Experimenting Coded Slotted Aloha (Work-In-Progress)

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1 Wireless Communication through Coded Slotted Aloha

1.1 Introduction and Context

In this document, we describe work in progress addressing one problem: massive machine type communication (mMTC), where numerous Internet-of-Thing (IoT) devices communicate towards a base station through long-range wireless link. Compared to traditional communication scenarios (e.g. UE's with 4G LTE), the difference is an increase of the number of devices ("massive") where up to 1,000,000 devices with rather small bandwidth requirement (as low as one small packet per hour) could be served by the base station. The scenario makes traditional multi-phase access inefficient (RACH in LTE) - the reason having motivated the exploration of new type of communication techniques. Such techniques include non-orthogonal transmissions (non-orthogonal multiple access, NOMA), either at the physical layer or at the MAC layer level, see [1]. One family of such methods, at the MAC layer, is "Coded Slotted Aloha" (CSA) [2], a sophisticated improvement of "Slotted Aloha" (SA) which allows more capacity and more importantly a low loss rate, allowing single phase access.

1.2 Coded Slotted Aloha

Many variants of CSA exist, we describe the first one of [2]. Time is divided into frames and each frame is divided into slots. In CSA, each active user transmits one packet (fitting a slot) by repeating it in several slots, randomly selected, as represented in Fig. 1. The receiving base station will process the whole frame. As in SA, it will be able to receive and decode packets without interferers (P1 on slot 2, P5 on slot 3). The novelty of CSA, is that each packet has a header indicating the slots of its other repetitions [4]: then a physical copy of the packet is subtracted from these other slots at the signal level: it is an inter-slot successive interference cancellation (inter-slot SIC). The decoding process is similar to a LDPC peeling decoder. CSA can asymptotically reach capacity of 1 packet/slot (large frame size, well selected parameters) which compares positively to the SA limit of 0.368.. .

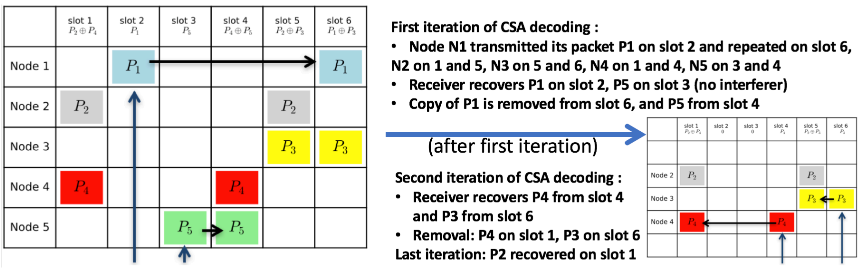

Figure 1 - Principles of Coded Slotted Aloha

2 Experimentation of Coded Slotted Aloha

Although, there is a large literature on the variants of CSA, many publications ignore fading or capture effects (as in [2], and for instance, [3] is one of the few papers taking the effect of path-loss into account). Additionally, in practice, the quality of the repeated inter-slot SIC is paramount to the performance of CSA, and is not so straightforward to estimate theoretically. **For this reason, it is of prime interest to perform empirical analysis/experimentation of CSA.**
Several FIT platforms are prime targets for performing such experimentation. FIT CorteXlab, and FIT R2lab would be well suited as they offer advanced SDR capabilities. However, by noting that only the receiver needs to perform special processing, we opted for the FIT IoT-LAB site of Saclay (for which we have direct access). As a result, in our experiments, transmitters are IoT nodes (M3 nodes with radio 802.15.4, 2.4 GHz, OQPSK) while the receiver is a PC with a software defined radio card (Nuand bladeRF). We exploit the GPS receiver of nodes of Inria Saclay (in range of an indoor GPS repeater), to perform synchronisation on the order of the microsecond.
Fig. 2. represents the status of current work. It describes one real experiment where the central receiver performs full CSA on 21 nodes within 23 slots (of 10 ms): 6 transmissions are without interferer, 5 are captures, 3 are recovered through intra-slot SIC, and 2 through successive inter-slot SIC. SIC could be improved and further work will estimate capacity/loss rate. Experimental and analytical results will be compared.
In addition, processing is an issue: another possible advanced topic is scalability analysis by exploring cloud-RAN designs for CSA decoding with Grid 5000.

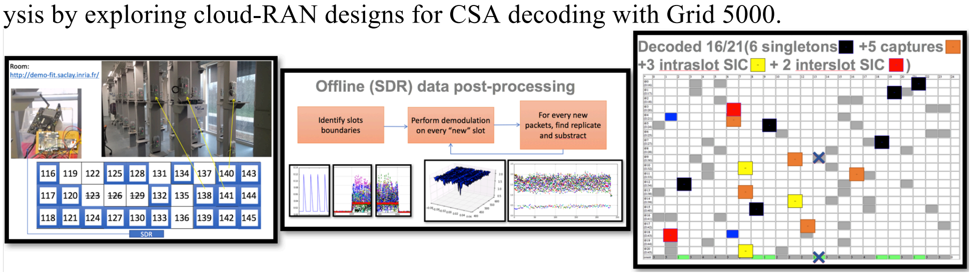

Figure 2 - CSA experiments: 21 participating nodes, processing, and CSA schedule/decoding

References

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4. Casini, E., De Gaudenzi, R. and Herrero, O.D.R., 2007. *Contention resolution diversity slotted ALOHA (CRDSA): An enhanced random access scheme for satellite access packet networks*. IEEE Transactions on Wireless Communications, 6(4).