

EXIGENCE – Quantification and exposure of energy consumption (CO2e) information of ICT systems

Ljupco Jorguseski | TMA Workshop 3rd July 2026

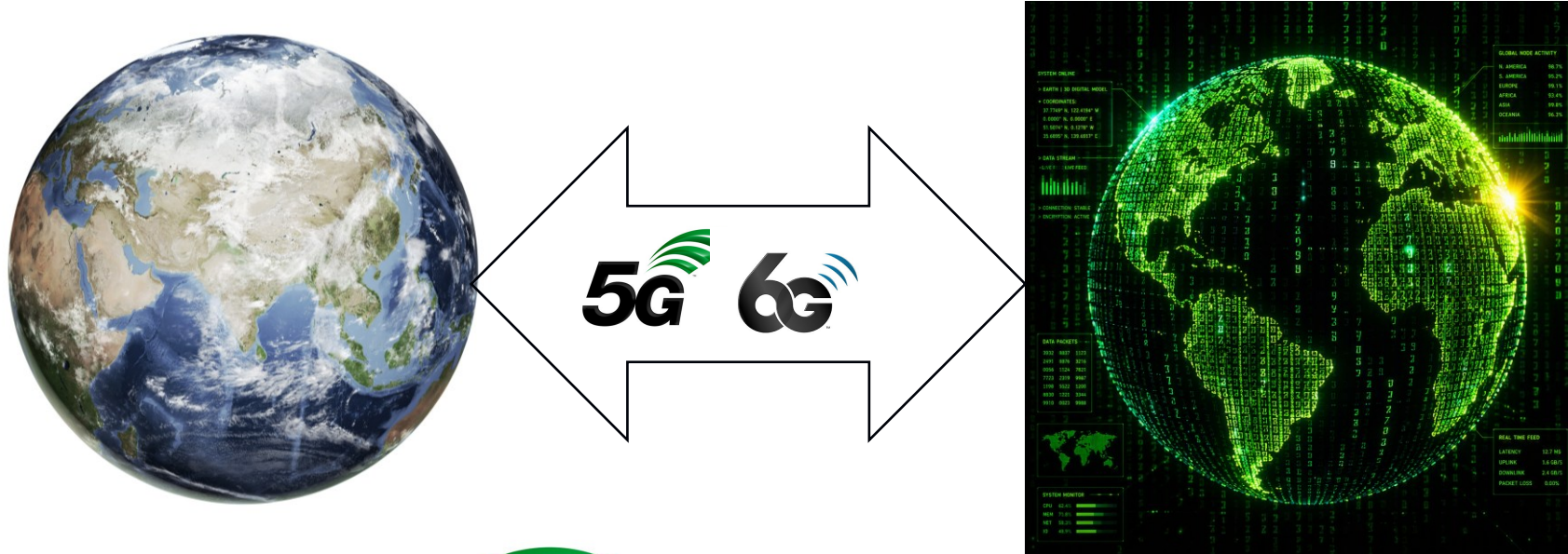


Outline (<https://projectexigence.eu/>)

- WHY (Challenges)?
- EXIGENCE's approach towards energy aware ICT systems
- Energy consumption (Carbon emission) measurements
- Standardization
- Summary and recommendations

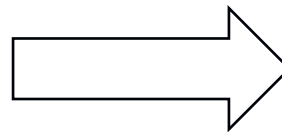
WHY?

Why Energy Awareness Matters (6G Example)?



2020

Communications



2030

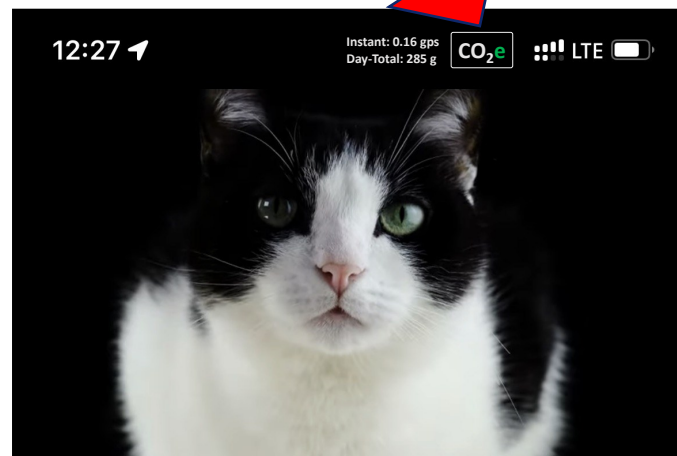
Communications + Sensing + AI

WHY?

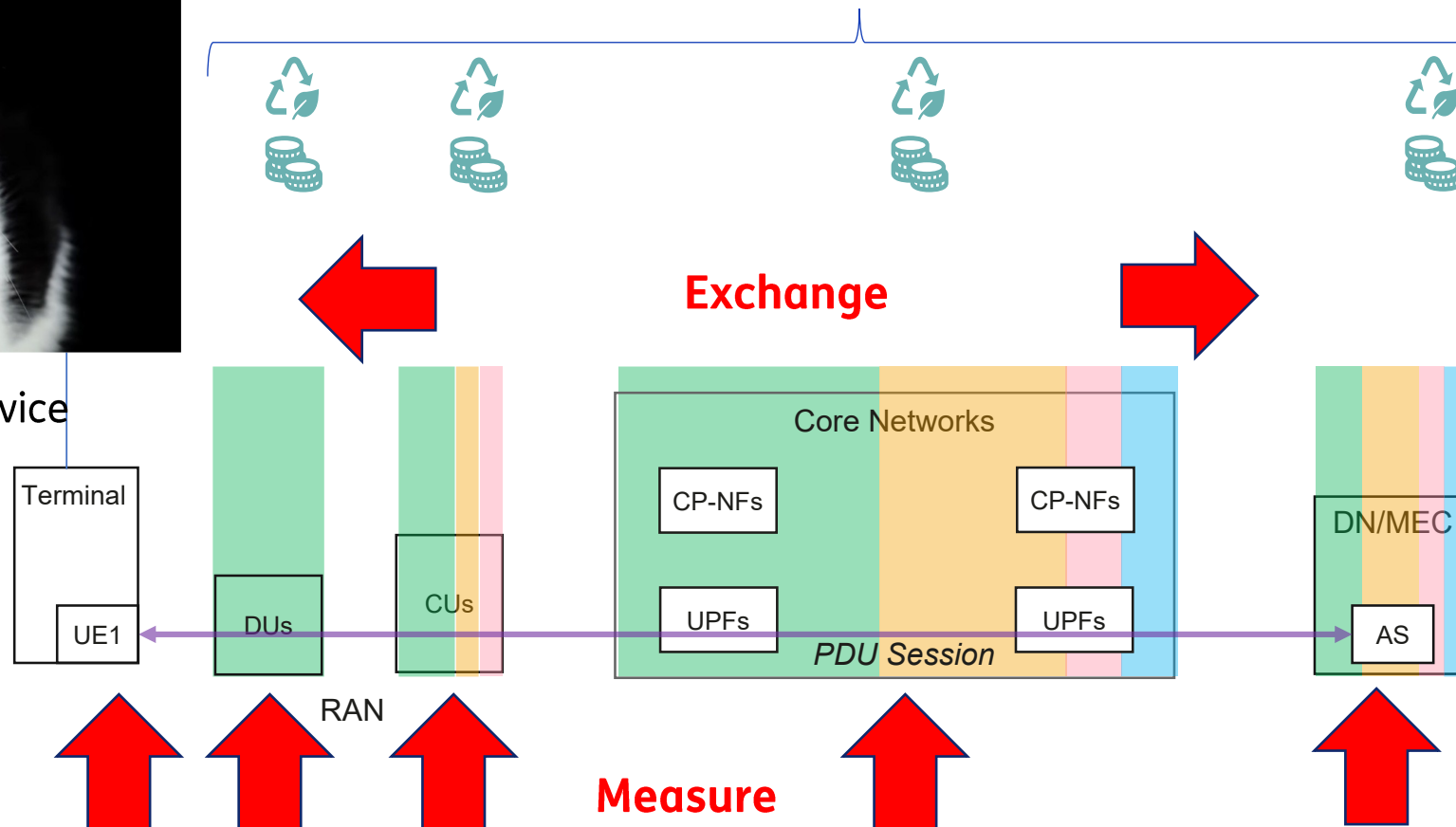
Example 'Green' Use Cases – Video Streaming

measure

Optimise & Incentivize

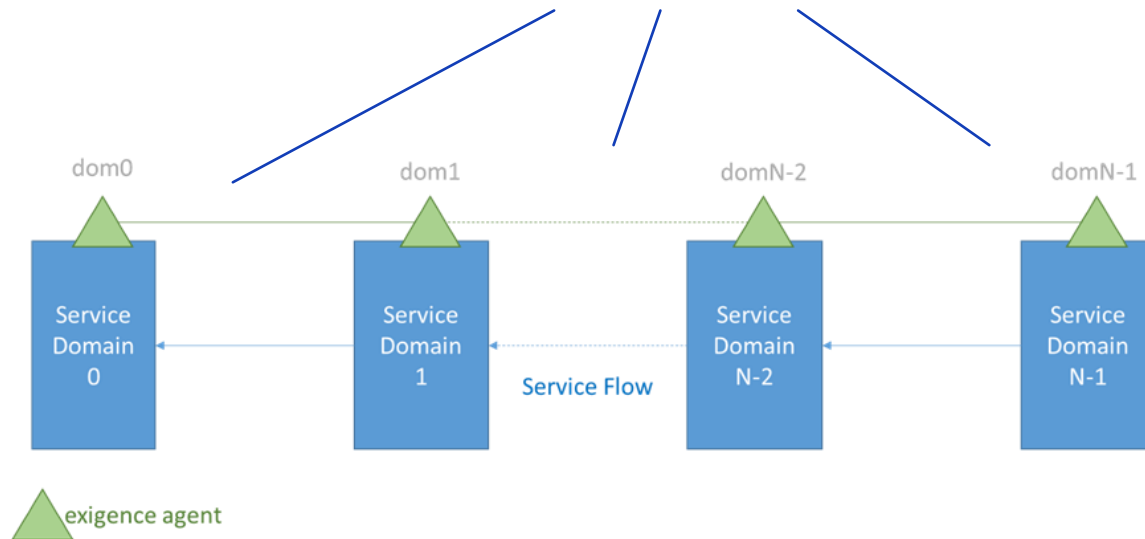


Video Streaming Service



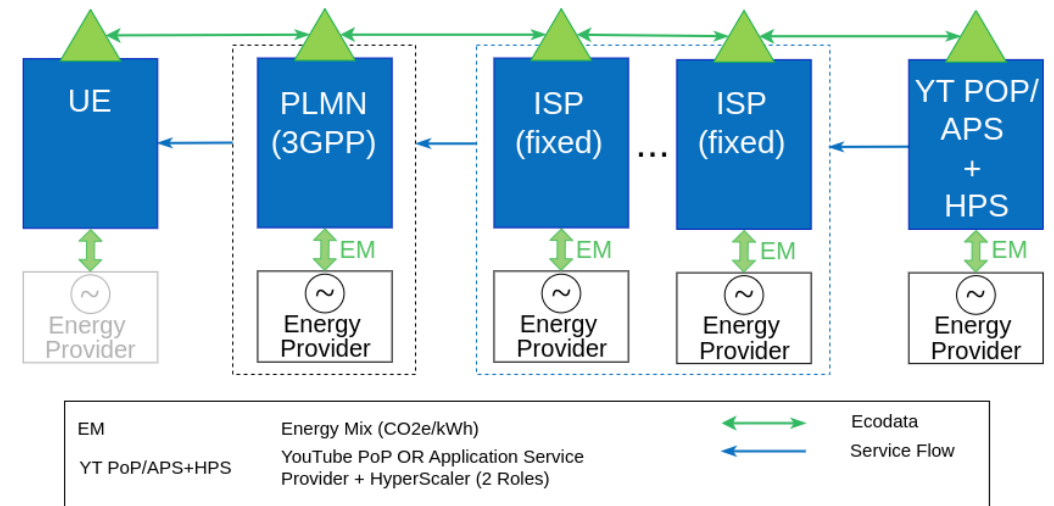
EXIGENCE: Energy aware ICT systems

service ID, energy consumption, signature, ...

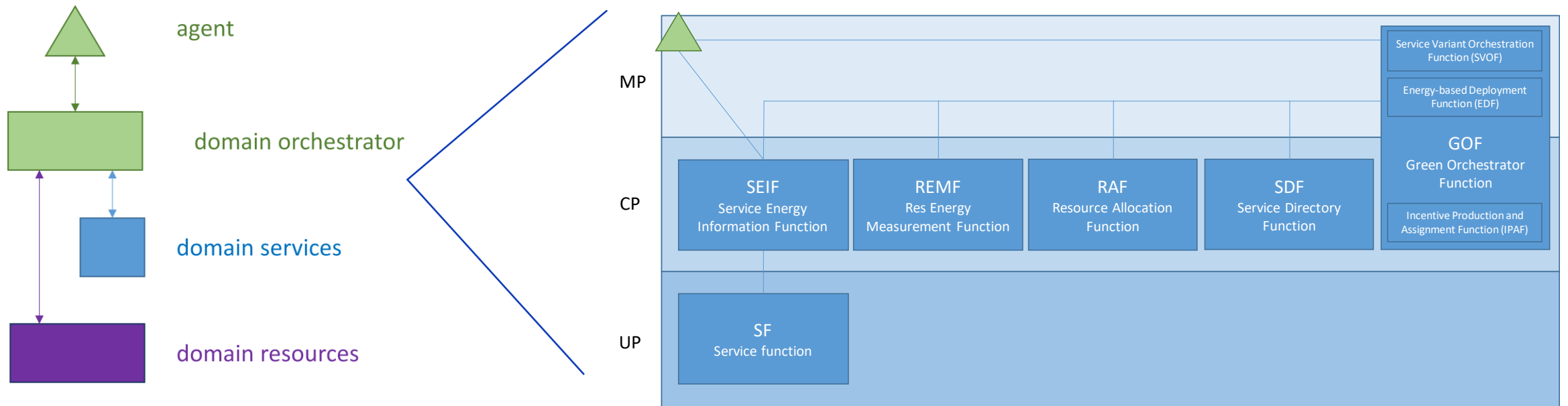


Inter-Domain Ecodata Exchange Architecture (IDEA)

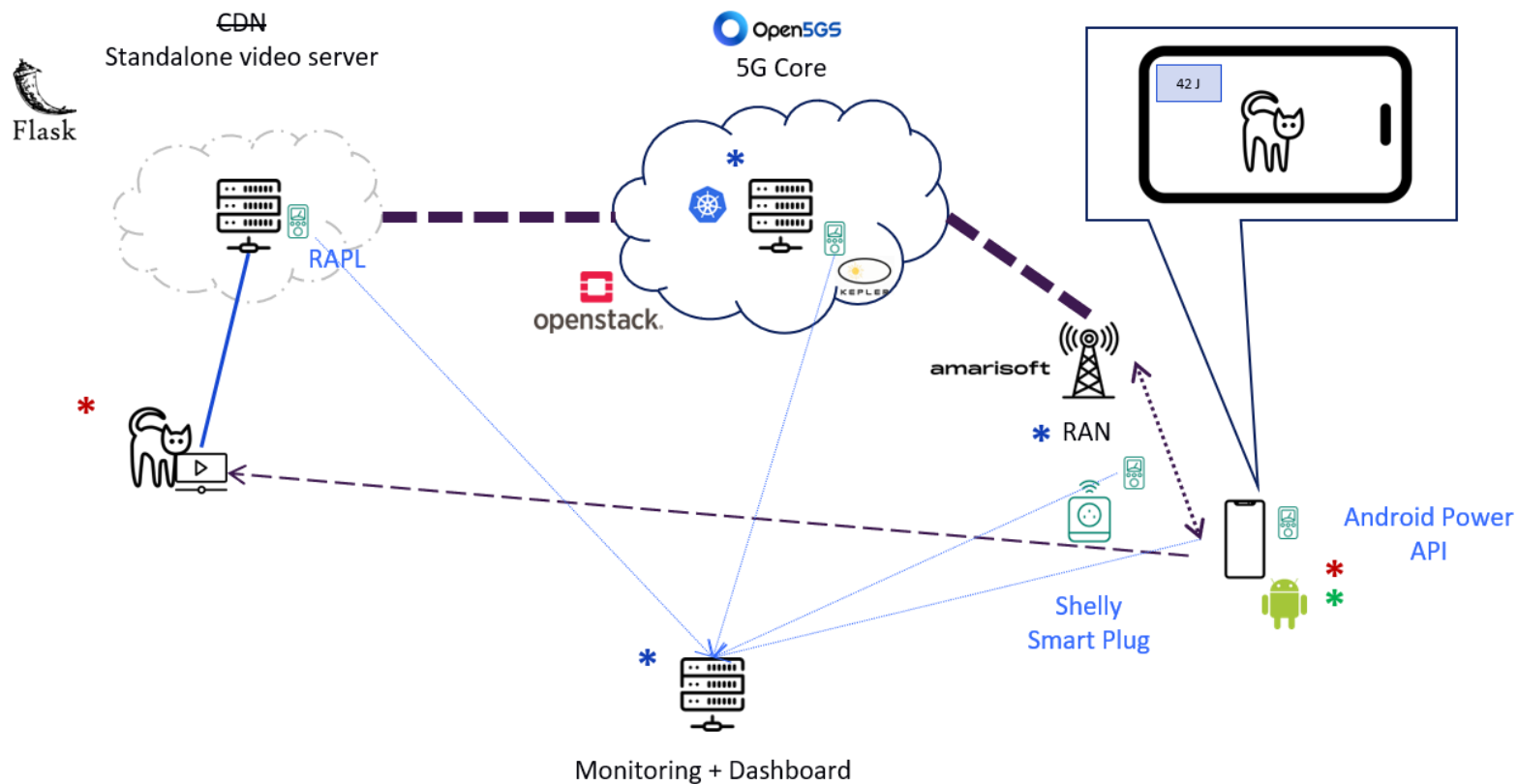
YouTube Instantiation of the IDEA



EXIGENCE – Intra domain view



EXIGENCE – TNO's Lab Measurements

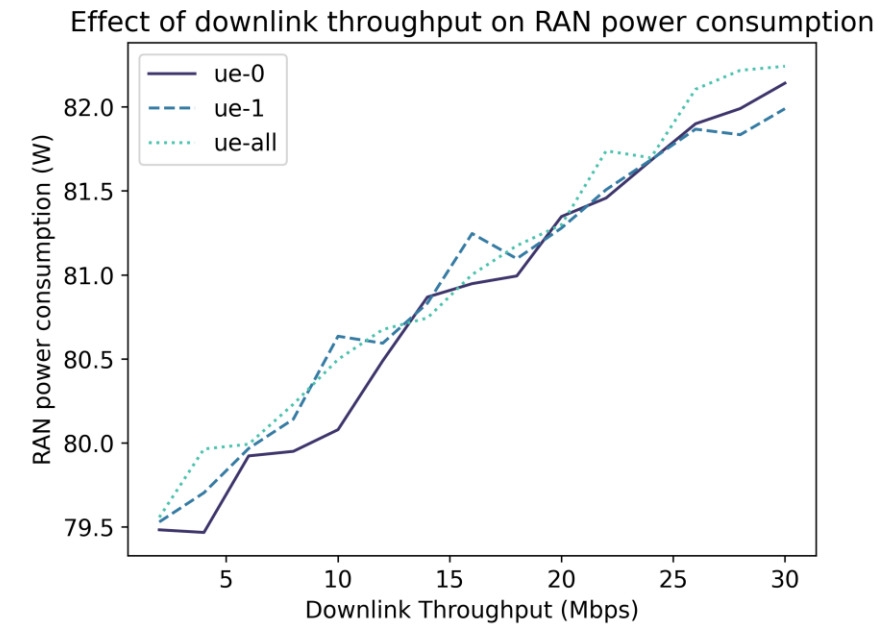
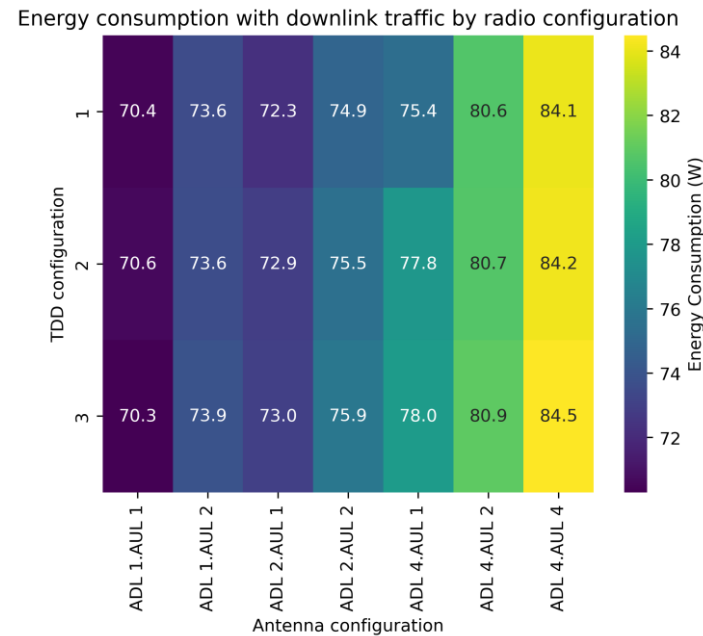
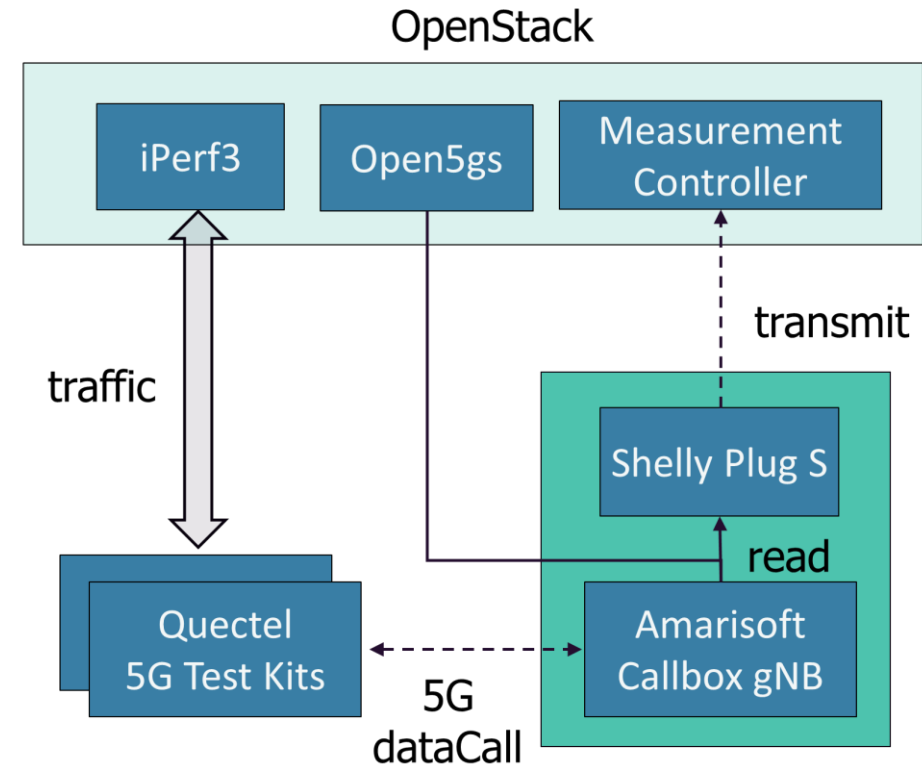


* Built as part of TNO Exploratory Research Program – Sustainable ICT 2024-25

* Built as part of SNS-EXIGENCE programme

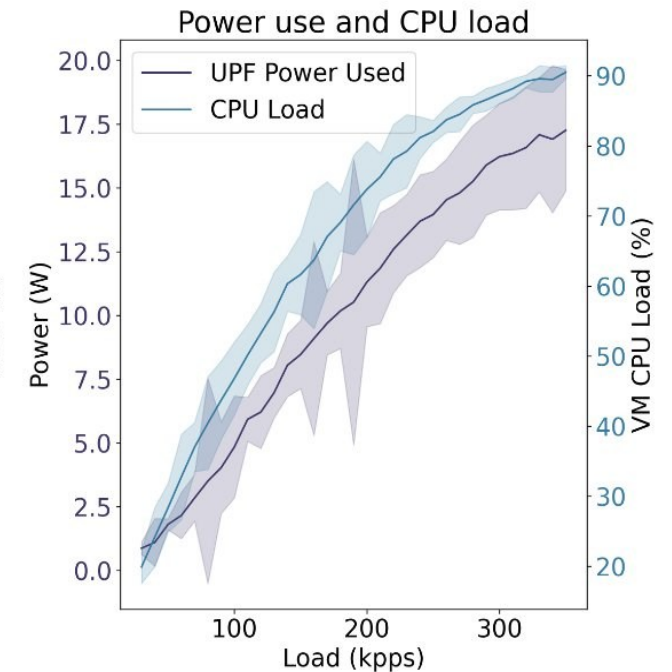
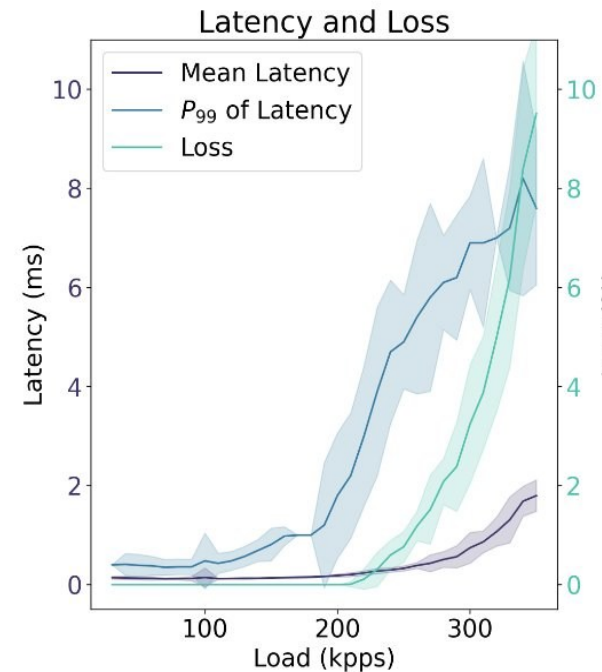
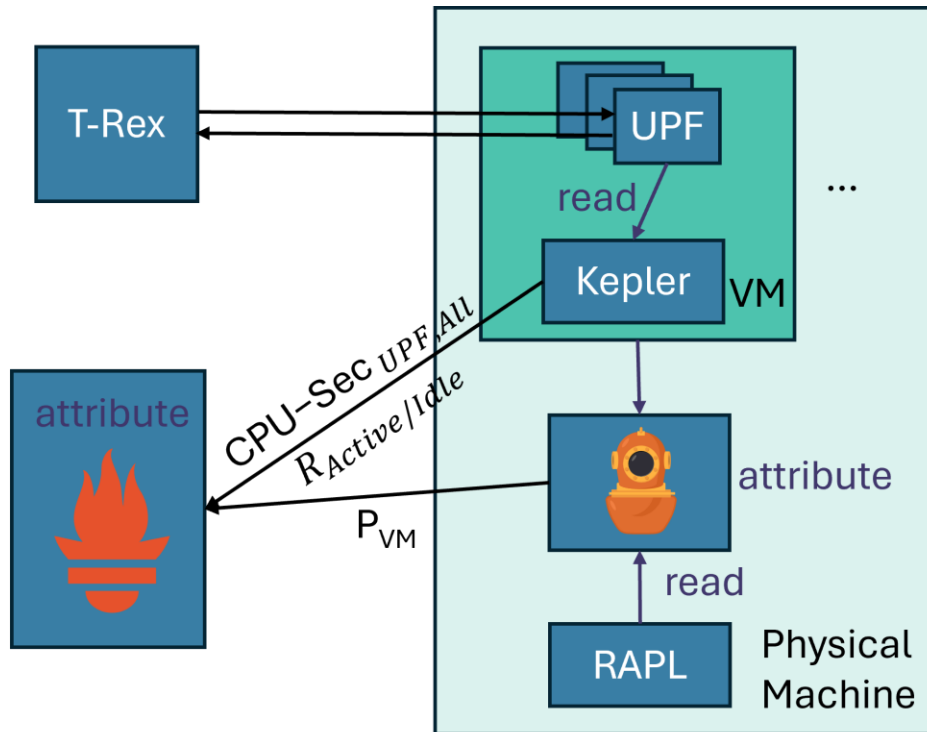
* Based on <https://github.com/dubrowgn/wattz>. Uses resources from <https://peach.blender.org/>

EXIGENCE – TNO's Lab Measurements RAN



$$P_{ue} = \frac{T_{ue}}{T_{total}} \times P_{Total}$$

EXIGENCE – TNO's Lab Measurements Core



$$P_{UPF} = \frac{\text{CPU-Sec}_{UPF}}{\text{CPU-Sec}_{All}} \times R_{Active} \times P_{VM}$$

EXIGENCE – Standardization Impact

έξιGence



TS 22.261: 5GA requirements on Energy Info Exposure;

5GA: Energy-based NF registration, discovery and selection, EIF enhancements for energy-based slice admission control

TR 22.870: 6G energy saving use case



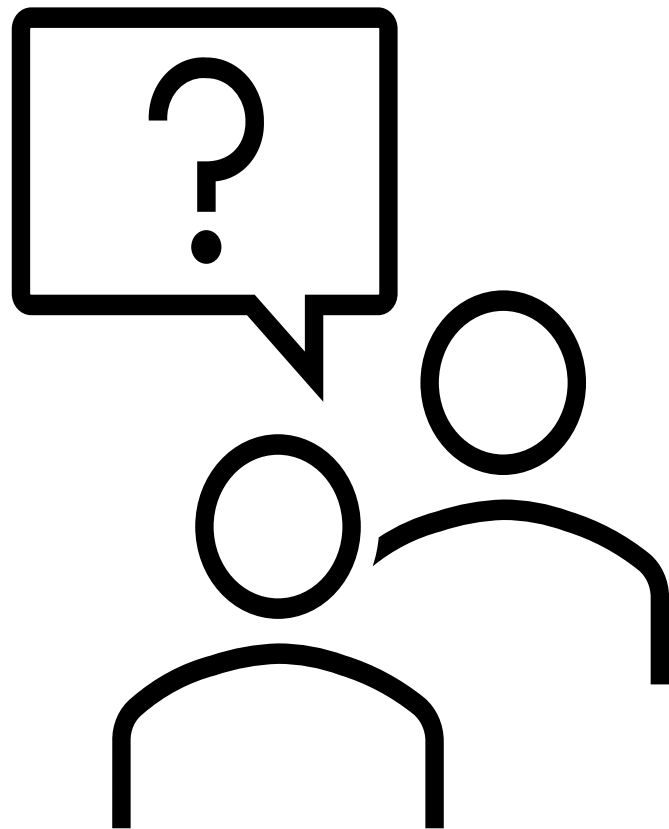
ISG on permissioned distributed ledger (PDL) for exchanging multi-domain data



GREEN working group:
PETRA, SmartPDU and the GREEN framework (incl. hackaton)

Summary and recommendations

- **End-to-end** (Inter-domain) energy consumption **visibility ENABLEs incentivization and optimization**
- **Intra-domain energy consumption measurement (and exposure) is feasible** i.e. methods/tools are available
- **Standardization support** (e.g. 3GPP, IETF, ETSI, etc.) for measurements, exposure and exchange
- Future work on:
 - Quantifying the energy consumption of Sensing and AI services (towards 6G)
 - Interfacing with energy suppliers for real-time energy mix (CO₂e)



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