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Allocation of Channels for Channelizing the IoT Traffic

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Abstract: With the evolution of Internet of Things (IoT), the generation of data has been increased to a remarkable extent. The sensors generate the data all the time and it is significant to transmit the data through Internet gateways with a good transmission speed. There are multiple links between the transmitting and receiving nodes and each link may have multiple channels. The selection of suitable channels is very important aspect for the faster transmission of the data and is a great challenging job for IoT based data transmissions due to enormous quantity of data. In this paper, a statistical MCDA technique based on SAW and PROMETHEE has been utilized for analyzing all the parameters that impact the channel selection mechanism and on the basis of the PROMETHEE outranking scores; the channel with the highest score is picked for data transmission. The statistical SAW method first obtains the priorities of each parameter which effects the decision of selecting the channel and then performs a pairwise comparison of the available channels. Finally, PROMETHEE method generates the scores for all the channels. The IoT node or gateway can select the channel with the maximum AHP score to forward the data for getting faster transmission speed. The result outcome of the proposed channel allocation scheme states that the channel selection based on MCDA method not only provides good data transmission speed but it also enhances the network capabilities by reducing delay in transmissions, by enhancing overall throughput of the channel and by balancing the network load.

Keywords: *PROMETHEE-II, channel selection, channel allocation, IoT, sensors, MCDA, IoT traffic*

1. Introduction

The Internet of Things has evolved into a global infrastructure that connects various heterogeneous devices via wired and wireless communication techniques. The IoT devices are connected through each other by Internet, sensors, cloud servers and IoT gateways to maintain seamless connectivity with the integrated services provided by the aligned technologies [1], [2], [3] as shown in Fig. 1. Software Defined Networking (SDN) is a new IoT technology that allows IoT users to manage diverse structures and resources while receiving safe services. There are many applications around us that are using IoT and Cloud services for fulfilling the needs of the end users as shown in Fig.2. The worldwide Internet of Things application growth trajectory is clear, and we are currently in a moment of strategic possibilities before the industrial explosion. In IoT networks, the data is generated by the sensors each second and analysis of this data is important to interpret the data for making certain decisions [4]. The data is generally segregated into normal data and abnormal data [5]. Most of the time, the abnormal data is deflected, and normal data is given remarkable importance [6]. Efficient channel allocation is a major challenge in managing network traffic, especially in the context of IoT. IoT devices rely on cloud servers, IoT gateways, AI tools, data analytics, and sensors to communicate with each other [7].

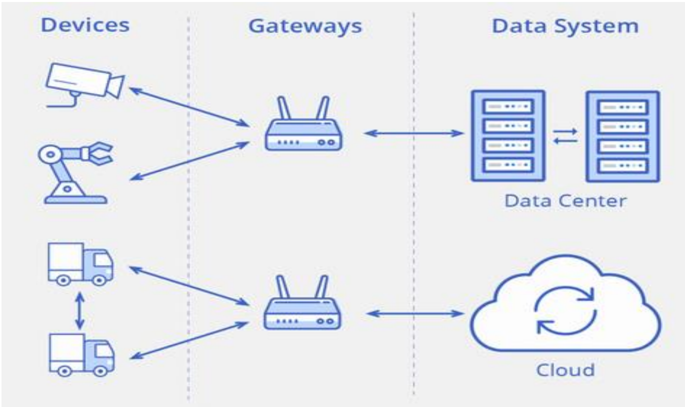

Fig.1.The connectivity among the IoT devices, IoT gateways and Cloud servers

The cloud servers allocate resources to IoT applications and facilitate data exchange between IoT devices, cloud servers, and IoT gateways. The transmission of IoT traffic requires prioritization of data exchange between cloud servers and IoT gateways, as this determines the speed of data transmission. However, as the number of IoT devices and IoT data traffic increases, it will put a strain on the software-defined networking (SDN)-enabled IoT ecosystem. Therefore, IoT is considered a new infrastructure that utilizes the advantages of cloud computing, telecommunication, and information technology to provide revolutionary solutions to end-users [8]. The heterogeneity notion is at the core of IoT-based infrastructure. With a wide range of IoT devices networks, cloud servers and data centres, and AI-based technologies and gateways, the IoT is becoming increasingly varied [9].

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Because IoT traffic is also dynamic in nature, channelization of dynamic traffic is a difficulty for both solution-specific gateways and Internet gateways. In [10], the author has presented a new policy for channelization in cellular networks and the policy is able to channelize the traffic over cellular networks by taking care of hands-off policies among the cellular networks.

Fig. 2. IoT based services with the aid of Cloud servers and aligned technologies

In [11], authors have tried to present a dynamic allocation of channels for Mobile networks where traffic is generated by mobile networks and a quick transmission is needed to forward the mobile data. In [12], a throughput-based scheme for allocation of channel is designed for opportunistic networks and the scheme is able to forward the traffic optimally for opportunistic networks. In [13], an adaptive method for adhoc networks is proposed to assign the channels for forwarding the traffic which takes care of dynamic nature of heterogeneous data. In [14], an interference-aware strategy for channelizing the mobile data on cellular networks is proposed. In [15], the channelization scheme is proposed for IoT based Apps. The scheme is using the concept of survivability of IoT traffic for allocation of channels. In [16], two networks are considered for channel assignment, ad-hoc and mobile networks. The channel assignment scheme works for both the networks. The distributed allocation of channels is proposed in [17] for mobile networks. The mobile based traffic is growing day by day and adaptive scheme for channelization of mobile data is the need of the current era. A partial overlapping scheme is presented by authors for wireless networks [18]. In [19], the authors discussed about the latency in communication devices and proposed a V2V model. The issue was to solve the channel allocation problem in vehicular networks. In [20], a non-overlapping approach is presented for channel allocation. Spectrum utilization model for channel allocation was elaborated [21]. This technology claims to increase the amount of bandwidth accessible to network users by reducing link congestion [22]. The allocation of channels should be performed by comparing the static and dynamic features of the channels. This dynamic allocation of channels is a serious issue for handling large volume of IoT traffic [23]. The other approaches are ignoring security factors while this scheme is also devising security mechanism in their proposed scheme [24]. An ad hoc network needs an integrated power management and routing approach to cut down on power use and extend node battery life[25]. In order to increase hybrid network throughput and subscriber decency, study in [26] focuses on the optimization of combined subscriber affiliation and frequency channel distribution. An evolutionary optimization approach is suggested for channel assignment in Cognitive Radio Networks (CRNs), where the assignment of the spectrum is regarded as a major research problem [27]. The weights of the seven criteria are computed using the analytical hierarchy process (AHP) in [28], and the best alternative or option is chosen using PROMETHEE. PROMETHEE I and PROMETHEE II are two models used for ranking options. PROMETHEE I provides a partial ranking and preferences while PROMETHEE II computes the whole ranking. To address spectrum scarcity in dense networks, Energy Efficient Dynamic Channel Allocation Algorithm (EE-DCAA) was introduced in [29], based on polling access methods and contention access to dynamically allocate slots for heterogeneous sensor nodes. Multi-channel ad hoc networks are also used in such scenarios. These techniques are in line with the IEEE 802.15.6 standard. The fundamental issue with channel access in dispersed multi-channel networks is channel allocation and its synchronisation [30]. In order to address this problem, a novel strategy using SDN-based networks to channelize IoT traffic is suggested in this research. The paper makes a suggestion for an integrated MCDA (Multiple-Criteria Decision Analysis) approach that may combine SAW with PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations). In order to lessen network congestion and increase transmission speed, this study focuses on allocating suitable channels to SDN-enabled IoT.

2. The Research Articlecontribution

The research article makes the following contributions:

1.The SDN controller is utilized for central connectivity of IoT devices as it manages the entire network.

2.Other SDN switches in SDN enabled IoT are connected to central SDN controller and the channelization of data is decided by the SDN controller.

3.We are proposing MCDA method where PROMETHEE and SAW methods are integrated in one MCDA module which is incorporated into the SDN controller.

4.The parameters that effects the decision making od MCDA module are channel bandwidth capacity, waiting time of channel, response time of channel, current traffic load, upcoming load, queue length of channel, and type of traffic.

5.The SAW method is utilized for deriving the normalized weights of all the parameters that contribute in decision making process.

6.The SDN controller maintains the records by using the network update service which depicts dynamic and static status of the channels about the current used capacity and remaining capacity to handle the upcoming IoT traffic.

7.PROMETHEE is a strong statistical method which is able to compare the alternative channels with respect to the priorities of the parameters for choosing the best channel to forward the IoT traffic.

8.The channels obtain PROMETHEE score at the end and the channel with the highest score can be allocated to the IoT traffic.

9.This process is repeated by the SDN controller whenever new traffic emerges at the link of SDN controller where all SDN switches forward the IoT traffic and then for channelizing the traffic to IoT gateway, the SDN controller repeats this procedure iteratively.

The paper is structured into four parts. The introduction section elaborates the existing work, background study and highlights of the paper. The next section discusses the SAW and PROMETHEE based integrated MCDA approach. The third part discusses results of the article. The last section is concluding the research work of this article.

3. Proposed Channel Allocation Scheme

SDN controller and SDN switches are used in the integrated MCDA suggested channel allocation for IoT traffic. Each SDN switch transmits the data to the controller for channelization of traffic towards Internet gateways. The SDN controllers use routers with embedded technologies to handle the IoT traffic in a smart manner [15]. Therefore, the SDN controller has enough capabilities to channelize the traffic by using embedded technologies in a faster manner. The MCDA module is incorporated in our proposed scheme to give advantage of statistical techniques to the SDN controller for channelizing the IoT traffic gathered from the SDN switches.

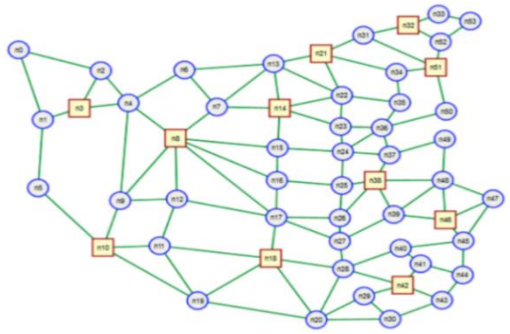

Fig. 3.The network which virtually connect SDN switches with the SDN controllers

The SDN switches can establish direct or indirect communication with the central SDN controller as shown in Fig. 3. In Fig. 3.the nodes represented by number n3, n8, n21, n14, n51, n32 are SDN controllers.

In an IoT network based on SDN controller can communicate with other SDN controllers. There are multiple SDN switches in each network, and they are connected to the SDN controller either directly or indirectly. To ensure continuous operation, a redundant controller is provided, which takes over if the primary controller fails. A virtual redundant controller is designated among the core switches to take over in case of any immediate disruption and ensure uninterrupted services of the SDN controller. The SDN controller incorporates the proposed channel selection mechanism, which guides the switches in selecting specific channels for transmitting traffic. The central SDN controller is responsible for connecting all other switches.

The SDN controller, which chooses alternate channels, incorporates the MCDM module. As illustrated in Fig 4, the control platform handles the transit of data from IoT devices to the SDN enabled IoT environment, and the SDN controller is in charge of channelizing the traffic via the Internet gateways. In general, IoT applications create data using sensors.

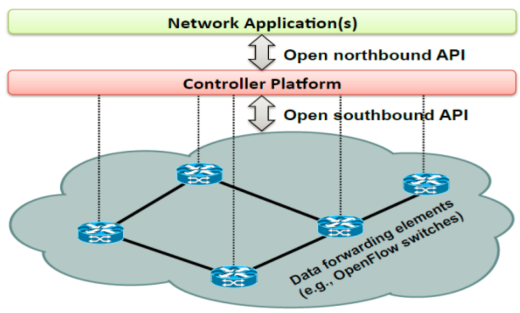

Fig. 4. SDN enabled IoT network with SDN controller and SDN switches

An SDN controller acts as an indexing router and embedded with specific capabilities to direct the IoT traffic on the selected channels and the selection is made by the underlying mechanism. In our problem statement, this work is achieved by the underlying MCDA scheme which is incorporated in SDN controller. There exits multiple SDN controllers in the SDN defined IoT networking systems. It is not feasible than a single SDN controller handles the entire load. There are group of SDN controllers and if one SDN controller fails or halts, its load is looked after by the other connected SDN controllers. The SDN controller acts as a special switch with extra capabilities to direct the IoT traffic from the source nodes to the destined gateways or intended nodes. The SDN controller manages the flow of the IoT traffic. The SDN controller utilizes the set of protocols to establish the communication among the SDN switches, core switches and internet gateways. One benefit of SDN controllers is that it can forward the packets to Internet gateways by selecting the optimal channel. The SDN controller also controls the flow when the data is generated in large volumes and effective flow control is mandatory to keep the entire data in place without missing the packets of the data. The supporting SDN controllers should also be there in the network to take the load of any SDN controller if that particular SDN controller fails to direct the traffic by selecting suitable channels.

The proposed channel allocation scheme, which is based on MCDA, is implemented in the SDN controller. The SDN switches communicate with the SDN controller, and the controller is responsible for selecting the appropriate channel for forwarding traffic to the intended nodes, based on the MCDA approach. The MCDA scheme combines two statistical techniques, SAW and PROMETHEE, to select the optimal channel for forwarding data to the Internet gateways. Several parameters are considered in the channel selection process, including channel bandwidth capacity, response time, waiting time, upcoming load, queue length, current traffic load, and type of traffic. These parameters are critical factors in determining the appropriate channel for forwarding traffic.

Then SAW technique is utilized to find out the priorities of each parameter and to define the normalized weights of the parameters on the basis of the priorities of the parameters defined by the network consumers. The weights are assigned with the help of experts or network users initially to all the parameters. The SAW method is applied to draw the normalized weights of each parameter. It is mandatory to determine the normalized weights or priorities of the parameters before applying the PROMETHEE MCDA method on the parameters. Once the SAW method completes its job by generating the normalized weights, the PROMETHEE method is applied to compare the alternative channels with each other against the priorities of the parameters. The ranking of the alternative channels is determined on the basis of PROMETHEE scores of the alternative channels. The channel with the highest PROMETHEE score is considered the best channel to transmit the data.

3.1. Channel Selection Algorithm

The traffic prioritization in the SDN controller involves scheduling traffic on channels in no particular order, starting from the fastest channel that can transmit traffic to the intended node the earliest. This process continues until all traffic in a given flow is scheduled. The channel selection mechanism employed by the SDN controller is presented as follows:

3.1.1 Algorithm: Channel Allocation Algorithm

Input: Parameters of channel as assigned as the input such as channel bandwidth capacity, waiting time of channel, response time of channel, current traffic load, upcoming load, queue length of channel, and type of traffic. These parameters play a significant role in selection of channel for forwarding the traffic.

Step1: Start

Step 2: While (the channel is free) do

Step 3: IoT Traffic → The IoT traffic is gathered at the SDN switches

Step 4: Forward → The data from SDN switch is forwarded to the SDN controller.

Step 5: Run → The SDN controller runs the MCDA scheme to find out the scores of the alternative channels

Step 6: Output → The channel with the highest score is assigned to the IoT traffic

Step 7: End while

Step 8: End

3.1.2 Algorithm: Assignment of channel by using MCDA

Step 1: Start

Step 2: Assign priorities to the parameters of the channel

Step 3: Apply SAW statistical techniques for realizing the normalized values of the priorities of the parameters.

Step 4: Supply the normalized weights of parameters to the PROMETHEE technique.

Step 5: Apply one of the preference functions of PROMETHEE for making comparison of the alternative channels

Step 6: Aggregation of the preference function is performed

Step 7: The ranking of alternative channels is obtained.

Step 8: Assign the channel with the highest PROMETHEE score.

Step 9: End

The MCDA scheme embedded in SDN controller decided the normalized priorities of the parameters that contribute in decision making. The SDN controller channelizes the IoT traffic on the selected channels where the selection is determined by the MCDA scheme. The functionality of SDN controller is complex due to the embedded intelligent mechanisms but comparatively the functionality of the SDN switch is very simple which just has to forward the traffic to the controller. The SDN controller not only selects the channel by applying MCDA scheme but also minimizes the congestion on the channels, increases the throughput of the channels by enabling them to handle the balanced traffic load and also minimizes the data latency by increasing the transmission speed of the IoT data.

3.2. Channel allocation based on MCDA scheme

The proposed MCDA scheme is utilizing the integrated approach where the advantages of two schemes are obtained. The SAW method is used to decide the priorities of the parameters that contributes in the decision-making process. PROMETHEE method is used to make pair wise comparative study of the alternative channels and it ranks the alternative channels. The best ranked channel is allocated to the IoT traffic for forwarding the data. The proposed MCDA channel allocation scheme aids the SDN controller to find out the appropriate channel for forwarding the data from SDN controllers to the Internet gateways. PROMETHEE method has not any integrated approach to decide the priorities of the parameters/attributes and therefore, for deriving weights of the parameters, other statistical approaches are used in collaboration with PROMETHEE [6], [17]. Many researchers have used AHP (Analytical Hierarchical Process) method in collaboration with PROMETHEE to derive weights but the usage of AHP The procedure of the MCDA scheme is described below.

3.2.1 Find out the parameter/attribute values

The first step is to obtain the values for each parameter/attribute used in channel selection, as shown in Table 1. The network status service is utilized by the SDN controller to get the static and dynamic values of the channels that provides the glimpses on the active channels and their current status.

with PROMETHEE is criticized by statisticians due to difference in these two approaches. Hence, we have

used SAW method which has no disadvantage to use it in collaboration with PROMETHEE method. The SAW method is utilized to define the weights of the parameters/attributes. Once the relative significance of each attribute is obtained, then PROMETHEE can be applied to rank the alternative channels.PROMETHEE method has advantage of using six diverse types of preference functions to while making the comparison of each alternative channel against all the attributes [17]. PROMETHEE method has two options; one is for partial ranking (formally known as PROMETHEE-I) and another is for full ranking (formally known as PROMETHEE-II). The partial ranking is used where further processing of decision outcome has to be performed and full ranking is used where the final outcome of PROMETHEE method is used as the output of the decision-making process. In our problem, we use complete ranking method of PROMETHEE or in other words we can say that we are using PROMETHEE-II for ranking of channels.

The parameters for the selection of channel are channel bandwidth capacity, waiting time of channel, response time of channel, current traffic load, spatial distribution which quantifies number of hops, upcoming load, queue length of channel, and type of traffic. These parameters play a significant role in selection of channel for forwarding the traffic.

Table 1. Attribute values as per the current status of each channel

Channels	Waiting time of channel (sec)	Spatial Distribution	Response time (sec)	Utilized Bandwidth (Gbps)	Current Traffic Load (Mbps)	Channel Utilization (%)	Upcoming Load (Mbps)	Type of IoT traffic	Remaining Bandwidth (Gbps)
Ch1	9	4	3	9	3000	40	2800	1	3
Ch2	10	4	7	8	3000	30	2500	2	4
Ch3	8	3	5	6	2000	60	2000	3	2
Ch4	5	2	5	7	2500	10	2500	1	5
Ch5	7	2	6	8	2600	30	2000	4	4

3.2.2 Determination of normalized weights using SAW method

Once the attributes are decided for consideration in the decision-making process, the priorities are defined. The SAW method is utilized to determine the importance of one attribute over another attribute. These priorities of the attributes are utilized to determine the significance of one attribute on other as given in Table 2. The priorities are defined in Table 2 as per the weights decided for the parameters on the basis of recommendations of the expert in aligned areas. The normalized values are obtained by adding all the weights together, which equals 40. Each attribute weight is divided by the summation value as shown in Table 3.

Later, the normalized weights of each parameter are provided to PROMETHEE-II for further processing.

Table 2. Weights given to attributes w.r.t importance

Attributes	Weights
Spatial Distribution	1
Response time of channel	2
Waiting time	3
Utilized Bandwidth	4
Upcoming traffic load	6
Current traffic load	4
Type of IoT traffic	5
Channel utilization	7
Remaining Bandwidth	8

3.2.3 Selection of preference function

There are six preference functions which can be used by PROMETHEE-II method for making comparison among the alterative choices against the attributes. In our research work, we have used first preference function named "usual preference function". This function permits to select the alternative 'a' to 'b' for greater deviations between *f(p)* and *f(q)*. The channel p is indifferent from alternative channel q when *f(p)* = *f(q)*. When these values are dissimilar, there is a strict preference for the function with the considerable value or a value more than the threshold value.

$$f(x) = \begin{cases} 0 \ \forall \ x \leq 0 \\ 1 \ \forall \ x > 0 \end{cases} \quad (1)$$

For example, if the value of channel utilization is more than 50% than the value is set to 1 otherwise it is set to 0. Table 4 represents the pair wise comparison by using usual preference function of PROMETHEE-II.

Table 3. Relative significance of criteria based on principle Eigen vector

Parameter/attribute	Normalized Values	Importance of attributes
Spatial Distribution	0.025	Eighth
Response time of channel	0.05	Seventh
Waiting time	0.075	Sixth
Utilized Bandwidth	0.1	Fifth
Upcoming traffic load	0.15	Third
Current traffic load	0.1	Fifth
Type of IoT traffic	0.125	Fourth
Channel utilization	0.175	Second
Remaining Bandwidth	0.2	First

3.2.4 Determination of outranking flows

The entering flow (summation of row as given in Table 5) is calculated by Eqn. 3. It elaborates the channel dominance in a row over the alternative channels. The leaving flow (summation of column as given in Table 5) is calculated by Eqn. 4.

$$\text{The entering flow is,}$$

$$\varphi^{+}(x) = \frac{1}{n-1} \sum_{b \in X} \pi(x, b) \quad (3)$$

$$\text{The leaving flow is,}$$

$$\varphi^{-}(x) = \frac{1}{n-1} \sum_{b \in X} \pi(x, b) \quad (4)$$

It elaborates the channel dominance in a column over the alternative channels. More value of entering flow for a channel states the superiority of the channel over other channels. Lower value of leaving flow for a channel states the inferiority of the channel over other channel

Table 4. Pairwise comparison against preference values of alternative channels

Pairs of channels	Waiting time of channel (sec)	Spatial Distribution	Response time (sec)	Utilized Bandwidth (Gbps)	Current Traffic Load (Mbps)	Channel Utilization (%)	Upcoming Load (Mbps)	Type of IoT traffic	Remaining Bandwidth (Gbps)
(Ch1,Ch2)	0	0	1	1	0	0	0	1	1
(Ch1,Ch3)	0	0	1	1	0	0	0	1	1
(Ch1,Ch4)	0	0	1	1	0	0	0	0	0
(Ch1,Ch5)	0	0	1	1	0	0	0	1	0
(Ch2,Ch1)	1	1	0	0	1	1	1	0	0
(Ch2,Ch3)	1	0	1	1	0	0	1	0	0
(Ch2,Ch4)	0	1	0	0	0	0	1	0	0
(Ch2,Ch5)	0	0	1	0	0	0	1	0	0
(Ch3,Ch1)	0	1	0	0	1	1	1	0	0
(Ch3,Ch2)	0	0	0	0	1	1	0	1	1
(Ch3,Ch4)	0	1	0	0	0	0	1	0	0
(Ch3,Ch5)	0	0	0	0	0	1	0	0	0
(Ch4,Ch1)	1	0	0	0	1	1	0	0	0
(Ch4,Ch2)	1	0	1	0	1	1	0	1	1
(Ch4,Ch3)	1	0	1	1	1	1	0	1	1
(Ch4,Ch5)	1	0	1	0	1	1	0	1	0
(Ch5,Ch1)	1	1	0	0	1	1	1	0	0
(Ch5,Ch2)	0	1	0	1	1	1	0	1	1
(Ch5,Ch3)	1	1	1	1	0	0	1	0	0
(Ch5,Ch4)	0	1	0	1	0	0	1	0	0

Table 6. Preference Index Matrix

(x_i, x_j)	Ch1	Ch2	Ch3	Ch4	Ch5	Row Summation
Ch1	1.00	0.55	0.55	0.17	0.35	2.625
Ch2	0.45	1.00	0.325	0.175	0.20	2.15
Ch3	0.425	0.625	1.00	0.175	0.1	2.325
Ch4	0.275	0.725	0.825	1.00	0.525	3.35
Ch5	0.45	0.775	0.375	0.275	1.00	2.875
Column Summation	2.6	3.675	3.075	1.8	2.175	

3.2.5 Determination of outranking flows

The entering flow (summation of row as given in Table 5) is calculated by Eqn. 3. It elaborates the channel dominance in a row over the alternative channels. The leaving flow (summation of column as given in Table 5) is calculated by Eqn. 4.

The entering flow is,

$$\varphi^{+}(x) = \frac{1}{n-1}\sum_{b\in X}\pi(x,b) \qquad (3)$$

The leaving flow is,

$$\varphi^{-}(x) = \frac{1}{n-1}\sum_{b\in X}\pi(x,b) \qquad (4)$$

It elaborates the channel dominance in a column over the alternative channels. More value of entering flow for a channel states the superiority of the channel over other channels. Lower value of leaving flow for a channel states the inferiority of the channel over other channels.

3.2.6 Total flow or ranking of the channel

The total flow Φ between the entering and leaving flow is determined by Eqn. 5. Table 6 shows the total flow and respective ranking of the alternative channels. It also specifies the complete ranking of the channels. The bigger value of the total flow signifies high ranking of channel.

$$\text{Final flow } \varphi(x) = \varphi^{+}(x) - \varphi^{-}(x) \qquad (5)$$

The ranking of channels obtained by the controller using the CAS method is as shown in Table 6. The ranking of alternative channels is (Ch4 >Ch5> Ch1> Ch3> Ch2) as given in Table 6.

Table 6. Total flow and ranking matrix

Channels	Entering Flow	Leaving Flow	Total Flow (φ+ (a)- φ- (a))	Ranks
Ch1	2.625	2.6	0.025	3
Ch2	2.15	3.675	--1.525	5
Ch3	2.325	3.075	-0.75	4
Ch4	3.35	1.8	1.55	1
Ch5	2.875	2.175	0.7	2

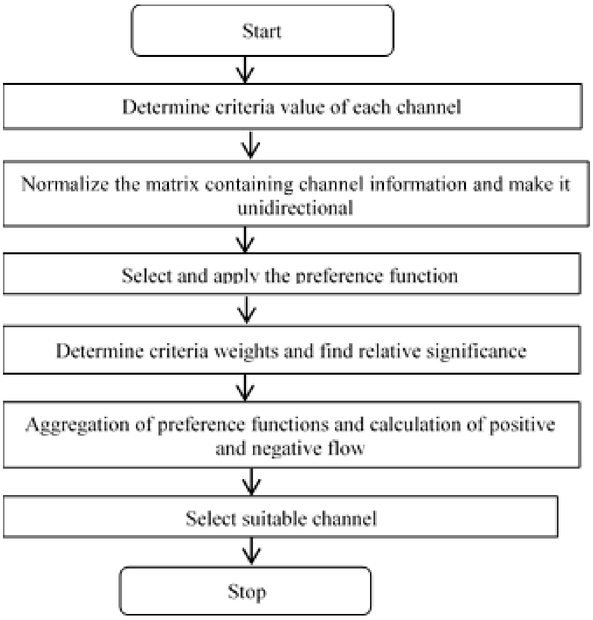

Fig 5. Channel Allocation process

The steps for the channel allocation process are shown in Fig.5

To get at a point of convergence between the responses into the calculation of this process, it is repeated over and over again. The following Eqn. 6 and Eqn.7 are used to normalize the weight $wt = \{w1, w2, , \ldots, wn\}$:

$$A_{wt} = \lambda_{max}\, wt \qquad (6)$$

Where

$$\lambda_{max} = \sum(atjwj - n)/wt \qquad (7)$$

Where A is the pairwise comparison, wt is the normalized weight, and λ_{max} represents the maximum Eigen value as obtained from Table II.

4. Results

The ranking of the channels is determined by the proposed MCDA scheme. After deploying the scheme in SDN enabled simulated environment where IoT traffic is controlled by the SDN switches, the results of our MCDA scheme are compared with two existing methods for throughput of the channel, congestion reduction, traffic transmission rate and reduction in transmission delays. The three existing techniques are taken up for comparative study which are EBP-HOP [2], TOCA [3], and ACAS [4].

The first factor considered for performance evaluation is packet delay in transmission of IoT traffic. The results of packet delay for IoT traffic are displayed in Fig. 6. It is proven from the results that proposed Channel Allocation Scheme (CAS) minimizes the packet delay for IoT traffic by optimal channelization and by balancing the traffic load on the channels by alternatively selecting the channels. The second best performance is shown by adaptive scheme abbreviated as ACAS [4], followed by throughput based scheme TOCA [3] and EBP-HOP [2] shown maximum delay for IoT traffic.

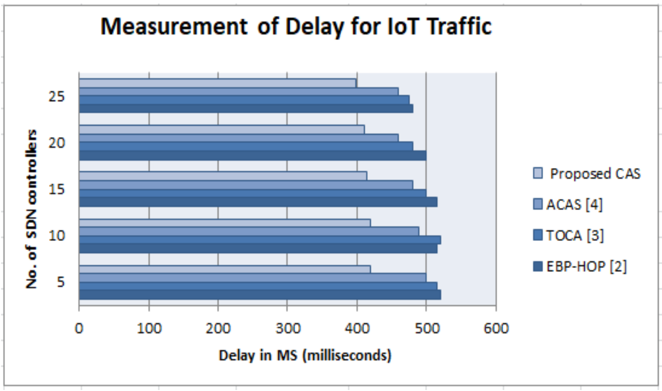

Fig 6. Packet delay by various techniques corresponding to number of SDN controllers

After comparing the results for packet delay, the next factor taken up for study is PDR (Packet Delivery Ratio). PDR shows the effectively transmitted packets successfully from the total transmitted packets. The PDR achieved by the four techniques ACAS [4], TOCA [3], EBP-HOP [2] and Proposed CAS is shown in Fig.7. This calculation is performed once the traffic is reached to Internet gateways after effective channelization of data. This evaluation matrix shows that the proposed CAS method outperforms ACAS [4], TOCA [3], and EBP-HOP [2] methods for achieving the successfully PDR.

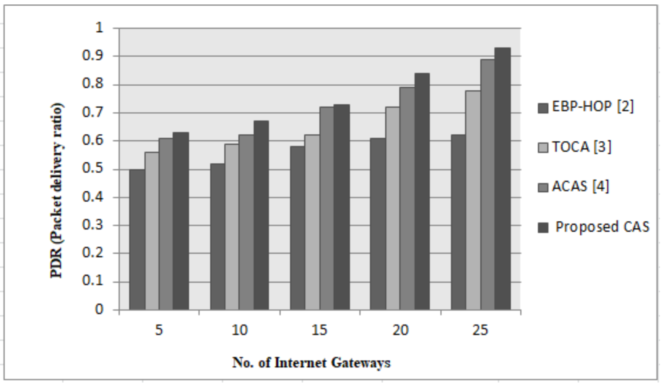

Fig 7. PDR achieved by various techniques on Internet gateways

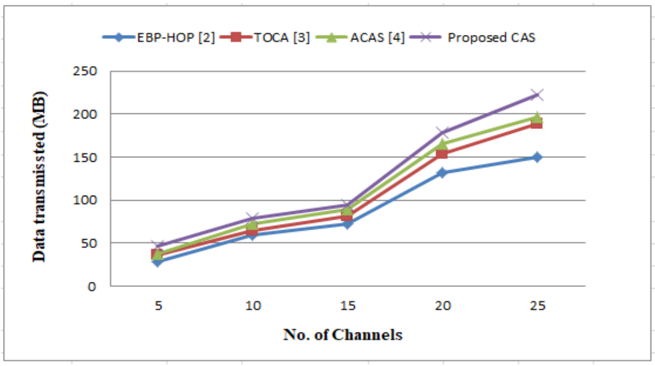

Fig 8. Data transmission rate over channels in MB with SDN defined IoT network

Fig.8 is showing the transmission rate of data achieved by the four techniques. Fig.8 also states the dominance of the proposed CAS scheme over the ACAS [4], TOCA [3], and EBP-HOP [2]. The statistical methods based proposed CAS is able to achieve effective performance for achieving high data transmission rate. The next factor for comparative study is throughput of the SDN controllers which channelize the IoT traffic by using statistical MCDA technique and it is observable from Fig.9 that the proposed CAS method aids the SDN controller to attain greater throughput and it again outperforms ACAS [4], TOCA [3], and EBP-HOP [2]. It is inferred that the results derived by the proposed CAS are effective for achieving the highest rate of data transmission among the techniques considered for comparison of performance. The last parameter taken up for comparative research is congestion control. In the proposed CAS scheme, the channels are analyzed before transmission of data and traffic load balance is performed by selecting the alternative channels. It helps in reducing the congestion over the channels.

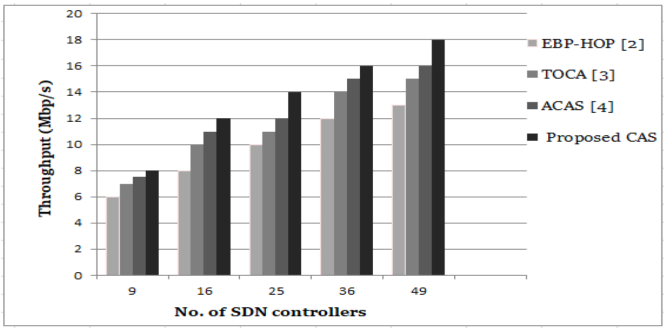

Fig 9. Throughput achieved by SDN controllers with various methods

The numbers of iterations of the algorithms are considered to measure the percentage of congestion on the channels. Congestion reduction by various schemes on channels in percentage is shown in Fig.10.

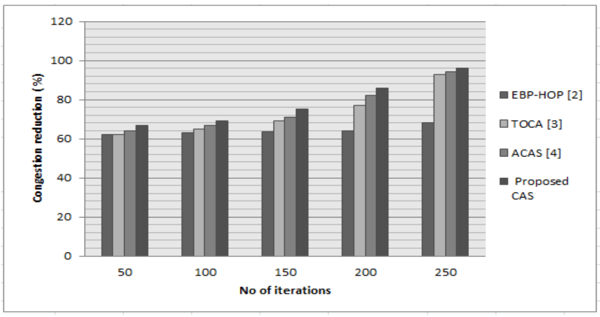

Fig 10. Congestion reduction by various schemes on channels

It can be clearly depicted from Fig.10 that the proposed method aids in reducing the congestion and outperforms the other schemes of channel allocation (outperforms ACAS [4], TOCA [3], and EBP-HOP [2]. From Fig.10 it is depicted that through the proposed scheme achieves 63.48% congestion control which is less as compared with ACAS [4], TOCA [3], and EBP-HOP [2].

It is clearly observed from the results given in this section that the proposed MCDA channel allocation scheme is performing well for reducing the congestion over the channels, for enhancing the throughput of the SDN controllers, for improving the transmission rate of IoT traffic, for minimizing the delay of packer delivery and for achieving the good PDR. This method can be integrated with SDN controllers for achieving better output as compared to deploying this method on onion routers or normal routers.

5. Conclusion

Channel Allocation Scheme (CAS) is proposed using the statistical approaches SAW and PROMETHEE-II. The proposed CAS is incorporated in the SDN controller for effective utilization of the proposed CAS. The SDN controller is responsible for selecting the channel based on the MCDA statistical approach. The SDN controller invokes the MCDA method for getting the ranks of the available channels and then selects the channel with the highest rank to transmit the IoT traffic. In this paper, a statistical MCDA technique based on SAW and PROMETHEE has been utilized for analyzing all the attributes that affects the channel selection mechanism and based on the PROMETHEE outranking scores. The channel with the highest score is selected for data transmission. The results indicate that the proposed MCDA based CAS is outperforming ACAS, TOCA, and EBP-HOP in terms of reducing channel congestion, improving the throughput of SDN controllers, enhancing the transmission rate of IoT traffic, and minimizing packet delivery delays. In future, additional parameters may be taken into account for channel selection

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