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Title: Fiber Optics Access Network Planning

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الآيـــــة

تعــالي قــال :

﴿ قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا ۖ إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ (٣٢) ﴾

دعاء

رَبِّ اشْرَحْ لِي صَدْرِي وَيَسِّرْ لِي أَمْرِي وَاحْلُلْ عُقْدَةً مِّن لِّسَانِي يَفْقَهُوا قَوْلِي

حكمة

يا رب هبني الشجاعة لتغيير ما يمكن تغييره

وهبني الإستعداد لقبول ما لايمكن تغييره

وهبني الحكمة للتمييز بين الإثنين.

ACKNOWLEDGEMENT

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ABSTRACT

The main objectives of this study is to maintain a proper Flexible Network to control and manage data transmission Over Access Network, with integrated effort of Associated section to make easy and fast implementation of New services allocation of bandwidth on demand,easy and Fast adaptation to the large changes and traffic pattern With more sophisticated technology and more intelligent Control,and to design a simple network with minimum Maintenance and operational cost, noise isolation, greater Security, manageability, flexibility, affordability.

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Definitions

Main Distribution Frame (MDF):

The main connection frame in a local Exchange on which local Cable pairs And Exchange multiples can be terminated. It is so arranged that any Cable Pair can be cross connected to any Exchange multiple number it is also Has protection and testing facilities.

Cross Connection Point (CCP):

It is a flexibility point which enables any incoming pair to be connected to Any outgoing pair by using a jumper wire or equivalent , also used as a Test point for primary and secondary Cables.

Distribution Point (DP):

The last point in the Access Network from which pairs are distributed to Individual Subscribers.

Main Cable:

Cable, usually of a large number of pairs, connecting the Exchange to the Cabinet.

Distribution Cable:

Cable connecting DPs to the Cabinet.

Link Cable:

Cable connecting two Cabinets to give relief and flexibility between them.

Direct Served Area:

The area in which the distribution pairs are directly connected to the local Exchange without passing through a cross connection point.ist is also

Known as exchange originated (E/O) of the inner zone.

Subscriber Service Line:

Line between DP and telephone set.

ABBREVIATIONS

ABR	Available Bit Rate
AN	Access Network
APON	ATM over Passive Optical Network
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
B-PON	Broadband Passive Optical Network
BRI	Basic Rate Interface
CAPEX	Capital Expenditure
CO	Central Office
CPE	Customer Premises Equipment
CRC	Cyclic Redundancy Check
CWP	Capital Work Program
DLC	Digital Loop Carrier
DON	Digital Overlay Network
DSL	Digital Subscriber Line
DSR	Duct Space Records
FDH	Fiber Distribution Hub
FTTB/C	Fiber to the Building/Curb
FTTH	Fiber to the Home
GPON	Gigabit-Passive Optical Network
HSE	Health Safety Environment
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
IPVPN	Internet Protocol Virtual Private Network
ISDN	Integrated Services Digital Network
ITU	International telecommunications Union
LAN	Local Area Network

LCF	Laser Control Field
LT	Line Terminal
MBR	Minimum Bend Radius
MDF	Main Distribution Frame
MPT	Maximum Pulling Tension
MSAN	Multi Services Access Network
NGDLC	New Generation Digital Loop Carrier
NGN	New Generation Network
OAN	Optical Access Network
ODF	Optical Distribution Frame
ODN	Optical Distribution Network
OLT	Optical Line Terminal
ONT	Optical Network Terminal
ONU	Optical Network Unit
OPEX	Operating Expenditure
OPS	Optical Passive Splitter
OTDR	Optical Time Domain Reflect meter
PON	Passive Optical Network
PRI	Primary Rate Interface
PSTN	Primary Switching Telephone Network
PTP	Point to Point
ROW	Right of Way
Qi's	Quality of Service
SDH	Synchronous Digital Hierarchy
SN	Serial Number
SNI	Service Node Interface
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
UPC	Usage Parameter Control
VC	Virtual Channel
VOD	Video-On-Demand

VSAT Very Small Aperture Terminal

WDM Wavelength Division Multiplexing

WLL Wireless Local Loop

Chapter One

Introduction

1.1 Telecommunications Network Concepts

The basic idea of telecommunications is exchange of information over Distance between separate locations, the information may include Voice Data, Text, Image. A telecommunication network is therefore a system Which can provide these services to a number of end users.

Telecommunication is fundamental to the progress of Nations, though The interaction between Telecomm. And economic development is too Complex to quantify the fact that inadequate Telecommunications

Infrastructure may Leads to stifling of growth of business activities Consequently, of a country cannot be denied.

International Telecommunications Union (ITU). With its many studies Spread across many countries, has demonstrated the relationship Between telephone penetration and capital Gross Domestic Product (GDP) Of a country, economics.

Structure may cause some deviations: for example a country with economy Mainly based on agriculture needs less Telecomm services than highly

Industrialized one.

Telecommunications is essential for our today's life as it is involved in Each & every thing, such as (economics, politics, social life,) As we all aware that Telecommunication is continuously offering new Challenges and opportunities to the Telecomm. Planners.

The ACCESS NETWORK is the last stage of the process and it is Considered as a bottleneck, as it is the portion that connect the customer Premises to the local switch.

Therefore the ACCESS NETWORK needs to be carefully planned in order to Have a long operational life with high efficiently and minimum cost.

1.2 Problems Statement :

Due to changing trends in the Telecommunications field and demand For multimedia and broadband services is growing very fast, planning Concepts are also to be reviewed accordingly In order to provide A cost effective and well tailored digital network to achieve Customer requirements and satisfaction.

And to avoid shortages throughout, the ACCESS NETWORK (MDF, CABs, DPs, , OLT, FDH, SPLITTER, ONT.) Based on proper forecast, considering changing from partially Analog to fully digital, also to eliminate changeover problems And to reduce the db. Loss and signal attenuation.

In addition, the future network would tend to be more complex than The present one, it will require more sophisticated technology and More intelligent control and management functions.

Digitalization and modernization of network is must, means to Introduce Digital Transmission and Switching Components in the Network the reason is mainly economical but there is some other Reasons, such as to improve and extend services to the customers, Improve transmission quality, improve operation and maintenance Facilities.

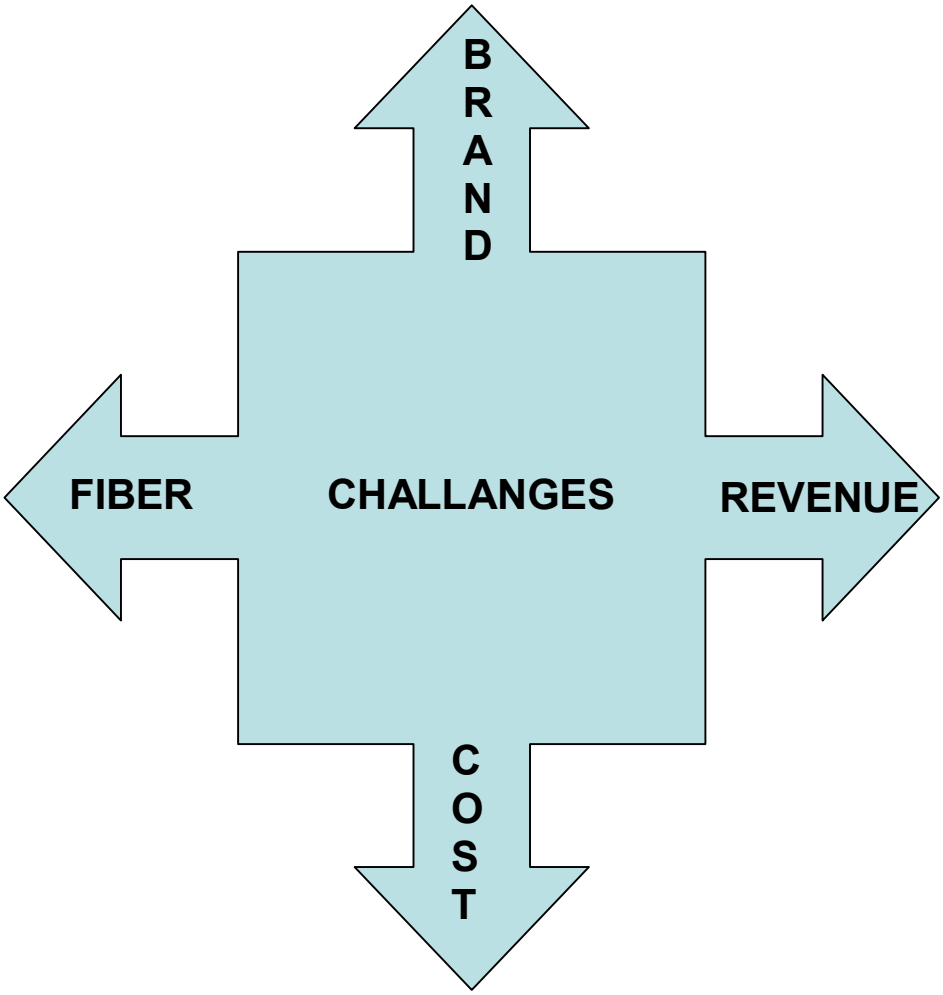
Planners would have to try hard to choose simple solutions to keep the network simple and minimize both capital and operational cost, Therefore Nework Planners must be equipped with conceptual knowledge of Fundamental concept of network Planning.

Having seen that Telecommunications is of utmost importance to National economy, Let us see how network Planning is important to Telecommunications Telecommunications equipment requires a large investment and has a Long operational life investment therefore should be based on sound Planning so that the right equipment at the right place at the right time And at the right cost.

To satisfy expected demand and give an acceptable grade of services in Order to achieve customer satisfactions and loyalty and achieve Considerable revenue.

1.3 Fiber Challenges

as shown below is to reduce the invested capital and to Offer new brands and to generate a considerable revenue



Chapter Two

2.1 Fiber Optic Cables

Optical fiber Cables normally consist of 4 (or more) glass Fibers Constructed to one of the following structures

A) PCOF (primary coated optical fiber) are remarkably strong and stable

But will fracture with excessive bending and twisting .it is one of the Lowest cost option.

B) SCOF (secondary coated optical fiber) has an additional layer of plastic

Extruded on top of the PCOF. This is a much more flexible in Construction but more expensive .

Fiber Characteristics & Advantages

A) High bandwidth

B) Cost-effective

C) Noise isolation

D) Greater security

E) Guarantees quality of services

F) Smaller physical (reduce civil work expenditure –re-use existing duct).

G) Ready for path upgrade

H) Manageability

I) Flexibility

J) Affordability

K) Reduce impact of incorrect forecasts.

L) Large repeater spacing therefore reduced equipments costs.

M) Complete electrical isolation

Fiber cable standards according to ITU-T G.652, Single-mode

Modified diameter:…….8.6 µm

Cladding diameter:……125 ± 0.1 µm

Cable size:……...3.1 X 2.9 mm

Cable weight:……..8 Kg/Km

Tensile strength:……Not exceeding 80 N

Bending radius:…… Not exceed 20 mm

Wavelength:…… … 1310 nm …...max. 0.4 dB/Km

1550 nm .....max. 0.3 dB/Km

2.2 Attenuation

The transmission characteristics of Fiber are usually given in terms of Attenuation for a given wavelength (range) over a given Distance (Length) Attenuation is the reduction of signal strength or light power over the Length of the light carrying medium Fiber attenuation is measured by decibels per Kilometer (dB/Km), Attenuation is very low compared to other Transmission Media

(Copper, Coaxial Cables, etc) with typical value of 0.35 dB/Km at 1300 nm.Attenuation at 1550 nm is even lower with a typical value of 0.25 dB/Km , Which will gives an optical signal, transmitted through Fiber, ability to Travel more than 100 km without regeneration or amplification

2.3 Dispersion

Dispersion is the time distortion of an optical signal that result from many Discrete wavelength components travelling at different rates. In a digital Transmission, Dispersion limits the maximum data rate, the maximum distance. or the Information carrying capacity of a single mode Fiber link.

2.4 Maximum Pulling Tension (MPT):

All F.O Cables have a rated maximum tension that is typically based on Cable specifications. The MPT is clearly shown on the Cable specification Sheet issued by Cable manufacture.

During installation, the tension applied to the cable MUST be monitored Wth a calibrated load cell or Tensiometer .once the Cable tension Reaches 90% of MPT, The installation must stop to troubleshoot the reason Pulling tension does not exceed the MPT rating, otherwise damage to the Cable performance may result.

2.5 Minimum Bend Radius (MBR)

Most of F.O Cables have the following minimum bend radius. Specific MBR IS normally shown on Cable specification sheet.

MBR = 20 times the Cable diameter at the maximum pulling tension.

MBR = 10 times the Cable diameter at no tension.

It is absolutely vital to maintain the minimum bend radius of the Cable at all Times to avoid the damage of the Cable components including the Optical Fibers.

Chapter Three

3.1 Structure of the Access Network

Investment in Outside Plant forms more than 50% in Telecommunications Network. It is therefore necessarily to understand the Concept in order to be able to optimize investment.

Generally Circuit between local exchange & the subscriber equipment Form the Access Network.

General Block Diagram can be shown as below :

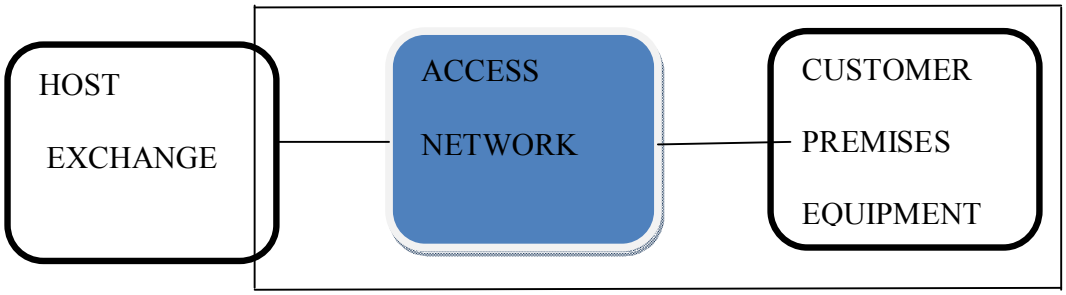


Figure -1

3.2 GPON

The Gigabit Passive Optical Network GPON specifications has been Released by the International Telecommunications Union (ITU) in the ITU-T G-984 Series of documents starting from 2003 Design of GPON Network (Refer to Fig-below – GPON Network) The objective is to develop a network, capable to deliver 100 Mbps per each Tenant. to optimize the size of network and corresponding investment to Match with the demand, the line plant shall be developed, meeting the Ultimate requirements.

GPON technology is becoming the logical choice for the Access Network build out and for the changeover for the existing ones.However, Deploying a successful GPON requires the optimum design of Optical Distribution Network (ODN),which the most difficult and costly to build,and Once built, the most difficult to change.

Careful Planning and the evaluation of the different design options are Essential to ensure a successful service and future bandwidth Requirements with the Passive Optical Networks Passive Optical Networks. There is no active components between the Central office and the customer premises, and passive optical components Are put into the network to guide traffic to endpoints based on splitting the Power of Optical signal along the way this replacement of active with Passive Components Provide cost saving to the service provider by

Eliminating the need to power and Maintain active components in the Transmission loop The passive splitters or Couplers are devices working to pass light and as Such, have no power or processing requirements as of an electronics Mux/ DeMux ,and have Virtually Unlimited Mean Time Between Failures (MTBF). That is why it is reducing the Maintenance cost for the service Providers.

Passive Optical Network (PON) consist of an Optical Line Terminal (OLT) Located at the central office (CO) and a set of associated Optical Network Terminal (ONT) located at the customer premises. Between them lies the Optical Distribution Network (ODN) comprised of Fibers and passive Splitters or Couplers.

In a PON a single Fiber runs from CO up to a common point. and then Individual Fiber strands to each building. this allow the the expensive Fiber Cable to be shared among many customer, means dramatically reducing The overall Cost of deployments of Fiber to the business (FTTB) or Fiber toThe Home (FTTH) applications.

With PON,a single Fiber from CO can serve 16,32,64 or more Customers A PON will have less optical reach than PTP Network which does not used Splitters.Typically a PON is capable of reaching subscribers 20 km from the OLT through the use of both passive devices to split the optical signal and

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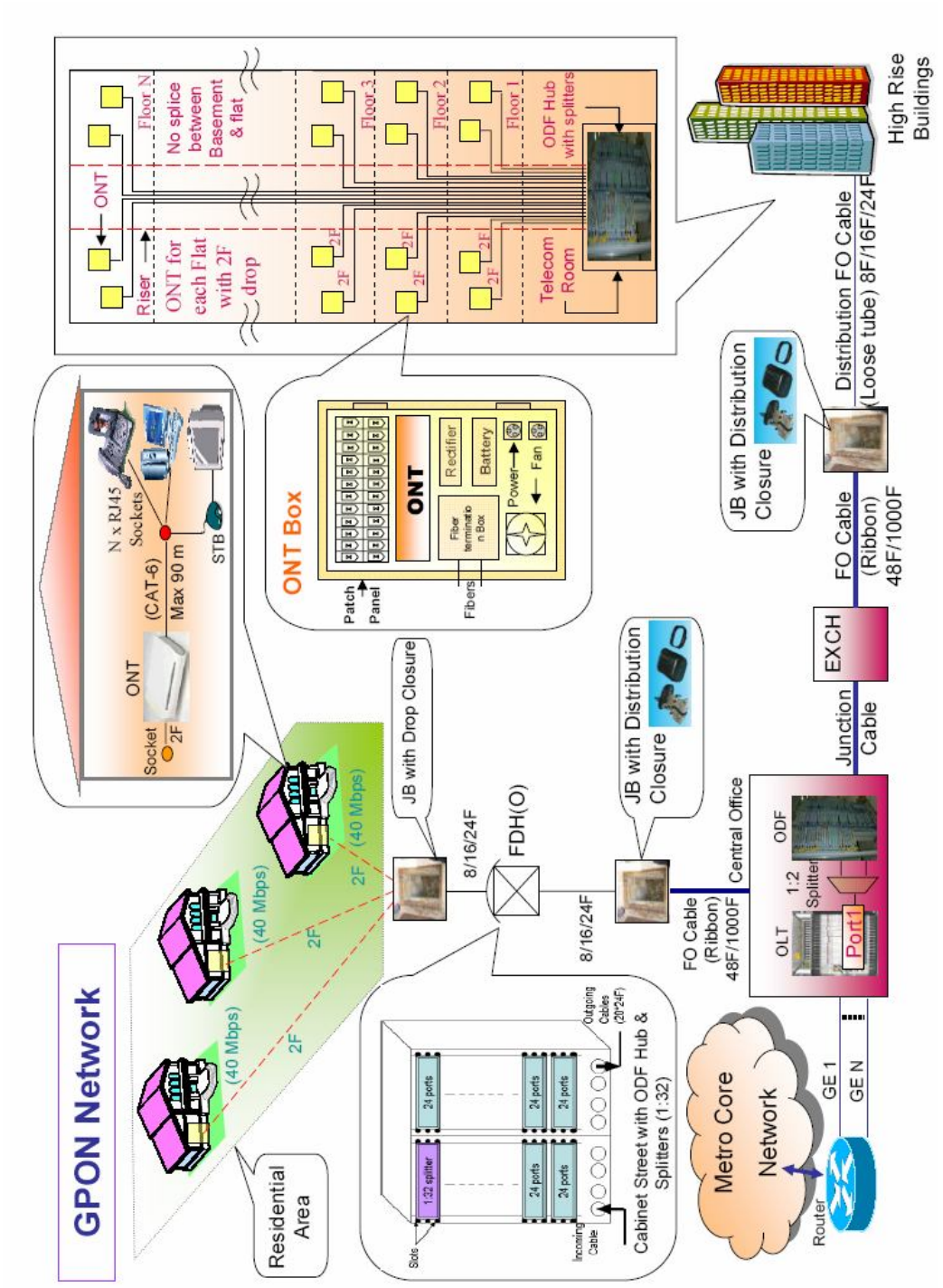

GPON Network
Residential Area
(40 Mbps)
2F
JB with Drop Closure
8/16/24F
FDH(O)
JB with Distribution Closure
Cabinet Street with ODF Hub & Splitters (1:32)
Outgoing Cables (20*24F)
Incoming Cable
24 ports
1:32 splitter
Slots
8/16/24F
FO Cable (Ribbon) 48F/1000F
Central Office
OLT
1:2 Splitter
ODF
Port1
Junction Cable
EXCH
FO Cable (Ribbon) 48F/1000F
Distribution FO Cable (Loose tube) 8F/16F/24F
JB with Distribution Closure
High Rise Buildings
Metro Core Network
GE 1
GE N
Router
ONT Box
ONT
Rectifier
Battery
Power
Fan
Fiber terminato n Box
Patch Panel
Fibers
N x RJ45 Sockets
(CAT-6)
Max 90 m
STB
ONT
Socket
2F
ONT
Riser
ONT for each Flat with 2F drop
Floor N
No splice between Basement & flat
Floor 3
Floor 2
Floor 1
ODF Hub with splitters
Telecom Room

Figure -2

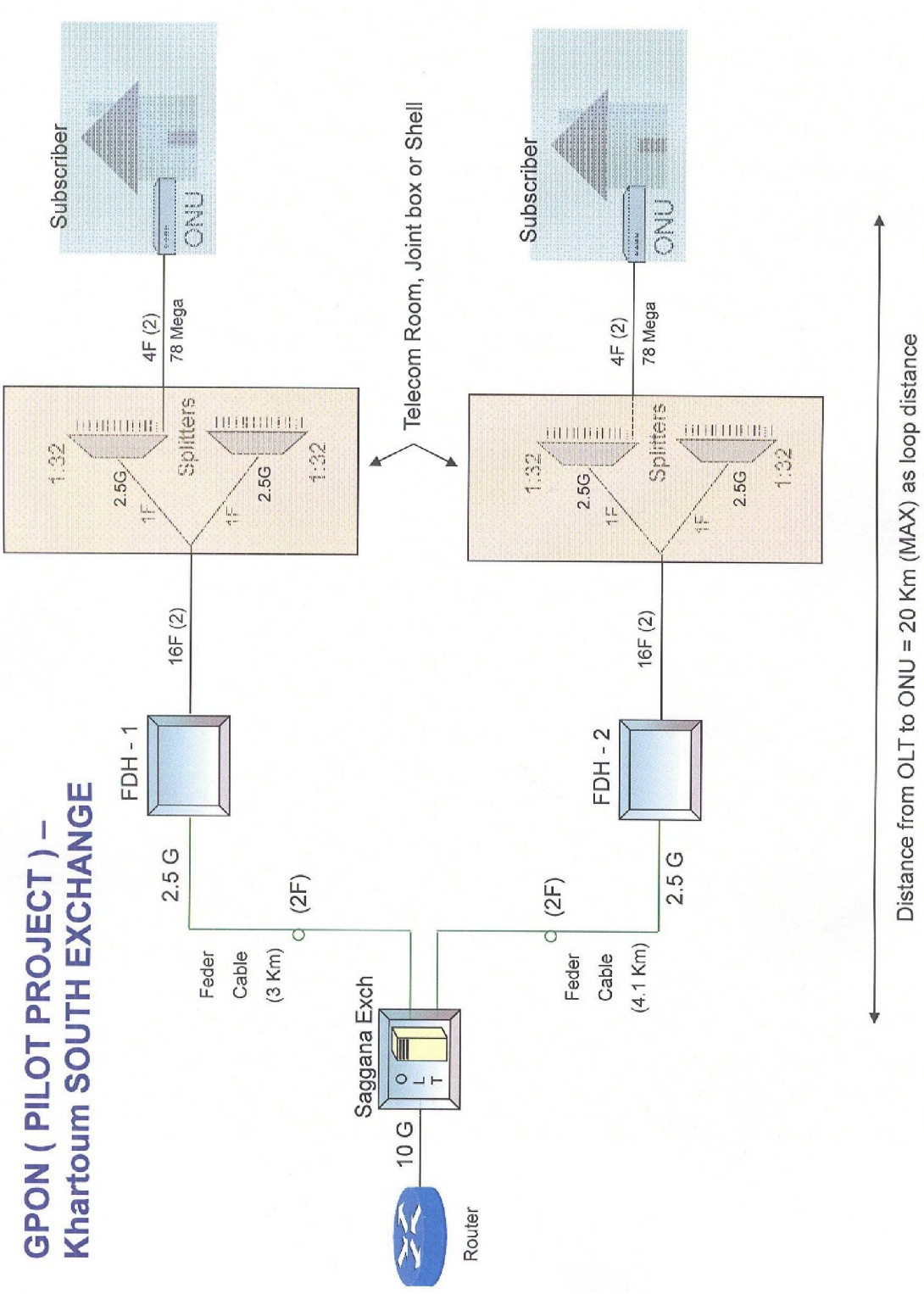

GPON (PILOT PROJECT) –
Khartoum SOUTH EXCHANGE
Subscriber
ONU
4F (2)
78 Mega
Telecom Room, Joint box or Shell
1:32
2.5G
1F
Splitters
16F (2)
FDH - 1
FDH - 2
2.5 G
(2F)
Feder
Cable
(3 Km)
(4.1 Km)
Saggana Exch
O
L
T
10 G
Router
Distance from OLT to ONU = 20 Km (MAX) as loop distance

Figure -3

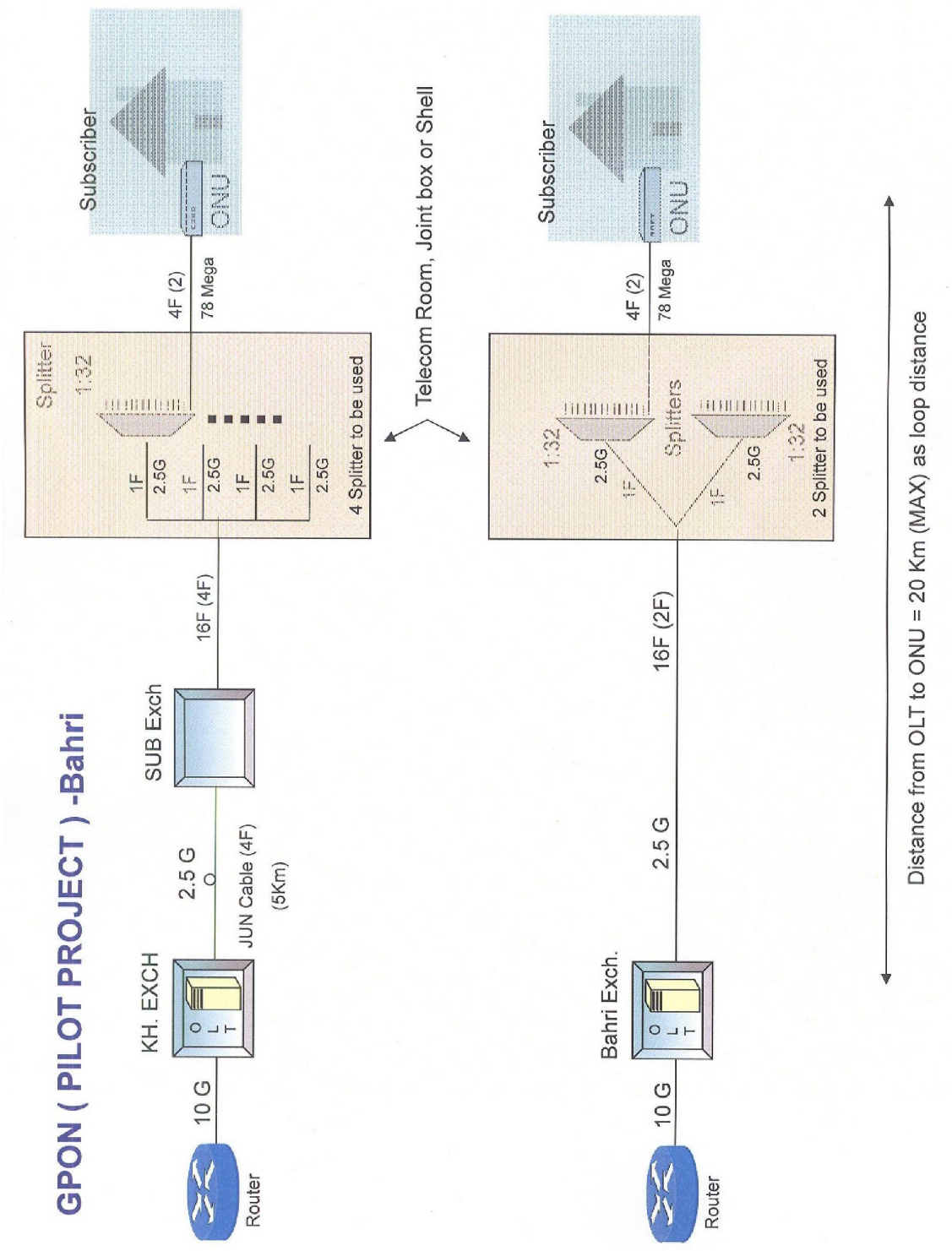

GPON (PILOT PROJECT) -Bahri
KH. EXCH
O L T
10 G
Router
2.5 G
O
JUN Cable (4F)
(5Km)
SUB Exch
16F (4F)
Splitter
1:32
1F
2.5G
4 Splitter to be used
4F (2)
78 Mega
ONU
Subscriber
Telecom Room, Joint box or Shell
Bahri Exch.
2.5 G
16F (2F)
1:32
Splitters
2 Splitter to be used
Distance from OLT to ONU = 20 Km (MAX) as loop distance

Figure -3A

PON Protocols to control the transmission of signals across the shared Access facility. the initial capability of delivery of the network shall be 40 Mbps, with1:2 splitters in the C.O (central office) and 1:32/2:32 at the Remote.

2.3 GPON Architecture: Network deployment & distribution architecture Should enable us to provide any single service to the customer from Our portfolio or 2-play / 3-play service bundles to the customers

2.4 The following criteria's have been considered in the development of

3.3 OSP Design of Planning Guidelines

- Scalable network
- Deployment of technically matured products
- Economical component prices
- Reduction in CAPEX and OPEX
- Ease to install, maintain and operate
- Quick to restore the service
- Minimum splice to extend reach
- Design FO network within 28 dB loss budget, end to end
- Centralized splitters
- Preconnectorised splitters
- Splitter ratio 1:2 in CO and 1:32/2:32 in remote
- Induction of 2F drop cables in Indoor and Outdoor

• SC/APC Connectivity

• Express SC/APC connectors drop cables

• Use of existing cabinet and or locations as splitter cabinet

• Ideally placed in High density area

• The proposed Central Office building shall be (new, or recently Build i.e. not marked for demolishing, space should be available For the ODF).

• Duct space availability

• Aim to serve 15 Km cable distance.

• FO Junction route/cable availability

• No Overlapping: OLTs to be considered for all Exchanges, avoiding Overlaps of serving areas, as much as possible.

The two directions for Optical transmission in the DON are identified as Follows:

Downstream direction for signal travelling from the OLT to the ONT(s).

Upstream direction for signal travelling from ONT(s) to the OLT.

Transmission in downstram and Upstream directions takes place on the Same Fiber and same components.

Two main DON topologies being used today:

3.4Types of Splitters

Centralised Splitters:

In a centralized architecture,the splitters are all located with FDH location Generally used More Future proof because it uses direct fiber link from the primary Felexbility point to the customers normally for high rise building.

Distributed Splitters:

In a distributed architecture, the splitters are distributed in multiple points
In a Cascading fashion.normally recommended for villas & houses
In either centralized or distributed cases,however using a higher split ratio
(i.e., 1:64) provide significant CAPEX saving in the outside plant as well as
In CO components and passive connectivity.an extra split(i.e.,1:64 vs 1:32)
Can reduce feeder plant cost and CO components and passive connectivity
Cost by 50%

Optical Passive Splitter:

Multiples of Optical Splitter (1:2) are proposed to installed in a Single stand alone 1U Uni Rack module, placed in the Central Office, simplifies the future upgrade and is scalable, for higher Bandwidth delivery.

Typical insertion loss is (3.6) dB (max). Insertion loss Uniformity is 0.6 dB.

The size is about 3.6 mm dia X 48 mm long.

To increase the bandwidth from (40 Mbps) to (80 Mbps), the (1:2) Splitter in the CO shall be bypassed and connected to OLT-port Direct.

Optical Splitter (1:32) is a standalone I U Uni Rack unit. With all ports Pre connected. These can be installed in an Indoor ODF (in the Telecom room of the high rise building or in the outdoor Cabinet To serve villas & small buildings. These are suitable for installation In the standard 19" rack.

Typical insertion loss is (17.2) dB.

Insertion loss uniformity is (1.7) dB. The size is about 7L X 6W X60H mm.

The Optical Splitter (2:32) is now available. The loss today is17.5 dB.

Definition of high rise buildings is a structure, where direct fiber Enters to the buildings, i.e. splitter inside the building.

In the residential area, villas types, Optical Splitter (1:32/2:32) Uni Rack unit is recommended to be placed in Outdoor Cabinet, nearer To Customers, to minimize the length of the distribution cables, to Simplify the construction process and to save expense. Please refer (Refer to the below figure -5 next page).

• **Splitter type: 1:32.**

Figure -5

3.5 GPON Structure

How to distribute the Fiber into differenet type of buildings Below figure shows the distribution in the high rise building From 6 storey and above

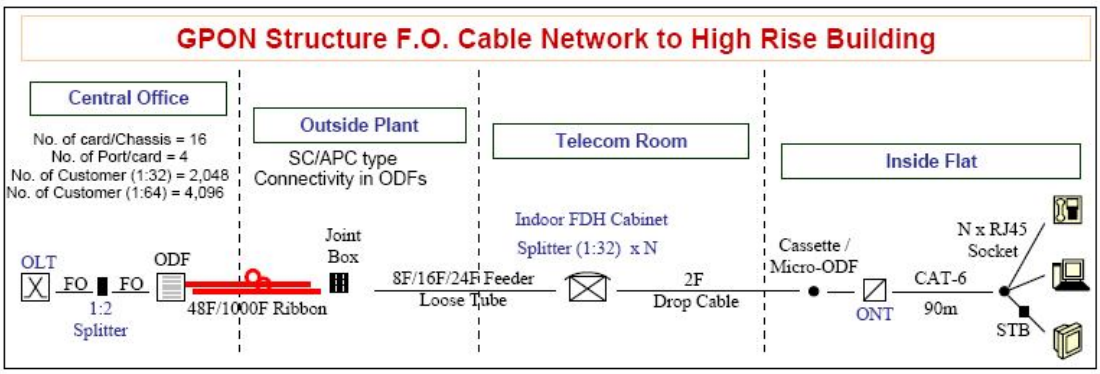
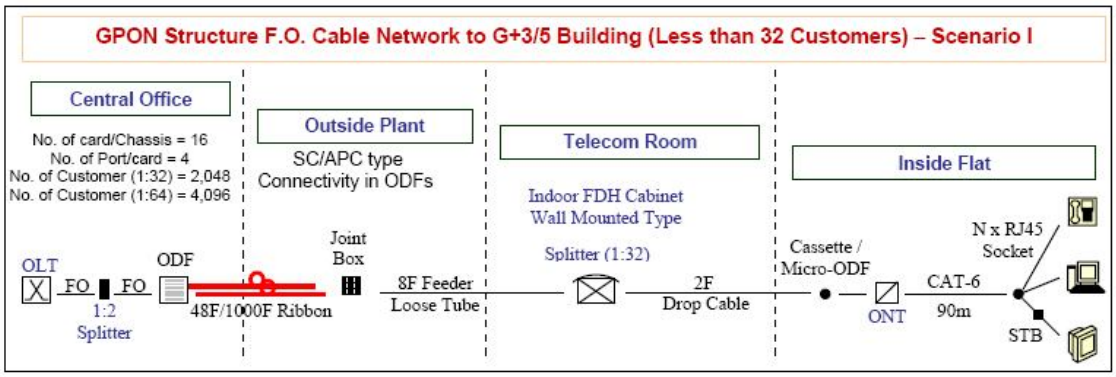


Figure -6

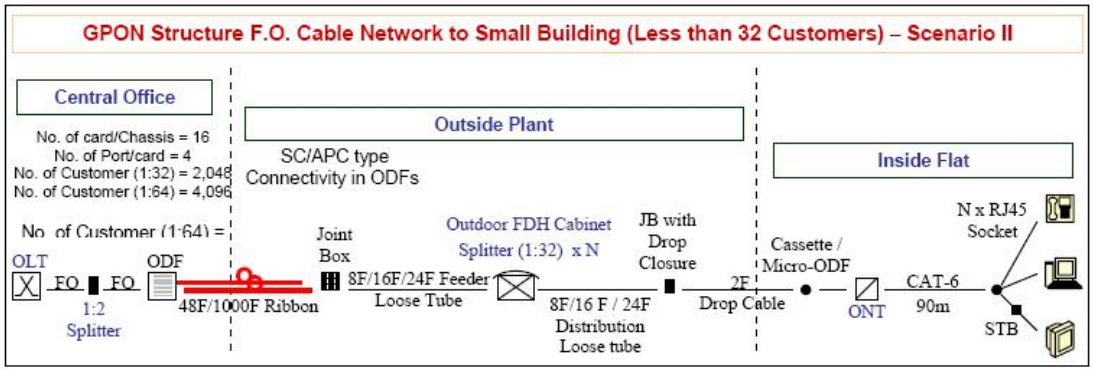
For up to G+3 / 5 storey buildings (Scenario I), a Wall mounted Splitter unit is suitable for in-buildings installation, where the number Of tenants are less than 32 customers. The unit has a splice tray for The incoming UG cable, a 1:32 pre connected Splitter ports, and Provision to terminate 32 Drop cables. This also has SC/APC Connectivity. (Refer fig. shown below).

Figure -6A



For small buildings where the numbers of tenants are less than 32 customers, these may be served from an Outdoor FDH/Cabinet

Figure -6B



The formula to arrive at the total No of splitter required per cabinet Area = 5th year tenancy forecast divided by 32, however Fiber Cables to be planned based on 20th year forecast, than 5th Year forecast.

Advantage of Centralized Splitters

- OLT efficiency
- Network testing and maintenance ability
- Splitter signal loss minimization
- Flexibility
- Protection
- Minimizing the number of splitters

3.6 Diversity Route :

Diversity means to provide services using a different route, it is a Policy to provide diversity on customer specific and cost basis.

Diversity is recommended to :

- Exchanges exceeding a certain number of lines
- Exchanges exceeding a certain number of 2 MB links and above
- Links that serve a number of exchanges
- Important / strategic Customers
- Whenever it can be achieved in the network, cost effectively.

Diversity is essential for Airport, Sea port, Defense, Police, Hospital Corporate… etc the fiber can be routed in two Different routes on Rechargibile basis .The OLT is typically at the CO but can be sited in a Remote location. The double input splitters to be considered as and When available to plan as a single ring topology, where diversity is Required, for ease in design, construction, maintenance and operation, Instead of ring & sub rings.

3.7 FDH (Fiber Distribution Hub)

The feeder cable section from OLT to splitter can be protected by Using (2:32) splitter and OLT port and feeder fiber should be Doubled, leaving the shorter cable section (distribution cable from Splitter to ONT) in star form and unprotected. The spare fibers

Available in the Junction Cable Network to be utilized to connect, OLTs in one exchange area and ONTs in the other Exchanges.

The duct network shall be considerably reduced and the Corresponding joint box / manholes can also be reduced, as the Number of FO cables that would be installed shall be far less than The legacy copper network Accordingly, the ducts shall be reduced to maximum 2W - D54 and Smaller Joint Boxes to be build. Large sizes of J/Boxes and manholes To be considered, only if the same cannot be avoided.

As far as possible the joints in the main cable, may not be planned to Be operated frequently to divert or put through fibers. The main joint Closures have 4 in ports and 4 out ports, which can be used for Multiple dropping of distribution Cables (up to 24F) The loose tube joint closures are suitable up to 24F loose tube Fibers These have 2 entries on either side, total 4 entries.

The drop closures are recommended to be installed inside joint Boxes, close to group of villas or as per site requirements. These Have single entry on one side and 24+ outlets for drop cables.

Regions shall propose the joint location for maximum utilization of full Outdoor - Fiber Distribution HUB (FDH) (refer to Fig-7 & Fig8) The outdoor Fiber Distribution Hub (FDH) provides for connections Between Fiber Cables and passive optical splitters in the OSP Environment.

The (FDH) utilize standard SC/APC to interconnect feeder and Distribution cables via 1:32 optical splitters and connectors.

The (FDH) is placed strategically in the FTTH network to facilitate Service connection specified for a particular fiber serving area.

These (FDHs) provide environmental and mechanical protection for Cables, splices, connectors and passive optical splitters.

The FDH(O) capacity and requirements are attached in the fig.

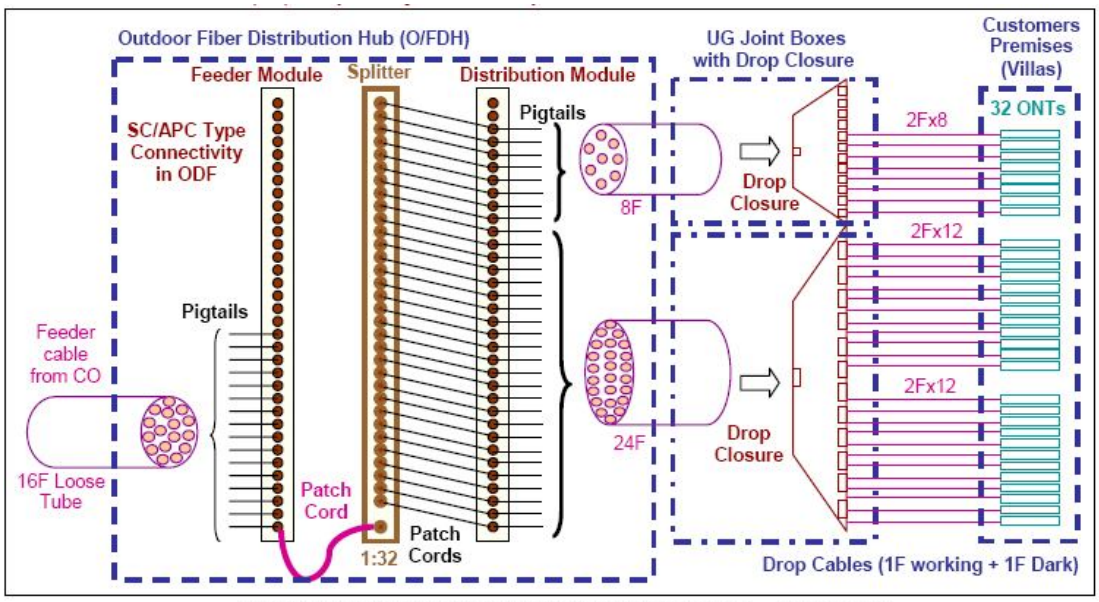


Fig-7 (Outdoor FDH & Cable Distribution - Example)

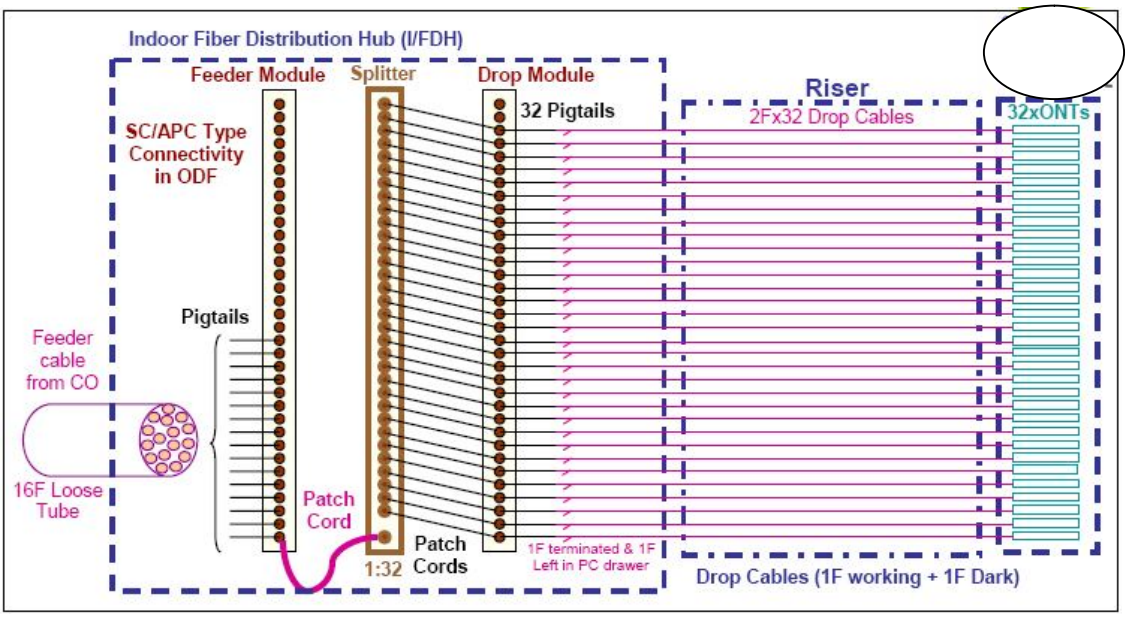
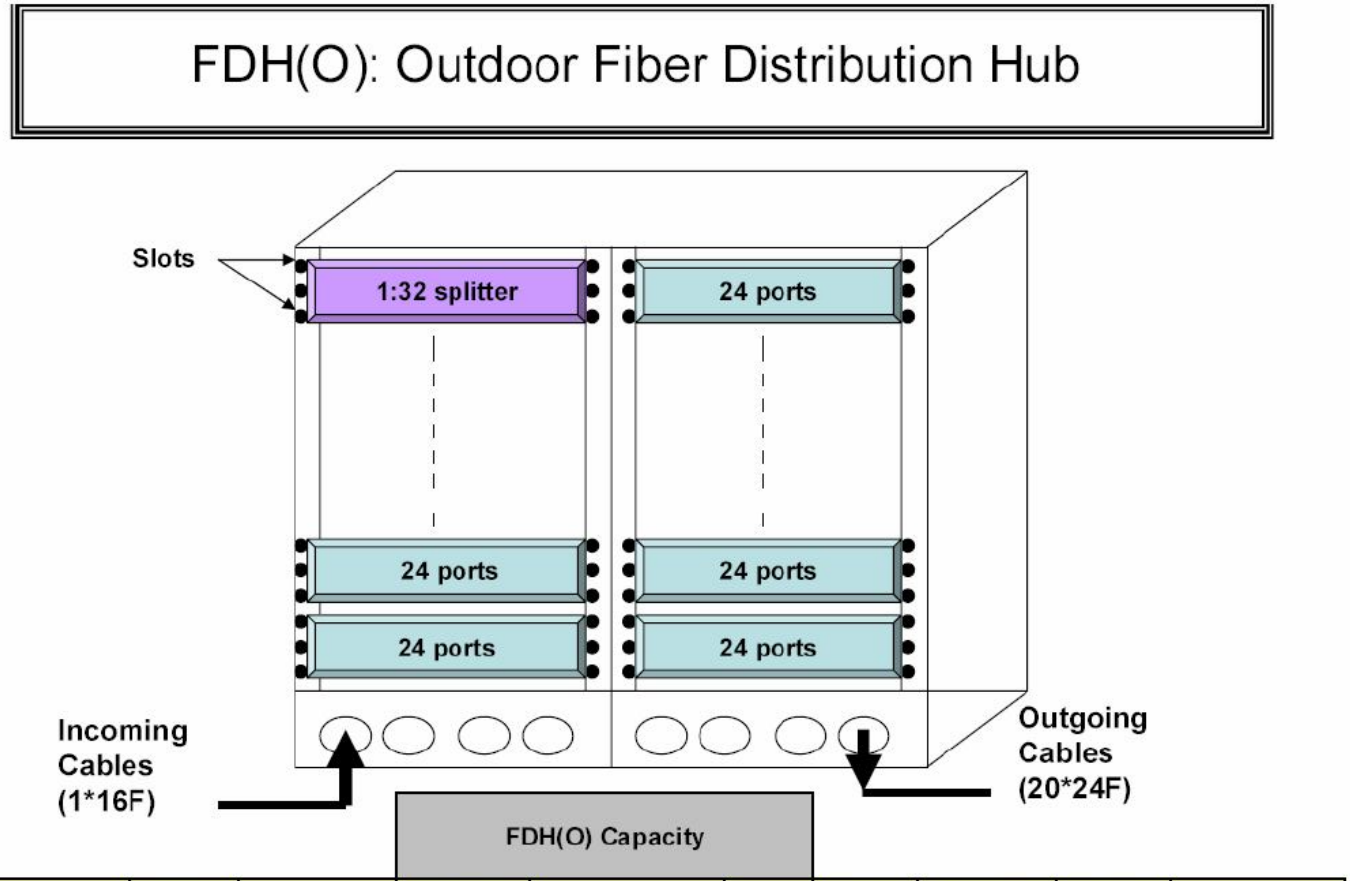


Fig – 8 (Indoor FDH & Cable Distribution –Example)

Figure –9



FDH(O) Capacity

No of slots		Slots per Unirack	No of Unirack		No of ports per Unirack	No of splitter ports per Unirack	In cable	Out (DIST) Cables	Tot No of 1:32 splitters	No of PC Drawers	Total Capacity
L side	R side	3 slots	L side	R side	24 Ports	1+32=33 Ports	1*8F 1*16F 1*24F	20*24F	15	2 if required	15 * 32 = 480 Homepasses
59	59		19	19							
Tot: 118			Tot: 38								

3.8 Choosing the Right Fiber

Fiber used can have a significant impact on network performance affecting Factors such as loop length and required link loss budget and future Bandwidth Growth. Standard PON systems are designed based on Single-Mode Fiber Optimized for 1310-nm transmission and use the ITU-T G.652 Specifications.the attenuation for most wavelength is generally around 0.35 dB/Km to 0.25 dB/Km.

3.9 Choosing the Right Fiber Cable

Along with the type of fiber.the network design must also consider the type The Fiber Cable to be used .depending on the type of deployment (e.g.,aerial,buried, into duct) and the network segment (e.g.,feeder,distribution,drop)many options needed to be considered for Optimal design.for example, Cables can be armored to provide Additional rodent protection and crush resistance in direct –burried Applications. Cables laid into duct should be loose tube fiber or ribbon Cables. while aerial Cable can be self-supporting or lashed to a While aerial Cable can be self-supporting or lashed to a messenger wire.

3.10 Scenarios for Selecting the OLT Location

1) Utilize the existing AN cable (if available) to serve any new Site by Deploying the FDH within the CO old boundary.

2) Extend the CO AN outside the old boundary to serve existing Copper/Fiber Cabinet / FDH in another exchange area.

3) Change over to be considered by utilizing the existing junction Cable, to be jointed at Zero Manhole of the exchange (Without any ODF Termination) within the Exchange boundary.

4) Serve any new sites by utilizing the junction cable passing From the zero manhole to the adjacent area and where Required by laying additional fiber optic cable to the FDH Outside the exchange boundary.

5) Utilize the junction Cables wherever possible to serve any new Area near the Central Office (as indicated in figure -4 next page)

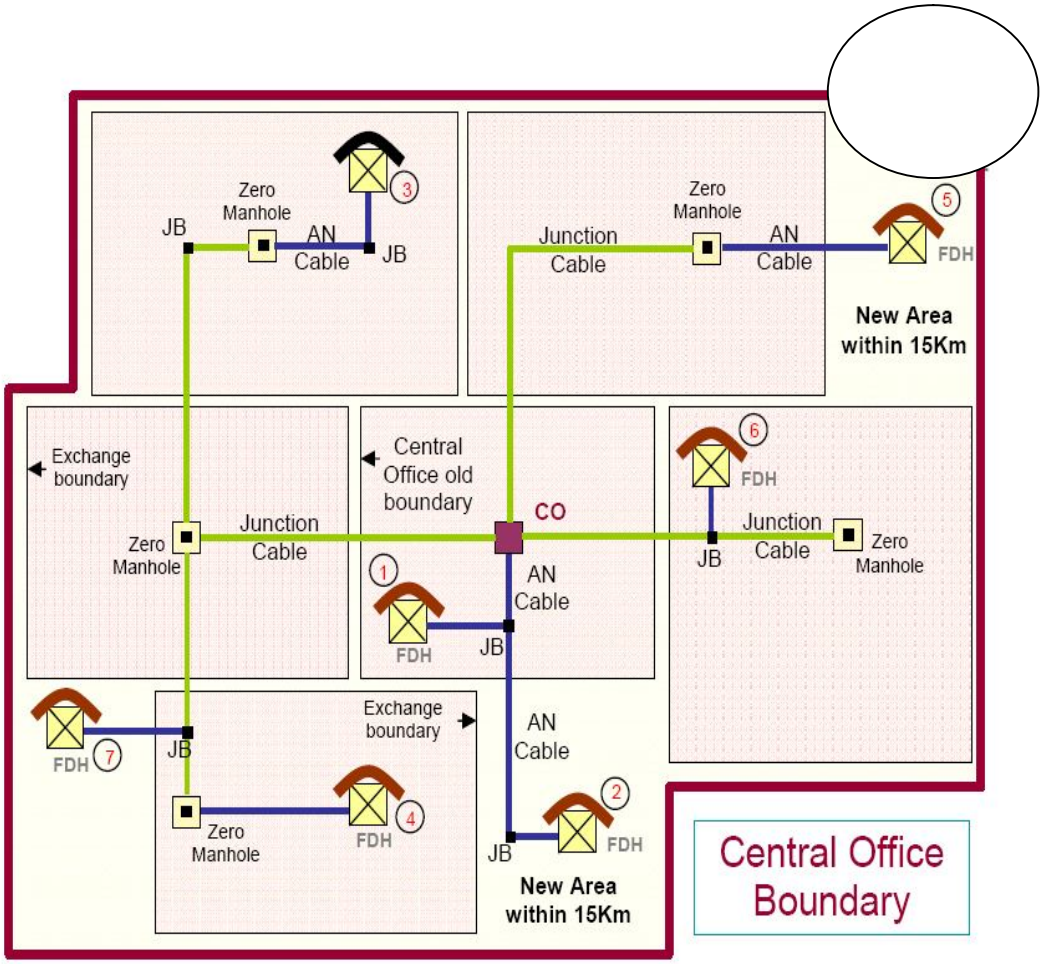


Fig-4 (Central Office Location-Example)

3.11 Fiber To The Home (FTTH)

The FTTH is simply the 100% deployment of the optical in the Access Network. It is commonly deployed in two specific configurations, as Shown below and in the next page

* Point-To Point. (PTP) Network – Fiber is dedicated to each user in the Access Network (refer to the below figure)

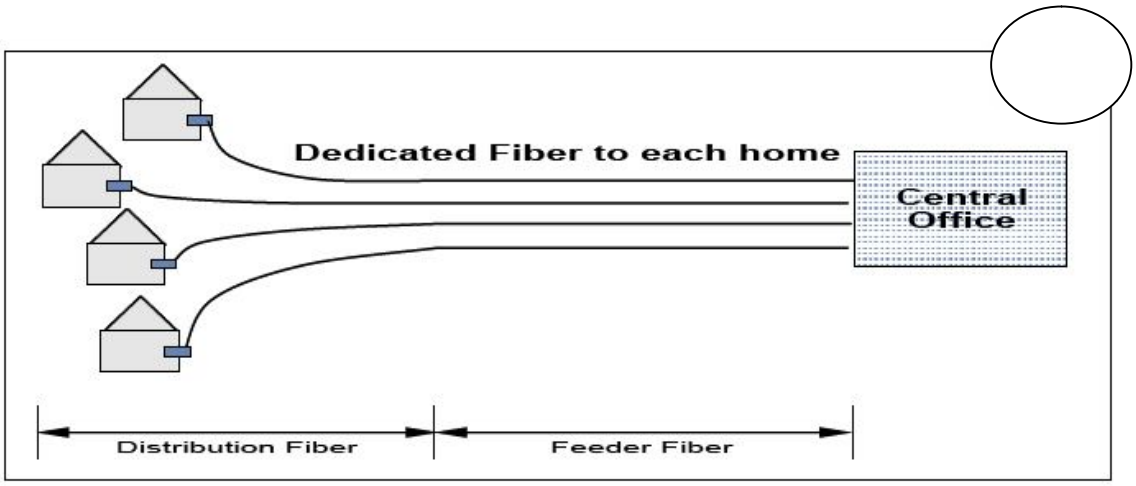


Figure -10

- Passive Optical Network (PON)- a single Fiber is shared (via splitter) Among number of users, typically thirty-two

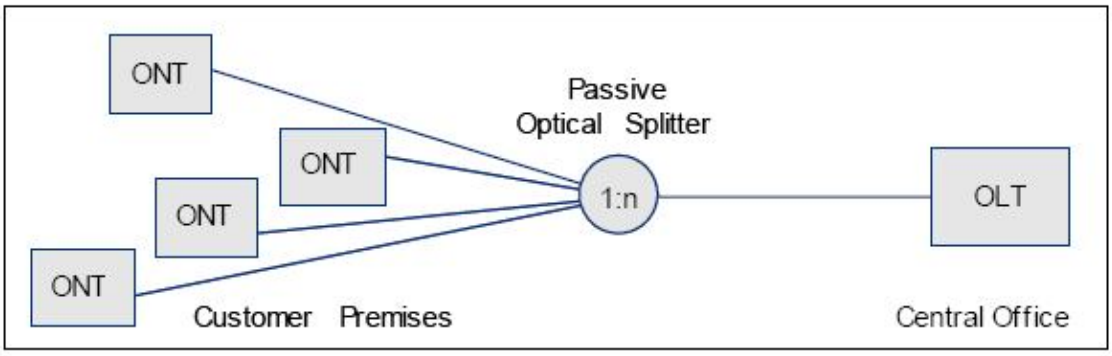


Figure -11

Overview of FTTH Outside Plant (OSP) Components A wide array of Outside Plant components are used to build FTTH Networks. all FTTH networks inherently are designed to deliver an Optical fiber to the subscriber. However, their design is highly Dependent on the unique nature of the access environment, so Product and design flexibility is critical.

As a medium, optical fiber‘s bandwidth is only limited by the transmitters of the OLT and hence future-proofs the Access Network because of its tremendous bandwidth capacity.

In short, at the core, FTTH Networks contain an Optical Line Terminal (OLT) Optical Cable and Optical Network Terminal (ONT). The OLT is normally Located in the (CO),but can also be sited in a remote Location.

The OLT houses the laser Transmitters dedicated to each user in PTP Network or shared across several users in a PON.

The OLT is also aggregation point for Voice, Data, and Video Networks.

The Optical Fiber carries the signal to the users; it is divided into three Sections:

Main Cable (terminated at the CO), distribution Cable which is (fanning out across the Access Network & connected to the main Cable), Drop Fiber (connected to Distribution Cable and to the customer premises Equipment CPE's).

The ONT receives the signal from the OLT and converts into usable Electronics Signal for the users,Telephone, Computer,TV,or other Devices.

PTP networks are characterized by the use of one fiber and laser per user.

A dedicated fiber is terminated at the subscriber and active devices at the Central Office (CO) for a Telecommunications provider.

PONs are characterized by the "splitting"of the same optical fiber along the Way, resulting in the sharing of the optical fiber among multiple users The fiber in a PON is designed to share between 2 to 128 users, depending Upon the availability of splitters.

A PON will have less optical reach than a PTP network, which does not use Splitters. Typically a PON is capable of reaching subscribers 20 kilometers From the OLT, this will cover most of the population.

GPON supports ATM, Ethernet and WDM using a superset multi-protocol Layer.

GPON provides support for ATM, Ethernet and WDM protocols The important characteristics of each PON technology are defined by two Important standards bodies, the IEEE and the ITU.

3.12 Advantages of FTTH

It is usually a passive network, so there are no active components from The CO to the end user. This dramatically minimize the maintenance cost As well as eliminating the need of a DC power network.

FTTH is a single fiber to the end user, providing revenue –generating Services including voice, high-speed data analog or digital CATV and Video on demand.

- FTTH features local battery backup and low power consumption
- FTTH is reliable, scalable and secure.
- FTTH network is future –proof architecture
- Furthermore, because fiber-optic technology is not influenced by Electrical Interferers such as cross-talk between copper pairs or Radio bands , it ensures high-quality of telecommunications services In the present and future. In addition, fiber does not exhibit radio Frequency (RF) emission that can interfere with other services.

  Easy and fast implementation of new services.

  Allocation of bandwidth on demand.

  Easy and fast adaptation to the large changes in the Telecom field.

3.13 ISP Design for FTTH

There are mainly two types of FTTH architecture custom-tailored for each Building these architectures are:

1)Direct Home-Run Architecture, In this case all F.O drop cables are laid from FDH/Splitter to the customer Premises and terminated in micro ODF(rosette) it is required more riser Space since individual drop cables will originate from the main telephone Room to the customer passing all floors where sub-telephone rooms are Located based on customer location

2)Multi-core Riser Architecture , Where a separate riser system is being Introduced to connect the Customer from FDH, A floor distribution box FDB is installed in each Floor To link link customer with FDH in the main Telephone room.

3.14 Fiber Optic Cable Laying

Following to be considered:

1) Roll Cable Drums in the direction indicated by the arrow shown on the Drum.

2) For long term storage of reels , it is advisable not to expose the reel to Direct sunlight or moisture.

3) Drum must not be laid flat for installation or storage.

4) When lifting the reel from above with a crane or other lifting device a bar Must be used to prevent the reel from damage.

5) Physical inspection to be carried out prior to the Cable laying at the site.

6) Frequent inspection of Cable drums to be done at warehouses where Rodent and termite attacks for the Cable are expected.

7) Periodic monitoring of Cable condition and quick reporting to the Damage Cable drum, also OTDR testing to the Cable reels found to be Damage.

8) Details records of warehoused Cable drums to be kept in a different Locations.

9) Health Safety and Environment (HSE) policy is widely taking care of A pre-survey of the route for all types of installations is strongly Recommended. problem areas should be identified, prior to start Installation.

10) Plan to be clearly defined for Duct systems, use of inner duct (sub duct) Which will provide additional Physical protection for the Cable as well as Optimal use of main Duct space and an individual low friction path for Each Cable.

11) All Ducts should be inspected before Cable installation, damage to be repaired and blockages to be cleared.

12) Use figure 8's for back feed pulling or other situation where removal of The Cable from the drum is needed. The size of figure 8 should be Marked with cones or other suitable devices. The figure 8 should be At least 5 meter long with each loop at leaset minimum 2 meter Dameter.

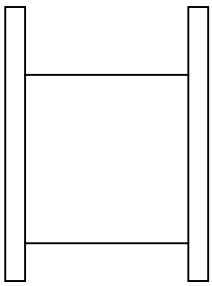
13) Petrol (gasoline) must not be used as a Cable cleaner for any type of F.O Cables.

14) Cable end to be sealed in order to prevent ingress of moisture. Installation of long F.O Cable is expected because the Cable is light And Selender. means number of pull through manholes which reduce The number of splice joint. which will cause reduction of splice loss Need to store access Cable length at the jointing manholes No more than 4 Cables of greater than 25mm diameter in one bore No more than 2 Main Underground cables in any bore No Local and Junction or Trunk cables in the same bore.

15) Use of warning tape is recommended

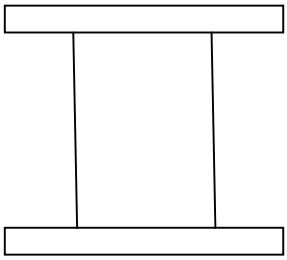
16) Cable drum must not be laid flat for installation or storage (refer to the next page)

Figure - 12



OK

Figure – 12A



Not Acceptable

3.15 Maximum Pulling Tension (MPT)

All F.O Cables have a rated maximum tension that is typically based on Cable specifications. The MPT is clearly shown on the Cable specification Sheet issued by Cable manufacture.

During installation, the tension applied to the cable MUST be monitored Wth a calibrated load cell or Tensiometer .once the Cable tension Reaches 90% of MPT, The installation must stop to troubleshoot the reason Pulling tension does not exceed the MPT rating, otherwise damage to the Cable performance may result.

3.16 Minimum Bend Radius (MBR)

Most of F.O Cables have the following minimum bend radius. Specific MBR IS normally shown on Cable specification sheet.

MBR = 20 times the Cable diameter at the maximum pulling tension.

MBR = 10 times the Cable diameter at no tension.

It is absolutely vital to maintain the minimum bend radius of the Cable at all Times to avoid the damage of the Cable components including the Optical Fibers.

3.17 Splicing

Fusion splice is done by aligning ,melting and pushing together two fibers, Usually with an electrical arc.

Resulting a minimum optical loss (0.1 dB) and has the advantages of Low loss, high strength, low back reflection (optical return loss), Long term reliability.

Low splice loss and high return loss is very dependent on the quality of the Cleave on.

Both fiber being spliced. Cleaving is done by using a sharp blade.In order To get a good fusion splices Both fiber ends need to be close to perpendicular to the fiber axis.Then When the fibers are fused, they will weld together properly.

Splicing to be done in a proper way to provide the optimum performance & Reliability .

There are two methods of splicing:

Mechanical method & fusion method

1) Mechanical splice method.

2) Fusion splice method.

3.18 Duct Space Records (DSR)

DSRs to be updated with the new information whenever & wherever new Cable is being laid,DSR shows a big difference between Copper Cables And F.O Cables:

1)Section number

2)Duct plan number

3) Exchange name

4) From J/Box to J/Box (J/Boxes numbers)

5) Center to Center distance (between J/Boxes)

6)Duct formation (drawing – 4w ,6w 9w , …...)

7)Way number (which Duct Bore)

8)Cable code (main , distribution , junction ,….)

9)Allocation (F.O , local , junction ,…)

10)Size and type of Cable (20 pr , 100pr, 1200pr, 12 F , 24F).

11)Diameter in MM

12)Year in (when laid)

Duct Separation to be 25mm both horizontally and vertically.

A mathematical method has been found which allow for congestion in the

Duct in order to apply that you must find:

1.1 The Cabling space for empty Duct (Duct space).

1.2 The space used by existing Cables.

1.3 The space left for the proposed Cables.

1.4 Size of the new Cables.

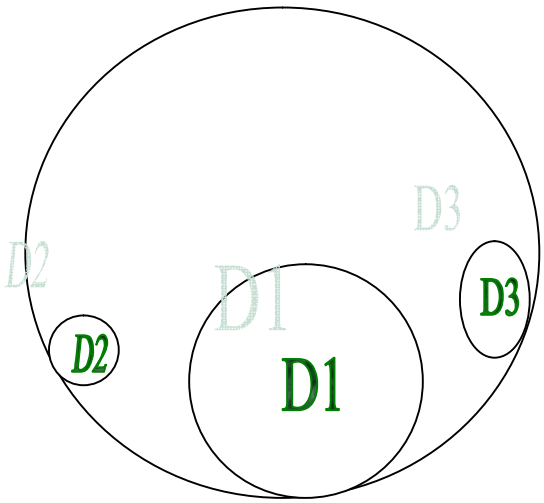
Space left = Duct space – Diameter of existing Cables

DUCT SPACE	S
SPACE USED	D
SPACE LEFT	S-D

For two (or more) Cables, Diameter D1 and D2 , will not necessarily use (D1+D2) amount of space in the Duct.

A) If the sum of the diameter of all the smaller existing Cables is less than Half the diameter of the largest existing Cable, then ignore all the Smaller Cables. As shown below

Figure -13



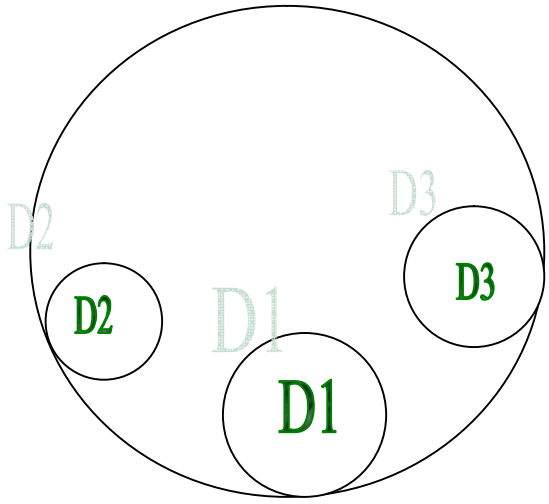
Because the smaller Cables will settle down beside the large one and Have no affect upon the space used.

A) If the sum of the diameter of all the smaller Cables is equal to, or Greater than half the diameter of the largest Cable, then all the Cables Must be considered.

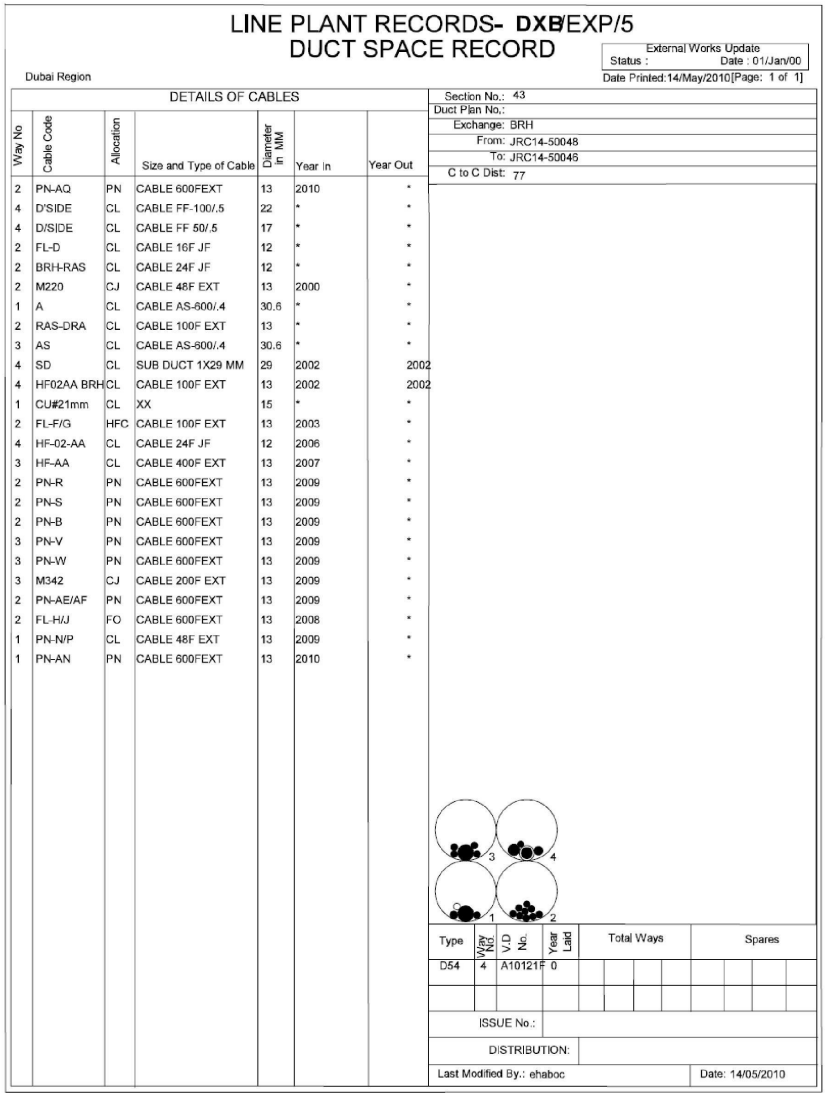
For two Cables diameter D1 and D2, will not necessarily use (D1+D2) Amount of space in the Duct, they will lie side by side, and only use (D1+D2) X 0.7 amount of space, so our table becomes:

DUCT SPACE	S
SPACE USED	(D1+D2+…….) 0.7
SPACE LEFT	S-(D1+D2+……) 0.7

Figure -13A



After Project execution by External Works staff, as built DSR to be Forwarded to Drawing Office staff in order to update the same in the Data Base. Next time if you add a certain Cable to the one of the bore And the Cable diameter is bigger than available space, then system will Reject unless you mark another bore.



LINE PLANT RECORDS- DXB/EXP/5
DUCT SPACE RECORD

External Works Update
Status : Date : 01/Jan/00
Date Printed:14/May/2010[Page: 1 of 1]

Dubai Region

DETAILS OF CABLES

Way No	Cable Code	Allocation	Size and Type of Cable	Diameter in MM	Year In	Year Out
2	PN-AQ	PN	CABLE 600FEXT	13	2010	*
4	D'SIDE	CL	CABLE FF-100/.5	22	*	*
4	D/SIDE	CL	CABLE FF 50/.5	17	*	*
2	FL-D	CL	CABLE 16F JF	12	*	*
2	BRH-RAS	CL	CABLE 24F JF	12	*	*
2	M220	CJ	CABLE 48F EXT	13	2000	*
1	A	CL	CABLE AS-600/.4	30.6	*	*
2	RAS-DRA	CL	CABLE 100F EXT	13	*	*
3	AS	CL	CABLE AS-600/.4	30.6	*	*
4	SD	CL	SUB DUCT 1X29 MM	29	2002	2002
4	HF02AA BRH	CL	CABLE 100F EXT	13	2002	2002
1	CU#21mm	CL	XX	15	*	*
2	FL-F/G	HFC	CABLE 100F EXT	13	2003	*
4	HF-02-AA	CL	CABLE 24F JF	12	2006	*
3	HF-AA	CL	CABLE 400F EXT	13	2007	*
2	PN-R	PN	CABLE 600FEXT	13	2009	*
2	PN-S	PN	CABLE 600FEXT	13	2009	*
2	PN-B	PN	CABLE 600FEXT	13	2009	*
3	PN-V	PN	CABLE 600FEXT	13	2009	*
3	PN-W	PN	CABLE 600FEXT	13	2009	*
3	M342	CJ	CABLE 200F EXT	13	2009	*
2	PN-AE/AF	PN	CABLE 600FEXT	13	2009	*
2	FL-H/J	FO	CABLE 600FEXT	13	2008	*
1	PN-N/P	CL	CABLE 48F EXT	13	2009	*
1	PN-AN	PN	CABLE 600FEXT	13	2010	*

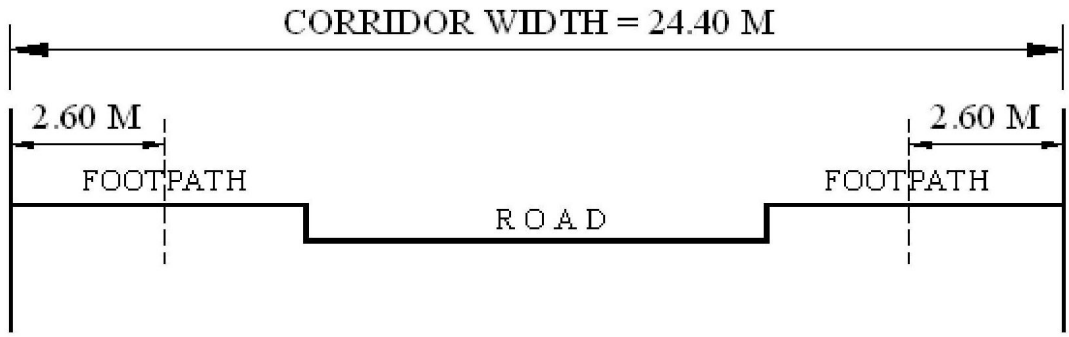
Section No.: 43
Duct Plan No.:
Exchange: BRH
From: JRC14-50048
To: JRC14-50046
C to C Dist: 77

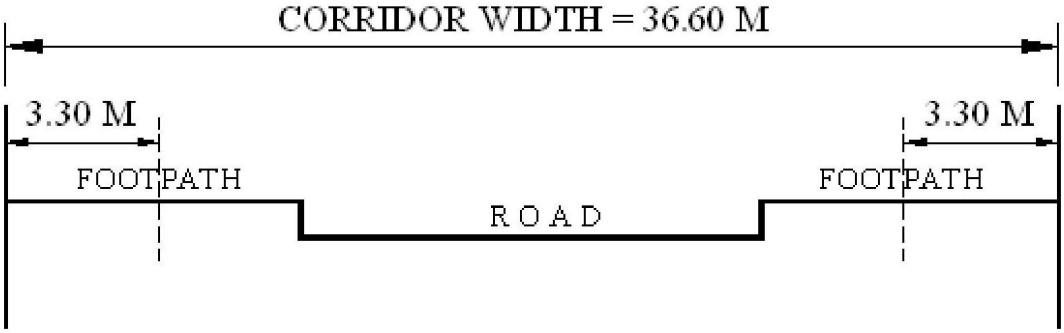
Type	Way Nos	V.D No.	Year Laid	Total Ways	Spares
D54	4	A10121F	0		

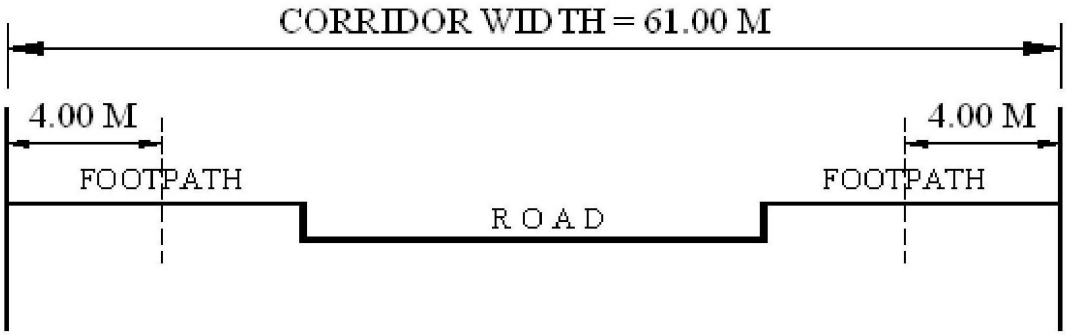
ISSUE No.:
DISTRIBUTION:
Last Modified By.: ehaboc
Date: 14/05/2010

DUCT SPACE RECORDS (DSR)

RIGHT OF WAY (ROW)







The above example shows differenet ROW (Corridor) based on distance From building line to building line and the footbath from building line to the Edge of the road which is to be shared between all services, Telecom, Electricity, water, drainage, gas.

Chapter Four

4.1 Fiber Transmission

Transmission in downstram and upstream directions takes place on the Same Fiber and same components.

Signal operates on different wavelengths for upstream and downstream Directions.

Downstream direction for signal travelling from the OLT to the ONT(s).

Upstream direction for signal travelling from ONT(s) to the OLT.

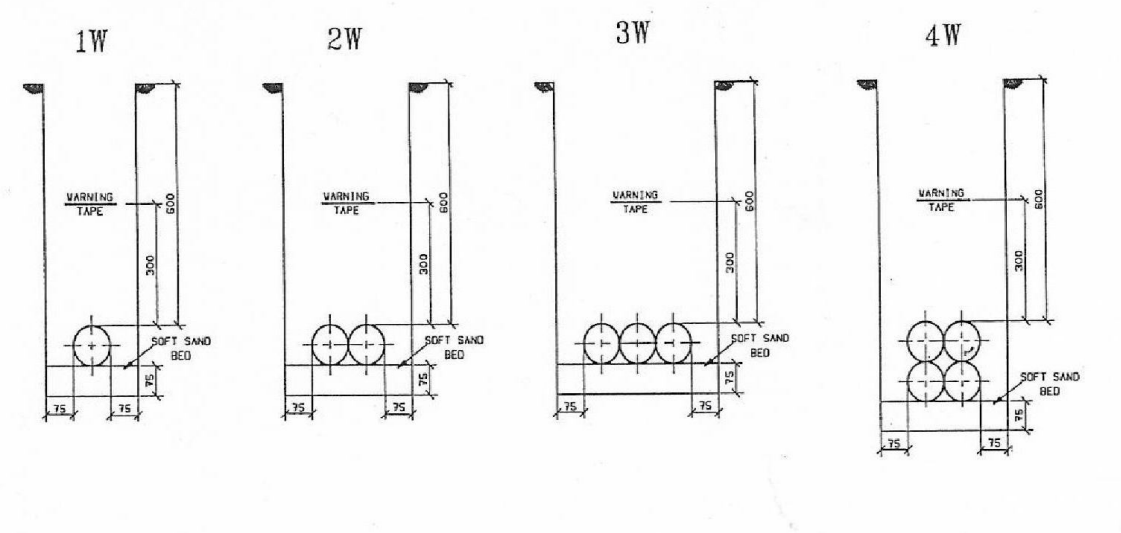
GPON supports Triple-play services,providing competitive all sevice Solution, also supports high-bandwidth transmission to break down the Bandwidth bottleneck of the access over twisted pair for Copper Cable Which will provide 4MB bandwidth as maximum.

By using Fiber and GPON technology we can deliver a high bandwidth to Serve IPTV and live TV broadcasts and high –speed Internet from ONT Component .

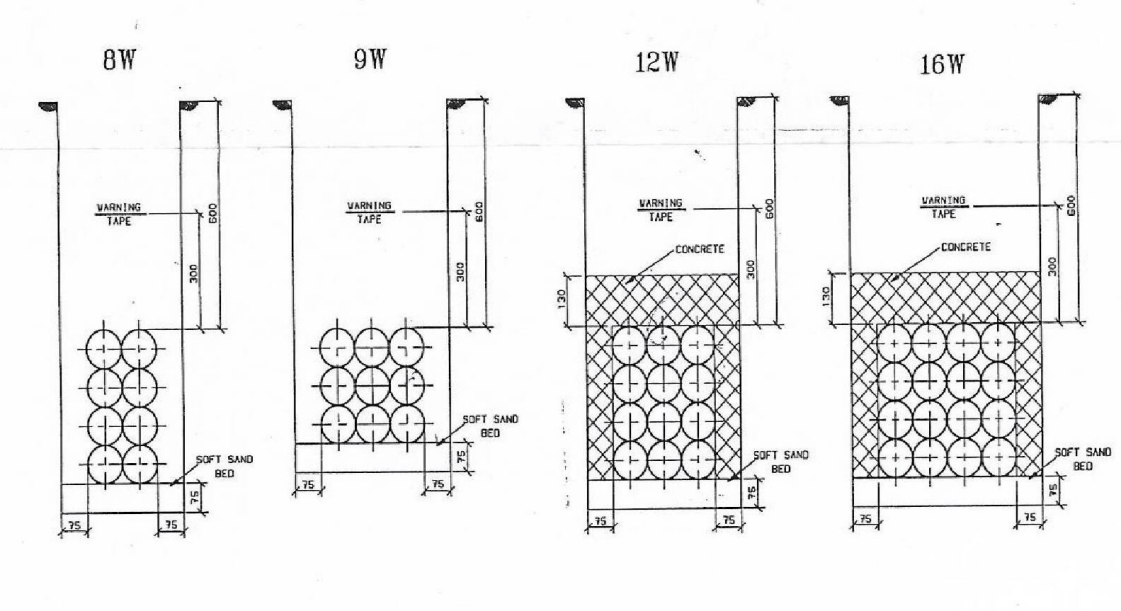
Also it is easy to enhance and upgrade, hence it will reduce the CAPEX and OPEX as there is no active components between the C.O and the end user Means power consumption is less and can serve up to 20km distance Minmum number of splice and provide scalable and manageable Network.

4.2 Manholes and Duct Space Comparison

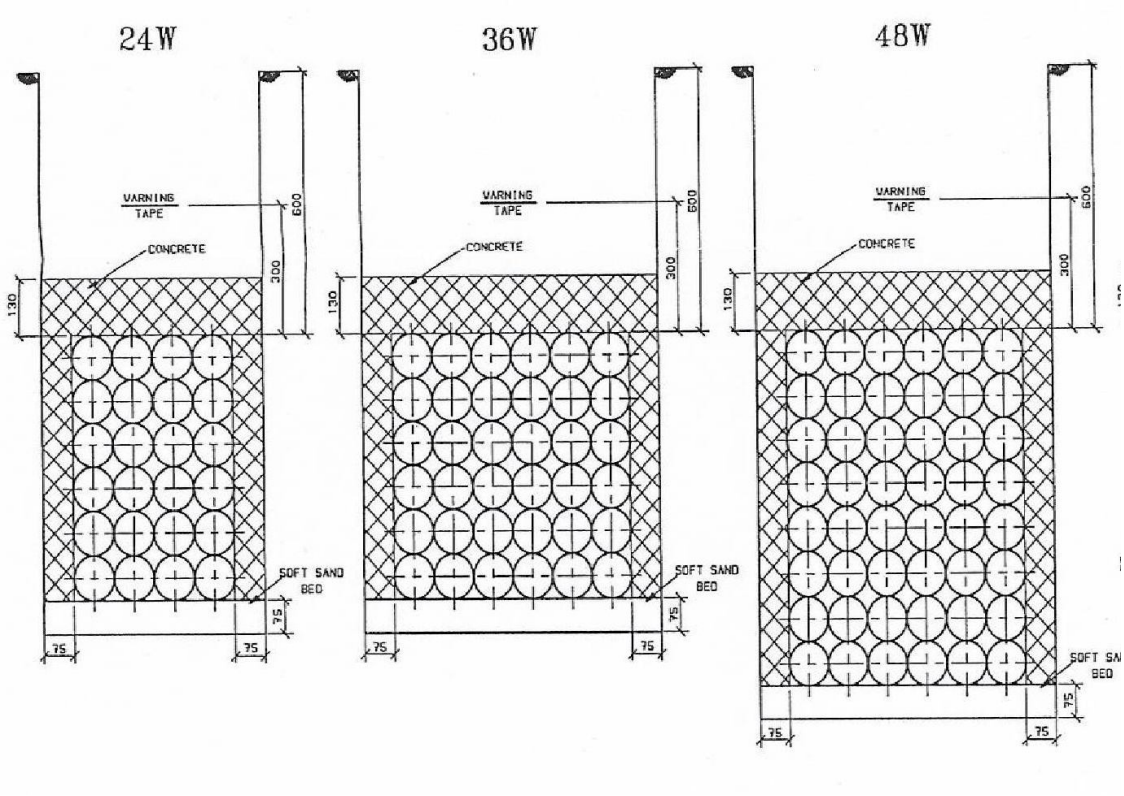
Maximum number of Duct Bore is 4W accordingly Manhole size will be Smaller which will reduce the cost of the Civil by more than 45%



While the cost of Civil for the Copper Network is very high due to the large Number of Duct and bigger size of Manhole



Also Fiber Network will accommodate small space in the dedicated corridor While the Copper one required a large space in the same.



4.3 Fiber & Copper Cable Size,Dimeter and Weight Comparison

Below Table shows the Copper Cable Size,Dimeter and Weight

Size	Diameter (mm)	Weight (kg/km)
100/0.5	23.6	600
200/0.5	30.7	1100
300/0.5	37.0	1700
400/0.5	42.7	2200
600/0.5	50.0	3200
800/0.5	56.6	4200
1000/0.5	63.0	5300
1200/0.5	68.8	6300

Below Table shows the F.O Cable Size,Dimeter and Weight

Size	Diameter (mm)	Weight (Kg/Km)
4 - 24	12	120
48	13	160
72 - 100	14	180
200	19	330
300	23	420
400 - 600	24	560

4.4 Attenuation & Loop Resistance Comparison

Below table shows the Attenuation and Loop resistance for Copper Cable:

Conductor Diameter	Attenuation dB /Km	Loop Resistance Ohms/Km	Max.Length Meeting 8dB Limit Km
0.32 mm	2.8	450	2.86
0.4mm	2.3	280	3.48
0.5mm	1.8	180	4.44
0.63mm	1.5	115	5.33
0.9mm	1.0	55	8.00
Drop wire No. 4	1.5	120	-
Drop wire No. 5	1.8	225	-

Below details shows the Electrical and Mechanical characteristics of Fiber Cable which is completely electrical isolation:

Fiber cable standards according to ITU-T G.652, Single-mode

Modified diameter:…….8.6 μm

Cladding diameter:……125 ± 0.1 μm

Cable size:……..3.1 X 2.9 mm

Cable weight:…….8 Kg/Km

Tensile strength:…… Not exceeding 80 N

Bending radius:……Not exceed 20 mm

Wavelength:…… 1310 nm …...max. 0.4 dB/Km

…… … …… 1550 nm .....max. 0.3 dB/Km

ATTENUATION ON FIBER (dB)				
Location	Wavelength 1260- 1650 nm			Remarks
		Type	Loss dB Max	
Exchange	1	Splitter 1:2	3.6	
	2	OLT Connector Loss	0.4	
	3	ODF Connector Loss	0.4	
OSP	4	Splice Loss /splice	0.01	
	5	Cable Loss / km	0.35	
	6	Splitter 2:8	10.5	
	7	Splitter 1:32	17.2	Not being Ordered Any More
CAB/Bldg	8	Splitter 2:32	17.5	
	9	ODF Connector Loss	0.4	
Sub Premises	10	Drop cable loss / km	0.35	
	11	Fast Connector Loss	0.4	
	12	ONT Connector Loss	0.4	

Table-6

- The loss allowance has the same value both in the downstream and upstream direction.

Example: Residential, Business & Mobile Scenario:

If Residential 20th year tenants F/C = 180 & the Business 20th year tenants F/C = 28 Mobile sites = 3, then The FO cable to feed the FDH will be calculated as follows:

- For Residential $= \frac{180}{32} = 6\text{F}$
- For Business + Mobile : $\frac{(28+3)}{(31)} = (1+1)\text{F}$; for Main & *Diversity*
- Total Actual Requirements: $\text{X} = (7+1)\text{F} = 8\text{F}$
- With 25% : $\text{Y} = [\text{X} + (\text{X} \times 25\%)]$

  = 8 + 2 = 10 = 16F (After rounding to the nearest cable size)

4.5 Fiber and Copper

Comparison	Fiber Cable	Copper Cable
Bandwidth	High	Low
Attenuation	Low	High
Speed	High	Low
Distance	Long	Short
Security	High	Low
Immunity and reliability	Immune & Reliable	Non-immune & Non-reliable
Field termination	Easy	Difficult
Migration	Easy	Difficult
Weight	Light	Heavy
RF Affects	Not Affected	Affected
Duct Space	Small	Large
Manholes	Small	Large
Life Time	Long	Short
Maintenance	Less	More
Cost	Low	High
Revenue	High	Low

Access Link Distance

Reference distance of customer from Exchange/POP location is shown below based on the type of Network configuration.

Network Configuration	From	To	Access Link Type	Distance	Pro SLA Redundancy Remarks
Fiber/Copper-based Network	POP Location/ Exchange	MSAN/ IPNGDLC Cabinet	Fiber	≤30 km	Route diversity shall be from Exchange up to MSAN Cabinet location only. However, customer shall be migrated to GPON, if available.
	MSAN/ IPNGDLC Cabinet	Customer Equipment	Copper	≤1.5 km	
GPON (with 1:2 splitter at POP & 2:32 splitter at FDH)	POP Location/ Exchange	Customer ONT	Fiber	≤12.5 km	
GPON (bypassing 1:2 splitter at POP. With 1:32 splitter at FDH)	POP Location/ Exchange	Customer ONT	Fiber	≤20 km	
GPON (bypassing 1:2 splitter at POP. With 1:8 splitter at FDH)	POP Location/ Exchange	Customer ONT	Fiber	≤35 km	
Dark Fiber (GE)	POP Location/ Exchange	Customer	Fiber	≤120 km	
Dark Fiber (10GE)	POP Location/ Exchange	Customer	Fiber	≤40 km	
Dark Fiber (FE 10/100)	POP Location/ Exchange	Customer	Fiber	≤25 km	

Chapter Five

5.1 Conclusion

The main objectives of this study is to maintain a proper flexible Network to control and manage data transmission over ACCESS NETWORK, with integrated effort of associated sections to make easy

And fast implementation of new services and bandwidth allocation on Demand.

Easy and fast adaptation to large changes and traffic pattern. with More sophisticated technology and more intelligent control, and to Design a simple network with minimum maintenance and operational cost.

Noise isolation, greater security, manageability, flexibility and affordability

5.2 Recommendations

To achieve the previous said objectives Following to be implemented carefully:

1) Collect, review and analyze the forecast information's

2) Prepare CWP. (Capital work program) budget for both primary And secondary network with optimum design and easy for Execution.

3) Specify and implement a method to update periodically the Information's in a DATA BASE.

4)Live link method for work flow for discussion and easy changes.

5)Proper scheduling for changeover and bifurcation.

6)Collect all no objection certificates (NOCs) from local authority And prepare design with estimated cost for the materials and Labor charges .

7)Determine the Locations of OLTs, FDHs , ONTs and fix the boundaries.

8)Consider the type ,size and numbers of manholes and Joint Boxes and Number and formation of P.V.C duct.

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((تم بعون الله وتوفيقه))