Breaking Up the Transport Logjam

Bryan Ford

Max Planck Institute for Software Systems

baford@mpi-sws.org

Janardhan Iyengar

Franklin & Marshall College

jiyengar@fandm.edu

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Evolutionary Pressures on Transports

- **Applications** need more flexible abstractions
  - better datagrams [DCCP], streams [SCTP, Ford07]
- **Networks** need new congestion control schemes
  - high-speed [Floyd03], wireless links [Lochert07], ...
- **Users** need better use of available bandwidth
  - dispersion [Gustafsson97], multihoming [SCTP], logistics [Swany05], concurrent multipath [Iyengar06]…
- **Operators** need administrative control
  - Performance Enhancing Proxies [RFC3135], NATs and Firewalls [RFC3022], traffic shapers
- We have partial solutions, **but no deployment**

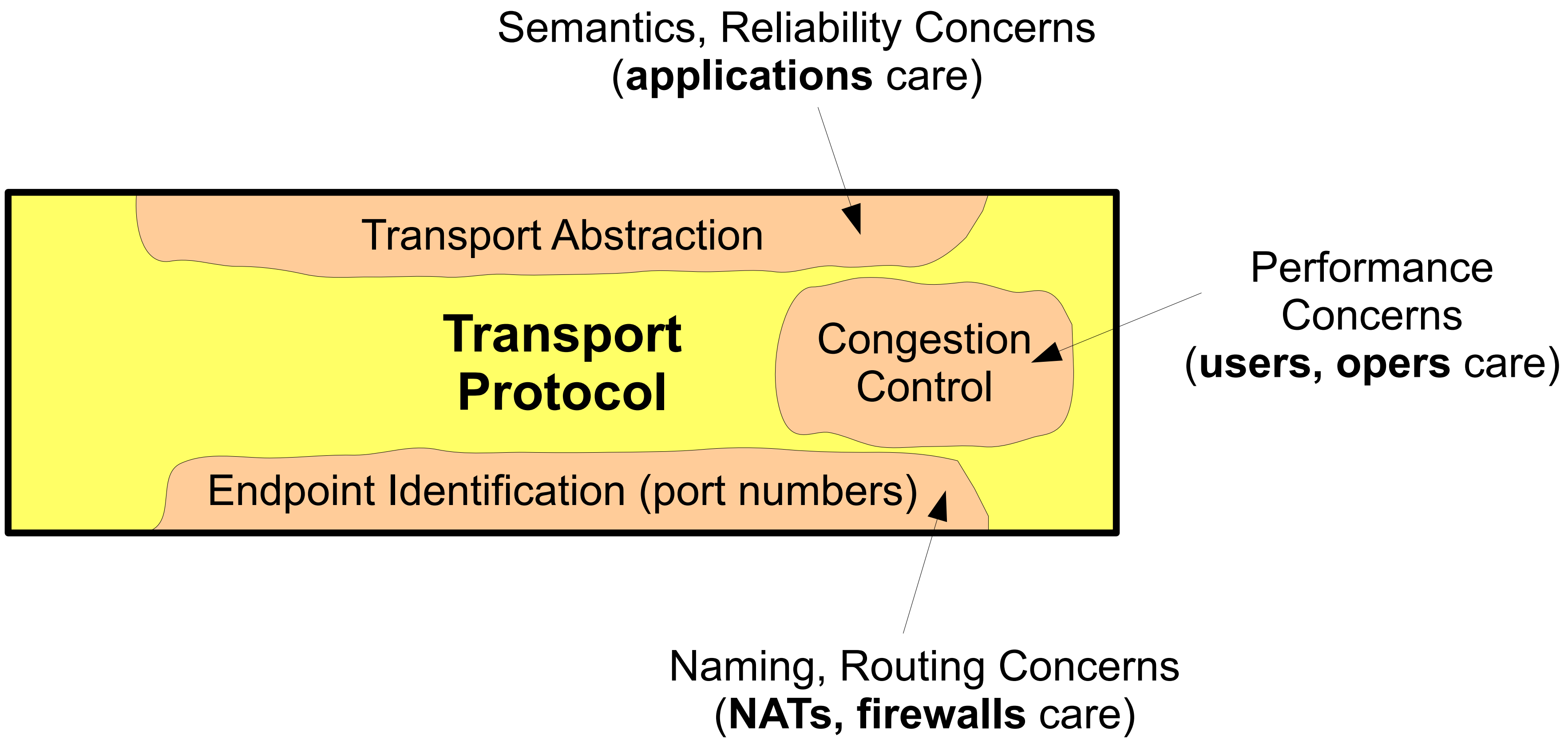
Many solutions, None deployable

- New transports **undeployable**
  - NATs & firewalls
  - which comes first: App-demand or OS kernel support?
- New congestion control schemes **undeployable**
  - impassable "TCP-friendliness" barrier
  - must work end-to-end, on *all* network types in path
- Multipath/multiflow enhancements **undeployable**
  - "You want *how many* flows? Not on *my* network!"
  - TCP-unfriendly?

The Transport Layer is Stuck in an Evolutionary Logjam!

The Problem

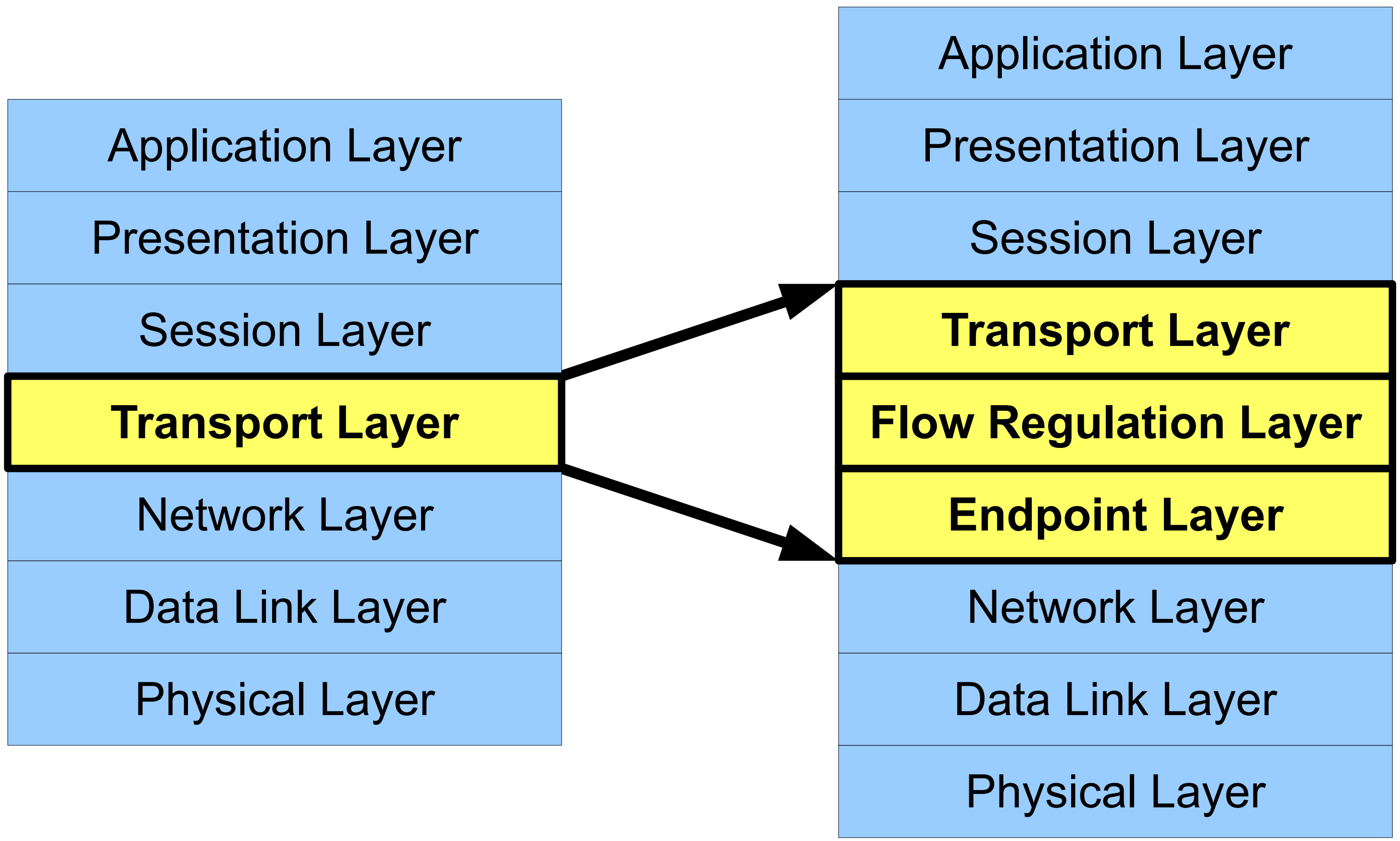
Traditional transports conflate **3 function areas**...



To break transport logjam, must **separate concerns**

Our Proposal

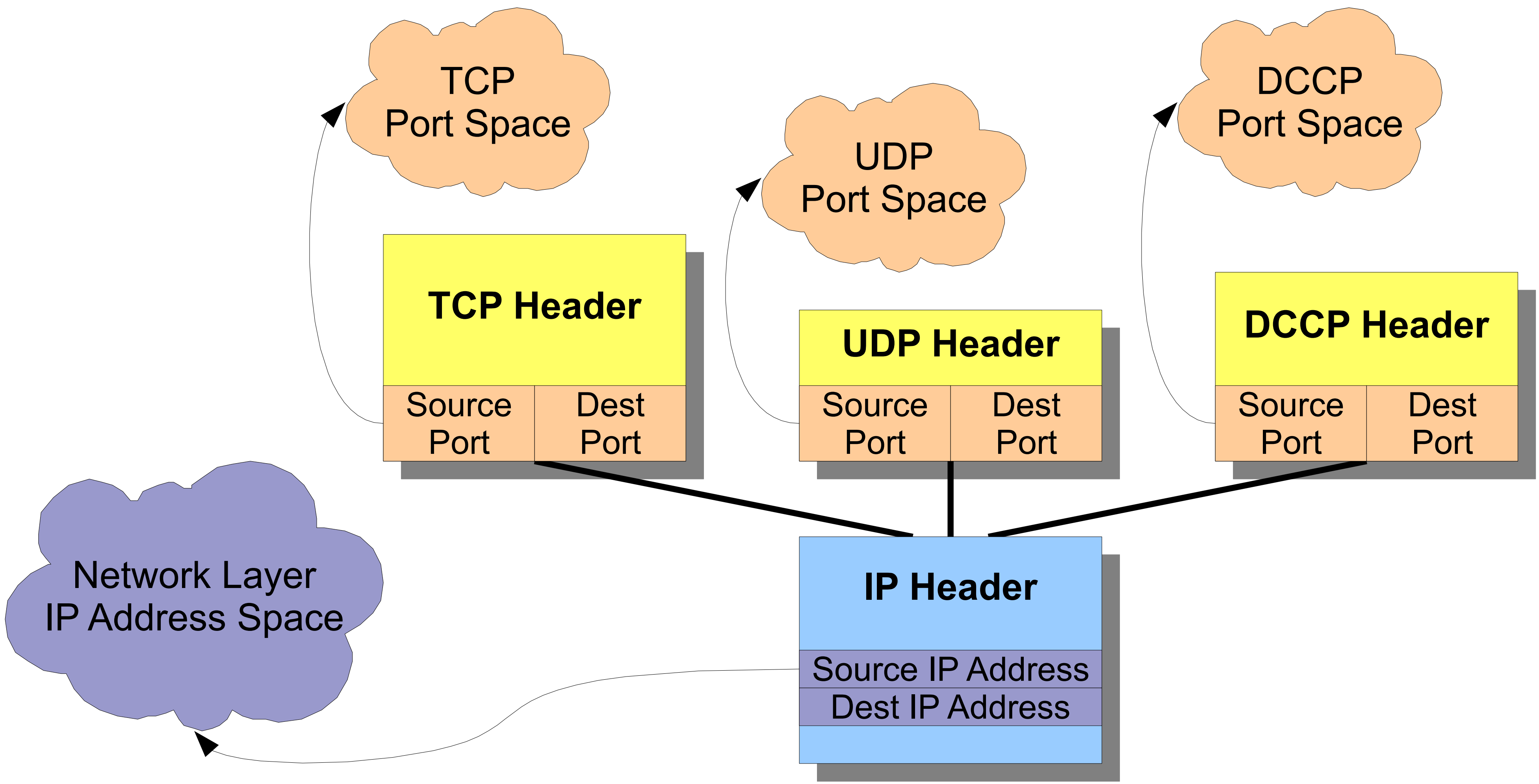
Break up the Transport according to these functions:



Endpoint Layer

Endpoint Identification via Ports

Current transports have **separate** port spaces



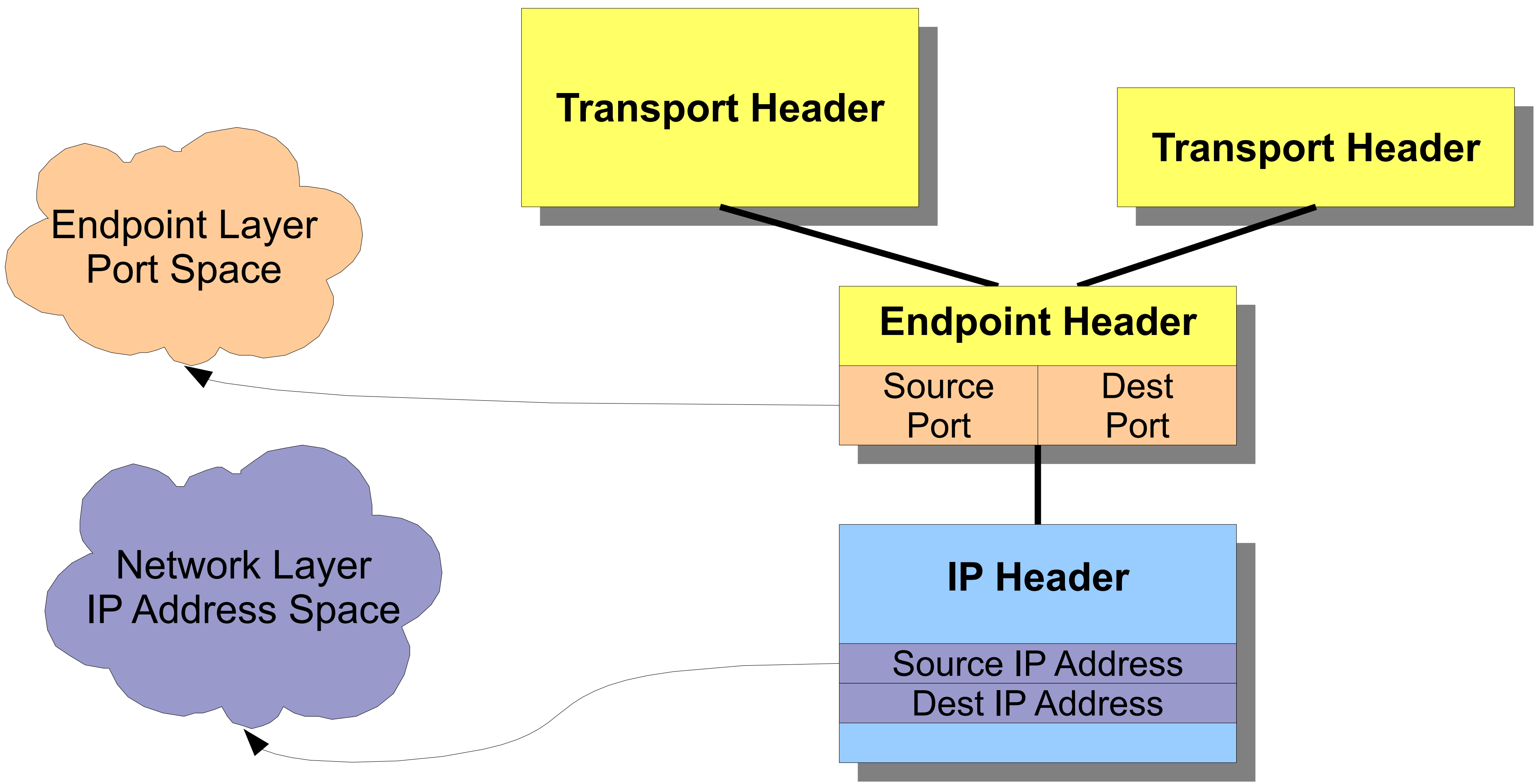
But What Are Ports?

- Ports are really **routing info**!
  - IP address ⇒ Inter-Host Routing
  - port numbers ⇒ *Intra*-Host Routing
- … *should* have been part of **Network Layer?**

- NATs/Firewalls treat ports as **routing info!**
  - Care about *application* endpoints, not just hosts
  - Therefore, must understand transport headers
- **Result**: Only TCP, UDP can get through

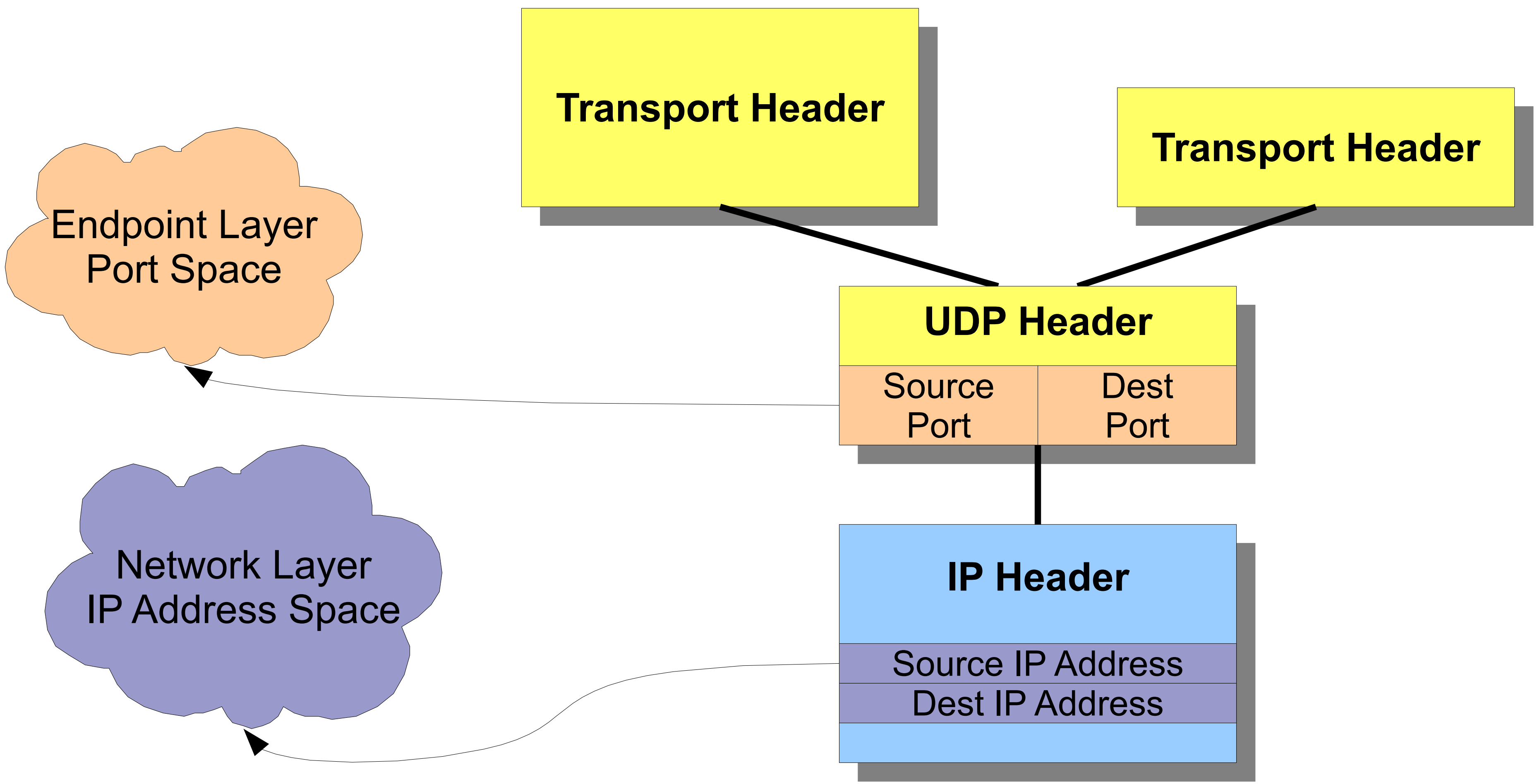
Proposed Solution

Factor endpoint info into uniform **Endpoint Layer**



Surprise!

Workable starting point exists — **UDP**!



Practical Benefits

Can now **evolve separately:**

- **Transport functions:**
  - New transports get through NATs, firewalls
  - Easily deploy new user-space transports, interoperable with kernel transports
  - Application controls negotiation among transports
- **Endpoint functions:**
  - Better cooperation with NATs [UPnP, NAT-PMP, ...]
  - identity/locator split, port/service names [Touch06], security and authentication info ...?

Flow Layer

Traditional "Flow Regulation"

Transport includes end-to-end **congestion control**

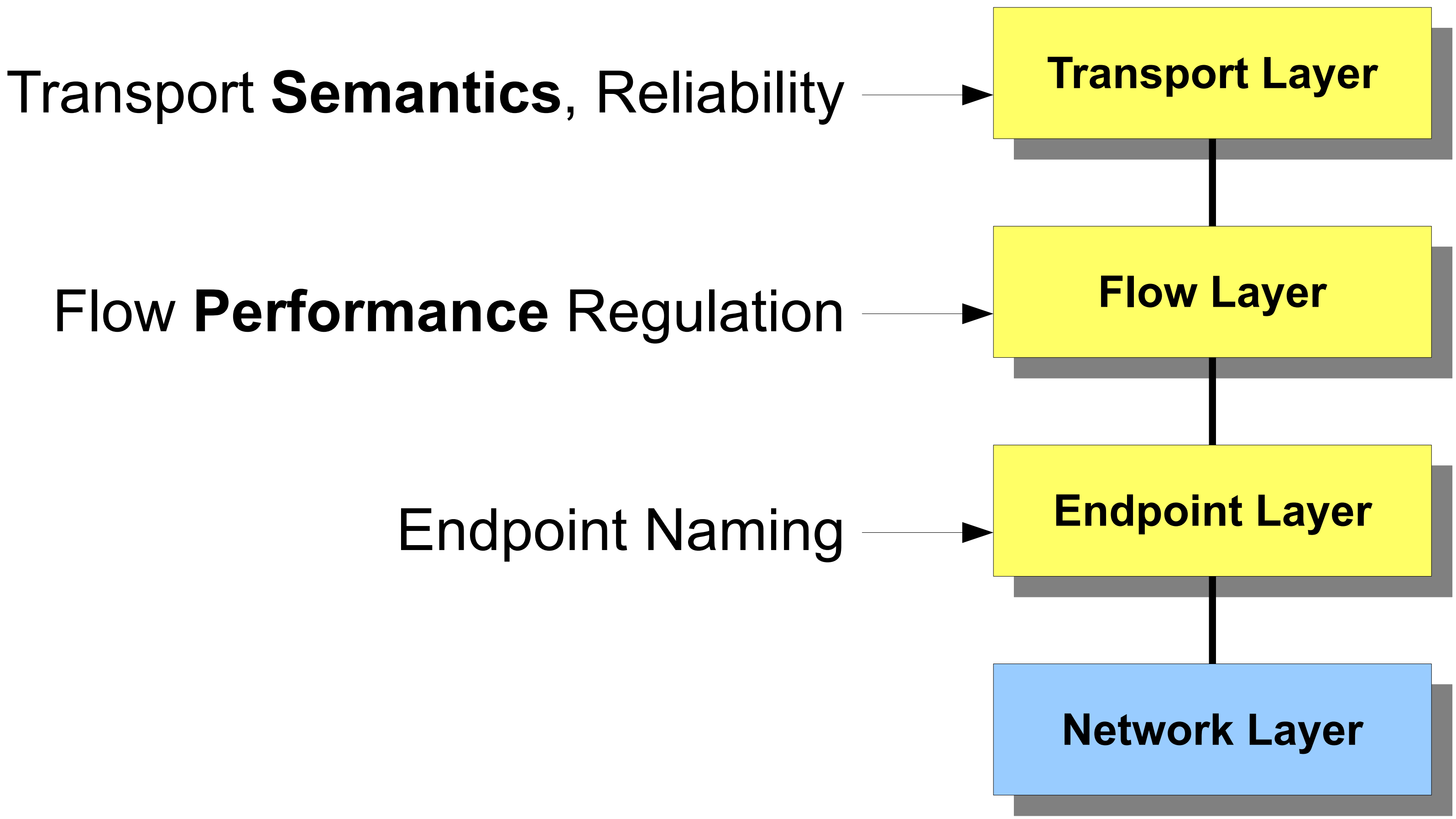
- to regulate flow transmission rate

But one E2E path may cross **many**...

- … different **network technologies**
  - Wired LAN, WAN, WiFi, Cellular, AdHoc, Satellite, …
  - Each needs different, specialized CC algorithms!
- … different **administrative domains**
  - Each cares about CC algorithm in use!

Proposed Solution

Factor flow regulation into underlying **Flow Layer**

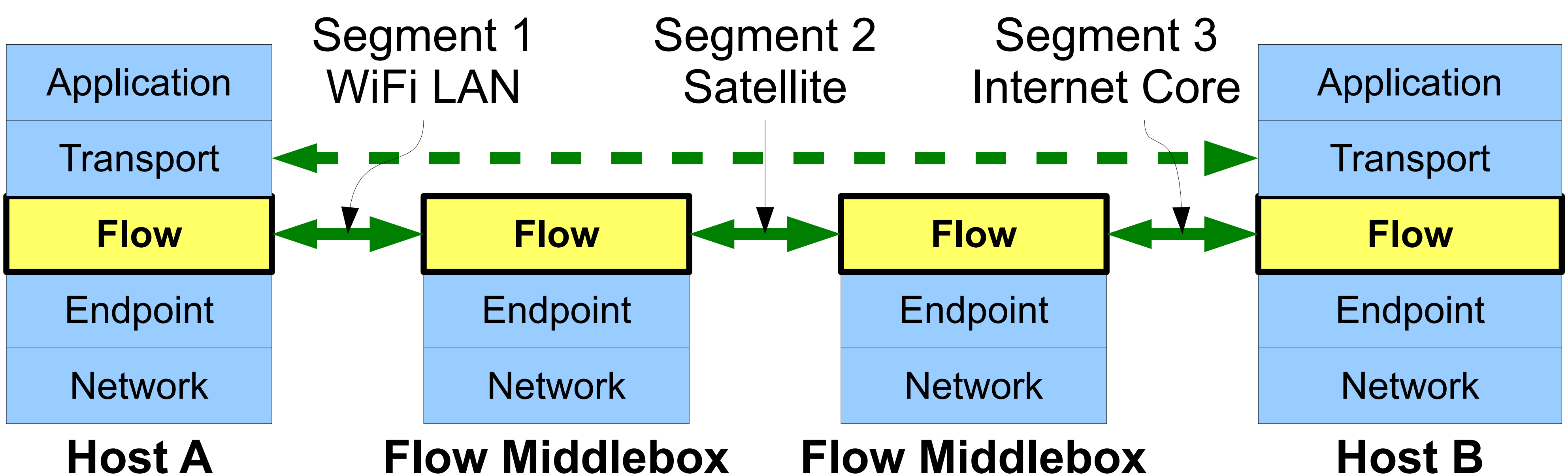


Practical Benefits (1/3)

Can split E2E flow into separate CC *segments*

- Specialize CC algorithm to **network technology**
- Specialize CC algorithm within **admin domain**

… without interfering with E2E transport *semantics*!

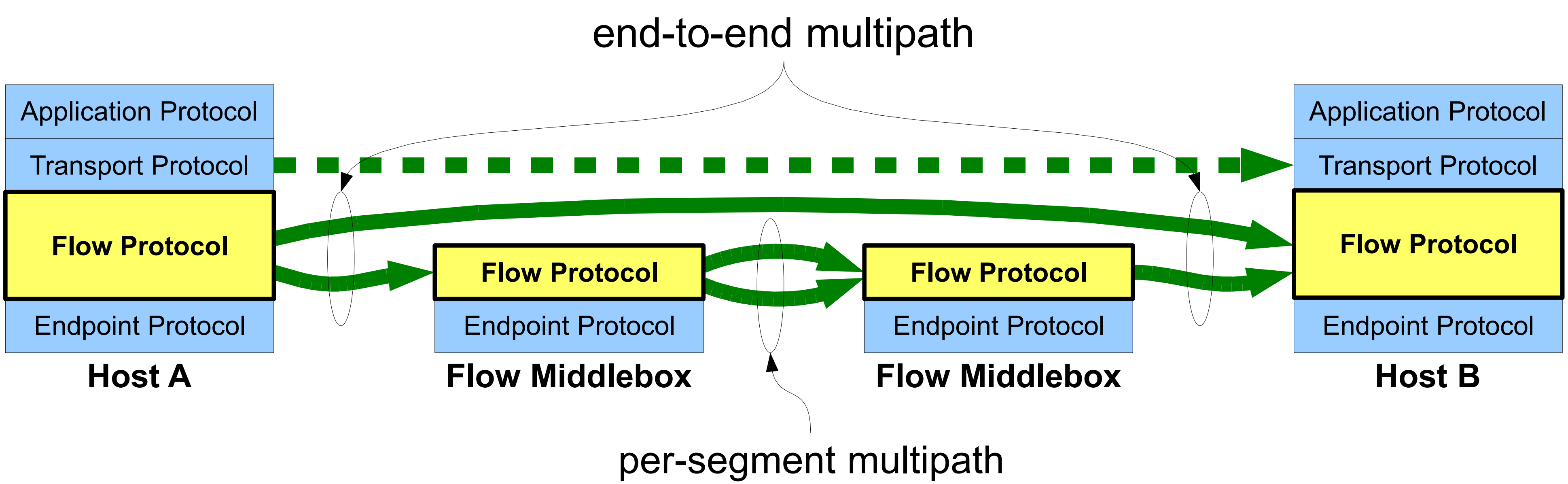


Practical Benefits (2/3)

Incrementally deploy performance enhancements

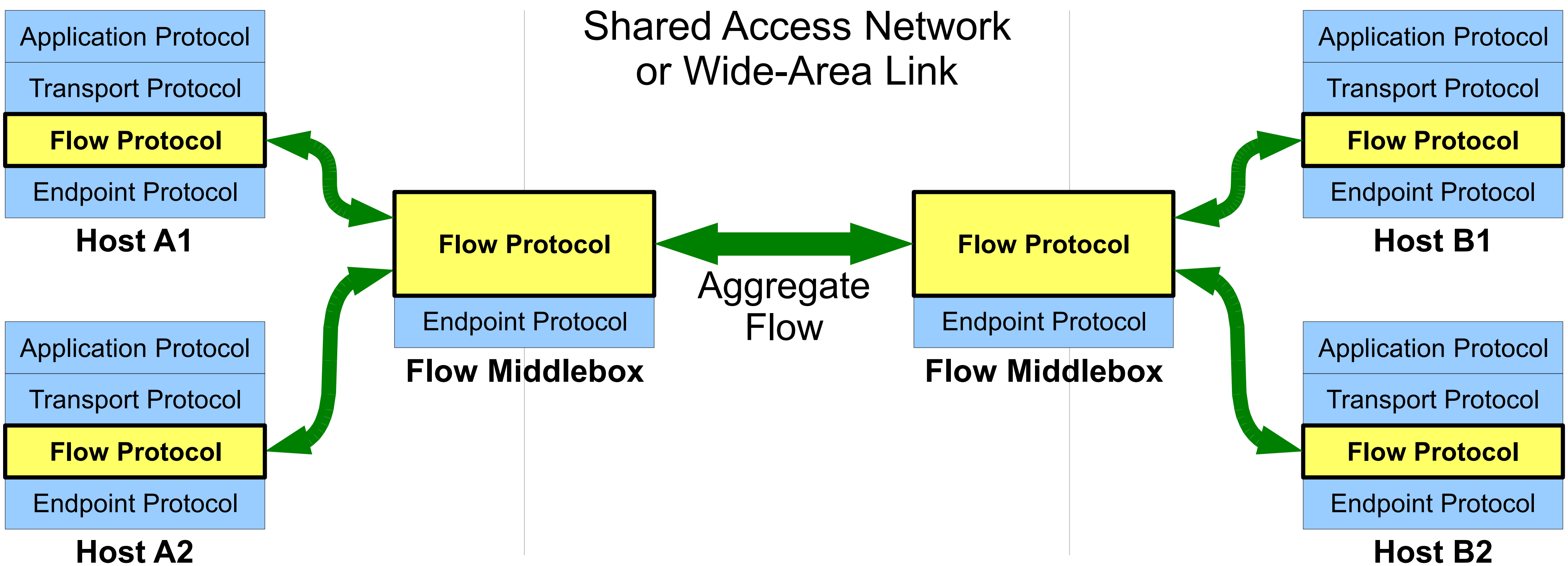
- multihoming, multipath, dispersion, aggregation...

… without affecting E2E transport semantics!



Practical Benefits (3/3)

- Can aggregate flows cleanly within domains for
  - Efficient traffic measurement, management
  - Fairness at "macro-flow" granularity



Developing the Flow Layer

- Two likely "starting points" already exist:
  - Congestion Manager [Balakrishnan99]
  - DCCP [Kohler06]
    (just stop thinking of it as a "transport")

- Major work areas:
  - Support for flow middleboxes, path segmenting
  - Interfaces between (new) higher & lower layers

Transport Layer

Transport Layer

Contains "what's left":

- Semantic abstractions that apps care about
  - Datagrams, streams, multi-streams, …
- Reliability mechanisms
  - "Hard" acknowledgment, retransmission
- App-driven buffer/performance control
  - Receiver-directed flow control
  - Stream prioritization
  - ...

Breaking Up the Transport Logjam

- New transports ~~un~~**deployable**
  - Can traverse NATs & firewalls
  - Can deploy in kernels or applications
- New congestion control schemes ~~un~~**deployable**
  - Can specialize to different network types
  - Can deploy/manage within administrative domains
- Multipath/multiflow enhancements ~~un~~**deployable**
  - Can deploy/manage within administrative domains

Only the Beginning...

Promising architecture (we think), but
lots of details to work out

- Functionality within each layer
- Interfaces between each layer
- Application-visible API changes

Big, open-ended design space

- We are starting to explore, but
  would love to collaborate with others!
- If you know of spaces where you could use this
  framework, we'd love to know!

Conclusion

- Transport evolution is **stuck**

- To unstick, need to separate:
  - Endpoint naming/routing into separate **Endpoint Layer**
  - Flow regulation into separate **Flow Layer**
- Leave semantic abstractions in **Transport Layer**

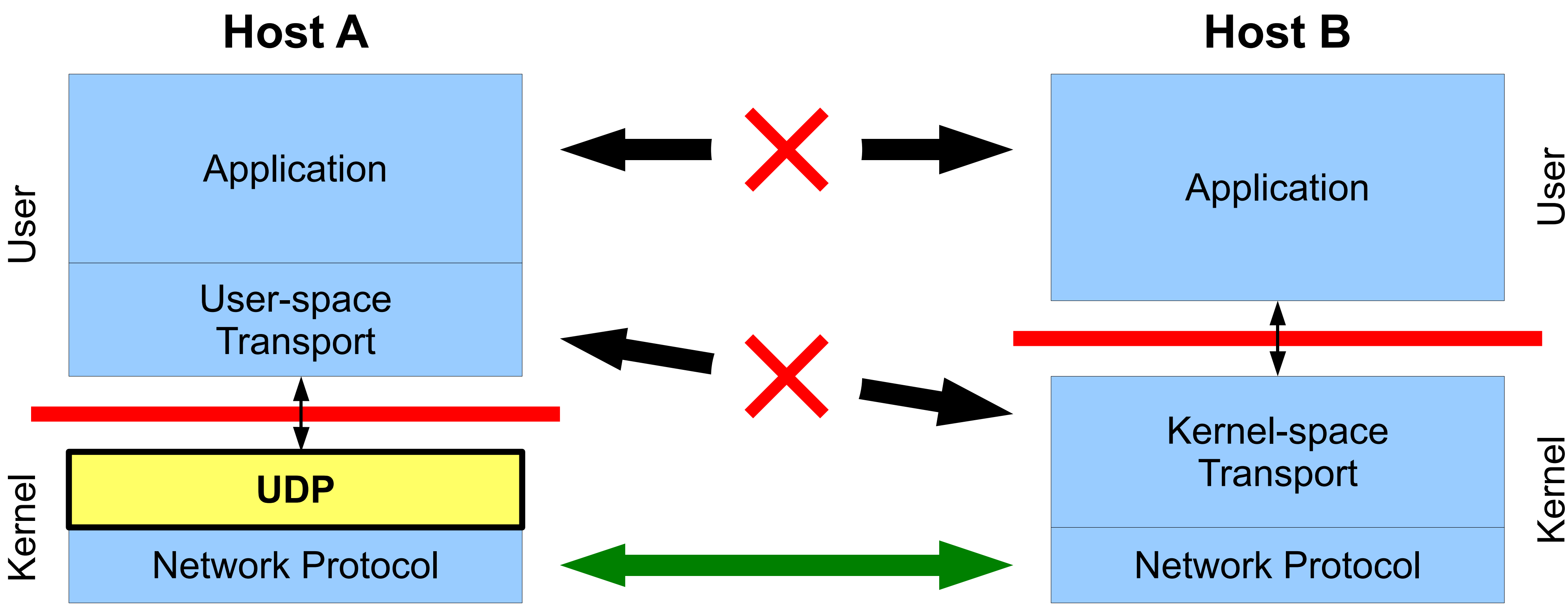
Complexity

- More layers
  => **increase**
- Puts necessary hacks into framework
  => **decrease**
- What's the balance?

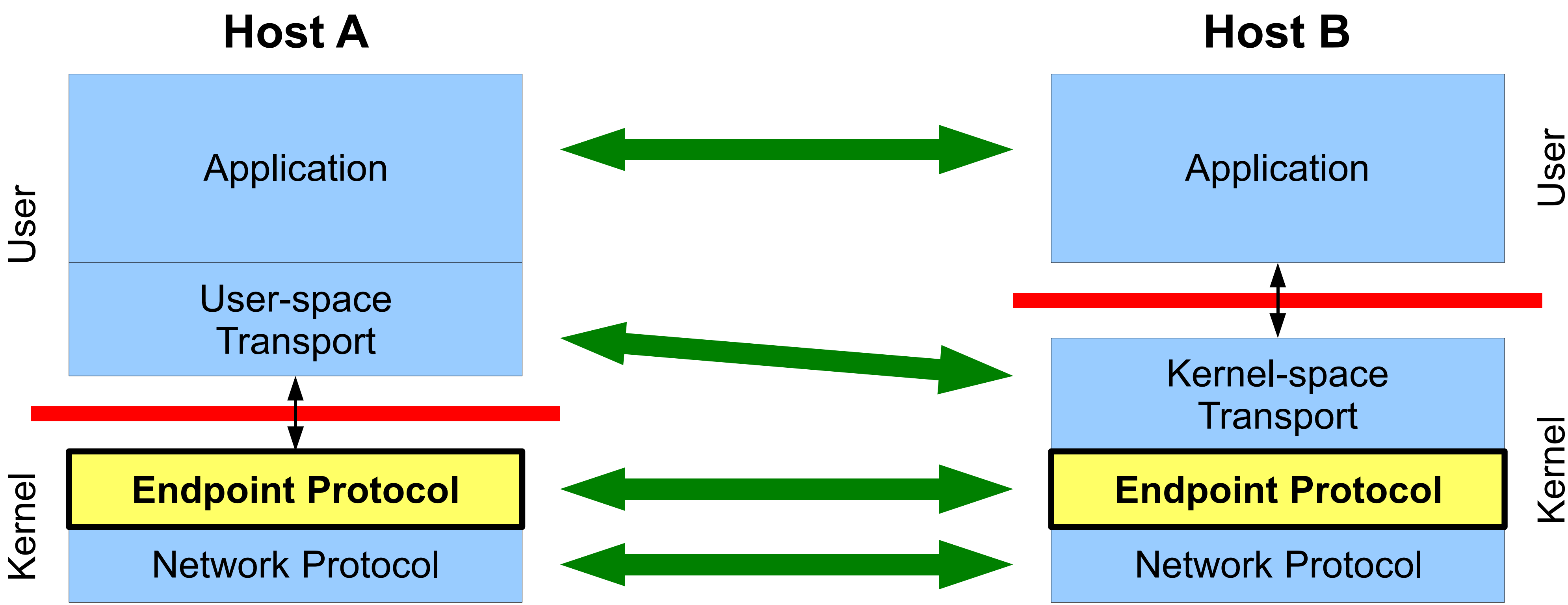
What about the e2e principle?

- Flow layer implements in-network mechanisms that focus on communication performance
  - Precisely the role for which the e2e principle justifies in-network mechanisms
- All state in the flow middleboxes is performance-related soft state
- Transport layer retains state related to reliability
  - End-to-end fate-sharing is thus preserved
- Transport layer is still the first end-to-end layer

Kernel/User Transport Interoperation



Kernel/User Transport Interoperation



“Zero-RTT” Transport Negotiation