Internet Protocol MANET vs Named Data MANET: A Critical Evaluation

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***Abstract*- Many researches have been done in the field of mobile networking, specifically in the field of ad-hoc networks. The major aim of these networks is the delivery of data to a given node at the destination, irrespective of its location. Mobile Ad-hoc Network (MANET) employs the traditional TCP/IP structure to provide end-to-end communication between nodes (we named this type of architecture is IP-MANET). However, due to their mobility and the limited resource in wireless networks, each layer in the TCP/IP model requires redefinition or modifications to function efficiently in MANET. Named Data MANET (ND-MANET) architecture is a recently emerging research area. The in-network chunk-based caching feature of NDN is beneficial in coping with the mobility and intermittent connectivity challenges in MANETs. In the natural disaster field, MANET is considered a challenging task because of the unpredictable changes in the network topology due to the absence of any centralized control. The goals of this paper have two ways: first, this study provides a performance comparison of IP-MANET to ND-MANET in terms of throughput, delay, and packet loss. While the second contribution is to identify which architecture has an impact on the natural disaster (i.e., Flooding disaster) in rural areas and suggests which one may perform better. For experimental purposes, our analyses IP-MANET and ND-MANET by extensive simulations in the NS 3 simulator under a number of different network scenarios, and show that how number of nodes and variety packets size affect their performance.**

Index Terms— MANET, Named Data Networking, Natural disaster, Network simulation 3

I INTRODUCTION

Mobile communication devices require a fixed network infrastructure of cellular towers or wireless routers. Consequently, mobile devices may not have service when infrastructure is damaged by any reason. In these situations, peer-to-peer communication between these devices is one possible solution. Furthermore, to increase the range of communications, a multi-hop network is needed. Mobile Ad-hoc Network (MANET) have been used in the past to provide peer-to-peer and multi-hop communications [1].

MANET is an infrastructure-less network architecture constituted by mobile devices [2]. The main advantage of MANET is that it can be formed at low cost in response to temporary needs, and thus is often used in battlefield and disaster-recovery networks. The major challenges in MANET are mobility and intermittent connectivity. Nodes are assumed to move at varying speeds, resulting in fast-changing topologies and extreme packet losses, and consequently high overhead for route construction and maintenance costs. Moreover, the performance may suffer from temporary network partitioning [3].

Named Data Network (NDN) [4] is a developed version of Content Centric Network architecture (CCN) [5][6], which is share the same concepts of the Information Centric Networking (ICN) paradigm for the future Internet architecture. Thus is given that the Internet is increasingly used for the dissemination and retrieval of information rather than just interconnecting a pair of particular end-hosts. The important features of NDN is the usage of content or application-level names for addressing, the possibility to cache content in routers as well as the integrated content discovery mechanisms [7]. While most research work investigated the use of ICN in wired networks (e.g., [8], [9], [10]). ICN provides some interesting and beneficial features for wireless networks, especially when users are mobile and have rather temporary connectivity with the Internet and between each other [7], Furthermore, this architecture uses the data names instead of host addresses to locate data, is a natural fit to MANET data retrieval. Every NDN data chunk has a uniquely identified name. This uniquely identified chunk naming enables the chunk-based in-network caching [3].

Mobility support in NDN is particularly important within the context of moving objects and things that are network connected [11]. NDN in mobile networks has already been the subject of several studies [12]. Early works investigated the applicability of existing MANET routing protocols for mobile CCN based on analytical models [13]. A hierarchical CCN routing scheme based on distributed meta information has also been implemented [14]. The Listen First, Broadcast Later (LFBL) [15] algorithm limits forwarding of interests at every node based on its relative distance to the content source. While CHANET [16] presented as a content-centric MANET that is built on a connectionless layer designed on top of legacy IEEE 802.11 protocols to provide content-based routing and transport.

The scope for this study focused on disaster area. It is a local or a region, heavily damaged by either natural or technological. One of the important things that make disaster areas affected on the communication between the populations [17]. Flooding is a simple example about the natural disasters (especially in rural areas when the network infrastructure damage or absent), which is caused when water submerges or overflows land that is usually parched [18]. In this case, emergency rescue teams are not easily communicated with each other by using infrastructure communication, such as, wireless routers or cellular towers. Fig 1 presents a simple of Natural flooding disaster scenario in rural areas.

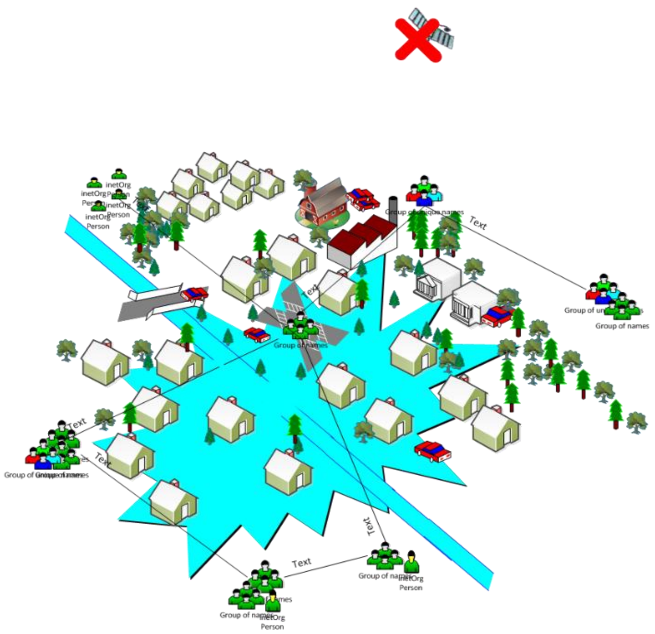

Fig. 1: Natural flooding disaster scenario of rural area

Therefore, these rescues must use alternatives to communicate with each other. In such catastrophic situations, communication will be an important key factor for an effective management and successful disaster recovery. Hence, all resources and recovery personnel should be able to exchange and share information with each other to successfully achieve their given tasks [2]. A typical scenario for disaster recovery is intrinsically hierarchical in two ways. Nodes are moving in groups, for example, emergency rescue team; and they are connected via local radio communications, which mean most information is creating and searching locally. Although that the challenge here with the radio communications may be a loss since nodes may be highly mobile and/or the node may scale; uses bandwidth (different packet size).

In this paper, we a critical evaluation the performance of IP-MANET to ND-MANET with varying number of nodes and variety packet size based on various quantitative metrics which can be used for evaluating the performance of IP-MANET to ND-MANET, consecutively. Thus, to confirm, which is the most suitable architecture, saves the network resource consumption (e.g. Bandwidth) in the flooding disaster field. The experiments have been carried out in a simulation environment setup using Network Simulator 3 (NS3) tool.

In particular, MANET in IP and NDN are provided in the Section II. In the next section introduce the related works. While in Section IV, outlining the simulation setup as well as evaluation metrics. Section V describes the results and discussions. Finally, the conclusion is presented in the VI Section.

II MANET IN INTERNET PROTOCOL AND NAMED DATA

MANET enables mobile equipments to establish a network in infrastructure-less. Hence, it can support the originating communication paradigms (content-centric communications), also requires overlaying a MANET with a Named Data Network. In this section we describe IP-MANET and ND-MANET, consecutively.

A. Internet Protocol MANET (IP-MANET)

Internet access through wireless communication has become crucial due to the trend of IP network. In Internet Protocol, the mobility support gives a standard solution for mobility at the layer of IP [19]. With wireless communication technology advancements, it is seen that low-cost and powerful wireless transceivers are used to a big extent in the field of mobile applications [20]. .

MANET is an upcoming technology that makes user communication possible with nil physical infrastructure irrespective of their geographical location. This is why it sometimes referred to as a network without infrastructure. The sample example of MANETs, the laptops in which are in the same transmission range is able to transfer the data packet between them directly. Yet, the mobile nodes that are not in the same range of transmission can be used asintermediate nodes for the transfer of data packets to thedestination [21]. MANET gets powerful and a fast growing network also due to the proliferation of cheaper, smaller and much powerful devices. Ad-hoc networks are self-organizing as well as adaptive.

Device in MANET needs to be able for detecting the presence of other devices and should be able to perform the essential setup for facilitating communication and sharing service as well as data. Ad hoc networking enables devices for maintaining connections to the network and allows for easy to add and remove devices to and from the network. Because of nodal mobility, the network topology may alter rapidly and unpredictably as time passes by. The network is decentralized, where message delivery as well as network organization has to be implemented by the nodes themselves. In decentralized environments, message routing is a problem. Here the topology fluctuates [22]. Topology of MANET topology may get altered as time goes by since the nodes adjust or move their parameters of transmission as well as reception [23].

B. Named Data MANET (ND-MANET)

In ad-hoc network environments, NDN method can be specifically beneficial. Based on the data requirement, mobile nodes can communicate rather than computing a particular path [24]. Implementation can thus be simplified because of the below reasons. At first it is longer needed to assign IP addresses to every node, rather nodes can make use of the application data names straight away for forwarding interests and data packets between them. Second, as there are no routing loops for this data names based design, interest paths can be forwarded along more than one path towards potential locations of data [5]; incase if more than one direction returns the data requested, a node can evaluate which path yield better performance and send future interest for the same data source in the very same direction as well. This multi path method is specifically useful in the ad-hoc networks. This is because; using multi paths alleviates the crucial dependence of the pre-computed single paths.

As such the stringent requirements are flexed on the timeliness of the routing updates and consistency of routing states in every node. Basically an ad-hoc network itself can be of dynamic in nature, whereby having less resources invested for chasing down the interconnectivity information all the time can be an expensive deal. In an NDN based network design of ad-hoc, there exists no need for assigning either IP addresses or identifiers to every node. Another advantage of using NDN for mobile networks is the capability of uniquely addressing and caching fragments of application data [25]. NDN is especially useful in giving mobility support. The mobile node can connect based on what information they require, rather than attempting to keep up a particular way to achieve a particular node. In this section, we demonstrate that NDN, with its capability to the named individual content, to safely bind name to the content, to keep per-packet state in forwarders, and to have an adaptable Interest sending system at every node, can extraordinarily rearrange the mobility outline in different angles. Keeping aside CCN high potential, just a couple of works have been tended to in the recent time on the utilization of wireless multi-hop [24].

III RELATED WORK

Raaid *et al*., [2] Performance of ad hoc network is analyzed for four routing protocols such as reactive (AODV and OLSR), and proactive (DSDV and OLSR) in MANET under varies different maximum number of connection and mobility. In this study they identifies whether MANET routing protocol has an impact on the artificial disaster and suggests which protocols may perform better. The results obtained show that DSDV gives a great improvement for using network resources, especially when the number of connections is high with low mobility. Hence, DSDV is considered as a better routing protocol that is used in the artificial disaster and emergency recovery application.

According to Srivastava, Kumar Gupta [26] in them work, they have considered that rescue team can be operated at three stages after hitting the disaster in particular location. The three stages are 1) disaster core location 2) first aid treatment central and hospital 3) ambulance as a link between them. These three stages can be communicated by using MANET network. The Mobility of MANET nodes between the three stages maintained with Reference Point Group Mobility (RPGM) based on level of attraction.

Umedu *at el.,* [27] proposes and assesses a MANET framework to perform salvage operation and keep up the area and individual data of victims in a disaster hitting region where fixed network's base is unrealistic. This network's gathers the data from terminals with GPS receivers using ad-hoc communication networks through terminals and vehicles. Here terminals are losses and vehicles become the ambulances. In this framework, the disaster influenced territory is separated into small networks and the data will be agreeably stored and shared by the mobile terminals in every region. On the other hand, if the ability to store the information in a region is insufficient, on a piece of the information will be migrated to neighboring zones. In their work, they have proposed a flooding based routing convention for communicating between vehicles called Received Message Dependent Protocol (RMDP). In RMDP, transmission time interim is balanced by number of received messages and recognized impact lapses to fulfill stable data exchange. Yet, RMDP is gone for distribution of street data gathered by vehicles, even without any direction. Therefore the changed RMDP is proposed for coordinated flood.

Lau and Mario [14], proposed a MANET CCN building design that acquires existing strategies, for example, easy to use name and data caching. Additionally, add functionalities intended to make it is powerful to wireless, lossy channels and mobile circumstances. As indicated by that, the principle commitments of this paper are; initially, outline and usage of CCN on an extensive scale MANET where high mobility and lossy channel exist. Second, MANET CCN utilizes network consumption, e.g., transmission capacity and power, exploiting gathering based mobility and a progressive network structure of the strategic filed. Finally, they demonstrated that CCN gives straight forward content and delivery framework in the combat zone and crisis circumstance.

IV SIMULATION SETUP AND PERFORMANCE METRICS

- **Selection of Simulation**

Simulation has widely been the option of mimicking dynamic scenarios mainly networks and real systems. It is a computer-based system model or generated using computer programming. Furthermore, simulation is a more flexible tool for studying the performance of various protocols [28]. Simulation was the chose method for performance evaluation in this study as this technique is widely used in representing the dynamic behavior and responses of real systems [29]. There are many discrete event network simulators available for use today. Some of these are commercial products requiring researchers to purchase them first and other are free and open source products that can be downloaded, used and modified free of cost. Some of the most popular tools that are available for communication network researchers are NS3, OPNET, OMNET, Qualnet, NetSim, J-Sim and GloMoSim [30].

NS3 is a free and open source network simulator that has been made available for teaching, research and development work under the GNU GPLv2 license [30]. It has the capability of being integrated with external animators and data analysis and visualization tools for betterpresentations of results [31]. NS3 has been developed using Python as well as C++ with scripting capability. Also, it has beendesigned in modular fashion as a set of libraries. These libraries can be combined together and with other external software libraries. NS3 has the capability of being integrated with external animators and data analysis and visualization tools for better presentations of results [31]. The main short coming of the NS3 is the lack of Graphical UserInterface and lack of support for wide variety of operating systems. Currently, NS3 can be installed only on Linux operating system in the native mode and for Microsoft Windows users need to install it on Cygwin for Windows [32]. Furthermore, the non-availability of backward compatibility with NS2 will also hinder the ready acceptance of NS3 as the default simulation tool as users will be reluctant to abandon NS2 immediately.

- **Simulation Parameters**

Experiment setup has been created in NS 3 running on operating system Ubuntu. The experiment setup and the experiments carried out have been explained in table below:

Table 1. *Simulation Parameters*

Parameters	Value
Network_Simulator	NS-3
Channel_Type	WiFi
Propagation_Model	Propagation/TwoRayGround
Net Interface_Type	YandWifiPhy
MAC_Type	AdhocWifiMac
Simulation Time	200ms
Simulation Area	1000m * 1000m
Mobility Model	RandomWayPointMobility Model
Architecture type	IP-MANET, ND-MANET
PeriodicUpdateInterval	15
Number of Nodes	10, 20, 30, 40 and 50
Packet Size	500, 750, 1000, 1250, 1500, 1750, 2000 bytes
Speed	10 m/s
Data Rate	8 Kbps

- **Evaluation Metrics**

In this work, compare the performance of the two networking architectures, it is important to select suitable set of performance metrics. We describe various quantitative metrics which can be used for evaluating the performance of a routing protocol for wireless mobile ad-hoc networks. Since this study is concerned with only comparing the performance of the two networking architectures, it is sufficient to use a single performance metric that can give an overall idea.

A. ***Throughput***: It is simply defined by the total number of application bytes received by the destination per unit of time (i.e., experiment time per seconds) [2][33]. The performance is good when the throughput is high. The following formula is often used to calculate Throughput value:

$$\text{Throughput} = \frac{\textbf{Numberof ReceivePackets}}{\textbf{LastPacketTime}-\textbf{FirstPacketTime}} \quad \ldots\ldots (1)$$

B. ***Delay***: It is the total time required to a packet to move or travel across the network from one node to another [2][34]. The following formula is often used to calculate delay value:

$$\text{RTT} = \boldsymbol{T_{receive}} - \boldsymbol{T_{send}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where T_{send} is sending time of a particular packet and $T_{receive}$ is receiving time of that packet. The performance is good when the delay is low.

C. ***Packet Lost***: It is defined as the ratio of the number of packet data lost while getting transmitted from the source[35] [36]. The performance is good when the packet loss is low. The following formula is often used to calculate packet loss value:

$$\text{Packet Loss} = \sum \textbf{Packets send} - \sum \textbf{Packets receive} \quad \ldots.. (3)$$

V RESULTS AND DISCUSSION

The following simulations are done to measure the performance of the IP-MANET and ND-MANET. The parameters used and their performance in these are explained below.

- ***First scenario***: Impact of number of nodes

To study the impact of number of nodes on performance of network, the maximum number of nodes was varied as10, 20, 30, 40 and 50. The network was simulated for packet size was 2000 bytes. Figures 2, 3, and 4 show the impact of number of nodes for IP-MANET and ND-MANET regarding the various performance metrics.

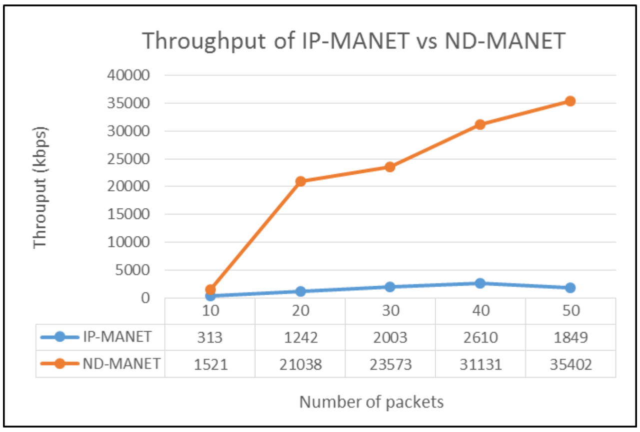

Fig 2. Throughput of IP-MANET vs ND-MANET, Packet Size is 2000

As shown in Fig 2 above, the throughput is best in ND-MANET when compared to IP-MANET. This is because of the packets fragmentation, when a packet single fragment was not received because of link failure or congestion which is lead to drop the packet and then request for retransmission reducing the throughput of the stream. IP-MANET has sufferedmore as every packets will need to receive from the sourcenode itself. While in the case of ND-MANET, even intermediate devices actively participate in connection using information stored in content store. This effectively reduces the packet losses improving the overall throughput of the network.

While we can showed in Fig 3 below, the delay is small for ND-MANET when compared to IP-MANET. In case of the delay under IP-MANET, when the number of nodes increases the delay also increases exponentially. While under ND-MANET, when the number of nodes increases the delay almost stays the same. This stems from the fact that IP-MANET situation. The intermediate nodes are forwarding packets to higher-level routers until reach the destination definitely. While in ND-MANET, the intermediate nodes get a copy of the request data inside content store. Hence, the interest packet would be satisfied immediately and with no need to travel a long distance, which can impact to reduce the delay time.

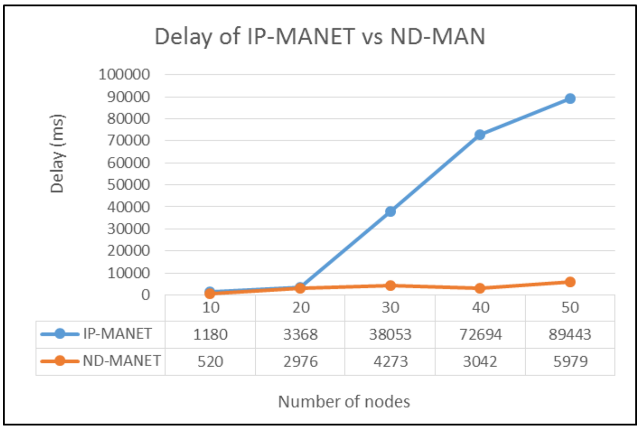

Fig 3. Delay of IP-MANET vs ND-MANET, Packet Size is 2000

We note in Fig 4 that when the number of nodes is great the packet loss also great. ND-MANET has good result as compare to IP-MANET. Packet loss problem is much more complicated in IP-MANET. Because wireless links are subject to transmission errors and the network topology changes dynamically.

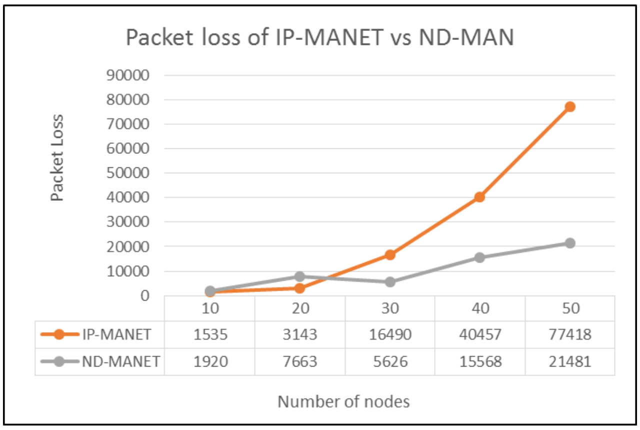

Fig 4. Packet loss of IP-MANET vs ND-MANET, Packet Size is 2000

A packet can be lost because of retransmission error, no route to end node, broken connections, and congestions. The impacts of these reasons are firmly connected with the network setting, particularly when the quantity of nodes increment. The effect of this issue may be less by utilizing ND-MANET since it accomplishes verging on ideal data delivery. In the event that congestion losses happen, caching mitigates the effect following retransmitted interest can be fulfilled by caching the data-packet just before the purpose of packet loss. Additionally, ND-MANET can maintain a strategic distance from the sort of congestions that can happen in today's Internet when a packet is lost close to its destination and rehashed retransmissions from the first source host(s) consume the vast majority of the bandwidth.

- ***Second scenario:*** Impact of variable packet size

To analyze the impact of packet size on performance of network, the maximum size of packet was varied as 500, 750, 1000, 1250, 1500, 1750 and 2000 bytes. The network was simulated for number of nodes was 30. Figures 5, 6, and 7 show the impact of packet size for IP-MANET and ND-MANET regarding the various performance metrics.

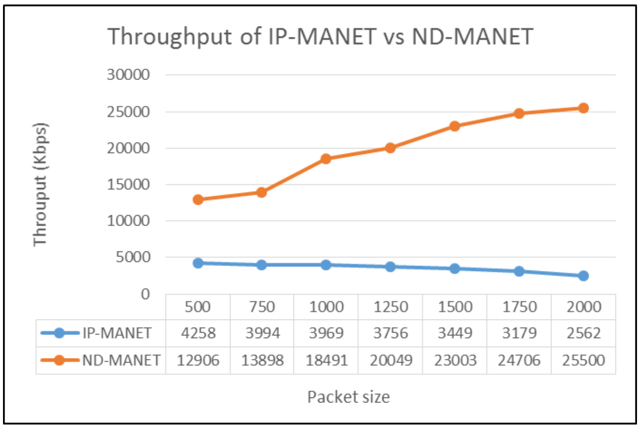

Fig 5. Throughput of IP-MANET vs ND-MANET, Number of Nodes is 30

The Fig 5 shows that the throughput for both the IP-MANET and ND-MANET under various data packet sizes. According to the results, in the IP-MANET, the throughput is an increase when the packet size is small. On the other hand, the throughput starts dropping when the packet size is decreased. This may be mainly directly to the fact that the links between this kinds of network take a long time to transmit/retransmit and process larger packets compared to smaller packets. While in ND-MANET the throughput is increasing as the packet size increasing, which is because the data stored in the content store on each ND-MANET (both the publisher and intermediate nodes) immediately after the first request for it. Therefore, we can conclusion that throughput of the ND-MANET is better to compare to IP-MANET.

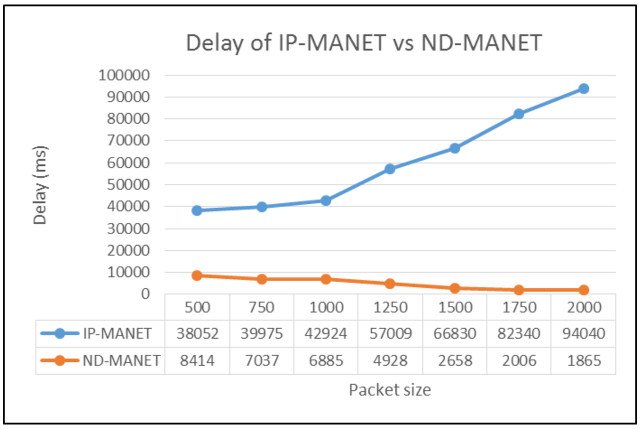

Fig 6. Delay of IP-MANET vs ND-MANET, Number of Nodes is 30

As shown in Fig 6, it can be seen that in both IP-MANET and ND-MANET delay decreases with the data packet size increases. The main reason for the above observation can be assigned to the basic principles and the nature of the architecture of networks themselves. Since the packets are impacted by the fluctuations of the intermediate network and devices which are natural. In the ND-MANET, any ND-MANET nodes which have the data which are provided in the content store can reply to any data request. In this experiment, all the publisher nodes and intermediate nodes as well, which are configured for the capability to hold the data in their content store. Hence, any node which is closer to the subscriber can always satisfy a request for reducing the network delay, especially when the packets size to have been large.

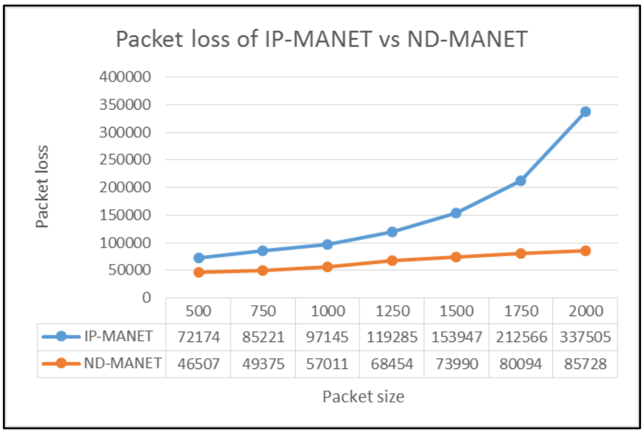

Fig 7. Packet loss of IP-MANET vs ND-MANET, Number of Nodes is 30

The packet loss in the MANET more than wire or mobile networks on account of sharing media among nodes. The Fig 7 shows the effect of packet loss for distinctive packet sizes to be continually on the core router to end routers. The outcome is delineated this figure. The ND-MANET has a decent result, while the IP-MANET has the most exceedingly awful. The packet loss diminishes as the packet size expanding on IP-MANET. If there should be an occurrence of ND-MANET, with data-plane plane criticism and feedback opportunity, individual ND-MANET routers can settle on nearby choices for sending packet through various interfaces for administration determination and burden adjusting, and can recognize issues rapidly and pick elective ways to get around the filler. Hence, it can diminish the packet loss in the networks.

In the case of disaster area such as flooding, disaster information network is required between the emergency rescue teams in order to quickly manage and distribute rescue teams and life supplies to residents. Hence, a post disaster situation demands an efficient communication and coordination among rescue teams. Exchange of real time information among responders and emergency management centers is critical to saving lives. In such scenario, MANETs are suitable for providing a communication mechanism, as they are easy to deploy and do not require elaborate infrastructure. This study achieves a realistic comparison of the two types of MANET architecture which are IP-MANET and ND-MANET. From the obtained results, ND-MANET was given a great improvement for using network resources as our simulation shown that.

ND-MANET performance is gained by reducing the delay experienced by the user and even efficient use of bandwidth in the network’s core. Furthermore, reducing traffic near the source of content reduces a publisher's processing load. Hence to achieve the major aim by improving the performance of the network for content distribution, improve a better delivery, more robust transport service and enhancing the level of service quality.

VI CONCLUSION

Mobile communication equipments have been required a fixed network infrastructure of wireless routers or cellular towers. For that, mobile equipments may not have service when infrastructure is damaged by natural disasters (i.e., flooding); or it is absent (i.e., in rural areas). In these scenarios, peer-to-peer communication among these equipments is one possible solution. Furthermore, to increase the range of connections, a multi-hop network is required. MANETs have been used in the past for providing peer-to-peer as well as multi-hop communications. This paper achieves a realistic comparison of the two types of MANET architecture which are IP-MANET and ND-MANET at different number of packet size and variety nodes. The simulation results found, ND-MANET outperforms the IP-MANET in delay and throughput. Since the IP-MANET gave a poor performance in case of increasing number of nodes as well as increase packet size. The reason behind that, ND-MANET has a positive feature due to the content is given more prominence rather than the place where the data are stored. As a final conclusion for natural disaster (i.e., flooding disaster), there will be a low or high density for the rescue team which depending on how much available at the event’s time. From the obtained results, ND-

MANET was given a great improvement for using network resources. Especially when the maximum number of nodes is high with packet size is 1000 bytes and when the packet size is large as the number of nodes is 30. Thus, make it a better network which can be used in disasters and emergency recovery applications.

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