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The Solutions to Organize Data for Traffic Infrastructure Managment Combined

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Abstract

In the 4.0 revolution, almost every problem is gradually being solved by technology; the pillars are still Cloud Computing, Big Data, AI, and IoT. Among these problems, the problem of the transport sector is fundamental. Because of its unique characteristics, the analysis and collection of survey data are challenging. The unique feature of the data of each transport infrastructure project is that the data is extensive and has many different formats; the information is updated regularly every year according to the process of conserving, renovating, and renovating. Upgrade if using the traditional way of storing and representing data, like the way database management systems and software are used, will not meet the demand. Therefore, it is necessary to implement a solution to build specialized databases, with a special organizational plan according to industry characteristics and the ability to integrate data from specialized applications to have linkage and unity data between authorities. This will be a data platform for exploitation and sharing for professional management work between authorities in the city and the whole country. The planning and maintenance of transportation infrastructure is a practical application. However, there is now interest in a new area of navigation applications in maritime transport and electronic charts. This feature requires GIS support. The transportation system is an essential factor serving the travel needs of the people, helping the production process to take place continuously and operate normally. In our country, transportation is more and more focused. Our country has been building an increasingly complete and developed transportation system; transport infrastructure is considered essential in promoting our country's economic, cultural and social activities. This paper proposes a solution to organize traffic infrastructure management data in combination with digital maps. Application to edit data of transportation infrastructure information for Hai Chau and Son Tra districts. At the same time, we have also integrated most of the famous map platforms in the world, such as Google Map, BingMap, OpenStreetMap, HereMap, and IOTLink

Keyword: Infracstacture, Traffic, GIS, Danang, Platform.

1. Introduction

The peculiarity of the data of each transport infrastructure project is that the data is very large and has many different formats; the information is updated regularly every year according to the process of maintenance, renovation, and upgrading if using the traditional way of storing and representing data, like how database management systems and management software are used, it will not meet the demand. Therefore, it is necessary to implement a solution to build a centralized specialized database, have a special organizational plan according to industry characteristics, and be able to integrate data from specialized applications to have a connection, unifying data between authorities. This will serve as a platform for data sharing and exploitation for professional management work between authorities in the city and the whole country. The development and maintenance of transportation infrastructure is a practical application. However, there is interest in a new area of navigation applications in maritime transport and electronic charts. GIS support is necessary for this kind of functionality (Britannica,16. November 2020).

The transportation system is a fundamental element that meets people's travel demands and aids in the continuous and smooth operation of the production process. In our nation, transportation is becoming increasingly concentrated. To support its economic, cultural, and social activities, our nation has been constructing a transportation infrastructure that is more complete and developed than ever before.

This paper concentrates on arranging data for digital maps and traffic infrastructure management.

2. Related work

In this topic, we have implemented the PostgreSQL Open Database Management System Study to deploy the object database and related properties of the Transport Infrastructure. At the same time, study the MongDB open database management system to deploy a database of properties to manage Transport Infrastructure combined with file data storage on Cloud Storage.

An object and relational database management system called PostgreSQL is based on POSTGRES, version 4.2, which the computing department of the University of California at Berkeley developed. Many crucial ideas that were not available to commercial data management systems until much later were made possible by POSTGRES. The PostgreSQL attribute database management system, a rival of the PostgreSQL attribute database management system, is expanding globally and quickly. Especially in the field of GIS, the PostgreSQL attribute database management system has an advantage over the MySQL attribute database management system because it can integrate with the PostGIS map database management system (Dávid, A., & Madudová, E., 2019).

In addition, because of the need to store shared data types such as string types, number types, and data types, users also need to store spatial data types to store objects such as Point, Line, and Polygon. Therefore, PostgreSQL also supports geometric data types (geometry) such as Point, Line, Polygon, and PostGIS is the tool that is added to PostgreSQL to support displaying geographic objects. Thanks to PostGIS, spatial capabilities in PostgreSQL are enabled, which allows PostgreSQL to use as an auxiliary spatial database for geographic information systems (Chinoracký, R., & Čorejová, T., 2019; Mako, P., & Galieriková, A., 2021).

PostGIS has made PostgreSQL spatially capable, enabling PostgreSQL to be used as a secondary spatial database for geographic information systems. A spatial extension for PostgreSQL is called PostGIS. High-performance multi-user PostGIS spatial databases are employed when a seamless dataset is needed. A spatial database can increase access speed, ease of management, and data integrity if you manage much read/write spatial data. PostGIS was created as an object extension for PostgreSQL and is "Simple Features for SQL" compatible, according to the Open Geospatial Consortium. The 2001 initial edition of PostGIS has since gained widespread adoption as a high-performance server for spatial objects (Marcu Turcanu, A. L., Moga, L. M., & Rusu, E. V. C., 2021; Jurkovič, M., & Dávid, A., 2015; Jurkovic, M., David, A., & Hargitai, C., 2016).

3. Organize the Transport Infrastructure Database combined with Digital Maps

3.1. PostgreSQL application in transport infrastructure GIS database organization

Spatial database generation and management are available with PostGIS. The only difference between a spatial and conventional database is the addition of spatial data types and their interactions. A spatial database comprises numerous spatial data tables, each of which has an attribute of the spatial data type that describes a real object in addition to the attributes of the common data type.

What is a spatial query? To determine the relationship between the objects in space, query statements are run on the spatial table in the database. This relationship can be the intersection, distance, area, perimeter, length, and the built-in support functions of PostGIS make writing query statements simpler. In order to make executing queries in space easier and easier to manipulate, PostGIS offers groups of functions to assist inquiries, such as groups of functions that construct spatial relationships, groups of functions that return new objects, etc.

With these outstanding advantages, we choose the PostgreSQL database management system to deploy the transport infrastructure database system on the digital map.

3.2. Spatial database

a. Spatial database

As a relational database system:

Provides spatial data types in data models and query languages.

Provides indexing types for the quickest query execution from large data tables and supports spatial data types in the implementation.

Explain:

Spatial data types such as Point, Line, and Polygon. Spatial databases provide basic abstract models for the structure of geometric entities in space, as well as the relationships between them, such as intersections (a, b) and properties such as areas, the perimeter of the model (area(a) or perimeter(a)), or find the intersection between the two models (intersection(a.b)).

Data indexing is crucial since it speeds up data queries and uses less memory in storage.

b. Spatial database characteristics

Spatial databases use spatial indexing to speed up database operations

Spatial databases may carry out numerous spatial operations in addition to standard SQL queries like SELECT statements. And it is supported by OGC

Spatial measurement can determine the separations between regions, points, etc.

Spatial functions: for example, modifying existing functions to create new shapes and functions to find points of intersections.

Spatial validation: it enables True/False queries to be run.

Constructor: generates new shapes by defining nodes that can form lines or polygons when the start and last vertices line up.

Tracing function: searches provide detailed results, such as the location of a circle's center or the beginning and end of a line.

c. Object model

There are two significant items that must be visible:

Space objects: these are celestial objects that can describe their geometry.

Single object: the fundamental objects are Point, Line, and Polygon (Stonebraker, M.; 1991)

POINT object: Shows an object's position in space only. A city, for instance, could be represented as a point in a model that describes a huge geographic area. POINT is frequently used to symbolize:

It is a single coordinate.

Objects do not need to show length and area.

Scores are used to render regions as they are rendered at a small scale.

LINE is a set of point sequences describing the feature in linear form. LINE has the following characteristics:

It is a sequence of coordinate pairs.

The beginning and the end are at one point.

Lines join or intersect at a point.

The coordinates of the point define the shape.

As well as the point feature, the line is also displayed at a small scale showing as a single line that is a polygon.

There is a distance measurement for the road.

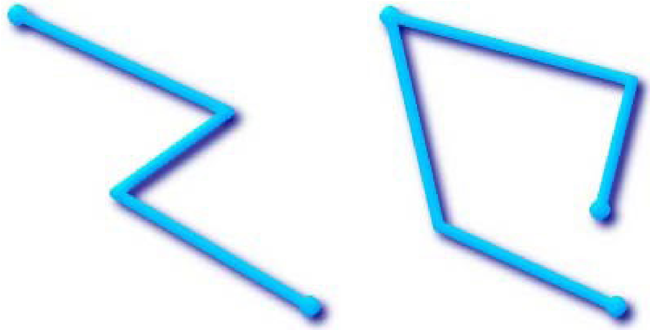

Fig. 1. LINE object model

The boundary of the lines defines POLYGON. Features that have an area and are closed by one are called regions—for example, lakes, buildings, parks, and cities.

The region is described by a set of lines and points

One or more lines are the contours of the region

There are perimeter and area calculations for polygons

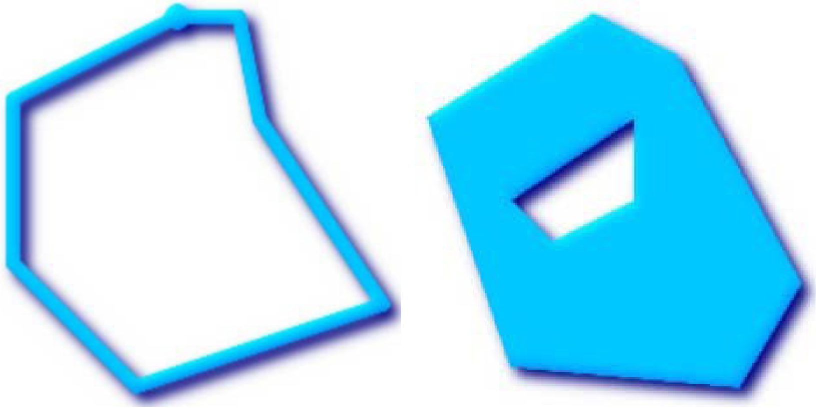

Fig. 2. POLYGON object model

d. Incorporating geometry into a DBMS data model

The main idea is to incorporate geometric models into the DBMS data model to represent "spatial objects" (objects that can be rivers, countries, cities, etc.) by geometric objects. The DBMS data model always supports data types such as integer, string, etc., or can be user-defined data types. Additionally, the DBMS data model enables additional types of geographical databases, including geometric types like the Point type, Line type, etc. (Marcu Turcanu, A. L., Moga, L. M., & Rusu, E. V. C., 2021; Jurkovic, M., David, A., & Hargitai, C., 2016; Manual on Danube navigation., 30.

October 2020).

For example: To describe the characteristics of the river or describe the characteristics of the city, we have data tables:

Rivers (rname : STRING, route : LINE)

Cities (cname : STRING, center : POINT, ext : POLYGON, cpop : INTEGER).

If you notice the two data tables, cities, and rivers, in addition to the usual data types like STRING and INTEGER, there are also geometric data types like LINE, POINT, and POLYGON. Exactly as described for each object type LINE, POINT, POLYGON…

The usual way to represent spatial objects in a 2D model is to use a coordinate system representation.

For example, to represent a point, POINT (0,0): the point is located at coordinate (0,0). Representing a LINE (0 0, 1 1, 1 2): the line connecting 3 points is located at the coordinates (0,0) -> (1,1) -> (1, 2) respectively.

Proposing implementation solutions

GIS database serving in traffic management includes 2 components:

Spatial database

Attribute database

3.2. Organization of GIS database and spatial attribute data in the construction of the Traffic Infrastructure Database

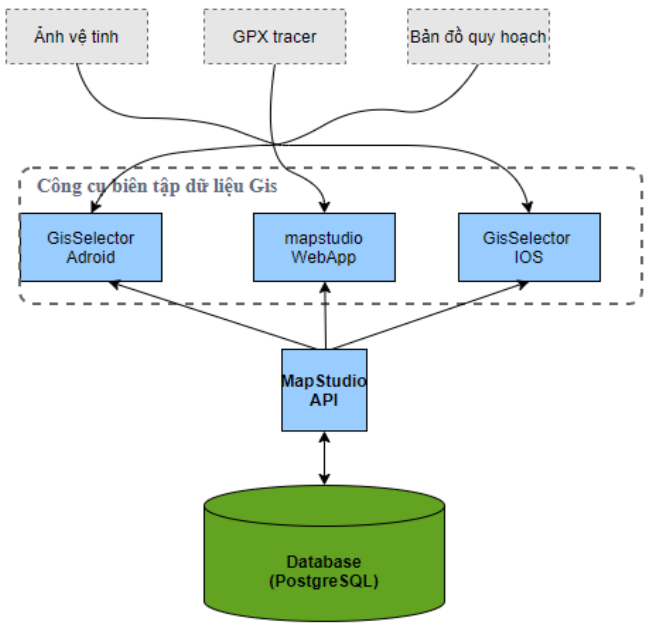

Fig. 3. Overall model Traffic infrastructure database

a. Database

All map information is stored in the database as Nodes, Ways, and Relations. PostgreSQL is the database software that is in use. The main database is accessed for editing via the API.

Node, Way, Relation database model:

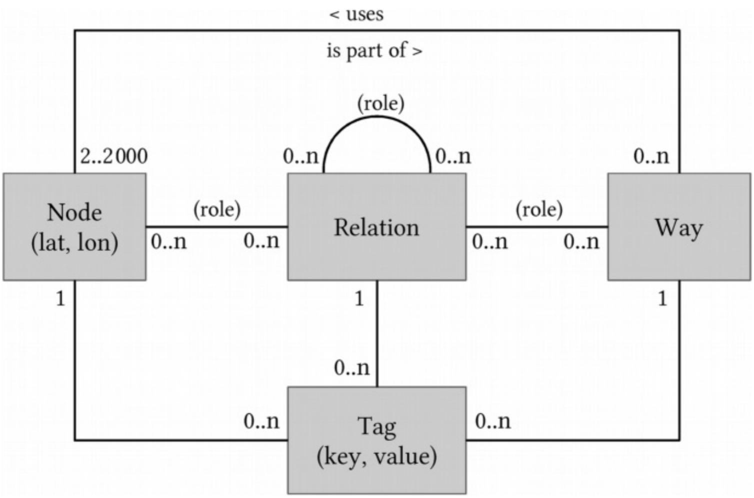

Fig. 4. GIS database model with Node, Way, Relation

In there:

Node

A Node represents a specific point on the earth's surface defined by its latitude and longitude. Each Node consists of at least an id and a coordinate pair.

Nodes can be used to define independent point objects such as ATMs, coffee shops, etc. A button will typically have at least one tag to identify its purpose. Buttons can have multiple tags (SPaP, 27. October 2020). For example, a cafe is often tagged as amenity=cafe, name=Café club.

Node is frequently used to describe the outline of a route. One or more roads contain several nodes, which determine the shape of the road. Nodes typically do not have tags when used as a vertical point of a path, though some of them can.

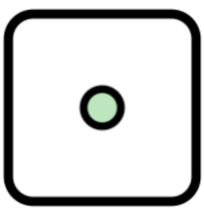

Fig. 5. Node object representation

Way

The way is one of the essential elements of the map. A way usually represents a road-shaped feature on the ground (such as a road, river, bridge, etc.). Technically a Way is an ordered list of nodes. A way must have a minimum of 2 nodes and a maximum of 2000 nodes.

There are the following types of Ways:

Open Way: There is a difference between the first and last nodes. Roads, rivers, streams, and railroads are typical examples because they all start in one location and end in another.

Closed Way: The initial and last nodes of the path are identical. Depending on its tags, such a manner can be interpreted as a closed polygon, an area, or both. An example of a closed way is a roundabout.

Area: An area is closed, such as a park, lawn, school, etc.

Fig. 6. Way object representation

Relation

One of the fundamental components of the map data is a relation. The relation defines logical or geographic relationships among other elements and consists of one or more tags and an ordered list of nodes, ways, or relationships as members. A relation member can optionally have a role that describes the portion of a particular feature in a relation.

Relationships are used to model logical (and often local) or geographic relationships between objects. For example, the relationship of national highway 1A includes members who are national highway sections stretching from north to south or are used in the relationship defining the boundary of ward/commune, district/province, province, and country.

Fig. 7. Relation object representation

Tags

All data element types (nodes, ways, and relations) can have tags. Tags describe the meaning of the particular element they are attached to.

A tag consists of two text fields; one ‘key(key)’ and one ‘value(value) .’Keys and values can contain Unicode strings, up to 255 characters. For example, highway=trunk defines a child as a highway.

An object cannot have 2 tags with the same ‘key(key)’, ‘key(key)’ must be unique.

Not every element has a tag. Nodes are usually not tagged if they are part of a path.

4. Organize the attribute database of the Transport Infrastructure objects

a. Management attribute data

The system stores information about the traffic system and specific infrastructure management attribute data. Through the WayId property, which has data types in the form of highways, rivers, and bridges, and the NodeId attribute, which has data types in the form of sites such as cameras and junctions, spatial attribute data and GIS database data are linked. GIS databases and data spatial properties circulate information about the coordinates of traffic infrastructure objects and some fundamental attributes such as name, number of lanes, and maximum speed. Infrastructure GIS databases store detailed information about the properties of transportation infrastructure (Stonebraker, M., 1991; Stroustrup, B., 2000; Wasserman, A. I., 1979, May).

Route management data and details:

Manage general information about the route

Detailed road structure information

Information about project construction, road project value

Information about other architectural infrastructure associated with the route: this information will be managed independently into objects: such as trees, trenches, cables, water supply, and drainage, and designed to link objects. Related objects in the infrastructure GIS data system

Information on the management of construction and installation status, warranty, and maintenance

Details on road repairs and problems, including problem detection, troubleshooting, handling times, and maintenance monitoring.

Bridge management data and related attribute information:

General information about the bridge

Detailed information about the bridge structure

Detailed information about construction works, construction units

Information about construction status, incidents, damage, maintenance, unit in charge, repair unit, etc.

Data of road intersection management:

General information about road intersections, including their location, kind, and form

Textual and visual descriptions of the best ways to direct traffic at intersections

Signal light management data:

General management information about signal lights: signal light installation location, location, type

Detailed management information of attribute data about signal lights: material, brand, origin, year of manufacture, installation time, warranty, and maintenance.

Traffic camera management data:

General management information about the camera: installation location, camera type

Detailed information on camera management properties

Waterway Management Data:

Information about waterways, location, range of coordinates, type standards

Detailed attribute information: width, length, normal flow, dangerous locations

Information about river crossing works on waterways

Waterway signaling system management data (buoys):

Management details regarding the waterway signaling system, such as its location and the canal it operates in

Detailed attribute data information: type, structure, installation, etc.

Details on failures, repair and maintenance schedules, and installation management qualities

Management data of sewers and traffic tanks:

General information about culverts and traffic tanks: location, type of culvert, pictures

Description of culverts, traffic tanks

b. Data organization chart:

We give two data organization diagrams for routes, bridges, inland waterways, and traffic sign poles as illustrative examples in this study.

Routes, Bridges, Inland Waterways

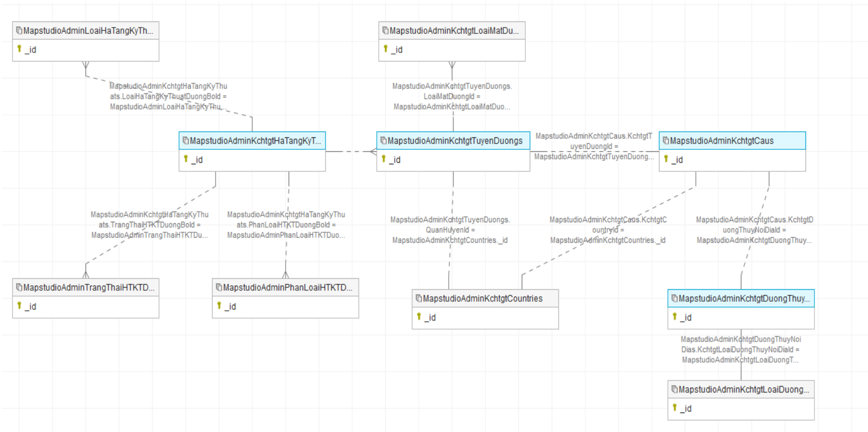

Fig. 8. Route, Bridge, Inland Waterway data organization

Traffic sign poles

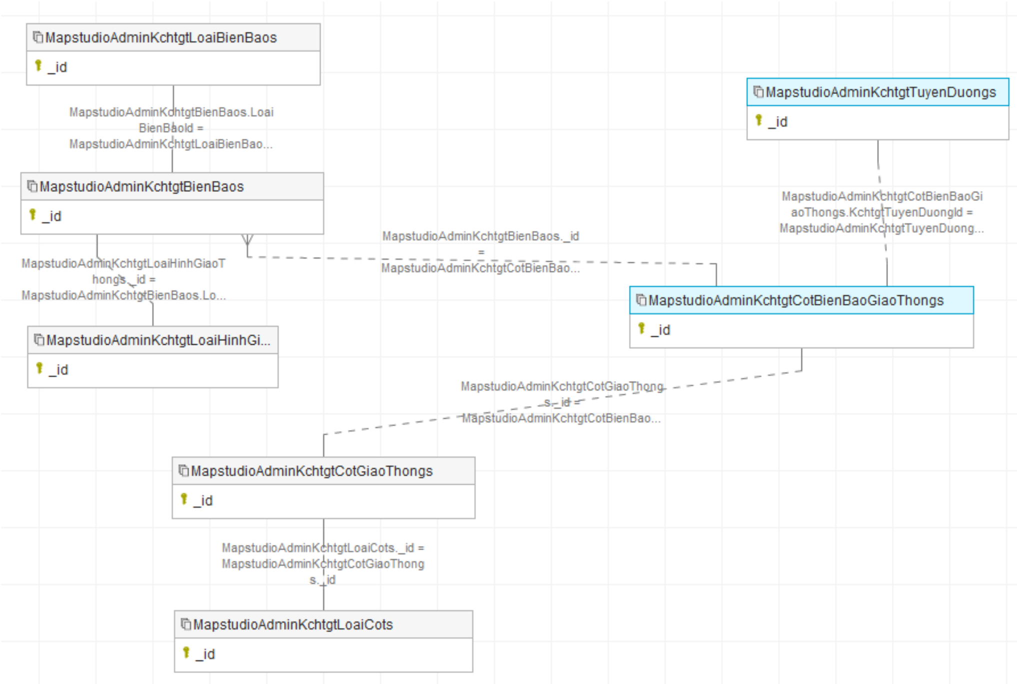

Fig. 9. Organize traffic sign columns

Organize the connection to the database system on the server

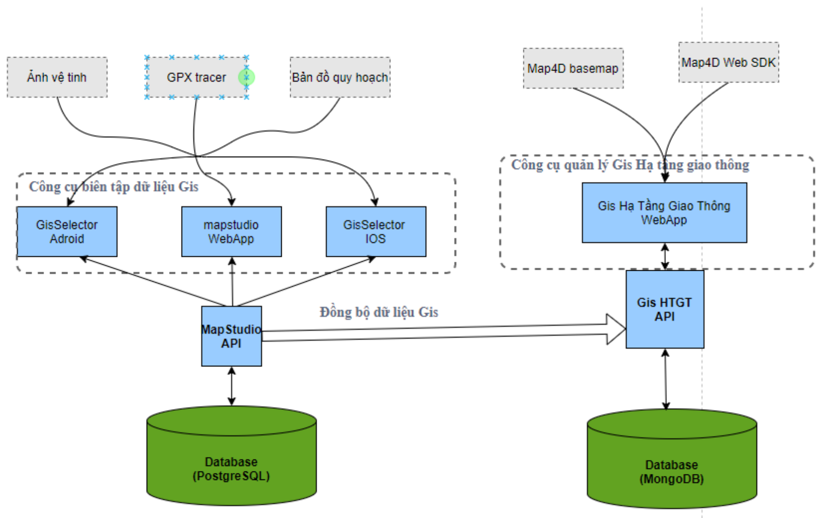

Fig. 10. Organize the connection to the database system on the server

5. Conclusions and recommendations

The peculiarity of the data of each transport infrastructure project is that the data is very large and has many different formats; the information is updated regularly every year according to the process of maintenance, renovation, and upgrading if using the traditional way of storing and representing data, like how database management systems and management software are used, it will not meet the demand (Zamolo, C., 1983). Therefore, it is necessary to implement a solution to build a centralized specialized database, have a special organizational plan according to industry characteristics, and be able to integrate data from specialized applications to have a connection, unifying data between authorities. This will serve as a platform for data sharing and exploitation for professional management work between authorities in the city and the whole country. In addition to having unique characteristics in terms of kind, size, etc., transportation data also has unique properties; therefore, big data storage and analysis solutions are required (BigData). A standard digital map is required for the management, representation, and exploitation of these data, which allows the visualization and modeling of traffic infrastructure items and their features plainly visible. Traffic infrastructure data is significant information that belongs to the country and must be kept confidential. It cannot be uploaded to a map platform under another nation's control, so the base map must be the foundation of Vietnam, managed by the Vietnamese.

Because of those characteristics, we have conducted in-depth research on the types of applications and GIS Databases that are already on the market, especially GIS databases for transportation infrastructure systems. The design of the transport infrastructure GIS database system is complete. It now includes two sets of databases for storing particular data: a spatial database and a database of attribute data. Additionally, the design is finished and ready for use after deployment on the cloud server system.

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