



Workshop Futuro da Internet



Information-oriented Internetworking

Vision and efforts towards the next wave of networking

Christian Esteve Rothenberg

16/04/2009

Agenda



Origin

Today

Future

?



information-centrism



TRIAD

content-centric networking

4Ward



DONA

Haggle

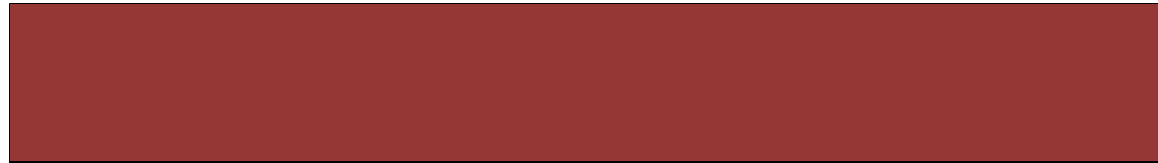
Thinking “out-of-the-TCP/IP-box”

Today



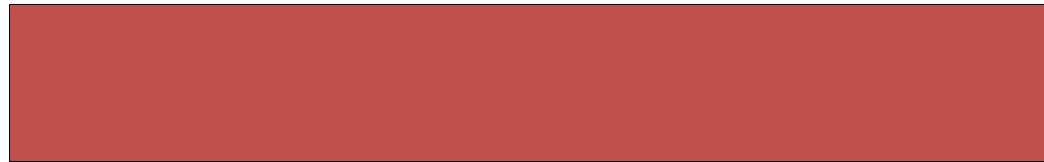
Internet traffic

HTTP 50%



YouTube 25%

P2P 45%

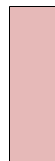


BitTorrent™ 20%

RT VoIP gaming 3%



Other 2%



Akamai 20%



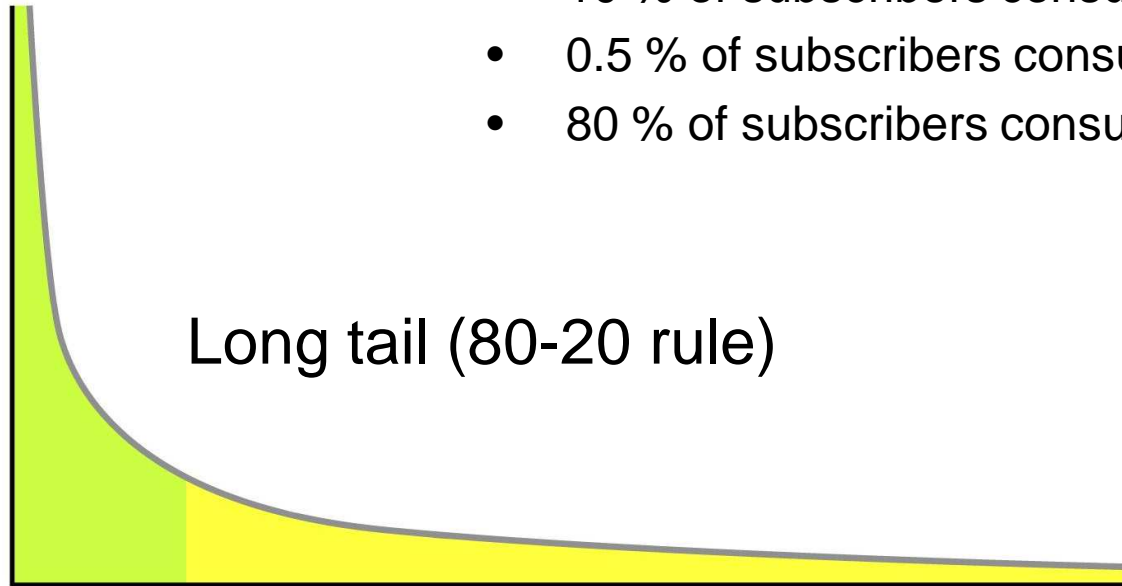
Sources: <http://gigaom.com/2008/04/22/shocking-new-facts-about-p2p-and-broadband-usage/>
<http://www.ipoque.com/resources/internet-studies/internet-study-2007>

Today



Internet traffic

- 10 % of subscribers consume 80 % of BW
- 0.5 % of subscribers consume 40 % of BW
- 80 % of subscribers consume < 10 % of BW



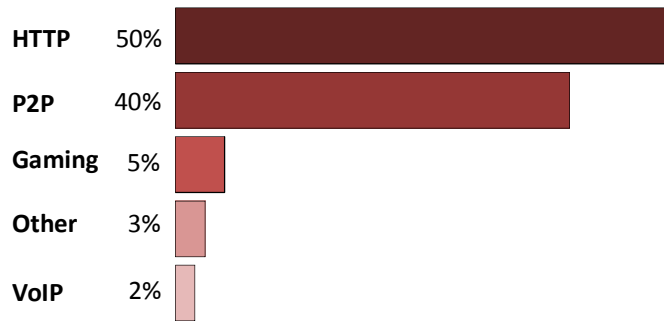
Source:

Future
?

Internet traffic



- + High Definition Content
- + Sensor Networks
- + Web 2.0
- + Mobile devices
- + Broadband



Source:

Origin

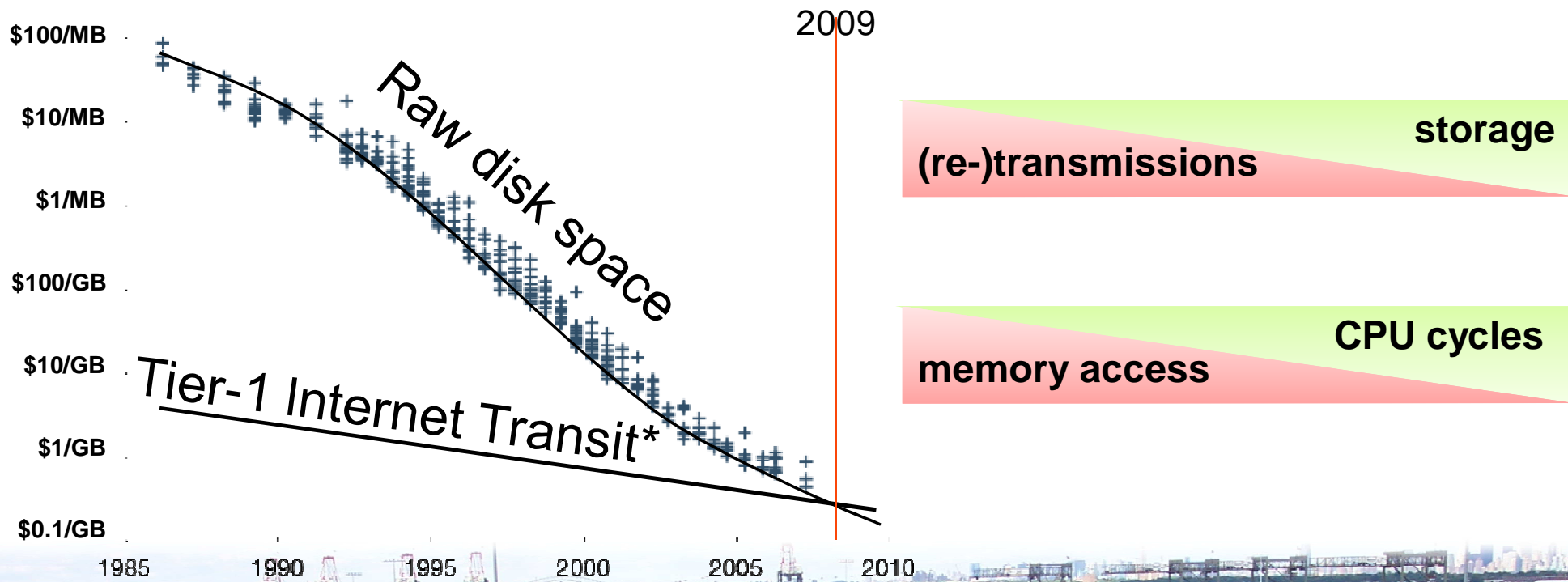
Today

Future



Network Economics

- Many of the technology assumptions behind the original end-to-end principle may no longer be applicable!



* Preliminary data [Nikander'09]

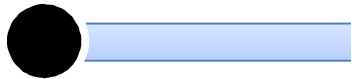
Network economics arguments for a back-to-basics reconsideration of the end-to-end networking model



TCP/IP



Origin



Solved the problem of resource sharing
(FTP, Mail, Telnet, HTTP*)



Today



TCP train wreck applications:

- Massive P2P traffic [Accountability/ re-ECN]
- Multimedia home networking [Wireless losses]
- Cellular networks [E2E control loop]
- High-delay & High-bandwidth links [BW x Delay]
- Data-centers & Cloud computing [Slow start]

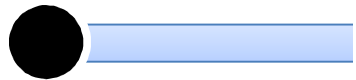


- TCP ignores higher layer needs & lower layer characteristics!
- TCP notion of **fairness** under debate



DNS

Origin



- Identify IP endpoints (computers, routers)
- Handled at human rate



Today



- Identify information objects (URI!)
 - Semantic overload: both info name & location
- Under machine-machine applications



- How to move from server locations to **naming of information** really?
- How robust, scalable, sensitive to attacks and mis-configurations?
- How to **HANDLE** IP resolution and **UPDATE** bigger & bigger databases?



Today



Content Delivery Networks

Future



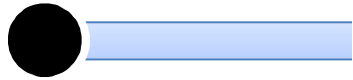
Akamai 20% of total Internet traffic

- Increased Quality of Experience 😊
 - Masks current Internet bottlenecks with an *overlay solution*



- **CDN lock-in**
- **Closed innovation**
- **Complex**
monitoring, DNS tricks

Origin



Observation

Today



Fundamentals of the Internet

- Collaboration
 - Reflected in forwarding & routing
- Cooperation
 - Reflected in trust among participants
- Endpoint-centric services
 - Mail, FTP, even Web
 - Reflected in E2E principle



Reality in the Internet

- Current economics favor senders
 - Receivers are forced to carry the cost of unwanted traffic
- Phishing, spam, viruses
 - There is no trust any more
- Information-centric services
 - Do endpoints really matter?
 - Information retrieval through, e.g., CDNs, P2P

IP, full end-to-end reachability

IP with middleboxes & significant decline in trust

the future of the Internet & the future Internet ?

Source: Jonathan Zittrain, The Future of the Internet — And How to Stop It, , <http://www.jz.org>.





FIND

Clean Slate Designs

Stanford University



Clean Slate Design
for the Internet

1.- “With what we know today, if we were to start again with a clean slate, how would we design a global communications infrastructure?”

2.- “How should the Internet look in 15 years?”

Van Jacobson's waves of networking

*“If a Clean Slate is the solution,
what was the problem?”*

99%

Named chunks of data
(Web, P2P, Video, etc.)



New problem!

- Dissemination of named pieces of data

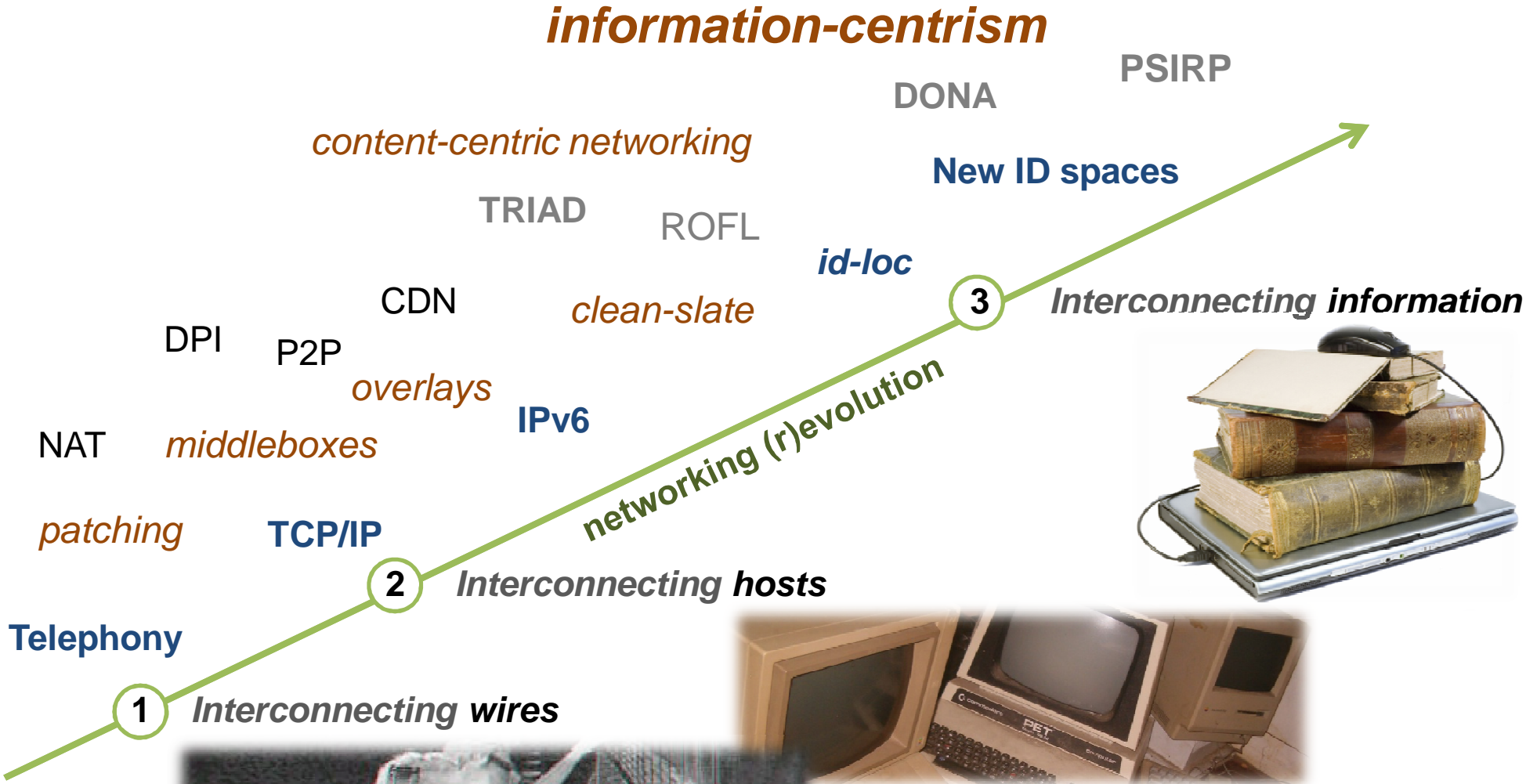


Answer:

- Content-Centric Networking



Re-Architecting the Future Internet



Information-oriented efforts



- Peer-to-Peer Networks (2000)
- The OceanStore Project (2002)
 - Global-Scale Persistent Data
- TRIAD: Content-Based Routing (2002)
 - Routing on FQDN for HTTP req. avoiding DNS resolution
- I3: Internet Indirection Infrastructure (2002)
 - DHT-based rendezvous points in the network
- LNA: Layered Naming Architecture (2004)
 - ID/Loc split at every layer
- DTN: Delay/Disruption Tolerant Networks (2003)
 - CNF: The cache-and-forward network architecture (2008)
 - Huggle: Pocket Switched Networks (2007)
 - IETF activities

Information-oriented efforts



- CCN: Content Centric Networking (2006)
 - Aggregation through structural naming of data pieces
- DONA: Data Oriented Network Architecture (2007)
 - Register / Find P:L
- 4Ward NetInf (2008)
 - Networking of information objects
- Wireless Sensor Networks
 - Data-centric routing approaches
- PSIRP: Publish Subscribe Internet Routing Paradigm (2008)
 - Replace IP with a pure pub/sub based inter-networking stack



PSIRP Project Overview



Project Coordinator

Arto Karila

Helsinki University of Technology, HIIT

Tel: +358 50 384 1549

Fax: +358 9 694 9768

Email: arto.karila@hiit.fi

Partners:

- . Helsinki University of Technology
Helsinki Institute for Information Technology (FI)
- . RWTH Aachen University (DE)
- . British Telecommunications Plc (GB)
- . Oy L M Ericsson Ab (FI)
- . Nokia Siemens Networks Oy (FI)
- . Institute for Parallel Processing of the
Bulgarian Academy of Science (BG)
- . Athens University of Economics and Business (GR)
- . Ericsson Magyarország Kommunikacios
Rendszerek K.F.T. (HU)

Duration: January 2008 – June 2010

Total Cost: €4.1m

EC Contribution: €2.5m

Contract Number: INFISO-ICT-216173

WP1 Management (TKK-HIIT)

WP2 Architecture Design
(TKK-HIIT)

WP3 Implementation,
Prototyping & Testing (LMF)

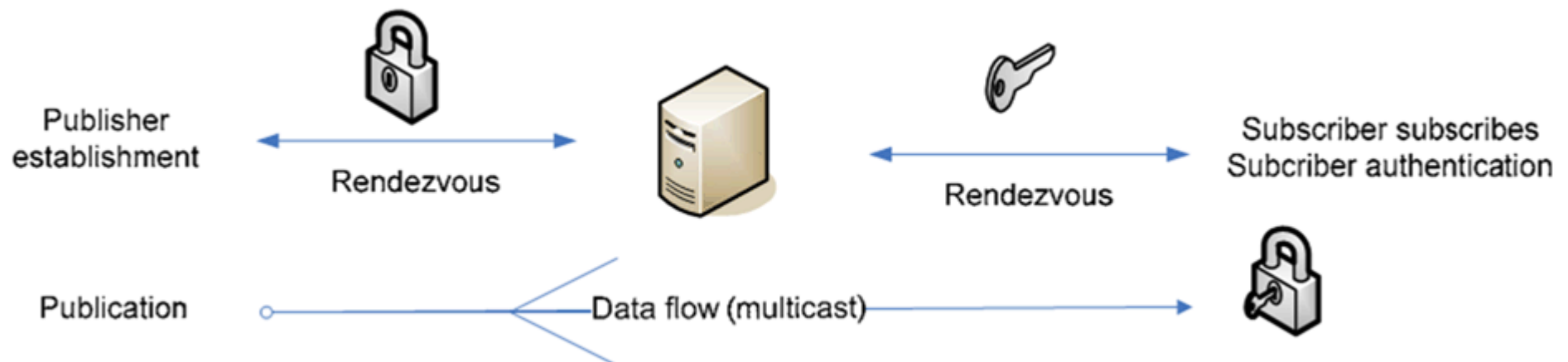
WP4 Validation and Tools
(BT)

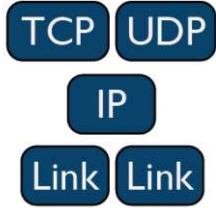
WP5 Dissemination and
Exploitation (NSNF)

Project website: www.psirp.org

PSIRP Project Goals

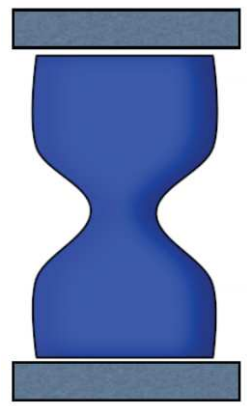
- Redesign the Internet architecture from the pub/sub point of view, taking nothing (not even IP) for granted:
 - Make *information* the centre of attention
 - Remove the *location-identity split* that plagues current networks
 - Innovative *multicasting* and *caching* features to optimize performance and efficiency
 - *Security* as a native core component of the architecture





Information-oriented Networking

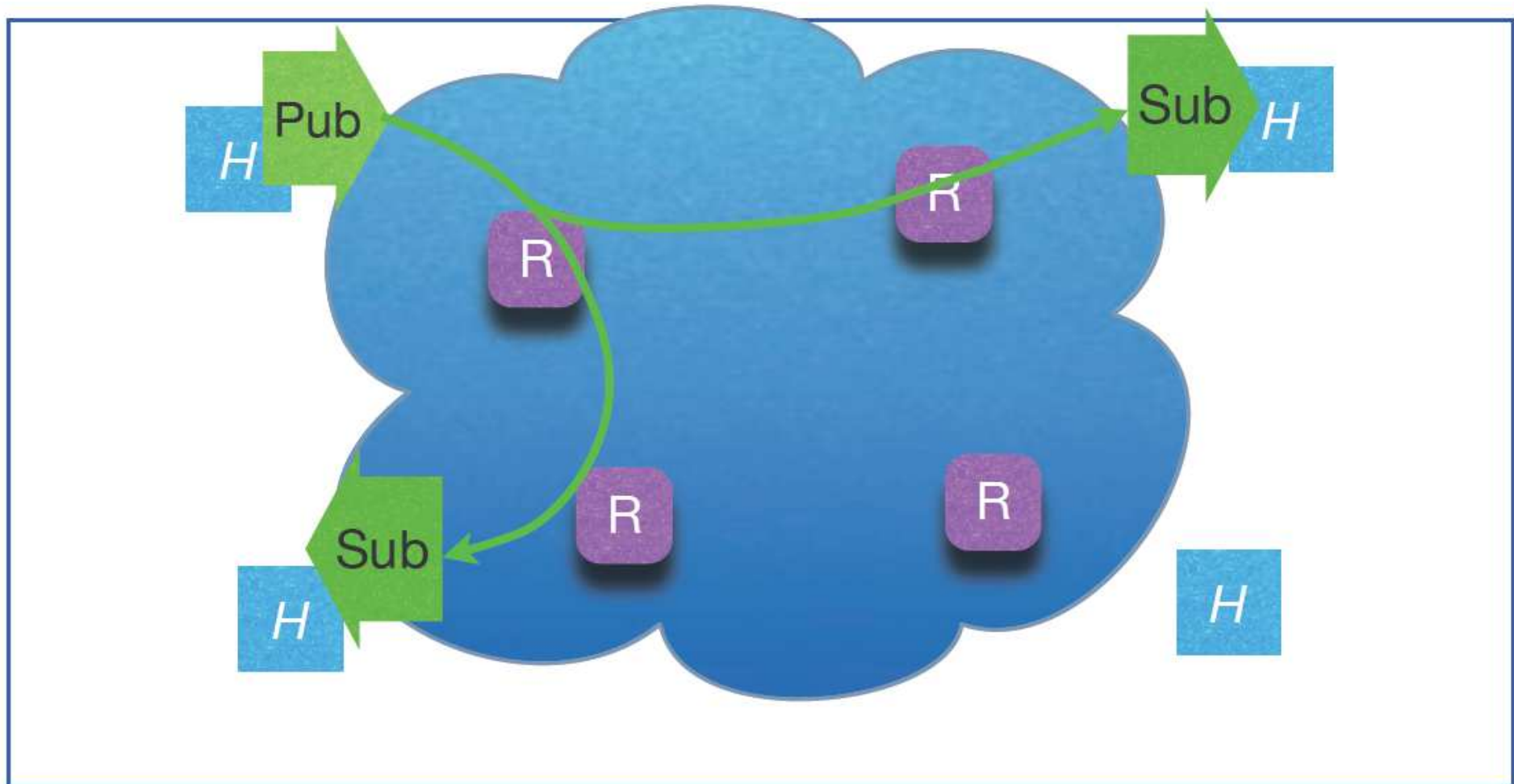
- Rethinking fundamentals -



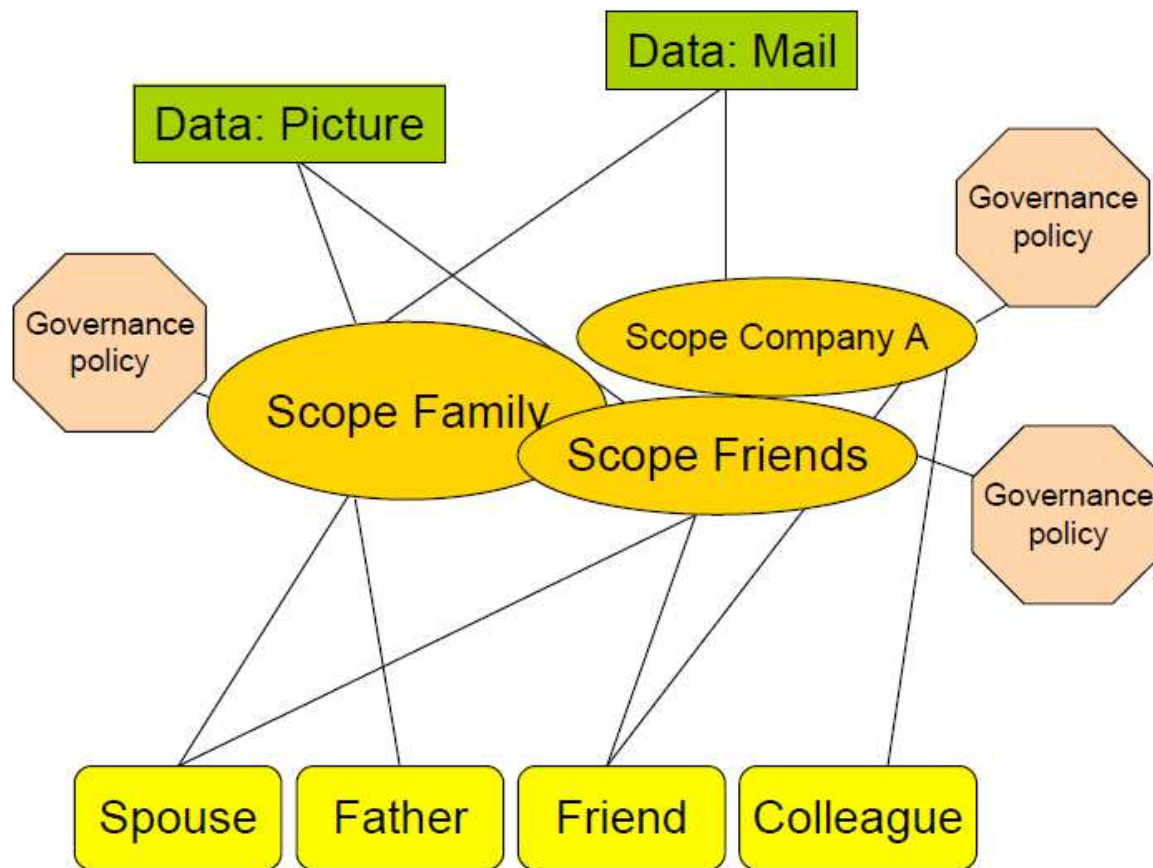
- **Send / Receive** → **Publish / Subscribe**
- **Sender-driven** → **Receiver-driven**
- **Host names** → **Data names**
- **Host reachability** → **Information scoping**
- **Channel security** → **Self-certified metadata**
- **Unicast** → **Multicast**



Pub/Sub

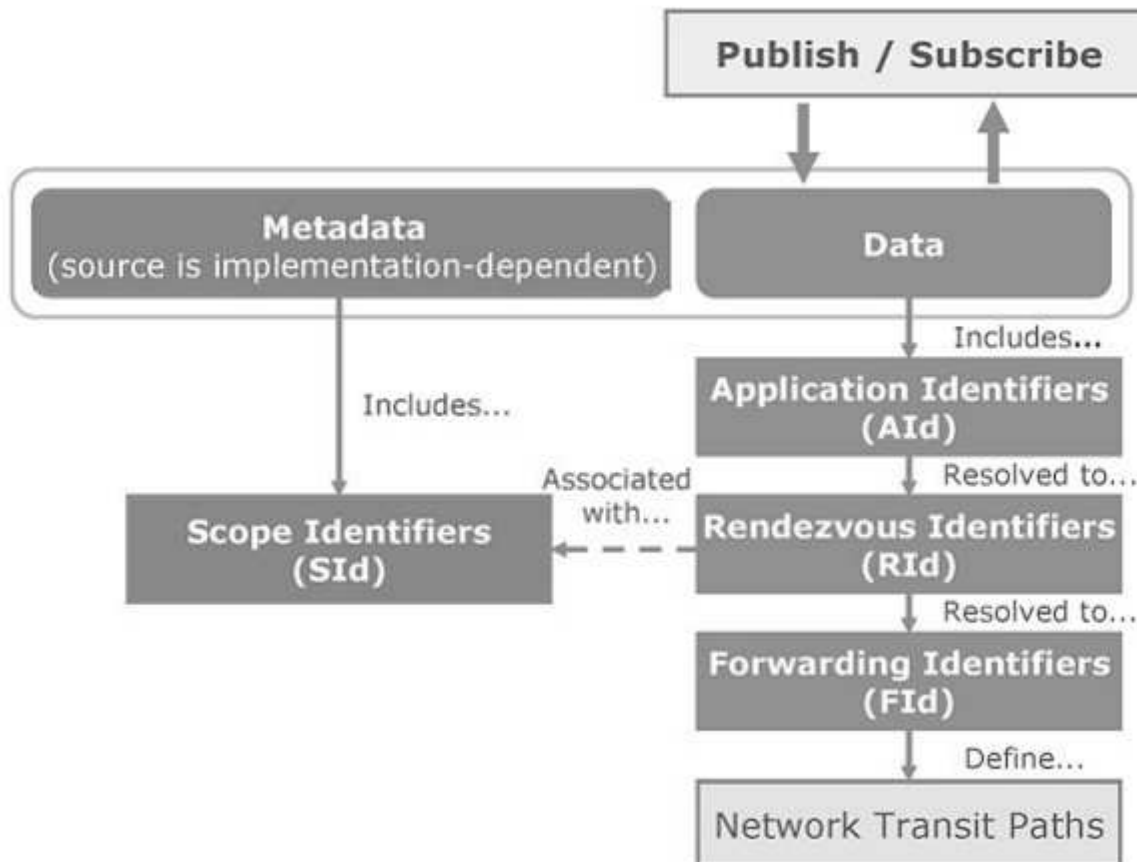


Information-Centrism is Key

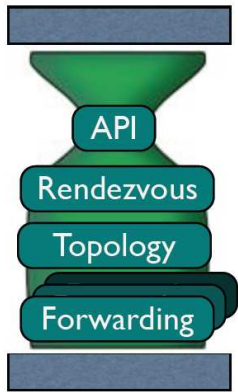


- **Information** is everything and everything is information
 - Bootstrap other concepts, e.g., identity, policy, ..., on top of generic information
- Scopes build **information networks**
- Policy is metadata
 - So is scope!
- **Producers** and **consumers** need no internetwork-level addressing!

Identifiers



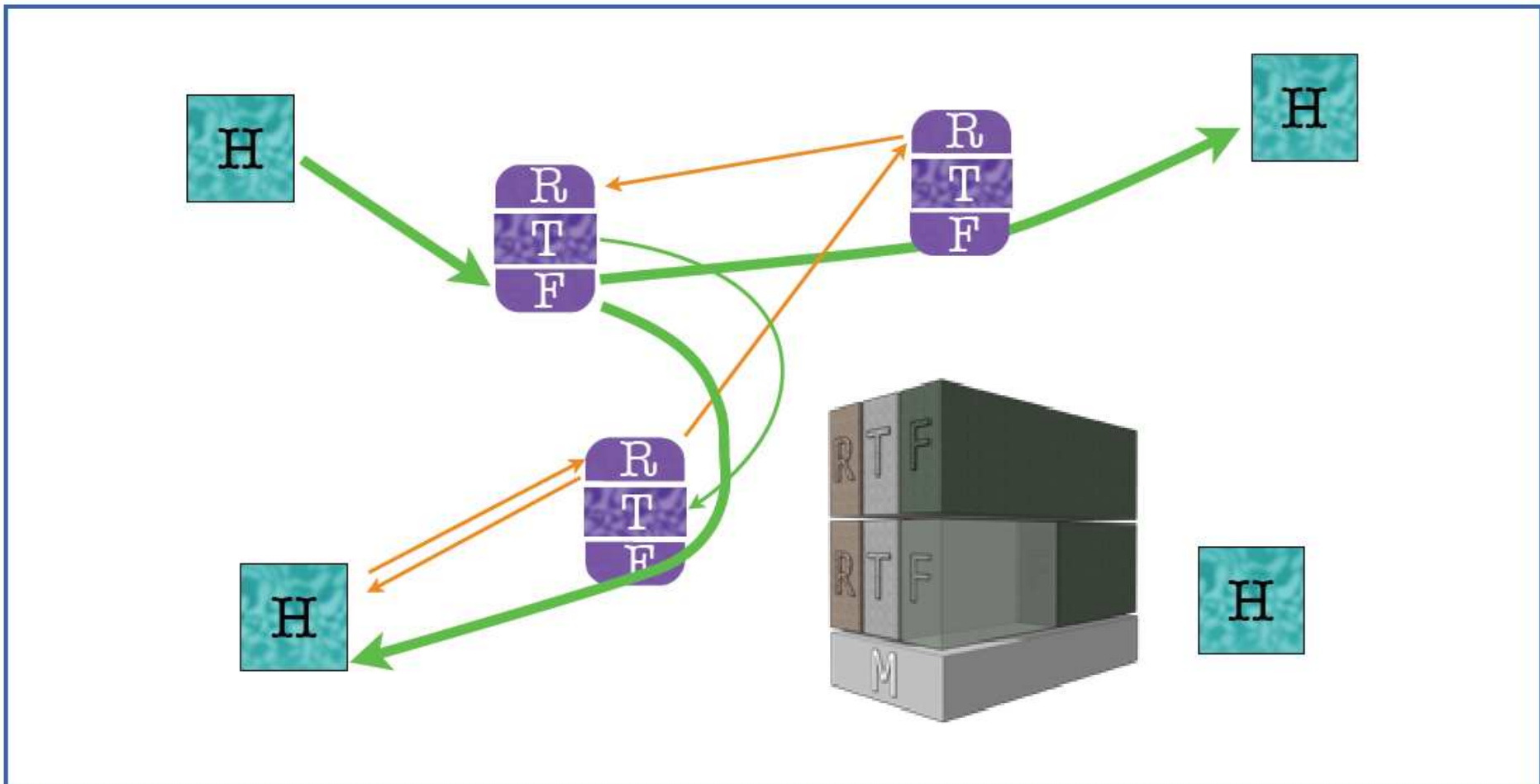
- Information is labelled with (statistically) unique **RId**
 - Anything can be information!
 - *Information* defined by application semantics!
- RId is assigned to one or more **SId**
 - Information can reside in several information networks
- Can build powerful application concepts from this
 - Identity, channels, documents, sensor swarms
 - Resolution from application ID to RId is not within scope!
- Implement network functions (e.g., fragmentation, ...) based on these concepts



RTFM



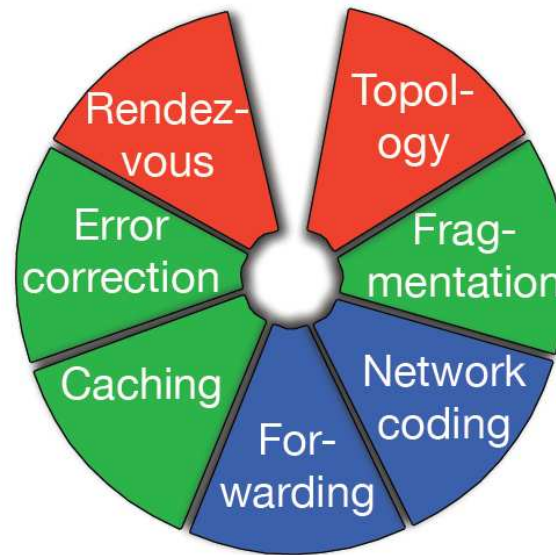
PSIRP
 PUBLISH-SUBSCRIBE
 INTERNET ROUTING
 PARADIGM
 MAJADAR
 www.psirp.org



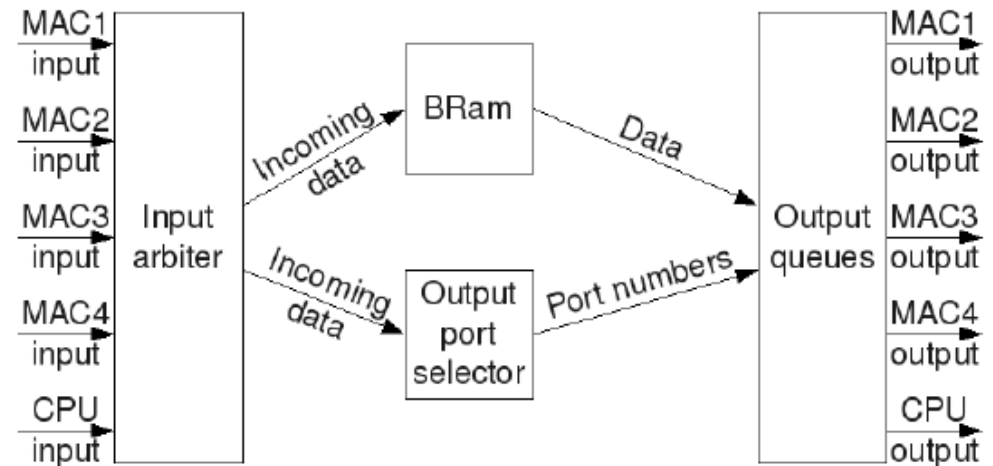
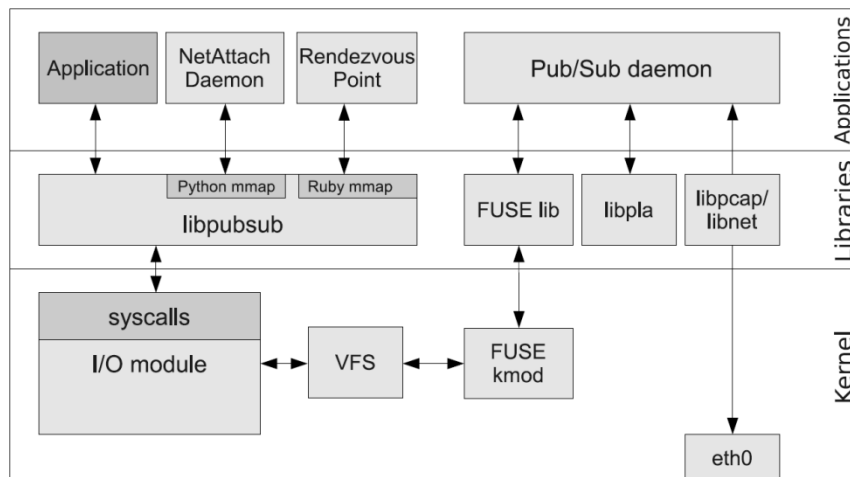
Prototype implementation

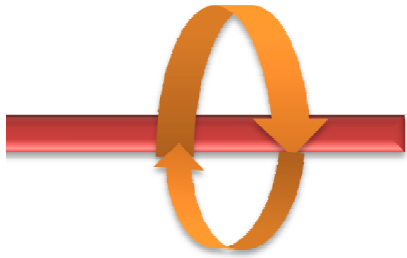


RTFM architecture

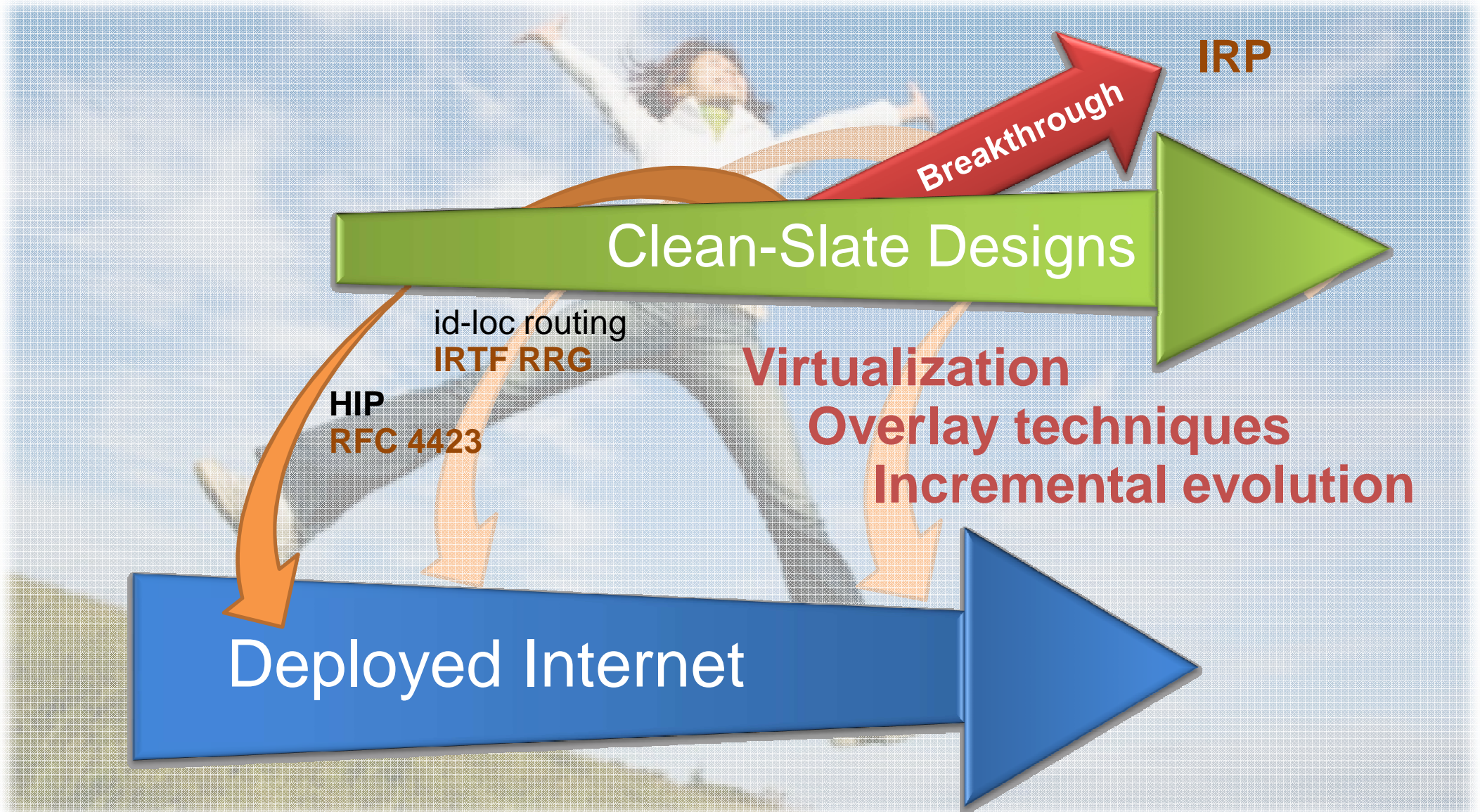
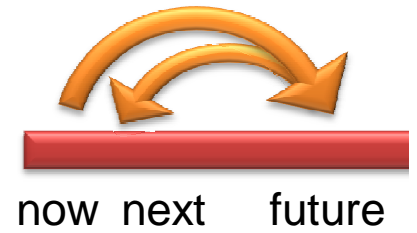


Component Wheel



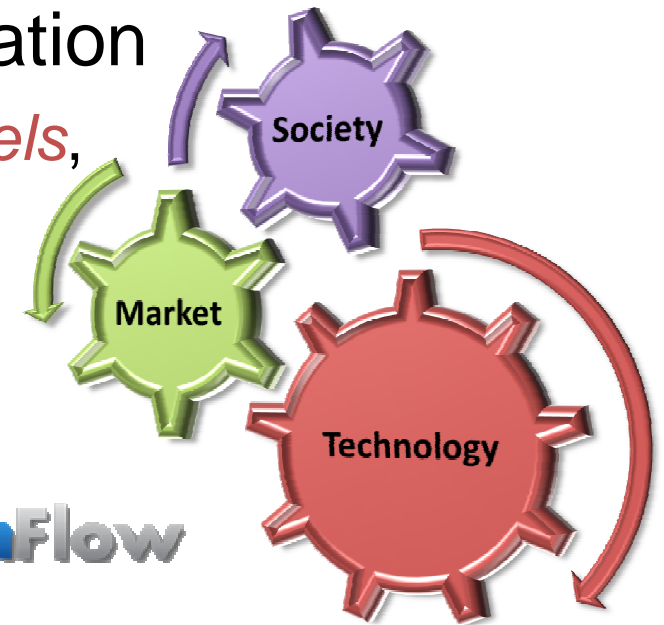


Closing the research loop: Late binding to reality



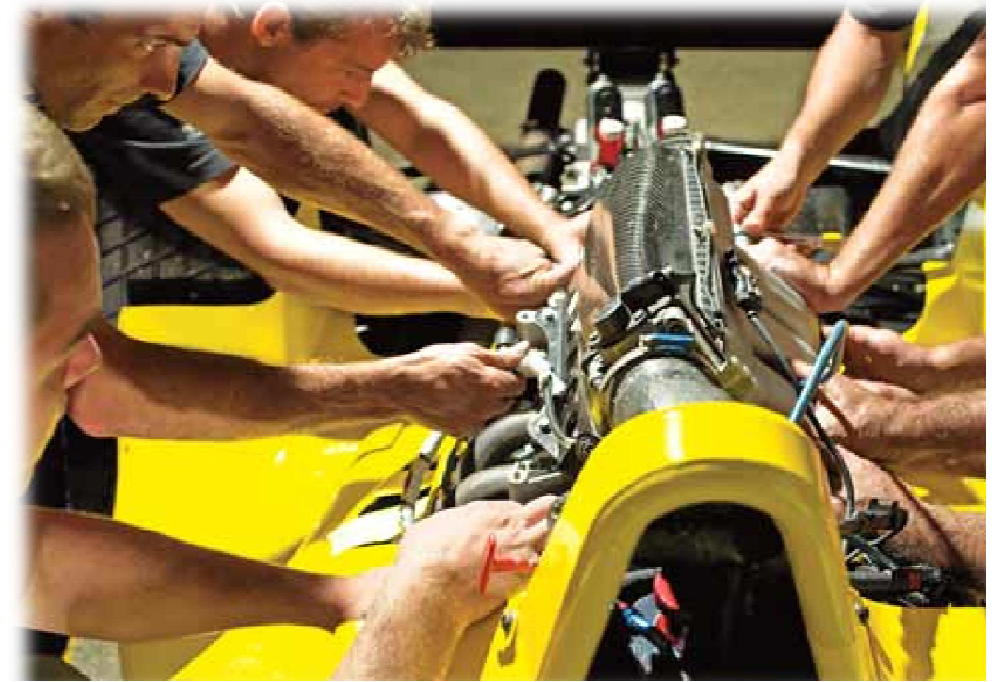
Future Internet Research 2.0

- **Wiki-like Research: Sharing & Collaboration**
 - *real* data sets (topologies, traffic) and *models*, *open* source (prototypes, simulators), etc.
- **Multi-disciplinary**
- **Experimentally-driven research**



Questions to think / work

- Naming and identity of information
- How much *awareness* in the network?
 - Service-aware networks vs. Network-aware applications
- Data *dissemination*
 - A basic network service, or on top of a E2E (?) transport service?
- Network *economics*
 - Incorporate technological, societal and regulatory economics
- Candidate *designs* of a future global network for the needs of 2020?
 - How to evaluate good designs?
 - When does the FI becomes the Internet?
- What are good design *principles*?
 - What minimal design principles should govern all designs?
- Design for *tussle* and *evolvability*





Obrigado!



Credits

- D. Trossen and P. Nikander, EU FP7 PSIRP project, <http://psirp.org>
- Van Jacobson, <http://video.google.com/videoplay?docid=-6972678839686672840>
- Ericsson Research
- ...

Images

- Jonathan Zittrain, The Future of the Internet — And How to Stop It, <http://www.jz.org>.
- Bert van Dijk at <http://flickr.com/photos/75478114@N00/2964148062>.
- [Rae Brune](http://flickr.com/photo/75219074@N00/126116912) at <http://flickr.com/photo/75219074@N00/126116912>
- [Roy van Wijk](http://www.flickr.com/photos/royvanwijk/2974434570/) at <http://www.flickr.com/photos/royvanwijk/2974434570/>
- *The Tango project* at <http://commons.wikimedia.org/wiki/Smiley>

