COMPUTOLOGY: Journal of Applied Computer Science and Intelligent Technologies
Volume 3, Issue 1, Jan-Jun 2023, pp. 61-69
DOI: 10.17492/computology.v3i1.2306
https://www.journalpressindia.com/cjacsit

An Integrated Framework using ATM and 5G Concepts for Next Generation Enterprise Network

Deepty Dubey and Thipendra Pal Singh***

ABSTRACT

Nowadays the usage of multimedia and real time applications is commonly increasing on the same platform. Asynchronous Transfer Mode (ATM) technology has become accessible in this period. To put its concept simply, 5G (fifth generation) is a digital cellular technology that will greatly improve upon 4G. Classical Transmission Control Protocol (TCP) over ATM concept is one way that approach will increase the use to overcome internet connectivity and technical challenges. Here the research objective is to develop an integrated framework that supports the NextGen enterprise network by utilizing ATM and the 5G concept. In this paper, a new framework has been described that separates TCP applications from quality of service considerations and includes the Energy-Aware Hybrid Lion-Whale Optimal Routing Protocol (EAHL-WORP). The experiments in this paper were carried out on NS-2. End-to-end delay, throughput, and packet delivery ratio are performance indicators that are compared to the existing approach and achieve the improved results.

Keywords: Asynchronous Transfer Mode (ATM); Transmission Control Protocol (TCP); Quality-of-service (QoS); Energy-Aware Hybrid Lion-Whale Optimized Routing Protocol (EAHL-WORP); 5G (fifth generation).

1.0 Introduction

Computer networks are becoming a necessary component of the way we run our daily business. On occasion, newer network technologies are sought to suit the continuously growing need for high bandwidth and little delay over great distances. Many high-speed network approaches have been developed to meet these needs. Often, networks are created based on the kind of data that will be delivered. Commercial switching phone networks with high-speed digital transmission facilities are two examples of switch networks that were once widely used to transmit moment data like voice and video. Users of the network can choose a networking technology to meet their needs for a particular communications application, however, the majority of businesses support a variety of applications. As a result, the majority of businesses are compelled to manage several networks, which leads to some inefficiency and rising communication costs [1]. Channel bandwidths of 5-20MHz or possibly up to 40MHz, speeds of at least 100 Mbps in motion and 1 Gbit/s in static conditions, an all-IP predicated packetized network, and the capacity to switch between many distributed networks concurrently are

**Corresponding author; School of Computer Science, University of Petroleum and Energy Studies, Dehradun, India (E-mail: deeptydubeys@gmail.com)*
***School of Computer Science, University of Petroleum and Energy Studies, Dehradun, India (E-mail: tpsingh@ddn.upes.ac.in)*

all required, 4G is defined by the International Mobile Telecommunications Advanced (IMT-Advanced). 5G is an emerging mobile communications technology that will improve upon 4G in a variety of ways, including speed, capacity, communication efficiency and the speed at which data may be transferred. Data transmission rates of above 1 Gbit/s, and support for tens of thousands of users are requirements set by the NGMN for 5G, multiple simultaneous connections, and signaling and spectrum efficiency that is higher than 4G [2].

The current industrial networks, however, were created for production processes that are static and require time-consuming maintenance procedures when they change. It's important to note that different traffic flows are routed through various industrial environments, each of which may have QoS characteristics that compete with one another. Present industry actors are unwilling to share production data with stakeholders due to the risk of losing crucial data, therefore higher security standards are also required. They are confident that the 5G mobile system's powerful software-based network programmability characteristics, together with other relevant technologies, will be crucial in allowing the sector to find success beyond the realm of Industry [3].

Although different ATM Adaptation Layers (AALs) are optimized for different classes of traffic, this does not mean that AALs intended for one class of traffic cannot be utilized for another, as this is not specified in the standards. Most activities at the ATM Forum have centered on AAL, and several ATM equipment manufacturers currently produce solutions that employ AAL to enable all of the aforementioned types of traffic. While there is some research on how different Adaptation Layers and the applications they carry can affect network performance, this area of study is still in its infancy. Hence it's a major challenge to design 5G network structures that minimize energy utilization. Energy-aware hybrid lion-whale optimized routing protocol (EAHL-WORP) is presented in this research, which details a 5G network design.

The following are the organization sections of this research: Section I has the introduction; Section II contains the literature review; Section III contains the proposed methodology; Section IV contains the results and discussion; and Section V contains the conclusion.

2.0 Literature Survey

The research [4] discussed the Differentiated QoS (DQoS) standards, which are networking protocols, methods, or standards that attempt to provide customized connections to paying users on a public network. A study [5] introduced 5G cellular networks that create a technology standard for high-speed, low-latency connection. Because it is readily available, it outperforms ATM technology in terms of cost, and 5G networks will provide democratized robotic telesurgery.

The research [6] evaluated the relative merits of TCP/IP and asynchronous transfer mode. To completely implement these integrated systems using TCP/IP, new network architectures must be created in a 5G environment that communicates with current standards, interfaces, and higher-layer protocols without any issues. For the transport of massive amounts of satellite data, a novel architecture based on Synchronous Digital Hierarchy (SDH) technology is suggested [7]. Service classes and the Adaptation Layers (AAL) between ATM and variable-length packet protocols that employ ATM provide quality of service. The AAL contains the information needed by the destination to reassemble the cells back into the original message [8].

The system comprises terrestrial networks, inter-satellite launchers (ISLs), stationary and mobile earth stations, handheld devices, portable devices, and satellite connections made using SDH, IP, ATM, or another network protocol. Study [9] provided an overview of the evolution, standardization, and implementation of ATM network service technologies and the underlying architecture concept and then the convergence of ATMs and the Internet Technologies employed in server system networks and their strategy and operation were the focus of the study [10]. At the same time, data sets are organized into diagrams that resemble computer networks.

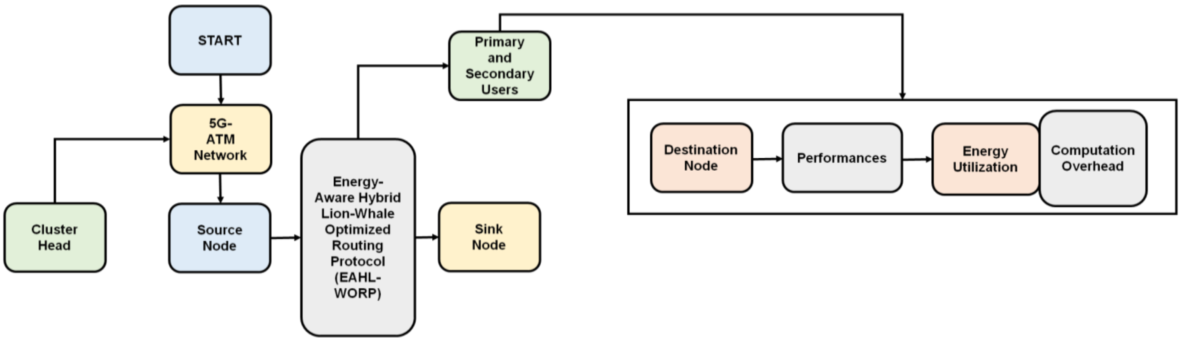
Table 1: Summary of Existing Ways to QoS for ATM, 5G and TCP/IP

References	Network System	Impact on Networking	Probable work on Networking
Obiodu et al. [4]	5G Network Slicing and Layer 2/3 technologies	Highest chance of success in the short/Medium term	Highest running within a single service provider's domain
Pawar et al. [6]	5G Network Slicing and ATM	Effective system proposal	No effective results
Dubey et al [7]	SDH technologies for 5G and ATM	Effective System proposal	No security features
Aju et al [8]	ATM Layers	Impact of ATM adaptation layers	Only ATM features
Ohnishi et al [9]	Issues in ATM network	ATM service network	Only on ATM deployment and standardization
Gaddam et al [13]	Weighted Round Robin (WRR) scheme	throughput and average end-to-end delay	Only for ATM

2.1 Proposed methodology

The framework of the proposed work is described in this section. The proposed workflow is depicted in figure 1. For effective communication in 5G networks, we have suggested an Energy-Aware Hybrid Lion-Whale Optimized Routing Protocol (EAHL-WORP) over Asynchronous Transfer Mode (ATM) architecture.

Figure 1: Flow of Proposed Methodology



2.2 Deployment of a 5G ATM network

Time Division Multiplexing (TDM) is used in the ATM system of data transfer. Connection-based ATM networks are used in cellular relay systems. Moving around files like songs, pictures, and data is simplified. After being stored in tiny cells of a consistent size, the data is having the responsibility of the selected Cluster Head (CH) to transmit data to the base station. The system is partitioned into clusters in advance of the rollout of the 5G ATM network. Each cluster has its CH as well as several other members. CHs are responsible for facilitating the transfer of data, the collection of information, and the integration of data among nodes that belong to the same cluster. This is when the CHs connect so that information may be sent from sender to receiver. The transmitter gathers information from a fully functional 5G ATM network that can be accessed by both secondary and main users. Thereafter, the EAHL-WORP protocol is called into action, which ultimately leads the original sender back to the original destination. The information is then sent to the "sink" node. One type of node known as a "sink node" collects information from other nodes. Finally, the recipients receive the information and view the output.

2.3 Cluster Head (CH)

The CH in a typical cluster-tree WSN is responsible for interacting with other CHs and passing along information from cluster nodes. As a result, network pathways degenerate or may be rendered inoperable due to their high energy consumption and limited lifetime. Algorithm 1 represents the Cluster Heads.

The base station of the 5G ATM network is deployed and then selection of cluster head is done, which transfers the information to the base station of the 5G ATM network. At first, before deploying the 5G ATM network, the network is split into a group of clusters. Each cluster is a blend of several cluster individuals and a single cluster head (CH). The responsibilities of cluster heads are data sending, data collection, and integrating data among every node of a similar cluster. CHs at that point interact with one another to communicate the collected data, from the sender to the receiver.

Algorithm 1: Cluster Head

The Sink node (SN) sends the location information to the CH closest to it.
As the FCH, the corresponding CH is selected to further data detection.
if the MS is not the previous node of the forwarded CH
Fix each Forwarded CH←← Sink node in turn.
The route update packet is transferred to the previous Forwarded Cluster Head by the forwarding cluster head.
Alter the next forwarding cluster head based on the outer grids' shortest distance.
FCH updates the routing data and sends it to the next CH.
Each downstream CH accepts route update packets.
{if the CH's previous subsequent node is not the existing receiver}
{Modify each CH node for the existing receiver.
if another CH downstream is indeed not NULL
Repair the existing cluster head on the transmitter.
The current cluster head passes the data to the future CH.}
else
Remove the erroneous data packet}

2.4 Energy-aware hybrid lion-whale optimized routing protocol (EAHL-WORP)

To choose the best channels for secured communication, the presented model combines the Lion Optimization Algorithm (LOA) and Whale Optimization Algorithm (WOA) models. It presumptively takes into account a variety of QoS factors, including energy, trust, and distance. A collection of likely routes is discovered between two nodes when the approach establishes the QoS and security variables. This model's goal is to select the optimal route out of all the ones that have been investigated while also achieving all the various goals that are supposed to go into a secure routing. By combining LOA and WOA, the update rules are generated. The social behavior of lions, which includes defending territory, claiming territory and using lagging lions, and pride, served as inspiration for LOA. Following that, WOA imitates the bubble net hunting style of humpback whales. Using the update rule of LOA in WOA, the Lion- Whale Optimization (LWO) model created optimal solutions that provide secure routing paths with energy awareness. Here, Energy-Aware Hybrid Lion-Whale Optimized Routing Protocol (EAHL-WORP) model's underlying mechanisms are described.

2.4.1 Initialization

A randomized initialization of the whale population W*j* with n alternatives is performed as the first step of the EAHL-WORP method. It is possible to characterize any solution W*j* as

$$W_j = \{p_1, p_2, p_n\} W_j = \{p_1, p_2, p_n\} \quad (1)$$

The $jthjth$ solution in W*j* is p_j. Two vector variables, B and I must be set to zero even during the method's startup phase.

2.4.2 Validation of fitness

The following step, which requires computing fitness, is to determine which choices are the best. Any given solution in a population is evaluated based on its multi-objective fitness, which is calculated by maximizing a set of 5 objectives. Before starting, the best search agent is the one whose answer has the highest fitness among the existing population, as the location is unknown.

2.4.3 Location estimation and updating

EAHL-WORP will then modify the locational hunting features such as proximity to prey, bubble-net assault, and looking for prey once the optimum agents have been selected.

$$G = |I.W^*(k) - W(k)| G = |I.W^*(k) - W(k)| \quad (2)$$

Where $GG$the distance is the vector and $W^*(k)W^*(k)$ is the ideal search agent's location vector in the first round. WOA's location vector at round $k+1k+1$can be expressed as

$$Y(k+1) = Y^*(k) - B.GY(k+1) = Y^*(k) - B.G \quad (3)$$

In this case, B and I are vector variables defined as

$$B = 2c * v - cB = 2c * v - c \quad (4)$$

$$I = 2 * vI = 2 * v \quad (5)$$

Where *c* is a random variable generated in the range [-2, 1], and c is gradually decreased from 2 to 1 throughout several iterations (0, 1). The WOA uses a method called spiral bubble-net attacking to update the location during the assaulting or exploiting phase. A key factor is how far away the agent is from the target. Then, it comes up with a plan inspired by the helix-shaped behavior of whales.

$$W(k+1) = G'.e^{q^f}.cos\,cos(2\pi f) + W^*(k)W(k+1) = G'.e^{q^f}.cos\,cos(2\pi f) + W^*(k) \quad (6)$$

Range $f\,f$ between the number one search units and the prey is represented by the number $G' = |W^*(k) - W(k)|G' = |W^*(k) - W(k)|$, where G' is an integer from the range. Since whales move in a continuous spiral motion and constantly round one another, this characteristic serves as the basis for the numerical method.

$$W(k+1) = \{\vec{w} * (k) - B.G; if h < 0.5G'.e^{q^f}.cos\,cos(2\pi f) + W^*(k); if h \geq 0.5$$
$$W(k+1) = \{\vec{w} * (k) - B.G; if h < 0.5G'.e^{q^f}.cos\,cos(2\pi f) + W^*(k); if h \geq 0.5 \quad (7)$$

Where h is picked at random from the range. The presented model employs the LO update rule, as shown below, to improve the search space.

$$W(k+1) = W(k) + \left(0.1_{g_2} - 0.05\right)\left(W^*(k) - g_1W(k)\right)$$
$$W(k+1) = W(k) + \left(0.1_{g_2} - 0.05\right)\left(W^*(k) - g_1W(k)\right) \quad (8)$$

Where g_1g_1 and g_2g_2 are arbitrary values in the range.

$$W^*(k) = W(k+1) + B.GW^*(k) = W(k+1) + B.G \quad (9)$$

When $W(k)W(k)$ the location vector is for this round and $W(k+1)W(k+1)$ is the location value for the subsequent round. This means that in 5G networks, Concurrent Multipath Transfer is no longer necessary. To facilitate low-power data transport in 5G networks, we proposed combining the EAHL-WORP algorithm with the standard TCP protocol.

3.0 Result and Discussion

Network Simulator-2 (NS-2) measures the suggested protocol's effectiveness. The suggested method EAHL-WORP is compared to the existing protocol like As Enhanced Energy Zam-Zam Transmission Control Protocol (EEZZTCP), Multi-protocol Label Switching-Ant Colony Optimization (MPLS-ANT), and Integrated Speed Bit Protocol (ISBP). Simulation results show the suggested methodology improves the state-of-the-art in every relevant statistic. PDR, end-to-end delay, and throughput measure system efficiency. Table 2 depicts the characteristics of the simulation. Table 3 depicts the performance analysis of the proposed and existing methods in the research.

Table 2: Updating the Simulation's Characteristics

Parameters	Values
Count of nodes	20
Simulator	NS 2.35
Simulation Time	150 s
Propagation	Two ray ground
Channel	Wireless
Types of Queue	Priority Queue
Mobility design	Random waypoint
Length	50 packets
MAC	802–11
Packet size	1024 bytes

Table 3: Performance Analysis of the Proposed and Existing Methods

Methods	PDR (%)	E2E delay(s)	Throughput (kbit/sec)
EEZZTCP[11]	89	40	70
MOLS-ACO [12]	92	35	90
ISBP [13]	85	25	130
EAHL-WORP [Proposed]	99	18	150

This is determined by comparing the number of data packets the sender involves sending to the number of packets the recipient receives. The performance of the protocol is compromised when packet loss is at its highest level. The formula is as follows (10):

$$PDR(\%) = \frac{\sum \; No\ of\ the\ packet\ received}{\sum \; No\ of\ packet\ sent} * 100PDR(\%) = \frac{\sum \; No\ of\ the\ packet\ received}{\sum \; No\ of\ packet\ sent} * 100 \quad (10)$$

Figure 2: Pack Delivery Ratio Performances Analysis of Proposed and Existing Methods

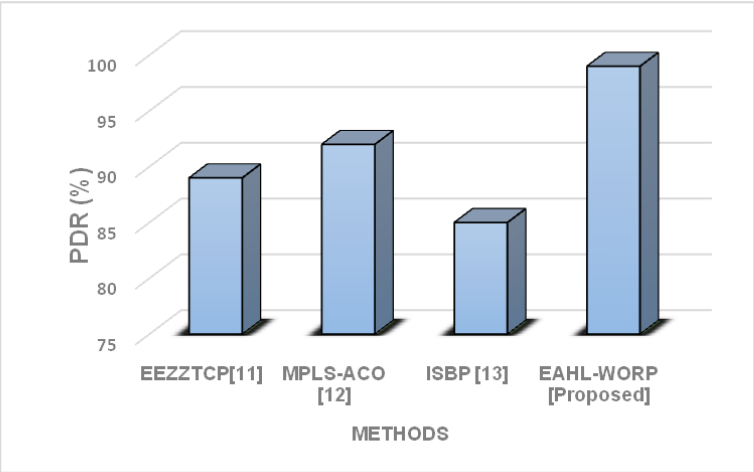


Figure 2 compares the PDR for the present and suggested approaches in terms of percentages. It is clear from comparing the proposed method to the existing approaches that it has a greater packet delivery ratio.

It's the cumulative data transfer between the network's nodes, through the transmitter to the receiver. Bits per second or packets per second are common ways to represent it. The throughput must be comparable to get better results. The throughput value is calculated using (11).

$$Thoughput = \frac{Packets\ received}{final\ packet - Initial\ packet} Thoughput = \frac{Packets\ received}{final\ packet - Initial\ packet} \quad (11)$$

Figure 3 depicts the comparison of the throughput. As shown in the graph, the suggested method offers a greater throughput when compared to current techniques. It is the typical amount of time needed for a successful transmission of data packets over a network from the source to the recipient. It includes, among other things, the sum of processing, queuing, and end-to-end (E2E) delays. Seconds are used to measure it. It is estimated (12): As stated in the equation:

$$E2E\ delay = \frac{\sum \; arrive\ time - sendtime}{\sum \; number\ of\ connection} E2E\ delay = \frac{\sum \; arrive\ time - sendtime}{\sum \; number\ of\ connection} \quad (12)$$

Figure 3: Throughput Performances Analysis of Proposed and Existing Methods

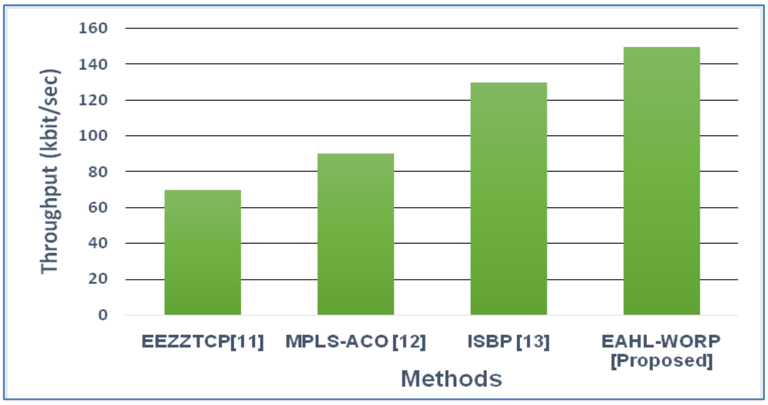


Figure 4: E2E Delay Performances Analysis of Proposed and Existing Methods

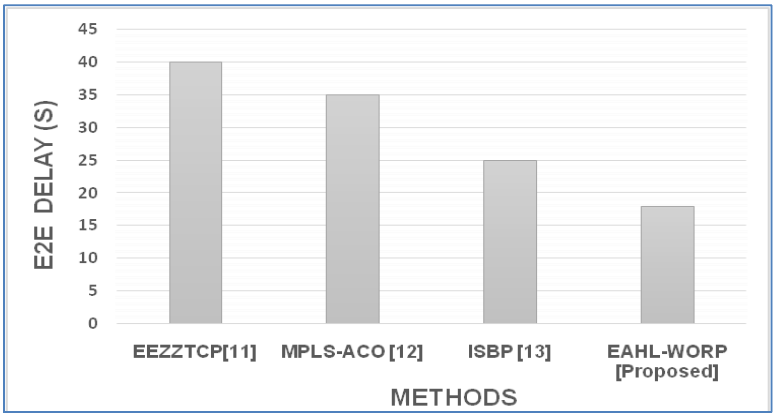


Figure 4 compares the E2E delays in seconds of the current and suggested techniques. As it can be seen in the graph, the suggested protocol results in noticeably less time spent in waiting for data to be transmitted than competing protocols. The energy-efficient indicator EEZZTCP is critical to the success of 5G development efforts. As a direct consequence of this, the challenge of designing 5G network topologies that are also efficient in terms of energy consumption is a significant one [11]. MPLS-ANT, which employs a cell switching technology to transport data to the location of the user's choosing, is regarded as a potentially useful method. Unfortunately, ATM performance is restricted by several reasons, including the complicated switching procedure, congestion, and queuing latency [12]. The primary cause for concern regarding the ISBP architecture is the delay that is being created by huge volumes of workloads at the wireless source nodes. So, to solve the identified issues, we presented the EAHL-WORP for 5G network frameworks, which primarily focuses on essential QoS measures in the model of 5G systems.

5.0 Conclusion

An energy-aware hybrid lion-whale optimized routing protocol (EAHL-WORP) has been devised by us for effective communication in 5G communication networks. The 5G ATM network utilizes the EAHL-WORP algorithm to examine QoS metrics. With the help of the NS2 simulator, the network was simulated, and performance metrics like packet delivery ratio, throughput, and E2E delay were examined. About these QoS metrics, we contrasted the suggested technique with several already-in-use protocols. An EAHL-WORP was proposed, and its results were 99% of PDR, 15s of E2E delay, and 150 kbit/sec of throughput. We found that every metric showed the suggested strategy to be superior to the current protocols. This indicates that it can be used for many real-time 5G applications and is considered to be a dependable protocol for communication in 5G access networks. Providing protocols to reduce resource complexity and handle functionality as well as security issues may be the focus of future research.

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