Investigation on the Revolution and Need of Energy Efficient Smartphone Development

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ABSTRACT
Nowadays Smartphones act as a PA (personal assistant) to most of the people and it offers essential services such as Mobile Internet, Geo Location and Maps, Multimedia Services, High Data Rate Connectivity and much more. Especially present younger generations accept Smartphones as a part of their life. Smartphone Apps (applications) are the heart of all phones and these Apps drain the Smartphone's battery dramatically. The full degree of freedom in mobile systems heavily depends on the energy provided by their batteries. In general, their capacities are limited and for sure, not keeping pace as the mobile devices are crammed up with new functionalities. Moreover, battery capacity is significantly restricted due to constraints on size and weight of the device. This paper discusses the importance of energy efficient Smartphone developments. The mobile batteries are analyzed and the clear picture of their deficiency and the revolution of capacity from Lead acid to Li-Ion are given. This paper also states the importance of energy efficient Apps developments from various perspectives.

Keywords
Energy Efficient Development, Mobile Development, smartphone development

1. INTRODUCTION
In the modern world, people want 'Always On and Always Connect'. Mobile devices especially Smartphones are very popular in communicative life today. There were 2.7 billion Smartphones that had been subscribed upto November 2014. It is expected to 6.1 billion in 2020 [14]. There are 4.4 billion subscriptions of HSPA/WCDMA and 3.5 billion LTE of subscriptions that in the world at present and is predicted to reach 8.4 billion by 2020. The research data [14] depict that in 2018, it is expected that 3G/4G will represent over 50% of all active M2M (Mobile-2-Mobile) subscriptions. LTE M2M device penetration is expected to increase from 3% to 20–30 percent in the year 2020.

The research data [14] clearly states that 90% of the world's population over 6 years old will have a mobile phone by 2020 and it reveals the importance of mobile technology in day to day life. The phrase 'Always On and Always Connect' with mobile batteries is a paradox. Unfortunately, the truth is that it is only the battery backup that decides how long one can use the mobile devices. The reality is, the growth of battery capacity is not equal to the growth of mobile advancement. Hence the responsibility falls on the researchers' to satisfy 6.1 billion users' expectations to be 'Always On and Always Connect'.

2. EVOLUTION OF MOBILE PHONES
First generation mobile technology established seamless mobile connectivity introducing mobile voice services and the mobile handset supported only monochrome displays. The second generation phones supported digital transmission of voice, data and multimedia applications. These services extended mobile device configurations and display unit and it demanded more operating energy too. In 2.5 generation mobile phones supported GPRS, extended multimedia services and third party software's [1]. These facilities gave rich user experiences and the mobile industries were boomed drastically. The high usage of network activities and multimedia services required massive battery backup. Third generation and LTE(Long Term Evolution) technologies optimized mobile for data enabling mobile broadband services, and is evolving for faster and better connectivity [1]. This generation technologies requires high end mobile phones for high speed data transfer, Mobile TV, Video Conferencing, Location-based services and Online games. The ordinary mobile phones do not supports 3G and 4G services, it desperately need Smartphone environment.

A Smartphone is a mobile device with more advanced functionalities and features compared to cell phones [2]. A Smartphone's hardware and software specifications are meant to perform functions such as web browsing, capturing high-quality images, and playing HD videos. It can install various applications that can perform several advanced functions. Smartphones have become popular because of their many capabilities and is often used for communication and online activities. Advances in technology have led to these phones which are being more compact and cheaper than other mobile devices such as tablets and PDAs.

3. EMERGING OF SMARTPHONE
People are in the misbelieve that Smartphones came in to existence only in the last 7 years when Apple introduced Smartphone in mass consumer market, but in reality the Smartphone has been in market since 1993. The difference between today's Smartphone and early Smartphone is that early phones were predominantly meant for corporate users and used as enterprise devices and also those phones were too expensive for the general consumers [5]. Smartphone era is divided into three main phases (see figure 1).

- Corporate phase (Blackberry)
- Consumer phase (iPhone)
- Android era

First phase was purely meant for enterprises. During this phase, all the Smartphones targeted the corporations and its features and functions were as per corporate requirements. This era began with the advent of the very first Smartphone by Simon from IBM in 1993. Blackberry was considered as

the revolutionary device of this era, that introduced many features including Email, Internet, Fax, Web browsing, Camera. This phase was totally based on Smartphone targeting enterprises [5] [6] [7].

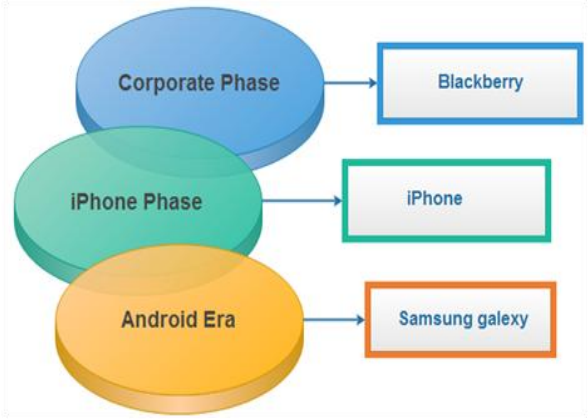

Fig 1: Phases of Smartphone Revolution

The second phase of Smartphone era started with the advent of iPhone, the major breakthrough of Smartphone market in 2007. Apple revealed its first Smartphone in 2007. This was the time when mobile industry introduced the Smartphone in general consumers market for the first time [8]. At end of 2007, Google unveiled its Android Operating System with the intention to approach the consumer Smartphone market. The emphasis during this time period was to introduce features required by the general consumer and at the same time keep the cost at lower level to attract more and more customers. Features like email, social website integration, audio/video, internet access, chatting along with general features of the phone were part of these entire phone [8][9][10][11]. Third phase was mainly closed the gap between enterprise centric and general consumer centric Smartphones provides and many other features.

- Improved display quality and display technology
- Stable mobile operating system,
- High speed data Communication
- Introduce of more powerful batteries
- Enhance the user interface
- Bundle of Mobile Apps

This phase logically started in 2008 with the upgrades in the mobile operating system and within the last five years there have been several upgrades in Apple iOS, Android and Blackberry OS. The most popular mobile operating systems (iOS, Android, Blackberry OS, Windows Mobile) and key Smartphone vendors (Apple, Samsung, HTC, Motorola, Nokia, LG, Sony etc.) are concentrating in bring features both in operating systems and devices which will provide exciting features for enterprise and general consumers. However the role of Android has been tremendous during this time period as it provided a great opportunity to all vendors to build devices using the great open source Android technology [8] [9] [10].

4. REVOLUTION OF HANDHELD DEVICE BATTERIES

Power sources are the heart of any electronic devices especially in mobile phones, tablet, laptops, PDA's and other gadgets. The manufacturers and governments invest in research on clean and energy-efficient technologies and longer-lasting batteries to cater for portable electronic devices with power-hungry features. Today, most known and most used batteries are based on

- Lithium-ion (Li-ion)
- Nickel-metal-hydride (NiMH),
- Lead-acid
- Nickel-cadmium (NiCd).

The Nickel–Cadmium battery (NiCd or NiCad) is a type of rechargeable battery using nickel oxide hydroxide and metallic cadmium as electrodes. It has longer cycle life, wider range of operating temperatures and lower price but it consumes enormous time to recharge. While the sale of NiCd batteries has been legally banned in the European Union due to toxic components [12]. Lead-acid batteries are typically found in applications which require high peak power, for instance, to start a car, or in scenarios, and for uninterruptable power supply where battery weight is a major concern. However, due to their low energy density, lead-acid batteries are not practical viable in the usage of mobile.

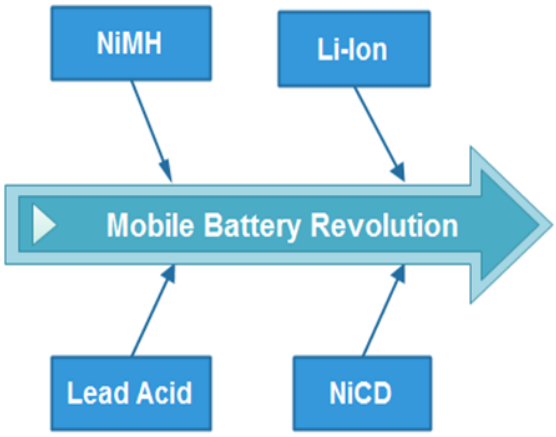

Fig 2. Revolution of Mobile Batteries

For these reasons, Li-ion and NiMH batteries are most commonly used in portable electronic devices, with Li-ion batteries usually offering a higher energy density than NiMH. In addition, Li-ion batteries allow a great number of charge/discharge cycles without memory effect, which ensures a long battery lifetime. It is estimated that Li-ion batteries lose upto 5 percent of charge per month due to self-discharge processes compared to NiMH batteries which lose upto 30% per month.

Form and weight are important factors for the choice of batteries in portable devices especially in mobile phones. Li-ion batteries exist in a wide variety of shapes and sizes while being relatively light weight and apt for mobile phone. Advantages of NiMH over Li-ion batteries include lower cost, high current, and no processor controlled protection circuits are needed. NiMH batteries are often found in digital cameras.

Table 1. Revolution of Mobile phone Batteries

Year	Wireless Technology	Battery Capacity	Talk time/ Standby time	Model
1983	Analog voice	Lead acid battery	1 hr /8 hrs	Motorola DynaTAC 8000X
1992	GSM	Slim NiCd 380 mAh	45 min /11 hr.	Nokia 101 (First GSM Phone)
1996	GSM	NiMH 500 mAh.	2.8 hrs/75 hrs	Motorola StarTAC (First Flip phone)
1998	GSM	Li-Po 600 mAh.	2 hrs - 3 hrs 20 min / 40 - 180 hrs	Nokia 5110
1999	GSM	NiMH 1250 mAh	4h 30min / 55 – 260h	Nokia 3210
2000	GSM	1000 mAh Li-Ion	2:30 hrs to 4:30 h / 55 h to 245 h	Nokia 3310
2003	GSM	Li-Ion 850 mAh battery	2 – 4.5 hours / 100 – 400 hours	Nokia 1100
2005	GSM/UMTS	Li-Po 1500 mAh	Up to 6 hrs / Up to 216 hrs	Nokia N92 (Mobile TV)
2006	GSM /WCDMA	Li-Ion 970 mAh	Up to 3.5 hrs / Up to 11 days	Nokia N70
2006	GSM/HSPA	Li-Ion 1500 mAh	15 h (2G) & 7 h (3G) / 600 h (2G) & 550 h (3G)	Samsung S8500 (First AMOLED) Nokia 6215i (First OLED)
2008	GSM/EDGE /HSPA	1220 mAh Non-removable Li-Ion battery	10 h / 300 h	Apple i-Phone 3G
2008	GSM/UMTS /HSPDA	Li-Ion 1000 mAh	3 hrs / 250 hrs	Samsung SGH-F480
2009	GSM/UMTS/ HSPA/UMTS	Li-Ion 1340 mAh,	8 hrs /600 hrs	HTC Magic,
2010	GSM/HSPA	Li-Ion 1,420 mAh	12 h (2G) & 5 h 50 min (3G) / 390 h (2G) & 400 h (3G)	iPhone 4
2011	GSM/HSPA	Li-Ion 1650 mAh	18 h 20 min (2G) & 8 h 40 min (3G) / 710 h (2G) & 610 h (3G)	Samsung I9100 Galaxy S II
2012	GSM/HSPA	Li-Ion 2100 mAh	21 h 40 min (2G) & 11 h 40 min (3G) / 590 h (2G) / 790 h (3G)	Samsung Galaxy S III
2013	GSM/HSPA /LTE	Li-Ion 2800 mAh	21 h (3G) / 390 h (3G)	Samsung Galaxy S4
2014	GSM/HSPA /LTE	Li-Ion 2600 mAh	17 h (3G) / 370 h (3G)	Samsung Galaxy S5
2015	GSM/HSPA	Li-Po 4000 mAh,	43 h (2G) & 25 h (3G) / 840 h	Lenovo P780

5. NECESSITY FOR ENERGY EFFICIENT SMARTPHONE DEVELOPMENT

High performance usually requires power sacrifices. The objective is to find a perfect balance between these two within a particular design. Optimum performance with low power is the ultimate target here. There are numbers of designs and process strategies for achieving economical performance at system level, Network and GUI, with long battery life (see figure 3).

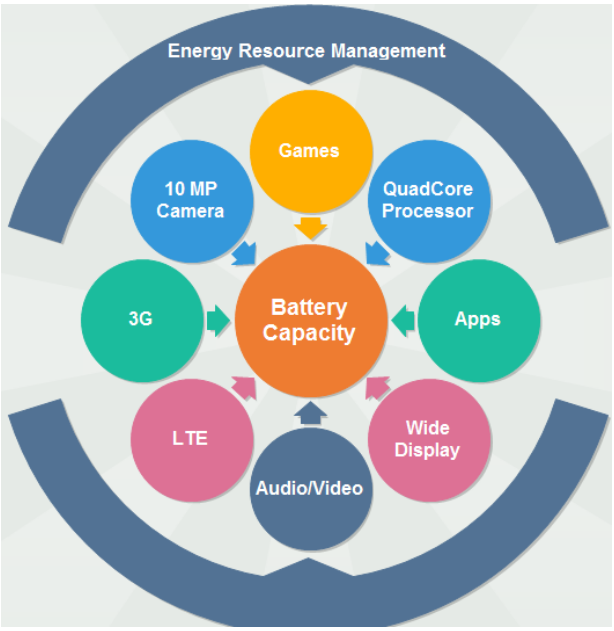

Fig 3. Energy Resources Management

Shannon's law predicts that the transmission performance improves by two times in 8.5 months. Given Moore's law, semiconductor manufacturers take 18 months to double the number of transistors and therefore double the microprocessor performance. In addition, battery makers take 5 to 10 years to achieve comparable increase in power density (See Table 1). These gaps are the major hurdles for successful commercialization of mobile devices.

The portable devices that free people to go anywhere anytime also keeps them tethered by electrical power cords, plugs, and sockets. Sophisticated devices with multimode radios, color displays, 3D audio, video, and gaming features demand more from batteries backup. Interestingly this has leaded the users of portable devices to become "socket seekers." Each year batteries become more powerful and circuitry improvements make devices more efficient but unfortunately this does not give feed to devices hungry.

The Table 1 shows the basic model of (first generation) mobile phone that required the range of 300 mAh to 600 mAh battery capacity with 45 min to 3 hrs of talk time. These generation phones have only basic display (Monochrome) and basic GSM communications so that it required minimum operating power. The second generation phones demanded the power range from 800 mAh to 1600 mAh because of enhanced display and networking (2.1 inch TFT LCD display, Dual ARM 9 CPU, Symbian OS, 2 MP Camera and Wi-FI, GPRS) so that it offered an average of 4 hrs to 10 hrs of talk time and operating times. Third generation phones provided advanced services (1 GHz Cortex-A8 CPU, Bada OS, Android, iOS, OLED, Super AMOLED capacitive touch screen with 16M colors 3.3 inches, 5 MP camera with 2592 x 1944 pixels). These services required minimum of 1500 mAh to 2500 mAh for comfortable usage. If the users want to use the feature as per the specifications, it will demand minimum of 2500 mAh to 3500 mAh battery power for a day. The table 1 shows that from the year 1992 to 2013 the battery capacity increased only to 2420 mAh in but 21st century, people use the mobile phone 24x7, parallelly the phone features and Apps grow each & every minute to meet their expectations. The growth rate of mobile phone specification is 25% and the growth rate of portable rechargeable (Li-Ion) battery is 10% [13]

However, batteries cannot cope-up with the rising expectations for longer life and its leads to the research on energy efficient software development. Whatever the physical component technologies are developing that will controlled by software's. Obviously the software is the soul of every handheld devices and it plays a vital role in regulating the power consumption. The typical energy efficient software minimizes power consumption and extends the battery life.

6. CONCLUSION

This paper discusses and reveals the evolution of mobile technology from first generation to present generation. It depicts why modern people want Smartphones. This study talks about the battery capacity and operating methods of first generation mobile phone and further it moves towards the present status.

This paper emphasizes the reason behind the need of energy efficient mobile development and also points out the lacking of present generation mobile phone batteries with statistical data. It clearly picture out the gap between the growth rate of mobile technology(i.e 25%) and battery capacity(i.e 10%). This gap will be reduced by energy efficient researches. In future the author will continue the research of reducing the energy consumption by display unit, GSM and Wifi.

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