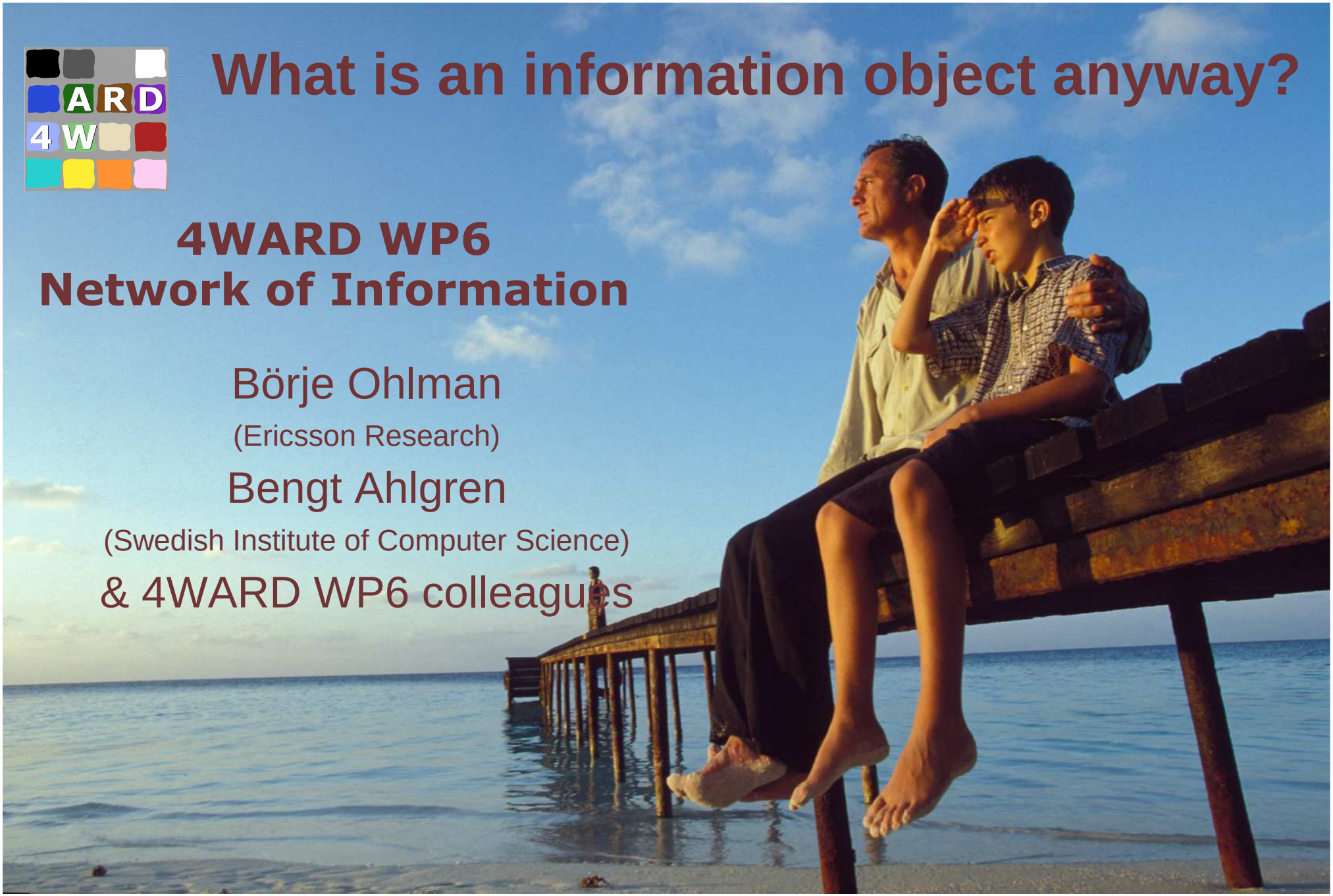
What is an information object anyway?



4WARD WP6
Network of Information

Börje Ohlman

(Ericsson Research)

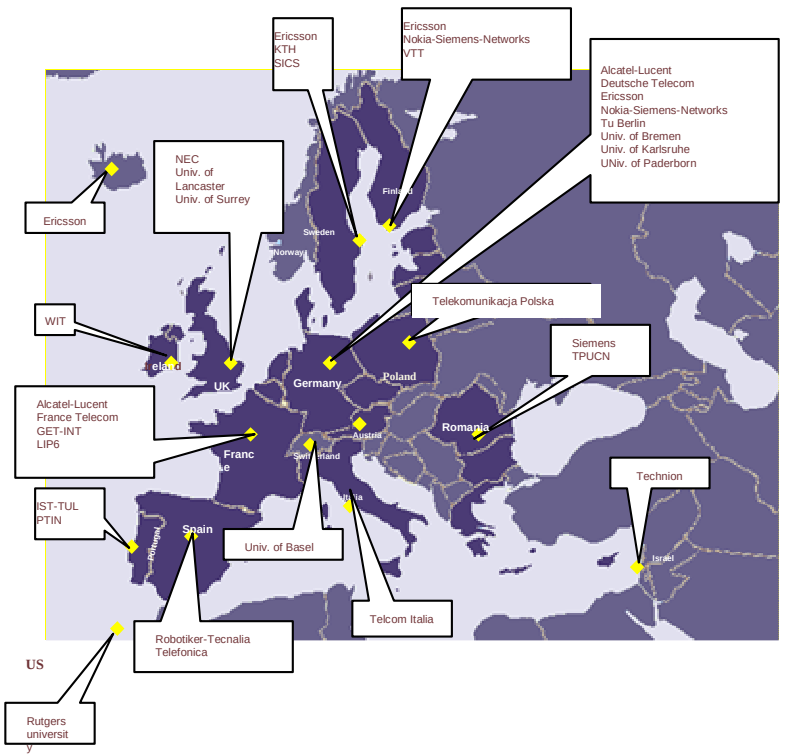
Bengt Ahlgren

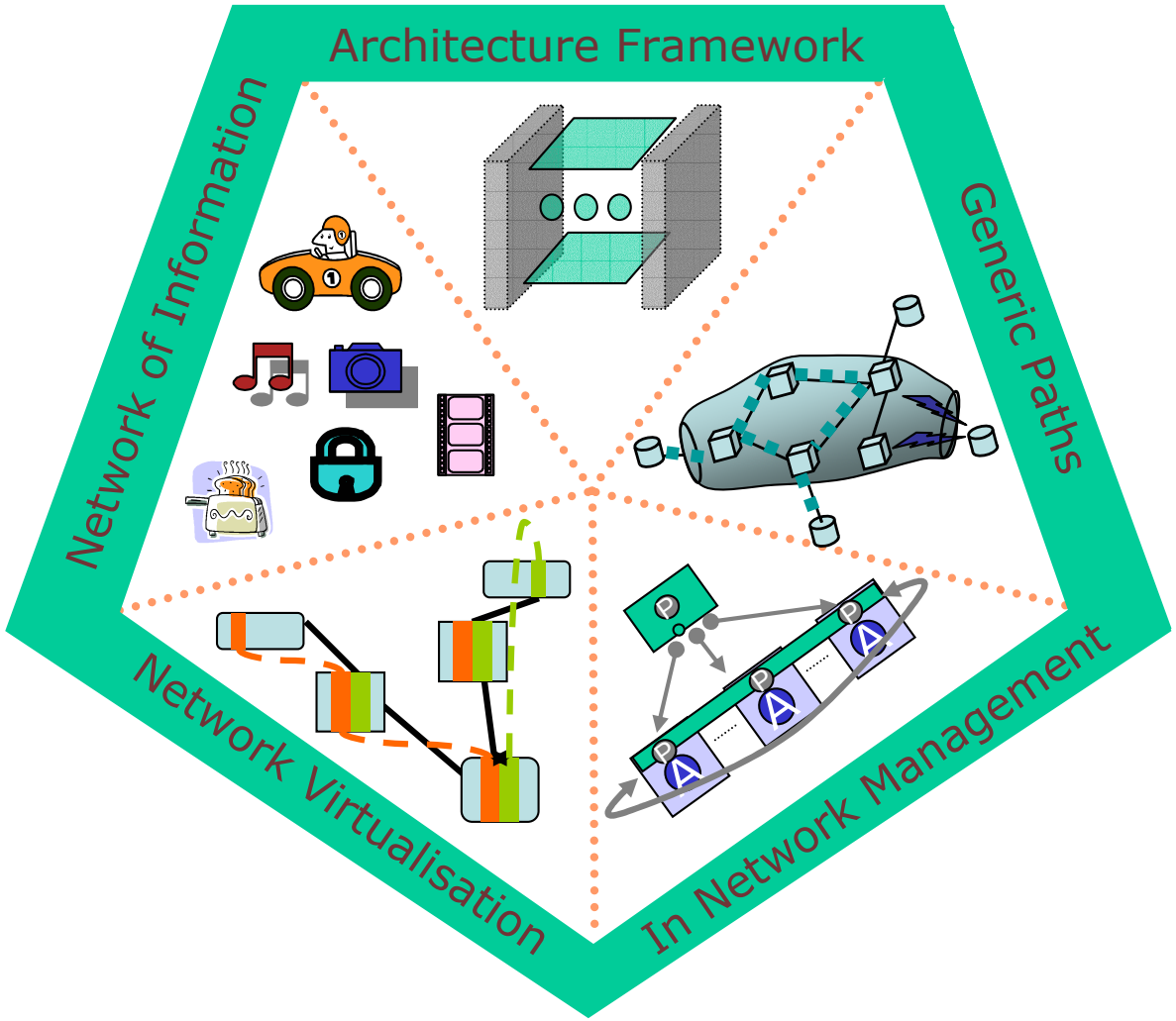
(Swedish Institute of Computer Science)

& 4WARD WP6 colleagues

SEVENTH FRAMEWORK PROGRAMME

4ward.nu

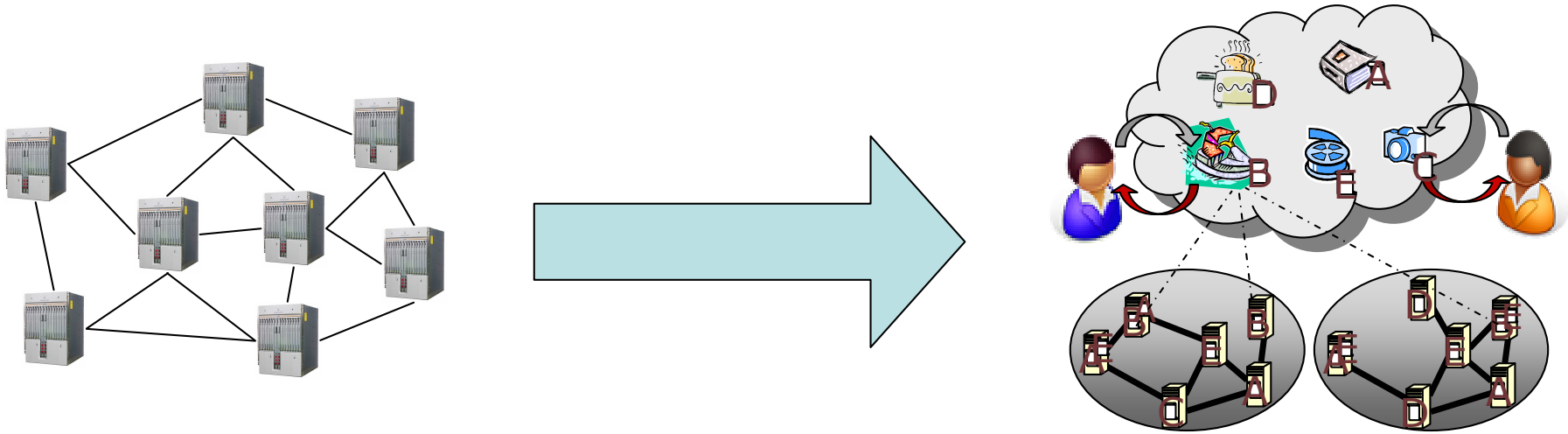




- Combination of clean-slate research approaches to address the **Network of the Future**
- Size: Roughly 23 M€
- Time frame: 2008-2009

SEVENTH FRAMEWORK PROGRAMME

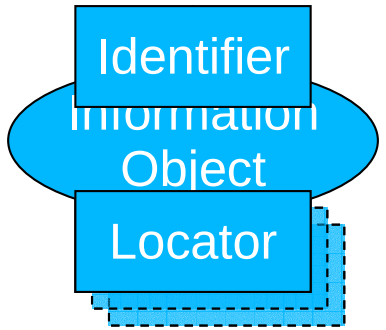
What is an information object anyway?



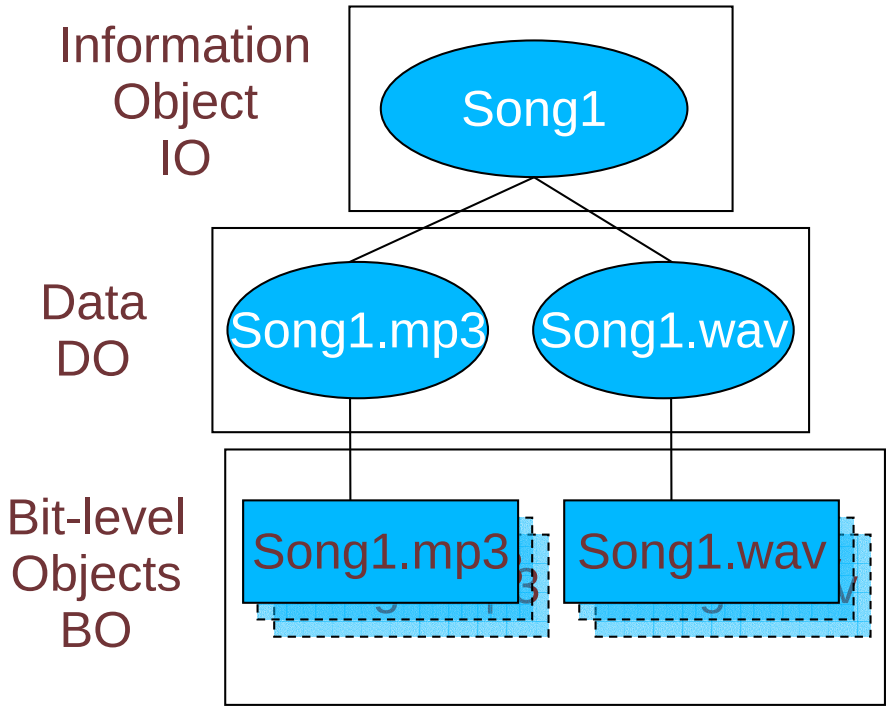
- What are the primary components of an information centric network?
- How should an information object be named?
- Desirable properties of a name
- Components of a proposed naming scheme

Identifiers and Information Modeling

- *Persistently identify information*
  - Location-independent identifiers
  - Represent *multiple copies*
- *Representation of information* via *Information Objects (IOs)*
  - Another level of indirection
  - Represent information **independent** of a *specific copy*
    - *E.g. a text, a song*
  - Consists of a set of attributes
    - Including media components, GPS location, access rights, encoding
- Information Objects can also represent:
  - Streams
  - Services
  - Real-world objects (e.g., a physical copy of a book, a person)
- IOs can be used to organize information



Organize Information – IO, DO and BO definitions



Information Object (IO)	An Information Object is a set of attributes defining the semantics of a data object. An IO may refer to a piece of music, a film or a webpage. Can be static, dynamic or real-world objects, including streams and services
Data Object (DO)	Sub-class of IO holding attributes for bit-level objects and pointer(s) to the actual data.
Bit-level Object (BO)	A specific sequence of bits, independent of any semantic meaning, also independent of where they exist, like in a file, on the wire, in the air or in a primary memory.

Naming Requirements

- NetInf prioritized:
  - Self-certification and self-generation
    - Reduce the need for trust in the infrastructure
    - Data integrity
    - No need for a new naming authority
  - Persistent names, inert to:
    - **Owner change**
    - **Content change**
    - **Algorithm changes** (hash or crypto)
  - Support for all types of information objects:
    - Real world, Services, Streams, Static files, Dynamic data
  - Globally unique names

- More on the wish list:
  - Owner/Publisher authentication
  - Variable length
  - Human readable
  - Minimize load on (Name Resolution) infrastructure

Naming tradeoffs

- Self certification vs. Dynamic objects, Real world object, Services
- Persistent naming vs. Self certification & Dynamic objects
- Verifying ownership by naming vs. persistent names and allowing change of ownership
- Simplicity vs. flexibility

NetInf Naming

Tag	$P=Hash(PublicKey_{Owner})$	L={Hash(C) | String}

Tag
- Defines the format
  - Hash algorithm used (SHA1, MD5, …)

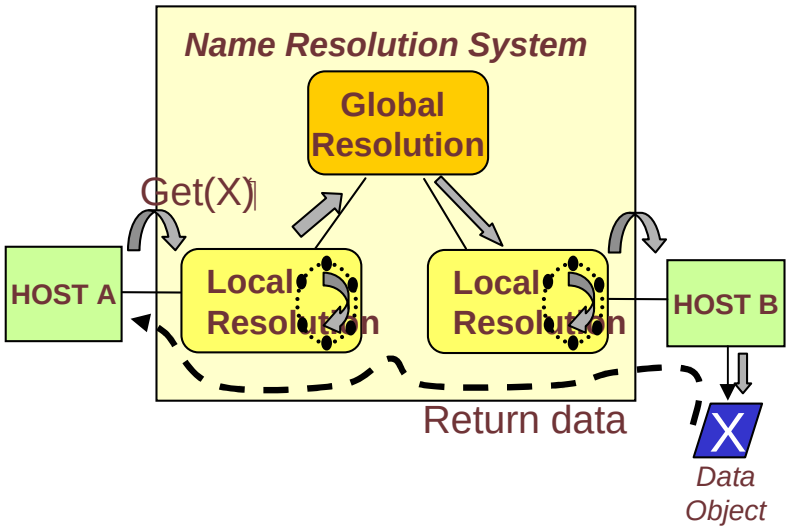
Principal (P)
- Object ‘publisher’ (optional)
  - Owner
  - Creator
  - Anonymizing service

IDs have no hierarchical structure
Strong influence on name resolution!

Label (L)
- Identifying individual object published by Principal
  - Hash of object or label created by principal

Two approaches to name resolution

- Multiple DHTs (MDHT)
  - Hierarchical DHTs (Provider-based)
  - Topological embedding of DHTs
  - Name-based routing



- Late Locator Construction (LLC)
  - Attachment registers to keep track of immediately attached neighbours
  - Hierarchical locators constructed on demand at the time of session initiation

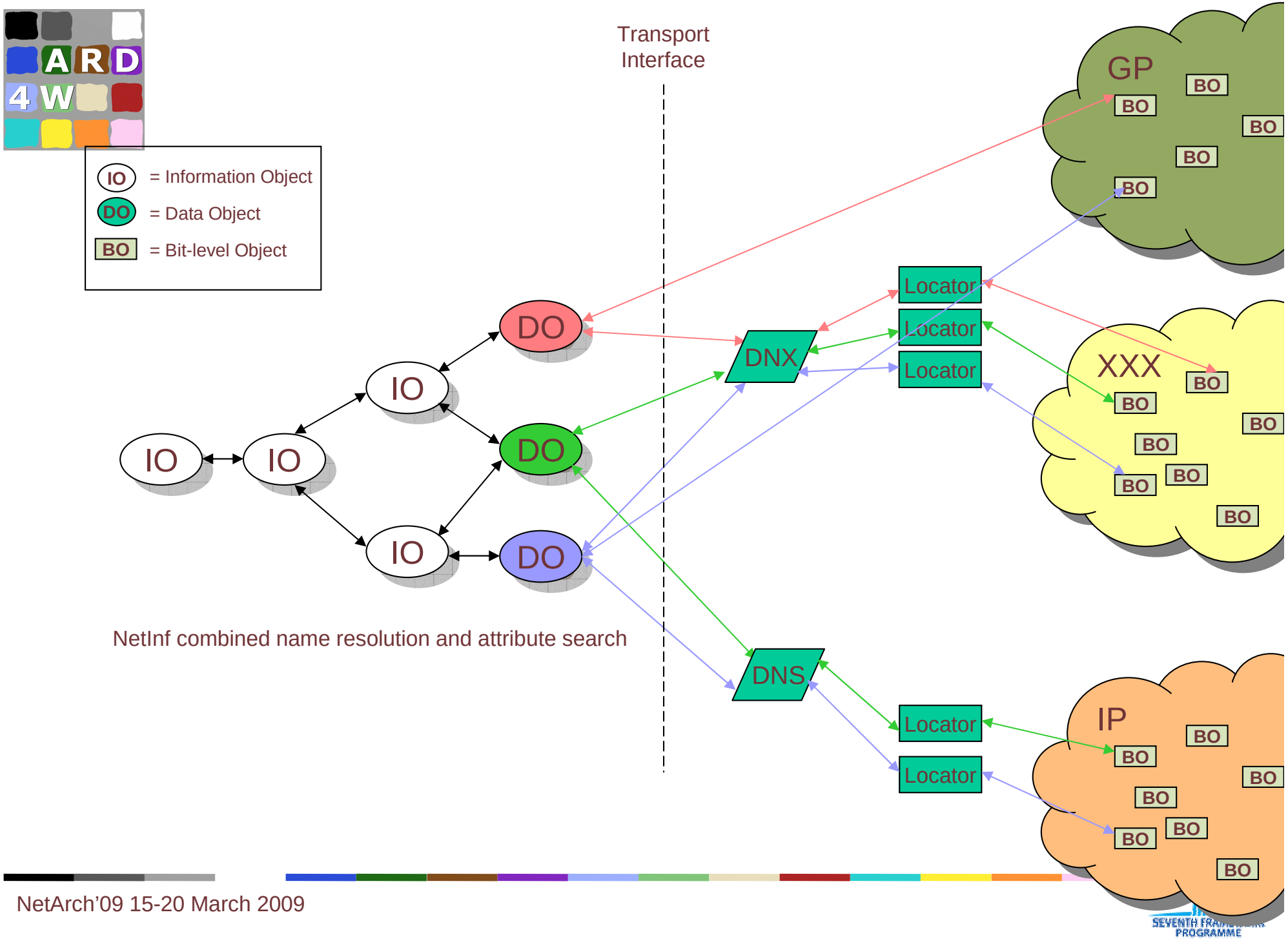
Conclusion

- Design of a *new network architecture* based on *information-centric* paradigm
  - Rather than based on a *host-centric* paradigm

- Some characteristics of Networking of Information (NetInf)
  - Information model: information object, data object, bit-level object
  - Naming scheme for *naming information objects* independent of nodes
  - Scalable solution for node and *network mobility and multihoming*
  - Enable efficient *information dissemination*
    - Benefit from *available copies, anycast, s*olve *Flash-Crowd Effect, …*
  - *Secure information-centric architecture* by embedding security into identifiers
  - A *common infrastructure and API* for accessing all types of objects (including real world objects), regardless of their location
  - *Scalable* name to locator resolution for 10^{15} objects and beyond
  - Designing NetInf to make it largely self-managing

Thank you for your attention

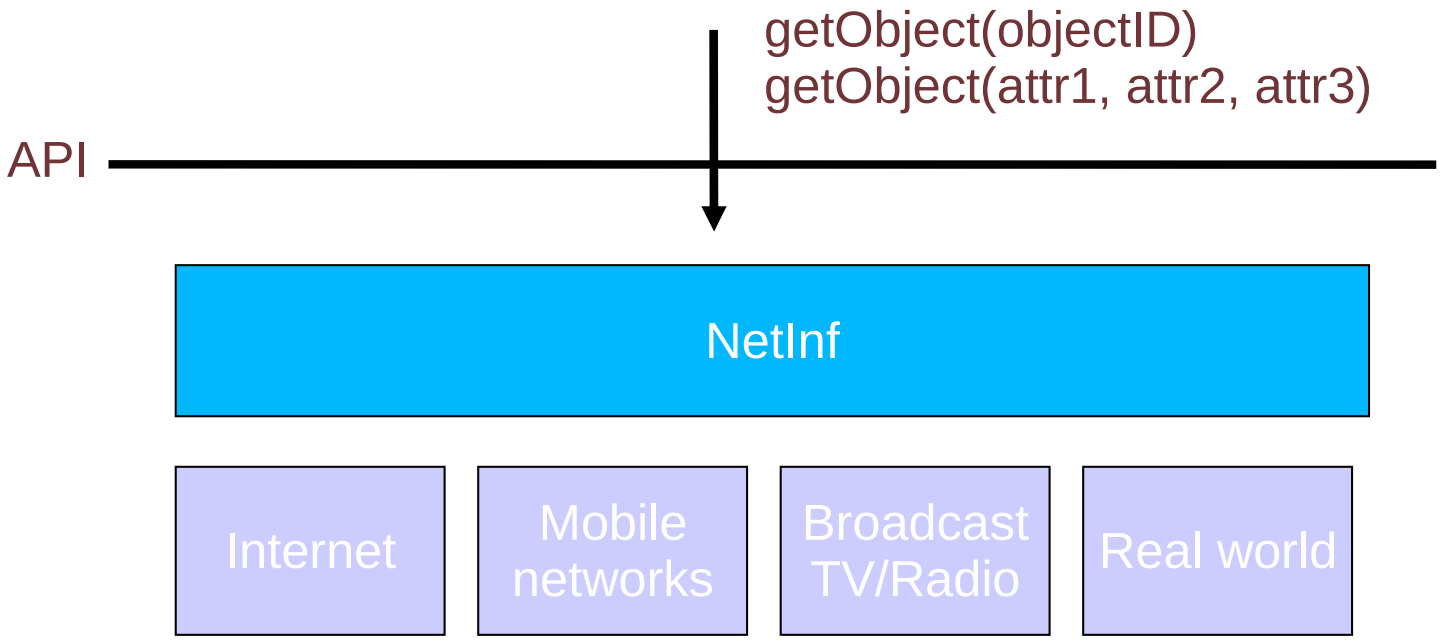
Backup Slides


IO = Information Object
DO = Data Object
BO = Bit-level Object
Transport Interface
IO
IO
IO
DO
DO
DO
DNX
DNS
Locator
Locator
Locator
Locator
Locator
GP
BO
XXX
BO
IP
BO
NetInf combined name resolution and attribute search

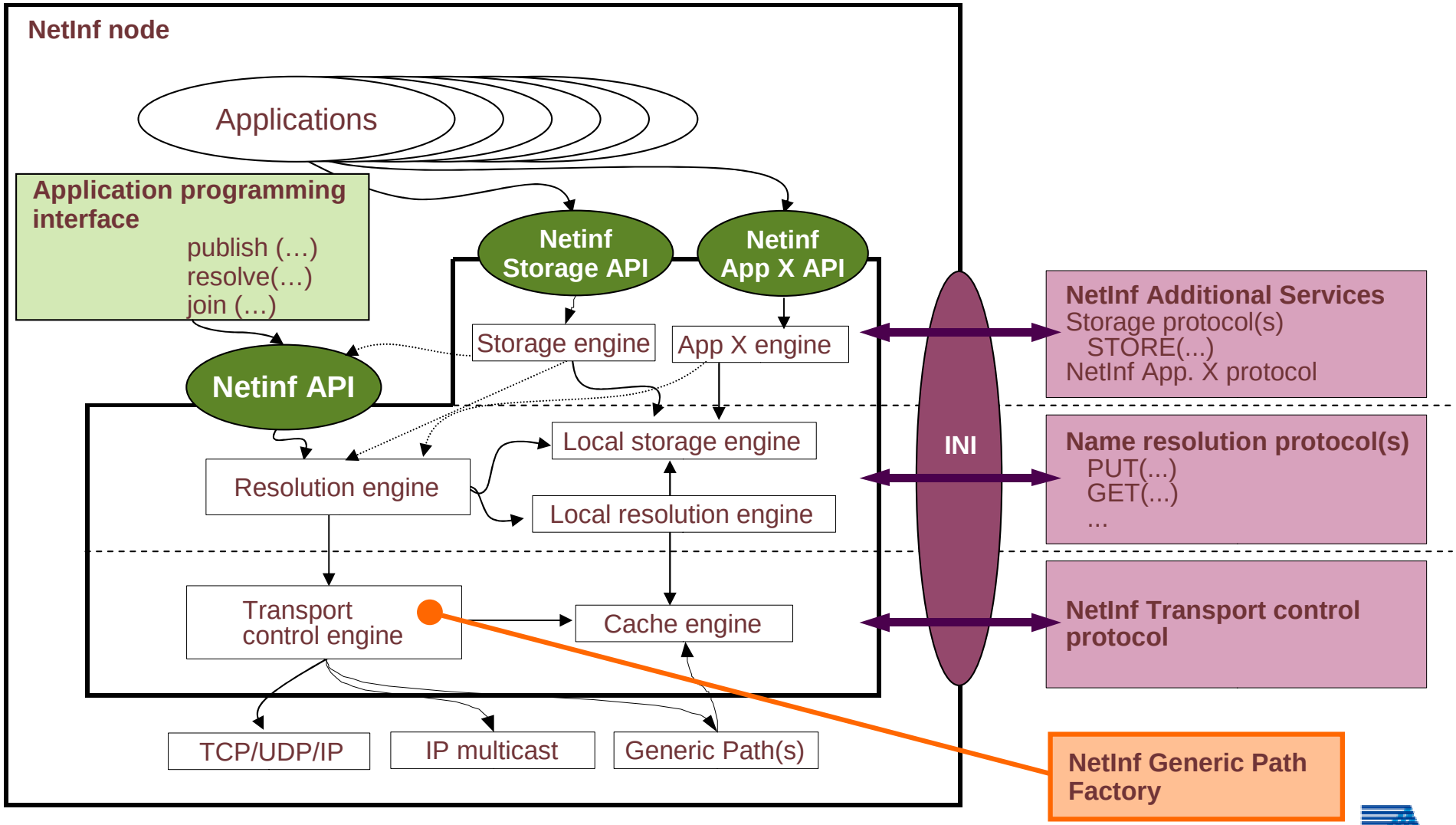
WP6 – NetInf publications

- *Service Platform for Real-World / Internet Integration in Mobile Applications*, C. Dannewitz, H. Karl, D. Warneke, In Proc. of the 13. Mobilfunktagung, May 2008.
- ***Scenarios and Research Issues for a Network of Information,* C. Dannewitz, K. Pentikousis, R. Rembarz, E. Renault, O. Strandberg, and J. Ubillos, MobiMedia 2008**
- *Would Information-centric Networking Consume Less Energy*; K. Pentikousis, W-GREEN 2008
- ***Providing Data Dissemination Services in the Future,* M. D'Ambrosio, P. Fasano, M. Marchisio, V. Vercellone, M. Ullio, WTC'08**
- ***Design Considerations for a Network of Information*, Bengt Ahlgren, M. D'Ambrosio, C. Dannewitz, M. Marchisio, I. Marsh, B. Ohlman, K. Pentikousis, R. Rembarz, O. Strandberg, V. Vercellone, ReArch '08**
- *Distributed Information Object Resolution*, K. Pentikousis, ICN 2009
- *Cooperative Multiaccess for Wireless Metropolitan Area Networks: An Information-centric Approach*, K. Pentikousis, F. Fitzek, and O. Mämmelä, CoCoNet 2009
- *Augmented Internet: An Information-Centric Approach for Real-World / Internet Integration*, C. Dannewitz, International Workshop on the Network of the Future 2009
- *Private Domains in Networks of Information*, R. Rembarz, D. Catrein and J. Sachs, Future-Net'09
- *Self-management for a Network of Information*, K. Pentikousis, C. Meirosu, A. Miron, and M. Brunner, Future-Net'09
- *Energy-efficient Multiaccess Dissemination Networks*, K. Pentikousis, GreenComm'09

API for accessing any type of object, regardless of location

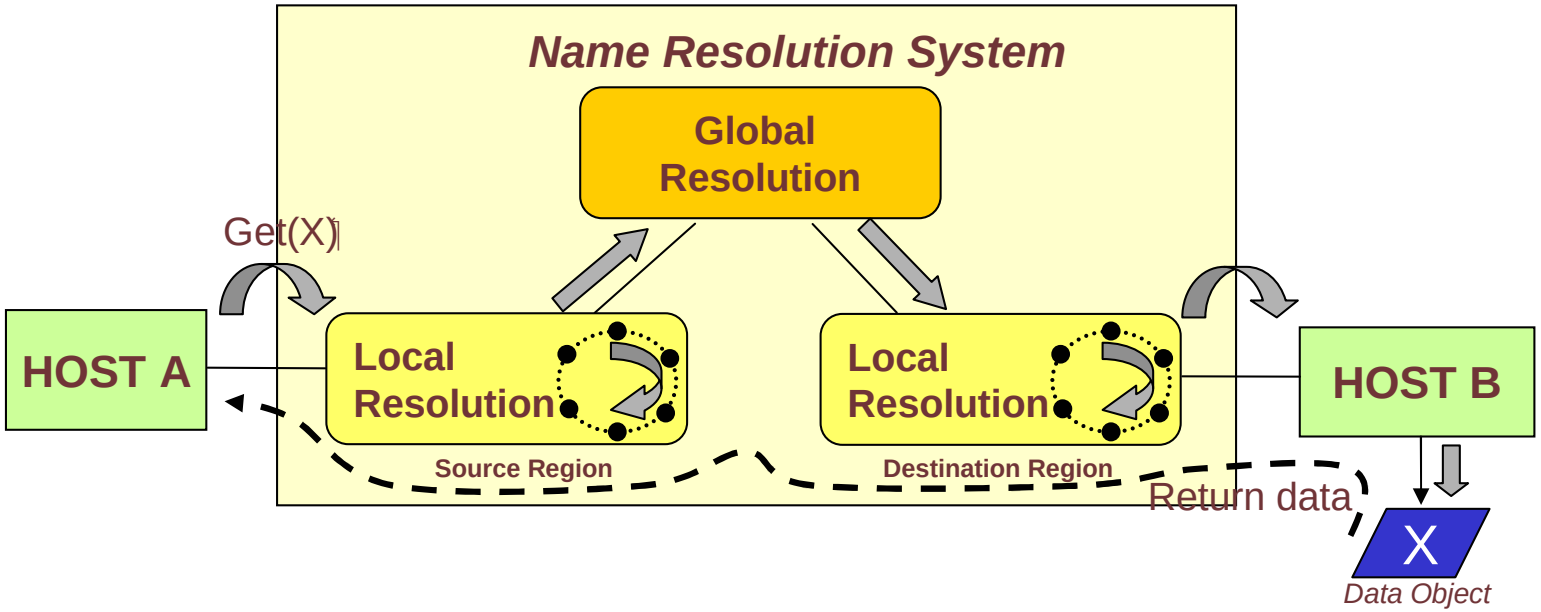


NetInf Architecture Overview



World-wide Scalable Name Resolution using Multiple DHTs (MDHT)

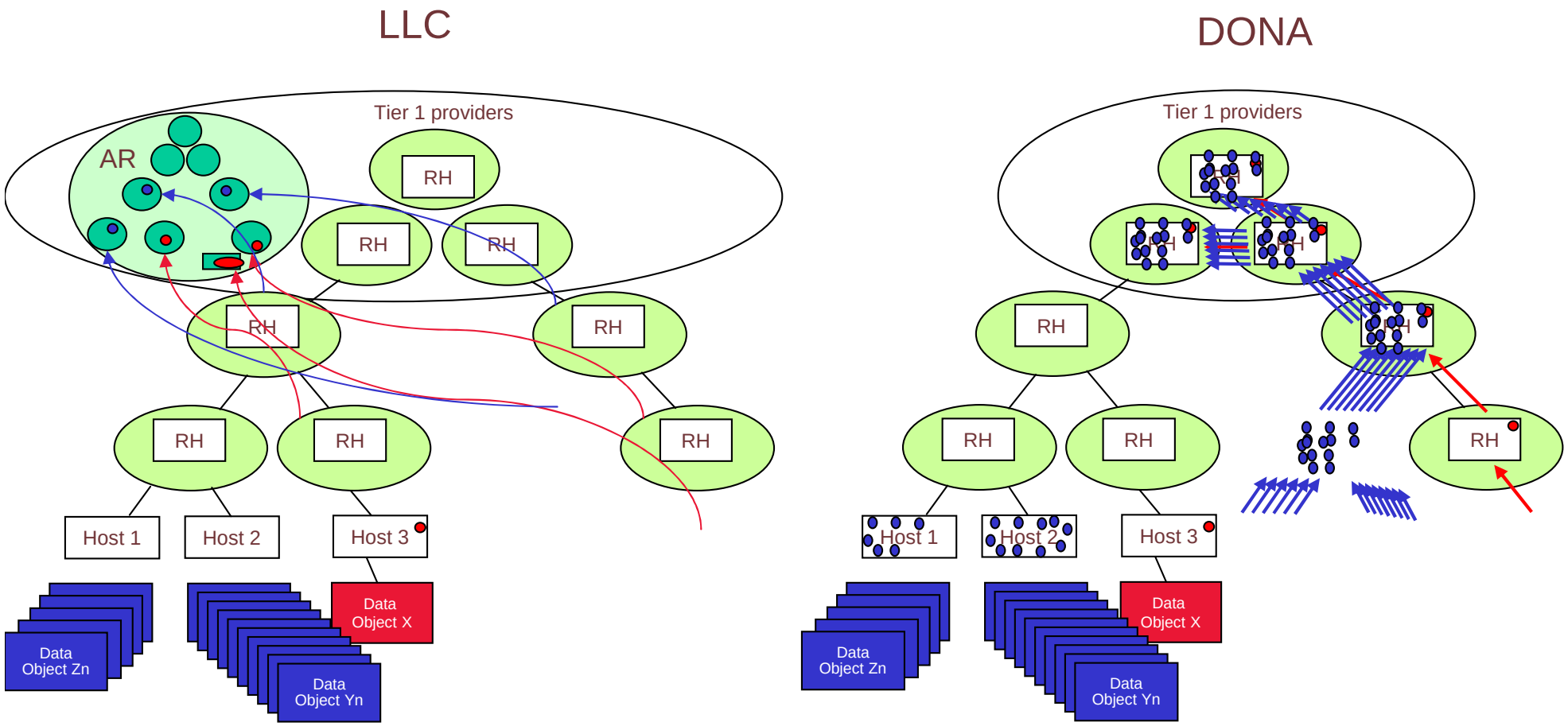
- Combination of:
  - Hierarchical DHTs (Provider-based)
  - Topological embedding of DHTs
  - Name-based routing



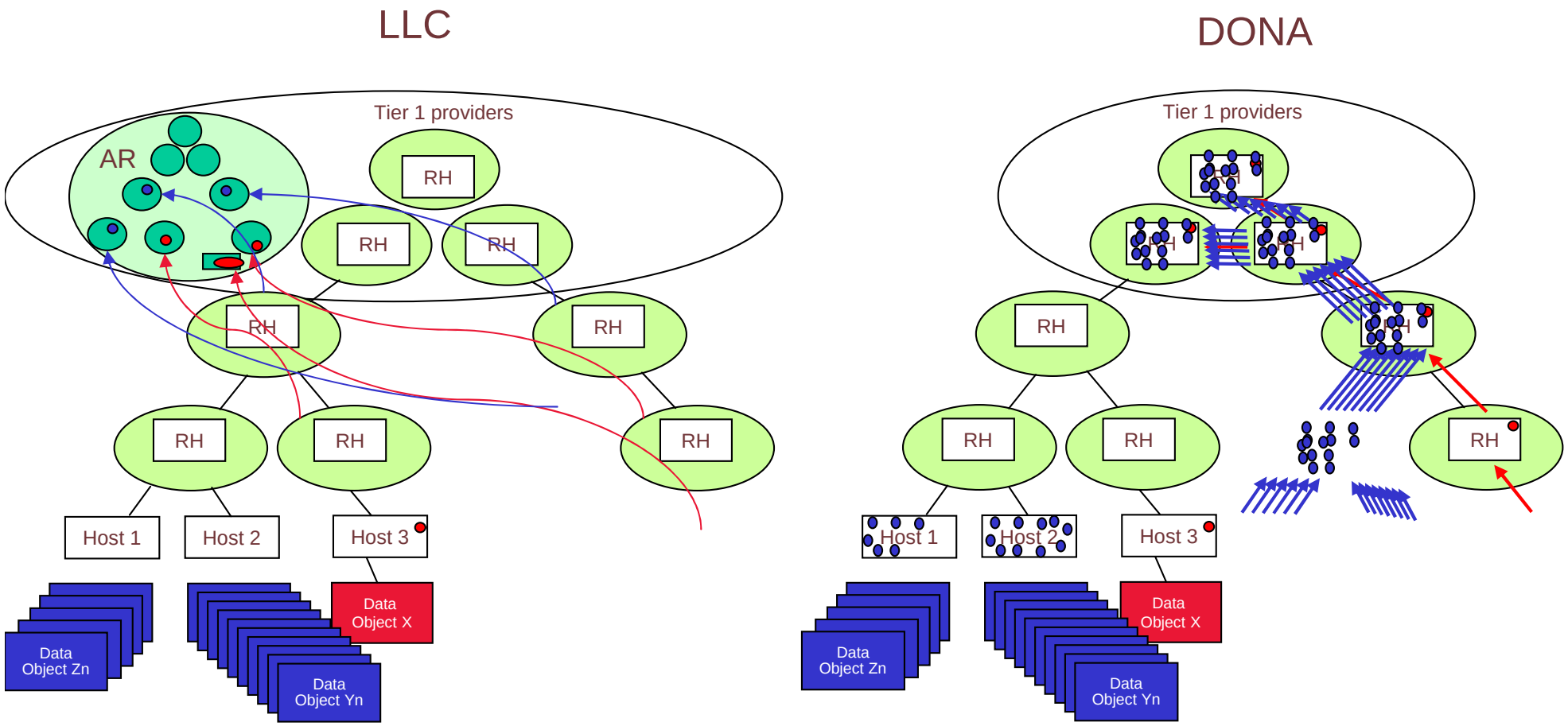
DONA *vs.* MDHT performance and scalability

	DONA	MDHT
Registered Items	10^{11}	10^{15}
Storage Memory per Node	4 TB at Tier 1 <4 TB at lower Tiers	4 TB on all network nodes of the global Internet
GET Rate	20K requests per Gbit/sec. i.e. 2 Requests/sec per user??	2 Requests/sec per user with current storage technology (better results with parallelization)
Number of users per node	No information published	$O(10^4)$ users per node with a rate of 2 Requests per second per user and current storage technology (better results with parallelization)
Refresh Process Bandwidth	No information published	10 Mbps
Refresh TTL	No information published	<6 days

Mobilty network state
LLC vs. DONA



Mobilty network state
LLC vs. DONA



Problems Resulting from a Host-centric View

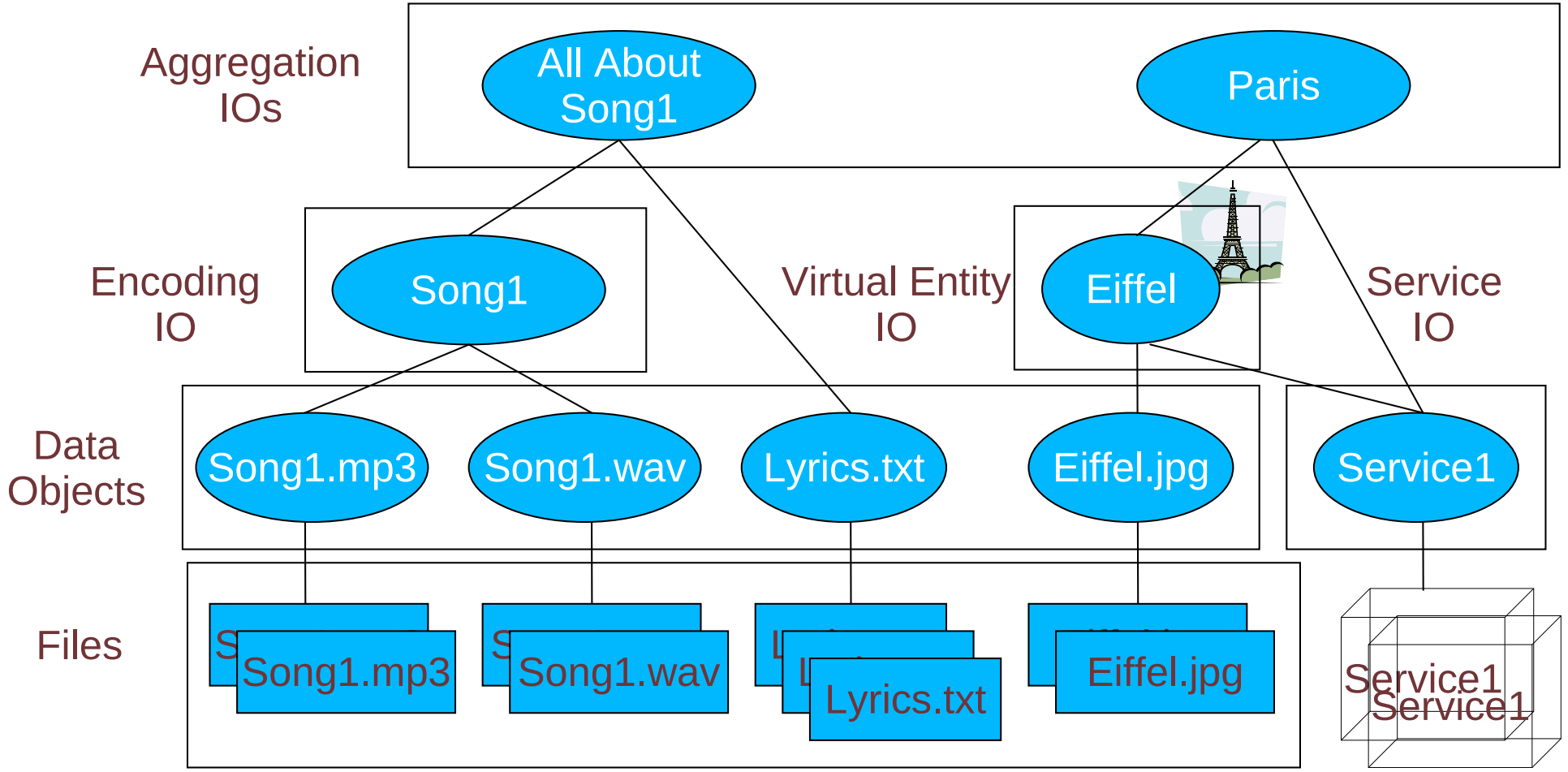
- No common *persistent naming scheme* for information
  - Information is named relative to the box they are located in, URLs resolves to IP-addresses
    - Moving information = changing it's name („404 file not found" errors)
- Mobility and multihoming for hosts and networks is problematic due to the semantic overload of IP-addresses
- No consistent *representation of information* (copy-independent)
  - No consistent way to keep track of *identical copies*
  - Different *encodings* (e.g., mp3, wav) worsen problem
- Security is host-centric
  - Mainly based on *securing channels* (encryption) and *trusting servers* (authentication)
  - Can't generally trust a copy received from an untrusted server

Problems can be solved in a consistent manner via an information-centric architecture

Future work

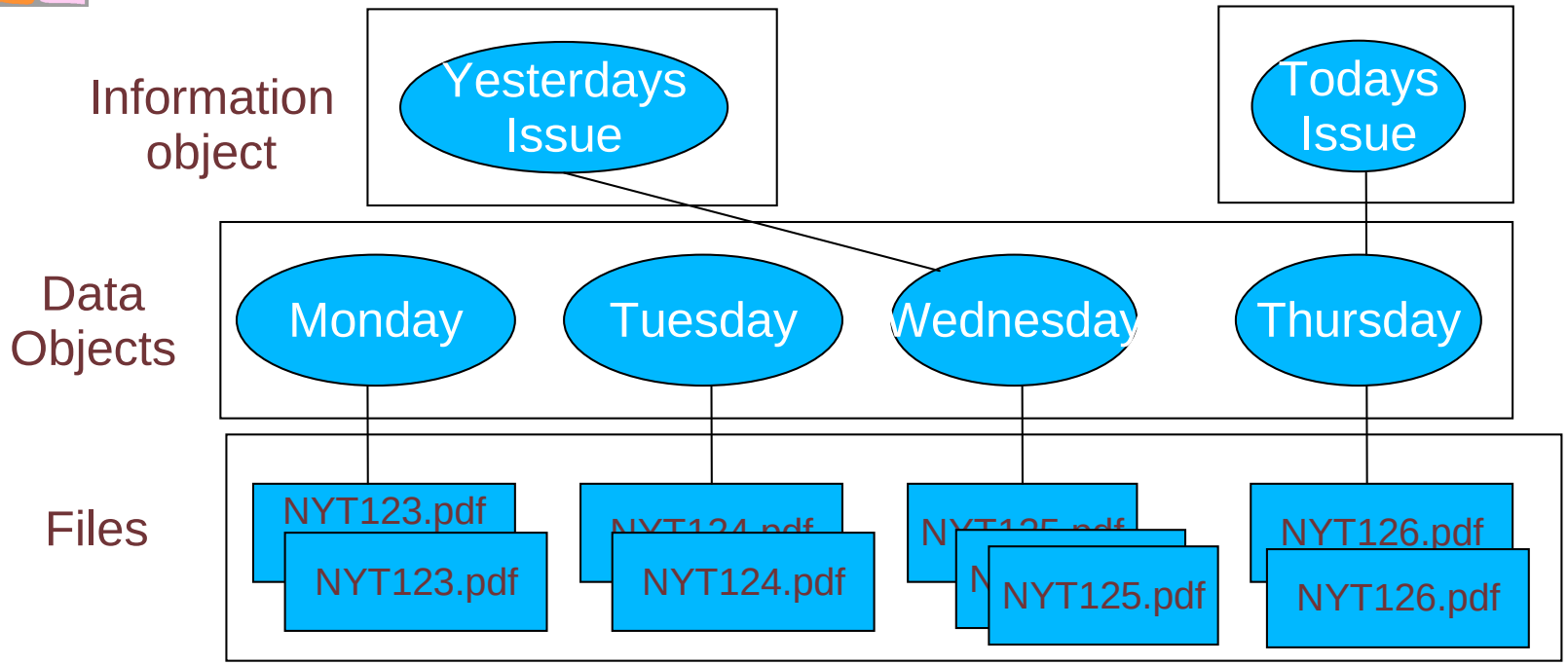
- Finalise security evaluation of naming scheme
- Define a service model building on the object model
  - Showing how services are embedded into the NetInf architecture
- Search?
- Extensions for delay-sensitive applications
  - Purpose: see how far into real-time domain the NetInf concept can reach
- Routing approaches:
  - Finalising designs, defining how they are combined into the same system design
  - Perform extensive evaluation, primarily with simulation, but some implementation
- Overall performance evaluation
  - simulation of personal mobile scenario and cooperative multi-access
  - Finalise simulation setup and produce results (T6.5)
  - Defining metrics and exploring parameter space
- Proof-of-concept prototyping
  - Serverless web and personal mobile scenario
  - Small scale performance evaluation, corroborating and providing parameters to the simulation

Organize Information – Examples of IOs and IO Hierarchies



- Generation of IOs and IO hierarchies:
  - Content owners, community-based (see e.g. Wikipedia)

Versioning and Revocation



Deletion challenges:
- Multiple copies
- Disconnected operation
- Central register?

Possible strategies:
- Self-deleting objects
- Objects needing recertification
- Invalidation of decryption key