Performance Verification Architecture Task Force

Update

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Jan 17, 2013
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Performance Verification Architecture

- Objective (from the charter):
  - The GLIF End-to-End Performance Verification Architectures task force is chartered to develop recommendations for a deterministic, scalable, and secure architecture for determining the delivered end to end performance characteristics of emerging light path (connection oriented) network services.
- Co-Chairs
  - Steve Wolff (Internet2)
  - Jerry Sobieski (NORDUnet)

Progress

- Discussion began in early 2012…
- Limited participation… (still not sure why…)
- Basic conference call: "Why can't we just use perfSONAR?..."
- …need a paper describing future services, why verification is important in this future environment, what needs to be verified, when, where, how by whom,… What capabilities will a comprehensive and deterministic PV process require?
- Paper is [almost] available:
- Purpose: Explain why verification of performance *guarantees* for Connection Services is different from characterizing conventional best effort performance – and why deterministic methods are necessary not just to insure delivery of predictable performance, but to understand how such services behave – or fail.

  → Get GLIF community to recognize why PV is critical for the success of guaranteed services.
- **"Performance Verification Architecture and Emerging Performance Guaranteed Network Services"**
  - …some editing is still in progress (18 pages + illustrations).
  - Will be circulated for review before Jan 2013.
- Summary follows…

Deterministic End to End Performance Verification Architecture

Offered for discussion to the GLIF Performance Verification Architectures Task Force

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Performance

"Measure what can be measured, and make measurable what cannot be measured."

- Galileo Galilei

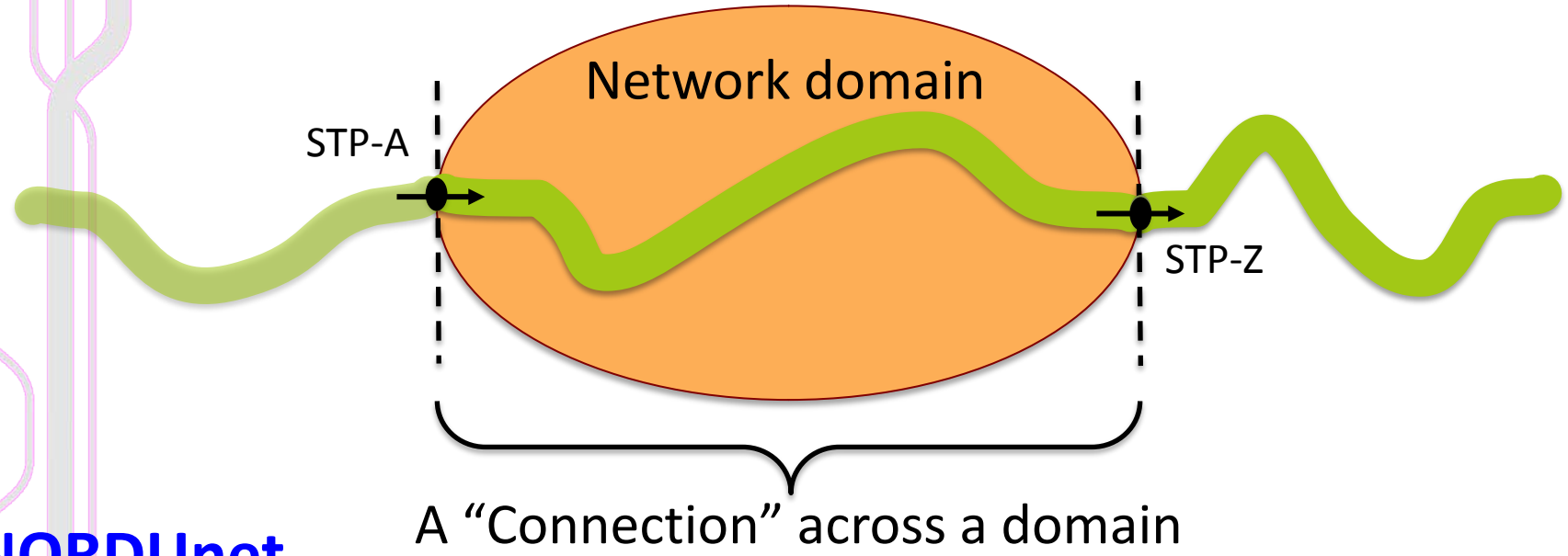
- Definition: Performance is a possibly multivariate quantity that can be measured to an agreed-upon precision by an agreed-upon measurement protocol.

The Problem

- Emerging Connection Services offer “guaranteed” performance …or so they say.
- How do we verify this performance?
  1. Determining when a Connection is performing as requested/required…or not.
  2. Determining which aspects of the performance guarantees are not functioning to spec
  3. Determine (to some resolution) “where” a Connection is failing
- Guaranteed services are intended to provide deterministic service – predictable, reliable, repeatable… And so require substantially tighter engineering constraints than best effort
  - Deterministic PV processes are critical
- If performance is flawed, it needs to be fixed, ASAP.
  - Identifying the under-performing segment and notifying the agent in charge via automated means is End Game (Automated Fault Localization)

What are we "verifying"?

- What networks do: transport user data from one point to another.
- Performance guarantees are network services that make that transport behavior *predictable* and *repeatable*.
- Connections are "logical conduits that carry user data transparently and unmodified from an ingress location to an egress location" (ref: OGF NSI Framework 2011)



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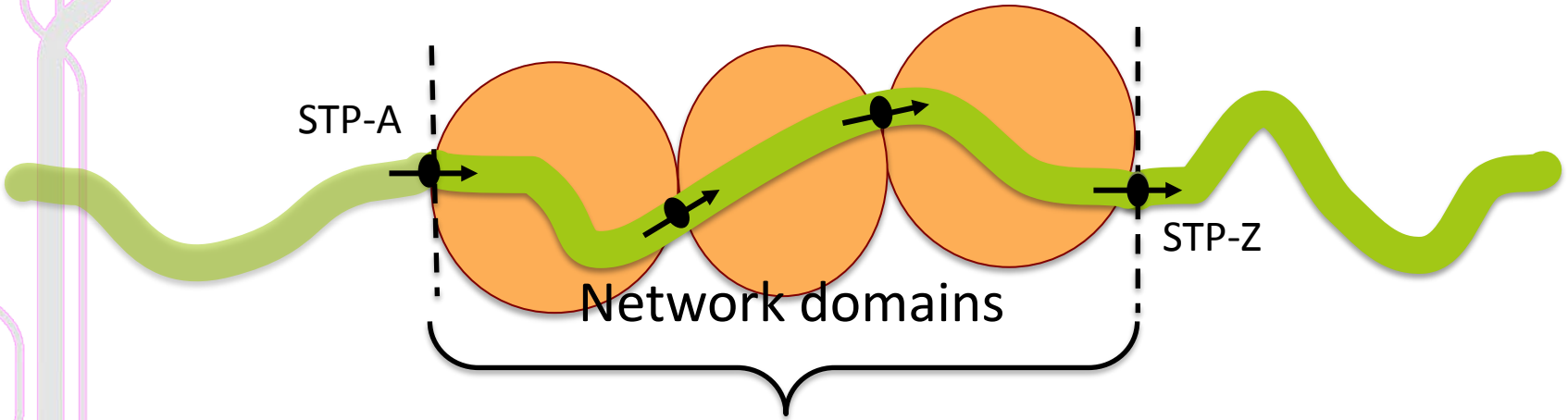
Basic Performance Verification Tests

- Bits went in, … did they come out?
  - Did any bits NOT come out? (lost/discarded data)
  - Did bits come out that did not go in? (mis-routed data)
- Since user data must be serialized for transport (e.g. large files/data sets), or is time sensitive intrinsically (e.g. video), there is a natural temporal aspect to guaranteed services:
  - Capacity/good put: Bits *PER SECOND* (or “per unit time”)
  - Latency: time the bits spend in the transport medium
  - Jitter: the variance in latency (time) for datagrams transiting the transport conduit
- Thus, PV needs to characterize the behaviour of the transport payload with respect to time
  - What was the the [payload] transmission schedule? What was the observed arrival schedule… How do they relate to one another?
  - The better the time resolution of these schedules, the better the understanding of network performance will be.

Global *inter-Domain* Services

- In the real world…End to End connection services are predicated across a multiple network service domain…
- "Inter-operating common services domains" are not equivalent to "a single administrative domain"…
  - These are separate and independent organizations and services
  - With local realities: levels of expertise, performance capabilities, authorization constraints, security/privacy concerns, accounting, legal environments, peering arrangements,…



How do we verify the performance end to end?

Service Instance and Service Definition

- A Connection is an Instance of a Connection Service
- A Connection Service has specific set of service attributes it recognizes and can provision and guarantee.
  - Examples:
    - Capacity = 0 to 100 Gbps
    - Max Frame Error Rate = 1 *10^-8
- Some conventional service attributes are are difficult or impossible to measure – as traditionally stated:
  - Example: Capacity
    - "5 Gbits per second" connection over a 10 Gbps link layer…
    - is that "10 gbits for half second followed by quiesence for half second."?
    - Why not 10 gbits for 10 seconds followed by 10 seconds of quiet"?
- The Service Definition needs to be specific, explicit, …
- And *measureable*

- Why ask for a service instance with an attribute that cannot be "felt" by the user…cannot be detected or measured.

Why verify?

- As Users, we specify performance requirements in advance so that we can predict how our application will behave …
  - Perhaps we want to know that our file transfer will complete by a certain deadline,…
  - Or we want to be certain that our video streams are of the highest quality (unaffected by unrelated traffic)
  - Or perhaps we are building our own virtual network and we want a known capacity or latency for our own purposes…
- Performance guarantees [*are supposed to*] provide a predictable *deterministic* service.

Deterministic Verification

- *Deterministic* means that given a set of known initial conditions, the result of a process is pre-determined…it will not vary
  - It is predictable
  - It is *reliably* predictable
  - It is repeatable
- For performance guaranteed connection services, the performance verification process should also be deterministic
  - Given the same data flow, the same performance will be observed, every time.

Why verify?

- As Users, we do not trust the provider.
  - The provider is incompetent – despite their best intentions and efforts, they can't get it right…
  - The provider is a shyster – the PA knowingly does not enforce the performance guarantees ("we have 100 Gbps core – we don't need to enforce bandwidth constraints in the core...")
  - The service itself is ill-defined wrt certain performance aspects
  - s#!t happens – something outside of the control of the provider broke.
- The user needs an *independent* means of determining whether the service they received meets the specifications they requested and were promised.

Why verify?

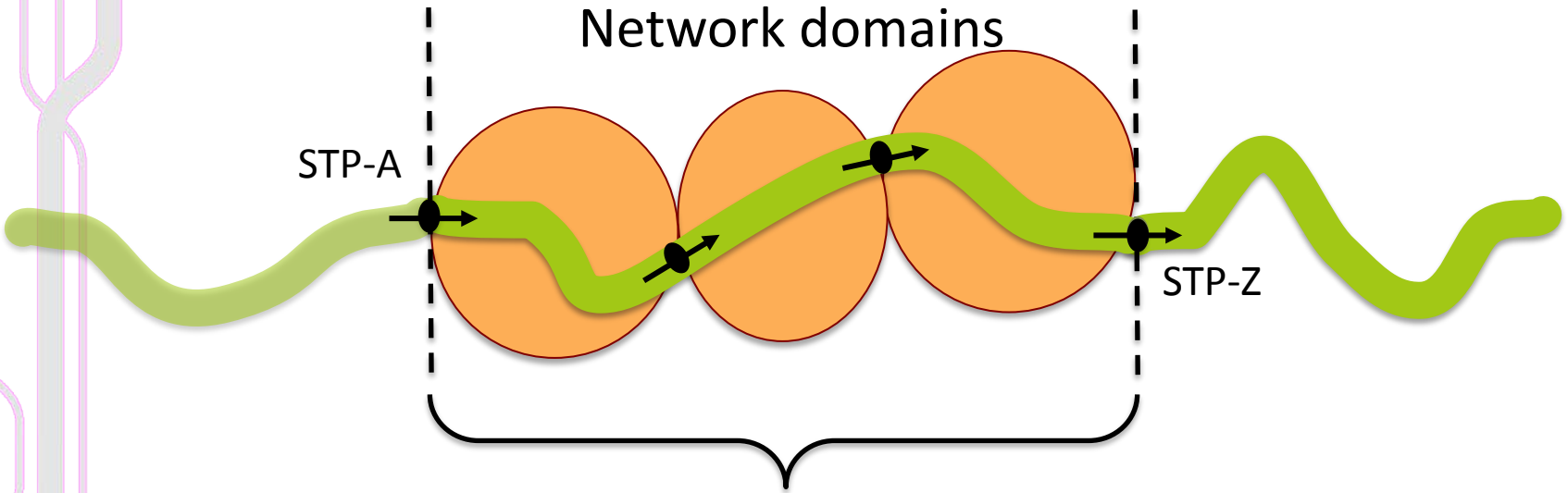
- As Providers, we do not trust the user:
  - Users are incompetent – they do not configure their end system(s) or access networks to properly interact with the provisioned performance capabilities.
  - The user has mis-interpreted the capabilities and is not conforming to the service guarantees (or the service is undefined with respect to some aspect.)
  - s%#$@t happens – something outside of our control broke – we can not rely on the user to notify us prior to the law suit.
- The Provider needs an independent means of determining whether the service they delivered meets the specifications they guaranteed

Independent Verification

- "Verification" means corroborating what the other party claims to be true.
- "Independent verification"
  - the user's verification testing does not rely on their provider assets/agents to provide corroboration
  - And the provider's tests likewise do not rely on the user's assets or agents for its results.
- The PV architecture must be able to provide an independent testing/measurement model.

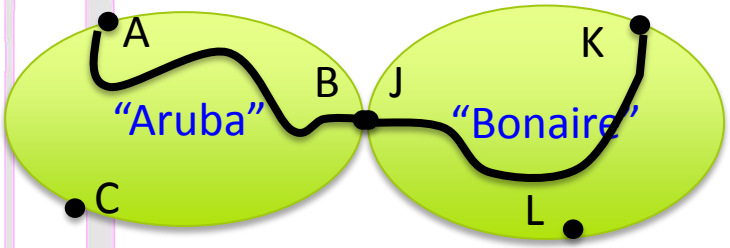
Deterministic Performance Verification

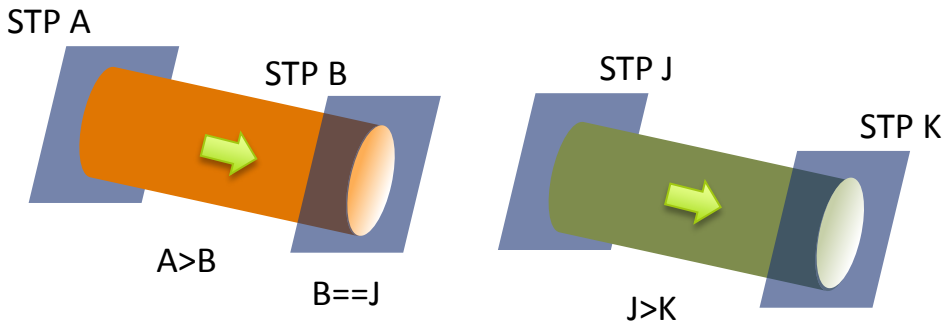
- Can we *deterministically* measure the performance of a Connection?
- Can we do so without perturbing the flow?
- Can we do so in such a fashion that we can determine where along the path performance problems are occuring?

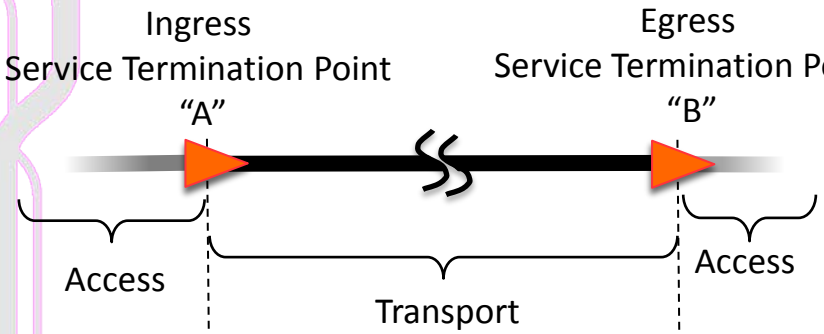


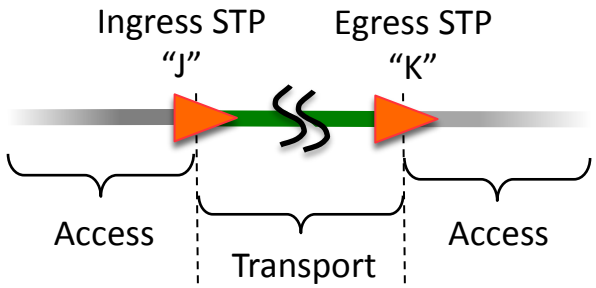
How do we verify the throughput from STP-A to STP-Z?

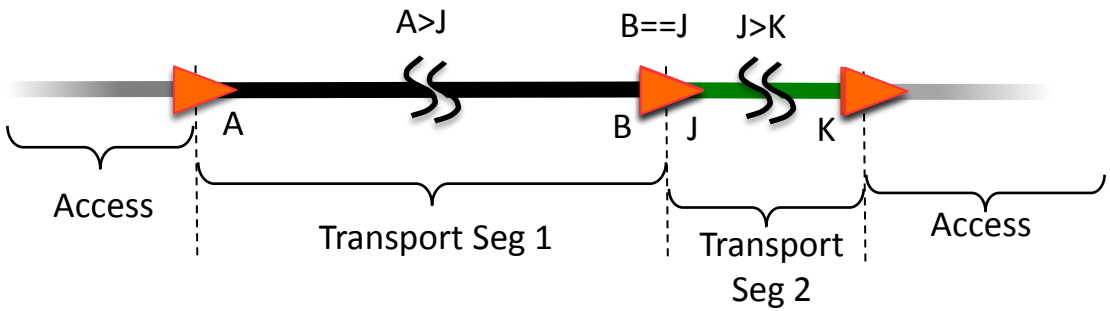
Connection Segmentation











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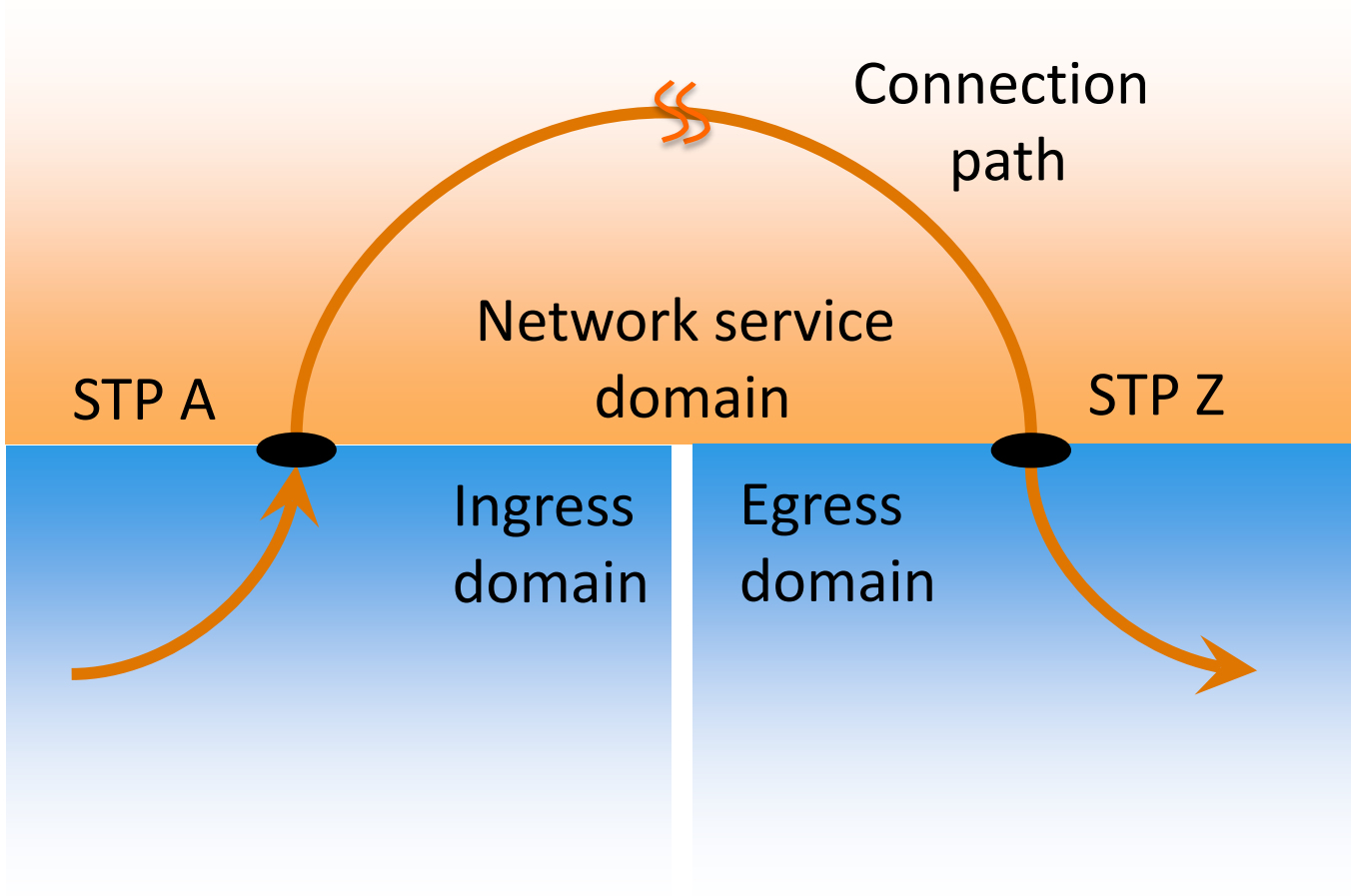
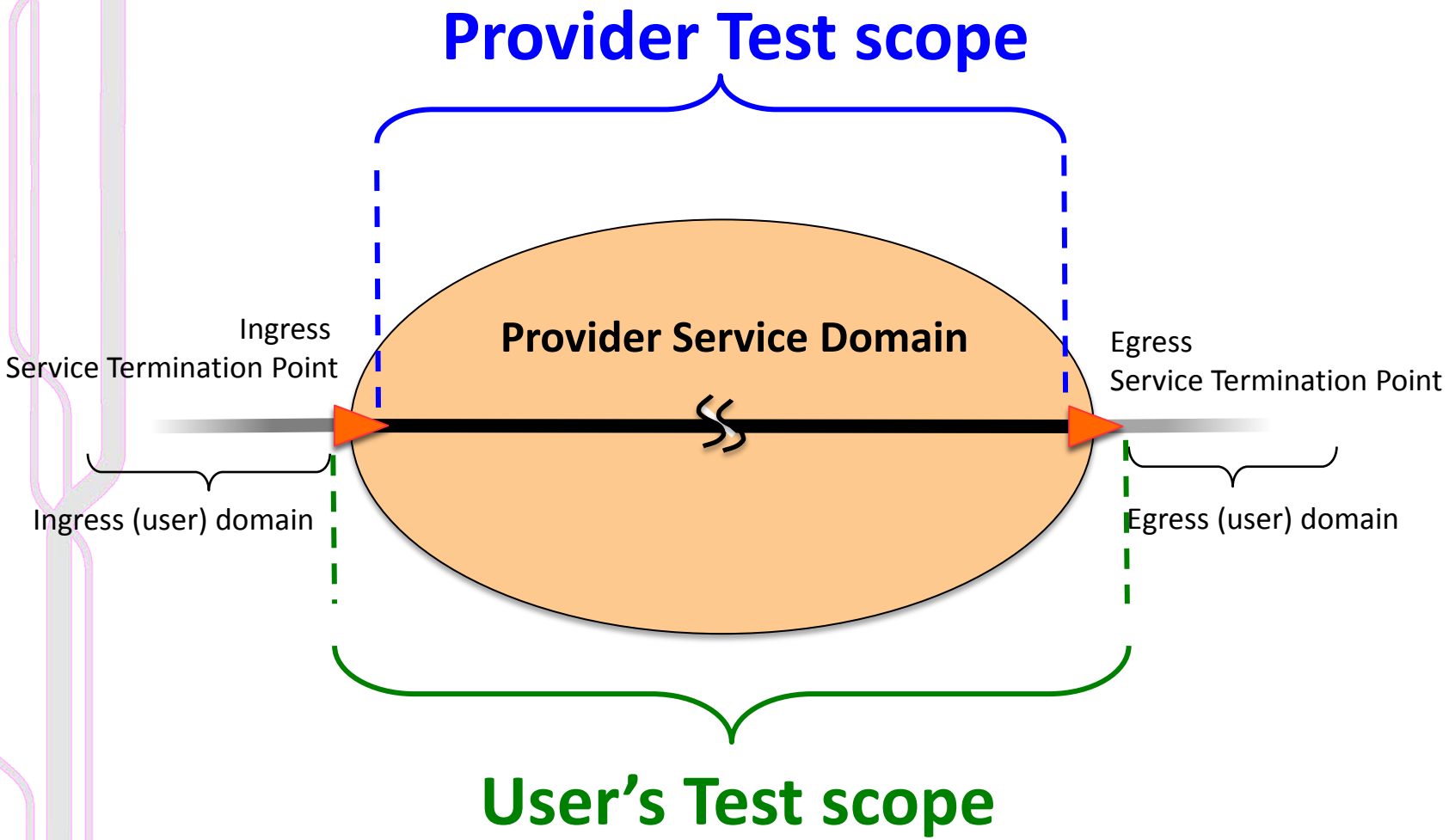
The Service Provider Demarc



PV “Test Scope”



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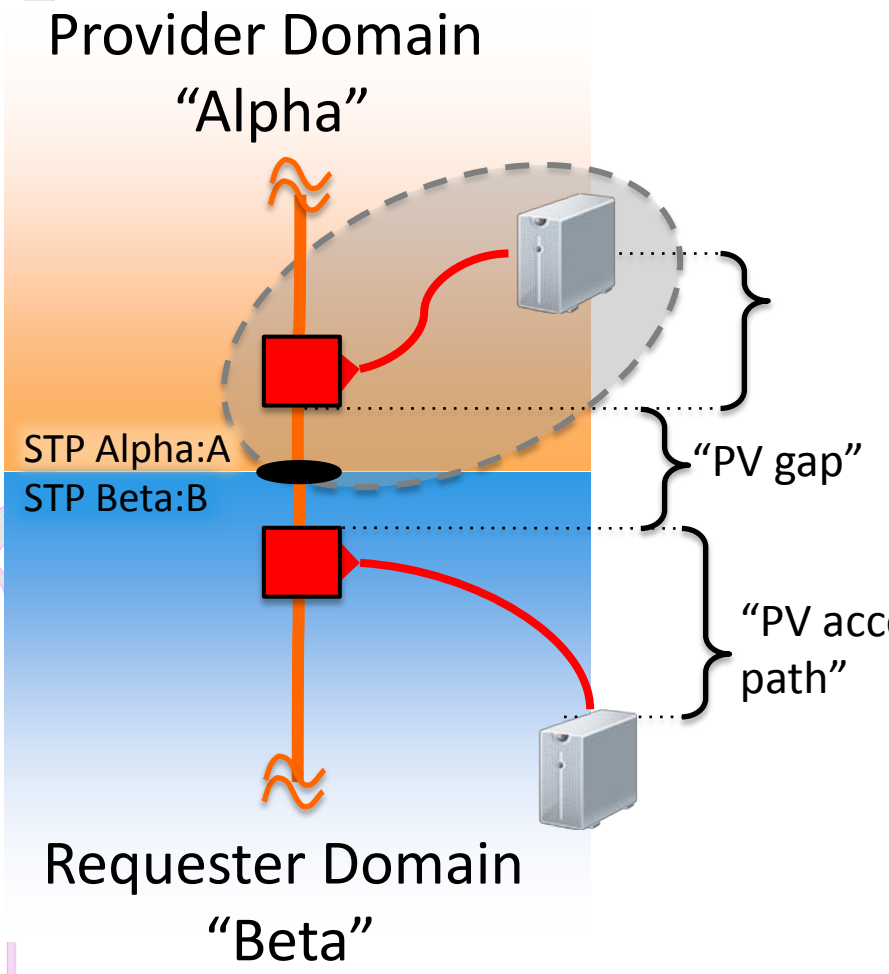
PV Test Point Engineering

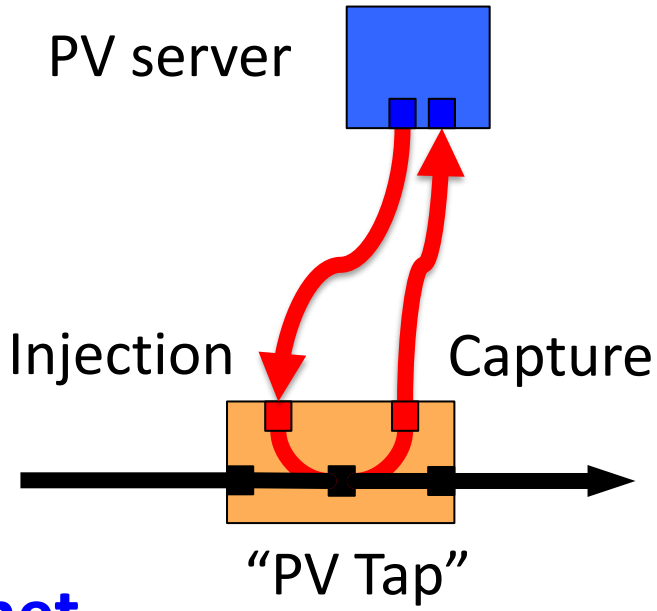


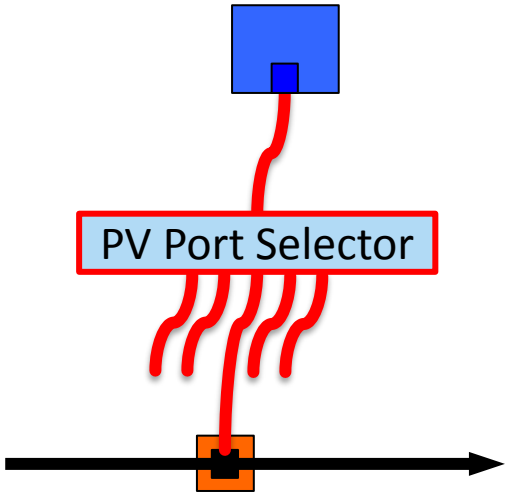
"PV Test Points" must be: situated as physically close to the demarcation STP as possible

- Minimize effects of difference ("gap") between PV test points in adjacent domains
- Compact PV access in order to minimize path effects introduced by PV infrastructure itself

PV Test Point Infrastructure

- "Tap" – A device in the data plane path that allows traffic to be inserted or observed.
- "PV Server" – an intelligent device that can source or sink data flows via the PV tap.
- PV Interface – the data channel between the PV Tap and the PV Server. (Note this may not be a simple patch cable)





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Notes on PV Test Point Engineering

- The Test Point “tap” is very inexpensive (scalable)
  - An optical splitter, or low cost UTP
- Many [high end] switches and routers already have similar functionality built into interfaces as “loopback” features…
- In some cases, the hardware technology already supports a similar “tap” capability:
  - E.g. Ethernet “span” ports…
  - The implementation of these features may induce or inject other artifacts into the PV path and should be well understood if used for this purpose
  - …but can provide almost free proof of concept

(Note: this “tap” technology has been used in various firewalls and monitoring products for many years.)

Notes on PV Test Point Engineering

- The PV Server contains more intelligence
  - The PV hardware interface NIC must be able to *at least* capture flows…thus must recognize 802.1, SONET/SDH, infiniband, or any other physical layer transport protocol
- The device must be able to capture the flow to long term storage at line rate
  - 100 Gbps (!?)
  - Performance analysis is done as a background process non-real time
- For emergent services – the capture process should anticipate multi-protocol flow identifiers

Notes on PV Test Point Engineering

- Timing: The interface must be able to time-stamp the flow appropriately, and accurately.
  - For asynchronous 10 Gbps packet networks (ethernet?), 50 byte (500 bits@8b/10b encoding) resolution would require ~50 nanosecond timestamp resolution
  - Jitter measurements would dictate somewhat smaller resolution order 1-5 nanoseconds
  - For 100 Gbps links, divide by 10… ~ 100 picosecond stamping.
- Accurate timestamps at this resolution will likely require external clocks
- End-to-end Latency timing will also need new technology (satellite based sync will not likely be sufficient for future services)

Notes on PV Test Point Engineering

- Scaling
  - The test device can be shared – e.g. one PV server for a bank of physical ports…
  - Switchable optronics can mate the port under test with the PV server with minimal path artifacts.
- Common PV Test Elements
  - Two peering networks could agree to share a test point
  - The trust issue can be resolved by verifying the performance of the test point itself
    - Once verified, the PV Test point can be “trusted”
    - “Mutually trusted third party” test points
  - This poses some challenges to the segmented test process…but it can still be deterministic

Performance Flow Correlation

- Understanding the behaviour of jitter, latency, and good put of a guaranteed service (“connection”) requires comparing the observed egress flow to the known ingress flow characteristics – “*flow correlation*”
- Deterministic PV captures and characterizes the source flow as tightly as the destination flow, and then the two flows are compared.
  - The comparison requires one or both captured flows be transferred to another host for correlation.
- Near real-time results can be had for most tests (delays of only seconds or minutes for large flow analysis.)
  - Flow correlation processing (transferring ingress and egress flows) must not interfering with test flows themselves.

Passive Performance Verification

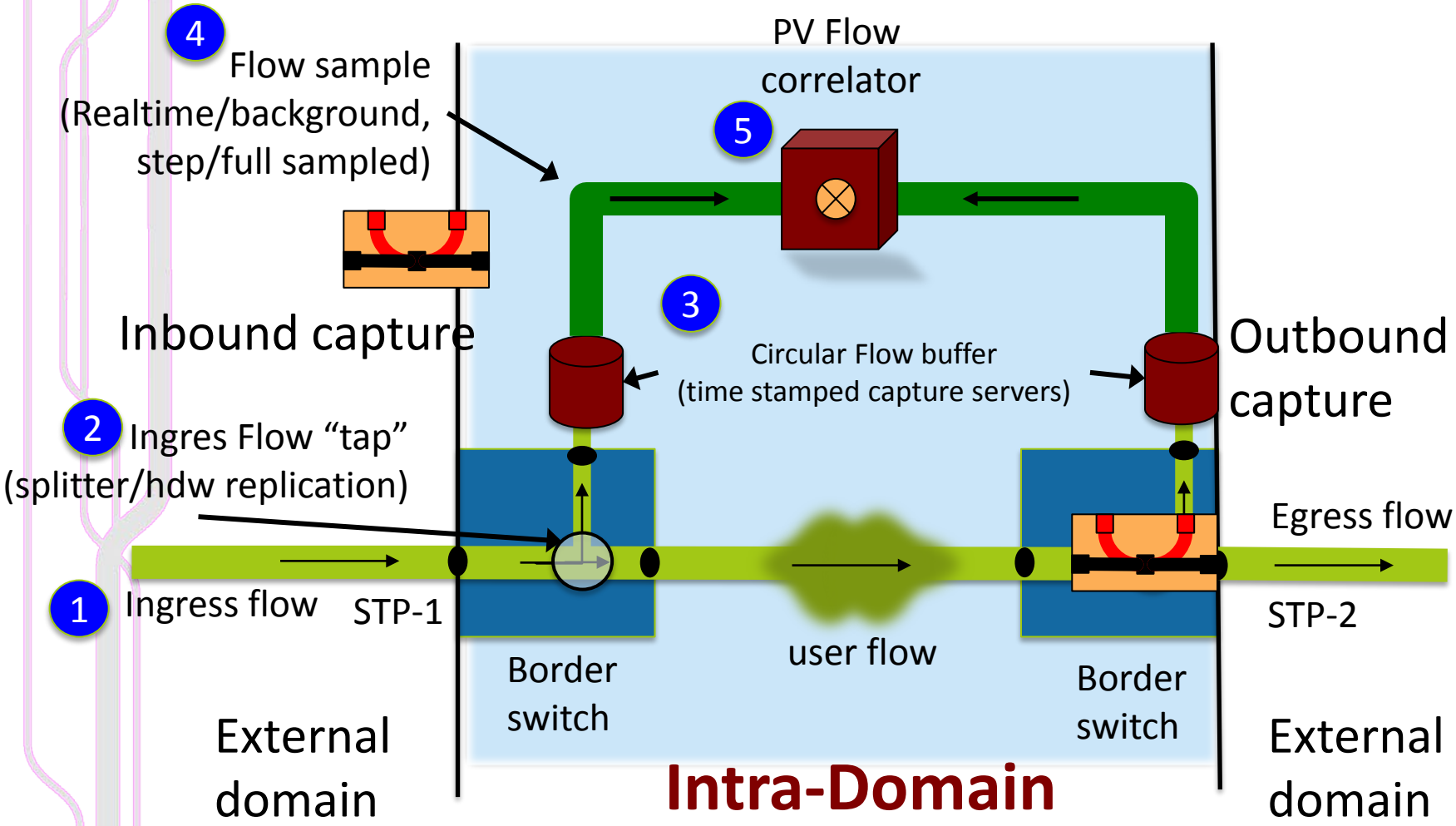
- Passive testing is preferred
- Passive PV is determined based upon observed traffic…
  - An independent source could send artificial (and potentially non-representative) traffic profiles
  - Or the test points can observe actual user traffic
- Does not require taking circuit out of service
  - The ingress test point and egress test points just listen (and capture)
- Can be run at any time(!) without affecting the user's actual flow(!!)
  - Provider can periodically perform a passive flow correlation to verify performance while in service
  - Provider can continuously monitor/capture flows in order to observe or replay specific failure events

    (Probably unrealistic to record large flows over long periods – but circular buffers can provide "black box" forensics.)

Active Performance Verification

- The active PV Server must be able to generate appropriate test flows:
  - Capacity - 100 gbps
  - Accurate shaping capabilities
- Some aspects of performance guarantees cannot be verified except in the presence of resource contention (competing congestive flows)
  - PV server(s) must be able to source multiple flows (at high capacity and with accurate shaping)
  - Servers must be able to coordinated/synchronize flows to create exterior conditions that meet particular verification requirements

A "Performance Flow Correlator"



Intra-Domain Passive Provider PV Flow Correlation

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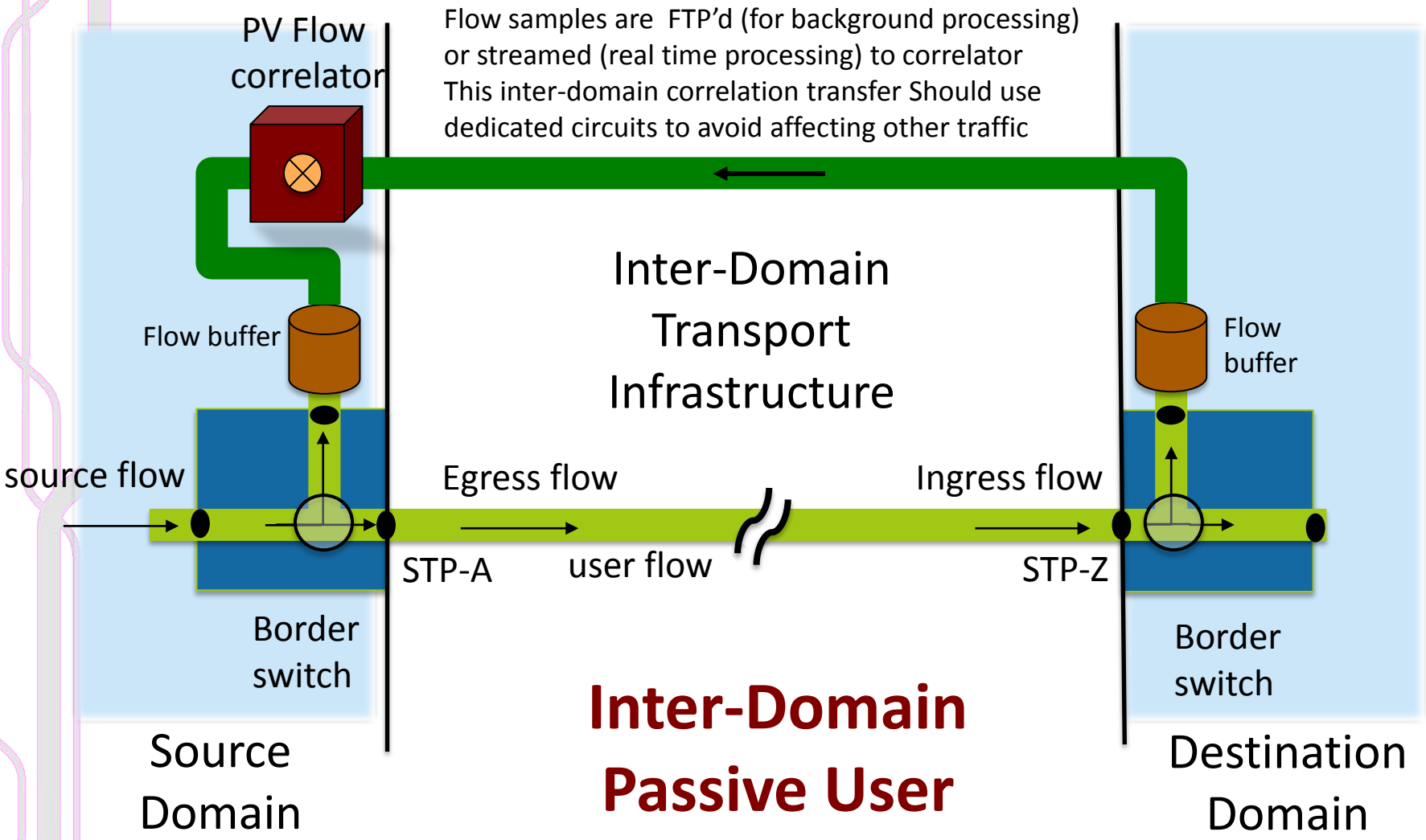
How the Flow Correlator Works

- The “PV tap” is implemented at every domain boundary interface
- The tap, when enabled, leads directly to a local capture device.
- The capture device must be able to:
  - Timestamp each datagram (depending on protocol).
  - Spool the captured stream to long term storage at line rate.
- The PV Capture Server can be sized and configured to capture an entire flow, or it can be sized to sample flows according to some rule or policy.
  - The correlation can be done in real time if engineered to do so…
  - or the flow can be captured and stored for later background analysis. … a few seconds later, or a few days later.
  - Correlation can be performed periodically, using short samples or real flows

An inter-Domain "Flow Correlator"



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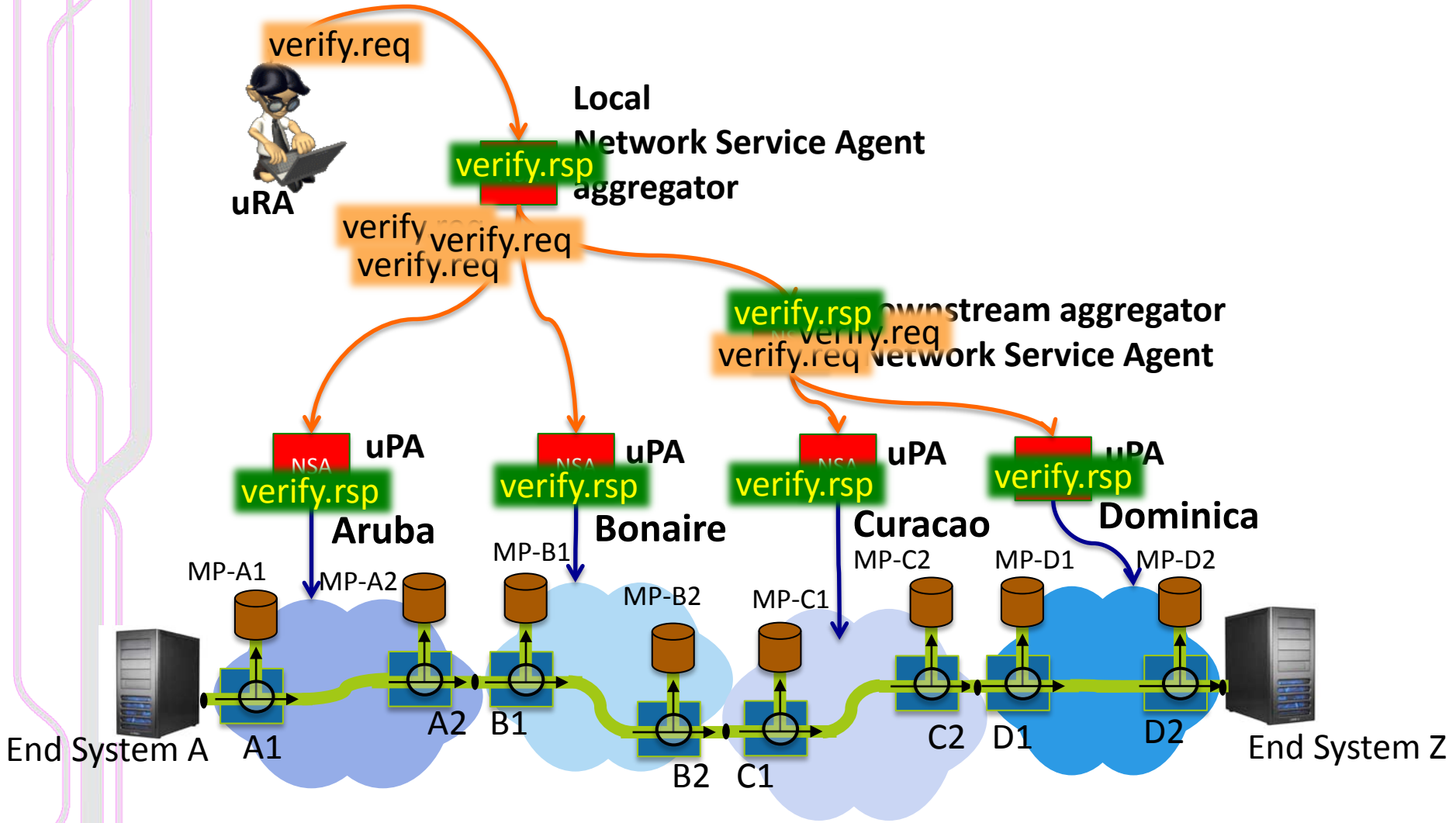
End to End PV as a Service



Summary

- PV for performance guaranteed services involves understanding
  - A) What the service purports to be able to do
  - B) What the service instance is guaranteed
  - C) what we can effectively test
  - New technologies:
    - Advanced service architectures
    - Advanced and well engineered network/data plane architectures
    - Advanced high resolution timing and interface technologies.
  - Use existing tools and packages where they can fit into the picture
- Use the GLIF PVA Task Force to define a “stake in the sand” from which to start.

- The End