From ID/locator split to ICN

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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.
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

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

Evolution
Web | CDN | P2P

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
- Extensive use of caching: “All copies are equal”
- Request aggregation and publish-subscribe for scalable point-to-multipoint

Get object B by name, e.g. hash(B)

Untrusted host

Any copy of object B

Untrusted connection

ni://content
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
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.