Techniques for Real-World Implementation of a MANET

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***Abstract*—To fulfill the demands of present scenario cellular or Ad-Hoc communication is desired. Mobile ad-hoc networks (MANETs) are composed of wireless motile nodes, which actively interchange data among themselves in the absence of a permanent set-up. A Test-bed is a structure which supports testing, contrasting & computing designs and protocols in the physical-world. Some essential requirements of MANETs, like power utilization or radio propagation, are naturally difficult to frame correctly in Simulators. One of the challenging issues in this field of investigation is to prove the truth and provide a clarification which is beneficial. This paper presents the review cum analysis of various Test-bed set up's along with their associated features, with the help of basic analytical determination, design and conventions for Ad-Hoc networks and real-world experiments. In addition, various evaluation techniques viz. simulation & emulation have been discussed for MANETs. As per our study & analysis, we can conclude that, still research is going on for establishing an absolutely successful test-bed architecture, which fulfills all the desired characteristics of mobile ad-hoc networks.**

Keywords—Test-Bed, Implementation of MANET, Ad-Hoc Networks, Simulation, Emulation, Real World Experiments

I. INTRODUCTION

Wired networks have been prominently replaced by cellular or ad-hoc networks in many places. Mobile Ad-Hoc network is a group of wireless motile nodes. As per the requirements in the absence of permanent set-up nodes interchange data among themselves. The growth of wireless networks with mobile nodes (e.g., mobile phones, minicomputer, handheld digital devices and personal digital assistants) is dynamically uprising the change in an information sharing system of our society [1]. These networks are an arrangement of nodes and independent systems consisting of routers and hosts. The nodes are restricted in potential; the range of frequencies used in specific telecommunication signals and estimated energy [2]. There are two primary reasons, which discriminate Mobile Ad-Hoc networks from the online networks. Firstly, the nodes are resource-constrained in the network. They are characterized with limited storage, power & estimating energy. Secondly, the topology switches instantly. These characteristics impose big challenges for the researchers [3]. The attributes of MANETs include bandwidth-constraints, multi-hop communication, decentralized network, dynamic network topology, distributed-terminal of nodes, lightweight terminals of nodes. The advantages of ad-hoc networks includes host movements, dynamically varying topology, freedom from wired structure, data forwarding through intermediate hops, absence of infrastructure and ease of deployment. Whereas, the limited processing power and providing an appropriate energy to a large number of nodes are amongst major issues in MANET. However, the facilities & features of a MANET make it an appealing alternative to conventional architecture. The conceptual evaluation provides elementary appreciation for the features of the investigated approach.

Simulation is the method of planning & creating a replica of a true system and organizing experimentations on the nodes, in order to understand the behavior of the nodes within the network system and furthermore assessing varied operations. Numerous simulations are used to perceive the behavior of routing protocols for quality models [5]. Simulators may be categorized as: GloMoSim, Network Simulator (NS2/ NS3), NetSim, OMNET++, OPNET etc.

We cannot rely on simulations absolutely, as it constantly needs certain theory about the real world. The major issue in this field of investigation is to prove the accuracy and provide a clarification, which is beneficial [6]. It may cause out to be false or it may be difficult to capture every situation or state that affects the working of protocols and algorithms. Conversely, it has become evident that in the assessment of designs of protocols & algorithms for MANETs, simulation can only be an initial step. It's naturally difficult to correctly model some essential features of MANETs in simulators, like power utilization or radio propagation. Simulators do not fulfill the purpose of their creation, as they do not facilitate & permit the results to be proved in the surroundings.

Network emulation is a method for evaluating the efficacy of real applications over a virtual network. Emulation is a blend of software and hardware, which is used to frame the working features & behavior of a network, with some of its parts being enforced within the real world and other parts are simulated [6]. The great revealed work has been done pertaining to emulators for wired as well as wireless networks. The purpose of designing emulators can vary, some can be designed for the preparation of real world experimentations and others can be designed for testing the protocols on the actual hardware. In real world experiments, virtual dynamic topology amongst the devices is created using emulation. It enables ease & flexibility in laboratory testing, without changing the position of nodes physically, around the fore-field of a complete experimentation. The Emulators are often divided into MAC and physical layer emulators.

To deal with the incompetency of simulation and emulation, real world experiments are required. A test-bed is a framework for performing transparent, replicable and rigorous testing of scientific theories, new technologies & computational devices. The test-bed is used to describe an experimental research framework and environments. The number of challenges would be faced while performing the experiments on ad-hoc networks in the laboratory. The most apparent challenge is to check the ad-hoc applications & the effect of nodules mobility on the ad-hoc routing protocols.

Reestablishing the signal transmission attributes & realistic environmental situations, using off the shelf computing nodules and Cellular Square in a laboratory testing is also very challenging. The purpose of this paper is to present the review & analysis of various Test-bed implementations for Mobile Ad-Hoc Networks. The section IV presents various Test-Beds used for Mobile Ad-Hoc Networks and the typical characteristics or parameters pertaining to each test-bed are shown in Table I. These mechanisms are essential to confirm or disconfirm the presumptions and to analyze, when to scrutinize the conventions or the design in an absolutely conclusive approach.

II. Literature Survey

This section presents the current trends and studies carried out for the design and implementations of mobile Ad-Hoc networks. As per the literature, there are three important procedures such as Simulation, Emulation and Test-bed, which works for the opinion of process and rules, required to be used in portable ad-hoc networks. On the other hand, these procedures always desired the solution of real-world effect, such as growth flexibility or radio aspect.

D. Cavin et al. [7] compared the simulation results of OPNET, NS2 and GloMoSim IEEE 802.11 MAC Thickness Layer applications and a very transparent flooding algorithmic program was prepared to characterize wireless ad-hoc networks, applying fifty mobile nodes. Authors, conjointly acknowledge that, in order to illustrate the accuracy of wireless network simulators, there is a lack of real experimentations. This paper is an essential motivation to achieve simulations, applying numerous simulation mediums and to analyze the simulation decisions along with the test-bed results. According to the authors, there was a large diversion between results from completely different simulators, and in a few cases the results were hardly comparable.

R. Bagrodia et al. [8] in 1997 used the Parallel Simulation Environment for Complex System. As per the authors, it is an efficient system for simulating an interconnection that consist of thousands of nodule and different communication channels, just as multicast and asymmetric interconnection. In enlargement GloMoSiM guides, conventional World Wide Web protocols, absolute satellite channel, and multi-hop cellular communication. The GloMoSiM can be used to define a cellular organization. It is also based on the study, related to serial and lateral simulator. It has an expandable simulation study, which is based on the Parallel simulation environment.

X. Zeng et al. [9] have developed a set of study modules. Each schedule in GloMoSiM features the peculiar mobile connection in the protocol pack. All structure layers apart from the material layer are carried out in a physical system, in the material layer emulator. These emulators damage the transmission signals, which were emitted by the wireless network of the nodules and presented the impact in the radio signals that would be observed in the real-world organization.

D. A. Beyer [10] in September 1990 presented the circumstance to constrict the transmit signal as PRISM/ SALT emulator, which was built for the SURAN project. The signals were available to supply with the chain into a procurable RF alternator. K. W. Chin et al. [11] have discussed that, these emulators are also used in exhaustion with related components though they are not procurable.

G. Judd et al. [12] in 2004, built the emulator which initializes the radio networks and then supply them into an individual processor, to sustain the individual transmission holding and then, the individual signal sent back into the cellular networks. D. Raychaudhari et al. [13] in 2005 presented an overview of ORBIT Test-bed, which is under development and can contain the 400 nodes in the internal radio- layer emulator and 50 nodes all out of the network. The internal network delineate [27] consists of sixty four fixed nodules, with IEEE 802.11 wireless network interfaces in a network layout.

Q. Ke et al. [14] in 2000 presented an emulation of multi-hop cellular interconnection in the MAC thickness emulator, which can be done by using a traditional simulator or it can be done by scripting the peculiar tools. Many Authors [14, 15, 16] in 2005, also presented an environment for the emulation in MANET. The emulators can be distributed to be placed on the possible interconnections, which can be refined by the useful tools like, IP Tables. Connections can also be particularly designed for the refined tools like, DSR MAC filter and APE. The DSR MAC filter experiences the designing and helps in building a cellular-interconnection for the implementation of a MANET test-bed and the APE Mackill is useful in the test-bed implementation, which predicts the way, to construct, install and run the APE test-bed in MANET. To signify the distributed refined protocols, the emulator additionally designed the objective with the nodule mobility.

III. Evaluation Techniques

This section presents the evaluation techniques viz. Simulation, Emulation and Real-world experiments for Mobile ad-hoc networks. Recently a variety of test-beds are delineated in the literature, whereas just a few of them are literally accessible. The Table I summarized the various features or parameters pertaining to existing test beds, which are obtainable in the public domain and analyzes their options with respect to the test-beds dimensions and therefore, the options of the package used for operating and managing the tested.

A. Simulation

A simulation is defined as the process of creating the imitation of the physical world system. This replica represents the functions, behavior & features of a physical or conceptual process or system. The simulation shows the operation of the system over time, whereas the model shows the system itself. Simulation is used in many ways, including simulation as a technology for safety engineering, performance optimization, testing, education, video games, and training & computer experiments. It is also used in scientific designing of human systems or natural systems. The network simulators can be categorized and explained on the basis of the following norms:

*1) Complexity:*A network simulator is meant to allow users to represent a constellation, the

distribution of the nodes and also the traffic connections between those nodes, which confirms the use of protocols in a network, shaping the situations ore difficult systems might permit the user to view everything that is related to the protocols used to regulate network traffic and also permit users to try additional advanced sorts of customization [17]. Simulations allow reconstruction, compact, enormous and cost effective inspection within a realm of possibility with different system software, system program and system analysis [5]. On the other hand, the negative aspect of a simulation is an absence of authenticity.

2) GUI (Graphical User Interface): Graphical user interface simulator tools give a straightforward and intuitive set of icons to represent the parts of a network and also allow the users to simply visualize the working of their simulated surroundings. Others may be programming-oriented tools that provide a programming framework, which is customized to form associate degree application that simulates the networking surroundings for testing.

Network Simulation Tools

There is a list of simulators used for MANETs. Simulation eventualities and their limitations are compared on the basis of different aspects like simulation surroundings, simulation language, resources & features.

Network simulator NS-2: The NS-2 simulator associates with open supply tools and therefore the development of this version is supported by the agency. It's a separate event simulator organized, followi ng the standards of the OSI model. Monarch CMU project, BlueHoc and BlueWare have supported the wireless networks [18]. The NS-2 simulator is employed to see the packet flow, queue buildup and packet drops. It is used to create the wireless network environment [19] with numerous routing algorithms like AODV, DSR, etc., and supported by UNIX and windows environment. However, it doesn't support graphical user interface, so it is necessary for the users to learn the scripting languages, queuing theory and modeling techniques to use this simulator. In NS-2, network modeling is incredibly complicated and it needs a lot of time. In spite of such complexities, NS-2 is extremely used & trusted tool in the network community. The core of Network Simulator-2 is written in the C++ programming language. It has more than eighty eight percent quality and finest graininess [18].

GLOMOSIM: It stands for Global Mobile Information System Machine. It is an open source tool for the network community. It stimulates each wired and wireless network. Its designs are utilized in parallel distinct event simulator, which is written in parsec. Parsec has the power to run on a Shared Memory, which is a bilaterally symmetrical Processor (SMP) computer. It suffers from lack of complete & detailed documentation. GloMoSim, supports various applications (TELNET, CBR, FTP, etc.), transport protocols (UDP, TCP), routing protocols (FLOODING, AODV etc.) and mobility designs (random waypoint etc.) [13]. It has four percent quality and fine granularity [9].

B. Emulation

The emulators present circumstances without alternation to the program and authenticate program clarification for ad-hoc networks [9]. An enclosure analysis will give an idea about, whether the simulation work is going on the suitable indication or not and whether, if it is going from the simulator to the absolute things, precisely to determine the execution. It also observes the consequences of routing conventions and portability. Authors, also deal in determining and selecting a suitable emulator in accordance with the given circumstances in an efficient course of action. They have presented an overview of emulation test-beds, for the determination of an appropriate mechanism in the MANETs or we can say in an infrastructure less network. The objective of these emulators is to modify, the testing protocols, which are built on the physical hardware, whereas the others are used to develop the real-world operations. Emulators may be categorized into physical and MAC layer emulators. The Fig. 1 depicts the modeling of real networks with the Emulated networks.

C. Real-World Experiments

In the Real-world experiments all elements of the system square measure totally purposeful in an exceedingly real-world setting. The total network is developed and tested beneath real environment, according to albeit experimental conditions. Real-world experiments include all effects & consequences on the network and might give an opinion for simulation or emulation. The real-world experiments provide a ground to prove the working efficiency of the associated formula or protocol.

A Test-bed is a structure which supports testing, contrasting & computing algorithms and protocols in the real-world. The available test-bed techniques for mobile ad-hoc networks are used to a larger span for scheming the test-bed. - For example, the APE [4] test-bed is a Linux sharing setup which may be booted either from CD, pen drives or traditional notebooks. Every observer applicant is notified to move according to a sequence of steps. On the positive side, the observer participant can perform the various operations again and again. The advanced MANETs test-bed is able to support a comprehensive platform for proving Ad-hoc protocols in original world scenarios, assembled with a relevant software environment for the facilitation of user's utility. Real-world testing is being drifting out to gratify for deficiencies of simulations, which are established at a momentous level of abstractions.

IV. TEST-BEDS FOR MOBILE AD-HOC NETWORKS

A. Analysis of Various Test-Beds for Mobile Ad Hoc Networks

This section presents the overview of various Test beds, the real world experimentations on MANET. As per the literature, various test-beds have been experimented like CMU, GA TECH, BBN and APE etc. In this section we have presented

the various features & parameters associated with each test-bed set up. The Table I present the analysis of various Test-beds implementations with respect to their varied characteristics like type of architecture, number of nodes used, mobility modeling, cost efficiency, scalability, protocols and applications. Although, there are some constraints with each test-bed implemented, but each is associated with its own benefits & limitations.

1) CMU: The CMU test bed share its name with its creator, The Carnegie Mellon University [21, 25]. It consists of two stages: laboratory and field testing. Within the laboratory, "MAC filter" software system was used, which was written in a order, that a group of test-bench-mounted laptops might emulate a dynamic mobile configuration, by selectively dropping and receiving packets from neighboring laptops that preconfigured on time scripts. This capability greatly simplified the task of the first debugging protocol implementation. It was followed by field trials in which wherever an ad-hoc network was created, with 5 mobile nodes installed in automobiles running with maximum speed of 40 km/ hr (rental cars) and 2 mounted nodes, it was interconnected with 900 MHz signal Local Area Network- I radios with a hypothetical range of 250 m and Global Positioning System for tracking purposes. The Routing decisions were performed with DSR protocol. The 2 mounted nodes were placed just about 617 meters apart at opposite ends of the route traversed by the movable nodes and also the mobiles would fight back and forth between the 2 mounted nodes in an elongated loop. This could produce a dynamic, comparatively linear topology between mounted nodes with a diameter of 2 to 3 hops.

2) APE: The APE stands for Ad-hoc Protocol Evaluation test-bed. The APE project was initiated as a study project at the Department of Computer Systems, at Uppsala University and was partly supported by Ericsson [4, 22]. It's designed specifically to evaluate the performance of MANET routing protocols. The APE aimed at reducing the complexities in performing the real world tests. It targets continuous reading and it has the capability to easily run many algorithms for comparisons and high capability of customization. The principle of APE is to focus the variations in routing conventions and finding issues pertaining to networking and routing. Moreover, APE also facilitates to evaluate the similarity among repetitive test runs. The APE test-bed could stand as an autonomous, standalone UNIX system which is mostly based on the surrounding.

3) BBN: This test bed [23, 34, 35] for ad-hoc networking is described using the directional antennas. The identical routing code is used for the real experiment as used for the simulation, in order to implement this system. The Hazy Sighted Link State (HSLS) routing protocol was used for routing. Twenty nodes (cars) were used for conducting an experiment that drove around a twelve kilometer area. The packet-per-packet base and 802.11b physical layer were used as a basis for selecting among automobiles supplied with four directional antennas. This system performed better with the same setup (20 cars, but with unidirectional antennas and OLSR protocol) as per the authors. Though, additional detailed information on this is unavailable. The helicopter was used as an aerial node in the second experiment.

4) JEMU: Flynn et al. [25] have discussed "JEMU", which is an emulation test-bed controlled centrally, and its dimension is twelve physical nodes. Its mobility environment is wired and there is a centralized collision notification on frame level. The Networks Systems & Telecommunications Analysis Group developed this test bed. The JEMU works centrally, therefore each packet is initially sent to the emulation device and then the machine decides, if the fixed node area unit is ready to accept it or there must be a collision/ impact.

5) ORBIT: Raychaudhuri et al. [13] have discussed the ORBIT test bed, which consist of four hundred radio nodules which are static and placed within one meter area. Virtual nodes are logically linked to every physical nodule in a network. The radio nodes are decked out with Bluetooth and IEEE 802.11x interfaces. Measurements are often implemented on the MAC stage, physical stage and network system. It is an internal radio grid emulator for performing indoor controlled experimentation and it also serves as an external experimental field network for evaluating users in settings of the physical world [13]. This emulator requires a noise originator, as it emulates greater nodule distances, by decreasing the signal-to-noise ratio.

6) WHYNET: Zhou Junlan et al. [26, 27, 28] have discussed WHYNET, which is a flexible test-bed used for the mobile wireless networking. It is made up of twelve interdisciplinary test-beds to check new wireless transmission technologies. The WHYNET examine and determine various kinds of wireless transmission technologies, one can view them on an individual basis and along with other various wireless technologies involved, like smart Antennas & sensor Networks. WHYNET is a hybrid wireless test-bed surrounding, focusing on scalable, realistic and versatile analysis of transmission technologies as well as applications [28]. This hybrid research approach uses actual and simulated parts (e.g., subnets, protocol layers or stages) in several combinations. WHYNET uses a physically divided set of actual wireless test-beds, creating results tough to be reproduced by an alternative analyzer.

7) MNE: William Chao et al. [30, 15] have explored MNE, which stands for Mobile Network Emulator. It is a real world test bed and it consists of ten physical nodes. It is a distributed, organized emulation test-bed. MNE is created to work on Linux-based sharing environment with IPTABLES network and as well as system filtering capabilities set up. The packet filter observes the header of the packets and depending upon the user-defined rules, it decides whether the packet should be allowed for advance processing or may be dropped. The applications of packet filtering include security, management and watchfulness. The MNE takes benefit of these features & control attributes of IPTABLES to restrict packets from a nodule under consideration.

8) NET: Herrscher et al. [20] have discussed NET, which stands for "The Network Emulation Test-bed" (NET). It is a Hybrid Emulation, which supports distributed management technique. The degree of nodule

virtualization is extremely high, up to thirty nodules per physical device. The introduction of artificial delay and bandwidth adaption can be implemented by shaping tools, like Net-Shaper. The "Net-Shaper" also defines the traffic for the emulation layer.

TABLE I. Analysis of Various Test-Beds

Name of Authors	Name of Test bed	Type of Architecture	Tested Size	Mobility Modeling	Cost Efficiency	Scalability	Routing Protocol	Description
Nordstrom et al. [22]	APE	Distributed	17 physical Nodules	IEEE standard 802.11	Medium	Low	DSR or AODV or OSLR	1. Linux based test environment. 2. It has Graphical User Interface. 3. It is a large scale Ad-hoc network test-bed.
Herrscher et al. [20]	NET	Distributed	64 physical nodes	Analytical Connectivity	High	High	AODV	1. The degree of nodule virtualization is very high, up to 30 nodules per physical device or machine.
Raychaudhuri et al. [13]	ORBIT	Centralized	400 physical nodule	IEEE 802.11 Standard & Bluetooth	High	Low	AODV & OSLR	1. To support multiple experiments, virtualization of radio grid resources is used. 2. It is scalable, but very expensive.
Maker et al. [30, 15]	MNE	Distributed	10 physical nodule	_	Medium	Low	OLSR	1. Simple, lightweight, distributed system, which does not require an expensive central piece of hardware. 2. Multicast support. 3. Supports auto configuration under motion.
De et al. [31]	MINT	Real-world test-bed	8 physical nodule	IEEE 802.11 standard & Robots	Low	Low	_	1. It connects to the prime characteristics of the well known work evaluation methods. 2. It achieves network system accuracy. 3. It provides hybrid simulation facility.
Ramanathan et al. [32]	DAWN	Real-world test-bed	10 physical Nodule	physical or real world/2.4GHz RF	Low	Low	_	1. Mobility Setup. 2. Hybrid Link State Routing.
Zhou Junlan et al. [26, 27, 28]	WHYNET	Distributed	_	physical or wireless	Medium	Medium	_	1. Hybrid wireless Test-bed for large scale networks. 2. Realistic or physical environment. 3. Flexible or adaptable in the evaluation of wireless environment. 4. It fits in a desktop.
Jorge Hortelano et al. [27, 29]	CASTADIVA	Centralized	_	IEEE 802.11 Standard	Medium	High	OLSR	1. Combination of wireless routers on Linux platform. 2. It is flexible. 3. It has real devices like routers, PDAs and computers.
Flynn Juan et al. [25]	JEMU	Centralized	12 physical Nodule	Analytical connectivity	Low	Medium	DSR	1. JEMU test bed was developed by the Networks Systems & a Telecommunications Analysis Group.

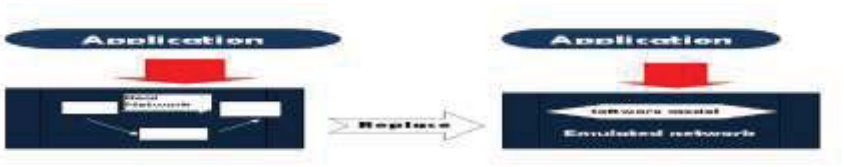

Fig. 1. Process of Emulation

V. CONCLUSION

The mobile Ad-hoc networks are characterized by dynamic topology. As per the literature, most of the analysis work has been performed on the machine. Consequently, testing the particular atmosphere is needed and it's terribly unbearable and time overwhelming. We have presented a survey cum review of various test-beds in this paper, which are associated with applicable tools for estimating ad-hoc networks. We have also discussed the various features of test-beds with respect to their size and quality modeling, quantifiability and value potency. In addition, other

evaluation techniques have been discussed, including simulation and emulation. Simulations are not absolutely reliable or authentic. Each emulator is associated with its own restrictions, some reveals smart ends up in a particular setting, whereas some might not achieve the same in an exceedingly similar perspective. As per the study, every test-bed has some pros and cons and its successful operation depends upon the variety of parameters. To deal with the incompetency of simulation and emulation, real world test-bed experimentations are required. But, as per our study & analysis, we can conclude that still research is going on for setting up the absolutely successful test-bed architecture, which fulfills all the characteristics of mobile ad-hoc networks.

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