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Evolving a Mobile App Society

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The Mobile Landscape

In the 1950s, only visionaries, if anyone, entertained the idea of a powerful pocket-sized computer, and only experts directly engaged in computing. Hardware was huge and operated slowly on unreliable vacuum tubes. Software was laboriously crafted from ones and zeros, exceedingly simple and orders of magnitude smaller than software today. Today's handheld mobile wireless devices massively outperform the mammoth early computers.

A quick trip down history lane reminds us that Bell Labs conceived the notion of mobile networks in 1947. Not until 1979, however, did Japan launch the first analog mobile network. The first commercial handheld phone appeared in the US in1983. It was bulky and limited to only to telephony. It cost over $8,000 in today's dollars.

And by December 2009, 286 million mobile subscribers existed in the US, spanning almost 91 percent of the population. Despite this surge, the US already lags in the wireless revolution. Other nations enjoy a significant tactical edge, lacking a backlog of legacy technologies to be overcome. According to the International Telecommunication Union 2010 report "*Measuring the Information Society,"* the world contained some 4.6 billion active mobile devices at the start of 2010. As of June 2010, China alone had 775 million mobile subscribers. China's overall wireless subscribership was growing at 15.4 percent by the third quarter of 2009. Overall the Asian-Pacific region houses 39 percent of the broadband market, supports 42 percent of all Internet users, and has the largest number of cell phone users world-wide.

A New Software Genre

While mobile technology certainly delivers telephony, service-based software drives today's mobile revolution. The software applications or "apps" that can be loaded onto advanced mobile devices create powerful, integrated and interactive computing platforms. The emergence of the cloud resolves storage issues by making data remotely and instantly accessible from afar. In short, your smartphone is nearly as much a computer as your laptop. Innovative, interactive software turns mobile computers into consumer "must-haves." Mobile games and applications entertain, connect, locate, inform, document, shop, search, and compute. Significantly, these apps no longer necessarily tether the user to the World Wide Web or to a fixed power supply. The virtual world has become far more instant and accessible.

Until recently, leading software applications resided and operated on computers that were physically tied to the Internet. SourceForge.net began collecting open source Internet software tools and applications as early as 1999. According to SourceForge, "as of February, 2009, more than 230,000 software projects have been registered to use our services by more than 2 million registered users, making SourceForge.net the largest collection of open source tools and applications on the net."

Today's mobile applications spearhead a staggering increase in new software. According to Wikipedia, the first iPhone app "One Trip" dates back to June of 2007, predating the first iPhone release. iPhone's app count passed 100,000 by November 2009. Not even a year later, Apple's highly website boasted "over 200,000" highly controlled iPhone apps. The numbers soar further with Google's Droid and other mobile products, whose open apps are growing at least as rapidly under less rigorous control. While core mobile apps often come pre-installed on phones, consumers frequently download a wide array of apps from "app stores" thus making the mobile device "their own." Apple and its tightly controlled App Store and Google and its free-for-all Droid open apps environment will continue to battle domestically in the short-run.

Why such growth? Is mobile app software easier to write? Are there more tools available? Or is it just fun? The answer is "all of the above." While not everyone can create custom apps, streamlined development tools greatly increase the number of people who can create a useful app in very little time. The phenomenal number of new mobile apps is analogous to the explosive individual website development in the 1990s.

Historical Perspective

History provides a deeper perspective on the full extent of the seemingly new mobile app phenomena and its migration to the cloud.

In the late 1940's and early 1950's, large first generation computers greatly outperformed mechanical calculators of the age. They arose from a solid theoretical base that emerged in the late 1930's through the 1940's: the suitability of Boolean algebra for computation and the necessary architecture for digital electronic computer design.

In the late 1950's, solid-state transistors ushered in the second generation of faster, smaller and cooler operating computers that lasted through the mid 1960's. These devices also arose against a powerful theoretical backdrop: These early theoretical breakthroughs in the 1940's and 1950's introduced the notions of stored programs, information theory, neural nets, artificial intelligence, cybernetics and general systems theory.

Taking advantage of integrated circuits, the third generation of computers extended yet faster, smaller, and cooler computers through the early 1970's. Operating systems began to oversee multiple simultaneous processes. The theoretical base extended the notions underlying general systems theory to embrace dynamic systems. Agent based computing, in the form of cellular automation, served as a means to demonstrate and quantify forms of emergent behavior. The notion of fuzzy logic extended neural nets and information theory.

The fourth computer generation, beginning in the 1970s, brought even better performance, as integrated circuits became microprocessors - whole processors on a single silicon chip. This gave rise to the Personal Computer and eventually the laptop. While some might argue that network technology represents a radical departure from prior generations, the emergence of networks, the Internet and the sudden appearance of the World Wide Web during the fourth generation revolutionized computing.

Against such a dramatic computational evolution across the fourth generation, culminating in vast computer networks, the theoretical community blossomed. Dynamic systems led to fractal geometry and ultimately spawned chaos theory. Agent based systems raced from single agents to multiple simultaneous agents, embracing genetic algorithms, artificial life and computational sociology along the way. The overarching study of complex adaptive systems became important. Complexity science grew from the Santa Fe Institute, established in 1984, and rapidly matured as it focused on self-organizing systems, autopoiesis, emergence, applied systems dynamics and, ultimately, network science. Today, networks extend well beyond physically linked computers to include engineered information from biological, cognitive, semantic, and social networks.

Complexity Implications

Together, all these elements formed the nexus of complexity science which now integrates the roles of agents, networks, and chaos. Complexity science acknowledges emergence, self organization, diversity, connectivity, interdependence and adaptation in modern systems thinking. Multidisciplinary complexity research has breached the fabled C.P. Snow “two cultures,” embracing both the hard and the soft sciences. Increasing knowledge expands the complexity phenomena to reach combinations of computer science, cognitive psychology, psychology, sociology, economics, anthropology, biology, biochemistry, chemistry and physics to name but a few affected fields. The former pre-eminence of linear systems thinking now frequently takes a backseat to nonlinear thinking. Reductionism and determinism remain popular, but are now often forced to coexist with dynamic, non-linear and sometimes chaotic systems.

Over a short time, the seemingly obscure theoretical ideas from preceding eras seemed to morph into the popular psyche. Stephen Wolfram’s “A New Kind of Science”, which defined the conditions by which cellular automata exhibits emergence, hovered among highest non-fiction sales rankings at Amazon.com. Albert Lazlo Barabassi’s New York Times runaway bestseller “Linked” popularized network science. James Gleick published “Chaos: Making a New Science”, extolled the general principles of chaos theory. The long dormant mathematical field of Graph Theory, stemming back to 1736, suddenly caught fire as a means of describing network relationships with mathematical precision. Finally, in 2010, Wired Magazine, which was inspired by Oscar Brand, declared that the World Wide Web (WWW) has succumbed to a plethora of mobile apps.

None of the new theoretical approaches would have been possible without the explosion of the fourth generation computer. As local and wide area networks became almost secondary to the WWW, users and their usage patterns become increasingly visible and significant. These, in turn, exposed large-scale socio-economic behaviors. While a bonanza for Internet-savvy marketing entrepreneurs, scientists were also able to get unprecedented looks at human social behavior both online and offline. Moreover, with powerful computers at their disposal, analysis of the massive data sets became entirely feasible. The same holds true for other phenomena that can only be viewed in the extreme macro or extreme micro views to reveal their truly complex characteristics. The Search for Extra Terrestrial Intelligence (SETI) program serves as a vivid example of the power of millions of networked PCs using spare cycles to crunch enormous mountains of data for a common purpose.

The explosive fourth generation, however, also significantly changed the very nature of social behavior. Today, electronic mail continues to challenge traditional post office functions. Mom and Pop stores are hard pressed to compete with electronic commerce giants. Blogs permit everyone who wants to air their opinions about virtually anything without editors or much accountability. Facebook, twitter and other social media are rapidly eclipsing email. Once viewed as very literal machines, today's networked and interactive computers and the social networks they host, have transformed static, standalone computational devices to fully immersive environments. Moreover, these highly interactive, non-linear environments are hospitable to literate people. Freely available multi-media experiences and vast global social networks provide an immediate sense of electronic community.

Millions of people have gravitated to these networks. Suddenly, the virtual whole has become far more than the sum of its physical parts. Mobile computers and their ubiquitous apps, often invoking the cloud, are the harbingers of things to come.

Some attribute the fifth generation of computers as the coming of age of AI, neural nets, fuzzy logic and agents. In reality, however, these tools have actually been in the toolbox for several of the previous generations. They will continue to evolve and adapt, but it is doubtful they will take center stage in the coming era. Instead, complexity theory prescribes a far different baseline for the fifth generation.

Today's "average" computer is liable to be hand-held, portable, highly networked, cloud connected and far more powerful than all preceding generations of computers. Once battery life is sufficiently prolonged, handhelds will become orders of magnitude more powerful than today's mobile devices. Innovative user interfaces will replace tiny keypads and displays. These devices will link with one another through ubiquitous virtual cloud environments. The action has already moved to the edges as emergent clouds provide the infrastructure for both flocking behavior and remote data storage. The fifth generation will usher an era of commodity computing. Access will be on demand and metered much like any other utility such as electricity and water.

Trusting Apps

General-purpose software has long been plagued by a reputation of inadequate reliability, forcing users into beta-testing, and shipping products simply to meet pre-defined release targets regardless of quality. However there are fields such as aviation, medicine, and nuclear power, that demand software that meets more rigorous quality standards to satisfy their safety-critical requirements.

Is mobile app software general-purpose, or does this software impact loss of life or finance? The answer is both. Software of any level of criticality or any type of functionality can be developed for handhelds. Direct access to hardware on these devices such as cameras, microphones, and sound all add to the diversity of potential apps, and also can add security risks. Moreover, access to the Internet and remote Ground Positioning System (GPS) satellites further add to the variety of features and potential for threat exploitation available on mobile devices. There is no question that the concept of trust should become more central in the mobile applications world.

Nick Bilton of the New York Times reported on a wallpaper application for a mobile phone. In addition to the pretty picture, the application also collected personal information and emailed it to an address in China. Such security threats are likely to become increasingly problematic as more and more people rely on relatively small and inexpensive pieces of software fetched off the Internet. Bilton quotes a mobile security expert from the company Lookout who said that nearly a third of all iPhone applications have the ability to access personal information on the iPhone.

There are many predictions that mobile phones will soon be used routinely as an "electronic wallet." The possibility to siphon money from phones may prove to be an attractive target. Since many phones share a small number of software platforms (such as the iPhone and Android phones), learning how to exploit vulnerabilities may have a high return on investment for malware developers. A quick scan of the latest DEFCON program reveals many presentations describing mobile security, and how it can be thwarted.

Tony Dyhous of *Computer Weekly.com* claims that mobile devices, operating systems, and apps are not designed with security as a priority. Dyhous writes, "Critically, those involved need to convince the buyer that security is worth waiting for or paying for." But the competitive pressure to deliver more functionality at a lower cost, and to grab market share as soon as possible, are forces that push against the kind of patience required both by developers and users if mobile security is to improve significantly.

Worse, as the relatively small apps mobile interact with common data, often across the cloud, a swarm-like environment can emerge. Likewise, mobile devices themselves exhibit crowd behaviour when viewed in aggregate. As these interactive devices increasingly link to the data-rich, but largely unstructured cloud, the security challenges become immense. Clearly, traditional Transmission Control Protocol/Internet Protocol level approaches to security will be inadequate to address the broader security issues surrounding this information centric environment. Rather, a pattern-based approach to information security using complexity analysis appears to be more suitable.

Military Utility

The Defense Advanced Research Projects Agency (DARPA) recently launched a new initiative titled Transformative Apps to develop a military-centric app store for war-fighters. DARPA states “A military apps marketplace will be created to enable rapid innovation to meet user needs based on a direct collaboration between a vibrant and highly competitive development community and involved communities of end-users. The program will address all the challenges - technical, business, and operational - faced to make the new capabilities available for use in the field. The end objective is to transition the resulting systems to the end users in the Services, and to foster a new model for rapidly and effectively acquiring, introducing, maintaining, and enhancing software.”

Thus the goal is to offer app developers a path to rapidly field their products in combat settings. If apps make it into the military app store, app providers are paid as their software is used. This “payment if used” model for software is dissimilar to traditional procurements using mil-specs. The technical challenges for such an app store revolve around security and trust. An application must not leak data to an enemy. The enemy must be prevented from tracking the device. Applications cannot drain too much power, and an app cannot crash the device. Warfighters must reliably synchronize their handhelds to return stored data (e.g. images and sound) and download upgrades securely. Moreover, the app store itself must never be accessible to the enemy.

The National Institute of Standards and Technology (NIST) focuses on vetting the vendor’s apps prior to app store inclusion. NIST employs three approaches based on app criticality. The first approach, derived from the Department of Homeland Security Software Assurance Acquisition and Outsourcing Checklist, uses a vendor questionnaire about their organization and development processes. The second approach involves a series of tests that search for common vulnerabilities and measure failure frequency. The third approach injects instrumentation code into apps to gather operational field data that is then fed back to the military or vendor. These three approaches offer a reasonable ability to vet apps without violating DARPA’s goal of rapid new technology adoption.

Commodity Computing in the Cloud

In 2010, it is commonplace to have a processor inside your pocket that is many times more powerful than early mainframes. Delivering this kind of information processing along with unprecedented connectivity to individuals may be the single most impressive technical achievement of the 20^{th} century. It isn’t yet clear what the full impact of this transformation will be, but it is already clear that we are different, in some fundamental way, because of our embrace of, and reliance on, cheap and accessible information.

The security implications are unprecedented, and we have not yet grasped the enormity of that challenge. We are already becoming immersed this new approach to information, without knowing how we can ensure that the technology and the people behind it can be trusted. It is our hope that we will increasingly focus on how the magic is accomplished, instead of merely being dazzled by the special effects.

Computing may be becoming more like running water and less like a battleship in our mental maps. Computing hardware continues to dive in price, soar in capacity and shrink in size. Internet and mobile phone connections are increasingly commonplace and natural. We expect to connect seamlessly to information in our daily routines, and we are surprised, inconvenienced and often annoyed when we can't. As our conscious attention dwells less and less on the details of how information is delivered, information becomes the real commodity.

If computing and information are to become "water-like," then cloud computing may be the supply-side infrastructure; and mobile apps are becoming the shiny new fixtures that deliver information into the hands of consumers. Both with the cloud and with the apps, the details behind the scenes are becoming less obvious to consumers. Both technologies hold the potential to reduce the cost and increase the effectiveness of information delivery.

Disclaimer: This paper was co-authored by Voas as a private citizen and not as a US National Institute of Standards and Technology (NIST) employee. It reflects Voas's personal opinion and does not reflect the opinions of the Department of Commerce or NIST.