BackFi: High Throughput Ambient Backscatter – Public Review

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The Internet of Things (IoT) promises to connect billions of intelligent devices in everyday life. These smart devices are usually small and run with very limited power source (tiny batteries or even without a battery, i.e., using power harvesting technologies), but required to operate for a long time. Therefore, the wireless connectivity between the IoT devices and the Internet should be extremely low power, but at the same time, it should have sufficient throughput and connection range. Recent research has demonstrated that backscatter communication, in which a device sends data by modulating its reflections of an excitation signal, is very promising to achieve both goals. Existing backscatter system, predominately Radio Frequency IDentification (RFID), requires a dedicated infrastructure for readers which is not widely deployed yet. Further, RFID readers introduce a new radio signal to already crowded ISM bands and how it coexists with other radio technologies is an open research question.

BackFi attacks this challenge from a different angle and ask: *Can we enable highspeed backscatter communication over an already commonly prevalent signal, i.e., Wi-Fi*? There are several appealing points in this idea. First, BackFi reuses the standard Wi-Fi transmissions as excitation signal, so to avoid the co-existence issue. Second, BackFi overlaps backscatter data on down-link Wi-Fi packets from the access point (AP), and hence improves the spectrum efficiency. Finally, BackFi integrates backscatter reader and Wi-Fi AP naturally in a single device. While previous work has demonstrated the feasibility of Wi-Fi backscatter with a low data rate, BackFi aims to improve the link throughput by an order of magnitude.

Achieving this goal, however, is technically challenging. As Wi-Fi is wide-band and also carries modulated data, techniques developed for RFID fall short in this case. BackFi builds on recent full-duplex radio technologies and designs a sensor circuit for high modulation rate, a backscattering protocol for wide-band self-interference cancellation, and a decoder that performs Maximal Ratio Combining (MRC) to improve the backscatter receiving performance. The system implementation and experimental results conform all design points and also show BackFi affects little on Wi-Fi link performance. The paper leaves several questions for the future work. For example, BackFi does not evaluate its performance over a network of backscatter devices. Also, the paper only describes BackFi over single antenna Wi-Fi. But most of current Wi-Fi APs already enable MIMO for data communication. How to backscatter for MIMO Wi-Fi systems remains unaddressed.

Finally, while BackFi manages to backscatter over Wi-Fi signals, it requires hardware changes on both backscatter devices and existing Wi-Fi APs. BackFi heavily relies on the full-duplex radio, which is still at its infancy. BackFi also needs to change the Wi-Fi behavior slightly, e.g., sending tiny pulses at the beginning of a backscattering slot. But this may lead to redesign all existing Wi-Fi chipsets. In the end, BackFi might still face many adoption and deployment challenges. While such debate could continue, it does not affect too much on the technical contributions of the paper. Hopefully, this paper will fuel more community interest and inspire more future works to design better wireless communication technologies for the IoT world.