Review F4Fp-SME-Stage 2 experiment

Testing low latency Industry4.0 applications using Fed4FIRE+ (Fed4.0-Stage2)

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Review

Online, 02 June 2021

Testing low latency Industry4.0 applications using Fed4FIRE+

FED4.0-STAGE2

Outline

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  - Objectives and motivation
  - Experiment set-up
- **Project results**
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- **Business impact**
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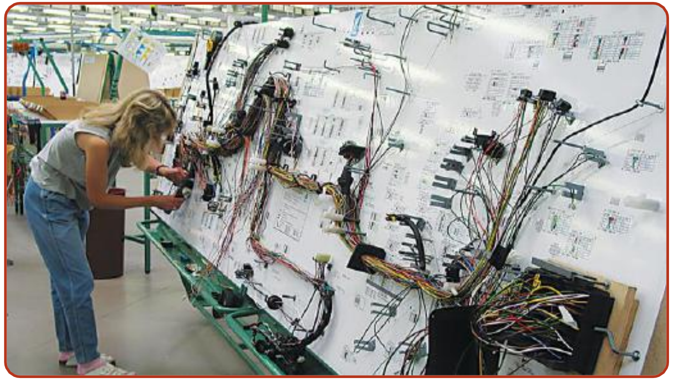
Experiment description

Background & Concept

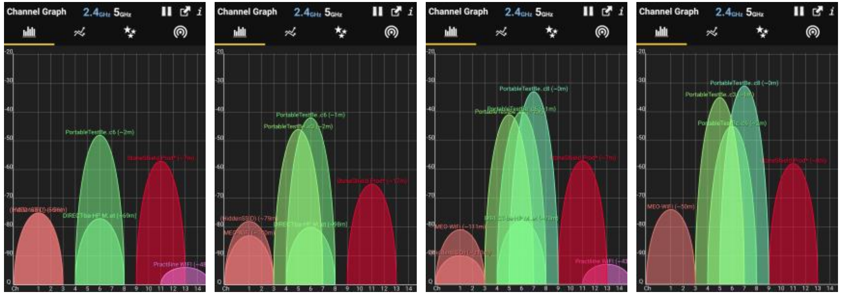
- Cable assembly for the automotive manufacture industry is still a manual process
- This industry is currently being modernized with robotic machines
- There is a lack of qualified technicians to operate these machines
- StoneShield is a manufacturer of robotic machines
- An AR application was developed to train technicians to operate and maintain these machines
- We want to measure how different wireless conditions impact the usability of the AR app.

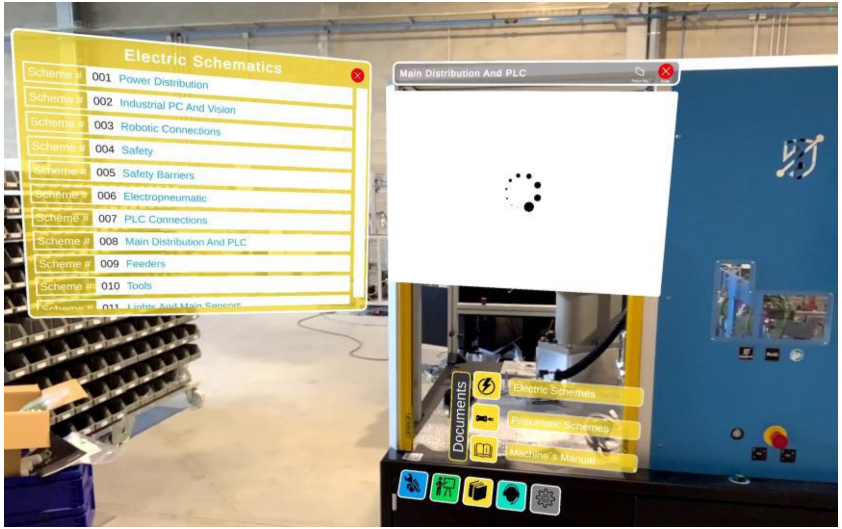


Experiment description

Objectives & Motivation

- Evaluate how different wireless conditions impact the user experience when using the developed AR application
- Evaluate LTE as a candidate substitute for WiFi in the usage of the AR application
- **Motivation:** Based on our survey with industry stakeholders, there is no commercial application for the remote maintenance of robotic machines used in the cable assembly industry.





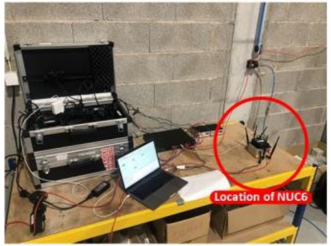
Experiment description

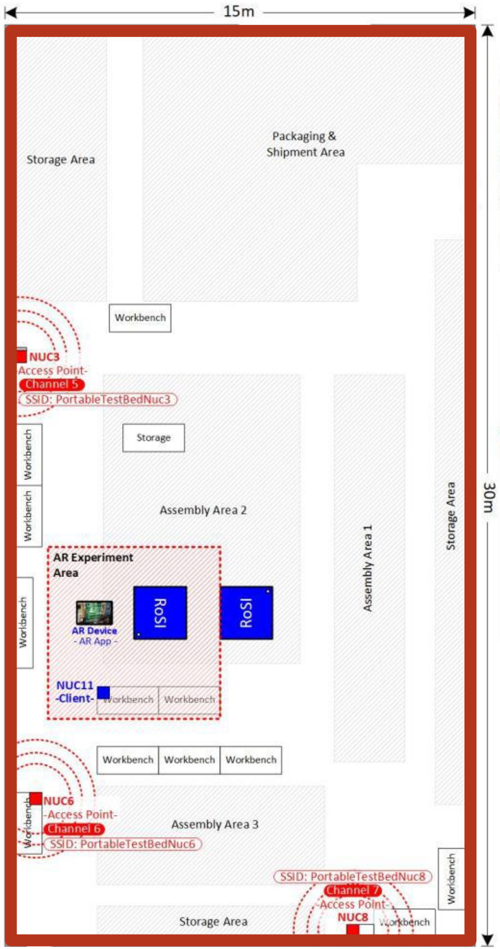
Experiment Setup

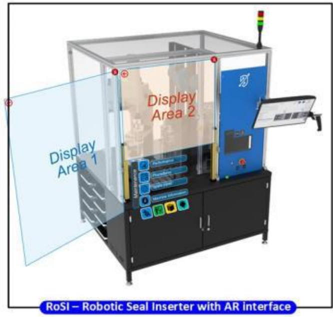
- The setup was implemented at STONESHIELD Assembly Warehouse, a large indoor open space

StoneShield ENGINEERING

Assembly Warehouse





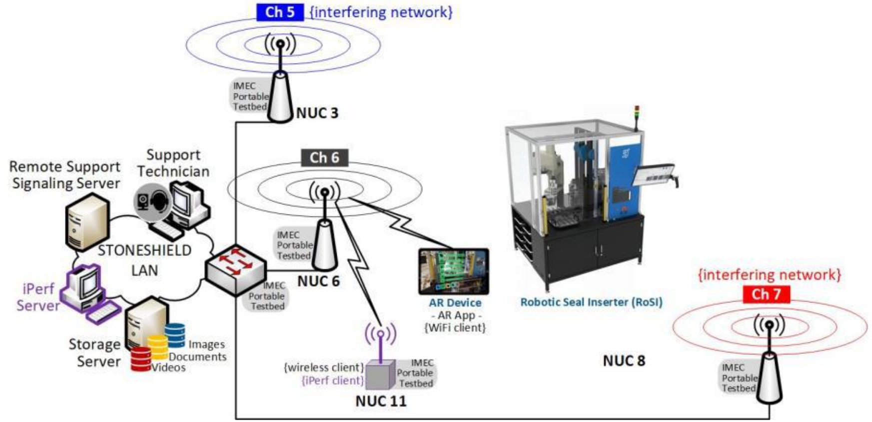


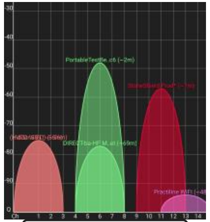
User Training

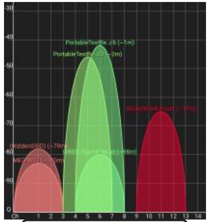
Experiment description

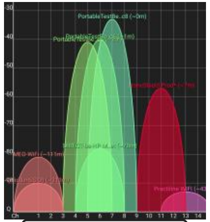
Experiment Setup

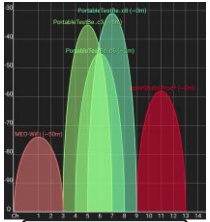
- Test Case 1 (Wi-Fi)



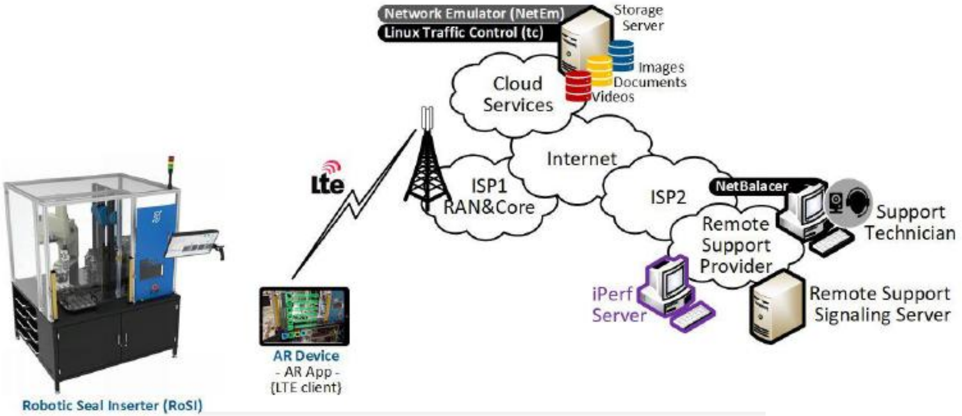

Scenario WiFi-1

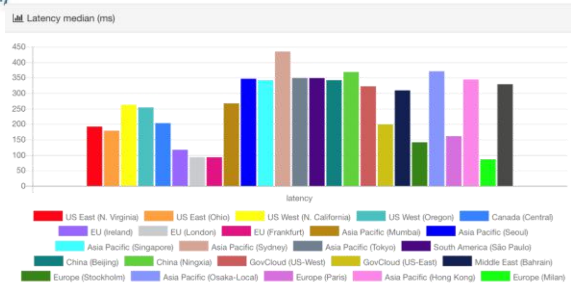

Scenario WiFi-2


Scenario WiFi-3


Scenario WiFi-4

- Test Case 2 (LTE)

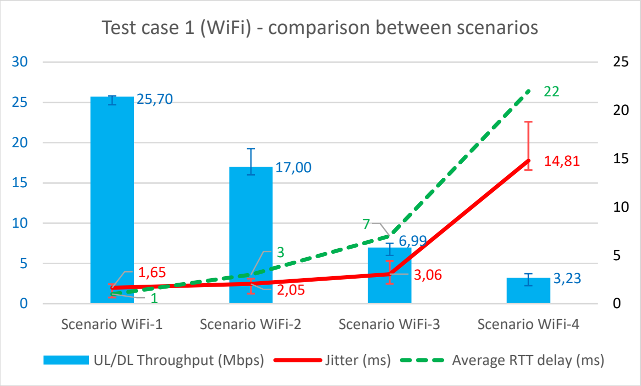




Project Results

Measurements: Test case 1

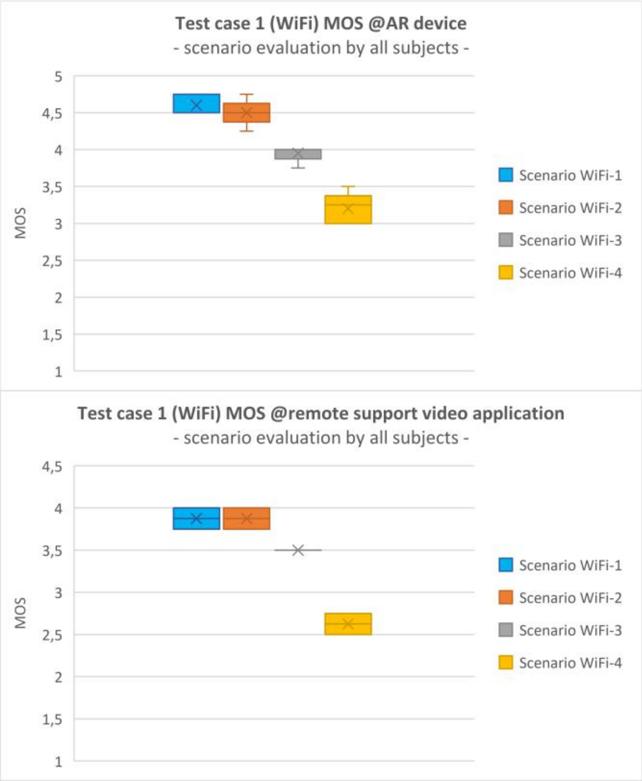
- Objective measurements



Data collected using the IMEC portable testbed built-in tools

Data collected through user Evaluation Score Boards using ITU-R scales

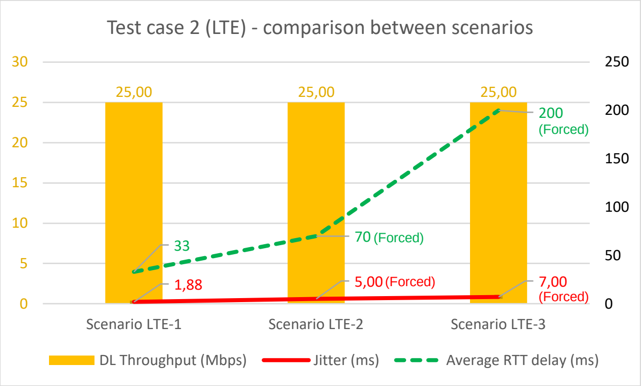
- Subjective evaluation



Project Results

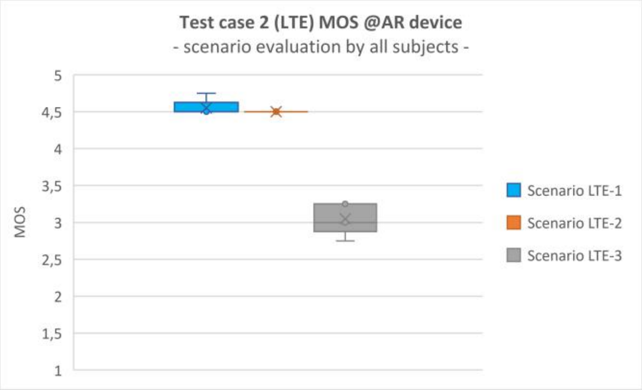
Measurements: Test case 2

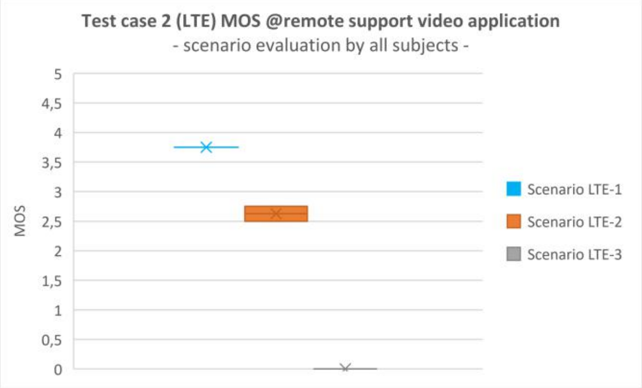
- Objective measurements



- DL throughput, network delay and delay jitter were forced using the Linux Traffic Control utility

- Subjective evaluation





Project Results

Lessons learned

AR application

- 1 interfering WiFi network (medium load) → negligible impact, MOS was ‘Excellent’.
- 2 interfering WiFi networks (medium load) → MOS dropped from ‘Excellent’ to ‘Good+’
- 2 interfering WiFi networks (heavy load) → MOS dropped from ‘Excellent’ to ‘Good-’
- LTE vs WiFi → no noticeable difference if a minimum bandwidth is guaranteed (~7Mbps)

Remote support video application

- Major impairment is delay and jitter. Delays above 30ms considerably impact the user MOS on interactive applications.
- When selecting a cloud service, especial care should be taken in analysing the RTT delay behaviour

Business Impact

Value perceived

- The Experiment allowed us to better know the network requirements for the AR application.
- Different application capabilities have different demands from the network:
  - Non-real-time communications, such as downloading images and documents, or play videos (e.g., from the tutorials) are mainly affected by DL throughput, with very noticeable influence from network delay or jitter.
  - Real-time communications, such as video conferencing, are affected by DL and UL throughput (up to a minimum), network delay and jitter:
  - The remote support video capability is asymmetric consuming more bandwidth when transmitting from the AR device and less when transmitting from the remote application – this is because there is less information transmitted by the remote application, since the background is static;
  - The video sent by the AR device and received by the remote technician suffers from the upload conditions offered by the network – this is especially critical in the LTE scenarios.

Business Impact

Impact on our business

- StoneShield is aware of the lack of applications for remote maintenance of robotic machines in the cable assembly industry
- StoneShield has developed an Augmented Reality application to target this
- For commercial exploitation, StoneShield needs to know how the application performs in different wireless scenarios
- This experiment enabled us to emulate different WiFi and LTE connectivity scenarios in an industrial environment.
- With the experiment results, updates are taking place and the objective is to have the remote maintenance service available to our clients by the end of this year.

Feedback

- As an SME, we do not have the wireless infrastructure required to carry out the proposed experiment
- The IMEC portable testbed was a means to implement and assess the constrains brought by WiFi connectivity in different scenarios and radio channel configurations
- Fed4FIRE+ funding was an important mechanism to decrease the risk of research and development.
- It would be valuable to have the following 3GPP technologies integrated in a portable testbed:
  - 5G NR SA
  - NB-IoT

FED4FIRE

Co-funded by the European Union

Co-funded by the Swiss Confederation

This project has received funding from the European Union’s Horizon 2020 research and innovation programme, which is co-funded by the European Commission and the Swiss State Secretariat for Education, Research and Innovation, under grant agreement No 732638.

WWW.FED4FIRE.EU

Business Impact

Do we plan to use Fed4FIRE+ in the future?

- StoneShield is interested in understanding the performance of existing Industrial IoT networks protocols under radio interference, as well as testing novel protocols and strategies that can deliver high and stable performance despite changing interference patterns (temporal and spatial).
- This, however, requires a proper testbed infrastructure where realistic interference patterns can be easily created in a precise and repeatable way.
  - A playback capability to regenerate recorded interference patterns is also required.
- StoneShield is interested in investigating the possibility of using Fed4FIRE+ wireless testbeds such as w-ilab.t for a massive IoT experiment