Campus of Del Polytechnic of Informatics in Geographic Information System Representation

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ABSTRACT

Del Polytechnic of Informatics or Del has a map or mockups the entire area of the campus. But, it is only a picture or mockups without any explanation of the building, position, direction to another building. When user wants to search about Del campus, user must see the mockup manually. There is no geographical data about each object in Del campus. Moreover, there was not any system that can store, manipulate and display data to the web.

Based on the stated problems, the main objective of this research is building Geographic Information System for Del. Geographic Information System is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical or spatial data. The geographical data are stored in the spatial database. This research started by collecting data through observation, for example collecting documentation of building, tracking position of building with Global Positioning System. The result of observation was spatial data stored in multiple shapefile that representing information of every object, such as area, building, room, park, and object position (coordinate) in the earth. Spatial data stored in database which is modelled using pictogram and implemented on PostgreSQL database.

Del Geographic Information System was able to show view of location, building, room, and direction or route to another position in the web application.

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1. INTRODUCTION

Del Polytechnic of Informatics (PI Del) has a map or mockups that show location and building's name that exist in PI Del. But, map is just a map, the information show in the map still manual and not yet complete. User has difficulties to reach another location because there is no information about position and direction in the mockup. Furthermore, the Geographical data was not stored in the map so that user cannot retrieve or manipulate it. In addition, PI Del did not have any system to store, manipulate and display geographical data about PI Del campus. So, if there is an addition of a new building, the architect only adds the building to the miniature mockups. Therefore, it is needed to store the geographical data about PI Del campus. It is needed to have technology that store, manipulate, analyze, manage, and present it in a proper interface. The system should help the user to know the geographical data of PI Del and help them to have direction from one place to another.

Geographic Information System (GIS) is a technology that combines geographic features with tabular data set or attribute that allows the data to be analysed, managed and displayed in the form of information [3]. GIS is also used to display data in a variety of ways such as maps, globes, reports, and charts. Basically, data that visualize on GIS is spatial or geographic data and attribute data. Spatial data shows geographic shape object such as position and shape of local area while attributes is an additional data that describe the object of geography.

2. RESEARCH METHOD

During this research, recent publication regarding building GIS is easily to be found. So, this research was started by collecting all the relevant sources regarding building GIS application. All these sources analyzed and organized to meet the requirements of this application that built in C# programming language. This GIS application is able to store, retrieve, manipulate and present geographical data of PI Del Campus. The chronological of this research are Literature review, observe and tracking PI Del to get geographical data, design the spatial data model and implementing web GIS application.

a. Literature Review

The first step in this research is literature review. The Literature review has been done by collecting all the relevant sources regarding building GIS application, such as: Spatial data type, Spatial Database, Geographic Information System, and Indexing in GIS.

i. Spatial Data Type and Spatial Database

Spatial data type is a data type that representing the shape of a geographic area which allows information to be stored in a database so it can be processed and used for the next purpose [4].
It consists of two types, geometry and geography [5]:

1. Geometry: Data planar (flat earth), type of data used to represent data in two dimensions. This data is used when you want to keep the data related to the location and a small area [6]. Example: Point, LineString, Polygon, LineArring.
2. Geography: Data Ellipsoidal (round-earth) data type that used to store the latitude and longitude of an area. This data is used when the data you want to keep in touch with long-distance measurement and needs the entire of earth data [6]. Example: GeometriCollection.

Each type of spatial data has a data object that is main representation of geography shape of a region. The types of data object are [4]:

- **Point**: Representation of a single coordinate point.
- **LineString**: Representation of two or more coordinate points as linear line.
- **LineArring**: Representation of three or more points with the coordinates of the starting point and end up the same.
- **Polygon**: Representation of an area consisting of one or more adjacent LineArring.
- **MultiPoint**: Representation of a set of points.
- **MultiLineString**: Representation of a set of LineString.
- **MultiPolygon**: Representation of a set of polygons, and
- **GeometriCollection**: Representation of a diverse set of data geometry.

Spatial database is a data repository that able to store and query spatial data. Spatial Database allows CRUD operations (create, update, delete) can be performed on the spatial data. Nowadays, there are three generations of spatial database [4]. First generation is spatial data stored in shapefile (flat file) and GIS software needs to interpret and manipulate the data in the shapefile. Second generation of spatial data storage performed on relational database. Spatial data is stored on a database by using the type of data in a relational database (without using of spatial objects). Last generation is spatial data and attributes can be stored in a relational database that supports spatial data storage.

In Spatial Databases, there are two additional tables that are used as meta-data to maintain data consistency. The tables are [6]:

1. Spatial Reference Systems (SPATIAL_REF_SYS): Store IDs and description of any coordinates used in spatial database in order to able to display geometry data for all of areas in the earth accurately.
2. Geometri_Columns: Used as an internal reference for each type of geometry data that exists in the database.

ii. Spatial data Modelling

Spatial data modelled using Entity Relationship Diagram (ERD) with add pictogram. Pictogram is a miniature representation of an object that is added to the ERD for allowing spatial data and the relationships modelled clearly. Pictogram distinguishes spatial data with other data by providing notations and symbols on the entity. Pictogram also describes the spatial relationships among the entities in the diagram, although there is no direct relationship through the key (primary key and foreign key) because basically every object has a spatial relation between the derivatives of one another [2]. An example is building A is located entirely in area B. This relationship is showed a function that has been provided by the spatial database as ST_DWithin, ST_Contain and ST_Disjoint.

iii. Indexing on Spatial Database

In order to handle spatial data efficiently, as required in computer aided design and GIS application, a database system needs an index mechanism that will help it retrieve data items quickly according to their

spatial locations. B-tree is the common type of index in database but it is less optimal when applied to spatial databases. For example, it is difficult to determine the position of an object such as point, line or polygon. Therefore there are some spatial indexes which defined to enhance the search operation in the spatial database, such as Grid-based index, Z-order, Quadtree, Octree, UB-tree, R-tree, and GIST [7].

GIST (Generalized Search Trees) is an index which is similar with R-Tree that has dynamic index structure for searching and updating [8]. GIST use the "Bounding Box" to make the index. Minimal Bounding box is a box with the smallest size that can accommodate the geometry of the data such as point, line or polygon. GIST index is also used tree to assist search data. Root on the index consists of one or more of the MBR. Node (stalk) that exists in the tree can have one or more leaves (leaves).

The index applied in this research is GIST because of several advantages such as [6]:

1. Handle objects larger than 8K.
2. Using the concept of "null safe" which means it can do an index on columns that have a null value.
3. Using the concept of "lossiness" that allows only save an important part of the object at the index, in this case is the only store bounding box of the object / spatial data. This reduces the failure in the search process because they do not come to save more spatial objects that may have a large size.

b. Observation

Observation is an activity collecting all the geographical data including all the documentation that exist for building GIS application. PI Del Campus categorized in four groups area: *Daerah/Wilayah, Area, Bangunan, Jalan, Taman, dan Ruangan.* The most important activity in the observation is tracking. Tracking is an activity to get the position (coordinate) and way route in the PI Del campus by using Global Positioning System (GPS). GPS track all the streets, from the smallest to the largest street on campus and mark any passed place or building during tracking. Furthermore, GPS mark all the corners of building to get the real size of the building.

c. Design

Design started with drawing the result of tracking using the metadata from GPS. Quantum GIS read the metadata and display it as a picture. To make it perfect, AutoCAD is used to get the visualization as in the real world. Design phase also covered spatial data modeling by using ER-Diagram with pictogram [2]. Pictogram used because the regular ER-Diagram cannot clearly describe spatial data types and their relationships.

d. Implementation

The Implementation consists of implementation of database design and displaying the data on web. Quantum GIS is mediator in creating tables and data [3]. The spatial data is stored in PostgreSQL which has PostSIG library to support spatial data. The spatial metadata is following Open Geospatial Consortium (OGC) standard. The data extracted by the application to visualize all object area in the web using AspMap. The implementation was using C# and .Net framework. To improve performance of the application, GIST index is applied in the spatial data.

3. RESULTS AND ANALYSIS

This section gives the result as well as the discussion of Campus of Del Polytechnic of Informatics in Geographic Information System Representation.

a. Observation

The important activity in the observation is tracking the area with GPS. The results of tracking were saved in .gpx file. These files consist of three layers are waypoints, track, and track_points. Waypoints store points that representing any location that recorded by GPS. Track store lines passed during using GPS. Track_points store points that representing intersection between curved roads. Figure 1 show the example result of tracking with GPS.

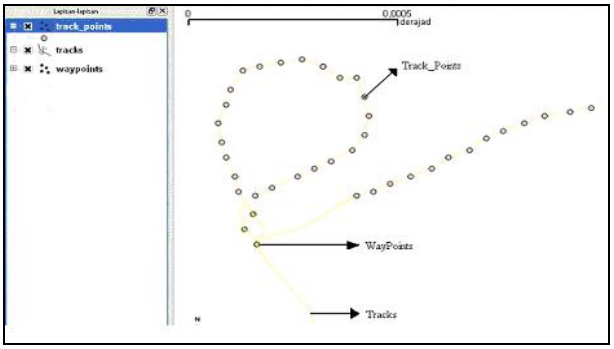

Figure 1 Contet of .gpx file

Figure 1 show the result of tracking is combination of point and line that form a path. To make a concrete path, file .gpx converted to a shapefile with Quantum GIS. A shapefile is a complete geographical data that ready imported to spatial database. Additional attribute or metadata can be added to the shapefile as a spatial data attribute. Based on literature study, spatial data must have data type spatial and the attribute. Therefore, observation indicates that data tracking can be associated with spatial data types. The spatial data are:

1. Regions and Areas
   PI Del and surrounding areas are generally shaped in many different side and wide. It can be connected with spatial data types Multipolygon.
2. Building
   The building is located in PI Del generally square, rectangular, and there are several buildings that have a spherical shape and have curved with vary widely, so it may be associated with spatial data types Multipolygon.
3. Garden
   The park is located in PI Del generally shaped many side which have different wide, so it may be associated with spatial data types Multipolygon.
4. Road
   Roads which are in PI Del generally shaped elongated or curved lines, so it can be linked to spatial data types Multilinestring
5. Room
   The rooms are located in each building generally have the same form, square, so it may be associated with spatial data types Multipolygon.

b. Data Modelling

Spatial data modelled by ER-Diagram wit add pictogram notation. Common ER-Diagram cannot clearly describe spatial data types and their relationships. The problem arises when an actual entity has a relationship but cannot be shown by using the concept of a foreign key. In the spatial database, the relation is defined using predicate. Predicate is a logical operator between two or more spatial data. The predicate return true or false value [1]. The operator logical or relationship between spatial data is Equal, Disjoint, Intersect, Touch, Within, and Contain. Basically, every object area has a spatial relationship between the derivatives of one another. The use of pictogram can be combined with data that allows the combination of common relational modelling of spatial and relational.

Figure 2 show spatial data modelling results of PI Del campus. It shows 6 entities (*Wilayah, Area, Bangunan, Taman, Jalan, Ruangan*) with spatial relationship and 1 entity (Inventori) with relational relationship. The spatial entities has spatial or geographic attribute called the_geom. The_geom attribute consist of longitude, latitude and type of spatial data. Every entity has other attributes to give detail about entity, such as name, address, and amount.

This Figure also shows every spatial entity has relationship each other and is depicted as a hierarchy. The hierarchy starts with *Area* as root. Area has three leaves, are *Bangunan*, *Jalan*, *Taman*. Last entity is *Ruangan* as a leaf of *Bangunan*.

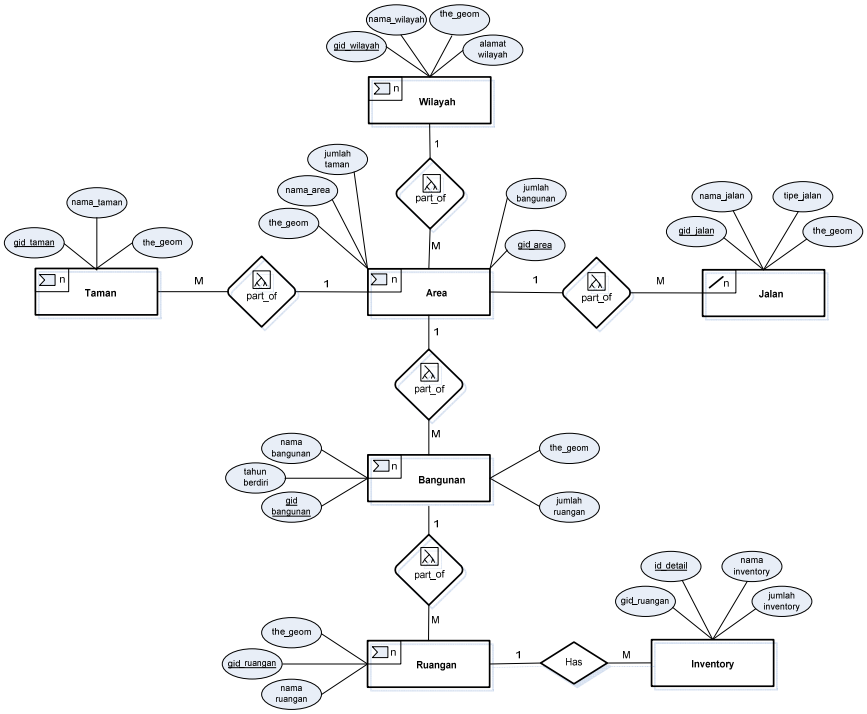

Figure 2 Spatial data modelling of PI Del Campus

c. PI Del Campus Geographic Information System (PI Del GIS)

PI Del GIS Application is a web based application used to extracted data from spatial database and displays it to the browser. This GIS was developed using .Net Framework with ASPMap library for extracting spatial data from PostgreSQL database and display it to the web application. ASPMap provide *Road Network Builder* utility for connecting all the tracks and finding the shortest path.

The main functionality of PI Del GIS web applications are: Spatial Data Processing, Display a map of PI Del in GIS web application, View detailed information about object area (such as name, position on the Earth's surface, pictures), Searching Place and show direction to other places. Figure 3 show the example snapshot of PI Del GIS.

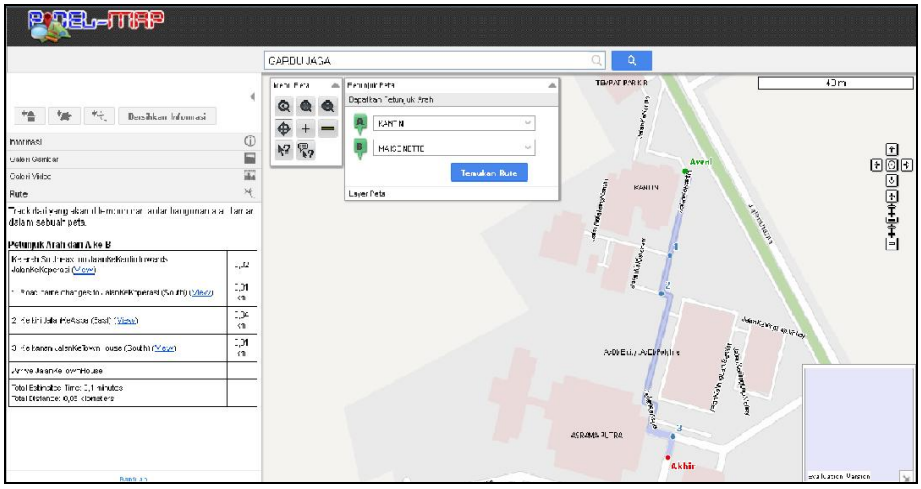

Figure 3 Snapshot of Finding route in PI Del GIS

GIST index was implemented to the GIS application. There are four indexes implemented on the application, they are, region index, area, building, and room. Region index is needed because the region will be the root of the spatial data, then the index area, building, and room is needed in the search data. The implementation of GIST index in the application can be described using the bounding box shown in Figure 5.

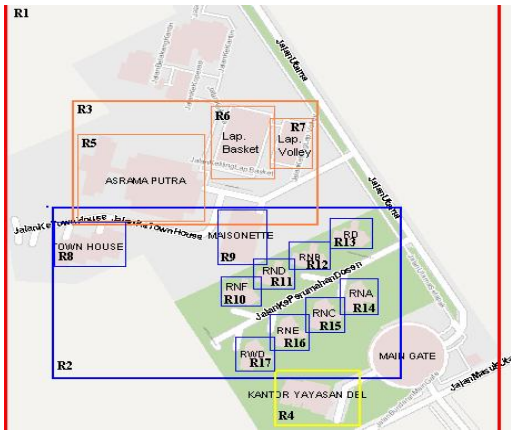

Figure 4 GIST index on the application with Bounding Boxes

4. CONCLUSION

As the result of this research, geographical data of PI Del campus tracked and modelled with ER Diagram. The result of data modeling is metadata (tables and attributes) to store spatial or geographical data in spatial database. The metadata already fulfill OGC standard which already followed by library of PostSIG in PostgreSQL database.

The geographical data can be extracted and shown in the web GIS application. GIS application show building, way route, and path to reach one place to another place. New object on PI Del campus can be added and modified through the application. In Addition, GIST index was implemented in GIS application to improve searching operation.

However, this research cannot yet fully cover the entire GIS application feature. The visualization of the object in the application is not real picture (3D visualization). Moreover, another improvement regarding to visualization, utility of the building and integrated with course schedule is still needed.

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