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Challenges and Opportunities in Green Networking

https://datatracker.ietf.org/doc/html/draft-irtf-nmrg-green-ps-01

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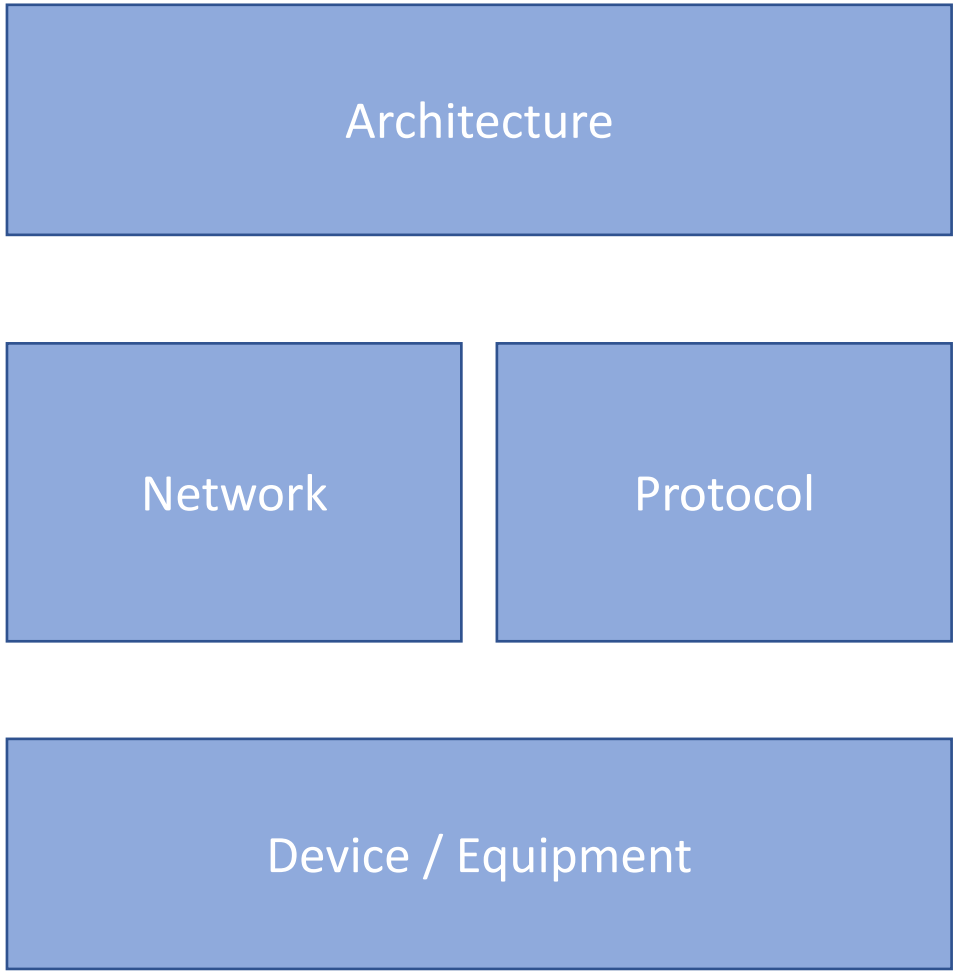
- Analyze challenges in green (sustainable, energy-efficient, carbon-neutral) networking
  - Reducing carbon footprint to “Net Zero” is one of mankind’s “grand challenges”
  - This challenge also extends to network technology
- List resulting research problems and opportunities according to a systemic structure



Updates since IETF 117

- Posted -01 (23 October)
- Editorial improvements throughout
- Addressed comments from Kiran Makhijani on the list
- Clearer explanation of interrelated terms: green vs sustainable, greenhouse gas emissions vs carbon footpring vs energy efficiency etc
- Additional references to related work in IoT

Next steps for this Draft

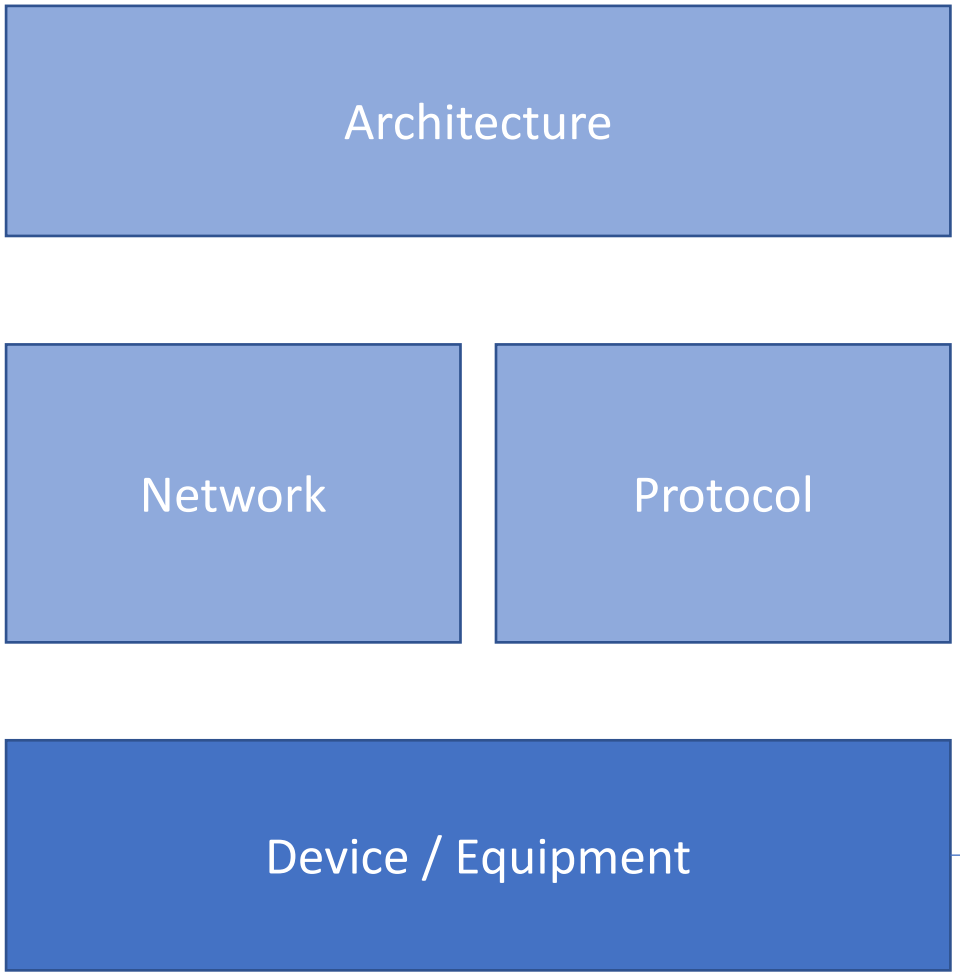
- Document appears fairly complete at this point...
- ... but it would benefit from more reviews and discussion
  - Most sustainability discussion is on e-impact, not nmrg – how can we bring them into the fold?
  - Consider moving to WGLC as a way to get more NMRG feedback?

Next steps beyond this Draft

- Considerable discussion on e-impact – informal mailer and IAB program
- Potential topics for further study include:
  - Visibility and instrumention, metrics & metrics Framework
    - Currently a draft in opsawg, but still with open-ended questions early for standardization, eg
    - Metrics beyond the device: flows and paths; virtual energy, conversion factors, ...
  - Network optimization for sustainability
    - Minimizing energy, carbon emissions through network operations
    - Under the constraint of meeting service level, resilience, elasticity goals
    - Holistic perspective – taking into account also compute, service placement, various tradeoffs
    - Include cost versus benefit of optimization themselves (e.g. AI has a carbon cost)
  - Green Intent and control knobs to navigate tradeoffs
  - Carbon Accounting and Incentive Schemes, pollution-aware traffic steering, ...
- Joint workshop of NMRG and E-Impact on this topic?

Backup

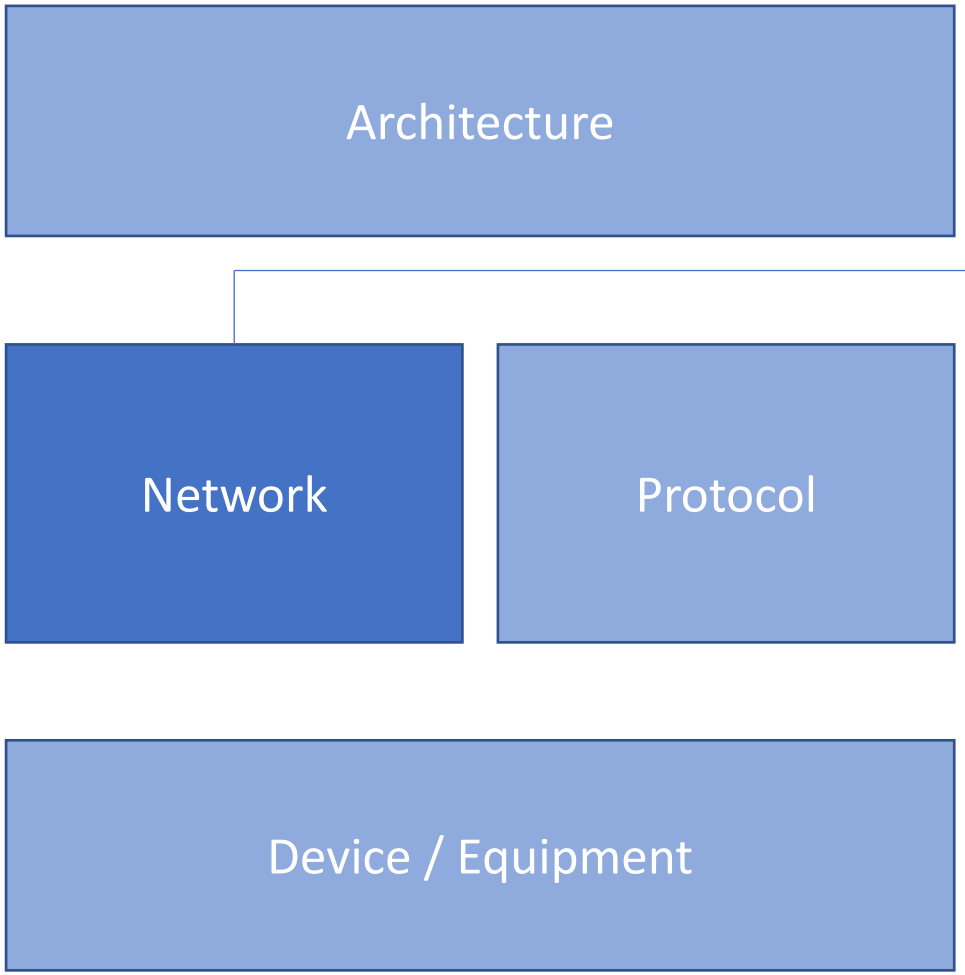
Recap



Provide visibility as foundational problem:

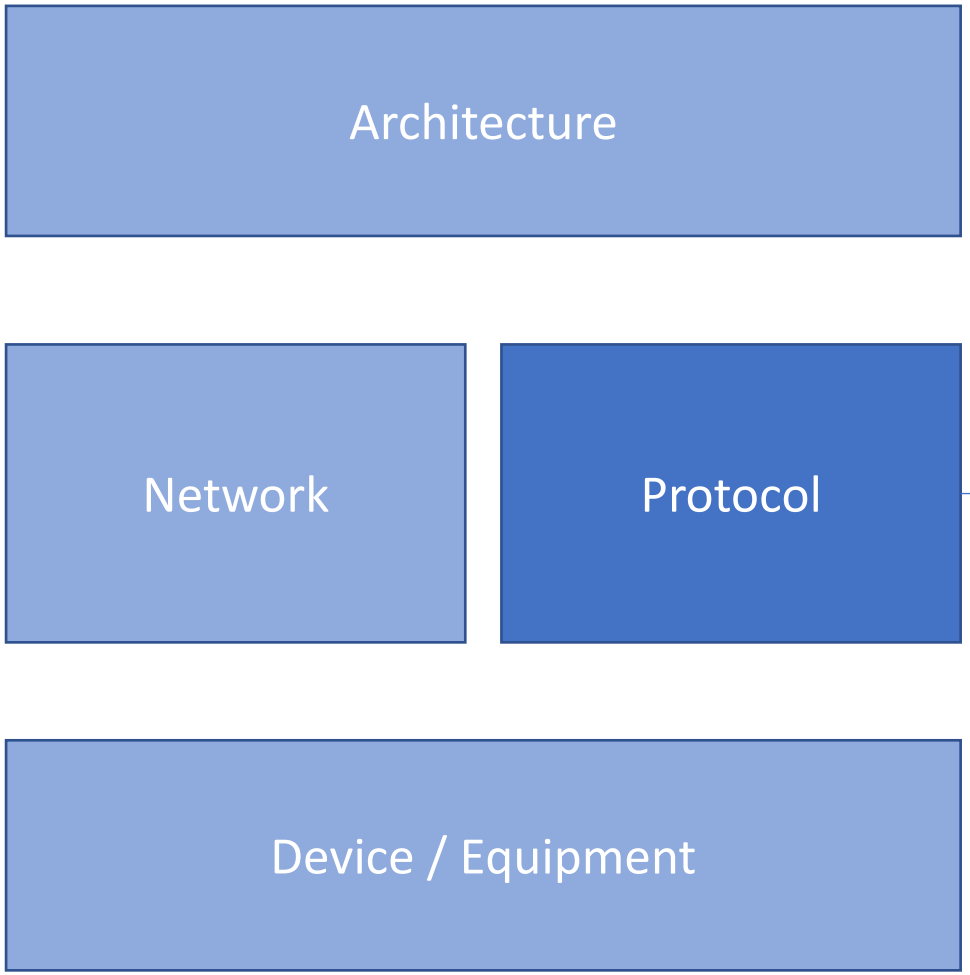
- **Assess usage, validate effectiveness**
- **Enable control loops** for energy/sustainability optimization schemes
- Requires **Instrumentation for energy metrics**
- Companion draft: Green Networking Metrics (draft-cx-green-metrics; https://datatracker.ietf.org/doc/draft-cx-opsawg-green-metrics/)
- 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



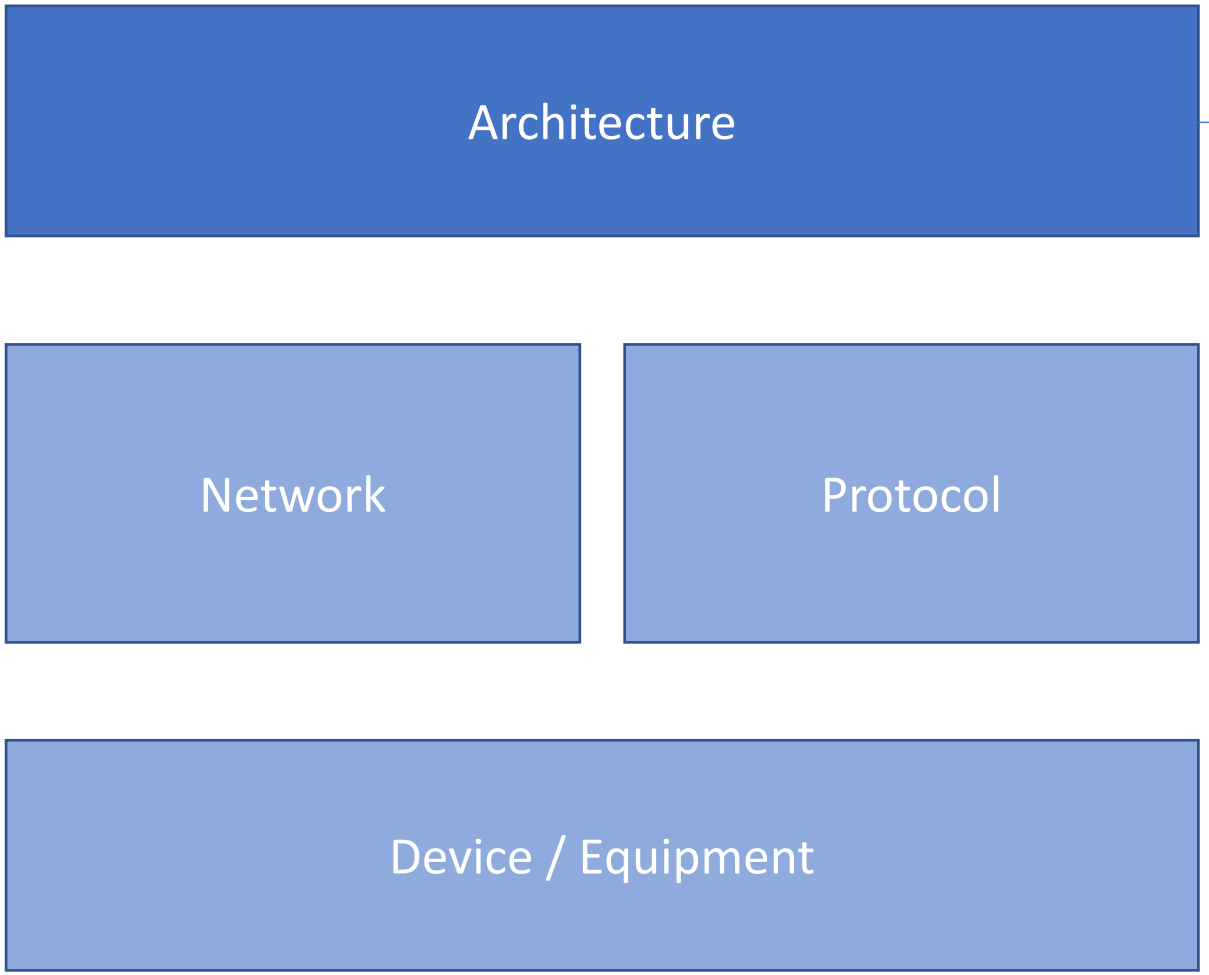
- **Network optimization**
  - Energy/carbon/pollution-aware routing & path configuration
  - Deployment / placement of VNFs
  - Optimize carbon footprint while maintaining other goals
  - AI and ML methods
  - Applicability of game-theoretic approaches
  - “Control knobs” for intent-based tradeoffs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

THANK YOU!

Comments? Questions? Please contact us

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