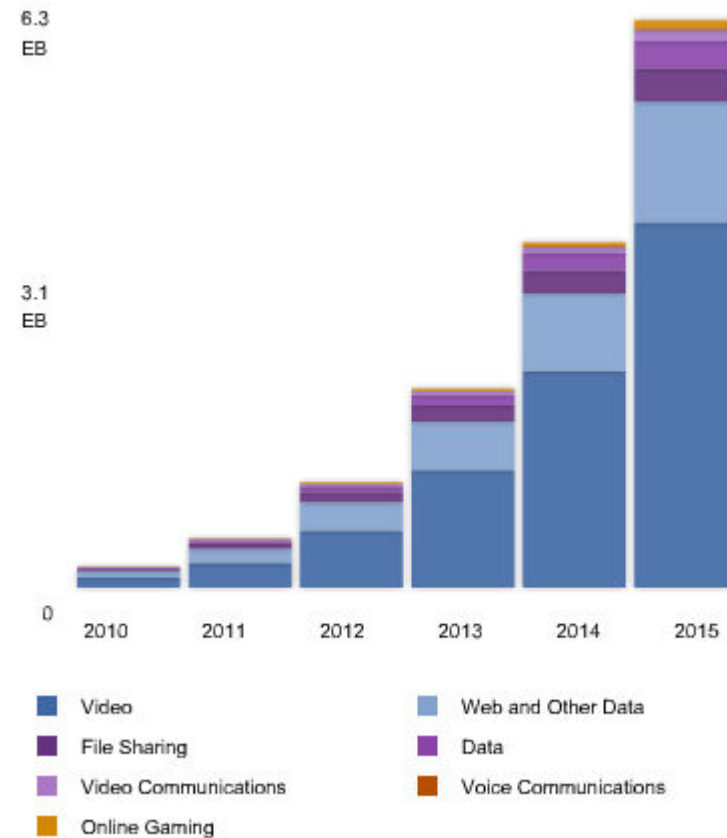# *Towards a Mobile Network of Information and Services*

Joint COMET/Envision Workshop

O2, Slough
2011–11–10

Pedro A. Aranda Gutiérrez – Telefónica I+D
Slides by: Dirk Kutscher – NEC Labs Europe
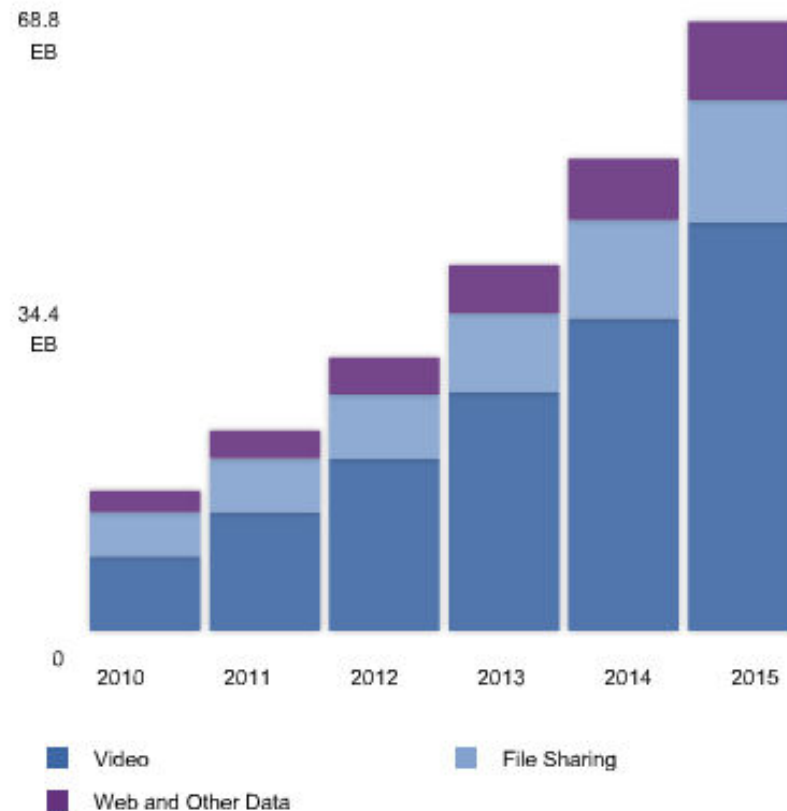EU–FP7 Project SAIL

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

Mobile Data Traffic Prediction

From 2010 to 2015: factor 26 increase expected

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

Video Data Traffic Prediction
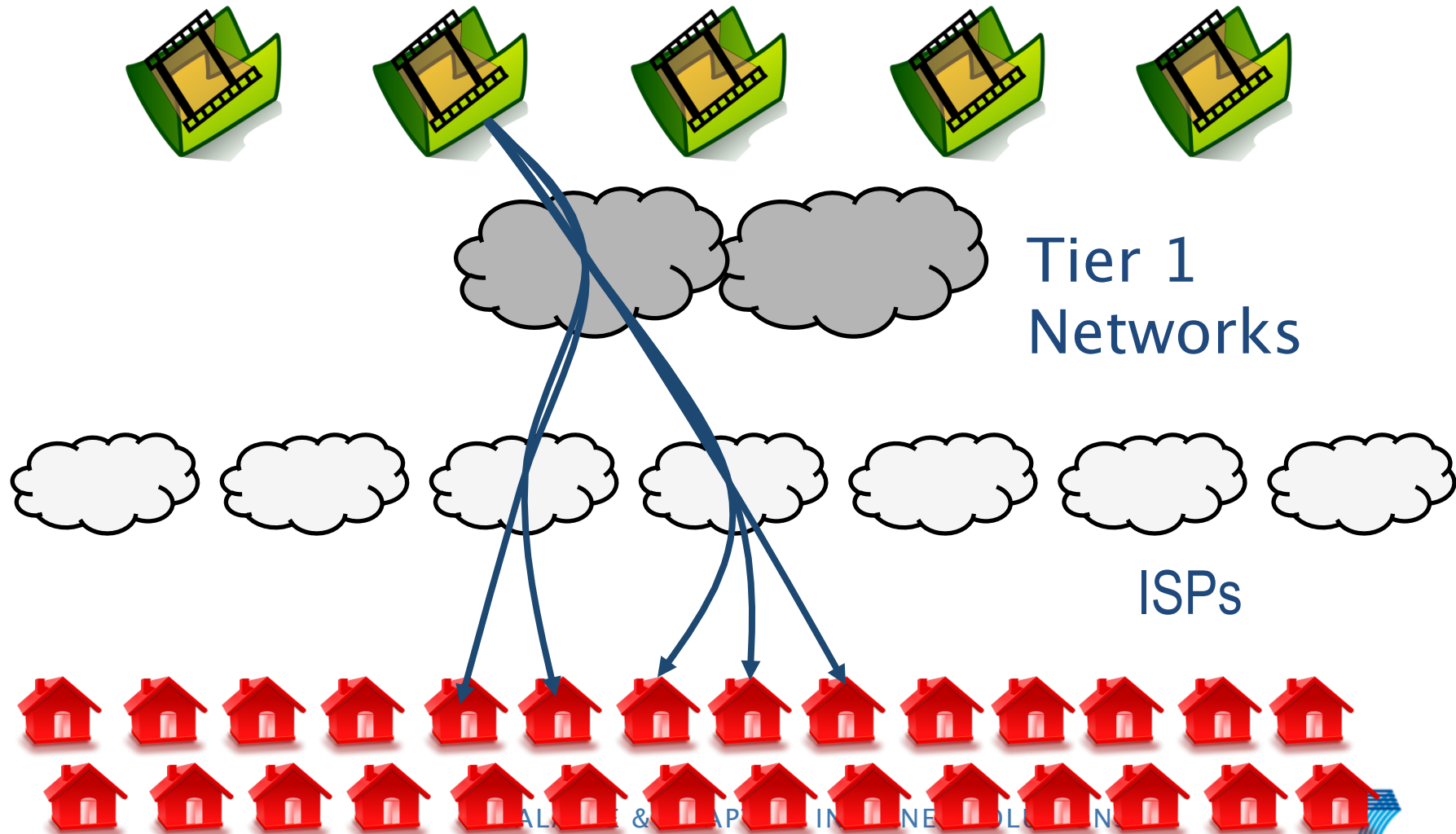
From 2010 to 2015:
factor 5 increase
expected

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

Popular Conception:
Content Distribution Over the Internet Does Not Scale

Tier 1
Networks

ISPs

Problems with Today's Networks

- URLs and IP addresses are overloaded with locator and identifier functionality
  - Moving information = changing it's name =>
    404 file not found

- No consistent way to keep track of *identical copies*
  - No consistent *representation of information* (copy-independent)

- Information dissemination is inefficient
  - Can't benefit from existing copies (e.g. local copy on client)
  - No "anycast": e.g., get "*nearest*" copy
  - Problems like *Flash-Crowd effect, Denial of Service,*

Problems with Today's Networks

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

- Application and content provider independence
  - CDNs focus on web content distributions for major players
  - What about other applications and other players?
  - **What about services?**

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

Information–Centric Networking

Today's Internet

Focus on
nodes
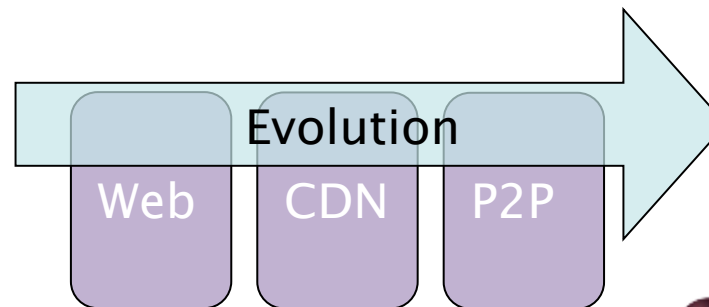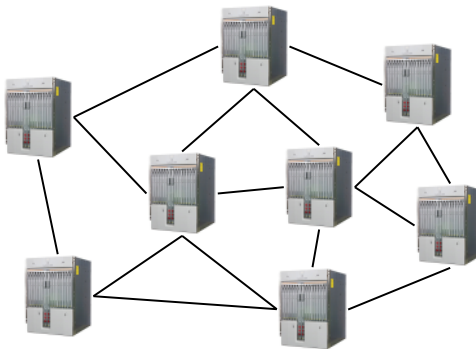
In today's Internet,
accessing information is
the dominating use case!

Evolution

Web CDN P2P

Future
Information–centric
Network

Focus on
*information objects and
real world objects*
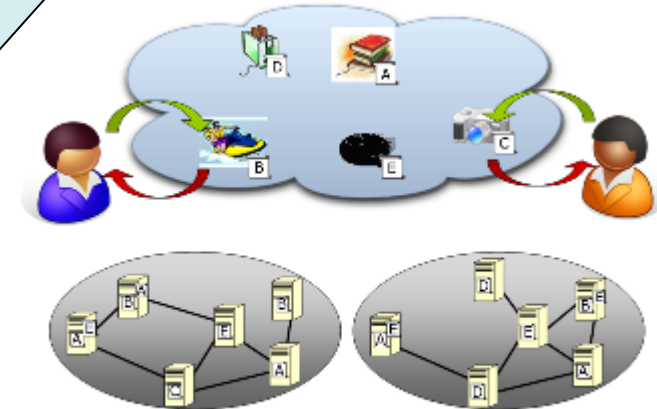
Scalable Adaptive Internet Solutions

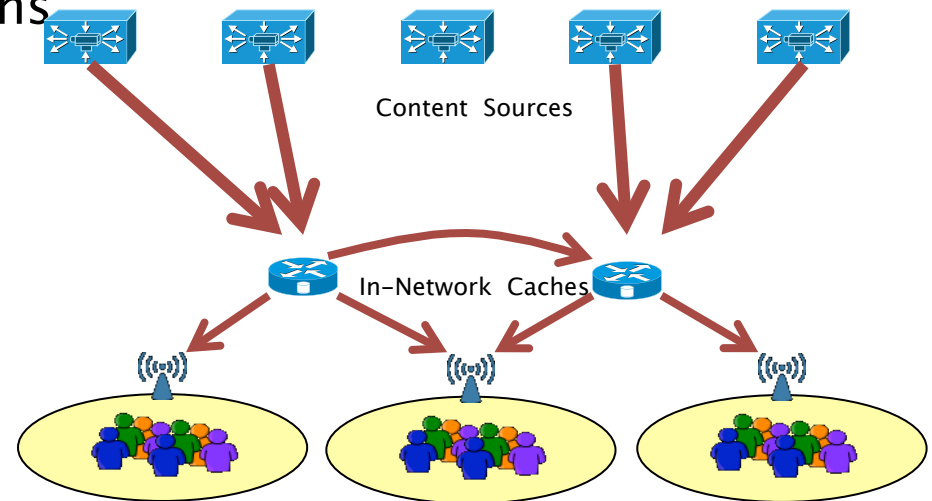## On-demand usage of network resources

- **Cloud Networking**: Tying Cloud Computing and Network Virtualization together

- **Open Connectivity**: Efficient use of multi-path, multi-protocol and multi-layer networking – over any fixed and mobile networks

- **Network of Information**: Access to named information as a principal network service
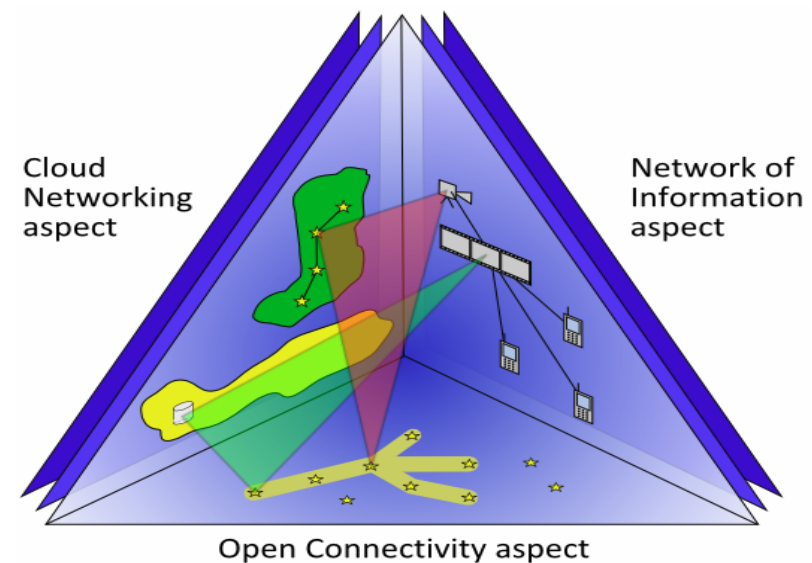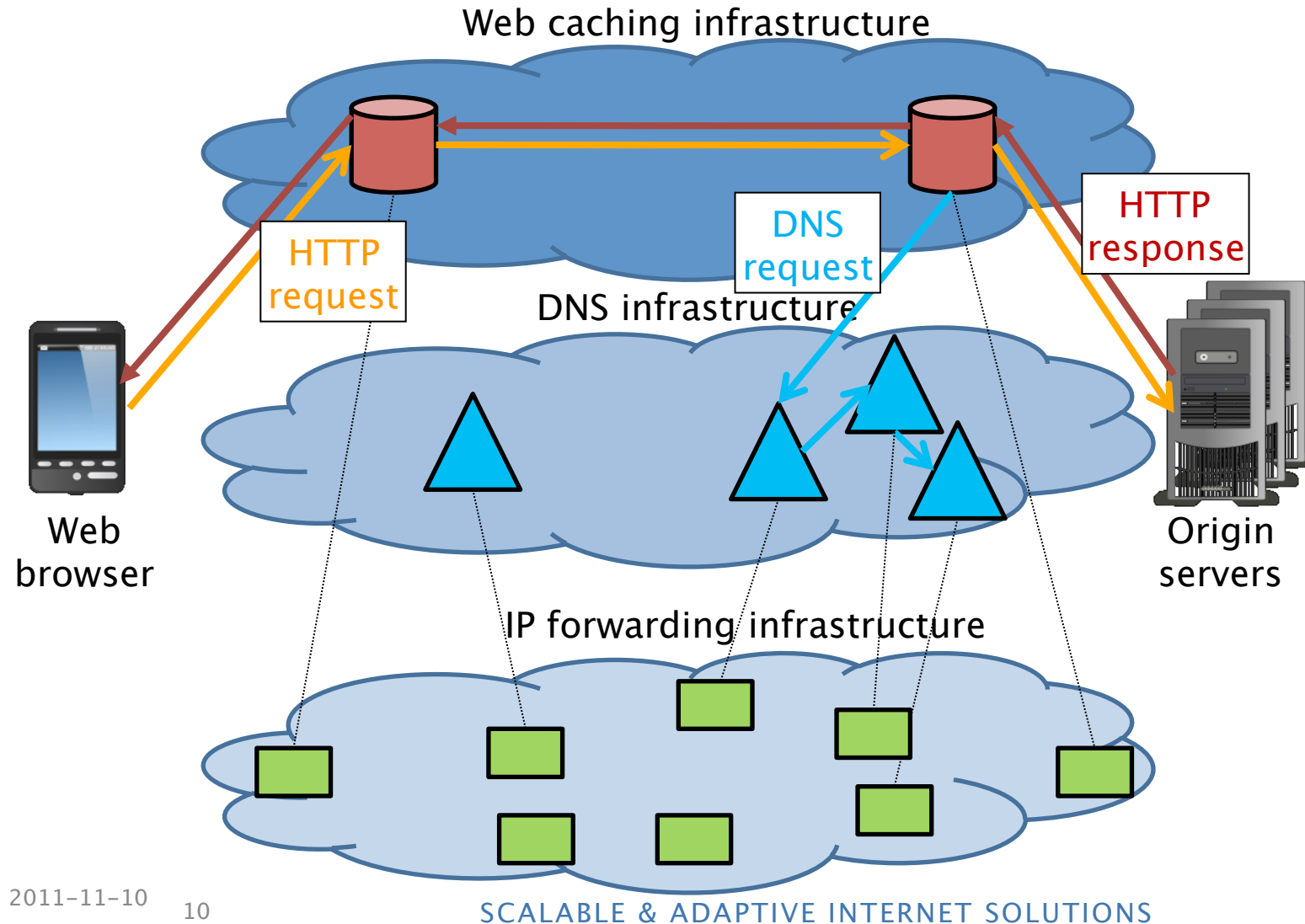
SAIL Network of Information

- Take information–centric networking to the next level
  - General–purpose information–centric architecture
  - Generalize CDN and P2P benefits to be integral part of network services
  - Commoditize application level content distribution
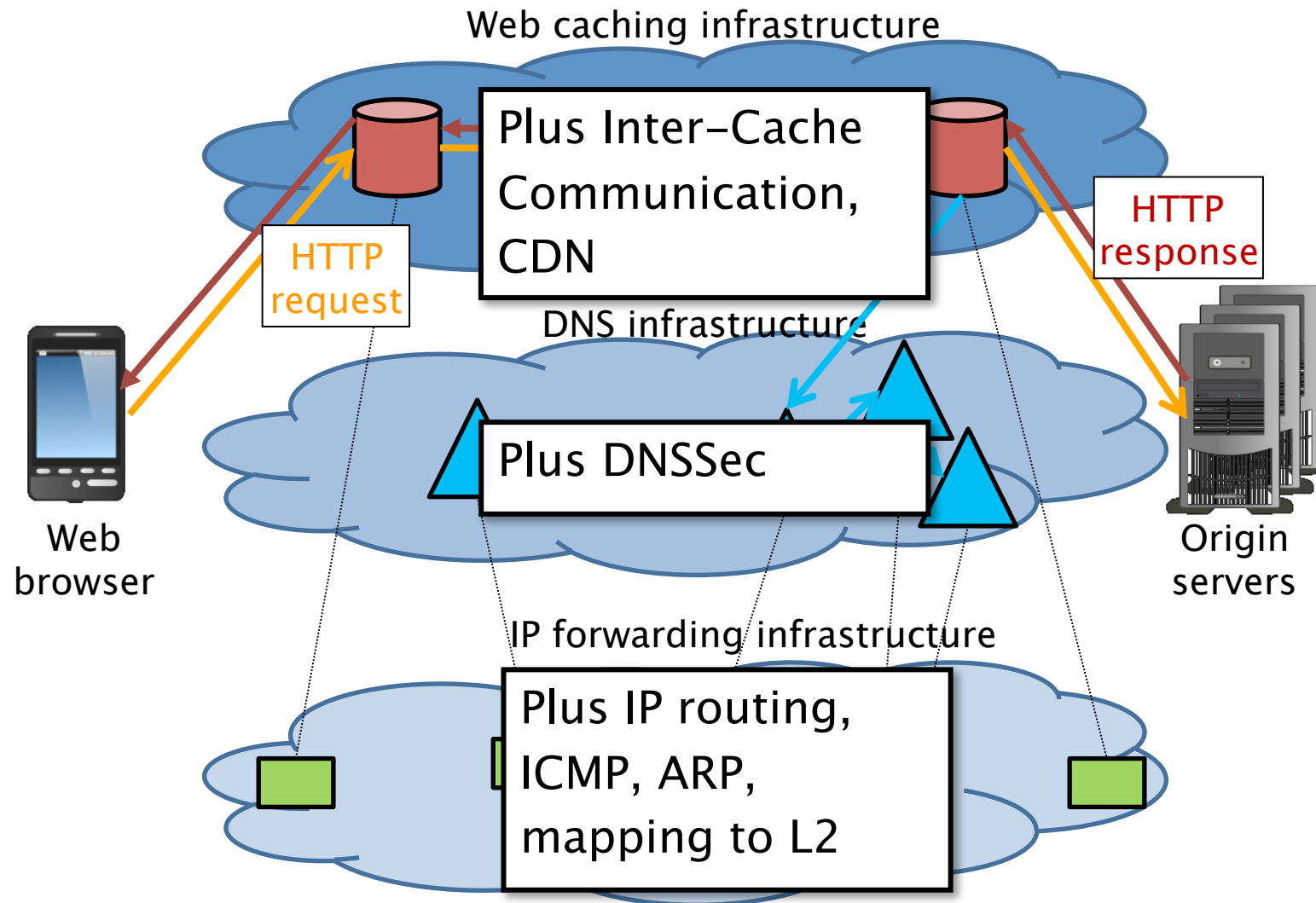 - …for a broad range of applications

- Concrete benefits
  - A natural solution for today's eminent applications
  - An efficient and cost–effective infrastructure for the next wave of Internet adoption
  - Enabling new types of applications, services, and interaction forms

Content Sources

In–Network Caches

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

SEVENTH FRAMEWORK PROGRAMME

Web–based Information Retrieval

SAIL

Web caching infrastructure

HTTP request

DNS request

HTTP response

DNS infrastructure

Web browser

Origin servers

IP forwarding infrastructure

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

SEVENTH FRAMEWORK PROGRAMME

Web-based Information Retrieval

Web caching infrastructure

Plus Inter-Cache Communication, CDN

HTTP request

HTTP response

DNS infrastructure

Plus DNSSec

Web browser

Origin servers

IP forwarding infrastructure

Plus IP routing, ICMP, ARP, mapping to L2

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

ICN-based Information Retrieval

Web browser

XY1

Original Content "XY1"

Owner "Joe"

Challenges for ICN

Naming of information objects

- Unique object identification
- Secure binding of names to objects and owners
- Names as keys for request/content routing

Web browser

XY1

Original Content "XY1"

Owner "Joe"
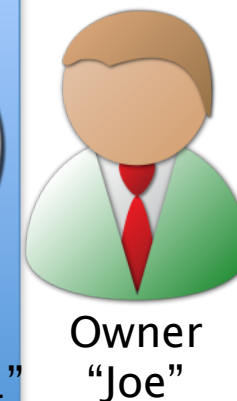
Challenges for ICN

Routing and Name Resolution

- Want to locate "best" copy of named objects
- Need a mapping/link between named objects and underlying network topology
- Want to support mobility and multi-homing
- Name-based forwarding: forward on names (based on corresponding routing protocol)
- Name resolution: resolve names to locators (leveraging underlying forwarding and routing infrastructure)

Web browser

XY1

Original Content "XY1"

Owner "Joe"

SCALABLE & ADAPTIVE INTERNET SOLUTIONS

SEVENTH FRAMEWORK PROGRAMME

Challenges for ICN

Resource Management and Transport

- Reliable, congestion- and flow-controlled transport of objects from a given location to interested receiver
- Good support for caching, multi-path, disruption tolerance
- Options
  - Receiver-oriented transport
 - End-to-end vs. hop-by-hop

Web browser

Original Content "XY1"

Owner "Joe"

XY1

Challenges for ICN

Security

- Host-based e2e security no longer applies
- Receiver is agnostic to object location
- Objects can be replicated, distributed without owner control
- Receiver (and network elements) MUST be able to
  - Validate name-content binding
  - Validate object integrity
 - Validate object-owner binding

Web browser

Original Content "XY1"

Owner "Joe"

XY1

SCALABLE & ADAPTIVE INTERNET SOLUTIONS
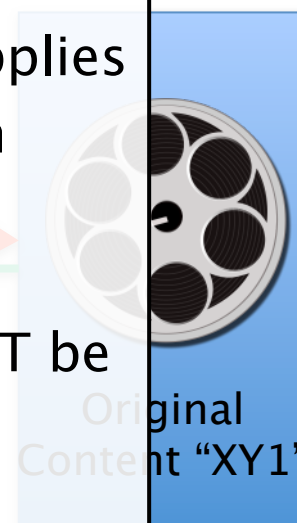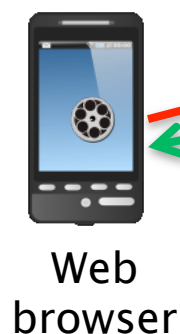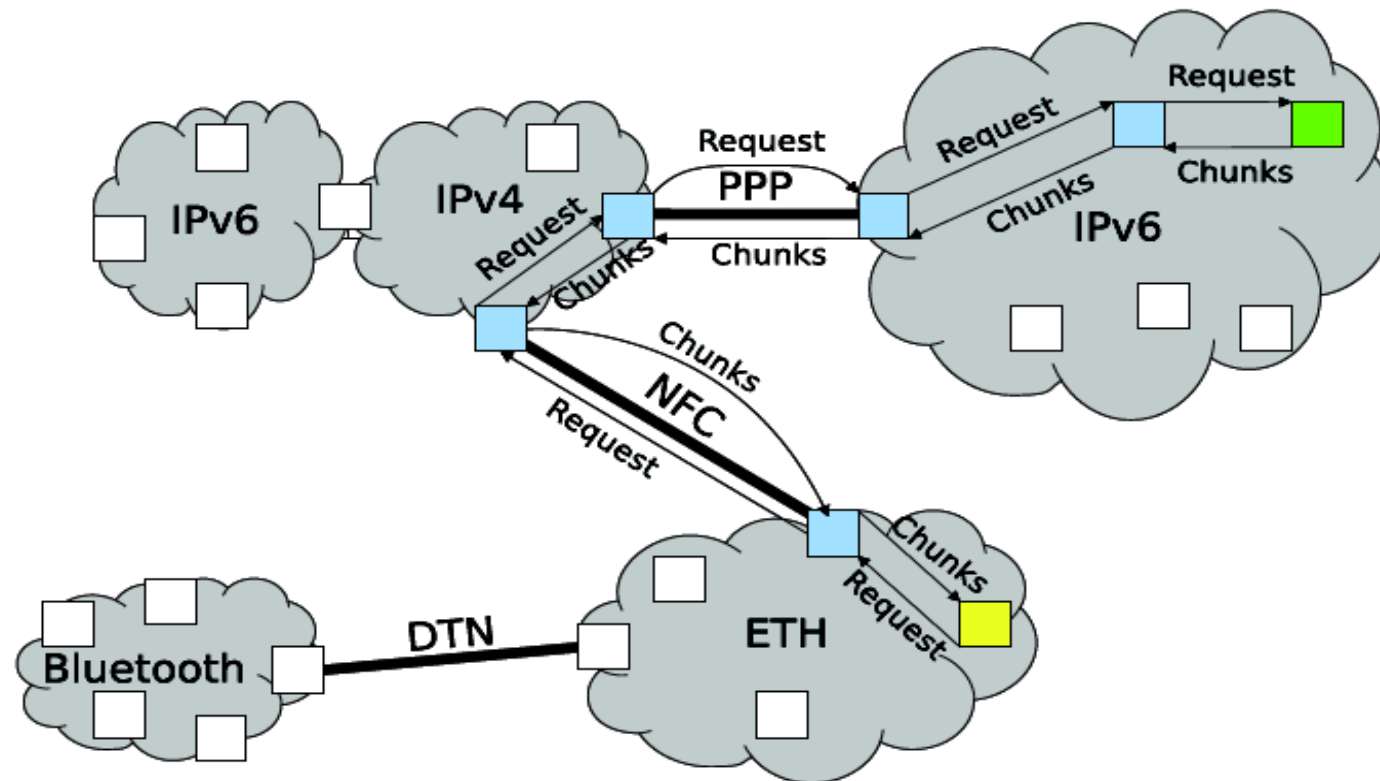
Challenges for ICN
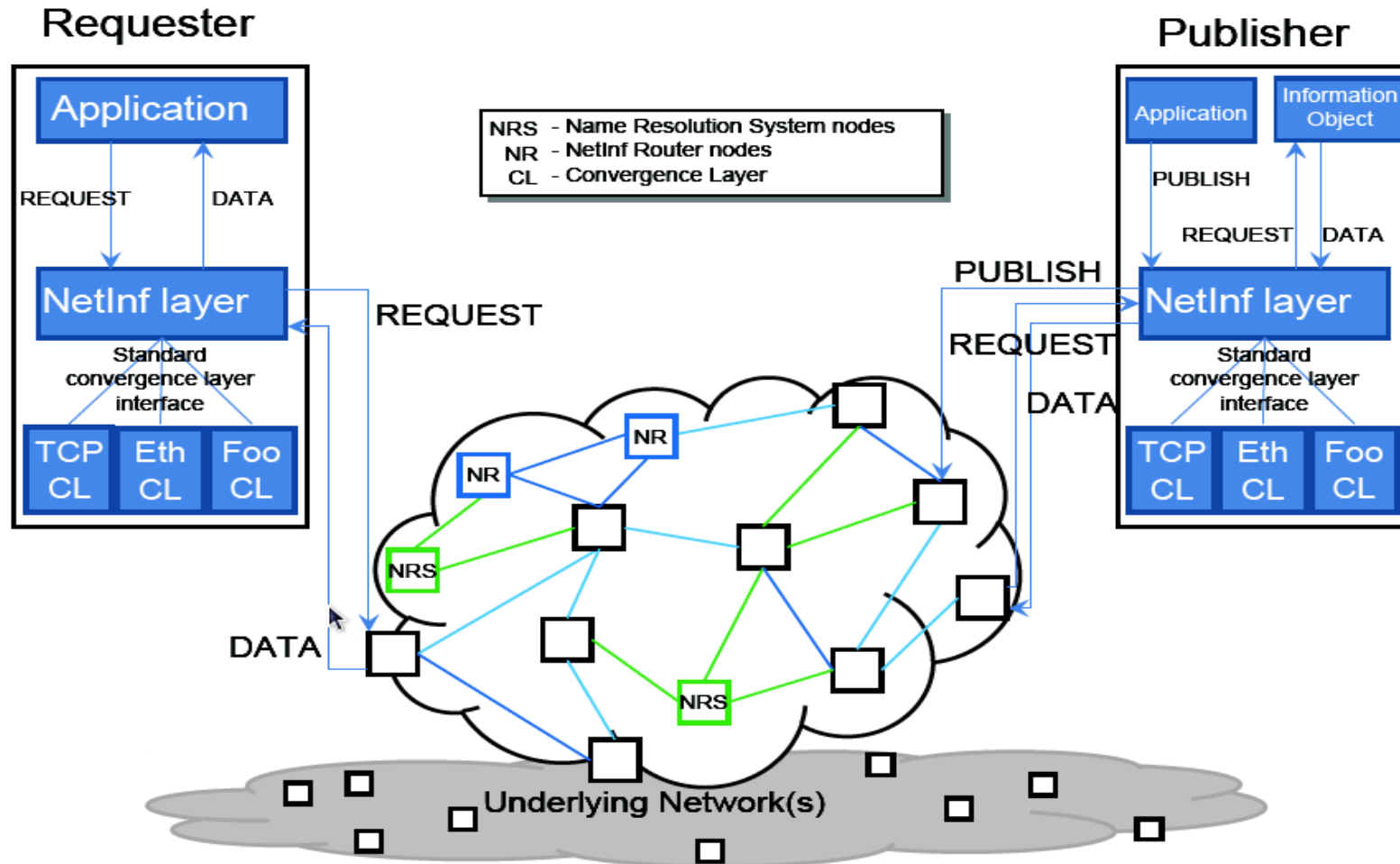
Interaction and Service Models

- Access to named content
  - Primary service
  - One name for replicated copies in the network

- Transactions?
  - Manipulate state on specific objects

- Services?
  - Notion of sessions, user contexts

Web browser

Original Content "XY1"

Owner "Joe"

XY1

SCALABLE & ADAPTIVE INTERNET SOLUTIONS
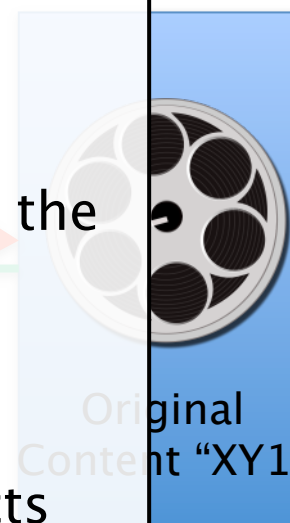
Heterogeneous Network of Information

The Network of Information

NetInf Naming

S A I L

- Internet Draft draft–farrell–ni

- "Minimalist" approach, only specifying name form but not resolution nor routing nor much else
  - But enabling various forms of those

- Basic idea: generic URIs for hash function outputs
  - Naming the hash function, the hash verification Input and its interesting payload, e.g. some kind of self–signed object (ssobj) that contains a JPEG image

```
ni://nec.de/dirks-webcam
```

```
ni://tcd.ie/ssobj:jpeg:sha256:
NDVmZTMzOGVkY2JjZGQ0ZmNmZGFlODQ5Mjky
ZDM0ZTg2ZDI5YzllMmU5OTFlNmE2Mjc3Z
```
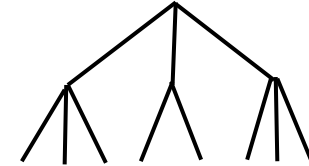
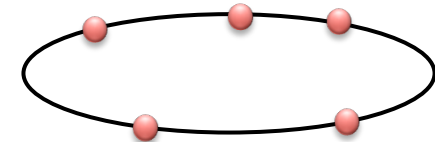SEVENTH FRAMEWORK PROGRAMME
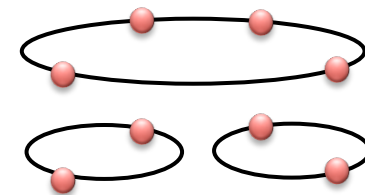
Name Resolution Design Space

- **Domain Name System (DNS)**
  - Requires hierarchical namespace to scale

- **Distributed Hash Table (DHT)**
  - \+ Scalable for flat namespaces
  - – Higher latency for global DHT
  - – Difficult to select close copy
    - System has no topological information

- **Hierarchical DHT (Hierarchy of DHTs)**
  - \+ Hierarchy: increase *robustness*, reduce *latency*
  - – Solving diff. problem: How to find *responsible node* vs.: Find the *best/closest copy*
  - – No efficient network usage

- Idea: Use hierarchy to increase network efficiency

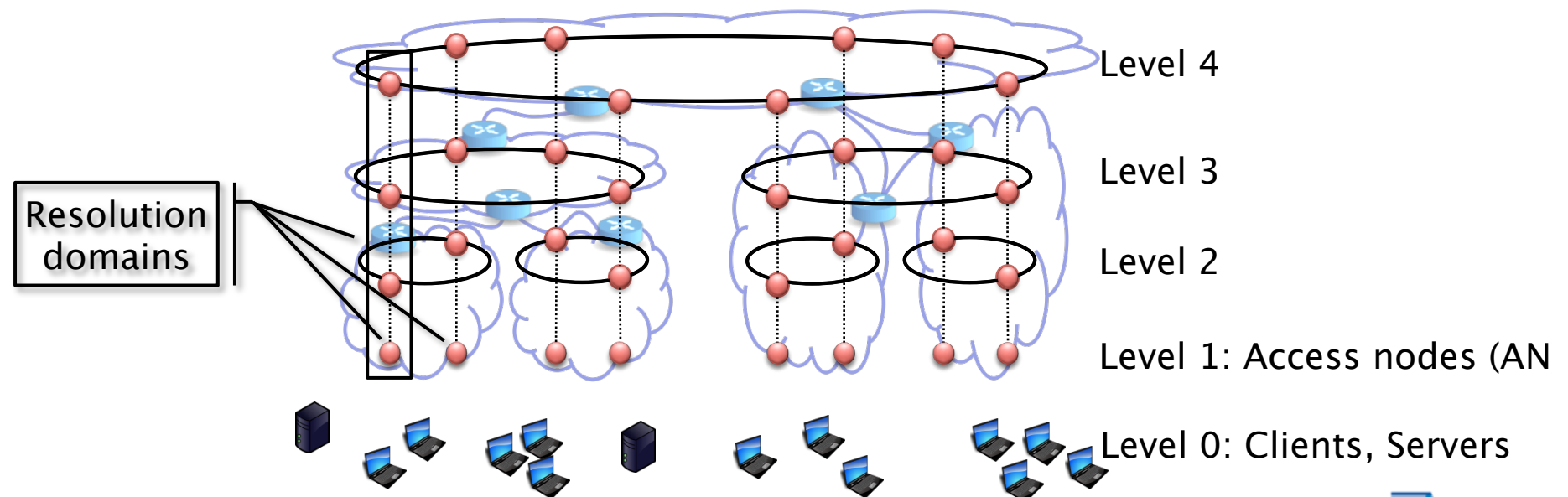# NetInf Name Resolution: Hierarchical NRS for Flat Namespaces

System-independent approach:

1. Resolution domains
   - Administrative autonomy: Simplify deployment
   - One or more resolvers, potentially interconnected via DHT

2. Build hierarchy of resolution domains
   - Topologically embedded: *enabler* for low latency, network efficiency

3. Inter-domain routing/forwarding scheme

4. Scheme to *(a) register* and *(b) request* objects
   - Essential for *low latency* and *efficient network usage*

☒ One specific implementation: MDHT

D'Ambrosio, Dannewitz, Karl, Vercellone; **MDHT: A Hierarchical Name Resolution Service for Information-centric Networks**; ACM SIGCOMM 2011 ICN Workshop; August 2011

(1, 2) MDHT – Hierarchy of Resolution Domains

- Designed as infrastructure network
- Topologically embedded
  - On following slides: logical view
- Nested design -> fast, robust inter-domain forwarding
- Heterogeneous -> supports different DHT variants
- Also supported: asymmetry, different depth, more levels, …

Resolution domains

Level 4

Level 3

Level 2

Level 1: Access nodes (AN

Level 0: Clients, Servers

SCALABLE & ADAPTIVE INTERNET SOLUTIONS