

Implementing an ArcGIS Application for Travel Model Network Development

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Abstract: Accuracy of travel model network data is critical to the accuracy of travel demand forecasting. Houston-Galveston Area Council's Transportation Department has been using a set of customized ArcInfo menus and AML programs to check network coding errors (such as duplicate links and nodes, missing links and nodes, and incorrect link attributes), update the attributes of network link and centroid connector, and export network link data in EMME/2 readable format as input files to EMME/2 travel demand model. In order to enhance the existing application by taking advantage of the open customization environment within ArcGIS, we decided to migrate the existing AML application to an ArcGIS application using ArcObjects technology. This paper will discuss the implementation of ArcObjects technology to enhance existing application and conclude with lessons learned from this process.

Introduction

The Houston-Galveston Area Council (H-GAC) has served as the Metropolitan Planning Organization (MPO) for transportation planning in the Houston-Galveston Transportation Management Area (TMA) since 1974. This eight-county TMA is about 8,876 square miles and, according to 2000 Census, contains about 4.6 million people. The region has been experiencing an extremely fast growth. Population in the region increased by 25 percent between 1990 and 2000. The resulting growth in the number of daily vehicle miles of travel (VMT) in the region has increased at a significantly fast rate. In order to support continued economic growth, the regional transportation system must keep pace with population and employment growth. Travel demand forecasting, as an integrated part of transportation planning process, can predict how population and employment growth will impact the transportation system.

H-GAC has been using EMME/2-based travel demand model to predict future demand for transportation facilities and services. In the travel demand model, digital cartographic networks are used to represent real world transportation systems, including the existing or future highway and transit systems. These networks are highly complex and serve as the backbone of data inputs to travel demand model. Therefore, the accurate development of model networks is critical to the forecasting results. Geographic Information System (GIS) has been used widely as a powerful tool in editing, displaying, storing, and plotting model networks. H-GAC Transportation Department has been using ESRI ArcInfo Workstation for development and maintenance of travel demand model networks for over ten years.

Travel Demand Model Network Development

In general, network development is an integrated process of building links, nodes, centroids, centroid connectors, and external stations. Links represent roadway or rail lines. Nodes represent roadway intersections. Centroids represent the center of an activity within a Traffic Analysis

Zone (TAZ). Centroid connectors represent generalized local streets connecting the centroids to the network. External stations represent connections to the major transportation routes into and out of the study area. A network is not only a representation of physical alignment or location of a highway and transit system, but more importantly, it is a representation of a transportation system supply, such as, capacity, speed, area type, length, intersection delay and turn prohibitions, as well as how travel demand can be loaded on transportation networks. In H-GAC Transportation Department, network development process can be generalized to the flow chart shown in Figure 1. Two sets of ArcInfo Workstation application are used for network development. One application is used for network editing. It was developed in ArcEdit environment with menus and AML programs to automate editing process. The other application, called “Linkmerge”, is used for model network checking, updating, and export to EMME/2 readable format files. It was developed in Arc environment using ArcInfo menus, AML programs, AWK scripts and UNIX commands.

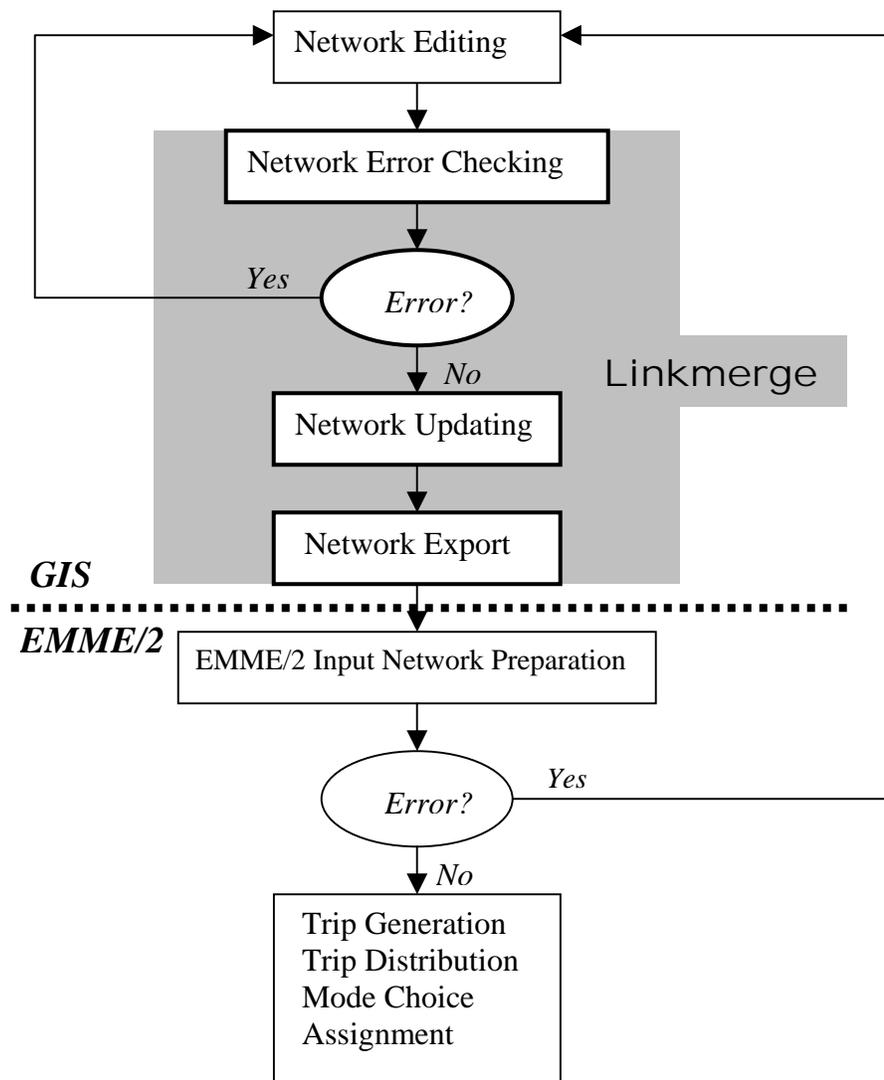


Figure 1. Network Development Flow Chart

Objectives of an ArcGIS Application Implementation

Advancing ESRI GIS technology calls for the migration of H-GAC legacy systems to new ArcGIS environments required to cater the extension in network development needs. In order to smoothly migrate from ArcInfo Workstation to ArcGIS, “Linkmerge” application was selected as a pilot project to explore the potential of desktop ArcGIS. This pilot project is to convert existing “Linkmerge” application to an ArcMap desktop application using ArcObjects and Visual Basic for Application (VBA), which are included in ArcGIS. The objectives of this project are to enhance graphic user interface, streamline network data checking and updating, and enhance the application capabilities.

1. Enhance Graphic User Interface (GUI)

The application interface should provide clear and organized visual layout for user to easily perform tasks. All inputs for network data processing should be placed in one form. All inputs in a form should be entered with mouse click other than typing in order to eliminate input errors.

2. Streamline data processing process

The application should integrate previously separated network data processing processes into one logically when necessary. The application should convert previous AWK scripts and UNIX commands into those procedures that can be used directly in Windows environment without depending on Cygwin, which is a Linux-like environment for Windows.

3. Enhance the application capabilities

The application should incorporate new functions as new needs rise. The application should take advantage of the open environment of ArcGIS to interface with other MS Office application, such as Excel. The application should provide error-handling, network validation and status checking functions. The application should be flexible to handle network alternatives within different TAZ structure.

NetCUP Interfaces and Functions

NetCUP is acronym of NETwork Checking, Updating, and Processing application developed in desktop ArcMap using ArcObject and VBA. VBA Editor included in ArcGIS is a powerful Integrated Development Environment (IDE) for application interface design and development. NetCUP interface is explicitly designed with a clear visual layout of three groups of functions: checking, updating and processing functions (see Figure 2.).

1. Checking Functions

Checking functions are used to check for several major network alignments and attribute errors. The original checking functions check for errors of Tunnel nodes, Tunnel links, duplicate links, and isolated nodes. The new application extend the previous checking capabilities by adding several new functions including checking for link’s missing values, centroid connector’s missing values, missing centroid connectors, redundant centroid connectors, and inconsistent links. Interfaces of these functions are shown in Figures from 3 to 9.



Figure 2. NetCUP Main Menu



Figure 3. Check for Missing Values in Network



Figure 4. Checking for Missing Values in Centroid Connectors and Missing Centroid Connectors

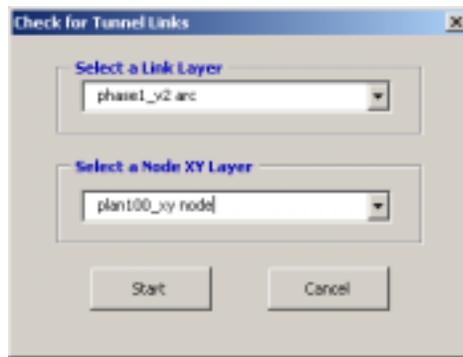


Figure 5. Checking for Tunnel Links



Figure 6. Checking for Duplicate Links



Figure 7. Checking for Isolated Nodes

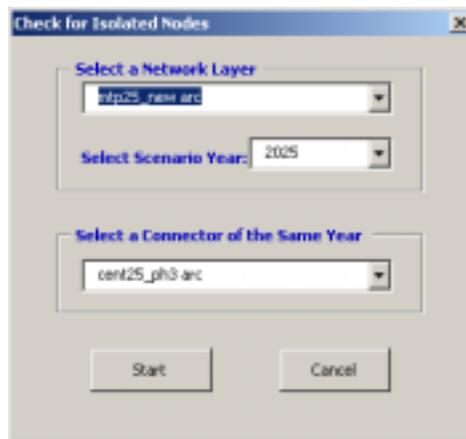


Figure 8. Checking for Tunnel Nodes

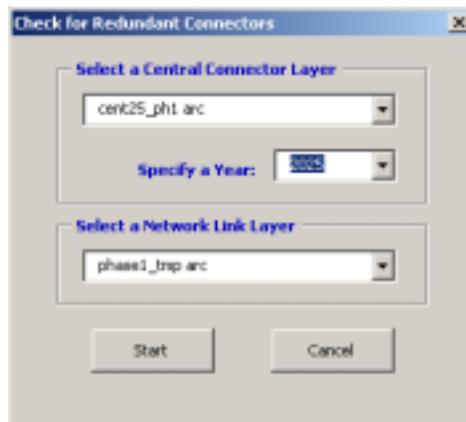


Figure 9. Checking for Redundant Centroid Connectors

2. Updating Functions

When no errors are found in a model network, it is time to update some required fields in model network, such as area type, sector number, Volume-Delay-Function (VDF), speed, and capacity. Updating functions are specifically restructured and streamlined. One is used for updating links with two look-up tables: AreaType-Sector-VDF and Sped-Capacity. The other is used for updating centroid connectors with one look-up table of AreaType-Sector-VDF. In addition, a new function is added by updating TAZ number of links with a new TAZ layer.

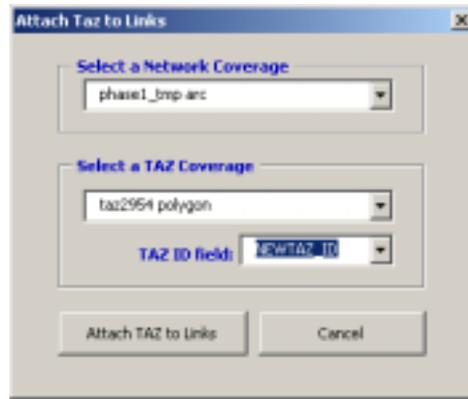


Figure 10 Update Link's TAZ ID



Figure 11. Update Link's Area Type, Sector, VDF, Speed and Capacity



Figure 12. Update Conector’s Area Type, Sector#, and VDF

3. Processing Functions

Processing functions includes Export and Summary functions. Export function is used to convert model network to EMME/2 readable format files. Export function is enhanced with better interface and streamlined process. User is required to enter all the inputs at one time and click “start” button to get outputs (see Figure 15.). The required inputs includes the year of network to export, network links layer, node XY coordinate layer, centroids XY coordinate layer, centroid connector layer, a zonal prohibit look-up table, a output directory. The export process generates twelve EMME/2 readable format files.

Link-Mile Summary is a new network analysis function and very useful tool to compare link miles by facility type and to conduct multi-year comparative analysis by running link mile summary of two years or more (see Figure 13. and Figure 14.). Link-Mile Summary function is a good example of taking advantage of the open environment in ArcGIS to access MS Excel functions.



Figure 13. Link Mile Summary

Microsoft Excel

Roadway Network for Eight-County Transportation Planning Region

Miles	Freeway/ Tollway	Principal Arterial	Other Arterial	Frontage Roads	Collectors	HQV Lanes	Total
Centroids	863	1,852	3,222	1,620	172	172	7,309
Link Miles	5,434	4,878	10,779	3,983	289	514	25,847

c:\msdmgchering25_new
 Freeway: X01, X02, X03, X04, X05, X06, X07, X08, X09
 Freeway to Arterial (discharge route):
 Principal Arterial: X09, X10, X11, X14, X15, X19
 Other Arterial: X12, X13
 Collector: X16, X17
 HQV: X20, X22, X23
 Frontage Road: X08, X10

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Figure 14. Link-Mile Summary

Export Network to EMME/2 Format

Select the Year of Network to Export

Select a Link Layer

Select a Central Connector Layer

Select a LUT for Zonal Prohibits
 ...

Select a Nodes XY Layer

Select a Centroids XY Layer

Specify a Directory to Hold Exported Data
 ...

Start Cancel

Figure 15. Export to EMME/2 format Files

Conclusions

This project was started out as a pilot project to explore the potential of ArcGIS environment. The experience from the project shows that using ArcObject technology we can achieve beyond the legacy systems. Migration to new desktop ArcGIS environment is more than technical issues. It is very important to get end-users involved in assessing legacy systems and to evaluate their existing and future needs. It is also very important to present progress and show benefits of new ArcGIS application to upper level management. Implementing GIS application using ArcObject with VBA apparently takes longer learning curve and more lines of codes than using AML. However, ESRI user forums provide very helpful technical resources that save time tremendously.

Acknowledgements

Many thanks to Michael Onuogu for sharing his valuable experience and knowledge in travel demand model network development and providing valuable suggestions in developing NetCUP application.

References

- Onuogu, M. and Kudowor, A., 2000, *The Modeling Group Network Interface Documentation*, Houston-Galveston Area Council (H-GAC), Houston, Texas
- Robert Burk, 2003, *Getting to Know ArcObjects Programming ArcGIS with VBA*, ESRI Press, Redlands, California
- National Highway Institute, 2002, *Introduction to Urban Travel Demand Forecasting*, Publication No. FHWA-NHI-02-040
- H-GAC Transportation Department, 2002, *The Vision*, Houston-Galveston Area Council (H-GAC), Houston, Texas

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