Non-RSSI based energy efficient transmission power control protocol for low power indoor wireless sensor networks

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Abstract

In this thesis, we present the state-based adaptive power control (S-APC) protocol that is aimed to reduce energy consumption in low power wireless sensors while maintaining an application specific packet success rate requirement. The state-based approach is unique of its kind that dynamically adapt to the varying path losses caused by the movement of mobile sensors, by obstructions appearing between the stationary sensor and the base-station and movements of objects or humans in between two communicating stations. Since the primary reason for a drop in transmitted packets is the poor signal-to-noise ratio, it is important for the sensor to select a set of RF transmission power levels that will deliver the packets within a specified error rate while using the least amount of energy. In a battery-powered wireless sensor node, the use of ARQ (Automatic Repeat reQuest) protocol will lead to retransmissions when an attempt to send a packet fails. The proposed adaptive protocol does not use received signal strength indication (RSSI) based beacon or probe packets nor does it listen to the channel before transmitting for channel estimation. The use of the proposed S-APC protocol is not limited to only sensor network. It is applicable to any kind of radio communication when the transmitting radio frequency (RF) modules have configurable output power and options for retransmission. This proposed protocol can comfortably work on top of existing MAC protocol that is contention based and listens to channel before transmitting.

The hardware used for evaluating the protocol parameters is the nRF24L01p transceiver module from Nordic Semiconductor Inc. This radio module is cheaper than other modules that provide the RSSI values to the chip and the application of the adaptive power control protocol can further reduce the overall deployment and running cost of a sensor network.

The proposed protocol is designed to respond to an unknown and variable radio channel in an energy-efficient manner. The adaptive protocol uses past transmission experience or memory to decide the power level at which the new packet transmission will start. It also uses a drop-off algorithm to ramp down power level as and when required. Simulation has been used to compare the performance with the existing RSSI and non-RSSI based adaptive power control protocol. Results have shown that when the channel condition is between average and poor (ratio of bit energy (E_b) and noise power spectral density (N_0) is less than 20 dB), the RSSI based adaptive protocol consumes 10-20% more energy. Following the simulations, exhaustive experimental trials were done to compare S-APC with the existing protocols. It was found that there can be an increase of energy efficiency up-to 33% over fixed power transmission. This protocol could be applied in mobile robots that collect data in real time from sensors and transmit to the base station as well as to body wearable sensors used for monitoring the health conditions of patients in a health facility centre. Overall, this adaptive protocol can be used in radio communication

where the channel has dynamic temporal and spatial characteristics to enhance the lifetime of battery powered wireless sensors.

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