Energy-Aware Differentiated Services (EA-DS)

IETF Draft: draft-sofia-green-energy-aware-diffserv

Rute C. Sofia, Dalal Ali

fortiss GmbH

IETF 123 – GREEN Session – 21.07.2025

Problem Statement

- QoS models lack energy-awareness
  - Diffserv as a representative model for QoS
- Sustainability goals demand integration of energy metrics.

- **Proposal:** Extend DiffServ using DSCP and telemetry for energy sensitive networking

EA-DS Approach

- Encode energy-sensitivity into DSCP values.
- Use telemetry (passive/active) for energy metrics.
- Maintain compatibility with RFC 4594 PHBs.
- Enable policy-driven energy-aware path selection.

Applicability Scenarios

- Cloud–Edge systems with AI or energy-constrained nodes.
- Industrial IoT (control vs telemetry traffic).
- SD-WANs with central controllers.
- Federated platforms (e.g., CODECO).
- **Assumptions:**
- DSCP respected across domains.
- Telemetry is available and privacy-preserving.

Proposed Energy Metrics

- **Node energy** as n_e(i): Per-node energy over time, aggregated from system sensors.
- **Link energy**, l_e(i,j): Dynamic energy cost for traffic across interface j of node i, derived from interface statistics and probing.
- **Node usage**: % of CPU available derived from interface statistics and probing.
- **Link usage**, l: traffic across interface j of node i, derived from interface statistics and probing.
- **Node power state transition** (e.g., idle, transmit, receive modes).
- **Other energy related metrics**, such as CO_2 footprint.
- Aggregated/combined path metrics

DSCP Energy-Awareness Mapping Example

DSCP	PHB /RFC	RFC 4594 TC	Energy sensitivity	Example usage	Example Behaviour
46	EF	Real-time interactive	Ignore	VoiP, IIoT	Route via path with lowest latency and jitter
26	AF31	Multimedia conferencing	Moderate	Interactive conferencing	Route via medium energy-consumption path, to balance energy and latency
0x2E	EXP	Experimental Energy saver	Very high	Delay-tolerant batch processing	Explicitely prefer paths that min energy consumption

Example Routing Behaviours

- **Minimize link energy consumption:** The aim is to define a policy that always selects links with lowest energy, independently of node energy or load
- **Minimize total (link + node) energy use**. The aim is to define a policy that results in the selection of routes with both total lowest cumulative energy, and low utilization, considering both link and node load.
- **Optimize for energy + load**. The aim of this policy would be to consider a combination of energy and load, to ensure that traffic WOULD be routed over nodes that can offer the path with low energy and also low usage
- No energy awareness — default QoS.

- Decisions adapt to DSCP and telemetry input.

Example Routing Behaviours

- Minimize link energy consumption: **Selected path: 1 -- C --D --2**
- Link costs:
- 1--C: 0.5, C--D: 0.4, D--2: 0.4 = 1.3 mJ/bit total link energy
- Alternative Path (e.g., via R1): much higher link energy (1.2+1.0)
- DSCP: CS1 (8) or BE (0)
- Traffic example: Background data sync, logs

```
                  R1
                /     \
   l_e=1.2,l=60%     l_e=1.0,l=50%
            /               \
           A                 B
            \               /
   l_e=0.8,l=40%     l_e=0.6,l=35%
              \       /
               R2----------\
                |           \
   l_e=0.7,l=30%             \ l_e=0.6,l=25%
                |             \
                C--------------D
              /                 \
   l_e=0.5,l=20%          l_e=0.4,l=15%
            /                    \
         (1)                     (2)  (Source and Destination)

  Figure 1: Example topology with link and node Energy/Load Metrics.

Where:

*  (1) Source node.

*  (2) Destination node

*  R1, R2 routers

*  A, B, C, D: Intermediate access routers/edge nodes

Between nodes, each link has the following costs:

*  e = energy per bit (in mJ/bit).

*  l = current load (in % usage)
```

Design Considerations

- DSCP spoofing, telemetry manipulation.
- Control plane manipulation, e.g., Load reports to induce congestion
- Energy specific threats, e.g., verload energy-efficient paths to force fallback to high-consumption infrastructure

Next Steps & Call for Action

- Alignment with other WGs, e.g., DetNet, and ROLL WGs.
- Collect more energy-metrics and other formulations of greenness
- Input from the WG

- - **Contact**: sofia@fortiss.org