Information-centric networking and NetInf – An approach to the network of the future

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Outline

• The ICN approach and its motivation
• Example: basic operation of ICN
• ICN components
• NetInf naming
• NetInf protocol
• Status of research
Background

- Various “Future Internet” initiatives, US, EU, etc
  - Motivated from problems with current technology, and the “ossification” of the Internet architecture
  - Often called “clean-slate” research
- At the network infrastructure level, two new approaches
  - Software-defined networking (SDN)
  - Information-centric networking (ICN)
Information-centric networking

Today’s Internet

Host-centric abstraction
Who to communicate with

In today’s Internet, accessing information is the dominating use case!

Information-centric network

Information-centric abstraction
What to communicate

Evolution
Host-centric networking

Connect to Server X and get object B

Trusted Server

Secure Connection

Connect to Server X and get object B
Information-centric networking

Get object B

Trustable copy of object B

Untrusted connection

Untrusted host
Problems resulting from host-centric view

- Information is tied to its location
  - Moving information = changing it's name ("404 file not found" errors)
  - No common *persistent naming scheme* for information objects

- Information distribution 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, ...*

- Mobility and disruptions become difficult to handle
  - Need to maintain end-to-end connectivity between hosts

- Can’t trust an object copy received from an untrusted server
  - Security is host-centric – no notion of publisher of information
  - Mainly based on *securing channels* (encryption) and *trusting servers* (authentication)

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

- *Clients* (C) send **requests** asking for named data
- *Routers* (R) in the network routes requests towards *publishers* (P)
- Any node with a cached copy can provide the corresponding **named data object** (NDO)
- **Remark:**
  - On the surface, this is exactly the function of HTTP,
  - but, the HTTP request is *always* addressed to a particular host
ICN communication model
ICN communication model
ICN communication model
ICN communication model

C1 -> R1 -> R2 -> P
C2 -> R3 -> R2

A?
ICN communication model
ICN communication model
ICN communication model

- C1
- C2
- R1
- R2
- R3
- P
ICN communication model
ICN communication model

C1

R1

R3

C2

R2

P

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2014-09-02
ICN communication model
ICN communication model
ICN communication model
ICN communication model
ICN main components

- **Name resolution/routing**
  - scalability main concern

- **Naming scheme for objects**
  - flat or hierarchical

- **Forwarding/transport**
  - with in-network caching

- **Security**
  - tied to the objects
  - and the names
NetInf – Networking of Information

• ICN architecture developed mainly in the SAIL EU project
  – Several prototype implementations exists

• Naming scheme for data:
  – `ni://example.com/sha-256;B_K97zTtFuOhug27fke4_Zgc4Myz4b_lZNgsQjy6fkc`
  – Taken up as standards track RFC in the IETF (RFC 6920)
  – Provides name-data integrity (above with content hash as part of the name)

• Http-based convergence layer (= transport protocol) using http POST
  – I-D draft-kutscher-icnrg-netinf-proto

• Name resolvers and routing scheme for named data
NetInf naming scheme

ni://<authority>/<alg>;<val>

- URI-style format where:
  - <authority>: publisher or other origin making the object available
  - <alg>: digest algorithm (cryptographic hash) used for <val>
  - <val>: digest value

- Example (for the string “Hello World!”):
  - ni://example.com/sha-256;B_K97zTtFuOhug27fke4_Zgc4Myz4b_lZNgsQjy6fkc

- Signature-based <authority> also possible
  - needed for dynamic objects

- Provides name-data integrity without consulting a third party

- Specified in RFC 6920 (Naming Things with Hashes) which is on IETF standards track
NetInf abstract protocol

- NetInf GET / GET-RESP
  - requesting named data and transporting data in response

- NetInf PUBLISH / PUBLISH-RESP
  - making named data available, creating NRS entry or pushing the complete object

- NetInf SEARCH / SEARCH-RESP
  - querying a NetInf node for available data objects
Example: NetInf GET / GET-RESP

• Abstract syntax
  - get-req = GET msg-id URI [ ext ]
  - get-resp = status msg-id [1*URI ] [ ext ] [ object ]
  - ext = json-coded-string
HTTP convergence layer

• Purpose: provide reliable transport and easy prototyping
  - (yes, there are better ways of implementing this!)

• NetInf request messages are encoded as a HTTP POST
  - NetInf request message parameters are encoded as a form fields in the POST

• NetInf response messages are encoded as a HTTP response with a mime-encoded body
Example: NetInf GET

- HTTP URI: /netinfproto/get
- URI, msg-id and ext parameters encoded as HTTP POST form data
- GET

- GET-RESP
  - multipart/mixed – with two parts:
    - application/json – with object metadata
    - foo/bar – whatever mime-type is appropriate for the data object
NetInf HTTP CL “protocol stack”

NetInf message (abstract)

HTTP convergence layer encoding

HTTP

TCP/IP
Two modes of operation

- **Request forwarding**
  - Each request is forwarded hop-by-hop until the corresponding object is found (cached or publisher)

- **Name resolution**
  - Objects are registered in a name resolution service (NRS) when published
  - Clients first consults the NRS to get location information, then sends the request to the obtained location
ICN Status

- Prototype code being released, for example
  - SAIL/NetInf: http://sourceforge.net/projects/netinf/
  - CCN: http://www.ccnx.org/

- ICN community is forming
  - Workshops arranged and journal special issues dedicated to ICN
  - Standardisation presence: IRTF ICN RG, contributions to existing IETF WGs

- Expected deployment
  - Short term: adoption of the general idea of named data, and of specific pieces, e.g., the naming scheme, in particular for specific applications
  - Long term: completely replacing current IP infrastructure unlikely – as an overlay for the forseeable future

- Projects
  - SAIL EU project: http://www.sail-project.eu/
  - EFRAIM: http://www.acreo.se/efraim
Summary

• Communication based on named data
  – Data is directly named independent of its container

• Request-driven, publish-subscribe-like interaction model
  – Publishers make named data available
  – Clients ask for named data

• Location of data is secondary – any node can satisfy a request
  – Unifies P2P with server-based delivery using same network mechanism

• Caching integrated in the network service
  – But ICN is not a replacement of CDN! ICN is protocols and mechanisms, while CDN is a business role
References


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