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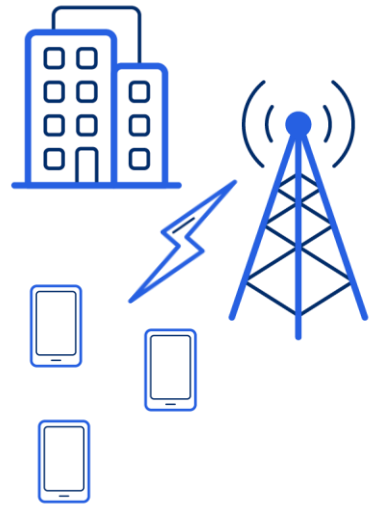
Energy Efficiency Testing in O-RAN: Power Consumption of Virtualized Environment

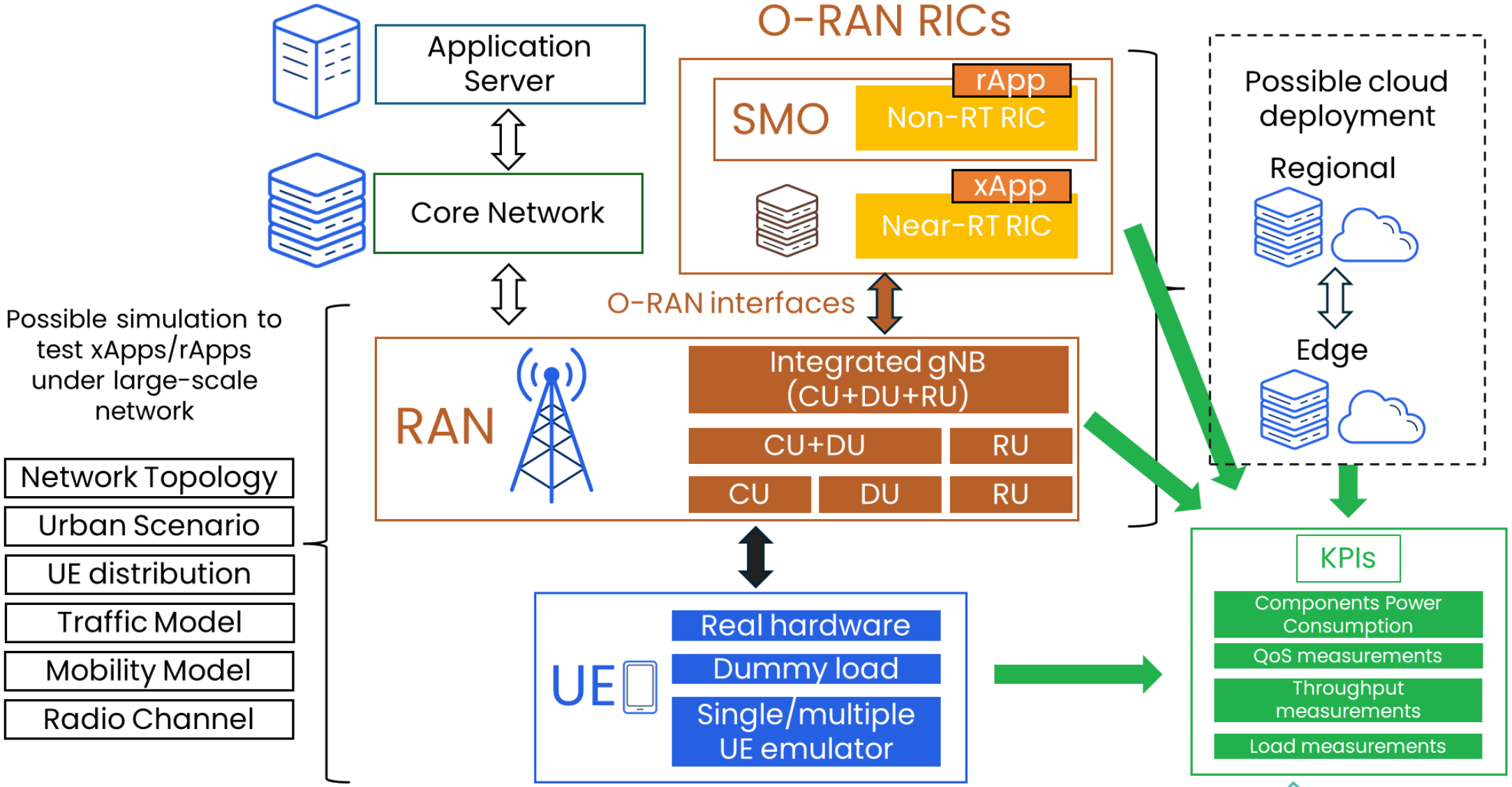
All things wireless

Challenges in O-RAN E2E Energy Efficiency Testing

- Multiple hardware and software vendors offer energy-saving solutions that are hard to compare – a lack of unified test definitions and scenarios
- Various organizations put effort into the energy efficiency testing, e.g., ETSI, 3GPP, O-RAN ALLIANCE, NGNM, TIP – yet their work cover different aspects of E2E EE Testing
- There is a demand to combine the current standardization efforts into the unified O-RAN E2E EE Testing Framework that would provide common procedures to evaluate energy efficiency of network components, like O-CU/O-DU/O-RU, and xApps/rApps

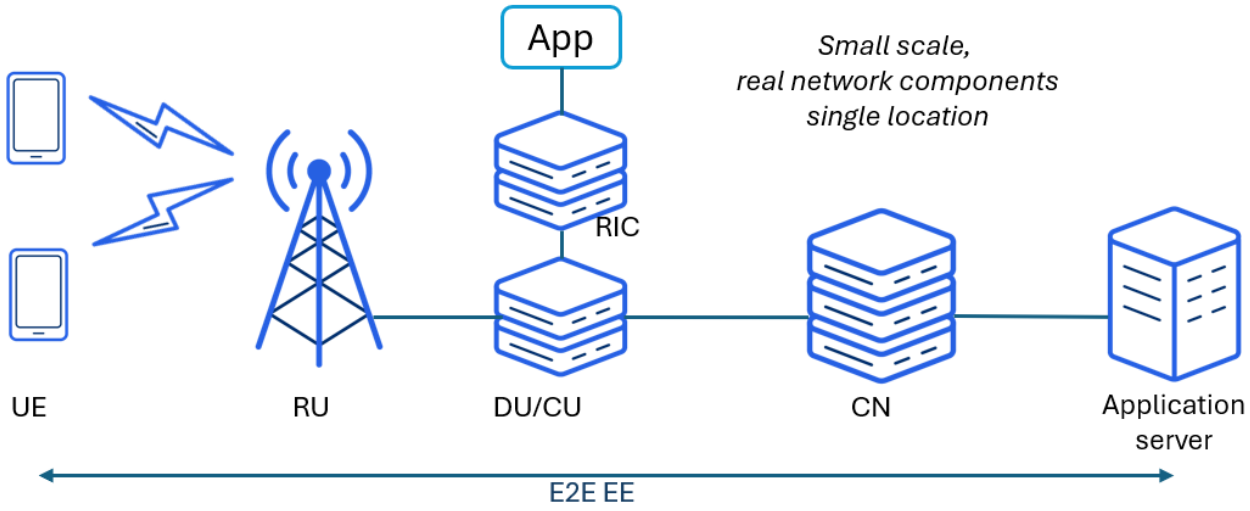


O-RAN E2E Energy Efficiency Testing **Framework**

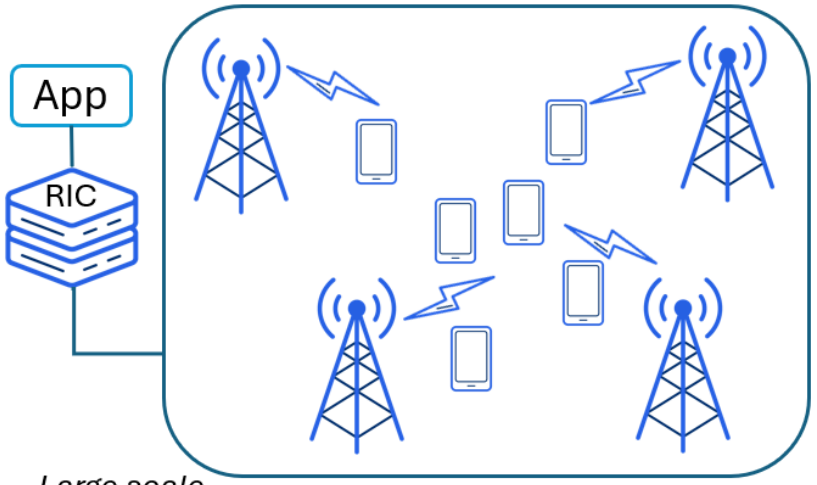


Different Views on E2E Energy Efficiency Testing

Component-level measurements for EE

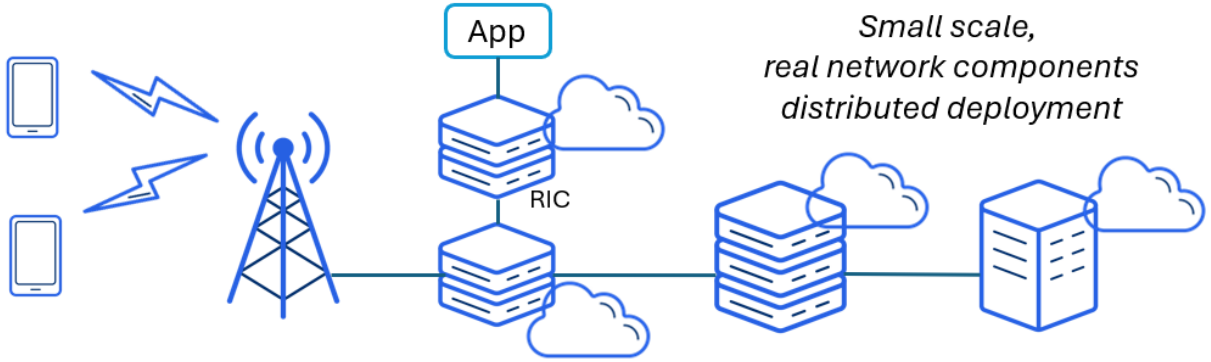


Global/feature based testing for EE

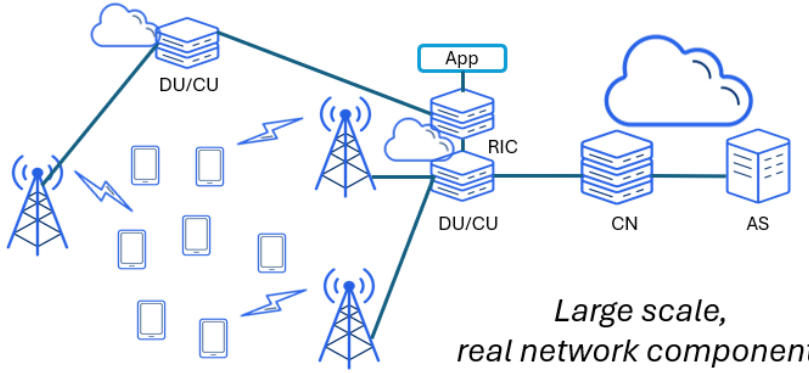


Large scale
Simulated RAN

Deployment view for EE testing



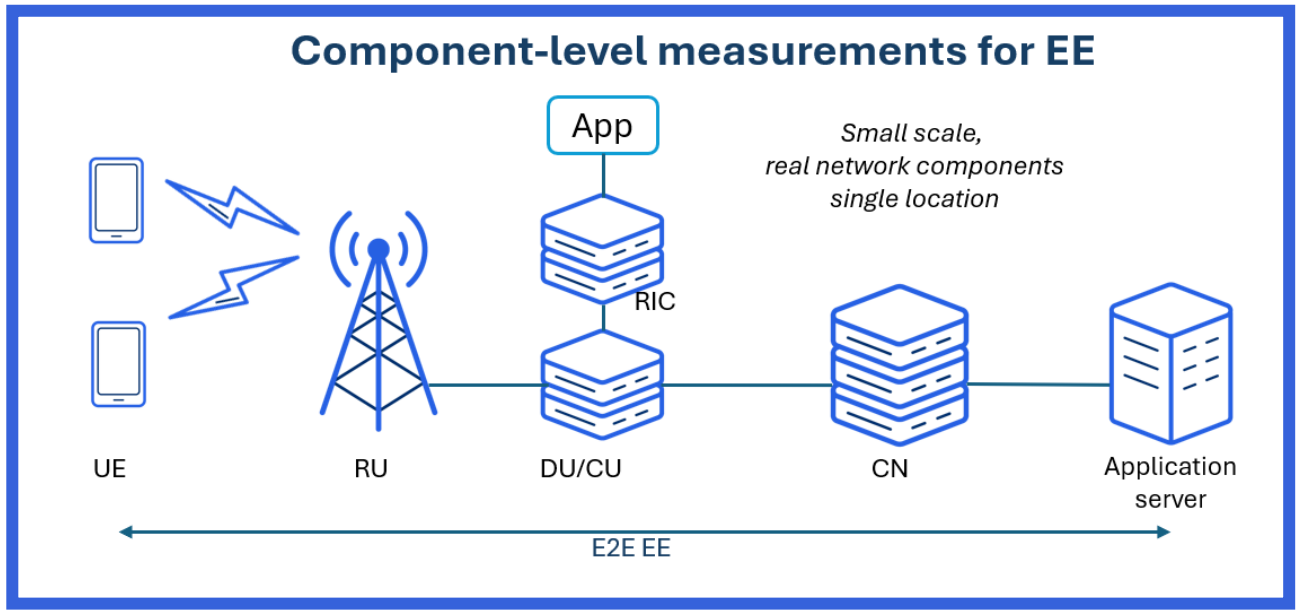
Multi-link/wide network EE testing

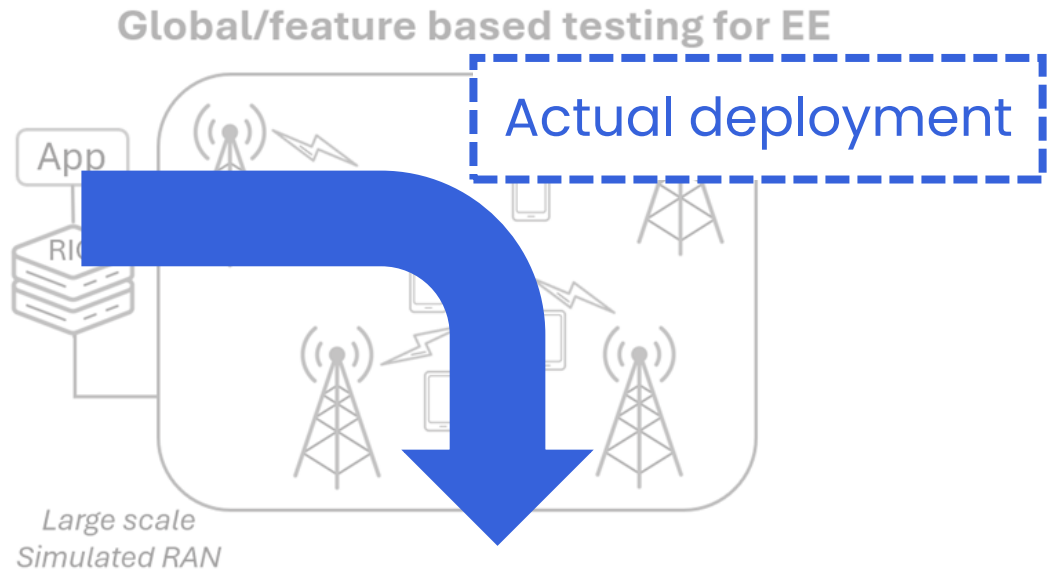


Large scale,
real network components

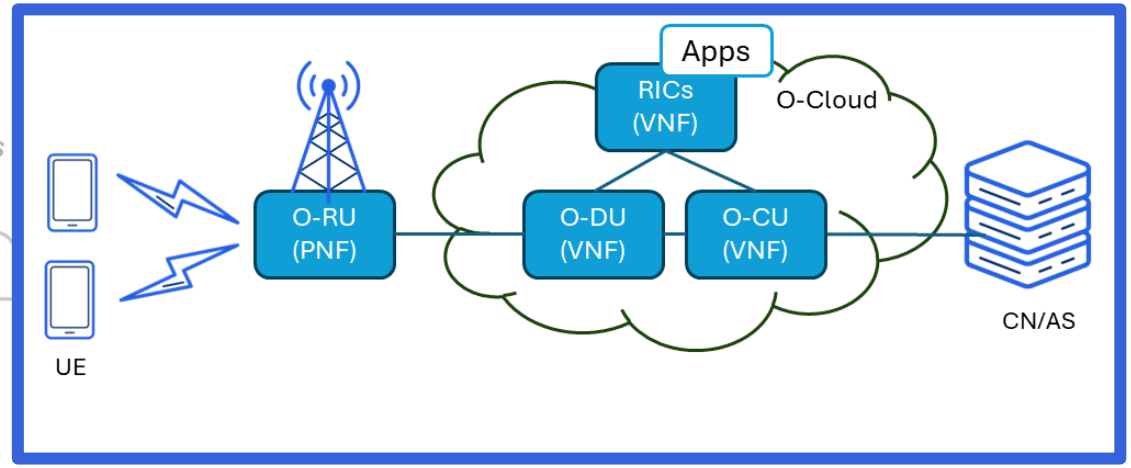
Measuring Power Consumption in a Virtualized Environment

Deployment Option for Energy Measurements

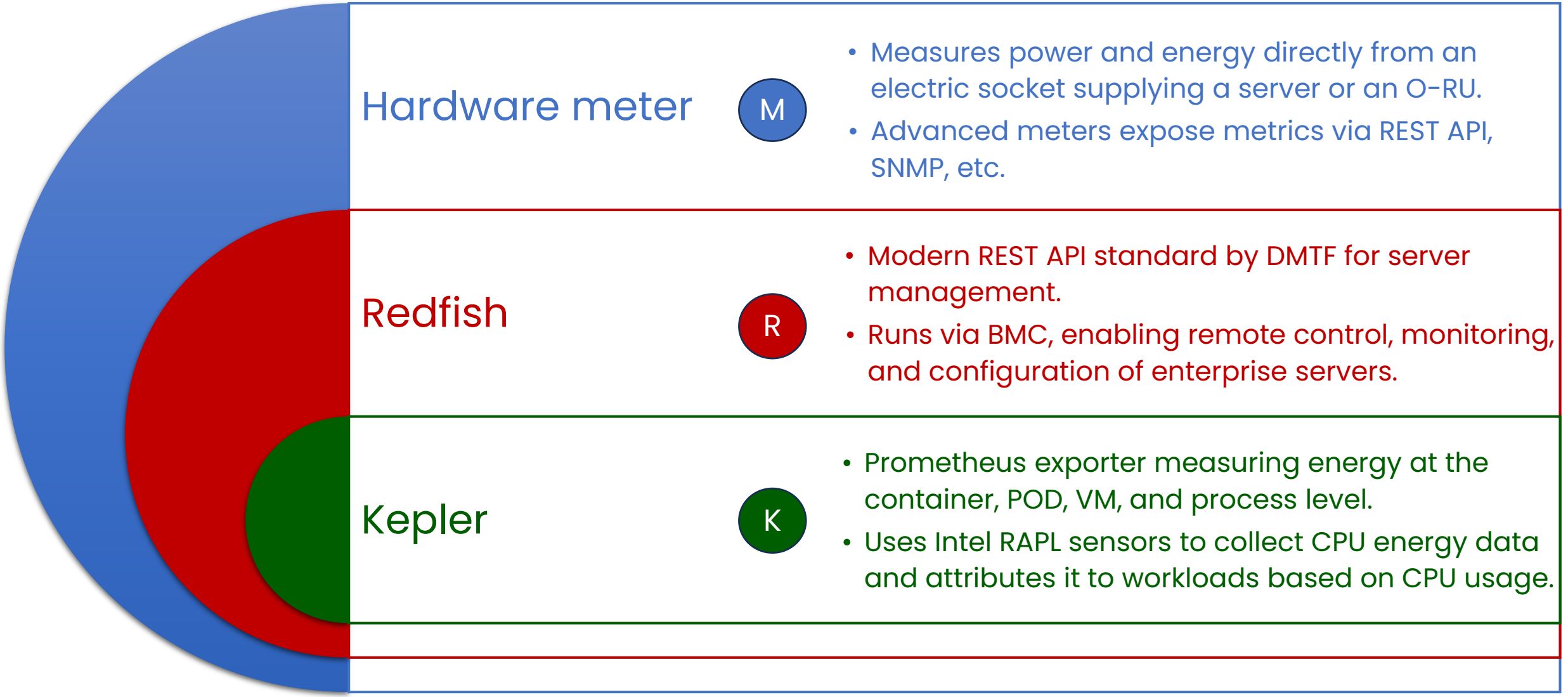




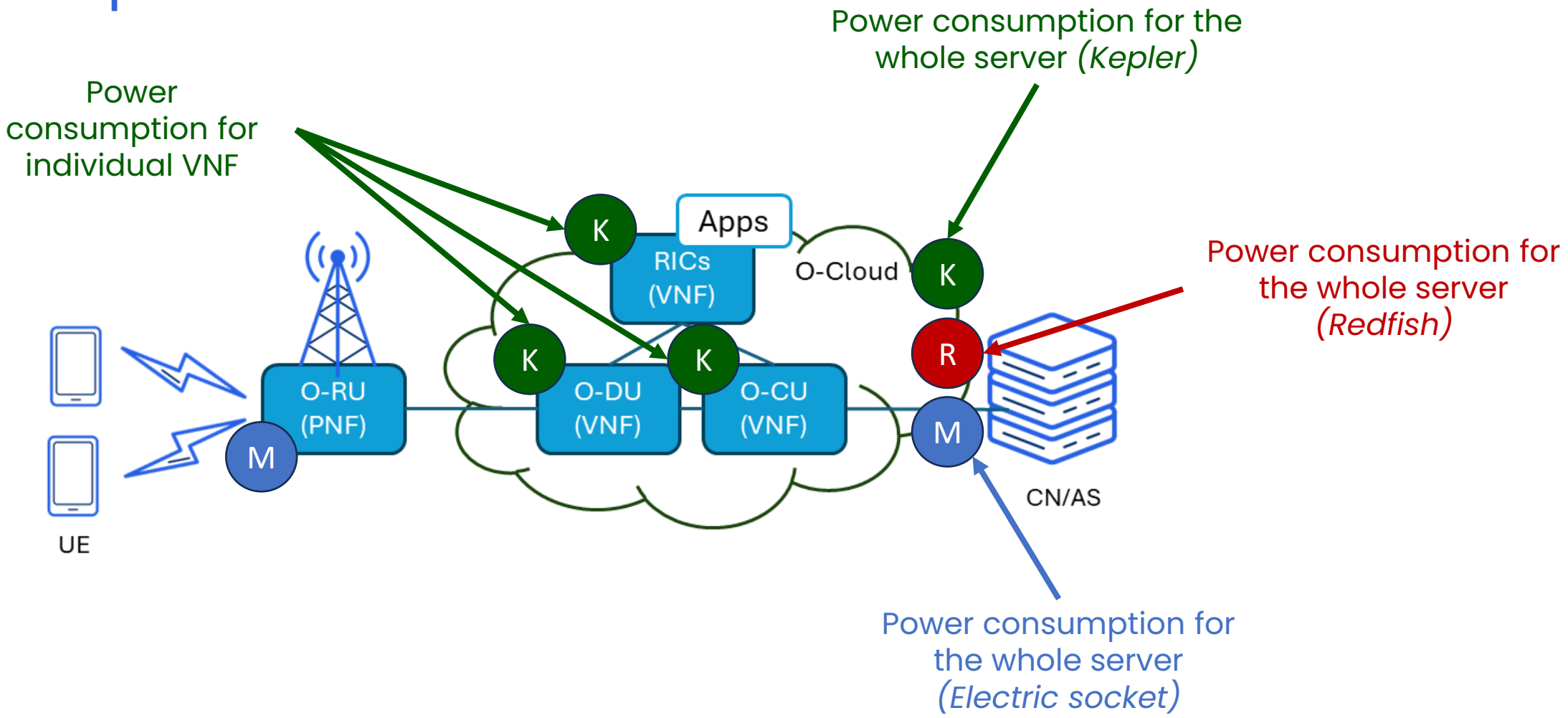
Energy testing framework option
used for current considerations



Power Consumption **Measurement Tools**



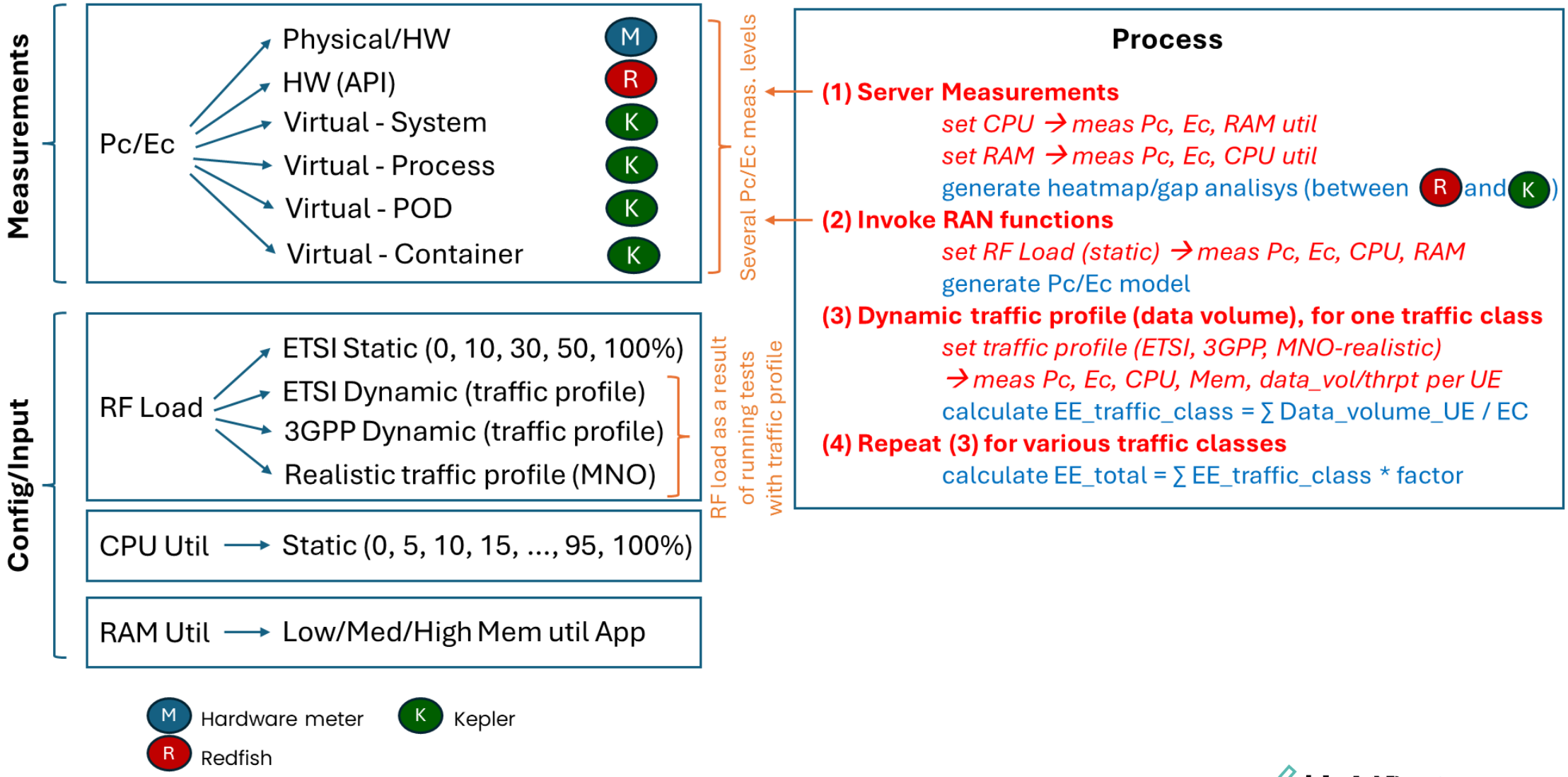
Measurement Points Definition for Power Consumption



M Hardware meter K Kepler

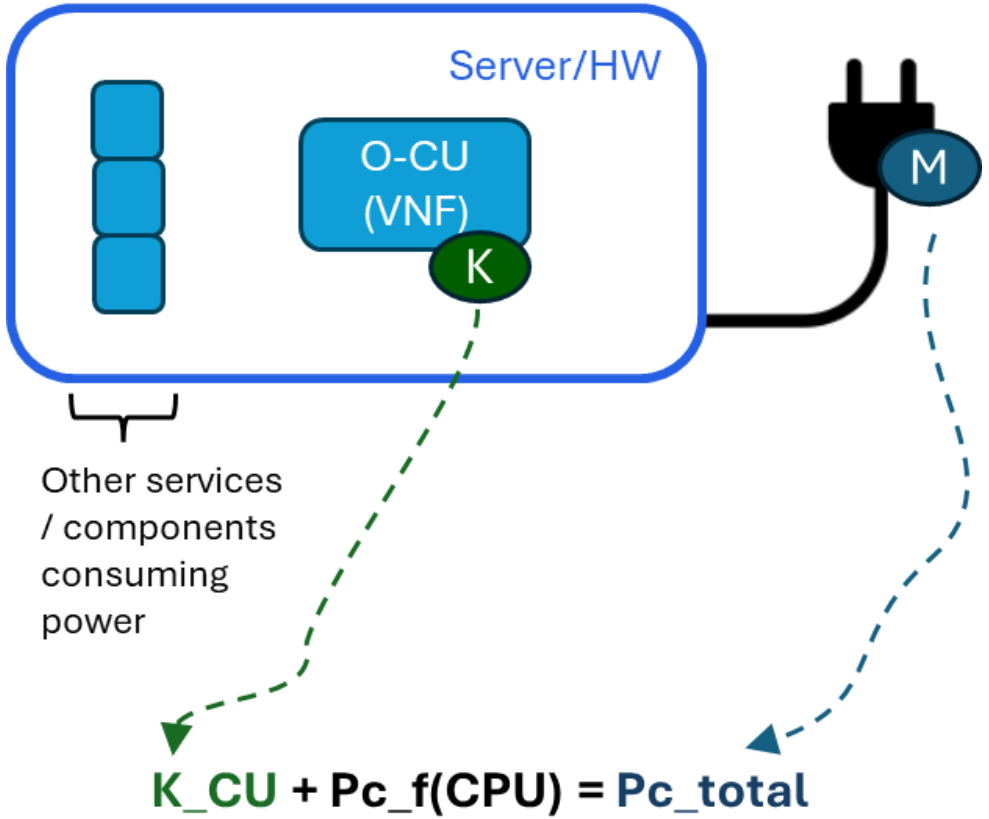
R Redfish

PC Measuremets – Configuration and Evaluation



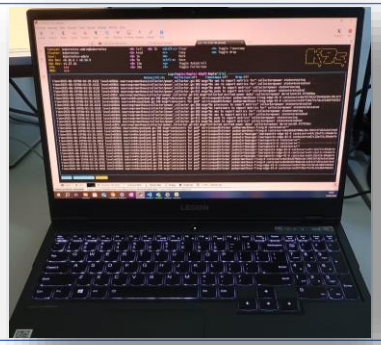
PC Measurements – Kepler vs Electric Socket

- Are both measurement types needed for reliable testing (i.e., Kepler and Socket-based)?
- Is there a specific function that binds measurement types so that we can measure one and estimate the other?

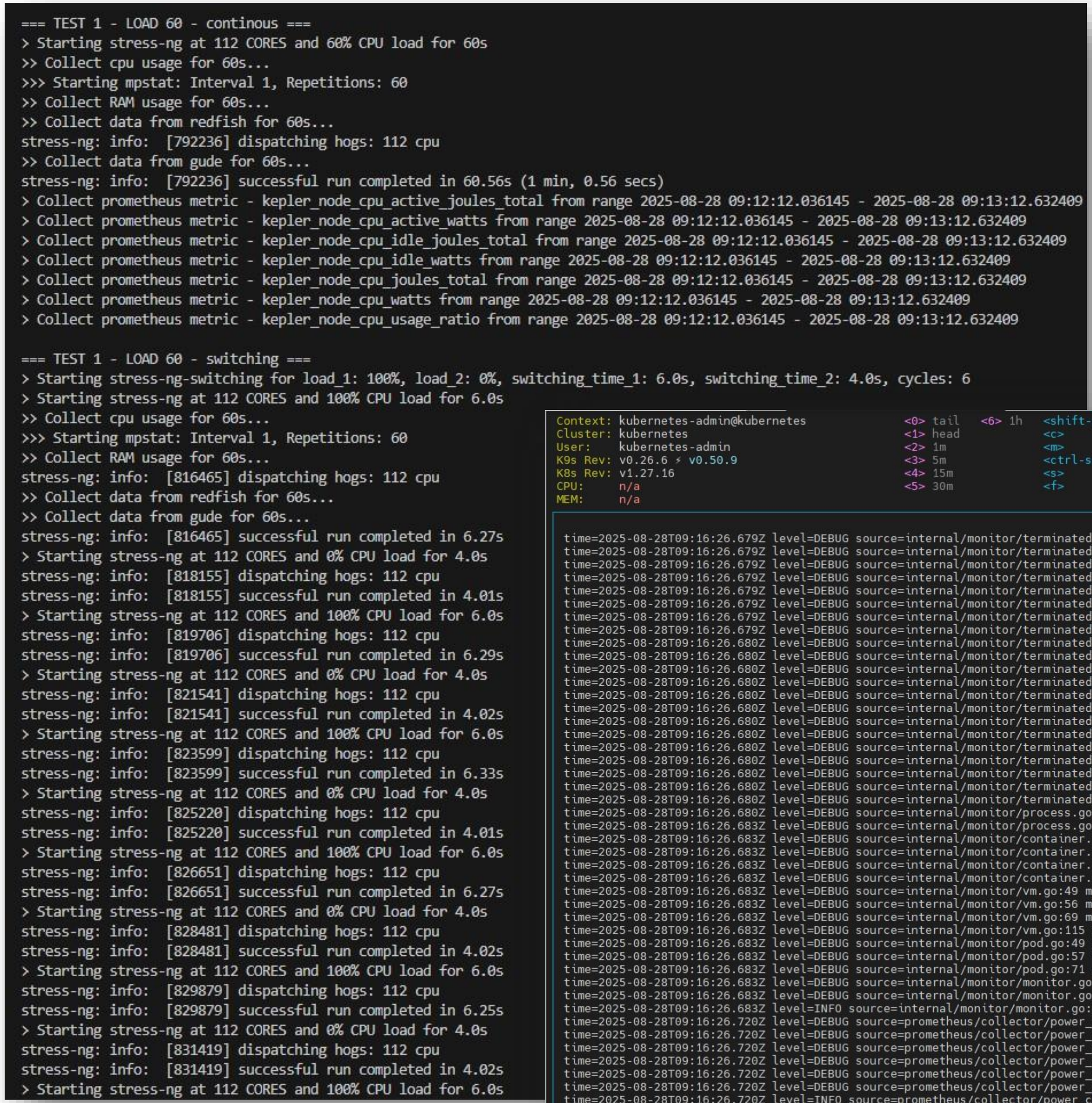


Power Consumption Measurement Results

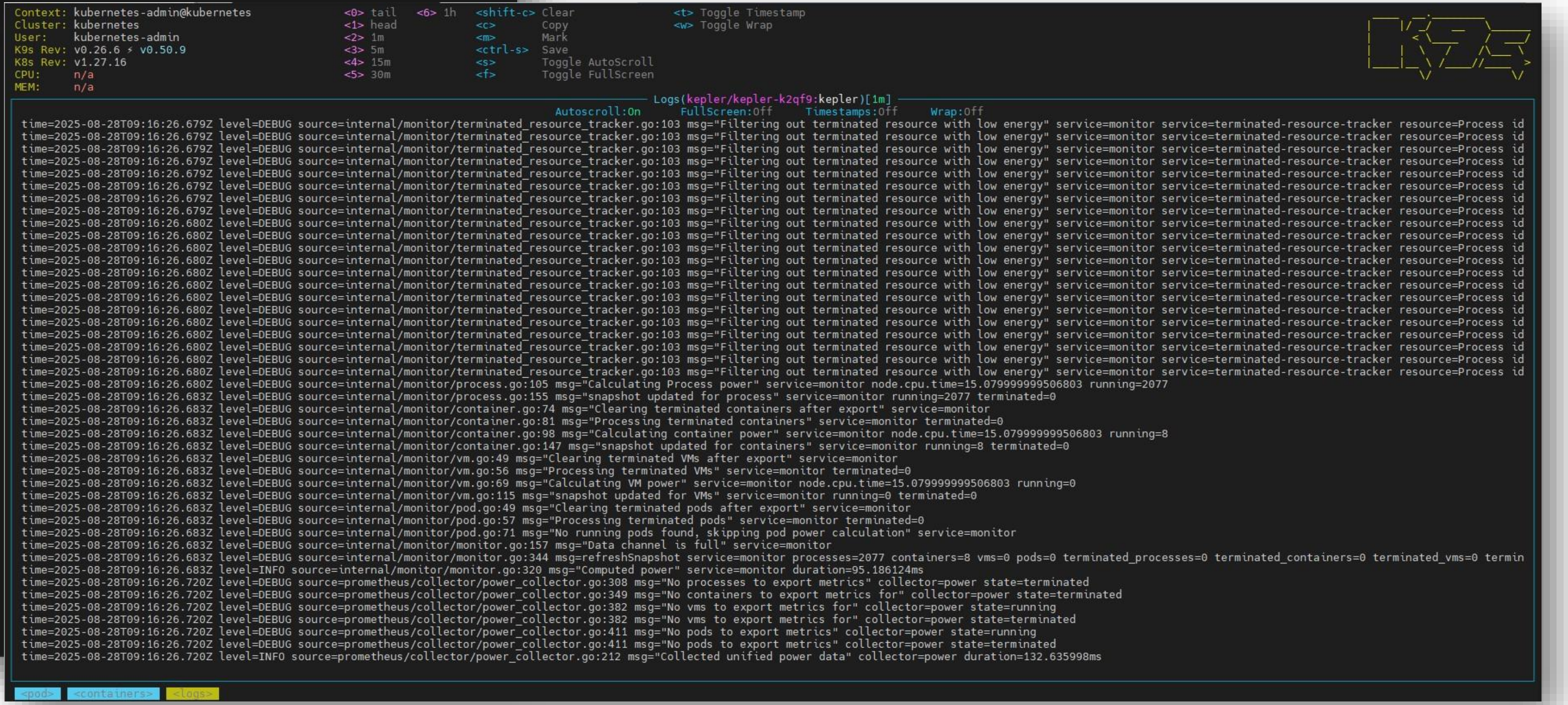
PC Measurements – Hardware Test Setups

	Dell R750 (enterprise grade server stored in i14y Lab's rack)	**Lenovo Legion 5 15ARH05** (consumer grade laptop)
CPU	2 x Intel Xeon Gold 6330N-2.2GHz (28 cores)	AMD Ryzen 7 4800H with Radeon Graphics 2.90 GHz (8 cores)
RAM	512 GB, 3200Mhz	32 GB, 3200Mhz
DISK	2xSSD 1.5TB	SSD 512GB
NIC	1 x 2-port 1GbE BCM5720 1 x 4-port 1 GbE Intel I350 4 x Intel XXV810 2-port 25GbE	1 x 1-port 1 GbE Wi-Fi 6 (802.11 a/b/g/n/ac/ax)
OS	Ubuntu 20.04.6 LTS	Ubuntu 22.04.5 LTS
Actual Hardware		
Power Measurement at Electric Socket	GUDE Electric Socket 	Shelly Smart Electric Socket 

Power Consumption **Measurements Collection**

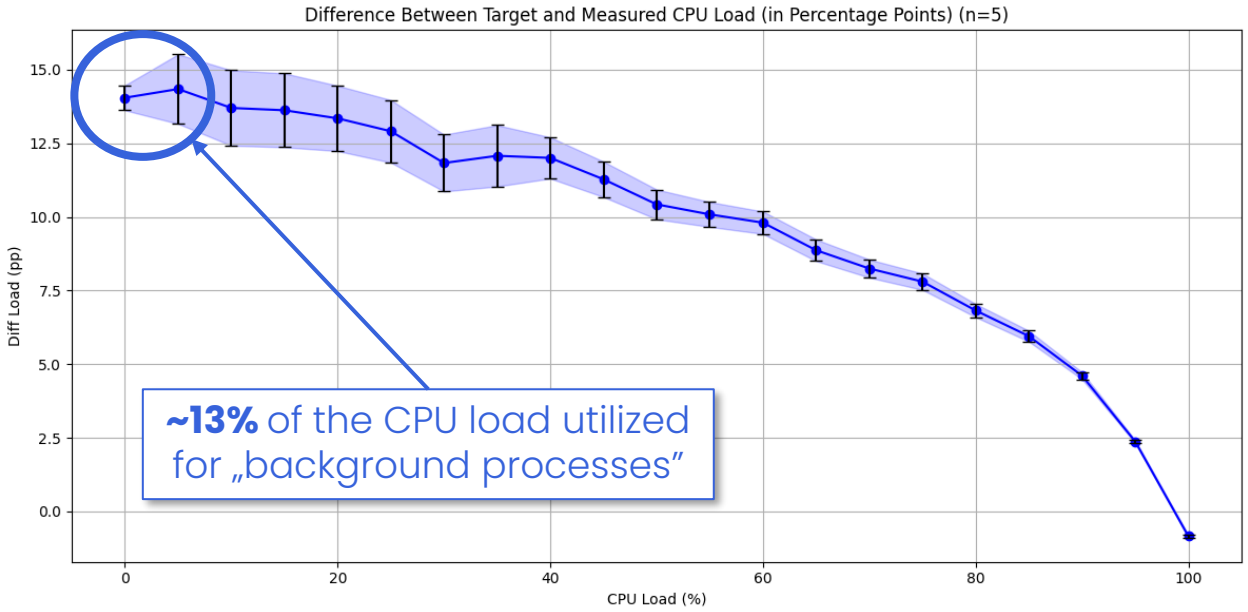


Gathering measurements from Kepler, Redfish, and Electric Socket at the same time

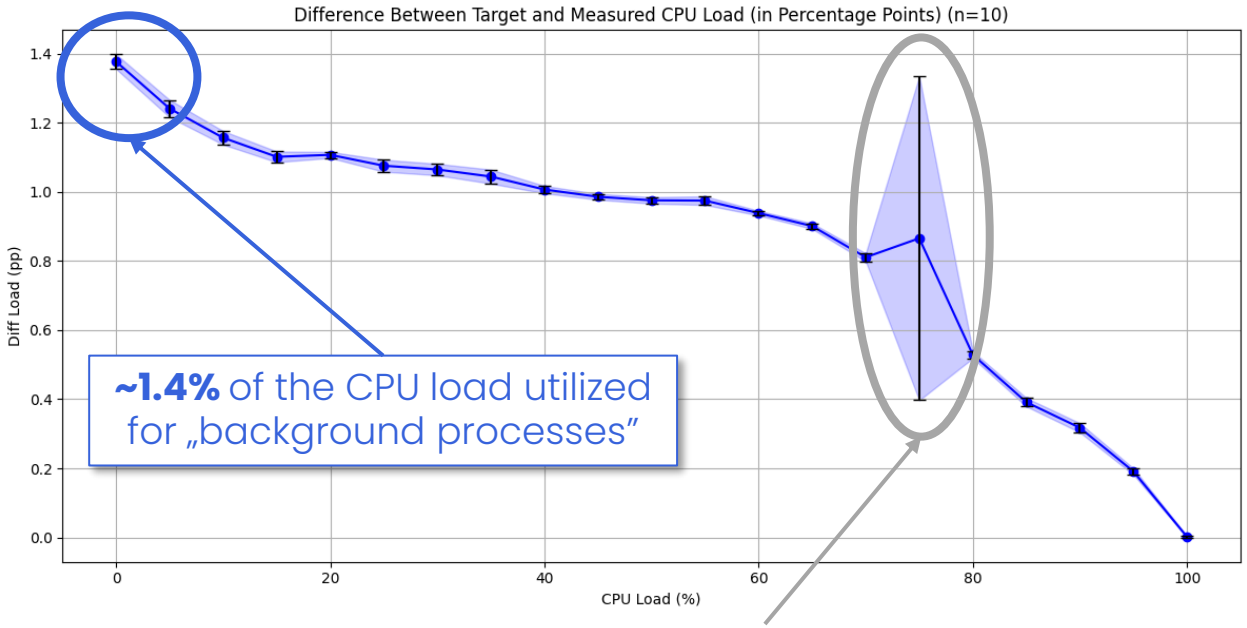


CPU Load – Enforced vs Measured

Dell R750 – Server



Lenovo Legion 5 15ARH05

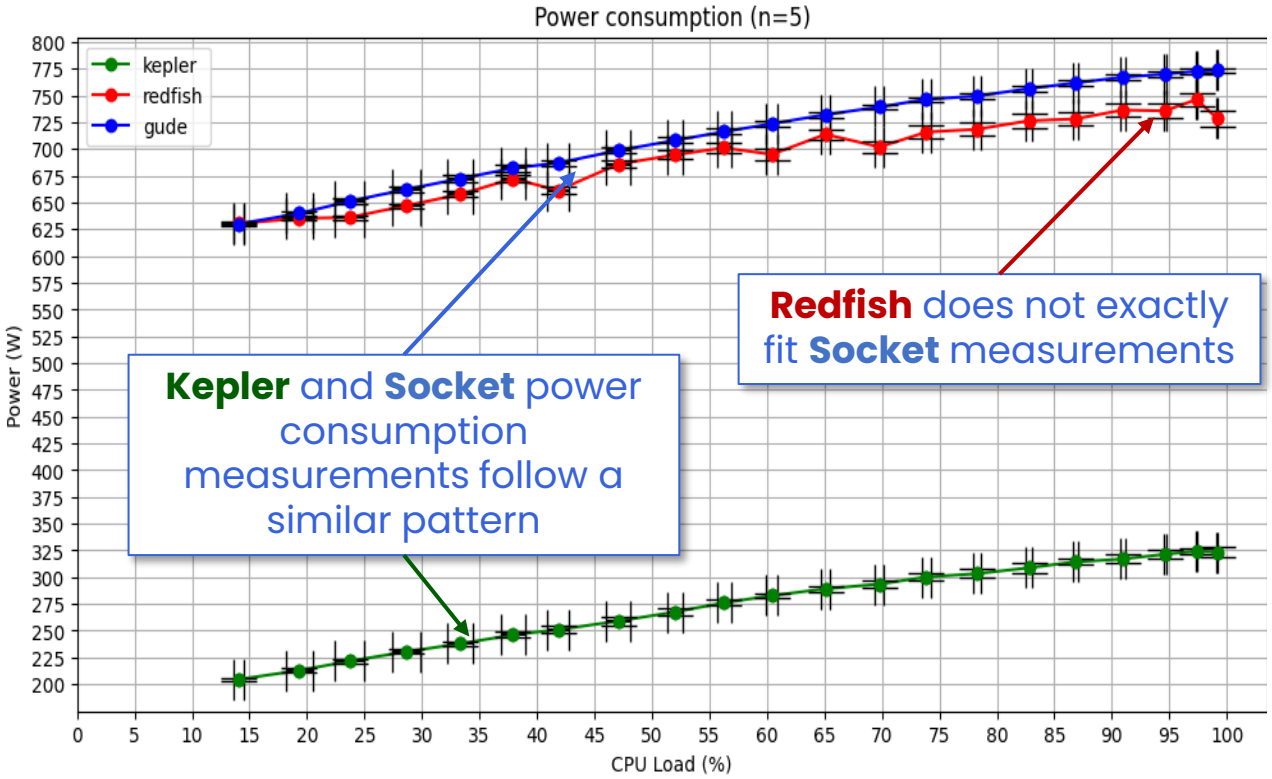


Some anomalies were observed for the laptop measurement, but their effect is minimal

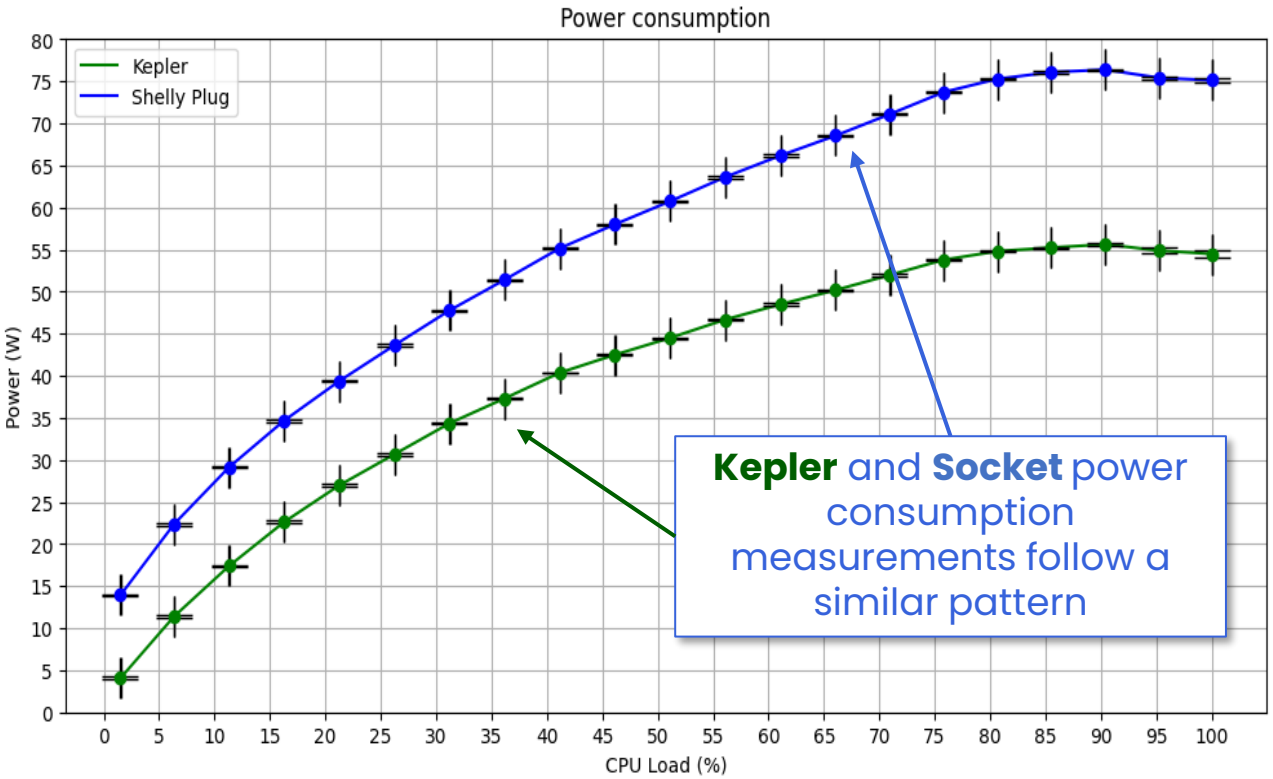
The **difference** between the **CPU load enforced by the stress-test application** and the **actual CPU load** is related to other processes

Static CPU Load - Kepler, Redfish, and Electric Socket

Dell R750 - Server



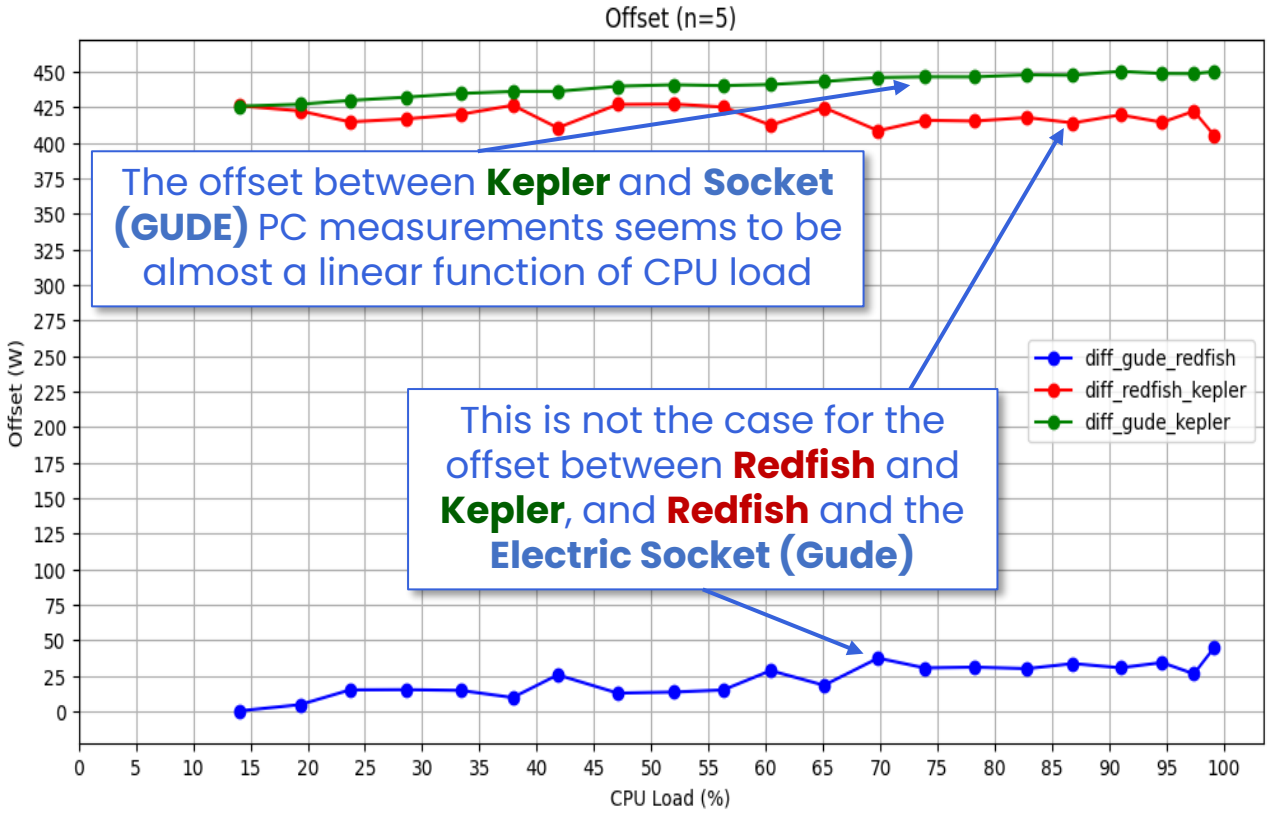
Lenovo Legion 5 15ARH05



Note: Redfish does not apply for consumer grade laptops

Static CPU Load - Offset Between Kepler, Redfish, and Electric Socket

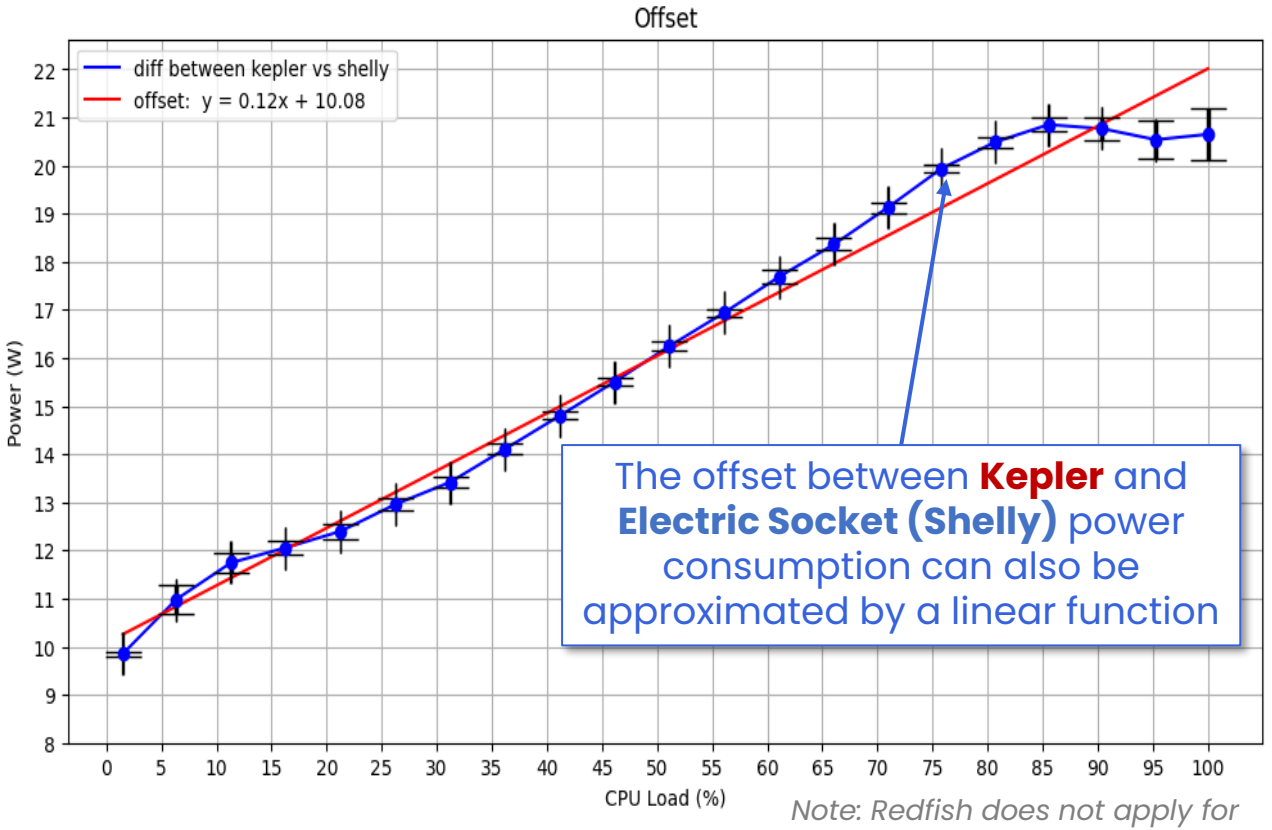
Dell R750



The offset between **Kepler** and **Socket (GUDE)** PC measurements seems to be almost a linear function of CPU load

This is not the case for the offset between **Redfish** and **Kepler**, and **Redfish** and the **Electric Socket (Gude)**

Lenovo Legion 5 15ARH05



The offset between **Kepler** and **Electric Socket (Shelly)** power consumption can also be approximated by a linear function

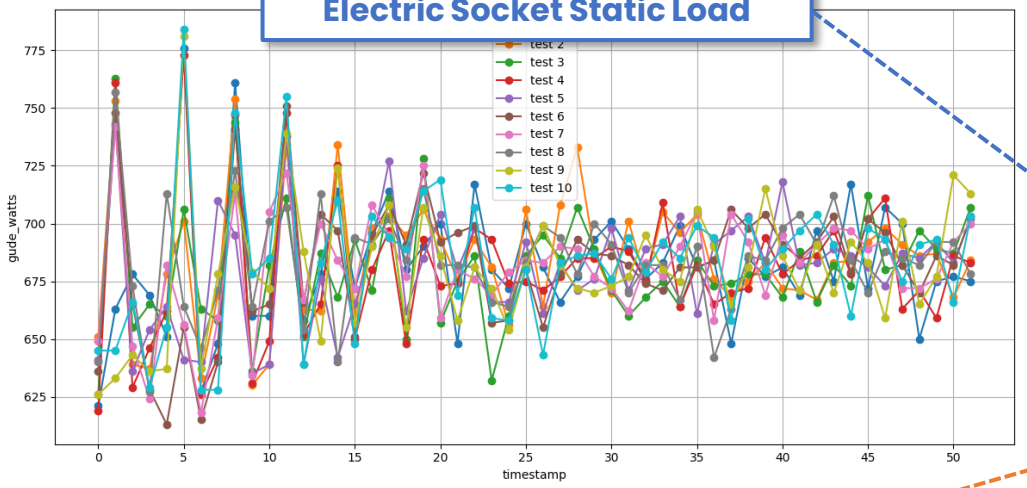
Note: Redfish does not apply for consumer grade laptops

In both cases, the **offset** depends on the **CPU load** and is **close to linear** characteristics

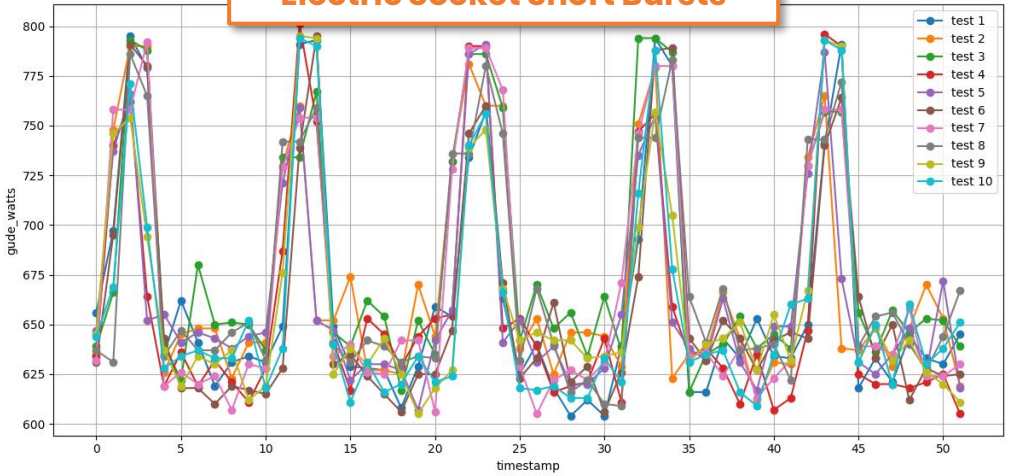
Static vs. Short Bursts CPU Load (Dell R750)

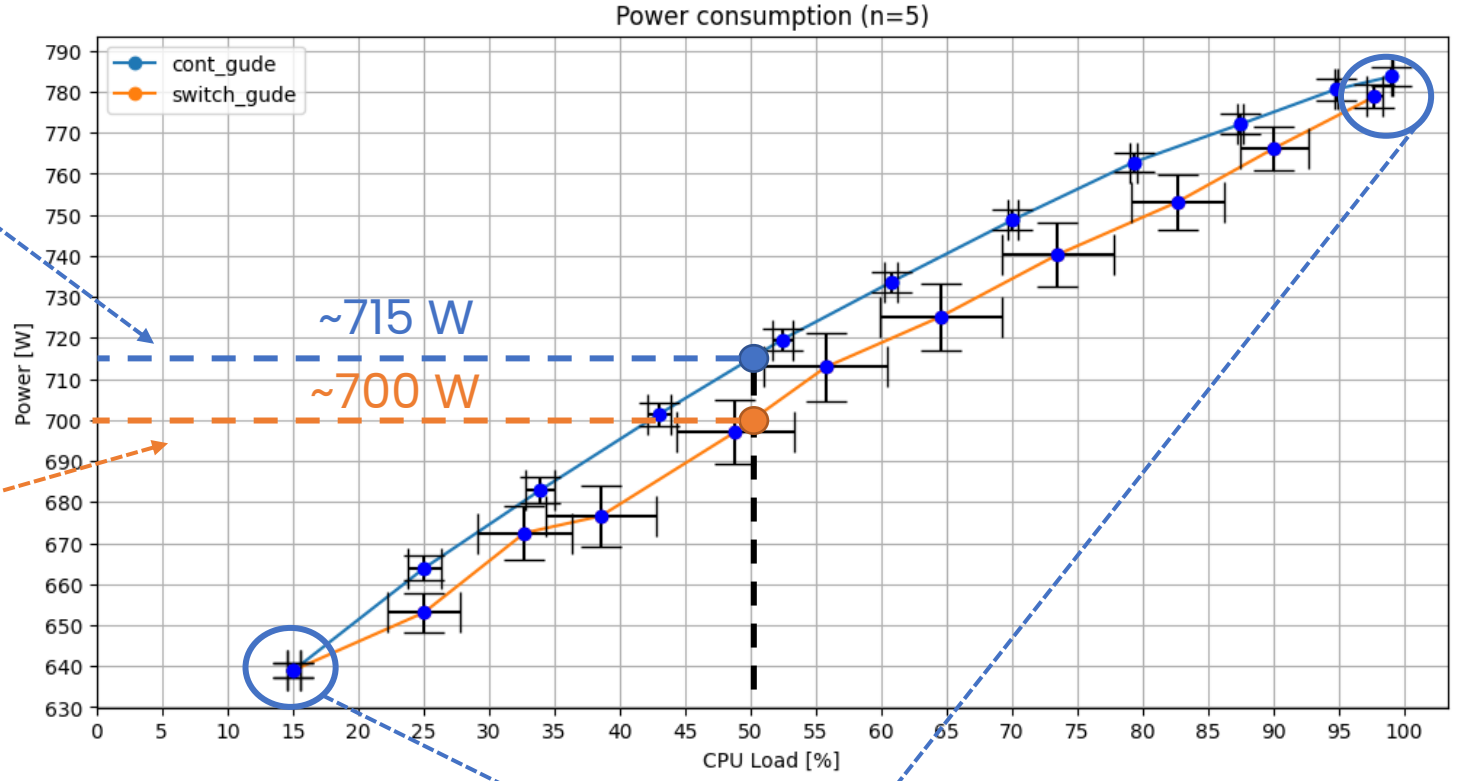
We compared the PC measurements under **static CPU load**, at 50% CPU load, against the **short bursts:** to achieve 50% CPU load, in 10s cycles → 5s of 100% CPU load, then 5s of 0% CPU load

Electric Socket Static Load



Electric Socket Short Bursts





~700 W: 640 x 0.5 + 780 x 0.5=710 W

A mismatch of 10W can be caused by a large results spread

Conclusions

Conclusions

- The component-level setup for EE measurement was selected for the next phase of the work.
- The current work is to define a methodology to measure the VNFs power consumption deployed on the same server.
- The following power consumption measurement points were identified:
  - Power Consumption for the whole server (Electric Socket, Kepler, Redfish),
  - Power Consumption for individual VNF (Kepler).
- Power consumption measurements for a consumer Laptop and a Dell Server were conducted under a static CPU load forced by a third-party APP.
- The gap between Kepler and the Electric Socket follows an almost linear function.
- In the case of a server, there is a big "constant" power value, even, if the CPU utilization is very low. It may be useful to have it occupied fully or switched off.
- Another set of tests for the Dell Server covered power consumption measurements under dynamic CPU load conditions using bursty traffic and showed that for such traffic, the average power consumption is similar to static load values.
- The next steps cover power consumption measurements of individual PODs, e.g., measurements for RIC and xApps operating under the simulated RAN environment.

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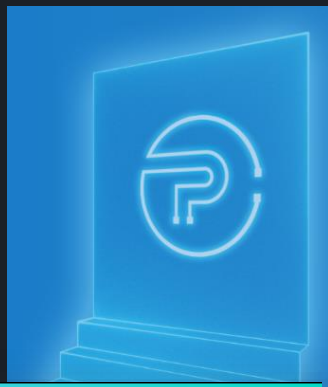
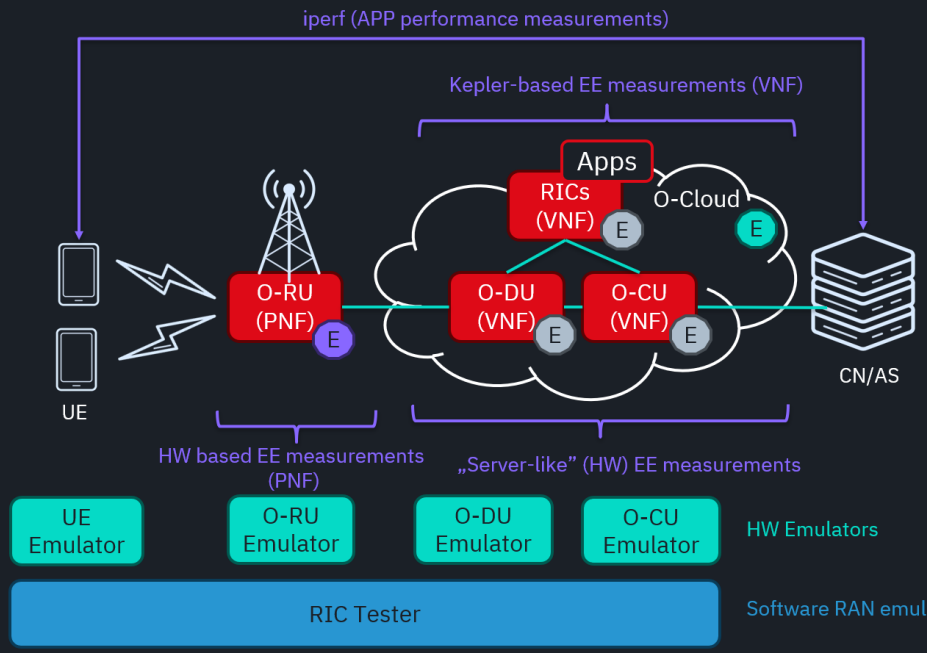


List of participants

Hosts:

In addition to the host, participants included

Building Blocks of E2E EE Testing Framework



Building block	Example partner
O-RU	O-RU Vendor 1
O-DU/ O-CU	O-DU/O-CU Vendor 2
RIC	Near-RT RIC Vendor 3 Non-RT RIC Vendor 3 or 4
xApps rApps	xApp Provider 1 rApp Provider 2
Measurement tools	Measurement Vendor 5
Hardware Emulators	O-RU, O-CU, O-DU, UE Emulator Vendor 6
RIC Testers	Vendor 7

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Joint Content Production

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RIC-Apps Conflict Management

White Paper

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i14y Energy Efficiency Testing Framework

White Paper

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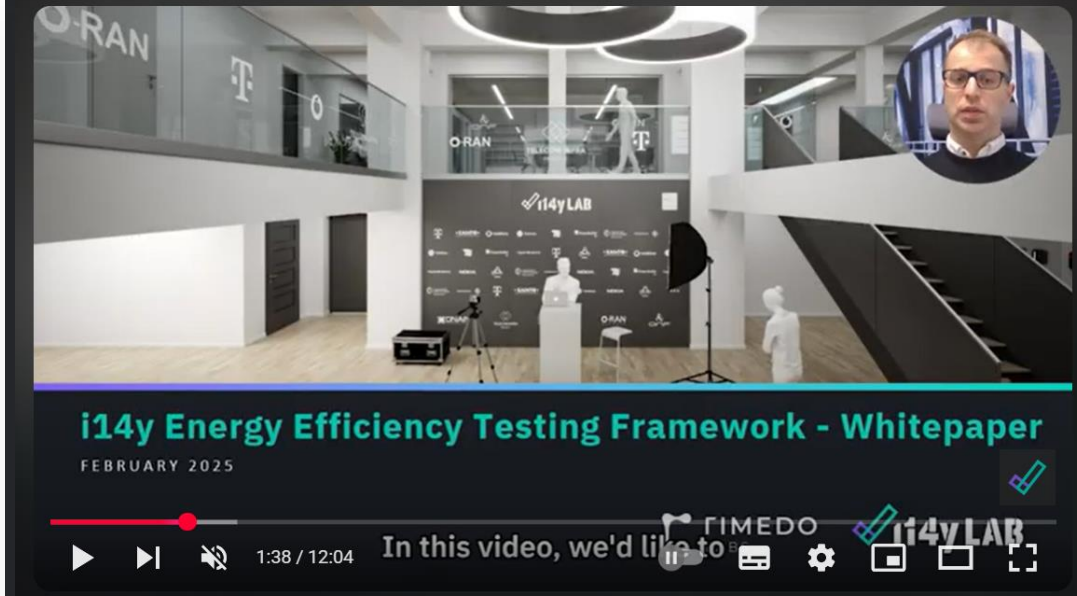

Energy Efficiency Testing Framework — White Paper | i14y Lab Unplugged

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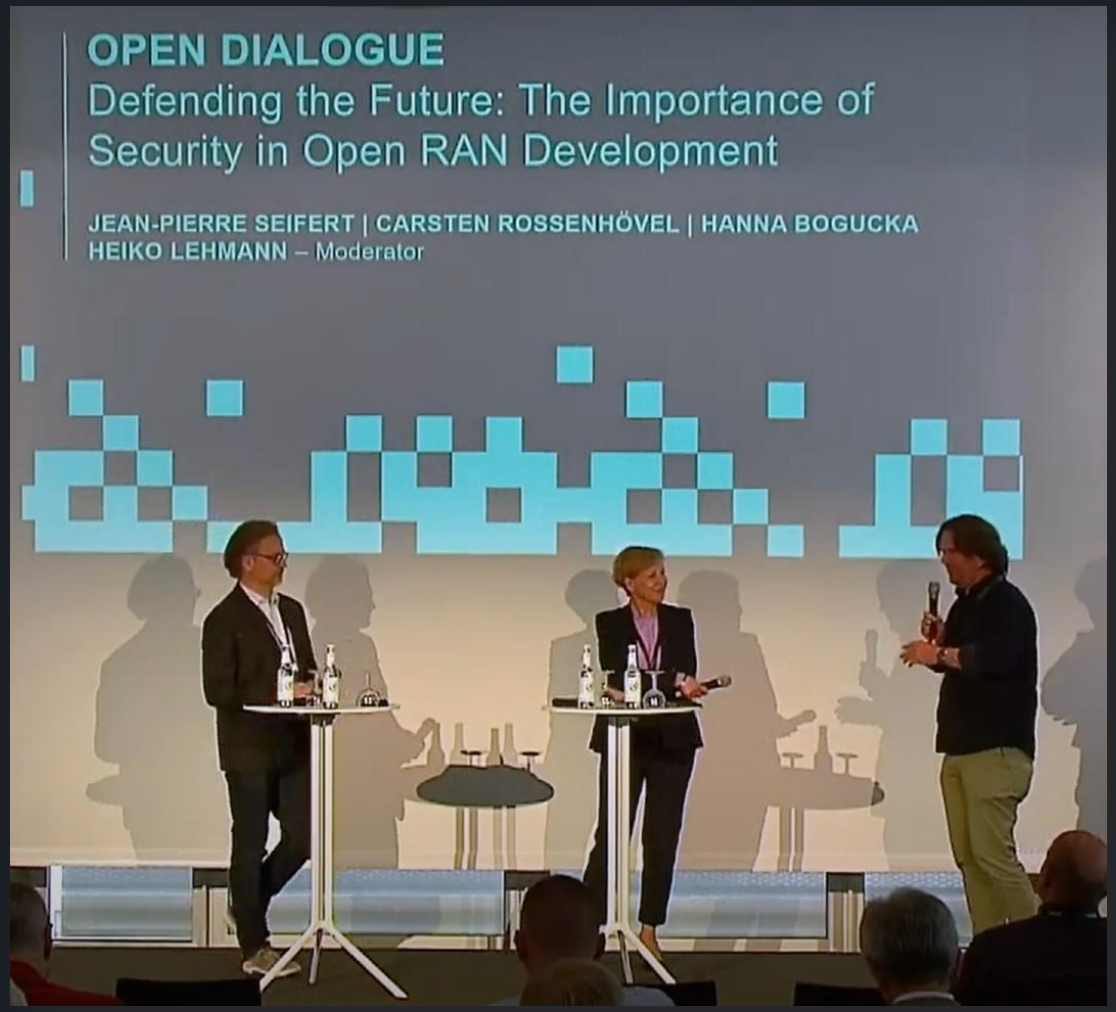
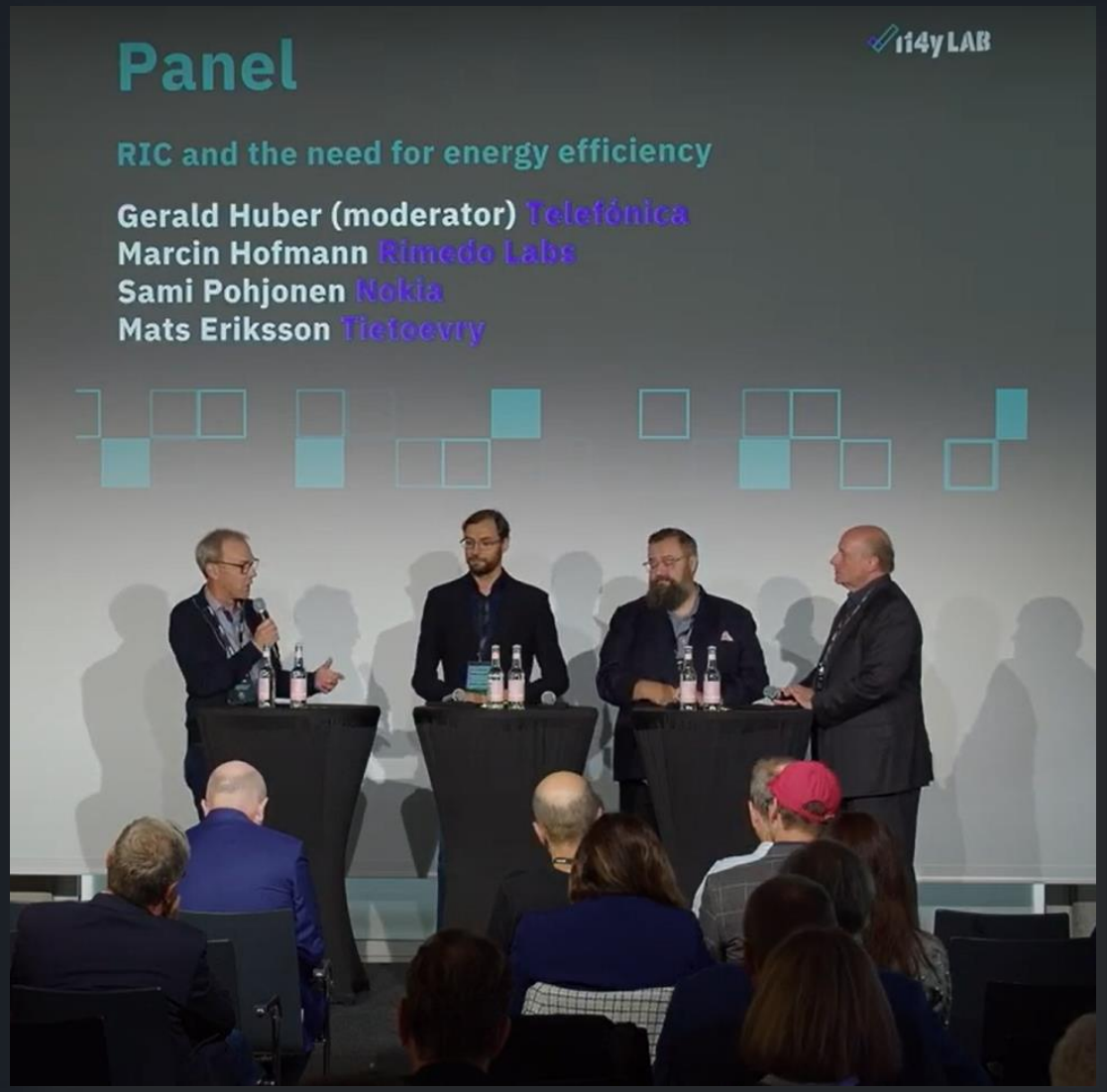
Participation in i14y Lab Summits





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