

NMRG@IETF116, Yokohama, Japan

29 March 2023

Challenges and Opportunities in Green Networking

<https://datatracker.ietf.org/doc/html/draft-cx-green-ps-02>

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draft-cx-green-ps-02

- 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
- We presented -01 of this draft in IETF 115

Updates in -02

- Editorial refinements throughout; document has grown by 5+ pages
- Structural updates: summarize specific challenges at the end of each section
- New subsections for challenges at the equipment level
 - Distinguish hardware aspects from visibility and instrumentation
- Reorganized subsections for challenges at the protocol level
- New subsections for challenges at the network level:
 - Network Optimization and Energy/Carbon/Pollution-Aware Networking
 - Assess Carbon Footprint and Network-Level Instrumentation
 - Convergence Schemes (to deal with dynamic fluctuations in carbon intensity, discovery, topology churn)

Recap (w/0.2 updates)

Architecture

Network

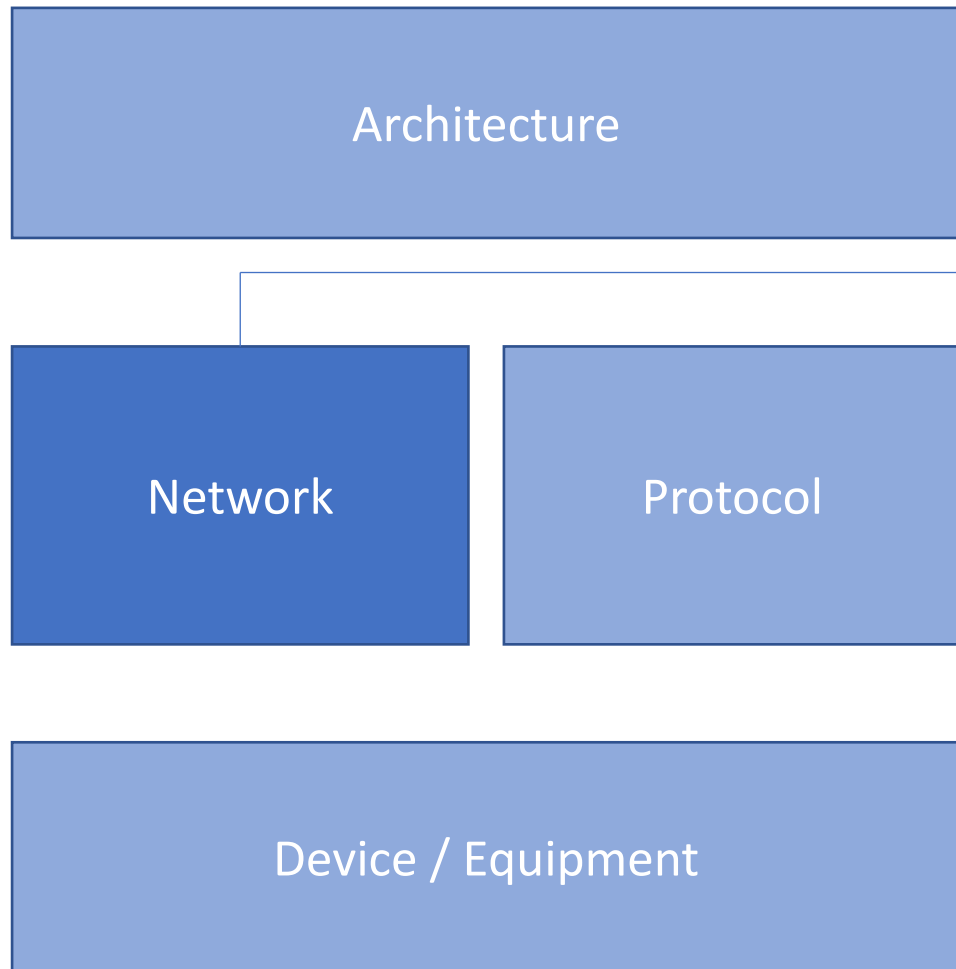
Protocol

Device / Equipment

Provide visibility as foundational problem:

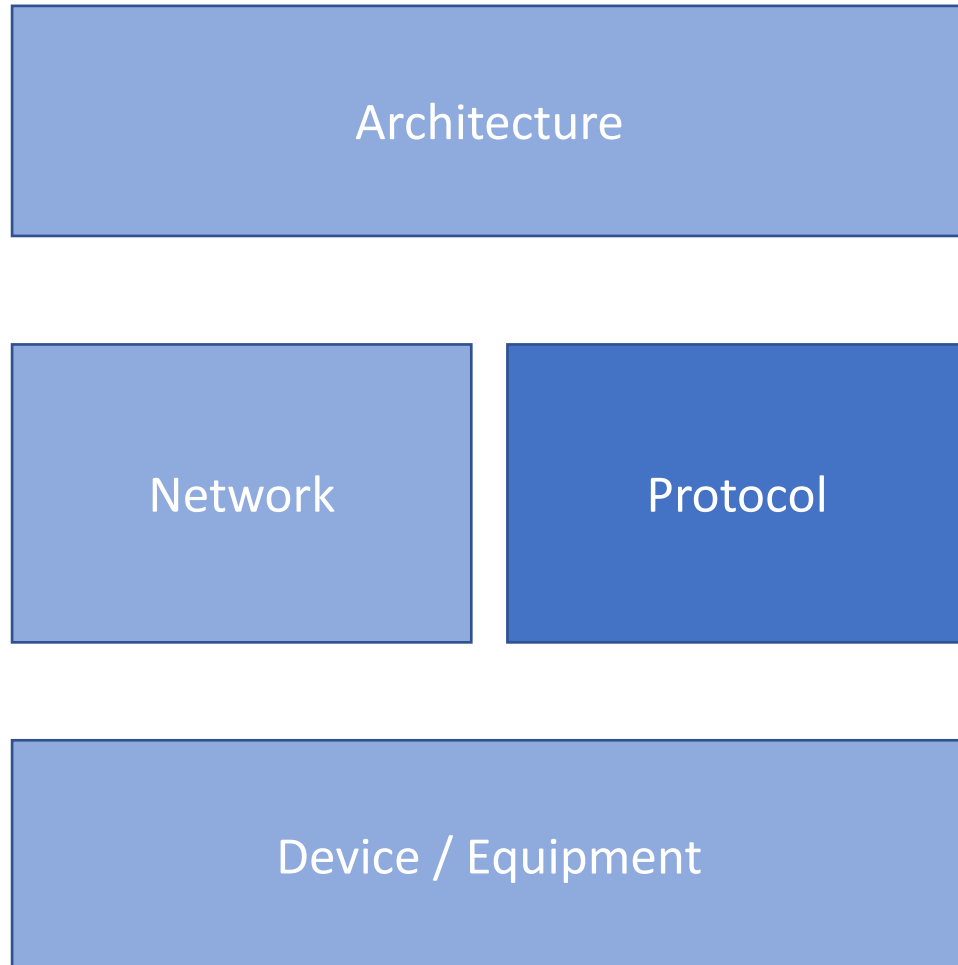
- **Assess usage, validate effectiveness**
- **Enable control loops** for energy/sustainability optimization schemes
- Requires **Instrumentation for energy metrics**
- Companion draft: Green Networking Metrics (draft-cx-green-metrics; <https://datatracker.ietf.org/doc/html/draft-cx-green-ps-02>)
- Selected 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 (w/ 0.2 updates)



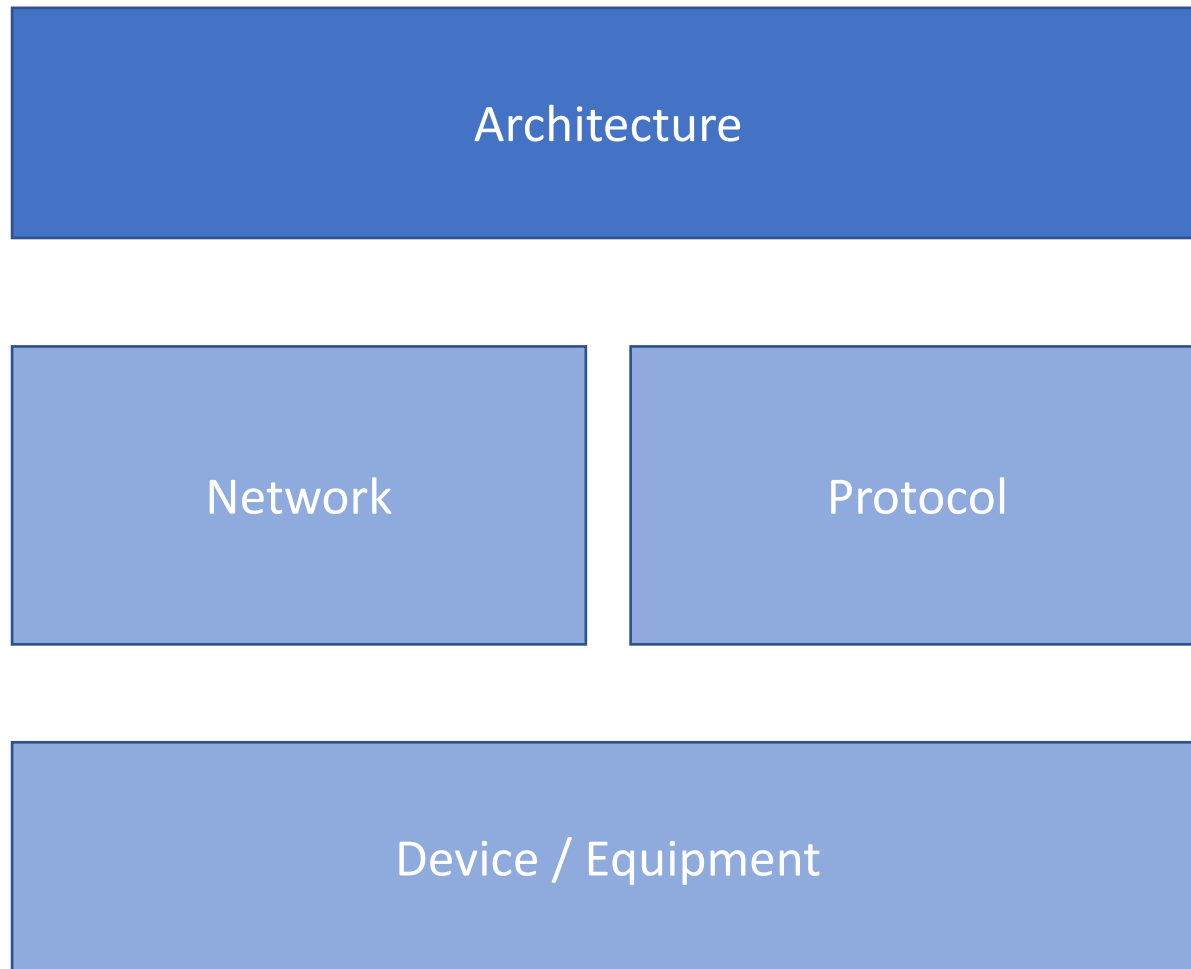
- **Network optimization**
 - Energy/carbon/pollution-aware routing & path configuration
 - Deployment / placement of VNFs
 - Optimize carbon footprint while maintaining other goals
 - AI and ML methods
 - Applicability of game-theoretic approaches
 - “Control knobs” for intent-based tradeoffs
- **Energy-related 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 (w/ 0.2 updates)



- **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 autonomies? of IBN?
- **Protocol optimization**
 - Traffic adaptation (e.g. bursty vs smoothed 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 (w/ 0.2 updates)



- **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)

Discussion

- Companion draft-cx-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 to be separated / presented in OPSAWG
- Request NMRG adoption of draft-cs-green-ps
 - Impactful subject where network management can make important contributions
 - Topic involves many open research questions, coupled with ability to identify standardization opportunities
 - Makes IRTF/NMRG an excellent candidate

THANK YOU!

Comments? Questions? Please contact us
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