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Mobile Ad Hoc Networks (MANETs) and Mobile Learning (m-Learning): A Survey

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Abstract
Mobile Ad Hoc Networks (MANETs) have many uses. Education is one of the many areas in which MANETs have been applied. MANETs in education have been proposed in the creation of mobile virtual classrooms to boost ubiquitous learning. While ubiquitous learning may be enabled through general e-learning, this paper concentrates on m-learning that is based on MANETs' principles. MANETs-based mobile virtual classrooms have been suggested for improving learning in marginalized areas—particularly in the developing countries. In addition, there are researchers who view MANETs as the future of e-Learning. As smartphones and smart devices become an integral part of our society, MANETs are viewed as cheaper way of forming networks in instances that traditional networks may not be feasible, damaged or lacking altogether. Because they do not require pre-existing infrastructure, MANETs are cheaper and more flexible to establish and launch. Mobile nodes/devices make up MANET networks. Network nodes can join or leave the network without affecting the overall functioning of other nodes. The ability of MANETs to reconfigure themselves without the need of conventional administration makes them very dynamic. In this article, the writer attempts to present the state of the art in the area of MANETs and m-learning. This paper attempts to identify the areas of convergence and divergence in MANETs and m-learning as reported in the literature. This article presents the MANETs frameworks proposed for mobile virtual classrooms, their shortcomings, their effectiveness, and possible areas for further improvements. Furthermore, the paper tries to present the history and advancement of MANETs in relation to mobile virtual classrooms. In every instance, the writer attempts to relate the two—MANETs and m-Learning.
Keywords: *Mobile Ad Hoc Networks (MANETs), Virtual Classrooms, Mobile Learning (m-Learning), Ubiquitous Learning, e-Learning.*

1. Introduction

Mobile ad hoc networks (MANETs) are characterized by their lack of pre-existing infrastructure and the ability of network nodes to reconfigure themselves[5]. Furthermore, the nodes link wirelessly to form a network. Respective nodescan move within the MANET network independently. Network nodes are at liberty to either join or leave the network without affecting the overall functioning of other member nodes.

Every node has the ability to receive and route data packets, hence acting as both a receiver and a transmitter. Although there is general agreement on the definition of MANETs', literature on m-Learning differ on what should make up its definition[6]. According to[6] the definition of m-Learning vary from one community to another. But one of the agreed concept of m-Learning is that it is a subcategory of either e-Learning, distance learning or educational technology. Every researcher in m-Learning agree that for it to occur, mobile devices must be involved.

Certain literature stylize Mobile learning as M-Learning, U-Learning, personalized learning, learning while mobile, ubiquitous learning, anytime/anywhere learning, and handheld learning [6]. In [7] mobile learning is defined as "any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies". Mobile learning may be viewed as a compliment to e-learning because it extends the concept of e-Learning by bringing in handheld mobile devices such as smartphones and PDAs. The main purpose of m-Learning is to enable ubiquitous learning[8].

Mobile Ad Hoc Networks (MANETs) and mobile virtual classrooms have an intertwined history. In each of the areas—MANETs and mobile classrooms, their advancements reflect the trends in the power of computing. Increased computing power has led to the widespread use of smartphones, particularly in the developing nations. The idea of commercializing ad hoc networks was caused by the arrival of notebook computers and other supplementary technologies and protocols[1]. This phenomenon occurred in 1990s. According to[1], it is in 1990s that the concept of using mobile devices as nodes in network begun appearing in various conferences. Almost in the same period, the IEEE 802.11 subcommittee started to look into ways of bringing ad hoc networks into mainstream use.

Although some researchers associate the early idea of m-learning to xerox' Dynabook project, the concept became practical only in the early 2000s[2]. Realistic mobile learning is tied to introduction of personal computers—mainly the tablets. From[1],[2], it is clear that the advancement and the use of MANETs and m-learning are interwoven by the history of personal computers. As technology advances, the cost of technology becomes cheaper, thus affordable to the general public. When the personal computers became affordable, the researchers started to propose and develop ways of using the personal mobile devices as nodes for establishing networks.

Originally, MANETs were used inmilitary, emergency and disaster environments, but of late, their applications have extended to other areas such as education[3]. Currently, MANETs are no longer limited to particular situations as before. Instead, they have found uses in homes, offices, and schools. As smart devices such as smartphones, tablets and PDAs increasingly find their way into the society, MANETs' uses will morph into a regular service resembling conventional networks. Until then, however, it remains an area of interest for research.

In a conference conducted at St. Petersburg in 2003,[4] observed that wireless networks would play a primary role in education. This prediction has come to fruition because since then, wireless networks have been steadily gaining prominence in education. In the same conference,[4] noted that it is unavoidable to discuss ad hoc networks while covering wireless networks. A key feature of wireless networks and thus the mobile ad hoc networks is the freedom of the nodes/devices. Nodes in a MANET are not restricted—in the sense that they can join and leave the network at will. MANETs being part of wireless and ad hoc networks offer flexibility, dynamism, and scalability. These traits are necessary for multicast services and adaptive design[4]. MANETs can be used in group communication and collaborative learning. Despite all the advantages of MANETs in m-learning, the lack of fixed infrastructure

comes with some challenges that will be explored further in this paper.

2. MANETs and m-Learning: Key Events and Milestones

This section reviews some of the key events in the history of MANETs and m-Learning as an effort to establish the points of convergence and divergence in their advancement and use. Moreover, this section attempts to establish the drivers of developments in both the MANETs and m-Learning. By reviewing their history, the writer seeks to answer the following questions;

a). do MANETs and m-Learning share some commonalities in their origins?

b). what factors have driven their advancement over time?

c). are there similarities in the factors behind the developments

d). what are the uses of both MANETs and m-Learning?

e). are they (MANETs and m-Learning) complementary or supplementary in their uses?

2.1 Mobile Ad Hoc Networks; Key events and Milestones

Based on[12],[14], ad-hoc network systems are categorized into three generations. That is, the first, the second and the third generations. Ad-hoc networks systems in use today are considered third generation. In 1970s, first generation of ad-hoc networks came into existence. During the 1970s, ad-hoc networks were known as the Packet Radio Networks (PRNET). PRNET was funded by the U.S.A's Department of Defense in 1970s. Later in 1980s, PRNET was developed into Survivable Adaptive Radio Networks (SURAN). According to[12], two ideas were incorporated in the creation of the PRNET. That is, the Areal Locations of Hazardous Atmospheres (ALOHA () and the Carrier Sense Medium Access (CSMA). ALOHA and the CSMA applies the idea of medium access control in conjunction with certain type of distance-vector routing protocol. Mainly, these two ideas were used in prototypes for battle fields. Upon enhancing the PRNET, the Department of Defense created SURAN (Survivable Adaptive Radio Networks) in 1980s.

Some literature, however, argue that the idea of MANETs was all started by the Advanced Research Projects Agency (ARPA) in 1962[13]. Based on a youtube lecture in[13], the ARPANet was launched in 1969. The ARPANet first connected the University of Los Angelas at Santa Barbra and the University of Utah. Initially, MANETs were known as packet radio networks in 1970s. Packet radio networks were created by the Defense Advanced Research Projects Agency (DARPA) in 1970. Originally, packet radio networks ideas were used in the development of the first IP internet protocols. In 1980s, however, DARPA decided to develop the Survivable Radio Network (SURAN). According to [13], it was in 1990s that 802.11 protocol was created. With the invention of affordable 802.11 radio cards, the personal computers became equipped with the capability of forming peer-to-peer networks. Presently, MANETs are mainly deployed for military use. For instance, MANETs are the basis for Joint Tactical Radio System (JTRS) and the Near Term Digital Radio (NTDR) systems used by the military.

Certain researchers go even further back in history to trace the origins of MANETs. According to[9], MANETs origins may be traced to an event by ARPANET in 1960. In 1960, the ARPANET demonstrated the concept of data packet switching. The primary advantage of packet switching is that it allows dynamic sharing of bandwidth among multiple users. Afterwards, 1972, DARPA started research on packet radio network (PRNet)[9]. The research indicated that DARPA officially acknowledged the potential of the concept of packet switching.

SURAN was able to support packet switching network in military combat environments. In 1980s, SURAN ad-hoc network ensured that radios would became smaller, less costly, and more secure from attack. Consequently, these radio features augmented their utility. With the advent of affordable personal computers and their

wireless connectivity capabilities in the1990s, researchers opened up discussions on the possibility of commercializing ad-hoc networks. It is during this time that many conferences on networking began presenting research ideas on how to connect different terminals to form on-the-go networks. By the middle of 1990s, there had been proposals and development of several ad-hoc network protocols. MANETs took their current shape in the second half of 1990s. During this period, several MANETs routing protocols were developed. For instance, the IEEE 802.11 protocol was proposed and approved as medium access protocol. IEEE 802.11 protocol dealt with avoiding the collision of signals while at the same time allowing concealed terminals to connect to the network.

MANETs assumed their current identity in third generation—noted to be in1990 [11],[10]. Upon the emergence of personal computers and other supportive technologies, MANETs drew interest from researchers and gained prominence for their dynamic nature of operation. Availability of mobile devices such as laptops, smartphones and PDAs led to the proposals of information routing protocols.

2.2 m-Learning on MANETs; Key Events and Milestones

M-learning as we understand it, traces its root to the year 1200 with the invention of the abacus [15]. The abacus transformed counting in the sense that human beings no longer needed to use their fingers. In the late 1800s and early 1900s, two other key inventions took place. Within the period, radio transmission and wireless phones set pace for today's m-Learning. However, not until 2000s that m-Learning started to assume its current form [16]. In [16], the m-Learning cycle is broken down for the period between 1970s and 2000s. Notably, the key idea of m-Learning in the 1970s-90s period is the advancement in personal computers. Towards the end of 1990s and the beginning of 2000s, PDAs begun coming into prominence. Since the beginning of the 21st century, the PDAs have become more powerful, smarter and possess improved wireless capabilities.

Some m-Learning historians observe that the 1968 marked the beginning of m-Learning as we know it[17]. According to[17], it was Alan Kay and his associates who kick started m-Learning by creating a book-size computer whose main purpose was learning. Kay and his colleagues called it Dynabook. M-Learning was further boosted by IBM in 1975 as it availed the first portable computer [17]. IBM's portable computer sold 5000 units. After more than two decades, later—in 1996, Palm introduced Palm OS. Palm Os which gave "access to learning and organization software on handset devices[17]". Responding to the imminent pervasion of technology in education, the European Commission started to fund a research labelled as Mobile Learn Project in 2001.

M-Learning has an astonishingly protracted and extensive history[18]. However,[18] notes that mobile learning progressed in 1970s and by 2000s, it was a widespread concept. Although mobile learning has pervaded learning in unprecedented manner, actual ubiquitous learning has been enabled by rapid advancements in the area of wireless technologies. In[18], it is noted that despite the long history of m-Learning, it is less advanced in comparison to the conventional networks and related technologies. As such, the area of m-Learning is an ever developing field that has drawn research interest from various quarters. Notably,there is no universal definition of m-Learningfrom the existing literature. Depending on the context of research, terms and phrases such "wireless, ubiquitous, seamless, nomadic or pervasive learning/education and mobile e-learning that all somehow indicates mobile learning[18]" are used.

According to an infographic in[19], m-Learning took off sometime in 1970s. Particularly, the m-Learning was propelled to another level by appearance of prototype mobile phones in 1973. Prototype mobile phones weighed some 2.5lbs

and had a volume of 1280cm$^{3.}$ By 2013, the normal mobile phone was "almost 23 times smaller, and over 10 times lighter[19]". With the explosion of internet in mid 1990s, further boosted m-Learning. For the last ten years, the world has seen a remarkable increase in advanced smartphones, tablets and other smart PDAs. As the power of computing progresses, so are the devices that appear on the scene. Powerful mobile devices will in turn mean new developments in m-Learning. Currently, smart devices are becoming affordable and more efficient. More people own and use smart mobile devices more than in any other time in human history. Contemporary researchers in m-Learning can only guess what the future holds. But what is undeniable is the fact that human beings will continue getting education and mobile smart devices will play a critical role.

3. m-Learning built on MANETs

Already, the literature on both the MANETs and the m-Learning points to a history and developments that share some experience. MANETs and m-Learning are related in the sense that it is possible to develop and launch m-Learning based on the principles of MANETs. Furthermore, both areas are greatly influenced with innovations in technology. For this reason, their history is littered with events and innovations that influenced their developments.

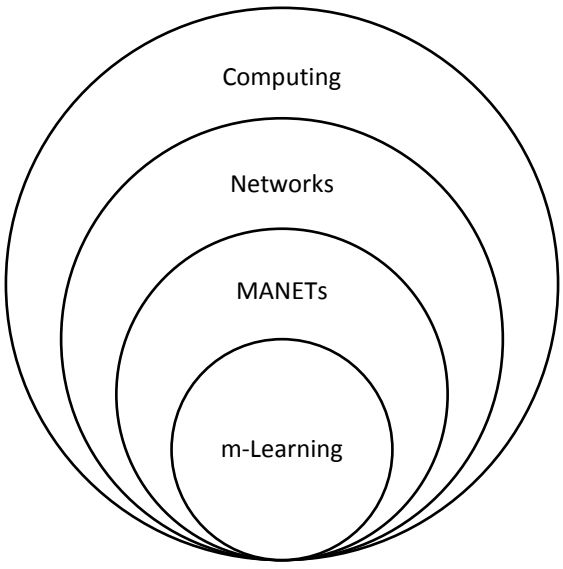

Figure 1: Relationship between MANETs and m-Learning

Many researchers propose building m-Learning platforms, frameworks and models on the principles of MANETs. Moreover, researchers acknowledged the ability of MANETs in the creation of virtual classrooms. But in most cases, the proposed scenario deals with setting up MANETs with nodes located in a single area such a school or within a business premises[20]. For example,[20] proposes creation of a virtual classroom using MANET for "residential institution" and limited to a distance radius of 1 km.

In a conference organized by the International Conference on Interactive Collaborative Learning (ICL) in Villach Austria,[21] presented a possible framework for using ad hoc networks for socializing in a classroom. In their article,[21] suggest that such a system can increase learning collaboration among the students. That is, peer-to-peer connections within a classroom. Another suggestion for a small area MANET virtual classroom is the one that[22] put forth. According to[21] argue for a MANET virtual classroom whose learning participants can launch ubiquitous learning as demand rises. In their proposed design, all learning tools are integrated into a single electronic gadget. Learners may access the learning resources from anywhere, anytime, while the learning facilitators can decide to begin a classroom at the comfort of their homes. Accordingly, a mobile class can enable learning both inside and outside a classroom[22].

In[23], a system to enable ad hoc message is suggested. The writers in[23] argue that although other e-Learning systems have been proposed before to use centralized database, their shortcomings exceed that of networks that depend on decentralized databases. Ad hoc messaging network (AMNET) is the phrase they used to describe their proposed system. AMNET is a peer-to-peer administered network—all necessary software for inter-device communication is regulated by independent gadgets[23]. Based on [23], the proposed learning system does not require human interaction. Often, synchronized and synchronized updating of files occurs, whereby,

data is moved, stored and shared within the network.

Generally, M-learning is deployed in the facilitation of learning between learners andfacilitators. Such collaboration may take place in diverse settings by means of MANETs[24]. According to[24], Mobile Ad Hoc Networks (MANETs) "are used to support communication and collaboration between students". M-Learning employvarious mobile technologies coupled with MANETsin the provision of educationto the learning participants in a ubiquitous manner. MANETs principles can be used to create networks that use varied transmissionranges. Approximation of transmission ranges is what the mobile devices deploy while in a network. Creating and deploying m-Learning on MANETs decreases the cost relative to other networks. Additionally, since MANETs do not require connection to the traditional internet, the cost of running them is comparatively low[24].

Wireless technology offers and fosters the prospectof creating shared learning by allowing mobility and flexibility in a network[4]. Mamoukaris and Economides[4] argue for a MANETs that enable learning for young students in an outside environment. According to[4], the MANET based learning system deployed "not only knowledge is transferred to students with the most pleasant way but also the students experience pragmatic activities in the real world, new challenging and motivating activities, outside of the school environment". The learning participants acquaint themselves with both the abstract and real learning. Such a learning network allows learners to experience both the abstract and practical aspects of learning. According to[4], MANETs offer flexibility necessary for ubiquitous learning. Because MANETs do not require pre-existing infrastructure such antennas, towers and electricity lines, they can be used in creating dynamic and flexible outdoor learning networks. Due to their affordability and dependability, MANETs appear to be the future in the outdoor learning environments.

4. Challenges, Issues and the Future of MANETs and m-Learning

From the literature, it seems that the history of MANETs and m-Learning are somewhat related. Their current status has been boosted by common events such as the coming to age of the internet and smart mobile devices. Computing power is developing at an astonishing speed. Capabilities of MANETs and m-Learning will largely depend on the advancement of computing power and the innovations in other technological fields such as networking. Their future depends on scientific and technological innovations—nobody knows which ones yet, that will next grace the stage. Since MANETs involve people and technology, there are so many factors to consider before building and running them. Although in theory MANETs networks may appear simple, in reality they are complicated endeavors.

4.1 Security Issues in MANETs and m-Learning

Despite their seemingly stellar history, MANETs and m-Learning experience some challenges. MANETs are part of a larger ad hoc networks group. This means that MANETs inherit majority of the challenges that face ad hoc networks. On the other hand, m-Learning being a dependent of MANETs, inherits majority of the weakness from the challenges that face ad hoc networks. Due to this relationship, this section will review the challenges and the future of ad hoc networks in general. The intersection in the below figure represents the shared challenges and future of ad hoc networks in general, and m-Learning built on MANETs in particular.

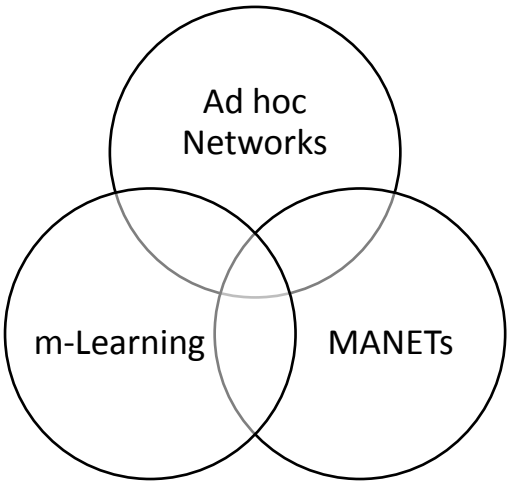

Figure 2: Relationship between Ad Hoc Networks, Mobile Learning (m-Learning) and MANETs

In MANETs, nodes/devices have the ability to move arbitrarily. As such, the topology of MANET can modify, adjust and evolveerratically and promptly at irregularintervals[25]. Unpredictability of MANETs due to their dynamism makes routing challenging. In many instances, it is very hard to tell the components of a MANET network since nodes can join and leave the network at their will. Another challenge that face MANETs is the energy constraint. Majority of the handheld/portable devices that form MANETs rely on batteries that are not powerful enough to guarantee long range of signal transmission. Devices that rely on battery power are also limited by time—many batteries die after a few hours. Power capacity constraints in ad hoc networks have elicited debates on issues of increasing power capacity, power optimization and conservation[25].

Ad hoc networks and to the extension, MANETs, bandwidth is a big challenge. Comparatively, wireless networks have a lower bandwidth to wired networks. Other challenges that face ad hoc networks include multiple access, fading, noise, and interference of objects (trees, buildings). As a result of such shortcomings, MANETs have less through put compared to traditional networks. Besides structure weaknesses in ad hoc networks, security issues is a major concern. Mobile and wireless networks are largely more subject to physical security threats than wired networks. Security threats such eavesdropping, spoofing and denial-of-service are common in ad hoc networks [25].

Research on MANETs security took place in the early 2000s[26]. From the research, MANETs' security issues were inherited from ad hoc networks. Collision of data packets is also a challenge. If a node is not in direct line of sight but within the communication range, packet transmitted may collide with the neighboring nodes. Breakage of transmission paths in MANET is also frequent. This scenario results from data packets collisions, "hidden terminals, interference, uni-directional links and by the mobility of nodes [27]." Loss of packets may result from broken paths of transmission[29]. Quality of Service (QoS) is also an issue and challengein MANETs. Some attacks are directed to lowering the quality of service in a network[28]. In addition, QoS is one of the key factors to be considered while establishing a MANET. But due to MANETs' dynamism, guaranteeing high QoS can be a tall order at times. Securing wireless ad hoc networks is an extremelyperplexingsubject.

Comprehendingpotentialtypes of threats and attacks is necessary in the development of security solutions [30][31]. What makes security issues in MANETs complex is the fact that they contend with security issues that face conventional wired networks in addition to issues that face ad hoc networks. As a result, many researchers propose a myriad of solutions and approaches. In MANETs, active attacks compriseof ill-intended "replication, modification and deletion of exchanged data [30]. "Furthermore, ad hoc networks and thus the MANETs face attacks in the form of impersonation, Denial of service, and Disclosure attack.

In MANETs, securing of routing information is also critical[30][31]. For routing information to be secured, it must be designed to deal with mischievous nodes that may corrupt the information being routed and the conventional

functioning of the routing protocols. Malevolent nodes achieve destructive goal by altering routing information, devisingdeceitful routing information and by mimicking other nodes. Wormhole is another threat that MANETs have to contend with. Wormhole is a form of attack where nodes that are far away from each other establish a false communication channel that makes it appear as if they are part of the network. Upon deceiving the rest of the nodes to being part of them, they are likely to win their trust thus sharing the network's information. Researchers propose that one way to respond to these threats by enforcing cooperation among the nodes.Cooperation enforcing is the act of ensuring that each node has a function to play in the operation of the network. For example, some nodes may specialize in forwarding of routing information while others may specialize in reception of the forwarded information[30].

Naturally, MANETs and to the extension the ad hoc networks do not assign roles to nodes. As a rule, ad hoc nodes and thus MANETs nodes act as both receiver and transmitter. Worded differently, ad hoc nodes are not dedicated to a particular role. Due to the lack of specialization in ad hoc nodes, it makes it very hard to enforce cooperation—however necessary .Nodes acting as a router in ad hoc networks make the whole network very insecure. Every time a node attempts to transmit more than a hop away, the information in transition is vulnerable to attacks.

4.2 The Future of MANETs and m-Learning

As the history of MANETs and m-Learning reveal in this article, both have shared key events and milestones. From their shared histories, their advancement has been influenced greatly by innovation in the wireless technology. Both the MANETs and m-Learning have their development fostered by initiative from governments and individuals. Consequently, these two concepts may share a future. This section will attempt to briefly outline the possible future of both the MANETs and m-Learning based on the existing literature.

Due to the accessibility of mobile technology worldwide, learning resources are available and open to individual learning participants[32]. Current mobile technology drives many efforts by groups, governments and individuals to make learning open to all. Open learning resources as a result of mobile technology, has made education affordable to many people. Mobile learning enables personalized learning through the "introduction of gesture-based interaction and affective computing[32]."The future of mobile learning is predicted to be more interactive with the learners. Interactive mobile technology in learning will be able to detect the emotions of the learners. Determination of the next activity for the learner will be decided upon consideration of the emotion status detected.Advancement in mobile learning technologies will, in the future, turn learning environment resemble gaming—a learner chooses what, how, where and when to learn. In other words mobile learning will enrich pervasive learning[32].

In some not so distant future, mobile learning will be equipped with Global Positioning System (GPS) capabilities to aid in learner location identification. By knowing the location of a learner, the learning facilitator decides on the relevant learning resources for that location. Applications that are attempting to enable GPS enabled learning include mScape[33]. Wearable learning technology is also possible in the future. Wearable learning technologies can be useful in embedding a learner's surrounding to the learning process and experience. Sensors will be applicable in the detection of the surrounding and incorporating it to the learning process.

Near Field Communication (NFC) is a phenomenon that is expected to invade mobile learning in the future. NFC has already been embedded in both Apple Pay and Google Wallet. This technology uses a small chip that permits transfer of data wirelessly between devices in close vicinity. Since this type network technology does not need a pre-existing infrastructure, it will be a cheap method of transferring files and

multimedia from one mobile device to another. LFC is likely to boost the culture of sharing information and knowledge, thus enhancing mobile learning[34].

Regarding the future mobile ad-hoc networks (MANETs),[35] observes that mobile routers will increase in use for the provision of wireless connection and access to the internet. With mobile routers, ad hoc networks users may move around the network without losing connection to either internet or the ad hoc network—ad hoc and the internet will be able to operate as a single unit. Currently, there are efforts to establish such hybrid networks. Mobile ad-hoc networks (MANETs)are increasingly being deployed in "distributed set of applications, such as distributed collaborative computing, distributed sensing networks, potential fourth generation wireless systems, and response to incidents that destroyed the existing communication structure[35]."

Mobile Ad Hoc Networks (MANETs) trend is moving towards "mesh architecture and large scale[36]". As mobile technology advances, there is a need for an increased capacity and bandwidth. For the future MANETs to be able to satisfy the demand for more capacity and bandwidth, there will be high frequency protocols and the need for an improved spatial spectral reuse. Due to propagation, spectral reuse, and energy issues, network technologies will move away from the traditional linked networks to a mesh of short links—very deployable in MANETs. Multi-hopping architecture is also expected to be an area of interest in the future. In the future, the nodes in MANETs are expected to be smaller, cheaper and more capable[36].

Table 1: Comparison between MANETs and m-Learning Key events/milestones

Key Event/ Milestone	MANETs	m-Learning
History	1900s	1200s
Drivers	Wireless Technology	PDAs, Wireless Technology
Uses	Ad hoc basis	Ubiquitous
Affordability	Affordable	Affordable
Security	Vulnerable	Vulnerable
Dependability	Dependable	Dependable
Flexibility	Flexible	Flexible
Dynamism	Dynamic	Dynamic

5. Conclusion and Recommendations for Further Research

Attempts have been in this paper to review the literature on both the MANETs and mobile learning (m-Learning. Based on the review, it has been established that MANETs and m-Learning share some commonalities in their history and the mode of operation. Referring to Table 1, the both concepts are based on mobility and dynamism. It is also notable that m-Learning can be built on MANETs. Figure 2 brings out the relationship between the two concepts. Due to the interconnection between the two ideas, they share majority of the issues such security and their possible future developments. In addition, this paper reveal that MANETs as well as m-Learning, can be viewed as part of the larger ad hoc networks family—refer to figure 1. Within this paper, the writer tries to highlight the future of MANETs and m-Learning as promising and enticing areas for future research.

Although this article provides some important snapshots in the development of MANETs and m-Learning, some topics are not covered in details. Particularly, the writer would wish to suggest that more reviews and research be conducted on the security issues and routing protocols in both areas. These two topics—security and routing protocols, were not comprehensively presented due to the scope of this article.

Conflicts of Interest: The author declares no conflict of interest

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