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# Application of MSVPC- 5G Multicast SDN Network Eminence Video Transmission in Drone Thermal Imaging for Solar Farm Monitoring

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**Abstract:** The impact of multimedia in day-to-day life and its applications will be increased greatly with the proposed model (MSVPC)–5G Multicast SDN network eminence video transmission obtained using PSO and cross layer progress in wireless nodes. The drone inspection and analysis in a solar farm requires a very high number of transmissions of various videos, data, animations, along with all sets of audio, text and visuals. Thus, it is necessary to regulate the transmissions of various videos due to a huge amount of bandwidth requirement for videos. A software-defined network (SDN) enables forwarder selection through particle swarm optimization (PSO) mode for streaming video packets through multicast routing transmissions. Transmission delay and packet errors are the main factors in selecting a forwarder. The nodes that transfer the videos with the shortest delay and the lowest errors have been calculated and sent to the destination through the forwarder. This method involves streaming to be increased with the highest throughput and less delay. Here, the achieved throughput is shown as 0.0699412 bits per second for 160 s of simulation time. Also, the achieved packet delivery ratio is 81.9005 percentage for 150 nodes on the network. All these metrics can be changed according to the network design and can have new results. Thus, the application of MSVPC- 5G Multicast SDN Network Eminence Video Transmission in drone thermal imaging helps in monitoring solar farms more effectively, and may lead to the development of certain algorithms in prescriptive analytics which recommends the best practices for solar farm development.

**Keywords:** 5G network; PSO optimization; drone inspection; thermal imaging analysis; solar energy harvesting; solar farms

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## 1. Introduction

The quality assurance of a solar farm includes millions of solar panels, cables, DC combiner boxes and invertors [1,2]. To ensure the operational reliability and the efficiency of the photovoltaic system, field fault diagnosis or the real-time visual inspection is vital. Considering the performance assessment methods like I-V measurements or the other field techniques, real-time thermal imaging of the PV panels and the electrical components are more effective [2]. Through this process, the thermal profiles of each panel in a large module is visible and it paves the way for analyzing the properties and identifying the faults such as micro and macro cracks due to the thermal stress. In addition, the thermal parameters on the electrical components enables us to analyze the mechanical stresses, which provides a better understanding about the PV system characteristics.

One of the major challenges in getting real-time visual data from the solar farm is the difficulty in video data transmissions [2]. The video data transmissions have been largely driven by the internet, which involves uploading and downloading multimedia data by the latest 5G technology through various devices including mobile phone, laptops, computers etc. Normal and emergency videos have been shared through mobile vehicles, and new methods are needed to streamline the bulk of multimedia data transfer with fastest data rate and without or almost zero-time delay. The 5G is one of the biggest evolutions of the network and adapts to many changes in the network and minimizes losses. The multicast routing protocol reduces the power consumption, transmission overhead, and control overhead and increasing the throughput by sending multiple copies of messages to various nodes in the configured network.

With the proposed 5G Multicast SDN network eminence, the solar energy intensity, wind speed, its direction and their variation over various parts of the country will be recorded and transferred as video packets to the centralized unit with the shortest delay, eliminating buffers and with the lowest error possible. The data collected at the centralized unit will help in arriving at decisions for monitoring the solar farms and detecting the faults. Smart and precision solar energy harvesting will facilitate renewable energy harvesters to be more informed and highly productive. A review article on the impact of 5G technology in smart farming, its opportunities and challenges, have been addressed by Yu Tang et al. [2] and the present research paper deals with renewable energy harvesting through a MSVPC model. Long Lu [3] et al. have addressed integrating internet of things (IoT) with wind and ocean energy harvesters for developing smart cities. A new innovative and more precise technique in the harvesting of solar and wind power will be introduced through integrating all the solar and wind power stations through the advent of this 5G technology with a multicast SDN network. Thus, a new revolution in the field of renewable energy power generation will be led throughout the globe by the IoT-based cloud computing service in the 5G network which provides flexible and efficient solutions for smart power generation. When transferring such huge data over 5G network the key challenges are the transmission delay and packet errors which have been addressed in this research work.

5G is one of the biggest evolutions of the network and it is enhancing the performance of the current network system, and it adapts too many changes in the network and minimizes losses. The headers of multiple layers lead to uniform interactions among the devices. These include routing layers, addressing concepts, UDP layer, MAC layers etc. The function of these layers is to extract and transmit data transmissions in the network. The general packet radio service (GPRS) tunneling protocol is attached to it, which allows devices in the network to be moved to different locations within the network area. The enclosed protocol operates as a tunneling protocol to create a data transmission path for video in 5G infrastructure. Then, the data packets of the devices can be sent and received through H.265 which is attached to the application layer.

Communications in the network transport layer are based on applications. Some devices may request some information from the main storage area of the server $M_{SD}$. The data-oriented network architecture aims to find the shortest path for sending information to the server near that device. It also helps to manage disconnections in the network path and to handle multiple transmissions simultaneously. In the proposed model, when the network traffic load is high, the protocol has to share the dynamic emergency data in the quality service mode. The multicast tree, which operates between a sender and its connecting nodes, uses a few methods. Accordingly, on each network, the built-in SDN software maintains the scaling and renovation of the network. Optimizers are deployed nearer to the edge server and the main server to manage the network traffic that varies from low to very high. Different types of traffic are grouped and the forwarder has been selected in the network through multicast mode and video streaming takes place through it.

In this proposed model, the speed of the node and the errors of conversion of the receiving packets have been calculated, the packets with the least changes and the video packets with the least delay have been found and sent through multicast routing mode. To regulate the transmission, the local best and global best nodes are selected in the particle swarm optimization mode and the packets sent. In this paper, Section 2 examines the literature survey, revealing the background ideas proposed for the MSVPC method, which states that video packets are transferred through a forwarder selected through PSO and data transmitted over SDN-enabled devices on the 5G network. Section 3 describes the design and methodology of MSVPC, Section 4 presents the results and discussions and, finally, Section 5 concludes with the influences and future challenges that need to be addressed.

## 2. Literature Review

SDN with network function virtualization, one can gain a global view of the entire network can be analysed using an open interface such as OpenFlow and with the centralized network controller. SDN can support new services and programs at any level of user requirement or need [4]. The current practice of focusing predominantly on rate-distortion performance with little consideration for these restrictions has led to the development of encoders that often perform poorly in non-ideal network conditions [1]. GPP has started discussions about technologies that could be standardized in future standards of 5G such as full dimension of multi-input multi-output, usage of unlicensed band, and multi-radio access technology coordination [5].

The availability of high-speed networks and the decreased cost of video capturing and displaying technology have opened the door for better monitoring systems in solar farms. Commonly used methods for the thermal imaging in the solar farms are by crane or lift, by walking and through drones. Considering the first two methods, the thermal imaging inspection is dependent on the module angle and the field topology. In addition, to obtain better results the thermal camera lens angle must be perpendicular to the panel surface. While both of these methods requires more time and resources, the third method, drone operation is much more effective and does not depend on the ground conditions, module angle, or field topology. Moreover, a centralized data set can be obtained from the drone inspection method and it is expected that video communication will be the dominating traffic over wireless and IP networks [6]. The data is aggregated and processed by servers to provide meaningful information or an actionable output. This output could be sent back through the network to trigger a set of actuator devices [7]. The related research fields such as embedded systems, computer networks, advanced hardware ranging from cameras, sensor nodes, boards and the like have been manufactured in industries has a bandwidth wider than 4G and higher scale of antenna array, higher the data rate and the computational burden due to digital signal processing far heavier [8]. The data flow from the streaming server could be controlled. The mobile network buffer queue serves the data in a rate that is modelled as a Poisson process. The client queue serves the data in its encoded bit rate [9]. UOWCs are vulnerable to numerous factors such as scattering, absorption and fading. In addition, UOWC performance is limited to short range and extensive research is required for long-range communications [10]. The variety of possible WLAN configurations and WIFI standards creates a need to determine their capabilities and to estimate the video stream transmission quality. The growing popularity of Wi-Fi networks creates a natural need to provide the same services in wireless environment [11]. A number of cross-layer techniques have been proposed to address the routing problem for real-time video transmission over multi-hop wireless networks in order to maximize the received video quality [12]. The MDC-FEC enables each video segment in a scalable mode of video coding standard to be packetized into multiple descriptions for the highest data protection against lossy transmission, and more fine-grained video streaming under varying bandwidth constraints and diverse playback capacities of mobile devices [13]. Engineering requirements for 5G and the design issues, M-MIMO, cloud-based networking, SDN, energy efficiency, spectrum regulation and standardization for 5Gwas proposed [14]. These devices are now playing an ever increasingly important role in lives. Recently, industry has made significant progress in resolving a lot of constraints due to the widespread adoption of wireless technologies [15]. It can be observed that the behaviour of radio signals is very different in the underground mines compared to that in outdoor and line of sight environments. In addition, the first step in increasing a wireless network performance is understanding the actual environment [16]. A systematic analysis is to investigate the effects of various underwater channel conditions, resulting from changing the water turbidity levels, on video quality and when different modulation techniques have been imposed [17]. The need for 5G technology in a smart grid and the areas where the new power grid can benefit the accessing of data was thoroughly discussed. The main aim of this work is to demonstrate 5G architecture in general compared to other wireless technologies and new networks in a smart grid, thus bringing the Internet of energy into the picture [18]. The introduction of RFID systems is attracting attention. IC cards are used widely as a secure form of door key. There is also a movement to incorporate VoIP technology into nurse call systems [19]. A video conferencing and internet television, delivered using multicast, can achieve high bandwidth efficiency. On the other hand, unicast delivery of such applications is inefficient in terms of bandwidth utilization, which is still an issue [20,21]. Chakravarthy. V, et al. [22] concluded on with an SDN-based load balancer which improves the efficiency of the network by distributing the traffic across multiple paths to optimize the efficiency of the network. Jeya. R, et al. [23] have addressed the video is considered as an input in the transmitter side and transformed into data frames and compressed with the help of ASCII-based Huffman algorithm. Using Affine ECC, the compressed data are encrypted as well as modulated with the help of the MQPSK method.

## 3. MSVPC Design and Implementation

### *3.1. MSVPC Network Design*

The set of nodes as N devices and S sensors formed in a network and the channels that connect those nodes wirelessly have been represented as $S = (s_1 \ldots s_2 \ldots s_n)$. Moreover, 5G mobile communication is created by establishing the hierarchical cellular connection among the cellular devices, access point $\mathrm{A_P}$, internet gateway $\mathrm{I_G}$, and internet server $\mathrm{I_S}$ are shown in Figure 1. At the beginning of the network $\mathrm{I_S}$ broadcasts its presence at regular intervals as t. Also, the set of video data packets are accessed by the nodes known as V.

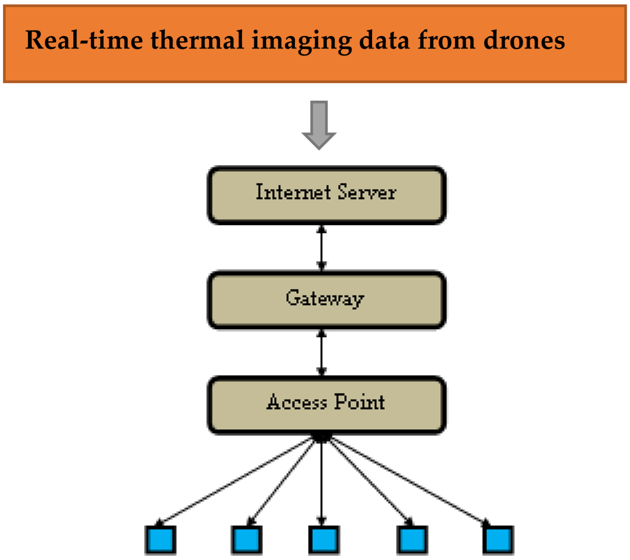

**Figure 1.** Network connectivity.

The aggregator node $A_N$ will continue to announce its presence on the network through its broadcast message. The network includes user devices and sensors. The sensors in the network sense the quality of the network and provide information about it. It realizes and shares information about the number of videos traveling on the network, bandwidth usage, transfer rate, information about the network port on which it travels and metadata about the video. If the sensor receives the $A_N$ message, it will update the aggregator ID immediately if the message has not been received before, or if it is already connected to an $A_N$, it will estimate the distance $D_{ist}$ between the new $A_N$ and the previous $A_N$ and upgrade the shortest-distance aggregator so as to communicate. The sensor then sends the link message to the $A_N$, which receives the message and stores the information of the sensors that sent reply message through the link. The $D_{ist}$ is calculated according to the Pythagorean theorem, where, the location of the sensor and user is termed as ($X_1$,$Y_1$), and aggregator location is ($X_2$,$Y_2$) and then, distance $D_{ist}$ between these two products are computed as per the following equation.

$$D_{ist=}\sqrt{\left|X_1 - X_2\right|^2 + \left|Y_1 - Y_2\right|^2} \tag{1}$$

The network is interconnected with a data-based network architecture, which we use to set names for source-to-destination navigation and to determine the name by individual group to respond to device packets. After creating the names, the data-based network configuration will publish it, and then, the connected devices will have to subscribe to it, thus assigning an address to each device as $\text{Addressing} \rightarrow D_{NS}$. This address is known as the domain name of the network and the connection ID. It is used to decide which node the data should be transmitted to during the process of providing a $D_{NS}$ IP address to each node. As a result, each device and sensor on the network is assigned an IP address, which is then utilized to detect device connections inside the network.

The actuators will continue to broadcast their presence at regular intervals with the ($X$, $Y$) location. Packets can quickly reach the destination by setting the status of the packets that arrive on the network so that the path can finalize according to the status. If the message is received by an $A_N$ or user, they will update the actuator's information along with actuator $\rightarrow$ ID and location points $\rightarrow$ $(\mathrm{X}, \mathrm{Y})$. If the user device is connected to the actuator, the actuator will generate an ID for the user and notify the device, and update it to the actuator's user list. Thus, when the actuator generates an ID for the device, it checks if it already has a $D_{NS}$ address, and then generates the ID using a random number between (0–1). Once the device receives and updates the ID, it creates a secure connection with the actuator, thereby establishing security within the network.

To create such a secure connection, the device will change its password $P_{WD}$ and its ID using $XOR$ mode, it then shares the security provisioning information with the actuator during the time of communication so that the actuator will retrieve the original password $R_P$ and ID attached to it then authorize the transaction if it is valid, besides it enables the final authorization to add the user to the network's link list as per the equation below.

$$R_P = ID\ XOR\ P_{WD} \tag{2}$$

When requesting a video description along with its location ($X$, $Y$) by a node, the details of the node ID, its authorized $P_{WD}$, its subscription information, and the location of the node are all attached for identification. When this information is verified, the device is checked for access control according to the $P_{WD}$ and its valid subscription particulars, and the virtual infrastructure system is activated. This virtual infrastructure system manages the different situations in the network and manages its processing and storage properly. Access control for each node is attached to the virtual infrastructure activated after validating several steps, such as the following monitoring steps: the first step is whether it is properly connected to the network or not, and the second step is whether it has received a connection ID, and is the a suitable $P_{WD}$ for it, all of these need to be verified.

If the $A_N$ receives the virtual infrastructure activation information, it will update the sensor counts and calculate their distance $D_{ist}$ It then sends information about short-range sensors request to storage $M_{SD}$ . The intermediator will select and send the appropriate video traffic ID upon receipt of that information, and updates the information about those sensors.

If the video is not available, then the actuator requests the internet server for the video and sends it to the user. Similarly, the internet server also sends the information about the sensor to the user. According to the report of the sensor, the user device starts streaming the video or stopping the video. The 5G network enables a nested data group system between the movable nodes; it forces to manage those types of groups properly.

Sometimes the network has to handle large amounts of data. The load balancer running on the network balances the data and converts it to the virtual network. There, the videos will be distributed to individual users or individual groups for a limited time. Thus, the distributed videos are arranged in a separate layer with a scalable code number. In the first layer, data can be sent individually based on network status and streamed with smaller data bits. In the top layer, high-quality videos are streamlined and integrated. All of these methods work according to the function of the network.

Once these videos reach the video optimizer, it will update the nodes in the cache about the sent node information so that it can know the demands on the network along with the specific file ID $F_{ID}$. If the destination node ID is not connected, the information will be sent to resource allocator $R_A$ to obtain the destination ID, otherwise it will be sent to the monitor node to obtain the current status of the network. Later, it will transferred to the storage, and the total packet bytes count of the video will be attached as shown in Figure 2. The monitoring node stores the sensor's information and uses it to regulate the channels through which data packets travel, thus storing more data on the storage device $M_{SD}$. The cached $C_S$ video size $V_S$ which is less than the storage capacity and the streaming duration noted as $t$, have been used to compute the cached video. Also, we can compute the total server storage size as $C_{VS}$.

$$C_{VS} = \sum V_S \leq \frac{C_S}{t} \tag{3}$$

$$\sum C_{VS} \leq M_{SD} \tag{4}$$

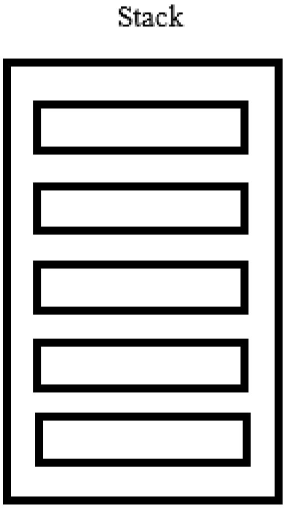

**Figure 2.** Optimization stack.

Part of the information is stored on the local network, and some high-quality videos are stored on the main server. It depends on the needs and functionality of the network. Similarly, the data layer in the network must be integrated with all parents. The cache information of the node is transferred to the virtual network optimizer. If it does not contain MPEG information it will be saved anew. If it is not already listed in the received data, it will be stored in the optimization layer as shown in Figure 3.

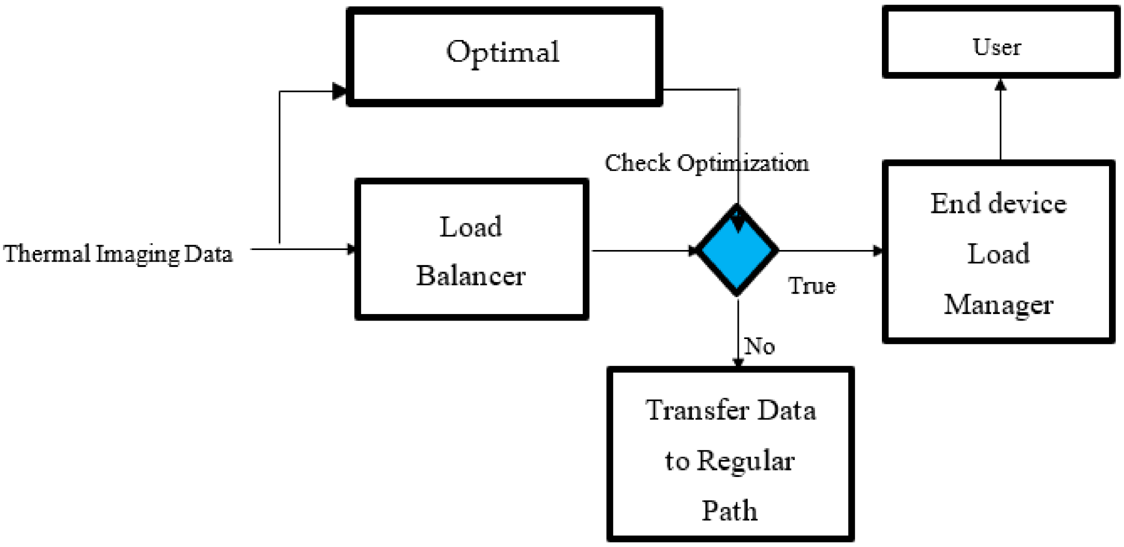

**Figure 3.** Load balancer operation.

The encryption process is activated after the frame ID and MEPEG data are added to the optimizer stack, which then sends it to the identification code. Furthermore, the load balancer is activated and the information is processed in a properly balanced manner, which ensures that there is no reflection of the data and it is integrated in the correct layer as shown in Figure 4. Otherwise, the optimizer will remove the content from the layer.

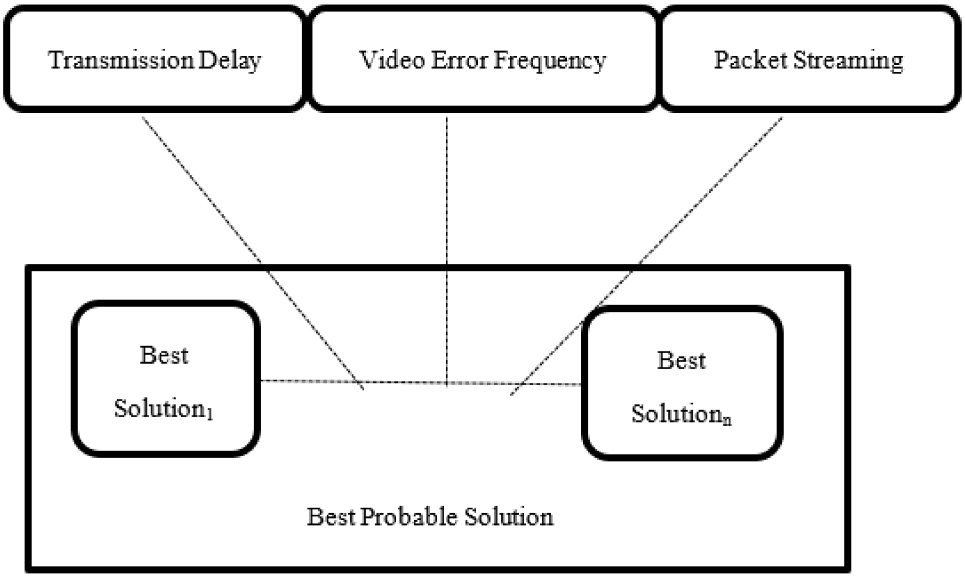

**Figure 4.** Optimization parameters.

Scanner nodes, which are registered on the network, store the data that the sensors record when their sensors change location. The cache node stores the information in the scanner node and the source registry. When data are collected from multiple locations at different levels, the data stored at the scanner terminal are used to detect connections between data using certain rules. This type of data verification allows you to immediately notify the network of changes in the network's infrastructure. It runs from the beginning of the network, which is powered by resource register software running on the network.

It monitors the performance of the hardware on the network and the services running on it. It monitors whether the data transfer is active or the connected storage is running.

### *3.2. Adaptive Video Streaming*

Each particle $P$ will bring some possible solutions with current and previous experiences. A network has a limited number of particle swarms $P = (p_1 \ldots . p_2 \ldots p_n)$ within its boundaries. Its moving speed $S$ at a time $t$ and its ideal resting location $R_L = (r_{l1}. .r_{l2} . .r_{ln})$ are calculated as per the below mentioned Equation (5)

$$R_L = S_t \alpha + S_{Va}(LR_L - R_L) + S_{Vb}(L_B - R_L) \tag{5}$$

Here, $S_{Va}$ and $S_{Vb}$ have explained the continuous transmission speed variations and nodes moving variations inside the network, $\alpha$ is the tuning parameter of the speed, $LR_L$ is the last resting location during the mobility and $L_B$ is the local best resting location among the set of selected locations with coverage area $C_R$. At this point, the $R_L$ is computed as per Equation (6), later updates the current $R_L$ as the last $LR_L$ and updates new one to obtain the movement points and also the movement speed $S_{t+1}$ at the time obtained from the maximum and minimum speeds of the particle.

$$R_L = R_{L(t)} + S_{t+1} \tag{6}$$

$$LR_L = R_L \tag{7}$$

$$L_B = BestR_L(r_{l1}..r_{l2}..r_{ln}) \rightarrow C_R \tag{8}$$

Here $L_B$ is the lowest boundary of the resting location. The travelling delay $T_D$ has been computed from the summation of packet buffering delay $B_D$ and transmission channel propagation delay $P_D$, and due to the transmission and because of the wireless nature, the packet transmission error $E_T$ can occur, the error difference $E_D$ is also calculated. The last transmission packet is $T_{PL}$ and the current transmission packets is $T_P$ respectively.

$$T_D = (B_D + P_D) \tag{9}$$

$$E_D = T_{PL} - T_P \tag{10}$$

$E_D$ should be minimum level than the error difference threshold of $E_{DT}$, $E_D \leq E_{DT}$. All these computations should be done before the packet expiry time along with the network state. These metrics provide the best quality of service in the network. Multiple benchmark decisions have been considered during the video transmission period to handle the storage and user query as shown in Figure 4.

Design considerations:

- Analyse packet expiry computations before and after;
- Reduce the data packets loss;
- To reduce the error rate of the transmission computed;
- Links are congested, causing packet buffer overflow at the networking device;
- Network reachability status changes causing certain packets to become destination unreachable and be dropped. The variations of the packet drop are shown in Table 1.

**Table 1.** Packet drops.

| Number of Users | ALVN | SVNVO | MSVPC |
|---|---|---|---|
| | Average Data Drop | Average Data Drop | Average Data Drop |
| 10 | 1.31% | 1.29% | 0.7% |
| 20 | 2.33% | 2.29% | 0.9% |
| 30 | 2.35% | 2.30% | 0.19% |

The above Table 2 shows the quality of the transmission according to the packet loss percentage. Occasionally there will be several changes in the aims mentioned above. It can be calculated as follows. It is necessary to find the optimal position.

$$\sum \mathrm{T_i} \delta\, \mathrm{f_i}(\, \mathrm{C_i}) - \sum\sum \mathrm{T_m} \delta \mathrm{f_m}(\, \mathrm{C_m}),\ \forall \mathrm{m} \ = \ 1, 2 \ldots \mathrm{m} \tag{11}$$

**Table 2.** Performance of the packet loss.

| **Packet Loss (%)** | **Quality** |
|---|---|
| 0% | Excellent |
| 1% | Respectable |
| 2% | Acceptable |
| 3% | Risk |

When a lot of metrics of this type are available, they are all stored in a matrix format in which the optimal solution is calculated. When different videos are transferred, many limitations occur. Similarly, many different functions $\mathrm{f_i}$ occur during transmission, so it is important to find transmissions with minimal variations. This will help us to find the optimal transmissions. Thus, we calculate the transmission rate of optimal video streaming.

$$\textit{Reduced}\ \mathrm{f_i}(\, \mathrm{C_i}) = \sum \psi(\, \mathrm{E_T},\ \mathrm{T}) \tag{12}$$

When videos are transmitted through different channels $\mathrm{C_T}$, it is calculated as follows. Here $S_T$ is the video travelling speed and $\mathrm{E_{TM}}$ is the maximum video error rate.

$$\mathrm{C_T} = \sum \psi(\, \mathrm{E_T}\, ,\ \mathrm{T}) \ + \ \sum \mathrm{C_R}(\mathrm{T} - \mathrm{T_D}) + \sum \mathrm{S_T}(\, \mathrm{E_T} - \ \mathrm{E_{TM}}) \tag{13}$$

The delay for all channels and the error rate of the arrival packets $\mathrm{D_E}$ are calculated as below. The delay variations and its performance given in Tables 3 and 4.

$$\mathrm{D_E} = T \sum \mathrm{T_R} + \ \mathrm{E_T} \sum \mathrm{S_T} \tag{14}$$

**Table 3.** Node vs. delay.

| | **Delay** | | |
|---|---|---|---|
| **Speed** | **ALVN** | **SVNVO** | **MSVPC** |
| 0.1 | 1.02829 | 0.49847 | 0.02787 |
| 0.2 | 1.08764 | 0.59379 | 0.03459 |
| 0.3 | 1.87493 | 0.78309 | 0.03768 |
| 0.4 | 1.78409 | 0.77537 | 0.04789 |
| 0.5 | 1.73680 | 0.7i367 | 0.06748 |

**Table 4.** Delay performance.

| **Delay (ms)** | **Quality** |
|---|---|
| ≤0.1 | Escellent |
| <0.3 | Respectable |
| <0.6 | Acceptable |
| <1 | Risk |

Tables 3 and 4 shows the delay performance according to the protocol based on speed variations. Thus, we can detect the video that is being streamed $\mathrm{S_V}$ in a very short time.

$$\mathrm{S_V} = \mathrm{minimum}((\, \mathrm{f_i}(\, \mathrm{C_i}) + \ \mathrm{D_E}) - \sum \ \mathrm{T_R T_D} - \sum \mathrm{S_T}\ \mathrm{E_{TM}} \tag{15}$$

According to this, we can find the perfect video streaming frequency $S_{VF}$ is as below:

$$S_{VF} = P_R(1 - \text{minimum}(D_E + T_D)) \tag{16}$$

By achieving minimum packet transmission delay and reduced packet error difference the video transmission gains higher video streaming frequency (Algorithm 1). Then, we form the global fitness $G_B$ path to transfer the video packets.

$$G_B = T_D - T_{D-1} \tag{17}$$

**Algorithm 1** Optimal Video Streaming Steps

```
Created 5G Multicast routing network
Deploy SDN enabled devices
Compute the Storage device size $M_{SD}$ and cached Video size $C_{VS}$
    a. $C_{VS} = \sum V_S \le \frac{C_S}{t}$
    b. $\sum C_{VS} \le M_{SD}$
Initiate particle swarm with Nnodes
Update swarm random locations L, Speed S of particles, at time t
Compute resting location $R_L$ of swarm
$R_L = S_t\alpha + S_{Va}(LR_L - R_L) + S_{Vb}(L_B - R_L)$
Repeat the process $R_L$ till end of the communication
For $i = i_1 \ldots i_n$
Update $R_L$ variations of $R_L = R_{L(t)} + S_{t+1}$
Compute data transmission error $E_T$ and traveling delay $T_D$
$T_D = (B_D + P_D)$
$E_D = T_{PL} - T_P$
Combination of delay and arrival packet error difference computed using
$D_E = T\sum T_R + E_T \sum S_T$
Computed perfect video streaming in network by
$S_{VF} = P_R(1 - \text{minimum}(D_E + T_D))$
Find local PSO best $L_B$ forwarder for multicast routing within coverage range $C_R$
$L_B = \text{Best}R_L(r_{l1}..r_{l2}..r_{ln}) \rightarrow C_R$
Construct final global fitness path $G_B$ for transmission
$G_B = T_D - T_{D-1}$
```

During transmission the network initiates the group formation on the primary server. If the internet server cannot be accessed directly, users will join the multicast group; information about the group ID will be given to all users in the group; later, according to the calculation, the node acts as a head in that local group, and is extended up to the destination by selecting the global best nodes throughout the path. The network paves its continuity path, and all users joining the group will be added to the multicast member list. This allows short interparticle distance nodes to act as forwarders and stream video as shown in Figure 5.

The physical 5G communication is configured in the physical medium using the 256 QAM Modulation and Beamforming. The software-defined network SDN is used to virtualize the network function by utilizing the virtual network. Multicast communication between the users and the server is generated by forming the multicast tree in the network layer as IP multicast, as shown in Figure 6. The multicast users can join and leave in the multicast group and the corresponding tree is updated dynamically. Once the IP multicast is created, the data center is used to encode the video to be streamed to all multicast users as in Figure 6.

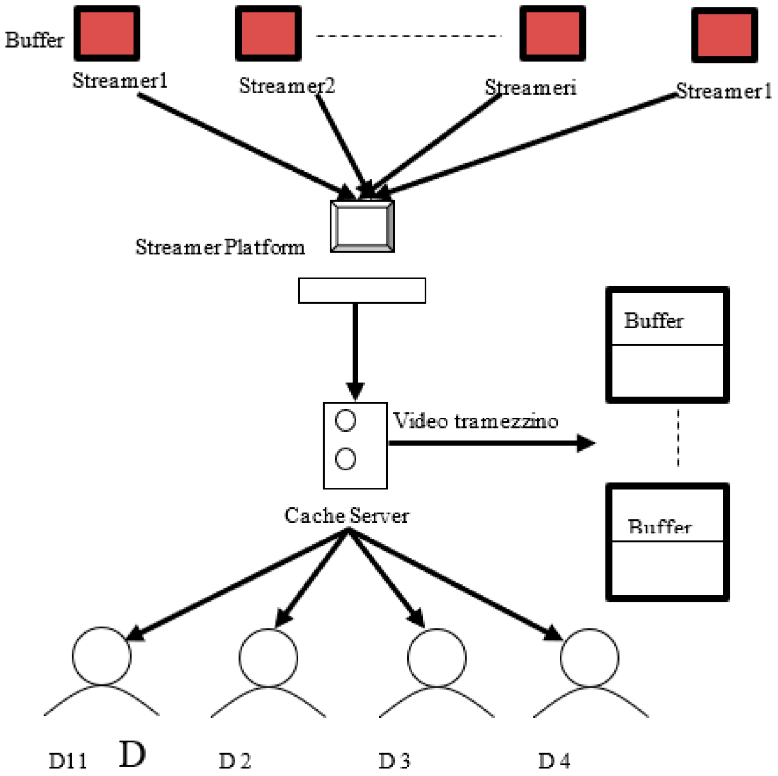

**Figure 5.** Streaming flow.

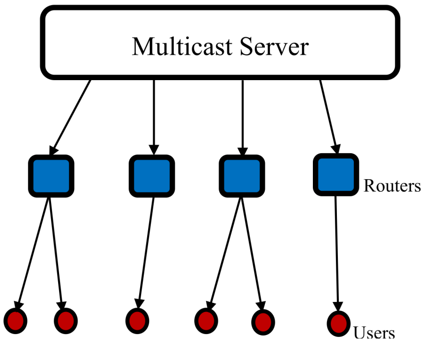

**Figure 6.** Multicast tree.

Descriptions are distributed across the multicast tree, during the video transmission. IP multicast minimizes the unnecessary transmission of replicated packets in the network. Data centre-based video multicast servers are represented as description providers which exhibit the packet in multicast IP containing information about its description which is forwarded to the controller. The transmission is completed using the SDN which also monitors and optimizes the video transmission. The video optimizer service is deployed on the edge of the 5G network with video traffic filtering. The video traffic is forwarded from a load balancer to the optimizer virtual network which handles the management plane as an efficient assignment of IP addresses to active users of the infrastructure. Also, the cognitive framework continuously quantifies the congestion degree of the network at a fine-grain level using the congestion index. When the congestion index surpasses the threshold, then it is processed by the cognitive layer leading to the application of the filtering rule in the associated virtual network.

## 4. Simulation Analysis

The proposed method uses the following parameters to build the network. The network is configured with 100 to 200 data points as various scenarios, five access points, five internet gateways and one streaming server. Furthermore, network terminals are built with a beam-forming MM wave antenna for transmission and receiver pockets and a multi-input-multi-output channel installed at each terminal for communication. The movement of the nodes is undertaken in random mobility mode. Each node moves at random speed from 0 to its maximum speed of 5 m in a random direction. As well as stopping for a short period after going a certain distance and then moving again known as pause time, and here pause time is mentioned as 10 milliseconds. In this mode the nodes travel across the network. Accordingly, video packets are converted to multicast routing mode. Table 5 shows the network parameters used.

**Table 5.** Network parameters.

| Network Parameters | |
|---|---|
| Information Point | 100–200 |
| Access points | 5 |
| Internet Gateway | 5 |
| Streaming Server | 1 |
| No of Antenna | 3 |
| Modulation Type | QAM256 |
| Simulation Time | 200 |
| No of Channel | 10 |
| Multicast Group Members | 30 |
| Antenna Type | Beam forming MM Wave |
| Coverage | 80 |
| Communication Type | MIMO |
| Traffic Application | H265Codec Video Streaming |
| Connection Type | UDP |
| Mac standard | IEEE P802.11ay |
| Maximum Bandwidth | 100 Ghz |

## 5. Results and Discussion

Packet delivery ratio (PDR) is the percentage of packets arriving at the destination from the source. As the percentage of such packets increases, the protocol running on that network is said to work better. Figure 7 shows that the proposed protocol MSVPC has received a large number of packets in percentage format. This is due to the network design and the routing methods in it. In addition, in the comparable scalable virtual video optimizer network (SVNVO) and ALVN, it can be seen that the percentage of packets it has received is reduced due to the lack of optimization system routing designed in the proposed model. Here, the network shows 81.1448 percentage of packet delivery ratio in MSVPC. Because of the swarm optimization-based video transmission and multicast routing this performance enhancement is achieved.

Network delay is the amount of time it takes to transfer video packets from source to destination. This includes transmission propagation delay, queuing delay and network delay. In Figure 8 the network delay is less than the proposed MSVPC method. The reason is the choice of network design and associated parameters. When the path for video transmission is selected in PSO mode, the delay is calculated as an important parameter and thus the local best node and global best nodes are selected and the path is set. This significantly reduces network delay and, as a result, more packets are delivered to the destination as in Figure 9. Network delay considers the queue, channel and propagation delay timings, and including all these timings MSVPC achieved 0.0694974 as a minimum delay compared to other protocols.

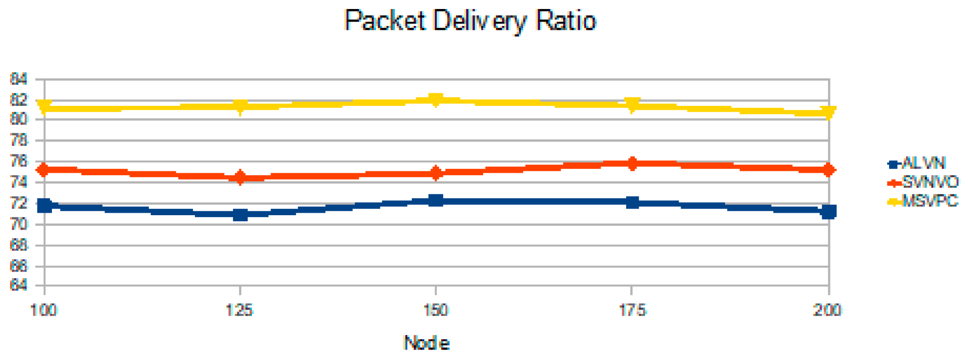

**Figure 7.** Packet delivery ratio.

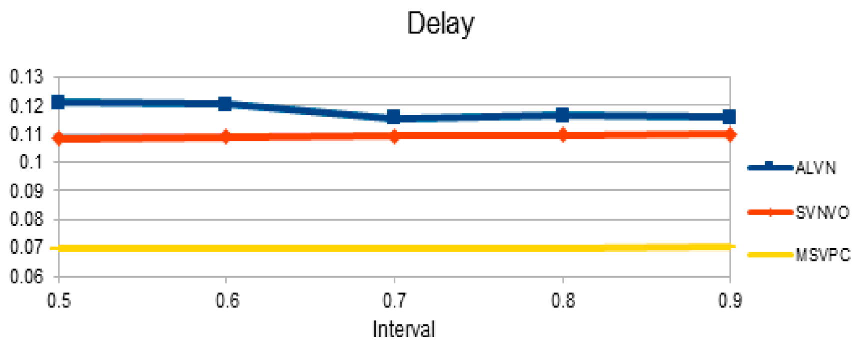

**Figure 8.** Interval vs. delay.

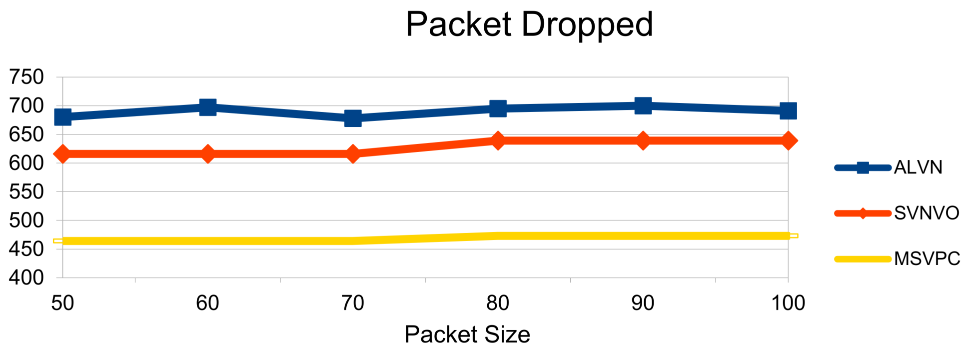

**Figure 9.** Packet size vs. packet dropped.

Packet drops are caused by time delays in the network and loss of communication between the network. It is necessary to choose a clear path to minimize the time delay. It has been reduced in the proposed method, MSVPC, as shown in Figure 9, by the particle swarm method, which chooses the multicast forwarder selection. This reduces the number of packets lost during video transmission over a 5G network. As packet losses decrease, packet delivery increases, and this can be detected by the quality measures given in it. Here, the packet drops based on the dropped packet counts. If the path is stable, the network can gain minimum packet loss during transmission. Here the proposed MSVPC lost less number of packets than the other protocols.

Throughput is the bits count of packets obtained at the destination. If the destination starts to obtain more bits, then the network design and protocols can be considered to work better. MSVPC obtains more packet bits in the network. To calculate this, the large packets in the destination can be multiplied by eight and divided by the time the packets transmitted. We assume that the routing of the network works best, if the nodes in the network can stream a large number of video pocket bits. Figure 10 shows the MSVPC proposed method can be seen to get more throughputs as 64232.7 for 100 nodes. The quality of service output has increased in proposed method compared to SVNVO method available in the literature and may be benchmarked for transferring of data through the 5G network.

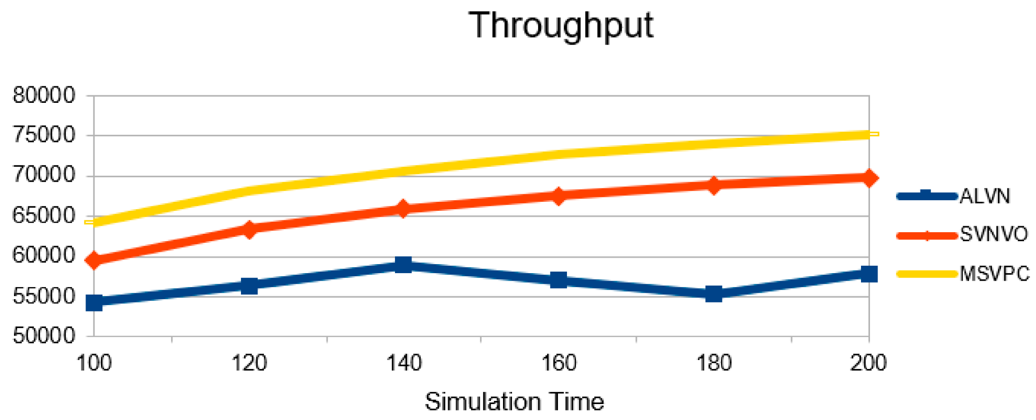

**Figure 10.** Simulation time vs. throughput.

In Table 6 the nodes, packet interval, packet sizes and simulation time are taken as inputs and the changes caused by its variations are calculated as results. The proposed protocol, MSVPC, has a higher packet delivery ratio than the other two protocols compared to it as well as less delay.

**Table 6.** Result.

| | Packet Delivery Ratio | | | Delay | | | |
|---|---|---|---|---|---|---|---|
| **Node** | **ALVN** | **SVNVO** | **MSVPC** | **Interval** | **ALVN** | **SVNVO** | **MSVPC** |
| 100 | 71.7632 | 75.2815 | 81.1448 | 0.5 | 0.120987 | 0.108215 | 0.0694974 |
| 125 | 70.8742 | 74.4645 | 81.2711 | 0.6 | 0.120453 | 0.109016 | 0.0698209 |
| 150 | 72.2848 | 74.8879 | 81.9005 | 0.7 | 0.115363 | 0.109288 | 0.0699412 |
| 175 | 72.0984 | 75.8989 | 81.398 | 0.8 | 0.116354 | 0.109507 | 0.0699325 |
| 200 | 71.2353 | 75.2242 | 80.6614 | 0.9 | 0.115744 | 0.109892 | 0.0702529 |
| | **Packet Dropped** | | | **Throughput** | | | |
| **Packet Size** | **ALVN** | **SVNVO** | **MSVPC** | **Simulation Time** | **ALVN** | **SVNVO** | **MSVPC** |
| 50 | 680 | 616 | 464 | 100 | 54,235.1 | 59,482.9 | 64,232.7 |
| 60 | 697 | 616 | 464 | 120 | 56,353.8 | 63,395.4 | 68,127.4 |
| 70 | 678 | 616 | 464 | 140 | 58,942.3 | 65,899.5 | 70,577.4 |
| 80 | 695 | 639 | 473 | 160 | 56,973.5 | 67,481 | 72,642.6 |
| 90 | 700 | 639 | 473 | 180 | 55,319.2 | 68,819.9 | 73,985.9 |
| 100 | 691 | 639 | 473 | 200 | 57,843.6 | 69,779.6 | 75,176.5 |

## 6. Conclusions

5G mobile communication is created by establishing the hierarchical cellular connection between cellular devices, and the physical 5G communication is configured in the physical medium using the 256QAM Modulation and Beamforming antenna. The software-defined network (SDN) is used to virtualize the network function. This research work aims to integrate and implement the 5G network for monitoring the thermal imaging of solar farms through drone's inspection. Multicast communication between the users and the server is generated by forming the multicast tree in the network layer as IP multicast using particle swarm optimization. Descriptions are distributed across the multicast tree during the video transmission process. IP multicast minimizes the unnecessary transmission of replicated packets in the network and the delay is minimized and packet error is lower to forward the packet. Here the video multicast servers are represented as internet servers that send a packet in multicast routing containing information about its description which is forwarded to the controller, and the transmission is completed using the SDN which also monitors and optimizes the video transmission. The video optimizer service is deployed at the edge of the 5G network with video traffic filtering. The video traffic is forwarded from a load balancer to the optimizer which handles the management plane as an efficient assignment of node addresses to active users of the infrastructure using the dynamic host control protocol service; also, the cognitive framework continuously quantifies the congestion degree of the network at a fine-grained level using a congestion index. When the congestion index surpasses the threshold, then it is processed by the cognitive layer leading to the application of the filtering rule in the associated optimizer.

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