

ON THE VISUALIZATION OF NETWORK DEVELOPMENT INFORMATION

Tamas Katona, Dr. Gabor Nemeth

e-mail: {tkatona, nemeth}@hit.bme.hu

*Budapest University of Technology and Economics, Department of Telecommunications,
H-1117 Budapest, Magyar tudosok korutja 2.*

Keywords: electrical supply network, geographical information system (GIS), intelligent/adaptive visualization

ABSTRACT

As the computer based models are getting more and more important in the electrical network's development plans, the need for intelligent/adaptive visualization increases. After analyzing the current problems, we describe the model of an adaptive user interface. Interesting analytical, mathematical and implementation issues of the new interface are given.

I. INTRODUCTION

As computer based models are playing bigger role in the development of electrical supply networks, the need for an intelligent and easy-to-use software interface is getting more and more crucial. In this paper we consider the computer based network model from the point of view of an electrical engineer; and we analyze the possibilities of a better interface from the point of view of a computer scientist.

The paper's logical structure is the following. We sum up the main properties and the application areas of the current computer based network models. We describe the deficiencies of the current state and define a solution direction. In the main part of the paper we are talking about analytical, mathematical and some implementation aspects of an adaptive interface that solves the problems of currently used GIS software.

II. COMPUTER BASED NETWORK DEVELOPMENT MODELS

Geographical information systems (GIS) are widely used in the development of many kinds of supply networks. GIS systems are used in the electricity supply industry, too [1]. At an increasing number of providers, the paper-based network documentation is substituted with a computer-based one.

Middle and long term network development plans are usually based on the middle and long-term prognosis of the network [2]. Besides the model of the physical network itself, the prognosis considers several additional parameters such as load and consumer load, statistical information about the economical developments in the area, and simulation results. Typically, these data are stored at separate locations and in different storage

structures. This dispersion of the data slows down the whole process; so, clearly, the integration of the databases is required. This means that the user of the computer model shall be able to access all these data on the same interface.

DATA SOURCES

As mentioned above, the basis of the development plan and prognosis is the network documentation. We mean by network the lines, transformers, switches etc, i.e. all the constituting objects of the electrical supply system. The network database contains the descriptors of these objects, i.e. the important electrical properties, name, other properties (e.g. physical condition, age etc.), and the geographical coordinates describing their location. Besides the pure coordinates, it is common to include public premises data for easier location of the specific network part [3].

The load and consumer load values describe the utilization rate of the network. Simulation results (e.g. short circuit analysis) are very important for the operation safety. Pre-announced loads of future (big) consumers also affect the prognosis and the development plan.

INTEGRATION OF THE DATA SOURCES

The integration of separate data sets into *one common* computer based model has several good and bad consequences. In this paper we assume that the integration can be carried out (this is a very strong precondition!), and we consider the consequences from the user's point of view.

Data integration results that significantly more data is displayed on the same user interface at the same time. The increment of the amount of displayed data implies two main questions

- How to protect the user from drowning into the "too much data". Most likely, a considerable part of the data is irrelevant for the current work – it only causes confusion.

- How to handle the display overhead that is caused by the increased data amount. Clearly, very fast implementation models are needed.

Another speed-up method is if some data is zoom-specific. In many cases, it is even impossible to display many labels on a small area of the screen.

III. VISUALIZATION PROBLEMS

The users of graphical design software have the freedom to control what kinds of data they want display on the screen. In most of the current GIS, data are organized into groups or layers [4]. This organization makes it possible for the users to select the object types necessary for their work at the moment. The display of the layers or the different object types can be toggled on a toolbar or in a specific menu item, in general.

BASIC PROBLEMS – ZOOMING

Toggling the unneeded objects is a quite easy task until the user doesn't do anything else, just uses the current view (actual zooming, displayed area, displayed objects etc). A problem comes up when the user changes the view; especially s/he switches to a larger scale (zooms out). The larger view with the same set of displayed objects means that the GIS has to display more objects at the same time than at the previous state. Zooming out can mean a strong growth of the displayed area. For example, in the case when a zoom-out step enlarges the displayed area to all directions by the same segment then the result is a 9 times larger area (Figure 1) involving a 9 times growth of the number of displayed objects on the average.

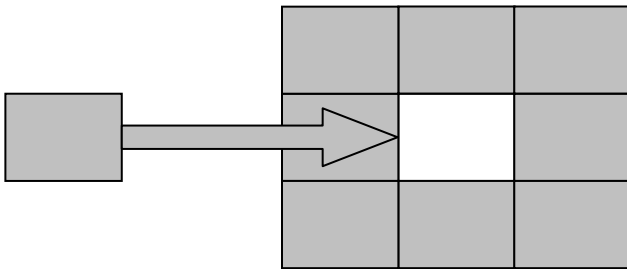


Figure 1. Changing the zoom level

The user waits or – if s/he can – interrupts the rendering process and switches off some object groups to shorten the time of visualization. Both the slow rendering and the manual cut-off of object groups significantly set back the work process.

BASIC PROBLEMS – MORE DATA

With integrating more kinds of data into one GIS, the goal is to ease down the designer's life. Importing various data sources into a system (that is already chaotic for some use cases) is very dangerous. Without any helping hand the user gets lost among the new data groups s/he can choose and so the extension started as an improvement strikes back.

SOLUTION DIRECTION: ADAPTIVITY

Giving the user the possibility to change the views manually is not enough. The system needs to be changed somehow in order to rescue the user from continuously having to control the display properties. An intelligent, rule-based solution has to be introduced that knows when and how to change several software properties in a way the user would have done it manually. In other words, an adaptive intelligent interface is needed [5], [6].

IV. TOWARDS A NEW VISUALIZATION

To affect the design process positively, the changes have to be introduced in a transparent way. This means that the current system has to be altered in a way that the user isn't disturbed by the new features at all. The intelligent and adaptive visualization shall be obvious to handle and easy to customize. Besides, fast implementation of the new features is required; adding new data sources shall not slow down the (adaptive) visualization considerably. This also involves that we have to use the data model of the current GIS.

In this paper we are presenting general principles that can be used in any specific GIS system.

DEFINITIONS

To prevent misunderstandings, let us start with the definition of the basic concepts.

1. GIS view is the set of objects, object groups or layers that are selected to display. All objects and groups have their display intervals (discussed later) set for the appropriate GIS view. We recommend creating task-related GIS views, such as load-flow calculation GIS view (that displays lines but no street names), operation safety GIS view, etc.

2. Zoom level means the scale of the area displayed in means of relative or absolute value. Note, that it is independent from the GIS view (the GIS view defines the objects to display, zoom level defines the zoom).

3. Display interval can be defined for objects or object groups, for a certain GIS view. This value prescribes to the visualization subsystem whether the object is to be displayed at the actual zoom level or not. For example, if the transformer name has the display interval [0%,15%] for the actual GIS view and the actual zoom level is 50% then the transformer name is not displayed; but as the user zooms in to 10% the transformer name appears.

Display interval value can be given in percentage (between 0 and 100, regarding the overall display interval of the system) or by specifying the exact scale. The latter is a trivial case when displaying a map. To comply with the major design frameworks, separate display intervals can be defined for screen and printer.

Display interval reflects the previously described problem that it is impossible to display a big number of elements on a small screen area [7].

4. Applied GIS view is a GIS view with the actual zoom level. So, those objects, object groups or layers are displayed, that belong to the actual GIS view, and their display interval makes it possible to display at the current zoom level.

THE THREE SCENARIOS

Our GIS view based model (that is presented in details in the next chapter) is suitable for the followings.

Adaptive (automatic) application of the GIS views, according to events. The concept of display interval adapts the GIS view to the zoom level. The GIS view itself can be connected to special events so that the event activates the view. Let us suppose that we have a load-flow GIS view that is connected to the “start the load-flow simulation” button. As the user starts a load-flow simulation by pressing that button, the system automatically switches to the load-flow GIS view (and hides the street names, as described before). This saves work for the user.

Manual application of the GIS views. The user has the possibility to switch between GIS views manually. The exact user interface is described later.

Customizing the GIS views. The user has the possibility to customize the built-in GIS views, and to add new ones. The exact user interface is described later.

V. HOW GIS VIEWS WORK

VIEWS IN RELATIONAL DATABASES

In GIS systems, the displayed image is built up from the selected objects. The process is very similar to the transaction when a user queries data from a relational database. In case of a DBMS (database management system) the user tells which rows s/he wants to see (by specifying some common properties), and these data rows are returned and displayed. In our case when the user selects the appropriate objects, s/he initiates a query on the GIS.

In the world of relational databases, it is possible to collect some columns of tables into a virtual table called view [8]. The view itself doesn't exist physically (the chosen columns are not duplicated, the data is joined at the moment of its use), but from the user's point of view, it works like a real table. Creating views makes the user's work easier.

GIS views are inspired by database views. Objects, object groups or layers may be collected into a GIS view. The view doesn't duplicate the data, just makes the user's

work easier (s/he doesn't have to toggle the visibility of the object separately). The difference from the relational database view is that GIS view adds some further data to the contained objects, namely the display interval.

GIS VIEW ALGEBRA

GIS views can be defined with a GIS view algebra.

Let us mark the GIS view by V , and object by o , and object group by O . GIS views can be defined from o_i and O_i elements, additively or subtractively. For example from simple objects:

$$V_i = o_1 + o_2 + \dots + o_n \quad (1)$$

$$V_i = o_1 + o_2 - o_1 = o_2 \quad (2)$$

Not only objects and object groups but also GIS views can be used in the definition. Hereby, the user gets the opportunity to define own views using already defined ones. Recursivity is not allowed.

$$\begin{aligned} \text{If } V_1 &= o_1 + o_2 \\ \text{and } V_2 &= o_3 \text{ then} \end{aligned} \quad (3)$$

$$V_i = V_1 + V_2 = o_1 + o_2 + o_3$$

Definitions are evaluated in a left-to-right manner, no explicit parenthesis is allowed. This makes it easy for the user to understand what is happening when customizing a view (s/he cannot accidentally put parentheses into the already defined part, causing confusion). Let us see an example where the order of the elements is important.

$$\begin{aligned} V_1 &= o_1 + o_3 \\ V_2 &= o_1 + o_3 \\ V_x &= V_1 + V_2 - o_3 = o_1 + o_2 \\ V_y &= V_1 - o_3 + V_2 = o_1 + o_2 + o_3 \end{aligned} \quad (4)$$

So, GIS view is defined in sense of adding and subtracting constituents, namely objects, object groups or other GIS views.

The elements of the GIS view definition are stored as references and not as values. This means that if we change V_i in Equation 4 by adding o_4 to it then V_x and V_y also changes.

OBJECT PROPERTY FILTER

Whilst using the GIS it may occur frequently that not all instances of an object (type) are relevant, just the ones the properties of those satisfy some conditions. For example, we want to see network lines over a given capacity only. Let us introduce the concept of *object filter* into the GIS view algebra. The object filter appears as an attribute of the constituent (object, object group or view).

$$V_i = o_1\{p_1 > 40\} + o_2 \quad (5)$$

In Equation 5 a filter condition on property p_1 of object o_1 is defined so that the view V_i is composed only from the instances of o_1 having a property p_1 larger than 40.

The following algorithm is used for the evaluation of the extended GIS algebra equation.

1. An initial, empty set is created (DS, display set).
2. The formula is evaluated from left to right.
3. In each addition step, if the constituent is
 - a. Object: those object instances are added to the DS that satisfy the property filter conditions.
 - b. Object group: step 3.a is followed for each object in the group.
 - c. GIS view: the GIS view application is evaluated and its result DS is added to the DS.
4. In each subtraction step, if the constituent is
 - a. Object: those object instances are removed from the DS that satisfy the property filter conditions.
 - b. Object groups: step 4.a is followed for each object in the group.
 - c. GIS view: the GIS view is evaluated and its result DS is subtracted from the DS.
5. The objects in the DS are displayed.

BUILT-IN AND CUSTOM VIEWS

To ease the user's work, GIS systems should contain some pre-defined, built-in views for the common tasks. For example, a general purpose view, or in case of an electrical supply system a view for short circuit analysis. Similarly, there should be default (non GIS view specific) display intervals for the common objects, so that as the user adds the object to new view, s/he doesn't have to customize so many attributes.

Of course, the user interface should give the possibility to flexibly change / add GIS views and display intervals.

HOW TO ACTIVATE A GIS VIEW

GIS views may be activated (switched on) manually or automatically. Manual view change is when the user selects a new view from a toolbar. In this case s/he has full control.

Adaptive interface is when the view is activated by an external event. Such event can be a user operation that implies that the user is starting a new task that requires a new view. As mentioned above, clicking on the "start simulation" button may imply such a change. However, the user should have the possibility to turn off or customize the adaptive behavior of the displaying.

VI. GUI COMPONENTS

The success of a new software feature highly depends on that whether the user understands it; so it should fit into the "logic" of the GIS systems.

Users of present graphical design and GIS software usually meet four different kinds of GUI components:

- Menus: almost every functions of the software can be reached from the menus. Their disadvantage is, that the more deeper the menu structure is, the harder is to oversee them
- Toolbars: these components provide a quick access to the frequently used or compound functions by shortcut icons.
- Tool window: window of a specific purpose tool.
- Browser windows: the viewer/editor window containing the main component the user works on.

GIS VIEW TOOLBAR

GIS views are frequently used object sets by their definition. From this definition follows, that they have to be quickly applicable, e.g. using a toolbar shortcut.

This toolbar is only for selecting a GIS view to be applied, the user can't customize the views – if s/he wants to do it, a more detailed tool is needed.

CUSTOMIZATION EDITOR

The customization editor is a tool for setting all the features discussed above: to customize existing GIS views by adding/removing constituents, setting display intervals and property filters; and to add new GIS views.

The customization editor can have graphical and/or script text interface. The graphical interface allows simple operations only. The scripting possibility guarantees complete flexibility.

The proposed layout of the customization editor's graphical interface is shown in Figure 2. The user selects the GIS view that s/he wants to customize from a drop-down list. In the upper frame, all constituents (objects, object groups and GIS views) are listed, showing if they are included or excluded from the currently customized GIS view. In this example, the object "Distributive mains" is included, "Transformer names" is excluded and GIS view "General view" is not affected (neither added nor subtracted). By double clicking on a constituent, additional customization is available (see the frame in the bottom) such as property filter and display interval settings. Other options (like connecting the view to an event) are available through the scripting.

Let us see an example how to create a new GIS view from the existing V_1 and V_2 GIS views, excluding object o_2 . First, we have to create a new GIS view from the menu. After this, the customization editor is started and our new

view is selected. We have to check the “+” box of V_1 and V_2 , and check the “-” box for o_2 (the order of the steps is important, see GIS algebra). So, the task is solved. The new GIS view will be shown among the other GIS views.

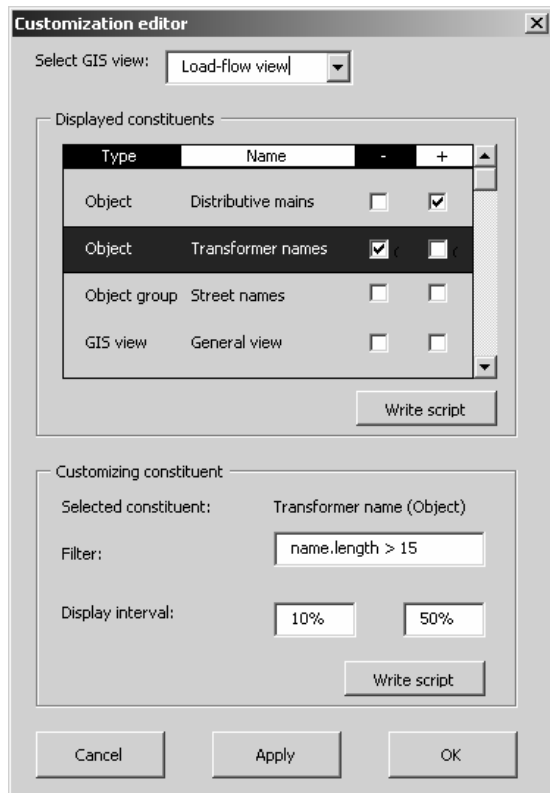


Figure 2. Customizing editor

SIMPLIFICATION OF GIS VIEW

It is an open question if the system should simplify the definition of a GIS view – if possible – not (e.g. $V_1=o_1+o_2$, $V_2=o_2$, $V_3=V_1+V_2 \rightarrow$ should it be $V_3=V_1$). The better answer is not, because GIS views are logical definitions. A future modification of V_2 would corrupt V_3 if simplification would be used. Of course, it is useful to inform the user when simplification is possible (so that s/he clears up unnecessary items manually).

PERFORMANCE ISSUES

A question might be raised, whether the views that are defined through multiple composition steps are not at the expense of the efficiency. An important property of the GIS views is they are constructed using logic rules *outside* of the visualization subsystem. The visualization subsystem itself doesn't even know that there are GIS views; it gets only a list of objects to be displayed in the output.

VII.SUMMARY

In this paper we discussed the visualization problems of the today's GIS systems of the electrical supply network. After identifying the problems, we introduced a solution possibility, namely an integrated, intelligent, and adaptive

graphical interface. We defined the main logical concepts of the interface. Besides the analytical aspects (GIS view algebra) and advanced properties (property filters) also some implementation guidelines were discussed.

REFERENCES

- [1] Lewis, V A; Ramsay, B. Geographic Information Systems (GIS) in the Electricity Supply Industry (ESI), The 1997 32nd Universities Power Engineering Conference, UPEC'97. Part 1 (of 2); Manchester; UK; 10-12 Sept. 1997. pp. 186-189. 1997
- [2] Agerholm, B., Lindboe, H. H., Franck, N. T., Kofoed-Wiuff, A. Long-term investments in the electricity system, 19th World Energy Congress, 5-9 September 2004, Sydney, Australia
- [3] Flynn, Kathryn M. The Alabama Watershed Demonstration Project: Water Quality and Geographic Information Systems, ANR-1162, New Oct 1999.
- [4] Pundt, H., Brinkkotter-Runde, K. Visualization of spatial data for field based GIS, Computers & Geosciences v. 26, no.1, pp. 51-56, 2000
- [5] Reichenbacher, T. Adaptive Methods for Mobile Cartography, Proceedings of the 21st International Cartographic Conference (ICC) Durban, South Africa, ISBN: 0-958-46093-0, 2003
- [6] Oppermann, R. Adaptive User Support: Ergonomic Design of Manually and Automatically Adaptable Software, in: Olson, G. M., Olson, J. S., Curtis, B. (ed) Computers, Cognition and Work. Lawrence Erlbaum Associates, 1994. p. 253
- [7] Cecconi, A., Galanda, M. Adaptive Zooming in Web Cartography, Computer Graphics Forum, Volume 21 Issue 4 Page 787, doi:10.1111/1467-8659.00636, 2002
- [8] Slazinski, E D. Views - The 'Other' Database Object. In The Proceedings of ISECON 2001, v 18 (Cincinnati): §27c.