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Research Article

Methods for Fully Connecting IoT Gadgets to LTE Networks

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Abstract: Connecting IoT devices to an architecture that allows for smooth transitions between services is becoming more important as the number of IoT-enabled devices in use grows. The number of internet-connected devices is expected to skyrocket from its current 10-billion strong to 34 billion by 2020.As time goes on, LTE systems become the ideal companion for meeting these evolving service needs. However, the signalling overhead in IoT systems will expand exponentially with the forthcoming expansion in the number of IoT devices. As a result, LTE systems' signalling overhead will rise. Due to the increasing number of exchanges between the transmitter and receiver, the current protocol stack of the LTE systems is not best adapted to manage the signalling traffic produced by the IoT devices. This suggested method not only boosts the speed of video flows but also improves the Quality of Service (QoS) of voice streaming via the Internet of Things. Even with the addition of IoT Traffic, numerical results demonstrated that the suggested strategy was able to boost overall system throughput. A crucial aspect of LTE-A systems is their ability to integrate seamlessly with other networks, which was made possible by the protocol stack and the scheduling mechanism.

Keywords : Internet of Things (IoT), (Quality of Service) QoS, THE LONG-TERM evolution, protocol stack

Introduction

The development of the first generation (1G) of cellular networks in the early 1980s marked the beginning of modern wireless technology. In the initial generation of systems, analogue interface technology was employed via circuit switched networks to provide solely voice communication. A new era of personal communication was ushered in despite the fact that 1G cellular networks offered only extremely limited functions, had poor voice quality, and had limited radio coverage. With the rising demand for cellular services and the need for higher quality and more features, the second generation (2G) of wireless cellular networks was developed in the early 1990s. Higher bandwidth, improved voice quality, and restricted data services were supplied by the 2G systems' digital air interface and primarily voice-centric technology's circuit-switched network. The 2G systems were widely adopted, and they were effectively implemented, all over the world. Later on, the improved second generation [2.5G] featured higher bitrates. The data speeds of the 2.5G systems range from 57.6 Kbps to 171.2 Kbps. Due to the overwhelming popularity of these systems and the rapid expansion of the internet, more powerful and reliable systems than 2G and 2.5G wireless are required. This ensured the continued development of 3G wireless cellular networks. In order to offer new data services and improve upon those provided by existing 2G and 2.5G systems, the third generation system promised wide-area coverage at 384 Kbps and small area coverage up to 2 Mbps. The Universal Mobile Telecommunications System (UMTS) is a well-known example of a 3G system; it was created by the 3rd Generation Partnership Project (3GPP)(Karenina et al 2005). UMTS guaranteed a transmission rate of up to 2 Mbps, which may enable new data services and improve those enabled by existing 2G networks. Figure 1 shows how the Wireless standard developed over time.

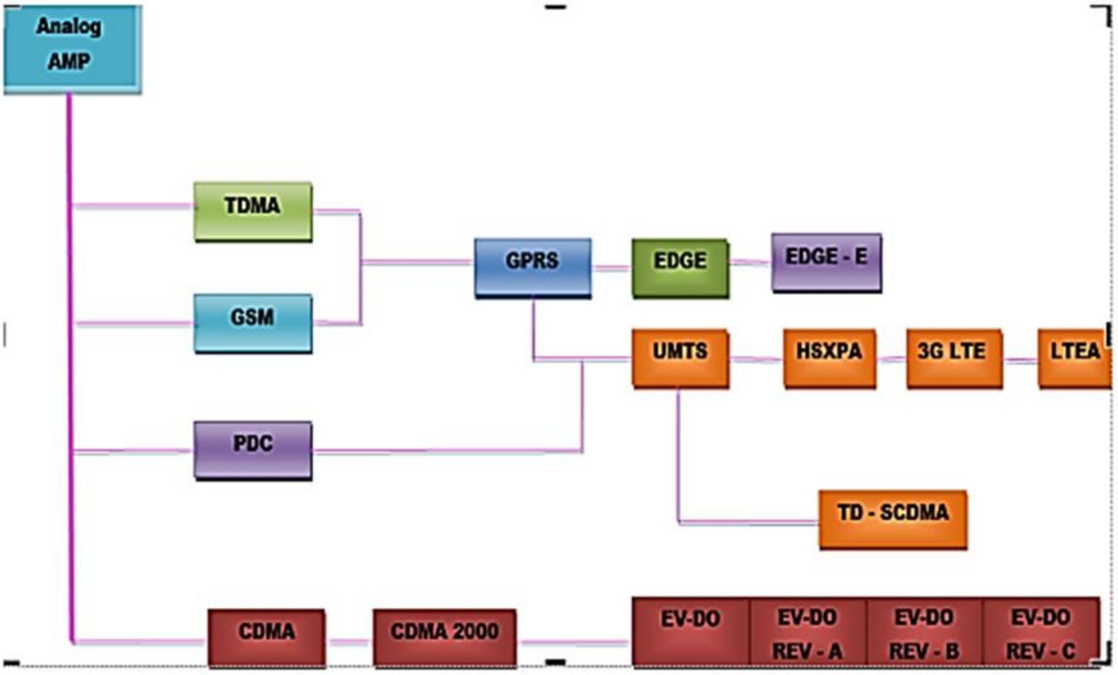

Figure 1 Evolution of Wireless Standard

However, predictions for the future of mobile wireless markets assumed services like multimedia on demand would reduce bandwidth. This is what made it necessary to look at alternatives to the slow data speeds provided by the already available 3G wireless technologies. Support for such high data rates has led to the creation of Broadband Wireless Access Systems (BWASs). In addition to the already established 3G UMTS, 3GPP has standardised the High Speed Downlink Packet Access (HSDPA) (TS 25.308 2003), a 3.5G BWAS. Theoretically, HSDPA may provide a data throughput of up to 14.4 Mbps, making it 7 times faster than UMTS. Another BWAS that may handle speeds of up to 70 Mbps is WiMAX, which was standardised by the IEEE 802.16 group (IEEE 802.16-2004), and then again in 2005 (IEEE 802.16e). By increasing network performance, these systems helped users better enjoy new converged services like audio and video streaming, mobile Internet browsing, Voice over IP (VoIP), etc., giving mobile data network operators a competitive edge. Such services need the wireless networks to provide support for many types of traffic with varying Quality of Service requirements. The creation of IEEE 802.16 standards allowed for the adaptation of 3GPP and 3GPP2 beyond 3G systems. All of the suggested systems use OFDMA technology, however their network design is more similar to IEEE 802.16 than to other standards. The 3GPP version of the beyond 3G system is known as Long-Term Evolution (LTE) or evolved universal terrestrial radio access (evolved-UTRA) (3GPP TSG RAN TR 25.912 v7.2.0), whereas the 3GPP2 version is known as ultra mobile broadband (UMB) (3GPP2 TSG C.S0084-001-0 v2.0). The IMT-2000 family of standards includes the 4G technologies Mobile WiMAX, LTE, and UMB since they all match the IMT-2000 specifications. The LTE networks were anticipated to provide high throughput, low latency, and maximum packet and resource optimisation allowing variable bandwidth deployments(3GPP TSG RAN TR 25.913 v7.3.0).While this was happening, a new network architecture was developed to accommodate packet-switched traffic with no interruptions in service, high quality of service, and low latency (3GPPTSG RANTR 23.882 v1.15.1). Due to the OFDMA downlink access strategy and the SCFDMA uplink access technique, the system allowed for adaptable bandwidths.

The LTE-A systems were supposed to provide for the maximum possible number of mobile stations (MS) in a network. Each MS received a certain number of channels out of the total available bandwidth or spectrum. In contrast to circuit switching, using these shared channels allowed for a greater number of MS to be supported, which in turn increased the network's efficiency. Provisioning Quality of Service in IEEE 802.16e systems occurred on three different levels: the admission level, the class level, and the packet level. In the past, quality of service (QoS) was guaranteed by implementing an appropriate Call Admission Control (CAC) method at the Admission level. The CAC algorithm decides whether or not to grant a fresh call request from the MS. To meet the QoS needs of the current MS, CAC maximised the concurrent number of allowed users. When there was adequate bandwidth available in the network, the new MS were granted access to accommodate the QoS needs of the new calls. Class level QoS provisioning referred to the system's scheduling mechanism, whereas packet scheduling referred to the act of resolving congestion for shared network resources. The technique also included deciding the transmission order and allocating bandwidth to the consumers. The system's scheduling algorithms were chosen after carefully considering the variety of network users and the necessary level of quality of service. This is used to establish how many transmission time frames should be allocated for each traffic class in order to satisfy the QoS needs of all users. Packet level QoS provisioning refers to the procedure by which packets are selected for transmission within a certain time period.Figure 2 depicts the relationship between the several LTE service classes and their respective layer 2 functional entities in the protocol stack.

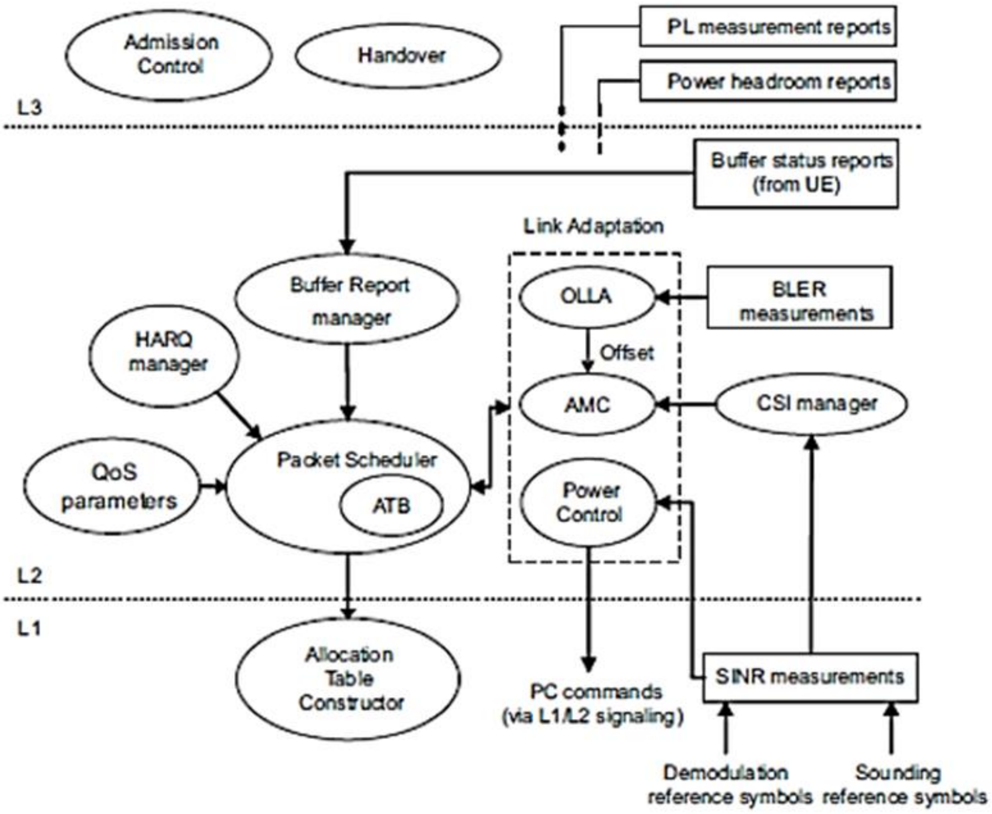

Figure 2 Interaction between various layer 2in LTE

The emergence of the Internet of Things (IoT) has had far-reaching consequences for society, from the way we purchase while travelling to the way manufacturers maintain track of inventories, and may soon need the development of specialised infrastructure.The Global System for Mobile Communications (GSMA) forecasts that IoT traffic will increase exponentially over time. By 2020, there will likely be over 24 billion electronic gadgets that can communicate with one another[1]. Machine Type Traffic from IoT devices is also anticipated to be distinct from Human Type Traffic[2].The majority of Machine Type traffic consists of relatively short data packets since the majority of the devices are idle and only come into existence or transmit when there is data to relay. Because of these trends, the control plane will soon be generating a tremendous volume of traffic, leading to severe bottlenecks at the evolved node B (eNB) and the mobility management entity (MME) [3]. As a result, the expense and burden on network service providers will rise as the volume of sent signals increases [4, 5]. In this scenario, we'd be working to solve LTE-specific bandwidth management issues.This thesis will present a systemic and efficient economic-based strategy to improve QoS support for IoT systems. Our solutions would maximise both the needs of users (for example, assured QoS) and the needs of network operators (for example, high profits). We present a queuing-based bandwidth management paradigm that works in tandem with physical layer interfaces..

Investigating the Crucial Parameters that influence the downlink scheduling in narrowband Internet of Things

There will be significant problems for cellular network service providers in the areas of speed, bandwidth, quality of service, and dependability due to the rapidly increasing usage of different Internet of Things (IoT) services. Long Term Evolution-Advanced (LTE-A) systems may be able to help with this. LTE-A may be the future backbone network to enable IoT services on a big scale thanks to innovations like carrier aggregation (CA), cooperative multipath propagation (CoMP), reuse of spectrum (RN), and multiple-input multiple-output (MIMO). In order for LTE-A networks to provide high Quality of Service (QoS) to the Internet of Things, a reliable scheduling mechanism is required. It is the responsibility of the Scheduler in the eNodeB of LTE-A systems to maximise spectral efficiency while maintaining enough throughput for all mobile users. Since there are many factors that might affect eNodeB scheduling, it is crucial to fully understand them all in order to optimise the performance of scheduling algorithms developed for LTE networks. In this chapter, we present and compile all the factors that have an effect on the downlink MAC scheduling methods' in the eNodeB.

A Simplified Protocol Stack for improved IoT support in LTE

As the number of Internet of Things (IoT)-enabled devices proliferates, there will be an increasing need to link these devices to an overarching framework that allows for the smooth transfer of data and services between them. The Long Term Evolution (LTE) technologies are the ideal companion for meeting these needs. Here, we introduce a novel protocol architecture called the Reduced Control Plane Protocol (RRCP) architecture suite, with the goal of minimising the amount of signalling messages sent or the amount of signalling messages sent twice when a UE wakes up and attempts to join an LTE network. We compare the suggested system with the present conventional architecture across a wide range of metrics, such as the number of channels allotted, the latency, and the energy spent, and show that the alternative design is far superior.

LTE is an IP-enabled architecture with various benefits that make it ideal for Internet of Things applications. These benefits include excellent security and spectral efficiency. Potential systems may need the assistance of LTE systems or dedicated IoT frameworks for their maintenance and survival, as Internet of Things systems play a vital role in defining the future of various Machine-to-Machine (M2M) commitments, including energy, transportation, predictive maintenance, logistics, medicine, and smart home systems. Other possible uses include wireless sensor network integration, smart grids, smart cities, and linked cars. In these scenarios, devices must limit their calculations to ease the burden on cloud apps and boost their own computing capacity. Even while LTE networks have enough of spectrum, the significant increase in the number of Internet of Things (IoT) devices in each cell predicted by 2020 would cause a severe bottleneck for cloud offloading, severely reducing the performance of these networks[4]. Traffic in LTE networks may increase dramatically as a result of IoT services and apps. In order to improve the IoT's performance in terms of speed, dependability, decreased energy consumption, and service realisations, cloud computing must become an integral element of it. Figure 2 depicts an example of an LTE reference architecture.In LTE systems, the Radio Network Controller is not present. The RNS/BSC's duties in these areas have been delegated to the eNodeB or the MME. As a result, fewer layers are required for aggregation and backhaul. To enable seamless communication between all of the LTE network's components, IP is employed as the network layer's interface. The existing hierarchy in the 2G/3G packet network is simplified as a result.

Using end-to-end IP also simplifies the creation and administration of each separate domain. A further distinguishing feature is the separation of the control plane and bearer plane operations into independent network pieces that make up the LTE packet core. The primary reason for transporting it is to improve its efficiency for self-sufficiency. Because of the modular nature of the Evolved Packet Core (EPC), wireless service providers may strategically place and activate EPC bearer and control plane network components. Because of this adaptability, service providers may implement LTE's core network in ways that were just not conceivable with earlier generations of networks. This increases the service providers' potential to generate income by improving the EPC's performance, scalability, and operational efficiency. For these reasons, LTE is the optimal technology for IoT networks.

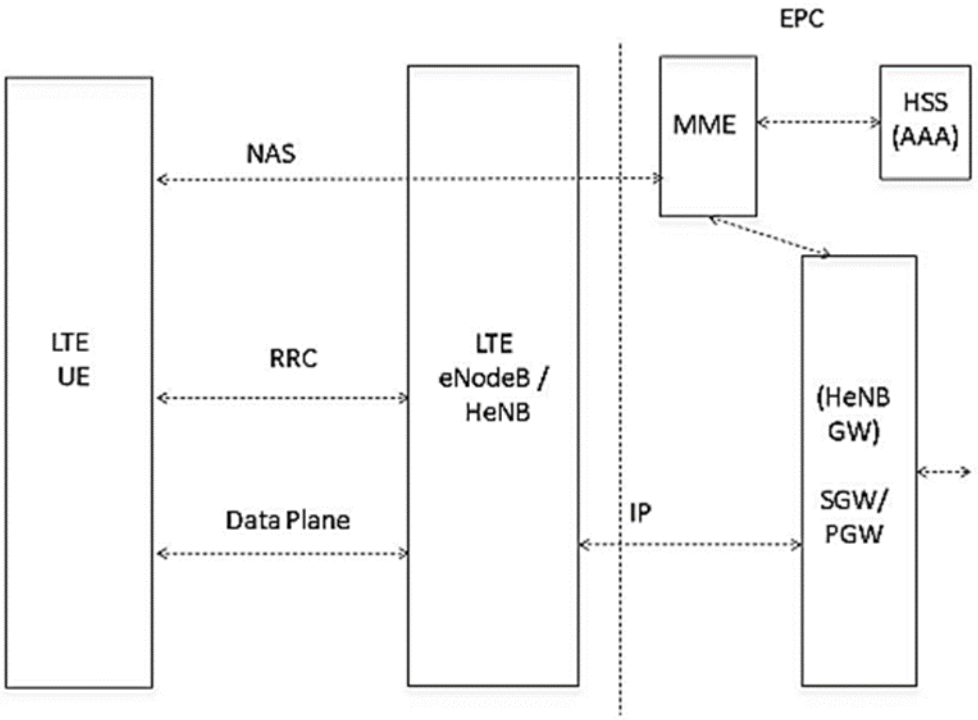

Figure 2.Conventional LTE Architecture

Any Internet of Things (IoT) device that wants to join an LTE network must first go through a mutual authentication process called Evolved Packet Systems - Authentication and Key Agreement (EPS-AKA), as detailed in the 3GPP Security architecture for LTE networks. Figure 2 depicts a typical EPS-AKA technique. This method employs a shared key approach, with the shared key 'K' being kept in the USIM of the LTE UE and the AuC of the HSS. EPS-AKA is executed as soon as an Internet of Things device is switched on so that it may begin the joining process [4]. Table 1 explains the various encryption and reliability protection keys used throughout the procedure. The KASME key encrypts user plane traffic between the eNodeB and LTE UE, while the KRRCenc and KRRCint keys are used by the RRC protocol at the eNodeB and the UE. Keys for NAS protocol encryption and reliability protection at MME and UE (KNASenc, KNASintand). In addition, some of the IoT devices may be dormant for long stretches of time, increasing the load on the LTE network's control plane as more of them attempt to connect. For the vast majority of their existence, they may just lie dormant, waiting to awaken to analyse newly discovered data and relay that information to the larger network. In this situation, the device is in a dormant state, and when it awakens and attempts to join the network, it must reinitiate most of the security contexts. Keeping the MME/HSS settings while disconnecting from the eNodeB would allow an IoT device to remain in sleep mode. When an IoT device seeks to re-join the LTE network, it must re-initiate some of the security processes, which adds the control-plane overhead.

Key(s)	**UE**	**EPC and LTE eNodeB**
K (shared key)	USIM	AuC / HSS
A pair of keys (CK, IK)	UE	AuC / HSS
K_{ASME}	UE	HSS / MME
K_{NASenc}, K_{NASint}	UE	MME
K_{eNB}	UE	(MME derives and provides to) eNodeB
K_{UPenc}, K_{RRCint}, K_{RRCenc}	UE	(Computed at) eNodeB

Table 1: List of Keys associated with LTE EPS-AKA PROCESS

Performance analysis

The Effective Bandwidth Admission Scheme (EBAS) is tested, and its results are compared to those of other popular scheduling methods. Radio resource allocation (ARRA) is one of the scheduling systems that is considered during an analysis. Numerous telecommunications providers use the ARRA plan because of its widespread popularity. Users of 4G wireless networks like the utility-based adaptive radio resource allocation (UARRA) system, however the efficient resource management scheme (ERMS) is also widely used. Table 2: Defined Simulation Parameters

Parameters	**values**
Bandwidth	10MHz
Total number of sub-carriers used per slot	600
Number of sub-carriers used per PRB	12
Number of available used per PRB	50
Sub carriers spacing	15khz
Slot Duration	0.5ms
TTI Duration	2 slots=1ms
Frame Duration	10 ms
Cellular layout	1 cell
Call radius	1500 m
Height of the eNodeB antenna	32 m
Path loss model	Cost HATA231

Table 2 Simulation parameters

System throughput for the proposed scheme and other commercially available methods are graphically shown in Figure 3. Under high traffic circumstances, the suggested approach shows a throughput improvement of 19.8% compared to UARRA, 35.5% compared to ERMS, and 52.5% compared to ARRA. This is due of the Poisson Process model of the traffic flow. Throughput is maximised by the scheduler by trading off power consumption, latency, and signal load, as well as selecting appropriate static optical characteristics based on the nature of the incoming traffic

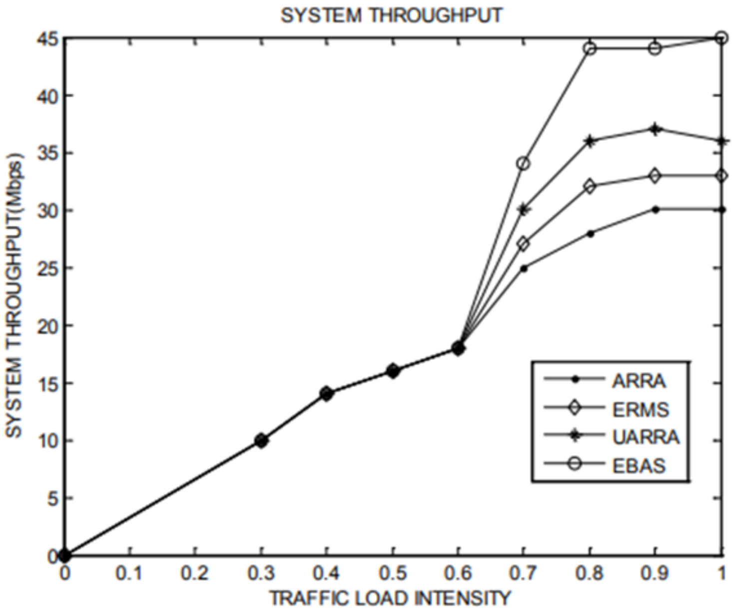

Figure 3. System Throughput

When it comes to real-time traffic like audio and video streaming, the performance of the Network is heavily dependent on the packet-dropping ratio. This is due to the correlation between the packet dropping ratio and the load on the network and the resulting decrease in throughput. Figures 4 and 5 show the dramatic decrease in packet loss seen by the proposed method. This is due to the fact that, unlike EBAS, none of the other systems offers satisfactory delay management. Data with a longer delay period is often given more priority by the other suggested systems. As a result, a lot of scarce resources go to waste. However, the suggested approach does not treat rate-sensitive traffic as a unique case, guaranteeing packet delivery with an adequate QoS as per the SLA..

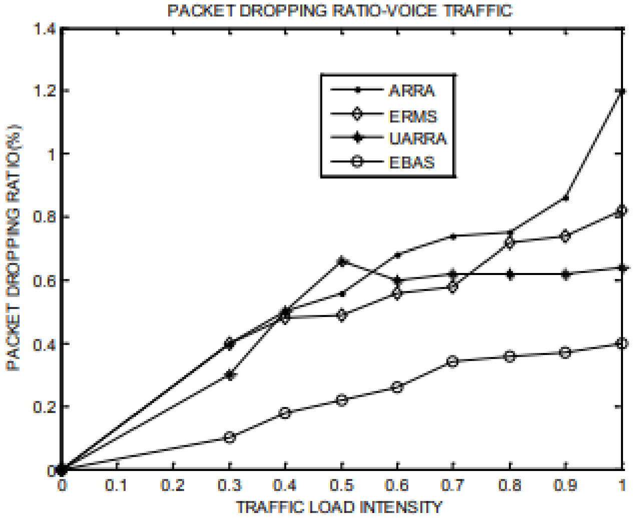

Figure 4. Packet Dropping ratio for Voice

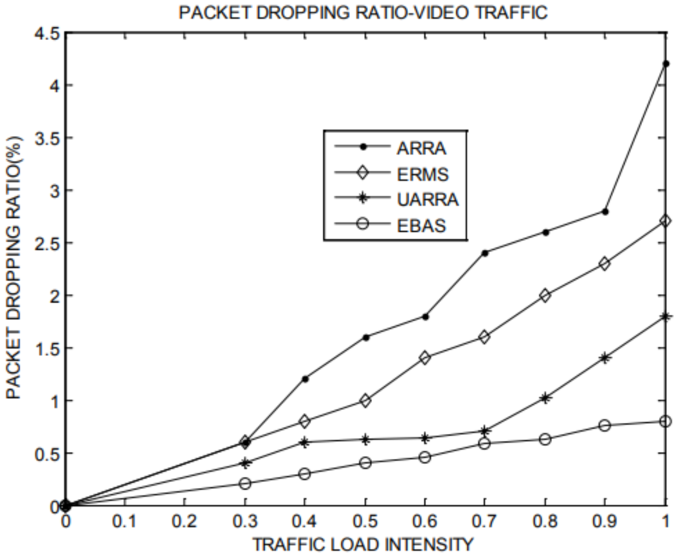

Figure 5. Packet Dropping ratio for Video

Conclusion

The constraints of the current protocol stack and scheduling techniques were discussed first in the article. It was suggested that a different protocol stack be used to handle the traffic from the IoT. To address the shortcomings of current scheduling schemes and to accommodate the proposed protocol stack, a new queuing model based scheduling technique was also presented. Real-time services were prioritised throughout the design of the protocol stack and the scheduling mechanism. The devised approach far outperformed the state-of-the-art for 3G networks. This method boosts the quality of voice and video streams while also enhancing the quality of IoT services. The numerical findings appear to show that the total system throughput was increased with the addition of IoT Traffic using the suggested approach. A key aspect of LTE-A systems is their ability to integrate seamlessly with other networks, which is ensured by the protocol stack and the scheduling mechanism. In a nutshell, the quality of service for real-time flows is improved by the two proposals. Given the severity of the threat to the service provider's business model, this is a crucial consideration.

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