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Improving Efficiency of power sectors by using GIS

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Abstract:

Electricity is universally accepted as an essential commodity for human beings. It plays an important role in overall growth and development of a nation.

Efficient functioning of utility is essential to sustain the growth of power sector and economy. After passing of electricity act 2003 by the Parliament, Electricity utilities in India underwent unbundling such as GENCO, TRANSCO, and DISCO. At the time of passing this act the utilities were facing severe problems because of lack of modernization and were also incurring huge losses due to which their survival was difficult.

In addition to restructuring initiatives, it is required that some latest and modern systems be utilized for improving efficiency of power sectors. GIS is a competent and effective tool for managing transmission and distribution activities. GIS can be effectively used for transmission line route alignment and managing electricity distribution facilities. It has the ability to improve upon traditional practices and hence today it has become an important aspect in power delivery.

1.0 Introduction:

GIS is a computer-based tool for the storage, manipulation, and analysis of geographically referenced information. It is a system of hardware and software used for performing multiple functions related to geographic data.

GIS are now used extensively in government, business, and research for a wide range of applications including environmental resource analysis, land use planning, location analysis, tax appraisal, utility and infrastructure planning, real estate analysis, marketing and demographic analysis, habitat studies, and archaeological analysis. The most important application to the electrical field is in utilities and power sectors.

The advantages of using GIS in electrical engineering applications are manifold. Some of the advantages are listed below:

- With GIS, one can manipulate and carry out tasks that are vital in management of electricity for proper and efficient results.
- When new facilities are installed, GIS database can be updated easily to accommodate new features. Thus map revision and digital mapping become easy in GIS environment.
- It is useful in planning of routine maintenance.
- Customers' enquiries can be handled easily.

▪ Sharing of data among different users simultaneously is possible.

▪ The results provide equally good information for other professionals such as Urban Planners to plan better, Construction Managers to reduce damages in construction work, Civil Engineers to locate problem areas quickly.

This paper outlines and reviews the use of GIS in optimal transmission line route alignment, distribution utilities for planning. The software like *CORman* and *ENIman* used for such purposes, their features, advantages and limitations of GIS are enumerated in this paper.

2.0 About GIS

A conceptual model of a GIS provides a useful way to visualize it as a set of map layers or themes, all registered together to a common map base or geographic area. Each layer typically contains one type of data.

There are two types of data namely, aspatial and spatial. Aspatial (alphanumeric) data can be easily converted to digital form but spatial (related to location and geography) cannot be digitized easily. To achieve accuracy for handling and managing both spatial and aspatial data, an efficient system like GIS can be used. In GIS, however, the number of registered map layers that can be collected and stored is theoretically infinite. The user can quickly retrieve, overlay, manipulate, and analyze any number or combination of layers. The user can then assess the results of the analysis on a computer screen or on a hard copy paper map produced by the GIS, or can summarize the results in a tabular format.

Management of electricity in transmission and distribution can be done efficiently using GIS.

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3.0 Challenges faced by Indian Utilities:

. Automation and use of sophisticated equipments by consumers demands better quality of power. Hence along with generation and transmission of power now utilities have to concentrate on quality of power.

Challenges faced by utilities are listed below:

- Shortage of power has created a large gap between supply and demand.
- Lack of effective control, co-ordination and proper communication.
- T & D losses upto 35%.
- Frequent interruptions, flickers and poor voltage are the issues of power quality.
- Revenue collection is poor due to which financial losses are higher.
- Lack of investment in power sectors due to which no modernization is possible.
- Most of the substations and transformers are affected by overloading.
- Negligent attitude of employees towards the problems of consumers due to monopoly in power sector.

4.0 GIS application to utility for efficiency improvement:

4.1 GIS application to transmission system management.

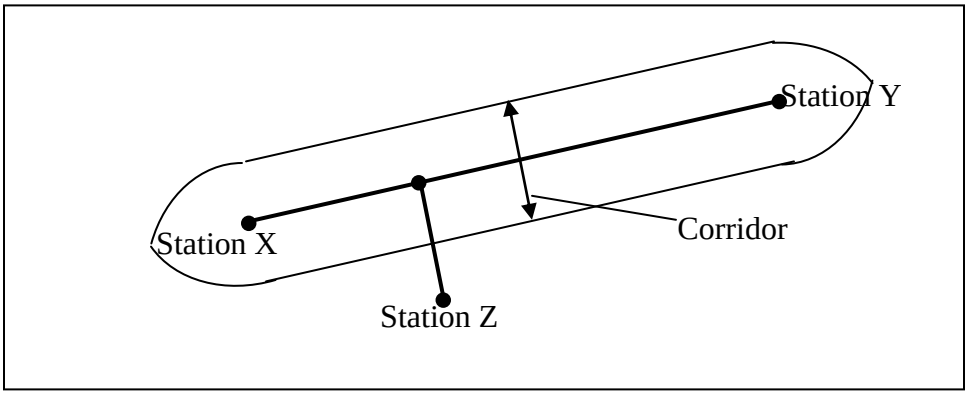
GIS can play a major role in designing, planning, corridor mapping, route identification, and cost-benefit analysis for power transactions.

Conventional methods adopted in transmission system are based on available paper maps, knowledge of person present in the field, survey of India toposheets, route walkover to define alignment, etc. Thus, the work approach is mainly based on thumb rules and preconceived notions.

Most of the drawbacks of conventional methods can be overcome by the *GRAP* approach.

The sequential steps involved in *GRAP* for route alignment process are as follows:

1. Prepare map of Area of Interest (AoI), which includes area around the two end points of the proposed Transmission Line.
2. B-line is then drawn – it is just a straight line connecting two points.
3. Around the B-line a corridor is marked with a width of 8 Kms. on each side. Thus AoI is identified.



4. After this SoI (Survey of India) toposheet index map is prepared for commencing digitization process.

   The layer wise information digitized from SoI toposheets include:
   - ✓ All major and minor roads.
   - ✓ Water bodies like rivers, canals, etc.
   - ✓ Railway networks.
   - ✓ Power and communication line crossings.
   - ✓ Historical and forest areas.
   - ✓ Play grounds, parks, stadiums, airports, etc.
5. Satellite imageries, which encompass AoI, are also identified.
6. Satellite coverage of AoI is browsed to verify quality of data. The merged data is enhanced using suitable filter circuits.
7. SoI topological maps on 1:50,000 scales covering the AoI are purchased from SoI.

8. SoI toposheets are scanned to the required resolution in color and digitized using CAD software.
9. Toposheets are projected to the desired co-ordinate system.
10. Toposheets are updated using georeferenced, satellite images.
11. Corridor maps are generated using updated digital vectors.
12. Detailed study of vectors is done to identify and choose three different suitable alignments using the defined factors. Alignments are identified using **CORman** application (Corridor Manager-it is a tool developed for automatically identifying the alternate route alignments and it is a user interface) by an expert to select the optimal route for transmission line.
13. Vector maps generated along with the marked route alignment are plotted in color.
14. **DTM** (Digital Terrain Model) is generated from the contours derived from SoI maps.
15. A model called **fly-through** model is generated to view the corridor along the alignments chosen.
16. Depending upon various constraints, such as reserved and protected forests, populated areas, flood-prone, marshy areas, national highways, railway lines, communication lines, etc., select the optimal route of alignment.

Similarly GIS is significantly useful during planning, acquisition, and implementation stages of any transmission line projects**.**

Modules of CORman:

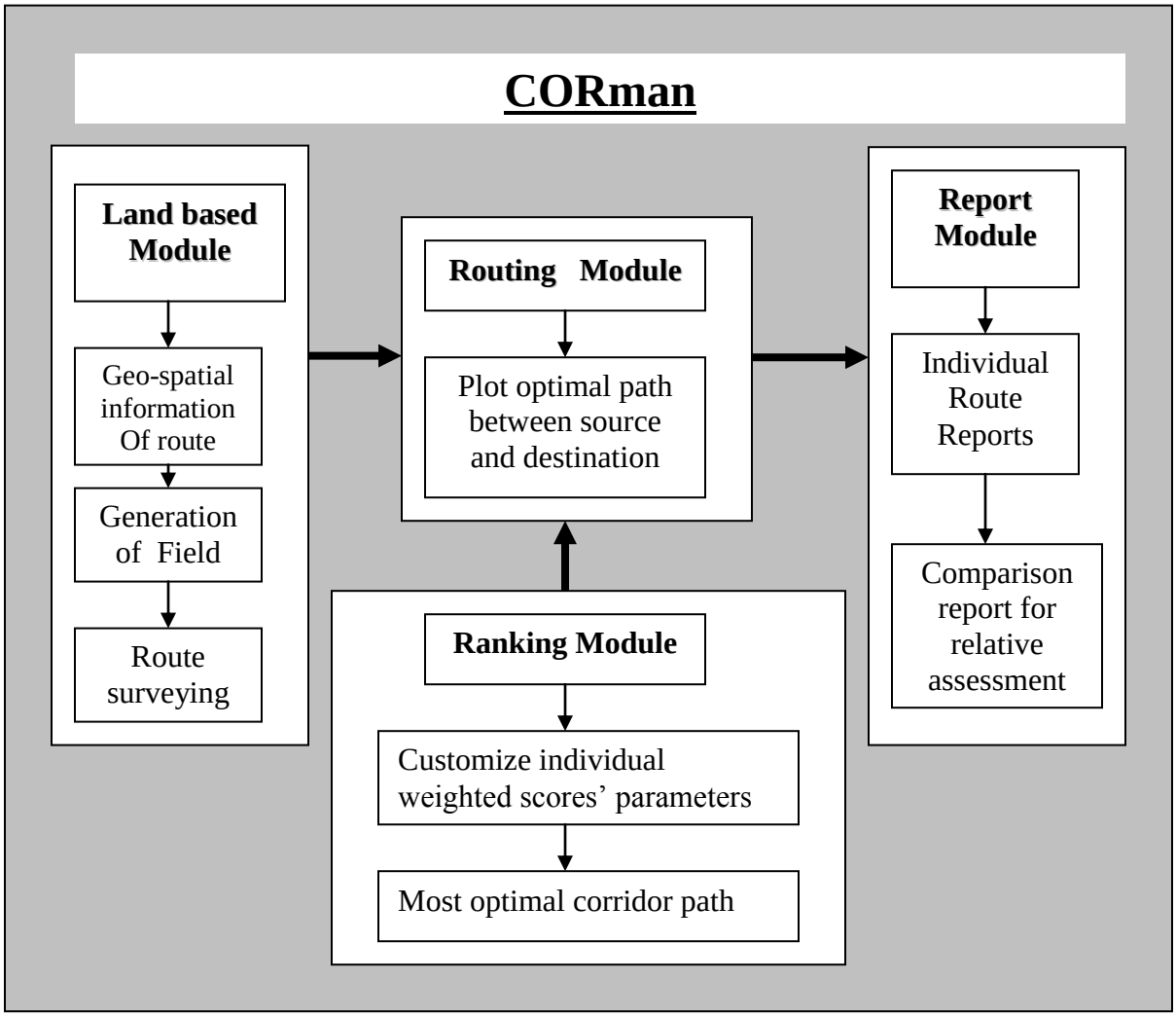
- **Land Base:** This module gives geospatial information of the route and surrounding terrain. It is useful in generating the field maps which will guide field engineers during route surveying.

- **Ranking:** It assigns weighteges to the selected possible route alignments. From the weighted scores the most optimal corridor path is selected.

- **Routing:** This module plots the optimal path between source and destination locations.

- **Report:** Individual route reports and from that comparative report is produced for relative assessment.

The block diagram of CORman features is drawn below,



4.2 GIS application to distribution system management.

To run distribution system efficiently for providing reliable service, it is required to manage geographic information, which can help engineers to operate the system as per the requirement.
GIS can be used for mapping complete electrical network including customer supply points. The process is called **eMAP** (electronic Measure And Plot). The steps involved are as follows:

1. The images obtained from satellites are geo-referenced to real world locations based on latitude and longitude positions obtained from soI toposheets/GPS. The land base features are captured in different layers like landmarks, buildings, rivers, railway crossings etc.
2. To display and analyze the information up to the consumer level scale of

mapping should be large typically from 1:500 to 1:2000.

3. Convert the paper maps and other records into digital form for capturing the spatial and nonspatial information. Once all the records are converted to digital form the user interface can be used to analyze further information.
4. For cases where network data is without a land base, a base map will have to be generated first . The base map can be created using SoI toposheets, high resolution satellite images, aerial photographs, GPS (Global Positioning System). It is an optimal approach in preparing the digital data.
5. Schematic diagrams of the network are prepared which are used for overall understanding of the network. Electrical features described in schematics with dimensions are also captured. These electrical features include cables, poles, conductors, transformers, etc.
6. The collateral schematics are prepared which include detailed drawings like substations, important cable sections and other equipments. These diagrams are also captured over the digital land base by identifying the location using road names and available landmarks.
7. After the above steps are completed maps are built with topology (spatial relationships). During this process, highlighted errors like undershoots, overshoots, silver polygons, pseudo nodes, etc., are removed. Once the data is made free from errors, it is cleaned for topology building that will check for intersection, correct geometric co-ordinates, etc.
8. Business processes such as network planning, repair, maintenance, connection and reconnection will also be based around the network model. Spatial analysis, query building, network tracing, and other interactive functions are then added by developing an application around the data model. The software, which uses all these functions in an interactive manner, is the **ENIman (**Electrical Network Information manager), which is a GIS based application for distribution sector. It also includes queries, interactive editing, network trace, report generation, analysis, etc.

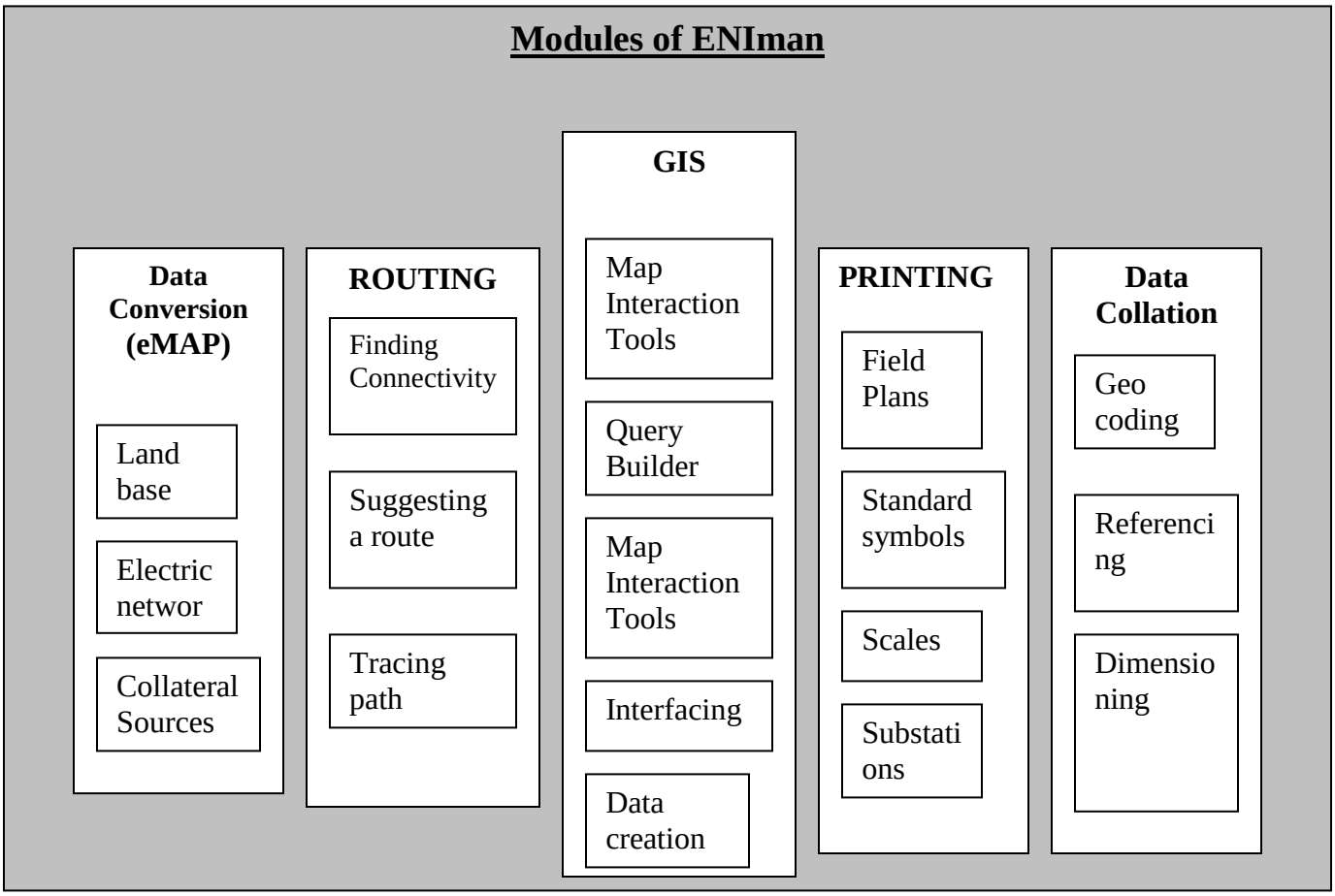
Thus GIS is the backbone to distribution utilities for providing higher levels of data integration and consistency and thus meeting customer needs and expectations.

Modules of ENIman:

- **Data conversion (eMAP):** This module creates digital map of electric network based on network data model. It consists of landbase, electric network, collateral sources as inputs.
- **GIS:** It contains query builder, map interaction tools, interfacing, data creation etc. This can be interfaced with SCADA.
- **Routing:** This module computes the shortest path and traces the connectivity for electrical facilities. This includes 3 interactive tools as finding connectivity, suggesting a route, and tracing a path.

- **Printing:** This module prints maps at the required scale. It has interactive tools such as field plans, substations data, standard symbols, scales, etc.
- **Data Collation:** It integrates schematic diagrams and other collateral sources to common spatial reference. This includes geocoding, dimensioning etc.

The block diagram of ENIman is given below with function of each module.



5.0 Recent trends:

5.1 Case studies in world:

Literature is available about the case studies of GIS in management of Electricity Distribution Network.

An automated system is developed for National Electric Power Authority (NEPA), Onitsha-North L. G. A., Anambra state, **Nigeria.** The developed system was put to test by carrying out a number of GIS operation and analysis. Results obtained were displayed in graphics and tables. From the results it has been ascertained that GIS is competent and effective tool for managing electricity distribution network.

Turkish largest electricity distribution system has GIS based system which carries out load flow analysis, power loss analysis, short circuit analysis, switching analysis etc.

In many utilities in **Canada,** GIS based distribution systems exist due to which reliability and maintenance of systems are quite good.

Thus GIS is a competent tool for managing utilities world wide. In future also it will emerge as an effective data collection source, helping the utility to function efficiently.

5.2 Case studies in India:

In India, North-Eastern region is fast developing due to which power demand is growing. Transmission utility company has undertaken high voltage transmission project covering states of Assam, Meghalaya and Tripura. The objective is to identify an optimal route passing through certain defined locations i.e. existing substations and probable sites fulfilling route alignment criteria.

The distribution utility tool ENIman is developed by WTI Advanced Technology Ltd. belonging to Tata group of companies. This software has a set of predefined electrical features and attributes which can be customized for any Indian DISCOM's needs. The data model can be migrated to any industry as per their requirements.

6.0 Coclusion:

Digital system provides timely, accurate and easier way of acquiring information, which are very vital in taking prompt and accurate decisions necessary in the economic development of any enterprise.

GIS technology used in utility sector is emerging as an efficient planning and decision making tool. The ability of GIS to integrate common database operations such as query and statistical analysis make it different from other traditional information systems. It has unique visualization and geographic analysis benefits offered by maps. Therefore it is valuable in planning strategies for Transmission and distribution system.

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