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| The Advent of the Smart Phone |
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Driven by the growth of information societies, the smart phone is an interdisciplinary technical achievement that has fostered a more educated society. After the success of the mobile phone proved large scale networks could be constructed to distribute voice data to and from programmable personal devices, information-hungry societies were soon inspired to develop the system to bring additional capabilities to the mobile phone. Several years later, new data networks became orders of magnitude faster, new hardware packed ever more computing power into a mobile device, and new software offered hundreds of thousands of different ways to use your phone in the form of applications[[1]](#footnote-1). With the added convenience of increasingly more information and computing power readily available, smart phone users have been able to do and learn more, leading to a more educated population.

The primary societal force that shaped and continues to shape the development of smart phone technology is the growth of the information society. An information society, as I refer to it, is any society that utilizes information technology to advance social and economic development. And information technology is defined as follows by a social science encyclopedia[[2]](#footnote-2):

*Broadly speaking, information technology refers to knowledge about how to create, manage, and use information to accomplish human purposes, and so includes not only advances in computing and telecommunications, but also advances in the techniques and skills for using these systems for such purposes as modeling and computer simulation.*

And so, examples of using information technology expand beyond activities often associated with IT departments such as maintaining computer servers and setting up wireless networks. Using information technology also includes communicating with email, banking online, creating electronic documents, and shopping on the internet. Thus the more a society’s members conduct those types of activities, the more the society has grown as an information society. So now why would a growing information society with increased use of email and online banking, create a demand for a mobile phone with added functionality, i.e. a smart phone? Because a mobile phone that can also email and bank online is better, especially if the extra functionality is flexible and costless.

One can historically observe that many products have tried to gain a competitive edge by offering multiple functionalities into a single product. The classic Swiss army knife contains a knife, scissors, screwdriver, and tweezers. Newer digital cameras also contain a video camera and basic image editing software. Many TVs also contain a VCR and DVD player built right in. Who doesn’t want more functionality in their product? Why not bundle as much functionality into one product as possible? The answer is because there is a limit to the benefits of products with multiple functions. Two barriers to the success of function packed products include an inflexible offering of functionality and negative side effects that come with additional functionality.

An example of decreased demand for an inflexible functionality offering could be a TV with integrated VCR and DVD player offered to a consumer who wants the new Blu-Ray disc player instead of the outdated VCR. Most integrated TVs do not have the flexibility to switch out their media players and so the integrated TV product would suffer popularity and demand from the inability to provide the newest and latest popular development function, in this case the Blu-Ray disc player. Another example can be gleaned from the website of Victorinox, the official supplier of Swiss Army Knives. Attempting to browse Victorinox’s selection of multi-tools reveals a choice of 256 product options of varying combinations of tools and design styles[[3]](#footnote-3). This many options is presumably offered to cater toward the exact preference of a customer, an attempt to ensure value is not lost in their product offering at the slightest change of a consumer’s preferences. This however, decreases the individual value of each product; with no flexibility, none of the options is exactly what every Swiss Army Knife customer wants. Victorinox’s apparent need to offer 256 variants of its Swiss Army Knife to satisfy its target customer base is a characteristic example of the disadvantages in offering inflexible bundles of functionality in a product.

Smart phone innovation benefited greatly from its electronic ability to offer flexible bundles of functionality in the form of applications. Smart phones can download and install applications just like desktop and laptop personal computers can. If developing the mobile phone system to support smarter phones would mean phone providers could offer consumers 256 different types of smarter phones that each offered a different set of functionality, the demand for these smarter phones would be much diminished. Imagine if one phone let you check your email but couldn’t check the weather while another let you check both but couldn’t make phone calls. These might be extreme examples, but they demonstrate how undesirable the wrong functionality offering can be. In addition, smart phones’ flexible offering made sure future functionalities could also be supported. While an inflexible integrated TV would not be able to support the new Blu-Ray disc format, the flexible smart phone would only have to wait for the development of a new application to support playing a video encoded with a new format. With no fear of being stuck with a fixed set of functionalities, the demand from growing information societies for the smart phone climbed unimpeded.

An example of the second limitation to functionality-packed products – negative side effects – is the Wenger Complete Swiss Army Knife. Before being bought out by Victorinox, Wenger was a second supplier of Swiss Army Knives that constructed the most multifunctional penknife according to the Guinness Book of World Records. This penknife boasts 87 tools with 112 functions including a corkscrew, fish line guide, golf club face cleaner, bike chain rivet setter, toothpick, and nail file[[4]](#footnote-4). These functions cover a quite comprehensive set of needs so who wouldn’t want all these tools in their pocket? Well, the problem is that each of these tools carries with it a negative side effect: physical space and weight. The Wenger Complete Swiss Army Knife is 3.75 inches long, 8.75 inches wide, and 2.75 pounds. In contrast, the classic Victorinox Swiss Army Knife is 2.25 inches long, 0.25 inches wide, and 0.1 pounds. That’s 35 times thinner and 27.5 times lighter. While it would be nice to have all the functionality of the Complete Swiss Army Knife, the enormous size and weight is a large drawback. One can imagine a similar problem with the integrated TV example as well. For example, it might be nice to have a TV integrated with a VCR, DVD player, and Blu-Ray Disc player. However, if this meant doubling the size and weight of the TV, this negative side effect limits the practical amount of media players that can be packaged into a single integrated TV.

Smart phone innovation again benefited from its electronic nature by avoiding the physical drawbacks of added functionality that affect physical products. For example, adding support for different media formats in the integrated television requires additional physical space and weight, while adding support for different video encodings on an electronic device does not; it only requires additional software code. It may be pointed out that additional software code consumes electronic memory and processing power that, if in enough demand, might require larger hardware that will consume physical space and weight. However, in 1992, the beginning of the decade in which mobile phones were becoming popular enough to begin using second generation networks[[5]](#footnote-5), electronic technology had already developed enough to support a proof-of-concept phone. The IBM Simon was a phone-sized device that contained basic software such as a calendar and address book[[6]](#footnote-6), proving that hardware at the time was capable of supporting additional software functionality in mobile-sized devices. This proof-of-concept in addition to Moore’s Law – which states the speed of computers will double every year or two[[7]](#footnote-7) – gave much reason to believe that electronic hardware would not prove to be a bottleneck constraint. Confident that hardware was progressing fast enough to support additional software on a phone without costing extra bulk, information societies had yet another reason to demand smart phone technology.

Promising flexible and practically costless additional functionalities, the smart phone would fit the needs of every person who used information technology in their life. No matter how small a niche a person’s desired functions might be or how variable a person’s needs might be throughout his/her life, the smart phone promised the ability to fulfill those functions and needs. Thus, as information societies grew with progressively more people using information technology for progressively more purposes, so grew the demand for the smart phone.

In response to society’s demand for increased functionality in their mobile phones, the technologists of the day undertook the technological development of the two components of the mobile phone system: the phone and the network. Developing one without the other would be meaningless since they worked as a system. Between the launch of the proof-of-concept smart phone in 1992 and today, technologists have developed the smart phone from a bulky, black-and-white, single-tasking device with ten available applications to a sleek, full-color, multi-tasking device with hundreds of thousands of available applications. Also within that time span, technologists have increased the mobile phone bandwidth from 20 kilobits per second[[8]](#footnote-8) to 2000 kilobits per second[[9]](#footnote-9). Together, the innovations in network technology and in phone technology combine to provide the functionality behind today’s modern smart phone.

The development of the communication network was a key to the success of the smart phone because the network dictates the speed and capacity of information transfer between a smart phone and the rest of the world, i.e. the Internet. With limited data speed and capacity, internet browsing, large file sharing, and any real-time data applications such as driving directions become impractically slow. To achieve a basic understanding of the advancement of network technology, it is sufficient to follow the technological progress of the most popular flavor used by 80% of all global mobile phone users[[10]](#footnote-10): Global System for Mobile communications or GSM for short. We will track the progress by the heavily advertised “generations” of network technology such as “2G” and “3G”. These “generations” refer to sets of specifications for network performance that the United Nations International Telecommunication Union establishes; thus, any network technology whose performance satisfies their “2G” specification can be labeled as a “2G” network. The different versions of GSM we will follow are only the most popular of many network technologies that satisfy these specifications.

Over the past two decades, GSM network technology has upgraded its network technology with progressively better data communications schemes and algorithms to support an increase of data transfer from 20 kilobits per second to 14400 kilobits per second. The first generation, or “1G”, GSM network supported only voice data and did not support any data transfer. Released in the 1980s, 1G GSM worked by transferring analog voice data from the mobile phone to cell towers that connected the data to the telephone system. The second generation “2G” GSM network was released in 1991 and introduced the benefits of digitizing the data transferred between the phone and cell towers. This major improvement allowed up to 20 kilobits per second data transfer[[11]](#footnote-11) thus opening up room for small data services like SMS to be implemented. A second benefit was the ability to encrypt the now digital voice data to prevent eavesdropping. The third generation “3G” GSM network, first released in 2001, was the result of ten years of network technology development that incorporated many independent improvements to achieve up to 2000 kilobits per second of data transfer[[12]](#footnote-12). The primary innovation that improved maximum data rates was the introduction of packet-switched data transfer. 2G networks used circuit- switched data transfer where each mobile phone user was assigned a dedicated circuit, i.e. a specific radio frequency and time-slot with which to send data, whether it was in use or not. Packet-switched data transfer does not waste network capacity on idle dedicated circuits, but instead packages all data into packets to be delivered on the first available frequency and time-slot. A drawback is that packet-switching introduces variability in the data transfer rate since the number of other packets being handled by the network will affect the speed with which an individual’s packets will be processed. However, overall, the average data transfer rate is dramatically improved since packet-switch more fully utilizes the network capacity. A second large innovation that improved maximum data rates involved the discovery of more efficient data coding schemes such as higher-order PSK/8 phase shift keying that take advantage of the phase of the data signal to convey additional data. A full understanding of the coding schemes is complex enough to require several pages and is thus omitted; the basic idea is that new ways to convey information with the digital data signal were discovered and taken advantage of.

Beyond network technology, the other side of innovating smart phone technology was of course developing the phone itself. This involved both advances in software to allow user friendly interaction with phone data, and advances in hardware to support the processing and memory needs of the software in a small, mobile form factor.

As mentioned before, hardware has been holding up its performance expectations by providing double computing speed and memory[[13]](#footnote-13) every one or two years in adherence to Moore’s Law. In addition, hardware has been developed to optimize efficient use of the limited battery power present in mobile devices. A particular processor chip design named ARM proved particularly energy efficient, and has consequently been employed in 98% of all mobile phones[[14]](#footnote-14).

On the software side, multiple advanced operating systems have been written to try to best take advantage of the data that networks could now provide phones. The most popular include Android, iOS, and Symbian. They are complex packages of software that need to juggle network connectivity issues, multiple mobile media formats, and different user input methods such as possibly pen input and finger gestures. Perhaps the most significant breakthrough for mobile software designers in making smart phones appealing to users was releasing an application software development kit with which anybody could independently develop their own smart phone application. Allowing the free public development of custom applications truly ensured that every potential smart phone user’s needs could be fulfilled; if the application didn’t already exist, a user didn’t need to rely and wait on the limited resources of a single company to release an appropriate application. Basic supply and demand could harness the entire world’s development community to supply applications that were in the hottest demand. In other words, mobile software development kits helped smart phones capture the “long tail” of potential consumers. The long tail refers to the numerous groups of needs that each fit a small population in contrast to the few groups of very popular needs. Most products attempt to address the very popular needs because it garners the highest demand per feature ratio. However, the length of the long tail, or number of unpopular needs, could be large enough to offset the small populations interested in each of them such that addressing the long tail could mean addressing quite a large market. It is beyond the scope of this essay to analyze just how large the long tail is in the mobile application market; however it is worth noting that public mobile software development kits go a long way toward capturing this long tail, however large or small it is.

Only with the combined advancement and innovation in network, hardware, and phone software technology is the modern smart phone made possible. Network technology made more data available from the internet, hardware made more advanced data manipulation possible without sacrificing physical space, and phone software made the user experience with the data intuitive and enjoyable, including providing flexibility in functionality – through applications – offered.

With the arrival of the new smart phones came immediate access to the internet’s wealth of information, which has led to the improved education of smart phone users. Certainly, with increased access to information, smart phone users are better informed. However, does the ability to check email more often and look up the weather forecast make a user better educated? Probably not; however, beyond granting increased accessibility to performing non-educational activities such as online banking, the smart phone does also offer opportunity for learning. From examining the behaviors of smart phone users, we can establish that they do use their smart phone applications and they use applications related to learning a significant portion of the time.

Local geography is a strong example subject in which smart phone users are better educated. Smart phone users use their smart phone on average 56 times per day, for an average of 30 seconds per session[[15]](#footnote-15), and of these sessions, the applications that users spend the most time on are related to maps[[16]](#footnote-16). It is then no surprise then that Google Maps is one of the top 5 applications used on every type of smart phone[[17]](#footnote-17). People use maps applications to learn where various destinations are located. Geographic information is enormous, so there is a lot to learn. In addition, it is not hard to imagine that a person might often be interested in learning more and more local geography. Whether it is to visit a friend for the first time or to take a vacation, people often have reason to learn about new places all the time. People could call their local friends, but with the convenience of the smart phone, people are encouraged to discover the locations of not only their immediate destinations, but also of the places that surround their locations of interest. Instead of hearing from a friend, “Turn left on Main Street and then a right after the big tree,” smart phone users have permanent access to a rich map of any area, complete with descriptions of all the nearby businesses and attractions. This readily available wealth of additional geographic information provides its user with a more efficient and comprehensive education of local geography.

Smart phone users also have better access to news, which encourages an education in current events. In fact, smart phone users use news applications more often than productivity applications. According to the popular marketing data company Nielsen, 36% of smartphone users used a news application in the past 30 days while only 22% of smartphone users used a productivity application in the past 30 days[[18]](#footnote-18). By keeping more up to date with the latest events, smart phone users are able to maintain a higher level of knowledge about their current world. Smart phones also grant news access during times where other sources of news may be unavailable to non-smartphone users; for example, when riding a bus or waiting in a hospital waiting room. This gives smartphone users a distinct advantage over non-smartphone users in the amount of time that news is available for them to read. With more time to read the news, people with smartphones will naturally be able to become better informed about the latest world events.

Although it is debatable what range of knowledge should be considered “educational” or not, it remains clear that the additional accessibility the smart phone provides its users can only make learning “educational” information easier. By being able to provide complete information at any time, such as a comprehensive map while on a train, smart phones are a resource richly prepared to educate their users in whatever subject they might be interested. With such a rich resource available 24/7 and the usage statistics that indicate educational applications are used often, a smart phone society can hardly help but use their devices to become more educated.

The smart phone has proven to be an incredibly popular innovation that appears on track to becoming as much of a staple personal item as a man’s wallet or woman’s purse. In 2010, almost all Americans had cell phones, a quarter of which were smart phones[[19]](#footnote-19). The dreams of the early information society in the 1980s have blossomed into reality. Over the previous two decades, innovators have developed all dimensions of the smart phone system – the network, the phone hardware, and the phone software – to deliver a versatile personal device with flexible and costless functionality. And with their smart phones, people perform information technology tasks at their convenience, unavoidably improving their education in the process. Information society wanted more convenient IT access, so engineering across multiple fields produced the smart phone, which continues to cultivate a more highly educated society.

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