Testing solution for Virtual Reality applications

DEKRA Performance Test Solutions

Motivation facts

- Mobile apps consume data differently depending on various network conditions.
- Carriers need to understand how the most popular Android and iOS apps consume data from a network.
- Carriers need to understand the network conditions that drive poor/excellent User Experiences.
- Carriers need to test an app in the exact same manner that customers use apps. No simulations…just real apps consuming real data.

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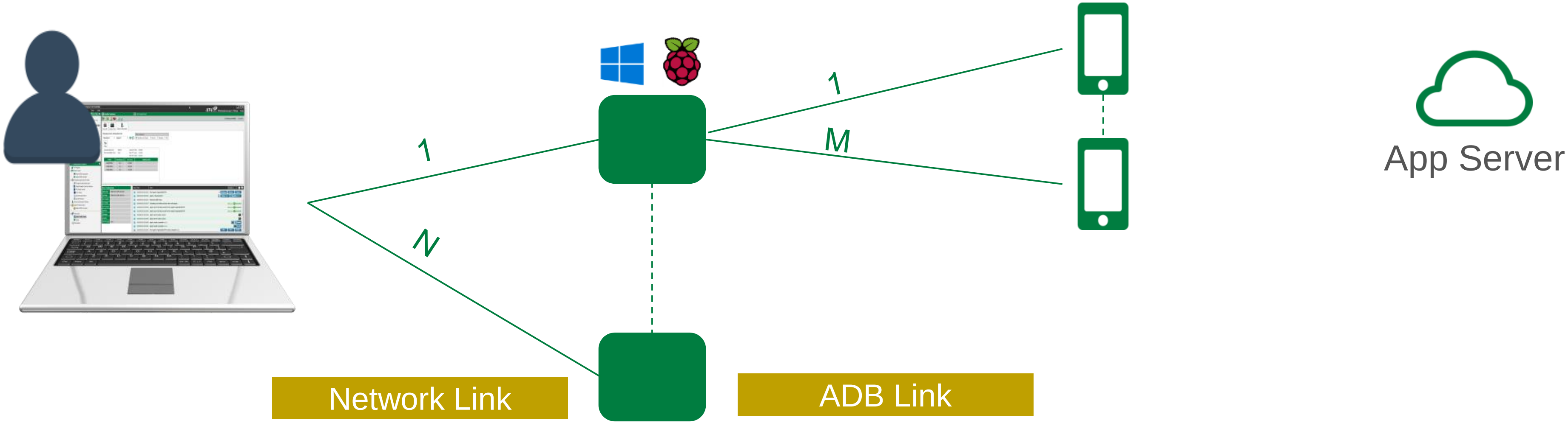
Starting Point: DEKRA's Current solution for non VR apps

- Non VR Apps:
  - Downlink Intensive Video Streaming (including 4k)
  - Uplink Intensive Video Streaming
  - Two-way Video Streaming
  - Social Media

Starting Point: Current solution for non VR apps

Testing Topology: High Scalability: M x N devices can be automated simultaneously

Test Controller | Automation Agents | Automated Devices | Internet

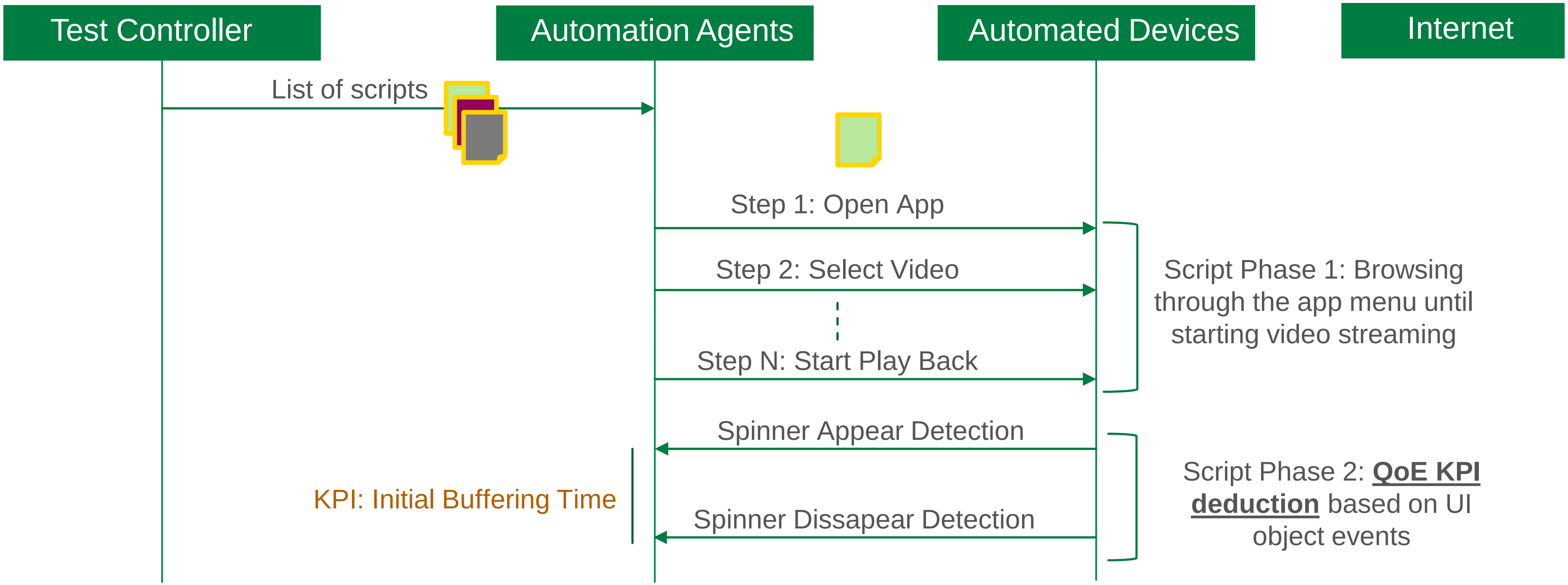


Automation Agents can be deployed in remote sites

ADB (Android Device Bridge) can use USB or Wi-Fi. in either case, Automated Devices must be in locally attached to the Automated Agent.

Starting Point: Current solution for non VR apps

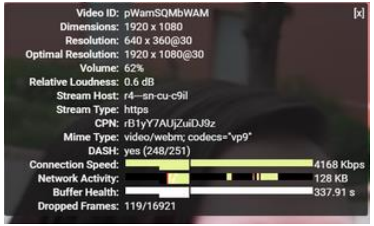
Automation Test Flow: Example – Video Streaming App



Starting Point: Current solution for non VR apps

Automation Agents ⟷ Automated Devices

- We use the following technologies:
  - Appium [*open source **test automation framework** for use with native, hybrid and mobile web apps] for*
    - Browsing through the App menu
    - Recognize UI objects (e.g., spinner, progression bar)
  - ADB [*Android Device Bridge*] for device file size usage reporting.
  - OCR [Optical Character Recognition] for extracting App information



Video Resolution
Buffer Health
….

Starting Point: Current solution for non VR apps

The following KPIs have been proved:

Mobile Apps	KPIs
All (App Agnostic)	Battery, Data Usage, Throughput
Netflix	Initial Buffering, Re-bufferings
YouTube	Initial Buffering, Re-bufferings, Video Resolution
Instagram	Access Time, Initial Buffering, Re-bufferings
Periscope	Initial Buffering, Re-bufferings
Skype Video Call	Call Setup Time, Call Result
WhatsApp	Sharing Time
Facebook	Access Time, Initial Buffering, Re-bufferings, Sharing Time
Snapchat	Send Content Time, Access Time
Livestream	Initial Buffering, Re-bufferings

Starting Point: Current solution for non VR apps

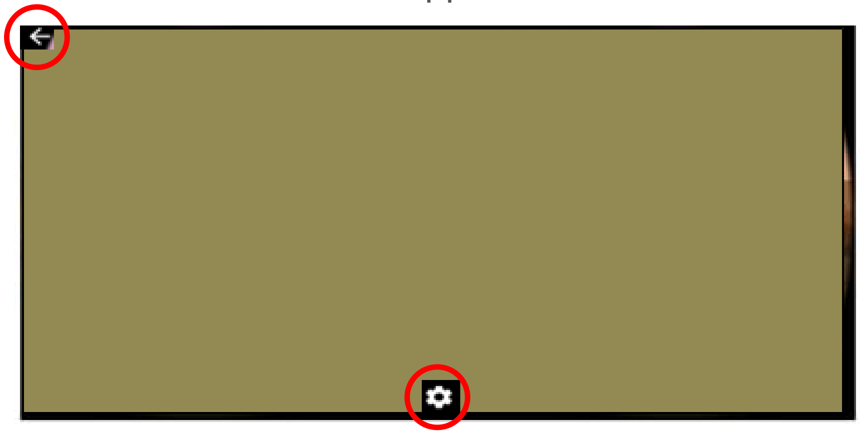
- Limitations of this approach for testing VR/Gaming apps:
  - Performing movement
    - VR and gaming apps requires physical movement of the hosting device. As the gyroscope and the accelerometer cannot be mocked, a hardware platform is required.
  - Retrieving App State
    - Unlike other apps, VR and gaming apps are programmed in an Android UI Canvas where the graphical engine works (e.g., Open GL). Appium (or similar) cannot recognize the UI objects inside an App Canvas.

Starting Point: Current solution for non VR apps

- Limitations of this approach for testing VR/Gaming apps:

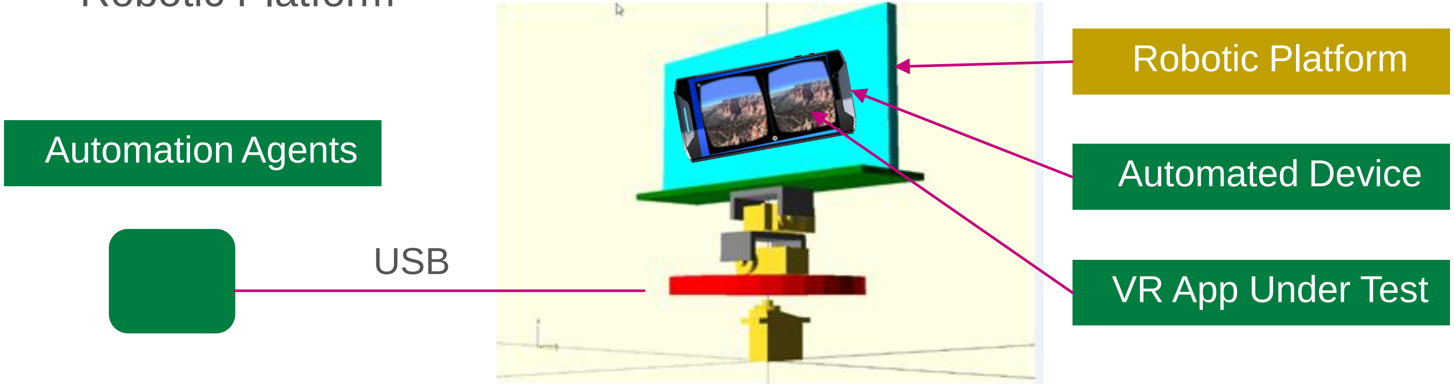
Actual App UI

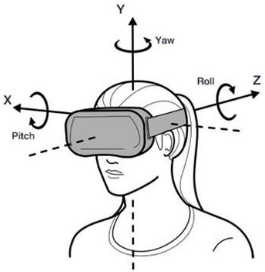
What Appium sees….



Testing Solution for VR/Gaming apps

- In order to overcome those limitations we have upgraded the architecture:
  - Robotic Platform





Four Servo-Motors:

1. Pitch (-90º, +90º)
2. Roll 1 (-180º, 0º)
3. Roll 2 (0º, +180º)
4. Yaw (-90º, +90º)

Testing Solution for VR/Gaming apps

System Requirements

- VR and Gaming Testing Requirements:
  - Ability to measure the KPI "time to load a virtual scene" (t_2-t_1), where
    - t_1 = user clicks on "start scene" button
    - t_2 = the scene is totally rendered in device screen

VR/Gaming QoE KPI Deduction

  - Minimize reaction time "(t_3-t_4)" where
    - t_3 = target appears on the screen
    - t_4 = tap on that target

VR/Gaming: Automate the browsing through the app where some UI could be moving objects.

Gaming: Shoot at moving target

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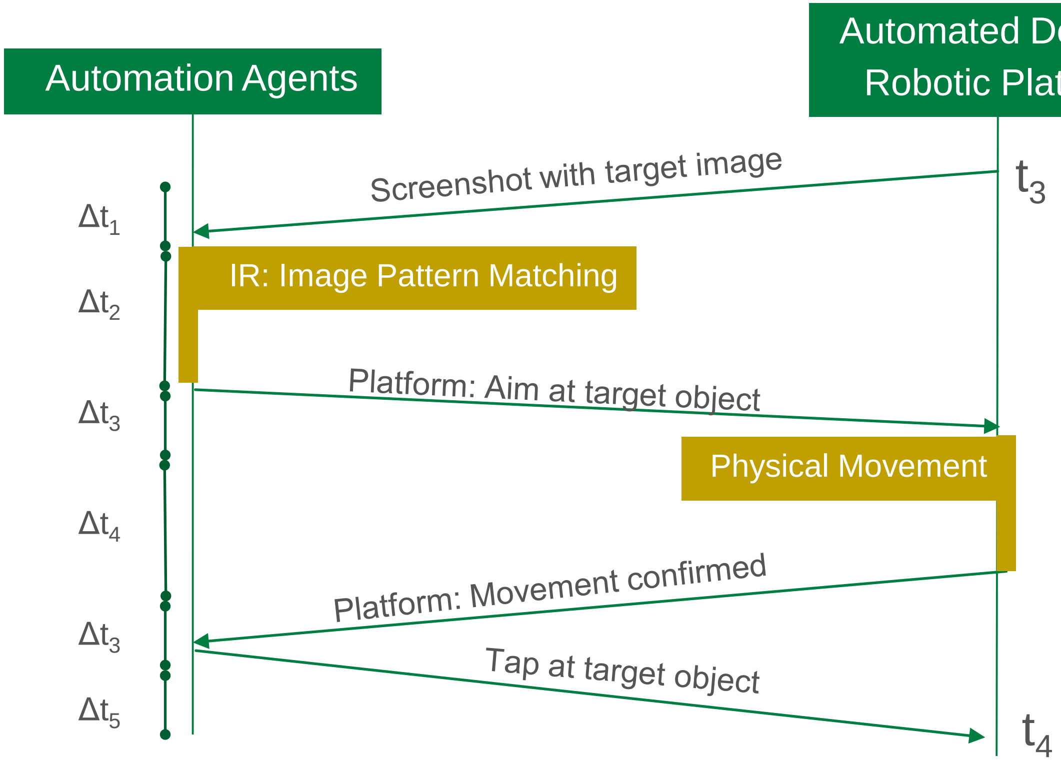
Testing Solution for VR/Gaming apps

Implementation Decisions

- High performance screen capture
  - Requirement: Higher than 24 frames per second
- Low delay screen touch
  - Requirement: Lower than 10 ms reponse time
- IR (Image Recognition)
  - Requirement: High pattern matching accuracy and high performance
  - Technology used: **OpenCV**: *“Open Source Computer Vision Library*

Testing Solution for VR/Gaming apps

Closed-Loop Implementation



Goal

Average Human Reaction Time: **284 ms**
[https://www.humanbenchmark.com/tests/reactiontime/statistics]

Implemented Reaction Time:

Δt_1 ~1-10 ms → TCP socket latency
Δt_2 ~100-200 ms → Image Recognition performance
Δt_3 ~1-10 ms → Serial COMM latency
Δt_4 ~ 100 ms → Time to aim at object
Δt_5 ~1-10 ms → TCP socket latency

DEKRA's solution Reaction Time = **(230, 330) ms**

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Testing Solution for VR/Gaming apps

KPIs Implemented

KPI	Definition
Network Resources Usage	Data Usage, Throughput
Device Resources Usage	Battery, CPU, GPU
Time to load the virtual world	Time elapsed from selecting a scenario (world, experience, etc.) to loading the 3D visual context
Immersion Cut-off	Probability that successfully started immersion is ended by a cause other than the intentional termination by the user
Time to load the virtual scene	Time elapsed from selecting a scene to reloading the 3D visual context

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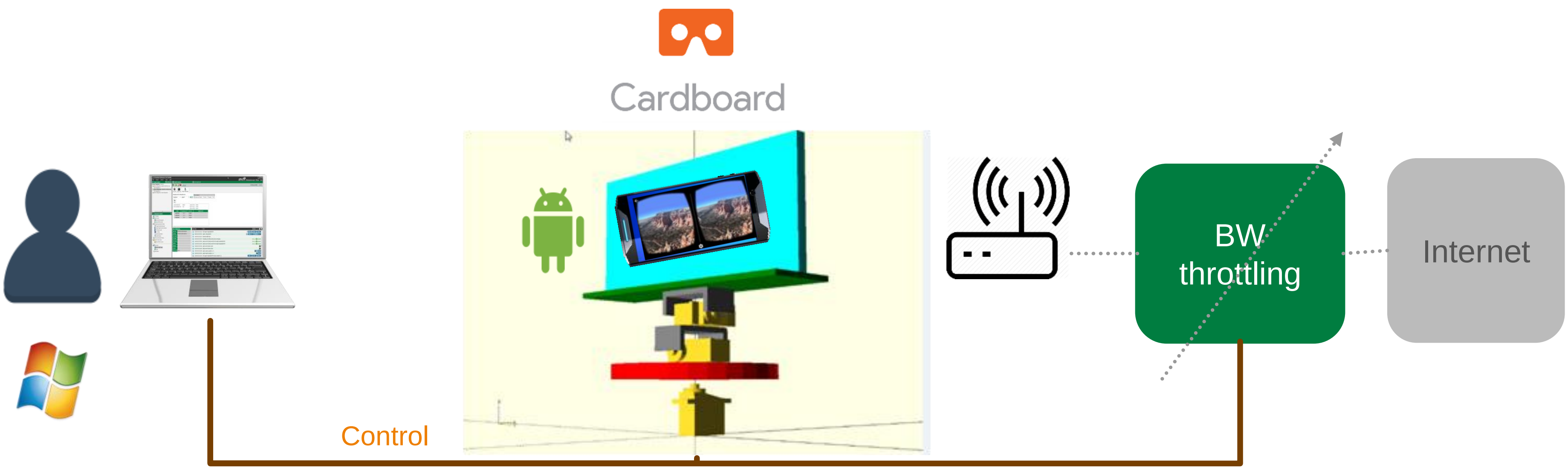
Showcase: Testing Google Cardboard App

- VR experience, e.g., for Google Earth
- Replacing the mouse by the head movement

Showcase: Testing Google Cardboard App

Testing Setup



Automatic test cycles: **40 repetitions / BW configuration**

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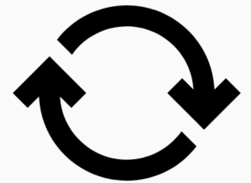
Showcase: Testing Google Cardboard App

Test repetition flow

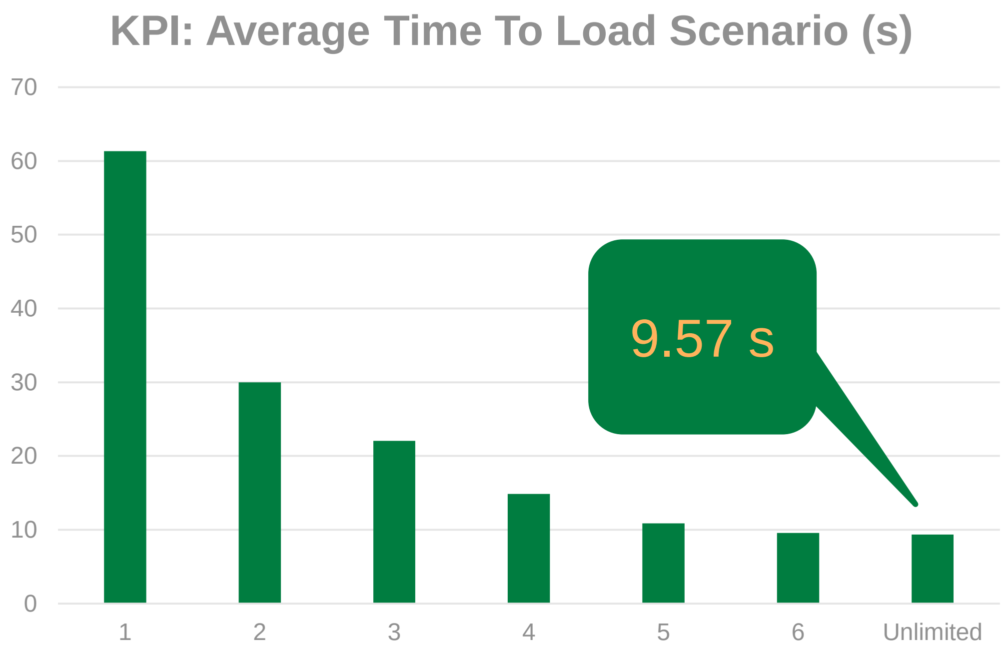
Open App ----- Navigate through the app until click “start experience” ------------------→ Measurement



Automatic test cycles: **40 repetitions / BW configuration**

Showcase: Testing Google Cardboard App

Test Results



X-Axis: Imposed BW (Mbit/s)

KPI: Time to load scene

9.57 s (best scenario)

KPI: Network Data Usage

8 MB (all scenarios)

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Conclusions

Key-takeaways

- The “time to load scenario” KPI is severely impacted by the quality of the network access, mainly the available bandwidth (Mbit/s).
- Online Virtual Reality apps consumes huge amount of network data, which has impact on network planning and deployments.
- Online Virtual Reality apps requires high device GPU performance.

Lesson-learnt

- Thanks to the fast closed-loop response time of the solution on Android, the solution can be also used to measure online games apps.
- The image recognition library matching score parameter has impact on the accuracy of the “time to load scenario” measurement.
- Nowadays Online VR apps do not implement video quality adaptation in order to adapt the app experience to the network conditions.