Session Management across Heterogeneous Wireless Technologies in a Rail Transport Environment

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5G PPP

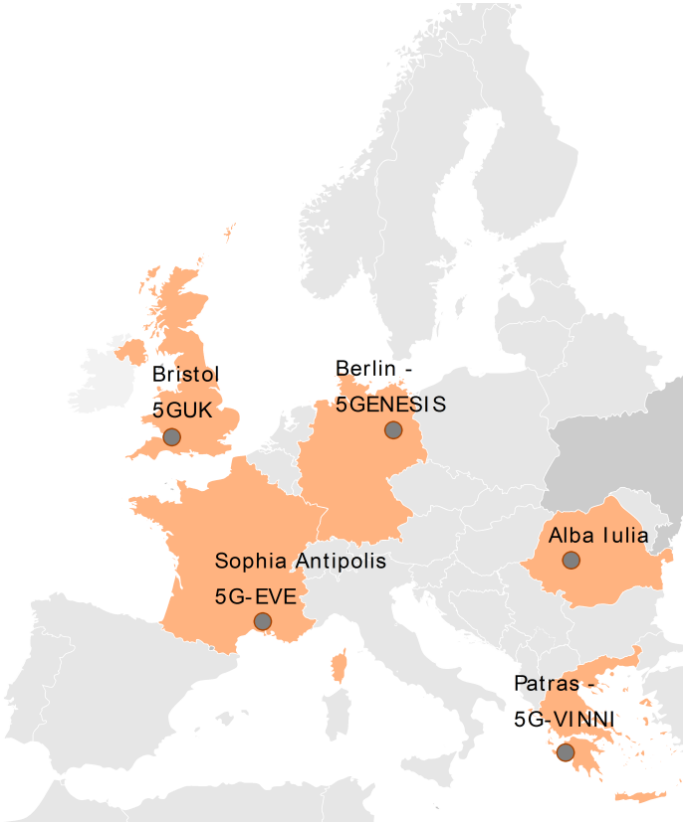
5G-VICTORI In a Nutshell

- ICT-19 Project

  “Conducting large scale trials for advanced 5G use case verification focusing on

Transportation | Energy | Media | Factories of the future | Cross-vertical use cases

- Duration: 3 years
- Budget: approx. 13.5 M€
- Consortium: 26 partners



5G-VICTORI Key Objectives

- 5G-VICTORI aims at conducting **large scale trials for advanced vertical use case** verification focusing on **Transportation, Energy, Media & Factories of the Future,** as well as **crossvertical use cases.**

- Design & deploy an open 5G infrastructure (leveraging on 3 ICT-17 & 5GUK platforms):

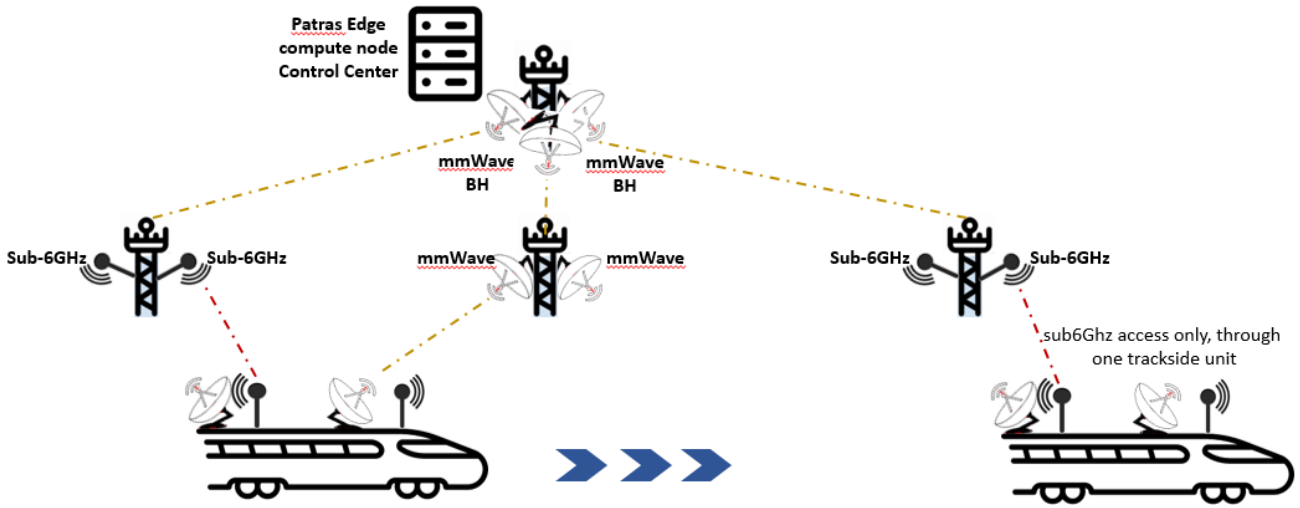
    - Capable of instantiating various particularly challenging vertical use cases/Apps even on a single 5G network deployment, towards substituting multiple legacy vertical specific networks (telecom, rail, energy), moving to "network as a service" model vision

    - Adopting the concepts of slicing and virtualization

    - Enabling flexible deployment of vertical-specific network functions based on App requirements (capacity, latency and reliability).

Motivation and Focus

- In this work, we focus on the Rail-Transport Use Case, deployed in the 5G-VINNI facility in Patras Greece
- Heterogeneous Track-to-train links will be deployed offering high-capacity links for on-board device connectivity
  - Using either sub-6GHz technologies (IEEE 802.11ax) or mmWave (60GHz V-Band)
- Wireless backhauling from track-side to an Edge Cloud is developed



Motivation and Focus

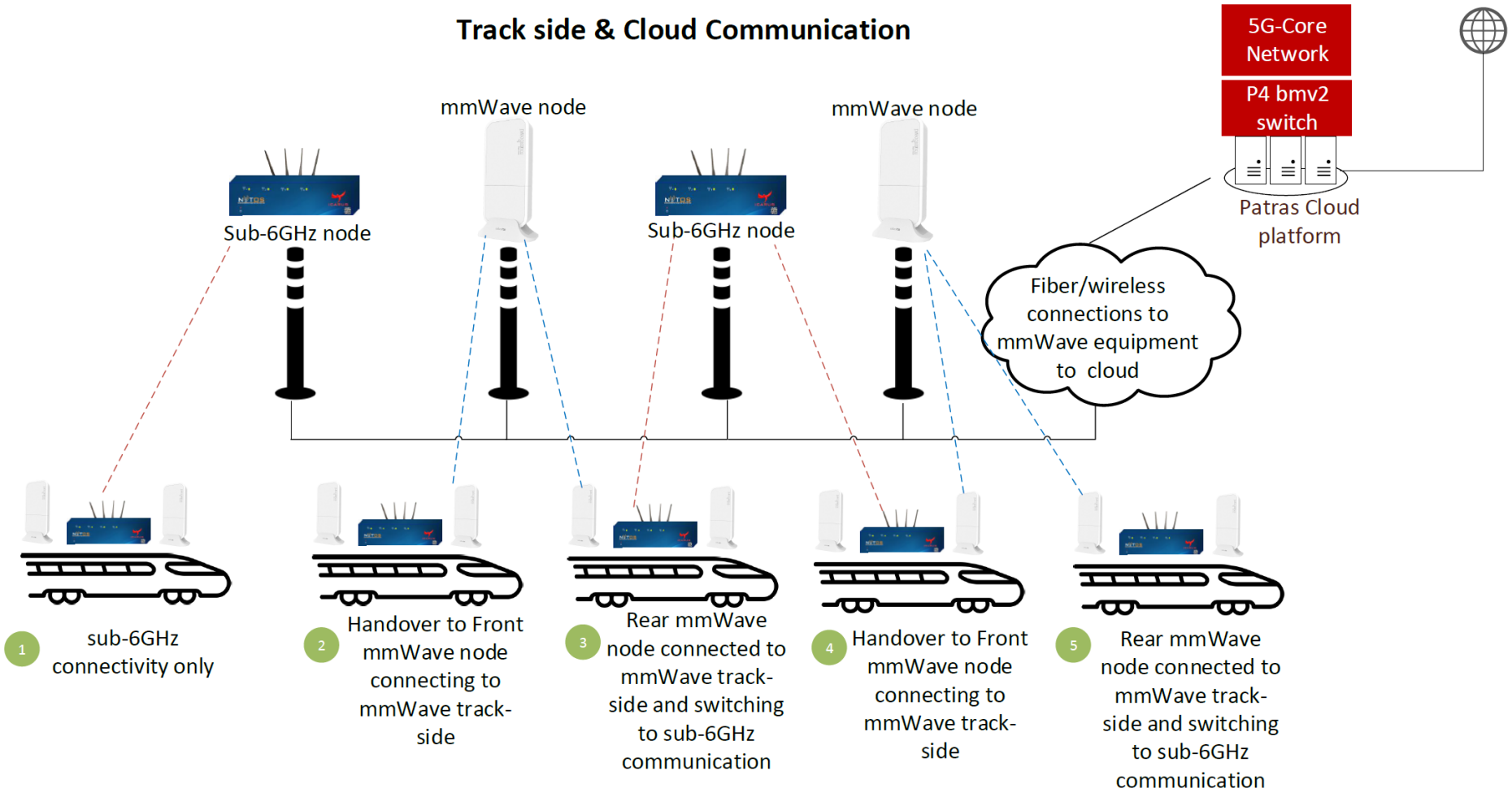
- Different types of vertical services will be deployed on-board, taking advantage of the high-capacity links
  - **Track monitoring** with on board cameras video streaming to Control center over 5G Rail network deployment
  - **Mission-Critical Push to Talk** (MCPTT) for railway operations
  - **5G data services for passengers** through the deployment of a disaggregated 5G-NR cell on-board
- Overall target: to consistently provide connectivity across handovers from the train side to different track-side access points

Managing Handovers

- As the train moves across different track-side APs and gets in their coverage, a handover takes place and needs to be managed
  - Managing the low-level network traffic results in presenting the applications running on top with a single end-to-end flow, regardless of the underlying technology
  - In order to manage the technology handover, we employ P4 switching
  - P4 allows the establishment of flows that can update any field of packets in high speed flows

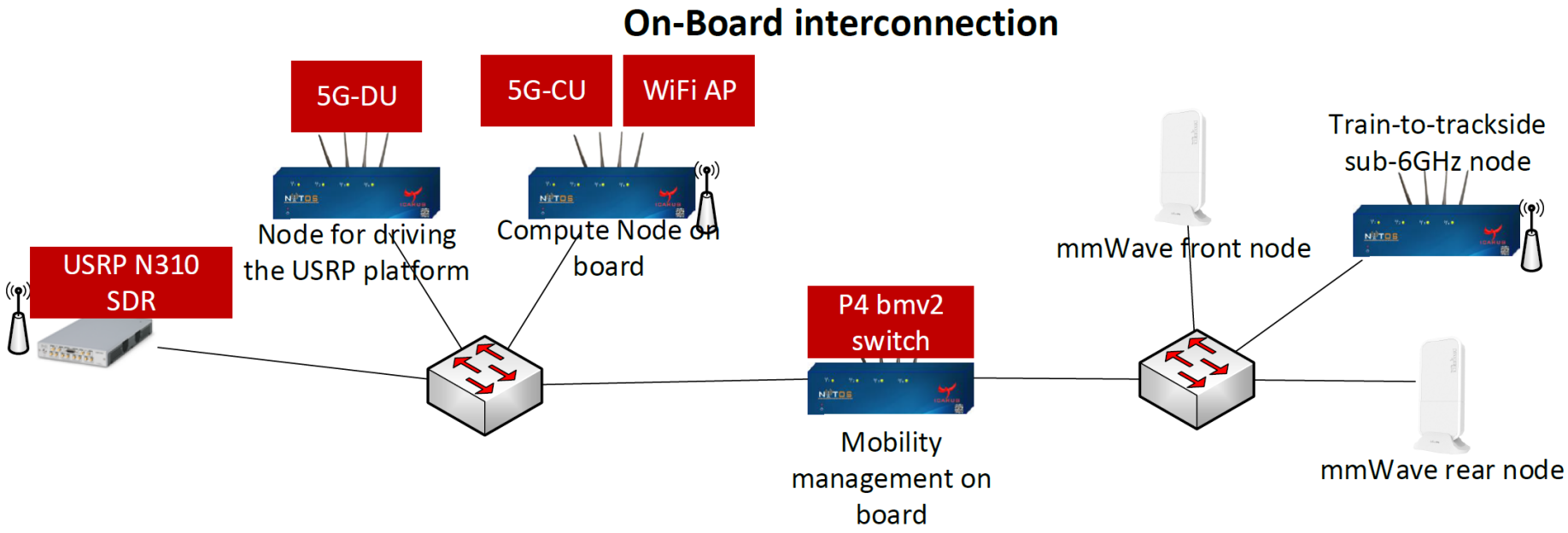
Handover Process

- Track-side deployment and Handovers needed



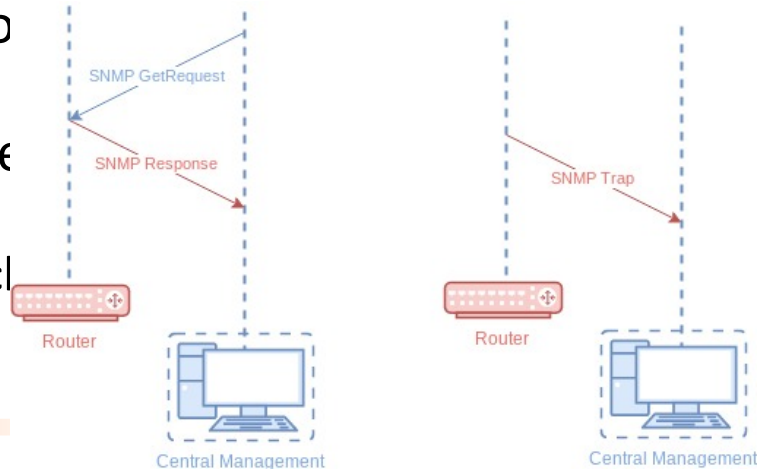
Handover Process

- On-board deployment:



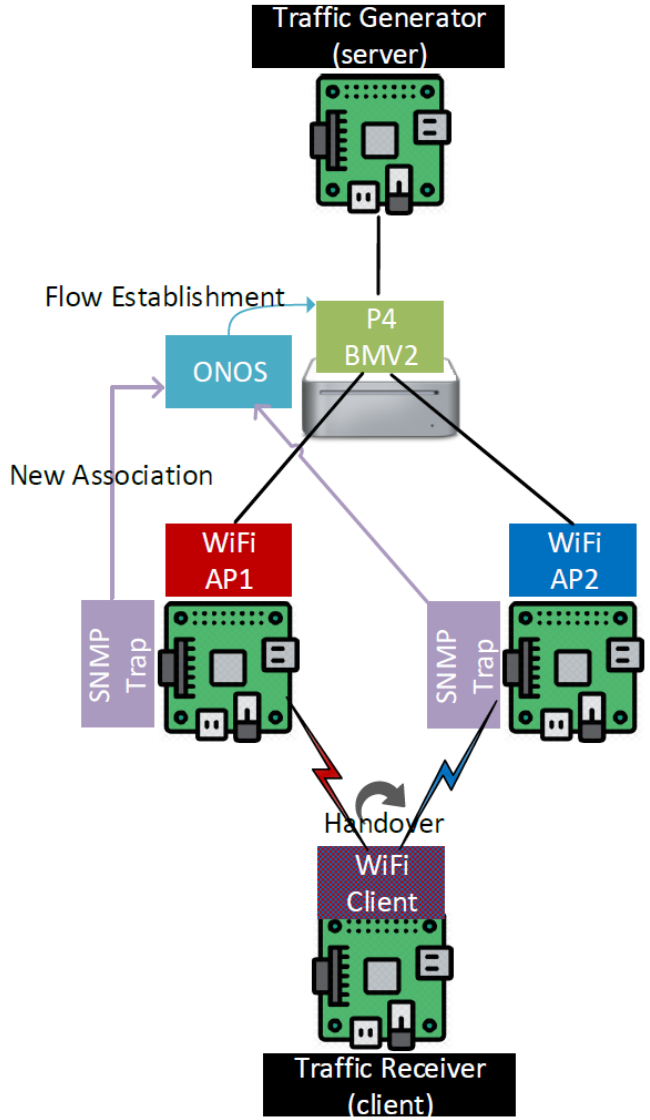
Managing Handovers

- Handovers need to be managed at two different sides:
  - On the train, selecting the antenna/technology that will be used for communicating with the track-side
  - On the cloud-side, selecting the track-side unit that will forward the traffic to the train
- For both cases the P4 controller managing the flows needs to know the pair of units that are associated at any time
  - We employ SNMP for getting this information, by querying the SNMP Object Identifiers (OIDs) on each AP
  - mmWave equipment provides such information o does not
  - We developed our own SNMP agents that provide need to query them, through SNMP Traps
    - Traps send an update to the controller whenever a cl



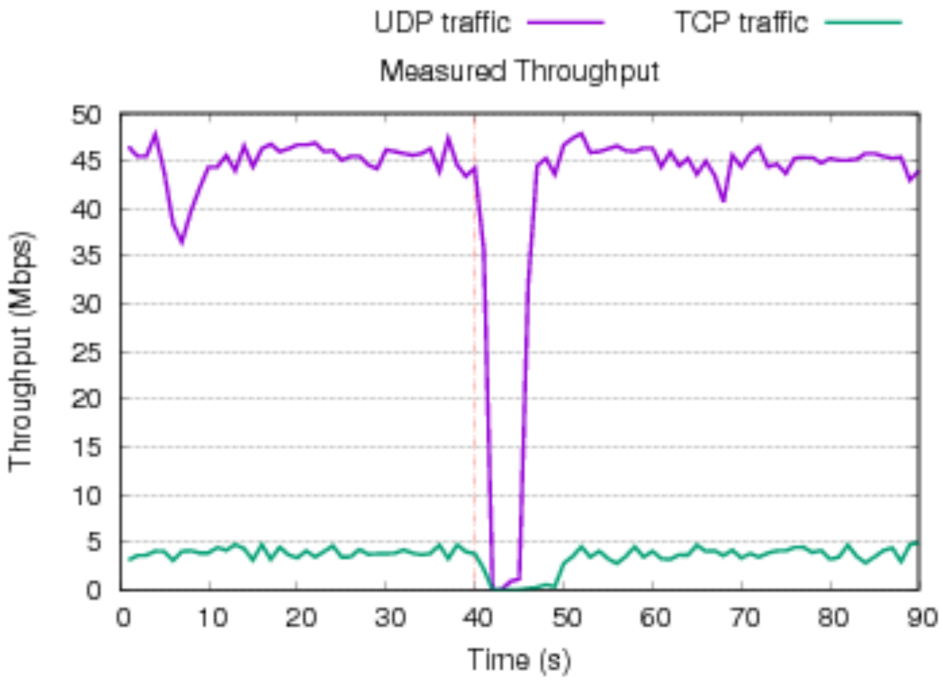
Evaluation

- We evaluate the initial handover scheme using P4 software switches and a scaled down version of the train testbed
  - The behavioral model (bmv2) switch is used, managed by an ONOS controller instance running on a mini PC (x86)
  - A number of different Rasperry Pis are used for emulating the track-side APs, the train antennas and generating traffic



Evaluation Results

- We focus on evaluating the session continuity through the developed solution of controllers
- We use the *iperf* tool to saturate the link from the server to the on-board devices with UDP/TCP traffic
- At approx. 40secs in the experiment, we force the station to connect to the second AP and monitor the end-to-end connections
- The SNMP traps detect the change, and instruct the controller to update the flows resulting in a seamless handover



Discussion & Future Plans

- Although handover delay seems to be high, it is a first feasibility study focusing on session continuity only
  - Established sessions from the traffic generator where established throughout the experiment
- The delays have been pinpointed to the current choice of tools
  - The P4 bmv2 software switch manages all traffic in application space, which in turn creates higher downtimes during flow establishment, as shown in a comparison between bmv2 and off-the-shelf Linux bridges

RTT Measurements		
Solution	Avg.	Min.
bmv2	9.88 ms	8.16 ms
bridge-utils	1.44 ms	1.12 ms

  - Flow establishment in practice is taking place instantaneously (less than a msec to send information through the SNMP trap, and controller to assign flows)

Discussion & Future Plans

- Solution: use of actual P4 switches or smartNICs that are P4 capable for establishing the flows even in multi-Gbps rates of traffic
- The fact that the mobility patterns are known across the track can help us further reduce the handover down-times
  - Especially between the sub-6GHz nodes, by employing driver-level optimizations for reducing the time that the client needs to discover the new AP and associate with it
- Currently we are in the deployment phase of the field trial
- The final handover scheme will be evaluated in-depth through network specific measurements, as well as application specific metrics for the deployed on-board services

Thanks for your attention!

5G-VICTORI Project
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