# Development of Bandwidth Utilization in a Dynamic Network Environment for Network Resource Allocation Using Neural Network

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## ABSTRACT

Bandwidth is a measure of how much information a network can transfer and receive. It is purchased from internet provider as a periodic monthly expense based on the amount of bandwidth selected by the establishment. Over the years' business owners, organizations, schools etc. that uses internet for their day to day activities have been allocated bandwidth by internet service providers (ISP) using historical data but most times allocation of this bandwidth could be in excess or too small a bandwidth resulting to slowness of internet access and wastage of bandwidth due to lack of a model or platform that assist the ISP in predicting and allocating the exact bandwidth needed by the users, excess of allocated bandwidth leads to wastage of bandwidth. Not knowing those parameters associated to bandwidth allocation and their consumption, limited amount of bandwidth causes slow network performance and slow download and upload speeds, inability to calculate the amount of bandwidth needed by an individual on a network. This paper uses inputted parameters like number of users, service usage either video or audio etc. this input determine the prediction and allocation, Carry out performance evaluation of the proposed system by comparing it with other existing systems. The methodology that was adopted is Object Oriented Analysis and Design Methodology (OOADM). Hypertext preprocessor (PHP) was used for the development while My Structured Query Language (MYSQL) for the database management. After the development the model was able to allocate accurate bandwidth to users.

**Keywords:** Bandwidth, Neural Network, Dynamic environment, Allocation, Prediction

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## 1. BACKGROUND TO THE STUDY

Bandwidth is the data transfer capacity of a network in bits per second (Bps) (Badrinath & Balakrishnan, 2021). Bandwidth is a measure of how much information a network can transfer and receive (Aracil & Morato, 2019). The volume of data that can be transported varies, impacting how effectively a transmission medium, such as an internet connection operates. Internet service providers (ISPs) typically denote bandwidth speeds in millions of bits per second (Bps), or megabits (Mbps), and billions of Bps, or gigabits (Gbps) (Cherry, 2019). Network bandwidth is a measure of the data transfer rate or capacity of a given network (Camillius et al. 2021).

Generally speaking, the higher the bandwidth, the quicker your devices download information from the internet. The amount of bandwidth required to surf the web seamlessly depends on the task the user wishes to undertake. For instance, an instant messaging conversation may use 1,000 bits, or one kilobit, per second in bandwidth. A voice-over internet conversation, in which someone's voice transmits through internet connections, typically uses more than 1 Mbps to 3 megabits per second. Moving further up the scale, standard-definition video takes 1 Mbps, while 4k needs at least 15 Mbps.2 the highest available, 8k, requires speeds of nearly 100 Mbps for seamless viewing. A good bandwidth allows you to transmit and receive the amount of data you need without overloading your connection's capacity. A medium business might require at least 25 Mbps down and 3 Mbps up speeds, while a smaller business could use less. However, the faster your bandwidth is, the better it is for you and your customers (Badrinath & Balakrishnan, 2021).

Chen et al, (2020) stated that the provision of the internet is carried out by specialized operators called "Internet Service Provider" (ISP). These ISPs operate on a different level ranging from continental to metropolitan local or ISPs. Internet service providers, regardless of the level on which they are operating, provide both network infrastructure and the bandwidth to both individuals and the corporate world. The users want the maximum bandwidth at lowest billing, while on the other hand the provider has bulk of bandwidth which can be free at off-peak hours. To distribute the bandwidth among a large number of users ISP uses different mechanism most commonly as static allocation at subscribed peak information rate (PIR). In static allocation, the excessive bulks of the bandwidth cannot produce advantages for both the users and providers. Where on the other hand bandwidth eager users want to browse and download at maximum data rates within their budgets. The above scenario arises as a challenge for the local and regional ISPs, trying to full fill the needs of their users with the best data rates (Choudhury et al, 2018).

Adaramola et al, (2019) stated that Bandwidth allocation is a technique used by ISPs. This involves dividing the total available bandwidth among users based on various factors such as their subscription plan, the time of day, and the type of data they are accessing. For instance, a user with a high-speed plan will be allocated more bandwidth than a user on a basic plan. Similarly, during off-peak hours, when fewer users are online, each user may be allocated more bandwidth. For businesses managing large enterprise networks, network performance is critical for productivity and seamless communication. To ensure optimal operations and user experience, accurately measuring your network's bandwidth is key. Measuring bandwidth goes beyond assessing Internet speed. It involves quantifying data transmission capacity within a given timeframe, essential for capacity planning, identifying bottlenecks, and making informed infrastructure decisions (Allioui & Mourdi, 2023).

Bandwidth can be categorized into four main types based on its usage and characteristics. The following are different modes of bandwidth allocation in a dynamic network:
   i.   Network Bandwidth: This refers to the capacity of a network communication link to transmit data. It is typically measured in bits per second (bps), kilobits per second (kbps), megabits per second (Mbps), or gigabits per second (Gbps).Memory Bandwidth: Memory bandwidth refers to the rate at which data can be read from or written to computer memory (RAM). It is usually measured in bytes per second or gigabytes per second.Signal Bandwidth: Signal bandwidth is the range of frequencies over which an electronic signal is transmitted. It is often measured in hertz (Hz) or kilohertz (kHz) and is crucial in telecommunications and signal processing.

ii.   Radio Frequency (RF) Bandwidth: RF bandwidth refers to the range of frequencies within the electromagnetic spectrum that a communication system can use. It is important in wireless communications, radar systems, and other RF applications. RF bandwidth is typically measured in hertz (Hz), kilohertz (kHz), megahertz (MHz), or gigahertz (GHz).

A dynamic network environment is designed as a dynamic structure in which nodes and edges can be added or removed from the network over time. Resource allocation organizes the technological and human resources available for a project. In a network a resource allocation simply means allocating the necessary sources for a network to function adequately. Over the years business owners, organizations and schools have been allocated excess bandwidth due to the fact that they can't measure the exact bandwidth needed which causes wastage of bandwidth [9], also inadequate bandwidth can cause poor performance of their services. However, accurate bandwidth measurement can be challenging due to network dynamics and various factors, this led to the introduction of neural network based bandwidth utilization prediction and allocation in a dynamic network environment.

This study tends to utilize neural network to predict and allocate bandwidth in a dynamic network environment. Neural networks are a robust tool that businesses use to solve complex business problems. Companies use this form of network to identify patterns and predict rare events like fraud detection. These networks are capable of developing a relationship between non-linear and complex inputs and outputs. This makes them perfect for projects that require data-based decisions to achieve success (Bo et al, 2016).

Over the years different approaches have been used by various authors to predict bandwidth which includes the use of IoT and deep learning. These approaches made significance effort towards the allocation of bandwidth by introducing a communication trial to enhance the bandwidth for IoT-based applications for an ICT-based organization and IoT environment. This trial was achieved only from a communication perspective. Also another approach used was a mechanism to predict the data bandwidth and connectivity between mobile devices. It was able to address IoT devices using machine learning (ML) and deep learning (DL) in IoT environment. Observations showed that the implementation infrastructure comprised only mobile devices. There is need to adopt the neural network because it can process and analyze complex, multifaceted data, can model and learn non-linear relationships in data, which is essential for capturing intricate patterns that linear models might miss.

Neural networks can learn from data, adapt to new information, and improve their performance over time. They can still perform well even when the input data is noisy or has missing values, making them resilient in real-world applications. Neural networks can automatically extract features from raw data, reducing the need for manual feature engineering. Neural networks can leverage parallel processing, especially with the use of GPUs, to speed up training and inference. They can process large datasets with many features, making them suitable for applications like genomics and high-resolution imaging. Finally neural networks can identify subtle patterns and insights in data that might be missed by traditional analytical methods.

## 2. STATEMENT OF PROBLEM

Bandwidth is a measure of how much information a network can transfer and receive. It is purchased from internet provider as a periodic monthly expense based on the amount of bandwidth selected by the establishment. Over the years' business owners, organizations, schools etc. that uses internet for their day to day activities have been allocated bandwidth by internet service providers (ISP) using historical data but most times allocation of this bandwidth could be in excess or too small a bandwidth resulting to slowness of internet access and wastage of bandwidth due to the following:
1. Lack of a model or platform that assist the ISP in predicting and allocating the exact bandwidth needed by the users.
2. Excess of allocated bandwidth leads to wastage of bandwidth. Not knowing those parameters associated to bandwidth allocation and their consumption.
3. Limited amount of bandwidth causes slow network performance and slow download and upload speeds. Inability to calculate the amount of bandwidth needed by an individual on a network

## 3. OBJECTIVES

The main objective of this study is to develop Bandwidth Utilization in a Dynamic Network Environment for Network Resource Allocation using Neural Network. Other objectives are as follows:
1. To design a Neural Network Model for bandwidth utilization in a dynamic network.
2. To develop the neural network based bandwidth utilization prediction and allocation system in a dynamic network environment by using inputted parameters like number of users, service usage either video or audio etc. this input determine the prediction and allocation.
3. Carry out performance evaluation of the proposed system by comparing it with other existing systems.
4. Creating a model that allocate resources in the network

## 4. METHODOLOGY

### 4.1 The Research Design
In this study, the methodology adopted is Object-Oriented Analysis and Design Methodology (OOADM) which attempts to properly define and document the class hierarchy from which all the system objects are created and object interactions are defined. Object-Oriented Analysis and Design Methodology is an effective guide to apply to business problems. In development activity which consists of objects, classes, frameworks and interactions. The use of this methodology helps to produce a better quality software product, in terms of documentation standards, acceptability to the user, maintainability and consistency of software. The choice of this methodology arose from the fact that it decomposes the system into modules where each module in the system denotes an object or class of an object. This methodology full supports software flexibility, modularity and allows for ease in the modification of any segment of the software.

## 5. DATA PRESENTATION
Data gathering for the purpose of this is qualitative methods which includes focus groups, group discussions and interviews was chosen as a choice of method of collection as it tend to use unstructured methods of data collection to fully explore the topic. The following are the methods of data collection used:

a) **Interview:** It involves an interaction between two persons, usually the interviewer and the interviewed. A face to face conversation is established and questions are raised and answers are supplied, with a sole aim of knowing more about the system. In the course of this method, interview was conducted with internet service providers (ISP) MTN to be precise and Evangel University Akaeze was visited to ascertain how bandwidth is been allocated to them. This afforded the chance of obtaining information by conversation. Here, we were able to obtain information directly from the interviewers. Information such how to predict bandwidth for users in the aspect of ISP and also wastage of bandwidth from the side of the users because of lack of adequate allocation of bandwidth.

b) **Observation:** Observation is a systematic data collection approach. Researchers use all of their senses to examine people in natural settings or naturally occurring situations. Observations were notes taking or records gotten by participants without discussion or interaction. With this, the researcher was able to obtain information such as how users download and upload content from the internet depending on the allocated bandwidth.

c) **Internet:** The Internet has appeared to be a very promising medium for researchers. The researcher employed the use of internet to further buttress the research work. With this method the researcher was able to review related literature on the research.

## 6. DISCUSSION OF FINDINGS

This paper presented a model that uses Neural Network based Bandwidth Utilization Prediction and allocation system in a Dynamic Network Environment. From the reviewed related literature there is no means where Neural Network Model of framework was used for calculating and arriving at the appropriate bandwidth utilization, also there is lack of bandwidth utilization prediction and allocation in dynamic network environment. The new system was developed to accommodate two users which are the general users and the administrator. The administrator will register users and also predict bandwidth for users. During prediction and allocation some parameters will be taking into consideration like number of users, service usage either video or audio etc. this input determine the prediction and allocation. The system uses Neural Network Model or framework for calculating and arriving at the appropriate bandwidth utilization of an individual in a dynamic network. The user will login to view allocated bandwidth and also update his or her profile. Figure 1 describes the complete processes of the new system and how information is navigated from one user to another.
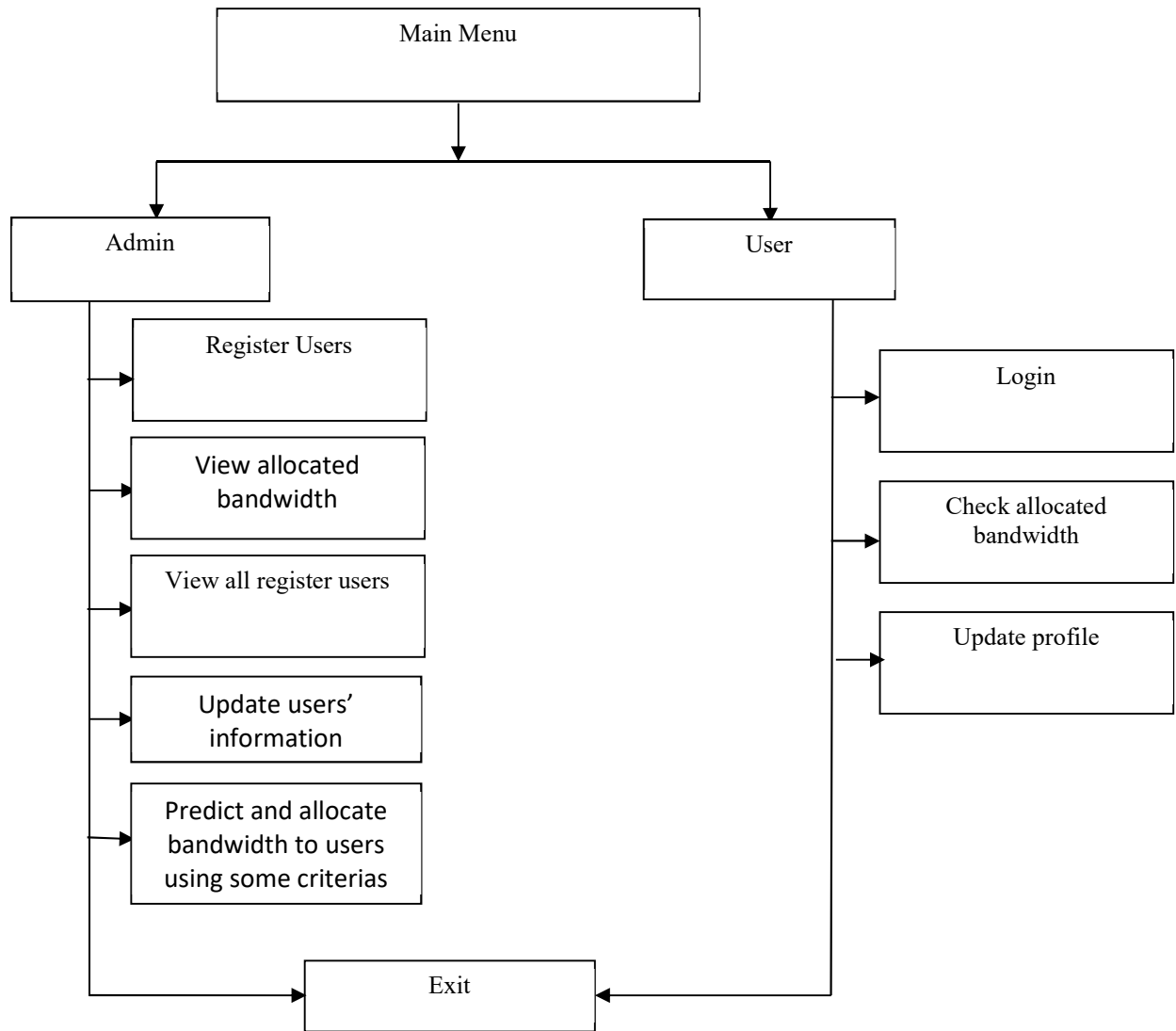
**Figure 1: High Level Model of the New System**

Figure 1 is the high-level model of the proposed system; here there are two users which are the general users and the administrator. The administrator will login with a specified username and password to access the system, if access is granted successfully the admin will be able to allocate bandwidth to users by inputting the number of users that will be surfing the internet, also the nature either is Volp, videos or streaming, the system will now use this criteria to predict the bandwidth for the user.   The McCulloch-Pitts neural model frameworks, which were the earliest ANN model, have only two types of inputs Excitatory and Inhibitory. The excitatory inputs have weights of positive magnitude and the inhibitory weights have weights of negative magnitude. The inputs of the McCulloch-Pitts neuron could be either 0 or 1. It has a threshold function as an activation function. So, the output signal yout is 1 if the input ysum is greater than or equal to a given threshold value, else 0. The diagrammatic representation of the model is as follows:
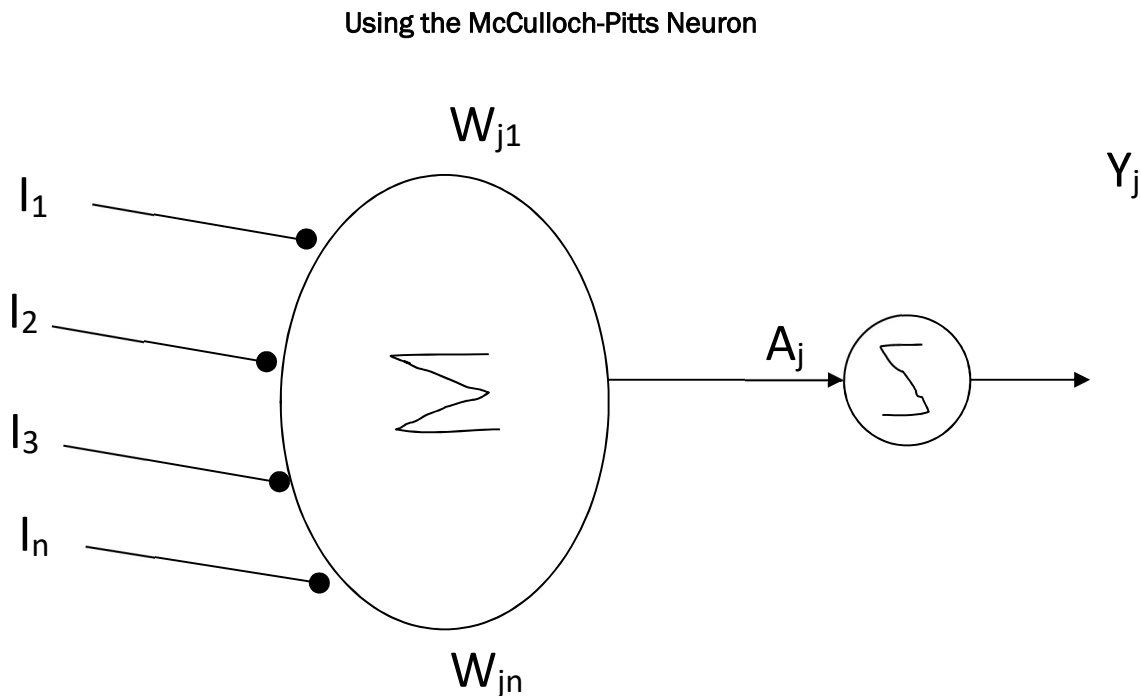
Using the McCulloch-Pitts Neuron



Figure 2: The McCulloch-Pitts neural model frameworks (Warren, McCulloch, and Walter Pitts)

Where $I_1$ ---- $I_n$ e=represent the parameters
$W_{J1}$ ---- $W_{jn}$ represent the weight of the parameters that is the bandwidth size, $A_j$

The summation of bandwidth size determine the allocation which is $A_j$ then utilized by $Y_j$
In summary, the author developed a bandwidth prediction and allocation system in a dynamic network environment. Many applications have been developed for the purpose of bandwidth prediction. There are two users to the application which are users and the administrator. The administrator enters some parameters to the system while the system uses these parameters to predict the actual bandwidth to be allocated.

## 7. CONCLUSION REMARKS

With the explosive growth of the Internet and of private networks related to it, the number of new demands has significantly increased. Low-volume Telnet conversations have been replaced by high-volume Web traffic and audio/video real-time applications that require an even higher network quality of service. In order to deal with these demands, we need not only to increase the capacity of the Internet but also to adopt accurate mechanisms to control the traffic.

## 8. CONTRIBUTION TO KNOWLEDGE

These paper was able to utilized Neural Network Model or framework for calculating and arriving at the appropriate bandwidth utilization of an individual in a dynamic network, using neural network based bandwidth utilization prediction and allocation in a dynamic network environment and finally in this paper inputted parameters like number of users, service usage either video or audio to determine the prediction and allocation. Performance evaluation of the proposed system was carried by comparing it with other existing systems.

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