Information-Centric Networking

AW2

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Agenda

Retrospection AW1

Information-Centric Networking

Related Work
- NDN / CCNx
- NetInf
- PSIRP

Comparison

Future Work

Retrospection AW1

Content Delivery Networks

- Approach to deliver large amounts of content in an efficient manner
- Objectives
  - Reduced latency
  - Improved Quality of Experience (QoE)
  - Reduced backbone load
- Utilises DNS and HTTP redirection mechanisms
- Steer users towards caches

CDN components

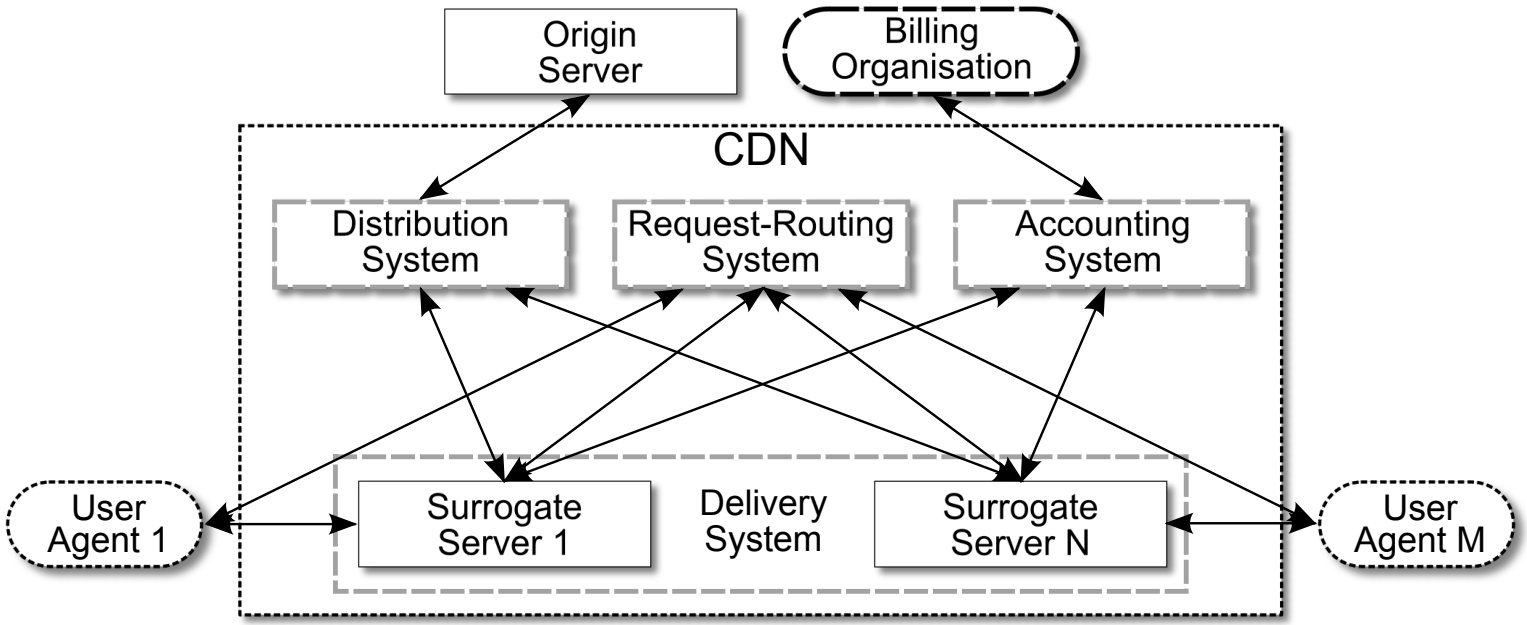

Figure: CDN components[13, 8, 9, 15]

- Delivery System
  - Deliver content
- Request-Routing System
  - Steer clients
- Distribution System
  - Distribute content
- Accounting System
  - Billing / statistic creation

Information-Centric Networking

Motivation

Internet use cases shift

- From *host-centric*

  Communicate via end-points (host/port)

- To *information-centric*

  Access content via the network itself

- Researchers take the view that the network should account stronger for content distribution

Target

- Designing a scalable and efficient content-aware network infrastructure

General ICN building blocks[6]

Publish / Subscribe paradigm

- Publish data In-network
- Receive data through subscription
- Matching publication and subscription through rendezvous mechanism

Caching

- In-network
  - Utilise content routers for caching
- At-the-edge
  - Utilise end-nodes for caching

General ICN building blocks[6]

Naming

- Via location independent identifiers

Security

- Secure content instead of communication channels
  - Data integrity (e.g. self-certifiability)
  - Author & origin authentication
- Popular to be coupled with content naming
- Receiver initiated data transfer

Routing and Forwarding

- Immediate routing of content requests (one-step resolve/retrieve)
- Name Resolution Service (NRS) (two-step resolve/retrieve)

General ICN building blocks[6]

One-step resolve/retrieve

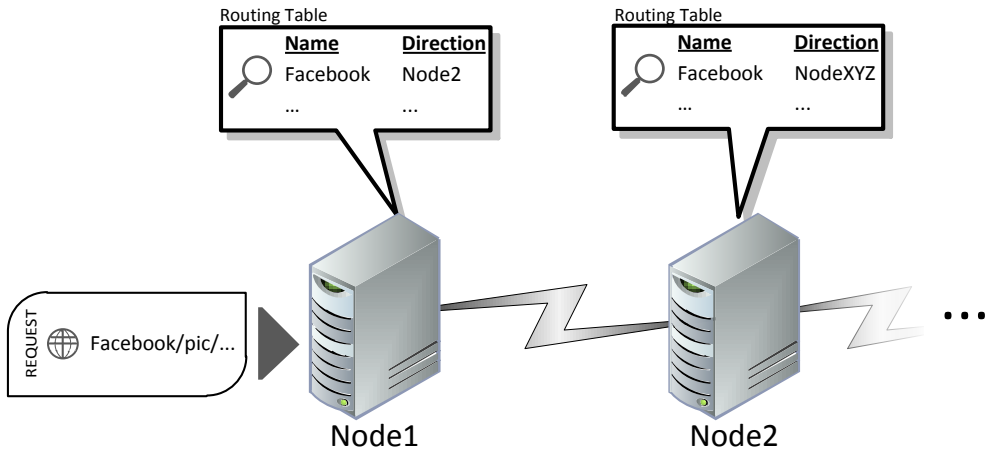

Figure: Conceptual view of one-step resolve/retrieve

Phases

- Finding (rendezvous)
- Delivering (forwarding)

General ICN building blocks[6]

Two-step resolve/retrieve

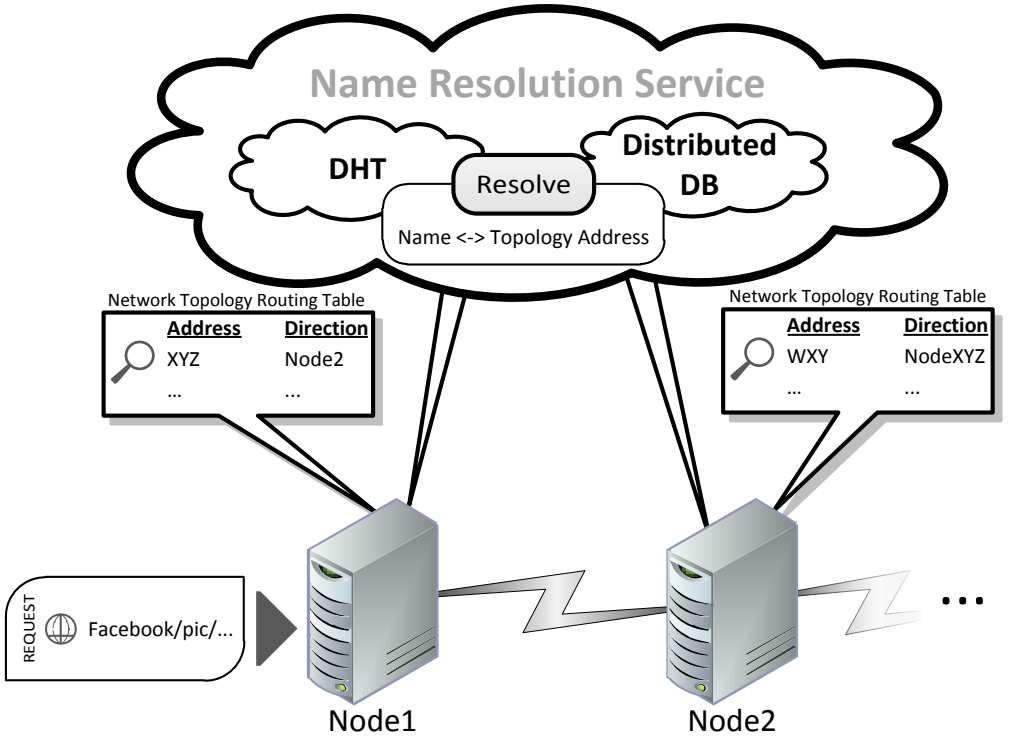

Figure: Conceptual view of two-step resolve/retrieve

Phases

- Finding (rendezvous)
- Constructing (topology)
- Delivering (forwarding)

Related Work

- NDN / CCNx
- NetInf
- PSIRP / PURSUIT

Related Work

- Taken into account here
  - NDN / CCNx from Parc[1, 11]
  - NetInf of the 4WARD and SAIL project[2]
  - PSIRP / PURSUIT project[3, 4]
- Early projects
  - TRIAD project of Stanford University (2001)
  - Data Oriented Network Architecture (DONA) (2007)

Related Work

- NDN / CCNx

NDN / CCNx Overview

- Named Data Networking (NDN)[1]
- Research project of Palo Alto Research Center (PARC)
- Prototype implementation named CCNx[11]

Naming

- Naming structure
  - Hierarchical
  - Aggregatable
  - Human-friendly format
  - Naming on chunk basis
  - Example: *ccnx:/parc/videos/intro.avi*
- Name resolution / routing
  - Interest packets are routed towards sources
  - Longest prefix match on content names
  - One-step resolve/retrieve
  - Multiple distributed sources possible
  - Reverse Path Forwarding through use of Pending Interest Table (PIT)

NDN / CCNx

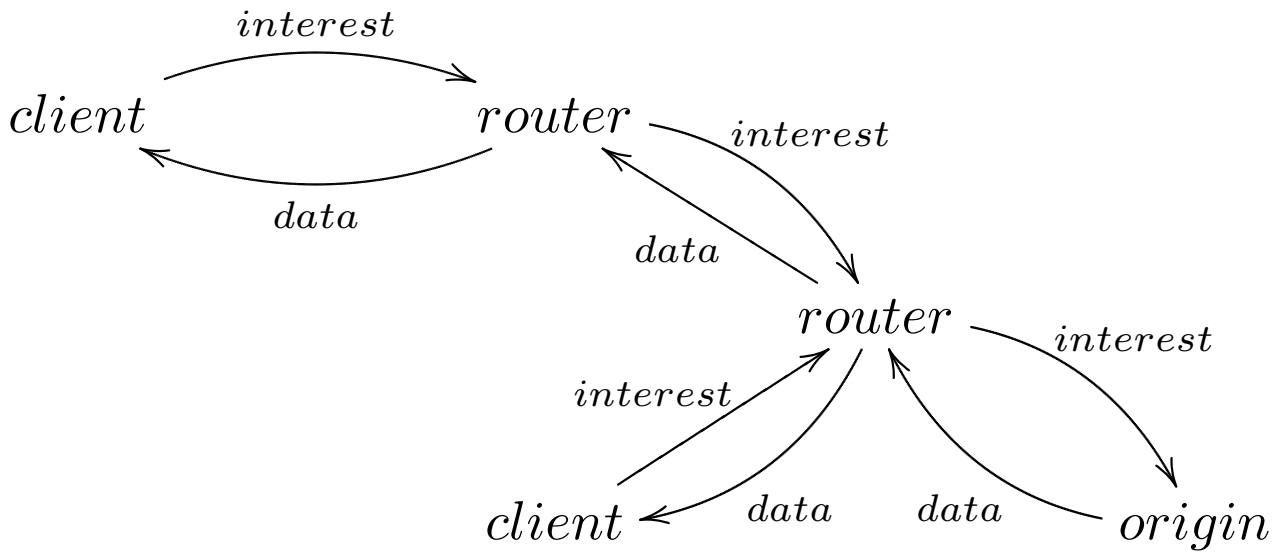

Figure: Abstract CCNx overview[6]

- Interest packets create soft-state (Pending Interest entry)
- Soft-states timeout or are cleared by corresponding data packet

NDN / CCNx

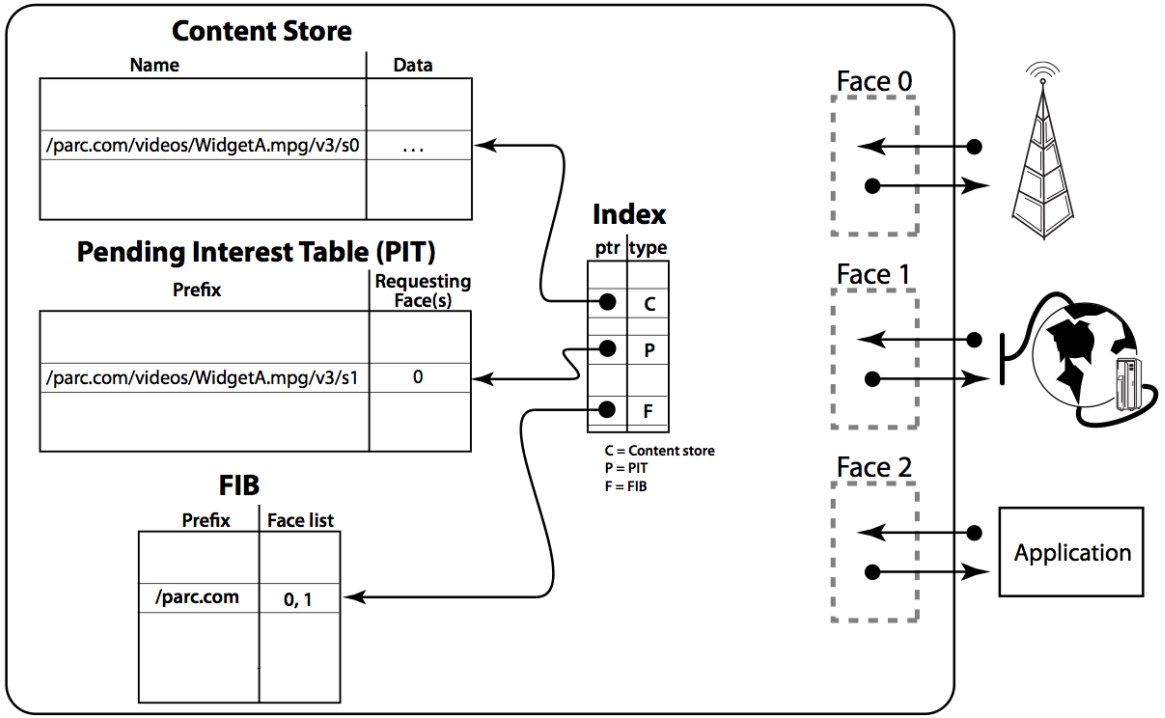

Figure: Conceptual CCNx router architecture[16]

Caching

- Performed on chunk basis
- Takes just on-path copies into account
  (on-path from subscriber to publisher)

Related Work

- NetInf

NetInf Overview

- Network of Information (NetInf)[2]
- Part of 4Ward and SAIL (European FP7 research Projects)

NetInf

Name resolution / routing

- Two-step resolve/retrieve
- Utilises Multilevel-DHT for rendezvous-system
- Rendezvous-system yields topology based address

Security

- Provides self-certifying data structures
  - No external trust mechanism needed to verify data integrity

Caching

- Two ways to find cached copy
  - Registered copy in Name Resolution Service (NRS)
  - On-net copy found while routing subscription to the source that the NRS returned

Naming

- Flat names
- Non human-friendly

Type	Hash(PublicKey)	Label

Figure: content id / name[5]

NetInf

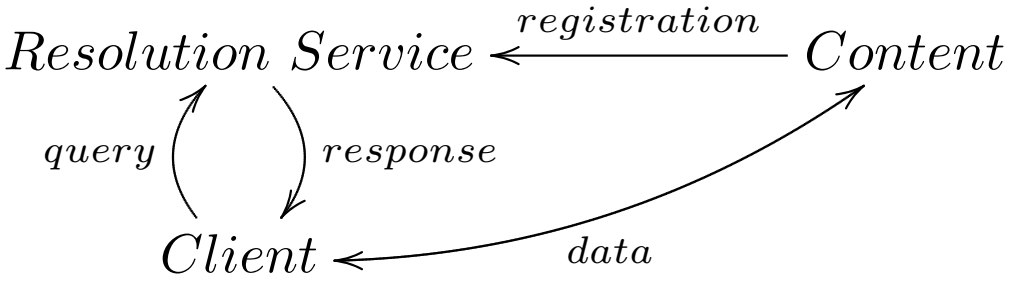

Figure: Abstract NetInf overview[6]

- NRS is queried for topology based address
- Content is transferred

Related Work

- PSIRP

PSIRP Overview

- Publish-Subscribe Internet Routing Paradigm
- European FP7 research project
- Continues as PURSUIT (Publish-Subscribe Internet Technologies)

Name resolution / routing

- Two-step resolve/retrieve
- Topology Manager creates zFilter (Bloom filter) describing path from subscriber to publisher
- Namespace scopes are restricted

PSIRP

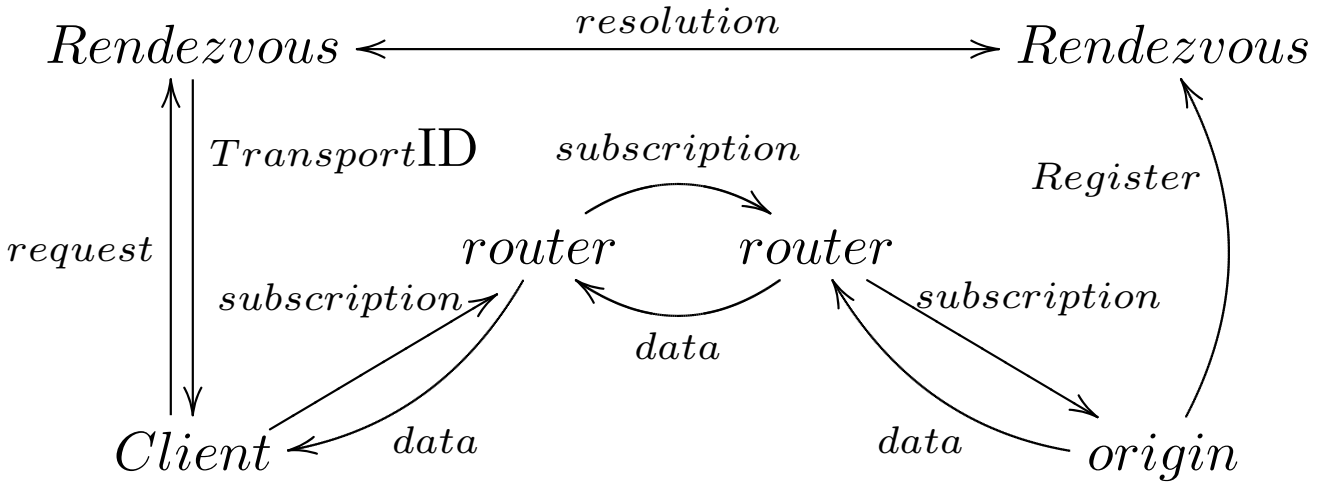

Figure: Abstract CCNx overview[6]

- Uses source routing
- NRS is queried for zFilter
- Request is routed to content source
- Content is transferred

zFilter[10]

- Use Link IDs to construct Bloom filter
- x_1 and x_2 are Link IDs
- Attached to every packet
- Hop-by-hop evaluation against link table
- False-positives possible

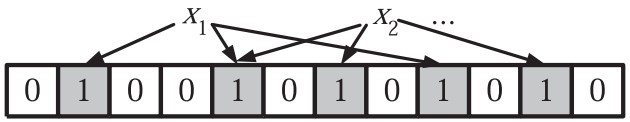

Figure: Bloom filter construction[7]

PSIRP

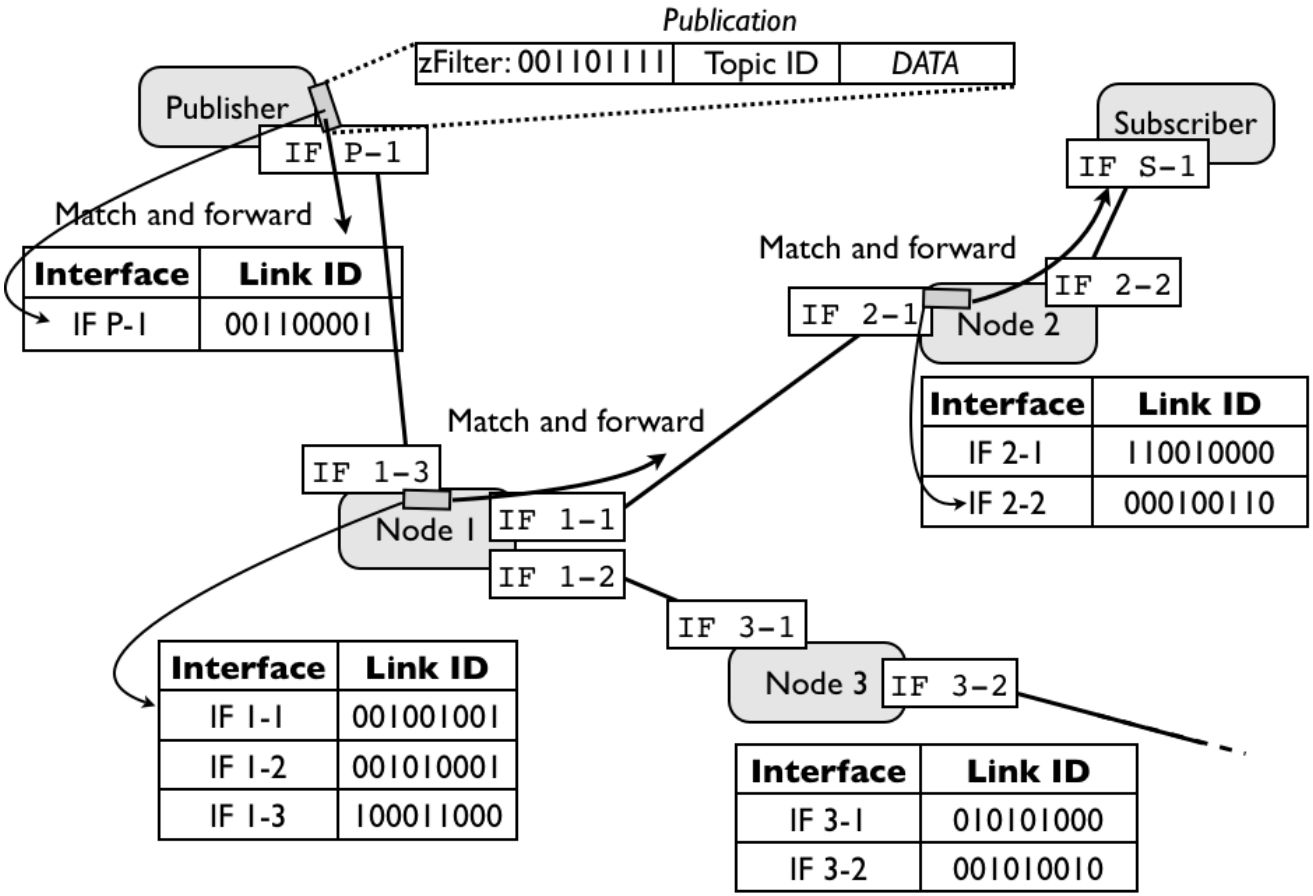

Figure: zFilter based forwarding[10]

- Uses source routing

PSIRP

Caching

- Along transmission path
- Registered within Name Resolution System

Naming

- Non human-friendly
- Split into various abstraction levels

Naming

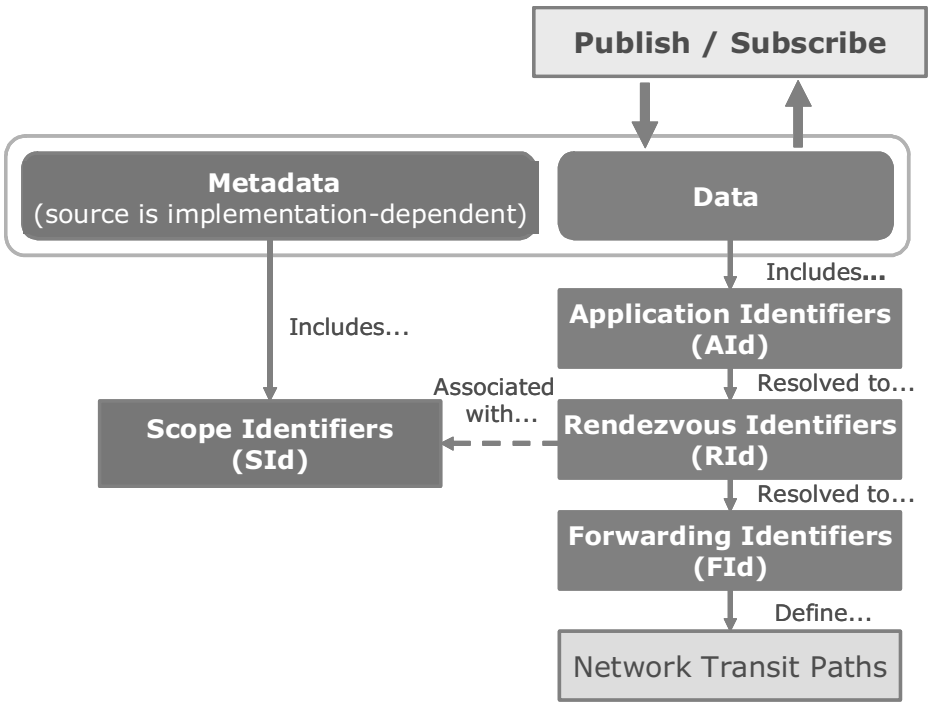

Figure: PSIRP ID coherence[12]

- Application ID

  Used by publishers and subscribers
- Rendezvous ID

  Bridge higher level with lower layer identifiers
- Scope ID

  Delimit reachability of given information
- Forwarding ID

  Defines network transit paths

Comparison

Comparison: Routing & Forwarding

Data path

- In NDN/CCNx data can only flow along the reverse path the interest packets take
- NetInf and PSIRP allow for different paths

Network states

- In CCNx soft-states are created by each interest packets what may lead to resource exhaustion (CPU/Memory)[14]
- PSIRP utilises zFilters attached to packets thus no states need to be maintained in the network

Comparison: Naming

Naming

- CCNx names are human-friendly
- NetInf and PSIRP are not human-friendly hence may require mapping service

Versioning

- NetInf and CCNx support versioning of content
- PSIRP leaves versioning to the application through the Application ID

Comparison: Information scope

Scoping

- NetInf has no mechanism of restricting the availability scope of content so far[1]
- PSIRP utilises a Scope ID to restrict the accessibility
- CCNx can use export policies to restrict routing information

[1] possible approaches are mentioned in [6]

Future Work

Future Work

Open topics

- Scalability
- Non human-friendly names

  Secure name mapping service needed
- Scoping of content

  Limiting the reach of information
- Source mobility
- Disruption Tolerance / Delay Tolerant Networking (DTN)
- Security

  Infrastructure attacks

Thanks for your attention!

References I

[1] The Named Data Networking Homepage.
http://www.named-data.net, 2012.

[2] The NetInf Homepage.
http://www.netinf.org, 2012.

[3] The PSIRP Homepage.
http://www.psirp.org, 2012.

[4] The PURSUIT Homepage.
http://www.fp7-pursuit.eu, 2012.

References II

[5] Ahlgren, B., D'Ambrosio, M., Dannewitz, C., Eriksson, A., Golic, J., Grönvall, B., Horne, D., Lindgren, A., Mämmelä, O., Marchisio, M., Mäkelä, J., Nechifor, S., Ohlman, B., Pentikousis, K., Randriamasy, S., Rautio, T., Renault, E., Seittenranta, P., Strandberg, O., Tarnauca, B., Vercellone, V., and Zeghlache, D.
Second NetInf Architecture Description.
Deliverable D6.2, 4WARD Project.

[6] Ahlgren, B., Dannewitz, C., Imbrenda, C., Kutscher, D., and Ohlmann, B.
A Survey of Information-Centric Networking (Draft).
Tech. Rep. 10492, Dagstuhl Seminar Proceedings, 2011.

References III

[7] Broder, A. Z., and Mitzenmacher, M.
Survey: Network applications of bloom filters: A survey.
Internet Mathematics 1, 4 (2003), 485–509.

[8] Day, M., Cain, B., Tomlinson, G., and Rzewski, P.
A Model for Content Internetworking (CDI).
RFC 3466, RFC-Editor, Feb. 2003.

[9] Hofmann, M., and Beaumont, L. R.
Content Networking: Architecture, Protocols, and Practice (The Morgan Kaufmann Series in Networking).
Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 2005.

References IV

[10] Jokela, P., Zahemszky, A., Rothenberg, C. E., Arianfar, S., and Nikander, P.
LIPSIN: Line Speed Publish/Subscribe Inter-networking.
In *Proc. of the ACM SIGCOMM 2009* (New York, NY, USA, 2009), ACM, pp. 195–206.

[11] PARC.
The CCNx Homepage.
`http://www.ccnx.org`, 2012.

[12] Tarkoma, S., Ain, M., and Visala, K.
The publish/subscribe internet routing paradigm (psirp): Designing the future internet architecture.
In *Future Internet Assembly* (2009), G. Tselentis, J. Domingue, A. Galis, A. Gavras, D. Hausheer, S. Krco, V. Lotz, and T. Zahariadis, Eds., IOS Press, pp. 102–111.

References V

[13] Vahlenkamp, M.
Content Delivery Networks - Chancen und Konzepte für Internet Service Provider.
Bachelor-Thesis, Hamburg University of Applied Science, Apr. 2011.

[14] Wählisch, M., Schmidt, T. C., and Vahlenkamp, M.
Backscatter from the Data Plane — Threats to Stability and Security in Information-Centric Networking.
Technical Report arXiv:1205.4778v1, Open Archive: arXiv.org, 2012.

[15] Yin, H., Liu, X., Min, G., and Lin, C.
Content delivery networks: A bridge between emerging applications and future IP networks.
Network, IEEE 24, 4 (July 2010), 52–56.

References VI

[16] Zhang, L., Estrin, D., Burke, J., Jacobson, V., and Thornton, J. D.
Named Data Networking (NDN) Project.
Tech.report ndn-0001, PARC, 2010.