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Let us save the planet
with congestion control !

ICCRG
8. 11. 2022, IETF 115, London
Michael Welzl

The importance of Internet energy saving

- The Internet helps against global warming (very likely: much more than it hurts!), but it does also contribute
  - How much? Very hard to estimate; a lot of misinformation
  - Some serious studies do exist
  - Conservative summary: perhaps ~ 0.5 % – 1.2 % contribution
    - Aviation: 3.5%, so Internet possibly ~ 1/7th to 1/3rd of aviation industry
    - This includes everything, also CPE, UE & embodied energy
  - Probably good to focus on "last mile" (several reasons)

- Relatively small in the "big picture" **...but:** it <u>is</u> still a large number, and standards can be an opportunity to **achieve a global impact !**

Energy efficiency today

- Often a performance trade-off
  - E.g.: sleep long / often = lower performance; use lower PHY rate = lower performance
  - Common motivations: reachability (WiFi rate adaptation), longer battery life (sensors), ..

| Telia N 📶 🛜 | 09:43 | 93 % 🔋 |

‹ Settings   **Battery**

Battery Percentage   🟢

Low Power Mode   ⚪

Low Power Mode temporarily reduces background activity like downloads and mail fetch until you can fully charge your iPhone.

Do you turn it on?

https://support.microsoft.com/... :
"When you plug the mobile PC into a power source, Windows switches the wireless network adapter power setting in the default power plan from the Medium Power Saving setting to the Maximum Performance setting. This turns off the 802.11 power save mode."

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The point of this talk

- It isn't <u>always</u> a trade-off

- Reducing the Flow Completion Time (FCT) means better performance <u>and</u> less wasted energy!
  – Trivially, because it increases the length of sleep periods

- This can be done with better Internet congestion control

Example:

Reducing WiFi end system energy

Michael Welzl: "Not a Trade-Off: On the Wi-Fi Energy Efficiency of Effective Internet Congestion Control", IEEE/IFIP WONS 2022, virtual, 30 March - 1 April 2022.

WiFi sleep strategies

- Various complicated schemes exist... but, in practice... simplified but not far from the truth:
  - WiFi: old Power Save Mode (PSM): **activity + 200ms** before sleep (regularly wake up for "is there data?" query after this)
    - Recent study finds this for 802.11ac and 802.11ax in smartphones

      S.Aggarwal, M.Ghoshal, P.Banerjee, D.Koutsonikolas, and J.Widmer, "802.11ad in smartphones: Energy efficiency, spatial reuse, and impact on applications," in IEEE INFOCOM, 2021, pp. 1–10.

    - Standard offers more complex schemes, especially for 802.11ax, but apparently they are not implemented, or disabled by default

- This plays a role for short transfers
  - The majority of Internet traffic is like this today
  - Packet loss is rare, transfers terminate in slow start (or have app-limited periods)
  - FCT is a function of RTT, transfer length and Initial Congestion Window

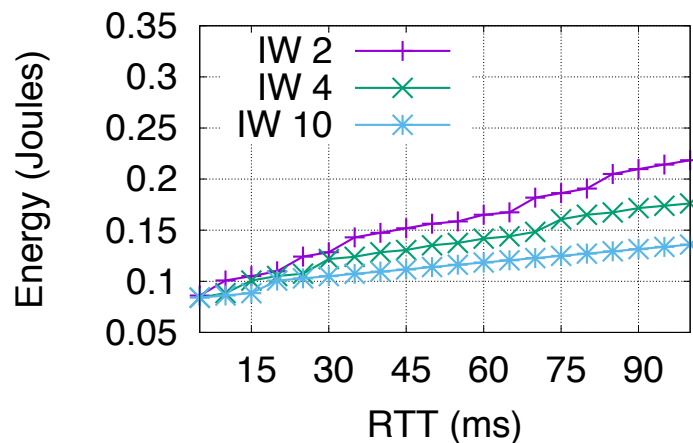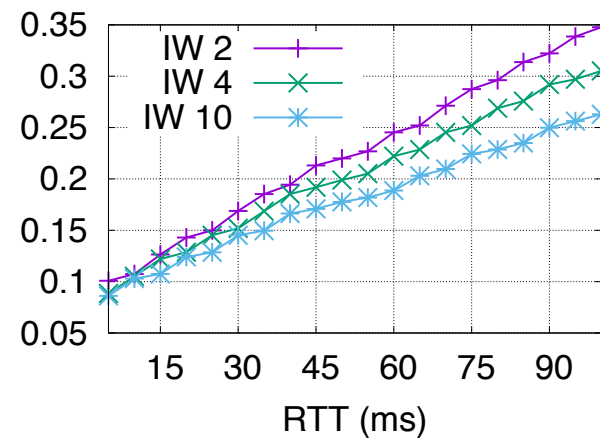# Poor Internet cc. wastes time <u>and</u> power
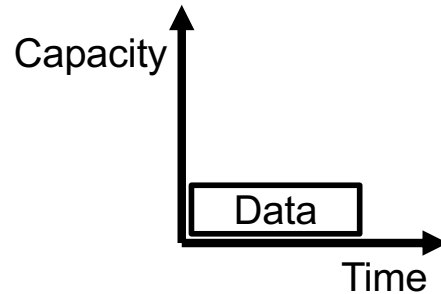
Poor resource utilization
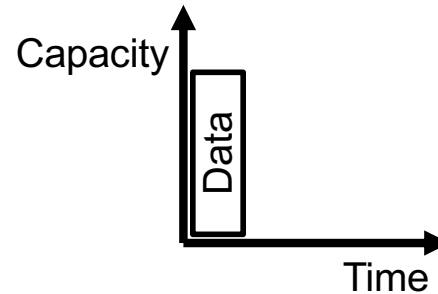
Good resource utilization: better performance __and__ better energy-efficiency

No trade-off !

- Tests with varying TCP Initial Window (IW), wired testbed, pcap files fed to "Energybox" (used by Spotify to determine mobile app WiFi energy usage)

10 packets

80 packets

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Conclusion

- **What can be done in Internet CC? Research examples:**
  - IW part of this paper

    X. Nie, Y. Zhao, Z. Li, G. Chen, K. Sui, J. Zhang, Z. Ye, and D. Pei, "Dynamic TCP initial windows and congestion control schemes through reinforcement learning," IEEE Journal on Selected Areas in Communications, vol. 37, no. 6, pp. 1231–1247, 2019.

  - Can we learn from other preceding or ongoing connections? (coupled CC)?
  - Maybe when using proxies?

- **Energy saving is an important topic**
  - Growing in importance, while the importance of improving performance seems to decline
  - Combining the two aligns incentives in the right way

The end