Google IoT Proposal: Real Time Visualization of Beacon Data

The primary objective of this proposal is to investigate the relationships between deployed set of beacons by visualizing the high dimensional associations between beacon induced user actions in three dimensions as a moving plot. The data will be processed as a time series data with a windowed approach to produce visualizations for each time period. Then these will be viewed in real time using our web based 3D visualizer. We will run several projects with different choices for windowing, 3D projection and beacon scenarios. This work builds on our successful 3D visualization of stock market data https://spidal-gw.dsc.soic.indiana.edu/ using WebPlotViz which supports time series and individual 3D plots.

By doing this analysis we would like to investigate the challenges in executing a complex visualization algorithms using data coming from the smart devices in real time. Further we will explore both how to produce such real-time visualizations and how best to build them.

When users respond to a beacon assisted events in smartphones, the apps are producing time series of events associated with each beacon. These time series vectors for different beacons form high dimensional vectors correlated with each other by a similar time stamp. These high dimensional relationships can be quantified using techniques such as correlation analysis. The quantified relationships will be projected to 3D in real time using Principal Component Analysis(PCA) or Multidimensional Scaling(MDS) and visualized as a real time moving plot. We will superimpose on display (as point colors and glyphs) different classifications of the points.

The system will consist of a simple Android application with a user action prompted when near a beacon. If the user chooses to act upon the prompt, a notification will be sent to the server. These notification will be handled as streams of events associated with a beacon and a streaming or a batch algorithm will be used to quantify the relationships between the beacons and project them to 3D. The 3D projections will be streamed to the 3D viewer to visualize in real time.

We expect the initial project with setup to take about 3 months and be followed by explorations of different ideas taking about a month each. We are ready to start now as the MDS and WebPlotViz software are operational. All software we develop will be placed in Open Source.

Technical Details

The Google beacon platform, Google Cloud platform and IoT solutions will be used primarily to assemble the system. The Google IoT solutions will be used to gather data from the devices.
This data will be streamed to Google Dataflow engine using pub/sub where they will be processed to produce the 3D projections. The Google Cloud platform (or its open source Apache Beam) will be used for producing the real time 3D projections using implementations of MDS or PCA that we have already developed. A web based 3D time series viewer WebPlotViz will be used for the visualization and we would like to host it in the Google Cloud. The 3D

visualizer can be deployed in a single instance of a Google Compute Engine for this project. The pub/sub service will be used to stream the 3D plots from the Google data flow to the WebPlotViz.

Additional info

We will be using the DSC-Spidal, which is a high performance machine learning library for data analytics. Spidal is an open source library. https://github.com/DSC-SPIDAL

WebPlotViz will be used for data visualization. https://github.com/DSC-SPIDAL/WebPViz, hosted at https://spidal-gw.dsc.soic.indiana.edu/.