Mobile Programming and Multimedia

Cross-Platform Frameworks

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Scenario

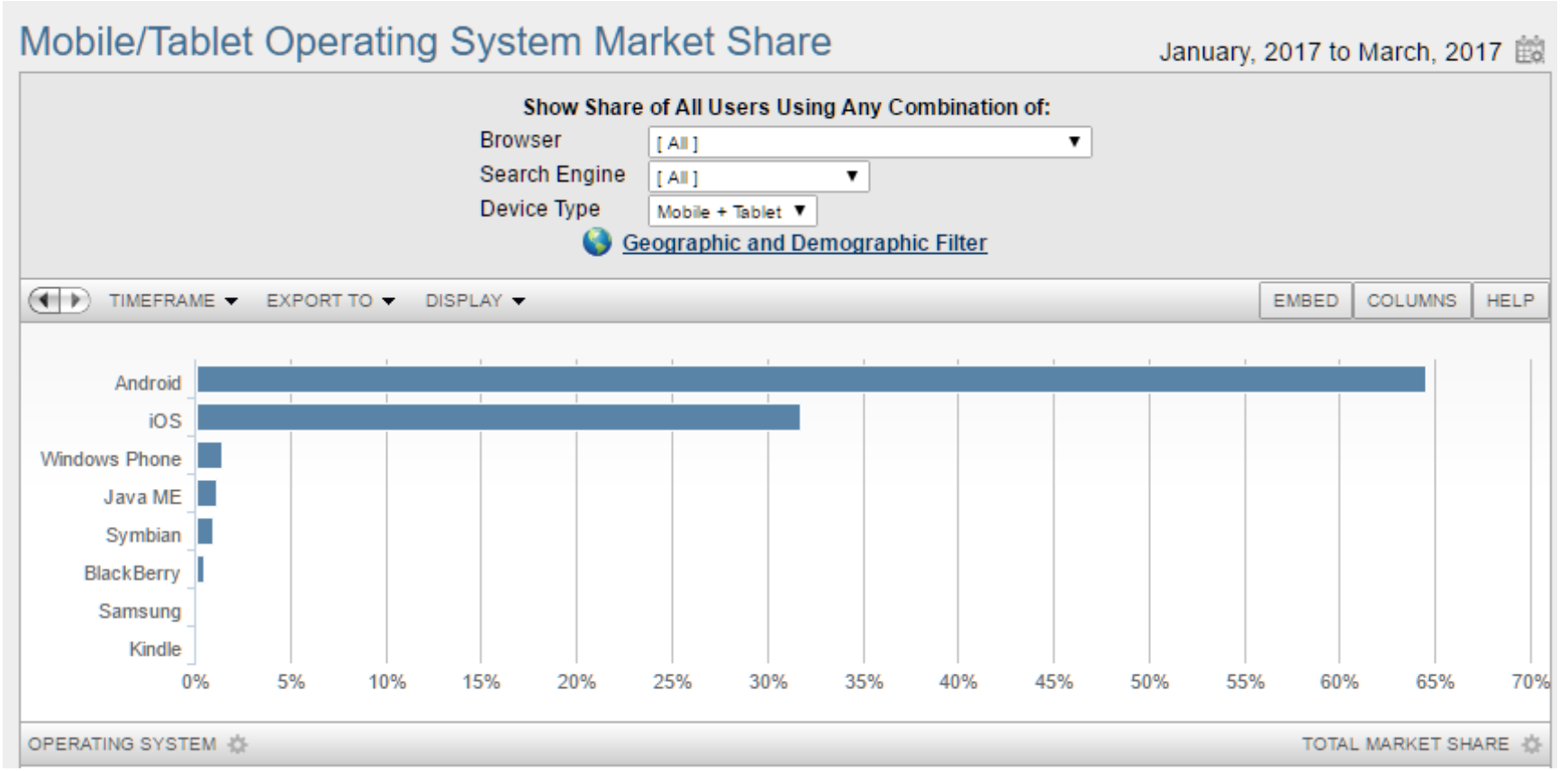
I have an exciting idea for a new app

I want to develop this fantastic app

I have an iPhone so…

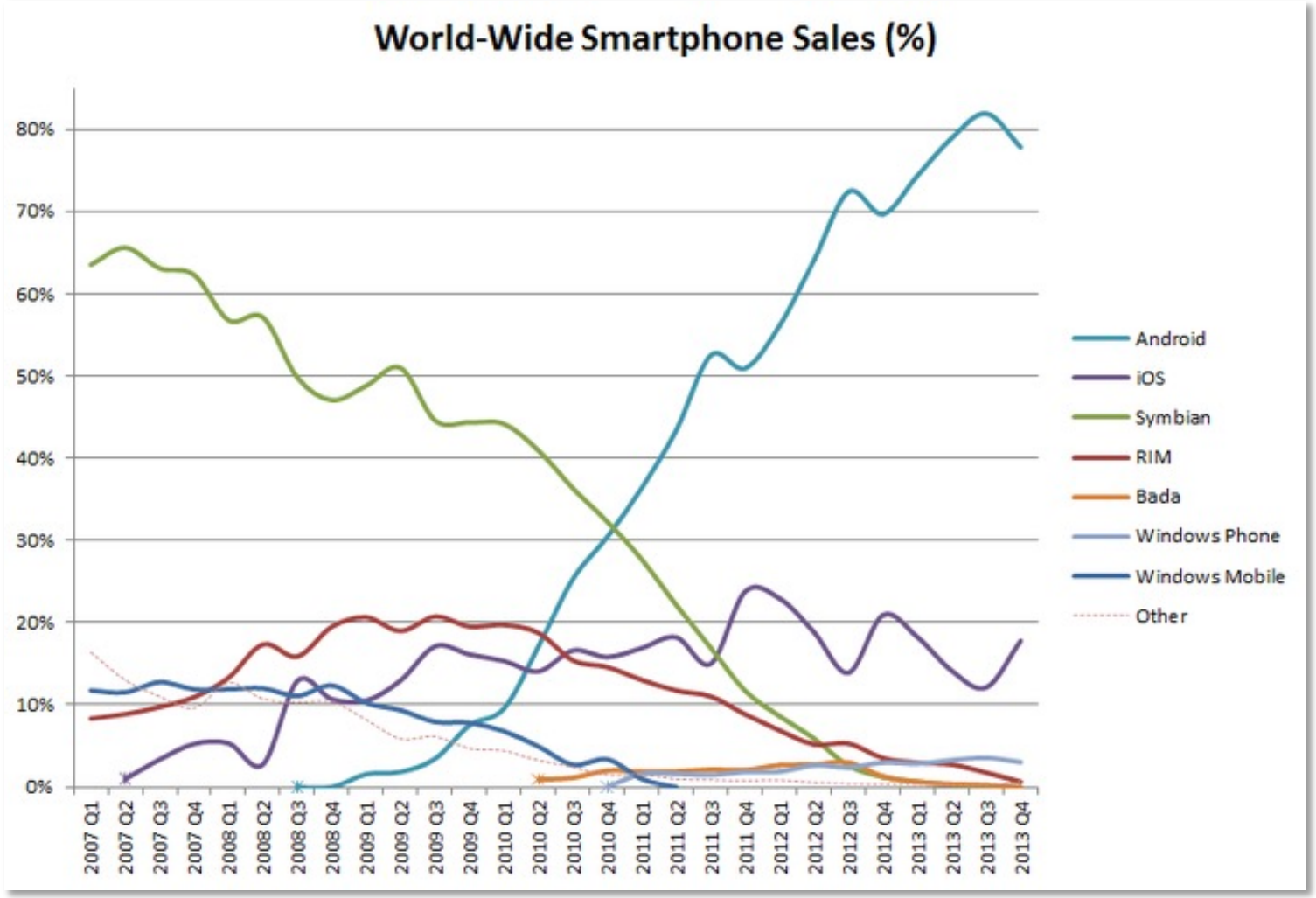
… I develop it in iOS

… but Android diffusion is higher than iOS!

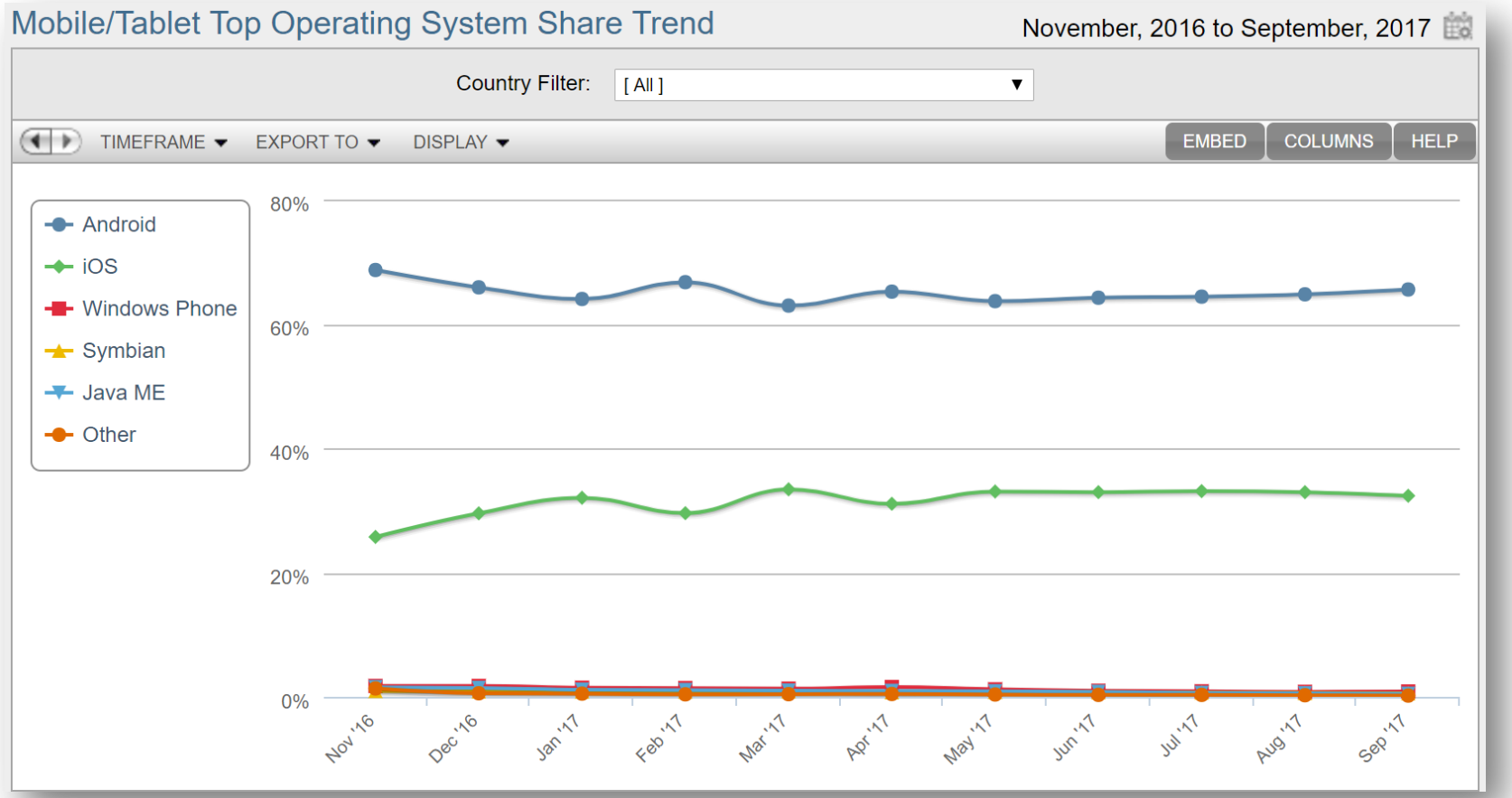


https://www.netmarketshare.com/

Solution: go back to 2010 or before ;-)

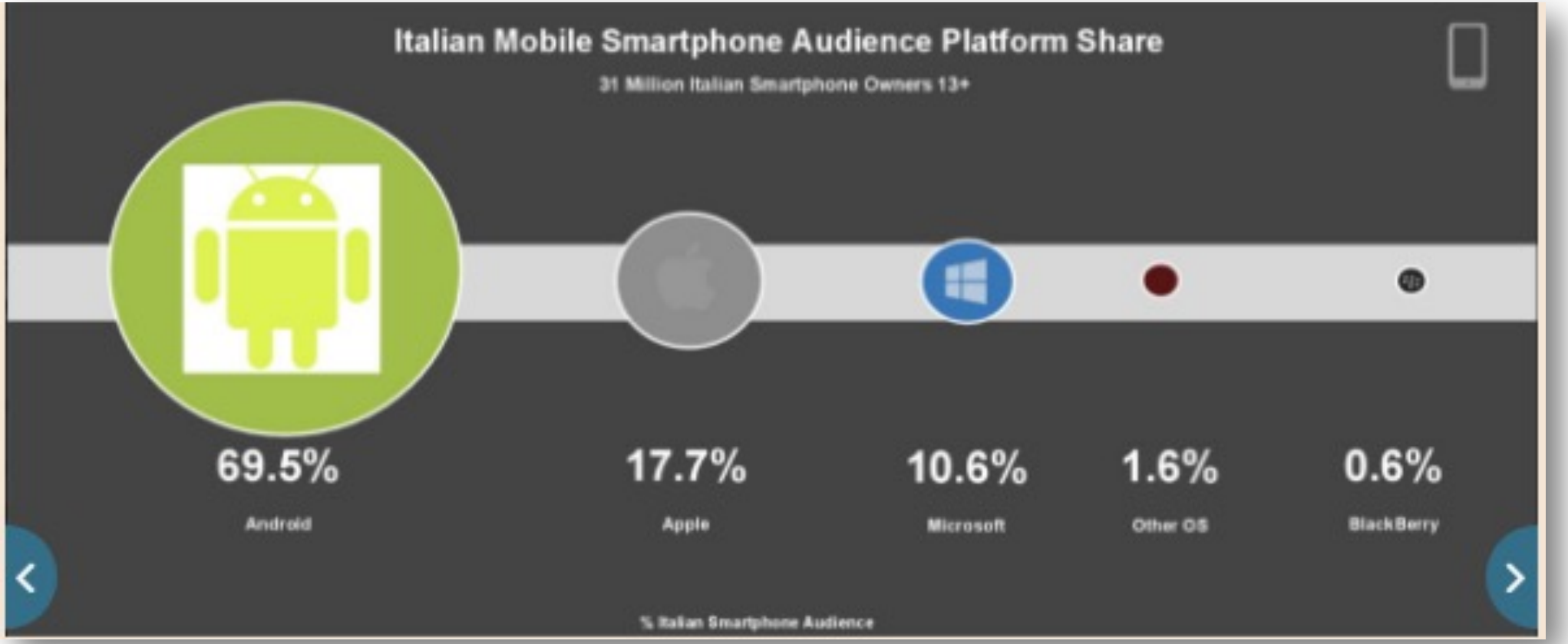


Market fragmentation



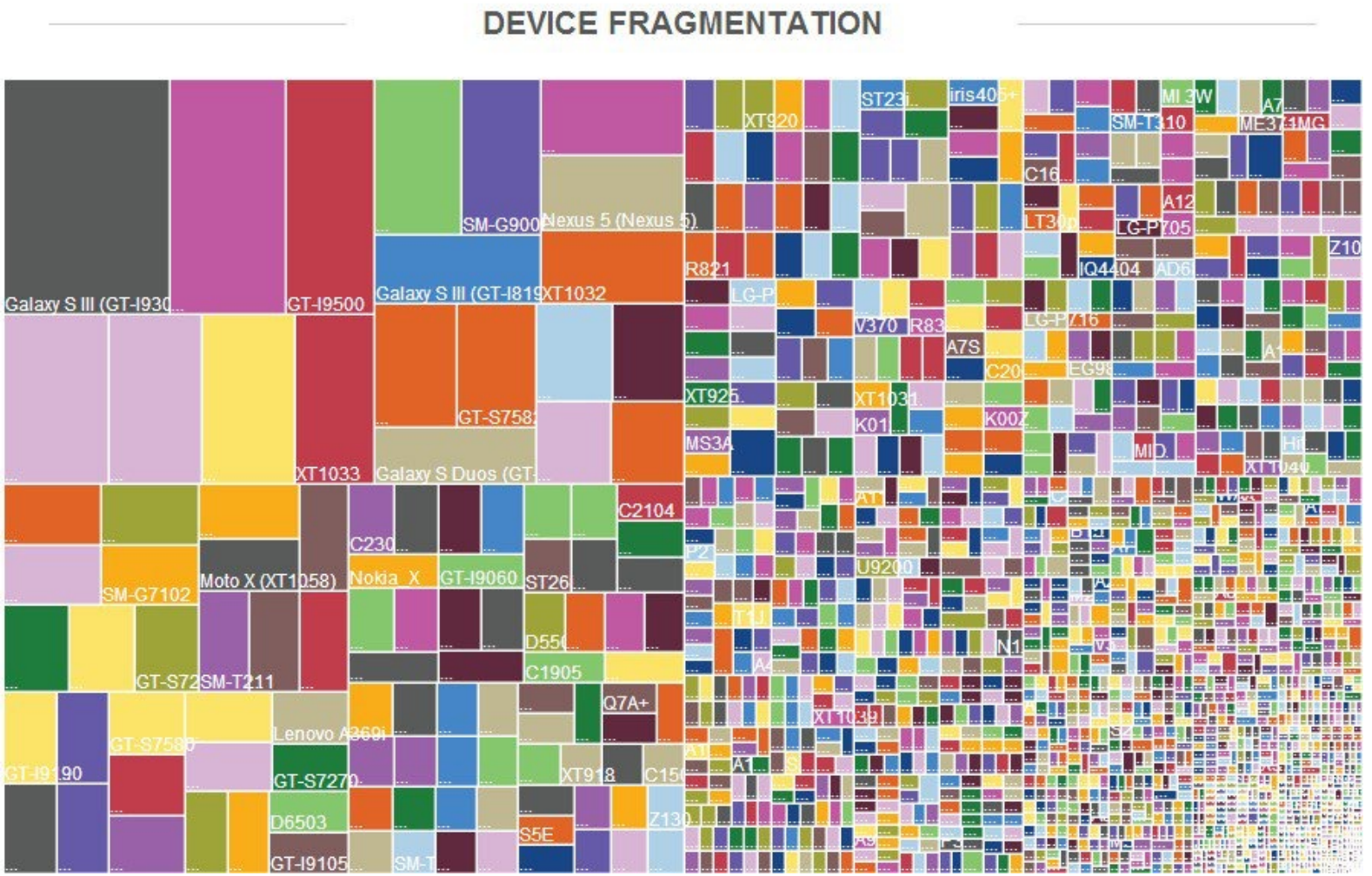
https://www.netmarketshare.com/

Italian market fragmentation



http://www.infodata.ilsole24ore.com/2016/09/02/samsung-e-apple-guidano-il-mercato-smartphone-in-italia-ma-occhio-a-huawei-cresce-del-140/

Android device fragmentation



http://android.hdblog.it/2014/08/22/Android-2014-presentati-quasi-19000-device/

Problem

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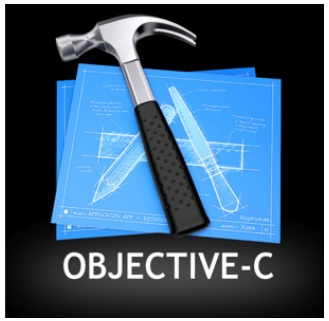
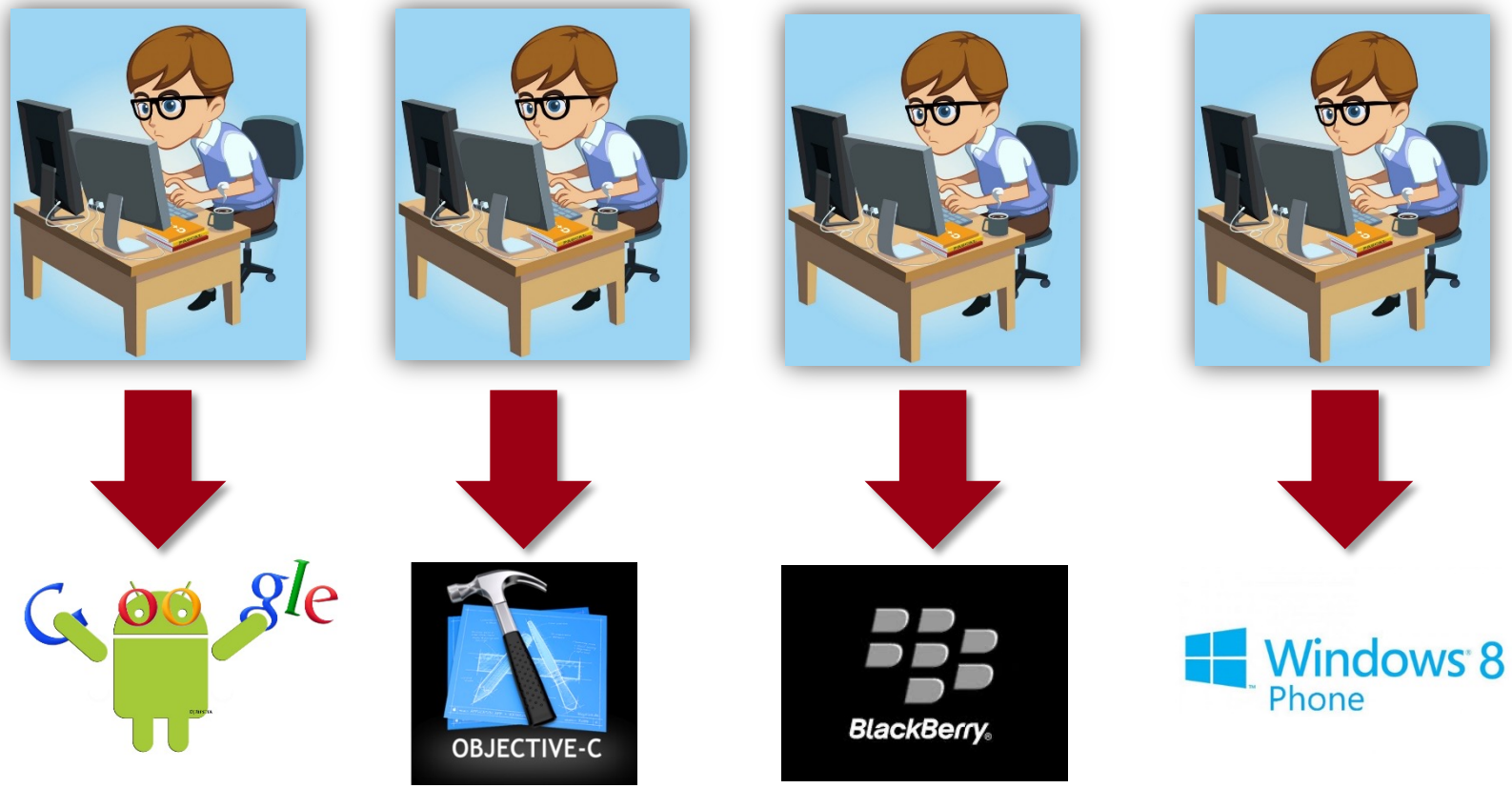
Different OS => different languages

It is necessary to develop different apps (al the same) for several devices



How many?

One for each operating system?



Highly expensive!

Which are the variables?

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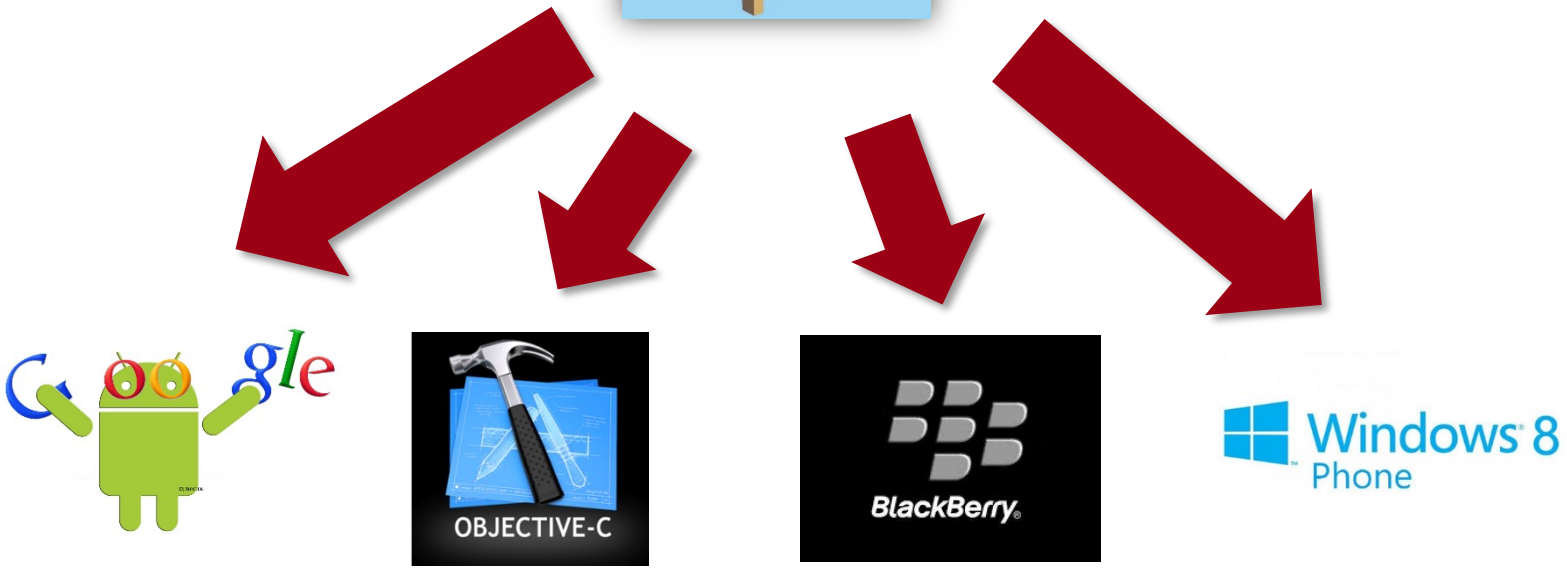
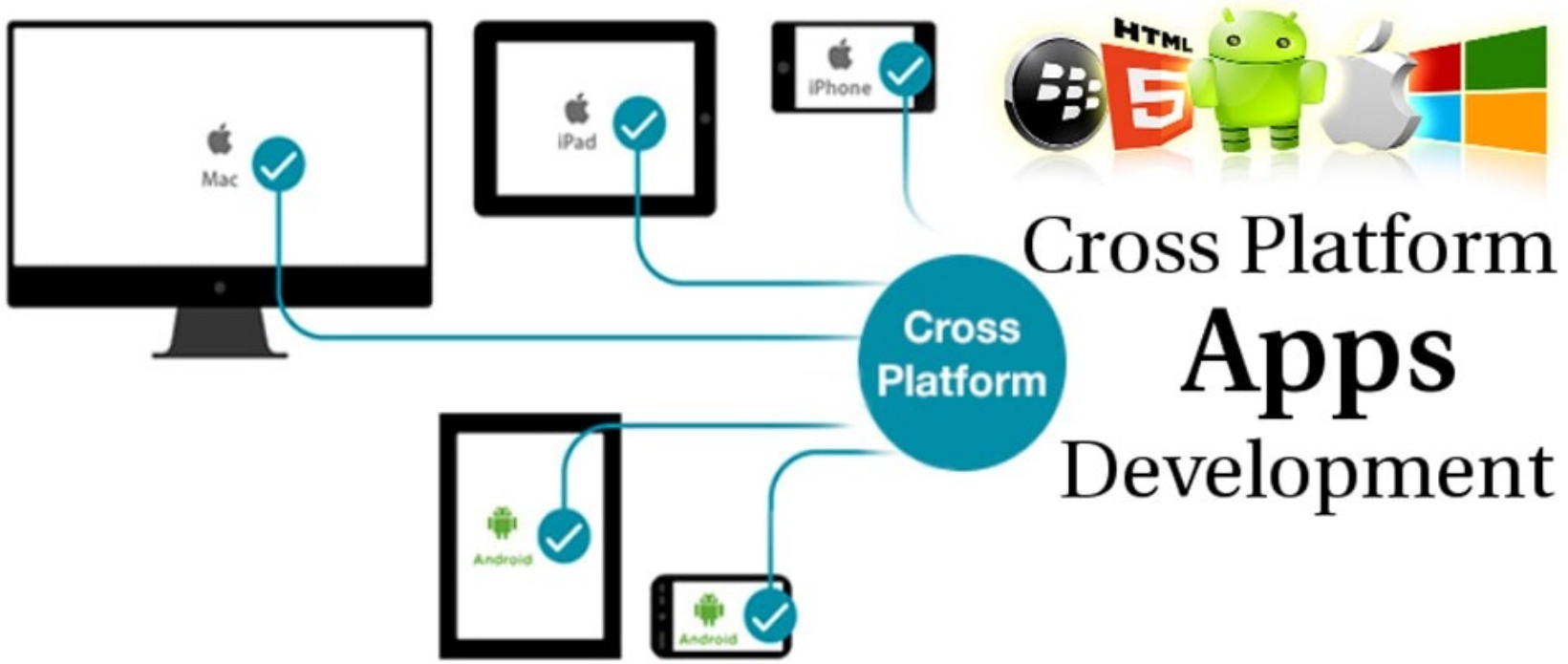
- Operating system
- Programming language
- Development tools (IDE, simulators, etc.)
- API
- Sensors/equipment
- Screen size
- Computational capacity
- …

Goal



Solution


Mac
iPad
iPhone
Android
Android
Cross Platform
HTML
Cross Platform
Apps
Development

A new approach

Cross-platform frameworks for mobile development reduce the negative effects of market fragmentation

«Write once, distribute everywhere»

Main features

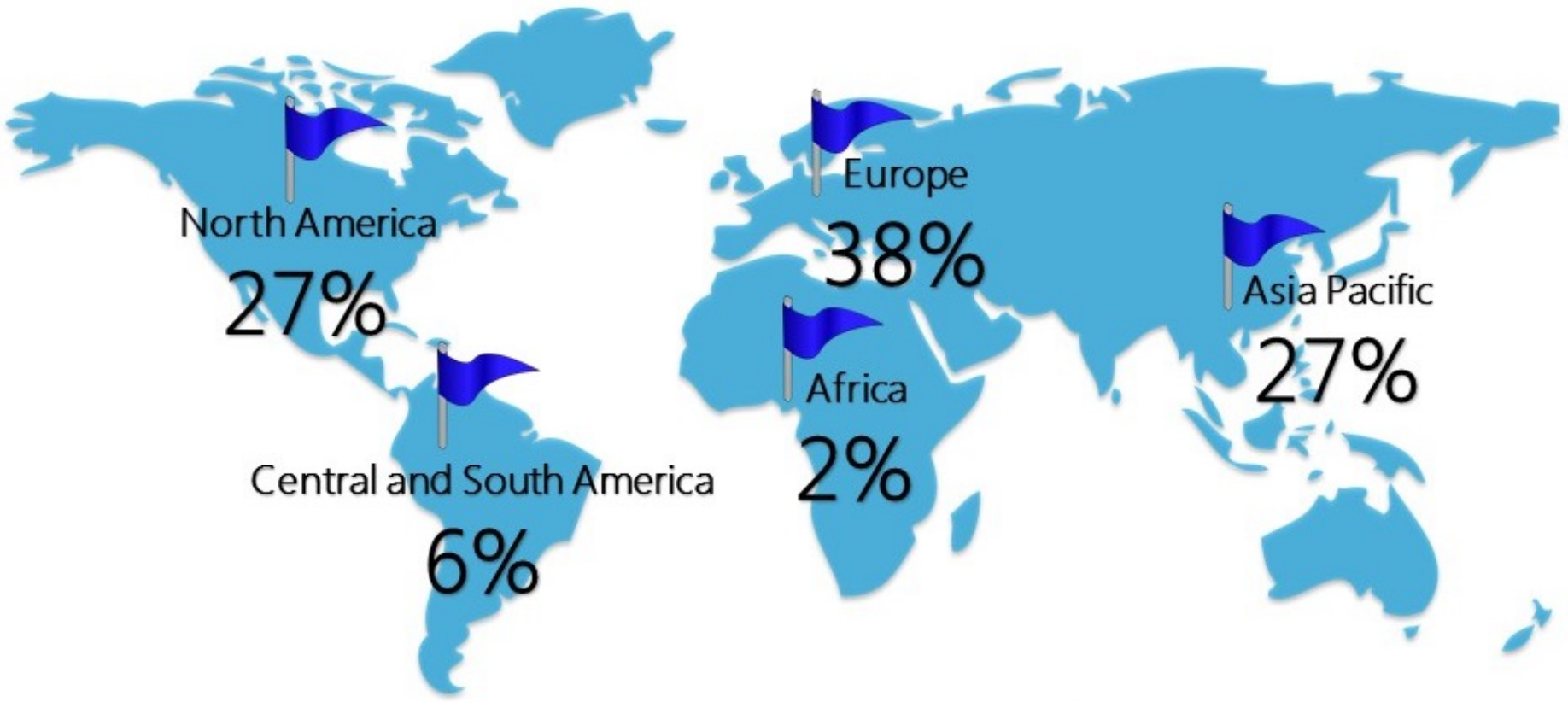
- Application developed on time, using only one programming language (or a set of languages)
- The chosen framework allows the distribution of the application in several applications stores (so, there are several applications deployed)
- The frameworks usually provide support for native API

Really the solution?


Market

https://www.rishabhsoft.com/blog/cross-platform-app-tools-infographic

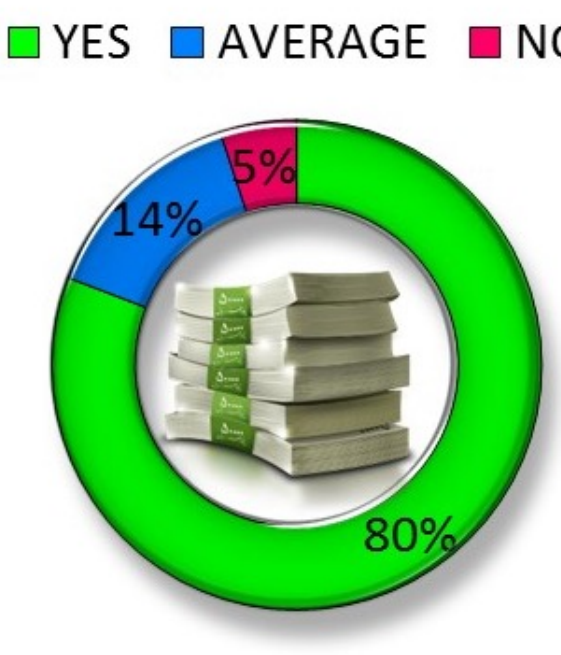
Geographical distribution

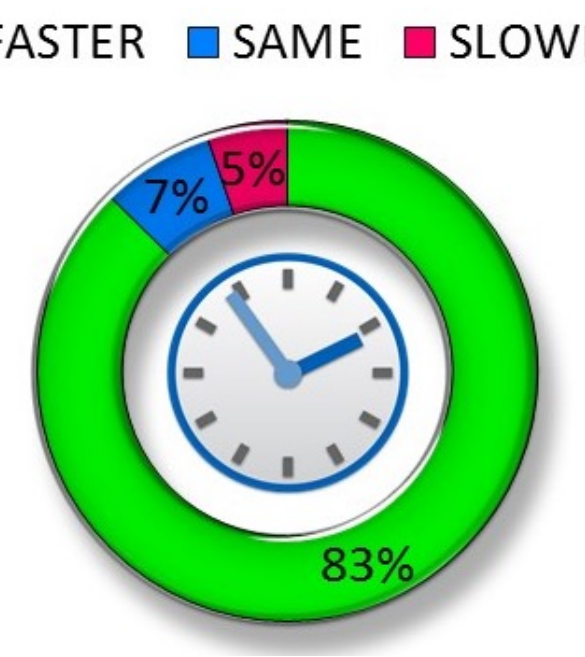


Benefits

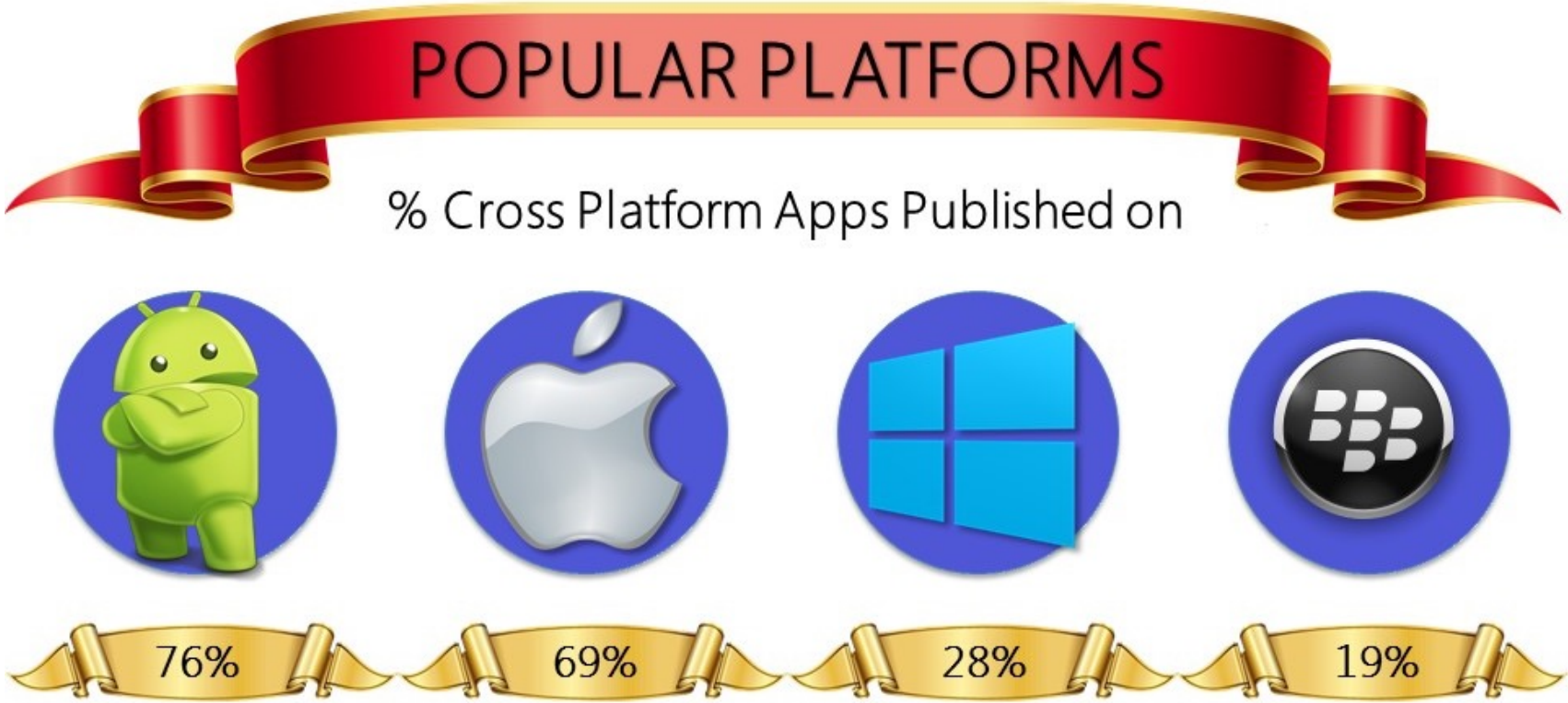

COST EFFECTIVE


TIME SAVING


YES
AVERAGE
NO
5%
14%
80%


FASTER
SAME
SLOWER
7%
5%
83%

Platforms


POPULAR PLATFORMS
% Cross Platform Apps Published on
76%
69%
28%
19%

Most popular

ADOBE® AIR™

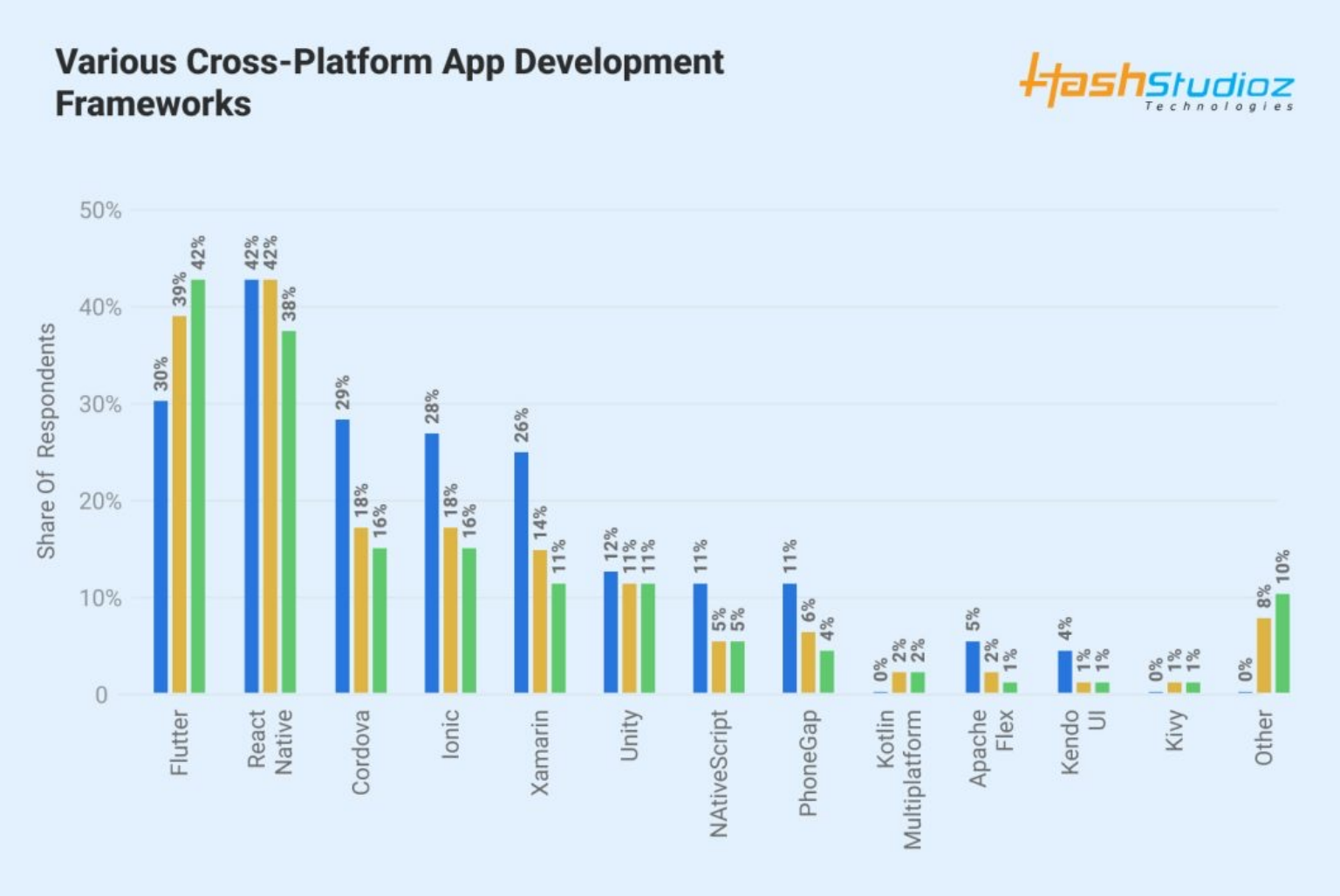
Sencha

Xamarin

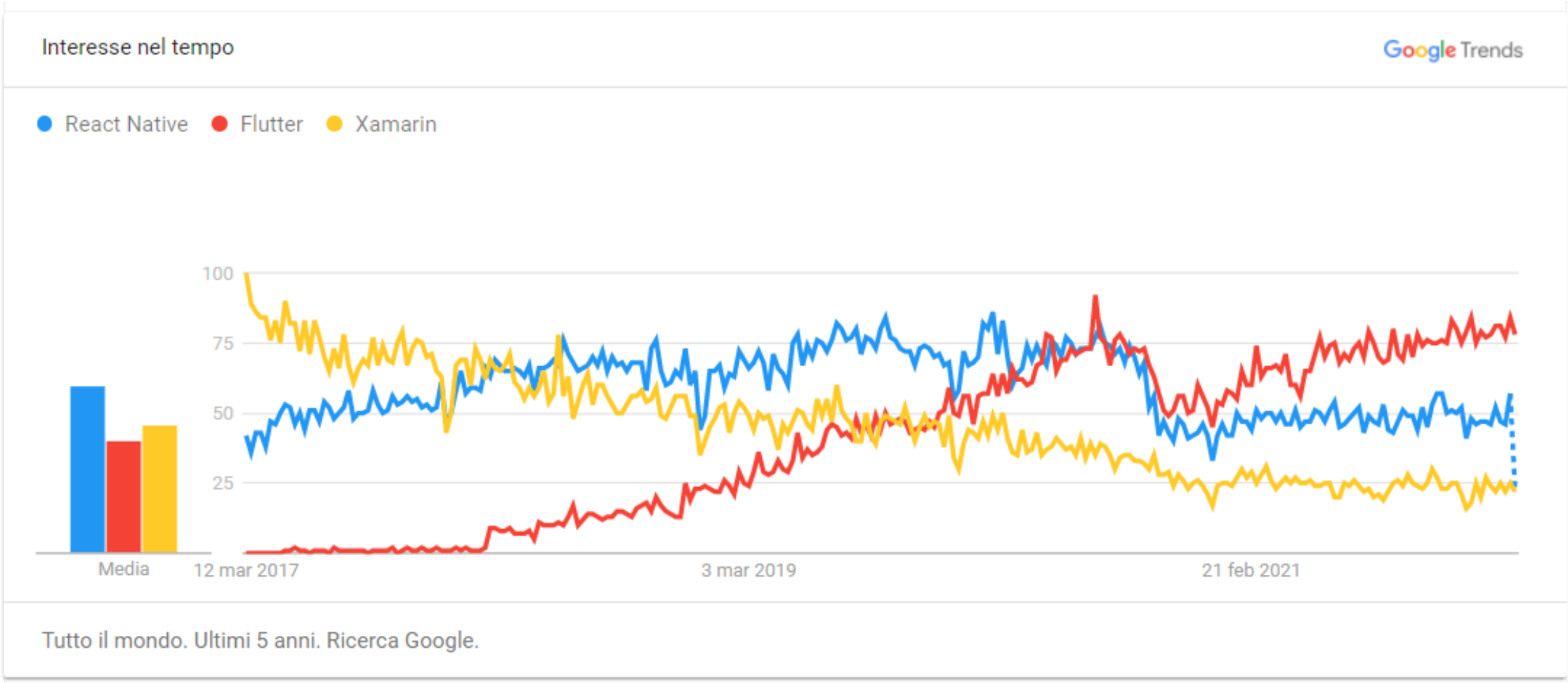
Corona

Pay attention to the stats!

Frameworks trend



Google statistics



Pros and cons of cross-platform

Cross-platform mobile development	
pros	**cons**
wide market reach	possibly slower performance
single codebase	UX and UI discrepancies
faster and cheaper deployment	
reduced workload	
platform consistency	

Native: Pros & cons

- Pros of native applications:
  - Usually, a native application offers a better user experience, a faster and more high-performance interaction
  - Non-native applications are limited by the expressivity of the used framework (e.g., available APIs)
  - An Apple computer is always needed
- Cons
  - Fragmentation = higher development costs
  - Problems with test
  - *How to choose the best framework?*

Steps for app development

App development involves 4 steps:

1. Idea analysis
2. Interface design
3. App development
4. Store deployment

Store deployment is necessary every time there is an update and for each platform

Native development requires repeating steps 2-3-4 for each platform

Frameworks classification

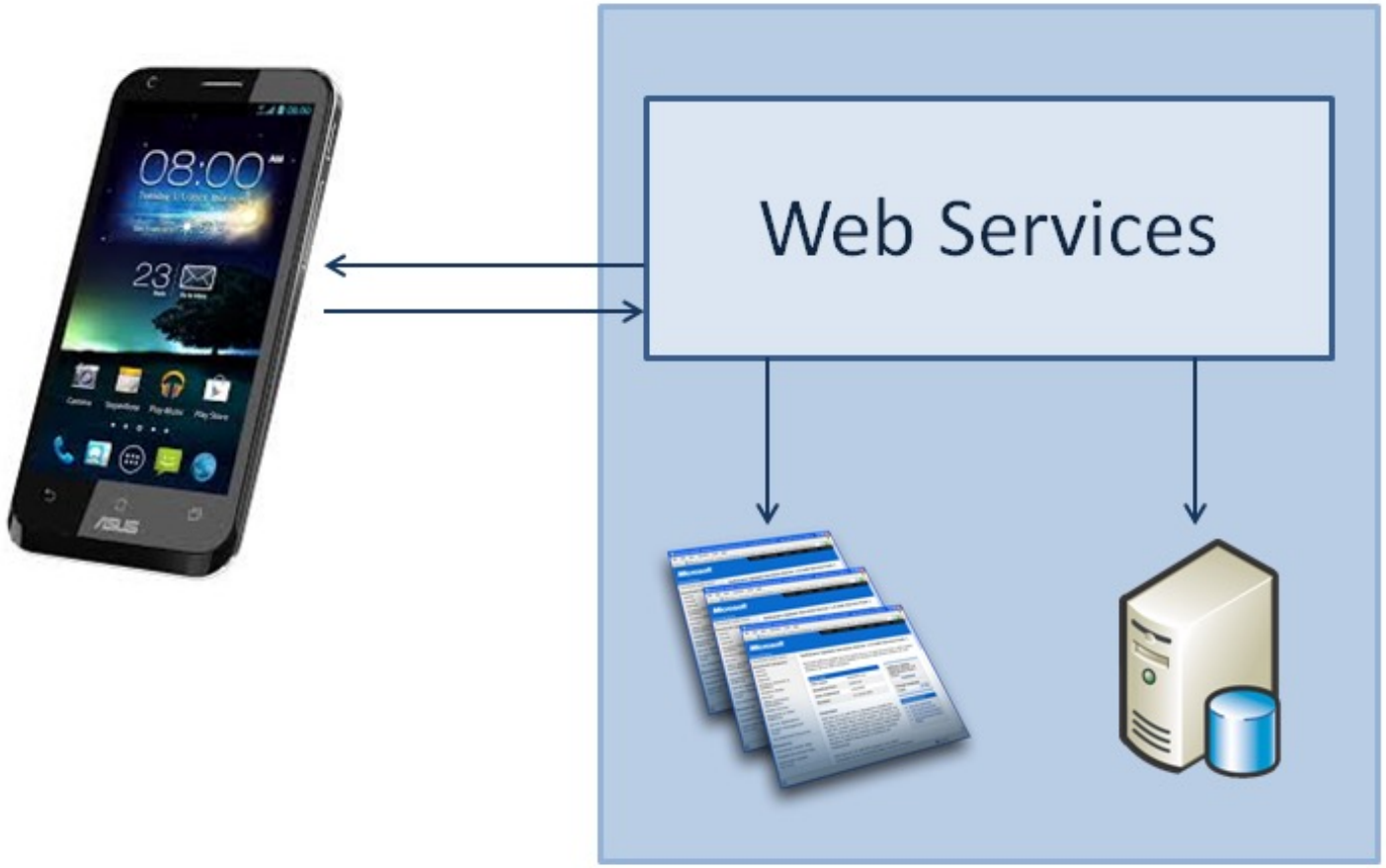
Frameworks' classification is still an open problem

Raj and Tolety classification define 4 different classes:

- *Web Approach*
- *Hybrid Approach*
- *Interpreted Approach*
- *Cross-compiled Approach*

R. Raj, S. Tolety. *A study on approaches to build cross-platform mobile applications and criteria to select appropriate approach*. In INDICON 2012, p. 625-629

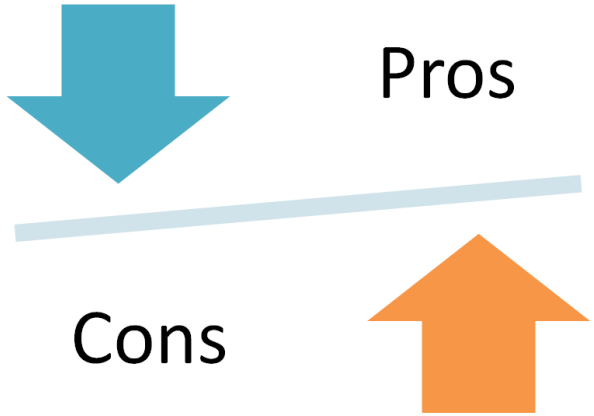
Web Approach



Web Approach: Pros & Cons

Pros:

+ Same interface (but not same experience) on all devices
+ No installation necessary
+ Easy update



Cons:

- No store publishing
- Network connection necessary (but..)
- Difficult test
- Strongly connected to HTML5 support of the device
- Non-native interfaces bring to low usability

Progressive Web App (PWA) - 1

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Progressive Web App (*PWA*) are web pages that behave like native applications. In particular:

- They are developed using web technologies, therefore HTML5, CSS3, Javascript
- It works independently from the browser, using *progressive enhancement* (the more features the browser provides, the more features provides the app)
- It works even offline, but with limited support
- Can be installed without using the store (but in this case, they are a sort of link)

Progressive Web App (PWA) - 2

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Progressive Web App (*PWA*) are web pages that behave like native applications. In particular:

- Like every web page, these apps adapt themselves to device size (*responsive*)
- Secure (https) and indexed by search engines
- Easy to update
- Support push notifications (but…)
- No need for stores to publish the app, but there is no payments management, and there is no control of what is published

Not a new concept

Steve Jobs coined the term web app in 2007

In 2015 Chrome developers coined the term *Progressive Web App* to describe those apps using new functionalities like service workers and web app manifest

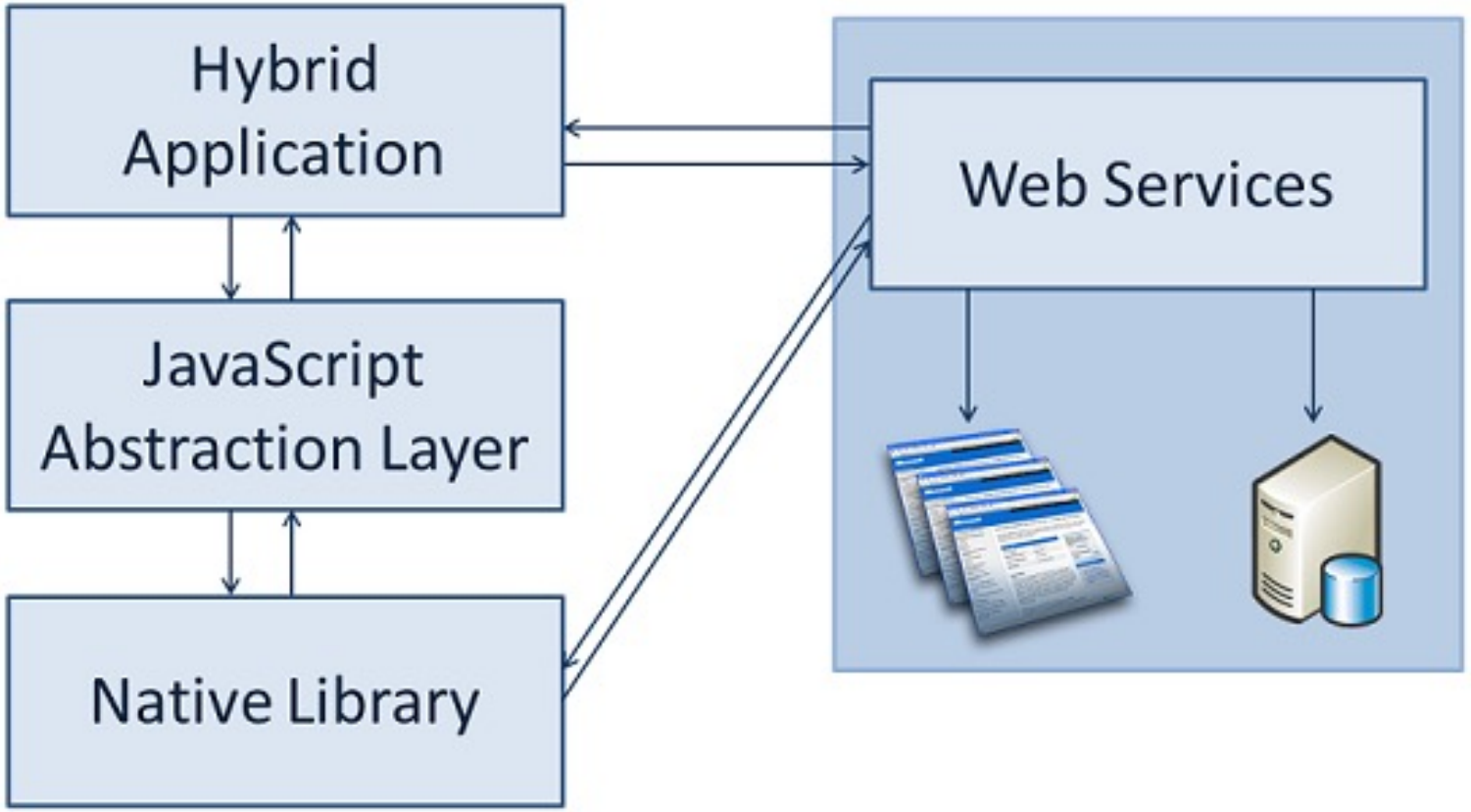
Examples

Sencha Touch

React

jQuery mobile

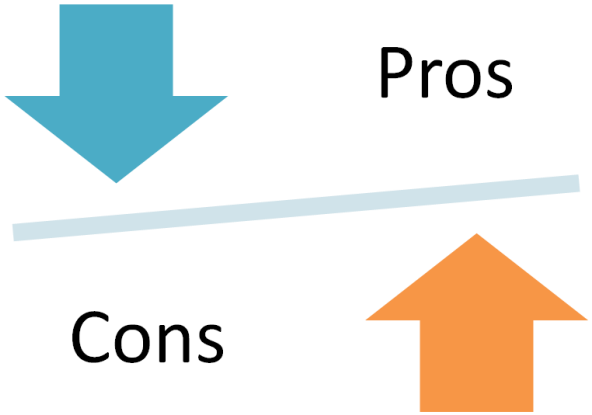
Hybrid Approach



Hybrid Approach: Pros & Cons

Pros:

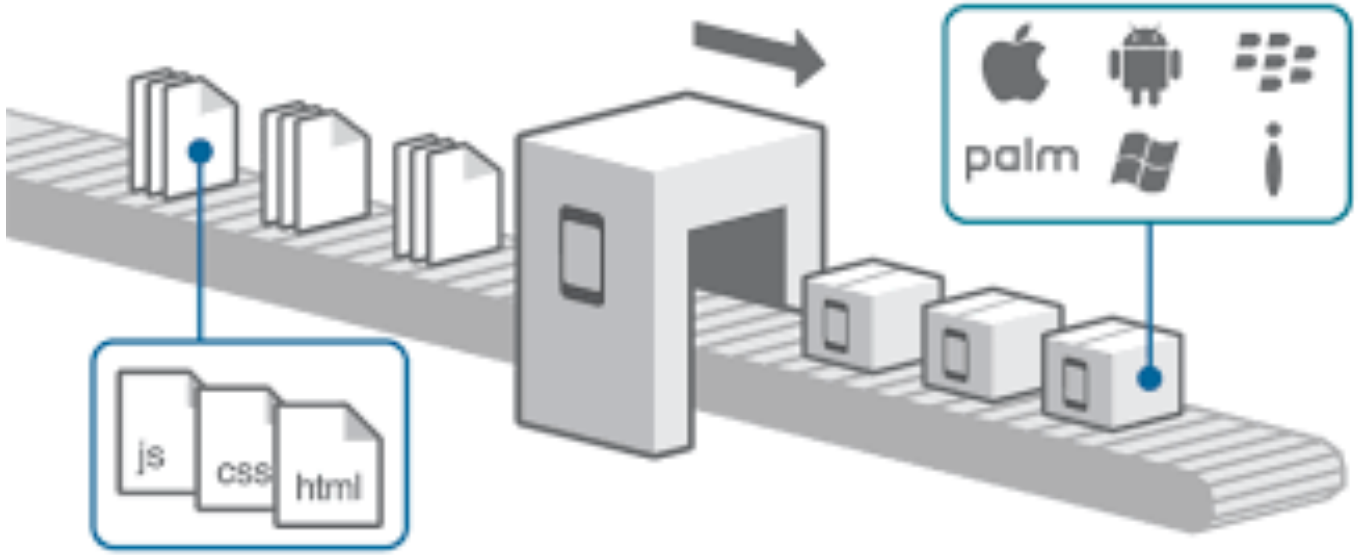
+ Store publishing available
+ Reusable UI
+ Usage of device components



Cons:

- Lower performances
- UI do not follow native Look and Feel

Example: PhoneGap/Cordova



A bit of history

The project started in 2008 trying to solve these problems:

- Development of mobile applications using web technologies
- Solve the problem of low support of mobile browsers to HTML5
- Allow access to different features of the device

Actual support to HTML5 of the mobile browsers and the HTML5 evolution have partially solved these problems

Apache Cordova and PhoneGap: what differences?

In 2011 PhoneGap code was offered to Apache to continue the development. Apache Cordova is the engine below PhoneGap, like WebKit is the engine of several browser

Development languages

Apache Cordova framework is a hybrid framework

- Applications development works with HTML, CSS and JSS; these languages are already well known by all web developers
- It uses plugins to access hardware components of the smartphone (camera, GPS, etc.)

It provides tools for testing (emulators) and deployment of the final application

HelloWorld – body

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```
<body>
  <div class="app">
    <h1>PhoneGap</h1>
    <div id="deviceready" class="blink">
      <p class="event listening">Connecting to Device</p>
      <p class="event received">Device is Ready</p>
    </div>
  </div>
  <script type="text/javascript" src="cordova.js"></script>
  <script type="text/javascript" src="js/index.js"></script>
  <script type="text/javascript">
    app.initialize();
  </script>
</body></html>
```

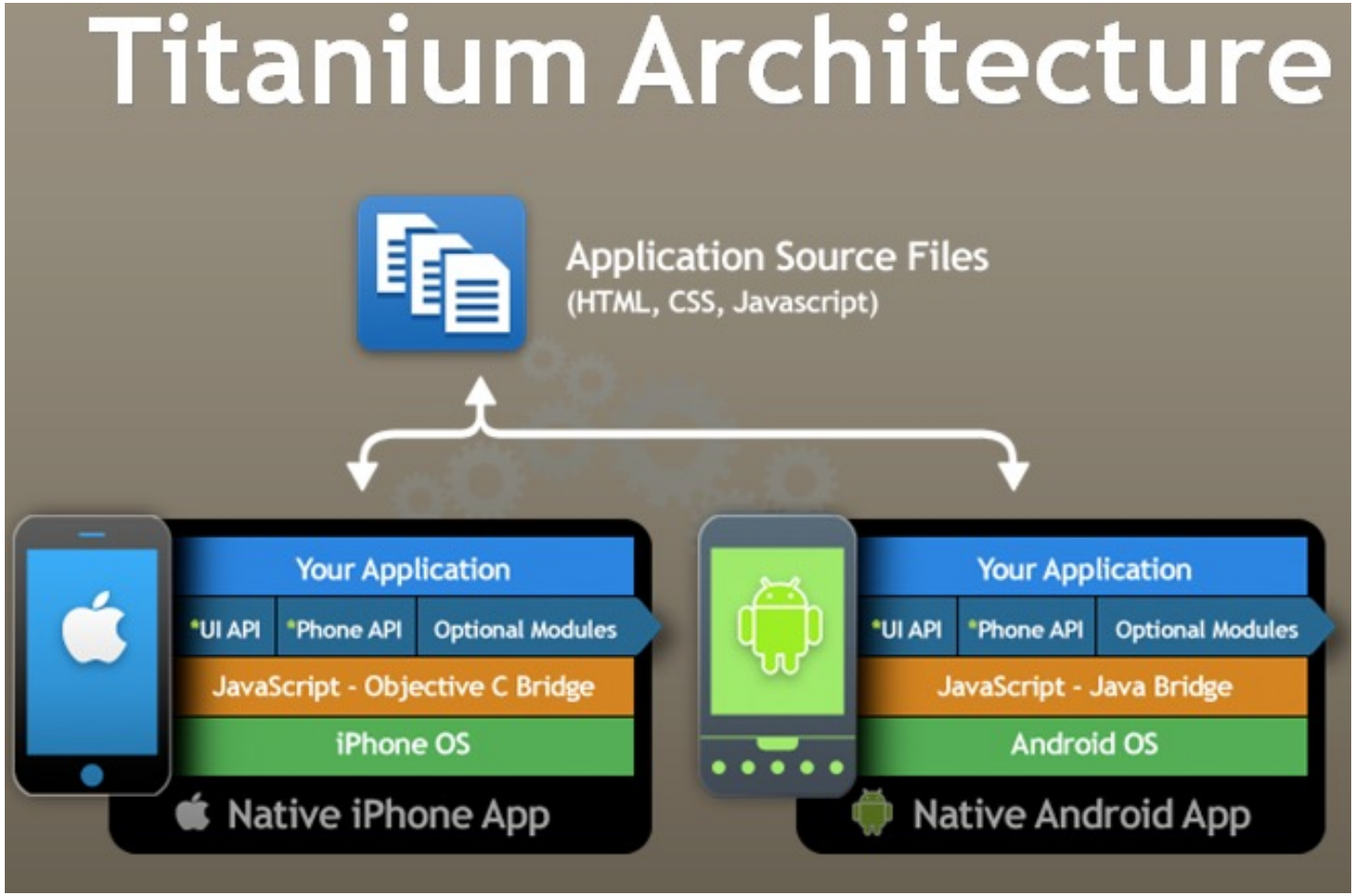
Other frameworks with Cordova

Other frameworks/tools allow app development using Cordova:

- Monaca
- Framework7
- NativeScript
- Ionic Capacitor
- Progressive Web Apps

Cordova usually is not used stand-alone, but as a support framework for other frameworks

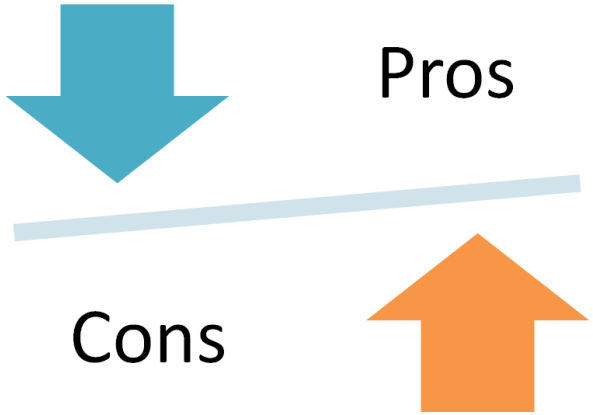
Interpreted Approach



Interpreted Approach: Pros & Cons

Pros:

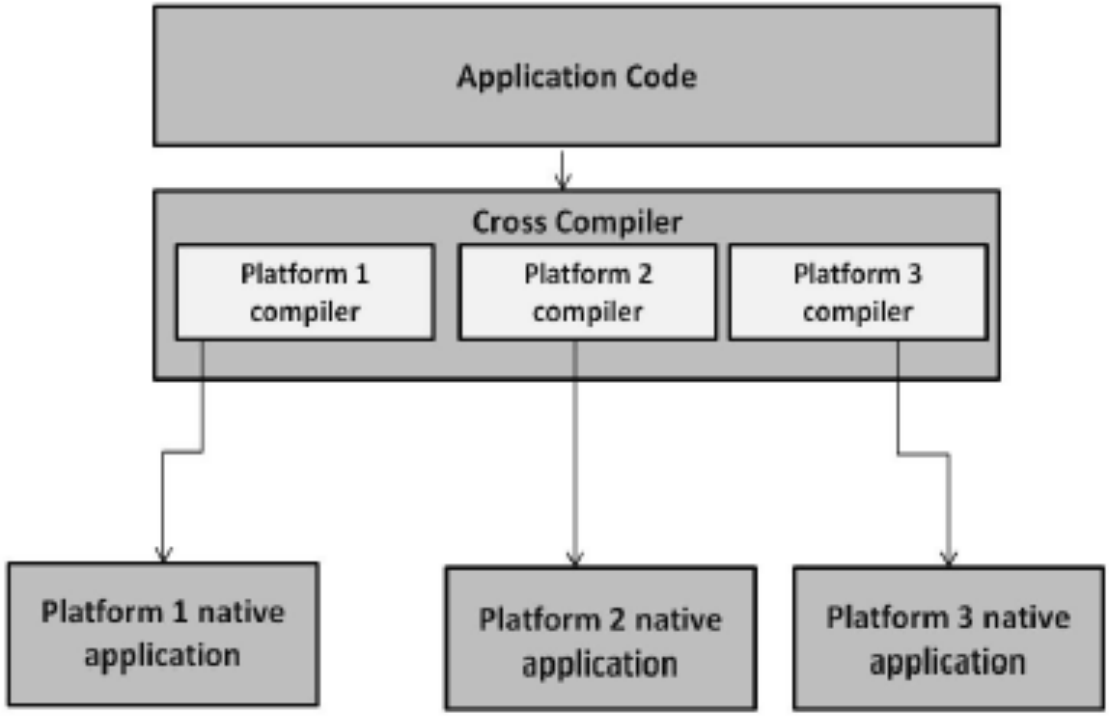
+ Native Look and Feel
+ Store publishing
+ APIs for device components



Cons:

- Really difficult to reuse the UI
- Available features depend on the framework
- The interpreter can have low performances

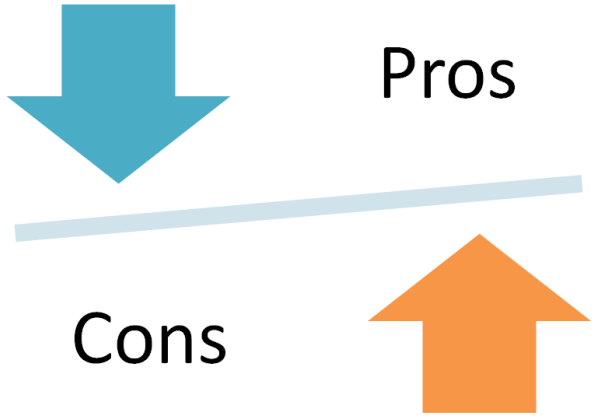
Cross-compiled Approach



Cross-compiled Approach: Pros & Cons

Pros:

+ Allows to use all the components available
+ Native interface
+ Good performances
+ Store publishing

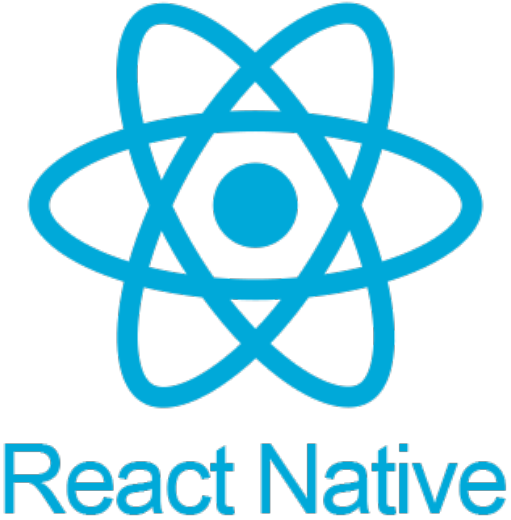


Cons:

- Not reusable UI
- Very complex apps can have problems during the building process

Examples

- Solar 2D
- React Native
- Flutter



Cross-platform Frameworks

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Approach	Programming language	Supported platforms	Pros	Cons	Example
Web	HTML, CSS, Javascript	Android, iOS, Windows, BlackBerry[a]	– Easy to update – No installation – Same UI over different devices	– No access to application store – Network delays – Expensive testing – No native UI	jQuery mobile, Sencha Touch
Hybrid	HTML, CSS, Javascript	Android, iOS, Windows, Blackberry,	– Access to application store[b] – Support to most smartphone hardware	– No native look and feel	PhoneGap
Interpreted	Javascript	Android, iOS, Blackberry	– Access to application store – Native look and feel	– Platform branching – Interpretation step	Titanium
Cross-Compiled	C#, C++, Javascript	Android, iOS, Symbian	– Native UI – Real native application	– UI non reusable – High code conversion complexity for complex applications	Mono, MoSync

[a] Support depends on the browser chosen by the user.
[b] Apple store usually tends to refuse applications developed with this approach [34].

M. Ciman, O. Gaggi. *An empirical analysis of energy consumption of cross-platform frameworks for mobile development*, PMC vo. 39, p. 214-230, 2017

Other classifications - 1

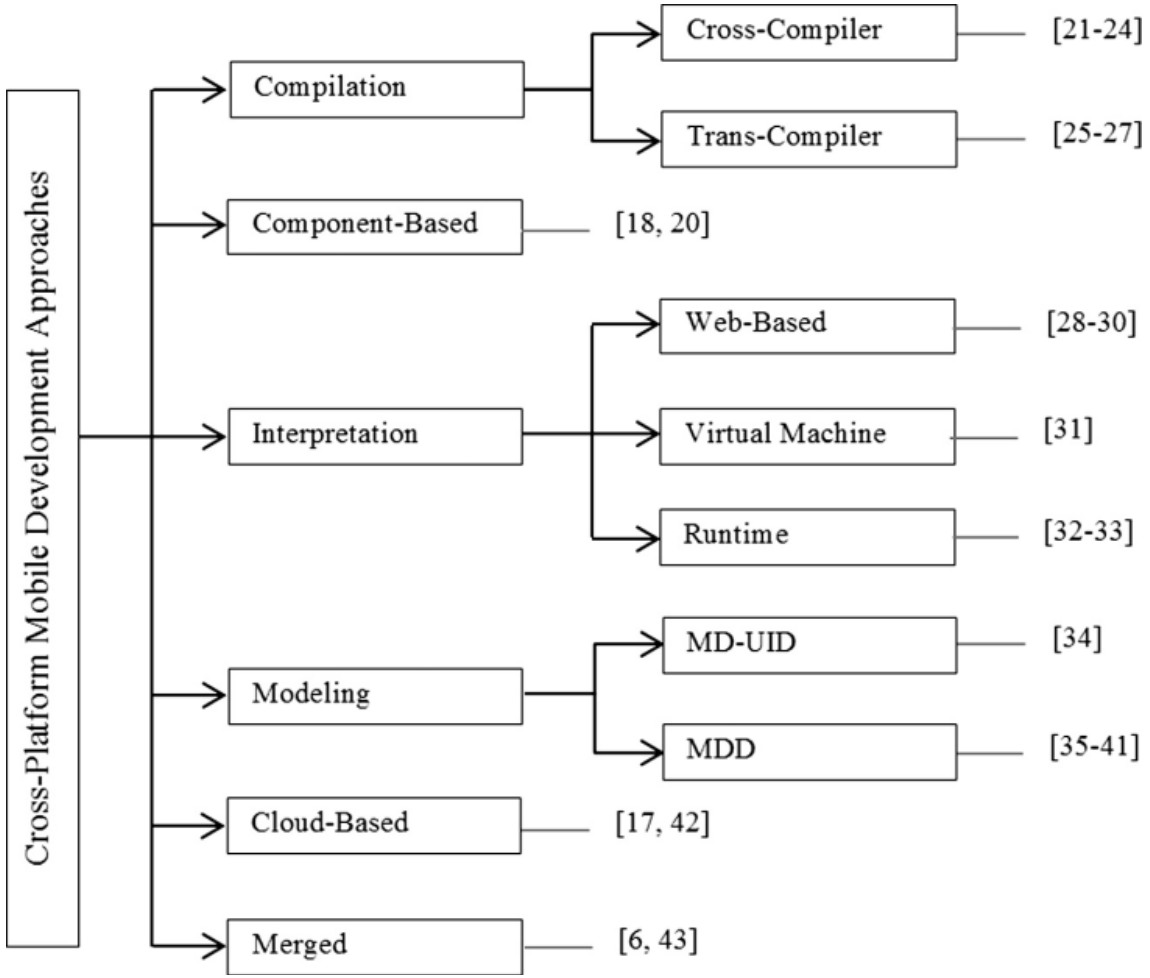
There are several methods for frameworks classification, some of them based on the development approach, others based on the result

El-Kassan et al. divide the apps into three categories

- Native app
- Web app
- Hybrid app

W. S. El-Kassas et al. *Taxonomy of Cross-Platform Mobile Applications Development Approaches*, Ain Shams Engineering J. 8(2), p. 163-190, 2017

Other classifications - 2



W. S. El-Kassas et al. *Taxonomy of Cross-Platform Mobile Applications Development Approaches*, Ain Shams Engineering J. 8(2), p. 163-190, 2017

Component based approach

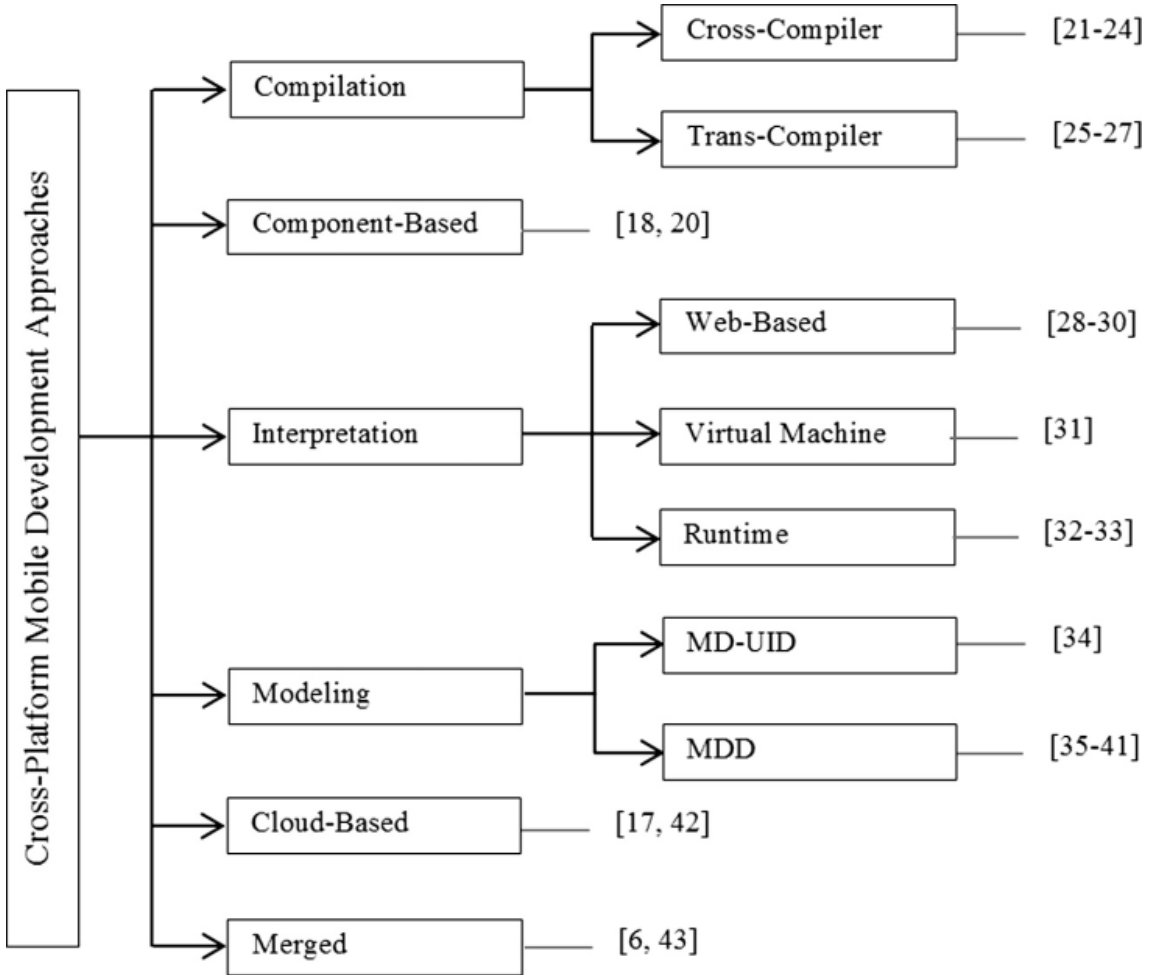
App development starts from different components that communicate together using interfaces

Each component has the same interface in every platform, but different implementations

Advantages:

- It simplifies the development, assuming that there are several *off-the-shelf* components available

Other classifications - 3



W. S. El-Kassas et al. *Taxonomy of Cross-Platform Mobile Applications Development Approaches*, Ain Shams Engineering J. 8(2), p. 163-190, 2017

Modeling approach

With this approach the developer uses several abstract models to describe user interface and functions of the application

Models are then translated into native source code

Cloud-based approach

With this approach, all the app computations are done in the *cloud*, and the application receives user interaction, sends them to the cloud, and shows the result of the elaboration.

Pros & Cons:

- Continuous network usage
- No need for specific hardware

How to choose the right framework?


Still an open research problem... But some steps have been taken!

Cross-platform frameworks comparison

Idea: write one application using different frameworks, deploy on 2 target platforms, and compare results

4 different approaches were considered: *Web*, *Hybrid*, *Interpreted*, and *Cross Compiled*

Case study

jQuery & jQuery Mobile

Desktop and mobile applications were developed as a single one

Hardware access depends on HTML5 support of the browser (therefore not controllable by the developer)

Low initial knowledge (Javascript, HTML, CSS)

Low development complexity

Animation support, but…

Complex animation performances rapidly decrease

PhoneGap/Cordova

An application developed with Cordova is a web application plus the WebKit rendering engine

Allows access to several device sensors (accelerometer, compass, etc.)

Good performances with simple apps, but poor performances with complex apps

Development languages: HTML, CSS, and Javascript

Titanium

Titanium allows maximizing reuse of pieces of code

Several APIs are available, especially for iOS and Android

Provides support for iOS (starting from version 5.0), Android (from 2.3.3), Window Phone, BlackBerry and Tizen

Apps with native *look and feel*

Development language: JavaScript

MoSync

Allows using different development languages: C, C++ and HTML+Javascript

Several APIs are available, but some of them are for obsolete operating systems versions

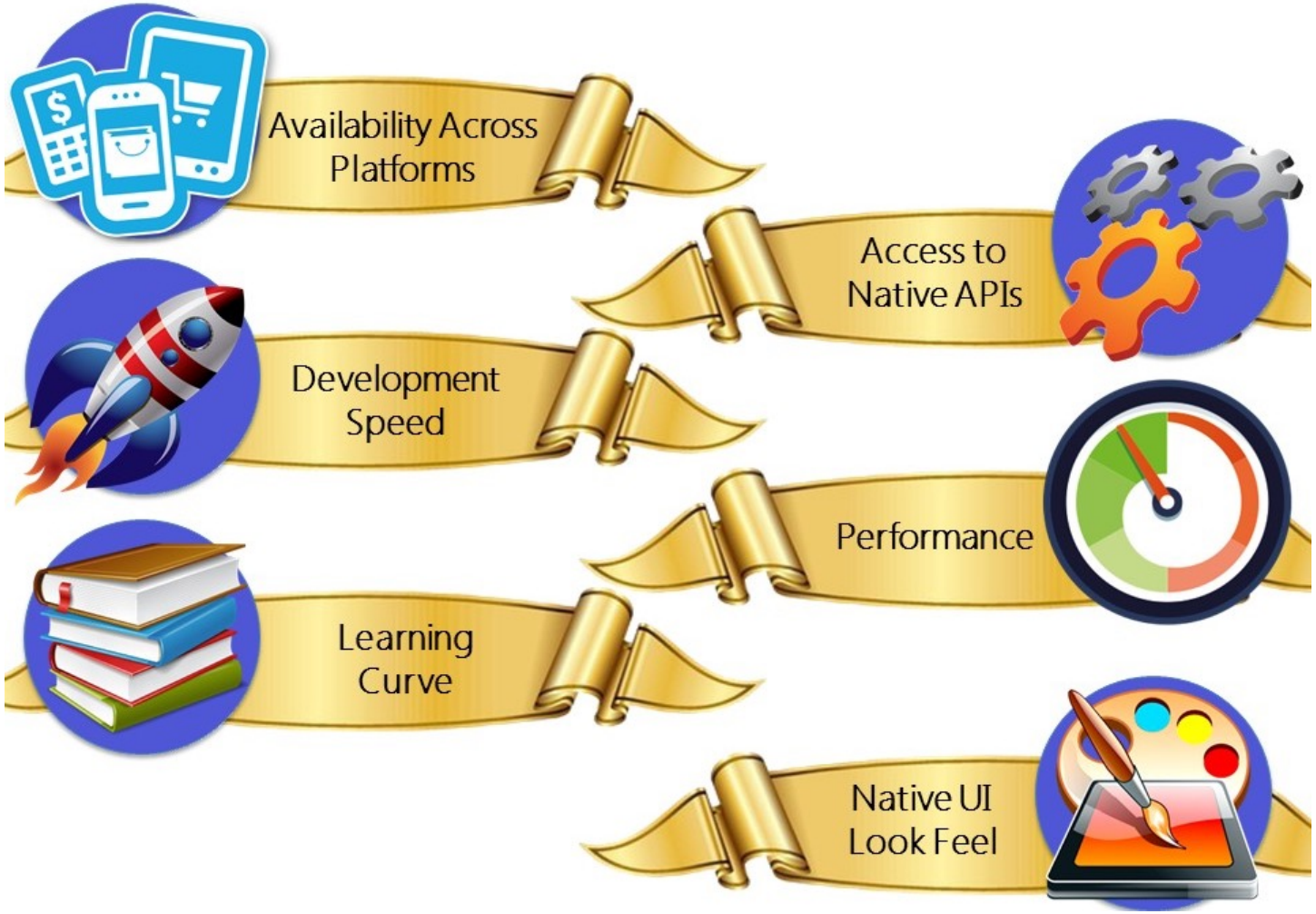
C++ development is a bit tricky

Native UI

Results

Licenses
APIs
Community
Tutorials
Complexity
IDE
Device support
Native UI
Learning curve

Selection criteria



https://www.rishabhsoft.com/blog/cross-platform-app-tools-infographic

Energy consumption analysis

Energy consumption is a crucial element for application success: apps that drain the battery are rapidly uninstalled by users

We considered the energy consumption of apps that acquire data from different sensors:

- Accelerometer
- Compass
- Microphone
- GPS
- Camera

And compared these results between native apps and the ones developed using cross-platform frameworks

How can we avoid interferences from internal (OS events) or external (user interaction) factors?

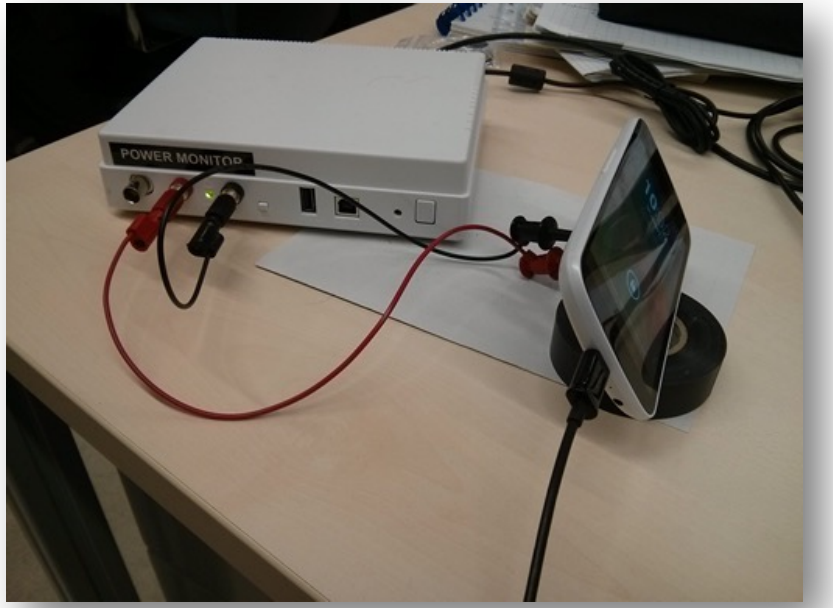
Some solutions

Several authors measured energy consumption of mobile applications

- Thompson et al. proposed a model-driven approach (SPOT, *System Power Optimization Tool*) for energy consumption estimation before application development
- *AppScope* (Yoon et al.) is an Android application that estimates energy consumption of each hardware component

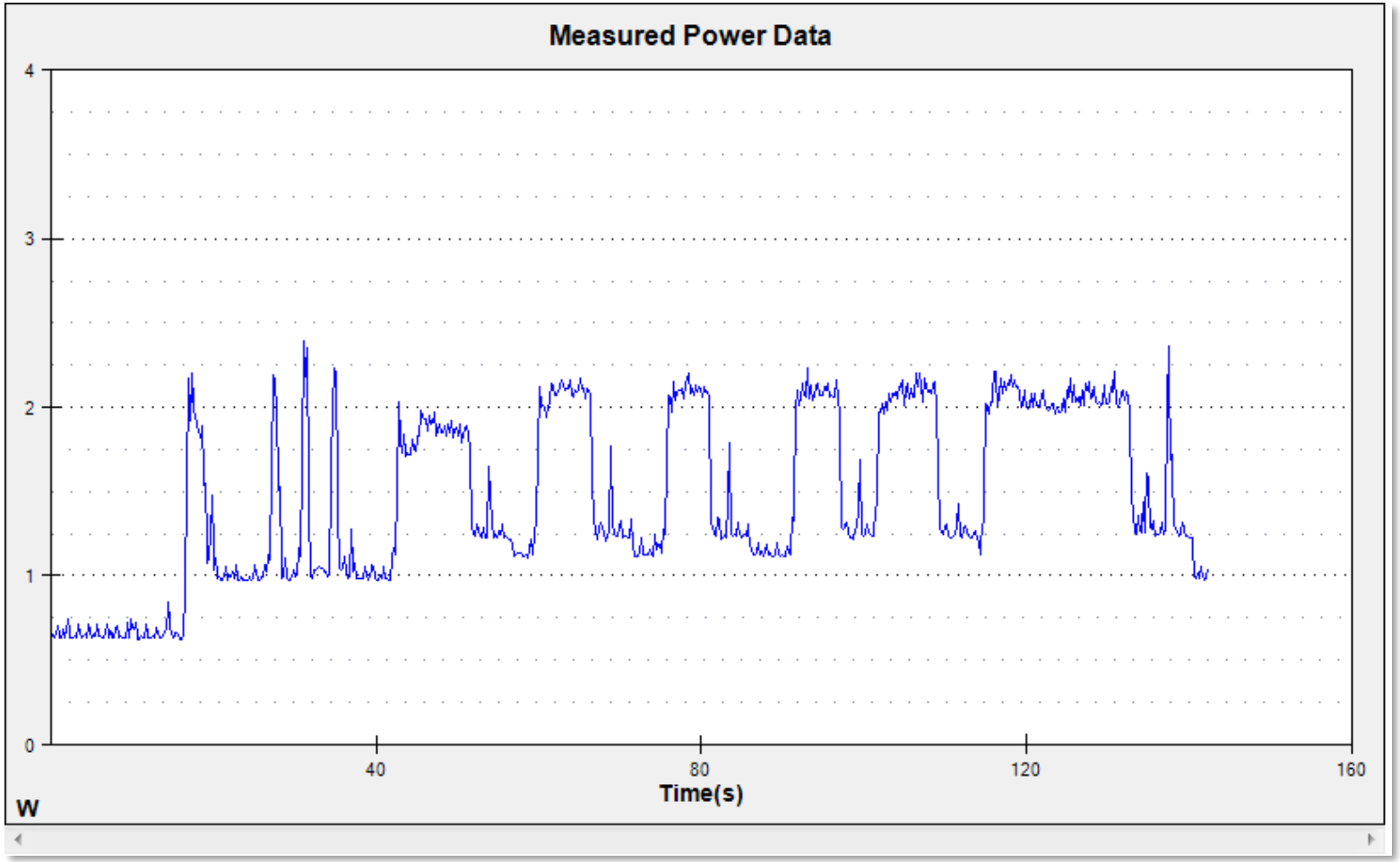
Measurement system

Monsoon Power Monitor

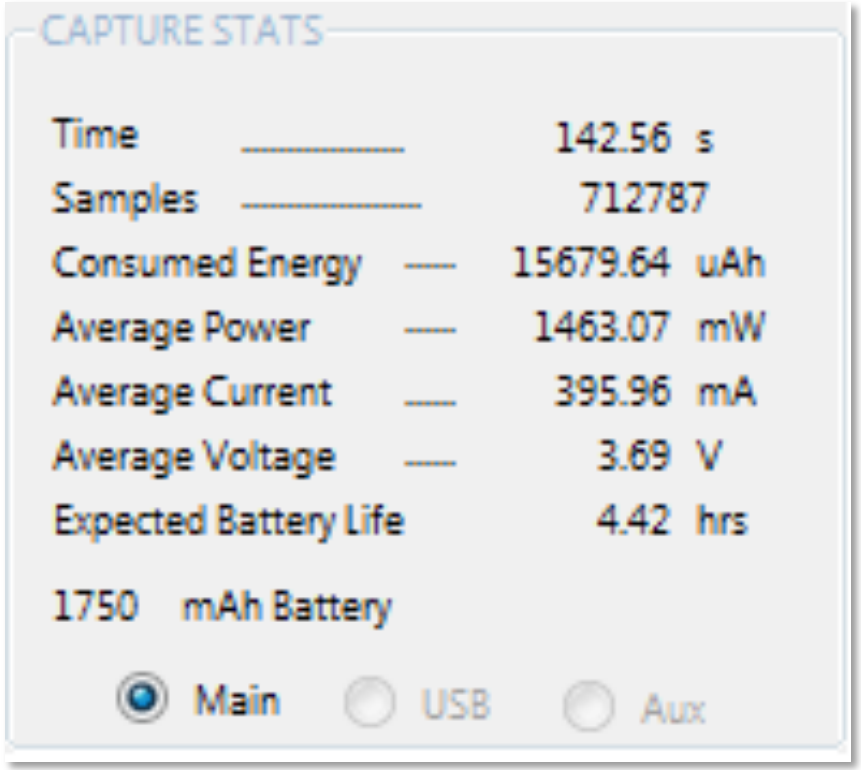


Provided data: energy consumption, average current and consumption, estimated battery duration, etc.

Monsoon PowerTool



Monsoon PowerTool



Analysis

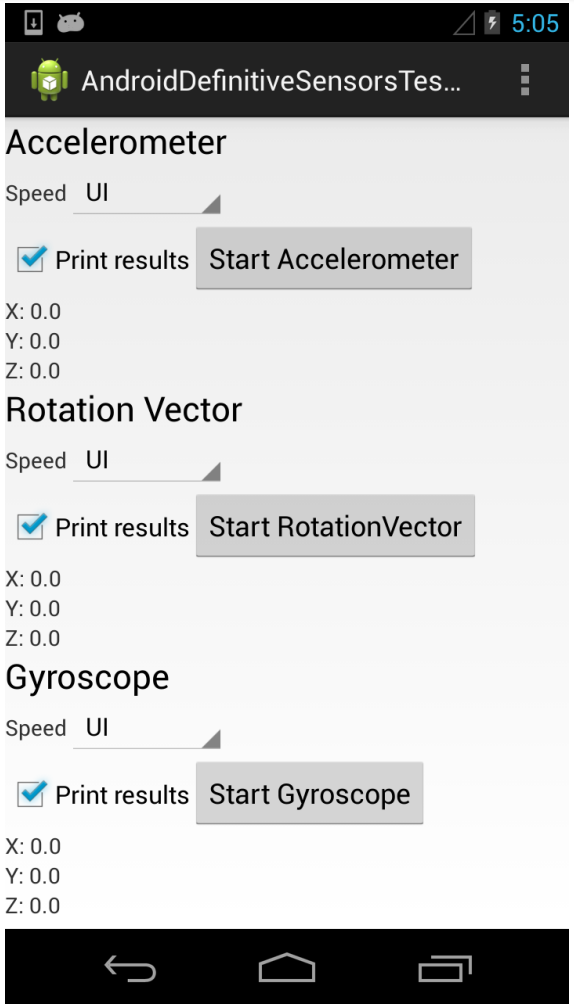
Goal: energy consumption comparison of different hardware components during data collection, considering different platforms and different frameworks

Applications considered:

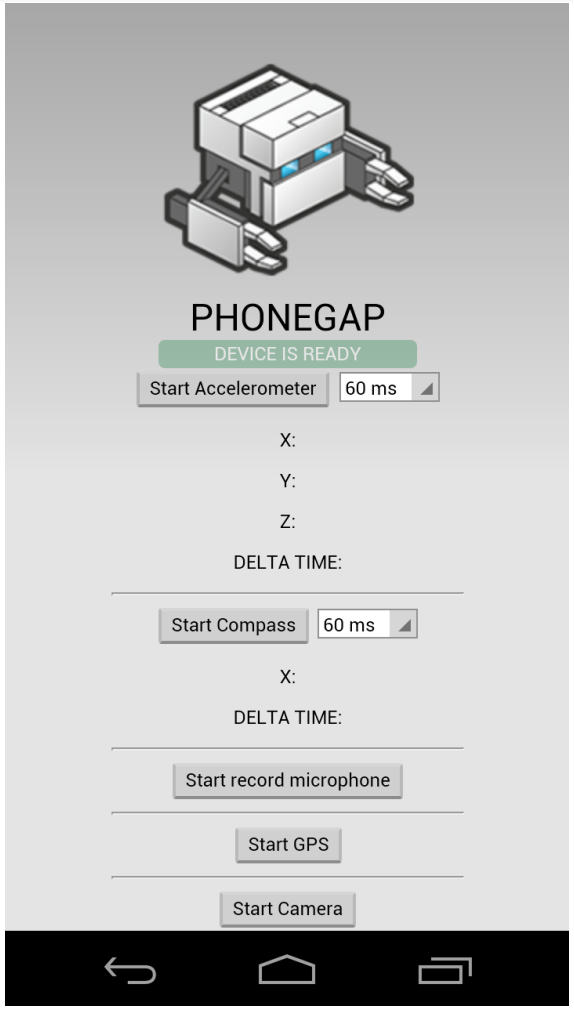
- Native Android application
- Web application
- Hybrid application developed with PhoneGap
- Application developed with Titanium
- Application developed with MoSync using C++
- Application developed with MoSync using Javascript

Sensors depend on the API available with each framework

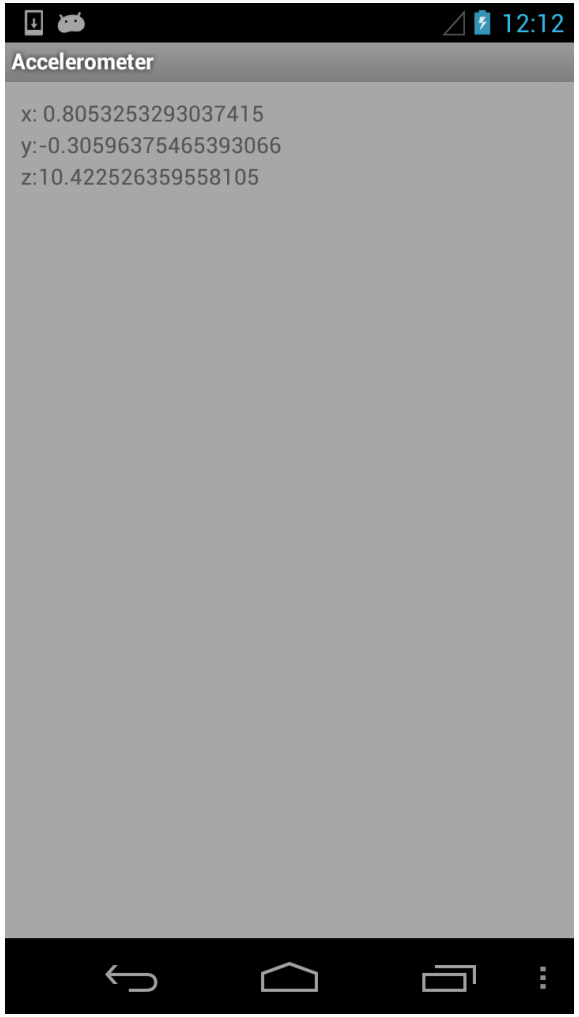
Applications



Native Application



Phonegap Application



Titanium Application

Developed applications

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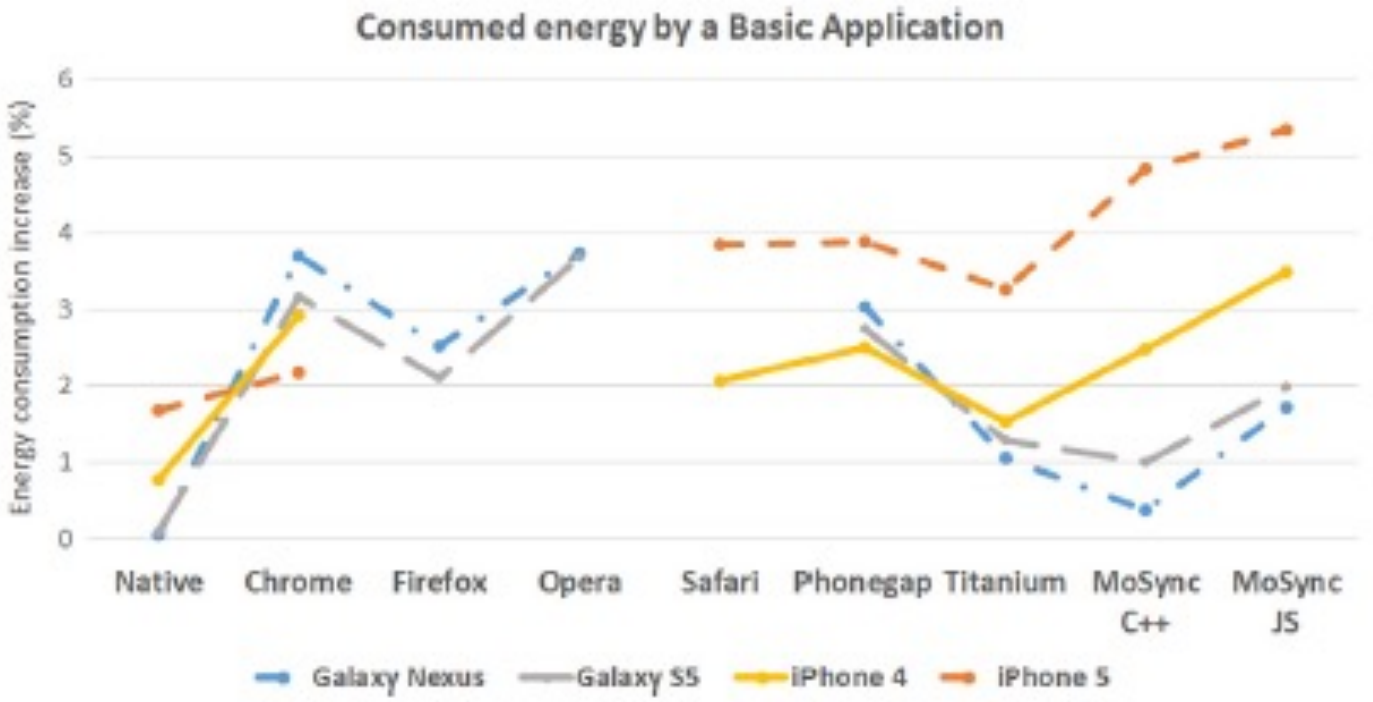
Elementary applications that collect data from different sensors at a given frequency, showing data with a simple interface

It is necessary to define a ***base level (or 0 level)*** of energy consumption: device in stand by, airplane mode, black screen with minimum white elements

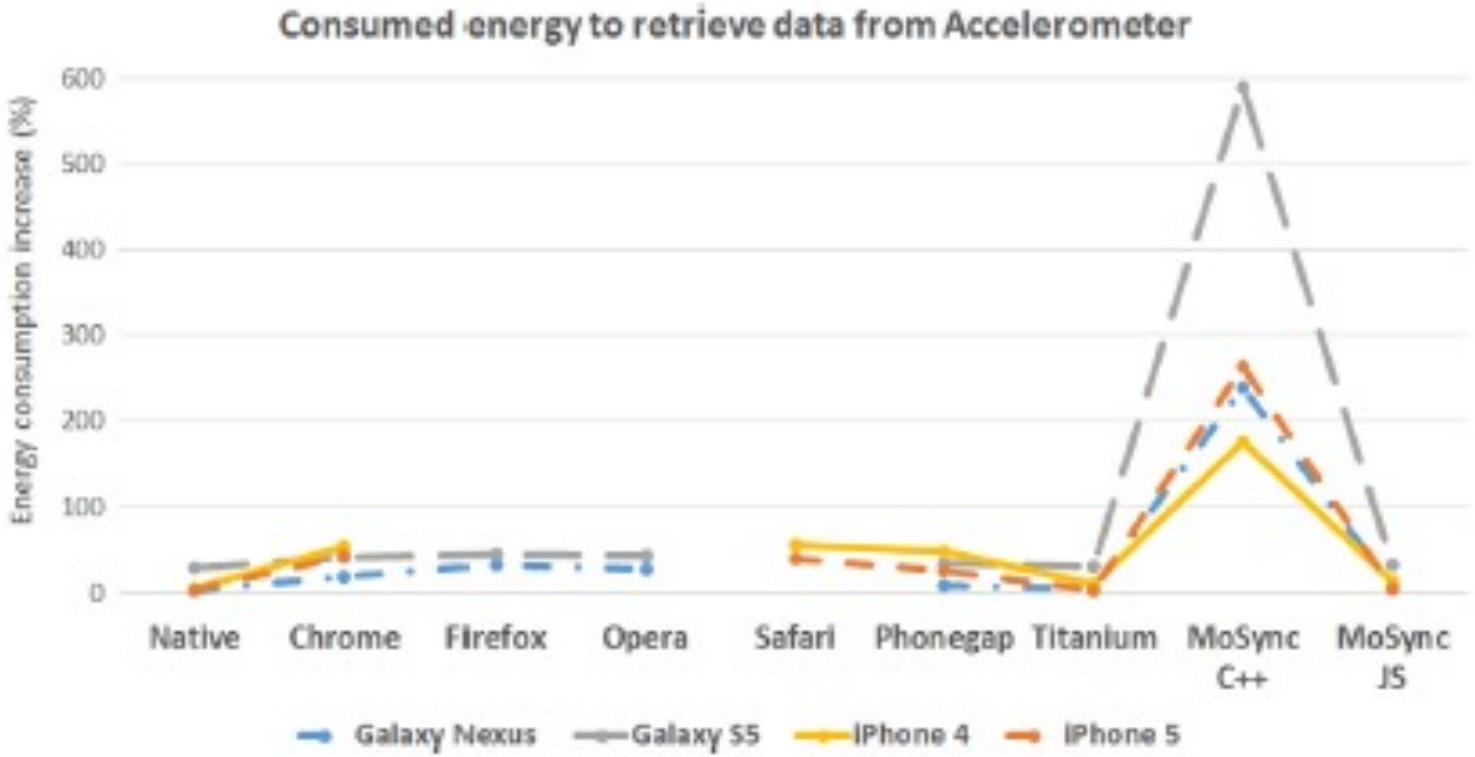
The base level depends on the device and its battery. Considered smartphones:

- An iPhone 4 and an iPhone 5
- A Samsung Galaxy Nexus and a Samsung Galaxy S5

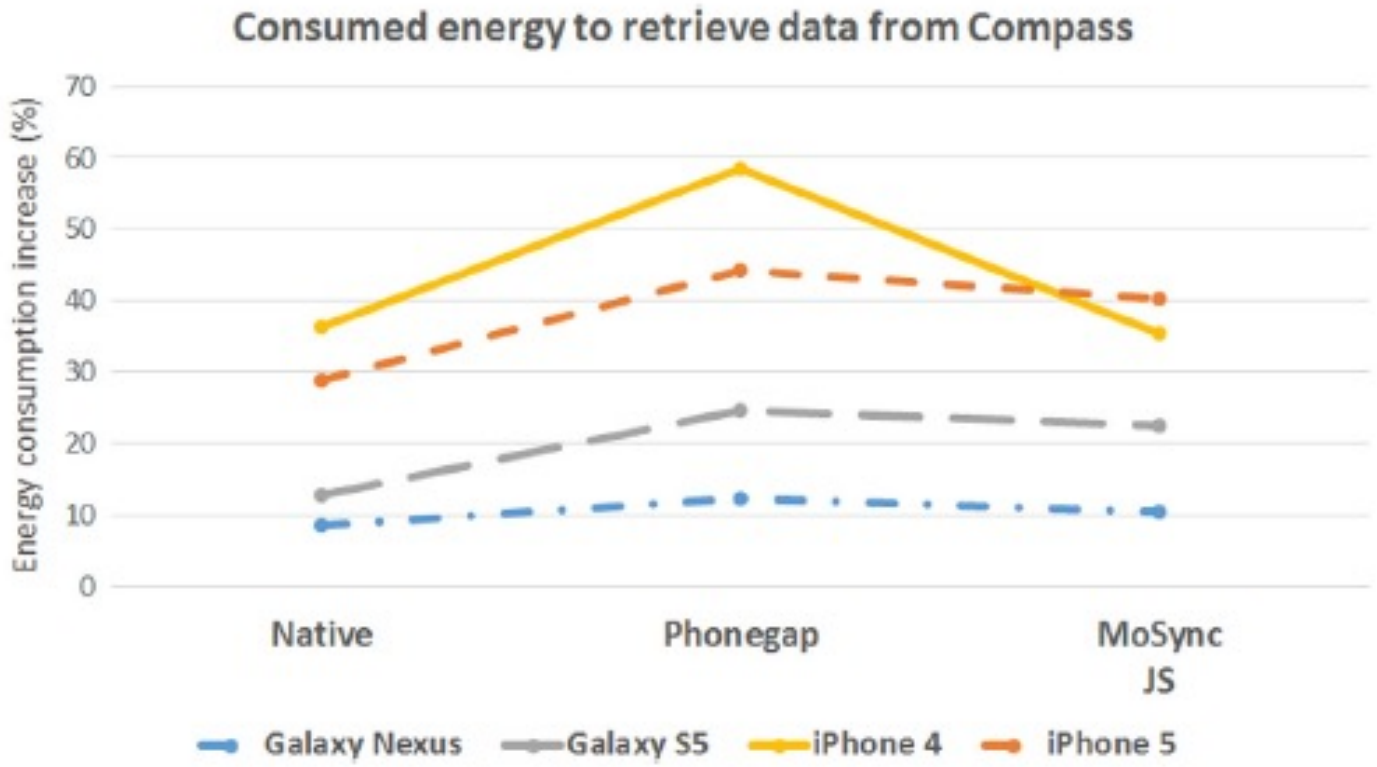
Base energy consumption



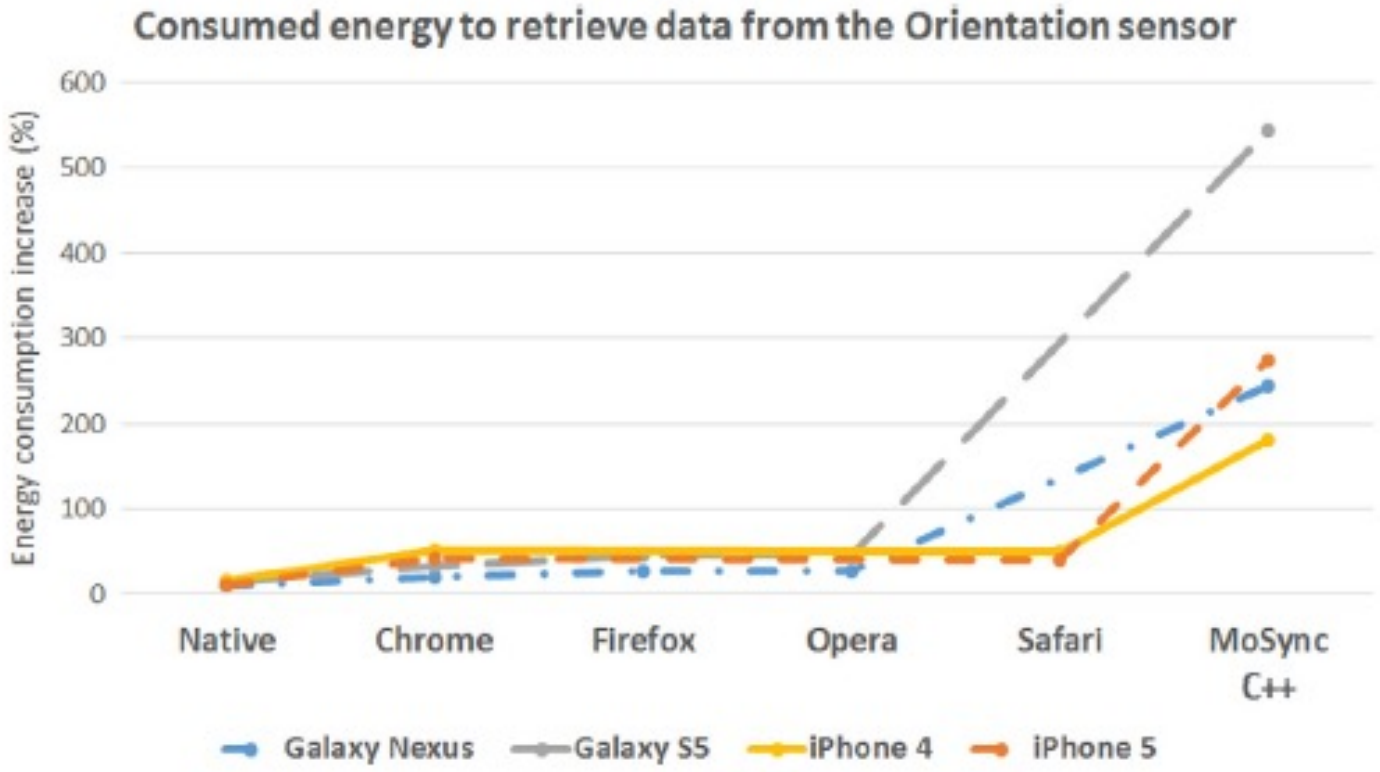
Results: accelerometer



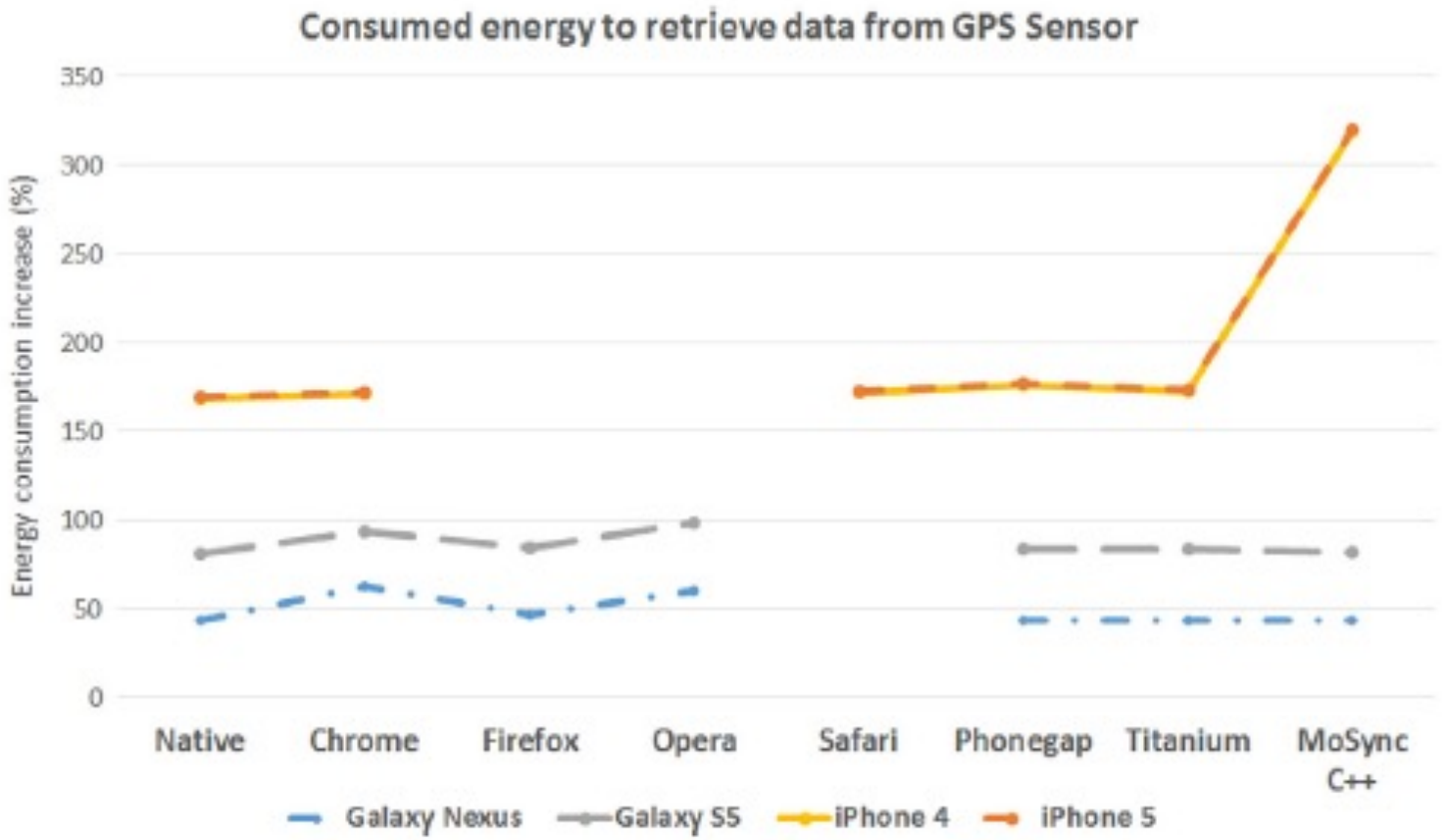
Results: compass



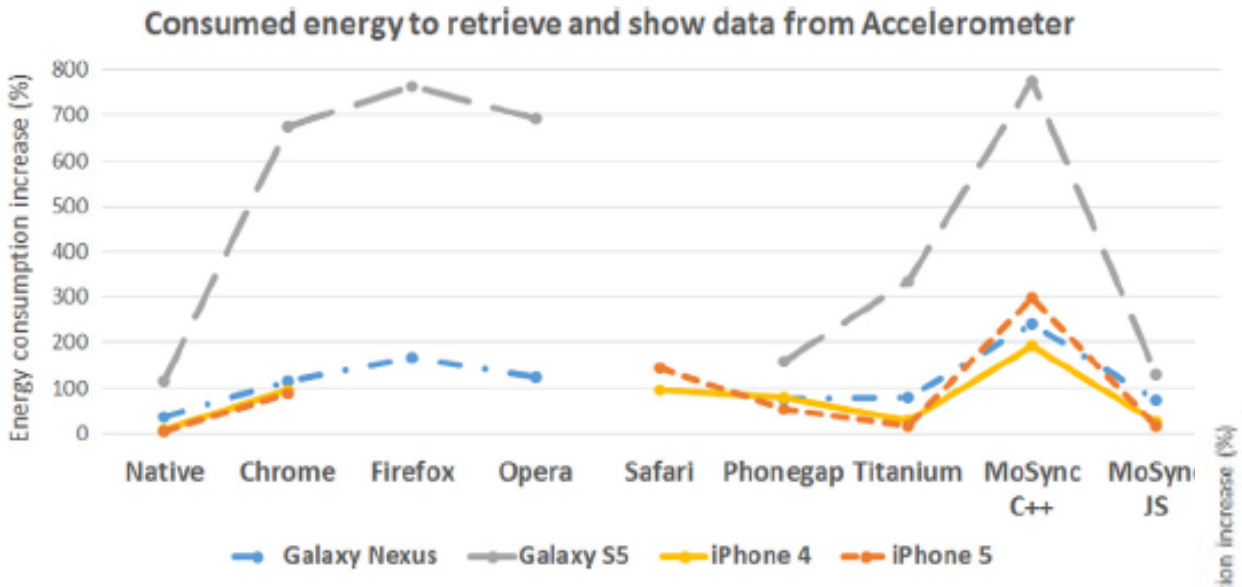
Results: orientation sensor

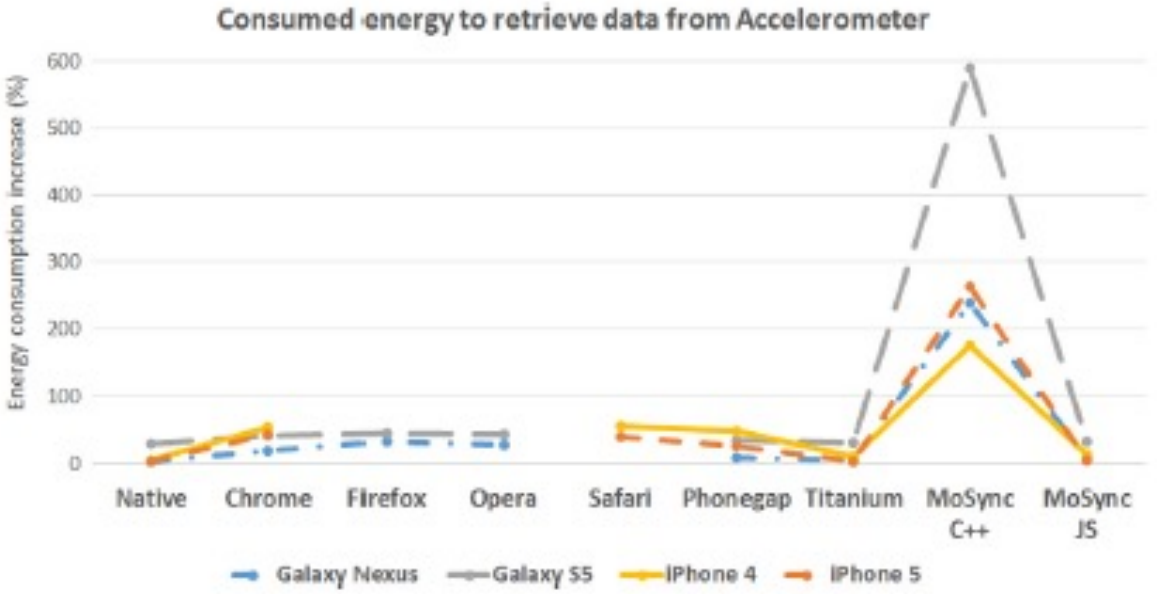


Results: GPS

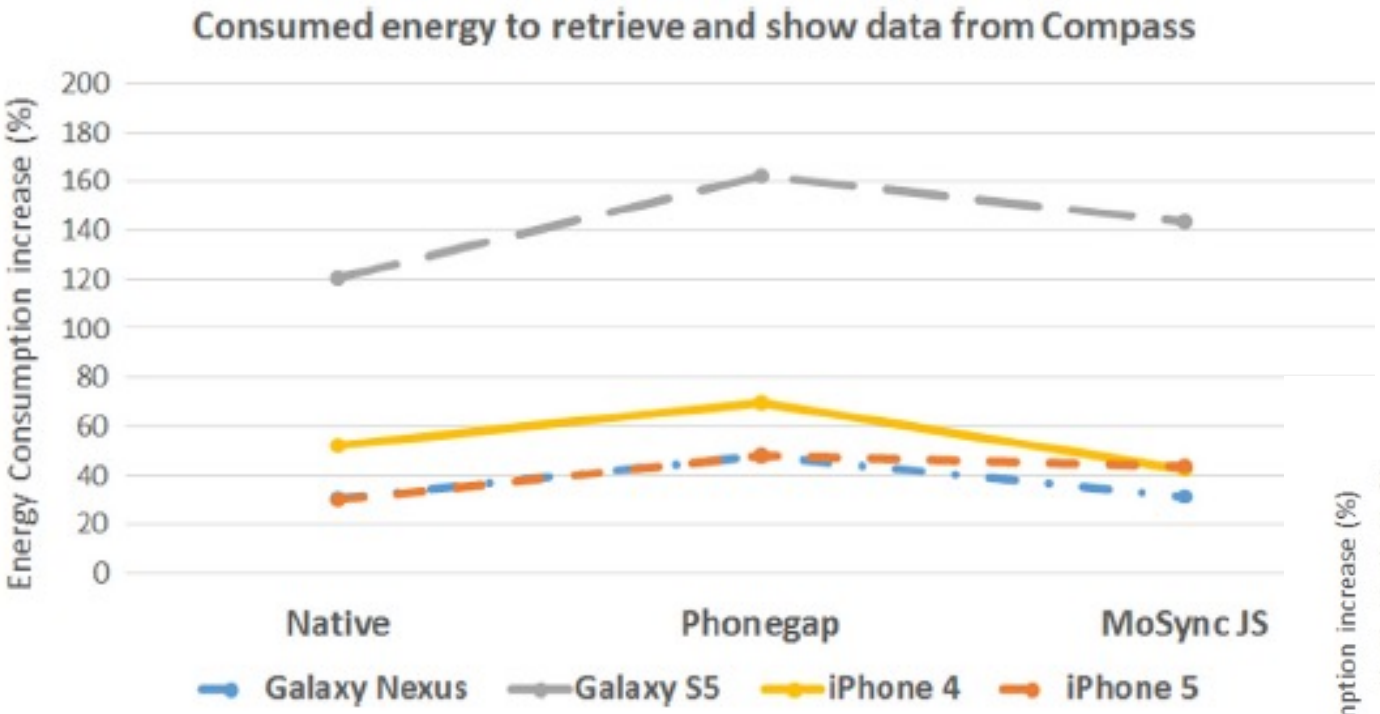

Consumed energy to retrieve data from GPS Sensor
Energy consumption increase (%)
350
300
250
200
150
100
50
0
Native
Chrome
Firefox
Opera
Safari
Phonegap
Titanium
MoSync C++
Galaxy Nexus
Galaxy S5
iPhone 4
iPhone 5

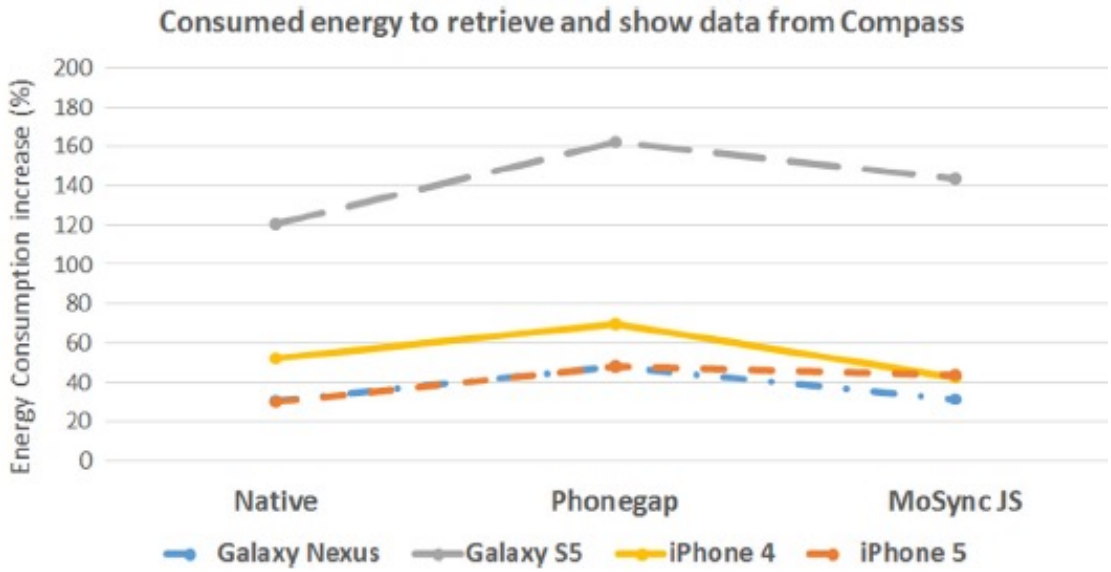
Data visualization: accelerometer





Data visualization: compass





Results

- Cross-platform frameworks determine higher energy consumption, even if the framework generates native code
- The most expensive task is the interface update
- Data acquisition frequency strongly influence energy consumption
- *Not really cross-platform!*
  - Frameworks have different energy consumption depending on the operating system where they are running

Conclusions - 1

- Results show that cross-platform frameworks consume more energy, hence determining lower performances and user acceptance
- Depending on the type of application, native development should be preferred:
  - Lower energy consumption
  - More APIs are available
- The results suggest that
  - Framework choice is critical
  - For a complex application, efficient frameworks are still missing

Conclusions - 2

- Framework choice is crucial because it can influence user experience
  - Providing an ugly application is worse than not providing an application at all
  - Results show that, *at the time of the experiment*, Titanium seems to be the framework with better consumption

Future development

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- An efficient cross-platform framework must provide an extremely efficient user interface rendering
- Improves of efficiency of rendering engines will provide improvements even for those frameworks that work with the web approach
- The cross-compiled approach seems to be the most promising, but it is not easy to implement
  - The development of these frameworks strongly depends on the development of a compiler able to produce an efficient code for the application
  - Development should be focused on the optimization of events handling and management

References

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Cross-platform classification

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2. W. S. El-Kassas, B. A. Abdullah, A. H. Yousef, A. M. Wahba. *Taxonomy of Cross-Platform Mobile Applications Development Approaches*. Ain Shams Engineering Journal, Volume 8, Issue 2, 2017, p. 163-190.

Results about cross-platform frameworks analysis were published in two different articles:

1. M. Ciman, O. Gaggi. *An empirical analysis of energy consumption of cross-platform frameworks for mobile development*, PMC vo. 39, p. 214-230, 2017
2. M. Ciman, O. Gaggi, N. Gonzo. *Cross-Platform Mobile Development: A Study on Apps with Animations*.Proceedings of the ACM Symposium on Applied Computing (SAC2014), pages 757-759, Gyeongju, South Korea, May 2014.