ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

A Simple GIS Based Method for Designing Fiber-Network

Zahraa M. Matrood, Loay E. George, Faleh H. Mahmood
Baghdad University, College of Science, Al-Salam Road, Karbala city, Iraq
Baghdad University, College of Science, University Complex, Aljaderia, Baghdad, Iraq
Baghdad University, College of Science, Remote Sensing Unit, AL-Karada, Baghdad, Iraq

Abstract*—Telecom operators usually develop business cases for the deployment of high speed fiber to the home(FTTH) networks, taking into consideration that the major limiting factor is the deployment cost which is mostly related to civil works. This leads to a deployment strategy that minimizing the cost or for a fixed investment that maximizing the network coverage. Consequently, telecom operators often hesitate to invest and delay the deployment of FTTH networks or operations for gradual and slow deployment. A Geo-graphic Information System (GIS)-based fiber tool provides more accurate planning for new fiber network and seamless management of the entire integrated infrastructure. In this paper a new, simple method is proposed to get an optimal deployment of a collection GIS-based network design tools. In this project, a prototype system had been developed for planning a FTTH network, automatically, depending on the geographic data of the area. At first, the geographic urban data for the region is gathered and some of the common errors are addressed to be handled. Then, the required relevant GIS tables are prepared; it includes street maps, buildings and house maps. As next step, the network layout is designed using either star and/or bus topology. The network design process includes determination of the distribution of network nodes and the proper routes of cables connecting the nodes in a way to ensure full coverage of the whole region with lowest possible cost. The design steps taking into consideration the bandwidth required in every part of the region, the amount of rounds of the streets in the region and lengths of cables required to cover the region and provide access to every home. Also, the prototype system provides the required documentation for the design results to facilitate the implementation task and to follow-up the work elements during and after establishing to network.

***Index Terms*—Fiber optic, FTTH, GIS, Network Planning, Region rotation, Region Segmentation.**

I. INTRODUCTION

FTTH stands for Fiber to the Home or Fiber to the Premises. Over the last decade the bandwidth required for services such as High Definition TV and Internet has grown explosively. In this light, several telecommunication carriers are already realizing fiber-to-the-home (FTTH) projects, and in addition, many companies are seriously investigating how such a network could be deployed. Given the vast investments that have to be madethe careful preparation of such a deployment project is indispensable; for example, an estimated amount of 40 to 60 billion Euros in total was spent for Germany alone. The planning of an FTTH network is a highly complex task comprising numerous interesting optimization problems. A GIS-based fiber tool provides more accurate planning of the new fiber network and seamless management of the entire integrated infrastructure [1,2]. This paper aims to introduce a new methodology that identifies the optimal deployment using GIS-based network design. Geographic information system (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present all types of geographical data. The acronym GIS is sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems. The importance of GIS as an integrating technology is also evident in its pedigree. The development of GIS has relied on innovations made in many different disciplines: Geography, Cartography, Photogrammetry, Remote Sensing, Surveying, Geodesy, Civil Engineering, Statistics, Computer Science, Operations Research, Artificial Intelligence, Demography, and many other branches of the social sciences, natural sciences, and engineering have all contributed [3]. The deployment of FTTH network is an expensive task, and it needs good planning and pre-knowledge about the roads and other public network infrastructures for the region covered by FTTH. To save time and money the GIS environment can be used for analyzing and preparing the required data easily within very short timelines and high accuracy; the work that takes weeks, may be months, can be done within few days and by small teams. Also, the break parts and faults identifications in the future can simply found using GIS maps and tools, so the maintenance can quickly be done. The idea of network planning depending on spatial information had gained large interest as a good way to simply and optimize network planning process, as in some studies, Google Earth can be used for visualizing network plans, in particular for FTTH networks, supporting automated GIS-based planning by reducing the need for physically visiting sites in order to inspect and verify the plans [4]. The involved design calculations are based on real geographic data (digital maps) and infrastructural information of the targeted area, using detailed and realistic cost models in order to provide results of practical interest [5]. The conventional labor-intensive FTTH designing practice had been streamlined into a Geographic Information system (GIS) based modularized process to achieve quick construction of fiber plant with capability of fully spatial and inventory managements [6].

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

Louchet[7] developed tools and methods that support the automated planning and optimization of FFTx networks. Such methods enable to optimize the network infrastructure with regard to capital expenditure (CAPEX) by selecting the optimal locations for central offices, fiber collects, distribution points as well as trails between them.

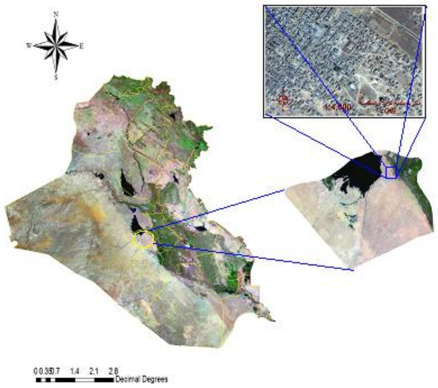


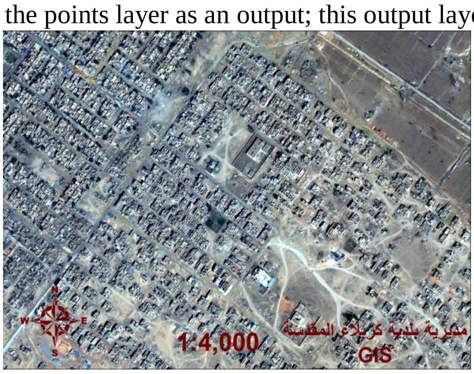
Fig 1.Orientation map of study area.

II. THE PROPOSED SYSTEM

A method based on utilizing the GIS-tools for automated planning of FTTH (Fiber to the Home) access networks is proposed. It is a systematic approach for planning access network infrastructure. A collection of GIS data and a set of developed algorithms were employed to make the planning process more automatic. The developed method implies different steps of planning process starting from using professional GIS system to prepare the required geographic data, and, then, migrating the data to an application developed by Visual basic 6 programming environment. The developed application performs all required pre-processing operations to prepare the required region information for planning the PON architecture, and finally preparing the necessary documents for describe the routes of fiber optic cables, the location of sectors feeders, splitters and the ending elements to the provider. However, the proposed method is not fully automatic planning process; it makes the planning process significantly fast and easy. The automatic generation of accurate and up-to-date network mappings and inventory reports is not an easy work. The network building process passes through the following stages:

A. Data Gathering and Region Planning

Geographic and Urban Information about the region must be provided from proper authorities (e.g. Directorate of municipalities and Communications). The urban information involves the buildings' numbers, their spatial distribution, and road network [8]. Geo databases usually contain all the required GIS information and maps. This kind of geo-information can be obtained easily for some local government offices; especially those already working on GIS systems. The selected area includes four districts, located in the province of the Holy Karbala within the Municipal boundaries of the city center in the north-east of the city, see figure (2D). It is located at longitude (44°00'26"-44°00'54") East, and latitude (32°32'51"-32°33'54") North. The total area of the studied region is about of 4.19043 km2, perimeter is 8,2242 meters. The number of: (i) residential buildings is 46,729, (ii) commercial and business buildings is 2977, (iii) governmental buildings is 235, (iv) number of Gardens is 247, and (v) vertical housing is 66 buildings. The tiff satellite image for the considered region is shown in figure (2A), the street layer is shown in figure (2B), and the blocks layer in figure (2C). Some data was provided from one of Karbala government offices. The construction of street layer (geo database) have been repeated due to the existing error in the supplied data; so the streets of the region of interest have been reconstructed using personal geo database which can be considered as additional updated database that can be used with Arc Map applications. From Figure (2B), each street intersection is represented as a start point of a block; each block is treated as a set of parcelsand each parcel representing one building. It can be used to represent a node in the network. These intersection points need to be calculated and stored in the database. The streets'database record consists of the fields shown in figure (3). Theobject field is represented by a unique ID. The shape field represents the type of drawing object used to draw the street. The Shape-Len field represents the street length. These fields are usually filled during the design phase. For each new drawn street on the Arc Map window a new record is added to streets database. To find the intersection points of streets and store them in a new database, one of the ArcMap toolboxes is used, (see figure 4). This toolbox takes the street layer as input and produce the points layer as an output; this output layer (i.e.,

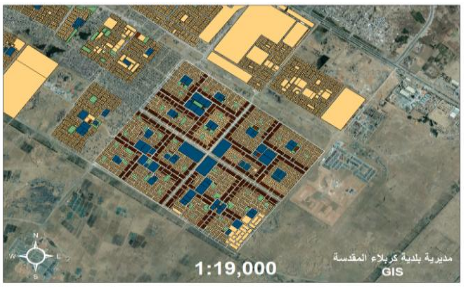


(A) Tiff image for the considered region

(B) Street layer for the considered region

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

(C) Blocks layer for the considered region



(D) Locations of 4 districts

Fig 2. The satellite image, street layer, blocks layer and the region of interest

Table — str

OBJECTID *	SHAPE	SHAPE_Len
1	Polyline	55.064874
2	Polyline	55.004174
3	Polyline	21.94477
4	Polyline	50.003269
5	Polyline	30.05853

(0 out of 1612 Selected)

Fig 3.Streets database

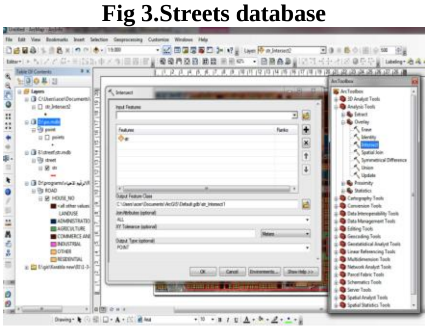


Fig 4. Toolbox intersect tool

To find the intersection points of streets and store them in a new database, one of the ArcMap toolboxes is used (see figure 4). This toolbox takes the street layer as input and produce the points layer as an output; this output layer (i.e. database) have three fields as shown in figure (5); Points' ID field, Streets' ID field, and a third field represents a copy of street length item taken from the street database. Also, the intersect tool adds the default fields to the nodes database, other important information are added to nodes database; they are the three calculated fields: (i) x field, the (ii) y field and (iii) the bandwidth field. The x and y fields represents the coordinates of the intersection nodes (i.e. x and y). Iraq is located within more than one zone; Karbala city lays within the region (its CM is indexed as 38) in term of UTM coordinate system. By Arc Map tools the real (x,y) coordinates are filled directly into the nodes database. The bandwidth fields have been filled according to street width, and the type of buildings surrounding each intersection point. When the street is wider than others it will be more vibrant because it would be more appropriate for companies and shops, also the governmental and business buildings use bandwidth more than other building types (like residential buildings). The nodes of the considered Karbala region have assigned three levels of bandwidth; they categorized into class "a", "b", and "c". Class "a" represents high bandwidth consumers, while class "c" is for low bandwidth consumers and class "b" represents the buildings near class "a" region. In the classification process, each type of block is represented by a certain color; for examples gardens are drawn as green blocks, commerce and market are Brown blocks, residential is yellow blocks, and government is blue blocks. The bandwidth value of each node is added to nodes database, and it can be displayed on the map, as shown in figure (6). All the data required by our developed system reside in the nodes database; which can be loaded (or migrated) without need to use ArcGIS application because it can be treated as an access file.

1. Data Preparation

In order to proceed in the network design computations, we have to check the clearness of the nodes database. There is only one database that contains all the required information to define streets and their intersection points. After data migration to the developed application, it must be capable to understand the relation between fields and can deal with them easily. In the nodes' database, streets are defined by their ID, in street ID field, and they can be drawn depending on their start and end points' IDs stored in node field in the same database. So, to define the correct points for each street, a checking step is applied, it starts with sorting the street's fields and check if there are two defined streets have same ID number, or there are two streets have same corresponding node points' IDs (i.e., one street is defined more than one time). Figure (7) shows an example of a street record (i.e., see street number 4 and its start and end points in the drawn map and in database).

Table — points

OBJECTI	FID-Str	x	y	len	bandwidth
2803	1400	408614	3601931	51	b
2804	1400	408584	3601891	51	c
2805	1401	408554	3601851	68	b
2806	1401	408513	3601797	68	a

(0 out of 3228 Selected)

Fig 5. The fields of nodes database

After getting the GIS database (created by ArcGIS

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

environment) for the region of interest, and making a check that all data required to start network planning process are registered in the database; this database can also, be accessed without ArcGIS application because it is an access file. This file can be read directly with visual basic program. A record named segment record is introduced to represent streets' segments. A temporary table was built to store all the data that has been loaded from the main GIS database.

Fig 6. Bandwidth level for each node

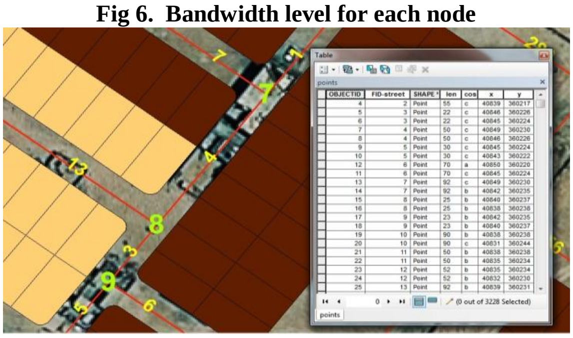


Fig 7. Street points in map and database

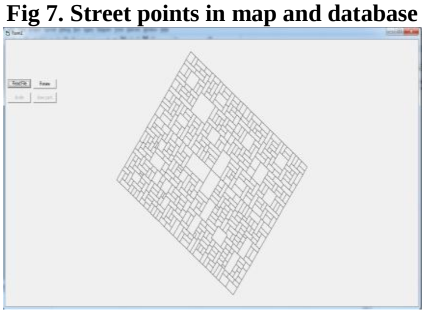


Fig 8. Street layer after mapping to vb6 environment

2. Data Migration

Each segment record is scanned to remove the repeated segments; this kind of errors could occur due to some mistakes occurred during the manual GIS design step. Then, as next step, the segments nodes are sorted; such that the node with small x is set as the start node. Some extra information about each segment is calculated using the following equations, the extra information includes the inclination angle (i.e., the direction angle) of each segment is determined using equation (1), and the length of street segment which is determined using the following equations:

$$Ang = tan^{-1}\left(\frac{\Delta x}{\Delta y}\right) \qquad (1)$$

$$Len = \sqrt{(\Delta x)^2 + (\Delta y)^2} \qquad (2)$$

Where, $\Delta y = y_2 - y_1$ and $\Delta x = x_2 - x_1$

A graph theory can be applied on the extracted region, such that the nodes represent the vertices of graph and the streets' segments represent the edges of graph. The use of the segments record, can lead to nodes records which are created to contain the nodes' ide, coordinates, connected nodes, bandwidth, the connected segments with required segment information. The inclusion of segment information in the nodes records is to facilitate the move from one node to another by its connections and edges.

3. Mapping

The coordinates used in GIS system for allocating the nodes positions are the east (x) and north (y) coordinates of UTM coordinates system, the projected coordinate system is WGS_1984_UTM_Zone_38N. This projection is the Transverse Mercator, with false easting = 500000.00000000, false northing=0.00000000,central_meridian=45.00000000, scale factor=0.99960000, the latitude of origin= 0.00000000, Linear Unit=Meter, Datum is D_WGS_1984, Prime Meridian is Greenwich, and the Angular Unit is Degree. The coordinates' data that extracted from Arc Map environment are linearly mapped to be drawn by vb6 environment. This mapping task is accomplished using the mapping algorithm. As an example of drawing output see figure (8). The steps of mapping algorithm work well with Vb6, because it has Scale Mode property. With other programming languages this algorithm cannot be used without making some extra computations; this is due to the need of using a set of linear mapping equations. The coordinates listed in nodes database is the UTM east (x) and north (y) coordinates; their values are large numbers such that they cannot be used directly to make on the computer screen. So for handling this problem an algorithm for conversion from UTM coordinates to pixel coordinates was applied. This algorithm acts like geo referencing process in the ArcGIS system. To handle the mapping task from UTM coordinates to image pixels coordinates the method of affain mapping is applied. According to this method we must choose at least three points. The selected points should have good visual appearance such that they can easily be allocated in the Tiff image, which opened in ArcGIS environment. The coordinates in east-X & north-Y format can be taken from the ArcGIS application, and their image pixel coordinates could be assigned using any image browsing application (like, paint application). These points are used to create the affain mapping coefficients (i.e., a_0, a_1, a_2, b_0, b_1, b_2) which are required to do the mapping process, according to the following equations:

$$x' = a_o + a_1 x + a_2 y \qquad (3)$$

$$y' = b_o + b_1 x + b_2 y \qquad (4)$$

Where (x, y) are the GIS coordinates and (x', y') are the corresponding image coordinates.

B. Region Rotation

One of the important information that must be obtained

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

and be as correct as possible, is the road network; because the road will be the way or the path the fiber will lie on. Most of the cities have a direction trend when their roads are planned; they almost built and expanded toward something specific, therefore streets are planned to have specific direction. The rotation of the region map is a proper choice, because it will cause a great simplification for the necessary calculation; this alignment can be useful to make the way of applying the routing optimization algorithm easy. The rotation step should be applied in a way that does not affect the real geographic layout of the area; it should be applied in a way just like rotating the map paper to make drawing tasks easy. The arbitrary alignment of the studied area may cause many computational difficulties in the region partitioning stage and in the stage of allocating the network main branching points, and also in the stage of selecting the optimal path points. So, to simplify the computation process a virtual re-alignment is needed to make the orientation of the area in proper form; such that the longest roads of the area should be nearly horizontal (i.e., along the east). This will greatly simplify the process of dividing the area into small sectors; such that each sector has a central feeding switch (or hup) which feeds services to the access nodes at homes. So, a new algorithm has been developed to align the streets such that longest ones become horizontal and others vertical (most of them). The first step in our developed rotation algorithm is the calculation of streets' direction angles, and then determining the direction (i.e., streets' angle) histogram. Then, as next step, the most redundant pair of perpendicular directions is found. This step is accomplished by scanning over all segments records to find those with directions near the most redundant pair of perpendicular directions. Then the average value of the most redundant close angles is determined. To decide the required rotation angle, the segments are distributed among the most probable angle (θ_1) and its perpendicular (θ_1+90) according to the closest angle criterion. Then, find the angle (θ) that lead to greater sum of segments lengths as the district direction angle. As a final step use the chosen angle (θ) to rotate the area, as shown in figure (9). In many geospatial-related applications (e.g., trip planning, urban planning-urban computing and traffic analysis) the urban area is often segmented into sub-regions for in-depth analysis or complexity reduction. Intuitively, a digital map can be segmented into equal-sized grids, where each grid is a rectangle [9].

C. Region Segmentation

Segmentation algorithm is usually depends on one of the two traditional algorithms: the K-D space partition algorithm and H-V algorithm (Horizontal-Vertical algorithm).The factor in the segmentation criteria, for FTTH networks, is the Coverage capacity of the centres office in PON architecture. Depending on this factor and the equipment's specifications used in the planning the region may be segmented or maybe not.

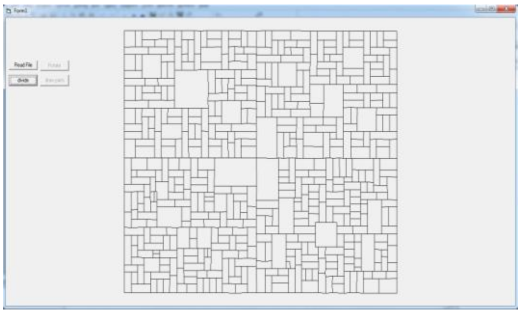


Fig 9.The region after rotation; it is drawn on VB6 form

The network planning process is a hard task; its complexity is greatly increased due to many factors, the most important ones are:

- The usability degree of the network services varies from place to other.
- The segments length and number of intersections in the region.
- The nature and number of obstacles forbids the passage of network lines across them.

One of the active ways to simplify the planning task is to partition the region of interest into sectors, and for each sector a central feeder (or splitter) is assigned; the central feeder is directly connected with the main city feeder that connects all cities in the country through large network; the connect point is considered as a dongle node to the region area. The configuration of these sectors depends on many factors.

- The attended simplicity of the design work
- The geometry of the region of interest.
- The spatial distribution of the network usability requirements.

Since, the region of interest in our study has a rectangular shape, so we have adopted the choice of partitioning the area into rectangular sectors, such that the area of each sector depends on the required services of the network within the sector. The main partitioning element of each sector is the central feeder coverage capacity. For simplicity we have chosen the sectors central point as the central feeder location; which in turn provides network access to the set of nodes chosen to cover the whole sector area. The number of sectors is different from one region of interest to another because it depends on the shape of the region and its urban nature. Another important thing is how the shape of the sector will be? is it circle, or is it rectangle or square?. Regions can have different shapes; it may be irregular shapes. Square shape is more suitable than others, because it can be partitioned into a grid of squares or rectangles. The applied partitioning algorithm in this work is an integration of two familiar partitioning algorithms (i.e., K-D space partitioning and H-V partitioning). The introduced partitioning algorithm contains a main loop and a number of steps; the first step is to calculate the number of points in the region and compared with a predetermined maximum permissible number, If the number of points is larger than the permissible number, then the region should be divided into two almost equal sectors, and

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

same partitioning criteria could be applied on these two daughter segments. To achieve the best and most reliable design of the network the region must be divided into sectors that dimensionally regular as possible as. Therefore, in our introduced system the region is divide according to the longest dimension (length or width), and this was done by applying H-V partitioning algorithm. After determining the direction of division the system determines the dividing points; these points would be the boundary reference points between the two new sectors. These dividing points are obtained by applying K-D partitioning algorithm, its steps start by sorting the coordinate's values of each street segment. Then, a pointer is put at the nearest right line that closes to left edge. At each partitioning trial instance the pointer is moved to calculate the number of intersection points on both sides to see if the current pointer position makes both sides are equal (or almost equal) in terms of intersection density. The point that gives nearly equal parts will be selected as partitioning node and saved. The division procedure is recalled on the generated partitions (sectors) until all the newly generated sectors containing the appropriate number of intersect points. Figure (10) shows the result if sector feeder coverage capacity=100, and figure (11) for the case sector feeder coverage capacity=500.

D. Network Planning

The first steps to build networks are to know the services desired by the subscribers and determine the bandwidth they need. In our considered study area there are several types of customers; they were classified into three categories; each scattered irregularly in the area. To build a fiber to the home network in accordance with the design of PON, the network should consist of a central distributor that can feed the sub-spreaders (or splitters) which in turn feed the access points at the homes of the subscribers. Every network is planned to have certain topology which represents the layout of connected devices in the network. In our network a hybrid network topology is established, it is a combination of bus and star topologies; for each sector there are four branch buses connected with the central sector feeder, as shown in figure (12).

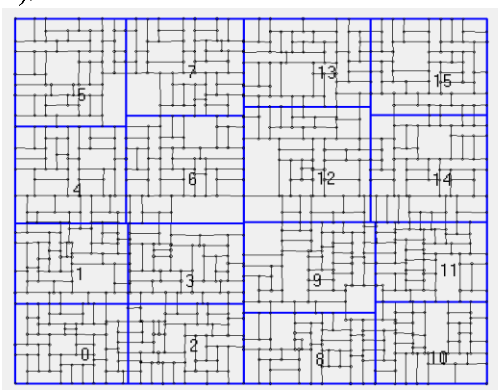


Fig 10. Street and nodes layers after segmentation process density of nodes =100

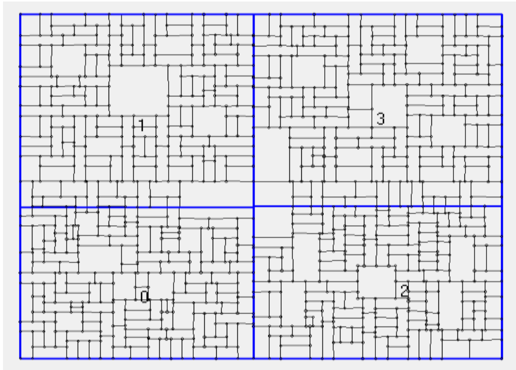


Fig 11. Street and nodes layers after segmentation process density of nodes =500

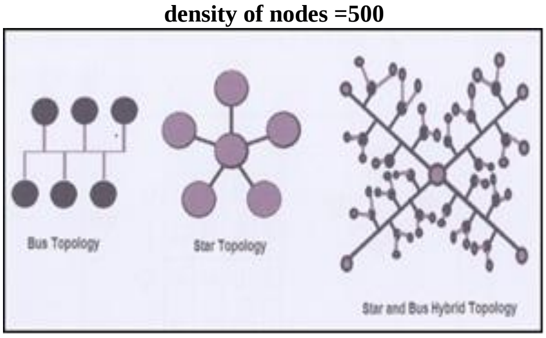


Fig 12. Network topology

Other important consideration in network planning is the length of the fiber used, so the best path to move from one node to another in the network must be available; it was calculated by applying Floyd-Warshall algorithm (described in section 2.4.1). A central distributor should be located for each sector and is allocated by PartCen algorithm (described in section 2.4.2). The network distribution was determined using the mechanism (described in section 2.4.3).

E. Shortest Path

One of the considerations in the network planning is the cost. Fiber length is one of the parameters that should be taken into account to reduce the cost of the network along with other required devices and equipment. Therefore, the routing algorithm calculates and finds the shortest path between each point and all other points in the region. It is used to help network planners to search for optimal network. In this study the Floyd-Warshall algorithm is used. A set of three parameters was adopted to specify the cost of the path, and according to their values and weights the best paths are chosen. This algorithm can be easily performed on the available data because the nodes have been, already stored as graph elements. Each sector contains a number of nodes, and they sorted in "Adjacency" Matrix which will be fed as input to Floyd algorithm. Floyd algorithm depends on the Adjacency matrix to find the optimal joints; this matrix sort values according to the relation between them, for example if node (I) has a direct connection to node (J) then the entry (I,J), in adjacency matrix, the length of the connection between them will be stored, and if there is no direct connection between them a very large (i.e., works are infinity) value will be stored, as shown in figure (13). The

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

cost can be determined by using one or more factors which have main effect on the trenching of fiber installation (like length factor, bandwidth factor, and segment direction factor). Each factor must assign a weight value according to its importance. So, the cost to move from any node to another is calculated using equation (5) and stored in the matrix. These weights can be changed and the results of best paths will change too:

$$D_{ij} = w_1 \times Len + w_2 \times BW + w_3 \times Ang \qquad (5)$$

Where, w_1, w_2, w_3 are the weights of distance, bandwidth, and angle parameters.

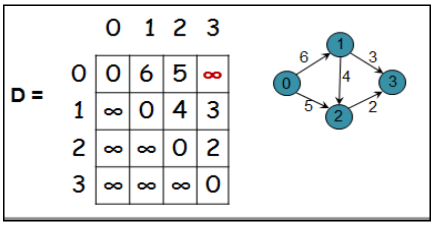


Fig 13. Adjacency matrix

While searching for the best path between node (I) and node (J) Floyd is assumed that, either there is a direct path between nodes or, there are intermediate nodes in the path {i, m, n,.., k, j}, so the core of the algorithm is a three nested "for" loops statements, the first loop take I node as start node and the second loop take J node as end node and the third loop takes the index of (k) of the intermediate node, the algorithm checks all possible paths by taking all possible intermediate nodes between (I), and (J) and finally chose the least cost path from them. In the Adjacency matrix the least cost value is stored, but the path from one node to the other node is not saved. An array (Path array) was used to find this path. A Path array is created and used to sort the last visited node before the target node. For example, if the path from node (i) to node (j) contains the set of nodes {i, m, n, k, j} then set path[i][j]=k, and path[i][k]=n and so on until reaching the “i” value, then the definition process of optimal path is completed. The constructed Path record contains start point, end point, and cost of the path. Each Path record is stored in a temporary file to be used for allocating the best paths when there is a need to move between nodes in network planning.

F. Location of the Sector Main Distributer

The heart of PON network design job is the determination of the optimal location of the central distributor location that must provide network access to all nodes in the sector. In our proposed system, after partitioning the region into sectors, the central node of each sector is adopted as the best node that can the network local distribution starts with, because it provides nearly equal distances to other nodes in the sector. To accomplish this job the necessary data of each sector is sent to PartCen algorithm. In figure (14) the blue circle, determined by equations (6, 7), represent the centres point of the sector; it is found by using the coordinates of four sectors’ boundaries (or corners). This point may be located on a building or a garden or a school; so to avoid this problem the Euclidean distance measure equation (8), is used to find the nearest registered intersection node to be the chosen place as the central main feeder node. As shown in figure (14) the red circle is the nearest node which chosen as the center of the sector:

$$mid_x = \frac{1}{2}(x_{min} + x_{max}) \qquad (6)$$

$$mid_y = \frac{1}{2}(y_{min} + y_{max}) \qquad (7)$$

$$Dis(i) = \sqrt{(mid_x - X(i))^2 + (mid_y - Y(i))^2} \qquad (8)$$

The chosen centre nodes are stored in array with the corresponding sectors’ IDs.

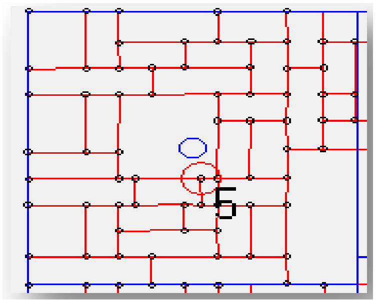


Fig 14. Part centres' nodes

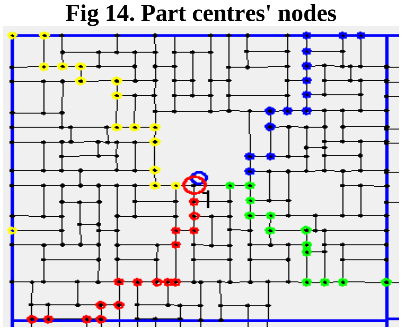


Fig 15.Center splitter and four main buses of sector number 1

G. The Branch Optical Cable

To distribute anything (like water, electric, gas, and other serving networks) the first two things come in mind are “where is the farthest node we try to reach” and “what is the best path to access it”; if the farthest nodes are served then all other nodes in its path are easily served. For the considered region in our study, each sector is nearly a square and the best distribution node is taken in the middle of the sector so the farthest nodes from the center are the four corners of the square. Corners can be found by using the minimum and maximum coordinates values of the intersection nodes. By using the paths record resulted from applying Floyd algorithm then the best paths from the center to each corner node is assigned; and then four paths are considered as the four main branch buses, as depicted in figure (15). The nodes along the four main buses can be used as nominated splitters nodes to feed the home access nodes, or any other nodes or ducts in FTTH network as it is required. Each splitter in the four main buses must feed all nodes along its right and left side (just like a river). Each main bus must have a boundary that limits its coverage area. To prevent overlapping between

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

main buses' coverage regions, (see figure 16), all nodes around the main buses are covered from the nearest to the farthest using shortest paths, and for each node the required fiber length is calculated. The chosen shortest path should be along the previous nodes till reaching the central splitter. The paths profiles are stored in files, see figure (17), to facilitate the implementation job. Some sectors may be large and the nodes at far distance from their main buses; this may require additional network devices to strengthen the signal to avoid signal distortions, therefore a branch bus could extended from the main bus to be used to cover some sub-sectors, this option is adopted just in cases there are large sub-regions placed as some sides of the main bus. The main bus feeds the branch bus which in turn feeds the nodes far from the main bus path. Branch bus approach can be used or not, this depends on the main bus and sector density. Figures (18) and (19) present an illustration diagrams for the adopted mechanism of network planning.

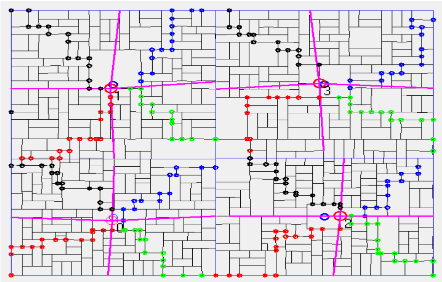


Fig 16. Each sector main buses' boundaries when center coverage capacity =500

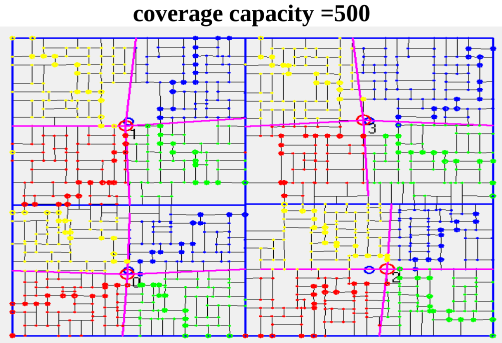


Fig 17. Each main bus feeds nodes on its' right and left sides, each main bus and itsNeighbours which are fed from it have same color

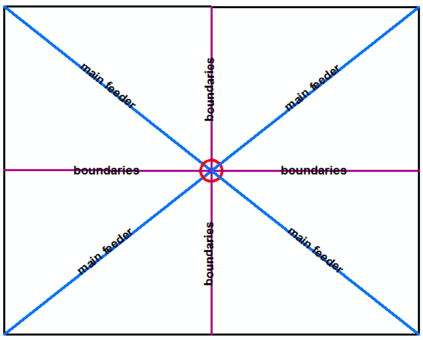


Fig 18. Mechanism of planning Main buses and boundaries

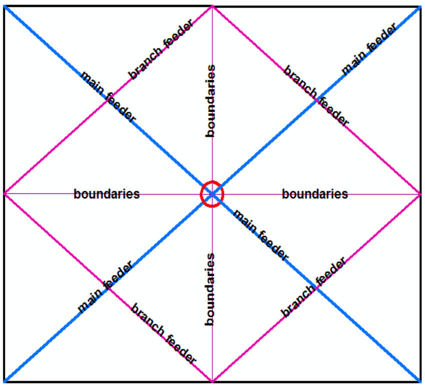


Fig 19. Mechanism of planning (main and branch buses)

H. Documents and Reports

Planners and engineers need maps and reports to implement the proposed mechanism; there are documents contain all nodes in the region and their connection, document for all street segments and their neighbours nodes and streets, document for shortest paths between each node and all other nodes in the region, and documents for feeders store feeders' nodes and all nodes fed from the feeder and the required fiber length.

III. CONCLUSIONS

The urban region map must be pre-processed before planning process in order to simplify the required computation steps; for example the region map must be aligned along a reference standard direction (like the horizontal direction) such that the long streets are aligned horizontal and their perpendicular streets become along the vertical. This will greatly simplify the computations process of dividing the area into small sectors. The idea of dividing the big regions into small sectors is useful to make the task of computing the optimal cables path more easy and controllable task. Besides, the division of the area into sectors can offer the flexibility of choosing more than one network topology (i.e., according to the sector shape). Many factors affect the possible construction of fiber networks. The most important ones are: (i) the shortest length of the fiber must be used, and places that have large rounding angles must be avoided (like, building corners), and (iii) taking into consideration the required networks bandwidth requirements. These factors have been taken into consideration when building this system. The choice of appropriate topological network is greatly influenced by the geometric and urban characteristics of the region. The established plan for the network construction should be aimed to cover the region with lowest possible cost but with high degree of construction flexibility (for example, avoidance of passing under building, minimum crossing of wide width streets, minimum rounding with acute angles,…etc). After building the network, all information about fiber lengths, network devices (splitters) locations, paths between splitters, maps for the region and the network, and all required information must be well documented to facilitate network builders' job.

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 4, Issue 2, August 2014

REFERENCES

[1] Orlowski, S., Werner, A., &Wessaly, a. R. (2011). "Estimating trenching costs in FTTx network planning. Berlin, Germany", Konrad-Zuse-Zentrum fur Informationstechnik Berlin.

[2] Ian Fitzgerald, Danny Petrecca, "Building Blocks: "How GIS provides the foundation for a more efficient fiber optic network", Directions Magazine, November- 5th, 2012.

[3] "Geographic Information Systems as an Integrating Technology: Context, Concepts, and Definitions", ESRI, Retrieved 9 June 2011.

[4] Jens Myrup Pedersen, Gustav HelgiHaraldsson, M. TahirRiaz, "Using Google Earth for Visualization in FTTH Network Planning", Image Processing and Communications Challenges 2, Advances in Intelligent and Soft Computing, Vol. 84, pp. 379-389, 2010.

[5] Attila Mitcsenkov, GézaPaksy, TiborCinkler,"Geography and infrastru-cture-aware topology design methodology for broadband access networks (FTTx)", Journal of Photonic Network Communications, vol. 21, Iss. 3, pp. 253-266, 2011.

[6] Rong-Show Kuo, Taiwan Pei-Chun Chen; I-Ling Huang; Chang-Ho Chen; Shih-Wei Lai; Lin, Y.-C.; Kuan-Hsiung Liang, "Implementation of the management of an Optical Distribution Network in a Geographic Information System", Network Operations and Management Symposium (APNOMS), held at 21-23 Sept. 2011, Asia-Pacific, pp. 1-4, 2011.

[7] Hadrien Louchet; Andre Richter; Erwin Patzak; Michael Schlosser; "Impact of strategic decisions on the planning of FTTx-Networks: A case study", Photonic Networks; 12. ITG Symposium; 12th ITG Proceedings of Photonic Networks, held at 2-3 May 2011, pp. 1-5, 2011.

[8] Nicholas Jing Yuan, Y. Z. (July 2012), "Segmentation of Urban Areas Using Road Networks", Microsoft Technical Report.

[9] Attila Mitcsenkov, GézaPaksy, TiborCinkler,"Geography and infrastructure-aware topology design methodology for broadband access networks (FTTx)", Journal of Photonic Network Communications, vol. 21, Iss. 3, pp. 253-266, 2011.