

OPTIMIZATION OF CABLE PATH IN A WAN USING GIS

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A network is a line coverage that is topology based and consists of connected linear features. A communication network, in its simplest form, is a set of equipment and facilities that provides as service: the transfer of information between the users located at various geographical points. Internet or inter network is no exception to this, which involves the interconnection of multiple networks into a single large area network. Today GIS is used extensively to plan, build and operate communication networks and associated services. GIS can handle complex network problems, such as road network analysis. There are, of course, other types of network analysis, involving stream networks. For example, GIS could be used to model the flow of water through a river system, to plan a flood warning system.

Shortest path analysis (SPA) is based on a network with the objective of finding the path with the minimum cumulative cost in either time or distance between points on the network. Familiar networks include road system, railways, public transit, streams and shorelines etc... Another network which is analogous to the above networks is the WAN using cables. However the cable networks are different from the networks mentioned above. Some of the salient features of these networks are

- ?? Need of detailed information of not only topography but also interior of the buildings.
- ?? Cable laying is normally performed at the different elevations. Hence the need of integration and information of details at different elevations is necessary.
- ?? More number of alternatives as compared to the other networks.
- ?? More number of constraints
 - ✂✂ Maximum length between the switch to a user is 90m.
 - ✂✂ Fiber cables should be mainly underground
 - ✂✂ Trenching involves labour cost , so trenching should be minimized
 - ✂✂ Cost directly proportional to length of the cable.
- ?? More number of components is involved; switch size, cable size etc...

Due to the aforesaid factors the analysis of cable networks is difficult and need spatial and non spatial information. Hence GIS (Geographical Information System) which is capable of handling both types of information is most suitable tool for such problems. A Geographic Information System (GIS) is a computer system for capturing, storing, querying, analyzing and displaying geographic data.

The paper presents a situation of planning a Wide Area Network (WAN) in technical education campus of **Birla Institute of Technology & Science (BITS), Pilani, Rajasthan,**

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INDIA. The aim of the project is to provide net access to around 3500 students and 600 staff's quarters.

The project aims at providing net access to all rooms by WAN. The cables used are the outdoor fiber and indoor copper cable. The basic plan is to take the outdoor fiber from a core (master) switch to a distribution switch from where the access switch can cater to the rooms using indoor copper cables. The number of distribution, access switch varies depending on the need. The project aims to find an optimum path for both the fiber and indoor copper cables and hence reduce the cost

Network analyst and shortest path analysis are used to find the optimum path for the cables so as to reduce the cost. Various constraints are taken care when using cables and few are mentioned before. We have used ARC VIEW GIS version 3.1 for the whole analysis and AUTOCAD RELEASE14 and AUTOCAD 2000 for creating images of the campus and hostels.

INTRODUCTION:

A network is a line coverage that is topology based and consists of connected linear features. A communication network, in its simplest form, is a set of equipment and facilities that provides a service: the transfer of information between the users located at various geographical points. Internet or inter network is no exception to this, which involves the interconnection of multiple networks into a single large area network. Today GIS is used extensively to plan, build and operate communication networks and associated services. A Geographic Information System (GIS) is a computer system for capturing, storing, querying, analyzing and displaying geographic data. Maps have been used for thousands of years, but it is only within the last few decades that the technology has existed to combine maps with computer graphics and databases to create geographic information systems or GIS. What distinguishes GIS from other forms of information systems, such as databases and spreadsheets, is that GIS deals with spatial information. GIS has the capability to relate layers of data for the same points in space, combining, analyzing and, finally, mapping out the results. Spatial information uses location, within a coordinate system, as its reference base. The most common representation of spatial information is a map on which the location of any point could be given using latitude and longitude, or local grid references.

GIS can handle complex network problems, such as road network analysis. There are, of course, other types of network analysis, involving stream networks. For example, GIS could be used to model the flow of water through a river system, to plan a flood warning system, to plan sewer and water pipe lines etc. In broad terms, a Geographic Information System could be defined as a set of principles and techniques employed to achieve one (or both) of the following objectives:

- ?? Finding suitable locations that have the relevant attributes. For example, finding a suitable location where an airport, a commercial forest or a retail outlet can be established. This is usually achieved through the use of Boolean (logical) operations.
- ?? Querying the geographical attributes of a specified location. For example, examining the roads in a particular locality, to check road density or find the shortest path, and so on. This is often achieved by 'clicking' onto the location or object of interest, and examining the contents of the database for that location or object.

Shortest path analysis finds the path with the minimum cumulative impedance between nodes on a network. The path may connect just two nodes – the origin and destination – or have specific stops between the nodes. It is based on a network with the objective of finding the path with the minimum cumulative cost in either time or distance between points on the network. It can help a traveler plan a trip; a van driver can set up a schedule for dozens of deliveries, or an emergency service to connect a dispatch station, accident location, and hospital. The network we are dealing with is the WAN using cable which is analogous to the road network. However the

cable networks are quite different as many salient features are to be taken into consideration. These can be

- ?? Need of detailed information of not only topography but also interior of the buildings.
- ?? Cable laying is normally performed at the different elevations. Hence the need of integration and information of details at different elevations is necessary.
- ?? More number of alternatives as compared to the other networks.
- ?? More number of constraints
 - ✂✂ Maximum length between the switch to a user is 90m.
 - ✂✂ Fiber cables should be mainly underground.
 - ✂✂ Trenching involves labour cost, so trenching should be minimized.
 - ✂✂ Cost directly proportional to length of the cable.
 - ✂✂ Future plans have to be kept in mind.
- ?? More number of components is involved; switch size, cable size etc...

Due to the aforesaid factors the analysis of cable networks is difficult and need spatial and non spatial information. Hence GIS which is capable of handling both types of information is most suitable tool for such problems. The software that we have used here is ARC VIEW 3.1.

METHODOLOGY:

The project presents a situation of planning a **Wide Area Network (WAN)** in technical education campus of **Birla Institute of Technology & Science (BITS), Pilani, Rajasthan, INDIA**. The aim of the project is to provide net access to around 3500 students and 600 staff's quarters.

The project aims at providing net access to all rooms by WAN. The cables used are the outdoor fiber and indoor copper cable. The basic plan is to take the outdoor fiber from a core (master) switch to a distribution switch from where the access switch can cater to the rooms using indoor copper cables. The number of distribution, access switch varies depending on the need. The project aims to find an optimum path for both the fiber and indoor copper cables and hence reduce the cost. The present paper aims to extend the use of GIS to cable networks integrated with drawing tools such as AUTOCAD. The aim of the project is to provide net access to all rooms by WAN. The copper wires used for this purpose are of two types

- (a) Outdoor fiber,
- (b) Indoor cables.

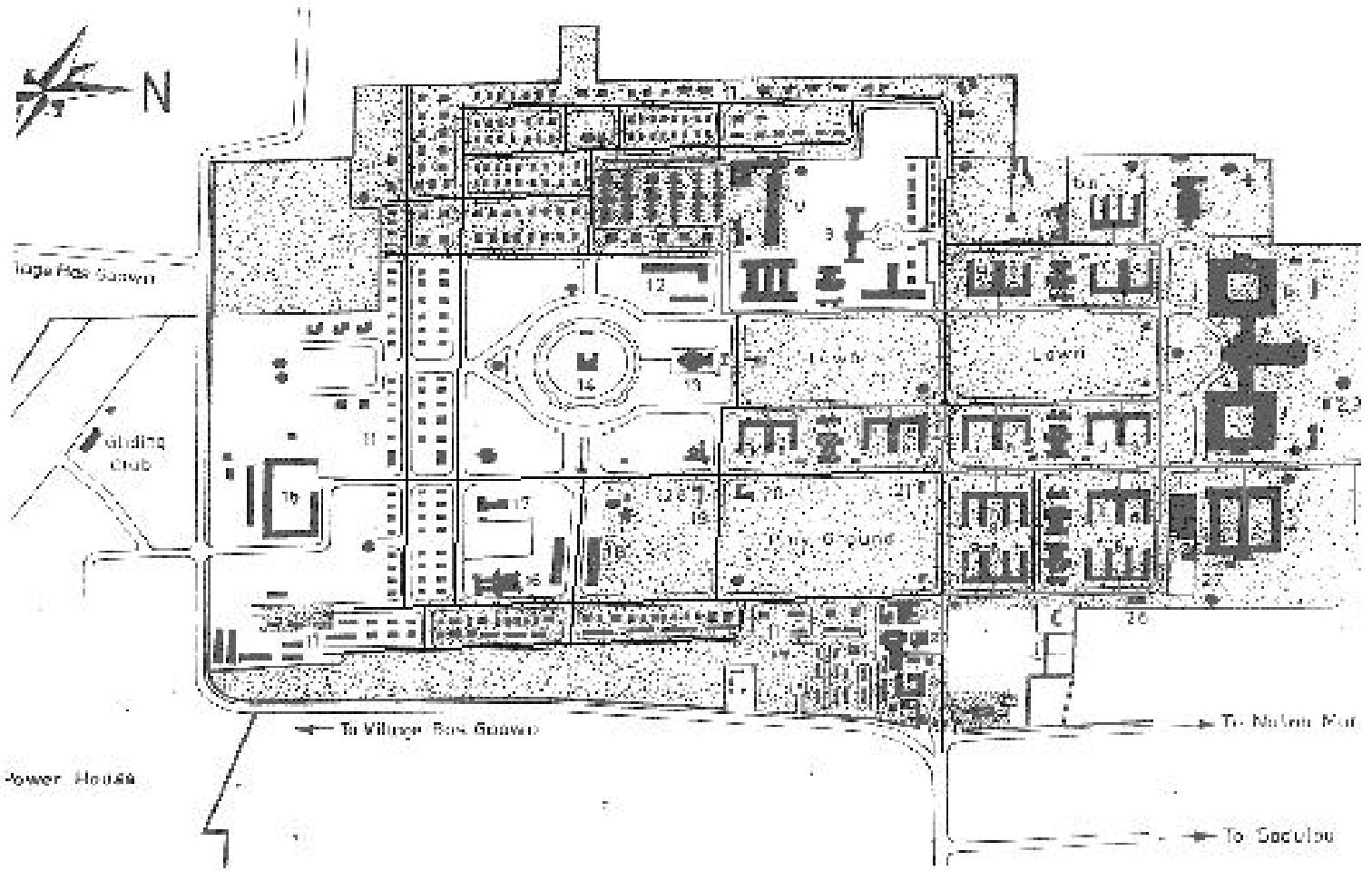
The outdoor fiber is taken from a master switch to a distribution switch, which is placed inside a building from where the indoor cables cater to access switches and also from the access switches to every room. The first phase of the project is aimed at finding an optimum path for the outdoor fiber i.e. from the master switch to the distribution switch so that the material cost and trenching cost is reduced. The images of the hostels and the interior view of the hostels are created with AUTOCAD RELEASE14 and AUTOCAD 2000 and then imported into ARC VIEW for analysis. Network analyst and shortest path analysis are used to find the optimum path for the cables so as to reduce the cost. Various constraints are taken care when using cables and few are mentioned before.

OPTIMUM PATH FOR OUTDOOR FIBER:

The digital map of the campus is taken and the basic operations such as Geo referencing, digitizing are carried out. For georeferencing we have to store the map in TIF image format and then create a note pad file with TFW extension. We should store both these in the same folder in which we are working and the other files which are created by Arc view are automatically stored in this folder. The georeferencing was done in comparison with the length and breadth of Budh bhawan. Then the different bhawans were digitized as a polygon theme and the road network was also digitized as a separate theme. The themes are stored as shape files with the .shp extension. Arc view automatically creates .dbf and .shx files for these themes.

THE PLANS:

The first phase of the project is aimed at finding an optimum path for the outdoor fiber i.e. from the master switch to the distribution switch so that the material cost and trenching cost is reduced. Basically we have two plans for the path of the out door fiber which has to travel from IPC to all the bhawans. In the above two plans we have taken into consideration future aspects i.e. we have not considered vacant lands for routing of the fiber. This is because in future there may be plans for constructing a building there, as a result of which the cables will be buried under them causing problems. In **plan-I** we have taken the fiber along the roads i.e. we have used the existing road network to get to the bhawans. The length of cable required for this purpose is shown in Table (1). The layout is shown in Fig (1). In **plan – II** the cables were taken along the walls of the bhawans. The length of cable required based on plan-II is shown in Table (1).The layout is shown in Fig (2). In this plan we aim to reduce the cost due to trenching also i.e. we are taking the fiber inside bhawans which are connected.

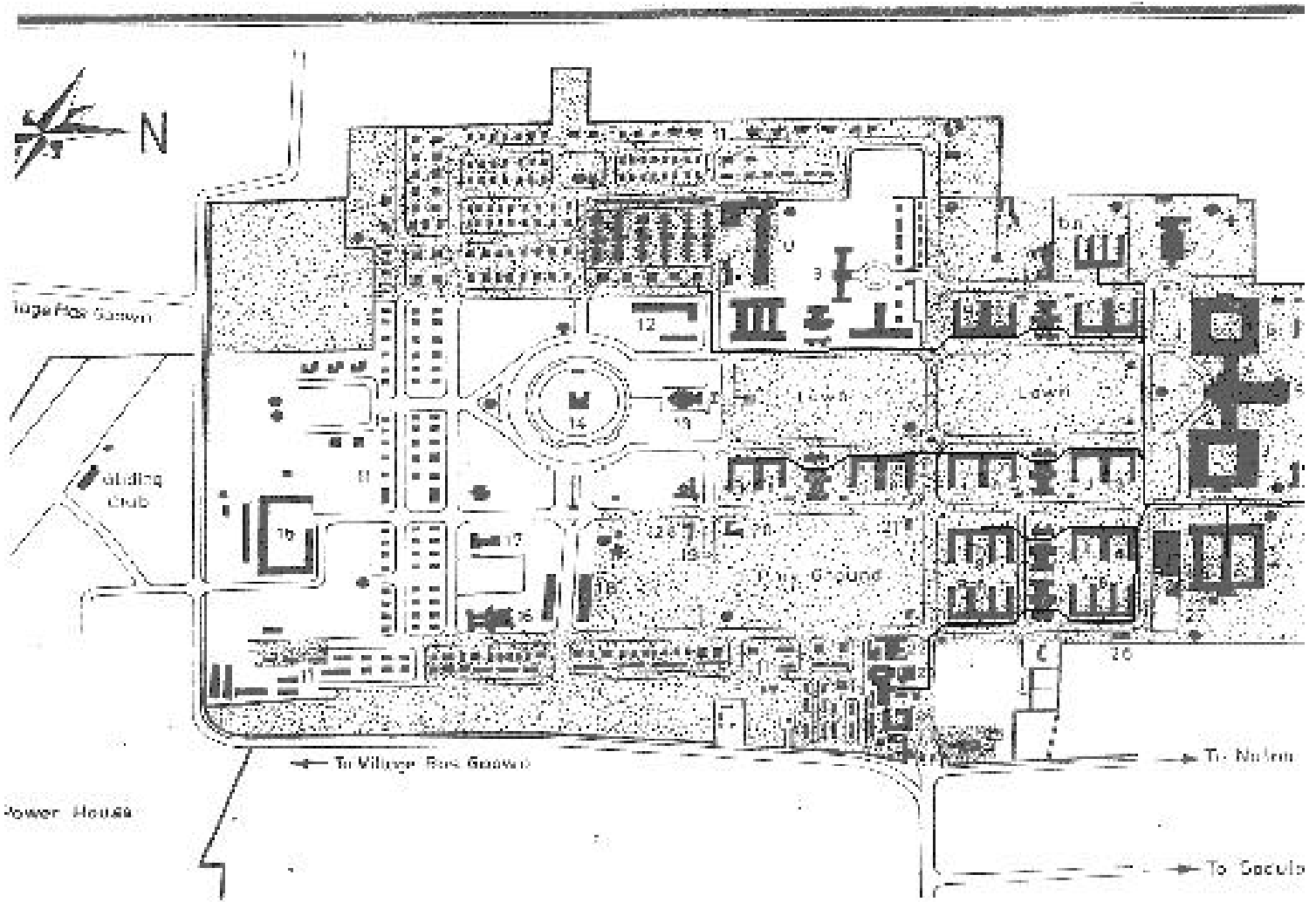


PLAN-I

Fig (1).

Plan – II

Fig (2).



LENGTH OF CABLE REQUIRED BASED ON PLAN-I AND PLAN-II

S.NO	FROM	T0	PLAN-I (meters)	PLAN-II (meters)
1	IPC	VK	304.935	295.731
2	IPC	LIBRARY	320.016	320.016
3	IPC	KRISHNA	381.545	336.026
4	IPC	RP	455.180	433.058
5	IPC	BAG	484.854	491.961
6	IPC	RAM	513.968	499.762
7	IPC	GANDHI	566.657	537.183
8	IPC	ASHOK	632.642	631.540
9	IPC	MAL	641.404	632.642
10	IPC	BUDH	703.179	679.829
11	IPC	SHANKAR	724.326	688.846
12	IPC	VFAST	840.842	837.654
13	IPC	VYAS	907.397	883.770
14	IPC	MEERA	1215.071	1235.628
		TOTAL	8692.016	8503.646

Table (1)

Length of cable required based on plan-I = 8692.016m
 Length of cable required based on plan-II = 8503.646m

We see that there is a saving of 200m of optical fiber in following plan-II. Even though plan-II shows a saving, the fiber has to confront many bends while taking it inside the bhawans. This is not advisable as it can result in head losses and reduce the life or even damage the fiber. Thus in terms of future aspects we can say that plan-I will be more efficient. As a result we can say plan-II shows a small saving at the cost of quality.

OPTIMUM PATH FOR INDOOR COPPER WIRES:

This part mainly describes the method followed for obtaining the best layout for the copper wires inside the bhawans. The first step is to obtain the digital map showing all the features of the bhawan, but unfortunately none exists. So we created a 3-d model of the bhawan using AutoCAD release-14. CAD drawings are mostly used to produce maps and occasionally to query block attributes associated with a symbol. In a typical GIS application, these attributes are stored as a

row in a table associated with a corresponding feature. Once you establish this link, you may query features based on attribute values and you may perform advanced GIS operations on these features. The length, breadth and height of the bhawan were measured physically as also for the rooms. Thus the AutoCAD image was an exact replica of the bhawan including the measurements. The next step was to use the AutoCAD image in arc view. Arc view supports CAD images with .dwg and .dwx extensions. The 2-D image of the bhawan was imported into arc view as a map. This map was georeferenced so that real measurements of the bhawan can be used. We then created network path similar to the road network. This catered to all the rooms in the bhawan taking into consideration all the constraints. The various constraints to be kept in mind are as follows:

- ✂✂ There should be only one distribution switch for each bhawan.
- ✂✂ Not more than four access switches are to be used but the number can be reduced provided it's an economic design.
- ✂✂ There should be only one separate wire catering to each room from the access switch i.e. if there are 12 rooms, then 12 wires are to be used from the access switch for catering to these 12 rooms.
- ✂✂ The length of each wire used should not exceed 90meters.
- ✂✂ Care should be taken such that the indoor copper wires are not exposed.

We then created a network inside the hostel such that all the rooms were catered to from the switches. This network is similar to the road network created for the campus. In this the source of all the paths are from the access switch which is also digitized at the desired location. For this we have four plans which help in giving us the best location for the access switches and the best path lengths for the wires. Thus it specifies which region of the hostel should be catered by which access switch and the total number of access switches to be used. Network analyst was used to find out the service area of an access switch. Finding a service area and service network around a site involves creating a polygon theme representing the accessible area and a line theme representing the accessible paths. This service area mainly helps us to find a good location for the access switch such that the length constraint is taken care of. Once the suitable locations for the access switches are obtained we apply the shortest path analysis to find the best paths for routing the wires to the rooms. All the four plans were created with the above procedure and the cost was procured. In all these 4 plans the double rooms are given double connections. The height between the access switches in the ground floor and the first floor was taken to be 7m.

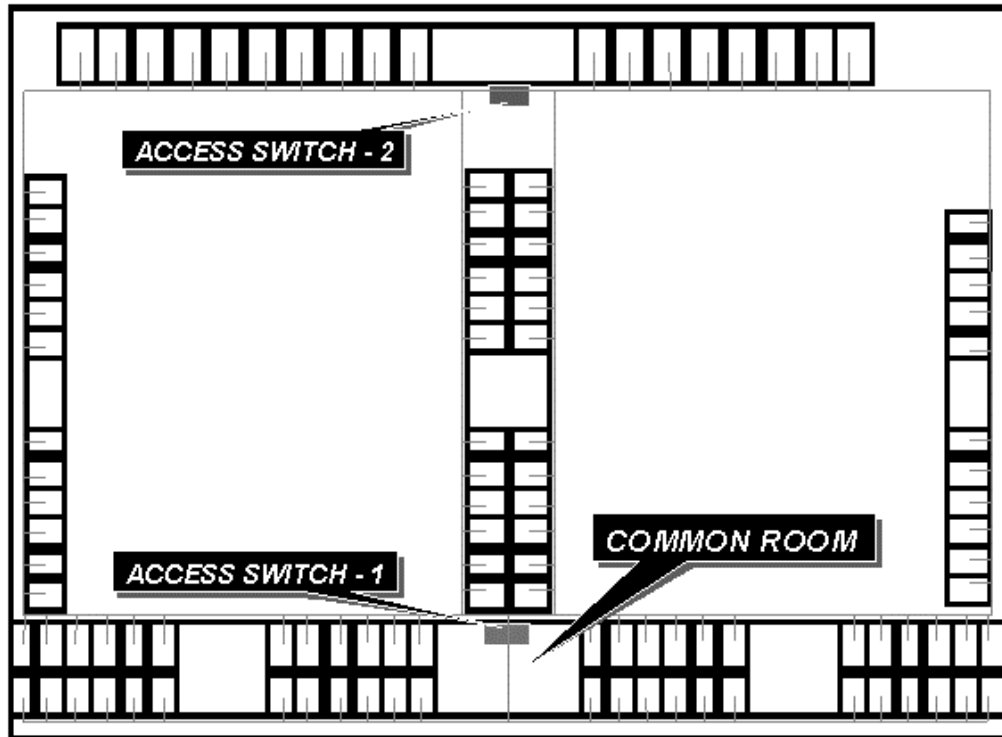


Fig (3)

PLAN-I:

In this plan we have used 4 access switches in one hostel, 2 in the ground floor and 2 in the first floor. In the first floor 1 is placed in the common room and the other directly opposite on the other end of the hostel and same arrangement applies for ground floor also. The figure(3) shows only the positions of the switch in the first floor.

The result obtained for this plan is shown in Table (2).

The length of wire for the first floor	4671 m
The length of wire for the ground floor	4671 m
The length of the wire from the distribution box to access switch	136 m
TOTAL LENGTH	9478 m
Average length per room(totally 226 rooms)	41.3 m

Table (2).

**PLAN-II:
CASE 1**

In this plan we have used 3 access switches in one hostel, 1 in the ground floor and 2 in the first floor. In the first floor 1 is placed in the common room and the other directly opposite on the other end of the hostel and in the ground floor just below the later. The result obtained for this plan is shown in Table (3).

The length of Wire for the first floor	4671 m
The length of wire for the ground floor	5175 m
The length of the wire from the distribution box to access switch	128 m
TOTAL LENGTH	9974 m
Average length per room(totally 226 rooms)	43.56 m

Table (3)

CASE 2

In this plan we have used 3 access switches in one hostel, 1 in the ground floor and 2 in the first floor. In the first floor 1 is placed in the common room and the other directly opposite on the other end of the hostel and in the ground floor just below the former. The result obtained for this plan is shown in Table (4).

The length of wire for the first floor	4671 m
The length of wire for the ground floor	5084 m
The length of the wire from the distribution box to access switch	68 m
TOTAL LENGTH	9823 m
Average length per room(totally 226 rooms)	43.16 m

Table (4)

PLAN-III

In this plan we have used 2 access switches in one hostel, none in the ground floor and 2 in the first floor. In the first floor 1 is placed in the common room and the other directly opposite on the other end of the hostel. The result obtained for this plan is shown in Table (5).

The length of wire for the first floor	4671 m
The length of wire for the ground floor	5528 m
The length of the wire from the distribution box to access switch	61 m
TOTAL LENGTH	10320 m
Average length per room(totally 226 rooms)	45.4 m

Table (5)

Summary of length of cables required based on the above plans is given in Table (6).

Plan	Total length	Average length
I	9478 m	41.3 m

II Case 1	9974 m	43.56 m
II Case 2	9823 m	43.16 m
III	10320 m	45.4 m

Table (6)

CASE STUDIES:

*In North America and Western Europe, the degree of change to external plant networks has been substantial, with fibre-optic cables replacing the copper wires. For example, in New York, fibre is replacing the entire conventional copper wire network, while in the UK, cable and wireless communications has bought in an excess of US\$20 billion in new infrastructure, primarily fibre-optic cables. GIS has been used to determine the most suitable method of transmission, plan network layouts, and target customers.(see Birkin et al, Chapter 51, for the outline of the sorts of GIS operations that this involves and Martin, Chapter 6, for an overview of some of the problems inherent in such applications).

*In countries with less well established networks, companies have used GIS to plan entire networks involving thousands of telephone lines. For example in the Philippines in April 1997 the international service provider and fixed network operator Isla communications contracted siemens public communication networks group to install 350000 telephone line and 20000 wireless lines (pyramid research 1997).

*Telecom Italia (Telecommunication Company) implemented GIS to locate and repair faults in public telephone network more quickly and to set up a network for authorizing electronic payments for telephone calls. The public telephone infrastructure in Italy comprises 450000 public telephone terminals. The primary task for the GIS was to improve Telecom Italia’s response to reported telephone faults.

* Shortest Path Analysis is an essential precursor to many GIS-T operations. It is critical for many route location models for determining the minimum environmental cost route (MERC: Lee and TomLin 1997; and see Eastman, chapter 35), for determining allocations in a location-allocation model, for trip assignment and transportation planning models (Nyerges, 1995).

*Church (chapter20), Church and Sorensen (1996) and Densham (1996) provide detailed and up-to-date discussions of location-allocation modeling within a GIS context.

CONCLUSION:

The result shows various other alternatives with respect to the previous plans without using GIS. This will not only help in reducing cost but also will help in proper planning of inventory control and in monitoring the contractor’s job.

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