Visualization Tool for Testing and Formulating Hypotheses on PoC Service Issues

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Abstract –As some cellular phone carriers are offering Push-To-Talk over Cellular (PoC) services to their clients, the service quality should be measured periodically. The problem raises when it is observed that the quality is poor. Actions are required to have the service working above the minimum acceptance threshold. Querying, evaluating and analyzing volumes of PoC KPIs (Key Performance Indicators) measurements may support hypotheses tests and pinpointing the root causes. This article proposes a visualization tool to accomplish such exploration tasks. We believe that using appropriate sensory and conventional symbols for representing multivariate discrete data, time information, geographic position data, and their relationships, it is easier to assess the current system state at glance. In addition, we propose some visual aids that may guide users in their exploration for testing her/his hypotheses and formulating the new ones.

Keywords – Push-To-Talk (PTT), Push-To-Talk over Cellular (PoC), Key Performance Indicators (KPI), Visualization.

1. Introduction

Push-To-Talk (PTT) devices are not new for anyone. Walkie-Talkies and amateur two-way radios are good examples for the success of this half-duplex way of communication. Because of success of PTT devices, Nextel Communications released in 1994 its cellular services based on Motorola's iDEN™ including direct connect push-to-talk feature. This service differentiation gave Nextel the highest ARPU (average revenue per user)($70) and lowest churn rate (the number of customers discontinuing service)(2.1 percent) among all major US wireless carriers [1]. This motivated other carriers and mobile devices manufacturers to release the PTT service as a Voice over IP (VoIP) service on their handsets, making usage of the 2.5G and 3G networks [2,3].

The PTT over Cellular (PoC), in theory, should work fine on 2.5G/3G networks, but in general a cell phone does not need real-time data transmission. PoC application not only requests real-time data but also data on movement, which requires fast handover scheme to keep the service viable [4]. To evaluate PoC service quality, some Key Performance Indicators (KPIs) were defined. There are 4 KPIs defined by Industry Consortium (IC) [5]:

KPI 1 – Initial push to tone. It measures the delay between pressing the PoC button and receiving the right to talk tone. This includes call setup time.

KPI 2 – Initial talk to heard. It measures the audio delay from an originating handset to a terminating one. This includes call setup time.

KPI 3 – Subsequent push to tone. It measures the delay between pressing the PoC button and receiving the right to talk tone (not including call setup time).

KPI 4 – Subsequent talk to heard. It measures the audio delay from an originating handset to a terminating one (not including call setup time).

As Figure 1 indicates, these KPIs measurements are taken during a single round trip volley: the initiating handset starts the call with a voice transmission, the receiving handset listens and responds with a subsequent voice transmission [6].

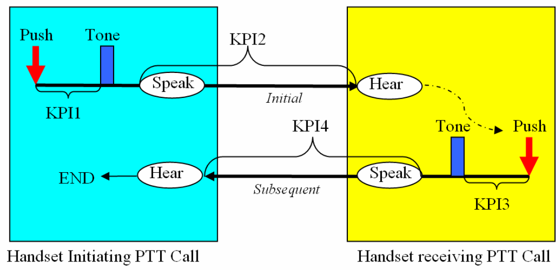

Figure 1. PoC KPIs collection proccess.

KPIs are good performance measures, but are not much useful to find out what is really happening with the network. That's why KPIs measurement tools automatically collect, in addition to KPIs data, data like the base station where handset is registered, geographic position (latitude, longitude), signal strength, success or failure of the call. Due to the collected data size, low KPI measures may be easily overseen. It is desirable that such data are preattentively processed and possible causes are interactively evaluated to support correct solutions.

To our knowledge, the visualization tools in the market today focuses on displaying KPIs average and percentage of failures [7,8] using gauges for each KPI. This is because that the primary objective of KPI is to show the progress of a system towards specified goals. Nevertheless, to test hypotheses on what the causes are, it is necessary to look at the extra collected data and try to identify correlations between the buried information. In average, it takes one to two days. This motivates us to propose a visualization tool that supports such query, explore and analyze tasks, in order to help a carrier to accurately identify the problem causes. In this paper we consider Motorola Push-To-Talk protocol for 2.5G/3G networks which is very similar to OMA PoC (Open Mobile Alliance Push-to-talk Over Cellular) protocol [9].

2. Exploration Environment

As the main objective is to formulate hypothesis on what's causing problems based on the data collected, it is important to be able to visualize the probable cause-and-effect relationships, so that the observer is guided to correct "conclusion" and actions.

Based on previous analysis experience, we formulated the hypothesis that the primary cause for a PoC call failure is the base station (cell) setup. To test this hypothesis we conjectured that the following PoC collected data are the most relevant ones for identifying the problem causes:

1. KPI 1 (milliseconds);
2. Received signal strength (dB);
3. Sample time (hh:mm:ss);
4. Cell id (integer);
5. Distance between cells and mobile.

2.1 Environment

As cell phone tower location and measurement sample position are needed to determine the "distance between cell towers and mobile handsets", we decide to visualize both of them in geographical context, so that the observer may easily perceive scale and distance of objects of interest. Figure 2 illustrates the positions where the samples were collected (in green) on a map.

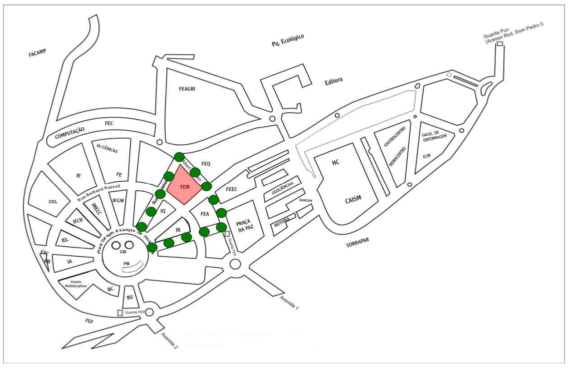

Figure 2. Geographical context.

2.2 Collected Samples

Besides the nearby cell phone tower and the distance of the mobile handset to it, 2 relevant data are collected. These data may be represented as a vector of 2 attributes. We propose to represent each sample as a cell phone and to map its multivariate attributes to graphical attributes that are as independent of one another as possible, so that they may be simultaneously visualized [10]:

1. KPI 1 $\rightarrow$ chromatic channel;
2. Received signal strength $\rightarrow$ chromatic channel;

We use a chromaticity range "green - yellow - red" on the “body” of phone’s glyph to reflect the data transfer speed, got from KPI 1, with respect to a pre-specified allowable limit: from the “pure green” (fastest), passing by “pure yellow” (warning state), to the “pure red” (worst one). We also used a chromaticity range "green - yellow - red" on the “antenna” of phone’s glyph to reflect the received signal strength, with respect to a pre-specified allowable limit: from the “pure green” (good received signal), passing by “pure yellow” (warning – not so good signal), to the “pure red” (no signal).

Considering that KPIs are usually collected each two minutes along a programmable route, we map the monotonically increasing sample time to the height of "sample cell phones" with respect to the geographical map. Visually these phones build a 3D spiral which provides a sense of progression [11]. This is because that we are more likely to construct visual entities out of visual elements that are smooth and continuous [10]. This progression cue, together with the color variations (yellowish-green or reddish-yellow colors) and the geographical map, provides, at a glance, a good perception of data transfer speed and strength progression along time in the space.

On the other hand, displaying spatially collected samples over a map, we may miss the correct geo-spatial perception. To overcome this problem an artificial spatial cue is added to enhance 3D perception. It is a dashed line linking the sample cell phone to the map, as shown in Figure 3. To avoid visual pollution, this spatial cue is switchable.

Figure 3. Artificial cue for correct geo-spatial perception.

2.3 Cell Phone Tower

According to our conjectures, the spatial and communication relationships between the mobile devices and the cell phone towers play an important role in the quality of push-to-talk services. To facilitate the evaluation of these relationships we propose to visualize the coverage area of each cell phone tower on the geographical map, as illustrated in Figure 4. We estimate this coverage area from the collected data, namely, the sample position and the nearby cell phone towers. Visual distressing may be avoided, if we limited the displayable cell towers to the ones that locate in the area of poor service.

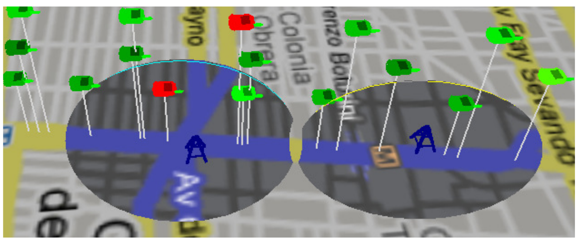

Figure 4. Cell tower and its coverage area.

2.4 Interactions

With our mapping proposal, we are able to put in one image all relevant collected data. We may evaluate at a glance the service status along the route of interest and the nearby cell phone towers. A snapshot of our proposed environment is given in Figure 5.

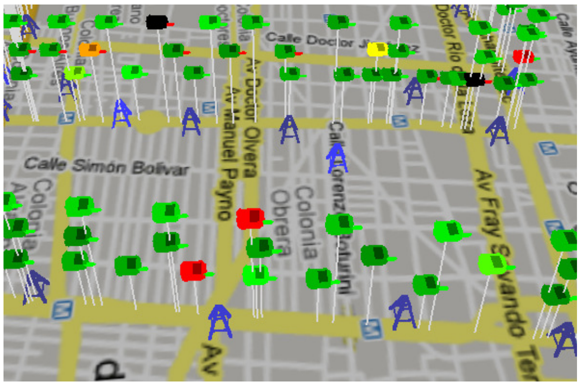

Figure 5. Proposed visualization snapshot.

Nevertheless, a static picture cannot appropriately support accurate spatial evaluation of each sample. Interactions with visualization are essential for inspecting attentive features. For the base station hypothesis, we designed three interaction activities to find out the possible cause-and-effect relationships:

1. 3D navigation: user may change the view point by moving the "camera" up and down, forward and backward, zoom in and zoom out.
2. Detail on demand: user may get more information about any graphics entity, either sample sphere or cell phone tower, by simple clicking on it.
3. Filtering: user may filter out the irrelevant data for a specific analysis, in order to reduce visual pollution.

3. Preliminary Results

To test our proposal, the software was developed on a Windows XP machine, using java and JoGL (Java OpenGL library for the 3D visualization). The maps were downloaded from Google Maps using a special API for it.

When evaluating the new visualization, new hypotheses were created as a result of the this visualization. Table 1 summarizes the new hypotheses created of probable causes for collected measures that are below the performance standard.

Collected Data	
1.	mobile data setup (milliseconds);
2.	data transfer speed (milliseconds);
3.	received signal strength (dB);
4.	PoC registered (boolean);
5.	sample time (hh:mm:ss);
6.	cell id (integer); and
7.	distance between cells and mobile.

Data			Probable Cause
6 – Same Cell ID	1 or 2 or 3 or 4 – NOK		A
3 – Good Signal	7 – Near Cell Border	1 or 2 or 3 or 4 – NOK	B
3 – Bad Signal	7 – Near Cell Border		B or C
3 – Bad Signal	7 – Near Cell		D
3 – Good Signal	4 – Not Registered	5 – All Time	E or F
3 – Good Signal	4 – Not Registered	5 – Time Slot	G or H
1 – Slow Setup	2 – Transfer OK	5 – All Time	A or F or I
1 – Slow Setup	2 – Transfer OK	5 – Time Slot	G or J
2 – Slow Transfer	5 – All Time		E or F
2 – Slow Transfer	5 – Time Slot		G or H

Probable Cause
A. Cells parameters for data transfer may be not configured properly.
B. Handoff issue.
C. Cell power issue.
D. A shadow area.
E. Network may not be working properly for data transfer.
F. PoC server may not be working properly.
G. A temporary network delay issue.
H. Handset could not register due to handset's internal timers.
I. Handset may have a problem to initialize data transfer.
J. PoC server bottle neck, due to multiple access at an specific time.

Table 1. Cause-and-effect relationships

The proposed visualization environment has been used on the analysis of PoC service at Telcel's network (Mexico). It was helpful in understanding the network and its issues, so that the analyses were done in 3 hours. On that time it was observed 2 main issues using this visualization:

1. A temporary network delay issue, observed by 12 continuous slow data setup / and slow data transfer samples.
2. Some handoff issues, observed as good signal strength at the cell's border, having no data transfer.

A visualization problem has been detected which requires further study: a satellite map, due to its texture, may confuse the graphics entities lied over it and lead to false conclusions.

4. Conclusion

To deliver a PoC service that works continually is not any easy task. KPIs measurements are constantly done to observe the service health, and the way these measurements are visualized is not useful for establishing cause-and-effect relationships.

Using the proposed visualization, it is possible to have the global system status at a glance and to find more data that seems important for validate our hypotheses. We believe that from these flexible interactions we may acquire new insights and formulate new hypotheses. Also, we are working to have a new visualization to handle these new hypotheses which came from the proposed visualization.

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