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CONTENTS

SPECIAL ISSUE ON Recent Advances in Next-Generation Wireless Networks and it's Applications

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Next-generation wireless networks are anticipated to see continued expansion due to the explosive growth of mobile applications in terms of traffic volume and heterogeneity, with new use cases such as novel multimedia content delivery, military applications, and many more. Such use cases require incredibly high bandwidth efficiency, ultralow latency, efficient resource allocation and enhanced quality of experience. Next-generation wireless networks must be outfitted to support these diverse applications. Further, Machine learning, a model-independent approach, can create usable solutions to next-generation wireless networking and communications problems. Thus, this Special Issue seeks articles covering various subjects that fall under its purview.

The first paper proposed an embedded system that can be attached to a soldier's body to measure critical parameters such as blood pressure, body temperature, oxygen levels, and the current position of an individual soldier. The proposed system can provide more security to soldiers by adding microphone capability for duplex communication and pinpointing their location more precisely.

In the second paper, authors investigated the downlink MIMO-NOMA cell-free IoT that enables huge data transmission between system nodes and a connected network of connected things on a large scale. It evaluates the resource allocation (RA) issue and develops a power control-based EE optimization model for the cell-free IoTs. The RA problem is solved using machine learning techniques, including a recursive combination of deep neural network and DLS algorithm.

The third paper is a comprehensive review of the GNN for health applications. The paper highlights the major graph theory concepts for analyzing graphs and GNN, along with its core working principles.

The fourth paper developed a novel model for Multimedia Content Distribution in Delay-Tolerant Networks using Average buffer Occupancy to analyse and estimate the expected buffer occupancy without communicating the messages in delay tolerant networks. The proposed model is simulated and validated state-of-the-art real-world mobility data-trace.

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LoRa COMMUNICATION FOR INDIAN SOLIDER SECURITY WEARABLE DEVICE

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Abstract
There is being a long time we are using internet and its application and certainly it has changed our life in manyaspects with its applications but among them Internet of things(IoT) is about to change the world all over again. The paper reports about a wearable technology for soldiers to monitor their health on battleground and warzone, since army assets are important for any country. Our soldiers sacrifice their life for our country. India has alreadylost so many soldiers in war-fields as there was no proper health backup and connectivity between the soldiers on the war-fields and the officials at the army base stations. Hence, our proposed device will work as a helping handfor them. The device is capable of measuring body parameters like heart rate, temperature, oxygen levels and withsome secure channel can transfer GPS location and all the information with the help of transducers.
Keywords: IoT, GPS , transducers

1. Introduction

IoT is a network of devices and sensors that receive or transfer data through wireless gateways. The IoT proposition has revolutionized research in the area of embedded system design and development. This technological advancement can improve the economic structure and security of all countries [1]. When it comes to security, soldiers play an important and decisive role in defending a country. During war, many of them sacrifice their lives and we tend to lose these precious assets. The main reason is poor or no connectivity and communication between soldiers on the battlefield and military base stations. This leads to inadequate and delayed medical facilities. Much research has been done recently to find ways to connect soldiers to base stationson the battlefield. The evolution and development of smart wearable devices has led researchers to explore technologies based on his Wi-Fi, Zigbee, RF, and Bluetooth technologies [2]. Mountable devices with Wi- Fi modules consume a lot of power, so the battery only lasts a few hours. A limitation of devices with ZigBee modules is their short range (approximately 100 m).As such, it is not desirable on the battlefield during wartime as it requires soldiers to be widely dispersed to monitor the enemy. GSM-based communication systems have limited use in hilly and mountainous areas, and mobile devices have been proposed. However, the wearable device proposed in this notice uses LoRa technology. Such module requires relatively less power to operate and can transmit data over longer distances. For this we relay data over MANET communication to nearby LoRa devices, which are eventually sent to the controlunit.

2. Related work

Many have reported on the WBASN (Wireless Body Area Network) technology used by ZIGBEE to transmitdata between control units and soldier units. They use the AT89C1 microcontroller, machine learning technology used in the system for data analysis, some of which propose a Bluetooth and HF wireless technology-based system to monitor the soldier's temperature and heart rate. In order to monitor the soldier with a GPS module and movement and pressure. Display collected data in a private app. The same is true forGPS and GPRS based embedded system for tracking purpose. All these work was lying in low range However, work on LoRa (Long Range Communication Technology) is being discussed for low power consumption and long range. This is very cheap compared to WIFI, ZIGBEE and GSM because in terms of cost he is suitable for IoT technology. It also consumes very little power and allows long-distance communication. The author also states that LoRa's communication range is 33 km^2 inrural and urban rural or open areas.

3. Proposed System

The proposed embedded system is a wearable device that can be attached to a soldier's body to measure critical parameters such as blood pressure, body temperature, oxygen levels, and the current position of an individual soldier.

All these biological information of soldiers is sent to the base camp using IoT ina fully encrypted manner via some gateway LoRa transceivers (planted on every entity). Our system consists of two units:

3.1 Soldier Unit

The Soldier unit consists of a sensor network including temperature sensor, heart rate sensor and Spo2. These sensors are used to collect health information for soldiers [3]. Atemperature sensor records the soldier's temperature and transfers this recorded data to the microcontroller. A heart rate sensor captures the soldier's pulse rate or heart rate (BPM) and relays this captured data to the microcontroller. These captured analog signals are converted to digital signals using A/D converters. The data is then compared with the normal state signal. In addition, if the compared data is below the normal state threshold, it is considered an emergency. The system has a GPS modem to locate soldiers anytime, anywhere. A GPS receiver is a global positioning system, a space- based satellite navigation system that provides position and time information from anywhere and in all weather conditions. Data from the GPS receiver is transferred to the microcontroller. All sensors such as GPS receiver, body temperature sensor, Spo2 sensor, heart rate sensor pass their data to the microcontroller then displays the data from all sensors on the display. Microcontroller compares the data to a normal human threshold. If the value is below the threshold, it sends an emergency message to the control unit via the LoRa module SX1278433M. A microcontroller processes the data from the sensors and transfers the information to the control unit via the LoRa module. There is a panic button that soldiers can use to summon emergency situations to the control unit or other appropriate soldiers for immediate action. When the soldier presses the panic button, an emergency call is automatically sent to the control unit via LoRa communications [5]. The architecture of proposed loRaWAN communication system is shown in Fig 1.

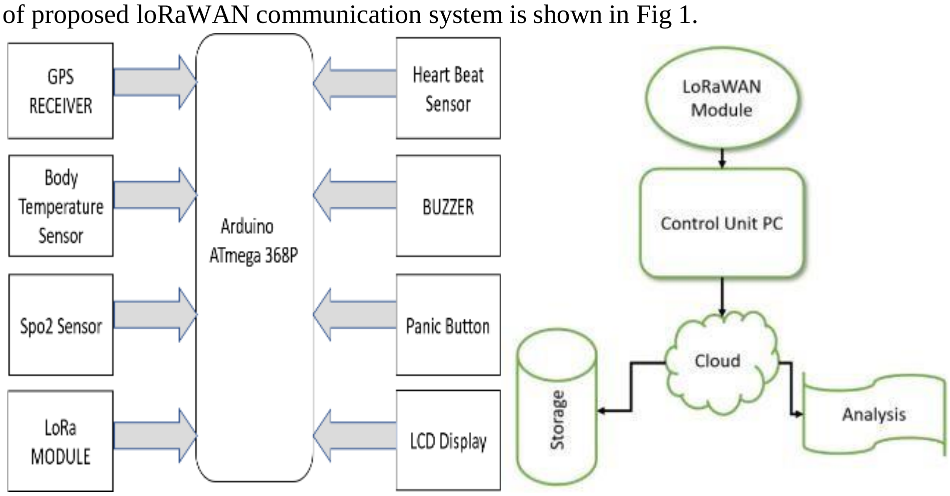

Fig 1: LoRa Communication with Soldier Welfare modules

3.2 Control Room Unit

Control units get data from gateways which areestablished via LoRa. And at the base camp wecan integrate the data as per requirement and thingspeak will be used for analysis of IoT data. Since each solider is working as individual node in ournetwork so it can do analysis as individual entity.

4. Architecture

We are using various types of hardware to implement proposed embedded system. All components shouldwork optimally and consume minimal power. The Arduino Mega serves as the microcontroller for this system with 54 I/O pins and an operating frequency of 16MHz of display module. Other sensors and modulesused in our system are : LM-35- Temperature sensor , XD-58C- measure pulse rates , MAX30100- Spo2 sensor GPS Modem – for location tracking, 128x64 OLED - display module is used.

Table 1: Sensor notations and their thresholds

Sensor (Notation)	**Threshold Level**
Spo2 (**Spo2**)	Under 90%
Heart Rate (**Hr**)	Less than 50 and greater than 120
Temperature (**BodyTemp**)	Less than 35 and greater than 39 in Celsius
GPS Location (**GPSLoc**)	Not receiving
Panic Button (**PBcall**)	ON

5. Working Methodology

i. Initiate soldier nodes by external power source and establish communication between Microcontroller to other components like GPS Modem, body sensors and LCD display and LoRa Module shown in Fig 2.
ii. Tracking the real time location of soldiers by GPS Modem and sent to nearer soldier nodes and to control room units.
iii. Measure the body temperature of the soldier node and it get display on the LCD, if it goes below threshold levelas given in Table 1, then the system will alert and inform the control room unit.
iv. Compute the oxygen level and heart rate using MAX30100 sensor, when it crosses threshold level, system will alert and inform the control unit as given in Table 1.
v. Soldier node's data will get continuously store on private cloud for real time surveillance as well as for future uses.

6. Future scope and Conclusions

Our system can provide more security to soldiers by adding microphone capability for duplex communication and pinpointing their location more precisely. The base station can monitor a soldier's physical condition in real time. And they can get medical and emergency instructions to get over their troubles [3]. A larger exhibition area can be added to this project. This is useful for displaying a digital map showing the location of allsoldiers associated with the unit and the distances between each soldier [6].

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Optimal Resource Allocation and Data Communication in 5G and Beyond with a Cell-free IoTs Systems

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Abstract: In this paper introduced optimum data communication and resource allocation in a cell-free IoTs systems. The optimal resource allocation has been done to improve the quality of service (QoS). In this paper, depth limit search (DLS) algorithm is used for optimum resource allocation with the aid of machine learning (ML) technology. The simulation results show that the proposed method achieved the optimum throughput and spectrum efficiency compared to the conventional network.

Key Word: Cell-free IoTs, Machine Learning, Data Communication, Resource Allocation.

1. Introduction

It has long been difficult for the traditional cellular network to offer effective resources to cell edge users. The distributed cell-free network working in tandem with the radio frequency transmitter (RFT) is one of the methods for giving the cell edge user effective resources. In every way, the cell-free network performs better than the conventional [1], [2]. The user-centric clustering strategy has recently been established in the cell-free network to give the cell edge users with enough resources. In a user-centric clustering, the RFT centers users, allowing end users to get the needed resource from the cluster unit (RFT cluster), or the serving cluster built with the RFT to serve each user separately.

A vast network made up of numerous data-sensing devices connected to the Internet is known as the Internet of Things (IoT). The IoT intends to connect everything to the network to make identification and control easier. The IoT faces difficulties with regard to sustainability and dependability due to a growth in the number of devices, interconnectivity, and data volume. A cell-free IoT system based on a cell-free radio communication system is suggested to advance the IoT's growth. The cell idea for wireless transmission in the IoT system has been diminished under the design of cell-free IoT, and when compared to the cellular IoTs, the reliability and resilience of the IoT system can be increased.

The dependability and sustainability of the current IoT systems will face unprecedented challenges as the number of linked devices and the amount of data transmitted between IoT devices grows significantly [3-4]. The service life of sensors will be governed by the energy in the batteries because wireless sensors are powered by batteries [5]. The sensors will stop functioning when these batteries run out of power. A potential solution to this issue is wireless power transmission (WPT) [6-7]. Unfortunately, long-distance transmission and multitarget transmission are not effective with current WPT technology. At the same time, the IoT's rapid expansion of linked devices has significantly increased energy consumption, creating new environmental problems. Therefore, increasing energy efficiency (EE) is the best way to address the energy difficulties brought on by the development of the IoT [8-11].

In this article, we investigated the downlink MIMO-NOMA cell-free IoT. Contributions of these article are as follow:

- It offers a cell-free IoT that enables huge data transmission between system nodes and a connected network of connected things on a large scale.
- It evaluates the resource allocation (RA) issue and develops a power control-based EE optimization model for the cell-free IoTs.
- The RA problem is solved using ML techniques that is a recursive combination deep neural network (DNN) and DLS algorithm.
- It assesses the cell-free IoT system performance by taking into account a number of criteria and implements the EE managing the system.

2. System model

In fugure-1, the CPU, RFTs and IoT are connected to the users and IoT devices. It is the realistic way for fulfillment of the 6G and beyond technologies. For the wide extension of the wireless network, the cell-free IoT is the one of the perfect candidate technology. As shown in figure-1, all the CPUs C_n are connected to the cloud network; RFTs R_n are connected to the CPUs and IoT devices, and I_K IoT devices are connected to the RFTs. Time-division duplex (TDD) is the method used by RFTs to serve IoT devices. It is expected that CPUs have sufficient capacity for data transmission and reception. It is expected that data transfer is considered good QoS if IoT devices could transmit or receive information directly via CPUs. To achieve good QoS, data transfer through RFTs must be taken into account because of their restricted capacity. Data from IoT devices and/or users can be collected and sent to RFTs using an ad hoc network.

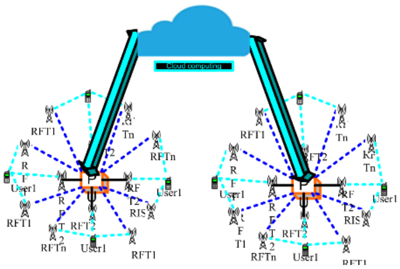

Figure-1: Cell-free IoT network

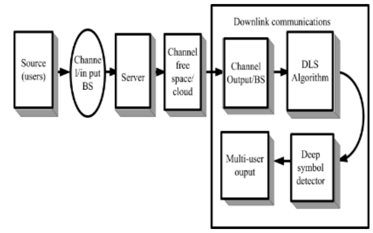

Figure-2: Source to Destination Data Flow in cell free IoT with DNN-DLSA

The channel gain g_{cn} is the coordination large scale fading and small-scale fading, it is represented as

$$g_{cn} = \sqrt{\beta} h_{ri}$$

Where β is the large-scale fading, h_{ri} is the Rayleigh fading channel coefficient between IoT device i and RFT R_n.In the uplink direction, the pilot sequence is sent to the RFT to determine the associated channel for IoT device. Hence, the equation for a pilot signal is represented as

$$y_{pr} = \sqrt{l^{CFU}\gamma^{CFU}} \sum_{i=1}^{n} g_{n\theta_n + W_n}$$

where, l^{CFU} is the length of the pilot symbol, γ^{CFU} is the signal to noise ratio of the pilot symbols received at the RFT,g_n is the channel gain between RFT and IoT device,. θ_n is the uplink pilot signal data, and W_n is the complex adaptive white Gaussian noise.

In the downlink data transmission, it does not require pilot symbol estimation, hence conjugate beam forming is used to estimate channels in both uplink and downlink directions. Then the received signals at the RFT is represented as

$$y_{r=\sqrt{\gamma^{CFU}}\sum_{i=1}^{n} g_i\sqrt{\alpha_i}q_i + W_{rn}}$$

where α_i is the power control coefficient of the n^{th} RFT, q_i is the transmitted symbol, W_{rn} is the complex Gaussian noise of the received RFT signal. It considers i^{th} IoT device, it requires P_i transmission power and measure the EE of the i^{th} user. The Total transmission power measured between IoT device and cell-free network via RFT. Basically, the EE is the ratio of data rate (DR) and total power consumption while transmitting the signals from source to destination. In another way the DR is calculated using the SE, that is product of SE and number cells per area. Then, the EE of the system is represented as

$$EE_i = \frac{DR}{P_T} = \frac{A \times SE}{P_T}$$

From the article [12], the SE is calculated using TDD protocol, which is represented as

$$SE_i = \frac{L}{l_c} E(\log_2(1 + SINR_i))$$

where, $SINR_i$ is the signal to noise ratio of the i^{th} user device received signal, $\frac{L}{l_c}$ is the transmission protocol of the TDD mode. The signal to noise ratio is

$$SINR_i = \frac{q_{i|h_i\gamma_i^{cpu}|^2}}{\sum_{i\neq k}^{K} q_{i|h_i\gamma_i^{cpu}|^2} + \sigma^2}$$

The throughput (Capacity) (bits/sec/hZ) of the system is measured as

$$\text{capacity} = \log_{10}(1 + SINR_i)$$

The throughput rate of the system is proportional to the SINR. Hence, above techniques used to measure the SE, throughput (TR) and EE.

3. Optimum Resource Allocation Algorithm

In this section we will discuss how to use ML to allocate the optimal power in cell free IoTs networks. A number of telecommunications-related issues can be easily solved with ML which is claim the authors of [13-15]. It can give trustworthy data, expedite operating procedures, and reduce mistake rates.

The data flow in the DNN-DLSA-enabled downlink connection from the BS to numerous users is shown in Fig. 2. A number of users can receive data thanks to the DNN network. Now, in order to ensure equity and provide adequate power to all consumers of poor signals, we must establish the long-term mean power (p_{avg}) value that will be utilized to regulate the power allocation system. This results in an average cumulative power rate that is constant over time.

$$\log_2\left(1+\frac{\beta^{\frac{1}{2}}\gamma_i\alpha_i}{\sum_{i\neq k}^{K}\beta^{\frac{1}{2}}\gamma_i\alpha_i+1}\right)+..+\log_2\left(1+\beta^{\frac{1}{2}}\gamma_1\alpha_1\right)-R_{avg}$$

The average power that is less than the sum of powers [16],

$$P_{i(max)} \geq \frac{noise\ power}{signal\ power}+\frac{1}{K}\sum_{i=1}^{K}\beta^{\frac{1}{2}}\gamma_i\alpha_i$$

$$P_{i(max)} > \frac{1}{K}\sum_{i=1}^{K}\beta^{\frac{1}{2}}\gamma_i\alpha_i$$

where β_l is the large-scale fading coefficient and $p_i(t)_{\max}$ is the ideal power level at the user's disposal. User 1 (UE1), who receives the least amount of power, consequently decodes its signal without interference. The DLSA is employed to carry out this strategy. The next sector provides an explanation of the DLSA's creation for MIMO-NOMA OPA in Downlink (DL) operations, and Figure-3 depicts the DLSA's workflow [17].

The DLS procedure for OPA under the DL approach is as follows:

Inputs of DNN,

$p_{avg,["X_1,X_2,X_3,......X_i"]}$, OPA to user with poor signal strength, bandwidth, the batch size, epochs, and learning-rate DNN output: supply of power $\{p_i, p_{i-1}, ...p_2, p_1\}$

i. Set b to be the batch size in order to provide input and output training.
ii. Create a DNN framework and begin a DLSA.
iii. Make a plan for allocating the best amount of power. Repeat t times more. Changing the value of range from 1 to i.
iv. Compare the output data [$\hat{x}_1, \hat{x}_2, , ...\hat{x}_i$] and the input data $\{X_i, X_{i-1}, X_{i-3}, ...X_1\}$ produced by the loss function action.
v. OPA to a user with a weak signal
vi. Bring it back / effective power allocation
vii. End

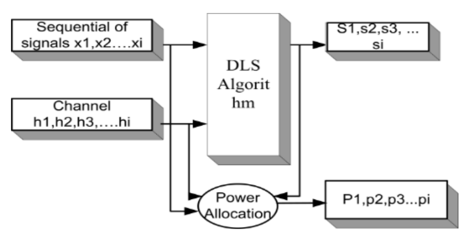

Figure-3: The DLSA for best resource allocation.

The DLSA offers the following benefits [18]:

The best DLSA is Adam's algorithm, which has the advantages outlined below:

i. Implementation in a clear-cut way
ii. Memory requirements are decreased.
iii. Effective computation
iv. Fixed diagonals have resized the gradient.
v. Most frequently, a moving object.
vi. Hyper parameters allow for straightforward iteration with minimal change.

4. Results and Discussion

In this section the simulation results are discussed in which various algorithms are implemented with MATLAB 2022b simulation software. We have assumed 1.5kmsq area and all parameters associate with its and their values included in table.1.

Table1. Parameters and its values.

Parameter	Value	Parameter	Value	Parameter	Value	Parameter	Value
Area	1.5ksq	Antennas	1-4	R_n	500	Path loss exponent α	4.02
power	0-12w	Channel gain	-144.25dB	I_K	200-300	Noise	9dB
Power control coefficient μ	0.6	C_n	2	B band width	20MhZ		

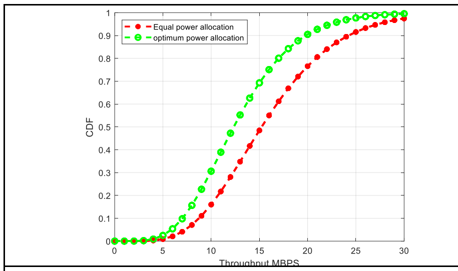

Figure-4: CDF vs. Throughput (Mbps) under different power allocation conditions.

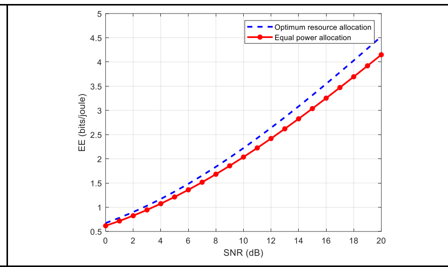

Figure-5: EE vs. SNR (dB), under different power allocation conditions.

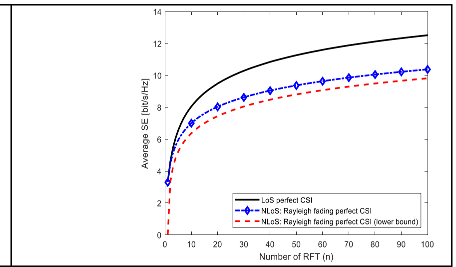

Figure-6: Average SE vs. number of RFT.

In Figure-4, commutative distributive function vs. throughput is observed in two different power allocation cases. In both cases, the cell edge user achieved the optimum throughput. The optimum resource allocation achieved a better result than the conventional resource allocation. Initially, the probability of achieving 10 MBPS is 30 percent in the case of optimum resource allocation and 18 percent in the case of equal power allocation. And finally, achieved 30MBPS in the case where optimum resource allocation is 100 percent and equal power allocation is 90 percent.

In Figure-5 EE vs. SNR shows that increasing the SNR increases the EE proportionally. Here, consider two cases those are optimum resource allocation and equal power allocation at RFT scenario. In the case of optimum resource allocation, the maximum EE is 4.5 (bits/sec), and equal power allocation is 4 bits/sec) at 20 dB SNR. Hence, the proposed result outperforms the conventional scheme.

In figure-6, the average SE ((bits/sec/Hz)) vs. number of RFTs is shown, consider both the LOS and NLOS Rayleigh fading channel. When the number of RFTs increases, the SE is also increasing exponentially. In this case, we consider different LOS and NLOS for the transmission of the data signal. In the case of LOS, the achieving effective SE is high, as observed with both perfect and impact channel state information. In the case of perfect CSI, the achieved SE is higher compare to other methods.

Conclusion

In the cell-free IoT, mobile users and IoTs are connected via RFT; therefore, coverage is wide and resource allocation becomes easier, and DNN with DLSA has provided optimal resource allocation to achieve optimal results. The cell-free IoT is directly connected with the cloud network which improve QoS. The simulation result that are shown in this paper has been performed by the DNN with DLSA to measure the SE, EE, and throughput. The cell-free IoT network outperforms the conventional cell-free network. The future direction of this research work is cell-free IoT with reconfigurable intelligent surfaces (RIS) to reduce power consumption and enhance both SE and EE.

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GNN in Health Applications: A Survey

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Abstract: Recently Graph Neural Networks(GNN) are gaining alot of attention due to their capability to analyze graph structured data. Many learning tasks require handling of graph data, which represents relational information betweenthe entities or objects. Representing social networks, learning molecular structure and classification of diseases need a model for learning from input graphs. Health is a promising area to use GNN, as data coming from the patients showgraphical structure many times. This survey paper gives a comprehensive review of the GNN for health applications.In the beginning, it discusses some graph theory concepts for understanding graphs and the issues in analyzing graphs.Then, introduction of GNN and its core working principles are elaborated. Health is an area where people are experimenting deep learning rigorously. Further, different researchers' work in this area have been discussed with keyfindings and limitations of the work. Paper also covers what GNN can do and gives idea about the potential researchwork which can be explored. At the end some research gaps are discussed to get the directions for future research work.

1. INTRODUCTION

Naturally graphs are already present in many real world applications, including social analysis, traffic prediction, fraud detection, computer vision, and many more[1]. Representation of the data in terms of graphs, encodes the relations among entities and provides more insights present in the data. Currently, researches for analyzing graphs using machine learning are getting attention because graphs' have good expressive power. The special characteristic of graph is that they capture the structural relations between data, and allows to extract more insight.

A graph can be defined as a data structure which contains two components: ***vertex,*** and ***edge***. To analyze relationshipsbetween objects, graphs are used as a mathematical structure. Definitely, graphs are difficult to process because graphsare non Euclidean or irregular data structure, that means they are difficult to represent using any coordinate system generally people are familiar with[2]. Another reason is, their representation is not fixed. A graph itself can be complicated, containing diverse properties and types[3]. Still graphs are getting high popularity in research. There arevarious reasons of popularity of graphs now a days. Complex problems can be solved by the simplification of the problems in to simple representation. Another reason is there are certain data which exhibits inherent graphical representation such as social network, power consumption, recommendation system etc.

2. GRAPH NEURAL NETWORK

GNN is a type of neural networks which is designed to process on graph data. They are network models that extractsthe dependency of nodes in graphs by message passing between set of entities or objects, which are nodes. In GNN, neural networks can directly be applied over graphs[4].Graphs have complex structure and that hampers the ability of getting true insights present in graphs. This complexity is due to non-Euclidean nature of graph structured data. Representational learning is gaining success in many applications, so a possible solution is learning graph representation in low dimensional euclidean space by embedding techniques such that the properties of the graph canbe preserved. GNN is a layered structure, every single layer has a bunch of steps, which are performed on every nodein the graph, these are Message Passing, Aggregation and update. Collectively, these three steps makes fundamental building blocks for the learning over graphs. Various researches in graph deep learning are making changes to these three basis steps. GNNs are known for the ability to learn structural information. Normally, nodes having similar features connected to each other. The GNN exploits facts and learns how some nodes connect to each other while some do not. To do so, the GNN uses neighborhoods of nodes in graph.

In a graph a node represents object or entity. Every node of a graph has properties associated with that object. This setof properties forms feature set of a node which is also known as node embedding[5]. Vectors can be used to represent these features. GNN models combine aggregation of features and transformations by learning a weight matrix at the same layer. These layers are further processed with the nonlinear transformation such as ReLu or regularization as a learning framework on the graph data. Stacking the layer of network also has the effect of introducing power of adjacency matrix, which is used to generate a completely new set of features for a node by aggregating neighbors' features at multiple hops. In GNN main task is to learn node embeddings, which are learned using feature propagationand aggregation of neighbouring node's information. Final embeddings are obtained by using a non-linear transformation with the trainable weight matrix, for a node. A simple layer in GNN is defined as:

$$H^{(i+1)} = \sigma(\tilde{A}_{sym} H^{(i)} W^{(i)}) \quad (1)$$

where

$$\tilde{A}_{sym} = \tilde{D}^{-\frac{1}{2}} \tilde{A} \tilde{D}^{-\frac{1}{2}} \quad (2)$$

$$\tilde{A} = A + I_N \quad (3)$$

$\tilde{A}_{sym}$ is a adjacency matrix after normalization which adds self-loops also. D, which is a degree matrix whose diagonal elements show number of total neighboring nodes to a particular node. H is a feature vector and W is weightmatrix which is trainable. I_N is an identity matrix. $H^{(i)}$ shows features obtained from the just previous layer, $W^{(i)}$ is weight matrix which is learnable and σ is a nonlinear activation function, which is normally ReLU.

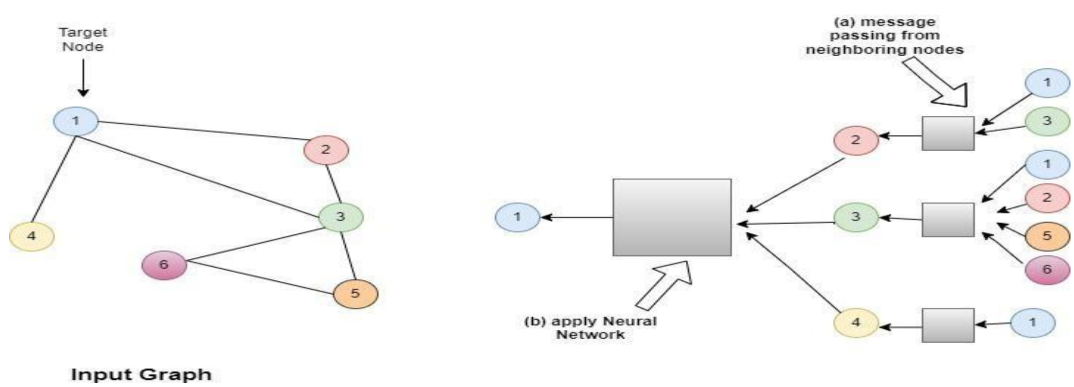

Figure 1: Input Graph and GNN processing

3. RELATED WORK

Medical diagnosis is an area where GNNs are used extensively. Graph structure is already present in information presented by patients. Brain structure is also graphical structure. On the other hand GNN learns embedding by takinginformation from other neighborhood also, so gives better understanding. Following review shows current researchesalong with their findings and limitations:

Xiang Yu et al.[6] discussed about developed model ResGNet, an effective model for COVID-19 identification with high sensitivity and specificity. This work is considered as first attempt for incorporating graph knowledge with the COVID-19 detection task. In ResGNet-C, two sub products were also developed. ResGNet-C showed average accuracy 0.9662, average sensitivity 0.97 and average specificity is 0.96 with five cross validation. Small number of images were used for this study and that directly impacts performance.
C. Mao et al.[7] describes ImageGCN which performed better identification of disease and localization task for chest diseases. It achieved good performance and better results than the parallel methods but Experiments have to betested with more relational attributes for generating relationships among the patients' data.
Jiang H et al. [8] developed graph neural network for learning useful representation for graph classification of Alzheimer disease. This model achieved an average accuracy of 73.1% to 78.5% and AUC of 82.3% to 86.5% on ABIDE/ADNI datasets. More comparison information with other parallel work is also required for the completenessof the research.

Sarah Parisot et al. [9] established the relevance of contextual pairwise information for the task of classification of Alzheimer by using two big databases ABIDE and ADNI. This research showed comparable performance 70.4% forABIDE and 80% for ADNI accuracy value corresponding to increase of 5% and 9% respectively for classifiers usingonly node features. Handling of highly imbalanced data should also be researched in this work. Bamunu Mudiyanselage et. al. [10] proposed a model for classification task, which outperformed in binary (Normal vs Covid) and three class (Normal, Covid, other) classification and eliminates overfitting in these models with fewerdata. It needs to be analyzed with different data sets as different variants of COVID are present now.

Pfeifer, Bastian et.al. [11] proposed explainable GNN for the detection of disease subnetworks in brain. It finds various protein areas by using node embeddings, which helps in finding the subnetwork areas which are disease areas.Research should be tested on high dimensional data sets to get better insight.

Lujing Wang et. al. [12] discussed a totally new deep learning model by combining performing feature selection, learning self attention graph structure and graph diffusion for the neurological diseases identification. Proposed modeloutperformed. Interpretability of this model is required for more insight. Researchers are focusing on extending this work using few shot learning for the further improvement in performance of the model.

In Zhen Chen et. al. [13] research extensive experiments confirmed effectiveness of developed model with different organs in CC-CCII and PROSTATEx datasets for prostate cancer disease classification and this model outperformedstate-of-the-art models. More experiments should be done to see the effects of increasing slice numbers.

Tengfei Song et.al. [14] research model showed better identification than other state of the art methods. This modelachieved 90.4% accuracy on the experiments which were subject dependent and gave 79.95% for subject independentfor SEED, and average accuracy of 85.02%, 84.54% and 86.23% are respectively obtained for different emotion classification tasks using DREAMER database. More work should be done to understand role of adjacency matrix because it was found that the elements which are present at diagonal positions of this matrix shows the contribution of EEG channels in EEG emotion detection.

Li. X. et. al.[15] proposed BrainGNN, an interpretable GNN on fMRI dataset. Model outperformed over other comparable graph learning and ML classification methods. By investigations on selected ROIs, this work finds the salient ROIs to detect autistic disease disorders in healthy controls. More powerful local feature extraction should beexplored to get summarized ROI information.

4. RESEARCH CHALLENGES AND FUTURE DIRECTIONS

This section provides insight for future research work. Here some potential issues and challenges have been discussedto give future research directions. Following are some challenges:

(i) Scalability: Solutions so far generated work good in case of small amount of data because graphs are complex structures to process, so better approaches are needed to handle large amount of data. Sampling is good option but there is loss of information, and sometimes most important nodes may also get elimination.

(ii) Dynamicity: Graphs in nature are dynamic that means nodes or edges may disappear or appear, so node or edgeinputs may be changed time to time. Graph learning methods are needed to adapt this dynamicity of graphs[6]. (iii)Availability of datasets for testing and verification of solutions is limited in some domains.

(iv) Solving the problem of how to efficiently perform sampling of nodes and extraction of the features of the nodesin neighborhood to the maximum extent, while doing neighborhood aggregation will be beneficial to the application of the algorithm.

(v) In graphs node degree is an important piece of information to find out neighborhood of a node, but some of the nodes are having a large number of neighbors, whereas some have very few. Solution is sampling technique. Researchers are working to find out how to handle this with the help of effective sampling strategies

(vi) Most of the approaches are developed by assuming static homogenous graphs i. e. similar type of features for every node, but in real life applications it is not necessary that only homogeneous graphs will be available. Some graphs may have different attributes for different node types. Already developed GNN can not be applied as it is to these graphs, so new learning methods have to be evolved for handling heterogeneity.

(vii) Node sampling is another dimension of research for feature extraction of neighboring nodes for the aggregation and feature updation as graphs are huge and complex.

(viii) Explanable AI is another area, which should be explored with learning methods to gain users' confidence in results. Health is an area, where patient wants to get explained the results before taking any decision. Since, graphs are complex structure, so methods for adding explainability with the developed method should also be explored.

5. CONCLUSION

In recent years, GNN has shown remarkable performance on various tasks. Motivated with great success of GNN models, this paper starts with the brief introduction of graphs. Further introduction of GNN is discussed. Working of GNN models is quite interesting, it includes message passing, aggregation and updation of node features to learn the node embeddings. GNN already has been shown its potential in various areas and health applications are one of them.Section 3 shows various GNN research efforts which are currently going on. Researchers are very aggressively usingGNN for various health areas such as: brain disease identification, Alzheimer and autism disorder detection, Covid- 19 classification and many more. At the end, research gaps are discussed which gives a direction for the future work.Overall this paper gives insight of the GNN along with the currently going research efforts in the field of health applications and finally gives idea for the future research work direction to explore.

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Multimedia Content Distribution in Delay-Tolerant Networks using Average buffer Occupancy

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Abstract

The multi-copy routing mechanisms in Delay Tolerant Network *(DTN)* lead to buffer congestion, which reduces the network's performance. Therefore, to minimize congestion, proactive buffer management is needed. The existing knowledge base regarding buffer management in *DTNs* is reactive and requires more message transmission. In this paper, we develop a novel model for 'Multimedia Content Distribution in Delay-Tolerant Networks using Average buffer Occupancy' to analyse and estimate the expected buffer occupancy without communicating the messages. To estimate the probability of a buffer overflow, we consider the Chernoff's bound. The proposed model *PBMTv2* is simulated and validated using haggle infocomm 2006 real-world mobility data trace.

Index Terms

Multimedia Content Distribution, Chernoff's bound, Probability, Real-World Mobility Data Trace.

I. Introduction

When the network is fragmented, the delay tolerant networking paradigm [1] is a powerful enabler of infrastructure-less communication that aids in message propagation. As a result, it is challenging to achieve end-to-end communication for message delivery in delay tolerant network. To establish a balanced delivery ratio, store-carry-forward techniques and the multicopy method of message delivery have been implemented. It follows that a large number of message duplicates provide better delivery predictability with less delivery delays under such a message delivery method (relative to single-copy routing). Because of the high buffer occupancy caused by unrestricted replication, the performance of the network suffers. It has been shown that *N/2* message replicas are sufficient to transmit information with a high degree of probability in a general homogeneous system model with *N* nodes. Therefore, any further replication is redundant and useless of network and node resources. Therefore, prior to developing routing protocols and proactive buffer management approaches, it can be helpful to have an insight of buffer occupancy.

In recent studies [2], the average buffer occupancy is either determined by a closed-form solution or by routing-specific considerations. Some of them have developed estimators, although doing so calls for node-to-node communication. This increases network overhead and buffer congestion. The chance of a buffer overflow must therefore be estimated in order to assess the possibility that a contact event will lead to retransmissions of messages.

To do this, we first calculate the average buffer occupancy *(ABO)* for the proposed scheme by modeling the occupancy of the buffer as the Binomial distribution, which provides a specific distribution of success probability. The ABO is derived from both homogeneous and heterogeneous node mobility. Without message exchange, we calculate the average buffer occupancy for the proposed scheme. The Chernoff bound for the finite buffer scenario is used to compute the probability of a buffer overflow, which can be used to calculate the likelihood that a packet would be discarded during a connection occurrence. In order to address issues with the wasteful use of buffer space, a Priority-based Buffer Management Technique *(PBMT)* has been proposed in [8]. In this article, *PBMT* is enhanced, and proposed an advanced version of *PBMTv2*.

The remainder of the paper is divided into the sections listed below. Section II discusses the proposed method. Section III provides a simulation-based performance assessment of the proposed framework. Section IV provides the paper's conclusion.

II. System Model

We consider a challenged network with *(N+1)* homogenous nodes, two of which are sources and destinations, and the other *N* nodes acting as relay nodes. Under some stochastic mobility model in which the nodes move, it is assumed that the intercontact time *(ICT)* between any two nodes is exponentially distributed. Multiple mobility models have been used to simulate the network scenario like a random waypoint, real mobility etc. As demonstrated in [5], such mobility models can be used to calculate the pairwise meeting rate. With a particular stochastic mobility model, the nodes move inside a constrained space with inter-contact times *(ICT)* that are either have an exponential tail and a mean or be exponentially distributed. Poisson trials are numerous Bernoulli trials with independent success probabilities.

In the challenged networks, consider *'mgi'* is the message generation time interval. Let N_1(t) represent the number of copies (according to a certain replication strategy) of the source message at time *t*. A node must only have one replica of each of the message groups that the source node generated up until time *t*.

In order to address issues with the wasteful use of buffer space, a buffer management routing scheme based on the priority of messages has been proposed in [8]. In this article, *PBMT* is enhanced, and proposed an advanced version of *PBMTv2*. When a source node transmits the message to the destination node, it first sends it, according to message priority, to the nearby nodes in its immediate vicinity. When exchanging summary vectors, the intermediary nodes queue the messages in their buffer according to message priority. The highest priority message is dispatched upon the opportunistic encounter of relay nodes. The highest priority message is finally delivered to destination node. Based on the message priority priorities that were previously allocated to these messages, the main benefit of this protocol is that messages arrive to their destinations faster and without any losses. By transmitting messages in a systematic and ordered manner, this approach enables resolving the fundamental issue of message randomness. The routing procedures are noticeably different according to the *PBMT*.

$$\gamma = M * mgi * p \tag{1}$$

The expected value of the binomial-random variable can be used to calculate the average buffer occupancy of the *PBMT*.

$$ABO\ \ of\ \ PBMTv2 = M - \frac{N_1 * \gamma}{p * mgi * z * N} \tag{2}$$

A relay node probabilistically transmits the message P (0 $<$ P $\leq$ 1) in probabilistic routing. In this mechanism, the forwarding and flooding are equivalent when $P = 1$. Now, using the Chernoff bound, we determine the probability of buffer overflow. The summation of independent random variables's tail distributions has constraints that are exponentially decreasing according to the Chernoff bound. A node's likelihood of a buffer overflow is calculated as follows:

$$P(Y \geq S) \leq e^{(-\lambda)} \tag{3}$$

$$where,\ \ \lambda = \frac{ABO}{3} * (\frac{S}{ABO} - 1)^2 \tag{4}$$

Using Eq. 1-3, *PBMTv2* is examined for buffer occupancy with the calculation of the buffer overflow probability using Chernoff bound. Now, the priority-based routing is done as discussed in algorithm 1. In Algorithm 1, the PBMTv2 protocol's pseudo-code is provided.

III. Evaluation

In this section, the proposed *PBMTv2* is simulated using ONE Simulator (version 1.5.1) [9] . For performance evaluation, we have modified buffer overflow probability in the benchmark schemes Epidemic [7], and ProPHET [6]. We compare our proposed model PBMTv2 with the above benchmark schemes. The Parameters for Simulation is represented in the Table I.

TABLE (I) Parameters for Simulation

Parameter	**Synthetic Model**	**Real Mobility Model**
Model	Random Way Point	Infocom 2006
Number of Nodes	100	98
Buffer Space	150 Messages	480 Messages
Message Size	64 KB	64 KB
Message Generation Interval	240-360 seconds	240-360 seconds
Time to live	10-12 Hrs	36-48 Hrs

A. Simulation Results using Random Way Point Mobility Model

In Fig. 1a, The quantity of messages can be observed for *Epidemic, PRoPHET, and PBMTv2*; increases as the forwarding probability is raised. This is explained by the fact that the amount of messages kept in each node's buffer increases with buffer size, increasing the likelihood that more messages will reach their destinations. In fact, the *PBMTv2* performs 6.57% better than the *PRoPHET* and 10.9% better than the *Epidemic*.

In Fig. 1b, We conduct a comparison using the Markov inequality method in order to assess how tightly the buffer overflow probability is constrained. The tightness of *PBMTv2, PRoPHET, and Epidemic* for q = 0.1 and q = 0.2 is compared in Figure 4(a). We get *PBMTv2* = 0.8, *Epidemic* = 0.92, and *PRoPHET* = 0.86 when the buffer space is set to 70 messages. When the buffer space is increased to 80 messages, the values for *PBMTv2*, *Epidemic*, and *PRoPHET* are respectively 0.5, 0.72, and 0.64. The graph shows that *PBMTv2*, which represents how tightly the likelihood of a buffer overflow is bound, falls gradually. However, as *Q* rises, *PRoPHET* declines linearly. Thus, *PRoPHET* is not as accurate as *PBMTv2* and is only a very approximate approximation of the buffer overflow likelihood.

Algorithm 1 Multimedia Content Distribution in Delay-Tolerant Networks

1: **Begin** N nodes (S_0, S_1, S_2, S_3,......S_n) in challenged network.
2: Suppose one node wants to transmit the message to other nodes.
3: **for** When two nodes S_i and S_j come into contact **do**
4: Source node S_i generates message M_i with p message priority values of {1, 2, 3, 4, 5}. 5 is the highest.
5: Select the highest priority message M_i from the buffer of node S_i
6: Calculate Average buffer Occupancy

$$\gamma = M * mgi * p$$

$$ABO \ of \ PBMTv2 = M - \frac{N_1 * \gamma}{p * mgi * z * N}$$

7: Calculate buffer overflow probability using Chernoff bound

$$P(Y \geq S) \leq e^{(-\lambda)}$$

$$where, \quad \lambda = \frac{ABO}{3} * (\frac{S}{ABO} - 1)^2$$

8: Check buffer overflow probability when transmitting the message to encountered node S_j.
9: **if** Node S_j's buffer is full **then**
10: Node S_i will transmit the message to S_j.
11: Pop message M_j from the buffer of node S_j with less than M_i in terms of priority.
12: Push message M_i to buffer of node S_j.
13: **if** All messages in node S_j's buffer are of higher priority, and the buffer of node S_j is filled. **then**
14: Do not transfer the messages
15: **else**
16: Push message M_i from the buffer of node S_i to S_j buffer.
17: **if** message M_i has reached at its destination **then**
18: **if** Check any other message in the buffer of node S_i for transmission **then**
19: messages are available for transmission then go to step 4.
20: **else**
21: Go to Last Step 25.
22: **else**
23: Go to Step 4.
24: Message delivered successfully at the destination.
25: Stop the process.

It can be seen that the overflow probability for *Epidemic, PRoPHET, and PBMTv2* decreases as the buffer size of the nodes in the network is raised. This is explained by the fact that the amount of messages kept in each node's buffer increases with buffer size, decreasing the overflow the messages and more messages will reach their destinations. In fact, the *PBMTv2* performs 8.12% better than the *PRoPHET* and 14.6% better than the Epidemic. In order to compare the accuracy, we found that a number of messages were lost when the buffer overflow probability was set to 1. This means that all the benchmark schemes ought to be able to recognize a buffer overflow when the buffer occupancy exceeds *Q* messages. However, the benchmark schemes may be less accurate and unable to recognize congestion at the proper moment if it causes more message drops.

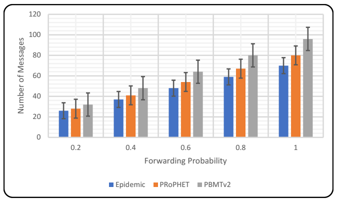
B. Simulation Results using haggle infocomm 2006 real-world mobility data trace

By using real mobility, all the simulations were conducted, and evaluated the buffer occupancy of the proposed model *PBMTv2*. The performance of the *PBMTv2* is compared against the benchmark schemes using real mobility data. The results are represented in the Fig. 1c, 1d. The number of message dropped is examined when nodes's buffer was full. This illustration is represented in Fig. 1d. The graph shows that *PBMTv2*, which represents how tightly the likelihood of a buffer overflow is bound, falls gradually.

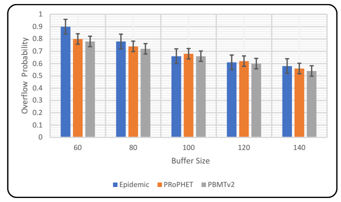
We demonstrate its accuracy under both the synthetic and real mobility mobility model through thorough simulation results. The Chernoff bound is then used to assess the probability of a buffer overflow. We demonstrate that the suggested strategy for buffer occupancy reduces the overall quantity of messages sent. Finally, using the Chernoff bound, we derive the probability of a buffer overflow. We demonstrate that setting the buffer overflow probability to 1 greatly reduces the amount of missed packets. This is due to the fact that, in comparison to the Markov inequality, the Chernoff's bound offers a more precise and tighter constraint.

IV. Conclusion

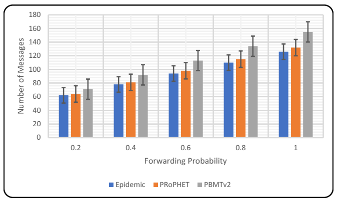
In this work, a novel Multimedia Content Distribution in Delay-Tolerant Networks using social context has been proposed. The Chernoff bound is used to assess the probability of a buffer overflow. We demonstrate that the proposed scheme for buffer occupancy reduces the overall quantity of messages sent. Finally, We demonstrate that setting the buffer overflow



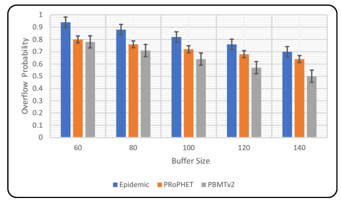
(a) Number of messages vs Forwarding Probability



(b) Overflow Probability vs Buffer Size



(c) Real Mobility data result: Number of messages vs Forwarding Probability



(d) Real Mobility data result: Overflow Probability vs Buffer Size

probability to 1 greatly reduces the amount of missed packets. This is due to the fact that, in comparison to the Markov-inequality, the Chernoff's bound offers a more precise and tighter constraint. In the future, the proposed *PBMTv2* may be used to secure transmission of messages, when we have limited amount of buffer space available on the network nodes.

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