DESIGN AND IMPLEMENTATION OF ANTI-COLLISION ALGORITHMS FOR DENSE RFID SYSTEMS

# Chapter 1

Radio Frequency Identification (RFID) is a technology that uses communication through radio waves to transfer data between a reader and electronic tags attached to an object, either to be identified or tracked. The RFID technology has benefits in reference to other identification technologies, such as no line-of-sight connection, fully automotive identification process and identification speed. Logistics is one of the most common applications, which use RFID. In such systems, a single RFID reader is responsible for identifying an unknown number of tags in the reading area. The main objective of this thesis is to minimize the identification time for the existing tags in the reading area.

# chapter 2

The conventional RFID system consists of three main components: First, RFID tag, which is attached to the object requested to be identified or tracked. Second, the RFID reader, which controls the whole identification process. Finally, the processing device, which is always a software processing device. In RFID systems, both readers and tags communicate using the same frequency. Thus, simultaneous transmission can happen which leads to collisions. Owing to the low price of the tags, they can neither sense the channel nor communicate with the other tags. Therefore, the readers are responsible for coordinating the network. In dense networks, as the number of tag collisions increases, the reading time increases. Hence, an anti-collision protocol is required to minimize the tags collision effect.

# chapter 3

This thesis focuses on the MAC-layer anti-collision protocols, because the PHY-layer anti-collision protocols are not cost efficient. However, the anti-collision protocol considers the modern RFID readers PHY-layer capabilities, namely, the collision recovery capability and the dynamic slot duration capability. The MAC-layer anti-collision protocols are classified into: deterministic (tree-based) protocols, used in systems with known number of tags, and probabilistic (ALOHA based) protocols, used in systems with unknown number of tags. Therefore, this thesis focuses on ALOHA based protocol. The EPC-global C1 G2 is the most commonly used RFID standard in logistics. It is based on Frame Slotted ALOHA which is the most widely used MAC anti-collision protocol for RFID systems.

# chapter 4

The performance of the FSA algorithm strongly depends on the accuracy of the number of tags estimation. The number of tags estimation function calculates the number of tags based on feedback from the previous frame, which includes the number of slots filled with empty, successful, and collided slots. The Maximum Likelihood (ML) number of tags estimation protocol gives the lowest mean identification time compared to the other estimation algorithms. However, the numerical searching complexity of the ML estimator limits the number of tags. Moreover, this method doesn’t not take into consideration the collision recovery capabilities of the modern RFID PHY-layer. This chapter proposes a novel closed form solution for a collision recovery aware ML estimator, which considers the effects of the receiver collision recovery probability. The theoretical derivations lead to a new analytical estimator that can be easily implemented in RFID readers. Using the proposed formula, neither look-up tables nor numerical searching is needed. Furthermore, the estimator gives more precise estimation error and reduces the total identification time compared to the other state-of-art proposals.

# chapter 5

The second main factor, which controls the FSA performance is the optimal FSA frame length calculation. This chapter presents different proposals of FSA frame length optimization. The first proposal is called “**Time aware frame length**”. In this proposal, the frame length considers only the differences in slots durations and no collision recovery effect is considered. The second proposal is “**Time and constant collision recovery coefficients aware frame length**”. This proposal considers the time differences in slots durations and the collision recovery capability of the receiver. However, it assumes constant collision recovery capability. The third proposal is “**Multiple collision recovery aware frame length**”. It considers the differences between the collision recovery coefficients. However, this proposal assumes constant slots durations regardless the slot type. Finally, the fourth proposal is “**Time and multiple collision recovery aware frame length**”. This proposal considers the differences in slots durations with variable collision recovery coefficients. A closed form solution for the optimum frame length is analytically derived for all the above scenarios and the average saving in reading time is calculated compared to the conventional FSA with frame length.

# chapter 6

This chapter presents compatible improvements of the EPC-global standard. It presents some modifications on the communication signal of Tag/reader. Using these modifications, the new system approaches the theoretical lower reading time limit of the conventional FSA. The proposed system is compatible with the EPC-global standard, i.e. the proposed tags could be jointly operated with conventional tags and identified by conventional readers without affecting the performance. Additionally, conventional tags can also be operated together with the proposed tags and can be identified by the proposed reader

# chapter 7

Despite the effort invested in this dissertation, there are still some remaining issues left that require further investigations. To mention but one example, the effect of the initial FSA frame length is neglected in this thesis. Moreover, the MAC can learn the channel by calculating the identification rate. Then, it should send a feedback signal to the PHY layer. In this signal, the MAC layer decides to start resolving the current collided slot either to a successful or unsuccessful slot, depending on the current status of the channel.