Robotics-as-a-Service Benchmarks over ROS (RAAS-O-ROS)

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We build Industry-grade AMR platforms for Integrated Solutions

250kg

750kg

Omni

Spatial AI

OMNIT Autonomous Mobile Robot

Secure Cloud Architectures for Scalable Fleet Operations

Robust fleet control in the worst wireless conditions

Secure fleet management for zero-downtime operations

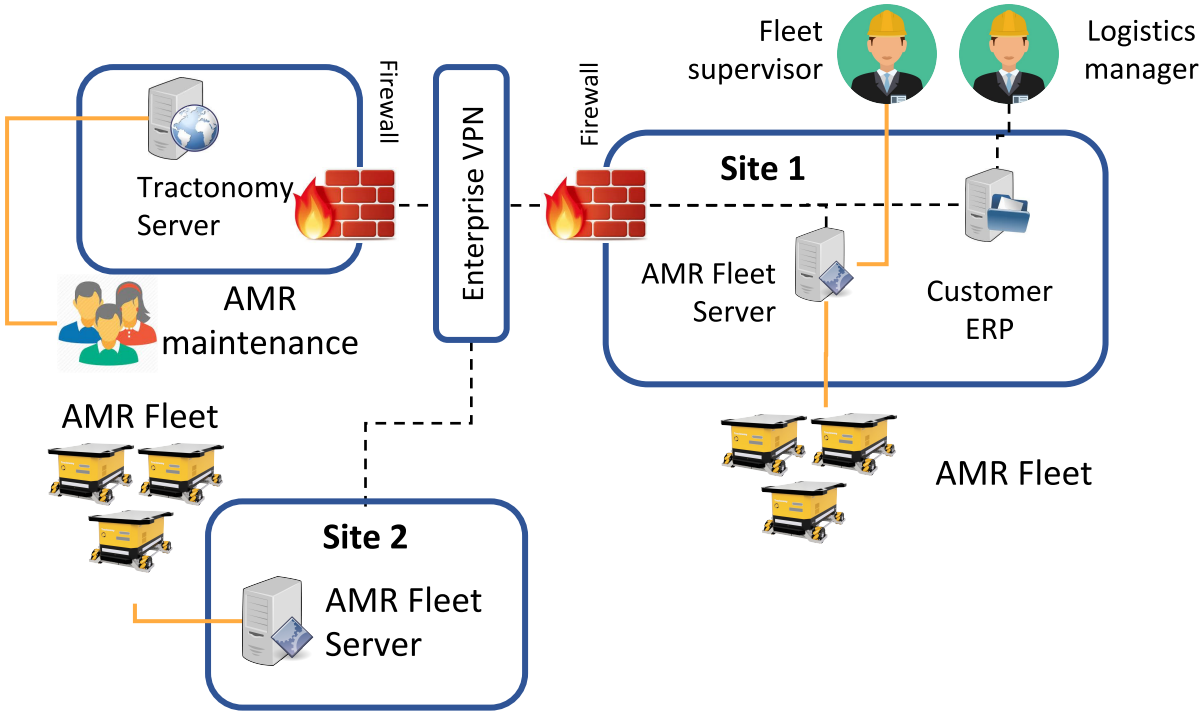
Delay-tolerant remote maintenance and troubleshooting

RaaS Requirements

Fast

Secure

Scalable



Robotics-as-a-Service with ROS

ROS originally a research framework

Quickly penetrating industrial robotics

ROS(1) was never designed for networking

ROS2 -> next gen middleware for robotics

+ Data Distribution Service (DDS) specification

+ Real-time Publish Subscribe (RTPS)

+ robust security policies

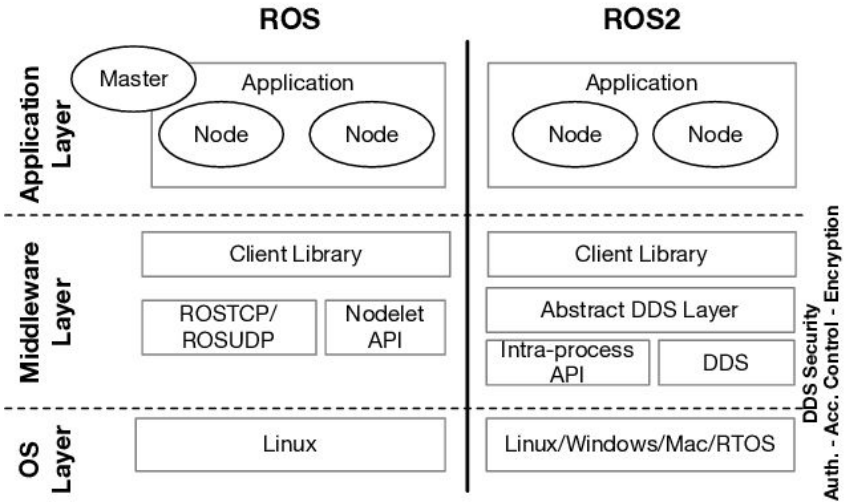


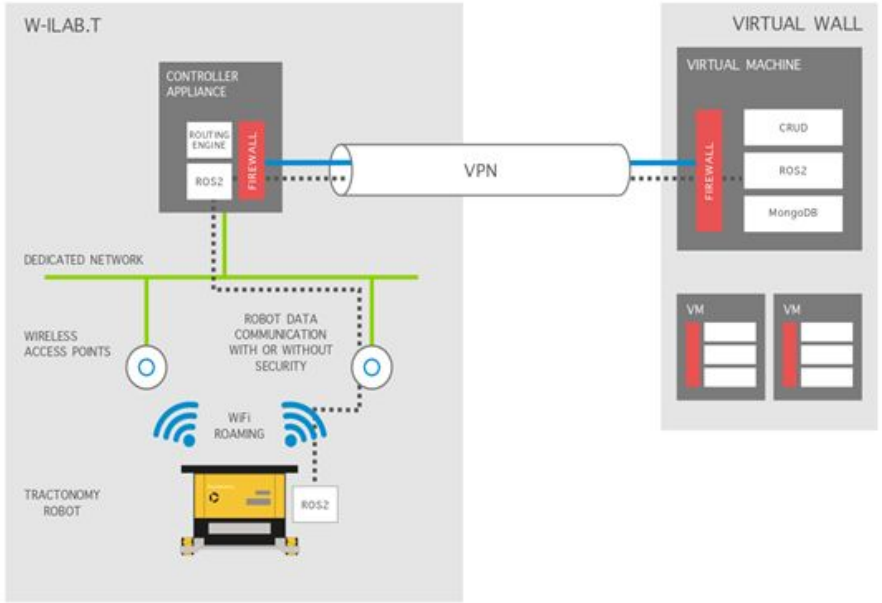
Image courtesy: G. Mazzeo, "TROS: Protecting Humanoids ROS from Privileged Attackers", 2019, International Journal of Social Robotics,

Phase 1 Objectives

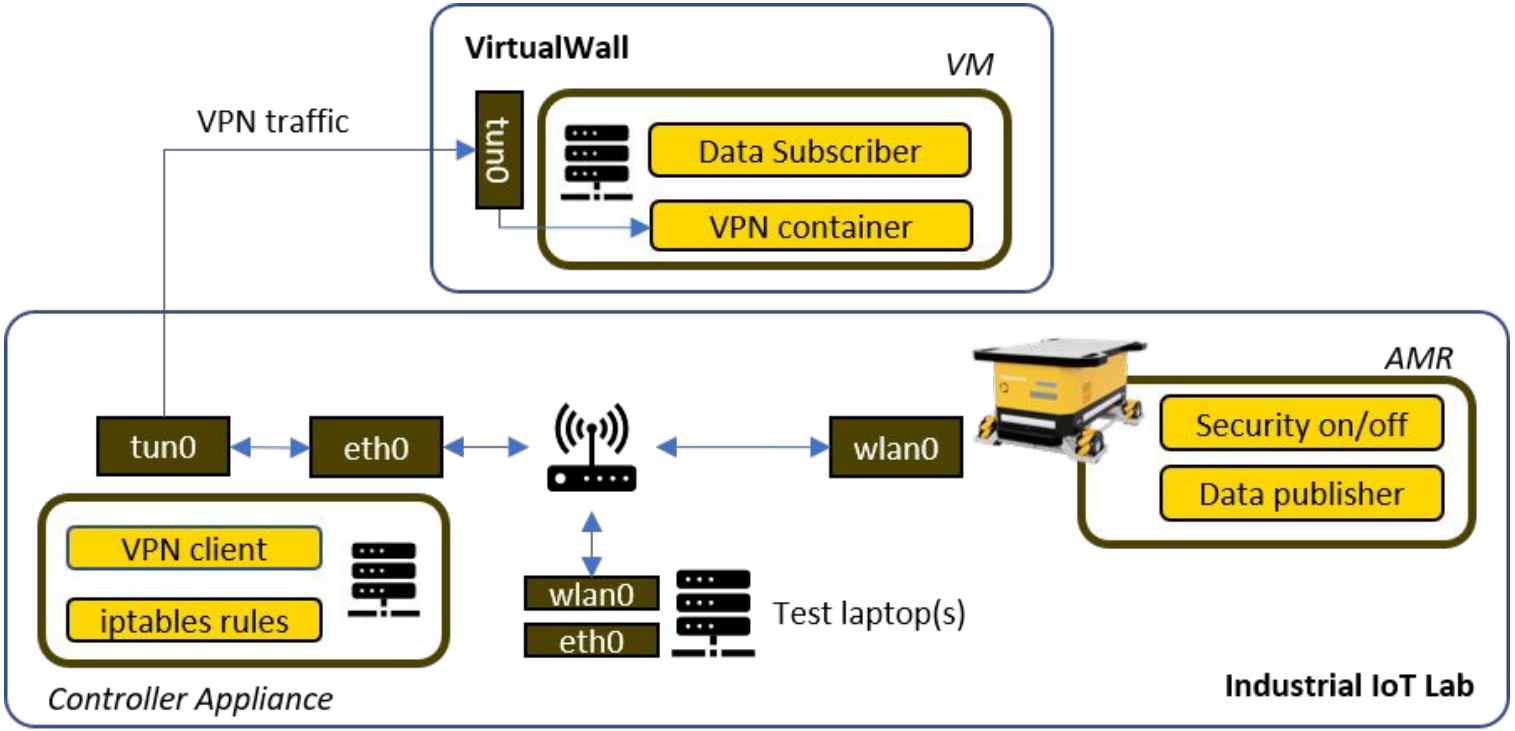
Deploy Tractonomy RaaS architecture with secure ROS2 on Fed4Fire testbeds

Benchmark ROS2 with and without security inside a state-of-art VPN - Wireguard

Tests if ROS2 security principles function as proposed by the ROS community



Technical Implementation



Fed4Fire Testbeds

FED4FIRE
FEDERATION FOR FIRE PLUS

European Commission

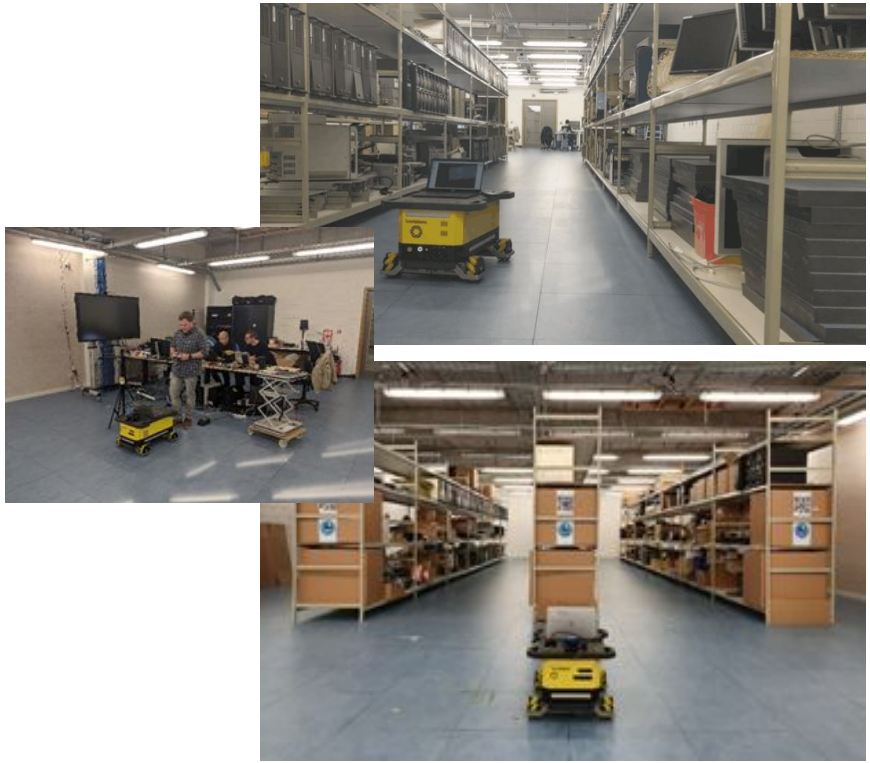
Used the VirtualWall, wi-lab.t and Industrial IoT lab testbed

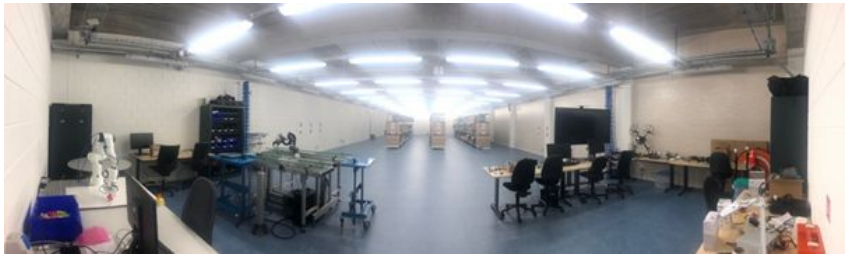
VirtualWall - For VM (Cloud)

wi-lab.t - wireless

IIoT Lab - realistic test environment

Above combination is ideal for AMR testing





Results

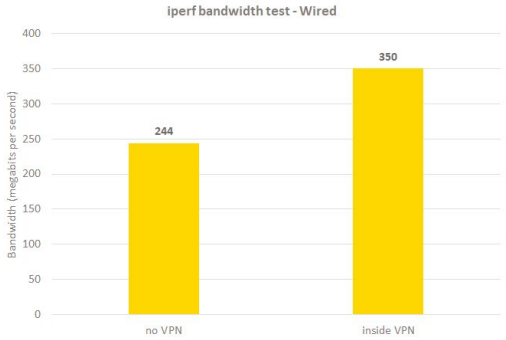
Achieved goal of ROS2 in a representative state-of-art VPN network with security.

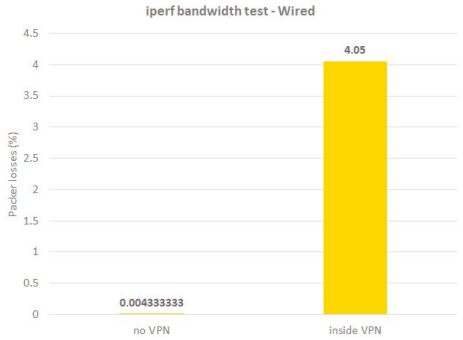
But many failures/contradictions...

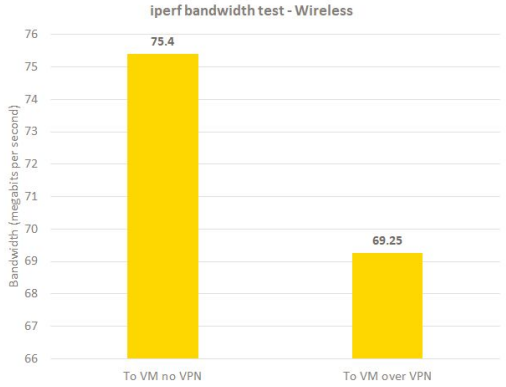
1 - Opposite VPN bandwidth in wired/wireless tests
2 – Traffic inside (double) encrypted tunnel used less traffic than outside
3 - Wireless roaming test failed

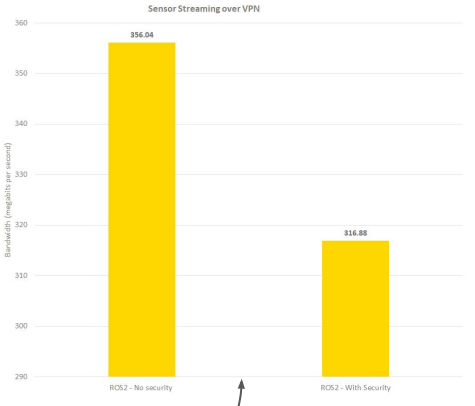
Several possibilities:

1 - Setup
2 - Other workloads
3 - iperf / iptraf
4 - wireless card on laptop









follow-up test in an isolated wired environment

Raas-o-ROS

localhost heartbeat manager

```
: Warmup finished. Continuing with the average interv
al of 2 seconds.
[component_container_mt-1] [INFO] [heartbeat_containe
r]: Found class: rclcpp_components::NodeFactoryTempla
te<heartbeat::Heartbeat>
[component_container_mt-1] [INFO] [heartbeat_containe
r]: Instantiate class: rclcpp_components::NodeFactory
Template<heartbeat::Heartbeat>
[component_container_mt-1] [INFO] [SN76178263.heartbe
at]: Starting heartbeat_node with rate 1Hz (period 10
00ms) and a loss of 5%.
[component_container_mt-1] [INFO] [heartbeat_manager]
: Loaded node with id 8
[component_container_mt-1] [INFO] [heartbeat_manager]
: Unloaded node with id 8
```

digitalocean remote server (logged into ROS2 container)

```
gitlab@tractonomy-vpn:~$ docker exec -it rosbridge-su
ite bash
root@70502203b4e3:/# ros2 topic list
/client_count
/connected_clients
/parameter_events
/rosout
root@70502203b4e3:/# ros2 topic list | grep /SN.*/hea
rtbeat
/SN17806000/heartbeat
/SN31850174/heartbeat
/SN85998495/heartbeat
root@70502203b4e3:/#
```

Not secure | 100.64.0.1

Tractonomy

LOGOUT

SN17806000
online

Basic Description

MAP BOOKMARK

SN85998495
online

Basic Description

MAP BOOKMARK

SN31850174
online

Basic Description

MAP BOOKMARK

SN64721167
online

Basic Description

MAP BOOKMARK

SN72443523
online

Basic Description

MAP BOOKMARK

SN93926742
online

Basic Description

MAP BOOKMARK

Conclusions

Despite issues, achieved a robust and scalable ROS2/VPN framework for our RaaS.

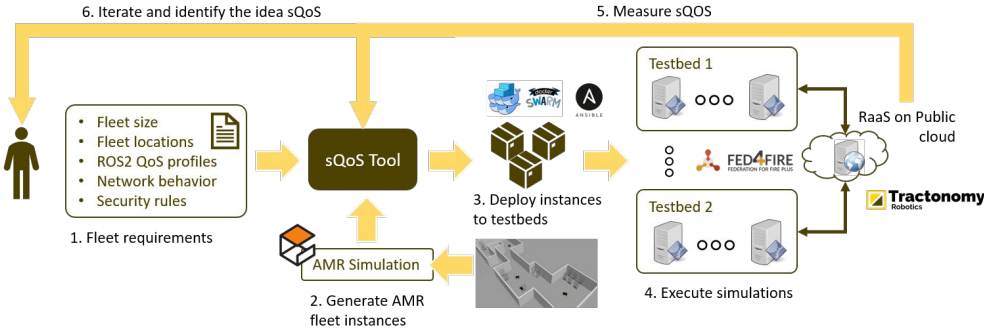
Fed4Fire testbeds have helped a lot, also in business development efforts

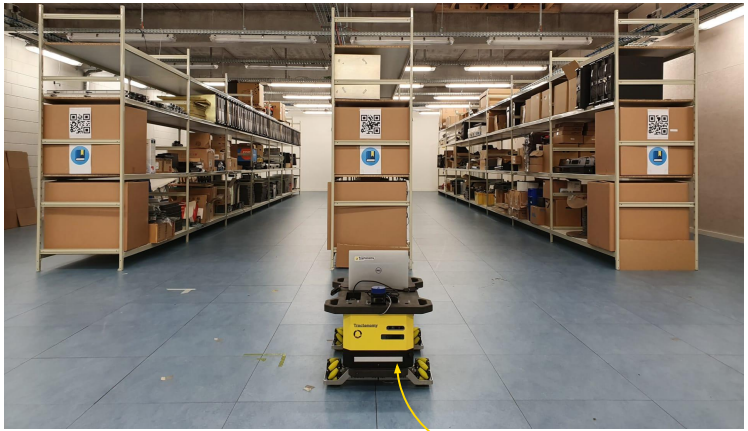
Captured ROS2 security insights needed for commercialization.

Default ROS2 Quality-of-Service (QoS) settings may have influenced the results

Next phase (awarded)

- Re-evaluate these issues with QoS
- Focus on large scale QoS estimation





Omnit @ IMEC's industrial IoT lab

Benefits of Fed4Fire and Next Steps

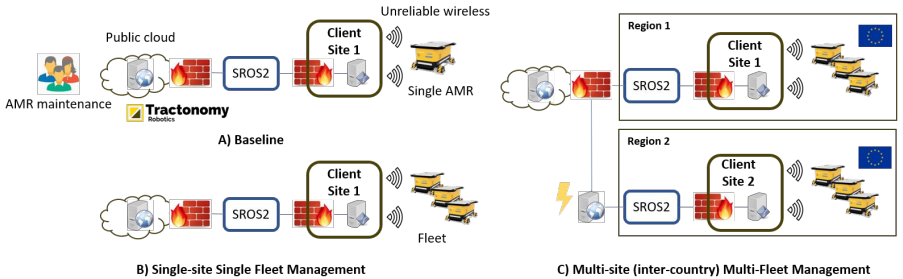
Accelerated development of the foundation of our RaaS platforms

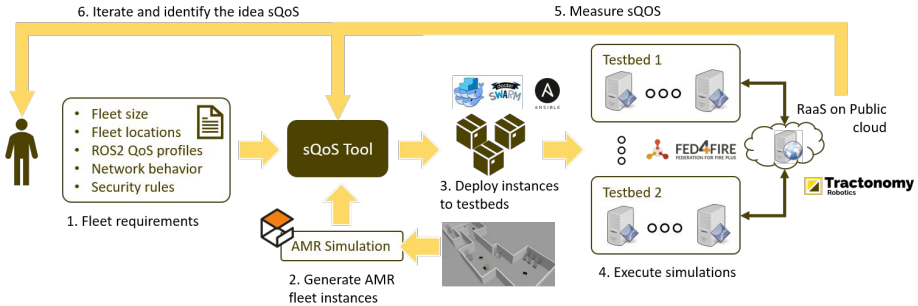
Financing was helpful - contracted specialists in IT and Security

Multi-disciplinary test environments (biased - limited to Ghent)

Experience has helped us identify Phase 2 targets

- Quality of Service (QoS) automation
- Using distributed simulated robots
- Leading to benchmarking at scale
- Tooling that is very handy for the future!





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