Delivering High-Definition Digital Life – FTTH Community Owned Networks

Legal Stuff

1) Summary

The Internet is an open marketplace of content and services blossoming with world knowledge, premium entertainment content, real-time communication tools, and powerful search engines. It is **vital** for the link connecting this growing **treasure** with the home to be **affordable**, **fast, and unencumbered**. The broadband link as provided by the telecoms and cable companies in the U.S. and its planned expansion will not meet these requirements.

Real-estate developers realize that delivering Internet-ready and future technology-proofed communities is a requirement in today's market. Those looking for market differentiation are exploring **Fiber to the Home (FTTH) community owned networks** as a key new amenity. These networks create critical value in response to the exploding digital life needs of homeowners: inexpensive and powerful Internet-based data, voice, and video services; home-based businesses running servers and conferencing applications; as well as customized home-to-school, home-to-retail, and home-to-doctor interaction—all in high-definition video. FTTH community owned networks give homeowners instant high-quality access to the important people, institutions, and services that educate and care for their children, assist their career paths, and provide them with quality and on-demand entertainment.

FTTH community owned networks provide a lower cost, significantly more capable, and future proofed alternative to offerings from the cable and telecom companies, whose business models are based on mass market practices and a "walled-garden" approach to services. This new amenity is a system consisting of structured low-voltage wiring in the home, an ultra-fast community network, and a private connection to the Internet. The cost of installing fiber based community networks is under $1,500 per home; with an additional monthly charge of about $30 for upkeep (can be added into HOA fees). While community networks are ideally suited to new developments, they can also be installed in existing communities by municipalities, utility companies, or even Home Owner Associations.

FTTH community owned networks' value-add and differentiation will become more apparent with time as Internet content and services evolve and become more vital. At some point in the near future FTTH community owned networks will be as vital to the well being of the community as water pipes and electric wires are today. Those developers with the foresight to implement these networks early will spare their communities the hassle of retrofitting in the future and will be well positioned to capitalize and benefit from this foresight and resulting differentiation.

This paper discusses the nature, motivation, and benefits of FTTH community owned networks, and how they are built and operated.

2) The High-Definition Internet

The Internet is spreading like a "Cloud" enveloping the globe. The wealth of the world's libraries, movies, TV and radio programming, news, documentaries,

music, publications, maps, satellite imagery, art museums, etc. is being digitized in high-definition and made available through the Cloud.

Internet services tend to be more economical and superior in functionality relative to their legacy counterparts. Internet telephony (VoIP) adoption is growing rapidly, owing to its significant lower pricing and availability to any Internet-connected device, regardless of physical location; for example, a subscriber to Vonage™ or Skype™ can place and receive calls anywhere a broadband connection is available, even beyond national boarders. Likewise hundreds of Internet music services, including radio stations, are accessible through the Internet worldwide.

The dynamic of economy and superior features is rapidly bringing video services to the Internet as exemplified by the recent announcements at CES '06. The world's major technology powerhouses (Microsoft®, Google®, Yahoo®, Apple, Sony) are making large investments in Internet video services, and some smaller players are basing their entire existence on such services (MovieLink®, CinemaNow, etc.). The existing "walled garden" and mostly broadcast TV era will rapidly take backseat to a far richer era of on-demand, search based, and interactive Internet video services.

In addition, it is abundantly clear that adoption of high-definition video is on the rise[1], thanks to mature standards and consumer affordability both on the capture (cameras) and viewing (TVs) sides. With broad consumer adoption of HDTV, we can expect the rapid evolution of Cloud services that will target and greatly benefit from this medium. The HDTV, not the PC, is the ideal target in the family room for Internet video services. HDTVs with native digital support, high resolution[2], large screen size, location in the family room in front of a comfortable couch (i.e., ten feet UI), and superior audio quality provide ideal windows into this inevitable set of video services in the Cloud.

The high-definition services will quickly overflow the existing and planned incumbent pipes to the home. Even video downloads are problematic today; with a dedicated DSL or Cable broadband connection, it will take more than two days to download a high-definition movie. The bandwidth requirements of live high-definition services for a typical household will rapidly exceed even 100 Mbps capacity; see the bandwidth analysis in the following section below. Furthermore, current Ethernet standards and technology afford delivering symmetric[3] 1 Gbps (1,000 Mbps) over fiber[4] to the home using commodity priced equipment.

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[1] According to the Yankee Group [1] about 60 million U.S. households will have HDTVs by 2008 and about 80 million by 2010.

[2] A minimum resolution of 720p (1280x720)—6.75 times NTSC-- that is evolving to 1080p (1960x1080)—13.75 times NTSC.

[3] Symmetric means simultaneous 1 Gbps upstream and 1 Gbps downstream.

By extending the reach of fiber to every home and removing artificial limits on bandwidth, the user experience based on high-definition services will improve exponentially. Examples of such user experiences include:

High-definition VoD and Networked PVR: the future TV watching experience will be characterized by on-demand, high-definition, rich search, and instant playback with interactivity (full trick-play control). Virtually all movies and TV programs ever made, including international programming, will be easily accessible based on personalization technology, video indexing techniques, and powerful search engines. Furthermore, a networked PVR service will spare the user from having to remember to monitor the eGuide and tag programs for recording ahead of broadcast time; rather, in addition to rich search the eGuide will be navigable into the past like it is into the future for instant playback. Also, the user will be able to resume watching a program in a hotel room, having started watching it at home.

Fast Movie download: with FTTH community owned networks a movie could be downloaded, upon purchase or rental, significantly faster than current broadband connections. For example, a two-hours 1080p movie (about 15 GB if encoded in a modern compression scheme) will download in less than 3 minutes over a GigE pipe versus more than two days over a 1 Mbps link.

Telecommuting: with high-definition cameras and TVs, ultraband networking, and the ability to stitch together a secure corporate network that reaches end user locations, telecommuting becomes significantly more effective and realistic.

Distance Learning: a student is home sick with the flu. She wants to lie down on the family room couch and tune the HDTV to her class for the day. Occasionally, she may want to step in and ask a question. Another student is preparing for a final, but he's uncertain about a particular topic. He searches by the professor name and topic, and replays the selected lecture on his HDTV.

Enhanced Shopping: a high-end fashion retailer, like Nordstrom, might offer a personal shopper service where new arrivals are shown in one-on-one high-definition video conference, thus eliminating the need to physically travel to the Mall for affluent and busy customers.

School camera: through a community outreach program, the local pre-schools and elementary schools place multiple high-definition cameras in classrooms for parents and grandparents to watch live from the comfort of their homes.

Remote Tutoring: certain forms of tutoring, for example singing or math lessons, will be effective via high-definition conferencing from the comfort and

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[4] It is feasible to run GigE (Ethernet at 1 Gbps) over copper but only for short distances of hundreds of feet (for example, inside homes); however, it is feasible to run GigE over fiber for distances of tens of miles.

convenience of home. This saves parents valuable time that it would take to drive and wait for their kids.

Community Events: the homeowner is down with a twisted ankle, but does not want to miss the daily tennis match between her neighbors. She tunes her HDTV to the community tennis court live feed, and has four camera angles available, including split screen options.

3) Requirements

With an open marketplace of high-definition services in the Cloud and HDTVs commonplace in the home, what is needed to tie the two together is the availability of unencumbered and inexpensive ultraband connectivity, as follows:

Bandwidth: high-definition video will plateau at 1080p resolution (1960x1080 at 60 frames per second) for the foreseeable future[5]. The bandwidth requirement for supporting a 1080p stream, if encoded in one of the modern compression schemes (AVC or VC1), is about 15 Mbps. With trick play (fast forwarding, rewinding, slow motion, etc.), the bandwidth requirement could easily spike at more than five fold— thus approaching 100 Mbps per stream. If we consider picture-in-picture and split-screen functionality and multiple HDTV sets per household, then the video on demand scenario alone eliminates any other possibility but GigE over FTTH[6].

Quality of Service: an IP pipe with plenty of bandwidth is not sufficient for delivering time-critical services, such as voice and video, there is a need for Quality of Service (QoS) support. For example, a live video conference to be conducted at high-fidelity, simultaneously with heavy network traffic, such as large file copying, is feasible only with an effective QoS scheme. The good news is that with high bandwidth availability the QoS problem becomes substantially more tractable.

Pricing: extrapolating from current bandwidth pricing, none of the scenarios above are affordable; for example, $200 per month for a 30 Mbps pipe according to the published plan for the FIOS service from Verizon implies even higher rates for a 1 Gbps pipe. The user can't afford to pay hundreds of dollars per month for connectivity; the expectation is that Internet connectivity will cost no more than $30 per month.

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[5] HDTVs that support 1080p are already approaching consumer pricing, and the advent of high-definition DVD players will popularize 1080p content. High-definition Media Center PCs are already 1080p capable, and the Sony PS3 will support 1080p when it ships later in '06.

[6] The leap to 1 Gbps that we're calling for, as compared to the current sub-5 Mbps broadband offerings in the U.S., is akin to Google's shattering the ceiling by offering 1 GBs of free email storage at a time when other providers nickel-and-dimed their users a MB at a time. The cost of HDD was approaching $0.5 per GB retail, which suggests that Google's offering was simply riding the technology advancements on the cheap. We're simply observing that on the bandwidth front the technology and economics are ready for a similar leap.

4) Inadequacy of Incumbent Offering and Plans

The offerings by telecom and cable companies today (DSL and Cable) and their future plans (limited fiber) fall short on what is needed for the high-definition Internet. The incumbent's plan of record consists of offering triple play services (TV, phone and data) over an upgraded network delivering up to 30 Mbps per household. In addition, the incumbents have the legal authority to block third parties from using their infrastructure.

Furthermore, with the incumbents in charge, the U.S. keeps on sliding in relation to broadband services. According to a recent report by Free Press [2]:

- On a per-capita basis the U.S. has dropped from 13th to 16th among nations globally in broadband penetration. This drop follows last year's fall from 11th to 13th.
- On a per megabit [per second] basis, U.S. consumers pay 10 to 25 times more than broadband users in Japan.
- The average speed of U.S. broadband connections has seen minimal increase over the past five years. Consumers in France and South Korea have residential broadband connections with speeds 10 to 20 times higher than those in the United States.

The incumbents owning the entire broadband relationship will leave consumers with limited choices. At the national level, this will stifle innovation and hinder the development and delivery of high-definition services.

The shortcomings in the incumbent offering include the following:

1. **Bandwidth**: high-definition video is the predominant bandwidth consumption driver. With on-demand 1080p video content on the horizon, required bandwidth will easily exceed 100 Mbps per household (see bandwidth analysis above).
2. **Coverage:** incumbents have been vague on when higher bandwidth access will be available across the bulk of their geographies. They are also vague on how far fiber will reach into the neighborhood, or whether fiber will reach every home. For example, the most aggressive announcements came from Verizon who plan to deploy a fiber-based service called FiOS. The announced plan promises up to 30 Mbps in bandwidth and targets deployment in Washington State starting in late 2006 to cover 60,000 out of 850,000 homes in the State. No announcements were made on when complete coverage of the state will be offered (if at all). Other carriers have no plans to bring fiber all the way to the home; rather, they plan to deploy faster variations of DSL that will not meet high-definition Internet requirements.
3. **Cost**: incumbents are charging higher rates for higher bandwidth. For example, Verizon's FiOS service is priced at $200 per month for 30 Mbps.

This is too expensive for most households, thus turning it into a niche market. Experience has shown that high penetration can only occur as access rates drop below the $30 mark.

4. **Business Model**: in incumbent parlance, Triple Play is a synonym for Walled Garden, the business model that incumbents are most comfortable with. In this model, the incumbent attempts to pull the user toward what appears to be an all-inclusive package instead of the Internet open marketplace of services. Walled Garden translates into fewer competitive offerings, limiting consumer choice, and most likely translating into higher user costs.

5. **Encumbering Access to Internet Services**: Incumbents feel that they own the pipe, and therefore have the right to control who accesses it and at what cost. In a series of rulings, the FCC declared that incumbents do not have to share their pipe with any data service providers, thus providing legal legitimacy for their Walled Garden business model and potentially other restrictions. This point is best illustrated by a highly publicized recent quote by SBC's CEO Edward Whitacre:

> *"How do you think they're [Internet service providers] going to get to customers? Through a broadband pipe. Cable companies have them. We have them. Now what they would like to do is use my pipes free, but I ain't going to let them do that because we have spent this capital and we have to have a return on it. So there's going to have to be some mechanism for these people who use these pipes to pay for the portion they're using. Why should they be allowed to use my pipes? The Internet can't be free in that sense, because we and the cable companies have made an investment and for a Google or Yahoo or Vonage or anybody to expect to use these pipes [for] free is nuts!"*

5) An Opportunity for Real-Estate Developers

It is vital that the link that connects the growing Internet treasure with the home be fast and unencumbered. The inadequacy of the incumbent offering presents a significant value-add and differentiation opportunity to real-estate developers of new communities (greenfields). To an informed home buyer, a community with an advanced communication infrastructure that insures an unencumbered and ultraband Internet pipe is of more value than a community without one. As the high-definition Internet evolves, home buyers' appreciation of this value-add and differentiation increases.

Implementing FTTH is simple and economical in new communities as trenches are open and homes are being built. According to present pricing, an investment of under $1,500[7] will cover the equipment and installation of a 1

[7] As reported in [4] "Utopia incurs $900-1,500 in capital costs per subscriber, according to David Shaw, General Counsel of Utopia." The difference in cost of silicon to support GigE versus fast

Gbps over fiber pipe per home (which is a small fraction of the overall home cost). This amount covers the customer premise equipment (CPE), switches, data centers, fiber, and labor.

Once FTTH is installed in new communities, developers can turn over management responsibilities to Home Owner Associations, and network maintenance charges can become part of the HOA fees. The cost for maintaining the community network and bridging it to the Internet backbone is about $30 per month (as illustrated by current broadband pricing).

To capitalize on the opportunity to differentiate, developers must provide a complete technology offering consisting of the following main components:

Low-Voltage Structured Wiring

The structured wiring inside the home is a key to delivering the Internet experiences to the different locations at home and also for sharing content and devices over the home network. It is recommended to run at least two Cat6[8] cables to every room, home-run to a common network hub, where centralized and shared home equipment could be safely located. To prepare the home for digital music and voice distribution, likewise home-run Cat6 as well as low-voltage power-grade cabling is recommended to all speaker locations.

The Ultra-Fast Community Owned Network

The community network consists of dedicated fiber from the community data center(s) and switches (a.k.a. concentrators) to a CPE placed inside the home network hub. This CPE readily connects to the home network via Ethernet over the Cat6 cables.

The Private Connection to the Internet

It is well known that there is an abundance of long-haul fiber in the U.S. that remains unused (dark-fiber). As a consequence dark-fiber is being acquired on the cheap for building private networks; for example, international conglomerates, such as the Ford Motor Company, are switching from reliance on the phone company to constructing their own networks, thus realizing operational savings and superior performance [3].

The availability of this unused and otherwise expensive infrastructure plays in favor of community owned networks, in that once the community network spans the last-mile it is safe to bet that there will be economical solutions to connect it with service providers and other community networks.

Ethernet (100 Mbps) over fiber to the home is negligible as illustrated by the retail cost of GigE switches approaching $5 per port.

[8] Cat6 is preferred over Cat5 and Cat5e since it is based on higher quality copper and hence provides a better medium for running high frequency signals, such as what GigE requires, over it for longer distances.

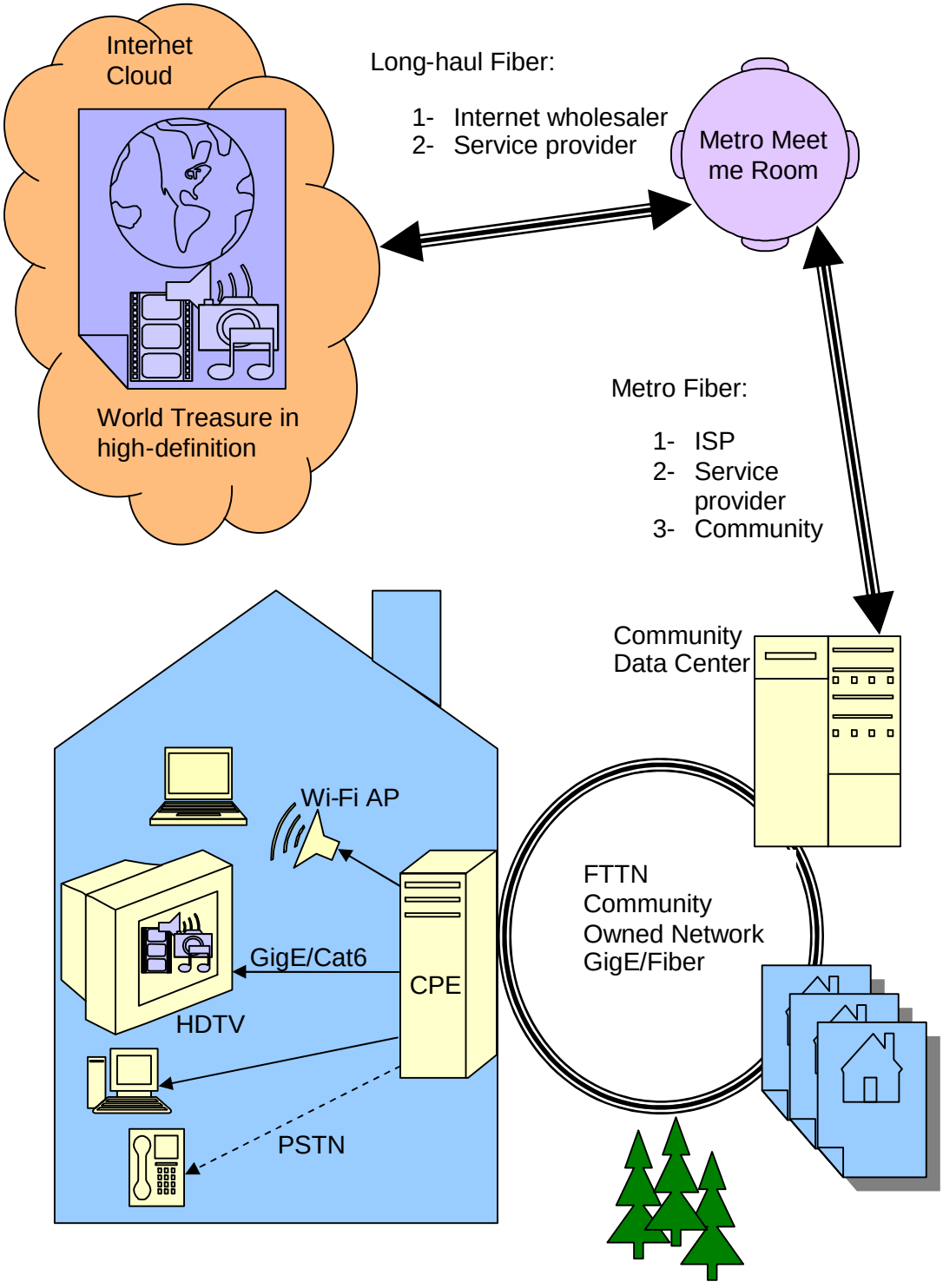

Figure 1: The high-definition Internet delivered at the family room

A number of business models will provide for the fast link between the community network and the Internet, including:

1. **ISP**: relying on an ISP to provide connectivity to the community network. This is the simplest approach, but likely not the most economical.

2. **Internet Wholesaler**: leasing or owning a link to an Internet wholesaler. This model is supported with the advent of "Meet Me Rooms", which are facilities conveniently located and equipped to simplify cross-connections between different organizations.

3. **No-Mediator**: In addition to alternatives #1 or #2 the community could choose to allow large Internet service providers (plural here is intentional) to directly link their private networks to the community network. Google is a good example here given its interest in being a premium video provider, and its rumored efforts to acquire dark fiber presumably to build its own national network [4].

The details of these alternatives are beyond the scope of this paper and will be addressed in a future paper or upon request.

6) Retrofitting Existing Communities

Existing communities are not difficult to retrofit. Utility companies have the widest reach and ability to provide maximum benefits with their right of way into every single home. Also municipalities have strong incentives for undertaking FTTH community owned deployments, not the least of which is their responsibility to provide taxpayers with a path to the high-definition Internet and its associated Cloud services. Other benefits include nurturing the local economy and job creation for the community; see the next section below.

Presently there are less than 500K U.S. homes with fiber (i.e., less than 0.5%). However, there are a few municipalities including Provo [5] and several in Salt Lake City (project Utopia) [6] in Utah, Lafayette in Louisiana [7], and numerous remote counties around the U.S. that have FTTH community owned network deployments championed by their respective power companies. These are examples where enlightened decision makers are preparing their communities for the future digital life.

7) A New Economy

With proper ultraband connectivity (which we define as approaching 1 Gbps) to the home, there's a lot more to the future than the highly touted Triple Play. The impact of all the new Cloud services is nothing short of creating a New Economy that is measured through improved economic conditions, reduced environmental impact, increased leisure and free time, and measurable improvements to the quality of life. Furthermore, ultraband connectivity will boost U.S. global competitiveness as suggested by a recent IEEE report [7] "Ubiquitous gigabit networks will provide superior ability for the U.S. economy to compete globally."

The likely impact on the economy includes:

Opportunities for new business & job creation: from servicing the home's digital life to the creation of content, services and new categories of Internet enabled devices. Market dynamics and human imagination is the limit on how to monetize the new infrastructure.

In-sourcing: effective video conferencing, as in you're almost there, will effect a more even re-distribution of jobs to communities that need the infusion. More importantly, at the national level, it allows for a more even distribution of jobs without the emotional and economic impact of relocation.

Reduced spending on roads and better environmental outlook: many past telecommuting experiences failed due to unreliability of links and audio-only capabilities. With high-definition video conferencing, a number of jobs, such as sales, software development, insurance, etc. can be effectively performed from home. The benefits in terms of reduced road congestion, not having to spend money on new roads, diminished dependence on fossil fuels, and lowered pollution levels will be remarkable on society.

Increased productivity: multi-channel high-definition video conferencing, coupled with high-speed application sharing, delivers an experience that is satisfactory enough to eliminate or reduce many in-person interactions. The contexts vary from business to personal, reducing time wasted in traveling, waiting for a meeting to happen, waiting for a city clerk to free up, etc. The end result is an increase in productivity and reduction in personal stress, which will be remarkable at a social level.

Improved educational and economic outlook: distance learning puts high-definition video cameras in top ranked classrooms, and allows remote locations to offer quality education to their students. This opens the possibility of a new generation of educational applications and services. With such remote educational services comes improved economic opportunities and decreased pressure on residents of remote areas to relocate seeking better education, and on school officials to cater to gifted students in remote areas.

8) Comparing Incumbent Offering to Community Owned FTTH Networks

Following is a table that compares a community owned FTTH to alternative incumbent offerings including planned higher bandwidth offering:

	Incumbent DSL/Cable	Incumbent future network	GigE over FTTH community owned
Monthly Costs	$30-$50	$75-$200	$20-$40
Performance	768K-3Mbps	10-30Mbps	1Gbps
Physical Network	Copper and Coax	Copper, Coax with limited fiber	Fiber
Upgradeability	Proprietary Equipment	Mixed bag	Standard based (Ethernet)
Number of simultaneous high-def streams at 1080p using MPEG4-like compression	0	0-1 in trick-play mode, 1-2 in normal-play mode	10+ in trick-play mode, 50+ in normal-play mode
Variety of services	Walled Garden, no high-def, ISP required	Walled Garden, limited high-def, ISP required	Open, unlimited high-def, no ISP required
Value proposition	Walled Garden implies higher pricing and lower value	Walled Garden implies higher pricing and lower value	Competition guarantees best value
Ability to self-host services, such as web servers, home business, etc.	Serious restrictions	Past restrictions suggest future ones	No restrictions
Coverage	85% U.S. households	At mercy of incumbent rollout plans – history suggest slow pace	Community choice
Future Proofing	None	Short-term	Long-Term

9) Conclusion

The situation at hand in the U.S. presents an opportunity for both developers and municipalities to create future proofing, value-add, and differentiation by making a relatively small investment that takes advantage of the dramatic progress in fiber technology and related standards in order to secure unencumbered and ultraband pipes to the home. The return on investment to the developer and municipalities through differentiation and improved economic conditions, respectively, is obvious and substantial.

Plextal Corporation is an independent consulting firm dedicated to educating developers, municipalities and communities on the opportunities around the high-definition Internet enabled by community owned FTTH networks and properly wired homes. This paper is a step by Plextal and other companies who are actively nurturing an ecosystem that caters to the deployment of community owned FTTH networks. There will be more steps in this regard that will be intended to further educate developers, municipalities and others, and facilitate their decision making process by clarifying the technology and methodology for implementing FTTH community owned networks. For further details check www.plextal.com.

10) References:

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2) ***Broadband Reality Check: The FCC ignores America's Digital Divide***, by Free Press, Consumers Union, and the Consumer Federation of America, August 2005.

3) ***Dark fiber: Businesses see the light***, CNET News.com, February 2005.

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