

DIGITAL TWIN AS A SERVICE (DTAAS): A PLATFORM VISION FOR REAL-TIME 6G NETWORK INTELLIGENCE

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- **Professor** | The School of Computing, Engineering and The Built Environment, Edinburgh Napier University, UK
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- **External Board Member & Academic Director** | BTS Group - Biggest Cloud & Networking Company in Turkey

- **Research Area:** Digital Twins, Real-Time Synchronization, AI-driven Orchestration, Semantic Communication

• Publications (Journals/Conferences/Patents/Submitted)	89 / 97 / 10 / 13
• Publications on Digital Twin (Journals/Conferences/Patents/Submitted)	40 / 32 / 6 / 10
• Active Students (Postdoc/PhD/RA/Visiting)	1 / 5 / 2 / 2
• Graduated Students (PhD/MSc)	7 / 21
• Total Secured Funds as PI (since 2020)	>1.5M GBP

- **Area Editor** in IEEE Communications Surveys and Tutorials
- **Lead Editor** in IEEE ComSoc Best Readings in Digital Twins
- **IEEE Senior Member**

My Research Team



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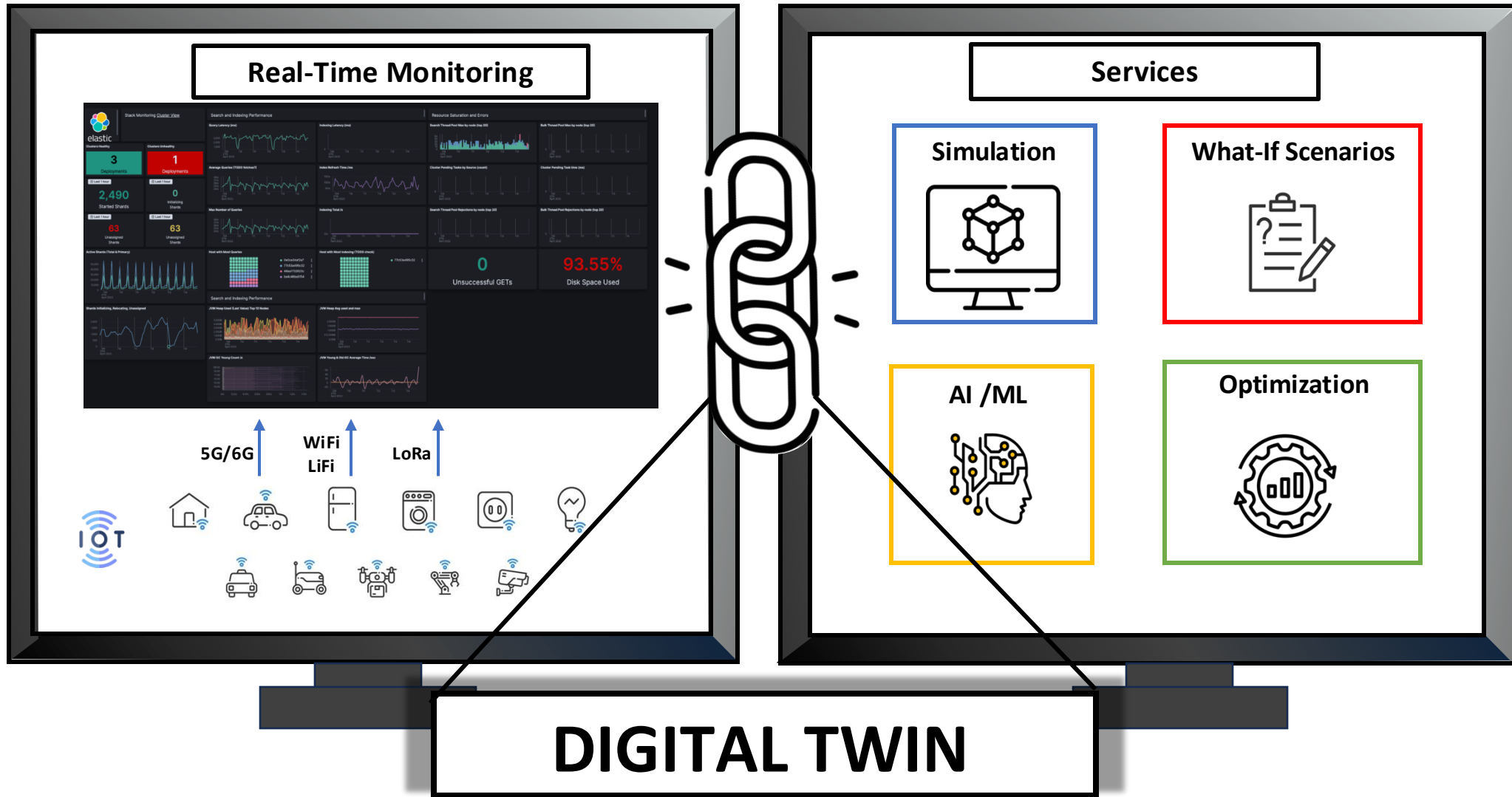


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PhD, ITU
Co-Advice

What is Digital Twin?



What is Digital Twin?

Digital Twin Design and It's Metrics

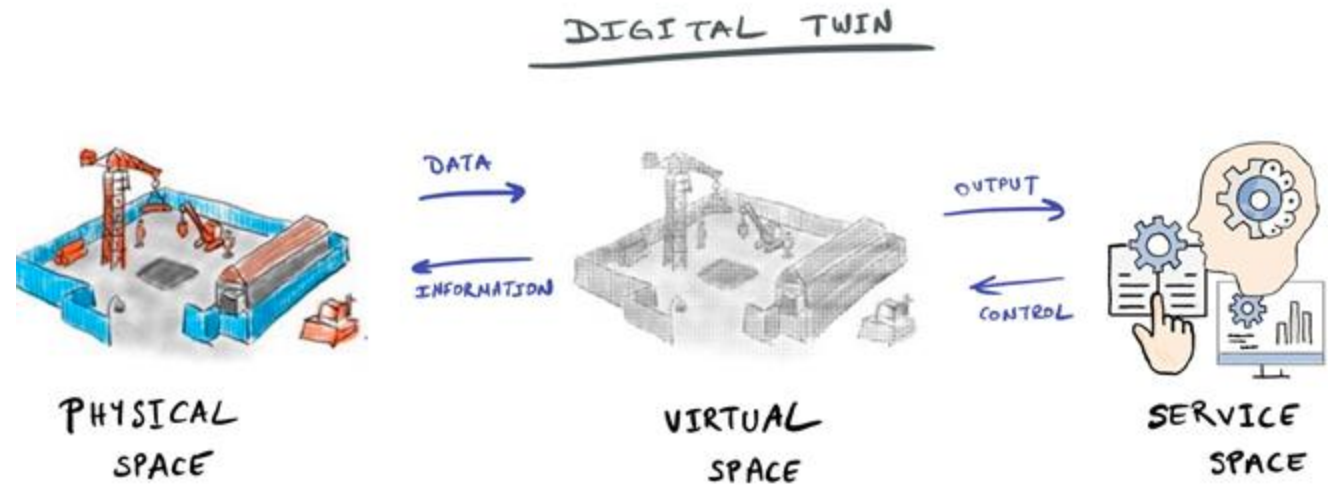
- Twin Fidelity:
 - How accurately does the DT reflect reality?
- Age of twin:
 - The time difference between the current state and the last update of the digital twin from the physical entity
- DT Elasticity:
 - How to autonomously scale a DT to meet its timelines requirement?
- Twin Granularity:
 - Which parts of the physical system are modelled and how deeply?
- Twinning rate:
 - The ratio of the frequency of updates from the physical system to the DT
- Polymetric twinning index:
 - Measures NDT performance across multiple dimensions, such as data handling, modeling, interface capabilities, and service delivery
- Twin communication overhead:
 - RTT delay and jitter

Simulation Features

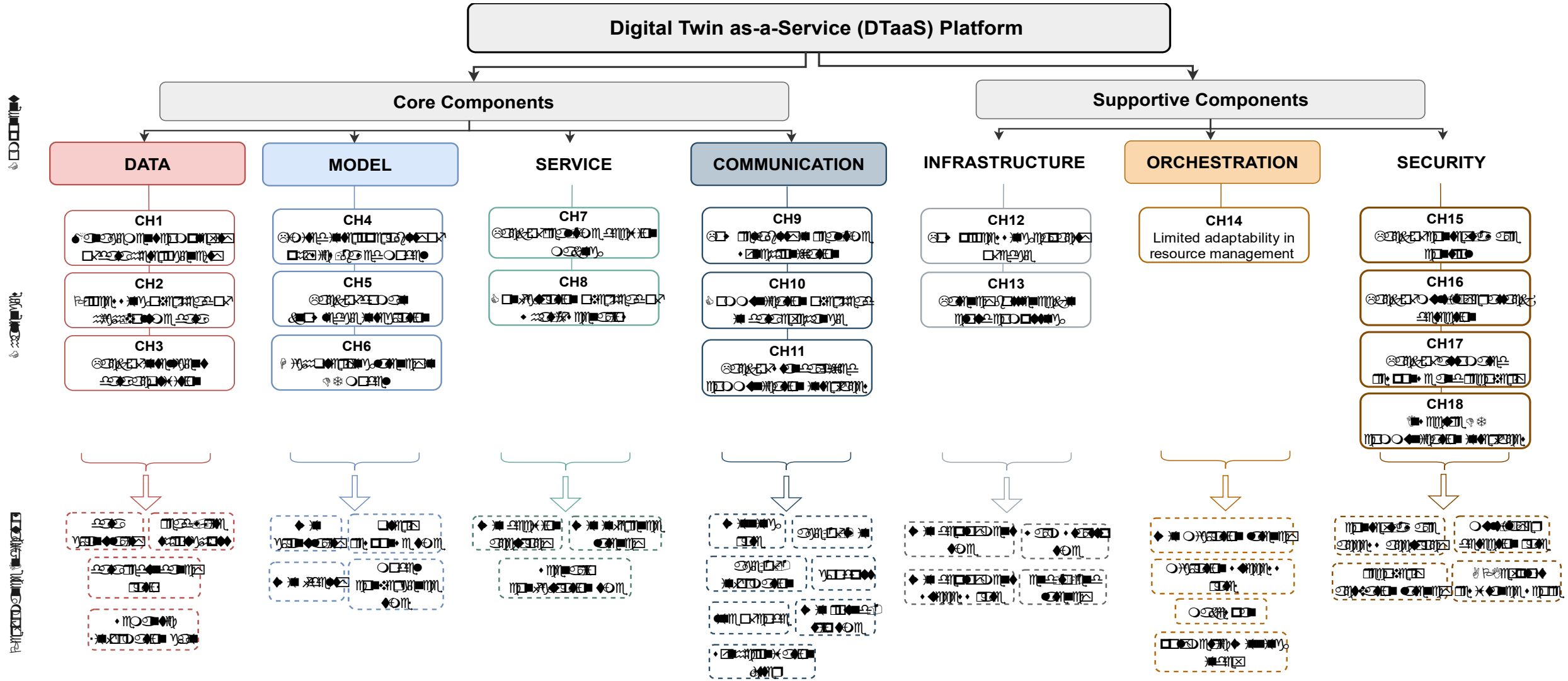
"What may happen in the system?"

Digital Twin Features

"What is actually happening?"



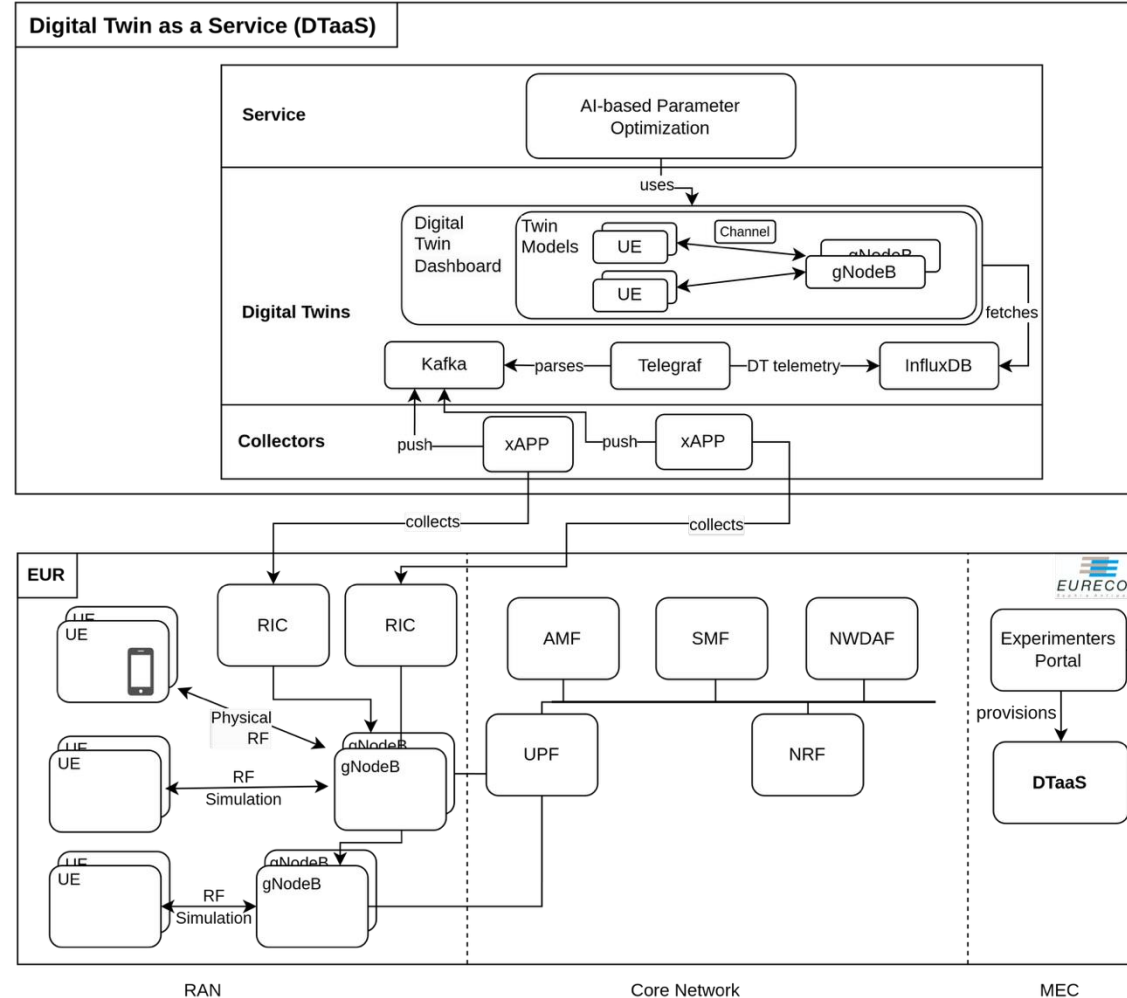
Digital Twin as a Service (DTaaS) Challenges



Projects

TwinRAN – Digital Twin Platform for 6G RAN Emulation

- RQ - How to create a scalable virtual test environment for 6G RAN?
- WHY - Limited physical infrastructure for multiple RAN deployments, and lack of mobility support in RF simulators
- HOW -
 - Containerized and Distributed DT Platform based on Open Air Interface (OAI) to support over 1000 UEs
 - AI-based channel hyperparameter tuning to support various UE-gNodeB mobility types



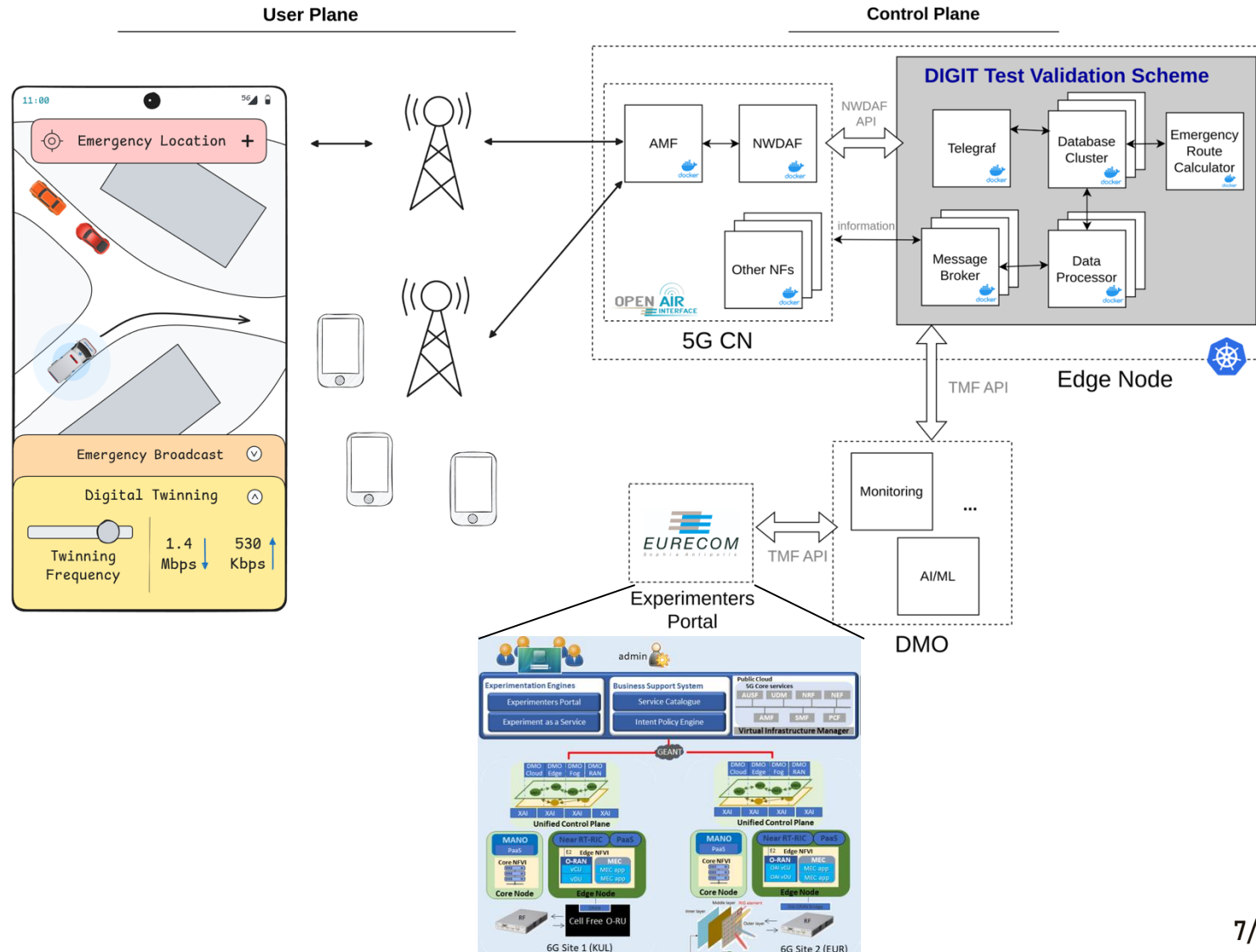
Some Outcomes

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- A. Masaracchia, V.L. Nguyen, D.B. da Costa, E. Ak, B. Canberk, V. Sharma, T.Q. Duong, 'Towards 6G-enabled URLLCs: Digital Twin, Open RAN, and Semantic Communications', IEEE Communications Standards Magazine, September 2024, Scopus Journal Quartile: Q1.

Projects

DIGIT – DT-based Performance Validation Framework for 6G

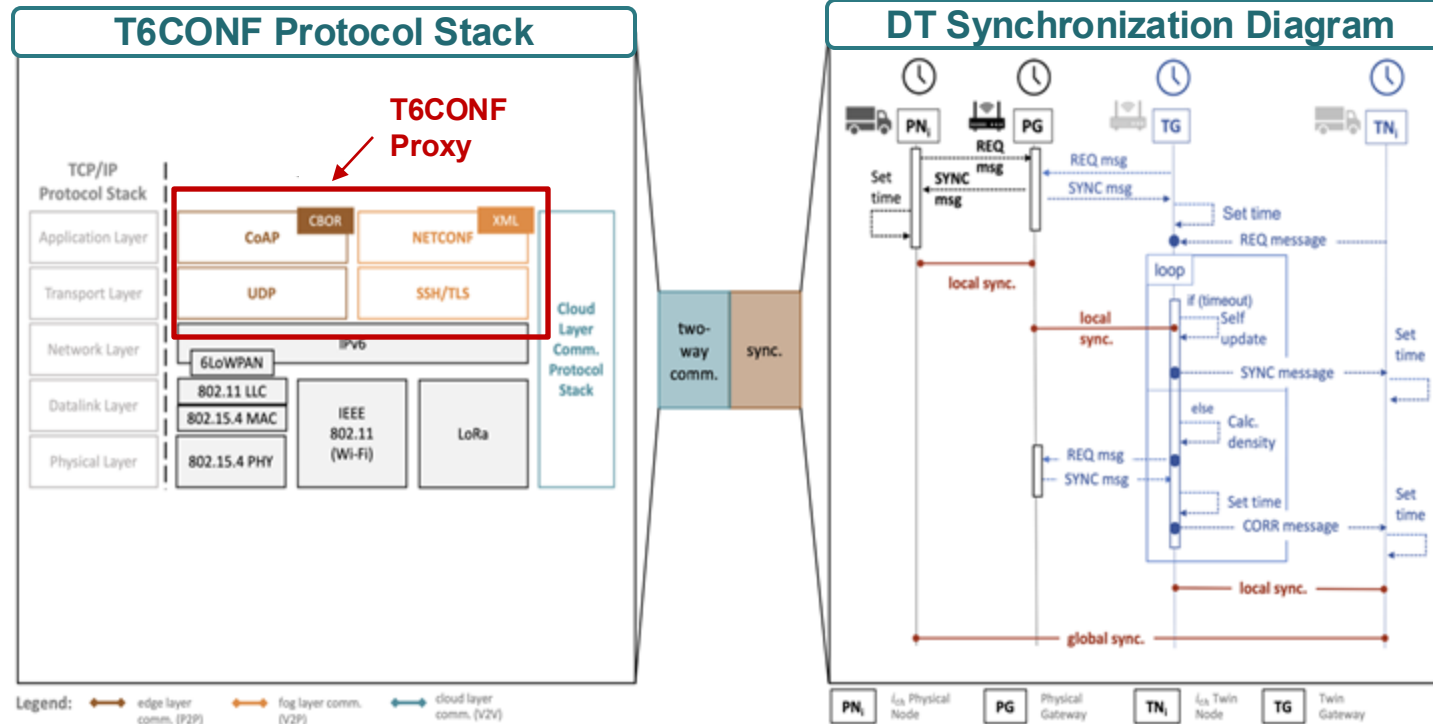
- RQ - How to test and validate the performance of a 6G experimentation infrastructure?
- WHY - 6G applications require stable performance under increasing user load but there are no validation schemes
- HOW -
 - UE agent API for physical-layer interaction with tunable DT frequency
 - Microservice-based DT-enabled testing and validation framework for real-time decision-making



Research

Real Time Digital Twin Communication Stack for Smart Cities

- RQ - How to synchronize digital twins in IoT networks?
- WHY - Resource constraints prevent real-time synchronization. The overhead of the communication has to be reduced.
- HOW -
 - Synchronization trigger based on topology changes
 - New Protocol using Automata Theory
 - Lower overhead
 - Decreased latency and RTT



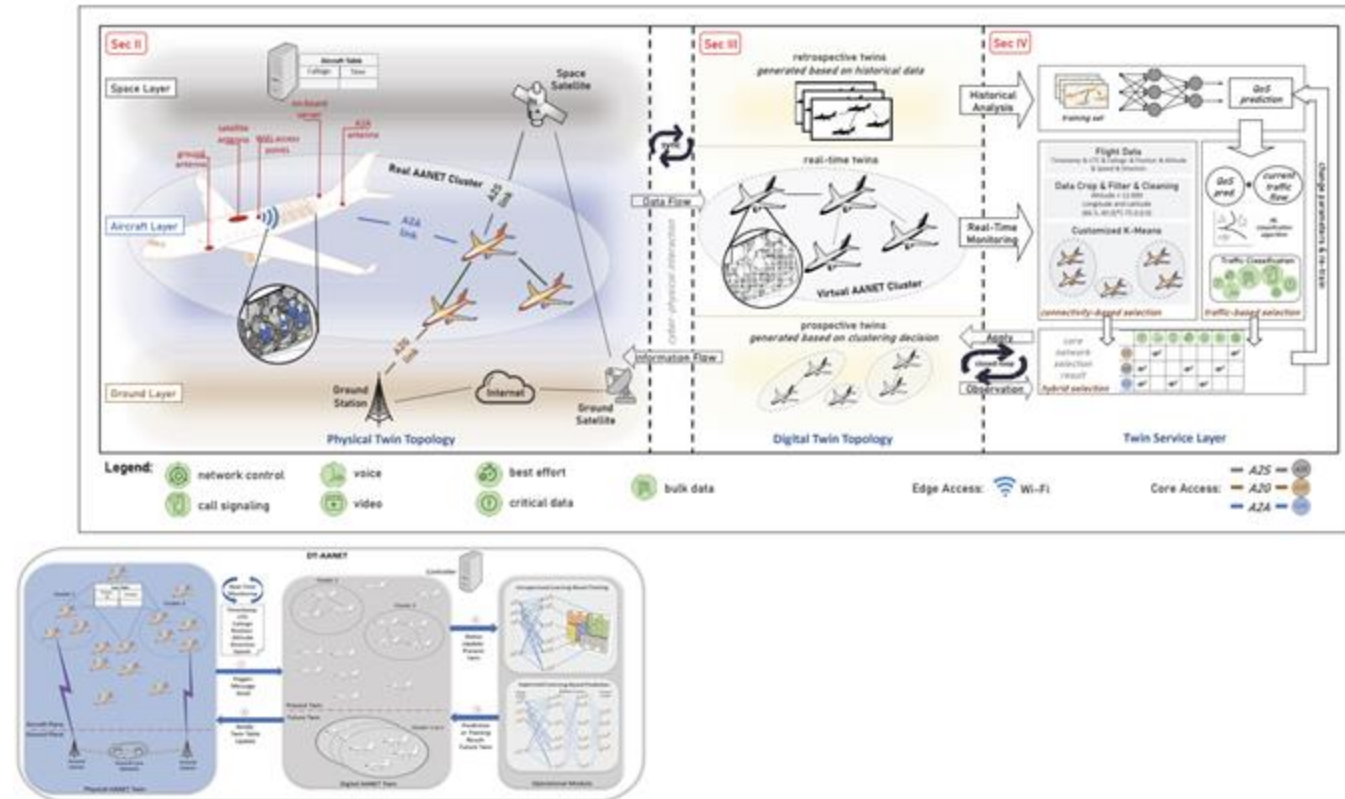
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- K. Duran, E. Ak, G. Yurdakul, B. Canberk, '6G-enabled DTaaS (Digital Twin as a Service) for Decarbonized Cities', in Workshop on Architectural Innovations for 6G: Native-AI and Digital Twin, IEEE International Conference on Communications (IEEE ICC), Rome, Italy, May 2023.

Research

Real-Time Core Network Selection for High Altitude Platforms (HAP) in 6G, tested in our DTaaS

- RQ - How to ensure uninterrupted and high-quality Internet access in aeronautical networks?
- WHY - The dynamicity of aeronautical topology and traffic behavior, causes delay and reduce packet delivery ratio. A real-time core network selection is needed
- HOW -
 - Online recommendations made using clustering the aeronautical network and using ML to predict traffic behaviors
 - Decreased network selection delay
 - Increased PDR



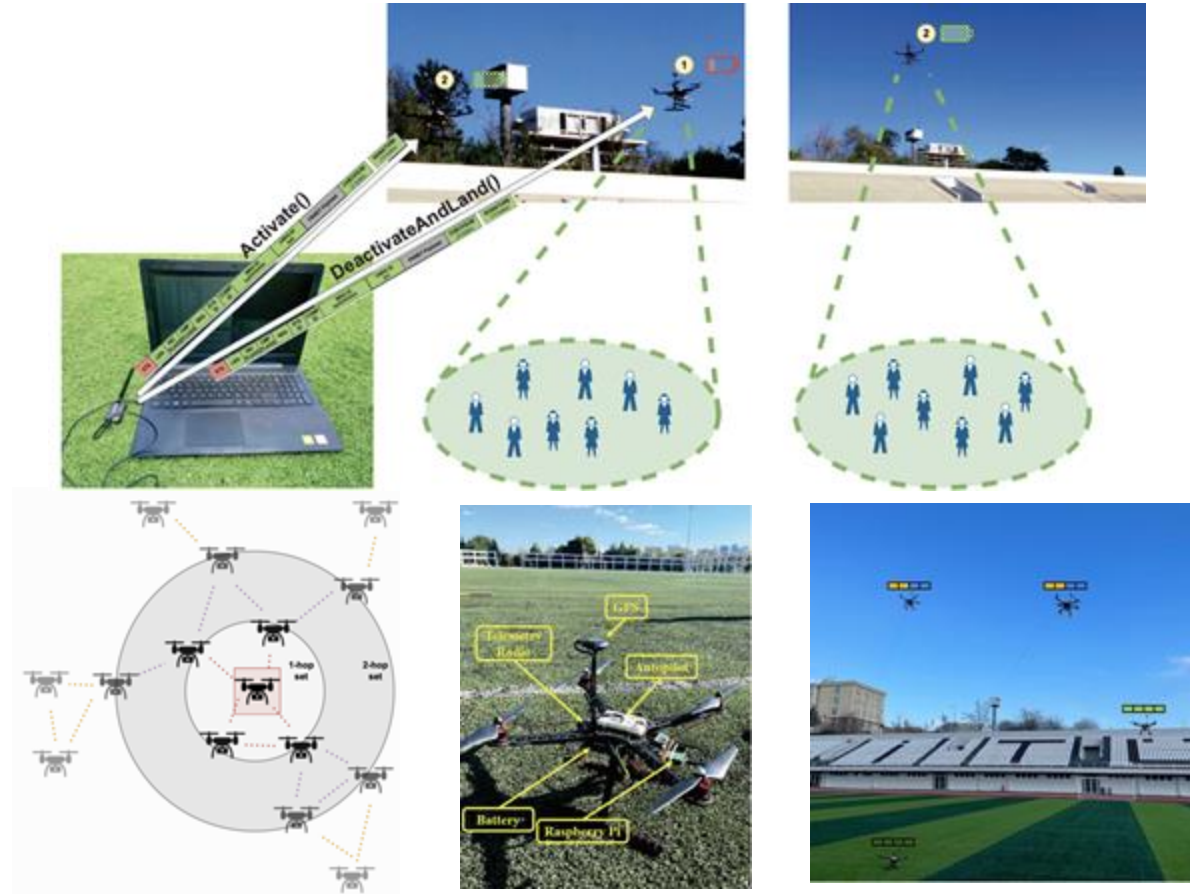
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Research

Energy-Aware Swarm Deployment for Drone-Base Stations in 6G: A DT Enhanced Approach

- RQ - How to serve distributed management of drone BS for optimum coverage?
- WHY - Battery constraints limit decision capability to maximize the coverage
- HOW -
 - Coordinated swarm flying algorithm via real-time communication protocol
 - Enhanced What-if analysis to test various scenarios via DT
 - Reduced relaying overhead
 - Reduced 'per drone deployment complexity'



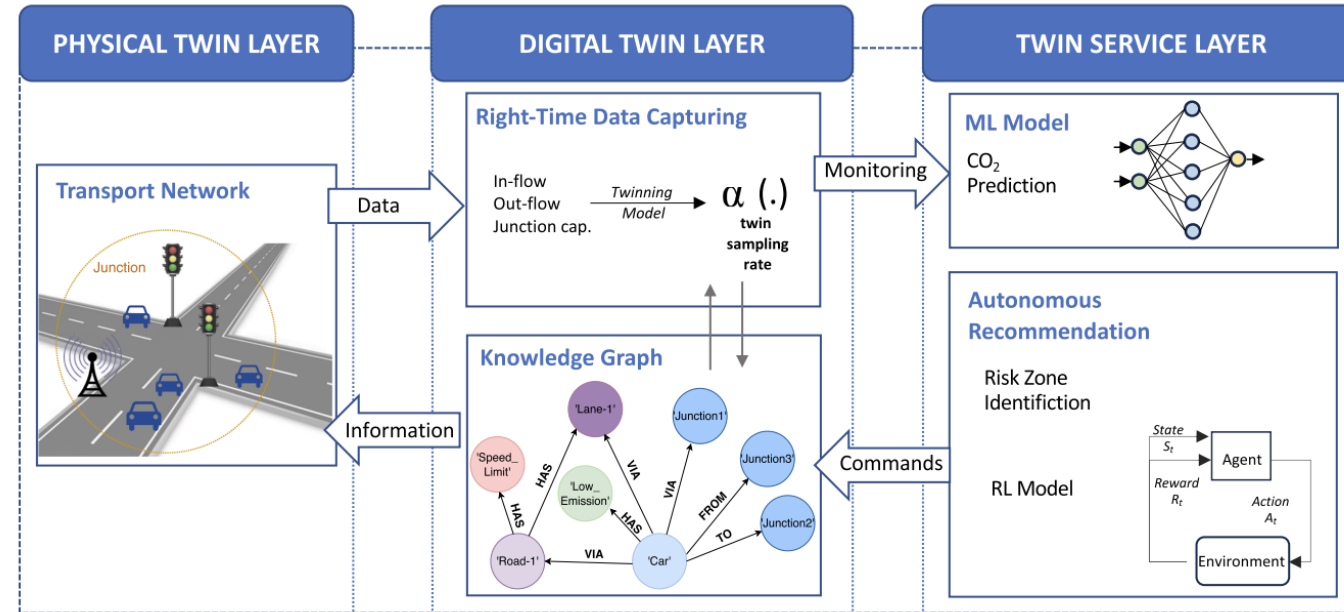
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Research

Digital Twin-aided Green Mobility Management in Transportation Networks

- RQ - How to reduce emissions and control traffic in road transportation?
- WHY – Lack of real-time control due to resource constraints and high latency in reasoning over traffic controls.
- HOW -
 - Using dynamically adjusted twin sampling rate and reducing the latency.
 - Reinforcement Learning-based decision-making
 - Reduced querying latency via knowledge graphs



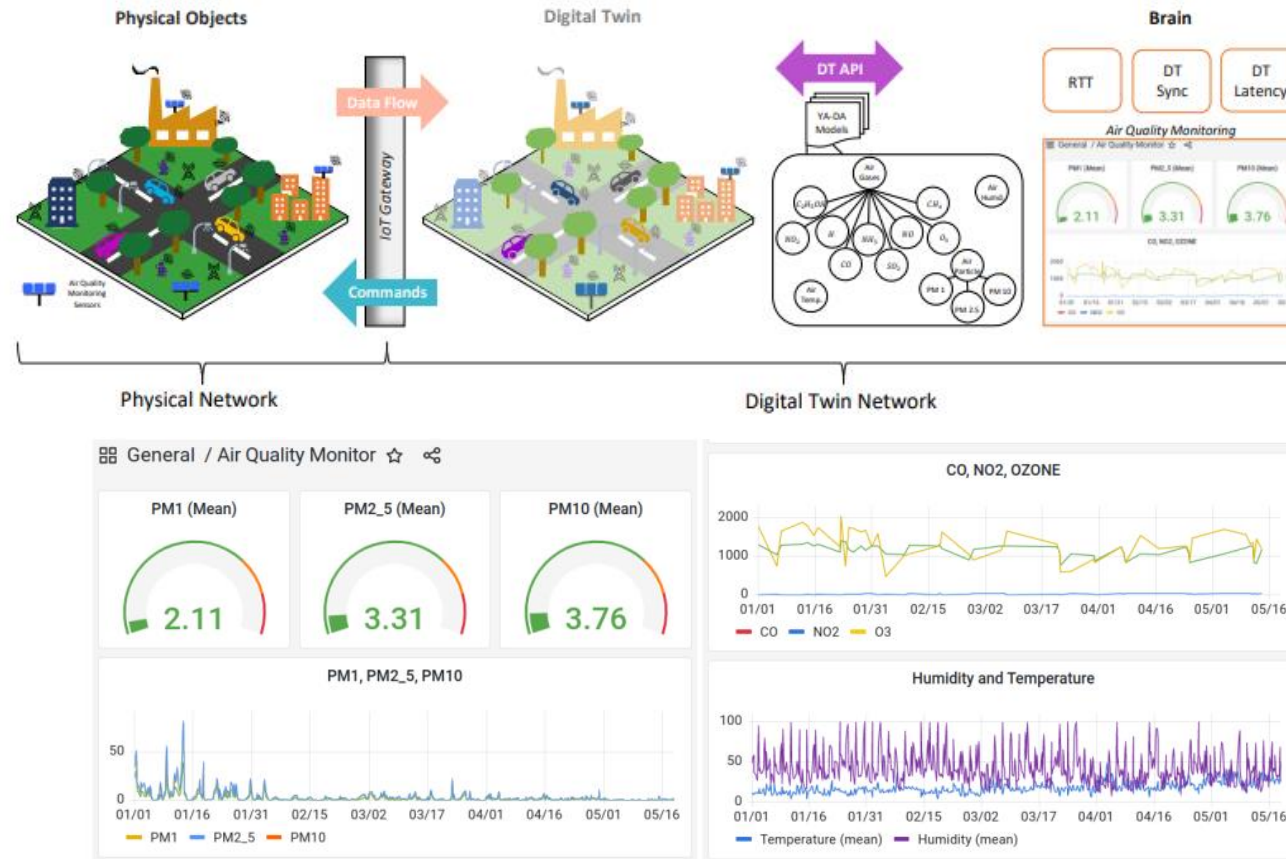
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Research

Optimized Air Quality Monitoring with YANG-Based Data Modeling and Digital Twin

- RQ - How to manage distributed sensors with different formats for efficient air quality monitoring?
- WHY - Existing solutions suffer from high latency and low synchronization, limiting real-time analysis
- HOW -
 - YANG-based data modeling converts all sensor data into a single format for seamless integration
 - Selectively collection of only necessary data reduces latency and improves synchronization



THE
ROYAL
SOCIETY



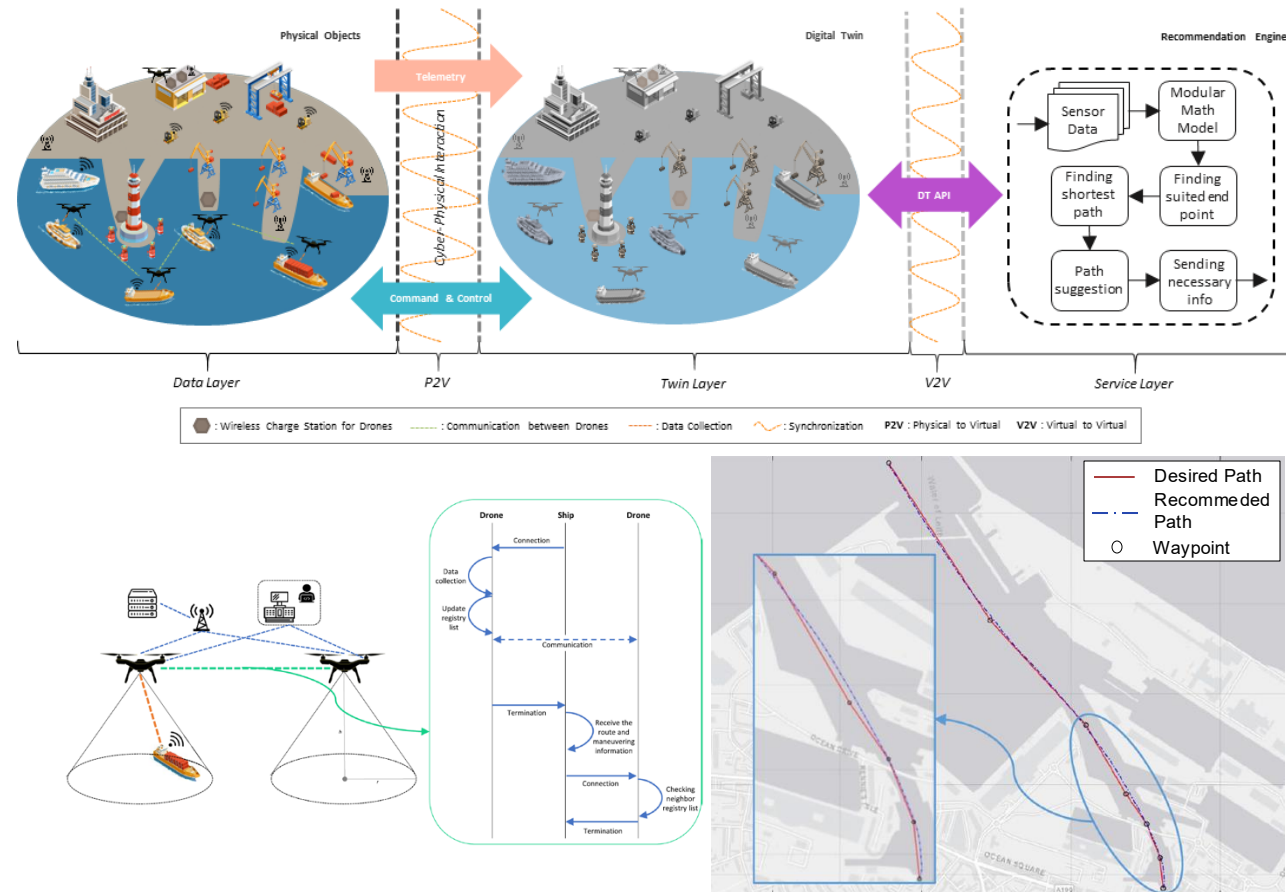
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- K. Huseynov, G. Yurdakul, Y. Yigit, B. Canberk, "Air Quality Monitoring System and Method", The Patent Cooperation Treaty (PCT), Application No. PCT/TR2022/051669, 2022.

Research

Digital Twin-enhanced 6G-Enabled Precise Ship Maneuvering for Efficient Naval Operations

- RQ - How to improve ship maneuvering in congested seaports?
- WHY - Current navigation methods are imprecise, leading to ship collisions, increased fuel usage, and delays in docking
- HOW -
 - Digital twin and drone-assisted data collection enables precise ship maneuvering
 - Recommendation engine gives optimized ship paths during docking
 - Reduced fuel consumption and minimized delays



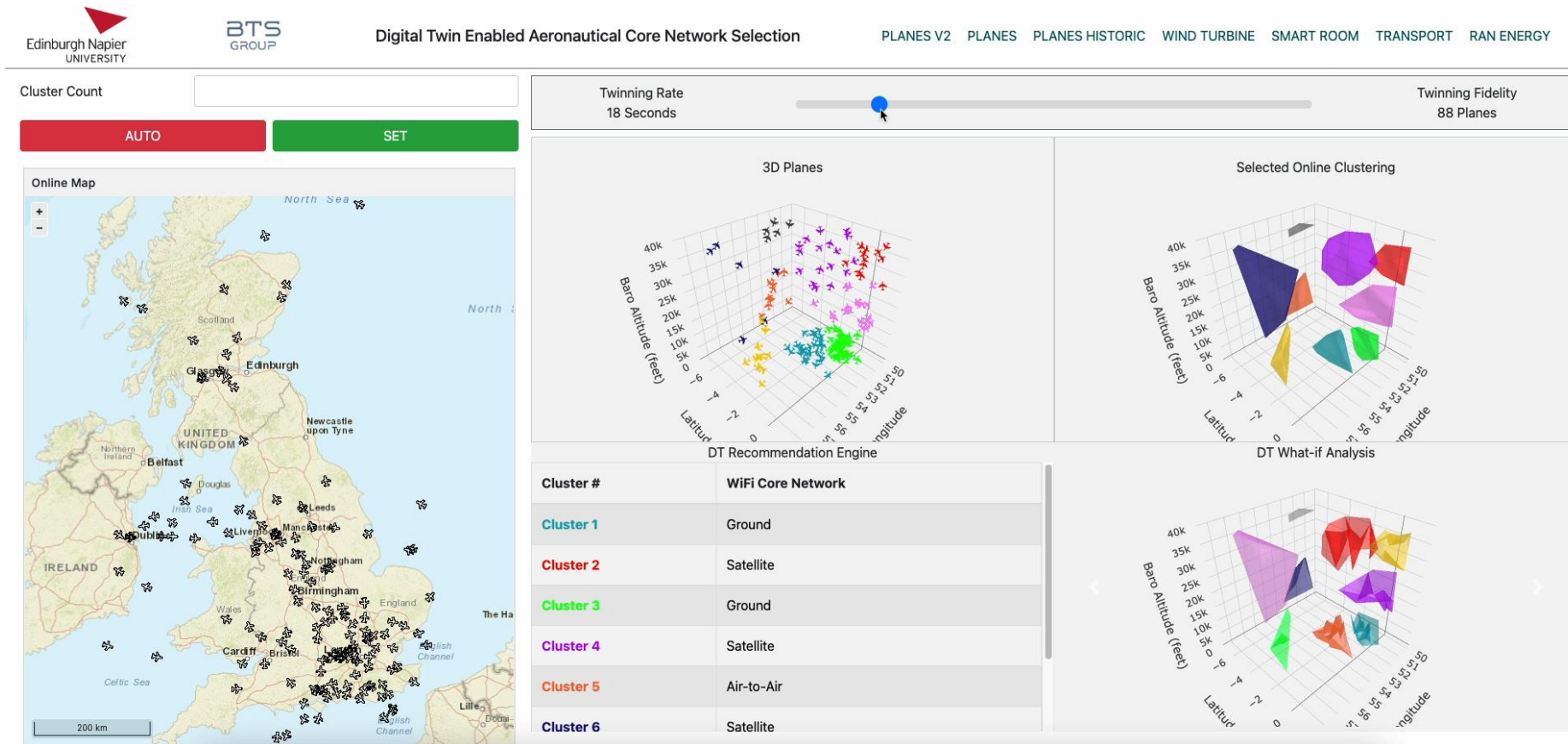
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- Y. Yigit, H. Ahmadi, G. Yurdakul, B. Canberk, T. Hoang, T.Q. Duong, 'Digi-Infrastructure: Digital Twin-enabled Traffic Shaping with Low-Latency for 6G Smart Cities', IEEE Communications Standards Magazine, April 2024, Scopus Journal Quartile: Q1.
- Y. Yigit, L.D. Nguyen, M. Ozdem, O.K. Kinaci, T. Hoang, B. Canberk, T.Q. Duong, "TwinPort: 5G Drone-assisted Data Collection with Digital Twin for Smart Seaports," in Nature Scientific Reports, vol. 13, August 2023

6G Network Intelligence @DTaaS

Digital Twin-enabled Aeronautical Core Network Selection

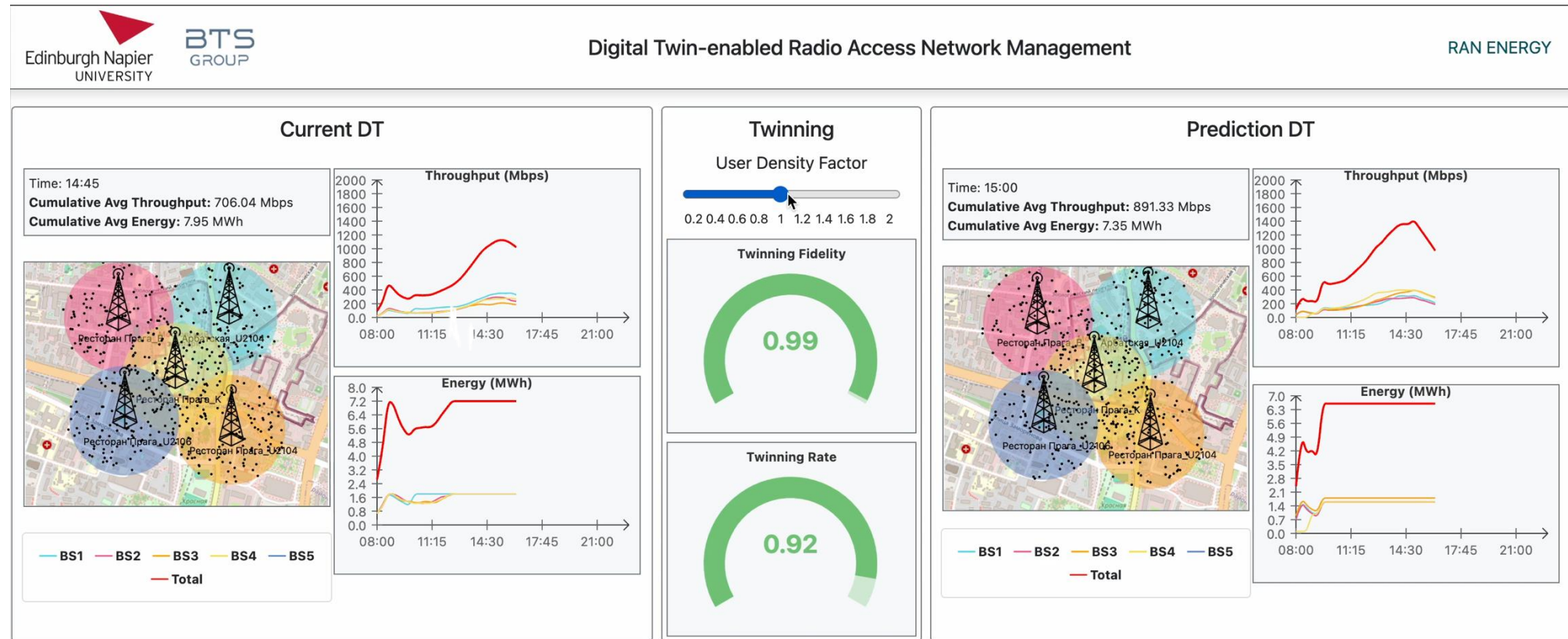
- Near real-time air traffic monitoring
- DT Recommendation Engine



6G Network Intelligence @DTaaS

Digital Twin-enabled Energy-Efficient Radio Access Network Management

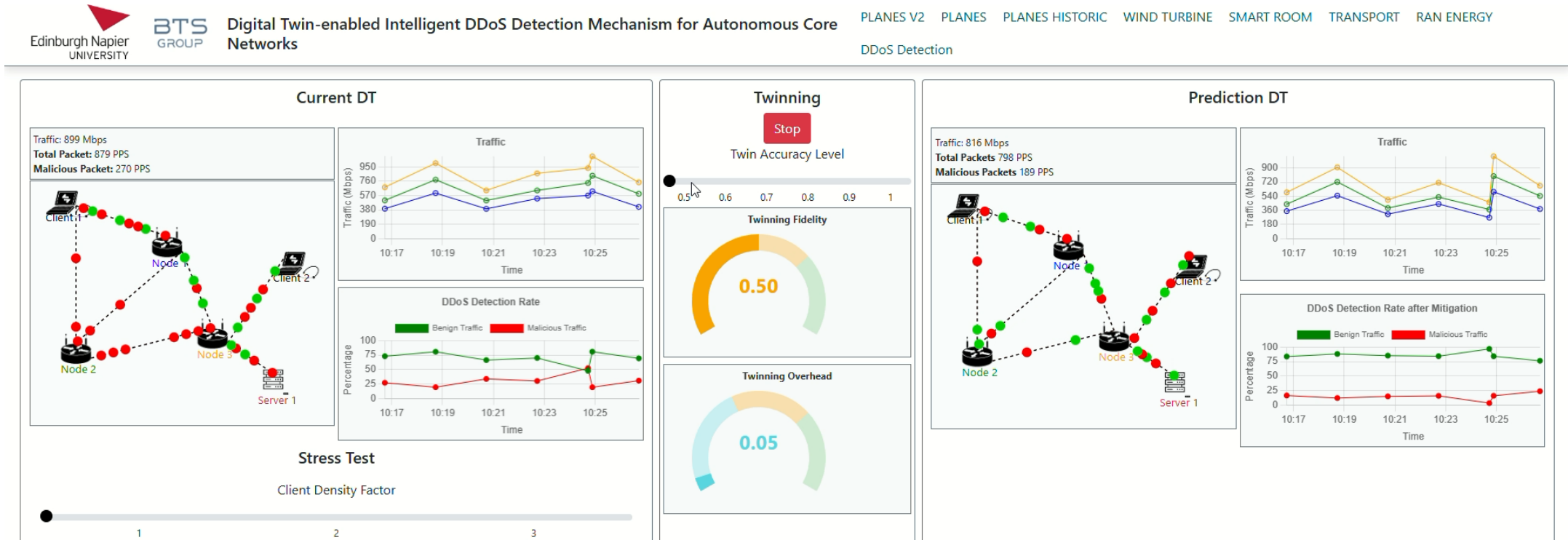
- Network performance and power consumption monitoring
- Scenario analysis on transmission power control for energy efficiency



6G Network Intelligence @DTaaS

Digital Twin-enabled Intelligent DDoS Detection Mechanism for Autonomous Core Networks

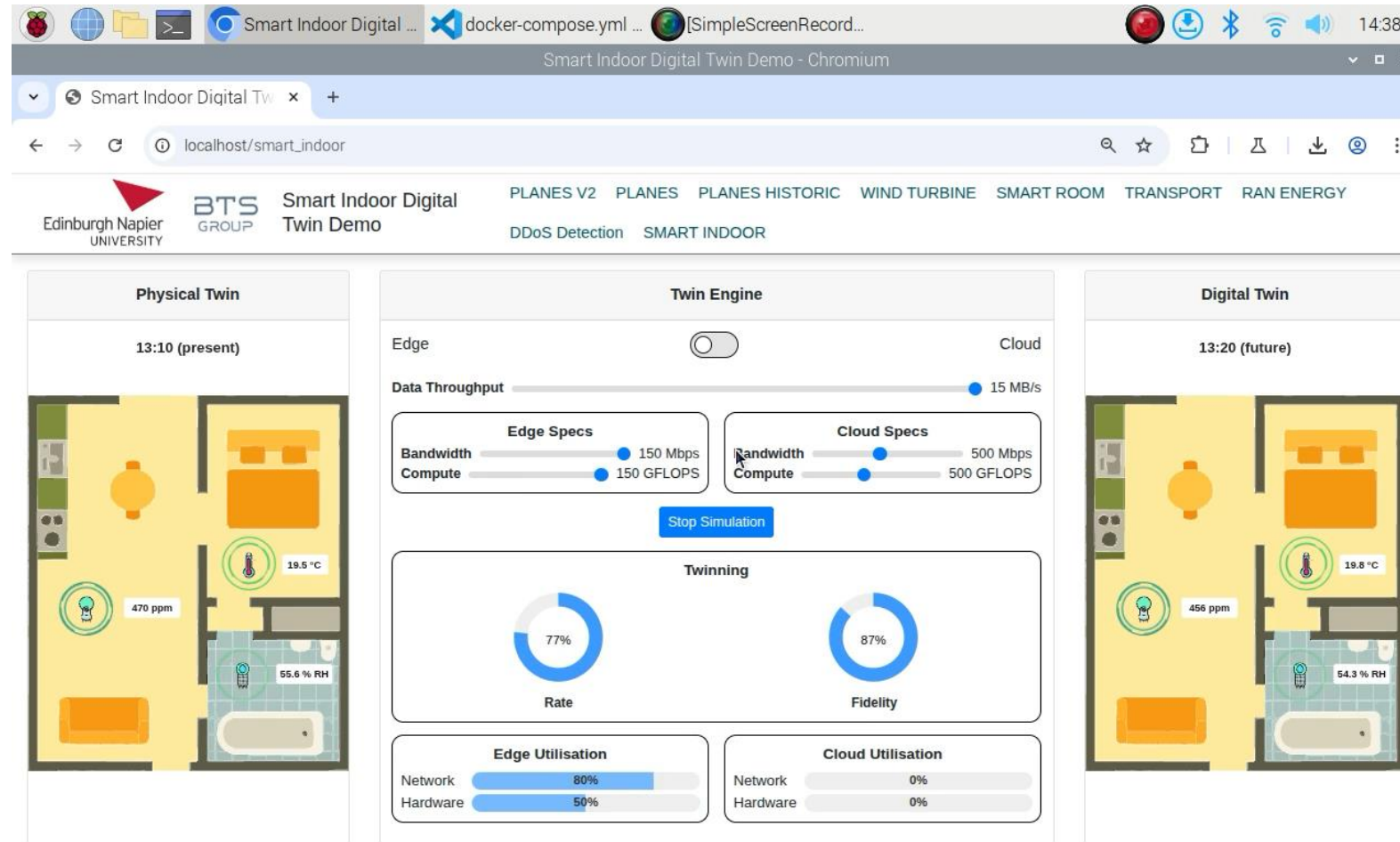
- Traffic monitoring, DDoS detection and mitigation
- Scenario analysis on twining fidelity



6G Network Intelligence @DTaaS

Digital Twin-enabled Air Quality Management of a Smart Building

- Multi-Step Time Series Forecasting using Long-Short Term Memory for temperature, humidity, CO₂, and smoke data.
- Twinning rate and fidelity analysis under edge vs cloud deployment



THANK YOU!

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