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Improving FFMPEG Performance with RTMP Server Using SDN-Controlled Routing in Containerized Wireless Mesh Networks

[1]Sanjay Kadam, [2]Vaibhav Pawar*, [3]Hanamant Sale, [4]Rahul Patil, [5]Ankush Gund, [6]Pravinkumar Patel, [7]Mahadeo Jadhav

[1,2,3,4,5,7] Bharati Vidyapeeth College of Engineering, Navi Mumbai, India.
[6] Bharati Vidyapeeth College of Engineering, Kolhapur , India

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Abstract

Because traditional networks lack flexibility, agility, and scalability, the highly demanding Over-The-Top (OTT) multimedia apps pose additional challenges for Internet Service Providers (ISPs) in providing a good Quality of Experience (QoE) to their customers. Through the use of software-defined networks (SDN) and network function virtualization, future networks will cloudify their network resources (NFV). New technologies, such as software-defined networking and network function virtualization, play a very important role in modernizing wireless mesh networks and improving bandwidth, latency, packet drop, and network security. In this paper we compared the multipath routing and forward routing. In this architecture we used unicast transmission through multipath packet forwarding using the POX controller and Forward routing sends network traffic from a source node to a destination node over a single route. This technique defines the route statically or dynamically depending on network factors such connection availability, congestion, and latency. Even if there are numerous paths in the network, all multipath packet forwarding is restricted to one path by using this controller. Real-time Message Protocol server for internet video networks: FFmpeg. Video streaming allows encoding, transcoding, effects, and more. FFmpeg simplifies live stream production and other video operations. FFmpeg streams RTMP, the early internet video streaming protocol. TCP-based RTMP provides persistent, low-latency streaming. This study proposes streaming the video of a virtualized wireless host container to wired and wireless clients using an FFmpeg RTMP server address outside the wireless mesh architecture and assessing its controller performance by collecting data from wired and wireless hosts. The container in the wireless mesh topology and outside topology may transmit video.

Keywords— SDN, NFV, FFmpeg, RTMP, Multipath, Forward Routing, Video streaming.

1. Introduction

As shown in fig. 1 a more contemporary style of networking design called "software-defined networking" (SDN) separates the network control plane from the data forwarding plane tasks[1]. SDN solutions typically have, in more recent attempts, been made to adapt the SDN paradigm for the setting and design of wireless mesh networks, which is beyond the purview of the SDN with regard to wired networks (WMNs). Utilizing the various communication interfaces that the majority of wireless devices already have, quicker routing convergence and optimal path identification are achieved by separating the data transfer. We then suggest a Wi-Fi host as well as a Docker containerized Wi-Fi host mixed with wired hosts for an autonomous system topology management plan that incorporates our SDN approach. Spanning tree is frequently used to prevent loops in a network architecture, we chose POX controller because it is built on the same foundation and design[2]. However, multiple paths that exist at the network topology level are eliminated using spanning trees. In other words, POX creates a single path between any two hosts. All fundamental programme libraries would be the same, and POX is thus a good experimental control for video streaming from Wi-Fi hosts with a Docker container. [19]

As shown in Fig. 2 Wireless mesh networks are designed to complement the wired backbone with a wireless network to provide Internet connectivity to organizations, educational institutes, and companies. Wireless mesh

network technology is constantly and dynamically changing in the modern digital world. In contrast, transmission in wireless mesh networks is typically directed towards gateways or gateways to access points (APs). Consequently, if multiple APs select the optimal bandwidth path to a gateway, the traffic loads on some pathways and mesh routers increase dramatically, thereby degrading the network performance.

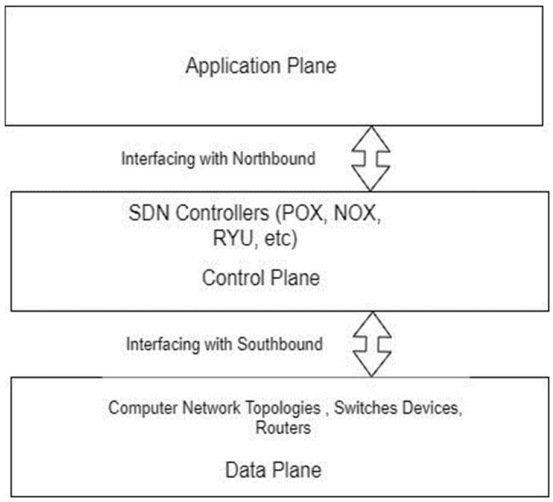

Figure 1 SDN architecture

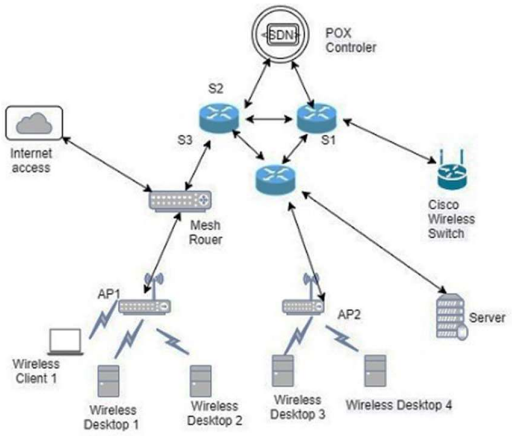

Figure 2 Wireless Mesh Network with SDN Controller

To accomplish this, we recommend Multipath, an innovative hybrid multi-path routing protocol that efficiently identifies multiple paths. We also propose sophisticated methods to balance traffic across these numerous pathways and improve overall efficiency[3]. The use of multipathing in communication networks is increasing because of its advantages of increased dependability, efficiency, availability, flexibility, and ability to balance loads. For seamless handoffs, VM migration, and the pooling of less-skilled resources to achieve overall high proficiency, wireless environments and datacenters are anticipated to heavily rely on multipathing capabilities. Because it is aware of the characteristics of end-to-end paths, the transport layer is in a position to improve performance through the more efficient use of multiple paths. Both routes were used consistently. Sockets at the application layer in the classic network model rely on sessions at the transport layer, which, in turn, rely on a static set of network and link nodes. Multipathing has been developed to facilitate the simultaneous use of multiple paths. The maximum throughput, load, and availability of a network can be improved using multipathing. Money can be saved by multipathing with a commodity network medium instead of a single-price network medium. Various multipath strategies exist, each with its own advantages and disadvantages. Multipath routing in an SDN controller may improve ffmpeg-rtmp server performance in various ways. Secondly, multipath routing lets the ffmpeg-rtmp server provide data to clients through several pathways. Distributing traffic load over various pathways reduces network congestion and boosts performance. Multipath routing lets the ffmpeg-rtmp server utilise several network interfaces for redundancy and dependability[3].

Multiple routes between the locations do not always indicate that both are taken all the time, though. A fixed pair of network-layer and link-layer endpoints support one application layer socket and one transport layer session, respectively, in a classical network topology[4]. A host or network may now use many pathways concurrently thanks to the development of multi-pathing. Numerous benefits of multipathing include increased maximum bandwidth, load balancing on the network, and redundancy. As a low-cost substitute for employing a single expensive network medium, multi-pathing using commodity network media can also be employed. Numerous multipathing systems exist, each with its own advantages and drawbacks.[15]

For instance, SDN's latency might increase because of the controller's slow reaction time if the control plane isn't tightly coupled to the data plane. Depending on the size of the network, this may or may not be noticeable, but in larger systems, it can have a negative impact on performance. Pushing more intelligence to the data plane or switching to some kind of distributed control plane architecture is the solution to many performance difficulties in big and expanding networks. While this can increase SDN performance, it goes against the spirit of SDN by mimicking legacy networks that weren't designed with completely decentralized intelligence in mind. Finding a happy medium where virtualization is maintained without sacrificing network speed or introducing single points of failure is critical. SDN and legacy network nodes may coexist with the aid of a suitable protocol that facilitates SDN communications while maintaining backward compatibility with current IP and MPLS control plane technologies – lowering the cost, risk, and interruption of services as they move to SDN[1].

The protocol powers Adobe Flash Player's live and on-demand streaming. RTMP was common when Flash controlled 97.9% of internet browsers. It is mostly utilised for transporting streams of movies, audios, as well as messages, and it offers a service that multiplexes communications in both directions. Most encoders and media servers can broadcast RTMP. Even Facebook, YouTube, and Twitch approve[5].

Live streaming may be accomplished over the internet by using FFmpeg's capabilities as a Real Time Message Protocol server in combination with internet video networks. Users are able to encode, transcode, apply effects, and do a great deal more while using video streaming. The FFmpeg programme is a versatile piece of software that may be used for the creation of broadcast live streams in addition to a variety of other video-related tasks. FFmpeg has the capability of producing RTMP streams. In the beginning of the internet, the protocol known as RTMP was the one that was used as the standard for streaming video over the internet. TCP-based RTMP has the ability to keep connections durable while keeping latency to a minimum, which enables it to deliver seamless streaming[6][7].

Our paper's primary claim is that it is possible to stream the video of a virtualized wireless host container to wired clients as well as wireless clients by making use of an FFmpeg RTMP server address that is situated outside of that wireless mesh topology. This assertion is the basis for the rest of the paper's arguments. Additionally, the performance of a pox controller with forward routing then with multipath routing done that gathers data from wired and wireless hosts will be evaluated and analysed during the course of this work. This will make it feasible for the video to be broadcast from a container that is positioned both inside and outside of the wireless mesh architecture[7]. This will make it possible for the video to be broadcast from a container as well as come to conclusion with suggestion that which is better forward routing or multipath routing at different conditions.[17][16]

.LITERATURE SURVEY

[7] Discusses the design and implementation of a live video on-demand system for a campus network. The system is based on two open-source software tools: Nginx and FFmpeg. Nginx is used as the web server and reverse proxy, allowing for efficient handling of multiple connections and streams. FFmpeg is used for video transcoding and streaming, providing support for a wide range of video formats and protocols. The system also includes a web-based management interface for controlling and monitoring the live streams. The authors report that their system was able to handle over 400 concurrent connections and provided a smooth streaming experience for users. The authors conclude that the use of Nginx and FFmpeg in the design and implementation of the system resulted in a high-performance, flexible and cost-effective live video on-demand system for a campus network. This paper also demonstrated the efficiency of using open-source software in building video streaming systems and it can be useful for educational institutions and other organizations looking to implement a similar system.[22]

[8]Regarding multipath related work with SDN researchers in this paper uses SDNs with a controller and OpenFlow switches. Switches submit routing requests to controllers for replacement traffic flow requests. The controller generates and configures routing tables for all switches on the best route after receiving the request message. Every switch has a bunch table, flow tables, and an action set. This research examined two distinct network topologies. The initial state is a network with seven OpenFlow switches (OF switches) and eight hosts. The second option, with forty switches and eighty-one hosts, may represent a bigger network. The intended load reconciliation approach was tested in the two cases. In an OpenFlow-based SDN knowledge plane, a dynamic multi-path load balancer reconciled load for each bigger and smaller network. The load balancer chooses initial distribution strategies to distribute traffic evenly. Mininet emulated network topologies. SDN OpenDaylight controllers with round robin and random load balancers govern the network.[18]

[9]presents a detailed overview of the design and implementation of a streaming media server cluster using the open-source software FFmpeg. The authors provide a description of the architecture of the cluster and the various components that make up the system, including the use of load balancing, transcoding, and streaming protocols. the paper falls short in several areas. One major issue with the paper is the lack of clear and specific evaluation of the system's performance. The authors only provide general statements about the cluster's ability to handle a large number of concurrent connections, but do not provide any concrete data or measurements to support these claims. This makes it difficult to assess the effectiveness of the system and its potential limitations.

[10] The authors of the paper propose the use of FFmpeg to analyze video streams in real-time, which is a cost-effective alternative to proprietary solutions. FFmpeg is an open-source software library for handling multimedia files and streams, which has a wide range of codecs and formats and can be easily integrated with other open-source libraries. The authors present a detailed description of the architecture of the system and the various components that make up the system, including the use of computer vision and machine learning techniques for object detection and classification. They also provide an evaluation of the performance of the system, which demonstrates its ability to detect and classify objects in real-time with high accuracy. One major issue is that the authors do not provide sufficient details on the implementation of the system. They briefly mention the use of computer vision and machine learning techniques for object detection and classification, but do not provide any specific information on the algorithms or libraries used. This makes it difficult for readers to understand the details of the implementation and replicate the work. Additionally, the authors do not provide a thorough evaluation of the system's performance. They only present a limited number of results and do not provide any comparison with other existing solutions. This makes it hard to assess the effectiveness of the system and its potential limitations.

[11] A Novel QoE-Centric SDN-based Multipath Routing Approach for Multimedia Services over 5G Networks is a research paper that presents a Quality of Experience (QoE)-centric Software-Defined Networking (SDN)-based multipath routing approach for multimedia services over 5G networks. The authors propose a new approach to enhance the QoE of multimedia services by considering different network parameters, such as packet loss, delay, and jitter. The proposed approach is evaluated through simulations, and the results show that it can somewhat improve the QoE of multimedia services over 5G networks. This paper presents a some contribution to the field of QoE-aware routing for multimedia services over 5G networks. The proposed approach takes into account the QoE of the services, as well as the network conditions, to select the most suitable path for the service.[11]

[12] This research paper provides a analysis of the Quality of Experience (QoE) of various video codecs for video streaming over 5G networks. The authors conduct a evaluation of the most popular codecs, including H.264, H.265, and VP9, using a variety of metrics such as PSNR, SSIM, and VMAF. They also examine the impact of different network conditions, such as packet loss and latency, on the QoE of the codecs. Here authors fail to provide a clear and thorough explanation of their methodology, making it difficult for readers to understand the experiments and results. Additionally, the paper lacks a comprehensive literature review[21]

Research Methodology:

This study seeks to determine the SDN-controlled multipath routing or forward routing that improves FFMPEG's performance as an RTMP server in a wireless mesh network. To achieve this goal, an experimental research methodology is adopted, in which experiments are designed and conducted to test the hypothesis that implementing SDN-controlled multipath routing can improve the performance of FFMPEG as an RTMP server in a wireless mesh network[5][6]. To conduct this research, a testbed consisting of a wireless mesh network with containerized wireless and wired hosts is set up. The FFMPEG RTMP server is installed alongside an Nginx web server, a Docker container, and a Mininet-Wifi network, which includes five wireless hosts, one Docker wireless container host, one wired host, and one wired Docker container host configured with ffprobe. The POX controller is used to implement multipath routing in the network, and data on the performance of the network, such as throughput and delay, is collected with and without the implementation of SDN-controlled multipath routing. The collected data is then analysed using statistical methods to determine whether the implementation of SDN-controlled multipath routing improves the performance of FFMPEG as an RTMP server in the wireless mesh network. This research methodology ensures a rigorous evaluation of the effectiveness of the solution and provides empirical evidence to support the conclusions.

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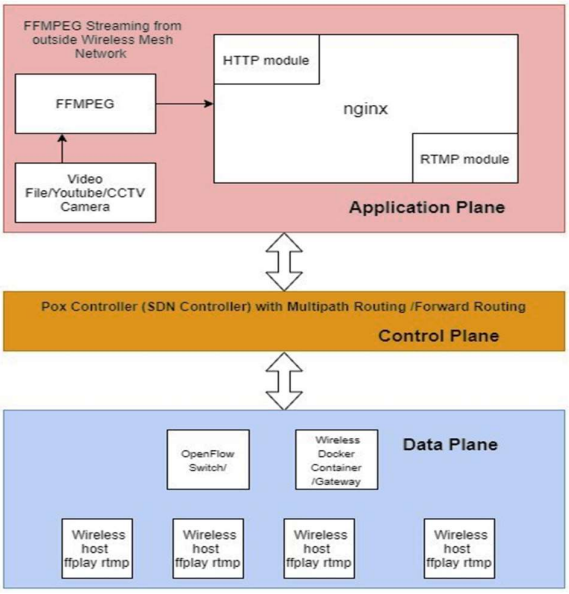


Fig. 3 Proposed Architecture

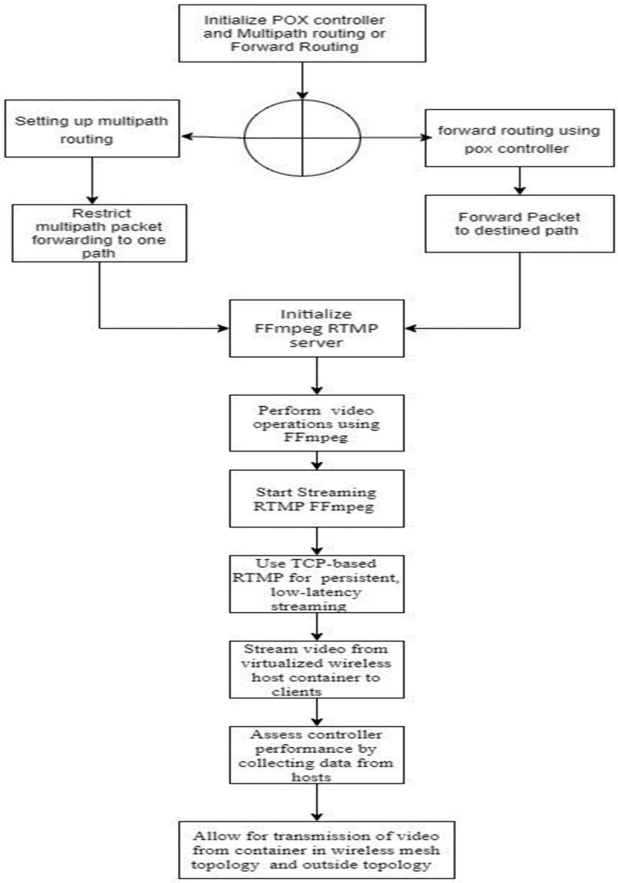


Fig. 4 Flow Chart

Results :

Following screen shots taken at different stages fig. 6 shows the mininet-wifi cli, ffmpeg terminal, and host xterm fig. 7 shows when at pox controller run with forward routing configuration and fig 8 shows when pox controller runs with multipath routing. [20]

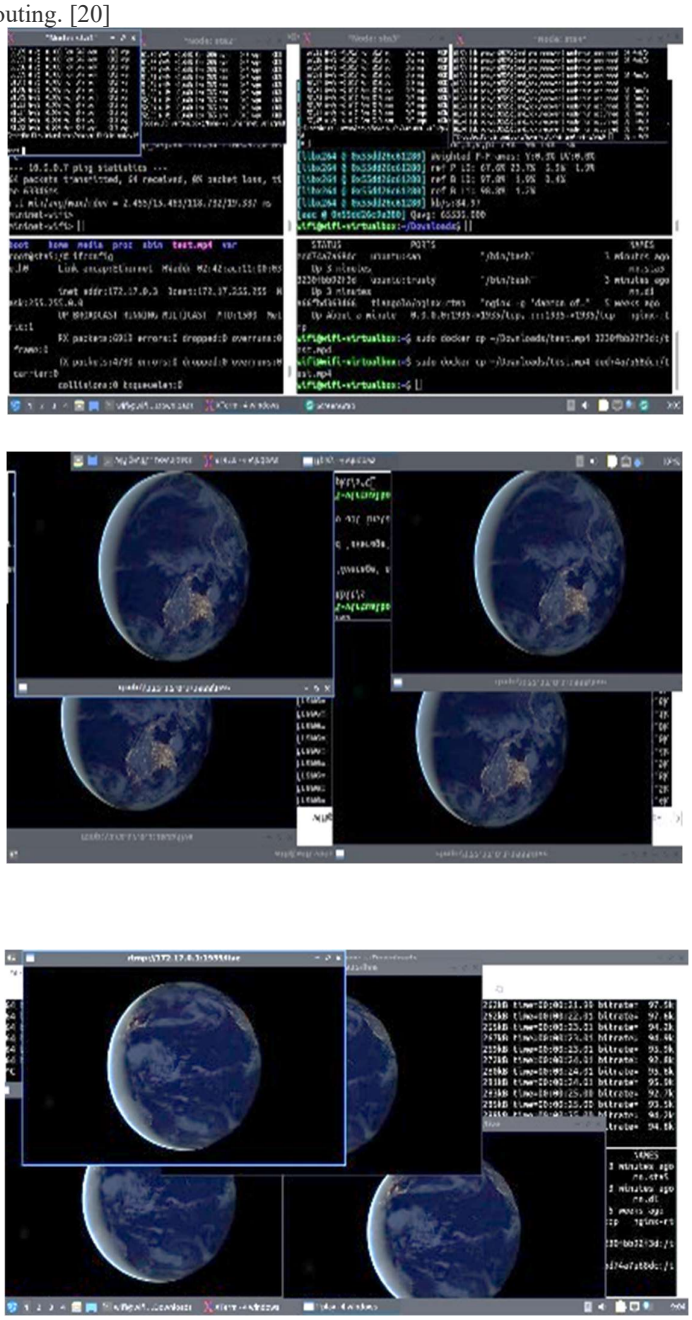


Figure 8 Multipath Routing Streaming

Based on the provided results from tables 1, we can analyze the performance of the POX controller based data multipath and data forwarding routing in a wireless mesh network with Docker container used as a gateway between ffmpeg RTMP server with wireless mesh topology.

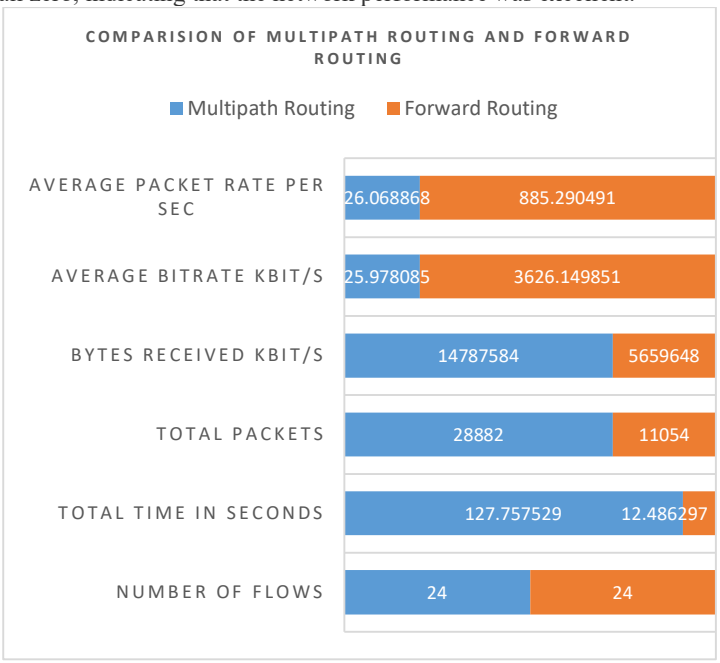
Table 1 Comparative analysis of Multipath and Forward Routing

Type	Multipath Routing	Forward Routing
Number of Flows	24	24

Total Time in Seconds	127.757529	12.486297
Total Packets	28882	11054
Minimum Delay	0	0
Maximum Delay	0	0
Average Delay	0	0
Average Jitter	0	0
Delay Standard Deviation	0	0
Bytes Received Kbit/s	14787584	5659648
Average Bitrate Kbit/s	925.978085	3626.149851
Average Packet Rate	226.068868	885.290491
Packets Dropped	0	0
Average Loss-Burst Size	0	0
Error Lines	0	0

The data multipath routing method has been used in this network to route data between the source and destination nodes using multiple paths. The results show that the network has handled a total of 24 flows over a period of 127.757529 seconds, with a total of 28,882 packets transmitted. No packets were dropped during this time, and the average packet rate was 226.068868 packets per second. The average bitrate was 925.978085 Kbit/s, and the average delay, jitter, and loss-burst size were all zero, indicating that the network performance was excellent.

On the other hand, the data forwarding routing method has been used to route data in the network using a single path. The results show that the network has handled a total of 24 flows over a period of 12.486297 seconds, with a total of 11,054 packets transmitted. No packets were dropped during this time, and the average packet rate was 885.290491 packets per second. The average bitrate was 3626.149851 Kbit/s, and the average delay, jitter, and loss-burst size were all zero, indicating that the network performance was excellent.



Graph 1 Comparative Graph

Comparing the two methods in Graph 1 , we can see that both methods have performed well in terms of packet delivery and no packet drops were observed. However, the data forwarding routing method has a higher average bitrate and packet rate compared to the data multipath routing method. This may be because the data forwarding

routing method uses a single path, which may have lower latency and delay compared to the data multipath routing method that uses multiple paths, which may introduce additional delay due to the need for path selection and packet forwarding across multiple paths.

Conclusion: Both the data multipath and data forwarding routing methods have performed well in the wireless mesh network with Docker container used as a gateway between ffmpeg RTMP server with wireless mesh topology. Multipath routing provides higher reliability and load balancing, while forward routing is a simpler approach but with less resilience to network failures. The choice between the two strategies depends on the specific requirements and constraints of the network, such as traffic load, network topology, and reliability requirements.

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