White Paper
Mobile Architecture
More than a Ubiquitous Delivery Channel

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As noted in previous works, four key disruptive forces continue to shape and reshape our digital world at a rapid and significant pace on a global scale. Those forces include Cloud Computing, Information Science (analytics, big data, etc.), Social Networking and Mobile Computing.
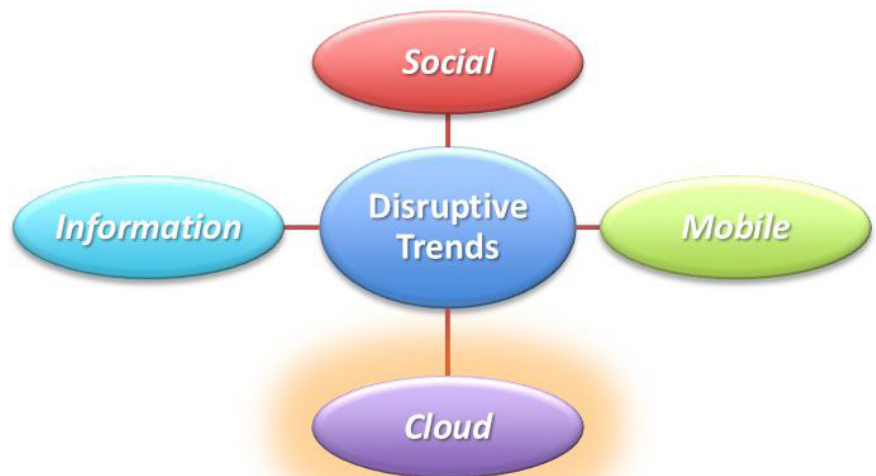

Figure 1 - Contemporary Disruptive Trends

The rapid pace of mobile technology is forcing organizations to reconsider their channel enablement strategies and architectural approach to service delivery. It is no longer sufficient to simply have a 'mobile-browser' friendly web site as consumers' expectations of device-oriented applications continue to grow. Enterprise Architects must ensure alignment between accelerated demands for mobile services and

the prevailing Enterprise Reference Architecture models already in place that were designed around the organization's strategic direction.

Firms struggle with trying to not only keep pace with the mobile world, but even more so when they try to exploit the unique capabilities the mobile computing paradigm has to offer. In this paper, we'll cover some basic mobile computing architectural concepts and then highlight several key elements of an effective Enterprise Mobile Strategy. These elements include:

- Aligning Mobile Strategy with the Enterprise Strategy

- Deliberately Deciding Whether to Lead, Follow or Get Left Behind

- Planning for Multi-Channel Transactional Customer Experience

- Establishing an Enterprise Mobile Reference Architecture

- Leveraging Mobile Design Considerations

Basic Mobile Computing Architecture

Let's begin our discussion of Mobile Computing Architecture with a simple pair of scoping statements to differentiate Mobile Computing (verb) from a Mobile Device (noun):

Mobile Computing	Mobile Device
"The act of using a computer while travelling from place to place or without being connected to electricity or other computers by wires: Mobile computing is taking over from desktop computing."	*"Any piece of electronic equipment such as a mobile phone or small computer [e.g. Tablet] that you can use in different places."*

Table 1 – Contrasting Mobile Computing from Mobile Device terminology [i]

While these definitions may seem a bit simplistic, they are useful to remind us that the realm of Mobile Computing and Mobile Devices is not limited to our favorite Smart Phone or the ability to connect to a network through a nearby 'Wi-Fi' connection. The generalized terms imply much broader characteristics and capabilities that are available to today's digitally enabled service consumer, who possesses the ability and expectation of having computing resources available whenever and wherever they might be. These expectations require organizations, if they haven't already, to adopt a new mobile-centric (or at least mobile-friendly) technology design paradigm, often just to keep pace with their industry peers.

This can be quite challenging for more established firms that may have amassed significant technical debt tied up in long-term legacy platform investments. The flexibility and resiliency of the firm's current technology

environment will become an important factor when it comes to the level of difficulty when 'going mobile'. Another factor is the introduction of non-traditional competitors, as independent developers have produced a large portion of the +1 million apps, or mobile applications available in the Android Google Play app store, as well as the +1 million apps available in Apple's App Store. Clearly the playing field among large and small companies has been leveled quite a bit, at least when it comes to offering consumers a viable and valuable mobile experience.

General Mobile Application Architecture

At the highest level, Mobile Application Architecture does not look inherently different from other layered technology platforms or 'tech stacks' that we've seen in the past. We still see typical resource requirements for compute, storage, network, security, user interface and functional application capabilities, broken out into familiar layers. What does differ is trying to fit all of that rich application experience into a small portable device with an unpredictable power supply and a natural tendency to flicker 'on and off' the network at any given time.

The following figure (Figure 2) portrays a common architectural view into the typical autonomous mobile application and its processing ecosystem. Looking at the Mobile Device container, we see that the user interacts with the Presentation Layer, which encapsulates the User Interface and Presentation Logic components. The Presentation Layer communicates with the Business Layer to access functional capabilities and at times the Common Utility Layer for services such as Configuration, Security and Communications. The Data Layer manages access to local data and provides corresponding services and utilities.

Leaving the device, we see the Remote Infrastructure, which provides additional data access, business functionality, middleware connectivity and other services. Those familiar with Client Server Computing architecture will recognize the similarity, underscoring the fact that not all of the concepts around mobile computing are new. In the seemingly perpetual ebb and flow of centralized versus decentralized processing, the pendulum shifts once again to leveraging client-side capabilities, coupled with available 'backend' services when connected to the Remote Infrastructure.
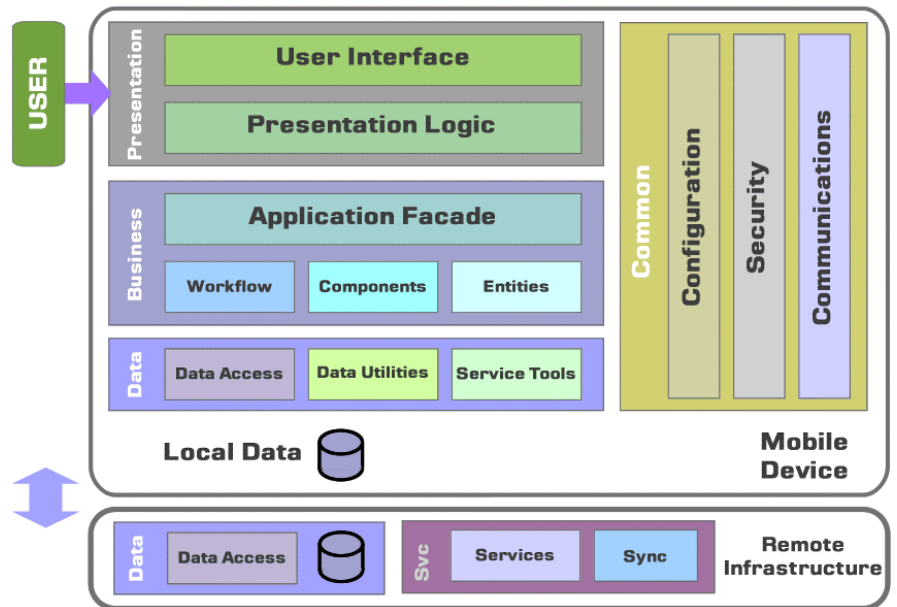
Figure 2 - Typical Autonomous Mobile Application Architecture [ii]

Mobile Application Architecture Approaches

At the time of this writing, there are generally three approaches to Mobile Application Architecture: Native Apps, Mobile Web, and Hybrid Apps. Native Apps, as the name implies, are written for and operate within the device's native operating system. Mobile Web Apps, in contrast, are basically web applications hosted in remote infrastructure and are accessed by the device's browser. Hybrid Apps are essentially Web Apps running inside a native application container, giving the application access to the device's local resources via native APIs. The following figure shows the relationship between each of the approaches as they correlate to device capability access and platform affinity.

NATIVE APPS
- Single platform affinity
- Written with platform SDKs
- Must be written for each platform
- Access to all native APIs
- Faster graphics performance
- AppStore distribution

HYBRID APPS
- Cross-platform affinity
- Written with web technologies (HTML5, CSS3 and JavaScript)
- Runs locally on the device, supports offline
- Access to native APIs
- AppStore distribution

MOBILE WEB APPS
- Cross-platform affinity
- Written with web technologies (HTML, CSS, JavaScript, or Server-side (PHP, ASP.NET, etc.)
- Runs on web server, viewable on multiple devices
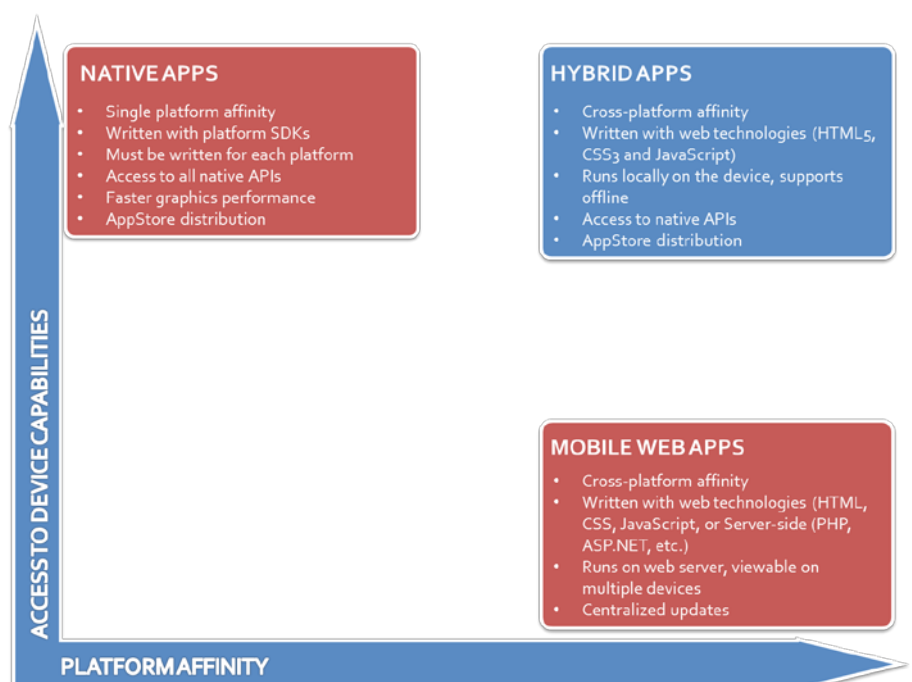- Centralized updates

Figure 3 - Mobile Application Approach Comparison [iii]

Each approach has its own positive and negative aspects. Keep in mind that all of the apps on the device will run the gamut of architectural approach types – none of them are mutually exclusive. Native Apps offer the best performance at the expense of portability. Mobile Web Apps have the broadest reach and use familiar techniques but at reduced discoverability and with reduced exploitation of device capabilities. Hybrid Apps leverage widely known technology skills with a widely reusable code base but may have higher performance sensitivity within the native application container and subtle implementation differences between OS platforms.

Approach	Pros	Cons
Native	• Full Access to Device/Platform/APIs • Best Performance (esp. with UI concerns) • App Store Discoverability	• Different skills/languages/tools for each target platform • Tend to be most expensive-to-develop, with thin margin • Client code not re-usable between platforms (of course)
Mobile Web	• Arguably the broadest reach • Can re-use existing, responsively designed sites • Code base is re-usable between platforms • Finding necessary skills isn't difficult	• Extremely limited access to device APIs • Limited discoverability (no app store presence) • Tend to be more difficult to monetize
Hybrid	• Natively-installed & run, but built with JavaScript, HTML & CSS • Code base is re-usable between supported platforms • App Store Discoverability • Access to many device APIs (& extendable via plugins)	• UI Performance affected by native webview implementation & (potentially) poorly written JavaScript/HTML • Differing webview implementations per platform

Table 2 – Pros and Cons of Different Mobile Approaches [iv]

Mobile Application Platforms

Rather than entertaining the debate as to which of the three leading mobile platforms is 'better' than the others or will outlast its challengers, we will give a brief overview of their pros and cons, along with an architectural view to help articulate the underlying differences of the current reigning champions: Apple's iOS, Google's Android and

Microsoft's Windows Phone*. As with anything, there will be certain use cases where one of the platforms outshines the others, even if only marginally. The choice of platform is more likely driven by the preferences and consumption patterns of your customer base than by pure technical perspectives, unless you have a very targeted business model that benefits from dictating the platform outward.

iOS

iOS is Apple's proprietary mobile OS that runs on their proprietary devices, namely the iPhone, the iPad and the iPod Touch. The following diagram depicts how the generalized mobile architecture pattern discussed previously is manifested in the iOS platform. Applications have access to multiple services within the iOS user space layers, including User Interface management, media rendering services and core foundational services required for the application to function within the device. Lower level system and machine level capabilities operate at the kernel space layer below.
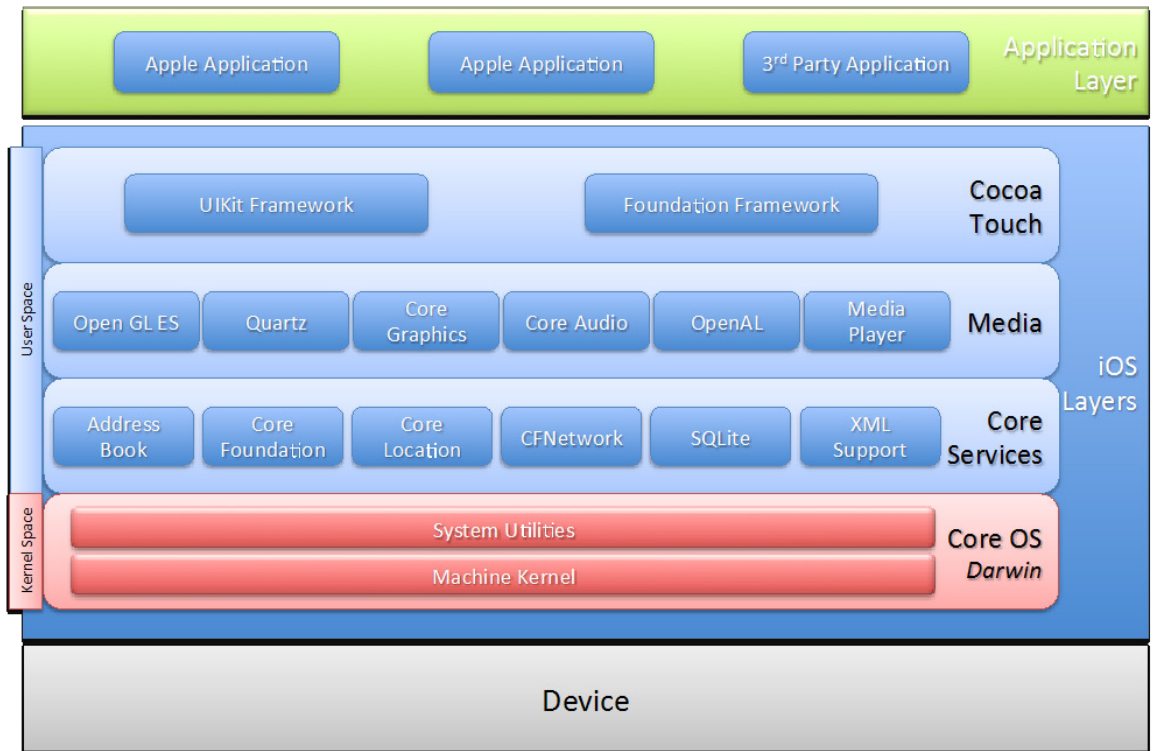

Figure 4 - Apple iOS Architecture

While not exhaustive, the following table highlights generalized positive and negative aspects of iOS. Consumer confidence in the stability of the operating system and in the quality of the device is endemic to the 'Apple' experience.

Pros	Cons
• Apps often come to iOS first • Strict App Policies • Highly Useable • Quality Hardware • High level of consumer confidence in app functionality and experience	• Lack of customization • Lack of device options

Table 3 - iOS Pros and Cons [v]

Android

Android is Google's open source OS platform, which is built on top of the Linux kernel. Android is primarily targeted to touchscreen mobile devices such as smartphones, tablets and wearable devices (e.g. Google Glass, smart watches, etc.), but is also beginning to find its way into other devices as well, such as digital cameras and gaming consoles.

The Android OS architecture provides a framework where applications have access to service managers that control a wide range of capabilities, including device activity monitoring, notification and alert mechanisms, resource consumption and telephonic features. Below the framework, Android uses a collection of libraries, including the Android runtime library that interfaces with the low-level Linux kernel where device drivers, memory and power resources are controlled and marshaled on behalf of all of the active applications.
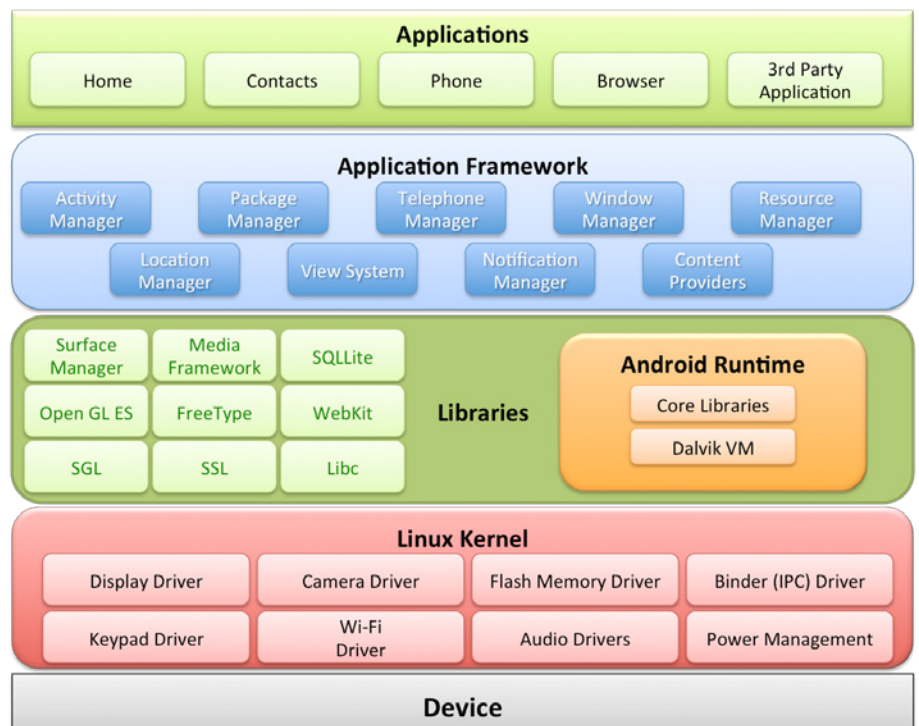
Figure 5 - Android OS Architecture

Although Android is licensed as open source technology, manufacturers and carriers often deliver 'Android' devices with a combination of open source and proprietary software. This has implications for application quality assurance in that there is a (rare) potential that a developed app may behave slightly differently on various device/carrier combinations than anticipated. This can be further complicated if the owner of the device decides to 'root' their device, in which case the 'tweaked' OS and proprietary software initially received on the device are removed and replaced with a 'pure' installation of the Android OS.

In contrast to iOS, Android supports a wide assortment of devices from a heterogeneous collection of manufacturers. There are requisite specifications, but the requirements are simplified and standardized to a point where numerous vendors can assemble 'Android compatible' devices from readily available commodity components. The environment is highly customizable and versatile, leading to less restrictive app policies for making apps available for distribution – good for developers, not as good for consumers as there is less quality control over both the application and the device. Similar to other open source community participants, Android users are demanding, but exhibit a certain affinity to the app providers in their tolerance of iterative releases.

Pros	Cons
• Device variety • Highly customizable • Less restrictive app policies • Extremely versatile software	• Lack of strict app quality controls • No control over device quality

Table 4 - Android Pros and Cons

Windows Phone 8

Windows Phone is the mobile OS from Microsoft, which is based on the Windows NT kernel beginning with the release of Version 8 in 2012. While not as restrictive in the short list of devices supported by Apple, it does require specifically compatible devices, initially limited to offerings from HTC, Nokia, Samsung and Huawei. [vi] Windows Phone app engineers have their choice of several development platforms and languages to work in, including HTML, CSS (Cascading Style Sheets), JavaScript, C/C++/C# and XAML (Extensible Advanced Markup Language). Applications interact with OS and device resources through frameworks, libraries and runtimes sitting above the NT kernel.
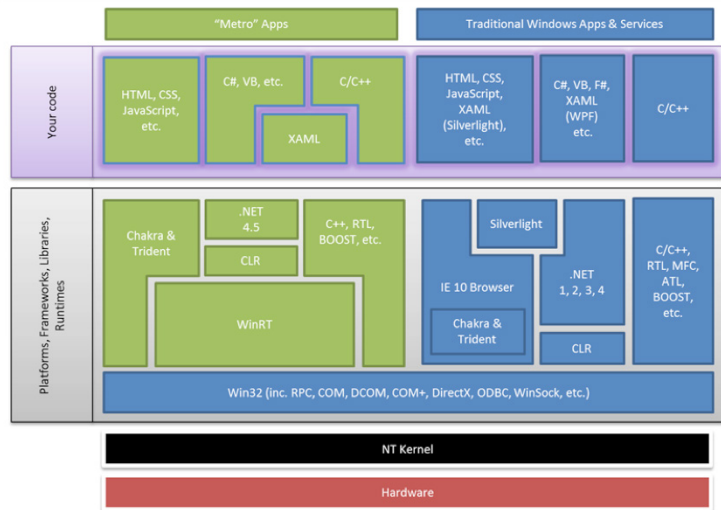
Figure 6 - Windows 8 System Architecture [vii]

Benefits found on the Windows Phone platform include a steadily improving environment and user experience, better power management and the ability for custom apps to interact with other 3rd party apps found on the device. With the move to the NT kernel with version 8, consumers and developers have to contend with compatibility issues – version 7 devices cannot be upgraded to version 8 and apps that take advantage of new version 8 capabilities are not backwards compatible. With rumors of Windows 10 circulating in the media, it isn't clear what that future migration path will look like in terms of impact.

Pros	Cons
• OS has been improving and approaching competitors in feature/functionality • Improved performance and battery life • Custom apps can communicate with other 3rd party apps	• Windows Phone 7 devices are not Windows Phone 8 compatible • Apps targeted for Windows 8 are not backwards compatible • Impact of Windows 10 unclear

Table 5 – Windows Phone Pros and Cons

There are other prominent mobile platforms in use today, and the lack of their inclusion is neither a slight nor an expression of opinion as to their value or future potential. We have simply chosen to condense our preliminary discussion to three of the more prominent platforms in widespread use today. At this point we will shift gears and begin discussing the elements of an effective Enterprise Mobile Strategy.

Enterprise Mobile Strategy

Although many firms have headed down the mobile path, not all of them have an effective Enterprise Mobile Strategy, other than perhaps

'everyone is doing mobile, we need to do mobile' as a central theme. As with any other promising technology investment, it is critical to couple the integration of new technology techniques and capabilities like mobile computing with the broader strategic direction of the organization. To do otherwise is to dilute both the organization's progression against their enterprise-wide objectives and the potential of the technology itself. The inverse is also true – business strategies should be evolving along with customer attitudes, expectations, and perceptions of product offerings. In the digital age, it is hard to ignore the changing mobility dimensions of customers and competitors alike.

> *"Fewer than half of all enterprises have clear mobile strategies in place"* [viii]

Hopefully the organization already has an effective and robust Enterprise Architecture practice, designed to help the firm adapt and capitalize on disruptive technologies like mobile. If the environment is endemically brittle, introducing and/or exploiting mobile computing won't be much easier than introducing other disruptive technologies into the firm's operating ecosystem, such as Social, Cloud or Big Data. Having a 'mobile device friendly' website may have been sufficient several years ago, but the inordinate pace of processing power availability, increasingly higher wireless bandwidth levels, and growing sophistication of alternatives available to end-users and competitors alike is driving change at an unprecedented rate; a rate that many organizations find themselves ill-prepared to effectively catch up with, let alone keep up with over time.

However, many organizations are actually succeeding quite well in the mobile computing space – both 'high-tech' oriented firms, as well as entities that use mobile technology to deliver other types of goods and services to their consumers. Those companies tend to have an effective and intentional Enterprise Mobile Strategy. For the balance of the paper, we'll discuss a few key elements found in such strategies – strategies that reflect and integrate the potential of mobile computing as a critical competitive tool that is designed to advance the organization's goals. Consider the following observation Dirk Nicol makes:

> *"Mobile devices, including smartphones and tablets, are transforming the way enterprises do business both inside the company and with customers and partners.*
>
> *In every interaction between you and your customer, the customer is armed with unprecedented computing power, information, and social and contextual insight at their fingertips.*
>
> *Those companies that fail to change the way they operate run the risk of losing to their competitors. As a result, enterprises need a comprehensive mobile strategy"* [ix]

Align Mobile with the Enterprise Strategy

It is easy to get caught up in the 'wow factors' and 'coolness' of mobile technology when trying to establish or refine the Enterprise Mobile Strategy. While not trying to stifle enthusiasm or limit innovative creativity, it is critical not to underestimate how complex delivering high quality mobile solutions is. As a starting point, consider the mobile strategy pointers in Table 6. All of them are intuitive and reasonable, but a surprising number of companies overlook them on a regular basis.

Top 10 Enterprise Mobile Strategy Considerations	
• An App is not a strategy	• Mobile is not a 'bolt on'
• Avoid the Wild West of app development	• Build apps that move needles
• Mobile Device Management is not a silver bullet	• Focus on innovative use cases
• Use visualization to drive innovation	• Incorporate ideas from other industries
• Simple apps for the complex enterprise	• User Experience can't be an afterthought

Table 6 - Top 10 Considerations for an Enterprise Mobile Strategy [x]

The eleventh item to be considered is the alignment of the mobile strategy with the broader business strategy, goals and objectives of the enterprise. For the 'greater good' of the organization, it is important to have a structured dialog around the development and evolution of the mobile strategy as an objective means to an end, rather than as the end in itself. You can use your current Enterprise Architecture Framework process to align mobile technology just as you would with any other form of strategic technology investment.

If you'd like something a little more lightweight, here's a simple tool you can leverage to help quickly structure the company's mobile computing point of view and strengthen its relationship to organizational goals. For each of your organization's strategic business drivers, such as the ones listed in Figure 7 below (e.g. Growth, Brand Perception, etc.), complete the following three statements by filling in the [blanks] as they pertain to your unique situation:

- Our mobile strategy aligns to our _____ strategy in the following ways: _____

- The value of our mobile strategy's impact on our _____ strategy will be measurable, demonstrated on a/an _____ basis by the following metrics: _____

- The impact on our _____ strategy by not addressing it as part of our mobile strategy would be _____
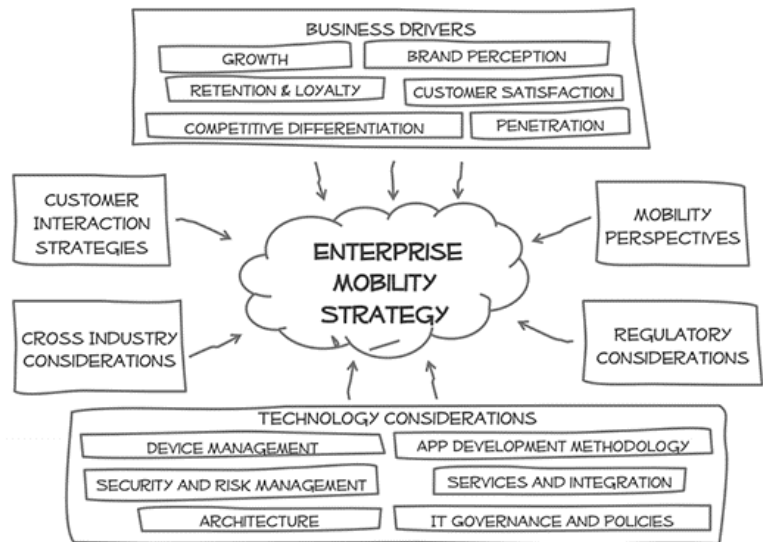
Figure 7 - Enterprise Mobility Strategy [xi]

Help direct the conversation to maintain a healthy vision and meaningfully challenging position without making outrageous statements driven by too much 'mobile' hype. The strategy should make sense to 'C' level executives across the board, not just the CIO or CMO. For example, if the mobile strategy will be providing economic benefits, such as increased revenue or reductions in operating costs, be sure to indicate both the scalar impact (e.g. is the impact £100 or £100M?) and the expected time period needed for the benefit to be realized. Be prepared to challenge highly optimistic monetary results with sound economic and financial reasoning that would pass the scrutiny of the internal financial controllers.

Use your organization's track record of adopting and integrating new and vastly different technology stacks into the legacy IT environment as a means of challenging overly optimistic speed to market assumptions. If the mobile strategy depends on monetization of the mobile app itself, keep in mind that the 'app for sale' model is steadily declining, as consumers are already able to obtain hundreds of thousands of free apps today. Two sobering predictions from Gartner should weigh into the value proposition of your Enterprise Mobile Strategy: [xii]

- 94.5% of downloaded apps will be free by 2017

- Less than 0.01% of consumer mobile apps will be considered a financial success over the next 4 years

Even if the estimates are off by as much as 25%, it is clear that monetization of the firm's mobile computing capabilities will have to be carefully thought out. If the mobile strategy is more of a non-fiscal play, such as channel enablement to augment or maintain positive brand perceptions, then it is even more critical to demonstrate how the mobile strategy ties back to enterprise goals.

Lead, Follow or Get Left Behind

According to their on-going research, the team at eMarketer anticipates about a 12% increase in mobile phone users worldwide over the next few years, growing from 4.6 billion to 5.1 billion users. During that same time frame, the Smartphone user population will grow at an even faster pace – going form 1.8 billion devices to 2.5 billion devices, which represents a staggering 43% growth rate. That means that the velocity of Smartphone growth will be 3½ times that of mobile phone growth around the globe. At that projected pace, by 2017 nearly 70% of the world's population will have a mobile phone, half of which will be 'smart'. [xiii] Depending on the demographics of your customer base, the odds are good that the majority of your existing and targeted consumers are already well connected or will be shortly.

With this in mind, successful organizations need to formulate an intentional mobile strategy that positions them as either a market leader, a market follower, or a market laggard. It is certainly easy enough to declare a desire to be a leader in this space, but as many have discovered, it is more difficult than it looks. Experiences are continually shaping customer expectations with mobile applications all around you and your company's mobile offerings (or the lack thereof). These experiences come from current competitors, unanticipated competitors, and totally unrelated sources, such as mobile social sites or highly contextual interactions that leverage knowledge about the device's location in real time.

Most firms want to come out publically and claim their intentions of being a market leader in the mobile space, wanting to avoid any stigma attached with merely following the field, or worse being perceived as a laggard. No matter which path is chosen, it is highly recommended that the company make a thoughtful and intentional decision regarding how aggressively they will pursue their mobile strategy. This includes ensuring the business case supports the end state and that there is a willingness to invest appropriately in talent, tools and initiatives. Mark Raskino shares some valuable lessons learned at Marks & Spencer, Bed Bath and Beyond and Morrisons in Figure 8.

It Matters Now	Mind the Competition	Effort Required
• What you do NOW in the early years of (physical) digital business matters more than you know • If you procrastinate, you are setting up deep problems later on • The market experiments, learning and capability development you need to do are not expensive or risky – compared to the long term health effects of inaction	• Ignoring your industry peers is a mistake. • Once some of the others get going you must move with the pace setters • You can't catch up quickly later just by throwing money at the problem • Its not just a matter of tech investment - Hearts and minds must be won and shifted	• You can't catch up by just acquiring your way into new capabilities • Acquisitions are often a poor fit or fall apart

Figure 8 - Lessons Learned by Digital Business Laggards [xiv]

Figure 9 highlights the important fact that there are three dynamic adoption curves to consider: (1) Your Customers, (2) Your Competitors, and (3) Your Organization. While not advocating the high risk associated with being on the leading edge of innovation unless that truly fits your business model, it is clear that the your competitors, as well as your target customer base are both on their own 'mobile adoption' path, regardless of where your organization is. Consumers have an amazing array of digital capabilities at their disposal outside the context of your organization's relationship with them. With that broad exposure to mobile technology comes a very demanding set of expectations – prototypes that may wow internal executives in conference rooms and employees during in-house demonstrations may elicit a mild yawn or sigh of ennui from today's digital customer. The longer an organization waits, the better their mobile offering needs to be in order to regain mobile consumer market share from other solution providers.
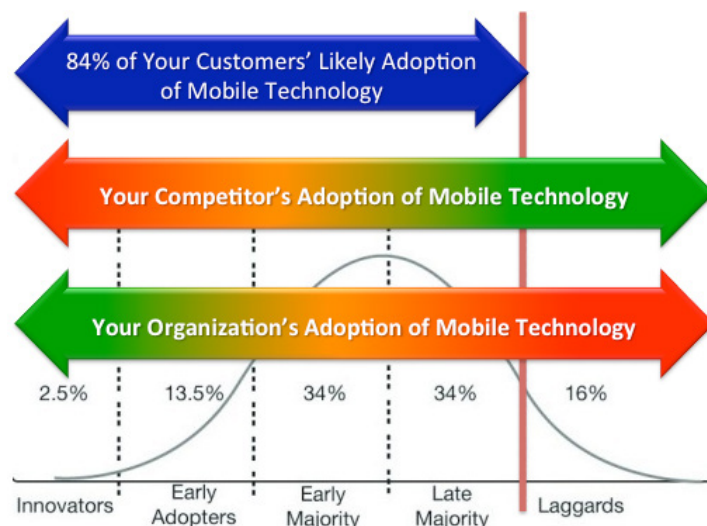

Figure 9 - Competitive Advantage for Early Movers

If we apply Rogers' Diffusion of Innovation adoption curve, more than 80% of your customers will have adopted mobile computing technology by the time the 'Late Majority' gets connected. [xv] The corresponding pace of your competitor's mobile offerings designed to reach your digitally-enabled customers represents potentially bad news for you the farther they are to the 'left' of the curve relative to being 'Innovators'. The opposite is also true; the farther to the left your organization is in terms of mobile computing offerings, the better for you and your customers than it is for your competitors. Each organization will have to weigh up the danger of starting too soon or too late, given their risk appetite and the potential value that will be generated from their mobile computing initiatives.

Multi-Channel Customer Experience Continuity

Another important element in an effective Enterprise Mobile Strategy is the recognition that consumers don't want to be bound to any particular channel, whether it be mobile, online, voice or physical location. Mobile solutions that are not integrated with the rest of the firm's operational channels make for a poor user experience and may become a disincentive to consumers that want or need to continue a 'conversation' across service delivery or communication channels. We've all experienced the situation where we call a company in regards to an issue, providing all of the necessary identification and situational details, only to be transferred to someone else, who requests all the same information, and then they transfer us again, where we provide the same information again, and the cycle seems to go on ad nauseam. Be mindful that you are not inadvertently introducing a disconnected experience for your targeted mobile consumers.

Smartphones are the most common starting place for online activities

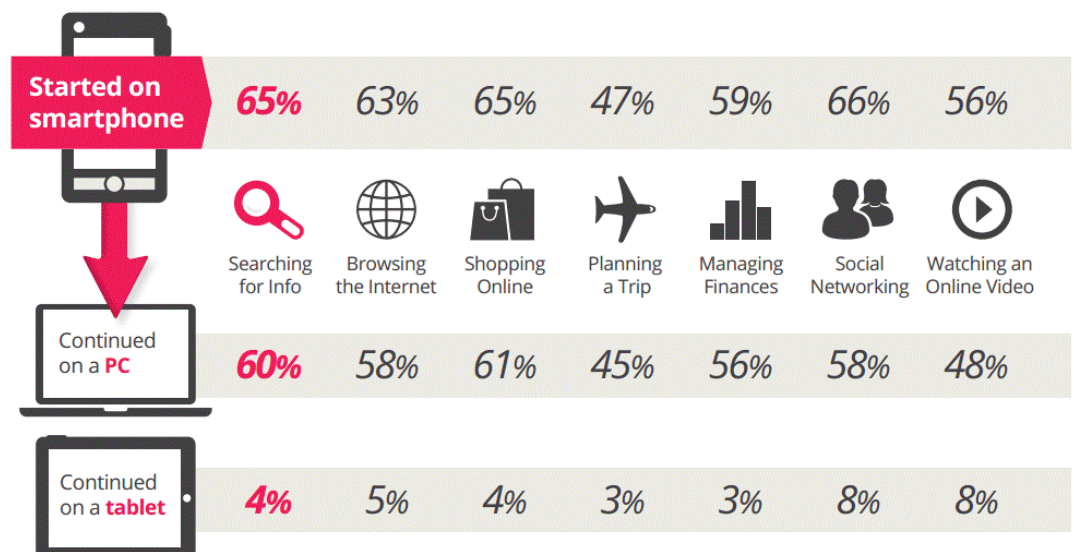|	Searching for Info	Browsing the Internet	Shopping Online	Planning a Trip	Managing Finances	Social Networking	Watching an Online Video
Started on smartphone	65%	63%	65%	47%	59%	66%	56%
Continued on a **PC**	60%	58%	61%	45%	56%	58%	48%
Continued on a **tablet**	4%	5%	4%	3%	3%	8%	8%

Figure 10 - Serial Device Activity [xvi]

It is vital that you take the time to think through the customer experience in a holistic manner in such a way that can support the consumer's decision to move back and forth between channels at their discretion. Companies that have mastered this tend to stand out, making those companies with disjointed channel support appear to be out of touch with the customer's needs. If this is an area that your company already struggles with, adding or enhancing your mobile channel without addressing this problem has the potential of making sub-optimal user experiences even worse. Seamlessly integrated consumer experiences are often complicated and typically not that easy to implement. A roadmap approach may be required to service-enable backend systems, synchronize systems of record and support active data caching to offset nightly batch processes. Introducing mobile does not solve this problem, so it is important to assess and understand the impact your mobile plans will have, not so much on the company, but on the experience of the digital consumer.

Establish a Mobile Reference Architecture

Another important element of an effective Enterprise Mobile Strategy is to establish the organization's Enterprise Mobile Reference Architecture. At this point the Enterprise Architect would work with their architectural and engineering counterparts across the organization to establish the baseline set of strategic go-to mobile tools, technologies and techniques. The reference architecture should clarify how and when each of the mobile application architecture approaches should be taken (Native, Mobile Web, or Hybrid), or not taken (anti-pattern approach), along with the associated programming languages and development environments suitable for each.

The benefit of establishing the reference architecture at the enterprise level is the amount of leverage it can provide to other delivery teams within the firm that need to add mobile computing elements to their own product portfolio. Organizations with more mature reference architecture practices will want to place the same rigor around their mobile computing tech stack as they do other platforms, providing common services and pre-built utilities to accelerate solution delivery at the enterprise level.

Figure 11 provides a sample high level Mobile Reference Architecture model. This particular example shows alignment between mobile architecture and the existing web architecture. Taking this sample model as a relative starting point, an organization would simply refactor it to meet their unique needs once technology selections have been made. Spend less time on the specific components portrayed in Figure 11 and focus instead on the different layers and their requisite capabilities. As the go-to technologies are identified, common services, components

and additional platform capabilities can be identified, created (or refactored) and communicated to the mobile development community for consumption. In the absence of establishing a reference architecture model at the enterprise level, just know that independent teams are more likely to implement a disparate combination of 'local' solutions that will inhibit reuse across the organization.
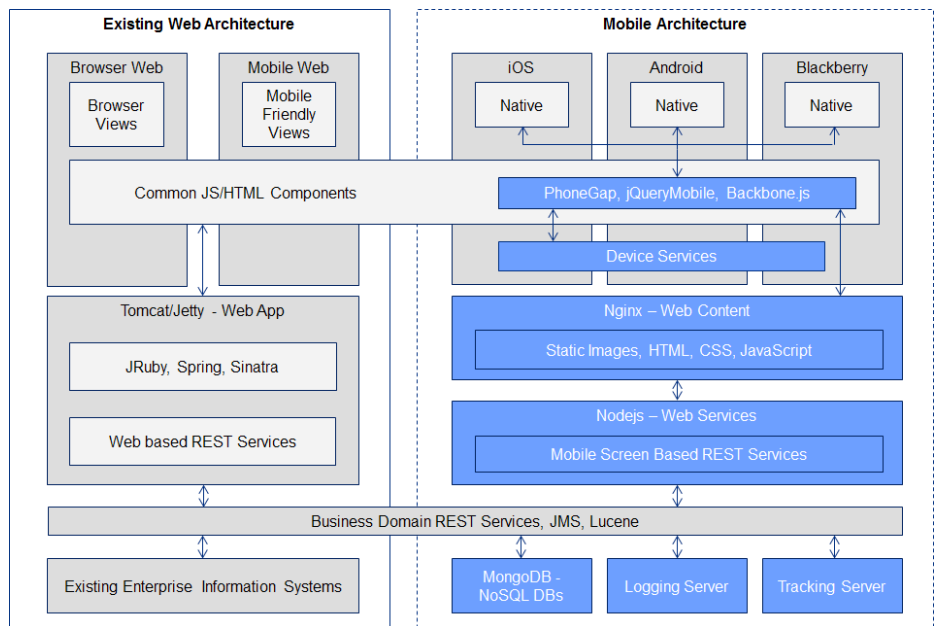
Figure 11 - Sample Mobile Reference Architecture [xvii]

It is important that the Enterprise Mobile Reference Architecture provide unambiguous clarification on the use of targeted Open Source mobile components and frameworks. Some engineers are of the opinion that Open Source rules for mobile should be 'looser' since the application runs on an independent device versus an application operating on computing resources within the organization's firewalls. While it is true that mobile apps typically take advantage of local resources, they still have a responsibility to protect their consumer on the local device, as well as interactions back and forth with the device through the organization's communication network. For this reason, mobile computing should not be immune to the organization's existing Open Source policies, procedures and vetting processes.

An example of an Open Source mobile framework is Apache Cordova. Apache Cordova provides a set of mobile device APIs that allow a mobile app developer to access native device functions with HTML, CSS and JavaScript. The device APIs provide access to physical and virtual resources, including:

- Accelerometer
- Camera
- Compass
- Contacts
- Files

- Geolocation
- Media
- Network
- Notifications
- Storage

Cordova, as well as PhoneGap, which is the Adobe distribution of Cordova, allows the mobile app to be built without the use of native code, such as Java or Objective-C. The JavaScript APIs are consistent across multiple device platforms and built on web standards, making the app generally portable to other device platforms with minimal changes. [xviii]

In Figure 12, you'll find Gartner's view on key mobile technologies and capabilities that will be relevant for the next few years. While all of these aspects may not immediately impact your organization, just know that they will be influencing your customer's mobile experiences outside the context of your interactive relationship with them. In other words, these trends will continue to shape their perceptions and, ultimately, expectations they are likely to have regarding your mobile applications available to them. For that reason, they should also be considered when establishing the organization's Enterprise Mobile Reference Architecture.

Multiplatform App Dev Tools	HTML5	Advanced Mobile UX Design

• 3x3 Future
 	
  • Three key platforms (Android, iOS and Windows)
 	
  • Three application architectures (native, hybrid and mobile Web)
 	
• Most large organizations will need a portfolio of several tools to deliver to the architectures and platforms they require
	• Fragmented and immature - poses implementation and security risks
	
	• Popularity of the mobile Web and hybrid applications will increase
	
	• Will be essential for delivering applications across multiple platforms
		• New techniques and methodologies, such as motivational design, "quiet" design and "playful" interfaces
		
		• Apps can accommodate mobile challenges, such as partial user attention and interruption
		
		• Leading consumer apps are setting high standards for user interface design

High-Precision Location Sensing	**Wearable Devices**	**New WiFi Standards**
• Accuracy of an individual's location to within a few meters • Ability to deliver highly relevant contextual information and services • Leverage technologies such as Wi-Fi, imaging, ultrasonic beacons and geomagnetics • Anew generation of extremely personalized services and information	• Smartphone will become the hub of a personal-area network consisting of wearable gadgets • Gadgets will communicate with mobile apps to deliver information in new ways, enabling a wide range of products and services	• Emerging standards will increase Wi-Fi performance • Demands on Wi-Fi infrastructure will increase (more devices, cellular offloading, denser access-point requirements) • Many organizations will have to revise or replace their Wi-Fi infrastructure

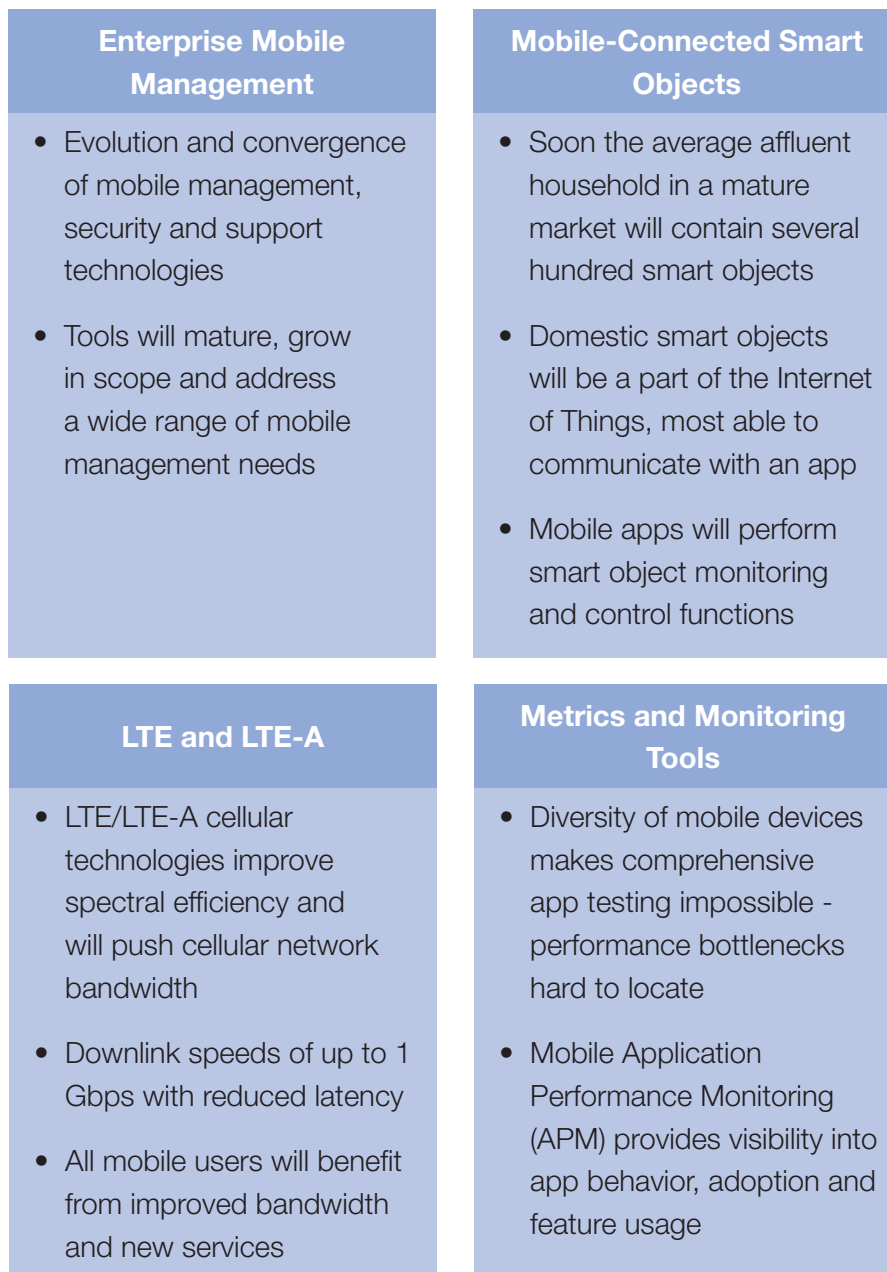| Enterprise Mobile Management	Mobile-Connected Smart Objects
• Evolution and convergence of mobile management, security and support technologies • Tools will mature, grow in scope and address a wide range of mobile management needs	• Soon the average affluent household in a mature market will contain several hundred smart objects • Domestic smart objects will be a part of the Internet of Things, most able to communicate with an app • Mobile apps will perform smart object monitoring and control functions
LTE and LTE-A	**Metrics and Monitoring Tools**
• LTE/LTE-A cellular technologies improve spectral efficiency and will push cellular network bandwidth • Downlink speeds of up to 1 Gbps with reduced latency • All mobile users will benefit from improved bandwidth and new services	• Diversity of mobile devices makes comprehensive app testing impossible - performance bottlenecks hard to locate • Mobile Application Performance Monitoring (APM) provides visibility into app behavior, adoption and feature usage

Figure 12 - Gartner's Top 10 Mobile Technologies through 2016 [xix]

Mobile Design Considerations

Mobile computing introduces a host of additional design considerations that are different from those used for other technology stacks. The level of familiarity with the uniqueness of designing applications for mobile computing will vary from company to company, depending on the skills and experience of the mobile engineering resources available. If we consider that NetHopper, Apple's first commercial mobile browser became available in 1996, odd as it may seem many organizations may find that they have 'legacy' mobile applications, and legacy-centric engineering skills to go with them. Some of the design considerations are similar as in the past, such as planning for unpredictable communication responsiveness and bandwidth, aggressive power conservation techniques and the need to secure local data.

What has changed is the level of computing power contained within the device itself, as well as numerous methods of connectivity with higher data throughput capacity. As we couple more powerful devices with more sophisticated consumers, we can appreciate the resulting digital 'mind shift' as identified in Figure 13. This mindset should influence the user stories and corresponding mobile design patterns utilized by the organization when delivering mobile solutions.
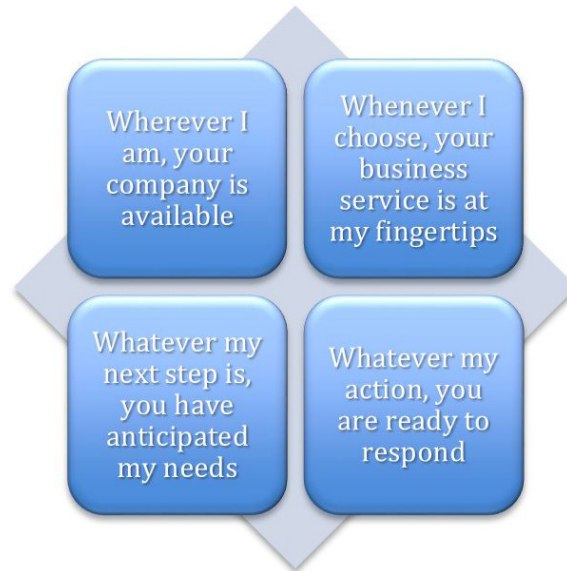

Figure 13 - Operating Principles of the Mobile Mind Shift [xx]

In addition to designing with the mobile mind shift in focus, highly successful mobile applications (often referred to as 'killer apps') are designed to add tremendous value to the end user. As counterintuitive as it may seem, these apps often don't have a massive number of functions or capabilities. That's not to say they are simplistic or limited in a negative way – the key is tapping into what the customer needs in the moment and resisting adding every bell and whistle possible. Keep in mind that no one 'tweeted' 140 character messages a few short years ago; proof that modest, innovative apps can certainly invoke new behavior on a global scale.

John McGill offers the following five characteristics of a killer app in Figure 14. There are certainly other characteristics you'll want to consider, but this list should help you begin to formulate and confirm your own point of view.
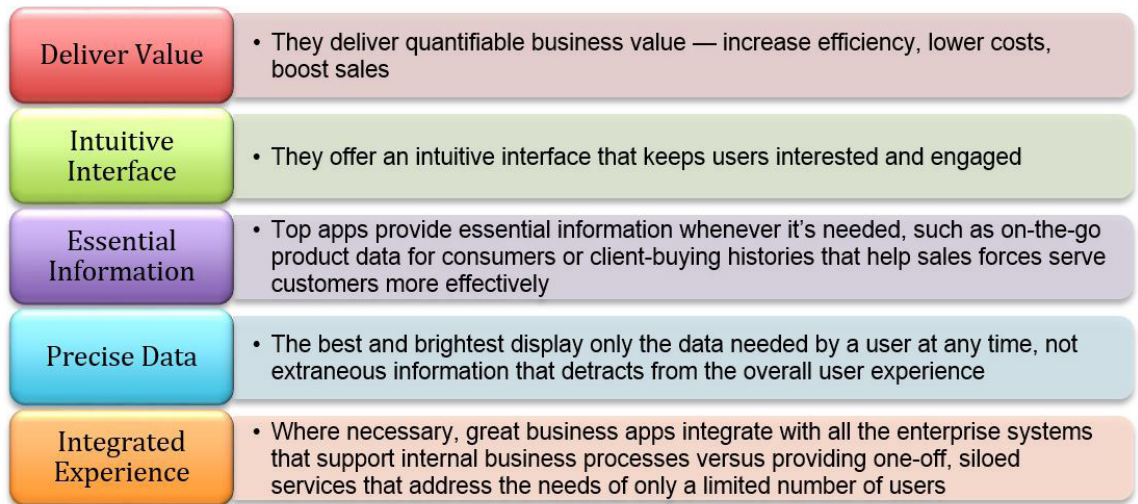
Deliver Value	• They deliver quantifiable business value — increase efficiency, lower costs, boost sales
Intuitive Interface	• They offer an intuitive interface that keeps users interested and engaged
Essential Information	• Top apps provide essential information whenever it's needed, such as on-the-go product data for consumers or client-buying histories that help sales forces serve customers more effectively
Precise Data	• The best and brightest display only the data needed by a user at any time, not extraneous information that detracts from the overall user experience
Integrated Experience	• Where necessary, great business apps integrate with all the enterprise systems that support internal business processes versus providing one-off, siloed services that address the needs of only a limited number of users

Figure 14 - Five Characteristics of a Killer Mobile App [xxi]

Before dropping into lower level detailed design, it is good to start with a higher-level point of view by answering the questions found in Figure 15. This is where the general architectural design approach will be established at a platform independent level, which will in turn influence and drive the solution's platform specific design. Due to the myriad of combinations of devices, mobile OS platforms and mobile application architectural approaches, we won't go into further detail in our discussion here. The key is for you and your organization to leverage these six design principles as a starting point to build your mobile technical strategy around.
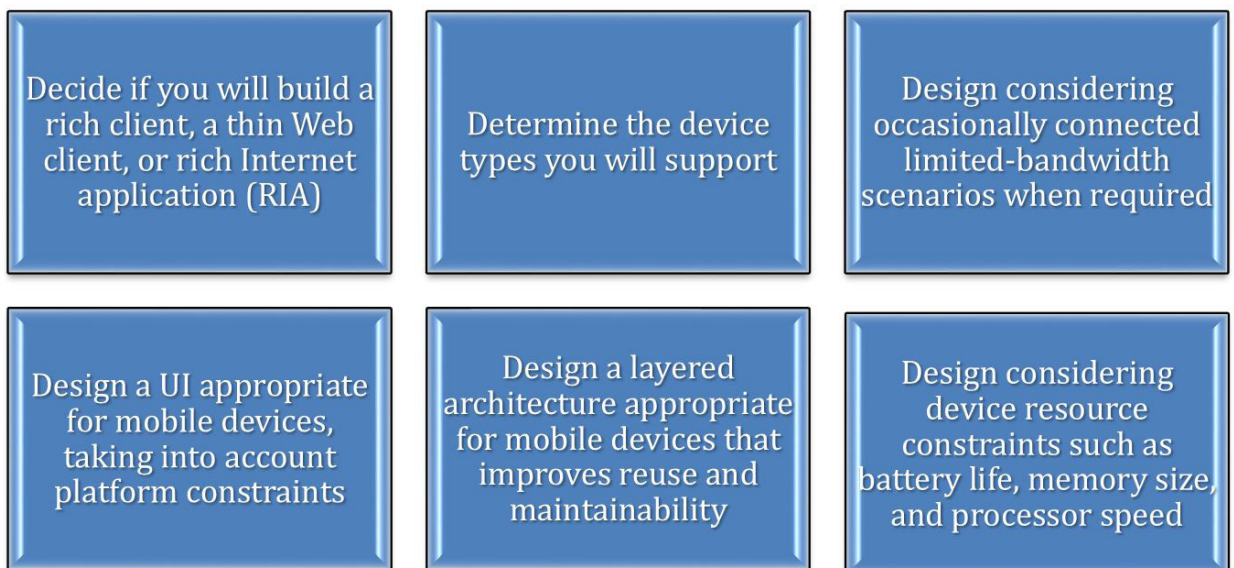
Decide if you will build a rich client, a thin Web client, or rich Internet application (RIA)	Determine the device types you will support	Design considering occasionally connected limited-bandwidth scenarios when required
Design a UI appropriate for mobile devices, taking into account platform constraints	Design a layered architecture appropriate for mobile devices that improves reuse and maintainability	Design considering device resource constraints such as battery life, memory size, and processor speed

Figure 15 - Mobile Design Considerations [xxii]

Flexibility

Speculation as to which of today's predominant mobile platforms will remain a few years from now is well beyond the scope of this document. This is a highly disruptive and fast-moving technology corridor that is subject to Taleb's Black Swan events, where something unexpected rapidly changes the landscape in unusual and unpredictable ways.

Knowing this, mobile design patterns should be built with as much nimbleness and flexibility as possible.

Organizations will have to determine the tradeoff between taking a more generalized approach, such as the Mobile Web app method for best cross-device/cross-platform compatibility at the risk of a richer end-user experience, versus a more enriched experience in a native or hybrid application approach. There are cross-platform development tools available to help minimize the level of customization across the environments. These tools continue to mature, but still may require some level of localized code customization. As pointed out earlier, it will more likely be the end user that will dictate which platforms need to be supported rather than the organization being able to successfully mandate a specific platform that consumers must adopt.

Gestures

Mobile devices have come a long way from the web-centric emulation of traditional event triggers of clicking, hovering, scrolling, and keystroke entry. Touchscreen interfaces operate on the principle of gestures – interactive behaviors between the user and the device designed to elicit some form of reaction or response by the device's applications and resources. With newer smartphones, physical 'touch' isn't always required. For example, my personal device responds to my voice, the moving of my hand over the screen in a certain directional path, and it will even pause video content playback when it detects that I am momentarily looking away. The Android operating system recognizes several gestures, including touch, long press, swipe, long press drag, double touch, double touch drag, pinch open and pinch close, just to name a few. A 2010 U.S. Patent held by Apple contains hundreds of other multi-finger gestures for such common tasks as cut, undo, paste, redo, copy, scroll, text select, text point, find, global search, global replace – many of which are yet to be implemented in iOS. [xxiii]

Part of the organization's mobile design consideration should be to anticipate new interactive behaviors, such as gestures, winks and blinks, audible sounds, wearable sensors, device shaking or inversion and so forth. In anticipation and preparation of such changes, basic encapsulation and segregation of end user behaviors from device functionality will help reduce refactoring efforts down the road. While this principle isn't terribly new or unique to mobile computing, it underscores the need to 'future-proof' mobile applications as much as possible given the rapid changes in device technology and the continually evolving human/machine interaction experience.

Device Communication Proximity Affect

One of the interesting challenges for mobile computing and application design is an awareness of the need for the device to be near a connection point, the bandwidth capability of that connection point, and how to handle the application's logic when the device flows from connection to connection in seemingly random waves. While not drawn to scale, Figure 16 demonstrates both the typical range and bitrate of the various types of connections the device is capable of. Each connection type is subject to degradation the further the device is moved from the point of connectivity. Consumers may also have dramatically different costs related to the amount of data sent to/from the device when using different communication protocols (i.e. cellular data rates from the carriers, free WiFi at a coffee shop, subscription fee-based WiFi while in the air, etc.). Applications that have high data transfer characteristics may unintentionally pose a disincentive to the consumer from actually using them, even though the app is capable of providing a very rich user experience.

DEVICE COMMUNICATION PROXIMITY SPECTRUM

NFC	Piconet	WiFi	Cellular	GPS
≈2-4 cm	≈7-9 m	≈10-20 m	≈35-200 km	≈global
≈.4 Mb/s	≈2.1 Mb/s	≈.3-1.3 Gb/s	≈.1-325 Mb/s	≈50-1k b/s
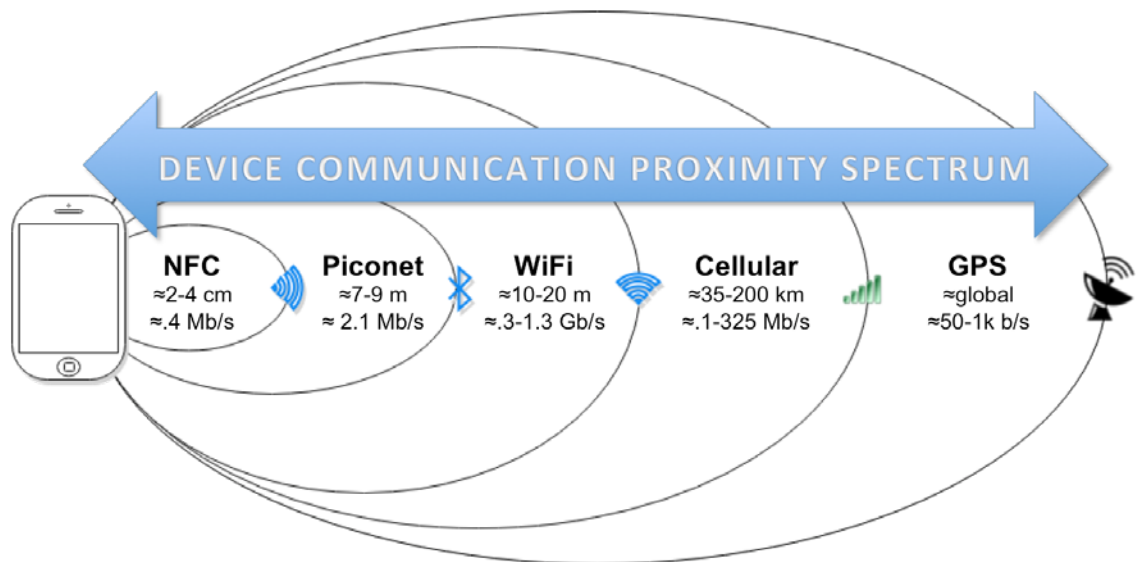
Approximate Range and Bit Rate per Communication Standards
Performance degrades as distance from connection point increases or with active device movement (stationary use versus mobile use)

Figure 16 - Mobile Device Communication Proximity Spectrum - Not Drawn to Scale

Mobile Security

The area of mobile security is broad enough to generate numerous white papers alone. We'll limit our discussion here other than to say an effective set of design considerations that are part of an effective Enterprise Mobile Strategy must unequivocally address security. Consumers are willing to put a surprising amount of personal data on their devices in applications they downloaded for free, provided by a generally unknown source. Attacks on mobile devices come from numerous sources and through various communication channels. These sources include attacks based on SMS text messages, communication

network hacks (cellular and WiFi), near-field package deployment via Bluetooth, as well as traditional sources such as the email from the venerable deposed dictator wanting to deposit a fortune in the message recipients bank account.

Mobile attacks can occur at all levels of the device's ecosystem – firmware, operating system, the browser, and other applications. This means your mobile app not only needs protection for its own resources and sensitive data, it has to protect itself from potential hacks from all directions. If that weren't enough, you also have to ensure that all communications between the consumer's device and your organization's infrastructure are secure as well. Think of all the things we've learned about vulnerability assessments and penetration tests on the web, and now multiply that by all of the additional characteristics that distinguish mobile computing from other forms of technology.

Figure 17 - Contemporary Mobile Security Concerns [xxiv]

Figure 17 groups mobile security concerns into seven broad categories that serve as a good starting point. Organizations can leverage what they already know about information security and system hardening, extended by research into additional risks the mobile computing platform poses to both the consumer and to the enterprise. The criticality of providing a secure mobile app cannot be overemphasized to the firm's mobile engineering team. This is one time where a more heavy-handed Enterprise Architecture governance approach is warranted.

Conclusion

In this paper we've reviewed basic Mobile Application architecture and identified several elements found within an effective Enterprise Mobile Strategy. These elements are not exhaustive, but can enhance and strengthen the impact of mobile computing on the organization and its constituents. Benefits of developing and executing an intentionally articulated enterprise-level mobile strategy include:

- Advancing the organization's strategic objectives in unique ways that only mobile can

- Providing a superior mobile experience to consumers

- Enhancing cross-channel capabilities for integrated service delivery

- Positioning the organization for the coming changes in mobile technology

- Accelerating past competitors through differentiation in the mobile space

Recommended Reading

Fundamentals of Mobile and Pervasive Computing
Adelstein, Gupta, Richard and Schwiebert (2005)

Mobile Strategy: How Your Company Can Win by Embracing Mobile Technologies
Nicol (2013)

Enterprise Mobility Management: Everything You Need to Know About MDM, MAM and BYOD
Madden (2014)

Mobile Design Pattern Gallery: UI Patterns for Smartphone Apps
Neil (2014)

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