Assessing the Viability of Performance Evaluation Methods in Network Research

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Abstract – Ad-hoc networks are to networks that are spontaneously and temporarily established without requiring any pre-existing infrastructure. These networks are often characterized by self-organization and may be spontaneously established to simplify communication across devices. Wireless Sensor Networks (WSNs) consist of diminutive, energy-efficient devices known as sensors, which are strategically placed in different settings to gather and send data without the need for physical connections. WSNs are often used for the purpose of monitoring and collecting data from the surrounding environment. This study focuses on the assessment of performance in network research, especially in the domains of Ad-Hoc and WSN. The analysis focuses on papers from renowned conferences in various domains and scrutinizes the validation methodologies used by authors. Simulations are the predominant approach used for performance assessment, with MATLAB being the favored simulator. Experimental verification is also carried out, but the articles lack comprehensive information, which poses a challenge for replicating the experiments. In general, a minuscule proportion of publications provide replicable results.

Keywords – Ad Hoc Wireless Networks**,** Ad-Hoc Networks, Wireless Sensor Networks, Low-Rate Wireless Personal Area Networks, Infrared and Radio Frequency.

I. INTRODUCTION

The present condition of computer networking is progressing towards ubiquitous computing with integrated components. The advancement of low-cost sensors, made possible by advancements in microelectronics and wireless communications, has resulted in their widespread use in the emerging field of ubiquitous communication. Due of their low cost and inherent adaptability, ad hoc wireless networks (AWNs) [1] are initially an ideal platform for gaining this goal. It leverages the integrated circuitry or supplementary cards of several mobile devices to enable peer-to-peer communication. These gadgets include a wide range of technology, such as PCs, PDAs, wearables, mobile phones, and several more. The introduction of sensors ushers in a new age for sensor-based AWN, characterized by densely packed, cost-effective, energy-efficient, compact, and mass-produced sensing devices. The characteristics of ad hoc wireless sensor networks (AD-WSN) make them ideal for establishing uncomplicated, decentralized, cooperative, and time-dependent networks.

Lack of network control mechanisms like WLAN, MPLS, and ATM leads to a substantial reduction in network intricacy and cost. It enables the distribution of mobile nodes (sensors) without a fixed topology. The network's capacity to monitor, collect data, or carry out surveillance relies on the collaboration of its sensors; nevertheless, individual nodes may be deliberately deactivated or deleted without affecting the network's overall efficiency. The 802.15.4 standard, sometimes referred to as 802.15.4, was created and introduced in response to the emergence of wireless sensor networks (WSNs). It is designed specifically for low-rate wireless personal area networks (LR WPANs) [2]. Its straightforward, energy-efficient, and cost-effective solutions have the potential to help several sectors such as wireless networking, industrial control, environmental monitoring, the military, home appliances, security, consumer electronics, and healthcare.

This article delineates the protocols governing physical (PHY) and the medium access (MAC) levels of a fully wireless network. Both simple 1-hop star networks and more intricate multi-hop peer-to-peer networks are compatible. In all scenarios, a PAN coordinator is selected to commence and supervise the functioning of the network. The first one facilitates unidirectional communication between devices linked to the PAN coordinator and the devices themselves, as well as between peers. In the second scenario, the underlying network is structured as a star network. The network may expand by designating a coordinator node or nodes to supervise each cluster or WPAN. Coordinator nodes establish a hierarchical tree network via the process of selecting more coordinators.

The purpose of this study is to assess the effectiveness of the performance assessment process in network research, with a special emphasis on the use of simulators and experimental validation. The researchers want to ascertain the efficacy and replicability of these methodologies in evaluating the feasibility of concepts and resolutions in network research. The researchers scrutinize a substantial volume of publications from renowned conferences in the domain of Ad-Hoc and WSN. They assess the validation methods used by authors and the extent of specificity presented in their papers. The study results emphasize the widespread usage of simulation-based assessments, with MATLAB emerging as the predominant simulator. Nevertheless, the absence of precise details about simulators and simulation settings impedes the ability to replicate these investigations. The researchers also address the difficulties of experimentally validating their findings, namely in reproducing results owing to external variables in test environments. The study seeks to get insights into the present methods and constraints of performance assessment in network research.

The rest of the article is arranged as follows: Section II presents an overview of concepts such as Ad-Hoc, and wireless sensor networks. Section III discusses the performance evaluation procedures, discussing concepts such as simulating protocols or experimenting algorithms, and relevant literature studies. Section IV presents a critical analysis of the results, such as evaluation procedures, and reproductivity. Lastly, Section V presents a summary of assessing the viability of performance evaluation methods in network research.

II. OVERVIEW OF CONCEPTS

Ad-Hoc

An ad hoc network (AHN) [3] is formed by accumulation of communication gadgets (nodes) that want to interact when there is no established infrastructure or predetermined configuration of available connections. Each node is responsible for autonomously acquiring knowledge about the specific nodes it may directly communicate with. Mobile ad hoc networks (MANETS) [4] are expected to be a crucial element in the future 4G design.

Table 1. Current and future applications of MANETs

Application	Possible scenarios/ services
Coverage Extension	• Connecting intranets, the internet, etc. • Increasing cellular network accessibility
SN	• Body area networks (BAN) • Tracking data on animal movements, biological and chemical detection, and ecological conditions • Smart sensors and actuators integrated into consumer gadgets for home use
Context aware services	• Information services, including time- and location-specific services • Follow-on services: mobile workspace, call-forwarding • Infotainment: touristic data
Entertainment	• Theme parks • Outdoor internet access • Wireless P2P network working • Robotic pets • Multi user games
Enterprise and home networking	• Network at construction sites • Meeting rooms, conferences • Personal networks (PN), personal area networks (PAN) • Office/home wireless networking
Education	• Virtual classrooms • Campus and universities settings • Ad hoc communications during lectures or meetings
Tactical networks	• Automated battlefields • Military operations and communications
Commercial and civilian ecosystem	• Network of visitors at airports • Vehicle services include inter-vehicle networks, taxicab networks, weather and road condition communication, accident or road guidance • Shopping malls, trade fairs, sport stadiums • E-commerce: electronic payments anywhere and anytime • Entrepreneurship: mobile offices, dynamic database access
Emergency services	• Supporting nurses and doctors in hospitals • Replacement of permanent infrastructure in the event of a natural catastrophe • Fire-fighting and policing • Search and rescue operations • Disaster recovery

The objective of this design is to establish computer environments that are present everywhere, allowing users to do tasks, get information, and interact using any device, regardless of the time or location. **Table 1** provides an overview of current and future applications of MANETs. A crucial assumption is that direct connections between all nodes in the network are not possible. Consequently, some nodes are required to act as intermediaries, relaying packets on account of other nodes to facilitate the transmission of data throughout the network. Due to the mobility and autonomy of nodes in an ad hoc network, the network's connection and link properties might undergo rapid variations. Infrared and radio frequency (RF) are only two instances of the many wireless technologies that may serve as the foundation for ad hoc networks.

The issue of ad hoc networking involves several layers. The physical layer has to adjust to swift variations in link attributes. The MAC layer must optimize collision avoidance, provide equitable access, and provide reasonably reliable data transmission over shared WN, even in the presence of fast fluctuations and exposed or concealed terminals. The network layer must ascertain and disseminate data required for route calculation in a manner that preserves efficiency in the face of frequent connection changes and limited bandwidth. Additionally, it must seamlessly connect with conventional, non-AHN and execute tasks like auto-formation in this evolving setting. The transport layer must possess the capability to manage delay and packet loss data that significantly diverge from those seen in wired networks. Applications must be built to effectively manage frequent reconnection and disconnection with peer applications, as well as handle significant variations in latency and packet loss properties. AHN are appropriate for situations when there is a lack of infrastructure, lack of faith in existing infrastructure, or a need to avoid reliance on infrastructure during emergencies. Some instances include: deployed military personnel; distributed sensors for biological detection in urban areas; a network of portable computers in a campus or conference environment; the lumber or forestry sector; tracking of endangered species; temporary offices (campaign headquarters), underwater operations, and space exploration.

The history of Ad hoc network (AHN) began in 1972 with the creation of the DoD-sponsored PRNET (Packet Radio Network) [5], which later established into the early 1980s Survivable Adaptive Radio Networks (SURAN) program [6]. These program`s goal was to give packet switched networking to mobile combat components in a dangerous ecosystem where troops, tanks, planes, and other things served as network nodes. For medium access, the PRNET employed a mix of ALOHA and CSMA, as well as a distance-vector routing system. SURAN made significant advancements in reducing the size, cost, and power consumption of radios, as well as enhancing the algorithms` scalability and the capacity to withstand electronic assaults. The routing protocols used a hierarchical link-state approach, resulting in a high level of scalability. During the early 1990s, there was a series of major advancements that indicated a new stage in ad hoc networking (AHN). Notebook computers gained popularity, along with open-source software, and functional communications appliance that relied on infrared and RF technology. The concept of a network consisting of mobile hosts without a centralized infrastructure was introduced in two conference papers [7, 8], and the IEEE 802.11 subcommittee officially accepted the name "ad hoc networks." The emergence of commercial AHN, excluding military applications, had occurred.

IEEE 802.11 and HiperLAN/2 are two other Ad Hoc technologies. The IEEE 802.11 standard establishes a WLAN standard that defines the wireless coordinate between an access point or a base station and a client, as well as wireless client communication. Direct-sequence spread spectrum (DSSS) [9] and Frequency-hopping spread spectrum (FHSS) [10] are the two physical features for radio-based WLAN detailed in the IEEE 802.11 standard [11]. They both utilize the ISM band at 2.4 GHz. The point coordination function (PCF) mode [12] and the distributed coordination function (DCF) mode [13] are the two network architectural modes that are described in the IEEE 802.11 standard. In the former, all network communication—including local activity among wireless clients—is supervised by a network access point, which operates in a centralized manner. The DCF mode allows wireless clients to communicate directly with one another.

The MAC layer employs the CSMA/CA algorithm for media access control. A terminal running in Distributed Coordination Function (DCF) mode, which intends to transmit data, first monitors the channel to ensure it is not being used by other terminals. It then proceeds to wait for a randomly determined length of time (backoff) before sending its data. After this waiting period, if no other station attempts to acquire access, the terminal may gain access in one of two ways: (1) The transmitting node transmits a request-to-send (RTS) packet [14] to the receiving terminal during the four-way handshake. When the request is accepted, the receiver sends a clear to send (CTS) packet. Once it is confirmed that there have been no collisions, the sender proceeds to transmit its data. (2) The sender promptly initiates the transmission of its information. This mode is used when the information packet is of limited length. Regardless of the mode, the receiver will send an acknowledgment (ACK) packet to confirm successful reception of the packet. The CSMA/CA technique is operational in the PCF mode as well. Despite this, the access point has total control over the channel because to its greater priority over terminals.

Wireless Sensor Networks

The rapid increase in prominence of wireless sensor networks (WSNs) in recent decades may primarily be attributed to the widespread use of microelectromechanical systems (MEMS), which enable the development of smart sensors. Unlike traditional sensors, these sensors are compact, possess restricted computing powers, and effectively handle data processing. The sensor nodes have the capability to detect, measure, and gather data from the environment. They may provide the data to customers via a localized decision-making process. Various industries use sensor networks for different purposes, such as military target recognition and surveillance, biological health monitoring, seismic detection, environmental hazard studies, and disaster relief efforts.

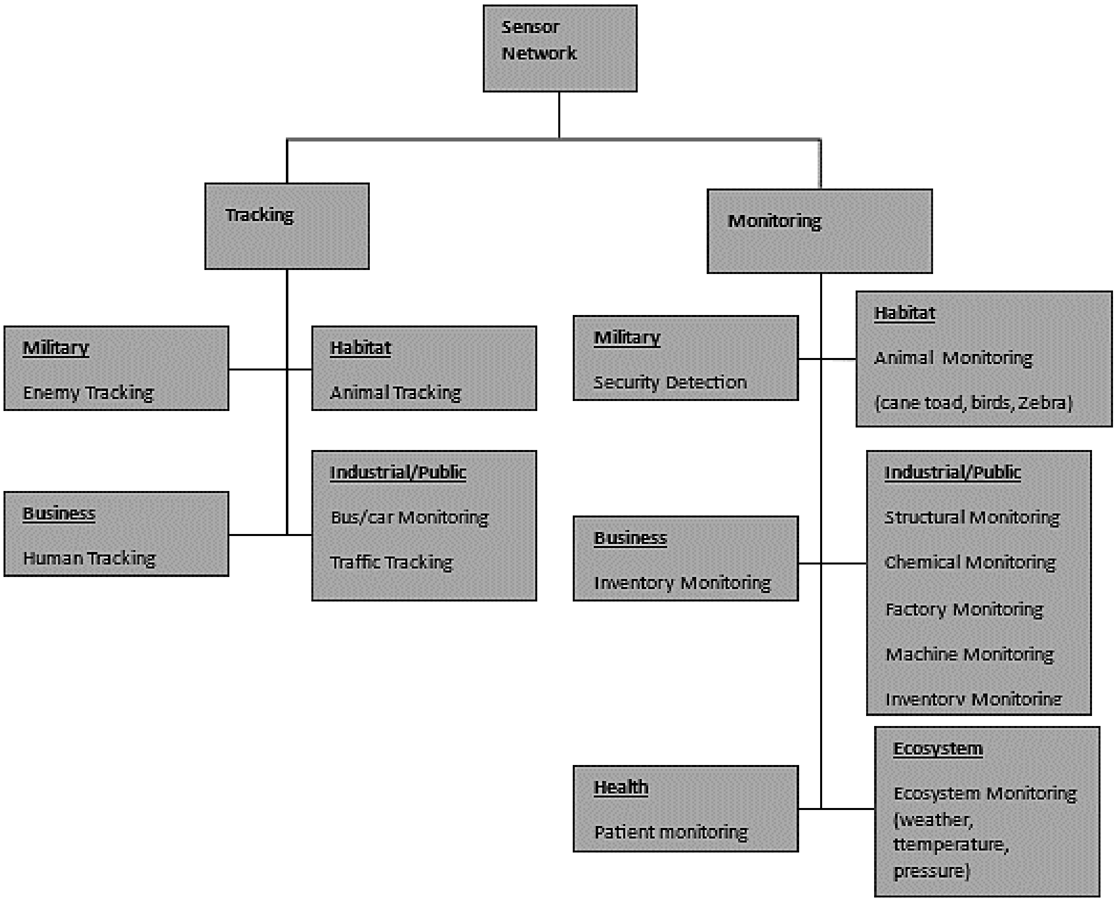

Fig 1. Sensor Application Overview

Wireless sensor networks (WSNs) could be used by the military for the purpose of target monitoring and oversight, particularly in the areas of incursion detection and related domains. Such occurrences include the coordinated and synchronized motions of tanks and soldiers into a spatially connected whole. Natural disasters may be foreseen with the use of sensor nodes because of their visual and analytical capabilities. Surgical implantation of sensors in bio medical applications may facilitate the monitoring of a patient's health. In order to detect the occurrence of earthquakes and volcanic eruptions, it is possible to place sensors in a spontaneous and temporary manner along the volcanic region for seismic sensing purposes. Applications of WSN may be categorized into two distinct groups: tracking and monitoring (refer to **Fig 1**). Monitoring applications include a wide range of activities, including as monitoring outdoor and indoor environments, tracking wellness and health, monitoring electricity use, tracking inventory locations, automating industrial and process operations, and monitoring structural and seismic conditions. Tracking applications include the monitoring of various entities such as objects, animals, persons, and vehicles. Although other applications exist, we will now provide descriptions of a few sample implementations that have been implemented and evaluated in real-world settings. PinPtr is a novel counter-sniper device designed for the purpose of identifying and pinpointing the exact location of those firing guns. The system employs a concentrated arrangement of sensors to identify and quantify the timing of shock waves and muzzle bursts resulting from a gunshot.

Sensors transmit their readings to a central station (such as PDA or a laptop) in order to calculate the precise position of the shooter. The sensors used in the PinPtr system are Mica2 motes of the second generation, which are coupled to a versatile acoustic sensor board. The design of each versatile acoustic sensor board includes a Xilinx Spartan II FPGA and three acoustic mediums. Mica2 motes operate on the [15] operating system platform, which manages radio communication, task scheduling, timing, and other functions. The program utilizes middleware services built on TinyOS, such as localization, message routing with information collection, and time synchronization.

The redwood macroscope is an example of a WSN that keeps track of documents in redwood trees in Sonoma, California. Every sensor node ascertains atmospheric pressure as well as the amount of sun radiation appropriate for photosynthesis. Various sensor nodes are strategically positioned at various elevations throughout the tree. Plant researchers monitor variations in the weather pattern around a redwood tree and verify their biological hypotheses. The study mentioned in [16] examines the use of oscillation signatures collected by sensors to anticipate equipment failure in semiconductor factories and oil tanker applications, with a specific emphasis on preventative equipment maintenance. The network architecture is designed to fulfill the data necessities of the utilization, taking into consideration the application requirements and the results of the site survey. Two tests were conducted: the first took place at a semiconductor production facility, while the second was performed aboard an oil ship located in the North Sea.

The objective was to consistently verify the specifications for firm settings and assess the impact of the SN structure. The research also examined the influence of platform features on the performance and architecture of actual deployment. A research conducted in [17] designed a platform for underwater SN, specifically for the purpose of long-term monitoring of fisheries and coral reefs. The SN comprises both mobile and stationary underwater sensor nodes. The nodes establish communication via direct connections utilizing high-velocity optical communications. Nodes transmit data using an acoustic protocol that is included into the TinyOS protocol stack. Their array of sensing gadgets includes pressure and temperature sensors, as well as webcams. Mobile nodes have the potential to position themselves and move above the stationary nodes in order to gather information and carry out network maintenance tasks such as recovery, relocation, and deployment. One of the main takeaways from this research was the difficulties encountered while putting sensors in an underwater setting.

MAX [18] is a system designed to facilitate anthropocentrism search of the physical environment. MAX enables individuals to efficiently search for and identify tangible items as required. It offers location information based on recognizable landmarks rather than exact coordinates. The design of MAX prioritized privacy, quick search functionality for labeled objects, and a user-centric operation. MAX utilizes a hierarchical structure that necessitates the tagging of items, the designation of sub-stations as landmarks, and the use of base-station computers to determine the location of the object. Objects may be labeled with tags that are designated as either private or public, allowing them to be searched by either the general public or alone by the owner. MAX is specifically designed for queries with low energy consumption and little latency.

III. PERFORMANCE EVALUATION PROCEDURES

After completing the modeling step in a typical research process cycle, network researchers and developers go to the validation method. During this phase, they assess the viability of their idea by using either an emulator or a simulator. Subsequently, network developers and engineers may conduct experiments to further validate their concept [19]. Therefore, actual deployments may begin once both the experimental measurements and the simulation results meet the required standards.

Simulating protocols or experimenting algorithms

Simulations are commonly considered the most effective approach for studying the performance of Ad-Hoc and Wireless Sensor Networks (WSNs) due to the complex settings and challenges they present for theoretical analysis, as well as the practical limitations of implementing large-scale real-world deployments. Several open source and publicly accessible simulators let users to exert more control on the nodes by often using a Graphical User Interface (GUI), and to preserve or streamline certain suppositions for the purpose of evaluating their solutions. Simulation assessment is a necessary step in the process of developing a protocol. Nevertheless, despite the simulation performance aligning with mathematical assessment, previous real-world implementations indicate that it is not advisable to continue directly with actual deployment. This is due to the potential occurrence of unforeseen events, such as node crashing or network disconnection, which engineers may encounter.

Intermediate experimentation platforms provide as a means to connect simulations and real world deployments. However, simulations have the opportunity to test a broader range of assumptions and hence possibly provide more comprehensive assessments. On the other hand, testbeds have certain constraints such as the physical environment, hardware, and network architecture. These facilities provide the chance to test solutions under actual situations, making them more realistic than those simulated in software. However, certain factors (such as symmetry, connection stability, and radio dynamics, and the influence of weather on conversations) are so unforeseeable that they may give findings that cannot be replicated with suitably precise confidence ranges.

Researchers should prioritize ensuring the reproducibility of their scientific findings in order to achieve their goal of generating meaningful results. Consequently, the behavior of the nodes should be unaffected by the ambient variables throughout the simulation assessment. Therefore, it would be optimal if the authors first validate their model using practical testing to accurately represent the challenges their solutions would encounter in actual implementation.

A Thorough Literature Study

This article presents a comprehensive analysis of prominent conferences that are closely associated with the research areas of Ad-Hoc and WSN. We have conducted a thorough analysis of all articles published at the following conferences: MobiHoc, Information Processing in Sensor Network`s IEEE/ACM International Conference, MobiCom, and SenSys. Our goal is to determine the current trend in validation methodology and how authors are addressing previously reported issues. Therefore, we thoroughly examine and analyze a total of 674 publications that were published in the conference proceedings throughout the last six years, from 2018 to 2023. Out of these articles, 596 are specifically connected to WSN & Ad-Hoc, as shown in **Fig 2**. We have discovered a total of 78 publications that specifically discuss alternative wireless technologies, such as WiFi and WiMAX, inside the framework of cellular networks.

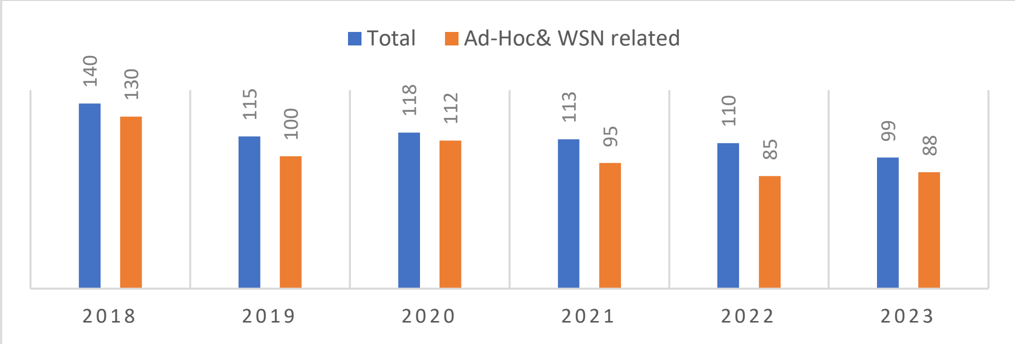

Fig 2. Number of Publications Each Year

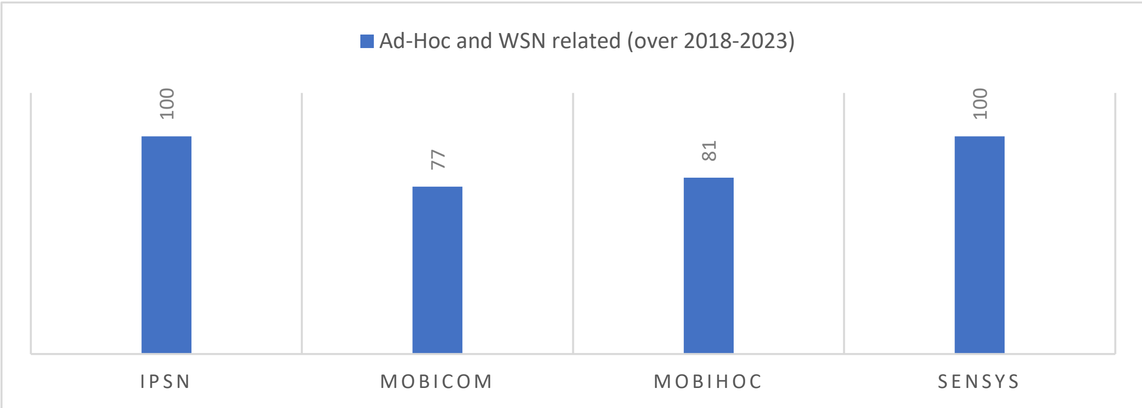

Fig 3. Suitability of our Conference Representative Group

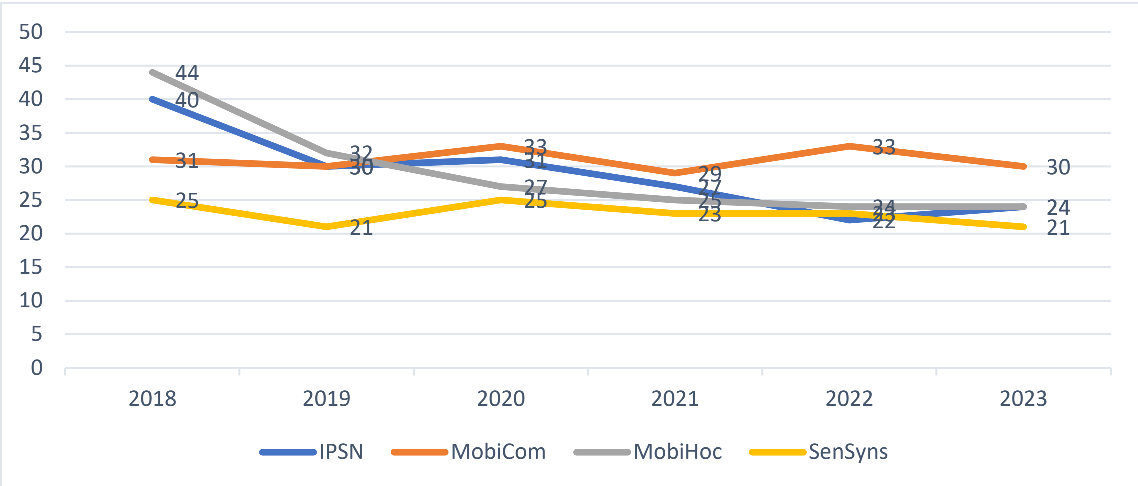

Fig 4. Journal Articles Published between 2018 and 2023.

A total of 140 papers out of 185 were discovered at the MobiCom conference, while 142 articles out of 175 were identified in the MobiHoc conference (refer to Figure 3). Although these conferences include a wide range of topics related to mobility and wireless communications, they are not exclusively focused on Ad Hoc and WSN. In the remainder of the paper, we place more emphasis on our examination of these 596 articles. Throughout our inquiry, we gather a multitude of data for each piece of task and then classify the pieces based on their shared characteristics. **Fig 4** presents comprehensive data on the total number of published publications, namely those linked to Ad-Hoc and WSN, for each preceding year. There is a noticeable decline in the number of published papers in the proceedings. Specifically, we have discovered a decrease of 43 articles between 2018 to 2023. To be more precise, MobiHoc and IPSN had a decrease in the number of approved papers, with MobiHoc going from 44 to 24 and IPSN going from 41 to 24. On the other hand, MobiCom and SenSys maintained a consistent number of accepted articles.

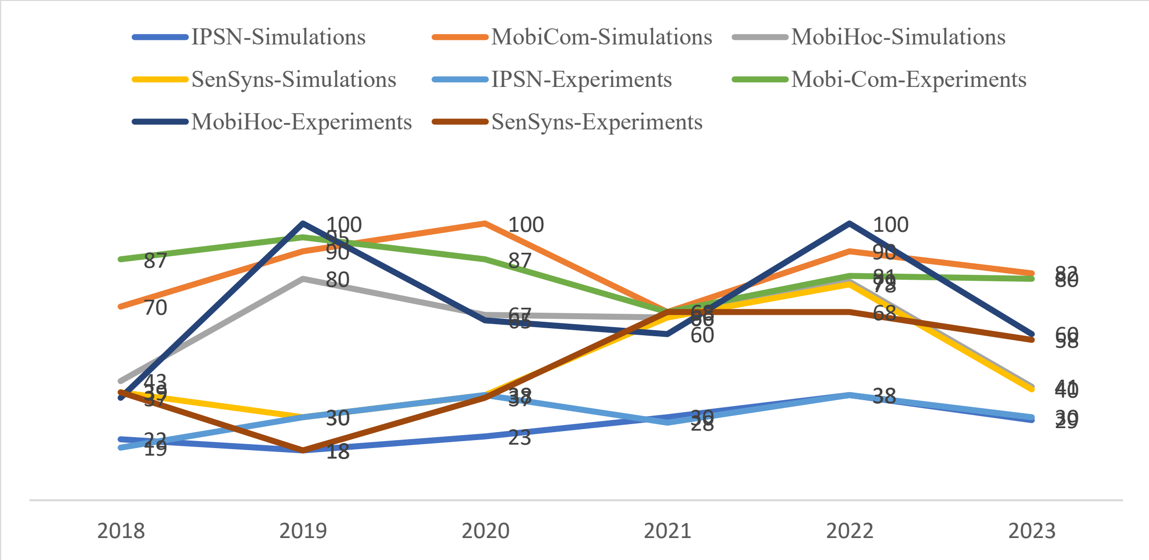

Fig 5. Potential Mobility-Related Outcomes in Performance Assessment Processes

Contemporary technology has included the capability of becoming mobile. Therefore, the research community prioritizes the development and testing of these components and situations. The tendency is supported by our research findings, as 148 publications (57%) simulated mobile settings. However, our statistical findings for MobiHoc and MobiCom, which are conferences focused on mobile technology, indicate that not all of the publications presented at these conferences include mobility situations. During the 2018 MobiHoc conference, we found that only 13 out of the 28 studies that used simulations included mobility in their assessments. Figure 5 demonstrates that 57% of articles linked to motility are influenced less by our conference sample, which includes MobiCom and MobiHoc, both of which are primarily focused on mobility-related subjects. Instead, these articles are more influenced by the overall excitement around mobile situations.

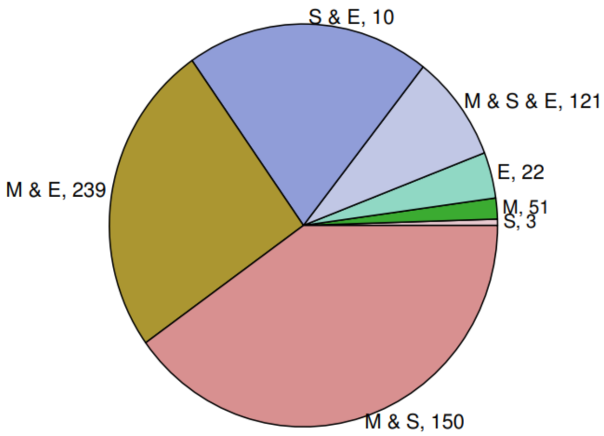

Fig 6. The validation techniques of 596 publications linked to Ad-Hoc and WSN make use of experiments (E), simulations (S), mathematics (M), and combinations of the three.

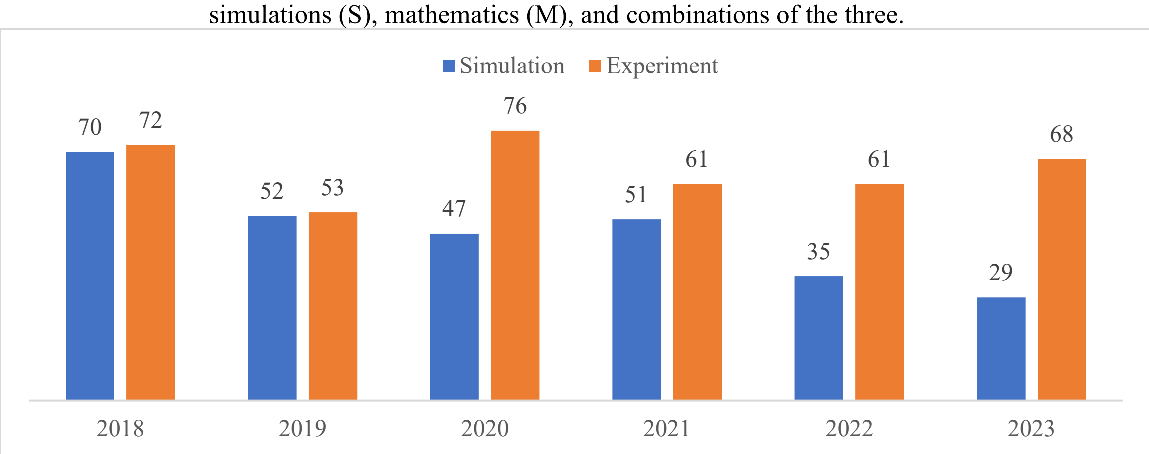

Fig 7. Papers Comparing Total Simulation Against Experimental.

IV. RESULTS OF ANALYSIS

Evaluation procedures

Within this section, we provide our examination of the validation techniques implemented by the authors. Initially, our objective was to classify the examined publications based on the assessment technique used. Specifically, we analyze the ratio of assessed works that use simulation, experimentation, and mathematical approaches (such as modeling or analysis). The main analysis reveals intriguing findings. To be more precise, our analysis reveals that the majority (561 articles) offer a logical depiction of their answer. Out of the total, the outstanding 35 only possess experimental or simulation outcomes. In addition, 284 publications substantiate their concept by simulation assessment, whilst 392 articles apply experimental evaluation for validation.

Approximately 20% of publications thoroughly investigate all 3 stages of the study procedure cycle, namely simulation, experimentation, and analysis. **Fig 6** depicts the quantity of articles possessing the aforementioned characteristics, based on a sample of 596 examined publications. Below, we outline the distinctive features of the articles that we examined. Figure 7 shows the proportion of research based on simulation compared to those based on experiments, out of a total of 596 publications examined. It is evident that simulations and experiments were equally used until 2009. However, the utilization of simulations has been consistently declining each year (with the exception of 2021), while experiments continue to be employed at a rather steady rate.

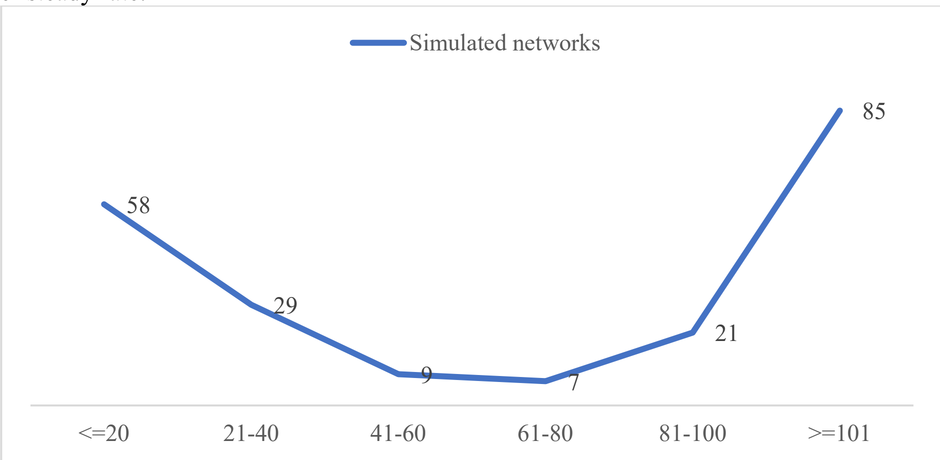

Fig 8. Use of Simulators and Simulated Network Sizes

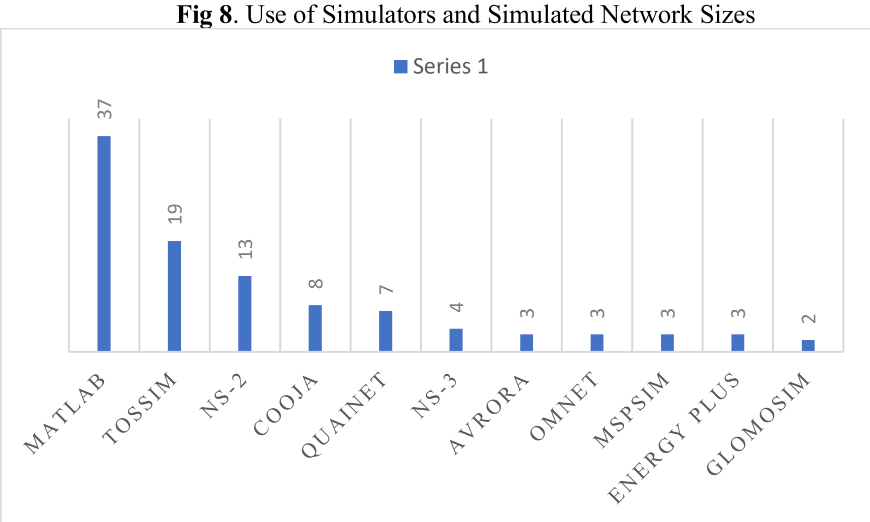

Fig 9. The Prevalence of Simulators

During the period from 2018 to 2023, a total of 284 research conducted simulation evaluations to evaluate their proposed ideas. We observed the use of simulators, the programming languages (PL) and the sizes of simulated networks employed for developing bespoke counterfeinters (refer to **Fig 4**). Merely 43% of the papers were verified using a recognized simulator, but 42% of the articles failed to disclose the instrument used by their writers (refer to **Fig 8)**. Out of the 284 simulation-evaluated articles reviewed, 14% created a homemade simulator using programming languages like Python and Java. Figure 8 shows this homemade simulator, while **Fig 10** displays the spreading dispersal of the most prevalent PL. We are now focused on assessing the use of the simulators. **Fig 9** clearly demonstrates that MATLAB is the preferred option in our community, with over 35 publications referencing it. Following closely after is TOSSIM, which has been mentioned in almost 20 articles. In addition, Network Simulator 2 (ns-2) ranks third with a total of 13 articles.

In the present day, the research community has the capability to assess suggested methods, models, and even novel technologies on open testbeds at a vast scale [20]. Network researchers are increasingly using experimentation to expand the range of their conducting assessment, as seen in **Fig 7.** Furthermore, the data shown in **Fig 11** clearly demonstrates that a significant proportion of researchers, namely 91%, choose to establish their own testbeds. Despite the existence of many open facilities that provide the necessary infrastructure for experimental IoT, WSN, or Ad-Hoc investigations, only 10% of the publications use these open platforms. Our accumulated data indicate that researchers have a preference for using their own settings when it comes to small scale deployments. Out of the 392 papers that include experimental data, 78% of them use an experimental setup with no more than 40 nodes (refer to **Fig 11)**. Therefore, the heightened challenge of accessing distant open testbeds, which include specialized hsoftware and ardware, network architecture, and booking procedures, may have prompted researchers to establish their own comparatively modest models.

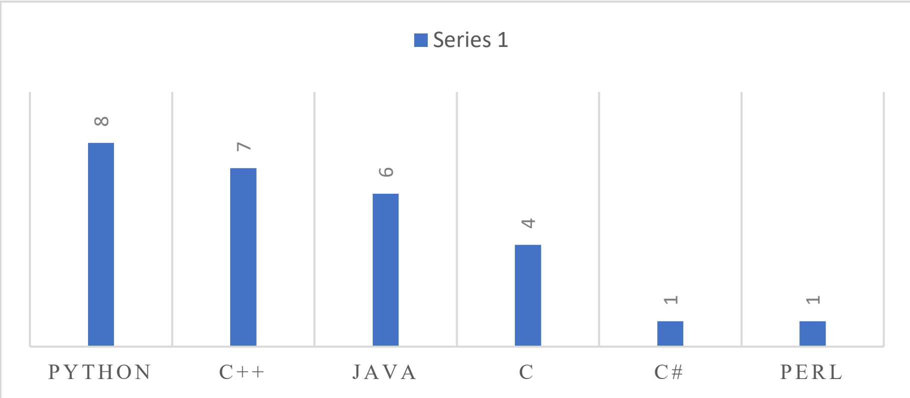

Fig 10. Popularity of Programming Languages for Custom Simulations

While just a few papers conducted experiments on open testbeds, we highlighted the widely used open platforms. According to the data shown in **Fig 12**, Harvard's Motelab has the highest number of papers (11), followed by TWIST with 10 research. Those institutions were the pioneers in opening up to the scientific community. Despite being introduced in 2021, the Indriya testbed has been used in 8 papers. This success within the community may be attributed to the fact that users are able to engage with the testbed using the same user-friendly web-based interface as MoteLab's.

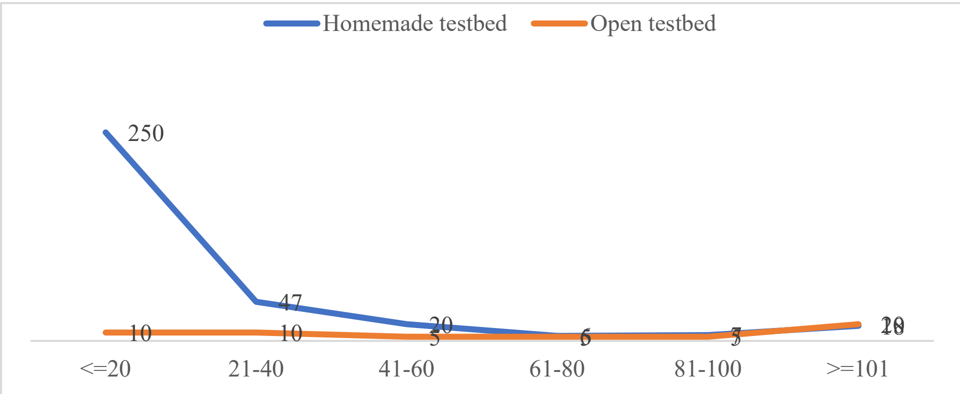

Fig 11. Use of Testbeds and Experimental Network Scales

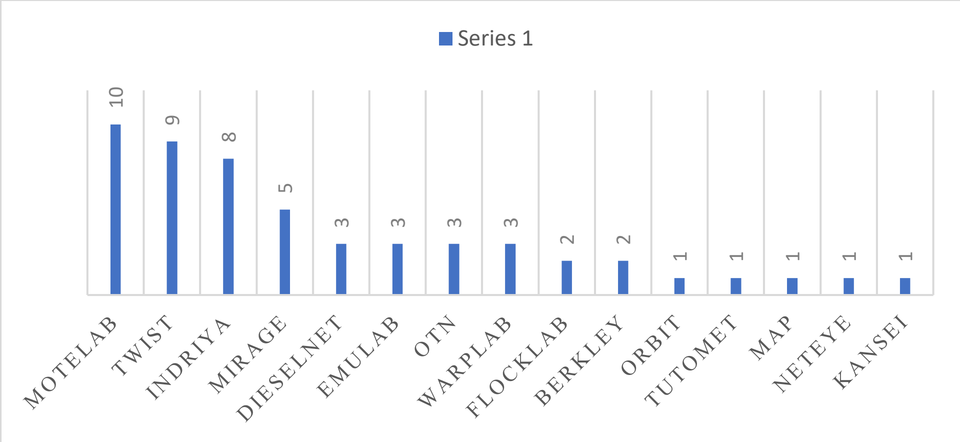

Fig 12. The Prevalence of Open Testbeds

Reproducibility

We proceed with our investigation to determine the practicality of replicating the findings reported in the evaluated literature, both via simulation and experimental endeavors. In order to continue, we sought crucial information (such as simulation setup, simulator indication, simulator specifics like number of nodes, library or version) that should be included in the papers being analyzed. To replicate the suggested solution, it is necessary for the authors to provide a comprehensive paragraph detailing the simulation or experiment parameters. Concerning the assessments based on simulations, only 43% of the articles specify the simulator used. However, out of those, 78% do provide specific information regarding the simulation settings. Out of them, 72% accurately specify the number of nodes affected.

Ultimately, we opted for incomplete setups after we encountered a dearth of crucial information on the technologies used in the simulations. As previously said, MATLAB is widely recognized as the predominant program for conducting simulations. To use it as a network simulator, researchers are required to load extra libraries, such as those provided by the WISLAB1 team. Reproducing a simulation study becomes challenging, if not impossible, when the version available simulator is unknown. Only 21% of the studies provide information about the specific version or library of the simulator used. This lack of information significantly hampers our ability to assess the reproducibility of the simulation-based articles. We used a comparable technique for the experimental validations. Considering the inherent characteristics of open platforms, we conclude that the 42 articles are generally capable of being reproduced.

Nevertheless, we saw a total of 8 research articles in which the authors conducted experiments on both customized and publicly accessible test environments. However, only three of these papers had sufficient details to reasonably presume that the experiments could be replicated. Conversely, the experimental findings obtained from constructed testbeds may be challenging or even impossible to replicate. This may be attributed to the fact that many of these devices are often used in workplace, residential, and outdoor settings, where the levels of ambient radioactivity fluctuate owing to the presence of external factors like access points, wireless routers, mobile phones, and similar devices. However, due to the specific characteristics (such as the application layer) of the solution being assessed, we identified 31 research based on homegrown methods that may potentially be replicated. After summarizing the above claims, we have determined that a mere 16.5% (65) of the articles based on experiments exhibit outcomes that can be reproduced.

V. CONCLUSIONS

The assessment of performance in network research entails the use of simulators or emulators to evaluate the feasibility of concepts. Simulations are a potent tool for investigating the efficacy of intricate network configurations, while intermediate experimentation platforms serve as a bridge between simulations and real-world implementations. Nevertheless, there are obstacles in reproducing real-life circumstances in simulations and test environments. The analysis examined papers at renowned conferences pertaining to Ad-Hoc and WSN research. The study revealed that most papers include analytical representations of their answers, while a lesser proportion incorporate simulation or experimental results. MATLAB is the predominant simulator, with TOSSIM and Network Simulator 2 (ns-2) being the subsequent choices in terms of use. Researchers are progressively using experimentation to broaden the scope of conducting assessment. A considerable number of researchers create their own experimental setups, with a substantial fraction opting for testbeds consisting of 40 nodes or less.

The widespread use of testbeds such as Motelab, TWIST, and Indriya is also acknowledged. The research emphasizes the need of include essential information in publications to guarantee the replicability of results. Nevertheless, the absence of precise details about the simulators used and the exact simulation settings poses a hindrance to the repeatability of the study. Experimental validations exhibit superior repeatability, while the presence of external variables might provide challenges to replication. To enhance the repeatability of their results, researchers should prioritize refining the level of detail they provide about simulation settings and experimental techniques. It is essential to exert efforts towards the development of simulators and testbeds that possess a high degree of realism and can faithfully reproduce real-world settings. Furthermore, the investigation of novel assessment methods and procedures may significantly improve the performance evaluation process in network research.

Data Availability
No data was used to support this study.

Conflicts of Interests
The author(s) declare(s) that they have no conflicts of interest.

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