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INTEGRATION OF THE RURAL ROADS DATABASE IN THAILAND WITH THE PARALLEL COMPUTING ENVIRONMENT

INTEGRACJA BAZY DANYCH DRÓG WIEJSKICH ZE ŚRODOWISKIEM OBLICZEŃ RÓWNOLEGŁYCH

Abstract

We present a solution to integrate the database of the Department of Rural Roads (DRR) in Thailand and to utilize the data on the environment of the parallel computing. We define and classify the usage of the data according to the level of the collaboration for different sources. For the user interface of the integration, we provide a web-based environment with the technique of the HTML5.

Keywords: roads database, HTML5, parallel computing

Streszczenie

Prezentujemy rozwiązania dotyczące integracji bazy danych Departamentu Dróg Wiejskich (DRR) w Tajlandii oraz wykorzystywania danych w środowisku obliczeń równoległych. Definiujemy i klasyfikujemy wykorzystanie danych zgodnie z poziomem współpracy dla różnych źródeł. Dla interfejsu użytkownika tej integracji zapewniamy środowisko webowe z technologią HTML5.

Słowa kluczowe: drogowe bazy danych, HTML5, obliczenia równoległe

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1. Introduction

Transport developments directly contribute to an improvement in standards of living. Roads provide access to schools and hospitals and connect communities. Urban mass transits, which are public transportations in cities, save time and expense. Inter-city passenger transport, which is provided by highways, makes it more convenient for people to travel either for pleasure or business. In addition, transport development can help to facilitate economic development, for example, by reducing the costs of doing business.

Among them, land transport is the most important mode of transport in Thailand accounting for 99% of total domestic passenger movement and 88% of domestic freight transport in 2006. Currently road is the most dominant mode of transport for both passengers and freight with the modal share of 85% and 86%, respectively, see Fig. 1. About 98.5% of the main roads and collector road in Thailand are paved. The quality is considered moderate, with the International Roughness Index (IRI) of around 3.5-4.5. However, the average IRI has decreased over the years [1]. Passenger transport in Thailand are dominated by personal vehicles (primarily cars and pickup trucks) and motorcycles. National personal vehicle ownership (expressed as in-use vehicles per thousand population) has been growing at an average of 8%–10% per year, and this trend is expected to continue. With the continuing per capita income growth, it has been expected that ownership of four-wheel vehicles will grow faster than motorcycle ownership [2]. Since the size of the four-wheel vehicle is much bigger than that of a motorcycle, it is necessary to plan an appropriate strategy to maintain the roads and to extend them.

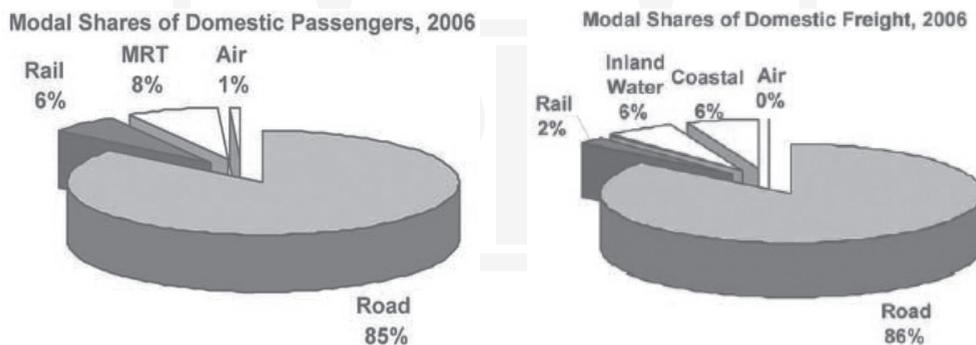


Fig. 1. Models shares of domestic passenger and domestic freight in Thailand 2006, Ministry of transport

The total road network in Thailand is estimated to be 400,000 kilometers (km) long. That can be classified into 3 types, namely, 1) Highways 2) Rural Roads and 3) Local Roads. Highways are arterial roads that connect regions in Thailand passing through several provinces providing high mobility with limited access, and the department of highways (DOH) oversees the Highways. Local roads, in contrast, provide access to all residences with compromised mobility and are overseen by the local administrative organization. Rural

Roads are classed in-between Highways and Local Roads and are overseen by the Department of Rural Roads (DRR). More precisely, Rural Roads connect local roads to highways and provide smooth traffic from and to those roads. Also, the function of the Rural Roads is that the road users need not get onto a highway to access the destination nearby the origin. They can use the rural roads, which are systematically organized as local regional networks so as to reach their destinations. DOH and DRR are managed by the Ministry of Transport, which is the department designated to formulate the policies for development, construction and regulation of the domain of Thailand. The Ministry of Transport oversees the land, marine, and air transportation systems on the basis of adequate services and decides the direction of the accessibility, efficiency, cost-effectiveness and fairness. On the other hand, the local administrative organization is managed by the Ministry of Interior, which has a different mission from the Ministry of Transport. Since the department of Local Roads lack of expert staff and budgets for construction and maintaining compared to Highways or Rural Roads, the main mission of DRR is being a technical mentor for local governments.

2. Overview of the integration of roads data

Thailand is faced with specific limitations in road-transportation on top of other major problems such as high traffic volume, the geometry of roadways, lack of parking space for large vehicles, noise from the vehicles, pollution and heavy fuel consumption due to the heavy traffic. Under these circumstances, we have to consider the following points:

- (1) A truck may not pass between two states, and goods must be transferred to other trucks that belong to a neighboring country. This generates extra costs in addition to a time-consuming issue with a high risk that products may be damaged;
- (2) Overloading trucks may result a high road-maintenances cost;
- (3) Laws and regulations relating to logistics and the transportation sector have not been enforced strictly up to international standards [3].

DRR has a main mission in order to plan for managing the rural roads around the country, that spanned for 40,000 km long, with a design and construction of the rural roads. In addition, DRR has to be a technical mentor for local governments who have to take care of the other 300,000 km of local roads nationwide. In order to develop rural roads effectively, the department applies both road engineering and a social science knowledge. Local Roads are always allowed to participate in all processes of the rural roads development. With the help of the participant of the Local Roads, DRR can understand the real needs of people and can carefully balance engineering with social requirements.

However, due to human resource constraints, DRR decided to introduce the information technologies to facilitate works as integrated. Information technologies we would like to apply to the work of DRR is divided into two categories; (I) Database System and (II) Geographic Information System. By using these solutions for the problems we faced in handling dramatically increasing data, which is sometimes inconsistent and inaccurate in the process of registration and duplication. The main reason for these problems is that DRR does not have sufficient collaboration from other bureaus who collect data and the format to collect data. Furthermore, data recorded into the road database systems is not so well organized. Therefore, it is difficult to analyse and convert this data into information for decision making.

Hence, the data integration is expected to be able to solve the problems concerned with moving, transforming, and consolidating information from various parts. The project's elements, i.e. systems, databases, applications, files, and web services, are going to be applied for the purpose of regulating and integrating sources of the road data. For the integration effort to be successful, it is important to use a formal sequence of steps:

- (i) Identifying data elements shared with bureaus. Other difficulties such as the redundancy and inconsistency of the data and modelling conflicts are examined at the same time;
- (ii) Fixing the above problems in terms of data consistency;
- (ii) Constructing metadata with the integration effort by accumulating and normalizing the database;
- (iv) Based on the metadata and related database, an interface to utilize this data should be constructed.

The purpose of work is to learn the difference and the common part of the roads data and to find a solution for the data integration. Further, with the help of the integrated data, we will proceed to consider the optimization of the road management of DRR in Thailand under the parallel computing facility.

For the implementation of the system, we use MySQL for the database and an HTML5 technique for the web interface. In most organizations today, data and other information is managed in isolated databases by independent teams using various data management tools. This is also true for DRR. In DRR, each bureau has created a database for use in their own projects. For example, the bureau of maintenance has created Central Rural roads Database management system (CRD) and Flood Management System (FMS), and the bureau of local roads development have created Central Local roads management Database system (CLD). The information and technology center also has created Geographic Information System (GIS). By surveying these circumstances, the integrated database in DRR can be classified into 3 types, 1) database for the main project, 2) database for various asset and resources management, 3) database for budget management.

Here, as the first step solution for integration of the databases, we will unify only road databases such as GIS, CRD and CLD, since these are used for supporting the main project in DRR as shown in Fig. 2.

To integrate road databases for the purpose of finding the relation between conditions of roads and traveling of masses of people, we examine the consistency in the duplication and how the data is collected. For example, the primary key is assigned to the ID number of the road. In that case, a difference may occur in the format of the ID number, i.e. numeric or alphanumeric. Further, even if the same format is used, the same road may have different numbers in different databases. Also, we need to check whether the data format of the road length and definition of the starting and end point is the same or not. A point in this examination is that we focus on the name of the roads, the unit of length (meter or kilometer) and the ID number to identify the road. After that, we have to create a master database constructed on MySQL.

In Fig. 3, we show an example of a unified road table in the master database by collecting the road's ID, "road code" and "road name" from the databases; GIS, CRD and CLD. Here, the "road code" is used as the name of the road, and "road name" shows the starting and end points of the road. As for the primary key of the unified table, we defined a new ID number in the format of "r#####", since the ID numbers in three databases are different numbers and the format.

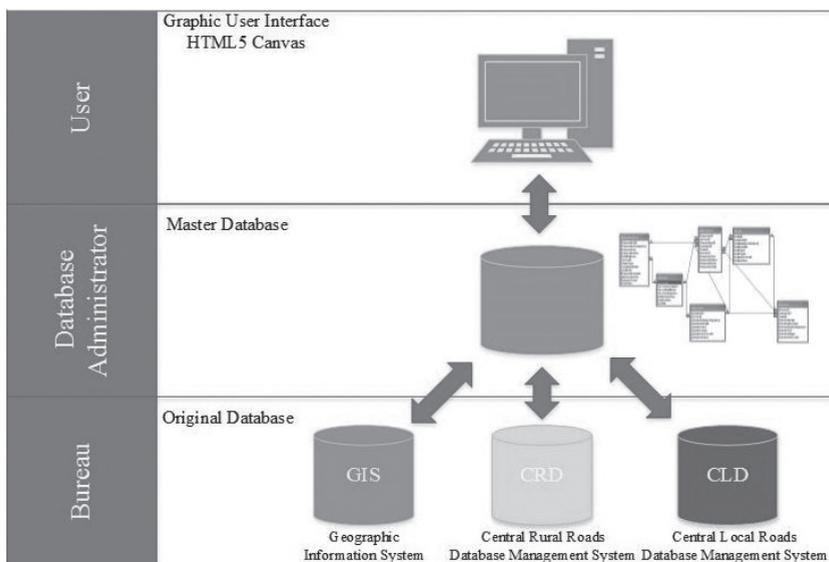


Fig. 2. (Color online) Concept of Integration Database in Department of Rural Roads

Master Database (Table. "road")

No.	Mroad_id	link_id	gid	way_id	Road_code	Road_name
1	r140001	10023	10023	-	กจ.3086	แยกทางหลวงหมายเลข 323 (กม.ที่ 1+400) - บ้านหนองขาว
2	r140002	10028	10028	-	กจ.3095	แยกทางหลวงหมายเลข 323 (กม.ที่ 114+400) - บ้านดอนกระเพรา
3	r140003	10029	10029	-	กจ.3096	แยกทางหลวงหมายเลข 323 (กม.ที่ 98+650) - บ้านองค์รักษ์
4	r140004	10030	10030	-	กจ.3097	แยกทางหลวงหมายเลข 323 (กม.ที่ 79+166) - บ้านหนองรี
5	r140005	10031	10031	-	กจ.4002	แยกทางหลวงหมายเลข 3492 (กม.ที่ 51+100) - บ้านหนองบัว
6	r140016	-	-	34374	กจ.ถ1-0001	บ.ลุ่มดงกระเบา - บ.ถ้ำ
7	r140017	-	-	34341	กจ.ถ1-0002	สายบ้านพลเสียบ - บ้านจันลูน
8	r140018	-	-	34595	กจ.ถ1-0003	บ.ดอนเจดีย์ - หนองขาว
9	r140019	-	-	34423	กจ.ถ16-001	พนมทวน - บ้านม้อหว้า
10	r140020	-	-	34323	กจ.ถ1-0015	บ.พังชี่ว - อ้อกระพุง

No.	link_id	road_id	road_name
1	10023	กจ.3086	แยกทางหลวงหมายเลข 323 (กม.ที่ 1+400) - บ้านหนองขาว
2	10028	กจ.3095	แยกทางหลวงหมายเลข 323 (กม.ที่ 114+400) - บ้านดอนกระเพรา
3	10029	กจ.3096	แยกทางหลวงหมายเลข 323 (กม.ที่ 98+650) - บ้านองค์รักษ์
4	10030	กจ.3097	แยกทางหลวงหมายเลข 323 (กม.ที่ 79+166) - บ้านหนองรี
5	10031	กจ.4002	แยกทางหลวงหมายเลข 3492 (กม.ที่ 51+100) - บ้านหนองบัว
6	10047	กจ.ถ1-0001	บ.ลุ่มดงกระเบา - บ.ถ้ำ

GIS (Table. "public.road")

No.	gid	road_code	road_name
1	10023	กจ.3086	แยกทางหลวงหมายเลข 323 (กม.ที่ 1+400) - บ้านหนองขาว
2	10028	กจ.3095	แยกทางหลวงหมายเลข 323 (กม.ที่ 114+400) - บ้านดอนกระเพรา
3	10029	กจ.3096	แยกทางหลวงหมายเลข 323 (กม.ที่ 98+650) - บ้านองค์รักษ์
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6	10047	กจ.ถ1-0001	บ.ลุ่มดงกระเบา - บ.ถ้ำ

CRD (Table. "Link")

No.	way_id	way_code	way_name
1	34374	กจ.ถ1-0001	บ.ลุ่มดงกระเบา - บ.ถ้ำ
2	34341	กจ.ถ1-0002	สายบ้านพลเสียบ - บ้านจันลูน
3	34595	กจ.ถ1-0003	บ.ดอนเจดีย์ - หนองขาว
4	34423	กจ.ถ16-001	พนมทวน - บ้านม้อหว้า
5	34323	กจ.ถ1-0015	บ.พังชี่ว - อ้อกระพุง
6	34565	กจ.ถ1-0018	บ.บ้านดอน - บ.บ้านดอน

CLD (Table. "way")

Fig. 3. (color online) Example of a unified road table as the master database

In the process of integration, we need to collect various road data such as road name, code, connection point with other road, structure and condition of roads and so on from the original database. In order to remain the same scheme to accumulate road data from the accrual of road conditions, we will not change or modify anything in the original database. Therefore, the metadata is necessary to be defined so as to unify the road conditions and capacities of all road databases (GIS, CRD and CLD).

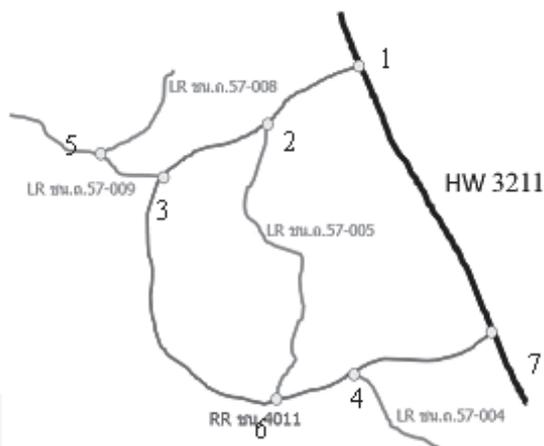


Fig. 4. (color online) Roads network and connection point

In Fig. 4 we show an example of the structure of the road network in Thailand. Thick black line (color online) shows the highway “HW3211”. A Rural Road, “No. 4011” connects to the highway HW3211 at the connecting point No. 1. Three Local Roads; “No. 57-005”, “No. 57-009” and “No. 57-004” connect to the Rural Road No. 4011 at points No. 2, 3 and 4, respectively. Also, a Local Road “No. 57-008” connects to the Local Road No. 57-009 at point No. 5. In the original databases; GIS, CRD and GLD, the attribute “road name” corresponds to the connection of the roads. However, the format of the road name is not appropriate to express the connection. Because, the road name is defined as the form as “starting point (point of the edge of the road + distance from the edge) – end point (name of the province)”. Hence, while the starting point is clearly defined, the end point is unclear, and we can only know the name of the province (village or town) of the end point.

By considering the situation of the road name, we construct a connection point table as shown in Table 1. This table has the attributes of the “connecting point ID”, “road 1” (the ID of the road) and “road 2” (the ID of the road: connected to road 1). Using this table, we can store the topological structure of the road connection to the unified database.

There is one thing we have to be more careful: it is whether the RDB (relational database) is appropriate to express the road connection. Usually, the connection of elements, such as CAD data, is treated in the object database. In our case, the elements are the roads themselves, and the structure of the table with the RDB scheme may become more complicated. Therefore, we define the connection as the point of two roads, which are identified by the road ID.

The relation from the unified table to each original database is constructed with road IDs, which have different names and numbers in GIS, CRD and CLD, in terms of the foreign key. The connection point is also a sub-table of the unified table through the road ID. So far, we only consider the integration of the three databases; GIS, CRD, and CLD. This procedure goes on to include other databases, such as Highway and Local Roads.

Information of the road connection provides us with a useful knowledge and a way to utilize the road data. On the table of the connection point, we define the connecting points using the two crossing roads. The roads contain information for the traffic, properties of

the road for instance, lengths of lane and its shape, surface type, condition. We express the connection of roads in terms of the “nodes” and “links”. Here, connecting points correspond to the nodes, which contain the population of the city around the connecting point, and roads are links.

Table 1

Example of connection point table

No.	Connection point ID	Road 1	Road 2
1	P14000001	HW3211	RR 4011
2	P14000002	RR 4011	LR 57-005
3	P14000003	RR 4011	LR 57-009
4	P14000004	RR 4011	LR 57-004
5	P14000005	LR 57-009	LR 57-008

Under this correspondence, we can simplify the topology of roads into the nodes and links as shown in Fig. 5. In this example, the thickness of the links shows the traffic. Other properties of the roads can be added to the link values. Similarly, the values of the nodes can be treated as the node values. Hence, the topological connection of nodes with links can simulate the situation of the data of DRR.

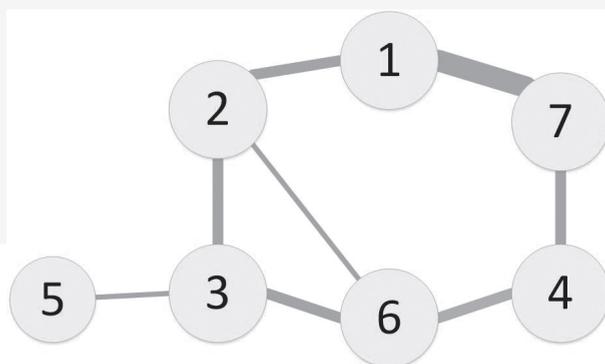


Fig. 5. Schematic figure of the road network

The remaining part of the development of the system is to design and construct the interface for making the connection of the nodes. For the interface part of the system, we implement the system on the web-interface using the HTML Canvas. Using the Canvas, the connection of links between the nodes can be easily done by an intuitive click-and-drag operation on the web browser. In the case for planning the re-construction or optimizing the road geometry and/or topological structure, we can change them with interactive operations.

As an advantage of Canvas, we can retrieve the structure value for the topological shape of the connection of the links and nodes. Once we obtain the structure value, we can estimate and optimize the topological shape of the road connection by putting it to a computational facility. To sum up and calculate the structure value, the process can be parallelized within the processes of calculation for the link and node values, since the attributes of these values are independent from each other. If the computational time is considerably short, we can examine the re-construction and its efficiency through the interface of the web-browser. We consider this process will be a useful tool for solving the problem on DRR in Thailand.

3. Summary and discussion

Data integration is a process in which heterogeneous data is retrieved and combined as an incorporated form and structure. Data integration allows different data types (such as data sets, documents and tables) to be merged by organizations for usages as personal or business processes and functions. In this work, we apply the data integration for the road data of DRR. It can solve problems on duplication and inconsistency of road databases. With the help of the integrated data, DRR will have more precise road data for a good decision or planning to construct and maintain the roads. It is expected that this solution can be applied for other types databases in DRR such as human resources databases, other asset management databases.

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