ALTO Extension: Path Vector

draft-yang-alto-path-vector-03
draft-gao-alto-routing-state-abstraction-03

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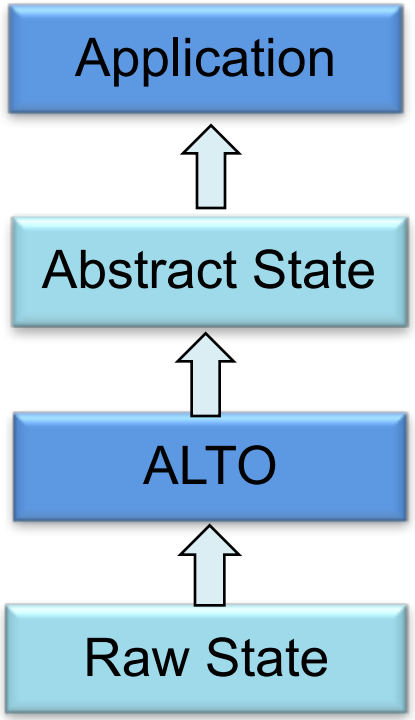
IETF96

Overview

- Going beyond “single-switch” topology abstraction is largely agreed upon in the WG with a charter item
- WG has multiple designs related on network graph, e.g.,
  - [NL] node/link graphs
  - [NLP] node/link graph + path vector
  - [AP] Path vector w/ abstract network elements
  - ECMP complexity
- Proposal: First finish the AP design as a delivery

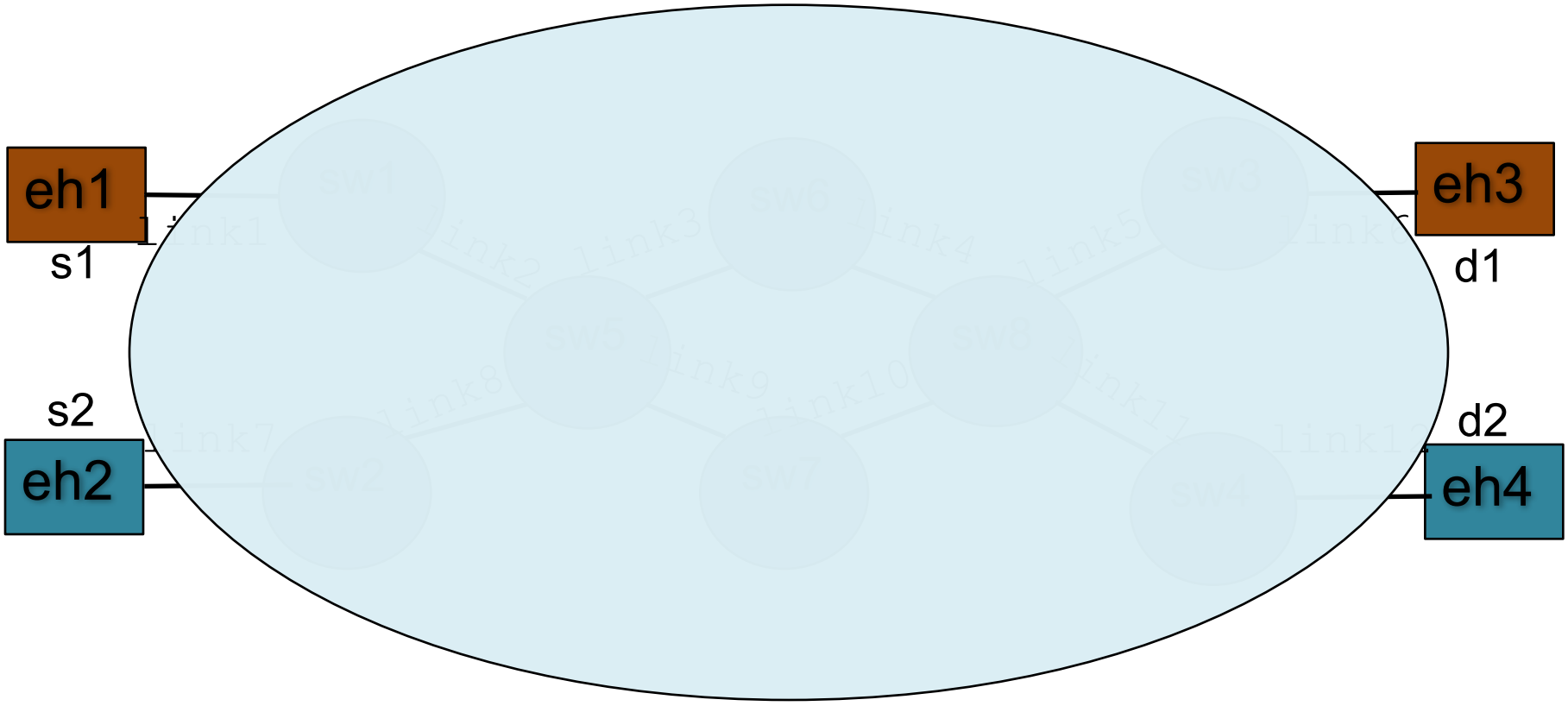


Application-Layer Traffic Optimization (TO) Framework

- App has a set of K flows f[i] = si -> di
- Path f[i].path for flow f[i] is computed by network
- App TO can do is to control traffic volume (f[i].x) for flow f[i]
  - x = [f[1].x, f[2].x, …, f[K].x]
  - App needs path properties (e.g., cost) of f[i] when computing f[i].x

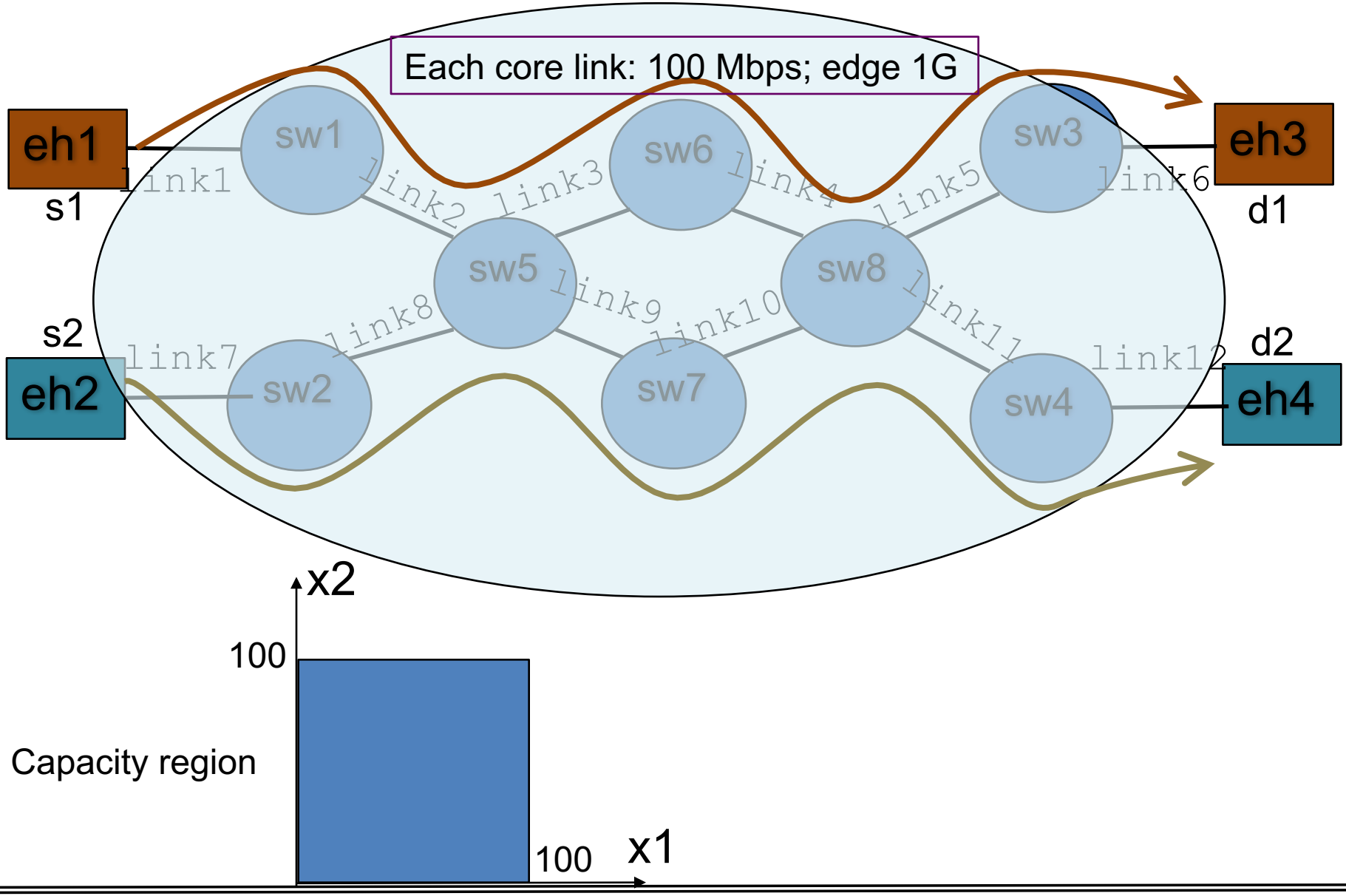
Value of ALTO is to provide hard-to-obtain, easy to use network information to applications.

Main Use Case of Network Graph is Capacity Region



- App requests available bandwidth for two flows (s1->d1; s2->d2)
- Cost map returns f[1].bw = 100 Mbps; f[2].bw = 100 Mbps
- But the result can be ambiguous

Main Use Case of Network Graph is Capacity Region



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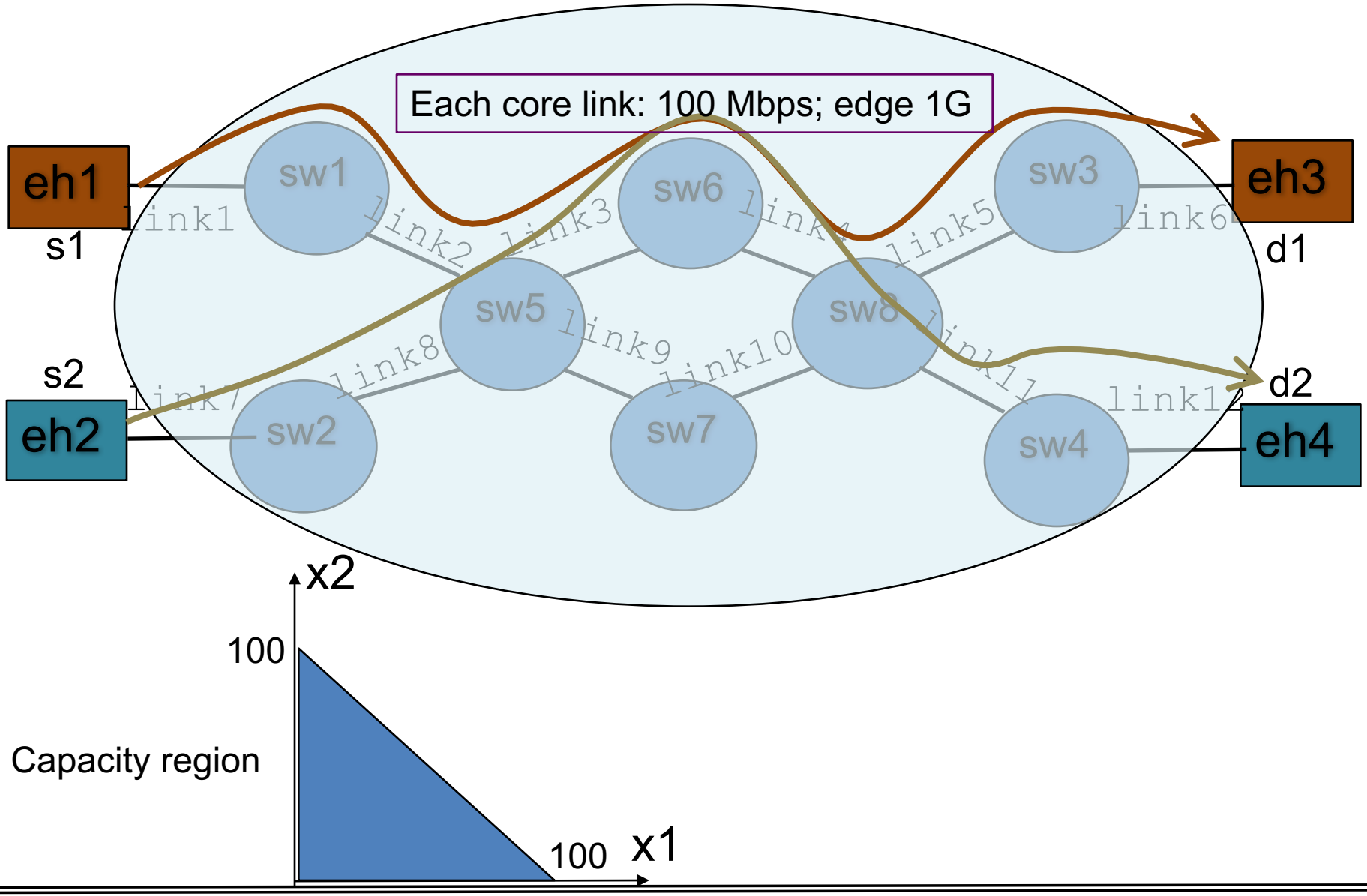

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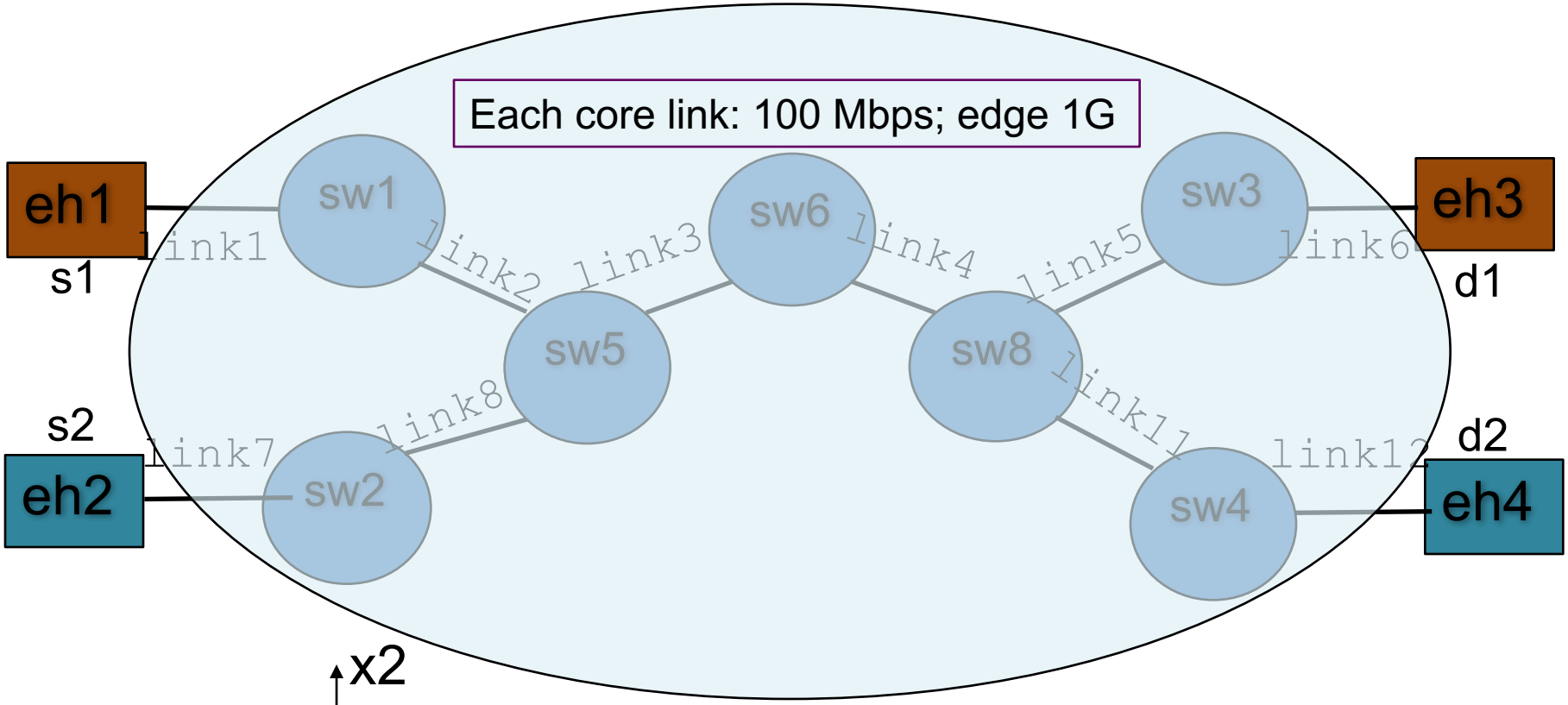
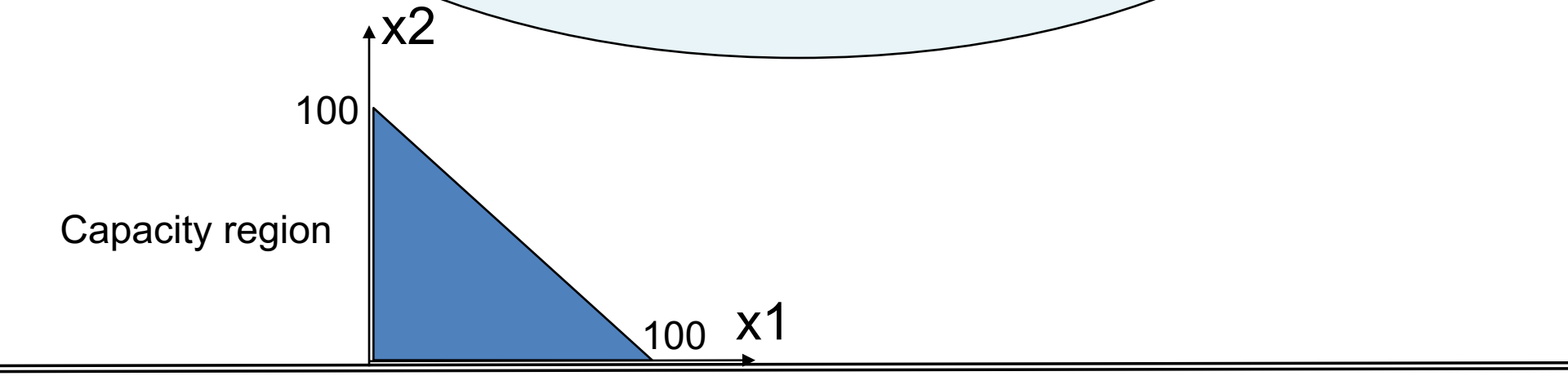
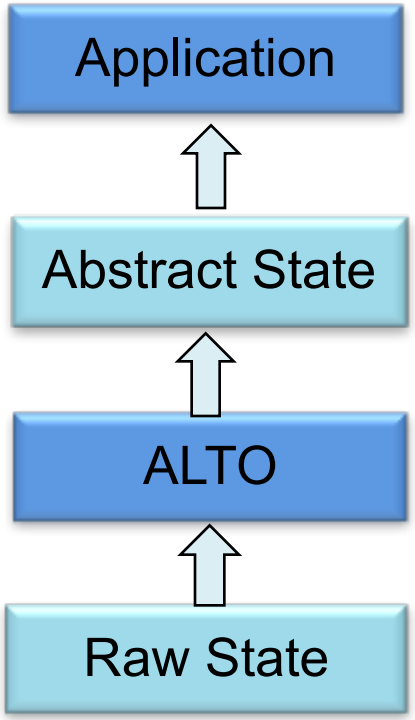




Design Choice

- [NL] node/link graphs:
  - Not enough information
- [NLP] node/link graph + path vector
  - No need for all the information
- [AP] Path vector w/ abstract network elements
  - Sweet spot



Path Vector Design Issue 1: Encode PV in Cost Maps

- **Cost Map w/ PV:**

```
HTTP/1.1 200 OK
…
application/alto-costmap+json

{
  "meta" : {
     "dependent-vtags" : […],
     "cost-type" : {“cost-metric”: ?, "cost-mode"  : ? }
  },
  "cost-map" : {
     "PID1": { "PID1":[], "PID2":["ne56", "ne67"], "PID3":[], "PID4":["ne57”]},
     "PID2": { "PID1":["ne75"], "PID2":[], "PID3":["ne75"], "PID4":[]}, …
  }
}
```

- Key Issue: What is the cost-metric and cost mode

AP Design Issue 1: Encode PV in Cost Maps

```
object {
      CostMapData cost-map;
    } InfoResourceCostMap
         : ResponseEntityBase;

    object-map {
      PIDName -> DstCosts;
    } CostMapData;

    object-map {
      PIDName -> JSONValue;
    } DstCosts;
```

```
object {
      EndpointCostMapData endpoint-cost-map;
    } InfoResourceEndpointCostMap
         : ResponseEntityBase;

    object-map {
      TypedEndpointAddr -> EndpointDstCosts;
    } EndpointCostMapData;

    object-map {
      TypedEndpointAddr -> JSONValue;
    } EndpointDstCosts;
```

- Authors of [RFC7285] anticipated that elements of a CostMap may need to be generic and hence used **JSONValue**

  =>

  CostMap and EndpointCostMap are **polymorphic (generic)** types that need type indicator, to indicate syntax and semantics
  - CostMap<T>
  - EndpointCostMap<T>

Issue 1: Design Choices

- I1-choice 1
  - Introduce specific cost-mode and cost-metric to indicate a PV Cost Map
- I1-Choice 2
  - A unifying cost-type scheme also handling multi-cost, cost calendar

Path Vector Design Issue 2: Query Precision

- Issue:
  - Current CostMap and EndpointCostMap are designed for **cross-product** queries
    {s1, s2, …., sn} -> {d1, d2, ..., dm}
    ===
    s1->d1, s1->d2, ..., s1->dm, s2->d1, ..., sn->dm
  - but such queries can involve a large number of paths, which may not be necessary but limit the opportunity for computing compact, abstract topology

Path Vector Design Issue 2: Query Precision

- Possibility: Make PV query to be non-cross product, e.g., a query enumerates the set of flows

```
POST /capacityregion/lookup HTTP/1.1
Host: alto.example.com
Content-Length: TBD
Content-Type: application/alto-flowparams+json
Accept: application/alto-costmap+json,application/alto-error+json

 {
    "flows" : [
          {"src": "ipv4:192.0.1.1", "dst": "ipv4:192.0.1.2"},
          {"src": "ipv4:192.0.1.3", "dst": "ipv4:192.0.1.4"},
          {"src": "ipv4:192.0.1.1", "dst": "ipv4:192.0.1.4"}
    ]
    … }
```

- Proposal:
  - Coordinate with flow cost service or more generally, do we proceed w/ Routing State Abstraction w/ Declared Equivalence

Issue 2: Design Choices

- I2-choice 1
  - Use native Cost Map for PIDs and Endpoint Cost Map queries
- I2-Choice 2
  - Introduce flows, and more general, introduce routing state abstraction query language as a general query mechanism

Path Vector Design Issue 3: Provide PV Elem. Properties

- Design choices
  1. Inline: Embed in the same cost map
  2. Reference: Use dependent-vtag to refer to a separate map (e.g., unified element properties)

Path Vector Design Issue 3: Inline

```
HTTP/1.1 200 OK
…
application/alto-costmap+json

{
  "meta" : {
     "dependent-vtags" : […],
     "cost-type" : {“cost-metric”: “ane”, "cost-mode"  : ”path-vector”  }
  },
  "cost-map" : {
     "PID1": { "PID1":[], "PID2":["ne56", "ne67"], "PID3":[], "PID4":["ne57”]},
     "PID2": { "PID1":["ne75"], "PID2":[], "PID3":["ne75"], "PID4":[]}, …
  }
  “nep-map” : {
     “ne56”: {“bw”: 10, … }
  }
}
```

- Key remaining issue:
  - How to indicate the properties/values specified in the nep-map?
  - Need to indicate multi-cost map for the nep-map in meta

Path Vector Design Issue 3: Reference

```
HTTP/1.1 200 OK
…
application/alto-costmap+json

{
   "meta" : {
      "dependent-vtags" : […
         refer to an nep map
      ],
      "cost-type" : {“cost-metric”: “ane”, "cost-mode"  : ”path-vector”  }
   },
   "cost-map" : {
      "PID1": { "PID1":[], "PID2":["ne56", "ne67"], "PID3":[], "PID4":["ne57”]},
      "PID2": { "PID1":["ne75"], "PID2":[], "PID3":["ne75"], "PID4":[]}, …
   }
}
```

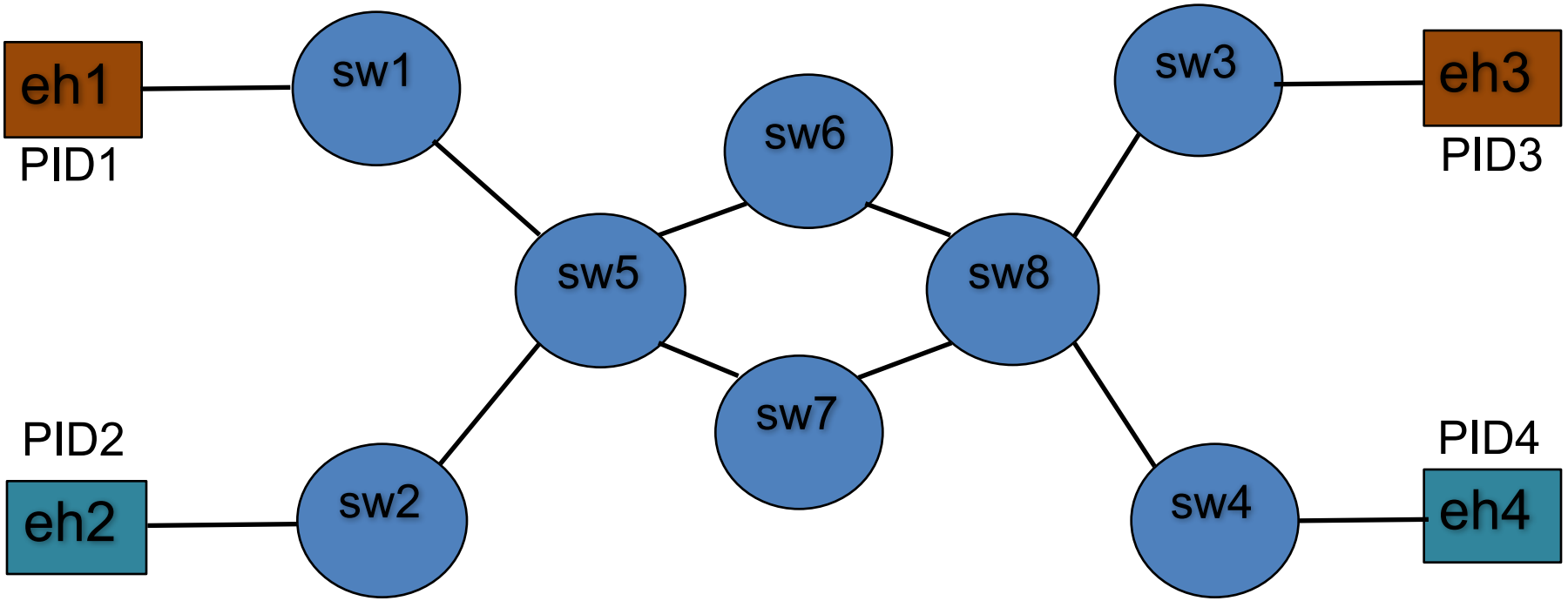
Road Map: Decision Points

NL Graph
NLGraph+PV
APV

Issue 1	Issue 2	Issue 3
Specific Cost Type	Native Cost Map Query	Inline
Scheme together w/ MC, CC	Flow Query+RSA	Reference

Backup Slides

Q: How to Support ECMP Path



- ECMP for eh1 -> eh3, single path through sw6 for eh2 -> eh4
  - PID1 -> PID3: [{“ne”: “sw5-6”, “w”: 0.5},
    {“ne”: “sw6-8”, “w”: 0.5},
    {“ne”: “sw5-7”, “w”: 0.5},
    {“ne”: “sw7-8”, “w”: 0.5}]
  - PID2 -> PID4: : [{“ne”: “sw5-6”, “w”: 1},
    {“ne”: “sw6-8”, “w”: 1}]

```
object {
   JSONNumber w;      // flow weight
   JSONString  ne;    // network element
} FlowElement;

object {
      cost-map.DstCosts.JSONValue
            -> FlowElement<0,*>;
      meta.cost-mode = ”flow”;
} InfoResourcePVCostMap : InfoResourceCostMap;
```

One More Example

- How do we allow statistics on a cost metric (e.g., routingcost)

```
HTTP/1.1 200 OK
…
application/alto-costmap+json

{
   "meta" : {
      "dependent-vtags" : […],
      "cost-type" : {“cost-metric”: “latency-stat”, "cost-mode"  : ”basic-stat-object”  }
   },
   "cost-map" : {
      "PID1": {
            "PID1”:{“min”; 1, “max”: 2, “avg”: 1.5} ,
            "PID2”:{“min”; 2, “max”: 5, “avg”: 2.5} ,
            …
      ...
   }
}
```

Path Vector Design Issue 1: Encode PV in Cost Maps

- The **"cost-mode"** field of the "cost-type" field of "meta" of each CostMap is the **type indicator**

```
object {
      CostMetric  cost-metric;
      CostMode    cost-mode;
      [JSONString description;]
} CostType;
```

  - CostMap<cost-mode>, i.e., CostMap<numerical> and CostMap<ordinal>
    - "numerical" indicates floating point numbers {6.1.2.1}
    - "ordinal" indicates "non-negative" integers {6.1.2.2}
  - "cost-metric": indicates the semantics (routingcost, bw, …)
    - CostMap<numerical> routingcost, bw
    - CostMap<ordinal> routingcost, bw
    - EndpointCostMap<numerical> routingcost, bw
    - EndpointCostMap<ordinal> routingcost, bw