

Chapter XII

A Focus on Location Context

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ABSTRACT

This chapter adds an in-depth description of location context, because location is the most prominent context property and the associated tracking technology is increasingly deployed in industry. First, we motivate a number of application areas for this technology in industry, healthcare, tourism, and more. We first describe the different physical properties location sensors can measure and then the principles and algorithms to calculate the locations of mobile entities based on this sensor data. Several commercial location systems and research prototypes are described as implementation examples. Finally, with the help of location models, the raw location information is processed to derive higher-level information meaningful to application services.

INTRODUCTION

One of the most important physical context parameters is location, because most other physical and situational context properties can be determined as functions of place and time. There are numerous applications for location tracking technology in real-time enterprises, healthcare, tourism, etc. Currently, especially the market for Local Positioning Systems is growing. Services that can adapt to the user's location are also often called location based services (LBS). A few application areas are listed below.

- **Navigation:** GPS-based navigation systems virtually belong to the standard equipment of new cars.
- **Enhanced 911 services:** The Federal Communications Commission requires wireless carriers to locate cell phones with an accuracy of 50-300 meters in case of emergency calls.
- **People tracking:** For example, child tracking in amusement parks, security personnel in enterprises, hospital patients, prison inmates, or employees in office buildings.

- **Asset tracking** to keep a real-time inventory of assets and their locations to make items easier to find when they are needed. Various types of equipment can be tagged, including vehicles, inventory in a manufacturing line, containers, forklifts, shopping carts, or medical equipment.
- **Buddy finder:** Instant messaging applications on mobile devices can not only reveal when friends are online, but also where they are and alert users when friends are nearby.
- **Conference assistant:** Whenever the user enters a conference room, the assistant uses the location and the conference schedule to identify the current speaker and the presentation title.
- **Advertisement:** Special offers from nearby stores or restaurants can be displayed on cell phones.
- **Mobile patient monitoring:** Dementia patients need constant monitoring. LBSs can prevent patients from leaving hospital wards or buildings by automatically locking doors or notify the nursing staff.
- **Theft protection:** Retailers typically experience annual loss of ~15% for shopping carts. By tracking equipment both in store and in the parking lot, retailers can reduce theft.
- **Safety:** If an emergency happens at a large building or tunnel construction site, the supervisor must be able to quickly get a list of people at unsafe locations and the locations where they have been seen last.
- **Security:** Certain chemicals react with each other and may not be stored in the same area. A tracking system can monitor the warehouse and alarm the staff when storage regulations are violated.
- **Tour guides** automatically present information to the user based on the user's location.

This chapter is organized as follows. We first describe the basic principles to determine one's location from various kinds of sensor data. Next, the signal propagation characteristics of electromagnetic waves are discussed. In the context of positioning systems, the different bands of the electromagnetic spectrum have vastly different properties. Understanding these characteristics is essential for the construction and selection of systems. We then describe a number of positioning systems with their properties. With the help of sensors and positioning algorithms, we are able to determine the position of people or objects in a representation that is specific to the location system. To derive information more meaningful to applications, for example, the location within a building, or the location relative to other people or objects of interest, we need location models.

POSITIONING PRINCIPLES

A positioning system consists of *navigation sources* and *users*. The locations of the navigation sources are known. The locations of the users are unknown and should be determined. A positioning system uses sensors to measure certain physical properties and calculate the users' positions based on this data. Essentially, we distinguish between the following kinds of sensor information:

- Binary information if communication between source and user is possible.
- Received signal strength (RSS), bit error rate (BER) or read success rate. These values give an indication of the quality of the communication link between source and user.
- Time of arrival (TOA). TOA is a measure for the absolute distance between source and user.
- Time difference of arrival (TDOA). In TDOA systems, only the differences of multiple TOA measurements to different sources are known.

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