A PC-Based Digital Road Map System (DRMS) for Metro-Manila

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This paper presents a PC-based Digital Road Map System (DRMS) for the city of Metro-Manila. The map system incorporates a two-level digital transportation network of the city. The DRMS not only provides basic graphic display and data management capabilities but also implements some applications which support transport planning and traffic engineering.

1. Background

Road maps are used by both the lay and the professionals. These are used in the ordinary way as a guide by people who do not have enough background information about the ins and outs of a certain area.The lay often refer to these maps to find out the locations of different places of interest and how to get to these places without using circuitous routes. To transportation-related professionals, road maps are fundamental sources of information, particularly to transportation planners and traffic engineers. To support the needs of both the lay and the professionals with respect to the usage of these maps, most of developed countries today implement a Digital Road Maps System (or a DRMS) in one form or another.

Often these digital road map systems are sophisticated systems which are usually implemented using mainframe computers. These are used as information systems, giving on-line data pertaining to traffic conditions, location of vehicles through satellite tracking, etc.; or are used as storage of transportation planning and traffic engineering data that can easily be accessed for general planning and engineering exercises like simulations, forecasting, and modeling. Needless to say, such sophisticated systems entail equally sophisticated hardware which ultimately translate to huge capital outlays.

The importance and potential of these systems, as tools for traffic engineers and transport planners, justify at least, the consideration of implementing such a DRMS in a major third world city (like that of Metro-Manila). However, substantial capital outlay for a true sophisticated DRMS, becomes a major negative factor in instituting such systems in less developed countries. There is, therefore a need for a simpler system, which should not only be configured to run in a relatively cheaper PC environment but also be designed to implement a broad subset of functions found in its more sophisticated cousins.

This paper presents the results of some work done towards the development of one such digital road map system applicable to the city of Metro Manila. The system basically maintains a database on the transportation network of the city which can be graphically displayed. The system likewise implements some applications which can be used by both transportation planners and traffic engineers in the pursuit of their professions.[1)]

2. Metro-Manila Transportation Network

The city of Metro Manila is actually a conglomeration of 4 cities and 13 municipalities. It spreads over a 636-square kilometer area extending about 50 km. from north to south and 20 km. from west to east. The transportation network is composed of a road network approximately 2,800 km. in length, a light rail transit (LRT) line, and a train service line operated by the Philippine National Railways (PNR).[2)] Several future light rail transit lines are currently in the planning stages and one (LRT line #3), is currently under construction. The city divisions and the overall configuration of the transportation network is shown in Figure 1.

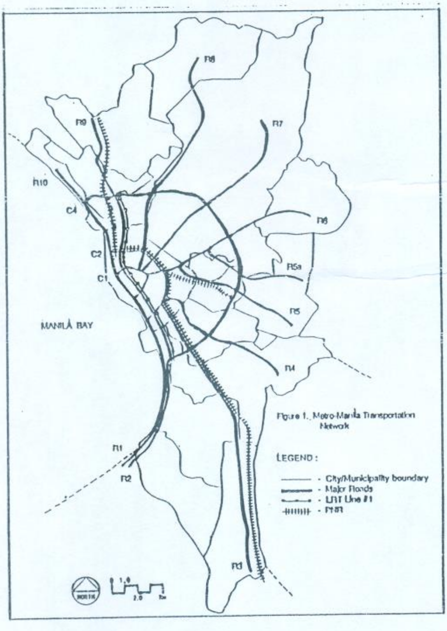

Figure 1. Metro-Manila Transportation Network

This road configuration has influenced the development of business and commercial areas particularly around the vicinity of the major radial and ring roads. The city landuse is predominantly of mixed residential-commercial type (especially within C4) resulting in complicated travel patterns which can be considered as indigenous to the city.[3)]

Public transport comprise mainly of buses, jeepneys, the LRT and PNR services, tricycles, and taxis. The total number of trips per day (in 1984) was around 14.8 million of which 24.6% used private vehicles and 75.4% used public modes. The most dominant public mode is the jeepney, carrying about 54% of the total public trips and the rest being carried by bus, LRT, tricycle, and a small percentage by PNR.[4)]

3. Digital Road Map System

The functional structure of the Metro-Manila DRMS is shown if Figure 2. The system is supported by a database which incorporates the digitized road map, information related to different nodes and links of the network, and other important transportation planning data. The DRMS provides basic data management functions, e.g., to manipulate the database, and has graphic display capabilities. The DRMS also provides some subsystems which support transportation planning and traffic engineering applications. Since these applications have modular constructs, future applications can easily be attached as they are developed.

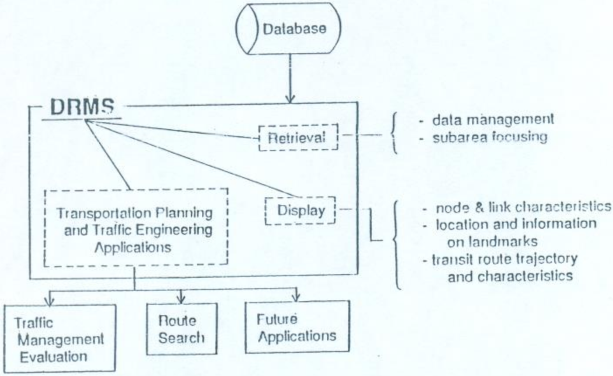

Figure 2. Functional Structure of the Metro-Manila DRMS

3.1 Digital Map

The digitized road map data are based on standard Universal Transverse Mercator (UTM) projection maps (scaled 1:10,000) in order that stored node positions can easily be adapted according to standard global positioning systems[5)6)] in the future.

To create the digitized map, Metro-Manila was divided into 119 grid of about 7.6 km^2 each shown in Figure 3. These grids enable the grouping of the transport network nodes and links (and other pertinent information) into files which are not only of manageable sizes, but also of semi-independent nature in order to address the issue of data portability. Using this scheme, related files which encompass a transport planning zone, can be easily grouped together and stored independently in a separate media, i.e., diskettes or removable hard drives, which can easily be ported to other PC's.

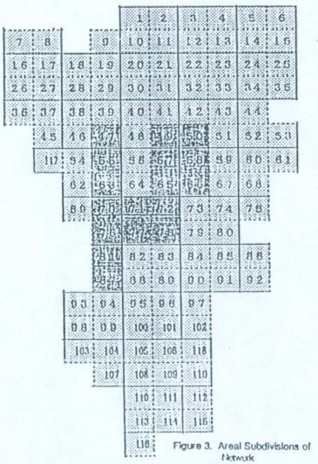

Figure 3. Areal Subdivisions of Network

Network data for each grid are digitized and sorted in two separate files each of which representing a different level of the digitized map. The first level includes primary arterials and roads used for inter-suburban traffic movement and those used as routes by public transit lines. The second level includes all roads not included in the first level. These are in general, non-primary roads whose main function is to provide access from other non-primary roads or from abutting property to the first level network. The first level, therefore, is a digitized representation of the overall Metro-Manila road network. It is however, implemented as a collection of grids to properly define the extent of the lower level maps. This way, each grid in the first level map automatically defines a corresponding lower level map which stores the details not found in the first level. The dark-shaded grids in Figure 3 are those which to date, had been digitized for the second level network. The two-level design of the digital road map therefore, is achieved through a multi-scale approach (as opposed to the usual multiple overlay approach). With this implementation, applications requiring the general form of the road network may use only the higher level maps, while those requiring more network detail may use the lower level maps. The multi-level design of the DRMS is illustrated in Figure 4.

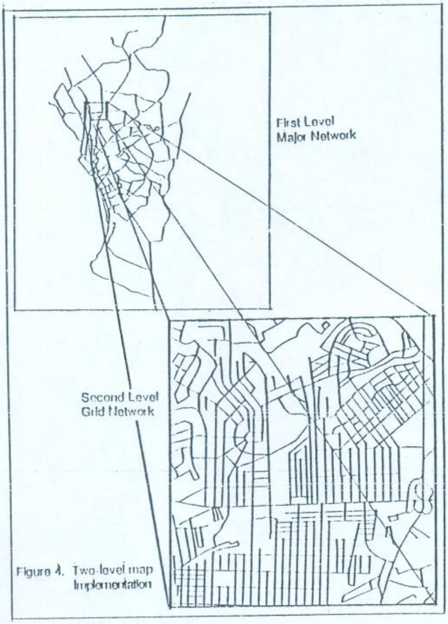

Figure 4. Two-level map Implementation

3.2 Database and Data Retrieval

The files that support the DRMS are designed to be transparently independent but these are actually interrelated by node-, link-, and area-indices. The collections of these files and their linkages as shown in Figure 5 represents a relational database from which information for the display function and other application subsystems of the DRMS may be extracted. The different indices are used as linkages in order to retrieve related information which are usually stored in different files.

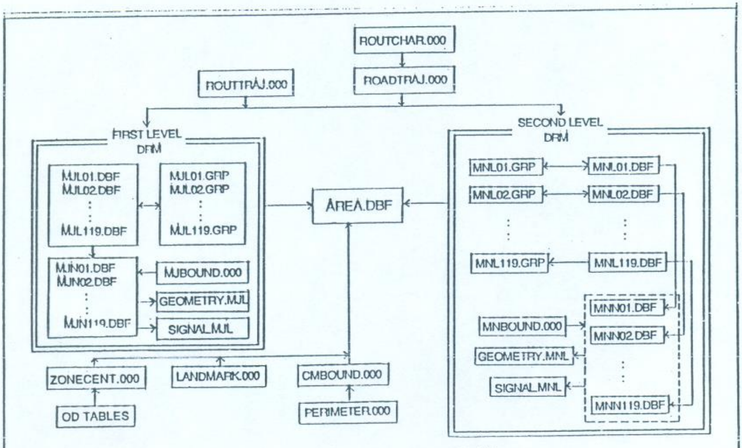

Figure 5. Metro-Manila DRMS Database File Linkages

3.3 Graphic Display

This DRMS function provides for the graphical display of most of the information stored in the database related to the nodes and links available in the database.

Nodes refer not only to network intersections but also to selected pedestrian crossing points, public transit terminals and train stations, and important landmarks. Landmarks[7)8)] refer to special point locations in the city such as hospitals, airports, government institutions, major department stores, embassies, hotels, etc. The DRMS can display the relative location of such nodes and some related traffic characteristics (whenever applicable). For example, for network intersections, the geometry, capacity, peak hour flows, and signal parameters may be displayed. For transit terminals and train stations, boarding and alighting data may be displayed. In the case of landmarks, locations of all hospitals in the city, for example, may be simultaneously displayed in order to get an overall picture of their relative positions. In addition, information on households will be incorporated in the database, e.g., household owners, addresses, etc. This will facilitate the search for the locations of individual houses (given the family names of the household owners) or the shortest routes from different landmarks to these households.

Links on the other hand, refer to a single connection between two network nodes (a road segment) or a group of links forming a trajectory. With this definition, single links may be selected so that their relative positions in the map and some attributes such as peak hour volumes, link width, number of lanes, etc., may be easily displayed. Groups of links may be selected for example, to trace the trajectory not only of a specific road but also of a route used by public transit lines. In the latter case, line frequencies, headway, etc. may be displayed. Sample graphic output formats are shown in Figures 6 and 8.

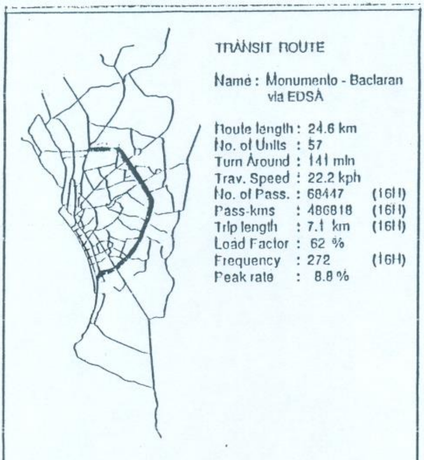

Figure 6. Transit Route Information Display

4. DRMS Applications

4.1 Route Search

This application module provides a search and display function for the trajectory of the minimum path between an OD node pair. The OD nodes maybe selected from the intersections in the major network or may be specific landmarks. The minimum path search basically uses Djiktra's method applied on the combination of the multi-level network. This is under the assumption that road users proceed according to the following general travel pattern, i.e., they leave the origin node, use secondary roads around the periphery of the origin node to access the major network, proceed along a perceived minimum path (using major links) until a certain area is reached where again, secondary roads are used to access the destination node. This process is illustrated in Figure 7 and a sample graphic output is shown in Figure 8.

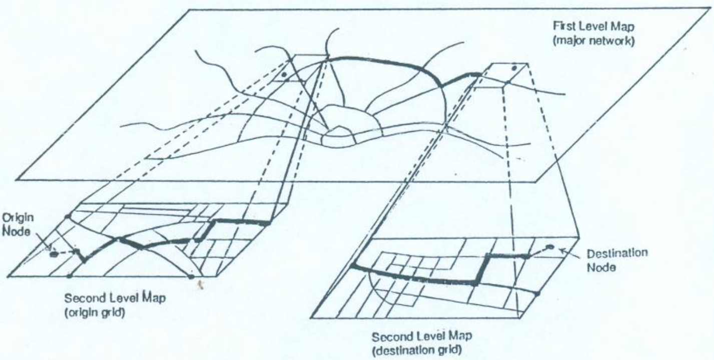

Figure 7. Two-level Map Implementation of Route Search

The minimum path search algorithm, therefore, uses the second-level maps in the grids where the origin and destination nodes are found and uses the first-level map in areas outside these grids. This module, if installed in strategic places, e.g., bus and jeepney terminals, LRT and PNR stations, gasoline stands, etc., can function as an information system accessible to the general public. It may also function as the core of an auto navigation system (given the proper hardware) in the future if installed in vehicles.[9)10)]

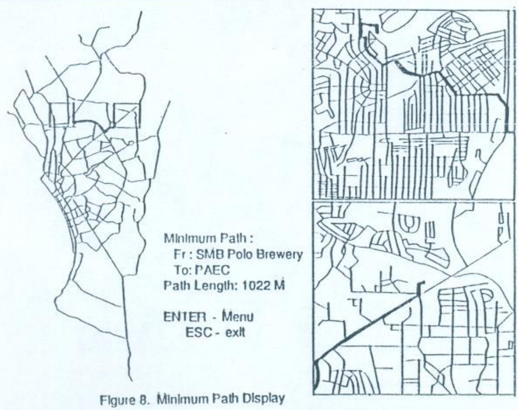

Figure 8. Minimum Path Display

4.2 Traffic Management Scheme Evaluation

This application module provides for the analysis of a planned traffic management scheme to be implemented in a particular study area within Metro-Manila. After identifying the extent of the study area, the nodes and links of the grids (as described in section 3.1) encompassing the area are extracted from the database to form a subarea database. Unnecessary nodes and links are then filtered out, additional nodes and links are added, node and link attributes (such as capacity, QV characteristics, directions of flow, etc., are edited, all depending on the different traffic management scenarios to be tested. Traffic assignment is later done (based on minimum paths discussed in Section 4.1) and link loadings analyzed in order to measure the relative performance of the different scenarios. Results are compared in order to select the best way the planned traffic management scheme should be implemented. This module was used to test the effects of different one-way implementations in and around the Makati area, one of the central business districts of Metro-Manila.

4.3 Traffic Flow Simulation

This application module provides three programs which can be used to analyze traffic flow. The programs individually focuses on different levels of the network, namely; a link (represented by a road segment), a node (represented by an intersection), and a specific area (represented by a collection of several network links and nodes).[11)]

The intersection simulation program can be used to evaluate the effectiveness of signal parameters in a signalized intersection or iteratively estimate the best combination of signal parameters for an intersection being planned to be controlled on an isolated control basis. The primary output of this program is the accumulated delay per intersection leg and total accumulated delay due to waiting time. A sample graphic output is shown in Figure 9.

The link flow program simulates the queuing and passing behavior of drivers in a two-lane road. The queuing and passing algorithm used in this program was used to simulate the effects of the closure of a section of one lane on vehicular flow. Such closure often occurs when a portion of a lane is under repair for a limited length of time. The main output of this simulation model is a summary of detector data from detectors placed at strategic locations within the simulation frame. A sample graphic output is shown in Figure 10.

4.4 Future Applications

The DRMS is designed to easily incorporate other modular applications which are planned to be added in the future. One such application is a dynamic network simulation program currently being improved and tested using the IO method. This module will supplement current traffic management scheme evaluation module and simulation modules. Another application being considered is the use of the DRMS to automate the process of generating LOS data of different transit routes, or the preparation of route alternatives for the purpose of disaggregate behavioral modeling.

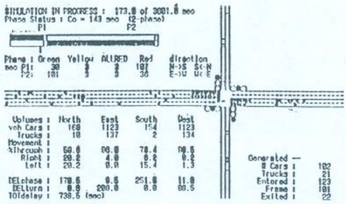

Figure 9 - Intersection Flow Simulation

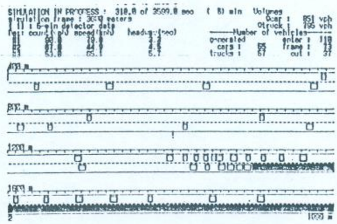

Figure 10 - Link Flow Simulation

5. Summary

The DRMS described, is still in its skeletal form, though as is, it performs the basic functions it was designed to do. The database as yet is not yet complete but is continually being updated. The digital road map is based on the latest available maps released in 1987 which are expected to be updated, at the earliest in 1997. The digitized network stored in this DRMS can easily be updated in order to cope with the changes in the transportation network as they occur until the next series of maps are published. This way, the DRMS remains current and its subsystems not dependent on old published maps.

The main thrust of the succeeding endeavors towards the finalization of this system at present, is the completion of the database system but studies are being continued in order to improve the current subsystems being implemented and in order to add more subsystems which can support transportation planning and traffic engineering in general.

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