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Framework of ATM Architecture Deliberation and TCP/IP Performance for 5G Network: An Overview

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Abstract

Rapid advancements in ATM and communications technology will create a plethora of new opportunities for value-added services. Video conferencing, audio/video transmission, and high-resolution image documents are just a few examples of interactive as well as distribution services. Current network communication trends indicate that new services are being prioritised over point-to-point data communications. Mobile services, direct broadcasting, private networks and hybrid high-speed networks are all gaining popularity. These networks would be developed on satellite fibre-linked networks. It is necessary to design new network designs that interact easily with current standards, interfaces and higher-layer protocols in a 5G environment to fully implement these integrated systems utilising TCP/IP.

Keywords: *ATM Technology, TCP/IP, Network Communication, 5G Network*

I. INTRODUCTION

As ATM technology becomes more extensively utilised, it is critical to connect geographically distant ATM networks. While ATM technology has been developed to allow end-to-end connectivity and statistical multiplexing through terrestrial networks, satellite-based ATM systems will be important to attaining global connection and statistical advancements in multiplexing while satisfying QoS requirements. The ATM paradigm aims to address the unique needs of a wide range of traffic sources while also delivering efficient and cost-effective transportation and switching services.

Satellite ATM networking is becoming more widespread as a result of the multiple advantages that satellite communications technology provides [3, 8]. “These advantages include (a) extensive geographic coverage, including ATM island interconnection; (b) multipoint-to-multipoint communications enabled by satellites' inherent broadcasting capability; (c) bandwidth on-demand or Demand Assignment Multiple Access (DAMA) capabilities; and (d) a disaster recovery alternative to fibre optic networks.”

Satellite systems, on the other hand, are hampered by a variety of fundamental restrictions. The resources of the satellite communication network, especially satellite and earth station, are costly and must be utilised carefully. A key concern is the substantial end-to-end delay associated with satellite communications. Aside from interoperability concerns, a transport layer protocol like as TCP must overcome a variety of performance challenges before it can properly function on satellite-ATM networks with high delay-bandwidth. The delay-bandwidth product is intricately tied to a connection performance using an acknowledgement and timeout-based congestion management approach (such as TCP's). As a consequence, congestion management issues in

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broadband satellite networks differ from those in low-latency terrestrial networks.

Performance improvements may be handled from two perspectives: network and end-system designs. The network may use several layer-level methods to optimise resource usage, fairness, and throughput. Only a few advances include feedback control, smart drop rules to maximise use, per-VC buffer management to ensure fairness, and even minimum throughput guarantees to upper layers[9]. The transport layer may utilise a range of congestion avoidance and management techniques to boost performance and prevent congestion collapse. At the transport layer, there have been various suggestions and implementations of congestion control systems. TCP employs slow start and congestion avoidance methods, as well as quick retransmission and recovery and selective acknowledgments [14].

The networking community is continually inventing new technologies and enhancing old ones to enhance data networks' quality, dependability, and 'flexibility.' When Internet Option Providers (ISPs) seek to provide "flexibility" and sell it to end customers as a premium service above "best effort" connections, they either fail to overcome net neutrality or struggle to acquire commercial momentum. This paper will employ Differentiated Service Quality (DQoS) standards. They are networking protocols, techniques or standards that enable clients on a public network to get customised connections.

This paper contributes significantly to resource utilisation optimization, fairness, and enhanced layer throughput by building a framework for TCP/IP over ATM architecture. To have a better understanding of the D QoS standards' objective. To begin, it examines their technoeconomic market trajectory to determine what factors contribute to their success. While the underlying technical aspects of D-QoS standards vary widely, the concept and purpose of all D-QoS standards is to utilise them to deliver a guaranteed connection that consumers willing to pay for. As a result, we combined transport layer technologies (such as ATM and Frame Relay), signalling technologies (such as RSVP), data packet markers (such as IP ToS, WME and QCI) and end-to-end separation solutions (e.g., Leased lines, Network Slicing). Second, we suggest that despite the inherent technological differences between Network Slicing and prior D-QoS standards, commercial performance of Network Slicing may end up equal to prior D-QoS standards compared to 5G Network Slicing. D-QoS testing suggests that enterprise-focused 5G slices operating inside the realm of a single service provider and controlled by service-level agreements will have the highest chance of success in the short/medium term.

Future 5G mobile communication systems will almost probably contain a satellite component in addition to a variety of radio access techniques. High-throughput satellite (HTS) systems and new mega-constellations that match 5G specifications for high bandwidth, low latency, and wider coverage, including rural regions, airways, and oceans, may help enhance 5G terrestrial services. The suggested 5G satellite network design simplifies interaction with terrestrial 5G network. Furthermore, a new methodology based on network coding is being researched in such a combined satellite-terrestrial system allowing simultaneous usage of different pathways. For TCP-based applications, an analytical model is offered to gain the ideal traffic split across terrestrial and satellite pathways and the highest degree of redundancy Satellite (HTS) systems and new mega constellations that meet 5G criteria for high bandwidth, low latency, and larger coverage, including rural areas, airways, and seas, may aid in the improvement of terrestrial services in the context of 5G. The proposed architecture for 5G satellite networks makes integration with the terrestrial 5G network simpler. Furthermore, in such a combined satellite-terrestrial system, a novel approach based on network coding is being studied for the simultaneous use of several paths. An analytical model is provided for TCP-based applications in order to acquire the optimal traffic split between terrestrial and satellite paths, as well as the greatest level of redundancy.

II. OBJECTIVES

The main contribution or objective of the proposed research work is given below:

- Analysis of data transfer efficiency in TCP/IP over ATM architecture for an enterprise network.

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- To develop 5G network architecture that interoperate with existing standards, interface and higher-level protocols.
- To evaluate TCP/IP performance over ATM Architecture using 5G network framework.
- Optimization of resource utilization, fairness and higher layer throughput using congestion control mechanism.

III. RESEARCH MOTIVATION

Current network communication patterns imply that new services are being prioritized over point-to-point data transfers. All are becoming more popular with mobile services, direct broadcasting, private networks and high-speed hybrid networks. These networks would be built on satellite fiber networks that would be connected together. Advanced 5G network designs must be created that interact smoothly with current standards, interfaces, and higher-layer protocols in order to fully realize these integrated systems.

The requirement for connecting of geographically scattered ATM networks through terrestrial networks has become evident as ATM technology has been more widely used. In order to preserve Quality of Service, improvements in global connectivity and statistical multiplexing will be compromised (QoS). Satellite systems, on the other hand, are hampered by a variety of fundamental restrictions. As a result, it's crucial that it's adaptive and scalable.

The significant end-to-end propagation delay associated with satellite links is a key concern. Apart from interoperability issues, a transport layer protocol like TCP must overcome a number of performance issues before it can operate successfully on satellite-ATM networks with high delay-bandwidth. The connection performance employing a delay-bandwidth product is intrinsically linked to the recognition and timeout-based congestion management (e.g. TCP's). This will make it harder to manage congestion on low-latency terrestrial networks.

Where ISPs strive to provide "flexibility" as a premium option above "bEST effort" connections and sell them freely to end-users, they either fail to overcome difficulties of net neutrality or are struggling to gain financial traction. The technological design and implementation of the D-QoS standards vary widely. Because of this variability, it is almost difficult to compare them in technical literature. For instance, the technical similarities between ATM and 4G QCI are insignificant. Similarly, it will be impossible to compare the end-to-end isolation concept of 5G Network Slicing with most earlier D-QoS standards. In terms of business, however, all D-QoS standards are remarkably similar in that they are all intended to ensure that customers are prepared to pay for the connection. In other words, Leased Lines and 5QI are analysed together as D-QoS standards despite their major technological variances since they share a commercial aim. The goal of this paper is to combine this technical difference with business realities in order to develop a framework that can be utilised to give insight to both technical and commercial stakeholders.

IV. LITERATURE REVIEW

Various aspects of the ATM networks are discussed in numerous books, reviews, and papers of which [5-7] deserve mentioning. From the standpoint of routing, the ATM-network can be considered as a typical packet switching network with preliminary establishment of a virtual connection for each arriving message. Therefore, in contrast to the classical channel switching networks, the ATM-networks enable efficient use of the network resources. On the other hand, the ATM-networks are characterized by essential distinctions form the classical packet switching networks. Let us take a brief look at the specificity of the ATM-networks which defines the specificity of the routing algorithms employed.

In recent years, service integration has been one of the most investigated areas in communication network engineering. The Asynchronous Transfer Mode attracted much attention[32]-[37] as a particularly successful way for creating an interconnected service grid. ATM separates the data into smaller, fixed cells that are

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specified as stream IDs and delivered via the network in a fashion similar to a multiplex packet switch. This information transport methodology allows the network to manage a broad range of data bit rates and diverse traffic kinds with various statistical characteristics [32]-[35]. This offers cost-effective service integration across an ATM-based network.

The idea of "virtual route," a cheap approach of establishing an ATM network, has been given [34]-[37]. The virtual route is a collection of virtual circuits equal to digital routes in synchronous transfer mode (STM) network(s)[38],[39]. The strategy [35]-[37] is all advantageous if you want to simplify the node topology, reduce node processing and regulate the routing and bandwidth.

According to Romanow et al.[29], TCP connection over packet-based networks over ATM networks with UBR service is much superior than TCP connections. TCP efficiency over ATM may be rather small, given their simulated results, when cells have been discharged because to network congestion. The poor performance of cells from corrupted packets is caused by bandwidth waste over the overcrowded channel. As already said, they have proposed the approach for Early Packet Discard to enhance TCP performance over ATM networks and also a simulated EPD study.

In the simulated assessment of TPC performance over over the overloaded ATM networks, Fang et al. [28] employed a variety of congestion management solutions, including a UBR service, a credit-based flow control process that backpresses certain virtual circuits and two select cell drop procedures. The ATM Forum does not however recommend credit-based flow administration for ABR services. The results of our simulations are based on an explicit price structure for regulating the congestion of ABR services. The performance of binary rate schemes that are less expensive than EPD systems is analysed further. [28] The drop-tail and drop-whole approaches have also been taken into consideration and they need to be buffered by VC. The drop-tail approach removes the cells from the VC when the queue is complete; the cells in the queue are also destroyed until an EOM cell is reached. Not only does the drop-out system lose a packet's tail but also the cells in the queue that is part of the same packet. It was shown to work miserably, contrasting to selective cell drop approaches, when TCP is used in connection with UBR basic service.

The interest in incorporating a satellite in the 5G ecosystem is developing now. ESA has stated that the ARTES 5G satellite programme would be launched, including development projects, service testing and test beds to enable the 5G satellite component to be implemented. Moreover, the EU European Technology Platform NetWorld 2020, which obeys 5G system research and development in the EU, has issued white papers that employ the satellite as a 5G radio access network. The EU-funded 5 G Public-Private Partnership (5GPPP)[30] is another significant endeavour to create future satellite 5G networks.

A regulatory definition on '5G system Service Requirements' was issued in the Third-Generation Partnership Project (3GPP), which includes fixed, mobile, wireless and satellite access technology. Release 15 is the first 3GPP standard for 5G systems supporting multiple RANs (Phase 1). Release 16 (phase 2), starting in late 2018, will carry on this development. The Chinese Communications Standards Association (CCSA) is already implementing a 5G global 3GP standard. ITU-R Working Group 4B is actively engaged in the development of 5G integrated satellite-terrestrial systems as part of the International Mobile Telecommunications - 2020 initiative (IMT-2020). To define a technological roadmap for 5G systems and beyond, the IEEE has initiated the Future Directions Initiative (which includes a 5G satellites working group). Founded in September 2017, the 5G India 2020 Forum aims to define the country's plan for adopting newer technologies by 2020. The Indian Telecom Regulatory Authority (TRAI) already had a sweeping look at 5G satellite service spectrum concerns.

V. METHODOLOGY

A novel architecture for a large amount of satellite data transport is presented which based on 5G technology,

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General framework shown in Figure1. This architecture consists of terrestrial networks, ISL satellites, fixed earth stations, portable and handheld terminals, and satellite connectivity terminals connected directly and indirectly to IP, ATM or other network Protocol. Datagrams such as cells and IP (internet protocol) ATM (asynchronous transfer mode) may be sent over networks between the satellites. The IP or ATM protocols may be used by any sort of ground terminal to interact directly with satellites.

A variety of options for the TCP/IP data transmission across a satellite ATM network are provided by existing and upcoming ATM standards. TCP/IP beat ATM in both cost and performance, the three service types – ABR, UBR and GFR – and their associated implementation possibilities. Consider the following criteria when comparing service types:

- Implementation Complexity
- Buffering requirements for switches and ATM end systems
- Network bandwidth utilization
- Bandwidth allocation

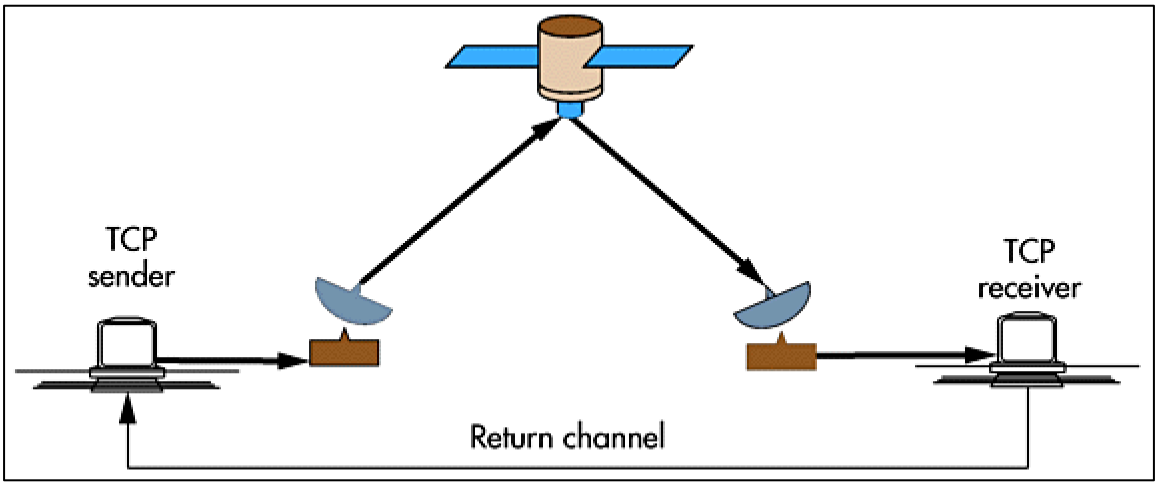

Figure 1: TRANSMISSION OF TCP/IP DATA OVER A SATELLITE ATM NETWORK

5.1 Implementation of Virtual Path Bandwidth Algorithm

The following is the basic method for managing the virtual path bandwidth: If the current bandwidth is not sufficient to connect the incoming call to the end node, the request bandwidth will be increased by a predefined amount. Increase and establish a virtual call circuit when extra bandwidth is available, else preserve the existing capacity and deny call. If possible, reduce the bandwidth by a certain step in response to the conditions of virtual route use. Figure 1 represents the whole structure of implementation, while Figure 2 shows TCP/IP network traffic through an ATM satellite.

Depending on the methodology, the steps to alter the bandwidth or control range. The set settings have a major influence on network performance using the method. The algorithm is beneficial only if the transmission efficiency is enhanced without affecting the advantages of the decreased processing load of the VRS. In order to define this level, transmission efficiency and processing load are studied. Several assumptions are made in order to make the analysis simple.

1) The bandwidth of each call is the same.

2) No statistical multiplexing impact is considered while assigning bandwidth for the call or virtual link, i.e. the bandwidth is deterministically assigned.

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5.2 Implementation of 5G Network Slicing

However, as shown in Figure 3, three important needs must be addressed in order to establish an effective optical transport network for 5G: Transmission high capacity, low latency transportation, high density mobile access and networking scalability.

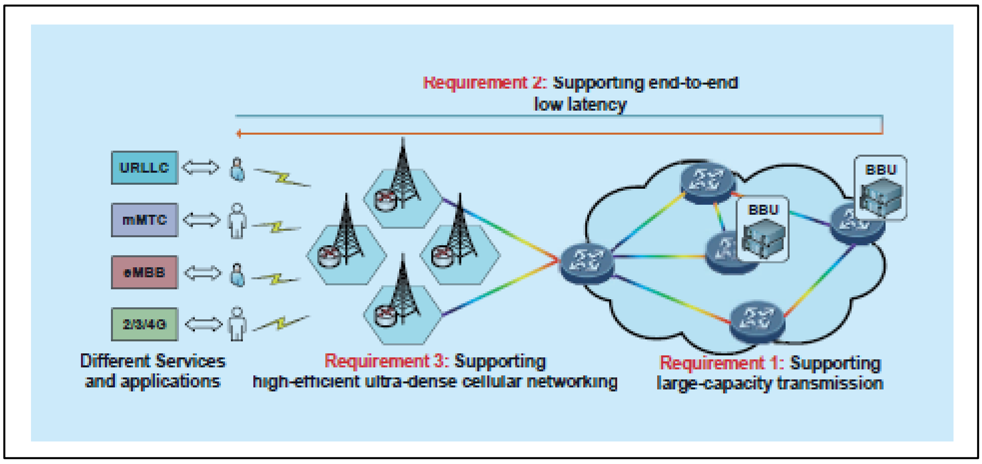

Figure 3: 5G Network Architecture Setup

D-QoS standards - including protocols, technologies and implementations - provide QoS across a number of networking stack layers on both fixed and wireless data networks. D-QoS methods may be classified into two groups in practise: 1 (for business purposes or on private networks) and 2 (for other applications) D-QoS methods (designed to be productized and commercialised as a premium service in a public network). The Class 1 mechanism in 4G (LTE) networks is for example the ARP (Allocation and Retention Policy), and the Class 2 mechanism in QCI. As explained in [4], in WiFi Networks there are several examples of QoS standards, all Category 1 cases.

For instance, the Wireless Multimedia Extension (WME) is a Category 2, standard approved by many providers (like Aruba), companies (like iPass), and venues (e.g. airports, hotels). This article discusses only standards in category 2. Figure 4 shows the generic TCP/IP framework for ATM networks in a 5G scenario.

VI. RESULTS AND DISCUSSION

Expected Outcome

There are two sections to the ATM 5G satellite network: a space segment with satellites that are connected by inter-satellite interconnections and a land segment with various ATM networks. A module links the satellite network to the ATM networks and conducts various call and control procedures. The management and distribution of resources across the network is controlled by a network control centre. Various elements must be addressed in the development of a satellite ATM network that correctly carries Internet traffic, including the model for ATM, media access protocols, and traffic management.

Analysis of data transfer efficiency in TCP/IP over ATM architecture for an enterprise network is done where measure performance is scalable and tailorable. We have built 5G network topologies that match current standards, interfaces, and protocols of higher level. With optimized resource utilization, fairness and higher layer throughput congestion control mechanism is implemented successfully which can be calculated using performance metrics. Comparative study of D-QoS standards for service assurance over an enterprise network has been done and proves quality can be improved.

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VII. CONCLUSION

D-QoS standards for data networks have been quite successful in the past, particularly when the target market is restricted and service guarantees inside an intradomain network are guaranteed. Although it was a very accurate predictor of prior business performance that targeted the small enterprise market, attempts to reach the broad market were mostly unsuccessful commercially. However, the improved quality of the internet's best efforts also leads IT management to reassess the usefulness of expensive D-QoS services in the corporate network. This is due to 5G Network Slicing that is trying to make a debut in a market that does not provide premium D-QoS services. Whereas work is under progress on the finalisation of Network Slicing technical standards and operational details, experience with past standards demonstrates that it is vital for more clarity in the business model and the level of service security provided to users to be as effective.

By 2020-2025, several HTS and mega satellite constellations can provide Bandwidth Terabits worldwide. These systems are used to offer the 5G Satellite Radio Access Network (RAN) to facilitate interaction with the 5G Terrestrial Component. The present 5G-satellite integration strategies and hurdles were quickly summarised. We have also shown the applicability of NC on future 5G integrated terrestrial and satellite networks with varying propagation delays, capacities, and packet loss rates. We proposed an NC-based technique to divide unicast encoded information across satellite and terrestrial areas, which demonstrated how traffic sharing and redundancy levels may be optimised for TCP applications. A further investigation is necessary in order to analyse integration choices and to evaluate the integrated system's virtualized functionalities. Finally, we need to assess the efficiency of various network codes.

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