Passive elements array antenna for wireless sensor networks

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Overview
Low power consumption is crucial for the long term operation of wireless sensor nodes. Typically, radio is the biggest energy spending device in WSN. We show that radio power consumption can be reduced with no adverse impact to transmission quality or link distance, and that the distance can be extend without increasing the power consumption using a passive element antenna array (PEAA) for data communication.

PEAA decreases the received signal noise significantly thus increasing the link quality. It is easy to change the transmission direction with PEAA, because it is done electronically.

PEAA prototype description
PEAA consists of a central radiator and passive elements located at equal distances around it. The central radiator is half wave monopole fed by 50 ohm signal cable. Passive elements are fed by transmission lines and terminated by varactor's (variable capacitance diode). Transmission line length is calculated so that the signal received by passive element at the end of transmission line is shifted in phase by $\pi/2$ radians and due to the variable reactance of varactor the total phase shift from 0 to $\pi$ is achievable. Because of superposition of waves and phase shift made by the passive element circuit the signal in each particular direction could be amplified or attenuated according to the capacitance of the varactor. Therefore, using different capacitances in the passive element circuits the directionality of the transmitted signal is achieved. The direction is controlled by a sensor node via I2C connected to a digital potentiometer. Finding of right capacitances complex task. However, for the purposes of antenna test, a simple technique was used.

Testing
We have made a testbed for PEAA using a stepper motor controlled rotation platform for the transmitting node with PEAA. The receiving node is connected to the computer for data collection and interpretation. We have made initial radiation pattern tests as well as the beam width measurements in horizontal and vertical planes.

Summary and future work
PEAA is good alternative for energy savings and increased radio coverage in WSN's. Radio link distance could be extended up to four times and radio noise reduction could be attenuated up to 5dB. Front to back signal level of 20 dBi was measured. In future, we will work on finding optimal passive element configuration and PEAA MAC level integration with TinyOS as well as real life measurement of PEAA direction switching speed and energy savings.