From ID/locator split to ICN

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Based on the *2015 IEEE Consumer Communications & Networking Conference (CCNC)* invited paper *From ID/locator split to ICN*

Börje Ohlman

Ericsson Research

Outline

- The Original idea
- What are the problems
- Proposed approaches to ID/Locator split
- Introduction to Information-centric Networking (ICN)
- An ICN inspired proposal to ID/Locator split
- ICN Outlook and Conclusion

The Original idea

In 1978 John F. Shoch, proposed the following general definitions:

- a ***name***
  - identifies what you want,
- an ***address***
  - identifies where it is and
- a ***route***
  - identifies a way to get there.

In 1982 J. Saltzer, proposed the following definitions:

- ***Service and Users***
  - These are the functions that one uses, and the clients that use them.
- ***Nodes***
  - These are computers that can run services or user programs.
- ***Network attachment points***
  - These are the ports of a network, the places where a node is attached.
- ***Paths***
  - These run between network attachment points, traversing forwarding nodes and communication links.

The Original idea (cont.)

Then in 1991 Paul F. Tsuchiya in *Efficient and Robust Policy Routing Using Multiple Hierarchical Addresses* comments on Shoch's definitions:

- Briefly stated, the problem with this "where" (addressing) notion is that
  1) we tend to think of things as ***being in only one place at a time***, implying that we ***need only one address at a time***
  2) since we relatively ***rarely move*** our computers or telephones, ***we tend to think of addresses as rather static***

He points out that:

- ***Some addresses are completely flat***, from a routing perspective, e.g. Ethernet addresses, i.e. they do not contain any routing information
- At the other end of the spectrum there are ***source routes***. If a source route is provided in the address field of a packet there is no need for any additional routing information such as e.g. routing tables

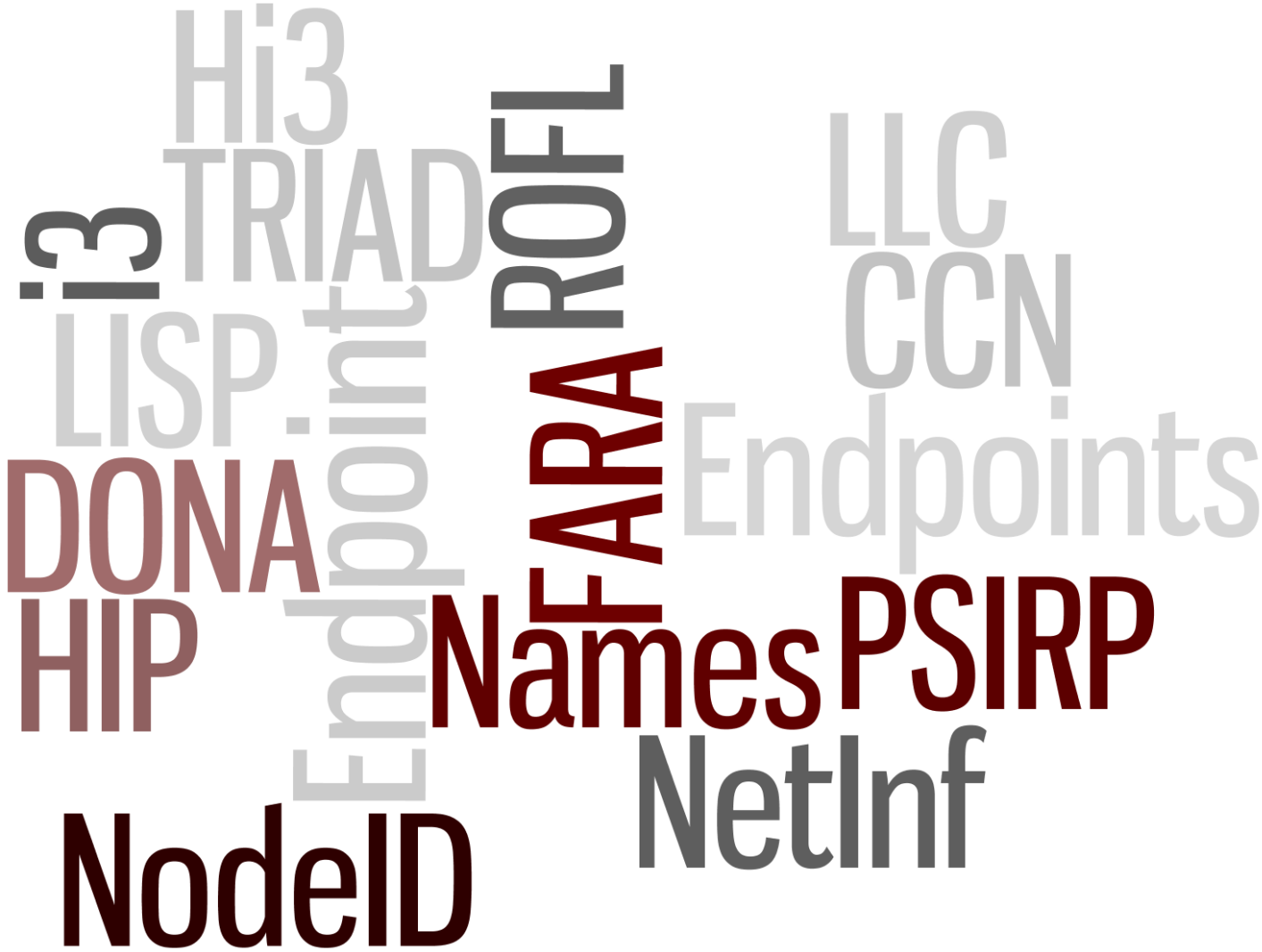
› He also argues that what we need are names and routes.

- ***Names*** identify what we want.
- ***Routes*** tell us how to get to a location where we can find an instance of the information object that we want. Locators thus are names that can be used to construct routes.

SO WHAT ARE THE PROBLEMS?

- Mobility and multi-access
  - The same Information Object (IO) (e.g. a video stream) should be delivered to different network attachment points as the receiver is roaming the network and/or change access technology (e.g. from 3G to WLAN)
- Naming and address space
  - Semantic overloading of IPv4 addresses is a well-known problem
- Point-to-multipoint and Flash crowds
  - The same IO should be delivered to multiple locators
- Quality of Service (QoS)
  - The same IO should have different names to be treated differently by the network
- Security
  - Due to many reasons, including IoT and Cloud, there is a strong urge to move to object security rather than securing channels

Proposed approaches to ID/Locator split



Some important ID/Locator split papers (1/3)

- Endpoints and Endpoint Names: A Proposed Enhancement to the Internet Architecture – 1999
  - J. Noel Chiappa introduces the idea of end-point identifiers [7], primarily to address the host mobility problem.
- TRIAD: An Architecture for Content Routing Support in the Internet - USENIX 2000
  - TRIAD [4] was one of the first projects that introduced the concept of content routing.
- Internet Indirection Infrastructure (i3) – SIGCOMM 2002
  - In the paper [8] the authors generalize the Internet's point-to-point communication abstraction to provide services like multicast, anycast, and mobility.
- FARA: Reorganizing the Addressing Architecture – SIGCOMM 2003
  - FARA [9] is one of the first proposals where the authors introduce the idea of mobility for other things than host.
- Host Identity Protocol (HIP) – IETF 2003
  - Host Identity Protocol (HIP) Architecture, RFC4423 [10] is primarily aiming to make the Internet more secure.
- Host Identity Indirection Infrastructure (Hi3) – SNCNW 2004
  - Hi3 [12] combined i3 and HIP to get secure communication also for point to multipoint communication.

Some important ID/Locator split papers (2/3)

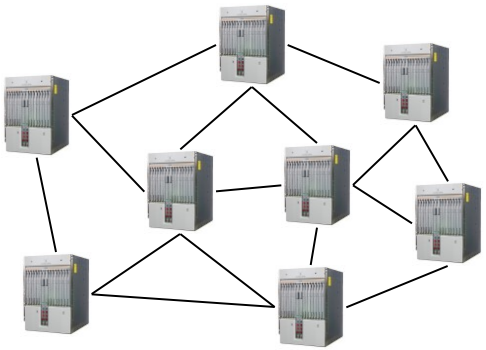
- A node identity internetworking architecture (NodeID) – GIS 2006:
  - NodeID [13] is a proposal for how to bridge heterogeneous addressing domains, e.g. IPv4 and IPv6 by introducing a new set of node identities
- Routing on Flat Labels (ROFL) – SIGCOMM 2006
  - ROFL [14] is proposing to get rid of locators altogether.
- Content Centric Networking (CCN) – Google Tech Talks 2006
  - Content-centric networking (CCN) or Named Data Networking (NDN) was introduced by Van Jacobson when he was at PARC
- Dynamic internetworking based on late locator construction (LLC) – GIS 2007
  - LLC [18] is proposing how locators can be dynamically constructed based on the current network topology.
- A Data-Oriented (and Beyond) Network Architecture (DONA) – SIGCOMM 2007
  - DONA [19] is one of the first approaches to bring up the issue of name persistence. DONA introduces names of the format P:L
- Network of Information (NetInf) – ReArch 2008
  - The initial NetInf ideas are presented in the paper Design considerations for a network of information [20] is primarily combing ideas from DONA and CCN, but also i3 and HIP have had mayor impact on the NetInf architecture.

Some important ID/Locator split papers (3/3)

- Publish Subscribe Internet Routing Paradigm (PSIRP) - ICT-MobileSummit 2008
  - In the paper RTFM: Publish/Subscribe Internetworking Architecture[21] PSIRP 4 is presented as a true clean slate architecture. It uses a number of identifiers. Application (Level) Identifiers (AId), Rendezvous Identifiers (RId) and Forwarding Identifiers (FId)
- Locator/ID Separation Protocol (LISP) – 2008
  - The primary motivation for LISP was to try to limit the growth of the routing tables in routers.

Evolution of networking

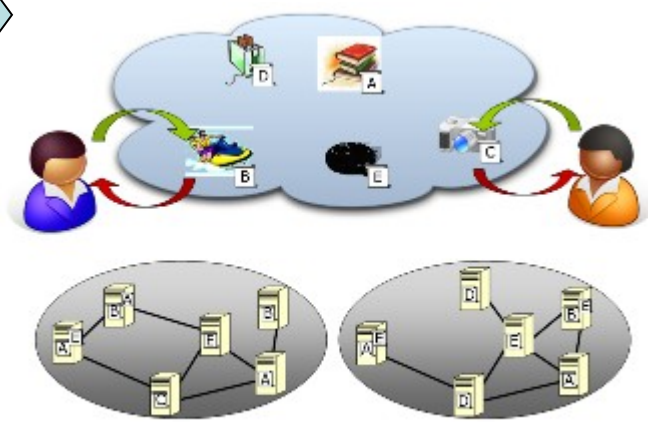
Today's Internet
Focuses on
Conversations between Hosts
Host-centric abstraction
Who to communicate with



Evolution

Web | CDN | P2P

Information-centric network (ICN)
Focuses on
Dissemination of Information objects
Information-centric abstraction



Major ICN approaches

- Content Centric Networking (CCN) / Named Data Networking (NDN)
- Network of Information (NetInf)
- Publish/Subscribe Networking (PSIRP / PURSUIT)

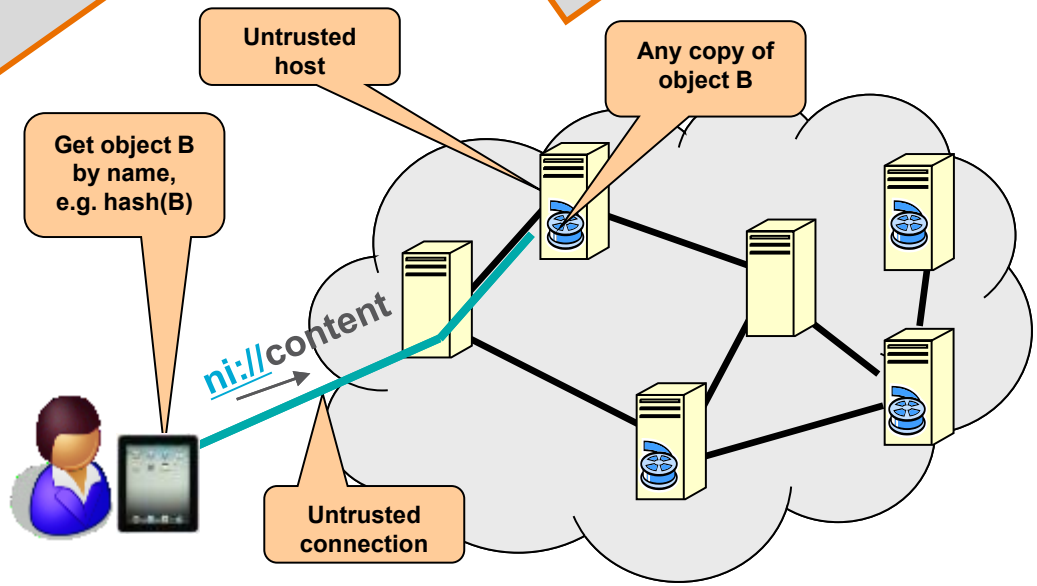
Information-centric Networking (ICN) – Basic principles

Naming content by globally unique identifiers

Security model: Name data integrity

Request aggregation and publish-subscribe for scalable point-to-multipoint

Extensive use of caching "All copies are equal"

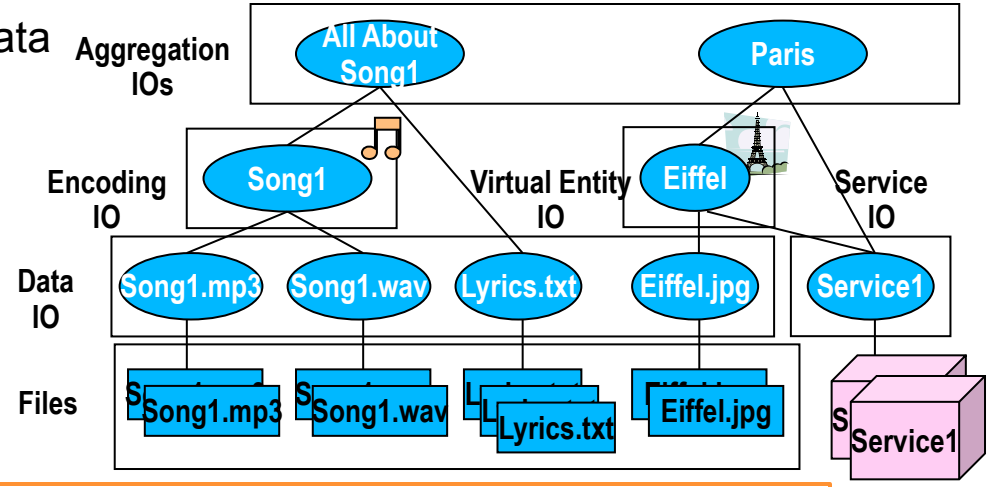


An ICN inspired proposal

- Prerequisites
  - An information object can have multiple names
  - Names can point to other names to provide indirection and aliasing.
  - Names can point to locators
- Proposal
  - *Name* (or more specifically *Named Object (NO)*)
    - a semantic object, i.e. a movie, a web page, a temperature reading, a light switch, a person or a specific network node
    - An *NO* is something that you want a copy of, want to talk to or want to manipulate in some way.
  - *Locator*
    - A *Locator* identifies an instance of an *NO*
    - A locator is a name that exist in context where it can be used to route to an instance of an *NO*

Identifier and Information Modelling

- 1. Step: *Persistently identify information* via *identifier/locator split*
  - Location-independent identifiers
  - Represent *multiple copies*
- 2. Step: *Representation of information* via *Information Objects (IOs)*
  - Another level of indirection
  - Represent information independent of *specific copy* and *encoding*
    - *E.g. a text, a song*
  - Contains *information-specific* metadata
    - E.g. access rights, attributes
- Information Objects can do more:
  - Representation of:
    - Streams
    - Services
    - Real-world objects (e.g., a book, person)
  - IOs can be used to organize information



- **Enables efficient information dissemination**
  - System can automatically choose encoding and copy (e.g. based on metadata)
  - User can navigate information (e.g. choose encoding)

CCN/NDN and ID/Locator Split

- CCN is similar to IP in the respect that it uses the names of the information objects as locators for routing.
- CCN is thereby not providing proper ID/locator separation.
- An example of the problems that this leads to is that it cannot find copies of the requested object in off-path caches.
- It will also not easily recognize if it in a cache has multiple copies of the same object if they have been published under different names (makes e.g. de-duplication in caches difficult).
- Support publisher mobility is missing

ICN Outlook

- Name persistence
  - names should remain constant and be independent of who has published them or where they are located (RFC 6920 “Naming things with hashes”)
- Access control
  - ICN objects providing object security can reside in untrusted caches including end-user devices
  - A promising technology here is Attribute Based Encryption (ABE)
- Publisher mobility
  - Allowing publishers to roam without need for anchor points
- Deployment
  - ICN supports media distribution by integrating CDN and peer-to-peer functionality into the network. In particular ICN can handle flash crowds for live video streams in a fully scalable manner.
  - Separating name for an information object from the location where it is produced is very appropriate for IoT. DTN support in ICN is also useful in an IoT context.

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