Networking of Information
An information-centric approach to the network of the future

Vinicio Vercellone - Telecom Italia
Bengt Ahlgren – SICS
& 4WARD WP6 colleagues
Network of Information

Today’s Internet Communication Model
Focuses on Conversations between Hosts

Future Information-centric Network Communication Model
Focuses on Dissemination of Information objects

In today’s Internet, accessing information is the dominating use case!
Problems resulting from Host-centric view

- No common *persistent naming scheme* for information
  - URLs and IPs overloaded with locator and identifier functionality
    - Moving information = changing its name ("404 file not found" errors)
  => Use *flat namespace* for persistent identification

- No consistent *representation of information* (copy-independent)
  - No consistent way to keep track of *identical copies*
  - Different *encodings* (e.g., mp3, wav) worsen problem

- Information dissemination is inefficient
  - Can’t benefit from existing copies (e.g. local copy on client)
    - Also true for *Content Delivery Networks* (e.g. Akamai)
  - No “anycast”: e.g., get “nearest” copy
  - Problems like *Flash-Crowd effect, Denial of Service, …*

- Security is host-centric
  - Mainly based on *securing channels* (encryption) and *trusting servers* (authentication)
  - Can’t trust a copy received from an untrusted server

---

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

- **Content distribution**
  - VideoOnDemand, Live TV, Web pages
  - Caching can be built-in from the beginning
  - Information can be retrieved from the closest available source
  - Common dissemination infrastructure for all applications, including network support
NetInf Scenarios

- **Content distribution**
  - VideoOnDemand, Live TV, Web pages
  - Caching can be built-in from the beginning
  - Information can be retrieved from the closest available source
  - Common dissemination infrastructure for all applications, including network support

- **Augmented Internet – Real-world objects**
  - Linking real world objects in the virtual information world
  - Clicking on and bookmarking real world objects
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)
NetInf Naming Scheme

**Type**
- Defines the format
  - e.g. Hash algorithm used (SHA1, MD5, …)

**Authenticator (A)**
- Binds the ID of the IO to a public key PK
  - Hash function used to compress length of PK

**Label (L)**
- Identifying individual object published by Authenticator
  - contains a number of identifier attributes associated with an IO
  - (A, L) combination needs to be globally unique

- Supporting the combination of:
  - name persistence, self-certification, owner authentication, and owner identification
  - for information objects that are static or dynamic, that change location, that change owner, and whose owner change organisational affiliation
  - without need to trust the delivering host

- Security metadata include
  - Cryptographic hash of the data
  - Certificate chain binding the IO key (PK_{IO}) to owner key (PK_{owner})
  - Signature of the self-certified data with SK_{IO} or any other authorised SK
  - All data needed for owner authentication and identification

- Separation of notion of *publisher* and *owner*, where the latter can stay anonymous
Mapping Information Model to NetInf name resolution

IO ID: \[ Type = A = \text{hash}(PK_{IO}) \quad \text{L} = \text{label} \]

Name resolution system

- **type**
  - meta data
  - IO
  - BO
  - BO

- **content**
  - metadata
  - IO ID'
  - locator\textsubscript{A}
  - locator\textsubscript{B}

Storage/caching

A

B

BO

BO
NetInf Node Architecture

NetInf Node

Additional services
Resolution and Routing functionality
Data transport functionality

Applications

NetInf API

Resolution controller
(M)DHT, Broadcast, Local

Transport controller
TCP/IP, GP, Other

Storage engine
Search engine
Local storage engine
Cache engine

NetInf Storage API
NetInf Search API

NetInf Additional Services
Storage protocol(s)
STORE(…)
NetInf App. X protocol

Name resolution protocol(s)
PUT(…)
GET(…)
...

NetInf Transport control protocol

INI
Scalable Name Resolution System

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

![Diagram of Scalable Name Resolution System]

- Global Resolution
- Local Resolution

HOST A

Get(X)

Local Resolution

Source Region

HOST B

Local Resolution

Destination Region

Return data

Data Object

X
Standardization issues

Issues to be considered for standardization:

- **NetInf interfaces**
  - User-Network Interface
  - Inter-Provider Interface
    - Name resolution service between different domains
      - registration/query protocols
      - name resolution records
    - Transport and routing of messages
  - Naming scheme
  - NetInf APIs
Standardization

❖ ITU Focus Group on Future Networks (FG FN)
  – NetInf and the information-centric approach presented at the first meeting of the focus group in Luleå, Sweden, July 2009

❖ IETF DECADE
  – NetInf presented at the DECADE BoF at the 76th IETF meeting in Hiroshima, Japan, November 2009
  – Internet-Draft submitted to the 77th IETF in Los Angeles
    • <draft-ohlman-decade-add-use-cases-reqs-00>, “Requirements for accessing data in network storage”
    • Proposes to widen the scope beyond P2P-based apps to also cover video distribution applications (incl. IPTV, YouTube) and enumerates a number of requirements to be addressed by the protocols
Summary and Conclusion

- NetInf is about the design of a new network architecture based on an information-centric paradigm.
- Some problems that are addressed by the NetInf:
  - Naming scheme for naming information
  - World-wide scalable Name Resolution mechanism for flat names
  - IOs as representation of information
  - Enable efficient information dissemination
    • Benefit from available copies, anycast, caching, solve Flash-Crowd, ...
  - Secure information-centric architecture by embedding security into identifiers
- Some significant results up to date:
  - Naming scheme with integrated security that is independent of hosts
    • Detailed definition and security analysis
  - Design of a scalable integrated name resolution and routing scheme (MDHT)
  - Scalable solution for mobility of objects, hosts and networks (LLC)
  - Overall NetInf architecture prototype
    • Demonstrated at international conferences
Thank you!

www.4ward-project.eu