CHAPTER 1
INTRODUCTION

Communication across a network is increasingly important in the work environment. Similar to processors or disks of the system, the behavior of the network has an impact on the operation of the computer. Network devices have become an ubiquitous fixture in the modern home and corporate networks as well as in the global communication infrastructure. Devices like Hub, Switch, Bluetooth, Wifi and Wimax reside on the same networks as the personal computers and enterprise servers and together form the world-wide communication infrastructure. To fully appreciate the scope and scale of such devices it is required to move beyond analysis of individual devices and their vulnerabilities. The analysis of such devices and the performance impact of a network are taken as the research work. This has been done using the queuing petri nets and Markov model. Based on these models a novel hybrid model is developed with security which can be used in future corporate and inter-networks.

1.1 CLIENT SERVER

The client–server model is a computing model that acts as distributed application which partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters, called clients. Often clients and servers communicate over a computer network on separate hardware, but both client and server may reside in the same system. A server machine is a host that is running one or more server programs which share their resources with clients. A client does
not share any of its resources, but requests a server's content or service function. Clients therefore initiate communication sessions with servers which await incoming requests.

The client–server characteristic describes the relationship of cooperating programs in an application. The server component provides a function or service to one or many clients, which initiate requests for such services.

![Fig 1.1 A Typical Client Server Model](image)

The client–server model has become one of the central ideas of network computing. Many business applications being written today use the client–server model. The interaction between any client and server is often described using sequence diagrams. Mathematical queuing model has support for such sequence diagrams which describes the data flow in between client and server.

### 1.2 NETWORK DEVICES

Computer networking devices are units that mediate data in a computer network. Computer networking devices are also called Network equipment,
Intermediate Systems (IS) or Interworking Unit (IWU).

A wired network is one in which all the components are connected with network cables. A Wireless network offer connectivity without the physical restrictions associated with building wired networks. Hubs work at the physical layer (layer 1) of the OSI model. The device is thus a form of multiport repeater. Repeater hubs also participate in collision detection, forwarding a jam signal to all ports if it detects a collision.

A network switch is a small hardware device that joins multiple computers together within one local area network (LAN). Bluetooth provides a way to connect and exchange information between devices such as mobile phones, telephones, laptops, personal computers, printers, Global Positioning System (GPS) receivers. Wi-Fi works with no physical wired connection between sender and receiver by using radio frequency (RF) technology, a frequency within the electromagnetic spectrum associated with radio wave propagation. WiMax is designed to efficiently support from one to hundreds of Consumer Premises Equipments (CPE). Wi-Fi works at 2.7bps/Hz and can peak up to 54 Mbps in 20
MHz channel. But other technologies like WiMax works at 5bps/Hz and can peak up to 100 Mbps in a 20 MHz channel.

1.2.1 Wired Network Devices

Hub

A hub is a common connection point for devices in a network. Hubs are commonly used to connect segments of a LAN. A hub contains multiple ports. When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets.

Hub may also come with an Attachment Unit Interface (AUI) connector to allow connection to network segments. The availability of low-priced network switches has largely rendered hubs obsolete but they are still seen in older installations and more specialized applications.

Switch

A network switch or switching hub is a computer networking device that connects network segments. The term commonly refers to a multi-port network bridge that processes and routes data at the data link layer (layer 2) of the OSI model. Switches that additionally process data at the network layer (layer 3) and above are often referred to as Layer 3 switches or multilayer switches.

In switches intended for commercial use, built-in or modular interfaces make it possible to connect different types of networks, including Ethernet, Fibre Channel and ATM. This connectivity can be at any of the layers mentioned. While Layer 2 functionality is adequate for bandwidth-shifting within one technology, interconnecting technologies such as Ethernet and token ring is easier at Layer 3.
Devices that interconnect at Layer 3 are traditionally called routers, so "Layer-3 switches" can also be regarded as (relatively primitive) routers.

In some service provider and other environments where there is a need for a great deal of analysis of network performance and security, switches may be connected between WAN routers as places for analytic modules. Some vendors provide firewall, network intrusion detection, and performance analysis modules that can plug into switch ports. Some of these functions may be on combined modules.

In other cases, the switch is used to create a mirror image of data that can go to an external device. Since most switch port mirroring provides only one mirrored stream, network hubs can be useful for fan-out data to several read-only analyzers, such as intrusion detection systems and packet sniffers.

1.2.2 Wireless Network Devices

Bluetooth

Bluetooth is a proprietary open wireless technology standard for exchanging data over short distances up to 10 meters in mobile devices, creating personal area networks (PANs) with high levels of security. It can connect several devices, overcoming problems of synchronization. If an optional amplifier is connected to Bluetooth device the range could be extended up to 100 meters. Bluetooth is essentially a wireless networking standard device that works at two levels:

1. It provides agreement at the physical level -- Bluetooth is a radio-frequency standard.
2. It provides agreement at the protocol level, where products have to agree on when bits are sent, how many will be sent at a time, and how the client server
communication can be sure that the message received is the same as the message sent.

**Wi-Fi**

Wi-Fi (Wireless Fidelity) is a mechanism that allows electronic devices to exchange data wirelessly over a computer network. A device enabled with Wi-Fi, such as a personal computer, video game console, smartphone, tablet, or digital audio player, can connect to a network resource such as the Internet via a wireless network access point. An access point (or hotspot) has a range of about 20 meters (65 ft) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio signals or a large area, as much as many square miles, covered by multiple overlapping access points.

Wi-Fi has a checkered security history. Its earliest encryption system, WEP, proved easy to break. Much higher quality protocols, WPA and WPA2, were added later. However, an optional feature added in 2007, called Wi-Fi Protected Setup (WPS), has a flaw that allows a remote attacker to recover the router's WPA or WPA2 password in a few hours on most implementations. Currently the only remedy is to turn off the WPS feature, although this may not possible on some router models.

**WiMax**

WiMAX (Worldwide Interoperability for Microwave Access) is a communication technology for wirelessly delivering high-speed Internet service to large geographical areas. The 2005 WiMAX revision provided bit rates up to 40 Mbit/s with the 2011 update up to 1 Gbit/s for fixed stations. It is a part of a “fourth generation,” or 4G, of wireless-communication technology, WiMax far
surpasses the 30-metre (100-foot) wireless range of a conventional Wi-Fi local area network (LAN), offering a metropolitan area network with a signal radius of about 50 km (30 miles). The name "WiMAX" was created by the WiMAX Forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes WiMAX as "a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL". WiMax offers data-transfer rates of up to 75 Mbit/s, which is superior to conventional cable-modem and DSL connections. However, the bandwidth must be split among multiple users and thus yields lower speeds in practice.

The bandwidth and range of WiMAX make it suitable for the following potential applications:

- Providing portable mobile broadband connectivity across cities and countries through a variety of devices.
- Providing a wireless alternative to cable and digital subscriber line (DSL) for "last mile" broadband access.
- Providing data, telecommunications (VoIP) and IPTV services (triple play).
- Providing a source of Internet connectivity as part of a business continuity plan.

1.3 NETWORK PERFORMANCE ANALYSIS

The performance of any wired and wireless network varies with respect to the devices connected to it. Such devices namely HUB, Switch, Bluetooth, Wifi and Wimax are considered as a key aspect to analyze the network.

Each of these devices carries various key parameters and the rate of data transfer also differs. To evaluate the rate of transfer, inter-arrival time and inter-
service time is calculated in between the request and response, with the support of queuing petri net and Markovian queuing model.

It is mainly focused on comparison of the devices and performance is analyzed to provide a multi mechanism model which may be used in many applications with secure and fast processing.

1.4 QUEUING NETWORKS

A service station consists of one or more servers and a waiting area which holds requests waiting to be served. When a request arrives at a service station, its service begins immediately if a free server is available. Otherwise, the request is forced to wait in the waiting area.

![Fig 1.3 Queuing Network](image)

The time between successive request arrivals is called inter arrival time. Each request demands a certain amount of service, which is specified by the length of time a server is occupied serving it, i.e. the service time. The queuing delay is the amount of time the request waits in the waiting area before its service begins. The response time is the total amount of time the request spends at the service station, i.e. the sum of the queuing delay and the service time. Queuing network consists of a set of interconnected queues where each queue represents a service station, which serves requests (also called jobs) sent by customers, analyzed by (Samuel Kounov...
1.4.1 Queuing Petri Net

A Petri net consists of Places (P), Transitions (T), and arcs. Arcs run from a place to a transition or vice versa, never between places or between transitions. The places from which an arc runs to a transition are called the input places of the transition; the places to which arcs run from a transition are called the output places of the transition.

Graphically, places in a Petri net may contain a discrete number of marks called tokens. Any distribution of tokens over the places will represent a configuration of the net called a marking. In an abstract sense relating to a Petri net diagram, a transition of a Petri net may fire whenever there are sufficient tokens at the start of all input arcs; when it fires, it consumes these tokens, and places tokens at the end of all output arcs.

1.5 JOB SCHEDULING

A scheduling is the method by which threads, processes or data flows are given access to system resources (e.g. processor time, communications bandwidth). This is usually done to load balance a system effectively or achieve a target quality
of service. The need for a scheduling algorithm arises from the requirement for the most modern systems to perform multitasking (execute more than one process at a time) and multiplexing (transmit multiple flows simultaneously).

The scheduler is concerned mainly with:

- **Throughput** - number of processes that complete their execution per time unit.
- **Latency**, specifically:
  - **Turnaround** - total time between submission of a process and its completion.
  - **Response time** - amount of time it takes from when a request was submitted until the first response is produced.
- **Fairness / Waiting Time** - Equal CPU time to each process (or more generally appropriate times according to each process' priority).

Scheduling disciplines are algorithms used for distributing resources among clients 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 clients utilizing the resources. Scheduling deals with the problem of deciding which of the outstanding requests is to be allocated. There are many different scheduling algorithms. In this section, some of these algorithms were used in the proposed work.
In packet-switched computer networks and other statistical multiplexing, the notion of a scheduling algorithm is used as an alternative to first-come first-served queuing of data packets.

The simplest best-effort scheduling algorithms are round-robin, fair queuing (a max-min fair scheduling algorithm), proportionally fair scheduling and maximum throughput. If differentiated or guaranteed quality of service is offered, as opposed to best-effort communication, weighted fair queuing may be utilized.

1.6 MARKOVIAN MODEL

Queuing theory is a branch of applied probability theory. The study of queues deals with quantifying the phenomenon of waiting lines using representative measures of performance, such as average queue length, average waiting time in queue and average facility utilization. Erlang's fundamental work in connection with telephone engineering was the origin of queuing theory in 1909. Since then many authors have developed the subject tremendously. In the earlier years of its growth the studies were confined to single arrival and personalized service systems. Mathematical analysis of queues suggests ways to shorten the waiting time and the waiting line which are the basic characteristics of a queuing system.

The pioneering work of Bailey originated the study of bulk queues. During the last 50 years, systems with bulk arrival or bulk service or both bulk arrival and bulk service have been extensively studied. During the last two decades the queuing models have been applied to model digital communication system such as multiplexers and packet switches. In this field, the multi server or bulk service queue fulfils a key role due to its wide range of applications, which includes ATM Switching element and data transmission over satellites, high performance serial
buses and cable access networks by (Denteneer 2003). Its wide range of practical applications in a variety of situations makes it attractive to many researchers to work on various queuing models and to obtain closed form solutions.

1.6.1. Single server model

A queuing model is used to approximate a real queuing situation or system, so the queuing behaviour can be analysed mathematically. Queuing models allow a number of useful steady state performance measures to be determined, including:

- the average number in the queue, or the system,
- the average time spent in the queue, or the system,
- the statistical distribution of those numbers or times,
- the probability the queue is full, or empty, and
- the probability of finding the system in a particular state.

These performance measures are important as issues or problems caused by queuing situations are often related to customer dissatisfaction with service or may be the root cause of economic losses in a business. Analysis of the relevant queuing models allows the cause of queuing issues to be identified and the impact of proposed changes to be assessed.

Single-server queues are, perhaps, the most commonly encountered queuing situation in real life. One encounters a queue with a single server in many situations, including business (e.g. sales clerk), industry (e.g. a production line), and transport (e.g. a queues that the customer can select from.)

To get the performance measures of the queuing systems there are two basic approaches:
analytic methods of queuing theory (formula based); and
• Simulation (computer based).

The reason for there being two approaches (instead of just one) is that analytic methods are only available for relatively simple queuing systems where as complex queuing systems are almost always analyzed using simulation. The simple queuing systems that can be tackled via queuing theory essentially have distributions for the arrival and service processes that are well defined (e.g. standard statistical distributions such as Poisson or Erlang); systems where these distributions are derived from observed data, or are time dependent, are difficult to analyze via queuing theory. To analyze the queuing system, need for information relating to: arrival process, service mechanisms, queue discipline, system capacity and service channels.

Arrival Process

The arrival pattern means the manner in which customers arrive and join the system. Arrivals may occur in single or in groups (batch or bulk arrival). It is specified by the probability of time between successive arrivals, that is, the inter arrival time distributions. The simplest arrival process is the one which has complete regular arrivals (the same constant time interval between successive arrivals). A Poisson stream of arrival corresponds to arrivals at random. In a Poisson stream, successive customers independently arrive after intervals are exponentially distributed. The Poisson stream is important as it is a convenient mathematical model of many real life queuing systems and is described by a single parameter- the average arrival rate. Other important arrival processes are scheduled arrivals; batch arrivals; and time dependent arrivals.

If the customer decides not to join the queue when it is too long then he is said to have balking and if the customer leaves that queue after waiting too long for
service he is said to have reneging. If the customer switches between queues as he thinks he will get served faster by so doing is known as jockeying.

**Service Mechanism**

Service mechanism is a description of the resources needed for service to begin. This explains the service time distribution, the number of servers available, whether the servers are in series (each server has a separate queue) or in parallel (one queue for all servers), whether preemption is allowed (a server can stop processing a customer to deal with another emergency customer) etc. The assumption that the service times for the customers are independent of the arrival process is common. Another common assumption about service time is that they are exponentially distributed. Customers may be served in batches also. In case of batch service, the service system is termed as bulk service system.

**Queue Discipline**

The queue discipline is the method by which the customers are selected for service from the set of customers waiting for service. The most common discipline that is observed in everyday life is first-in first-out (FIFO) also known as First-come first-served (FCFS) under which, the customers are served in the strict order of their arrival. Another queue discipline is last-in first-out (LIFO) which is applicable to some inventory systems where there is no obsolescence of stored units, as it is easier to reach the nearest items, which is last-in. Yet another queue discipline is service in random order (SIRO) in which the customers are served randomly irrespective of their arrivals into the system.

Priority queue discipline allows priority in service to some customers in relation to other customers waiting in the queue. It is further subdivided into two
categories via preemptive priority and non-preemptive priority. In preemptive case the customer with higher priority is allowed to enter service immediately suspending even the service in progress to a customer with lower priority. In the non-preemptive case the higher priority customer goes to the head of the queue but gets into the service only after the completion of service to the customer with lower priority. It is assumed that, once a server who is able to provide service to a waiting customer becomes free, the customer immediately enter service without loss of time.

System Capacity

The number of customers in the queue and in service put together is called system capacity. A system may have a queue of finite capacity or effectively infinite capacity. A system with finite capacity can be viewed as one with forced balking of a customer arriving when the system is to its full capacity. If the system capacity is not mentioned, it is assumed to be infinite.

Service Channels

A queuing system may have one or more service channels (servers) to provide service. The service channels may be arranged in parallel or in series or a combination of both depending on the nature of the service. It is generally assumed that the service mechanisms of the parallel channels operate independently of each other. A queuing system of only one server is called a single server model and a system with two or more number of parallel servers is called a multi server model. In case of multi server models the customers may form a single or a parallel queue in front of each server.

Markovian Queuing Model

Queuing Models with exponential inter arrival times and exponential
service times are Markovian Queuing Model. Batch service queuing system with
batch size (a,b) without server’s vacation has been analyzed.

1.6.2 Bulk Service Rule

A common assumption about service time is that they are exponentially
distributed. Customers may be served in batches also. In case of batch service, the
service system is termed as bulk service system. The batches may be of fixed size or
of variable size. Neuts (1967) introduced the general bulk service rule. As per the
rule, (i) the server starts service only if the minimum batch size ‘a’ (quorum) the
number of customers are waiting in the queue and the maximum capacity is ‘b’ (ii)
if the server finds ‘m’ (a≤ m ≤b) customers in the queue then the entire queue is
taken up (iii) the queue length is more than ‘b’ then the first ‘b’ customers are taken
leaving others to wait in the queue. The late arrivals are not allowed to join the
ongoing service. In particular, if a=1, the above rule will be called as usual bulk
service rule. Batch service queuing systems with single and multiple vacation for
a=1 are studied by some authors. Lee et al (1997) have discussed M/M(a,b)/1
queuing model with server's delayed vacation.

1.7 NETWORK SECURITY

Security consists of the provisions and policies adopted by the network
administrator to prevent and monitor unauthorized access, misuse, modification, or
denial of the computer network and network-accessible resources. Security involves
the authorization of access to data in a network, which is controlled by the network
administrator. Users choose are assigned an ID and password or other
authenticating information that allows them access to information and programs
within their authority.
Steganography and Cryptography

Steganography is the art of writing hidden messages in such a way that no one, apart from the sender and intended recipient, suspects the existence of the message, a form of security through obscurity.

![Steganography Mechanisms](image)

**Fig 1.5 Steganography Mechanisms**

Cryptography is the practice and study of techniques for secure communication in the presence of third parties. More generally, it is about constructing and analyzing protocols that overcome the influence of adversaries and which are related to various aspects in information security such as data confidentiality, data integrity and authentication.

![Cryptography Mechanisms](image)

**Fig 1.6 Cryptography Mechanisms**

Modern cryptography intersects the disciplines of mathematics, computer science, and electrical engineering.
1.8 SCOPE OF THE RESEARCH

This research work has been done based on the mathematical models and the overall architecture of the work is modeled as shown in the figure 1.7

Data Transfer between any devices is inevitable event in a day-to-day life. Data transmission is not at all possible without any interface technology. Most of such interfaces come in the form of various network devices. Behavior of these devices depends on Speed, Time and rate of transfer. Hence, the initial work of this research work has been carried out for the efficient usage of such devices in a network by analyzing the inter arrival time and service time of each devices.

- Detailed analysis of various wired and wireless network for data
transition is done using Markov Model M/M/(1,b)/1.

- This work has been dealt with the usage of Queuing Network and extended with Petri net which is an appropriate solution to analyze the system connectivity.

- A novel security mechanism is included which deals with the transformation of a message into a binary image which cannot be identified as a cipher text or stego object. This scheme is very much useful for transmitting a confidential data from client to server and vice versa.

- A Multi Mechanism hybrid model is finally developed to save the client waiting time in the queue, using both wired and wireless technologies, which provide the best performance when compared to existing topology.

**Organization of the thesis**

The First chapter gives an introduction on client-server, Markovian Model, Queuing Network, Petri net, Job scheduling and Network Security. It also discusses the issues of the proposed system relating to information access in the multi mechanism client server.

The Second chapter highlights the various Client Server, Markov, Petri Net and network security techniques and the review of the literature.

The Third Chapter discusses the efficient usage of network devices in a network using Markovian Model.
The Fourth chapter focuses on the queuing network using job scheduling algorithm.

The Fifth chapter explains the need of Queuing Petri Net which is implemented with job scheduling algorithms.

The Sixth chapter deals with the network security mechanism using proposed novel encryption decryption approach.

The Seventh chapter sums up the findings of the researcher with recommendation for multi mechanism client server.

The eighth chapter leads to future enhancement.