Category: Concepts, Trends, and Challenges

Topology for Intelligent Mobile Computing

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INTRODUCTION

We discuss an *interconnectivity framework* for data and content delivery to *mobile devices* that allows data of higher priority to reach the mobile unit in the *shortest time* possible. Two possible scenarios are presented; one that connects the servers in an *N-cube* configuration network, and another that shows the same N servers connected in a grid type network. The goal is to minimize the rate of *data jumps* from server to server until it reaches the mobile device. As the mobile user travels, the mobile device registers itself with the next server and the session is migrated from the old server to the new one without interruptions, in an analogous way, cell phones move from one cell to another. Starting with the idea that all data is not equal (in importance/priority), this article suggest a framework topology for intelligent mobile computing that guarantees data will reach the mobile device in a minimum amount of time, assuring at the same time the privacy of transmission. The integration of this type of technology into the 3rd Generation (3G), and 4th Generation (4G) *mobile computing* is also discussed.

Pervasive computing is rapidly emerging as the next generation of computing with the underlying premise of simplicity (of use), minimal technical expertise, reliability, and intuitive interactions. As technology continues to advance and mobile devices become more and more omnipresent, the aim towards achieving easier computing, more availability and prevalence is becoming a given. Through the clever use of advanced technologies, the new generation of intelligent mobile computing has the opportunity to serve user needs via prevalent computing devices that are ever more transportable and connected to an increasingly ubiquitous network structure. *Mobile communication* is changing as the trends of media convergence including the Internet and its related electronic communication technologies and *satellite communications* collide into one.

A change is being ushered by the 3G (3rd Generation) mobile technology with the usability and usefulness of information delivered to mobile devices taking on added features. For example, *multimedia messaging*, as opposed to *voice transmissions*, being delivered to cell phones has rendered such mobile devices an integral part of people's lives and a core part of how they conduct their daily business rather than an add on tool (Buckingham, 2001).

The *3G mobile phone* system aims at unifying the disparate standards of current second generation *wireless systems*. The idea is to eliminate the different types of *global networks* being adopted with a single standard network. This will allow for the delivery of multimedia content and propagation through the network without the need for conversion from one standard to another. 3G systems need smaller cells thus the need for more base stations (mostly due to their operating frequency, power requirements, and modulation) and in many cases will not be feasible to install them in areas where population is not so dense (i.e., rural areas) (Garber, 2002). Because of these requirements and conditions, a better way to deliver the communication must be established. However, global access to such mobile devices will create *data delivery* challenges and servers can become clogged with unwanted communication, like that of wired Internet access. The need for moving relevant data to mobile devices in the shortest time possible becomes of utmost importance.

BACKGROUND

As the evolving functionalities of mobile computing take on primary roles at both the individual and the organizational levels, researchers and developers move to further enhance the technology. Bettstetter, Resta and Santi (2003) offer a random waypoint model for wireless ad hoc networks suggesting that the spatial distribution of network nodes movement, according to this model, is in general nonuniform and impairs the accuracy of the current simulation methodology of ad hoc networks. They present an algorithm that looks at the generalization of the model where the pause time of the mobile modes is chosen arbitrarily in each waypoint and a fraction of nodes remain static for the entire simulation time. They further show that the structure of the resulting distribution is the weighted sum of 3 independent components: the static, pause, and mobility (Bettstetter et al., 2003)

Xie and Akyildiz (2002) address the problem of excessive signaling traffic and long signaling delays in mobile IP. They argue that it is possible to have a distributed and dynamic regional location management scheme for Mobile IP where the "signaling burden is evenly distributed and the regional network boundary is dynamically adjusted according to the up-to-date mobility and traffic load for each terminal". This is suggested for minimizing the cost of content delivery over mobile IP networks (Xie & Akyildiz, 2002).

La Porta (2002) describes mobile computing as "a confluence of communication technologies (particularly the Internet), computing devices and their components, and access technologies such as wireless." He argues that a mobile computing environment will include not only real-time mobility of devices, but also mobility of people across devices, stressing the fact that the environment must include a wide range of devices, applications and networks (La Porta, 2002).

Zimmerman (1999) states that "The proliferation of mobile computing devices including laptops, personal digital assistants (PDAs), and wearable computers has created a demand for wireless personal area networks (PANs)" showing at the same time the fact that the mobility of such devices places considerable requirements on PANs not only for connectivity, cross-platform and networks but also for content delivery in minimum time (Zimmerman, 1999). This article further addresses the subject of data and content delivery to mobile devices with a keen interest in time and cost issues.

MOBILE COMMUNICATION SYSTEMS

There are four major categories in which data can be classified. These are real-time data, daily data, occasional data, and junk data:

1. **Real-Time Data (RTD):** Both hard and soft real-time is data that needs to be sent/received as soon as possible regardless of cost.
2. **Daily Data (DD):** Data that is sent only once or twice a day at a predetermined time (status reports, weather forecasts, etc.).
3. **Occasional Data (OC):** Data that is sent from time to time (software updates, customer service reports, etc.).
4. **Junk Data (JD):** Data that is considered useless (spam).

One way to speed up the data delivery is called data shorthand, where properly configured computers can send chunks of data based on data changes so only the changed data is sent to the mobile device (Ungs, 2002). But this type of data exchange requires mobile devices to store each of the exchange. Caching transmissions can be used successfully for non real-time data communication (like browsing the Internet, checking e-mail, etc.). For real-time message exchanges, caching cannot be used and other methods of speeding up delivery become necessary.

Convergence between broadband wireless mobile devices and access is currently a significant issue in wireless communications. With the recent technological advances in digital signal processing, software-definable radio, intelligent antennas, and others, the next generation of mobile wireless systems is expected to be more compact, with limited hardware and will feature flexible and intelligent software elements (Rao, Bojkovic, Milovanovic, 2002). Wireless mobile Internet (WMI) is a key application of the converged broadband wireless system where the actual device will be compatible with mobile and global access services, including wireless multicasting and wireless trunking. Some of the characteristics of these mobile devices will be: at least 90% of the transmission traffic will be data, voice recognition functions will be operational for every command, the mobile device will support multiple users and various service options, the mobile device will be adaptive and upgradeable, and the entire transmission will be encrypted for ensuring privacy of communication (encryption will be done in hardware for faster processing).

Mobile wireless communication implies support for user's mobility and the overall communication infrastructure needed to handle movements within the home network cell/servers map but also outside the home network in situations where communication is provided by other providers (Agrawal & Zeng, 2003; Rao et al., 2002). A mobile station (MS) should be able to communicate without session interruptions as it travels anywhere using local wireless infrastructure facilities. Because of this, session handoff between cells and mobile switching centers (MFCs) of various wireless service providers should be supported. As a MS travels from a location to another, it has to register itself with the next cell/server that serves that particular area. Each of the servers maintains a visitor location register (VLR) that is an index of the MS IDs that are in its active area. As the MS leaves a cell/server, an entry is made in the home location register (HLR) of the home network so the current location is known at all times. Based on these registers, data can be sent over the network to reach the mobile device. Our work is concerned less with the way the handoff of the communication session takes place, but more with how many times the data has to jump before it reaches the mobile device as is described below.