

Q1 Additional Topics 2003 (relates to lectures 1-3 by A Hopper)

- (a) Give three methods of computing location of cell phones and indicate the accuracy in each case. [10]
 - (b) What is the location accuracy of GPS (Global Positioning System) and how can it be improved. [5]
 - (c) Give the accuracy of the ultrasonic Active Bat location system and discuss how it might compare with radio-based ultra wideband location systems. [5]
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(a)

Time of flight method, three readings give location, estimate of time poor because transmission timing slip is the measure, poor accuracy approximately 250 meters 65% of time 2 km 95% of time

Time difference of arrival method, uses synchronized clocks at base stations, hyperbola is locus of $t_1 - t_2$, three base stations give unambiguous location, medium accuracy approximately 15 meters 65% of time 50 meters 95% of time

Angle of arrival method, requires twin (or more) antennas at each base station, hyperbola is locus of time difference from each antenna, three base stations for unambiguous location, accuracy similar to time difference of arrival method

(b)

GPS has medium accuracy 30 meters 95% of time, improved by using Differential GPS, this is a locally transmitted correction based on a surveyed point and received satellite data at that point. The biggest source of error was Selective Availability (SA), which jittered the clock and worsened the clock sync from its normal 10 nsec level but has now been switched off.

(c)

Active Bat has very good accuracy of about 3 cm 95% of time, mainly influenced by reception of ultrasonic signals in ceiling receivers, shaping transmitted ultrasonic pulse and correlating at receiver gives good time measurement precision, sound travels at approximately 1msec/30cms, time measurement has to be at the 100 microsecond level

Ultrawideband systems use very short radio pulses of about 100 psec, radio waves travel at about 1nsec/30cms, time measurement has to be at the 100 psec level for location accuracy similar to Active Bat, it remains to be seen how well ultrawideband works as such systems are only just coming into use