Spatial Coupling-based Class Prioritization for IoT Networks Using Coded Random Access

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***Abstract*—Future wireless networks are expected to support massive number of users for various applications and requirement such as prioritized access for specific class, for example, ambulance or any related problems endangering human life. This paper studies the prioritization for future group access in randomly massive wireless networks by exploiting the spatial coupling effect in low density parity check (LDPC) codes. With this saturation effect phenomenon, we are expecting that the wireless networks can both provide high priority to some users and higher number of total users, compared to the networks without priority. The performance is evaluated using extrinsic information transfer and packet loss rate compared to the existing networks, for example, ALOHA systems.**

***Index Terms*—Spatial coupling, coded random access, channel coding, LDPC codes, massive wireless access.**

I. Introduction

In this paper, we study the spatial coupling-based prioritization of a class of users higher compared to other class of users, of which the applications is, for example, the ambulance communications rather than devices for other applications without involving human life directly, for example smart parking. We consider spatial coupling [1] because of its capability have a performance close the capacity limit, where in the wireless networks supporting massive number of users, we define a network capacity as the number of successful decoded users given the number of total time-slots.

II. System Model

We consider a wireless network supporting massive number of users with the model following [2] all references therein. All users are assumed using single carrier transmissions with binary-phase shift keying (BPSK) modulation and random transmissions.

III. The Proposed Prioritization

We propose prioritization for future Internet-of-Things (IoT) networks as described in Fig. 1, where the circles represent the users, while the squares represent the time-slots.

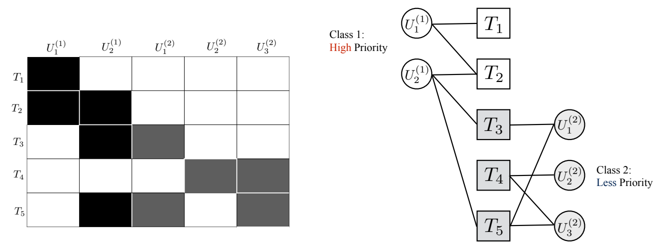

Fig. 1. Spatially coupled-based networks with prioritizatio: (a) An example of random access table describing the accesses of two clasees $U_i^{(1)}$ and $U_i^{(2)}$, where users of Class 1 have access to all time-slots, while users of Class 2 have only access to time-slots T_2 – T_5, and (b) A bipartite graph representing a wireless network having two classes with high and less priority.

IV. EXIT Analysis

We evaluate using extrinsic information transfer (EXIT) chart based on the binary erasure channel (BEC) since the channel can capture the erased packets probability, which is in general happens in a wireless networks. Some of practical problems, e.g., header detection to detect erased packet or received packet has been presented, for example, in [3], in this paper we focus on the discussion of spatial coupling effect in the wireless networks with priority.

We define q as the erasure probability emanating from a user node (UN), while p from the slot nodes (SN). With N as the length of SN, and M as the number of UN, we have a traffic of $G = M/N$. Assume that in Fig. 1, each class of users use special transmission degree distributions $\Lambda_1(x)$ and $\Lambda_2(x)$ exhibiting rate of R_1 and R_2, we then have erasure probabilities

$$q_1 = \lambda_1(x), q_2 = \lambda_2(x), \tag{1}$$

where $\lambda_i(x)$ is the edge perspective of the UN, $i \in \{1, 2\}$. However, by assume that the length of border L defined as the difference between total access of Class 1 and Class 2, we have the erasure probability

$$p = 1 - (\omega_L(1-q) + x^L \cdot e^{-q\frac{(G_1+G_2)}{(R_1+R_2)}}), \tag{2}$$

where $\omega_(x)$ is the edge perspective of the SN border.

V. Conclusions

We expect that spatial coupling helps the networks decode higher number of users close to the network capacity.

References

[1] S. Kudekar, T. J. Richardson, and R. L. Urbanke, "Threshold saturation via spatial coupling: Why convolutional ldpc ensembles perform so well over the bec," *IEEE Transactions on Information Theory*, vol. 57, no. 2, pp. 803–834, Feb. 2011.

[2] K. Anwar and M. N. Hasan, "Uncoordinated transmissions in multi-way relaying systems," in *ITG Conference on Systems, Communications and Coding (SCC)*, Hamburg, Germany, February 2015, pp. 1–5.

[3] K. Anwar, Juansyah, B. Syihabuddin, and N. M. Adriansyah, "Coded random access with simple header detection for finite length wireless iot networks," in *2017 Eighth International Workshop on Signal Design and Its Applications in Communications (IWSDA)*, Sept 2017, pp. 94–98.

This research is supported in part by the Indonesian LPDP RISPRO 2017–2018 under the Project of PATRIOT-Net No. PRJ-/LPDP/2017.