Mobile App Speed Index
- How fast or slow is the mobile app?

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Web Speed Index

• In the project of “WebPageTest” by Google
  • [https://sites.google.com/a/webpagetest.org/docs/using-webpagetest/metrics/speed-index](https://sites.google.com/a/webpagetest.org/docs/using-webpagetest/metrics/speed-index)

• What is “The Speed Index” for a web page?
  • The average time at which visible parts of the page are displayed
  • The speed index takes the visual progress of the visible page loading and computes an overall score for how quickly the content painted.

• Why do we need this?
  • Slow web will lose subscribers: Google Search, Amazon, Netflix, ...
  • Enhance user experiences of web service
    • To content providers as well as carriers or ISPs
Speed Index = \int_0^{end} 1 - \frac{VC}{100}

end = end time in milliseconds
VC = % visually complete

Remaining to be Rendered for "A"

Remaining to be Rendered for "B"

Speed Index = 1219

Speed Index = 9022

https://sites.google.com/a/webpagetest.org/docs/using-webpagetest/metrics/speed-index
Web Optimization

• Google PageSpeed
  • https://developers.google.com/speed/pagespeed/?csw=1

• CDN
  • Akamai ION

• Cloudflare

• DNS
Network Issue

5 Mbps Cable

1.5 Mbps DSL

https://sites.google.com/a/webpagetest.org/docs/using-webpagetest/metrics/speed-index
How to measure Web Speed Index?

1. Run web browser for the target website automatically
2. Capture the video of the browser rendering process
3. Calculate the Speed Index with the video and the web page file
   • look at each pixel of the image and compare it to the final image and then calculate the % of pixels that match for each frame
   • using the Paint Events that are exposed by Webkit

https://sites.google.com/a/webpagetest.org/docs/using-webpagetest/metrics/speed-index
Mobile App Speed Index?

• How fast or slow is the mobile app?
  • Basically similar with web speed index in the aspect of the concept
Challenges for Mobile App Speed Index

1. Run web-browsers mobile app automatically
   • Initially load a mobile app and execute several user events: touch, swipe, scroll

2. Capture the video of the browser app rendering process

3. Calculate the Speed Index with the video and the web-page app file
   • Look at each pixel of the image and compare it to the final image and then calculate the % of pixels that match for each frame
   • Using the Paint DisplayedTime(), reportFullyDrawn() Events that are exposed by Webkit Android
     • Still we have difficulty in finding the end of each user session
Our Solution for Mobile App Speed Index

1. Run mobile app automatically
   • Random user event generator with ADB, Monkey, UiAutomator
2. Capture the video of app rendering process
   • ADB script
3. Calculate the Speed Index with the video and the web page app file
   • look at each pixel of the image and compare it to the final image and then calculate the % of pixels that match for each frame
   • using the DisplayedTime(), reportFullyDrawn() Events that are exposed by Android
     • Session end, Rendering complete estimation algorithm
Android Developer’s Tool

• **Android Debug Bridge (ADB)**
  
  ```
  $adb shell
  $adb shell am start -a android.intent.action.VIEW -d http://www.naver.com
  ```

• **Monkey**
  
  - The Monkey is a program that runs on your emulator or device and generates pseudo-random streams of user events such as clicks, touches, or gestures, as well as a number of system-level events.

  ```
  $ adb shell monkey -p your.package.name -v 500
  ```

• **UI automator**
  
  - UI Automator is a UI testing framework suitable for cross-app functional UI testing across system and installed apps.

  ```
  adb shell uiautomator dump

  UI hierarchy dumped to: /sdcard/window_dump.xml
  ```

• **Logcat**

![Logcat](image)
App Speed Measurement System

Configuration file

APK file

Random User Event Generator(Device)

Event Generation Module

Ulautomator

Video Recording Module

Speed Analyzer(PC)

Session End Detection Module

Rendering Complete Detection Module

Speed Index Calculation Module

App Speed Index
Implementation

• Random user event generator
  • Load a mobile app
    • ADB (Android Debug Bridge)
    • Monkey: generate user event (touch, scroll, swipe) for each coordinate → low event hit rate
  • Generate UI events with UiAutomator
  • Record video clip for each user event session

• Speed analyzer
  • Session end detection in Python code
  • Rendering complete detection in Python code and OpenCV
  • Speed Index calculation in Python
When does a user event session end?

Session

Response time for user event

Generate user event (Session begins)

Ulautomator

Parsing xml Parsing xml Parsing xml Parsing xml Parsing xml

2~3s

Examine Node in Uiautomator xml file

10 22 30 30 30

Constant node count

Session Ends
UI Automator XML File

<?xml version='1.0' encoding='UTF-8' standalone='yes' ?>
<hierarchy rotation="0">
  <node index="0" text="" resource-id="" class="android.widget.FrameLayout" package="com.google.android.packageinstaller" content-desc="" checkable="false" clickable="false" enabled="true" focusable="false" focused="false" scrollable="false" long-clickable="false" password="false" selected="false" bounds="[39,0][1041,1920]">
    <node .... >
Difference between FullyDrawn Event and Rendering Complete Event
Rendering Complete Detection

Moving images at the end of rendering
Experiment

• Galaxy A5 device
• Android 6.0.1
• 5 user events for each mobile app
  • 1\textsuperscript{st} initial event to load a mobile app
  • Four run-time events to use a mobile app: touch, scroll, swipe
• 1,093 mobile apps
• Speed index threshold considering 4 seconds
  • Web users tend to feel the rendering in 4 seconds
Initial vs. Run-time Speed Index

- Initial Speed Index
- Run-time Speed Index

- 77.4%
- 3.3%
- 1.8%
- 17.5%
Category

Comics
Entertainments
Usually have many images
Speed Index by Session or Mobile App

Speed index of a mobile app: average of 5 user event sessions
What makes Mobile Apps slow?

• Possible reasons
  • Traffic volume
  • TCP connections
  • RTT
  • Contents
    • Advertisements
    • Popup
    • Many images

• Contents analysis
  • Need to look into xml files
Speed Index by Traffic Volume, TCP Connections
Speed Index by RTT
Speed Index by Images or AD

![Graph 1: Speed Index vs. Number of Images]

![Graph 2: Speed Index vs. Number of AD]
(a) Four clustering with quantitative metrics

(b) Classification of Bad_SlowLoading
Summary

• Mobile app speed index
  • To improve user experience: developers, network operators

• Approach
  • Automatic app execution
  • Collecting mobile app log data and analyzing speed index

• What to do
  • Find out the reasons of slow mobile apps and provide the appropriate guideline

• Issues
  • Crawl mobile app (.apk files in Android)
  • Mobile apps with login