The objective of the project was to develop a 3-Dimensional(3-D) visualization tool from an adjacency matrix\(^1\) representing connectivity between elements and usage of connectivity paths between these elements. The visualization of connectivity was studied for elements like routers and websites.

Router connectivity information was determined by generating a matrix based on router tables derived from protocols like Open shortest path first (OSPF) and flooding algorithms. The matrix was a representation of a simplified graph representing a small area of the network of routers for simulation purposes. The motivation behind the project was to simulate 3-D visualization of very large datasets represented as simplified matrix representations.

3-D visualization makes it easier to determine problems arising due to an unbalanced network structure or overload of usage in a certain section of the network. This can be used as a tool for intrusion detection by generating a visual alarm. Solutions for network problems, once determined, can be tested by modifying the 3-D visualized figure representing the chosen network.

---

\(^1\) A graph is a series of vertices connected by segments called edges. A matrix whose entries are the number of edges that connect one vertex to another may represent the term “graph”. Such matrix is also known as an Adjacency Matrix. The adjacency matrix is a representation of a directed graph with n vertices using an n × n matrix, where the entry at (i,j) is 1 if there is an edge from vertex i to vertex j; otherwise the entry is 0.
Background and Related Work:

It is very difficult to analyse information about networks in text forms or even 2-Dimensional figures[1]. The project aimed at visualizing data using powerful tools especially for bottleneck paths and malformations in the various router configurations.

Since routers would be cross platform Java was the choice for development due to its platform independence, robustness and scalability. The Powerful features of Java 3D[2] were utilized for visualization. For storing and manipulating router configurations flat files were used. The GMatrix class in the Java 3D API was used to store the router information as it is easily expandable. This was mapped onto a 3-D Cylinder. Another reason for selecting Java is that this tool also has applications in analysing web site structures and web site usage[3]. Therefore this tool could easily be enhanced with technologies like Java Servlets, Java Server Pages and Java compatible web servers.

The 3-D figure was given a constant feed of data from a matrix of float and integer values to represent real time network usage, which would then update the figure instantly. This could prove to be a very effective tool to detect visual alarms for network intrusion[4] and hacking of web sites, both based on the usage loads.

Approach and Uniqueness:

For generating the three dimensional representation a generalized matrix was proposed to represent router table of each router. This matrix was generated from the graph representation of a small area of the network with a set of routers. Once the matrix is generated it is sent to the 3D tool as a file to create the figure. The matrix is a generalized matrix so that it can be expanded dynamically if there is a need to include a larger area of the network.

The 3D figure itself is based on an object oriented model, where each element of the figure is a class so that various elements of the figure can be manipulated. The generic figure used for representation is a cylinder. It is a wire frame cylinder where the lines represent connectivity and router information. The Adjacency Matrix maps on to a 3D Cylinder. The vertical lines represent the routers. N routers correspond to N Vertical
The horizontal lines are spaced across N levels on each vertical line representing that routers connectivity to other routers.

**Results and Contributions**: 
During the entire period of research it was observed that various tools had the means oo representing complex networks mostly in 2-Dimensional. However due to this the complex structures of web sites or router networks becomes very difficult to comprehend in such figures. It requires complex analysis and several resources to utilize such information. It was observed that once such data is visualized in 3-D it becomes simplified even for a novice user to understand interconnections and their relevance. 
The most interesting aspect is when the frequency matrix representing the real time usage of the network or web site is mapped onto the Cylinder. This gives a real world perspective to this project, by creating a tool for analyzing a network or web site load. 
This project was further modified by developing a tool to constantly update the matrix dynamically so that a simulation of network load could be performed and the cylinder constantly updated the data thus creating a very strong, real time visualization factor to it. This could be very useful for detecting security breaches where the number of horizontal lines going into a point increase dramatically to raise an alarm for a network. A function was also created to switch the matrix rows and columns so that a change in the network structure could also be visualized and thus analyzed for better performance.

Include a separate paragraph (max 100 words) for publication in the conference proceedings that serves as a succinct description of the project.

The project was aimed at visualization of complex and large datasets gathered from routers, in the form of matrices, using Java3D especially bottleneck paths and malformations in network configurations. Graphics features like zoom in, zoom out and rotation about an axis and manipulation features like matrix switching were also added to this figure. Matrix switching would modify the structure of the cylinder thus representing a change in the structure of the network connectivity. Constant feed was give to the
cylinder for representing the network or web site usage load in time windows. This involved taking snapshots of the cylinder and comparing them at various time intervals, to detect any abnormal activity. In essence this could be enhanced to work as visual alarms in the networks.

Reference:

1. Example of a 2-Dimensional monitoring tool: Cisco Cluster Management Suite

2. Sun Microsystems. Java 3DTM API Specification
   http://fag.grm.hia.no/dt2420/j3dguide/j3dTOC.doc.html

3. Web-traffic analysis: Product Comparison
   http://www.infoworld.com/cgi-bin/displayArchive.pl?/99/17/webtrafa.dat.htm

4. Example of Intrusion detection: Hackers storm White House Web site
   http://www.zdnet.com/zdnn/stories/news/0,4586,5082369,00.html