Notification No: F.NO. COE/ Ph.D./(Notification)/552/2024

Date of Award: 25/01/2024

Name of the Scholar	**:**	**Sultana Parween**
Name of the Supervisor	**:**	**Prof. Syed Zeeshan Hussain**
Name of the Department/Centre	**:**	**Department of Computer Science**
Topic of Research	**:**	**A Framework for the Performance Enhancement of Cross Layer TCP for IoT**

Findings

Keywords: Transmission Control Protocol (TCP), Internet of Things(IoT), Congestion Control (CC), Cross Layer Design (CLD), Acknowledgement (ACK)

The Internet of Things (IoT) is an emerging technology that provides connectivity between various heterogeneous devices to send data through the network. Various sensor nodes act as IoT devices that are interconnected and it is applied for various applications. Several IoT protocols such as Advanced Message Queuing Protocol (AMQP), Message Queuing Telemetry Transport (MQTT), Constrained Application Protocol (CoAP), Hypertext Transfer Protocol (HTTP), and Extensible Messaging and Presence Protocol (XMPP) have been used for performing data transmission between heterogeneous IoT devices. These protocols have provided effective communication among IoT devices that are used in the applications such as embedded systems and industrial 4.0. However, various challenges are presented in IoT data transmission between sensor nodes due to their individual transmission rate which leads to high network congestion. To address these challenges, TCP, a transport layer protocol, is implemented for efficient data transmission. TCP manages the transmission of large volumes of data traffic globally and mitigates network congestion, thereby enhancing quality of service (QoS) in the IoT environment. This protocol provides effective data transmission with better performance in terms of load, connectivity, low latency, reliability, and speed when compared with user datagram protocol (UDP). The most significant contributions of the thesis are described as:

In this thesis, initially, an in-depth Systematic Literature Review (SLR) of the TCP performance enhancement in IoT has been conducted. This review included a critical study of TCP performance, along with their prominent reasons for degradation. Moreover, the critical comparison of performance metric parameters and their merits and demerits has also been described in a more detailed manner.

Moreover, an explorative analysis of some of the current challenges related to TCP and elaboration along with their probable solutions has been done. When TCP is applied in an IoT system, a variety of challenging issues have to be dealt with. IoT encounters many shortcomings of wireless networks, while also posing new challenges due to its uniqueness. The main issues which arise due to the heterogeneous characteristics of IoT are the Retransmission Timeout (RTO) algorithm issue, congestion, packet loss issue, header overhead, high latency issue, link layer interaction issue, etc. There are several probable solutions to the above-mentioned issues in the case of IoT scenarios.

Furthermore, a comparative analysis of several TCP and CoAP-based CC mechanisms highlighting some of their merits and demerits has been presented. Some of the popular TCP variants used for congestion control in IoT networks are Loss-based, Delay based, and Hybrid-based Congestion Control (CC) algorithms. Loss-based TCP variants such as Tahoe, Reno, New Reno, SACK, FACK, etc. are advantageous for networks that require a low transmission delay. On the other hand, TCP Vegas is delay-based and it is recommended for applications that are unable to support data loss. TCP Westwood is also a delay-based CC mechanism that is optimized for wireless networks and can perform well in networks with high levels of packet loss. Hybrid-based CC algorithms adapt to changes in network conditions by detecting both packet loss and changes in RTT. Hybrid-based CC algorithms i.e. TCP BBR, TCP CUBIC, TCP Compound, TCP Scalable, and TCP Westwood+, etc. combine both loss and delay-based mechanisms to achieve better performance. On the other hand, CoAP-based CC is specifically designed for IoT networks. It uses a lightweight protocol that is optimized for resource-constrained devices and can adapt to changing network conditions, allowing for efficient data transmission and reduced energy consumption. CoCoA, an improved CC method for CoAP, optimizes performance by integrating RTO computation, weak RTTs, a VBF, and an aging mechanism.

Thereafter, a novel approach using a cross-layer framework to enhance the performance of TCP in an IoT environment has been proposed. First, network construction is performed based on grid topology to increase the flexibility and scalability of the network which leads to high communication efficiency with low transmission delay. Secondly, packet scheduling is performed by implementing a fitness-based proportional fair (FBPF) scheduling algorithm and selection of best subflows and optimal path to reduce the jitter and transmission delay efficiently. Finally, congestion control is performed to improve the performance using the proposed algorithm that consists of three sub-processes namely congestion detection and avoidance, fast retransmission, and fast recovery.

When congestion is detected by several metrics in that RTO is adaptively estimated using the cat and mouse-based optimization (CMBO) algorithm. The adoption of the metaheuristics algorithm improves the convergence speed thereby improving the user throughput. After congestion is detected fast transmission and fast recovery are performed by reducing the count of duplicate acknowledgments which reduces the transmission latency during data transmission. The performance of the proposed method is evaluated using NS-3 by considering several performance metrics to illustrate the performance of TCP such as throughput, goodput, packet loss, jitter, transmission delay, and congestion window size. The overall proposed work improves the throughput, and goodput, and reduces the jitter and transmission delay in the TCP IoT environment.