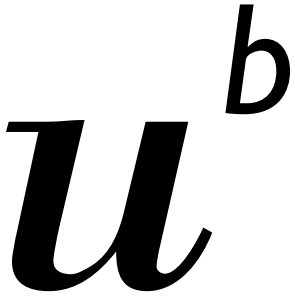

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Advanced Networking and Future Internet

VIII. Information-Centric Networking

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Advanced Networking and Future Internet: Information-Centric Networking

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Table of Contents

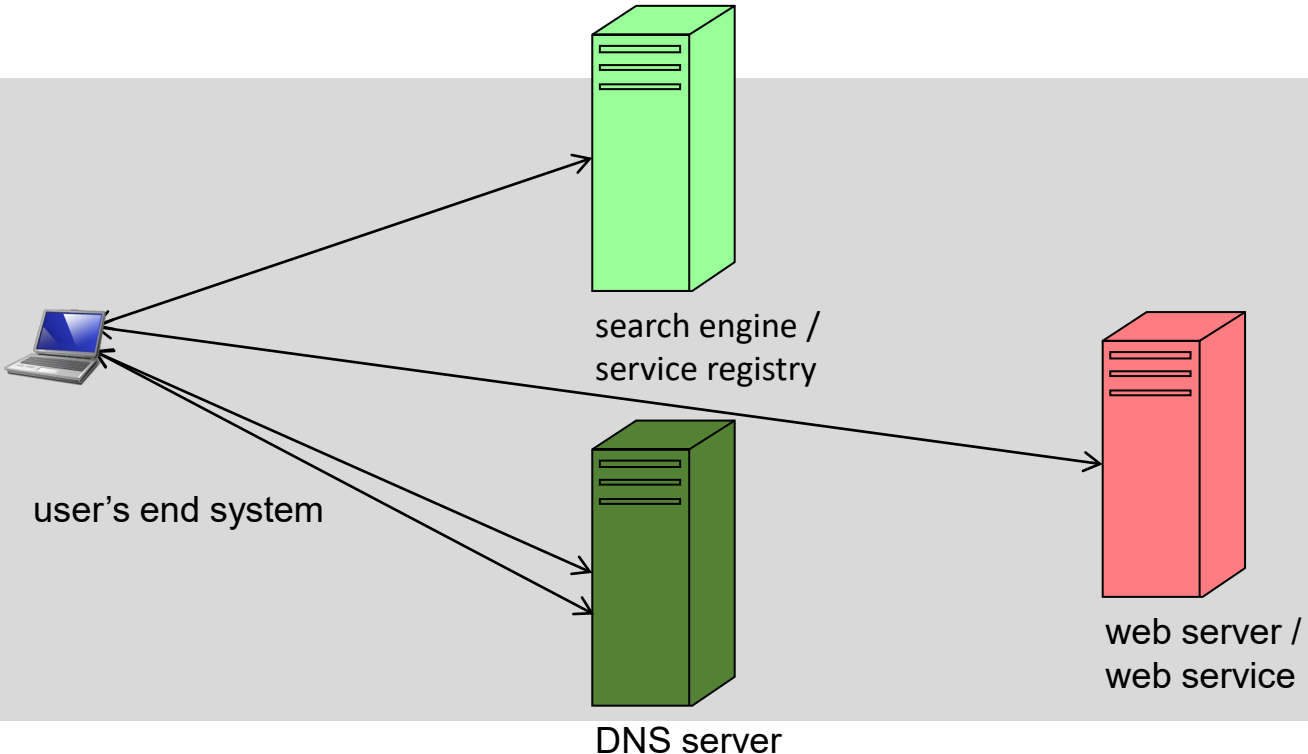
1. Introduction

1. Motivation for Information-Centric Networking

- Today's network traffic is dominated by information retrieval rather than point-to-point communication between machines or humans.
- Circuit communication model is not considered as appropriate any more.
- Future communication architecture should focus on information objects instead of nodes.
- Today, wires and memories solve complimentary aspects of the same problem:
  - Wires move information in space.
  - Memories move information in time.
- Future communications architecture should unify both issues.
- Flash crowds are difficult to avoid in IP-based networks.

1. Introduction

2. Traditional Web Retrieval / Web Services



2. ICN

1. Related Work

- Peer-to-Peer Networks
  - Construction of overlay networks
  - Content / service discovery, e.g., using distributed hash tables, flooding, random walks, etc.
- Web Caching
  - Providing content for local users
- Content Distribution Networks
  - Routing and redirection of HTTP requests
  - Cache management

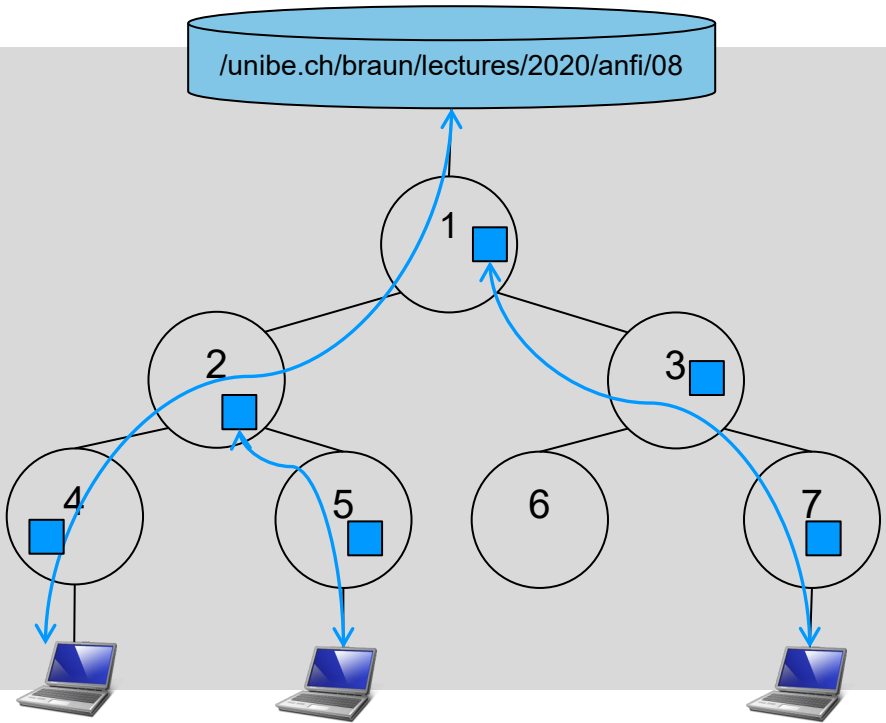
2. ICN

2. Key Principles and Functions

- Naming of content rather than hosts / interfaces
  - Content is independent of devices that store it.
  - Naming is location independent (mobility support !)
- Receivers (subscribers) request content.
- Senders (publishers) advertise content.
- Receivers and senders do not have to be aware of each other, and are decoupled in time.
- Functions needed
  - Name resolution (rendezvous) to match subscriptions and publications
  - Routing and path formation
  - Forwarding content from publisher to subscriber

2. ICN

3. Content Distribution



2. ICN

4. Naming Approaches

Human-readable, hierarchical names

- support aggregation.
- need coordination.
- Example: CCN

Flat (self-certifying) names

- are often based on hashing content name and / or owner's public key.
- Aggregation is more difficult.
- Examples: PSI

2. ICN

5. Name Resolution and Data Transport

Decoupled

- Name resolution and data transport are independent of each other, cf. DNS, with possibly different nodes for resolution and data transport.
- allows different, possibly already existing transport mechanisms, also multi-path
- Examples: PSI

Coupled

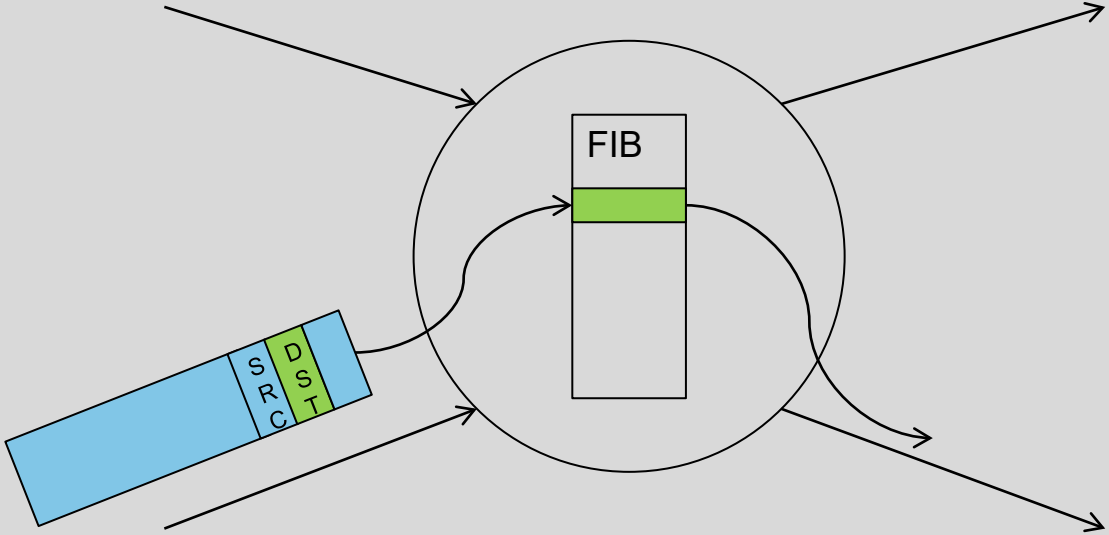
- Nodes for both name resolution and data transport with inverse data path compared to search path
- rather disruptive technology
- Local routing procedures advantageous in case of short link disruptions
- Variants
  - 2 phases: mapping of ID to locator, routing to data source
  - 1 phase: direct ID-based routing to data source
- Example: CCN

3. Content-Centric Networking

- Combination of content lookup and message routing
- Idea: describe the users' interests in the message header, but not where to get it
- Messages (using XML encoding)
  - Interest: content name, selector
  - Data: content name, signature (info), data
- Hierarchical content names
  - Example: /unibe.ch/braun/lectures/2020/anfi/08
- Related Projects
  - NDN = Named Data Networking, www.named-data.net
  - CCNx = Open Source Core Software Project for Content-Centric Networking, www.ccnx.org

3. CCN

1. IP Model

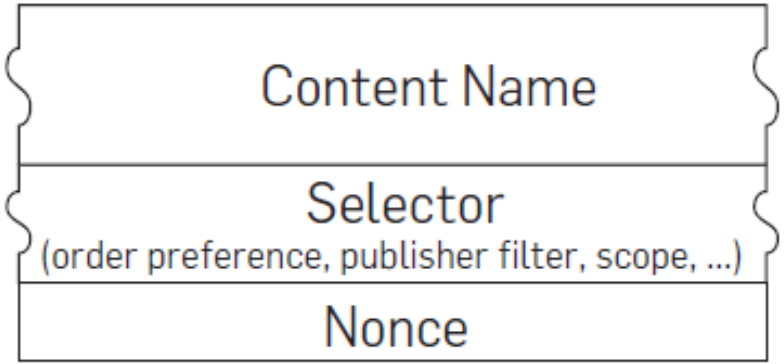


FIB: Forwarding Information Base

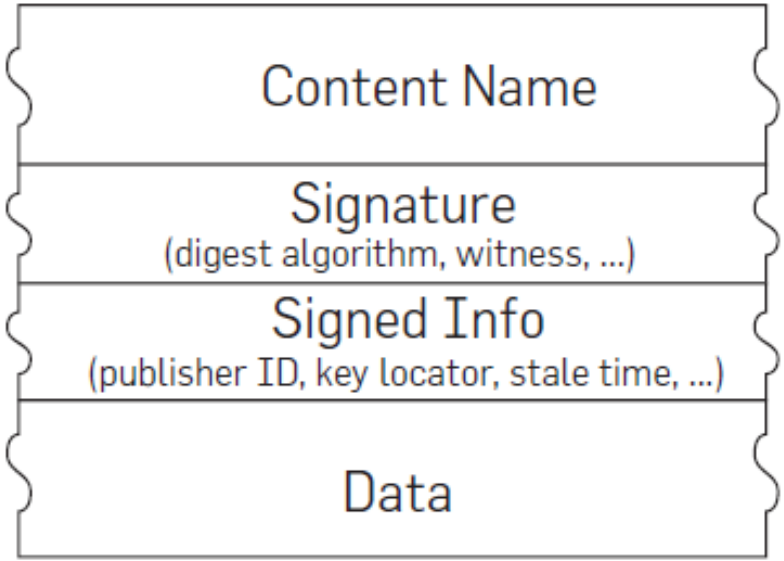
3. CCN

2. Messages

Interest Message



Data Message



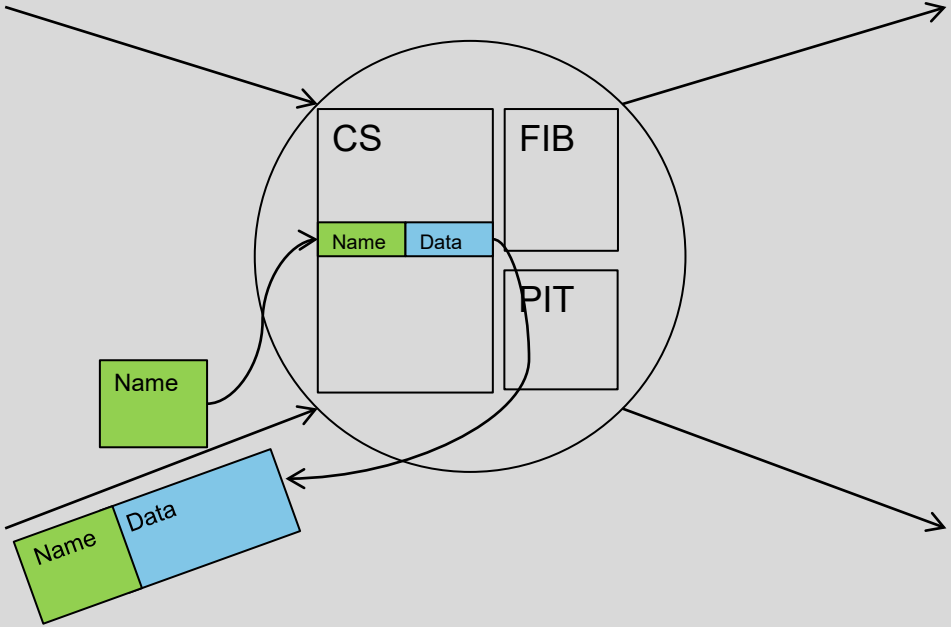
3. ICN

3. Interest Message Processing

1. Longest prefix match on content name in **Content Store**: returning data and discarding Interest
2. **Forwarding Information Base** match: forwarding of Interest towards data
   - FIB population by announcements of content availability
3. **Pending Interest Table** match: adding request to PIT and discarding Interest

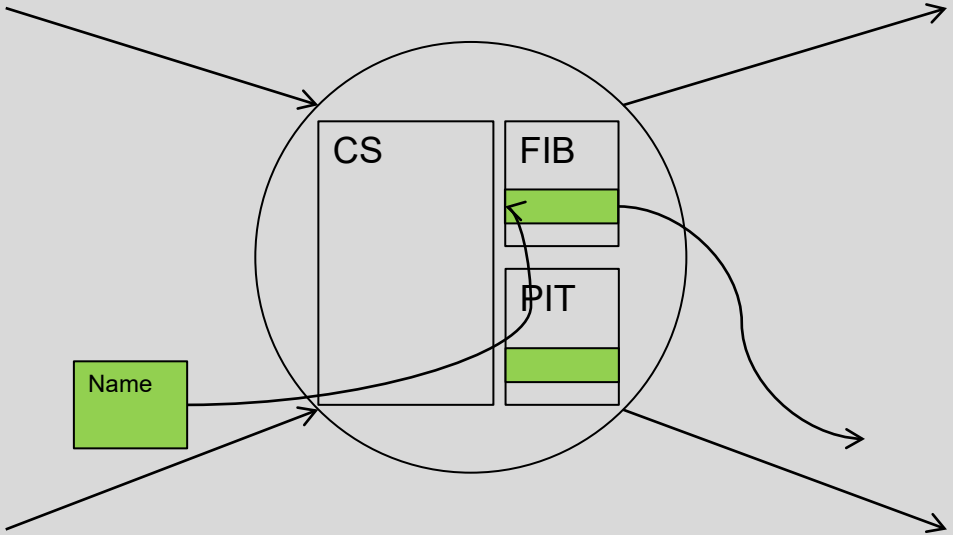
3. CCN

3.1 Match in Content Store



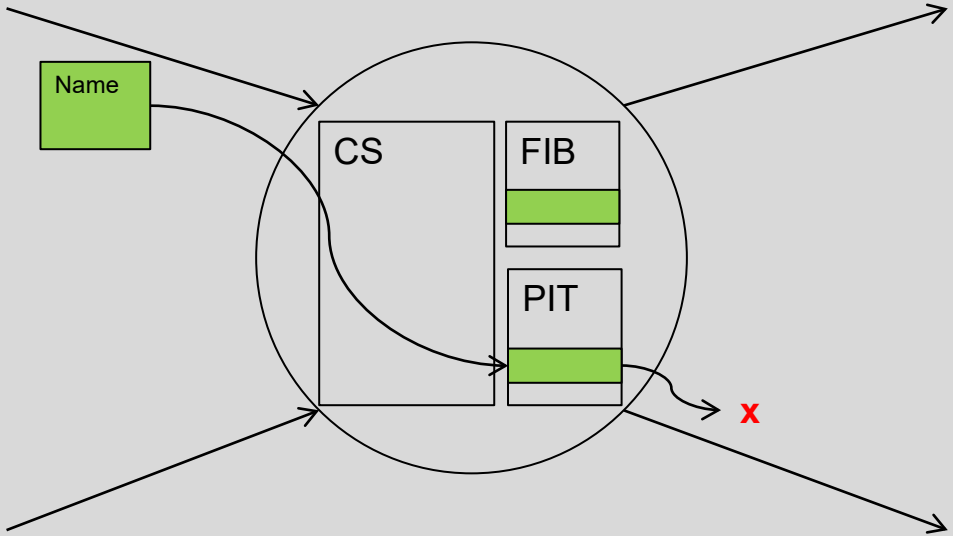
3. CCN

3.2 Match in Forwarding Information Base



3. CCN

3.3 Match in Pending Interest Table



3. CCN

4. Naming

- Any kind of names are possible
  → flexible naming
- Examples
  - /unibe.ch/braun/lectures/2020/anfi/08
  - /unibe.ch/E8/Room003/Projector
- Support for simple operations
  - %C1.org.ccnx.frobnicate~1~37
  - command in namespace org.ccnx
  - operation is frobnicate, which takes 1 and 37 as arguments
- Naming resolution approach: coupled with 1 phase

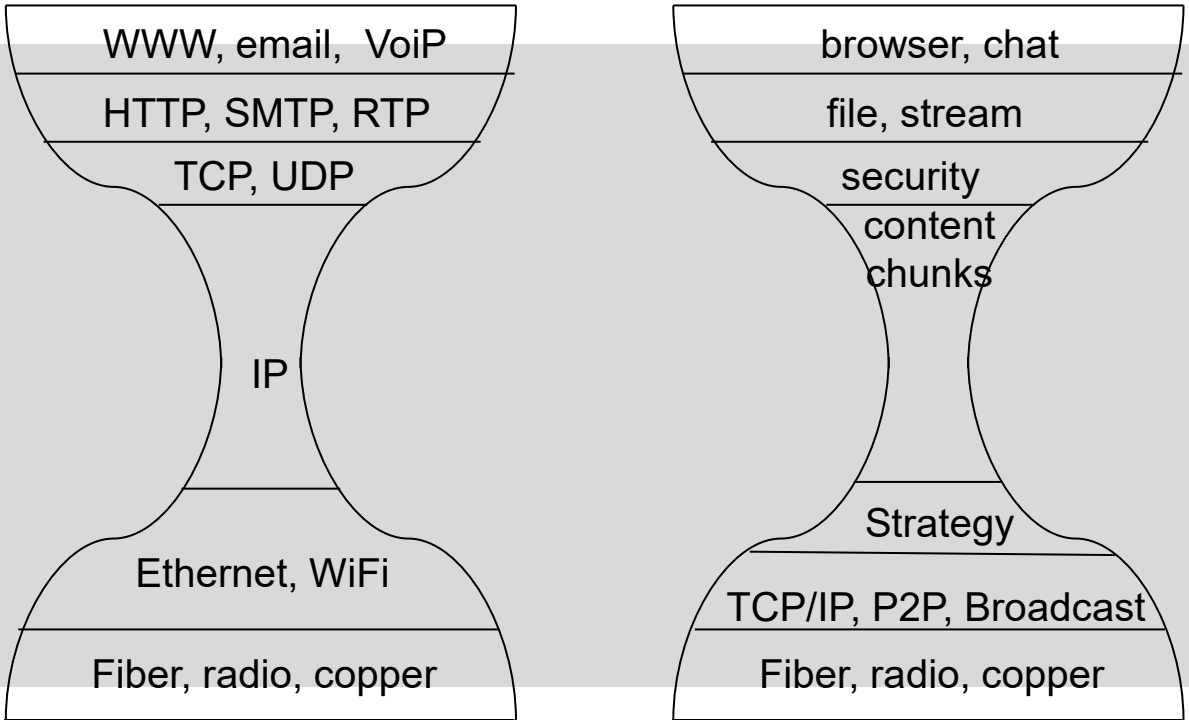
3. CCN

5. Routing

- Longest Prefix Match Routing (as in IP)
- But: different FIB entry semantics
  - IP: IP address prefix *will be reached* via an outgoing interface for an existing FIB entry.
  - CCN: Content name prefix *might be reached* via an outgoing interface for an existing FIB entry.
- FIB entries should be populated proactively for known content.
- Alternatively, searching for content, e.g., using broadcasting

3. CCN

6. Hour-Glass Models



3. CCN

7. Transport

- Stateless operation with receiver control
- Pipelining: multiple outstanding Interest messages
- Reliability by local retransmissions in strategy layer
- Hop-by-hop flow control
- Sequence numbers in names

3. CCN

8. Security

- Signing of names and data in each packet
- Denial-of-Service attacks are difficult:
  Combination of multiple Interests and only 1 data packet per Interest

3. CCN

9. Discussion

Advantages

- Automatic content distribution
- Latency < 1 round-trip-time
- Minimization of latency
- Minimization of bandwidth
- Local congestion control
- Built-in security

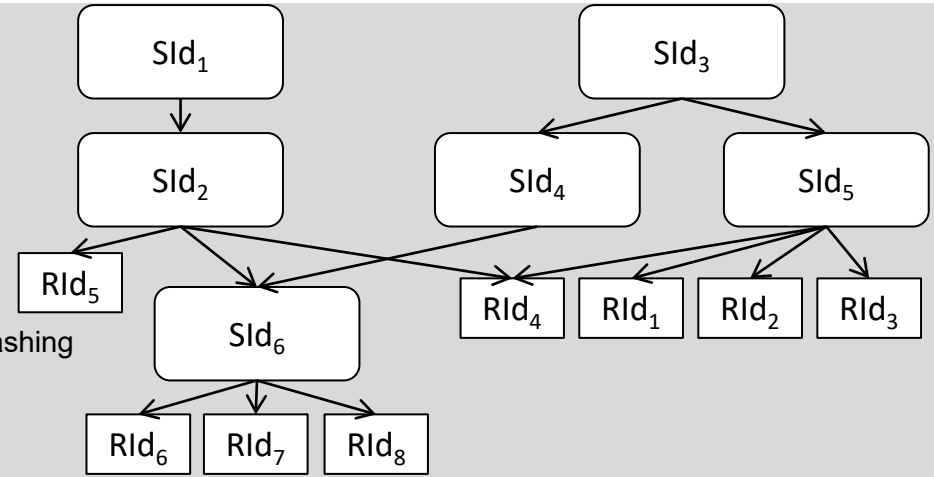
Drawbacks and problems

- Routing
- Hierarchical naming
- Source mobility

4. Publish-Subscribe Internet

1. Naming

- Information items = files, streams, services
- Each information item has its own name.
- Names are unique (SID, RID) pairs
  - Rendezvous Identifier (RID)
    - denotes information item
    - fixed-length, (flat) bit string
    - produced by application specific function, e.g., hashing
  - Scope Identifier (SID)
    - denotes scopes
    - Sequence of RID-like strings
    - Each information item may belong to one or more scopes.
    - Basis for access control
- Scope hierarchy with information belonging to different scopes.



4. PSI

2. Network Primitives

Subscribe

- used to express interest in information items
- Users can subscribe to information items or scopes. (SID/RID) must be known.

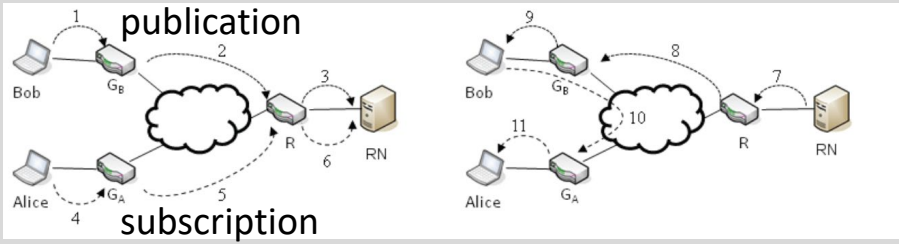
Publish

- used to announce information items or scopes

4. PSI

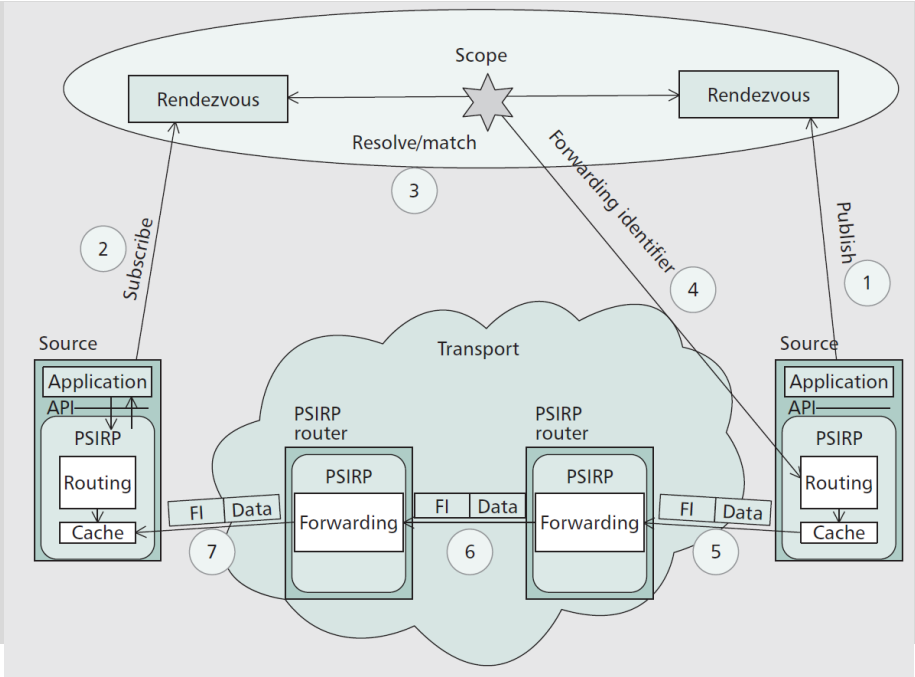
3.1 Operation

- Information producer publishes information item to rendezvous system consisting of rendezvous points. (1-3)
- Rendezvous points are responsible for certain scopes.
- Information consumer subscribes to information item. (4-6)
- Rendezvous system
  - matches announcements and subscriptions
  - triggers delivery from information producer to information consumer, e.g. using OpenFlow, (7-11)
- Various caching strategies: on-path, off-path, replication



4. PSI

3.2 Operation



Thanks

for Your Attention

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Bern, 02.11.2020