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Analysis of Network Part-Topology in Autodesk Map 6

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Abstract

This paper is about how to perform network analysis tools on only a correct part of an inhomogeneous network topology in GIS.

The built-in analysing tools in Autodesk Map 6 use always the whole set of objects belonging to the topology which does not meet always the demands of users. So I have worked out and now introduce a new concept of network part-topology which meets the claim of analysing inhomogeneous topologies.

The usage of this new concept is demonstrated perfectly by my Autodesk Map application developed in Visual LISP which is based on a special model of urban public transport.

Key Words and Phrases: network topology, its analysing tools, Autodesk Map Release 6, Visual LISP

1. Introduction

The vector based geographic information systems applying topologic data model are suitable for execution of the most varied data analysis tools. These systems store information about the neighbourhood in an explicit form, which makes them able to define three types of topology. My results concern the analysing tools of network topology.

Network topology defines the interconnection of links and, optionally, nodes at link junctions. Links can be lines, open polylines, or arcs. Networks may contain loops. Network topologies are effective tools for representing graphical information about linear geographic features like rivers, streets, subway lines, power lines and pipe networks.

Autodesk Map is a GIS and mapping software that combines the power and precision of AutoCAD with the specialised tools for creating, maintaining and producing maps and geographic data. It is optimised for precision mapping and

GIS analysis in the AutoCAD environment and used to solve both traditional and unique mapping challenges across many areas and industries.

Once a topology is created, you can use it as a basis for spatial analysis and geographic analysis. In Autodesk Map Release 6 three types of network tracing analysis are available:

- Shortest path
  calculates the shortest path between two points or determine the optimal route based on values of direction and resistance.

- Best Route
  calculates the best route from a starting point, to one or more visit points, and back to the starting point.

- Flood trace
  determines how many links and nodes can be travelled starting from a point specified in advance before the accumulated resistance exceeds the specified maximum resistance.

These tools perform their process on the whole topology that is to say each component of the topology can take part of the result. Although in case of inhomogeneous network topology you may not satisfied with this property of the analysing tools.

2. Topology contra part-topology

I have worked out and now introduce a new concept of network part-topology which meets the claim of analysing inhomogeneous topologies. An inhomogeneous topology consists of links belonging to different entity types. For example: traces of bus, tram and trolley and streets can define a single network topology. (In Figure 1. solid, dashed and dotted lines represent them respectively.)

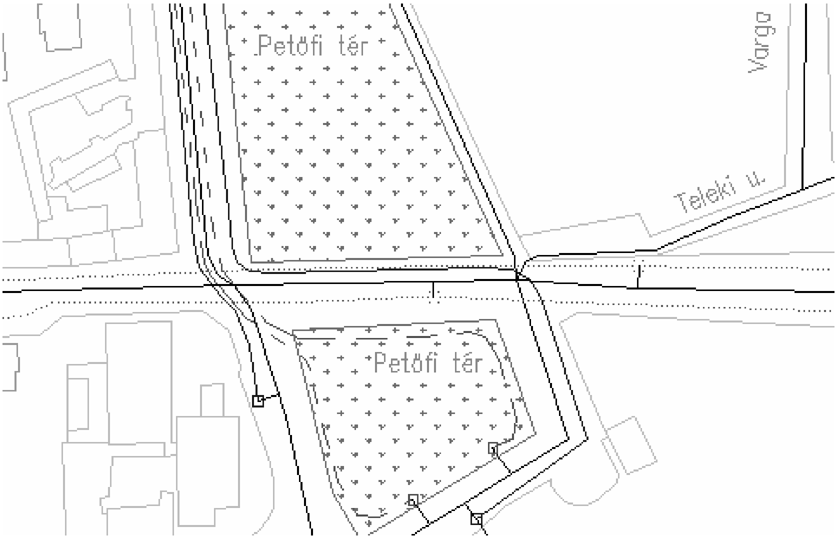

Figure 1. Different entity types form a network topology

2.1. The concept of part-topology

Definition 1. *Let us consider the set of points N and the set of links L, in the following way:*

$$N = \{p_i | i = 1, \ldots, m\} \text{ and } N \neq \emptyset$$

$$L = \{l | l = (p_j, p_k) \text{ where } j, k \leq m\} \text{ and } L \neq \emptyset$$

Let us indicate the set of objects arisen this way with H(N,P) and call it network in what follows.

Definition 2. *Let us consider the networks $H_1(N_1, P_1)$ and $H_2(N_2, P_2)$ satisfying*

$$N_1 = \{p_i | i = 1, \ldots, m_1\} \; N_2 = \{q_i | i = 1, \ldots, m_2, m_1 \geq m_2\} \; N_1 \cap N_2 = \emptyset \; L_1 \cap L_2 = \emptyset$$

The network $H(N, L)$ is called the enlargement of H_1 with H_2, and is indicated with $H = H_1 + H_2$ if it satisfies the following relations

$$N = N_1 \cup N_2$$

$$L = L_1 \cup L_2 \cup L_3, \;\; L_3 \neq \emptyset$$

$$L_3 = \{l | l = (p_j, q_k) \text{ where } p_j \in H_1, \; q_k \in H_2, \; j = 1, \ldots, m, \; m \leq m_2\}.$$

Notation. Let us indicate the topology defined by the network $H(N, P)$ with $T(H)$ in what follows.

Definition 3. *We say that the topology $T(H)$ is correct, if the data of topology is consistent that is to say does not contain any invalid reference.*

The consistence of data can be aborted by deleting a node, which is still determining a link. In this case the consistence can be restored by either deleting the link with one node, or replacing the missing node.

Definition 4. *The part-topology denoted by* $T(H) - H_2$ *of topology* $T(H)$*,* $H = H_1 + H_2$ *is the topology that is created by removing the links of* $T(H)$ *belonging to* H_2*, and the appearing pseudo nodes.*

Theorem 1. *The part-topology* $T(H) - H_2$ *of* $T(H)$*,* $H = H_1 + H_2$ *is correct.*

Proof. Deleting of nodes does not influence the correction of topology, because the information about neighbourhood is recorded by the identification numbers of starting and ending nodes.

Only nodes without connecting links are removed following the definition. This ensures us that no node exists in database, which would reference to the deleted node.

Conclusion. *The part-topology* $T(H) - H_2$ *is suitable for execution of analysing tools.*

Generalising the Definition 2. the multiplied enlargement of network can be determined. Several part-topologies can be created from the topology defined by a multiplied enlarged network applying the Definition 4. These part-topologies satisfy the following form of generalised Theorem 1.

Theorem 2. *Let us consider the topology* $T(H)$*, where* $H = H_1 + H_2 + \ldots + H_n$*. All of its part-topology* $T(H) - H_i$ *is correct for any values of* $i = 1, \ldots, n$*.*

Proof. The order of proofs is not influenced by the fact, that the network is created by multiplied enlargement. The proof of the two theorems is identical.

2.2. Its realising in Autodesk Map using Visual LISP

The basic idea for realising the part-topology in practice was provided by the following observation. If objects of the same topology are available both in the project and the source drawings then it can be selected where to load the topology information to the memory from. The parameters of the VLISP function used to load a topology from an application are able to determine the origin of the data also.

In case of loading the topology from the source drawing the set of object cannot be controlled. But, if we can achieve that only a subset of the objects defining the topology would be copied to the project, which topology information is correct and complete when auditing, then there is no more difficulty to overcome.

The following facts and properties were needed in order to realise a part-topology in a project file:

- Objects can be grouped by layers.
- Objects can be copied from source drawings to the project by querying.

- Topology information can be loaded from the project drawing also.
- The status of topology can be determined by auditing.
- Object data tables are removable.
- The process of trace analysis can be controlled by a profile file.
- The development of the Visual LISP function removing all objects of the selected layers.

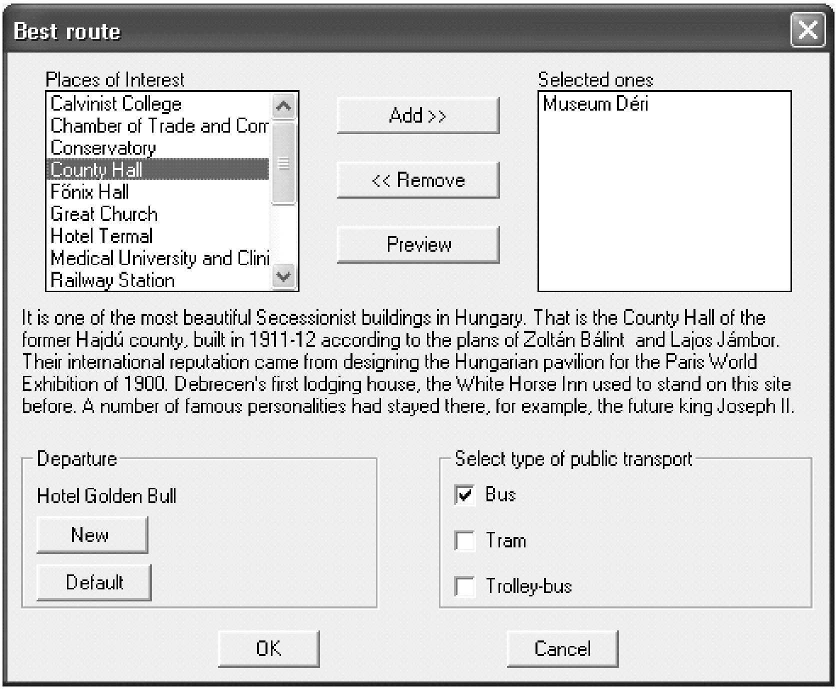

Figure 2. The main dialogue box of the application

2.3. The application demonstrating the new concept in practice

The new concept can be demonstrated perfectly by my Visual LISP application, which is based on a specific model of urban public transport. In the model a single network topology is defined from all the objects of polyline situated on the layers related to transport. The network of this topology can be considered as the enlargement of streets with traces of different types of public transport.

There are three checkboxes controlling the available types of public transport in the main dialogue box of the application (Figure 2). Their fillings control the set of links, which can be used to determine the best route that is to say the part-topology used for tracing analysis depends on the user's input. So, questions of following types can be answered easily.

- Which is the fastest route which starts from a given point, passes one or more visit points determined in advance, and finally turns back to the starting point if, for example, the use of buses is allowed?
- Does this route change, and how if the use of tram is permitted also?
- What about if we cannot use public transport?

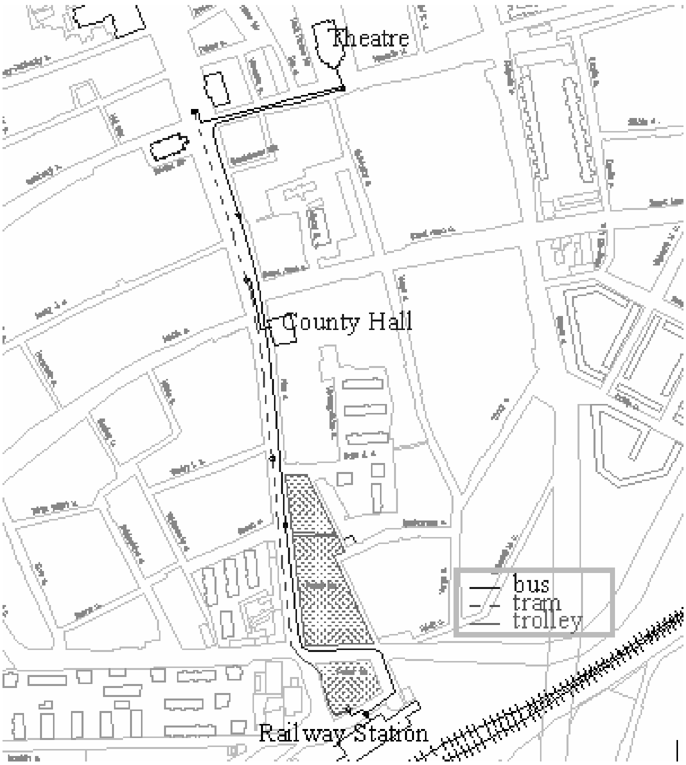

Figure 3. A suggested best route

After performing the appropriate analysis the answers appears on the screen (Fig. 3).

2.4. Additional features

The application can communicate with the users in two languages (Hungarian and English) at the moment. To change the language I defined a separate toolbar, which helps to modify the current language by clicking on the appropriate icon representing national flags. The scope of the available languages can be widen or restricted arbitrary without any need of change in the source code of the application.

To improve the efficiency of the application I wanted to ensure somehow the portability of the derived information appearing on the screen. So I appended additional two submenus to the menu system of the application, which make possible to print a report or a draft map about the suggested route. The brief report can be appears on the screen also and contains information like streets names, stop names of getting on and getting off, numbers identifying the public transport, etc.

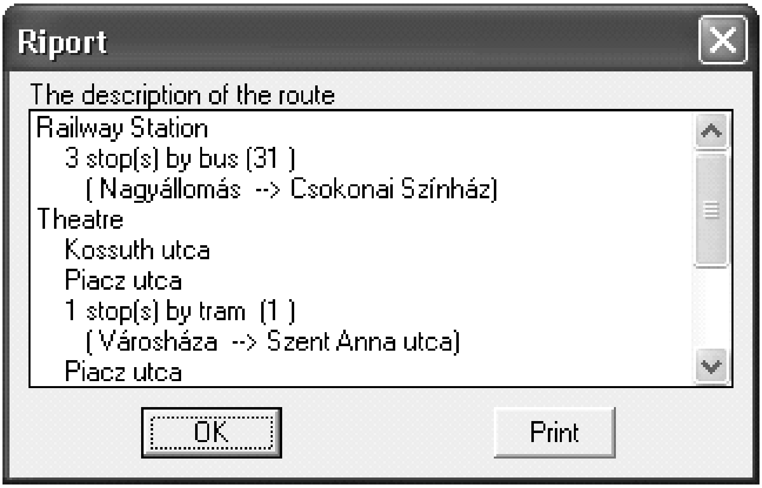

Figure 3. A suggested best route

I completed the application with a user-friendly additional function as well that helps to determine the exact location of a street. After selecting the name of the street from a list, the corresponding objects become highlighted, and the view of the drawing changed depending on the objects' visibility.

During developing the model and the application I made extra efforts that the graphical database could be exchanged at a later date, by not only the developer. As a result of this purpose I gathered sufficient information and instructions to build the physical model again. So any new source drawing about a settlement can be attached to the project, that is to say new maps can be analysed by performing network tracing tools.

3. Conclusion

Finally I stress the importance that the realisation of the analyses the part-topology created from an inhomogeneous network topology increases the power of analysing tools, its application and it makes possible to execute more complicated investigations. This extremely powerful and versatile new concept has proven invaluable for solving such real-world problems. The wide range of usage in every-day life always proves us that it is worth developing these systems.

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