Redistributing WSN Energy Consumption

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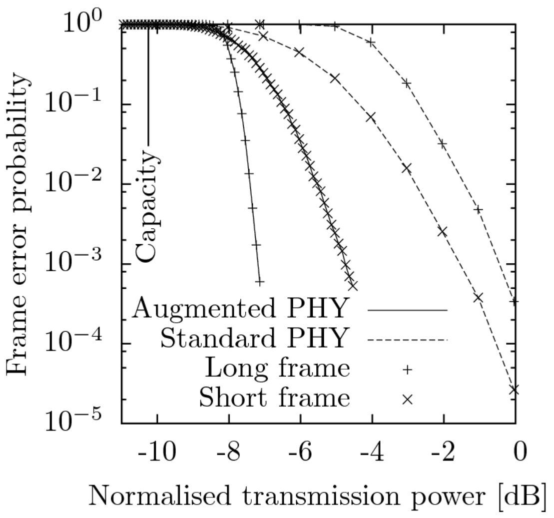
Project Aims

To beneficially redistribute energy consumption in wireless sensor networks. Typically, sensor nodes have scarce energy resources and must rely on energy harvesting to prolong their life. By contrast, the sink node is often integrated into a higher-level system and can benefit from the accompanying plentiful energy resources, such as the mains. It is therefore desirable to redistribute energy consumption from the sensor nodes to the sink node. This can be achieved using iterative decoding.

Iterative Decoding

We proposed the use of iterative decoding to augment the IEEE 802.15.4 physical layer (PHY). In this approach, error correction is performed repeatedly, rather than just once like in the standard IEEE 802.15.4 PHY. As a result, our approach improves the achievable error correction capability, as shown in the plot provided below.



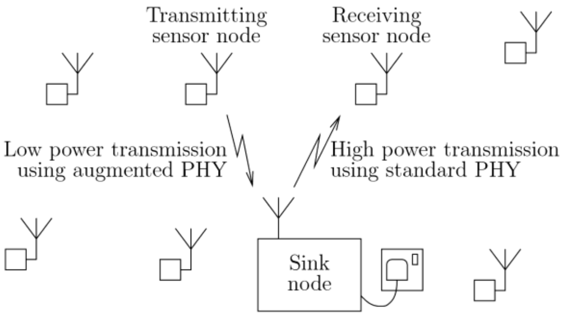
Variation in frame error probability

This plot shows that the augmented PHY is able to successfully recover significantly more data frames than the standard PHY, when both schemes transmit with the same power. As a result, the augmented PHY significantly reduces the need for sensor nodes to retransmit lost data, reducing the drain on their scarce energy resources. An alternative interpretation of the above plot is that the augmented PHY can achieve a particular error probability with a significantly lower transmission power than the standard PHY. Lower transmission powers are another way to reduce the drain imposed upon the scarce energy resources of the sensor nodes.

Observe that, in the above plot, the standard PHY achieves a higher error probability when long data frames are transmitted. This is because long frames contain more data and so are more susceptible to corruption. By contrast, long data frames are associated with lower error probabilities when the augmented PHY is adopted. This is beneficial because header information provides only a small fraction of long data frames and hence imposes only a small overhead.

Network Scenario

Note that the improved error correction capability of our augmented PHY is achieved at the cost of an increased decoding complexity, since it performs error correction repeatedly. For this reason, the augmented PHY should not be adopted when transmitting to a sensor node. Instead, the arrangement shown in the figure below is motivated.



Perceived network scenario

In this arrangement, all data frames exchanged between sensor nodes (for the purposes of smart sensing, for example) are routed via the sink node. This arrangement is desirable when the sink node's higher-level system requires access to all sensed data, for example. Here, the scarce energy resources of the sensor nodes are benefited by transmitting at a low power using the augmented PHY. While this imposes a high decoding complexity upon the sink node, it can readily afford this owing to its plentiful energy resources. Similarly, the sink node can afford to transmit data frames to the sensor nodes using a high transmission power. If the standard PHY is employed for these transmissions, the sensor nodes incur only a low decoding complexity and their scarce energy resources are not squandered. In this way, our augmented PHY can interoperate with the standard IEEE 802.15.4 PHY.

References

1. R. G. Maunder, G. V. Merrett, A. S. Weddell, B. M. Al-Hashimi, and L. Hanzo. Iterative Decoding for Redistributing Energy Consumption in Wireless Sensor Networks. In Proceedings of the IEEE International Conference on Computer Communications and Networks Conference (ICCCN), St. Thomas, US Virgin Islands, USA, 3-7 August 2008.