Localization in Smart Dust Sensor Networks

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Recent developments in wireless communications resulted in the design of low-cost, low-power, multi-functional, small-sized sensor nodes that can communicate over short distances. There are many application areas for these sensor nodes such as command, control, surveillance, reconnaissance and targeting in military scenarios, animal habitat, agriculture and water quality monitoring in environmental scenarios and patient monitoring as a healthcare scenario. The need for accurate location information for these applications has attracted a lot of interest. There are many factors that affect the choice of the algorithm to be used for a specific application. Some of these factors are the network architecture, the node density, the geometrical shape of the network area and the distribution of the sensors in that area, sensor time synchronization and the signaling bandwidth. The performance of the chosen algorithm can be expressed in terms of accuracy, precision, complexity, scalability, robustness and cost.

Sensor node localization requires measurement of a set of signal parameters, depending on the accuracy requirements and constraints on the transceiver design. Then, these measurements are used to locate the target node with the help of three or four beacon nodes, whose locations are known a priori, in 2D or 3D, respectively.

Our research goal is to design a robust localization system that offers good accuracy even in the harsh indoor and outdoor environments by handling problems in the physical layer. In this respect, localization based on ultra-wide band (UWB) technology with time-based ranging is a good candidate because of the fine delay resolution that is provided by UWB signals. The system achieves centimeter level accuracy by estimating the time-of-arrival (TOA) of the direct path between the transmitter and the receiver. However, the accuracy and the reliability of the system decrease especially in dense multipath environments since the detection of the direct path becomes more difficult. Non-light-of-sight (NLOS) propagation is another effect that decreases the system accuracy due to the fact that the propagation through walls introduces a positive bias to the TOA estimation. This results in a large error in range estimation as the propagation speed of the signal is high.

Although the other error sources of time-based ranging in UWB systems are clock drift, synchronization and interference, our current research is aimed at detection of direct path in dense multipath environments and mitigation of the NLOS propagation error. In order to detect the direct path between the transmitter and the receiver, proper signal processing techniques have to be employed at the receiver. However mitigation of the NLOS propagation error first requires the identification of the obstructed path. Then a weighting algorithm that suppresses the effect of obstructed paths can be employed in order to locate the target node.