Hardware Advancements Effects on MANET Development, Application and Research

Amr ElBanna[1], Ehab ElShafei[1], Khaled ElSabrouty[1], and Marianne A. Azer[1,2]

[1] Nile University, Cairo, Egypt
{amr.banna,ehab.elshafei}@nileu.edu.eg, sabrouty@gmail.com
[2] National Telecommunication Institute, Cairo, Egypt
mazer@nileuniversity.edu.eg

Abstract. Mobile devices' development has remarkably improved in light of the fast growing hardware advancements. These advancements include multi-core processor chips, ultra large main memories and batteries that last for hours even when running modern applications such as file transfer, voice communication and video streaming … etc. In this paper, we shed the light on recent and future trends of hardware advancements for mobile devices, and their impact on MANET developments. In addition, the effect of such advancements is investigated on application and different research areas.

Keywords: Ad hoc Networks, batteries, processing power, mobile devices capabilities.

1 Introduction

Mobile Ad hoc NETworks (MANETs) have been considered a worldwide trend in the past few decades. MANETs do not depend on centralized infrastructure; their strength is in using mobile wireless devices. MANET devices communicate directly with each other when they are within the same communication range. Otherwise, they rely on their neighbors to route messages. Due to the open medium and wide distribution of devices, MANETs are vulnerable to a wide range of security threats. In the early days, MANETs' wireless devices, such as laptops, PDAs or mobile phones, have limited processing capabilities and power resources. Therefore, developing lightweight protocols and security mechanisms were considered as a challenge.

The extensive use of mobile devices has phenomenally pushed the limits of hardware development in micro-processing devices. Exploring the usage of Graphics Processor Unit (GPU) as a general-purpose co-processor to accelerate compute-intensive applications has been an active research subject in the past few years [1]. This can be noticeably seen at non-professional end users in playing games, capturing and editing videos scenes, or even more in watching HD or 3D videos. On top of that, large enterprises are working very hard to provide ubiquity solutions to their industry professionals to be at their fingertips. This is to cope with the rapidly growing market

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and to flatten all hurdles that could delay business from going forward. We can obviously see this now in common solutions that were implemented to let professionals interact with their emails, chat, or do minimal jobs with their business colleagues wherever they are. This helps mobile market to continuously expand. This has also encouraged mobile manufacturers to build mobile devices as general business computers; in order to replace the desktop or even small or medium scale servers. The experimental investigations in [1] confirm that a mobile GPU, although designed primarily for low power rather than maximum performance, can provide significant performance speedup for vision tasks on a mobile platform. This is similar to the role of its high performance counterparts in the desktop and server systems. In this paper, we focus on recent hardware advancements for mobile devices and their impact on applications and different research areas of MANETs.

The remainder of this paper is organized as follows. Section 2 focuses on recent Advancement in hardware. Practical implementations of such hardware advancements and their impacts on MANETs research are presented in section 3 and section 4 respectively. Finally, in section 5, we conclude this paper.

2 Recent Hardware Advancements

Throughout the last few years, mobile devices' hardware has been subject to noticeable improvements. In section A and B, the processing and batteries advancements are presented respectively.

2.1 Processing Advancements

In this section, we conduct a comparison between most recent mobile phone devices versus some old ones developed five years ago by the same manufacturers. The results of our comparison from [2] are summarized in Table 1. We selected two of the biggest manufacturers in mobile devices (Apple & Samsung) and picked two mobile phones for each manufacturer. One released in year 2007 and the most recent one that released in 2012.

From Table 1, we can see that the processing capabilities in Apple increased by around 315% more than its five years counterpart. Similarly, this comparison shows the processing capabilities developed even more and increased by 424%. This is apart from other noticeable advancements in other components such as (screen, memory, GPS, batteries … etc.).

Nonetheless, [3] shows the giant mobile manufacturer "Samsung" licensed two 64bit processors designs; it signed in a contract with ARM, a British company that is considered as one of the biggest companies for developing processors. The magazine also mentions that faster 64-bit processor will appear in servers, high-end smartphones and tablets. Hence, we can anticipate remarkable turn over in micro-processing advancements.

Table 1. Comparison between mobiles manufactured in 2007 & 2012 by Apple and Samsung

Company	Apple		Samsung	
Year	2007	2012	2007	2012
Model	iPhone	iPhone 5	i450	Galaxy S3
CPU	412 MHz ARM 11	1.3 GHz Apple A6 (Dual Core Apple Swift)	330 MHz ARM 1136	1.4 GHz Cortex-A9 by ARM (Quad-core)
GPU	PowerVR MBX	PowerVR SGX 543MP3 (triple-core graphics)	PowerVR MBX	Mali-400MP
Internal Mem.	4/8/16 GB	16/32/64 GB	40 MB	16GB, 32GB, 64GB
RAM	128 MB[1]	1 GB	Null	2 GB
WLAN	WiFi 802.11b/g	WiFi 802.11 a/b/g/n, dual-band, WiFi hotspot	Null	WiFi 802.11 a/b/g/n, DLNA, WiFi Direct, WiFi hotspot
Battery	Standard battery, Li-Ion	Standard battery, Li-Po 1440 mAh (5.45 Wh)	Standard battery, Li-Ion	Standard battery, Li-Ion 2100 mAh
GPS	Null	Yes	Null	Yes

2.2 Battery Advancements

Mobile devices have witnessed a huge leap and technological advancements over the years, mainly thanks to the advancement in processors and memory modules. However, there's always been a sort of a bottleneck in mobile devices development; and that is power consumption and battery capacity.

Development of batteries' capacity is not following the same pace as the processors (according to Moore's law) [4]. Figure 1 [2] shows a comparison between three market leaders in manufacturing mobile phones. It shows batteries advancements have growing exponentially for last few years. However, in light of the recent developments, we believe that batteries capabilities are adequate to implement some practical applications based on 802.11 Ad Hoc networking.

The Smartphones now have evolved to encompass different type of applications and circuitry. A combination of these applications can function simultaneously very well for at least good four hours on Samsung Galaxy, Nexus, HTC, or iPhone for example. If we consider a real life scenario of using ad hoc networking for collaboration between users in a class session or a business meeting, these four hours can be good enough. We can also consider a scenario of inter vehicles communication on

[1] Apple provides no information regarding the RAM used in the iPhone, but software analysis has confirmed that it has 128 MB onboard

roads as to enhance the security and traffic jams prediction, where the drivers' smartphones would gather, analyze and share data. Four or five hour per day is again quite adequate considering that the average driving hours per day are four hours in a city like Cairo. Another scenario would be mobile games, and games tournaments; where multiplayer games would be installed on the players' mobile devices and teams can form on the spot and start to compete.

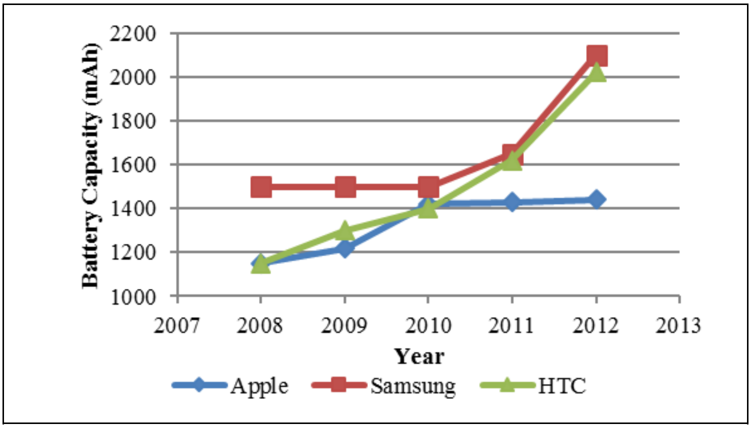

Fig. 1. Illustrated the battery manufacturing advancement made over year in terms of capacity per different vendors [2]

Most of the Smartphones nowadays support many types of wireless technologies, especially: 3G, WiFi and Bluetooth. We are focusing mainly on the power utilization over WiFi (802.11). The standard has different versions, each with a different power utilization profile. Usually, battery capacity is measured in milliAmpere/Hour. It is important to assess for how long, in terms of hours, would the devices be able to remain functional? Table 2 [5] illustrates the different versions of the 802.11 protocol and the associated speed and power consumption.

Table 2. 801.11 Versions and Power Consumption [5]

Standards	Range (m)	Speed (Mbps)	Power Consumption
802.11a	120	54	TX 510 mA@ 3.3 V
802.11b	140	11	TX 380 mA@ 3.3 V
802.11g	140	54	TX 400 mA@ 3.3 V
802.11n	250	600	TX 450 mA@ 3.3 V

The Nokia Energy Profiler is an application running on the mobile device that allows making measurements without any external hardware. It provides the values for power, current, temperature, signal strength and CPU usage. In Table 3 [6], researchers used a Nokia N95 smartphone to measure the power utilization for different wireless communications technologies. The team in [6] has compared results obtained with the energy profiler with the ones obtained with the Agilent 66319D and found no significant difference between those two. Agilent is a hardware device that offers several features ideal for testing wireless and battery powered devices. A node in ad hoc networks can bear the responsibility of sharing internet connections or acting as a gateway to another type of networks. The same paper covered these results. Figure 2 [6] illustrates the power utilization as measured from a mobile phone utilizing an individual communication technology or the equivalent summed up energy consumed for utilizing a combination of these technologies, e.g. WiFi, UMTS, Bluetooth, … etc.

Table 3. Measures for Wireless Power Consumption [6]

Technology		Action	Power [mW]	Energy [J]
Wireless Data	Bluetooth	BT off	12	
		BT on	15	
		BT connected and idle	67	
		BT discovery	223	
		BT receiving	425	
		BT sending	432	
	WiFi IEEE802.11 (infrastructure mode)	In connection	868	8.2
		In disconnection	135	0.4
		Idle	58	
		Idle in power save mode	26	
		Downloading@4.5Mbps	1450	
	WiFi IEEE802.11 (ad hoc)	Sending @ 700 kB/s	1629	
		Receiving	1375	
		Idle	979	
	2G	Downloading @ 44Kbps	500	
		Handover 2G->3G	1389	2.4
	3G	Downloading @ 1Mbps	1400	
		Handover 2G->3G	591	2.5

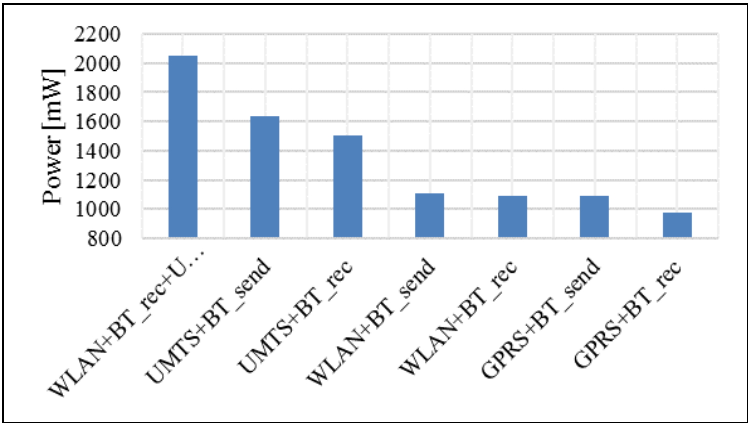

Fig. 2. Power Utilization per technology [6]

Another team of researchers [7] made an approach to model the energy consumption for Android smartphones, specifically the wireless interfaces of the device. They demonstrated the device capabilities from the power point of view with respect to time or to the amount of data transferred. Both aspects were proof that a node can handle a relatively high load suitable for practical implementations. In ad hoc networks: nodes would operate approximately four to five hours dealing with data transfer on WiFi. WiFi transferred 5.91 GB in download and 5.66 GB in upload.

3 Case Studies of Practical Implementations

From the preceding section, it is clear that advancements in hardware in the last few years can support modern applications processing requirements and maintain the battery life for hours. This section demonstrates the impact of this on real life MANET implementations and projects that benefit from modern mobile devices. Section A presents an under developing mobile telephony platform based on ad hoc network, whereas section B displays a commercial company's MANET based products.

3.1 Practical Wireless Ad Hoc Mobile Telecommunications

The Serval Project in [8], we believe it is the first practical mesh mobile telephony platform, is an example of MANETs real life implementation. It was initiated to provide mobile telecommunications for those who have abnormal events, such as war or terror attack, natural disaster or when governments deny their own citizen's mobile communications. These events lead to disconnect people form current mobile infrastructure oriented approach. Another situation for implementing such a project is for population in nomadic and remote locations who are not served well. Mobile companies may not invest in infrastructure implementation, as it is not economically feasible.

The system, which could operate in these circumstances, should be use free, not licensed – spectrum (WiFi), operate on WiFi enabled cell phones (as the only network hardware component), relay calls without a carrier, without telephone numbers allocation from authority and is completely self-organizing.

The Serval Project uses BATMAN [9] as the underlying mesh routing protocol. Distributed Numbering Architecture (DNA) was introduced to overcome telephone numbers allocation. It allows any device to request/respond the numbers from/to its neighboring devices. As described in the project, the telephone numbers self-allocation and distribution form untrusted environment. All introduced approaches that proposed to overcome this issue depend on the person who uses the system not the system itself. We think that this is not enough especially in such abnormal situations, we discussed before, in which this type of communication operates. The voice application consists of an embedded open source PBX software suite Asterisk

The System was tested in a three simulation cases: (a) Rescue mission, providing coverage to several square kilometers to be able to contact unreal lost person. (b) Provide service to quarantined remote group without any additional infrastructure except their cell phones. (c) Reestablish telephony service for remote community. For the third test, they provided mobile telephone service for the first time to a village in a matter of 20 minutes. In addition, they delivered an alternate landline service to remote administration building from the open space around the village.

All three use cases were simulated by a fly-in-fly-out team in less than eight hours. The mesh telephony function was tested without support from any infrastructure using several HTC Dream Android phones; this is shown in Table 4. It was estimated that the effective range between phones was of the order of 500m, and likely>1km from ridge to ridge where the phones would have enjoyed clear Fresnel Zones.

Mobile phones can run for approximately 6-10 hours on the mesh depending on how much they are used. This is considered as an appropriate time to access these types of networks. One of the teams [8] is working on gathering statistics about battery life in different mobile phones.

Table 4. Specifications of Mobiles used in Practical Implementations [2]

		HTC Dream	Motorola Es400
	Announced	2009, February	2010, June
Features	OS	Android OS, v1.6 (Donut)	Microsoft Windows Mobile 6.5.3 Pro.
	Chipset	Qualcomm MSM7201A	Qualcomm MSM7627
	CPU	528 MHz ARM 11	600 MHz ARM 11
	GPU	Adreno 130	Adreno 200
	GPS	Yes	Yes, with A-GPS support
Connectivity	2G Network	GSM 850/ 900/1800 /1900	GSM 850/ 900/ 1800/ 1900
	3G Network	HSDPA 2100	HSDPA 850/ 1900/ 2100
	WLAN	WiFi 802.11 b/g	WiFi 802.11 a/b/g
	Bluetooth	Yes v2.0 with A2DP, headset support only	Yes, v2.0 with A2DP
Battery		Li-Ion 1150 mAh battery	Li-Ion 1540 mAh battery
	Stand-by	Up to 406 h	Up to 250 h
	Talk time	Up to 5 h 20 min	Up to 6 h

3.2 COCO Communication

CoCo Communications Corp. (CoCo) [10] is a US software company. They develop and deploy MANET solutions to provide reliable, secure, and scalable communications solutions for mobile and fixed environments. They have many software/hardware products, the next lines focus on one of them.

"CoCo Node" software, which is federally tested by the U.S. Coast Guard, U.S. Army and U.S. Navy, could be installed on a variety of mobile phones, Windows and Linux systems. It creates instant networks that do not depend on centralized infrastructure. Devices share their network connectivity with the rest of the network automatically. Devices are protected by certificate based security, which secure network communications on the network level, not the application layer. This protects the network against man in the middle and other attacks.

CoCo has its own proprietary modified distance vector protocol intended to increase usability, reliability, mobility, and security shown in Fig. 3 [10]. CoCo stack fits between existing OSI layer 2 and layer 3. It is divided into four layers: Routing, Circuit, Identity, and Addressing. Motorola ES400, this is shown in Table 4, is one of CoCo selling product that is powered by CoCo node software

<table>
<tr><td colspan="4">Address Translation</td></tr>
<tr><td colspan="4">Identity Management</td></tr>
<tr><td colspan="4">Circuit Routing</td></tr>
<tr><td colspan="4">Packet Routing</td></tr>
<tr><td>Cluster MANET</td><td>Satellite Data</td><td>Carrier Data</td><td>WiFi Hotspot</td></tr>
</table>

Fig. 3. CoCo Protocol Conceptual Layers [10]

4 Impacts on MANETS Developments

In this section, we discuss the impacts of hardware advancements on routing, quality of service and security. They are presented in sections 1, 2, and 3 respectively.

4.1 Routing

As we can see from [11], "due to small physical size, nodes in ad hoc networks have various constraints on bandwidth, memory, power and computational ability. Nodes usually have limited power sources which deplete very quickly with time and need to be recharged." This study has been done in 2006. Hence as seen in Table 1, the specifications of recent mobile devices, manufactured in 2012, are very highly developed compared to their counterparts from five years (in 2007) with the same manufacturers. Accordingly, we can elaborate here that processing and batteries capabilities should no longer considered a big concern for efficient routing protocols. Furthermore, recent studies in routing are based "Global Positioning System", GPS equipped devices. The proposed routing protocol called LANDY in [12]. LANDY is an acronym that stands for Local Area Network Dynamic. It is a position based routing protocol.

4.2 Quality of Service

Speaking of normal development path for MANETs, they should support real time communications such as audio, video, or even online games. This requires certain level of Quality of Service (QoS). QoS is defined as a set of bounds such as latency, jitter, throughput, and packet loss to be maintained by the network for a particular data flow [13]. Batteries and processing capabilities were always major concerns in MANETs. Utilizing the new hardware capabilities to enhance MANETs QoS will have positive impacts on many applications such as phone calls, the practical implementation shown in section 3.

4.3 Security

Nodes in MANETs are very susceptible to numerous attacks due to dynamic topology changes and open air medium. Hence, we can see that Intrusion Detection Systems (IDS) play an essential role in MANETs to secure the communication and dismiss malicious nodes [14]. As in [15], IDS architectures can be categorized into three: (a) standalone, (b) cooperative, and (c) hierarchical. The presence of IDSs brings a burden of processing and calculations that might impact the overall performance of MANETs. Therefore, all previous researchers were very conservative in implementing IDSs. They did not want to overload nodes with IDS processing. On contrary in recent days, with these remarkable advancements in processing and batteries, we believe that those IDS solutions should be revisited to increase their efficiency and accuracy. The hardware advancements opened the door also for Cryptography. Cryptography is also highly impacted; this can be seen in a recent study in [16], were the researchers used a powerful device with Core 2 Duo T7250, CPU and 3-GB RAM [16]. Hence, they used RSA [17], a public cryptography algorithm; and DSA [18], a digital signature algorithm. These two algorithms are quite known with complex computation complexity.

5 Conclusions and Future Work

Mobile devices are considered the cornerstone for MANETs developments. Throughout this paper, we presented the tremendous advancements in mobile phones capabilities, such as processing power and batteries developments. We also considered specifications of modern mobile phones that belong to different mobile phone manufacturers. They are capable of building MANETs and running modern applications. Case studies have shown that batteries could last for six hours on average during real life applications. It is concluded that we should not be worried about node capabilities and power consumption when developing different solutions for MANET. Furthermore, it is noteworthy to revisit all previous solutions that have been implemented for mobile devices with low capabilities with their limited energy; as these limitations should not resemble a concern any longer. Our future work will be a more detailed study on the impact of these advancements on MANET routing algorithms, QoS and security. A special attention will be given to specially location based routing as almost all manufactured devices come out with GPS devices enabled.

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