[10-25]

Arbitration Method of Beacon Transmissions in a Positioning System for Ubiquitous Computing

Moon Kyou Song

Dept. of Electrical, Electronic and Information Engineering, Wonkwang University

mksong@wonkwang.ac.kr

Abstract

An arbitration method is proposed toq resolve a collision and arbitrate beacon transmissions in an indoor positioning system consisting of multiple beacons and listeners. Although two or more beacons may compete to transmit signals simultaneously, a single winner in the competition is determined autonomously through the arbitration process while they are transmitting. So, the beacon can continue to send its data, but the others give up their transmissions during the arbitration process. As a consequence, update rate for location information and channel utilization can be improved by avoiding that all beacons fail due to a collision. Once a beacon succeeds in transmitting its signal, a low-level priority is assigned to it. And a high-level priority is allocated to a beacon which gave up its transmission during arbitration process. This will guarantee every beacon has fair transmission opportunity with the arbitration method. As no centralized control is required among beacons, a positioning system can still be easily deployed and expanded with this arbitration method.

I. Introduction

Ubiquitous computing is an emerging research area that seeks to build systems for a world where computing and communication are ubiquitous in our physical environment. An important class of applications in this area are "context-aware" ones, which can adapt their behavior to the nature and conditions of the physical environment in which they run[1]. A particularly important context is location or spatial context, which is useful for location-aware applications in both indoor and outdoor environments. The widespread deployment of location-dependent applications inside buildings and homes has the potential to fundamentally change the way we interact with our immediate environment, where computing elements will be "ubiquitous"[1,2].

Such applications require the ability to learn about the physical space in which they are. As GPS is available for finding a user's location in outdoor, a certain type of a positioning system is also necessary for indoor ubiquitous environment where no GPS signal reaches.

There have been several works on a positioning system[1]. Examples of those systems include Active Badge and Active BAT(1999) from AT&T Research, RADAR(1999) and Easy Living(2001) from Microsoft Research, Pinpoint of RF Technology, Smart Floor (2000) of GeogiaTech, SpotON(2000) of University of Washington. However, these are location tracking systems where a central system can track the user's location, so they have common trouble in user privacy.

A positioning system for ubiquitous computing needs to have privacy-oriented architecture, where the infrastructure only transmits signals, and user device itself recognizes the location using them. It is also desirable to have no centralized control among beacons for easy deployment. Thus, each beacon independently needs to try an asynchronous, random, and distributed contention-based transmission.

Examples of positioning systems suitable for ubiquitous computing include Cricket of MIT(2000)[2,5], IPS of Bristol university(2002)[3] and Dolphin of Cambridge university (2003)[4]. This paper mainly refers to Cricket system as a typical positioning system for ubiquitous computing.

Cricket system consists of wall- and ceiling-mounted beacons spread through the building and listeners attached to a mobile computing device. It uses a combination of RF and ultrasound to provide spatial information about the location where a user or a device resides. Each beacon publishes location information on an RF signal. It is sufficient to use simple OOK(on-off keying) for RF transmission, which may be the best in terms of price particularly for spreading beacons in wide area since data from a beacon is not much. With each RF advertisement, the beacon transmits a concurrent ultrasonic pulse.

A listener measures the difference of time-of-arrival between RF and ultrasonic signals from a beacon to calculate a distance to the beacon, taking advantage of the fact that the speed of sound is much smaller than the speed of