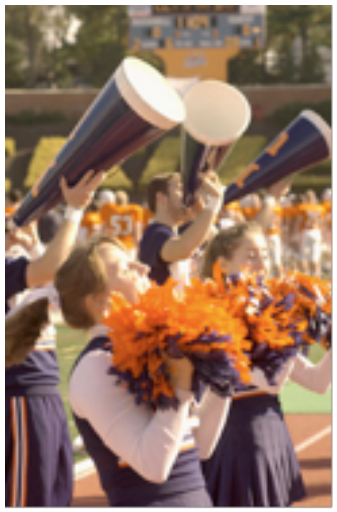
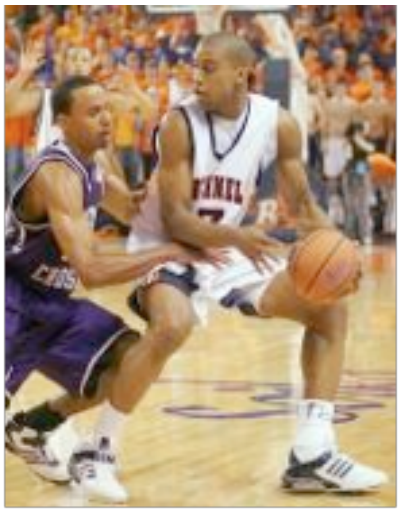
Bucknell UNIVERSITY

Data Visualization for Network Simulations

Christopher S. Main L. Felipe Perrone Greg L. Schrock

Department of Computer Science
Bucknell University, PA, U.S.A.



Acknowledgments

ns-3

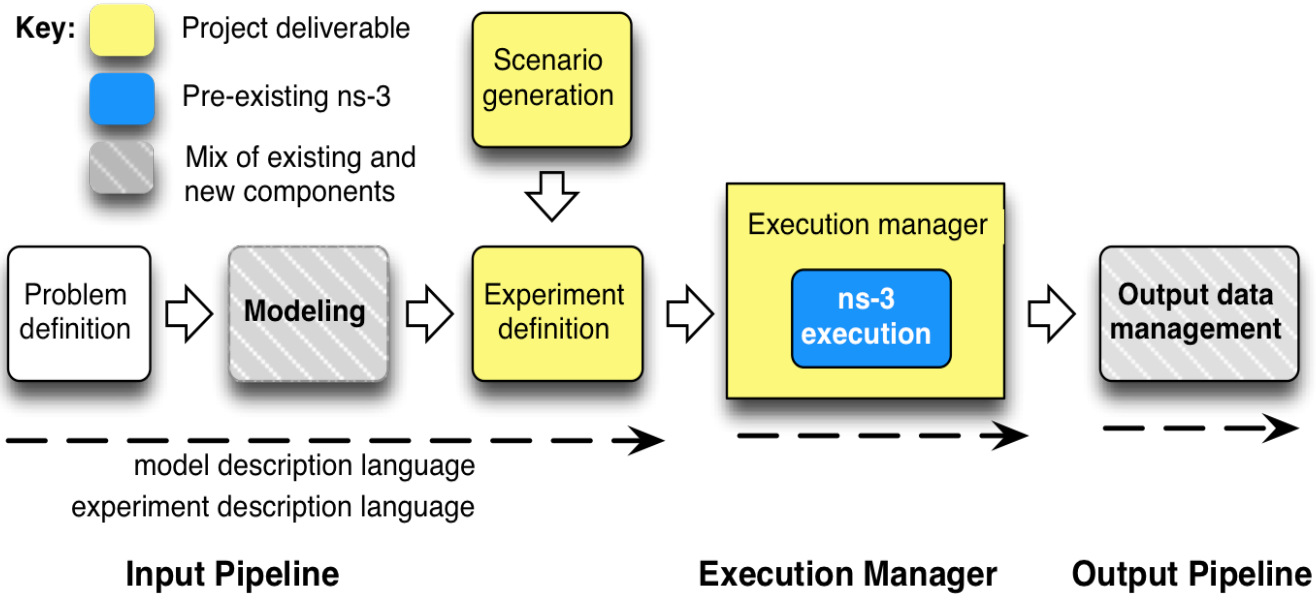
ns-3 is a free, open source software project building and maintaining a discrete-event network simulator for research and education

Technical goals:

- Build and maintain a simulation core aligned with the needs of the research community
- Help to improve the technical rigor of network simulation practice

Frameworks for ns-3

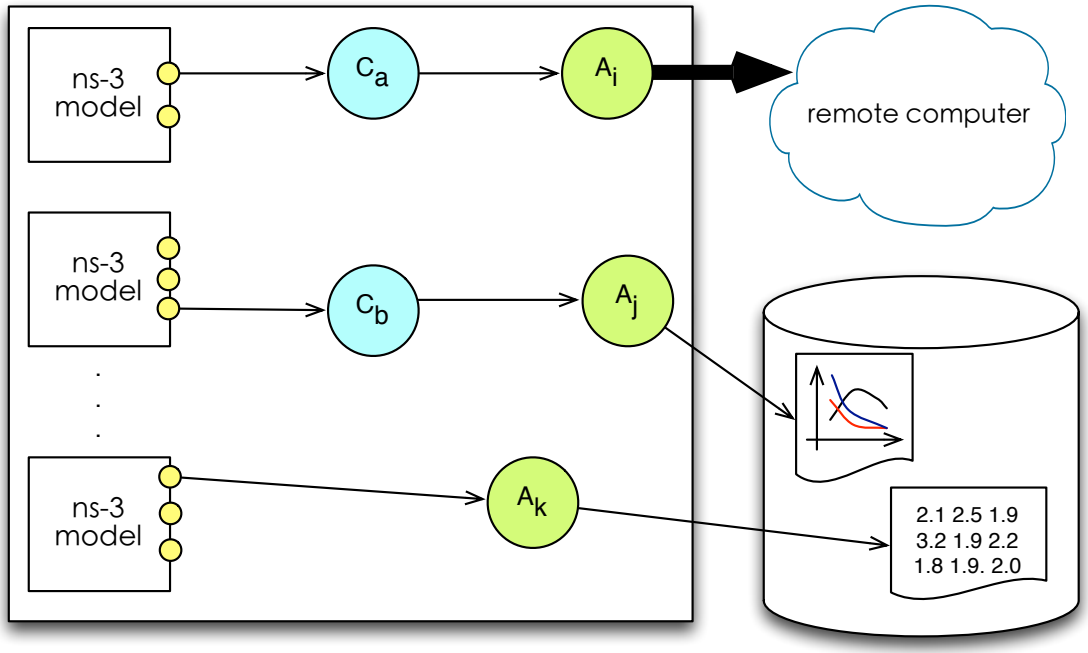
NSF CISE Community Research Infrastructure
University of Washington (Tom Henderson),
Georgia Tech (George Riley),
Bucknell University (L. Felipe Perrone)



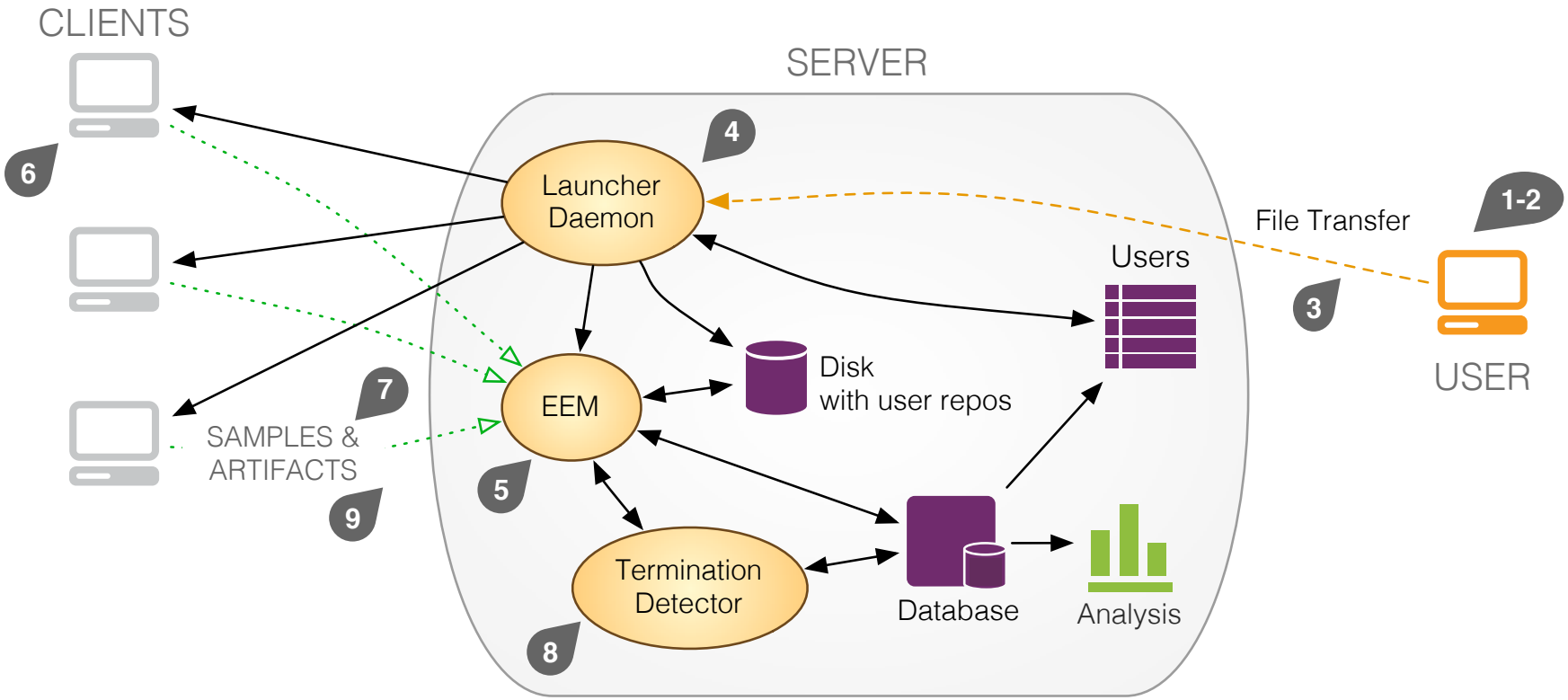
Data Collection Framework (DCF)

Perrone, Henderson, Watrous, and Felizardo (WSC 2013)

- DataCollectionObject: base class for DCF elements.
- Probe: extends TraceSources for controllability.
- Collector: encapsulates arbitrary computations on sampled data.
- Aggregator: marshals data into various output formats.



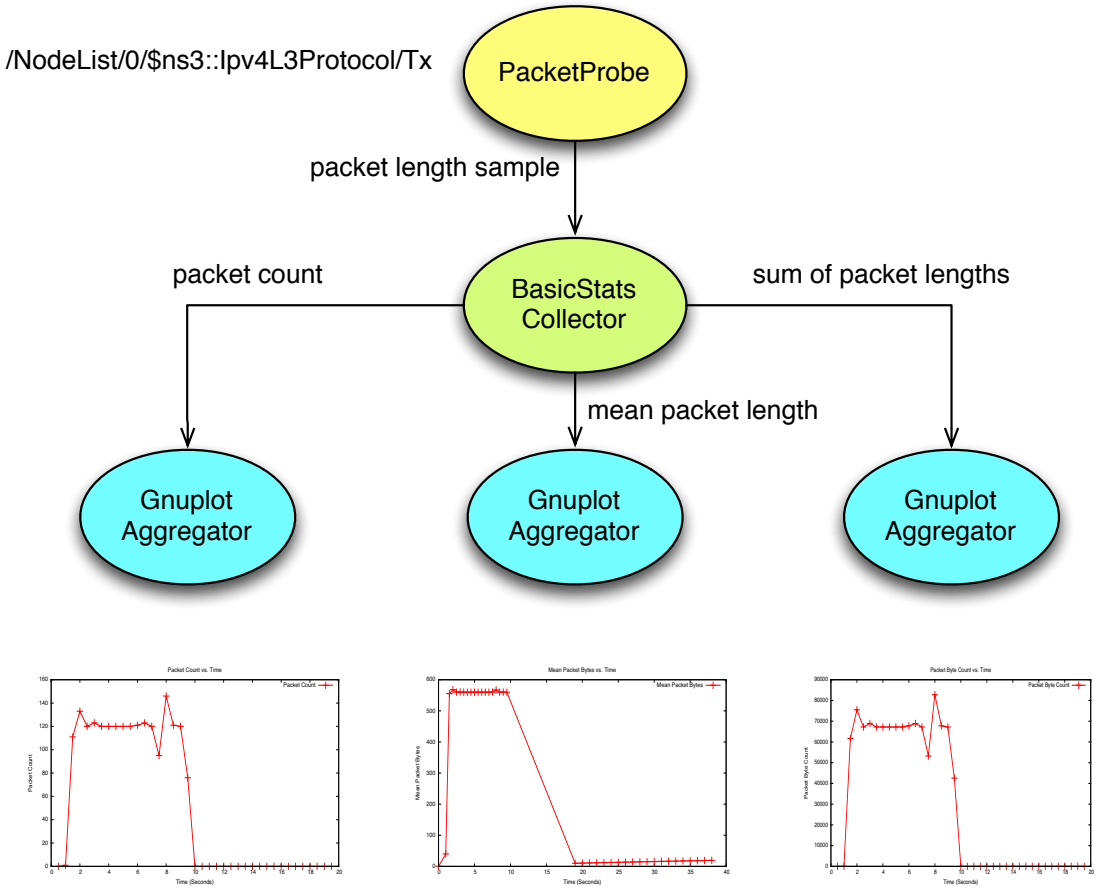
Simulation Automation Framework for Experiments (SAFE)



Perrone, Main, and Ward (WSC 2012)

Gnuplot: Aggregator and Helper

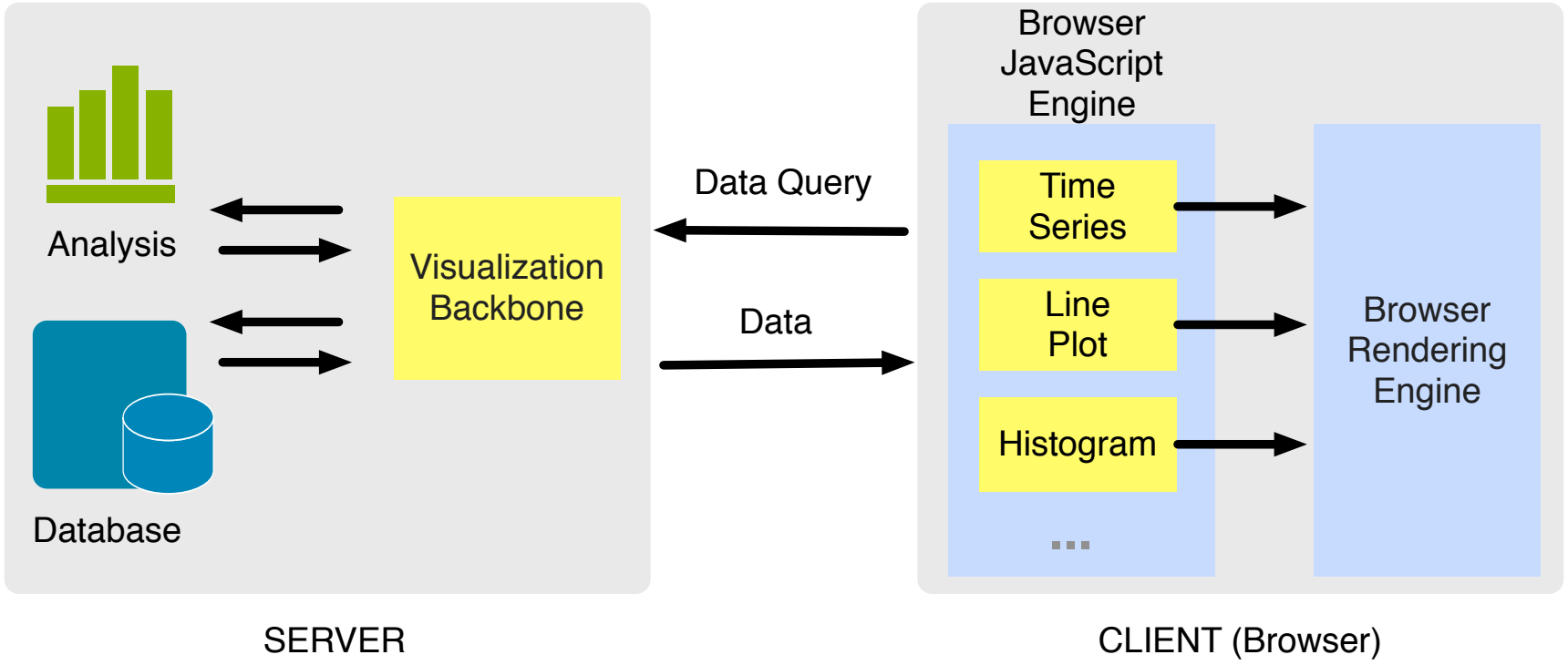
- Address basic visualization needs of the ns-3 user (non-interactive plots)
- Guarantee basic properties of plots
- Create separate files with data and gnuplot script
- Uses any format supported by gnuplot



SAFEty Net for Novices

- Offer various types of visualization
- Make retrieval from database easy and powerful
- Automate color selection
- Guarantee complete plot metadata
- Export various file formats (PNG, PDF, ...)
- Constrain choices to best practices
- Web-based UI

Visualization in SAFE



The point is…

There exists a extensive body of knowledge on visualization that we can leverage.

And..

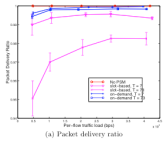
One can incorporate these lessons to put visualization intelligence into visualization tools.

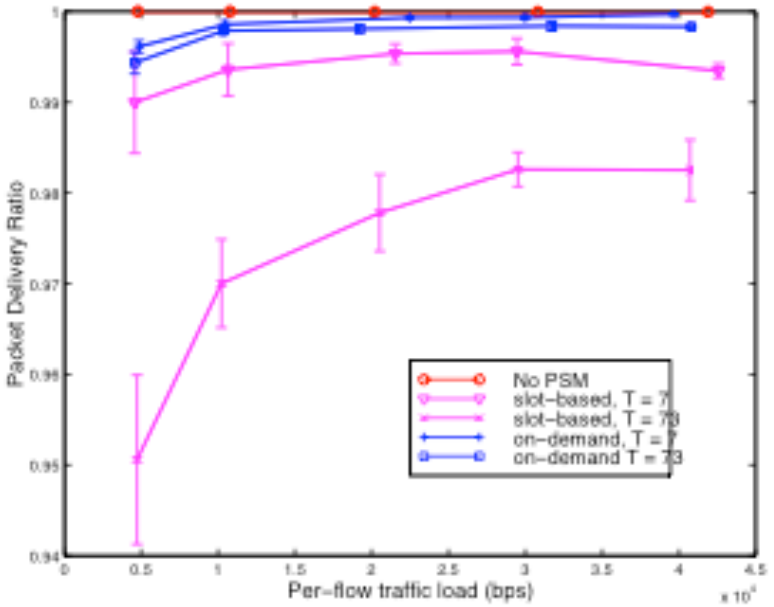
What is Sometimes Forgotten (Ignored?)

Human perception

Retinal Variables (Bertin 2010)

- size
- value
- texture
- color
- orientation
- shape





(a) Packet delivery ratio

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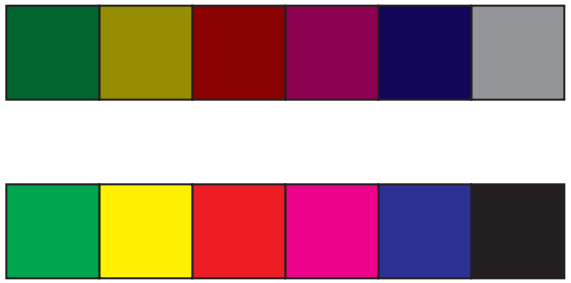

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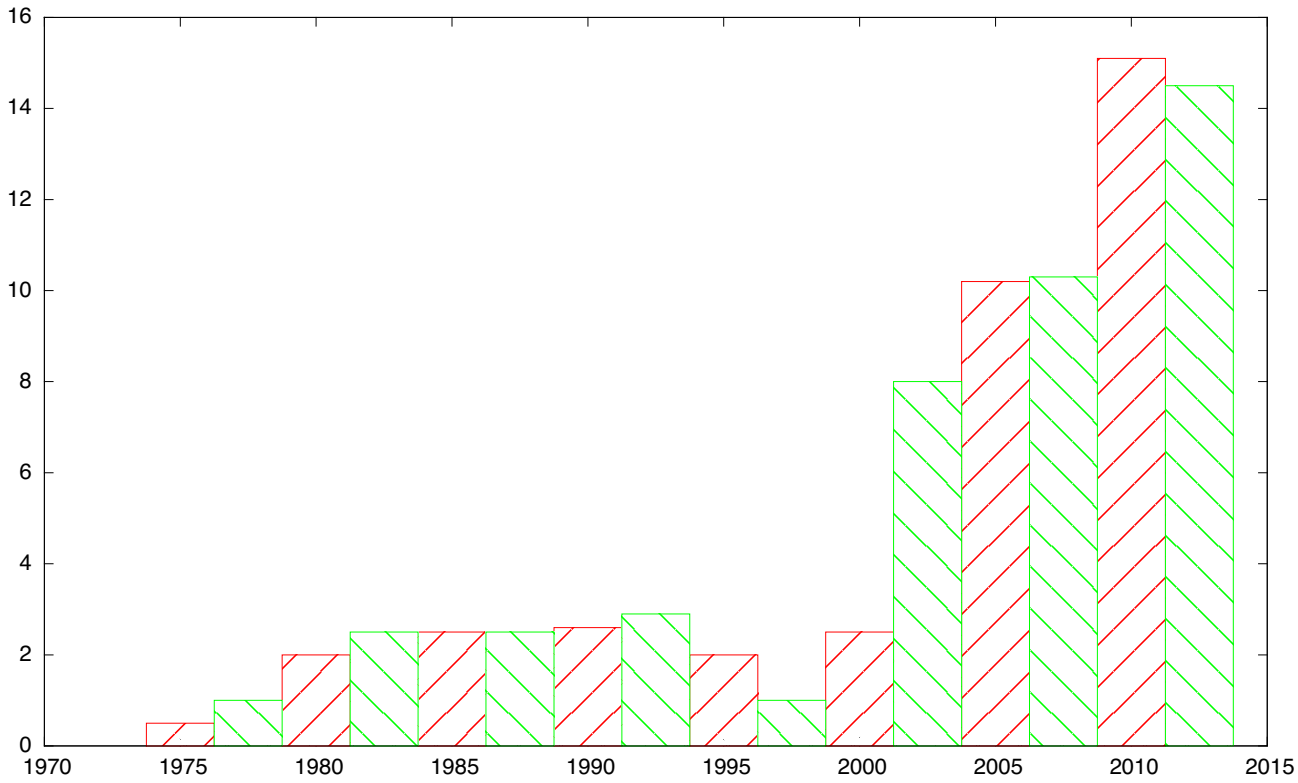

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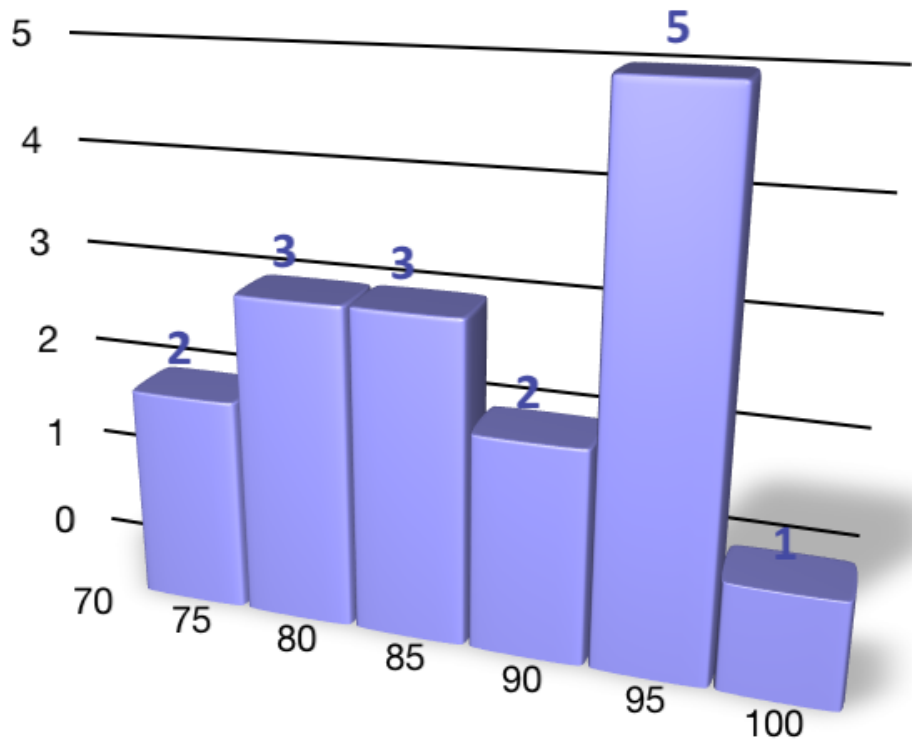

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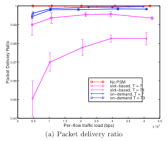
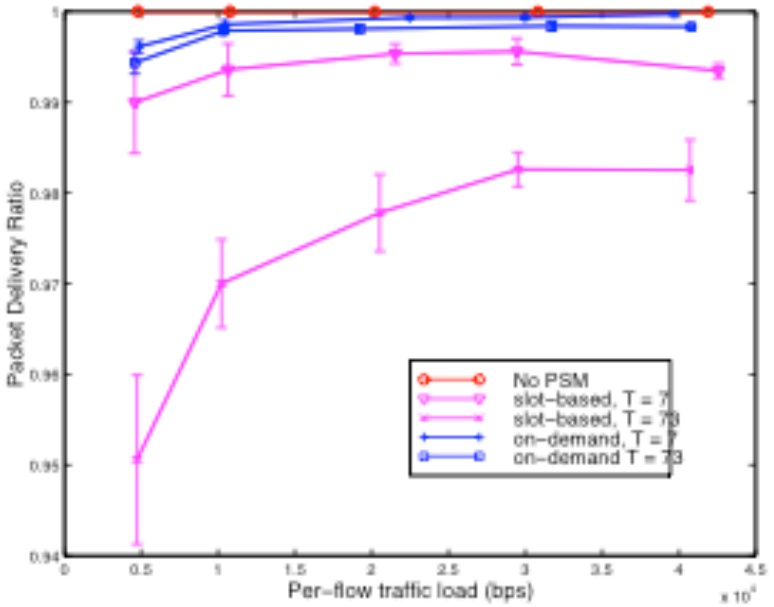
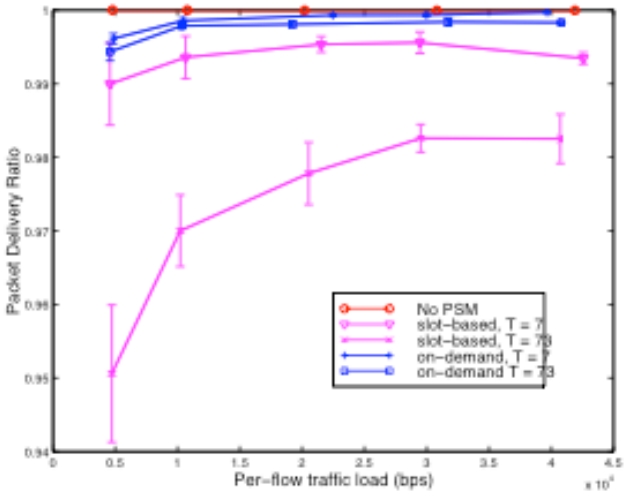




(a) Packet delivery ratio

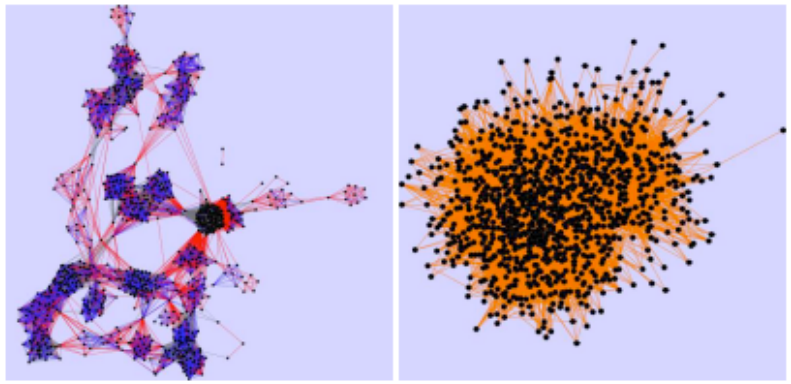
Visualization Needs of Network Simulation

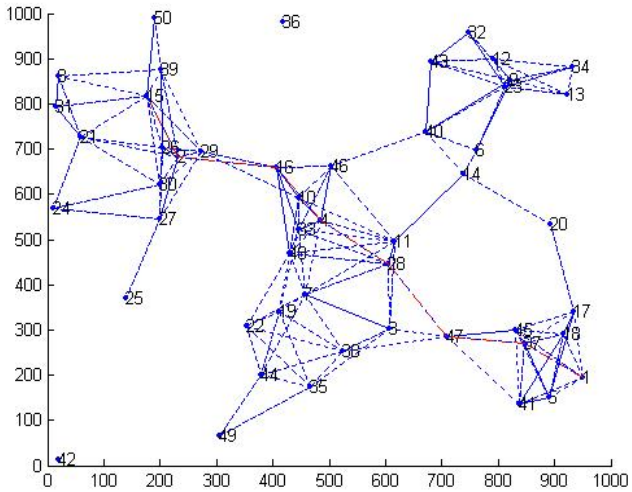
line plot



(a) Packet delivery ratio

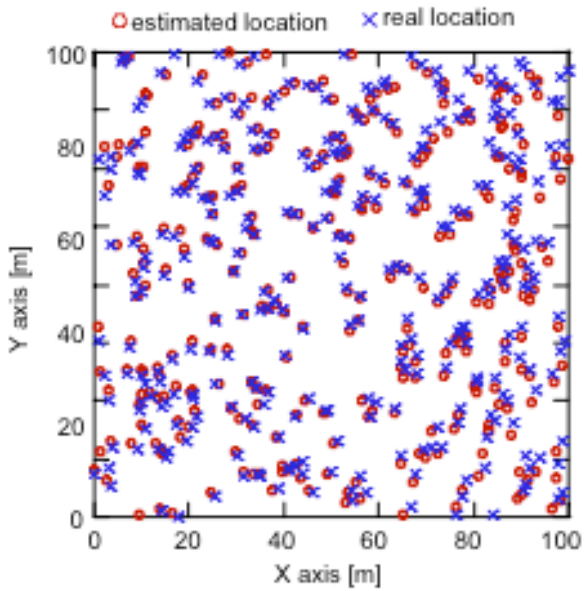
graphs



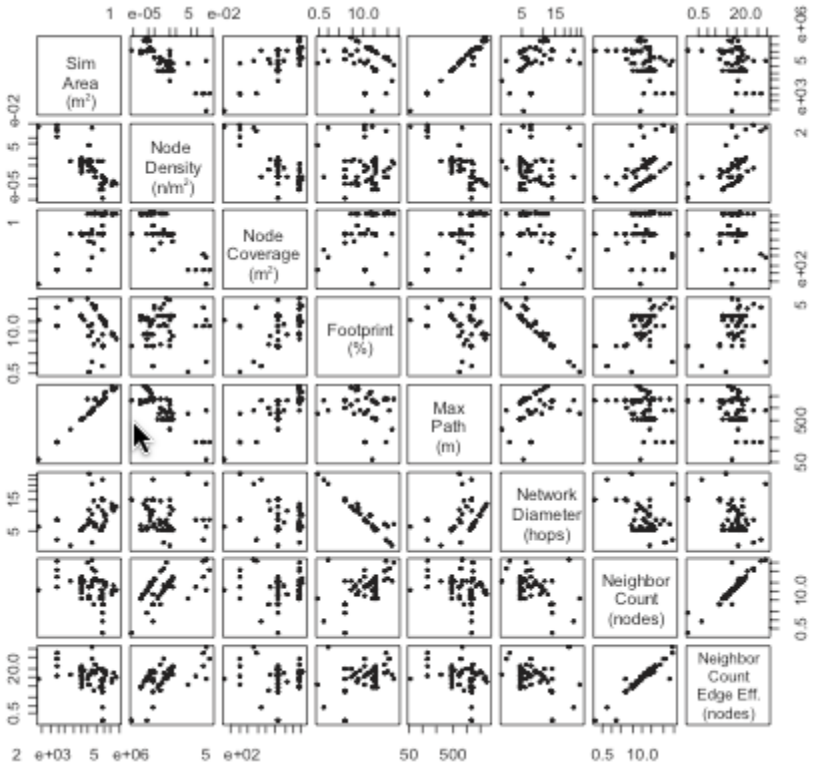


Visualization Needs of Network Simulation

scatter plot

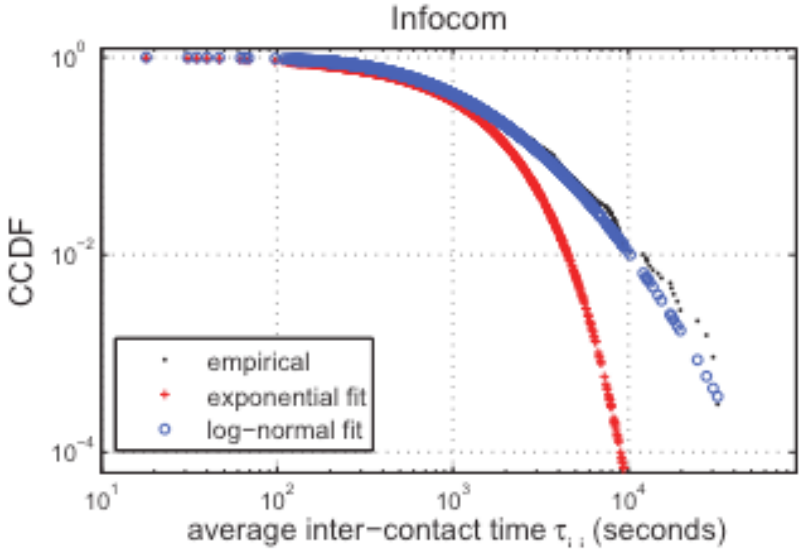


scatter plot matrix

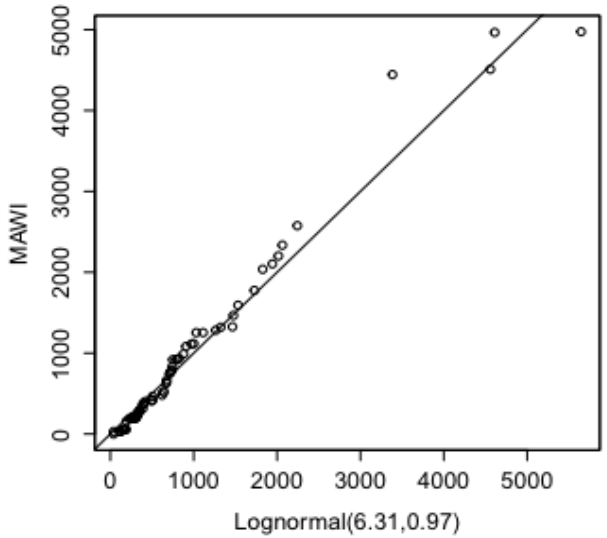


Visualization Needs of Network Simulation

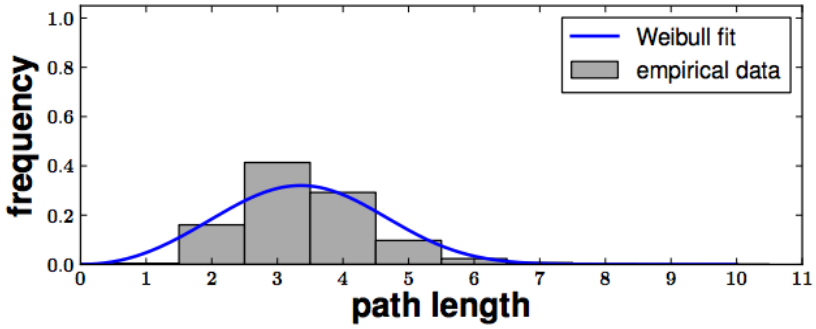
probability distributions



q-q plot

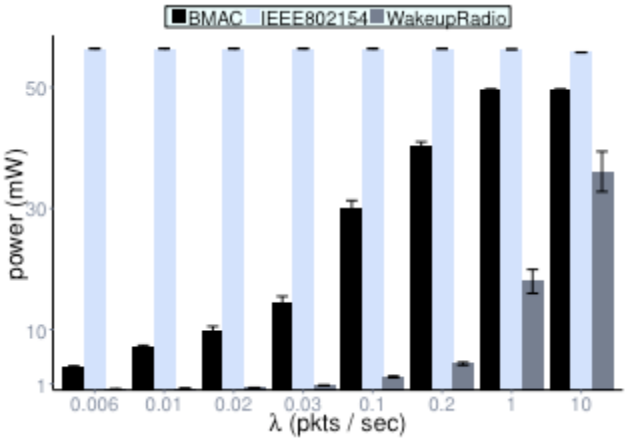


histogram

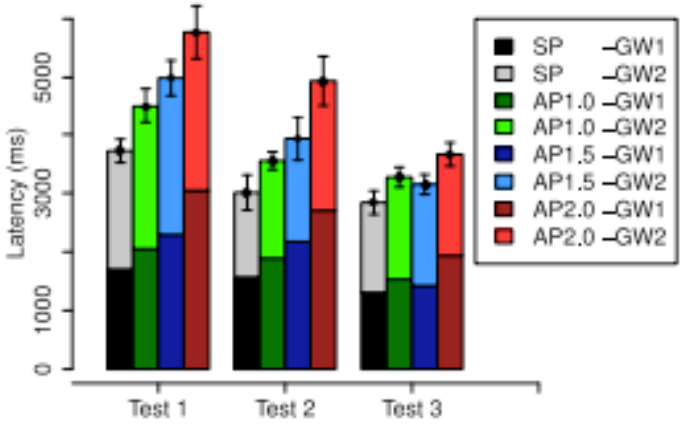


Visualization Needs of Network Simulation

bar graph



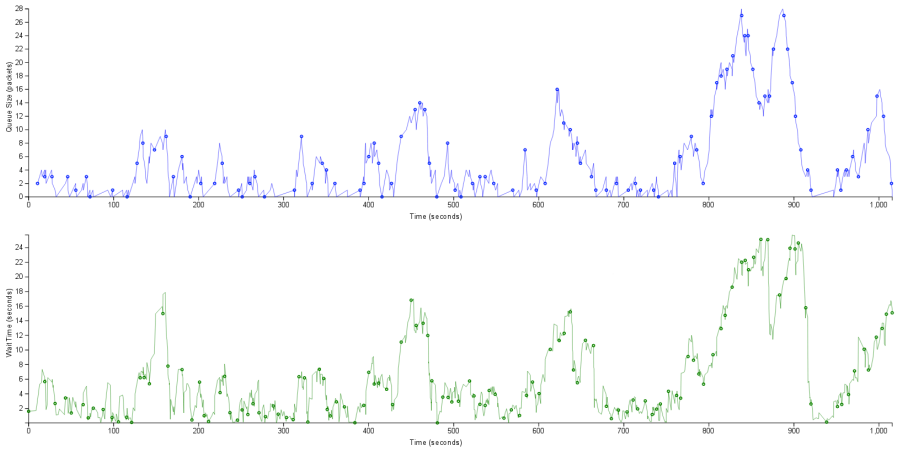
stacked bars



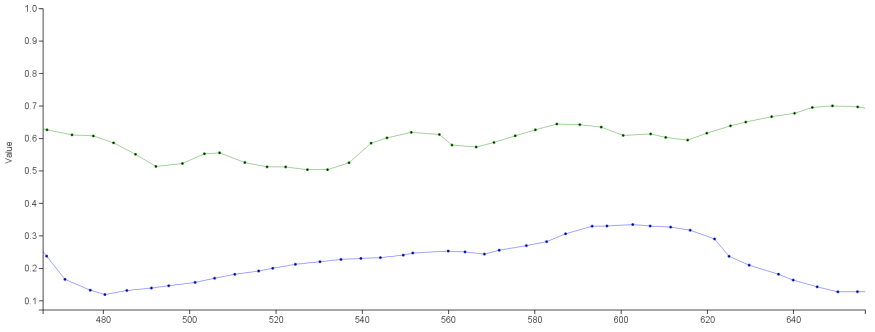
(a) Average latency

State of Development in SAFE

- Web-based UI: going into a third iteration
- Incorporates database retrieval, filtering, "smoothing"
- Supports for comparisons via:

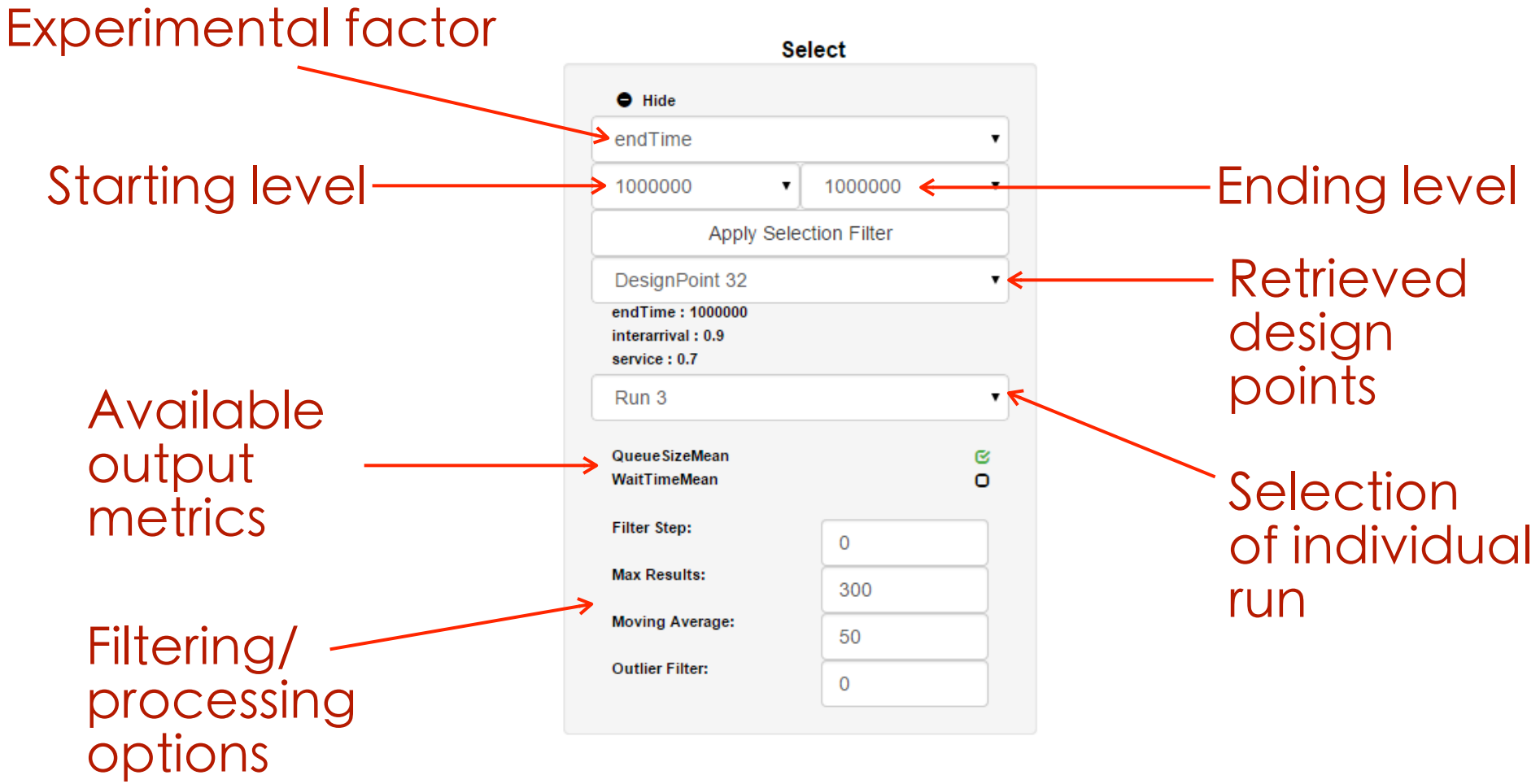


faceting

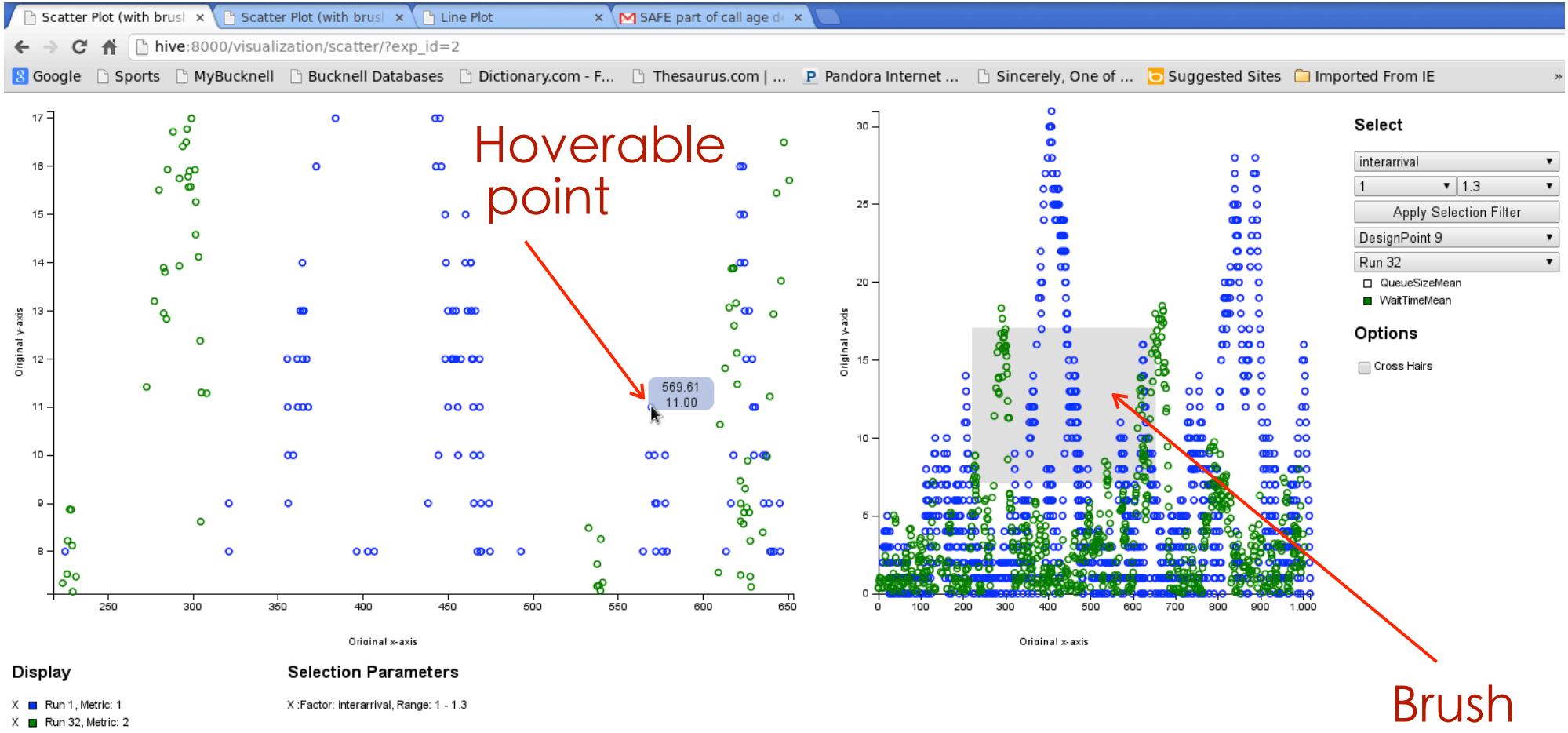


normalization

Control Panel



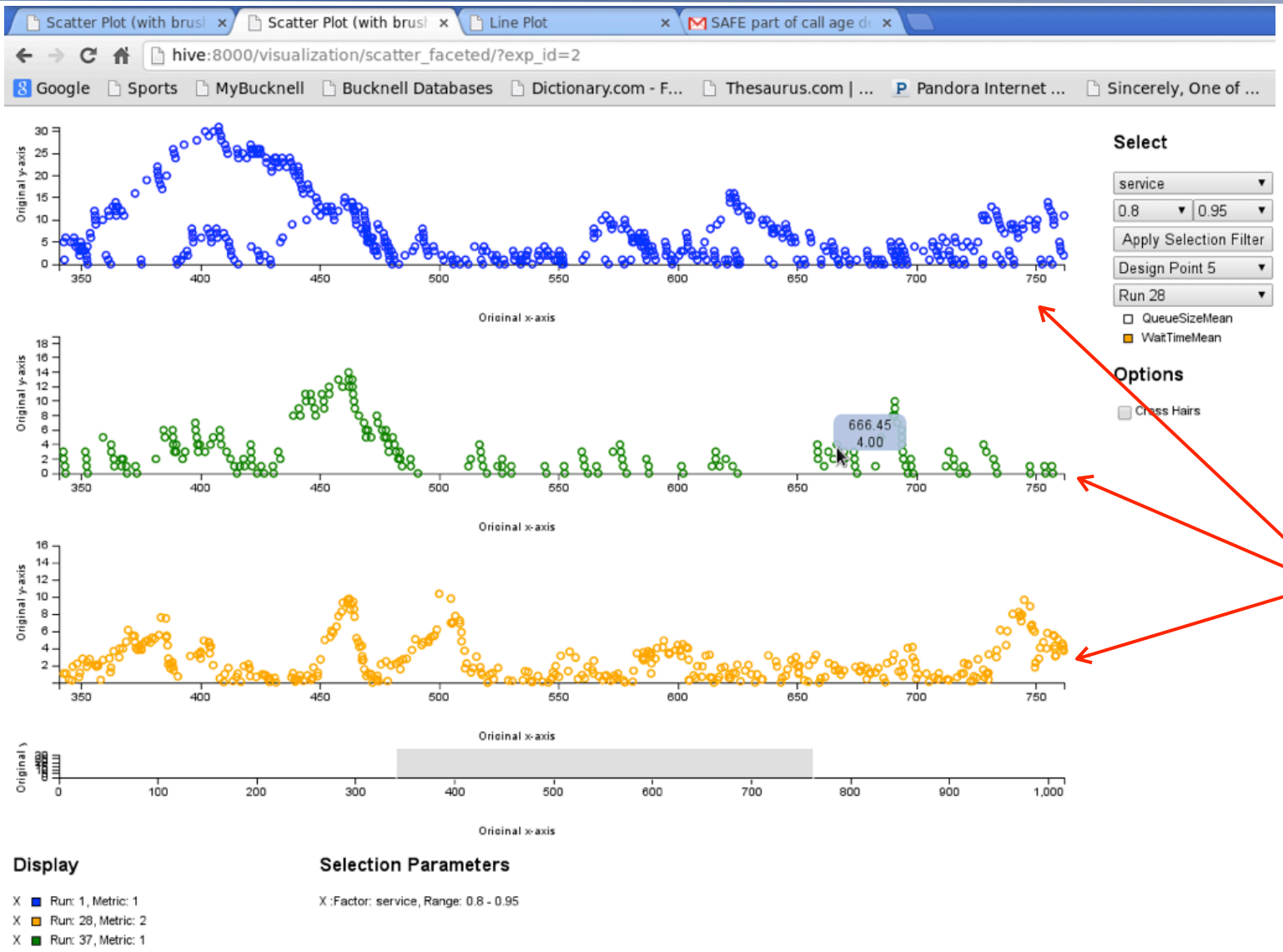
SAFE Visualization: Scatter plots



Focus
"Micro"

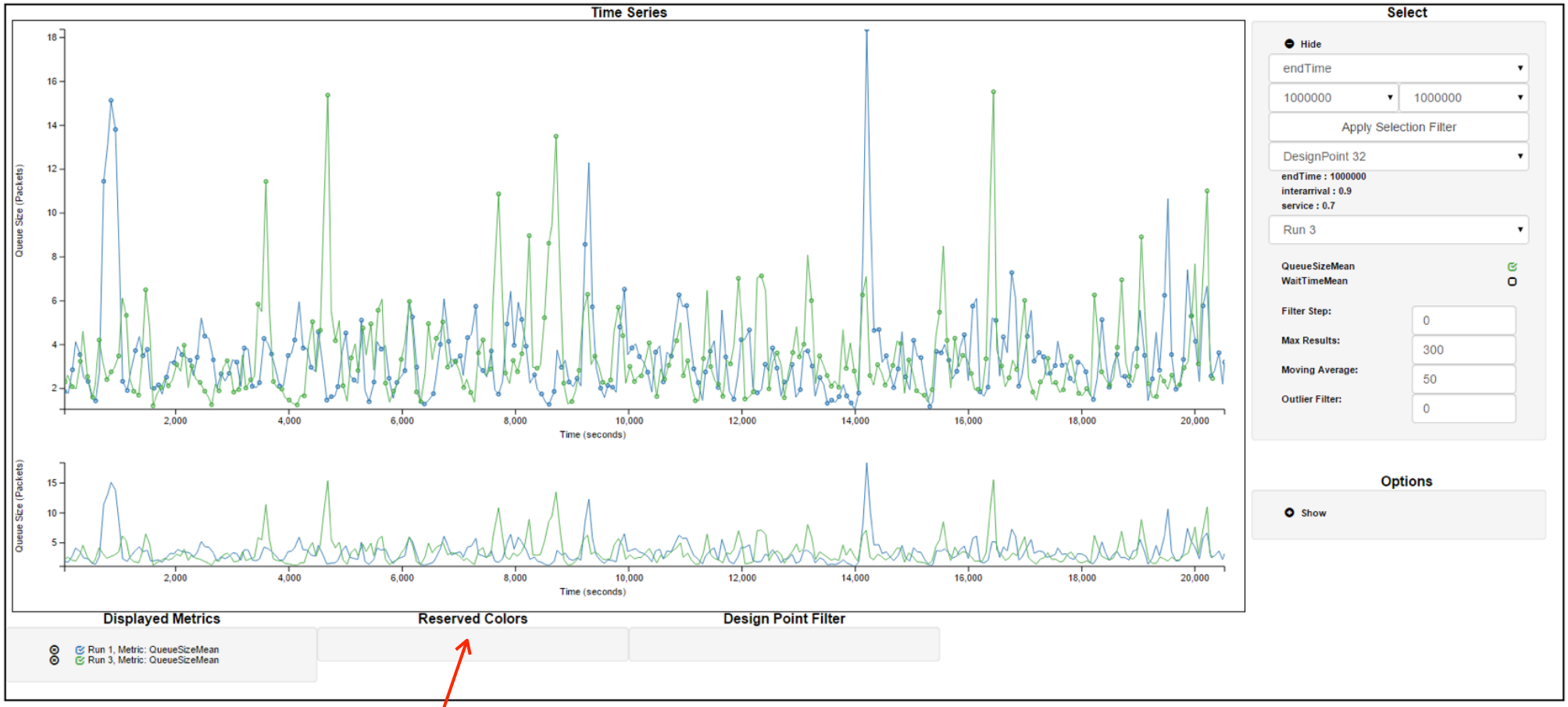
Context
"Macro"

SAFE Visualization: Comparing Scatter plots



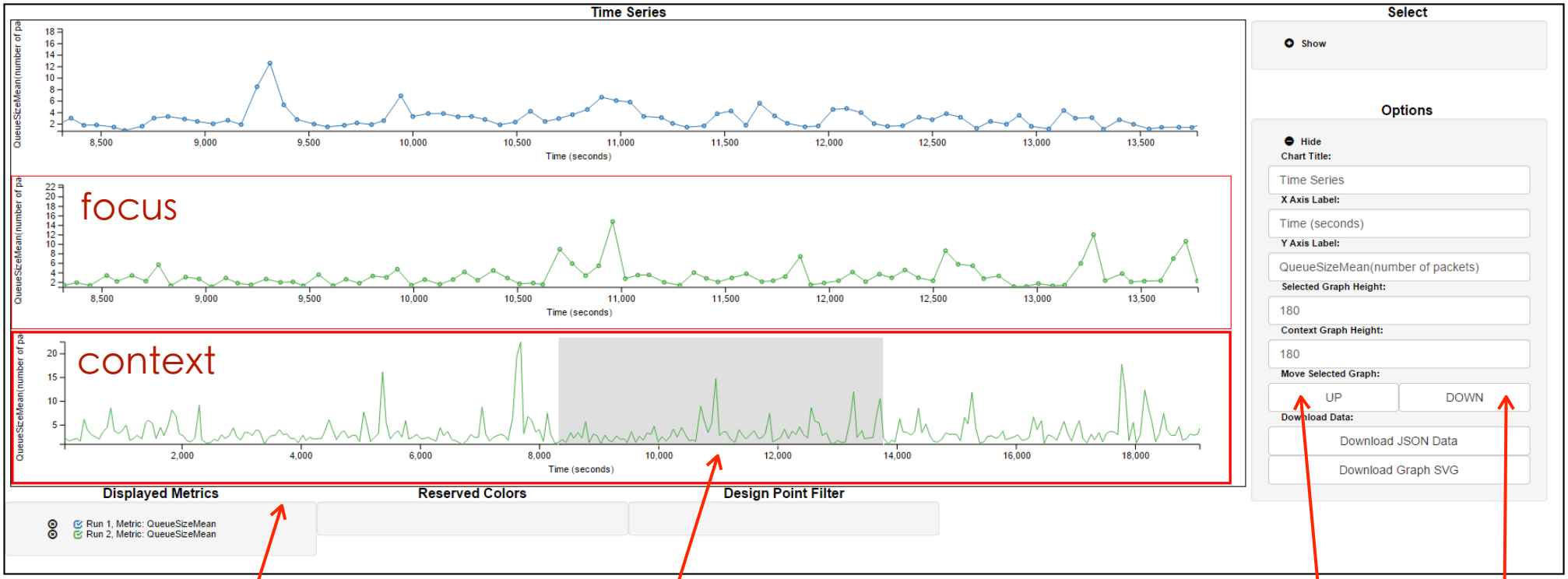
Faceting

SAFE Visualization: Time Series (selection)



Colors available for plotting

SAFE Visualization: Time Series (options)

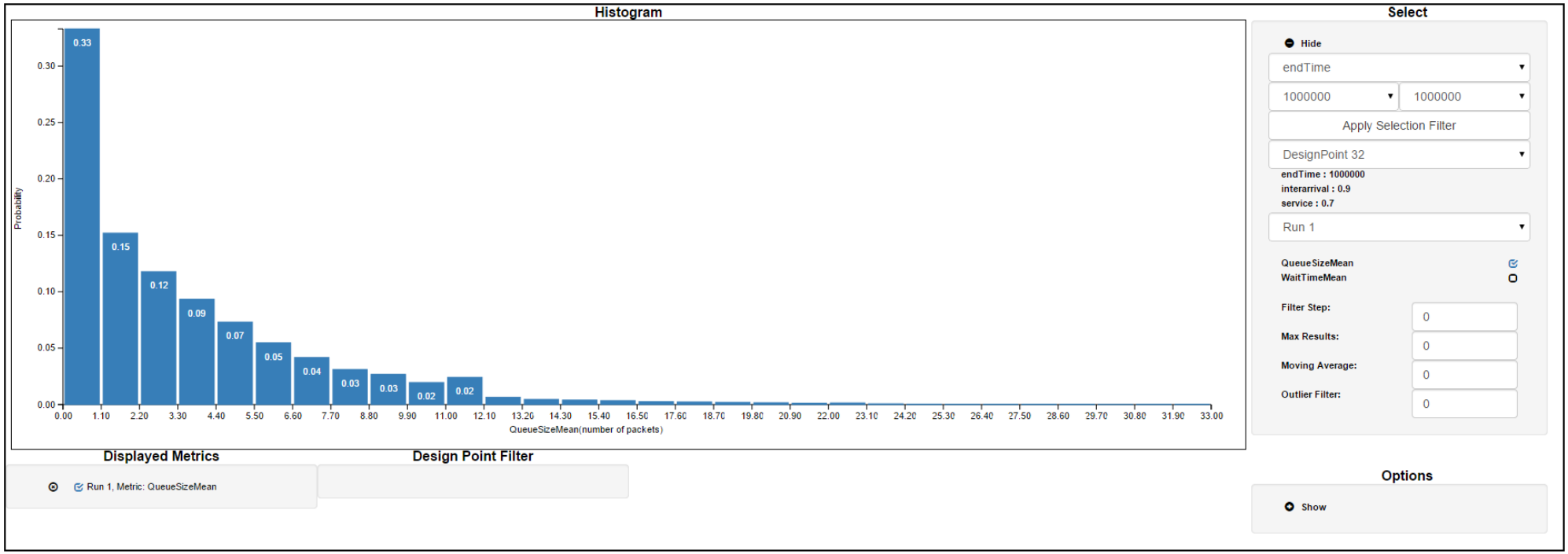


brush

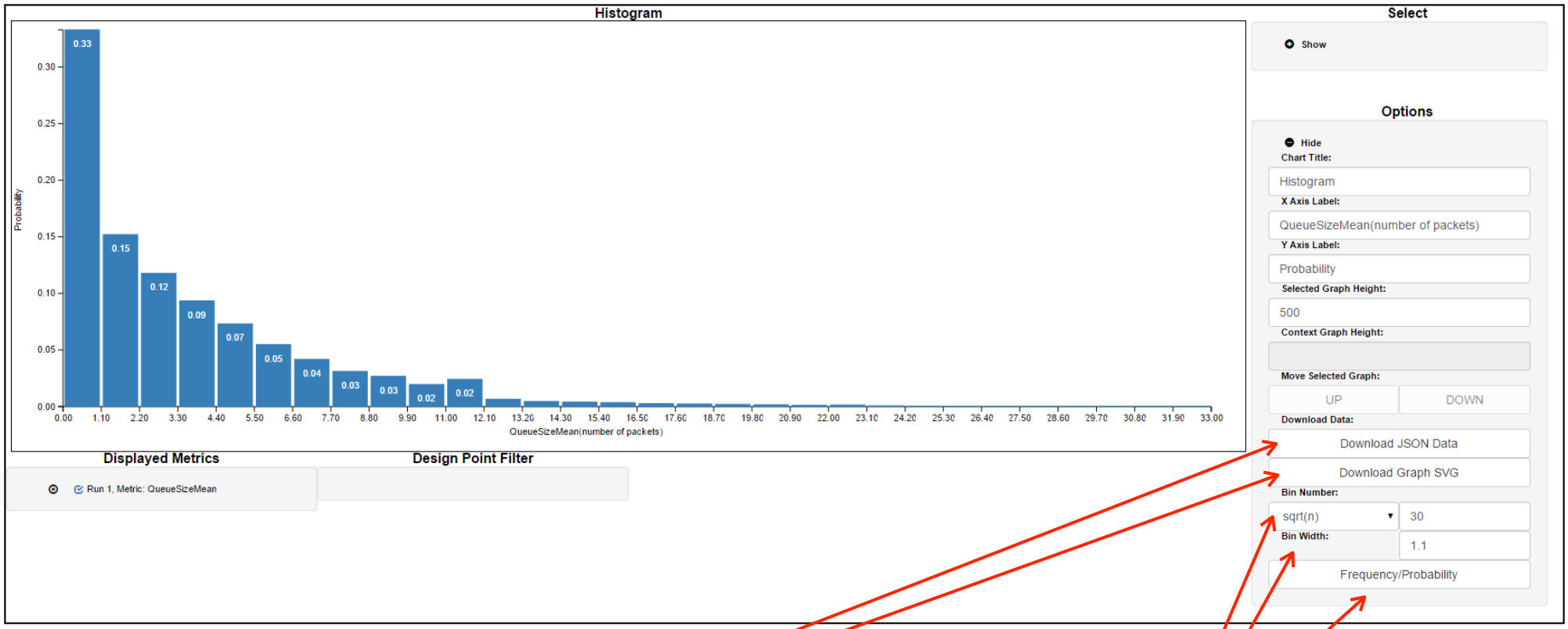
Selected facet

Facet movement

SAFE Visualization: Histograms (selection)



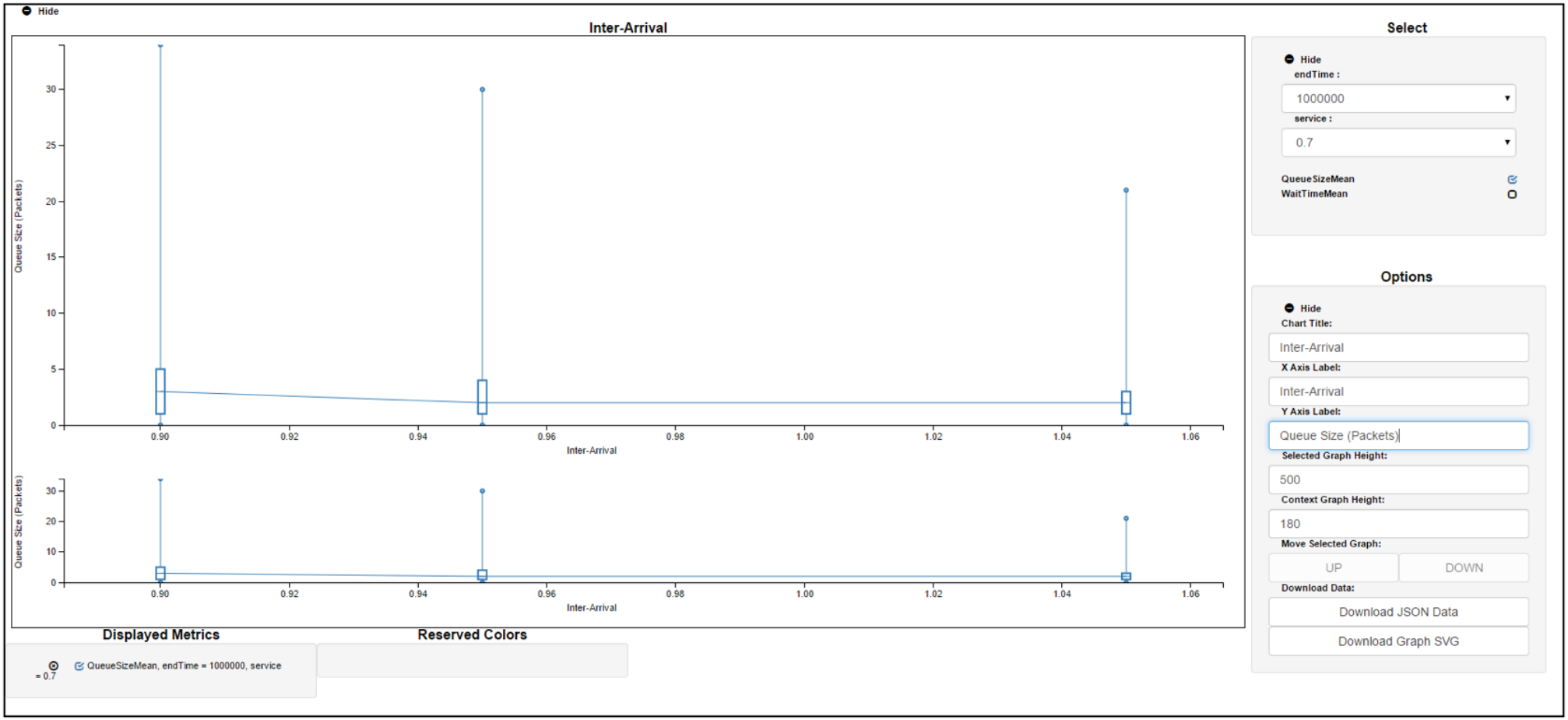
SAFE Visualization: Histograms (options)



Export options

Contextual options

SAFE Visualization: Box-and-Whiskers

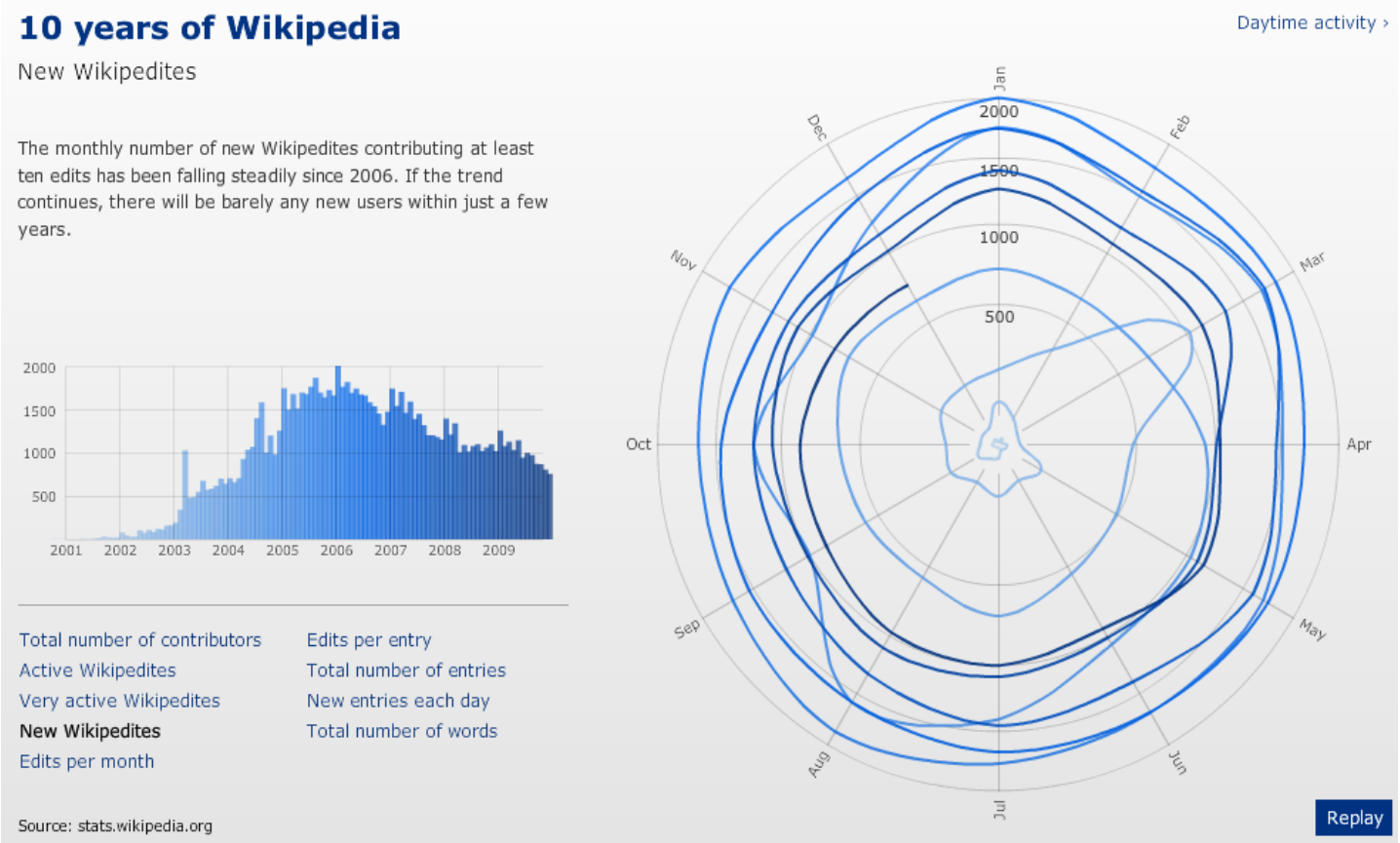


Future Directions

- Improve color selection mechanism
- Implement normalization
- Integrate with experiment management UI
- Experiment with advanced visualizations

Advanced Visualizations: Spiral Graph

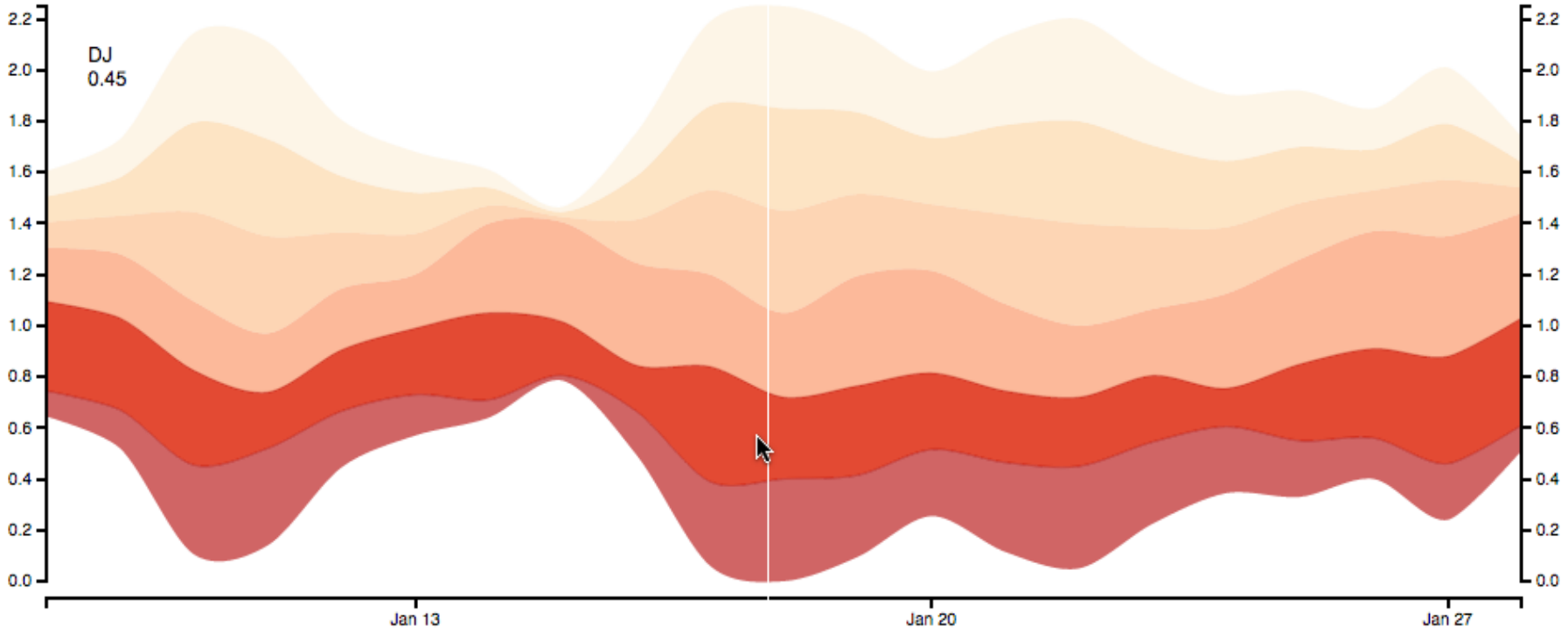
Time Oriented Cyclical Data



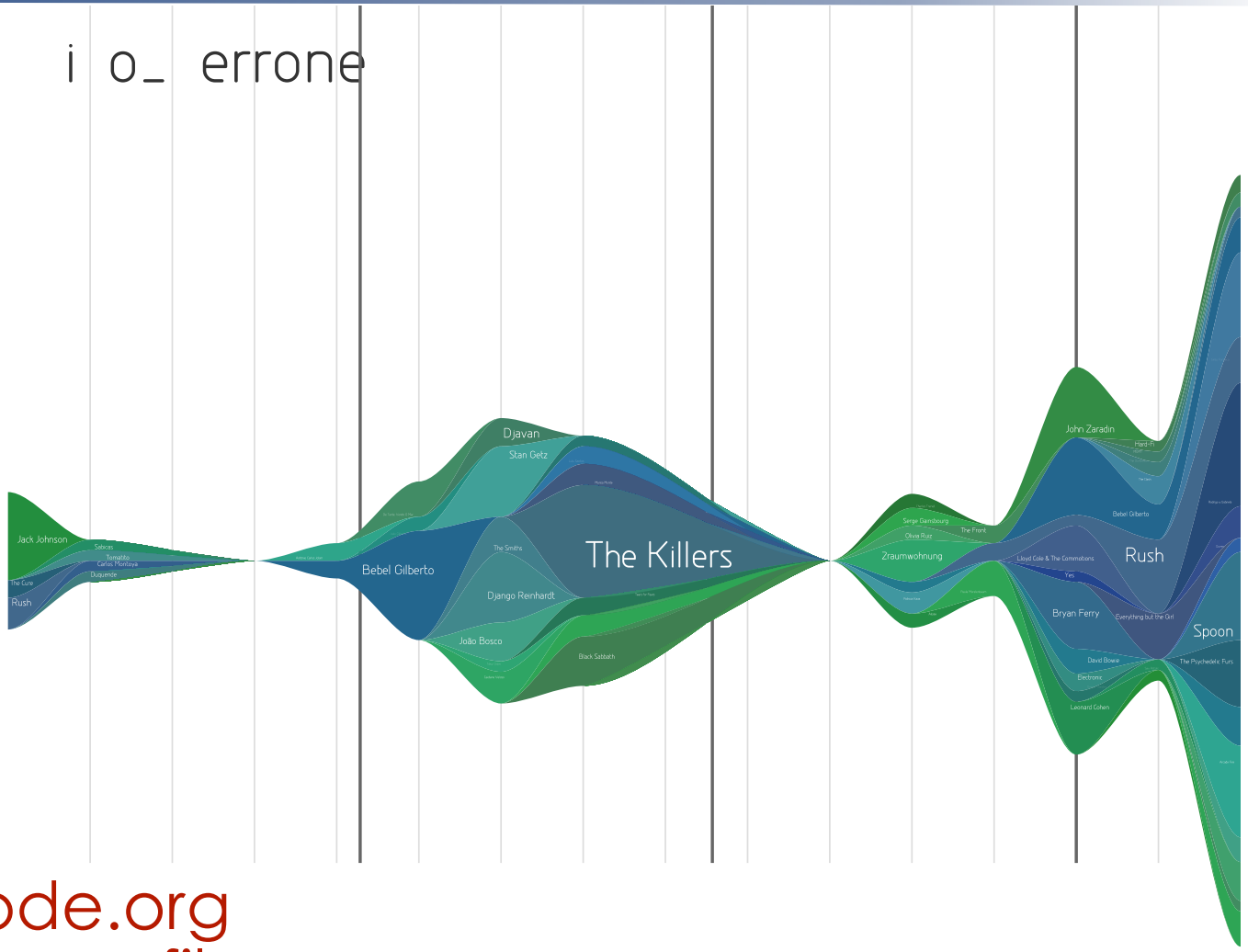
A recurrence of epochs

Advanced Visualizations: Stream Graph

Time Oriented Data



Unrelated Example of StreamGraph



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Thanks for your attention!

Questions?