Analysis of Subscriber Radio Location Techniques through a Deterministic Propagation Model

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The interest in radio location algorithms originates from need to guarantee emergency services to calls made by mobile phone users; indeed, beginning October 2001, the FCC requires that, in the US, all emergency calls (911) from cellular phones must be located within 125 m in 67% of the time. Nevertheless, the number of applications for location information is growing rapidly: for example, a location-aware service is to connect the Yellow Pages with a map database giving the information about the address of a certain site (hotel, restaurant, museum) in the closeness of user. Furthermore, location information can be very useful for the network operator, especially in Radio Resource Management (RRM) functions, e.g., selection and handover.

A radio location system operates by measuring physical quantities related to radio signals traveling between a mobile station and a set of fixed base stations. The received signal is used to estimate the length and/or direction of arrival of radio paths, and the mobile position is derived from geometrical relationships. In particular, radiolocation systems can be implemented that are based on the angle-of-arrival (AOA), the signal strength, the time-of-arrival (TOA.), the time-difference-of-arrival (TDOA), or their combinations (James Caffery, Gordon Stuber, "Subscriber location in CDMA cellular networks" *IEEE Transactions on Vehicular Technology*, vol. 47, no 2, May 1998).

In this work, it is shown that a deterministic simulator of the electromagnetic propagation in urban areas can be usefully employed to optimize and validate a subscriber radio location technique for third generation cellular networks. In particular, a fully three-dimensional simulator based on high-frequency ray-techniques has been applied to validate a TOA radio location algorithm which requires the knowledge of the time of arrival delay at three different base stations. For each mobile position, the received signal is evaluated as the summation of ray contributions reaching the base station after reflections or diffractions, so that non-line-of-sight conditions can be suitably accounted for. Contributions up to the third order for reflections from the walls of the buildings have been also included. Diffractions from the edges of buildings are evaluated through approximate dyadic coefficients which are valid for impedance surface models. Moreover, computer graphics algorithms have been used to speed up the ray-tracing procedure.

The algorithm has been tested in a Manhattan-like microcellular environment and the performance have been evaluated in terms of the absolute location error. The effects of the time of arrival quantization are also taken into account. Extensive simulations demonstrated that it is possible to achieve a location error with a mean value of 33 m and a standard deviation of about 20 m. A detailed description of the radio location algorithm implemented will be given at the conference. Work is in progress to include into the algorithm other signal parameters, *e.g.*, amplitude and direction of arrival of the signal received at the base stations, with the specific aim of both increase the accuracy of the algorithm and reduce to less than three the number of base stations required.