Visualisation of ATM network connectivity and topology*

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Abstract

ATM networks have varying service classes available for different forms of traffic and allow dynamic reconfiguration of the virtual path connection between each origin and destination pair. We are developing a tool to display information specific to how an ATM network can alter its virtual path connection network as well as providing a graphical metaphor to convey this information in a compact view. Our intention is to provide administrators and network researchers with a concise display of the change in the dynamic structure of the virtual path connection network.

1 Introduction and Problem Description

Computer networks are essential to modern society, and a thorough understanding of how they behave is necessary for their efficient operation[2]. In the past decade, networks have been developed with higher speed and capacity capabilities. Of these networks, ATM has become established in the network industry due to its speed and variable quality of service feature.

ATM networks are designed to carry a wide range of service classes, with differing bandwidths and quality of service requirements. Visualizing these teletraffic data and the routes on which they are transmitted allows network administrators to identify network anomalies and bottlenecks and optimize the network operations. Traditional network analysis tools have largely produced only static displays of the network(SeeNet[2] and Avatar[7]). They failed to provide sufficient feedback on the dynamic structure of an ATM network.

We developed a high-level tool which can visualise the logical connectivity of ATM networks and the changes that occur in these networks as a result of changing traffic and service demands. Graphical displays, particularly network maps, have long been recognized as a tool for analysing

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network data[2]. We are interested in ATM network structures as well as traffic data on the network.

Our tool aids understanding of the network topology and dynamic connectivity involved in ATM networks. We will show how our revised conventional network map and a newer conceptual view of network will enhance the user's understanding of the network structure.

2 Theory and Background

Conventional network analysis tools tend to concentrate more on the structure of the network, and less on the various forms of traffic in the network, this is highlighted in Becker, Eick and Wilks [2]. This design principle does not mesh well with ATM networks. ATM networks can accommodate varying traffic classes and loads from low bandwidth voice communication to high bandwidth multimedia and video conferencing. Network visualisation tools for ATM networks consider both the network structure and the network traffic in solving network problems.

Dynamic reconfiguration is a network management control which reserves transmission capacity on the communication links in order to form dedicated logical paths for each origin-destination flow[3]. Reconfiguration will occur in the ATM network as it adapts to the slow time scale variations in the traffic call patterns. This highlights an issue which needs to be addressed in network analysis tools : can the analysis tool provide a means for detecting structural changes in the virtual path connection network that is designed on top of the physical network.

ATM networks allow for a large number of nodes which means that the graphical network map might be cluttered when representing the numerous nodes and links. SeeNet, a network visualisation tool documented in Becker, Eick and Wilks[2], has addressed this problem by using a matrix view. Similarly, the Avatar system, developed by Scullin, Kwan and Reed[7] overcame the problem using a three-dimensional scattercube matrix metaphor. Despite the advantage of visualising large amounts of data using matrix views, both these approaches incur a loss of geographical information and spatial data between links and nodes.

SeeNet and Avatar were developed when ATM networks were less widespread. As a result, unique ATM characteristics were omitted and this degrades the value of their visual output. Neither of these tools took the dynamic routing ability, changing logical link capacities, node and link redundancies of ATM networks, into account.

In the following section, we will highlight our design decisions which address the previous areas of concern described in this section.

3 Design Issues and Implementation

We have undertaken to visualise the process of dynamic reconfiguration, in collaboration with the University of Stellenbosch, Department of Computer Science. In our visualisation we wanted to highlight two important views on ATM connectivity :

1. a conceptual metaphorical view (see Section 3.1) placing emphasis on detecting change in an ATM network between successive network reconfigurations.

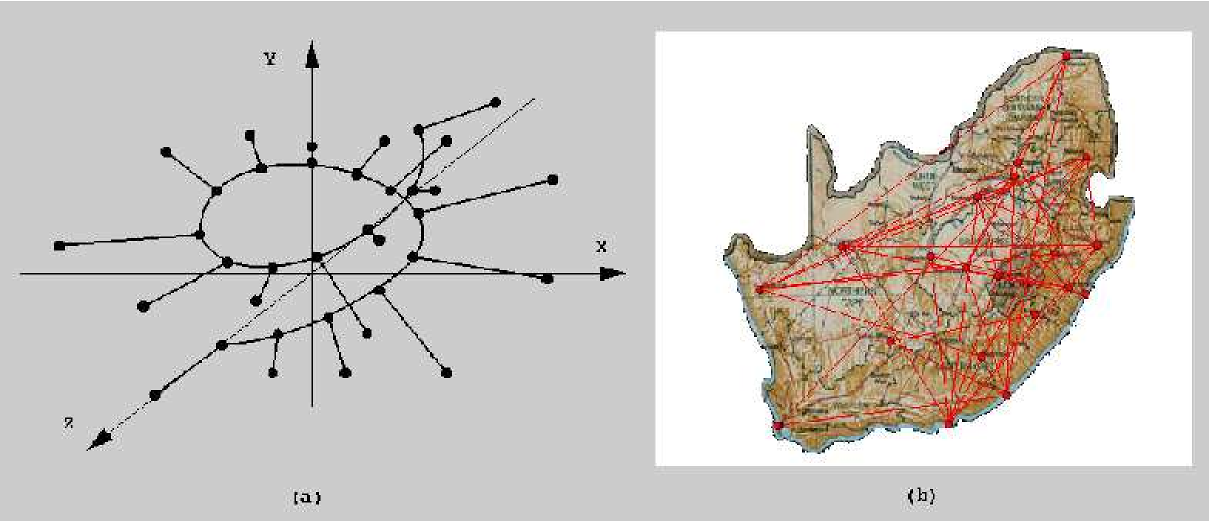

Figure 1: (a)Conceptual metaphorical view: Helix, (b)Physical view

2. a network map (see Section 3.2) detailing ATM specific characteristics including dynamic routing, variable link capacities and node and link information.

We chose to use our in-house iIsh[1] system as our visualisation tool. iIsh is based on the Inventor 3D C++ library, together with the Tcl/Tk languages. iIsh provides an interpretive environment for writing interactive three- dimensional graphics programs. It was developed as a toolkit for creating information visualization systems. Compared to more traditional programming tools based on compiled programming languages and libraries, it provides:

- a short development and test cycle,
- an easy learning curve, and
- a convenient and compact way of storing different versions of a visualization program.

3.1 Conceptual metaphorical view : HELIX

The helix view(see Figure 1(a)) is a compact view of the current network configuration. Its main purpose is to provide an informative overview of the logical capacity configuration between origin-destination(OD) pairs and also the final optimal network configuration.

The helix provides the following information in a graphical form :

1. number of OD pairs in the current network configuration
2. change in the number of circuits for each OD pair after reconfiguration
3. percentage of routes in this OD pair against the total number of routes in the network
4. highlight OD pairs which are physical links

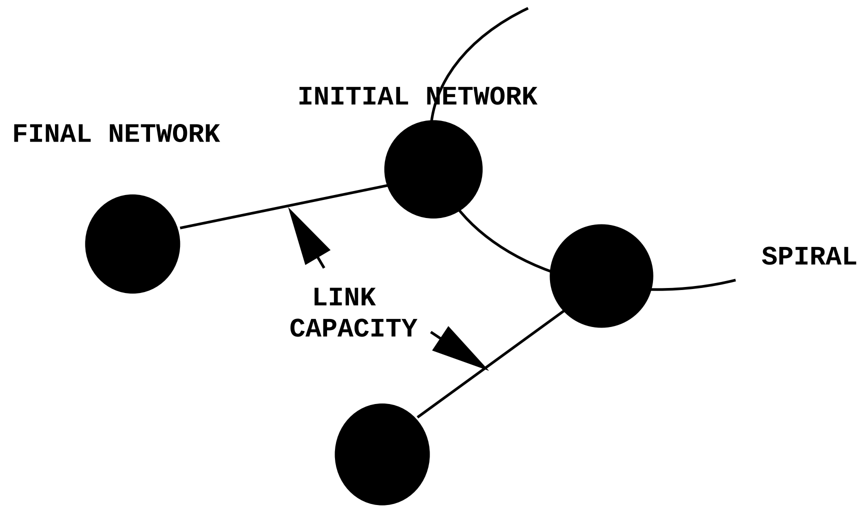

Figure 2: Spheres representing initial and final network OD pairs with change in bandwidth represented by length of link

The two major advantages of this metaphor over a matrix metaphor used in SeeNet[2] and Avatar[7] are:

Firstly, the helix is a graphical view which allows more extendable graphical features to convey more information than is possible using a matrix view. The helix form also allows scope to include a matrix view in its representation.

Secondly, the large amount of network data are of importance to our design objectives, The 3-D helix has the advantage of accommodating large amounts of traffic data compair to the 2-D matrix form.

In our implementation, we separate the initial network state from the final state using two spheres(see Figure 2). The link between the spheres represents link capacity change resulting from route reconfiguration for a single OD pair. We have used colour to represent an increase or decrease in capacity because if we chose an alternative like line thickness, we have the possibility of graphic clutter when the spheres are positioned close together. We also provide a "thermometer" indicator to indicate the percentage of routes of the OD pair against the total number of routes in the network.

3.2 Physical/Logical View

Since we are interested in the network structure, our tool employs graphical techniques to show locations for nodes and link geometry. SeeNet and Avatar placed more emphasis on traffic visualisation and therefore largely neglected the structural information. SeeNet did however represent structural information using simplified node and link maps and therefore has not completely ignored geographical information. In Figure 3, the tradition network map offers the geographical information of the nodes and links between them. However, we do not want to confine our tool to a completely abstract view of the network topology, since it will suffer from the same problem, namely loss of geographic information, experienced in Avatar[7] with its scattercube matrix representation. The loss of geographic information is particularly costly

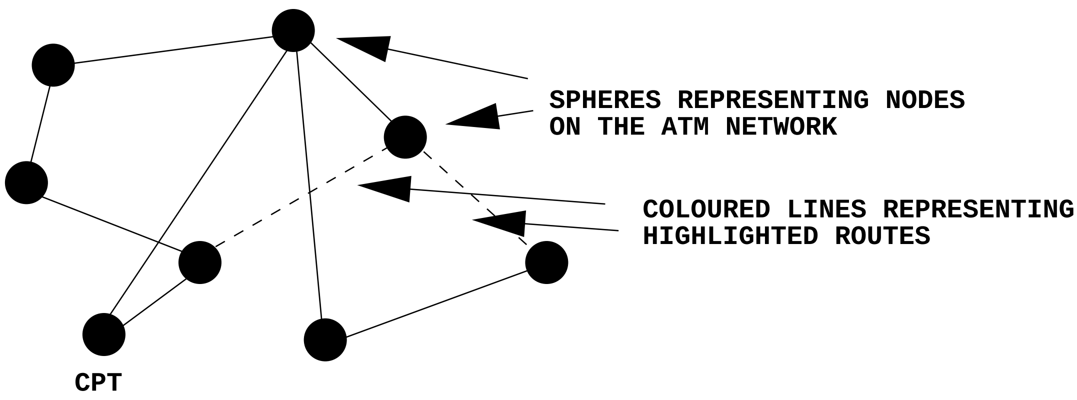

Figure 3: Geographical information can be supplied using tradition network maps

when considering most administrators may not have the mathematical background needed to interpret matrix representations.

In this regard, a geographically correct visual representation of the network nodes and links, accompanied with specific information on each node and link will be advantageous. See Figure 1(b).

Besides an abstract conceptual view (discussed previously in Section 3.1), we developed two other views to visualise the network: the physical view and the logical view. The physical and logical views are commonplace in most network visualisation tools. These views provide a layout of the network structure on a plane with circular objects representing nodes and the links between these nodes are represented by coloured edges. We distinguish between physical and logical views in order to clarify what represent physical links and what are generated by the virtual link properties of ATM networks.

3.3 Interaction

Interaction in a visualisation tool can significantly improve the user's understanding of a complex picture. The ability to query certain links and nodes in a network can prove advantageous in a visualisation tool. This interaction can be used to determine the capacity on a link; the operational status of a node; the total bandwidth for an origin-destination pair and the placement of logical routes between two nodes. Most interaction should occur through user queries to a menu system or directly to the graphical objects which make up the network topology. This interaction could also allow management capabilities through which an administrator can alter the network characteristics and performance.

Interaction in SeeNet was mostly confined to querying the essential information on a network. This needs to be expanded to cater for the diverse characteristics in an ATM network.

3.4 Centre on area of interest

Allowing close inspection of a network link or node might yield interesting characteristics. This is particularly true for a network experiencing congestion and deadlocks. As a result, our tool is

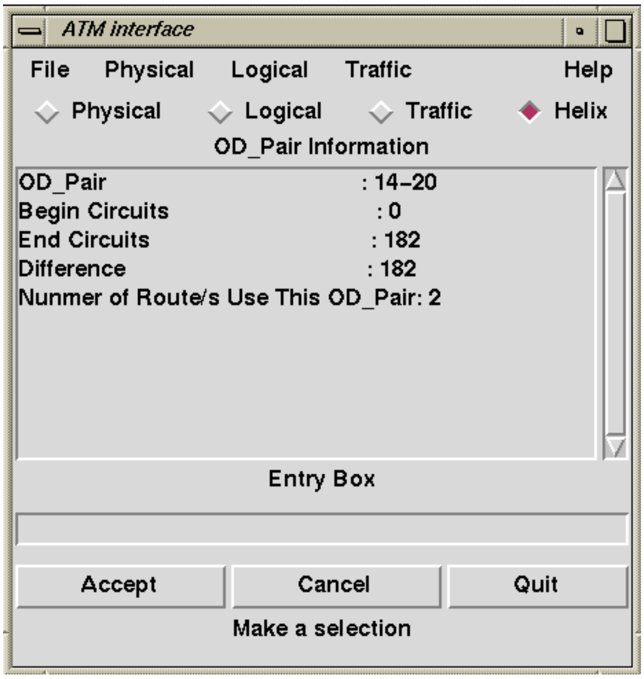

Figure 4: User interface of the ATM network visualisation tool.

based on a three dimensional world coordinate system which allows users to focus on particular areas. The detail of the investigation into this area depends on the user. The tool allows the user to zoom into a particular subnet of the network or directly to a node.

4 Initial Experience with the System

This visualisation tool provided insight into the changing network structure that resulted from the dynamic routing algorithm. Changes in routing decisions were more easily detected than with textual data, an example is shown in Figure 4. It lists all the textual information about the OD pair 14-20. In Figure 5, this OD pair is highlighted in both helix view and the physical/logical view. In the helix view, this OD pair is coloured blue. The distance between two spheres represents the changes in the number of circuits. In comparison with other OD pairs, user could easily know that the capacities of this OD pair have not increased much after reconfiguration. Meanwhile, in the physical/logical view, this OD pair is coloured green. We can detect the geographical location of these two nodes in OD pair and the two routes that used this OD pair. User could get further information in the user menu about these two routes separately by clicking on the route in the physical/logical view.

As described above, the overall trends and problem in the behaviours of the algorithm were more evident in our viusalisation tool. It conveys information more effectively.

5 Conclusion

We have described the physical, logical(see Section 3.2) and helix views(see Section 3.1) for showing the structural characteristics of ATM networks and the changing traffic carried on these networks. By applying the helix view, we have provided more conceptual information in a more understandable manner. Visually, the users can understand the geographical layout in the physical view immediately with little explanation. At the same time, the users can detect the virtual path connection in the logical view. Equally important, the users have more opportunity to understand the network through interaction.

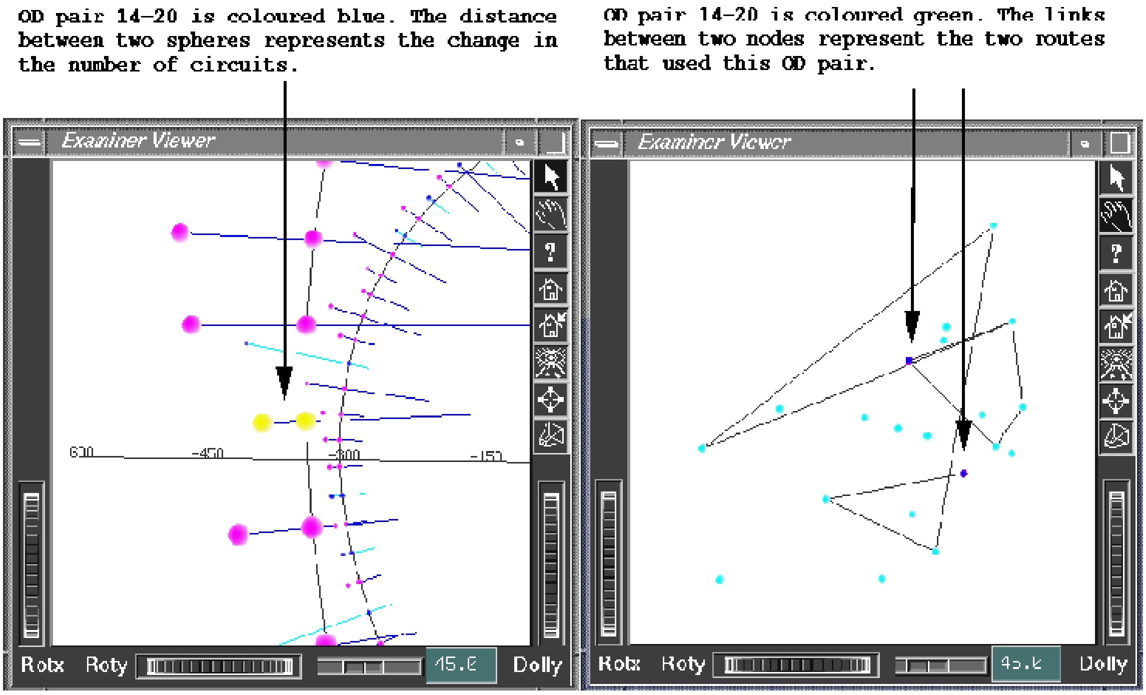

Figure 5: The left hand side examiner viewer illustrates the helix view of OD pair. It has been focused on a certain part of spiral. The right hand side examiner viewer shows the logical view of the network. The annotation have been added to original screen dumps to clearify the missing colour information.

5.1 Future Work

A limitation of our system is that it currently provide no step by step visualisation of how dynamic routing algorithm works on the ATM networks. It might provide more features to identify network operations.

Our work task will be create an animation of the changes in the network over time. It may give us new insights that will help to improve our system.

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