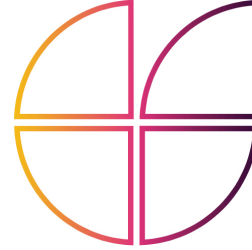




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Real-Time Telemetry for Carbon-Aware Networking: Measuring and Reducing Environmental Impact

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Growing Environmental Impact of Networking

- ❑ The Information and Communications Technology (ICT) sector, which includes data networks, currently consumes approximately **2-3% of the world's electricity**.
- ❑ By **2030**, this could grow to **8-21%** if left unchecked due to rapid global internet expansion and increased device usage.
- ❑ Unlike data centers, which have seen improvements in efficiency, networks have lagged behind
 - **complexities** in measurement
- ❑ Data transmission has become a significant, yet often overlooked, source of carbon emissions.

Challenges in Measuring Network Power Consumption

- ❑ Quantifying and subsequently reducing the consumption of electricity is no easy task:
 - Many contributors (client device, infrastructure, communication links)
 - Lack of awareness of the problem
 - Lack of **standards**
 - Lack of **tools for collecting data**

- ❑ Current network monitoring tools **collect traditional metrics** (latency, throughput, and packet loss).
 - Related to **performance or security**, rather than power consumption and its link to carbon impact

- ❑ Much of the work on power consumption has focused on **data centers**, rather than end-to-end networked systems.

Carbon Intensity as a Key to Network Emissions

- ❑ Knowing the total electricity usage is not enough.
- ❑ The **carbon-intensity** of that electricity must be derived to determine **the carbon footprint** of network elements.
- ❑ **Carbon intensity** is defined as the amount of carbon by weight emitted **per unit of energy** consumed.
- ❑ The data that we do have suggests that networks are a **dominant component** in the carbon footprint of digital infrastructure.

Enabling Real-Time Carbon Efficiency in Networking

- To properly account for the **carbon efficiency** of networking, we argue for an **end-to-end approach**, specifically:
 - Devices should be able to report their **real-time or near real-time** electricity consumption.
 - Devices should be able to report the **carbon-intensity** or quality of consumed electricity.
 - Applications and services should **react in (near) real-time** to carbon-related information collected from the network.

Challenges in Network Telemetry for Carbon Reporting

- ❑ Network equipment manufacturers tend to report **the maximum power consumption** of a platform.
 - The difference between **average and maximum** may be large (or small).
 - This may not accurately represent the actual platform carbon emissions.

- ❑ The absence of **hardware support** within the platform does not mean that we need to wait for new devices to come to the market.
 - It is possible to leverage **proxy data** that will indicate usage.

- ❑ To make use of the real-time information, there is a need for an **end-to-end reporting mechanism**.
 - Similar to in-network telemetry used for end-to-end network performance

Challenges in Network Telemetry for Carbon Reporting

- ❑ Electricity consumption **is not an indication** of carbon emissions.
 - The carbon intensity of the energy source must be factored in.

- ❑ A distinction could be made between elements consuming electricity from **renewable energy sources** versus **fossil fuel**.

- ❑ The availability of carbon intensity data is not without its challenges:
 - While many regions globally are making carbon intensity data available publicly, **coverage is incomplete**.
 - The **frequency of the data updates** varies considerably across regions.
 - The measurement data must also be **verifiable**.

Challenges in Network Telemetry for Carbon Reporting

- ❑ Both the **energy provider**, and **the network operator**, would need to add new support.
- ❑ The energy provider should send **electricity-quality information** (periodically or through dedicated API).
- ❑ The network operator should **process and propagate** this information as part of in-network telemetry (INT) updates.

Conclusion

- ❑ Networking needs to be **carbon-efficient**, like any other part of digital infrastructure.
- ❑ To achieve real progress, **standard metrics** need to be supported and reported by network devices.
- ❑ We call on the IETF community to join the effort to **define these metrics**. Together, we can make networking truly **green**.