Visualizing the Flow of Users on a Wireless Network

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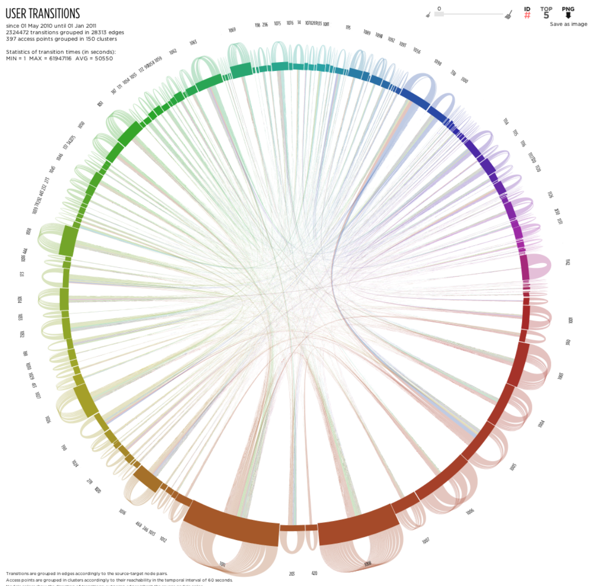

Figure 1 *The static artifact of the network's flow of transitions occurred during 2010.*

1 Introduction

This information visualization project depicts the flow of users within the various access points of the eduroam network of the University of Coimbra. The developed application allows the visualization of an interactive graph (see Figure 1), which covers a certain time span, and animates the changes in the network's flow of information over time. The nodes of the graph represent access points and the links represent transitions of users between them. A transition is registered when a user stops the connection to an access point and connects to another one. Clustering is used to merge access points that are deeply connected, promoting the visual clarity of the artifact while providing additional information to the viewer.

2 Approach

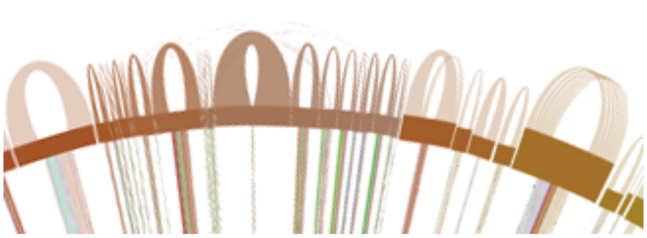

Figure 2 *Detail of expanded and collapsed clusters, and the respective incoming and outgoing transitions.*

We adopt a circular layout inspired in sunburst diagrams (Stasko and Zhang, 2000), applying it to the visualization of wireless networks with a new interactive technique to explore the network's structure on a local and global level. The access points (APs) are nodes represented by arc blocks along the main circle. The length of a block is proportional to the sum of all its incoming and outgoing transitions, the thickness of a node is proportional to the number of its children. Each node has a color that provides the direction to its transitions, since the outgoing transitions inherit the source node's color. The transitions are depicted by Bézier curves, thinner on bends and larger on extremities. The width of an extremity corresponds to the total number of transitions between the source and the target nodes. The incoming and outgoing transitions of a node are organized by width in descending order, from the center to the right and left margins of a node. The transitions within the same node or cluster are drawn outside of the main circle (see Figure 2). In the absence of spatial information about the localizations of APs, the implemented clustering algorithm groups nodes by proximity, using the average transition time associated between pairs of nodes. First, the most accessed point is chosen, becoming the central node of the new cluster. Then, all nodes reachable within a timeframe of 60 seconds are recursively added to the cluster. Cluster's children inherit the color of the father cluster with a small variation in saturation. To promote clarity and efficiency, we provide a filtering technique that deletes rarely accessed APs and rarely occurred transitions, below a given threshold.

The processed data is mapped to the graphic layout, which consists of nodes forming a circumference, with transitions' curves connecting them. The following types of transitions are represented: cluster-cluster, cluster-node, node-cluster, and node-node. The novel interactive technique allows users to expand or collapse any cluster, allowing them to control the level of detail of the visualization. When a cluster is collapsed, the transitions of all its nodes are represented by the cluster. When expanded, one can observe the incoming and outgoing transitions of the individual nodes represented at the cluster's position. Pointing with the mouse cursor over a node shows its ID number and its technical name. Users may turn on all node IDs at once, expand top 5 biggest clusters and filter the displayed data using the respective controllers included in the interface. The dynamic artifact was produced by considering a sliding time-frame of one week, which moves in 3 hour increments. The animation reveals how the network's structure and connectivity changes over time.

3 Experimental Results

The interactive visualization and the animations represent the overall user movement within the network, allowing one to perceive the flow of users and common patterns of movement. The graph emphasizes the most common movement patterns in the network due to the edges' thickness. The most accessed points are also highlighted due to their bigger arc lengths. The network structure is revealed by the clusters' grouping factor and the node arcs' thickness. Transitions between the same node/cluster prevail over the transitions between distant nodes, which occur less often.

Acknowledgements

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References

Stasko, J. and Zhang, E., 2000. Focus+context display and navigation techniques for enhancing radial, space-filling hierarchy visualizations. *IEEE Symposium on Information Visualization*, IEEE, pp. 57–65.

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