Pervasive Systems Centre

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RF-Based Time-of-Flight Ranging

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Project Aims

To develop a narrow-band RF-based Time-of-Flight (ToF) ranging method with sub-meter ranging resolution which can be adopted in wireless sensor networks (WSNs) for the purpose of localising sensor nodes. The use of RF will enable point-to-point ranging over larger distance (>50m) than current Ultra-wideband (UWB) based TOF systems with significantly less use of channel bandwidth.

Time-of-Flight Ranging for WSN Locationing

The location of nodes within WSNs is important in order to make sense of data recorded by the sensor itself. The location of nodes may be known from a prior knowledge, i.e. by recording position co-ordinates during deployment, however, many WSN applications exist where this technique is either impractical or not a valid solution. The process of 'localisation' where sensor nodes can determine their position relative to a number of fixed reference nodes is an attractive solution to this problem. In order for nodes to localise themselves within a WSN, they must perform two fundamental stages: 1) nodes must perform ranging in order to determine their point-to-point distances; 2) a computational algorithm is used to determine all relative positions of nodes within the WSN.

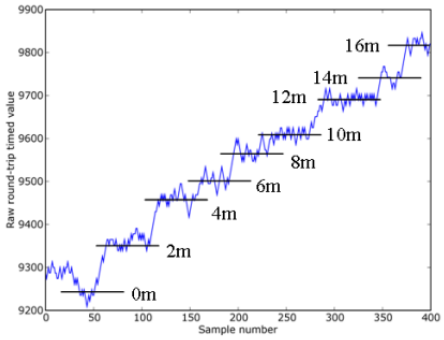
Chipcon CC2430 Development used to prototype Rf-based TOF ranging algorithm.

Time-of-Flight ranging has significant performance advantages in terms of immunity to noise and signal multipath. TOF has been adopted in locationing systems using time-difference-of-arrival (TDOA) architectures which require wired infrastructure between reference nodes for data transfer and timing synchronisation. This limits the locationing of sensor nodes to applications with fixed architectures.

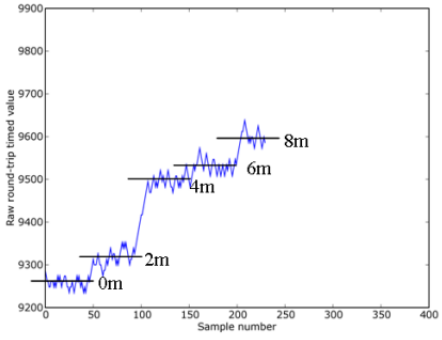
Prototype test apparatus. Ranging data recorded using a laptop computer, measurement referenced to measured distance in metres.

Ranging System

The TOF ranging algorithm has been prototyped using a Chipcon CC2430 development kit. The CC2430 is a fully integrated IEEE 802.15.4 compliant RF transceiver and Intel 8051 MCU. The algorithm is fully implemented in software and requires no additional hardware for operation. Transceiver-transceiver synchronisation is relaxed with ranging performed on a single 250kb/s channel in the 2.4Ghz ISM band.



Typical real time performance of prototyped ranging algorithm for Line-of-Sight (LOS) condition. Two metre increments.



Typical real time performance of prototyped ranging algorithm for non-line-of-sight (NLOS) condition in a residential dwelling. Two metre increments.

References

1. T.C. Karalar and J. Rabaey. **An RF ToF Based Ranging Implementation for Sensor Networks**. *IEEE International Communications Conference*, University of California, Berkeley, Vol 7, pp. 3347-3352, Jun 2006.
2. R.J. Fontana, S.J. Gunderson. **Ultra-Wideband Precision Asset Location System**. *IEEE Conference on Ultra Wideband Systems and Technologies*, Baltimore, MD, 2002.
3. R.J. Fontana, E. Richley, J. Barney. **Commercialization of an Ultra Wideband Precision Asset Location System**. *IEEE Conference on Ultra Wideband Systems and Technologies*, Reston, VA, Nov 2003.