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Three main pain points from today's Smartphones

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Abstract

The massive usage of smartphones that has occurred last years has been a boon for the telecommunications industry. Smartphone is blossoming freely and have been widely used in our daily life, learning, and working. The services, applications, and connectivity that the industry provides is something that consumers talk, blog, and tweet about with passion. The average Smartphone consumes only 10% of the data traffic that a laptop does, but smartphones, largely driven by the applications that consumers love, can connect to the network in the background hundreds or even thousands of times daily, pushing signaling traffic higher than network planners ever imagined. Unfortunately, with the widespread introduction of the smartphones, mobile network operators are confronted with the new challenges: congested network resources, worsening network KPI's and increasing complains from end users. What users want: The ingredients for a good quality experience can be summarized in four words: convenience, immediacy, simplicity and reliability. Users want a service that is efficient, predictable and easy to use. Factors contributing to a poor quality experience include lengthy loading times, no access, crashing, slowing down, poor battery life or anything potentially complicated or confusing. So the task before us all is to understand how handsets, their batteries, networks, and applications work together, to show/ determine and try by optimizing the proper performance balance for each so that both end user experience and network efficiency can be optimized.

Keywords: mobile apps, battery, signaling, smartphones

Problem statement

Current satisfaction levels in the world of consumers are closely linked with brand perception. The total consumer experience is made up of many parts, with loyalty building, service & support, account management, billing & payment and the initial purchase process each playing a formative role. Smartphone usage pain points issues considered the most frustrating for users include poor internet connection, app crashes and slow speeds (congestion, poor signal level etc). This frustration stems from the desire to be constantly connected. On the other hand, the successful aversion of these three issues can play a significant role in improving the user experience, as well as increasing data consumption among light and frequent users. Identifying the main contributors: In the eyes of the user, most connectivity issues tend to be associated with the operator. If these problems occur more regularly than once a week then overall satisfaction with the operator is likely to deteriorate – even if the problem is not related. Figure 1 shows what users believe to be the main contributors to usage problems. A slow network is one of the main contributors, along with poor coverage and app malfunctions. App malfunctions could cause many issues for the user itself and network from other side. Slow or low memory smartphones are also contributors, and yet interestingly in the case of iPhone users (Ericsson report).

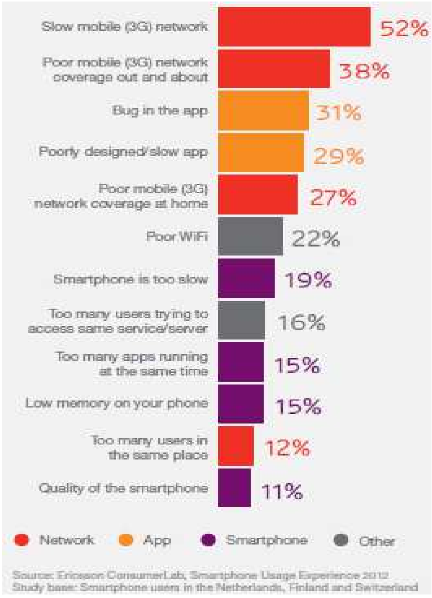

Figure 1. Main contributors to usage problems (Ericsson report)

As it can be seen from Figure 1, apps issues, congestion (signaling part as one contributor) and smartphone hw quality (here we are interested for battery hw part) directly impact the users. These three aspects will be considered on this paper in order to highlight main contributors on their behavior and proposal made to overcome as much as possible them in order to improve user service perception. For this paper we have used analysis made from some main mobile equipment vendors and also web pages reviewers.

1. Mobile Applications

Someone best characterized application vs. platform in just a dozen words, as follows: A good application never surprises, a good platform never stops to surprise. Many services and apps are based in the cloud, which means that ensuring high quality internet access is not just an advantage – it's a necessity. Users who experience regular issues will quickly lose patience, become annoyed and start to search for better alternatives. Issues are common – a majority of users experience regular glitches, the most common being internet connection issues, app/service crashes and slow speeds as already mentioned before. Main traffic volume for mobile Internet is used for web browsing, and the rest is used for streaming media and file transfer. Mobile Internet is widely deployed and the traffic rate increases. Smartphones are equipped with more functions. Mobile streaming media services will be widely used and the main traffic volume will be occupied by video service. Instant communications with text, voice, and video are more preferable, and network access becomes more frequently. Meanwhile, the technique Hypertext Markup Language (HTML5) becomes increasingly mature. Cloud service will replace traditional web browsing and file transfer as the dominant player. The smartphones for mobile Internet become small and diverse. More and more smart machine terminals and M2M services, such as smart electrical household appliances, auto meter reading, and mobile payment come into being (Huawei whitepaper). All these functionalities mentioned naturally are connected with specific applications used on smartphones in order to provide the needed service to the users. But from the other side how their functionalities combined with network operator QoS are having a big impact on user perception on offered service. In the Figure 2 it's shown the Mobile/Tablet Operating System Market Share till September 2013 worldwide. So believe that for each kind of OS there are thousands and hundreds of apps available and for sure many of them do not meet any quality.

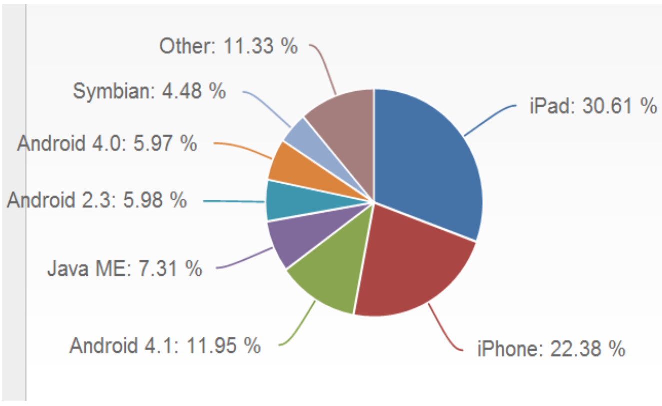

Figure 2. Mobile/Tablet Operating System Market Share till September 2013 (netmarketshare web)

Although not a big name or that well known, the *AQuA* is fast becoming relevant for developers. Founded in 2011, the non-profit association is funded by AT&T, LG, Motorola, Nokia, Oracle, Orange, Samsung, and Sony Mobile and has been on a mission ever since to improve the quality of smartphone and tablet applications. “It’s a way developers can improve the quality of their app and demonstrate that they have gone through their own testing to show that they haven’t fallen into traps first time developers often fall into,” Wrigley told TabTimes (Tabtimes web). Here a report from API Company Apigee indicates that app users get most frustrated when their app freezes or crashes; with 96% of these feeling irritated enough to write a bad review. The 2012 Mobile App Review Survey questioned 502 American mobile app users aged 18 and older in October, and aimed to find out what these users’ expectations were when using smartphones and tablets apps. The study, carried out online by *uSamp*, found that freezing (76%), crashing (71%) and slow responsiveness (59%) were the primary bugbears when it came to app problems, with heavy battery usage (55%) and too many ads (53%) also mentioned. Users stressed that performance mattered the most on banking apps (74%) and maps (63%), with the latter no doubt much to the chagrin of Apple, which has had some difficulty with its own maps software on iOS 6. While some could argue that these complaints are quite normal, what was really striking about the study was the sheer number of people who would feel compelled to write a bad review when coming across a bad app. For almost every respondent (96%) said that they would write a bad review on an under-par app, while 44% said that they would delete the app immediately. Another 38% said that they would delete the app if froze for more than 30 seconds with 32% and 21% respectively indicating that they would moan about the app to their friends or colleagues in person or over Facebook and Twitter. A considerable 18% would delete an app immediately if it froze for just five seconds, but 27% said that they would persist with the app if they paid for it. Those experiencing bad apps urged developers to fix the problem (89%) first and foremost, followed by offering easy refunds (65%) and a customer service number (49%). Apigee’s survey also looked at app discovery and discovered that the majority of app users find new apps by searching app stores periodically (75%), although word of mouth (58%), Facebook (45%), stories in the media (26%) and Twitter (14%) were also cited. “In the growing app economy, there's a natural Darwinian effect, and only the best apps will survive," said Chet Kapoor, Apigee CEO. "These survey findings underscore the importance for developers to closely monitor app performance, identify problems quickly and react immediately to resolve them.” (Apigee). Also a web reviewer (thingthatscale) is listing quite a few issues with mobile applications. He lists 10 top issues in no particular order, but we will mention some main of them. *Unexpected entitlements*. Some applications are more equal than others. For instance, try signing-out from your primary Gmail account on Android. It won’t work unless the whole device is wiped clean. *Power efficiency*. Some applications turn the radio on very often and can even be quite chatty whenever they do so. In absence of a “green rating” for applications, it’s a trial and error process of loading some applications and then discovering that battery autonomy has suddenly tanked compliments of a “fat” application in that mix. *Applications work unless they don’t*. It’s hard to know why an application suddenly gets into the habit of aborting launch. It silently goes back to being a cute square icon, ready to fail again just the same. *Stale coding practices*. The application development environments don’t leverage any of the new ideas in software engineering, like Ruby on Rails with its built-in unit/functional testing. *Porous sandboxes.* The sandbox that an application operates in has several back-alley read/write access pathways to free-for-all data (e.g., the keyboard cache and address book on the iPhone, as described here), thus creating opportunities for Trojans and covert channels. *Cloakers and phishers*. Some applications mean big business and naturally attract ill-intentioned copycats. There are just so many pixels to copy. Current defenses are mainly non-technical – e.g., the presence in the iTune store hinges on relationships between vendor, Apple, and the user community. They are not as effective in the bazaar style of application store. Tabtime at (Tabtimes 10 key tips) reviewers helps by listing many areas where improvements can be done or considered. Like: *Make the user interface consistent and easy to use*. An ever-changing user interface risks confusing and annoying the user to the point where they're not sure how to use the application. *Get your app's privacy watertight*, personal security has become a hot topic in every walk of life, both for consumers and businesses. There must always be a privacy policy in the app. This is becoming a really hot topic now," says Wrigley. *Control the mother of all app problems: App crashing***.** App crashing is the single most annoying thing to the end user, and often results in users writing some pretty frank reviews and app downloads dwindling to nothing. *Help out troubled users…and quickly***.** Some market research has shown that app users really like to have help at hand when things go wrong. *Developers must test apps when they lose a network connection,* which developers often fail to test their apps when they lose their network connection, with this often leading to the app dying and users having to re-boot their device. *Look out for image problems when changing orientation*. Switching your iPad or Android tablet from landscape to portrait can sometimes take longer than expected, but such a simple gesture can also have big repercussions for developers.

As well for NSN vendor it's important for a balance to be found so that excellence in application design does not come at a cost of excess battery drainage or massive signaling increase. Ways that application developers and device manufacturers can help to find this optimal balance among end user performance, battery lifetime, and signaling volumes include: *Optimizing data transmission* for size and minimizing the size of keep-alive messages in order to utilize Cell_FACH/RACH. *Optimizing usage of presence updates* and status update messages. *Taking advantage of caching* and reducing optionally downloadable data items such as images or attachments. *Avoiding protocols that require polling. Closing data connections when* no longer needed. *Opting for TCP over UDP* since TCP requires fewer keep-alive messages – this is especially important for always-on applications such as push email. *Choosing periodic bursty data* transfers rather than a constant "drop-by-drop" transfer. *Utilizing network access* optimization APIs (such as the notification API) in order to synchronize/group transactions with the network. *Using message buffering/aggregation* between different applications as much as possible. *Reducing network interaction when* the application is not in active use.

2. Signaling increase

Signaling traffic consists of the small background messages exchanged between a handset and a network to set up or end a data connection. Some of the most popular smartphone applications are also some of the greatest generators of signaling traffic. Social networking applications, in which friends stay connected with each other for extended periods of time, inherently involve frequent back and forth messages or status updates. Online networked gaming is also moving to mobile platforms. Most smartphones have a screen that is large enough and a processor that is powerful enough to run online games. NSN vendor by testing a popular online multiplayer poker game and measured the data and mobile network signaling traffic generated by playing the game for 30 minutes on both a laptop and a smartphone, in this case the iPhone version 4.1, the laptop generated 188 signaling messages during the half hour, while the smartphone generated more than 10 times that amount, at a staggering 1996 signals during the half hour.

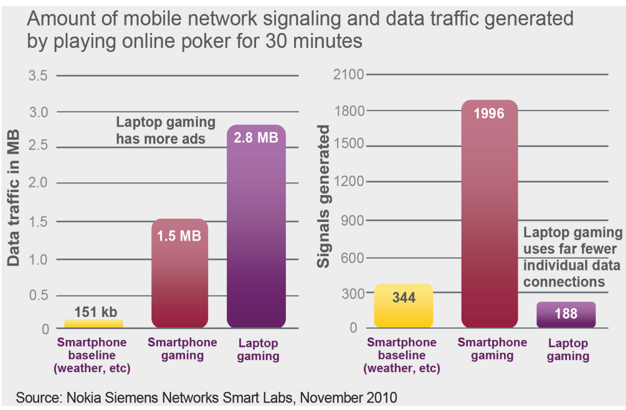

Figure 3. NSN Lab tests on smartphone signaling (NSN smartlab)

Customers in the U.S. and Europe started complaining that the quality of their voice and data services was no longer good. In some densely populated cities, the issues were particularly acute, and the end-user complaints particularly loud. Analysis of the network traffic showed that – surprise! – smartphones were the problem. Operators worldwide had initially optimized their wireless networks for browsing. One way that they did this was by keeping the data channel active as long as possible to give a smooth end-user experience. The only drawback to this approach is that prolonged time spent in the active data transmission mode consumes significant amounts of battery power. Manufactures power-saving features ended up being a significant root cause of increased signaling load (NSN smartlab). Nowadays as it can be seen, for most of applications on mobile devices polling technology is used widely, and the same application can be implemented with different technology on different platforms and represent different heartbeat characteristics, such as Facebook application. Always on-line PDP feature changes the traffic model of mobile phones greatly. Longer PDP context duration means less PDP activation attempt in the busy hour but possible more Iu signaling procedures such as paging, service request and Iu release. At the same time always-on-line PDP context consumes the static resources of the network equipment, which is ultimately limited by the physical memory size of the equipment. Furthermore, always-on-line PDP context also leaves the smartphone a permanent IP reachable endpoint in the IP network and subject to malicious programs, such as virus attacks. Compared with the wired Internet, the attacks destined to mobile Internet devices not only threaten the smartphones but also endanger the mobile network by causing paging storm and consequently, a connection setup storm, which would overload the mobile network (Huawei analysis). Heartbeat messages for most smartphone applications maintain connections with servers and update their status. Many Applications adopt small heartbeat intervals to update the status. Frequent heartbeats together with smartphone fast dormancy feature are the root cause of massive signaling on wireless networks, as shown in Figure 4. In actual network applications, some applications generate large amount of signaling. Too frequent signaling brings too much load to wireless and core network equipment (Huawei whitepaper).

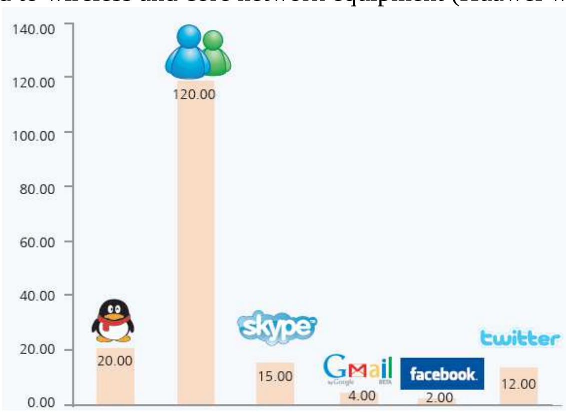

Figure 4. Signaling load on wireless networks by different applications over Android OS (Huawei whitepaper)

NSN vendor for network operators propose taking some actions that can bring better network performance: *Activating Cell_PCH* for the whole network. *Activating Network Controlled Fast Dormancy* (also known as 3GPP Release 8 Fast Dormancy). *Setting T1+T2* to be less than five seconds in order to reduce smartphone power consumption. *Optimizing other RNC parameters* to suit the network-specific traffic profile. *Utilizing Cell_FACH* for the most efficient handling of very small “keepalive” messages. *Direct tunnel* use will over pass SGSN from signaling by use of Gn interface etc. *HW replacement or expansions* will allow use of more overloaded Network.

3. Battery drain

The average power consumption of the smartphone mobile devices has grown significantly. The battery technologies have also developed, but not nearly as fast as the smartphone devices. Figure 5 illustrates the gap between the amount of energy needed by a Nokia mobile device for two days’ active usage, and the amount of energy that can be provided by a standard-sized battery, according to Nokia’s internal analysis (forum nokia). The red curve in the figure shows how the energy demand of the devices has grown and is estimated to grow in the coming years. The energy available from a standard size battery depicted in the figure with the blue curve is clearly not sufficient. Because of the big gap between the energy needed by the mobile device and the energy available from the battery, the average battery life of the mobile devices in active use is less than two days and sometimes it can be one day or even less. In today’s mobile phones the maximum
power consumption has grown, which means that there is a greater variation in the power consumption of the phone. In standby state without an internet connection the battery can last for several days. If the user instead has a GPS-based map application running in the background while browsing the web and listening to music, the battery can be completely drained in a couple of hours. The battery life is thus more unpredictable in the new mobile phones.

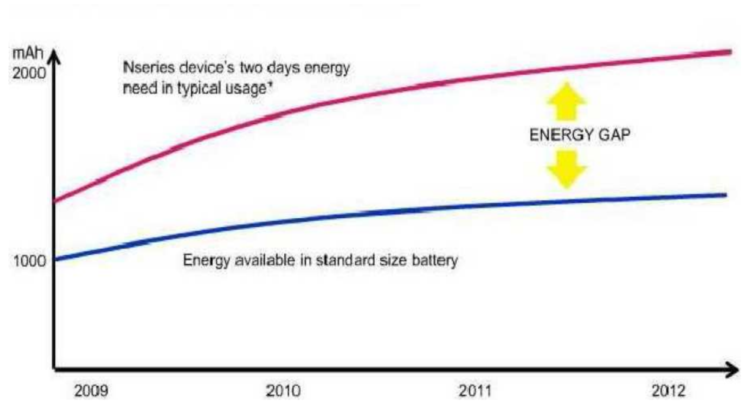

Figure 5: Mobile phone energy need vs. energy availability (forum nokia)

As services/apps are the main distinction among mobile devices from different vendors, the manufacturer will always use the fully available computational power to develop new services. In general more features and services smartphone offers, larger the energy consumption can be. This increase in energy consumption results in lower operational times for the users also referred as stand-by time. As the stand-by time has become one important purchase criteria, energy saving strategies is becoming more and more important. This is not only a problem for users, but for mobile service providers as well. If the phone runs out of battery, users cannot access mobile services any longer, reducing the revenues of providers. Therefore mobile phone manufacturers are very keen in developing solutions to extend the battery life. Using batteries with more capacity could be a trivial solution, but unfortunately their technological evolution does not follow the trends dictated by Moore's law. While the computational complexity is doubled every two years according to Moore, the battery capacity is doubling only every decade. In the current state of the art, most smartphones are powered by *lithium-ion* batteries (mpoweruk web). These batteries are popular because they can offer many times the energy of other types of batteries in a fraction of the space. At the moment, engineers cannot sufficiently increase the amount of energy created by the chemical reactions and the only way to create more powerful batteries seems to be making them larger. However this does not well match with the evolution of mobile terminals which tend to have less room available for the battery in order to accommodate additional components and technologies. There are some new trends though. Some researchers at Stanford University are using nanotechnology to make batteries able to produce 10 times the amount of electricity of existing lithium-ion batteries. Other researchers try to exploit the movement of the user to recharge the battery. But these are only initial research fields.
As mentioned batteries are important components in mobile phones. The autonomy of mobile phone is directly dependant of them. There are three basic types of rechargeable battery used in mobile phones: Lithium Ion (Li-Ion), Nickel Cadmium (NiCd) and Nickel Metal Hydride (NiMH).

3.1 Lithium-ion batteries

Lithium-ion batteries are so common today in cell phones because they are one of the most energetic rechargeable batteries available. These kinds of batteries appeared when researchers attempted to develop rechargeable lithium batteries. In the beginning failed due to safety problems. Because of the inherent instability of lithium metal, especially during charging, research shifted to a non-metallic lithium battery using lithium ions. Although slightly lower in energy density than lithium metal, lithium-ion is safe, provided certain precautions are met when charging and discharging. In 1991, the Sony Corporation commercialized the first lithium-ion battery. Other manufacturers followed suit. Lithium-ion is a low maintenance battery, an advantage that most other chemistries (active chemicals used in the cell) cannot claim. There is no memory and no scheduled cycling is required to prolong the battery's life. In addition, they also have a self-discharge rate of approximately 5-10% per month, compared with over 30% per month in common nickel metal hydride batteries, approx. 1.25% per month for Low Self-Discharge NiMH batteries and 10% per month in nickel-cadmium batteries.

3.2 Lithium-ion discharge curve

Lithium-ion batteries have a fairly flat discharge curve while others such as Lead acid have a pronounced slope. A flat discharge curve simplifies the design of the application in which the battery is used since the supply voltage stays reasonably constant throughout the discharge cycle. A sloping curve facilitates the estimation of the

State of Charge of the battery since the cell voltage can be used as a measure of the remaining charge in the cell. Modern Lithium Ion cells have a very flat discharge curve and other methods must be used to determine the State of Charge (mpoweruk web).

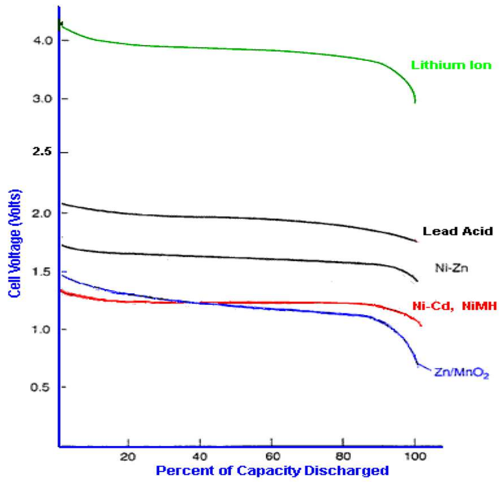

Figure 6. Lithium-ion discharge curve (mpoweruk web)

In Figure 6 the X axis shows the cell characteristics normalized as a percentage of cell capacity so that the shape of the graph can be shown independent of the actual cell capacity. If the X axis was based on discharge time, the length of each discharge curve would be proportional to the nominal capacity of the cell.

3.3 Temperature Characteristics

Cell performance can change dramatically with temperature. At the lower extreme the electrolyte may freeze setting a lower limit on the operating temperature, while at the upper extreme the active chemicals may break down destroying the battery. In between these limits the cell performance generally improves with temperature. Figure 7 shows how the performance of Lithium-ion batteries deteriorates as the operating temperature decreases.

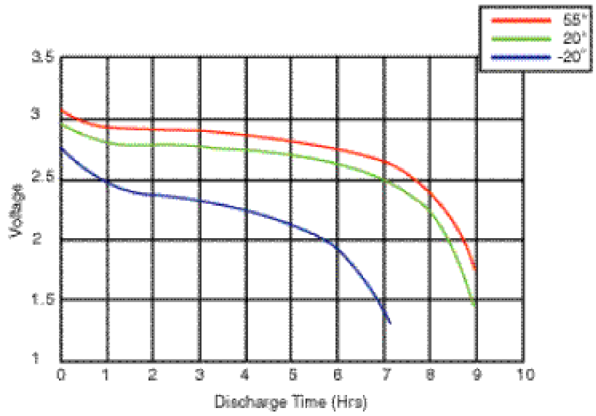

Figure 7. Temperature characteristics (mpoweruk web)

As mentioned before, mobile phones have been undergoing a breathtaking evolution over the years, starting from simple mobile phones with only voice services towards the transition of smart phones offering several kinds of services. Mobile Terminals (Smartphones) are battery driven to allow the highest degree of freedom for the user and therefore they have limited resources in terms of energy and power. It is crucial to understand the difference between these two terms that sometimes are used interchangeably.

Power: the rate at which work is performed) Power = Work = Time [Watts]
Energy: the time integral of Power) Energy = Power f Time [Joules]

Power and energy play some key roles in the evolution of smartphones as the improvement of battery capacity is quite moderate compared to the increase of the complexity due to new hardware and services. Since the battery stores a fixed amount of energy, the operational time the user is able to use its phone within one charging cycle, namely battery life, is fixed as well. As smartphones are offering more and more energy hungry features and services, battery life gets shorter. To overcome this problem, energy consumption needs to be reduced. In some cases reducing the power consumption is sufficient to reduce the energy consumption as well. This is true for tasks with a constant duration (i.e. video and audio playing, voice calls) because the energy spent is proportional to the average power consumption. On the other hand, some other tasks will require less energy if performed faster but with high power rather than slower with low power consumption (mpoweruk web). An example is data downloading and uploading. However using high power, even for a short time, has a limit due to the heating of the mobile phone. Therefore, it is crucial to reduce the energy consumption in order to allow the evolution of smartphones, though often it is not that trivial. We have to bear in mind that the mobile phone consumes different power depending if it is in connected mode or in idle and this for Data part.

There are been done quite many studies (on paper research) and many tests to better improve battery drain on smartphones. Most of them consists based specific network and mobile conditions (also parameters) and also based on some proposal made from NSN in mobile apps mentioned on this paper. Based on them there are proposed and developed many algorithm, simulations and even apps (but few apps) to prove improvement on battery consumption. We believe that a better combination and coordination of Network parameters and mature power saving apps will bring improvement on smartphone battery.

Conclusion:

Smartphone usage pain points issues considered for users include poor internet connection (due to congestion, signaling overload…), mobile apps and battery drain (some of the most frustrating). This frustration stems from the desire to be constantly connected on the network, as discussed on this paper. On the other hand, the successful optimization of these three issues can play a significant role in improving the user experience, as well as increasing data consumption among light and frequent users. Application developers and device manufacturers naturally focus on creating the best end-user experience possible. While this is the ultimate goal of all members of the mobile broadband ecosystem, it’s important for a balance to be found so that excellence in application design does not come at a cost of excess battery drainage or massive signaling increase.

Our future work will consist in optimizing better the MDSA algorithm (Multi decision scheduling algorithm which is under study/evolution) for power saving app we plan to implement for Nokia Symbian OS and as well keeping in mind not creating more signaling.

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