FED4FIRE
Federation for FIRE Plus

How Galgus tests its prototypes on Fed4FIRE testbeds

3rd Fed4FIRE+ Open Call

FEC4, Brugge (Belgium)

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Galgus, www.galgus.net

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Outline

- **Brief summary about Galgus**
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  - Our products
- **Why do we apply to Fed4FIRE OCs?**
- **How do we use Fed4FIRE testbeds?**
  - Fed4FIRE tools
  - Our methodology
  - Feedback
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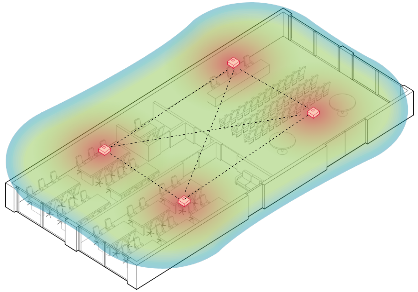
- **Our work for future Fed4FIRE OCs**

Brief summary about Galgus

- Who are we? What do we do?

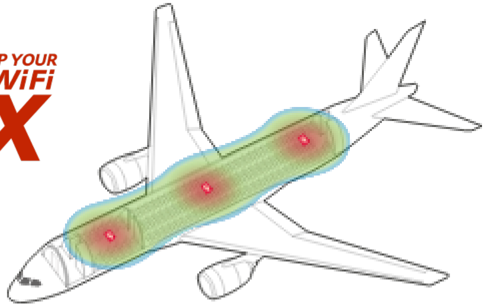
- Galgus is a highly specialized SME focused on the design of smart wireless solutions
  - We are developing our multi-platform embedded software for Wi-Fi APs: ***CHT*** (Cognitive Hotspot Technology™)



Our vision:

*You decide the AP or wireless router that satisfies your specific requirements, and **CHT** release its true potential with a simple software upgrade*

SPEED UP YOUR WiFi 5X



- ***CHT*** transforms Wi-Fi APs into **smart devices that**
  - Sense their environment
  - Share information with each other
  - Collaborate among them in order to **improve connectivity, performance and the end-user QoS**

- ***CHT*** is a fully distributed and decentralized technology → **every AP is an intelligent agent**

Brief summary about Galgus

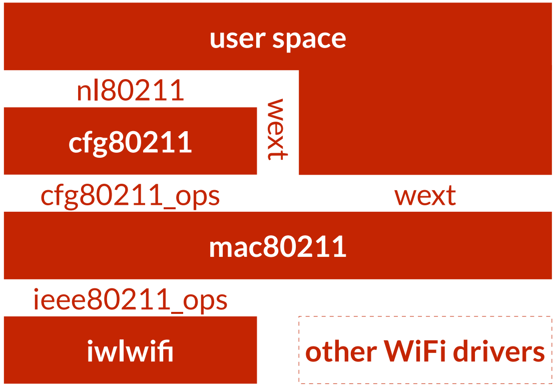
- Our products

CHT

– A multi-platform embedded software for Wi-Fi APs

– We only use information available in the Operating System's user space of the AP:
  - SNIR, RSSI, MCS, number of transmitted packets…

– This way:
  - We can provide a plug&play software
  - We do not need to modify the firmware of the AP
  - We can install our solutions in practically any AP (e.g. APs with a Linux distro)
  - We do not need to install proprietary software in Wi-Fi stations

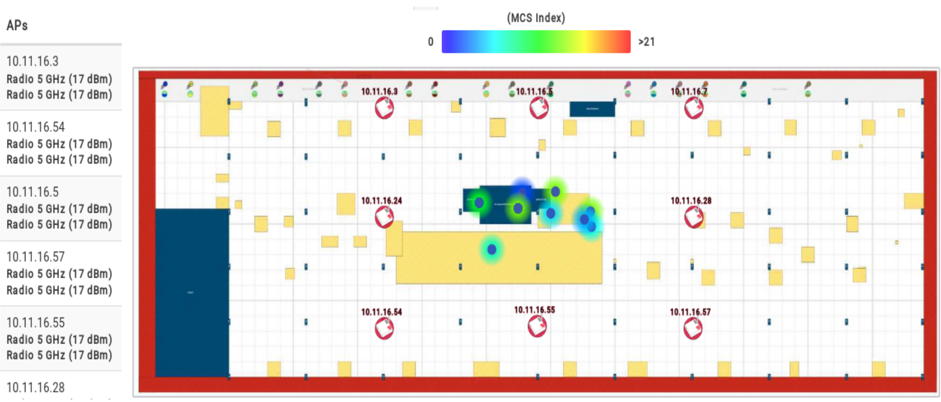


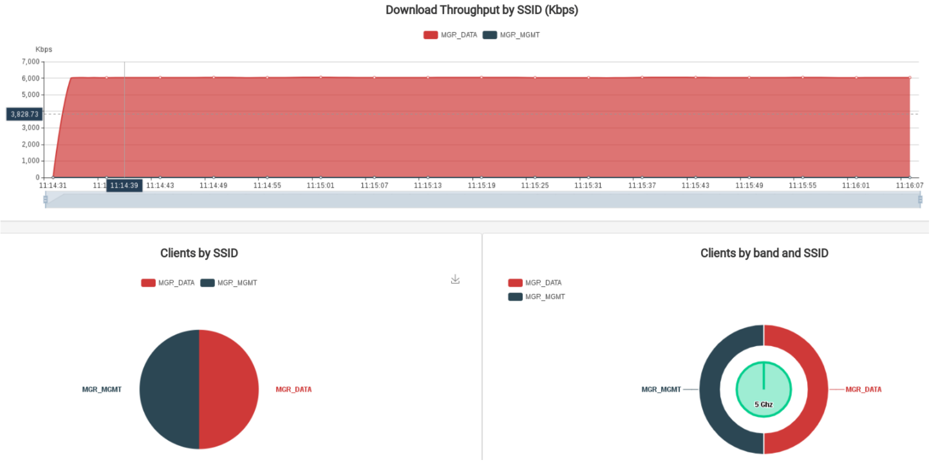
Brief summary about Galgus

- Our products

Cloud Manager

– A tool designed to manage, configure, monitor, upgrade and troubleshoot all the WiFi APs





Why do we apply to Fed4FIRE OCs?

- Our main motivation is to be able to evaluate the behavior and the performance of our algorithms in the WiLab testbed

Galgus laboratory	WiLab testbed iMinds
✘ It is difficult to replicate results because the radioelectric spectrum is shared with all the wireless networks and devices in our surrounding	✔ This laboratory provides an environment free of external interference
✘ We cannot analyze the behaviour of some of our algorithms in an accurate way because our laboratory lacks of a mobility testbed	✔ WiLab provides a very useful and versatile mobility testbed wherein you can get the location of each node in real time and configure the path and speed of each mobile node
✘ We have limit of space in our installations	✔ WiFi devices are deployed in a 66x20,5 m² open room and in three floors of the iGent building

- The funding is also a motivation for us

Why do we apply to Fed4FIRE OCs?

- Thanks to our experiments within a Fed4FIRE OC, we have been able to

Technical impact	Business impact
- speed-up the testing of our algorithms	- speed-up the time-to-market of our solutions
- gain new expertise and improve our laboratory scripts in consequence	- compete in public/private tenders that require these new solutions
- extract very useful information to define the improvement guidelines of our algorithms	- be more competitive in the market
	- fulfill the acquired compromise with our customers
	- increase our sells expectations

- **All of these benefits without investing our own economic resources!**

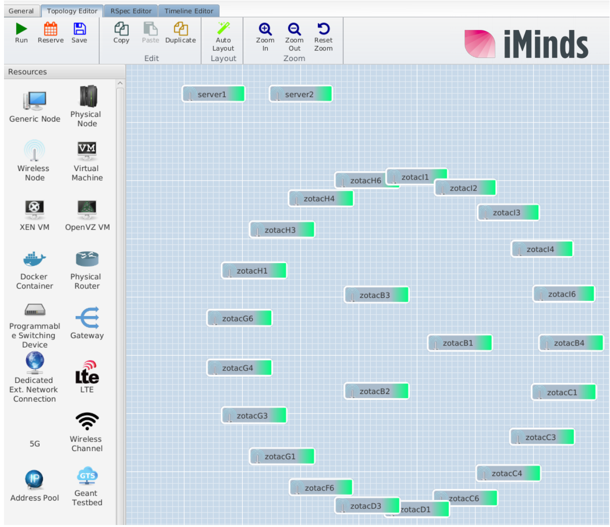
How do we use Fed4FIRE testbeds?

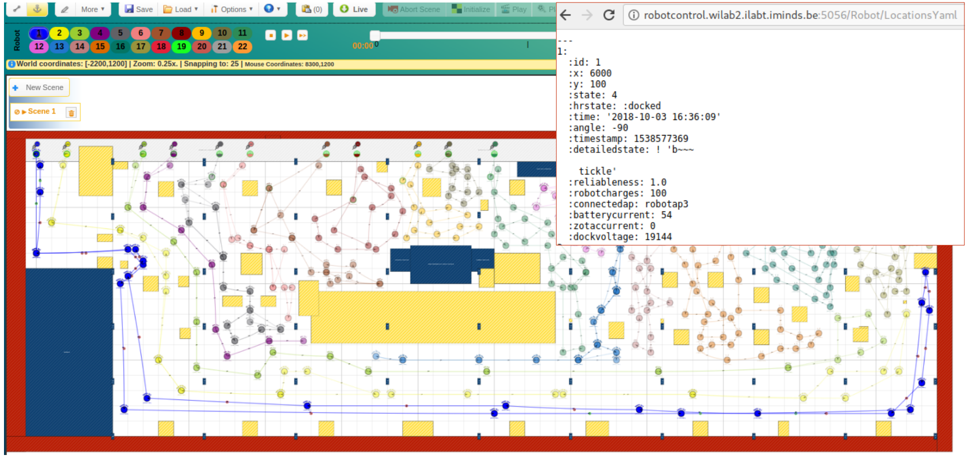
- Fed4FIRE tools

- We mainly use two Fed4FIRE tools

1) The jFed experimenter GUI to initiate nodes with our custom URNs within the WiLab testbed

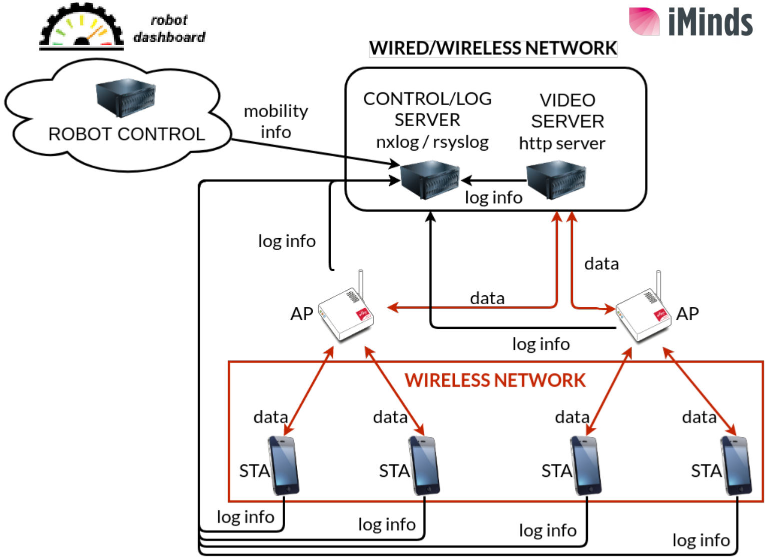
2) The robot dashboard to configure and control mobile nodes

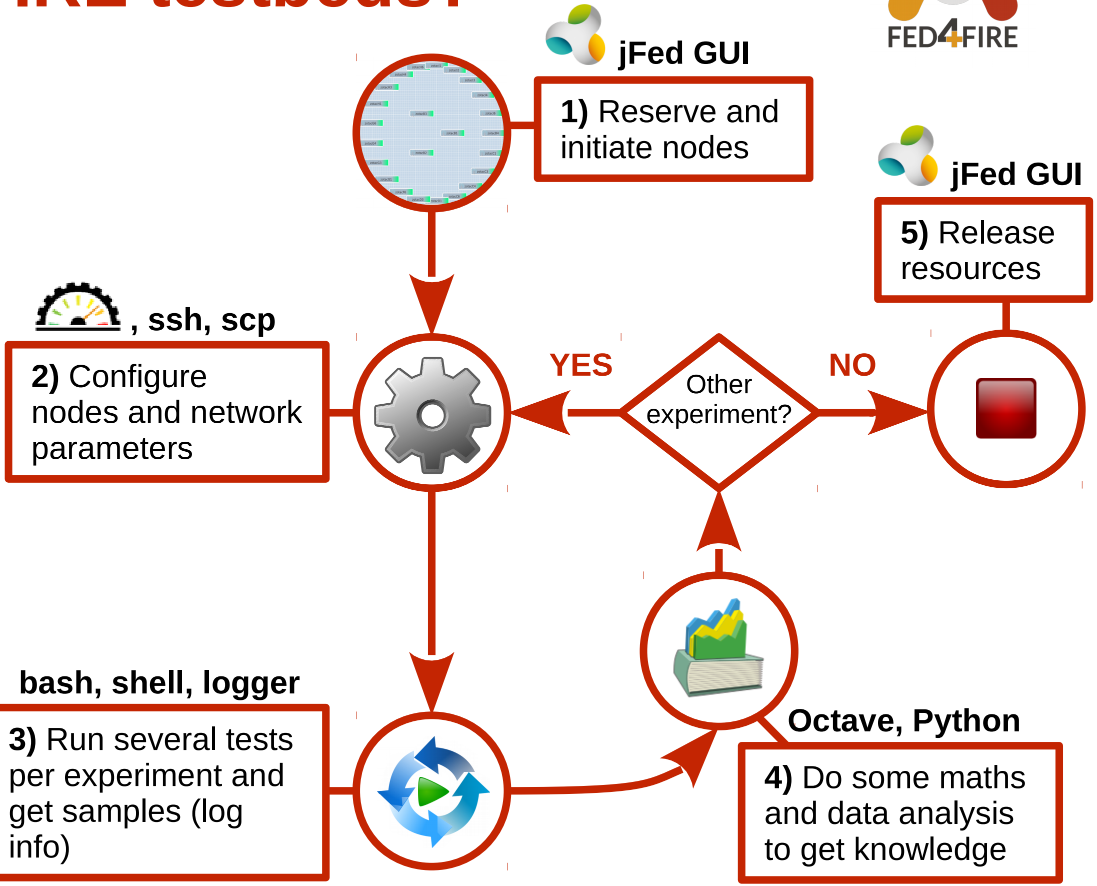




How do we use Fed4FIRE testbeds?

- Our methodology





How do we use Fed4FIRE testbeds?

- Feedback

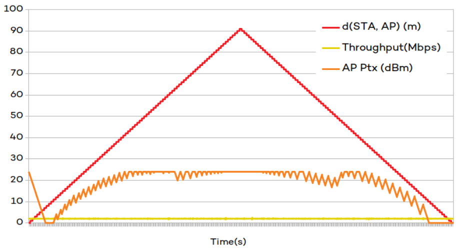
	Positive remarks	Remarks for possible improvements
jFed experimenter GUI	- Very easy to use - Possibility of create custom URNs - Fast experiment initialization thanks to the use of XML (RSpec)	- Reduce the RAM memory consumption
Robot control dashboard	- Very versatile tool where you can configure paths and speeds of every mobile node - It provides the location of each mobile node in real time (web page)	- Provide a user guide (.pdf) with all the possibilities of this tool
iMinds WiLab testbed	- A controlled radioelectric environment - Many WiFi devices, including mobile nodes - It provides a very veratile mobility testbed, without which we would have been unable to analyze the behaviour of our localization algorithm - The provision of KVMs and LEDE speeded-up the integration of our technology	- Provide a graphical monitoring tool to show the radioelectric state of the testbed in real time

MAGIC project

- Objectives

Analyze the behavior and performance of our algorithms specifically designed to tackle the following Wi-Fi challenges:

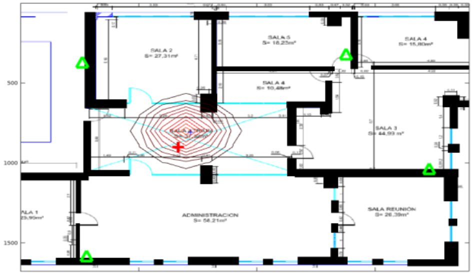
1) How to dynamically adjust the AP transmission power to guarantee the expected QoS? → TPC



$$y = min(AP_{Ptx}),$$
$$s.t. QoS\ requirements$$

Simulation results of our TPC in NS3

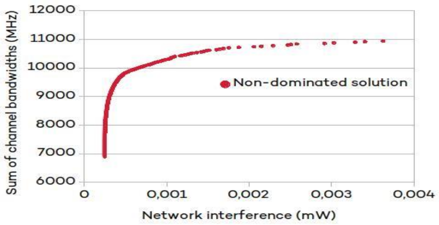
2) How to locate and track Wi-Fi users? → LOC, PROAM



$$(x, y) = f(RSSI_{AP1}, \ldots, RSSI_{APn})$$

Indoor location of Wi-Fi devices in our laboratory

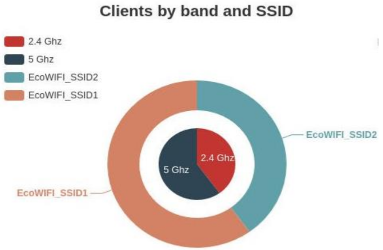
3) How to jointly assign channels and channel bandwidths for a set of Wi-Fi APs? → MO-ACA



$$y_1 = max(\sum bandwidth)$$
$$y_2 = min(\sum interference)$$

Pareto front obtained in a simulated environment

4) How to configure and control a set of decentralised APs from a single location? → CHT-MANAGER



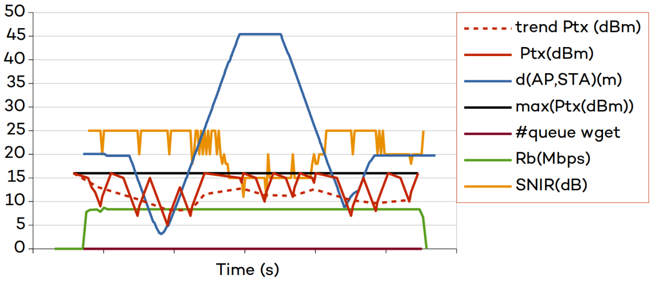
Monitoring option of our software CHT Manager

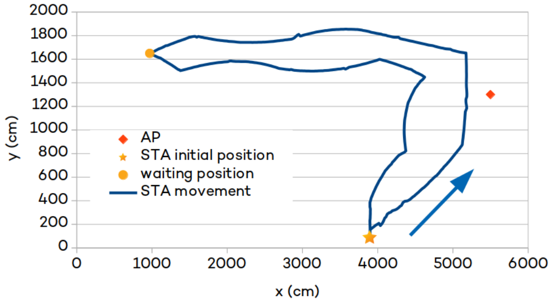
MAGIC project

- Some results

- **Challenge 1:** How to dynamically adjust the AP transmission power to guarantee the expected QoS? → **Transmission Power Control (TPC)**

AP: zotacB4. **STA:** mobile8. **Traffic:** videostreaming of 8Mbps





Goal: minimize Ptx without degradation of the users' Quality of Service (QoS = f(SNIR))

Algorithm operation:

1) Progresive decrement of Ptx

2) Fast recovery upon detecting degradation of QoS

	Reduction in Ptx (%)		Throughput (Mbps)		# queue wget processes	
	mean	std	mean	std	mean	std
with TPC	36.14	22.58	33.41	0.23	0.00	0.00
without TPC	0.00	0.00	33.41	0.30	0.00	0.00
p value	0.00 < 0.05		0.17 > 0.05		-	

36% of power reduction without QoS degradation

MAGIC project

- Some results

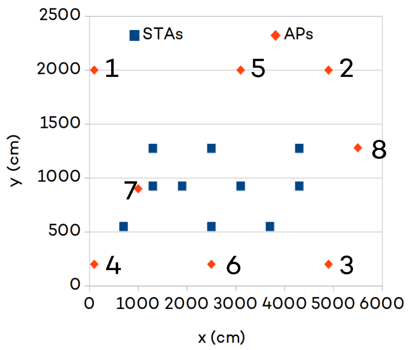
- **Challenge 2.1:** How to locate Wi-Fi users? → **LOC**

Our LOC algorithm is based on a machine learning technique that only uses information gathered by the APs to estimate the location of WiFi terminals

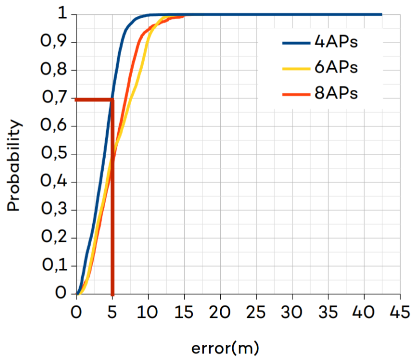
$$(x, y) = f\left(RSSI_{AP1}, RSSI_{AP2}, \ldots, RSSI_{APn}\right)$$

➔ We don't need additional network hardware nor proprietary software installed on WiFi STAs

Experiment with static STAs:
up to 8 APs (zotac nodes) and 10 static STAs (zotac nodes)



Location error below 5 meters with a probability of 70%



CDF of the location error

MAGIC project

- Some results

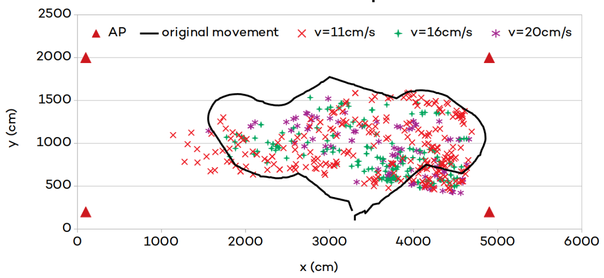
- **Challenge 2.1:** How to locate Wi-Fi users? → **LOC**

  Our LOC algorithm is based on a machine learning technique that only uses information gathered by the APs to estimate the location of WiFi terminals

Experiment with a mobile STA at different velocities:

4 APs (zotac nodes) and 1 mobile STA (mobile10)

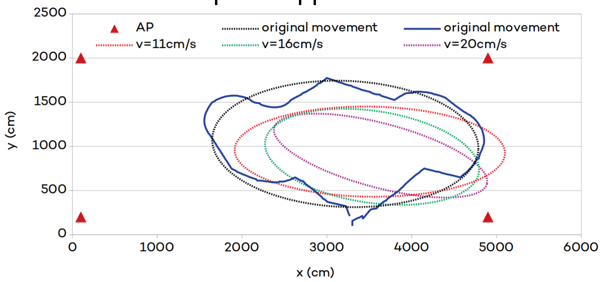
Measured samples

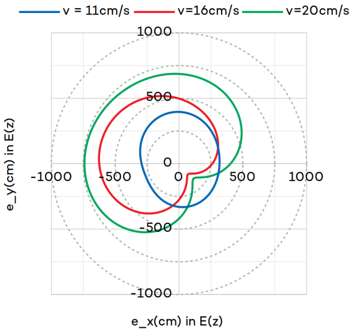


Original movement ≈ ellipse

We can use elliptical curve fitting to analyze the location accuracy for different user's velocities(*)
E(z) = f(x, y, ellipse params)

Elliptical approximation





(*) Both samples ([wget(w-ilab.t's webpage), CHT_LOC call]) must be taken exaxctly at the same time to properly evaluate the location accuracy. We had to use curve fitting because it was not possible to synchronize both sampling methods

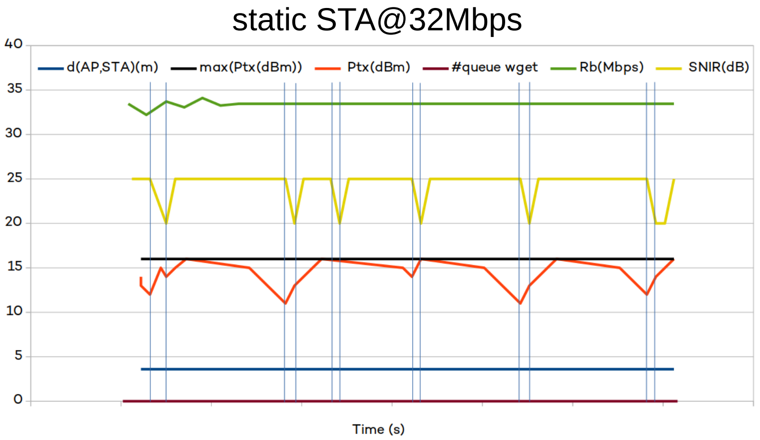
1) The location error increases with the user's velocity
2) The stronger (or nearest) AP dominates our model:
- All the samples tend to be closer to that AP
- This is the reason why the location error is minimum when the user is near to that AP

MAGIC project

- Lessons learned

- **Challenge 1:** How to dynamically adjust the AP transmission power to guarantee the expected QoS? → **Transmission Power Control (TPC)**

Goal: minimize Ptx without degradation of the users' Quality of Service (QoS = f(SNIR))



37% of power reduction without QoS degradation

Algorithm operation:
1) Progresive decrement of Ptx
2) Fast recovery upon detecting degradation of QoS

Future improvements:
- React to every slight change of QoS may make unstable our algorithm

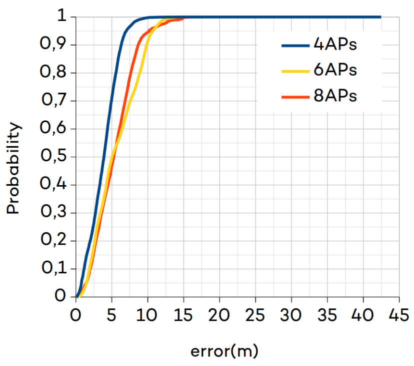
- We will study mechanisms to filter instant changes in the QoS due to (among others):
  - Fast fading
  - Operation of the rate control algorithm (e.g. Minstrel)

MAGIC project

- Lessons learned

- **Challenge 2.1:** How to locate Wi-Fi users? → **LOC**

Experiment with static STAs:



Location error below 5 meters with a probability of 70%

Future improvements:

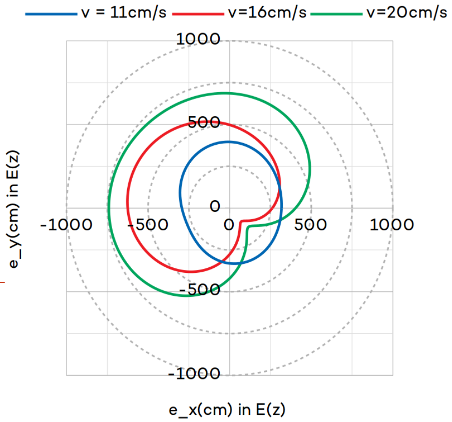
- We will readjust our model because:

  - The location error increases when increasing the number of APs

  - The location error increases with the user's velocity

  - The stronger (or nearest) AP dominates our formulation

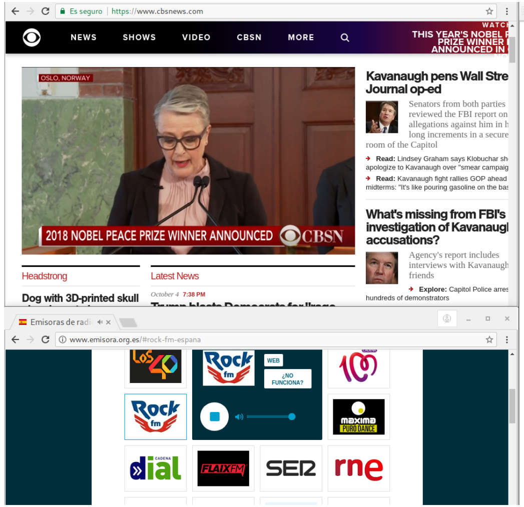
Experiment with a mobile STA

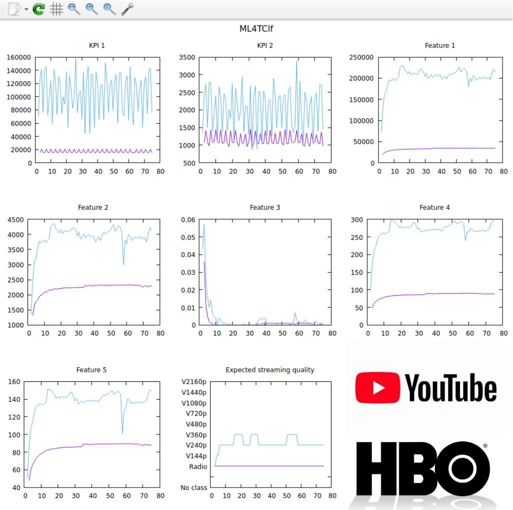


Our work for future Fed4FIRE OCs

- User traffic classifier

- A machine learning technique designed to classify multimedia traffic
  - Live video, live radio, buffered video
  - We only catch certain features of packets (up to L4 layer) → we don't use DPI tools





Motivation:

- Be able to discriminate multimedia traffic
  - Give more priority to this type of traffic
  - ISPs tend to modify the ToS field of IP packets
- Infer QoS degradation in the application layer (L7) and take measures in L2 layer before the user appreciates QoE degradation

Other applications:

- As part of the LWIP system in LTE for traffic offloading
- As part of any other system that requires of traffic discrimination

We are studying whether our system may be interesting for future Fed4FIRE Open Calls

MAGIC - F4P03-L06 -

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