Network and Complex Systems
ISSN 2224-610X (Paper) ISSN 2225-0603 (Online)
Vol.5, No.5, 2015
www.iiste.org

A Model for Estimating Network Infrastructure Costs: A Case for All-Fibre Networks

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Abstract
The 21st century is an era that has been characterised by phenomenal growth in data rates at the local area network (intranet), extranet and the Internet, a trend pushed by deployment of “bandwidth hungry” applications such VoIP, security surveillance systems, video conferencing and streaming of online multimedia content. Due to demand placed on network resources by these applications physical layer cabling solutions have had to evolve to support faster, improved LAN technologies such as Gigabit Ethernet. Although new network architectures (such as Centralised Fibre networks) address current and long term demands of the modern networking environment, concerns have been raised about its cost viability. The key problem identified in this study was an inadequacy of suitable tools that aid decision making when estimating the cost of a network infrastructure project. Factors of importance in this regard were collected in a survey and used in development of a cost model. A network was designed based on two architectures – centralised fibre (all-fibre network) and hierarchical star (UTP for horizontal cabling and optical fibre for backbone cabling). Thereafter, cost of implementing these two architectures was calculated using the model. Based on the results computed from the cost model, the all-fibre network (centralised fibre architecture) was found to be more cost effective than the hierarchical star network.
Keywords: centralised fibre architecture, hierarchical star architecture, structured cabling, multimode optical fibre, singlemode optical fibre, backbone

Introduction
“Optical fibre revolution…”– that is the phrase that perhaps best captures the growing prominence of the fibre optic media in various aspects of present day communication. Nearly everywhere you turn today in the sphere of telecommunications, you will no doubt come across footprints of fibre optic communications. Its preference for data communication has been as a result of its near limitless capability, low attenuation and immunity from electromagnetic interference (EMI). Though for a long time regarded as an expensive cabling solution, gradually declining costs of cable and associated equipment has spurred interest in various application areas. Examples of areas where application has been popular include international submarine cabling, “last mile” broadband connectivity and vertical cabling in enterprise networks.

A fibre optic cable is made up of very thin strands of a glass material which are then enclosed within a strong jacket to protect the cable from the elements. In fact due to the nature of environments the cable is used, such indoors or outdoors (e.g. buried in trenches or under the sea), the outer jacket protection of the cable varies. Fibre strands are made from a special type of pure glass and carries digital information more commonly over long distances (Freudenrich, 2001). See Figure 1

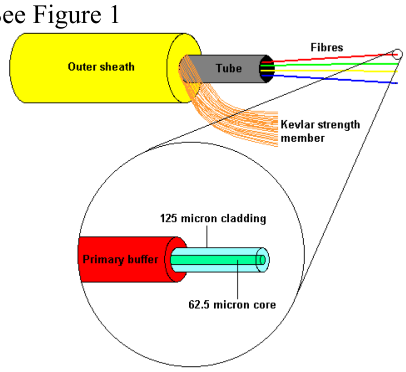


Figure 1: Fibre Optic Cable (Patrick, 2012)

Generally there are two main types of optical fibres, single mode and multimode fibre (Freudenrich, 2001). The core used in a single mode cable is smaller (3.5 x 10-4 inches or 9 microns in diameter) than that of multimode. It has low attenuation features and run for up to 2 kilometres without the need to use repeaters. Multimode fibre has larger cores (2.5 x 10-3 inches or 62.5 microns in diameter) and is common in local area environments where it is run for 300 metres before the need arises to use intermediary devices or optical amplifiers. While single mode carries a single signal emitted from a laser light source, multimode carries multiple signals often emitted from LEDs (Dell, 2006). Some optical fibres can be made from plastic. They have a larger cores (0.04 inches or 1 mm in diameter and transmit visible red light (wavelength = 650 nm) from light emitting diodes.

Perhaps the biggest factor that has preceded fibre optic revolution has been the exponential growth in data rates both on private and public networks. Data rates, said to double every year, have exploded courtesy of networks that are increasing in both size and bandwidth requirements (Haile-Mariam & Stammely, 1998). In 2004 for instance, global Internet traffic – data transferred between networks over the Internet – exceeded 1 exabyte for the first time. In 2007, it was over 5 exabytes. In 2010, this transfer stood at 21 exabytes and it is estimated to grow to 56 exabytes by the year 2013, according to technology firm Cisco Systems (Miller, 2010). And according to a newspaper article, it is estimated that by 2007 video-sharing site YouTube – the third most visited site - alone consumed bandwidth with as much capacity as the entire Internet in 2000 (Carter, 2008). On the local area networking front, deployment of "bandwidth-hungry" applications – such security surveillance systems, voice over IP, video conferencing and other multimedia applications – has pushed upwards data transfer rates.

In keeping up with increased performance and bandwidth requirements, focus has shifted to the physical layer cabling solutions that make all this possible: copper and fibre optic media. Whereas copper remains dominant in LANs, optical fibre largely remains in the realm of backbone connections or "last mile" connectivity. This research analysed prospects of using of a fibre optic media as an alternative for UTP copper, in particular by exploring the cost implications of all fibre architectures vis-à-vis hybrid UTP copper/fibre optic architectures.

The objectives of the research were:

- To establish factors that influence selection of cabling infrastructure.
- To determine cost factors related to LAN cabling infrastructure.
- To review existing models on LAN infrastructure costs.
- To develop a model comparing costs of centralised fibre and hierarchical star network architectures.
- To test validity of the cost model.

Fibre vs. Copper: Battle for the Cabling Systems Market

A standard feature of any local area network (LAN) is its structured cabling system. Rosenberg (2000) describes a structured cabling system as the "complete system of cabling and associated hardware which provides a comprehensive telecommunications infrastructure." Dell (2006) elaborates that it is the cabling "that is embedded within a building and connects network devices around the building together." The cabling itself is typically enclosed within cable ducts in a building's ceiling space and walls, and may span multiple floors.

The structured cabling system is composed of a number of subsystems. The first section is the work area. This is the area where user devices - such as computers, network printers, VoIP phones, security cameras among others - are located, and these devices connect to the wiring system via patch cords which link to wall-mounted telecomm outlets. The second subsection is the horizontal cabling, which runs from the work areas to the telecommunication room (TR). It is usually mounted on cable ducts or raceways that run along the floor's wall.

Horizontal cabling leads to the TR (or wiring closet). This is the central wiring point for equipment and user devices in each building floor. However, extensive work area sections may have multiple TRs and depending on the area served, it may be a large cabinet or even an entire room. Horizontal cabling then leads to the vertical (or backbone) cabling section. This section typically has high-bandwidth cable links (usually multimode fibre) since they carry the bulk of traffic within a network.

Backbone cabling converges in the main equipment room or the main cross connect (MCC). The features of the MCC are similar to that of TR, except in size since it acts as the main equipment room and may have devices or equipment only present in that facility. The last subsection is the demarcation point. This is the point at which equipment from the service provider ends and equipment at the customer's premises begins.

Structured cabling design and installation is governed by a set of standards that specify guidelines for various sub-elements such as those described in the previous segment including issues on type of cabling (e.g. Cat 5e, Cat 6) and modular connectors. The most popular standard is the TIA/EIA standard (Dickman, 2002). Primarily the standard provides guidelines on how to lay out the cabling in topologies in line with customer requirements. Additionally the standard will contain guidelines on various media (wired or wireless), connector types and types of topology (Barratt, 2009).

Copper has remained the dominant media of choice since the advent of local area networking since the early 1980s. And although it has faced an onslaught on its supremacy in LANs, especially in the face of the growing popularity of optical fibre media and wireless technologies, opinion is divided among industry experts on whether it will still remain king of structured cabling. Considering that factors such as cost effectiveness, ease of implementation, and progress in bandwidth potential keep realigning, supremacy battles between optical fibre and UTP copper may be far from over.

Given the relation between bandwidth potential and network media, interest in wireless or wired transmission alternatives has been on the rise. Historically, choosing between fibre optic and UTP copper was a choice between performance (fibre optic) and cost (UTP copper). The cost and performance disparities between the two media types were significantly high (Curtis, 2000). Recently however, this has been changing; on one side trends have constantly showed a downward trend in the price of all fibre network equipment while on the other, new specifications of twisted-pair cabling are supporting much faster data rates including capacities exceeding 1,000 Mbps. Currently there are a selection of both UTP copper and optical fibre media providing capacity for a variety of bandwidth requirements.

Prices of fibre optic components have traditionally been very expensive. About a decade ago for instance, a 24 port optical fibre switch (100Base-FX) cost nearly five times as much as a similar 24 port UTP copper switch (100Base-TX). To many users the "perceived minor advantage in fibre's performance was completely overshadowed by its prohibitive costs" (Curtis, 2000). But one of the issues (other can equipment and cabling costs) that made fibre networks expensive, was the erroneous assumption that these networks ought to follow a similar physical layout to that of copper infrastructures. There exists a variety of physical topologies that are specifically ideal to fibre optic infrastructures, which considerably lowers the cost of all fibre architectures. Other benefits of optical fibre are as summarised in Table 1.

Table 2: Benefits of Fibre Optic Cable

Advantages of Optical Fibre Media
• Less expensive – Fibre cable costs much less than copper for the same transmission capacity. (Dutton, 1998). Consequently, cost benefits of providing services such as cable TV and Internet services may likewise be passed on by service providers to their clients. (Freudenrich, 2001).
• Small size and weight – Optical fibres are much smaller than copper cables, contributing to their compactness, flexibility including being lightweight. In addition, they have better advantages than copper with regard to "storage, handling, installation and transportation (Arumugam, 2001).
• Higher information transmission capacity – Information carrying capacity, commonly defined in terms of bandwidth, is "directly proportional to the carrier frequency of the transmitted signals" (Arumugam, 2001). Optical frequency is more extensive in fibre than conventional communication systems. Besides, using multiplexing technology transmission capacity can be extended to virtually unlimited potential (Dutton, 1998).
• Less signal degradation – "The loss of signal in optical fibre is less than in copper wire" (Freudenrich, 2001). Attenuation describes the transmission phenomena where strength of a signal propagated degrades over time. This has implications on how long a cable run can be done without the need for repeaters or amplifiers, which are used to regenerate the signal. The standard length for a cable run (without the need for amplifiers) is 300 metres for multimode fibre compared to 90 metres cable run for copper-based UTP media.
• No electromagnetic interference – In a building fibre optic cables can be placed even where electrical cables would have problems, such as near equipment with large mortars, or heavy duty electrical devices. That is because electromagnetic interference from these sources has no effect on fibre cabling (Dutton, 1998).
• Digital signals – Optical fibres are "ideally suited for carrying digital information", an issue which is very helpful in telecommunications and computer networking technologies (Freudenrich, 2001).
• Better security – In an era where network infrastructure supports mission-critical operations, security of information resources in transit in networking systems is very vital. "The transmitted information through the fibre does not radiate" and hence, tapping or eavesdropping of communication processes is much more complicated when fibre optic is used. (Arumugam, 2001).

LAN Infrastructure Cost Models

As already noted UTP copper cabling dominates wiring in structured cabling systems, specifically on direct connections to end devices such as workstations, network printers, and IP telephones. Perhaps an appropriate question here becomes: Why does it still dominate despite the numerous benefits of optical fibre media? Day (2009) argues that "perhaps the largest barrier is perception" (p. 35). Many people still consider fibre to be more expensive than copper notwithstanding new information about the technology.

The value of a cost model is that it allows objective assessment of a technology's economic value in comparison to an alternative available. Hence, it proves to be an important input to the decision making process on which media is most suitable for an organisation's network. The main benefit in all of these is that an organisation will save of costs of implementing and maintaining a high performance data communications network.

3.1 The Tolly Group Cost Model (2000)

This cost model considers the first install costs of a LAN cabling project. The cost model design is based on four input parameters, namely:

- Telecommunication Room – Distributed architecture
- Telecommunication Room – Centralised architecture
- Main Equipment Room – Distributed architecture
- Main Equipment Room – Centralised architecture

It presents two scenarios. Scenario 1 consists of a 60,000-square foot building with 267 users, a distributed architecture with five telecomm rooms and one main equipment room at average-per-user cost of USD 962.75 (Ksh. 80,781) for Category 5e and USD 972.85 (Ksh. 81,971) for Category 6 cabling. These costs also include cost of horizontal hardware, TRs, and the main equipment room. The centralized fibre architecture in contrast requires two TRs, and one main equipment room for an aggregate per-user cost of USD 806.80 (Ksh. 67,771). Consequently the centralised architecture results to savings of more than USD 40,000 (Ksh. 3.3 million). See Table III-1.

Table 3: Scenario 1 - Tolly Group Cost Model

60,000-square foot building	Size	Cost (USD)
Telecommunications Room, Distributed architecture	10' x 11'	32,226.35
Telecommunications Room, Centralised architecture	2.5' x 4'	13,228.25
Main Equipment Room, Distributed architecture	20' x 20'	33,361.90
Main Equipment Room, Centralised architecture	20' x 22'	37,428.30

The second scenario consists of a 240,000 square foot building with 1067 users, a distributed architecture with 23 telecommunications rooms and one main equipment room at an average per-user cost USD 996 (Ksh. 84,660) for Category 5e cabling and USD 1,006.10 (Ksh. 85,519) for Category 6 cabling. By contrast, a centralised model with fibre requires only 11 telecommunications rooms and one main equipment room for an aggregate cost of only USD 773.09 (Ksh. 65,705) per user. This translates to an aggregate savings of more than USD 235,000 (Ksh. 19.9 million) in hardware costs in favour of centralised architecture. Table III-2 shows the summary:

Table 4: Scenario 2 - Tolly Group Cost Model

240,000 square foot building	Size	Cost (USD)
Telecommunications Room, Distributed architecture	10' x 11'	32,226.35
Telecommunications Room, Centralised architecture	2.5' x 4'	13,328.25
Main Equipment Room, Distributed architecture	30' x 40'	47,629.40
Main Equipment Room, Centralised architecture	34' x 40'	56,893.20

Overall, the Tolly Group cost model finds "significant capital savings" on the implementing the centralised fibre architecture. Other than hardware costs, removal or reducing number of telecommunication rooms brings about additional benefits such as environmental control (consolidates uninterrupted power, and of heating, ventilation and air conditioning), as well as on spare hardware costs (fewer spares required to support fewer devices). Finally, considering optical fibre's long term viability as a cabling solution, users will continue enjoying "reduced recurring costs over the life of the cable installation."

3.2 TIA FOLS LAN Infrastructure Cost Model (2005)

TIA FOLS cost model focuses on four standards compliant architectures common today:

- Traditional hierarchical star, where UTP is used as horizontal cabling and fibre is used for the backbone.
- Centralised Cabling, also called Fibre-to-the-desktop (FTTD).
- Fibre-to-the-telecom-enclosure (FTTE) implementation low density, serving 16 users per TE.
- Fibre-to-the-telecom-enclosure (FTTE) implementation high density, serving 72 users per TE.

The cost model is implemented using a "building" of eight stories, each with 54 ports per floor. The choice of 54 ports per floor is represents a switch port count approximately 50% between two common port sizes, 48 and 60. Labour costs are also factored in at USD 60/hour (Ksh. 5,040). Input factors to the cost model include: (i) Desktop support equipment / NIC; (ii) Horizontal cabling; (iii) TR Support equipment; (iv) Workgroup switches; (v) Vertical cabling; (vi) MC support equipment; (vii) Core switches; (viii) Miscellaneous; and (ix) Labour. The summary of results is shown in Table III-3.

Table 5: TIA FOLS Cost Model Summary

Description	Hierarchical star	Centralised Fibre	FTTE – Low density	FTTE – High density
Desk Support Equip/NIC	6,274.64	67,068.00	6,272.64	6,272.64
Horizontal Cabling	29,224.80	24,591.60	7,970.40	7,970.40
Telecomm Room Support Equipment	86,324.88	25,146.32	21,002.8	15,571.3
Workgroup Switches	48,556.80	71,811.36	26,811.1	48,556.8
Vertical Cabling	1,262.40	16,173.60	4,368.00	2,922.40
Main Cross-Connect Support Equipment	3,120.69	29,021.73	3,663.27	3,120.29
Core switches/GBIC/Blades	62,653.46	41,698.73	72,284	62,653.4
Misc	130.02	1,170.11	195.03	390.06
Labour	21,504.00	17,841.00	17,612	15,904.00
Totals	$259,049.2	$294,522.7	$160,180.	$163,361.36
Approx Ksh. (Million)	21.7 M.	24.7 M.	13.4 M.	13.7 M.

This model shows that the cost for deploying multimode fibre throughout the network is often either at cost parity, and sometimes even less, than installing new grades of UTP copper cable in the horizontal and multimode fibre optic in the building riser. The fibre advantage is expected to be even greater due to the anticipated higher costs of newer Augmented Category 6 UTP cable. The main contributing factors to lower costs are fewer of building a telecommunication room (TR) and the diminishing cost of the related support equipment. While the need for multiple TRs is a necessary cost factor in the hierarchical star architecture (scenario 1), the TR and related equipment can be amalgamated into a single TR or by extending the fibre optic backbone into the office area using the TE. Fibre enables these new types of architectures as it can support cabling distances of 300 metres using multimode fibre.

As much as these models discussed are useful, there are a number of weakness/challenges that could be identified relating to each. A major setback of the Tolly Group's cost model is that it does not take into account all major parameters that constitute as structured cabling project. For instance, labour costs are ignored and it is clear that it was not taken into account in the aggregate total costs of the two scenarios it describes. Moreover, it merges all cost elements as either TR-related or main equipment-related. As a result it fails to provide insight on the breakdown of cost factors relating to individual components e.g. types of cable (such Cat 5e, Cat 6 or Amplified Cat 6), switches, equipment cabinets, patch panels etc. all of which are important when analysing deployment costs. In addition, the reference to users, rather than the number of network connections (e.g. 200 data and 200 voice hosts), of individual network hosts in a work area, as described in the model overlooks the real world network environment where planning is based on estimated network connections, not users. A given number of users may not directly translate to an equivalent number of network connections. The TIA FOLS cost model compares three major multiple architectures for using fibre cabling in LAN and limits itself to only first install costs. When analysing a project that will have a time span at least fifteen years, considering merely the initial installation costs may not provide an accurate evaluation of cost projections. Although it may difficult to capture and quantify total installed lifetime costs, an attempt may have been made to capture relevant input factors e.g. maintenance costs.

4.Research Methodology

A qualitative research approach was followed and forms of qualitative research data obtained for purposes of the research. First, secondary information was derived from the available body of knowledge through literature review. An interaction research approach was followed in conducting the literature review. This method is based on theory conditions (non-empirical), which were used to set the direction of the research. In the literature study the purpose was to present results on the work of existing models which deal with network infrastructure costs. Secondly, exploratory data was collected based on a survey conducted on IT professionals with a working knowledge of network cabling infrastructure.

4.1 Sampling

IT professionals surveyed were drawn an electronic mailing list of 40 network and system administrators in Kenyan organisations and companies. Other responses were drawn from IT staff from the following sectors: two universities – public and private (6 respondents); two commercial banks (4 respondents); government ministries and state corporations (6 respondents); and privately owned IT firms (4 responses). The survey in total targeted 60 respondents.

Purposive sampling was adopted in creation of the target sample size. This approach was followed because it allowed the researcher to "use cases that have the required information with respect to the objectives of this study" (Mugenda & Mugenda, 2003). Sample selection design adhered to the following criteria: background (technical/administrative), years of experience and industry sector (public or private).

4.2 Data Collection Methods

Questionnaires were developed based on the research objectives and sent out. The questionnaire was available in a web-based format and was delivered to recipients via email to the target sample.

- The following sources of data were used to obtain secondary data:
- Available databases in Strathmore University's online library Catalogues
- Published articles in journals in the library
- Relevant textbooks and;
- The Internet

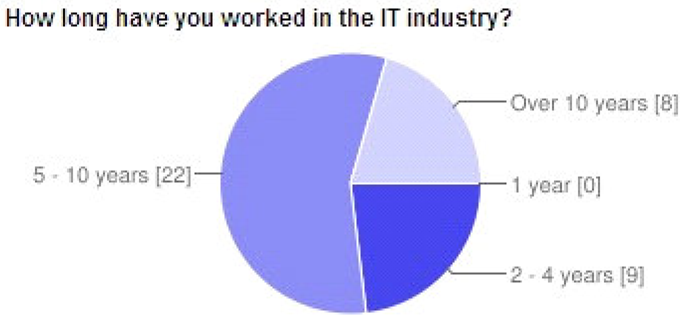
4.3 Data Analysis

Data obtained was analysed using Microsoft Excel. The following approaches were thereafter used to represent data: graphical analysis, tabulated data and pie charts.

4.4 Research Quality

The adequacy of the research design and the quality of tools and techniques used to obtain and analyse the data are critical measures since the quality of the research project is dependent on methods. "In order to collect data, some form of measuring instruments has to be used" (Morton, 2005). For a measuring instrument to be reliable, it has to be proven to provide consistent results. For the data to be useful and adequate, it is essential that the data collection method (e.g. questionnaire) be proven reliable and valid. For the measuring instrument to be valid, the instrument must be proven to accurately measure a situation as intended by the researcher. This was adhered to during the conduct of this research.

5. Research Findings



1 year	0	0%
2 - 4 years	9	23%
5 - 10 years	22	56%
Over 10 years	8	21%

A total of 39 responses were obtained out of the total 60 initially targeted, representing a 65% response rate. The respondents were drawn from at least five sectors: Telecommunications (1), Banking (3), Government ministry/State Corporation (8), Education/Training (15), IT consulting (4) and the remainder (11) from the wider private sector practice. Over 75% of them had at least 5 years working experience in the IT sector. See Figure 2.
Figure 2: Experience in IT Industry

5.1 Factors that Influence Selection of Cabling Infrastructure

Cable bandwidth received the topmost support of 77% (30 responses) on the question asking respondents which factors they rate highest with regard to cable selection. Length of cable run came in second at 59% (23 responses), resistance to EMI third at 46% (18 responses), and ease of installation fourth at 44% (17 responses). Interestingly, cost gained the least percentage (36%) of respondents who consider this aspect as very important when choosing a network medium.

Area or location where the communication medium will serve was also cited as an additional factor to take into account. Other factors were maintenance, security and future reliability of the cable.

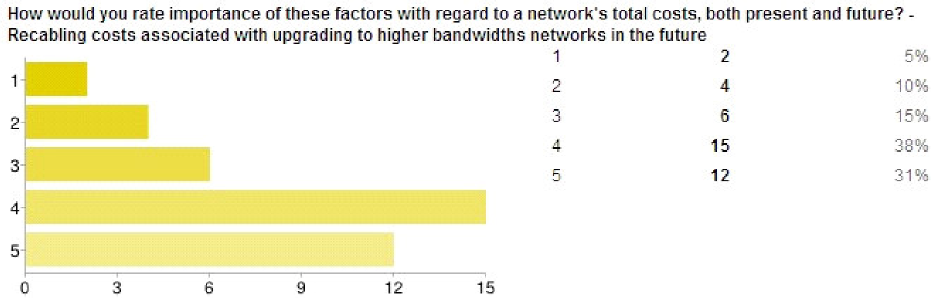
5. 2 Factors Associated with LAN Infrastructure Costs

On a scale of 1 to 5 (1 – Least Important and 5 – Highest Importance), the following factors were listed and respondents queried on the extent to which they matter when considering costs of LAN infrastructure:

- Cabling component costs, including the cable, wall outlets, patch panels, patch cords and connectors;
- Labour costs to install and test the cabling systems;
- Equipment or device costs, such as switches and equipment cabinets
- Activation costs, including the labour and software needed to activate the network;
- Downtime costs, including the impact of network outages on productivity;
- Maintenance costs;
- Network management costs, including the recurring cost of network changes;
- Costs associated with re-cabling when upgrading to higher bandwidth networks in the future.

With the exception of activation costs, all these factors were rated above 50% on Very important/Highest importance (i.e. a score of 4 or 5) when estimating network infrastructure expenses. Equipment/device (such as switches, patch panels etc) costs had the highest score at 80% (31 respondents). Seventy two per cent (28 respondents) polled for network management whereas labour costs got an approval of 51% (21 respondents).

Maintenance costs received support from at least 25 respondents, representing 64% of the total sample. Other general factors cited were civil works costs and insurance costs.



Another area to note was feedback concerning re-cabling costs associated with upgrading to higher bandwidth (an aspect of maintenance). On this, 69% of respondents acknowledged this as very important aspect (i.e. score of 4 or 5) in so far as total network costs were concerned. See Figure 3

Figure 3: Re-cabling Costs

6. Proposed Cost Model

The proposed Cost Model focuses on two common architectures considered by network designers:

- Hierarchical Star Network, where UTP is used as horizontal cabling and fibre is used for the backbone;
- Centralised Fibre Cabling also called Fibre-to-the-Desktop, where fibre is used for both horizontal and backbone cabling.

Costs are organised into four pillars: Desktop or work area costs, Telecommunication room costs, Main cross-connect costs, Labour costs, Maintenance costs and Miscellaneous/Other costs. See Table VI-1.

Table 6: LAN Infrastructure Cost Model

From this conceptual structure, two more detailed cost models were derived, one for the hierarchical star architecture and the other for the centralised fibre architecture. This is shown in Table VI-2 and VI-3 respectively.

Table 7: Hierarchical Star Architecture Cost Model

Hierarchical Star architecture – Cost Model		
Cost input	**Item**	**Details**
Desktop	NIC	NIC 10/100Base-T
	Patch Cord	Patch Cord 3m Cat6
	Wall Plate	2 Port Face plate
	Jack	Cat6
Telecomm Room	Horizontal Cabling	Cat6 Plenum, metres
	Patch Panel	Patch Panels Cat6 24-port
	Patch Cord	Patch Cord 3m Cat6
		Patch Cord 6m Cat6
	Workgroup Switch	Switch, Layer 3, 100Base-T
	Fibre Patch Cord	Patch Cord 3m LC-SC
	Fibre Adapter Panel	Adapter Panel Enclosure, 24-Fibre
	Fibre Adapter Panel (Pre-loaded)	Pre-Loaded Adapter Panel, LC Adapters
	Fibre Connector	LC Connector, Simplex MMT
	Equipment Cabinet	42 U Floor standing
Main Cross-Connect / Wiring Closet	Vertical cabling – Fibre	12-Fibre Riser Cable 50/125 microns, meters
	Fibre Connector	LC Connector, Simplex MMF
	Fibre Connector Duplexing Clip	LC Duplexing Clip
	Fibre Adapter Panel (Pre-Loaded)	Pre-loaded Adapter Panel, LC Adapters
	Fibre Patch Cord	Patch Cord 3m LC
	Core Switch	Core Switch
Others	Uninterruptible Power Supply	1 kVA UPS
	Fibre Termination Consumables	LC Consumable Kit
Labour costs	Calculated for each cost input or as a percentage of material cost	Ksh. 250 per hour or 10% - 30% of material cost
Maintenance cost	Cost of recabling the network to upgrade the network Replacement of faulty components	
Hierarchical Star Network Total Cost		

Table 8: Centralised Fibre Architecture Cost Model

Centralised Fibre architecture – Cost Model		
Cost Input	**Item**	**Details**
Desktop	NIC	NIC 100Base-FX
	Patch Cord	Patch Cord 3m LC-SC
	Wall Plate	2 Port Face Plate
	Duplex Adapter	LC Adapter, Duplex
	Connector	LC Connector, Simplex MMF
	Duplexing Clip	LC Duplexing Clip
Telecomm Room	Horizontal Cabling	4-fibre Plenum Round 50/125 microns
	Splice	Mechanical Splice
	Enclosure	Splice Enclosure, Rack Mount
	Splice Tray	Splice Tray, for Rack Mount
Main Cross-Connect	Equipment Cabinet	For the main telecommunications room
	Vertical Cabling	144-fibre Riser Cable 50/125 microns
	Connector	LC Connector, Simplex MMF
	Adapter Panel Enclosure	Adapter Panel Enclosure, 144-Fibre
	Adapter Panel (Pre-loaded)	Pre-Loaded Adapter Panel, LC Adapters
	Duplexing Clip	LC Duplexing Clip
	Workgroup Switch	Switch, Layer 3, 100Base-FX
	Core Switch	Core Switch
	Patch Cord	Patch Cord, 3m LC-MTRJ
Others	Uninterruptible Power Supply	1 kVa UPS
	Fibre Termination Consumables	LC Consumable Kit
Labour costs	Calculated for each cost input or as a percentage of material cost	Ksh. 250 per hour or 10% - 30% of material cost
Maintenance cost	Cost of recabling the network Replacement of faulty components	
Centralised Fibre Network Total Cost		

6.1 Assumptions

The "building" used to demonstrate the model is a two storey building with three floors, each with 40 end user ports. Floor space per floor is approximately 1,500m^2. The proposed model compares the cost of a horizontal UTP/vertical fibre network (Hierarchical Star) to the cost of fibre-to-the-desktop network (Centralised Fibre) for a network implemented on the "building." The following is a summary of the requirements assumed:

- 3 floors with active end user ports
- 40 active end user ports per floor
- 1 Gigabit uplink per 24-port 100Fx/TX switch port
- 1 Gigabit server port per 48 end users

For the purposes of the model, labour costs may be worked out at the rate of Ksh. 250 per hour (approx $3). Labour costs may also be pegged on the cost of project material (about 10% to 30% of total material cost.) The model was implemented using a spreadsheet file template. Effort has been made to qualify all costs involved. Any differences in how costs are aggregated may not be large enough to invalidate conclusions drawn from the model when implemented.

6.2 Results

In implementing the model, average prices were used for calculations with regard to various components used for this project. The summary of results is as shown in Table VI-4.

Table 9: Proposed Cost Model Summary

Description	Hierarchical star	Centralised Fibre
Desk Support Equip/NIC	72,000.00	722,400.00
Horizontal Cabling	660,000.00	462,000.00
TR Support Equipment	227,460.00	465,000.00
Workgroup Switches	780,000.00	675,000.00
Vertical Cabling	12,600.00	11,700.00
MC Support Equipment	139,540.00	262,050.00
Core switches/GBIC/Blades	774,000.00	450,000.00
Misc	35,000.00	34,500.00
Labour	270,060.00	616,530.00
Maintenance / Upgrade	2,376,528.00	847,728.75
TOTALS	**KES 5,347,188 (USD 62,910)**	**KES 4,546,909 (USD 53,944)**
Cost/Mbps/Km		
	KES 53,472 (USD 630)	**KES 90,938 (USD 1,070)**

Labour costs for Centralised Fibre architecture were based on 20% of material costs, which was higher than the 10% used for the Hierarchical Star architecture. Other than being a more recent field, optical fibre installation is a relatively specialised area compared to working with UTP copper installations, thus explaining the higher labour costs. Furthermore, costs are higher too due to costly and dedicated equipment used in fibre optic cable termination.

Table VI-4 also shows a comparison based on Cost per Megabit per second per Kilometre (Cost/Mbps/Km). In this regard, the network design can support bandwidth of at least 100 Megabits per second. Since fibre optic cable is less affected by attention than UTP copper - providing for longer cable runs – overall cost of its network infrastructure will be considerably lower due to a better order of magnitude difference in the Cost/Mbps/Kilometre.

Finally, the results show consistency between data collected from respondents and the actual results after implementing the model. Cost of devices, notably the cost of switches, patch panels, equipment cabinets and UPS units accounted for over 75% of total costs. During the survey, 80% of IT professionals had cited device/equipment costs as very important/highest importance when estimating costs of a network project.

7. Conclusion and Recommendation

The cost of implementing an all fibre network (based on the Centralised Fibre architecture) is slightly above that of implementing the conventional Hierarchical Star network (based on UTP copper horizontal cabling and multimode fibre vertical cabling.) The model shows that the cost for deploying optical fibre throughout the network is only higher by about 14%. This is the case when first install costs are the only consideration. See Figure 4.

Figure 4: First Install Costs

Costs in the long run, however, are in favour of an all-fibre architecture. This is the scenario when costs of network maintenance and upgrade are incorporated. Following this approach the overall total network cost for fibre networks is less by at least 25% when compared to the Hierarchical Star network. Network maintenance and upgrade costs in this model were shown by implementing an upgrade from Fast Ethernet to 10 GE. (See Figure 5) Two factors contributing to overall lower costs of an all-fibre network is the fact that the upgraded network will not require reinstalling cabling infrastructure - only device and connector changes may apply - and the gradual decline of fibre optic devices plus equipment. In contrast, an upgrade to 10 GE will require an overhaul of the cabling system in a hierarchical UTP copper architecture. This undertaking is costly and disruptive of organisational functions. Moreover, the expense factor is compounded by rising costs of higher grade UTP copper cabling (e.g. Cat6a, Cat7) which support 10 GE.

Figure 5: Total Costs (including network upgrade)

In summary the study conducted demonstrates that all-fibre networks are cost effective since they have a better order of magnitude difference in the Cost/Mbps/Km. (See Figure VII-3.) Whereas you can run multimode fibre for a distance of at least 500m, UTP is limited to only 100m. In this regard fibre optic provides a better return on cost per bandwidth per kilometre. This further highlights the long term savings that fibre-based networks offer.

Figure 6: Hierarchical Star Vs Centralised Fibre (Cost/Mbps/Km)

However, what may not be very clear based on this research is the question of whether fibre-based networks may overturn the prominence of UTP copper networks in organisations. Although network planners acknowledge the superior benefits of going all fibre, not all may upgrade their networks to fibre-based architectures. This is interesting to note because, even though they cited bandwidth as the factor with the highest importance when selecting a cable (77%), only 51% would be willing to upgrade their LAN infrastructure to an all-fibre design. This therefore shows that the case of an-fibre network may be impacted by other considerations apart from cost.

Network planners should deploy appropriate tools and techniques when evaluating LAN infrastructure costs and, more importantly, ensure that the design adequately supports the organisation's business requirements – both present and medium long-term.

In addition, new network installations should be based on centralised fibre architecture. As this research has shown, though cost may be higher initially compared to conventional UTP/optical fibre networks, in the long run they provide a better return both in terms of cost and reliability.

Further studies can be done based on other standard architectures such as Fibre-to-the-telecommunications-enclosure (FTTE) low density (few users) and FTTE high density implementations (many users) in evaluating total costs of a network. Overall cost estimates including network maintenance costs can be compared with those of the UTP copper-based architecture.

Moreover, in addition to first install costs and maintenance costs, other models can be developed and used to evaluate other aspects of network life cycle costs such as network management costs.

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