Challenges and Opportunities in Green Networking

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• Purpose: Analyze challenges and opportunities in green (sustainable, energy-efficient, carbon-neutral) networking
  • Reducing carbon footprint to “Net Zero” is one of mankind’s “grand challenges”
  • This challenge also extends to network technology
• Adopted after IETF 116 – Thank You!
Recap

Provide visibility as foundational problem:
• **Assess usage, validate effectiveness**
• **Enable control loops** for energy/sustainability optimization schemes
• Requires **Instrumentation for energy metrics**
• Companion draft: Green Networking Metrics (draft-cx-gm-green-metrics; https://datatracker.ietf.org/doc/draft-cx-opsawg-green-metrics/)
• Selected challenges+opportunities
  • Certification and compliance assessment methods
  • Virtualized energy and pollution metrics
  • Accounting for energy mix, energy sources
  • Fair carbon footprint attribution to flows & paths
Recap

- **Network optimization**
  - Energy/carbon/pollution-aware routing & path configuration
  - Deployment / placement of VNFs
  - Optimize carbon footprint while maintaining other goals
  - AI and ML methods
  - Applicability of game-theoretic approaches
  - “Control knobs” for intent-based tradeoffs

- **Energy-related control protocol extensions**
  - Energy as a cost factor – in IGP, SDN controllers
  - Assess carbon intensity of paths, optimize networks to minimize overall footprint

- **Carbon-aware traffic steering**
  to steer traffic along greener paths

- **Green abstractions**
  taking into account memory, processing, transmission
Recap

- **Protocol enablers for network energy saving mechanisms**
  - Blur mgmt. and control – taking resources on/offline on short time scales requires mechanisms for fast discovery, fast state reconvergence
  - Role of autonomics? of IBN?

- **Protocol optimization**
  - Traffic adaptation (e.g. bursty vs smoothened transmission to maximize efficiency; control knobs for carbon-aware traffic pacing)
  - Data volume reduction (e.g. codings, efficient retransmissions)

- **Network addressing and deployment**
  (e.g. smaller tables to maintain)

- **Instrumentation** (again)
  e.g. energy telemetry at flow & path level
Recap

- Facilitate organization of networking applications to minimize energy consumption
- **Holistic carbon impact assessment methods** for alternative approaches
- **Examples**: retrieval of content, computation placement (compare CDN/ICN/COIN but from energy perspective)
Notes & discussion

• Next steps: revise document per comments received
  • E.g. Kiran Makhijani: clarify taxonomy further – energy efficiency vs pollution metrics, some other refinements (e.g. level of granularity at which challenges need to be addressed)

• Companion draft-cx-opsawg-green-metrics is tackling green networking metrics
  • Involves considerable research challenges as well (e.g. virtualized energy, attribution of carbon footprint to flows, compliance/verification, ...)
  • May be closer to standardization, hence in OPSAWG
Regarding feedback on green as NMRG topic

• What types of further contributions to work on in NMRG?
  • Carbon telemetry (solutions to assess footprint of a communications service including all factors – requires end-to-end model, ability to snapshot telemetry along a path, etc)
  • Network carbon optimization as a use case for AI (tieing the two together) - e.g. path optimization, function placement (carbon-efficient DC vs less carbon-efficient edge, etc) (facilitated by ML)
  • Enablers for energy savings mechanisms – e.g. retention of certain state to facilitate fast discovery and reconvergence
  • Green Intent and control knobs to navigate tradeoffs
THANK YOU!

Comments? Questions? Please contact us
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