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Random Access Mechanism Based on Priority Discrimination in Internet of Things

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Abstract. The prioritized random access mechanism has been researched in this paper. The current situation of large-scale node multiple access in the Internet of Things leaded to channel congestion and increased blocking rate. In M2M communication, there were a large number of nodes trying to RA. In this case, serious physical random access channel overload would occur, making it even difficult to access the network. Nodes spent a lot of time accessing the network, and even given resource management schemes could not guarantee acceptable end-to-end latency meet QoS guarantees. So, the traditional method has greater limitations in supporting different QoS in M2M communication, It would also have an unimaginable impact on the web, Therefore, it was necessary to propose a scheme to reduce the access delay while ensuring the success rate, The current priority-differentiated random access mechanism needed to consider how to match with the new features of M2M services. The reasonable random access scheme and efficiently manage the resource and allocated the channel were designed in the system where the traditional H2H service and the new M2M service coexist. The weights of different services were obtained by modeling and simulation. Therefore, by setting different threshold detecting preamble index matching service type and calling different back-off indexes to reduce the access collision, so as to optimize the random access mechanism. This study could make the node indicate its priority in the access process, and reduced the conflict and access delay. Under 5G communication technology, this solution would be widely used.

Keywords. Internet of Things, prioritization, random access mechanism, congestion control.

1. Introduction

Internet of things was the beneficiary of 5G communication technology, but with a large number of M2M serviced in a short time intensive access network would cause network congestion, then reduced the QoS(Quality of Service) of H2H. In order to reduce the negative impact of M2M distribution on traditional H2H services and support large-scale M2M distribution, existing cellular networks must be optimized according to the characteristics of M2M services. The solution to this problem was to

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use the RACH to satisfy the data requests of the MTCD, however, a large number of signaling and data congestion on the channel would lead to a significant increase in collision, increased in packet loss rate and performance degradation of MTC and HTC. By setting priority, the QoS of high-priority services could be guaranteed, but the QoS of low-priority services would be sacrificed.

3rd Generation Partnership Project defined RAN congestion as: a large number of M2M services burst caused by the wireless Network congestion and Signaling Network Congestion, increase delay, resulting in packet loss or even unreachable services, especially the random access channel congestion. Reference[1] presents several challenges that M2M brought to the air interface of cellular networks: The Limited number of physical control channels, the congestion of random accessed channels and the rational allocation of wireless resources, this could all be seen as a manifestation of the RAN congestion problem. It was considered in that the RAN congestion problem was mainly presented in the random access process and belonged to the RACH channel congestion problem[2-4], and noted the signaling congestion problem in the common control channel in RAN[5], one-to-one paging on a large number of M2M devices would overload the paging channel and increased the paging delay and network load.

RACH channel congestion was a kind of uplink signaling control channel congestion. The reason was that a large number of M2M equipment burst random access competition, which led to RACH channel congestion. Using the MAC mechanism of random contention reservation and fixed multiple access, the process of random access essentially allows the terminal to compete for the network resources and pass the relevant parameters to establish the RRC connection and assign the wireless channel. With a large number of random accesses users in the upstream public RACH blind competition, resulting in the RACH channel congestion, accessed delay increase and accessed success rate decline.

This study classified the priority of services by analyzing the requirements of different service attributes for different transmission performance in IOT. Then, we mastered the function of the leading code in the access of cellular network, optimized the large-scale multi-access problem in the Internet of things, and detected the business type by setting different leading code index, called Different back-off index to reduce access collision. To reduce the contradiction between the congestion of Wireless Data Channel and the increase of the blocking rate of H2H access caused by a large number of M2M traffic bursts, to maximize the use of wireless channel resources, and to alleviate the impact of M2M traffic bursts on H2H in data channels, at the same time, it improved the carrying capacity of M2M Service. This scheme could not only guarantee the service quality of H2H services, but also reduced the transmission failure of M2M services and improved the system performance and wireless resource utilization.For MTC equipment grouping, in some scenarios, it was necessary to further consider the mobility of MTC equipment, the design of more flexible MTC grouping method[6].

3GPP had conducted a lot of research and discussion on this issue, and proposed a variety of solutions, such as ACB/EAB (Extended Access Barring) mechanism which could limit the number of M2M services to arrive in the case of Network Congestion[7]; The back-off mechanism could distinguish the priority of M2M and H2H by setting a bigger back-off window for delay-tolerant M2M, and the H2H/M2M mechanism could avoid the burst impact of MTC on H2H traffic, The time-slotted access mechanism could distribute the burst M2M traffic evenly in time and reduce the arrival intensity of the M2M traffic, and the pull-up mechanism could trigger the M2M communication through the network and control the M2M access by paging.

2. Overview of Integrated Service Load and Multi-Service Access Mechanism in Internet of Things

The complexity and diversity of Internet of things applications had made the intelligent requirements of the network more stringent. Nowadays, the Internet's bearer network was focused on the best efforts of packet transmission network, while the reliability of Internet of things services was ignored, internet of things carried the network around the requirements of telecommunication grade characteristics, aiming at the network's security, credibility, controllable and objective, service quality had more strict standards. So in order to support the Internet of things, we must continue to improve the metropolitan area network, backbone network, access network telecommunications level requirements. Namely the network self-healing ability, service protection ability, network security, end-to-end quality of service ability and so on. This paper focused on the quality of service capability.

The existing Internet of things applications could be divided into six basic types as shown in table 1: monitoring alarm class, data collection class, information push class, video monitoring class, remote control class, recognition and location class, their capability metrics would be summarized in eight sections: Upstream Traffic, Downstream Traffic, QoS Requirements, Data Security, Management Configuration, Connectivity Requirements, Terminal Mobility, and Application Scenarios[8].

Table 1. Comparison of network carrying capacity requirements of six basic IOT applications

Capacity indicator	monitoring alarm class	data collection class	information push class	video monitoring class	remote control class	Identification and positioning class
Upstream Traffic	small data	large data	small data	large data	zero data	large data
Downstream Traffic	zero data	small data	large data	small data	small data	small data
Quality of Service Requirements	application correlation	application correlation	application correlation	application correlation	application correlation	application correlation
Data Security	application correlation	application correlation	application correlation	application correlation	application correlation	application correlation
Management Configuration	remote management	remote management	remote management	remote management	remote management	remote management
Connectivity Requirements	strong	strong	strong	strong	strong	strong
Terminal Mobility	application correlation	application correlation	application correlation	application correlation	application correlation	application correlation
Application Scenarios	home security	weather monitoring	smart museums	global eyes	industrial automation	logistics and delivery

The basic IoT architecture consisted of four layers[9]: access, transmission, control and application. The access layer was used to collect the data of articles and environment, the transmission layer was used to transmit the data uploaded by the access layer to the designated position in the wireless or wired way, and the control layer was the gateway of the node of the management control access layer network The application layer used the data collected by the access layer to realize the specific business and service. Internet of things accessed and networking technology included access and backbone transmission and other multi-level content. After the large-scale use of the sensor network as the representative of the peripheral network, in the face of access to the backbone network, the network technology must be fully coordinated with the backbone network. The perception layer was like an organ of human perception, whereas the Internet of things recognizes objects and collects information based on the perception layer. In the perception layer, the embedded objects with the detection device and the radio frequency tag form a local area network, which could detect the surrounding environment or its own state collaboratively, and according to the corresponding rules to respond positively, and the intermediate or final processing results were connected to the network layer through various access networks[10].

3. PRA Scheme

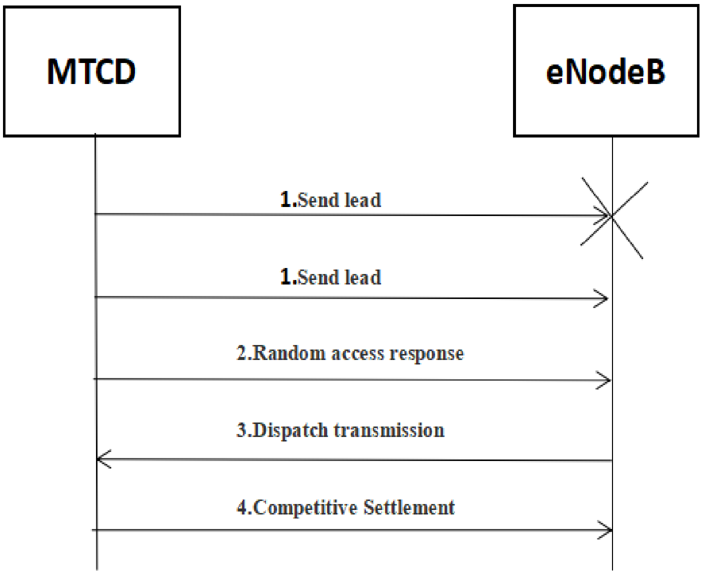

Figure 1. Traditional random access scheme

The traditional random access scheme is shown in figure 1. It consisted of only four steps: Send lead, Random access response, Dispatch transmission and Competitive Settlement. According to the features of the different services mentioned in part two,The weights of different services were obtained by modeling and simulation. By setting different threshold detecting preamble index matching service type and calling different back-off indexes to reduce the access collision, so as to optimize the random access mechanism. This study could make the node indicate its priority in the access process, and reduced the conflict and access delay.Reference[11] presented several challenges that a random access mechanism was proposed to improve the access success rate of equipment in 5G communication network. However, there are still some deficiencies in this study, only considering the network scenario composed of macro base stations and micro base stations.The process reliability of four-step random access is high, but it is not the best way in access efficiency. Therefore, NR Rel-16 introduced a two-step random access technique to optimize and enhance the random access process[12].

In Cellular IoT, random access was used for initial uplink access to connect to and synchronized with eNodeB (evolution Node Base-station). Because data transfer was not performed during this process, the QoS guarantees of different services were not considered in the access phase of RA in cellular networks. This made it difficult for the node to indicate its priority during the access phase. However, after establishing a connection with eNodeB through RA, the node could indicate its QoS and request the amount of time-frequency resources needed for communication. In other words, after the RA program completes, the node could request its QoS during resource allocation.However, in M2M communication, there were a large number of nodes trying to RA. In this case, serious physical random access channel overload would occur, making it even difficult to access the network. Nodes spent a lot of time accessing the network, and even given resource management schemes could not guarantee acceptable end-to-end latency with QoS guarantees. So it was limited to support different QoS in M2M communication by traditional methods.

In a Cellular network, the MTCD needed to send a lead Access network over the PRACH Channel in the form of Slotted-ALOHA[13]. According to different competition methods, it was divided into non-competition-based random access and competition-based random access[14]. non-competition mode was mainly used for cell transmission and based station notification MTCD downlink data arrival. The total number of random access leading codes available in each cell was 64, most of which were used for contention-based random access processes and the rest for non-contention-based random access processes, such as handoff. Competition-based access leading codes were allocated to H2H and M2M services.

As shown in table 2 was four cases for marking the leading condition of a node. A was set to 1 meant that any node uses the same precursor and had the same TA value. Otherwise, A was set to 0. B was set to 1. If eNodeB detected the same preamble with different TA values, B was set to 0.

Table 2. Four cases for marking the leading condition of a node.

A	B	Meaning
0	0	No conflict and not detected, resulting in soft conflict
0	1	Success
1	0	Conflict, but no detected, causing soft conflict
1	1	A collision was detected and occurred, resulting in a hard collision

Assuming that the machine node was fixed, the PRA scheme consisted of five steps. The first step was forward synchronous code transmission, the second step was RAR message transmission, the third step was TA matching, the fourth part was scheduling transmission, and the last step was competition solution . The first step was to send the lead, the machine node needed to randomly select one of the NP orthogonal preamble and transmit the preamble to eNodeB in PRACH, especially when the machine node sends the Selected Pilot Code, at the end of the first step, the eNodeB accepted the aggregated signal and detected which preamble indexes were used in the previous step. The eNodeB performed two steps in this process. Firstly, eNodeB checked the index of high-priority preamble by high-level detection threshold, and then generated RAR message Secondly, eNodeB checked the index of low-priority preamble by low-level detection threshold, and generated RAR message Because the eNB excluded the high-priority leading-code index when it found the low-priority leading-code index, the RAR message would consist of the leading-code index of the node trying to access the high-priority node and the corresponding TA value the second step was RAR message transmission. If the leading code was detected, the eNodeB would send RA response messages through the PDCCH . The RAR message included, cell radio network temporary identifier, uplink license, and TA information. If two or more machine nodes send the same lead code, they receive the same RAR message. This could lead them to use the same resource for the next step, which could lead to conflict. The third step was TA matching transmission. The machine node compared the stored TA value with the TA value in the received RAR message. If they matched, we move on to the next step. Otherwise, the machine node immediately enables the back-off mechanism[15]. Because in step 3, each machine node determines in advance whether the remaining steps occur, the remaining program was aborted if the TA did not match Therefore, the probability of success of the remaining steps of TA matching a successful node could be improved In the fourth step, the machine node sent its C-RNTI as Identifier and scheduling information on the physical uplink shared channel allocated in the second step. As the information was sent, the node needed to start the CR timer to detect the occurrence of conflicts . Finally, to resolve the contention, eNodeB echoes the identity of the node on the PDSCH , that was, information was transferred successfully in step But in step 4, if two or more nodes use the same resource, that was, the node does not receive random access response information from any base station during the working time of the CR timer, and if the number of times MTCD re-passes the leading does not reach the maximum number defined, a conflict will occur, Then the collision node will start the back-off mechanism after the CR, and after the node received back-off select a new leader to send again, the execution of the uplink competition random access. Otherwise, the MTCD sees RA as a success. In this paper, the conflicts detected in TA matching process were called soft conflicts, and those detected after the end of CR timer were called hard conflicts.

4. Conclusion

This study made the access delay of high-priority nodes the shortest, but the access delay of low-priority nodes was much shorter than that of conventional schemes. In the case of higher priority nodes competing more fiercely, their access latency would increase, and lower priority nodes would increase more, so lower priority leading indexes were more strictly excluded. So this study shown that if we give up the low-priority nodes, we could reduce the access delay of the high-priority nodes. However, the scheme only focused on collision probability and accessed delay, and even a few downlink data distribution would have an unimaginable impact on future cellular IOT scenarios with a large number of MTCD. So how to reduce the base station load, and further reduce the total load in the network continues to need further research.The network scenario considered in the dynamic preamble allocation strategy is relatively simple, in the follow-up work can further consider the coexistence of multiple delay types of MTC equipment scenarios. In addition, multiple access methods can be compared with the proposed strategies.

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