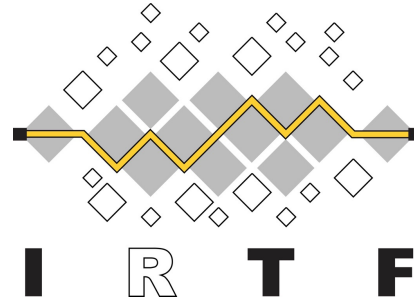**UiO : Faculty of Mathematics and Natural Sciences**
University of Oslo

Sustainability and the Internet:
An Overview of IETF Activities

Michael Welzl

- "The Internet Engineering Task Force (IETF), founded in 1986, is the premier standards development organization (SDO) for the Internet. The IETF makes voluntary standards that are often adopted by Internet users, network operators, and equipment vendors, and it thus helps shape the trajectory of the development of the Internet. But in no way does the IETF control, or even patrol, the Internet."
[https://www.ietf.org/about/introduction/]

- "The Internet Research Task Force (IRTF) focuses on longer term research issues related to the Internet while the parallel organization, the Internet Engineering Task Force (IETF), focuses on the shorter term issues of engineering and standards making." [https://www.irtf.org]

- "The Internet Architecture Board provides long-range technical direction for Internet development, ensuring the Internet continues to grow and evolve as a platform for global communication and innovation. The IAB does not operate from a grand-architecture blueprint of the Internet. Rather, the IAB's efforts are guided by fundamental design principles—the Internet's building blocks and their interactions—that make the global, open Internet what it is." [https://www.iab.org/about/]
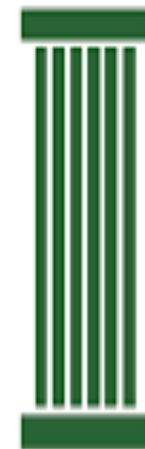
Sustainability Defined

"Meet the needs of the present without compromising the ability of future generations to meet their own needs."

Environmental   **Social**   **Economic**

Sustainability encompasses **many** things!

Networking contributes to SDGs

- **Target 9.1:** Develop quality, reliable, sustainable and resilient **infrastructure**, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all

- **Target 9.c:** Significantly increase **access to information and communications technology** and strive to provide universal and affordable access to the Internet in least developed countries by 2020
  - Indicator 9.c.1: Proportion of population covered by a **mobile network**, by technology

- **Target 17.6.1:** Enhance North-South, South-South and triangular regional and international cooperation on and access to science, **technology** and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism
  - Indicator: Fixed **broadband subscriptions** per 100 inhabitants, by speed

Narrowing the focus

- Two IRTF Research Group (RG) are examples of long-lasting IETF/IRTF activities that are focused on sustainability:

  1. Human Rights Protocol Considerations (hrpc)

  2. Global Access to the Internet for All (gaia)

$\Rightarrow$ Rest of this talk: environmental sustainability.

  – Primarily about the footprint rather than handprint
  – Primarily about the CO_2 footprint

Why care? CO_2 footprint of the Internet

- **What is "the Internet"?** Studies differ widely
    - Age; considerations of: CPE; UE; **embodied energy**; data centers

    > I will come back to this!

- Using various different sources, we can arrive at a range of:
  0.5% – 1.17% [*Michael Welzl, Ozgu Alay, Peyman Teymoori, Safiqul Islam: "Reducing Green House Gas Emissions With Congestion Control", IAB Workshop on Environmental Impact of Internet Applications and Systems, 5-12 December 2022*]

- One possible derivation: **"SMARTer2030 report" states that ICT has a CO2 "footprint" of 2.7% of global emissions in 2020**
    - **Numbers from 2012: telecom electricity = ICT / 3**
      [S. Lambert et al, "Worldwide electricity consumption of communication networks". Opt. Express, 20(26), Dec 2012.]
    - If this relationship still holds, then roughly, worldwide 2020 GHG emissions from telecom: **0.9%**

Is this a small number?

- From https://ourworldindata.org/co2-emissions:
  - **2021: UK 0.93%, Norway 0.11%**

- We're all asked to reduce our personal CO_2 footprint
  - In Norway, the public press offers a calculator…
  - Population 5.408 M, so very roughly, per-person contribution: $2*10^{-8}$

- If we could reduce the Internet's power by 10%...
  - From 0.9% to 0.81%... that's 4.5 M Norwegians ☺
  - Okay… stopping here, it gets a bit silly

- My point is: with standardization, the potential is **enormous**

Environmental sustainability & the IETF

- 2022: IAB workshop on Environmental Impact of Internet Applications and Systems
  - https://datatracker.ietf.org/group/eimpactws/about/
  - **RFC 9547:** Report from the IAB Workshop on Environmental Impact of Internet Applications and Systems

- 2023: creation of **Environmental Impacts of Internet Technology (eimpact) IAB program**
  - https://datatracker.ietf.org/group/eimpact/about/
  - There's a quite active mailing list

Environmental sustainability & the IETF /2

- **2024:** creation of **Getting Ready for Energy-Efficient Networking (green)** IETF WG

- **2025:** creation of **Sustainability and the Internet** Proposed **Research Group (sustain)** IRTF RG

SUSTAIN:
The IRTF RG with the best looking chairs!

What is the GREEN WG about?

...explore use cases, derive requirements, and provide solutions for identifying and characterizing energy efficiency metrics, methods related to energy consumption of network devices, and optimizing energy efficiency across the network. **The Working Group will concentrate on the following:**

- Collecting and updating requirements for the management of energy-efficient networks.

- Defining use cases for managing energy-efficient networks.

- Defining terms and definitions related to energy efficiency metrics. Where possible, terms and definitions in existing RFCs will be reused.

- Developing YANG models to enable measuring and reporting of energy usage through metrics and attributes at component, device, and network levels.

- Providing YANG models to allow operators to optimize energy usage in network components, devices, and across the network, via configurable energy efficiency capabilities.

- Developing or selecting a framework for energy efficiency monitoring, energy efficiency capability discovery, and management within a network domain.

So, network management is relevant here

- Also, knowing how energy proportional devices are (differs greatly!)
- Could e.g. dynamically reroute / load balance, disable devices, ...
  Relevant discussions also happen in:
    - **IRTF Network Management Research Group (NMRG)**
    - **IRTF Decentralization of the Internet Research Group (DINRG)**
    - **IETF Time-Variant Routing (tvr) WG**
    - **IETF Operations and Management Area WG (opsawg)**

- RFC 9657 "*Time-Variant Routing (TVR) Use Cases*" contains "Operating Efficiency" use case: use TVR to optimize cost
    - "Beyond financial costs, assessing the environmental impact of operating a node may also be modeled as a cost associated with node operation, to include achieving carbon credits or other incentives for green computing."
    - But using Carbon data is out of scope of GREEN! **So... where?**

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SUSTAIN RG scope

- <u>Long-term</u> research challenges in <u>developing</u> and <u>operating</u> an <u>environmentally, socially and economically sustainable</u> Internet,

- <u>Networking perspective</u>, mindful of overall impact to systems & services (considering user side, as well as data centres (source),

- Critical view on <u>evidence and data</u> (trustworthiness of research results and their dissemination),

- <u>Architectural and policy implications</u>, <u>without going into advocacy.</u>

- Focus on the <u>Sustainability of the Internet (env, social, econ. footprint), &</u> appreciation of the Internet for Sustainability (handprint).

- <u>Multidisciplinary, systems</u> perspective with <u>lifecycle</u> and <u>supply chain</u> considerations.

A word on SUSTAIN RG ambition

- We want to build a <u>lasting research community</u>:
  - <u>Community</u> => common vision, goals, understanding & methods
  - <u>Research</u> => in depth, experimental, diverse, evidence based
- First and foremost, we are after <u>research questions</u>: we want to debate and understand the questions together before innovating on their solutions
- We encourage <u>scientific publications</u>
- We will build a <u>network</u> internally, connecting <u>researchers to implementors</u> and with other organizations externally.

Research Areas – a selection

> Carbon data based ideas are welcome!

- Characterization and reduction of the Internet environmental, social and economic footprint

- Investigation of and experimentation with novel approaches to greenhouse gas (GHG) emissions reductions

- **Materials/resource efficiency/use, equipment upgrade cycles, circularity, total-cost-of ownership (TCO)**

> Network Softwarization is relevant!

- Investigation of the relationship between environmental sustainability and the Internet architecture to understand the implications and impact of differing approaches to network design and the trade-offs

- Investigation of the environmental limits and boundaries within which the Internet and its applications should operate safely and the corresponding policy implications.

Softwarization ⇔ Hardware re-use

- Embodied emissions = emissions during the entire life cycle
  - production, transportation, waste

- For all of ICT, embodied emissions represent 36% of total emissions
  [*Jens Malmodin, Nina Lövehagen, Pernilla Bergmark, Dag Lundén, "ICT sector electricity consumption and greenhouse gas emissions – 2020 outcome", Telecommunications Policy, Volume 48, Issue 3, 2024, 102701, ISSN 0308-5961*]
  - **"Embodied = approx. 1/3 of ICT based emissions" probably reasonable**
  - Note: that's very device dependent

Carbon footprint
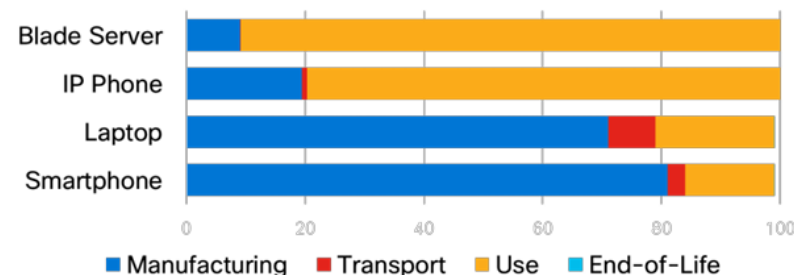
Source: Cisco (2020), via IAB E-impact mailing list (Carlos Pignataro)

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How good is softwarization? Only good?

- Good: especially cloudification opens the door to hardware pooling, sharing and optimization

- Bad: outsources the burden of managing GHG footprint and reporting it, eroding accountability
  - Reporting scope 3 emissions not easy
    (**scope 3**: from activities on assets not owned or controlled by the reporting organization, but that the organization indirectly affects in its value chain.)

Thank you!

Questions?

A "roadmap" URL: *https://wiki.ietf.org/en/group/sustain*