Wire Images and Path Signals

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measurement | architecture | experimentation

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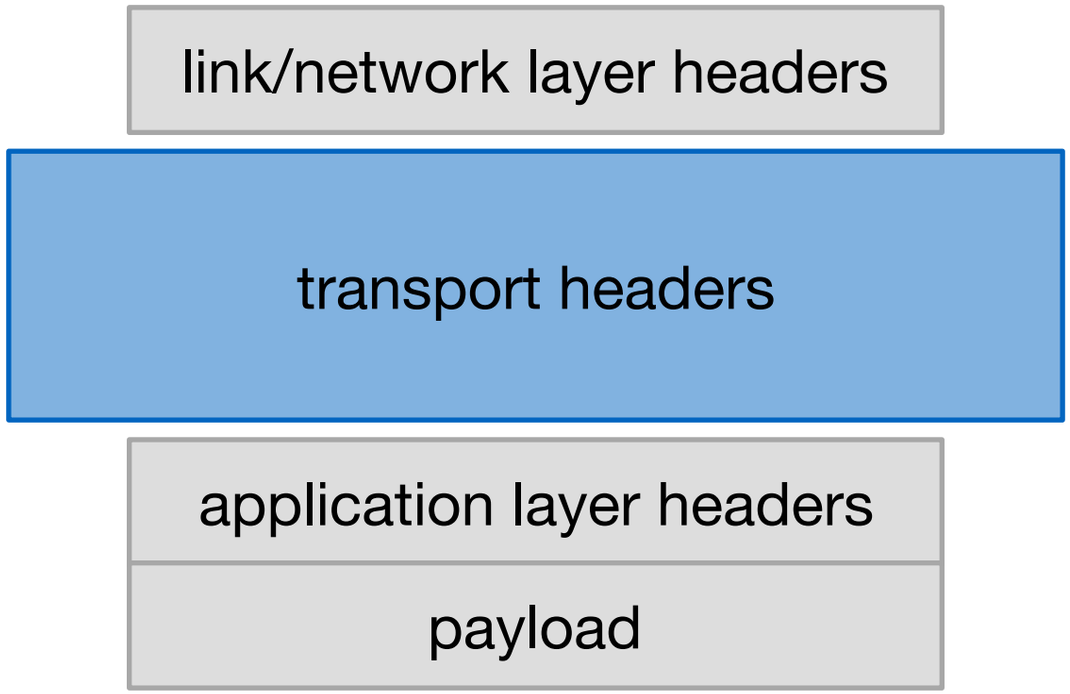
Transport protocol design, 1990s style



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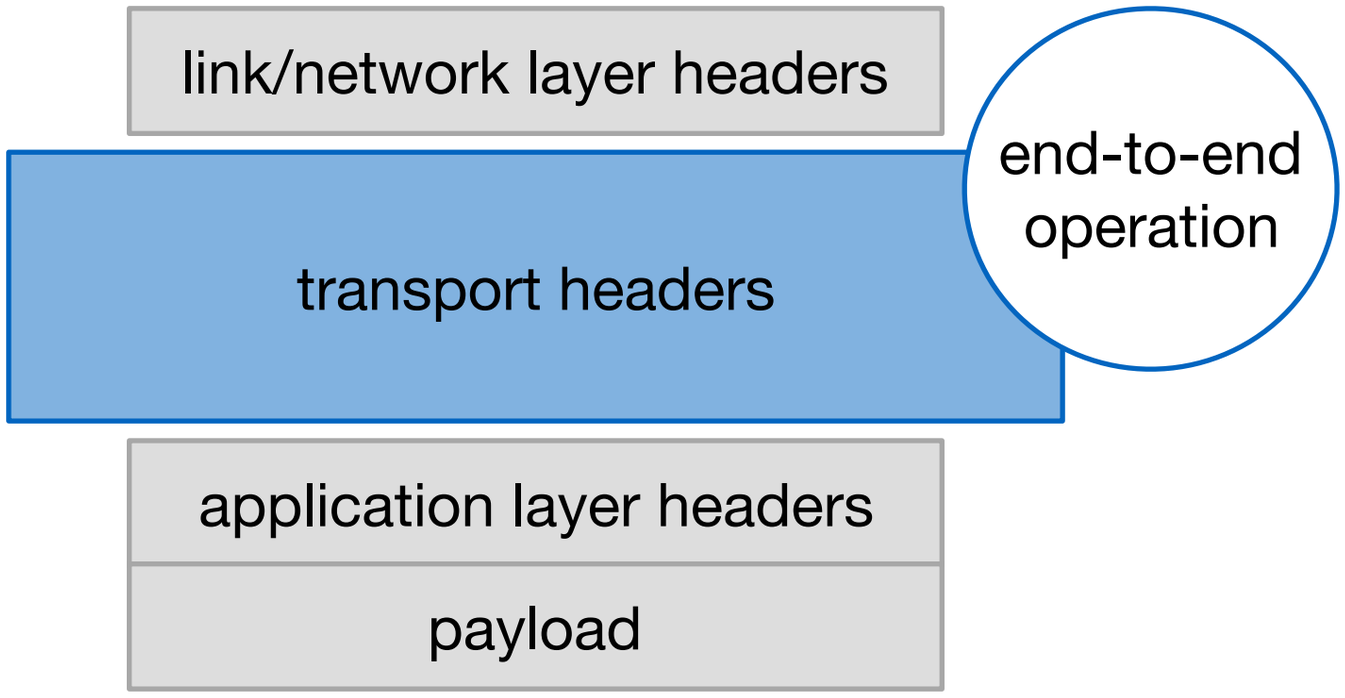

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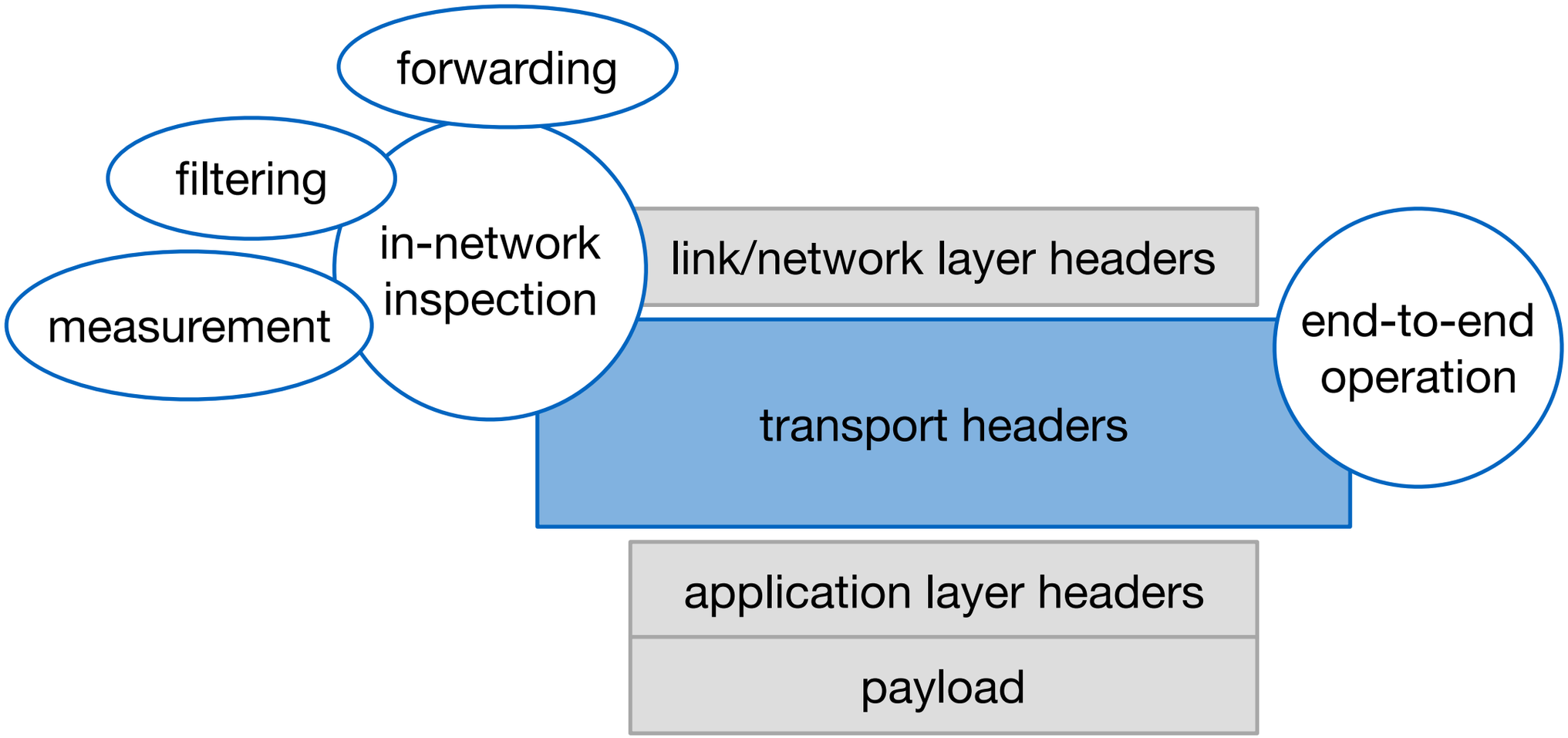

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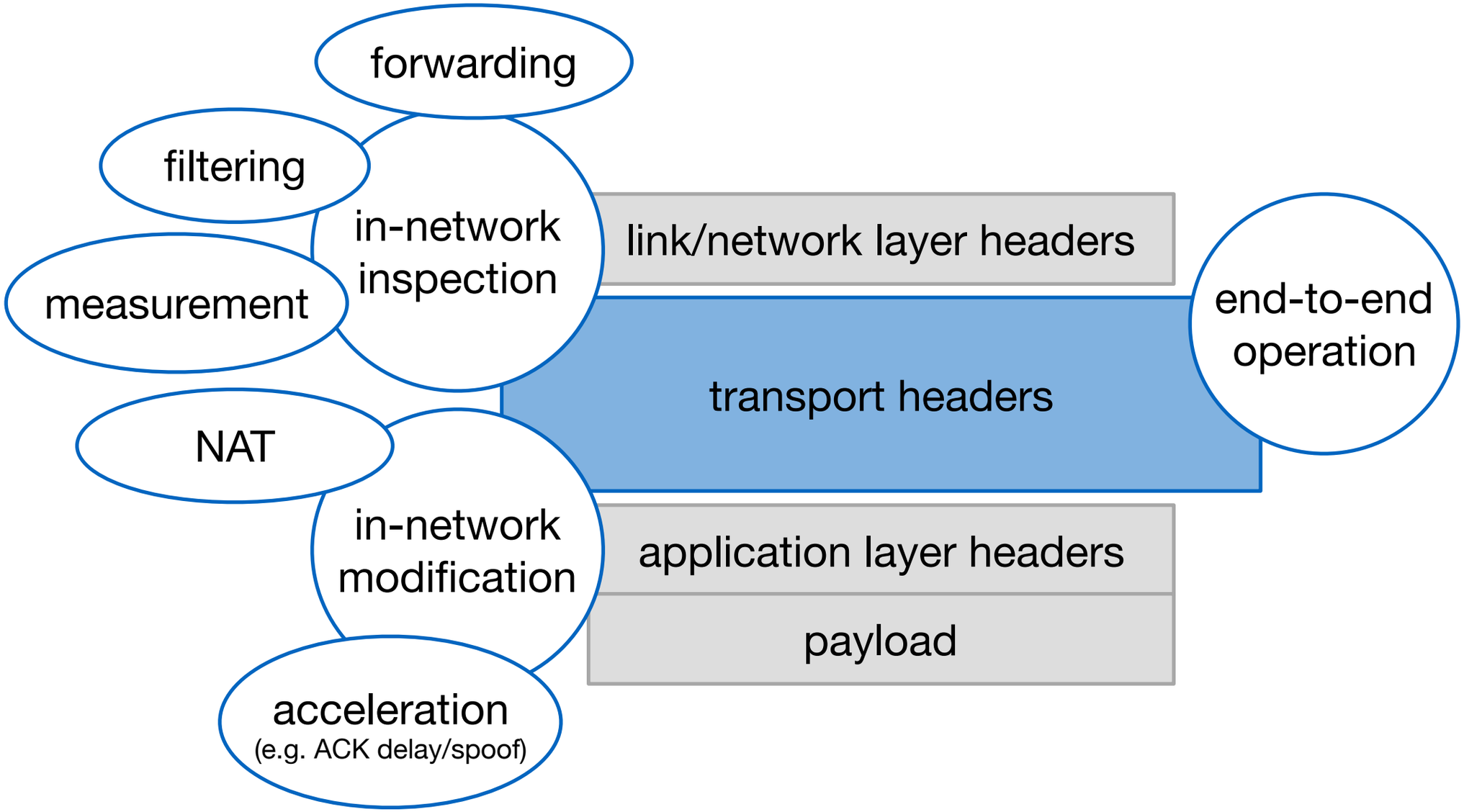

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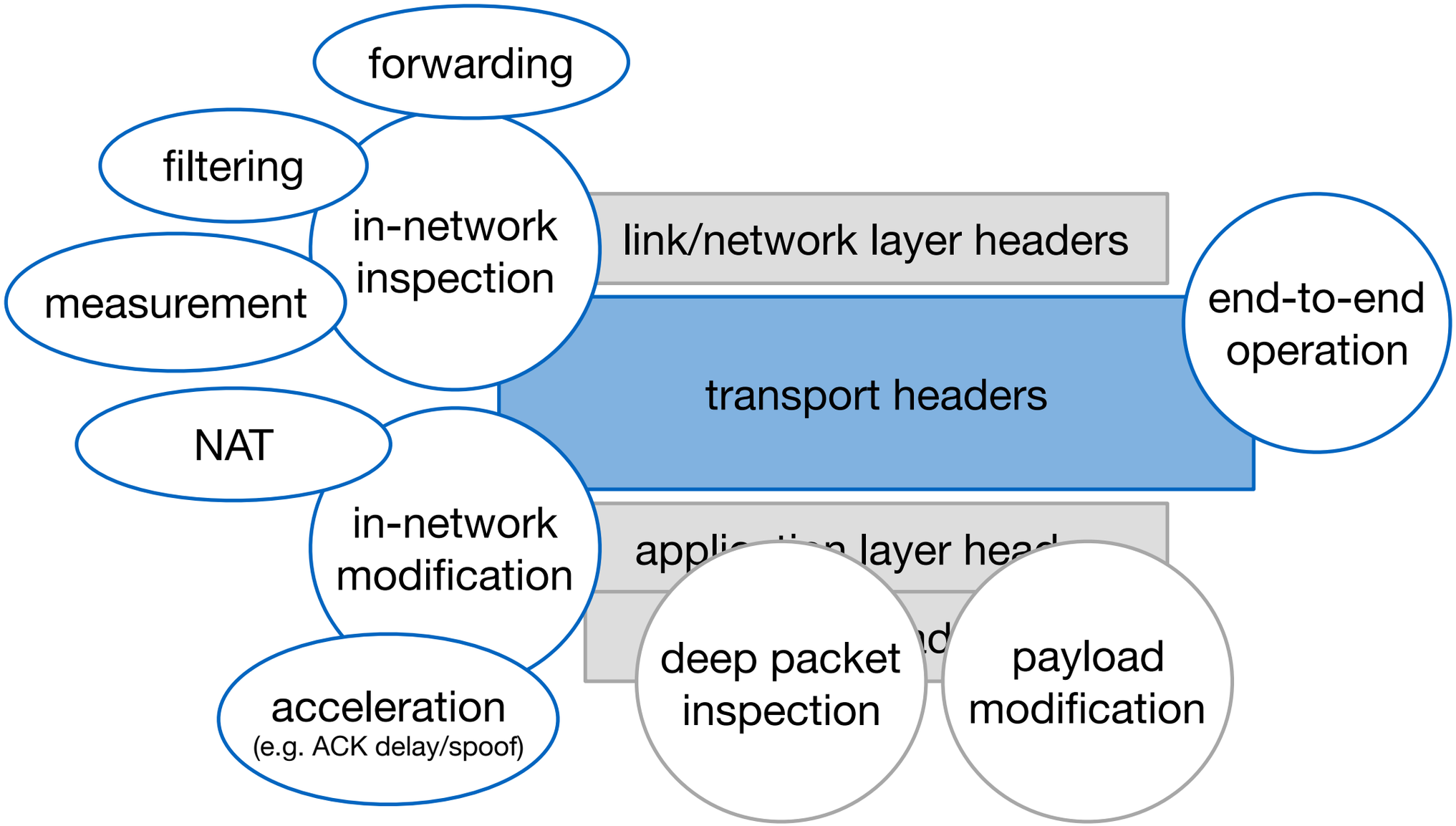
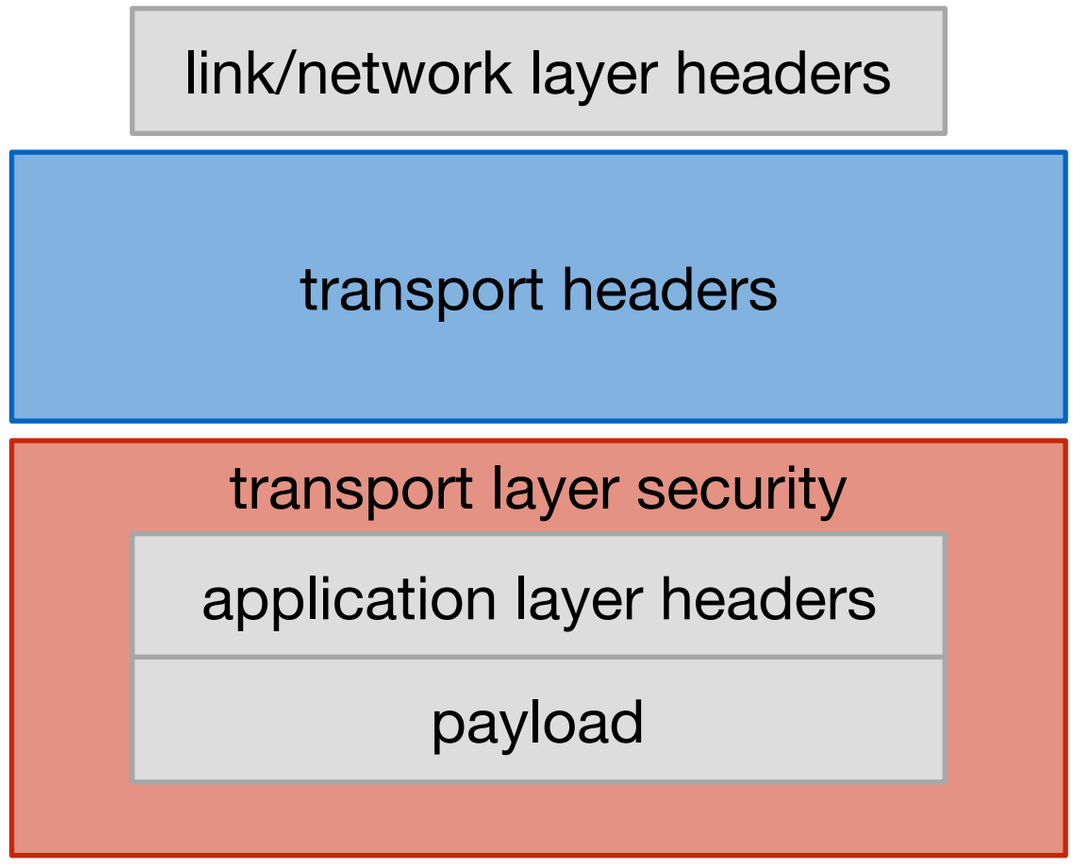


Transport protocol design, now with security!



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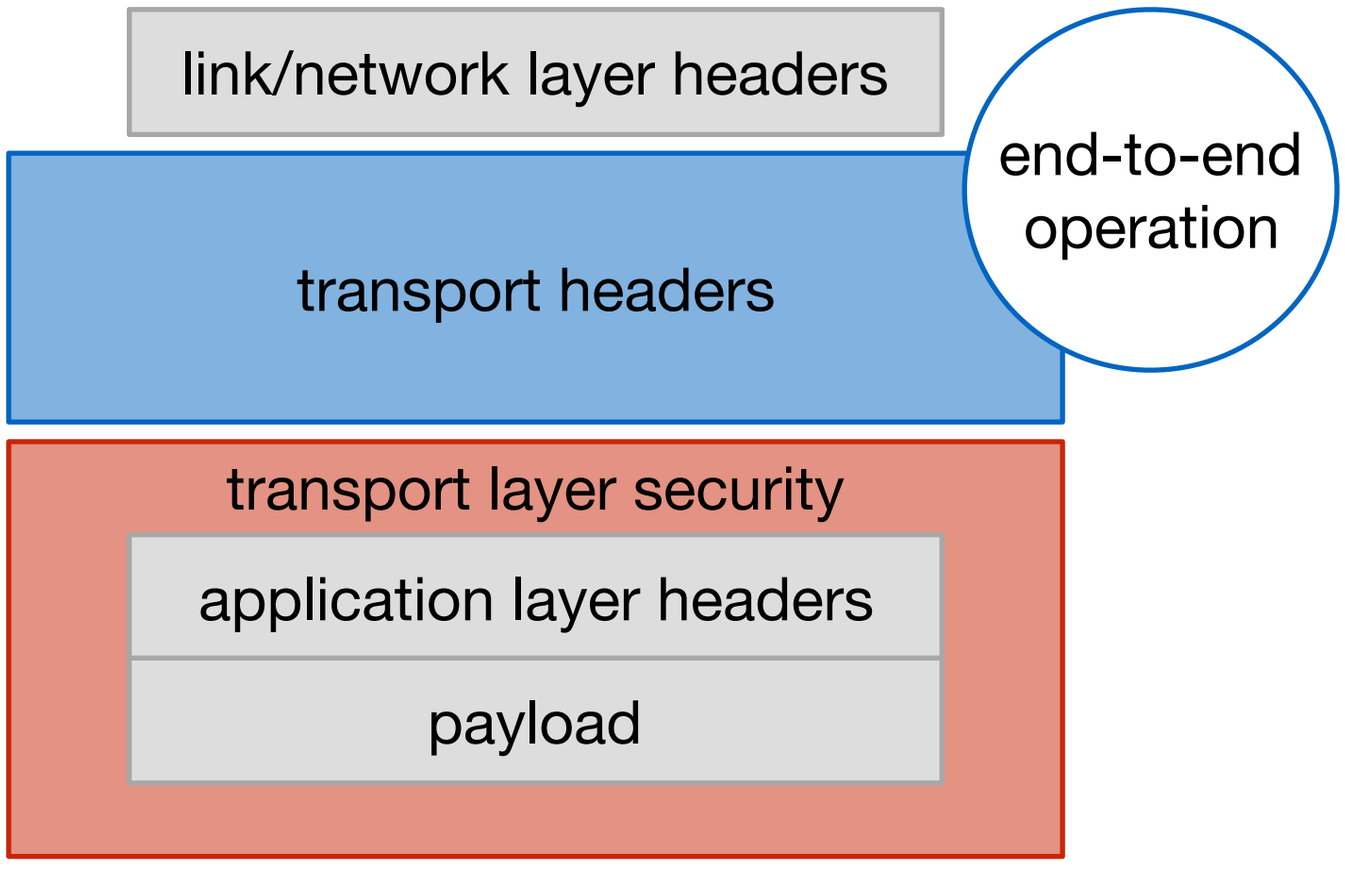

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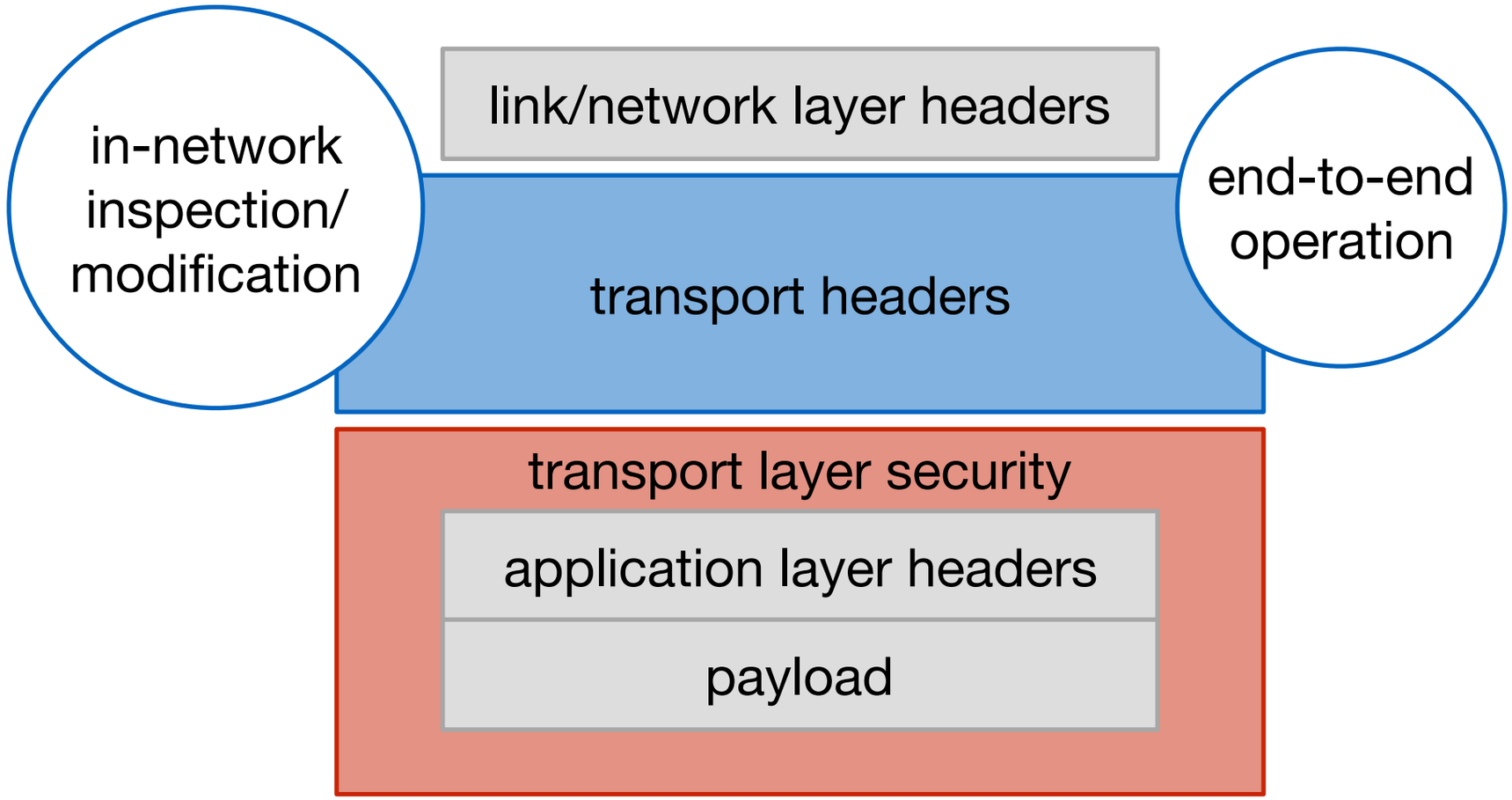

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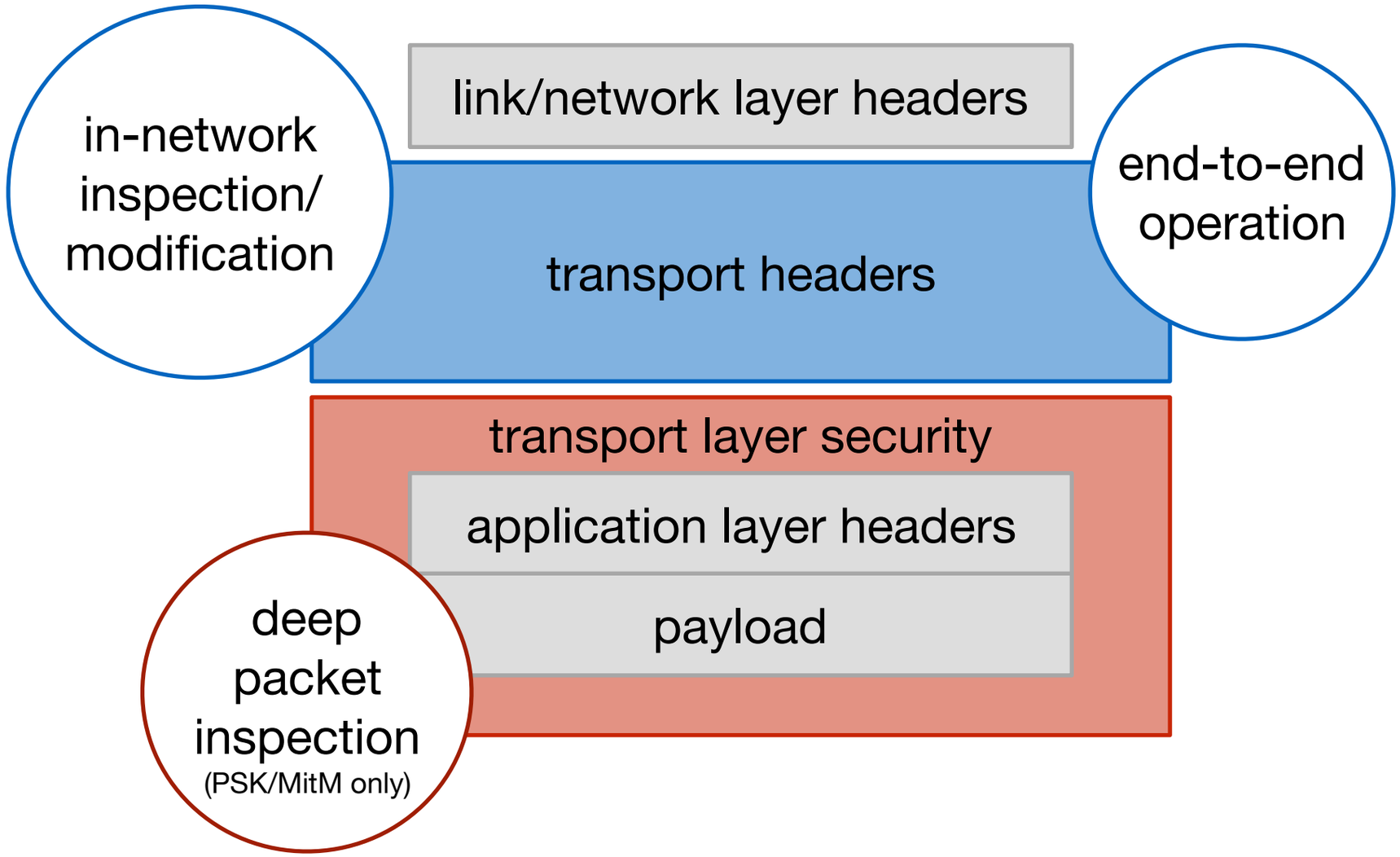
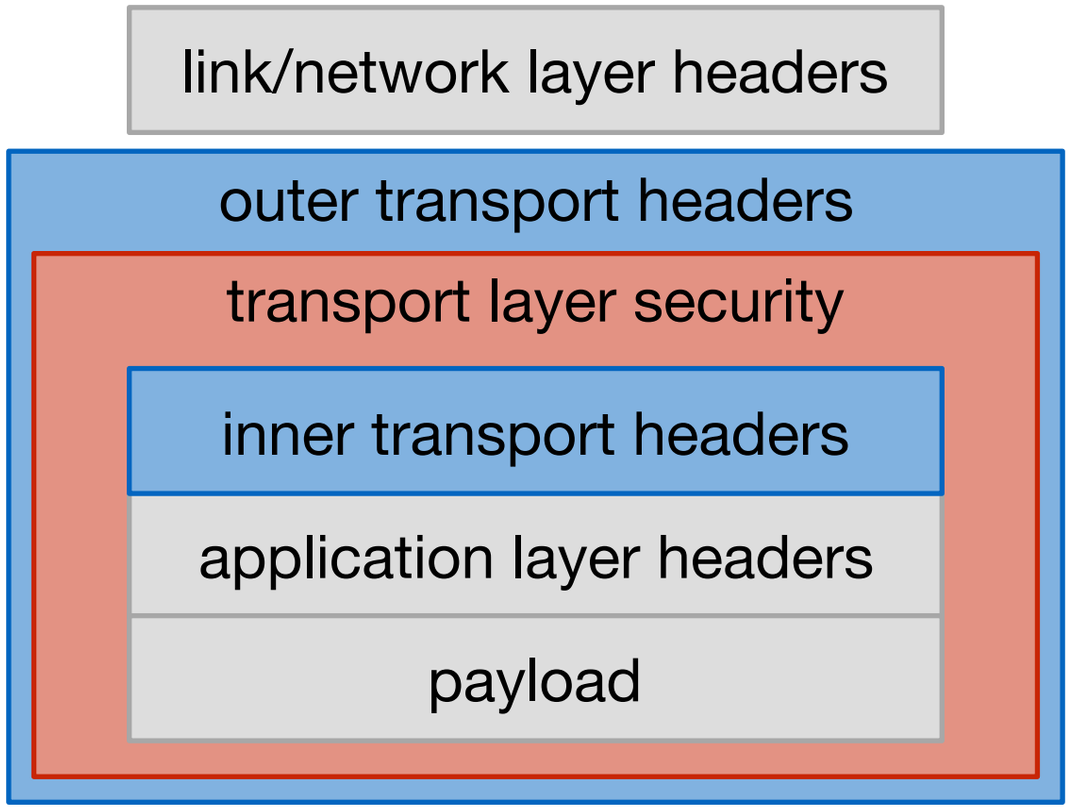


Encrypted transport protocol design



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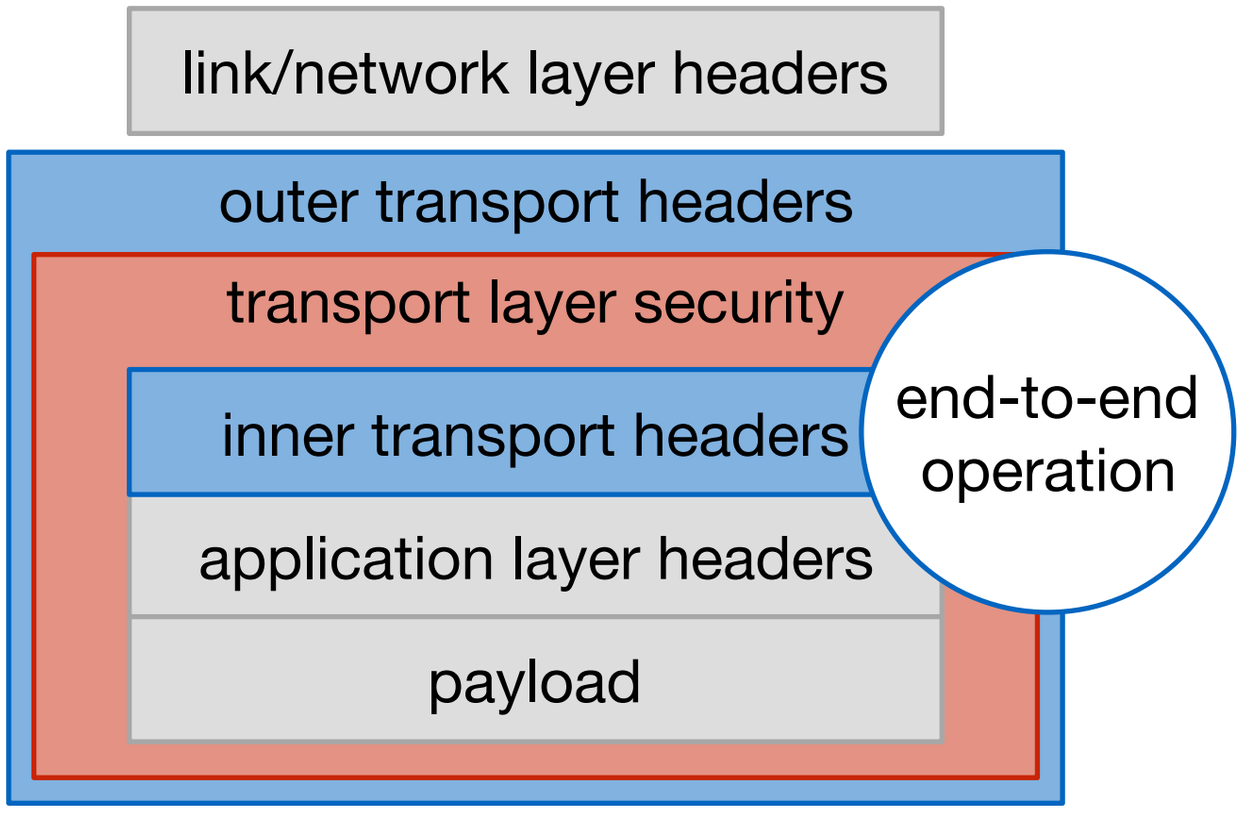

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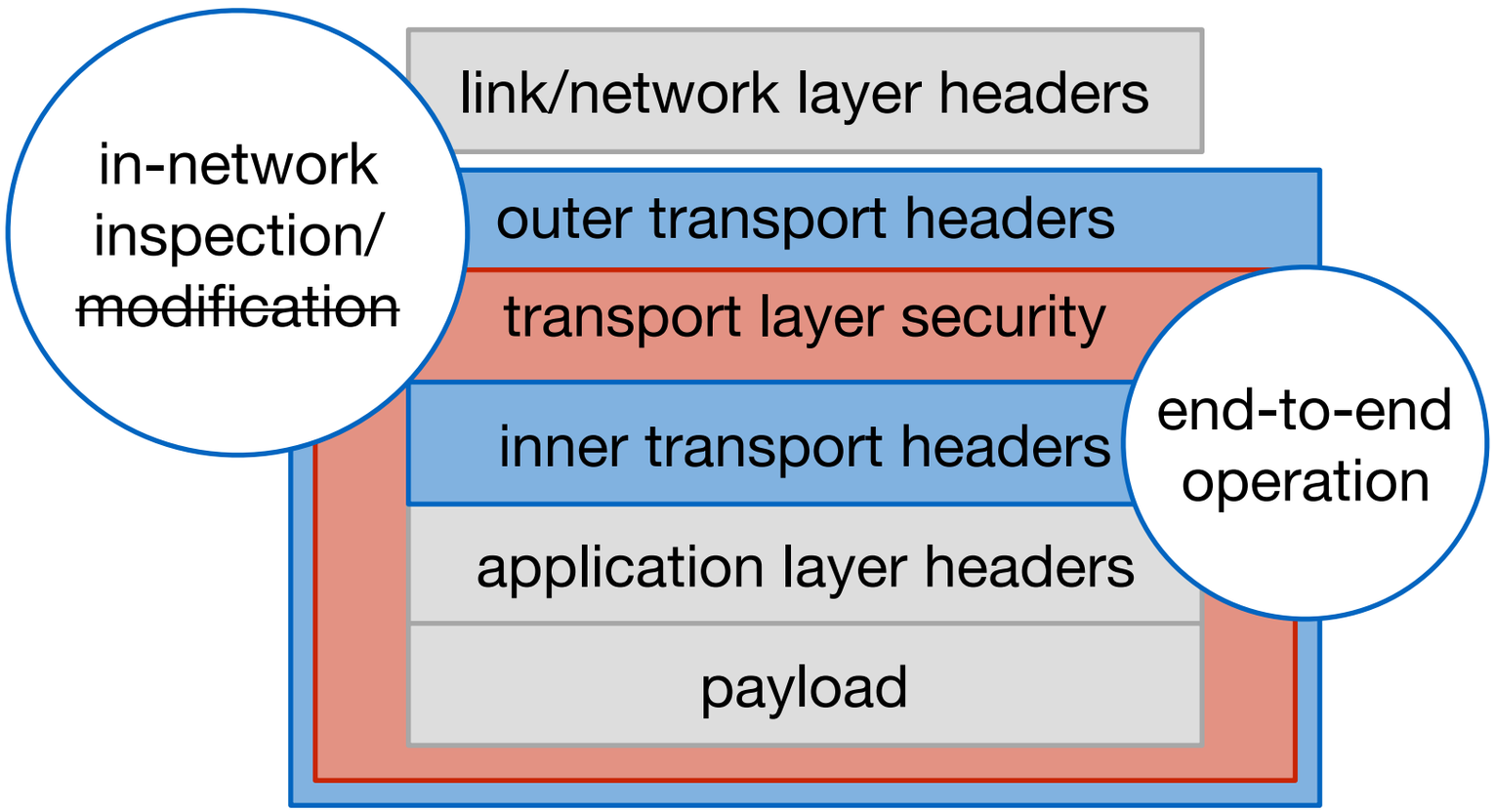

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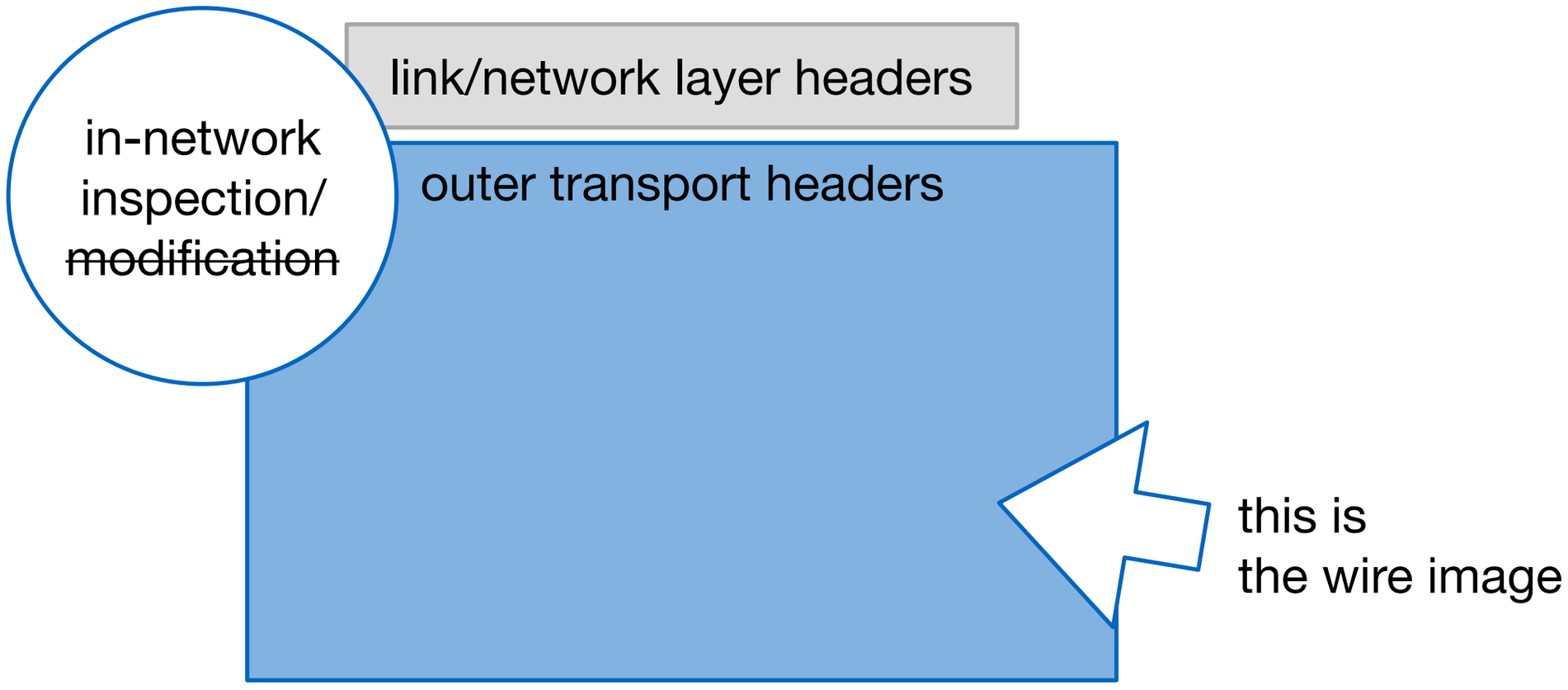

Three (and a half) levels of accessibility

- Unprotected (as TCP today): all bits can be seen at all points along the path, and can be modified without endpoint knowledge.
  - Supports manipulation of transport internals.
- Integrity-protected (e.g. QUIC outer header): all bits can be seen at all points along the path, but modification is endpoint detectable (and leads to packet rejection).
  - "Scratch space" (e.g. PLUS extended header): bits intended for modification on the path; content not protected, length/meaning integrity-protected.
- Encrypted (e.g. QUIC frame headers): no bits can be interpreted, modification leads to corruption and rejection.

The Wire Image, more formally (draft-trammell-wire-image)

- The sequence of messages sent by each participant in the protocol
  - each expressed as a sequence of bits,
  - with an associated time at which each was sent.
- Only unencrypted bits have assignable semantics
  - encrypted size → upper bound on information content

- Separating transport machinery from the understandable parts of the wire image is new, presents both problems and opportunities.

Signaling in the wire image (draft-hardie-path-signals)

- Encrypting transport mechanics limits the availability of *implicit signaling* in transport headers to in-network functions.
- We have four options to deal with this:
  - Do nothing.
  - Replace transport information with network-layer signaling.
  - Add *explicit signals* on a per-transport basis
  - Add *explicit signals* on a common wire image shared by multiple transports

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> Transport-layer headers were never meant to be used by the network. It's the network's fault for abusing them, and solely the problem of in-network function developers and users to solve.

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Talking to the network is a network-layer function. Therefore any explicit signaling should happen in the network layer.

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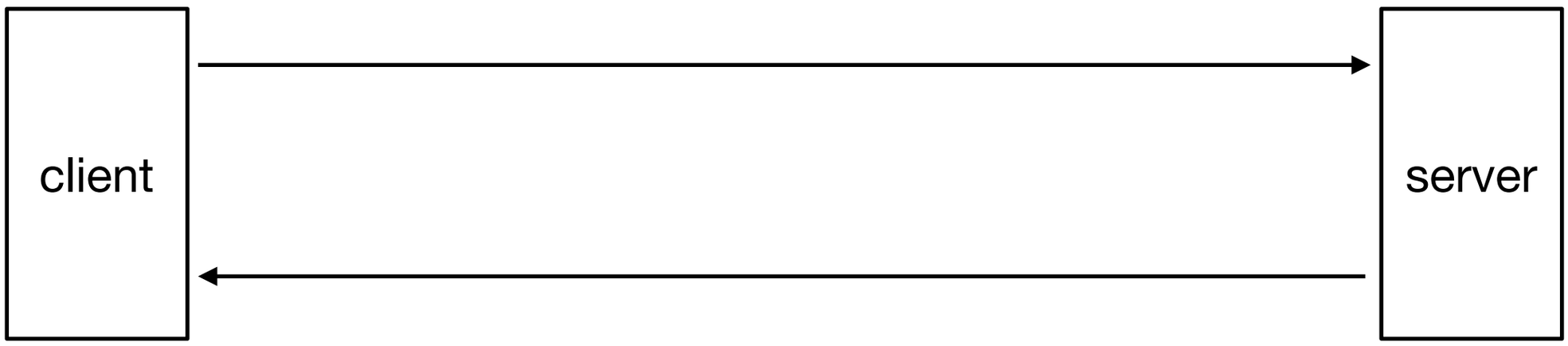
An example explicit signal: draft-trammell-quic-spin

- Proposed bit in QUIC short header, visible/integrity-protected.
- Algorithm ensures bit changes 0→1 or 1→0 once per RTT.
- Allows on-path determination of RTT on a per-flow basis.
- Replaces TCP seq/ack and tsval/tescr for this purpose.



- Discussion in QUIC WG, 09:30-12:00 Thursday

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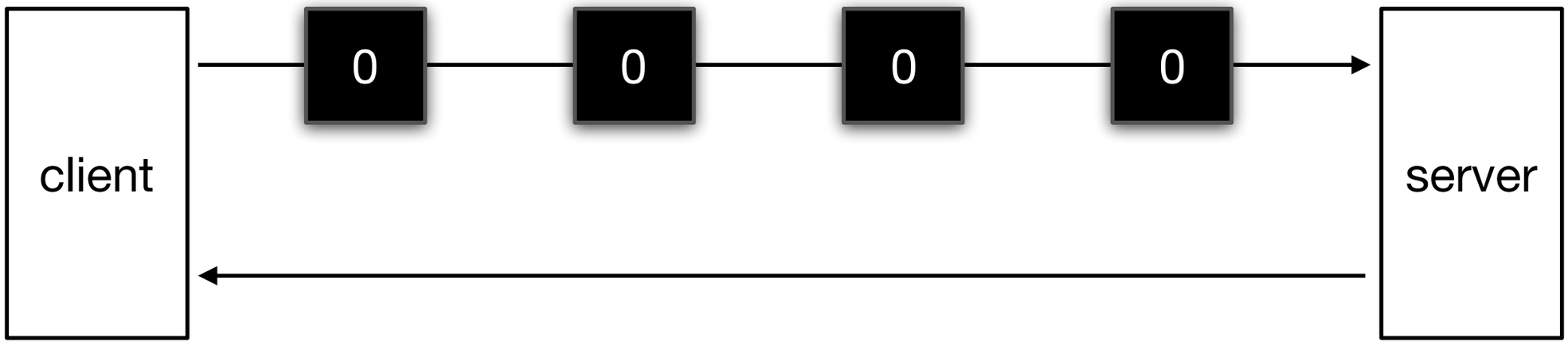

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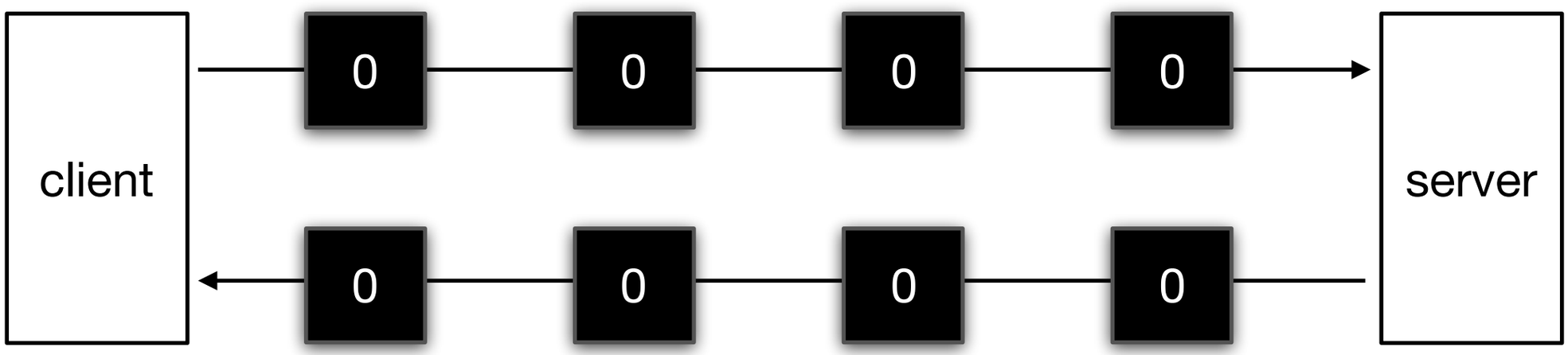

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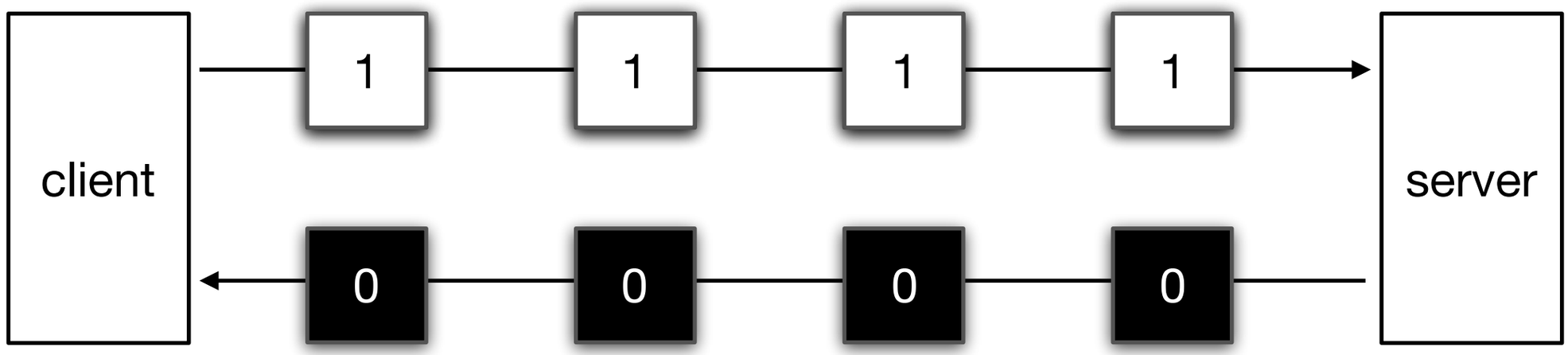

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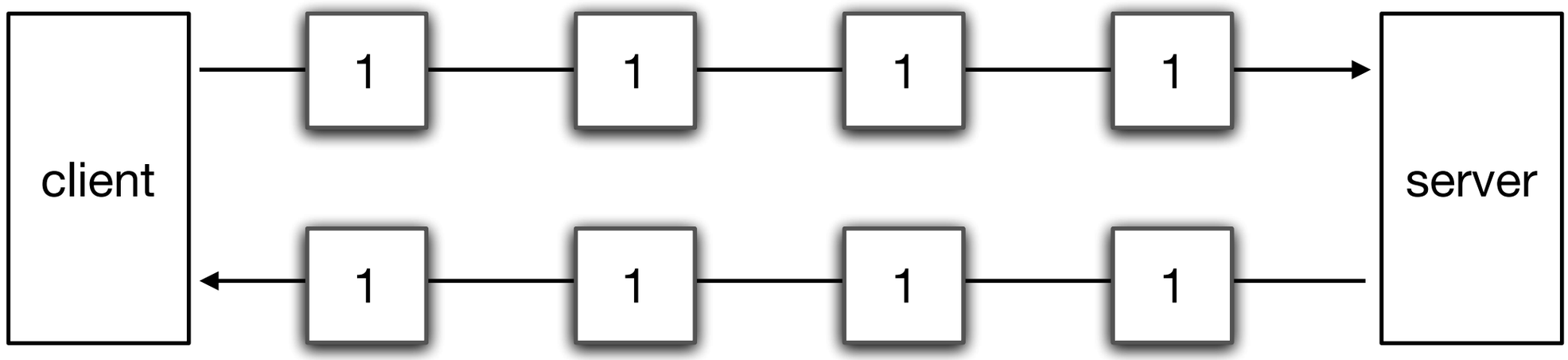

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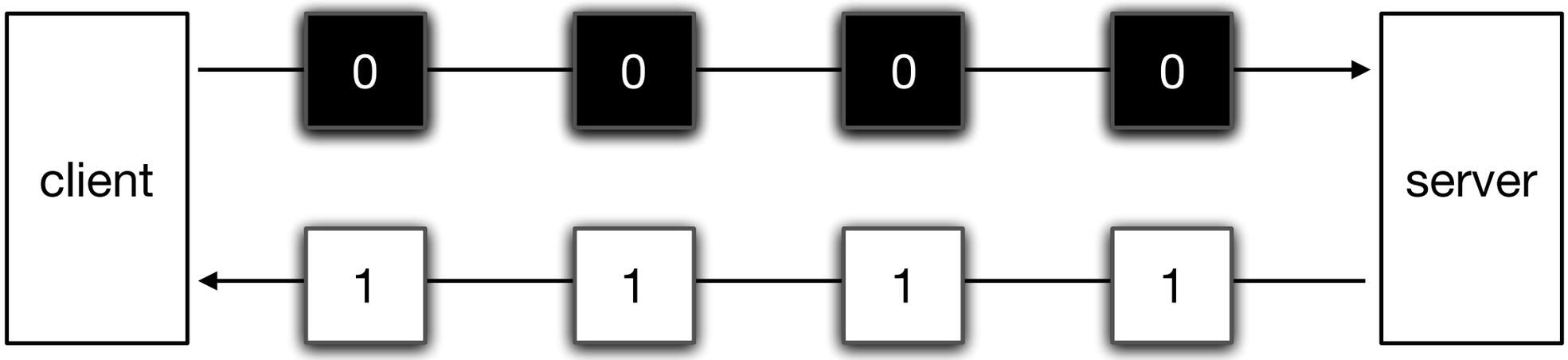

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The Way Forward

- Header encryption is necessary for transport layer evolution.
  - Every visible bit of information in a protocol's wire image will eventually be used → we now know "everyone can see everything" is the wrong approach.
- Finding a balance between security, privacy, evolvability, and maintenance of current in-network functions is crucial.
  - Explicit signaling to the path must be done on a per-protocol, per-function basis.
  - Signal design must consider *who* needs to see *what* and *why*, and provide the *minimum necessary information* to drive the function.