreement were never fulfilled, in 2000 when the franchise agreement expired and the cableco wanted to extend it, the cableco paid the City a settlement of \$900,000. The settlement included a clause that stipulated that the cableco would provide all public and private schools in Fullerton that were within 200 feet of the cableco's infrastructure with Internet connectivity and Internet service free of charge. This was never done. Recently lengthy franchise negotiations with Time Warner resulted in the cableco paying the City \$500,000 which some city staff indicated might be used for a fiber-optic I-Net.

In the July 2002 Final Report of the Technology Infrastructure Task Force, the commission recommended to City Council that a fiber-optic network be created that would connect government, educational and medical facilities and other institutions in Fullerton that might want to have access to a very high bandwidth, state-of-the-art fiber network. Following up on this recommendation the current TWG has conducted a significant amount of research in order to obtain the support of the institutions in the City for such a system, to create a conceptual design, to identify the applications that it must support, and to build a case for creating it.

As part of its research, TWG members met in Santa Monica with Jory Wolf, Santa Monica's CIO, to review that city's I-Net and how it was created. Jory Wolf graciously gave the TWG copies of all supporting documentation. The committee also held a videoconference with Dr. George Araya, CIO of the Desert Sands Unified School District in La Quinta, to learn how he was able to create a Gigabit Ethernet fiber network that connects at least 27 schools with a single strand of fiber in the local cableco's system. Jack Marshall, formerly CIO at the City of Ventura and now CIO at Huntington Beach, met with the TWG and described how Ventura was able to create an I-Net when its two cablecos rebuilt their systems. In addition Bill Statler, Director of Finance and Information Technology, City of San Luis Obispo, sent the TWG a CD describing the construction of San Luis Obispo's I-Net and the ways in which it is benefiting the community. Rob McIntosh, CIO for the City of Anaheim, informed city staff that Anaheim has created two separate fiber networks; one that connects electric utility sites and another that connects other governmental facilities and is used for public safety/public works applications. None of Anaheim's schools or other institutions shares in the use of either of these networks.

Initially the TWG strongly considered trying to partner with Fullerton's cableco in creating an I-Net. However, Lee Afflerbach, consultant to the TWG, was able to determine from a contact that he had within Adelphia that the Fullerton cable network does not contain any significant amount of unused fiber and the system architecture is not conducive to the construction of a modern, failure-proof network. Consequently, the TWG and city staff embarked upon creating a clean-sheet, state-of-the-art network.

Several members of the TWG attended a conference in Loma Linda, CA sponsored by Broadband Properties magazine and saw first-hand how a properly designed and constructed Gigabit Ethernet system can provide service that is orders of magnitude better than an upgraded legacy system such as the one that AT&T is currently constructing in Fullerton.

One TWG member also attended the FirstMile.US conference hosted by Calit2, University of California San Diego, where he learned about the development of new applications that are feasible to use only with gigabit bandwidth telecom networks. One demonstration was of videoconferencing at a bandwidth of 1 Gbps with groups in South America and USC using a projector with 4000 x 2000 pixel resolution. The

experience was similar to being in the same room with the participants even though some were thousands of miles away. Other visualization demos were just as graphic and outstanding.

## Goals and Options

The goal of the City of Fullerton/TWG is to create a fiber-optic Gigabit Ethernet infrastructure that will serve the current and future bandwidth needs of institutions in the City. It needs to be constructed in such a manner that it will have a useful life of many decades.

Fiber is expected to be the backbone of a network that not only serves the sites where it terminates, but myriad devices, both wired and wireless, that may be connected to it by partner institutions through gateways at those sites. For example, the City may wish to use the network as the backbone of a wireless mesh covering the City that supports public safety/public works applications. Similarly it could serve as the backbone for a private/public partnership that provides wireless telecom services to paying customers or a free, ad-supported service.

In addition, it is envisioned that such a system will meet the demands of the participant institutions for future telecom services, many of which will require very high bandwidth. In order to best meet the demands of educational, governmental, medical and other public institutions, the goal is to construct an I-Net that is customer-owned and controlled, open access and open architecture, but for which the operation and maintenance can be outsourced.

At least five options for creating the I-Net have been identified and considered. They are:

- 1) Construct a new fiber I-Net similar to the one that the City of Santa Monica created in partnership with Adelphia. This network consists of a central backbone loop that connects several hubs. The hubs house the opto-electronics and serve as the point at which lateral lines connect institutional facilities to the central core. This model is the most robust in providing for later expansion. Possible sources of funds are transportation and homeland security grants, developer fees, redevelopment funds, and telecom savings including the capture of E-rate reimbursements. One or more of these sources of funds may also be available to fund the other options below.
- 2) Create a fiber I-Net similar to the one that the City of Monterey constructed in partnership with AT&T Cable. Monterey created its I-Net by having AT&T Cable dedicate additional fiber to the City when AT&T was expanding and upgrading its system. Monterey agreed to pay for the additional fiber, but received it free as liquidated damages when AT&T Cable did not meet certain conditions. Monterey has subsequently extended the I-Net to institutions throughout the County of Monterey. If Time Warner has plans to upgrade and/or expand the existing system in Fullerton, this approach might be an option.
- 3) Create an I-Net from existing fiber infrastructure by gaining access to dark fiber within the Time Warner, SCE and AT&T systems and connecting institutions to this fiber infrastructure. Southern California Edison and several other telecom firms have dark fiber in Fullerton that may be advantageously located and available for incorporation into this network. This approach is the one that was taken by the Desert Sands Unified School District. If the local cableco were to cooperate, it may be the easiest and least expensive to implement. It may not be as robust as the other two options above, but technology such as wavelength division multiplexing may make it viable today and scalable in the future. **Our consultant, Lee Afflerbach, however, has determined that this is probably not a viable option for reasons cited above.**
- 4) Construct an I-Net using wireless technology. Several point-to-point wireless technologies, such as those created by DragonWave, GigaBeam, Loea, and Orthogon Systems, provide bandwidth that approaches or equals that of fiber. Wireless, however, has limitations that fiber does not and some additional research would be needed to determine if this is likely to be a cost-effective approach that meets the needs of our institutions. A company named Trillium approached the

school districts and the TWG about constructing a microwave-based wireless network, but the estimated cost exceeded quotes received from Corning for a fiber-optic network so the proposal was not pursued. Fiber is the preferred infrastructure when it can be done cost-effectively.

- 5) Create an I-Net by combining two or more of the above approaches and technologies.

After considerable research, the TWG has concluded that Option 1 above is the best one to pursue. Fiber infrastructure that is adequately sized and optimally designed is considered to be future proof in that it will have a useful life of decades. Only the opto-electronics, which have a nominal cost, will have to be upgraded periodically. Wireless technology, however, may need to be included to connect some sites to the I-Net.

The network that is being proposed will have virtually unlimited bandwidth because it will be easy to upgrade as more advanced opto-electronics become available and applications require more bandwidth. **When bandwidth is unlimited, imagination is the only limitation.**

## **Justification**

### The State of Telco and Cableco Networks in Fullerton

AT&T is in the process of upgrading its legacy telecom system in Fullerton (Project LightSpeed). It is creating up to 80 nodes in the City to which it will extend fiber-optic cable. Unlike Verizon, it is not running fiber to each building to which it provides service. Existing copper wiring remains the final link between the nodes and the buildings that AT&T serves. By shortening the length of copper, AT&T is able to increase the bandwidth that it can deliver. The maximum bandwidth that will be provided is reported to be on the order of 5 Mbps upstream and 20 Mbps downstream. Bandwidth in a network such as this can be increased by adding more nodes, by shortening the copper links, and by increasing the initial bandwidth. AT&T is betting that while minimizing the upfront investment that it is making in its legacy system, it will be able to keep abreast of the increasing demands of its customers for greater bandwidth.

In contrast, Verizon, in its service areas, is connecting buildings directly to fiber-optic cable. It is using a passive optical network (PON) architecture in which the cost to connect buildings directly to fiber is higher. Verizon is betting that by initially spending more money for each customer than AT&T, it will be able to more easily make future upgrades and be in a better competitive position relative to the cablecos in its service areas. Verizon projects that it will be able to recover the greater initial cost of its system over time with a greater take rate for its services. In addition in some areas in Texas Verizon has begun to overbuild communities with fiber in direct competition with AT&T.

Within two years when Internet protocol TV (IPTV) becomes the common technology for delivering digital high definition TV, bandwidth requirements will increase dramatically. IPTV with MPEG3 compression requires about 19 Mbps for each high definition TV in a residence. Two IPTVs will require a minimum of about 40 Mbps. Consequently within a very short time most residences will probably need to have minimum bandwidth of 50 Mbps for voice, video and data service. With MPEG4 compression the requirement for each IPTV is lowered to about 10 Mbps and the useful life of the telco upgrades may be extended.

To remain competitive with the telcos, cablecos such as Time Warner will have to upgrade their systems. The technology for doing so exists in DOCSIS 3.0, which will permit cablecos to provide service at 100 Mbps or greater. Field trials have been conducted and DOCSIS 3.0 is being implemented in a few areas, but it is not known how or when Time Warner is likely to make the investment to upgrade its local system.

**Fullerton's institutional telecom infrastructure today resembles a dumbbell.** At one end are the institutional facilities all of which are wired internally with Category 5 or Category 6 wiring which is capable of providing data rates of 100-1000 Mbps. At AT&T's central office on Pomona Avenue various regional telecom firms are able to provide connection to the outside world at data rates of 1 Gbps or better. However, between the institutional facilities and the central office, all sites are currently connected via T-1

lines that move data at a rate of 1.5 Mbps. Schools that want greater bandwidth currently do so by adding additional T-1 lines. Creating a fiber-optic network that connects institutions in the City of Fullerton will break this bottleneck at a reasonable cost.

### Present and Future Uses/Applications

Some of the present and anticipated future uses/applications for a Gigabit Ethernet network by the networks' participants are listed in Appendix 2. Many future uses have yet to be conceived, but it is certain that they will require significantly more bandwidth than is available today, because **when bandwidth is unlimited the only limitation is the human imagination**. To quote Frank Coluccio whose consulting firm, DTI Consulting, in New York City has created fiber networks for Wall Street financial firms, "a great deal of benefit to be derived from an unencumbered fiber network doesn't show up in first cost economics, nor does the agility afforded by such a platform ever become known until the network is put to use. All sorts of new and wonderful capabilities become possible, which heretofore, in its absence, could only be contemplated in Utopian-like terms."

It has been well documented that the need for bandwidth is growing exponentially with the recent trend of sending more and more video information across the Internet. Unlike the past when clients received content from a few content providers, clients are now generating copious amounts of content that are being sent to their peers. Consequently, it is no longer reasonable to assume that downstream bandwidth can and should be significantly greater than upstream bandwidth. In a recent article in the Wall Street Journal, (January 20, 2007) Bret Swanson has forecast a coming exaflood of data that is likely to swamp most existing networks if they are not rebuilt or upgraded in anticipation of the deluge. As Swanson concludes, "Today's networks are not remotely prepared to handle this exaflood." An excerpt from this article is attached (Attachment 1).

### Advantages of an Open Access, Open Architecture, Customer-Owned, Fiber-Optic Network

The City and its partners will realize many benefits from building and owning their own telecom network. In building a fiber network from the ground up, the consortium is able to create a state-of-the-art network that is not compromised by the need to upgrade a legacy system. The system will be able to deliver many times more bandwidth than AT&T plans to deliver with the upgrade to its system that it is now in the process of making. In the future the consortium will be able to increase bandwidth to meet increasing needs by making a nominal investment in upgrading the opto-electronics attached to the fiber infrastructure. The consortium will control the timing of the upgrades and the type of equipment that is purchased. The timing and nature of telco and cableco upgrades are determined by entities that have little or no connection to the community and whose decisions are determined almost solely by economics. **The highest priority for telco and cableco upgrades is typically given to larger cities and driven by competitive pressure. Telco and cableco decisions rarely coincide with the needs and desires of the communities in which they operate.**

The consortium will be able to determine when and where it wants to add capability to the system such as a wireless public safety/public works network and applications without having to consult another party. The consortium will have complete freedom to determine what firms will provide content and services over the network. There will not be any middlemen to deal with. The issue of network neutrality that is now playing out in the telecom industry will never be an issue. Telcos have clearly stated that they intend to charge content providers a fee for premium access to their customers. Those who own their own networks will never be held hostage by the telcos or cablecos. The owners will be free to set their own operational guidelines and impose terms of use for service providers and clients. These and other reasons for creating a customer-owned, fiber-optic network are summarized in Tables 1 and 2.

Ownership of infrastructure that is critical to providing municipal services has become a significant issue as municipalities attempt to enable firms to provide alternative telecom services to their constituents. For example, because Anaheim owns its own electric utility and its streetlights, it was able to partner directly with Earthlink to provide wireless Internet service to its citizens. Anaheim did not have to obtain access to streetlights and power from third parties. In contrast Fullerton owns most of its streetlights, but thus far

has been stymied in partnering with a wireless firm for citywide wireless service because Southern California Edison has been unwilling to formulate an agreement for providing power to the network. Although Southern California Edison recently began quoting a rate of \$11 per pole per month for pole access and power together, they have not obtained permission from the CPUC to quote a rate for power alone. Unfortunately in Anaheim's case, Earthlink was not able to sell enough network subscriptions to the public to make the network profitable and as a result has decided to terminate operations.

Like Fullerton the City of Ontario does own its own streetlights. It signed an agreement with MetroFi to create a citywide wireless network and was planning to move ahead in spite of the fact that Southern California Edison refused to state what rate it will charge for the electricity that powers it. For its wireless networks in Northern California, MetroFi worked out a rate formula with PG&E that has been approved by the CPUC. The City of Ontario decided that it would use that same formula with MetroFi in the creation a citywide wireless network. However, the MetroFi project in the City of Ontario has been given low priority by MetroFi because MetroFi is no longer relying on advertising revenue to pay for its systems, but is now demanding that a city purchase a minimum amount of wireless services from it before building a citywide wireless mesh network. Even more recently MetroFI has elected to terminate the operation of many of its networks because none of its business models seem to be viable.

Prior to Southern California Edison's willingness to provide access and power on its streetlights, Ken Desforges, Diamond Bar IT manager, proposed extreme measures to gain access for a citywide wireless network. Because most of Diamond Bar does not have DSL service, the City was anxious to have a citywide wireless network installed. The City seriously contemplated using eminent domain to gain access to the streetlights. It obtained an appraisal with which to make an offer and start the process. Other cities such as West Hollywood and Santa Clarita had expressed an interest in joining Diamond Bar in any lawsuit that it brought against Southern California Edison because SCE also owns their streetlights.

**In conclusion the more critical the assets for delivering city services that a city owns, the greater control a city has over its own destiny.**

#### Current Telecom Costs of Participants

The FSD and the FJUHSD are paying at least \$152,461 and \$221,892, respectively, for voice and data connectivity or a total of \$374,353 per year before discounts. This equates to a discounted monthly rate per site of \$110 and \$411 for the FSD and the FJUHSD, respectively. The City of Fullerton is paying \$130,000 per year for voice and data connectivity or \$542 per site per month. These amounts are for T-1 (1.5 Mbps) bandwidth. Consequently, the City and the school districts are paying around \$504,000 per year for voice and data connectivity that is no longer adequate. Increased needs for bandwidth are being met by adding more T-1 lines. **Adding T-1 lines one or two at a time is a band-aid approach to increasing bandwidth**, is inefficient, does not significantly impact bandwidth bottlenecks, and discourages imaginative creation and use of many applications that require high bandwidth.

In contrast Phil Clark, CEO of Paxio, estimates that the cost to operate and maintain the proposed fiber-optic I-Net and provide a minimum of 100 Mbps bandwidth to the 55 school and city sites will be about \$318,000 per year. Voice service can be added for a small increase.

## Conceptual Design

The I-Net has been designed to be a customer-owned network (see the Glossary for the description of a customer-owned network) using the Ethernet protocol that delivers bandwidth of up to 1000 Mbps (1Gbps) for each site (see network design in Figure 1). The signal will not be split as it is in a PON system. Customer-owned, fiber-optic I-Nets have proven to be excellent solutions for serving the high bandwidth telecom requirements of institutions that aggregate their telecom demands to create them. They are not unlike the customer-owned or controlled fiber networks that major corporations have created to link national and international corporate sites. If the City of Fullerton is viewed as being a campus that contains within its boundaries numerous institutional facilities, the City is very analogous to California State University at Fullerton that has all the attributes of a small city. Ten years ago CSUF connected all of its buildings to a fiber-optic, Gigabit Ethernet network that it owns and operates.

The conceptual design for the I-Net was created in cooperation with the TWG and Fullerton city staff by Lee Afflerbach, Columbia Telecommunications Corporation. Lee Afflerbach had been highly recommended by Jory Wolf, CIO City of Santa Monica and Jack Marshall, former CIO City of Ventura, who had worked with him in creating I-Nets for those cities.

The I-Net as presently conceived consists primarily of aerial fiber. The central core of the I-Net is a ring of fiber 17 miles in length that connects six fire stations and city hall with at least 144 and possibly 216 strands of fiber (see network map Figure 1 and Appendix 3 for a list of possible sites and their locations). Each of the fire stations in turn serves as a hub from which 12 strands of fiber are run to each of those institutional sites closest to each hub. There are several advantages to this architecture. The loop of fiber connecting the hubs provides for redundancy. If the fiber in the core is cut in one place none of the facilities being served will be without telecom service. If a lateral is cut, only the site(s) served by that lateral will be affected. In addition the fire stations are accessible 24/7 for any emergency maintenance that might need to be done and they are secure. The capacity of the central loop can be readily doubled by running fiber-optic cable down Harbor Boulevard and splitting the central loop into two fiber loops, one serving the western half of Fullerton and the other the eastern half.

There are currently 55 sites that are likely to be connected to the hubs by the laterals. The city has 22 sites and approximately 7.8 miles of laterals. The Fullerton School District is expected to connect 22 sites with approximately 11.8 miles of laterals and the Fullerton Joint Union High School district has 11 sites that will require approximately 12.1 miles of laterals.

The bandwidth and telecom protocol for the I-Net will be Gigabit Ethernet. Assuming that the owners select wavelength division multiplexing opto-electronics with which to send data in the form of light over the fiber, the owners will be able to send multiple wavelengths of light over each single strand of fiber. The advantage of this technology is that each wavelength of light within each fiber will be a separate, secure means of sending data over the network.

In some parts of the network it may be more economical to use high-speed point-to-point or point-to-multipoint wireless technology to reach more remote parts of the network. This wireless technology should not be confused with WiFi or WiMax wireless that is typically of lesser bandwidth and used by the general public. The bandwidth of the wireless technology that may be used in the I-Net is on the order of 200 Mbps to 2 Gbps. However, at this time it is expected that all sites will be connected with fiber.

## **Cost Estimates for Constructing the I-Net**

Corning Corporation is a major supplier of fiber, which also has a cable systems division, that designs and builds fiber-optic networks with certified partners. Corning is also a major supplier to Verizon which is building residential fiber networks. As a result of this relationship, Corning has greatly streamlined the installation process, reducing the cost to build. Corning is capable of overseeing all aspects of the installation process and uses its own personnel to splice cable, test it and provide documentation. Much of the cable portion of the network is prefabricated at a Corning factory thereby minimizing the amount of work that needs to be done in the field. Corning also works closely with opto-electronic firms that activate the networks and with certified partners who can operate, maintain and monitor the network on a 24/7 basis.

Corning's Cable Systems Division was asked to review the conceptual design in Figure 1 and provide a preliminary estimate of the cost to build it. A summary of Corning's estimate is contained in Tables 3 and 4. The network contains approximately 50 miles of cable, about 90-95 % of which will be aerial with the remainder buried underground. The cost to double lash aerial cable is estimated by Corning to be \$2.50 per foot and \$15 per foot to directionally drill and bury it. PacketFront, a manufacturer of opto-electronics recommended by Corning which specializes in activating open access networks like the I-Net, estimates that the opto-electronics will cost about \$400,000.

The cost breakdown for each of the participating institutions is shown in Table 4 with the whole project costing approximately \$2.0 million. This figure includes installation of both the cabling and the opto-electronics, but not some of the incidental expenses associated with housing the opto-electronics at the hubs. Adding a contingency of \$200 thousand brings the estimated cost to \$2.2 million. Because labor represents about 75-80% of the installation cost, it is prudent to put as much fiber in the system as possible when it is first built. Adding 50% more strands of fiber in the core (216 strands) will add approximately \$100 thousand to the cost and may be well worth the extra money. \$2.5 million is thought to be the upper limit for this project.

Massive increases in bandwidth that are possible with fiber-optic cable not only greatly lower the cost per bit of data rates, but lead to significant cost efficiencies in the operation of IT departments. Fiber also makes feasible applications that are not practical at lower bandwidths. Consequently the cost/benefit of fiber is significant, but hard to measure quantitatively. Many institutions that have moved to fiber report payback periods of 2-5 years.

## **Funding Sources and Operating/Maintenance Costs**

Potential sources of funds to construct the I-Net are listed in Table 5. The various participants will have to decide what is the optimal way for them to pay for their share. As part of its renegotiation of the franchise agreement with Time Warner, the City recently received a contribution/settlement of \$500,000 that city staff have suggested might be used to fund a portion of the I-Net such as the central loop. If the City pays to build the core, it may wish to grant the school districts access to fiber strands in the core in exchange for access to two fibers in each lateral in anticipation of creating a city-owned or third party gateway for a citywide wireless mesh. In the future similar rights might be exchanged with other institutions. Alternatively a vendor operating the network on behalf of the City and participants might lease fiber in the central loop from the City and charge the school districts for access to the central loop because these costs would be eligible for E-rate discounts.

The City of Anaheim plans to use a Homeland Security grant to bury fiber in conduit along Brookhurst to Commonwealth and along Commonwealth to the Fullerton Municipal Airport and the Fullerton Police Station. When this fiber is installed, Fullerton will have the opportunity to bury conduit in the trenches for a portion of the central loop of the I-Net. It will be easy to connect Fire Station 2 at the corner of Valencia and Brookhurst to the loop through this conduit.

Broadband Associates, Michael Brinskele CEO, was recommended by Corning as a company that could operate and maintain the network once it was built. Broadband Associates recently completed construction of a fiber-optic network for the Santa Clara Unified School District and Santa Clara University. Michael has offered to build, operate and maintain a 1Gbps network for a term of ten years for \$1266 per month per site. Assuming that Broadband Associates qualifies for E-rate reimbursement, the monthly cost including voice would be about \$270 and \$420 per month per site for the FSD and FJUHSD, respectively. The City's monthly cost with voice service would be about \$1376 per site (Table 6). At the end of ten years, ownership of the network would be turned over to the City.

Phil Clark, CEO of Paxio, another firm that was recommended by Corning, met with the TWG and described his experience in creating fiber networks in Pulte home developments in Northern California. His firm has obtained a SPIN and qualifies for E-rate reimbursements. Paxio is also capable of operating and maintaining fiber networks. He too is willing to build and operate the system and eventually assign ownership to the City.

The FCC's E-rate program is expected to pay a significant portion of the capital cost to connect the school facilities to the central loop. The capital cost is paid by the service provider and reimbursed through service fees paid to the provider.

Assuming that the City pays for the central loop, Phil Clark estimates that the monthly cost to operate and maintain the I-Net will be about \$500 per site per month (\$318,000 per year for 55 sites) for a minimum of 100 Mbps bandwidth connectivity. The discounted cost to the FSD would thus be about \$95 per month per site and to the FJUHSD about \$123 per month per site. To this must be added the discounted cost of voice service (approx. \$30 and \$110 per month per site for FSD and FJUHSD, respectively). The discounted cost of connecting each school to the central loop will add about \$80 and \$160 per month per site (FSD and FJUHSD, respectively) for five years. The total discounted monthly cost per site to the FSD and FJUHSD for voice and data service over a fiber-optic network will be about \$205 and \$393, respectively. As a result annual telecom costs for the FSD might increase by about \$25,000 for significantly greater bandwidth than it currently has. The FJUHSD, on the other hand, might see some small cost savings with the creation of a fiber-optic network. These estimates do not take into account other possible savings resulting from changes in how the school districts' operate their IT functions. The districts currently have decentralized file-sharing infrastructures due to the lack of WAN bandwidth. They have multiple file servers at each site for local applications and file sharing. One of the benefits of the I-Net will be the ability to create central server farms with virtual servers and a SAN. This will increase storage space and reliability and decrease purchase, maintenance, and facility costs. Moving to voice over IP will increase institutional savings even more. In addition Phil Clark estimates that the monthly fees may decrease significantly over 5 years as other institutions begin to share the network.

The central loop, which is estimated to cost about \$612,000, will generate revenue to the City as other institutions begin to share the network. If a vendor such as Paxio were to lease fiber in the central loop in order to serve the school districts, a fee of \$60,000 per year, for example, would reduce the cost of connectivity to 22 city sites to \$360 per month for voice and data service. If Paxio in turn passed this fee on to the school districts, their monthly fee per site would increase from \$205 to \$234 for the FSD and from \$393 to \$430 for the FJUHSD (Table 6).

Cameron McCune suggested that developer fees might be the source of some school funds, although schools cannot own their portion of the I-Net if they are to be eligible for E-rate funding. City staff has also suggested that redevelopment and cableco franchise settlement funds might be used to pay for the City's portion of the I-Net.

Because it has been difficult for the TWG to determine the optimal way to fund construction of the I-Net and assess the ongoing operating and maintenance costs, the TWG sought a consultant who is conversant with these issues and who can prepare an RFP for the project if one is required. Michael Brinskele highly recommended Michael Crose, C&M Technology, who runs the library system for Washington State. Crose has served as the consultant for the creation of the fiber network recently built for the Santa Clara Unified School District, is working as a consultant for the Gilbert Unified School

District, AZ and prepared the technology plan and the bond measure for the 119 Washoe County schools in Reno and Tahoe, NV. In addition C&M Technology did the cost justification for King County, WA, when it had to decide whether continuing its I-Net program was in the public interest. However, Thad Sandford, a recent addition to the TWG, has now prepared an excellent RFP for the I-Net.

### **Participation in Construction of the I-Net**

The Fullerton School District and the Fullerton Joint Union High School District are the institutions that would like to be primary partners with the City in the creation of the I-Net. However, the I-Net can be built in phases as funding becomes available from various sources. The most important phase is the creation of the central loop that connects six fire stations and city hall. The City of Fullerton will initially be the greatest beneficiary of the construction of the central loop and should take the lead in its creation. However, all other parts of the network depend upon completion of the central loop. These sites can be connected to the fire station hubs as desired. This is true of both city sites and school sites, although it would probably be best if the city and school sites were included in the first phase. There will be economies to be had in some locations by having several sites and participants share cable runs and connections to a hub.

Assuming that the loop contains adequate dark fiber, other institutions such as Fullerton College, medical centers and private schools will be able to connect to the loop when they desire to do so. Major businesses in Fullerton that may want access to a modern, high bandwidth network can also be served by it. The system has been designed to be readily scalable and expandable as long as there is enough unused fiber in the central loop.

### **Means of Participation**

The I-Net is likely to be operated under a Joint Powers Authority. Institutions that wish to be part of the I-Net consortium will join by applying to the Joint Powers Authority, signing a memorandum of understanding and guaranteeing a stream of income to the JPA that will pay for the infrastructure required to connect them to the backbone loop at a hub or hubs. It has not been determined if participants will pay a one-time fee for access to or ownership of fibers in the central loop. Participants will be assessed an annual maintenance and operations fee, but will probably contract directly with any one of many possible qualified Internet service providers to deliver content and services. .

Institutions that contract with the Joint Powers Authority may be given representation on a committee that provides oversight to the Joint Powers Authority.

### **Communication with Prospective Participants (I-Net Forum)**

On February 20, 2007 the TWG held an I-Net forum at CSUF for the purpose of informing City and school district staff and decision makers of the case and justification for creating the I-Net. Attendees included school board members, and administrators and staff from both the City and school districts. Roger Burtner, Chair, TWG, presented the case for creating the I-Net. Amir Dabirian, Chief Information Technology Officer, CSUF, described the fiber network at CSUF and how it is being used. Ellen Jung, Associate Dean, CSUF, informed attendees about the use and effect of the network in teaching at CSUF. Ted Malos, IT Manager, Ventura Unified School District, described how its Gigabit Ethernet network has had a significant, positive impact in the district's operations, and Joe Felz presented the conceptual plan and the cost to implement it.

### **Conclusions and Recommendations**

The TWG has developed a plan for a customer-owned or controlled, open access, open architecture, Gigabit Ethernet, fiber-optic I-Net that is modular, scaleable and expandable. Creation of a central loop of fiber that connects hubs at six fire stations and city hall is crucial to the participation of Fullerton institutions. Once the central loop is built, any number of participants can be added to the network at any

time. The conceptual design for the I-Net has already attracted the interest of independent telecom firms that would like to offer services over it. The central loop will also play an important role in the creation of other telecom infrastructure in the City such as wireless to support public safety/public works applications. In addition it will also have a significant supporting role in traffic management and video surveillance systems. **Thus the TWG recommends that the City immediately move to authorize building of the central loop and connecting government facilities to it.**

**Based upon the cost analysis performed above, the TWG is convinced that it is in the best interests of the City of Fullerton and the school districts to form a consortium to build out the I-Net.** The school districts and the City of Fullerton are the natural primary anchor tenants in the I-Net, although any institution that wants may be included. Other institutions will be able to join the consortium at any time and reduce the cost of connectivity to each participant.

**The TWG believes that Corning Corporation is one of the best but not the only qualified vendor that could be chosen to build the I-Net.** They and their certified partners can perform all aspects of the design, construction, testing and documentation. Partners with whom they have worked are fully capable of operating, maintaining and monitoring the I-Net for the participants.

**The TWG recommends that any lump sum payment by Time Warner to the City of Fullerton resulting from the franchise negotiations be used to create the central fiber loop of the I-Net.**

**The TWG recommends that the school districts request connection of their facilities to the central loop under the terms of the E-rate program.**

**The TWG recommends that the City contract with a qualified, state-licensed, telecom firm that is Teleconnect eligible to operate, maintain, and monitor the I-Net. Said firm should be one that has successfully bid to provide E-rate services to the school districts.**

**The TWG recommends that the I-Net be completed during the current E-rate funding cycle.**

Prepared for and submitted on behalf of the Technology Working Group by:  
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## Appendix 1

### Glossary of Terms

Bandwidth -- data rate in bits/second.

Bit -- binary digits, which may each have the value 0 or 1.

Byte -- 8 bits equal 1 byte. Byte is used when referring to file size or storage capacity.

1Kbps = 1000 bits/second; 1Mbps = 1000Kbps; 1Gbps = 1000Mbps

Customer-owned network — in the case of a fiber-optic network, it is one in which institutions own specific strands of fiber within a fiber bundle that constitutes the network infrastructure. Customer-owners are responsible for purchasing, maintaining and upgrading the opto-electronics that they connect to the fiber infrastructure. Together with other owners they share maintenance of the common parts of the network infrastructure. Customer-owners have the flexibility to determine when and how they want to upgrade their portion of the network and whom they will select to provide services and content.

E-rate — the federal government taxes telecom service to create a fund from which it pays telecom firms to provide Internet service to schools and libraries at reduced rates. The discounted rate that a school pays depends upon its affluence. The difference between the true rate and the discounted rate is paid by the federal government to the telecom firm providing the service to the school. Any entity other than a school that provides the service to the school or library can qualify to receive E-rate funds.

I-Net -- a fiber-optic or combination fiber and wireless network that serves the telecom requirements of various institutions including governmental, educational, medical and others.

Network neutrality — a situation in which a telecom carrier does not control the content or the data rates at which content is provided to a customer. All service vendors and content providers have the right to send material unimpeded as requested by the customer.

Open access network — a network in which the customer-owner has unfettered access to all vendors of telecom services and content.

## Appendix 2

### City government applications to be supported by the I-Net

- Computer networks at 100 Mbps to 1 Gbps Ethernet data rates connecting 22 facilities
- Voice over IP telephony
- Internet protocol television (IPTV)
- Parking structure occupancy and signage system
- Security cameras
- Voice communications using media converters
- Video conferencing
- GIS applications requiring high bandwidth
- WiFi hot zones in 2 library branches and downtown Fullerton
- Traffic signal management system (i2TMS)
- Police in-vehicle cameras and communication with computer assisted dispatch system
- Roadside directional signage
- Additional WiFi hot zones in open spaces and parks
- Ubiquitous broadband mesh wireless network for government communications
- Traffic management camera system
- SCADA
- Building inspection, code enforcement and asset management
- Water utility meter reading

### Fullerton School District applications to be supported by the I-Net

#### Communications

- Interactive video conferencing
- Podcasting – downloading and publishing
- Potential to use voice over IP applications
- Audio streaming of meetings – Board meetings, staff development
- Ability to make multimedia portfolios available for online access by parents
- VPN access to network by staff
- Use of IP-based security systems (video monitoring, etc.)

#### Technical Support

- Remote diagnostics and troubleshooting
- System software updates on-site
- Remote imaging of computers
- Providing a library of technical support videos available to staff over the network

#### Instructional Applications

- Fewer limitations in the use of video streaming applications
- Higher bandwidth use of interactive video conferencing
- Distance learning utilizing exceptional teachers teaching over the network
- Sharing online course content created by District teachers

### Hope International University applications to be supported by the I-Net

- Distance learning course delivery
- Course multicasting to multiple locations
- On demand course delivery - web-based learning
- Online support for “brick & mortar” courses
- Online research
- Collaboration with faculty/students of other educational institutions

- Periodicals and journals, databases, other reference material
- Digital media delivery
  - E-books, audio/video resources
- Inter-library book and media loans
- Host online "ePortfolios" for students, alumni, and faculty
- Video conferencing
  - Distance learning – provide real time student/professor interaction
  - Student communications – support video "phone home" capabilities
- Voice over IP telephony
  - Offset or eliminate traditional voice T-1 lines
- Internet broadcasting
  - Athletic events
  - Student operated radio/television stations
- Traditional Internet communications
- VPN access for remote staff and faculty
- Inter-campus networking and communications
- Systems mirroring between remote locations for disaster recovery support
- Broadband Internet access for on-campus students via wired dorm rooms and
  - campus-wide wireless access points
  - Web-surfing
  - Broadband entertainment
- Campus safety
  - Communication with local law enforcement and emergency services

## **Requirements**

- Bandwidth scalable as needs increase – 100 Mbps symmetrical initially
- Standard network protocols utilized for uplink – e.g. TCP/IP
- Access to future educational and public networks when available (i.e. Internet 2)
- Quality of Service (QOS) and Service Level Agreement (SLA) guarantees
- Unrestricted access to the public Internet
- Hope International University representation in the management/operation of the municipal network

## Appendix 3

### Potential I-Net Sites

#### Fullerton Joint Union High School District (11)

Buena Park High School, 8833 Academy Drive, Buena Park, CA 90621  
Fullerton Union High School, 201 East Chapman Avenue, Fullerton, CA 92832  
La Habra High School, 801 West Highlander Avenue, La Habra, CA 90631  
Sonora High School, 401 South Palm Street, La Habra, CA 90631  
Sunny Hills High School, 1801 Warburton Way, Fullerton, CA 92833  
Troy High School, 2200 East Dorothy Lane, Fullerton, CA 92831  
La Sierra High School, 201 West Amerige, Fullerton, CA 92832  
La Vista High School, 909 North State College Blvd., Fullerton, CA 92831  
Education Center, 1051 West Bastanchury Road, Fullerton, CA 92833  
District Services Center, 1021 South Leslie Street, La Habra, CA 90631  
District Warehouse, 1100 East Truslow, Fullerton, CA 92831

#### Fullerton School District (22)

District Office	1401 W. Valencia Drive, Fullerton, CA 92833
Nutrition Center	389 W. Truslow Avenue, Fullerton, CA 92832
Acacia Elementary School	1200 N. Acacia Avenue, Fullerton, CA 92831
Beechwood School (K-7)	780 Beechwood Avenue, Fullerton, CA 92835
Commonwealth Elem. School	2200 E. Commonwealth Avenue, Fullerton, CA 92831
Fern Drive Elem. School	1400 W. Fern Drive, Fullerton, CA 92833
Fisler School (K-8)	1350 Starbuck Street, Fullerton, CA 92833
Golden Hill Elem. School	732 Barris Drive, Fullerton, CA 92832
Hermosa Drive Elem. School	400 E. Hermosa Drive, Fullerton, CA 92835
Ladera Vista Junior High	1700 E. Wilshire Avenue, Fullerton, CA 92831
Laguna Road Elem. School	300 Laguna Road, Fullerton, CA 92835
Maple Elem. School	244 E. Valencia Drive, Fullerton, CA 92832
Nicolas Junior High	100 W. Olive Avenue, Fullerton, CA 92833
Orangethorpe Elem. School	1400 S. Brookhurst, Fullerton, CA 92833
Pacific Drive Elem. School	1501 W. Valencia Drive, Fullerton, CA 92833
Parks Junior High	1710 Rosecrans Avenue, Fullerton, CA 92833
Raymond Elem. School	517 N. Raymond Avenue, Fullerton, CA 92831
Richman Elem. School	700 S. Richman Avenue, Fullerton, CA 92832
Rolling Hills Elem. School	1460 E. Rolling Hills Drive, Fullerton, CA 92835
Sunset Lane Elem. School	2030 Sunset Lane, Fullerton, CA 92833
Valencia Park Elem. School	3441 W. Valencia Drive, Fullerton, CA 92833
Woodcrest Elem. School	455 W. Baker, Fullerton, CA 92832

#### City of Fullerton (22+)

Fullerton Senior Multi-Service Center, 340 W. Commonwealth Ave  
(?) Garnet Community Center, 3012 Garnet Lane  
Maple Senior Multi-Service Center, 701 S. Lemon  
Valencia Center, 320 W. Elm  
Orangethorpe Community/Sports Center, adjacent to Orangethorpe Elementary School

Fullerton Tennis Center, 110 Valencia Mesa Dr.  
Fullerton Sports Complex, 560 Silver Pine Dr.  
Independence Park, 801 W. Valencia  
Fullerton Museum Center, 301 N. Pomona  
Fullerton Airport, 4011 W. Commonwealth Ave.  
Fire Station # 1, 312 E. Commonwealth Ave.  
Fire Station # 2, 1732 W. Valencia Dr.  
Fire Station # 3, 700 S. Acacia Ave.  
Fire Station # 4, 3251 N. Harbor Blvd.  
Fire Station #5, 2555 E. Yorba Linda Blvd.  
Fire Station #6, 2691 Rosecrans Ave.  
Library Main branch, 353 W. Commonwealth Ave.  
Library Hunt Branch, 201 S. Basque  
Maintenance Services Department, 1580 W. Commonwealth Ave.  
Police Department, 237 W. Commonwealth Ave.  
City Hall, 303 W. Commonwealth Ave.  
Transportation Center, E. Santa Fe  
Major Parking Garages

**Other Institutions (10)**

St. Jude Medical Center, 101 E. Valencia Mesa Drive  
Western State University College of Law, 1111 N. State College Blvd.  
Southern California College of Optometry, 2575 Yorba Linda Blvd.  
Boys and Girls Club of Fullerton, 348 W. Commonwealth Ave.  
Fullerton College, 321 E. Chapman Ave.  
YMCA, 2000 Youth Way  
Rosary High School, 1340 N. Acacia Avenue  
Eastside Christian School, 1645 W. Valencia Drive  
Fox Theater, 540 N. Harbor Blvd.  
Hope International University, 2500 Nutwood Avenue

**Table 1.**

**Reasons for Creating an Institutional Network (I-Net)**

Government, education and health care institutions have an ever-increasing need for more telecom services and applications that require ever-greater bandwidth.

Institutions have a desire to control their telecom costs.

Institutions can share costs and achieve economies of scale by building one network that serves all.

An I-Net can serve as the backbone for new telecom technologies and applications.

New telecom technologies significantly increase worker productivity, especially field personnel.

An I-Net will promote new forms of collaborative education and economic development.

**Table 2.**

**Reasons for Creating a Customer-Owned, Fiber-Optic I-Net**

Payback is typically on the order of 2-5 years.

System is newer and more reliable than existing telecom systems.

Bandwidth is typically much greater than can be obtained from telcos and cablecos and their legacy systems.

Fiber has long life and is future proof. Only the opto-electronics need upgrading. Hubs are manned and accessible 24/7.

Each customer-owner owns and controls access to specific strands of fiber and supporting opto-electronics. Great system security.

Each customer-owner can perform upgrades whenever desired.

Operation and maintenance can be outsourced. System can be monitored remotely.

Large choice of vendors from whom to purchase services. Open access to all qualified vendors. Purchase only needed services.

Network neutrality is not an issue.



**Table 5.**

**Possible Sources of Funds for Creating the I-Net**

Redevelopment funds

Homeland security and transportation grants including partnership with City of Anaheim

Cableco contribution/settlement (\$500,000)

Telecom cost savings

Developer fees

Capture of school E-rate funds that now go to telco

Independent telecom firm builds all or part and leases open access dark fiber to institutions

Major businesses, independent investors, and developers

**Table 6.**

**Average Monthly C/S\* for 100-1000 Mbps vs 1.5-6 Mbps Service**

1. Vendor finances, builds, operates, maintains I-Net for 10 years (Broadband Assoc.)

Monthly C/S \$270 \$110 (FSD) \$420 \$411 (FJUHSD) \$1376 \$542 (City)

2. E-rate pays districts' connection to City's central loop over 5 yrs. thru service fees

Monthly C/S \$205 \$110 (FSD) \$393 \$411 (FJUHSD) \$610 \$542 (City)

3. Vendor leases access to City's central loop for school districts (\$60,000/yr.)

Monthly C/S \$234 \$110 (FSD) \$430 \$411 (FJUHSD) \$360 \$542 (City)

\*C/S = Discounted Cost per Site I-Net Cost including voice Cost Today for Voice and Data

In 1 above City owns the whole I-Net after 10 years and monthly cost per site decreases to \$610. Costs to school districts for voice and data should decrease to approx. \$125 and \$233 per month per site for FSD and FJUHSD, respectively, when I-Net is paid off. In 2 and 3 above City pays cost of I-Net central loop and connection of its own facilities to the loop. In 2 and 3 the costs to the school districts decrease by about \$80 and \$160 per month per site for FSD and FJUHSD, respectively, after 5 years. Cost for voice service included in all of the above numbers (\$30 per month per site for FSD and \$110 per month per site for others) will decrease as voice over IP is implemented.

## Attachment 1

Excerpt from:

### The Coming Exaflood

By: [Bret Swanson](#)

The Wall Street Journal

January 20, 2007

Think of this. Each year the original content on the world's radio, cable and broadcast television channels adds up to about 75 petabytes of data -- or, 10 to the 15th power. If current estimates are correct, the two-year-old YouTube streams that much data in about *three months*. But a shift to high-definition video clips by YouTube users would flood the Internet with enough data to more than double the traffic of the entire cybersphere. And YouTube is just one company with one application that is itself only in its infancy. Given the growth of video cameras around the world, we could soon produce five exabytes of amateur video annually. Upgrades to high-definition will in time increase that number by another order of magnitude to some 50 exabytes or more, or 10 times the Internet's current yearly traffic.

We will increasingly share these videos with the world. And even if we do not share them, we will back them up at remote data storage facilities. I just began using a service called Mozy that each night at 3 a.m. automatically scans and backs up the gigabytes worth of documents and photos on my PCs. My home computers are now mirrored at a data center in Utah. One way or another, these videos will thus traverse the net at least once, and possibly, in the case of a YouTube hit, hundreds of thousands of times.

There's more. Advances in digital medical imaging will soon slice your brain 1,024 ways with resolution of less than half a millimeter and produce multigigabyte files. A technician puts your anatomy on a DVD and you send your body onto the Internet for analysis by a radiologist in Mumbai. You skip doctor visits, stay home and have him come to you with a remote video diagnosis. Add another 10 exabytes or more of Internet data traffic. Then there's what George Gilder calls the "global sensorium," the coming network of digital surveillance cameras, RFID tags and other sensors, sprawling across every home, highway, hybrid, high-rise, high-school, etc. All this data will be collected, analyzed and transmitted. Oh, and how about video conferencing? Each year we generate some 20 exabytes of data via telephone. As these audio conversations gradually shift to video, putting further severe strains on the network, we could multiply the 20 exabytes by a factor of 100 or more.

Today's networks are not remotely prepared to handle this exaflood.