GIS Application for Patrolling Route in Natural Reserve Forest of Thailand

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Abstract
This paper is the implementation of a Geographic Information System (GIS) that can assist in planning patrol activities or route mapping within forests. Uthai Thani's Huai Kha Khaeng wildlife sanctuary was selected as the case study. All principles and data used were acquired from the National Park, Wildlife and Plant Conservation Department. The Routing Decision Support System (RDSS) is a GIS application implemented for the analysis of the forest patrol routing. RDSS was implemented using visual studio 2005 and ArcGIS Engine 9.2. This article provides a patrol route creation concept which is appropriate for patrol routing in the forest and as a system for patrol routing. The route creation concept applied GPS patrol data and Topographic maps for making the most suitable patrol route. RDSS is capable of supporting the executive to make decisions in planning, managing and choosing patrol routes to increase the efficiency of patrol routing.

1. Introduction

The forest patrol is different from other patrols. This patrol has patrol limitations such as the problem of communication, the problem of patrol routing and the problem of equipment used in the forest. Some of these limitations render their work difficult. Patrol route in forests is distinct from with other area because in forests do not have the roads or other signs which can be used for guidance. Sometimes they have a trouble with patrol routing to go to an infract position immediately or as fast as possible. They cannot search or find the most suitable patrol route for such situations because they do not have the precise routes as have the urban police. In the worst case, if they arrive to the infract position too late, they only find the carcasses or exhibits. A satellite image of Thailand taken in 2004 shows that forested areas cover sharply 167,590 km^2. Factors like immigration, population growth, deforestation and bush fires contributed to this decline, and general apathy on the government's part as well as insufficient patrols may have worsened the situation further (Bin and David, 1996). Geographic Information System (GIS) is mostly used as Decision Support System (DSS) for designing and implementing the Information System (IS). The Design and implementation of a Spatial Decision Support System for Site Selection is a well-known GIS research area which uses DSS for conceptual design. The varieties of environmental are problems in a 300 sq. mi. area around the Savannah River, which is located along the border between South Carolina and Georgia. The system had to be both flexible and generic enough to address a variety of site location projects. This project used AML programming to let developers customize the user interface. Also, it incorporates vectors and grids based on the modeling function of ArcInfo, while ArcView serves as the front end for accessing site selection tools. Discussed topics include needs assessment, system design, graphical user interface, incorporation of a spatial model, and cartographic display. (Ehler et al., 1995) Later, the creation of an Intelligent Transportation System (ITS) used an advanced computer system. The project encompasses communication, technologies, transportation, traffic planning, travel time optimization, security issues, and overall efficiency. ITS uses data collected from each vehicle to form an overall view of the traffic system and plan ahead to avoid or warn motorists of traffic congestion while also attempting to minimize transit times. The traffic analysis system uses Dynamic Network Mode to calculate factors like origin and destination, number of vehicles on a given section of the road and statistical breakdowns for each period of a given day. (Bin and David, 1996) Also, in years 2008, GIS used as a basis for the development of a school bus management system that can determine shortest and fastest routes and also schedule them while also enhancing security. The area around Sujatha High School in Hyderabad, India is used as the project's scope. Development tools included ArcGIS 9.1 Network Analyst and VBA. (Mohamed, 2008).

2. Materials and Methods.

2.1 Study Area

Huai Kha Khaeng Widlife Sanctuary covers approximately 2,780.14 km^2 in the north of midland

Thailand between coordinates 15° 00' - 15° 45' N. and 99° 00' - 99° 30' E. as shown on the map in the Figure 1. It is located east of Uthai Thani province and covers areas like Kok Kwai, Ma Krud, Ban Rai, Tonglarng, Huai Krut, La Bum and Orr districts in Uthai Thani province. It also covers several districts including Maa Ra Mung and Anm Pang in Tak province. Huai Kha Khaeng's central office is located in Hin Daeng village, Lann Sak, Uthai Thani. There are 19 and 2 ranger units to cover land and water areas. The sanctuary's management considers the area to be separated into four parts according to landscape characteristics. The first part consists of Sub Fa Pa, Ka Puk Ka Peang, Kaw Kew, Huai Yu Bi, Huai nam kao and Tung Fang forest protection units.

The second consists of Wang Pai, Cyber, Huai Bi Sa, Pan So and Sub Pa Pru units. The third consists of Maa Dee, Krong Sera and Kaw Ban Dai units. The fourth consists of Grung Gai, Ong Tang, Ta Pern Kee and Bang Kwui units. Grung Gai houses two bastions that cover 200km stretches on both sides of the area's river. This area is quite close to the sanctuary's boundaries. Huai Kha Khaeng Wildlife Sanctuary selected the *Management Information System: MIST* as GIS System. MIST was developed by Wildlife Conservation Society or mostly calls WCS. MIST was used to collect data, such as patrol data, wildlife data, GIS data, law case data, etc. Also, MIST was used for reporting of the patrol. *Firebird* was used to develop the MIST database management system.

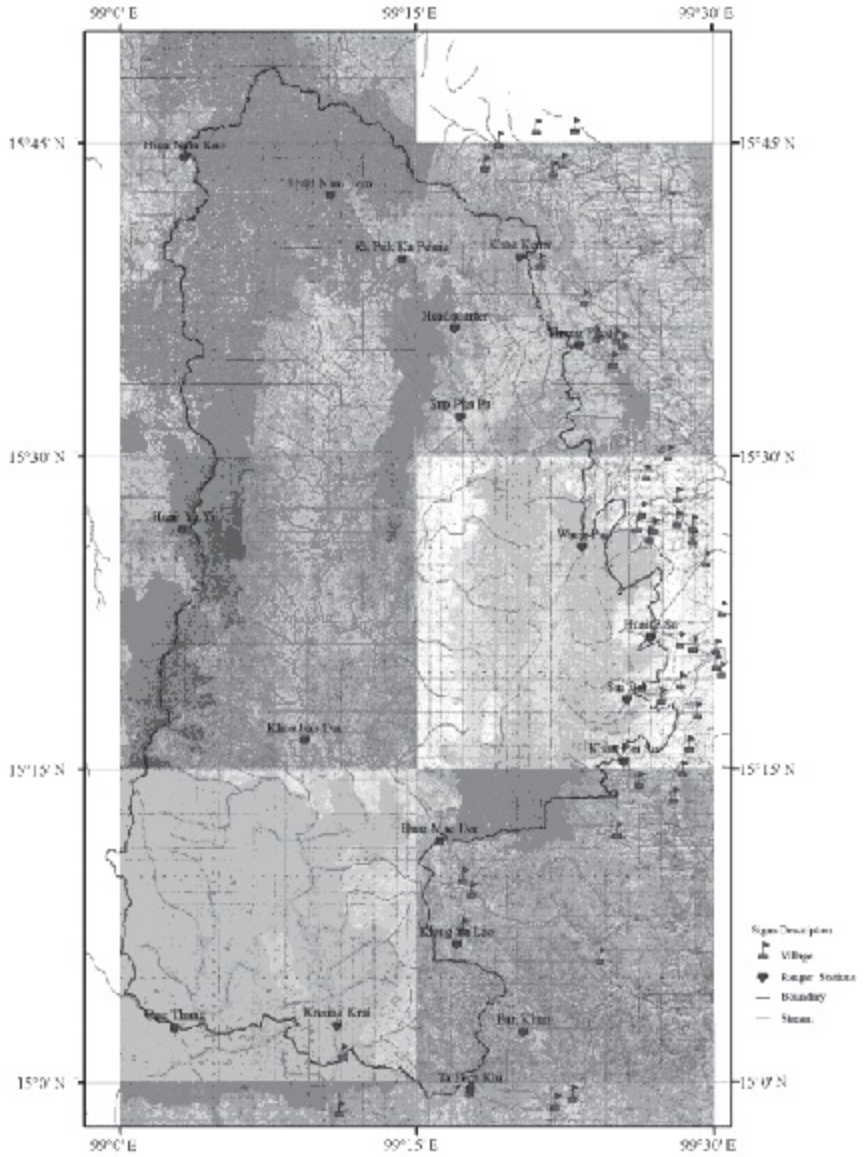

Figure 1: Location of the study area on Huai Kha Khaeng Wildlife Sanctuary

2.2 Materials

This research used Microsoft Visual Basic 2005 and the ArcGIS v9.2 Engine for programming and user interface design. The database management systems used in research is Microsoft SQL Server 2005 and Firebird 2.1. The Microsoft SQL Server 2005 is used for the Geo-database. The DBMS Firebird 2.1 is used for connected the MIST data. The ArcGIS v9.2 Desktop was used for the Geographic Information System work such as Network analysis, map digitizes and patrol route creation. The ArcSDE Personal Edition was used for the Geo-database management system. Routes are created with seasonal changes taken into account.

2.3 Methodology

This research separates the hierarchy of work into 5 steps. Figure 2 is shows about the working process.

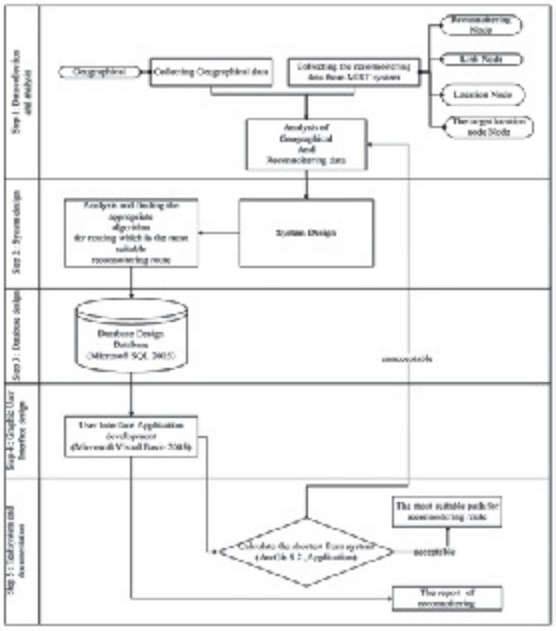

Figure 2: Hierarchy and diagram of development process

2.3.1 Data collection and analysis

Analysis of Huai Kha Khaeng's forest patrol system and all associated data. The sanctuary employs GPS technology, a MIST system and ArcGIS. This research is primarily concerned about spatial data like vector and raster data. All the spatial data used in this research have 7 layers are consisting of river (stream), road, and protector unit station, boundaries of Huai Kha Khaeng, boundary of protector unit zone, Topographic and GPS data can see the detail in Table 1.

Table 1: Map layers used for research

	Data Layer	Type of Spatial Data	Description
1.	River	Line	River names
2.	Road	Line	Road names *UTM, WGS84*
3.	Protector units station	Point	Names, locations *UTM, WGS84*
4.	Boundaries of Huay Kha Khaeng	Polygon	Huay Kha Khaeng boundary areas in sq. km.
5.	Boundaries of protector unit zones	Polygon	Name, locations *UTM,WGS84*
6.	Topographic	Raster	Digital topographic map *1 : 50000 ,L7017* *WGS84*
7.	Patrol	Point	Reconnicitering route data, *GPS* tracking and waypoint data; *UTM, WGS84*

2.3.1.1 GPS data and DNR-GARMIN

The GPS data used in this research are from the Huai Kha Khaeng Widlife Sanctuary. They used the GPS handhelds for tracking the patrol route. The GPS handhelds that they used consists of GARMIN 12, GPS MAP 60 CSX and GARMIN12XL. The coordinate system which use for GPS is *WGS 1984 ZONE 47 N* and used the DNR-GARMIN for transfer data from the GPS handhelds to computer text files. These text files are consists of waypoint number, waypoint position and waypoint timestamp as the patrol information. These text files were manage by saving them into the computer and separate those by text file name patrol area, date time and patrol group number. As an example for a of text file name *HKK-140751-722 HKK* is patrol area of *Huai Kha Khaeng*, *140751* is presented the date of collection, and *722* is presented the patrol group number of Huai Nam Kao. The maps in Figure 3 are shown the patrol waypoint data (represented by points). This map separates the patrol data into four parts, represented by different colors pink is representing the patrol management part1, red is management part 2, the blue is management part 3 and brown is management part 4. Researcher separates the route class because the types of route are different. Moreover, the time cost for the main road layer is lower than for the patrol route.

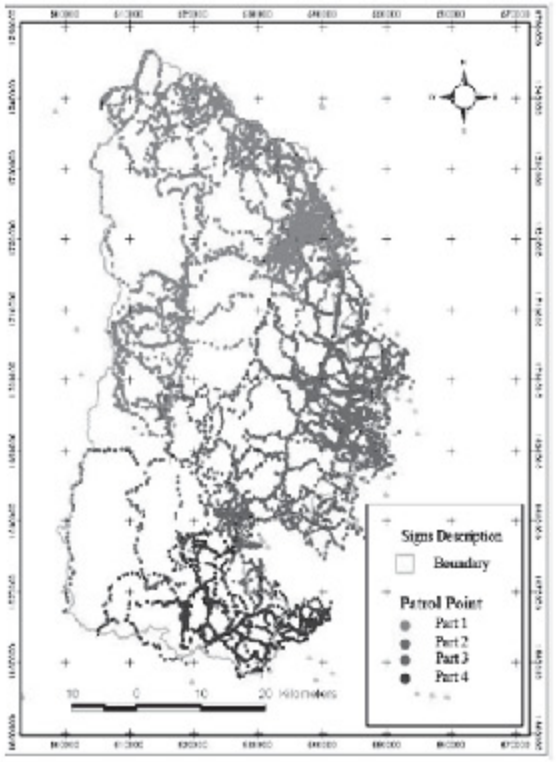

Figure 3: Patrol waypoints which created from GPS text files. MNRE (Ministry of Natural Resources and Environment), 2006

Patrol route and main road layers will be merge when overlap. Sometime, when patrol routes created from the waypoints are overlap or closest too much. This research selected the summary route by calculation method. First, create the buffer for each line that overlap or those are too close. The interval of buffer used in this research consists of 100, 200 and 300 meters, with 300 meter being the maximum distance that a human can see in the forest. If a line in a buffer includes other lines or other points of the other lines, researchers will adjust them to the same line.

2.3.1.3 Topographic map

The topographic maps acquired from Huai Kha Khaeng consist of many topographic maps merged from one bigger map. Maps that cover the sanctuary's area were cut out for usage, and then transposed to the same scale as the Patrolling routes map and patrol protector unit location map. The topographic map data are consists of main roads, local roads, villages, contour lines, stream lines, protector unit stations and terrain information.

2.3.1.4 Network analyst maps

The route map for the Network analyst consists of multiple fields considered appropriate for analysis. Fields relevant to this research are the following:

- FID is the identification of the polyline.
- Shape* is a vector format.
- DIRECTION is the direction of the polyline.
- DISTANCE is the length of the polyline in, meter unit.
- FNODE is the identification of the start node in a polyline.
- TNODE is the identification of the end node in a polyline.
- FT_minutes is the traveling time from start node to end node in a polyline in minute units.
- TF_minutes is the traveling time from end node to start node in a polyline in minute units.
- Name is the name of polyline.

This research measures the cost of network polyline in two ways time and *distance*. Time calculation is based on timestamps of coordinates within each line, while distance calculation uses interpolation between coordinates within each line. Values for *TF_minute* fields are set to the same as *FT_minutes* fields because of data limitations. This research does not use the slope value for route calculation. The patrol data set used was collected for a period ranging between July 2007 and December 2008.

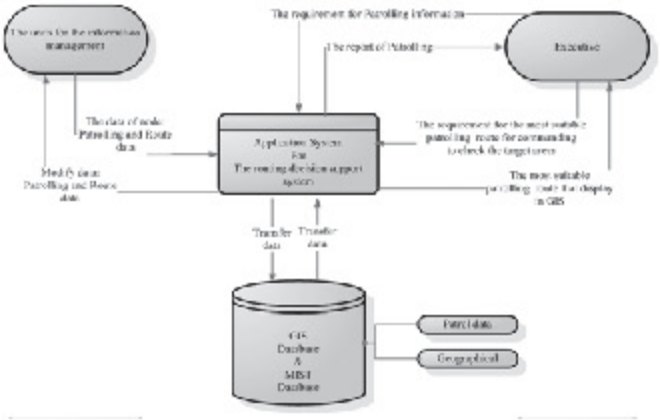

Figure 4: Decision Support System (RDSS) diagram

2.4.2 System design

The RDSS was designed to display the most suitable routes that will then be presented to executives for final decisions and orders. The RDSS working process can be split into four parts in Figure 4. The first part of the working process concerns the database system. The second part is the application program. The application program is connected with database system for displaying the patrol route map. The third part is concerns about the cartographer who is managing the patrol route map. For this part, cartographers can update map information via the ArcGIS Desktop version 9.2. And the last working process is the executive's part. This part concerns patrol information that is present to executives for decisions and orders. The routing function for this research is the closest facility function in ArcGIS 9.2.

2.4.3 Database design

Database design was separated into two parts MIST and Geodatabase. The MIST portion focuses on patrol data (attribute), while the Geodatabase part involves routing data (spatial and attribute). The MIST system was built using Firebird. And RDSS can connect to Firebird via the ODBC function. The Arc/SDE Personal Edition used to generate the Geodatabase. This research used Microsoft SQL Server 2005 to collect the database that generate from Arc/SDE. RDSS can connect the both database system by used OLEDB function.

2.4.4 Graphic user interface design

Microsoft Visual Basic 2005 and ArcGIS Engine 9.2 tools were used in this task. ArcGIS 9.2 was used to design and implement the Patrolling route map layer, while "Closest Facility" was used to determine the most suitable routes. The map display functions of ArcGIS were then linked to the routing decision support application using Visual Basic 2005 and ArcGIS Engine 9.2.

2.4.5 Test system

The reliability of RDSS was tested by a user who is a representative of the National Park, Wildlife and Plant Conservation Department of Thailand.

3. Result and Discussion

3.1 Patrol Routes

The Patrol GPS shape files which used for create the route have 189 files. All of these fileswas picked from Huai Kha Khaeng patrol management Zone 1. All patrol routes layers have 3,466 lines.

In this project, researcher selected the main road layer to make the routing route. The main road layer, researcher digitized from Huai Kha Khaeng topographic map (see the details in Table 1). It has 3722 lines. The buffer range used created the patrol routes was 100 meters in Figure 5. This buffer range is the most suitable for executives to look at to decisions and to give orders because this range is the clearest. The patrol routes created from this range do not loose relevant detail for patrols. All route layers were merged together shown in the map in Figure 6. The route layer has 7168 records. All these records consist of fields as mentioned section 2.4.1.4. FNODE and TNODE fields were generated from the information of each polyline. FT minutes and TF minutes were calculated from the traveling time in each line. These map data were collected in the database manages by Arc/SDE and Microsoft SQL Server 2005. The Network Analyst is an extension from ArcGIS version 9.2. This extension was used for patrol routing. Time and distance was used to compute routing costs. The patrol map was divides these costs in two category maps used time costs and used distance costs. The Closest Facility is a function in Network Analyst. This function was taken for routing by using the network routes and facilities. The facility that set for this function is a position of patrol station. The patrol stations used for this task consist of Sub Fa Pa, Ka Puk Ka Peung, Kaw Kew, Huai Yu Ei, Huai nam kao, Wang Pai, Cyber, Pan So, Tung Fang and Headquarter. There should be at least four facilities to be found by routing because sometimes the initially selected facilities are not appropriate for that time because of inconvenient physical circumstances. This is a requirement of the National Park Department. The patrol routing method was initially designed for routing the path from the facility to the incident point.

3.2 RDSS application

RDSS application was implemented by Microsoft Visual Basic 2005 and uses the libraries in ArcGIS 9.2 Engine to call the function in ArcGIS Desktop. The Network Analyst function used for routing was connected by the ArcGIS v9.2 Engine library. In part of Graphic User Interface, map control interface is call from ArcGIS Desktop via ArcGIS Engine function. All map layers that used for RDSS are called with the ArcGIS Desktop via Arc/SDE. Arc/SDE was set to connect with Micosoft SQL Enterprise 2005 by OLEDB.

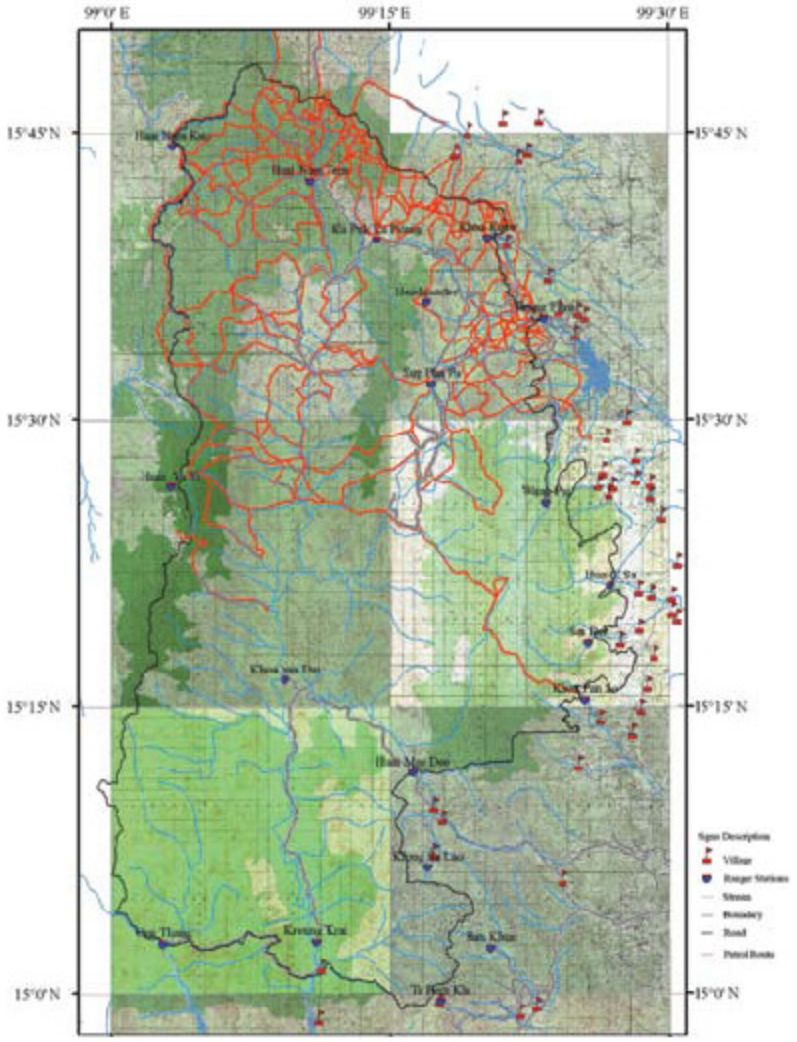

Figure 5: The route map from the interpolate map range 100 m

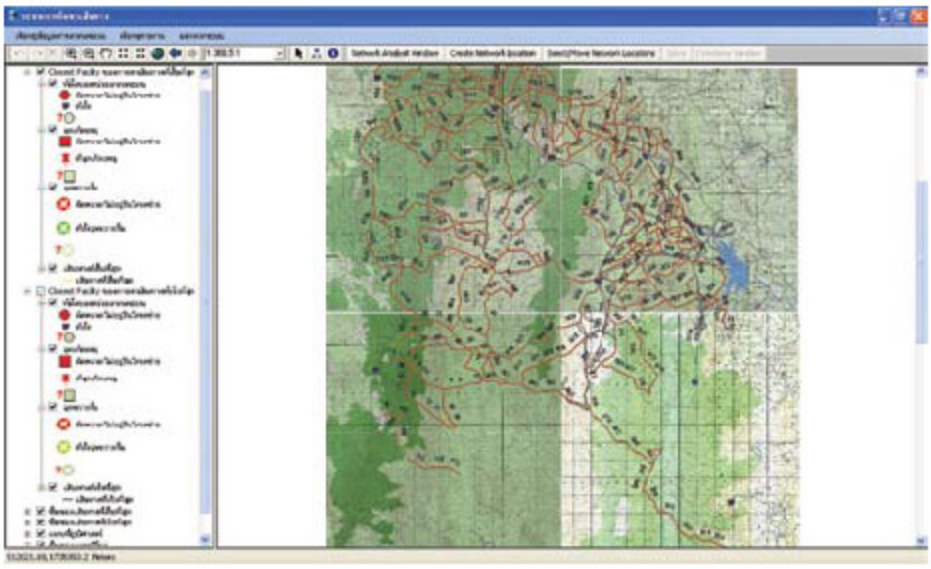

Figure 6: This is a RDSS user interface that was shown about routing function, reporting function and map control function.

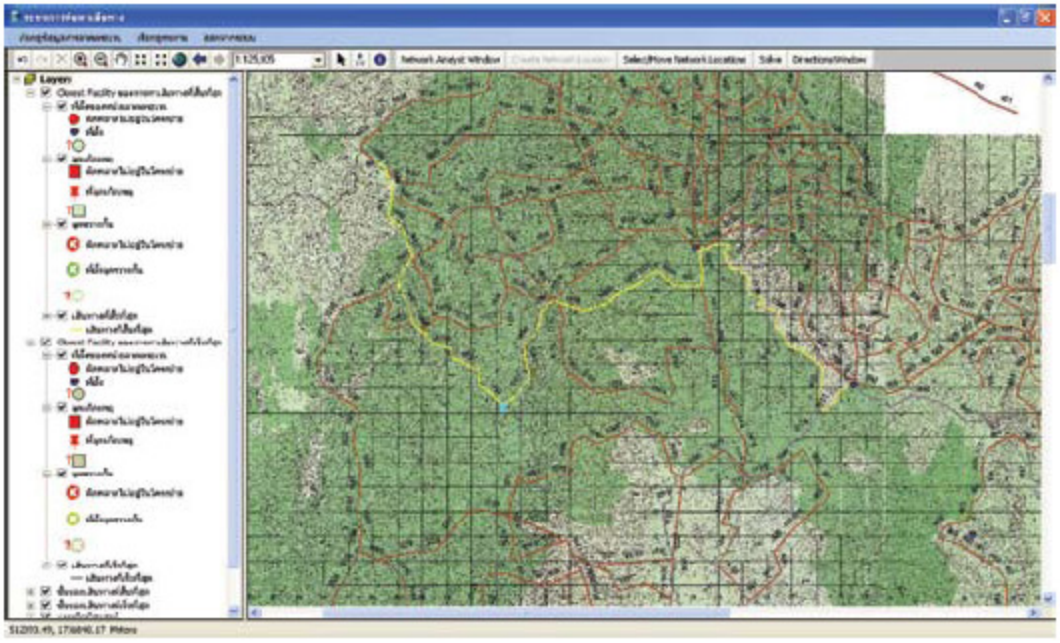

Figure 7: This is an example of routing map. The yellow lines shown in figure are routing routes. This yellow line was generated from RDSS program

Figure 8: The example of routing report. This report is shown about route name, routing route map, time cost in each route, distance cost in each route and direction.

In this task when the RDSS Application run every module will be connect via Microsoft .Net framework 2.0 and ArcGIS.net environment 9.2. RDSS was used for display the routing route and reporting in Figure 8. This system can work with Window XP Version 2007 operation system. In Figure 7 was shown about the RDSS graphic user interface.

4. Conclusion

This research was studied from between years 2008 to 2009. The groups of patrol data was collected from between July 2007 to December 2008. This research is the implementation model for patrol's route management system (RDSS). RDSS was implemented from Smart Patrol (MIST). This system is appropriate for managing patrol routes in Thailand. The patrol data for implementation acquired from Huai Kha Khaeng Wildlife Sanctuary. These data was used for design and create new prototype patrol route for RDSS. The officer can use RDSS for management about patrol routing. Officer cans routing the most suitable route to the patrol destination for protecting the invader or brush fires. This can assist the officer to planning for patrol and increase the efficiency of protecting the invader or brush fires. RDSS can help the officer to decrease the redundancy route because they can plan the patrol route from system before they go to patrol.

Acknowledgements

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