Energy-aware Routing Using Flex-Algo in Segment Routing

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Motivation to explore Energy-aware Routing

- Growing importance of energy efficiency in networks due to sustainability and operational cost reductions.
- Need for routing mechanisms that optimize paths based on energy consumption.
- What this document proposes:
  - Proposal to enhance Flex-Algo in Segment Routing (SR) to integrate power consumption metrics.
  - Consideration of supporting legacy and modern router capabilities to manage energy usage dynamically.
- Previous work acknowledged and considered for this work
  - Specially [I-D.liu-spring-sr-policy-energy-efficiency], but not only

Energy Consumption Metrics for Routing

- Metrics cover both node and interface levels:
  - Node: maximum energy, real-time consumption, unit energy per traffic.
  - Interface: maximum and real-time unit energy consumption.
- Static metrics are retrieved from inventory; dynamic metrics require periodic updates.
- Additional info includes adjustment factors to reflect environment or administrative policies, default values for legacy nodes, and power mode states.

Proposed TLV Formats for Energy Metrics

- New TLV structures for IS-IS introduced; OSPF to be covered in next version.
- Absolute metrics
  - TLV includes fields for adjustment values, default value indication, power modes, and precise power value split into integer and fractional parts.
- Relative metrics
  - TLV captures the measurement time interval and average power per traffic unit.
- Enables precise and scalable reporting of energy metrics for routing protocols.

Integration into Path Computation

- Node Score aggregates power consumption of all device components.
- Link Score sums power consumption across all links on a path.
- Total Path Score = Node Scores + Link Scores; used to determine energy-efficient routes.
- Supports hybrid algorithms incorporating traditional metrics (latency, bandwidth) alongside energy metrics.
- Enables network controllers to select paths minimizing energy use while meeting performance goals.

Open Questions and Future Work

- Clarify the application of adjustment factors and power modes to relative metrics.
- Define reporting frequency for dynamic energy measurements.
- Consider handling of energy consumption by line cards.
- Develop methods to estimate energy impact of new traffic flows.
- Address scenarios involving power mode changes during path computation.
- Explore defining custom power states and modes.
- Consider merging with [I-D.li-lsr-flex-algo-energy-efficiency] to jointly work in a unified approach