

Web-based Data Visualization for Simulation Results

Background

The popular ns-3 network simulator, developed with funding from the National Science Foundation (NSF), has established itself as a thorough and reliable tool for research and development of communication networks. Because of the steep learning curve associated with this tool, the NSF has funded the development of the Simulation Automation Framework for Experiments (SAFE), which is a workflow environment that enforces best practices in simulation experiments with ns-3. SAFE guides the user through sound simulation methodology avoiding the errors that can be easily introduced throughout the experimental process. It also records all configuration and setup used for an experiment, which enables experiments to be replicated easily, enhancing their scientific value.

Abstract

SAFE presents to the user a web-based interface for creating new experiments, configuring and executing them, and inspecting the results produced. I have focused on the creation of several data visualization tools, which were selected according to the most common use cases within network simulation.

The visualization tools work with control panels that allow the user to extract the data of interest from a large and complex database of results. Additionally, the visualizations incorporate modern practices of data visualization, such as micro/macro display, which gives the user two viewing areas. The macro area gives an overview of an entire data-set allowing a broad understanding of its features. From this display, details are provided according to user demand. A user is able to select a portion of the macro data to view in detail through a magnified micro view. The combined effect is immediate access to all data within a set no matter the number of values it holds.

Resources

D3 (Data Driven Documents) - A JavaScript library used to manipulate web page elements based on data. It was an integral piece in the design of the visualizations because of its ability to dynamically update pages in response to selected experiment data.

Bootstrap - A framework for web development which allows pages to be easily designed and implemented and to contain a consistent style.

Data Selection

Data is retrieved from a complex database. For this purpose, I created the selection panel. The selection options are updated dynamically as the user narrows options as follows.

- Design Point (C)
- Simulation Run (D)
- Measurement Metric (E)

Using the selection filter, options can be further limited by specifications as to the desired design parameters to be observed.

- Factor to be Limited (A)
- Desired Range of the Selected Factor (B)

Figure 1: Control panel used for the selection of results to be displayed

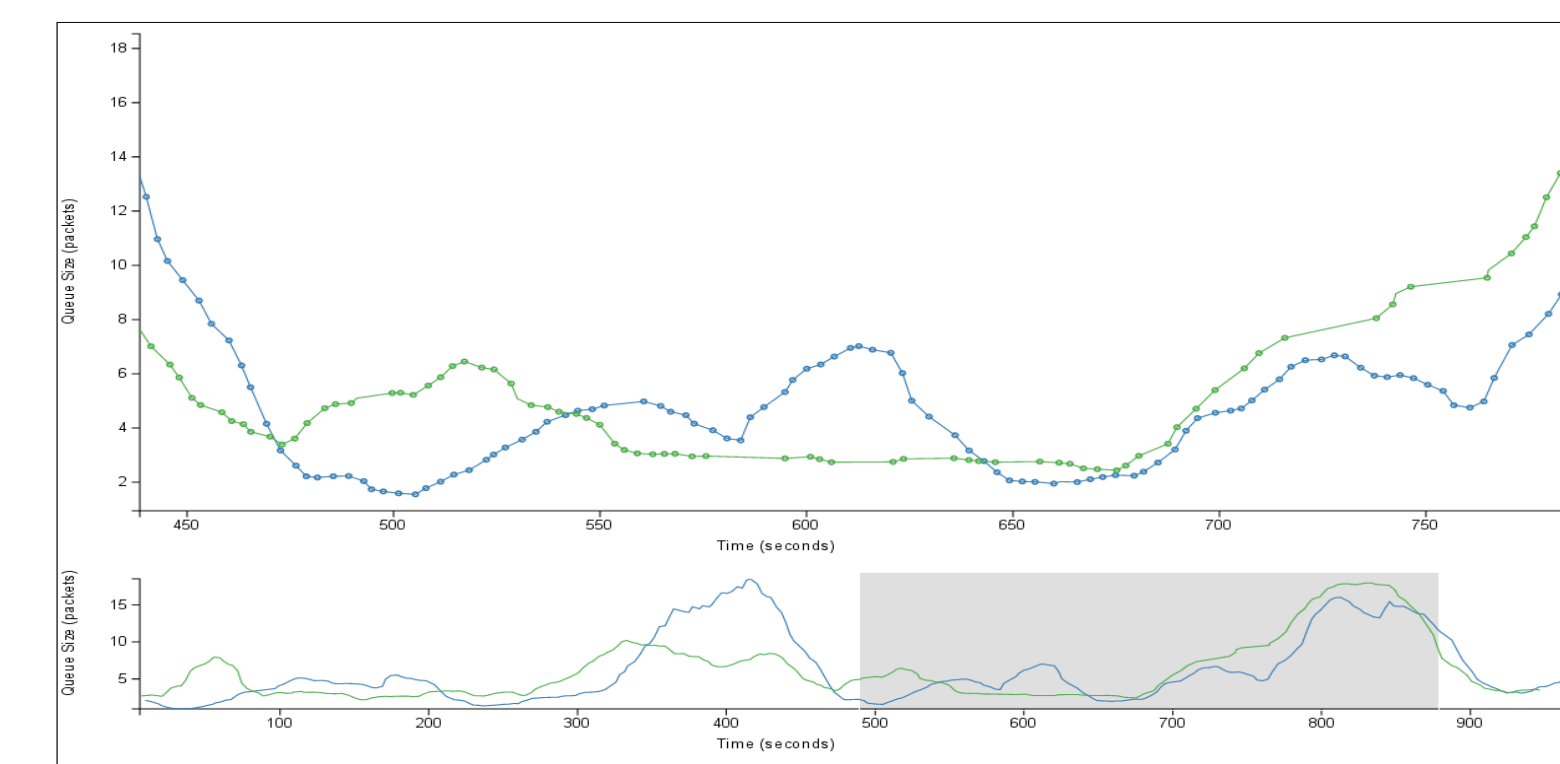


Figure 2: Time-series - Shows how metrics sampled through simulation evolve across time.

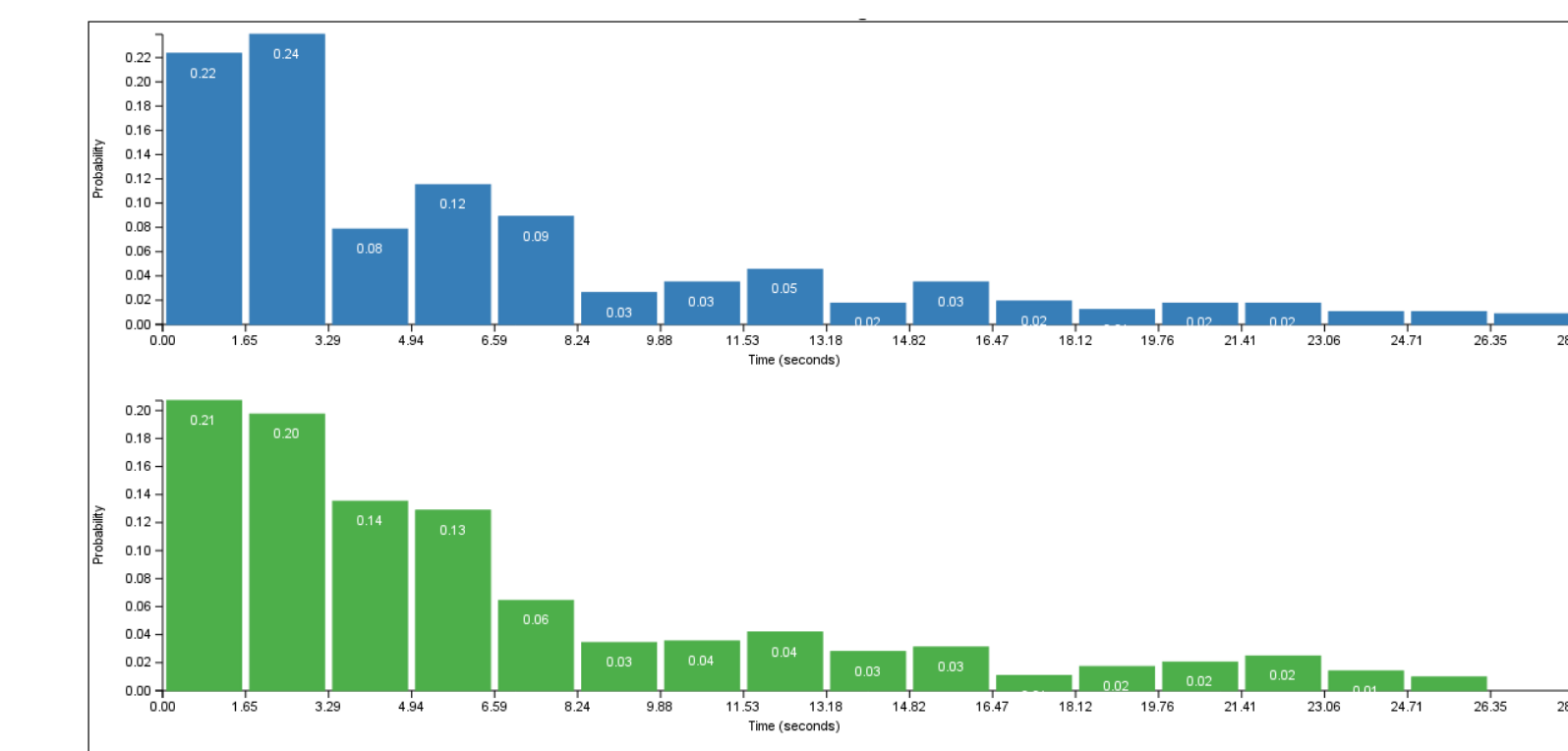


Figure 3: Histogram - Can be used to show routing path lengths. This also demonstrates faceted graphs (stacked on top of each other).

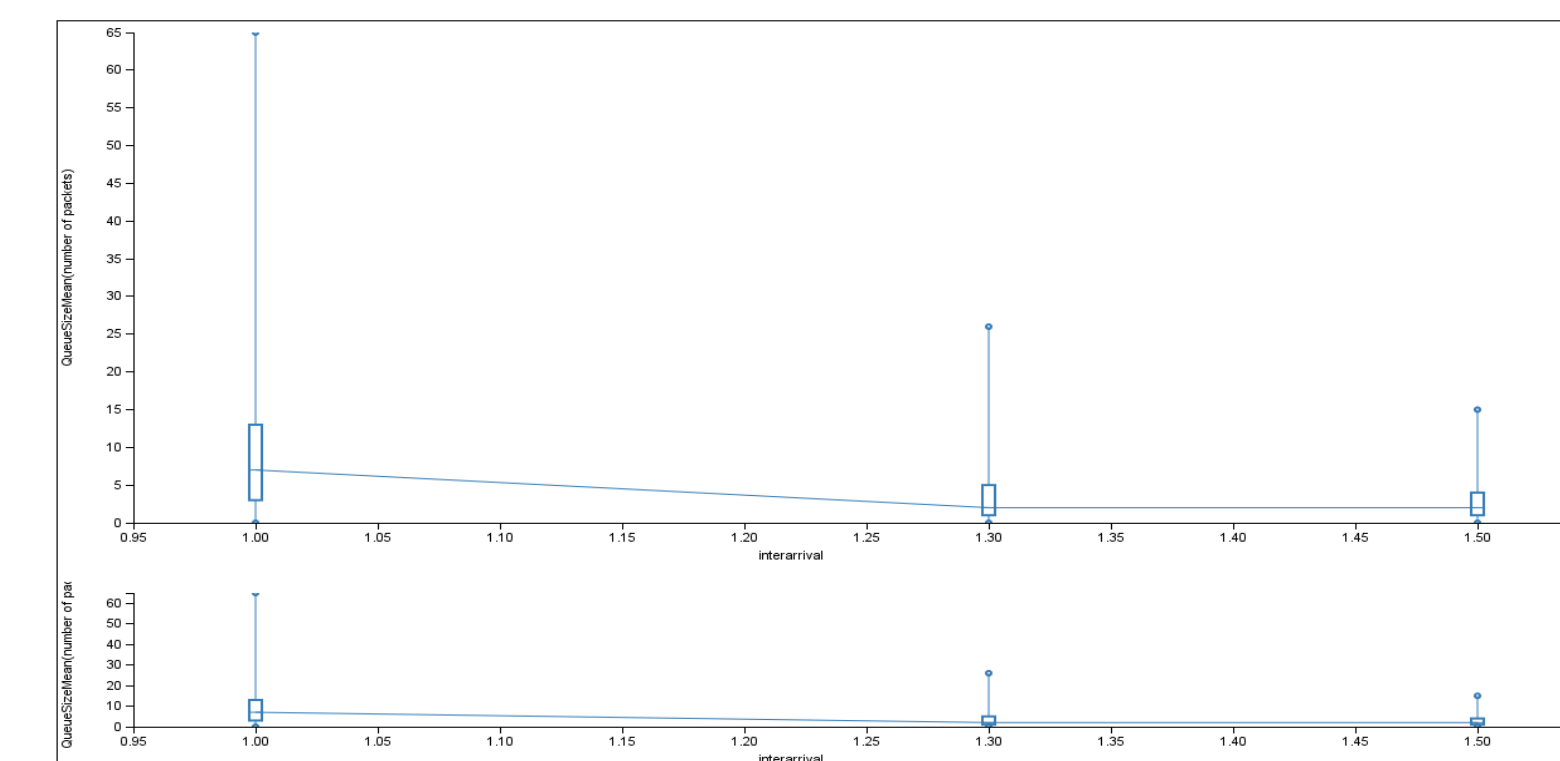


Figure 4: Box and Whiskers Plot - Indicates information about the probability distribution.

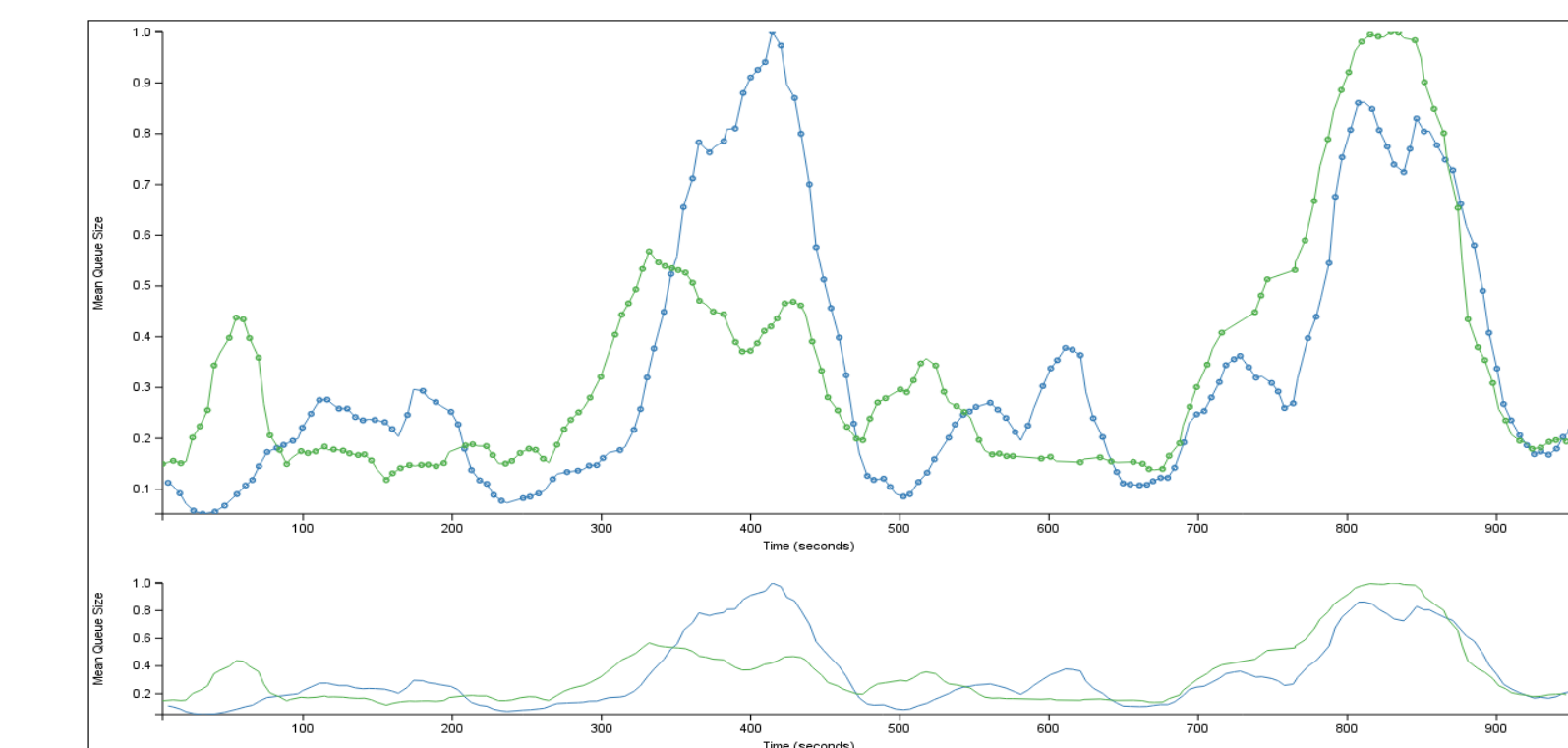


Figure 5: Time-series - Demonstrates the use of normalization of the data.

Visualizations

- Time-Series
- Line-Plot
- Box and Whiskers Plot
- Scatter-Plot
- Histogram
- Quantile-Quantile Plot

Variations

- Faceted Graphs
- Normalized Data

Visualization Architecture

In SAFE's framework, the user's web browser is given the JavaScript code for the display of information. The data is then dynamically retrieved from the database as needed. Analysis can also be requested for data being returned.

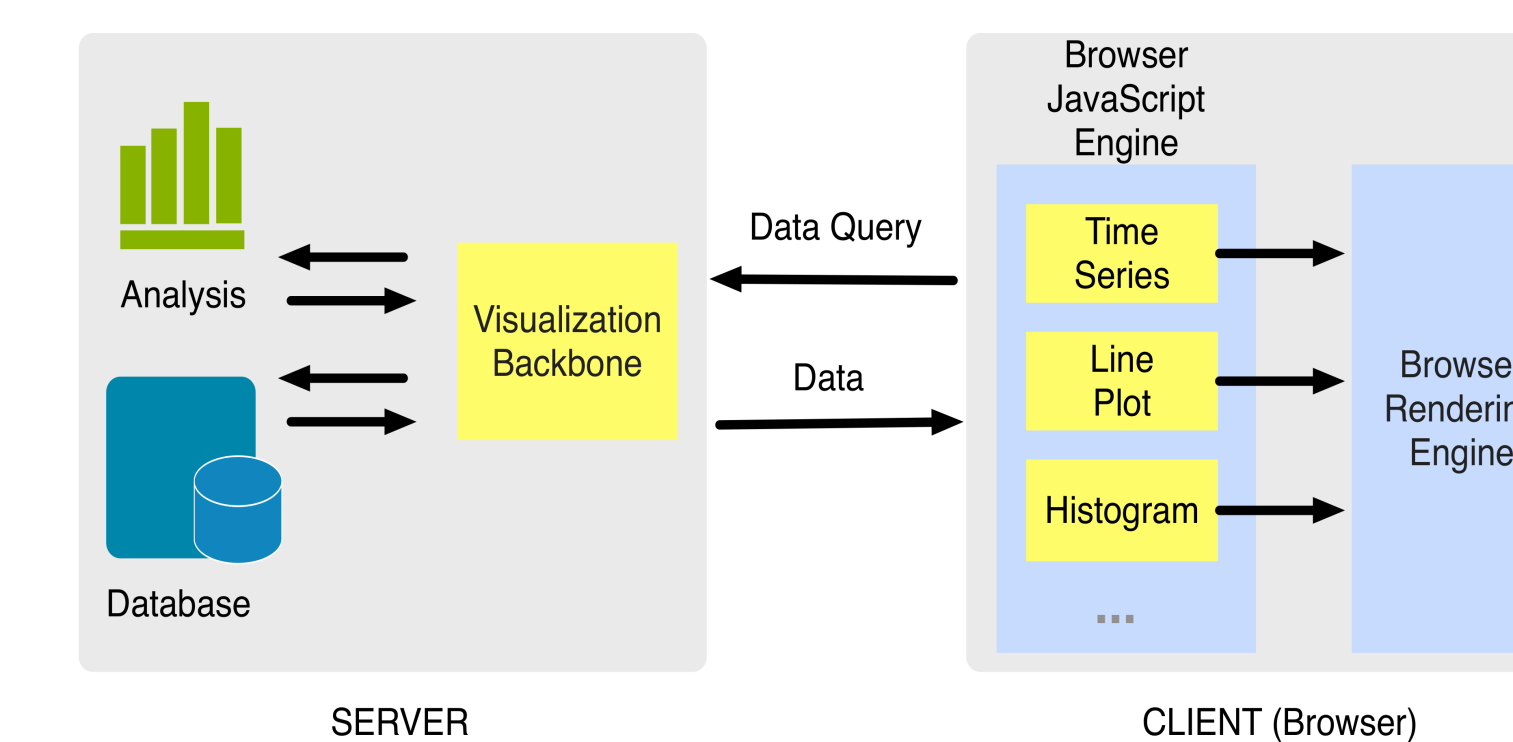


Figure 6: SAFE Visualization Framework

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Future Work

In the future, we hope to incorporate more diverse visualizations into the list of data analysis tools SAFE provides. These could include unique interactive visualizations such as the Spiro-graph and stacked plots.

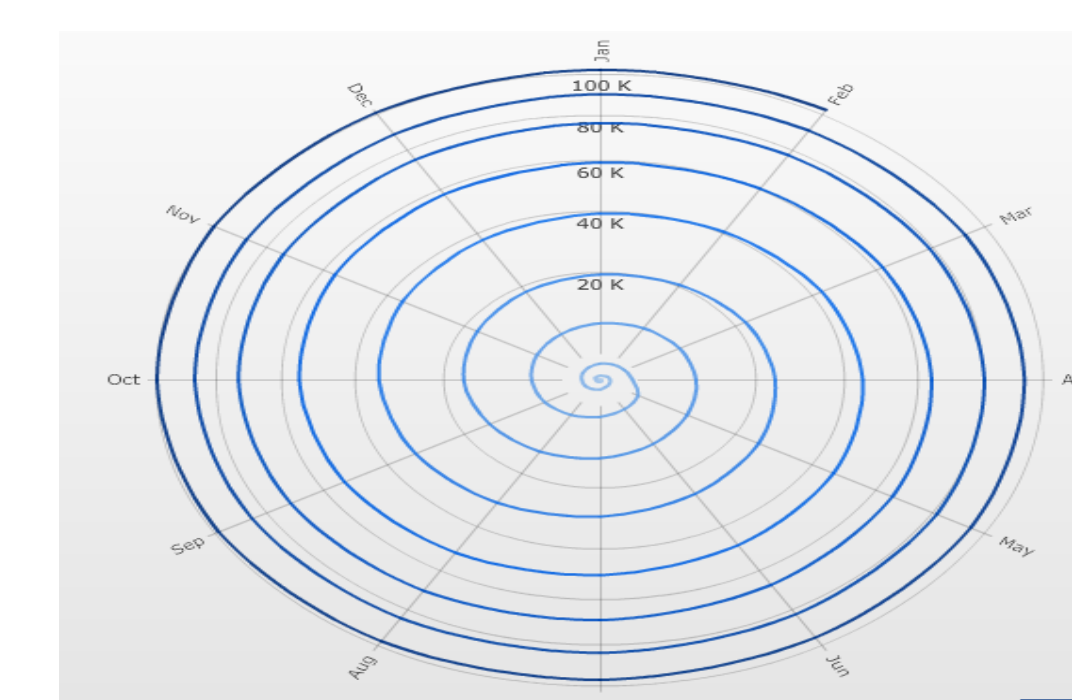


Figure 7: Spiro-graph: Time plot emphasizing periodic occurrences
<http://visualdata.dw.de/en/wikipedia/>

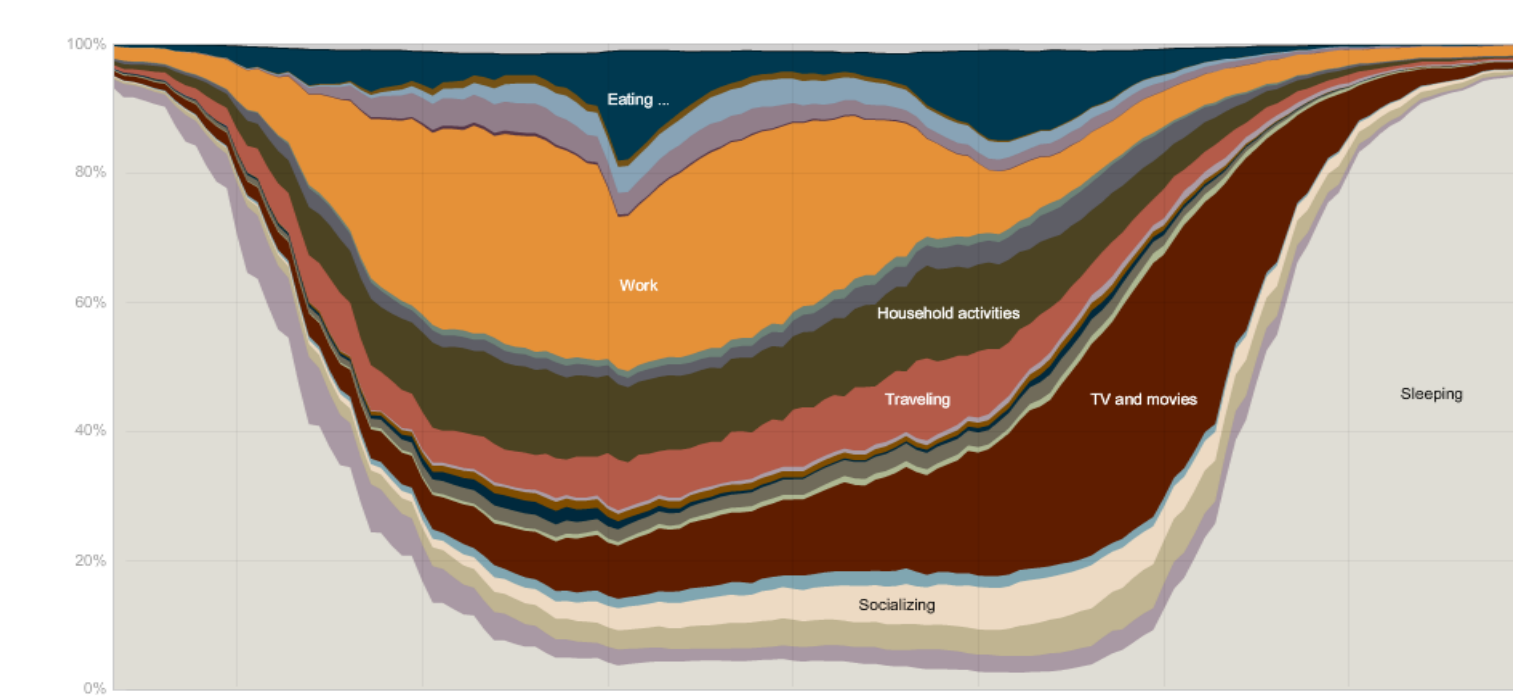


Figure 7: Stacked plot: Allows comparisons of proportional changes over time.
http://www.nytimes.com/interactive/2009/07/31/business/2008-0801-metrics-graphic.html?_r=0

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