2014 Research Report

Broadband Internet access technology commissioned research

Final Report

Grantor:

Abstract

Key words: Broadband Internet, network access technology, Fiber To The Home (FTTH)

In an effort to improve the efficiency of digital broadband and upgrade the quality of broadband Internet service for the benefits of general public, this study concentrated on broadband Internet technology with emphasis on broadband technical research and ROC broadband policy. For this purpose, this study had extensively examined the statuses of *Broadband To The Hom*e in many countries and gathered the data relevant to broadband development strategies. Moreover, this study reviewed many types of broadband services such as FTTH, FTTB/FTTC + xDSL, FTTB/FTTC + Cable, FTTB/FTTC + Wireless, and FTTB/FTTC + PLC adopted by various countries such as USA, England, France, Japan, China, and Singapore, focusing on the differences between the broadband services provided by telecommunication service providers, such as Internet speed, the timing of use, restrictions on services, and access efficiency.

The research results indicated that, as far as network access is concerned, broadband service providers in most countries provide users with high speed network services through FTTn and xDSL at this moment. Nevertheless, all broadband service providers will switch to FTTH sooner or later. In this connection, how to accelerate the access speed remains the most crucial task in the days to come. Presently, most telecommunication service providers use VDSL2-related technologies and upgrade their technological capabilities through the cables that have been installed for commercial service. The difficulties associated with deployment are considerably lower. Equipment providers can easily upgrade ITU G.993.2 VDSL 17a version or lower versions and thereby support ITU G.993.2 VDSL 30a simply by upgrading their firmware. There is no doubt that the upgraded specifications are easy to follow. Therefore, *Fiber To The Building* (FTTB) is deployed in many apartments and office buildings; Digital Subscriber Line Access Multiplexer (DSLAM) is connected to digital wires and divided into several segments for small-capacity users. In huge areas like residential buildings and industrial parks, *Fiber To The Node* (FTTN) is deployed to accelerate service speed and thereby surmount the obstacles imposed by distance at the same time. This study had tested all access technologies one after another. The results indicated that, when transmission speed reached 100Mbps or higher, fiber transmission lost the smallest amount of signals under the restrictions imposed by distance, followed by coaxial cables, xDSL and PLC, whereas the largest amount of signals were lost in wireless transmission.

To cope with the growing demand for high speed broadband, this study recommended that fiber and Ethernet should be deployed in new buildings; meanwhile, old buildings' VDSL2 specifications should be upgraded from 17a to 30a; the specifications of coaxial cables and ITU G.hn should be upgraded as well. Moreover, FTTC, FTTB, and FTTN + node should be deployed together with FTTH. It is important to note that the installation environment varies, depending on the location. Therefore, new buildings, old buildings, and roads require different access methods. In conclusion, this study presented recommendations for the modifications of the *Regulations Governing the Technical Specifications for Telecommunication Equipment Deployed Inside and Outside of Buildings* (Attachment 3) together with tangible recommendations regarding the future development to the project grantor for its reference.

Chapter 1 Introduction

In most countries, high speed broadband is treated as an important tool for economic development. A number of countries are eager to realize social equity and to eliminate the difference between urban and rural areas through broadband. According to the white paper *Digital Britain* released by British government, a next-generation high speed broadband network combining fiber and wireless network will be deployed in 2017. In Japan, a super high speed broadband network with access speed higher than 100Mbps is expected to be implemented in 2015. In Taiwan, broadband is still unable to satisfy the growing demand for digital convergence although Taiwan has a high broadband penetration ratio. For the well-beings of the people in the digital era, the Executive Yuan has passed a *Digital Convergence Development Plan* that is designed to upgrade Taiwan's digital convergence industry and thereby boost Taiwan's competitive edge in terms of the next-generation broadband. According to the Plan, FTTH with access speed 100Mbps will be deployed in 2015, allowing the general public to enjoy the convenience of high speed Internet.

Section 1 Background

Broadband transmission has developed progressively in recent years. FTTH requires EPON or GEPON (Ethernet Passive Optical Network, EPON) conforming to the IEEE/EFM standards prescribed for Ethernet packaging data; 802.3ah standards conform to IEEE 802.3 standards. Presently, xDSL sector is progressively developing VDSL2.0 technique and CATV digital service providers are DOCSIS 3.x technique. Based on the facts stated above, this study presented tangible recommendations in connection with modifying the regulations and ordinances governing broadband deployment and meanwhile compared the requirements for the latest broadband transmission techniques and related services in order to identify the technical solutions and tangible measures for high speed broadband deployment in Taiwan.

Section 2 Purpose

This study focused on broadband Internet techniques with emphasis on the research of broadband techniques and thereby formulated a suitable broadband policy for Taiwan and upgraded digital broadband efficiency, thus allowing the general public an access to a higher level of broadband Internet services.

1. Creating a suitable convergence environment for industrial development

Technological convergence has developed ceaselessly and broadband access technology has been upgraded tremendously in recent years, allowing the general public to enjoy their daily lives conveniently. In the beginning, broadband access technique could provide a single service at one time. Now, broadband can provide 3 services at the same time, namely, digits, voice, and images. Broadband access technology contributes to the rapid development of telecommunication, CATV, and Internet, creating new demands and new business opportunities for the industries. It is therefore very important to upgrade the Internet environment not only for the people to enjoy better broadband convergence services and to upgrade their digital abilities, but also for the industries to upgrade their competitive strength. At the time that digital convergence industry continues to grow, how to upgrade broadband techniques and how to modify the regulations are an important task for the development of telecommunication, CATV, and Internet industry.

2. Upgrading broadband service quality and broadband technology

A perfect market competition mechanism is indispensable for a nation to upgrade its competitive strength. It is therefore very important to upgrade broadband techniques and to modify broadband policy for the telecommunication industry to implement a superior Internet environment, develop the content of digital services, and upgrade the service quality. A superior broadband Internet environment not only allow the general public to enjoy a better Internet quality, but also helps broadband access service providers to upgrade the digital broadband efficiency, thereby upgrading the broadband Internet services for the well-beings of the general public.

Section 3 Scope of research

This study discussed the current status of broadband access techniques intensively in order to identify the technical development and the appropriate measures for the development of high speed broadband in Taiwan, followed by the examination of broadband network and analysis of various broadband access techniques for the reference of technical supervision. A research plan was formulated based on the research goals. Research topics are listed as follows:

- Gathering data related to FTTH from various countries, analyzing the broadband services provided by the telecommunication service providers in those countries as well as the Internet speed, timing of use, restrictions on the services, and digits related to access efficiency in those countries.

- Comparing the differences between various international standards prescribed for the five tasks stated above with emphasis on the status of broadband network, restrictions on transmission distance and transmission speeds, as well as how to cope with the new services related to broadband networks.
- Testing the existing broadband network's performance: selected examples of FTTH application and tested various broadband networks with emphasis on the highest connection speed and access performance in order to find out if the technical requirements and criteria prescribed for 100Mbps were suitable for the samples.
- Formulating broadband policy and promotion measures as follows: *Engineering Techniques for Telecommunication Equipment Deployed Inside and Outside Buildings* and *Regulations Governing the Deployment and Maintenance of Broadband Inside and Outside Buildings*.

This study gathered related data extensively and exchanged opinions with all parties concerned in order to find out the techniques required for deploying telecommunication equipment inside and outside buildings as well as differences between the broadband services provided by telecommunication service providers in Taiwan and by telecommunication service providers in elsewhere of the world. For the research purpose stated above, this study examined the measurement of broadband access techniques, discussed foreign countries' samples as well as integration into the world, and presented tangible recommendations for high speed broadband technical requirements and development strategies to the grantor for reference and for the development of broadband industry.

Section 4 Research methods and procedure

This study abided by the requirements prescribed in the tender documents issued by the grantor and thus gathered data related to FTTH deployment in various countries, status of broadband technical development and broadband development strategies adopted by those countries based on the requirements prescribed for the research project. Moreover, this study analyzed various broadband network techniques with emphasis on connection speed and access performance. The team extensively gathered examples of FTTH applications from various countries with respect to the status of development and future planning. Furthermore, this study selected on FTTH, FTTB/FTTC + xDSL, FTTB/FTTC + Cable, FTTB/FTTC + Wireless, and FTTB/FTTC + PLC as the subjects. Then, this study researched the broadband services in USA, England, France, Japan, China,

and Singapore with emphasis on the Internet speed, timing of use, restrictions on services, and access efficiency.

Chapter 2 An overall analysis on CATV set-top box locks adopted by various countries

Broadband Internet Service means the capability to upgrade network transmission efficiency and data transmission speed using digital compression techniques. There are two types of transmissions, namely, wires transmission and cable transmission. Presently, fiber is considered a perfect tool to transmit the maximum amount of broadband. At the time that the demand for network continues to grow, the latest broadband hybrid network – FTTx – is undoubtedly the best choice for CATV and xDSL service providers.

Section 1 An overview of broad Internet Service

All countries in this world are upgrading their parallel infrastructures, and courage their fixed network, CATV and mobile network service providers to provide broadband services. At the time that network techniques develop by leaps and bounds, it is unfeasible to formulate policies based on a single technique. If a policy is formulated based on a specific technique, the technical value or service lifecycle is likely to be overestimated and meanwhile non-technical factors are likely to be underestimated. It takes several techniques to provide broadband services and help the general public to enjoy the convenience of broadband services at the same time.

Section 2 Current statuses of FTTH in various countries

1. USA

Telecommunication industry and CATV are competing fiercely in USA. As a result, fiber hybrid networks are distributed extensively across USA. Other broadband access methods include satellite, mobile network, cable digits, power line network, etc. All service providers are penetrating into every region progressively. Some service providers have a large market share while some others can hardly maintain their market shares. Major service providers are listed as follows:

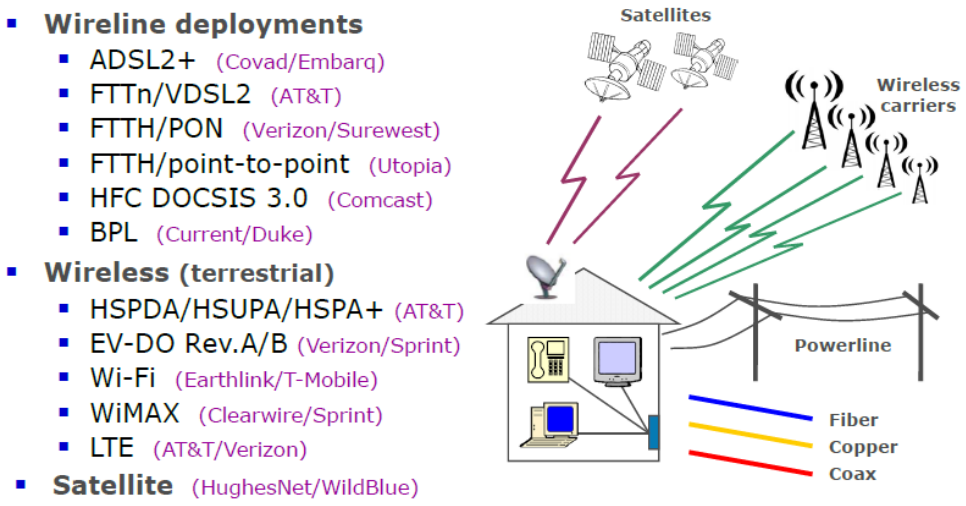

Fig. 1 Broadband access techniques and service providers in USA

2. Japan

In Japan, private corporations construct and deploy broadband whereas government creates a fair environment for competition and surmounts the obstacles that impede the development of broadband. Moreover, the government appropriates budgets for the remote areas, encouraging broadband service providers to construct and deploy broadband networks through public investment. Japanese government provides many incentives to encourage private corporations to construct broadband networks, such as tax exemption and financing, thus motivating the investors. In 2010, Japanese government started to promote Broadband Development Plan, making use of the idle broadband resources to develop an informational society. The Plan urged NTT to liberate as much as 74% of fiber networks in Japan, allowing other broadband service providers to use it at low costs in order to upgrade the broadband penetration ratio in Japan.

3. Korea

Korean Telecommunication (KT), with approximately 18 million telephone users, 8 million broadband network users, and 4.7 million IPTV users, is the largest broadband network service provider in Korea. KT provides FTTH access services with broadband 1Gbps. KT and Ubiquoss provides digital service and access service using ITU -T G.hn technique to accelerate the access to Internet.

G.now, an upgraded technique of ITU G.hn, is designed for cable broadband access network. As compared to the 100 Mbps speed of conventional VDSL system, G.now provides a higher transmission speed more than 500Mbps, using TDD framework provided with

upstream/downstream together with the latest FEC and automatic retransmission technology to restrict and decrease near-end crosstalk.

4. Europe

According to the statistics released by FTTH Council Europe in the end of 2013, there were 201 million FTTH/FTTB users across European Union. In 2013, the number of fiber access users in Europe grew from 15% to 20%. France and Sweden saw the fastest growth. As to the countries outside EU, Russia has 9 million users and Ukraine has 1.3 million users.

5. Singapore

Singapore Telecommunications Limited (SGX) is one of the 30 largestmobile communication service providers of the world. SGX provides Internet access service and fixed network service as well. Moreover, SGX is an investor in overseas marekt, such as Autralia's Telecommunication Corporation Optus and Taiwan's New Century InfoComm Tech.

6. China

China Telecom is the largest fixed network service provider in China. China Telecom is progressively promoting the National Broadband Plan promulgated by Chinese government, and is expected to increase the national broadband penetration rate within 2011 – 2015. In 2013, China Telecom started to provide FTTx downloading service with speed 100Mbps. However, all regions differ from one another in terms of technical capabilities. For example, 100Mbps service wasn't available in Beijing before 2014; uploading bandwidth was merely 2Mbps even if users applied for 100Mbps.

Section 3 Trend of broadband Internet services in various countries

As of August 2014, Japan's NTT is the leader of the world in terms of FTTH downloading speed – as high as 1Gbps. Most service providers make use of FTTx technique together with xDSL and DOCSIS access techniques to transmit data within 45~152Mbps speed. In USA, Vcrizon makes use of FTTx together with LTE access technique to provide broadband downloading service at 75Mbps speed.

Table 1 Access techniques and downloading speeds in various countries

	美國				韓國	英國	
寬頻業者	AT&T	Verizon	Comcast	EarthLink	KT	Virgin Media	British Telecom
接取技術	FTTx/DSL	FTTx/DSL/LTE	FTTx/ DOCSIS	Satellite	FTTx/DSL	FTTx/DSL/ DOCSIS	FTTx/DSL
光纖最高下載速率(bps)	45M	500M	-	-	100M	-	76M
其他接取技術最快下載速度(bps)	6M	xDSL : 15M/ LTE: 75M	DOCSIS : 150M	15M	-	DOCSIS :152M xDSL : 100M	xDSL : 17M

	法國	日本	荷蘭	中國	新加坡
寬頻業者	Orange Telecom	NTT	Royal KPN N.V.	中國電信	新加坡電信
接取技術	FTTx/DSL	FTTx/DSL	FTTx/DSL	FTTx	FTTx/DSL/LTE
光纖最高下載速率(bps)	500M	1G	80M	100M	500M
其他接取技術最快下載速度(bps)	VDSL : 15-50M ADSL : 1M	xSL : 100M	xDSL : 10M/	-	xDSL : 15M/ LTE: 70M

Chapter 3 Examples of broadband application and variance between international technical standards

As far as data transmission is concerned, fiber communication is unquestionably the best transmission method. Nonetheless, many areas have not been provided with fibers yet. Fiber hybrid network remains popular up until today. Fiber hybrid network is unable to provide high speed transmission service, which is essential for multimedia, due to the limited capacities of xDSL, DOCSIS or power line. Nevertheless, when several fiber transmission points are established, users are likely to receive more Internet broadband services than before. For the comparison of various transmission speeds, please check the table as follows.

Table 2 Transmission speeds of various broadband Internet access techniques

WAN	xDSL		DOCSIS		EPON/GEPON		PLC	
版本	17a	30a	3.0	3.1	IEEE802.3ah/av		UPA	HPA
傳輸速率 max(Bps)	180M	200M	160M	1G	1G	10G	200M	

Section 1 Fiber To The Home (FTTH)

Announced in 2004, EPON, or GEPON (PON Ethernet Passive Optical Network), complies with the IEEE/EFM standards prescribed for Ethernet packaging data. 802.3ah standards conform to IEEE 802.3 standards. At the time that users require more and more bandwidths, G/EPON (Gigabit-capablc / Ethernet Passive Optical Network) network has become an important infrastructure for broadband access network and GPON network has become a major access technique adopted by most telecommunication service providers. Fiber is provided with Time Division Multiple Access (TDMA) technique to identify users' access to upstream digits. GPON network has a high downstream speed, as high as 2.5G bps. The network is provided with splitter to divide one fiber into multiple fibers, and is thus capable of providing as many as 128 users with 10 - 100M bps broadband services with upstream speed roughly 1.25G bps.

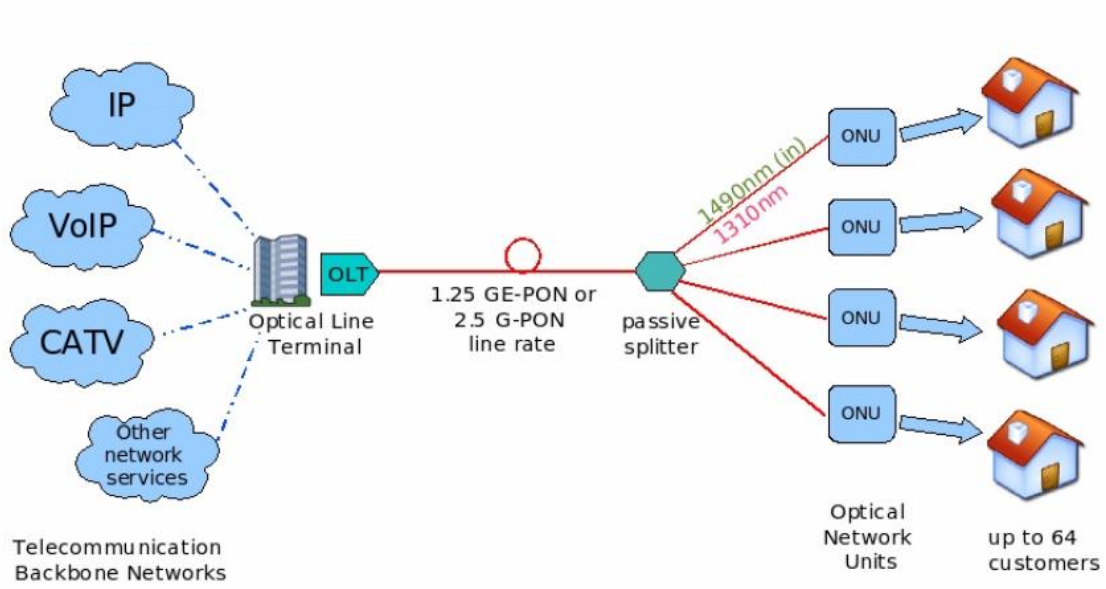

Fig. 2 GPON Ethernet Passive Optical Network

FTTdp framework is designed to surmount the obstacles related to access techniques, increase service speed using xDSL and G.Fast, and reduce implementation costs at the same time. Moreover, G.Fast can be integrated into power lines, instead of xDSL, to construct FTTdp transmission network.

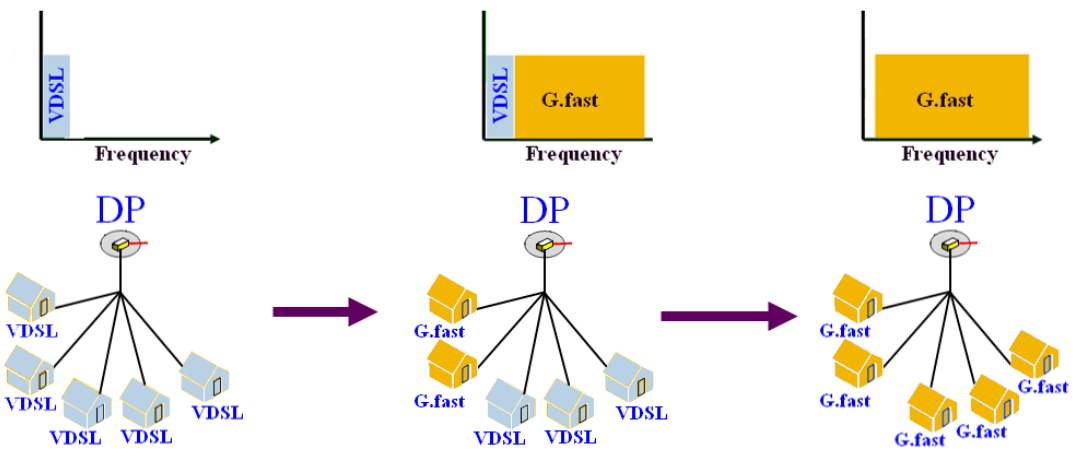

Fig. 3xDSL and G.Fast coexistence

Section 2 xDSL

Digital Subscriber Line (DSL) refers to digital connection through copper wires or local telephone network in which data is transmitted through OFDM. xDSL technique was developed from ADSL to VDSL2. In 2006, ITU announced G.993.2 VDSL2 technical specifications. Transmission speed has reached 100Mbps since then. Now, VDSL2 is the considered the most important DSL technique. There are a number of transmission speeds

under G.993.2 standard; USA specification (G.993.2 Annex A) has the fastest transmission parameter 30a. Different copper wires and difference distances determine the different amount of signals lost in the transmission. If it is unlikely to maintain 30a, transmission parameter can be decreased to 17a or lower and thereby facilitates the transmission through a long distance. Presently, 30a allows transmission speed as high as 200M bps.

Section 3 Data Over Cable Service Interface Specifications (DOCSIS)

DOCSIS, approved by ITU, serves as the standard specifications for cable modem. All cable modems compliant with DOCSIS are interchangeable. Moreover, DOCSIS conforms to the CATV standards established by CableLabs, an organization formed by CATV service providers across USA. In 1997, DOCSIS 1.0 was developed. DOCSIS standards developed rapidly ever since. DOCSIS 1.1 requires data safety mechanism. Released in 2001, DOCSIS 2.0 provides more uploading bandwidths, 42.88Mbps for downloading and 30.72Mbps for uploading. In 2006, CableLabs estimated that the market demand for bandwidths would grow larger as time passed by. Therefore, Cablelabs included downloadi8ng bandwidth 343.04Mbps and uploading bandwidth 122.88Mbps into specifications, supporting IPv6 and AES 128-bit encryption. Released in October 2013, DOCSIS 3.1 has a remarkable improvement in network service response time and frequency spectrum, allowing the capacity to increase nearly 50% when spectrum remains the same. Meanwhile, data transmission capacity has been upgraded tremendously, from 343.04/122.88 Mbps (through 8×4 channel bounding) to 1 Gbps. DOCSIS has gone a long way, from DOCSIS 1.0 to the latest DOCSIS 3.0 adopted by all system service providers. Please refer to following table for the upstream and downstream of various DOCSIS versions.

Table 3 Transmission speeds of various DOCSIS version

Synchronization speed (Usable speed)		
DOCSIS Version	Downstream	Upstream
1.x	42.88 (38) Mbit/s	10.24 (9) Mbit/s
Euro	57.20 (51) Mbit/s	10.24 (9) Mbit/s
2.0	42.88 (38) Mbit/s	30.72 (27) Mbit/s
3.0	+160 Mbit/s	+120 Mbit/s

Mobile communication network (3G/4G)

Third generation mobile communication technique (3rd-Generation,3G) refers to the cellular communication technique designed to support high speed data transmission, capable of transmitting voices (communication) and information simultaneously. 1st and 2nd generation mobile communication devices were designed to provide voice transmission service whereas 3rd generation mobile communication devices are designed to provide broadband services, allowing digits and multimedia to be transmitted together with voices at the same time. 3rd generation communication was developed using Code Division Multiple Access (CDMA) technique. CDMA was originally applied to military communication in which weak signals were transmitted through an extremely path in order not to be detected by enemies. Now, CDMA can transform voice signals into digital signals and assign an address to each voice package. Signals are scrambled and transmitted to the sky. Users have to have same decryption information in order to receive the messages that are sent to them.

Long Term Evolution (LTE) is one of many standards promulgated for 4G, and is highly recommended by 3GPP (3rd Generation Partnership Projec) standardization organization. In December 2010, ITU officially defined LTE-Advanced version as 4G. Many telecommunication corporations exaggerated LTE, calling it 4G LTE. Actually, LTE does not conform to the specifications prescribed by ITU regarding 4G. At this moment, LTE-Advanced is the only version that conforms to the 4G specifications prescribed by ITU. LTE-Advanced version is technically compatible to LTE. Time-Division Duplexing, or TD-LTE, was developed as a Chinese standard and has a satisfactory performance in terms of spectrum use as well as streamlined equipment and cost efficiency. The Frequency-Division Duplexing (FDD-LTE) developed by Europe has a satisfactory performance in anti-interference, and is the 4G standard adopted by most telecommunication service providers of the world today.

Section 4 Power wire network (PLC/BLC)

Designed to transmit electricity, power wires are needed by all families. Power wires transmit not only electricity, but also digital data, allowing power corporations to read the data related to power consumption directly. Decades ago, power corporations started to provide voice-over-Internet service and video-on-demand service through power wires. Power wires can provide Internet access speed 200Mbps or higher without additional wire and without using communication frequency at all. With high penetration ratio and easy access, power wires are undoubtedly a perfect solution for broadband Internet access.

Section 5 ITU-T G.hn

In September 2010, International Telecommunication Union passed ITU -T G.hn standard that combined HomePNA, HomePlug, and MoCA, and has thus become the technical standard for the new generation of Ethernet over Coax (EoC). ITU-T G.hn comprises a number of technical standards including physical layer standard G.9960, data connection layer standard G.9961, and G.hn, administration and error diagnosis protocol G.9962, power wire multi-input and multi-output standard G.9963, spectrum and efficiency standard G.9964 and family network standard intercommunication protocol G.9972, as well as WAN user-end equipment administration protocol G.9980. G.hn supports a comprehensive array of standards, and is therefore supported by many telecommunication service providers across the world, such as AT&T, BT. NTT, and China Telecom.

Section 6 Other LAN techniques

LAN is known as the basic network connection method. An LAN is established when two or more computers are connected to each other. Wireless transmission access technique allows users to acquire images, voices, and digits through a highly moving process. As such, wireless broadband network is superior to the wired network. Following table contains the LAN transmission techniques that are known to the general public. Power wires, cables, and telephone lines have been integrated into ITU-T G.hn. Ethernet network and wireless LAN technical standards are discussed in this section.

Table 4 LAN network transmission techniques

LAN	ITU-T G.hn			Ethernet		WiFi
版本	PLC	RF	Home Line	1000 BASE-T	IEEE 802.3ae	802. 11n
傳輸速率 max(bps)	500M	1G	700M	1G	10G	600 M

Chapter 4 Broadband network performance measured

According to the results obtained from actual measurement, WiFi required transmission speed higher than 100Mbps, and transmission speed started to decrease when object moveed more than 10 meters away. Theoretically, power wire network and xDSL have the same capacity in terms of transmission distance. In many places, however, multiple power wires were merged into a single power wire. It was therefore believed that a large amount of signals could be lost in the transmission process. On the other hand, few telephone wires were merged. According to the results obtained from field measurement, when signals were transmitted through power wires, a large amount of signals were lost, transmission speed started to decrease when distance was less than 20 meters, and coaxial cable had the capacity to be loaded with a large amount of bandwidths with a little loss of signals. Apparently, coaxial cable is better in terms of transmission performance. However, no data regarding deployment was available to justify the coaxial cable's performance. After examining coaxial cable's materials and data related to signal loss, it was found that coaxial cable allowed transmission speed 100Mbps or higher when distance grew larger than 500 meters, and fiber was the best in terms of transmission distance. According to filed measurement, when distance was less than 1 kilometer, transmission speed was larger than 100Mbps without amplifier or any other component.

Chapter 5 Recommendations for technical specifications

Section 1 Regulations Governing the Technical Specifications for Telecommunication Equipment Deployed Inside and Outside of Buildings

Regulations Governing the Technical Specifications for Telecommunication Equipment Deployed Inside and Outside of Buildings were made based on the requirements stated in ANSI/TIA specifications. This chapter starts from ANSI/TIA/EIA specifications, followed by the recommendations for Taiwan. Following are the recommendations proposed by this study:

1. Adopting CATV coaxial cables

Several types of wires are deployed as transmission wires inside and outside buildings, such as telephone wires, network wires, fiber & coaxial cables. *Regulations Governing the Technical Specifications for Telecommunication Equipment Deployed Inside and Outside of Buildings* should be adopted to create an unbiased platform for all service providers. Please refer to Attachment 2 for the recommended specifications.

2. Rearrangement

Design Samples and *Test Records* should be presented as attachments; indexes should be established to facilitate readings.

3. Updating ANSI / TIA / EIA-568 information

TIA / EIA-568-B.2 has been replaced by TIA / EIA -568-C.2 already. Cat.5e Table of loss has been updated as the following Table. Therefore, the requirements for Network Wire Test stated in 18.5 of original specifications should be revised accordingly and thereby correspond to the grades of cables stated in Table 18-10 contained in 18.5.4.3 “definitions of parameters and standards prescribed for UTP/SCTP wire tests”.

Section 2 Specifications for deployment and maintenance of broadband in buildings

Recommendations:

1. Following data should be submitted for review: construction plan, system structure chart, as well as wiring diagram, installation drawing, plain layout diagram, piping distribution chart, and equipment infrastructure related to deployment.

2. Fiber deployed inside and outside buildings: the single-mode fiber deployed inside and outside buildings have to conform to ITU-T G.652D and ITU-T G.657 requirements. Service providers may use 62.5/125 μm multiple-mode fiber or laser-enhanced 50/125 μm multiple-mode fiber. Indoor fiber has to be inflammable whereas outdoor fiber has to be waterproof and weatherproof as required by residential buildings and outdoor deployment between buildings. Fiber connectors have to conform to ANSI/TIA/EIA 568-B.3 and 568-C.3 requirements.

3. Construction and installation: according to Regulations Governing the Technical Specifications for Telecommunication Equipment Deployed Inside and Outside of Buildings, bending radius has to be 25mm or more and has to be 15 times or more of the fiber's diameter when fibers are installed. After construction, the bending radius has to be 10 times or more of the fiber's diameter when the fiber is free from tension. 1~2m of extra length have to be reserved on both ends of fiber for connection and extension of fibers in the future. Both ends have to be marked for identification.

4. Maintenance: Fiber's cutting surface has to be smooth and flat. Bare fibers have to be stored properly. It is strictly forbidden to wipe bare fibers with organic solvent, such as cleaning naphtha and diesel. Prior to connecting fibers, it is very important to check all safety measures and to find out if any fiber is defected. Fiber connection points have to be determined according to the installation environment. It is also important to determine how to store the extra length of fibers and prepare fiber racks in advance. 1~2m of extra length should be reserved. If bushing-type fibers are installed, it is very important to prepare tubes with same colors as core wires and align core wires according to their

colors. Waterproof devices have to be provided to protect fibers from moisture.

Chapter 6 Conclusions

I. Broadband access techniques adopted by various countries and test results

1. Most broadband service providers provide high speed network services using FTTx and xDSL. In this connection, FTTH is the ultimate goal to be accomplished by all broadband service providers and how to upgrade broadband speed, or how to shorten the distance of last mile, remains the most important task for them. With the rapid development of LTE transmission technique and the swift expansion of service areas, fixed network users have switched to LTE one after another. As a result, the number of fixed network user decreases year after year. On the other hand, the number of mobile communication user grows steadily although the mobile communication market has been considered a saturated market for years. With the rapid technological development, users can connect to Internet through LTE just as quickly as they connect to Internet through FTTH. LTE is likely to influence FTTx. In Japan, for example, fiber communication market has saturated and is expected to grow negatively.

2. Following table contains the restrictions for various access techniques when transmission speed exceeds 100Mbps. Smallest amount of signals is lost when data is transmitted through fibers, followed by coaxial cables, xDSL and PLC. Largest amount of signal is lost when data is transmitted through wireless transmission device.

Table 5 Restrictions for various access techniques when transmission speeds exceeds 100Mbps

	WiFi	PLC	光纖	xDSL	Cable
接取技術	802.11n 802.11ac	HomePlug AV2	GPON Gigabit Ethernet	VDSL2 G993.2 17a/30a	Docsis3.0
理論傳輸距離限制	100m	200m	10km	550m	1km
一般傳輸距離限制	<10m	<20m	>1km	<100m	<500m

II. Recommendations for technical specifications

Regulations Governing the Technical Specifications for Telecommunication Equipment Deployed Inside and Outside of Buildings were made based on the requirements stated in ANSI/TIA specifications. This chapter starts from ANSI/TIA/EIA specifications, followed by the recommendations for Taiwan. For details, please refer to Section 1, Chapter 5. Following are the recommendations for revisions proposed by this study:

- Adopting CATV coaxial cables (For details, please refer to Attachment 2)
- Rearrangement: electronic files have shall be revised and provided.
- Updating ANSI / TIA / EIA-568 versions

Most buildings rely on fibers for access to Internet. Please refer to the requirements stated in *Building Technical Regulations* promulgated by Ministry of the Interior, ANSI / TIA / EIA, CNS, as well as the requirements stated in Section 2, Chapter 5, and Attachment III.

III. Recommendations for the promotion of high speed broadband and tangible measures

1. New buildings should be provided with fibers and Ethernet network : adequate space should be reserved in the cable distribution boxes. The single-mode fibers depooyed inside and outside buildings should be compliant with the requirements stated in ITU-T G.652D and ITU-T

G.657. Service providers may use 62.5/125 μm multiple-mode fiber or laser-enhanced 50/125 μm multiple-mode fiber. Fiber connectors have to conform to ANSI/TIA/EIA 568-B.3 and 568-C.3 requirements.

2. As to the old buildings, VDSL2 should be upgraded, from 17a to 30a. Service providers may use coaxial cables in compliant with ITU G.hn technical specifications.

3. FTTC, FTTB, and FTTN + node should be deployed together with FTTH. It is important to note that the installation environment varies, depending on the location. Therefore, new buildings, old buildings, and roads require different access methods.

4. There are many access methods. Wire transmission remains the most reliable method, followed by fibers and coaxial cables. Copper twisted pairs and power wires are less efficient in terms of transmission speed.