A First Step Towards Call Survivability in Cellular Networks

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Abstract

Despite recent advancements in cellular phone network infrastructure, survivability of the calls is still an open issue. Important business calls and tele-conferences cannot benefit from mobility because landlines are preferred owing to their reliability and tolerance to failures. In this paper, we present a framework to improve call survivability by monitoring the user's location and intimating him about the possibility of loss of connectivity, interference, and room schedules that might disrupt conversation. In addition, if a call drops because of unforeseeable circumstances like battery failure or cell-phone damage then the call is switched to the nearest available device capable of streaming voice.

1. Introduction

Disruptions in cellular calls are caused by both physical and human factors. Amongst physical factors, *Bad Reception* is the primary cause of call-dropping. A cell phone works by communicating with its service network through a base station. As a cell-phone user drives down the street, the signal is handed from tower to tower. Cellular signals are "line of sight" and can be blocked by obstructions such as metal, concrete, brick, lead and masses of earth (e.g. hills). *Low battery capacity* adds to the problem since most handheld phones have a maximum output power of 0.2-0.6 watts. Errors in *handoff* are another problem; in one location it is usually the case that the user is blanketed by more than one tower. Towers handoff calls to each other seamlessly as the user moves out-of-range but it is common that both towers get out-of-range simultaneously resulting in a call drop. Sometimes handoff timing can also be a cause like in the case of a high speed vehicle crossing many small cells in a short time. *Cell dragging* happens when the user moves slowly away from the cell and the tower doesn't recognize it due to a strong average signal. It can also happen that the user inadvertently walks into an area of high *interference* because of a large quantity of metal or electro-magnetic equipment. Human factors may include sitting in a movie or meeting where cell-phones may not be allowed. All these factors contribute to a breach in communications survivability.

Reception may be improved by increasing the number of towers so that a user is always in the range of overlapping carriers but unfortunately there is no sharing of cell sites by competing carriers. In fact, even the distribution of cells is a very closely guarded secret of carrier companies and so an out-of-band solution is necessary.

2. Survivability - a Definition

Communications infrastructure components change frequently and are subject to disruptions. Survivability is the capability of maintaining timely communication in face of underlying faults. For this paper we define survivability as the following: given an entity A communicating with B, the system guarantees that B (i) will be able to call A at any time of the day and (ii) can maintain an uninterrupted conversation with A while the latter's position changes constantly.

3. A Location-Aware Survivability Framework

We are designing a programmable location-aware Voice-over-IP (VoIP) system that augments the cellular network for tracking user location and maintaining call survivability. It allows ubiquitous phone numbers that are not tied to particular hand-sets by dynamically changing the call routing tables. So if a user misplaces his handheld, the nearest available phone or wireless device will automatically become its substitute. In addition, it tracks the user's location providing him continuous feedback based on stored contextual information e.g. "room will have limited reception" or "scheduled for a meeting" (See Figure 1).

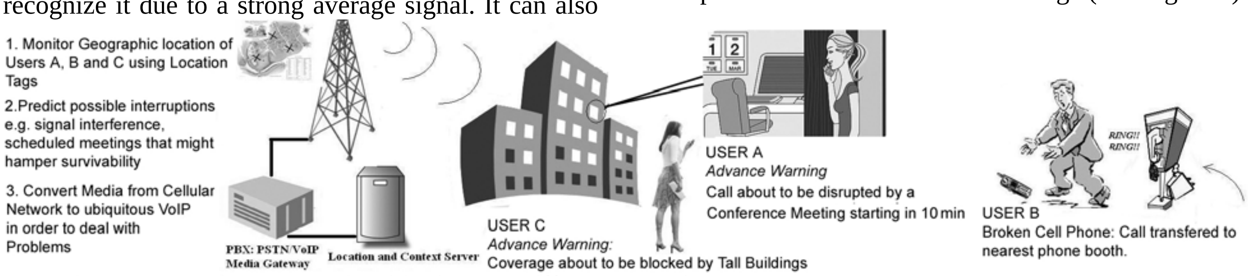

Figure 1: Ensuring call survivability in three different scenarios

3.1. Implementation

We extend a Virtual Communication System [1] which allows users to receive calls at convenient locations with flexible privacy control. The design of our system consists of three major components: (1) a Gateway for inter-conversion of VoIP and Cellular voice packets (we experimented with both our own implementation and 'Asterisk' -an open source PBX), (2) a Location service, and (3) a Context Engine.

The location service is the source of location information for the gateway. It fuses data from multiple sensors, resolves conflicts, answers object and region-based queries based on subscriptions for location-based conditions and notifies the application when the conditions become true. To subscribe, one has to create spatial regions and associate properties to them.

The context service tracks activities taking place in the coverage area for instance meetings. It stores interference prone and 'no coverage' areas. This information is learnt dynamically from the experience of other users. It employs a simple and expressive clausal model that defines various properties of context and valid operations.

3.2. Ubiquitous Voice-over-IP Soft Phones

Our test prototype is deployed in the Gaia Active Spaces Lab at the Siebel Center for Computer Science at the University of Illinois at Urbana-Champaign. The Siebel Center offers blue-tooth enabled touch panels lining its corridors. We use the building's state-of-the art communications infrastructure to transfer voice packets. Users can stand next to touch panels running SIP Soft phones and use blue-tooth phones to handoff calls.

3.3. Unobtrusive Feedback

We use an out-of-band mechanism for location tracking and providing warning to users. Currently we are working with Ubitags [4] which are small tags worn by a person or attached to an asset allowing it to be accurately located within an indoor environment.

3.4. Policy Based Configuration Management

The ubiquity provided by this system creates several concerns regarding system management and privacy. How to configure preferences? Should the system track all movements? A policy information server keeps track of ingress and egress client policies. User requirements such as bluetooth and codecs support are specified as preferable or mandatory capabilities in XML and stored at the server to be published to the rest of the clients. Constraints such as availability of time are translated to general rules in the policy language. Enforcement of private rules can be carried out by clients and that of the public by the server.

4. Results

We experimented with the accuracy of our location detection. Figure 2 shows A's movements as he leaves a room, meets his friend and subsequently decides to enter another room in the second corridor with a high interference. The graph shows his Euclidean distance being calculated on the fly.

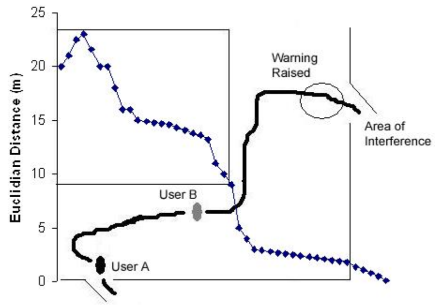

Figure 2: Tracking Movement

Notice that when A moves quickly, the trace is jerkier and prediction accuracy is low. It improves as A slows down before entering the second room.

5. Related Work

Quint [2] talks of enhancing battery life while Varshney et.al [3] concentrates on ways of decreasing cellular network failures. The research community is also looking into ways for a seamless handoff between cellular and WiFi. Our work is different because we recognize the limitations of the cellular infrastructure and provide alternative means of survivability by augmenting it with location and context information.

6. Future Work

We are working to incorporate a new feedback mechanism directly into cell phones, using GPRS. Current location sensing technology such as Ubisense and RF tags is so far restricted for indoor purposes. In the future, we plan to extend this mechanism to outdoor use. An assumption we make for our work is that the location signals will work where the cellular signal will fail. So far in our testing we have not found any co-relation between the strength of the two signals. Future testing will study if the signals are correlated for certain environments.

7. References

[1] J. F. Bresler, "A Location Aware Virtual Communication System," MS Thesis, Univ of Illinois, '05

[2] J. Quint, "The Role of Batteries in Cell Site Survivability" *Wireless Business & Tech Magazine*, Dec 03

[3] U. Varshney, A. Snow, A. Malloy, "Reliability and Survivability of Wireless and Mobile Networks," *IEEE* Computer Society Press, July 2000, p. 49.

[4] UbiSense, "Local position system and sentient computing."