

# Mobile Positioning Technology

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## INTRODUCTION

A radio mobile-position system operates by measuring, processing, and storing physical quantities related to radio signals travelling between a mobile terminal and a set of transceivers, for example, satellites or Base Stations (BSs). Positioning techniques in cellular networks are of great importance for supporting emerging services that require a sufficient, precise estimation of the position of the mobile terminal (MT) associated with a number of given base stations. The ability to support position location within wireless networks provides network operators with valuable services, as well as users with a host of new applications. This includes navigation, location-based services, network management, and security applications. Nowadays in GSM networks, there is no specific algorithm included in the software to locate subscribers. The only possibility to locate a subscriber is accomplished by using *GPS* technology or special firmware.

An innovative development should be the design and implementation of certain location positioning techniques, as *Time of Arrival* (ToA) and *Angle of Arrival* (AoA), over the existing GSM network. Although there are already next generation networks in use nowadays (UMTS, GPRS, WLAN), and there also is extensive research towards the fourth generation cellular networks, GSM seems to be the most popular network so far. GPRS network is a data network over GSM platform and it exists only with GSM architecture. The reason is that GPRS uses the GSM air interface (Radio Network Part) and it only diverts in the core network where it transmits the data packets towards a different switch. UMTS, on the other hand, is a unique network supporting cellular and voice-data applications, and is the evolution of GSM towards IP applications. Although it could be implemented separately from GSM, most of the operators preferred to implement it in a GSM convergence mode towards the core network for eliminating the investment. As a result, in most countries GSM is the major network with full geographical coverage and network location positioning techniques are most implemented in a network environment with a satisfactory number of Base Stations.

## BACKGROUND

In 1991, European Telecommunication and Standardization Institute (ETSI) accepted the standards for a new upcoming mobile, fully digital, and cellular communication network (Figure 1).

The purpose of positioning the mobile is to provide location-based services (LBS), including wireless emergency services (Porretta, Nepa, Manara, Giannetti, Dohler, Ben, & Aghvami, 2004). The handset based positioning techniques require that the existing handsets have to be redesigned in order to meet new requirements, while the network based positioning techniques need adjustments only at the Base Stations (BSs) or switching centers. Furthermore, with the first approach, the MT utilizes transmitted signals from the BSs to estimate its own position while with the second approach the BSs measure the transmitted signals from the MT and relay them to a central site for processing.

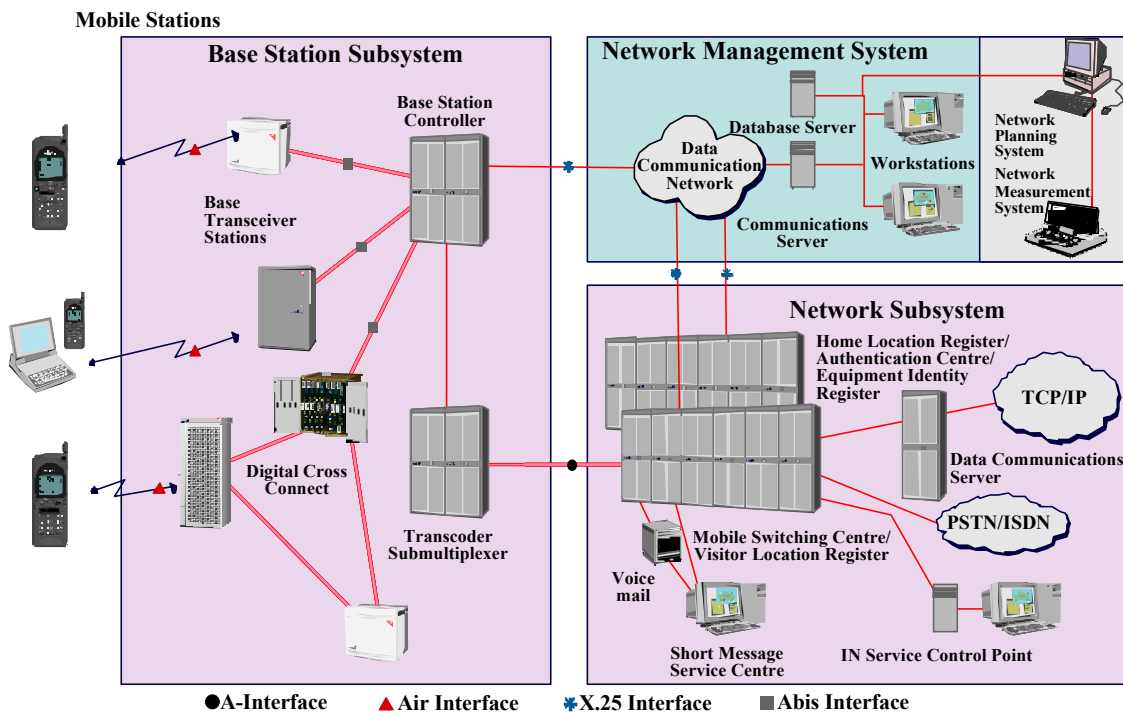
## Handset-Based Mobile Positioning Technology

It is referred to as “handset based” because the handset itself is the primary means of positioning the user (Smith, 1991), although the network can be used to provide assistance in acquiring the mobile device and/or making position estimate determinations based on measurement data and handset based position determination algorithms (Kothris, Beach, Allen, & Karlsson, 2001). The representative techniques of handset based positioning technology are:

- **Enhanced Observed Time Difference (E-OTD)**

This technique is also encountered as handset based Time Of Arrivals and specially equipped handsets are required. Enhanced Observed Time Difference (E-OTD) technique operates by instating location receivers called location measurement units (LMU) at several places geographically dispersed in the radio coverage area of a cellular network.

Figure 1. GSM network architecture



- Global Positioning System (GPS)

Unambiguously, the main technology for the implementation of handset based positioning is the Global Positioning System (GPS) which has changed navigation and position forever. It is a universal system consisting of three interlocking segments: the space segment, the user segment, and the control segment. The space segment consists of 24 satellites each in its own orbit 20,000 km above the Earth which means that it takes 12 hours to orbit the Globe.

- Assisted Global Positioning System (AGPS)

GPS suffers position errors from satellite clock, satellite orbit, ephemeris prediction, ionospheric, and tropospheric delays, and so forth. In order to reduce these errors and correct the initial position estimation, additional information can be applied to GPS receivers. A substantial correction method is Differential GPS (DGPS). According to this method, a

reference GPS receiver at a proper position is used to send correction data to the requested MT (Zhao, 2002).

## Network Based Mobile Positioning Technology

It is called “network based” because the mobile network, in cooperation with network-based position determination equipment (PDE) is used to position the mobile terminal. It is also referred to as “unmodified handset” which means that there are no changes and, thus, additional cost for the subscribers in the mobile device. On the contrary, this technology requires changes in the infrastructure of the GSM elements.

- Fingerprint method

It is an implementation used mainly for indoor application (Pahlavan, Li, & Mäkelä, 2002), which makes use of

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