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Information Centric Networking: a model for an improved Internet (and mobile/ad hoc networks)

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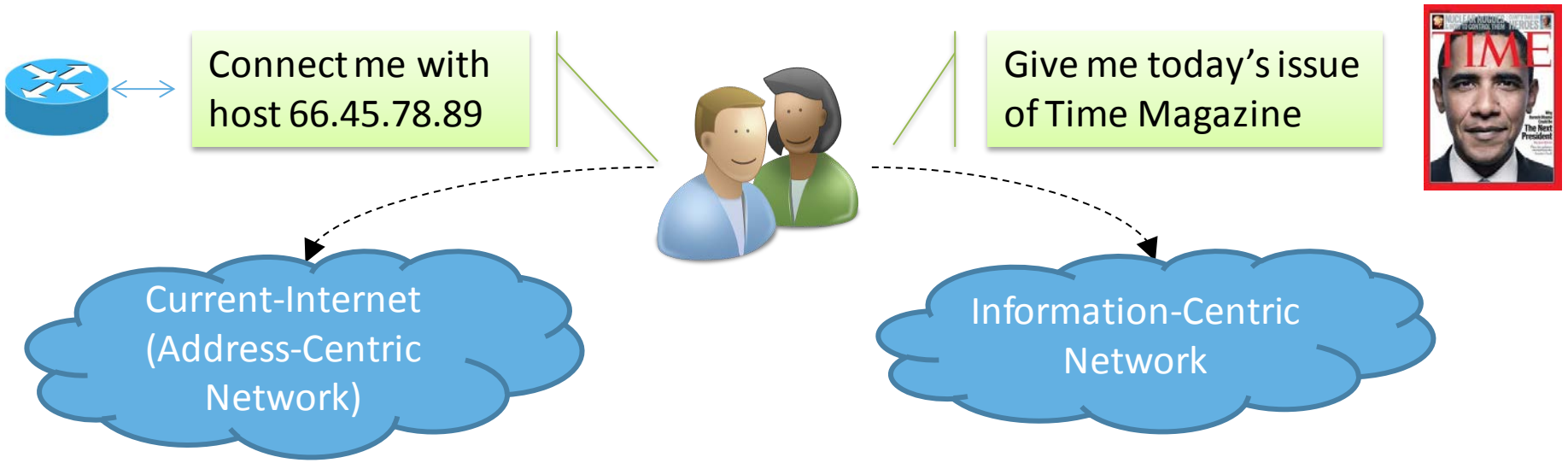
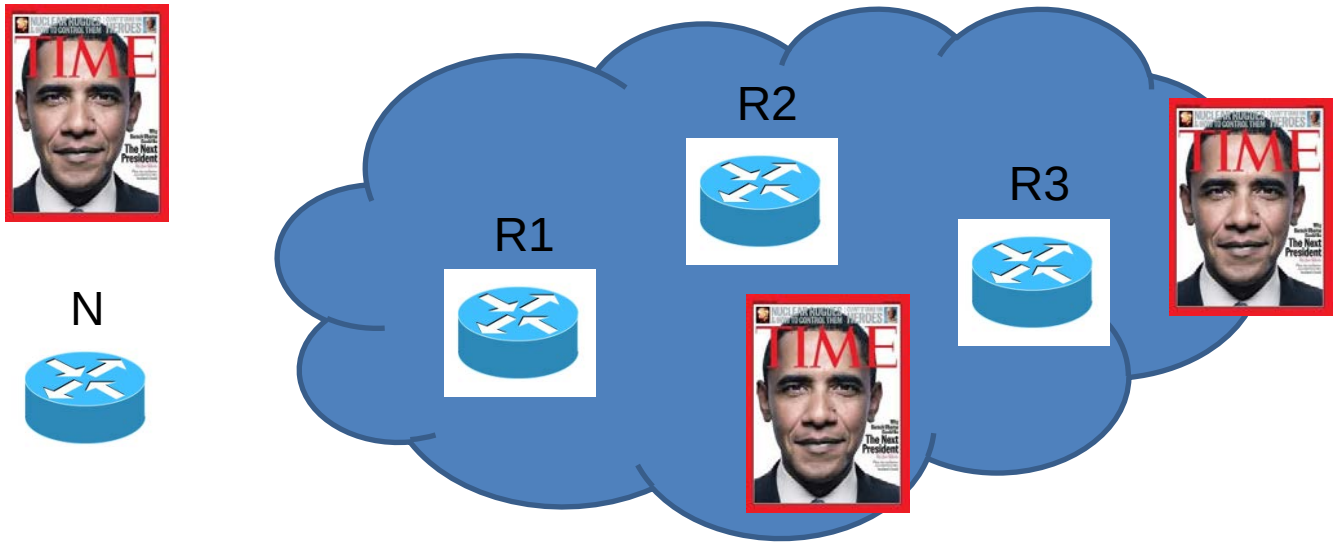
Information Centric Network

- The network layer provides users with contents, instead of providing communication channels between hosts, and is aware of content identifiers



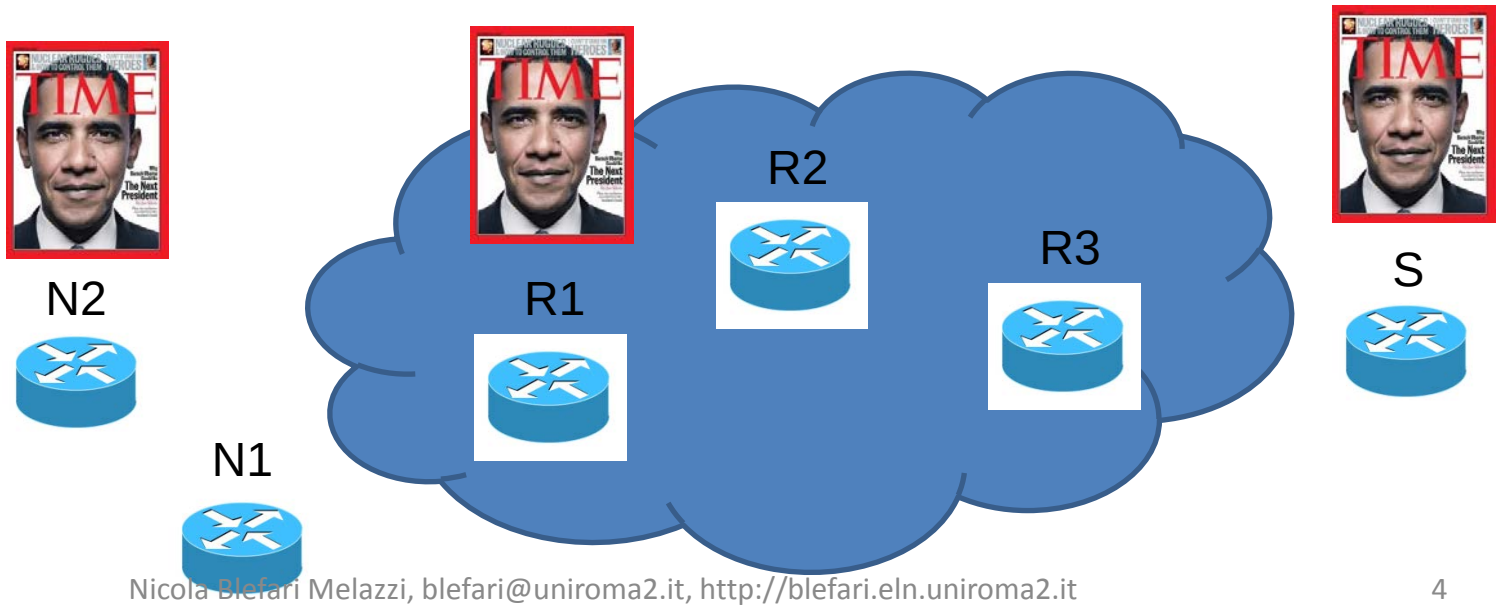
Shift of paradigms

- Circuit Switching, Telephone Network: a PCM slot contains only user data
- Packet Switching, Internet: an IP datagram contains (among other things) destination addresses and user data
- Content "Switching": data units contain (almost) everything

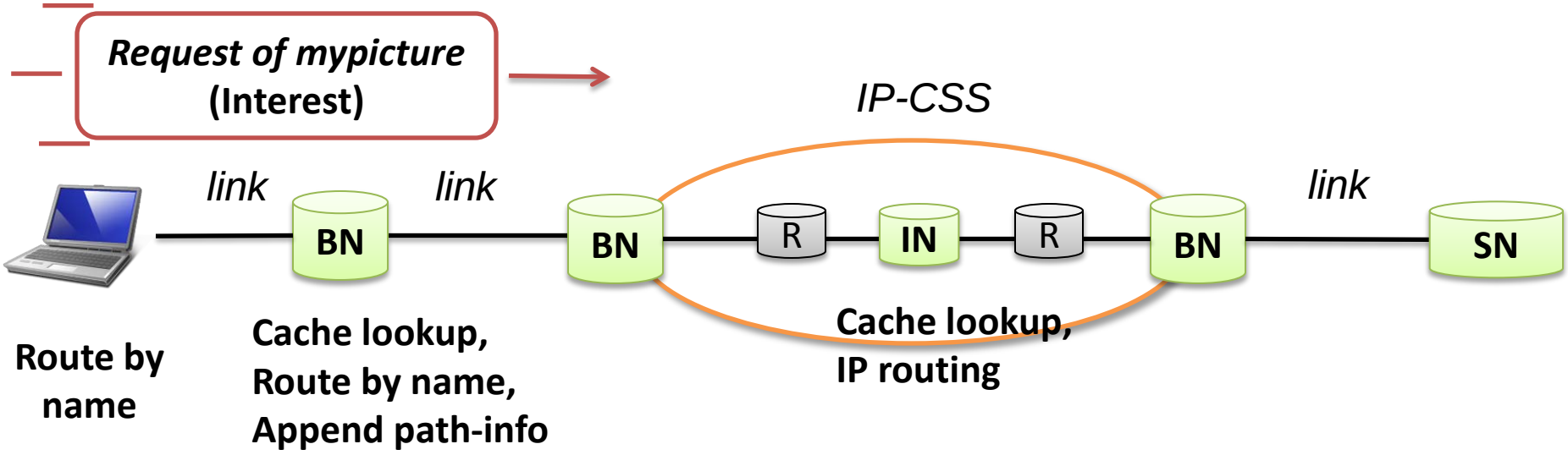


Basic network functions

- **address contents, adopting an addressing scheme based on names** (identifiers), which do not include references to their location
- **route-by-name**: route a user request, which includes a "destination" content-name, toward the "closest" copy of the content with such a name; this copy could be stored in the original server, in a cache contained in a network node or even in another user's device
- **deliver back the content to the requesting host**



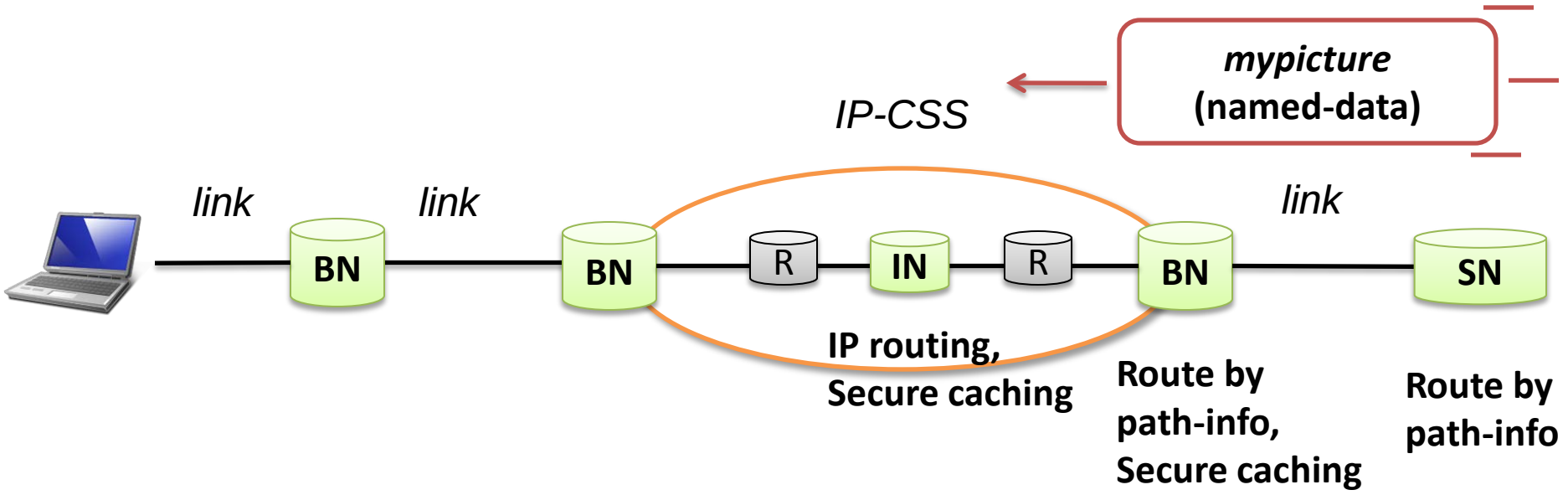
Mode of operation (upward)



Name-based routing table

Name	Mask	Next Hop Address	Interface	Metric
timemagazineissue	ff.ff.ff/0	00:18:84:1f:d5:99	Eth0	1
latestmovie	ff.ff.ff/0	160.80.80.1	IP0	1
mypicture	ff.ff.ff/0	172.34.6.19	tun0	1

Mode of operation (downward)



Information Centric Networking : Node Model

Cache (content store)

Name	Data
/foo.eu/video1/SN=1/BW=100.mp4/$cn1	…

Face 2

Forwarding Information Base (FIB) (prefix match)

Name	Face
/foo.eu/video1	2

Face 1

Pending Interest Table (PIT)

Name	Requesting Faces
/foo.eu/video1/SN=1/BW=100.mp4/$cn1	0 1

Face 0

ICN research

- Workshops
  - IEEE NOMEN 2012, 2013, 2014, 2015
  - ACM SIGCOMM 2011, 2012, 2013 (ICN-2014, 15, 16 full conference)
- Tens of papers in journals and general conferences
- Special issues (Computer Networks in press, Computer Communications in press, IEEE Networks, cfp)
- Standardization: IRTF Information-Centric Networking Research Group (ICNRG), BoF at IETF
- Projects
  - TRIAD, DONA, PSIRP, 4WARD, COMET, COAST, CONVERGENCE, SAIL, NDN, PURSUIT, MobilityFirst, GREENICN, BONVOYAGE

Specific advantages of ICN

1. Efficient content-routing: as a built-in facility of the network, which would transform the Internet to a “native” Content Distribution Network
2. In-network caching: caching enabled today by HTTP proxies requires complex operations (plus nowadays traffic is encrypted at the source)
3. Simplified handling of multicast and mobile communications: multicast is built-in and mobility greatly simplified (no states/anchor points)
4. Simplified support for time/space-decoupled communications (e.g. ad-hoc networks, vehicular networks, social gatherings, mobile networks on board trains, planes, or networks stricken by disaster)

Specific advantages of ICN

5. Simplified support for peer-to-peer communications
6. Content-oriented security model: securing the content itself, instead of securing the communication channels, allows for a more flexible and customizable protection of content and user privacy and protects in-network caches from fake content
7. Content-oriented access control: ICN can provide access to content as a function of time, place (e.g., country), or profile of user requesting the item
8. Content-oriented quality of service differentiation (and possibly pricing)

Specific advantages of ICN

9. Creating, delivering and consuming contents in a modular and personalized way
10. Network awareness of transferred content

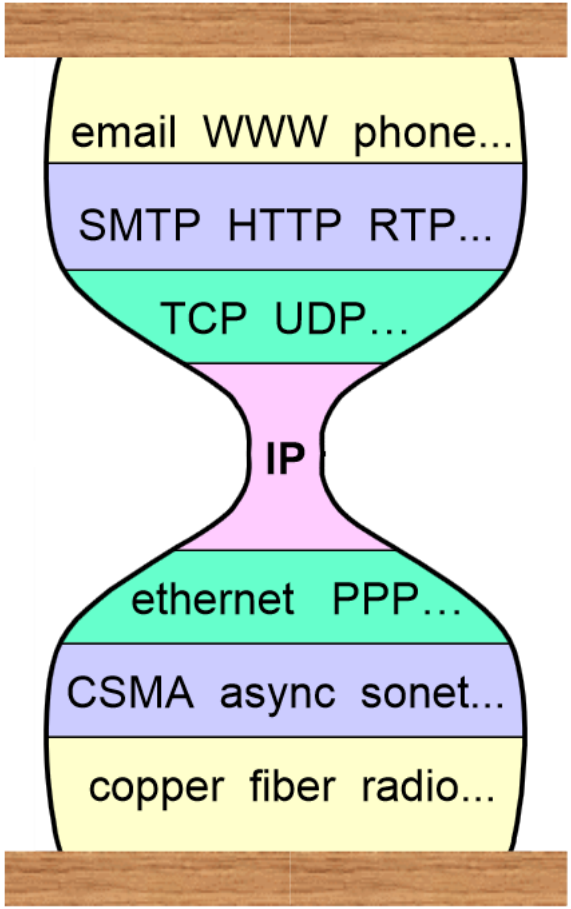
Key conceptual advantages of ICN

1. Simplification of network design, operation and management
   - Currently, content and service providers have to “patch” shortcomings and deficiencies of IP data delivery by using several “extra-IP” functionalities, such as HTTP proxies, CDNs, multi-homing and intra-domain multicast delivery, to name a few
     - e.g. try implementing pub/sub over CCN wrt over IP

2. Inter-content communications (and bi-directional links)
   - Instructions manual associated with a mobile phone
   - Glasses with RFID and related VDI
   - Elements of houses and cities, beams, walls, doors, bridges, railways talking to persons in disaster scenarios
   - Inter-things communications with pub/sub

Disadvantages

- Scalability concerns
  - number of different contents and corresponding names much bigger than number of host addresses
- Changes in the Internet thin waist (IP)
  - But 5G, SDN, NFV, slicing

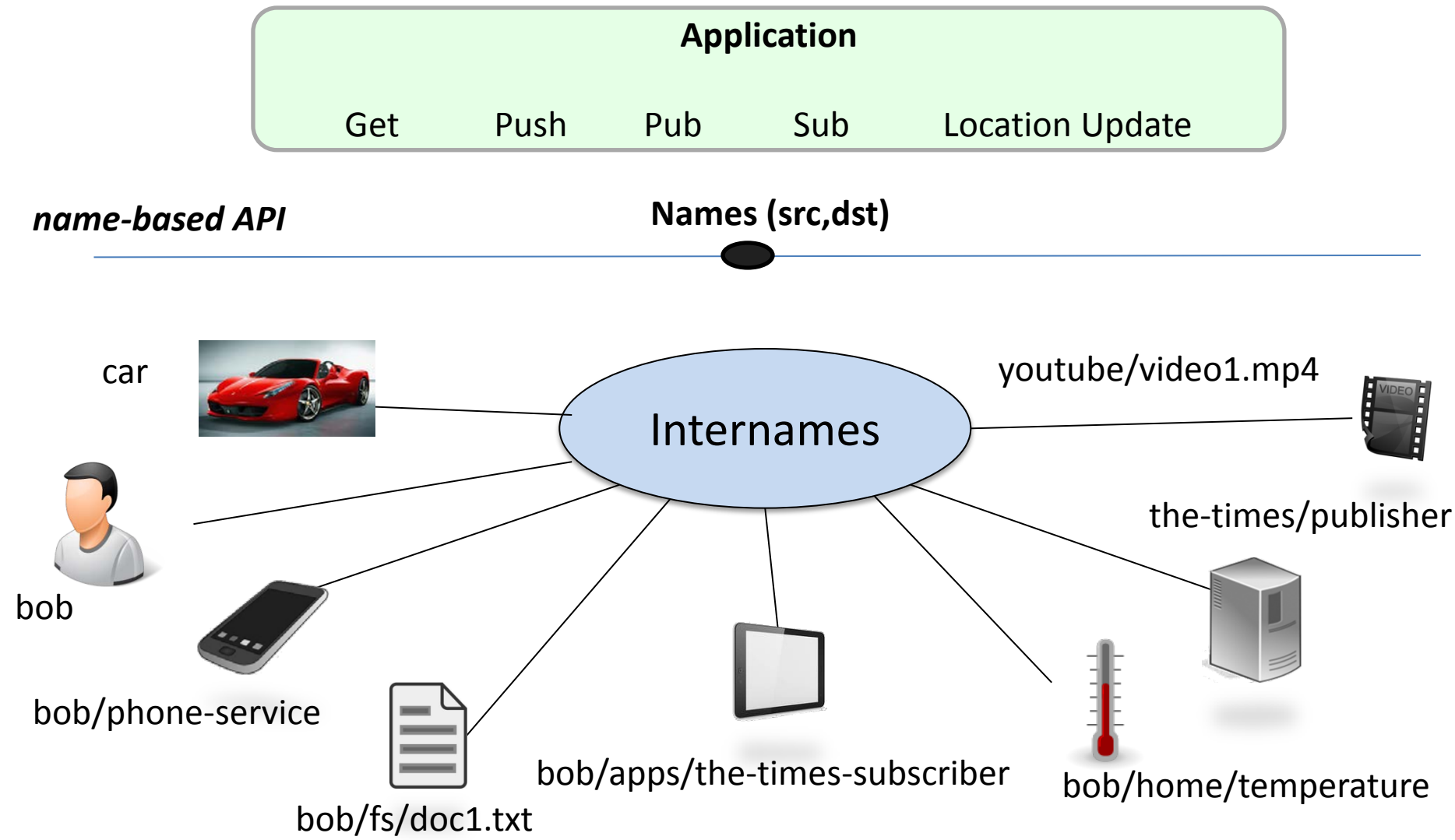


By Steve Deering, 2001

Internames: a name-to-name architecture

- An architecture in which names are used to identify all entities involved in communication: content, users, devices, logical as well as physical entities and services
- Names are not statically bound to their current location
  - entities can be mobile, and can be reached by any of a number of basic communication primitives
  - communication can span networks with different technologies and allow for disconnected operation
  - the communication path can be dynamically bound to any of a number of end-points (**both** source and destination), and the end-points themselves could change as needed

Internames


Application
Get
Push
Pub
Sub
Location Update
name-based API
Names (src,dst)
car
Internames
youtube/video1.mp4
VIDEO
the-times/publisher
bob
bob/phone-service
bob/fs/doc1.txt
bob/apps/the-times-subscriber
bob/home/temperature

Disaster management scenario

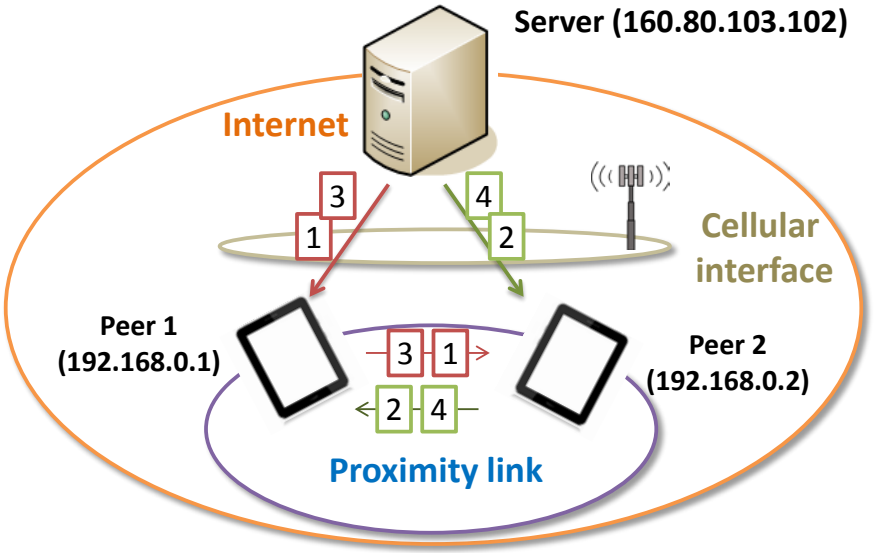
- ICN helpful in disaster situations:
  - Routing-by-name: very handy in a fragmented network where reference to location-based, fixed addresses may not work; ICN does not rely on reachability of application-layer servers (e.g. DNS resolvers)
  - Sessionless: ICN does not require full end-to-end connectivity (Delay Tolerant Networks-like forwarding is possible)
  - Caching helps to avoid congestion events typical of the aftermath of a disaster
  - Authentication of named data objects without relying on a trusted third party or PKI
  - Support of group communications, which arise very often after a disaster
  - Content-based access control: ICN can regulate access (e.g. only to a specific user or class of users) (CP-ABE)
    - a message can only be decrypted by someone with attributes “Public Official” and “Rank> Executive” or “Emergency Team” and “Any Rank”

Use cases

- Package of information containing three different sets of documents to be distributed to government representatives, rescuers and citizens
- Telecom operator managing the network: network devices and even network entities can be identified and addressed with a name, facilitating: i) entities discovery; ii) anycast routing; iii) end-to-end management, including user terminal; and iv) operation in fragmented networks

Applications scenarios

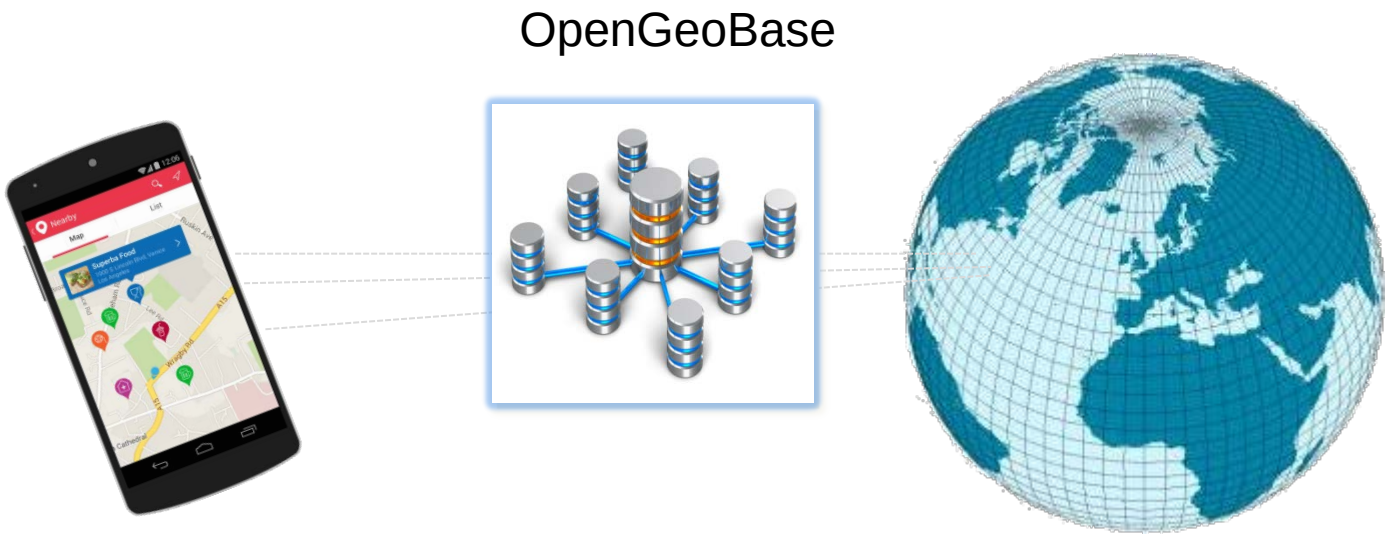
- Cooperative peer-to-peer application for live streaming of videos



- Topic-based, publish-subscribe MANET systems

OpenGeoBase

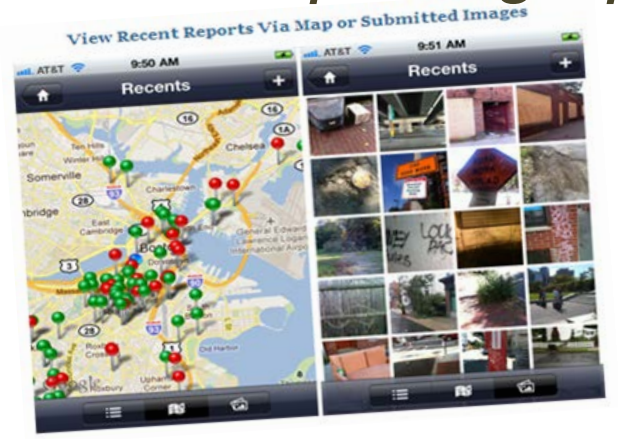
- A decentralized large scale storage system used for building georeferencing mobile and web applications



Many Possible Apps

Journey Planners

Citizen Reporting Apps



Video Games with Real World Map

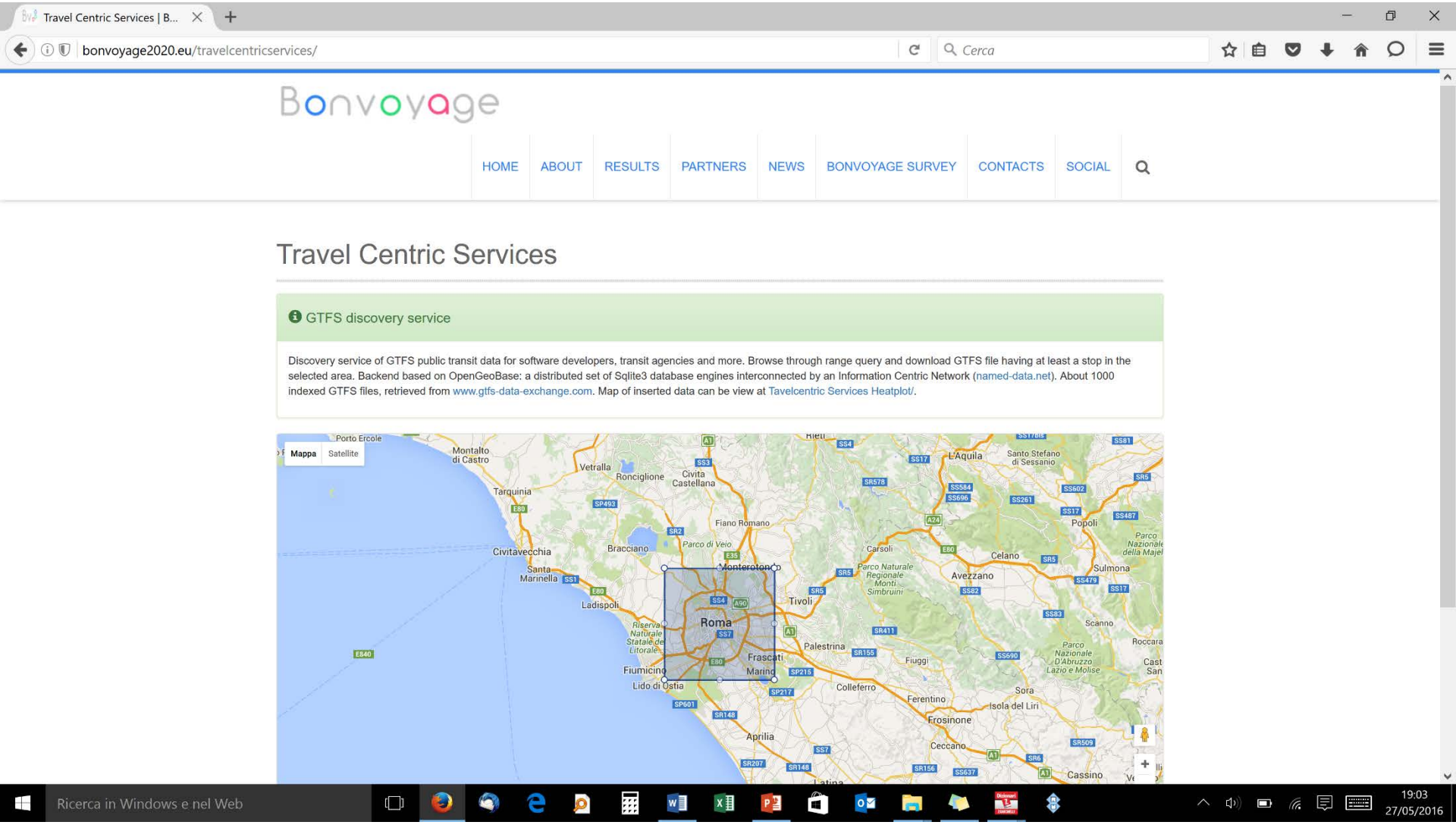
Augmented Reality

Features

- **Multi-Tenant Multi-User:**
  - Tenant is the App owner
  - Users of a Tenant can share geo data
  - Tenants can chose to share data of their users
- **Fast**:
  - Distributed and/or Decentralized storage
  - Parallel operations
  - Caching
- **Reliable**:
  - Replication and Sync
  - No single point of failure, e.g. no node for indexing or key resolution, etc.
- **Secure**:
  - Access control with user permissions
  - Cyphering
- **Scalable**:
  - in-production horizontal scalability
- **Application Frameworks:**
  - JAVA, C, ANDROID, JAVASCRIPT, PYTHON

OpenGeoBase

http://bonvoyage2020.eu/travelcentricservices/



Thank you
Questions?

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