Chapter 3.23
Positioning Technologies for Mobile Computing

Michael J. O'Grady
University College Dublin, Ireland

Gregory M. P. O'Hare
University College Dublin, Ireland

INTRODUCTION

Mobility is, as the name suggests, the defining characteristic of mobile computing and the primary differentiator between it and other computer usage paradigms. Traditionally, computers were used in what may be termed a static context. However, when computers are used in a mobile context, a number of difficulties that challenge traditional assumptions emerge. Not least amongst these are those difficulties that arise in delivering a service that is relevant and consistent with the situation in which the end-user find themselves. Should a person be waiting at a bus stop, he or she does not wish to go online and browse a bus timetable. Rather, he or she wishes to know when the next bus will stop at his or her particular stop. Thus location and time would be fundamental to the provision of such a service. Capturing time provides no major difficulties. However, identifying the physical location of a service subscriber may prove problematic.

In this review, we summarize some of the key technologies that enable the position of a mobile computer user to be determined.

BACKGROUND

Research in mobile computing and associated disciplines (Vasilakos, 2006) began in earnest the 1990s as the feasibility of the paradigm became increasingly clear. As the various research issues began to crystallize, researchers became aware of the desirability of using additional known facts of the end user's prevailing circumstances as a basis for customizing or personalizing the service for the individual end user. The term *context-aware computing* was coined to conceptualize these ideas. Pioneering research in this area was conducted at Xerox Parc in California by Schilit Adams,

and Want (1996). The Oxford Concise dictionary defines context as "the interrelated conditions in which something exists or occurs." Intuitively, everybody understands what context is. Almost paradoxically, this has made the derivation of an agreed definition almost impossible, leading some researchers to reconsider its philosophical roots (Dourish, 2004) and inherently dynamic nature (Greenberg, 2001). One issue commonly agreed is that a person's location or physical position forms an indispensable aspect of his or her context—so much so that Schmidt, Beigl, and Gellerson (1999) almost remind researchers that there are other aspects of context that should be considered. The reasons for researchers' enthusiasm are understandable. In the mid-1990s, the global positioning system (GPS) was deployed, making it possible to determine position to within 100 meters for those people equipped with a GPS receiver. Thus the technological issues were being addressed in a meaningful way. However, it was developments in wireless telecommunications that provided the spur for the upsurge in business interest in what would be termed location-aware computing (Patterson, Muntz, & Pancake, 2003).

In 1996, the Federal Communications Commission (FCC) in the United States announced the E-911 directive. In brief: this obliged public telecommunication network operators to provide the position of those people making emergency calls, thus enabling police, medical, and other personnel to react quicker. It soon became clear that this facility could have other uses for commercial purposes as, in principle at least, the location of any subscriber could be identified. Thus an era of location-aware services was anticipated. This era has yet to materialize, but as outstanding technological issues are continually being addressed, it is only a matter of time before a suite of location-aware services are available for subscribers.

To deliver location-aware services, it is necessary that an appropriate technology be selected that will provide a subscriber's position within a certain range. In the next section, some of the principal technologies for determining position are described.

TECHNOLOGIES

Various technologies and techniques are described in the academic literature for determining user position. Naturally, each has its respective advantages and disadvantages. For the purposes of this discussion, it is useful to classify them as satellite techniques, cellular network techniques, and hybrid. Each classification is now considered briefly.

Satellites Technologies

Trilateration is the basic principle for determining position using satellites. In short, the time taken for a signal to travel from a satellite at a known position to a receiver is calculated. This process is repeated for three satellites and a solution can be generated. In practice, a fourth measurement is necessary to account for the lack of synchronization between the atomic clocks on the satellite and the receiver's internal clock. The accuracy of the resultant calculation may vary due to a number of factors, including atmospheric conditions and the satellite constellation configuration. However, a reading within 20 meters of the receiver's exact geographic position may be realistically expected.

At present, there are two satellite systems in operation that broadcast signals:

1. *Global positioning system* was deployed in 1996, covers the entire earth, and is freely available. It remains under the control of the United States military. It is currently the de facto standard with specialized receivers on the market for all kinds of purposes including aviation, maritime, and leisure. To use GPS, a mobile computer user would