Mobile App Speed Index

- How fast or slow is the mobile app?

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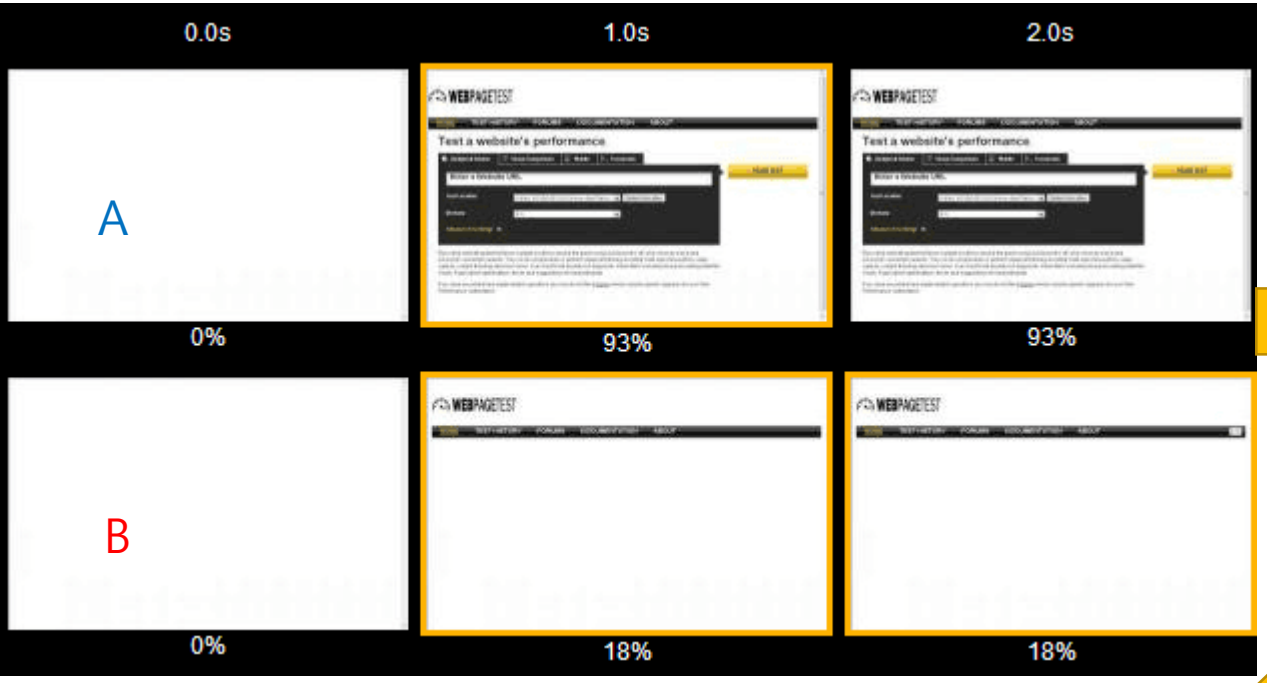
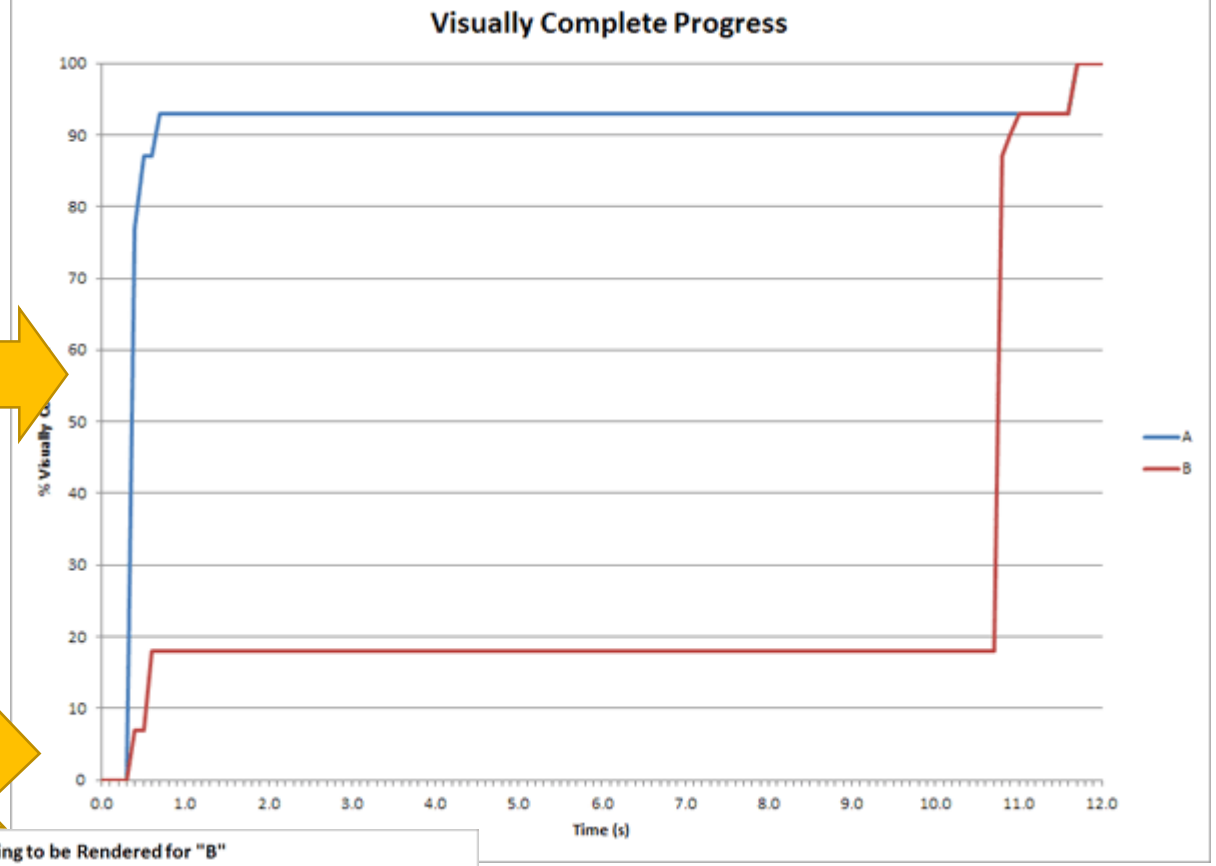
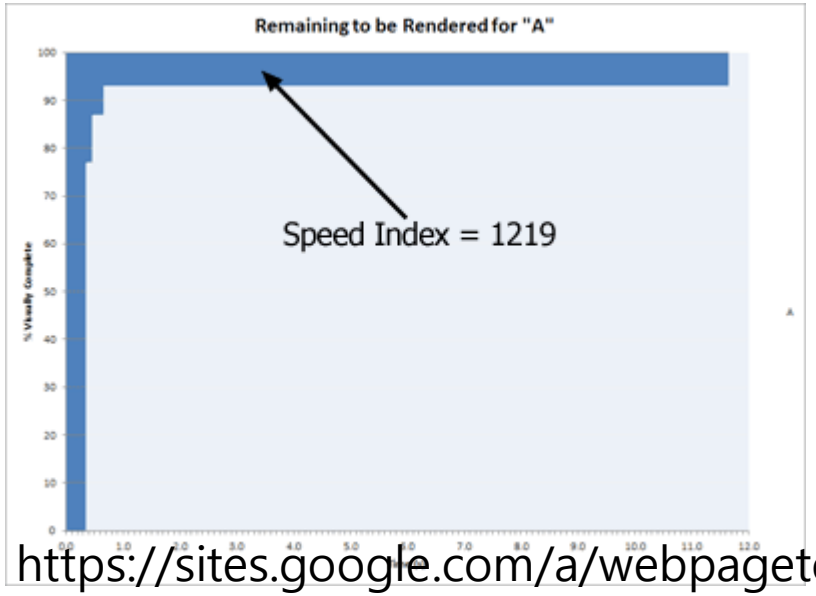
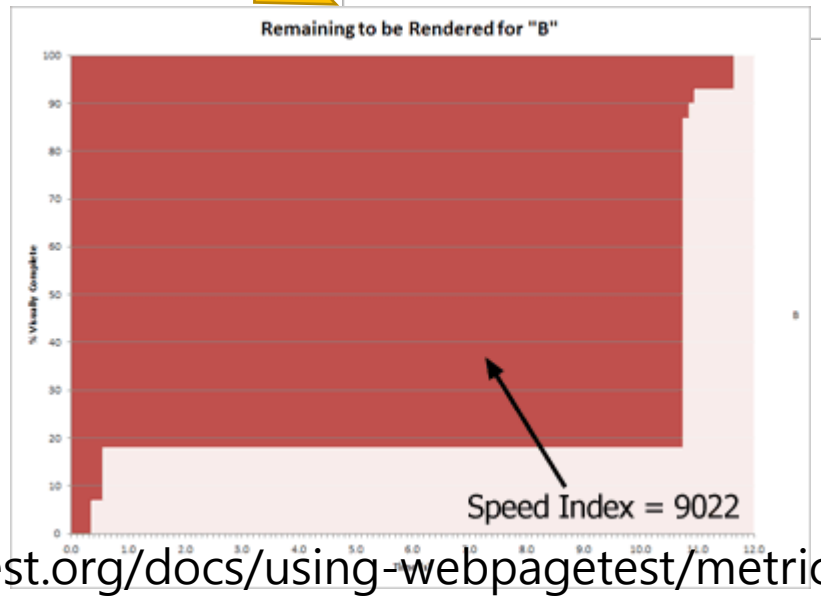
Web Speed Index

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









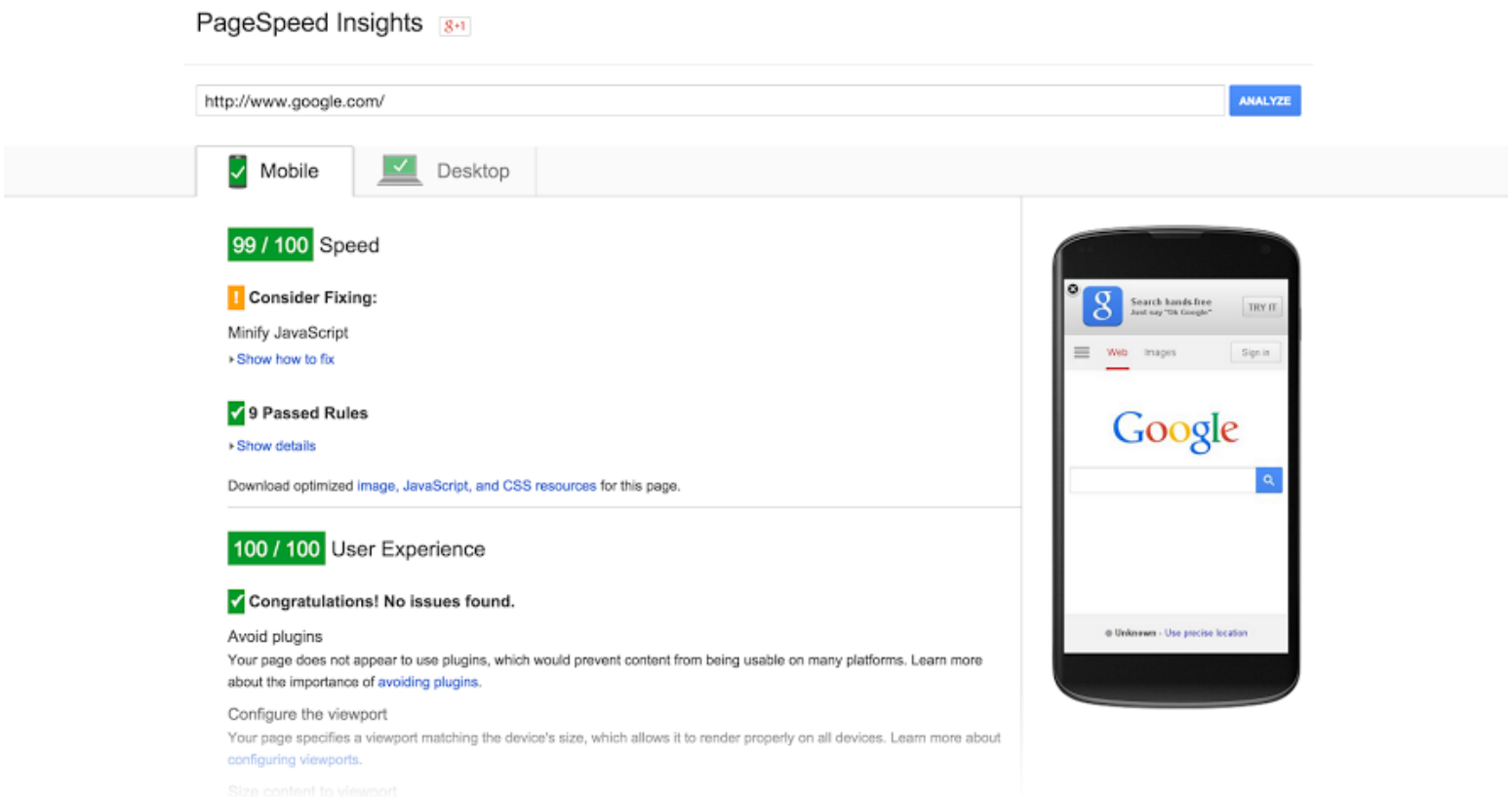
$$\text{Speed Index} = \int_0^{end} 1 - \frac{VC}{100}$$

end = end time in milliseconds
VC = % visually complete

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

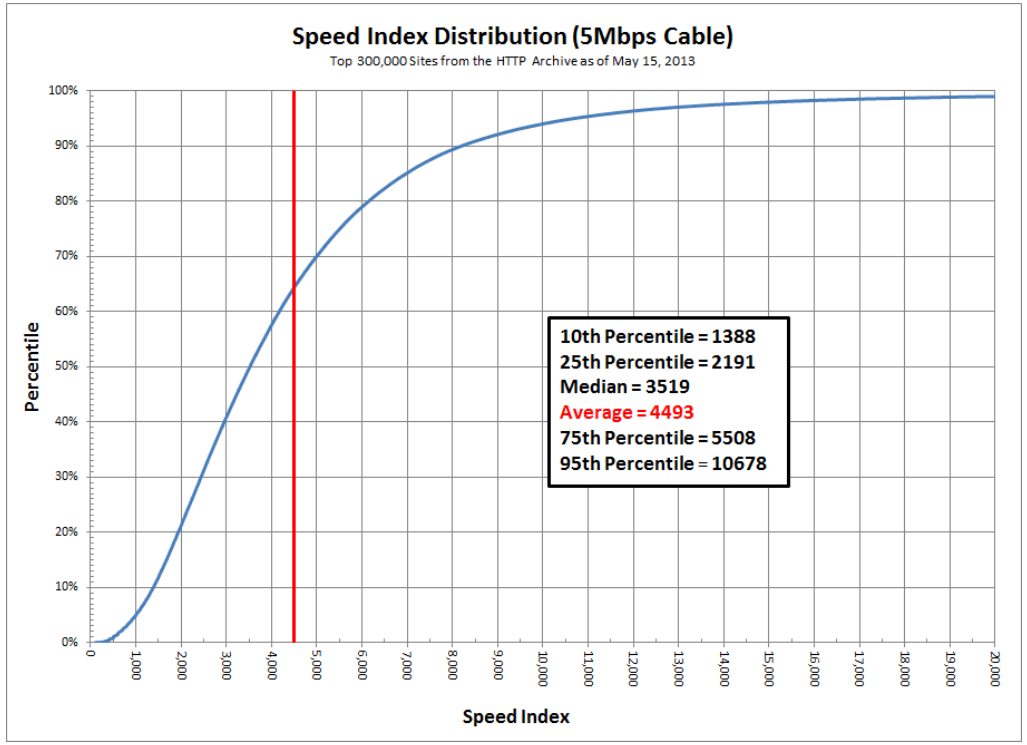
Web Optimization

- Google PageSpeed
  - https://developers.google.com/speed/pagespeed/?csw=1
- CDN
  - Akamai ION
- Cloudflare
- DNS

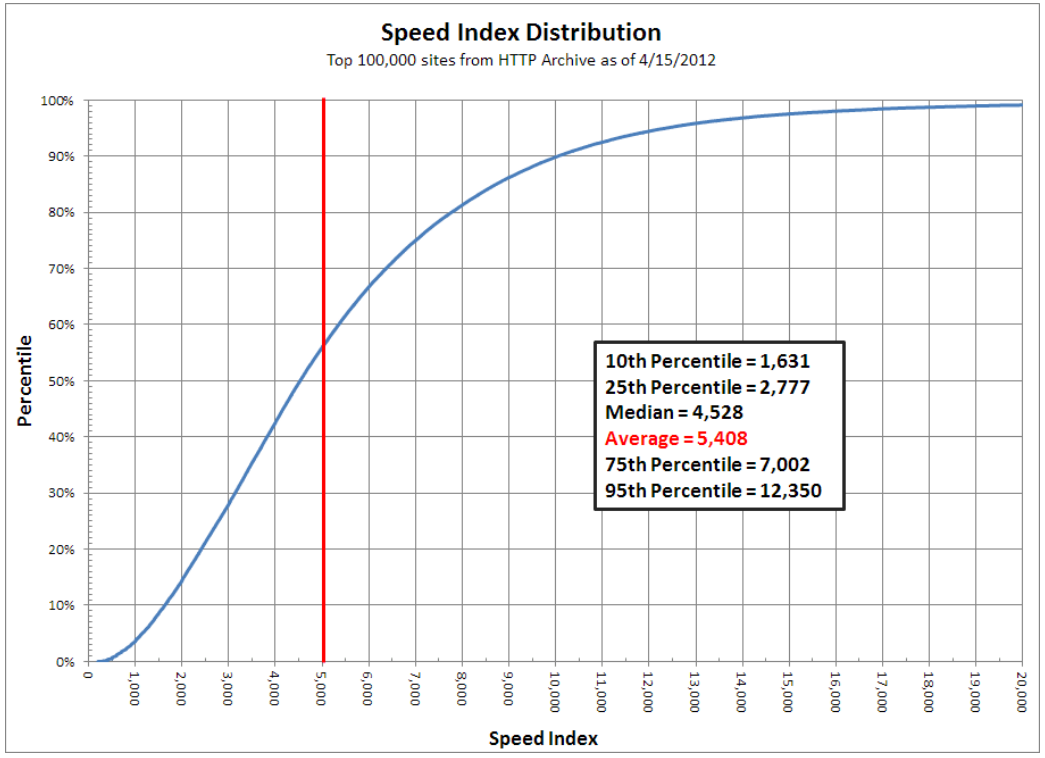


Network Issue

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

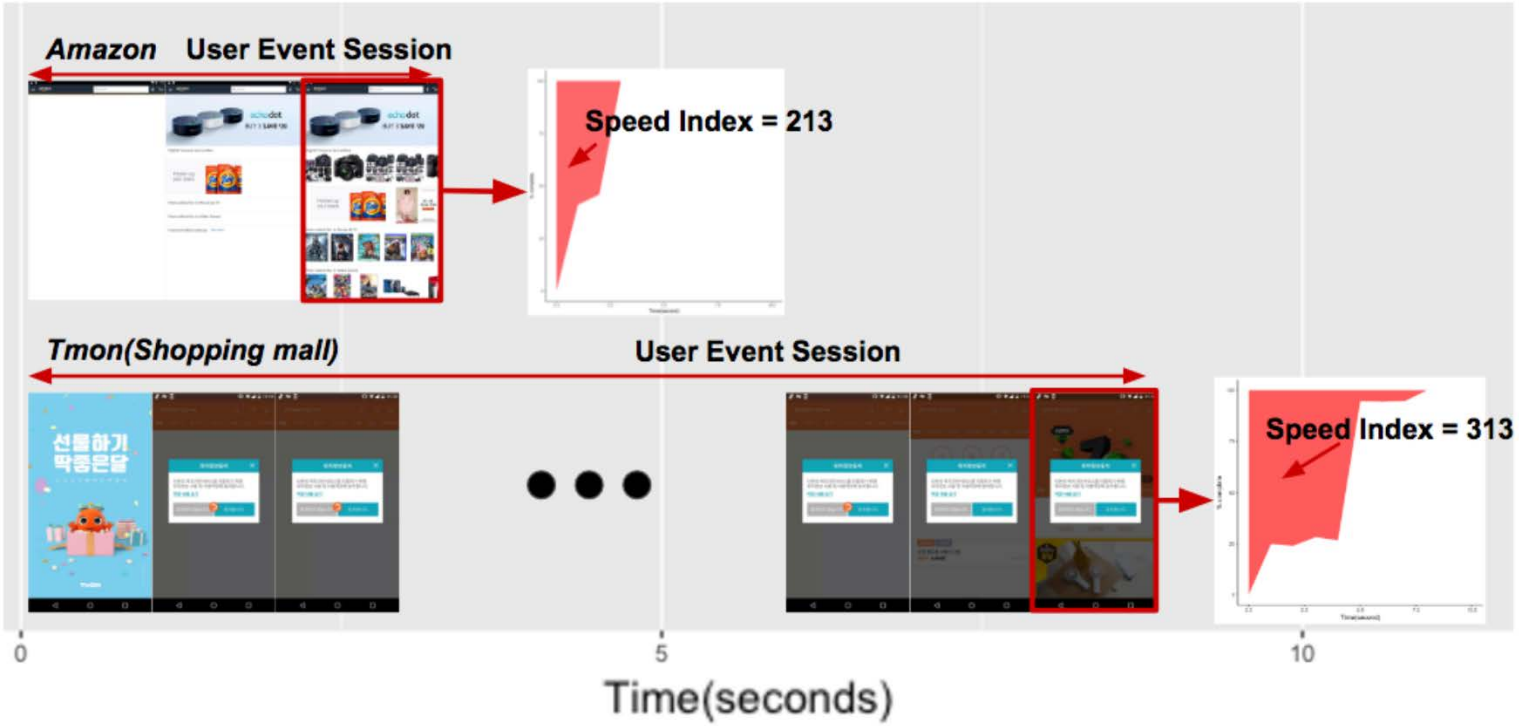


Figure 1: Speed Index of two mobile apps: Amazon vs. Tmon (Shopping mall) apps

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.

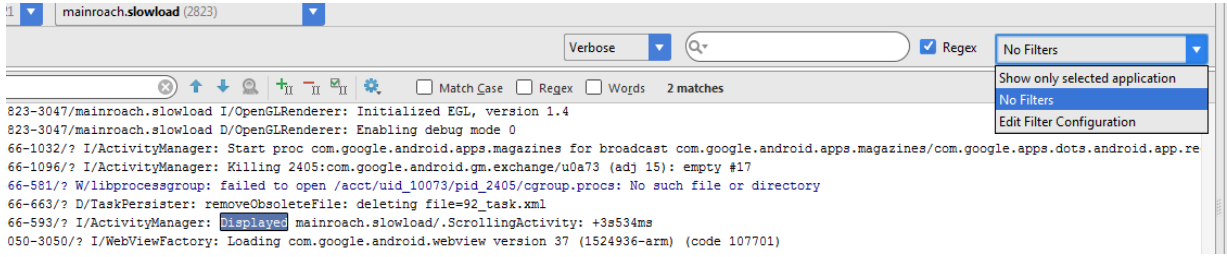
```
$ adb shell monkey -p your.package.name -v 500
```

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

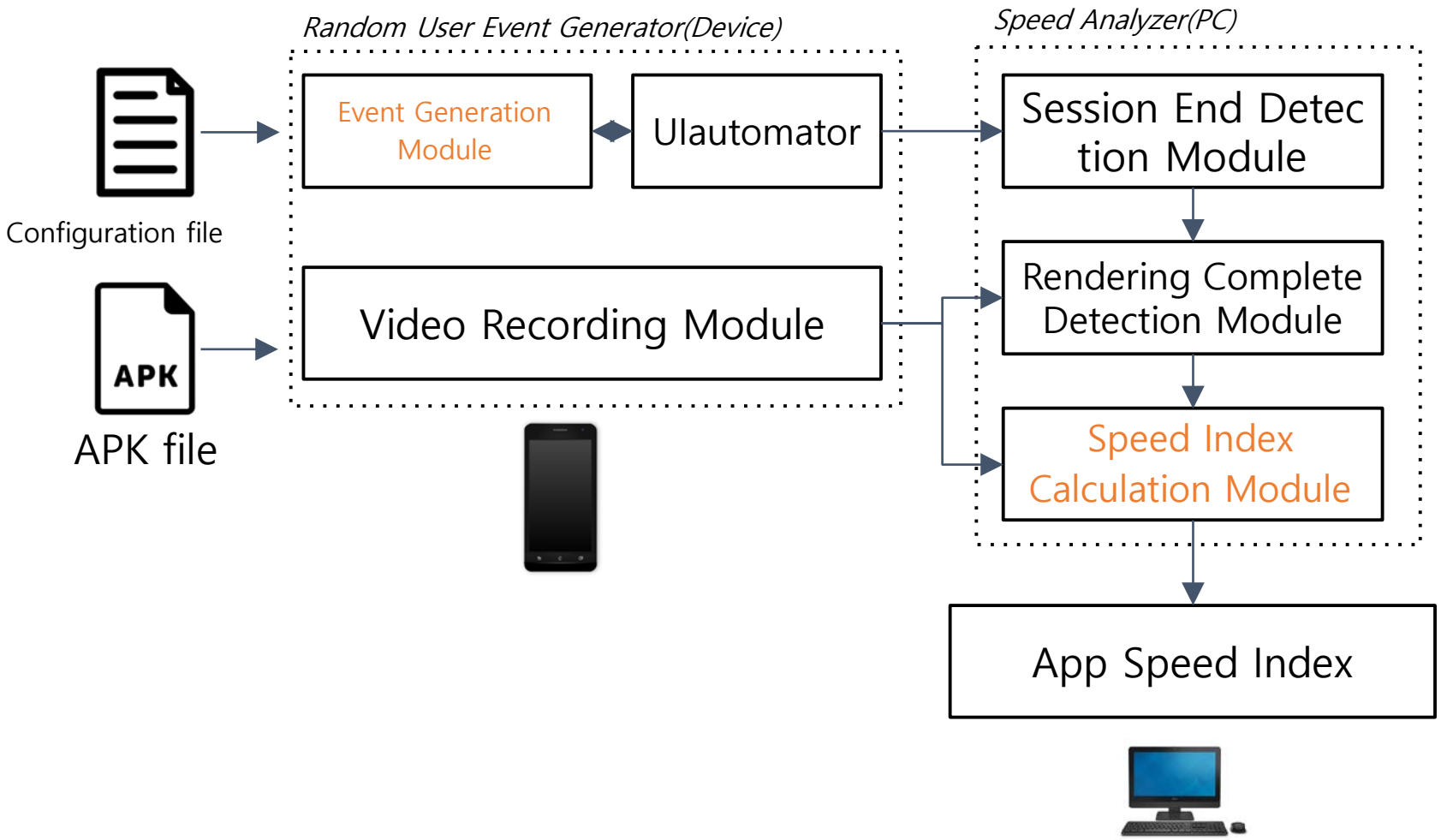
```
adb shell uiautomator dump

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

- Logcat



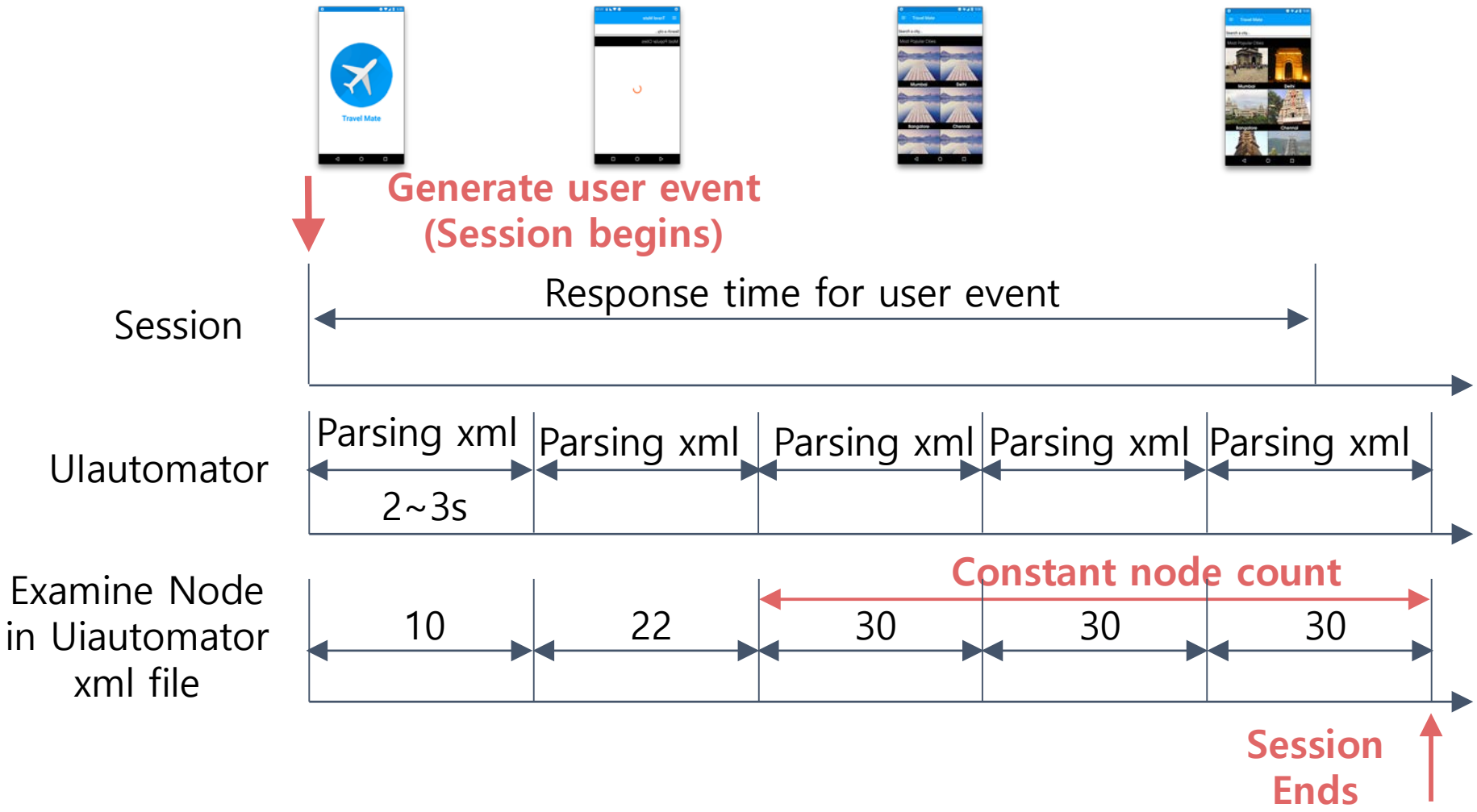
App Speed Measurement System



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?



UI Automator XML File

<?xml version='1.0' encoding='UTF-8' standalone='yes' ?>
<hierarchy rotation="0">
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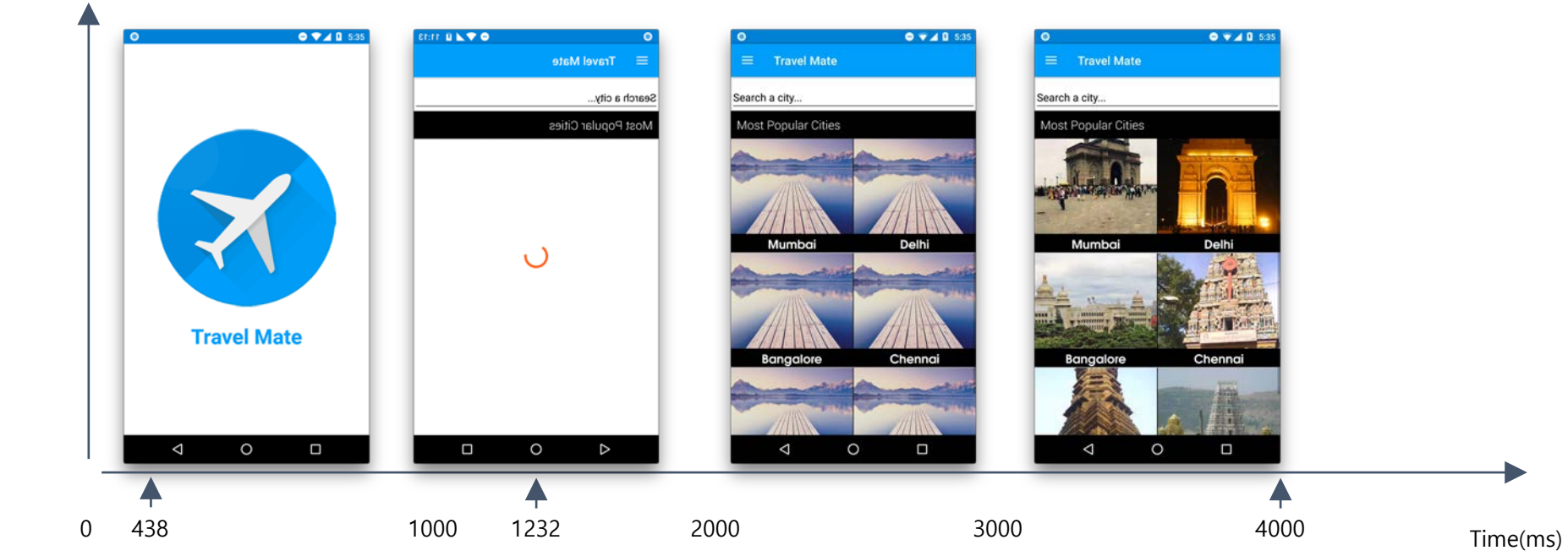
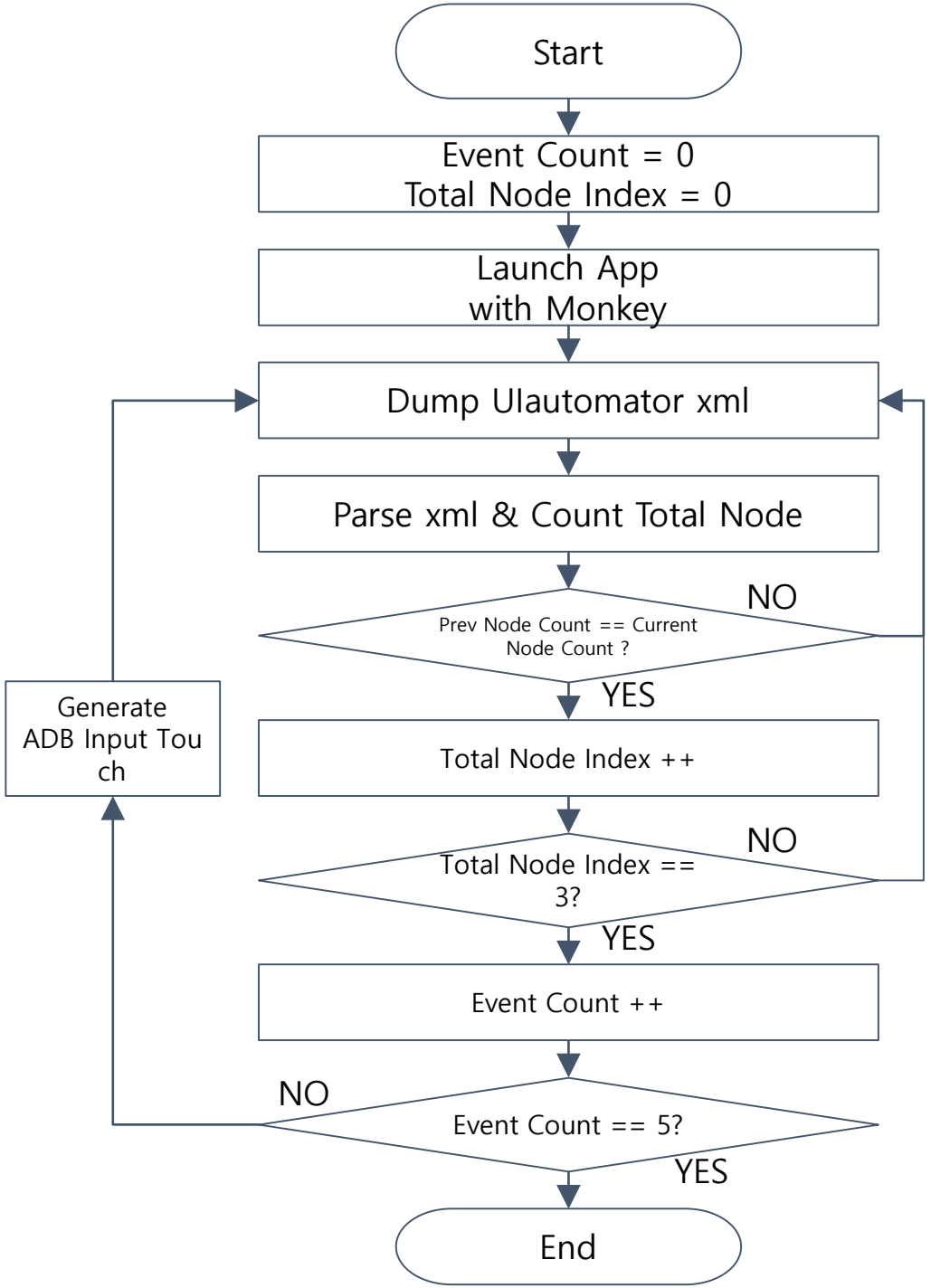
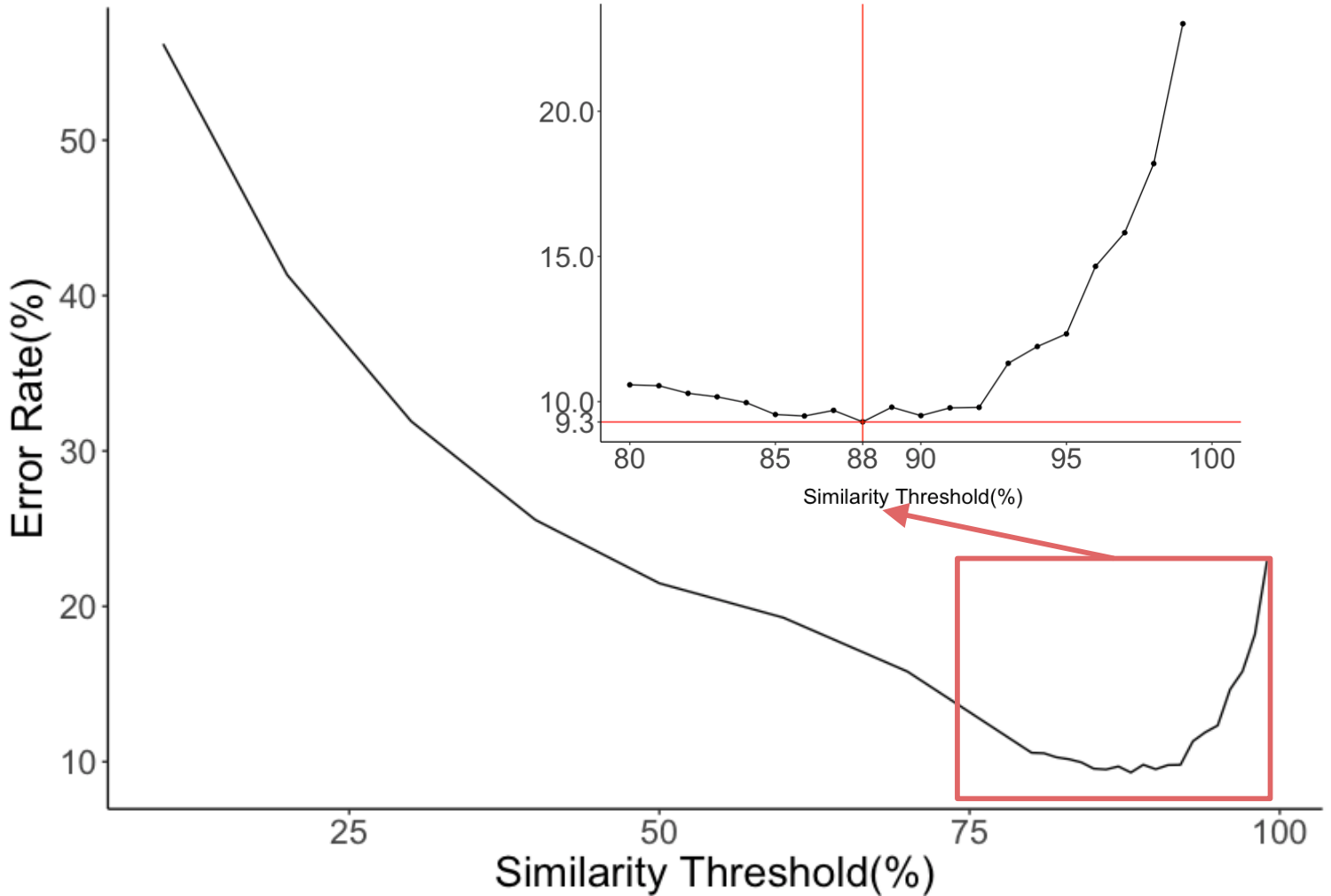
<node .... >

Difference between FullyDrawn Event and Rendering Complete Event




Start
Event Count = 0
Total Node Index = 0
Launch App
with Monkey
Dump UIautomator xml
Parse xml & Count Total Node
Prev Node Count == Current Node Count ?
NO
YES
Total Node Index ++
Total Node Index == 3?
NO
YES
Event Count ++
Event Count == 5?
NO
YES
End
Generate ADB Input Tou ch

Rendering Complete Detection

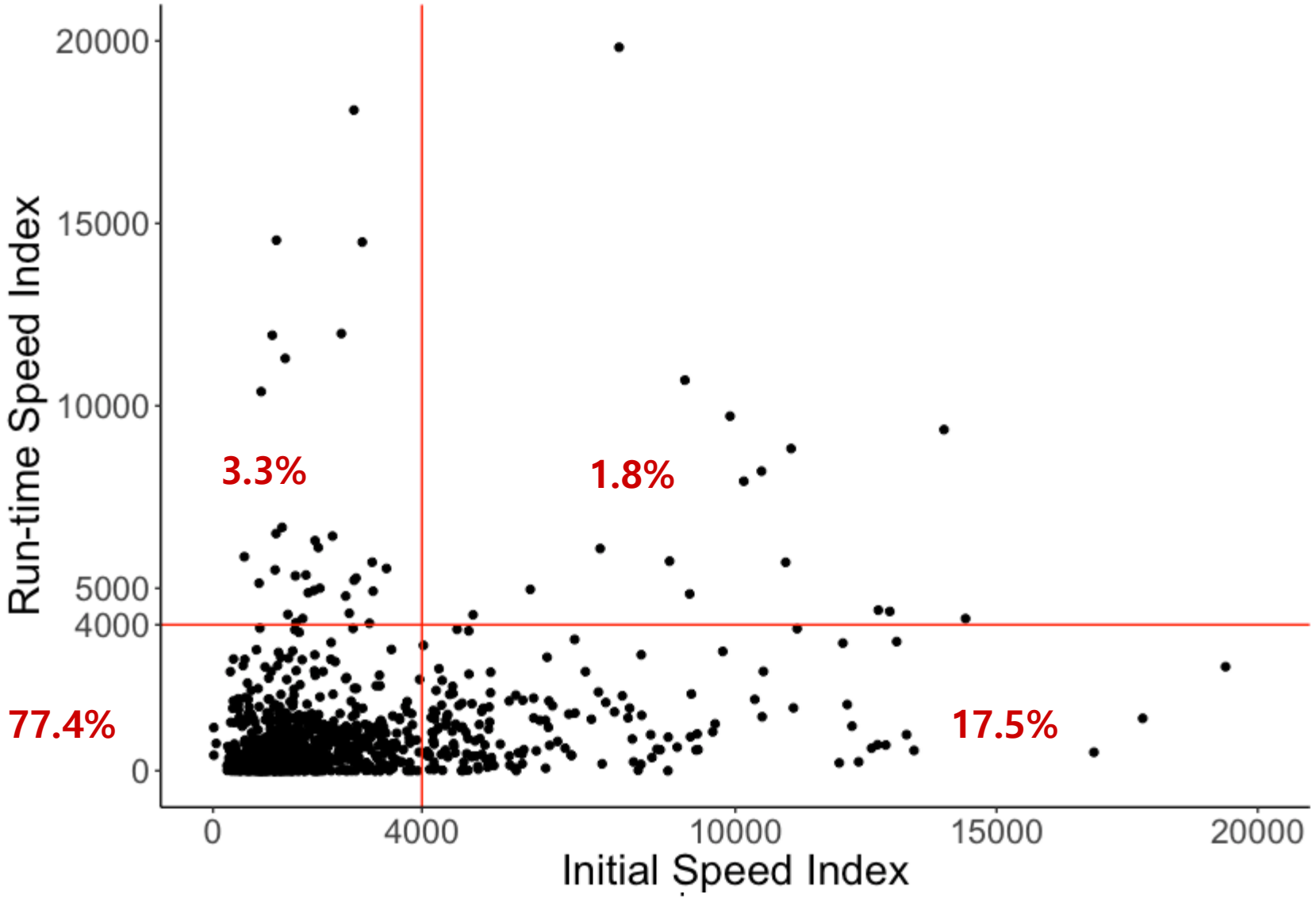


Moving images at the end of rendering

Experiment

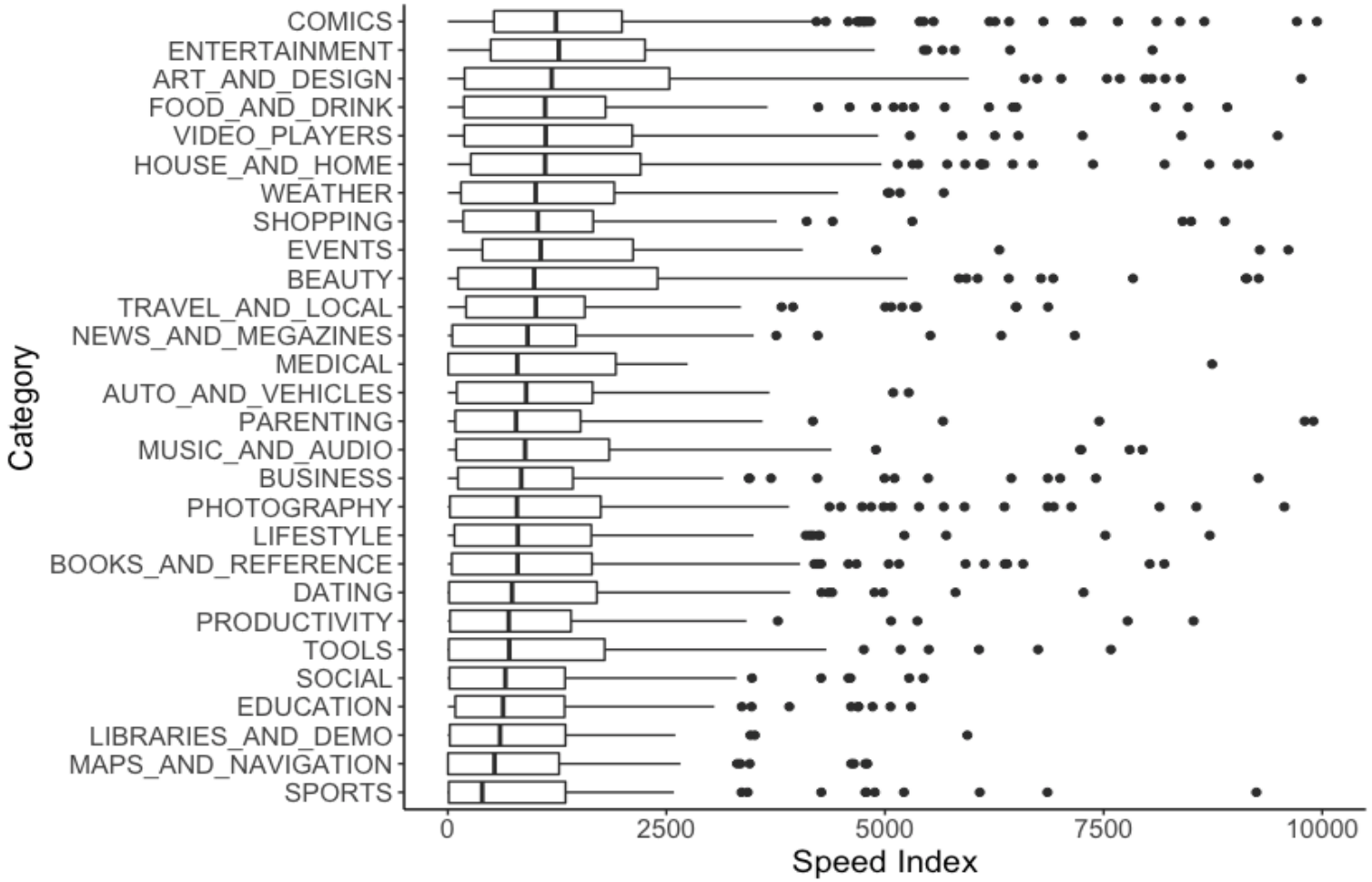
- Galaxy A5 device
- Android 6.0.1
- 5 user events for each mobile app
  - 1st initial event to load a mobile app
  - Four run-time events to use a mobile app: touch, scroll, swipe
- 1,093 mobile apps
- Speed index threshold considering 4 seconds
  - Web users tend to feel the rendering in 4 seconds

Initial vs. Run-time Speed Index



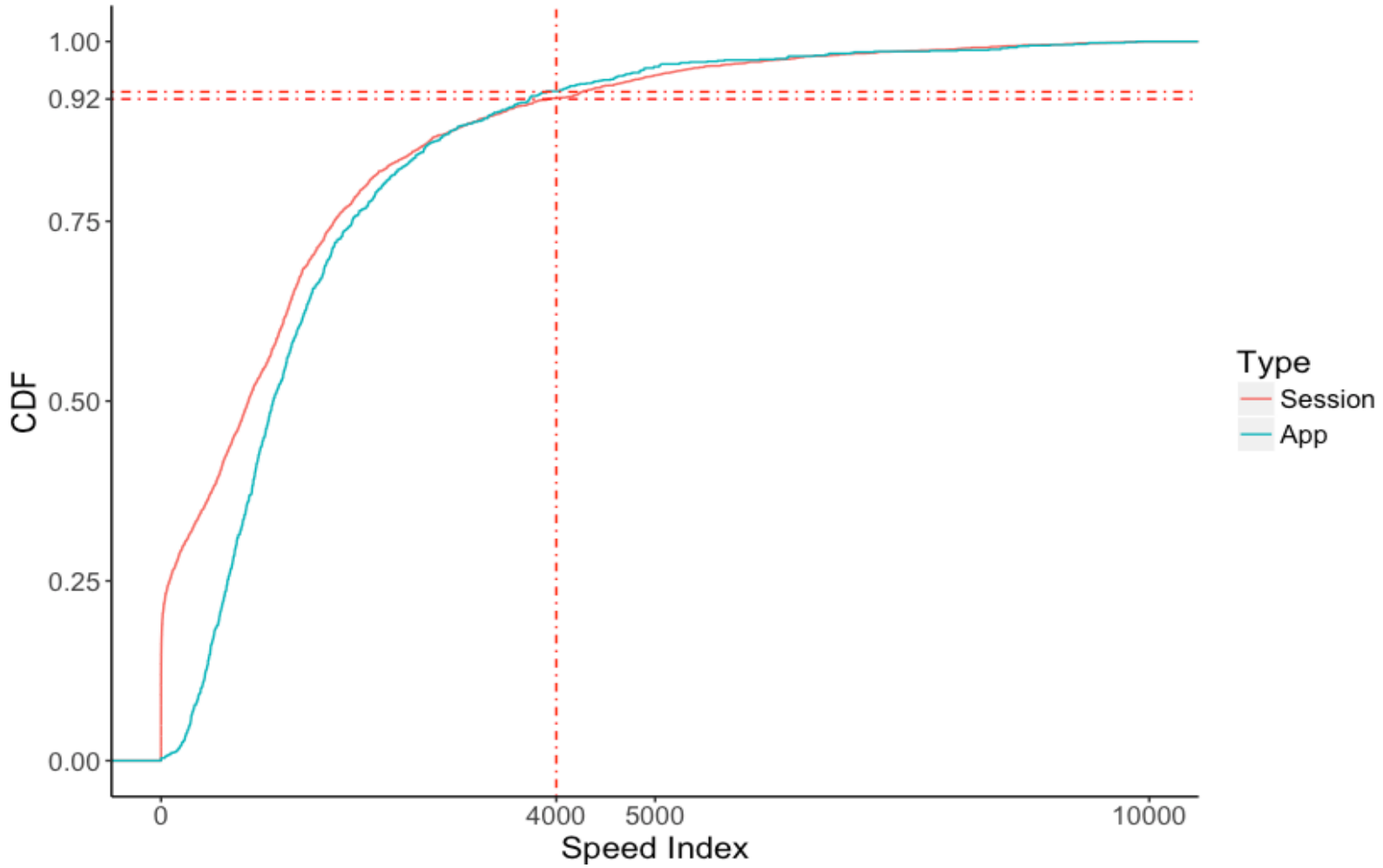
Category

Comics
Entertainments
Usually have many images



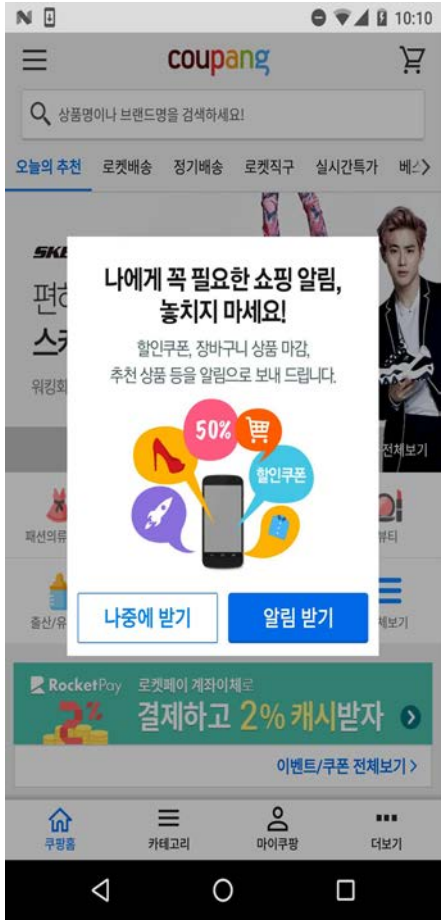
Speed Index by Session or Mobile App

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



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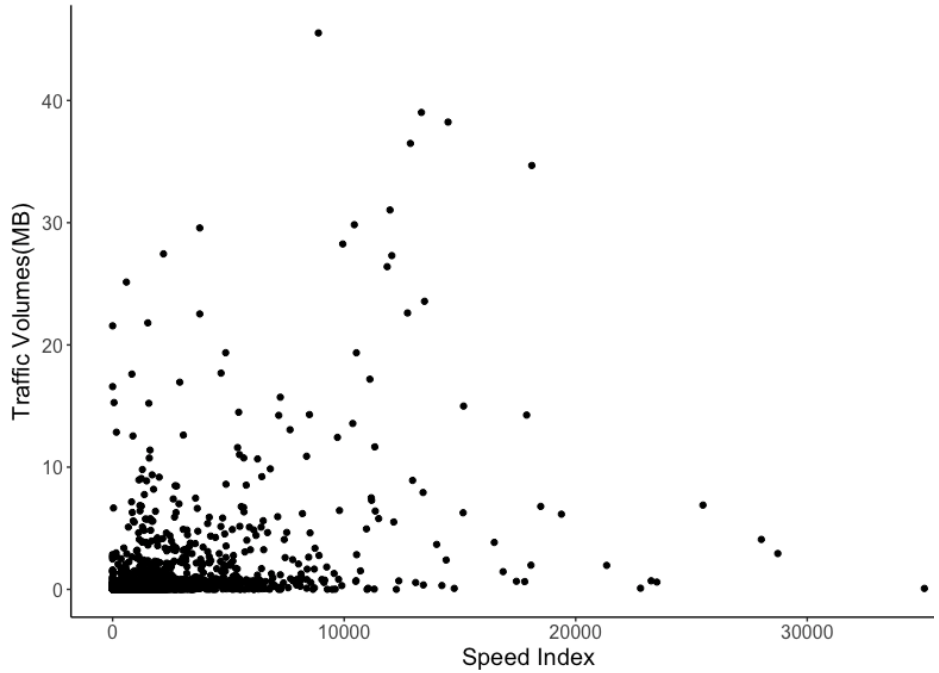
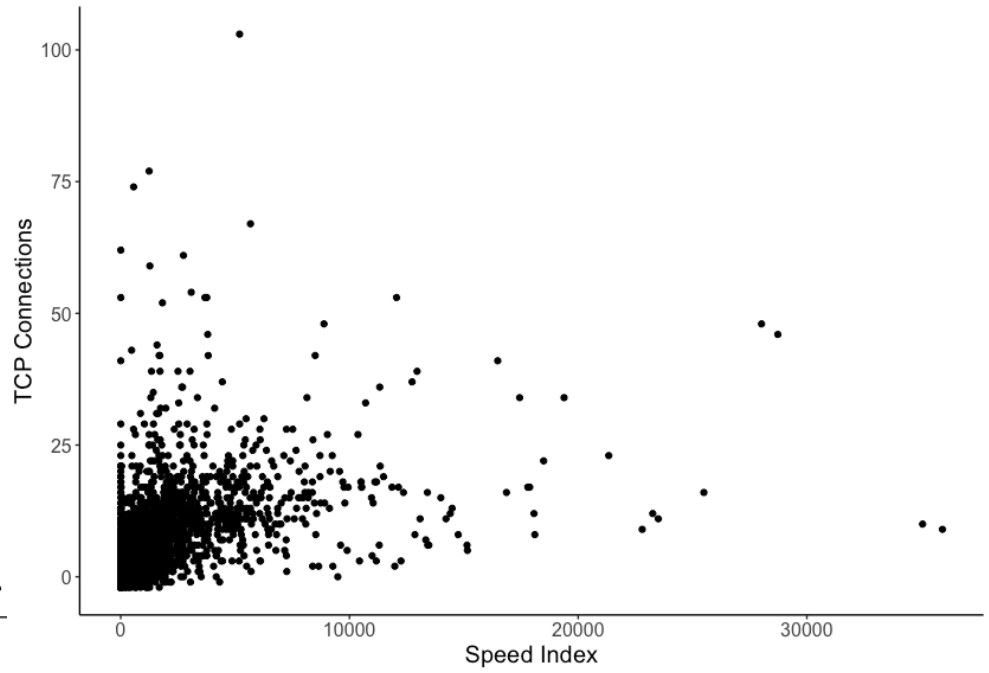
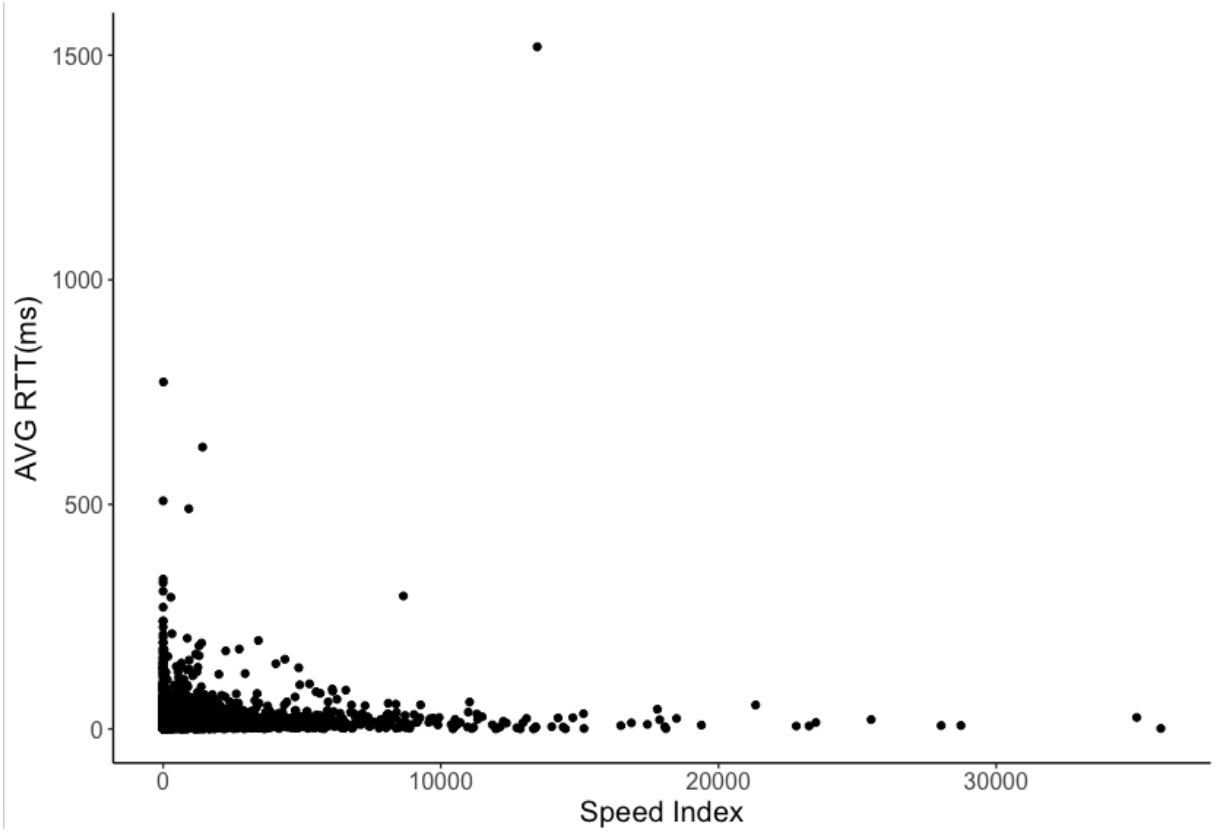
Speed Index by Traffic Volume, TCP Connections

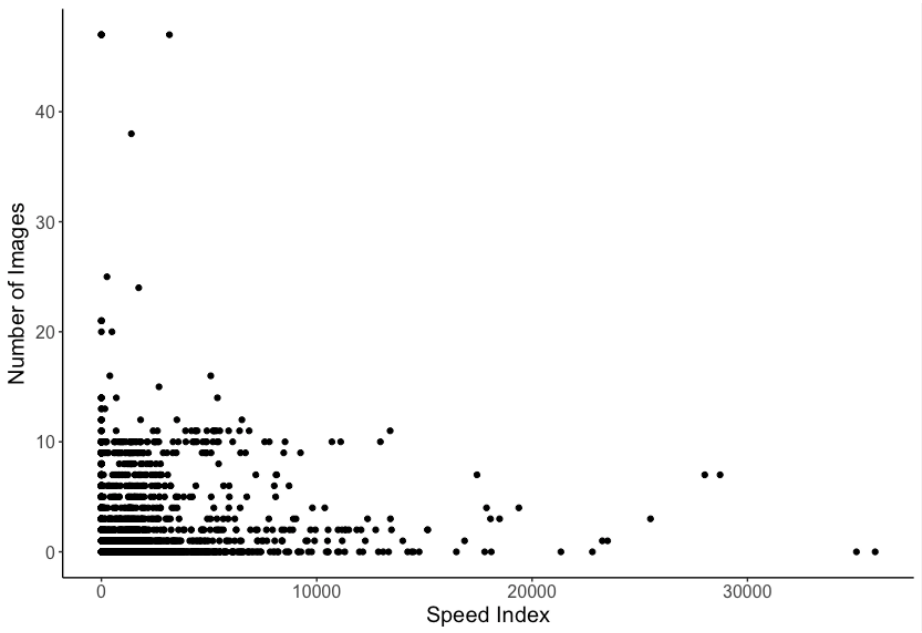


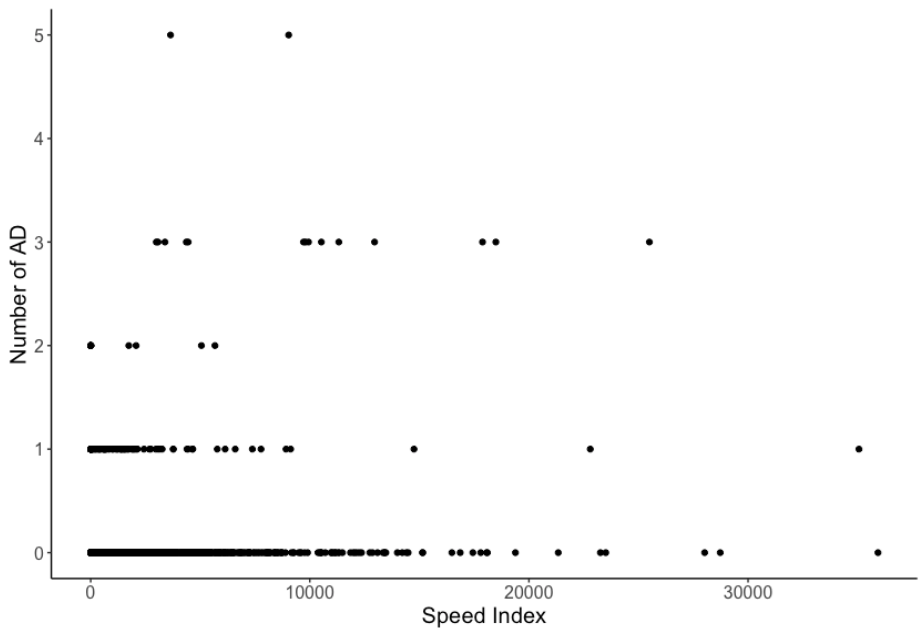


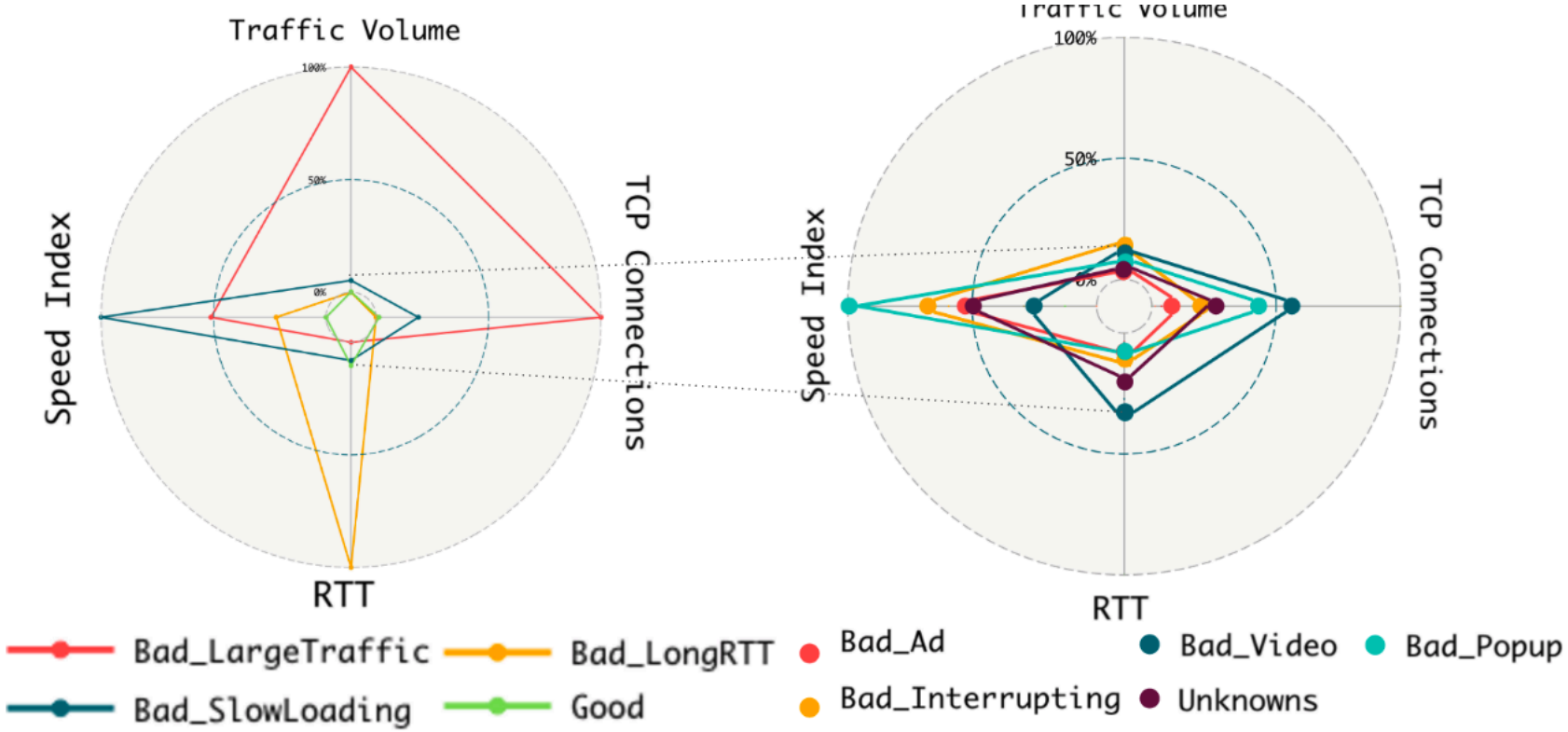
Speed Index by RTT



Speed Index by Images or 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 appropria te guideline
- Issues
  - Crawl mobile app (.apk files in Android)
  - Mobile apps with login