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Use of Geographic Information Systems to Build and Management a Geometric Network for Electricity

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ABSTRACT

The main goal of this paper is to use the geometric network in the ArcGIS system to build and management the distribution of the electricity network in the College of Engineering at Sudan University of Science and Technology, which includes load distribution control and management, maintenance, new extensions and decision support. The major source data is a 10 cm spatial resolution aerial photograph of the research region, as well as network data obtained in the field, which comprises transformers, supply sub-stations, distribution keys and cables from various portions of the electrical network. Different thematic layers, such as building, vegetation and electrical network parts, were created to meet the paper's goal. A digital map of the electrical network, including underground cables, was created and the loads for various sectors were estimated to manage maintenance and new extensions and to determine the network's weaknesses. The ArcGIS system's geometric network was proven to be useful and has the potential to be used in electricity network analysis and management the flow directions of electricity power in the network.

***KEYWORDS:** Sudan, Electricity Network, GIS, Geometric Network, Utility Network Analyst*

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1. INTRODUCTION

Because of the constantly increasing demand brought on by population growth and industrialization, effective energy utilization has been a key challenge in recent years. The world's energy supply has been put under tremendous strain as a result of this rising demand for energy [1].

The ability to consume and govern energy is one of the first contributions to our life's evolution across time. The application of Geographic Information Systems (GIS) to the administration of electric networks has substantially improved the energy sector's efficiency. New methodologies and specific strategies can be used to solve planning problems in the distribution system [2].

In the power utility, GIS is a viable solution for connecting database information such as billing, material account, distribution analysis, and outage reporting. For the mapping and modeling of utility network systems, Geographic Information Systems (GISs) are currently frequently employed.

A geographic information system (GIS) is a software package that handles a wide range of data handling activities and is specifically developed for use with geographic data [3].

A geometric network corresponds to a logical network. The logical network is a physical representation of network connectivity that can be seen as a set of tables with no shape that is linked to network features [4].

In a feature dataset, a geometric network is a connectivity relationship between groupings of feature classes. Each feature serves as an edge or a junction in the geometric network. In a single geometric network, multiple feature classes may play the same role [5].

Geographic information systems and network analysis are both developing topics with rapid methodological and scientific progress in recent years. A geographic information system (GIS) is a digital computer program that captures, stores, manipulates, analyzes, and displays geographic data.

geographic information is distinguished from all other types of information by its geographic location. Data that lacks location is referred to be non-spatial and has minimal usefulness in a GIS. Many GIS benefits are thus based on location: the ability to map, the ability to measure distances, and the ability to connect different types of data because they all refer to the same location [6].

The National Electricity Corporation and the Ministry of Energy and Dams are in charge of electricity generation and distribution in Sudan's two interconnected grids, the Blue Nile Grid and the small Western Grid, which cover only a small portion of the country around Khartoum and south to Blue Nile State and serve only about 30% of the country's population. Even in those places, supply is insufficient, with output hovering around 500 megawatts for much of the 2000–2010 decade, well below demand, and unreliable; power outages were widespread, even in the capital. As a result, power generation is reliant on tiny diesel-fired power plants and oil-fueled generators owned by users [7].

The goal of this paper is to build and management the geometric electricity network environment in terms of:
1. Build a geographical database for the relevant part of a study of the selected area.
2. Build a geometric network for the electricity network.
3. Load distribution management.
4. Analysis of performance.

2. METHODOLOGY

Sudan University of Science and Technology's Engineering faculty was chosen as a study area.

The primary source data includes a 10 cm spatial resolution aerial photograph of the study area, as well as spatial data was obtained from the field through various survey methodologies and attributes data for the built environment and electrical network components.

In this study, the Arc GIS program was utilized to link spatial and attributes data, build a geometric network and conduct analysis.

There are three phases to this paper. The first phase is concerned with data acquisition and management. In phase two, a geometric network for the study region was built. The analysis and an assessment were carried out in phase three.

The test data was collected, acquired, and handled using a variety of methods and resources (Figure 1). An aerial photograph of the college boundary and all the college's details were obtained. Field surveying for electrical network components, such as transformers place, supply sub-stations, distribution keys and cables was carried out, as well as attributes data was collected, such as available load and used load measured with a Digital Clamp Meter device. A Global Positioning System (GPS) receiver based on UTM Projection and WGS 1984 Datum was used to observe the coordinates of the ground control points inside the study region. To conduct the analysis, data was managed. In the Arc GIS program was inserted the aerial photograph. Ground Control points Coordinates were used to dereferencing an aerial photograph. Using the data gathered above, layers for college and electrical networks were built in the Arc GIS program, these layers include, Frame, Halls, Vegetation, Departments, Labs, Workshops, Toilets, Services, Offices, Transformers, Cooling Support Stations, Cooling Control Points, Cooling Tabloons, Cooling Cables, Light Support Stations, Light Control Points, Light Tabloons and Light Cables. All layers' attribute tables and fields were edited, and all data for each object was entered in its field.

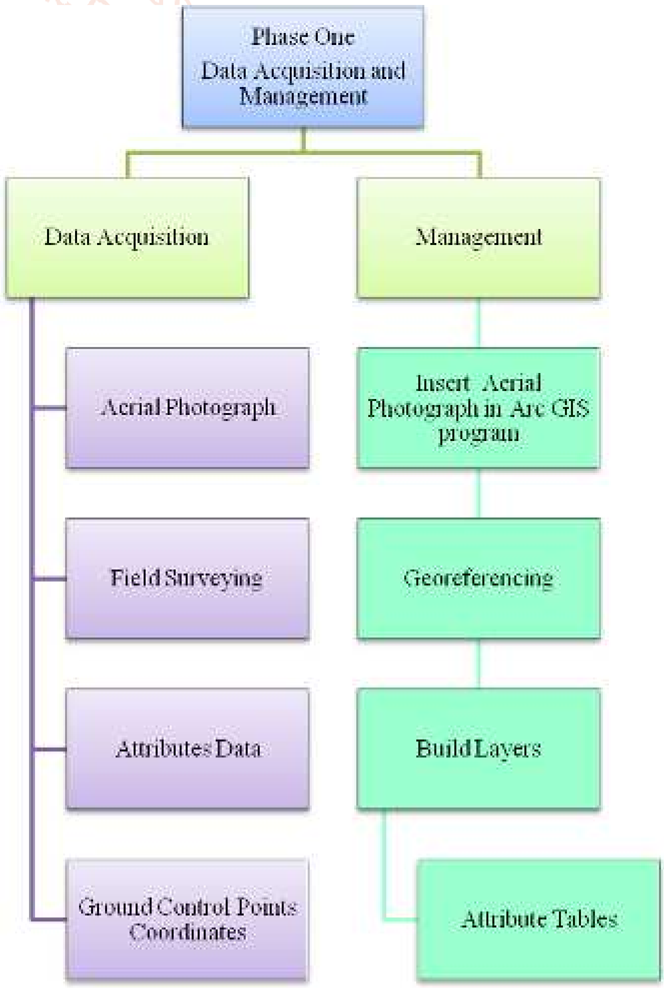

Figure 1: Data Acquisition and Management

Inside feature datasets in Arc Catalog, a geometric network was built using existing data (Figure 2). The properties of a geometric network were used to generate connectivity rules. Then, in the Arc Map program, a geometric network was called.

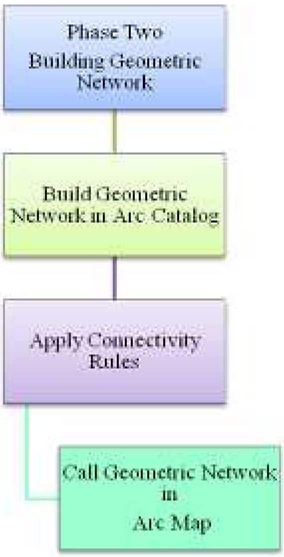

Figure 2: Building Geometric Network

The analysis was carried out using geometric network in Arc Map program the (Figure 3). Some inquiries were made, to determine the least used load of Cooling Control Points in order to establish new extensions for new buildings, to achieve that, from access the attribute table of Cooling Control Points layer and pick Statistics from the field that represents Used Load. Utility Network Analyst was used to find Path between two features by put the Flags on the intended features. A Path Upstream was found, where the flow of electrical lines in the direction of Flag appears by a red line. Upstream Accumulation was used to find all lines that pour into the point. We can see that there are weaknesses in the network by looking at the attribute table of Light Support Stations layer.

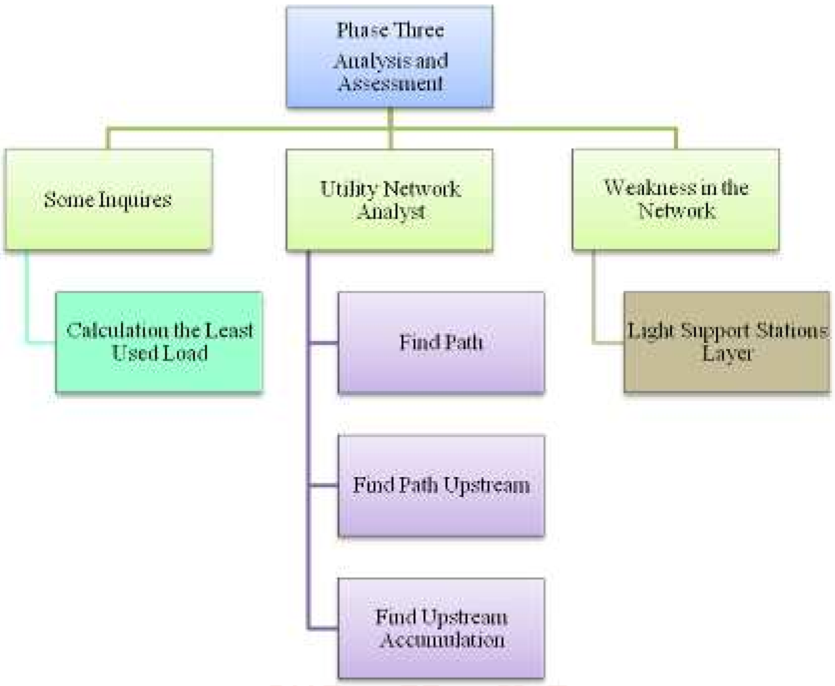

Figure 3: Analysis and Assessment

3. RESULTS AND ANALYSIS

All prior operations were performed in the Arc GIS 9.3 program, and thus the geographical database for the study area, including the geometric electricity network, was obtained. As an example, Figure 4 shows the attribute table of Cooling Control Points layer, while Figure 5 shows the study area layout.

* OBJECTID	* SHAPE	NAME	LOCATION	SOURCE	AVAILABLE_LOAD_AMP	USED_LOAD_AMP
13	Point	CCP 8	PRODUCTION	T2	1200	512
10	Point	CCP 7	NEAR OF SOUTH DEPARTMENT	T1	600	263
20	Point	CCP 13	LH 3	CSS 7	600	171
21	Point	CCP 14	LH 11	CSS 7	600	324
15	Point	CCP 10	STUDENTS UNIT	CSS 6	600	118
37	Point	CCP 6	HALLS OF PROF HASHM	CSS 5	1200	142
36	Point	CCP 5	HALLS OF PROF HASHM	CSS 4	1200	102
5	Point	CCP 3	READING LIBRARY	CSS 3	600	291
7	Point	CCP 4	ELECTRONICS DEPARTMENT	CSS 3	1200	544
2	Point	CCP 2	SOUTH DEPARTMENTS	CSS 1	600	374
23	Point	CCP 1	NORTH DEPARTMENTS	CSS 1	600	370
14	Point	CCP 9	LABS OF BAKREY	CCP8	600	240
18	Point	CCP 12	E _ATELIER OF ARCHITECTURE	CCP 8	450	122
22	Point	CCP 15	LH 12	CCP 14	300	180
17	Point	CCP 11	LH 9	CCP 10	300	118

Figure 4: Cooling Control Points Layer Attribute Table

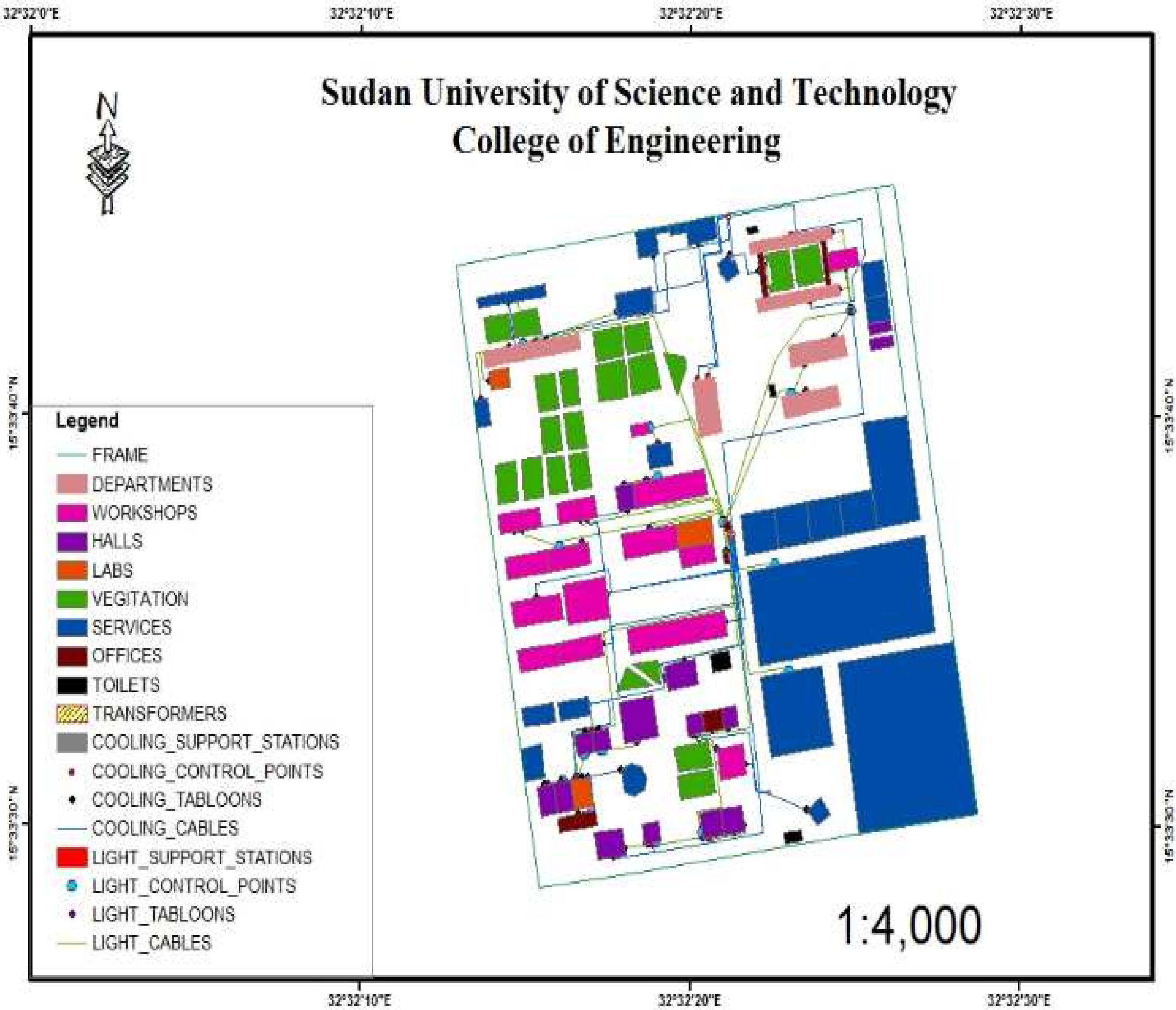

Figure 5: Study Area Layout

There was conducted some inquires. To determine the least used load of Cooling Control Points in order to establish new extension for new buildings, from attribute table of Cooling Control Points (CCP) layer from Statistics was found the Cooling Control Point 5 (CCP 5) in it the least used load (Figure 6), and then establish the new cable to new builds from it.

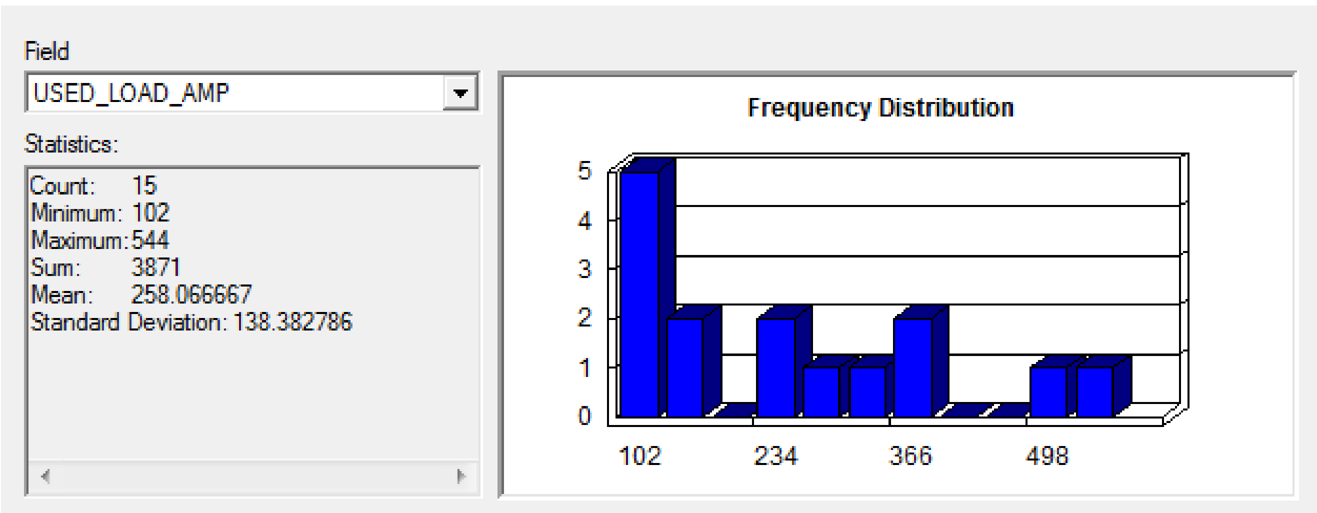

Figure 6: Least Used Load of Cooling Control Points

The path between Light Support Station (LSS) and Light Tabloon 4 (LT 4) was discovered. From Utility Network Analyst, pick Add Junction Flag Tool from Analysis and place the Flag in LSS and LT 4, then choose Find Path from Trace Task, the path between LSS and LT 4 was appeared by a red line (Figure 7).

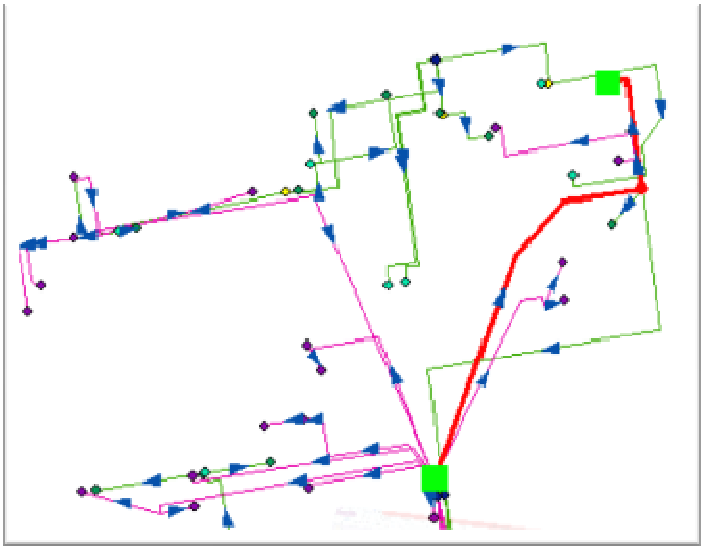

Figure 7: Pass between Light Support Station and Light Tabloon 4

By putting the Flag in Cooling Tabloon 5 (CT 5) and selecting Find Path Upstream, the Path Upstream for CT 5 was discovered. The flow of electrical lines in the direction of CT 5 was appeared by a red line (Figure 8).

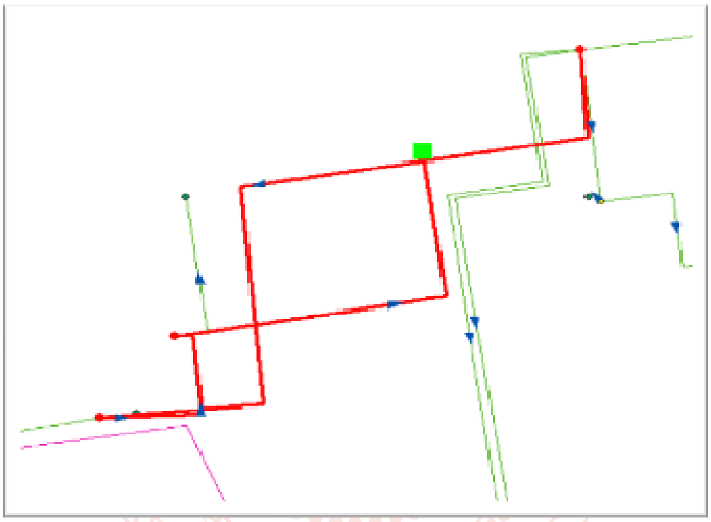

Figure 8: Cooling Tabloon 5Path Upstream

By putting the Flag in Cooling Control Point 2 (CCP 2) and selecting Find Upstream Accumulation, all lines that are pouring in CCP 2 were found (Figure 9).

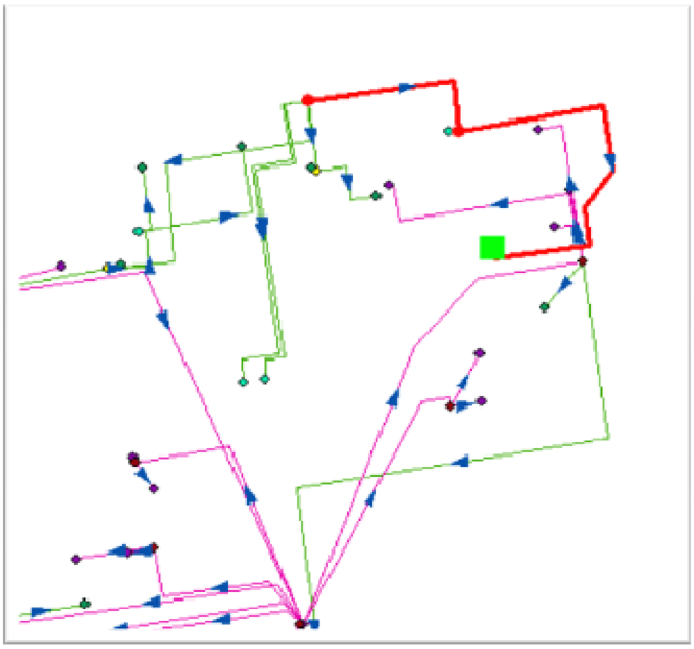

Figure 9: Cooling Control Point 2 Upstream Accumulation

According to the attribute table of Light Support Stations layer (Figure 10), there is only one Support Station for all lighting in the college, indicating a network weakness where a malfunction in the Support Station would shut down all lighting, and thus propose the solution by establishing new lighting Support Stations.

* OBJECTID	* SHAPE	NAME	FROM_WHERE	LOCATION	AVAILABLE_LOAD_AMP	LOAD_AMP
1	Point	LSS	T2	near of office of electrical tech	3600	1755

Figure 10: Light Support Stations Layer Attribute Table

4. CONCLUSION

According to the results of the tests conducted in this paper, it can be concluded that:

1. A geographical database for the relevant part of the study area was obtained.
2. For the study area, an electrical geometric network was constructed.
3. The geometric network aids in the selection of a suitable load for new extensions.
4. The constructed geometric network may be used to govern the flow directions of electricity power.
5. The network was found it be capable of detecting network performance weakness, as all the lighting in the college is done by a single Support Station.

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