Joint delay and energy Minimization using instantly decodable network coding for LoRaWAN

Dr. S. Mary Joans [1], G.Aishwarya[2]

[1] Professor and head, Department of Electronics and Communication Engineering, Velammal Engineering College,Chennai, India.

[2] PG Student, Department of Electronics and Communication Engineering, Velammal Engineering College, Chennai, India.

Abstract- **The internet of Things (IoT) plays a major role in smart applications so LoRaWAN is vitally used all around the world. In this paper, Instantly decodable network coding (IDNC) is used for improving the completion time and joint delay of LoRaWAN with physical-layer rate awareness. We utilize the stochastic shortest path technique to study the problem of completion time and joint delay problem by selecting the maximum clique node and also to reduce its complexity. A split and merge algorithm used for consuming energy and delay experienced by all receivers. Simulation results show that the cooperation between nodes not only reduces energy consumption but also reduces the complexity of data exchanging in the network.**

Key words: LoRaWAN, IDNC, Merge and split algorithm.

I. INTRODUCTION

Network coding (NC) is a cheapest coding technique that provides fast and reliable real-time communications in a wireless transmission scenario which been a hot topic in recent years [1]–[6]. The main benefit of network coding is to reduce the number of transmissions when packet loss occurs in LoRaWAN. NC is a promising technique to improve throughput and to reduce delay in LoRaWAN. For the purpose of improving a system performance metric in a transmission scenario, the main issue involved is how to determine coded packets at the sender as well as at the receivers. In Instantly Decodable Network Coding (IDNC) the coded packets are produced through simple XORing and decoded immediately at their reception. The target of this paper is to study the completion time of delivering a group of messages to the remote computers using rate-aware IDNC (RA-IDNC) and reducing the joint delay of the LoRaWAN. The joint optimization of message combinations and employed rates in each of the transmissions is investigated, so as to minimize the overall completion time. The split and merge algorithm creates an appropriate coailitions groups accounting to energy efficiency and the delay. The rest of the paper is as follows. In the next section,we present the related works of the instantly decodable network coding.Section III introduces the proposed data model. Section IV introduces the new methodology. Section V introduces the simulation results and discussions.

II. RELATED WORKS

In [1] the authors proposed about the conventional centralized systems, in which all decisions are carried out by a base-station. The limitation is usage of energy is very high and complexity is poor. In [2] the author investigated the effect of controlling the decoding delay. The paper formulates the problem of packet loss. In [3] the author proposed novel Content-Aware IDNC scheme that improves content quality of each packet. The limitation is high consumption of energy. In [4] the author analyzed the problems of completion time and decoding delay in generalized instantly decodable network coding. The limitation is missing of packets. In [6] the author explained about the effect of feedback loss events of generalized instantly decodable network coding. The drawback is the packets received at the receiver are not accurate. In [8] the author introduced the two novel packet retransmission techniques for multicast in the framework of Instantly Decodable Network Coding (IDNC). These methods are suitable for order- and delay-sensitive applications, where some information is of high importance for an earlier gain at the receiver's side. An Unequal Error Protection (UEP) scheme is showed by simulations that the Quality of Experience (QoE) for the end-users is improved even without complex encoding and decoding. The limitation is quality of service is low and feedback implosion problem. In [9] the author investigated a base-station broadcasting a set of packets. The limitation is data loss are very high.

III. SYSTEM MODEL AND DEFINITIONS

A. LoRaWAN

LoRaWAN is a long wide communication at a low bit rate. The life time of the battery is around 10 years. LoRaWAN aims to exchange information between devices and server through gateways.

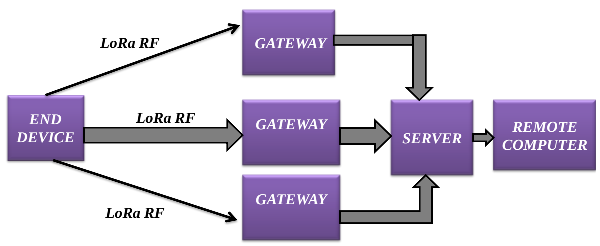

Fig.1. Typical LoRaWAN network landscape

B. DATA MODEL

Consider a network composed of end device which delivers the data to remote computer. In the initial phase, end device transmits the uncoded packets with rates chosen according to the selected node scheme. An acknowledgment is transmitted for each successfully received packet. A packet is retransmitted only if loss occurs. The first phase ends when each packet of the frame is acknowledged by nodes. The user can XOR the messages with the received coded message combination to extract the wants message .

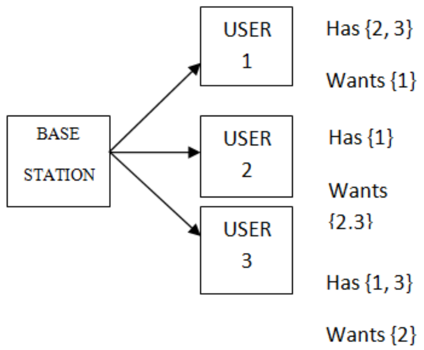

Figure 2. Schematic view of Instantly decodable transmission

The figure 2, illustrates an example of an IDNC transmission in a network composed of 3 users and 3 messages. The packet combination 2 and 3 is: Instantly decodable for user 3 contains only one message so users 3 can XOR the combination 2 and 3 with message 3 to retrieve message 2.

IV. METHODOLOGY

A. RATE AWARNESS INSTANTLY DECODABLE CODING

In the network-layer configuration, the RA-IDNC is used as a tool to determine all possible message combinations and identify the users that can instantly decode each of these combinations. It allows the identification of the messages combinations, transmission rate and the set of remote computers for transmitting decodably in the network. For each user, the set of achievable rates is the set of achievable capacities observed by other users. The RA-IDNC for a network composed of 3 users and 3 messages. The RA-IDNC achieves the completion time. Each clique in the RA-IDNC represents a transmission of a message combination that is decodable to all the users designated by the clique's node.

B. MERGE AND SPLIT ALGORITHM

The algorithm is based on two simple rules of merge and split that modify a partition of clique node to send data to remote computer 1 and remote computer 2. The end device has data that sends to the receiver so the end device will send the data to the clique node in merge rule and the clique node will collect the data and stored in it. After storing the data in the clique node, the data will split based on the requirements of remote computers. The remote computer will get the required data without any loss.

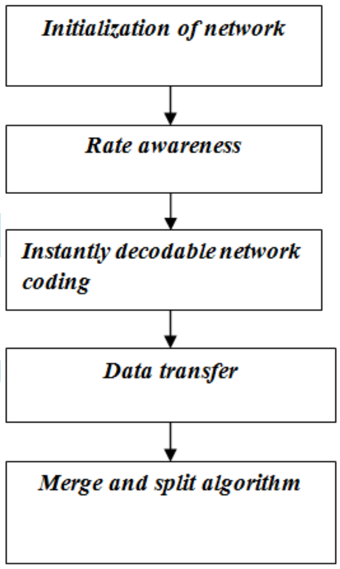

Figure 3. Flowchart of working process

The working process is described in figure 3 which is described briefly below in following steps.

STEP1:Initialization of Network Basic configuration.

Initialization of network is arranging the nodes and setting up the values in the animator window.

STEP 2: Applying rate awareness.

The uncoded message will be send from end device to remote computer. The feedback signal is sent from all the nodes to the end deices about the data rate of each node. According to the data rate, end device will adjust and send the data to each node.

STEP 3: Computing instantly decodable network coding

In network layer, the network coding is used to find the clique node. The clique node is founded by the maximum weight and shortest path technique.

STEP 4: Merge and split algorithm

The end device sends the data to the clique node in merge rule. The new data will be stored in the clique node. The clique node will split the data according to the requirements of the remote computer based on the calculation of the path and count of the data.

STEP 5: PERFORMANCE ANALYSIS

The output are analyzed for the performance of the network using the parameters such as accuracy, energy consumption, data recovery rate and joint delay.

V. SIMULATION RESULTS AND DISCUSSIONS

Network Simulator-2 is widely used tool to simulate the behavior of wireless networks. The packet will transfer from end device to remote computers. The rate awareness technique is applied for knowing the energy level of all nodes to find clique node which is displayed in values (joules).The clique node collects data from end device in merge form and sends the data to remote computers in split form.

The graphical representations are the comparison of existing and proposed method. The below given graphical representation are the comparison of the accuracy, packet delivery, energy consumption and joint delay.

A. ENERGY CONSUMPTION

Energy consumption is the important problem which plays a vital role in networks. Energy consumption should be reduced so that network life will prolong.

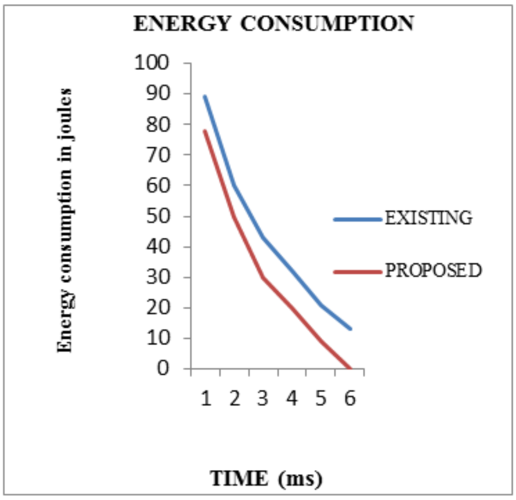

Figure 4 Graph describing energy consumption

The figure 4 shows the comparison of energy used in the existing and proposed system. The energy consumption used in proposed system is reduced by the usage of instantly decodable network coding.

B. JOINT DELAY

The length of time for sending and receiving the signal between the sender and receiver of the system causes delay.

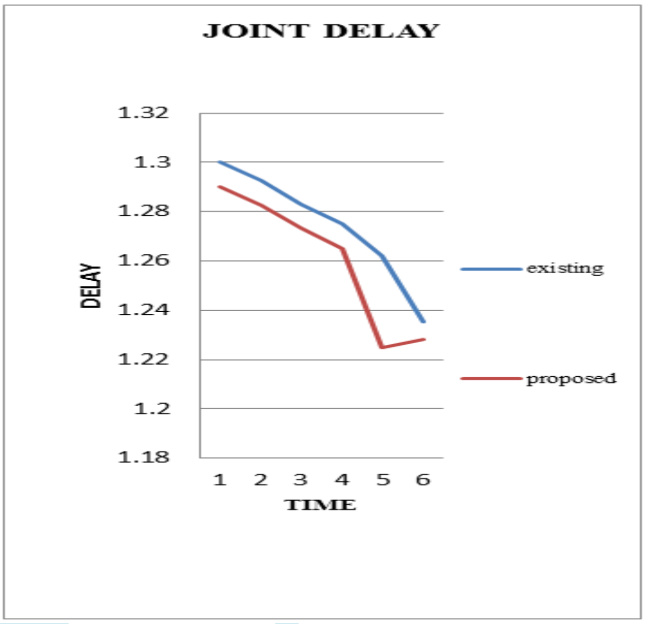

Figure 5. Graph describing joint delay

The figure 5 shows the comparison of joint delay used in the existing and proposed system. The joint delay used in proposed system is reduced by the usage of merge and split algorithm.

C. PACKET DELIVERY RATIO

Packet delivery ratio is defined as the ratio of data packets received by the remote computers to those generated by the sources.

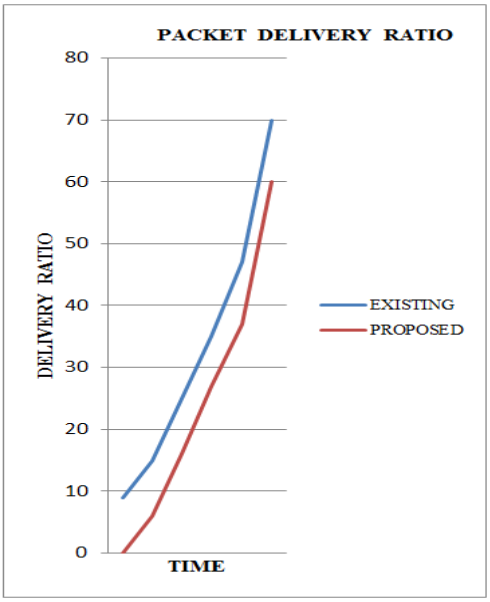

Figure 6. Graph describing Packet delivery ratio

The figure 6 shows the comparison of packet delivery ratio used in the existing and proposed system. The packet delivery ratio used in proposed system is increased by sending packets to the remote computers by finding the clique node.

D. ACCURACY

The degree of the result of a measurement leads to the correct value.

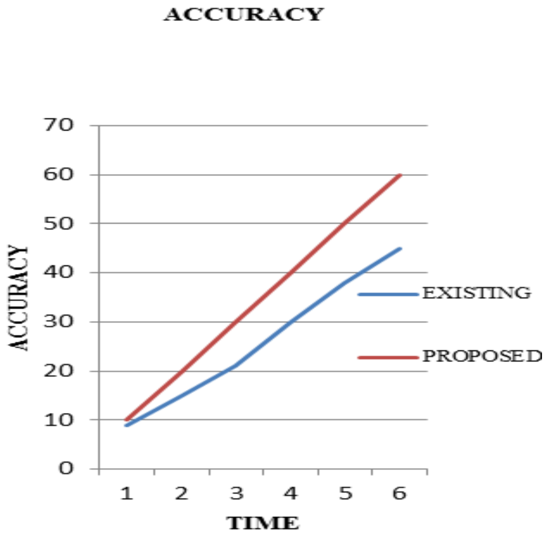

Figure 7. Graph describing accuracy

The figure 7 shows the values which is compared between the existing and proposed system. The packets are delivered from sender to receiver is more accurate when compared with the existing system.

CONCLUSION

In this paper, we discussed about the adopted methods and techniques of instantly decodable network coding which is implemented in LoRaWAN. To collect data from IoT devices, a LoRaWAN is proposed. We have concluded that instantly decodable coding technique and distributed merge and split algorithm are implemented in cross layer of OSI model using network simulator (NS2). By the simulation and execution of the proposed system, it is clear that the performance level in case of joint delay, delivery time and energy consumption are reduced. The performance measure for joint delay, packet delivery ratio, energy consumption and accuracy are represented graphically by comparing the existing and proposed method in LoRaWAN. According to the result, it is clear that the Instantly decodable network coding technique in LoRaWAN has much more effficent way of reducing the completion time,delay and consumed energy without any lost.

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