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PAPER REVIEW
WIRELESS NETWORKING (ET4394)
2017-2018

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April 4, 2018

1 Paper summarized

Title:

Empowering Low-Power Wide Area Networks in Urban Settings

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Published in:

SIGCOMM 17, August 2125, 2017, Los Angeles, CA, USA

2 Summary

The paper elaborates on the problems of dense, city-scale Low Power Wide Area Networks (LP-WANs). More specifically, it suggests a system called Choir that may resolve collided transmissions from clients that transmit at the same time, thus improving the throughput, latency, battery life of the node and the range of teams of LP-WAN sensors nodes with correlated data.

In order to separate collided transmissions from clients that use the same spreading factor, it tries to estimate the frequency offsets of different clients to within a fraction of each bin of the Fourier transform. The algorithm works as follows: First it multiplies the received signal with a down-chirp, i.e. a chirp whose frequency decreases with time, to get n tones at n frequencies. Then it applies a Fourier transform of size 2^n, where n is the number of peaks, that results in n peaks corresponding to n different transmissions. This process is repeated for subsequent received chirps, thus disentangling the transmissions from the n clients.

A problem with the above approach is that the clearness of a peak depends on the distance between the client and station, meaning that strong transmitters interfere with the weak ones. In

order to overcome this situation, Choir first measured frequency offset and channels of all the strong transmitters and subsequently subtract the signals of these transmitters from the received signal to eliminate this interference. Now, in order to decode data from collisions where data as well as preamble symbols collide, one first must detect the peak locations, i.e. frequency offsets averaged across each symbol of the preamble. Then they must repeat the process to find the peak locations for the data symbols. One can subtract the frequency offset from the data frequency to obtain the data.

Another problem that Choir addresses is that data transmitted by LP-WAN sensors which reside beyond the communication range can not be decoded by the base station due to the low SINR of the received signal. However, if these sensors would like to transmit identical data packets they can synchronize their transmissions so that identical symbols across transmitters add up to reinforce received power. The base station transmits a beacon packet to these sensors and expects a response (this is possible because it affords a much higher transmit power than them). The sensors respond concurrently with packets in the next time slot and despite the synchronization is not perfect (there is a small timing offset between the packets), this offset is smaller than one symbol. Consequently, the base station can observe such peaks, at least for sensors above the noise-floor at the base station.

The contribution of the above system is quite significant because it improves network throughput of commodity LP-WAN clients by 6.84 and expands communication range by 2.65 .

3 Assessment

The structure of the paper and the analysis is done in a clear and comprehensive way. In the first place the authors state the problem and the challenges, the related work and they give their idea in a nutshell. Subsequently they move on to the description of the system and the presentation of their algorithms, thus leaving the reader without any doubts about their solution and contribution. Finally, they use correct metrics in order to prove the advantages of their suggestion, i.e. network throughput, latency, total number of transmissions and re-transmissions required to send one packet worth of data and communication range. It is also worthwhile to mention that the experiment setup is analytically described in the paper, thus making it easy for another researcher to repeat the experiment and confirm the paper's results.

4 Potential improvement(s)

It would be interesting to repeat the same measurements in a different environment other than the CMU campus, preferably a denser one like the city center of a megacity. The most IoT devices are more likely to be in places where the population is denser. Also, another idea to further evaluate this method is to measure the maximum amount of nodes that can communicate at the same time. Finally, one more interesting research topic would be to compare the power consumption between the different existing methods for LP WAN.