From Traceroute to OTel Traces



Modeling Network Paths with OpenTelemetry

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Agenda

01 The observability gap

02 Modeling the path as a trace

03 Demo

04 Correlating network and application data

05 Incident investigation

06 OpenTelemetry Network SIG

07 Takeaways

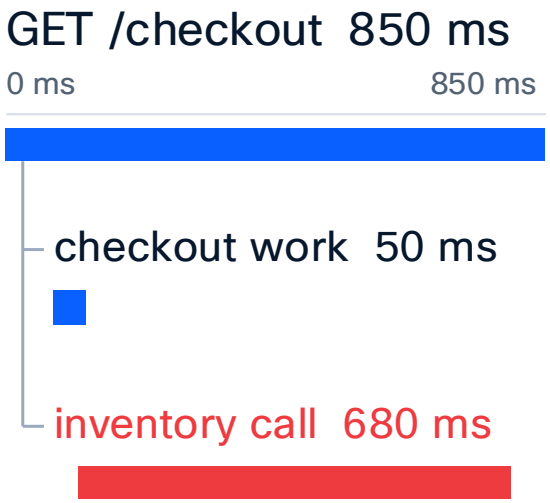
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The observability gap

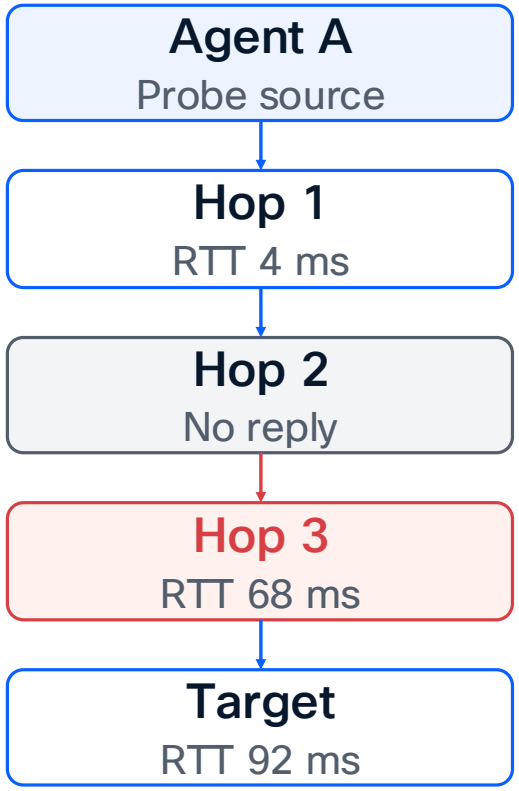
The gap in an incident

Application trace



680 ms in the outbound HTTP call

Network path



Application traces show a slow request through services.

Network Path trace shows the route observed by network probes at that time, along with reachability.

Both views belong in the same investigation.

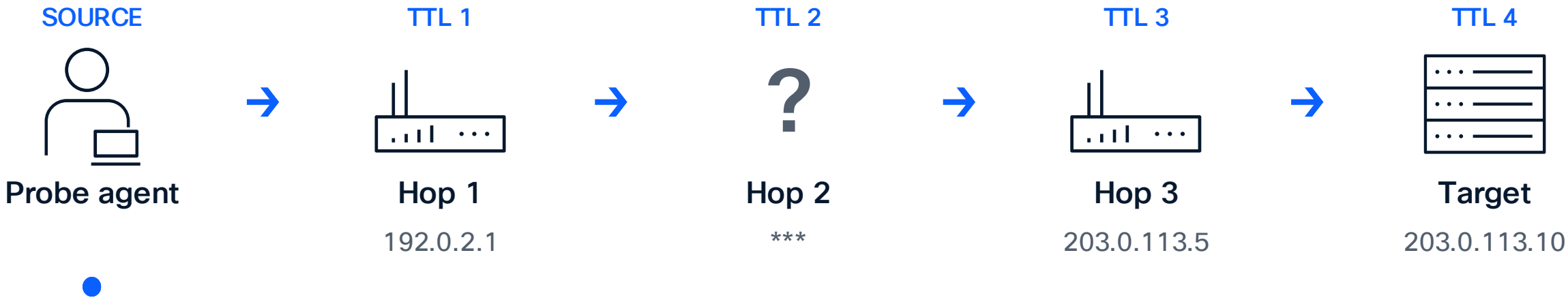
The sampled probe path does not prove the route of that request.

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How traceroute discovers hops

Illustrative path: a new probe with a larger TTL can reach one hop farther.



Traceroute-style output

TTL	Reply	RTT
1	192.0.2.1	4 ms
2	***	no reply
3	203.0.113.5	12 ms
4	203.0.113.10	20 ms

RTT is measured from the agent to the responding hop and back.

*** means this probe received no reply. It does not prove forwarding stopped.

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Modeling the path as an OTel trace

From traceroute data to OTLP

01 Collect the traceroute

02 Normalize attempts and hop gaps

03 Enrich the network data

04 Create edge spans and trace

Example implementation: ThousandEyes Network Path streaming

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Raw data to a normalized path

01 RAW TRACEROUTE

TTL	Reply	RTT
1	192.0.2.1	4 ms
2	*	no reply
3	203.0.113.5	12 ms
4	203.0.113.10	20 ms

02 NORMALIZED PATH



The missing reply stays in the path as an unknown hop, preserving TTL order.

Illustrative values. Every RTT is measured from the source to the responding hop.

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Normalize incomplete paths

Missing hop identity

Later hops can still respond.

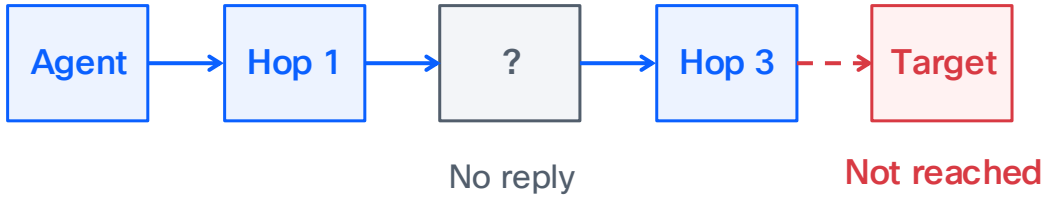


1 192.0.2.1
2 unknown hop 2
3 203.0.113.5

Keep hop order. A missing reply does not establish forwarding loss.

Destination not reached

Configured target shown for context



Target 203.0.113.10
Not reached

Show the configured target for context, but mark it as not reached.

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Enriching each hop IP

We already have the IP address of each responding hop.

Hostname	Reverse DNS lookup
ASN	Autonomous system associated with the IP
Prefix	Network block associated with the IP
GeoName ID	Inferred location

Available values become hop span attributes. Missing values remain absent.

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Network path to spans

NORMALIZED PATH



OTEL TRACE RESULT

9 spans shown;

attempt grouping omitted

1 INTERNAL root
4 CLIENT sends
4 SERVER receives

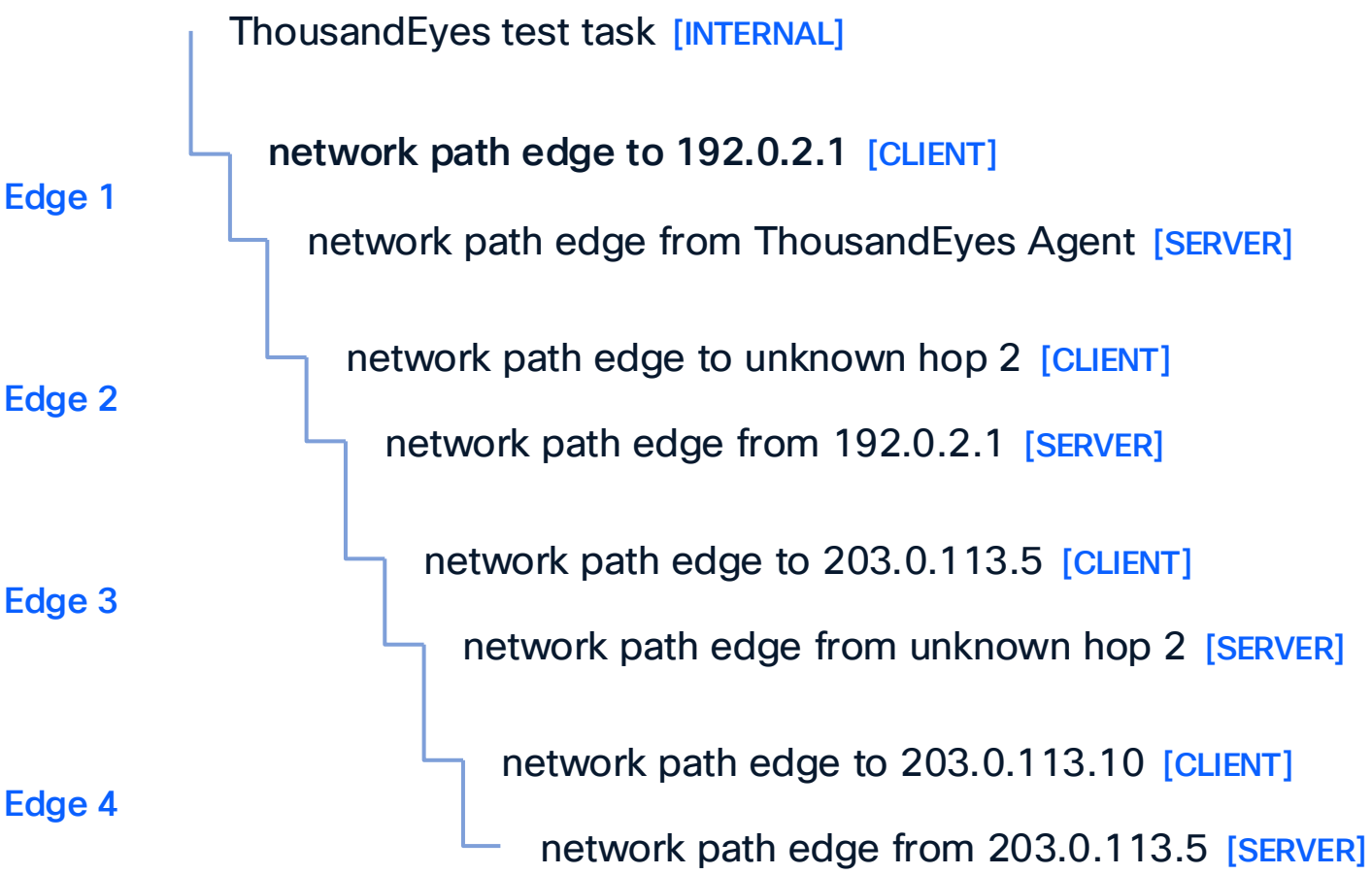
CLIENT span targeting Hop 3

Measured network.path.hop=3
Measured network.peer.address=203.0.113.5
Measured thousandeyes.network.path.hop.rtt_ms=12
Enriched network.peer.hostname=gw.example.net
Enriched network.peer.prefix=203.0.113.0/24
Enriched network.peer.as.number=64500

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Trace hierarchy for the full path



9 spans

1 INTERNAL
4 CLIENT
4 SERVER

Parentage preserves path order.

One additional INTERNAL span groups this attempt.

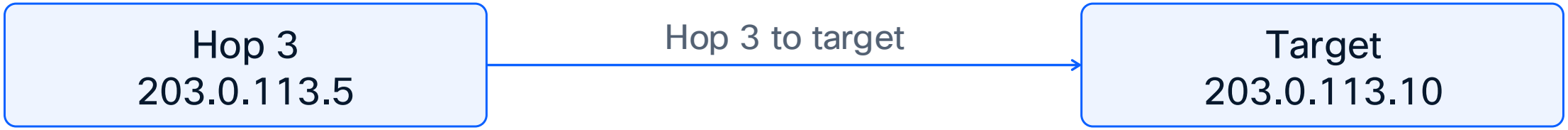
Each topology edge uses a CLIENT and SERVER pair. RTT stays in an attribute.

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Local and peer addresses on each span

One observed edge



CLIENT span on Hop 3

network.local.address = 203.0.113.5

network.peer.address = 203.0.113.10

SERVER span on Target

network.local.address = 203.0.113.10

network.peer.address = 203.0.113.5

Local and peer addresses swap with the span’s perspective.

Constructed from probe observations. The routers do not emit these spans.

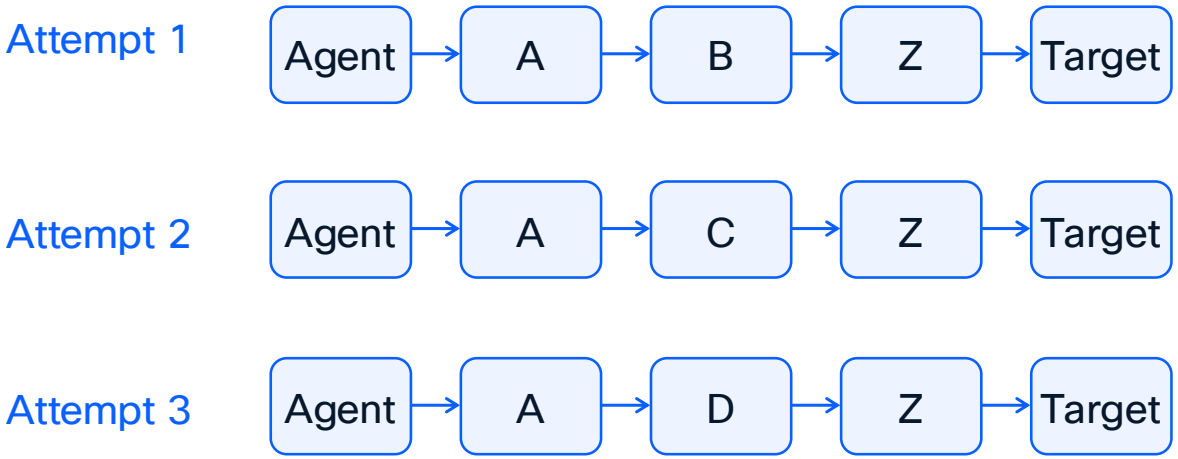
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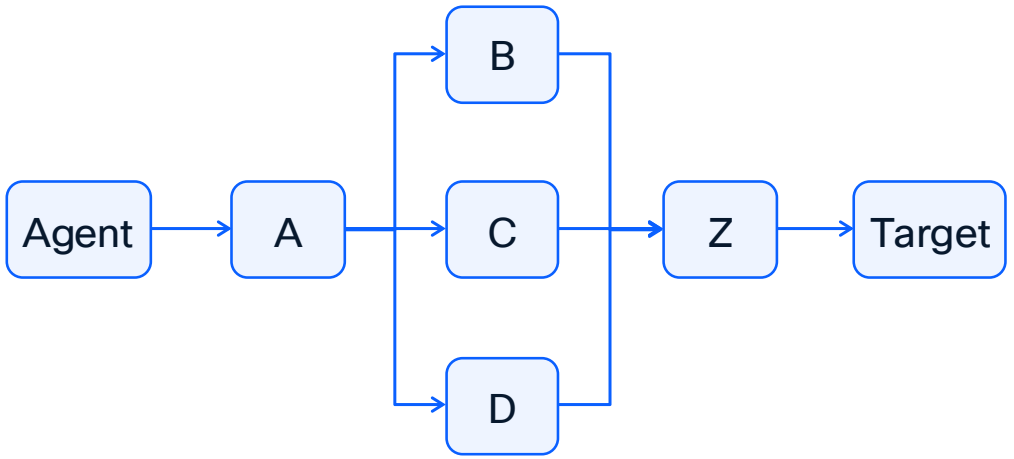
Three attempts, one branching graph

An attempt is one path-discovery run, using probes to discover successive hops.

Keep each attempt separate



Combined topology



Why can attempts observe different hops?

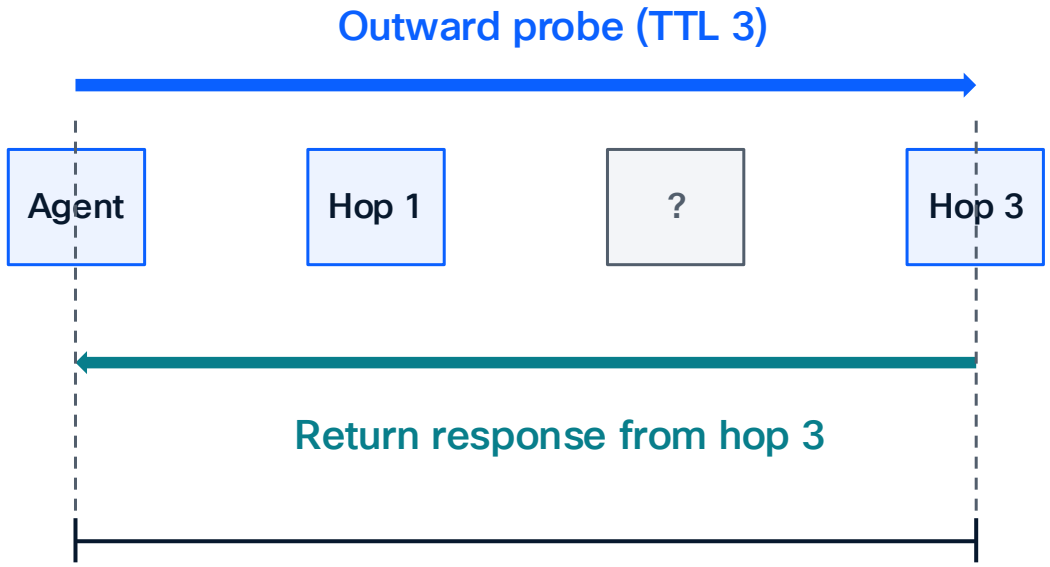
Each TCP attempt uses a different source port.
Routers may use that port to choose a different route.

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A timing trap

One probe, one measured round trip



RTT = 12 ms

Measured at the agent; return path may differ.

RTT to hop 3 includes the outward probe and the return response.

It cannot isolate one-way delay from hop 2 to hop 3.

A waterfall bar built from those RTT values would imply timing that was not measured.

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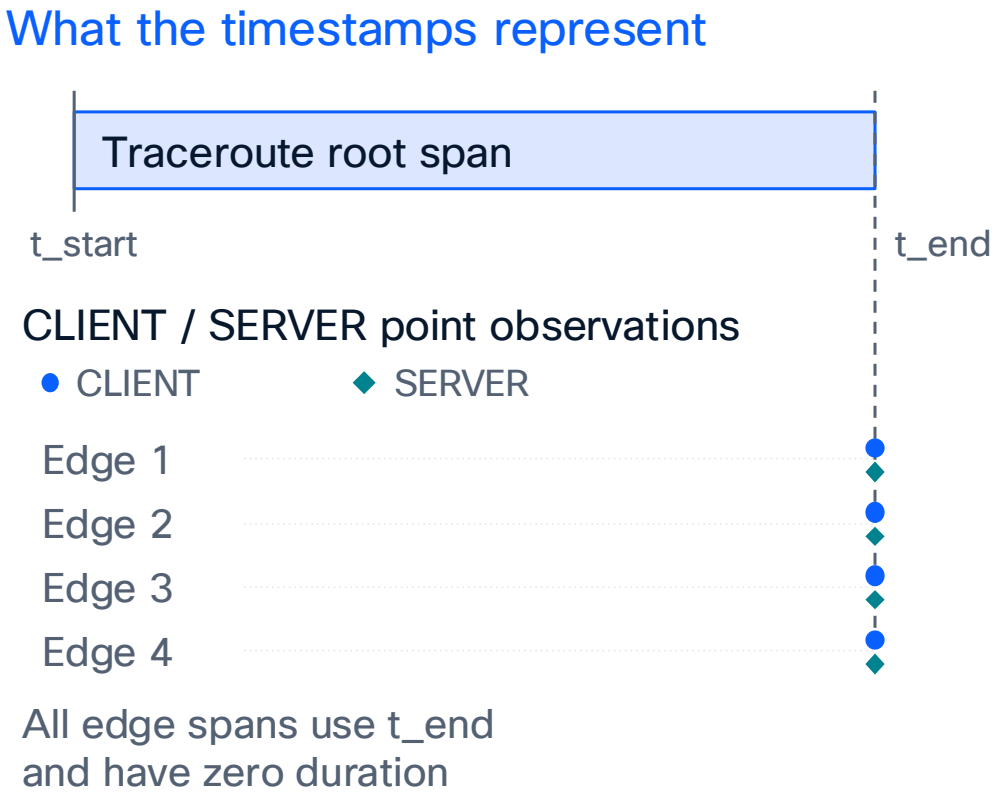
Traceroute time and hop RTT

RTT lives in an attribute.

Root span: measured traceroute start to end

Edge spans: point observations

Hop RTT: source to receiving hop, in milliseconds



PREVIEW ATTRIBUTE

thousandeyes.network.path.hop.rtt_ms

Temporary project namespace until the model is proposed for OpenTelemetry community review.

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Attributes that make the trace useful

Span attributes: path and endpoints

network.path.hop	Receiving hop index
thousandeyes.network.path.hop.rtt_ms	Source-to-hop RTT
network.local.address network.peer.address	Endpoint address
network.local.hostname network.peer.hostname	Reverse DNS hostname
network.local.prefix network.peer.prefix	CIDR prefix
network.local.as.number network.peer.as.number	Autonomous system number
geo.geoname.id	Optional inferred location

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ThousandEyes attributes in a path trace

Resource attributes

thousandeyes.account.id	Identify the ThousandEyes account
thousandeyes.test.id / thousandeyes.test.name	Test executed
thousandeyes.source.agent.id / thousandeyes.source.agent.name	Identify the source agent
thousandeyes.source.agent.location	Locate the source agent
thousandeyes.stream.id	Identify the export integration
thousandeyes.stream.name	Readable name of the export integration
thousandeyes.permalink	Open the original ThousandEyes view

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How ThousandEyes constructs the spans

ThousandEyes constructs these spans from normalized paths + enrichment

Routers do not emit them.

Unreached destination → attempt span:
status.code: ERROR · error.type: destination_not_reached

Probe measurements → **ThousandEyes** → **OTLP traces**

Hop IPs, RTT and reachability

Span attributes and parent-child relationships

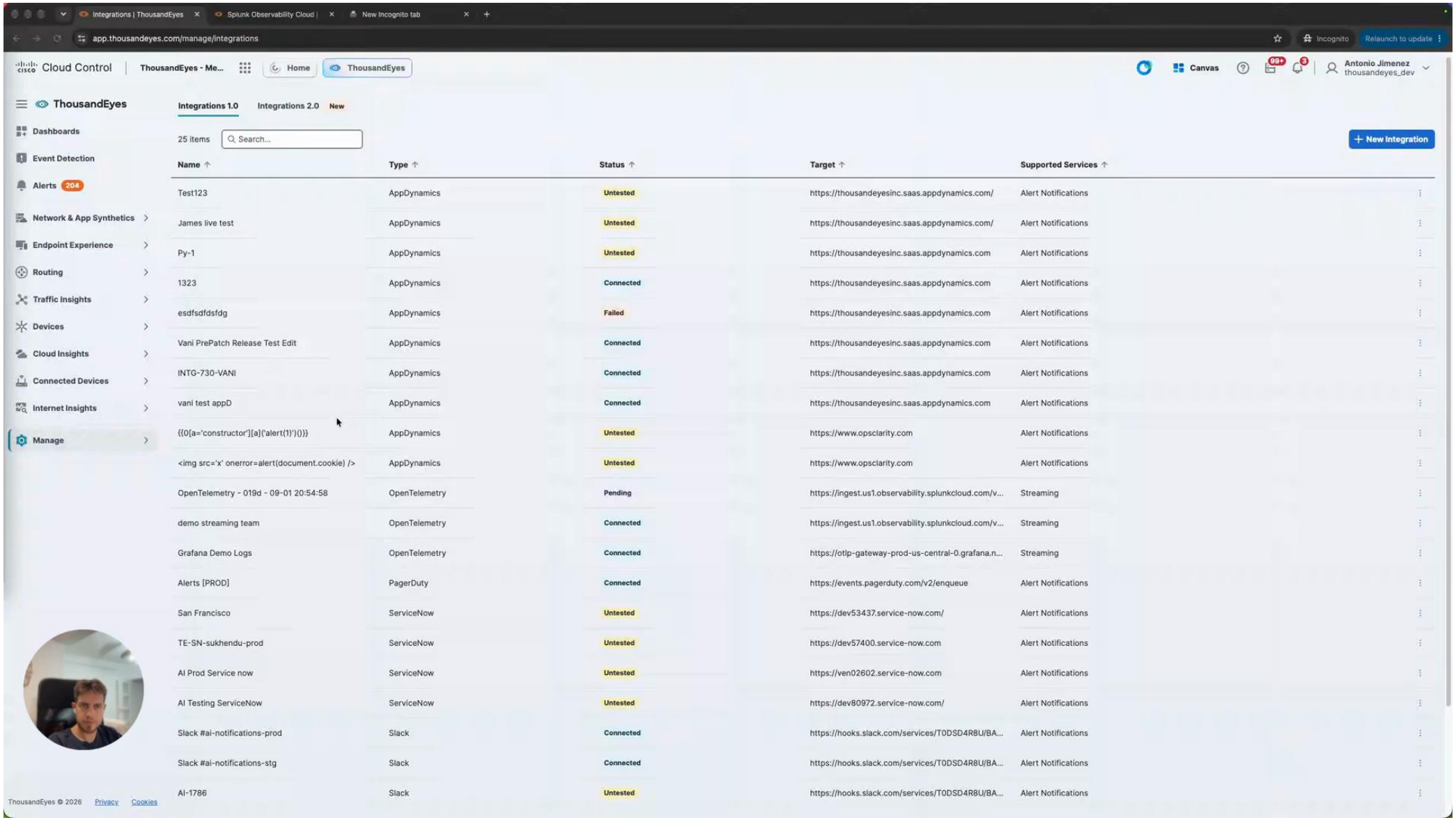
Trace waterfalls and topology views

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Demo

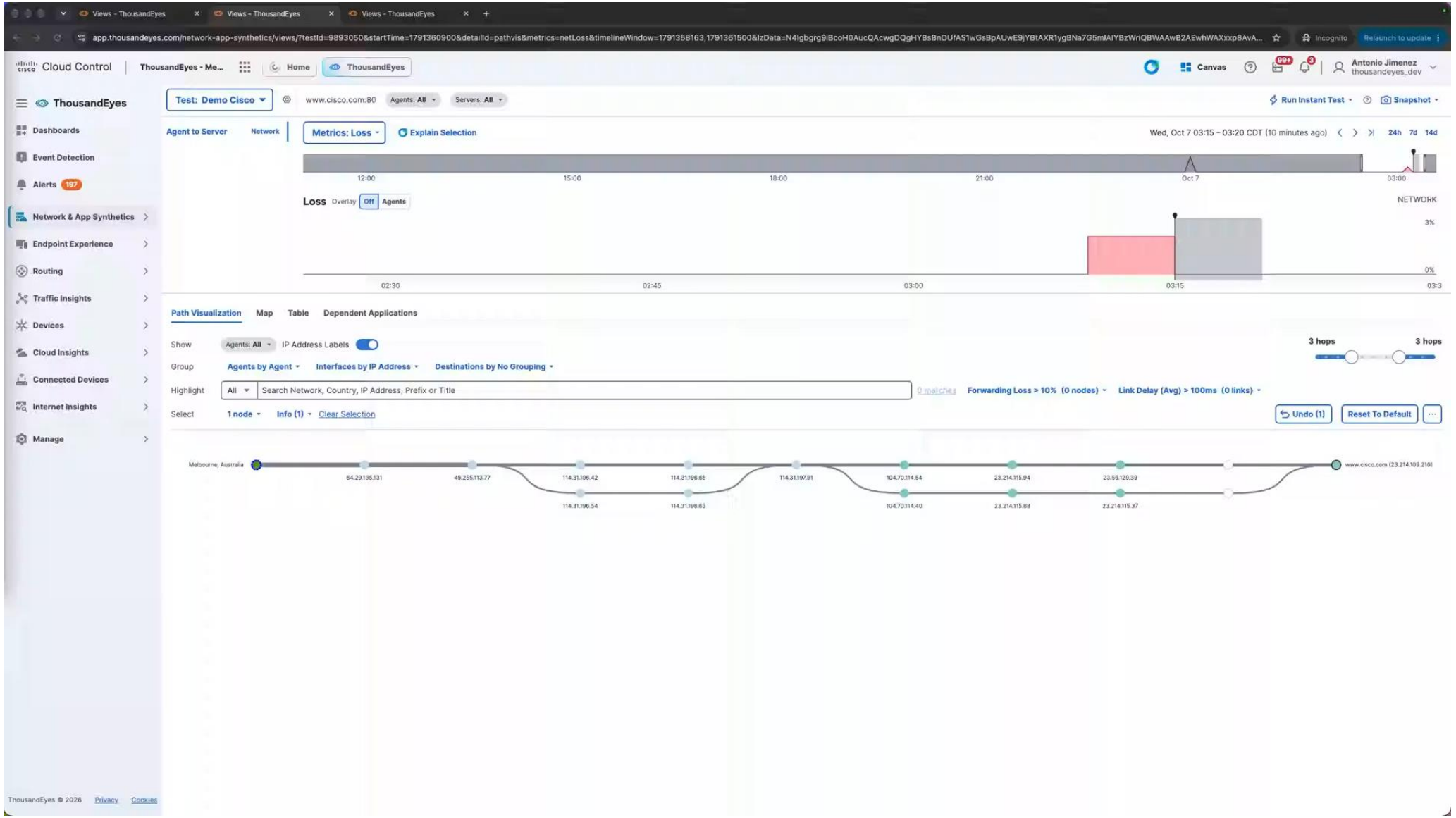
Create OpenTelemetry integration



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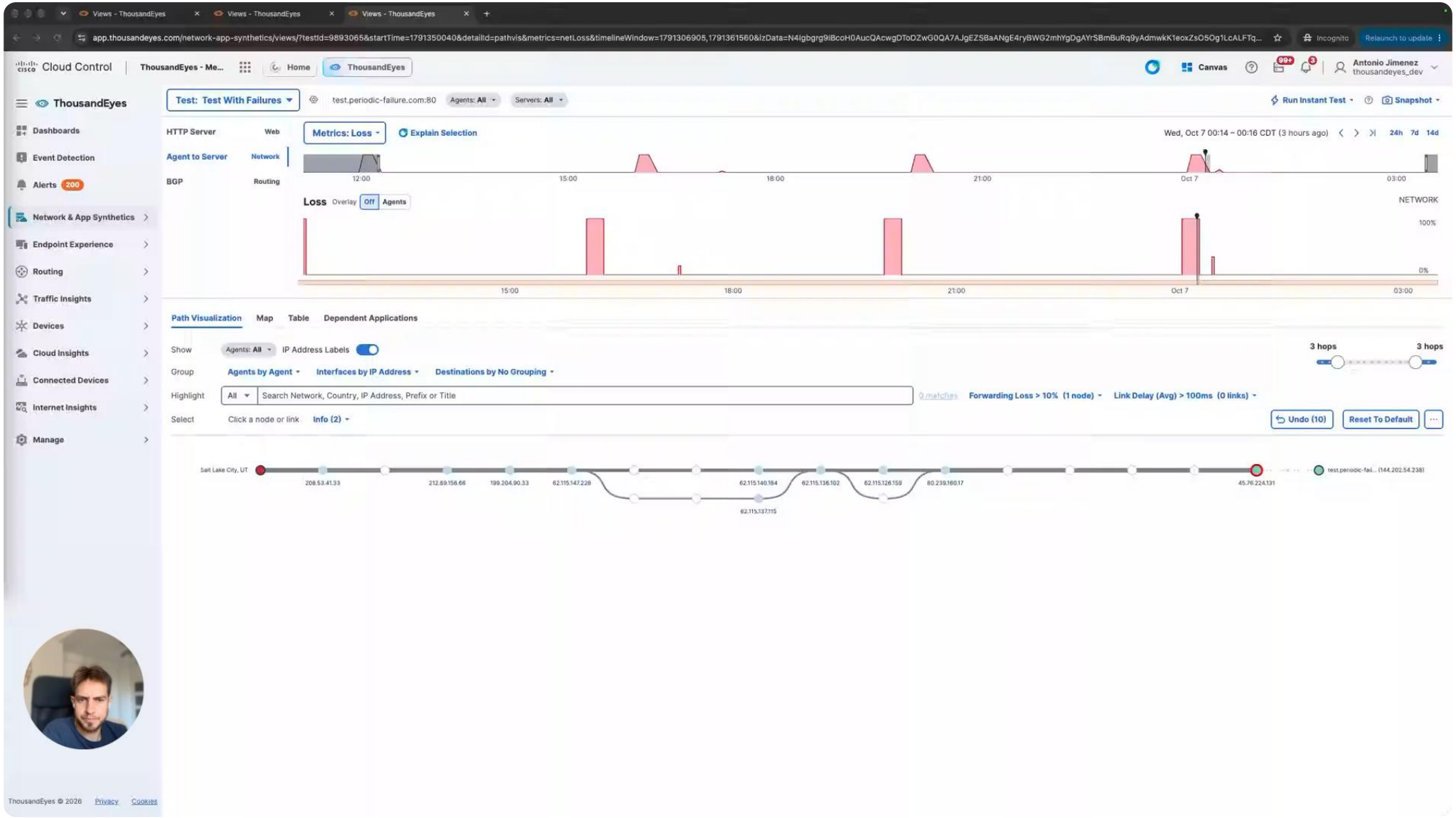
OpenTelemetry traces representing network path



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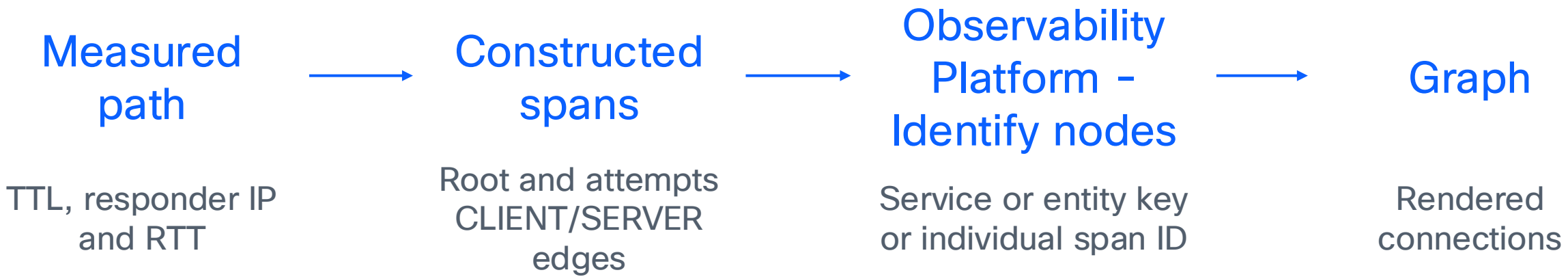
OpenTelemetry traces representing a **failing** network path



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How path spans become a topology view

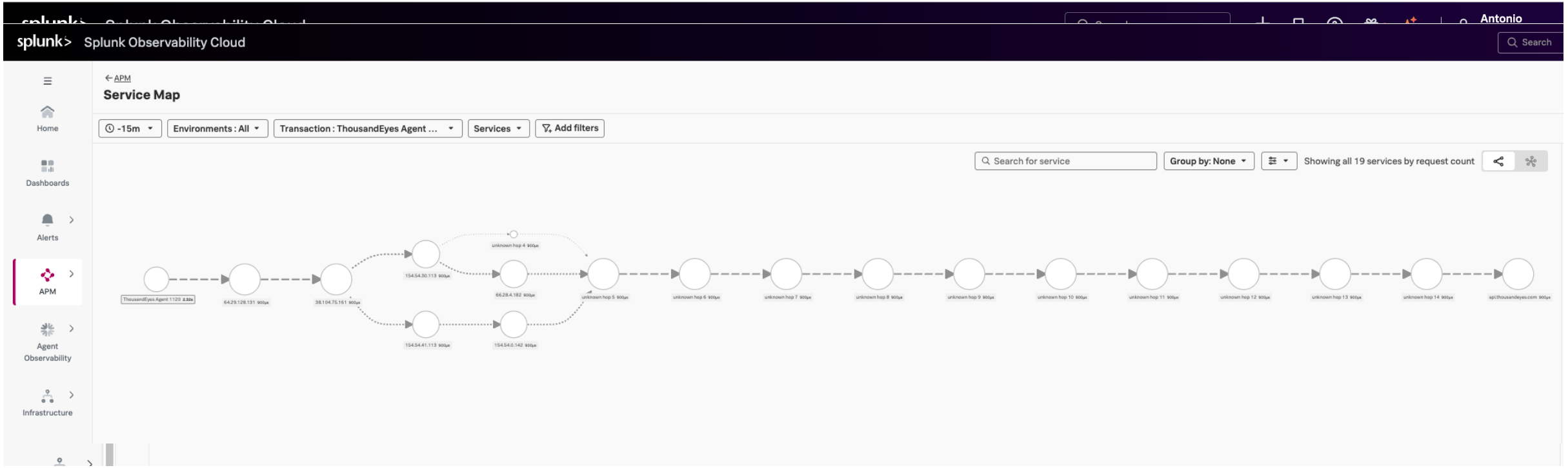


- Routers do not emit these spans.
- Backends can merge nodes or retain individual spans.

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Splunk: trace flow and service map



Representative backend service

Service map observed

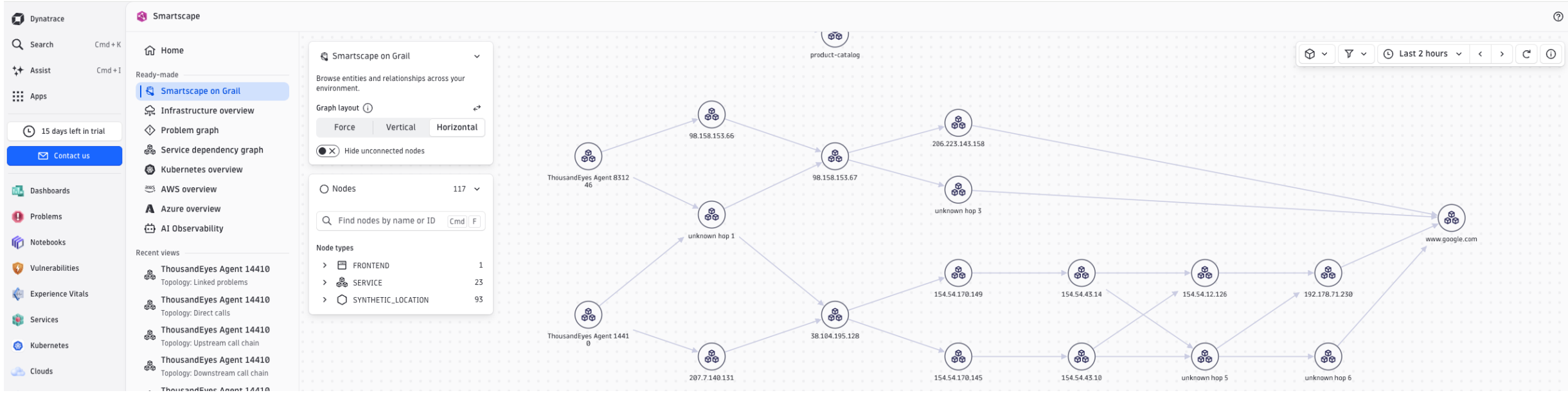
Selected trace, multiple attempts

Retransmit window

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Dynatrace: topology across observed paths

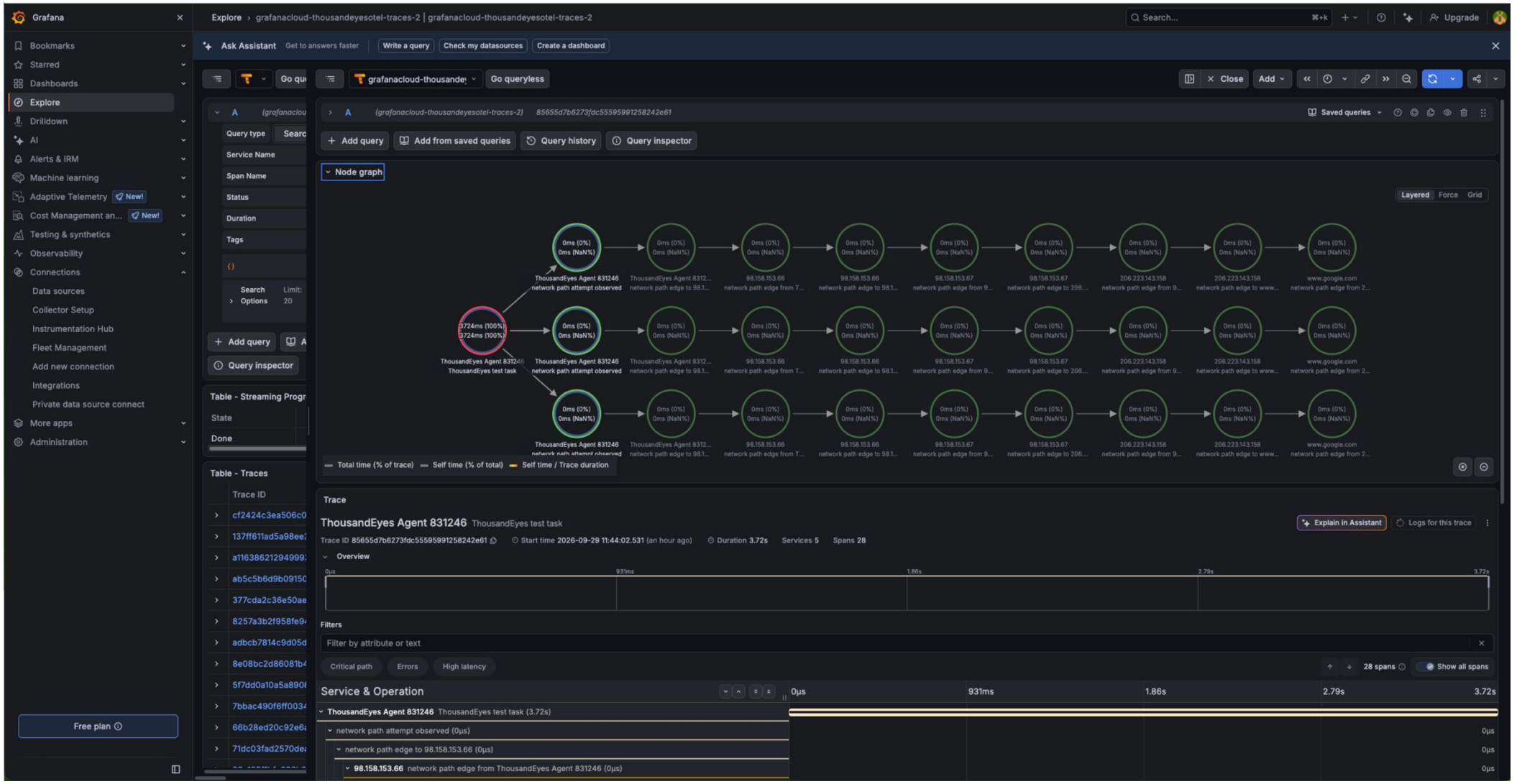


Representative backend view: Selected two-hour window

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Grafana: a node graph of individual spans



Representative backend view: Selected trace, span hierarchy

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Correlating network and application data

Why application and network correlation matters

Correlation connects an application symptom with relevant network evidence, so you can narrow where and when to investigate.

Contextual comparison today

Match the UTC window, resolved destination IP and source vantage point.

Use test and agent IDs to open the original path measurement.

Proposed Span Link correlation

A Span Link could relate the independent traces when the application span context is available.

This remains a proposed design.

Shared context helps focus the investigation. The request's exact network route remains unverified.

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Comparing context across two traces

Compare the 680 ms inventory call with a nearby probe round.

Context	Application trace A	Network path trace B
Time in UTC	inventory call, 680 ms at 14:00:02	Probe round 14:00:00 to 14:00:04
Destination	inventory.example.com 203.0.113.10	inventory.example.com 203.0.113.10
Source	Checkout service egress	Agent A (42), same egress

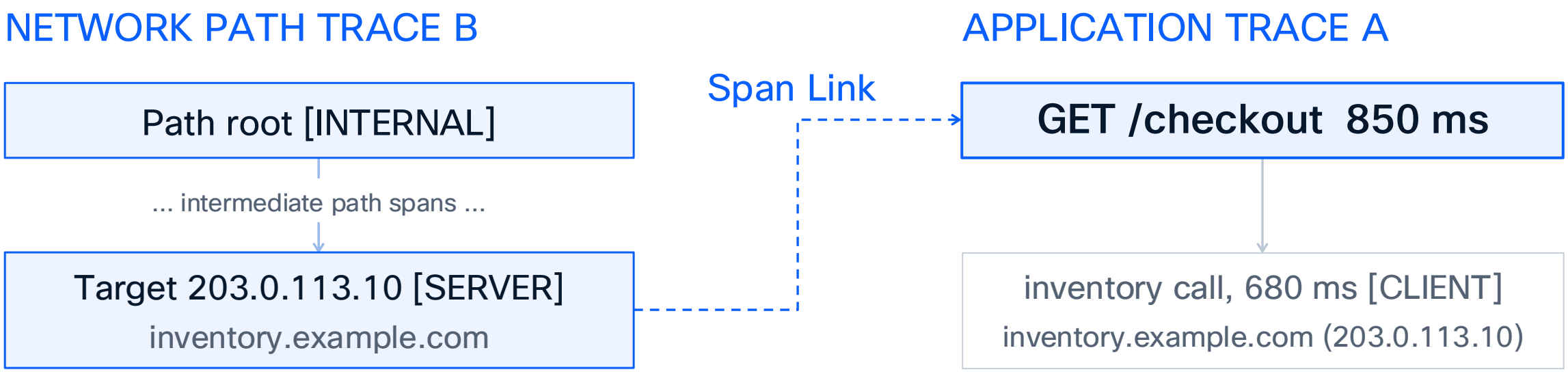
The time window overlaps. The destination and egress match.

The path adds network context to the application symptom. Both traces remain independent.

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Proposed Span Link correlation



The target SERVER span records the link.

Requires the first application span’s trace ID and span ID.

Each trace keeps its own trace ID.

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Investigating with path traces

Using a path trace during an incident

Keep the target and probe settings consistent.

01 **Compare with a healthy round**

Find changes in route, reachability or RTT.

02 **Match the application trace**

Align destination, UTC window and relevant egress.

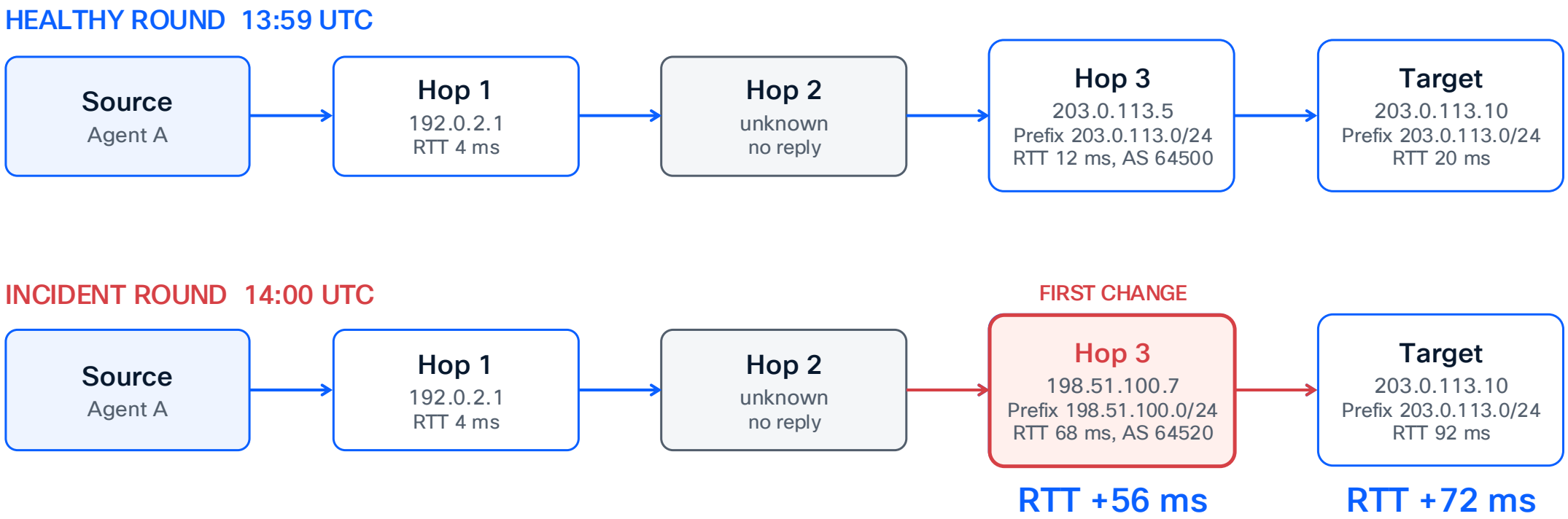
03 **Compare a second agent**

Then inspect routing and provider telemetry.

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Healthy round and incident round



What changed between these two rounds?

What would you check next before naming a cause?

Illustrative case. Prefixes and ASNs are enriched metadata.

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Agent comparison and routing history

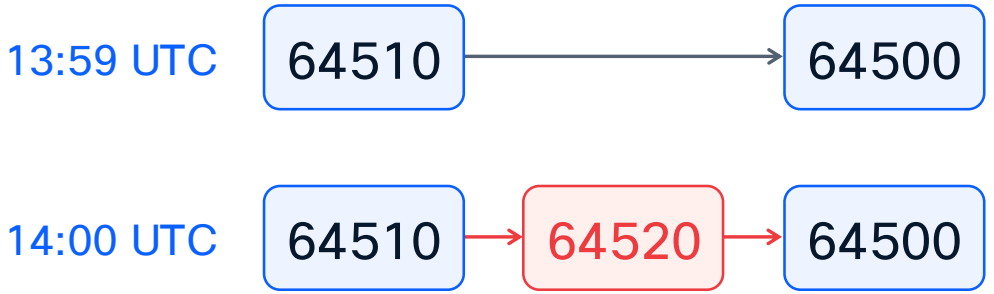
Target 203.0.113.10

Destination RTT

Source	13:59 UTC	14:00 UTC
Agent A: branch	20 ms	92 ms
Agent B: alternate	22 ms	23 ms

Agent A’s AS path

Destination prefix 203.0.113.0/24



Does the route change explain the latency?

Check Agent A’s route for congestion or errors, then retest.

Illustrative case. A route change is a lead to investigate.

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More questions across path traces

Latency and packet loss

Where does RTT rise? Which paths coincide with packet loss?

Search by IP

Which tests, agents, and destinations observed this IP?

Frequently observed paths

Which IPs and routes appear most often in the selected window?

Shared dependencies

Which tests cross the same prefix or ASN? What changed?

Path frequency reflects synthetic observations, not production traffic volume.

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OpenTelemetry Network SIG

OpenTelemetry Network SIG: Community and scope

01 How the Network SIG started

Issue #3769 organized a dedicated group for network telemetry conventions.

02 Open weekly meeting

Monday at 07:00 PT. Meeting notes carry the latest agenda.

03 #otel-network on CNCF Slack

The channel hosts discussion and meeting coordination. New members can join the CNCF workspace first.

04 Network project board

The board tracks proposals, issues, and current priorities.



Network SIG resources

Meeting, Slack and roadmap

Everyone is welcome to participate. Join the channel or choose an issue from the board.

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Contributing network context to semantic conventions

	CONTRIBUTION	PROPOSED ATTRIBUTE	WHY IT MATTERS
01	**CIDR prefix** Issue #3731 PR #4144	network.peer.prefix	Separates a network block from one endpoint.
02	**ASN** Issue #3740 PR #4115	network.peer.as.number network.peer.as.organization	Adds routing domain and operator context.
03	**Reverse DNS hostname** Issue #3741	network.peer.dns.name	Carries a PTR-derived name while keeping the peer IP.

Open proposals. Attribute names and scope remain subject to community review.

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Span kinds for network-path modeling

Our preference: CLIENT / SERVER with a dedicated scope

Approach	Benefit	Tradeoff
CLIENT / SERVER (preferred)	Existing API and OTLP values. Familiar endpoint roles.	Check the scope to identify network-path spans.
New network kinds	Make network roles explicit.	Requires changes to the OTel specification.

Proposed scope name

scope.name = "network.path.model"

Scope describes the producer. The community still needs to validate how request/response kinds apply to reconstructed path observations.

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Proposing network-path semantic conventions

We want to contribute the network-path trace model

01 **Discuss the model with the Network SIG**

Review CLIENT/SERVER, scope and network-path attributes.

02 **Refine the model together**

Use examples to agree on a common representation.

03 **Propose semantic conventions**

Submit the model for community review.

Proposed direction. Subject to community review.

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Takeaways

Three modeling rules

Use the trace tree to preserve path order.

Keep source-to-hop RTT as a measured attribute.

Join app and path evidence with explicit context.

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Questions



Network SIG resources

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