NEW TECHNIQUE FOR PROPOSING NETWORK'S TOPOLOGY USING GPS AND GIS

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ABSTRACT

The problem of proposed topology for network comes when using Prim's algorithm with default distance (unrealistic distances) between network's nodes and don't care about the lakes, high hills, buildings, etc. This problem will cause incorrect estimations for cost (budget) of requirements like the media (optic fibre) and the number or type of Access-points, regenerator, Optic Amplifier, etc.

This paper proposed a new technique of implementing Prim's algorithm to obtain realistic topology using realistic distances between network's nodes via Global Positioning System GPS and Geographic Information Systems GIS packages. Applying the new technique on academic institutes network of Erbil city from view of media (optic fibre) shows that there is disability in cost (budget) of the media which is needed $\cong 4$ times if implement default Prim's algorithm (don't using GPS & GIS) base on unrealistic distances between the nodes.

KEYWORDS

Prim's algorithm, Media, Realistic topology, GPS, GIS

1. INTRODUCTION

The important stage for proposed any modern (optic fiber) Internet Protocol **IP** networks (*Internet, Intranet, or Extranet*) which are common in use now in the world is the infrastructure, this infrastructure will contain Access-points (**Routers**/ Asynchronous Transfer Mode **ATMs**), Synchronous Optic Network **SONET**, the backbone network which is constructed from Dense Wavelength Division Multiplexing **DWDMs** [3, 10].

The connection of the access points, SONET, or backbone's nodes needs proposed topology (*the way which are connect the nodes of network*), there are multiple modeling method [8], algorithms, etc use to obtain the topology, the important one and commonly in use is Prim's algorithm which gives an efficient (*low cost and high traffic*) topology because it is important application of *Graph Theory* base on Minimum Spanning Tree **MST** as show following in the Prim's algorithm [1]:

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Input: A weighted connected graph G with n vertices and m edges Output: A Minimum Spanning Tree T for G Q = new heap-based priority queue s = a vertex of G {pick up any vertex s of G} Initialize T to mull for all v € G.vertices() if (v = s) then setDistance(v, 0) {set the key to zero} else setDistance(v, ∞) {parent edge of each vertex is null} setParent(v,Ø) Initialize the Q with an item ((u, null), D[u] for each vertex u, where (u, null) is the element and D[u] is the key. D[u] is the distance of u while - O.isEmptv() $(u, e) \leftarrow Q.removeMin()Add$ vertex u and edge e to T for all e € G.incidentEdges(u) $z \leftarrow G.opposite(u, e)$ {for each vertex z adjacent to u such that z is in Q} $r \leftarrow weight(e)$ {= w(u, z) } if r < getDistance(z) setDistance(z, r){update the D[z] in Q}setParent(z, e){update the parent of z in Q} return the tree T

2. RELATED WORK

The problem of suggestion topology comes when using Prim's algorithm with distances between the nodes of network taken by default, i.e. depending on distance of maps (e.g. the distance between countries, cities, villages) or using unrealistic distances, it means don't care about natural preventives (the lakes/rivers, high hills, buildings, etc) so become the suggested topology in common unrealistic.

This problem commonly will cause:

- **i.** Incorrect estimations of the needs of the expensive media which is used in modern IP network (*e.g. optic fiber which is fast and unlimited bandwidth*) and mistake in numbers of other requirements which are needed in IP network like Access-points, SONET, DWDM, regenerator, OA, etc.
- **ii.** Shortage in budgets because the designers make their computations base on unrealistic distances, and that will cause the implement of proposed IP network later impossible, i.e. the designers haven't enough devices, media, equipments, etc for implement.
- **iii.** Later can't done the maintenance for IP Network in easy way (low costs) because may have natural preventives.

3. THE AIM OF RESEARCH

Solving the problem of unrealistic distance between the nodes of IP network and take in consideration all natural preventives, that will give realistic topology, i.e. will obtain real costs to implement and later doing an easy maintenance of networks.

The main goal of this research is obtaining realistic topology using Prim's algorithm base on real distance between nodes rather than default or unrealistic distances (don't care about real distance and natural preventives), so will need a new technique base on **GPS**, **UTM**, and **GIS** packages which are explaining later.

4. NEW TECHNIQUE OF PROPOSING NETWORK'S TOPOLOGY

The new technique of suggestion a network's topology limited in a flowchart involve 6 steps as shown in Figure 1:



Figure 1. Flowchart of new technique for proposing network's topology

5. IMPLEMENTING THE NEW TECHNIQUE

Applying the new technique of proposing network's topology on the campuses of **Academic** Institutes **Net**work in Erbil city is called **AcademicNet** to obtain realistic topology. This application will determine only the media (fibres) need using a new technique as follow:

A. Collecting information about the AcadmeicNet's campuses in Kurdistan-region from <u>M</u>inistry of <u>H</u>igher <u>E</u>ducation and Scientific Research MOHE as shown in Table 1, then get satellite image of Erbil city from Erbil's government.

Campuses Network	Number
University's Colleges + Ministry	24
Institutions	3
Private University	2
Total	29

Table 1: Reveals the AcademicNet's campuses.

B. Find the coordinates of each campus of Table 1 by visiting each campus using GPS, then convert these coordinates to Easting (X) and Northing (Y) using UTM calculator [2,5], which is shown in Figure 2.



Figure 2: UTM Calculator Process

The converting of each campus reveals in Table 2 [6]. Table 2: Converts GPS's coordinates to X & Y by UTM calculator

C. Create Table 2 using MS-Excel, to become ready to use by ArcGis 9.2 as GIS package [9, 4], as referring to in flowchart in section 3

		GPS Coordinate		UTM Calculator	
No.	Campus of AcademicNet's network	Latitude	Longitude	Northing Y	Easting X
1	Ishek university	N36:11:38.90	E44:01:29.20	4005923	412321
2	Shahana Britches collage	N36:13:03.40	E44:00:33.80	4008540	410963
3	SABIS university/Education	N36:12:27.40	E44:00:12.70	4007436	410424
	collage				
4	Dijla collage	N36:13:06.10	E44:00:37.30	4008621	411051
5	Islamic Science collage	N36:11:13.20	E44:01:03.90	4005137	411680
6	Dentist collage	N36:11:58.50	E44:01:15.00	4006530	411972
7	Medicine collage	N36:11:52.50	E44:01:10.90	4006346	411868
8	Fine art collage	N36:11:05.30	E44:00:10.90	4004907	410354
9	Kurdistan university	N36:10:53.90	E44:00:20.60	4004552	410592
10	Medicine university	N36:11:24.40	E44:02:23.80	4005463	413680
11	Management &Economic	N36:09:49.50	E44:00:57.20	4002559	411486
	collage				
12	Dean of agriculture collage	N36:09:38.90	E44:00:52.60	4002234	411368
13	Art collage	N36:09:34.20	E44:00:50.30	4002091	411309
14	MOHE	N36:09:39.30	E44:00:53.70	4002245	411397
15	Human education	N36:09:43.10	E44:00:55.00	4002364	411430
16	Fine art institute	N36:09:29.60	E44:00:45.70	4001950	411194
17	Hawler medicine institute	N36:09:31.30	E44:00:47.30	4002000	411237
18	Agriculture collage	N36:09:44.50	E44:00:49.10	4002409	411283
19	Science collage	N36:09:10.90	E44:01:16.50	4001364	411957
20	presidency of Salahalddin	N36:09:50.50	E44:00:58.40	4002590	411516
	university				
21	Education collage	N36:09:44.40	E44:01:00.00	4002401	411554
22	Teaching collage	N36:08:56.40	E44:01:09.70	4000920	411782
23	Hawler Technical institute	N36:08:37.70	E44:01:01.50	4000374	411571
24	Law collage	N36:08:35.70	E44:01:40.30	4000274	412541
25	Collage of sports education	N36:08:36.20	E44:01:36.00	4000291	412434
26	Collage of Engineering	N36:08:33.10	E44:01:25.40	4000198	412167
27	Hawler Technical collage	N36:08:36.40	E44:02:17.20	4000288	413464
28	Hawler computer institute	N36:10:03.40	E43:58:22.90	4003028	407637
29	Gihan university	N36:10:16.10	E43:57:52.00	4003426	406867

D. Project the coordinates of each campus (X and Y) from Excel file which created in C on satellite image of Erbil city using ArcGis 9.2, then select the optimal distance from multiple options between each adjacent campuses (lowest cost and easy maintenance in future) of AcademicNet as shown in Table 3.

No	Campus-to-Campus (Adjacent Two)	Optimal Distance	No	Campus-to-Campus (Adjacent Two)	Optimal Distance
1	MOHE-to-Hawler Computer Institute	4740	27	Fine art institute-to-Agriculture College	600
2	MOHE-to-Technical Institute	2360	28	Fine art institute-to-Human education	760
3	MOHE-to-Art College	170	29	Fine art institute-to-Economic	940
4	MOHE-to-Agriculture College	170	30	Fine art institute-to-Medicine university	5850
5	Hawler Computer Institute-to-Science	6100	31	Slahaldin presidency-to-Agriculture deans	515
б	Hawler Computer Institute-to-teaching College	6260	32	Slahaldin presidency-to-Human education	225
7	Hawter Computer Institute-to-sports	7740	33	Slahaldin presidency-to-Economic	70
8	Hawler Computer Institute-to-Economic	4890	34	Agriculture deans-to-Humane education	270
9	Technical Institute-to-Art College	1750	35	Agriculture deans-to-Economic	470
10	Technical Institute-to-Law College	1400	36	Human education-to-Economic	200
11	Technical Institute-to-Technical College	2520	37	Kurdistan university -to-Islamic science	1700
12	Art College-to-Education science	315	38	medicine institute-to-Kurdistan university	3030
13	Art College-to-Agriculture College	435	39	Kurdistan university-to-Fine arts collage	680
14	Science College-to-Teaching College	680	40	Kurdistan university-to-Economic	2610
15	Science College-to-Sports	2150	41	Kurdistan university-to-Shahana British	4620
16	Science College-to-Eng College	1700	42	Fine arts collage-to-medicine university	4540
17	Science College-to-Dijla Private University	8420	43	Fine arts collage-to-Fine art institute	3500
18	Teaching College-to-Sports College	1030	44	Islamic science-to-Medicine institute	3760
19	Teaching College-to-Eng College	1000	45	Islamic science-to-Ishek university	1680
20	Sports College-to-Eng College	1500	46	Collage of medicine-to-Ishek university	1030
21	Law College-to-Agriculture College	3200	47	Collage of medicine-to-Shahana British	3180
22	Law College-to-Technical College	2445	48	Shahana British-to-Sabis	2135
23	Education science College-to-Agriculture College	340	49	Sabis-to-Dijla	2050
24	Education science College-to-Technical College	4450	50	Dijla-to-Gihan	8100
25	Agriculture College-to-Law College	2850	51	Collage of medicine-to-Dentist	560
26	Fine art institute-to-Salahaldin presidency	990			

Table3: Optimal/Realistic distances in meters between adjacent campuses (via ArcGis 9.2)



E. Use the 51 distance of Table 3 in implementing Prim's algorithm via java applet to obtain realistic topology of AcademicNet which contains 29 campuses (nodes) as shown in Figure 3.

Figure 3: Implement Prim's algorithm for AcademicNet's topology using java applet

F. Project the realistic topology of AcademicNet which is obtained in E on the satellite image of Erbil city via ArcGis 9.2, as shown in Figure 4 to make AcademicNet ready for designer to obtain accurate computation for implementation and maintenance in future.



Figure 4: Projection a realistic AcademicNet's topology (obtained in E) using ArcGis 9.2

5.1 Comparing the topology of new technique with default topology

Table 4 shows comparison between the new technique of suggestion topology of network which is applied on AcademicNet with another topology of the same campuses network for Erbil city within "Designing of <u>K</u>urdistan <u>S</u>cientific <u>Information Intranet Network</u>" is called KSIIN, the topology of campuses in KSIIN is obtained by implementing Prim's algorithm base on default distances (i.e. don't using GPS & GIS) between the campuses [7].

No.	Characteristic	AcademicNet's Topology using new technique of GPS & GIS	Topology of campuses in KSIIN which obtained without using GPS & GIS
1	No. of campuses & edges	29 campus and 28 edge	26 campus and 25 edge
2	Coordinate & distance	Depended on GPS device and real distance using GIS program	Depended on pixels of monitor and default (unreal) distance
3	Software	Additional of Java applet will use GPS, UTM, Excel/SPSS, and GIS program.	Using java applet program only
4	Environment of Projection	The projections of nodes are applied on satellite image of Erbil city using GIS	The projections of nodes apply on the map of Erbil city
5	Length of Media(Fiber)	57125 meter	11465 meter

Table 4: Comparison the topology of new technique with the default topology

5.2 The experimental results

The new technique of proposing topology is fault-tolerance in determination of the distances or coordinates for campuses, this cause a different topologies for the following reasons:

- **a.** Using the GPS and there aren't previously fixed points (labels) for campuses that make at another time (e.g. implementation stage) or when another person determine the coordinates of nodes (campuses) this will cause by differing distances.
- **b.** Depending on un-recent satellite image for the location (city, country, etc) that will make later the projection of coordinates using GIS with recent satellite image gives differing distances.

For example Table 5 reveals two different determinations of distances for the same collection of campuses in AcademicNet, the difference just in (1) and (2) of Table 5 supposing happened for the reasons (a) or (b) above that difference in distances will give different topologies. Figure 5 appears the topology for the collection of AcademicNet's nodes using the first determination of distances in Table 5 with the shortest path (minimum distance which are colour by blue in Figure 5) for the topology calculated (**24000** meter), while Figure 6 reveals

another topology for the second determination of distances in Table 5 for the same collection of AcademicNet's nodes, by shortest path calculated (**22120** meter).

No	Campus-to-Campus(Adjacent Two)	First Determination in Meter	Second Determination in Meter	
1	Hawler Computer Institute -to-Science	6200	6100	
2	Hawler Computer Institute -to-teaching College	6160	6260	
3	Hawler Computer Institute -to-sports	7740	7740	
4	Hawler Computer Institute -to-Economic	4890	4890	
5	Science -to-teaching College	680	680	
6	Science -to-sports	2150	2150	
7	Science -to-engcollege	1700	1700	
8	Science -to-dijla	8420	8420	
9	sports -to-engcollege	1500	1500	
10	teaching College -to-sports	1030	1030	
11	teaching College -to-engcollege	1000	1000	

Table 5: Different determination of distances for collection of AcademicNet's nodes



Figure 5: Shows topology of *1st* determination of distances for AcademicNet's nodes collection



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Figure 6: Shows topology of 2nd determination of distances for AcademicNet's nodes collection

6. CONCLUSIONS

Applying the new technique of suggestion topology for network gives the following conclusions:

- The optic fibers which is needed in AcademicNet's topology using the new technique is different by 45660 meter than topology's campuses in KSIIN which obtained without using GPS and GIS as shown in Table 4; 5, i.e. if take in consideration the extend in academic institutes of Erbil at the interval between proposed the two topologies as referring to in subsection 5.1, will see topology's campuses in KSIIN's computed 20% only from media, so there is disability in cost (budget) ≅ 4 times than AcademicNet's topology.
- 2. The other requirements will affect by that shortage in distances, i.e. the effect can see in following levels:
 - **i.** Network of access-points (campuses), may need ATM switches (which are covered more distance but expensive) more than routers.
 - **ii.** SONET's network the shortage in this level will require more numbers of regenerators, Add Drop Multiplexer **ADM**, etc.
 - iii. Backbone (DWDM) network the shortage of distance will cause needing more OAs, Optic Add Drop Multiplexer OADM, etc.
- **3.** Realistic distances of campuses are taking base on streets/roads of Erbil city to avoid the natural preventives this will cause lowest cost for network maintenance in future.

4. Avoiding the fault in determination of the distances or coordinates of the network's nodes as referring to in subsection 5.2, by determining previously fixed point (label) for each node and dependence on recent satellite image.

REFERENCES

- [1] Algos, copyright (2004) "Prime's algorithms", INRIA, UNSA.
- [2] Abdel-Rahman, I.K. (2009) "Analysis and Planning of Kurdistan Regional Power System", MSc thesis of science in Electrical Engineering, University of Sulaminya.
- [3] CMC Microsystems (2007) "NATIONAL DESIGN NETWORK ", Canadian Microelectronics Corporation April 18.
- [4] Garmin, Copyright © (2010) "What is GPS?" retrieved from http://www8.garmin.com/aboutGPS.
- [5] International Journal of Geographical Information System Applications and Remote Sensing (2010), Copyright © ICSRS publication, Vol. 1, No. 1, July 2010, ISSN 2077-771X.
- [6] Saber, N. S. (2011) "Spatial Planning of the Topology of an Optic Metropolitan Area Network MAN or the Erbil Academic Institutions", Higher diploma project in Spatial Planning Institute, University of Duhok, Duhok-Iraq.
- [7] Shamoon, D. F. (2008) "Designing of Kurdistan Scientific Information Intranet Network), MSc thesis in software engineering dept, University of Salahaddin Erbil-Iraq.
- [8] Shin'ichi Arakawa, Naoto Hidaka, and Masayuki Murata (2011) "A Modeling Method for Router-Level Topologies based on Network-Cost Optimization", International Journal of Computer Networks & Communications (IJCNC) Vol.3, No.5, Sep 2011.
- [9] Sriharsha Vankadara (2005) "GIS Based Topological Modeling for Infrastructure Systems" MSc thesis in George Mason University.
- [10] Vojtěch J., Novák V. (2008) "Deployment of a DWDM system with CLA Optical Amplifiers in the CESNET2 Network", Technical report, CESNET.

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