# Visualization of Node Interaction Dynamics in Network Traces

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# Outline of the Talk

# Background and Motivation

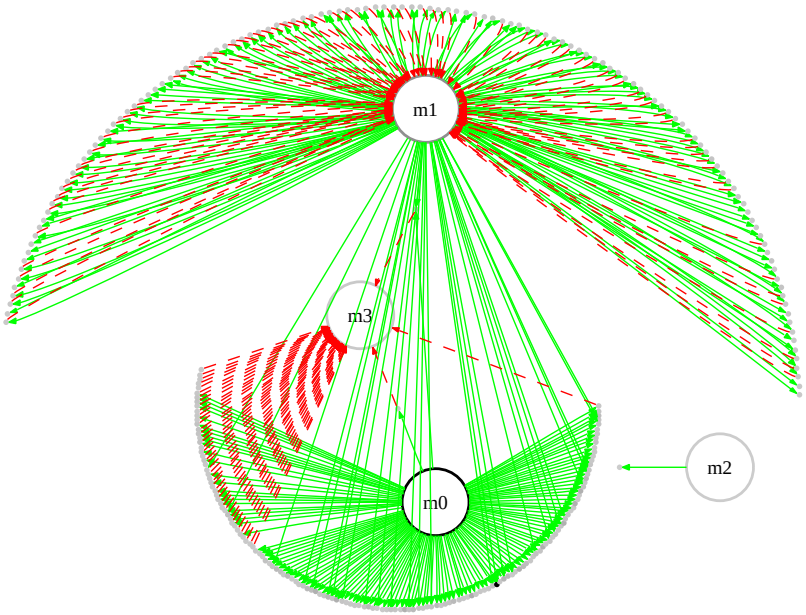
# Background: SNMP Trace Collection and Analysis

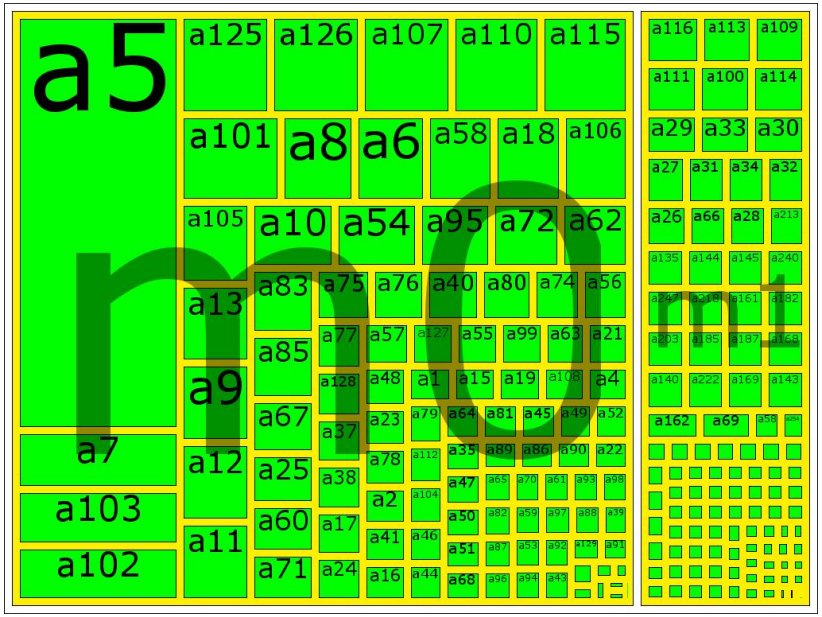
- SNMP trace collection and analysis developed since 2006 by the NMRG of the IRTF and the EMANICS project

- Insights to be gained from the analysis of traces:
  - basic trace statistics
  - periodic versus aperiodic traffic
  - message size distributions and latency distributions
  - manager and agent concurrency levels
  - table retrieval algorithms
  - popular MIB modules and MIB objects
  - usage of protocol specific features
  - ...

- For more background information, consult [1, 2, 3].

# Early Analysis Results (trace l06t01, IM 2007)




- Analysis covering the whole trace capture period
- Traffic broken down into flows ($\neq$ NetFlow/IPFIX flows)
- Static visualizations using flow graph layouts (Graphviz) and flow traffic treemaps

# Visualization of Node Interaction Dynamics

## Some Research Questions

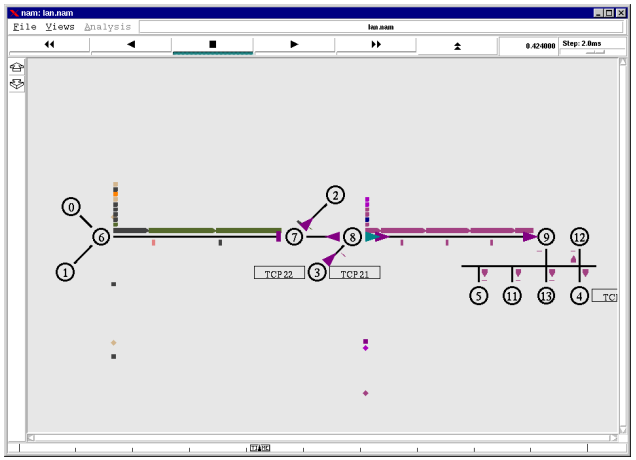
- Does a data collection engine spreads the data retrieval traffic over a polling cycle or does it send a burst of polling requests at the start of each cycle?
- Are there any topology changes or even pattern of topology changes?
- Do notifications change the traffic pattern generated by management applications?

## Approach

- Visualize node interaction dynamics in order to gain insights into the short-term properties of SNMP traffic.

# Experiment #1: NAM (C, C++, Tcl/Tk)

# Network Animator NAM



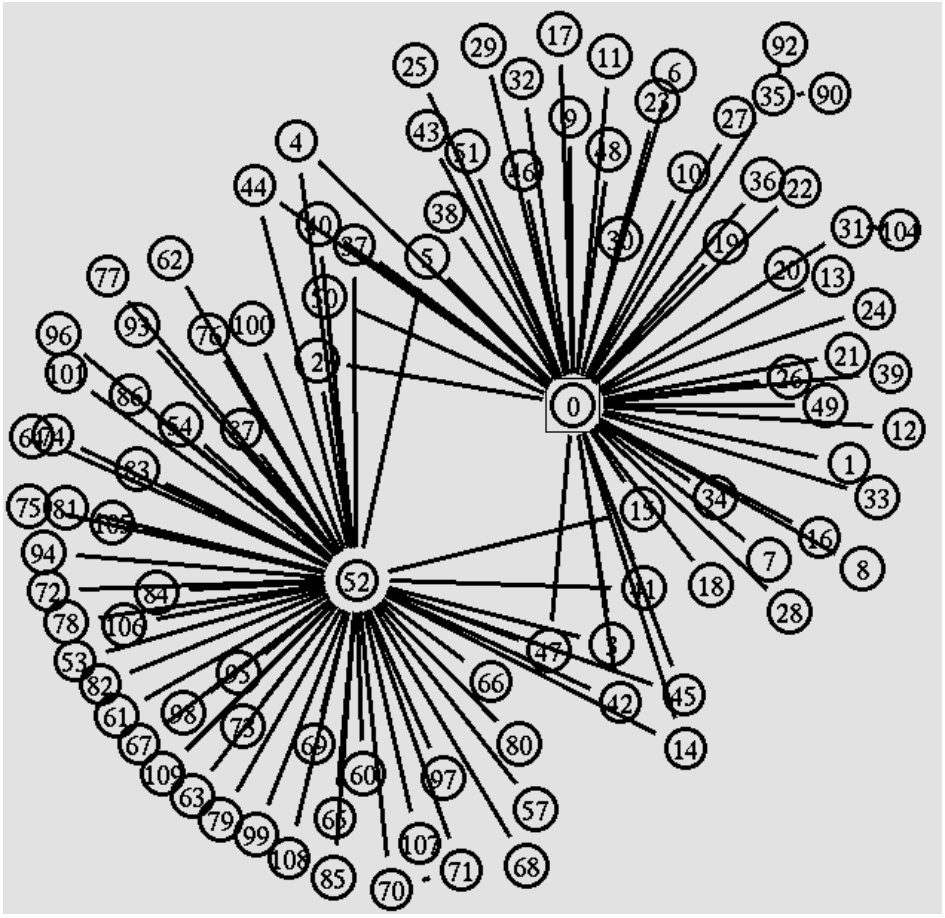

- Animation tool for viewing network simulation traces and real world packet traces
- Created in 1990 at LBL and further developed at ISI
- Includes an editor to create network diagrams
- Supports the visualization of queues and packet drops

# Visualizing SNMP Traces with NAM

## Conversion Algorithm

- Read an SNMP trace file in the CSV format
- Generate a NAM trace file header defining nodes and links
- Generate send/receive events for each SNMP message
- Set the link delay to 60 seconds (parameter)
- Set the link data rate to 1kbps (parameter)

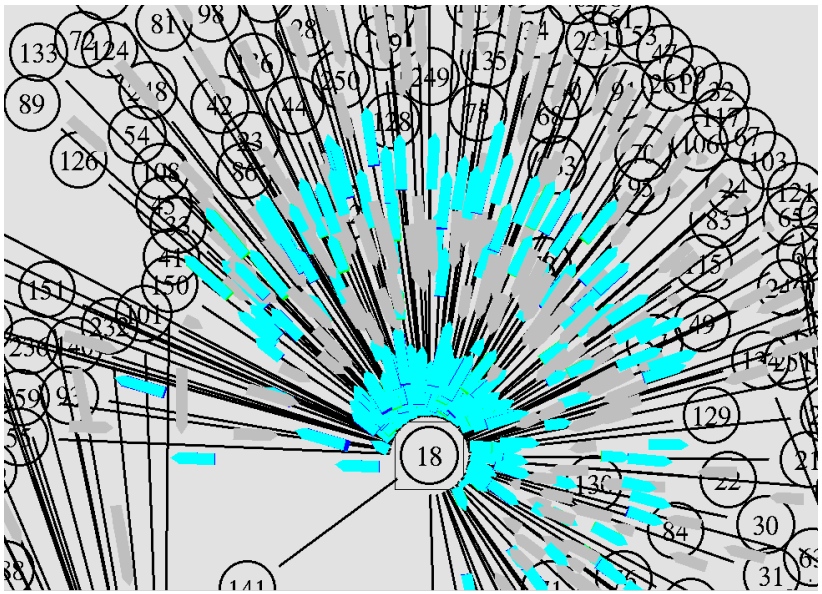
# NAM Results



The graph layouts produced by NAM are of relativly poor quality (overlapping nodes, overlapping links)

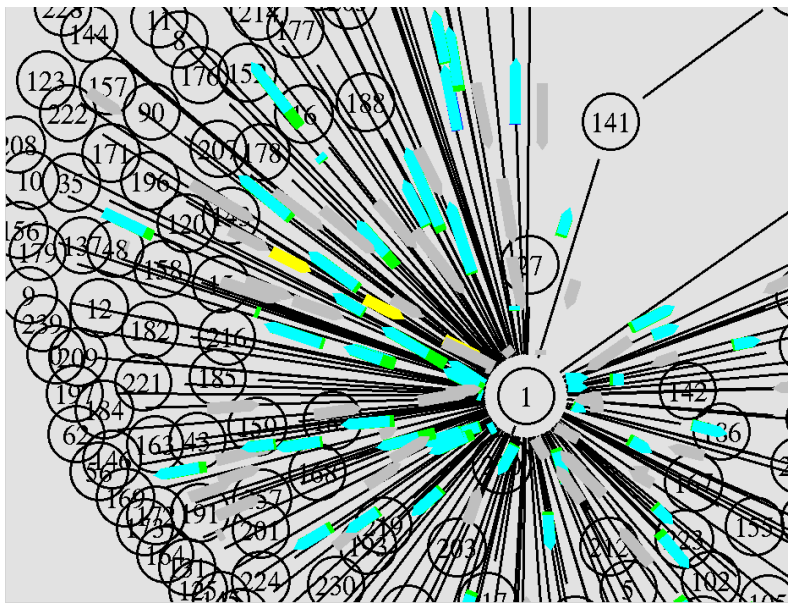
The builtin zooming capabilites of NAM are only of little help

# NAM Results (trace l06t01)




A manager polling devices in “waves”, causing bursts of SNMP traffic

A manager distributing polling requests well over time plus a notification originating from one agent



# NAM Discussion

## Positive NAM Experience

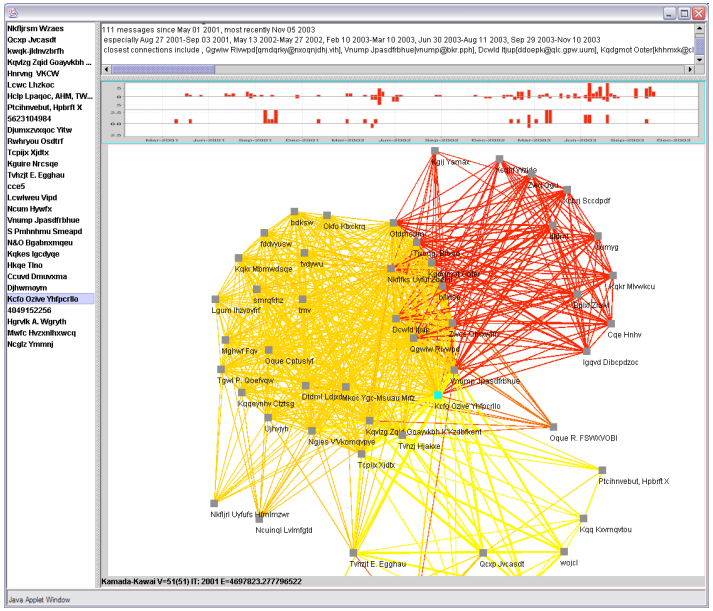
+ Availability (part of the popular ns-2 simulation toolkit)
+ Easy to get started (textual intermediate file format)

## Negative NAM Experience

- Difficult to extend mixture of C, C++, and Tcl/Tk
- Weak deeply embedded graph layout algorithm
- Graphics quality poor according to today's standards
- Performance problems when dealing with larger traces
- GUI controls optimized for short timescales

# Experiment #2: JUNG (Java)

# JUNG Graphics Library



- Java Universal Network / Graph Framework (JUNG)
- Written in 2003 by PhD students (University of California at Irvine)
- Analysis of social networks

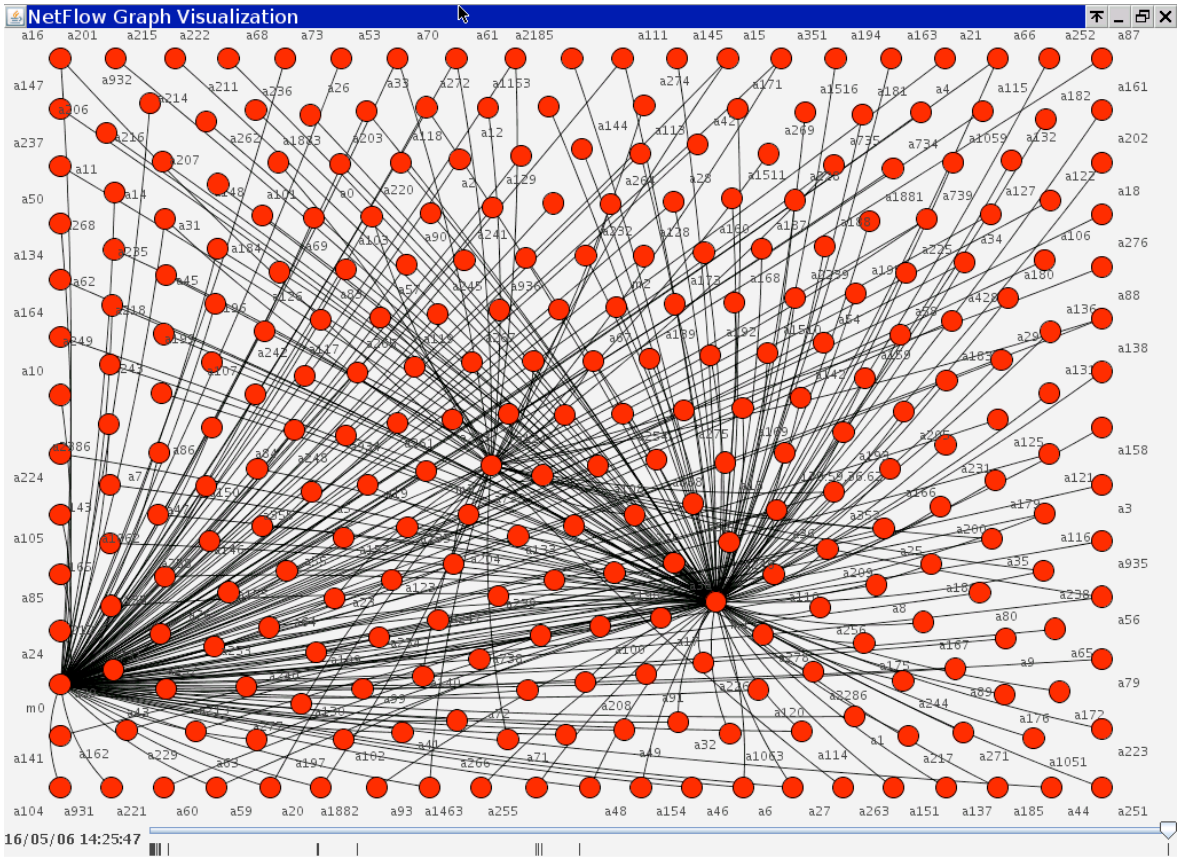
- Our goal: visualize topology changes over time (nodes / links appearing / disappearing)
- Generate an intermediate file with graph change events
- Visualize the changing graph using JUNG

# Visualizing SNMP Traces with JUNG

## Conversion Algorithm

- Read an SNMP trace file in the CSV format
- Generate vertex add (Va) and edge add (Ea) events when a new node appears or a node starts communication with some other node it has not communicated with recently
- After $t_{link}$ seconds of inactivity, an edge is removed by generating an edge remove (Er) event
- A node without any links is removed after $t_{node}$ seconds by generating a vertex remove (Vr) event

# JUNG Results




The timeline shown at the bottom of the window indicates when changes happen in the topology

# JUNG Discussion

## Positive JUNG Experience

+ Much better graph layout algorithms (compared to NAM)
+ Very good documentation of the JUNG library
+ Many code examples make it easy to get started

## Negative JUNG Experience

- Performance problems with the animation of larger graphs
- Topology change timeline is essential due to change blindness of the human visual perception system
- Controlling graph “stability” is complicated

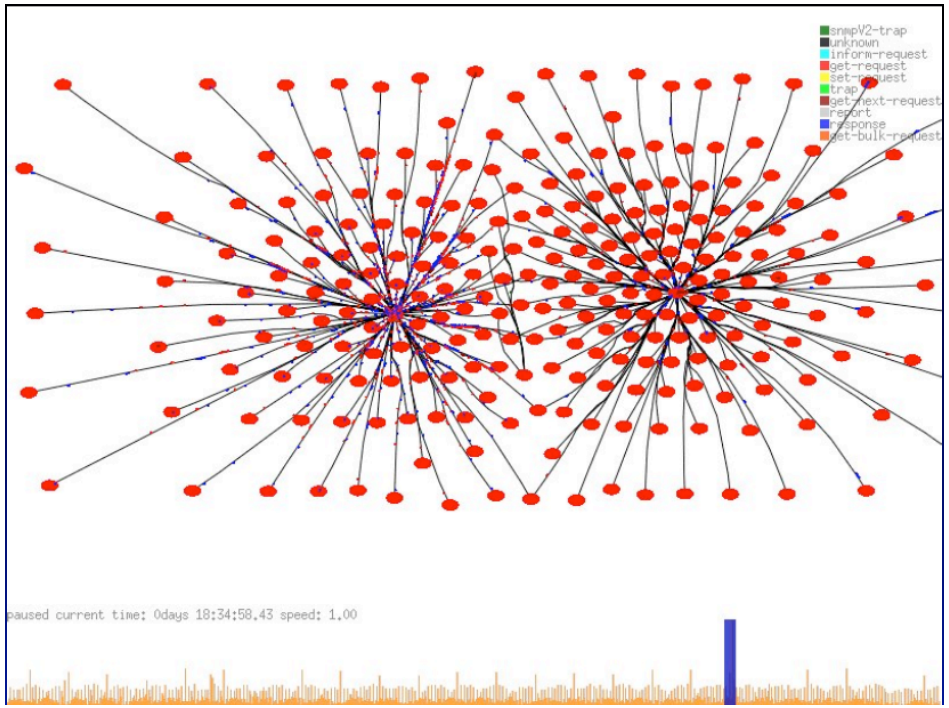
# Experiment #3: SNAM (OpenGL)

# SNAM

## Features

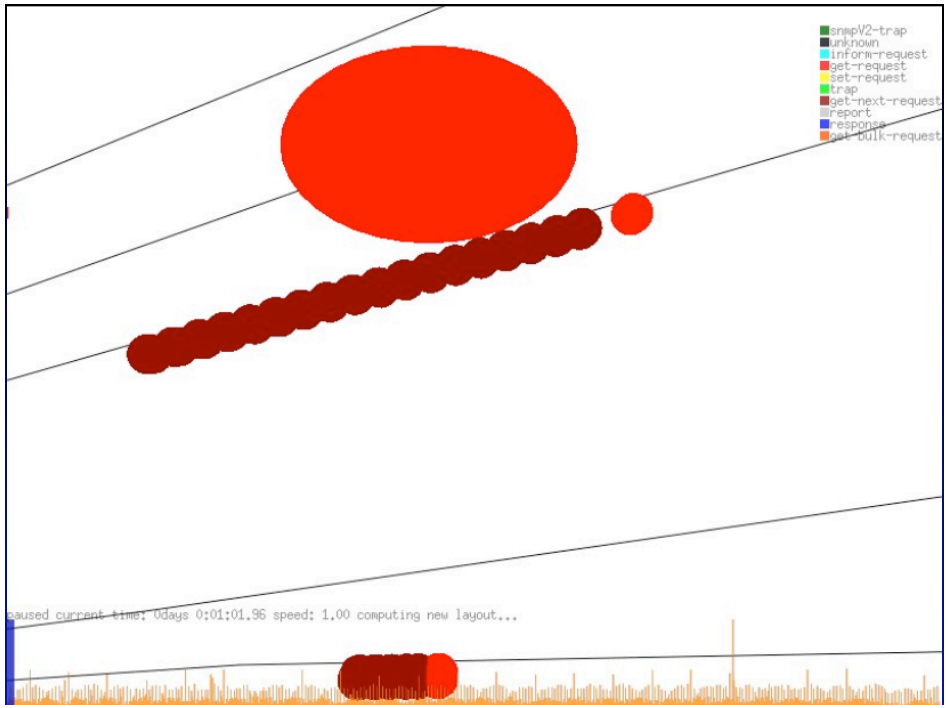
- Written in C++ utilizing fast graphics hardware
- Graph layout outsourced to Graphviz
- Layout recalculations run as a separate thread
- Links can be represented as splines
- Supports fast forward/backward animations and jumps
- Inspection of annotations of nodes, links, messages
- Uses an “extended subset” of the NAM file format

# SNAM Results #1



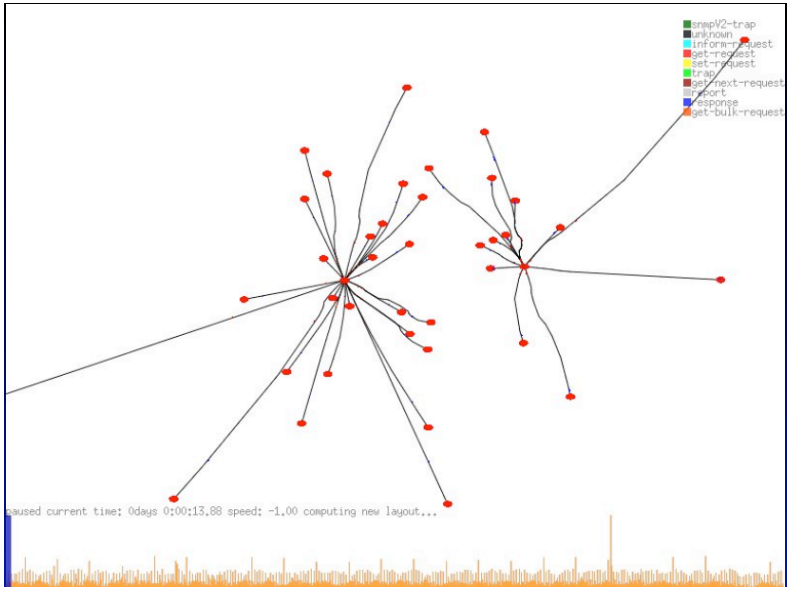

- Topology, color coded messages, activity timeline
- Textual information displayed in the background
- Controls to zoom, change speed, jump in the timeline, ...

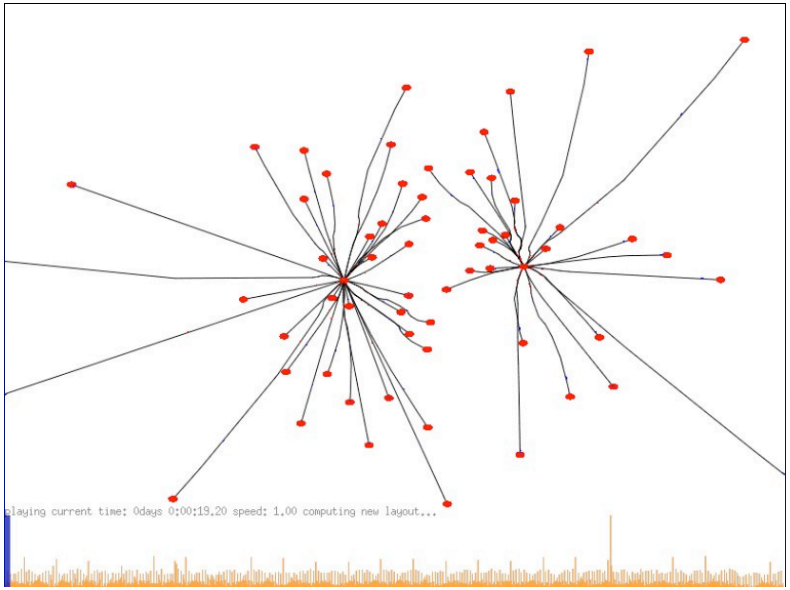
# SNAM Results #2

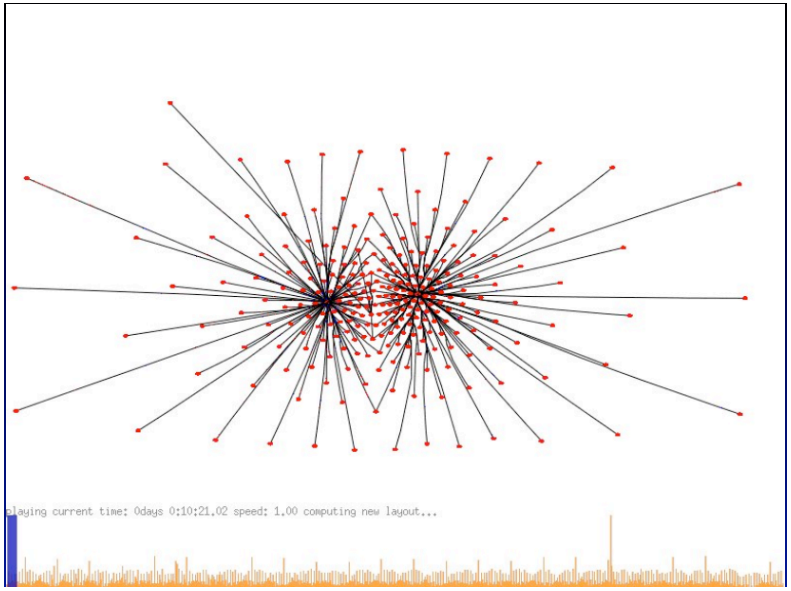



- A manager trying a get-bulk-request and then falling back to a series of get-next-requests
- Obviously not caching learned SNMP agent capabilities

# SNAM Results #3



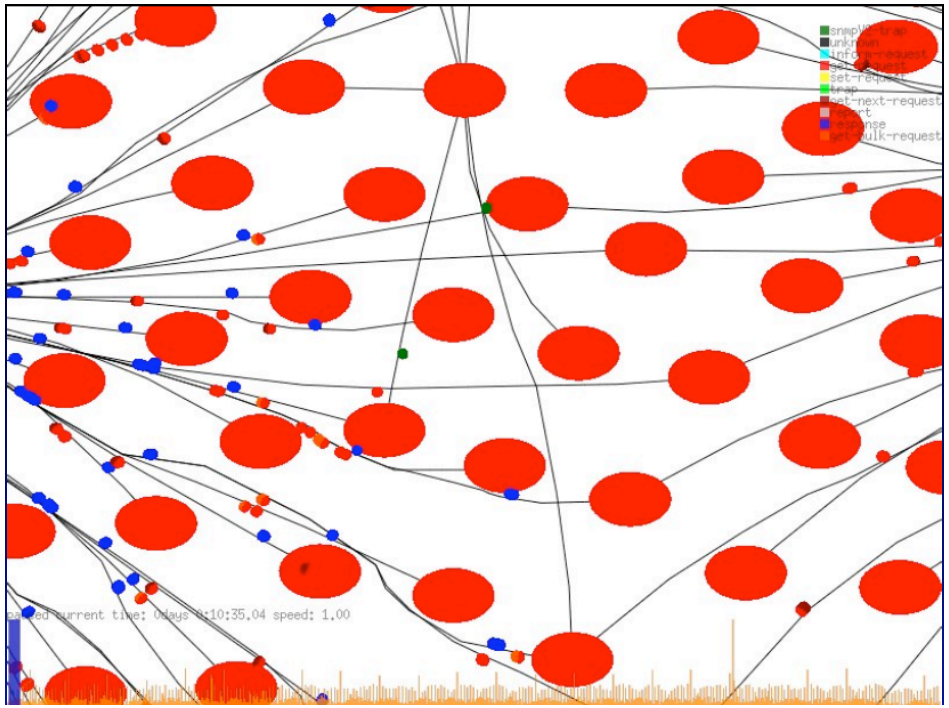




The graph topology changes dynamically (similar to the JUNG prototype)

New layouts are calculated in the background

# SNAM Results #4



- Graph layout can use splines to avoid links crossing nodes
- Messages travel along the splines
- Zooming is cool — lenses might be even cooler...

# SNAM Discussion

## Positive SNAM Experience

+ OpenGL is crucial for scalable fast visualizations
+ Using Graphviz allows us to focus on the main problem
+ Simple installation and high fun factor
+ Intermediate file format decouples visualization from the data source

## Negative SNAM Experience

- Selecting suitable Graphviz options sometimes difficult
- Significant startup time (no streaming of trace data)
- Portable user controls take effort to implement
- Incomplete feature set (only subset of NAM supported)

# Conclusions

# Conclusions

## Contribution

- Created three tools to visualize node interactions
- Scalability is important for dealing with larger traces
- Reuse graph drawing libraries, use multi-threading
- OpenGL solution (SNAM) has the highest fun factor

## Future Work

- SNAM will be open sourced (its pretty small)
- We like to encourage people to try and improve it
- More visualizations (multiple alternate views)
- More interactive controls (select, highlight, filter, . . . )

# References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