Transmit Diversity for Backscatter RFID: Preliminary Results

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The range and reliability of passive, backscatter radio frequency (RF) tags are often limited by the *forward link* of the backscatter channel – i.e., the radio propagation channel that exists between the reader transmitter and the RF tag. Path loss, shadowing, and multipath in the forward link can limit the power that is delivered to the RF tag's integrated circuit and prevent the RF tag from powering on. One way to overcome this problem is to design RF tag integrated circuits that consume less power; however, several methods exist that can increase the power delivered to existing RF tags. Two examples are power optimized waveforms [1], [2] and the use of multiple antennas on the RF tag [3]. In this poster, we investigate an additional method to increase the power at the tag, transmit diversity.

Transmit diversity uses multiple antennas to increase the RF power incident on the RF tag. However, rather than blindly transmitting additional power, transmit diversity uses the complex conjugate of the complex, forward-link channel coefficients to precode the continuous wave signals transmitted from the reader. The outcome is that the signals transmitted from each antenna add coherently at the RF tag. For narrowband RF tag applications, the result of transmit diversity is essentially equivalent to that of time reversal[1] [4] and adaptive beam forming [5, pg., 236].

While transmit diversity and adaptive beam forming have been investigated for backscatter channels (e.g., see [6] and [7]), their ability to increase the power delivered to the RF tag has not received great attention. This is because many commercial RF tags are confined to operate in portals with a strong line-of-sight (LoS) to the reader and adding additional channels with phase control adds to reader cost. However, for applications in which the RF tag is not confined to a portal and is subject to a time-varying, multipath channel, the added performance of transmit diversity may justify this cost.

Potential applications for transmit diversity include using backscatter tags for radio frequency identification (RFID) or as backscatter sensors in the presence of people or where the tags cannot be confined to a portal. If sufficient multipath is present and an adequate number of reader antennas are used, transmit diversity will provide spatial focusing that may help alleviate data collisions because fewer tags will be turned on [7]. Of course, the forward link of the backscatter channel must be measured for transmit diversity to be applied. This measurement requires that communication be established with the RF tag. Therefore, transmit diversity may best be used in situations where communication is established with the tag when the reader-to-tag separation distance is small and then increased or in time-varying, multipath channels where the tag may be powered on and then loose power unexpectedly. If the channel is sampled at a rate higher than that of the channel fluctuations, it is anticipated that coherent addition of signals at the RF tag can be maintained as the tag is moved or as the channel fluctuates.

This poster reports preliminary results for a backscatter transmit diversity system using four, coordinated, 5.8 GHz monostatic readers. The poster will describe the 5.8 GHz backscatter system (purchased from Southern States, LLC), the measurement setup, and present plots of the spatial power fluctuations of the forward link with and without transmit diversity applied.

Azhar Hasan performed this research while a lab associate at Disney Research Pittsburgh.

[1]From a diversity perspective, Lerosey *et al.* [4] create multiple signal branches using multiple frequencies. In this work, however, multiple signal branches are created using spatially separated antennas.

References

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