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Tutorial: Mobile BI

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Abstract:

Smartphones and tablets are ubiquitous for personal use and are increasingly employed for business purposes. When paired with business intelligence to create mobile BI, workers are able to access information wherever they are, at any time, and through a variety of devices. This use has the potential to increase employee productivity, enhance customer service and satisfaction, improve decision making, provide a competitive advantage, and improve the bottom line. Mobility can make BI pervasive throughout an organization, but it is most likely to be used by executives, mid-level and operational managers, sales representatives, and field and internal technicians. To be successful with mobile BI, we must address various issues and challenges such as creating a roadmap, getting started right, meeting user expectations, creating an appropriate technology infrastructure, designing for screen size, and providing for security. Case studies of U.S.Xpress, a leading trucking company, and GUESS, a leading retailer of clothing and accessories, provide many real-world examples of the concepts, options, and best practices associated with mobile BI. Following mainframe, client/server, and Web-based approaches, mobile BI is the fourth generation of how information is delivered.

Keywords: Mobile BI, Mobile, Business Intelligence, Analytics, U.S.Xpress, GUESS.

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1 Introduction

Smart devices such as tablet computers and smartphones are ubiquitous[1]. Forrester, a leading research and advisory firm, predicts that 257 million smartphones and 126 million tablets will be in use in the US by 2016 (Shandler & McCarthy, 2012). Smart devices are used for making calls, texting, reading email, playing games, watching videos, sharing pictures, paying bills, making purchases, and more. Many people feel lost and disconnected when they don't have their smartphone. Interestingly, the next generation of workers will have used smart devices their entire lives.

While smart devices are used primarily for consumer and personal uses, their role in business and business intelligence (BI) has been increasing. In 2003, Research in Motion (RIM) introduced the BlackBerry smartphone, and, with dark humor, this device was often called the "crackberry" because of its addictive nature. While it was a hit among business users for email, its limited screen size made it less attractive for BI (Bitterer & Sood, 2012). Interest in mobile BI grew in 2007 with the introduction of the iPhone as it quickly became the "cool" device to have. The arrival of the iPad in 2010 further drove interest in mobile BI because of its "coolness" and ability to display more information (Stodder, 2012). Later that year, MicroStrategy, a leading BI vendor, introduced a mobile BI application for the iPad and other vendors quickly followed suit (Bitterer & Sood, 2012). For companies with a BI infrastructure in place, it became relatively easy to extend the reach of BI to on-the-go workers[2].

We can easily understand the business potential of smart devices. In a typical business, thousands of decisions are made every day and many of them are made outside of the office. Many workers don't even have a company-supplied office any more. Decisions are made on the road, in warehouses, with customers, and in airport lounges (Bitterer & Sood, 2012). For example, it can help a traveling executive monitor a business problem through performance metrics delivered on a dashboard or provide a smartphone alert to a quality control manager that the percentage of defects in a production run exceeds the acceptable limit. Providing mobile decision support can create many benefits, such as increasing employee productivity, enhancing customer service and satisfaction, improving decision making, providing a competitive advantage, and improving the bottom line (Yellowfin, 2011).

A driving force behind mobile BI is not mobility itself (Yuen, 2013). Rather, it is the ease of use, engaging user experience, convenience, and fast access to relevant and timely business information. These are the same attributes that are associated with popular consumer apps. Mobile BI is a perfect example of the consumerization of information technology (IT), wherein work-related IT expectations are based on experiences with personal devices and applications (Stagliano, DiPoalo, & Coonelly, 2013).

The importance of mobility and mobile BI is reflected in many surveys, projections, and top trends lists. For example, Forrester has mobile applications for both customers and workers at the top of its technology trends to watch in 2014-2016 (Hopkins, Owens, & McCarthy, 2013). In a recent Computerworld survey, mobility ranked higher than any other technology in terms of competitiveness and long-term sustainability of the enterprise (Computerworld, 2014; Symantec, 2014). Another leading research and advisory firm, Gartner, predicts that, by 2015, over 50 percent of mobile users will rely exclusively on mobile devices for insight delivery and the number of BI users will grow by 20 percent (Yuen, 2013). Figure 1 illustrates mobile BI on smartphones and tablets.

This tutorial defines mobile BI, explores how it is used, and discusses the issues, challenges, and possible solutions associated with successfully implementing mobile BI in companies. The latter includes getting started correctly, meeting users' expectations, implementing an appropriate technology infrastructure, designing effective screens, and ensuring security. I provide case studies of U.S.Xpress, a leading trucking company, and GUESS, a leading retailer of clothing and accessories. The cases provide many real-world examples of the concepts, options, and best practices associated with mobile BI. The tutorial concludes with an appendix that traces four generations of how information is delivered: mainframe, client/server, Web-based, and now mobile.

[1] Laptop computers are sometimes considered mobile devices. When it comes to BI, they are more like desktop systems, and I do not include them in this tutorial on mobile BI. There are other smart devices such as "wearables", but they have little applicable to mobile BI and I do not discuss them either.

[2] At the present time, Apple iOS and Google Android devices dominate the mobile BI scene. Of all of the app downloads, only four percent belong to Microsoft Windows and three percent to BlackBerry devices (ABI Research, 2013). While vendors support Apple and Android devices, support for Windows and BlackBerrys is less common. As a result, I focus on Apple and Android devices, but most of the concepts are applicable to other vendors' devices.

Figure 1. Mobile BI on Smartphones and a Tablet (MicroStrategy)

2 Mobile BI Defined

Most definitions of mobile BI include the ability for users to access information wherever they are, at any time, and through a variety of devices (Yellowfin, 2011). In addition to mobile BI, the terms mobile analytics, and less frequently mobile decision support, are sometimes used[3]. Regardless of the terminology, mobile BI has the potential to help fulfill the 40-year promise of DSS/BI/analytics to provide decision makers with the information they need, when they need it, and wherever they are to improve organizational efficiency and effectiveness.

Moreover, mobile BI is not limited to use on the road or out in the field (i.e., location independence) (Yellowfin, 2011). For example, a manager in a meeting down the hallway might access information on a tablet, which also illustrates the importance of device independence: users should be able to access information through a variety of devices.

Smart devices can do more than extend the reach of BI. Through cell tower triangulations, GPS, or WiFi networks, one can identify users' location. With this location information, one can send location-aware information (i.e., context dependent) that better meets users' needs. For example, before a sales visit, a sales representative could access a report about that customer and information about other customers in the area. Smart devices can also be used to create useful information. For example, a smartphone picture taken of a competitor's new window display might be helpful to a regional sales manager (Bitterer & Sood, 2012).

3 How Mobile BI Is Used

In a study conducted by The Data Warehousing Institute (TDWI), executives, managers, information technology (IT) and BI managers and professionals, and consultants were asked to provide information about mobile BI in their companies (Stodder, 2012). The findings, along with other studies, provide

[3] For a discussion of the decision support field and its naming, see Watson (2009). Power (2007) provides a more comprehensive history of the field.

insights about who the users of mobile BI are, the kinds of information provided, the information access and business benefits, and where mobile BI is being used.

3.1 The Users

It is fairly easy to identify the potential users of mobile BI: employees who spend time outside of the office or away from their desks and need information to perform their jobs (Eckerson, 2011). Workers who are normally at their desks can usually be better supported through desktop BI.

Senior executives (e.g., CEO, CFO) are at top of the list of mobile BI users (Stodder, 2012). They have considerable travel and a constant need for reports, dashboards/scorecards, and other information about the business. They are normally experienced with BI and understand its value in running the company. Mid-level and operational managers are also strong candidates. They may not travel as much as senior executives, but they need to monitor the performance and operations of the business. They typically need additional detailed and real-time data to perform their jobs.

Sales representatives are another high-value target for mobile BI. They need up-to-date information prior to meeting with customers and should be able to access sales-related information (e.g., past orders) during meetings. Their information requirements call for timely and detailed data in addition to historical and summary information.

Both customer-facing and internal technical support personnel should have access to mobile BI. They need to be able to check on the status of work requests, access previous work records, check inventory data, submit work orders, and so on. They benefit from reports, dashboards/scorecards, querying capabilities, and alerts. Table 1 summarizes the most likely users of mobile BI, their need for mobility, their mobile-related tasks and information requirements, data needs, and their need for mobile BI.

Table 1. Mapping Users to Mobile BI Requirements (Eckerson, 2011)

Type of user	Mobility	Mobile BI tasks	Data	Need
Executives	Travel to and from customer and work sites: Nights/weekends	**Dashboards**: check KPI status with simple drilldown and time-series views **Dimensional reports**: 360-degree views of customers, employees, suppliers, projects, etc.	Historical, summary	High
Mid-Level managers	Travel to and from conference rooms	**KPI dashboards**: check status with simple drill down and time-series views **Project reports**: timelines and details	Historical, summary, detail	Low
Line managers	Supervise domain by walking and talking	**Dashboards**: monitor store and employee performance **Operational reports**: check inventory, shipments, complaints, staffing **Actions**: scan inventory, order products, schedule meetings, award merits/demerits, etc.	Historical, summary, detail, real time	High
Outside salespeople	Travel to and from clients	**Dimensional reports**: 360-degree view of customers sales/interactions **Actions**: update customer records, submit orders	Historical, summary, detail, real time	High
Field technicians	Travel to and from customer/work sites	**Dashboard**: review personal performance and bonus points **Reports**: check customer records, submit orders **Actions**: update customer/work site records, submit orders	Historical, summary, detail, real time	Moderate
Internal technicians	Travel across corporate campus: Nights and weekends	**Dashboards**: view KPI status and real-time trends **Alerts:** view errors and exceptions **Actions:** log in, trouble shoot	Historical, summary, detail, real time	Moderate

3.2 The Kinds of Information Provided

Mobile BI provides information that typically falls into the following categories (Yellowfin, 2011):

- **Push/scheduled reporting***:* to illustrate, a sales manager might be sent a report every Monday morning on sales for the previous week. An executive might be sent a weekly dashboard that shows KPIs on product quality metrics.
- **Pull reporting**: users select the information and the filters they want to apply and the specified information is returned to them. For example, a marketing manager might want to see the top five customers based on past month sales.
- **Exceptions and alerts**: users proactively receive information about unscheduled events and incidents. For example, a sales rep might get an alert that an item in inventory is low and should not be promoted in any of the day's sales calls.
- **Sharing:** users can share information (e.g., reports), add commentaries, ask questions, and give directives. For example, a regional sales manager might send a graph showing sales by region to a subordinate and ask the subordinate to investigate why sales are below quota.

3.3 Information Access and Business Benefits

The TDWI study also provides insights about the access to information and business benefits that organizations seek when implementing mobile BI (Stodder, 2012). As Table 2 shows, giving executives faster and easier access to information heads the list (with 83%) of information access benefits. Executives can quickly and easily download and use an app or a browser to access information. The apps are designed to make it easy to find specific information. Next on the list is easier self-service access to data sources (67%). With well-designed apps, users are automatically connected to the right information. Users can also personalize their experience by deleting options and features without having to engage IT. Third, users can access timely information to support their roles in business processes or operations (54%).

Table 3 shows the business benefits that organizations seek in implementing mobile BI. At the top of the list is improved customer sales, service, and support (with 65%). Many employees in these sales-related roles have never had ready access to the kinds of information provided by mobile BI, such as reports with data and analyses of both a single customer's issues and trends across customers that can be used to enhance interactions. Next is more efficiency and coordination in operations and business processes (60%). Workers are more efficient if they do not have to spend time looking for information. Poor information flows can cause delays and raise costs in supply and demand chains.

Table 1. The Information Access Benefits from Mobile BI (Stodder, 2012)

Information access and business benefits	Percentage of Firms
Give executives faster and easier access to information	83
Easier, self-service access to data sources	67
Right-time data for users' roles in processes or operations	54
More frequently updated information for all users	51
Improved data visualization and graphical presentation of data	51
Unified information access to structured and unstructured information	35
Secure access to carefully governed information	32
Based on 1,527 responses from 406 respondents; about 4 responses per respondent, on average.	

Table 2. The Business Benefits from Mobile BI (Stodder, 2012)

Information access and business benefits	Percentage of firms
Improved customer sales, service, and support	65
More efficiency and coordination in operations and business processes	60
Faster deployment of BI and analytics applications and services	50
Customer self-service benefits (e.g., decreased contact center costs	45
Financial performance accountability and transparencies	36
Increased business use of messaging and internal/external social networks	27
Improved supplier or partner performance in supply and value chains	23
Regulatory compliance and governance	13
Based on 1,306 responses from 406 respondents; about 3 responses per respondent, on average.	

3.4 Where Mobile BI is Used

Though the potential of mobile BI is great, the promise is still greater than the reality in most firms. The TDWI study found that, in the majority of the companies studied (53%), less than 10 percent of current BI users performed some or all of their work on mobile devices (Stodder, 2012). Only 3 percent of the companies had adoption rates of over 75 percent. Not surprisingly, the adoption rates were higher in firms that have already had a high percentage of BI users in general. These firms view mobile BI as part of a strategy of "democratizing" the organization's data and expanding BI and analytics to a wider population of users (Stodder, 2012).

A study by Dresner Advisory Services found that small firms (1-100 employees) have the highest adoption rates for mobile BI (Dresner, 2012). Small firms are more agile than larger ones and are able to adapt to market conditions quickly. They have a high degree of cultural readiness for mobile BI because they use and are comfortable with mobile technology. The study also found almost twice as many small businesses as mid-size and large organizations view mobile BI as "critically important".

4 Issues, Challenges, and Potential Solutions

In any case, mobile BI still faces challenges that have to be successfully addressed to fully realize its benefits. These challenges include creating a roadmap, getting started right, meeting user expectations, designing for screen size, creating an appropriate technology architecture, and providing for security.

4.1 Creating a Mobile BI Roadmap

While companies should develop their own roadmap for introducing and evolving mobile BI, a general path that many organizations follow does exist. As Figure 2 shows, companies often begin by enabling access to existing reports, dashboards, and information-querying capabilities (Gutierez, 2013). This is usually done relatively quickly by either using an existing BI platform or acquiring software specifically for mobile BI.

At the next stage, companies use mobile BI to engage, collaborate, and share. The social nature of mobile devices is used to bring in new users, who, along with existing members, communicate and share information regardless of their physical location.

In the third stage, companies use the unique features of mobile devices to create new capabilities and applications. For example, because of smart devices geo-location capabilities, companies can provide context-aware information, such as performance metrics for a store that a regional sales manager is planning to enter.

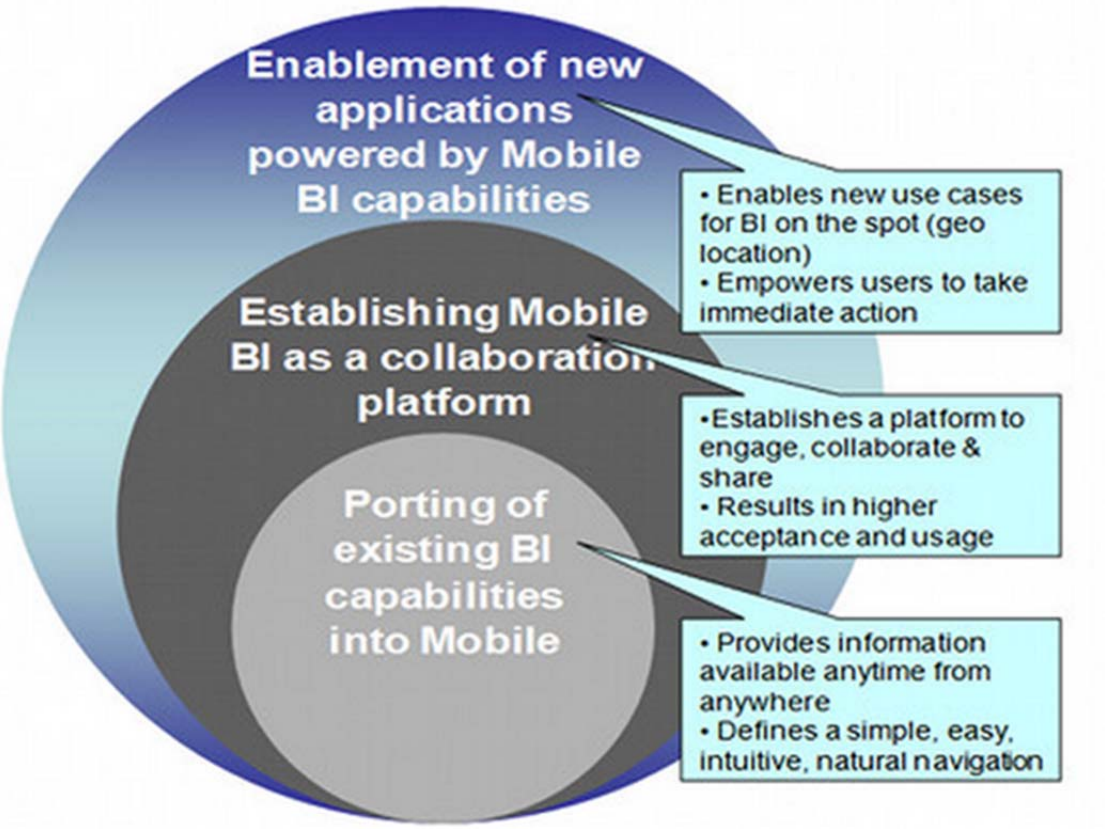

Figure 2. A Mobile BI Roadmap (Gutierez, 2012)

4.2 Getting Started Right

A company's first mobile BI project needs to be successful; if not, a second opportunity might not present itself soon. An engagement by Capgemini, a consulting firm, provides a good example of a successful first project and best practices (Capgemini, 2011). The client was a major consumer products company in North America, and the top 50 executives were seeking immediate access to sales data. The executives were already receiving sales data, but it was in weekly Excel spreadsheets. They needed more timely data that was better displayed and available wherever they were.

The fact that there was a well-defined business need was important. Projects should be business rather than IT driven. Consulting firms often talk about identifying the "organizational pain" to ensure that a project is truly needed. It was also helpful that the project was mobile-enabling an existing reporting application because it was possible to take advantage of the people, processes, and data already in place. The users and the developers were also on "the same page" about what was needed. Also, a project that involves executives is a great starting point. If they are pleased with the project, they are in a position to drive mobile BI forward.

At the time of the engagement, the executives were not familiar with mobile BI, and many of them had only recently been issued a tablet. Rather than spending weeks working on an initial design that might not meet the executives' needs, the consultants immediately held a workshop and showed the users three different options for how the information could be displayed. Based on the feedback, the consultants developed a set of four sales reports.

Users typically have a difficult time articulating their information needs, especially if they are unfamiliar with BI or if the application or technology is different from what they have used before. For this reason, a prototyping/agile design methodology is strongly recommended (Ambler, 2014). It is best to give users something to react to and then iterate the process until consensus is reached on the final design.

The consultants initially rolled out the sales report to a pilot group of executives who gave feedback that led to further refinements to the app before it was given to all the executives. By having a pilot rollout, the

consultants could identify possible problems and issues and correct them before introducing it to a wider audience.

The app also met a specific, targeted need. Indeed, users find apps that try to do too much to be too confusing and difficult to use (Kapustka, 2014). Users will give up after a click or two if they don't find the information they want. Simplicity should be the goal of the user experience. Getting the user interface right is the most challenging aspect of mobile application development (IDG & CDW, 2014).

The app also needs to be developed quickly (Kapustka, 2014). If it isn't, line-of-business managers who need the app are likely to look outside the firm to get it developed, which can result in a mishmash of apps created with different technologies and code that create long-run problems.

It is important to market an app to the target user base before, during, and after its rollout (Kaneshige, 2014a). For example, a sales-oriented app might be promoted at an annual sales meeting, or company social media might be used to create interest. Because an app can have an initial spike in interest and then a decay in usage, it is important to monitor usage so that actions can be taken to investigate and hopefully correct any problems.

4.3 Meeting User Expectations

Mobile BI makes BI more pervasive. Some users will experience BI for the first time; for others, even seasoned BI veterans, receiving BI-related information on their smart devices will be a new experience. While the BI experience is new, all users are essentially familiar with smart devices (especially smartphones) and have expectations about how applications should look, work, and feel. Workers expect the same experience with workplace-oriented apps as they do with consumer-oriented ones (Bock, 2014). For example, they expect gestures such as swipes and taps to do certain things, and they expect fast response times.

Developers should understand that the bar for apps is set by consumer apps, not corporate ones. If companies do not have developers with the mindset, skills, and experience in developing mobile apps, they may need to go outside the firm for the necessary talent.

Because of user expectations, companies should carefully think about how BI apps are developed. Many companies often treat mobile BI as an extension of desktop BI. With this approach, traditional BI content is reformatted and sent to mobile devices. This approach is problematic. A sophisticated, graphics-heavy screen may look and work great on a desktop computer but be questionable on a tablet and impossible to read on a smartphone.

Gartner has predicted that, by 2015, over 50 percent of mobile users will rely exclusively on mobile devices for receiving BI content (Information Builders, 2014). Because of projections like this, some people recommend a mobile-first approach in which content is first developed for mobile consumption and then later expanded to meet desktop users' needs (Information Builders, 2014). This line of thinking is especially appropriate for smartphone "information-snacking" applications with which users simply want precise, focused information that answers specific questions. It is similar to using a smartphone weather app to simply see the current temperature and whether is likely to rain.

4.4 Mobile BI Architecture

There are different possible architectures for mobile BI. Some firms implement in a "greenfield" environment where there are few constraints on the architecture and companies have maximum flexibility. For example, they have options in terms of how apps are developed, what software is used, what data storage devices are employed, and whether the data is stored on-site or in the cloud.

The most common situation adds mobility to an existing BI environment. When this is the case, it is highly likely that the firm's BI software vendor already has a mobile BI module that is part of the vendor's BI platform. For example, MicroStrategy offers MicroStrategy Mobile, and IBM Cognos has Cognos Mobile. There are good reasons for extending mobile BI onto the existing architecture, including cost and ease of development.

At a high level, there is normally a three or four-tier architecture for mobile BI. Users access information through a tablet or smartphone. The information is prepared by either a native app (discussed in next paragraph), which is analogous to a "fat client" or a Web server in the case of Web-based apps. The BI

platform's application server performs the analyses called for by the app. It communicates with a backend database for required data.

One of the most interesting and important architecture decisions is whether to develop native or Web-based apps. A native app is standalone software that is designed and optimized to run on a specific mobile device platform, such as an iPad (Borg & White, 2013). Such apps are downloaded to users' smart devices, just like consumer apps. Depending on the smart devices' vendor/operating system, a user goes to a marketplace, such as the Apple App Store for Apple/iOS apps or Google Play for Adroid apps[4], to obtain the apps. Because the apps are created for a specific platform (i.e., hardware and operating system), it can be designed to use all the features and capabilities (e.g., swipes, local storage) that workers expect and need.

Web-based apps (also called browser-based) run in a Web browser window like on a desktop computer (Borg & White, 2013). The apps can be designed in a way, however, that the browser window is embedded in the app and does not appear and the app is accessed as an icon on the user's screen. While users love native apps, they are more challenging to develop. Companies must either have the development personnel and skills in-house or outsource the work[5].

In contrast, companies typically have people with considerable experience developing Web-based applications who can quickly pick up developing mobile apps. These apps can run on any device with a standards-compatible browser (e.g., Internet Explorer). It is likely, however, that screens designed for desktop BI will have to be at least minimally redesigned (the form factor) to accommodate the more limited "real estate" (i.e., screen size) of smartphones and tablets.

Another disadvantage of native apps is that they need to be developed for every device/operating system that management decides to support[6]. By comparison, Web-based apps work with nearly all mobile devices with little or no additional work. This desirable feature is often referred to as "write once, deploy anywhere". In general, native apps take longer to deploy and tend to be more costly than their Web-based counterparts.

Native apps are designed to use a smart devices' storage capabilities by caching data and/or screens, which can lead to superior performance and allows users to access information when they are offline (e.g., while on a flight), or when they cannot get a good Internet connection. However, when sensitive data is on the device, there is a greater security risk if the device is lost or stolen.

With web-based apps, security risks are decreased because data is stored on a server rather than the device. Keeping data on the server also helps keep data in synch among all devices (e.g., desktop computers, smart devices) because current data is downloaded each time the app is accessed.

Table 4 summarizes the major pros and cons of the native app and browser-based alternatives.

Table 4. Advantages and Disadvantages of Web-based and Native Apps (Borg & White, 2013)

Mobile BI approach	Advantages	Disadvantages
Web-based	• Easier and faster to deploy • Compatible with all mobile browsers • Data consistency across devices • Greater security	• Not optimized for mobile • Less functionality • Poorer user experience • No offline capabilities
Native app	• High performance • Greater functionality • Optimized for mobile • Great user experience • Offline access to data	• Not compatible with all mobile platforms • More costly and difficult to deploy • Greater security concerns

[4] Gartner (2013) predicts that, by 2017, 25 percent of enterprises will have their own enterprise app store rather than using the Apple App Store or Google Play. The primary driver behind this trend is greater control over the apps, especially for security purposes.
[5] An IDG and CDW (2014) survey found that the percentage of mobile apps developed using internal versus external resources was split 50-50.
[6] The major devices and operating systems include Android, Apple iOS, Windows Phone, Windows Mobile, BlackBerry, and Symbian (Kaspersky, 2014).

It may seem that native apps are generally a better choice unless deployment speed and limiting costs are the major issues. There are other considerations, however, that complicate the selection decision in both the short and long run. HTML5 is the latest version of HTML. It is still evolving and incorporating features (e.g., the ability to provide a touch-centric graphical interface and local storage) in native apps that make them so appealing. To date, HTML5 cannot deliver as great a user experience as native apps, but this may change over time.

A recent study by the Aberdeen Group, a BI research company, found that companies are selecting native over Web-based apps by a 2:1 ratio and that this ratio rose when compared to an earlier study (Borg & White, 2013). The study also found that companies with native apps did better than those with Web-based ones in terms of the ability to drilldown on data; support real-time data feeds; provide an ability to annotate, collaborate, and share; and provide automated alerts.

In a perfect world, apps would be built once and deployed on any supported device and still have all of the features associated with native apps. This desire has led some app developers and vendors to take a hybrid approach that combine aspects of the native and Web-based alternatives (Eckerson, 2011; Stodder, 2012). For example, an app may be built using a cross-platform integrated development environment (IDE) that employs industry standards such as HTML5. After the core application is built, developers "tweak" it (i.e., write code in the native language) for use on different devices and operating systems so the devices' features and capabilities are more fully used. For example, small amounts of data may be cached on the device to improve responsiveness and support offline access.

Many software vendors offer a variety of technology options and approaches for developing, implementing, and maintaining mobile BI apps. All of the vendors support the Apple iOS platform and nearly all of them support Android devices (Howson, 2014). There is a growing trend for vendors to provide pre-built apps for particular industries and applications, especially for line-of-business managers.

In most cases, mobile BI apps connect to databases, data marts, data warehouses, or operational systems (Stodder, 2012). These data sources are typically relational, but non-relational databases (e.g., NoSQL) may be used for some kinds of big data (Watson, 2014). Some companies such as U.S.Xpress place their data for mobile BI in the cloud. Potential advantages of the cloud include fast deployment, cost savings, and the ability to handle unknown spikes in demand. Other companies such as GUESS use a columnar database to improve query performance.

Currently, most apps connect to a single data source (e.g., data mart), but Gartner has predicted that, by 2016, more than half of real-time dashboards will provide a panoramic view that provides information from multiple sources (Yuen, 2013). Adding additional data sources to a dashboard enhances decision support by providing more context for interpreting the information. For example, a dashboard might inform a product manager that sales were 40 percent below normal in the morning. This figure is disturbing, but if the dashboard also includes a notification that the corporate website experienced an outage or a competitor dropped their prices, the manager is in a better position to understand what occurred and to take action (Yuen, 2013).

4.5 Designing for Screen Size

Screen size is one of the most significance differences between desktop and mobile BI. Users need to be able to view and work in the size of the screen of their mobile device(s). What is appropriate for a desktop app probably needs to be different for a tablet and most certainly for a smartphone.

Tableau Software provides excellent tips for designing dashboards (the most prevalent application on mobile devices) for tablets (Fields, 2011).

- Put the most important view on the top left, which is where users' eyes naturally start.
- Limit the dashboard to two to four views. Overcrowding the dashboard will make it less usable.
- Be stingy with legends and views. Eliminate all but the most necessary filters.
- Bigger is better. Use large marks so they are easily selected by users' fingers. Use large font sizes so that text can be easily read.

Figure 3 shows a dashboard designed for a desktop; it has five views and five filters.

Figure 4 shows the same dashboard but designed for a tablet. It has three views and filters. The most important view, daily sales, is large and on the top left. The two views that are removed are accessible

through tabs. There is the potential for confusion when users see essentially the same information displayed differently on different devices, but this can be handled through user training.

4.6 Security

Historically, information technology (IT) groups had complete control over companies' desktop computers—from procurement to set up, maintenance, and replacement. IT controls which PCs are purchased, what software runs on them (to a large extent), and how they are secured. This complete control is no longer possible as workers are increasingly bringing their own devices to work and want to use them to access company data. In 2012, the market research firm IDC estimated that more than two-thirds of the business-use smartphones worldwide were employee-owned devices (IDC, 2013).

Figure 3. Daily Sales Dashboard on a Desktop Computer (Fields, 2011)

While there is great convenience in being able to access information at any time, any place, and on any device, it also creates the greatest concern about mobile BI—the fear that sensitive corporate information might be exposed because a device is lost, stolen, or exposed to viruses, spyware, or malware (Stodder, 2012)[7]. There are also concerns about complying with government regulations (e.g., HIPAA). However, if properly handled, these threats can be mitigated.

When companies give workers smart devices, they reduce some of the threats because the company has greater control over them. For example, the company might not permit personal apps, which eliminates the risk that they might infect the device, or they may only allow users to download personal apps that are "white listed"[8]. When a device is lost or stolen, the device can be wiped clean without concern about pictures, music, or personal applications.

[7] While companies have invested in security that protects all endpoints in their corporate networks and firewalls that prevent unauthorized external access, mobile devices effectively cross through the protective firewalls. When these devices are infected with viruses or Trojan horses, potential security problems are created in corporate networks (Kaspersky, 2014).

[8] The security system on the smart device only allows apps on an approved list to be downloaded. For example, there is often concern about file sharing software such as Dropbox and Box because they do not provide enterprise-quality security and can potentially be carriers of infected files that can steal login credentials and other company information. When Chinese hackers attacked *The New York Times*' networks in 2012 and 2013, they used malware infected files distributed by Dropbox (Accellion, 2014).

Figure 4. A Daily Sales Dashboard on a Tablet Fields (2011)

Many companies allow workers to use their personal smart devices to access company information. This practice is referred to as bring your own device (BYOD). Its obvious advantage is reduced costs because companies do not have to pay for the devices (though there are additional costs to secure and support the devices)[9]. Less obvious is the great potential for increased worker productivity. A BMC Software survey found that BYOD-carrying employees work an extra two hours every day and one out of three check their email before work (i.e., between 6 and 7am) (Kaneshige, 2014b).

When employees are allowed to access corporate systems with their personal devices, the company needs to create BYOD policies (Hassell, 2012; Stagliano et al., 2013; Brown, Jackson, & Scarfone, 2013)[10]. These policies typically cover what devices are permitted (e.g., Apple, Android), the required logon processes (e.g., more complex than a typical four digit PIN), what kind of support IT will and won't provide (e.g., a loaner device while a broken one is being repaired), what will happen if a device is lost or

[9] In August 2014, the California Court of Appeal ruled that companies must reimburse employees for work-related use of personal devices (Kaneshige, 2014b). If this becomes the law of the land, it would substantially change the economics of BYOD.
[10] Some companies, such as CARFAX, Kraft Foods, Citrix Systems, and Proctor and Gamble, offer their employees incentives to use their own devices for work-related purposes (Stagliano et al., 2013).

stolen (e.g., remote wipe), what apps or websites are banned (e.g., social media), who pays for data usage charges (e.g., the company pays up to $50/month), and what happens when an employee leaves the company (e.g., wipe of all company apps and no email access). The policy should strike a balance between the management oversight and security controls that the business and IT require while not imposing procedures and restrictions so severe that they undermine users' needs and productivity (Symantec, 2014).

BI platforms provide at least basic security. For example, MicroStrategy Mobile has encryption, authentication (e.g., remote revocation of access, remote wipe/lock), single sign-on, forced logon after opening or inactivity, and integration with third party security providers (MicroStrategy, 2014). For advanced security, many companies also use software from companies such as AirWatch, MobileIron, and Symantec. These products are called mobile device management (MDM) software and, increasingly, mobile application management (MAM) or enterprise mobility management (EMM) suites as they have begun to feature more capabilities and gain a broadened scope (e.g., application management, inventory management) (Gartner, 2014).

Symantec (2014) organizes and describes the functionality of its mobility management software in the following way:

- Device management: including password control, remote wipe, profile reporting, and integration with Cisco Identity Services Engine.
- App and data protection: using an app-wrapping/containerization[11] technology to manage business apps individually and collectively, single sign-on control, and data encryption.
- Enterprise app store: distributing in-house or third party apps directly to employees and other authorized users, such as partners or contractors, rather than using, for example, Google Play.
- Threat protection: malware and privacy protection that leverages technology such as Norton Mobile Insight, an app risk-reporting engine.

Security is obviously an important issue in mobile BI, but there is a tradeoff between control and the user experience (Bock, 2014). In general, the greater the controls, the poorer the user experience—one needs to find the right balance.

5 Mobile, Real-time BI at U.S.Xpress

Located in Chattanooga, Tennessee, U.S.Xpress is a top five North American truckload carrier with more than 9,000 trucks, over 21,000 trailers, and 78 service depots[12]. This 29-year-old company has been top ranked in overall value among 3,000 shippers by *Logistics Management & Distribution Magazine* for multiple years.

A key to U.S. Xpress's success is that co-founder and CEO Max Fuller is an innovator who "loves technology" and believes that technology can be a "game changer" with customers. U.S.Xpress was an early adopter of satellite communications in trucks and uses this capability to improve operational efficiency and effectiveness and enhance customer service. In addition, Fuller wants all of his employees to have "information at their fingertips".

5.1 The Need for Real-time, Mobile BI

To be successful in the trucking business, a company must provide great service at a competitive price, which is not a simple task with thousands of drivers and trucks to schedule, thousands of customers to deliver to, many unexpected events, and myriad opportunities for cost inefficiencies. Without BI, it is essentially impossible today for large trucking companies to compete effectively.

Not only is there a need for BI, there is a need for real-time mobile BI. It can provide situational awareness to drive alerts and optimize resource allocations. Drivers, fleet managers, sales personnel, depot managers, general managers, and senior executives all need up-to-date information wherever they are to perform their jobs well. To illustrate, drivers must be able to receive information about where to stop for

[11] This allows business and personal apps to be stored separately on the same device (Kaspersky, 2014). The business apps are placed in containers that share corporate data but not with the personal apps that are outside the container. This supports additional security, such as encrypting all business data in the containers or doing a remote wipe of all business apps in the containers.
[12] This description is based on Watson and Leonard (2011).

the least expensive gasoline. Fleet managers need to be alerted to when trucks cannot reach their destinations on time so they can be rerouted for on-time service. Depot managers must reroute trucks to service depots when a time or mileage threshold is reached so that maintenance is a managed process that minimizes costs and downtime. Vice presidents need to be able to see current conditions and trends in their business areas to manage deviations and ensure alignment with tactical and strategic initiatives. Executives need current and accurate metrics that provide information about how their corporate goals and vision are being achieved.

5.2 Attacking the Idle Management Problem

Much of the data needed for operational excellence was associated with drivers and trucks, such as where they are, where they have been, whether the truck is moving or idling, and what customer is being served. U.S.Xpress captured most of this data with a mobile in-cab communications system that collected over 950 pieces of data and provides information about essentially everything that was going on with the trucks.

Though U.S.Xpress was rich in data from its in-cab system, the data was unorganized, non-cleansed, and untrustworthy. This was especially problematic with data relating to vehicle location, which made it impossible to determine, for example, where trucks were stopping and for how long. To correct this problem, there was a major initiative to standardize data across trucks and to improve the accuracy and reliability of the data.

High-quality data for operational BI is as or even more important than it is for operational systems. Bad decisions made on incorrect data can significantly increase costs or damage customer relationships. But, with better data in place, U.S.Xpress was positioned to attack a major problem—the unproductive idling of trucks. Every hour of idle time costs over $2.00 in fuel waste and also adds to the emission of pollutants to the environment. Of course, some idling is inevitable, such as when a truck is in traffic (referred to as “short idle”). But others, such as when a driver is taking a break or eating lunch (“long idle”), can be avoided.

U.S.Xpress decided to place its BI data in the cloud to leverage economies of scale that are difficult to achieve in traditional data centers. New skill sets are required to work in a hybrid environment, but integrating existing traditional data center and cloud resources creates much higher access to BI data across the enterprise. Reporting from BI data in the cloud also provides scalability, availability, and architectural simplification and reduces the total cost of ownership.

The next step was to implement a near real-time messaging system that takes the in-cab data and integrates it with other data, such as CRM and order entry data. As the data comes in, it is cleansed, consolidated, transformed, and placed in an operational data store and a data warehouse. This data is organized and aggregated to best suit overall and specific applications. For example, there is a driver “cube” that integrates all data about the driver, such as what truck the driver is assigned to and where the driver has been in the last 30 days[13].

Given this data infrastructure, it was possible to make information available to users in the form of alerts, KPIs, dashboards/scorecards, and geographic applications (using either Google or Bing Maps). To really be useful, however, the data needed to be near real-time and mobile, and, hence, available through a variety of mobile devices (e.g., iPads, Android devices). Developers were hired to code in the Cocoa Touch framework and Xcode for the iPad and in other mobile Android devices. Applications were developed for users all the way from drivers to the CEO.

The source, integration, aggregation, and consumption layers form what U.S.Xpress refers to as the Information Management Integration Stack (see Figure 5). The stack supported the development of a variety of dashboard and geographic information system applications available to most mobile devices.

Many U.S.Xpress users access information using iPads. Because it is cumbersome to use the iPad browser, the decision was made to develop native applications and distribute them through the Apple store. Interns at local universities performed much of the development work.

An incentive program was put in place to help motivate the drivers to reduce idle time. In particular, if they reduced their idle time by 15 percent, they received a 42” flat screen TV. The return to U.S.Xpress from

[13] A “cube” is a multidimensional organization and view of data that supports the “slicing and dicing” of data by different dimensions and specific measures.

this reduction in idle time was many times the cost of the incentive. Policies were also set to address bad idle behavior.

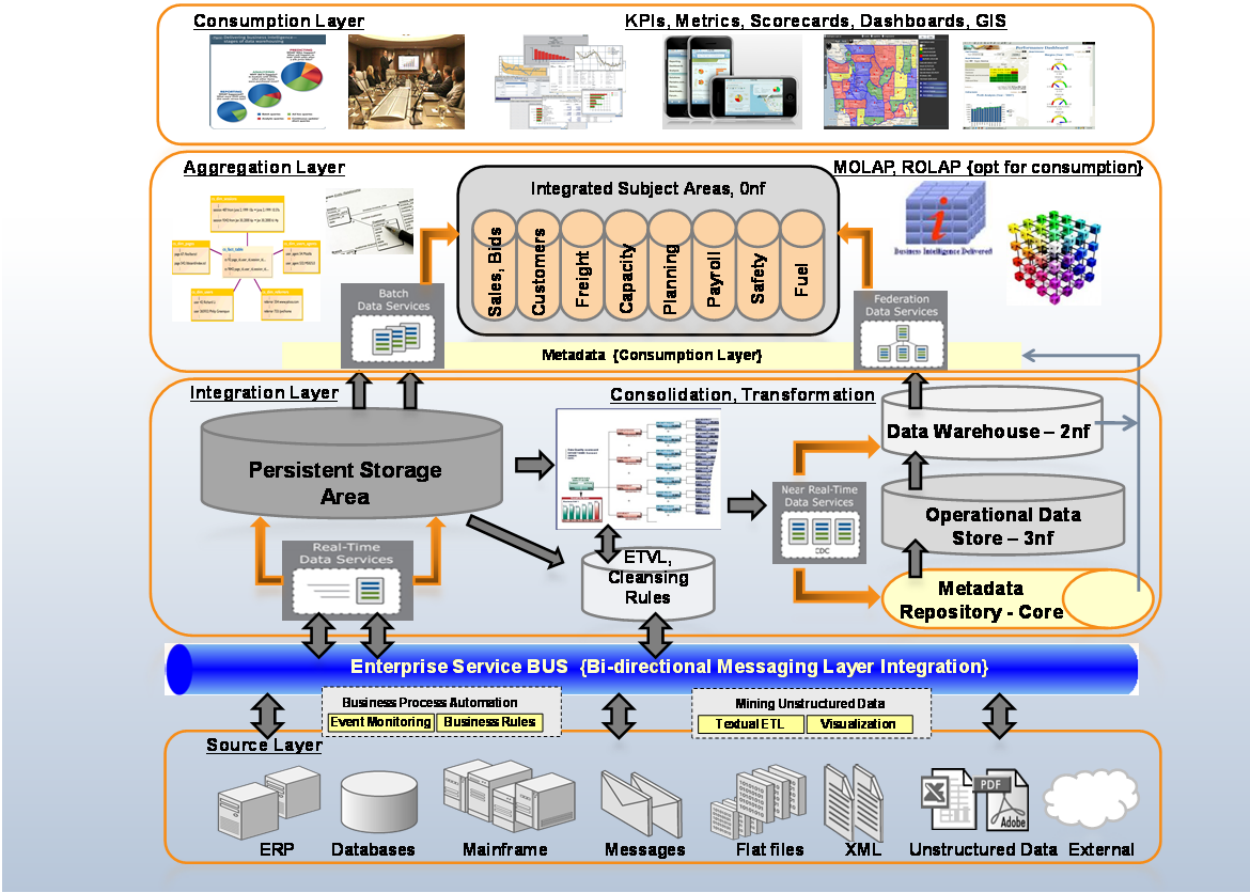

Figure 5. U.S. Xpress's Information Management Integration Stack

5.3 Return on Investment for Idle Management

U.S.Xpress realized an impressive ROI on its idle management program: in the first three months, the ROI was 100 percent. Over the first year, savings were over USD$3M on fuel consumption, and these savings are sustainable over time. The application has also resulted in significant reductions in toxic emissions, which has supported the company's environmental commitment. As many as 800 staffers across the country share a dashboard of truck idle time that allows them to pinpoint instances where truck idle time is excessive and to take corrective actions. No longer is there a situation where a truck idles for a full seven days.

The success of the idle management program also led to other initiatives. For example, it was found that idle time is seasonal. In the summer and winter, the drivers tend to idle more for cooling and warming purposes, respectively. To address the problem, trucks with the best air conditioning systems are now used in the south during the summer and proficient heater systems are used in the north during the winter. Also, other departments, especially sales, requested that mobile applications be developed for them.

6 Mobile BI at Guess

Consider another case study, this time from the retail industry. Since 1981, GUESS has been one of the most widely recognized apparel brands in the world[14]. GUESS designs contemporary clothing and accessories for women, men, and children and distributes its merchandise to stores in 85 countries. Its designers focus on creating fashionable products lines, and they closely monitor best-sellers to

[14] This description is based on Briggs (2011) and Watson, Wixom, and Yen (2013).

understand trends. Merchandisers ensure that products are placed in the right stores at the right times to meet the needs of GUESS' fashion-savvy customers. Designers, merchandisers, and executives travel extensively across the global GUESS network and are a highly mobile workforce.

6.1 BI on Mobile Devices

In early 2008, GUESS adopted mobile BI by successfully rolling out a mobile BlackBerry application to executives and regional sales directors for sales reporting. In 2009, the company added dashboards to its mobile BI offerings. These dashboards had stylish, well-designed screens and provided information to additional, nontraditional BI users such as buyers and planners.

Then, in 2011, GUESS delivered a BI app for the iPad after CIO Michael Relich and BI director Bruce Yen became convinced that the iPad could be a game changer in delivering graphical analytics to their highly visual and creative business users. The app provides interactive access to best seller trends and current sales figures for products arranged by styles, colors, and stores. The app meets the needs of a wide range of work styles and work processes and was adopted by a diverse set of business users. GUESS refers to the iPad app as GMobile.

Executives use the app to understand the company's current sales, profitability, and performance trends over time. Merchants use GMobile for store visits. Rather than using it mostly at stores, merchants access GMobile to brush up on store management and sales history before entering a store. It allows a merchant to understand how a store is performing and what mix of products comprises the store's best sellers. Designers use the app to view and analyze their best sellers so that they can understand the current sales and design trends. See Figure 6 for a screenshot of GMobile.

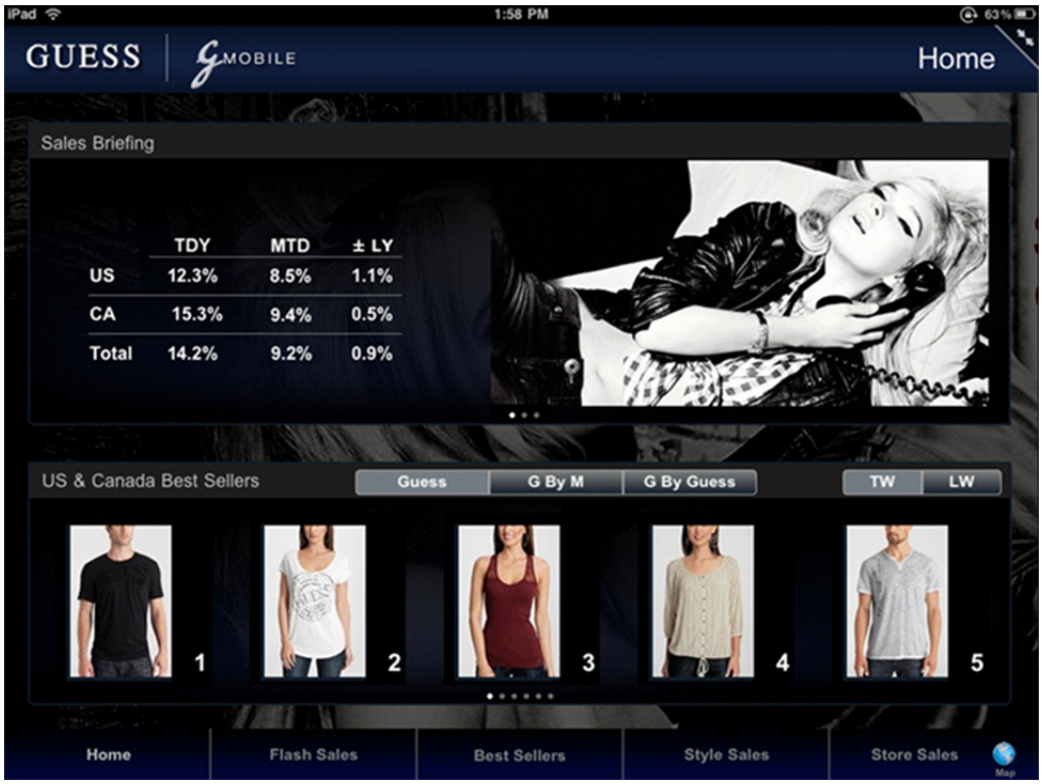

Figure 6. GMobile iPad Application

6.2 How GMobile Was Built and Implemented

The BI team at GUESS learned that deploying BI on mobile devices was different than their past BI efforts in important ways.

6.2.1 Design with the Device in Mind

Not all mobile devices are created equal. In fact, each device—whether it is an iPad or a BlackBerry or an Android phone—has unique capabilities to leverage and important constraints to be considered.

Though smartphones are important devices for delivering certain kinds of information (e.g., alerts), they have inherent limitations (e.g., the size of the screen) that make them less than ideal for displaying some kinds of information. At GUESS, the BI team distributed PDF reports via BlackBerrys. Since the devices have small screens, the team used few bells and whistles, and they ordered the reports so that the most popular reports would be listed at the top to decrease the need for users to scroll through a long list to find the needed information.

With the iPad, GUESS developers took a much different approach. They created a highly interactive and visually-appealing app that took advantage of the iPad's graphical capabilities. The team produced colorful charts and graphs and mashed data with maps to communicate performance by geographical regions down to the store level.

Instead of replicating dashboard displays that they created for their non-mobile Web-based dashboard application, the team created GMobile with an investigative workflow, where users could take myriad paths through the app and easily return to an earlier screen or to the home screen at any point. The app incorporated common Apple-supported gestures, such as swipes and taps. GMobile integrated content that was equivalent to twelve dashboards from the Web-based system because of the interactive nature of the interface.

Because of the iPad's and GMobile's intuitive feel, there has been little or no user training. User feedback was incorporated along the way to make the system as intuitive as possible, and no formal training has been requested.

6.2.2 Keep the Technology Aspects well Removed from Users

The term "business intelligence" wasn't used with the target audience. The app was marketed as GMobile rather than as BI. The hope was that users would be naturally drawn into using it. To that end, the GUESS BI team also tried to avoid "giving users the feeling that they were going into a world of dashboards and data". Instead, they designed an app that gives users an enticing starting point—an opportunity to be briefed on the business at any one point in time, essentially, and then to dig deeper if they choose.

6.2.3 Ensure that the Device Delivers BI Quickly

Mobile BI veterans agree that speed is the number one usability factor for mobile BI; most try to achieve a response time of three seconds or less for their mobile BI applications. Fast response can be easier said than done, however, particularly when working with devices such as iPads, which have limited processing and memory capacities. To achieve performance improvements, development teams may need to break up long-running queries into multiple screens or limit background loads on the device to when it is idle.

The GUESS BI team decided to help close the performance gap for the GMobile app by implementing a data warehouse appliance because the iPad simply could not perform quickly without it. They implemented a columnar database appliance, and queries that took 20-30 minutes on their traditional data warehouse technology improved to 5-10 seconds, which made product affinity and market basket analyses more feasible. Because of its speed, the appliance was jokingly called "the Maserati" after the race car, and the name stuck with users.

6.2.4 Develop a "Bring Your Own Device" (BYOD) Policy

When the iPad app was first introduced at GUESS, about half of the users brought their own iPads to work and wanted GMobile loaded onto them either because there was a limited availability of devices or because users didn't want to carry two iPads around. The team was concerned that an iPad would be lost and that confidential company information would be compromised. To address this issue, users signed a waiver that allowed software to be placed on their iPads that would allow the GMobile app to be wiped clean in case an iPad was reported lost or stolen. Today, more company iPads are available, and most employees opt for a GUESS iPad rather than using their own. In some cases, it is a way for users to get a more current iPad version.

Every company needs to create a BYOD policy that states whether and how an employee can use their own device and the controls that users need to accept if they do. A balance has to be struck between the risks associated with the loss or theft of a mobile device and the impact that security controls have on ease of use. Appropriate mobile security software has to be selected to safeguard information available through the device. Increasingly, mobile security software will incorporate location awareness as an additional way to control where, when, and what data is available for viewing on devices.

6.2.5 Leverage the Excitement of the "It" Device

Mobile devices, such as the iPad, have a "coolness" factor. Nearly everyone wanted the trendy mobile device, including executives. At GUESS, some users initially wanted BI in part because they really wanted an iPad. This did not concern the team because, over time, users with iPads ultimately became highly engaged BI users.

At GUESS, an interesting consequence of using a popular device for mobile BI is that the staff fielded many questions about iPads that are unrelated to BI. Users approached the GUESS IT group for device help. Instead of explaining that their question was out of scope, the team used the request as an opportunity to satisfy their users and, thereby, strengthen the IT-user relationship.

6.2.6 New Roles Are Needed to Best Exploit the Device

Developing mobile BI applications at GUESS required two new types of project team roles. The first was a developer who was fluent in developing apps specifically for the iPad. This individual ensured that the app leveraged Apple widgets and was designed with an Apple-savvy user in mind. The BI team realized that their GMobile app was not competing with other IT systems but against iPads apps that users interacted with regularly, such as "Angry Birds".

Another new role at GUESS was a graphic artist who ensured that GMobile looked good. The designer helped to implement a visually appealing app that incorporated a theme with related graphics and colors. For GMobile, the theme was Hollywood, which included a movie clapboard graphic, best-seller product photos appearing in a "walk of stars", and a flashy color palette.

To test out designs, co-workers with a good fashion and design sense—and a good feel for the GUESS image—were invited for impromptu feedback sessions. It wasn't very formal; people were called and asked, "Hey, do you have 10 minutes?".

6.2.7 Expand the BI Experience to Include Device Features

Devices come with a wide variety of features to appeal to consumers, and features such as cameras, location awareness, and SMS may serve new and helpful purposes for BI applications. At GUESS, users found their iPad cameras to be particularly helpful for decision making and began incorporating their photos into daily work processes. They took pictures using the iPad to capture store layouts, window designs, and even competitor marketing efforts. These photos were then emailed to headquarters or decision makers or saved to the iPad to be referenced in upcoming meetings.

Some companies are investigating how to use device cameras to serve as bar code readers. In this way, users would be able to scan product codes and use them to generate reports. Similarly, a device's location awareness can be incorporated into BI reporting and produce geographically based reports according to where a user is working.

6.2.8 Expect a Variety of Benefits from a Mobile Workforce

In many companies, decisions are not made behind a desk; instead, they are made by highly mobile employees who make decisions and take actions throughout the day and who require on-the-go, instant access to BI. Among the benefits of mobile BI, time savings can really add up. At GUESS, store merchants used to take hours preparing for store visits because of the need to gather up reports and review them prior to entering the store location. Now merchants can sit on a bench outside a store with their iPads and get up to speed in minutes. A Biotech company calculated that each of their sales rep saved 30-90 minutes each day using mobile BI, which translated into a more than USD$4M annual savings or productivity boost for the company.

Some benefits from mobile BI are less tangible but still important. For example, some companies are reaping reputational benefits from having employees using devices that are perceived to be leading edge.

At GUESS, the iPad device and appealing GMobile app resonated well with the company's many global partners. Additionally, GMobile's adoption and popularity fostered innovation internally at GUESS, prompting other iPad-related projects elsewhere in the company.

7 Conclusion

There has always been a need for mobile BI. When traveling, executives would buy copies of *The Wall Street Journal* to keep abreast of business developments. In the early days of executive information systems, one vendor (i.e., Comshare) had an application called Briefing Book that contained information (e.g., KPIs) similar to what executives would print and take with them on trips. Executives' phone calls back to the office would garner information on recent events. If there was a computer available, they would check their email. While the need has always been there, only recently has the technology (e.g., the Internet, software, and a variety of smart devices) been available to support mobile BI.

An analogy is often made between blood in animals and information in organizations. Each is necessary to sustain life. Throughout organizations, individuals can benefit from information to support the thousands of decisions they make every day. Mobile BI has the potential to better inform much of this decision making. However, understanding the who, what, how, when, and where issues of decision support are not trivial undertakings. One needs to understand the "rhythm" of the organization. The right information must be delivered at the right time to decision makers and decision making processes. One should clearly understand the business processes and rules and how and when streams of information can be used by decision makers and automated systems. The information must be displayed in the best possible way on a variety of devices. It takes time and effort to ensure that users and processes integrate the information into their work. Technology can handle data and analysis latency, but humans must integrate new information into work processes and change processes when necessary (Watson, 2009). To understand organizational rhythm, developers should not only look at existing information flows and interview users but also do job "shadowing" to fully understand the work they do, the decisions they make, where decisions are made, and the information they need (Masters, 2010).

Despite its importance, there has been limited research on mobile BI, and practitioners have conducted most of the research that does exist. Industry research companies such as TDWI, Gartner, and IDC have focused on various frameworks, surveys of current practices, and recommended best practices. While this research is very helpful, it has not covered the full-range of topics of interest to practitioners. Also, there are opportunities for traditional academic, theory-based, empirical research.

The following are some of the more interesting research opportunities:

- Many benefits are cited for mobile BI: increased employee productivity, enhanced customer service and satisfaction, improved decision making, and an improved bottom line. While these claims are likely correct, there is little empirical research to quantify and verify them. What's the ROI for mobile BI?
- As users are increasingly using their personal devices to access corporate systems and information, BYOD policies become more important. The right balance should be struck between ensuring security and providing a good user experience. We need frameworks that identify the key components of BYOD policies and empirical research that investigates the impacts of specific policies.
- What motivates users to accept and use mobile BI? Some of the reasons seem obvious: a need for the information provided; a well-designed app; timely, accurate information; and fast response times. Academics have used factor studies (Wixom & Watson, 2001) and theories such as the technology acceptance model (TAM) (Davis, 1989) to explore and better understand the acceptance of new technologies, and they can also be applied to mobile BI research.
- Maturity models continue to be popular with practitioners. The models provide a way to think about and envision the logical evolution of a technology or application through various stages of maturity (Watson, Ariyachandra, & Matysa, 2001). For some models, data is collected and maintained from a variety of organizations to better understand current practices and how the evolution proceeds. For example, TDWI has done this with an analytics maturity model (Halper & Stodder, 2014). A maturity model for mobile BI might be developed and survey data collected to record organizational progress through the stages.

- Best practices case studies help companies progress without having to learn about every step in the journey on their own. Case studies also help faculty and students understand what is possible in practice today. Advanced analytics and big data are two other topics that are currently important. Case studies on what leading-edge companies are doing to integrate advance analytics and big data into mobile BI would be useful.

The experiences at U.S.Xpress and GUESS illustrate how companies are benefiting from mobile BI. However, mobile BI is still in its infancy. We can expect significant further progress, especially as the technology improves. Consider, as an example, Siri, the iPhone agent that allows users to verbally ask questions and get answers. It is easy to envision smart devices with the ability to respond to business questions, such as what orders a specific customer placed in the past 30 days, and have the answers displayed or spoken (Hiltbrand, 2014). These and other possibilities point to a bright future for mobile BI.

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Appendix A: Mobile BI: The Fourth Generation of Information Delivery

Mobile BI is a new generation in the way that information is delivered. Figure A1 displays the various generations. To varying degrees, the generations build on one another and coexist today.

One can think of mainframe computing in the 1960s as the first generation. Individuals used card readers and "dumb" terminals (i.e., no internal processing power) to input data, programs, and instructions, and information was output to terminals and printers. The term "green bar reports" was used to describe reports printed on paper with alternating green and white stripes and, for a long time, were the primary source of computer-based decision support.

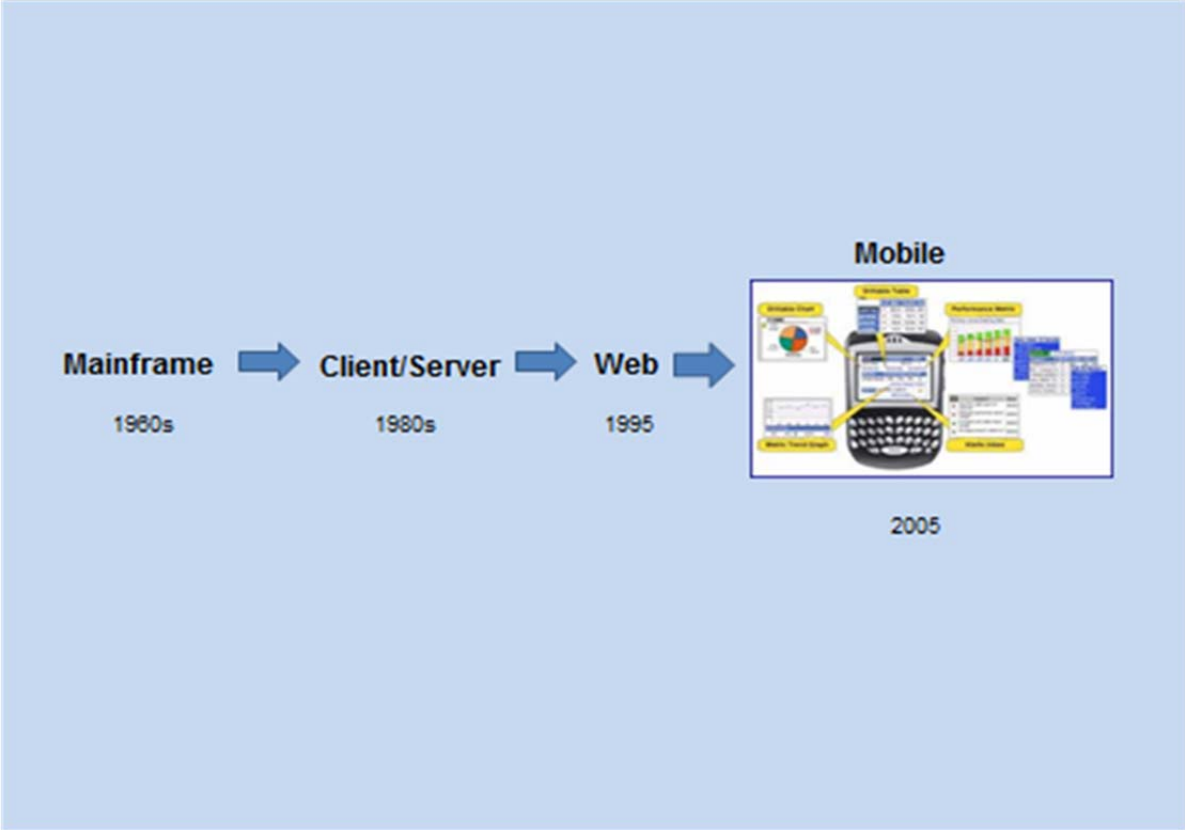

Figure A1. GMobile iPad Application

Client/server computing (the second generation) emerged in the 1980s with the arrival of powerful desktop computers. In this computing model, processing is shared and distributed between a centralized server and desktop computers. The "fat" client (i.e., the desktop computer and software that resides there) and the centralized server supported powerful analyses and presentation of information. Executive information systems, geographical information systems, and early dashboard/scorecard applications were some of the applications that often relied on this computing model.

Usage of the Web (the third generation) grew tremendously in the mid-90s and the Web dramatically increased the amount of information available and how it was accessed. Anyone with a browser and an Internet connection could access a wealth of company and external information. From a technology perspective, BI vendors redesigned their products' architectures to four-tier, with a Web browser (i.e., the "thin" client) connecting to a Web server, to an application server, and to a backend database(s).

Laptops and the Internet allowed workers to access information when they were away from their desks, and began the movement to mobile computing (the fourth generation) in the early 2000s. It accelerated when executives and managers wanted information delivered to their cell phones (often BlackBerrys at the time). Today, executives, managers, sales people, field service personnel, and others have access to information through tablets and smartphones.

About the Authors

Hugh J. Watson is a Professor of MIS and a holder of a C. Herman and Mary Virginia Terry Chair of Business Administration in the Terry College of Business at the University of Georgia. He is a leading scholar and authority on business intelligence and analytics, having authored 24 books and over 150 scholarly journal articles. He helped develop the conceptual foundation for decision support systems in the 1970's, researched the development and implementation of executive information systems in the 1980's, and for the past twenty years has specialized in data warehousing, BI, and analytics. He is a Fellow of the Association for Information Systems and The Data Warehousing Institute and is the Senior Editor of the *Business Intelligence Journal* and is a member of the *CAIS* Advisory Board. He is the founding Director of the Teradata University Network, a free portal for faculty who teach and research BI/DSS, analytics, data warehousing, and database.

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