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

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This paper discusses some preliminary work done towards the creation of a PC-based Digital Road Map System (DRMS) for the city of Metro-Manila. The system implements a two-level map configuration and has basic display and data management capabilities. The DRMS also provides some applications which support transport planning and traffic engineering.

1. Background

The importance of road maps is underscored by the wide number of private citizens who refer to them in order to find out the relative locations of different places of interest. More importantly, road maps are fundamental sources of information to transport planners and traffic engineers. This is the primary reason why most of the developed countries today implement a Digital Road Map System (DRMS) in one form or another.

Often these DRMS's are sophisticated systems (usually implemented using mainframe computers) used in a variety of ways such as an information system, giving on-line data pertaining to traffic conditions, location of vehicles through satellite tracking, etc., or are used as repositories of transport 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 sophistication entail equally sophisticated therefore expensive hardware.

The importance and potential of these systems, as tools for traffic engineers and transport planners, justify at least, the consideration of whether to implement such a DRMS in a major third world city. However, substantial capital outlay for a true sophisticated DRMS, becomes a major deterrent in instituting such a system in less developed countries. Hence, there is the need for a simpler DRMS, which not only implements a possible subset of the functions found in more sophisticated systems but also configured to run in a relatively cheaper, possibly diskette-based PC environment.

This paper presents the results of preliminary work done towards the development of such a DRMS as applied to the city of Metro-Manila.

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).[1] Two future light rail transit lines are currently in the planning stages and are expected to be built in the very near future. The city divisions and the overall configuration of the transportation network is shown

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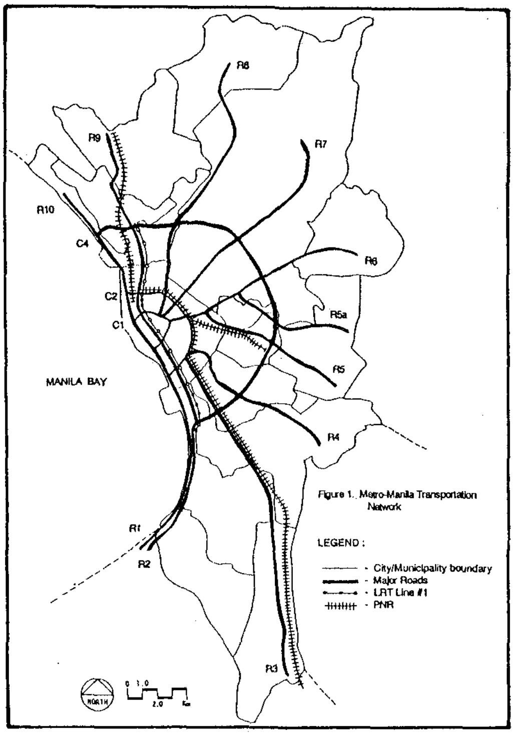

Figure 1. Metro-Manila Transportation Network

in Figure 1.

This road configuration has influenced the development of business and commercial areas particularly in 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.[2)]

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.[3)] 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.

3. Digital Road Map System

The functional structure of the Metro-Manila DRMS is shown in Figure 2. The system is supported by a database which incorporates the digitized road map, information related to different nodes and links, and other important transportation planning data. The DRMS provides basic data management functions (to manipulate the database) and has graphic display capabilities. The system also provides some subsystems which support transportation planning and traffic engineering applications. Since these applications have modular

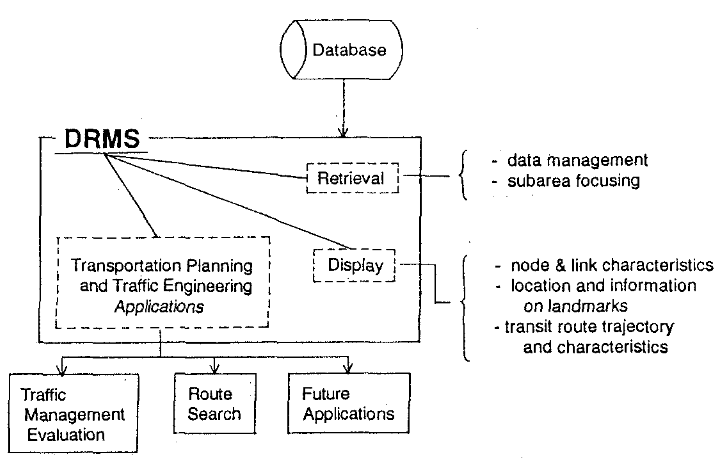

Figure 2. Functional Structure of the Metro-Manila DRMS

constructs, future applications can easily be attached as they are developed.

3.1 Digital Map

The digitized road map data are based on standard Universal Transverse Mercator (UTM) projection maps (with a scale of 1:10,000) so stored node coordinates can easily be adapted and used according to standard global positioning systems in the future.[4)5)]

To create the digitized map, Metro-Manila was divided into 119 grids of about 7.6 km^2 each shown in Figure 3.

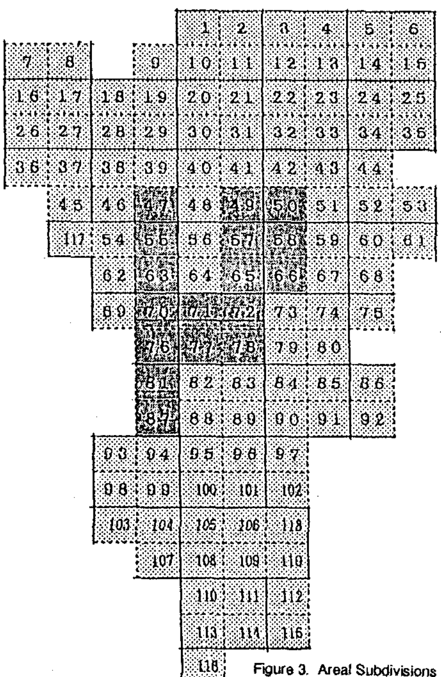

Figure 3. Areal Subdivisions of Network

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. In doing so, related files, for example, those that encompass a transport planning zone, can be easily grouped together and stored independently in separate diskettes.

Network data for each grid are digitized and stored in two separate files each of which representing a different level of the digital 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 the digitized representation of the overall Metro-Manila network. It is however, stored 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. This way, applications requiring the general form of the network may use only the higher level, while those requiring more network detail may use the lower level. The multi-level design of the DRMS is illustrated in Figure 4.

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 collection of these files and their linkages 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 or paths

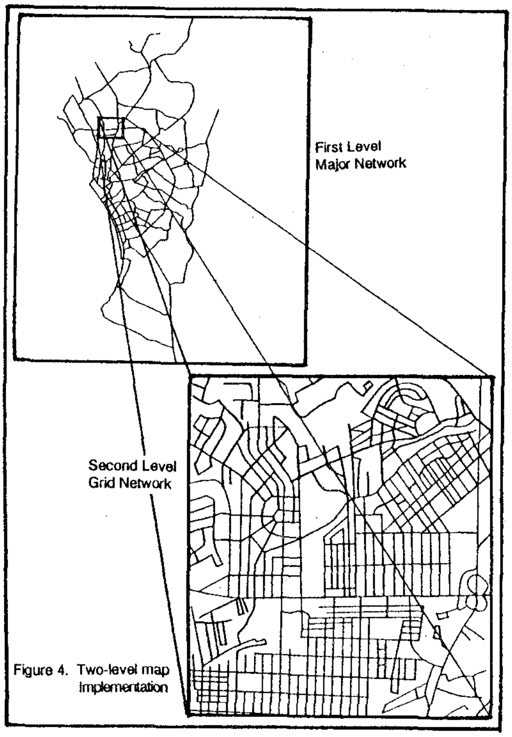

Figure 4. Two-level map implementation

in order to retrieve related information which are stored in different files. Figure 5 shows what is currently available in the DRMS database. It shows that the first level network, conceptually one map representation is composed really of several files.

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.[6)7)] Landmarks 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 (when applicable). For example, for network intersections, the geometry, capacity, peak flows, and signal parameters may be displayed. For transit terminals and train stations, boarding and alighting profiles 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., names of household owners,

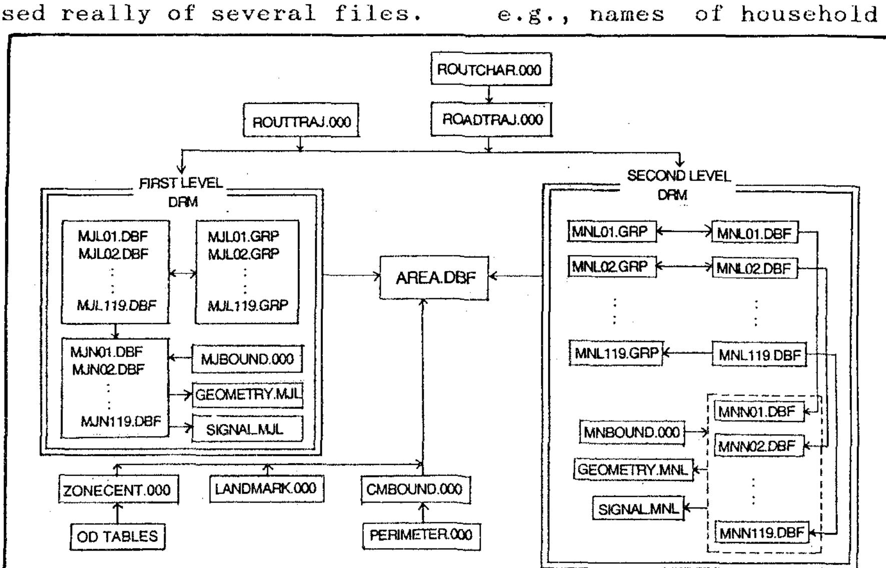

Figure 5. Metro-Manila DRMS Database File Linkages

addresses, etc. This will facilitate the search for 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. This way, single links may be selected so that their relative position 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.

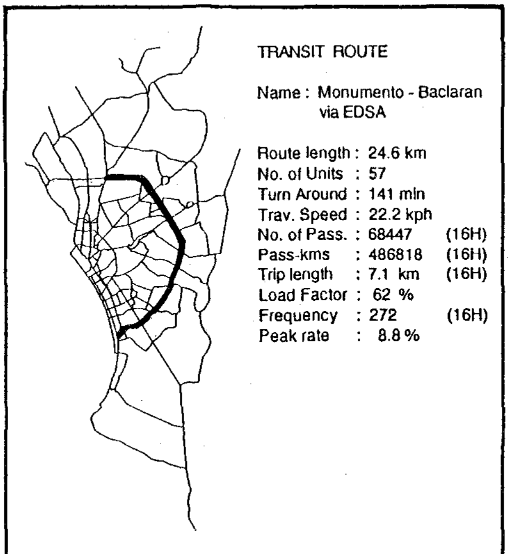

Figure 6. Transit Route Information Display

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 may be selected from the intersections in the major network or may be specific landmarks. The minimum path search basically uses Dijktra'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. 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 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[8] (given the proper hardware) if installed in vehicles.[9]

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,

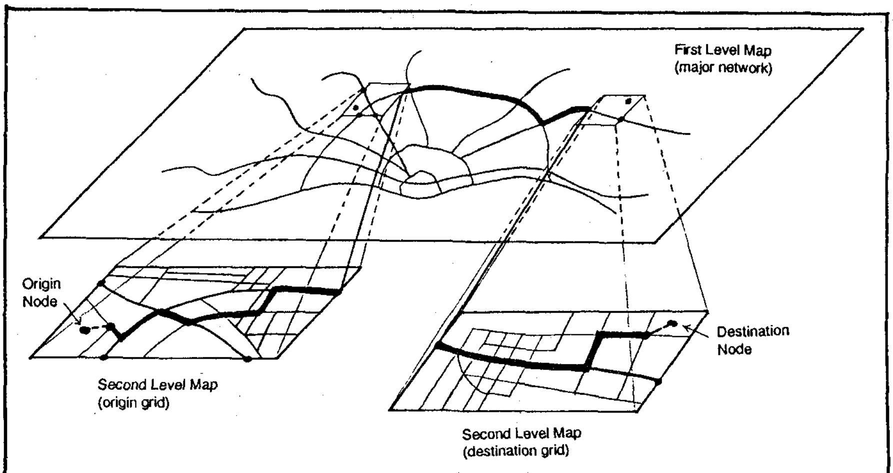

Figure 7. Two-level Map Implementation of Route Search

direction of flow, etc.), are edited, depending on the different traffic management scenarios to be tested. Traffic assignment is later done 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 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 developed using the IO method.[10] This module will supplement the current traffic management scheme evaluation module. Another application being considered is the use of the DRMS to automate the process of generating LOS data of different transit routes, or the prepara-

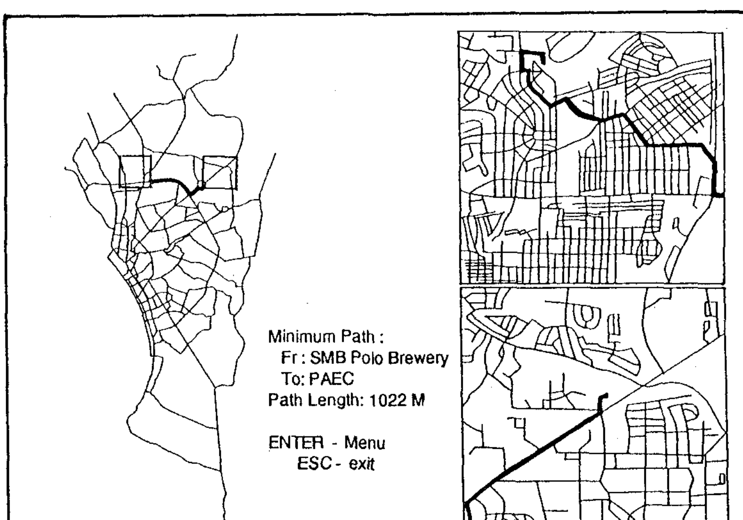

Figure 8. Minimum Path Display

tion of route alternatives for the purpose of disaggregate behavioral modeling.

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 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 at which time a general overhaul of the digital map can be done. 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 in the future.

References:

1. JUMSUT Report:Metro-Manila Transportation Planning Study, Manila, 1984, 1985.
2. Felias,H.A., Sasaki,S., Analysis of Metro-Manila's Trip Demand Structure Based on Characteristics Determined by Zonal Socio-Economic Variables, (To be published), Japan Association for Planning Administration.
3. Nakamura,R., Kashima,S., The Basic Study on Mode Choice Characteristics in Metro-Manila, Proceedings of the 5th World Conference on Transport Research, 1989, Yokohama, Vol 3, pp.657-670.
4. Parkinson,B.W., et al, NAVSTAR : Global Positioning System-Ten Years Later., Proceedings of IEEE, Vol. 71, No.10, 1984, p.1177.
5. Payne, C.R., NAVSTAR Global Positioning System:1982,3rd International Geodetic Symposium on Sattelite Doppler Positioning, 1982,p.993.
6. Nakamura,H., Hayashi,Y., Miyamoto,K., Uchiyama, H., Computer Aided Transport and Landuse System (CALUTAS) for Evaluating Infrastructure Planning, Proceedings of the 4th World Conference on Transport Research, 1983, Hamburg, Vol.1, pp. 620-633.
7. Seetharam,K.E., Shibazaki,R., NakaMura,H., Integration of Geographical and Expert Systems for EIA in Urban Transportation Planning, Infrastructure Planning Review, JSCE, 1990, pp.281-288.
8. Kawamura,S. et al, Development of Navigational Equipment for Automobiles, Jidosha Gijutsu, Vol.39, No. 5, 1985, pp. 525-531. (in Japanese)
9. Seymour,H.R., History of Automatic Vehicle Monitoring (AVM), IEEE Transactions on Vehicular Technology, Vol. VT-26, No. 1., 1977, pp. 2-6.
10. Metropolitan Expressway Public Corporation, A Study on Information System Methods, Report, Japan Society of Traffic Engineering, March 1988. (in Japanese).