mami

measurement and architecture for a middleboxed Internet

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FIRE Future Internet Research and Experimentation

Measurement-based Protocol Design

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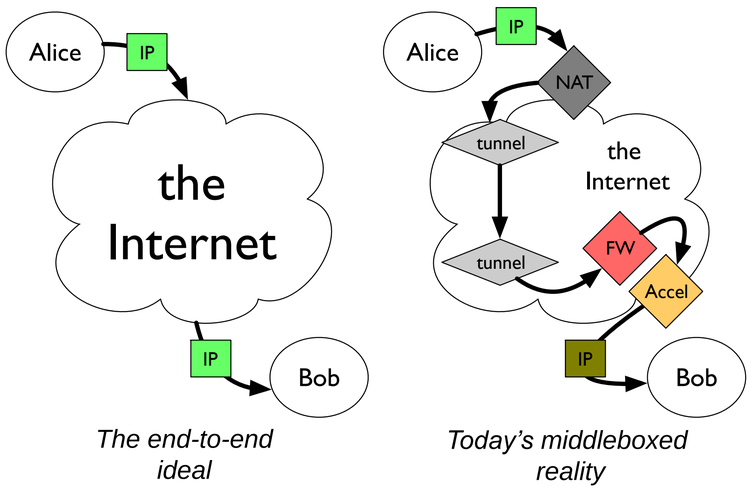
IN-NETWORK FUNCTIONS AND ENCRYPTION

Current generation of mobile networks use many middeboxes [1]

- e.g. for NATs, firewall, or performance enhancing as transcoding often utilising **clear text information** in protocol headers/payload
- e.g., TCP sequence and acknowledgement numbers to measure RTT for performances diagnostics



The end-to-end ideal — *Today's middleboxed reality*

Three driving forces presents a need for an architectural change:

Expanding deployment of encryption to protect end-user privacy

Restoration of the end-to-end principle in the face of increasing ossification

Dependency on in-network functionality to support network operations

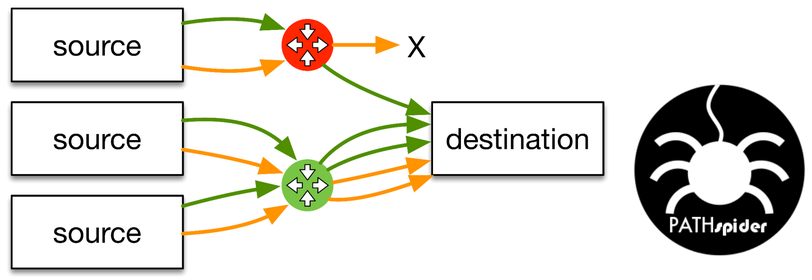
This raises new questions on the design of transport protocols:

- How does encryption impact existing deployed infrastructure?
- What options exist to design new protocols with explicit support for certain in-network function?
- What operational support is needed to deploy new protocols?

[1] Z. Wang, Z. Qian, Q. Xu, Z. M. Mao, and M. Zhang, "An untold story of middleboxes in cellular networks," in ACM SIGCOMM, 2011.

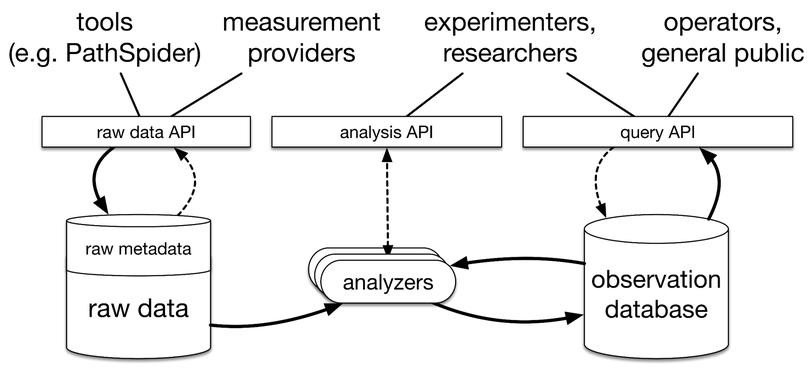
MEASUREMENT AS PART OF THE DESIGN PROCESS

- Using PATH*spider* to measure Internet path transparency: publicly available on GitHub https://pathspider.net/



A/B-testing as performed by PATH*spider*

- Experimental evaluation using the MONEOE Mobile Broadband testbed: https://www.monroe-project.eu/
- Complemented measurement of the path with tools such as Tracebox: http://www.tracebox.org/
- Large-scale data collection from diverse sources in the Path Transperancy Observatory (PTO): http://observatory.mami-project.eu/
  - **Observation**: a given *condition c* was observed on a given *path p* at a given *time t*
    - e.g. that ECN was successfully negotiated, or TFO works



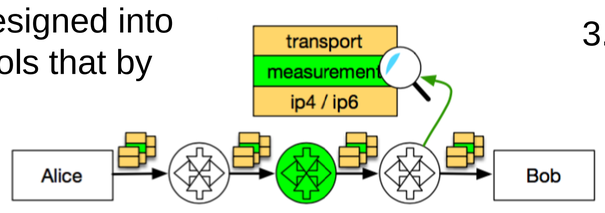
→ Measurement data from different tools and networks are used to form **maps of middlebox manipulation** within the Internet to provide background for design decisions about **protocol engineering and evolution.**

PROTOCOL DESIGN FOR MEASUREMENT

The availability of large scale measurement data enables a new approach to protocol design:

Goals

1. Increase the likelihood that new protocols will be deployable across the entire Internet, regarding the range of effects from middlebox manipulation on various packet headers
2. Support for in-network performance measurement to be explicitly designed into next generation network protocols that by default encrypt all end-to-end protocol information



Design Principles

1. Information exposure has to happen under explicit endpoint control
2. Least exposure of minimum amount of information required by the proposed mechanism to solve the identified problem, in this case in-network measurement
3. Trust by verify under the assumption that two endpoints have a trust relation for integrity protection and encryption, but generally no requirement for explicit trust relationship with network devices.

The *Path Layer UDP Substrate* (PLUS) proposes a framework for information exposure with a focus on measurements and diagnosability in a transport-protocol-independent way: see https://datatracker.ietf.org/doc/draft-trammell-plus-spec/

measurement architecture experimentation

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