TASK SCHEDULING AND PORTIONING FOR SOFTWARE DEFINED NETWORK USING REINFORCEMENT LEARNING

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Abstract— The Internet of Things (iot) connect millions of devices in diverse areas such as smart cities, e-health, transportation and defence to meet a wide range of human needs. To provide these services, a large amount of data needs to be transmitted to the iot network servers. Currently emergency data packets do not get any special priority while routing through the Internet of Things (iot) networks. These data packets flow through routers using conventional qos process which does not guarantee that an emergency data packet traveling in congested iot network will actually be routed to control room on time. A major challenge in packet scheduling is that the behaviour of each traffic class may not be known in advance, and can vary dynamically. Therefore, innovative packet prioritization techniques, e.g., queue management approach needs to be developed to overcome prioritization problems in iot networks. This project proposes an Artificial Intelligence Packet Priority Queuing model P2 Queue based emergency data packet classification with a prioritization algorithm to provide a required transmission priority for emergency data. In this project, LSTM is used to classify the emergency data packet. Then, according to the model characteristics, a deep intelligent scheduling algorithm based on a Deep Q Network (DQN) framework is proposed to make scheduling decisions for communication. Effective simulation experiments demonstrate that the proposed P2Queue can effectively create scheduling strategies for emergency data packet flows. Results confirmed the machine learning module achieved 91.5% of accuracy when identifying the emergency data and assigning the expected priority.

I. INTRODUCTION

The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data. Thanks to the arrival of super-cheap computer chips and the ubiquity of wireless networks, it's possible to turn anything, from something as small as a pill to something as big as an aeroplane, into a part of the IoT. Connecting up all these different objects and adding sensors to them adds a level of digital intelligence to devices that would be otherwise dumb, enabling them to communicate real-time data without involving a human being. The Internet of Things is making the fabric of the world around us smarter and more responsive, merging the digital and physical universes.

1.1.1. IoT Works

IoT devices are empowered to be our eyes and ears when we can't physically be there. Equipped with sensors, devices capture the data that we might see, hear, or sense. They then share that data as directed, and we analyse it to help us inform and automate our subsequent actions or decisions. There are four key stages in this process:

Capture the data

Through sensors, IoT devices capture data from their environments. This could be as simple as the temperature or as complex a real-time video feed.

Share the data

Using available network connections, IoT devices make this data accessible through a public or private cloud, as directed.

Process the data

At this point, software is programmed to do something based on that data – such as turn on a fan or send a warning.

Act on the data

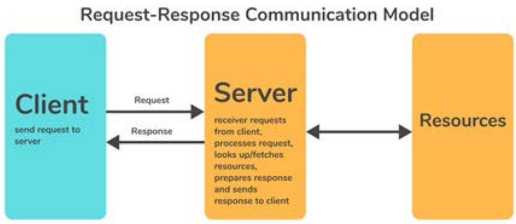
Accumulated data from all devices within an IoT network is analysed. This delivers powerful insights to inform confident actions and business decisions.

1.1.2. Communication models in IoT

In general, the Internet of Things is about connecting devices to the Internet, but how they connect is not always obvious. IoT devices connect and communicate through their technical communication models. An effective communication model shows how the process works and helps one understand how communication can be done. The Internet of Things (IoT) enables people and things (devices) to be connected wherever they are, using any network or service they like. Types of communication models –

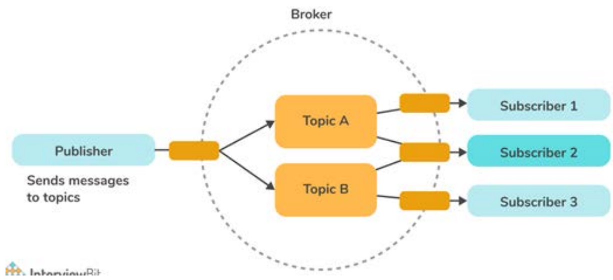
- *Request-Response Model*

This communication model is based on the client (IoT Device) making requests and the server responding to those requests. Upon receiving a request, the server decides what response to provide, fetches the requested data, prepares the response, and then sends it back to the client. This model is stateless because the data between requests is not retained, therefore each request is handled independently.



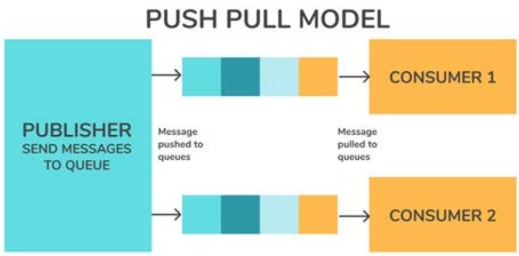
- *Publisher-Subscriber Model*

Publishers, brokers, and consumers are all involved in this communication model. Publishes are the sources of data that send data to topics. The broker manages the topics, and consumers (consume data from topics) subscribe to the topics. Publishers and consumers are unaware of each other. Upon receiving data for a topic from the publisher, the broker forwards it to all subscribed consumers. As a result, brokers are responsible for receiving data from publishers and sending it to the appropriate consumers.



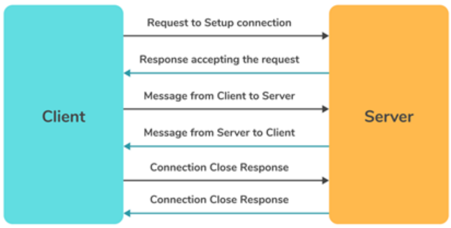
- *Push-Pull Model*

This communication model entails data producers pushing the data into queues, while data consumers pull the data from the queues. Neither producer nor consumer needs to know about each other. The queues help decouple the messages between the consumers and the producers. Also, queues act as a buffer when there is a mismatch between the rate at which producers push data and the rate at which consumers pull it.



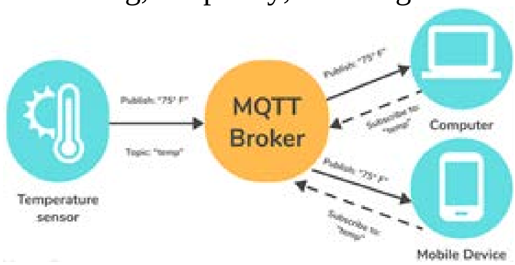
- *Exclusive-Pair Model*

Exclusive pairs are full-duplex, bidirectional communication models developed for constant/continuous connections between a client and server. After a connection is established, clients and servers can exchange messages. As long as a client doesn't send a request to close the connection, the connection remains open. The server is aware of every open connection.



- *MQTT (Message Queue Telemetry Transport Protocol)*

The Message Queuing Telemetry Transport protocol (MQTT) is a publish/subscribe message protocol designed for networks with limited bandwidth and IoT devices with extremely high latency (delay in data transmission). This messaging protocol is simple and lightweight, suited to devices and networks with low bandwidth, high latency, or insecure networks. It has been designed to reduce network bandwidth and resource requirements of devices and to ensure supply security. Furthermore, these principles are beneficial for IoT or M2M devices, since battery life and bandwidth are very important. Because MQTT is efficient and lightweight, it can be used to monitor or control a large amount of data. Nowadays, MQTT is used in a variety of industries, including automotive, manufacturing, telephony, oil and gas.



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1.1.3. IoT Use cases

- *Optimize industrial operations*

Create rich and scalable industrial IoT applications to remotely monitor operations, improve quality, and reduce unplanned downtime.

- *Build differentiated consumer products*

Develop connected consumer applications for home automation, home security and monitoring, and home networking.

- *Reinvent smart buildings and cities*

Build commercial IoT applications that solve challenges in infrastructure, health, and the environment.

- *Transform mobility*

Deliver IoT applications that gather, process, analyse, and act on connected vehicle data, without having to manage any infrastructure.

II. LITERATURE SURVEY

1.Priority-Aware Fast MAC Protocol for UAV-Assisted Industrial IoT Systems

Author: Shreya Khisa;Sangman Moh
Year: 2021
Link: https://ieeexplore.ieee.org/document/9400366

Objective:

This article proposes a priority-aware fast mac (pf-mac) protocol for uav-assisted iiot systems, ensuring fast and robust data delivery. The hybrid pf-mac protocol integrates the benefits of both contention-based and contention-free protocols for a remote iot scenario.

Methodology:

This paper proposes a priority-aware fast MAC (PF-MAC) protocol for UAV-assisted industrial Internet-of-things (IIoT) systems, ensuring fast and robust data delivery. At first, the IoT devices under the UAV communication range transmit a reservation frame to the UAV to catch transmission opportunities using CSMA/CA. The devices utilize static traffic priority and a novel adaptive backoff mechanism during CSMA/CA. After receiving the reservation frames from the IoT devices, the UAV calculates the dynamic device priority based on their static traffic priority, communication duration, sampling frequency, and remaining energy. Then, time slot is assigned by the UAV to each device for data transmission. To ensure fairness, if a device fails in contention during the CSMA/CA period, the static traffic priority is raised in the next retransmission. There is no prior work in the literature that considers both the traffic priority and the device priority to ensure Quality of Service in IIoT and related systems.

Advantages:

- Uav-assisted industrial internet-of-things (iiot) systems, ensuring fast and robust data delivery.

Disadvantages:

- Developments in wireless and mobile networking technology have affected every aspect of our everyday lives.

2.Dynamic Wavelength Grouping for Quality of Service in Optical Packet Switching

Author: Hafsa Bibi;Farrukh Zeeshan Khan
Year: 2021
*Link:*https://ieeexplore.ieee.org/document/9405790

Objective:

This article aimed to analyze DWG with more functions like plr, pdv, bit error rate and response time. Also, design a framework provisioning of resources in more adverse load situations at edge ops switches with assurance of same impact on these factors

Methodology:

This paper proposed and analyzed an advanced technique DWG for absolute qos in an op, which makes dynamic and most appropriate partitions of available wavelength resources and allocate them to traffic of each class of service in rapidly varying traffic loads by tracking the current link load status. The wavelength grouping changes over time with change in load share of each class, and results in efficient utilization of wavelength resources at each link. We described a baseline ops model to express the expected performance, and then briefly examined the proposed technique over various qos metrics to evaluate its performance and effectiveness. A number of possible simulation scenarios are evaluated to understand the effect of dwg on blocking probability in fluctuating traffic loads of different classes.

Advantages:

- Flexible approach, efficiently functional even when the share of the high-priority load is temporarily low.

Disadvantages:

- Ops have higher packet delay variation (pdv), packet loss ratio (plr) and transmission delay than ocs.

3.An Efficient Reservation-Based MAC Protocol for Multi-Priority Traffic in Slotted Multi-Channel Distributed Cognitive Radio Networks

Author: Jaehwoon Lee
Year: 2020
*Link:*https://ieeexplore.ieee.org/document/9218918

Objective:

This article proposes protocol and the analytical results show that higher priority traffic can be transmitted first ahead of the lower priority traffic.

Methodology:

This article having data packets with different class of priorities transmits its control packet containing the priority value through the control channel. The order of access to primary channels is determined based on the priority of the data packet and the position of the non-colliding control packet. The access order determines the idle primary channel that an SU uses to transmit its data packet. In this protocol, there is no performance degradation either from SU's choosing a busy primary channel or multiple SU's choosing the same idle primary channel. Moreover, even though the SU cannot transmit its data packet because there is no idle primary channel that the SU can utilize, it can re-transmit its control packet without having concern over additional collision.

Advantages:

- Data packet arrives at an SU in idle state at the beginning of a slot, the SU changes its state to the sensing state.

Disadvantages:

- Traffic can be transmitted first ahead of the lower priority traffic.

4.Queue and Priority-Aware Adaptive Duty Cycle Scheme for Energy Efficient Wireless Sensor Networks

Author: Bashir A. Muzakkari;Mohamad A.
Year: 2020
*Link:*https://ieeexplore.ieee.org/document/8963893

Objective:

This article proposed scheme is validated using numerous experiments conducted under different network conditions to evaluate the significance of energy preservation, extended network lifetime and minimize packet delay.

Methodology:

This paper proposes a scheduling algorithm that uses an optimized random early detection algorithm to provide low queuing delay for priority packets with an exponential weighted moving average to solve the problem of starvation suffered by low priority classes by keeping the value of the average queue length below the minimum threshold.

Advantages:

- Duty cycling coordinates the sleep/wake-up time of sensor nodes to maximize the network lifetime.

Disadvantages:

- Energy consumption is considered as the most fundamental issue of wsn, and it is widely affected by the communication.

5.Priority access for QoS support in distributed wireless networks

Author: Zhou Xin; Zheng Changwen
Year: 2019
*Link:*https://ieeexplore.ieee.org/document/8945571

Objective:

This article proposes scheme significantly improves the real-time traffic capacity, throughput, delay, fairness and packet loss rate.

Methodology:

This paper proposes a scheme called the priority access based on busy tone (PABT) for distributed wireless networks. It uses an in-band slot-length busy tone (BT) signal, i.e., sine signal, to reserve the channel for absolute priority access. Based on that, it also improves the real-time traffic capacity and the aggregated throughput significantly through the optimal CW tuning for each traffic type individually.

Advantages:

- The priority channel access, this scheme uses an in-band busy tone to limit the transmission of lower-priority traffic when higher-priority traffic has packets to send

Disadvantages:

- It is not so easy to support QoS in wireless networks, because the signal transmission may suffer from the interference.

6.Performance Analysis of D2D Underlying Cellular Networks Based on Dynamic Priority Queuing Model

Author: Jianfang Xin;Qi Zhu;Guangjun Liang
Year: 2019
*Link:*https://ieeexplore.ieee.org/document/8624403

Objective:

This article simulation results show the validity of the theoretical analysis. Moreover, by comparing the dropping probability of the priority queuing model with and without the jump strategy, the rationality of the introduced model is confirmed.

Methodology:

This article develops a spatiotemporal mathematical model for analyzing the performance of prioritized data transmissions in the device-to-device (D2D) underlying cellular network. A dynamic interference model of a D2D user is constructed by exploiting thinned poison point process to model the D2D user location with data stored in the buffer. A dynamic priority queuing model is adapted to analyze the performance of multiple types of traffic, in which the priority jump strategy is proposed to provide increased transmission opportunity for low-priority user packets. Then, we employ a two-dimensional geo/g/1 markov chain to describe a queue model with priority jump and evaluate it using quasi-birth-and-death process approach.

Advantages:

- Provide increased transmission opportunity for low-priority user packets.

Disadvantages:

- Delay outage performance was analyzed with random arrival of traffic in heterogeneous cellular networks.

7.HPQS: A Fast, High-Capacity, Hybrid Priority Queuing System for High-Speed Networking Devices

Author: Imad Benacer;François-Raymond Boyer
Year: 2019
*Link:*https://ieeexplore.ieee.org/document/8842569

Objective:

This article proposes a hybrid priority queuing system (HPQS) with two distinct configurations. The first configuration is intended for strict priority scheduling with distinct queues.

Methodology:

This article presents placement and routing results of the HPQS in a ZC706 field programmable gate array (FPGA) board and xcvu440 device, the total capacity can reach 1/2 million packet tags of 16-bit priority keys in a single FPGA. The HPQS is proposed for high-speed networking devices operating in constant 1-cycle latency per packet (queue operation) targeting 10 to 40 gb/s network links. Moreover, the performance of the proposed HPQS is independent of the PQ capacity. Also, the proposed HPQS architecture is entirely coded in C++, providing easier implementation and more flexibility than some reported works

Advantages:

- Reducing latency to best support the upcoming 5g wireless standards.

Disadvantages:

- Increasing traffic and tight requirements of high-speed networking devices, a high capacity priority queue.

8.Research on Multi-Level Priority Polling MAC Protocol in FPGA Tactical Data Chain

Author: Hongwei Ding;Chao Li;
Year: 2019
*Link:*https://ieeexplore.ieee.org/document/8656465

Objective:

This article proposed a multi-level priority polling mac protocol mppmp, which controlled the arrival rate of each user with a priority weight matrix according to the priority level of different users in the tactical data link system, and dynamically guarantees the data transmission of the priority site.

Methodology:

This article ensures the urgency of priority site transmission in tactical data link system and better serve information warfare, we use the idea of multi-priority service to improve the traditional gated polling system and propose a multi-priority polling control protocol. Depending on the priority, multiple priorities are set. The protocol adds a priority control field to the ieee 802.11 mac frame, and uses the priority control field to distinguish the user’s priority. The smaller the value of the priority control field, the higher the priority.

Advantages:

- Important impact on system performance and has always been a hot issue in tactical data link research.

Disadvantages:

- Multiple users will co-exist in the tactical data link system, and each user’s privilege level will not be the same. The importance and urgency of the messages transmitted by each user are also different.

9.Achieve Privacy-Preserving Priority Classification on Patient Health Data in Remote e-Healthcare System

Author: Guoming Wang; Rongxing Lu
*Year:*2019
Link: https://ieeexplore.ieee.org/document/8606116

Objective:

This article aims at solving the above challenges; we propose an efficient and privacy-preserving priority classification (PPC) on patient health data in remote e-healthcare system, which allows authenticated users to periodically send medical packets to the healthcare center through WBAN-gateways.

Methodology:

This article proposes an efficient and privacy-preserving priority classification scheme, named PPC, for classifying patients’ encrypted data at the WBAN -gateway in a remote e-healthcare system. Specifically, to reduce the system latency, we design a non-interactive privacy-preserving priority classification algorithm, which allows the WBAN-gateway to conduct the privacy-preserving priority classification for the received users' medical packets by itself and to relay these packets according to their priorities (criticalities). A detailed security analysis shows that the PPC scheme can achieve the priority classification and packets relay without disclosing the privacy of the users' personal information and the confidentiality of the healthcare center's disease models

Advantages:

- The PPC scheme, an efficient privacy preserving non-interactive priority classification scheme for users' medical packets in WBAN-gateways.

Disadvantages:

- The attacker knows some users' information or some disease models. Even in this context, the attacker cannot recover other plaintext of the corresponding encrypted data

10.A Priority-Based Reservation MAC Protocol in Multi-Channel Cognitive Radio Network

Author: Jaehwoon Lee
*Year:*2018
*Link:*https://ieeexplore.ieee.org/document/8481351

Objective:

This article proposed protocol in an independent and distributed manner. Also, any new SU's can enter the network at any time. It is because a new SU checks the control channel during one slot and can know the current status of the network

Methodology:

This article has presented a priority-based reservation mac protocol in slotted multi-channel cognitive radio networks. In this protocol, a common control channel is exclusively used by SU's to determine the access priority of the SU's. A slot of the common control channel is further divided into the time period to sense all primary channels and number of minislots. Moreover, minislots can be divided into two parts: reservation part and contention part. When a data packet arrives at an SU, the SU counts the number of successful control packets by monitoring one slot of the control channel. And then, the SU randomly chooses one of the minislots belonging to the contention part. If the control packet is successfully transmitted without collision, then the SU gets the priority based on the position of the control packet.

Advantages:

- SU's to transmit control packets in order to determine the priority for accessing the primary channels.

Disadvantages:

- Results show that the number of Su's affects the performance due the collision possibility of random access.

III. EXISTING SYSTEM

Existing works for data packet scheduling are mainly divided into three types: first-come, first-served (FCFS), earliest deadline first (EDF), and emergency task first rate monotonic.

- *Priority queuing*

Packets are sorted into different priority queues. Higher priority packets are transmitted ahead of lower priority packets. The priority-based scheduling algorithms include two types: preemptive scheduling and non-preemptive scheduling. In the non-preemptive scheduling algorithm, a packet once started to be processed, other packets, even though the priorities are higher, have to wait until the packet processing is completed. Differently, preemptive scheduling algorithm is more flexible. At each node, the packets with higher priorities can preempt packets with lower priorities. Evaluate preemptive scheduling and nonpreemptive scheduling through a lot of experiments.

- *Deadline-Based Scheduling*

In this type of packet scheduling, the deadlines of packets are considered. In the RMS algorithm, the priorities of packets are static priorities, which are assigned based on the deadlines of packets. The priorities of the data packets for RMS are static. Thus, the RMS scheme is limited and inapplicable. In the EDF algorithm, the priority of each packet is determined according to the deadline. Thus, the overhead is relatively large.

- *Packet-Type-Based Scheduling*

There are different types of packets in this scheduling scheme, such as real-time packets and non-real-time packets. The priorities of the packets are determined based on the packet types.

- *Class-based queuing*

Packets are sorted into queues, one queue per class. Packets within each queue are transmitted FCFS. Different queues are served in round-robin fashion.

- *Dynamic Multilevel Priority (DMP)*

Packet scheduling technique exists for WSNs in which the sensor nodes are arranged into a hierarchical structure.

- *Shortest job first (SJF)*

This technique ensures the packet delivery on the basis of their priority with lesser.

- *Earliest Deadline First (EDF)*

In which involves the arrival time and deadline as their basis of data processing respectively.

Disadvantages

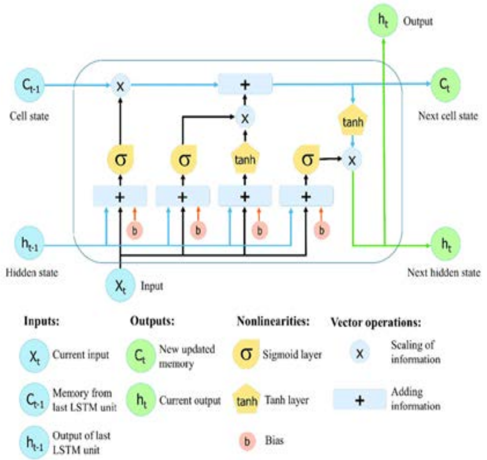
- Lack of efficient scheduling algorithms
- Inappropriate delivery of emergency packets
- Real time data mismanagement
- Packet dropping
- Unwanted delays
- Lesser network lifetime
- Large waiting time and inefficient energy utilization

IV. PROPOSED SYSTEM

The proposed system prioritizes data on IoT devices on the basis of data importance extracted from the deep learning based LSTM model for prediction, which enables it to reduce the total data traffic for real-time prediction while maintaining prediction accuracy. The proposed system consists of two main components: IoT devices and an edge server. IoT devices (such as probe vehicles, WBAN, smartphones, and UAVs) prioritize collected data and send high importance input data for prediction to the edge server. The edge server aggregates the data received from IoT devices, complements the missing parts of the data, and performs prediction. Predicted packets are then scheduled using Deep Q Learning.

- *LSTM – Long Short Term Memory*

LSTMS are a special kind of RNN which is capable of learning long-term dependencies. LSTMs are designed to dodge long-term dependency problem as they are capable of remembering information for longer periods of time. Long short-term memory (LSTM) units (or blocks) are a building unit for layers of a recurrent neural network (RNN). A RNN composed of LSTM units is often called an LSTM network. A common LSTM unit is composed of a cell, an input gate, an output gate and a forget gate. The cell is responsible for "remembering" values over arbitrary time intervals; hence the word "memory" in LSTM. Each of the three gates can be thought of as a "conventional" artificial neuron, as in a multi-layer (or feedforward) neural network: that is, they compute an activation (using an activation function) of a weighted sum. Intuitively, they can be thought as regulators of the flow of values that goes through the connections of the LSTM; hence the denotation "gate". There are connections between these gates and the cell. The expression long short-term refers to the fact that LSTM is a model for the short-term memory which can last for a long period of time. An LSTM is well-suited to classify, process and predict time series given time lags of unknown size and duration between important events. LSTMs were developed to deal with the exploding and vanishing gradient problem when training traditional RNNs.



The popularity of LSTM is due to the Getting mechanism involved with each LSTM cell. In a normal RNN cell, the input at the time stamp and hidden state from the previous time step is passed through the activation layer to obtain a new state. Whereas in LSTM the process is slightly complex, as you can see in the above architecture at each time it takes input from three different states like the current input state, the short-term memory from the previous cell and lastly the long-term memory. These cells use the gates to regulate the information to be kept or discarded at loop operation before passing on the long term and short-term information to the next cell. We can imagine these gates as Filters that remove unwanted selected and irrelevant information. There are a total of three gates that LSTM uses as Input Gate, Forget Gate, and Output Gate.

A. *Input Gate*

The input gate decides what information will be stored in long term memory. It only works with the information from the current input and short-term memory from the previous step. At this gate, it filters out the information from variables that are not useful.

B. *Forget Gate*

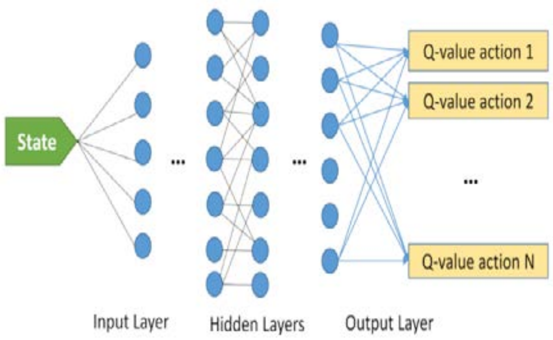
The forget decides which information from long term memory be kept or discarded and this is done by multiplying the incoming long-term memory by a forget vector generated by the current input and incoming short memory.

C. *Output Gate*

The output gate will take the current input, the previous short-term memory and newly computed long-term memory to produce new short-term memory which will be passed on to the cell in the next time step. The output of the current time step can also be drawn from this hidden state.

Deep Q-Learning Algorithm

As one of the main reinforcement learning algorithms, Q learning is a model-free learning method which provides the intelligent system with the ability to select the optimal action according to the action sequences from experience in the Markov environment. A key assumption of Q-learning is that the interaction between the agents and the environment can be treated as a Markov decision process (MDP), i.e., the current state and action of the agent will determine the state transfer probability distribution and the next state with an immediate reward.



The goal of Q-learning is to find a policy that can maximize the reward. The Q-value is an important parameter in Q-learning. It is defined as the sum of rewards for executing the current related actions and those to be performed subsequently in accordance with a certain strategy. A given state s and action a correspond to a given Qvalue Q(s,a). Q-value is used in the learning process to select the action. If the subsequent actions are performed according to the optimal polices the corresponding Q-value is referred to as the optimal Q value Q*,

$$Q^*(s,a) = r(s,a) + \gamma \sum T(s,a,s') max Q^*(s',a')$$

where T (s, a, s') represents the transfer probability from states to state s' via action a, r(s,a) represents the reward for executing action a from states, γ∈(0,1) is the discount factor, which indicates the degree of farsightedness. If the γ value is small, the system pays attention to only the recent actions. If γ is large the actions during a relatively long period of time are involved. An agent learning process can be viewed as selecting an action from a random state using a strategy. The value of Q(s,a) is updated according to

$$Q_{t+1}(s,a) = (1-a) + Q_t(s,a) + a[\gamma max(s',a')]$$

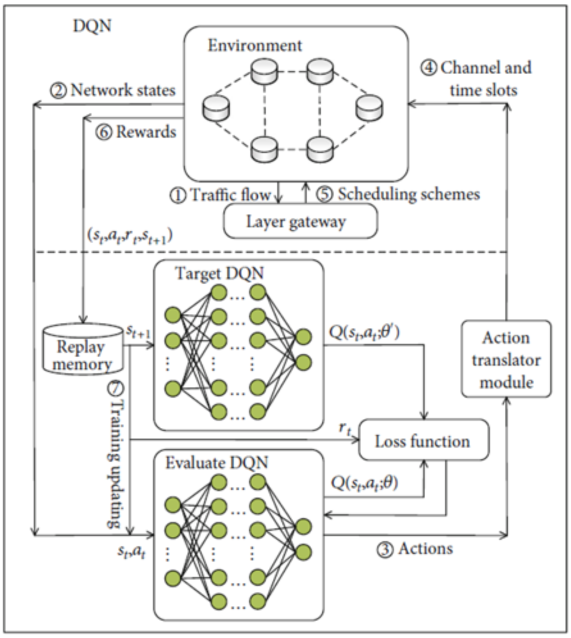
where α∈ (0,1) is the learning factor used to control the speed of learning: the greater the value of α, the faster the convergence speed. After performing the selected action, the agent observes the new state and the reward obtained, and then updates the Q-value of the state and action based on the maximum Q-value of the new state. In this way the agent continually updates the action according to the new state until it arrives at the terminal state with an optimal Q-value Q*.

Advantages

- Accurately predicting the emergency data packet.

- Emergency data will get higher priority and less delay over normal data;
- Data aggregation will result in less energy consumption and longer network lifetime.
- Control the network congestion effectively and increase the network throughput.
- Minimization of end to end delay
- Network lifetime maximization
- Efficient energy consumption
- Reduced waiting
- Time and delivery of data before expiration of deadline

V. SYSTEM ARCHITECTURE



VI. MODULE DESCRIPTION

IoT Network Simulator

In this module, design a hierarchical structure to generalize all the contents in the IoT network.There are three layers in this structure: the device layer, the fog intelligence layer, and the centralized intelligence layer. The device layer is composed of all objectives, IoT Device, users, and smart terminals that can collect sensed data from live environments. The fog intelligence layer provides distributed, low-latency, and limited computing resources between the device layer and the higher layer. The centralized intelligence layer consists of cloud data centers that aggregate data from lower layers.

Fog Application and Service Layer

This layer applies services for IoT data analytics and periodically processes sensor data to make IoT based decisions using Publish/Subscribe Machines (PSMs). The output of this layer is the data packets containing decisions. In a scalable fog architecture, multiple PSMs may perform simultaneous operations and generate a low-rate periodic IoT decision traffic pattern independently Context Broker (CB), PAS - A Publish/Subscribe Machine (PSM), Fog Connector (FC).

Priority Aware Scheduling

The purpose of this module is to recognize the received information packets and process them according to their priority.

VII. IMPLEMENTATION

Problem Description

IoT devices (such as probe vehicles, smartphones, and UAVs) continuously collect data at a specific sampling interval. Part of the collected data is sent to an edge server for prediction. To decide whether a data should be PP or NPP, the controller fetches the importance of the block where the IoT device is currently located. The controller orders the transmitter to send the data or not in priority based on the importance of the current block received from the fog server. The fog server receives collected data from IoT devices, aggregates and pre-process the data, and predicts the real-time spatial information of the next time slot using LSTM. The aggregator and pre-processor on the fog server receive data from the transmitters of several IoT devices, pre-process the data, and complete the missing parts of the data. The predictor predicts real-time spatial information. The importance extractor extracts the importance of blocks from the pre-trained LSTM model for prediction. The responder sends the importance of blocks to each IoT device. In each time slot, Deep Q Learning decide whether to transmit the data observed in the time slot based on the importance of the data. The importance of data corresponds to the importance of the block where the data was observed.

Data Packet Description

For test purposes, we chose to insert the identifier within the MAC layer Any packet data has two major parts, the header and the information. We are focusing on the packet headers. All packet headers contain the same features in the IEEE 802.15.4 standard. The headers are described in the MAC frame format (refer to Table 1). This format consists of the reserved bits that can be used for any specific application. We are using this specific reserved bit to save an identifier at the sensor level. An identifier is only two bits which means it will not take a lot of memory space. Hence, the identifier is included in the header part rather than taking up space in the memory of the application defined information.

VIII. RESULT

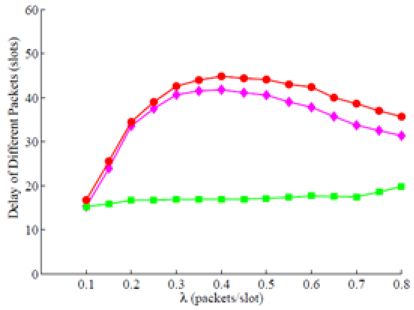
In this section, we evaluate our proposed PPQM with the waiting time, the end-to-end delay, and the packet loss rate as metrics.

Waiting Time

In the simulation experiments, we control the packet generation rate to simulate the normal network load. In order to improve the accuracy of the simulation, three different experimental situations are set up. The ratio of PP packets, NP packets, and NPP packets is set as {3:5:2, 1:1:1, 5:3:2} corresponding to these three situations. The average value of the experimental results obtained from the three situations is the final result.

End-to-End Delay

It is the average time from the packet generation to delivery in the network. The emergency packets need to be delivered as fast as possible. Thus, the end-to-end delay is an important metric to evaluate the real-time performance of the scheduling scheme. It can be seen that with the increase of the packet arrival rate, the end-to-end delay of BS scheme first decreases then increases. The reason is that the BS cannot generate enough pressure at the low network load because there is not enough queue backlog difference gradient. BS scheme will explore all possible paths, so the end-to-end delay increases. When the network load increases, the end-to-end delay of BS scheme reduces because the queue backlog difference gradient is formed. Subsequently, the queue backlog starts to increase, which leads to the increase of end-to-end delay.



End-to-end delay of different packets.

IX. CONCLUSION

Packet classification and Scheduling is one of the fundamental problems in IoT networks. In this project, we developed a Packet Prioritization Queueing for the analysis of IoT-Fog data traffic and propose a scheduling policy for reducing wait time gaps observed in the multi-level priority queue design. Driven by this trend, the combination of edge computing and deep reinforcement learning has received a tremendous amount of attention. In this project, by employing LSTM Model to classify the emergency packets and the classic deep Q network (DQN) architecture in intelligent scheduling, our PPQM can identify reasonable channel and time slot combinations with competitive performance. Extensive simulation experiments were implemented, demonstrating that our PPQM can obtain better network performance than the traditional scheduling schemes.

Future Enhancement

For a more practical evaluation, in future work, other deep learning models along with suitable feature selection methods for the models should be considered.

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