Measurement-Driven Protocol Engineering
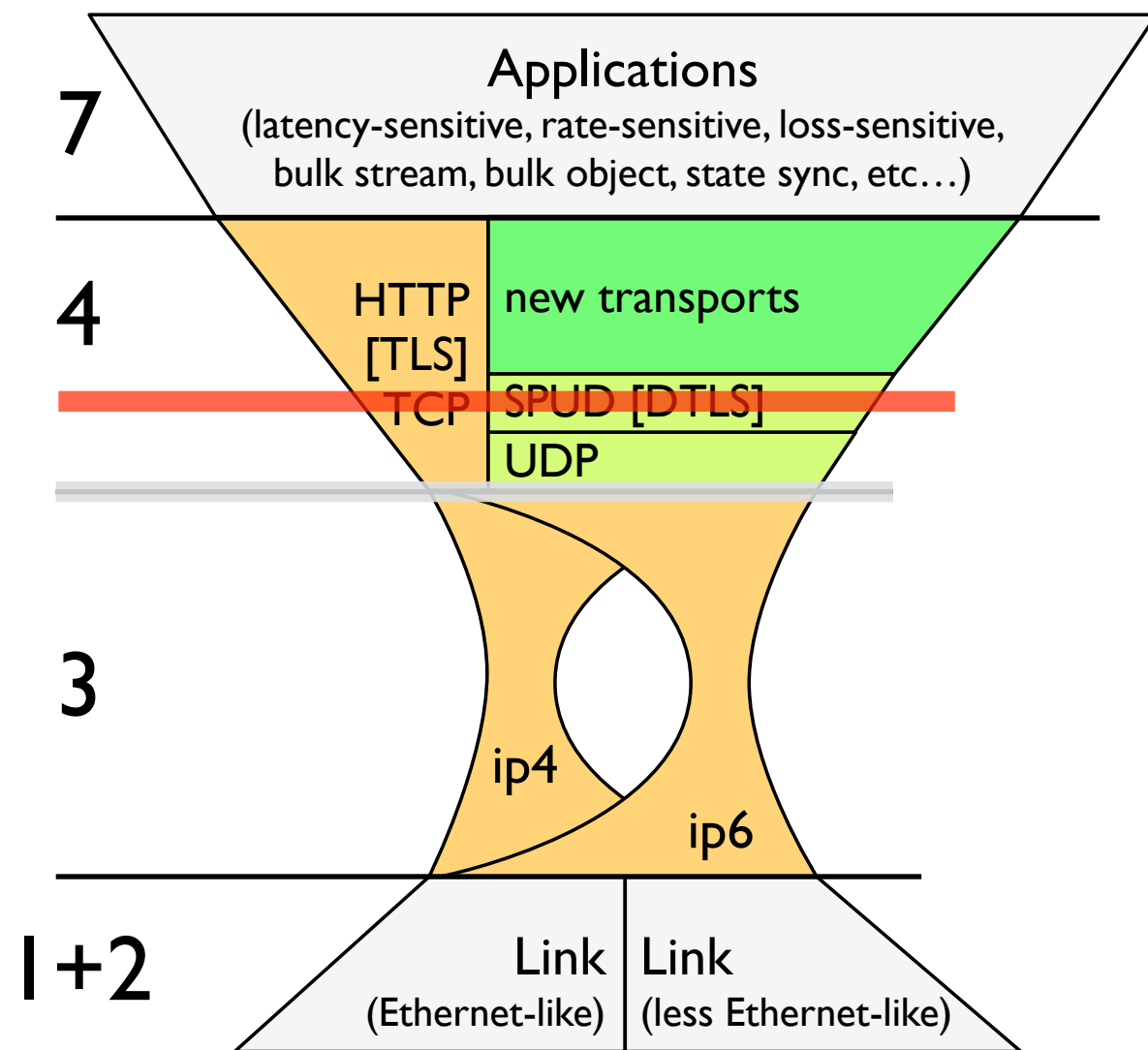
IAB Technical Plenary, IETF 94 Yokohama
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Evolving the stack:
explicit relayering and cooperation

- Goal: support deployment and user-space experimentation of new transport protocols in today's Internet.

- Approach: rethink the layer boundary

  - UDP encapsulation (ports for NAT)

  - crypto (reinforce the boundary between endpoint and path visible headers)

  - explicit cooperation (give back transport and application semantics the path actually needs)

Will any of this actually work?

What can go wrong?

Modification	Planetlab	Ark
NAT	**74.9%**	**79.0%**
ECN IP	**13.7%**	**13.2%**
ISN	**10.7%**	1.8%
MSS	**10.8%**	5.9%
Exp. Option	8.8%	0.5%
MPCAPABLE	8.4%	0.3%
ECN TCP	0.6%	0.6%
SackOK	0.3%	0.0%
TS	0.3%	0.4%
WS	0.2%	0.2%

- NAT everywhere
- Many features mostly work
- Impairments based on implementor and operator assumptions
- Variation based on vantage point
- **Best studies look at O(10k) paths[1].**

[1]: R. Craven, R. Beverly, M. Allman. **A Middlebox-Cooperative TCP for a non End-to-End Internet**. SIGCOMM, August 2014.

How can we do better?

- We want our protocols to work when stuff breaks.

  - Engineering tradeoff: robustness against path conditions vs. robustness of implementation.

  - NAT? Design for it, even if it's hard.

  - A custom hack in one AS squatting on a codepoint? Probably not worth more than the most trivial effort.

- Engineering decisions about protocols to deploy in the Internet should be based on relevant data about the environment they will face.

  - Design for common occurrences.

  - Know the risks of uncommon ones.

  - Apply measurement liberally to know the difference.

Measuring path impairment

- Path impairment: the likelihood that traffic with given characteristics will experience problems on a given path.

  - Increased latency, reordering

  - Increased loss/connectivity failure

  - "Bleaching" or selective disablement of features

- Utopian goals:

  - given a proposed protocol feature, know the prevalence of different types of problems with that feature on different networks.

  - given a source and destination, know the types of protocol features that will work along the paths between them.

- First step: sharing what we know. **HOPSRG** (hops@ietf.org)

Measuring the Internet is hard

- Measurements often don't measure what you want.

  - e.g.: ICMP latency and connectivity correlate less than we'd like with application latency and connectivity.

- The Internet is not homogeneous.

  - e.g. how much crypto you see on a given link depends on application mix and the vagaries of CDN policy[2].

- Selection bias: what is easy to measure is not necessarily most relevant.

- Tradeoffs with visibility versus (business) confidentiality and (user) privacy.

[2]: P. Richter et al. **Distilling the Internet's Application Mix from Packet-Sampled Traffic**. PAM, March 2015.

Improving
the best available data

- We have lots of **tools**…

  - platforms and testbeds (e.g. Atlas, mLab, Ark, BisMARK, SamKnows, PlanetLab…)

  - protocols (e.g. O/TWAMP, PSAMP, IPFIX, LMAP)

- …but lack a framework to bring **comparability** and **repeatability** to their observations.

  - Common information models for noting different observations mean similar things.

  - Common measurement control and query protocols[3].

[3] e.g. mPlane, ict-mplane.eu, draft-trammell-mplane-protocol

Measuring
without measuring

- Lots of things that don't look like measurement actually are.

  - TCP measures itself as a side-effect of its operation.

  - Version negotiation and fallback mechanisms (e.g. MPTCP, WebSockets) generate data about where features work.

  - Platform-level diagnostics[4] a potentially rich source.

- Let's design protocols with this fact in mind.

  - Extend common information models to runtime logging.

  - Add explicit measurement primitives to protocols.

  - Exploit what we've learned from doing it the hard way.

[4] e.g. telemetry.mozilla.org

A principle of measurement?

- There are many other insights to be gained from the Internet by measuring it in different ways.

  - Integration of measurements from different sources (active measurements, passive observation, application logs) can lead to more insight.

- Questions to ask:

  - What **assumptions** about the environment is protocol X based on? Do these hold?

  - What **sources** already exist that allow me to verify these assumptions?

  - What information does the protocol **generate** as a side effect that can lead to better insight?

(segue to Alberto)