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More General Sophisticated Method of Implementation of Fiber to the Homes

Othman AL-Rusaini and Adnan Affandi
Dept. of Elect.& Comp. Eng., Faculty of Eng./ King Abdul Aziz University Jeddah, KSA

Abstract:*Fiber to the Homes (FTTH) is one of the most important fiber optic applications, since FTTH provides huge bandwidth. The single fiber offering multi services such as :(Data, Voice, Video etc.).Comparing FTTH and copper network fiber provides the highest reliability, the lowest maintenance costs, the highest security and the most revenue potential. It will mainly be used for broadband services such as high speed internet access, cable TV etc. but also will be able to support the existing customer services currently working over copper cables. FTTH deployment project costs tend to be heavily because much of the infrastructure has to be put in place before the first customer can be connected. This research guide has been produced in order to standardize the methods and procedures of planning and Implementation of FTTH schemes.*
Keywords:*FTTH, Access Networks, Optical Networks, Passive Optical Network (PON).*

I. Introduction

The major driver for the advancement in the areas of access technologies is increasing demand for higher speed Internet.Of the techniques used in the provision of broadband connection: Cable Modem, Digital Subscriber Line (DSL) and Wireless technology.These technologies do not meet the needs of users enough (HD-TV, E-learning, very high speed internet,IP-TV and online game etc.) because the speed is limited, depends directly on the distance between the user and the central office and the quality of copper.

Networks based on fiber optic have evolved quite significantly due to consumer desire for multiple applications and multimedia services. Service providers need a wide range to meet this demand, fiber optic technologies satisfy this purpose, and it offers very high bandwidth and flexibility required for two-way interactive services, video-based services.

The most appropriate choice for the purpose of long-term (easily increase bandwidth in the future) is fiber to the home service (FTTH) if the client was fully connected by the optical fiber [1]. By FTTH service providers can offer a variety of services:

- Interactive video.
- High-speed Internet.
- Cable television broadcast.
- Telephony.
- Online gaming

All these services are offered via single fiber optic.

FTTH deployment project costs tend to be heavily because much of the infrastructure has to be put in place before the first customer can be connected for that most service provider are worried to begin offering this service [2]. This paper presents an approach for getting a clear estimate of expenses for an FTTH.

II. Fiber optics overview

Fiber optic is glass or plastic, the thickness of the head hair can transmit information by light. Fiber optics communications present the most exciting, and probably the most challenging, aspects of modern systems fiber are exciting because they seem to offer so many benefits. Fiber optic cable is smaller and lighter than conventional cables, which use copper wire, but it can carry much more than that information, which makes it very useful for transferring large amounts of data transfer between computers, and for Television broadcast and for phone calls [3]. Fiber opticscarries light signals rather than electrical signals. The information signals are converted from electrical signals into infrared light-waves. The light waves travel through the fiber until they reach the receiver where the light waves is converted back to electrical signals. Fiber opticsis best for transmitting signals at high speeds or over long distance between fixed points [4].

The finished fiber optic looks simple enough but it is complicated to manufacture (Figure 1). The glass used must be exceptionally pure. In normal glass used for windows, for example, if you look at the edge it looks green. This is because of distortion and impurities in the glass. The glass is made of sand but not the sand in the desert or on the beach. It is special type of sand called silica. Glass must be very pure because it needs to transfer light rays effectively over long distances. That ordinary glass loses its signal within a few meters because of impurities that would disperses light in fiber.

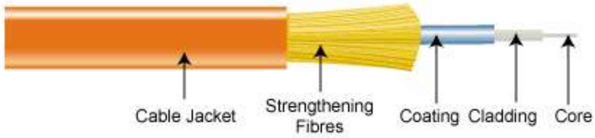

Figure 1. Fiber Optic Cable

The problem with a glass rod is that light can leak out wherever the rod touches something other than air. So, the main solution was to make a two- layer fiber.Light could travel in the inner layer or core of the fiber (Figure 2). The outer layer, the cladding, would keep the light within the core because its refractive index (like that of air) was less than that of the core.The cladding also help prevent light leakage, the light is reflected back from the external cladding to the core and continue the light moving in fiber.The cladding is made of pure silica glass while the core is silica glass doped with certain elements to give a refractive index higher than the cladding.

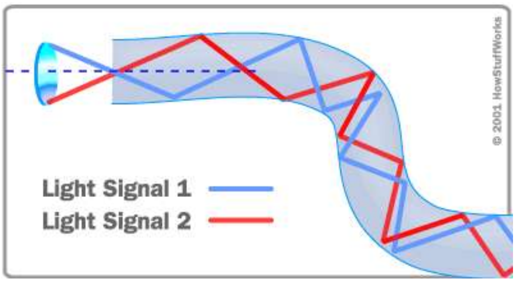

Figure 2. Signal transferring inside fiber

2.1Fiber optic cable propagation modes

Fiberoptic cable has two propagation modes [5], [6]: multimode and single mode (Figure 3).In Single mode Fiber (sometimes called monomode) light can going in straight line only, because it is very small core diameter. Single mode is higher bandwidth, lower fiber attenuation and used for long transmission.

In multimode fiber the light take any number of paths. The difference in the core diameter is the major difference between multimode and single mode. Multimode fibers usually have a wider core that makes it easier to couple to the source or detector. The multimode fiber optic can classified based on refractive index into two types: step index and graded index multimode

Step index multimode

- The density of core remains constant from the center to edges until it reaches the interface of the core and the cladding.
- Beams in the middle travel in straight the core and reach the destination without reflecting or refraction.
- Other beans strike the interface of the core and cladding at different angles causing the beams to reach the destination at different times.
- Mostly used for imaging and illumination.

Graded index multimode

- It is fiber with varying density (highest at center of the core and decrease gradually to its lowest at the edge).
- This difference causes the beams to reach the destination at regular intervals.
- Can be used over distance of up to about 1000 meters.
- Used for data communication and networks carrying signals for typically no more than a couple of kilometers.

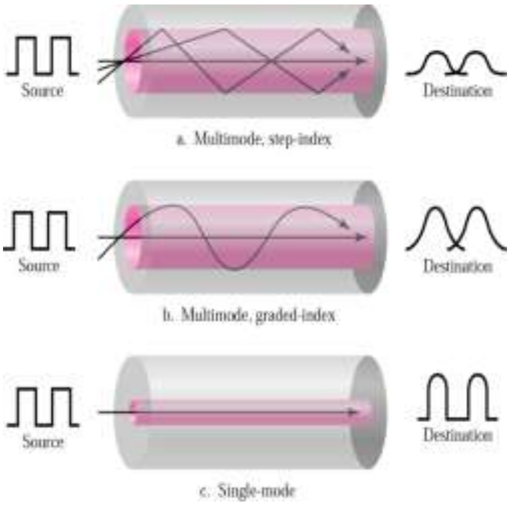

Figure 3. Single mode and Multimode

2.2 Fiber optic cable construction

While fiber optics is very important technology,cables constructions have developed spectacularly, so there are new technologies that provide for the construction of cable. However, most of the mechanisms used in the copper cables construction can be applied for fiber cables. There are many different requirements to be met according to whether the cables will be used inside or outside or if they need extra protection from damage or chemicals etc. One main requirement is to provide a buffer jacket on the fiber. There are either loose buffers (fibers in a tube) or tight buffers (fibers coatings by plastic).To relieve the tension in the fibers of a member of the force introduced into the steel cable or synthetic material. Also are filling compounds to protect them from water, such as grease and metal barriers such as lead can be used to keep out chemicals. The outer jacket is the sheath of the cable and this could flame retardant PVC for internal use or polyethylene for external use [7], [8], [9].

2.3 Cable Design

The fiber optic cable consists of several parts as shown in Figure 4 [10].

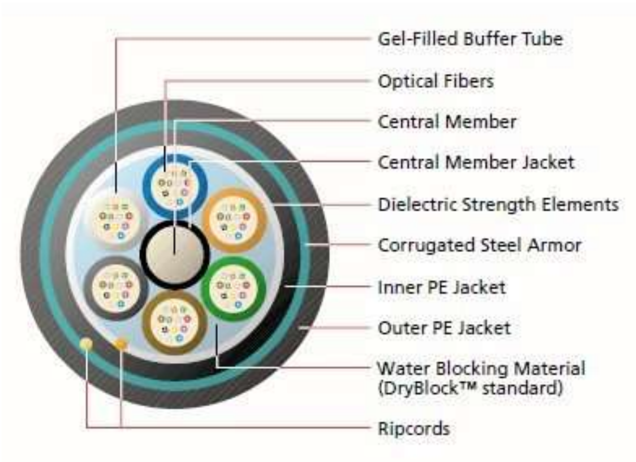

Figure 4. Fiber optic cable

Primary Coating

The primary coating prevents abrasion of the fiber surface during production. This is added when the fiber has just been produced to protect from surface damage caused by handling or atmospheric attack which can lead to reduced strength of the fiber. A thin plastic coating is added immediately after manufacture. Silicone resin is commonly used as a primary coating.

Secondary Coating

The secondary coating protects the fiber from micro-bending losses. It may consist of a tight coating or a loose tube. It could be applied to the fiber or as part of the cable structure. Tight packaging involves coating the fiber with a thick buffer coating (e.g. 1 mm nylon coating) but ensuring that applying the coating does not affect the fiber. Loose packaging involves placing the fibers in a tube, usually 1 mm diameter, to protect from external forces. The tube may be filled with water resistant silicone compound.

Strength Member
A component is added to the cable structure to take the loads involved in cable installation and limit the cable strain. This could be made of steel, polyester, nylon, Kevlar or carbon fibers.

Cable Sheath
An outer sheath is added to protect against abrasion and crushing.

Water Barrier
This will prevent water entering the cable and could be a layer of aluminum foil or polyethylene film.

2.4 Fiber Optic Cable
There are two main groups, loose tube cables (outdoors cables) and tight buffer cables (indoor cables) (Figure 5) [10], [11].

Figure 5. Types of Fiber Optic Cable

Loose Tube Cables
Loose tube cables used for long distances and for outside use (Figure 6), it is low attenuation. These cables contain gel or absorbent tape to protect fibers from water (Figure 7).

Figure 6. Loose Tube Cable

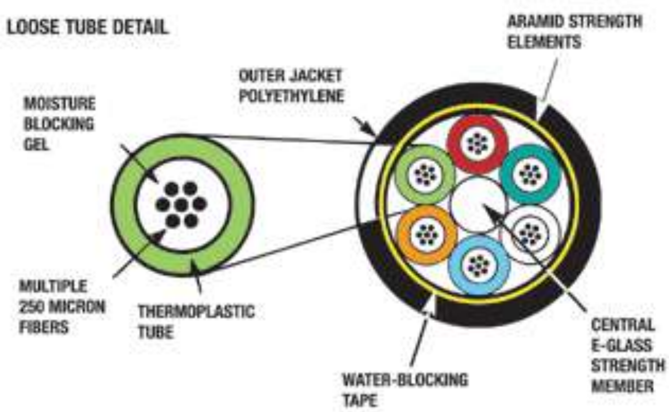

Figure 7. Cross-section of loose tube cable

If the cable contains a single tube, it is called a uni tube and if it contains several tubes, it is called a loose tube cable. Each tube contains up to 12 fibers, sometimes up to 24 fibers.

The tube has a diameter commonly between 2.8 and 3.2mm, but tubes with a diameter 1.2mm have been developed. Nevertheless the tube has still space for 12 fibers (Figure 8).

Figure 8. Loose Tube Cable Structure

Tight Buffer Cables

Tight buffer cables for indoor use (Figure 9). In these cables no gel filling needed because indoor use eliminates the need to use gel for protection and let them appropriate for vertical installing.

Figure 9. Tight Buffer Cable

PVC Buffer is extruded directly onto the coating each fiber is covered by a buffer (900µm) and this is makes cable more flexible and Easier to terminate. Commonly used are sizes from one single fiber up to 24 fibers (Figure 10).

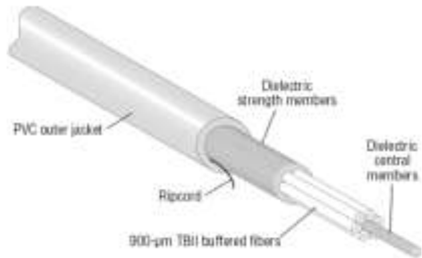

Figure 10. Tight Buffer CableStructure

These cables not good for outside use because the buffer strains the fiber as temperature fluctuates, increasing attenuation.

III. Fiber to the homes (FTTH)

The far distance between subscribers and the main telephone exchange and the high request on the new digital services which became available was the reason for the companies of high technology to develop different systems such as FTTH (Figure 11) .

Figure 11. FTTH Network

FTTH would enable telecom companies to provide customers with 6 telephone lines, one Cable TV output and a fast internet port on one pair of fiber. It will also help the company meet the resilience requirements, consolidate the access network reliability and put the company in a better competition position.

Comparing FTTH and copper network (Figure 12), fiber provides the highest reliability, the lowest maintenance costs, the highest security and the most revenue potential.

It will mainly be used for broadband services such as high speed internet access, cable TV, etc. It will also support the existing customer services currently working over copper cables [12].

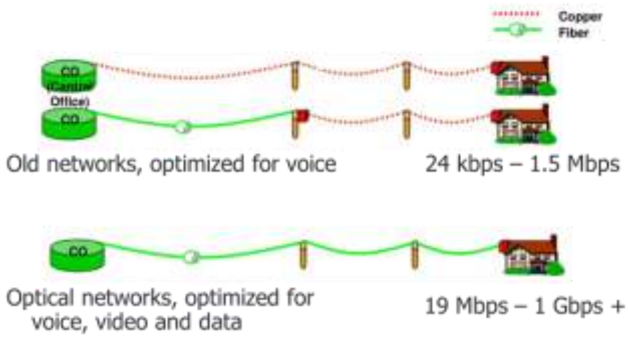

Figure 12. Comparing FTTH and copper network

3.1 Fiber access

In the next generation network, fiber access is most important technologies.By fiber access, network access layer is sustainable development and the access layer bandwidth is increase. Optical Access Network (OAN) embraces technologies: active optical network (AON) and passive optical network (PON).

Depending on the optical network unit (ONU) location and the fiber cable length, fiber networks (FTTx) come in many varieties [13]as shown in Figure 13 and listed inTable 1.

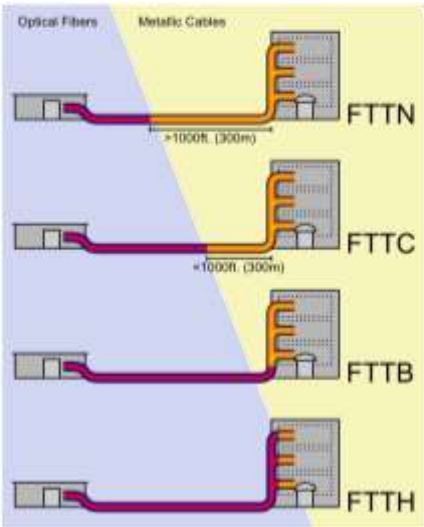

Figure 13. Fiber To The x (FTTx)

Table 1.FTTx varieties

	ONU Location
Fiber to the Home (FTTH)	In the home or office indoor
Fiber to the Building (FTTB)	In the building or corridor
Fiber to the Node (FTTN)	In the Cabinet/Curb
Fiber to the Cabinet/Curb (FTTC)	In the neighborhood or last amplifier

Table 2 list main features for the most important kinds of FTTx models.

Table 2.FTTx Features

Application Mode	FTTC	FTTB	FTTH
ONU Capability	Hundreds	Tens	Single Family
Distance between OLT and ONU	5~100km	< 20km	< 20km
Distance between ONU and User	1~3km	< 500m	0~20m
Bandwidth per User	2 to 25Mbps	50/100Mbps	>=100Mpbs
ONU Interface	POTS, ADSL/ADSL2+, VDSL2	FE, POTS, VDSL2/TDM	FE, POTS, Wifi, RF
ONU Type	ONU (Large Capability)	MDU/ MTU	SFU
International Abbreviation	FTTN , FTTZ	FTTK	FTTP , FTTU

3.2 FTTH Architecture

AON and PON are to alternate network designs for fiber broadband connections. Each design has his own way to transfer data to the right place [11], [14].

Active Optical Network (AON)

AON (or point-to-point (P2P)) uses switching equipment, such as a router or a switch, to manage distribution of signal and directing signals directly to specific customers. This means that each user has a fiber optic line dedicated to him (Figure 14).

Passive Optical Network (PON)

PON is a point to multipoint (P2M) network. Via a passive optical splitter each customer is connected into the optical network, this mean no active electronics elements in the distribution network and bandwidth is shared from the source to the user (Figure 15). Optical splitter device split incoming light and distribute it through multiple fibers, or in the other direction combine multiple light streams over a single fiber.

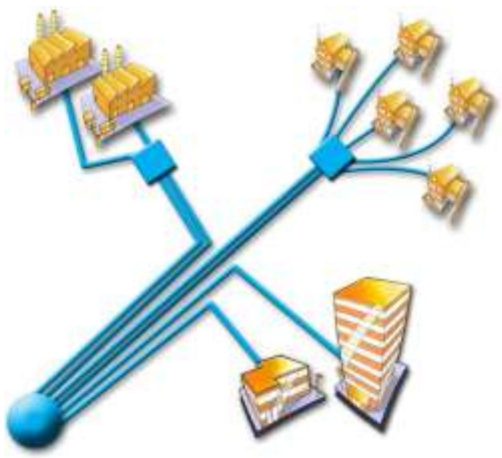

Figure 14. Active Optical Network (AON)

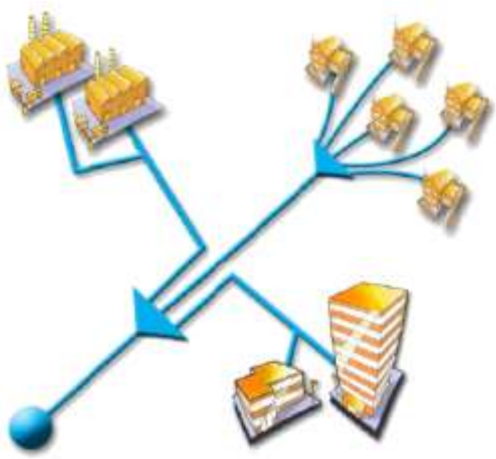

Figure 15. Passive Optical Network (PON)

3.2.1 Types of PON solution

Many types of PONs have been defined [13, 15 and 16]:

- **APON:** ATM PON.
- **BPON:** Broadband PON.

- **GPON:** Gigabit PON.
- **EPON:** Ethernet PON.
- **GEPON:** Gigabit Ethernet PON.
- **CPON:** Composite PON.
- **WPON:** WDM PON.

APON
ATM PON (APON) is the first PON system built on Asynchronous Transfer Mode (ATM).

BPON
Broadband PON (BPON) is the enhanced version of APON, it transmission speed up to 622 Mbps. APON has dynamic bandwidth distribution, protection system and other functions.

GPON
Gigabit PON (GPON) is based on the new generations of broadband passive optical access.GPON provides very high bandwidth up to 2.5 Gbps, it also has access network level protection technique and full OAM (Operations, Administration and Maintenance) functions. GPON is widely used in FTTH networks.

EPON
Ethernet PON (EPON) is the competitor to GPON which uses Ethernet packets. EPON use 1.25Gbps upstream and downstream rates.It is a fast Ethernet over PONs which are point to multipoint (P2M) in which single fiber optic is used to serve multiple users. It has a good economy because through a single fiber optic access system, can access to the data, voice and video service.

WDM-PON
Wavelength Division Multiplexing PON (WDM-PON) uses multiple optical wavelengths to increase the upstream/ downstream bandwidth available to end users. WDM-PON is the key to providing the bandwidth symmetric and continuously up to 1Gbps per user. And also it provides the higher security, which is an added advantage.

Table 3 list some features of different PON standard.

Table 3 Comparison of different PON standard

Features	BPON	GPON	EPON
Bandwidth	Down Stream up to 622 Mbps Up Stream up to 155.52 Mbps	Down Stream up to 2.5 Gbps Up Stream up to 2.5 Gbps	Down Stream up to 1.25 Gbps Up Stream up to 1.25 Gbps
Downstream λ	1490 nm & 1550 nm	1490 nm & 1550 nm	1490 nm
Upstream λ	1310 nm	1310 nm	1310 nm
Layer-2 Protocols	ATM	ATM, Ethernet, TDM over GEM	Ethernet
Frame	ATM	GPON Encapsulation Method	Ethernet Frame
Max. Distance (OLT to ONU)	20 km	20 km (supports logical reach up to 60 km)	10 and 20 km

3.3 FTTH infrastructure

The FTTH infrastructure elements are listed in Table 4 and shown in Figure 16 [10].

Table 4. FTTH infrastructure elements

Infrastructure Elements	Typical physical form
Access Node or POP (point of presence)	Building communications room or separate building.
Feeder cable	Large size optical cables and supporting infrastructure e.g. ducting or poles
Primary fiber concentration point (FCP)	Easy access underground or pole-mounted cable closure or external fiber cabinet (passive, no active equipment) with large fiber distribution capacity.
Distribution cabling	Medium size optical cables and supporting infrastructure, e.g. ducting or poles.
Secondary fiber concentration point (FCP)	Small easy access underground or pole cable joint closure or external pedestal cabinet (passive, no active equipment) with medium/low fiber capacity and large drop cable capacity.
Drop cabling	Low fiber-count cables or blown fiber units/ ducting or tubing to connect subscriber premises.
Internal cabling Fiber in the Home	Includes fiber entry devices, internal fiber cabling and final termination unit.

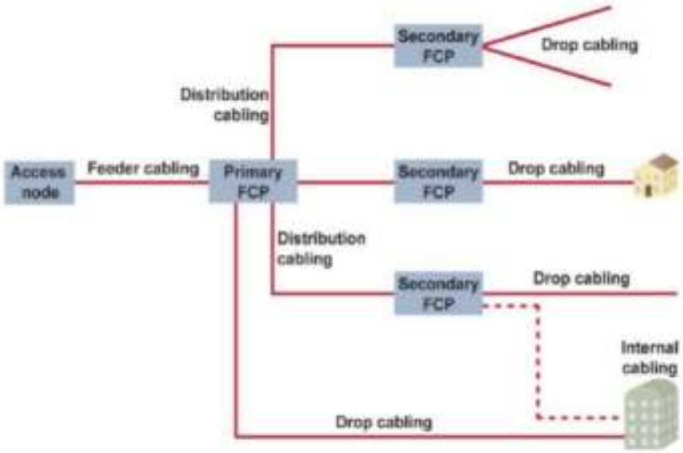

Figure 16. Main elements in a FTTH network infrastructure

3.3.1 Fiber in the Home (FITH) cabling reference model

In house installation extends from a building entrance to an optical outlet in the user's premises (Figure 17) [10].

Figure 17. Design of basic fiber in the home network

A reference model specifies infrastructure elements and described processes (Figure 18).

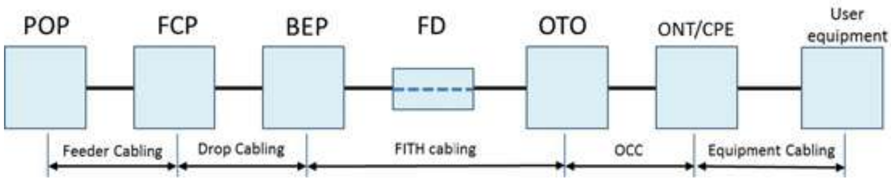

Figure 18.FITH reference model

Infrastructure elements of the reference model are listed:

- Point of Presence (POP): POP is starting point for the fiber optic to the user.
- Feeder Cabling: it is run from the POP to the Fiber Concentration Point (FCP).
- Fiber Concentration Point (FCP): FCP convert a feeder cable to small drop cables for further routing via drop cables.
- Drop Cabling: Connects the FCP to the building entry point (BEP).
- Building Entry Point (BEP): BEP is the interface between the drop cabling (outdoor) and the internal home network (indoor).
- Floor Distributor (FD): FD is allowed to switch from the vertical to the horizontal indoor cable (it is an optional).
- Fiber in the Home cabling (FITH cabling): The FITH cabling connects the BEP to the Optical Telecommunications Outlet (OTO).
- Optical Telecommunications Outlet (OTO): The OTO provides an optical interface to the ONT/CPE equipment.
- Optical Network Termination (ONT): The ONT includes an electro-optical converter.
- Customer/SubscriberPremise Equipment (CPE/SPE): CPE/SPE is any active device which provides the customer/subscriber with FTTH services (high-speed internet, TV, telephony, etc.). ONT and CPE/SPE can be integrated.
- Optical Connection Cable (OCC): The connection cable between OTO and CPE/SPE.
- Equipment cabling: The Equipment cabling supports the distribution of applications (internet access, TV, telephone, etc.) within the premises.
- User equipment: The user equipment is all equipment allows the user to access services such as personal computer, TV, phone, etc.

3.4 FTTH deployment Techniques

The most method of underground cable installation used is duct infrastructure, creating a duct network to enable new installation of cables by different techniques (pulling, blowing or floatation). A duct network can be constructed in many ways [10]:

1. The main duct containing small sub-channels allocated to the extension of the individual cables.
2. Large diameter ducts allowed withdrawing cable gradually with network expansion.
3. Small diameter ducts used for installation single cable.

A duct infrastructure allows for additional network expansion and reconfiguration the network.

3.5 Fiber Management

Fiber optics cable management system needs to protect fiber cables when it is installed.Reducing movement of exist fibers is also protection. Fiber management systems maintain minimum bend radius requirements(Figure 19).

To ensure optical performance should protect bend radius,to protect bend radius properly and reduce cost maintenance should have clear paths for cable routing [17].

Network architecture selection should take considerable care.Network design based on reducing capital expenditure with a focus on maintaining the network flexibility and reducing operational expenses will be more likely to succeed than those that focus only on the capital account.

Figure 19. Fiber Management

3.6FTTH cost calculations
One estimate by optical solutions shows this breakdown on the cost of a FTTH network as shown in Figure 20 [10].

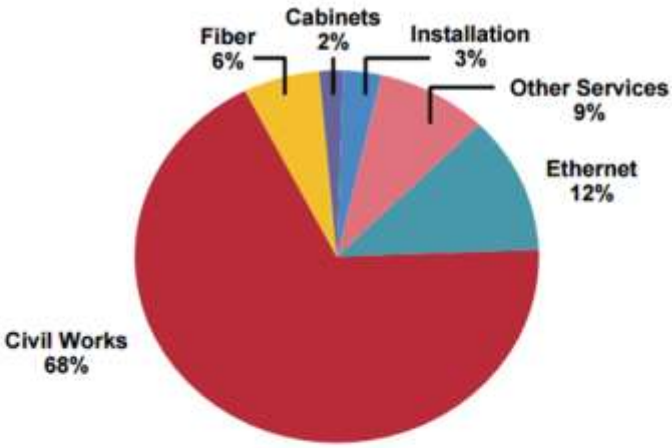

Figure 20. FTTH cost breakdown

The detail involved in the actual work and how the contractor will be paid is different from how the planner estimates the cost. His difficult for the planner be accurate in foreseeing exactly the work involved and also very time consuming .
The planner should use the most recent issue of the planners schedule of unit rates in order to make the estimate .

Because of that in this paper has been a development a general computer aided to provide a good designing tool that assists network planners to evaluate and compute the total cost in order to meet the requirements of FTTH.

IV. Implementation of the program

The software is implemented into a web page using ASP.net C# and databases were built using SQL Server. The purpose of the program is to help planners in estimating and computing the cost of implementation FTTH technology.

The program divided into four parts: New Project/Item, View All Project/ Project Details, Add Items to Project and Project Forecast.

4.1 New Project/Item
This option gives ability to enter new project/item information as shown in Figure 21 and Figure 23. After enter the information, user should press "Save" to save data to database, if he press "View All" can see all existsprojects/items information as shown in Figure 22 and Figure 24

4.3 Add Items to Project

This option gives ability to add items to project, after add new item to database we can add it to a project as shown in Figure 25 and also should assign the item quantity to calculate it cost, then user should press "Save" to save data to database.

4.2 View All Project/ AProject Details

This option gives ability to view all projects distributed by work type as shown in Figure 26, this give us ability to see which work that requires more funds for all project. And in this section we can see a project details as shown in Figure 27.

4.4 Project Forecast

To estimate the total cost of implementation of a project to certain area. Enter the total number of customers' homes and the distance between the telephone exchange and the customers' area. the total estimate cost and cost for each elements will be appear as shown in Figure 28.

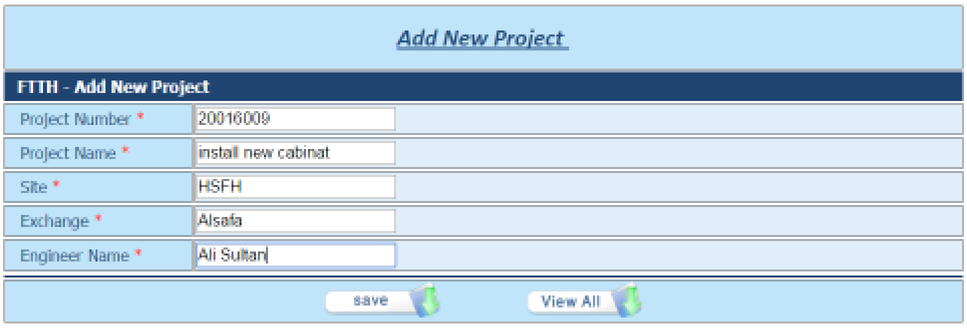

Figure 21. Add New Project

Figure 22. View all Projects

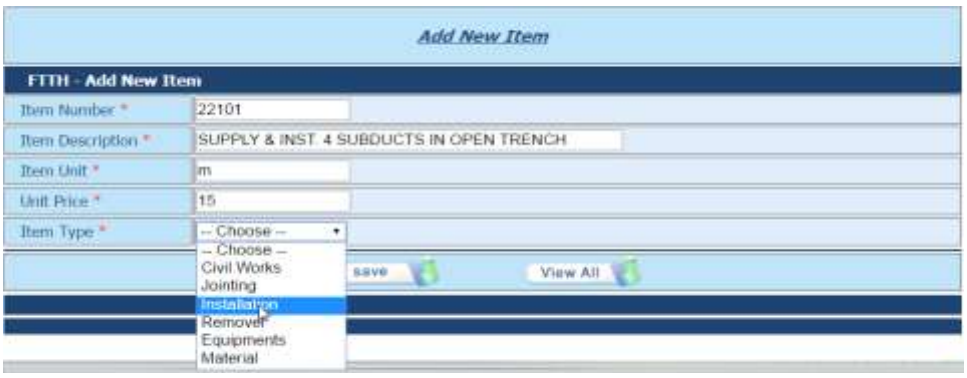

Figure 23. View allItems

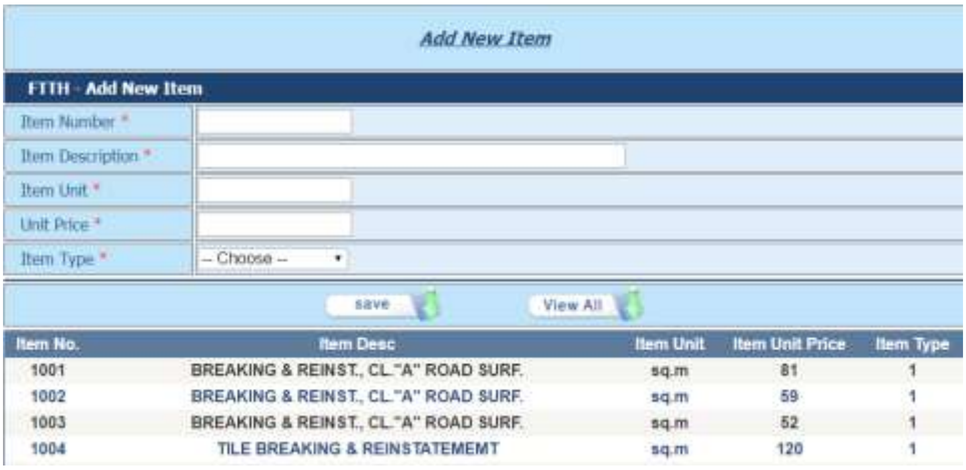

Figure 24. Add Items to Project

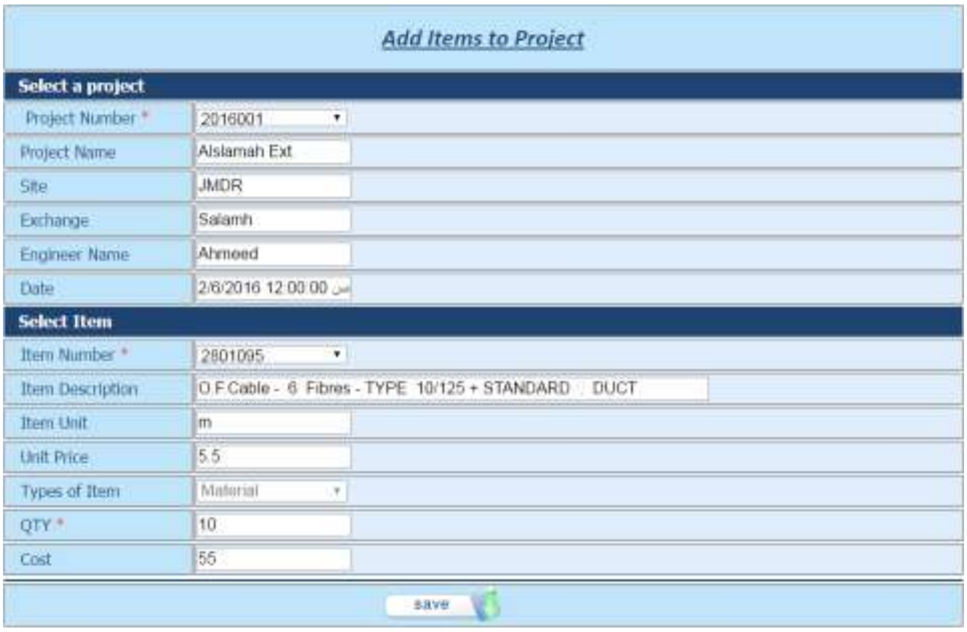

Figure 25. Add Items to Project

View All Projects

FTTH - View All Projects

	Project No.	Item No.	Desc.	Unit	Unit Price	Qty	Cost
Civil Works	2016001	1001	BREAKING and REINST., CL. A ROAD SURF.	sq.m	81	3	243
	2016001	1002	BREAKING and REINST., CL. A ROAD SURF.	sq.m	59	30	1770
	2016001	1003	BREAKING and REINST., CL. A ROAD SURF.	sq.m	52	11	572
	2016002	1001	BREAKING and REINST., CL. A ROAD SURF.	sq.m	81	44	3564
	2016002	1002	BREAKING and REINST., CL. A ROAD SURF.	sq.m	59	10	590
	2016002	1004	TILE BREAKING and REINSTATEMEMT	sq.m	120	11	1320
	2016002	1002	BREAKING and REINST., CL. A ROAD SURF.	sq.m	59	5	295
	2016003	1003	BREAKING and REINST., CL. A ROAD SURF.	sq.m	52	20	1040
	2016006	1003	BREAKING and REINST., CL. A ROAD SURF.	sq.m	52	5	260
	Total Civil Works Cost = 9654						
Jointing	2016001	3421	SET UP JOINT FIBRE CABLE IN MAN HOLE	each	250	12	3000
	2016002	3421	SET UP JOINT FIBRE CABLE IN MAN HOLE	each	250	2	500
	Total Jointing Cost = 3500						
Installation	2016001	2115	SUPPLY and INST. 4 SUBDUCTS IN OPEN TRENCH	m	10	20	200
	2016003	2115	SUPPLY and INST. 4 SUBDUCTS IN OPEN TRENCH	m	10	5	50
	Total Installations Cost = 250						
Installation	2016001	2115	SUPPLY and INST. 4 SUBDUCTS IN OPEN TRENCH	m	10	20	200
	2016003	2115	SUPPLY and INST. 4 SUBDUCTS IN OPEN TRENCH	m	10	5	50
	Total Installations Cost = 250						
Material	2016001	5811	RECOVERY OF COPPER CABLE ANY SIZE INSIDE DUCT	m	2	100	200
	2016002	5811	RECOVERY OF COPPER CABLE ANY SIZE INSIDE DUCT	m	2	3	6
	Total Materials Cost = 206						
Equipment	2016001	3146961	OPTICAL DISTRIBUTION FRAME 24 FIBRES	each	2500	20	50000
	Total Equipments Cost = 50000						
Removel	2016001	2801095	O.F.Cable - 6 Fibres - TYPE 10/125 + STANDARD . DUCT	m	5.5	33	181.5
	2016002	2801095	O.F.Cable - 6 Fibres - TYPE 10/125 + STANDARD . DUCT	m	5.5	5	27.5
	Total Removel Cost = 209						
Total Cost	*63819*						

Figure 24. View All Projects details

Figure 25. View Project Details

Figure 26. Project Forecast

V. Conclusion

Fiber to the home (FTTH) is a technology deliver fast signal to homes using fiber optic. Calculation of the cost of delivering the service is one of the constraints in this technology.In this paper we successfully developedthe general computer aided software to provide a good designing tool that assists network planners to evaluate and compute the total cost in order to meet the requirements of FTTH.

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