VizSEC 2007
Workshop on Visualization for Computer Security

Graph-based Monitoring of Host Behavior for Network Security

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Overview

1. Motivation
2. Related work
3. Behavior Graph
4. Automatic accentuation
5. HNMap integration
6. Case Study
7. Evaluation
8. Conclusions

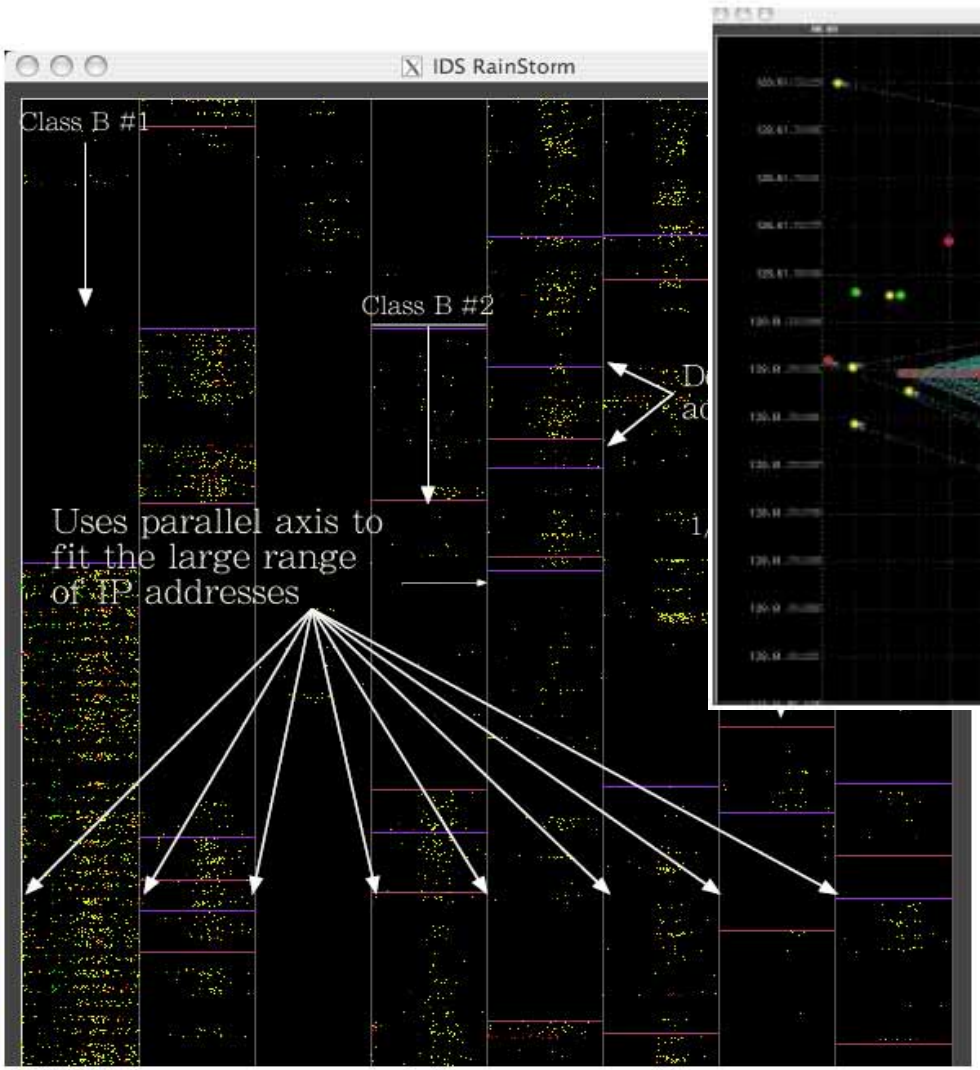
1. Motivation

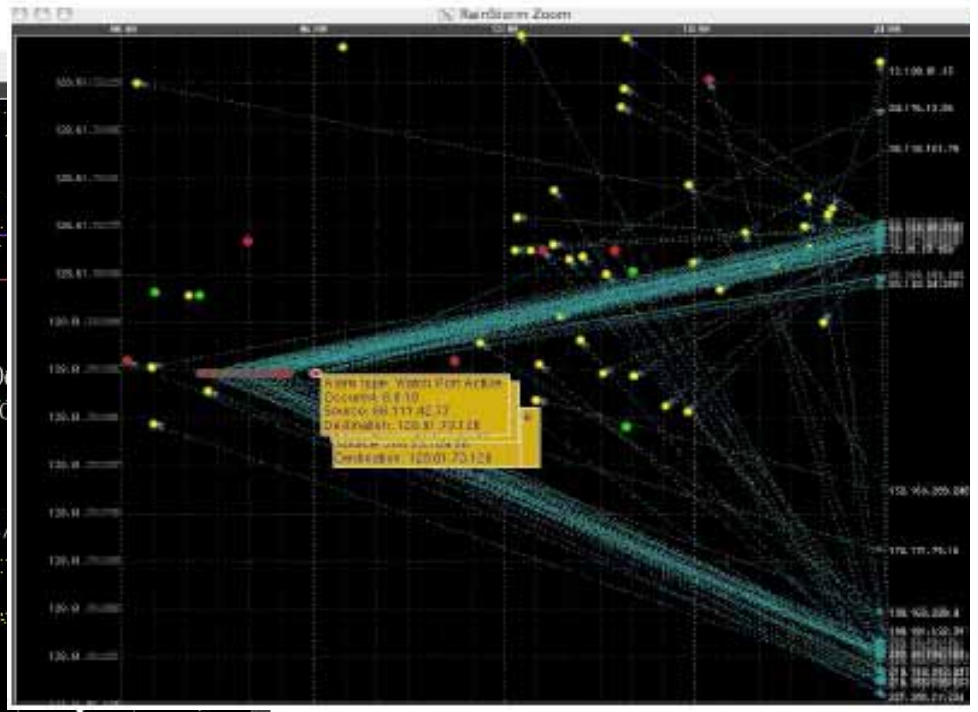
- **Visual analytics research**
  links visualization with automatic analysis methods to combine flexibility, creativity, and background knowledge with the enormous storage capacity and computational power of today's computers.

- **Our goal**:
  to use visual analytics methods to gain more insight into network traffic and intrusion detection data sets.

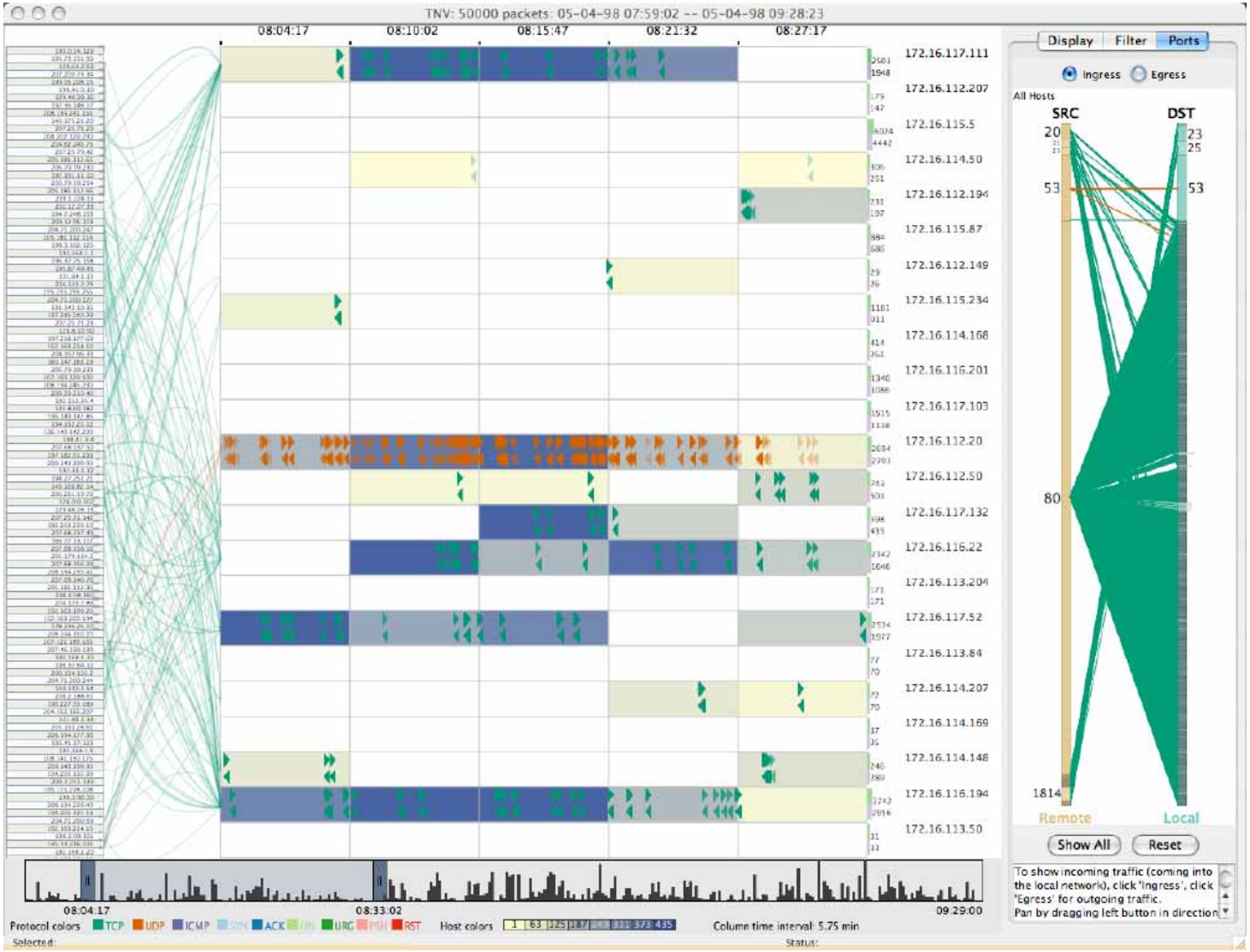
- Focus of this work:
  tracking behavioral changes in network traffic of a collection of **hosts**.

2. Related work: IDS Rainstorm

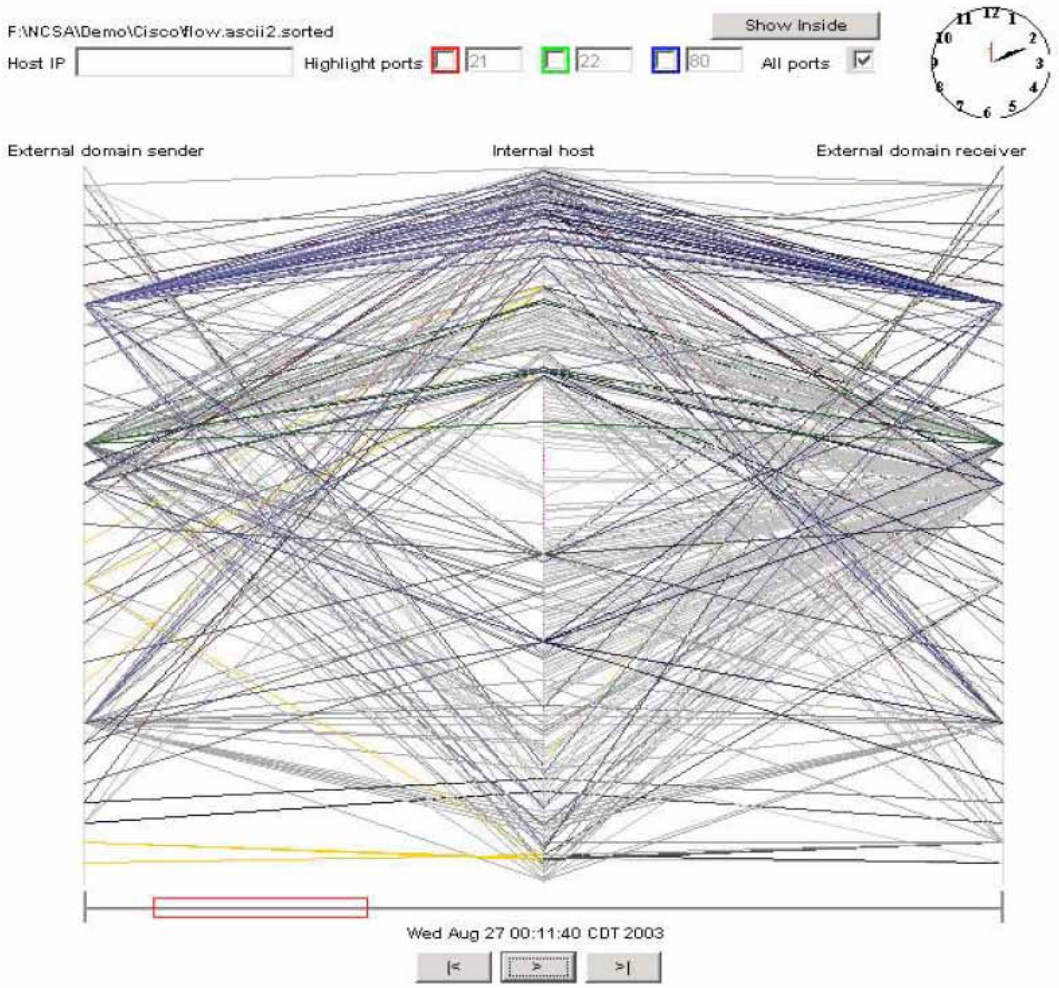




2. Related work: TNV



2. Related work: VisFlowConnect



3. Behavior graph: application design

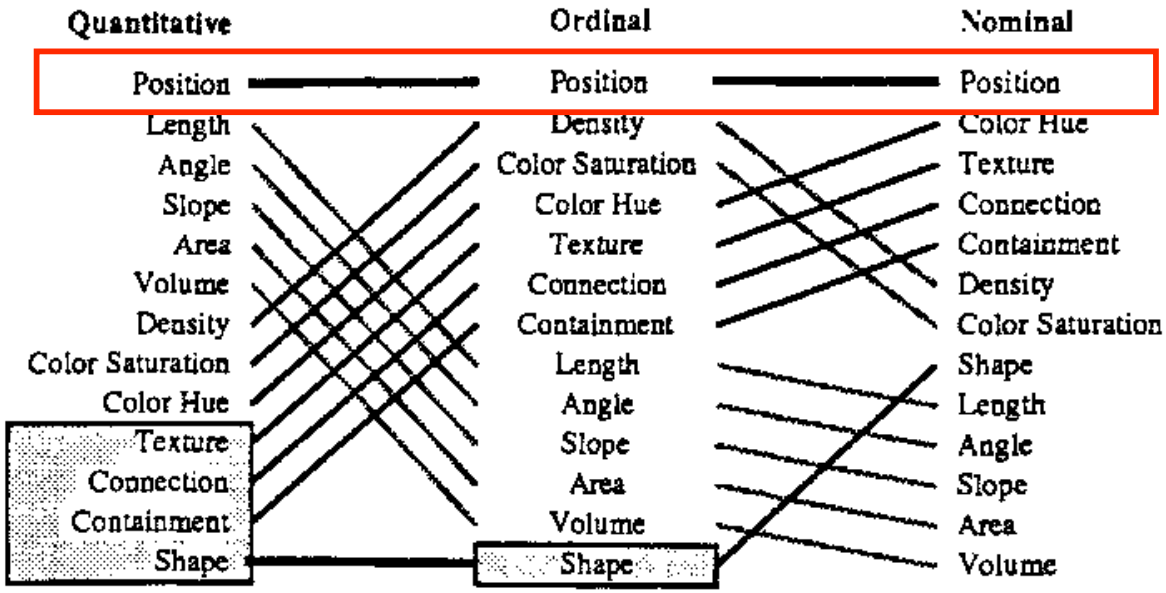
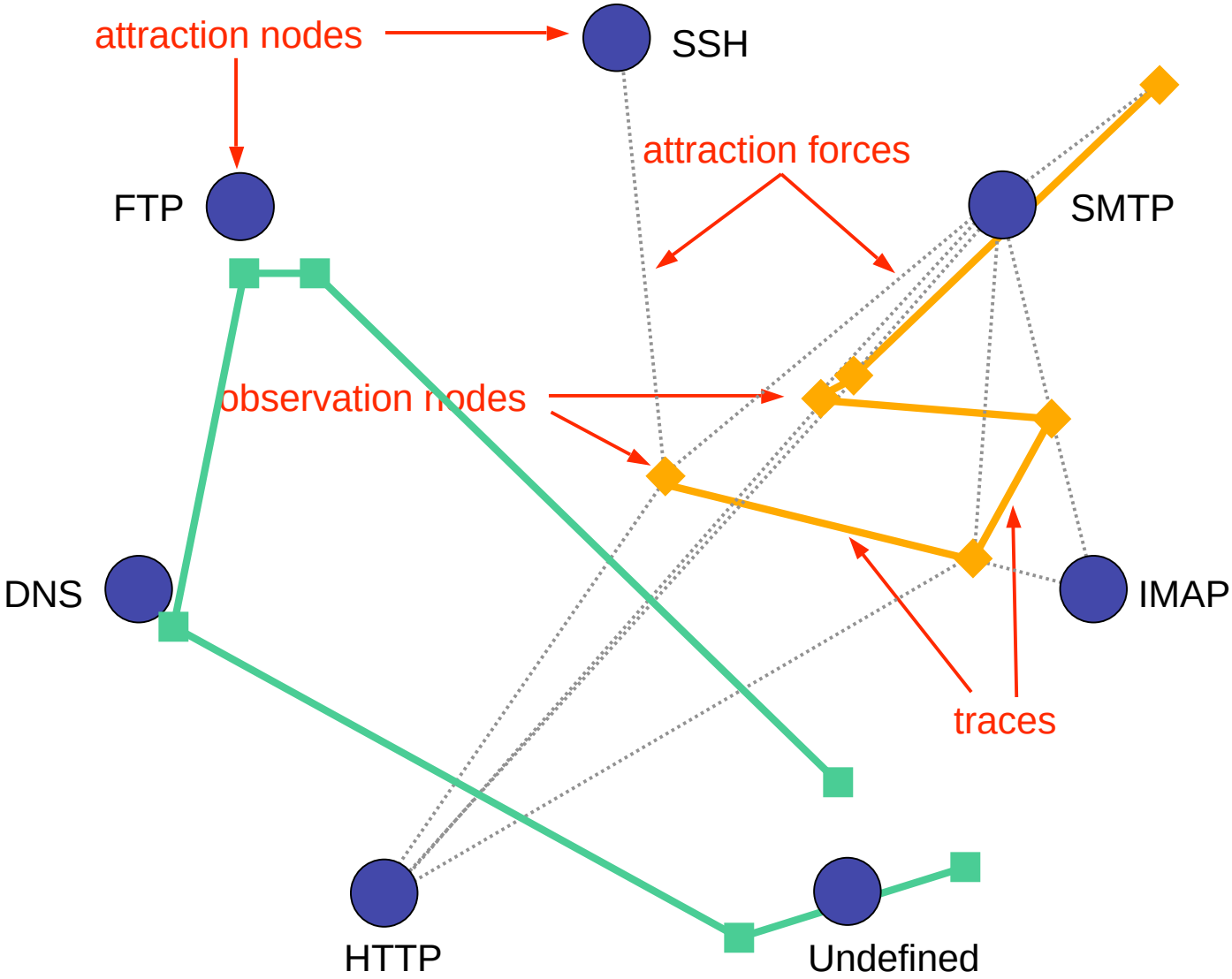


Figure 15: Ranking of Perceptual Tasks. *The tasks shown in the gray boxes are not relevant to that type of data.*

Graph-based host behavior monitoring

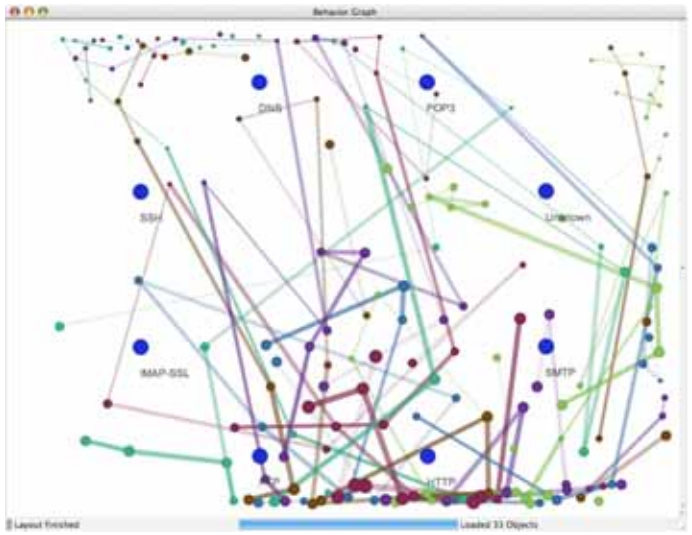


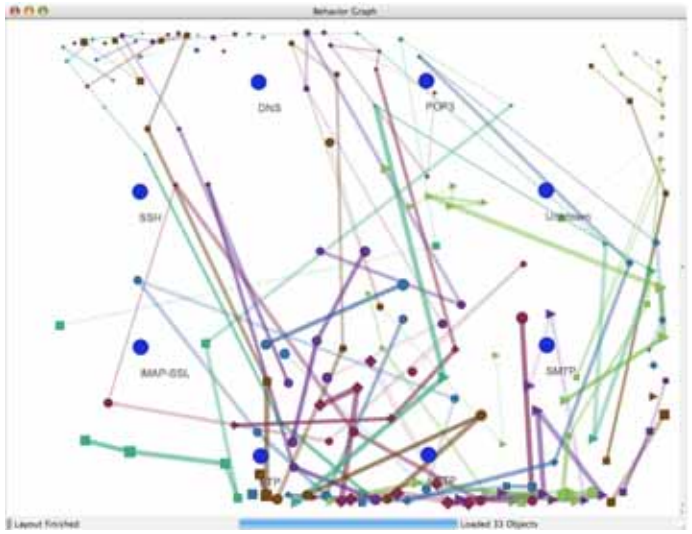
Implementation

- PostgreSQL database to **calculate forces** for each observation node and time span.

- Fruchterman-Reingold **spring embedder** as provided in the JUNG graph drawing library to calculate graph embedding.
  - Efficiency
  - Robustness of force and iteration parameters

Node representations





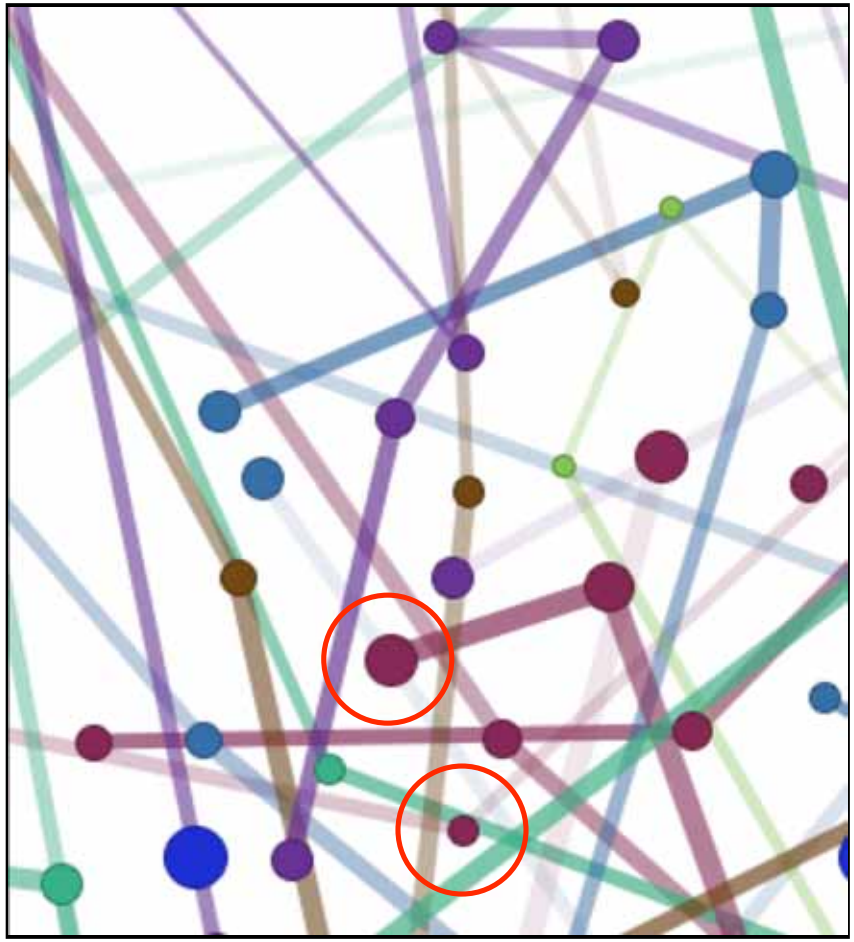
Problem:

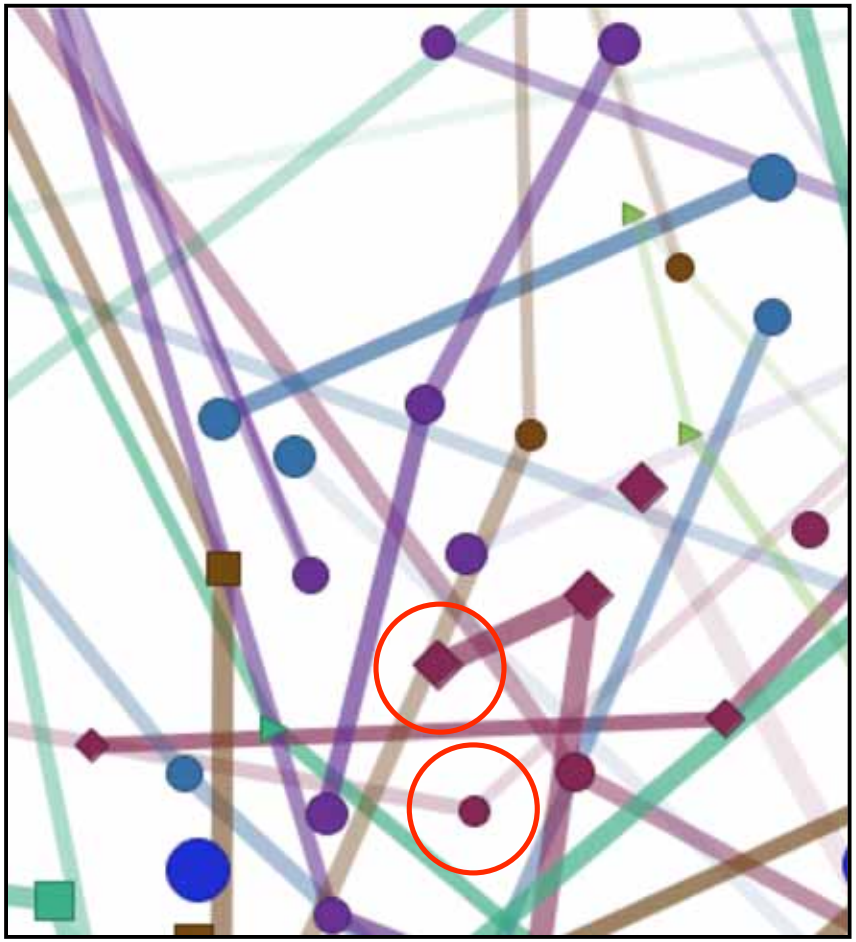
- **Coloring**: only a finit number of colors are distinguishable
- How much traffic?

Solution:

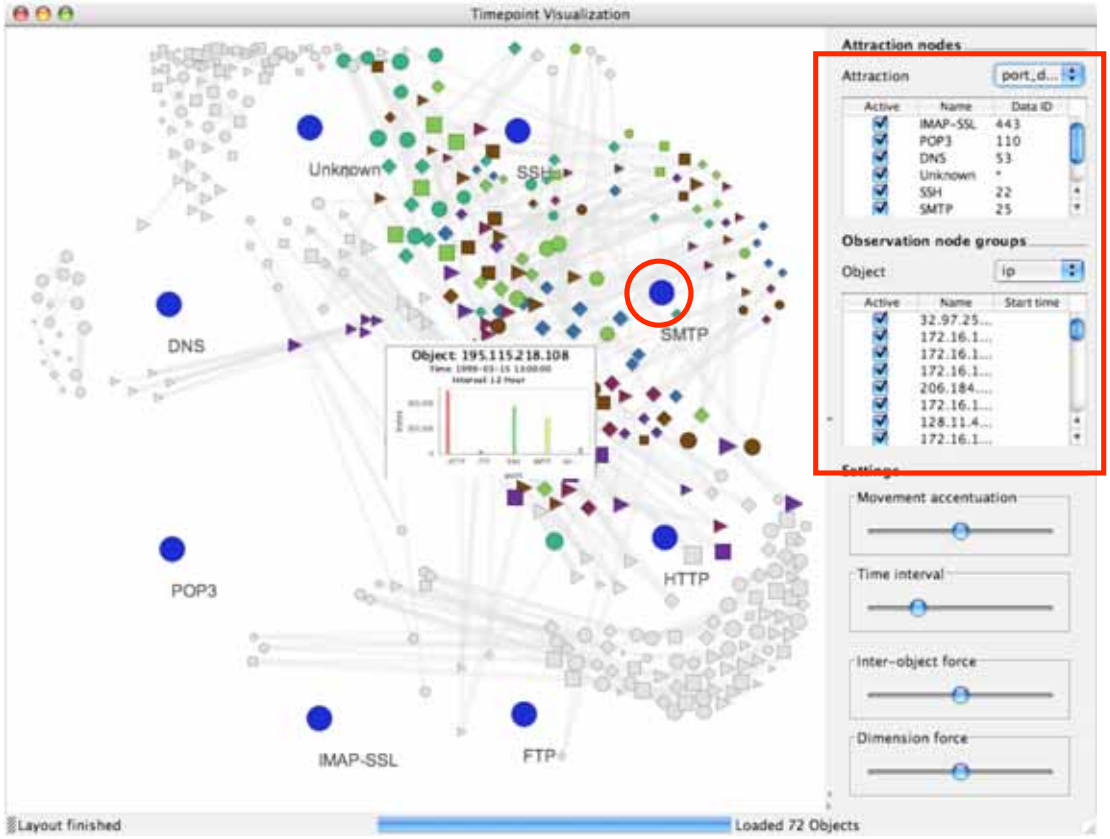
- Combination of **color and shape** (gray-scale usage possible)
- Mapping traffic volume to size (scaling)

Node representations





User interactions

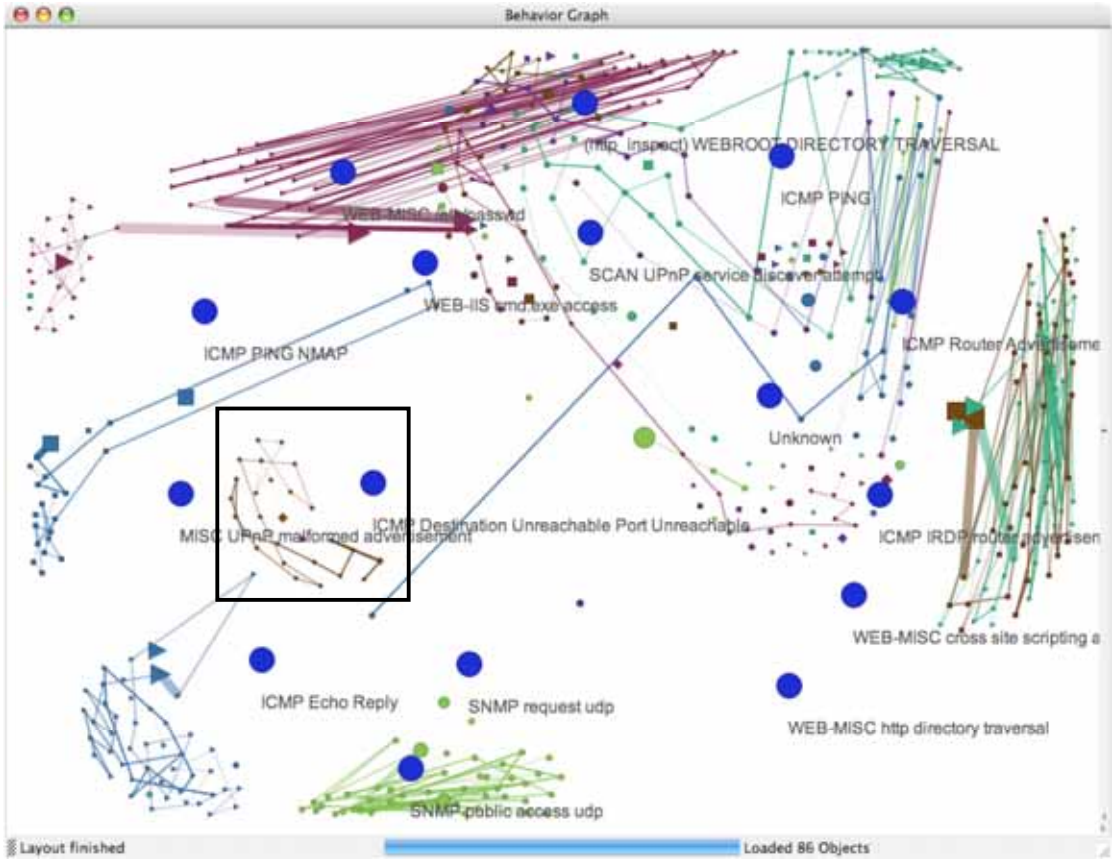


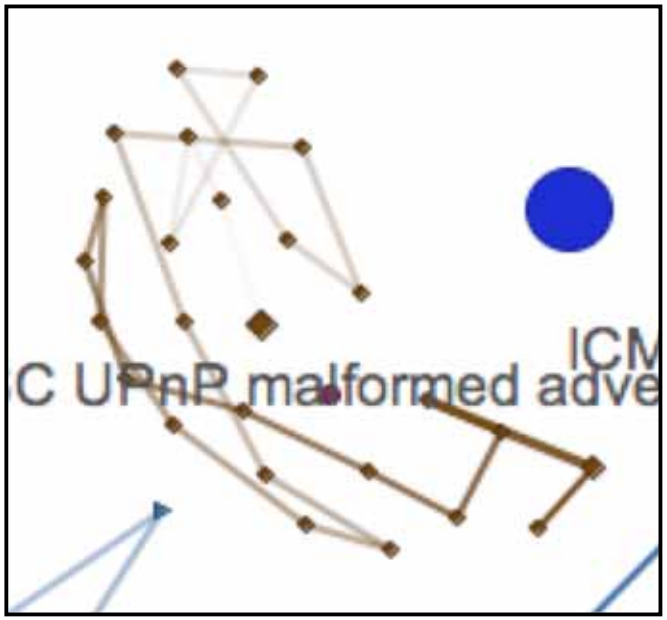
- **Details** (bar chart) on mouse-over
- **Select** node observation group or attraction nodes
- **Add and remove** attraction and observation **nodes**
- **Repositioning** of attraction nodes (drag & drop)

User interactions

- **Movement accentuation** highlights suspicious hosts with highly variant traffic (more later …)
- **Time interval**: increase/decrease the amount of observations per host
- **Inter-object force**: control attraction forces within a node observation group (one group per host)
- **Dimension forces**: fine-tune attraction forces between observation and attraction nodes.

Time visualization





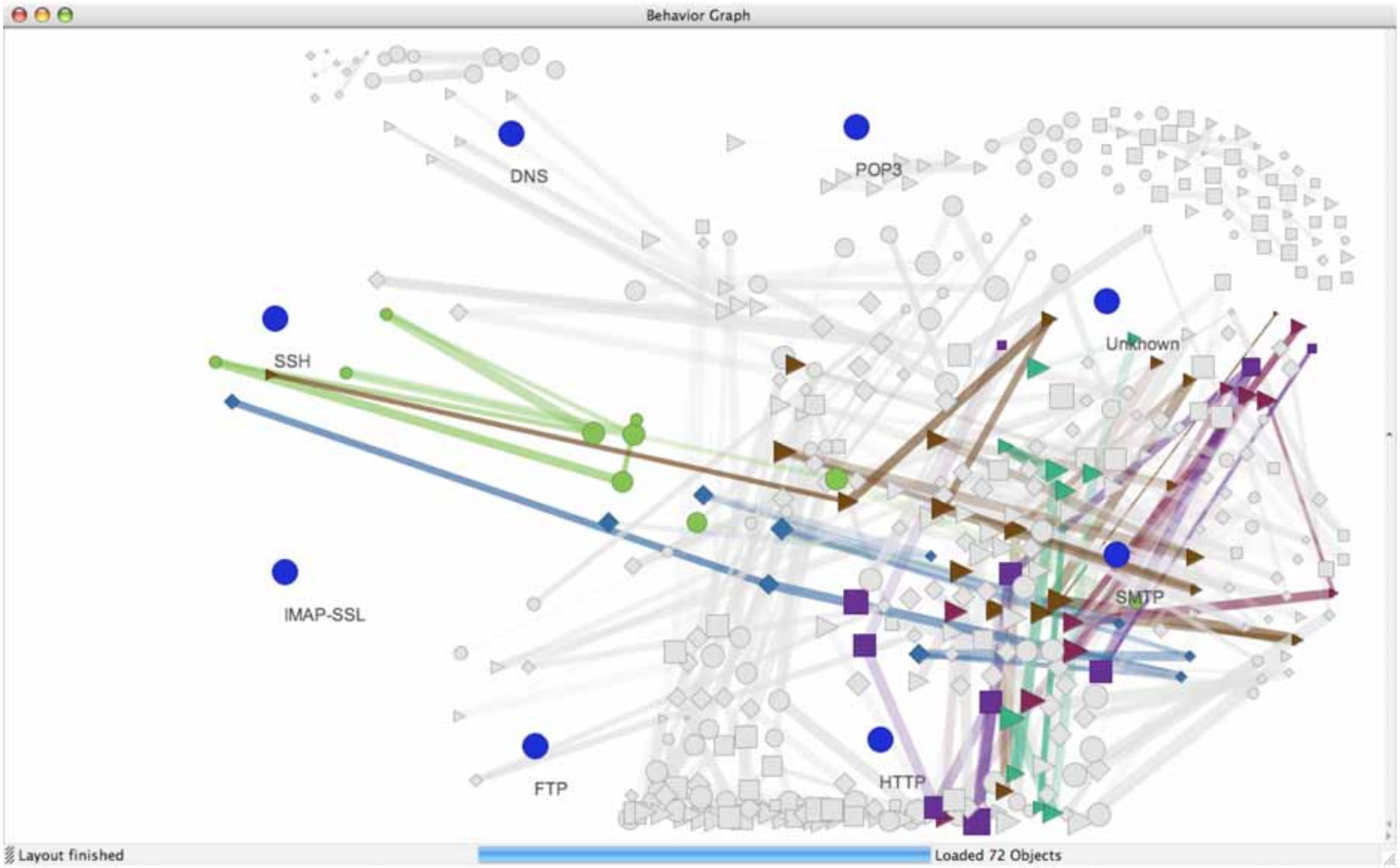
4. Automatic accentuation of node groups with highly variable traffic

Position of a host at a particular timespan in high-dimensional Euclidean space

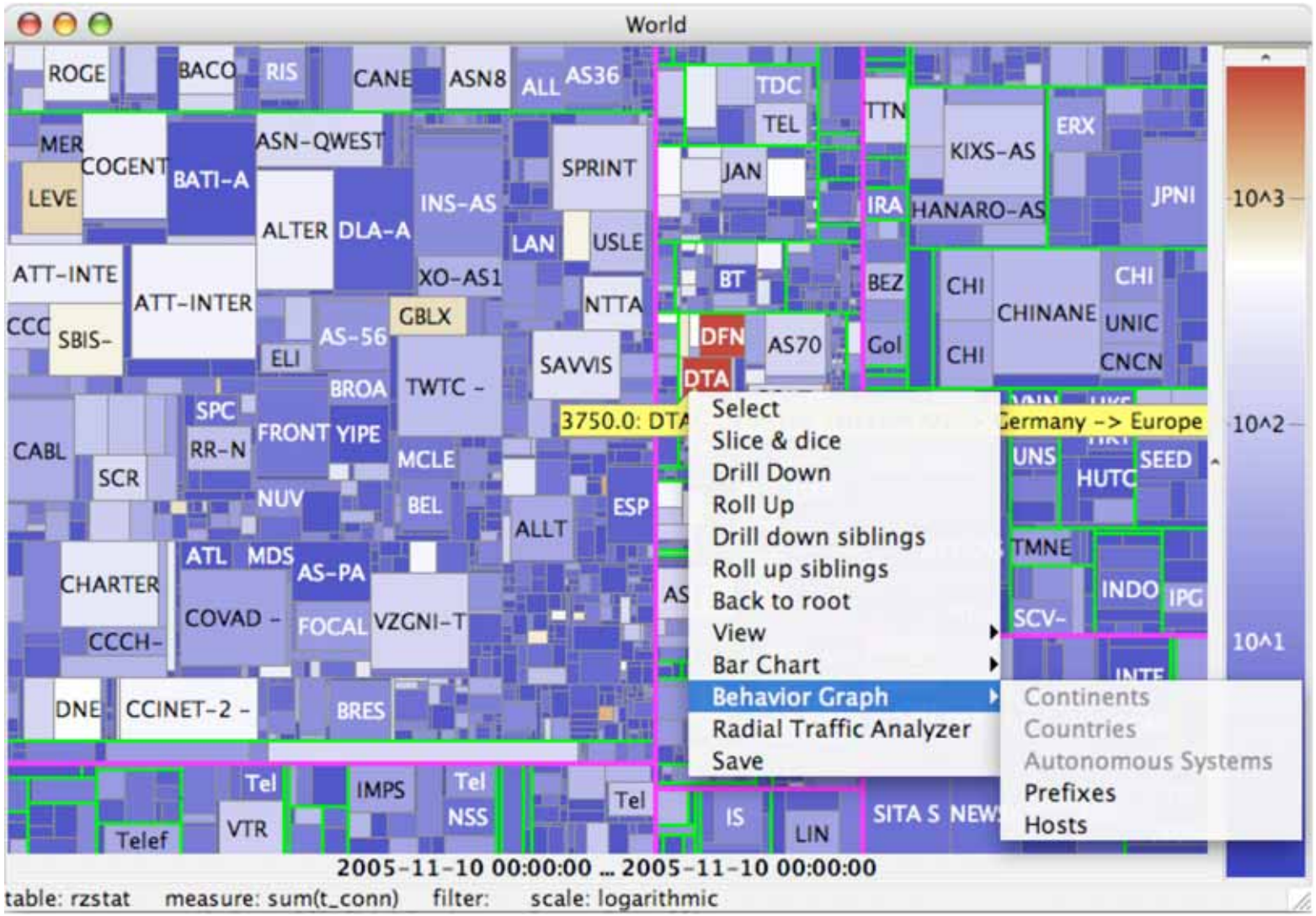
$$\vec{o}^{\,r} = \frac{\vec{o}}{|\vec{o}|}$$

$$pc_{norm} = \frac{\sum_{t=1}^{t_{max}-1} |\vec{o}^{\,r}_t - \vec{o}^{\,r}_{t+1}|}{t_{max}}, \qquad 0 \leq pc_{norm} \leq 2$$

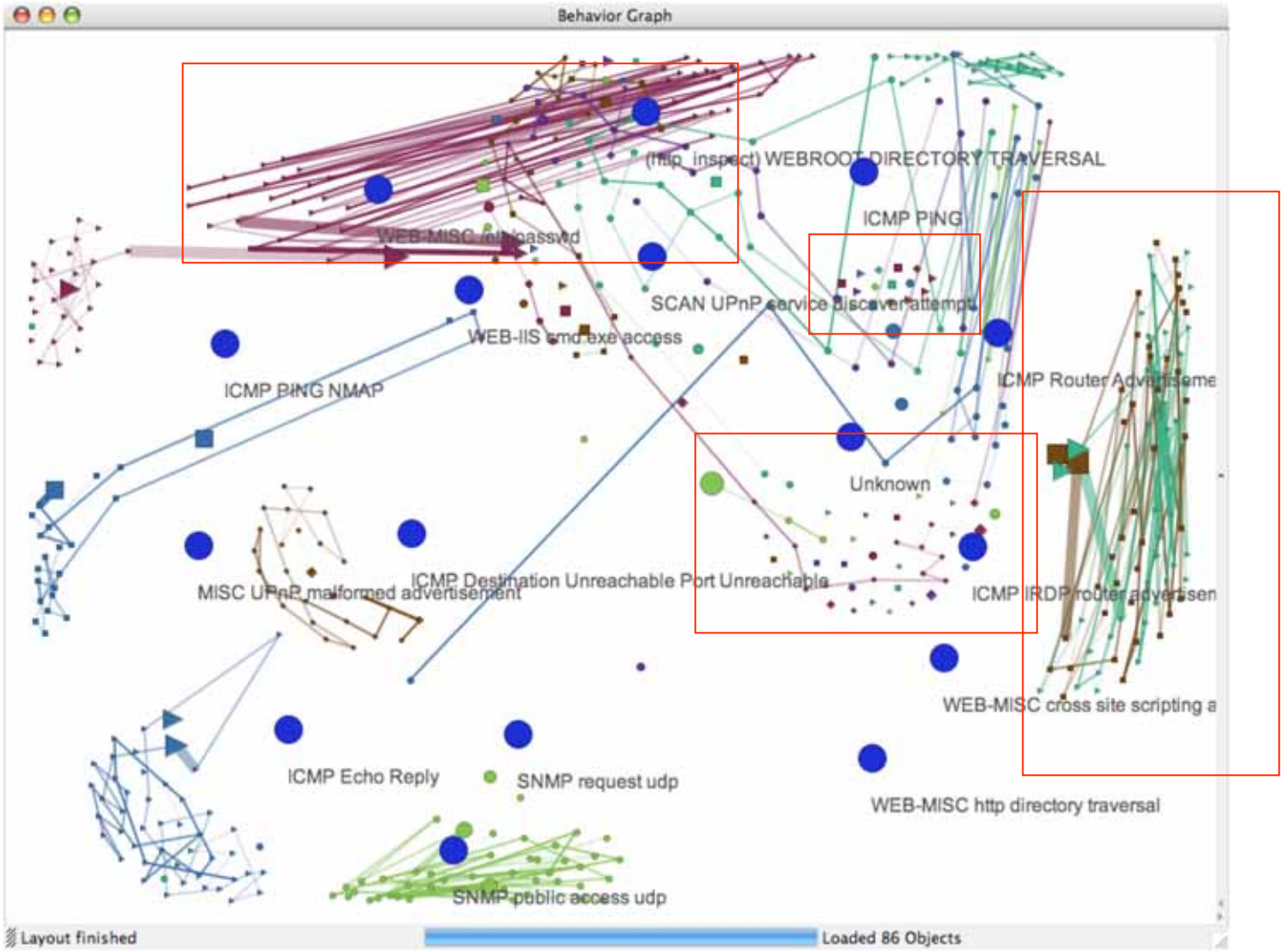
4. Automatic accentuation of node groups with highly variable traffic



5. HNMap integration: Monitor network traffic behavior

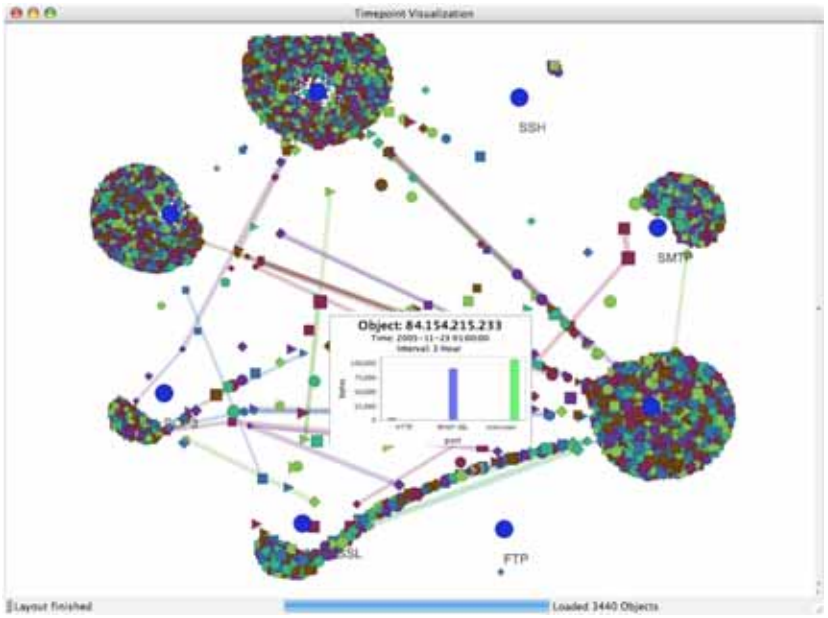


6. Case study: 19 000 SNORT alerts

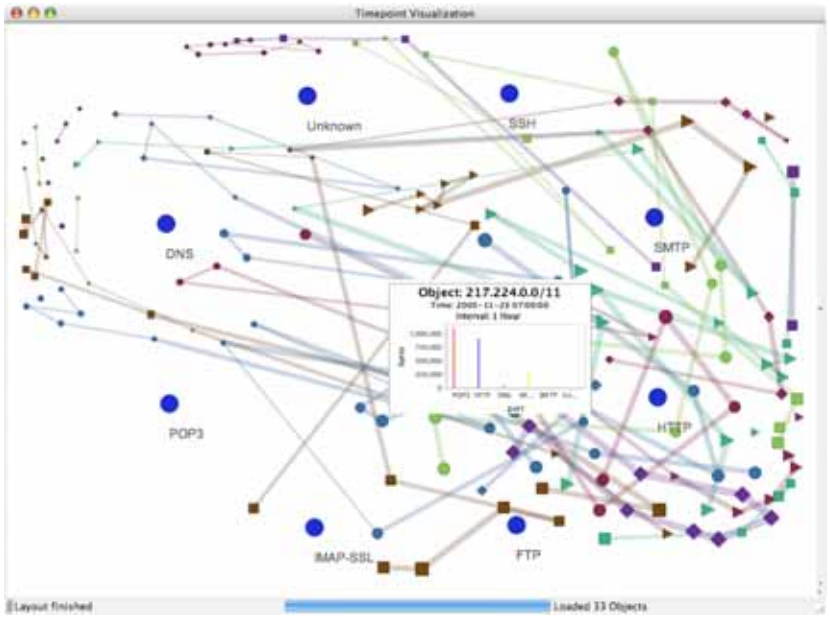


7. Evaluation: Scalability

- Max: 1000 observation nodes
- hosts * intervals



Hosts of AS 3320



Prefixes of AS 3320

7. Evaluation

Drawbacks

- Scalability limitations (1000 observation nodes)
- Only rough approximation of traffic proportions (ambiguity).

Advantages

- Changes in the traffic of many different nodes is made visible.
- Interactive exploration of data sets
- Automatic accentuation of high-variance hosts
- Usefulness of the approach is demonstrated

8. Conclusions

1) We presented a **novel graph-based network traffic visualization** to monitor host behavior using a force-base graph layout

2) HNMap integration: apply graph on **hosts, prefixes, ASes, countries, and continents**

3) Usefulness demonstrated on network traffic (university gateway router, IDS events)

4) Visual analytics feature: **automatic accentuation** of suspicious node groups with highly variable traffic

Future work: spacio temporal data analysis, text visualization

Acknowledgment

- Lorenz Meier for his excellent work
- Data sources:
  - MIT Lincoln Lab (DARPA 99)
  - Fabian Fischer (Snort alerts)
  - Rechenzentrum
- BWFit: information at your fingertips – interactive visualization for Gigapixel displays
- DFG GK 1042: „Explorative Analysis and Visualization of Large Information Spaces“

Questions?

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References

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