2017

BROADBAND GUIDELINES

Technical Unit

National Telecommunications Regulatory Commission

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Table of Contents

1.0 INTRODUCTION

The power of Internet has brought greater awareness, skills and resources, helping markets reach to a diverse global audience. Broadband provides the opportunity to do things differently, to achieve better outcome for people, countries and to ensure continuous growth of economy and social development. The proliferation of the broadband enables growth of Information and Communication Technologies (ICT), content, applications and services which may help Saint Lucia and in part the Caribbean to become a truly competitive knowledge based economy and leverage citizens to become healthier, better educated and more engaged in their community & society.

Internet and Broadband access are widely recognized as catalysts for economic and social development of a country. Availability of broadband services at affordable price can contribute to higher Gross Domestic Product (GDP)[1] for growth rates, provide for a larger & more qualified labor force and increased working efficiency. There is a correlation between the broadband adoption rate and the GDP for various countries. Providing broadband access to citizens, communities and public institutions is one of the strategic objectives for governments worldwide. As per the report of World Bank[2], a 10-percentage increase in broadband penetration accounted for 1.38 percentage increase in per capita GDP growth in developing economies. This is much higher than the impact of mobile telephony growth on GDP. The report also indicates that across all telecom services, the positive effect on GDP is higher in developing countries (Saint Lucia) than in developed countries. In case of broadband this impact is about 15% more in developing countries than in developed countries.

Convergence and popularity of IP networks is leading to Next Generation Networks (NGN) worldwide. Provision of various services over IP network reduces capex and opex and provides competitive advantage in highly competitive market. A robust broadband network will be necessary to support all types of services; especially bandwidth intensive applications. As the bandwidth requirement is inversely proportional to the literacy level of user, the rural areas will require much higher bandwidth than their urban counterparts. In UK, British Telecom (BT) who pioneered NGN implementation realized that success of NGN implementation is dependent on availability of high speed access network. Accordingly, it has reviewed its plan for implementation of its project 21CN and higher emphasis is being given for upgradation of copper access network to fibre network to support growing demand for super-fast broadband services.

[1] It should be noted that this document focuses on technical guidelines. Research on Economic and Social developments are not included within this document. However as mentioned above various studies have revealed, expected growth of these two elements once broadband and the QoS of broadband is upgraded.
[2] IC4D 2009: Extending Reach and Increasing Impact

2.0 TYPES OF BROADBAND

2.1 Digital Subscriber Line (DSL):

DSL is a wireline transmission technology that transmits data faster over traditional copper telephone lines already installed to homes and businesses. DSL-based broadband provides transmission speeds ranging from several hundred Kbps to millions of bits per second (Mbps). The availability and speed of your DSL service may depend on the distance from your home or business to the closest telephone company facility.

2.1.1 Types of DSL Transmission Technologies:

Asymmetrical Digital Subscriber Line (ADSL) – Used primarily by residential customers, such as Internet surfers, who receive a lot of data (download) but do not send much (upload). ADSL typically provides faster speed in the downstream direction than the upstream direction. ADSL allows faster downstream data transmission over the same line used to provide voice service, without disrupting regular telephone calls on that line.

Symmetrical Digital Subscriber Line (SDSL) – Used typically by businesses for services such as video conferencing, which need significant bandwidth both upstream and downstream.

2.2 Cable Modem

Cable modem service enables cable operators to provide broadband using the same coaxial cables that deliver pictures and sound to your TV set.

Most cable modems are external devices that have two connections: one to the cable wall outlet, the other to a computer. They provide transmission speeds of 1.5 Mbps or more.

Subscribers can access their cable modem service by simply turning on their computers, without dialing-up an ISP. You can still watch cable TV while using it. Transmission speeds vary depending on the type of cable modem, cable network, and traffic load. Speeds are comparable to DSL.

2.3 Fiber Optic

Fiber optic technology converts electrical signals carrying data to light and sends the light through transparent glass fibers about the diameter of a human hair. Fiber transmits data at speeds far exceeding current DSL or cable modem speeds, typically by tens or even hundreds of Mbps. The actual speed you experience will vary depending on a variety of factors, such as how close to your computer the service provider brings the fiber and how the service provider configures the service, including the amount of bandwidth used. The same fiber providing your broadband can also simultaneously deliver voice (VoIP) and video services, including video-on-demand.

Telecommunications providers sometimes offer fiber broadband in limited areas and have announced plans to expand their fiber networks and offer bundled voice, Internet access, and video services.

Variations of the technology run the fiber all the way to the customer's home or business, to the curb outside, or to a location somewhere between the provider's facilities and the customer.

2.4 Wireless Broadband

Wireless broadband connects a home or business to the Internet using a radio link between the customer's location and the service provider's facility. Wireless broadband can be mobile or fixed.

Wireless technologies using longer-range directional equipment provide broadband service in remote or sparsely populated areas where DSL or cable modem service would be costly to provide. Speeds are generally comparable to DSL and cable modem. An external antenna is usually required.

Internet access services offered over fixed networks allow consumers to access the Internet from a fixed point while stationary and often require a direct line-of-sight between the wireless transmitter and receiver. These services have been offered using both licensed spectrum and unlicensed devices. For example, thousands of small Wireless Internet Services Providers (WISPs) provide such wireless broadband at speeds of around one Mbps using unlicensed devices, often in rural areas not served by cable or wireline broadband networks.

2.5 Wireless Local Area Networks (WLANs)

Provide wireless broadband access over shorter distances and are often used to extend the reach of a "last-mile" wireline or fixed wireless broadband connection within a home, building, or campus environment. Wi-Fi networks use unlicensed devices and can be designed for private access within a home or business, or be used for public Internet access at "hot spots" such as restaurants, coffee shops, hotels, airports, convention centers, and city parks.

2.6 Mobile Wireless Broadband

Services are also becoming available from mobile telephone service providers and others. These services are generally appropriate for highly-mobile customers and require a special PC card with a built-in antenna that plugs into a user's laptop computer. Generally, they provide lower speeds, in the range of several hundred Kbps.

2.7 Satellite

Just as satellites orbiting the earth provide necessary links for telephone and television service, they can also provide links for broadband. Satellite broadband is another form of wireless broadband, and is also useful for serving remote or sparsely populated areas.

Downstream and upstream speeds for satellite broadband depend on several factors, including the provider and service package purchased, the consumer's line of sight to the orbiting satellite, and the weather. Typically, a consumer can expect to receive (download) at a speed of about 500 Kbps and send (upload) at a speed of about 80 Kbps. These speeds may be slower than DSL and cable modem, but they are about 10 times faster than the download speed with dial-up Internet access. Service can be disrupted in extreme weather conditions.

2.8 Broadband Over Powerline (BPL)

BPL is the delivery of broadband over the existing low- and medium-voltage electric power distribution network. BPL speeds are comparable to DSL and cable modem speeds. BPL can be provided to homes using existing electrical connections and outlets. BPL is an emerging technology that is available in very limited areas. It has significant potential because power lines are installed virtually everywhere, alleviating the need to build new broadband facilities for every customer.

3.0 TECHNOLOGICAL DRIVERS

Liberalization and competition in the telecommunications market have brought new and innovative technologies in the market. The convergence of technologies and ubiquitous use of IP networks will increase broadband use. The distinction of medium for existing services such as voice, data or video, will blur with increased adoption of convergence. The move towards IP based services will make broadband technology integral part of our life as users will try to reap the full benefits of convergence.

The capabilities of smart phones bundled with pre-loaded features and inbuilt applications permit access to new domains using Internet access. Data cards and Wireless Broadband CPEs facilitate availability of broadband anytime, anywhere further fueling wireless broadband demand.

Technological innovation permits new ways of creating, distributing, preserving, sharing and accessing digital content. As economies move to become more knowledge-intensive, information-rich activities will increase; new content will be created, collected, managed, processed, stored, delivered, and accessed. This spread will contribute to further innovation, growth and enhanced utilization of broadband.

4.0 ARCHITECTURE

4.1 DSL and Cable Modem Networks

4.1.1 Digital Subscriber Line

Digital subscriber line (DSL) technology is a modem technology using existing twisted pair telephone lines to carry high-bandwidth applications, such as multimedia and video. The term xDSL covers a number of DSL technologies, such as Asymmetrical Digital Subscriber Line (ADSL), Symmetrical Digital Subscriber Line (SDSL), Hi-Speed Digital Subscriber Line (HDSL), HDSL-2 (HDSLv2), ITU DSL standard (G.SHDSL), ISDN Digital Subscriber Line (IDSL), and Very-High-Data-Rate Digital Subscriber Line (VDSL).

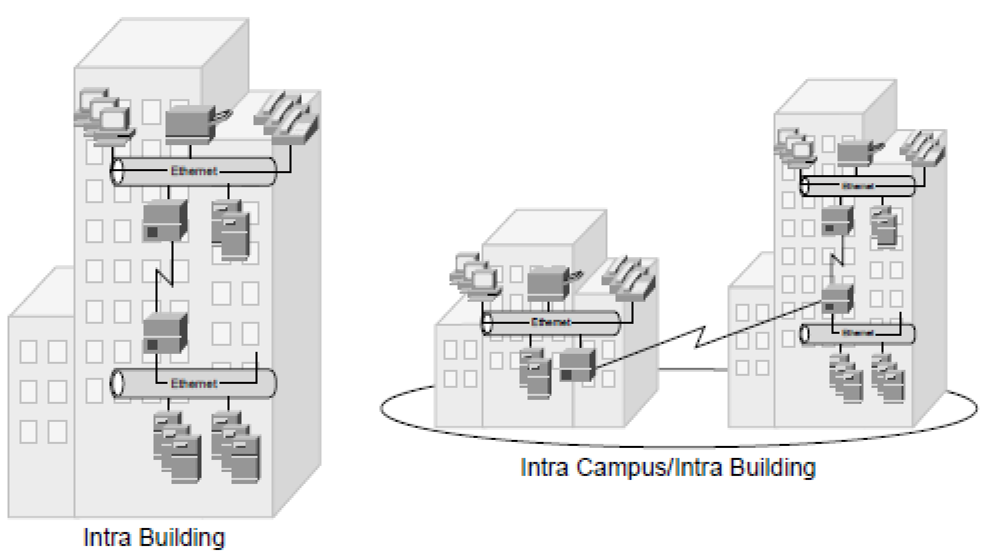
xDSL services are dedicated point-to-point network access over twisted-pair copper wire on the local loop (last mile) between a network service provider's (NSP) central office (CO) and the customer site. xDSL also can be deployed in intra-building and intra-campus environments, as illustrated in Figure 1.

xDSL offers two chief benefits over dial-up service:

• Dial-up service is limited to 53.3 Kbps, whereas xDSL service can enable up to 6.122 Mbps.

• Dial-up service is initiated "on-demand" by the end-user, but xDSL service is a dedicated connection, meaning that it is "always on."

Figure 1
Intra Building and Intra-Campus/Intra Building

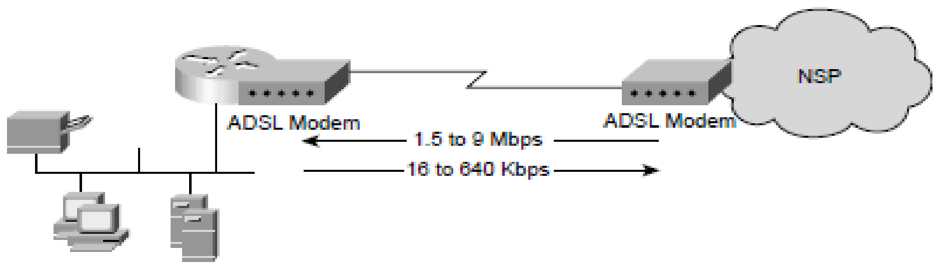


ADSL is often deployed in the small office/home office (SOHO) environment and is the traditional DSL service for residential deployment. The asymmetry is ideal in these environments because the majority of upstream bandwidth is consumed by Internet requests; for example, users navigating through web sites. These upstream requests are small compared to the downstream response, such as the web site fulfilling the user's request.

4.1.2 ADSL

ADSL technology makes more bandwidth available downstream, from a NSP central office (CO) to the customer site, than it makes available upstream, from the customer site to the CO. Figure 2 illustrates an example of an ADSL connection.

Figure 2
ADSL Connection



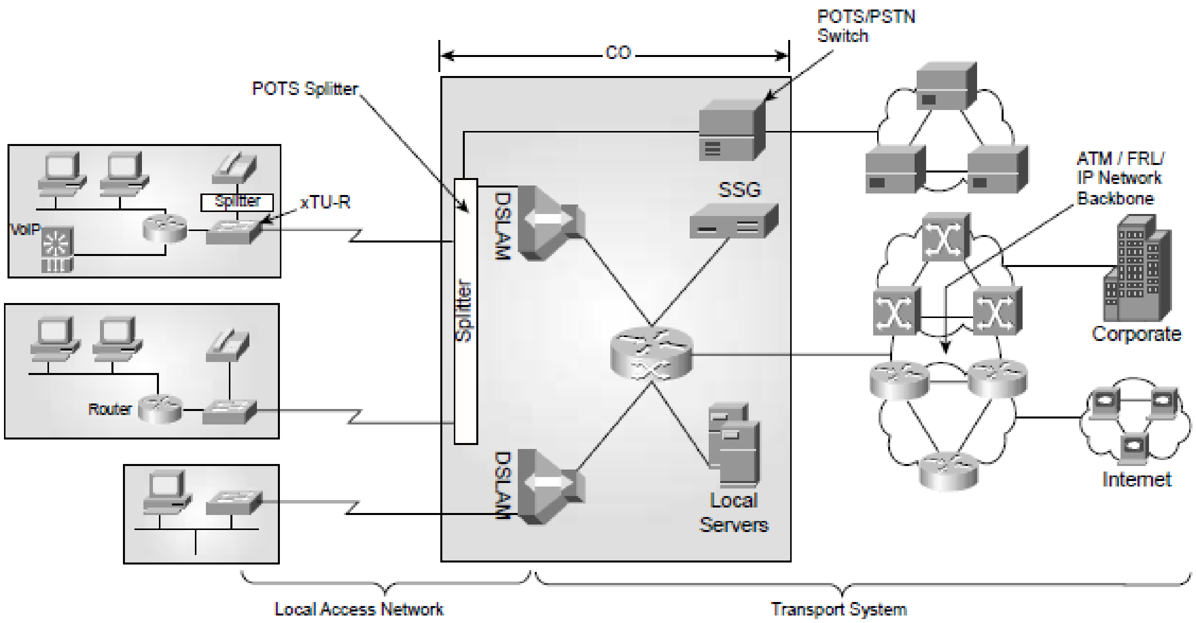
The asymmetry of ADSL, combined with always-on access (which eliminates call setup), makes ADSL another solution for Internet/intranet surfing, video-on-demand, and remote LAN access because users of these applications often download more data than they upload.

4.1.3 ADSL Architecture

ADSL circuits connect ADSL modems on each end of a twisted-pair telephone line, creating three data channels:

• A high-speed downstream channel—Ranges from 1.5 to 9 Mbps.
• A low-speed upstream channel—Ranges from 16 to 640 Kbps.
• A basic telephone service channel—The basic telephone service channel is split off from the digital modem by filters or plain old telephone service (POTS) splitters, providing uninterrupted basic telephone service.

Figure 3



ADSL architecture is made up of the following components:

• Transport System—Provides the carrier backbone transmission interface for the DSLAM system. This device can provide service specific interfaces such as T1/E1, T3/E3, OC-1/3, and STS-1/3.
• Local Access Network—Uses the local carrier Inter-CO network as a foundation, providing connectivity between multiple service providers and multiple services users, often with Frame Relay or ATM switches.
• Digital Subscriber Line Access Multiplexer (DSLAM)—Concentrates data traffic from multiple DSL loops onto the backbone network for connection to the rest of the network.
• DSL Transceiver Unit-Remote (xTU-R)—The customer site equipment for service connection to the DSL loop.
• POTS Splitters—Optional device at both CO and service user locations, enabling the copper loop to be used for simultaneous DSL and transmission and single line telephone service. POTS splitters come in two configurations:
— Single splitter version for mounting at the residence
— Multiple splitter version for mass termination at the CO

POTS splitters are either passive or active. Active splitters require an external power source, and passive splitters require no power and often have a higher mean time between failure (MTBF) than the active splitter. Passive splitters enable lifeline services, such as 911, in the event of a DSLAM or xTU-R power loss; active splitters require backup power.

ADSL Data Rates
Downstream bandwidth depends on a number of factors:

• Length of the copper line
• Wire gauge of the copper line
• Presence of bridged taps
• Presence of cross-coupled interference

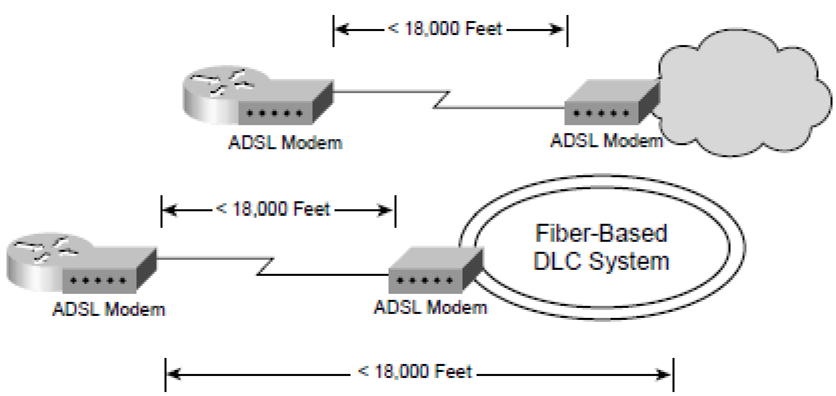
Line attenuation increases with line length and frequency, and decreases as wire diameter increases. Ignoring bridged taps, ADSL performs as shown in Table 1.

Table 1
ADSL Rates (Ignoring Bridged Taps)

Rate (Mbps)	Wire Gauge (AWG)	Distance (feet)	Wire Size (mm)	Distance (km)
1.5 or 2	24	18,000	0.5	5.5
1.5 or 2	26	15,000	0.4	4.6
6.1	24	12,000	0.5	3.7
6.1	26	9000	0.4	2.7

Customer sites beyond the previously listed distances can be reached with fiber-based digital loop carrier (DLC) systems, as illustrated in Figure 7-4.

Figure 4
ADSL with and Without Fiber-based DLC



4.1.4 Other xDSL Technologies

There are several xDSL implementations in addition to ADSL. These are as follows:

• Single-lined digital subscriber line (SDSL)—A rate-adaptive version of Hi-speed digital subscriber line (HDSL) which like HDSL is symmetric. SDSL enables equal bandwidth downstream from a network service provider CO to the customer site as upstream from the customer site to the CO. SDSL supports data only (maximum of 1.544 Mbps) on a single line and does not support analog calls.

• High-data-rate digital subscriber line (HDSL)—Developed by Bellcore, high bitrate DSL (HDSL)/T1/E1 technologies have been standardized by ANSI in the United States and by ETSI in Europe. HDSL is a more cost-efficient method of installing T1 service to a customer site than traditional dedicated DS1 service.
• HDSL 2—Standard enabling symmetric service at T1 speeds using a single-wire pair rather than the two pairs of HDSL service. HDSL-2 also was developed as a standard by which different vendors' equipment can interoperate.
• G.SHDSL (ITU HDSL Standard)—A standards-based, multirate version of HDSL-2, which offers symmetrical service.
• Integrated Services Digital Network (ISDN) digital subscriber line (IDSL)—A cross between ISDN and xDSL, using a single-wire pair to transmit full-duplex data at 128 kbps.
• Very-high-data-rate Digital Subscriber Line (VDSL)—Transmits high-speed data over short reaches of twisted-pair copper telephone lines, with a range of speeds depending on actual line length. The maximum downstream rate under consideration is between 51 and 55 Mbps over lines up to 1000 feet (300 m). Downstream speeds as low as 13 Mbps over lengths beyond 4000 feet (1500 m) also are in consideration.

4.2.1 Cable Access Technologies

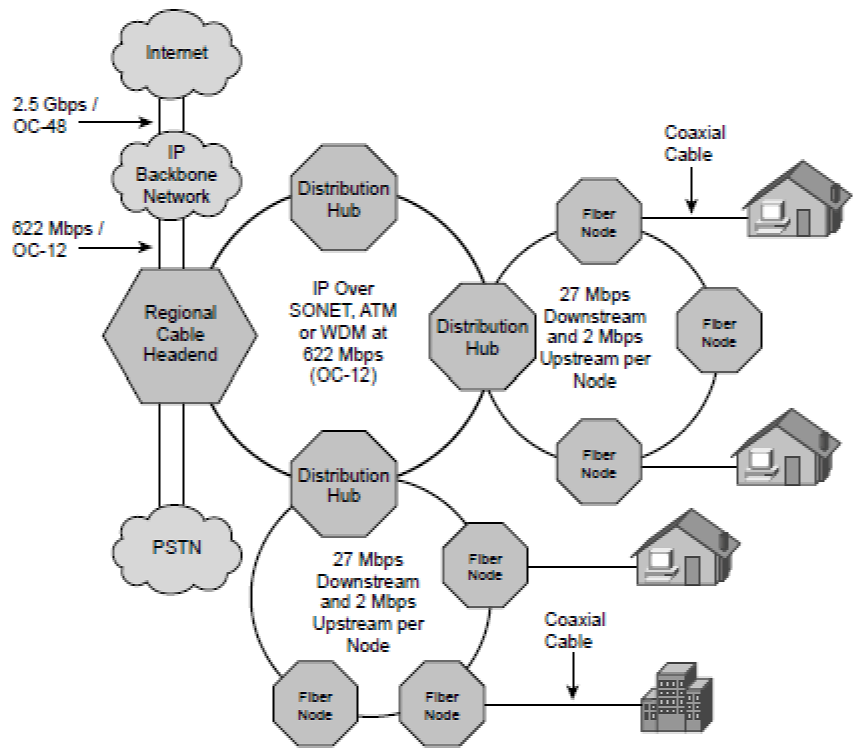
Cable television (CATV) is a unidirectional medium carrying broadcast analog video channels to the most customers possible at the lowest possible cost to the CATV service provider.

4.2 Cable Access Architecture

To deliver data services over a cable network, one television channel (50 to 750 MHz range) is allocated for downstream traffic to homes and another channel (5 to 42 MHz band) is used to carry upstream signals.

Figure 5 illustrates the architecture of a cable access network for both CATV and cable modem services.

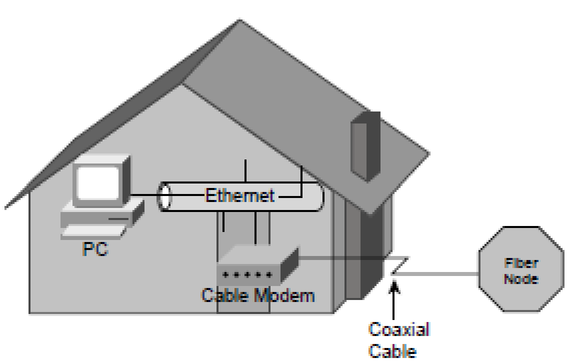
Figure 5
Cable Access Architecture



The following list details the cable access network architecture:

• Residential and business end-users are connected to fiber nodes by coaxial cables. Users attach to this cable through an Ethernet network interface card (NIC) installed in the PC, in turn connected to a cable modem, as illustrated in the Figure 6.

Figure 6
Cable Modem Access



•The fiber nodes house the Cable Modem Termination System (CMTS) at the head-end, communicating with the cable modems at the end-user premise. This communication creates a LAN connection between the end-user and the cable modem service provider.
• Most cable modems are external hardware devices connecting to a PC through a standard 10Base-T Ethernet card or Universal Serial Bus (USB) connection.
• These fiber nodes are connected by fiber rings (such as SONET) to the distribution hubs, which are in turn connected by fiber rings to a regional cable head-end.
• The cable head-end then forwards the traffic to the appropriate network—the PSTN for VoIP applications and the public Internet for all other IP traffic.

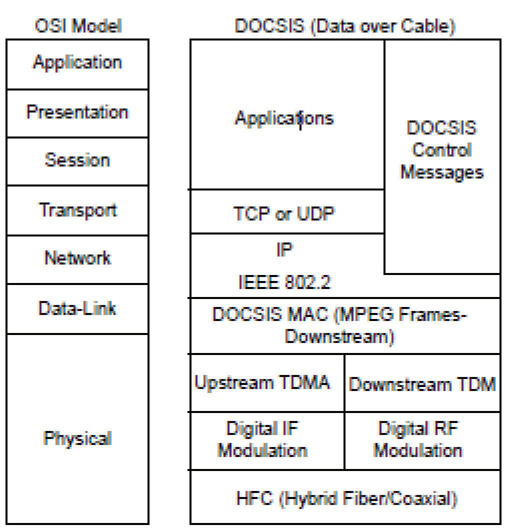
A single downstream 6 MHz television channel can carry up to 27 Mbps of downstream data throughput from the cable head-end; upstream channels can deliver 500 Kbps to 10 Mbps from home and business end-users. This upstream and downstream bandwidth is shared by other data subscribers connected to the same cable network segment, which is often 500 to 2000 homes on a modern network.

An individual cable modem subscriber can reach speeds from 500 Kbps to 1.5 Mbps or more, depending on the network architecture (for example, oversubscription ratio) and traffic load.

4.3 DOCSIS Standards, Signaling Protocols, and Applications

Data Over Cable Service Interface Specification (DOCSIS) is a set of standards for transferring data by CATV and cable modems. The DOCSIS interface specifications enable multivendor interoperability for transporting Internet Protocol (IP) traffic. The DOCSIS layers are compared with the OSI Reference Model layers in Figure 7.

Figure 7
OSI Layers and DOCSIS Layers



The following list details the correlation between the OSI Reference Model and the DOCSIS standard:

• TCP/IP support:
— IP services at the network layer (OSI Layer 3)
— TCP/UDP services at the transport layer (OSI Layer 4)
• Data-link layer:
— Logical Link Control (LLC) sublayer conforming to Ethernet standards
— Link security sublayer for basic privacy, authorization, and authentication
— Media Access Control (MAC) sublayer supporting variable-length protocol data units (PDU)
• Physical (PHY) layer comprised of the following:
— Downstream convergence layer conforming to MPEG-2
— Physical Media Dependent (PMD) sublayer for downstream and upstream data transmission; through Time Division Multiplexing (TDM).

Table 2

DSL Service Summary

DSL Type	Description	Data Rate Downstream; Upstream	Distance Limit	Application
ADSL	Asymmetric digital subscriber line	1.544 to 6.1 Mbps downstream; 16 to 640 Kbps upstream	1.544 Mbps at 18,000 feet; 2.048 Mbps at 16,000 feet; 6.312 Mbps at 12,000 feet; 8.448 Mbps at 9,000 feet	Used for Internet and web access, motion video, video on demand, remote LAN access.
HDSL	High-data-rate digital subscriber line	1.544 Mbps duplex on two twisted-pair lines; 2.048 Mbps duplex on three twisted-pair lines	12,000 feet on 24-gauge wire	T1/E1 service between server and phone company or within a company; WAN, LAN, server access.
SDSL	Single-line digital subscriber line	1.544 Mbps duplex (U.S. and Canada); 2.048 Mbps (Europe) on a single duplex line downstream and upstream	12,000 feet on 24-gauge wire	Same as for HDSL but requiring only one line of twisted-pair.
VDSL	Very-high digital subscriber line	12.9 to 52.8 Mbps downstream; 1.5 to 2.3 Mbps upstream; 1.6 Mbps to 2.3 Mbps downstream	4500 feet at 12.96 Mbps; 3000 feet at 25.82 Mbps; 1000 feet at 51.84 Mbps	ATM networks; Fiber to the Neighborhood.

5.0 FIBRE OPTICS

5.1 General Guidelines

The following contains information on the placement of fiber optic cables in various indoor and outdoor environments. In general, fiber optic cable can be installed with many of the same techniques used with conventional copper cables. Basic guidelines that can be applied to any type of cable installation are as follows:

- Conduct a thorough site survey prior to cable placement.
- Develop a cable pulling plan.
- Follow proper procedures.
- Do not exceed cable minimum bend radius.
- Do not exceed cable maximum recommended load.
- Document the installation.

5.2 Conduct a Site Survey

The purpose of a site survey is to recognize circumstances or locations in need of special attention. For example, physical hazards such as high temperatures or operating machinery should be noted and the cable route planned accordingly. If the fiber optic cable has metallic components, it should be kept clear of power cables. Additionally, building code regulations must be considered. If there are questions regarding local building codes or regulations, they should be addressed to the authority having jurisdiction, such as the fire marshal or city building inspector.

5.3 Develop a Cable Pulling Plan

A cable pulling plan should communicate the considerations noted during the site survey to the installation team. This includes the logistics of cable let-off/pulling equipment, the location of intermediate access points, splice locations and the specific responsibilities of each member of the installation team.

5.4 Follow Proper Procedures

Because fibers are sensitive to moisture, the cable end should be covered with an end cap, heavy tape or equivalent at all times. The let-off reel must never be left unattended during a pull because excess or difficult pulls, center-pull or back feeding techniques may be employed.

5.5 Do Not Exceed Cable Minimum Bend Radius

Every cable has an installation minimum bend radius value. During cable placement it is important that the cable not be bent to a smaller radius. After the cable has been installed, and the pulling tension removed, the cable may be bent to a radius no smaller than the long term application bend radius specification.

The minimum bend radii values still apply if the cable is bent more than 90 degrees. It is permissible for fiber optic cable to be wrapped or coiled as long as the minimum bend radius constraints are not violated.

5.6 Do Not Exceed Cable Maximum Recommended Load

While fiber optic cables are typically stronger than copper cables, it is still important that the cable maximum pulling tension not be exceeded during any phase of cable installation. In general, most cables designed for outdoor use have a strength rating of at least 2700 N. Fiber optic cables also have a maximum recommended load value for long term application. After cable placement is complete the residual tension on the cable should be less than this value. For vertical installations, it is recommended that the cable be clamped at frequent intervals to prevent the cable weight from exceeding the maximum recommended long term load. The clamping intervals should be sufficient to prevent cable movement as well as to provide weight support.

5.7 Leave Extra Cable

A common practice is to leave extra cable at the beginning and at the end of the cable run. Also, extra cable should be placed at strategic points such as junction boxes, splice cases and cable vaults. Extra cable is useful should cable repair or mid-span entry be required.

5.8 Document the Installation

Good record keeping is essential. This will help to ensure that the cable plant is installed correctly and that future trouble shooting and upgrading will be simplified. All fiber optic cables have a unique lot number shown on the shipping spool. It is important that this number be recorded. Cable pre- and post- installation test data should be recorded in an orderly and logical fashion.

5.9 Pulled Installations

In order to effectively pull cable without damaging the fiber, it is necessary to identify the strength material and fiber location within the cable. Then, use the method of attachment that pulls most directly on the strength material—without stressing the fiber. As a general rule, it is best to install cable prior to connector attachment. After connectors have been attached, it becomes more difficult to protect the fiber from inadvertent stress. If a pull is to be made entirely in one direction, connectors may be pre-installed on one end, leaving the other end for pulling. If the cable must be installed with connectors attached, every practical means must be taken to protect the connectorized end from damage or stress. Cushioned enclosures should be used to protect connectors during pulling.

The leading end of the cable should be sealed to prevent intrusion of water or other foreign material while pulling. Bi-directional pulls are possible by laying the cable into large "figure-8"-shaped loops on the ground, from where it can feed from both ends. For ease of cable installation, the area of the cable divided by the area of the duct or conduit should be less than 53% per a single cable. Permissible area to be occupied for 2 cables is 31%, for 3 or more cables it is 40%.

5.10 Direct Attachment

Strength member is tied directly to the pulling fixture. The cable end must be sealed to prevent intrusion of moisture while pulling.

With direct attachment, cable strength material is tied directly to the pulling fixture. Conventional cable tools may be used. Loose fiberglass threads are not suitable for direct attachment because they may break if knotted. Fiberglass epoxy rods are too rigid to tie, but may be secured to the pulling fixture by using tight clamping plates or screws.

5.11 Indirect Attachment

Pulling forces are distributed over the outer cable structure.

With indirect attachment, pulling forces are distributed over the outer portion of the cable structure. If cable strength materials are located directly beneath the jacket, this method will produce the least amount of stress on the fiber.

A popular type of pulling fixture for indirect attachment is the "Chinese Basket" or "Kellems Grip".

The Kellems Grip is usually reliable for cables of 1/4" diameter or more. Large pulling forces are possible with a Kellems Grip if the grip's diameter and length are properly matched to cable characteristics. A Kellem Grip should spread pulling forces over a 1m length of cable. For small cables, prestretching and taping the Kellems Grip to the cable helps to assure even pulling.

5.12 Cable Lubricants

Many lubricants are available for lowering friction forces. These include greases, waxes, clay slurries and water-based gels. Fiber optic jacket materials are compatible with most of these. For new conduit, lubrication of the conduit before pulling is suggested—particularly if there are several bends.

5.13 Air Plenums, Trays, Raceways

Installation procedures for open placement of fiber optic cables are the same as for electrical cables. Care should be taken to avoid sudden, excessive force so as not to violate tensile load and radius limits. Sharp bending and scraping at entrances and covers should be avoided.

5.14 Direct Burial

Outdoor cables may be buried directly in the ground. Environmental hazards include freezing water, crushing forces from rocky soil, ground disruption from construction, and rodents.

Burying the cable 90 to 120 cm deep may help prevent most of these hazards. Direct plow-in installation requires a cable capable of withstanding uneven pulling forces. Loose tube cables are best suited for these types of installations. Double jacketing, gel filling, metal sheathing and (CST)armoring are used as water barriers. Use of double jacketed armored cables can sometimes be avoided by burying polyethylene pipe to form a simple conduit. The pipe makes a smooth passageway and may be curved to allow easy access at manholes and other pull points. Cables may be subsequently replaced without digging.

5.15 Cable Storage

It is frequently required to store cables prior to installation. Temperature ranges for cable storage are listed in the corresponding catalog- or datasheet pages. It is recommended that cable ends be sealed to prevent intrusion of moisture. Polyethylene pipe can be used as a simple conduit. This allows use of less expensive cables in direct burial applications.

5.2 Cable Preparation

The following is a general description of cable preparation and termination procedures.

5.2.1 Jacket Removal

The procedure for stripping fiber optic cables is very similar to electronic cables. However, care should be taken not to cut into the layer of aramid directly beneath the jacket. This would either reduce the pull strength of the cable, or weaken the connection. For this reason, if a blade must be used, a cut which does not completely penetrate the jacket can be made. This will weaken it sufficiently and allow the jacket to be peeled. Most cables utilize a ripcord capable of tearing the outer sheath.

5.2.2 Cutting and Trimming Aramid

Aramid can be easily cut with sharp scissors if the threads are confined in movement so that cutting pressure can be applied. Ceramic scissors may also be used.

5.2.3 Steel and Fiberglass Epoxy Rod Members

Temperature stabilized cables of both loose and tight buffer constructions often have steel or fiberglass epoxy rods. Use of heavy-duty cutters is recommended for these hard materials.

5.2.4 Buffer Tube Trimming

Buffer tubes are made of plastic materials with various characteristics of hardness and flexibility. Buffer tubes are both flexible and strong, but may be trimmed easily. The simplest way is to score one side of the buffer tube firmly with a razor blade, then bend the tube sharply away from the score mark. The broken-off piece is then pulled straight off, leaving the fiber intact. A stripping tool which barely cuts through the tube is also satisfactory. If it is intended to cut through both the buffer tube and the fiber, use diagonal cutters and cut through cleanly.

5.2.5 Breakout Element Trimming

Breakout subunit element jackets are most easily removed by a stripping tool which cuts circumferencially. The jacket may then be pulled straight off, exposing the aramid.

5.3 Fiber Preparation

5.3.1 Fiber Stripping

Optical fibers must be stripped of buffer coatings to allow a close fit within precision connectors. (Note: always wear safety glasses or goggles when working directly with fibers.)

Buffer coatings are usually removed mechanically with sharp blades or calibrated stripping tools. In any type of mechanical stripping, the key is to avoid nicking the fiber.

(Note: Dispose of broken pieces of fiber by placing them on a piece of tape. Glass fibers are difficult to see and may not be felt until through the skin. Eyes should not be rubbed while working with fibers.)

5.4 Splicing Optical Fibers

Preparation of fibers for splicing is very similar to the process described under connectorization. After jacket materials, strength members and buffer tubes have been cut to the appropriate lengths, the fiber buffer coatings must be removed.

5.4.1 Cleaving

After the buffer coatings have been removed, fibers must be cleaved in preparation for splicing. Cleaving is a method of breaking a fiber in such a way as to create a smooth, square end on the fiber.

5.4.2 Principles of Cleaving

Glass is typically strong until a flaw occurs and creates a region of high stress under pressure. The first step in the cleaving process is to create a slight flaw or "scribe" in the outer surface of the fiber.

Optical fibers can be scribed with a sharp blade of hard material such as a diamond, ruby, sapphire or tungsten carbide. The scribe is made by lightly touching the cleaned fiber, at a right angle, on the desired cleave point with a scribing tool. Only the lightest pressure is required to produce a scribe if the blade is sharp. NOTE: DO NOT USE A SAWING MOTION. A crude or slanted scribe will produce shattered or scalloped end surfaces.

After the scribe is made, a straight pull will produce the cleanest break. If bending accompanies pulling, a square break is less likely, especially with large fibers. Dispose of broken fiber pieces by placing them on a piece of tape. ALWAYS WEAR SAFETY GLASSES WHEN WORKING WITH OPTICAL FIBERS.

The level of quality required for a given cleave depends on the application. For fusion splicing, mechanical splicing and some connectors systems, cleaves must be nearly perfect. Some connector and splicing systems use cleaving to produce the final end surface on the fiber (no subsequent grinding or polishing). However, for quick continuity checks with a flashlight, less than perfect cleaves may be acceptable. A 30x to 50x hand microscope is useful for quick checks of cleave quality. Cleaving tools are available in inexpensive hand models or more sophisticated mechanized tools.

5.4.3 Splicing Methods

There are two basic types of splices: Fusion and Mechanical.

5.4.3.1 Fusion Splicing

Fusion splices are made by positioning cleaned, cleaved fiber ends between two electrodes and applying an electric arc to fuse the ends together. A perfusion arc is applied to the fiber while the ends are still separated to vaporize volatile materials which could cause bubbles. Final precise alignment is done by moving fiber ends together until there is slight pressure between end surfaces.

An ideal fusion cycle is short and uses a ramped or gradually increasing arc current. A short, ramped cycle is considered least likely to produce excessive thermal stress in fibers. Cold temperatures require increased time and arc current.

Experienced operators consistently produce fusion splices with losses less than 0.2 dB per splice and averaging 0.3 dB on multimode fibers. Sophisticated fusion splicing systems for single-mode fibers produce typical splice losses of 0.05 to 0.1dB.

5.4.3.2 Mechanical Splicing

Mechanical splicing systems position fiber ends closely in retaining and aligning assemblies. Focusing and collimating lenses may be used to control and concentrate light that would otherwise escape. Index matching gels, fluids and adhesives are used to form a continuous optical path between fibers and reduce reflection losses.

5.4.4 Testing

5.4.4.1 The Flashlight Test

A simple continuity test for short-to-medium length fiber optic links is to shine a flashlight into a cleaved or connectorized link and observe if light comes out of the other end. On short lengths, it may be necessary to cleave only the end where the flashlight injects light into the fiber. This simple check can be made on cable lengths of up to a 1,5km and more. If cable ends are outdoors, sunlight may be used. NOTE: on longer lengths, the light observed at the opposite end may appear red in color. This is normal and is caused by the filtering of light within the fiber.

CAUTION: NEVER LOOK DIRECTLY INTO A FIBER CONNECTED TO LIGHT LAUNCHING EQUIPMENT. THIS CAN CAUSE PERMANENT EYE DAMAGE.

5.4.4.2The Optical Time Domain Reflectometer (OTDR)

OTDRs are typically used to measure distance and attenuation over the entire fiber link. They are also used to identify specific points along the link where losses occur, such as splices. An OTDR is an optical radar which measures time of travel and the return strength of a short pulse of light launched into an optical fiber. Small reflections occur throughout the fiber, becoming weaker as power levels drop with distance. At major breaks, large reflections occur and appear as strong peaks on an oscilloscope. Testing of short and medium distance fiber optic systems seldom requires an OTDR. In smaller systems, optical power meter tests are faster and more useful.

5.4.4.3 Magnifying Glasses and Microscopes

Because the naked eye cannot detect scratches or defects in optical fibers, use of magnification equipment is required. For most routine inspections, and ordinary battery-powered illuminated microscope of 30x to 100x can produce satisfactory results. Some microscopes are available with special adapters specifically designed for use with fiber optic connectors.

6.0 BROAD BAND OVER POWER LINES

Broadband over Power Line (BPL) is a term used to identify technologies, equipment, applications and services intended at providing end users with communications means over existing power lines. BPL is also referred to the transmission of high-speed data over the electricity power line to provide communications service such as voice, video and data. The concept of transmitting signals over power lines has been around for many years and has been used by power companies to transmit data signals at low frequencies and low speed. In the year 2005, a new generation chipset at 200 Mbps was made commercially available offering enhanced performance of this technology. This development has made it possible for data to be transmitted at a much high speed.

6.1 General Requirement for Operational of BPL Physical Network Layer

Network Overview The system architecture should consist of the backhaul data network that connects the BPL network to the telecommunications network, and the BPL network which overlays the electricity distribution network.

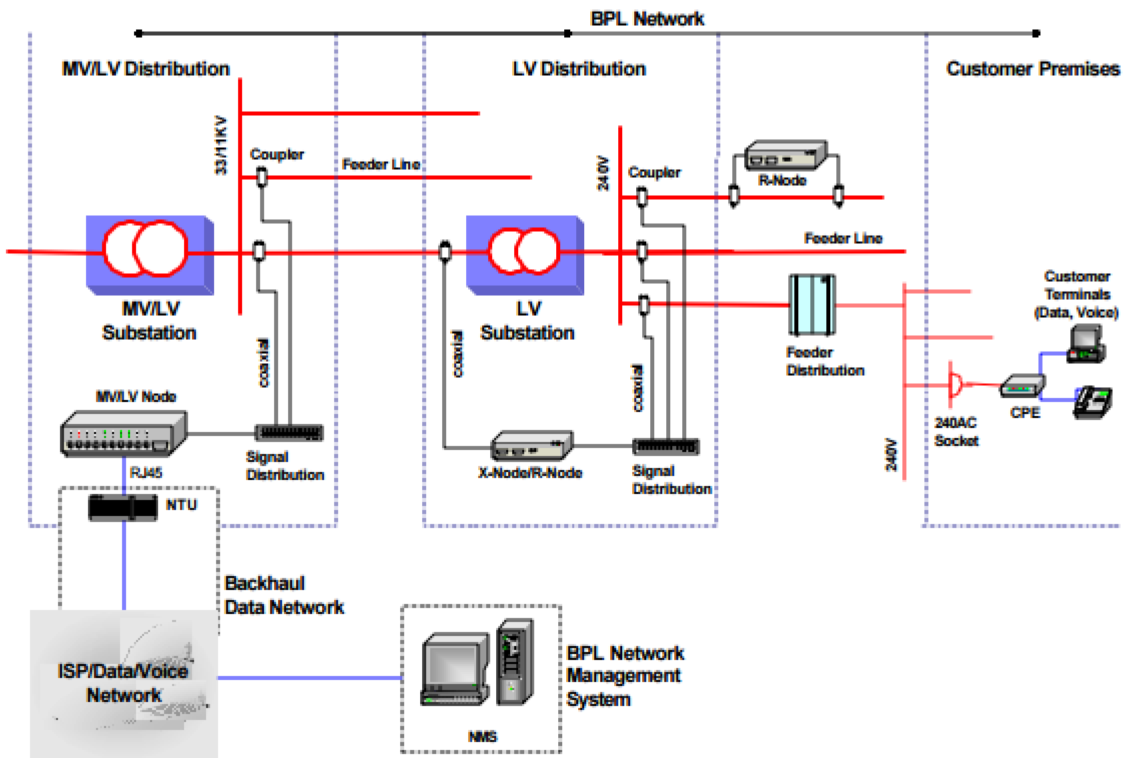


Figure 1: BPL Network Overview

Backhaul Data Network The backhaul data network is the telecommunications backbone to which the BPL-empowered distribution system is connected via high-speed data link.

BPL Network:

a. The BPL network is integrated with the electricity distribution system and is utilizing the electric power lines for broadband access communications.

b. The BPL system should have Network Management System (NMS) as parts of the network.

c. The BPL system should only be deployed on the MV and LV distribution systems.

BPL Physical Network Layer Components A number of electronic devices (or nodes) are deployed at various points in the electricity distribution network to overlay a communications network on the electric power lines. These devices are characterized as "Physical Network Layer components" and are designed to accomplish specific tasks along the BPL network. The list of nodes includes:

6.2 Medium/Low Voltage Node (MV/LV-Node):

The Medium/Low Voltage Node (MV/LV-Node) is a device that converts the normal IP-based communication signal to other signal appropriate for transmission over the electric power lines. It should be capable to support a variety of interfaces and functions, such as;

a. Backhaul connections to the telecommunications backbone.

b. BPL signals aggregation for transmission over the MV/LV feeder lines.

c. BPL local network management that provides various functions such as sub-elements configurations, controlling and monitoring, error correction and security.

Due to safety reason, the MV/LV-Node interface to the electric power lines should not be designed to directly connect to the electric power lines, instead, a coupling device either inductive or capacitive should be used. The connection between the MV-Node and coupling unit is generally by means of a coaxial cable.

A standard data interface ports (RJ-45) should be made available for connection to the telecommunications backhaul equipment.

6.3 Transformer Node (X-Node)

The Transformer Node (X -Node) is a device, which is installed in the transformer room and can provide two functions;

a. to transfer (i.e., by-passing the transformer) communication signals between MV and LV lines; and

b. as a repeater along the MV lines.

6.4 Repeater Node (R-Node)

The Repeater Node (R-Node) is a device, which is installed along the electric power lines (external or internal types) and is used to provide greater reach on long lines or lines with high attenuation so that the end-to-end communication quality is maintained. In some cases, the R-Node is a modified X-Node.

6.5 Customer Premises Equipment (CPE)

The Customer Premises Equipment (CPE) contains a BPL interface to the LV line, terminates and converts the BPL signal back to the normal IP based. The CPE should be modular in construction to allow a variety of other interfaces for in-home services. These will include support for an in-home data network and for telephony services with standard (RJ-11) analogue telephone ports.

6.6 Couplers

Couplers provide the means to transmit on and receive the communication signals from the electric power line. There are two methods for coupling the signal to the power line - capacitive and inductive coupling.

a. Capacitive coupler – The usage of capacitive coupler for the overhead MV and LV lines is preferred. For indoor applications, one should be mindful that the installation takes into consideration the issues related to the Malaysian electrical environment.

b. Inductive coupler – This is a passive-type coupler that can be installed without interrupting the supply across the electric power lines. It should operate in overhead, pad mounted and underground scenarios and is capable of withstanding high voltage level, weather elements, external elements and surges due to lightning and switching.

6.7 Line Conditioning Devices

Line conditioning devices are placed on both the MV and LV distribution lines and are responsible for the sectionalizing of the electricity distribution network. In all cases these devices should be designed to be active in the communications frequency band and not in the electricity frequency band. The functionality of the devices is to pass or block the signal as appropriate.

6.8 Electromagnetic Compatibility and Interference Requirements

6.8.1 General

The BPL equipment should have features to perform efficiently under the electrical environment and they should be Electromagnetic Compatible (EMC) to work with surrounding equipment and immune to the Electromagnetic Interferences/Radiations (EMI).

6.8.2 EMI Requirement for BPL Installation

a. The radiated emission limits for BPL installation should follow the Federal Communications Commission (FCC) Part 15 § 15.209 using a QP detector, specified as follows:

Frequency	Bandwidth	Radiated emission limits
1 to 30 MHz	9 kHz	30 μV/m (29.59 dBμV/m) at 30 meters
30 to 88 MHz	120 kHz	100 μV/m (40 dBμV/m) at 3 meters

b. The radiated emission should be measured as recommended in FCC Part 15, 15.31, 15.33 & 15.35.

6.8.3 Security Requirement

General Security of the BPL system should be mandatory to ensure reliability of the BPL system itself and the existing electricity services quality. Due to the criticalness of electricity services and to abide the national regulations on the electrical energy quality of service, priority of service should be given to electricity in any case.

For deployment of BPL system, two security measures should be adopted;

a. Security to the electricity distribution system and services.
b. Security to the BPL system.

7.0 End user

7.1 Broadband Speed Guide

The table below compares typical online activities with the minimum download speed (Megabits per second, or Mbps) needed for adequate performance for each application. Additional speed may enhance performance. Speeds are based on running one activity at a time.

Activity	Minimum Download Speed (Mbps)
General Usage	
General Browsing and Email	1
Streaming Online Radio	Less than 0.5
VoIP Calls	Less than 0.5
Student	5 - 25
Telecommuting	5 - 25
File Downloading	10
Social Media	1
Watching Video	
Streaming Standard Definition Video	3 - 4
Streaming High Definition (HD) Video	5 - 8
Streaming Ultra HD 4K Video	25
Video Conferencing	
Standard Personal Video Call (e.g., Skype)	1
HD Personal Video Call (e.g., Skype)	1.5
HD Video Teleconferencing	6
Gaming	
Game Console Connecting to the Internet	3
Online Multiplayer	4

7.2 Net Neutrality

The Commission is of the view that all content should be treated equal and users should not be charged or discriminated based on content, website, platform, application, type of attached equipment of method of communication. The Commission has conducted its own investigation into ISP providers after users complained of certain OTT services being blocked. The investigation revealed the offending providers, who were then approached by the Commission. After which all OTT services were in proper operation.

8.0 GLOSSARY

Broadband: a high-capacity transmission technique using a wide range of frequencies, which enables a large number of messages to be communicated simultaneously.

Net neutrality: is the principle that Internet service providers treat all data on the Internet equally, and not discriminate or charge differently by user, content, website, platform, application, type of attached equipment, or method of communication. For instance, under these principles, internet service providers are unable to intentionally block, slow down or charge money for specific websites and online content. This is sometimes enforced through government mandate. These regulations can be referred to as "common carrier" regulations. This does not block all abilities that Internet service providers have to impact their customer's services. Opt-in/opt-out services exist on the end user side, and filtering can be done on a local basis, as in the filtration of sensitive material for minors. Net neutrality regulations exist only to protect against misuse.

Next-Generation Network (NGN): a packet-based network which can provide services including Telecommunication Services and is able to make use of multiple broadband, quality of Service-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies.

Video on demand (display) (VOD): are systems which allow users to select and watch/listen to video or audio content such as movies and TV shows when they choose to, rather than having to watch at a specific broadcast time, which was the prevalent approach with over-the-air broadcasting during much of the 20th century.

Synchronous Optical Networking (SONET): SONET and Synchronous Digital Hierarchy (SDH) are standardized protocols that transfer multiple digital bit streams synchronously over optical fiber using lasers or highly coherent light from light-emitting diodes (LEDs). At low transmission rates data, can also be transferred via an electrical interface. The method was developed to replace the plesiochronous digital hierarchy (PDH) system for transporting large amounts of telephone calls and data traffic over the same fiber without synchronization problems.

9.0 ACRONYMS

ADSL: Asymmetrical Digital Subscriber Line
ATM: Asynchronous Transfer Mode
BPL: Broadband over Powerline
CATV: Cable Television
CPE: Customer Premise Equipment
CMTS: Cable Modem Termination System
CO: Central Office
DLC: Digital Loop Carrier
DOCSIS: Data Over Cable Service Interface Specification
DSL: Digital Subscriber Line
DSLAM: Digital Subscriber Line Access Multiplexer
GDP: Gross Domestic Product
HDSL: Hi-Speed Digital Subscriber
ICT: Information and Communication Technologies
IP: Internet Protocol
ISDN: Integrated Services Digital Network
ISP: Internet Service Provider
Kbps: Kilo Bites Per Second
Mbps: Mega Bites Per Second
NIC: Network Interface Card
NGN: Next Generation Networks
NSP: Network Service Provider
OSI: Open System Interconnection
PC: Parallel Communication
PDH: Plesiochronous Digital Hierarchy
POTS: Plain Old Telephone Service
PSTN: Public Service Telecommunications Network
TCP: Transmission Control Protocol
SDSL: Symmetrical Digital Subscriber Line
SDH: Synchronous Digital Hierarchy
SOHO: Small Office/Home Office
VDSL: Very High Data Rate Digital Subscriber Line
VOIP: Voice over IP
WISP: Wireless Internet Services Providers