BUILDING STREETS NETWORK ANALYST SYSTEM FOR HEBRON CITY

BY

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RABAH ISAILI

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CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

COLLEGE OF ENGINEERING AND TECHNOLOGY

PALESTINE POLYTECHNIC UNIVERSITY

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Certification

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In accordance with the recommendation of project supervisor and acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the college of Engineering and Technology in partial fulfilment of requirements of the department for degree of Bachelor of Surveying and Geomatics Engineering.

Signature of Project Supervisor	**Signature of Department Chairman**
Name……………………….	**Name**………………………….

HEBRON-PALESTINE

June 2008

إهـــــداء

إلى الذين كان لهم أثر في مداد هذا القلم .....

إلى الذين رفعوا أيديهم لقيوم السماوات والأرض .....

..... داعين لنا بالتوفيق .....

إلى الشمعة التي أضاءت لي طريق الأمل .....

إلى من ضحت بحياتها لتراني أفضل الناس .....

.... إلى أمي ..... رمز العطاء والحنان .....

إلى من أضاء لي طريق العلم و المعرفة ..... دون مقابل .....

إلى من له الفضل في وضعي أول الطريق ..... إلى أبي ...

إلى من سهروا بجانبي ..... وكان لهم الفضل في نجاحي ...

... أخوتي وأخواتي .....

إلى من حثنا للوقوف في طريق النور .....

..... طريق الدعوة إلى الله .....

إلى الذين كانوا ولازالوا سائرين في نشر الخير..... والهداية للناس .....

إلى الذين أدعو الله من كل قلبي أن يرزقهم الفردوس الأعلى .....

إلى كل صديق دون استثناء .....

إلى من فرح لفرحي وحزن لحزني .....

نهدي هذا المشروع ...

فريق المشروع ...

شكر و تقدير

بداية نشكر المولى عز وجل الذي أعاننا على إنجاز هذا العمل المتواضع، كذلك نشكر جامعة بوليتكنك فلسطين التي احتضنت مسيرتنا التعليمية كما ونشكر دائرة الهندسة المدنية والمعمارية، للحصول على درجة البكالوريوس في تخصص هندسة المساحة والجيوماتكس. ونتوجه ببالغ الشكر والتقدير إلى جميع مدرسي قسم هندسة المساحة والجيوماتكس.

و نتوجه بالشكر العميق إلى أمهاتنا وآبائنا وأهلنا الأعزاء الذين كدوا وبذلوا ما بوسعهم لنواكب هذه الطريق.

كما نتوجه بالشكر العميق إلى مشرفنا المهندس الماهر " أبو خالد " العويوي، على ما قدمه لنا من نصح و إرشاد ومساعدة قيمة خلال إنجاز هذا المشروع.

ولا ننسى أن نتقدم ببالغ الشكر والتقدير إلى بلدية الخليل على جهودهم ونخص بالذكر م.روان أبو عيشة على ما قدمته لنا من مساعدة ونصح وإرشاد.

Abstract

BUILDING STREETS NETWORK ANALYST SYSTEM FOR HEBRON CITY

BY

DIAA DAHMAN **HASAN RAJABI**

RABAH ISAILI

Palestine Polytechnic University

Supervised By:

ENG.MAHER OWAIWI

The increasing demand on Hebron city streets network make it very important to build a digital streets network model as part of integrated planning strategy for Hebron city development plan. This will help in finding the shortest or fastest path from point to point in some critical condition or in some economic cases.

A clean and ready to use digital streets network database for Hebron city is created. This system can be run under ArcGIS 9.2 network Analyst extension.

Our final application enables the users to;

1. Calculate drive distance to nearest transit stop.
2. Calculate time needed for Ambulance to drive to accident area.
3. Calculate time needed for Fire cars to reach accident area.
4. Determine the service area for pharmacy, schools, mosques and many others.

Analysis of the distribution of schools and mosques in Hebron city using our application shows a lack of schools in Hebron city while there are enough mosques.

ملخص

بناء شبكة طرق رقمية لمدينة الخليل

إعداد

حسن رجبي   رباح العسيلي   ضياء دهمان

إشراف:

المهندس: ماهر العويوي

تعتبر مدينة الخليل من اكبر مدن الضفة الغربية صناعيا ومع ذلك تفتقر إلى وجود نظام شبكة طرق محوسبة، حيث أنه من الجدير بالاهتمام تطوير هذا النظام وتطبيقه.

يتضمن المشروع إعداد وتحضير شبكة طرق محوسبة باستخدام نظم المعلومات الجغرافية والذي يقوم بتحليل الشبكة وعرضها على المخطط الهيكلي لمدينة الخليل.

قام هذا المشروع بإعداد وتحضير شبكة طرق محوسبة لهذه المدينة على نظام GIS لكي يتم استخدامه في تحديد اقصر وأسرع مسار من حيث الزمن والمسافة. ولذلك ارتأينا أن نطبق هذا النظام على مدينة الخليل آملين أن يجري تطبيقه على باقي مدن الضفة الغربية.

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Chapter One

Background and Site Description

This chapter covers the issues related to problem facing the use of Network analyst system in Hebron city, and the methodology that will be followed to reach the expected results, and the objectives of the study. The chapter covers the following items:

1.1 Background
1.2 Problem Definitions
1.3 Duration of the study
1.4 Objectives
1.5 Methodology
1.6 Expected Results & outputs
1.7 Expected benefits
1.8 Literature Review

1.1 Background

Hebron city is located 36 km south of Jerusalem city, in the southern part of the West Bank. It is 3,050 feet (930 m) above sea level. It is considered to be the biggest industrial city in West Bank, with population exceeds 200,000 inhabitants. The length of its paved streets is about 450 kilometer with 20,000 vehicles running on these streets, in which about 250 heavy trucks carrying stones from and out of the city, in addition to the effects of the vehicles related to other industries, such as shoes and leather companies.

GIS is a combination of different instruments (tools), which are used to store, modify, and display spatial data after collection. It mainly represents earth's geographic features and analyses the data given by geographic or spatial coordinates. One alternative to a sequential display would be to use an interactive GIS map interface to display the passively detected routes and nodes overlaid on land-use and road network.

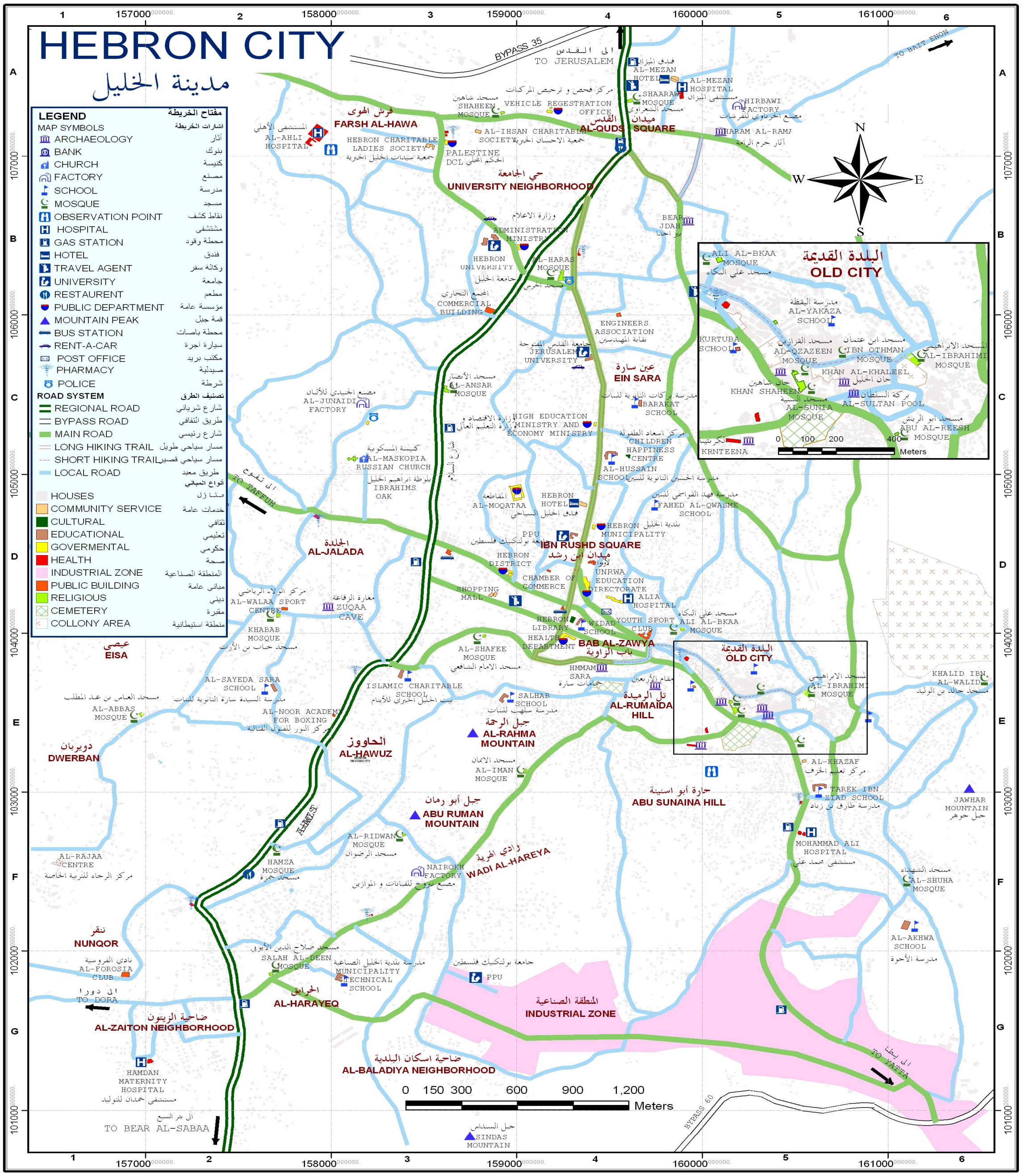


Fig. 1.1: Hebron city, Ref.(9).

1.2 Problem Definitions

Hebron city is considered to be the biggest industrial and largest population city in West Bank, and including a big number of vehicles running on its streets that requires a wide road network, in addition to the effects of the vehicles related to other industries, such as shoes and leather companies.

The increasing demand on Hebron city streets network make it very important to build a digital streets network model as part of integrated planning strategy for Hebron city development plan. This will help in finding the shortest or fastest path from point to point in some critical condition or in some economic cases.

The recent development in information technology facilitates the management of different sectors of our life. The GIS system is one of these modern database technologies, which proved its ability and strength in many applications, including environment, transportation, municipal activities, and military actions.

The idea of this project came in to mind as a result of Hebron city necessity for a road network to find the shortest or fastest path, and finding service area to make a study on schools, mosques and other applications.

1.3 Duration of the study

The following tables show the work phases of the first and second semesters 2007/2008.

Table 1.1: work phases chart of 1st semester.

Tasks	**Number of Weeks**	**Time Frame In Week**														
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Choosing The Project	**2**	■	■													
Problem Definition	**3**		■	■	■											
Literature Review	**2**				■	■										
Collecting data	**10**						■	■	■	■	■	■	■	■	■	■

Table 1.2: work phases chart of 2nd semester.

Stages	**Week Number**	**Time Frame In Week**														
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Updating the street shapefile	**2**	■	■													
Modify the attribute table and filling the questionnaire	**2**		■	■												
Clean map by topology	**2**				■	■										
Clean map by geometric network	**2**						■	■								
Operate the application of network analyst	**3**								■	■	■					
Writing and editing the report	**12**				■	■	■	■	■	■	■	■	■	■	■	■

1.4 Objectives

The main objective is to apply the network system in Hebron city.

1.4.1 Specific Objectives

1. To build a cleaned and effective network.
2. To prepare network that can determine the best route between any two points.
3. Determine the service area for important facilities such as (schools , pharmacies, mosques ...etc).
4. Determine the closest facility(s) from any given point.
5. Determine the OD cost matrix for the needed facilities.

1.5 Methodology

1. Recognition of the study area (Hebron city):
   Data collection, this includes collection of information about the Hebron streets Network as a digital master plan and number of paths of each street segment from Hebron Municipality.
2. Editing attribute table.
3. Building topology and geometric network.
4. Build Network Analyst System:
   Networks are systems of roads, rivers, pipe lines and so on. In GIS networks are sets of interconnected line features that present these systems. In our project we concern with roads network to find the best routes based on the shortest distance or shortest time between destinations, for this purpose we will use ArcGIS/ArcView.
5. Using network analyst system to find best route, closest facility, service area, and OD cost matrix.

1.6 Expected Result & outputs

1. Cleaned and ready to use spatial referenced digital streets network for Hebron city.
2. Making a literature for Hebron city schools.

1.7 Expected benefits

1. Optimize route for police inspector in Hebron city.
2. Public safety –route emergency response crews to incidents
3. To make scientific literature using service area.

1.8 Literature Review

There are many projects, which is related to our project; the first is entitled "Streets Network for Hebron City ", done by Musa'b Shahin and Eyed Abu Isneineh as an under graduated project in the Department of Geomantic and Survey Engineering at PPU, the project was done using Arc view 3.2 software.

The second project is entitled " Building Streets Network for the City of Dura Working Under GIS Network Analyst Extension ", done by Fadi Amro, Fadi Dweik and Wesam Amro as an under graduated project in the Department of Geomantic and Survey Engineering at PPU, the project was done using Arc GIS software.

The third project is entitled "GIS Model for Schools in Hebron District" done by Samer Amro and Areej Al Amleh as an under graduated project in the Department of Geomantic and Survey Engineering at PPU, the project was done using Arc GIS software to facilitate and speed up the management of schools, teachers replacement and students movement.

Chapter Two

Theoretical Background

This chapter covers the theoretical background and the technique, software and applications that we will use in the study. The chapter covers the following items:

2.1 Geographic Information System (GIS)

2.2 ArcGIS System

2.3 ArcGIS Network Analysts

2.4 Geometric network

2.5 What is topology?

2.6 What is a network dataset?

2.1 Geographic Information System (GIS)

2.1.1 Definition of GIS

A Geographic Information System (GIS) is essentially a collection of digital maps that can be stacked, viewed, and- most importantly- used for spatial analysis.

The spatial and tabular data, plus a little computing power, work together to produce the real strength of GIS which lies in its ability to do spatial analysis. With the appropriate maps, a GIS can be used to calculate the area in use as farmland, to find the length of streams, to highlight streets with a certain name, to generate a map which represents the distance to the nearest park, to determine slope from a digital elevation model, or to delineate watersheds. Any one of these tasks would be slow and tedious with standard paper maps, but can be executed with ease using a GIS. By asking the GIS a combination of questions and performing queries, a wide variety of real world questions can be answered.

Geographic...

This term is used because GIS tend to deal primarily with `geographic' or `spatial' features. These objects can be referenced or related to a specific location in space. The objects may be physical, cultural or economic in nature.

Information ...

This represents the large volumes of data, which are usually handled within a GIS. All real world objects have their own particular set of characteristics or descriptive attributes. This non-spatial alphanumeric data plus location information needs to be stored and managed for all spatial features of interest.

Systems...

This term is used to represent the systems approach taken by GIS, whereby complex environments are broken down into their component parts for ease of understanding and handling but are considered to form an integrated whole. Computer technology has aided and even necessitated this approach so that most information systems are now computer based.

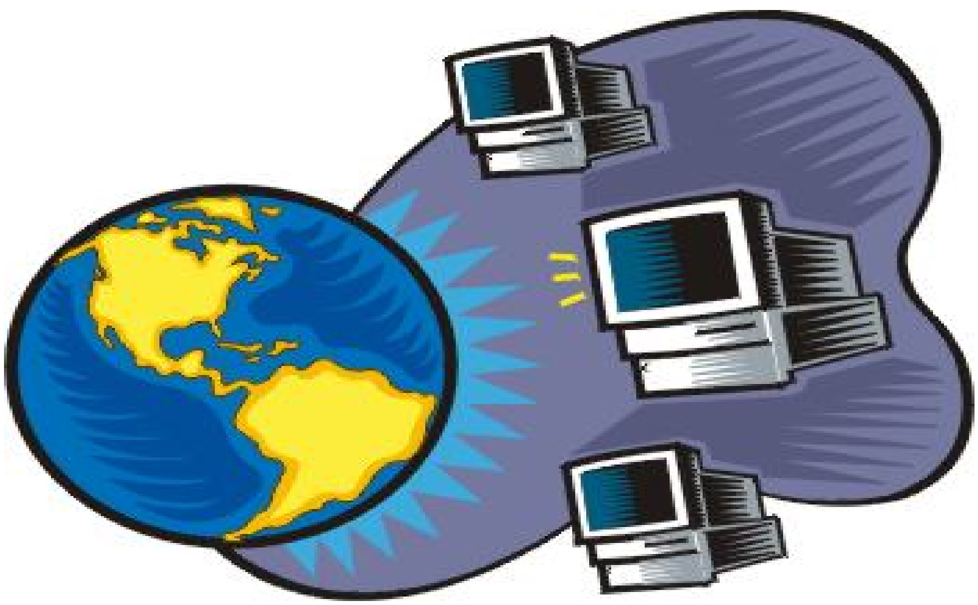


Figure 2.1: Visual approach to GIS definition, Ref.(10).

2.1.2 Components of GIS

GIS have five primary components, namely, see figure (2.2).

1. **People**, computer staff, experts from various science disciplines, GIS operators, GIS experts, applications developers.
2. **Data**, which may be of type *spatial*, *temporal*, or *attribute*.
3. **Software,** that performs various data storage, retrieval, analysis, reporting, and communication functions.
4. **Methods,** A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.
5. **Hardware**, including workstations and networks, disk and tape storage, digitizers, plotters, and communications devices.

Figure 2.2: GIS Components, Ref.(2).

2.1.3 GIS Functions

A GIS is a computer system which facilitates the phases of data entry, data management, data manipulation and analysis and data presentation. This requires an information system that has four main functional subsystems:

- The **data input** subsystem allows the user to capture, collect and transform both spatial and tabular (attribute) data into digital form.
- The **data storage** and retrieval subsystem organizes the data into a form that allows it to be retrieved by the user for analysis. This usually involves the use of a database management system.
- The **data and manipulation and analysis** subsystem allows the user to define spatial and attribute queries to derive information.
- The **data output** subsystem allows the user to generate graphic displays (maps and charts) and tabular reports. Figure (2.3).

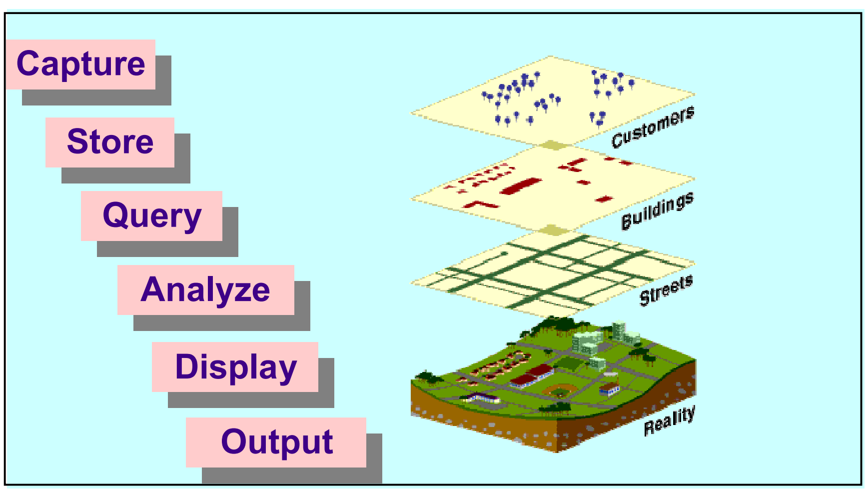


Figure 2.3: GIS functions, Ref.(3).

2.1.4 Sources of data in GIS

A GIS is designed to accept geographic data from a variety of sources, including maps, satellite photographs, and printed text and statistics. GIS entry tools can scan some of this data directly—for example, a computer operator may feed a map or photograph into the scanner, and the computer "reads" the information it contains. The GIS converts all geographical data into a digital code, which it arranges in its database. Operators program the GIS to process the information and produce the images or information they need.

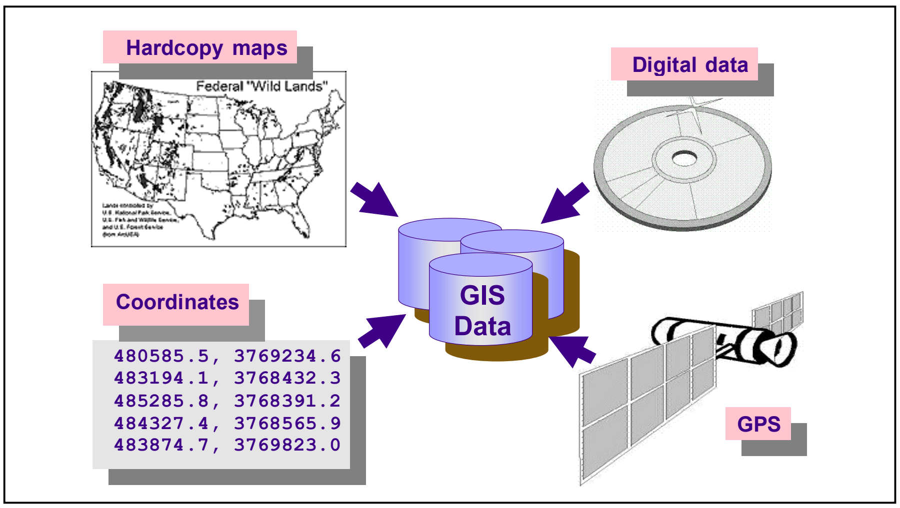


Figure 2.4: Data sources in GIS, Ref.(3).

2.1.5 GIS Applications:

The applications of a GIS are vast and continue to grow. By using a GIS, scientists can research changes in the environment; engineers can design road systems; electrical companies can manage their complex networks of roads; governments can track the uses of land; and fire and police departments can plan emergency routes, some application as:

- Agriculture.
- Forestry & Wildlife Management.
- National.
- State.
- County.
- Regional.
- Local mapping and geographic inventory.
- Archaeology.
- Geology.
- Oil and gas exploration and production.
- Municipal Applications such as:
    - Properties/Cadastre.
    - Facilities.
    - Utilities.
    - Water.
    - Sewer.
    - Storm Sewer.
    - Environment.

- Areas/Districts.
- Utility Applications.
- Electric.
- Streets.
-

2.2 ArcGIS System

The ArcGIS System supports:

- Data visualization and query.
- Data analysis and integration.
- Data creation and modification.
- Data management.

ArcGIS Desktop product (windows) includes:

- ArcView.
- ArcEditor.
- ArcInfo.
- Several optional software extention.

2.2.1 ArcGIS Components

- ArcMap: Mapping , editing, analysis.
- ArcCatalog: Manage spatial data, database designs, creation and management of metadata.
- ArcToolbox:GIS data conversion and geoprocessing.

- 3D Analyst extension: Visualization and analysis of 3D data, ArcScene application.
- ArcObjects: Collection of COM components with GIS functionality technology framework of ArcGIS, figure(2.5).

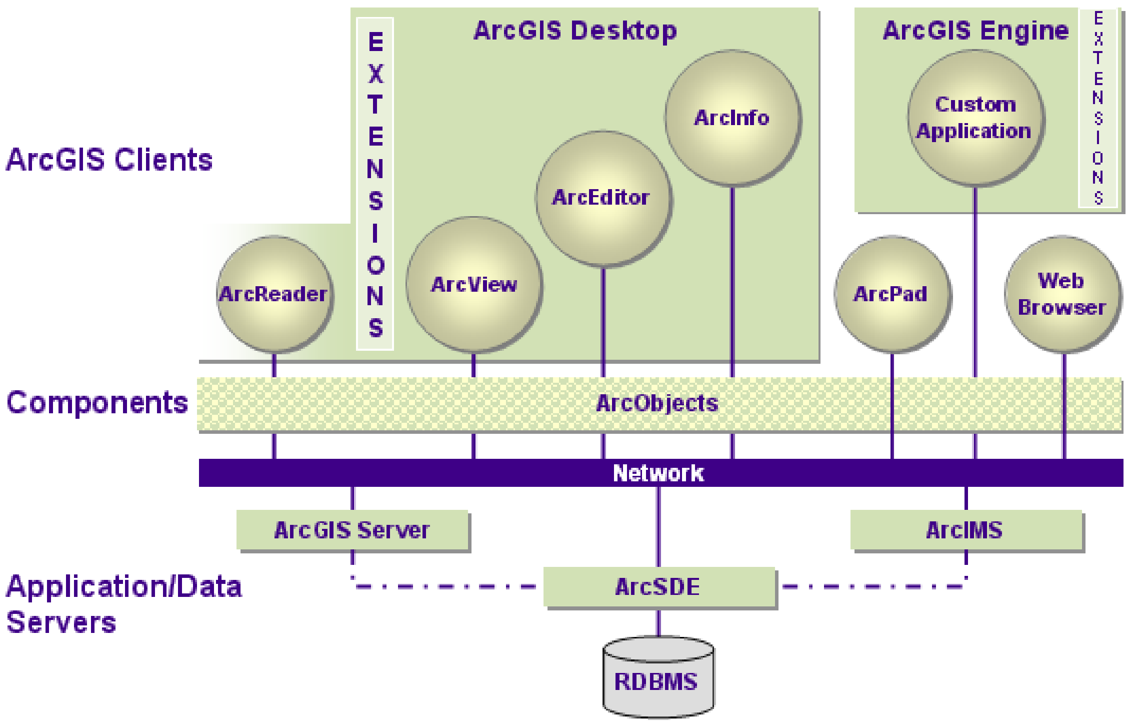


Figure 2.5: ArcGIS components, Ref.(3).

2.2.2 ArcGIS Extensions

The capabilities of ArcGIS can be further extended using a series of optional add-on software extensions:

- **ArcGIS 3D Analyst**: allows you to effectively visualize and analyze surface data. Using ArcGIS 3D Analyst, you can view a surface from multiple viewpoints, query a surface, determine what is visible from a chosen location on a surface, create a realistic perspective image that drapes raster and vector data over a surface, and record or perform three-dimensional navigation.
- **ArcGIS Geostatistical Analyst** is an extension to ArcGIS Desktop that provides a variety of tools for spatial data exploration, identification of data anomalies, optimum prediction, evaluation of prediction uncertainty, and surface creation.
- **ArcGIS Network Analyst** is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility, and service area analysis, turn restrictions, speed limits, height restrictions, and traffic conditions, at different times of the day.
- **ArcGIS Schematics** enables users to generate, visualize, and manipulate diagrams from data in a geodatabase. ArcGIS Schematics provides tools to operate, manage, and view any network in a wide variety of geographic and schematic representations.
- **ArcGIS Spatial Analyst** provides powerful tools for comprehensive, raster-based spatial modeling and analysis. Using ArcGIS Spatial Analyst, you can derive new information from your existing data, analyzes spatial relationships, build spatial models, and perform complex raster operations.

- **ArcGIS Survey Analyst** is an ArcGIS Desktop extension that provides surveyors and GIS professionals with tools to create and maintain survey and cadastral data in ArcGIS. With this application, surveyors can centrally locate, process, and manage their data, enabling them to work more efficiently. GIS professionals use ArcGIS Survey Analyst to manage and continually enhance the accuracy of their data using existing survey methodologies.
- **ArcGIS Tracking Analyst** provides tools for playback and analysis of time series data. Tracking Analyst helps visualize complex time series and spatial patterns and interactions while integrating with all other GIS data within the ArcGIS system.

2.3 ArcGIS Network Analysts

It is allows you to create and manage sophisticated network data sets and generate routing solutions.

ArcGIS Network Analyst is a powerful extension for routing and will provide a whole new framework for network-based spatial analysis (i.e., location analysis, drive time analysis, and spatial interaction modeling). This extension allows ArcGIS Desktop users to model realistic network conditions and scenarios, figure (2.6).

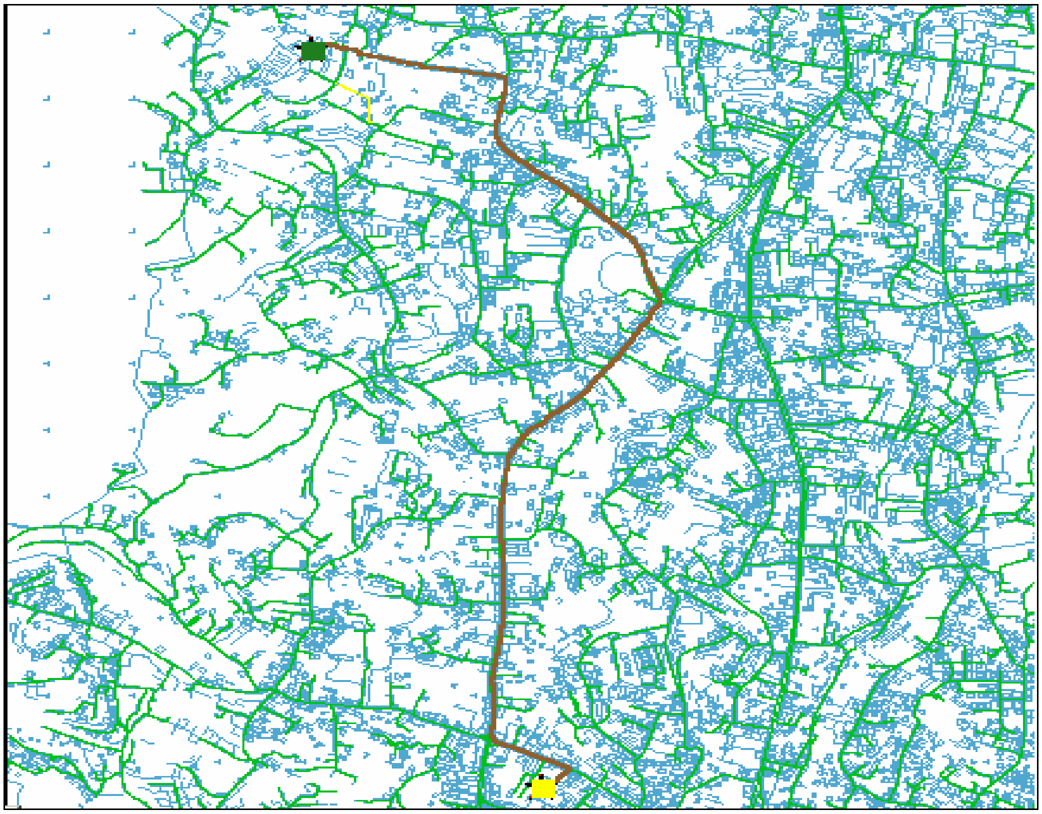


Figure 2.6**:** Hebron city streets network example, Ref. (7).

2.3.1 Conduct with ArcGIS Network Analyst

ArcGIS Network Analyst enables ArcGIS users to solve a variety of problems using geographic networks:

- Drive-time Analysis.
- Point-to-point routing.
- Route directions.

- Service area definition.
- Shortest path.
- Optimum route.
- Closest facility.
- Origin destination.

Network-based spatial analysis is available for ArcGIS Desktop (ArcView, ArcEditor, or ArcInfo), ArcGIS Engine, and ArcGIS Server.

For desktop users, ArcGIS Network Analyst provides a rich environment with easy to use menus and tools, as well as the robust functionality available in the geoprocessing environment for modeling and scripting.

In addition, ArcGIS Network Analyst has improved the core functionalities and added new features. ArcGIS Network Analyst requires ArcView, ArcEditor, or ArcInfo.

2.3.2 Who will use ArcGIS Network Analyst?

All software users who need high-quality GIS-based routing and network analysis will leverage ArcGIS Network Analyst. Industries that benefit from ArcGIS Network Analyst include transportation, health care, public safety, education, utilities, local government, business and many more.

ArcGIS Network Analyst can be used to determine the time it takes to transport goods from a manufacturing plant to a warehouse and also calculate delivery from a warehouse to business or residential locations.

2.3.3 Key features

2.3.3.1 The Best Route

The best route on a network using time or distance as a cost factor. The stops may exist as a shapefile, or can be picked graphically using the Graphic Pick Tool, figure (2.7).

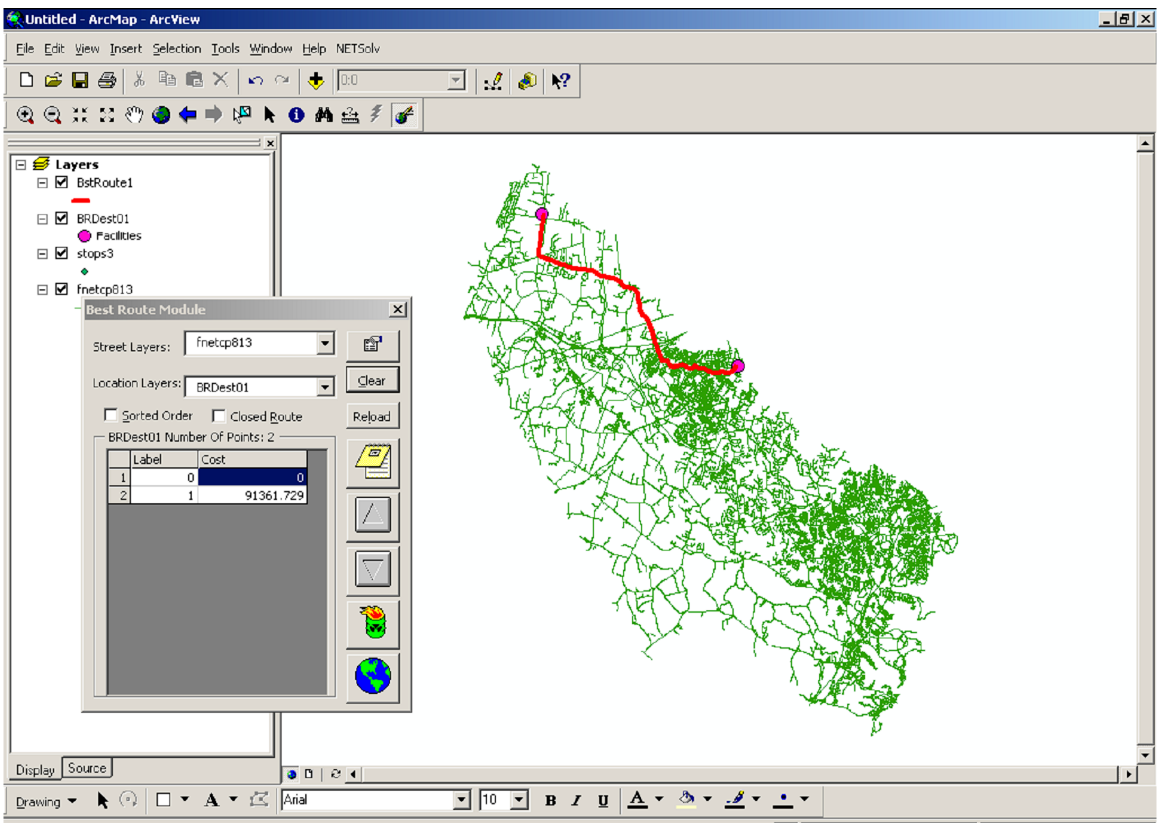


Figure 2.7: Best Route, Ref.(3).

An analyst can choose the user-defined order for stops option, select the sorted order option, or define a closed route, meaning that the route must end at the original starting point.

The system allows the user to change the order of stops, add stops, and delete stops. Once a route is generated, the system is able to provide street-by-street driving directions as well as a savable text file.

2.3.3.1.1 The best route analysis layer

You can create the route analysis layer from the Network Analyst toolbar by clicking New Route.

When you create a new route analysis layer, it shows up in the Network Analyst window, along with its three categories--stops, barriers, and routes.

The route analysis layer also shows up in the table of contents as a composite layer, Route (or Route 1, Route 2, and so on), composed of three feature layers--Stops, Barriers, and Routes. Each of the three feature layers has default symbology that can be modified on its Layer Properties dialog box.

2.3.3.1.2 Components of a route analysis layer

╬ Stops feature layer

This layer stores the network locations that are used as stops in route analysis. The Stops layer is symbolized by default in four types: Located Stops, Unlocated Stops, Error, and Time Violation Stop. You can modify the symbology in the Layer Properties dialog box of Stops. There is a new symbology category, Network Analyst Stops, added for the stops network analysis class. You can modify the symbol, color, or text symbol for any type of stop, figure (2.8).

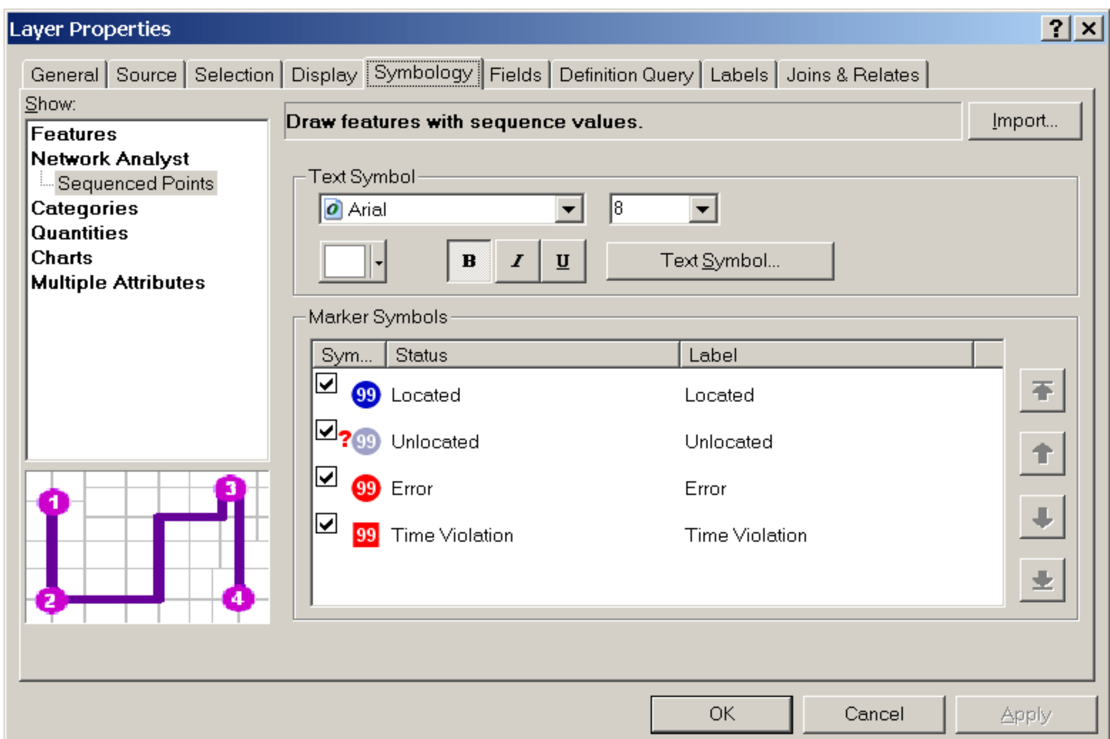


Figure 2.8: Layer properties window, Ref.(3).

When a new route analysis layer is created, the Stops layer has no features. It is populated only when network locations are added into it.

╬ **Barriers feature layer**

Barriers are used in route analysis to denote points from which a route cannot traverse through. The Barriers layer is classified by default in three types: Located, Unlocated, and Error. The symbology of each can be modified in the Layer Properties of the Barriers layer. The Barriers layer functions as any other feature layer in ArcMap.

When a new route analysis layer is created, the Barriers layer has no features. It is populated only when network locations are added into it.

╬ **Route feature layer**

The Route feature layer stores the resultant route of route analysis. As with other feature layers, its symbology can be accessed and altered from the Layer Properties dialog box.

The Route layer on the Network Analyst Window is empty until the analysis is complete. Once the best route is found, it is displayed on the Network Analyst Window.

2.3.3.2 Closest Facility

The closest Facility determines the closest facility, or facilities, to an event, figure (2.9). This module needs a both facilities layer and the streets layer. The event itself may be a shape file containing a number of points, or a graphic pick for a single point. The Closest Facility Module is able to determine either a selected number of closest facilities to the event, and the corresponding best routes to get to them, or the closest facility to a number of events. The closest facility route is rendered by cost to visually display the closest facility or facilities. The system also provides the directions to or from events.

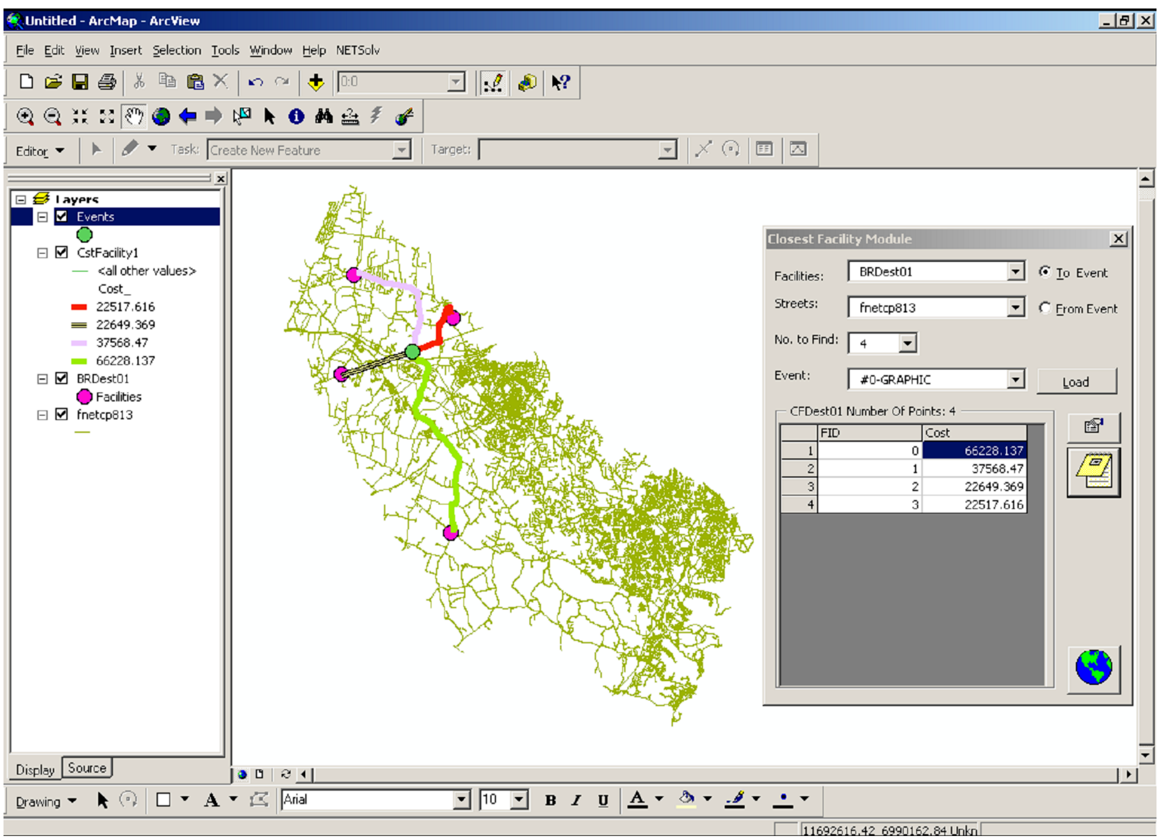


Figure 2.9: Closest Facility, Ref.(3).

2.3.3.2.1 Closest facility analysis layer

You can create the closest facility analysis layer by clicking New Closest Facility under Network Analyst, from the Network Analyst Window.

When a new closest facility analysis layer is created, it shows up on the Network Analyst Window with four categories: Facilities, Incidents, Barriers, and Routes. Additionally, it shows up in the table of contents as a composite layer, Closest Facility (or Closest Facility 1, Closest Facility 2, and so on), composed of four feature layers: Facilities, Incidents, Barriers, and Routes. Each of these feature layers has default symbology that can be modified on its Layer Properties dialog box.

2.3.3.2.2 Components of a closest facility analysis layer

♦ Facilities feature layer

This layer stores the network locations that are used as facilities in closest facility analysis.
The Facilities layer is classified by default in three classes: Located, Unlocated, and Error. You can modify the symbology of each of these types in the Layer Properties dialog box of the Facilities layer. You can modify the symbol, color, or text symbol for any type of facility. When a new closest facility analysis layer is created, the Facilities layer has no features. It is populated only when network locations are added into it.

♦ **Incidents feature layer**

The layer stores network locations used as incidents for closest facility analysis. The Incidents feature layer behaves in the same manner as the Facilities feature layer. It is empty when the closest facility analysis layer is created and is populated when incidents are added interactively, by geocoding an address, or loading from another feature class or feature layer.

♦ **Barriers feature layer**

Barriers are used in closest facility analysis to denote points where a closest facility route cannot traverse. The Barriers layer is classified by default into three types: Located, Unlocated, and Error. The symbology of each can be modified on the Layer Properties dialog box of the Barriers layer. The Barriers layer functions as any other feature layer in ArcMap. When barriers are added, the Barriers list on the Network Analyst Window displays the newly added barrier, along with all existing barriers.

♦ **Routes feature layer**

The Routes layer stores the resultant paths of the closest facility analysis. As with other feature layers, its symbology can be accessed from the Layer Properties dialog box. The Routes layer on the Network Analyst Window is empty until the analysis is complete. Once the closest facility is found, the route from the incident to the facility is displayed on the Network Analyst Window.

2.3.3.3 Service Area

The Service Area Module requires the street network file and facilities file(s). A user specifies a cost in either time or distance, and based on that parameter, the system selects all the streets around the facilities which are within the specified cost, and color codes them, figure (2.10).

The result from the Service Area Module is two layers that are generated, selected streets and the corresponding bounding polygons. The cost is defined in terms of time or distance.

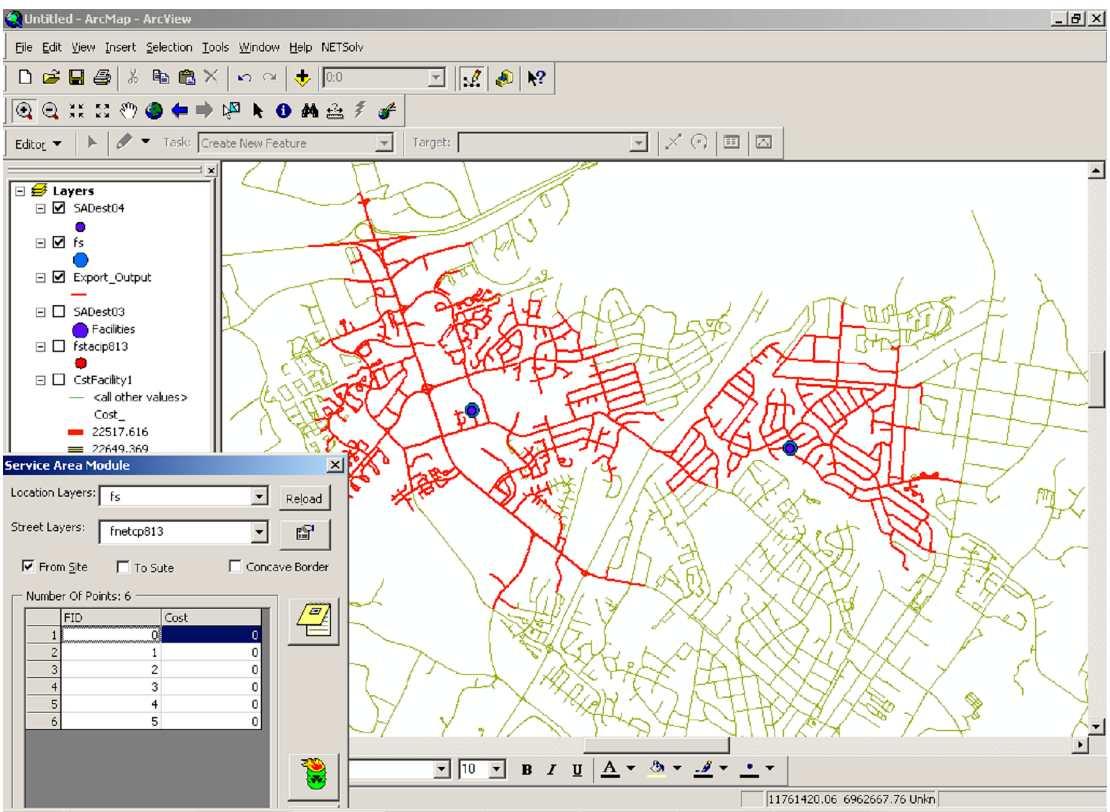


Figure 2.10: Service Area, Ref.(3).

2.3.3.3.1 Service area analysis layer

You can create the service area analysis layer, from the Network Analyst toolbar, under Network Analyst, by clicking New Service Area.

When you create the service area analysis layer, it shows up on the Network Analyst Window, along with four categories—Facilities, Barriers, Lines, and Polygons.

Additionally, the service area analysis layer shows up in the table of contents as a composite layer, Service Area (or Service Area 1, Service Area 2, and so on), composed of four feature layers—Facilities, Barriers, Lines, and Polygons. Each of these feature layers has default symbology that can be modified on its Layer Properties dialog box.

2.3.3.3.2 Components of a service area analysis layer

♠ Facilities feature layer

This layer stores the network locations that are used as facilities in service area analysis. The Facilities layer is classified by default in three classes: Located, Unlocated, and Error. You can modify the symbology of each of these types in the layer properties of Facilities. You can modify the symbol, color, or text symbol for any type of facility. When a new service area analysis layer is created, the Facilities layer has no features. It is populated only when network locations are added into it.

♠ Barriers feature layer

Barriers are used in service area analysis to denote points from where a service area cannot traverse. The Barriers layer is classified by default in three types: Located, Unlocated, and Error. The symbology of each can be modified in the Layer Properties dialog box of the Barriers layer. The Barriers layer functions as any other feature layer in ArcMap. When barriers are added, the Barriers category on the Network Analyst Window displays the newly added barrier along with all existing barriers.

♠ Polygons feature layer

The service area polygons feature layer stores the resultant polygons of service area analysis. As with other feature layers, its symbology can be accessed from the Layer Properties dialog box. The service area polygons layer on the Network Analyst Window is empty until the analysis is complete. Once the service area is computed, the polygons are stored in the feature layer and are listed on the Network Analyst Window.

♠ Lines feature layer

The service area lines feature layer can be symbolized in the same manner as other line feature layers. While performing service area analysis, service area lines are not generated by default. You have to set the parameter to generate Lines on the Service Area Analysis Layer Properties dialog box.

2.3.3.4 Creating an OD cost matrix

With ArcGIS Network Analyst, you can create an origin–destination (OD) cost matrix from multiple origins to destinations. An OD cost matrix is a table that contains the total impedance from each origin to each destination. Additionally, it ranks the destinations that each origin connects to in ascending order of the time it takes to travel from that origin to each destination.

The paths from each origin to each destination are represented as straight lines on the map, which can be symbolized by color, representing which point they originate from; or by thickness, representing the travel time of each path.

2.3.3.4.1 Creating a OD cost matrix analysis layer

You can create the OD cost matrix analysis layer from the Network Analyst Window, under Network Analyst, by clicking New OD Cost Matrix.

When you create a new OD cost matrix analysis layer, it shows up on the Network Analyst Window along with four categories: Origins, Destinations, Lines, and Barriers.

Additionally, the OD cost matrix analysis layer shows up in the table of contents as a composite layer, OD Cost Matrix (or OD Cost Matrix1, OD Cost Matrix 2, and so on), composed of four feature layers—Origins, Destinations, Barriers, and lines. Each of these feature layers has default symbology that can be modified in its Layer Properties dialog box.

2.3.3.4.2 Components of an OD cost matrix analysis layer

Origins feature layer

This layer stores the network locations that are used as origins in OD cost matrix analysis.
The Origins layer is classified by default in three classes: Located, Unlocated, and Error. You can modify the symbology of each of these types on the Layer Properties dialog box of Origins. You can modify the symbol, color, or text symbol for any type of origin. When a new OD cost matrix analysis layer is created, the Origins layer has no features. It is populated only when network locations are added into it.

Destinations feature layer

This layer stores network locations that are used as destinations in OD cost matrix analysis. In ArcMap, this layer behaves exactly like the Origins feature layer. It is classified by default in three classes: Located, Unlocated, and Error. You can modify the symbology of each of these types on the Layer Properties of Destinations. You can modify the symbol, color, or text symbol for any type of destination.

Barriers feature layer

Barriers are used in OD cost matrix analysis to denote points where a route cannot traverse. The Barriers layer is classified by default in three types: Located, Unlocated, and Error. The symbology of each can be modified on the Layer Properties dialog box of the Barriers layer. The Barriers layer functions as any other feature layer in ArcMap. When barriers are added, the Barriers list on the Network Analyst Window displays the newly added barrier along with all existing barriers.

Lines feature layer

The Lines feature layer stores the resultant paths of OD cost matrix analysis. As with other feature layers, its symbology can be accessed from the Layer Properties dialog box. The Lines layer on the Network Analyst Window is empty until the analysis is complete. Once the OD cost matrix is computed, the lines are stored in the feature layer. The total number of lines created is listed on the Network Analyst Window.

The individual lines are not listed on the Network Analyst Window. This is because OD cost matrix analysis often results in many lines, which cannot be displayed on the Network Analyst Window. The individual paths can be seen in the Lines attribute table.

2.4 Geodatabase Items

Geodatabases organize geographic data into a hierarchy of data objects. These data objects are stored in feature classes, object classes, and feature datasets. An object class is a table in the geodatabase that stores nonspatial data. A feature class is a collection of features with the same type of geometry and the same attributes.
A feature dataset is a collection of feature classes that share the same *spatial reference*. Feature classes that store simple features can be organized either inside or outside a feature dataset. Simple feature classes that are outside a feature dataset are called

standalone feature classes. Feature classes that store topological features must be contained within a feature dataset to ensure a common spatial reference.

ArcCatalog contains tools for creating object classes (tables), feature classes, and feature datasets. Once these items are created in the geodatabase, further items such as subtypes, relationship classes, geometric networks, and topologies can also be created. These geodatabase items are covered in subsequent chapters, figure (2.11).

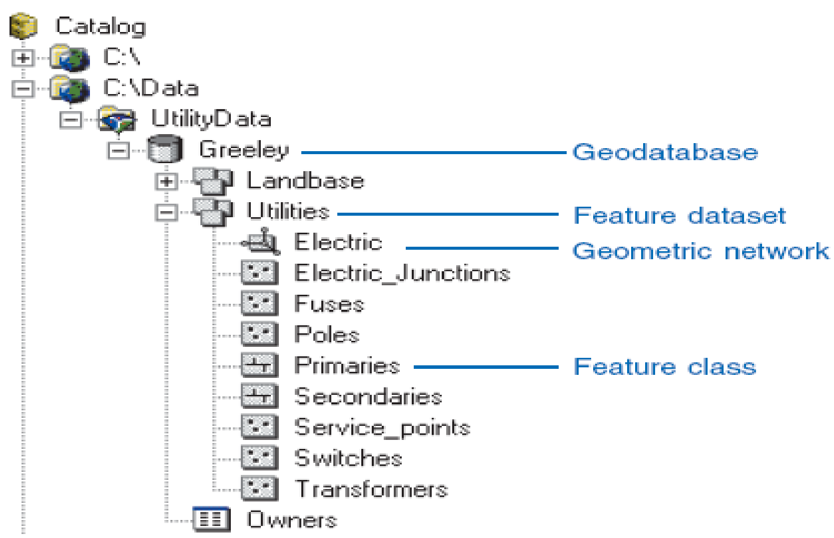


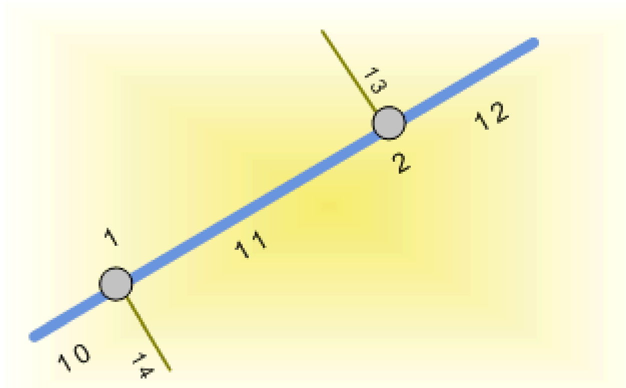
Figure 2.11: Geodatabase items, Ref. (3).

2.5 Geometric network

Geometric networks offer a way to model common networks and infrastructures found in the real world. Water distribution, electrical lines, gas pipelines, telephone services, and water flow in a stream are all examples of resource flows that can be modeled and analyzed using a geometric network.

A geometric network is a set of connected edges and junctions, along with connectivity rules that are used to represent and model the behavior of a common network infrastructure in the real world. Geodatabase feature classes are used as the data sources to define the geometric network. You define the roles that various features will play in the geometric network and rules for how resources flow through the geometric network.

In the following graphic a geometric network models the flow of water through water mains and water services which are connected by water junction fittings:



Water mains (Lines)

OID	Shape	Diameter	Material
10		8	Concrete
11		10	PVC
12		8	Concrete

Water services (Lines)

OID	Shape	Service ID	Material
13		1001	Cast iron
14		1002	Copper

Water junction fittings (Points)

OID	Shape	Equip ID	Valve Type
1		816-32	T203
2		816-45	Y53

Figure 2.12: Edges and junctions in network, Ref. (3).

A geometric network is built within a feature dataset in the geodatabase. The feature classes in the feature dataset are used as the data sources for network junctions and edges. The network connectivity is based upon the geometric coincidence of the feature classes used as data sources.

Geometric networks are comprised of two main elements: Edges and Junctions.

Edges - An edge is a feature which has a length through which some commodity flows. Edges are created from line feature classes in a feature dataset and correspond to edge elements in a logical network.

Examples of edges: water mains, electrical transmission lines, gas pipelines, telephone lines, etc...

Junctions - A junction is a feature that allows two or more edges to connect and facilitates the transfer of flow between edges. Junctions are created from point feature classes in a feature dataset and correspond to junction elements in the logical network. *Examples of junctions: fuses, switches, service taps, valves, etc...*

Edges and junctions in a network are topologically connected to each other—edges must connect to other edges at junctions; the flow from edges in the network is transferred to other edges through junctions.

There are two types of edges in a geometric network:

- **Simple Edges** - Simple edges are always connected to exactly two junctions, one at each end. An example of a simple edge would be a water lateral in a water network. The water lateral connects at one end to a junction along the main distribution line and, at the other end, to a service point junction (such as a tap or pump).

  Simple edges have no mid-span connectivity. If a new junction is snapped mid-span on a simple edge, thereby establishing connectivity, then that simple edge is physically split into two features. A simple edge corresponds to a single edge element in the logical network.

- **Complex Edges** - Complex edges are always connected to at least two junctions at their endpoints but can be connected to additional junctions along their length.

An example of a complex edge would be a water main in a water network. The main water distribution line is a single complex edge with multiple lateral lines connected to junctions along its length. The water main is not split at the junction where each lateral connects to the main. Complex edges have mid-span connectivity. If a new junction is snapped mid-span on a complex edge, that complex edge remains a single feature. Snapping the junction does cause the complex edge to be split logically—for example, if it corresponded to one edge element in the logical network before the junction was connected, it now corresponds to two edge elements.

Complex edges correspond to one or more edge elements in the logical network.

There are two types of junctions in a geometric network:

- **User defined junctions** - Junctions that are created based upon a users source data (point feature classes) when the geometric network is first established. Junctions correspond to a single junction element in the logical network.
- **Orphan junctions** - When the first edge feature class is added to the geometric network, a simple junction feature class is created, called the orphan junction feature class. The name of the orphan junction feature class corresponds to the name of the geometric network appended with '_Junction'. For example, a geometric network named 'Electric_Net' would have a corresponding orphan junction feature class named 'Electric_Net_Junctions'. The orphan junction feature class is used by the geometric network to maintain network integrity. During the creation of the geometric network, an orphan junction is inserted at the endpoint of any edge at which a geometrically coincident junction does not

already exist in your source data. Orphan junction features can be removed from the geometric network by subsuming them with other junction features. To subsume an orphan junction is to incorporate it into the network by deleting it and replacing it with a user defined junction while still maintaining network connectivity.

The orphan junction feature class is deleted when its geometric network is deleted. For this reason, the schema of the orphan junction feature class should not be modified.

2.5.1 The logical network

When a geometric network is created ArcGIS also creates a corresponding logical network, which is used to represent and model connectivity relationships between features. The logical network is the connectivity graph used for tracing and flow calculations.

An edge or junction element in the geometric network corresponds to one or more edges or junctions in the logical network. All connectivity between edges and junctions is maintained in the logical network.

The logical network is managed as a collection of tables that are created and maintained by ArcGIS. These tables record how the features involved in a geometric network are connected to one another. The logical network allows ArcGIS to quickly discover and model the connectivity relationships between connected edges and junctions in a geometric network during editing and analysis. This allows for fast network tracing and facilitates the generation of on-the-fly connectivity while editing.

When edges and junctions are edited or updated in the geometric network the corresponding logical network is automatically updated and maintained as well.

The following graphic shows how a water main, represented by a single complex edge in the geometric network, is comprised of multiple elements in the logical network. The water mains corresponding tables in the logical network are created and maintained by ArcGIS. When edits are made to the water main in the geometric network, ArcGIS automatically updates the corresponding elements in the logical network and connectivity between features in the geometric network are maintained.

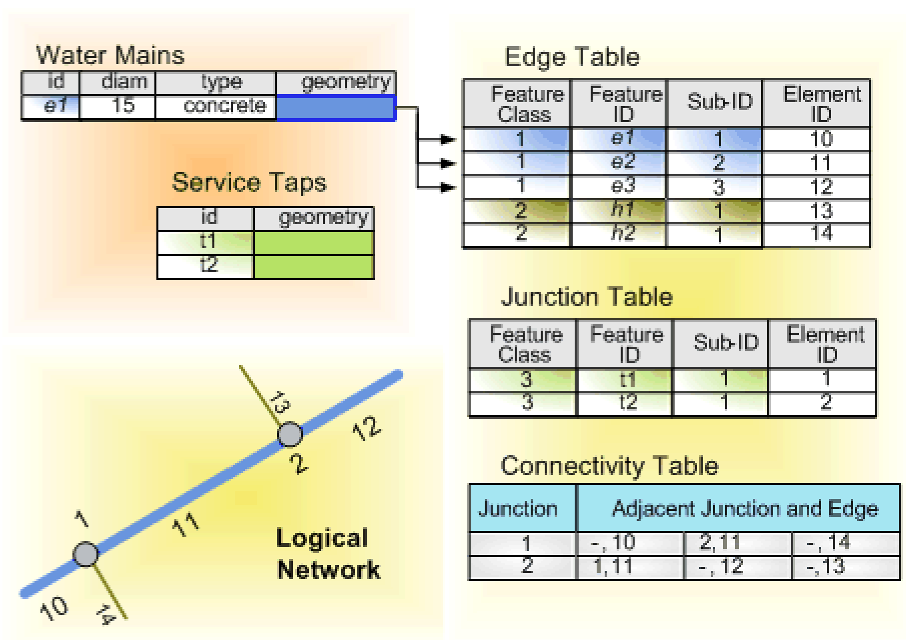


Figure 2.13: Logical network, Ref.(3).

2.5.2 Network weights

A network can have a set of weights associated with it. A weight can be used to represent the cost of traversing an element in the logical network. For example, in a water network, a certain amount of pressure is lost when traveling the length of a transmission main due to surface friction within the pipe.

Network weights apply to all elements in the network. Weight values for each network element are derived from attributes on the corresponding feature. In the transmission main example above, the weight value is derived from the length attribute of the feature.

A network can have any number of weights associated with it. Each feature class in the network may have some, all, or none of these weights associated with its attributes. The weight for each feature is determined by an attribute for that feature. A network weight can be associated with only one attribute in a feature class. The weight can also be associated with multiple feature classes. For example, a weight called Diameter can be associated with the attribute Diameter in the water main feature class and also associated with the attribute Pipe diameter in the water lateral feature class.

A network weight value of zero is reserved and is assigned to all orphan junctions. Also, if a weight is not associated with any attributes of a feature class, then the weight values for all network elements corresponding to that feature class will be zero.

2.5.3 Enabled and disabled features

Any edge or junction in a geometric network may be enabled or disabled in the logical network. A feature that is disabled in the logical network acts as a barrier. When the network is traced, the trace will stop at any barriers it encounters in the network including disabled network features.

The enabled or disabled state of a network feature is a property maintained by an attribute field called Enabled. It can have one of two values: true or false. When building a geometric network from simple feature classes, this field is automatically added to the input feature classes. When you use ArcCatalog to create a network feature class, Enabled is a required field for the feature class. When adding new features to a network, they are enabled by default.

Values stored in the network weight, ancillary role, and enabled fields are the user's view of the state of the feature in the logical network. When analysis—such as tracing and flow direction calculation—is performed against a network feature, the value of these fields within the feature is not directly referenced to determine the enabled, ancillary role state of the feature or its weight. Instead, these states of the feature are stored in the logical network, which is queried during these operations. This is done for performance reasons.

When you edit a network feature and change the value of the enabled, ancillary role, or weight field, the state of the feature in the internal topology tables is modified to remain in sync with the field values of the feature.

2.5.4 Network Build Errors

When building a geometric network, the feature classes that are selected to participate in the network may contain features whose geometries are invalid within the context of a geometric network. These geometries include:

- Features that have empty geometry (error 10).
- Edge features that contain multiple parts (error 11).
- Edge features that form a closed loop (error 12).
- Edge features that have zero length (error 13).

At the end of the build process, a summary of these errors displays in a dialog box. Features with invalid geometries are also identified and recorded in the network build errors table. The table lists the Object ID, Class ID and the reason why a feature's geometry is invalid. The table is located at the workspace level and named as the geometric network's name appended with '_BUILDERR'.

The table is used by the Network Build Errors command within ArcMap to identify the features with invalid geometries. The network build errors table does not get updated when you edit features, so you should update the table's contents as soon as possible after editing features.

2.6 What is topology?

Topology has historically been viewed as a spatial data structure that is used primarily to ensure that the associated data forms a consistent and clean topological fabric. With advances in objectoriented GIS development, an alternative view of topology has evolved. The geodatabase supports an approach to modeling geography that integrates the behavior of different feature types and supports different types of key relationships. In this context, topology is a collection of rules and relationships that, coupled with a set of editing tools and techniques, enables the geodatabase to more accurately model geometric relationships found in the world.

Topology, implemented as feature behavior and rules, allows a more flexible set of geometric relationships to be modeled than topology implemented as a data structure. It also allows topological relationships to exist between more discrete types of features within a feature dataset. In this alternative view, topology may still be employed to ensure that the data forms a clean and consistent topological fabric, but also more broadly, it is used to ensure that the features obey the key geometric rules defined for their role in the database.

2.6.1 Why use topology?

Topology is used most fundamentally to ensure data quality and to allow your geodatabase to more realistically represent geographic features. A geodatabase provides a framework within which features can have behavior, such as subtypes, default values, attribute domains, validation rules, and structured relationships, to tables or other features. This behavior enables you to more accurately model the world and maintain referential integrity between objects in the geodatabase. Topology may be considered an extension of this framework for behavior that allows you to control the geometric relationships between features and to maintain their geometric integrity. Unlike other feature behavior, topology rules are managed at the level of the topology and dataset, not for individual feature classes.

2.6.2 How do I work with topology?

Different people work with topology in different ways, depending on their role in an organization and its GIS design and management work flow.

Initially, creating a topology requires a geodatabase designer. A topology organizes the spatial relationships between features in a set of feature classes. The designer analyzes an organization's data modeling needs, identifies the key topological relationships required in the geodatabase, and defines the rules that will constrain different features' topological relationships.

Once the participating feature classes have been added to the topology and the rules defined, the topology is validated. Data quality managers use the topology tools to analyze, visualize, report, and where necessary, repair the spatial integrity of the database after it is initially created as well as after editing.
Topology provides these users with a set of validation rules for the topologically related features. It also provides a set of editing tools that lets users find and fix integrity violations.

As the geodatabase is used and maintained, new features are added and existing features are modified. Data editors update features in the geodatabase and use the topology tools to construct and maintain relationships between features within the *constraints* imposed by the database designer. Depending on the work flow of the organization, the topology may be validated after each edit session or on a schedule.

2.6.3 Creating a topology

A topology consists of a set of rules structuring the relationship between collections of features in one or more feature classes in a feature dataset. To create a topology, you must specify which feature classes will participate in the topology and what rules will govern the interaction of features. All feature classes participating in a topology must be in the same feature dataset.

Because creating topological relationships involves *snapping* feature vertices together to make them *coincident*, a cluster *tolerance* must be specified for the topology. Vertices within the cluster tolerance may move slightly in the snapping process. The default cluster tolerance is the minimum possible cluster tolerance and is based on the precision defined for the dataset. The cluster tolerance should be small, so only close vertices are snapped together. A typical cluster tolerance is at least an order of magnitude smaller than the accuracy of your data. For example, if your features are accurate to 2 meters, your cluster tolerance should be no more than 0.2 meters. Often, you will want to be able to control which feature classes are more likely to be moved in the *clustering* process.
For example, when features in one feature class are known to have more reliable positions than another set of features, you may want the less reliable features to snap to the more reliable ones.

Ranks are assigned to the feature classes in the topology to accommodate this common situation. Vertices of lower ranking features within the cluster tolerance will be snapped to nearby vertices of higher ranking features. Vertices of features of equal rank that lie within the cluster tolerance will be geometrically averaged together.

2.6.4 Line rules

Must Not Overlap

This rule requires that lines not overlap with lines in the same feature class. This rule is used where line segments should not be duplicated, for example, in a stream feature class. Lines can cross or intersect but cannot share segments.

Must Not Intersect

This rule requires that line features from the same feature class not cross or overlap each other. Lines can share endpoints. This rule is used for contour lines that should never cross each other or in cases where the intersection of lines should only occur at endpoints such as street segments and intersections.

Must Not Have Dangles

This rule requires that a line feature must touch lines from the same feature class at both endpoints. An endpoint that is not connected to another line is called a dangle. This rule is used when line features must form closed loops such as when they are defining the boundaries of polygon features. It may also be used
in cases where lines typically connect to other lines as with streets. In this case, exceptions can be used where the rule is occasionally violated as with cul-de-sac or dead-end street segments.

Must Not Have Pseudos

This rule requires that a line connect to at least two other lines at each endpoint. Lines that connect to one other line (or to themselves) are said to have pseudo-nodes. This rule is used where line features must form closed loops, such as when they define the boundaries of polygons, or when line features logically must connect to two other line features at each end, as with segments in a stream network, with exceptions being marked for the originating ends of first-order streams.

Must Not Intersect Or Touch Interior

This rule requires that a line in one feature class must only touch other lines of the same feature class at endpoints. Any line segment in which features overlap or any intersection not at an endpoint is an error. This rule is useful where lines must only be connected at endpoints, such as in the case of lot lines, which must split (only connect to the endpoints of) back lot lines and which cannot overlap each other.

Must Not Overlap With

This rule requires that a line from one feature class not overlap with line features in another feature class. This rule is used when line features cannot share the same space. For example, roads must not overlap with railroads, or depression subtype of contour lines cannot overlap with other contour lines.

Must Be Covered By Feature Class Of

This rule requires that lines from one feature class must be covered by the lines in another feature class. This is useful for modeling logically different but spatially coincident lines such as routes and streets. A bus route feature class must not depart from the streets defined in the street feature class.

Must Be Covered By Boundary Of

This rule requires that lines be covered by the boundaries of area features. This is useful for modeling lines, such as lot lines, that must coincide with the edge of polygon features, such as lots.

Endpoint Must Be Covered By

This rule requires that the endpoints of line features must be covered by point features in another feature class. This is useful for modeling cases where a fitting must connect two pipes or a street intersection must be found at the junction of two streets.

Must Not Self Overlap

This rule requires that line features not overlap themselves. They can cross or touch themselves, but must not have coincident segments. This rule is useful for such features as streets, where segments might touch, in a loop, but where the same street should not follow the same course twice.

Must Not Self Intersect

This rule requires that line features not cross or overlap themselves. This rule is useful for lines, such as contour lines, that cannot cross themselves.

Must Be Single Part

This rule requires that lines must have only one part. This rule is useful where line features, such as highways, may not have multiple parts.

2.7 What is a network dataset?

Networks used by ArcGIS Network Analyst are stored as network datasets. A network dataset is created from the feature source or sources that participate in the network. It incorporates an advanced connectivity model that can represent complex scenarios, such as multimodal transportation networks. It also possesses a rich network attribute model that helps model impedances, restrictions, and hierarchy for the network. The network dataset is built from simple features (lines and points) and turns.

In ArcGIS, the network dataset stores this persistent network. You can save this network, modify its properties, and model a variety of networks using network datasets. There are numerous options available when creating a network dataset. A network dataset can be built from feature classes in a feature dataset of a personal or enterprise geodatabase. Since a feature dataset can store multiple feature classes, the network dataset can support multiple sources and model a multimodal network.

The shapefile-based network dataset provides ArcView GIS users the opportunity for rapid migration of their data. The shapefile network dataset is created from a polyline shapefile containing the network source (for instance, a street network) and, optionally, a shapefile turn feature class. Such a network dataset cannot support multiple edge sources and cannot be used to model multimodal networks.

2.7.1 Network elements

Network datasets are made of network elements. Network elements are generated from the sources used to create the network dataset. The geometry of the source features is used to establish connectivity. In addition, network elements have attributes that control navigation over the network.

There are three kinds of network elements: edges, junctions, and turns. Edges are elements that connect to other elements (junctions) and are the links over which resources flow. Junctions connect edges and facilitate navigation from one edge to another. Turn elements record information about movement between two or more edges. Edges and junctions form the basic structure of any network. Connectivity in a network deals with connecting edges and junctions to each other. Turns are optional elements that store information about a particular turning movement; for instance, a left turn is restricted from one particular edge to another.

2.7.2 Understanding connectivity

When you create your network dataset, you will make choices that determine which edge and junction elements are created from source features. Ensuring that edges and junctions are formed correctly is important for accurate network analysis results. Connectivity in a network dataset is based on geometric coincidences of line endpoints, line vertices, and points and applying connectivity rules that you set as properties of the network dataset.

2.7.3 Understanding the network attribute

Network attributes are properties of the network elements that control traversability over the network. Examples of attributes include the time to travel a given length of road, which streets are restricted for which vehicles, the speeds along a given road, and which streets are one-way.

Network attributes have five basic properties: name, usage type, units, data type, and use by default. Additionally, they have a set of assignments defining the values for the elements.

Network attributes are created either in the New Network Dataset wizard (when defining a new network) or on the Network Dataset Properties dialog box on the Attributes tab. To create network attributes, first define the name of the attribute, its usage, units, and data type. Next, assign evaluators for each source that will provide the values for the network attribute when the network dataset is built. This is done by selecting the attribute and clicking Evaluators.

Network attributes can also have parameters that can be used by its evaluators. Parameters allow for dynamic analysis with network attributes by modeling such descriptor attributes as truck height or weight, weather factors or current speeds.

2.7.3.1 Cost

Certain attributes are used to measure and model impedances, such as travel time (transit time on a street) or demand (the volume of garbage picked up on a street). These attributes are apportionable along an edge; that is, they are divided proportionately along the length of an edge. For example, if travel time is modeled as a cost attribute, then traversing half an edge will take half the time as traversing the whole edge. This means that if the travel time to traverse the edge is 3 minutes, it takes 1.5 minutes to traverse half the edge. If you are looking for a 1.5-minute route along this edge, the route feature will be created from the first half of the edge feature.

Network analysis often involves the minimization of a cost (also known as impedance) during the calculation of a path (also known as finding the best route). Common examples include finding the fastest route (minimizing travel time) or the shortest route (minimizing distance). Travel time (drive time, pedestrian time) and distance (meters) are also cost attributes of the network dataset.

2.7.3.2 Descriptors

Descriptors are attributes that describe characteristics of the network or its elements. Unlike costs, descriptors are not apportioned. This means that the value does not depend on the length of the edge element. For example, the number of lanes is an example of a descriptor on a street network. Speed limit of streets is another descriptor attribute for a street network. Although it is not a cost attribute and cannot be used as impedance, it can be used in conjunction with distance to create a cost attribute (for example, drive time) that can be used as impedance.

2.7.3.3 Restrictions

Restrictions can be identified for particular elements, such that during an analysis, restricted elements cannot be traversed. For example, one-way streets can be modeled with a restriction attribute, so they can only be traversed from one end to another and not in the reverse direction. In all cases, a restriction attribute is defined using a Boolean data type.

In another example, certain sources where pedestrians are not allowed could be restricted using the attribute No_Pedestrians. In this case, the restriction can be used as a parameter during best route analysis to ensure the pedestrian does not use streets that are restricted.

2.7.3.4 Hierarchy

Hierarchy is the order or grade assigned to network elements. A street network might have a road class hierarchy for separating interstates from local roads. In finding a shortest path from one point to another, the user preference to take or avoid interstates can be modeled through a hierarchy.

In ArcGIS Network Analyst, different classes of hierarchy can be grouped into three ranges: primary roads, secondary roads, and local roads. If your network has more than three classes of hierarchy, you can reclassify them into the supported ranges when you create your network dataset.

When you use a network that supports hierarchy for analysis, you can choose to create a route that uses hierarchy or you can create an exact route not using hierarchy. You can modify the hierarchy ranges at that point as well.

2.7.4 Turns in the network dataset

Turns can be made at any junction where edges connect. There are n^2 possible turns at every network junction, where n is the number of edges connected at that junction. Even at a junction with a single edge, it is possible to make one U-turn.

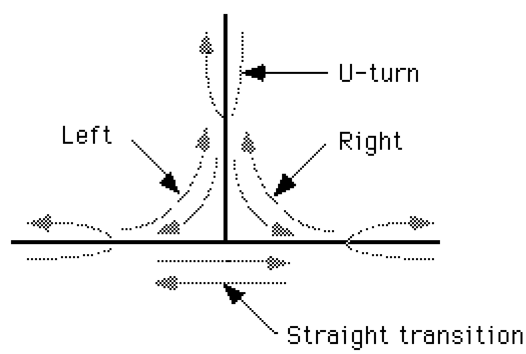


Figure 2.14: Network junction turn, Ref. (3).

2.7.4.1 Multiedge turns

A simple turning movement between two edges connected at a junction is referred to as a two-edge turn. ArcGIS Network Analyst supports modeling multiedge turns. A multiedge turn is a movement from one network edge element to another through a sequence of connected intermediate edge elements. These intermediate edges are referred to as the interior edges of a turn. In a street network, the interior edges of a turn are typically those edge elements that represent the interior of an intersection of divided roads.

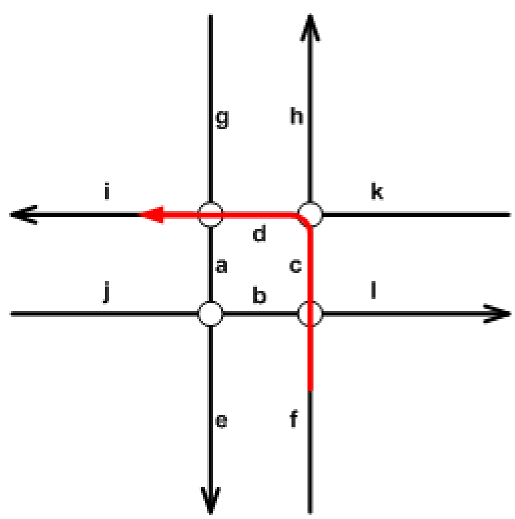


Figure 2.15: Network junction turns, Ref. (3).

The example shown above depicts a multiedge left turn on an intersection of two divided roads. Edges *c* and *d* represent interior edges of the turn, while edges *f* and *i* represent the exterior edges.

2.7.4.2 U-turns

A U-turn is a movement from an edge element through one of its ends back onto itself. It is typically modeled as a turn with two entries in the edge sequence, where both entries are the same edge element.

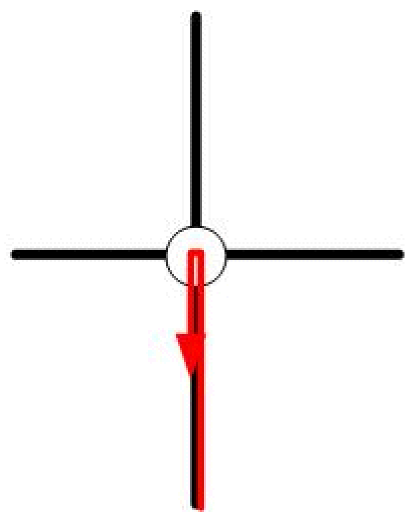


Figure 2.16: U turn junction, Ref. (3).

When dealing with divided roads, a U-turn is modeled as a multiedge turn, where edges *f* and *e* are exterior edges and *c*, *d*, and *a* are interior edges.

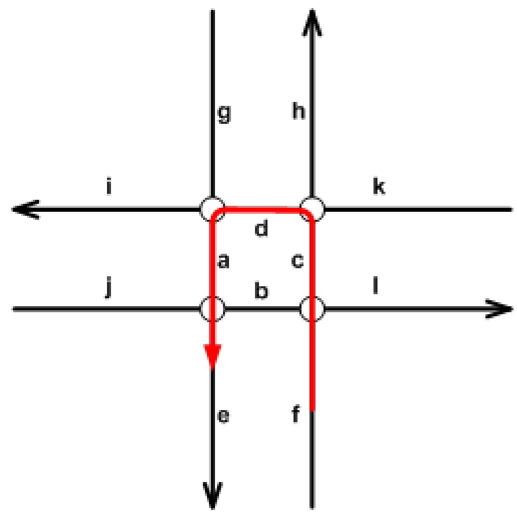


Figure 2.17: Multiedge U turns, Ref. (3).

2.7.5 Setting directions

The minimum requirements for a network dataset to support directions are:

- A length attribute with length units.
- At least one edge source.
- At least one text field on the edge source.

The directions generated when a route is computed are customizable at the network dataset level. This means that the street names used for reporting directions, shields, and boundary information are stored with the network dataset schema. These settings can be modified by the users to customize the directions.

2.7.5.1 Directions settings

The units used to report directions can be modified on the General tab. The Display Length Units are the units used to report the length. For example, if miles were chosen, all directions generated for this network dataset would be reported in miles. ArcGIS Network Analyst supports the following five length units: feet, kilometers, meters, miles, and yards.

The Length Attribute is used to calculate the length of each segment of the route for which the directions are reported. Any cost attribute can be selected as the length attribute. ArcGIS automatically searches through the network attributes and tries to assign the relevant cost attribute.

The Time Attribute is used to calculate the time taken to traverse each segment during the reporting of directions.

The Road Class Attribute is used to provide specific directions for different types of roads.

2.7.6 Using parameters with network attributes

Network attributes can have parameters that can be used by its evaluators. Parameters can be used to model some dynamic aspect of an attribute's value. For example, a tunnel with a height restriction of 12 feet can be modeled using a parameter. This restriction will then evaluate to true or restricted if the vehicle is higher than 12 feet. Similarly, a bridge could have a parameter to specify a weight restriction.

Chapter Three

Data Acquisition and Attribute Table Editing

This chapter covers the data collection and preparation, and network operations. The chapter covers the following items:

3.1 Data collection
3.2 Attribute Table Editing
3.3 Network operations

3.1 Data collection

Our project aims to build a network analyst system. Several shapefiles from Hebron Municipality that represent buildings, street centre lines, and streets type, were obtained, transferred to proper format cleaned and used in our project, figure (3.1).

The characteristic of these shapefiles are:

- Buildings shapefile contains street ID, area, perimeter and type.
- Street center lines shapefile contains street ID, type, length, name, wide and number.
- Streets type shapefile contains street ID, path, key, name, width, type, area and perimeter.

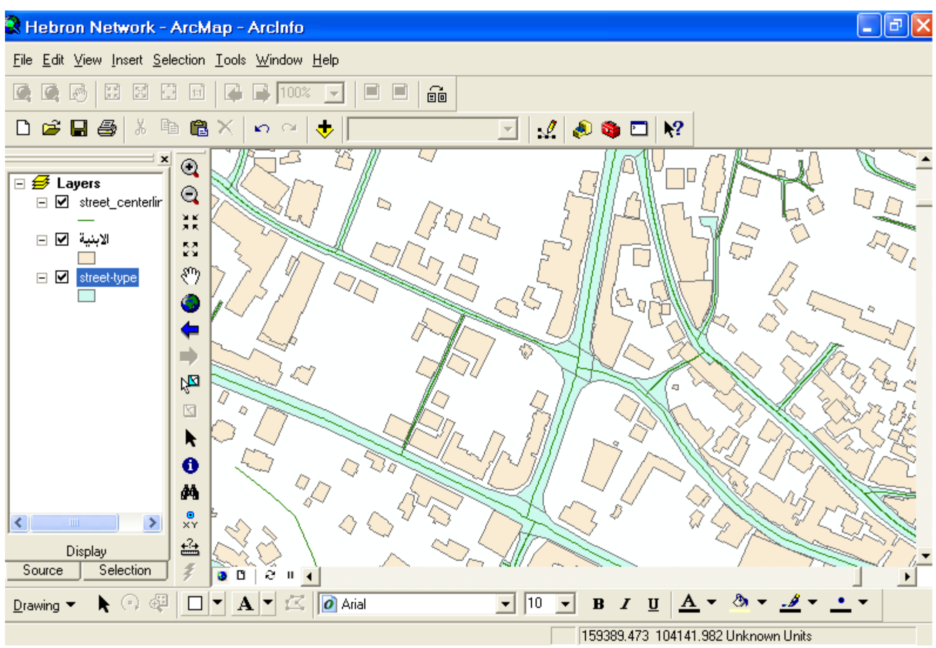


Figure 3.1: Shapefiles for Hebron city.

- Facility shapefiles containing schools, pharmacies, mosques, clinics, police stations, gas stations, hotels, banks, factories, universities.

3.2 Attribute Table Editing

3.2.1 Hebron Network Attribute Table

Network attributes are properties of the network elements that control traversability over the network. Examples of attributes include the time to travel a given length of street, which streets are restricted for which vehicles, the speeds along a given street, and which streets are one-way.

Restrictions are always Boolean, whereas a hierarchy is always an integer.
The following table summarizes the added fields, and their properties

Table (3.1): Summery of the added fields and their properties.

Field	**Format**	**Type**
Meters	Double	Cost
One-way	Text	Restriction
Minutes	Double	Cost
Foot time	Double	Cost

3.2.1.1 Cost Fields added to Hebron Network Attribute Table

3.2.1.1.1 Speed on Streets

The speed of travel of each street within Hebron Municipality area were obtained from Hebron police center and some information were obtained by distribution of a questionnaire to drivers within Hebron Municipality area.

The following Table summarizes the speed on a sample of street within Hebron Municipality.

Table (3.2): Summary of speed on a sample of street within Hebron Municipality.

No.	Street Name	Speed (Km/h)
1	شارع عين سارة	٤٠
2	شارع السلام	٣٥
3	شارع الحاووز	٤٠
4	شوارع وسط المدينة	٢٠

3.2.1.1.2 Length of Streets (meter)

3D Analyst Extension of ArcMap is used to build TIN model to create 3D shapefile for calculating slope length of streets, figure (3.2). The steps of creating 3D shapefile can be summarized by:

1.Turning on the 3D Analyst extension.

2. Creating TIN from feature, specifying layer (polyline) and height source (elevation).

3.Convert the shapefile (street) to 3D shapefile.

4. Adding a field contains slope length based on elevation.

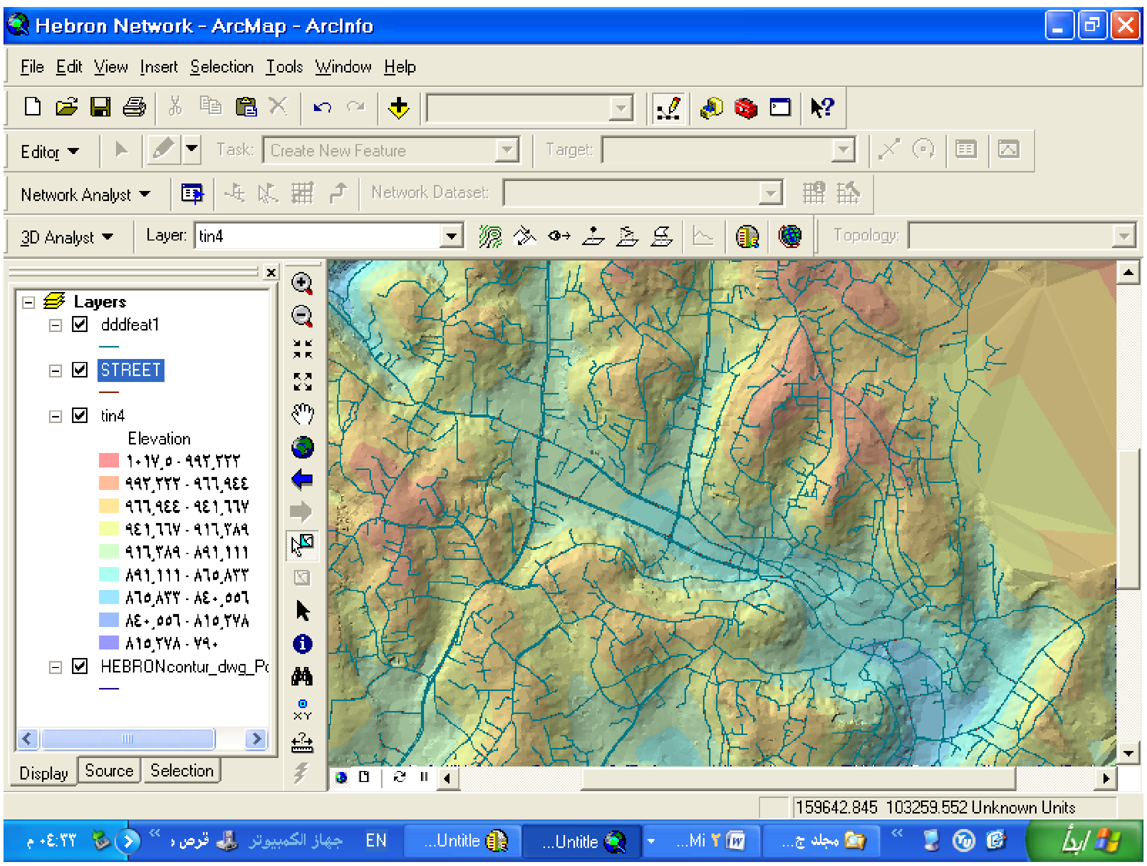


Figure 3.2: TIN and Street model.

ArcScene was used to show the TIN in 3D model and capturing picture for model, figure (3.3).

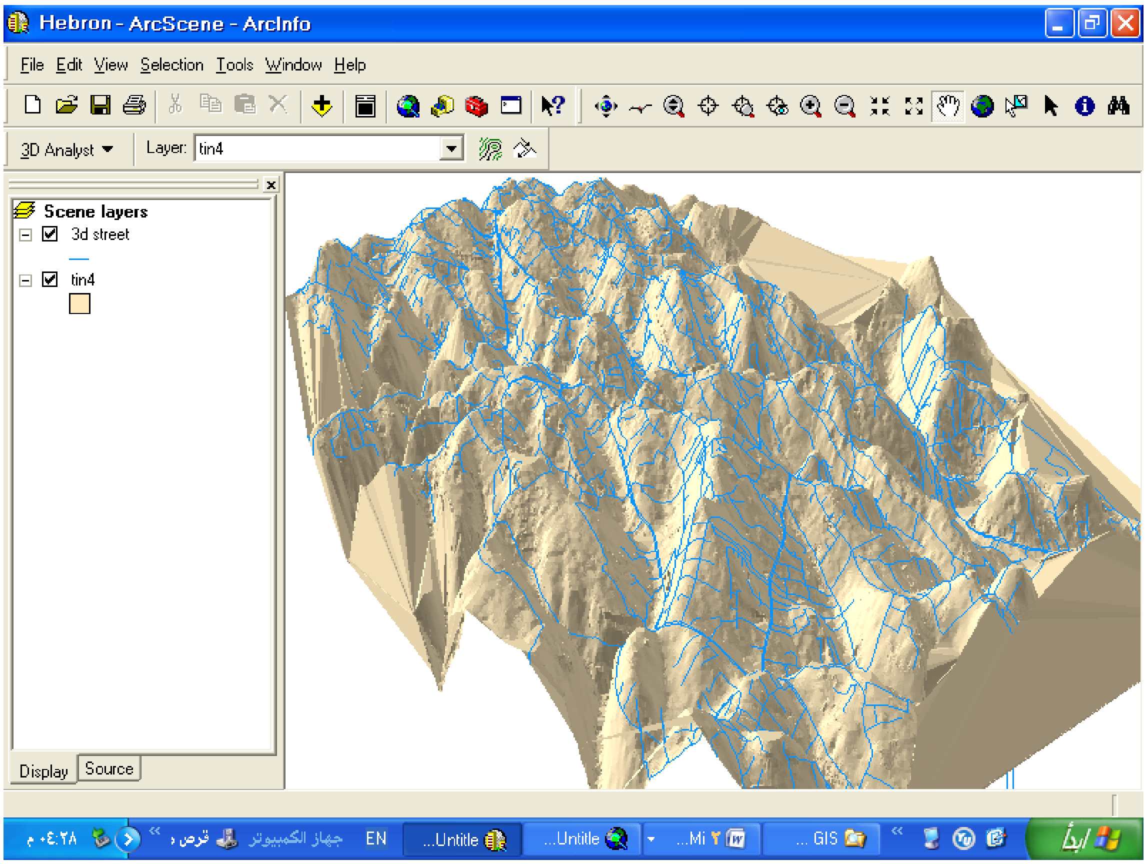


Figure 3.3: TIN and Street model.

3.2.1.1.3 Time field (minute)

Calculating time depending on speed and length fields. All junctions having traffic lights cost 15 seconds.

3.2.1.2 Add Restricted Field to Hebron Network Attribute Table

To work in network analysis it is important to give each part of the center line its direction, this need adding field restrictions (one _way) on the attributes table.

3.3 Turns in the network dataset

Turn movements automatically generated in the network at every two- edge transition, Right turns, left turns, u-turns, and straight-aways. Only applied at locations without turn feature.

Typical use: Apply a "global left-turn penalty"

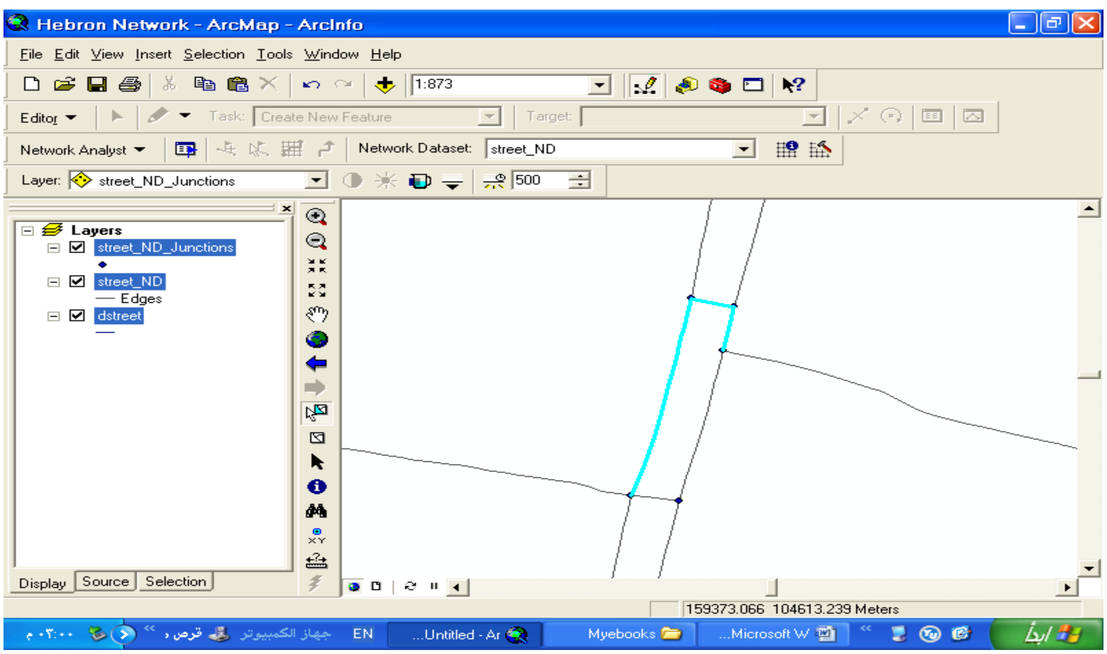


Figure 3.4: Example of an U turn.

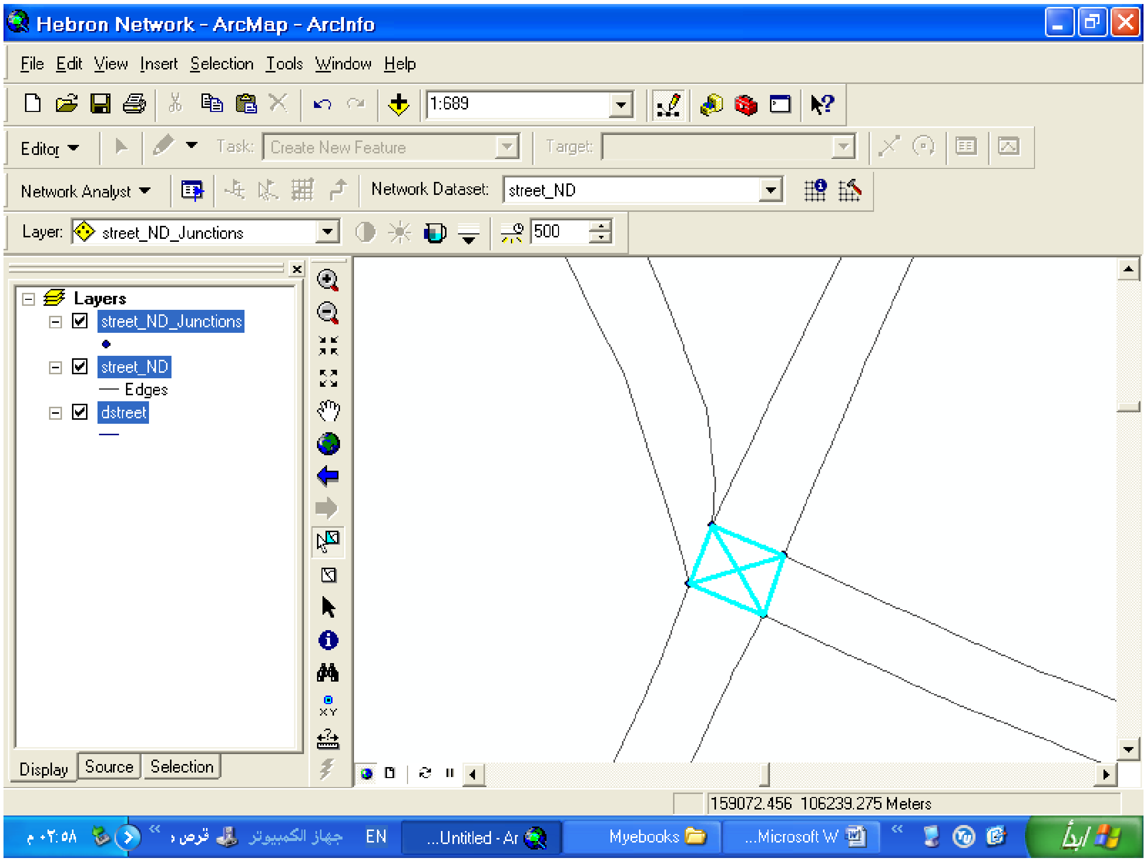


Figure 3.5: Example of turns.

Chapter Four
Topology and Geometric Network

This chapter covers building Geodatabase to create Geometric network to produce clean map that will be used for building network dataset.
The chapter covers the following items:

4.1 Topology
4.2 Geometric Network

4.1 Topology

Topology has historically been viewed as a spatial data structure that is used primarily to ensure that the associated data forms a consistent and clean topological fabric.

4.1.1 Building a topology

ArcCatalog contains tools to create a topology for certain data. The process of building a topology from existing data can be summarized in the following steps:

1. Use ArcCatalog to build geodatabase that contains feature dataset.
2. Use the Feature Class to import a shapefile into a new geodatabase feature class.
3. Use ArcCatalog tools to convert and load data into a feature dataset in a geodatabase.
4. Use the ArcCatalog Topology wizard to build a topology from existing simple feature classes.
5. Name the topology.
6. Set a cluster tolerance for the topology.
7. Choose the feature classes that will participate in the topology.
8. Add topology rules to structure the spatial relationships between features.

The following topological rules, has been used, figure (4.1).

1. Must not have Dangles
   Any end point where the line doesn't touch another line is an error.
2. Must not have Pseudos
   Any end point where the line touches one other line is an error.
3. Must not intersect or touch interior
   Any line where features overlap or any point of intersection is an error.

4. Must be single part

   Any line feature with more than one part is an error.

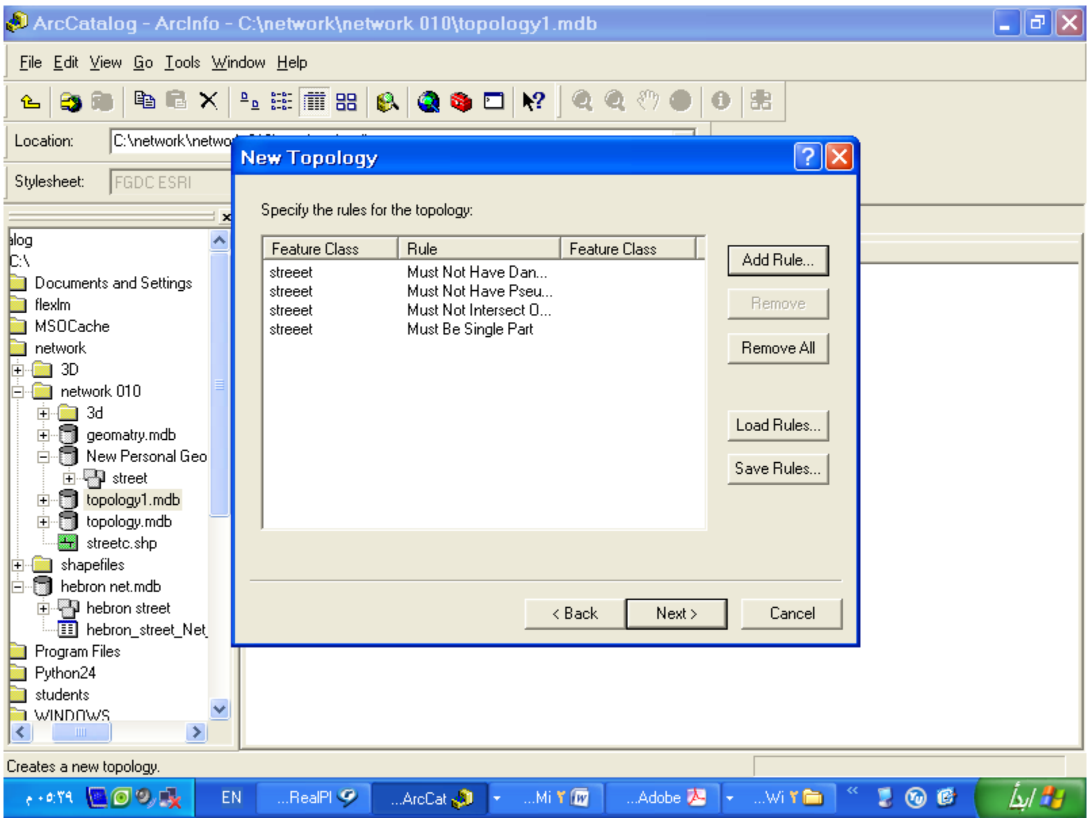


Figure 4.1: Rules in topology.

9. Create the topology, figure (4.2).

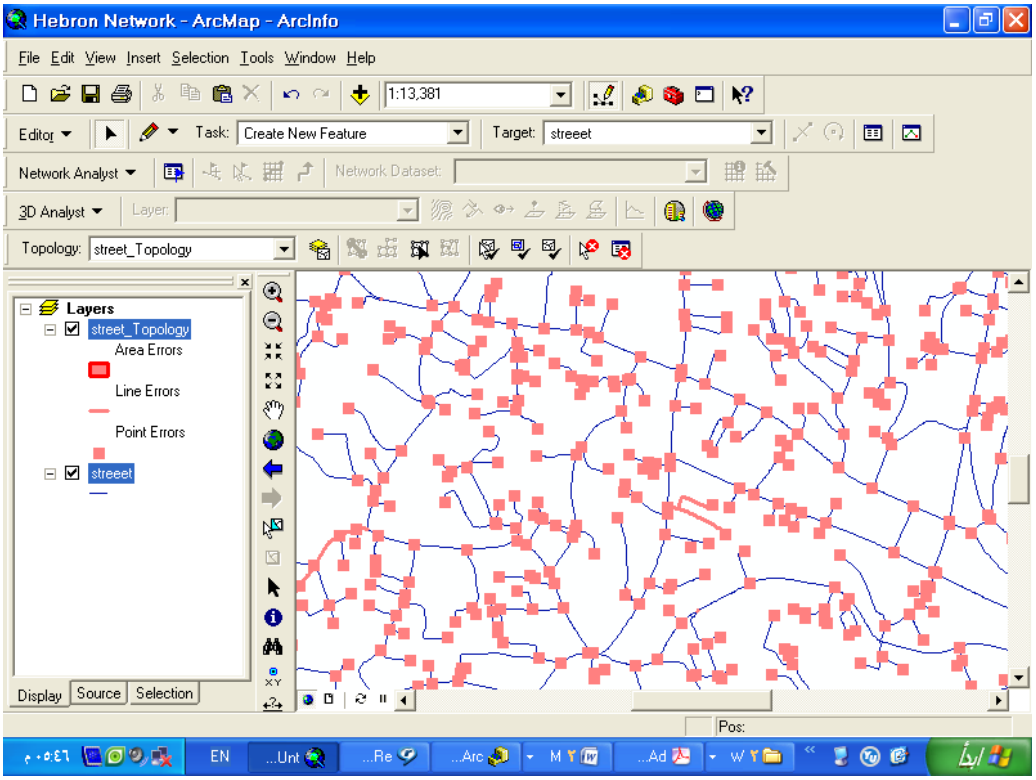
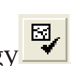


Figure 4.2: Topology errors.

4.1.2 Editing topology

In this section we want to repair the topology errors.

1. Use the ArcMap Topology Error Inspector to identify topology errors.
2. Use split or subtract to repair errors in "Must not intersect or touch interior" rule. Then validate the topology , figure (4.3).

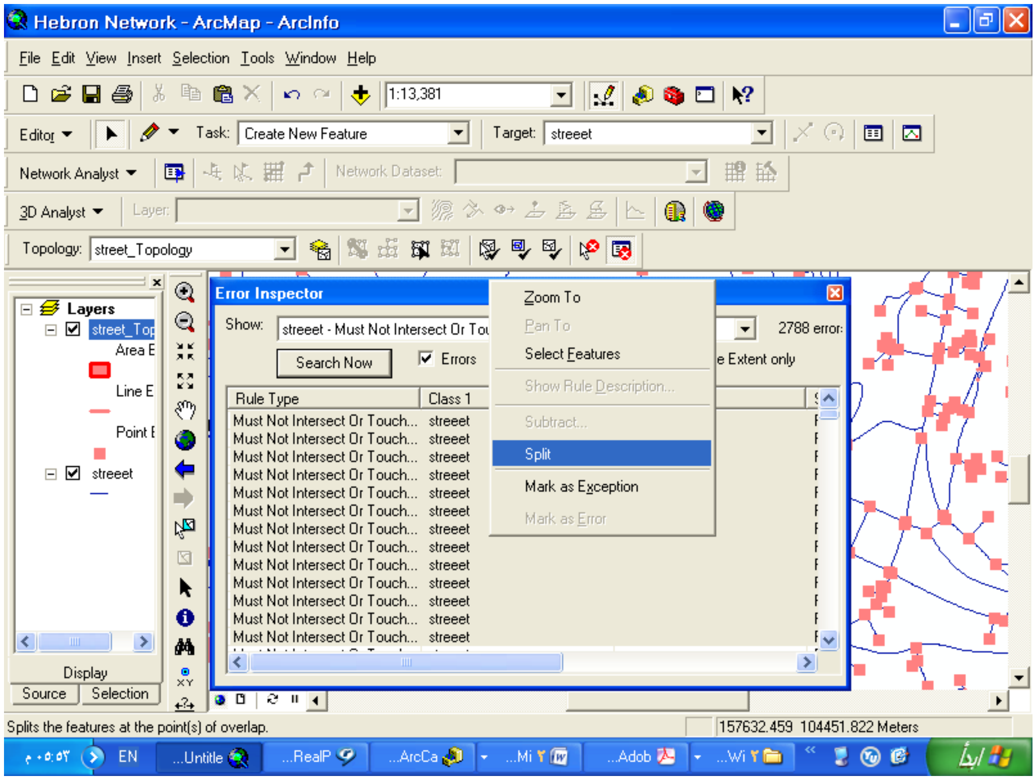


Figure 4.3: Repair error in "Must not intersect or touch interior" rule.

3. Uses merge to largest to repair error in "Must not have Pseudos" rule. Then validate the topology , figure (4.4).

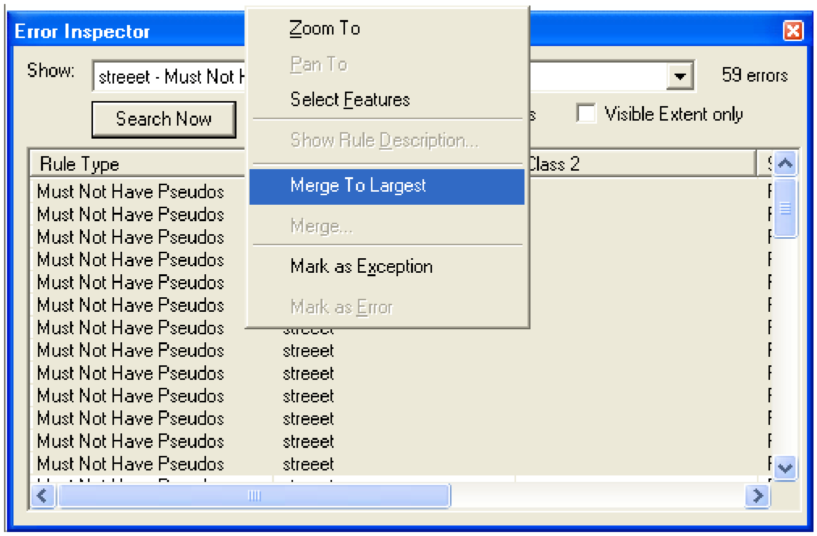


Figure 4.4: Repair error in ""Must not have Pseudos" rule".

4. Use snap, extend or trim to repair errors in "Must not have Dangles" rule. Then validate the topology , figure (4.5).

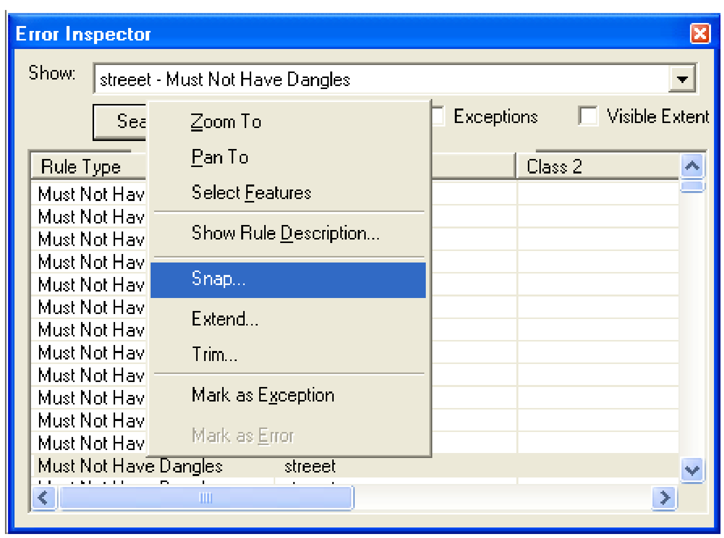


Figure 4.5: Repair error in "Must not have Dangles" rule.

5. Uses explode to repair errors in "Must be single part" rule. Then validate the topology , figure (4.6).

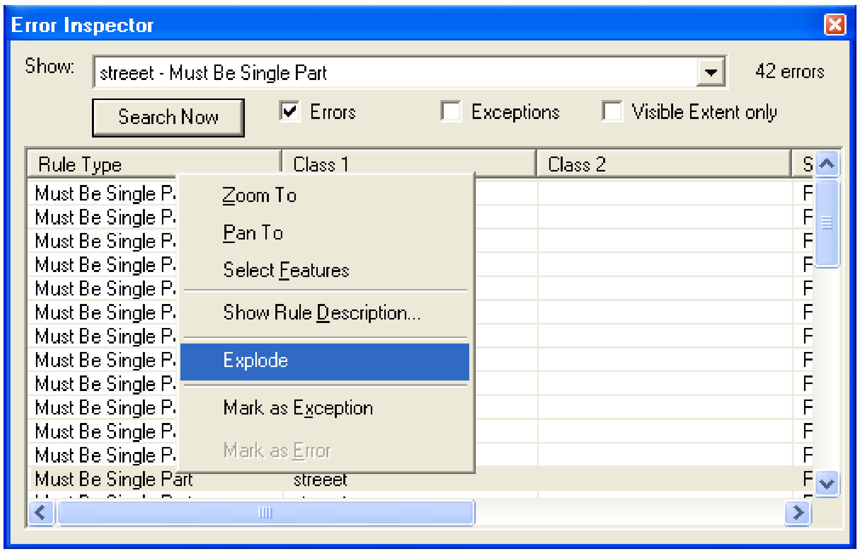


Figure 4.6: Repair error in "Must be single part" rule.

6. The resulted cleaned map will appear as follows, figure (4.7).

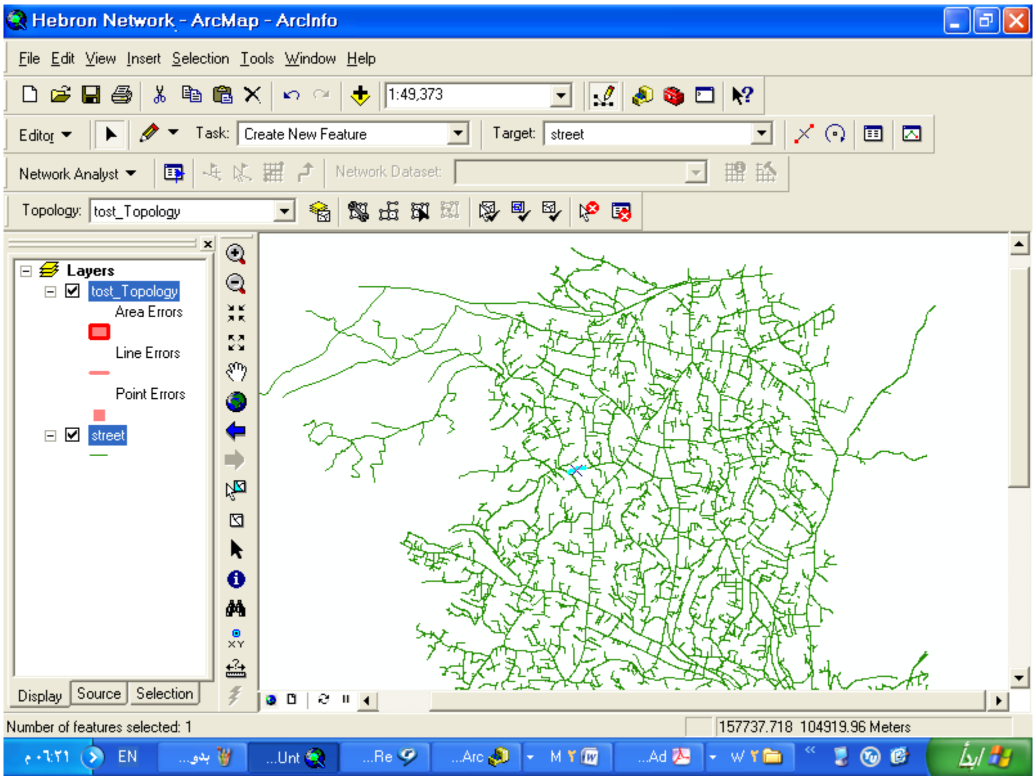


Figure 4.7: Result topological map.

4.2 Geometric Network

A geometric network is a connectivity relationship between a collection of feature classes in a feature dataset. Each feature has a role in the geometric network of either an edge or a junction. Multiple feature classes may have the same role in a single geometric network.

4.2.1 How Geometric Networks are built

Geometric networks are created and managed using ArcCatalog. The following steps show the way:

1. Use ArcCatalog to build geodatabase that contains feature dataset.
2. Use the Feature Class to import a shapefile into a new geodatabase feature class.
3. Convert and load data into a geodatabase.
4. Build a geometric network from existing simple feature classes using Arc catalog.
5. Select feature classes and network name.
6. Select preserve existing attribute in the field called "enable".
7. Select the type of edges "simple".
8. Select snap tolerance equals to one meter.
9. Assign weights (cost) which is Length, Speed, and Direction.
10. Repair errors in the geometric network from editing tools, figure (4.8).

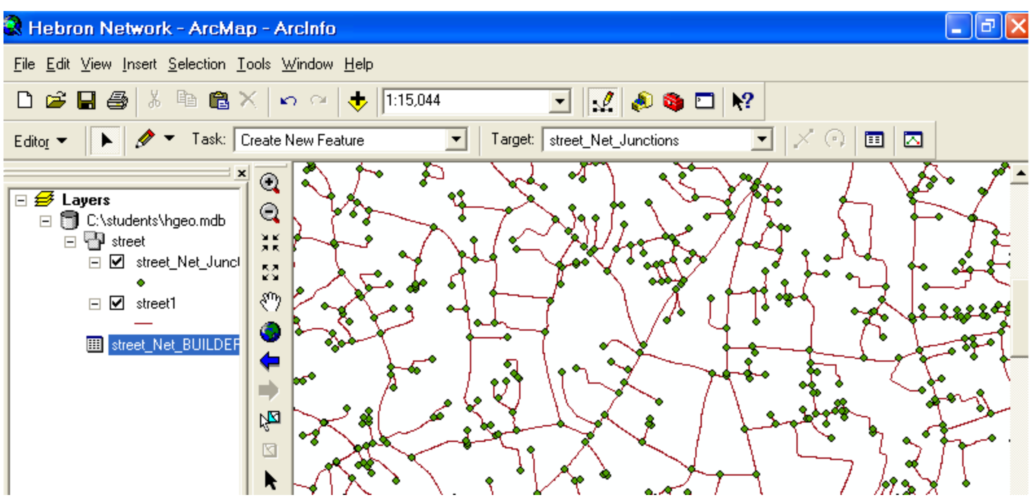


Figure 4.8: Editing tools.

9. Rebuild the geometric network from geometric network tools, figure (4.9).

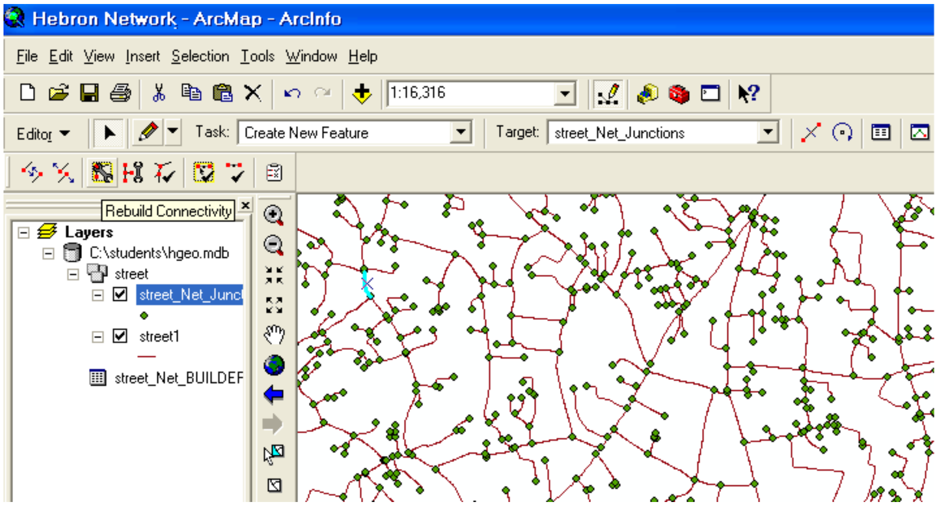


Figure 4.9: Geometric network tools.

10. Recreate the geometric network from the corrected feature class.

Chapter Five

Network Dataset

This chapter covers building a Geodatabase to create Geometric network to produce clean map that will be used for building network dataset.
The chapter covers the following items:

5.1 Network Operations
5.2 Creating a network Dataset
5.3 Finding the Best Route using A network Dataset
5.4 Finding the Closest Facility
5.5 Calculating Service Area
5.6 OD Cost Matrix analysis layer

5.1 Network Operations

5.1.1 Drive distance to nearest transit stop

We need to compute the minimum time and distance from all households to the nearest transit park-and-ride site**.**

5.1.2 Time Needed for Ambulance to Drive to the Accident Area

Information obtained from (Fadi Amro) graduated project indicate that the ideal time needed to reach the accident area is 8.30 min.

5.1.3 Time Needed for Fire Cars to Reach the Accident Area

The ideal time needed to drive from Hebron Municipality fire station to the accident area is 6 min, as stated by the fire stations employees, Ref. (5).

5.1.4 The Pharmacy Service Area

100 m is the radius of the pharmacy service area as stated by Palestinian Pharmacy Association, Ref. (8).

5.1.5 Schools Service Area

From the international standards and from (Fadi Amro) graduated project, the ideal service area for basic schools is found to be 500m.

5.1.6 Mosques Service Area

The time for Mosques service area is considered to be 10 min. This time is the time between (AL-AZAN) and the start of the praying.

5.2 Creating a Network Dataset

We will create a geodatabase based network dataset using the streets feature class for Hebron city.

1. Use ArcCatalog to build geodatabase that contains feature dataset.
2. Use the Feature Class to import a shapefile into a new geodatabase feature class.
3. Create a geodatabase based network dataset using Arc catalog, figure (5.1).

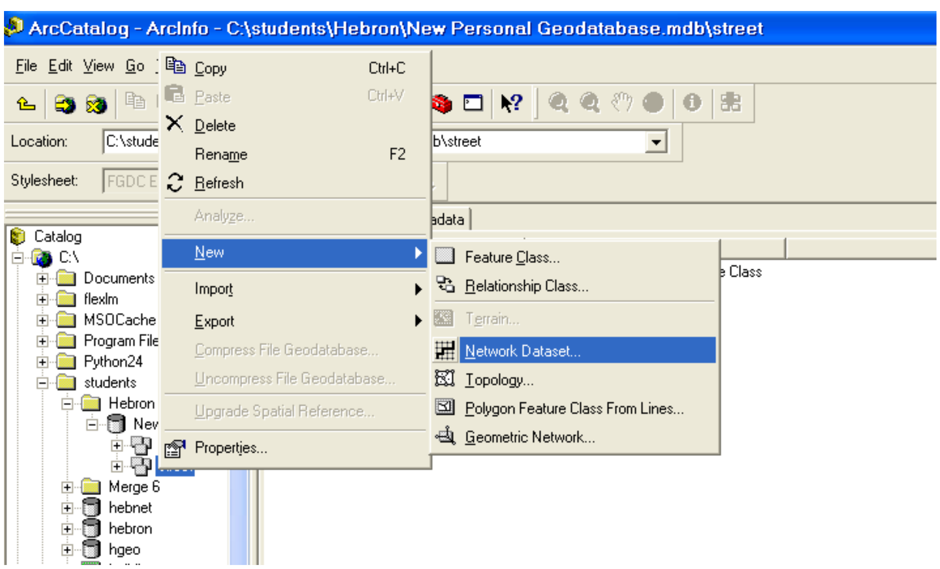


Figure 5.1: Geodatabase based network dataset.

4. Enter name for the network dataset.
5. Select the feature class that will participate in the network dataset.
6. Specify the attributes for the network, figure (5.2).

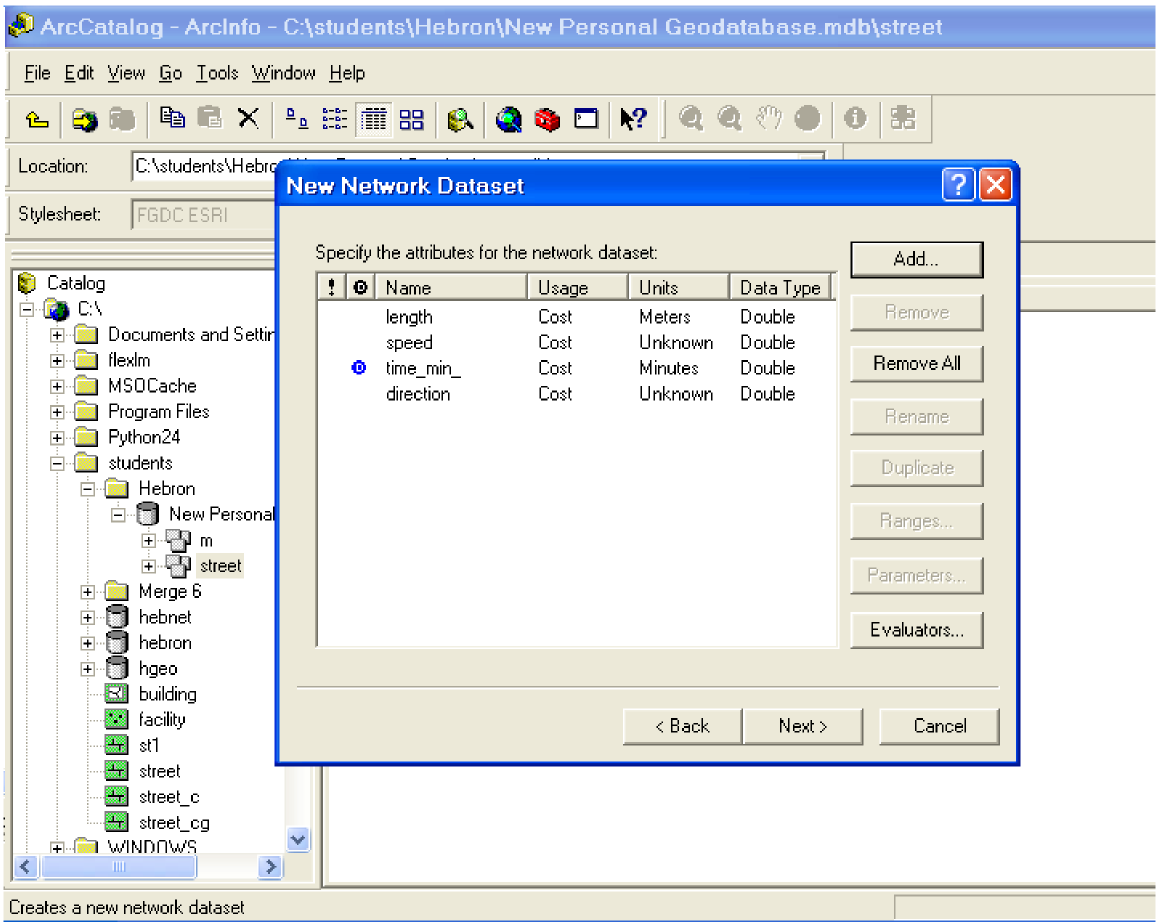


Figure 5.2: Attributes for the network dataset.

7. Establish driving direction settings for the network dataset, figure (5.3).

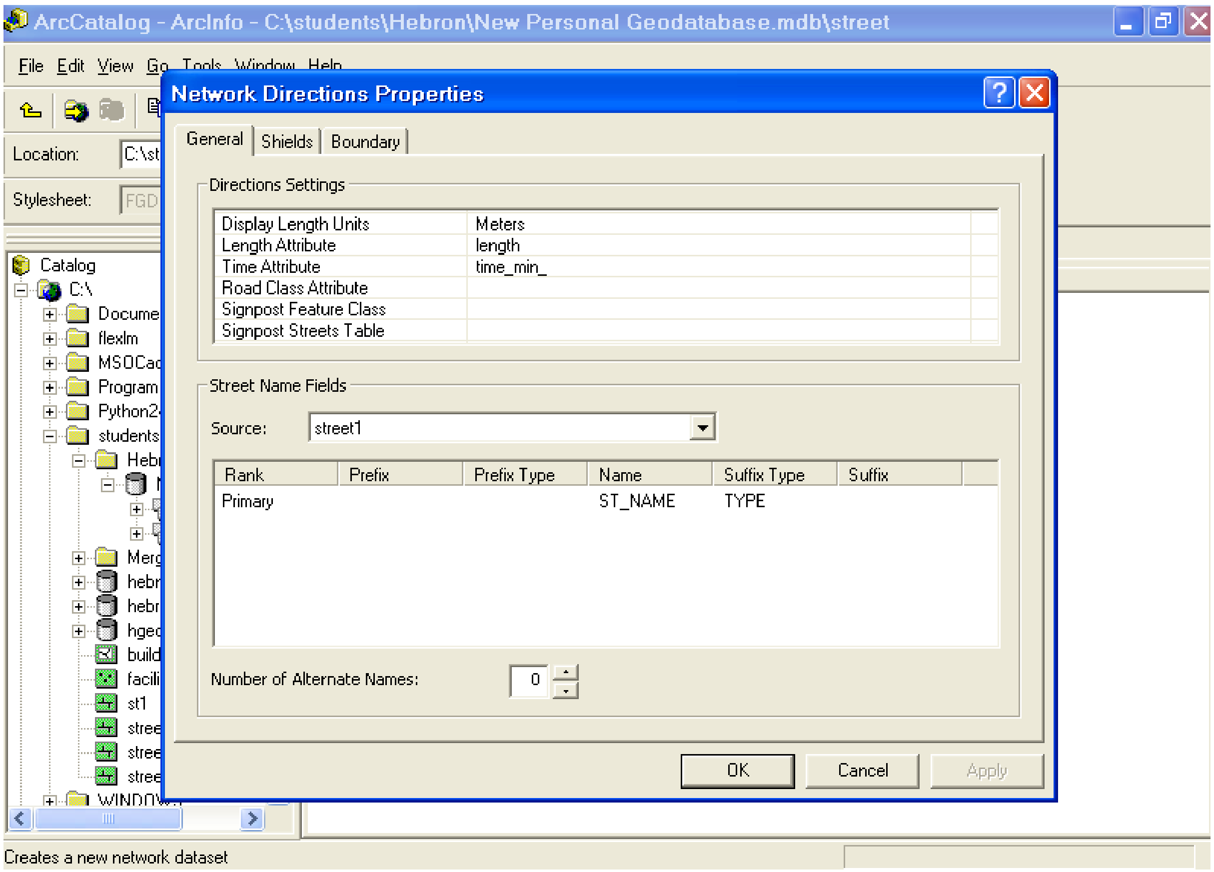


Figure 5.3: Driving direction settings.

5.3 Finding the Best Route using A network Dataset

We will find the best route for the given order of stops based on travel time.

1. If the Network Analyst Extension is not enabled, on the Tools menu, click Extensions and in the Extensions dialog, click Network Analyst.
2. If the Network Analyst toolbar is not already present, on the Main menu, click View, point to Toolbars, and click Network Analyst, figure (5.4).
3. If the Network Analyst Window is not already open, click the Network Analyst Window button on the Network Analyst toolbar, figure (5.4).
4. On the Network Analyst toolbar, click the Network Analyst dropdown menu and click New Route , figure (5.4).

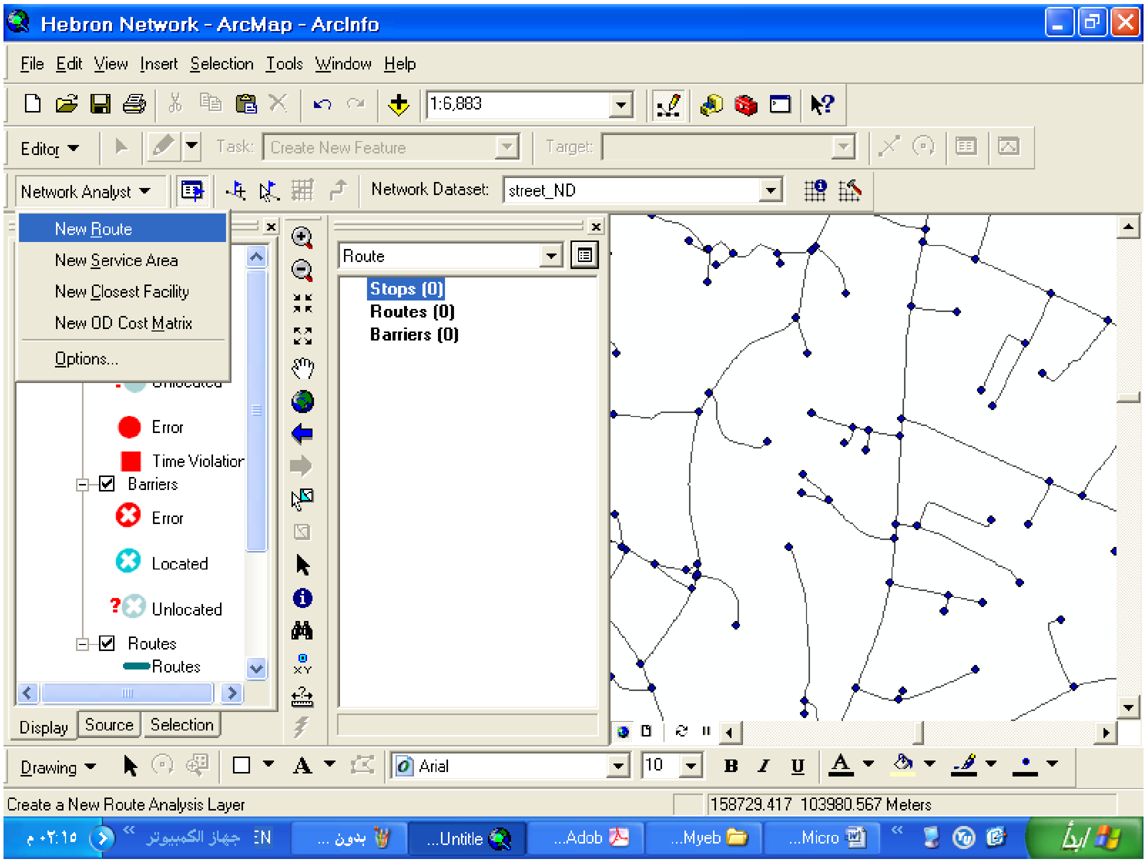


Figure 5.4: Network toolbar.

5. Add stops to the Network using create network location tool .. The first stop is treated as the origin and the last, as the destination. If a stop is not located on the network, it will appear with an unlocated symbol, figure (5.5).

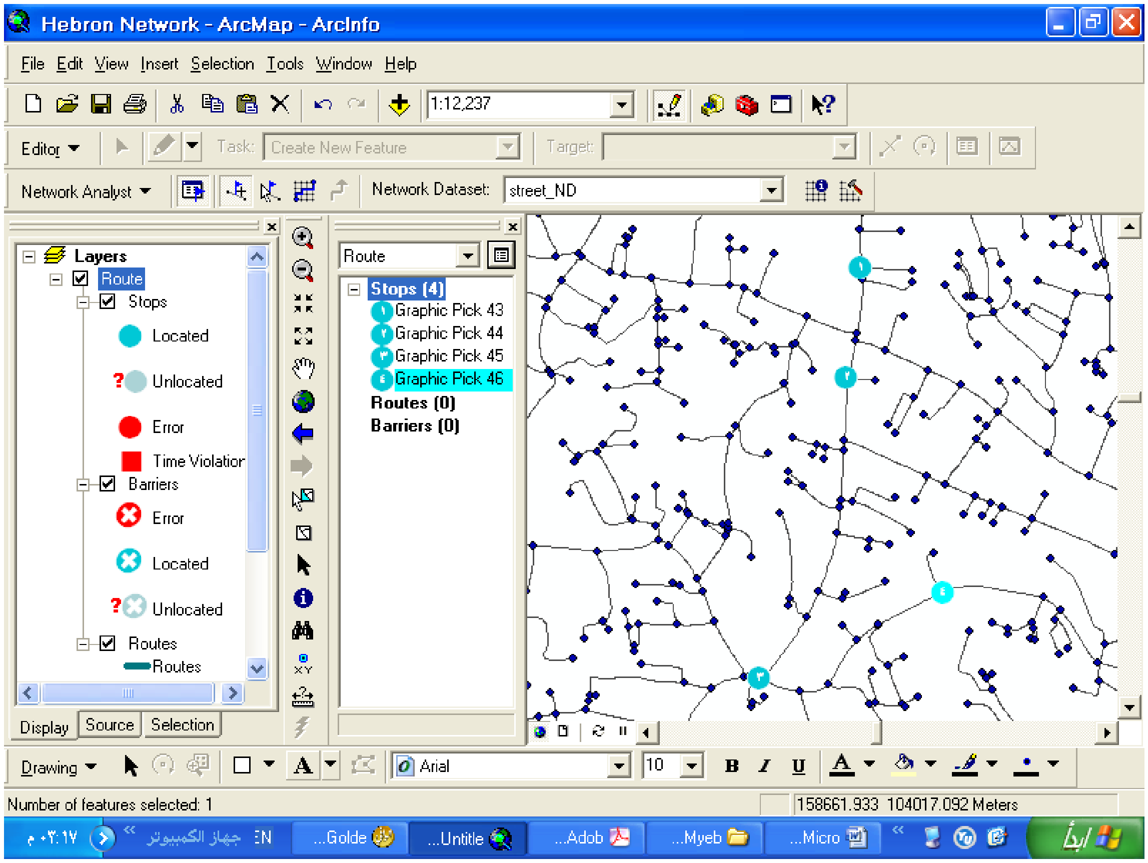
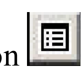


Figure 5.5: Adding stops.

6. In the Network Analyst Window, click the Analysis Layer Properties Button  to bring up the Layer Properties dialog box.
7. Setting up the parameters for the analysis from analysis setting tab, figure (5.6)
    - From impedance we can choose the best route with respect to time or length.
    - Set the distance unit (meter).

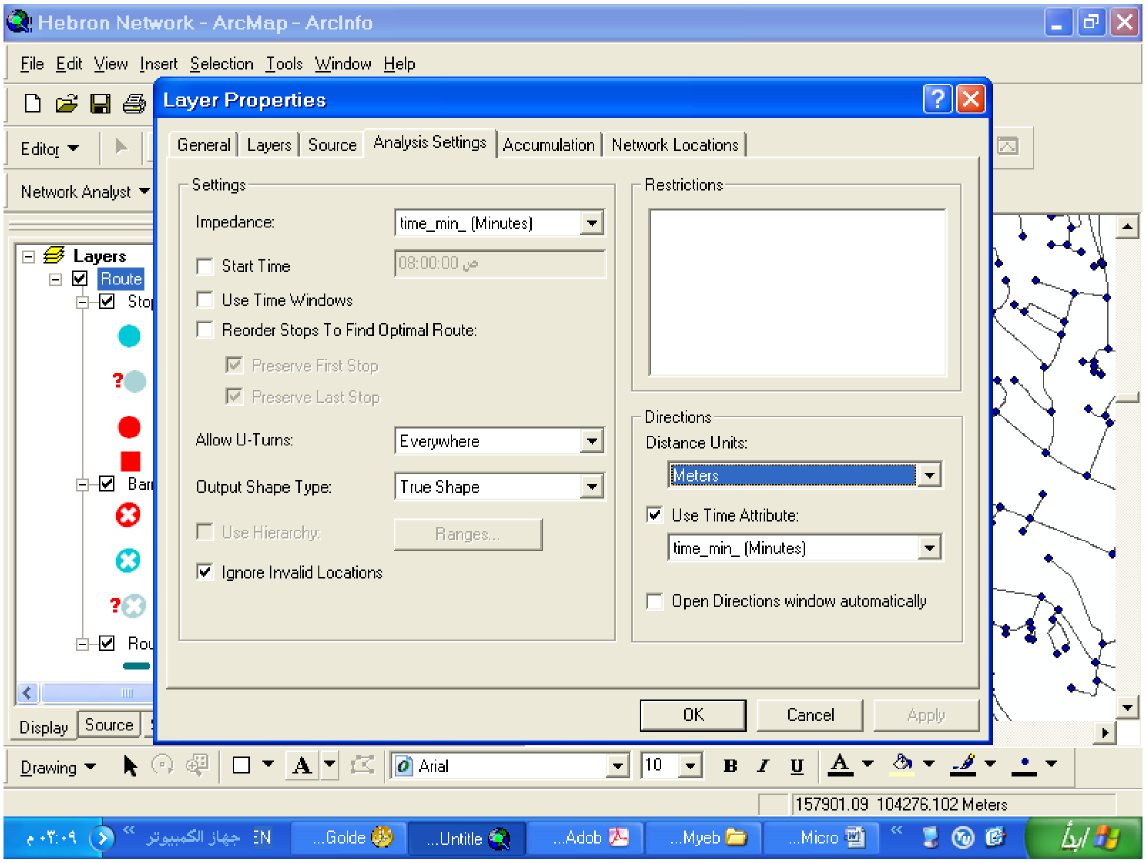
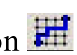


Figure 5.6: Layer properties window.

8. Run the process to compute the best route from Solve button  on the Network Analyst toolbar, figure (5.7).

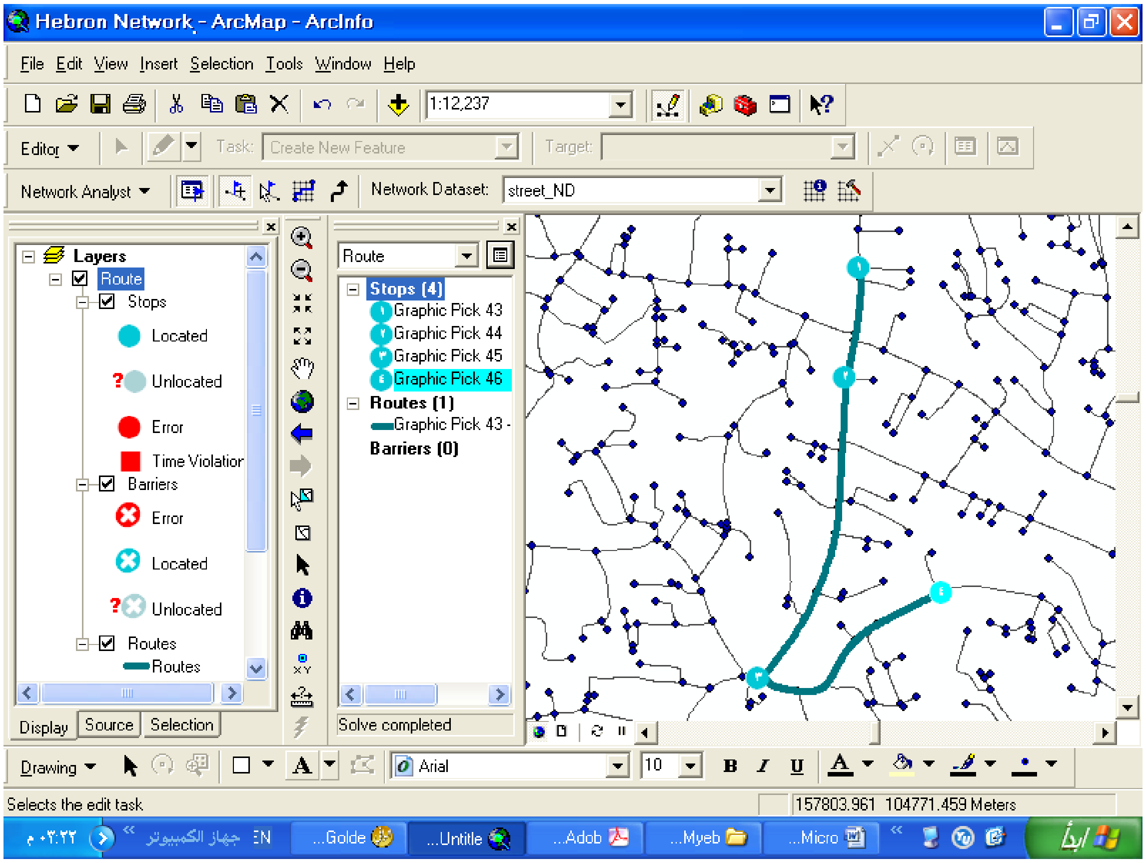


Figure 5.7: Best route solution.

9. Show direction window by clicking on  symbol, figure (5.8).

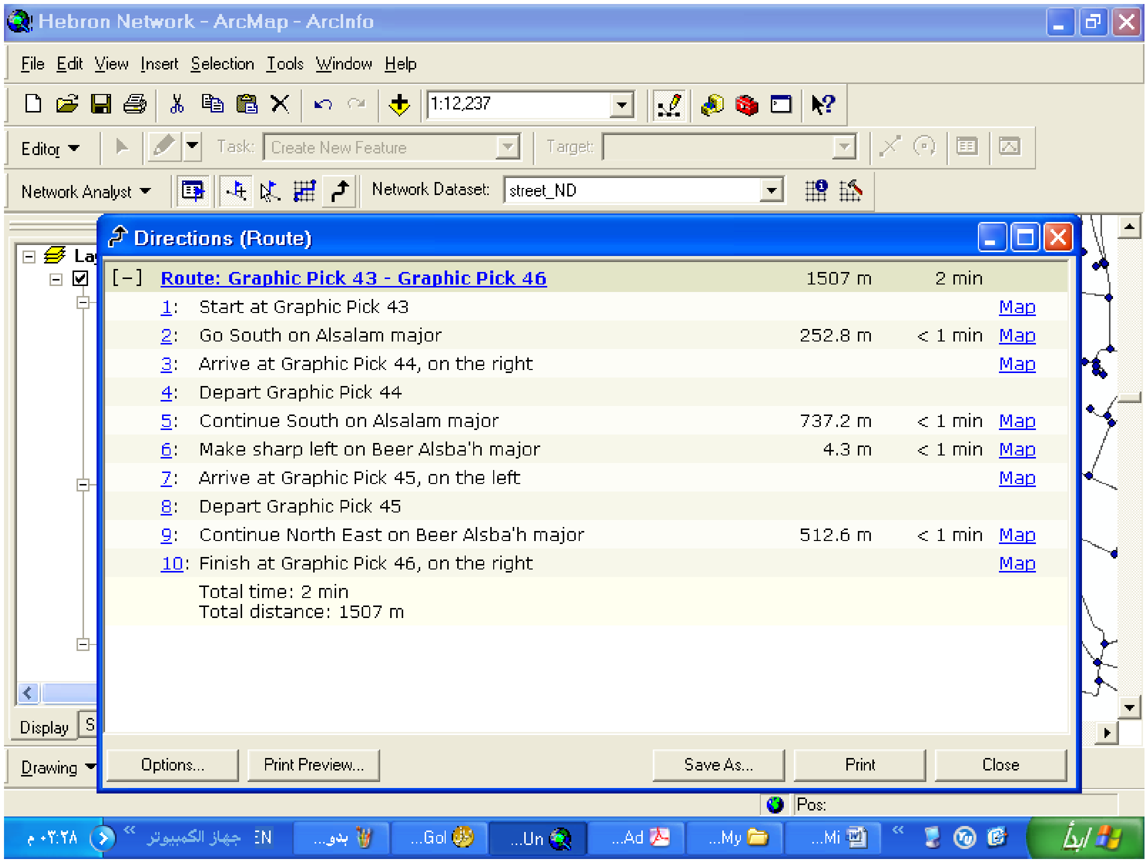


Figure 5.8: Direction window.

10. Add a barrier on the route that represents a road block and find an alternate route to the destination, avoiding the road block, figure (5.9).

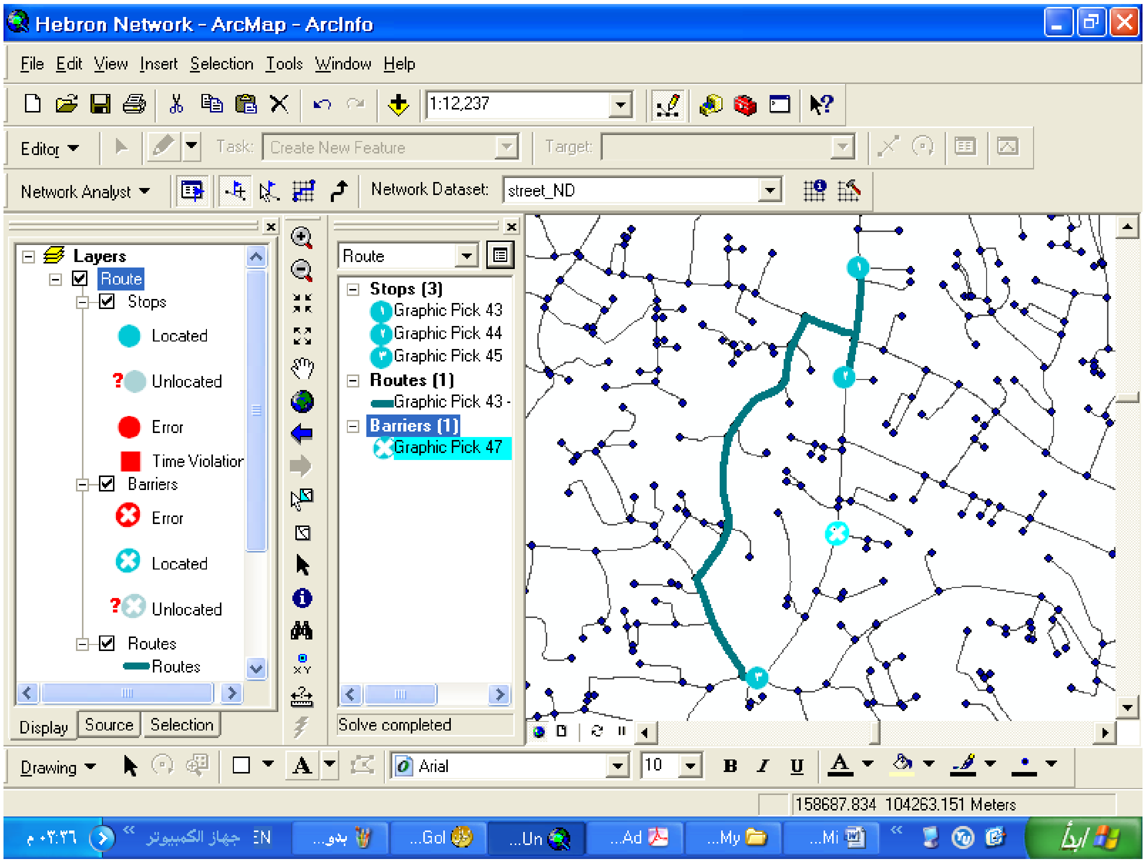


Figure 5.9: Adding barriers.

5.4 Finding the Closest Facility

We will find the closest facility that can respond to an incident at a given address. You will also generate the fastest route from each of these facilities that will be provided to each driver of the incident engine.

1. Creating new shapefile containing Mosques, Hospitals, Clinics, Schools, Police centers, Petrol stations, figure (5.10).

2. If the Network Analyst Extension is not enabled, on the Tools menu, click Extensions and in the Extensions dialog, click Network Analyst.
3. If the Network Analyst toolbar is not already present, on the Main menu, click View, point to Toolbars, and click Network Analyst, figure (5.10).
4. If the Network Analyst Window is not already open, click the Network Analyst Window button on the Network Analyst toolbar, figure (5.10).
5. On the Network Analyst toolbar, click the Network Analyst dropdown menu and click New closest facility, figure (5.10).
6. Add facilities from a point file for which a layer file has been created.
7. Add an incident for Closest Facility Analysis using create network location tool .

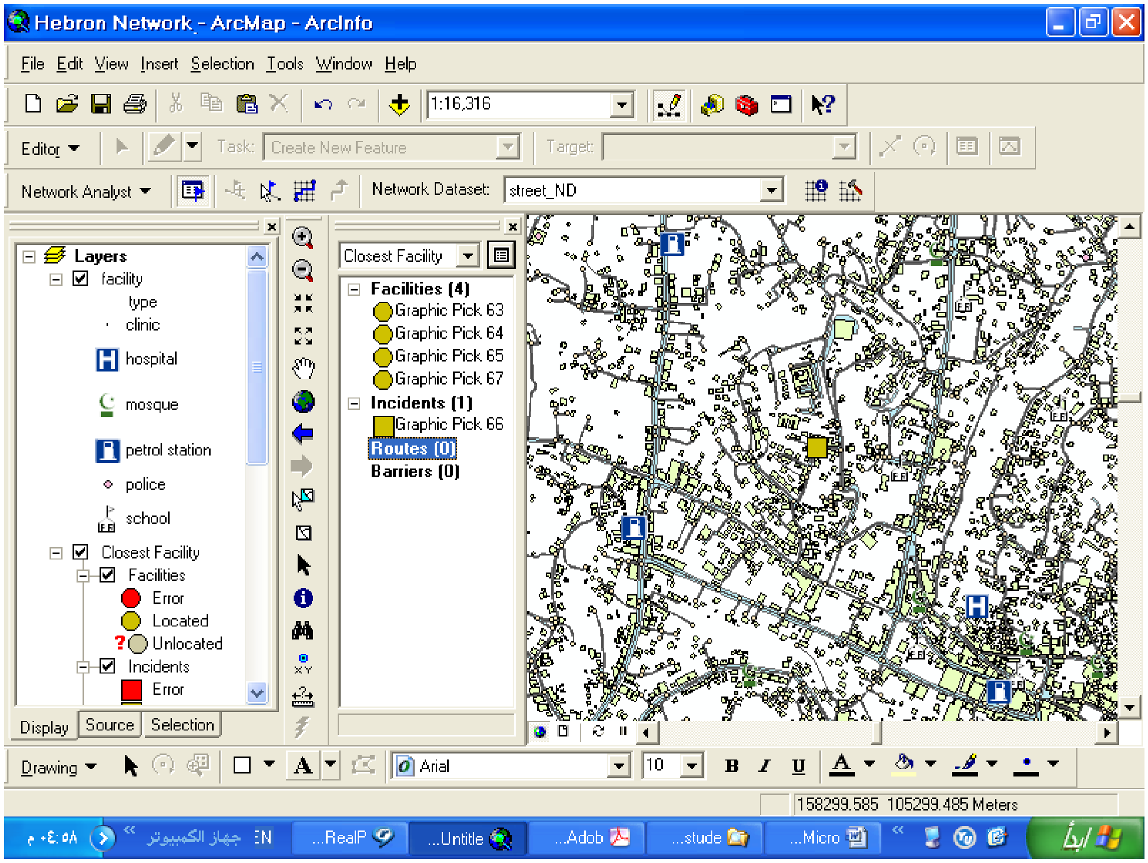
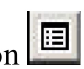


Figure 5.10: Adding Facilities and Incident.

8. In the Network Analyst Window, click the Analysis Layer Properties Button  to bring up the Layer Properties dialog box.
9. Specify the parameters for the analysis from analysis setting tab, figure (5.11)
   - From impedance we can choose the closest facility with respect to time or length.
   - Set the distance unit (meter).
   - Specify the number of facility to find.
   - Determine the travel path either from facility to incident or from incident to facility.

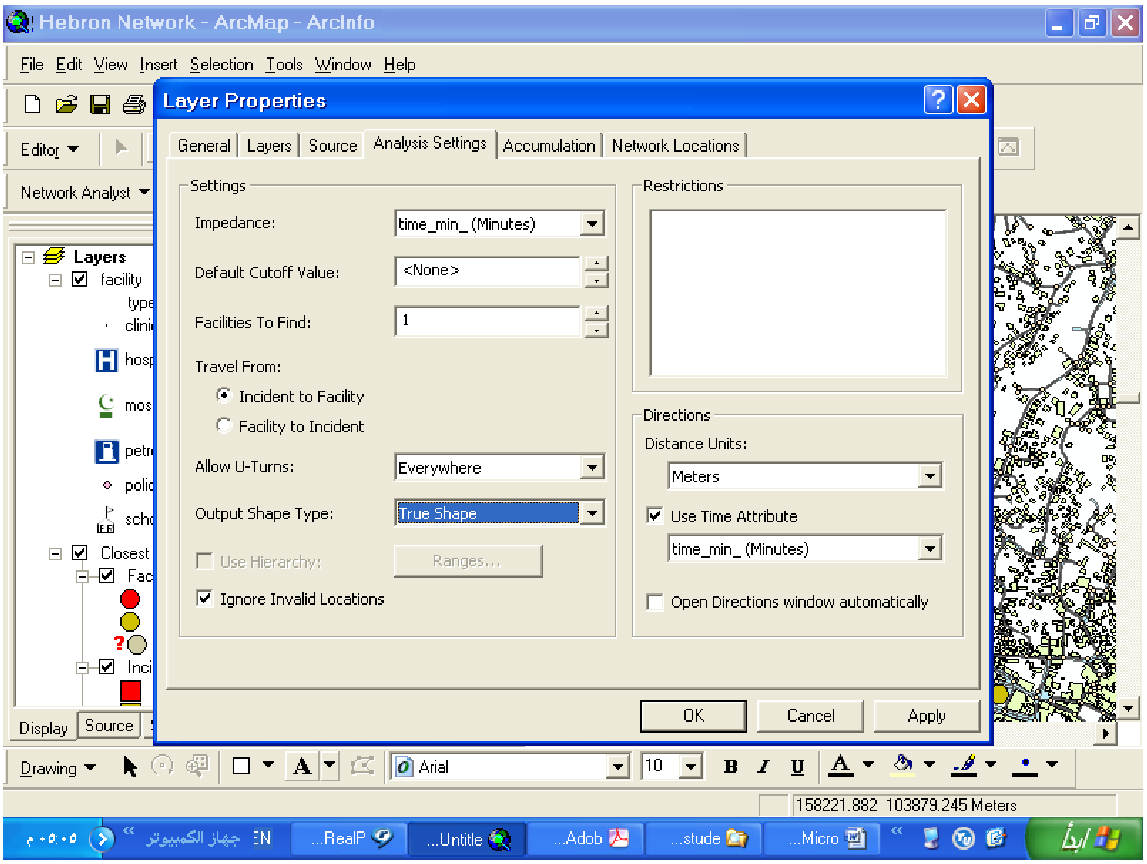
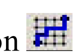


Figure 5.11: Layer properties window.

10. Run the process to identify the closest facility from Solve button  on the Network Analyst toolbar, figure (5.12).

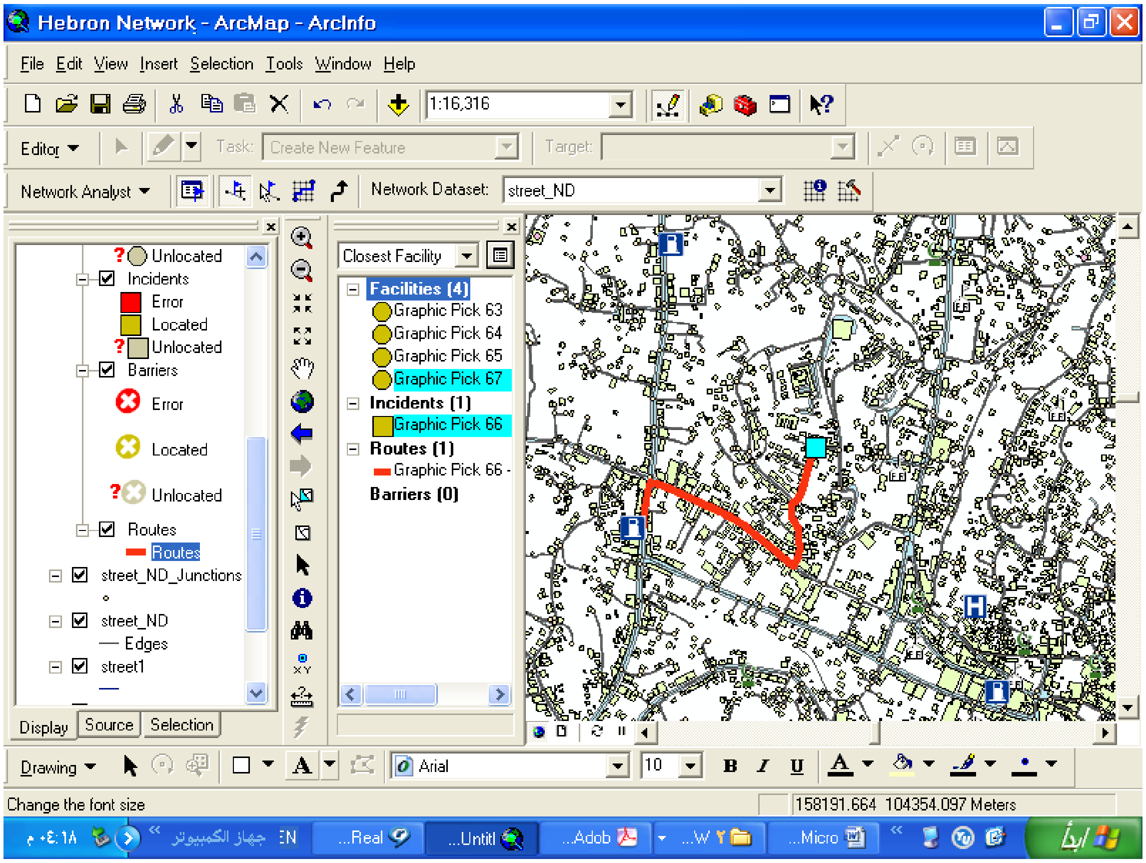
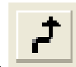


Figure 5.12: Closest facility determination.

11. Show direction window by clicking on  symbol, figure (5.13).

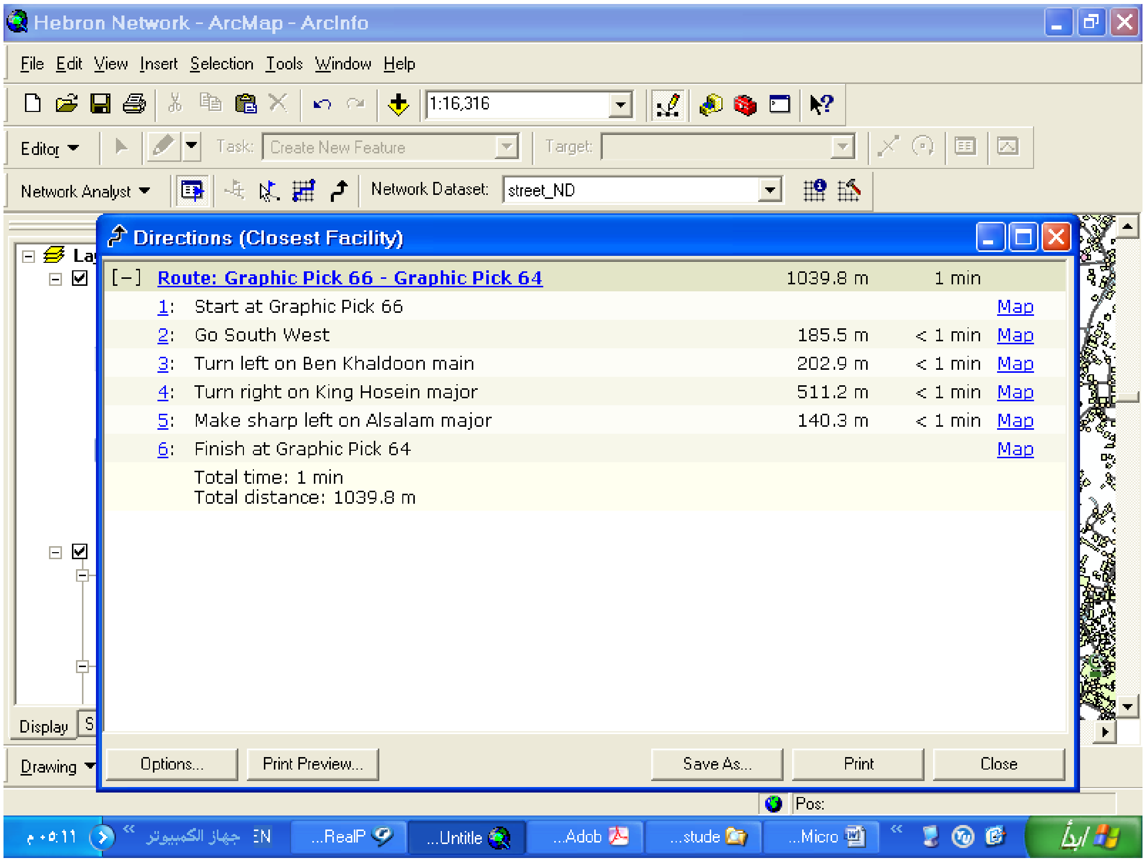


Figure 5.13: Direction window.

5.5 Calculating Service Area

We will create a series of polygons representing the distance that can be reached from a facility within a specified amount of time. These polygons are known as service area polygons. You will calculate 3, 5, and 10-minute service area polygons for facilities in Hebron.

1. If the Network Analyst Extension is not enabled, on the Tools menu, click Extensions and in the Extensions dialog, click Network Analyst.
2. If the Network Analyst toolbar is not already present, on the Main menu, click View, point to Toolbars, and click Network Analyst, figure (5.14).
3. If the Network Analyst Window is not already open, click the Network Analyst Window button on the Network Analyst toolbar, figure (5.14).
4. On the Network Analyst toolbar, click the Network Analyst dropdown menu and click New service area, The Network Analyst Window now contains an empty list of Facilities, Barriers, Lines, and Polygons categories. Additionally, the table of contents contains a new Service Area analysis layer, figure (5.14).
5. Add facilities for which the service area polygons will be generated using create network location tool ., Or right-click facilities (0) on the Network Analyst Window click Load Locations. Select Facilities in the Load From dropdown list. figure (5.14).

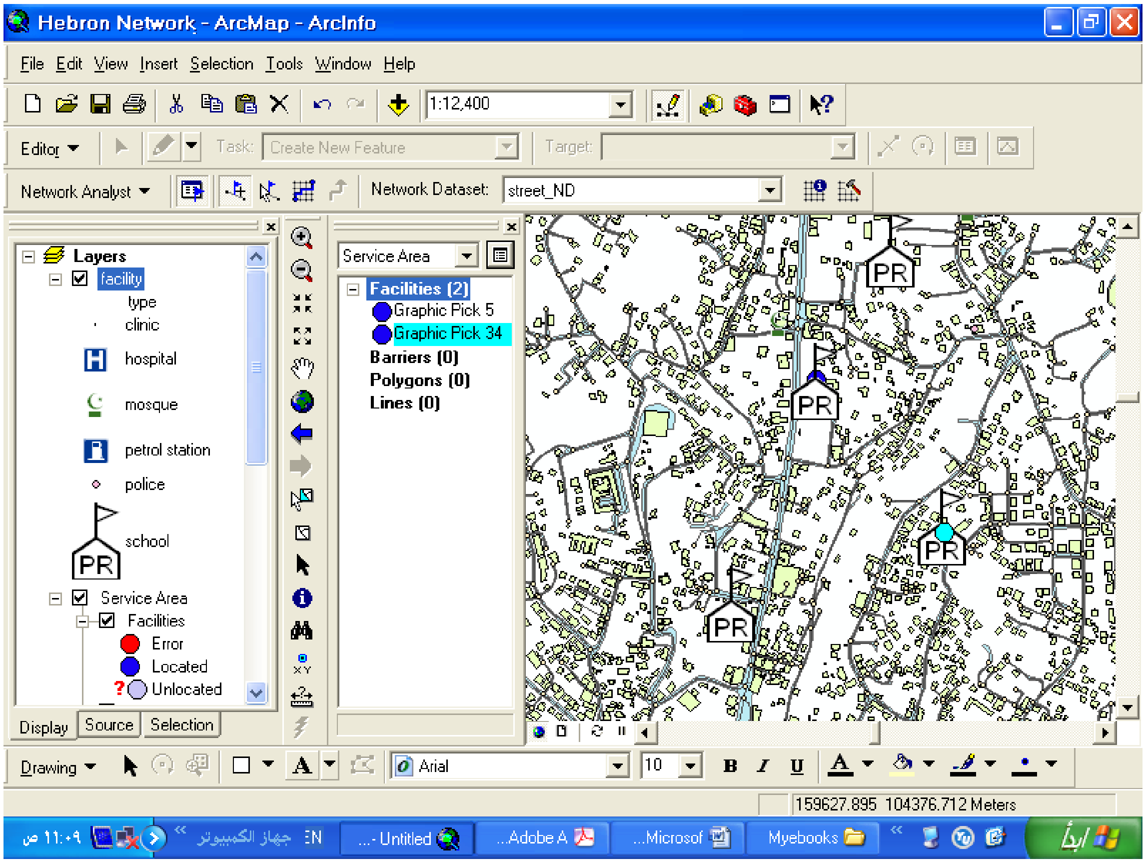
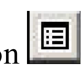


Figure 5.14: Adding facilities.

6. In the Network Analyst Window, click the Analysis Layer Properties Button  to bring up the Layer Properties dialog box.
7. Specify the parameters for the analysis from analysis setting tab, figure (5.15)
    - From impedance we can choose the service area with respect to time or length and then using default breaks you can determine the time (minutes) or distance (meter).
    - Set the distance unit (meter).

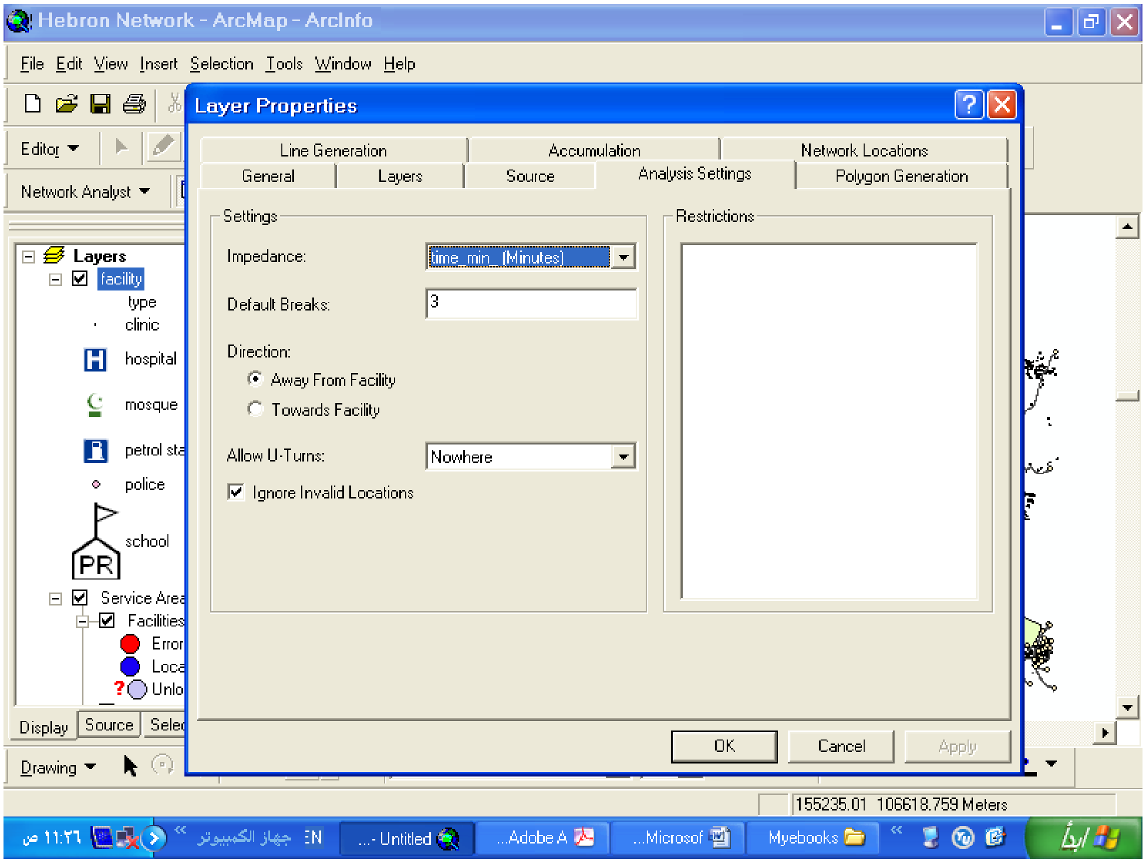
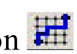


Figure 5.15: Layer properties window.

8. Run the process to identify the service area from Solve button  on the Network Analyst toolbar, figure (5.16).

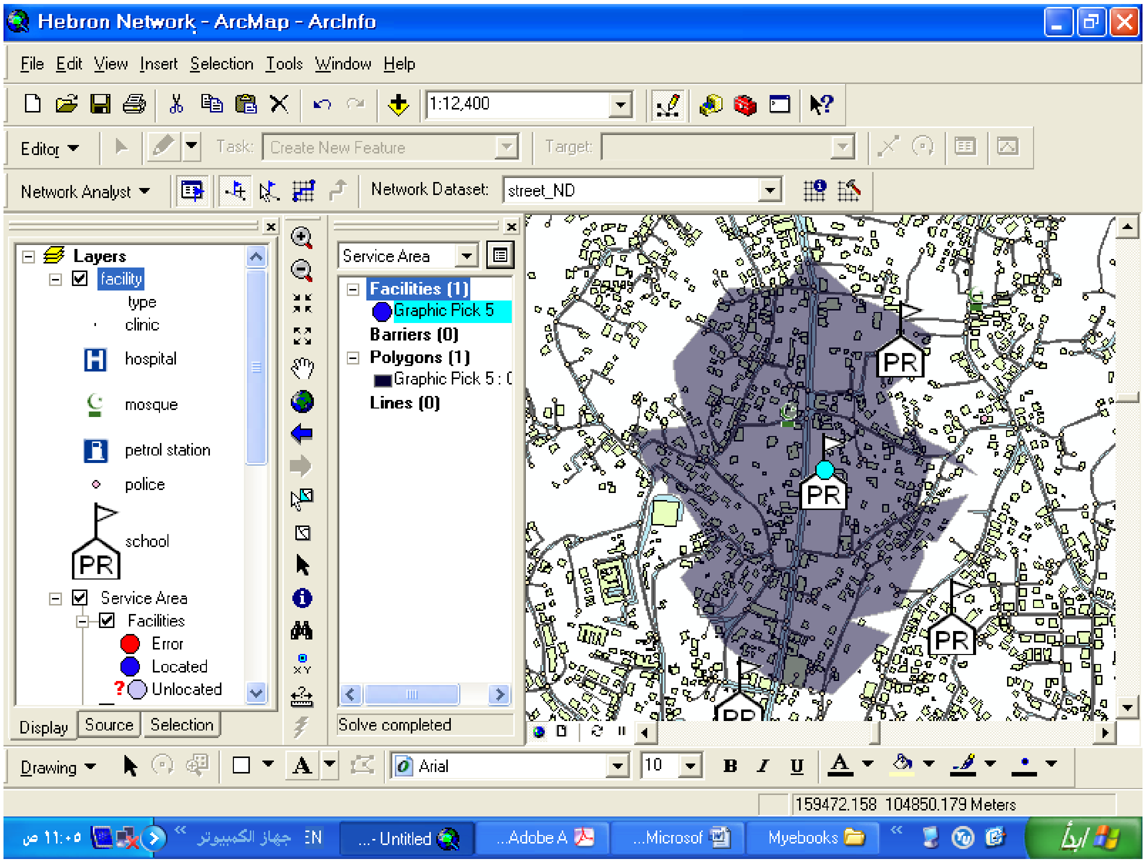


Figure 5.16: Service area solution.

5.5.1 Service Area example

In the study area -Hebron city- we applied an example for the surface area. In this example we choosed basic boys' school, basic girls' school and mosques to know how much the excess and lackness in them.

5.5.1.1 Basic boys' school

We applied a 500 meter service area on basic boys schools. It can be noticed that there is a lackness in the schools with respect to the maximum distance the student walk regardless of population, figure (5.17) and figure(5.18).

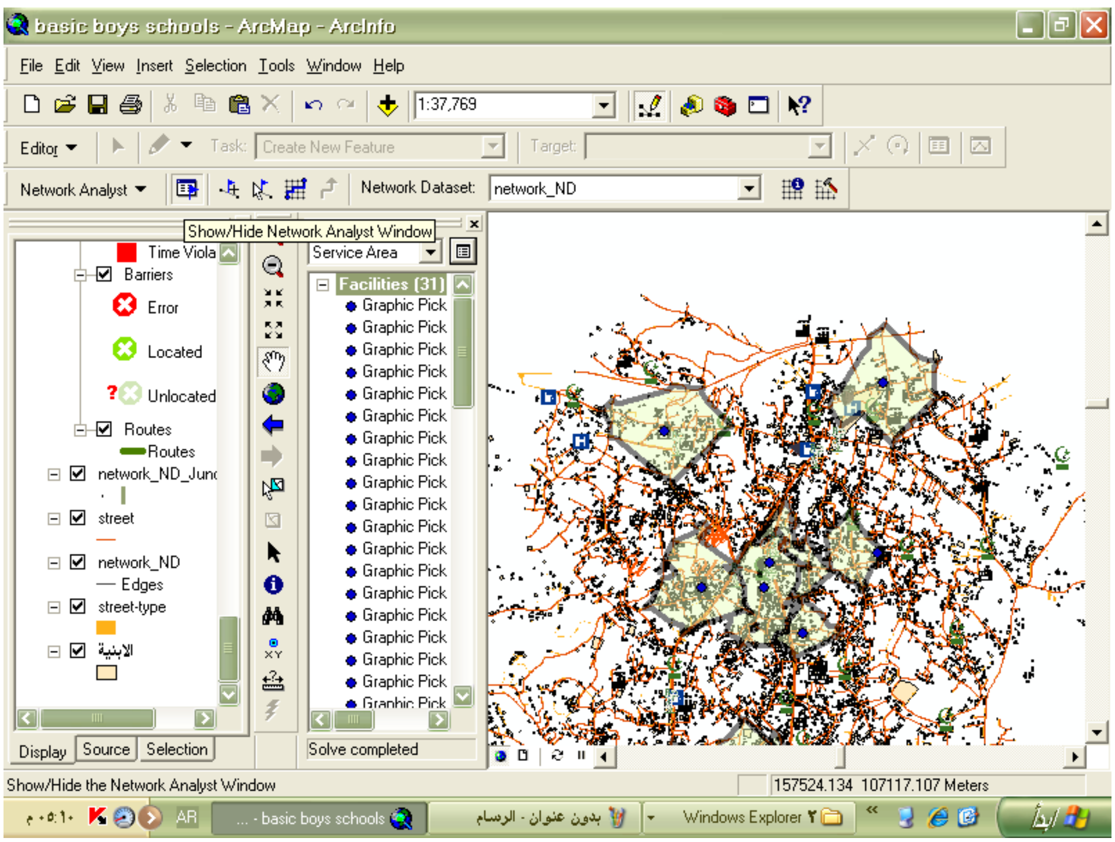


Figure 5.17: Lackness in northern area.

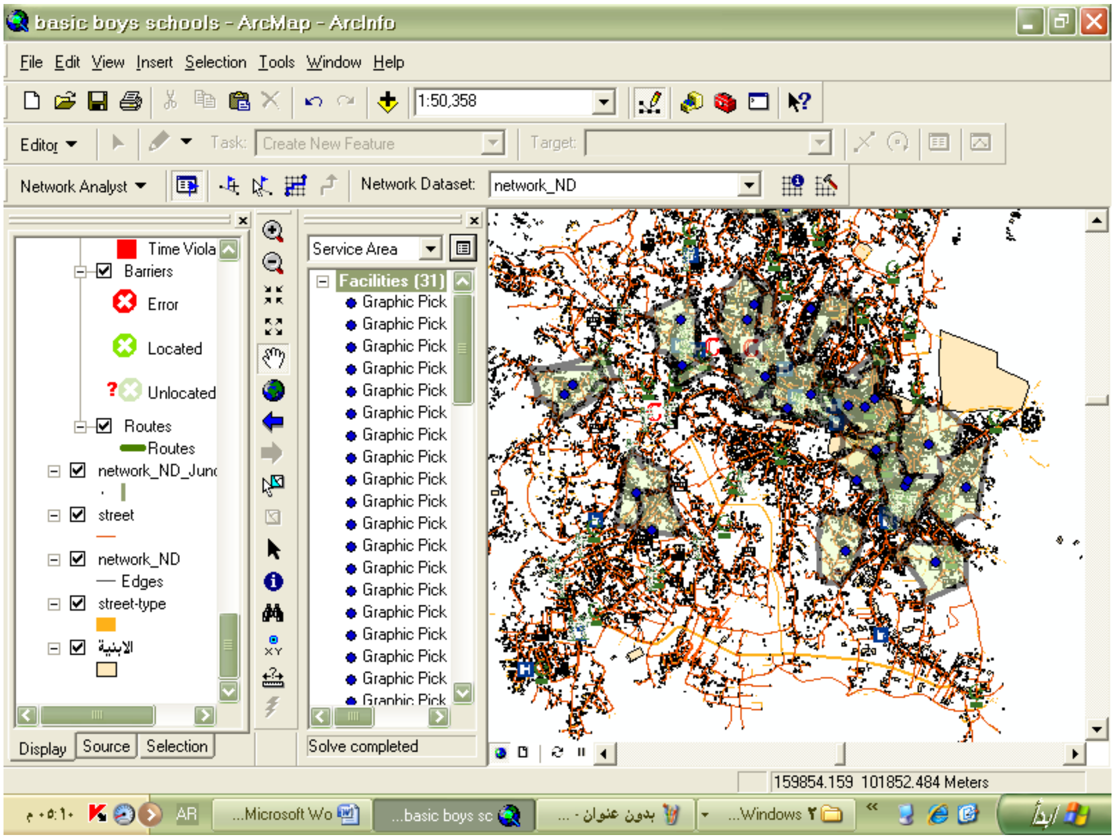


Figure 5.18: Lackness in southern area.

5.5.1.2 Basic girls' school

We applied a 500 meter service area on basic girls' schools. It can be noticed that there is a lackness in the schools with respect to the maximum distance the student walk regardless of population, figure (5.19) and figure(5.20).

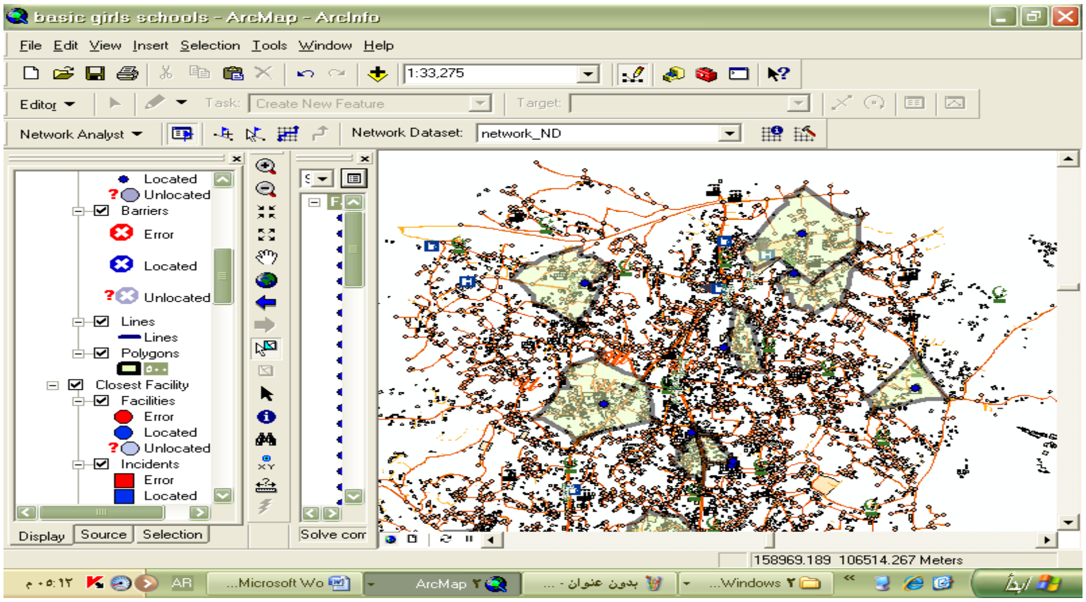


Figure 5.19: Lackness in northern area.

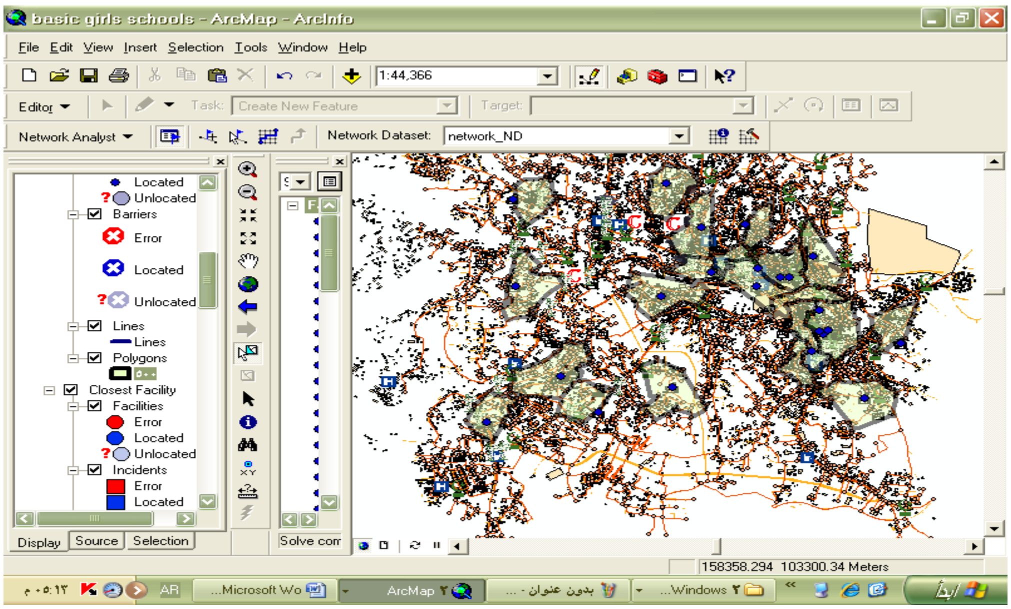


Figure 5.20: Lackness in southern area.

5.5.1.2 Mosques

We applied A 10 minutes service area on mosques. It can be noticed that the number of mosques is suitable with respect to the maximum time the prayer walk regardless of population, figure (5.21) and figure(5.22).

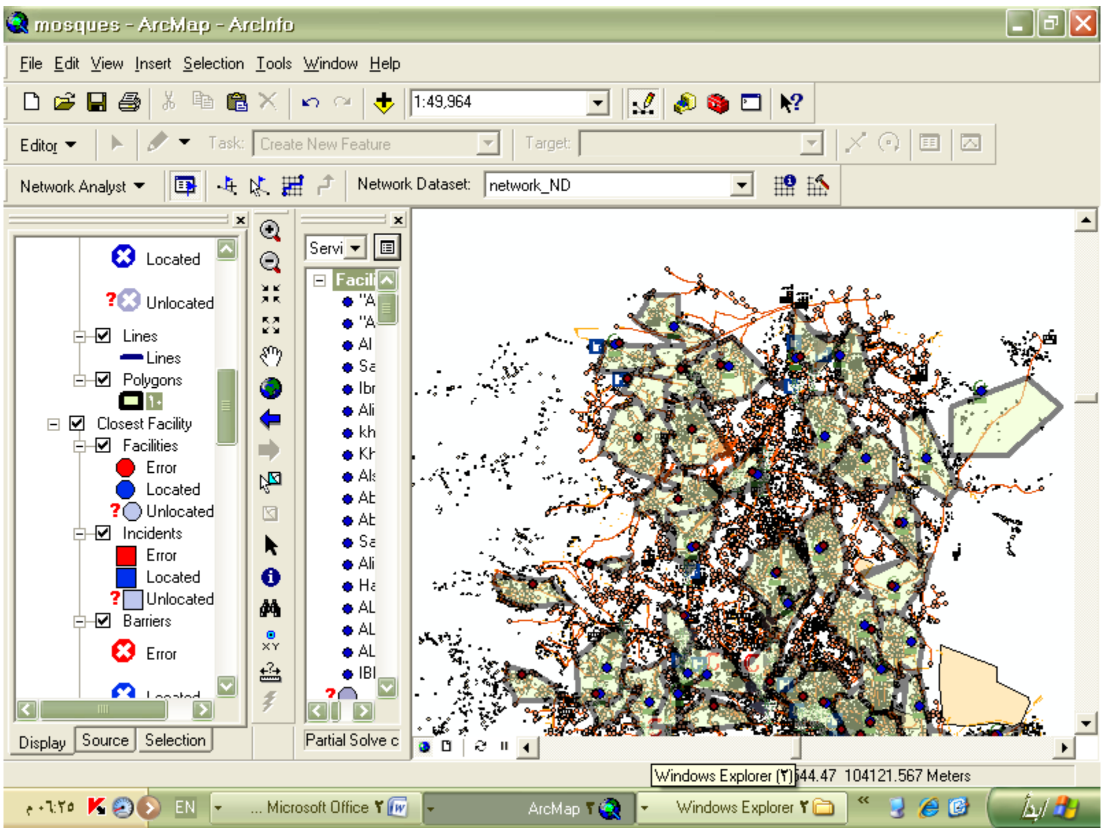


Figure 5.21: Mosques coverage in northern area.

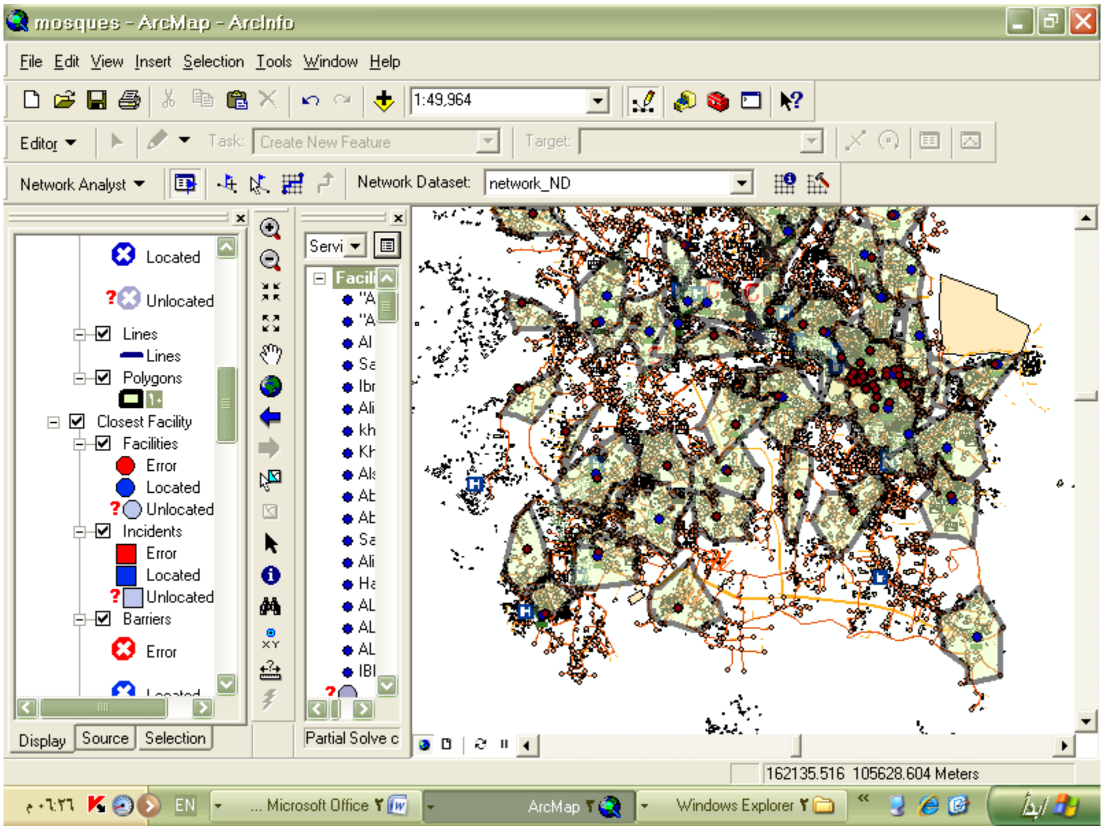
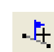


Figure 5.22: Mosques coverage in southern area.

5.6 OD Cost Matrix analysis layer

Creating an Origin-Destination cost matrix for deliveries from the new warehouses to each store can be done by OD cost matrix. The results of this matrix can be used to identify the stores that will be serviced by each warehouse within a 10-minute drive time. Also, you would like to find the total drive time from each warehouse to its stores.

1. If the Network Analyst Extension is not enabled, on the Tools menu, click Extensions and in the Extensions dialog, click Network Analyst.
2. If the Network Analyst toolbar is not already present, on the Main menu, click View, point to Toolbars, and click Network Analyst, figure (5.23).
3. If the Network Analyst Window is not already open, click the Network Analyst Window button on the Network Analyst toolbar, figure (5.23).
4. On the Network Analyst toolbar, click the Network Analyst dropdown menu and click New OD cost matrix, The Network Analyst Window now contains an empty list of Origins, Destinations, Lines, and Barriers categories. Additionally, the table of contents contains a new OD cost matrix analysis layer, figure (5.23).
5. Adding origins one by one using create network location tool . Or right-click Origins (0) on the Network Analyst Window click Load Locations. Select Facilities in the Load From dropdown list.
6. Adding destinations one by one using create network location tool . Or right-click Destinations (0) on the Network Analyst Window click Load Locations. Select Facilities in the Load From dropdown list.

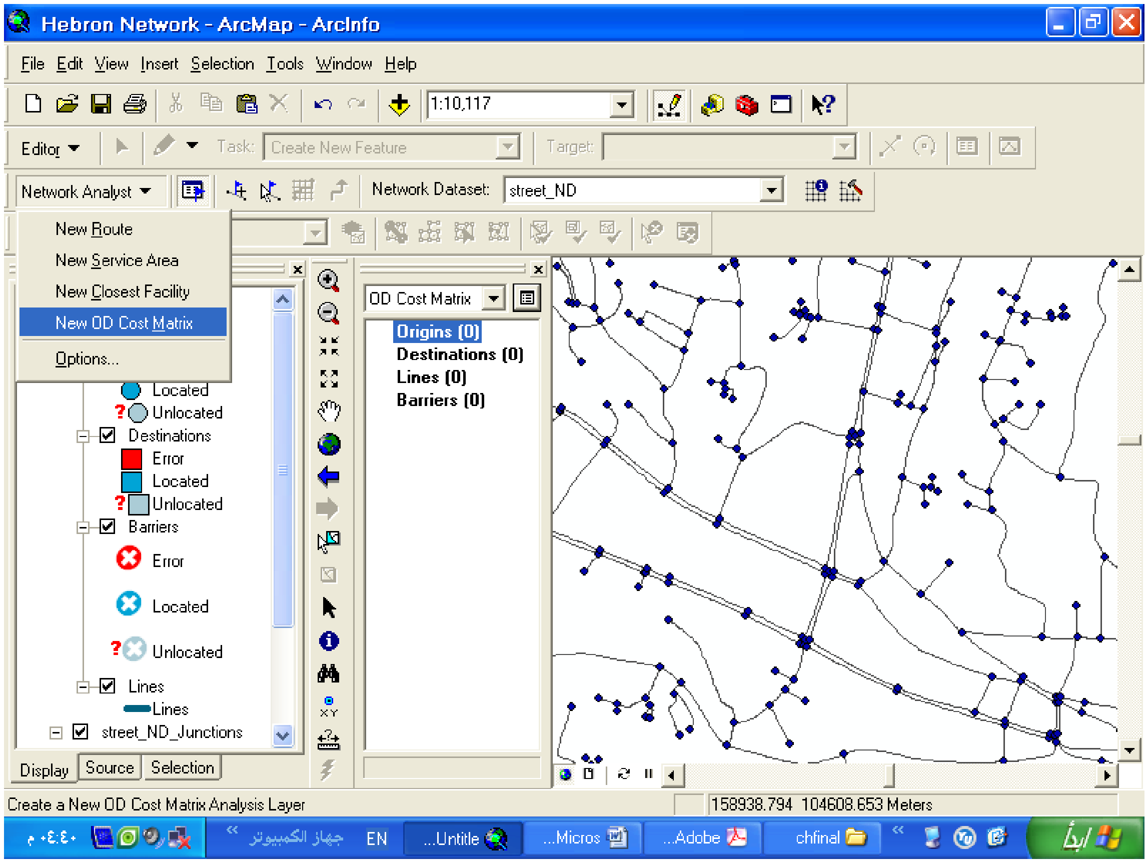


Figure 5.23: Adding Origins and Destinations.

7. In the Network Analyst Window, click the Analysis Layer Properties Button  to bring up the Layer Properties dialog box.
8. Specify the parameters for the analysis from analysis setting tab, figure (5.24).
   - From impedance we can choose the OD cost matrix with respect to time (minute) or length (meter).

- Input any time or any length in the Default Cutoff Value dropdown list. This will create origin destination paths from each origin to all destinations that can be reached within the selected time or length.
- Specify the number of destinations to Find.
- Select Straight Line from the Output Shape Type.
- Set the distance unit (meter).

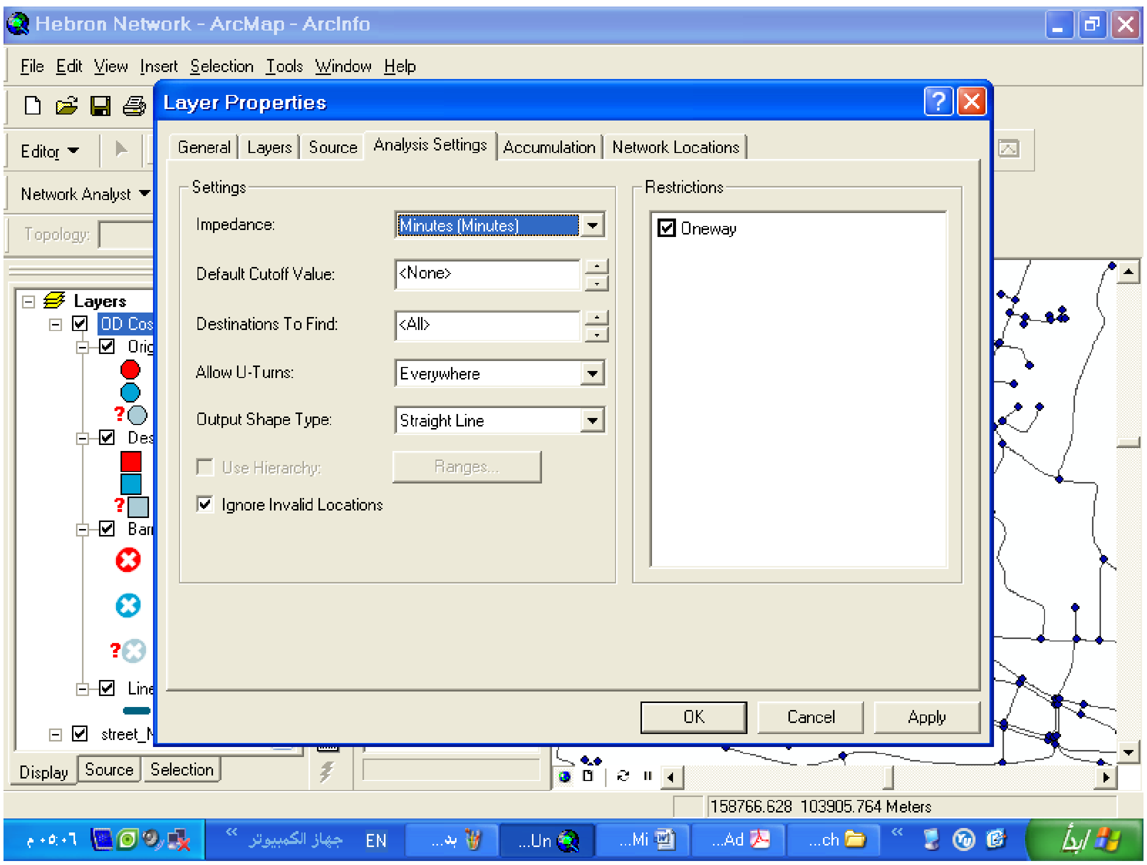
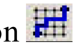


Figure 5.24: Layer properties window.

9. Run the process to identify the OD cost matrix from Solve button  on the Network Analyst toolbar, figure (5.25).

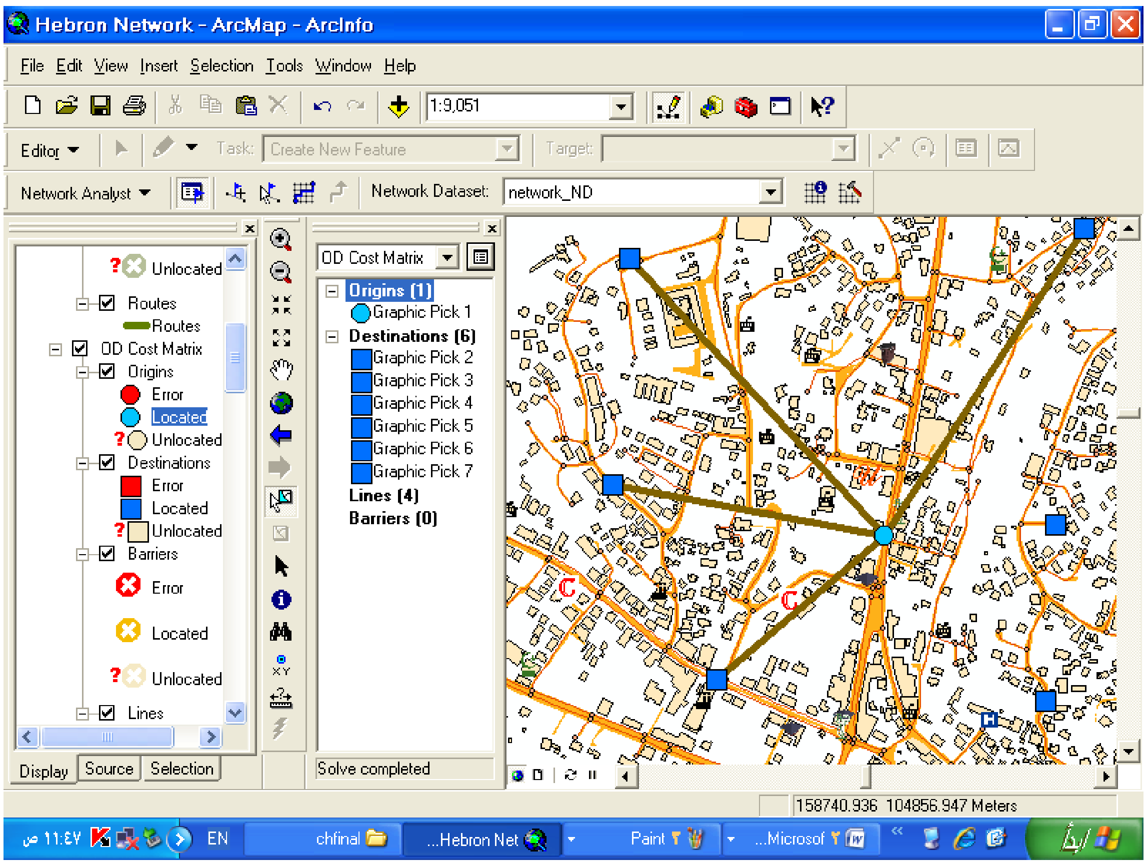


Figure 5.25: OD cost matrix solution.

10. Allocating destination to origins, based on the OD Cost Matrix, you can now identify the destination that would be served by each origins. Right-click on Lines (24) on the Network Analyst Window and click on Open Attribute Table to open the OD cost matrix, figure (5.26).

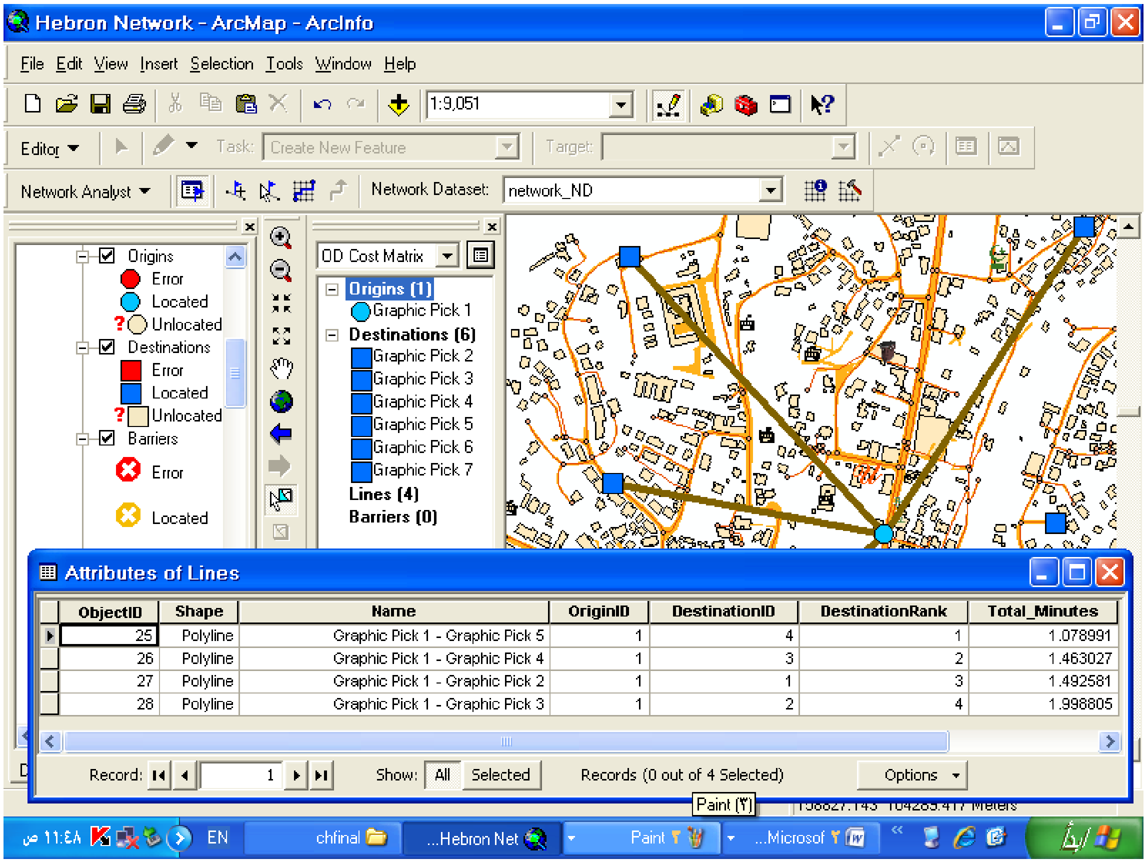


Figure 5.26: Attribute of lines.

Chapter Six

Conclusion and Recommendations

This chapter covers the following items:

6.1 Conclusions

6.2 Recommendations

6.1 Conclusions

1. The prepared network will help the vehicle drivers, ambulance vehicle, police, planners, and ministry of education and many others.
2. Topology shows a great efficiency as a network editing tool.
3. Best route is determined inside the program using internal operations called travel time matrix.
4. Analysis of the distribution of schools and mosques in Hebron city using our application shows a lack of schools in Hebron city while there are enough mosques.
5. Real time is calculated using slope distance which in turn is determined using 3D shapefile.
6. This project could be used in tracking analyst system.

6.2 Recommendations

1. This project was applied on Hebron city and we wish to be applied on West Bank.
2. We advise the Police, Fire stations, and Ambulances to apply this project.
3. We hope that the Municipality of Hebron to update the streets networks periodic.
4. We hope that the Ministry of Education covers the shortage in basic schools for boys and girls.

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APPENDIX

APPENDIX-A
COMPUTER PROGRAMS USED IN THE PROJECT

A-1 ArcView 3.2a

It is a Geographic Information System "GIS" computer package that produced by the Environmental System Research "ESRI" a leading company in GIS Industry. It is one version of many series versions of GIS packages by ESRI.

A-2 Arc GIS desktop- Arc View

Is full-featured GIS software for visualizing, analyzing, creating, and managing data with a geographic component; most data has a component that can be tied to a place: an address, postal code, global positioning system location, census block, city, region, country, or other location. ArcView allows you to visualize, explore, and analyze this data, revealing patterns, relationships, and trends that are not readily apparent in databases, spreadsheets, or statistical packages.

A-3 ArcMap

ArcMap is a comprehensive map-authoring application for ArcGIS Desktop (ArcInfo, ArcEditor, and ArcView). It is the central application for all map-based tasks including cartography, map analysis, and editing.

ArcMap offers two types of map views:

Geographic data view—an environment where geographic layers are symbolized, analyzed, and compiled into GIS datasets. A table of contents interface organizes and controls the drawing properties of the GIS data layers in the data frame. The data view is a window into any GIS dataset for a given area.

Page layout view—an environment where map pages contain geographic data views as well as other map elements such as scale bars, legends, north arrows, and reference maps. The page layout view is used to compose maps on pages for printing and publishing.

A-4 ArcGIS

Is an integrated collection of GIS software products for building a complete GIS. ArcGIS enables users to deploy GIS functionality wherever it is needed—in desktops, servers, or custom applications; over the Web; or in the field.

A-5 ArcInfo

Is the most complete GIS available. It includes all the functionality of ArcView and ArcEditor and adds advanced spatial analysis, data manipulation, and high-end cartography tools. Professional GIS users use ArcInfo for all aspects of data building, modeling, analysis, and map display.

A-6 ArcEditor

Is a powerful GIS desktop system for editing and managing geographic data. ArcEditor is a member of the ArcGIS family of GIS products and includes all the functionality of ArcView and adds a comprehensive set of tools to create, edit, and ensure the quality of your data.

ArcEditor supports single-user editing as well as a collaborative process between many editors. An extensive set of tools is included for simple data cleanup and input as well as for sophisticated design and versioning.

A-7 ArcGIS Network Analyst Extension

Is a powerful extension that provides network-based spatial analysis including routing, travel directions, closest facility and service area analysis. ArcGIS Network Analyst enables users to dynamically model realistic network conditions, including turn restrictions, speed limits, height restrictions, and traffic conditions, at different times of the day.

A-8 ArcCatalog

ArcCatalog is a shared ArcGIS application that allows you to organize and access all GIS information such as maps, globes, datasets, models, metadata, and services. It includes tools to:

- Browse and find geographic information.
- Record, view, and manage metadata.
- Define, export, and import geodatabase schemas and designs.
- Search and browse GIS data on local networks and the Web.
- Administer an ArcGIS Server.

Users employ ArcCatalog to organize, find, and use GIS data as well as document data holdings using standards-based metadata. A GIS database administrator uses ArcCatalog to define and build geodatabases. A GIS server administrator uses ArcCatalog to administer the GIS server framework.

APPENDIX-B
SOME OF DEFINITION'S

B-1 Attribute

1. Non spatial information about a geographic feature in a GIS usually stored in a table and linked to the feature by a unique identifier. For example, attributes of a river might include its name, length, and sediment load at a gauging station.
2. In raster datasets, information associated with each unique value of a raster cell.
3. Information that specifies how features are displayed and labeled on a map; for example, the graphic attributes of a river might include line thickness, line length, color, and font for labeling.

B-2 Attribute table

1. A database or tabular file containing information about a set of geographic features, usually arranged so that each row represents a feature and each column represents one feature attribute. In raster datasets, each row of an attribute table corresponds to a certain zone of cells having the same value. In a GIS, attribute tables are often joined or related to spatial data layers, and the attribute values they contain can be used to find, query, and symbolize features or raster cells.

B-3 Azimuthally projection

1. A map projection that transforms points from a spheroid or sphere onto a tangent or secant plane. The azimuthally projection is also known as a planar or zenithal projection.

B-4 Shapefile

1. A vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.

B-5 Simple edge feature

1. In a geodatabase, a line feature that corresponds to a single network element in the logical network.

B-6 Barrier

1. In network analysis, an entity that prevents flow from traversing a network edge or junction.
2. A line feature used to keep certain points from being used in the calculation of new values when a raster is interpolated. The line can represent a cliff, ridge, or some other interruption in the landscape. Only the sample points on the same side of the barrier as the current processing cell will be considered.
3. For geometric networks in ArcMap, a temporary graphic that is placed on the network, past which a trace cannot continue.
4. For geometric network datasets in ArcMap, a network location in a network analysis layer that restricts the traversability of a network element (edge or junction) in the network dataset.

B-7 Theme

1. In ArcView, a set of related geographic features such as streets, parcels, or rivers, along with their attributes. All features in a theme share the same coordinate system, are located within a common geographic extent, and have the same attributes. Themes are similar to layers in ArcGIS 8.x and 9.0.

B-8 Layer

1. The visual representation of a geographic dataset in any digital map environment. Conceptually, a layer is a slice or stratum of the geographic reality in a particular area, and is more or less equivalent to a legend item on a paper map. On a road map, for example, roads, national parks, political boundaries, and rivers might be considered different layers.
2. In ArcGIS, a reference to a data source, such as a shapefile, coverage, geodatabase feature class, or raster, that defines how the data should be symbolized on a map. Layers can also define additional properties, such as which features from the data source are included. Layers can be stored in map documents (.mxd) or saved individually as layer files (.lyr). Layers are conceptually similar to themes in ArcView 3.x.

B-9 Feature layer

1. A layer that references a set of feature data. Feature data represents geographic entities as points, lines, and polygons.

B-10 Centerline

1. A line digitized along the center of a linear geographic feature, such as a street or a river that at a large enough scale would be represented by a polygon.

B-11 Connectivity

1. The way in which features in GIS data are attached to one another functionally or spatially.
2. In a geodatabase, the state of association between edges and junctions in a network system for network data models. Connectivity helps define and control flow, tracing, and path finding in a network.
3. In a coverage, topological identification of connected arcs by recording the from-node and to-node for each arc. Arcs that share a common node are connected.

B-12 Connectivity group

1. In network datasets, a logical grouping of point features, line features, or both, that controls how network elements is connected. Connectivity groups are defined when a network dataset is built. A network dataset may have multiple connectivity groups.

B-13 Geodatabase

1. A collection of geographic datasets for use by ArcGIS. There are various types of geographic datasets, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others.

B-14 Edge

1. A line between two points that forms a boundary. In a geometric shape, an edge forms the boundary between two faces. In an image, edges separate areas of different tones or colors. In topology, an edge defines lines or polygon boundaries.

B-15 Export

1. To move data from one computer system to another, and often, in the process, from one file format to another.

B-16 Extension

1. In ArcGIS, an optional software module that adds specialized tools and functionality to ArcGIS Desktop. ArcGIS Network Analyst, ArcGIS StreetMap, and ArcGIS Business Analyst are examples of ArcGIS extensions.

B-17 Feature

A representation of a real-world object on a map.

B-18 Point feature

1. A map feature that has neither length nor area at a given scale, such as a city on a world map or a building on a city map.
2. In ArcGIS software, a digital map feature that represents a place or thing that has neither length nor area at a given scale.

B-19 Polygon feature

1. A map feature that bounds an area at a given scale, such as a country on a world map or a district on a city map.
2. In ArcGIS software, a digital map feature that represents a place or thing that has area at a given scale. A polygon feature may have one or more parts. For example, a building footprint is typically a polygon feature with one part. If the building has a detached unit, it might be represented as a multipart feature with discontinuous parts. If the detached unit is in an interior courtyard, the building might be represented as a multipart feature

with nested parts. A multipart polygon feature is associated with a single record in an attribute table.

B-20 Polyline feature

1. In ArcGIS software, a digital map feature that represents a place or thing that has length but not area at a given scale. A polyline feature may have one or more parts. For example, a stream is typically a polyline feature with one part. If the stream goes underground and later reemerges, it might be represented as a multipart polyline feature with discontinuous parts. If the stream diverges around an island and then rejoins itself, it might be represented as a multipart polyline feature with branching parts. A multipart polyline feature is associated with a single record in an attribute table.

B-21 Line feature

1. A map feature that has length but not area at a given scale, such as a river on a world map or a street on a city map.

B-22 Geometric network

1. Edge and junction features that represent a linear network, such as a utility or hydrologic system, in which the connectivity of features is based on their geometric coincidence. A geometric network does not contain information about the connectivity of features; this information is stored within a logical network. Geometric networks are typically used to model directed flow systems.

B-23 Geometric element

1. One of the most basic parts or components of a geometric figure: that is, a surface, shape, point, line, angle, or solid.

B-24 junction

1. For network data models in a geodatabase, a point at which two or more edges meet.
2. In a coverage, a node joining two or more arcs.

B-25 Junction connectivity policy

1. In network datasets, a connectivity policy that defines how a junction may connect to an edge. There are two junction connectivity policies: honor and override.

B-26 Layout

1. The arrangement of elements on a map, possibly including a title, legend, north arrow, scale bar, and geographic data.
2. In ArcGIS, a presentation document incorporating maps, charts, tables, text, and images.
3. In ArcView 3.x, one of the five types of documents that can be contained within a project file. A layout is used to prepare hard copy maps. It can be composed of views, tables, charts, imported graphics, and graphic primitives and can also contain cartographic elements such as scale bars and north arrows.

B-27 Network attribute

1. A type of attribute associated with a network element in a network dataset. Network attributes are used to help control flow through a network (similar to a weight in a geometric network). All network elements in a network

dataset have the same set of attributes. There are four types of network attributes: cost, descriptor, hierarchy, and restriction.

B-28 Cost

1. A function of time, distance, or any other factor that incurs difficulty or an outlay of resources.
2. In ArcGIS Network Analyst, an attribute of a network element used to model impedance and demand in network datasets. Cost is an attribute that is accumulated during traversal of a network.

B-29 Hierarchy

1. A type of network attribute for a network element in a network dataset. Hierarchy can be used during network analysis to assign priority to a network element. For example, in a transportation network dataset, a "road class" hierarchy can be assigned to edges to favor major roads instead of local streets.

B-30 Restriction

1. A Boolean network element attribute used for limiting traversal through a network dataset. "One way street," "no trucks allowed," and "buses only" are examples of restrictions

B-31 Descriptor

1. A type of attribute for network elements that cannot be apportioned. The value of a descriptor stays the same through the length of an edge element in a network dataset. Descriptors describe characteristics of the element; for example, the number of lanes for a particular road in a road network.

B-32 Route

1. Any line feature, such as a street, highway, river, or pipe that has a unique identifier.
2. A path through a network.

B-33 Route analysis

1. In ArcGIS Network Analyst, a type of network analysis that determines the best route from one network location to one or more other locations. It can also calculate the quickest or shortest route depending on the impedance chosen. The order of the stops may be determined by the user. For example, if the impedance is time, then the best route is the quickest route.

B-34 Stop

1. In ArcGIS Network Analyst, a network location used to determine a route in route analysis. Users can specify multiple stops, of which two must be used to represent an origin and a destination. Stops in between (known as intermediary stops) are visited en route from the first to the last stop.

B-35 Street network

1. A system of interconnecting lines and points that represent a system of roads for a given area. A street network provides the foundation for network analysis; for example, finding the best route or creating service areas.

B-36 Tool

1. A command that requires interaction with the GUI before an action is performed. For example, a zoom tool requires a user to use the mouse to

click on or draw a box over a digital map before the tool will cause the map to be redrawn at a larger scale.

2. A geoprocessing command in ArcGIS that performs such specific tasks as clip, split, erase, or buffer.

B-37 Toolbar

1. A graphical user interface (GUI) with buttons that allow users to execute software commands

B-38 field

A column in a table that stores the values for a single attribute called a field.

APPENDIX-C
THE REPORT OF QUESTIONNAIRE

بسم الله الرحمن الرحيم
جامعة بوليتكنك فلسطين
Palestine Polytechnic University

استبيان عن تقدير السرعة على الطرق في مدينة الخليل

1. وقت الازدحام المروري (2-11) مساء

السؤال الأول:

معدل سرعة السيارة في الأماكن التي يوجد فيها ازدحام مثل (...................................).

25km/hr	20km /hr
35km/hr	30km/hr
غير ذلك (حدد)	لا أعرف

السؤال الثاني:

معدل سرعة السيارة في الشوارع الرئيسية مثل (..).

45km/hr	40km/hr
55km/hr	50km/hr
غير ذلك (حدد)	لا أعرف .

السؤال الثالث:

معدل سرعة السيارة في الشوارع غير النافذة .

35km/hr	30km/hr
45km/hr	40km/hr
غير ذلك (حدد)	لا أعرف

بسم الله الرحمن الرحيم
جامعة بوليتكنك فلسطين
Palestine Polytechnic University

استبيان عن تقدير السرعة على الطرق في مدينة الخليل

2. وقت الازدحام المروري (9.00-7.30) صباحا

السؤال الأول:

معدل سرعة السيارة في الأماكن التي يوجد فيها ازدحام مثل (....................................).

25km/hr	20km /hr
35km/hr	30km/hr
غير ذلك (حدد)	لا أعرف

السؤال الثاني:

معدل سرعة السيارة في الشوارع الرئيسية مثل (..).

45km/hr	40km/hr
55km/hr	50km/hr
غير ذلك (حدد)	لا أعرف

السؤال الثالث:

معدل سرعة السيارة في الشوارع غير النافذة .

35km/hr	30km/hr
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بسم الله الرحمن الرحيم

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استبيان عن تقدير سرعة سيارة الإسعاف على الطرق في مدينة الخليل

3. عند عدم وجود اختناقات مرورية (حوادث سير)

السؤال الأول:

معدل سرعة السيارة في الأماكن التي يوجد فيها ازدحام مثل (...................................).

25km/hr 20km /hr

35km/hr 30km/hr

غير ذلك (حدد) لا أعرف

السؤال الثاني:

معدل سرعة السيارة في الشوارع الرئيسية مثل (...).

45km/hr 40km/hr

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السؤال الثالث:

معدل سرعة السيارة في الشوارع غير النافذة .

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45km/hr 40km/hr

غير ذلك (حدد) لا أعرف