



# ANALYSIS OF CROSS-PLATFORM TECHNOLOGIES FOR MOBILE APPLICATIONS DEVELOPMENT

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## ABSTRACT

In the design and development of applications based on mobile technologies there are significant technical and technological difficulties associated with the integration of these applications into a single information landscape of the enterprise, and support for various versions of mobile operating systems. Because of the above-identified difficulties, the time and budgets of developing mobile applications, the cost of implementation and ownership of these systems significantly increase. In addition, there is no quick response to new market challenges, jeopardizing perspectives for business development companies. For solving given issues are used specialized cross-platform technologies, which provide the transfer of the program code on various versions of operating systems and devices. The aim of this study was to determine the effectiveness of existing cross-platform technologies for mobile applications development. The study contains analysis of modern cross-platform technologies including such aspects as development environment, testing environment, deployment environment, visual design environment, cross-platform and analytic features.

**Keywords:** software development, mobile applications, cross-platform technology.

## 1. INTRODUCTION

Currently, mobile devices in terms of functionality are not inferior to personal computers, which open up a wide field of application for mobile devices in various spheres of human activity. This circumstance gives rise to a demand for the development of various mobile applications. Currently, however, mobile devices are manufactured based on a variety of mobile operating systems, such as android, iOS, Windows Phone. Each of mobile operating systems in the mobile application development requires using their own development tools and programming languages. Development of mobile applications separately for each operating system is a fairly time-consuming and expensive solution to this problem [1]. To optimize the software development process for different mobile platforms apply specialized cross-platform technologies. These technologies provide transferring the programming code of the mobile applications on the various versions of mobile operating systems. The main advantages of the cross-platform technologies for mobile applications development are the following [2, 3]:

- Code reuse in applications.
- Access to application software modules and plug-ins, which simplifies their integration into other services or tools.
- Ability to develop applications using modern development platforms.
- It is not necessarily have additional knowledge and experience in software development technologies for different mobile platforms.

- Reduction of time for debugging and publishing applications.
- Absence of complexity with control version of applications, and adding a new functionality in the project.

According to consulting firm Gartner, in 2016 more than half the applications developed for mobile devices, will be implemented based on cross-platform technologies [4].

This work contains descriptions of the main methods of cross-platform development mobile applications, including their features, as well as advantages and disadvantages of the given approaches.

The aim of this study is to determine the effectiveness of existing cross-platform technologies for mobile applications development in terms of flexibility of mobile application development process including such aspects as coding, debugging, testing, deployment.

## 2. METHODS

From the technology marketing analysis of the cross-platform mobile application development tools, the most popular development tools are the following [5, 6]:

- Appcelerator Titanium Platform (Appcelerator Incorporated, USA).
- Konoye Platform (Kony Company, USA).
- Adobe PhoneGap (Adobe Systems Incorporated, USA).
- IBM Worklight (IBM Corporation, USA).



- Telerik Platform (Telerik Company, Bulgaria)
- Xamarin Platform (Xamarin Company, USA).
- RhoMobile Suite (Zebra Technologies Incorporated, USA).

The cross-platform mobile application development tools have a wide range of development features. To determine the strengths and weaknesses of these tools, we consider in more details each of them.

### 2.1 Appcelerator titanium platforms

Appcelerator Titanium Platform is a web-based mobile framework that allows web developers to use existing skills to build native applications for the iPhone and Android. However, despite the usual JavaScript language, developers are required to study the Titanium API, which is quite different from the classic web libraries and frameworks [7].

All source code is loaded into the mobile phone, where it has to be interpreted. This means that some of the source code errors cannot be detected before running the application. Loading time of the application significantly exceeds the related indicator of the applications written in platform-specific SDK. This is because the code required additional processing before running the application.

The key features Appcelerator Titanium includes [8]:

- Support for all web design basic tools (HTML, CSS, JavaScript) on all platforms.
- Support for languages such as PHP, Python and Ruby for the desktop mobile application.
- Support for popular JavaScript-frameworks, including jQuery, YUI, MooTools, Scriptaculous.
- Platform-independent API provides access to the UI-components of mobile platforms: panels, menus, dialog boxes, messages, as well as operating system functionality: sound, networking, databases, file system.
- API for mobile platforms features: accelerometer, maps, geolocation.
- The store for additional plug-ins and components, including analytics, advertising, cloud storage, social networks, graphics.
- Analytical platform, which provides monitoring application performance, application data, logs.
- Built-in connectors to the most popular Enterprise-platform (Salesforce, SAP, Oracle, Microsoft

Dynamics and SharePoint), connectors to popular services (LinkedIn, PayPal, DropBox, Facebook, Twitter). The ability to create their own connectors to any servers.

### 2.2 Konoye platform

Konoye Platform is an application development tool for mobile platforms, and it is used for coding, deploying, and managing mobile applications. Konoye Platform supports a variety of platforms, including IOS, Google Android, Windows Phone and Blackberry.

The developed applications consist of a virtual machine that implements scripting language (JavaScript or Lua), and that Konoye Platform uses in conjunction with the library for each platform in a variety of devices: BlackBerry, Windows Mobile, Java, Symbian, and web-browser clients.

Key Konoye Platform capabilities include [9]:

- Ability to develop web, hybrid and platform-dependent applications.
- Support for the full cycle of creating applications (design, development, testing, deployment and management applications for different mobile platforms).
- Ability to work and to share the prototypes between designers and developers.
- Access to services using RESTful API.
- Flexibility to choose the frameworks for development including JavaScript, PhoneGap.
- Ability to view the application layout in real time.
- Ability to send messages and notifications to users (push services).
- Synchronization services allow connecting to corporate information systems.
- Reporting and analytics provide monitoring application performance, application data, logs and definition of mobile devices.
- Tools for providing security including authorization, role based models.
- Versioning and deployment policy management.

### 2.3 Adobe phone gap

Adobe PhoneGap is an open source platform, which allows developing applications for multiple mobile platforms using standard web technologies. Adobe



PhoneGap supports operating systems such as Android, iOS, Symbian, Windows Phone, Bada, WebOS.

The applications are developed in JavaScript using HTML and CSS for layout. The development of mobile applications looks like an ordinary web site or web service. PhoneGap platform extends the API browser, and adds the following features: access to the accelerometer, the compass, contact list, file system, local storage, Web SQL, and allows access to any cross-source address [10].

There are the following features in application development under PhoneGap [11]:

- Writing code in HTML, JavaScript, CSS with the ability to use third-party libraries.
- Debugging applications using web browser.
- Applications do not support multi-threading.
- Problematic implementation of long lists (more than 1000 items).
- The complexity of the settings of the software environment for writing and debugging applications.

#### 2.4 IBM work light

IBM Worklight is a cross-platform mobile application IDE based on Apache Cordova approach. The applications were developed using HTML, CSS and JavaScript technologies. IBM Worklight allows creating hybrid and native applications. It also supports third-party JavaScript libraries such as jQuery Mobile, Sencha Touch and Telerik Kendo UI, as well as native programming languages of targeted operating systems [12].

IBM Worklight includes development and test environment, tools for integration with back-end components, deployment, analytics and control application lifecycle tools. IBM Worklight contains the following components [13]:

- IBM Worklight Studio - development environment for native and hybrid applications, which helps to optimize the reuse of code and accelerate the application development process.
- IBM Worklight Server - optimized for mobile technologies intermediate server used as a gateway between the application server side and third party web services.
- IBM Worklight Device Runtime Components - library of APIs used by the application to ensure safety, optimal navigation and better user experience.
- IBM Worklight Application Center - tool for managing applications distributed through app stores of mobile devices.

- IBM Work light Console - administration tool provides real-time analytics on servers, adapters, applications, and services, the notification for the control, monitoring of mobile applications.

Using IBM Worklight allows:

- Developing cross-platform mobile apps using native, hybrid or web approaches.
- Integrating mobile applications with existing business solutions, including databases, cloud services and other business systems.
- Providing information security of mobile applications at the device level, application level, data access level, and interaction with other distributed services.
- Managing application data from the single graphical interface and get detailed analytics in real time.

#### 2.5 Telerik platform

Telerik Platform is a platform for creation of hybrid applications based on web technologies such as HTML5, CSS and JavaScript. Telerik Platform provides a cloud-based development environment, implemented using web technologies, as well as a wide range of plug-ins for existing modern IDEs. When using a cloud development environment (AppBuilder) given the choice between the browser-based client and the client under the OS Microsoft Windows, plug-in for Microsoft Visual Studio, the command line interface and a package for Sublime Text IDE. If you use an integrated development environment for third-party vendors, you can download the necessary software libraries from Telerik and use them for application development [14].

The platform provides the following key tools [15]:

- AppPrototyper is web-based tool for creating design prototype of mobile applications. It allows creating the transitions between screen applications by creating links. Then you can preview the application in interactive mode. Thus, the user, creating a prototype application, can move between screens, as if working with a final application. The tool allows users to work on the same interface for multiple developers.
- AppBuilder is a cloud web integrated development environment, which simplifies development of cross-platform mobile applications. AppBuilder provides the benefits of desktop development environments and opportunities of cloud applications. AppBuilder provides design, coding and testing hybrid applications for various mobile platforms.



- Backend Services is a set of cloud services that allow developers to create and manage mobile apps, making it easy to scale the process of interaction with data stores, user management and interaction with the server side of the application.
- Mobile Testing is an automated solution for testing native, hybrid and web applications. It provides environment for writing the test scripts and running them in the cloud services on all available platforms and devices, including iOS, Android, Windows Phone, mobile and desktop browsers.
- AppManager is a management solution for deployment the application to different mobile platforms such as android, iOS, Windows Phone. AppManager supports such features as version control, list of users, and list of devices that are installed applications.
- AppFeedback provides built-in mechanism for obtaining feedback from the application users.
- Analytics is a service for getting analytical information about usage of mobile applications.
- Xamarin iOS Designer for Xamarin Studio and Microsoft Visual Studio makes it easy to create the interface, allowing using the functions of graphic designer and edit the properties of controls.
- Xamarin Android Designer provides a graphical user interface for Xamarin Studio and Visual Studio. The project included files with AXML extension, containing data with information on the location of controls for Android.
- Microsoft Visual Studio and Microsoft Blend provides designer graphical user interface for creating Windows Phone applications.

The typical architecture of mobile applications written using Xamarin contains the following software layers [17]:

- Data layer.
- Data access layer.
- Business logic layer.
- Layer of access to external services.
- Layer of the specific code for the target operating systems.
- Presentation layer.

Initially, the graphical user interface had to be designed for each target platform separately. Currently Xamarin Platform includes set of libraries Xamarin.Forms, which allows creating graphical user interface using the universal controls optimized for all target operating systems.

## 2.6 Xamarin platform

Xamarin Platform is a platform for building cross-platform applications for mobile operating systems. The platform is an evolution of Mono project, which provides the implementation of .NET Framework for popular operating systems.

As a development environment Xamarin Studio can be used, supplied with Xamarin platform, or Microsoft Visual Studio, for which the plug-in is available. Xamarin Platform contains the following set of tools to develop applications for Android, iOS and Windows Phone:

- C # programming language allows developers to use a powerful set of features and syntax tools such as Generics, Linq, and Parallel Task Library.
- Mono .NET Framework provides a cross-platform implementation of the Microsoft .NET Framework.
- Compiler provides the code building and its optimization of native applications, depending on the target mobile operating systems.

Although Xamarin provided application development using C # and created the builds for multiple platforms, the actual implementation for each platform may differ. Each target mobile operating system has its own method for creating design of graphical user interface [16]:

## 2.7 RhoMobile suite

Rho Mobile Suite is a platform for creating cross-platform mobile applications for iOS, Android, Windows Phone, Blackberry based on web technologies approach.

Rho Mobile Suite included the following key components [18, 19]:

- Rho Studio is an integrated development environment based on Eclipse enabling to develop, test, and debug mobile applications. Rho Studio includes Rho Simulator is the simulator of mobile devices, and it is configured to develop mobile applications in Rho Mobile environment.
- Rho Mobile is a native container, which running mobile applications developed on web technologies. It supports programming languages such as JavaScript, HTML, CSS, and Ruby.



- Rhodes is a software library that allows access to the hardware capabilities of mobile devices and mobile operating systems functions.
- RhoConnect is a server application providing tools for the integration of mobile applications with data sources. RhoConnect allows you to connect mobile applications to wide range of data sources, including CRM, ERP.
- Hosted Services is a set of services that allow performing remotely the assembly of applications for all target operating systems, without requiring a local installation of development tools from the official suppliers of operating systems. Hosted Services are also responsible for managing mobile applications and publishing them to app stores of mobile OS.

RhoMobile Suite supports the following operating systems: iOS 6.0 or later, Android 2.3 or later, Windows Mobile 6.x, Windows CE 5.x-7.x, Windows XP, Windows Phone 8 and newer, and Windows Desktop (7 and newer).

## 2.8 Methodology of cross-platform technologies analysis for mobile applications development

Analysis of cross-platform technologies for mobile applications development based on the methodology is described below.

The expert examines each of the selected cross-platform technologies. Then, based on the knowledge and experience of their usage, the expert evaluates given technology by the appropriate functional assessment criteria.

In the process of testing and evaluation four staff members were involved, two of them were employees of the research organization and two were the independent consultants.

The expert studied each of the cross-platform technologies by working with trial versions, and the examination of relevant technical documentation,

including the description of the technology, administration and developer guides.

The expert carried out evaluation of cross-platform technologies by related criteria. These criteria grouped into logical functional groups. The description of the functional groups and the relevant criteria presented in Section 2.9.

The evaluation of cross-platform technologies by each criterion performed by five-point scale. Table-1 presents the ratio of estimated value and the degree of compliance with the implemented functionality.

**Table-1.** The degrees of compliance with functional capabilities of technologies

Degree	Value
0	Absence of related functionality
1	Does not satisfy the requirements
2	Partially satisfies the requirements
3	Satisfied, but there are serious drawbacks
4	Satisfied, but there are minor drawbacks
5	Fully satisfies the requirements

The final rating evaluated cross-platform technologies are the sum of estimates for all functional criteria. The maximum possible overall rating of the technology equals the number of criteria multiplied by the maximum possible score is 235 (47 x 5).

The averaged overall rating, exhibited by the group of experts, was determined by the following formula: Sum of final ratings of all experts divided by the number of experts.

## 2.9 Evaluation criteria of cross-platform technologies for mobile applications development

For testing and evaluation of cross-platform technologies the list of functional criteria was formed. The criteria reflect the features and the most important aspects of mobile applications development [20, 21]. Table-2 presents the list of given evaluation criteria.



**Table-2.** The list of evaluation criteria of cross-platform technologies

No.	Group of criteria	Description of criteria
1	Development environment.	Support for programming languages. Code editor. Advanced graphical user interface. Version control.
2	Project management tools.	Planning of the development processes. Communications of development team. Unified process of information management. Universal project for all support platforms.
3	Testing environment.	Automated testing. Unit testing. Detailed test reports. Cloud Testing Service. Testing web applications. Testing native applications. Testing hybrid applications. Support emulators for testing.
4	Publish and deploy applications.	Deploying applications on the dedicated environment. Deploying applications on the cloud environment. Publication application in the app store.
5	Analytic tools.	5.1 Code analysis tools. 5.2 Application performance analysis tools. 5.3 Application errors analysis tools. 5.4 Application functions analysis tools.
6	Cross-platform development features.	6.1 Creating native applications. 6.2 Creating web applications. 6.3 Creating hybrid applications. 6.4 Access to internal functions of mobile devices. 6.5 Supported mobile platforms. 6.6 Support for remote application management tools. 6.7 Support for multicultural applications. 6.8 Support for USSD-services. 6.9 Support for sending messages and notifications to users. 6.10 Support for various development environments. 6.11 Maintenance of application audit, performance, error logs.
7	Visual design environment.	7.1 Creating a graphical user interface. 7.2 Support for WYSIWYG technology. 7.3 Graphical components for definition of business logic. 7.4 Graphical components for accessing to data sources. 7.5 Support for visual programming tools.
8	Application store.	8.1 Support for application stores. 8.2 Remote management applications in stores. 8.3 Support for user feedback. 8.4 Support for application updates. 8.5 Support for application access policy.
9	The quality of the documentation and the technical support.	9.1 Completeness of the documentation. 9.2 The quality of learning materials (demo examples, case studies, code samples). 9.3 The quality of technical support.

### 3. RESULTS AND DISCUSSIONS

Functional testing and evaluation of cross-platform technologies for mobile applications development have been made based on the study of their

technical core features, flexibility of development and maintenance of mobile applications.

Table-3 presents the results of testing and evaluation of the cross-platform technologies by related evaluation criteria (Table-2).

**Table-3.** The results of testing and evaluation of cross-platform technologies for mobile applications development.

Criteria \ Estimation of system, points	Appcelerator platform	Kony one platform	Adobe phone gap	IBM work light	Telerik platform	Xamarin	Rho mobile
1. Development environment.	18	18	15	16	19	18	16
2. Project management tools.	18	18	10	9	18	10	9
3. Testing environment.	27	28	21	25	37	24	26
4. Publish and deploy applications.	13	13	9	14	15	10	12
5. Analytic tools.	9	15	3	17	15	20	16
6. Cross-platform development features.	28	35	22	46	42	33	42
7. Visual design environment.	20	22	18	21	25	23	20
8. Application store.	18	15	0	11	21	8	9
9. The quality of the documentation and the technical support.	11	10	13	11	13	15	12
Total estimation	162	174	111	170	205	161	162

The following overall rating of cross-platform technologies for mobile applications development achieved:

- Telerik Platform (205 points).
- Konoye Platform (174 points).
- IBM Worklight (170 points).
- Appcelerator Titanium Platform (162 points).
- RhoMobile Suite (162 points).
- Xamarin Platform (161 points).
- Adobe PhoneGap (111 points).

According to the results of testing and evaluation, the most effective cross-platform technologies the following were defined:

- Telerik Platform (Telerik Company, Bulgaria)
- Konoye Platform (Kony Company, USA).
- IBM Worklight (IBM Corporation, USA).

These technologies have the best functional and performance among other cross-platform technologies for mobile applications development. Each technology gives different advantages and disadvantages, but in common, these technologies represent the complex platform, which provides full development lifecycle including design, coding, testing, deployment and maintenance. In addition, it should be noted that given technologies are based on hybrid approach, which provides creating mobile

application using modern web technologies (HTML5, JavaScript) as well as utilizing internal capabilities of mobile devices.

#### 4. CONCLUSIONS

The object of analysis was cross-platform technologies for mobile applications development, including their key features such as Development environment, Testing environment, Project Management, Publish and deploy applications, Analytic tools, Cross-platform development features, Visual design environment.

The main objective was to determine the effectiveness of existing cross-platform technologies for mobile applications development in terms of flexibility mobile application development process including such aspects as coding, debugging, testing, deployment.

The achieved result determined the following leaders: Telerik Platform, KonyOne Platform, IBM Worklight.

Given systems provides the best functional and technical features among other cross-platform technologies for mobile applications development. Overall, reviewed cross-platform technologies provide the following advantages:

- Code reuse in applications.
- Using specified software modules and plug-ins, which simplifies their integration into other services and tools.
- The possibility for developers to develop applications using familiar technologies and programming languages.



- The debugging and publishing applications much faster.
- There are no problems with version control of applications, and the adding of new changes in the developing project.
- Reduce the time and cost of developing mobile applications in 2-5 times compared to using the standard development tools.
- Reduce the cost of system integration of enterprise applications in 2-3 times compared to using the service bus solutions.
- Reduce the cost of ownership of mobile applications is 2-4 times compared to using standard application support.

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