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DSDV AND AODV PROTOCOLS PERFORMANCE IN INTERNET OF THINGS BASED AGRICULTURE SYSTEM FOR THE WHEAT CROP OF PAKISTAN

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Agriculture is considered as the economic backbone of developing countries. Smart agriculture system can be implemented by adopting innovative technologies. The competition in the international market depends on the rate and production of agriculture yield. Future is all about the Internet of Things (IoT) where each device is going to be smart and interconnected with each other through available network. These IoT based devices are intelligently controlled and accessible across the world. The purpose of this research work is to introduce the crucial role of IoT in the field of agriculture, and its viable application make a smarter agriculture system of Pakistan. The farmers are still using the traditional methods to look after their crops. Traditional methods and lack of technology eventually decrease the production rate gradually. To enhance the production of crops, in this paper we proposed the IoT based model for the real time agriculture systems of Pakistan. By employing this model in agriculture system, our farmers will be aware of their crop conditions irrespective of their locations. The key feature of this model is that it experiences less congestion at the sink node, so the farmers get an accurate sensing information about their crops. This model also have the solar energy harvesting system to cope with the energy issue of sensing nodes. In this paper two well-known routing protocols namely as (a) Destination Sequenced Distance Vector (DSDV) and, (b) Ad hoc On Demand Distance Vector (AODV)are deployed in the grid topology of our proposed IoT based agriculture environment of Pakistan to get the accurate sensing information. Moreover, the generated results revealed less congestion in proposed system in terms of Packet dropped ratio (Pdr).

Keywords: IoT based agriculture system, Smart agriculture system, Multipath routing protocols.

INTRODUCTION

Internet of Things (IoT) is a popular technology which is used to connect devices intelligently through internet and irrespective of their locations. The functionality of controlling from irrespective location makes IoT famous. According to the authors (Atzori*et al.*, 2010), the number of devices connected to the internet will be ~ 50 billion in the year 2020. Another study done by the authors (Yaqoob *et al.*, 2017) demonstrate that IoT structure comprises of three components: (a) Application layer, (b) Transport layer, and (c) Sensing layer. All these layers have different functionalities. Application layer have the management and interface functionalities to user to provide how to control these devices. Transport layer have all the network related information. Sensing layer comprises of sensor to be deployed on the host side of the network with some sort of hardware.

Wheat is an important crop of Pakistan. To get the more yield this crop is usually cultivated before the 20th November. In other words, we say that this crop is cultivated before the start of the winter or "Rabi" season. According to recent study done by the Government of Pakistan (Govt. of Pakistan, 2018), this crop is important for us because its alone contribution in our economy as Gross Domestic Product (GDP) is 2.1% in the year 2015.

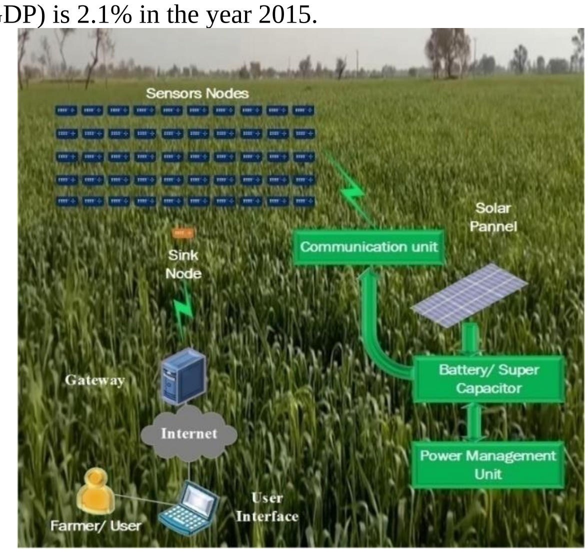

Figure 1. Proposed IoT system model for agriculture of Pakistan

This crop not itself fulfills our food needs but the ban of this crop is also used for animals for feeding purposes as well.

Wheat is cultivated in areas of Punjab, KPK, Baluchistan, and Sindh. In Pakistan, according to the report released by (Govt. of Pakistan, 2018), it is usually cultivated ~20million-acre land and produce a yield of ~23 million tons.
More than 80 % of the famers cultivated this crop in their lands. The good yield of wheat crop can only be achieved when farmerstimely do the following tasks

- In time plantation
- Proper and appropriate irrigate the crops with water
- Favorable weather conditions
- Use the fertilizers timely
- Early prediction in disaster scenarios.

Table 1. Other major countries production.

Rank	Country	Wheat Produced in Tons
1	China	134,340,630
2	India	98,510,000
3	Russian Federation	85,863,132
4	United States of America	47,370,880
5	France	36,924,938
6	Australia	31,818,744
7	Canada	29,984,200
8	Pakistan	26,674,000
9	Ukraine	26,208,980
10	Germany	24,481,600

Table 1 (Nag, 2019)depicts the overall wheat production of all over the world. According to author (Nag, 2019), China is the top most country which produced a wheat of 25 % equivalent to 134,340,630 tons of the world. India came on the second rank with the wheat produced of almost 98,510,000 tons equivalent to 18% of the total wheat produced in the world. Pakistan ranks on the eighth place with a total production of 26,674,000 tons. We can increase our production rate of the wheat crop only by adopting the IoT based environment which includes sensors and actuators. Figure 1 illustrates the proposed model of IoT based agriculture system for Pakistan. By employing the smart IoT environment, we can reach to highest rank in terms of wheat production. The production in terms of percentage is shown in pie chart of Figure 2.

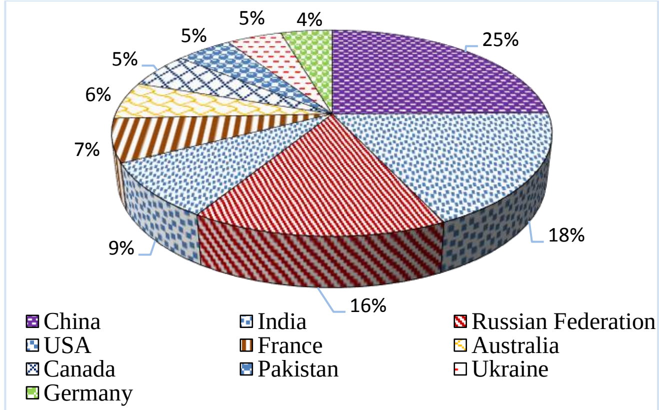

Figure 2. Wheat production in terms of percentage for different countries

Source: https://www.worldatlas.com/articles/top-wheat-producing-countries.html

While talking about Pakistan wheat crop production, according to the Pakistan Bureau of Statistics and report released by the author (Masood, 2014), the wheat crop has been cultivated on the 8734 thousand hectares area of Pakistan, however, we saw a decrease in this crop production during the year 207-18. The statistics is shown in the Table 2. If we incorporate the Smart IoT environment in the field of crops and agriculture, then can positively increase production. Figure 3 illustrates the overall percentage production of wheat during the years 2013-2018.

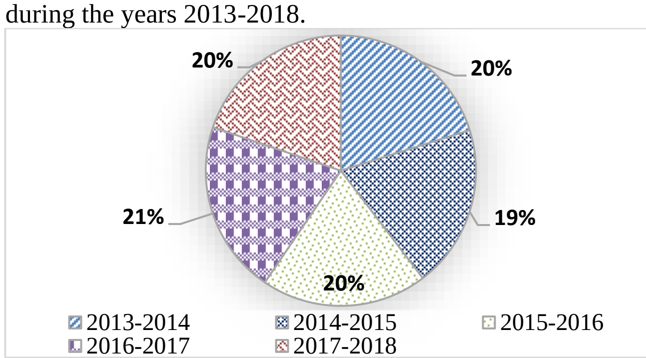

Figure 3. Pakistan's Wheat Production in Tons

Source: Pakistan Bureau of Statistics 2019

All above task can be accomplished if we make our agriculture system IoT based. We must deploy sensors in the

Table 2. Wheat production and yield of Pakistan for different years.

Year	Area		Production		Yield	
	(hectares)	% Change	(Tons)	%Change	(kg/ha)	%Change
2013-14	9199	-	25,979	-	2824	-
2014-15	9204	0.1	25,086	-3.4	2726	-3.5
2015-16	9224	0.2	25,633	2.2	2779	1.9
2016-17	8972	-2.7	26,674	4.1	2973	7.0
2017-18	8734	-2.6	25,492	-4.4	2919	-1.8
Punjab Provisional						

Source: Pakistan Bureau of Statistics

land to get the above described conditions timely irrespective of the farmer location. As sensors are deployed on the wheat crop which is a host side. Thus, sensors are responsible to collect all the information related to crop and send this information to the network through some sort of routing protocol. As Heterogenous Ad hoc Networks (HANET) comprises of Wireless Fidelity Networks (WFN), Wireless Sensor Network (WSN) and Vehicular Ad hoc Network (VANET). HANET is an important part of IoT (Qiu *et al*., 2017). Itis a static environment because the sensors are deployed on the crops which remains stationary. We have used the Destination Sequenced Distance Vector (DSDV) and Ad hoc On Demand Distance Vector (AODV) routing protocols. These two protocols are the part of IoT routing protocol taxonomy as discussed by the authors Poluru and Naseera(2017). According to the authors (Nagaraj *et al*., 2011), these two protocols are the topology-based routing protocols in which packets are shared through links with other nodes.

AODV: According to the authors(Perkins *et al*., 2003)AODV works on the principle of hop to hop methodology. Through this methodology we can discover routes on the basis of hop to hop distance. AODV performs two types of operations route discovery and route maintenance. In this protocol when source node want to send information to destination, so it creates a route on that time. Hence, it creates routes on request that is why it is sometimes known as on demand routing protocol.

DSDV: In this study the authors Perkins and Bhagwat(1994) discussed that DSDV is a multipath routing protocol which basically builds a routing table. This routing table contains sequence number and hop. Advertisements in this protocol is done based on broadcasting and multicasting. When the source node wants to send information to destination, it's basically build a routing table which has the destination information along with number of hops. Sequence number has also been stored for each particular entry.

Motivation and Contribution: We proposed a system model for the wheat crop of Pakistan which can make our agriculture system IoT based. By employing this system model in Pakistan in farming, we can enhance the production rate of wheat crop. This model predicts the farmer about in time plantation, proper and appropriate time to irrigate the crops with water, use the fertilizers timely, early prediction of favorable weather conditions in good time as well as in disaster scenarios. Then we applied two routing protocols namely as DSDV and AODV to analyze their performance in a grid topology-based scenario. We illustrated the two different scenario in which we deployed 50 sensors nodes. We increase the number of CBR/FTP source nodes which are sending the TCP Reno traffic towards one sink node and decreased the other nodes which didn't send the TCP reno traffic. All the nodes are said to be static because in the real time agriculture system we don't need to have the sensors that are moving in the whole crop. The performance analysis has been determined in both scenarios for the two routing protocols AODV and DSDV.

MATERIAL AND METHODS

System modeling: The proposed model for agriculture system is that we firstly deployed sensor nodes on the host side. The host side here is the land in which the crop has been cultivated. In our case we set 50 nodes in the form of (5x10) grid topology which constantly sends the data towards the sink node. The sink node is deployed separately which directly connected to the gateway. The sink node sends the sensing data that has been collected from the 50 source nodes towards the gateway. The gateway is connected with internet. The farmer who lives far away from their field can now observed the conditions of his crops through sensor readings with the help of user interface.

The Constant Bit Rate (CBR)and File Transfer Protocol (FTP) which we consider as source nodes and sensing nodes consists of three parts namely as the communication unit, processing unit and the sensing unit. The sensing unit basically collects all the data from the surrounding environments and forwards towards the processing unit. The processing unit which comprises of processor command and memory unit. These two units can read and write the sensing information coming from sensing unit and send this data towards communication unit. The communication unit triggers its communication operation with other nodes. Hence, the data has been sent towards the sink node and the gateway.

As energy of the nodes is depleted during communication with each other so we suggest a solar energy harvesting system in which we used solar panels to collect the light rays coming from the sun. This light is converted into Direct Current (DC). This direct current can be transferred into battery or super capacitors for storage purpose. When any of the node energy is depleted then energy can be transmitted to that node with the help of communication unit. For getting the maximum and minimum value of energy, a power management unit has also been installed for this purpose. The proposed system model is shown in Figure 4.

Mathematical Model: By using the assembly line algorithm presented by the author Rubinovitz and Levitin(1995), we formulate our mathematical model as follow**.** Let $S^*(n)$ represents the sink node deployed at the edge of the crops to collect data from other nodes. The sink node and every other node receive data from the previous node which is $S(n-1)$. So, we can write the equation as

$$S^*(n) = S(n) + C(n) \text{where } 0 \leq n \leq k \quad (1)$$

and k represents the kth node value and $C(n)$ represents the initial cost of the node. The other, nodes i.e. $S(n)$ values can be calculated by using following equation (2).

$$S(n)= S(n-1) + C(n-1) \text{ where} 1 \leq n \leq k \quad (2)$$

We assume

$$C(0) = 0 \quad (3)$$

for all the initial nodes.

When all the nodes transmit data at same time we can write as

$$S^*(n) = \sum_{n=1}^{k} (S(n-1)) + \sum_{n=1}^{k} (C(n-1)) \quad (4)$$

It may be the case that when the nodes transmits data at different times then we can reformulate equation (4) as

$$S^*(n) = \sum_{n=1}^{k} (S(n-1)) + \sum_{n=1}^{k} [(C(n-1) + T(n-1)] \quad (5)$$

Proposed Environment and Experimental Scenario: In this section the proposed environment and overall experimental scenario has been discussed for the both protocols namely as AODV and DSDV. The performance of the two protocols has been analyzed in our proposed environment.

To perform all the experiments, we opted NS 2 platform presented by Fall and Varadhan(2017). NS2 is an open discrete simulator and has been widely used for simulating the network. Writing a code is a lengthy and time-consuming activity so we used NSG2.1 developed by (Wu, 2018)which provides a GUI based interface and generates the desired Tcl codes at the end. For designing the overall topology of the network, we used NSG2.1 tool. The trace files have been further processed in NS2 visual trace analyzer (Rocha, 2018)for collecting the flow statics of the network. For experimental scenario, a total of 50 nodes were arranged in the form of grid topology and one node namely as sink node is deployed separately. We choose a simulation time of 1000 secs for this purpose. All the remaining other parameters which we used in our simulation has been presented in Table 3.

As the desired crop is the wheat crop so we conducted separate experiments with TCP Reno as a traffic type and, CBR and FTP sources. All nodes including the sink one, deployed in the wheat crop of agriculture system were stationary. We divide the task into two cases. First case is for conducting the experiments and simulations with CBR source nodes with TCP Reno traffic type and second case is for the FTP sources with TCP Reno traffic type.

In first case of the CBR source nodes scenario,50 nodes were set in the form of grid topology. Initially 10 CBR sources nodes send the traffic towards sink node. The remaining nodes are also static which don't send the TCP Reno traffic towards one sink node. All the nodes were stationary while sending the TCP Reno traffic. All the desired flow statics have been collected for this simulation. Figure 5 depicts the diagrammatical representation of this scenario.

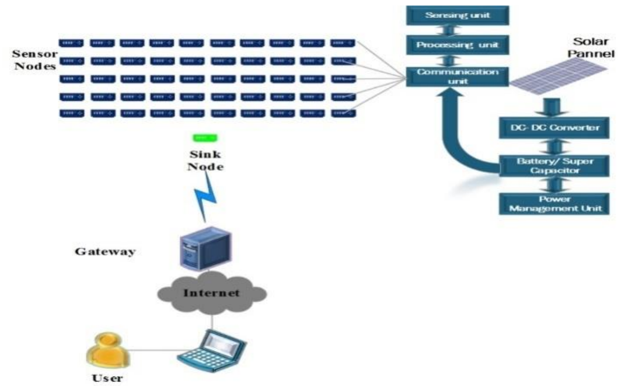

Figure 4. System Model for agriculture system for the crops of Pakistan

The number of CBR source nodes increases incrementally for the second scenario and reached to 20. Now, the TCP Reno traffic send by these 20 CBR source nodes towards one sink node. These 20 CBR source nodes which sends the traffic towards the sink node along with other nodes which didn't send traffic towards sink nodes are stationary and static. The data has been collected for this scenario as well and has been processed further. This topology is diagrammatically shown in Figure 6.

For the remaining proposed scenarios, we incrementally increase the number of the CBR source nodes i.e. 30,40 and 50 which sends the TCP Reno traffic towards one sink node and decrease the remaining nodes i.e. 20,10 and 0 which didn't send the TCP Reno traffic towards one sink node, respectively. Figure 7 depicts the final topology of 50 CBR/FTP source nodes.

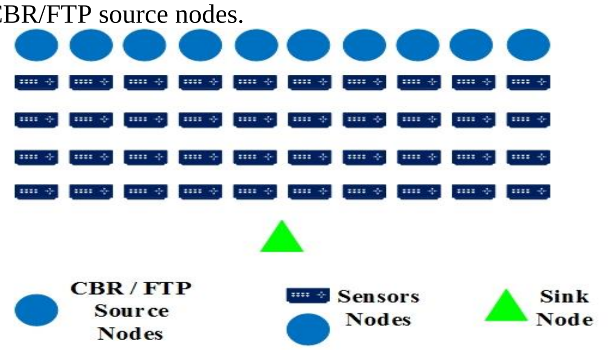

Figure 5.CBR/FTP source nodes (10) with TCP Reno traffic type

Table 3. Required Parameters.

Node Type	Number of CBR/FTP source nodes range	Routing Protocols	Antenna type	Speed of CBR source nodes(m/s)	Packet size (Bytes)	MAC protocol type	Queue type	Traffic type
CBR, FTP	0-50	AODV, DSDV	Omni direction-al	Static (0)	20	802.11	Drop tail/ Pri queue	TCP Reno

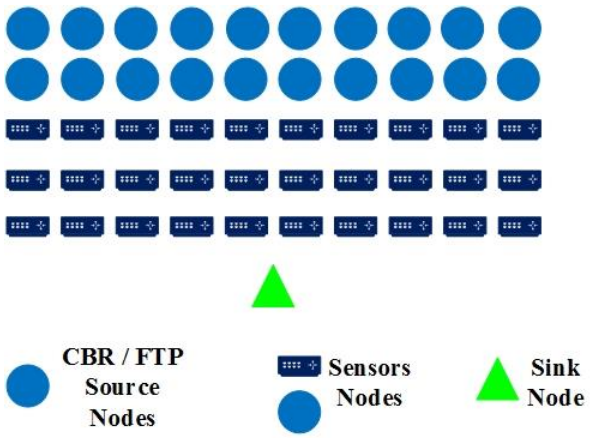

Figure 6. **CBR/FTP source nodes (20) with TCP Reno traffic type**

The same kind of scenario as described earlier for CBR source nodes has been considered for FTP source nodes as well in lieu of TCP Reno traffic type.

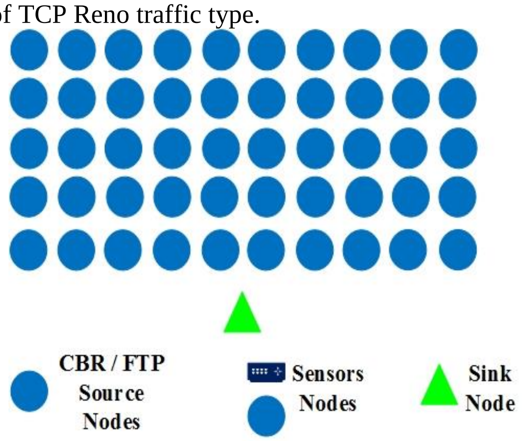

Figure 7. **CBR/FTP source nodes (50) with TCP Reno traffic type**

RESULTS

Delay: DSDV demonstrates higher delay as compared to AODV.DSDV showed a maximum delay of 4806.05 milliseconds (ms) across 30 CBR source nodes while for the AODV the delay is 223.65ms. When the number of CBR source nodes increases to 50 the delay of both protocols decreases which are 137.7ms for DSDV and109.47ms for AODV.

When we increased the number of FTP source nodes that sends TCP Reno traffic towards one sink node, then across 50 FTP source nodes DSDV showed a delay which is much more as compared to AODV. The maximum delay for AODV and DSDV is 109.48ms and 142. 57ms respectively as shown in Figure 8.

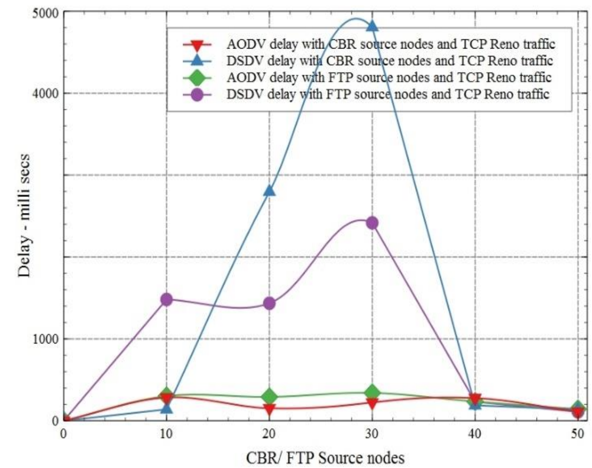

Figure 8. **Delay with CBR/FTP source nodes and TCP Reno traffic type**

Jitter: Jitter which is also known as packet delay variation has been analyzed for both protocols. Considering CBR source nodes, the jitter for DSDV increases with the increase number of CBR source nodes i.e. across 10 and 20 CBR source nodes. While the jitter for AODV first increases and then decreases across 20 and 50 CBR source nodes. When the number of CBR source nodes increase to 50 the decrease in value for both protocols have been observed which is 57.46ms and 54.85 msfor DSDV and AODV respectively as depicted in Figure 9.

A similar behavior is observed as described above for the FTP source nodes. In initial stages, the jitter first increases with the increase in number of FTP source nodes. After 30 FTP source nodes the jitter value decreases for both protocols. With50FTP source nodes DSDV Jitter values come out to be 51. 87ms and for AODV it is 83.60ms.

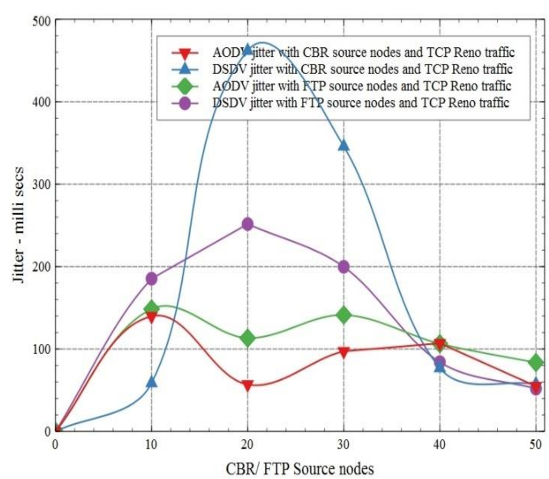

Figure 9. **Jitter with CBR/FTP source nodes and TCP Reno traffic type**

Packet dropped ratio: The next performance metric which we analyzed for both protocols is Packet dropped ratio (Pdr). At initial phase, the AODV Pdr has been increased across 10 and 20 CBR source nodes which is 22.54% and 22.94%. However, forDSDV the Pdr is slightly less across 10 and 20 CBR source nodes which come out to be, 5.11% and 12.12%. At full load i.e. across 50 CBR source nodes the Pdr for DSDV is 2.35% while for AODV it is 11.34%.

The DSDV only dropped 2.34% across 50 FTP source nodes while the Pdr for AODV across 50 is 12.33%. respectively. It is clearly observed from the graph as shown in Figure 10 that DSDV revealed better performance across both CBR and FTP source nodes and with TCP Reno traffic type as compared with AODV.

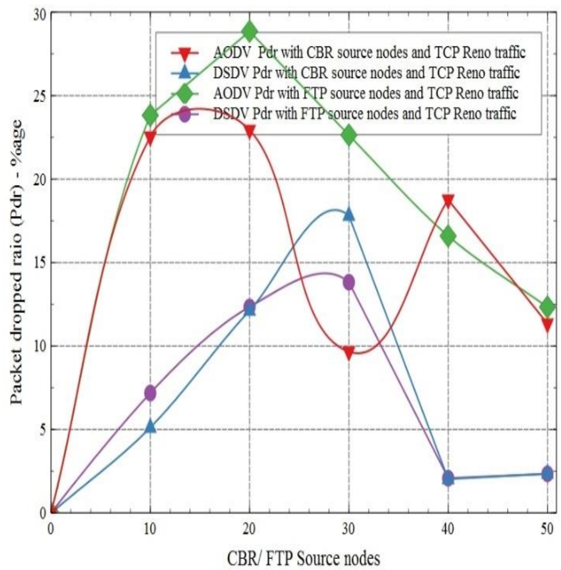

Figure 10. Pdrwith CBR/FTP source nodes and TCP Reno traffic type

Generated Throughput: From the graph illustrated in Figure 11, it is clearly understood that with the increase in the number of CBR/FTP source nodes the generated throughput of the both protocols have also been increased. The throughput generated with CBR source nodes are higher as compared to FTP source nodes. DSDV showed a generated throughput of 12kilo Bytes/seconds(kB/secs) across 50 CBR source nodes whereas it is 7kB/sec for AODV.

When 50 FTP source nodes transferred the traffic towards one sink node then a maximum generated throughput for DSDV is 11 kB/secs and for AODV it come out to be 7kB/secs.

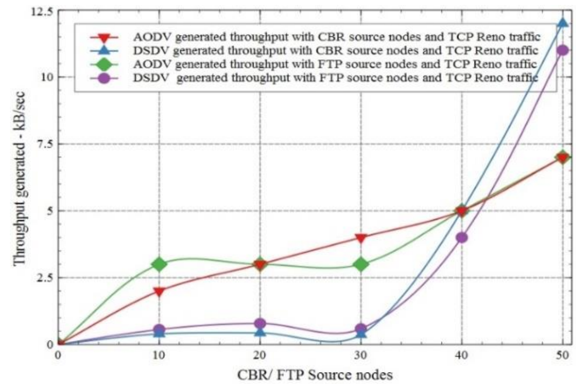

Figure 11. Generated throughput with CBR/FTP source nodes and TCP Reno traffic type

Transferred throughput: When the number of CBR source nodes increases in lieu of TCP Reno traffic type, the results revealed that DSDV performed much better as compared to AODV. Both protocols showed an incremental increase with number of CBR source nodes. The maximum value of generated throughput across 50 CBR source node has been 12 kB/secs for DSDV whereas it is 6 kB/secs for the AODV.

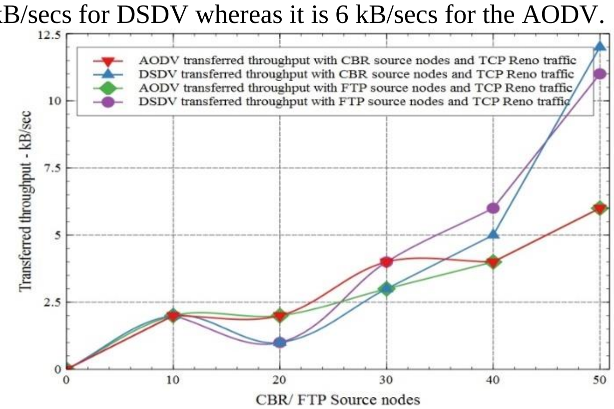

Figure 12. Transferred throughput with CBR/FTP source nodes and TCP Reno traffic type

Figure 12 depicts the graph of transferred throughput.We observe a similar behavior for the FTP source nodes as well. The transferred throughput value for both protocols have been increased exponentially as well. At 50 FTP source nodes, the transferred throughput is 11kB/secs and 6kB/secsfor DSDV and AODV as demonstrated in the graph.

Table 4 and Table 5 demonstrate the results of both protocols with CBR source nodes and TCP Reno traffic type. However, Table 6 and Table 7 describe all the obtained results of both protocols with FTP source nodes and TCP Reno traffic type.

Table 4. DSDV results with CBR source nodes and TCP Reno traffic type.

Number of CBR source nodes	Delay (ms)	Jitter (ms)	Packet dropped ratio (Pdr) (%age)	Generated Throughput (kB/secs)	Transferred Throughput (kB/secs)
10	139.55	58.69	5.11	0.399	2
20	2796.53	461.95	12.12	0.436	1
30	4806.05	345.75	17.81	0.371	3
40	188.51	76.9	2.03	5	5
50	137.7	57.46	2.35	12	12

Table 5. AODV results with CBR source nodes and TCP Reno traffic type

Number of CBR source nodes	Delay (ms)	Jitter (ms)	Packet dropped ratio (Pdr) (%age)	Generated Throughput (kB/secs)	Transferred Throughput (kB/secs)
10	284.29	139.71	22.54	2	2
20	152.65	56.91	22.94	3	2
30	223.65	97.18	9.66	4	4
40	277.27	106.97	18.76	5	4
50	109.47	54.85	11.34	7	6

Table 6. DSDV results with FTP source nodes and TCP Reno traffic type

Number of CBR source nodes	Delay (ms)	Jitter (ms)	Packet dropped ratio (Pdr) (%age)	Generated Throughput (kB/secs)	Transferred Throughput (kB/secs)
10	1480.9	185.32	7.18	0.562	2
20	1435.05	251.59	12.34	0.788	1
30	2416.56	199.75	13.82	0.591	4
40	232.17	84.11	2.08	4	6
50	109.48	51.87	2.34	11	11

Table 7. AODV results with FTP source nodes and TCP Reno traffic type

Number of CBR source nodes	Delay (ms)	Jitter (ms)	Packet dropped ratio (Pdr) (%age)	Generated Throughput (kB/secs)	Transferred Throughput (kB/secs)
10	302.13	148.46	23.82	3	2
20	290.99	113.28	28.85	3	2
30	340.36	141.27	22.64	3	3
40	234.04	106.45	16.59	5	4
50	142.57	83.6	12.33	7	6

DISCUSSION

As we have opted TCP Reno traffic and take the CBR/FTP sources which send the data towards the sink node. The TCP Reno is a slow start, additive increase multiplicative decrease, fast retransmission and fast recovery mechanism. TCP Reno is helpful in accordance with the (5x10) grid topology to cope the congestion problem.

When the number of CBR/FTP source nodes sends the TCP Reno traffic towards one sink node, then TCP Reno enters in the slow start phase. During this slow start phase we achieved minimum delay for both of the protocols. When we increase the number of CBR/FTP source nodes, the delay is also increasing for both protocols namely as AODV and DSDV. This increase in delay is due to the loss of packets and the congestion has been detected by TCP Reno. The loss of individual packet has been identified, when three duplicate acknowledgements have been received for the individual packet. The TCP Reno enters in the fast retransmission phase. In this phase the TCP Reno used the process of additive increase and multiplicative decrease in which the congestion window is set the half of the original congestion window size and then it increases linearly. That's why at the end, the delay has been observed minimum for both protocols.

With the delay behavior, a similar pattern has been observed for the jitter. The jitter for both protocols has been increased but at the end we saw a decrease in terms of jitter for both protocols i.e. AODV and DSDV.

The Pdr is closely related with the congestion. If the topology experienced more congestion towards the sink node, the percentage of Pdr will be significantly high. If the bottle necks seemed towards sink node will be less, then the percentage of Pdr will be also low. In our case, the Pdr for both protocols AODV and DSDV is observed to be very low and fewer percentage of packets have been dropped at the sink node. So, our topology experienced less congestion in terms of Pdr at sink node. Our topology also experienced less congestion because of the TCP Reno traffic type. The TCP Reno is also helpful in terms of generated and transferred throughput. The generated and transferred throughput for both protocols has been increased with the increase number of CBR/FTP source nodes. These both performance metrics are related with congestion. If the congestion or the loss of packets have been detected by the TCP Reno, then the TCP Reno sets the congestion window size to half of the original congestion window size and then increase linearly that’s why the throughput generated and transmitted for both protocols has been increased in our case with the increase number of CBR/ FTP source nodes.

***Conclusions*:** In this research, we proposed an IoT based system model for the agriculture system of Pakistan in which farmers get the accurate sensing information irrespective of the location. We analyzed and evaluated performance of two routing protocols: AODV and DSDV for our proposed system. Their performance has been analyzed based on delay, jitter, Pdr, generated and transferred throughput taking into account the CBR/ FTP source nodes and TCP Reno traffic type. An application scenario is designed for this purpose. A low congestion has been achieved in our designed topology in terms of Pdr. Considering CBR source nodes, DSDV works better on these performance metrics which are Pdr, generated throughput, transferred throughput. While AODV demonstrated better results in terms of delay and jitter considering the CBR source nodes. With FTP source nodes, DSDV has showed better performance in terms of delay, jitter, Pdr, generated throughput and transferred throughput.

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