Flexible Algorithms for Energy Efficiency

draft-li-lsr-flex-algo-energy-efficiency-00

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IETF 123

Background

The increasing energy consumption of the Internet has led more and more operators to pay attention to the energy consumption management of communication systems and pursue higher energy efficiency.

GREEN WG Scope:

- Collecting and updating requirements for the management of energy-efficient networks.
- Defining use cases for managing energy-efficient networks.
- Defining terms and definitions related to energy efficiency metrics. Where possible, terms and definitions in existing RFCs will be reused.
- Developing YANG models to enable measuring and reporting of energy usage through metrics and attributes at component, device, and network levels.
- Providing YANG models to allow operators to optimize energy usage in network components, devices, and across the network, via configurable energy efficiency capabilities.
- Developing or selecting a framework for energy efficiency monitoring, energy efficiency capability discovery, and management within a network domain.

Out of Scope:

- Routing protocols and algorithms, including those that consider energy factors.

Introduction

[draft-liu-spring-sr-policy-energy-efficiency-00]
[draft-cx-green-green-metrics-00]

Energy Metrics

Node Energy Consumption:

- Node Maximum Energy Consumption: The power consumption of a node at full load.
- Node Real-Time Energy Consumption: The real-time power consumption of a node.
- Node Maximum Energy Consumption per Bit: The power consumption of a node at full load divided by traffic.(W/GB)
- Node Real-Time Energy Consumption per Bit: The real-time power consumption of a node divided by real-time traffic. (W/GB)
- Node Average Energy Consumption per Bit: The change in power consumption of a node over a measurement period divided by the change in traffic.(W/GB)

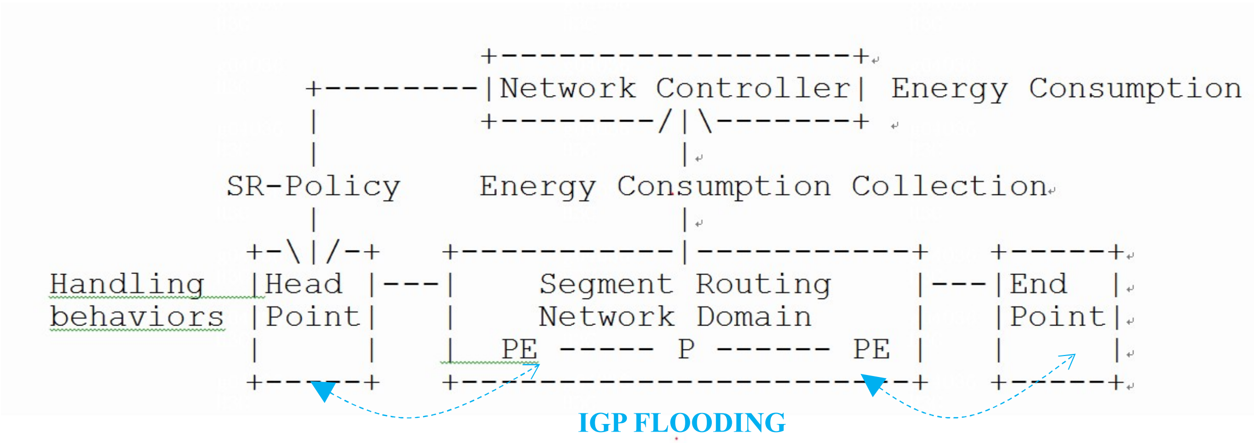
Interface Energy Consumption:

- Interface Maximum Energy Consumption per Bit: The power consumption of an interface at full load divided by traffic, measured in watts per gigabyte (W/GB).
- Interface Real-Time Energy Consumption per Bit: The real-time power consumption of an interface divided by real-time traffic, measured in watts per gigabyte (W/GB).
- Interface Average Energy Consumption per Bit: The change in power consumption of an interface over a measurement period divided by the change in traffic, measured in watts per gigabyte (W/GB).

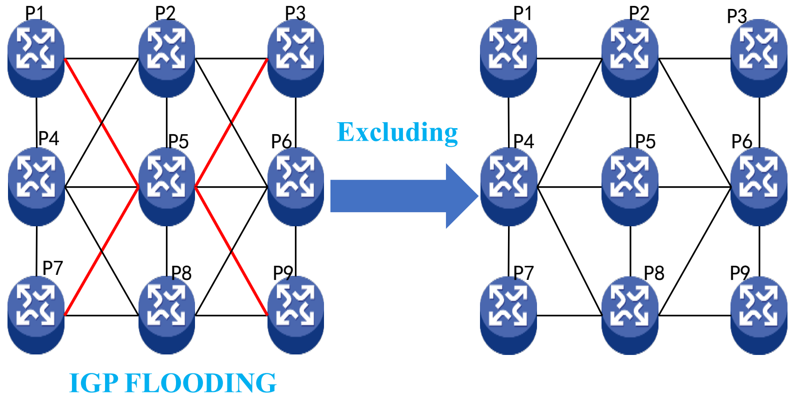
Static Metric
Dynamic Metric

Framework

Method 1



Method 2



Centralized Low Energy Consumption Path Planning:

- IGP protocol floods energy consumption information within the domain and ultimately transmits it to the controller, enabling the controller to perform routing calculations based on energy consumption metrics.

Distributed Path Computation:

- The IGP floods energy consumption information within the domain and advertises a Flex-Algo with energy consumption metrics as path constraints. All nodes then exclude links that fail to meet the energy consumption requirements based on the algorithm's constraints, ultimately performing path calculation using the Shortest Path First (SPF) algorithm.

Draft Extended TLV Overview

--NEW IGP TLV to flood energy metrics

- Link energy consumption metrics
  - Maximum Energy Consumption Per Bit
  - Real-Time Energy Consumption Per Bit
  - Average Energy Consumption Per Bit
- Node energy consumption metrics
  - Node Maximum Energy Consumption
  - Node Real-Time Energy Consumption
  - Node Maximum Energy Consumption Per Bit
  - Node Real-Time Energy Consumption Per Bit
  - Node Average Energy Consumption Per Bit

--NEW Flexible Algorithm Definition Metric Types & Constraints

- Exclude Maximum Node Maximum Energy Consumption
- Exclude Maximum Node Real-Time Energy Consumption
- Exclude Maximum Node Maximum Energy Consumption Per Bit
- Exclude Maximum Node Real-Time Energy Consumption Per Bit
- Exclude Maximum Node Average Energy Consumption Per Bit
- Exclude Maximum Interface Maximum Energy Consumption Per Bit
- Exclude Maximum Interface Real-Time Energy Consumption Per Bit
- Exclude Maximum Interface Average Energy Consumption Per Bit

Advertise Link energy consumption(IS-IS)

IS-IS energy consumption Sub-TLVs in Extended IS Reachability TLV

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Type           |    Length       |              Resv         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Value                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

energy consumption Sub-TLV Types:
TBD1 : Link Maximum Energy Consumption Per Bit
TBD2 : Link Real-Time Energy Consumption Per Bit
TBD3 : Link Average Energy Consumption Per Bit

Advertise Link energy consumption(OSPF)

OSPF Link energy consumption Sub-TLVs included in **Opaque LSA**

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|           Type                |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                              Value                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
OSPFv3 Opaque LSA Header:
  LS Age: 3600
  LS Type: 0x200B (Area Scope Opaque LSA)
  Link State ID: 0x00000001
  Advertising Router: 1.1.1.1
  LS Sequence Number: 0x80000001
  LS Checksum: 0x1234
  Length: 24

TLV Section:
    Local Interface IP Address
    Remote Interface IP Address
    Link energy consumption sub TLVs
```

Sub-TLV Types:
TBD4: Link Maximum Energy Consumption Per Bit
TBD5: Link Real-Time Energy Consumption Per Bit
TBD6: Link Average Energy Consumption Per Bit

Advertise Node energy consumption(IS-IS)

IS-IS Node energy consumption TLVs

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Type         |   Length      |               Resv            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Value                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TLV-Type:
TBD7 : Node Maximum Energy Consumption
TBD8 : Node Real-Time Energy Consumption
TBD9 : Node Maximum Energy Consumption Per Bit
TBD10 : Node Real-Time Energy Consumption Per Bit
TBD11 : Node Average Energy Consumption Per Bit

Advertise Node energy consumption(OSPF)

OSPF Node energy consumption Sub-TLVs included in **Opaque LSA**

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Type              |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                             Value                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
OSPFv3 Opaque LSA Header:
  LS Age: 3600
  LS Type: 0x200B (Area Scope Opaque LSA)
  Link State ID: 0x00000001
  Advertising Router: 1.1.1.1
  LS Sequence Number: 0x80000001
  LS Checksum: 0x1234
  Length: 24

TLV Section:
  Node energy consumption sub TLVs
```

Sub-TLV Types:
TBD12: Node Maximum Energy Consumption
TBD13: Node Real-Time Energy Consumption
TBD14: Node Maximum Energy Consumption Per Bit
TBD15: Node Real-Time Energy Consumption Per Bit
TBD16: Node Average Energy Consumption Per Bit

Flexible Algorithm Definition

Utilize energy consumption metrics to bypass obsolete devices or devices with poor energy efficiency in the network.

New IGP-Metric Types:
TBD17: Node Maximum Energy Consumption
TBD18: Node Real-Time Energy Consumption
TBD19: Node Maximum Energy Consumption Per Bit
TBD20: Node Real-Time Energy Consumption Per Bit
TBD21: Node Average Energy Consumption Per Bit
TBD22: Interface Maximum Energy Consumption Per Bit
TBD23: Interface Real-Time Energy Consumption Per Bit
TBD24: Interface Average Energy Consumption Per Bit

```
Flexible Algorithm Definition Sub-TLV
   Algorithm
   Metric Type: (Energy Consumption Types)
   Calculation Type: spf
   Priority: 64
   Constraints: (Energy Consumption Types)
```

New IGP-Metric types to specify the use of energy consumption for path selection in Flex-Algo.
"IS-IS Flexible Algorithm Definition Sub-TLV“ and "OSPF Flexible Algorithm Definition TLV"

Flexible Algorithm Definition Constraints(IS-IS)

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Max energy consumption                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
Flexible Algorithm Definition Sub-TLV
    Algorithm
    Metric Type: (Energy Consumption Types)
    Calculation Type: spf
    Priority: 64
    Constraints: (Energy Consumption Types)
```

Constrain Sub-TLV Types:
TBD25: Exclude Maximum Node Maximum Energy Consumption
TBD26: Exclude Maximum Node Real-Time Energy Consumption
TBD27: Exclude Maximum Node Maximum Energy Consumption Per Bit
TBD28: Exclude Maximum Node Real-Time Energy Consumption Per Bit
TBD29: Exclude Maximum Node Average Energy Consumption Per Bit
TBD30: Exclude Maximum Interface Maximum Energy Consumption Per Bit
TBD31: Exclude Maximum Interface Real-Time Energy Consumption Per Bit
TBD32: Exclude Maximum Interface Average Energy Consumption Per Bit

Flexible Algorithm Definition Constraints(OSPF)

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Type                     |      Length                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Max energy consumption                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
Flexible Algorithm Definition Sub-TLV
   Algorithm
   Metric Type: (Energy Consumption Types)
   Calculation Type: spf
   Priority: 64
   Constraints: (Energy Consumption Types)
```

Constrain Sub-TLV Types:
TBD25: Exclude Maximum Node Maximum Energy Consumption
TBD26: Exclude Maximum Node Real-Time Energy Consumption
TBD27: Exclude Maximum Node Maximum Energy Consumption Per Bit
TBD28: Exclude Maximum Node Real-Time Energy Consumption Per Bit
TBD29: Exclude Maximum Node Average Energy Consumption Per Bit
TBD30: Exclude Maximum Interface Maximum Energy Consumption Per Bit
TBD31: Exclude Maximum Interface Real-Time Energy Consumption Per Bit
TBD32: Exclude Maximum Interface Average Energy Consumption Per Bit

Next Steps

- Absorb suggestions from the WG.
- Any questions or comments are Welcomed.

Thanks