Delivering knowledge and solutions at your fingertips: strategy for mobile app development in agriculture

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Abstract: The mobile revolution transformed the ways we socialize and conduct business. Today, mobile technology is an essential element of every aspect of digital success. More people are accessing the Internet through mobile devices than through wired connections. Mobile device users are always connected, actively leveraging information, knowledge and social activities. The rapid growth of mobile usage in the world created many opportunities that leverage the ubiquity of mobile networks. Clearly mobile revolution will continue, and organizations not only create mobile strategy, they devote more resources to deliver innovative mobile services and next must-have applications (apps) for the agricultural sector. There are many design challenges and considerations in developing mobile apps that can be widely accepted by users in agricultural communities. This paper discusses mobile apps in the agricultural domain, considerations and challenges for successful mobile app development and focuses on a cross-platform mobile development approach adopted by University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS). This cross-platform framework is an intuitive approach to developing apps quickly, easily and cost effectively. A mobile portal and sample mobile apps developed at UF/IFAS are presented. Effective and quality mobile app deployment in agriculture needs a clear mobile strategy, creative ideas and collective efforts from developers, domain experts and organizations.

Keywords: mobile technology and apps, cross platform, agriculture

1   Introduction

Twenty-first century agriculture faces many challenges including: 1) food security and safety, 2) climate change, 3)sustainable natural resource management, 4) pests, 5) increased international trade and competition, and 6) growing demand for energy.   In coping with the above challengesin a global knowledge-based economy, Information Technology (IT) plays an increasingly important role and provides a powerful foundation for addressing many of the problems

we are facing today and in the future.   Among the many recent advances in IT, mobile technology is one of the highlights.   Currently there are over 1,500 million smartphone users worldwide today.   Mobile technology and apps were identified as the top 10 strategic technology trends for 2014 by Gartner Inc. (Gartner, 2013).   In 2014, Gartner estimates 139 billion apps will be downloaded worldwide.   With the rapid transformation of mobile technology and consumer behavior, interaction with customers using mobile devices creates an opportunity for efficient delivery of knowledge and solutions any time, any place and using any device.   Google found 72% of consumers expect brands to have a mobile friendly website.   Usable mobile software design does not simply consist of

shrinking a screen to fit on a mobile device. It requires a different approach and understanding of user behavior to ensure that applications are engaging and effectively address a need.A common approach to software design is focused on "mobile first"to take advantage of user expectations and behavior, as well as mobile technologies.Smartphones are no longer simple communication devices, but rather real-time information delivery channels that address needs and support decision making. For this purpose IT specialists in agriculture must have a distinct mobilestrategy that focus on business challenges, improve efficiency and customer satisfaction(Disabato,2014). It is important to incorporate the mobile strategy into your organization's business strategy and choose the right technology, focus on the right problems, and deliver apps on-time, and on-budget.

Today's agriculture has become an information-intensive enterprise. In this context, U.S. farmers and ranchers are using IT and mobile solutions to increase efficiency and generate higher profits (Brugger, 2011; Xin, 2012; Qiang et al., 2012; Davison, 2013; Doering, 2013; Hopkins, 2013; Graul, 2014). Despite rapid growth of mobile app development in many sectors, the agricultural sector generally lags in the adoption of mobile apps. Challenges include lack of development talent, cost of the systems, lack of effective leadership, and collaboration among organizations. To keep pace with the demands of a rapidly growing modern digital culture, it's imperative to take advantage of mobile engagement opportunities to deliver knowledge and solutions to our clientele at their fingertips. The objective of this paper is to 1) highlight potential apps in the agricultural domain, 2) discuss low cost development approaches for cross platform deployment, and 3) illustrate and share some sample apps as well as development experiences at UF/IFAS.

2   Materials and methods

2.1 Potential mobile apps in the agricultural domain

Millions of apps have been published in major app stores. Although the agricultural sector's use of apps is growing rapidly, its development and adoption is slower than mobile technology used in other sectors. For farmers, better access to weather, market, and price information can have a positive impact on their income. We now see producers using smartphones for monitoring and evaluation in agriculture (USAID, 2012), and managing operations, ranging in everything from robotic milkers, to wind machines that churn up the air in an attempt to thwart extreme weather in vineyards (Davison, 2013). Opportunities for mobile technology are ample, and below are only some example domains for mobile apps.

1.   Market Information – provides real-time agricultural market information. An example is **Commodity Prices** by Jaybus and **Agriculture Price Alert** by YehTsung Ming.

2.   Extension Services and m-Learning – Learning from mobile devices have been adopted from education institutions and similar approaches can be used to deliver Extension publications and learning modules, which can be downloaded on a mobile device, and read in a farm field. An example is **EDIS** developed by UF/IFAS.

3.   Weather – specific tailored for agricultural weather information and management tools to assist farmers on decision making. Examples are **FAWN** by UF/IFAS, and **Weather Underground** by Weather Underground.

4.   Pests, plant diseased diagnosis and plant nutrition management – The mystery of a pest or plant disease can now be solved in a matter of minutes by snapping a quick photo on a smartphone and consult with specialists and clinics in a plant diagnostic network. Examples of these apps are **DDIS,slPest**and **NPDN Citrus Diseases**developed by UF/IFAS.

5.   Agricultural news – provide subscription management and up-to-date, scientific based, unbiased, relevant news to users through mobile apps or social

media.   Examples are **AgWeb News & Markets** by Farm Journal, Inc. and **Subscribe** by UF/IFAS.

6.   Geo-based management and information – map related farm information and management tools, farm mapping and Best Management Practices (BMP).   An example is **SoilWeb** developed by Dylan Beaudette.

7.   Financial calculation and payment – order products and payment through mobile environment.   Examples are **Mobile Pay** byBank of America Merchant Services and **PayPal** by PayPal Mobile.

8.   Data visibility and product tracking – collecting farm activity data and tracking agricultural products from farms to consumers for food safety.   An example is **HarvestMark Food Traceability** by YottaMark, Inc.

9.   Agricultural emergence management – local and regional resources to cope any agricultural outbreaks and disasters. An example is **FLSART** by UF/IFAS.

10.   Management, monitoring and data collection tools – tools that help farmers' daily management and monitoring needs. An example is **SeedStar** developed by Jon Deere.

2.2 Challenges and considerations for successful mobile app development

Challenges come from different areas such as a constantly changing mobile technology, platform and device fragmentation, development approaches, data access, user experience, developmentcosts, monetizing, finding IT talent, identifying solutions, adoption, and leadership to foster collaboration among all stakeholders.

Successful delivery of a mobile solution depends on many factors through a lifecycle of the mobile app such as discover the needs, planning, architecting, selecting a solution, developing and deploying, operating and evolving the solution. The delivery process commonly requires a multidisciplinary collaboration, such as users, domain experts, talented IT specialists, agricultural extension services, universities and institutions, government at different levels, and marketing specialists depending nature of the project.   Below are development methodology and consideration factors.

1)   Analysis (Why) - define the business strategy and discover stakeholder needs to create the app.   Focus on solving business challenges and increasing efficiency. Determine the cost of the development and ongoing maintenance.

2)   Design (How)

a)   Frameworks – choose an effective development framework, and consider the approaches to mobile app development: web, native or hybrid.

b)   Languages and tools – decide to use a native development environment or cross-platform approach such as JavaScript, HTML, and CSS.   Developers should have skills they need and be productive within infrastructure, take advantages of mobile capabilities not available on a PC, and design for layers of user experience for different users.

c)   Data connectivity if a local or server-side database is needed, such as SQL or NoSQL database.

d)   Integration with back end systems.

e)   User experiences.

f)   Security.

3)   Development and implementation– communicate your plan with stakeholders and adopt agile or other best practice development approaches for quality delivery.

4)   Deployment

a)   Marketing – monetization in app stores or other channels to promote an app, usually amongst millions of apps in an app stores.

b)   Maintenance – technical, performance, stability and security.

c)   Support and scale mobile solution – ensure a good experience and relationship with users.Scale up the system to meet users' needs.

There are three primary approaches to building mobile apps today: mobile web, native, and hybrid.   Mobile development can be complex and disruptive.   There are many factors to consider including different operating systems, devices, development tools, as well as a technology landscape that continues to be a constant state of change.   A successful app should address the users'

needs and their expectations as well as supports multiple platforms with cost effective development.

2.3 Develop a winning mobile strategy

A mobile strategy is necessary for organizations to achieve their business goals in today's business, social and personal environments.   Fig.1 shows the main factorsthat need to be considered in the development of an effective mobile strategy.

A mobile strategy must align with and support the organizations' overall strategy and business goals. Creating business value for the organization and its stakeholders is the purpose of any app.   When a mobile app implementationis planned, it is important to articulate its value and a complete and comprehensive set of features.   This can be followed by a roadmap that defines starting with a few critical features that can progressively be built upon until the full feature set is achieved –think big, start small, and go fast.Because constrainscan result in deployment delays, such as finances and user adoption,it is advisable to release an app as early as possible with limited but useful functionality.

Figure 1.Factors for consideration in developing a mobile strategy

With the fast development of mobile technology and many choices of development tools, proper selection of a technology portfolio is critical.   The technology should be constantly reviewed to leverage changes of the mobile technologies and tools as they become available.

Today's users have high expectations for apps they use.   Unless an app clearly addressesusers' needs, it is unlikely that current users will remain asfuture users of the app.The user experience is a decisive factor for successful adoption.Quality apps should not only have an appealing design, but must be useful and usable.

Organizations conduct daily business through web applications that can be conducted on mobile devices.When moving a business apps into a mobile platform, it is important to extend the functionality found in the web applications to convenientlydeliver services that cannot be easily provided on stationary devices

Most organizations today recognize that value of data and information resources assets.   Especially for applications that have access to sensitive data or systems security must be a major consideration.   The app should be implemented and deployed in such a way that all know risks are mitigated.

2.4 Framework to develop cross platform apps: an experience from UF/IFAS

Organizations considering the development of mobile apps need to decide how mobile technology can support their mission, and choose scalable, quick to implement and affordable mobile solutions for their team and their projects.   Although each app is unique and may need a specific solution, a common framework is necessary that allows developers to develop apps once and deploy them simultaneously on multiple platforms.   It is important to select a framework that allows developers to concentrate on the business logic instead and not on the implementation details. Knoernschild(2010) provides a good guidance framework for developing a mobile app strategy.   As mobile technology moves forward, more options and better development tools are available for app development.   Our goal is to leverage our existing web development skills and choose a set of technologies to deploy apps everywhere (mobile web and hybrid) using a single source codebase.   After a review of available

mobile development frameworks, UF/IFAS selected a set of common technologies for development considering: 1) leveraging existing development skills, 2) covering multiple platforms for web, native and hybrid, 3) local storage support, and 4) past successful examples and long-term sustainability of vendors.   Figure 2 illustrates technologies we have adopted to develop cross-platform apps to cover aspects of a) native apps using iOS and Android SDK, b) cross-platform approach (JavaScript, HTML5, CSS), c) local data storage using Web SQL (SQLite), IndexedDB or JSON, d) accessing mobile back end as services, and e) touch mobile user experience design.
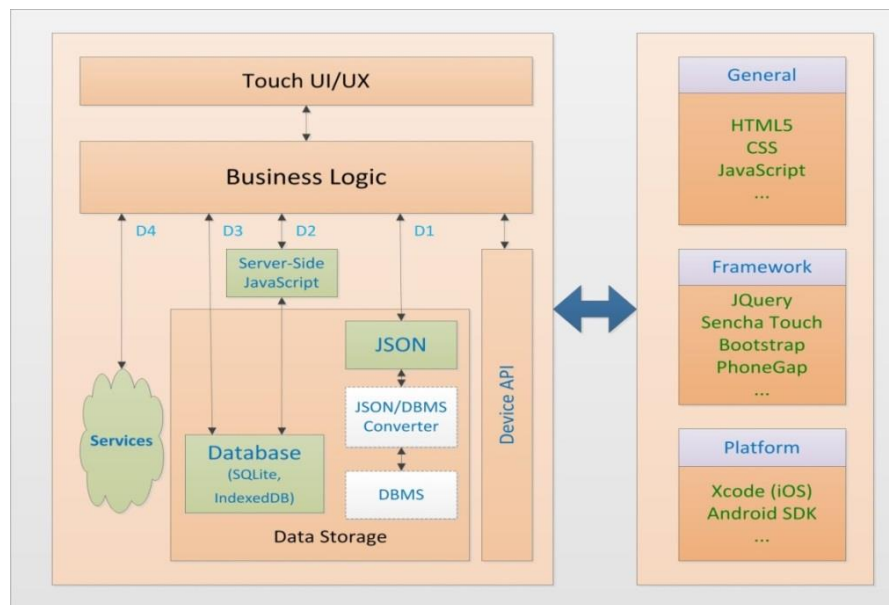

Figure 2. A mobile development framework.

JavaScript, HTML5 and CSS are widely supported by all browsers, and this approach has become a popular choice and a blueprint to deliver cross-platform apps through modern web app architecture (Brian, 2014; Brian and Knoernschild, 2013).   It should be noted that today's JavaScript is no longer the"toy language" as was perceived years ago. It has emerged as a powerful mix of interesting general purpose language across platforms and devices (Kienle, 2010).   From frameworks and data visualization to tool sets, JavaScript is widely used in mobile apps to realize sophisticated functionality and database manipulation.   JavaScript's uniform support from browsers, various JavaScript libraries, and improved performance have placed JavaScript, HTML5 and CSS3 as a mainstream enterprise application development environment. Now even more developers are building mobile apps with JavaScript, CSS, and HTML5, then bundling them with a thin, native wrapper.   Features of AJAX are one of the factors making JavaScript popular.

Additionally, JavaScript tools like jQuery Mobile, Polymer, Google Closure, Angular, Sencha Touch, Kendo UI and Bootstrap make the language even more attractive.   The results sometimes may not be as attractive as native code, but the approach is good enough and portable to the Web, and it's a fast way to create cross-platform apps.   JavaScript not only dominates the client side but also the server side by embracing tools like Node.js.

Our experience indicates that the cross-platform mobile development technology (JavaScript, HTML5 and CSS) is a viable solution for mobile apps. However, this choice has some performance issues that need to be clearly   understood.   Similar   to   the Model-View-Controller (MVC) concept, this technology has the ability for separation of content (HTML5 – content, JavaScript – logic, CSS - presentation style). For successful enterprise mobile app development, persistent data storage is essential.   Client-side storage is

an effective way of storing data on the user's hard drive instead of the server to improve performance and to make the app available offline. Database systems like Web SQL and IndexedDB are widely used mobile databases even with fragmented browser support. The usage of Web SQL takes advantage of the simplicity and power of structured SQL querying and relational database management system. The disadvantage of using Web SQL is that it is not supported by all browsers to host as a web app. Although the Web SQL storage is being deprecated in HTML5, the SQLite database can be saved to the user's hard disk as a local file thereby reducing the data population time and improving the overall performance. An Indexed database was intended to combine the advantages of Web storage and Web SQL database storage and eliminating their limitations. It lies between local web storage and Web SQL database by using key-value pairs as in web storage yet supporting indexing like the Web SQL's relational databases.

If an app has small data storage requirements, a good alternative solution is JavaScript Object Notation (JSON). Mobile deployment tools like Adobe's PhoneGap provide an excellent and simple way to wrap apps developed using these technologies and publish them to multiple operating systems and devices, including iOS, Android and Windows. Figure 3 shows the development environment using HTML, CSS, JavaScript and JSON technologies.
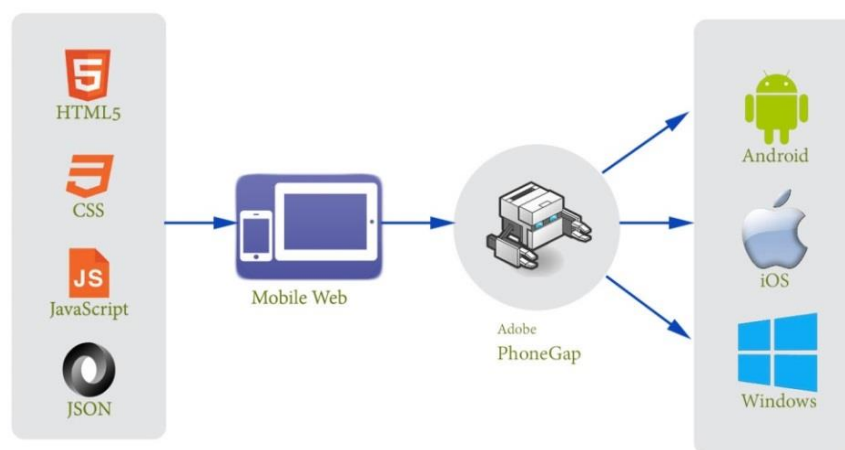

Figure 3. Cross-platform mobile development environment using a single codebase.

The advantage of using JSON as local storage is that the apps can fully deploy to mobile web and cross-platform mobile devices through a single codebase. To a certain degree, key-value object representation in JSON can mimic data representation in a relational database, and the format has simple data format for easy manipulation through JavaScript. However, maintaining JSON objects can be tedious and inefficient. As Fig.2 illustrates, a management tool can be used to convert a relational data into a JSON object in a development environment. One of the examples using JSON is the Southeast Landscape Pests app. Figure 4 shows JSON objects to represent pest information and data association. Mao and Xin (2014) have discussed JSON usage in mobile apps. With the introduction of binary JSON (BSON) for improved storage space and scan-speed, JSON and the framework discussed here become at this time very attractive. We have found that this cross-platform framework is an intuitive approach to developing apps quickly and cost effectively.

2.5 Examples of Mobile Apps Developed at UF/IFAS

A mobile portal was created for apps developed at UF/IFAS (http://m.ifas.ufl.edu). The portal contains both mobile web and hybrid apps for users to choose from. The Mobile web portal allows us to take advantages of existing development skills in Java, Object C or .NET. Together with the client side techniques, such as JQuery Mobile, HTML5 and CSS, mobile web is

the cost-effective choice when a large database is required.   Mobile apps hosted in a store are buried with millions of other apps, and it makes difficult for users to find your individual app.   While hosting apps in stores, the centralized portal provides an efficient venue to promote apps through the portal with unconventional clients in agricultural communities.   Figure5 illustrates screen design of the mobile portal, and description of each app developed by faculty and staffs at UF/IFAS is listed in Table 1.
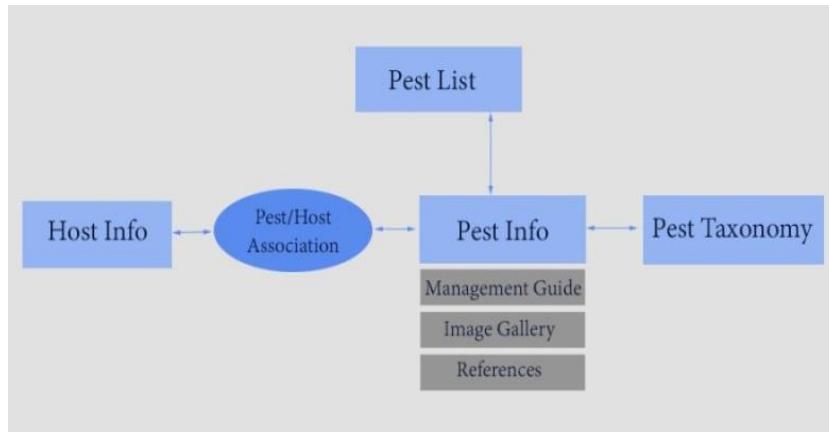

Figure 4. JSON objects and associations for landscape pests.

Figure 5.Illustration of the UF/IFAS mobile web portal (http://m.ifas.ufl.edu)

Table 1 Sample mobile web and apps developed   at UF/IFAS

	DDIS – Distance Diagnostic and Identification System. Provides tools to take photos of plant pests and management issues and submit them for diagnosis by specialists, clinics at UF/IFAS and any external experts.
	EDIS – Extension Data Information Source. It's a comprehensive, single-source repository of all current UF/IFAS peer-reviewed over 7000 Extension publications, which is the output of UF/IFAS Extension programs.
	FAWN – Florida Automated Weather Network. It provides real-time weather data around the state specifically for agricultural management and cold protection. Weather related farm management tools are also provided.
	Subscribe – A centralized subscription and clientele management system to engage clientele with up-to-date, relevant and reliable research-based information in agricultural related topics.
	slPests – Southeast Landscape Pests. A tool to support the diagnosis and information content of common insect and mite pests. The system is an example of cross-platform deployment using a single codebase.
	FFL Plant Guide – Florida-Friendly Landscaping Plant Guide. This app contains over 400 Florida plants to assist users finding the right plant for the right place.
	FLSART – Florida State Agricultural Response Team. This app provides emergency contacts, county resources and locations to support an effective and coordinated incident response for the animal and agricultural sector in the State of Florida.
	NPDN Citrus Diseases – This app is a symptom-based, illustrated identification guide that encompasses citrus diseases that are in the United States as well as those of immediate concern.
	NPDN Citrus Pests – This app is designed to help users determine which type of citrus insect pest they have encountered by featuring an illustrated, descriptive fact sheets for each pest.
	Florida Seafood @ Your Fingertips – This app brings you the most current recommendations for seafood along with complete information about how each item should be prepare, recipes and more.
	Protect U.S. Citrus Diseases and Pests - This app is designed for detecting and screening pests and diseases of citrus. It is an illustration based identification guide that encompasses citrus diseases and citrus pests that are in the United States.
	Smartirrigation Citrus - This app is designed to help growers to generate irrigation schedule recommendations based on real-time weather and short-term forecast to better meet water needs and minimize nutrient leaching due to excessive irrigation.

3   Discussions

Mobile technology will continue to evolve rapidly in the immediate future. Technology leaders, such as Apple and Google, continually roll out new programming languages and APIs that make app development easier and more cost effective. Despite growth of usage of mobile technology, the agricultural sector is slower in its adoption when compared to mobile technology use in other types of business. With deeper penetration of mobile devices, more people are dependent on mobile technology for use in their daily lives. In particular, today's users want to be connected to useful information at the time and place of need. There is enormous potential for use of mobile apps, as proven by valuable apps currently used in the agricultural sectors. A wide range of apps can be developed to support agricultural businesses. However, the success of mobile apps requires strategies and solutions that address users' need and provide a satisfying user experiences. More importantly, find solutions to address agricultural issues and challenges that we are facing in the 21st century.

4 Conclusions

The wide adoption of mobile technology creates the opportunity to provide mobile solutions to serve agricultural clients. The potential to deploy a wide range of apps across the agricultural domain is huge. We have only illustrated a small set of app examples. The development framework discussed in this article demonstrates a model for an efficient and cost effective way of utilizing existing development skills to deliver cross-platform solutions.

Successful delivery of mobile apps requires a mobile strategy that should focus on the needs in agriculture. The technical issues and application development are only a part of this mobile strategy. Due to the uniqueness and nature of the application domains in agriculture, effective deployment of IT applications requires collaborative efforts from multidisciplinary specialists, including IT specialists, domain experts, private sector, agricultural Extension services, universities and government at different levels. Mobile technology will continue to evolve and create new opportunities. It's up to us to leverage new mobile technology to make agricultural business more efficient and competitive. In fact, it's not about the technology; it's more about creating value and great solutions with the technology. It does mean thinking strategically about how information and mobile technology create significant value for agricultural production and services. Such success needs creative ideas and strong leadership to foster collaborations and take full potential of current and future technology that can address today's agricultural challenges and deliversknowledge and solutions to users' fingertips.

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