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# E2E Service Verification Architecture

An architectural proposal for defining, engineering, and verifying Performance Guaranteed services

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## Context and Motivation

- The R&E (GLIF) community has been exploring lightpath services for almost a decade now..
  - We are now recognizing that the practical useability of lightpaths is dependent upon a combination of technologies that are necessary to deliver a "lightpath *service*":
    - E.g. Standardized and ubiquitous user interfaces, on-demand and book-ahead scheduling, inter-domain reservation and provisioning processes, topology distribution and intelligent automated path computation, security and authorization,...
- A key feature common to these new services is the "performance guarantee" (PG)
  - i.e. the network *guarantees* a certain performance level
  - Might be transport capacity, or availability, or some other characteristic,...or some combination there of.

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## Context and Motization

- As dynamic global layer 0/1/2 connection services emerge, “*performance*” on these services means something different than conventional best-effort IP services:
  - These are not IP services so you cannot assume IP verification models will be appropriate (e.g. perhaps an ethernet VLAN is being requested...)
  - Not all “performance verification” is about packet loss or congestion (perhaps the service is required at a specific time, or via specific route, or with certain protection features...)
  - Virtualization and mult-protocol layering hide physical layer topology
  - Contemporary security, privacy,and scaling realities make detailed global E2E network information gathering difficult if not impossible.

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# A New Notion of "Service"

- Just as service *delivery* of performance guaranteed services requires new service paradigms, service *verification* of these new services requires a new approach; different assumptions...
  - We need a fresh notion of "service architecture" that better addresses the global E2E issues of Performance Guaranteed services
- These questions have been debated in many forums of recent years –
  - Especially GLIF R&E community,
  - In commercial forums and consortia...
  - And quite recently, and in great detail, within the OGF NSI Working Group
- This talk will pose an architectural approach that tries to integrate these ideas into a formalized set of design prinicples.

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# The Fundamental Transaction

- The “Fundamental Transaction” for PG network services:
  - The user requests, in advance, a specific level of service of the network
  - The network has an opportunity to verify that it can indeed meet the user’s criteria, and arrange to do so…
  - If the network can meet the requested service criteria, it will respond with a confirmed commitment to the user.
  - If the network cannot meet the service requested, it then has an opportunity and responsibility to reject the request.
- A correlary of the Fundamental Transaction:
  - Both the requester and the provider should be able to *<u>independently</u>* determine if the service provided meets the requested constraints.
  - Guaranteed performance in a modern global internetwork cannot rely on trust that a delivered service meets spec -> service performance must be <u>measurable and verifiable</u>.

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# The Fundamental Transaction

- The sacrosanct requirementof the FT:
  - Once the network commits to providing a service, it is irrevocably responsible for meeting that commitment.
  - A failure to meet the obligation – *for any reason* – constitutes a service outage.
  - But the network is accountable to the constraints as formally presented by the request
- The concomitant responsibility of the user then is:
  - To be exact and complete in specifying the necessary service constraints, as there is no guarantee implied for any other aspect of the service
  - And be prepared to assume the cost of the resources allocated and dedicatd tofulfilling those constraints.

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## The Fundamental Transaction

- The FT also *objectively* defines the service expectations:
  - If the constraints are satisfied, the connection is Good,
  - If the constraints are *not* satisfied, the connection is Bad.
- The fundamental transaction established “delegated responsibility”...
  - Delegated responsibility can be used by the network to subdivide the user’s request into smaller pieces and delegate each piece similarly to other service providers
- Delegation hides complexity and provides scalability
  - Each network can function as an opaque autonomous system – it’s internal structure and processes are private
- Likewise, delegation enables federation
  - “Networks of networks” can be composed that reflect common service preferences or shared resources...

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## The OGF Network Service Interface

- The OGF Network Service Interface WG – spawned from GLIF activities – has described a service interface architecture that supports the Fundamental Transaction.
- The Network Service Interface (NSI) Framework describes a set of interactions between a Requesting Agent (the user) and the Provider Agent (a network).
  - The NSI Connection Service protocol (NSI-CS) begins with a ReserveRequest primitive that constitutes the fundamental transaction.

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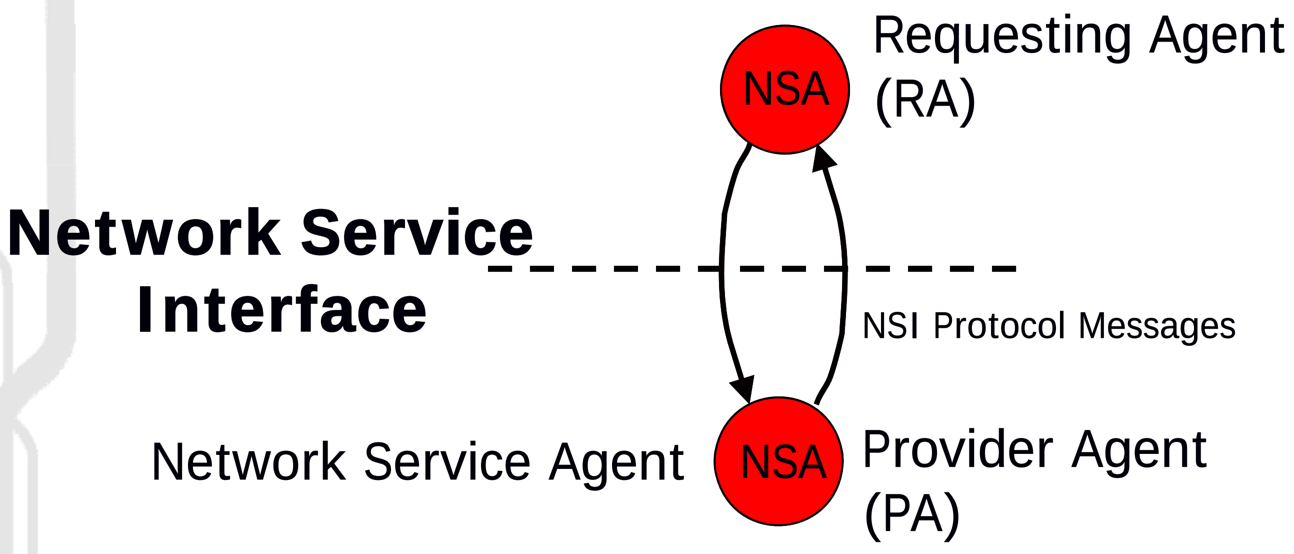
# The Basic Network Service Interface



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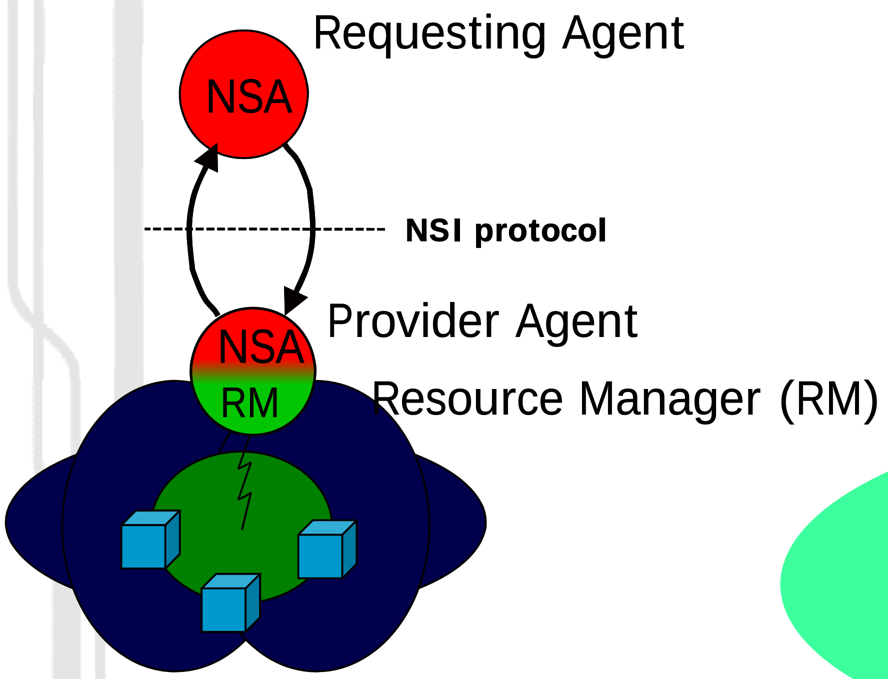
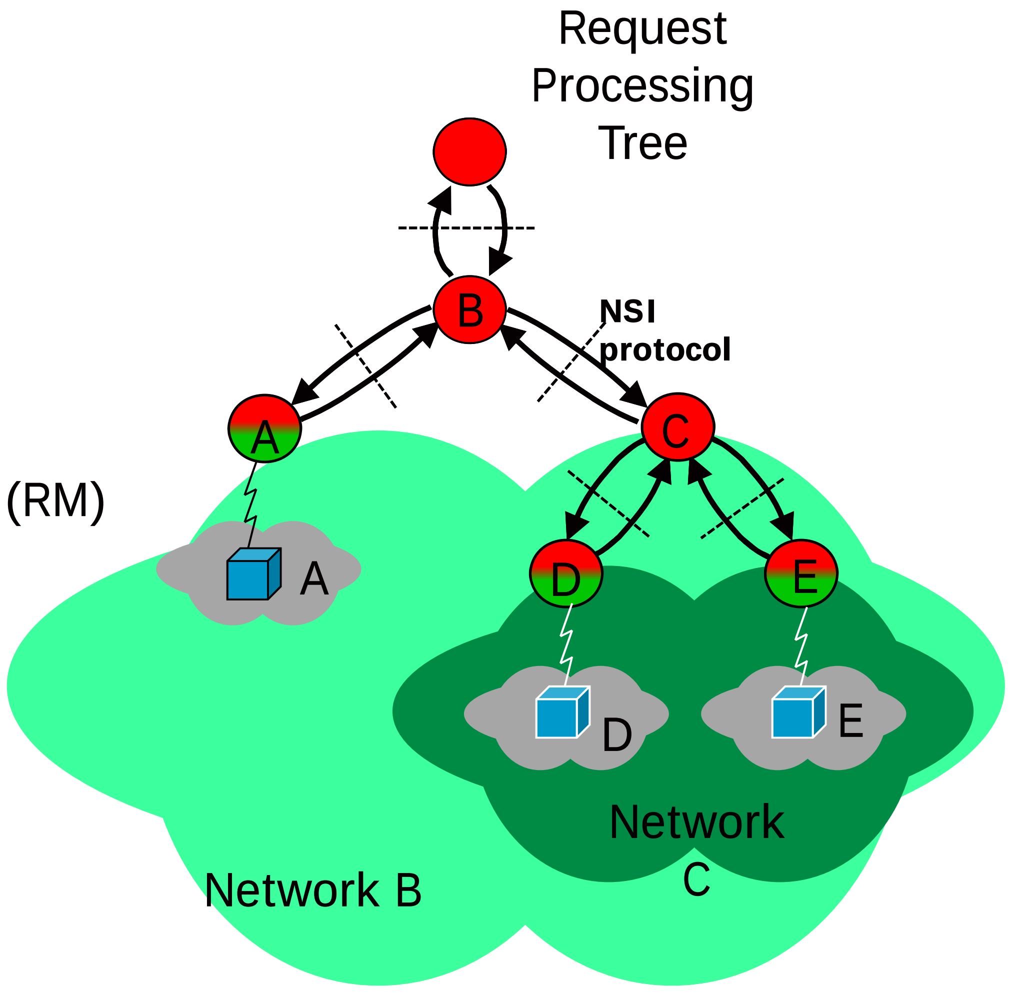
# Delegation in the NSI Model





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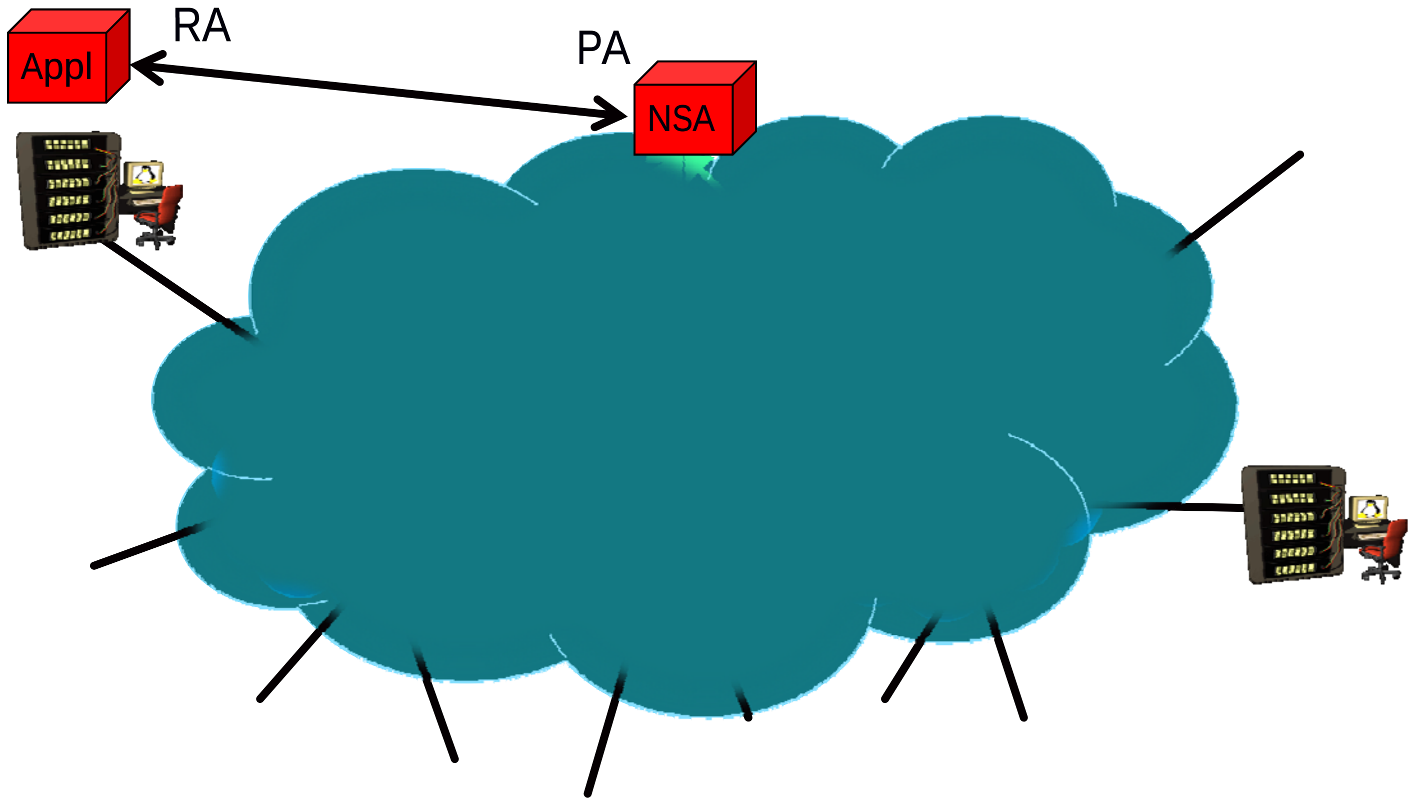
# The FT and Delegation in NSI

The user application



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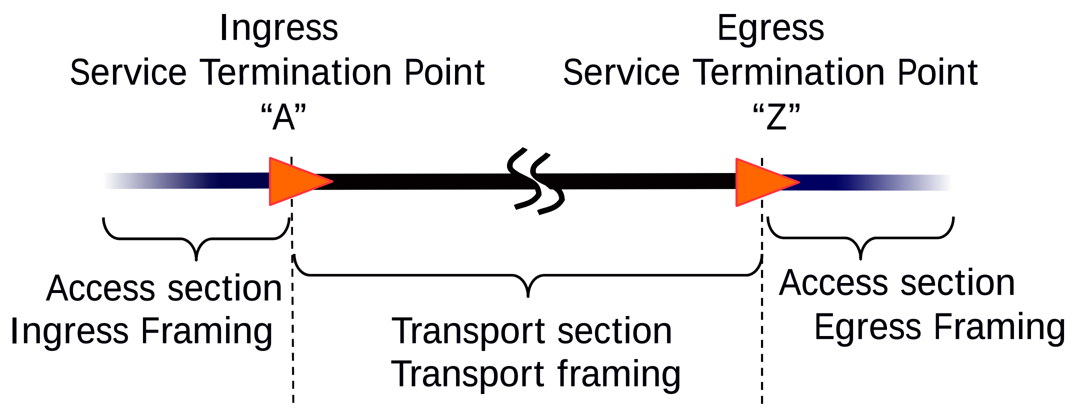
# Anatomy of a Connection



- The User (RA) specifies connection constraints (ostensibly externally measurable) for the access portion of the service instance
- The Network (PA) decides how to fulfil those constraints across the transport section.

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## Service Constraints

- The FT relies on clearly specifying any and all constraints associated with a connection request:

```
ReserveRequest{
    Orig="//NTNU/CloudCluster-p1";
    Dest="//KeioUniversity/Vizstation3";
    Capacity=1 Gbps;
    StartTime=2011/3/1 00:00:00 EST;
    EndTime=2011/3/1 18:00:00 EST;
    FrameLossRate=10^(-8);
    BurstSize=1 Gbps;
    Auth="Abcdef";
    Policy="prefer domain=[NORDUnet,GEANT,JGN2Plus]
        include domain=MANLAN, exclude=domain USLHCNET"
}
```

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## The Service Definition

- “Service Definitions” describe the scope and range of the service offered by a particular network.
- The Service Definition abstracts the network specific service capabilities away from the processes and functions that implement the [NSI] Connection Service
  - This allows the service implementations in different network domains to be defined and tailored as a process separately from the software and service architecture that delivers these services.
- Each network defines their respective service offering (SD)
- A group of networks can get together and define a *common* service definition

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## The Service Definition

- The Service Definition specifies all relevant service parameters associated with a particular network service offering
  - A provider constructs the SD docment listing the service parameters they are willing/able to support
  - Each parameter has a range of allowed values and a default where appropriate
  - The Service Definition acts as a template for service requests; User specified values overlay those found in the SD base.
  - Thus all service requests are fully specified

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## The Service Definition

- Service Definitions are defined separately from the service protocols

```
Service Defintion{
    Name="GLIF-Ethernet";
    Guarranteed {
        Orig:=[NSI-DirectorySvc(<p>)];
        Dest:=[NSI-DirectorySvc(<p>)];
        Capacity:=[Range(1,1000,1)] Mbps;
        Framing:=802.1ad |802.1, default=802.1;
        StartTime:= DateTime(<p>);
        EndTime:= DateTime(<p>) | Dur(<p>);
        Auth:=[EduGain(<p>)];
    }
    Prefered {
        Policy:= default="none";
    }
}
```

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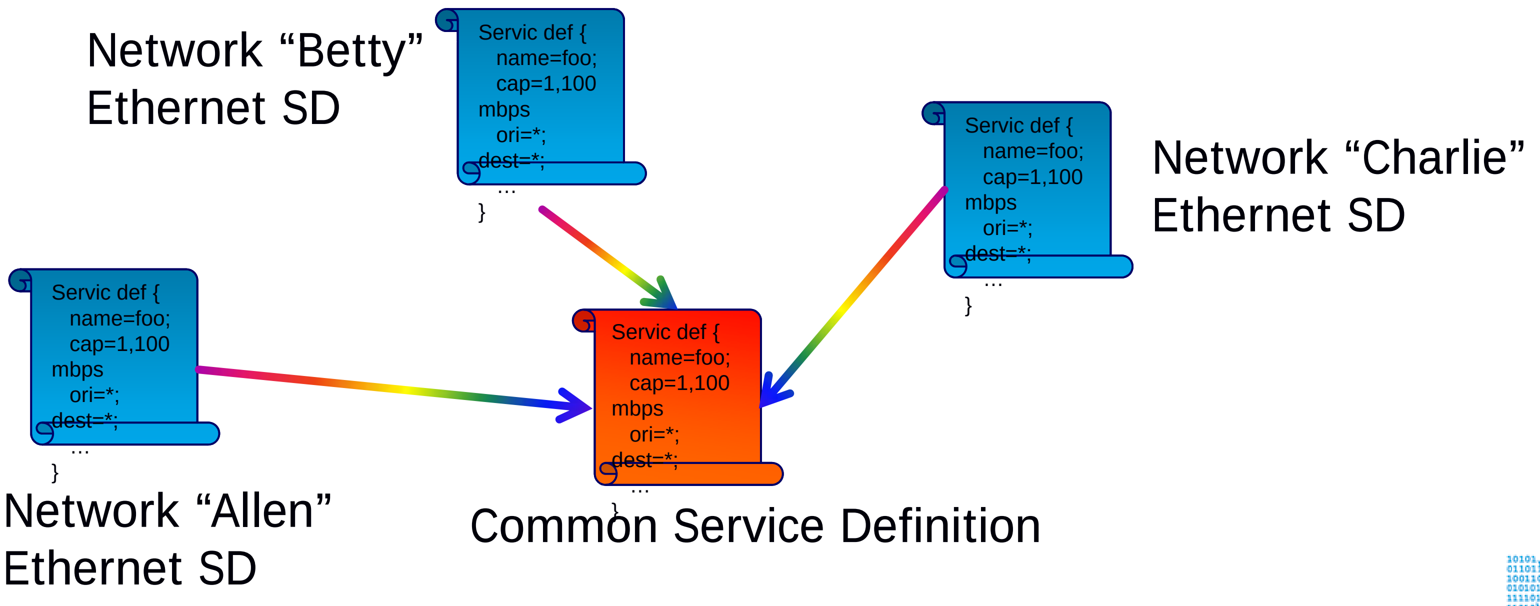
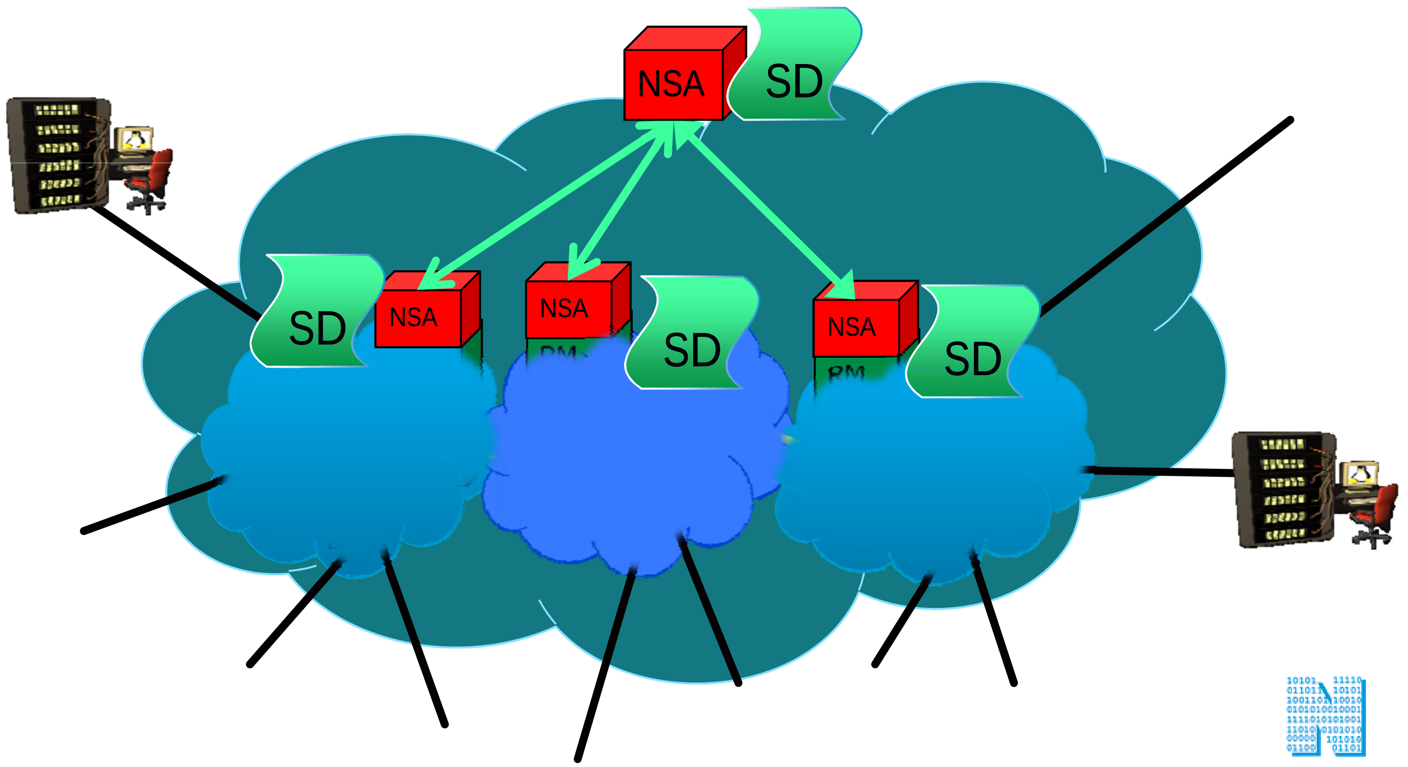
# The “Common” Service Definition

- Each network defines their own service offering (SD)
- A group of networks can then get together and define a “common service definition” CSD
- The CSD contains a set of agreed common service parameters, but each network can still augment this set and/or set specific ranges for the common parameters


Network “Betty” Ethernet SD
Servic def { name=foo; cap=1,100 mbps ori=*; dest=*; … }
Network “Charlie” Ethernet SD
Servic def { name=foo; cap=1,100 mbps ori=*; dest=*; … }
Network “Allen” Ethernet SD
Servic def { name=foo; cap=1,100 mbps ori=*; dest=*; … }
Common Service Definition
Servic def { name=foo; cap=1,100 mbps ori=*; dest=*; … }

- Common Services are established when several networks agree on a common set of service parameters and values



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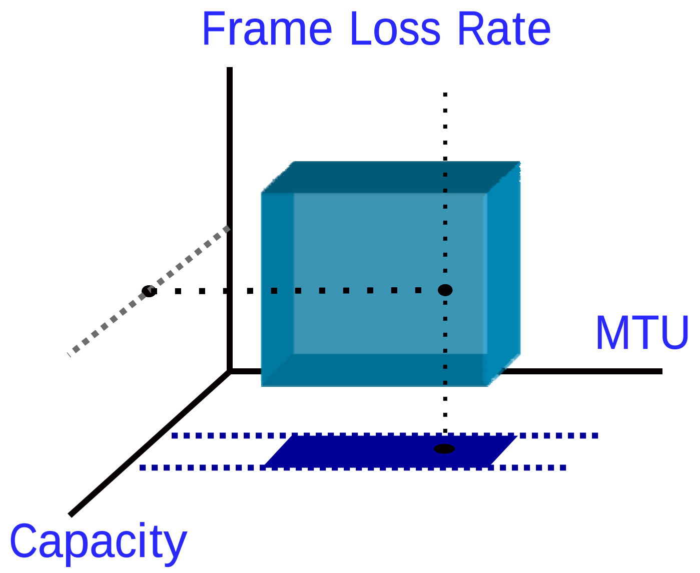
## Service Definition

- A Service Definition can be conceived of as a multi-dimensional volume in n-space.
  - Each service parameter defines an axis
- Service Requests can similarly be conceived as a point within the same n-space
  - Service requests that project inside this n-dimensional service space can be provisioned.
  - Service requests that lie outside cannot be established.



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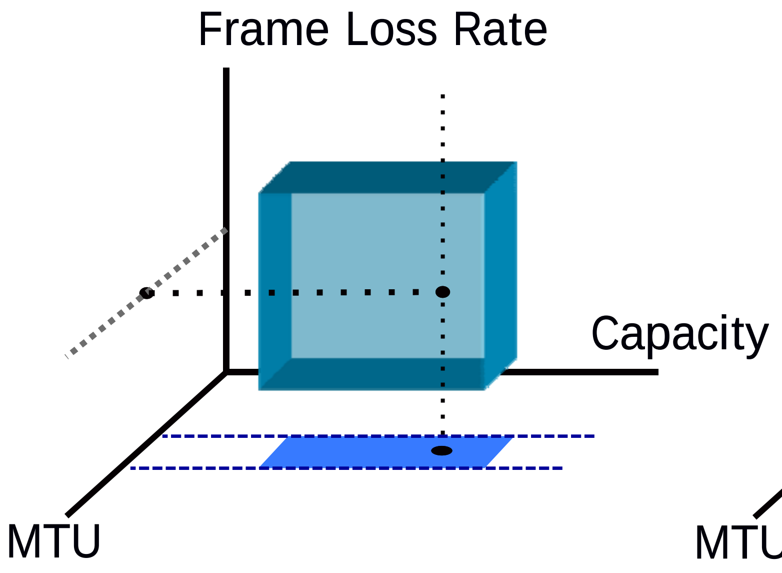
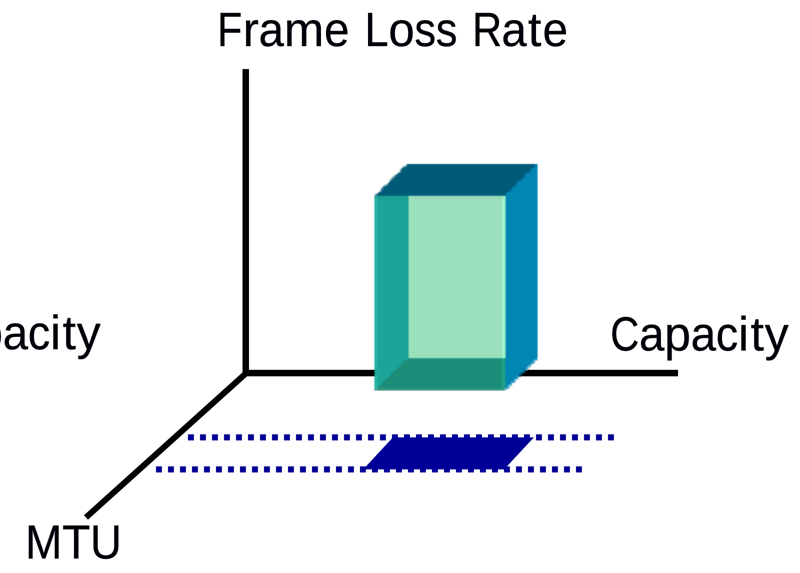
# Service Matching

- Since peering networks may have slightly different service definitions, there is a need to “compare” service requests E2E for compatibility:





- Individual service requests can be projected onto this intersection to ascertain path viability

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## Service Verification

- A confirmed service instance with guaranteed performance criteria should be independently verifiable:
  - i.e. the user should not have to take the word of the provider that the service meets spec; (provider based assurances have an inherent conflict of interest)
  - Required service constraints should be *detectable* by the user. If the constraints were indeed met, then they can be detected and measured.
- A user agent must be able to measure the “as built” service characteristics and verify that all the constraints were met
  - For pure performance and schedule constraints, conventional iperf style measurements at the end points will suffice
  - But for policy constraints, independent verification is not obvious as to how it would be accomplished...

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## Service Verification

- The provider should similarly be able to verify independently (from the user) that the "as built" performance meets spec
  - For pure performance and scheduling aspects, the PA should be able to verify that the information flow presented by the user at the ingress is within profile and that this flow is being presented at the egress intact.
    - Why? E.g. Tcp windowing problems are examples of end system issues that masquerade as network performance problems... The pro-active network is able to refute or coraborate user claims of service outages.
- But policy verification is much more insidious...
  - How can a user independently verify policy constraints?
    - E.g. "include MANLAN" or "do not transit Libya" ...
  - Access to as-built and other circuit information will be necessary to confirm policy cpnstraints

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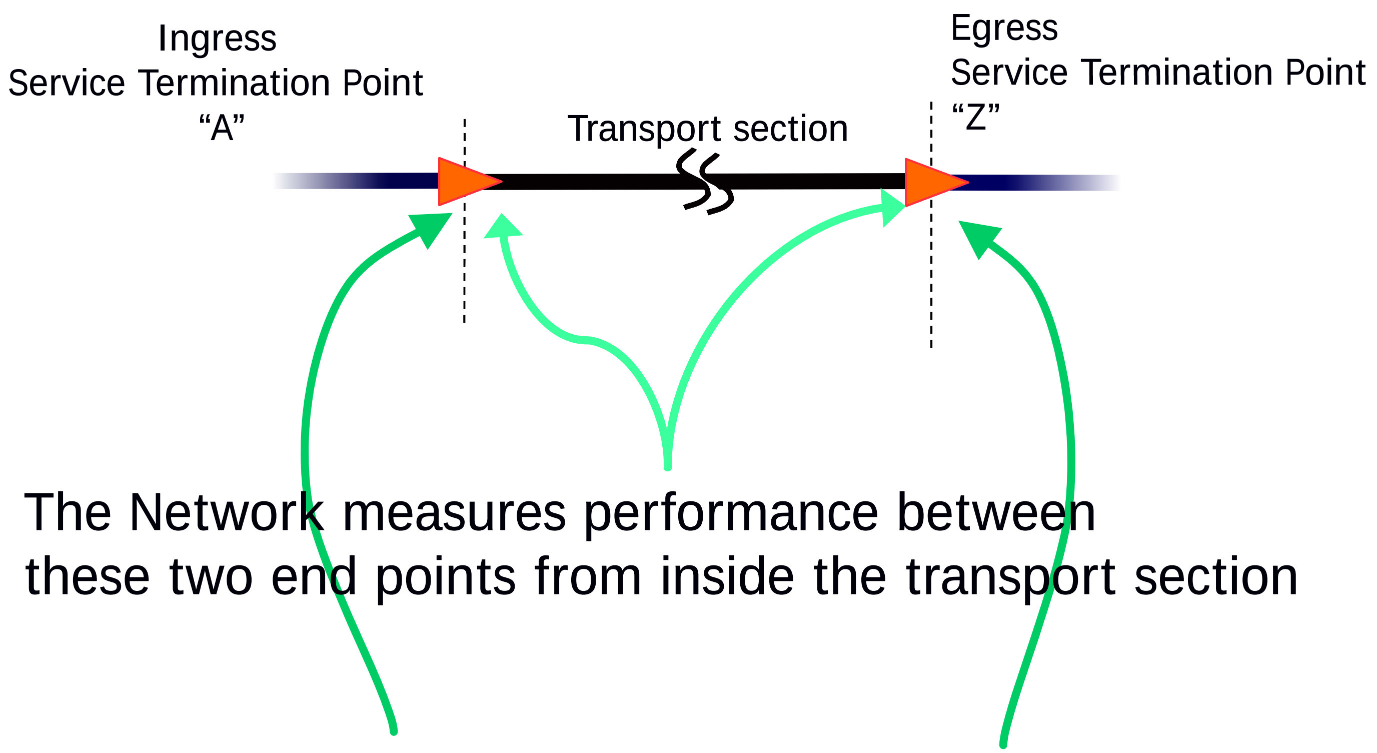
## Service Verification



The Network measures performance between these two end points from inside the transport section

The User measures performance between these two end points from outside

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## Verification Processes

- Circuit services move information from ingress to egress.
  - The end points are key for performance and availability constraints
- A circuit oriented performance verification and AFU process should be congruent with the service architecture-
  - I.e. Performance verification should correspond to the service requests.
  - By construction, and asserting delegation, we can identify which service instance is not meeting spec.

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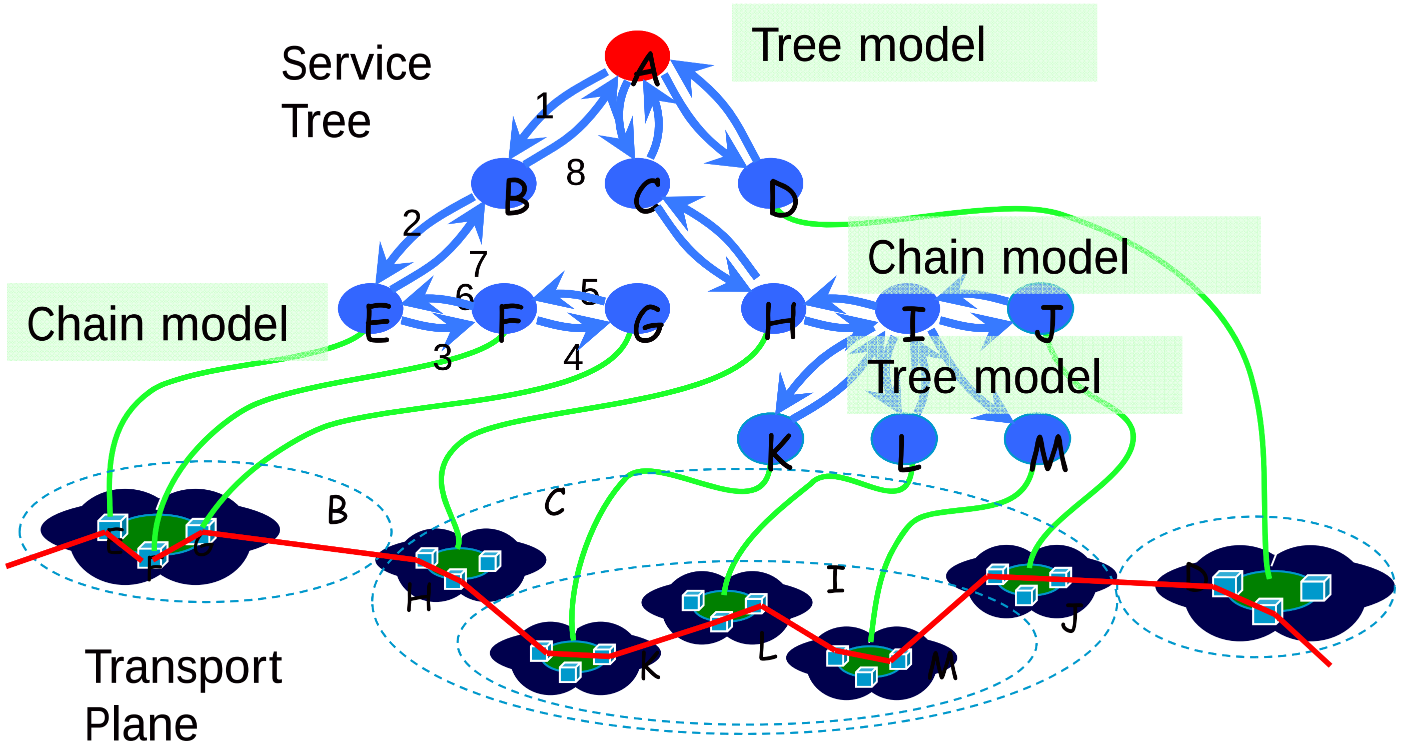
# The Service Tree

- The service reservation process creates a “service tree”.
  - The path and authorization structure is inherenent in the NSAs that comprise the tree for any given request



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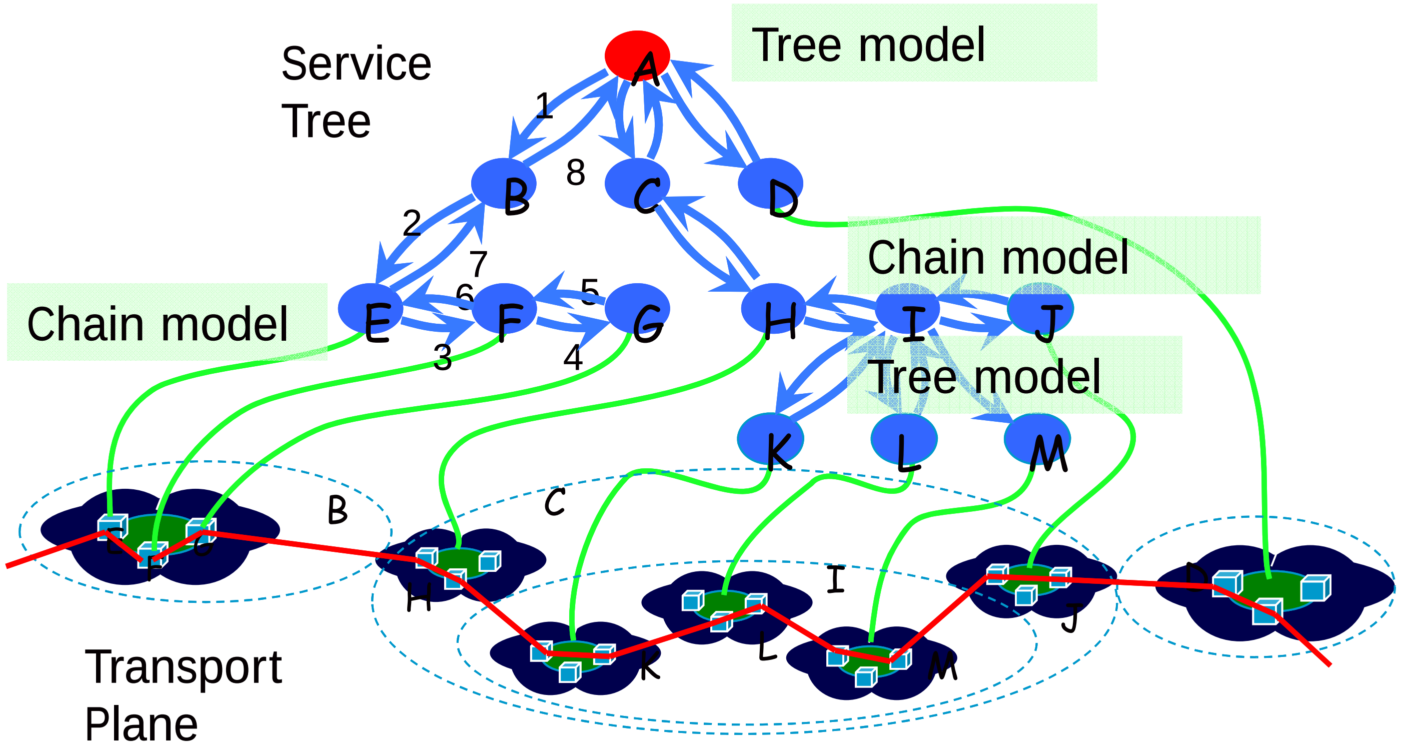
## The Service Tree

- By walking the service tree, an AFU agent could [theoretically] reconstruct, under authorized access, the delegation breakdown and data plane path of a service instance.



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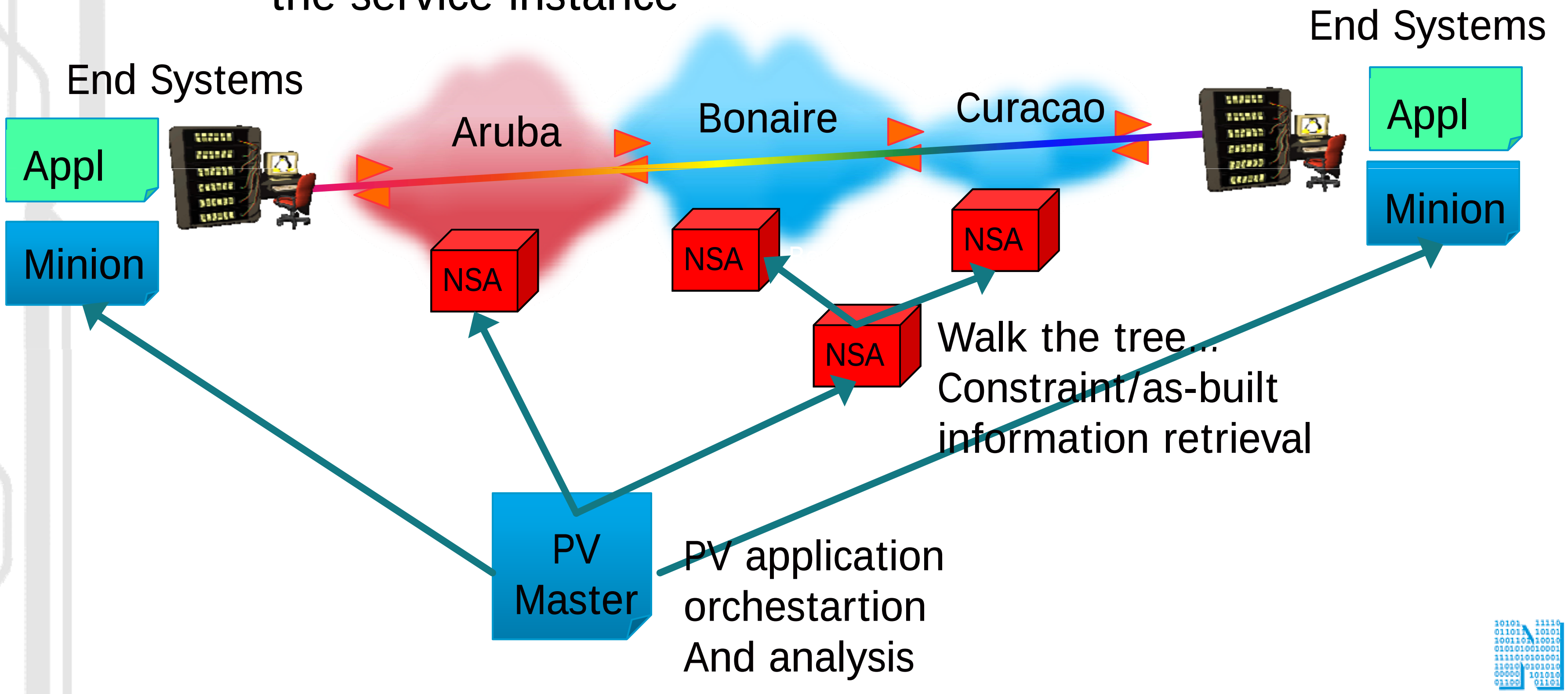
# A Performance Verification Application

- Since the service instances will be integral components of distributed applications, it stands to reason that the PV/AFU process should also be a similar distributed application
  - The PV/AFU application dynamically assume a congruency with the service instance



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## Summary

- The PV/AFU process must be adapted to reflect the nature of the services under test, and the environment in which they will be used.
- Independent verification of service delivery is critical to future application requirements
- Delegation of responsibility for PG services allows us to decompose the problem to divide and conquer
- New protocols and new models of integrating the PV function into the user virtual environment must be designed and developed
- We must assume a secure and autonomous network model for these PV and AFU processes – no more free access to sensitive information.  But access should still be available to authorized agents.

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## Summary

- We need a conprehensive approach that considers how performance verification processes is intrinsically linked to and parallel with the delivery of performance guaranteed services.
- Such a formalized architecture will be much more effective approach to performance verifcation and fault localiztion.

- Lets engage on this...