Traffic Engineering Service

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NDN Services for Tactical Networks Tutorial

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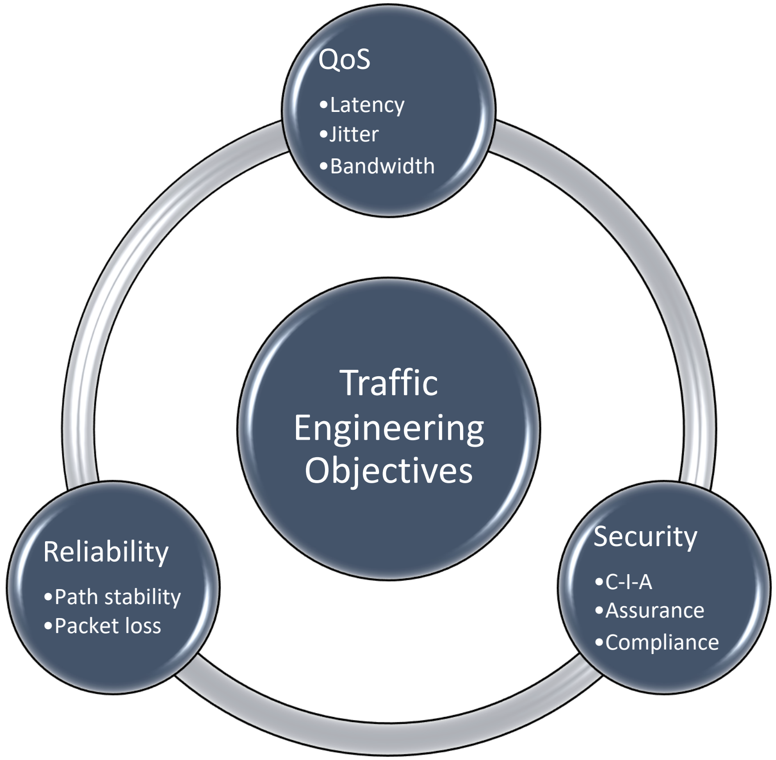
Defining Multi-Domain Command and Control

Traffic Engineering Service

- Manipulation of traffic to reflect network intent (mission requirements)
  - Traffic prioritization
  - Traffic shaping
  - QoS signaling
- Primary focus of a number of protocols such as OSPF-TE



Elements of Traffic Engineering

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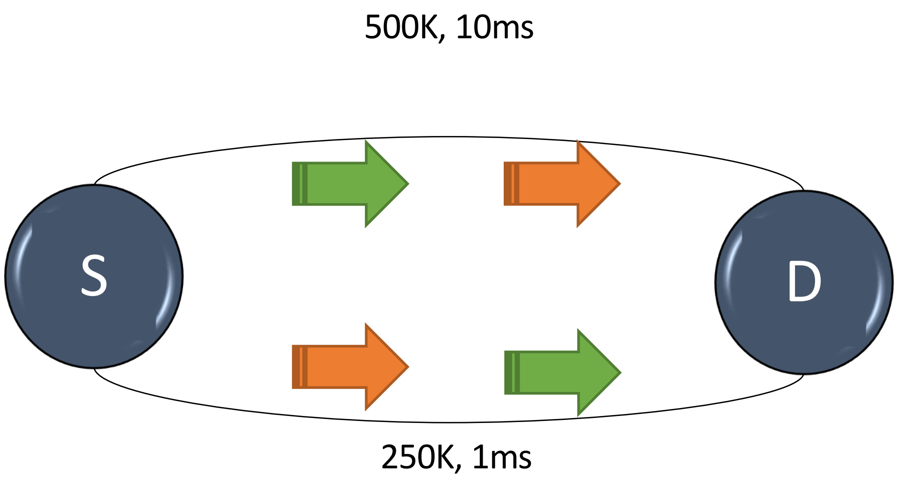
- **Load balancing**
- Load distribution
- Different objective functions
- Broadcast, multicast, and unicast
- Estimation and measurements
- Priority signaling



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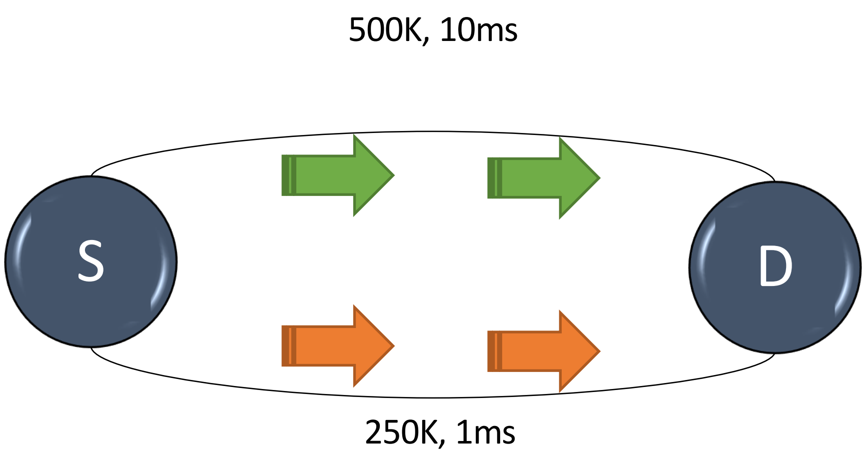

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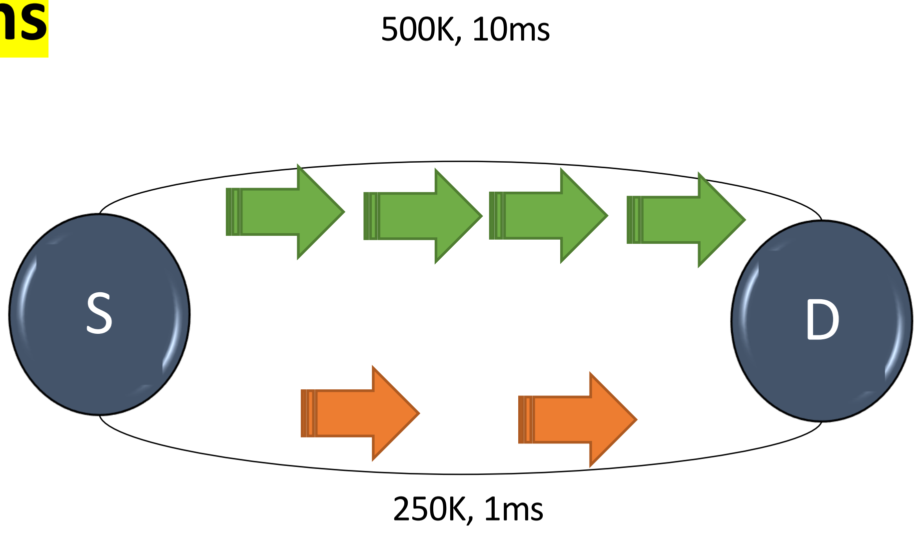

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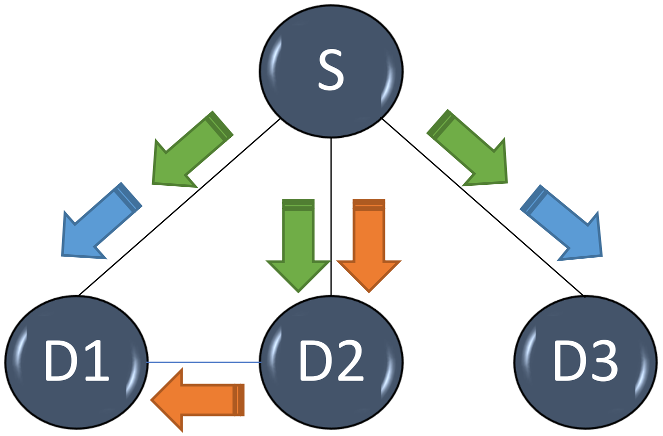

Elements of Traffic Engineering

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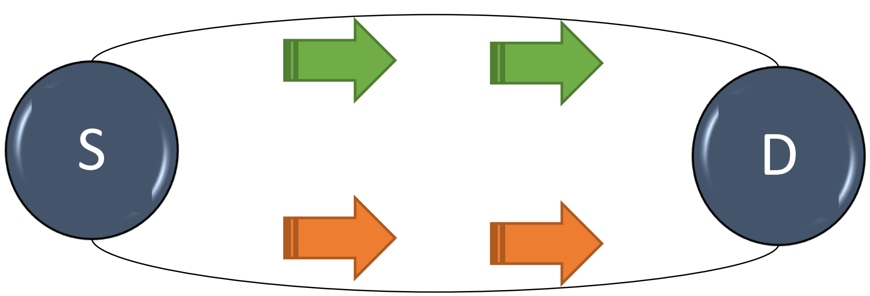
Link reliability

Link latency

Link data rate

Traffic demand
- Measurement
- Estimation
- Request

500K, 10ms



250K, 1ms

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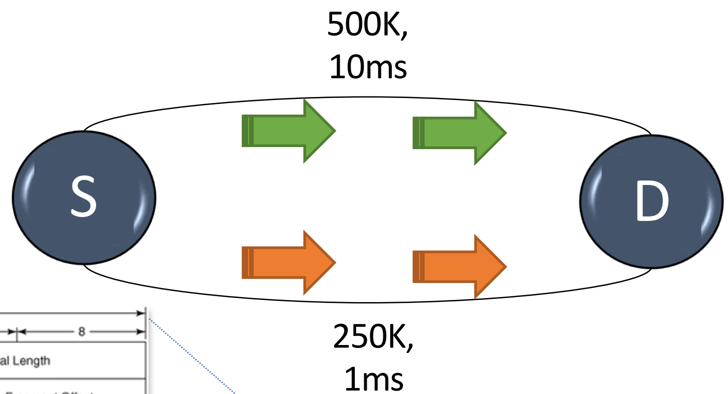

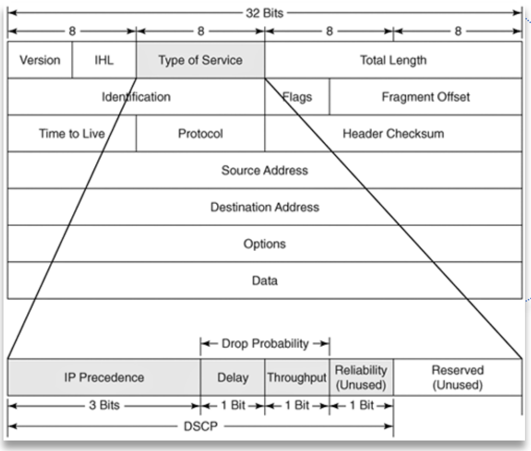

Differentiated Service Code Point (DSCP)

Who signals traffic prioritization?

Application does it	• Tragedy of the commons
In-line device that prioritizes traffic	• Loaded with a static (non-adaptive) asynchronous traffic prioritization policy • Some of them perform caching functions

Today’s model

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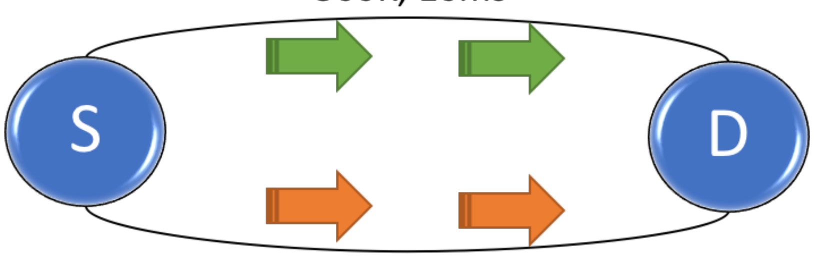
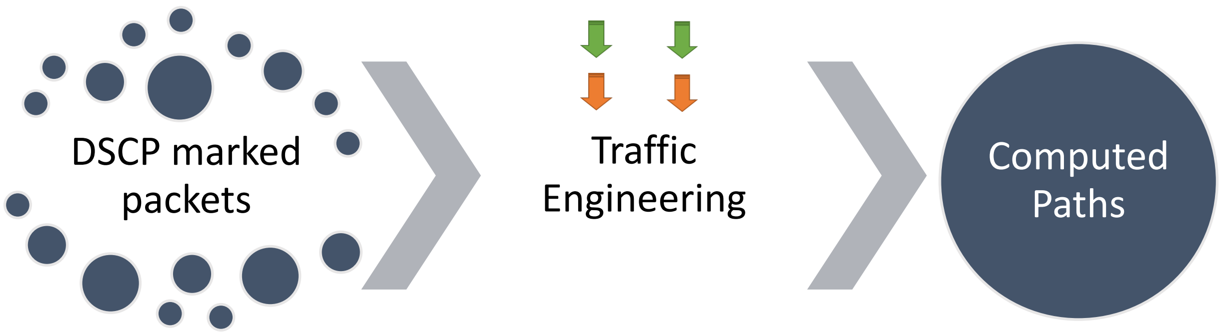
- Today’s traffic engineering model is anchored off of end-point semantics and not content
  - Anchored off of TCP/IP header information
  - Per-flow granularity





Why is this approach limiting?

- QoS must reflect content not end-point semantics
  - Different chunks of data may carry information with different QoS requirements
  - Per-chunk granularity as apposed to per flow granularity
- The dynamics and challenges of tactical networks mandate an adaptive approach

Example application: CoT

- Track info with different content

<?xml version=‘1.0’ standalone=‘yes’?><event how=“m-r-p” opex=“e-JCIDEX” qos=“0-r-c” stale=“2016-04-12T16:47:42.72Z” start=“2016-04-12T16:45:42.72Z” time=“2016-04-12T16:45:42.72Z” type=“a-f-G-I-r-h” uid=“Debug.032” version=“2.0”><detail><_flow-tags_ debug=“2016-04-12T16:46:28.00Z” /></detail><point ce=“122.4” hae=“550.1” lat=“42.5533154” le=“431.9” lon=“-71.3267596”/></event>”

Ground hostile target → Reliability, Low latency

Ground friend target → Reliability

NDN functions for TE

NDN functions can provide the foundation for strong Traffic Engineering

- Producer or consumer driven QoS signaling
- Caching policy can retain latency-constrained data longer
- Forwarding strategy can select forwarding paths based on QoS req.
- NDN Sync can be used to synchronize policies

QoS signaling: producer driven

- Explicit QoS signaling (embedded in the name)
  - /ndn/ucla/tutorials/milcom2019/QoS/latency-max=2
  - Same CoT data can be serviced at different QoS
- Implicit QoS signaling (inferred from the name)
  - /mission-a/CoT/ground/hostile → reliability and low latency
  - /mission-a/CoT/ground/friendly → reliability
  - CoT data chunks can carry different QoS signals
- Forwarding strategy will attempt to honor both QoS signaling approaches

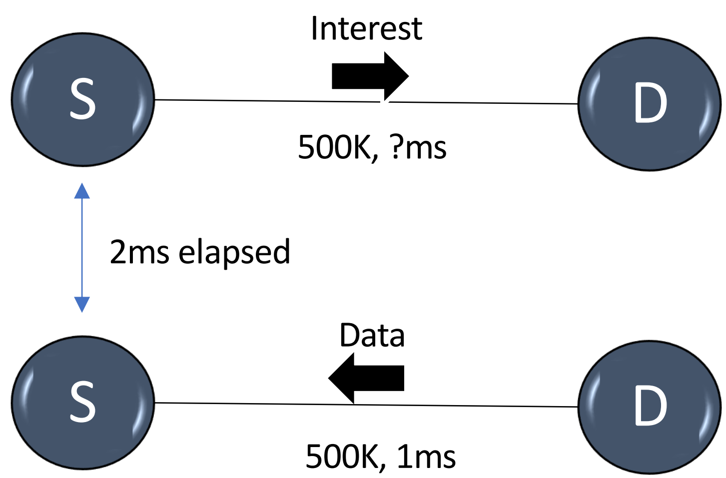
QoS signaling: driven by consumer

- QoS signaling can be part of the ApplicationParameters of an Interest packet
  - /mission-a/CoT/ground/friendly
  - Forwarders will attempt to honor the embedded QoS signal

```
Interest = INTEREST-TYPE TLV-LENGTH
             Name
             [CanBePrefix]
             [MustBeFresh]
             [ForwardingHint]
             [Nonce]
             [InterestLifetime]
             [HopLimit]
             [ApplicationParameters [InterestSignature]]
```

TE Driven Forwarding Strategies

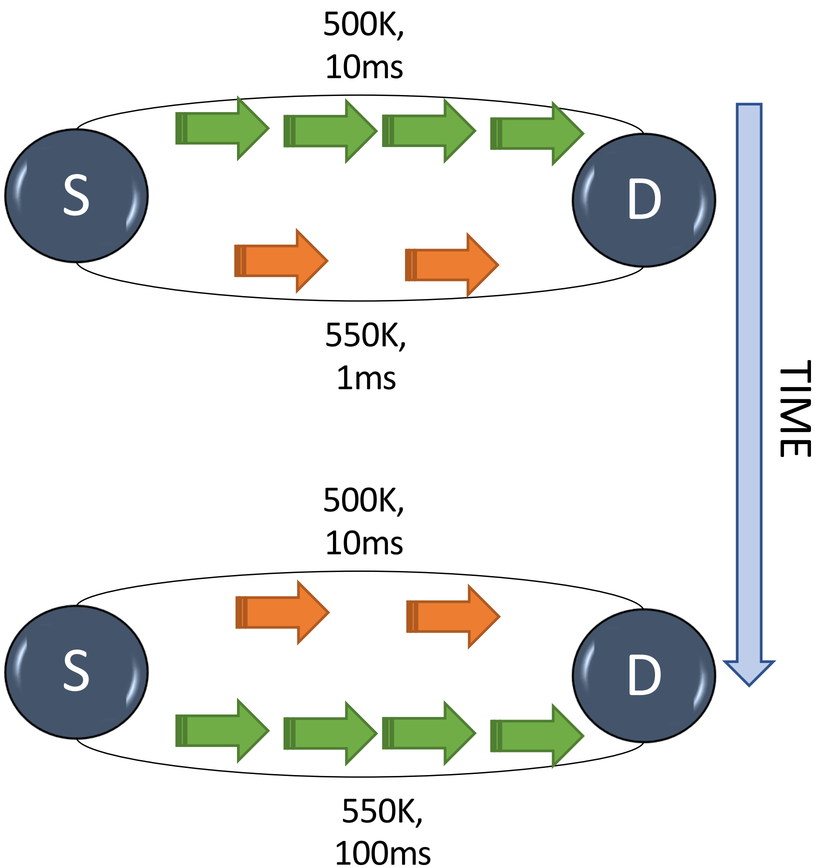
- Forwarding strategies are equipped to provide very strong TE mechanisms
  - Can derive link (or path) reliability through the Interest ←→ Data packet feedback loop.
  - Can derive link (or path) latency through the Interest ←→ Data packet feedback loop.
  - NDN-LP provides reliability and latency information between NDN nodes



- Can also measure traffic demand from Interest rate/class of service

TE Driven Forwarding Strategies

- Forwarding decision can be based on QoS signaling from consumer and/or producer
- Forwarding strategy can continue to leverage the in-band Interest/Data feedback loop to measure demand as well as link (or path) characteristics and adjust FIB accordingly



Traditional load balancing

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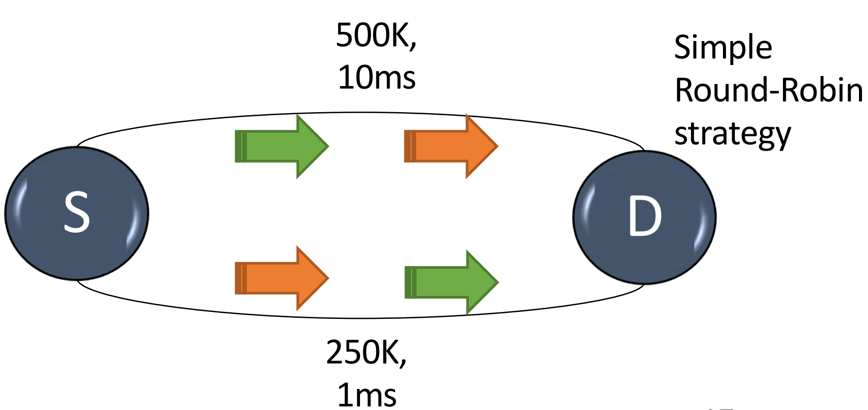
- Load balancing is typically not implemented because of the impact of putting TCP segments from the same flow on two different links (different latencies can cause out-of-order delivery)

Forwarding strategies can drive load balancing

- An NDN forwarding strategy can be devised to accomplish load balancing (and/or load distribution)



TE Driven Forwarding Strategies

- Forwarding strategies can easily service unicast, multicast, as well as anycast (anyone has this data type) request

Examples:

- /mission-a/CoT/ground/hostile
  - Broadcast since this information is important to deliver to all nodes fast
  - Other nodes can enable opportunistic caching for this prefix
- /mission-a/CoT/ground/friendly/latency=x
  - Send on link with latency less than x/2.
- /mission-a/ftp/file-111219
  - Send on highest capacity link

QoS-aware Caching strategy

- Insertion and eviction policies can factor in QoS
  - Retaining chunks that are latency-sensitive in the network (e.g. hostile tracks)
  - Factor in the value of the information over time
  - Factor in reliability of links where the data is typically serviced

Example policies:

- Retain only latest sequence of chunks where older sequence numbers do not matter
  - PLI information
- Retain chunks longest when the only path to retrieve them is through an unreliable link
  - Denied, Disrupted, Intermittent, and Limited bandwidth (DDIL) links

Policy synchronization

- QoS policy dataset can be retained and synchronized across the network using Sync protocols
- Appropriate security measures can be provided
  - Access control (who is authorized to a read/write policies)
  - Authentication (tie specific policies to specific administrative domains)
  - Confidentiality
  - Integrity (built-in by default)
  - Policy override (domain policy overrides local policy)