Genetic Algorithm For LoRa Transmission Parameter Selection

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***Abstract*—The exponential grow of IoT application in both industry and academic research raises many questions in wireless sensor network field. Heterogeneous networks of IoT devices strongly depend on the ability on IoT devices to adapt their data transmission parameters to the application requirement running at each time. One of the most important problem of IoT network is that IoT devices are limited in terms of energy consumption and computation capability. Our work is motivated by the idea of matching each transmission configuration with a reward and cost values to satisfy applications requirements. Our goal is to make IoT devices able to select the optimal transmission configuration and send their data to the gateway with the QoS required by the application running on the device. Determining the best configuration among 6720 transmission configurations is difficult, this is mainly due to the lack of tools that could take both applications requirements and external environment in consideration to select the best transmission parameters. To address this problem, we use a genetic algorithm in an edge computing to select the transmission parameters needed by the application. Genetic algorithms are used in selection and ranking problems to model the natural selection of chromosomes in human generation. In our case, each configuration represents a chromosome that need to be selected to match better the QoS criteria. Particularly, we analyze the impact of selecting one configuration in 3 kinds of applications: text, voice and image transmission by modeling a new adaptive configuration selection process. We validate our approach by using both simulation and real environment testbed.**

I. Introduction

The need of Low power wide area network (LPWAN) networks increased quickly these last years. The main factor is that IoT devices require low power consumption to transmit data in a wide area. Lora, Sigfox and NB-IoT are the most known technologies that satisfy these requirements. Applications like smart building and smart environment are one of hundreds use cases that need to be deployed with such technologies. Unlike Sigfox and NB-IoT, Lora is more open for academic research because the specification that governs how the network is managed is relatively open. LoRa is a wireless modulation technique that uses Chirp Spread Spectrum (CSS) in combination with Pulse-Position Modulation (PPM). The transmission could be configured with 4 parameters: Spreading factor (SF), Transmission power (Tx), Coding rate (CR) and Bandwidth (Bw), to achieve better performance. The main LPWAN research directions are about large scale networks to support massive number of devices, interference issues, link optimization and adaptability. Thus heterogeneous network deployments and Spreading Factor (SF) allocation strategies need to be studied. In this paper, we investigate the performance of homogeneous networks (i.e. when all the nodes select the same LoRa configuration) and heterogeneous networks (i.e. when each node selects its LoRa configuration according to its link budget or their needs) for large scale deployments (up to 10000 nodes per gateway). For that purpose we have developed a LoRa Module, based on improved WSNet simulator, including a spectrum usage abstraction, the co-channel rejection due to the quasi-orthogonality of SFs and the gateway capture effect. Simulation results show the performance comparison in terms of reliability, network capacity and power consumption for homogeneous and heterogeneous deployments as a function of the number of nodes and the traffic intensity. The comparison shows the benefits of the heterogeneous deployment where each node selects its configuration according to its link budget.

This paper is organized as follows. Section II elucidates summary of related works. In section III, we propose our ... to .... Section IV evaluates the performance of our ... in terms of packet delivery ratio, throughput, and power consumption. Section V concludes the article and gives some ideas for future work.

II. Related work

Transmission parameter configuration mechanisms such as ADR scheme need to be developed to fit each application requirement. Taking into account low power consumption, solutions running on LoRa node should be as simple as possible and has been required in LoRaWAN specification. However, LoRa network server could run complex management mechanism, which can be developed to improve network performance. Therefore, the related works discussed in this paper focus on server-side mechanism. The basic ADR scheme [1] provided by LoRaWAN predicts channel conditions using the maximum received Signal Noise Rate (SNR) in the last 20 packets. The basic ADR scheme is sufficient when the variance of the channel is low, it reduces the interference compared with using the static data rate [2] ,[3]. However, their simplicity causes many potential drawbacks. First, the diversity of LoRa Gateway models that measures SNR make the measurement inaccurate as a result of hardware calibration and interfering transmissions. Second, selecting the maximum

SNR each 20 packets received could be a very long period in many IoT applications that require less uplink transmission. Third, transmission parameters adjustment considers only the link of a single node. If many LoRa nodes are connected to the near gateway, all nodes connected to this gateway will use the fastest data rate. In this case, the number of LoRa nodes using the same data rate will increase and the possibility of collisions also increases dramatically. Most of researchers in the literature utilize SNR or Received Signal Strength Indication ($RSSI$) information to control Transmission Energy (Tx) and Spreading Factor (SF). For example, the authors in [3] slightly modify the basic ADR scheme by replacing the maximum SNR with the average function.

III. Methodology

A generic scheme to solve the configuration selection problem and any other similar selection problem is given in Figure 1. The genetic selection scheme consists of three main steps, the first step contains a set of small parallel fuzzy logic (FL)-based subsystems, the second step is a multiplecriteria decision making (MCDM) system, and the third step is a genetic algorithm (GA)-based component to assign a suitable weight for the criteria in the second component. The scheme decision phase can be described in more detail as follows.

(i) The heterogeneous wireless environment contains up to n networks (RAT 1 ,RAT 2 ,...,RAT n) and the framework has to select the most promising one or to rank the RATs according to their suitability.

(ii) The selection depends on multiple criteria up to i (c 1 ,c2,...,c i). Different type of criteria can be measured from different sources to cover the different view points of the users, the operators, the applications, and the network conditions. Each criterion is measured then passed to its FL-based control subsystem in the first component.

(iii) Every FL-based subsystem gives an initial score for each RAT that reflects the suitability of that RAT according the FL subsystem criterion. The different sets of scores (d 1 ,d2,...,d i) are sent to the MCDM in the second component.

(iv) The GA component assigns a suitable weight (w 1 ,w2,...,w i) for each initial decision according to the objective function that is specified by the operator according to the importance and sensitivities of ANS criteria to the different characteristics of a wireless heterogeneous environment.

(v) Using the initial scores coming from the first component and the weights that are assigned manually or using the third component, the MCDM will select the most promising AN or will rank the available RATs according to their suitability.

IV. Experimentation

A. Range

B. Response time

C. Connection speed

D. Power consumption

V. Discussion

The main challenge of this work is to explore using genetic algorithm to model LoRa transmission parameter selection to satisfy each application requirement. Our main contribution was to build 3 applications that requires 3 different levels of QoS, such as text transmission, sound transmission and image transmission. We used a low cost LoRa gateway on a Raspberry-pi with 2 Arduino boards equipped with 2 LoRa Transceivers based on the SX1276 specification. To measure the accuracy of applying genetic algorithm in the edge computing to select the best LoRa configuration we used both simulation and real environment testbeds. Our simulations compare the performance of each configuration selection

References

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