COST Exploratory Workshop on Smart Cities
26-27 September 2011, Université Paris Dauphine, France

SMART Cities: challenges & opportunities for communication operators

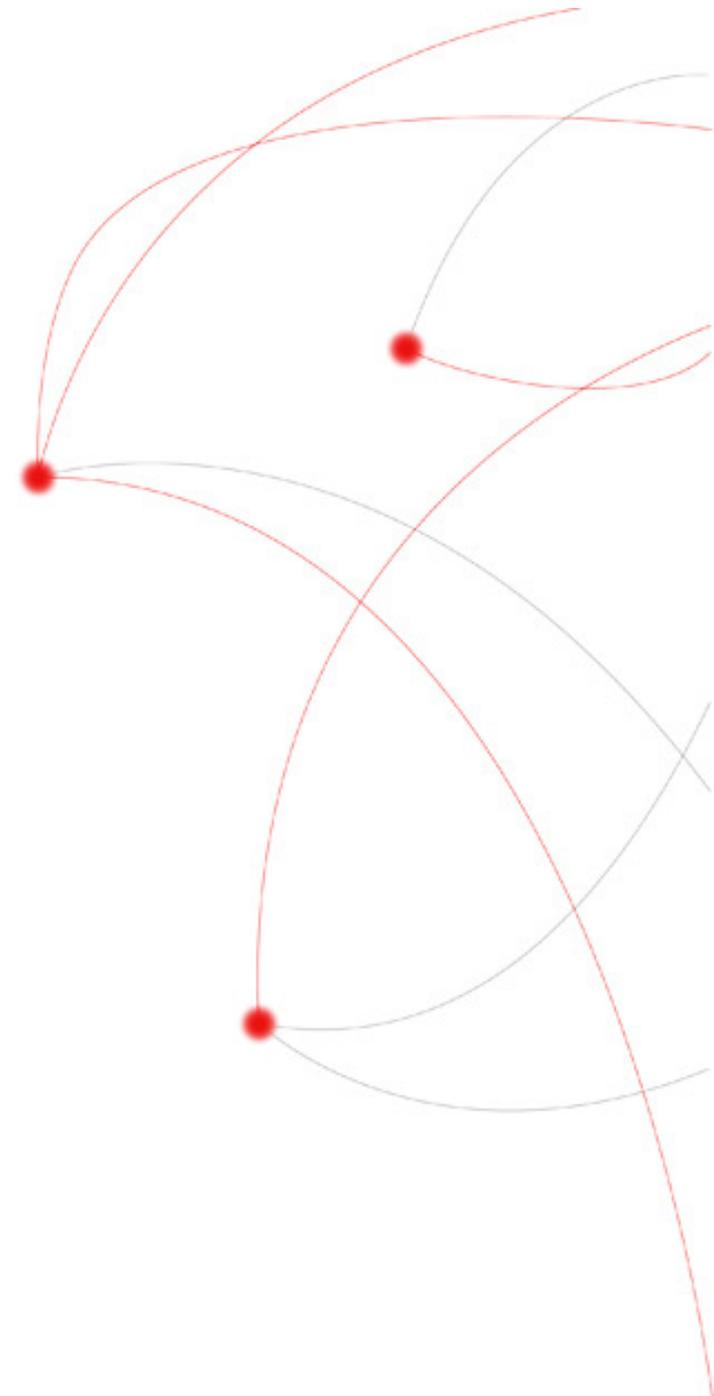R. Minerva, Telecom Italia / Future Centre

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Agenda

- **Opportunities & Challenges for the Operators**

  - **The trends …**

- **A data view on Smart Cities**

  - **Lot of smart objects at the edge of the networks**

  - **The integration of Personal Data with City Information (a bit of scenarios)**

- **A Network as a Platform**

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Telecom Italia / Future Center
Roberto Minerva

The current Operators Approach

R. Minerva, Telecom Italia / Future Centre
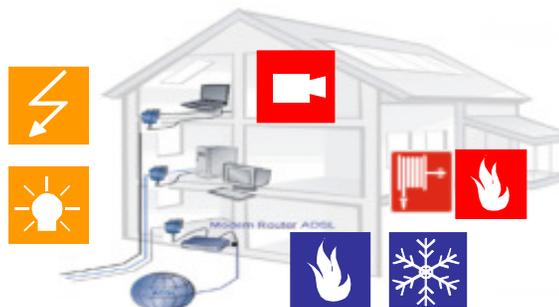
Some Services for *Smart City*

MOBILITY

AMBIENT

EMERGENCY

Smart town

SECURITY

BUILDINGS

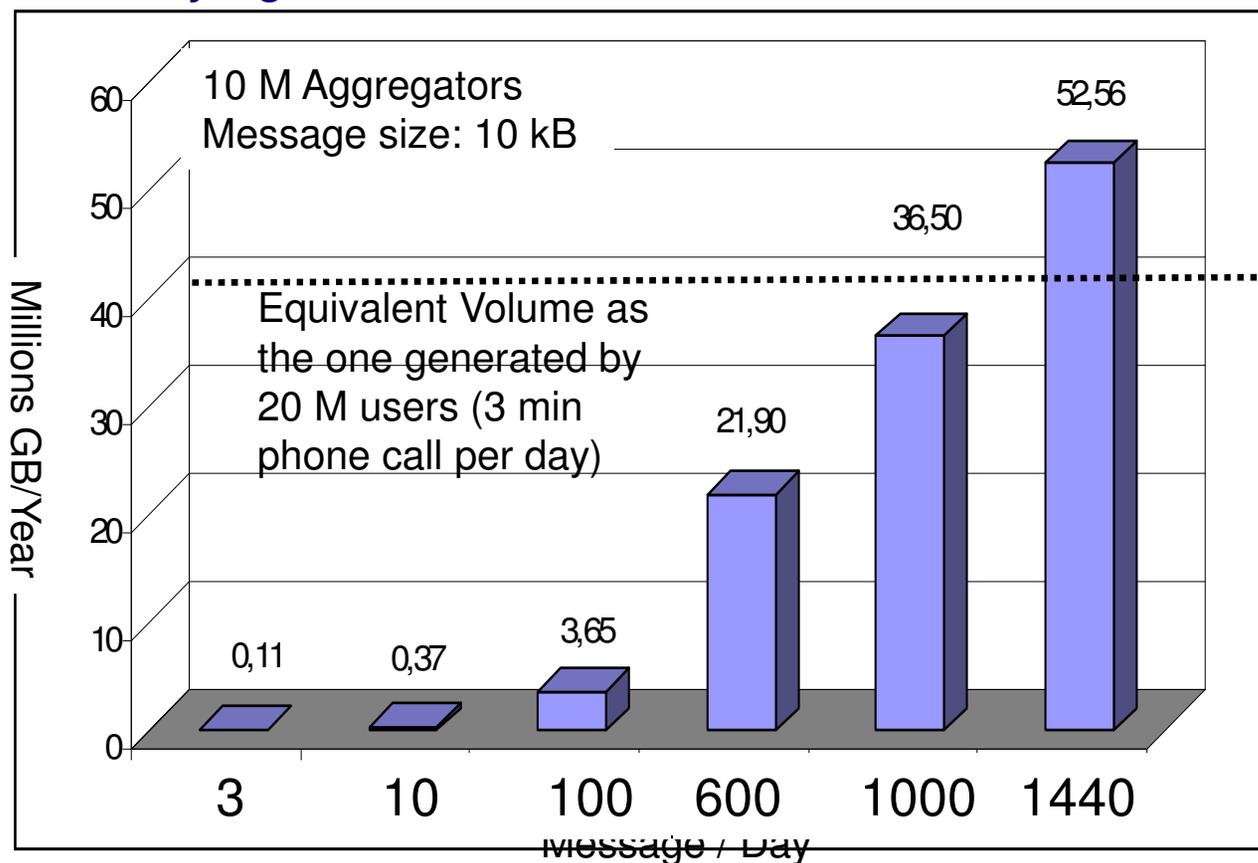**COMMUNICATION**

WiFi

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How Many Nodes, How Many Messages, How Much Bandwidth ?

Traffic will be significant if:
- **IoT applications will make a substantial use of multimedia content**
- **The total number of communicating things will be very very high**

Operators should try to be Aggregators by providing real-time messaging engines (e.g., based on PubSub), by creating communities, and by supporting the deployment of the infrastructure (at home and in the public domain)

10 M Aggregators
Message size: 10 kB

Equivalent Volume as the one generated by 20 M users (3 min phone call per day)

Message / Day	Millions GB/Year
3	0,11
10	0,37
100	3,65
600	21,90
1000	36,50
1440	52,56

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Towards a Network of Networks
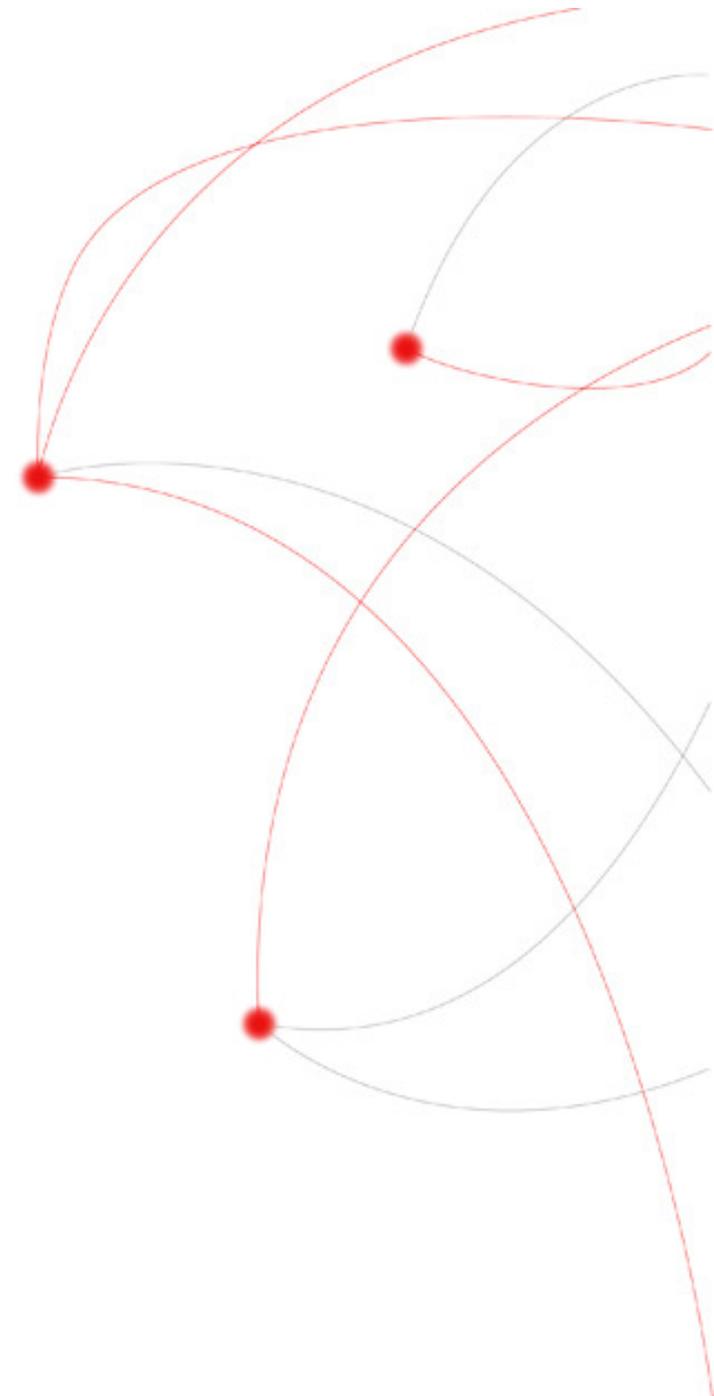
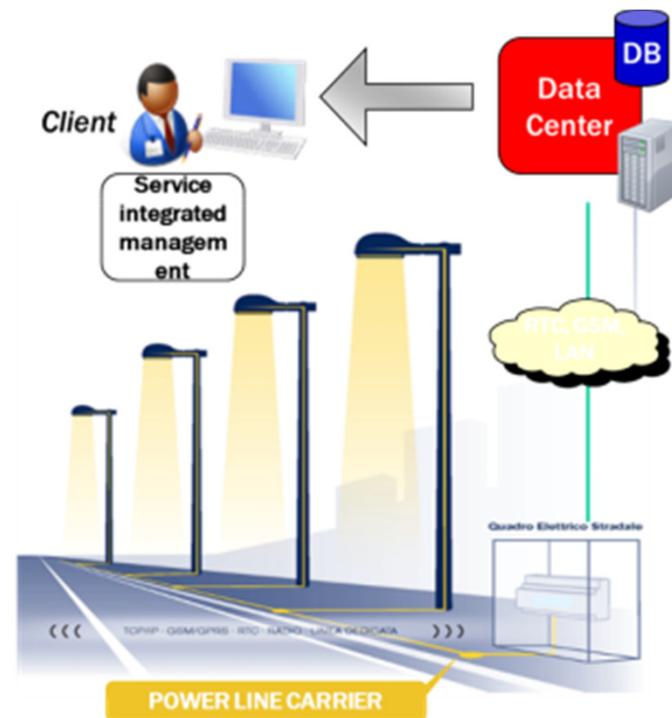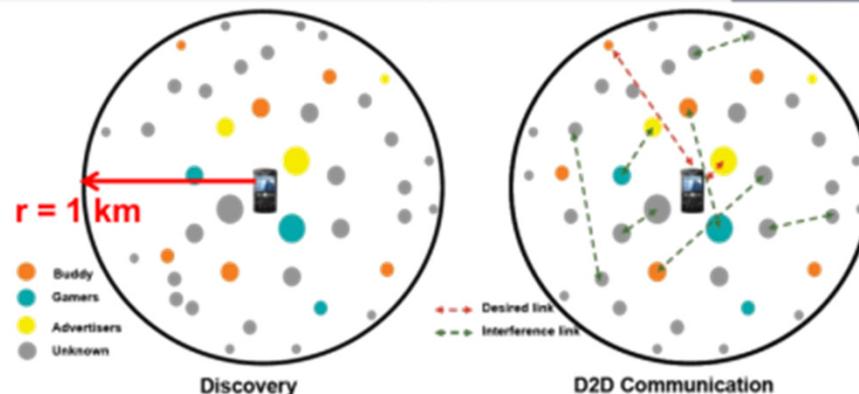R. Minerva, Telecom Italia / Future Centre

Towards City Networks

Wireless access points in Barcelona used for municipal applications

A network of networks

FlashlinQ: A Clean Slate Approach to D2D

r = 1 km

- Buddy
- Gamers
- Advertisers
- Unknown

- Desired link
- Interference link

Discovery

D2D Communication

FlashlinQ

1. Discovery Autonomicity, Range and Number of Devices
2. Self Organized Device-to-Device (D2D) Communication
3. Session Mobility to/from FlashlinQ & Cellular/WiFi/etc.

FLASHLINQ

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R. Minerva, Telecom Italia / Future Centre

The network itself is a source of Information

R. Minerva, Telecom Italia / Future Centre
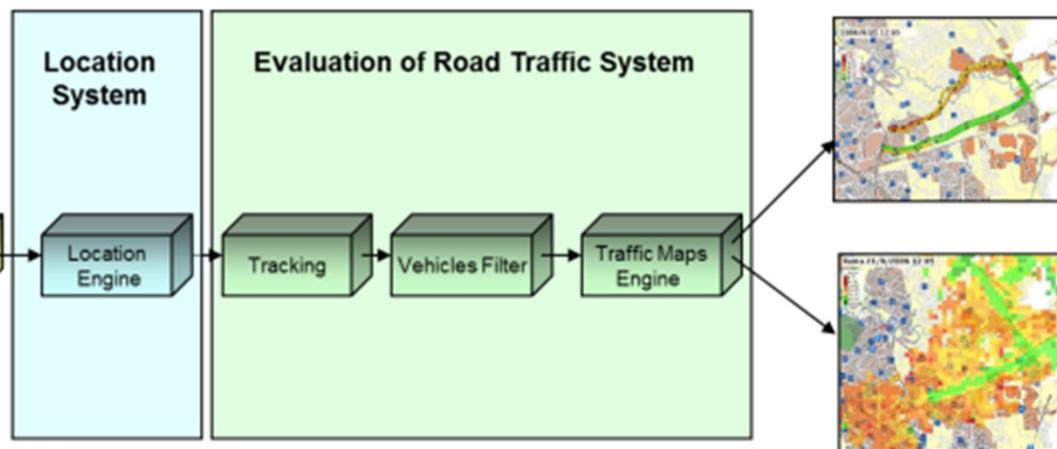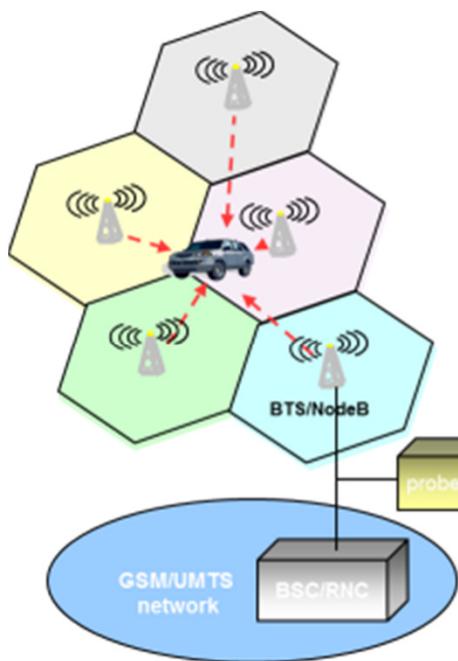
Living in the Smart City

How much PERSONAL information could a CITY need/generate/provide/manipulate ?
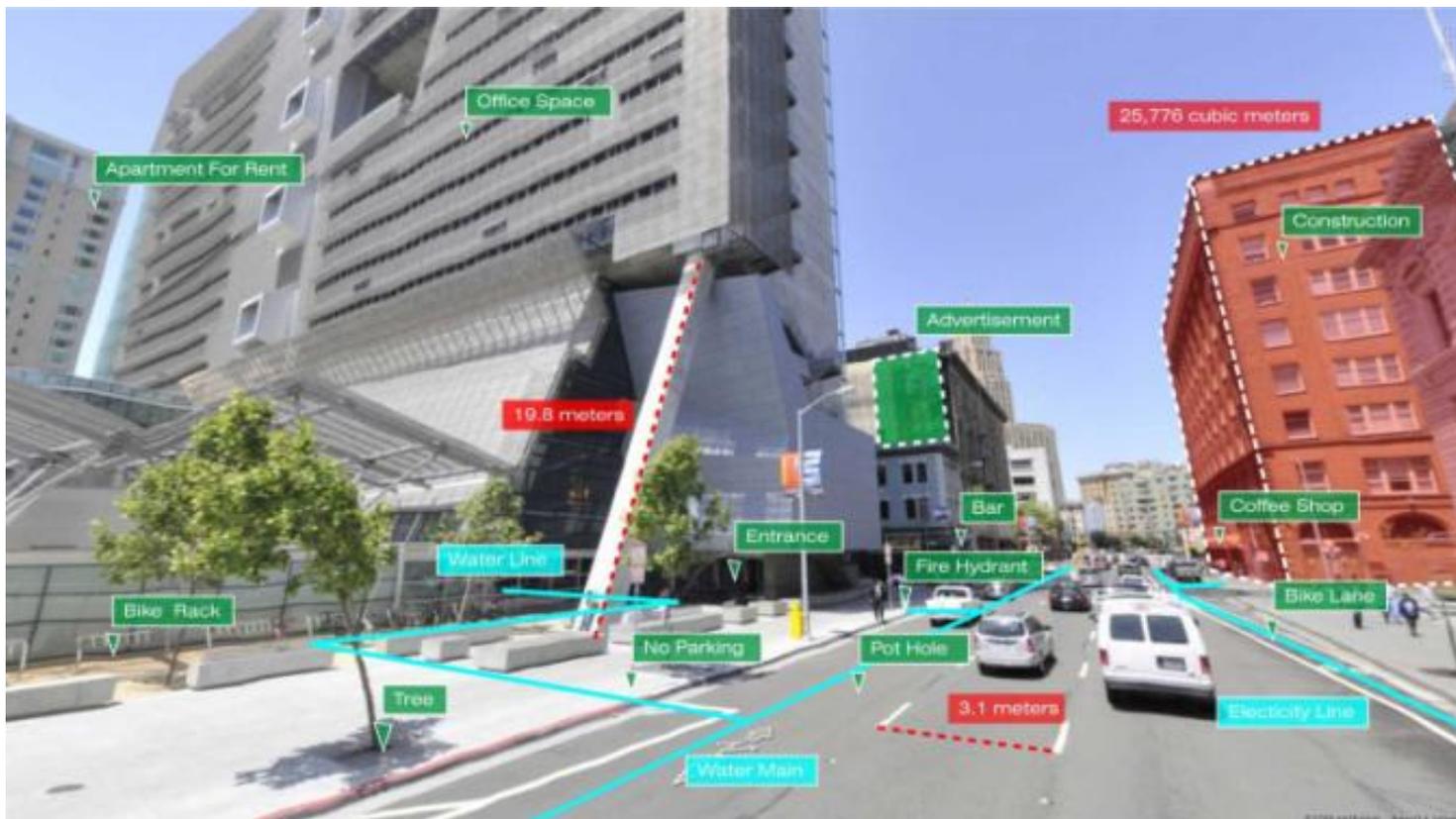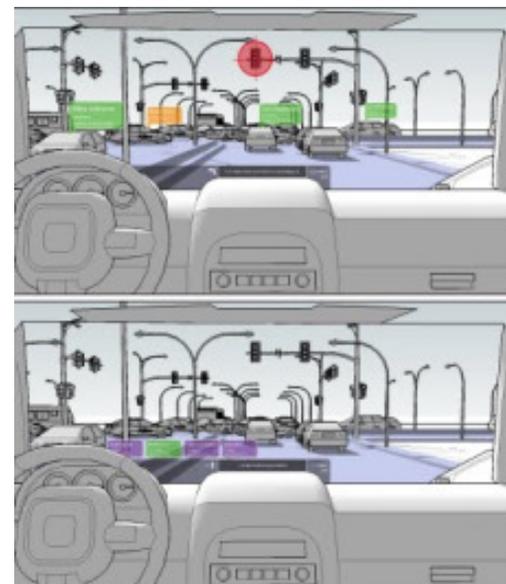
What is the PERSONAL contribution that a single citizen could give without been tracked ?

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Objects, Terminals, Networks as Personal Info Producers

Smart Objects

Intelligent Terminals

Smart City Services and Systems

NFC, Wifi, UWB, BT, …

3G, 4G, other public nets, …

Servers

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Automotive Communication Scenarios (CALM)

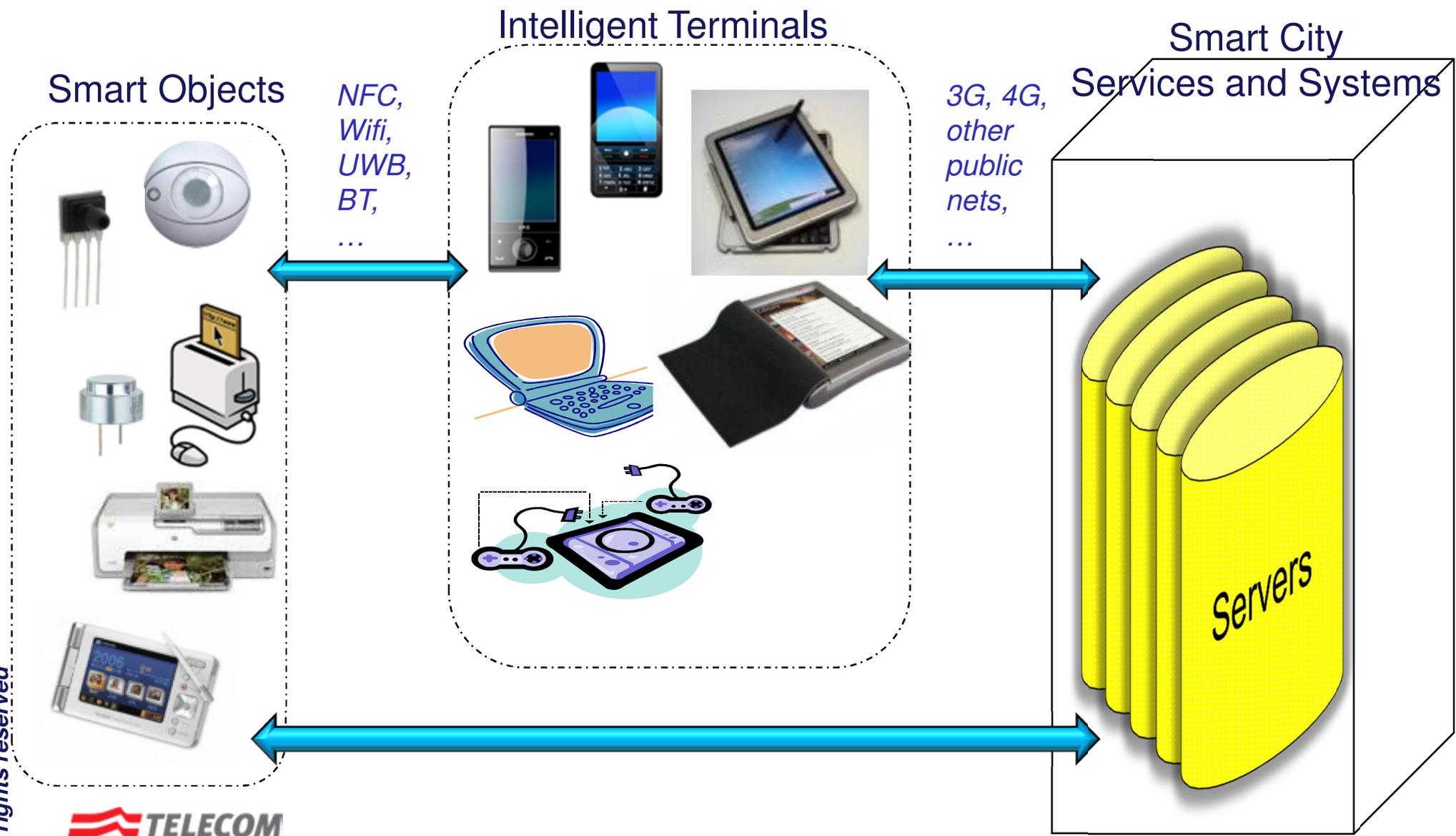- CALM (Communications, Air-Interface Long and Medium Range) architecture is defined by ERTICO

- What is it for ?

  - Wireless Automotive Communication

  - Electronic Toll Collection

  - „Advising" Road Signs

  - Internet in the Car

  - Electronic Travel Guide

  - Inter-Car Communication

  - More than 100 Applications identified

- Lots of data related to individuals

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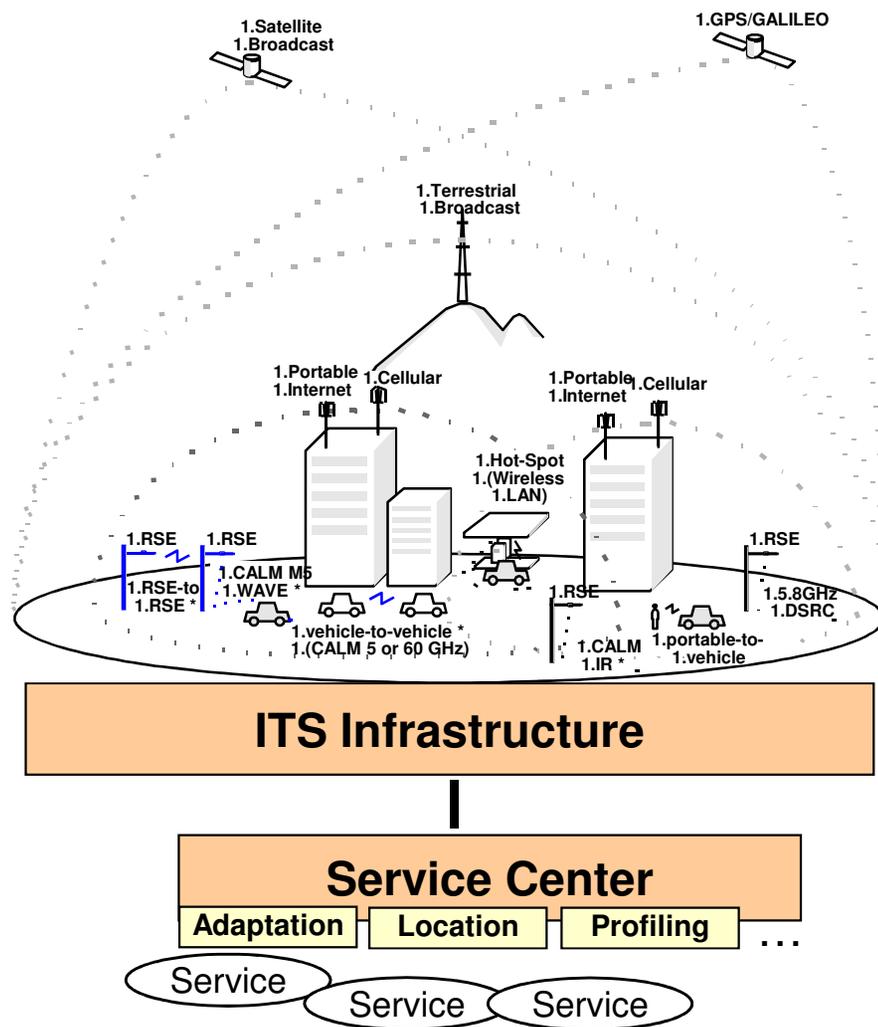
Home Sensor Networks

- The wired home: www.bwired.nl

  - Server xeon, hundreds of sensors (from the fridge to the toilet room)

  - "Home made" technology

  - Possibility of remote control
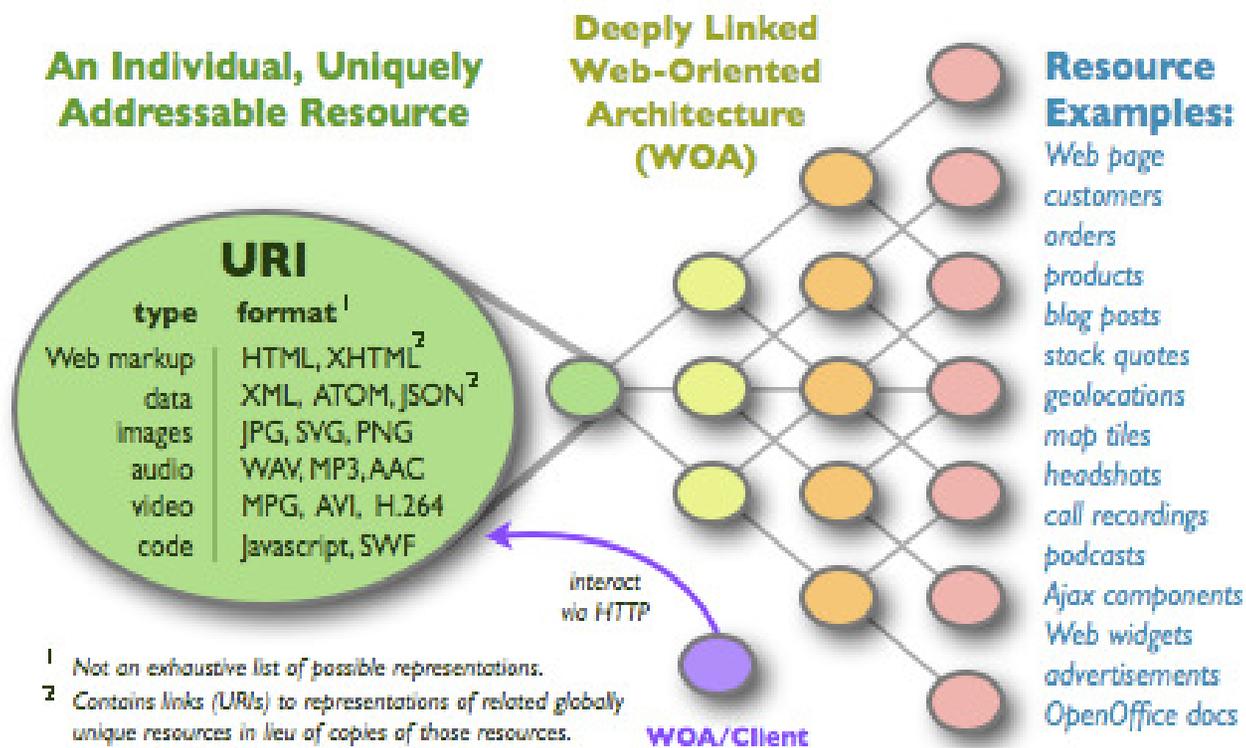
➜ Bad Usability, but

➜ <u>Plenty of Data</u>

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Identity of Things

- **Each Resource is addressable**

- <u>**Each resource is CONNECTED**</u>
  - **Connectivity must be guaranteed in a variety of environments**
  - **Secure Links have to be guaranteed**

An Individual, Uniquely Addressable Resource

Deeply Linked Web-Oriented Architecture (WOA)

Resource Examples:
Web page
customers
orders
products
blog posts
stock quotes
geolocations
map tiles
headshots
call recordings
podcasts
Ajax components
Web widgets
advertisements
OpenOffice docs

URI

type	format[1]
Web markup	HTML, XHTML[2]
data	XML, ATOM, JSON[2]
images	JPG, SVG, PNG
audio	WAV, MP3, AAC
video	MPG, AVI, H.264
code	Javascript, SWF

interact via HTTP

WOA/Client

[1] Not an exhaustive list of possible representations.
[2] Contains links (URIs) to representations of related globally unique resources in lieu of copies of those resources.

Source: Dion Hinchcliffe. http://hinchcliffe.org. Some Rights Reserved, 2008.

- <u>**Each Resource can be associated to a User (Identity)**</u>
  - **Who owns these relations :UserId - Location - ResourceId - data used/generated ?**

- **Things can collect user related actions and data**
- **Each Thing can be used for tracking Users**
- **Owners of Things can collect a lot of data**

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A First Issue: proper Management of Personal Data

Source: Bain & Company

Personal data	Personal data creation		Storage, aggregation	Analysis, productisation	Consumption	
	Devices	Software				
Volunteered	Mobile phones/ smart phones	Apps, OS for PCs	Web retailers	Market research data exchanges	End users	
Declared interests	Desktop PCs, laptops		Internet tracking companies	Ad exchanges		
Preferences		Apps, OS for mobile phones	Internet search engines		Government agencies and public organisations	
...	Communication networks		Electronic medical records providers	Medical records exchanges		
Observed	Electronic notepads, readers	Apps for medical devices				
Browser history			Identity providers	Business intelligence systems		Small enterprises
Location	Smart appliances	Apps for consumer devices/ appliances	Mobile operators, Internet service providers			
...				Credit bureaus	Businesses	Medium enterprises
Inferred	Sensors	Network management software	Financial institutions			
Credit score				Public administration		Large enterprises
Future consumption	Smart grids		Utility companies			
...	...	...	...	...		

Communication standards

A "user-centric personal data eco-system" (WEForum)

<u>Volunteered data</u>: created and explicitly shared by individuals

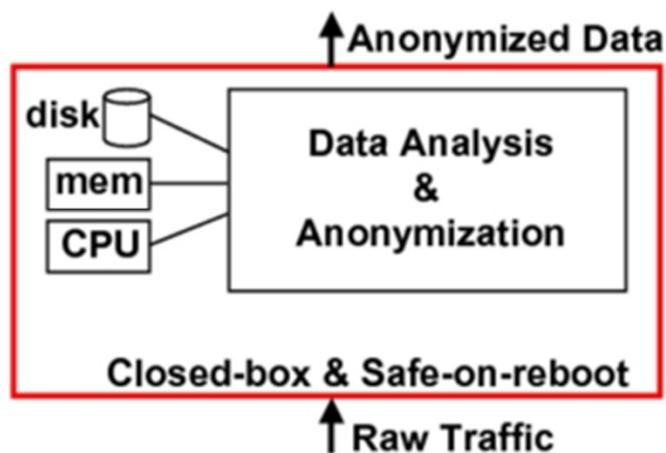<u>Observed data</u>: captured by recording the actions of individuals

<u>Inferred data</u>: based on analysis of volunteered or observed information

Personal Data should be properly managed

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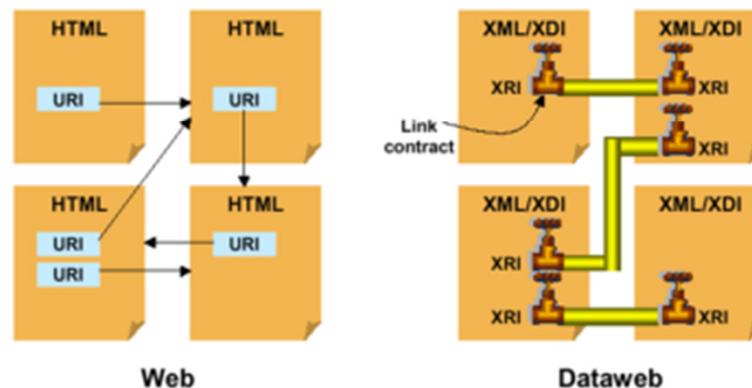# Dealing with Data: Data Anonimization, Contracts and Contextualization

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Towards Networks of Networks

the network
is more
powerful
than the
node etc.

@hugh

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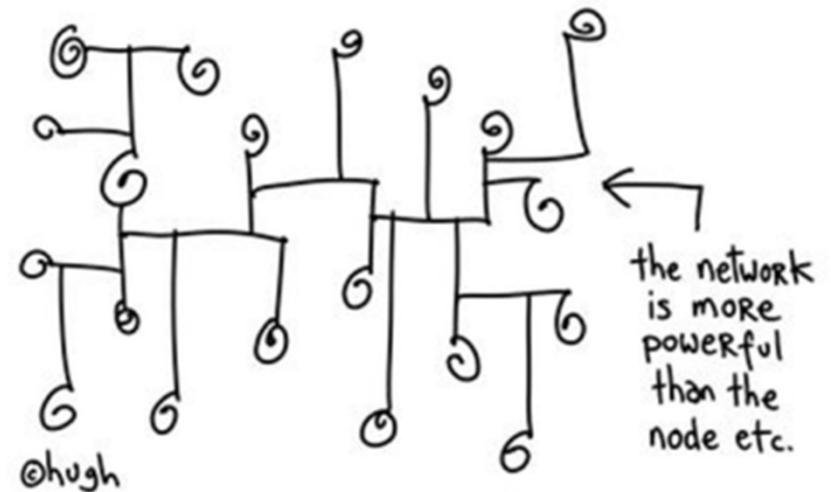
(Mobile) Object Networks

- **Many Objects scattered in the env** (with local communication)

- **Some Aggregators gathering and dispatching information**

- **Networks to cross**
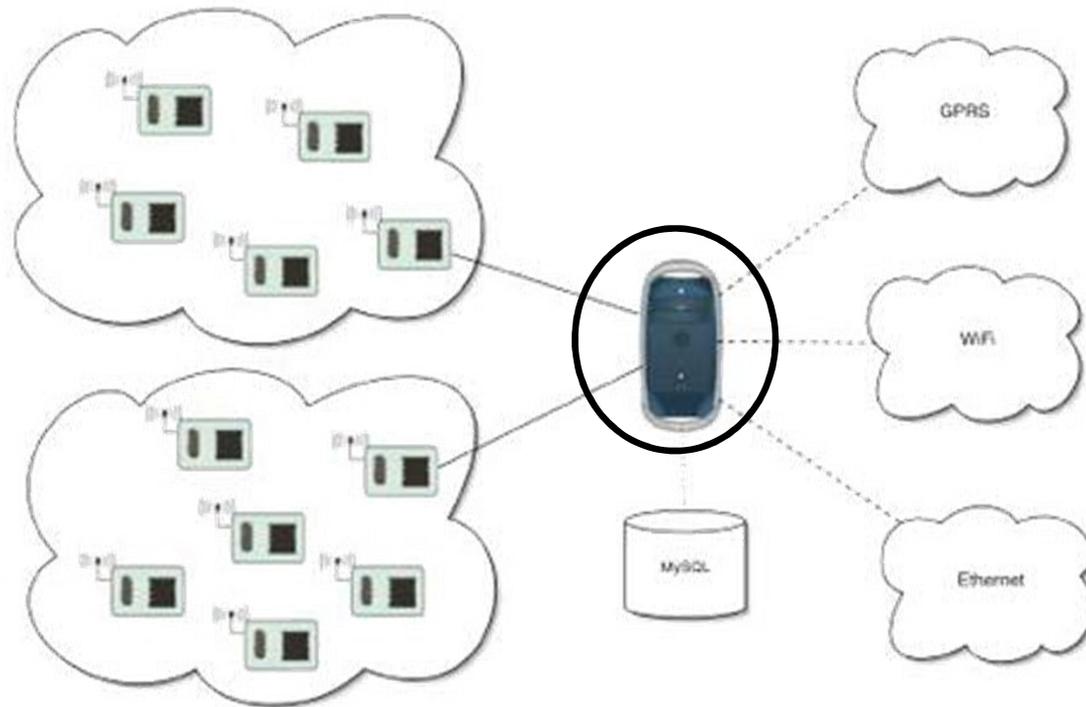
Nodes will connect each other in unpredictable ways

Aggregation 2

Aggregation 1

Aggregation 3

1

2

3

Node Aggregation at time t_1

3

1

2

Aggregation 1

Aggregation 2

Node Aggregation at time t_2
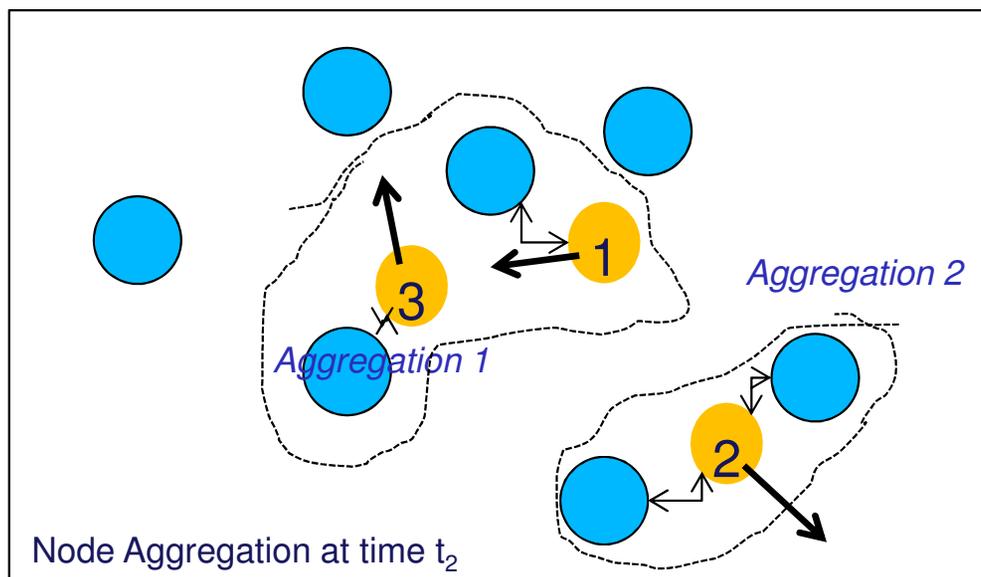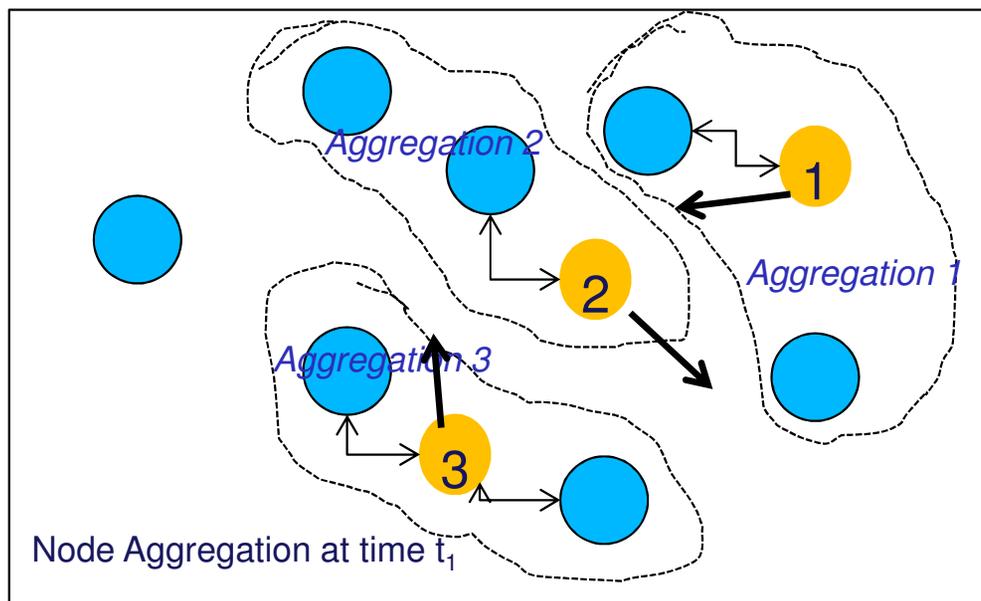
Increasing richness and complexity at the edge of (Operators') networks
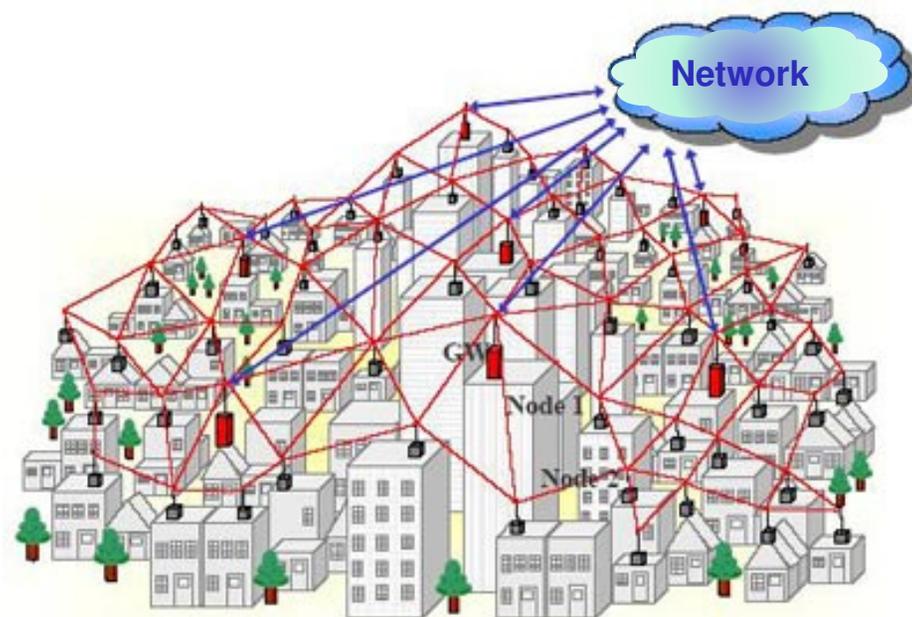
Network

http://muxware.net/sol_mesh.php

A Second Issue: Complexity is moving to the edge

- Functionalities and data generation/consumption and storage in the edge

  - Networks will comprise smart objects and processing, storage, communication resources

  - Data and Info will be the user target and not mere connectivity

- Complexity coalesces at the edges (more nodes and more capabilities)

  - While big networks are flattening and becoming simpler (less nodes)

  - Local aggregation vs. average coverage

    - Aggregation of intelligent points will be mainly unpredictable and even if high average connectivity capabilities will be provided, such a dynamic concentration will challenge the networks capabilities

      - Competition for scarce resources for a limited period of time

- Terminals will have a key role

  - Terminals as an integral part of the communication environment

  - Mobility will be assumed for the majority of terminals

- Need to control new complex systems without human intervention

  - The Operator's network needs to support and help in this new context

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Dealing with Complexity at the edge: Self-Organization of Networks
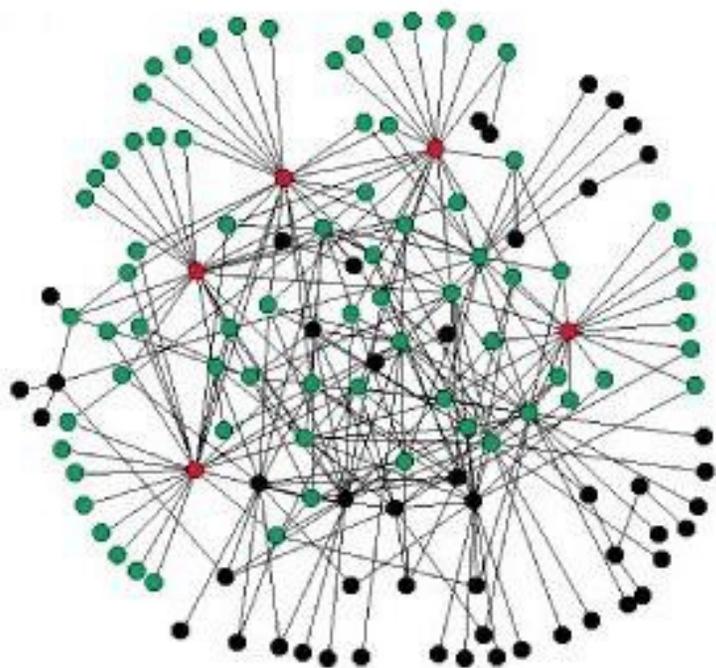
Scale-free

Management of complex and dynamic "Network s of Networks" will be critical

- **No human intervention possible**
- **Competition on resources**

Require

- **Self-organization**
- **Game theory techniques for highly distributed systems**

http://innovation.gsa.gov/blogs/OCIO.nsf/dx/Management-Innovators-Bookshelf-Small-Pieces-Loosely-Joined-A-Unified-Theory-of-the-Web-by-David-Weinberger-2002

Telecom Italia

The "Digital Mirror" and the "The Bank of User Data"

Telecom Italia/Future Centre

Where are the Personal Data ?

• What data Sources ?

- From the personal terminal OS**:**

  - from "logs" of terminal activities: e.g.,. calls, SMS, MMS

  - From the local "firewall", e.g., for IP apps (browser, chat, VoIP, …)

  - From terminal related sensors: e.g., GPS, proximity sensors

  - From "wrapper" of special applications: e.g., cameras, player, file management,…

  - Need for login for some shared terminals:

    - E.g.,. Home PC → to correlate activities of different people

- From the Net:

  - To intercept actions when the terminal is not available

  - To provide unique identifiers for the actions (e.g., callId, sessionId) that are related to more users

  - Aggregation of interactions of "personal smart objects"

  - To offer context-awareness enablers

  - Etc..

  - In addition, it could certify data and actions (e.g., for providing info on not completed communication)

• What data Sinks (Data Spaces) ?

- Fragmented between different Providers:

  - Provider collects and store personal information

  - Personal data are used to provide specific services

  - Different Providers collect same type of information

  - No user control and limited privacy

- In the terminal

  - pros: alway-on connectivity not requested

  - cons: storage space, difficulties in sharing of data, limits in scalability for the execution of applications

- in a "Virtual Individual Server" in the network ("property" of user like an e-mail inbox)

  - pros: unique virtual terminal encompassing more physical terminals (e.g.,. mobile, PC, tablet), possibility to execute data –intensive applications
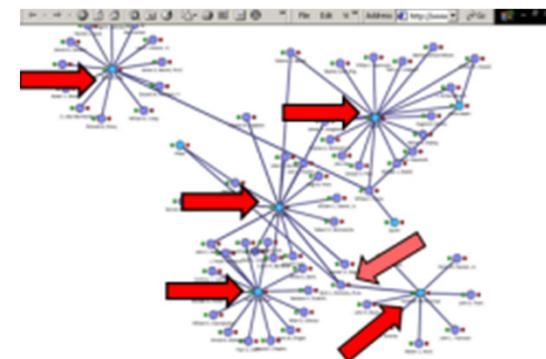
  - cons: need of always-on connections

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A New Role: The Bank of User Data (BUD)

- Protect the information of a "customer":
  - Collect and store it in a secure fashion (security, disaster recovery)
  - Ease the (semantic) organization end the retrieval (search)
  - Control the access (privacy, "user managed access")
  - Certify the ownership, legitimacy, and the genuineness (e.g., identity management)
- Capitalize (leverage and monetize) the information:
  - By enabling new applications (e.g., based on aggregation, mass analysis, semantic representation, …)
  - By aggregating the information according to the social relationships (and the social graph) of the user
  - By selling/leveraging the information (in a controlled and controllable way) to applications providers ("knowledge" in social networks or service provider) in order to "generate opportunities for economic and societal value creation":
    - Let the economical and/or social value of single user data emerge and help the usage and exploitation;
    - Let the economical value of information growth, by means of aggregation of several users data also considering their relationships;
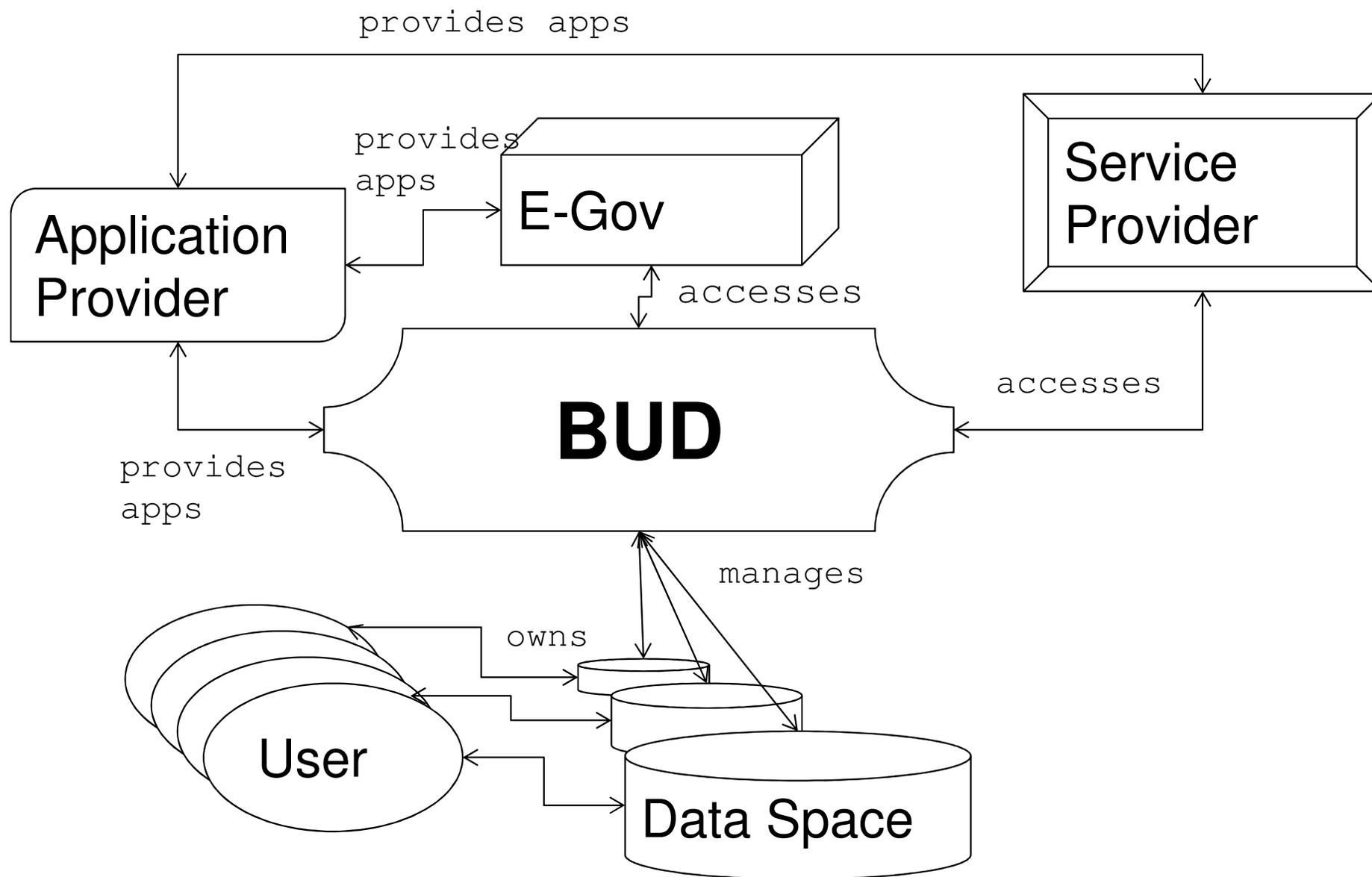   - Return a larger part of this value to the users (owner of personal information).

The fundamental principle of this approach is that DATA pertain to the User

Telecom Italia/Future Centre
C. Moiso, R. Minerva

But what is the Value of Personal Data?

- The value of the single datum depends on the usage context:

    - The kind of collected datum: `V(CreditCard) > V(SocialSecurityNumber)`

    - Time reference: `V(CreditCard, today)>> V(CreditCard, 4years ago)`

- The value of the Person in the usage context:

    - Importance of the person `V(CreditCard, SB) >> V(CreditCard, RM)`

- The linkage of the datum

    - The connection of the datum and the person:

        - How many data can be connected to the datum (es.: FoaF)

        - Is the datum owner well connected (a Hub kind of person) `V(a) > V(b)`

    - How much data (derived from http://www.thoughtfarmer.com/blog/2009/04/27/intranet-roi/)

        - Metcalfe's Law: **n(n-1)/2**

        - Reed's Law: $\mathbf{2^n - n-1}$

        - Briscoe, Odlyzko, and Tilly Law: **n log (n)**

        - Beckstrom Law: $\boldsymbol{V = \Sigma B - \Sigma C}$

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The Digital Mirror EcoSystem

provides apps

provides apps

Application Provider

E-Gov

Service Provider

accesses

BUD

accesses

manages

owns

provides apps

User

Data Space

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Digital Mirror: Architectural View

Applications for visualization, search, etc..

Applications for analysis, processing, etc..

application space

end-user's physical device(s)

API

Communications from Intelligent terminals

Control of sharing towards social network and opening towards service provider

Synch and update

API

Sharing

end-user's personal smart objects

Short range Communication

Synch and update

services (trusted platforms)

Communications from connected objects

end-user's virtual server

• Resources/content
• Actions' description
• Results of apps

User's owned data

The environment for personal data supported by the BUD

legenda:

Partial view on data

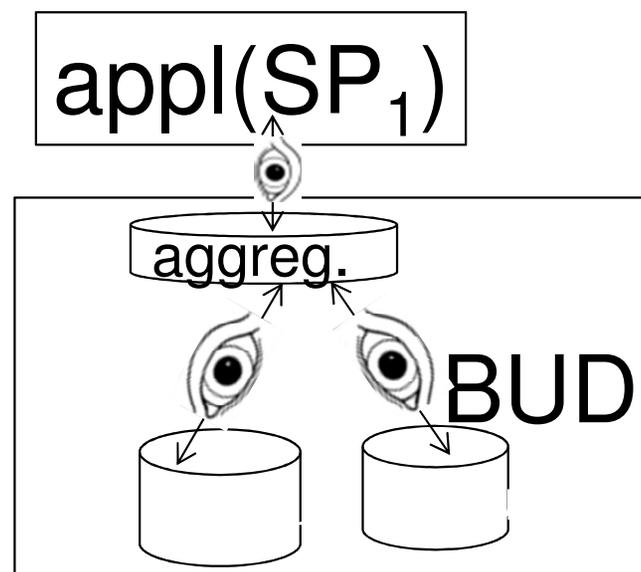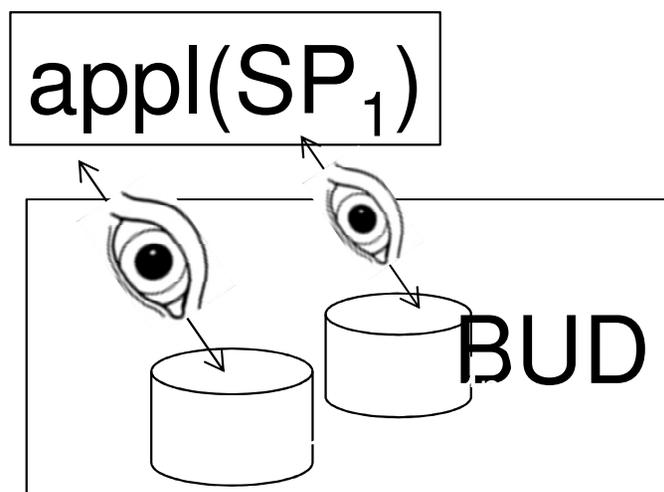# Different levels of openness of personal data

appl(u$_1$)

BUD
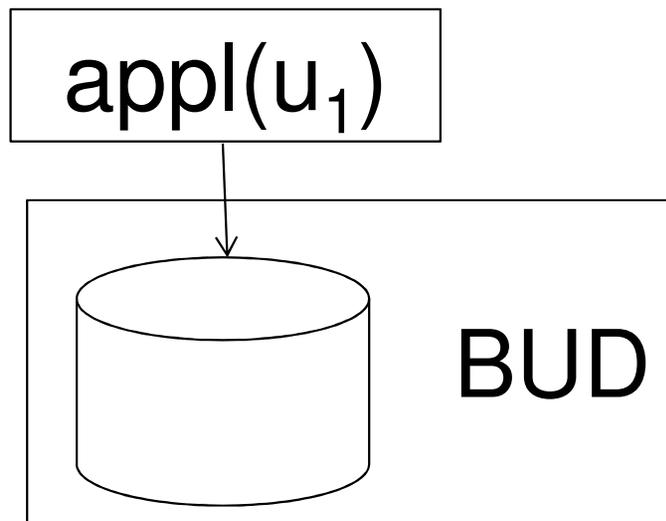
Applications on the Data Space of a single user

appl(u$_1$)

BUD
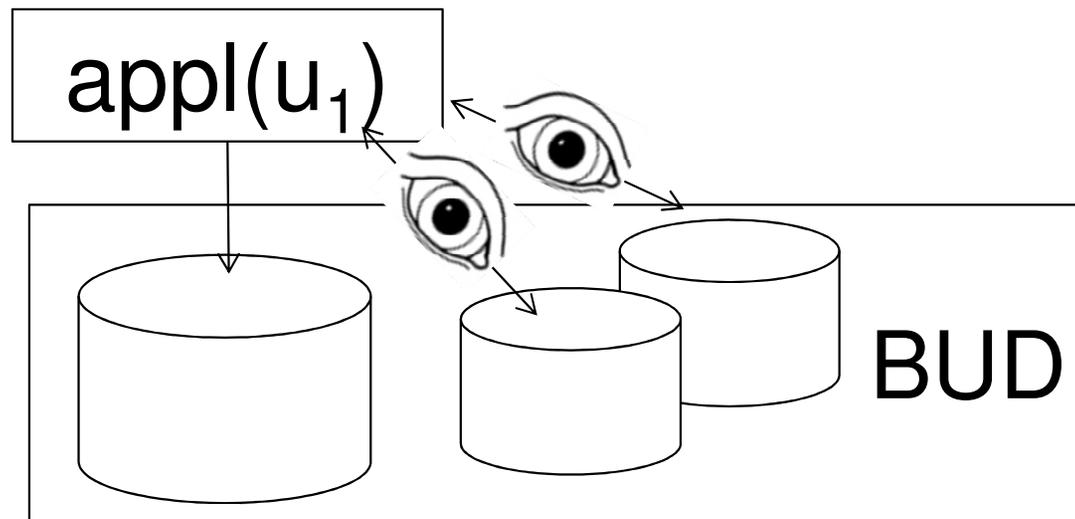
Applications based on sharing Data Spaces in a social graph

Third Parties apps based on single Data Spaces

Third Parties Apps based on aggregation of Data Space

appl(SP$_1$)

BUD

appl(SP$_1$)

aggreg.

BUD

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New Scenarios ?

$$b/c > k$$
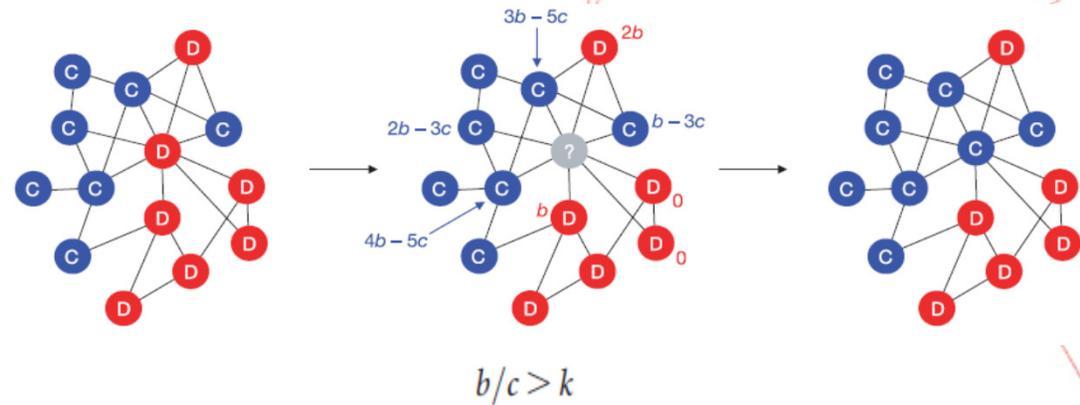
The ratio of benefit to cost of the altruistic act has to exceed the degree, k, which is given by the number of neighbours per individual.

A simple rule for the evolution of cooperation on graphs and social networks
H. Ohtsuki et alii

R. Minerva, Telecom Italia / Future Centre

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Do Smart Cities become smarter with the contribution of Citizens ?

- Social Cooperation in the context of Smart Cities
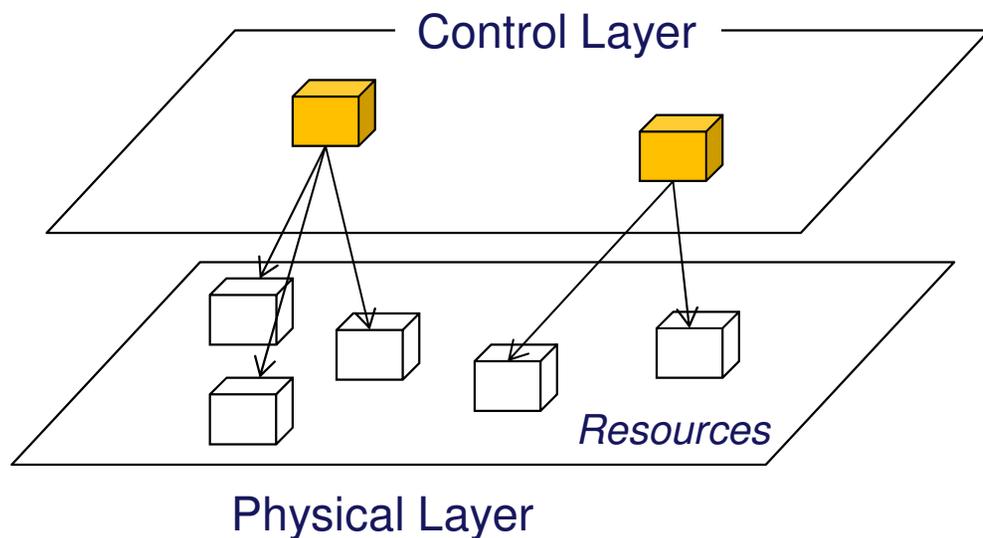 - Users share socially relevant data and create "social networks" in the context of smart cities
  - Personal data contribute to a better monitoring of the city environment (think to bwired.nl) providing real-time data, but still keeping users/citizens owners of data

- Examples
  - Enforce security by monitoring assigned areas with webcams
  - Control of environment by measuring pollution parameters locally
  - Share of road traffic data (taken from cars, from the home, …)
  - Games related to reducing personal carbon footprint
  - How many people in a place (e.g., the italian strikes)

- User data can extend public databases (integration with OpenData initiatives)
  - Users/Citizens have to be incentivized

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A Bit of Architecture ...

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Current Paradigms are not future proof

Control Layer

Resources

Physical Layer

Network Intelligence (e.g., IMS) is a hierarchical model based on the assumption that control has to be exterded by a few specialized control nodes

Client – Server model totally disregards the network aspects and can easily lead to a tragedy of commons (misuse of common networking resources)

Client — network — Server

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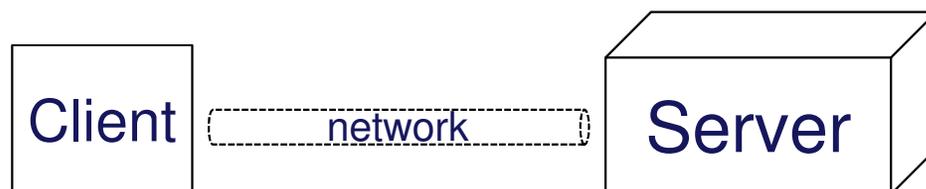
New Control Patterns: Publish – Subscribe Model

The future is distributed: There will be big hubs, many small hubs, and tons of publishers and subscribers. Publishers, subscribers, and hubs may play multiple roles.
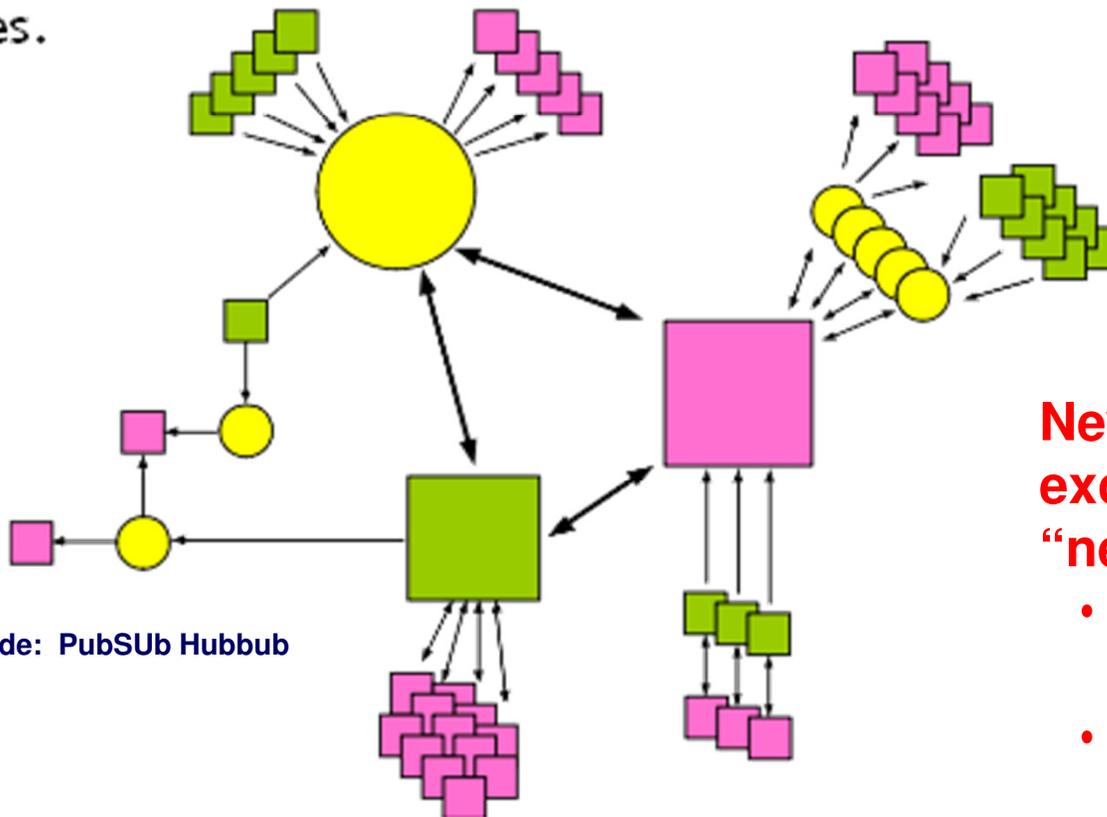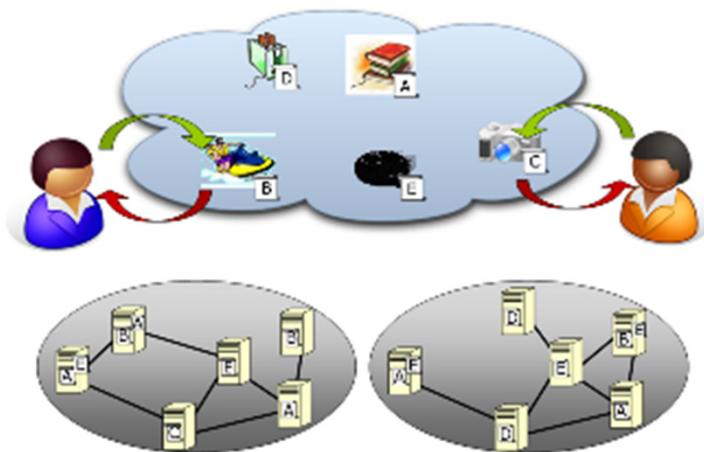

Google code: PubSUb Hubbub

New Control Patterns that exceed the client-server and the "network intelligence" models
- **Transaction oriented processing**
- **PubSub**

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Information Centric Networking

4ward project: in this paradigm, the communication abstraction presented to applications is based on transfer of application data objects instead of the end-to-end reliable byte-stream used by the majority of applications today.
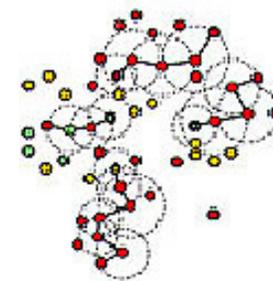
**Content Centric Networking
A Self-Organizing Network That Meets Information Needs
What Is It?
A new approach to networking that enables networks to self-organize and push relevant content where needed.
Content-centric networking enables communication to happen anywhere, anytime, and with any device - using any available means.**

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Main enabling technologies: Overlay Networking

- **Overlay networks enable the creation, optimization, and maintenance of distributed virtual environments, for the deployment and execution of distributed applications:**

  - **handling of dynamic and unpredictable introduction and remove of nodes;**

  - **abstraction of underlying resource and network heterogeneity;**

  - **abstraction of network topology and networking protocols;**

  - **functions for unique addressing of virtual nodes, and for routing messages;**

  - **fully distributed peer-to-peer control and self-management of nodes and aggregations, according to several architectures (e.g., structured, unstructured, hybrid);**

R. Minerva, Telecom Italia / Future Centre
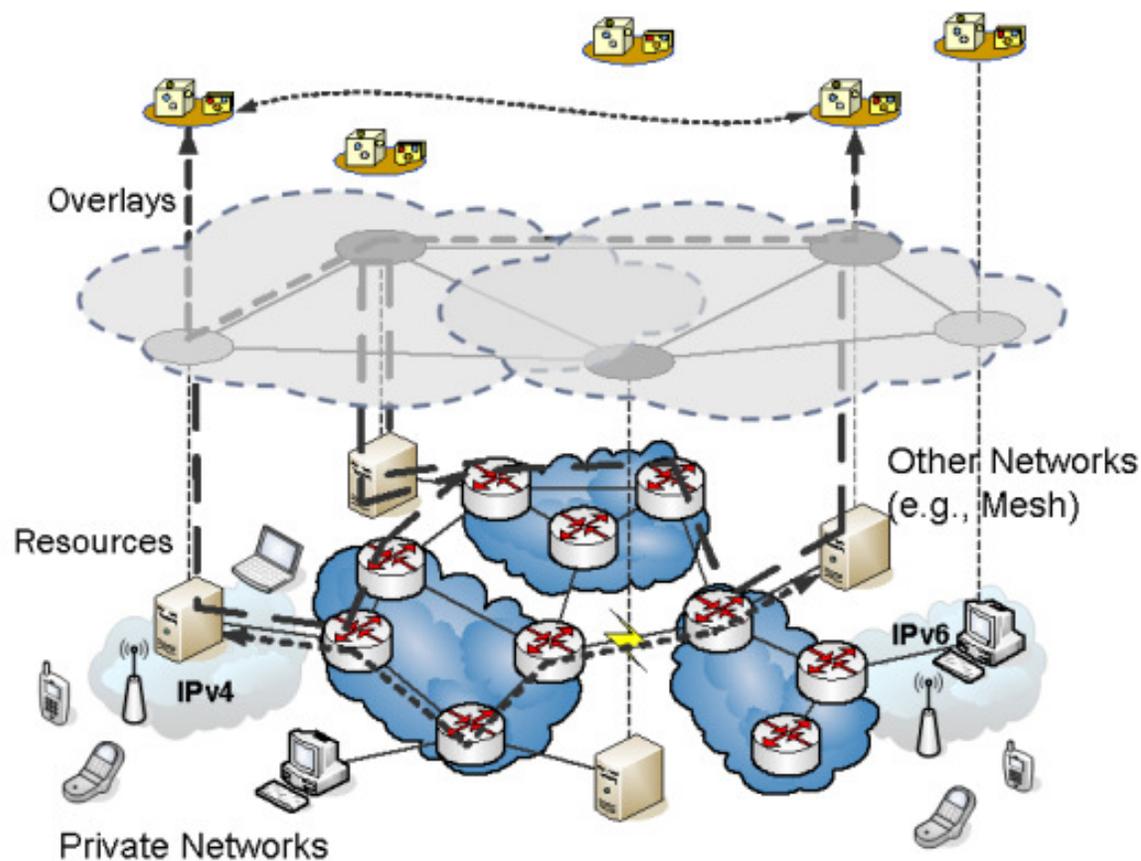
BluePrint for a Network Platform

- **Security**. Currently it is tackled as an issue at the edge, while the network(s) could contribute to relieve some issues (e.g., DDOS)

- **Mobility**, the current Internet has not been designed for an optimal management of mobility, the Future Internet has to deal with a multitude of highly mobile objects (mobility built in)

- **Digital Identity Layer**, Users are not recognized and managed in the network, they are managed only at the edges (by specific servers or applications) owned by Providers)

- **Integration of Applications and Transport/Control Layers**. Currently there are not consolidated interfaces that allow for a better cooperation between the Network and the Apps. Many applications do not use resources properly (e.g., p2p applications do retrieve data from far away hosts)

- **Edges are becoming themselves Networks**. There is the need to understand and manage the dynamics around Networks of Networks: i.e., complex systems that impulsively request resources and use them while these resources have been designed to support statistically determined needs

- **Focus on data and info** and not on transport of bits

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What Role for Operators ?

the network
is more
powerful
than the
node etc.

SXSW'10

R. Minerva, Telecom Italia / Future Centre
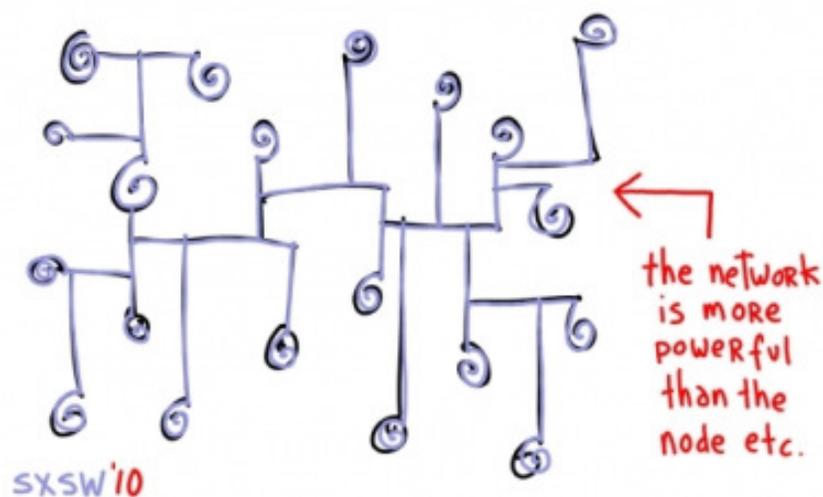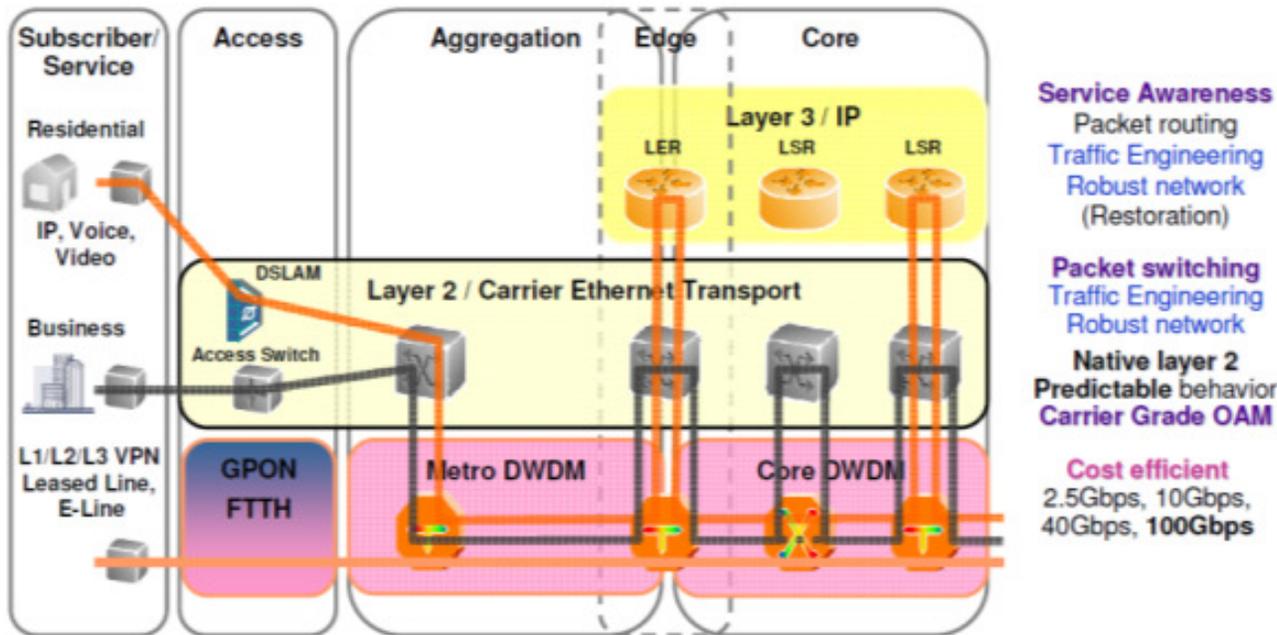
Choose Your Role and Your Network (1)

Photons are cheaper than bits
A Service Provider is involved with L3
A Bit Carrier is mainly involved in L1/L2

Network Architecture Model

http://www.eibrum.com/public/documents/OIF_20080204_NSN_Gruber_v3.1.pdf

Choose Your Role and Your Network (2)

- Service Provider

Eco-systems of services

- Service Enabler
  (Platform Provider)

Overlay Networks of autonomic components

- Bit Carrier

- Transport the data
  - in the better way for the customer
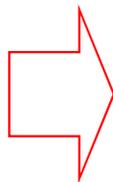
  → **Bit Carrier**
  Be good to transport lots of bits

- Helping Customer in retrieving and managing INFORMATION
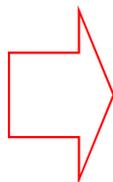
  → **Platform Provider**
  Build a Data oriented Platform (new networking + data handling) for others to use

- Ease the work of finding data and information, linking them into something meaningful and manage them
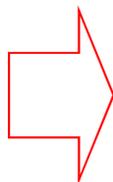
  → **Service Provider**
  Transform Data into Information and create plenty of services by means of meaningful interfaces

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Choose Your Role and Your Network (3)

Focus on a Network OS (Service Enabler Role)
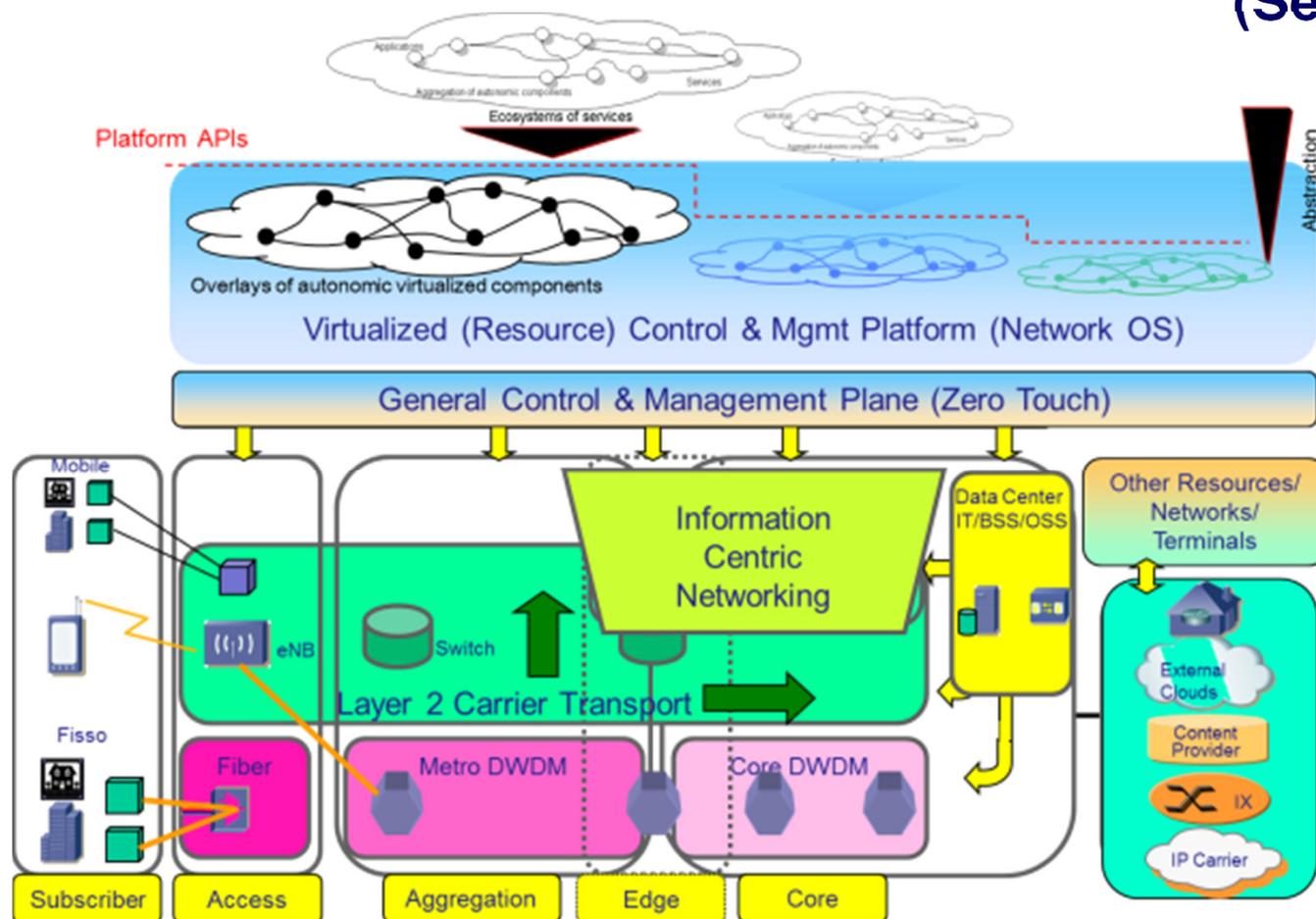
- **Operator's Nodes are super nodes in an overlay network**
- **Service Providers integrate the Operator Nodes according to their needs**
- **The logical Network of the Operator can exceeds regional boundaries**
- **Resources can be communications, processing, storage and "Things"**

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How The Network Could Look Like

Telecom Services

Third Party Servics

Retail Evolution

Virtual Env.ss

Future Learning

Smart Cities

Future Ener..

e-gov

Enterprise Processes

Ecosystem of Services

Service Provider

Other Service EcoSystems

Service Enabler

Overlays of autonomic virtualized components and Data

Other Plarforms

Virtualization Layer

General Control and Management (Zero Touch)

Customer Owned and Shared: Terminals/ PCs/gateways/ sensors/ Wifi / ...

ACCESS

Wireless

Fixed (Fiber)

Bit Carrier

ICN Platform

Optical Platform

Aggregation

Edge

Core

Customer owned: Networks/ NASes / Routers / ...

Customer owned: Data Centers/ Servers / IT Resources / ...

Other Resources (not shared)

Shared and virtualized device/reource

Other resources

Simple Devices/Networks

Complex Devices/Networks

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Thank you!

Roberto Minerva

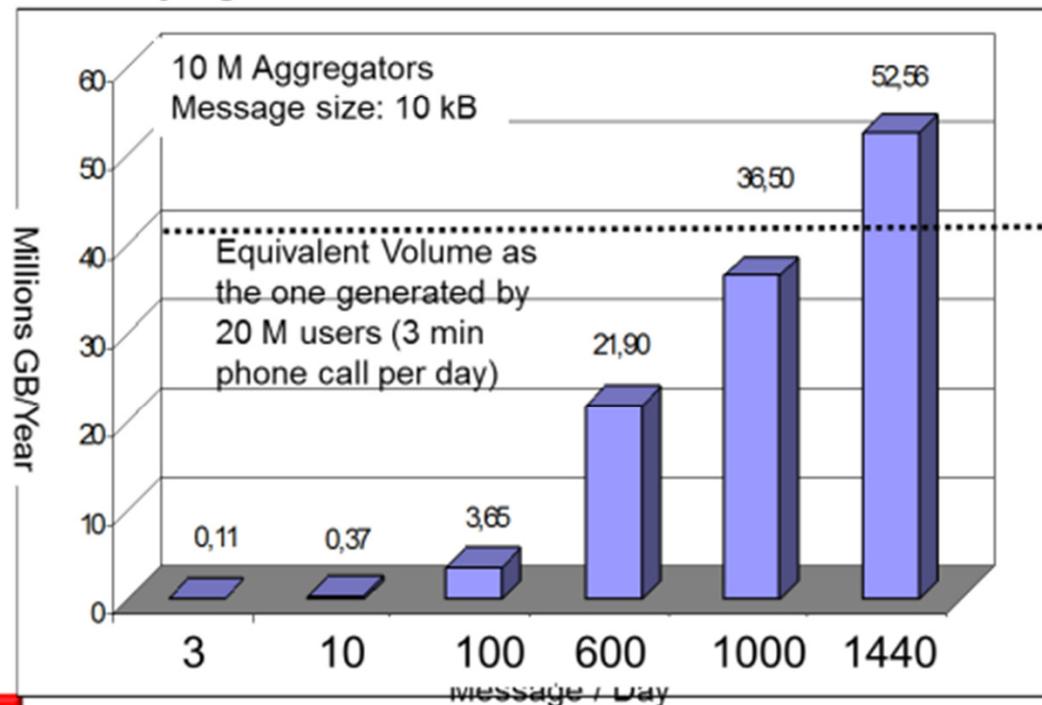**TELECOM ITALIA**

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Operators' Trends

Traffic will be significant if:
- IoT applications will make a substantial use of multimedia content
- The total number of communicating things will be very very high

10 M Aggregators
Message size: 10 kB

Equivalent Volume as the one generated by 20 M users (3 min phone call per day)

Millions GB/Year

Message / Day	3	10	100	600	1000	1440
	0,11	0,37	3,65	21,90	36,50	52,56

Some Services for *Smart City*

MOBILITY

AMBIENT

EMERGENCY

SECURITY

BUILDINGS

COMMUNICATION

Services in cooperation with City Administrations

La Rete di un Abilitatore dei Servizi

Applications

Aggregation of autonomic components   Services

Ecosystems of services

Applications

Aggregation of autonomic components   Services

Abstraction

Platform APIs

Overlays of autonomic virtualized components

Virtualized (Resource) Control & Mgmt Platform (Network OS)

General Control & Management Plane (Zero Touch)

Mobile

Information
Centric
Networking

Data Center
IT/BSS/OSS

Other Resources/
Networks/
Terminals

eNB   Switch

Layer 2 Carrier Transport

External
Clouds

Content
Provider

IX

IP Carrier

Fisso

Fiber   Metro DWDM   Core DWDM

| Subscriber | Access | Aggregation | Edge | Core |

The Network as a Platform

Autonomic,Transactional, Programmable, Adaptive, Virtualized, Cognitive, Open, Functionally Rich PLATFORM based on Overlays of virtualized resources with personalized APIs

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