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Umbrella Cell Approach Based Coverage in Ubiquitous Computing Environment

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Abstract*— Ubiquitous computing environment envisions computing devices assisting human beings in their day to day routine life activities, staying invisible from their attention. To fulfill this basic requirement of hindrance free environment, users of the system should be able to move from one place to other. So, user mobility, without any break in service, is the fundamental assumption of Ubiquitous Computing Environment. The coverage area in ubiquitous computing environment has been divided into various clusters of cells. As the user moves away from transmitter the signal strength on mobile device decreases. When the user crosses the boundary of a cell the user connection is handed off to the base station of new cell. This process is known as hand off. This paper describes about a handoff strategy known as umbrella cell approach to improve the coverage range of mobile users, moving in different cells in Ubiquitous Computing.

Keywords*— Ubiquitous Computing, Cellular System, Handoff, Umbrella Cell Approach.

1. Introduction

Ubiquitous Computing [1] aims to provide continual service to the users without any break, along with user mobility support. Thus the infrastructure for ubiquitous computing environment shall contain large number computers supporting transparency in service access, as in distributed computing systems, and user mobility, as in cellular systems.

Internet and cellular systems are most successfully implemented infrastructures. Both of these systems provide services to users over a large area, distributed over globe. However, these systems differ at the level of basic architecture. Cellular systems are designed to provide the facility of voice communication to the mobile users. Cellular system divides service coverage area into different cells. Each one of these cells have a wireless transceiver to provide wireless connectivity to its users, any where in that cell. The communication in between user and transceiver is controlled and monitored by Base Station Subsystem (BSS). There is one Mobile Switching Centre controlling the functioning of many BSS. Different MSCs are connected to provide service coverage in a large area. Contrary to this Internet consist of connection of computer LANs. Most of these computers, in Internet infrastructure are non-portable. But due to collection of large number of high speed computer, Internet infrastructure provides faster communication and processing speed. So, ubiquitous computing infrastructure devices may be arranged to form hexagonal cells with minimal proximity range to improve coverage of user's mobile device [2].

This paper is organized into four sections. Section 2 presents introduction about a cellular system. Section 3 describes various handoff strategies and section 4 presents use of umbrella cell approach in ubiquitous service access. Section 5 concludes this paper.

2. Cellular System

A cellular system has been designed to support mobility of users' mobile phones, also called Mobile Stations (MS). In a cellular system the complete area of coverage is divided into various hexagonal cells each managed by a Base Station Subsystem (BSS). Many BSCs are further connected to a Mobile Switching Centre (MSC). Unique identification of MS does not change with movement from one MSC to another and MS need not re-establish the identity in new BSS. Cellular systems provide very good provision for subscriber mobility but it does not provide the same type of service access as Internet infrastructure [3].

2.1 Ubiquitous Computing Infrastructure based on cellular system

Basic requirements of ubiquitous computing system may be fulfilled by combining the features of Internet and cellular system. Computing devices may be arranged in the form of cells (coverage area of one BSS), with each cell having one transceiver to cover the user devices in the cell. These cells (Fig1) may be called Active Areas (AA) in ubiquitous system. For mobility support each user device must have a consistent global unique identification, which does not change when user moves from one LAN/ BSS/ AA to another

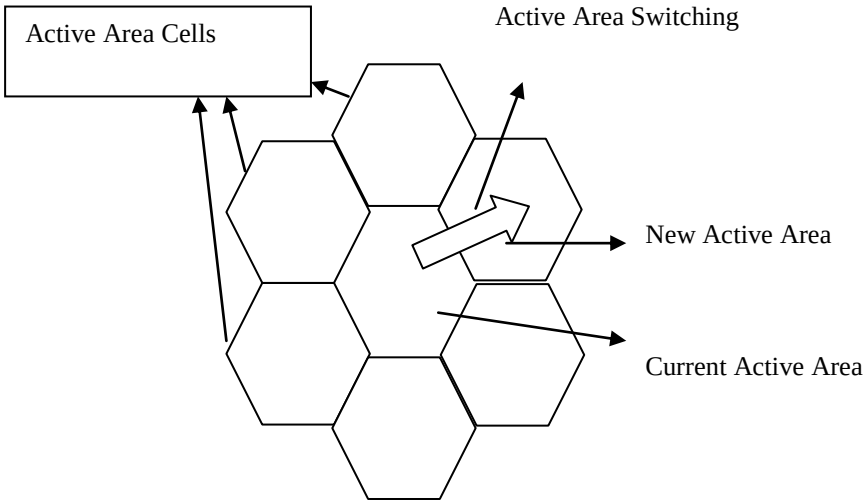

Fig 1: Cell cluster to support user mobility

All the user's devices have unique identification tags like RFID to track their location. Whenever a user device is detected in an active area other than its home, it will be identified by its unique identification tag.

2.2. Power Consumption in Cellular System

Cellular system provides a very good support and coverage for mobility of users. Users in ubiquitous computing scenario have mobile battery operated devices. So communication system in ubiquitous computing should be energy efficient to sustain battery power for long time. Cell size plays an important role in this context. Power required to transmit a signal between user mobile and base station transceiver is increases with the increase in distance between mobile device and base station transceiver. Power of the signal generated by transceiver of base station and mobile station will be same throughout a given cell as exact distance between base station and mobile user can not be determined. So, the power of signal for proper communication is dependent on the radius of cell as mention below [4]

$$Esignal = Eref * d^{i}$$

where

Esignal is average signal power required to successfully transmit signal from mobile device to base station transceiver and vice versa.

Eref is signal power required to transmit signal over one unit of distance (e.g. 1m)

d is maximum distance between base station transceiver and user's mobile device transceiver i.e. radius (R) of the cell in a cellular system.

i Value of 'i' depends on environmental factors, like medium of transmission, level of noise. In noise free environment value of 'i' is '2'.

So, power consumption per unit of data transfer is higher in a cellular system with larger size of cells. In other words a signal with higher power/amplitude will travel larger distance. Consequently there is a tradeoff between area covered by a transceiver and rate of power dissipation of batteries of mobile devices covered in that area

3. Handoff Strategies

When a service is in progress and the user moves from one cell to another then MSC automatically transfers the user to the new Base Station. This procedure is known as Handoff. Handoffs are of two types:

1. Hard Handoff
2. Soft Handoff

Hard handoff is "Break before make". In this the user is disconnected due to low power of signal, received from parent base station and new cell base station. The status of user is preserved in the parent base station while disconnected. Hard handoff normally occurs in the case of FDMA and TDMA where channels are divided on the basis of frequency or time division [5]. On the other side soft handoff is to select the appropriate signal received from other base stations. To perform a successful hand off it is most important to check the power level of user's device when the user is moving toward the cell boundary. A particular signal level is specified as minimum acceptable level to maintain a connection. The threshold level is fixed at slightly greater than this minimum acceptable level.

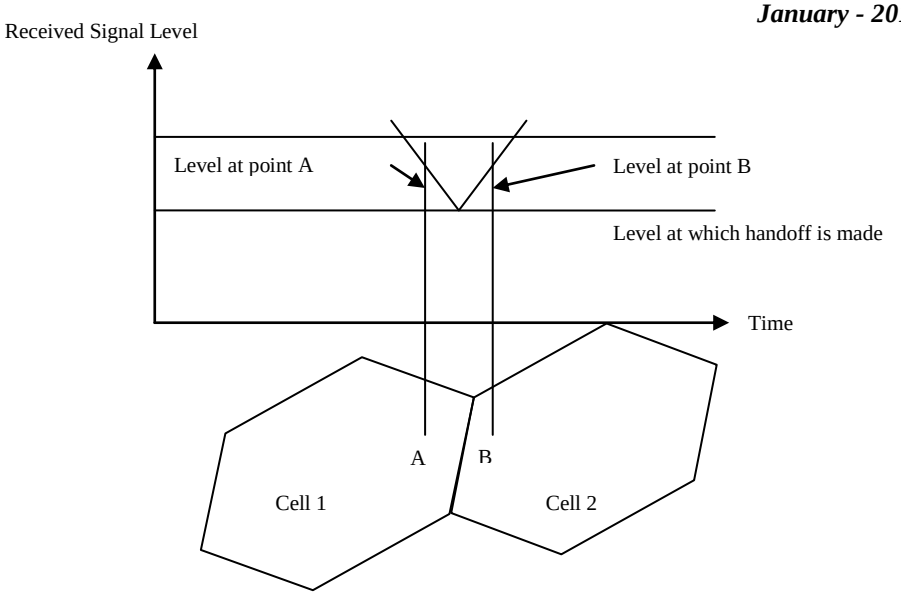

Fig 2: Proper Handoff

The difference between the threshold level and minimum acceptable level of power is known as Δ.
and $\Delta = P_{r\ handoff} - P_{rminimum\ usable\ level}$

The value of Δ should be decided carefully because it can not be too large or too small. If the value of Δ is too large then unnecessary handoffs may create burden on the MSC. If the value of Δ is too small then the user is disconnected before the handoff due to insufficient time to transfer a user connection to a new base station. Fig. 2 shows handoff between two cells Cell1 and Cell2 in which user connection is transferred to the base station of second cell before going to disconnect. It is proper handoff. If the user is disconnected before handoff then it is improper handoff.

4. Umbrella Cell Approach in Ubiquitous Service Access

High speed moving vehicles crosses the active cell area of a cell within few seconds then the requirement of handoff is very frequent. When handoff increases constantly under an MSC then that particular MSC quickly become burdened. On the other side the slow moving users or pedestrian do not cross any active cell area, so there is no need of handoff. Several techniques are used to handle the situation for high speed and low speed users while minimizing the number of handoffs. The practical limitation is to obtain new cell sites. It is very difficult to find out new cell sites in urban areas.

By using different antenna heights and different power levels, it is easy to provide active area coverage to high speed as well as low speed users with less number of handoffs. This approach is known as Umbrella Cell Approach. In which large active area coverage is provided to high speed users and low active coverage area is provided to low speed users. In this approach the active area of Ubiquitous service is divided into no of micro cells or called a cluster which is a collection of seven cells (Fig. 3).

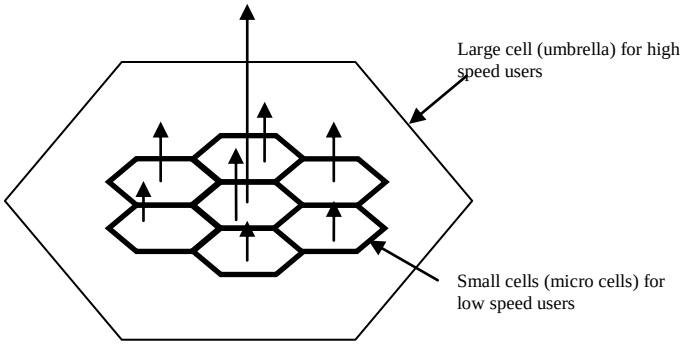

Fig. 3 Umbrella Cell Approach to minimize Handoff

Antennas of small heights are connected in each micro cell with less transmitting power. While the height and power of antenna used to provide coverage to large cell is high. The speed of movement of user is estimated by the base station or MSC by evaluating how rapidly the signal strength of user's device is changing over time. As the large cell active area provides coverage to high speed users the number of handoffs is minimized and for low speed users low power transmitters are sufficient to provide coverage [4].

5. Conclusion

By implementing cluster of small cells in a large cell, coverage capacity of an active area cell is increased. It will also provide better coverage as well as minimize the number of handoff. For an MSC it is important to avoid unnecessary handoffs. To overcome the burden of MSC and improve user bandwidth, umbrella cell approach is good solution. By using microcells the low speed users do not require any handoff, due to slow cell to cell transition, as well as the coverage will be sufficient with low power transceivers. However hardware cost of low range transceivers is less as compared to long range transceiver. Apart from improving coverage of users' mobile devices, low range transceiver also insures more precise prediction about location of a user. For example, Bluetooth transceiver with 1m range can detect a user location with a precision of 2m (i.e diameter of cell). With improvement of precision in location detection, implementation of context based services, like display of user data on closest infrastructure panel, becomes feasible. In ubiquitous computing it is not necessary to increase number of computing devices, rather only number of transceiver need to be increased. Number of computing devices may be managed by dividing active cell areas in two sizes, as in umbrella cell approach.

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