"AN EFFICIENT DATA PACKETS SCHEDULING OF SCHEME FOR INTERNET OF THINGS NETWORKS"

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CERTIFICATE

It is certified that the work contained in this thesis entitled **"AN EFFICIENT DATA PACKETS SCHEDULING OF SCHEME FOR INTERNET OF THINGS NETWORKS"** by **RAJNI KUMARI** for the award of **Master of Technology** from Babu Banarasi Das University has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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Place:

ABSTRACT

Due to the scarce energy supplies of the internet of things (IoT) devices, it is necessary to design the architecture and operation of the network to optimize the power usage. Scheduling algorithm is an essential part of WSNs and IoT networks.Such algorithms allow to classify the queues and decide which process to run. Therefore, scheduling message at cluster head nodes has been suggested for this study. Long hop (LH) first algorithm is new unified scheduling technique that schedules high priority for data comes from far distances and accesses higher number of devices to be routed first to the target. The performance experience shows the proposed method compares with two existing studies, a popular scheduling algorithm is called first-come-first-serve (FCFS) and nearest job next (NJN) algorithms. The results and simulation have been shown that the proposed study has less Packet loss and maximize throughput. In addition, it minimizes the packets delay and loss, transmission distance.

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LIST OF ABBREVATIONS

BS : Base Station

CH : Cluster Head

LH : Long Hop

IOT : Internet of Things

STP : Short Time Process

EDF : Earliest Deadline First

NJN : Nearest Job Next

QOS : Quality of Service

FCFS : First Come First Serve

TSCH : Time Synshronised Channel Hopping

FIFO : First In First Out

CHAPTER-1

INTRODUCTION

IOT is a global infrastructure for the information society (Creation of information, manipulation of information and access of such information) enabling advance services by interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies. It is a multidisciplinary paradigm in which many of the smart and self-configuration devices that are networked and communicated to each other through a global network infrastructure. The main aim of this technology is to connect the smart devices by means effective communication in resource constrained networks [2, 3]. Each of these devices and systems will be working on their existing protocol stacks, architectures and data formats.

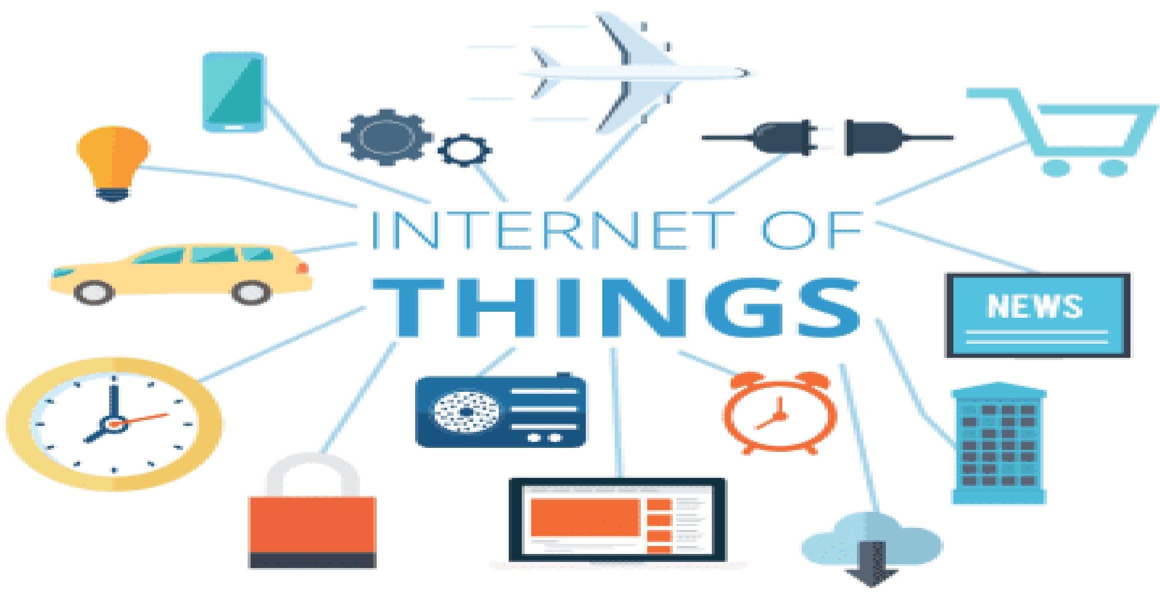


Fig. 1: Internet of Things Element

This will provide a new paradigm of communication between digital contents, computing, applications and services within the physical world. This creates unprecedented opportunities for governments, education, and industries in a wide variety of sectors [4]. The communication of IoT networks combine three categories based on their technology elements that can be seen in Fig. 2.

- **People to People (P2P) connection:** is the data transfer from one person to the other. It occurs through video call, telephone call, and social communications. It is usually called collaboration connection.
- **Machine to People (M2P) connection:** is the data transfer from machines such as computing devices, sensor nodes or others to the users for analysis purposes. For example: weather forecasting uses smart devices to gather the data from the environment and send it back to the administrators in the control center for further analysis.

- **Machine to Machine (M2M) connection:** is the data transfer between devices without human interactions. For instance, a car talking to another car about its speed, lane change or breaking intentions, etc.

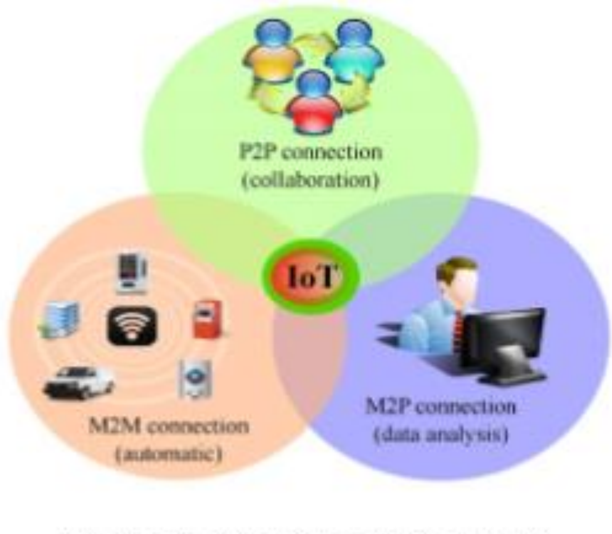


Fig. 2: Network connection in IOT

Simple equation of IOT:

IOT = HUMAN + PHYSICAL OBJECTS +INTERNET

Where,

Physical Objects=Sensors, Controllers, Devices, Storages

Most of IOT- devices are low capacity, processor, memory, and thus low power end node objects that are powered by battery or means of energy harvesting. This means it will not be rational to waste the energy by transmission of unneeded data and protocol overheads like existing protocols do such as HTTP and TCP, etc., therefore direct implementation of these devices is not efficient. In most of IOT applications, the traffic patterns are classified into [3, 4]:

• **One-to-One**: is the data transfer between two points or end-to-end users. It occurs through telephone call, video call, or social communications.

• **One-to-Many (or broadcast):** It occurs when many nodes can receive the data disseminated by one node. For example, the base station (BS) sends the update information (such as update routing table, software, etc.) to all the nodes connect to it.

• **Many-to-One:** is the data transfer from all sensor nodes belong to it network to one central point. For example, weather environment for a city uses many sensors to sense the area and then send it to the central application

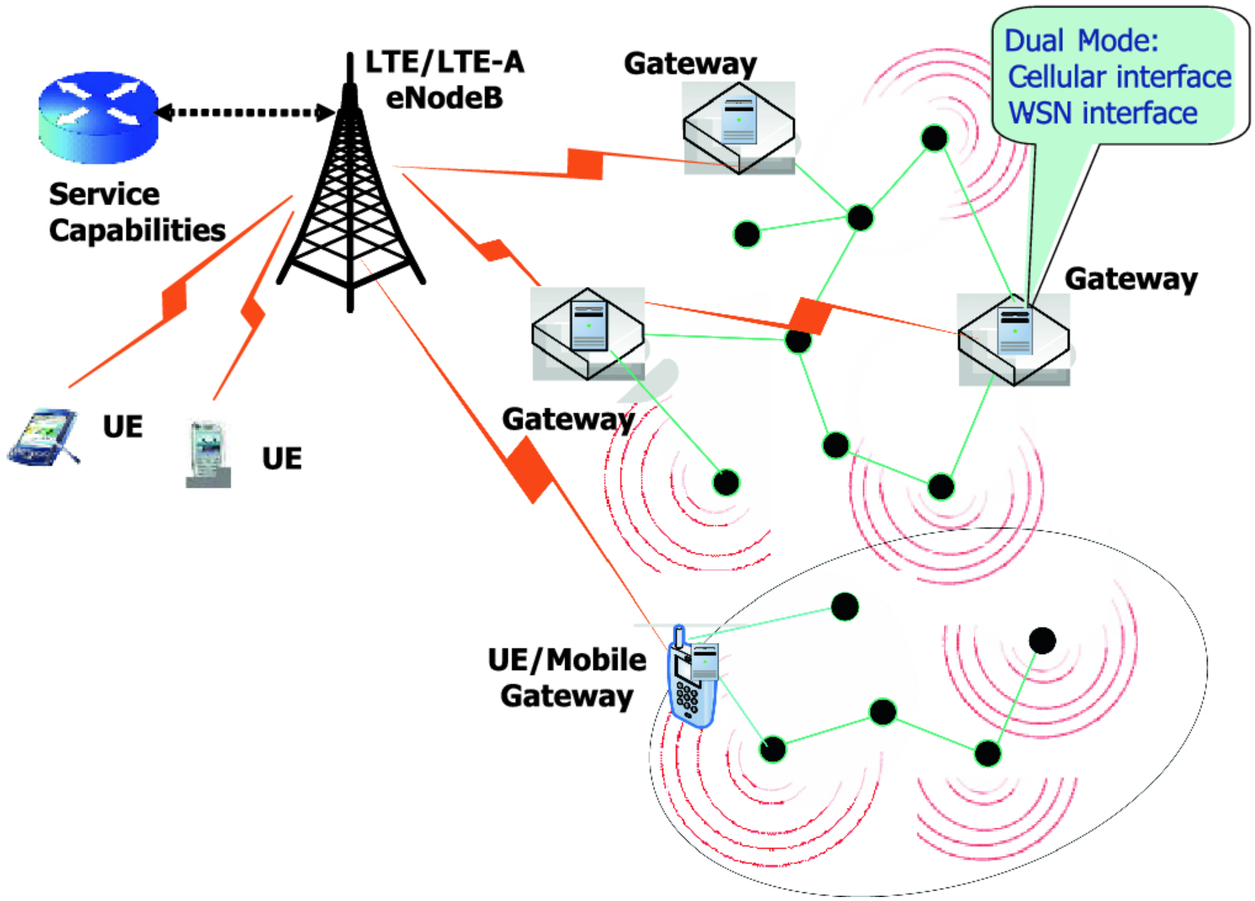


Fig.3: Network Architecture of IOT

Sensor networks consists of anywhere from a few hundred up to thousands of connected sensors [1]. Thus, the rapid technological development of WSNs becomes the key technology for internet of things (IOT).Area are divided into subgroup and all subgroups are controlled by a particular Gateway. All the devices sent data to that particular Gateway through which they connected and similarly all gateway collect data form all the devices and sent data to base station (BS). In many-to-one connection, sensor nodes send their information to the ultimate receiver by using intermediate nodes due to the radio transmission for these smart objects are a few meters. The intermediate nodes play as relays for packets. Therefore, packets access multiple links and devices to reach the destination [5]. During multi hop of packets amongst the nodes especially on a large network, the probability of the packet drops increase. This is because of various factors such as packet arrival rate, timeout for message expiry or simply due to the limitations of node because of its constrained nature (low processing, memory and bandwidth resources). Therefore, to avoid packet loss in the network, receipt acknowledgment of transmitted packets or otherwise retransmission of the lost data packets must happen. Internet control message protocol (ICMP) Generated by the network devices is an error-reporting protocol sent to the original source whose

IP address is encapsulated in the IP packet. The minimum size of ICMP packet would be 8 bytes of ICMP header + 20 bytes of IPv4 or 8 bytes of ICMP header + 40 bytes of IPv6 for ICMPv4 and ICMPv6 respectively [7]. Each retransmission will require transmission of these headers and overheads as well. This can significantly impact system performance if the retransmission is not optimized properly. This can more load on the already constrained network and contribute further to the power depletion of the nodes. Retransmission increases latency due to additional time needed for packets drop. It also increases the number of hops that could increase the packets loss and delay. Packets loss increase when number of devices proliferate due to network resource limitation. This affects the quality of service (QOS) and throughput of the network [7,8] .Network of the future will deploy numerous devices covering large area. Therefore, the solutions should take into consideration higher number of nodes and larger areas. To this end, the aim and scope of this study is to reduce packets loss and energy usage for IoT applications. Long hop (LH) first scheduling algorithm has been proposed for this study. LH strategy is dynamic scheduling algorithm used for real-time tasks to place processes in a priority queue. The queue will search for packets come with higher number of nodes and far distances to be routed first to the ultimate receiver. The working process of IOT is explained in Fig.4. The data transmitted from Source to destination in IOT is done through Sensor node where sensor node (like Temperature Sensor, Motion Sensor, Pressure Sensor & Proximity Sensor) sense and send data to gateway, Gateway through cloud server send data to base station(BS) based on the requirement of end user different application(Military, Education, Healthcare & Agriculture) work.

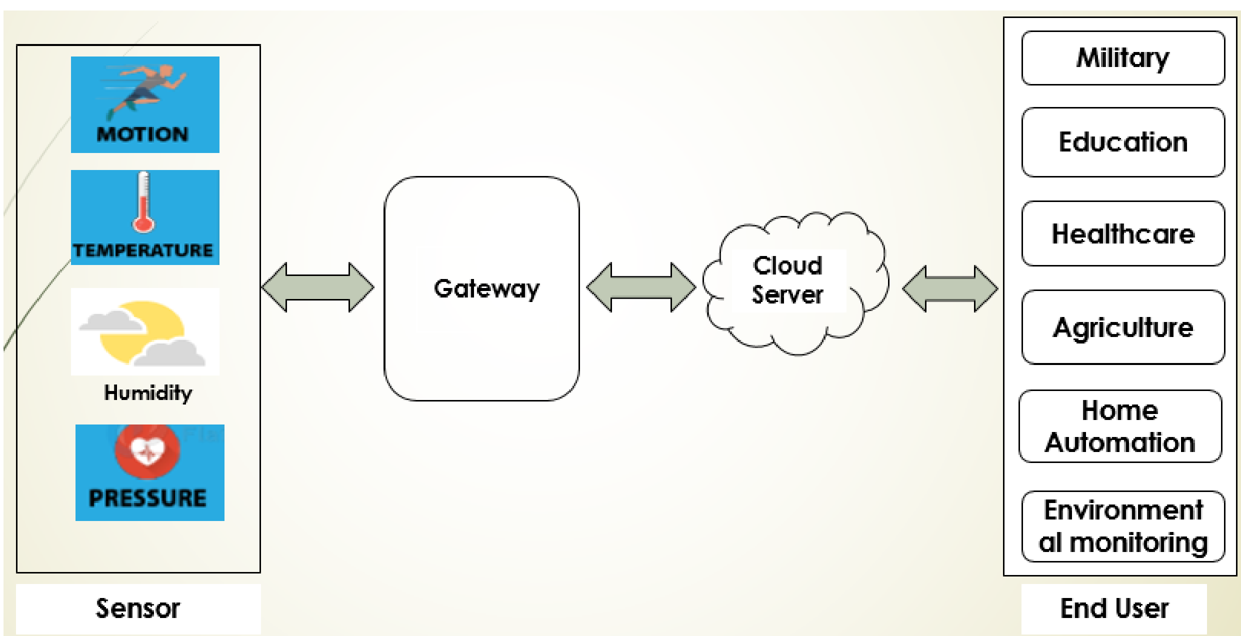


Fig.4: IOT Architecture

1.1 Main Component On which Iot work:

With so many advantages of IoT, it is interesting to see the main ecosystem components that IoT works on. Here are the main components on which IoT works on.

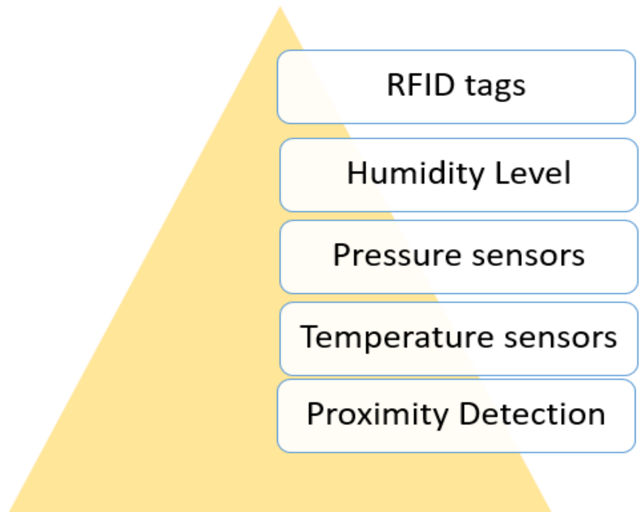


Fig .5:Components of Iot

In broad strokes, there are four main components of an IoT system:

1. The Internet.
2. The Thing itself (that is, the device)
3. Back-end services (enterprise data systems, or PCs and mobile devices)
4. The local network (this can include a gateway, which translates proprietary communication protocols to Internet Protocol)

1.2 Application areas in which IOT use:

These are the following application areas where iot work:

- **Military-** Internet of Things has strong military applications, connecting ships, planes, tanks, drones, soldiers, and operating bases in a cohesive network that increases situational awareness, risk assessment, and response time. For monitoring soldiers' physical and mental state. Biometrics aren't just limited to identifying combatants. Sensors embedded in military uniforms and helmets can send information to a command center about a soldier's physical condition, helping him or her survive otherwise lethal enemy attacks.
- **Healthcare-** Real-time monitoring via connected devices can save lives in event of a medical emergency like heart failure, diabetes, asthma attacks, etc. With real-time

monitoring of the condition in place by means of a smart medical device connected to a smartphone app, connected devices can collect medical and other required health data and use the data connection of the smartphone to transfer collected information to a physician.

- **Smart City-** Large cities have thousands of public buildings, each with its own energy patterns, air quality issues and sensor devices. It can be challenging for managers to identify those which are operating efficiently, and those that are not. An IoT platform is required that is flexible and easy to use, generating alerts when something is not right. It needs to provide user-friendly apps such that building managers can take actions in real-time to optimize resource consumption and keep building occupants safe and comfortable. It must be able to connect to any internet connected device, collect data and manage the device. Internet of thing about the smart city concept is that it's very specific to a city. The problems faced in Mumbai are very different than those in Delhi. The problems in Hong Kong are different from New York. Even global issues, like finite clean drinking water, deteriorating air quality and increasing urban density, occur in different intensities across cities. Hence, they affect each city differently. The Government and engineers can use IoT to analyze the often-complex factors of town planning specific to each city. The use of IoT applications can aid in areas like water management, waste control, and emergencies.

- **Smart Home-** A smart home is one in which the various electric and electronic appliances are wired up to a central computer control system so they can either be switched on and off at certain times (for example, heating can be set to come on automatically at 6:00AM on winter mornings) or if certain events happen (lights can be set to come on only when a photoelectric sensor detects that it's dark). Most homes already have a certain amount of "smartness" because many appliances already contain built-in sensors or electronic controllers. Virtually all modern washing machines have programmers that make them follow a distinct series of washes, rinses, and spins depending on how you set their various dials and knobs when you first switch on. If you have a natural-gas-powered central heating system, most likely you also have a thermostat on the wall that switches it on and off according to the room temperature, or an electronic programmer that activates it at certain times of day whether or not you're in the house.

- **Smart Farming-** IoT enabled agriculture has helped implement modern technological solutions to time tested knowledge. This has helped bridge the gap between production and quality and quantity yield. Data Ingested by obtaining and importing information from the multiple sensors for real time use or storage in a database ensures swift action and less damage to the crops. With seamless end to end intelligent operations and improved business process execution, produce gets processed faster and reaches supermarkets in fastest time possible. IoT based Smart Farming improves the entire Agriculture system by monitoring the field in real-time. With the help of sensors and interconnectivity, the Internet of Things in Agriculture has not only saved the time of the farmers but has also reduced the extravagant use of resources such as Water and Electricity.

- **Industrial Automation-** Internet of things (IoT) in automation industry is proving to be a game changer for automation companies. Industrial automation companies that use IoT solutions can reap new benefits. The Internet of Things (IoT) helps to create new technologies to solve problems, enhance operations, and increase productivity. The IoT can be explained as the connection of inimitably identifiable electronic devices using Internet 'data plumbing' including Internet Protocol (IP), cloud computing and web services. Internet of Things (IoT) Impact on Industrial Automation is very high and it makes us to use tablet computers, smart phones, virtualized systems, and cloud storage of data. Almost all the processes can be automized with the help of IOT. Smart sensor networks that are connected to a cloud system can offer great amount of control on your process. This will decrease the need to hire employees for such tasks. In order to reduce the risk of low-quality production, the IoT sensors are connected to the machines. It gives signals before the actual breakdown of machines. The maintenance warning will be given to help you to plan the tasks. This has made the predictive maintenance possible in industries of all kinds.

- **Home Automation-** IoT based Home Automation will enable the user to use a Home Automation System based on Internet of Things (IoT). The modern homes are automated through the internet and the home appliances are controlled. The user commands over the internet will be obtained by the Wi-Fi modems. Home automation is a modern technology that modifies your home to perform different sets of task automatically. Today Automatic frameworks are being favored over manual frameworks. No wonders, home automation in India is already the buzz word, especially as the wave of second generation home owners grows, they want more than shelter, water, and electricity. The first and most obvious advantage of Smart Homes is comfort and convenience, as more gadgets can deal with more operations (lighting, temperature, and so on) which in turn frees up the resident to perform other tasks. Smart homes filled with connected products are loaded with possibilities to make our lives easier, more convenient, and more comfortable. There is no shortage of possibilities for smart home IoT devices as home automation seems to be the wave of the future. The requirement for Office and Home automation arises due to the advent of IoT, in a big way in homes and office space. The smart home/office gadgets interact, seamlessly and securely; control, monitor and improve accessibility, from anywhere across the globe. These smart automation devices happen to have an interface with IoT.

- **Education-** IoT can help us make education more accessible in terms of geography, status, and ability. There are boundless opportunities to integrate IoT solutions into school environments. IoT applications in education will be the foundation on which these classrooms operate. Students will be automatically counted as present or tardy when the bell rings. Wearable devices will determine when the class is too tired or disengaged and may need a break, and whiteboards will record all notes taken in a class. Smart-microphones may even recognize when a teacher mentions there is a homework assignment due and update students' planners accordingly. IoT may prove helpful for students who identify as disabled. Hearing impaired students may utilize a system of connected gloves and a tablet to translate from sign language to verbal speech, converting sound into written language. Using IoT devices and systems is a constructive way to provide educational assistance to disabled learners.

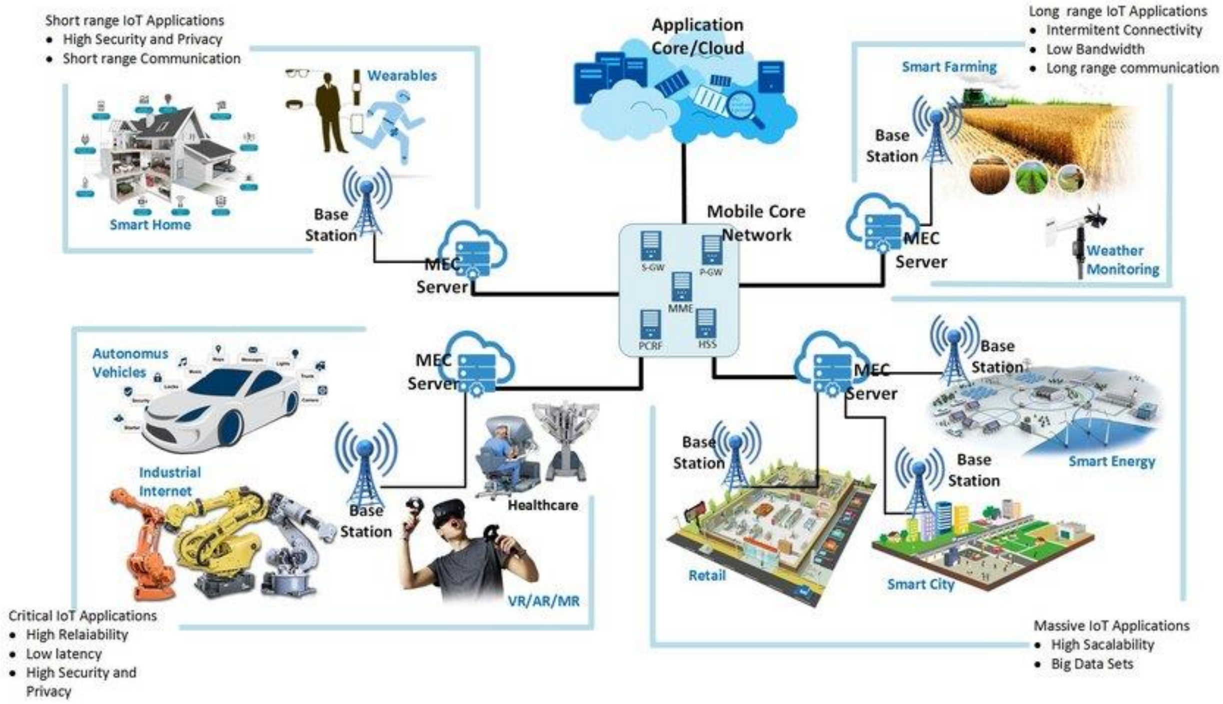


Fig.6: Application Areas of IoT

- **Environmental Monitoring-** We will learn 3 important applications of IoT Environmental Monitoring, which are beneficial for the environment.

   A. <u>Waste Management</u>: The problem of waste management is very crucial issue in big cities, due to two reasons; first the cost of service and second the problem of storage of accumulating garbage. In order to save and make use of inexpensive environmental advantages, a deeper penetration of information and communications technologies solutions in this field will be required. For example, intelligent waste containers help identify the level of load the trucks carry and allow for an optimization of the collector trucks route, which in turn can reduce the cost of waste collection and improve the quality of recycling. To incorporate and make effective use of such smart waste management services, the IoT will connect these intelligent waste containers, to a control center where an optimization software will process the data and determine the optimal management and route the collector truck should follow.

   B. <u>Vehicle Tracking</u>: The vehicle tracking facility makes use of road sensors and intelligent display systems that help drivers to find the best path for parking in the city. The benefits from this service are many such as faster the car takes to locate a parking slot means lesser CO emission from the car, lesser traffic problems, and ultimately happier citizens. The IoT infrastructure can directly integrate the vehicle parking facility.

C. **Extreme Weather:** Powerful, advanced systems currently used for weather forecasting allow deep monitoring, but they suffer from using broad instruments, such as radar and satellites. These instruments that are used for small details lack the accurate targeting potential for smart technology. Effective weather forecasting procedures require high detail as well as flexibility in instrument type, range, and deployment. This results in early responses to prevent loss of life and property through early detection.

1.3 Quality of Service (QOS)

Quality of service (**QOS**) refers to any technology that manages data traffic to reduce packet loss, latency and delay on the network. In other word we can say that Quality of Service (QoS) manages network capabilities and resources to provide a reliable backbone to IoT connectivity. In order to offer secure and predictable services, QoS will manage delays, delay variation, bandwidth and packet loss by classifying traffic and registering channel limits. There are many different ways to measure the performance of a network, as each network is different in nature and design. Performance can also be modeled and simulated instead of measured

Different parameters through which we can measure quality of service (QOS) are:

- **Energy Consumption-** is the amount of energy or power used during transmission of data. There are two major processes that consume energy in an IoT network: wireless transmission and task computation. The energy consumption of the former is and the latter is thus the total energy consumption is the sum of both (wireless transmission and task computation).

- **Loss-** Occurs when one or more packets of data travelling across a computer network fail reach their destination. Packet loss is either caused by errors in data transmission, typically across wireless networks or network congestion. Packet loss is measured as a Percentage of packets lost with respect to packets sent. The Transmission Control Protocol (TCP) detects packet loss and performs retransmissions to ensure reliable messaging. Packet loss in a TCP connection is also used to avoid congestion and thus produces an intentionally reduced throughput for the connection.

- **Latency-**A time delay between the cause and the effect of some physical change in the system being observed. Latency is the amount of time a message takes to traverse a system. In a network, it is an expression of how much time it takes for a packet of data to get from one designated point to another. It is sometimes measured as the time required for a packet to be returned to its sender
- **Throughput-**Network throughput is the rate of successful message delivery over a communication channel. Throughput is controlled by available bandwidth, as well as the available signal-to-noise ratio and hardware limitations. Throughput for the purpose of this

article will be understood to be measured from the arrival of the first bit of data at the receiver, to decouple the concept of throughput from the concept of latency. The data these messages belong to may be delivered over a physical or logical link, or it can pass through a certain network node. Throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second (p/s or pps) or data packets per time slot.

- **Jitter-** Jitter is the deviation from true periodicity of a presumably periodic signal often in relation to a reference clock signal. Jitter is the variation in the time between data packets arriving, caused by network congestion, or route changes. The longer data packets take to transmit, the more jitter affects audio quality. The standard jitter measurement is in milliseconds (ms). If receiving jitter is higher than 15-20ms, it can increase latency and result in packet loss, causing audio quality degradation.

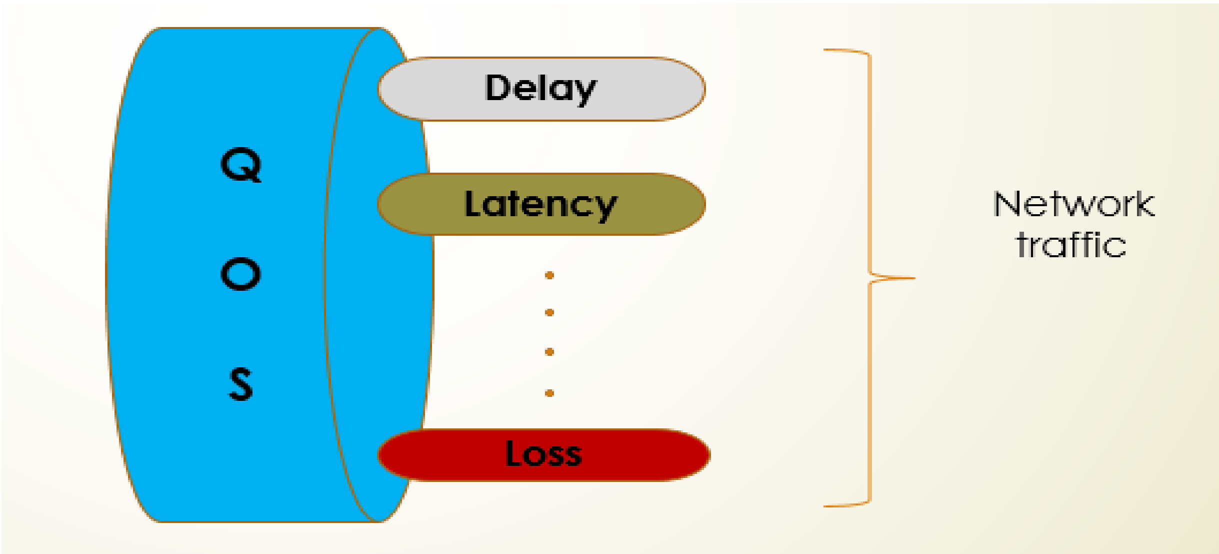


Fig.7:Quality of Service(QoS)

1.4 Basic QoS Architecture

This section describes the main categories of the Cisco QoS toolset and includes the following topics:

- Classification and Marking tools
- Policing and Markdown tools
- Scheduling tools
- Link-specific tools
- Auto QoS tools
- Call Admission Control tools

Cisco provides a complete toolset of QoS features and solutions for addressing the diverse needs of voice, video and multiple classes of data applications. Cisco QoS technology lets complex networks control and predictably service a variety of networked applications and traffic types. You can effectively control bandwidth, delay, jitter, and packet loss with these mechanisms. By ensuring the desired results, the QoS features lead to efficient, predictable services for business-critical applications. Using the rich Cisco QoS toolset, as shown in Fig.8,

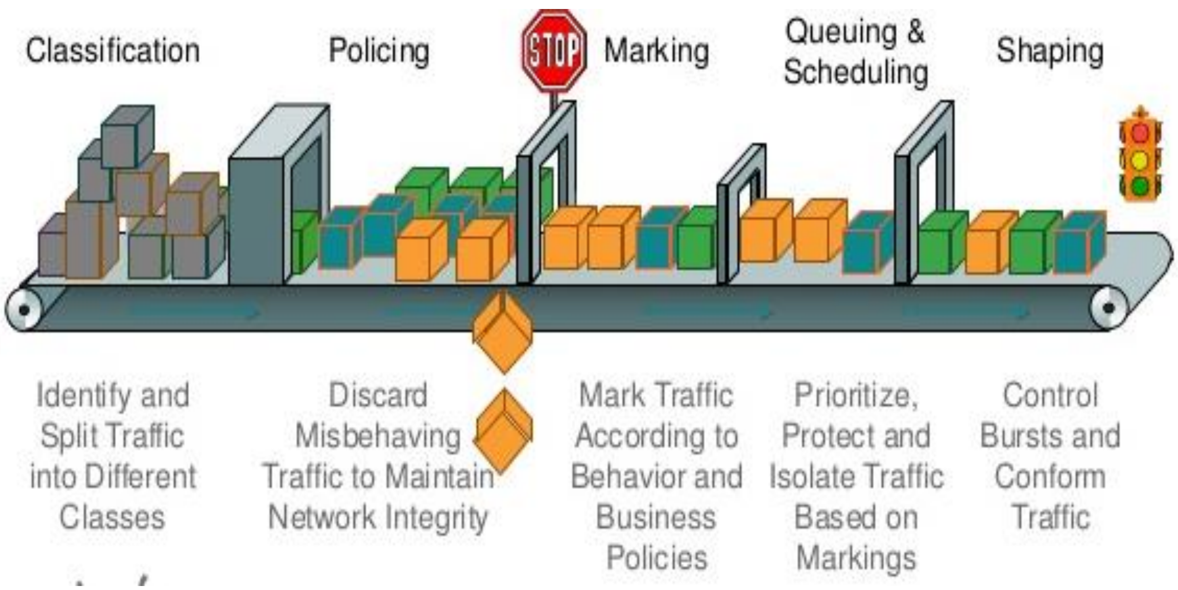


Fig.8:Basic QoS Architecture

Classification and Marking Tools- The first element to a QoS policy is to classify/identify the traffic that is to be treated differently. Following classification, marking tools can set an attribute of a frame or packet to a specific value. Such marking (or remarking) establishes a trust boundary that scheduling tools later depend on.

- **Policing and Markdown Tools-** Policing tools (policers) determine whether packets are conforming to administratively-defined traffic rates and take action accordingly. Such action could include marking, remarking or dropping a packet. A basic policer monitors a single rate: traffic equal to or below the defined rate is considered to conform to the rate, while traffic above the defined rate is considered to exceed the rate. On the other hand, the algorithm of a dual-rate policer (such as described in RFC 2698) is analogous to a traffic light.[19] Traffic equal to or below the principal defined rate (green light) is considered to conform to the rate. An allowance for moderate amounts of traffic above this principal rate is permitted (yellow light) and such traffic is considered to exceed the rate. However, a clearly-defined upper-limit of tolerance is set (red light), beyond which traffic is considered to violate the rate.

- **Scheduling Tools-** Scheduling tools determine how a frame/packet exits a device. Whenever packets enter a device faster than they can exit it, such as with speed mismatches, then a point of congestion, or bottleneck, can occur. Devices have buffers that allow for scheduling higher-priority packets to exit sooner than lower priority ones, which is commonly called queueing.

  Queueing algorithms are activated only when a device is experiencing congestion and are deactivated when the congestion clears. The main Cisco IOS software queuing tools are Low Latency Queueing (LLQ), which provides strict priority servicing and is intended for realtime applications such as VoIP; and Class-Based Weighted Fair Queuing (CBWFQ), which provides bandwidth guarantees to given classes of traffic and fairness to discrete traffic flows within these traffic classes.

- **Link-Specific Tools-** Link-specific tools include the following:
  - Shaping tools—A shaper typically delays excess traffic above an administratively-defined rate using a buffer to hold packets and shape the flow when the data rate of the source is higher than expected.

  - Link Fragmentation and Interleaving tools— With slow-speed WAN circuits, large data packets take an excessively long time to be placed onto the wire. This delay, called serialization delay, can easily cause a VoIP packet to exceed its delay and/or jitter threshold. There are two main tools to mitigate serialization delay on slow (768 kbps) links: Multilink PPP Link Fragmentation and Interleaving (MLP LFI) and Frame Relay Fragmentation (FRF.12).

  - Compression tools—Compression techniques, such as compressed Real-Time Protocol (cRTP), minimize bandwidth requirements and are highly useful on slow links. At 40 bytes total, the header portion of a VoIP packet is relatively large and can account for nearly two-thirds or the entire VoIP packet (as in the case of G.729 VoIP). To avoid the unnecessary consumption of available bandwidth, you can use cRTP on a link-by-link basis. cRTP compresses IP/UDP/RTP headers from 40 bytes to between two and five bytes (which results in a bandwidth savings of approximately 66% for G.729 VoIP).

- Transmit ring (Tx-Ring) tuning—The Tx-Ring is a final interface First-In-First-Out (FIFO) queue that holds frames to be immediately transmitted by the physical interface. The Tx-Ring ensures that a frame is always available when the interface is ready to transmit traffic, so that link utilization is driven to 100 % of capacity. The size of the Tx-Ring is dependant on the hardware, software, Layer 2 media, and queueing algorithm configured on the interface. The Tx-Ring may have to be tuned on certain platforms/interfaces to prevent unnecessary delay/jitter introduced by this final FIFO queue.

- **Auto QoS Tools-** The richness of the Cisco QoS toolset inevitably increases its deployment complexity. To address customer demand for simplification of QoS deployment, Cisco has developed the Automatic QoS (Auto QoS) features. Auto QoS is an intelligent macro that allows an administrator to enter one or two simple Auto QoS commands to enable all the appropriate features for the recommended QoS settings for an application on a specific interface. Auto QoS VoIP, the first release of Auto QoS, provides best-practice QoS designs for VoIP on Cisco Catalyst switches and Cisco IOS routers. By entering one global and/or one interface command, depending on the platform, the Auto QoS VoIP macro expands these commands into the recommended VoIP QoS configurations (complete with all the calculated parameters and settings) for the platform and interface on which the Auto QoS is being applied.

- **Call Admission Control Tools-** After performing the calculations to provision the network with the required bandwidth to support voice, video and data applications, you must ensure that voice or video do not oversubscribe the portion of the bandwidth allocated to them.[19] While most Diff Serv QoS features are used to protect voice from data, Call Admission Control (CAC) tools are used to protect voice from voice and video from video.

CHAPTER-2

LITERATURY SURVEY

Network of the future will deploy numerous devices covering large area. Therefore, the solutions should take into consideration higher number of nodes and larger areas. To this end, the aim and scope of this study is to reduce packets loss and energy usage for IoT applications. Multi-hop topology is practically useful for WSN and IoT networks because both techniques are deployed over a wide geographical region [6]. It also provides an opportunity for better quality of services (QoS) and higher network capacity. Packets loss increase when number of devices proliferate due to network resource limitation. To reduce packets loss and energy usage for IoT applications. Long hop (LH) first scheduling algorithm has been proposed for this study. LH strategy is dynamic scheduling algorithm used for real-time tasks to place processes in a priority queue. The queue will search for packets come with higher number of nodes and far distances to be routed first to the ultimate receiver. Wireless sensor networks (WSN) consist of limited power and cost multifunctional sensor nodes that communicate wirelessly over short distance. During transmission of collection of data from one place to another place efficient mobility management is required by keeping the data latency and energy consumption to be minimum a dynamic network clustering technique called DCMC is proposed. DCMC reduced mobility management cost, end-to-end delay and energy consumption which increase the network lifetime and the packet delivery ratio [1].Now a days Internet of Things (IoT) is becoming more and more pervasive in everyday life and connecting an array of diverse physical objects. Billions of objects communicate each other with or without human intervention to achieve smart applications. Therefore, for implementing autonomous smart systems, efficient energy consumption is imperative. For this we introduces a novel scheduling algorithm called Long Hop (LH) first to optimize energy usage on a Wireless Sensor Network (WSN) that enables IoT system.

2.1 Queueing theory

A queueing system can be described as customers arriving for service, waiting for service if it is not immediate, and if having waited for service, leaving the system after being served. A queue is a waiting line (like customers waiting at a supermarket checkout counter); queueing theory is the mathematical theory of waiting lines. More generally, queueing theory is concerned with the mathematical modeling and analysis of systems that provide service to random demands.

A queueing model of a system is an abstract representation whose purpose is to isolate those factors that relate to the system's ability to meet service demands whose occurrences and durations are random. Typically, simple queueing models are specified in terms of the arrival process the service mechanism and the queue discipline. The arrival process specifies the probabilistic structure of the way the demands for service occur in time; the service mechanism specifies the number of servers and the probabilistic structure of the duration of time required to serve a customer, and the queue discipline specifies the order in which waiting customers are selected from the queue for service. Selecting or constructing a queueing model that is rich enough to reflect the complexity of the real system, yet simple enough to permit mathematical analysis) is an art. The ultimate objective of the analysis of queueing systems is to understand the behavior of their underlying processes so that informed and intelligent decisions can be made in their management.

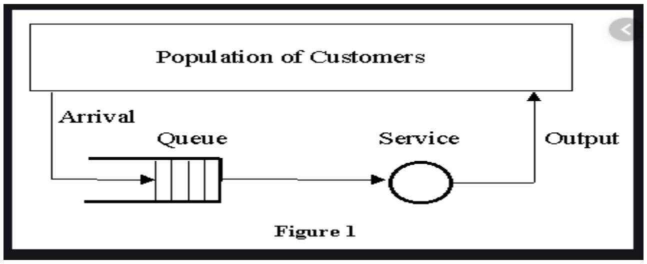


Fig.9: Queuing theory

To begin understanding queues, we must first have some knowledge of probability theory. In particular, we will review the exponential and Poisson probability distributions;

- **Poisson Distributions** -The Poisson point process is often defined on the real line, where it can be considered as a stochastic process. In this setting, it is used, for example, in queueing theory to model random events, such as the arrival of customers at a store, phone calls at an exchange or occurrence of earthquakes, distributed in time. In the plane, the point process, also known as a spatial Poisson process can represent the locations of scattered objects such as transmitters in a wireless network particles colliding into a detector, or trees in a forest.
  A Poisson point process is characterized via the Poisson distribution. The Poisson distribution is the probability distribution of a random variable Probability of events for a Poisson distribution.
  An event can occur 0, 1, 2,…..times in an interval. The average number of events in an interval is designated λ (lambda). Λ is the event rate, also called the rate parameter. The probability of observing *k* events in an interval is given by the equation

$$P(k \text{ events in interval}) = \frac{\lambda^k e^{-\lambda}}{k!}$$

where

- λ is the average number of events per interval
- *e* is the number 2.71828... (Euler's number) the base of the natural logarithms
- *k* takes values 0, 1, 2, ...
- $k! = k \times (k-1) \times (k-2) \times ... \times 2 \times 1$ is the factorial of *k*.

- **Exponential Distribution** –The exponential distribution is the probability distribution of the time between events in a Poisson point process, i.e., a process in which events occur continuously and independently at a constant average rate. The exponential distribution is not the same as the class of exponential families of distributions, which is a large class of probability distributions that includes the exponential distribution as one of its members, but also includes the normal distribution, binomial distribution, gamma distribution, Poisson, and many others.

  Probability density function:

  The probability density function (pdf) of an exponential distribution is

$$f(x;\lambda) = \begin{cases} \lambda e^{-\lambda x} & x \geq 0, \\ 0 & x < 0. \end{cases}$$

  Here $\lambda > 0$ is the parameter of the distribution, often called the *rate parameter*. The distribution is supported on the interval $[0, \infty)$. If a random variable X has this distribution, we write $X \sim \text{Exp}(\lambda)$.The exponential distribution exhibits infinite divisibility.

- **Birth-Death Processes**: We define the number of people located in a queuing system, either waiting in line or in service, to be the state of the system at time. The behaviour /state of a single queue (also called a "queueing node") can be described by a birth-death process, which describe the arrivals and departures from the queue, along with the number of jobs (also called "customers" or "requests", or any number of other things, depending on the field) currently in the system. An arrival increases the number of jobs by 1, and a departure (a job completing its service) decreases *k* by 1.

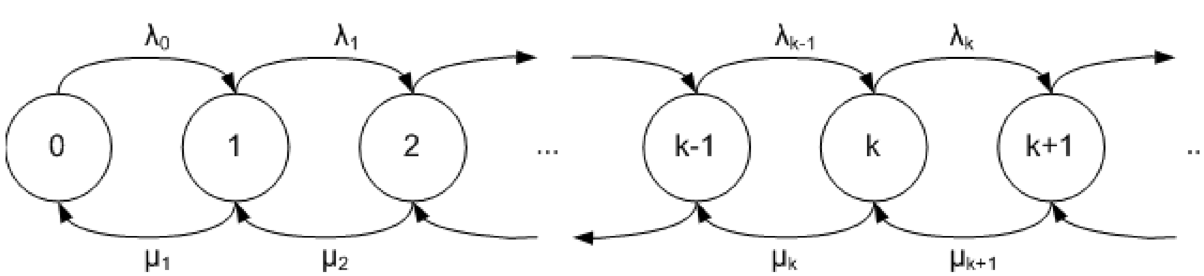


Fig.10: Birth-Death Processes

2.2 Components of a Queueing System

While analyzing a queueing system we can identify some Basic elements of it. Namely,

Input process: if the occurrence of arrivals and the offer of service are strictly according to schedule, a queue can be avoided. But in practice this does not happen. In most cases the arrivals are the product of external factors. Therefore, the best one can do is to describe the input process in terms of random variables which can represent either the Number arriving during a time interval or the time interval between successive arrivals. If customers arrive in groups, their size can be a random variable as well.

Service mechanism: the uncertainties involved in the service mechanism are the number of servers, the number of customers getting served at any time, and the duration and mode of service. Networks of queues consist of more than one servers arranged in series and/or parallel. Random variables are used to represent service times, and the number of servers, when appropriate. If service is provided for customers in groups, their size can also be a random variable.

System capacity: at most how many customers can wait at a time in a queueing system is a significant factor for consideration. If the waiting room is large, one can assume that for all practical purposes, it is infinite. But our everyday experience with the telephone systems tells us that the size of the buffer that accommodates our call while waiting to get a free line is important as well.

Service discipline: all other factors regarding the rules of conduct of the queue can be pooled under this heading. One of these is the rule followed by the server in accepting customers for service. In this context, the rules such as First-Come, First-Served (FCFS), Last-Come, First-Served (LCFS), and Random Selection for Service (RS) are self-explanatory. In many situations customers in some classes get priority in service over others. There are many other queue disciplines which have been introduced for the Efficient operation of computers and communication systems. Also, there are other factors of customer behavior such as balking, reneging, and jockeying , that require consideration as well.

2.3 Classification of Systems

Queueing nodes are usually described using Kendall's notation in the form of A/B/m/K/n/D.The following notation, known as **Kendall's notation**, is widely used to describe elementary queueing systems:

Let us denote a system by

$$A / B / m / K / n / D$$

Where,

A: distribution function of the inter arrival times,

B: distribution function of the service times,

m: number of servers,

K: capacity of the system, the maximum number of customers in the system including the one being serviced,

n: population size, number of sources of customers,

D: service discipline.

Exponentially distributed random variables are notated by M, meaning Markovain or memoryless. Furthermore, if the population size and the capacity is infinite,

the service discipline is FIFO, then they are omitted. Hence M/M/1 denotes a system with Poisson arrivals, exponentially distributed service times and a single server. for an example of the notation, the M/M/1 queue is a simple model where a single server serves jobs that arrive according to a Poisson process (inter-arrival durations are exponentially distributed) and have exponentially distributed service times. In an M/G/1 queue, the G stands for general and indicates an arbitrary probability distribution for service times.

2.4 M/M/1 queuing model

M/M/1 queuing model has been used to calculate service rate and arrival rate for all messages coming from devices. M/M/1 is a queuing theory within the mathematical theory of probability that shows the queue length of a single server in the system. Service times have an exponential distribution and exponential arrivals are determined by a Poisson process [16]. The service rate and arrival rate for m messages are introduced by μ and λ respectively.

Procedure:

An M/M/1 queue consists of a First-in First-Out (FIFO) buffer (queue) with packet arriving randomly according to a Poisson arrival process, and a processor, that retrieves packets from the buffer at a specified service rate. Three main parameters affects the performance of an M/M/1 queue, namely:

- Packet arrival rate,
- Packet size, 1/μ
- Service capacity, C

$$\lambda = \frac{1}{R\ time}$$

$$\mu = \frac{1}{T\ trans}$$

$$P = \frac{T\ trans}{R\ time} = \frac{\lambda}{\mu}$$

Where,
P < 1 (packet access)
P >1 (avoid packet access)

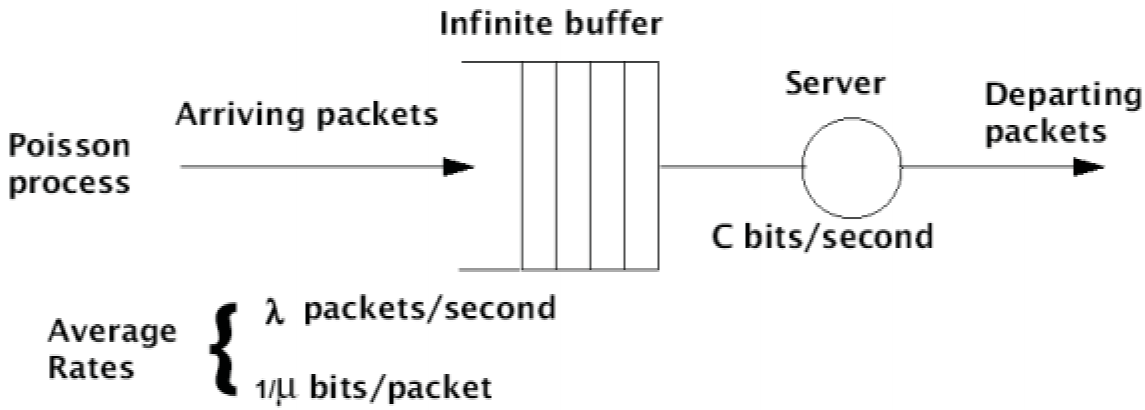


Fig.11: M/M/1 Queuing

Due to the scarce energy supplies of the internet of things (IoT) devices, it is necessary to design the architecture and operation of the network to optimize the power usage. Scheduling algorithm is an essential part of WSNs and IoT networks because allow to classify the queues and decide which process to run inside the network. Data transmitted inside queue is done through different scheduling algorithm.

2.5 Scheduling Algorithm

Scheduling is the method by which work is assigned to resources that complete the work. The work may be virtual computation elements such as threads, processes or data flows. Scheduling disciplines are algorithms used for distributing resources among parties which simultaneously and asynchronously request them. Scheduling disciplines are used in routers (to handle packet traffic) as well as in operating systems (to share CPU time among both threads and processes), disk drives (I/O scheduling), printers (print spooler), most embedded systems, etc. The main purposes of scheduling algorithms are to minimize resource starvation and to ensure fairness amongst the parties utilizing the resources. Scheduling deals with the problem of deciding which of the outstanding requests is to be allocated resources.

There are many different scheduling algorithms:

Time synchronised channel hopping (TSCH)- Scheduling algorithm for IEEE 802.15.4e MAC protocol is called time synchronised channel hopping (TSCH). This approach fits for multi-hop WSNs based on the highway addressable remote transducer. The proposed scheme promotes wireless sensor networks by improving low latency and duty cycle and thus utmost power efficiency.

Short time process (SPT)-The short time process (SPT) algorithm has been implemented in [10]. The proposed scheme divides the sensing area into sub-groups and each group has a broker. The SPT protocol deploys at brokers level to select and deliver packets to the final destination based on traffic intensity. The outcomes have shown the efficiency and effectiveness of the proposed algorithm for IoT networks in terms of energy consumption and service response time

Earliest deadline first (EDF)-Earliest deadline first (EDF) algorithm is a dynamic scheduling algorithm uses for real-time operating system. It assigns high priority for messages closest to their exceeded time in the queue. However, it does not consider packets arrive at the same time and packets spend higher energy. So, the scheduling tasks will complete within expire times even in the presence of fault.

First Come First Serve (FCFS) - First Come First Serve (FCFS) is a popular technique uses to forward the packets according to their arrival time on the queue. First packet arrives in the queue then first packet deliver to the destination. It is fair for data forward to the target, but unfair method that makes data accesses multiple devices and links and thus uses high energy to wait in the system. Therefore, the probability of retransmitted these packets will increase due to waiting time. The proposed algorithm gives low throughput, poor performance, unstable system, and longer average waiting time.

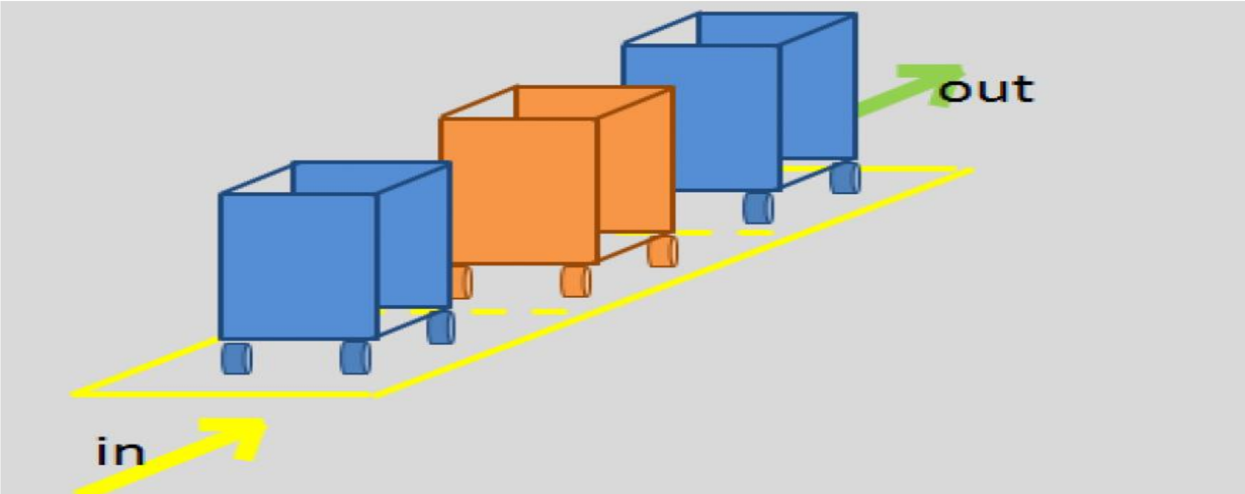


Fig no.12: First Come First Serve (FCFS)

Nearest job next (NJN) -Nearest job next (NJN) protocol is a scheduling algorithm that always selects the nearest device as the first job to collect and then deliver it data to the ultimate receiver. The proposed study helps the system to reduce the latency. Nearest job next (NJN) protocol is also called shortest job first (SJF).

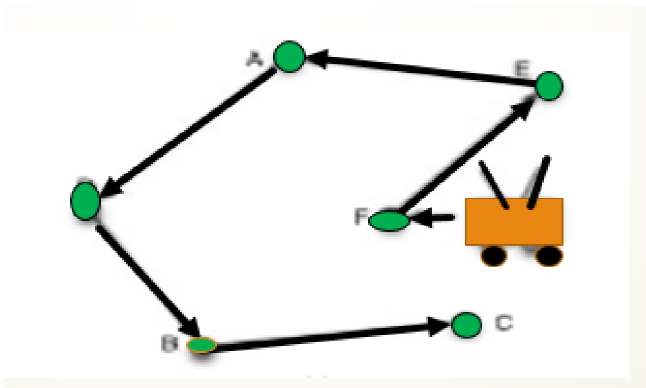


Fig.13:NJN (Nearest job Next)

Most of these applications deploy in random area to do specific job. Therefore, we need smart energy optimization to solve the problem for nodes located in different locations and used different number of hops to deliver their packets. The number of sensor nodes deploy in the world may be in order of million, billion or more after IoT launched. Normally, these smart devices use multi-hop technology due to radio transmission range. Thus, packets travel through other intermediate nodes to reach the ultimate receiver. This finding is the packets transmit from nodes located in far distances use higher number of devices to reach target and thus consume nodes energy and network bandwidth as well. Therefore, the factor of number of hops (and hence distance) should also be taken into consideration to optimize the power spent and extend the lifetime of network. To accomplish the previously stated goal, long hop (LH) first scheduling scheme has been introduced in this study. LH algorithm schedules high priority for packets coming with more hops and longer distances to be served first at the gateway nodes shows promising results for energy optimization of the WSN Fig 14 shows the working of LH algorithm [4].

In WSN network, due to simultaneously transmission of a large number of data simultaneously packet loss, delay and more energy consumption occur to overcome this problem we can extracted information from gathered sensory data with a specified level of accuracy in a timely and a power efficient approach. A new solution to distributed information that make use of morphological watershed algorithm. Watershed segment is a high level programming abstractions for query based information extraction system [5]. Energy efficiency in sensor enabled wireless network domain has witnessed significant attention from both academia and industries. It is an enabling technological advancement towards green computing in Internet of Things (IoT) eventually supporting sensor generated big data processing for smart cities.
An energy oriented path selection and message scheduling framework for sensor enabled wireless network environments. A path selection strategy is developed based on shortest path and less number of links on path (SPLL).

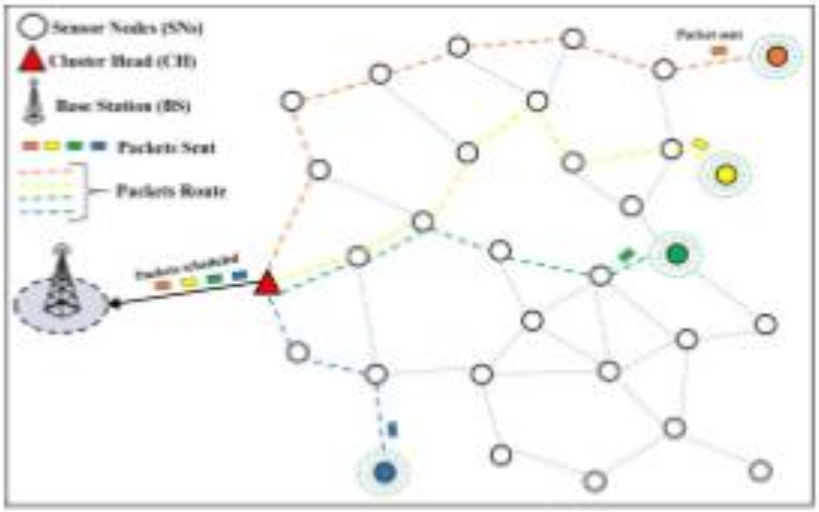


Fig. 14: The partial schedule of four tasks under LH algorithm.

The location of message sender, and number of processor in specific sensor are utilized for developing a longer hops (LH) message scheduling approach. Form the design, development and analysis of the proposed framework, that the cooperation between path selection and message scheduling approach significantly improves energy efficiency in sensor enabled wireless network environments [6]. IoT connects heterogeneous devices that provide sensing, control, actuation, and monitoring activities for smarter environments. With the emergence of IoT, new regulatory approaches to ensure its energy, scalability, security and privacy, human-in-the-loop, big data, etc. become necessary. The IoT revolution is expanding connectivity via the internet and a wide range of applications (e.g. actuators, sensors and other embedded systems).This will have an effect on the quality, different life styles and the way we behave and interact with humans, machines and devices in the future [8].

Fig.15: IoT Challenges and Opportunities

According to recent report by General Electric, an industrial Internet of Things (IoT) is emerging as a commercially viable embodiment of the IoT where physical sensors gather data readings from the field and deliver the traffic to the Internet. The collected real-time big data, in turn, allow the optimizing of entire industry verticals with enormous return of investments. Although opportunities are ample, it comes along with serious engineering design challenges as industrial applications have stringent requirements on delay, lifetime and standards-compliance. To this end, we advocate the use of an IEEE/IETF standardized IoT architecture along with a recently introduced data-centric scheduling algorithm known as traffic aware scheduling algorithm (TASA).A Traffic Aware Scheduling Algorithm (TASA), a centralized scheduling algorithm which exploits matching and coloring procedures to plan the distribution of slots and channels across the entire network topology graph [9].

In IOT network a large connecting diverse objects/things together. The focus is on scheduling the messages in an IoT environment where things/sensors are clustered into IoT subgroups, each subgroup has a message broker that delivers the messages originated from the group to the ultimate receiver of the sensed data. The message scheduler works at the broker level to decide which message to be transmitted this scheduling improves the overall IoT system efficiency. Working of scheduler is shown in fig.7.

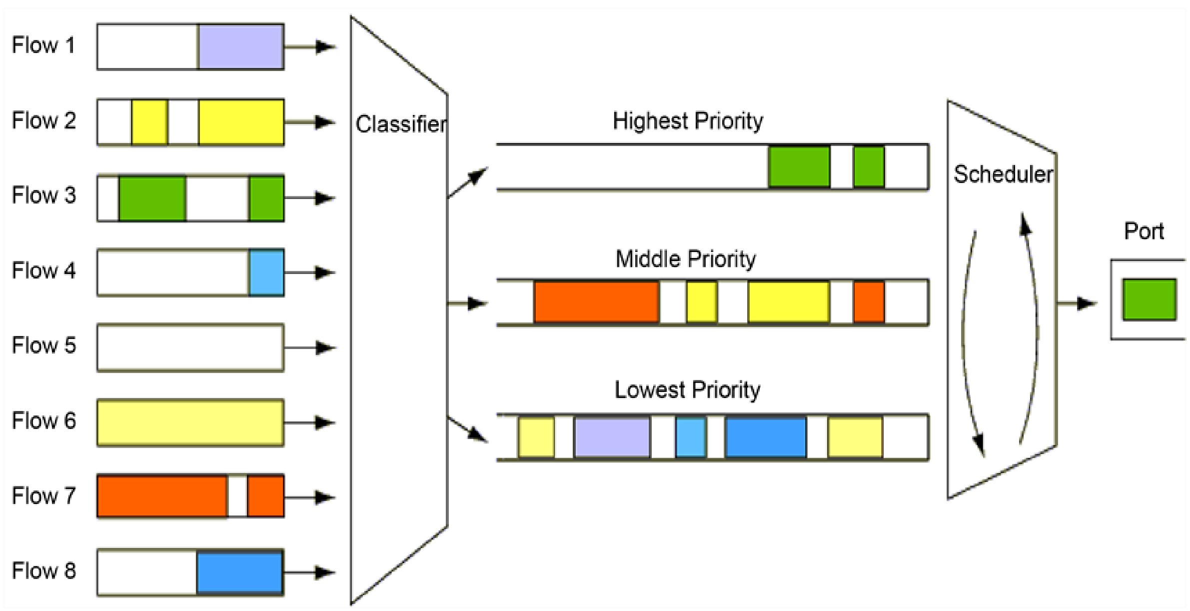


Fig.16: Queuing for multi class scheduling algorithm.

An energy efficient message scheduling algorithm in IoT system is proposed. Here IoT subgroups are having objects/sensors in it, and master node working as a broker is randomly selected. Scheduler is running at the broker which is selecting the messages sent from the incoming stream of messages from all of the members of its subgroup. We have considered

SPT first algorithm here. An energy efficient recovery and backup node selection for IoT systems followed with energy efficient message scheduling due the large number of connection inside the network the faults or failures identified on time help to initiate recovery or replacement procedures. Failures are being considered in two aspects, first is according to node repair probability for the faulty nodes and then back up node selection for dead nodes. The effectiveness and the efficiency of the proposed message scheduling algorithm both in terms of service response time and energy consumption. The energy efficient backup node selection procedure in algorithm could be improved in term of considering residual energy of the active backup node [10]. Real-time scheduling theory plays a key role in many time critical control systems or applications. An interesting property of the Earliest Deadline First (EDF) algorithm, which has never been discussed before, is examined [11].

Any packet routing network can be formulated as a queuing network where each server has a constant service time (Queueing theory shown in fig.8) If each server had exponentially-distributed service time, queueing theory techniques could be used to determine the expected packet delay. However, It is not known how to compute the average packet delay for all but the simplest networks with constant time servers. It has been conjectured that to get an upper bound on expected packet delay in the constant service network, one can simply replace each constant time server with an exponential server of equal mean service time. Here for a large class of networks, this conjecture is true, but that surprisingly there exists a network for which it is false. This large class of networks is all queueing networks with Markovian routing.

Queueing networks with Markovian routing are important because they include many packet-routing networks where the packets are routed to random destinations [12].To achieve a real time delivery the path must deliver the data on time. The algorithm selected for packet scheduling of real time data to achieve predictable and end-to end latencies while meeting the deadline of queries in which NJNC (Nearest job next with combination) outperforms in mobility assisted data collection with combination of multiple requests served together in on-demand manner without starvation problem as in the case of existing schemes like first- come- first- serve (FCFS), shortest- job next (SJN).NJNC provides better performance than the nearest-job-next (NJN).

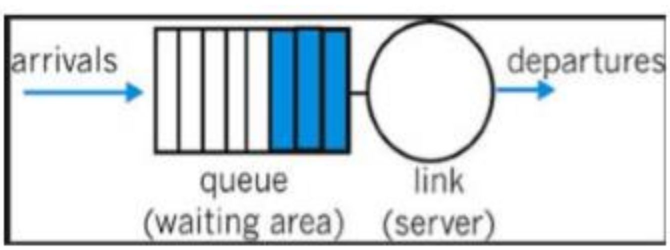


Fig.17: The Scheduler Model

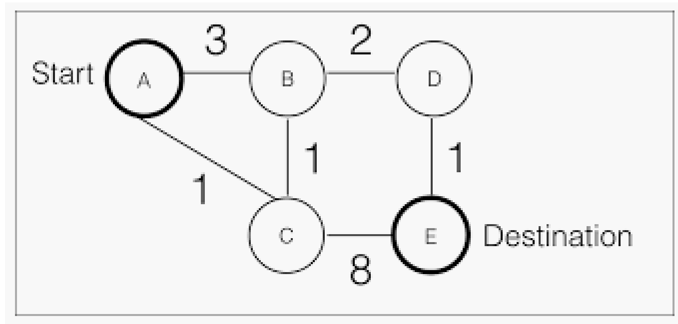
In WSN for real-time mechanism with mobility assisted data collection various scheduling scheme is used like NJNC, FCFS and NJN but here we use NJNC because it gives better performance than NJN and FCFS in terms of data collection time, delay, throughput and packet reception ratio. The adopted NJNC works without starvation problem and with a clear queuing behavior. NJNC is analyzed and suited for sophisticated applications in WSNs. NJNC analyze for single ME here [13].The data packet scheduling at sensor nodes are important to prioritize applications of wireless sensor nodes.

The data packets are classified as real-time and non-real time Most existing packet scheduling algorithms of wireless sensor networks are neither dynamic nor suitable for wide range of applications, since these schedulers are predetermined and not dynamic but static, and cannot be changed immediately to response for change in the application requirements or environments. In sensor network we have analytical evaluation of an intuitive service disciple for mobile data collection. How to schedule [shown in fig.9] the movement of mobile elements throughout the field due to limited mobility of mobile elements.

By using NJN and NJNC scheduling scheme (because it gives better performance than FCFS even in worst condition also)with an intuitive service disciple the on demand scenario Where data collection request arrive at the mobile element progressively investigated and the data collection process is modelled(as an M/G/1/c queue system)the performance of data collection is evaluated through both theoretical analysis and extensive simulation(due to this model)and gained more insight on the starvation problem that NJN and NJNC suffer from [14].

Mobility-assisted data collection in wireless sensor networks brings in new opportunities to improve the energy efficiency of sensor nodes. Here focusing on the scenario where a mobile sink is available to carry out the data collection for this a simple and efficient data collection scheme is proposed i.e. Partition-based Nearest Job Next (P-NJN) which schedules the travel of the mobile sink based on a clustered structure of the network. The P-NJN scheme clusters the sensor nodes by partitioning the sensing field into grids, and schedules the data collection carried out by the mobile sink based on this clustered structure. The P-NJN scheme in terms of the data collection latency [15].Sometimes we have to focus on message scheduling in an IoT environment where things or sensors are clustered into groups with each group has a message broker that delivers the messages originated from the group to the ultimate receiver of the sensed data. An energy-efficient messaging scheduling algorithm for IoT environment.

Here IoT subgroups are having objects/sensors in it, and master node working as a broker is randomly selected. Scheduler is running at the broker which is selecting the messages sent from the incoming stream of messages from all of the members of its subgroup. We have considered Shortest processing time first algorithm here. The aim of this work is to be investigated both aspects (Network layer routing and Application layer) in unified system architecture [16]. Inside sensor network the selection of shortest path problem is one the classic Problems in graph theory. Many algorithms have been developed to provide a solution for shortest path problem in a network to find the distance between nodes. One of common algorithms in solving shortest path problem is Dijkstra’s algorithm [17].



Fig, 18: Dijkstra's algorithm

Energy saving becomes one of the most important features of the sensor nodes to extend the lifetime of networks containing mobile sink. A novel tree-based power saving scheme is proposed to reduce the energy consumption and to reduce the data transmission distance of sensor node so that a significant improvement of the energy saving and network lifetime can be achieved in wireless sensor networks with mobile sink. A tree-cluster routing structure for the sensor nodes is created by adopting the dynamic sorting Algorithm and employing the multi-hop concepts. Based on the location of mobile sink, the distances between [18].

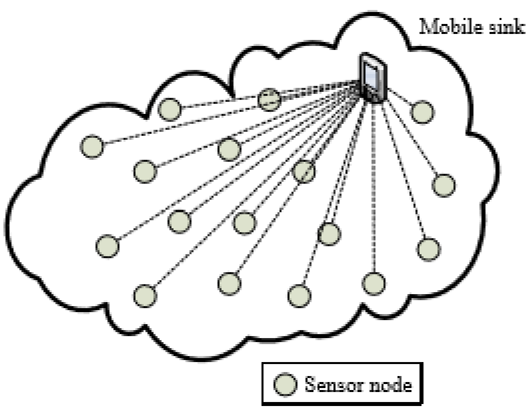


Fig.19: Direct communication protocol In WSNs with mobile sink.

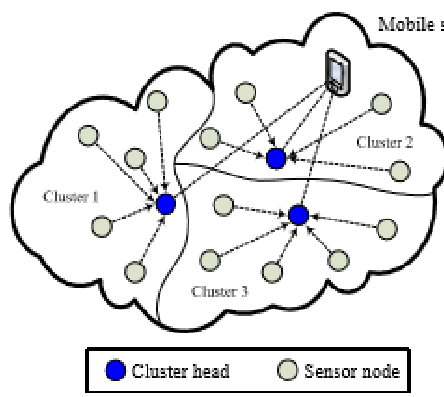


Fig.20: Cluster-based routing protocol In WSNs with mobile sink.

2.6 Long hop (LH) Scheduling Algorithm

As we discussed earlier all sensor nodes send the collected information to the central application (BS) through the CHs. Therefore, a CH becomes overloaded due to the higher number of packets send from the sensors around it. In contrary, IoT devices have a very small memory to hold packets while they are processing (packets sent and received). Furthermore, the device cannot afford to have big memory to avoid delay packets and potential drops and misses. A buffer must be allocated and free at the time a data arrives. Otherwise, the data will be dropped and the number of misses is incremented. Our previous manuscript has been accepted that proved some packets could be discarded due to memory size is full. While in this study, packets loss occur when the data reach at the same time or time exceeded messages at CHs queue. Each message node msg (Rtime,Ttrans) has request time period $Rtime$ and successful transmission time of the request Ttrans [16]. During traffic congestion, data cannot immediately transmit to the intend destination. Therefore, the data buffered for period until their queue is ready to serve. We assume that these devices send the tasks to the BS and buffer at the CH, it waits their queue to serve. Each task comes has different number of hops and distance. LH protocol re-arranges the packets at CH buffer based on biggest number of hops and longer distances to forward it first to the BS. During queuing time, some packets discard due to time exceeded message (i.e. yellow packet). Also, (orange and green) packets reached the RF antenna at the same time. In that case, LH policy takes the packet that used higher energy (i.e. green packet) and drops other (i.e. orange packet).working explain in Fig.2;

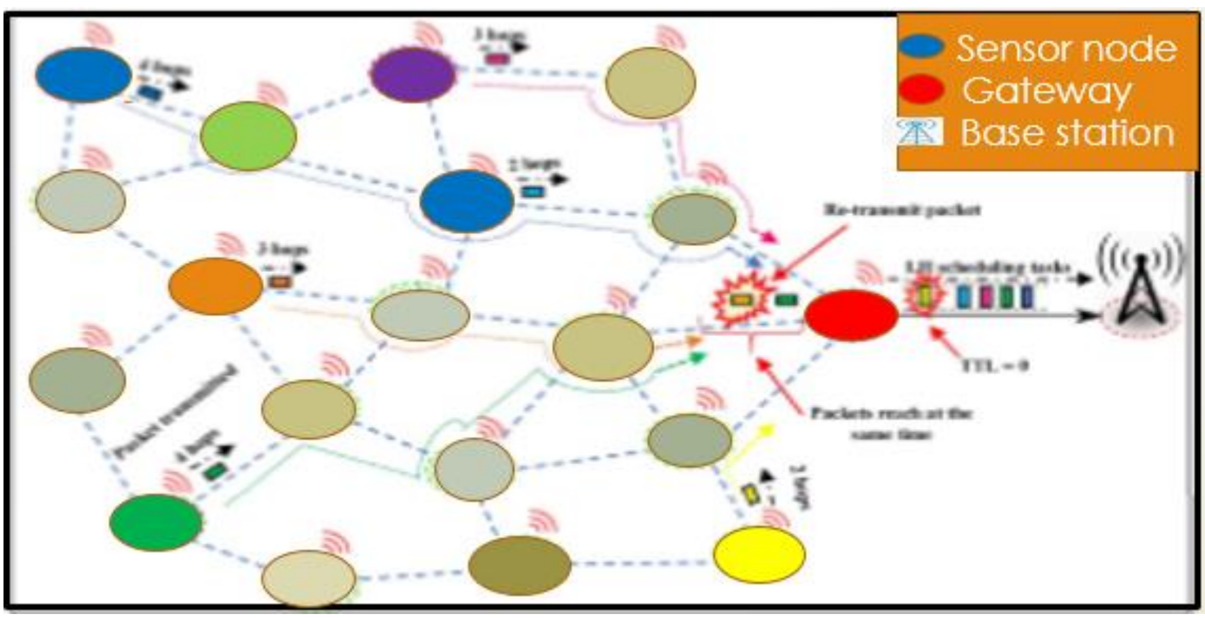


Fig.21:LH Scheduling Scheme

Long hop (LH) first algorithm is new unified scheduling technique that schedules high priority for data comes from far distances and accesses higher number of devices to be routed first to the target. The performance would be compares with two existing scheduling algorithm FCFS (First-Come-First-Serve) and NJN (Nearest Job Next) algorithms. The main aim of this technology is to connect the smart devices by means effective communication in resource constrained networks. LH strategy maximize the throughput, improvement on power saving and lifetime can be realized in IoT applications.

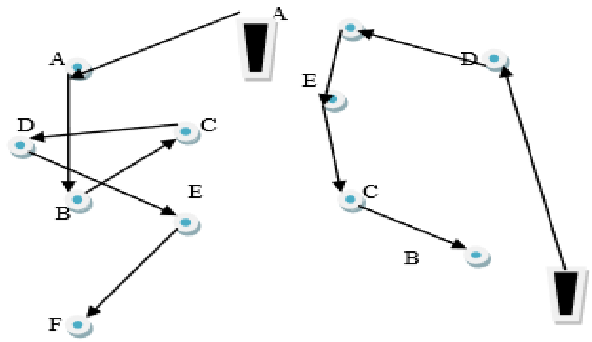


Fig 22: Comparison of FCFS and NJN service

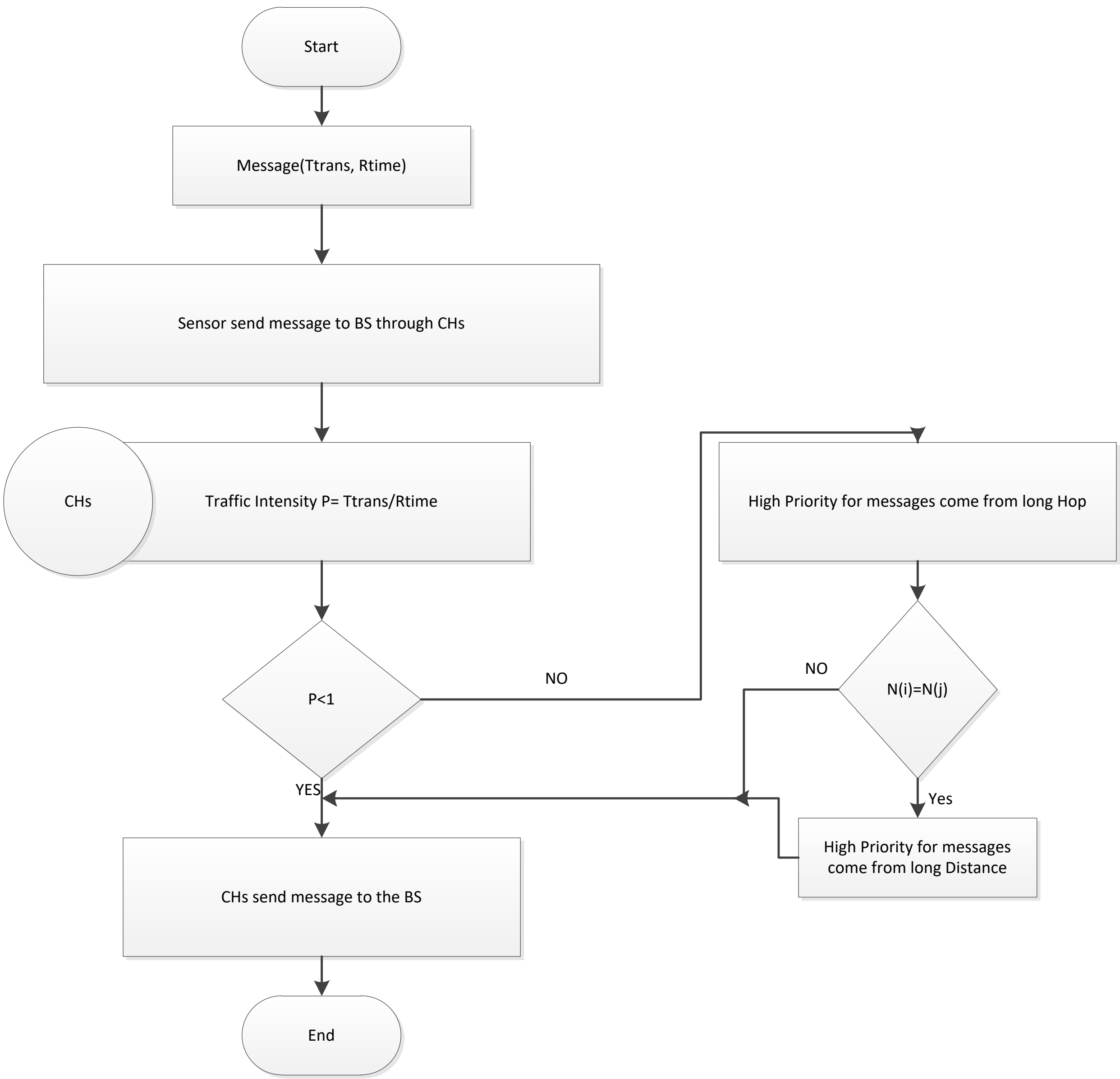


Fig.23:Flowchart of LH

2.7 Energy Consumption Model for LH

A common power model [4] is assumed for the proposed scheme. Sensors follow shortest path route to disseminate their packets to the next hop. Dijkstra algorithm [17] has been implemented to find shortest path between nodes

Total energy dispatches can be calculated by the following equations:

-To transmit a number of bits:

$$E_{Tx}= \text{k}(E_{elec} + \varepsilon_{amp} * d^2)$$

-To receive a number of bits:

$$E_{rx} = (k * E_{elec})$$

-Total energy used by each sensor:

$$E_{total} = L(E_{tx}) + M(E_{rx})$$

where,

$$E_{rx} = Energy\ dissipated\ to\ receive\ bit$$

$$E_{tx} = Energy\ dissipated\ to\ deliver\ bit$$

Where ERx is the energy depleted to receive number of bits (k). ETx is the energy dissipated to deliver chunk of bits from the source to the next object. Eelec is presented the energy depleted to run the receiver or transmitter circuitry, and ————————————amp is the energy dissipated in transmission to amplify the signal enough to reach the next target

The complexity of the proposed algorithm can be analysed in terms of storage and computation complexity. WSNs have small CPU that carries out the instructions of a computer program to send and receive packets. It is important to reduce the burden on this processor unit to prevent the fault. Therefore, the computational complexity is the major components in the analysis of the proposed protocol. The time complexity of the LH algorithm is (n2 +8n). Therefore, the time complexity is obtained to be O(n2), which is similar or better than other protocols which have complexity in order of O(n2) and O(n3).

Nodes use multi-hop scenario and shortest path to disseminate their packets. We assume that sensors are distributed outdoor to collect the information from the environment and send it to the CHs. The CHs process and deliver it to the central application (BS). In every round, each sensor sends 500 bytes to the BS.

2.8 EDF(Earliest deadline first)

Earliest deadline first is a real time scheduling scheme that gives high priority for message closest to their exceeding time in the queue, it does not consider packet arrive at the same time and the packet spend higher energy . It mainly focus on completing task within their expire times even in the presence of fault.

CHAPTER-3

PROBLEM STATEMENT

Objective: To improve the Quality of Service (QoS).

Problem Formulation: We will try to develop new Scheduling scheme that improve the QOS(Delay, Throughput and Energy Consumption)for data comes from far distances should be given high priority and accesses higher number of devices to the target (receiver).

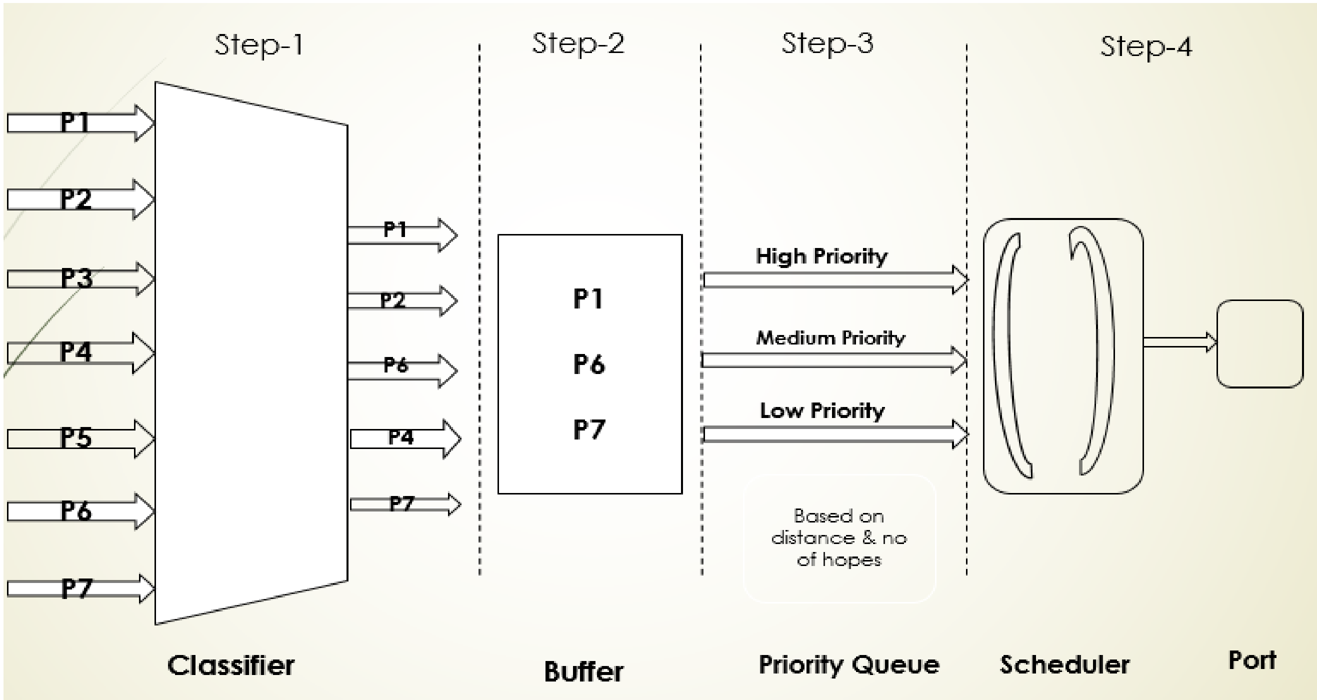
CHAPTER-4

SOLUTION METHODOLOGY

1) Classify the data packet based on the requirement.
2) Send data packets inside buffer and store some packet and discard rest.
3) Priorities of data packet will be given on the basis of distance and no. of hops.
4) The data coming from far distance and having large no hopes will give high priority and further reach to the destination.
5) On basis of that calculate packet loss, Avg. number of Hops, Throughput (%) and Avg. transmission distance Through MatLab.
6) By comparing the performance of LH with FCFS & NJN scheduling technique we can show the improvement in quality of service

CHAPTER-5

SYSTEM ARCHITECTURE



Different Algorithm Steps

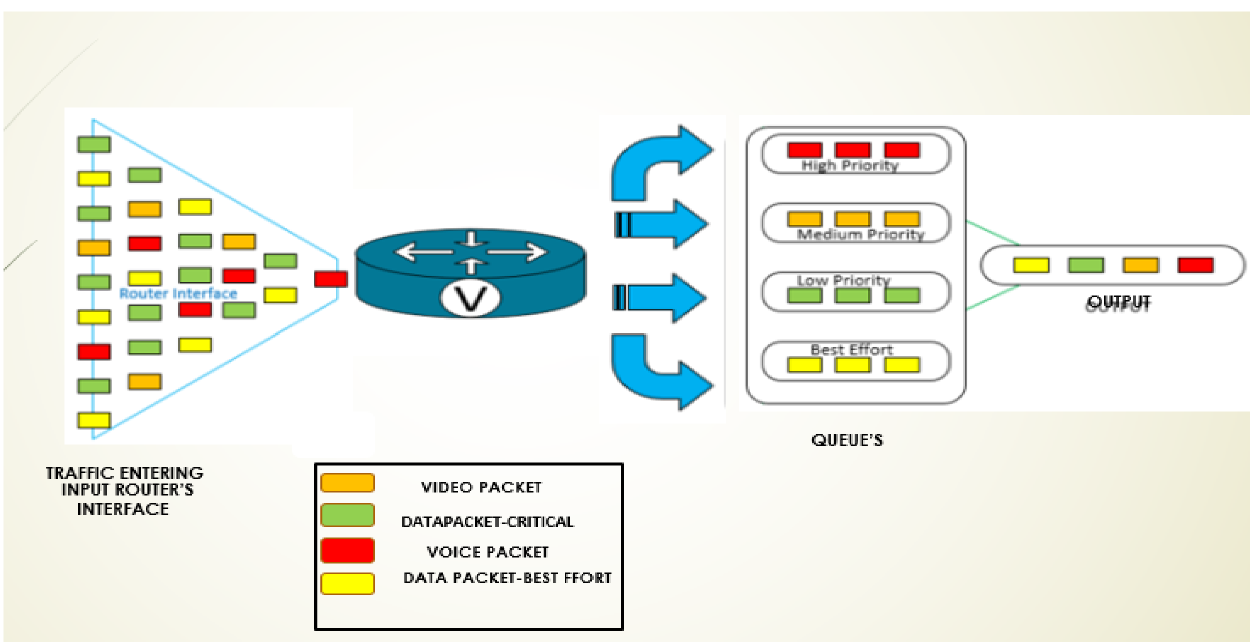
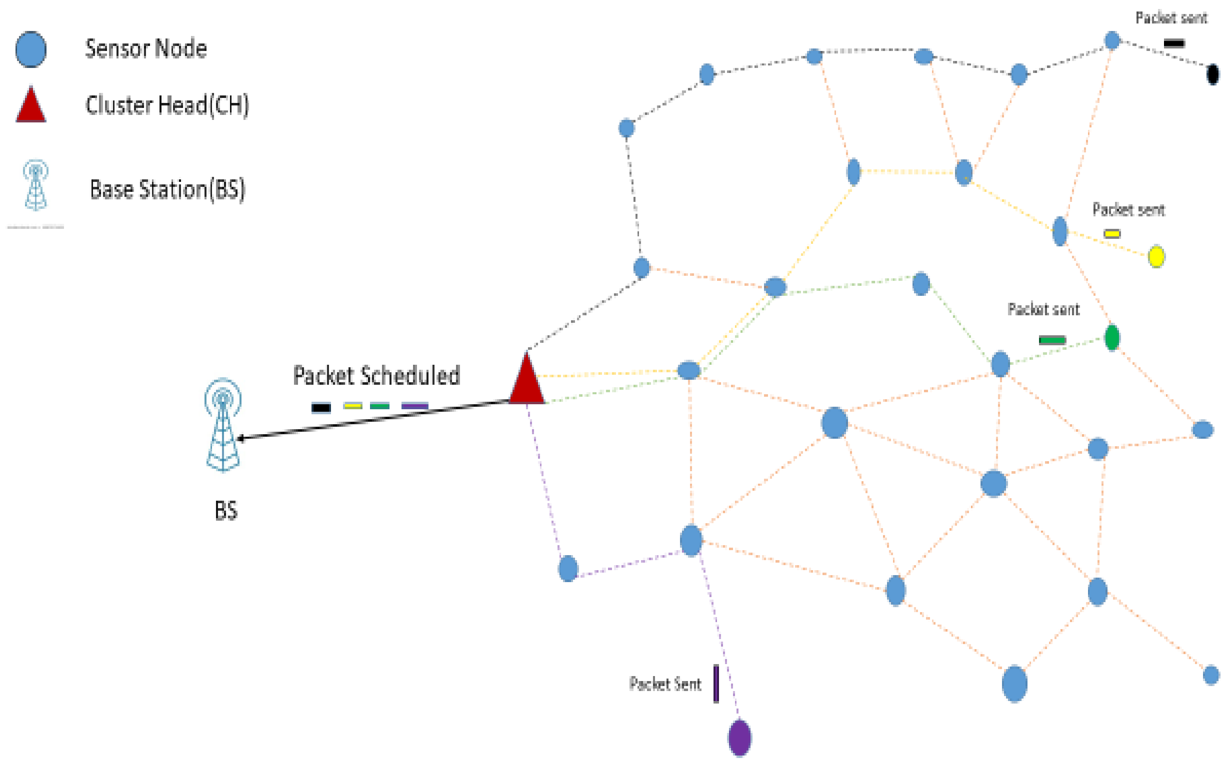


Fig.23: Example of proposed Algorithm

Network Architecture of LH scheduling scheme



CHAPTER-6

RESULT AND SIMULATION

SIMULATION TOOL

For performance evaluation, we use Pythan software which is similar to C language where the code is executed line by line.

SIMULATION PARAMETER:

Electronic energy(Eelec)=50nJ/bit

Initial energy of node(Einit)=0.25J

Threshold value of distance(d0)=87m

Data Rate=250 kb/s

Throughput=96000 bytes

Payload + Header Size=500 bytes

Communication energy(fs)=10pJ/bit/m2

Retransmission overhead size=8 bytes + header size

Communication energy(mp)=0.0013pJ/bit/m4

Number of Nodes(N)=200

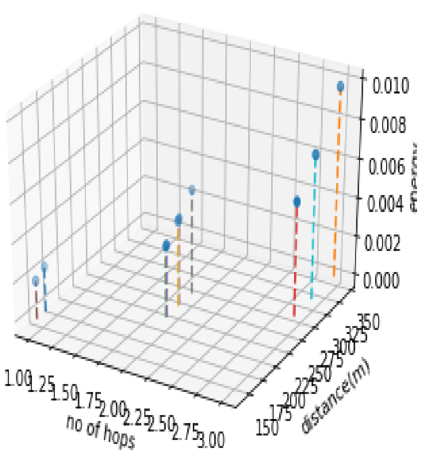
Sensing Area=500x500m

Simulation Result:

Results Obtained till now:

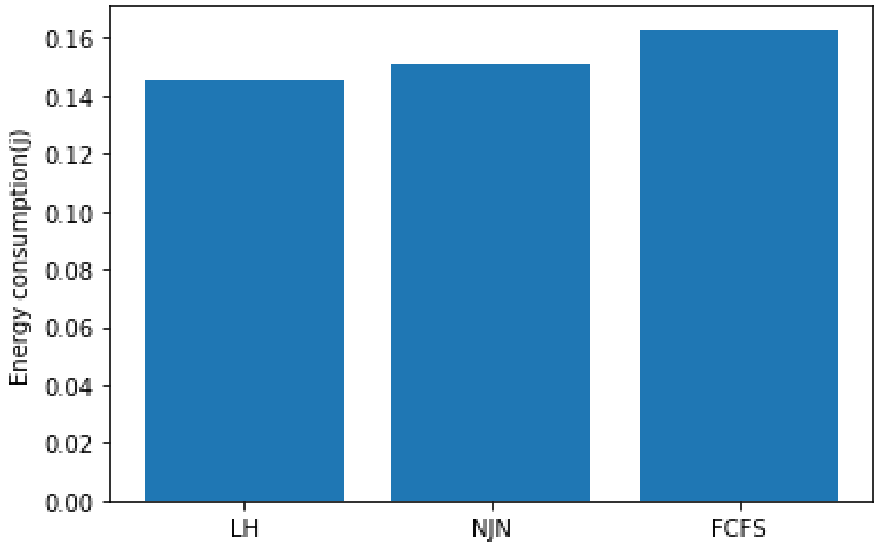
1. Energy Consumption node

```
[[1.00000000e+00 1.55433909e+02 2.32853831e-03]
 [3.00000000e+00 3.41854501e+02 9.72866161e-03]
 [2.00000000e+00 2.02078450e+02 3.65969329e-03]
 [3.00000000e+00 2.61886426e+02 5.87473007e-03]
 [2.00000000e+00 2.03666639e+02 3.71113226e-03]
 [1.00000000e+00 1.40704300e+02 1.98034342e-03]
 [2.00000000e+00 2.26108160e+02 4.48102454e-03]
 [2.00000000e+00 2.49301625e+02 5.36120247e-03]
 [2.00000000e+00 2.23987723e+02 4.40483994e-03]
 [3.00000000e+00 2.96118388e+02 7.39950759e-03]]
[1. 3. 2. 3. 2. 1. 2. 2. 2. 3.] [155.43390878 341.85450121 202.07845011 261.88642577 203.66663939
 140.70429986 226.10815996 249.30162454 223.98772288 296.11838849] [0.00232854 0.00972866 0.00365969 0.00587473 0.00371113 0.00
198034
 0.00448102 0.0053612  0.00440484 0.00739951]
```



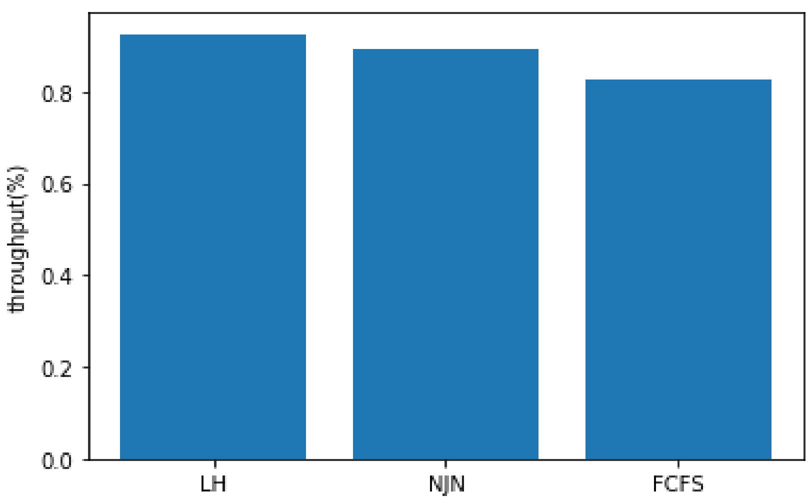
2. Results:

```
d.energy()
```



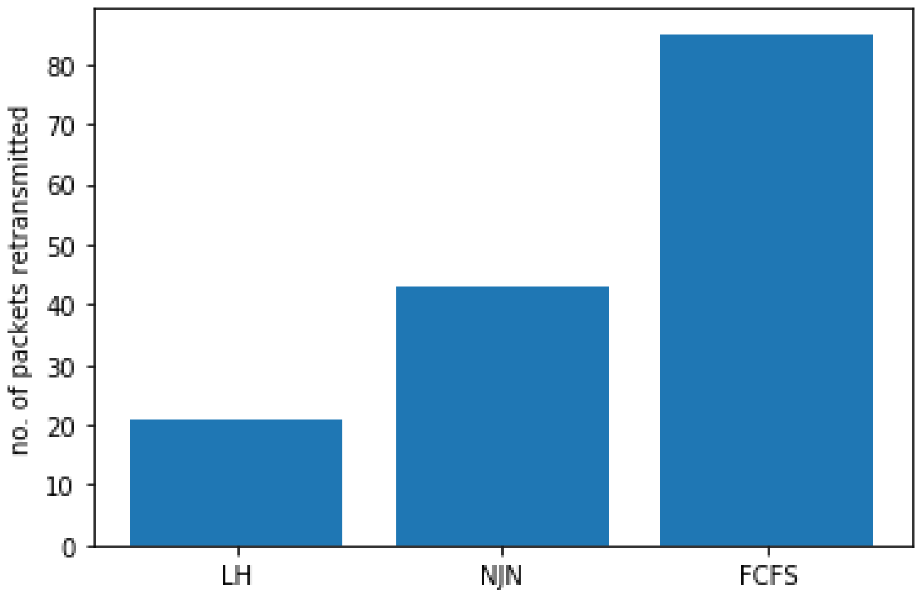

```
d.throughput_graph()
```

```
0.9257830581700355 0.892458723784025 0.8274720728175424
```

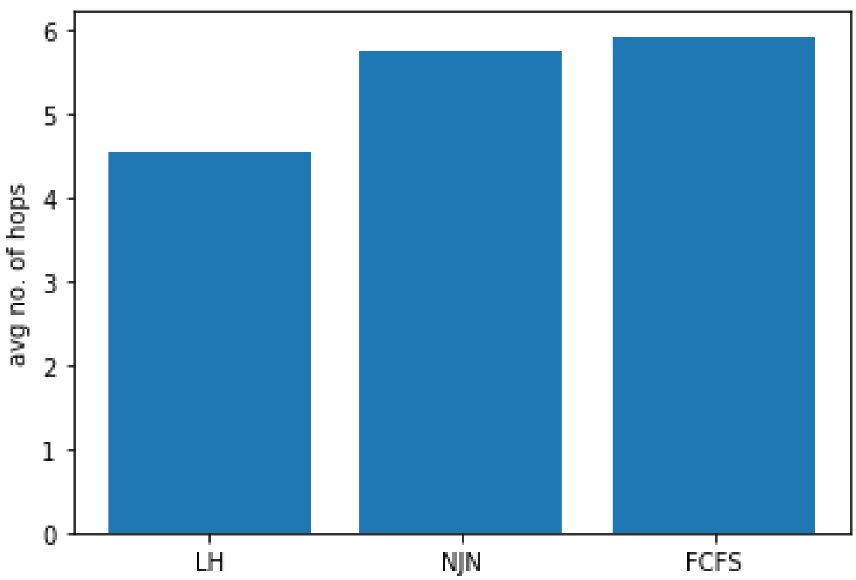


3.Result:

```
d.drops()
```

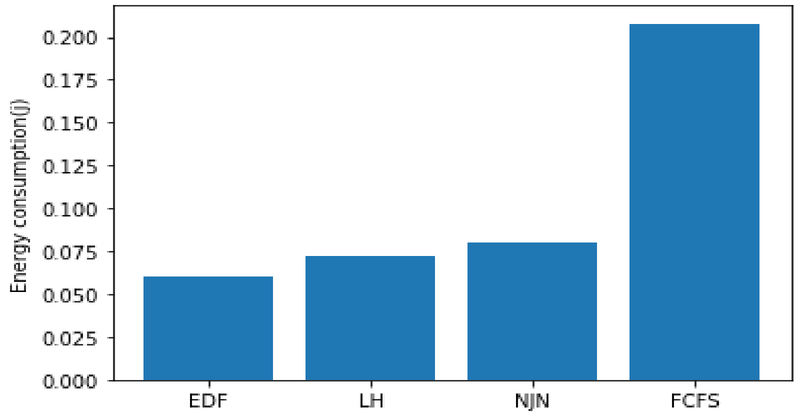



```
d.no_hop()
```

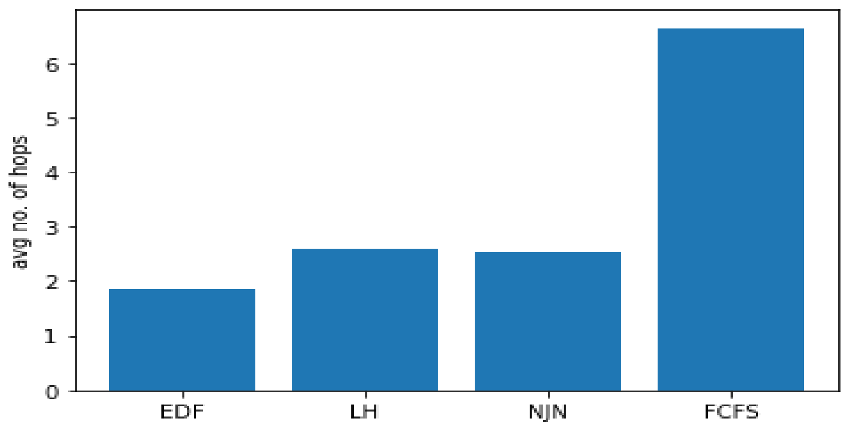


Improved Result:

```
d.energy()
```

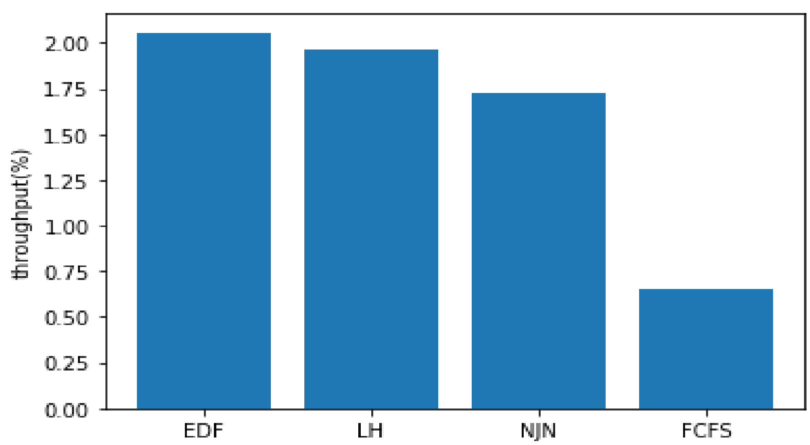



```
d.no_hop()
```




```
d.throughput_graph()
```

```
2.0562028786840303 1.9672131147540983 1.7246335153779822 0.6486486486486487
```



REFERENCES

1. Abuarqoub, M. Hammoudeh, B. Adebisi, S. Jabbar, A. Bounceur, and H. Al Bashar,“Dynamic clustering and management of mobile wireless sensor networks,” Comput. Netw., vol. 117, no. C, pp. 62–75, Apr 2017.

2. W. Stallings, Foundations of Modern Networking:SDN, NFV,QoE, IoT,and Cloud. Addison-Wesley Professional, 2015.

3. A.J.Abboud,“Protecting documents using visual cryptography,”International Journal of Engineering Research and General Science, vol. 3, pp. 479–492 Apr 2015.

4. L. Farhan, A. E. Alissa, S. T. Shukur, M. Hammoudeh, and R Kharel, “An Energy Effcient Long Hop (LH) First Scheduling Algorithm for Scalable Internet of Things (IoT) Networks,” in the 11th International Conference on Sensing Technology. IEEE, Nov 2017.

5. M. Hammoudeh and R. Newman, “Information extraction from sensor networks using the watershed transform algorithm,” Information Fusion, vol. 22, pp. 39–49, 2015.

6. L. Farhan, R. Kharel, O. Kaiwartya, M. Hammoudeh, and B.Adebisi, “Towards green computing for internet of things:Energy oriented path and message scheduling approach,” Sustainable Cities and Society, vol. 38,pp. 195 – 204, 2018.

7. J. Abboud and S. A. Jassim, “Image quality guided approach for adaptive modelling of biometric intra-class variations,” 2010.

8. L. Farhan, A. E. Alissa, S. T. Shukur, M.Alrweg,U.Raza,and R.Kharel,“ASurveyon the Challenges and Opportunities of the Internet of Things (IoT)” in the 11th International Conference on Sensing Technology. IEEE, Nov 2017.

9. M. R. Palattella, N. Accettura, L. A. Grieco, G. Boggia, M.Dohler, and T. Engel,“On Optimal Scheduling in Duty-Cycled Industrial IoT Applications Using IEEE802.15.4 TSCH,” IEEE Sensors Journal, vol. 13, no. 10, pp. 3655–3666,Oct 2013.

10. S. Abdullah and K. Yang, “An Energy Efficient Message Scheduling Algorithm Considering Node Failure in IoT Environment,” Wireless Personal Communications,vol. 79, no. 3, pp. 1815–1835, Dec 2014.

11. H. Wang, Jie Jin, Zhijun Wang, and L. Shu, “On a novel property of the earliest deadline first algorithm,” 2011.

12. M. Harchol-Balter and D. Wolfe, “Bounding delays in packet routing networks,” in Proceedings of the twentyseventh annual ACM symposium on Theory of computing - STOC ’95. New York, New York, USA: ACM Press, 1995.

13. R. Gomathi and N. Mahendran, “An efficient data packet scheduling schemesin wireless sensor networks,” in 2015 2nd International Conference on Electronics and Communication Systems (ICECS). IEEE, feb 2015.

14. L. He, Z. Yang, J. Pan, L. Cai, J. Xu, and Y. J. Gu, “Evaluating service disciplines for on-demand mobile data collection in sensor networks,” IEEE Transactions on Mobile Computing, vol. 13, no. 4, pp. 797–810, Apr. 2014.

15. M. Ahmadi, L. He, J. Pan, and J. Xu, “A partition-based data collection scheme for wireless sensor networks with a mobile sink,” in 2012 IEEE International Conference on Communications (ICC), June 2012.

16. S. Abdullah and K. Yang, “An energy-efficient message scheduling algorithm In Internet of Things environment,” in 9th International Wireless Communications and Mobile Computing Conference (IWCMC). IEEE, jul 2013.

17. S. Broumi, A. Bakal, M. Talea, F. Smarandache, and L. Vladareanu, “Applying dijkstra algorithm for solving neutrosophic shortest path problem,” in 2016 International Conference on Advanced Mechatronic Systems (ICAMechS), Nov 2016.

18. J.-Y. Chang and T.-H. Shen, “An Efficient Tree-Based Power Saving Scheme for Wireless Sensor Networks With Mobile Sink,” IEEE Sensors Journal, vol. 16, no.20, pp. 7545–7557, oct 2016.

19. https://westcom-medium.com/classification-prioritization-voip-traffic/