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 $Total\ Carbon\ Emission\ of\ network\ operatio$n divided by Total Data Traffic (See NCIe 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

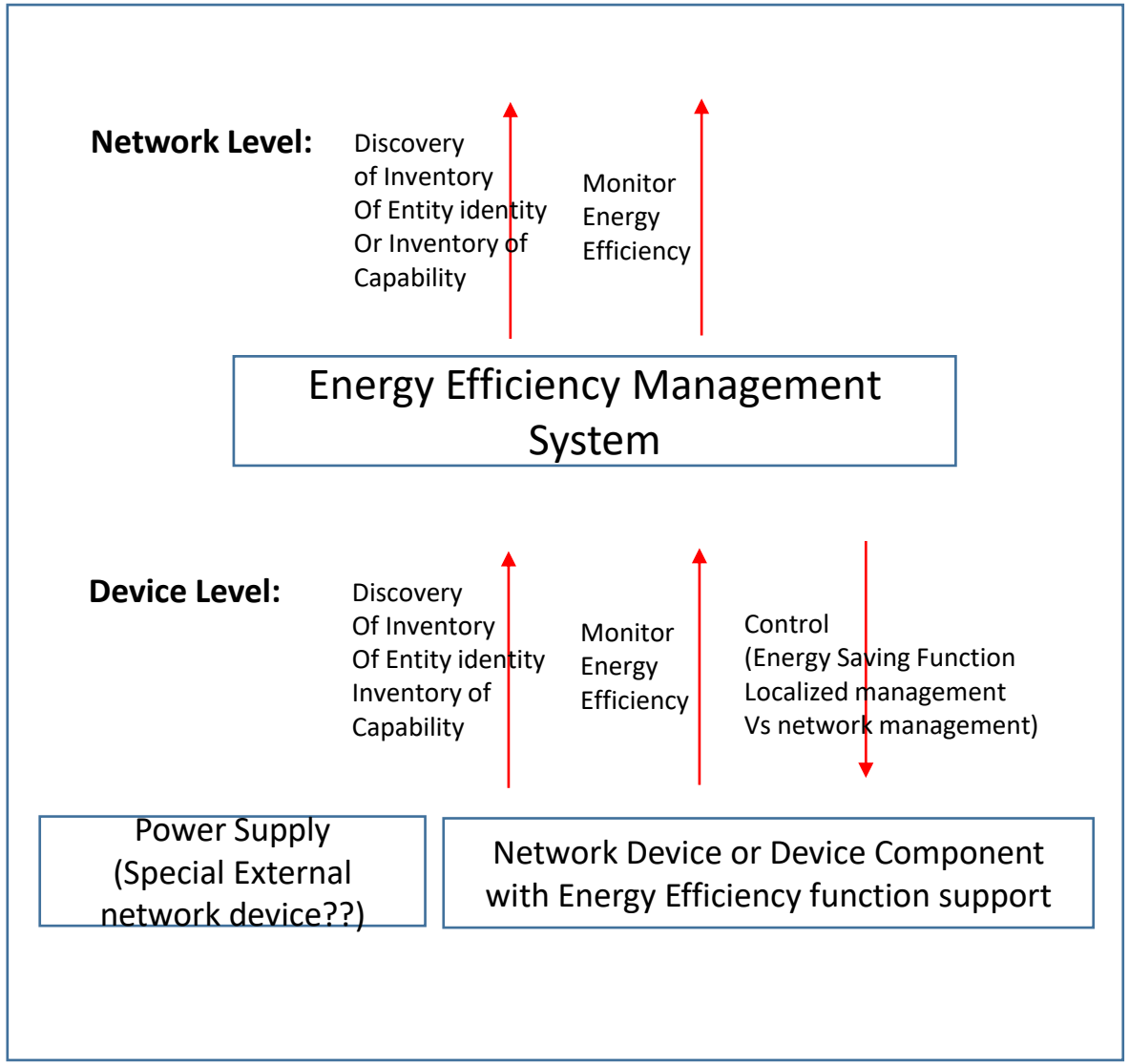
Energy Efficiency Management Framework

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.

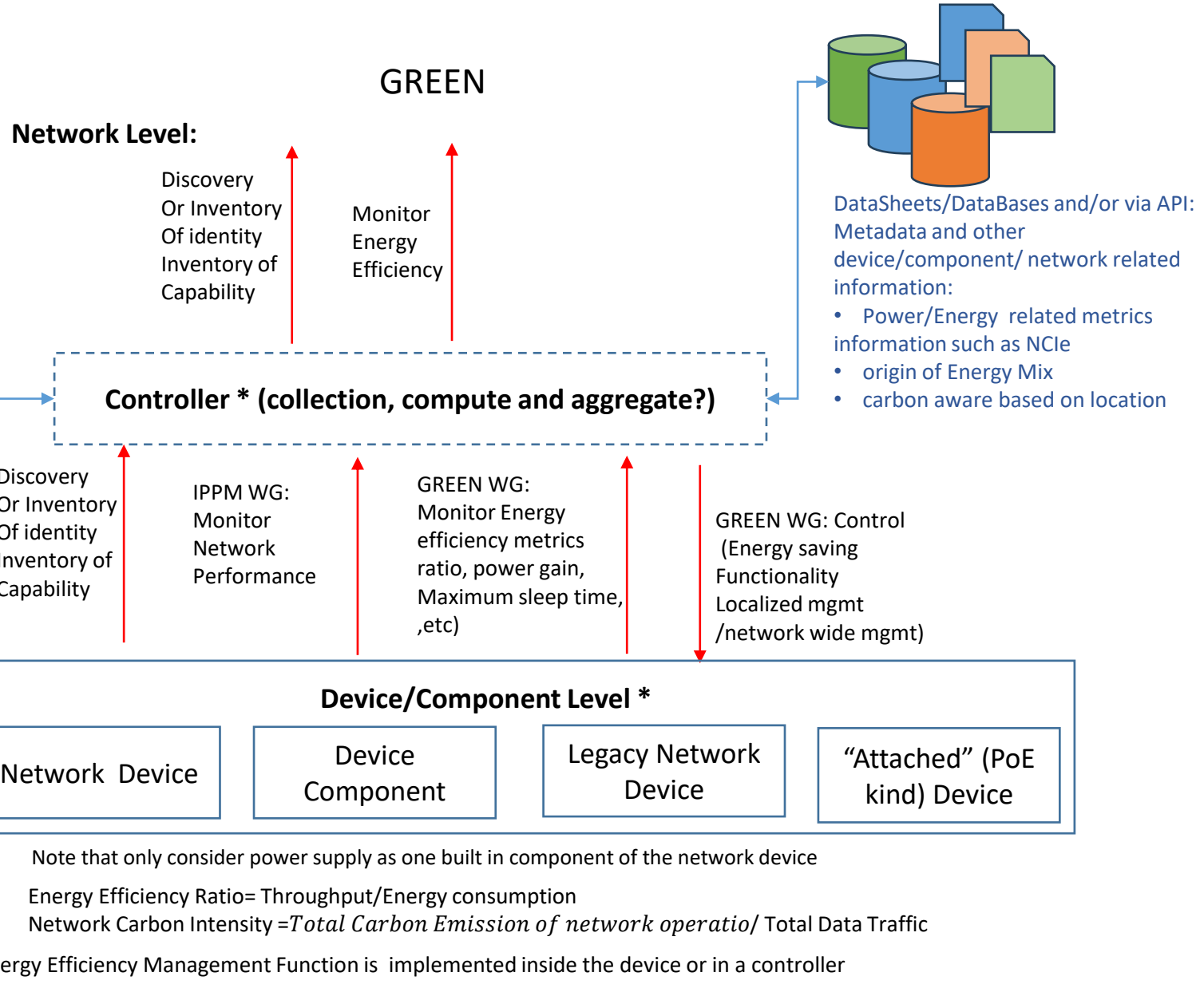
- Applicability analysis for usages of these network level metrics and static capability parameters



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



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

Energy Efficiency Goal: Less Watt more bit