What proponents think the WG should do

GREEN BOF Proponents
Overall Goal: Energy Efficiency Observability and Management

• Network operators are seeking for automation tools and solutions to better assess and control the energy consumption of networks, devices, and devices/components across their networks.
  • The focus of targeted devices or device components are the ones consuming most of energy
    • E.g., pure network element in mobile network or fixed network
    • Hybrid scenario such as Power supply(e.g., PDU)+ network elements in data center Network
  • Use cases such as
    • Network visibility to energy consumption per device, per component, energy efficiency per device, per component,
    • Power usage effectiveness measurement on the whole data center network, etc

• Power Consumption monitoring on devices is not sufficient since
  • Monitoring only tell you how much power are consumed at specific device.
  • But doesn’t tell you when where to consume such power, why consume so much power and how to save the power.

• Technology trend is moving from power consumption monitoring toward energy efficiency observability and management
  • Global visibility to network topology data, capability inventory data, power data, energy data since
    • Mapping or correlation between data at component level, device level and network level modelled data are visible
    • Allow optimizing energy use on network devices based on capability while improving the overall network utilization
Energy Efficiency Requirements

• Capability/Identity Inventory Discovery
• Power consumption monitoring
• Energy Efficiency monitoring
• Energy Efficiency Optimization and Control
Energy Efficiency Requirements-Part 1

• Capability/Identity Inventory Discovery
  • Dependency Relation between thing, component, device and network is complex
    • Complex relationship between things, e.g., fans run based on temperatures not just based on command
    • Dependency relationship among components, e.g., can not tune X bcos Y depend on it for function F
    • Power relationship across device, e.g., who provide, who consume?
    • Virtualization, etc
  • Power interface static parameters, e.g., Nominal Voltage, Ampere, temperature setting
  • Component specific capabilities, e.g., port on off, fan adjust speed, etc
  • Component independent capabilities
    • E.g., the number of supported power states
    • Energy saving support
    • or local management vs network wide management

• Power consumption Monitoring
  • Consumption at component level, device level
    • Component/device identification and dependency between components are needed
    • Device level metric such as power gain
  • Consumption for specific time period or every timer interval
    • Time based attribute or schedule based attribute is needed
  • Consumption exposure at the network level
    • Network Identification is needed
    • Network level metrics such as Power Usage Effectiveness (PUE), partial PUE, Cooling Load factor, Power load factor, etc in the data center
Energy Efficiency Requirements- Part 2

• Energy efficiency monitoring
  • Component, device and network identification is needed (e.g., components dependency)
  • Monitor energy proportionality (Apply to all network devices)
  • Monitor the tradeoff between power and performance (not apply to all network devices)
    • Primarily using the data traffic per unit of energy consumption ratio across the network
    • Alternatively using Total Carbon Emission of network operation divided by Total Data Traffic (See NCle in ITU-T L.3333)
    • Monitor the maximum throughput between LAN and WAN in the ingress direction
      • IP network interface rates have risen from gigabit to 10GE/50GE at the access, from 100G to 400G at the metro and core
      • Consider various different traffic load such as idle load, full load
      • In case of the energy saving being switched on or off, maximum wakeup time, sleep time can also be measured

• Energy Efficiency Optimization and Control
  • Turn on or off of energy saving capability per component based on discovered capabilities
  • Allow control and optimize energy usage to make the trade-off between network performance and power consumption.
  • Allow both local management and network wide management
    • The local management will be used mostly
  • Allow dynamic energy saving
    • e.g., shutdown unused linecard and port
    • Or adjust the number of SerDes bus or working network processor cores based on network traffic load change, network condition change
      • Allow resource to be allocated or released when the number of component changes
Data Models for Energy Efficiency Management

• Data model technology Selection
  • MIB is good at Monitoring but not for control functionality
  • MIB has limitation to define complex type and constraint for correlation and map while YANG not and continues to evolve
  • IESG statement encourages to use NETCONF/YANG
    • Widely adopted by key stand body and industry
    • Foundation for automation
    • Enable automated operation
    • Rich integration with OSS and SDN controller

• YANG Data model Design
  • Device Level Model (Network element <-> The management system)
    • Capability information exposure
    • Power and energy information exposure
    • Configuration on energy saving function control and optimization
  • Network Level Model (NBI interface of the management system)
    • Inventory capability exposure
      • Extend and use network inventory to describe relationship among components and device
    • Dynamic metric monitoring
      • Extend and use base network topology model to describe relationship among network and device and component
Energy Efficiency Management Framework

The Scope of Framework:

• Define Energy Efficiency Management functional architecture with key function blocks such as
  • Efficiency management system
  • Discovery function, monitoring function, control function, etc

• Document key requirements related to Discovery function, Monitoring function, Control function.

• Applicability analysis for usages of these network level metrics and static capability parameters
Energy Efficiency Management Framework

The Scope of Framework also include:

- Differentiate controller vs. device functionality, metric, capability
- Accommodate the current reporting capabilities from Legacy network devices on power related information using their existing interfaces
  - Open question: Do we need to define metadata DB related to carbon information?
    - Note that carbon information is only generated by the controller
    - One network metric is Network Carbon Intensity Energy KPI NCiE defined in ITU-T L.1333
      - Emission factors apply different power source including solar, wind.
    - Possible usage is to allow operator or customer to look up carbon information based on Location

Note that only consider power supply as one built in component of the network device

Energy Efficiency Ratio = Throughput/Energy consumption
Network Carbon Intensity = \( Total \ Carbon \ Emission \ of \ network \ operation / Total \ Data \ Traffic \)

(*) Energy Efficiency Management Function is implemented inside the device or in a controller
Take away

• Energy efficiency observability is crucial to network operators
• Energy efficiency management allow monitor, energy usage, control/optimize energy saving functionality based on discovered capability and network performance using YANG model technology.
• Energy Efficiency management allow derive carbon aware metric based on energy efficiency related metric
  • Emission factor for different power supply should be considered
• Some other topics where the proponents do not have agreement yet
  • Lifecycle Embedded Carbon
  • Connected Device (e.g., PoE device)
  • Metadata format
  • Science Based Targets Initiative (SBTi) liaison
    • https://github.com/marisolpalmero/GREEN-bof/issues/88
  • Report usage/impact per user or per service
    • https://github.com/marisolpalmero/GREEN-bof/issues/89
Back up
Energy Efficiency Terminologies and Definitions

• Characterization of Energy Efficiency related Information
  • Static Capability Inventory information vs Dynamic Metric information
  • Component level vs Device Level vs Network Level
  • Discovery function vs Monitoring function vs Control function
  • Device Model vs Network Model
  • Power and Energy information vs Energy Efficiency Information vs Environment Setting information
  • Fixed Energy saving vs Dynamic Energy Saving
• Factor to be considered for metrics and attributes such as:
  • port transceiver power information (optical power, status, etc.)
  • port group power information (power, status, etc.)
  • board power information (Volt, Ampere, Watt, temperature, status, etc.)
  • chassis power information (available volume, Watt, status, etc.)
  • power supply information (type, status, redundancy manner, quantities, etc.)
  • fan information (status, speed, tuning manner, etc.)
  • energy consumption levels (basic, standard, deep, etc.)
  • energy efficiency ratios (device, network, etc.)
GREEN Scope Overview

- **TERMINOLOGY DEFINITION**
  - Characterize various different metrics and measurement results, static capability parameters, at the component level, device level, network level.
  - Introduce new metrics definition

- **FRAMEWORK**
  - Define Functional Architecture for energy efficiency management
  - Document key requirements related to 3 key functions
  - Applicability analysis for usages of these network level metrics and static capability parameters
  - Incremental deployment from Data sheet to real time monitoring, control

Function Extension

- **INVENTORY DISCOVERY**
  - Environment Setting
  - Component specific Capability (e.g., port on, off, adjust fan speed)
  - Component independent Capability (e.g., energy saving support, dynamic energy saving)

- **POWER CONSUMPTION MONITORING**
  - Power gain, Power usage effectiveness (PUE) for Data Center Network
  - Power consumption every time interval or for specific time period
  - Power consumption at the network level (e.g., Power per site, Power per connection)

- **ENERGY EFFICIENCY MONITORING**
  - Energy efficiency ratio
  - Various Traffic Load
  - Maximum throughput
  - Maximum wakeup time vs sleep time (in case of energy saving support)

- **ENERGY EFFICIENCY OPTIMIZATION AND CONTROL**
  - Turn on/off energy saving capability
  - Dynamic energy saving support
  - Support tradeoff between energy consumption and network performance
  - Allow local management/network wide management/hybrid management

Energy Efficiency Goal: Less Watt more bit

EMAN Scope

- **Basic Monitoring**
- **Basic Capability Discovery**
- **Component level Measurement**
- **Device Level Measurement**
- **Power monitoring**
- **Power Attribute Monitoring**
- **Power state monitoring**
- **Measurement context information**
- **Deprecated / unused Features**
- Battery Monitoring
- HVAC Monitoring
- Logical Entity and Physical Entity Management
- Power relationship among device
  - Power interface such as Power inlet, outlet

Hardware YANG and Network Inventory YANG have already described relationship between components or between component and devices

Power relationship among devices applied to IoT or campus not in the scope

Power relationship between devices and power supply in the data center can be considered

HVAC monitoring are modelled separately