



4th CALL- EXPERIMENTS: IoT & 5G

IIoT-REPLAN (Industrial IoT- Driven Remote Path Planning)

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FEC5

Copenhagen, April 24

Outline



Experiment description

Project results

Impact

Feedback



Background



Aim: Develop and test novel path planning and estimation algorithms for low-cost robotic agents, that use the capacities of the cloud and edge computing resources.

Requirements: (i) Time and Energy Efficiency, (ii) Optimality in Trajectory Planning, (iii) Robustness, (iv) Compliance with Safety Constraints

The experiment was designed to reveal insight on the tradeoffs between local and remote computing, and led to new control and estimation mechanisms

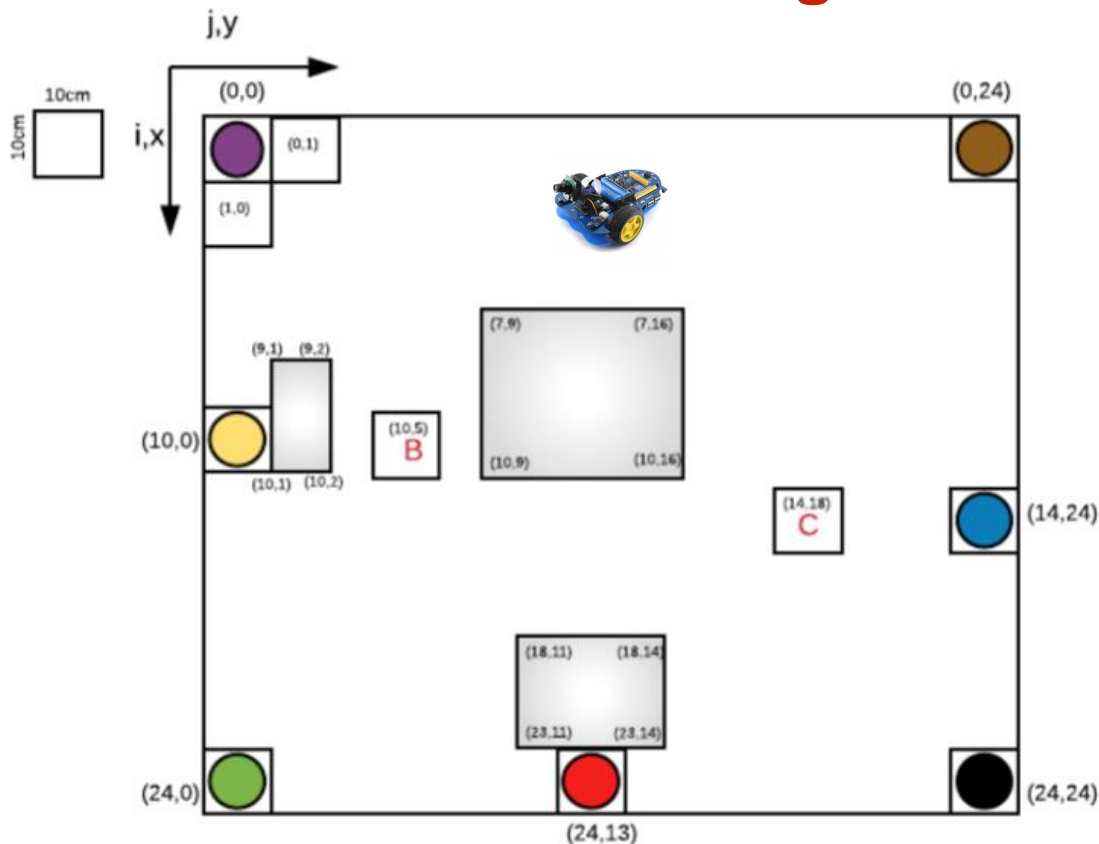
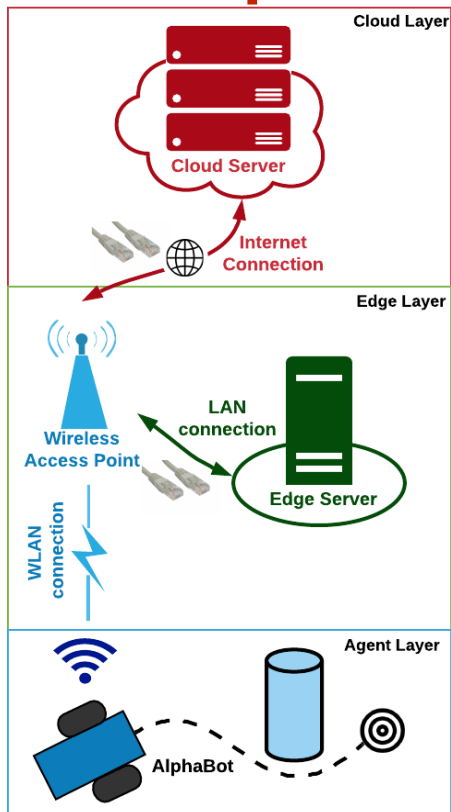
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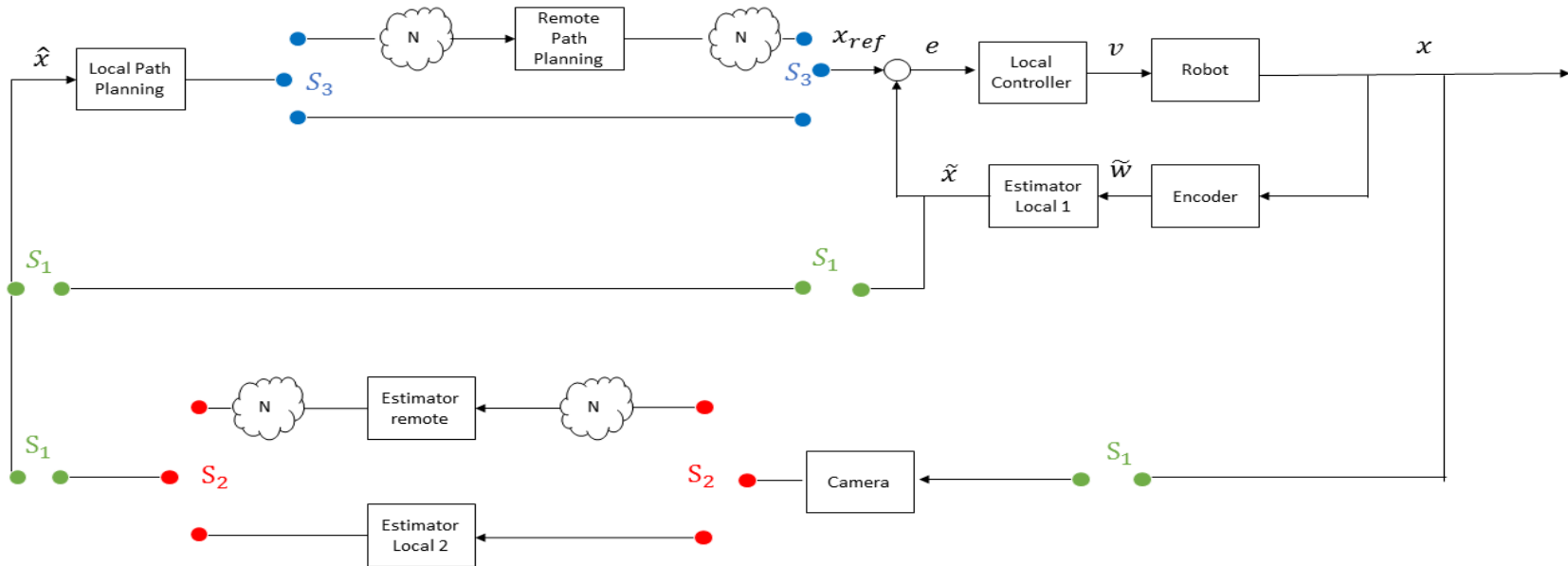
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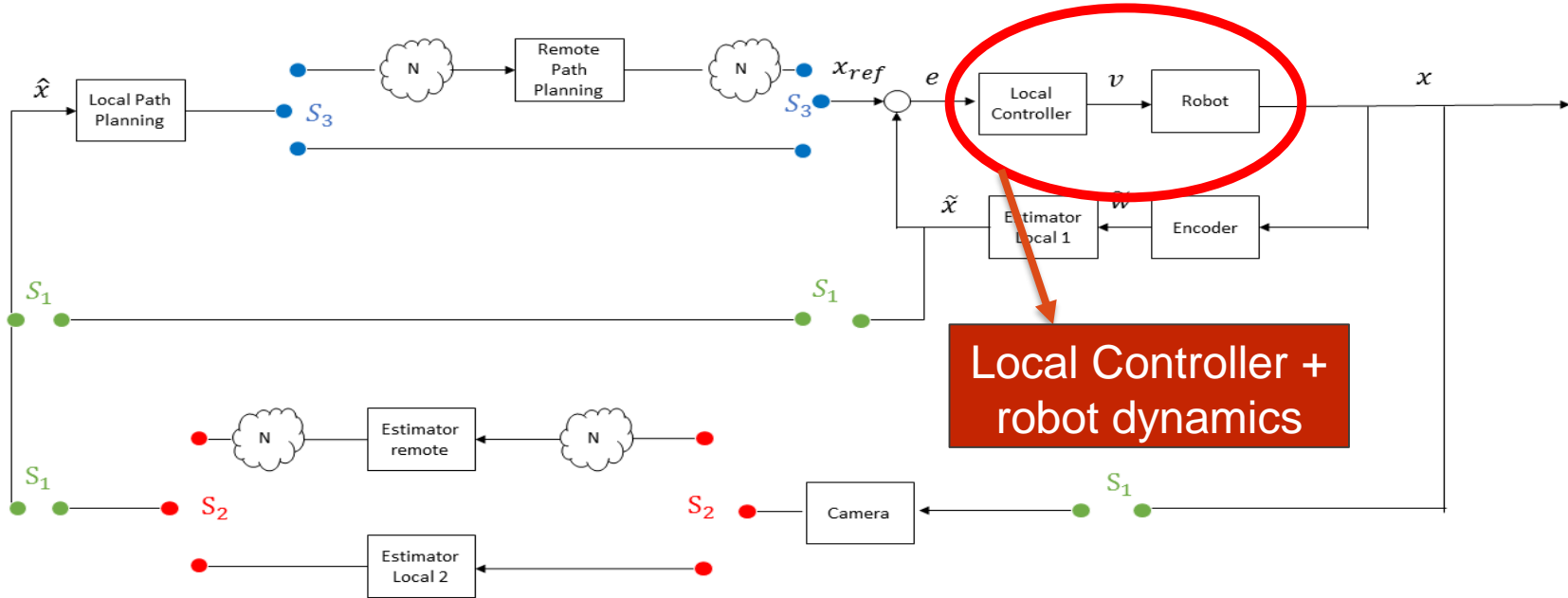
Path planning and estimation offloading



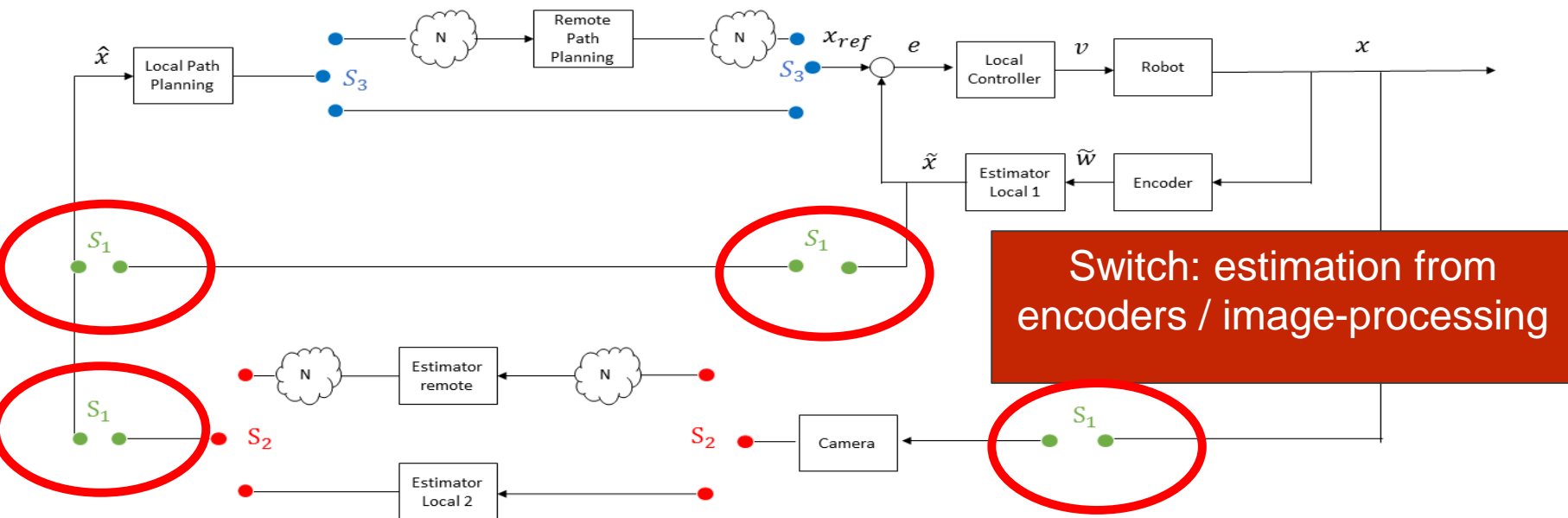
Path planning and estimation offloading



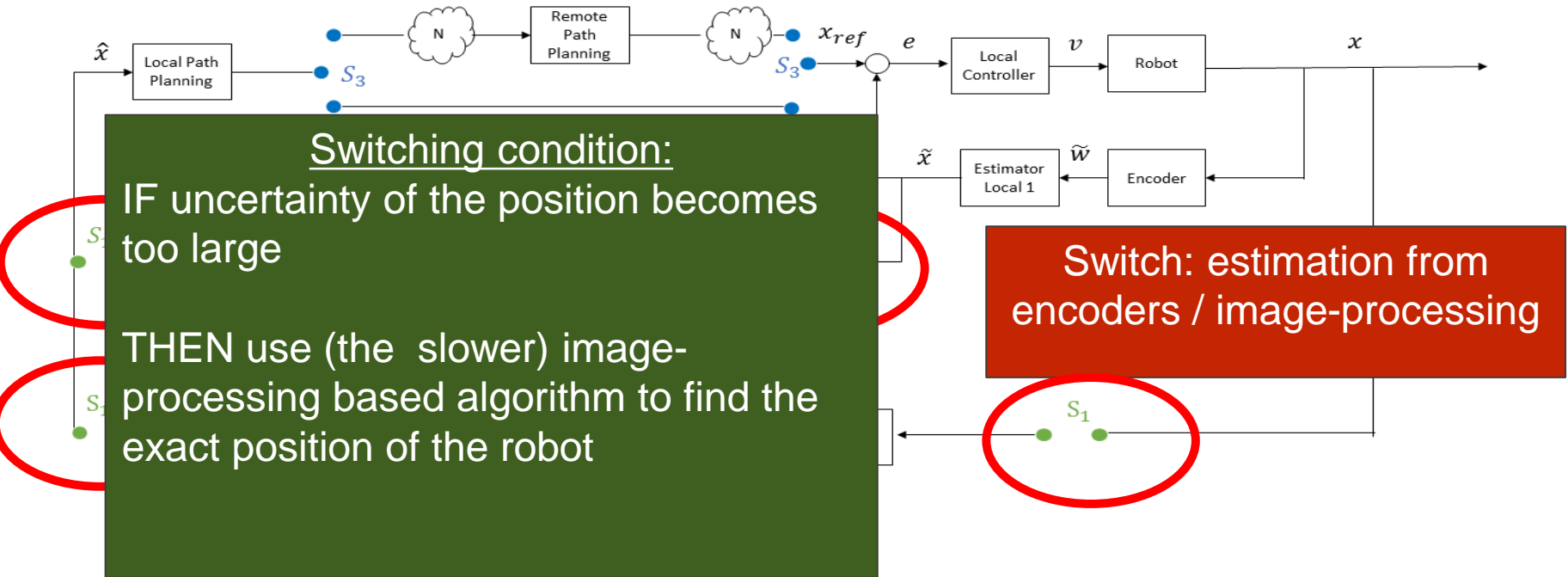
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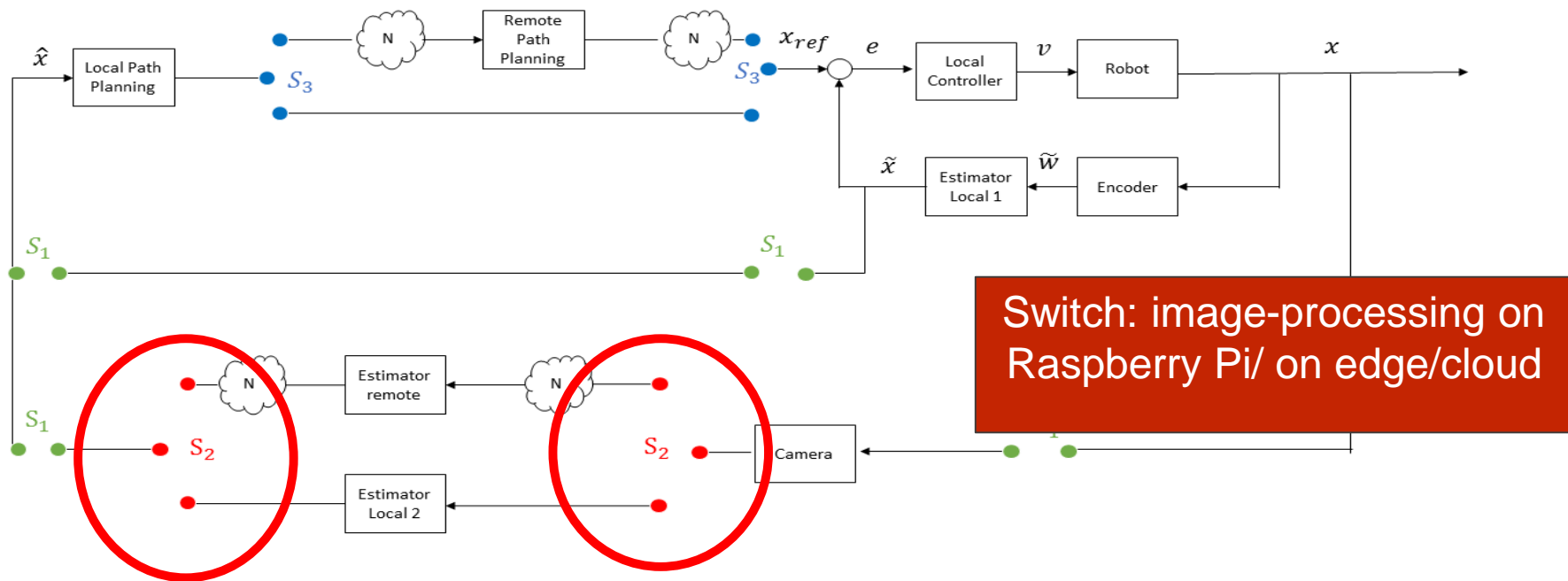
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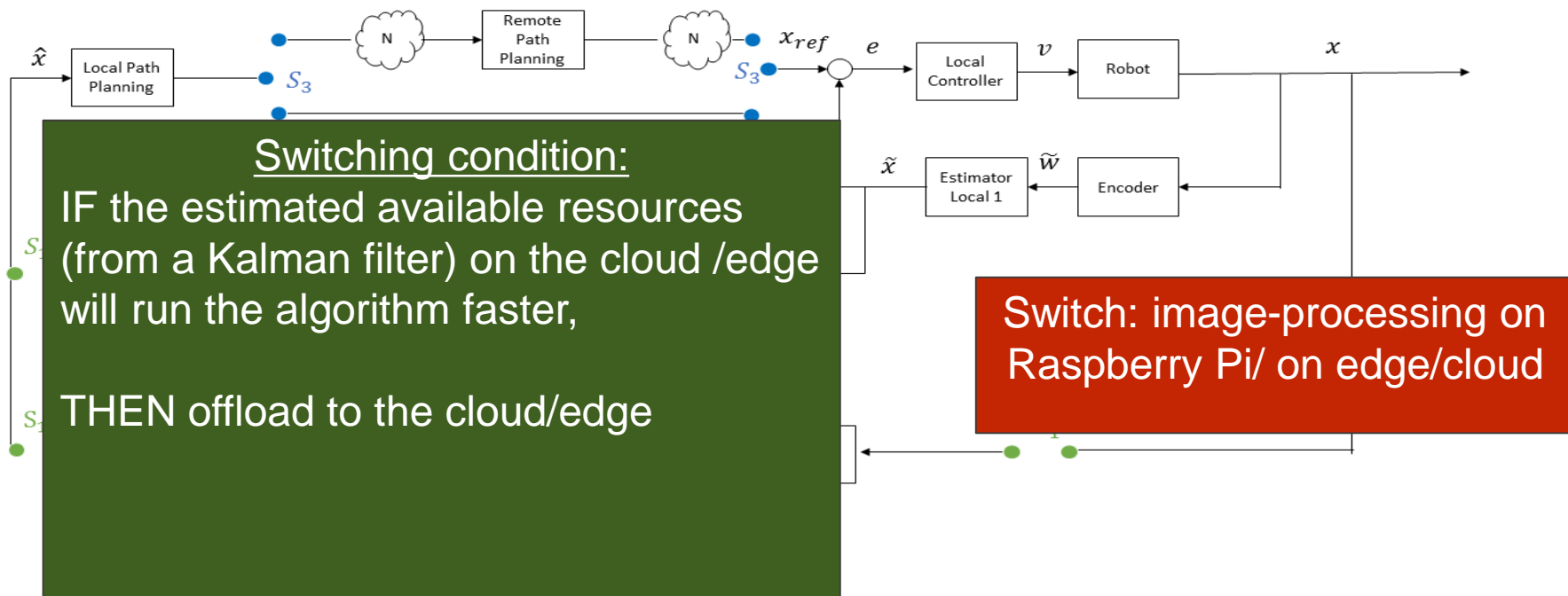
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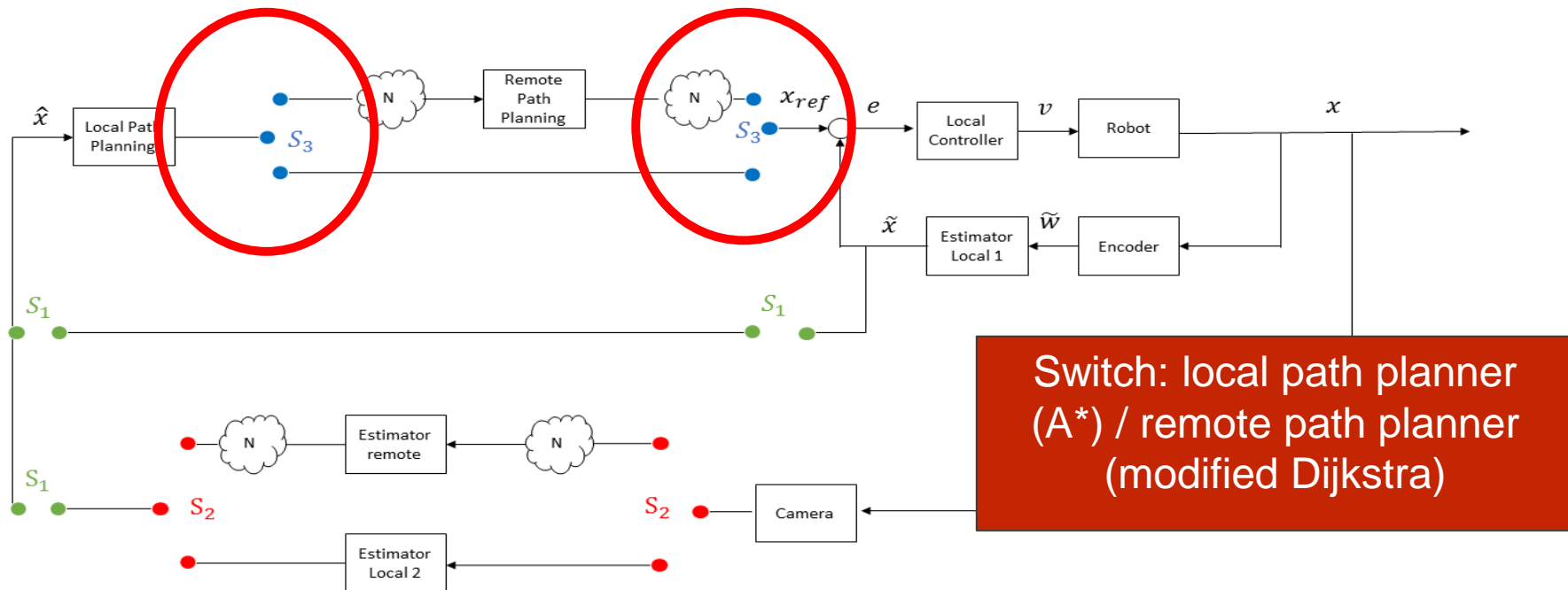
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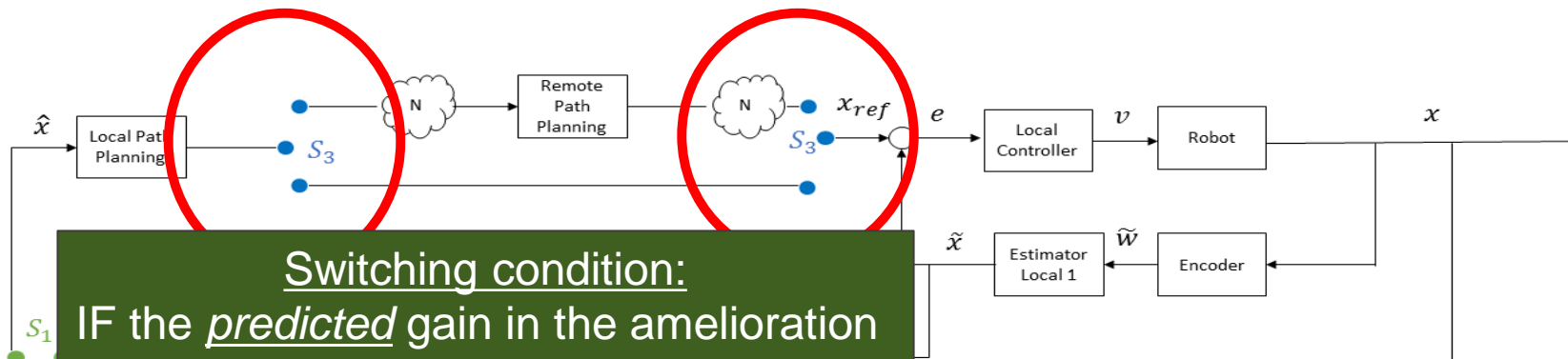


Path planning and estimation offloading



Switch: local path planner (A*) / remote path planner (modified Dijkstra)

Path planning and estimation offloading



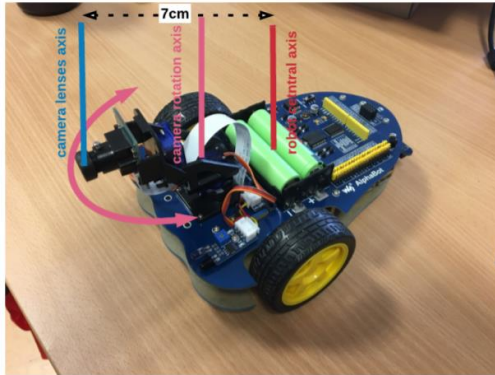
Switching condition:

IF the *predicted* gain in the amelioration of the trajectory planning is high enough,

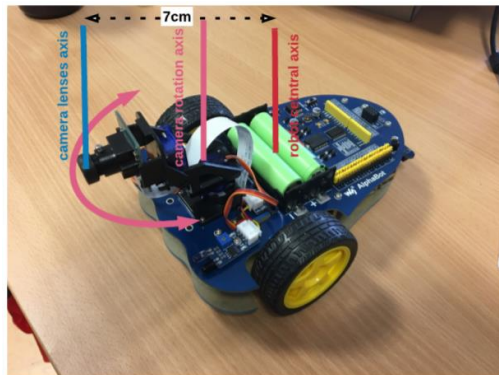
THEN offload to the cloud/edge the (slower) path planning problem (modified Dijkstra)
ELSE use A* solution

Switch: local path planner (A*) / remote path planner (modified Dijkstra)

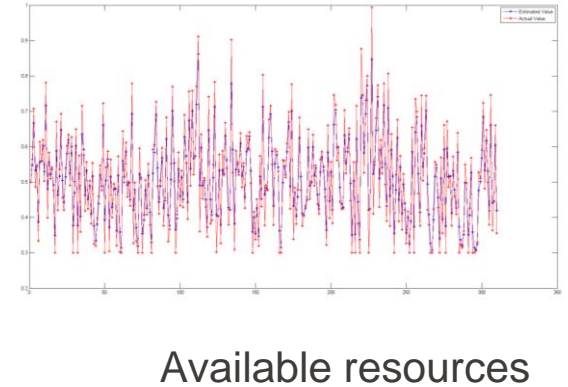
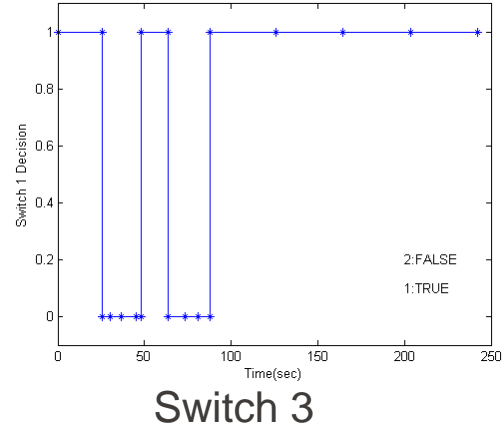
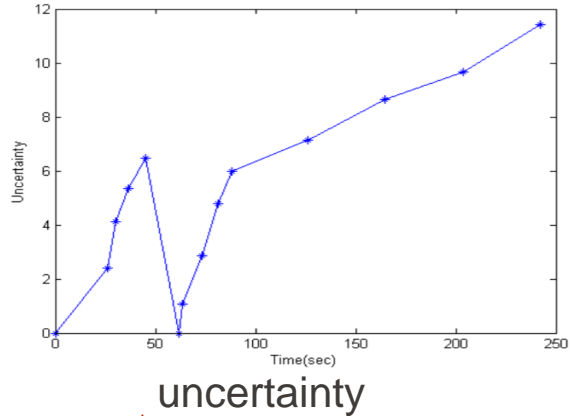
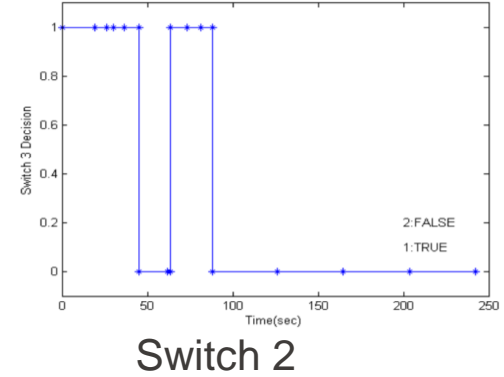
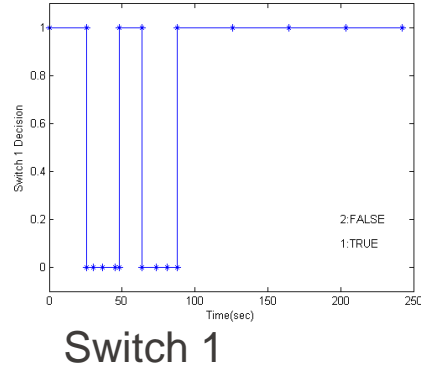
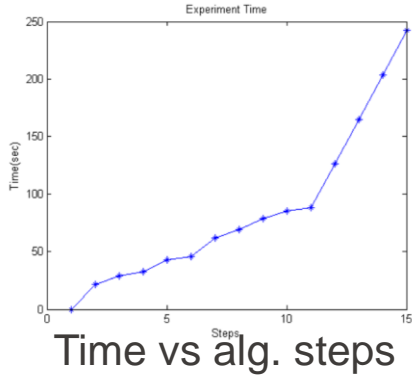
Results / experiment



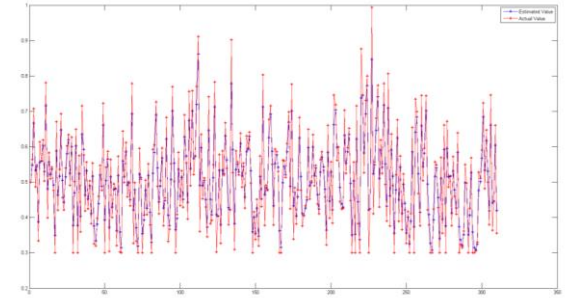
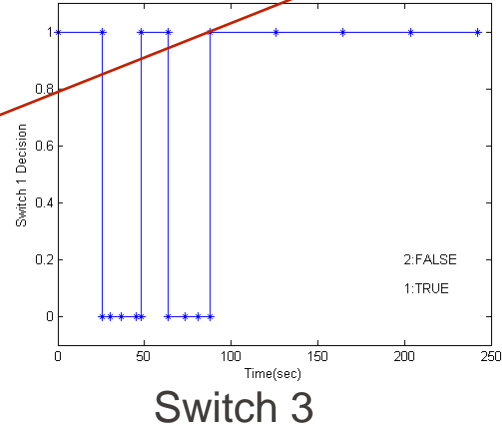
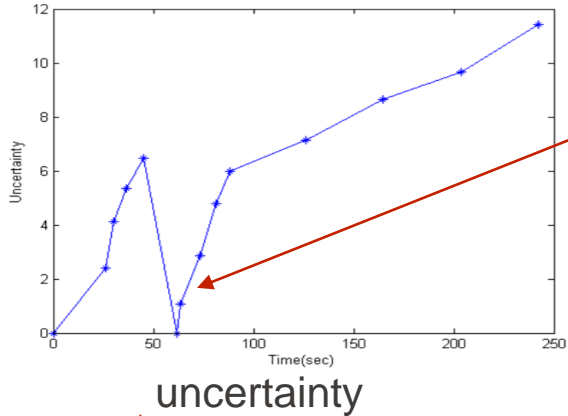
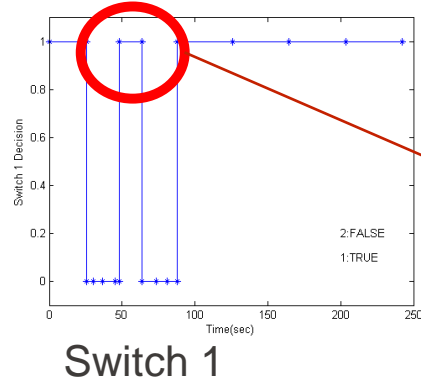
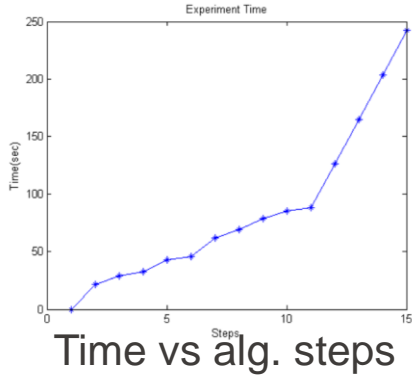
Results / experiment



Results / experiment



Results / experiment



Impact



Proof-of-concept for the need of path planning and estimation offloading for solving planning problems in a smart way.



Impact (theory)



- (i) New event-triggered mechanisms for estimation (uncertainty dynamics), path planning (resources estimator and improvement predictor)
- (ii) New path planning mechanisms (modification of Dijkstra's algorithm blends graph-based search with optimal planning)
- (iii) New beacon based localization algorithm



Impact (application)



(i) New insight on robotic applications (e.g., huge variations of uncertainty for different lighting conditions, nonlinearity of the dynamics, and many more!)

(ii) Gained technical knowledge on resource allocation, virtual machines, programming

(iii) Technical knowledge on measuring network characteristics, resource availability (via docker)



Value perceived and added value from FED4FIRE+



-Unique opportunity to avail of different testbeds in Europe, geographically dispersed edge/cloud servers

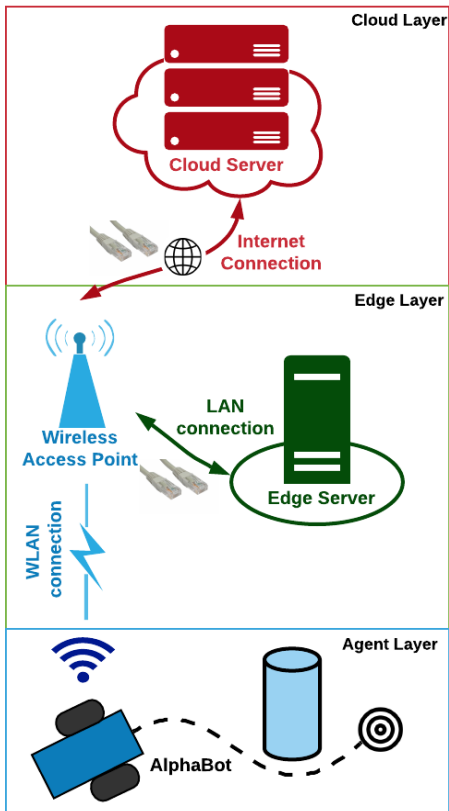
-Interaction / collaboration with researchers from different fields and with valuable expertise!



-Dedicated person months for experiment

-Access to technical and scientific knowledge of the patron

Resources and tools



Mobile robot: Alphabot, equipped with Raspberry Pi 3B+, Camera Pi, Wireless connection.

Edge server: NETMODE testbed Intel Atom CPU (0.25-1.5 cores allocated), 8GB Ram, 1Gbit Ethernet port

Access point: 100Mbps 2 Single Band (2.4GHz)



Cloud server: IMEC testbed server virtual wall 2 1x 6core Intel E5645 (2.4GHz) ram 12GB RAM

Fed4FIRE+ portal, JFed, Omni

Feedback Code is on github

Branch: master New pull request

maravger Merge branch 'master' of <https://github.com/maravger/alphabot-ppl> Latest commit 4ece4d7 on Feb 1

alphabot-ppl	squash minor bugs	3 months ago
demos	change project layout	3 months ago
deprecated	create gitignore and deprecated code directory	3 months ago
docs	include docs directory	3 months ago
edge_server	add implementation of rest api service for dna.py to edge server	3 months ago
.gitignore	alpha version	3 months ago
LICENSE	include MIT license	3 months ago
README.md	add some documentation	3 months ago
config.yaml	squash minor bugs	3 months ago
requirements.txt	alpha version	3 months ago
setup.py	change project layout	3 months ago

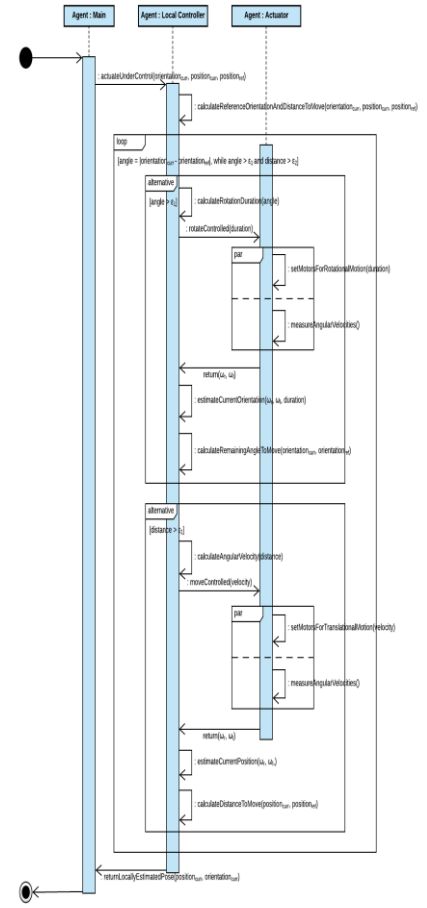
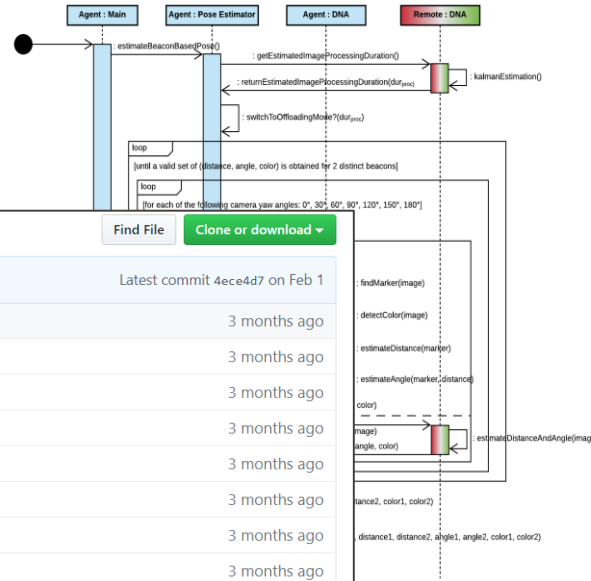
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estimateDistance(marker)
estimateAngle(marker, distance)
color
image
angle, color
distance1, distance2, angle1, angle2, color1, color2

estimateDistanceAndAngle(image)
estimateAngle(marker, distance)
estimateDistance(marker)
detectColor(image)
findMarker(image)

Latest commit 4ece4d7 on Feb 1

The aim of this project is to develop and test novel path planning algorithms that use the capacities of the cloud and edge computing resources for control, satisfying time and safety constraints. The experiment is designed to reveal insight on the tradeoffs between local and remote computing, and will lead to new decision mechanisms that are near-optimal, fast, and energy-efficient.



Additional
documentation/explanations
in report

Feedback



Tools	Used	Please indicate your experience with the tools. What were the positive aspects? What didn't work?
Fed4FIRE+ portal		<u>Positive</u>
JFed		<u>Positive: Steep learning curve, bug report not always working, error messages could be more explanatory, GUI might need polishing</u>
Omni		<u>Positive: Generally positive, a little difficult to set up</u>

- Positive experience from administration/overheads
- OS and some software can be updated in some nodes (did not allow to use latest version of Docker platform in the cloud)
- Hardware components more than adequate
- Very good technical support
- Overall no obstacles when integrating resources from the testbeds (Virtual Wall & NETMODE)

Feedback (on the robots)



Alphabot are small, versatile and low cost robots equipped with a multitude of sensors (camera, infrared, ultrasonic and can extend to IMU etc), accepting both Raspberry Pi and Arduino,

However, motor and encoder components did not always work correctly, might need a better chassis as well,

Perhaps nice to add static sensors.

Feedback



Overall, we were able to conduct an experiment with great hardware diversity and capabilities in a realistic environment providing the first proof-of-concept of our event-triggered approach to estimation and path planning offloading!





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.

**THANK YOU FOR
YOUR ATTENTION!**

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