QoS in SDN for Content Delivery using Blockchain based Smart Contract

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ABSTRACT

The multimedia content in the current internet traffic is widely escalating. The substantial amount of data being delivered from the multimedia, becoming difficult for the Network Service Provider (NSP) and Content Provider (CP) to deliver better video quality service to the end-users. It has become an important aspect to guarantee the desired service requested by the end-user. Software-Defined Networking (SDN) architecture helps the enterprises to build flexible and scalable networks that adapt to meet the dynamic business needs. This work deals with the link congestion in the network and delivers higher Quality of Service (QoS) to the end-users. We propose a dynamic link pricing model using Stackelberg game theory and use Blockchain technique to deal with the security challenges of single-point failure of the controller. Additionally, it prevents malicious flows in SDN. It also supports price management for the Content Provider.

CCS CONCEPTS

• **Networks** → **Network management**; **Network monitoring**.

KEYWORDS

Blockchain, Link Pricing, Quality of Service, Software Defined Networking, Stackelberg Game

1 INTRODUCTION

The popularity of different multimedia applications such as online gaming, video on demand, live streaming, telecommunication has increased tremendously over the past decade. The present Internet architecture is becoming more complex due to the coupled nature of the control and data plane on the same networking device. According to the Cisco report for 2021, it is observed that the request for video resolutions are 41% for Standard Definition (SD), 47% for High Definition (HD) and 12% for Ultra High Definition (UHD). As the number of devices using the internet is rising at a startling rate, it creates a demand for resources such as bandwidth on the heterogeneous constrained backbone network which results congestion in the network. Thus users paying for the usage of these applications do not get the desired services. Therefore, the bandwidth requirement has become a constraint for NSP to deliver the desired video service to the end-users in the network [1].

1.1 Motivation

The significant growth of video/audio data traffic flows generated from the different multimedia services put pressure on the underlying networks and NSP [3]. At present, the Internet provides a best-effort service for all applications, i.e., it does not guarantee the QoS for the desired service. The static pricing approach used in the current Internet architecture by NSP's decreases the revenue for the different services offered [2] if congestion exists in the network.

Software-Defined Networking (SDN) technology enables the network to be centrally controlled (or programmed) using software applications through automation. The different applications are deployed on the top of the controller (or control plane) such as network monitoring, access control list, and security. SDN can control and direct data traffic, thus makes it simpler to implement QoS for multimedia applications. Besides, SDN also provides an ability to adhere to the problems by finding new promising solutions to avert the revenue losses getting faced by the different NSPs.

2 SYSTEM MODEL

2.1 Proposed Architecture

Figure 1 represents the proposed network architecture of the SDN with blockchain. It consists of three layers - **1) Application layer:** The QoS module in the application layer comprises of two sub-modules - the first one is a dynamic pricing module and the second computes the shortest path using the Dijkstra algorithm. **2) Controller layer:** The control plane provides a global view of the network and directs the network traffic according to the policies written and stored in the blockchain to the forwarding layer [4]. It communicates with the application layer using the NorthBound APIs. **The forwarding layer**: It consists of the network devices (switches or routers) which forward the data traffic or the requests from the users on the route specified by the controller. It interacts with the control plane using the Openflow protocol (SouthBound APIs).

2.2 Dynamic pricing model using Stackelberg Game

In the proposed architecture, end-users (or service requestor) requests video services such as SD, HD, and UHD from the Content Provider (CP). The demand of specific service from end-users, result in congestion and thus users do not get the guaranteed bandwidth service as promised by the NSP. The dynamic pricing model will be implemented using the Stackelberg game to analyze the pricing

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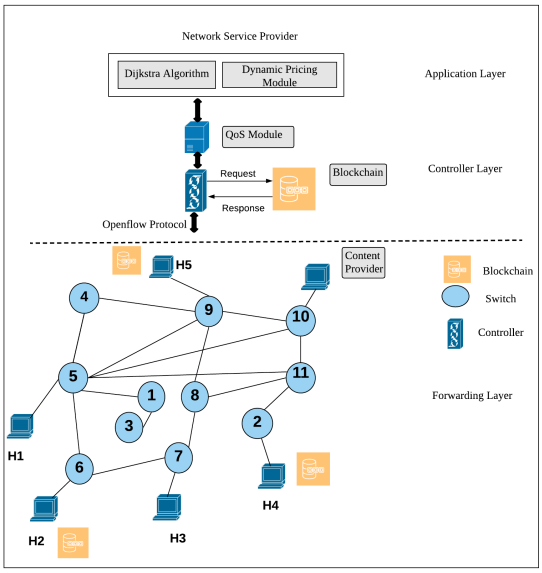

Figure 1: QoS in SDN using Dynamic Pricing module and Blockchain

strategy for solving the problem of link congestion in the network. In the model, if the aggregate traffic from different sources at a particular link exceeds its link capacity, the link price will increase between the switches, else it will be decreased. Thus, only the legitimate users will get the desired link which has the least cost, therefore users will be benefited by the NSP. It includes two kinds of players - one is the user (or service requestor) and the other is a service provider (NSP). In this game theory technique, firstly the leader (NSP) chooses its strategy and the followers (users) respond accordingly [5]. The strategy for NSP is to charge the price from users based on the period and bandwidth usage of the link. It aims to maximize its revenue. The end-users adopt a strategy to get the desired video service at the lowest price. They choose the service from NSP based on the various QoS metrics such as throughput, price, and response time. However, it becomes a necessity to formulate an agreement between the end-users, NSP and the CP.

The Nash equilibrium for the proposed game approach between the end-users and NSP will have a specific strategy [5], where neither of the players drifts from their original strategy. Therefore, game theory can be adapted to overcome the issues of link congestion in the network by maximizing the utility function of the NSP and end-users.

2.3 Securing SDN Architecture using Blockchain

The blockchain technology gains popularity from cryptocurrencies and securing data of transactions. Blockchain has a distributed, decentralized architecture consists of a list of blocks (or records) contain data and connect the previous block using hash values (or hash pointer). The blockchain architecture consists of smart contracts deployed on the ethereum nodes. There are manifold benefits of using blockchain in the proposed architecture. Firstly, if a transaction occurs price gets automatically deducted from the user's account. Thus, the blockchain technique helps to cut down the cost of CP because it does not need any centralized authority (or a third party). Secondly, in SDN Distributed Denial of Service (DDoS) attack can cause a single point failure problem due to the presence of a centralized controller. The blockchain-based service framework helps to prevent the DDoS attack, from the enormous users request arriving at the controller.

3 SIMULATION SETUP

The proposed architecture can be simulated using the Mininet network emulator, Floodlight SDN controller. The private Blockchain can be created using "geth tool". The smart contracts are deployed on the ethereum nodes. The solidity framework is used for implementing smart contracts. The Web3.js API is used in the Floodlight module to retrieve the information from the blockchain running on the controller. It has an assembly of libraries that helps to connect with other ethereum nodes.

4 CONCLUSIONS

In this paper, we proposed a dynamic pricing model using the Stackelberg game theory which reduces the link congestion in the network. The service agreements between the different parties such as end-users, Network Service Provider and Content Provider is written in smart contracts (blockchain), then deployed on the ethereum nodes. The blockchain technique helps to reduce the costs for service providers, thus they can deliver high QoS video service to the end-users at a low price. The use of smart contracts prevents the DDoS attacks from the users and also makes infeasible to forge the data.

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