Internet Architecture Beyond IP

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Background

- After its initial deployment in the 1970's and 1980's, Internet architecture has remained fundamentally unchanged, despite phenomenal growth of traffic and applications
- Numerous new technologies and protocols have been added; nevertheless, these can be regarded as patches to the basic infrastructure determined by the Internet Protocol suite
- Even IPV6 is in this regard an incremental overhaul of an unchanged architecture

Pressures for Change

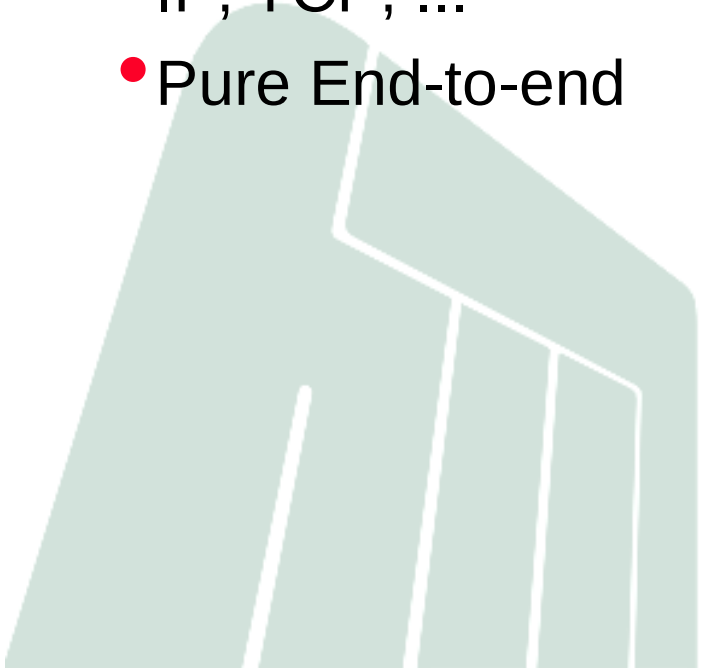
- At present, most experts agree that eventually a more radical overhaul of the Internet architecture will be needed
- This should address fundamental changes in how Internet is being used:
  - Most Internet terminals will be mobile
  - Internet usage is essentially data-oriented: users search and access data objects, and are not necessarily concerned where they are located
- The pressing issues of security, trust, and privacy on the Internet should be handled in an integrated fashion that takes the underlying microeconomics into account

What We Should Keep

- Openness; network neutrality
  - Innovation speed
- Universal naming
- Survivability / robustness
- Multiplexing variable sized packets
  - Openness to new, unanticipated applications
- Scalability
  - No per-flow state

What We Must Get Rid Of

- Easily accessible location names
- Recipient-oriented rendezvous
- Single-packet connectivity / zero-set up packet transmission
- IP, TCP, ...
- Pure End-to-end



Things We Are Not Sure Of

- Layers
- Global addressing
- Full transparency (WYSIWIG)
- TCP friendliness (flow fairness)
- DNS names

Things We Speculate About

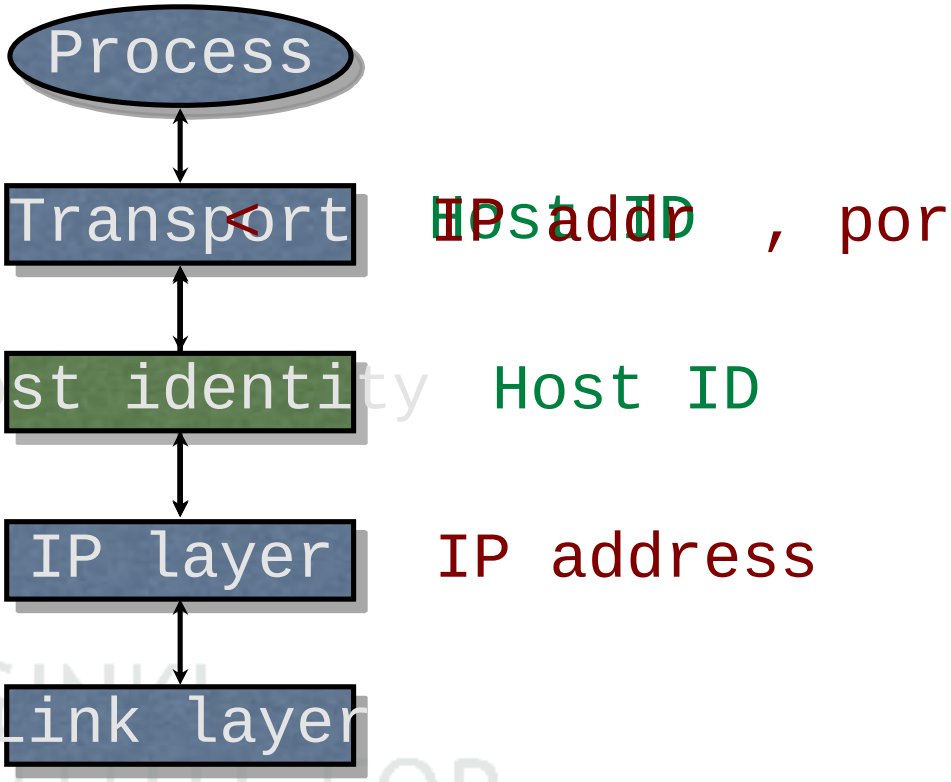
- Privacy vs. accountability: new balance
- Market layers
- Explicit and ubiquitous trust and reputation
- Compensation mechanisms and incentives
- Naming and addressing: just what should be named?

Baseline: Identifier-Locator Split

- The original Internet architecture does not address terminal mobility at all: IP numbers designate a fixed topological location on the net
- Mobile IP (V4/V6) patches the architecture to support mobile hosts; however, the protocol is complex and prone to security problems
- The fundamental solution is the so-called identifier-locator split: introduce a new naming layer in the Internet that separates the dual function of IP numbers
  - routing: the present topological location of a host (interface)
  - identity: the unchanging identity of a host (interface)

Host Identity Protocol

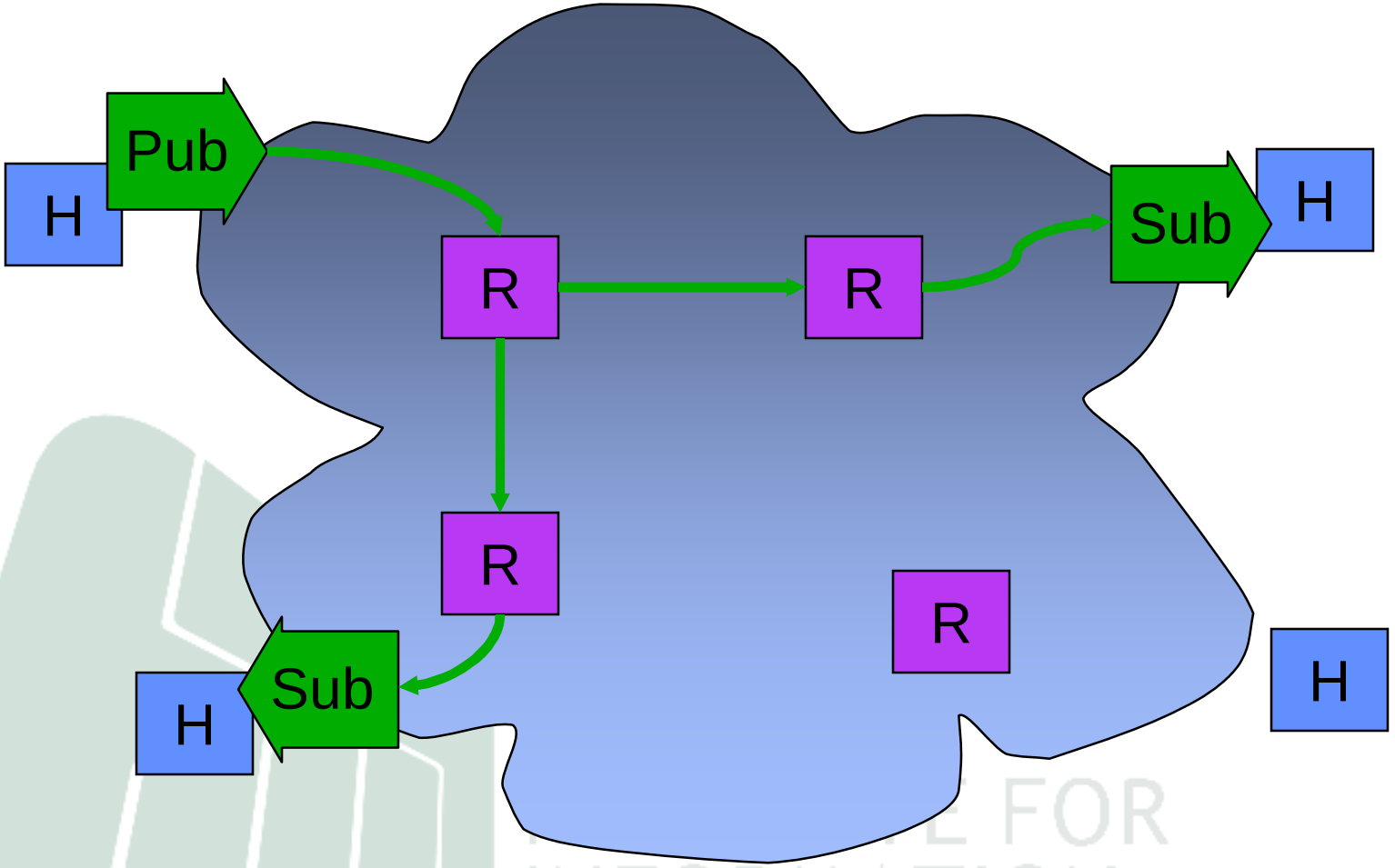
- A new Name Space of Host Identifiers (HI)
  - Public cryptographic keys
  - Presented as 128-bit long hash values, Host ID Tags (HIT)
- Sockets bound to HIs, not to IP addresses
- HIs translated to IP addresses in the kernel



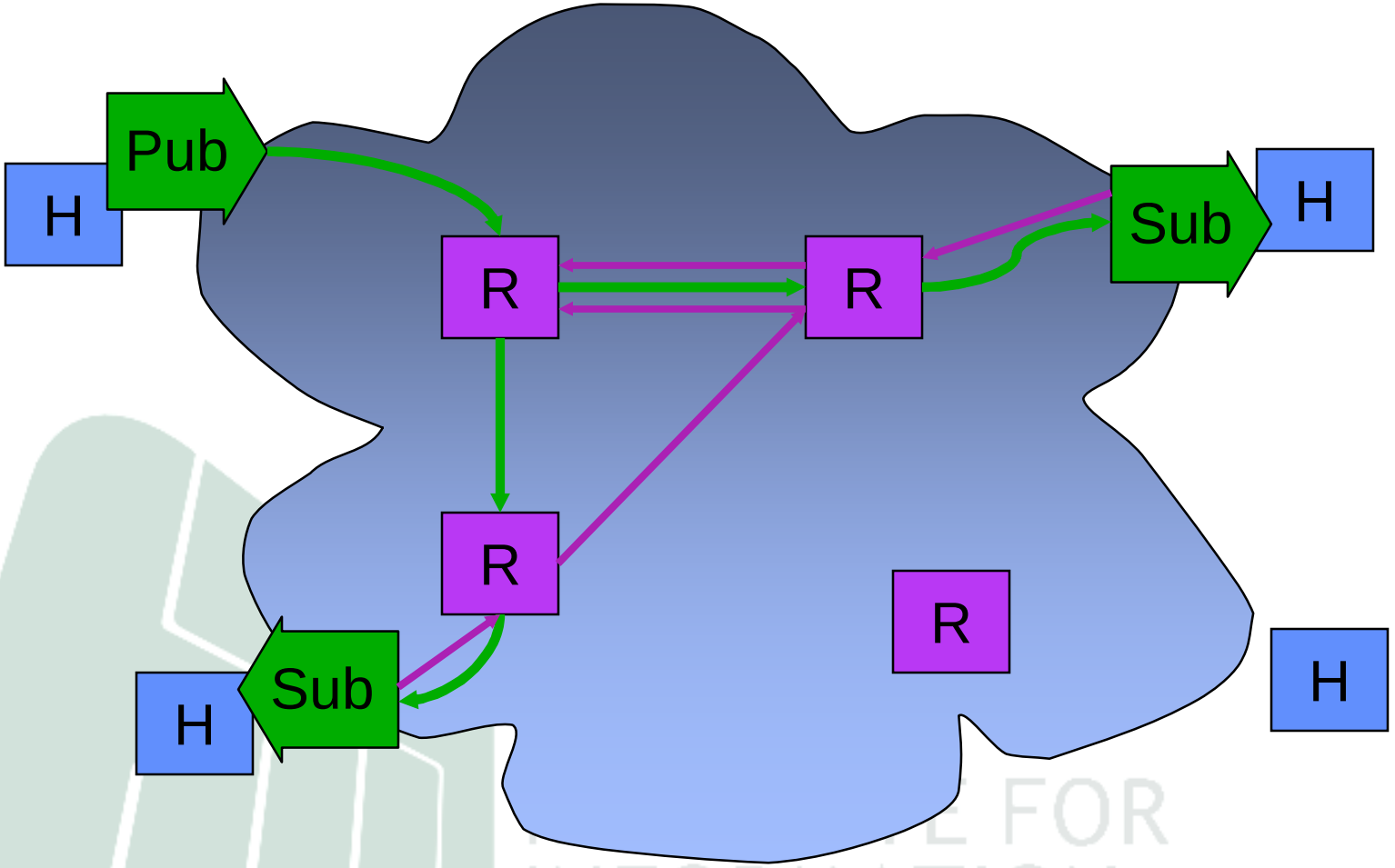
The Way Beyond

- HIP itself is not a radical innovation
- However, it opens the door for more thorough revisions that exploit the new namespace and the new infrastructure
  - Data-oriented Internet: Publish-subscribe architecture
  - Novel forms of P2P

The Thing



The Thing, More Detail



Allocation of Effort

- A data-oriented approach changes the allocation of effort for establishing security
- At present, Internet naming is designed to address scalability, and the network is responsible for security
- In a data-oriented Internet, security is handled by cryptographic names, while the new anycast-like routing scheme provides scalability
- We argue this leads to a better and more scalable allocation of the burden

To Do and To Understand

- Infrastructure
- Network management
  - Policy development
- Routing
  - E.g. upstream routing of subscriptions, downstream forwarding of publish events
- Attack scenarios
- Microeconomics
- ...

HIIT's Position and Plans

- Infrastructure for HIP
  - Co-operation with ICSI and UCB, USA
  - Also IIT Kanpur, India; LARC, Brazil; Aalborg, Denmark; Petrozavodsk, Russia; MIT, USA; NEC Europe, DoCoMo Eurolabs
- Trustworthy Internet
  - Co-operation with ICSI and UCB, USA
- NordicHIP
  - Co-operation with SICS, Sweden
- DAAD
  - Co-operation with University of Aachen, Germany

Initiatives

- USA
  - Global Environment for Networking Innovations (GENI)
  - **Future INternet Design (**FIND**)**
- EU 7FP
  - The Network of the Future (Call 1, 200 M€)
  - New Paradigms and Experimental Facilities (Call 2, 40 M€)

ICSI-Finland Center for Novel Internet Architectures

- Long-term research on Internet architecture on the basis of joint research agenda
- Researcher visits, joint projects, teaching, industry relationships
- ICSI: Scott Shenker, Ion Stoica, Sally Floyd, Vern Paxson
- HIIT: Martti Mäntylä, Pekka Nikander, Andrei Gurtov, Sasu Tarkoma, Arto Karila, Antti Ylä-Jääski
- Through this initiative, we aim to have a good view also to the work to take place in GENI and FIND

Summary

- Publish-Subscribe architecture
- Only publishers have names
- Routing and forwarding work in reverse directions
- Lots of open questions
- Major activities planned both in Europe and in the USA; HIIT is well placed to work on both theatres