CHAPTER 1

INTRODUCTION

1.1 Background

In 2020 there are 1 billion Internet-of-things (IoT) devices connected to the network through a cellular connection, and it is predicted that around 5 billion devices will be connected by 2025 [1]. Recent technology of communications with the fifth generation (5G) network enables not only for consumers but also for various industries and society of which can't be achieved by its predecessor [2]. One of the keys in 5G addressed by 3GPP up to release 13 is that the network system should support for massive numbers of IoT connection [3]. Fig. 1.1 illustrates the waves of massive connected devices in the future of telecommunication. International Telecommmunications Union-Recommendation (ITU-R) also define the future challenges of 5G in 3 possible main challenge [4] ,i.e., (i) enchanced mobile broadband (eMBB), (ii) massive machine-type communications (mMTC), and (iii) ultra-reliable and low latency communications (URLLC).

This thesis focuses to solve the problem on the second main challenge, i.e. massive machine type communication. The massively connected devices to the network need multiple access that can transmit information without any issues, one of which is coded random access (CRA). CRA is a multiple access technique with users aiming to transmit packet randomly in selected time-slots. Set of uncoordinated devices or users aims to transmit over the shared wireless access medium to the same receiver at a given period, where the random access mechanisms are needed to enable successful wireless access due to the nature of massive number of users [5]. As a nature of massive number of devices, random access technique is preferable for future multiple access scheme since perfect scheduling can be replaced by random scheduling, where all users transmit their message randomly without overhead due to scheduling. Although a solution for multiple access has been found, there are still exist several challenges, such as low throughput and high packet-loss floor due to stopping set. A new problem arises when the network should provide priority access to some users, e.g., ambulance and firetruck, rather than others. Based on these problems, this thesis proposes prioritization in CRA network combined with SIC + Zigzag decodable codes (ZDC) that can prioritize user

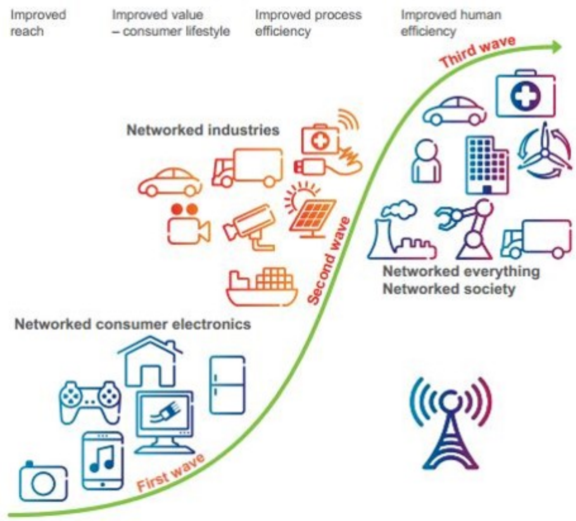

Fig. 1.1: Industrial wave phase.

but keep network performance high. The other method such as Reed-Solomon Codes (RS) normally operated over large finite field [6]. Thus, incurs several problems including high encoding and decoding complexities [7]. The RaptorQ Code is not suitable for a low performance devices since the inactivation decoder has higher complexity than most iterative decoder [8]. On the other hand, ZDC uses bit-wise shifting and XOR operation [8, 9], but on this thesis we use an addition and subtraction that has low computing power on devices. This thesis proposes a multiple access network consisting of three groups i.e. top emergency (TE), emergency (EM), and normal (NM), of which TE has the highest priority (e.g., Ambulances) rather than EM (e.g., Fire Trucks) and normal (e.g., Public car). With SIC and ZDC for CRA, we expect a better throughput and low packet-loss rate.

1.2 Problem Identification

The current multiple access technique cannot distinguish which users should be prioritized (e.g. ambulance, military equipment, fire truck, etc.). Because of massive number connected devices in the future, our current network cannot withstand and eventually degrade its performance. Because of its poor performance, some users need a higher priority rather others. The current multiple access technique cannot maximize throughput where top priority and normal priority car users are involved. Fig 1.2 shows mindmap of problem and solution in this thesis. When there is no more singleton node

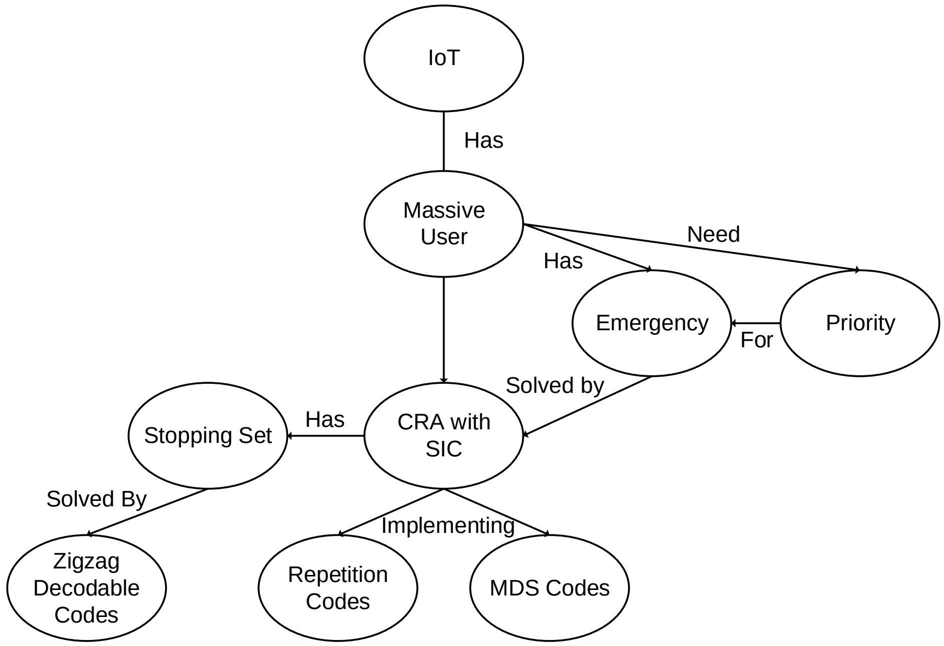

Fig. 1.2: The mindmap used in this thesis.

on CRA network, the stopping sets occurs, resulting a decrease in performance. Thus, we propose the ZDC to solve the stopping sets.

1.3 Objectives

This thesis considers following assumptions:

1. This thesis designs a communication system that can prioritize a group in a network consisting of top emergency (TE), emergency (EM), and normal (NM) groups.
2. This thesis optimizes the degree distribution of a prioritized network.
3. This thesis provides investigates the stopping sets occurrences probability with real simulation.
4. This thesis proposes ZDC in the prioritized networks to solve the stopping sets.

1.4 Scope of Work

1. Coded random access is used as multiple access schemes.
2. Repetition codes are considered with no multiuser decoding (MUD).
3. We consider using Binary Erasure Channel (BEC)–based equivalent additive white Gaussian noise (AWGN) as channel model to simplify the analysis of wireless network and packet ransmission.
4. Binary phase shift keying (BPSK) is used for the basic modulation. However, an extension to higher modulation is straightforward.
5. We assume perfect header detection and perfect header synchronization.
6. The performances are evaluated using computer-based MATLAB simulation.

1.5 Expected Results

In the previous works [10] [11], prioritization on the network only consisting of two groups i.e., human and machine. It shows good results, with higher throughput and low packet loss rate for human rather than the machine. However, the degree distribution in [10] [11] cannot be applied for more than 2 prioritization. This thesis proposes degree distributions on CRA network that can prioritize 3 groups of TE, EM, and NM, which is expected to be suitable for the network with 3 priorities. Furthermore, this thesis proposes zigzag decoding to decode stopping set. We expect a better throughput and low packet–loss rate than previous works.

1.6 Research Methodology

In this thesis, we use fundamental study and experiment based on work-packages (WP). These are the following WP for this thesis:

WP1: Evaluate PLR and throughput using regular and irregular degree distribution.

WP2: Verify the degree distribution of slot-node.

WP3: Apply the ZDC for the prioritized network.

WP4: Analyze the stopping sets and sytem performance under the fading channel.