Architectural Support For Network Troubleshooting

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Architecting for Troubleshooting: Principles

Responsibility:

- Who has jurisdiction for ***solving*** a problem?
- Enable users to generate ***credible*** and ***actionable*** problem reports
  ⟹ sufficient evidence to unambiguously demonstrate problem
- Responsible party likely in the best position to perform detailed diagnostics

Beyond Modularity:

- Fundamental tension between modular design and troubleshooting
- Interface narrowness allows for separation of concerns and rapid innovation …
- … but interface narrowness tends to mask problems, as errors and exceptional conditions must propagate across layers of abstraction in some meaningful form

Tracking Causality:

- Network events entail lengthy sequences of activity dependent upon / affected by previous activity
- Determining chain of events that lead up to failures enables separating ***symptoms*** from ***root causes***

Enriched Logging:

- ***Annotations*** associate meta-data with network activity
- Logging requires ***distillation*** into more abstract forms over time
- Logging requires ***dialog*** between components generating log entries and the logging infrastructure
  ⟹ callbacks support distillation and interactive debugging

Privacy:

- Information that facilitates debuggability can also facilitate detailed tracking of user activity
- We need mechanisms that, when possible, decouple logs of user activity from user identities
- Must recognize *tussle* between tracking activities for operational purposes versus masking it for reasons of privacy
- Problem even harder since often information needs to cross organizational boundaries
- Requests for information should include ***provenance*** attesting to the requester's right-of-access:
  ⟹ E.g., demonstrate knowledge of related details or nonces known only to the traffic participants

Troubleshooting and Robustness:

- Troubleshooting and robustness are deeply intertwined
- Better troubleshooting can lead to automatic diagnosis and mitigation…
- … Which in turn can lead to masking problems
  ⟹ As can any robustness mechanism coupled with a narrow interface

Architecture for Troubleshooting: Preliminary Mechanisms

VAST: Visibility Across Time and Space

Interactive repository of ***event level*** descriptions of network activity
- Implemented using "FastBit" database technology

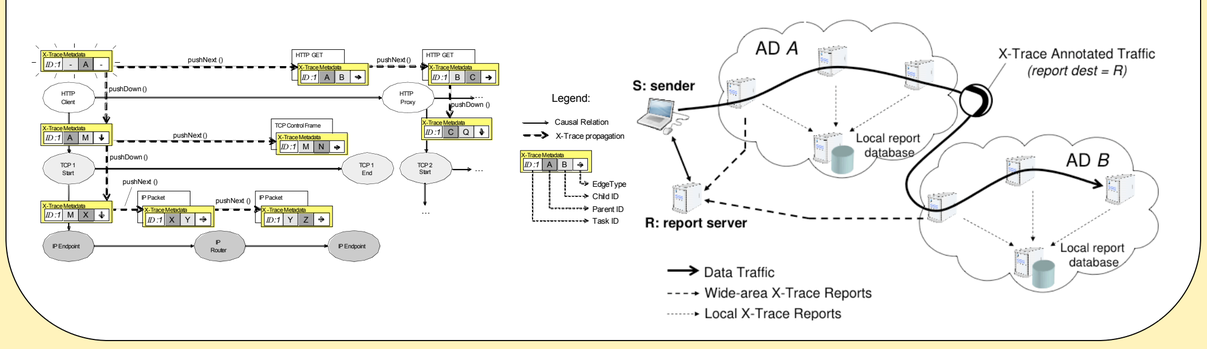
Supports programmatic querying, aging, distillation, aggregation, and expiration

Designed to support cross-organizational data sharing

Queries for past activity can be mirrored into proactive monitoring for ***future*** activity

X-Trace

- *Pervasive Network Tracing Framework*
- Architectural support for annotations

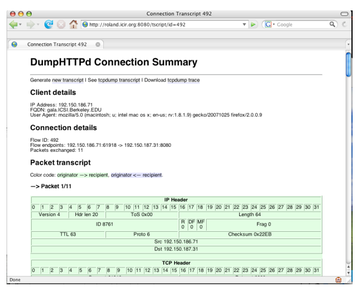


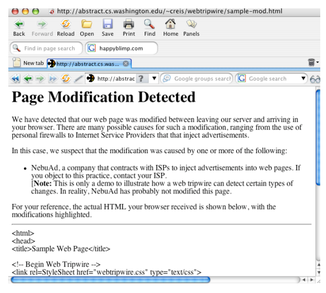
Network Radar

What are the elements along a network path?

How do they appear from different vantage points?
- Many elements not naturally exposed by standard operations

One technique: measure transformations to known content





Reactive Measurement

Observations trigger measurements in response

Observations can come from:
- User reports
- Passive analysis
- Proactive active probing

Changes measurement from an ***event*** to a ***process***

Combine disparate measurement techniques by using the results of one measurement to drive additional assessments

For troubleshooting we can winnow possible root causes by using context-sensitive diagnostics

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