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# ALTO Traffic Engineering Cost Metrics
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Abstract

Cost Metric is a basic concept in Application-Layer Traffic Optimization (ALTO). It is used in both the Cost Map Service and the Endpoint Cost Service. Future extensions to ALTO may also use Cost Metric.

Different applications may benefit from different Cost Metrics. For example, a Resource Consumer may prefer Resource Providers that have low delay to the Resource Consumer. However the base ALTO protocol [ALTO] has defined only a single cost metric, i.e., the generic "routingcost" metric (Sec. 14.2 of ALTO base specification [ALTO]).

In this document, we define eleven Cost Metrics, derived from OSPF-TE and ISIS-TE, to measure network delay, jitter, packet loss, hop count, and bandwidth. The metrics defined in this document provide a relatively comprehensive set of Cost Metrics for ALTO focusing on traffic engineering (TE). Additional Cost Metrics such as financial cost metrics may be defined in other documents.

Requirements Language The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on January 23, 2015.



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## 1. Introduction

Cost Metric is a basic concept in Application-Layer Traffic Optimization (ALTO). It is used in both the Cost Map Service and the Endpoint Cost Service. In particular, applications may benefit from knowing network performance measured on several Cost Metrics. For example, a more delay sensitive application may focus on latency, and a more bandwidth-sensitive application may focus on available bandwidth.

The objective of this document is to define eleven cost metrics, listed in Table 1, to support the aforementioned applications. Hence, this document extends the base ALTO protocol [ALTO], which defines only a single cost metric, i.e., the generic "routingcost" metric (Sec. 14.2 of ALTO base specification [ALTO]).

| Namespace | Property | Reference |
|---|---|---|
| | delay | [RFCxxxx], Section 3 |
| | delayjitter | [RFCxxxx], Section 4 |
| | pktloss | [RFCxxxx], Section 5 |
| | hopcount | [RFCxxxx], Section 6 |
| | bandwidth | [RFCxxxx], Section 7 |
| | maxbw | [RFCxxxx], Section 8 |
| | maxresbw | [RFCxxxx], Section 9 |
| | unresdbw | [RFCxxxx], Section 10 |
| | residbw | [RFCxxxx], Section 11 |
| | availbw | [RFCxxxx], Section 12 |
| | utilbw | [RFCxxxx], Section 13 |

Table 1.

An ALTO server may provide a subset of the cost metrics defined in this document. When an ALTO server supports a cost metric defined in this document, the server SHOULD announce the metric in its IRD.

The definitions of a set of cost metrics can allow us to extend the ALTO base protocol (e.g., allowing output and constraints use different cost metrics), but such extensions are not in the scope of this document.

One challenge in defining the metrics is that performance metrics often depend on configuration parameters. For example, the value of packet loss rate depends on the measurement interval and varies over time. To handle this issue, ALTO server may collect data on time periods covering the past, present or only collect data on present time.

Following the ALTO base protocol, this document uses JSON to specify the value type of each defined metric. See [RFC4627] for JSON data type specification.

## 2. Data sources, computation of defined cost metrics

The cost metrics defined in this document are similar, in that they may use similar data sources and have similar issues in their calculation. Hence, instead of specifying such issues for each metric individually, we specify the common issue in this section.

### 2.1. Data sources

An ALTO server needs data sources to compute the cost metrics defined in this document. This document does not define the exact data sources. For example, the ALTO server may use log servers or the OAM system as its data source [ALTO-DEPLOYMENT]. In particular, the cost metrics defined in this document can be computed using routing systems as the data sources. Mechanisms defined in [RFC3630], [RFC3784], [OSPF-TE], [ISIS-TE], [BGP-LS] and [BGP-PM] that allow an ALTO Server to retrieve and derive the necessary information to compute the metrics that we define in this document.

### 2.2. Computation of metrics

An ALTO server process measurements from data sources to compute exposed metrics. It may need performance data processing tasks such as aggregating the results across multiple systems, removing outliers, and creating additional statistics.

One specific challenge in defining the metrics in this document is that these performance metrics depend on some configuration parameters. For example, the value of packet loss rate depends on the measurement interval and varies over time. If the ALTO server uses aforementioned routing protocol based mechanisms as data sources, then the measurement interval may be preconfigured by the routing protocol. For example, Section 5 of [ISIS-TE] defines a default measurement interval of 30 seconds. This document uses the term Measurement Interval to refer to the measurement interval used by the data sources. The Measurement Interval(s) of the data sources can be different from the interval that this document defines the metric. Hence, an ALTO server needs to resolve the mismatch, when it happens. [TODO: Need more specification.]

Another issue of converting from data source measurements to ALTO exposed metric values is that the measurement results that the ALTO Server retrieves may be defined for only links, and hence, the server will need to compose the link metrics to obtain path metrics used in

services such as the Cost Map Service. In this definition, we define the metrics to be independent of link or path, considering that future ALTO extensions may define link-based services, and hence the defined metrics should still be usable.

## 3. Metric: Delay

Cost Metric name:

Delay

Cost Metric string:

US-ASCII string 'delay'

Metric Description:

To specify spatial and temporal aggregated delay between the specified source and destination or the time that the packet spends to travel from source to destination. The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit:

The unit is microsecond.

Metric Value Type:

A single 'JSONNumber' type value containing a non-negative integer component that may be followed by an exponent part.

```
Example 1: Delay value on source-destination endpoint pairs
 POST /endpointcost/lookup HTTP/1.1
 Host: alto.example.com
 Content-Length: TBA
 Content-Type: application/alto-endpointcostparams+json
 Accept: application/alto-endpointcost+json,application/alto-error+json

{
  "cost-type": {"cost-mode" : "numerical",
                "cost-metric" : "delay"},
  "endpoints" : {
    "srcs": [ "ipv4:192.0.2.2" ],
    "dsts": [
      "ipv4:192.0.2.89",
      "ipv4:198.51.100.34",
      "ipv4:203.0.113.45"
    ]
  }
}

HTTP/1.1 200 OK
Content-Length: TBA
Content-Type: application/alto-endpointcost+json
{
  "meta" :{
    "cost-type": {"cost-mode" : "numerical",
                  "cost-metric" : "delay"
     }
   },
    "endpoint-cost-map" : {
      "ipv4:192.0.2.2": {
        "ipv4:192.0.2.89"    : 10,
        "ipv4:198.51.100.34" : 20,
        "ipv4:203.0.113.45"  : 30,
    }
  }
}
```

## 4. Metric: Delay Jitter

Cost Metric name:

Delay jitter

Cost Metric string:

US-ASCII string 'delayjitter'

Metric Description:

To specify spatial and temporal aggregated jitter (latency variation) over the specified source and destination. The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit:

The unit is microsecond.

Metric Value Type:

A single 'JSONNumber' type value containing an integer component that may be followed by exponent part.

```
Example 2: Delayjitter value on source-destination endpoint pairs
POST /endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBA
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

{
  "cost-type": {"cost-mode" : "numerical",
   "cost-metric" : "delayjitter"},
  "endpoints" : {
    "srcs": [ "ipv4:192.0.2.2" ],
    "dsts": [
      "ipv4:192.0.2.89",
      "ipv4:198.51.100.34",
      "ipv4:203.0.113.45"
    ]
  }
}
HTTP/1.1 200 OK
 Content-Length: TBA
 Content-Type: application/alto-endpointcost+json
{
  "meta": {
           "cost type": {
           "cost-mode": "numerical",
           "cost-metric":"delayjitter"
    }
   },
  "endpoint-cost-map": {
           "ipv4:192.0.2.2": {
           "ipv4:192.0.2.89"    : 0
           "ipv4:198.51.100.34" : 1
           "ipv4:203.0.113.45"  : 5
         }
      }
   }
```

## 5. Metric: Packet Loss

Cost Metric name:

Packet loss

Cost Metric string:

US-ASCII string 'pktloss'

Metric Description:

To specify spatial and temporal aggregated packet loss over the specified source and destination. The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit:

The unit is percentile.

Metric Value Type:

A single number value containing an integer component that may be followed by a fraction part and/or an exponent part.

```
  Example 3: pktloss value on source-destination endpoint pairs
  POST /endpointcost/lookup HTTP/1.1
  Host: alto.example.com
  Content-Length: TBA
  Content-Type: application/alto-endpointcostparams+json
  Accept: application/alto-endpointcost+json,application/alto-error+json

    {
      "cost-type": {"cost-mode" : "numerical",
       "cost-metric" : "pktloss"},
      "endpoints" : {
        "srcs": [ "ipv4:192.0.2.2" ],
        "dsts": [
          "ipv4:192.0.2.89",
          "ipv4:198.51.100.34",
          "ipv4:203.0.113.45"
        ]
      }
    }
  HTTP/1.1 200 OK
  Content-Length: TBA
  Content-Type: application/alto-endpointcost+json
  {
      "meta": {
                  "cost type": {
                "cost-mode": "numerical",
                "cost-metric":"pktloss"}
         }
      },
     "endpoint-cost-map": {
              "ipv4:192.0.2.2": {
              "ipv4:192.0.2.89"   : 0,
              "ipv4:198.51.100.34": 1,
              "ipv4:203.0.113.45" : 2,
                                  }
               }
   }
```

## 6. Metric: Hop Count

The metric hopcount is mentioned in [ALTO] as an example. This section further clarifies its properties.

Cost Metric name:

Hop count

Cost Metric string:

US-ASCII string 'hopcount'

Metric Description:

To specify the number of hops in the path between the source endpoint and the destination endpoint.

[Editor Note: Need to specify which level (AS, IP perhaps), details TBD for multiple-layer aspect.]

Metric Unit:

The unit is integer number.

Metric Value Type:

A single 'JSONNumber' type value containing an integer component.

```
  Example 4: hopcount value on source-destination endpoint pairs
  POST /endpointcost/lookup HTTP/1.1
  Host: alto.example.com
  Content-Length: TBA
  Content-Type: application/alto-endpointcostparams+json
  Accept: application/alto-endpointcost+json,application/alto-error+json

    {
      "cost-type": {"cost-mode" : "numerical",
       "cost-metric" : "hopcount"},
      "endpoints" : {
        "srcs": [ "ipv4:192.0.2.2" ],
        "dsts": [
          "ipv4:192.0.2.89",
          "ipv4:198.51.100.34",
          "ipv4:203.0.113.45"
        ]
      }
    }
  HTTP/1.1 200 OK
  Content-Length: TBA
  Content-Type: application/alto-endpointcost+json
  {
      "meta": {
                 "cost type": {
                "cost-mode": "numerical",
                "cost-metric":"hopcount"}
         }
      },
     "endpoint-cost-map": {
              "ipv4:192.0.2.2": {
              "ipv4:192.0.2.89"   : 5,
              "ipv4:198.51.100.34": 3,
              "ipv4:203.0.113.45" : 2,
                                  }
                }
   }
```

## 7. Metric: Bandwidth

Cost Metric name:

Bandwidth

Cost Metric string:

US-ASCII string 'bandwidth'

Metric Description:

To specify spatial and temporal aggregated bandwidth over the specified source and destination. The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endhost to endhost); and the temporal unit is specified as the measurement interval in the query context.

This is just a definition of a class of cost metric 'bandwidth'. The use of this cost metric is always in conjunction with what it represents, which could be Max Bandwidth (maxbw), Residual Bandwidth (residuebw) etc.

Metric Unit:

The units are bytes per second.

Metric Value Type:

A single 'JSONNumber' type value containing an integer component , which may be followed by a fraction part and/or an exponent part.

## 8. Metric: Maximum Bandwidth

Cost Metric name:

Maximum Bandwidth

Cost Metric string:

US-ASCII string 'maxbw'

Metric Description:

To specify spatial and temporal maximum bandwidth over the specified source and destination. The values correspond to the maximum bandwidth that can be used (motivated from RFC 3630 Sec. 2.5.6.). The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endhost to endhost); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit and Metric Value Type:

See definition for the Bandwidth Cost Metric.

Example 5: maxbw value on source-destination endpoint pairs

```
POST/ endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBA
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

{
   "cost-type": { "cost-mode":  "numerical",
   "cost-metric":  "maxbw"},
   "endpoints":  {
      "srcs": [ "ipv4 : 192.0.2.2" ],
      "dsts": [
        "ipv4:192.0.2.89",
        "ipv4:198.51.100.34",
        "ipv4:203.0.113.45"
      ]
    }
  }

HTTP/1.1 200 OK
Content-Length: TBA
Content-Type: application/alto-endpointcost+json
{
    "meta": {
           "cost-type": {
           "cost-mode": "numerical",
           "cost-metric": "maxbw"
           }
    },
"endpoint-cost-map": {
          "ipv4:192.0.2.2": {
          "ipv4:192.0.2.89":    0,
          "ipv4:198.51.100.34" : 2000,
          "ipv4:203.0.113.45":  5000,
                      }
        }
}
```

## 9. Metric: Maximum Reservable Bandwidth

Cost Metric name:

Maximum Reservable Bandwidth

Cost Metric string:

US-ASCII string 'maxresbw'

Metric Description:

To specify spatial and temporal maximum reservable bandwidth over the specified source and destination. The value is corresponding to the maximum bandwidth that can be reserved (motivated from RFC 3630 Sec. 2.5.7.). The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit and Value Type:

See definition of the Bandwidth Cost Metric.

Example 6: maxresbw value on source-destination endpoint pairs

```
POST/ endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBA
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

  {
    "cost-type" { "cost-mode":  "numerical",
    "cost-metric":  "maxresbw"},
    "endpoints":  {
      "srcs": [ "ipv4 : 192.0.2.2" ],
      "dsts": [
        "ipv4:192.0.2.89",
        "ipv4:198.51.100.34",
        "ipv4:203.0.113.45"
      ]
    }
  }
HTTP/1.1 200 OK
Content-Length: TBA
Content-Type: application/alto-endpointcost+json
{
    "meta": {
           "cost-type": {
           "cost-mode": "numerical",
           "cost-metric": "maxresbw"
           }
    },
  " endpoint-cost-map": {
         "ipv4:192.0.2.2" {
         "ipv4:192.0.2.89" :    0,
         "ipv4:198.51.100.34": 2000,
         "ipv4:203.0.113.45":  5000,
                           }
          }
}
```

## 10. Metric: Unreserved Bandwidth

Cost Metric name:

Unreserved Bandwidth

Cost Metric string:

US-ASCII string 'unresbw'

Metric Description:

To specify spatial and temporal unreserved bandwidth over the specified source and destination. The values correspond to the bandwidth that can be reserved with a setup priority of 0 through 7. Therefore this metric is endcoded as an array of 8 values. The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit and Value Type:

See definition for the bandwidth Cost Metric.

Example 7: unresbw value on source-destination endpoint pairs
In this example, the Collection method specifies that the 'unresbw' values are defined as the 'unavailable bandwidth' specified in section 2.5.8 of RFC3630: 8 unavailable bandwidth value are reported in the same OSPF message using the same TLV. Each value is corresponding to the bandwidth that can be reserved with a setup priority of 0 through 7.

```
POST/ endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBA
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

  {
   "cost-type" { "cost-mode":  "numerical",
   "cost-metric":  "unresbw[1,8]" },
   "endpoints":  {
      "srcs": [ "ipv4:192.0.2.2" ],
      "dsts": [
        "ipv4:192.0.2.89",
        "ipv4:198.51.100.34",
        "ipv4:203.0.113.45"
      ]
    }
  }

HTTP/1.1 200 OK
Content-Length: TBA
Content-Type: application/alto-endpointcost+json
{
   "meta": {
          "cost-type": {
          "cost-mode": "numerical",
          "cost-metric": "unresbw[1,8]"
        }
  },
"endpoint-cost-map" {
           "ipv4:192.0.2.2" {
           "ipv4:192.0.2.89" :   [0,0,0,0,0,0,0,0],
           "ipv4:198.51.100.34": [0,0,0,0,0,0,0,2000],
           "ipv4:203.0.113.45":  [0,0,0,0,0,0,0,5000],
                        }
       }
}
```

## 11. Metric: Residue Bandwidth

Cost Metric name:

Residue Bandwidth

Cost Metric string:

US-ASCII string 'residbw'

Metric Description:

To specify spatial and temporal residual bandwidth over the specified source and destination. The value is calculated by subtracting tunnel reservations from Maximum Bandwidth (motivated from [I-D. ietf-isis-te-metric-extensions], Sec.4.5.). The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit and Value Type:

See definition of the general Bandwidth.

Example 8: residuebw value on source-destination endpoint pairs

```
POST/ endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBA
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

  {
   "cost-type": { "cost-mode":  "numerical",
   "cost-metric":  "residubw"},
   "endpoints":  {
     "srcs": [ "ipv4 : 192.0.2.2" ],
     "dsts": [
       "ipv4:192.0.2.89",
       "ipv4:198.51.100.34",
       "ipv4:203.0.113.45"
     ]
   }
}

HTTP/1.1 200 OK
Content-Length: TBA
Content-Type: application/alto-endpointcost+json
{
   "meta": {
          "cost-type" {
          "cost-mode": "numerical",
          "cost-metric": "residubw"
        }
    },
"endpoint-cost-map" {
         "ipv4:192.0.2.2" {
         "ipv4:192.0.2.89" :    0,
         "ipv4:198.51.100.34": 2000,
         "ipv4:203.0.113.45":  5000,
                      }
        }
}
```

## 12. Metric: Available Bandwidth

Cost Metric name:

Available Bandwidth

Cost Metric string:

US-ASCII string 'availbw'

Metric Description:

To specify spatial and temporal availaible bandwidth over the specified source and destination. The value is calculated by subtracting the measured bandwidth used for the actual forwarding of best effort traffic from Residue Bandwidth (motivated from [I-D. ietf-isis-te-metric-extensions], Sec.4.6.). The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit and Value Type:

See definition of the general Bandwidth.

Example 9: availbw value on source-destination endpoint pairs

```
POST /endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBA
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

  {
   "cost-type": { "cost-mode":  "numeric",
   "cost-metric":  "availbw"},
    "endpoints":  {
      "srcs": [ "ipv4 : 192.0.2.2" ],
      "dsts": [
        "ipv4:192.0.2.89",
        "ipv4:198.51.100.34",
        "ipv4:203.0.113.45"
      ]
   }
     }

HTTP/1.1 200 OK
Content-Length: TBA
Content-Type: application/alto-endpointcost+json
{
   "meta": {
          "cost-type": {
          "cost-mode": "numeric",
          "cost-metric": "availbw"
         }
   },

  "endpoint-cost-map": {
            "ipv4:192.0.2.2" {
          "ipv4:192.0.2.89" : [6,5,7,8,4,10,7,6],
          "ipv4:198.51.100.34" : [7,4,6,8,5,9,6,7],
          "ipv4:203.0.113.45" : [7,6,8,5,7,9,6,8],
                       }
         }
  }
```

## 13. Metric: Utilized Bandwidth

Cost Metric name:

Utilized Bandwidth

Cost Metric string:

US-ASCII string 'utilbw'

Metric Description:

To specify spatial and temporal utilized bandwidth over the specified source and destination. The value is corresponding to the actual measured bandwidth used for all traffic (motivated from [I-D. ietf-isis-te-metric-extensions], Sec.4.7.). The spatial aggregation unit is specified in the query context (e.g., PID to PID, or endpoint to endpoint); and the temporal unit is specified as the measurement interval in the query context.

Metric Unit and Value Type:

See definition of the general Bandwidth.

Example 10: utilbw value on source-destination endpoint pairs

```
POST /endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBA
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

 {
  "cost-type": {"cost-mode" : "numerical",
  "cost-metric" :  "utilbw"},
  "endpoints":  {
       "srcs" : [ "ipv4 : 192.0.2.2" ],
       "dsts" : [
         "ipv4:192.0.2.89",
         "ipv4:198.51.100.34",
         "ipv4:203.0.113.45"
      ]
    }
 }

HTTP/1.1 200 OK
Content-Length: TBA
Content-Type: application/alto-endpointcost+json
 {
  "meta": {
         "cost type": {
         "cost-mode": "numerical",
         "cost-metric": "utilbw"
        }
  },
"endpoint-cost-map": {
           "ipv4:192.0.2.2" {
           "ipv4:192.0.2.89" :   0,
           "ipv4:198.51.100.34" : 2000,
           "ipv4:203.0.113.45" :  5000,
                        }
         }
}
```

## 14. Security Considerations

The properties defined in this document present no security considerations beyond those in Section 15 of the base ALTO specification [ALTO].

However concerns addressed in Sections "15.1 Authenticity and Integrity of ALTO Information", "15.2 Potential Undesirable Guidance

from Authenticated ALTO Information" and "15.3 Confidentiality of ALTO Information" remain of utmost importance. Indeed, TE performance is a highly sensitive ISP information and sharing TE metric values in numerical mode requires full mutual confidence between the entities managing the ALTO Server and Client. Numerical TE performance information will most likely be distributed by ALTO Servers to Clients under strict and formal mutual trust agreements. One the other hand, ALTO Clients must be cognizant on the risks attached to such information that they would have acquired outside formal conditions of mutual trust.

## 15. IANA Considerations

IANA has added the following entries to the ALTO cost map Properties registry, defined in Section 3 of [RFCXXX].

| Namespace | Property | Reference |
|---|---|---|
| | delay | [RFCxxxx], Section 3 |
| | delayjitter | [RFCxxxx], Section 4 |
| | pktloss | [RFCxxxx], Section 5 |
| | hopcount | [RFCxxxx], Section 6 |
| | bandwidth | [RFCxxxx], Section 7 |
| | maxbw | [RFCxxxx], Section 8 |
| | maxresbw | [RFCxxxx] Section 9 |
| | unresdbw | [RFCxxxx], Section 10 |
| | residbw | [RFCxxxx], Section 11 |
| | availbw | [RFCxxxx], Section 12 |
| | utilbw | [RFCxxxx], Section 13 |

## 16. References

### 16.1. Normative References

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