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Minimum Route Distance Estimation to facilieies in Azarbayjan Regional Electeric Company

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Abstract:

Primary goal of any utility is to plan and manage the use of facilities to deliver a commodity such as water, natural gas, or electricity to its customers. GIS is used for monitoring and planning power generation resources. Sophisticated spatial analysis is useful for determining optimum generation, distribution, studying environmental impact, and managing facility assets. GIS is used to spatially analyze network congestion, consider growth opportunities for renewable energy sources, determine site feasibility, and create energy resource market scenarios. Network analysis has a strong theoretical basis in the mathematical disciplines of graph theory and topology, and it is the topological relationships inherent in networks that led to revolutionary advances in GIS data structures. Power companies are using new business strategies to better manage and improve service. In the Regonal Eletrical Company of Azarbayjan like other companies around the world in the first step required spatial data collected and prepared for GDB construction according to the conceptual models which structured by governmental power supervisor company (Tavanir Co). Considering the necessity of keeping the GDB up to date, this study has analysed the methodologies by which it could be possible to quantify the optimal length of transmition roads to access to the electrical entities for instance substitutions, etc and to automatically visualise the related recommended routes.

Key words: GIS, Electrical, network analysis, access route.

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Introduction

Electric companies were instrumental in launching the modern world when they began delivering energy to cities, businesses, and homes. Thomas A. Edison, who formed the Edison General Electric Company in 1890, said, "If there's a way to do it better—find it." Today's electric companies continue to find that better way by using GIS in all parts of their network and business operations. Around the world, GIS is advancing management of generation, transmission, and distribution operations.[8]

GIS is about discovery. It is about visualizing trends for better decision making. It is about finding weaknesses in electric utility infrastructure before disaster hits.

GIS is most powerful at a utility when it is integrated into the IT infrastructure. This allows electric companies to visualize data in the form of intelligent maps in systems such as customer, supervisory control and data acquisition (SCADA), work management, and financial and human resource systems.[8]

Today, is a time of major change in the utility industry. Privatisation, deregulation, and the

introduction of advanced technology are all having profound impacts on utilities. Nowadays, GIS plays a major role in modern management of electric utility companies. GIS is a fundamental tool in the areas of suitability analysis and the optimum route finding for high voltage lines, the profile analyses, the engineering design of towers and wires, and the cost estimation, power outage and load study analysis. GIS is not only useful in developing accurate database, improve internal efficiency levels pertaining to power supply monitoring, commercial and customer services but also extremely useful for important functions like network analysis, facility management, energy saving, event and load management, theft detection etc. Digital system provides timely, accurate and easier way of acquiring information, which is very vital in taking prompt and accurate decisions necessary in the economic development of any enterprise/ industry.

Conceptual model of a GIS provides a useful way to visualize it as a set of map layers or themes, all were over laid together in a common map base. In the last few decades, the electric power sector has been developing power substations, transmission, high voltage and low voltage lines to keep up with the rapid growth of the power demand. On the other hand, the optimum locating of routes for new substations and transmission lines has been getting restricted, due to development of rural areas and the growing concern over environmental and economical issues. Information of best locating voltage and distribution of electricity of these facilities seem to be very crutial .However, setting up GIS system could solve this problem wisely, linking the database to map and also integrating GIS with other company systems that called national SDI. Since GIS databases are updatable it thus caters for the needs of maintaining the enormous power infrastructure.

GIS effectively manages information on the distribution of electricity to customers and information describing the attributes of each customer such as location, contacts and electricity use. Power companies use GIS for management of the network of electrical features. GIS is a valuable tool not only for mapping facilities but also in improved decision making and better managing infrastructure. Although the needs and uses of GIS are slightly different in the power sector than other industries, GIS is just as valuable as an information technology in the electric utility industry.

Installations on the power network are mapped digitally using DGPS or hand GPS and digitization facilities of the GIS software creating a digital map of all the supply areas with the precise location and engineering information. GIS in electric power companies has been incereasingly used for the study and analysis for electrical distribution system, analysis and design, suitability analysis. GIS can also be integrated with the transport management system which reduces response time remarkably. GIS and GPS could be also integrated for mobile mapping and analysis of electric distribution circuits. Utilities throughout the world are facing unprecedented change.

No longer are energy and water providers able to rely on regulatory protection of territory and customers. Accurate use of spatial data is one of the key areas of focus for many electrical, gas, and water utilities.Improved hardware, software, and networking technology have created opportunities for the utility industry to build and benefit from more comprehensive and sophisticated GIS. GIS applications have evolved from their foundation in map production to advanced analysis tools for planning and operations. GIS products are commonly used by utilities for marketing, facilities location, and engineering applications.There are two common objectives a GIS system: decrease expenses and improving energy transmition. Broadly speaking, In electrical companies GIS could be applied for:

1- Information Retrieval: For example, if an engineer needs to know the voltage of a given transformer, all that he has to do is to click on that transformer symbol. The attributes attached to this transformer will show him the data. Another time if he wants to assess the requirement of a cable to be laid along a certain road, the GIS will return him the results of processing considering even all the bends and turns the road may have. The cable length so shown by the GIS will be precise and will therefore help him evaluate the exact required quantity of the cable.

2- GIS in Maintenance & Monitoring: The electrical network could be overlaid with a satellite image or a vector base map in GIS, with the facility for zooming, resizing and scrolling. Availability of accurate GIS-based distribution network map showing the geocoordinates and network configuration is an important prerequisite for analysis, planning, optimization and load flow studies. Proper GPS survey and creation of an accurate digital base map for the distribution network is essential for a successful GIS implementation. Considering an engineer wants to send a cable jointer in the field to access a certain underground cable joint. The engineer can take the digitized map file of the area, mark a small portion of that area in the neighborhood of the joint, and print that small part on a piece of paper. This printed map of that small area will show, to the jointer, the location of the joint with proper distance and bearing references to the nearby identifiable objects. With these references so readily available with the jointer, his work will be easy and quick. There will be no need for him to have any guesswork or to constantly contact the office for knowing the joint location.

3-GIS in site identification: Evaluation of topographical data or sattelighte imags of a study site in GIS softwares could give a view of how the project will affect the environment which is a requirement Environmental Impact Assessment for electric power projects such as transmission, distribution lines and substations.[3]

4-Data management: Through digital image processing in an integrated syetem of Remote sensing-GIS it is feasible to identify even small features. To select site for putting new transmission towers and lines especially in hilly terrains, the density of trees, elevation differences has to be carefully studied indetail. In such cases, remote sensing plays a vital role for the preparation of database on landforms, landuse/landcover and related database. This information is integrated in GIS platform, enabling one to generate threedimensional terrain model (DTMs) of the area, which can be further updated with the multidated satellite images and aerial photographs.[6]

5- Cost Efficiency: is the most prominent characteristic of a GIS based- system. For instance, CenterPoint Energy, in Houston, Texas, is America's third largest combined electricity and natural gas delivery company, with more than five million metered electric and natural gas customers. It is also the third largest employer in the energy industry. The power company implemented a comprehensive enterprise GIS installation that includes links to its financial, customer supply chain, environmental, and asset management systems. CenterPoint's decision making, communication of assets, and collaboration processes have all benefited from the enterprise approach. In addition, an underground location tool GIS application saved CenterPoint $1 million in the first year it was implemented. [8] GIS system combines various layers of information about a place for better understanding and depending on the purpose, different layers can be put together for better analysis. The literature reveals that, a well-designed GIS based transmission and distribution network may help minimize loss of electricity and enable pooling of supply and demand in order to maximize efficiency of the electric power system and reduce environmental impacts of power generation. [7]

Map data used by GIS are collected from existing maps, aerial photos, satellites, and other sources. A digitizer or similar device is used to convert compiled map data to a digital form in order to make it computer compatible. This transformation allows the storage, retrieval, and analysis of the mapped data to be performed by the computer. Maps produced by a GIS are typically displayed on computer monitors or are printed on paper. The power of GIS lies in its ability to analyze the data and to present the results of that analysis as more meaningful information than any other traditional systems. [9]

ArcGIS is used to create, import, edit, query, map, analyze, and publish geographic information.[8] GIS is an important tool where the value of visual feedback is used to supplement the detailed result tables coming from circuit analysis tools. Geographic based circuit maps let us explore ways to improve circuit performance through more accurate placement of capacitors and this helps reduce power losses and improve operating voltages.

In short, GIS can be used in distribution systems management for:

- Fault Management
- Routine maintenance can be planned.
- Network extensions and optimization
- Network reconfiguration
- Improved revenue management
- SCADA can be integrated with GIS
- Rights of way and compensation [7]

This study examines how GIS has been used by electrical, gas, and water utilities. It has focused on transportation network management. Critical utility applications include network analysis, layer editing, OD matrice analysis and route managements, network modelling, and executive information systems are briefly examined.

Materials

1-shapefile of transportation lines including: Highways, Freeways and streets.

2-shapefile of the substitutions under the supervision of Regional Electrical Company of Azarbayjan

3-shapefile of the central office of the company

4-cities of the teritory

In the figure 1 the materials is mapped using ArcGIS software.

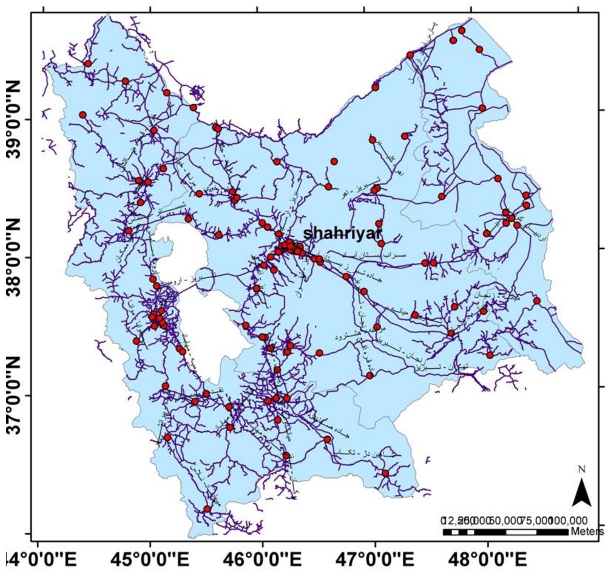


Figure1: access roads and substitutions of regional electrical company of Azarbayjan

Method and Results

Networks model the transportation of people and resources such as water, electricity, gas, and communications. Networks constrain flow to edges such as streets and river reaches, which join at junctions such as intersections and confluences. The geodatabase has two core network models: the network dataset models transportation networks; and the geometric network models directed-flow systems such as river networks and utility lines. Networks pervade our daily life. We drive cars from home to work on a street network, cook our dinners with natural gas delivered through gas utility lines, catch up with news and send emails through the internet, and visit relatives by flying on an airline route system. Networks can represent an alternative datum for geo-location in the context of linear referencing and support a set of tools for graphical display known as dynamic segmentation. Many network location problems are among the most difficult to solve in terms of their combinatorial complexity and, therefore, provide both a challenge and an opportunity for GIScience researchers.

Networks channel flow. Certain phenomena flow in a continuous field across a region, such as rainfall or temperature. But rainfall collects into streams, and nearly all resources that we process or goods that we manufacture flow in a constrained way, carried along networks of streets, pipes, cables, and channels. A network is a one-dimensional system of edges that connect at conjuctions that transport resources, communications, and people. Three common types of networks are transportation, rivers, and utility networks. In this study, transportation network is discussed.

Transportation networks

Transportation involves the movement of people and the shipment of good from one location to another. Streets are the ubiquitous network—everyone spends a fraction of every day traversing this network. Streets have two-way flow, except for situationsuch as one-way streets, divided highways, and transition ramps. Streets form a multi-level network. While most roads are at surface level, bridges, tunnels, and highway interchanges cross each other in elevation; a simple overpass has two levels, a highway interchange typically has four.

People make their daily travel optimal by hopping from one mode of transport to another, switching between walking, driving, riding a bus or train, and flying. People also use natural hierarchies in the transportation network. Trips of any distance usually begin by driving to the closest freeway on-ramp and proceeding to the off-ramp closest to the destination. Street, rail, and subway systems have well-defined geometry for the edges of the network, but transportation systems such as airline routes and shipping lanes have indeterminate or variable edges with geographic junctions at airports and harbors.[4]

Creating a network

Network datasets are more analogous to a geodatabase topology a network dataset has network sources defined on simple features. These features undergo no modification and can also participate in a topology.With network datasets, you can update connectivity on demand with a rebuild of the entire network. Network datasets better model undirected networks. They allow flow in any direction and employ turns to model restrictions. Network datasets have an attribute environment that uses costs, descriptors, restrictions, and hierarchy. Network datasets are optimized for large transportation networks. In this study he network dataset was created using Arccataloge which is depicted in the figure 2.

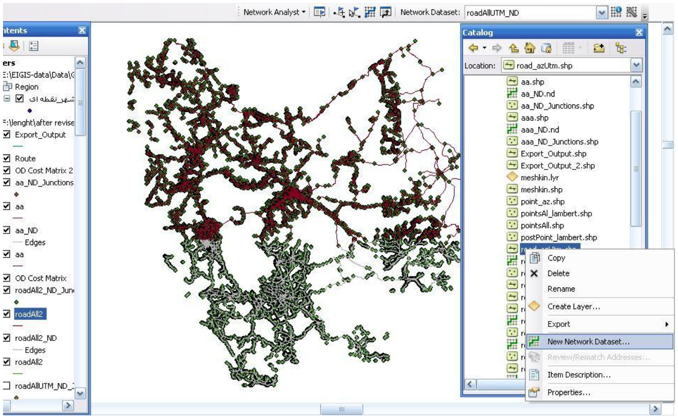


Figure2:Network creation using layers of roads and substitutions

Before creating network, all layers had been modified and corrected for errors following the steps which are explained below:

1- Convertion of substitution layer from polygon to point:

2- Maintaining the connectivity of roads using topology(figure3). In the figure 3 the discrete features are recognised with creating topology and then the discountinous lines were corrected.

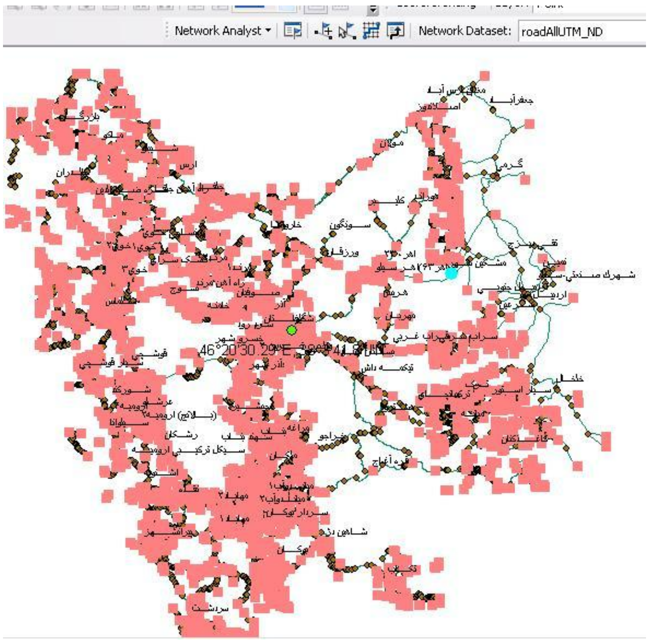


Figure3: monitoring discountinous lines and discrete points using topology toolbar

3- Road planirizing for creating flow in the network(figure4)

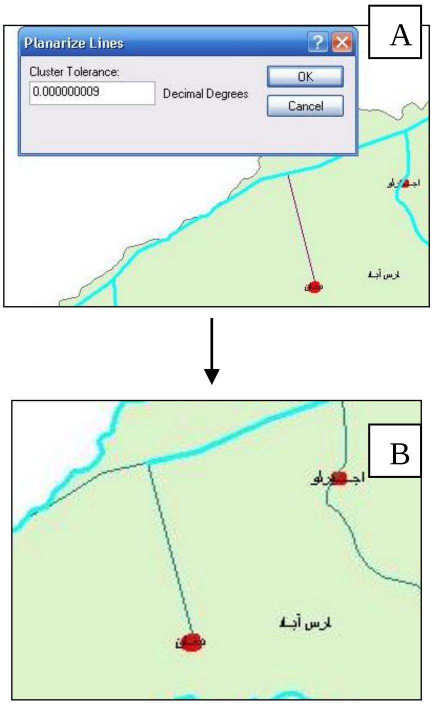


Figure4: A)before planarizing B)after planarizing(all the features divided in conjuctions to create network flow

4- Snapping the substituion points to roads with a defined distance(figure5)

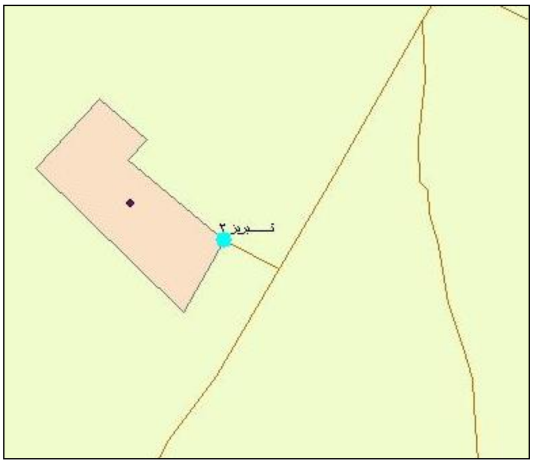


Figure5: 1-conersion of polygon to point 2- snapping the point to the nearest access road

Managing network connectivity

A key difference between geometric networks and network datasets is how network connectivity is maintained. A geometric network is made initially from simple line and point features, which become junction, simple edge, and complex edge features. Once created, network connectivity is continuously updated during edits.

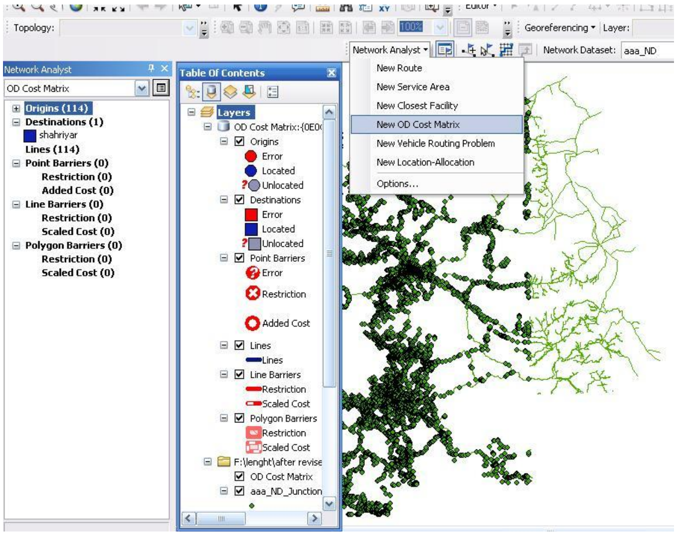
A network dataset has network sources from which a connectivity model is discovered on demand. Geometric networks and network datasets have logical networks. A logical network is a set of tables representing network elements and their connectivity. Forgeometricnetworks, the logical network is incrementally updated through edits. For network datasets, you regenerate the logical network with every network build.[4]

Network analysis

1-Od matrice: The closest facility and OD cost matrix solvers perform very similar analyses; the main difference, however, is in the output and the computation speed. OD cost matrix generates results more quickly but cannot return the true shapes of routes or their driving directions. It is designed to quickly solve large M x N problems and, as a result, does not internally contain the information required to generate route shapes and driving directions. Alternatively, the closest facility solver returns routes and directions but performs the analysis more slowly than the OD cost matrix solver. If you need driving directions or true shapes of routes, use the closest facility solver; otherwise, use the OD cost matrix solver to reduce the computation time. [1]

The closest facility solver measures the cost of traveling between incidents and facilities and determines which are nearest to one other. When finding closest facilities, you can specify how many to find and whether the direction of travel is toward or away from them. The closest facility solver displays the best routes between incidents and facilities, reports their travel costs, and returns driving directions. In this study the OD cost matrix was estimated to measure the traveling distances between central office and all electric sustitutions distributed in the network. [2]

In the window of OD Cost Matrix, the origin (substitutions) and destination (central office) were entered and the minimum distances could be obsereved in the figure7



Figre6: OD matrix estimation

Lines

Total_Length	Name
183554.773222	سردار بوکان - shahriyar
15736.345227	تراکتورسازي - shahriyar
13717.063731	ماشين سازي - shahriyar
31751.269912	سبار شهرک سرمايه گذاري خارجي - shah
4243.379192	شفا - shahriyar
24363.396853	سبار شهرک پاک - shahriyar
48286.664111	بستان آباد - shahriyar
10957.956267	راه آهن تبريز - shahriyar
11132.632424	قراملک - shahriyar
6586.252274	اماميه - shahriyar
172572.365874	قره آغاج - shahriyar
100483.552992	هشترود - shahriyar
273354.982315	کاغذکنان - shahriyar
169384.253952	خراجو - shahriyar
272135.233276	سبار استور - shahriyar
167419.137442	ترک - shahriyar
68557.721398	تيکمه داش - shahriyar
123286.427405	ترکمانچاي - shahriyar
245575.938335	ميانه - shahriyar
122940.058934	هريس - shahriyar
108079.516997	اهر ۲۳ - shahriyar
102965.75856	اهر سيلو (اهر ۶۳) - shahriyar
164065.984399	هوراند - shahriyar

Figure7: minimum distance of access roads

Monitoring the closest route

2-Applying route estimation in the network analysis tool, the route which indicates the minimum traveling distances between central office and substitutions along the access roads could be extracted. One of the traveling routes is shown in the figure 8.

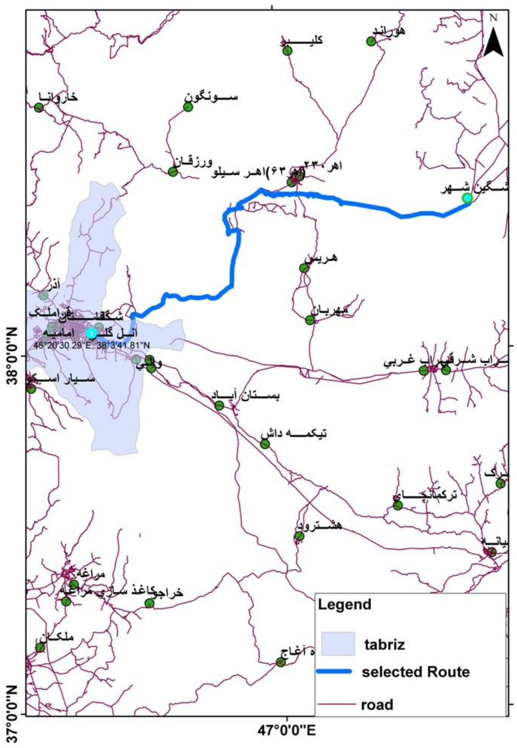


Figure8: the route monitoring (one possible example is the green curve from central office to Meshkinshahr substitution)

Conclusion

The capability of GIS for displaying and analyzing information from diverse sources provides suitable and appropriate solutions for any ground base networks.[5] In case of power systems, GIS enhances its visualization by associating spatial data with transmission and other assets. To take proper decisions, information must be collected and analyzed to its full extent. Information on the facilities, their condition and their connectivity is important in taking control decisions. With the use of GIS, power companies can collect and store a large amount of data that can be readily accessed and analyzed. Hence, GIS and its applications play an important role in modern power system planning, analysis and control. Thus there is a wide variety of disciplines with interests related to network analysis, and a well established ability within GIS to model networks and perform such analyses. This strongly suggests that network GIS will be a dynamic sub-discipline within geographic information science for the foreseeable future. The growing interest in GIS network analysis may lead to an increased pace of innovation in this field and more rapid integration of scientific advancements into software packages.[5] In this study, we have considered transport accessibility and calculated access to each substitution independently of others. This enabled the economical and cost analysis of any transport in the company. Thus, more reliable decision making could be feasible. Moreover, the study emphasizes the essence of GIS and Spatial Informatics in Electric Power Systems and its major rule in optimized transportation system by determination of nearest access to facilities that will transform the power sector, which is extremely important for any growing developing country like Iran.

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