Towards Future Internet

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ICT SHOK Future Internet
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Telecom Forum '2008, TKK, 4.11.2008

Content

- Internet = Critical infrastructure for society
- What's wrong in the current Internet

- Future Internet technology
  - New functionality split between protocol layers
  - Routing
  - Evolution towards information centric networking

- Cooperation is a must in Future Internet infrastructure development
  - Approaches
  - Future Internet Initiatives

[Sources: ICT SHOK Future Internet Program, EU initiatives, …]

NSN vision 2015 – the World connected

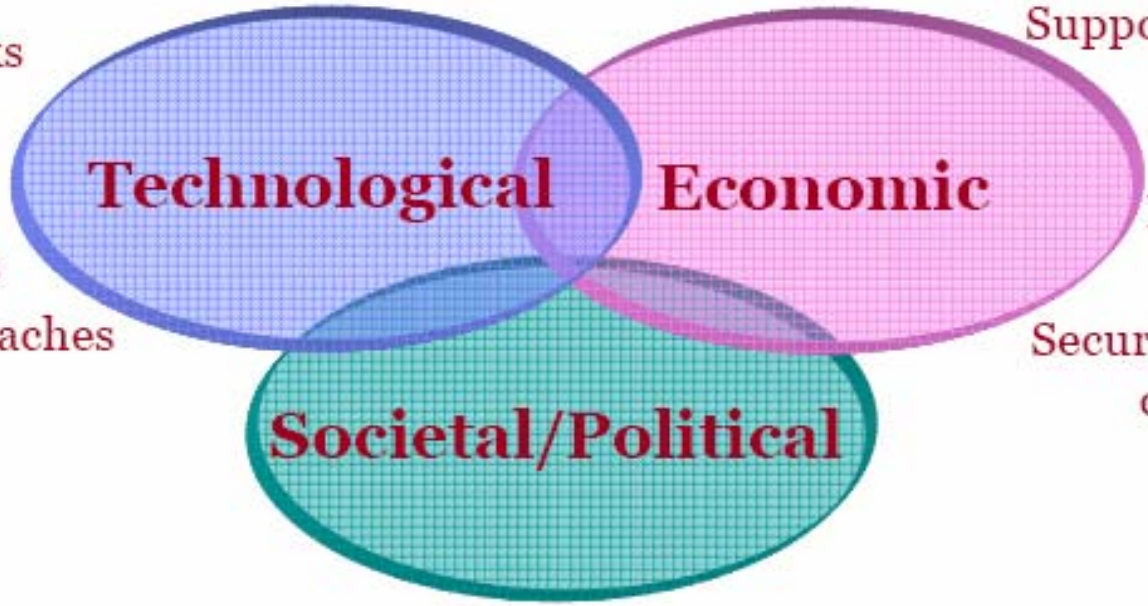
Applications predominantly in internet

Multitude of business models

Broadband everywhere

Dimensions of Future Internet

Terabyte networks
Complexity
Mobility
Internet of things
Clean slate approaches
...

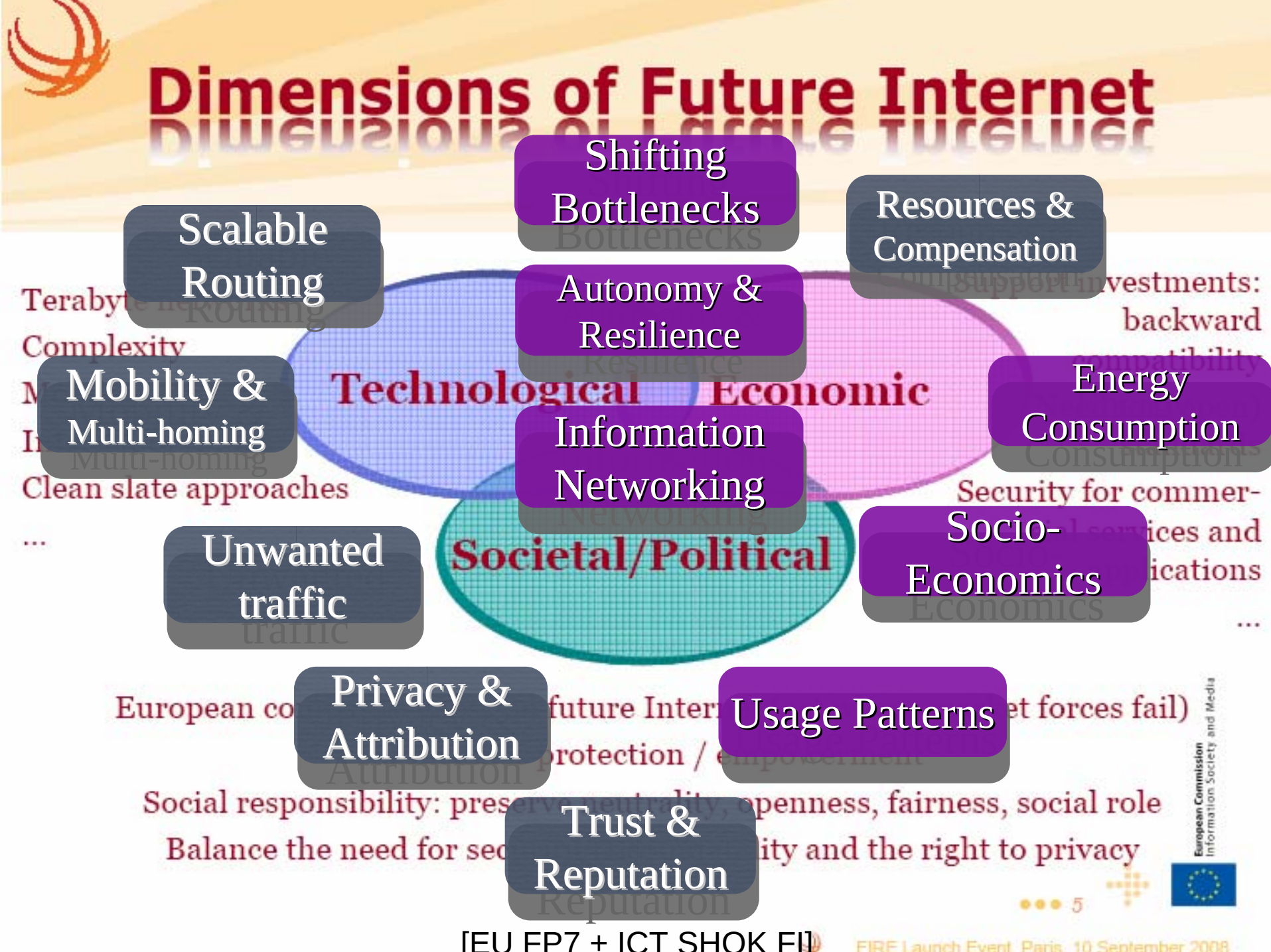


Support investments: backward compatibility
Need for (open) standards
Security for commercial services and applications
...

European competitiveness on future Internet (act where market forces fail)
Consumer protection / empowerment
Social responsibility: preserve neutrality, openness, fairness, social role
Balance the need for security/accountability and the right to privacy

European Commission Information Society and Media

Dimensions of Future Internet



[EU FP7 + ICT SHOK FI]

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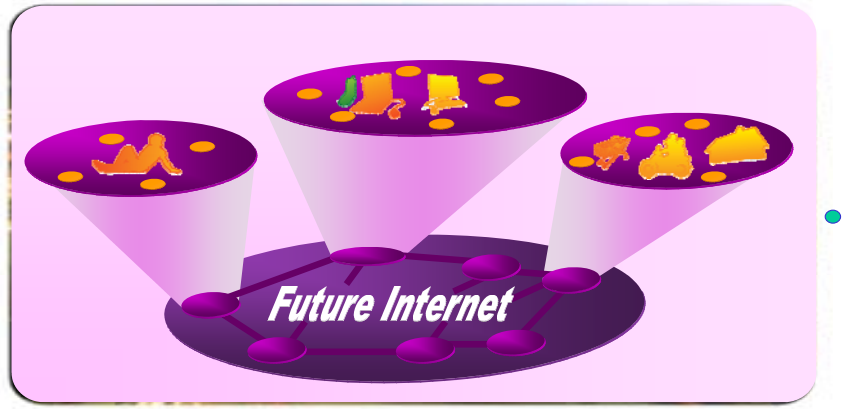
Future Internet Technology

Enables economic progress and development of our society

Vision

Billions of people and trillions of devices connected anywhere and anytime



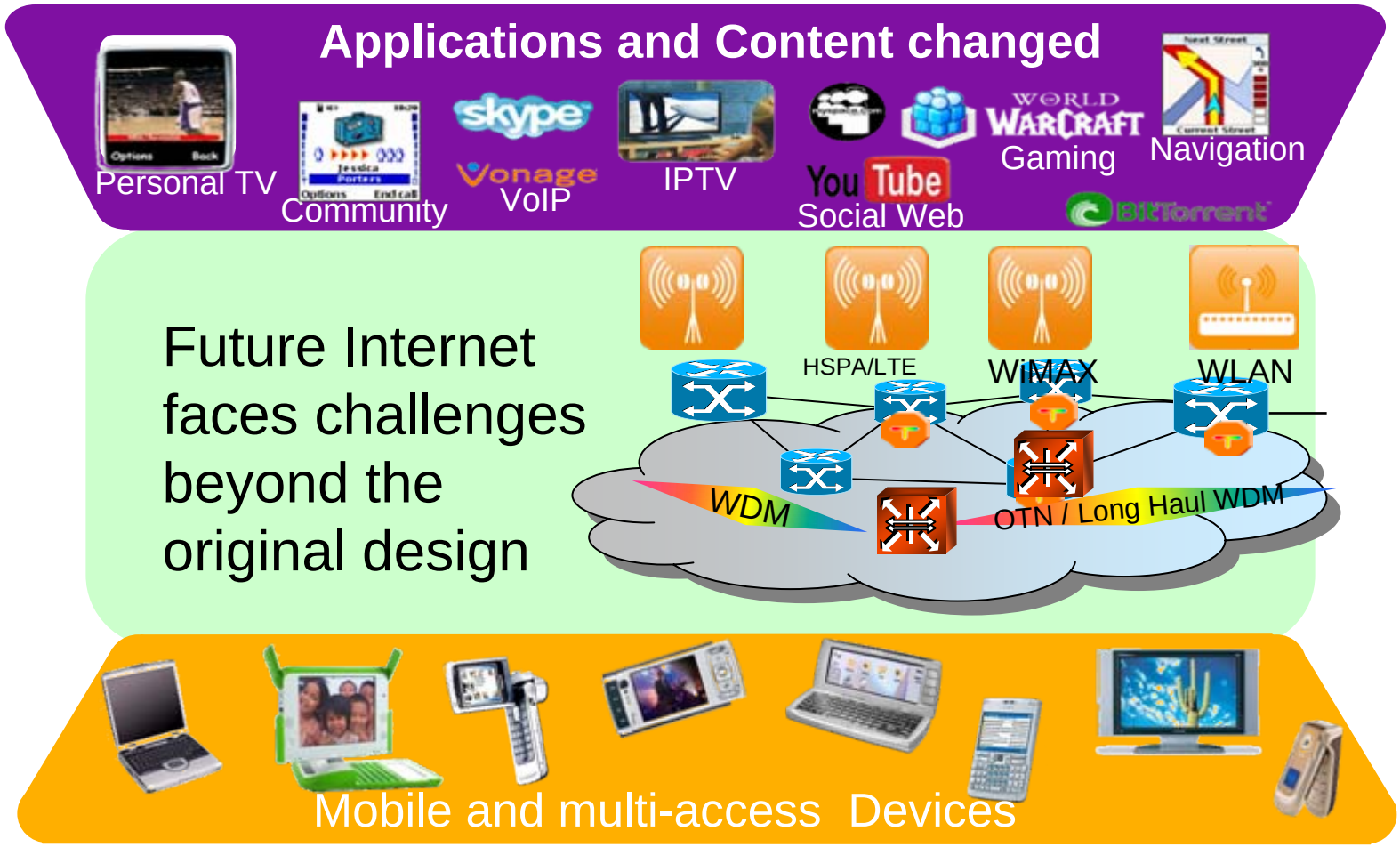
Challenges and opportunities

Internet is expanding from an “information service” to a “critical infrastructure” for all aspects of society

Current technologies can be, and need to be improved significantly to meet the challenges stemming from scale and new usage forms:

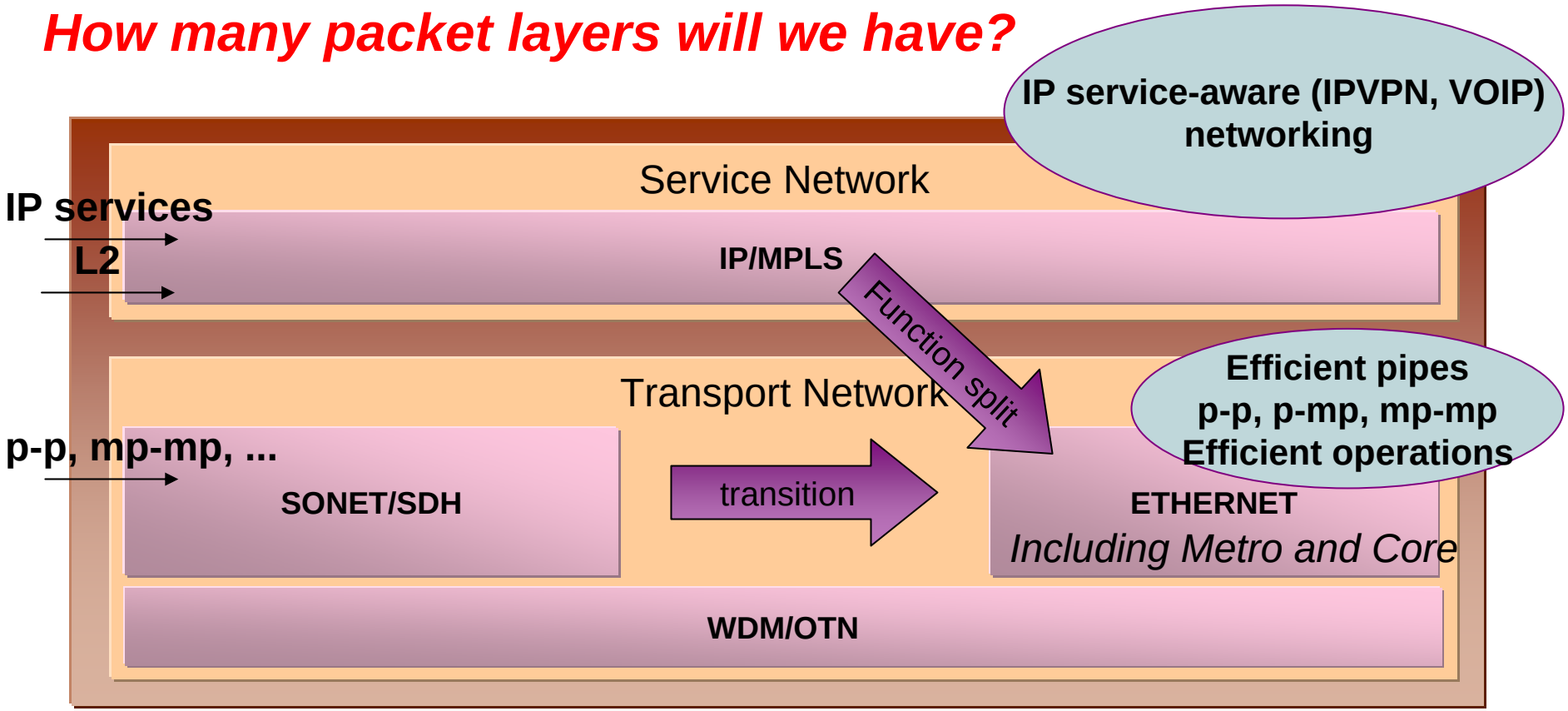
- New functionality split between protocol layers
- Routing scalability
- Evolution towards information centric networking

Drivers of the Future Internet



New Lower Layers (L1,L2) technologies guide how networks are built

How many packet layers will we have?



- **IP is the convergence platform for applications and services.**
- **Ethernet will be the convergence platform for transport.**

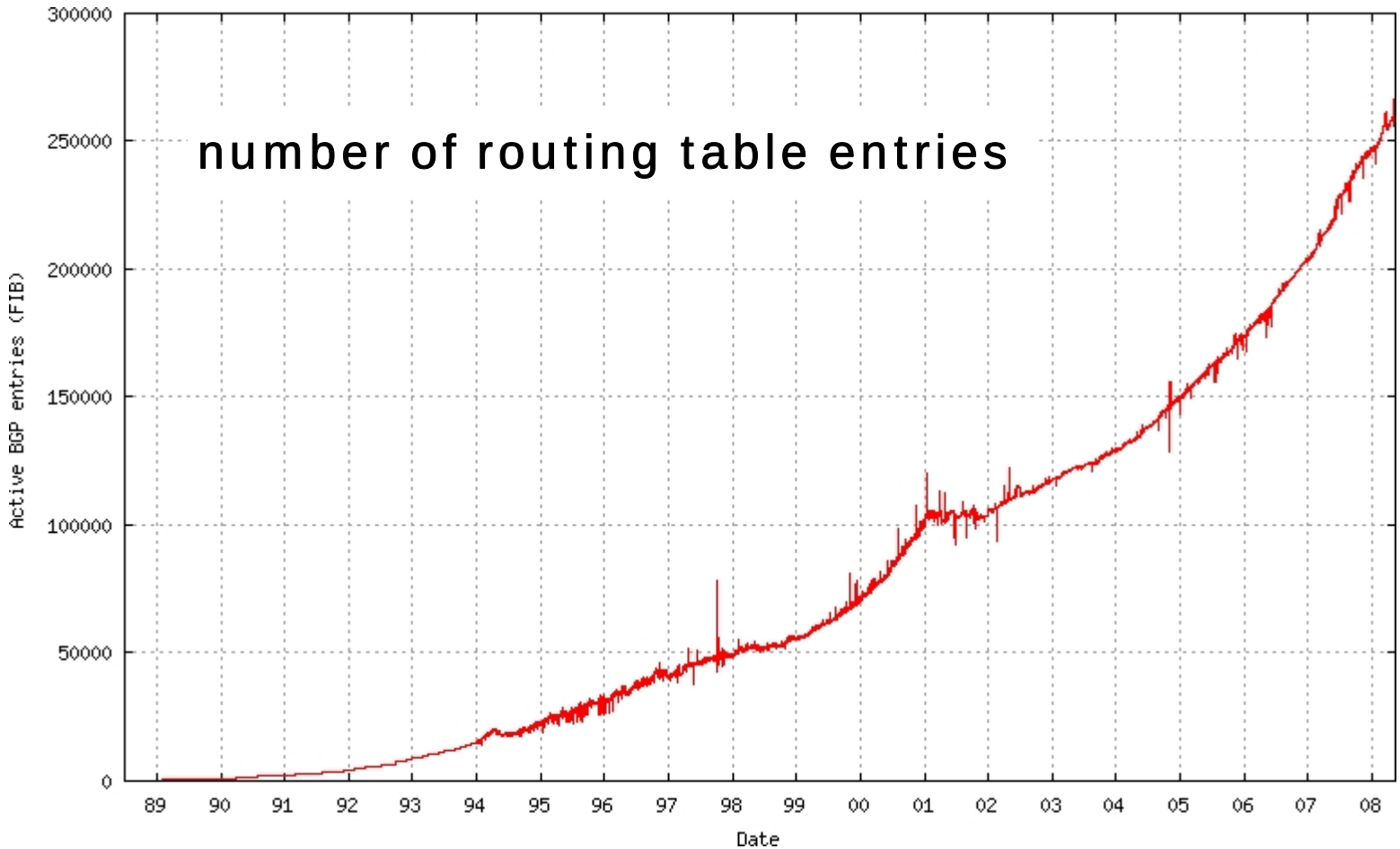
The Routing Scalability Problem

- The ability of the Internet routing system to cope with the growth of the Internet has been a concern during almost the entire life of the Internet

- The routing and addressing architecture has stayed very similar from the initial days
  - BGP designed in the 1980's
  - CIDR (Classless Inter-Domain Routing) introduced in the 1990's
  - IPv6 designed in the 1990's

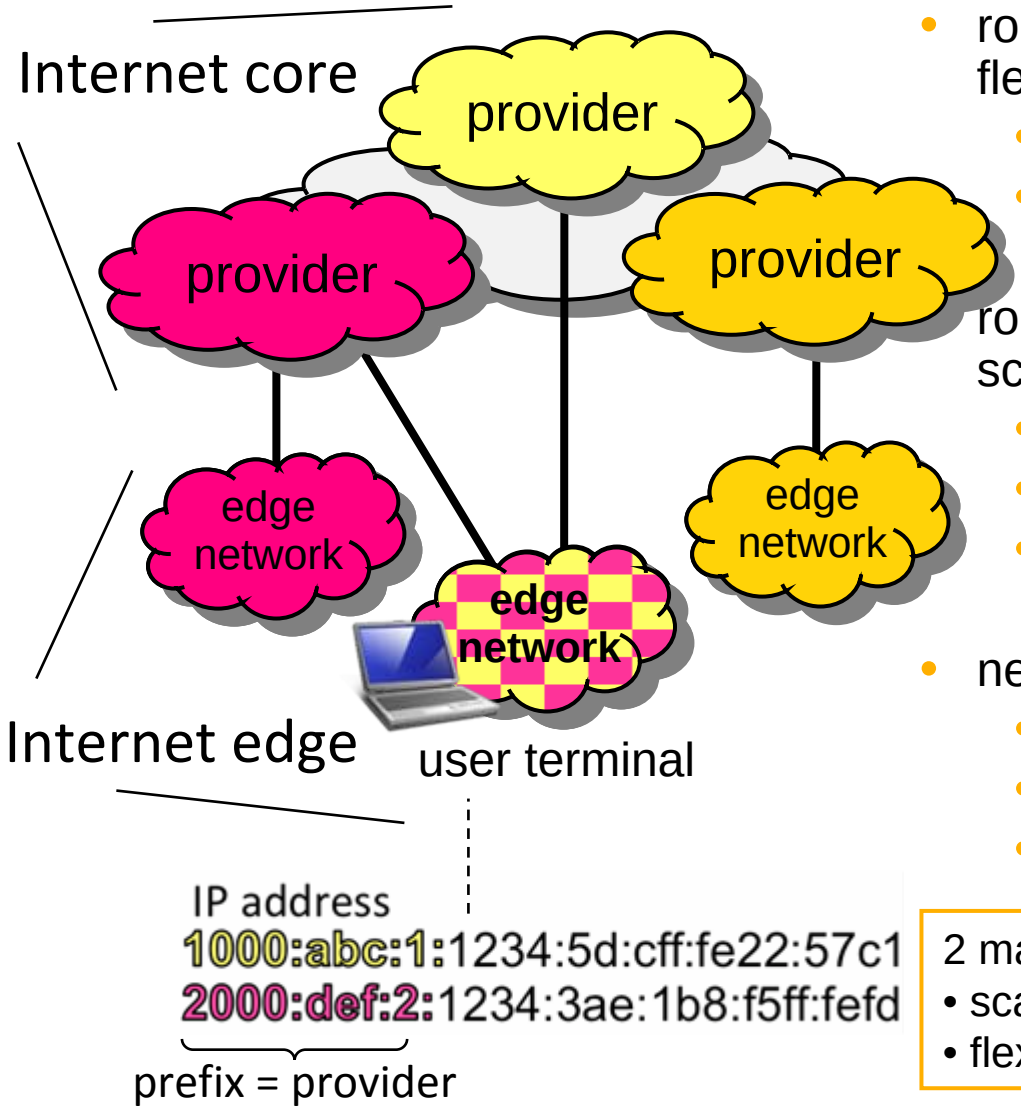
- Recent concern from major operators about the growth of the routing problem (~ Cost!)
  - The growth of the Internet itself
  - Moore's law

Evidence of Problem (“Internet Growth”)



- Number of routing table entries doubled in last 5 years
  - One (conservative) analysis predicts 2M entries in 10 years
- Twice as fast as natural Internet growth (ALSO: Update freq.)

Scalability and Flexibility in Routing illustrated



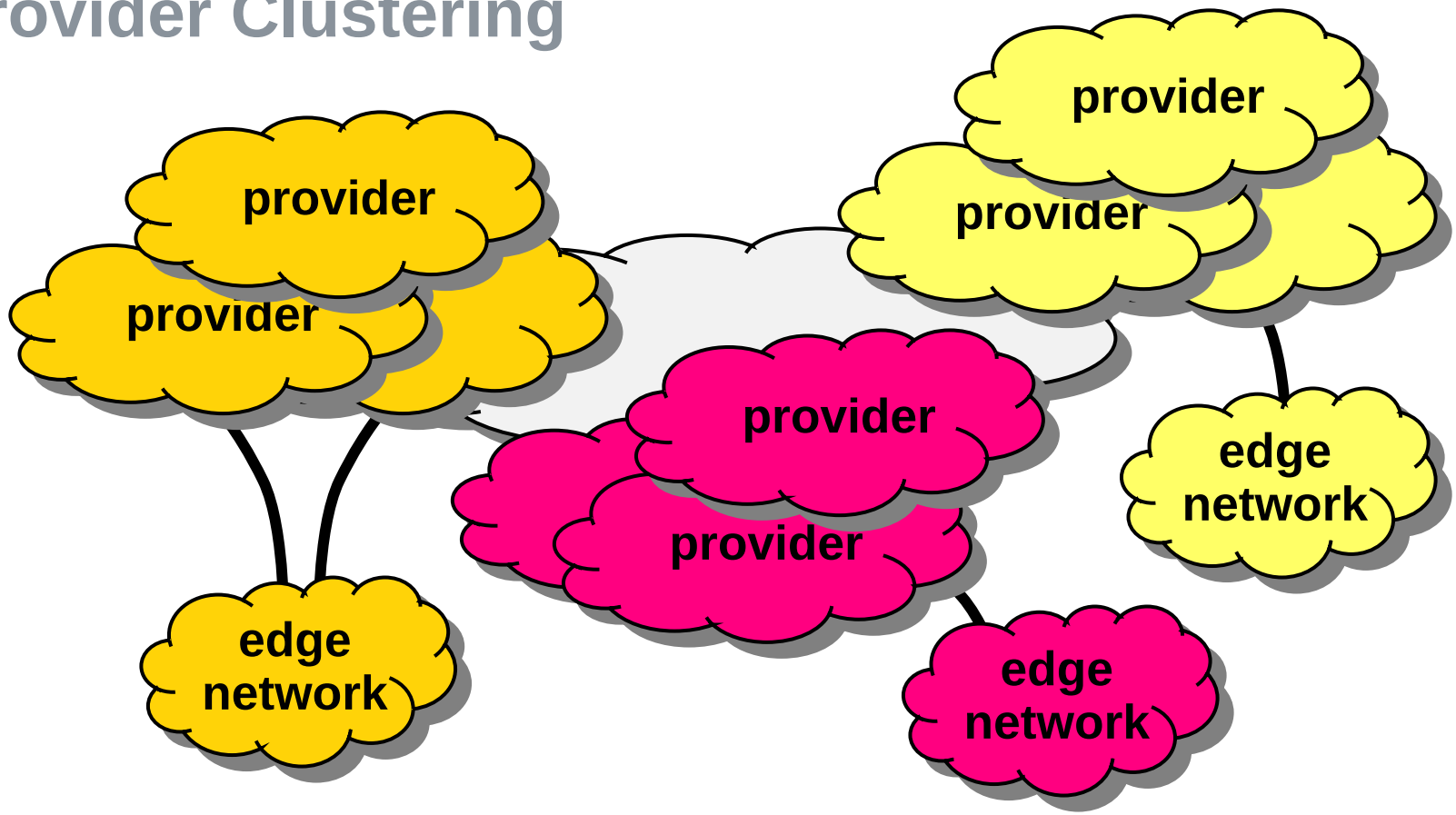
- routing in Internet core:
  flexible, but not scalable
  - global routing table at every provider
  - track route changes Internet-wide

routing at Internet edge:
scalable, but inflexible
- addresses provider-allocated
- renumbering on provider change
- multi-homing infeasible

- need routing system that…
  - is scalable
  - avoids renumbering
  - supports multi-homing

2 main properties that routing system should have
- scalability - growing number of users
- flexibility - choose between available routes

Provider Clustering

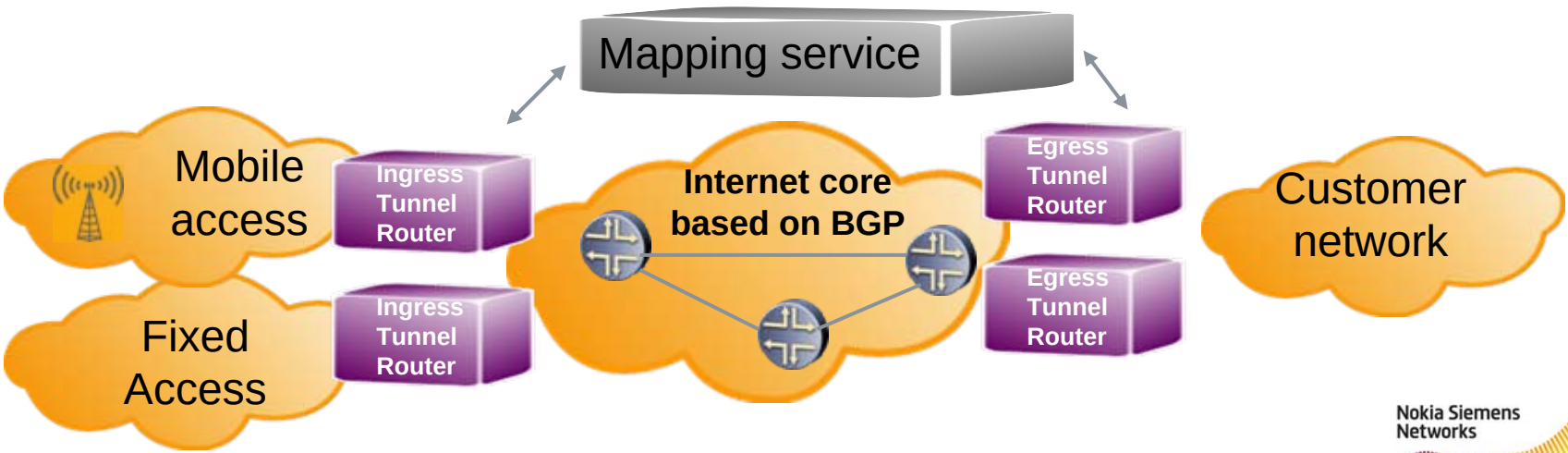


- groups of adjacent providers share address space
- addresses usable for all providers within group
  - no renumbering for provider changes within group
  - multi-homing between providers of a group

New interconnection approaches

Based on end system identity and locator separation:

- The edges use different address space from what is used in the core network (address indirection)
- Core network is assumed to continue to use BGP
- Edge and core address spaces are bound together with mapping infrastructure
  - New business relations based on who provides the mapping service and who allocates the end system identifiers
  - Potential to change peering and transit relationships



Information centric networking

- Most of the current Internet usage is already about access to information
  - Not to specific server or host
  - Video content will dominate

- Point-to-point and client-server communication mode is replaced with distributed dynamic information within a web computers

- ***Micro-economics*** of the current communication mode favors sender and forces the receiver to carry the cost of unwanted traffic

Three Revolutions

- First revolution: Connecting wires
  - Telephone network
- Second revolution: Connecting hosts
  - Original Internet
- Third revolution: Connecting information
  - Information – centric networking,
    a.k.a. information networking,
    a.k.a. data – oriented networking, …
  - Original Internet was not designed for this
  - Problematic for content providers and users

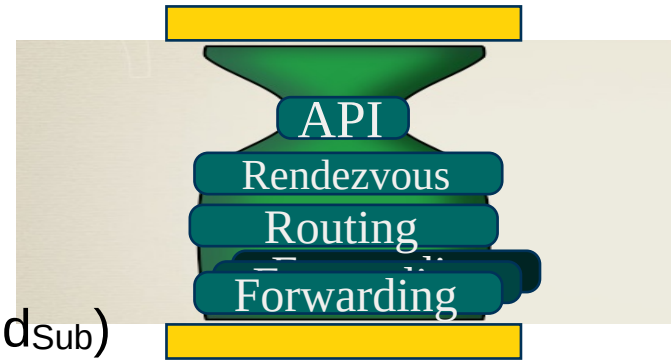
[Van Jacobsen, Xerox PARC + others]

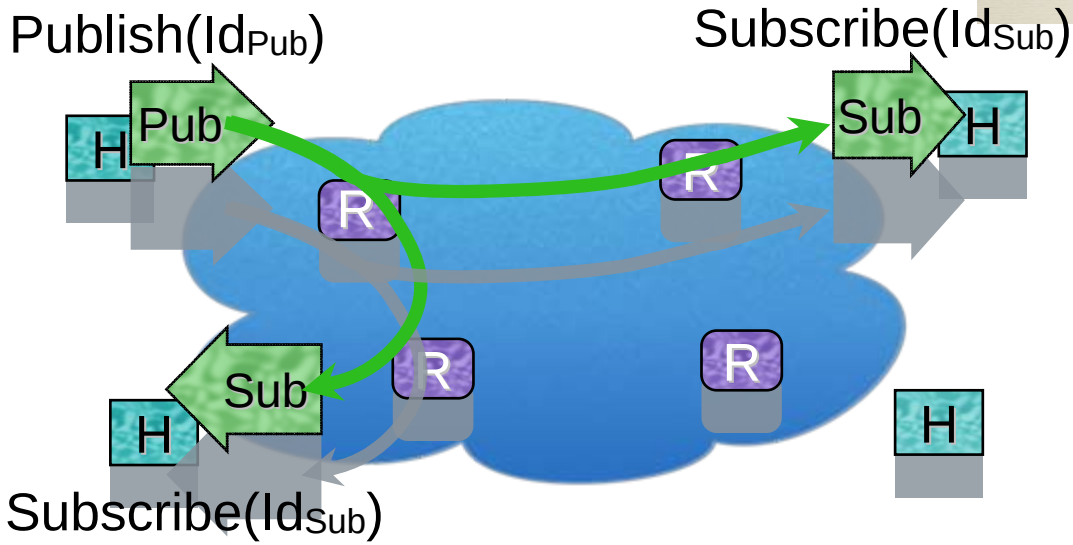
Information networking research issues

- Architecture: Finding information, mapping providers & users together
- Naming: Mapping from real world to network
- Relevance and integrity of the information: Versioning, Identity, Security, Privacy, Trust, …
- Performance
- Implementation

Publish-Subscribe Internet Routing Paradigm [EU FP7 project PSIRP]

- A new internetworking architecture based on the publish-subscribe paradigm
  - Control unwanted traffic and provide inherent security
  - Apply the Pub/sub across the protocol stack
  - Provide efficient information networking





Evolution towards information centric networking

- IP is about connecting computer network interfaces
- New abstraction: connecting at content level
  - **Address information**, *not computer network interfaces*
  - **Explicit request of information**, *no unwanted traffic at the network layer*
  - **Delivery from anywhere the requested information exists**, *avoid dependence on off-path infrastructure*

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Approaching the Future Internet

"Clean slate" path adopted by the research community

- Starting point: Internet has grown out from its original scope and the previous design assumptions do not hold
- FIND and GENI programs in the US, FP7 programs in Europe and a number of national projects
- 4WARD and PSIRP EU projects (see later slides).

"Evolutionary" approach by standards making bodies

- Incremental improvement to fix pressing problems: routing, addressing, mobility, security, etc
- Ethernet evolution (towards revolution)
- Routing Area

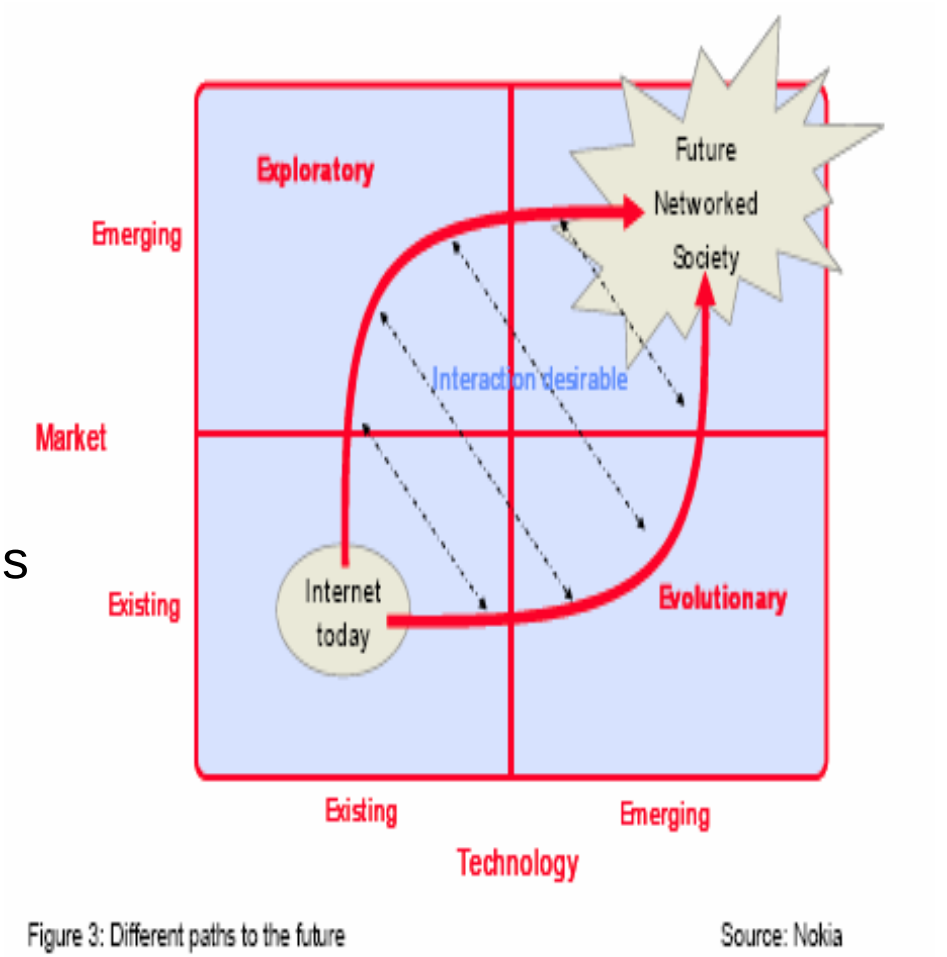
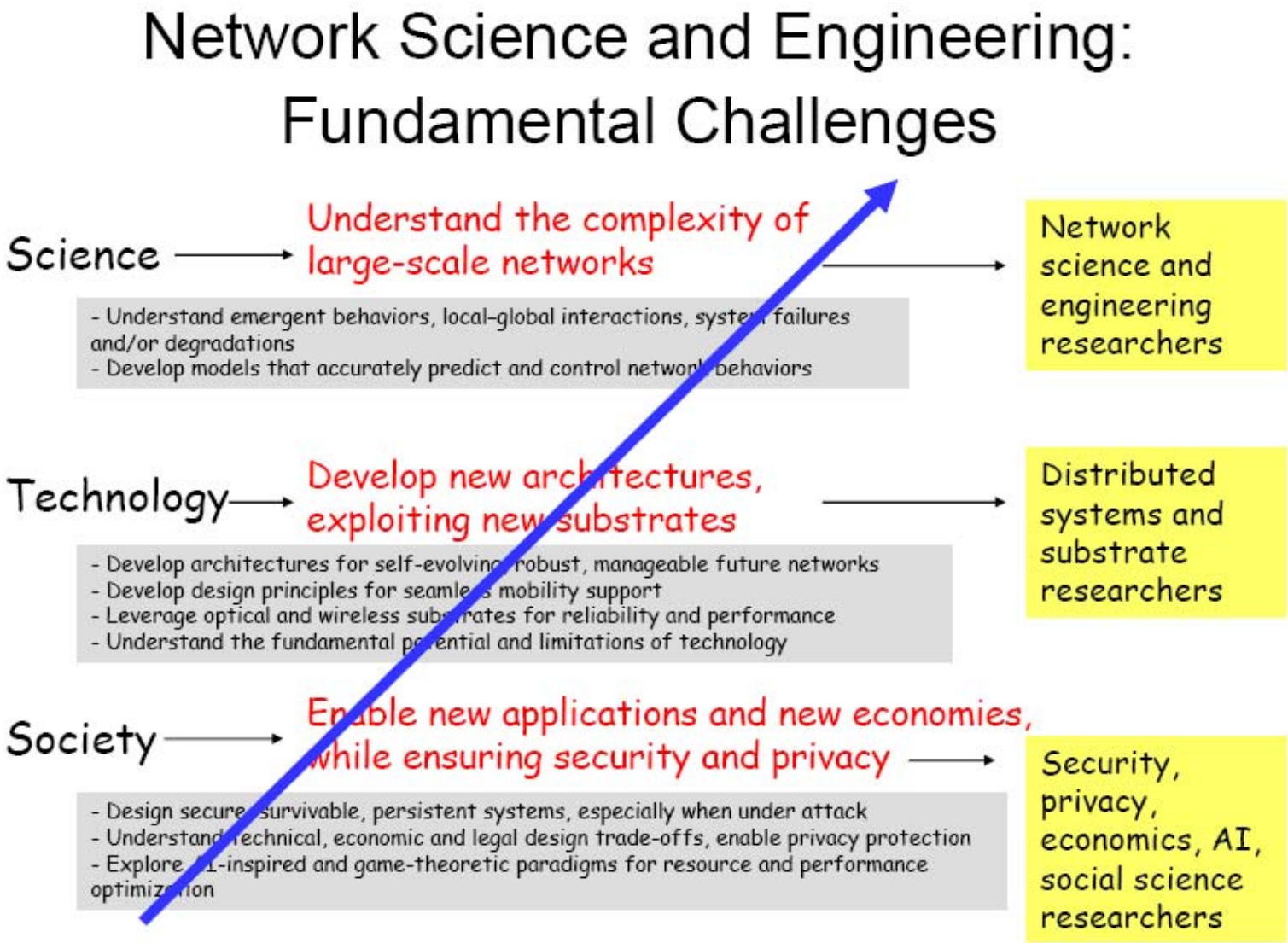


Figure 3: Different paths to the future Source: Nokia

U.S. Future Internet activities

- NSF/Computer and Information Science and Engineering (CISE)
  - FIND (Future Internet Design) , SING (Scientific Foundations for Internet's Next Generation), NGNI (Next-Generation Networked Information) Programs → NetSE Program
  - GENI (Global Environment for Network Innovations)

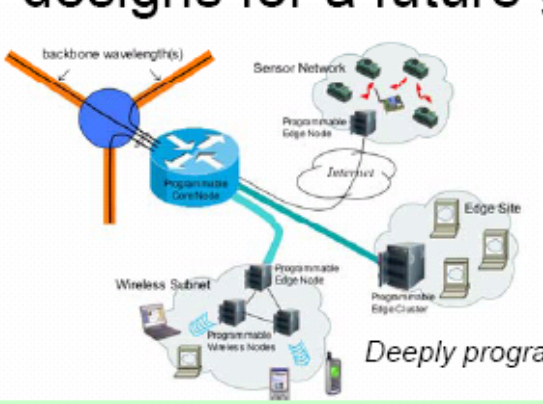
US: NSF/CISE/NetSE



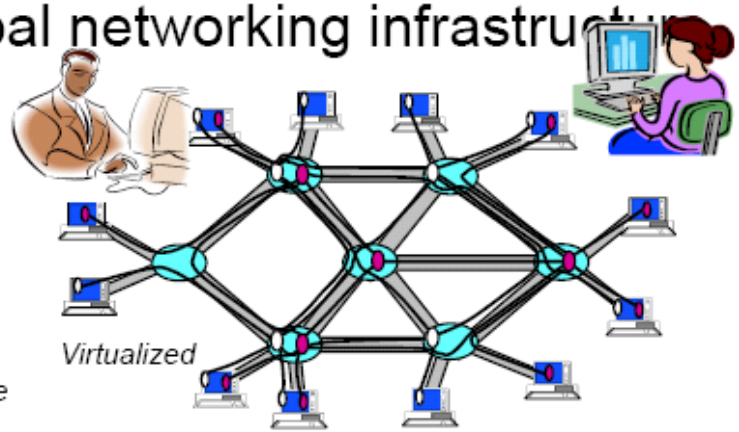
US: GENI

The GENI Vision

A national-scale suite of facilities to explore radical designs for a future global networking infrastructure

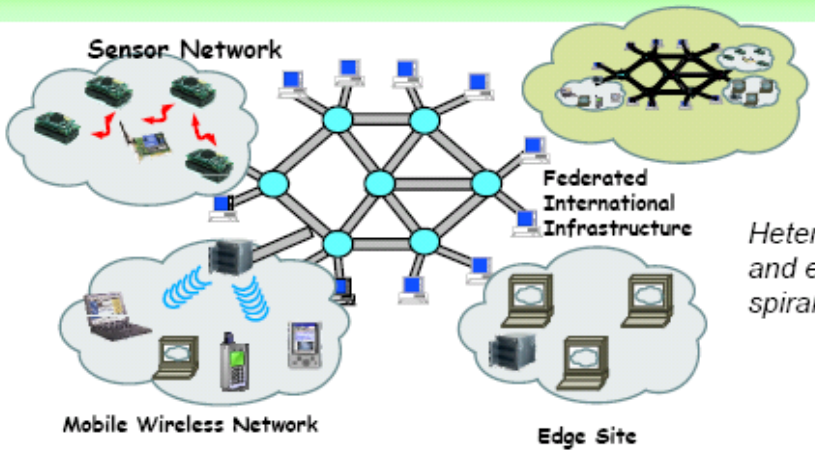


Deeply programmable



Virtualized

Programmable & federated, with end-to-end virtualized "slices"



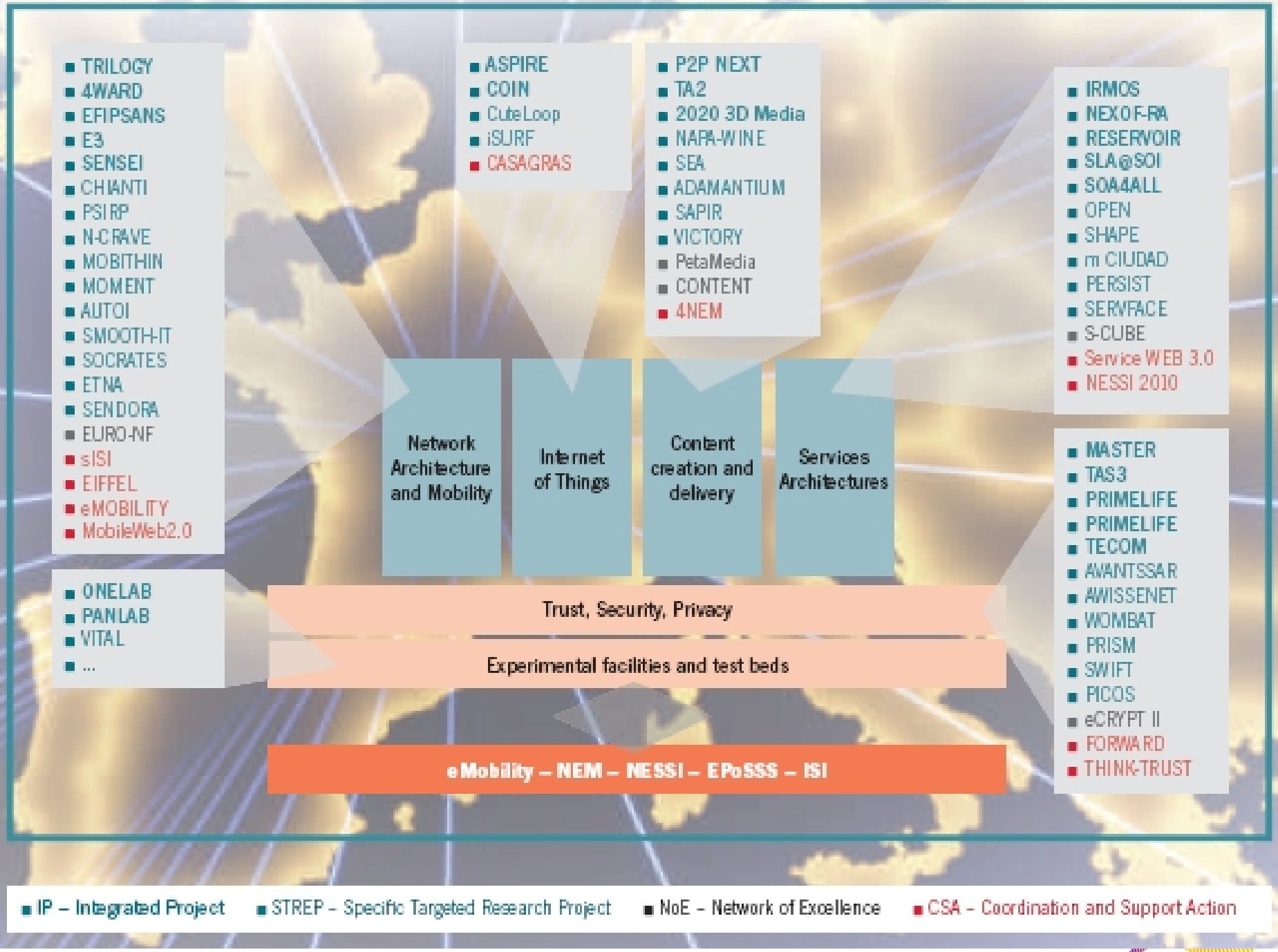
Heterogeneous, and evolving over time via spiral development

European Future Internet activities

- Future Internet Assembly
  - Cross domain future Internet issues are discussed leading to enhanced and effective coordination across domains
  - A shared vision emerges of what needs to be done for the future Internet in Europe by Europe
  - EU stakeholders are better positioned in scientific and economic terms regarding the challenges of the Future Internet
- FIRE (Future Internet Research & Experimentation)

- EU FP7 projects
  - Call 1: 2008 – 2009/10
  - Call 4..5: 2010 –

- www.future-internet.eu


TRILOGY
4WARD
EFIPSANS
E3
SENSEI
CHIANTI
PSIRP
N-CRAVE
MOBITHIN
MOMENT
AUTOI
SMOOTH-IT
SOCRATES
ETNA
SENDORA
EURO-NF
sISI
EIFFEL
eMOBILITY
MobileWeb2.0
ONELAB
PANLAB
VITAL
...
ASPIRE
COIN
CuteLoop
iSURF
CASAGRAS
P2P NEXT
TA2
2020 3D Media
NAPA-WINE
SEA
ADAMANTIUM
SAPIR
VICTORY
PetaMedia
CONTENT
4NEM
IRMOS
NEXOF-RA
RESERVOIR
SLA@SOI
SOA4ALL
OPEN
SHAPE
m CIUDAD
PERSIST
SERVFACE
S-CUBE
Service WEB 3.0
NESSI 2010
Network Architecture and Mobility
Internet of Things
Content creation and delivery
Services Architectures
Trust, Security, Privacy
Experimental facilities and test beds
eMobility – NEM – NESSI – EPoSSS – ISI
MASTER
TAS3
PRIMELIFE
PRIMELIFE
TECOM
AVANTSSAR
AWISSENET
WOMBAT
PRISM
SWIFT
PICOS
eCRYPT II
FORWARD
THINK-TRUST
IP – Integrated Project
STREP – Specific Targeted Research Project
NoE – Network of Excellence
CSA – Coordination and Support Action

Long term research issues

The original Internet design has successfully enabled multiple waves of innovation! But...

Novel societal and commercial usages are pushing the original Internet architecture to its limits:

- Mobility and pervasiveness
- Security, trust, dependability
- QoS for commercial video streaming applications and broadband services
- Heterogeneity of devices and services/applications (e.g. RFIDs, sensors)
- Complexity of network management
- ...

European Commission
Information Society and Media

2

FIRE Launch Event, Paris, 10 September 2008

4WARD – Architecture and Design of the Future Internet

Motivation

- Major architectural changes stemming from heterogeneity that will affect the integrity of the core architecture

Objectives

- Enable very different architectures to co-exist and interoperate:
  - Network virtualization, addressing and naming schemes
- Develop “network of information”
  - Addressing of informational objects
  - Protocols and management of information dissemination
- Management of rich communication paths (QoS, Security, mobility, multicast)
  - Resource management for cross-layer techniques
  - Distributed monitoring protocols
- Develop an integrated framework for network architectures

FP7 Summary 1(2)

FP7/Call4 will open in November 2008 and the proposals have to be submitted by 17 March 2009

- Call4 will include research areas which are relevant for FI:
  - Spectrum-efficient radio access to Future Networks
  - Converged infrastructures in support of Future Networks
  - Content aware networks and network aware applications
- Building up the consortiums is ongoing
- Active preparation of the proposals will be started in November-December
- Projects will start in January 2010 and end in December 2011

FP7 Summary 2(2)

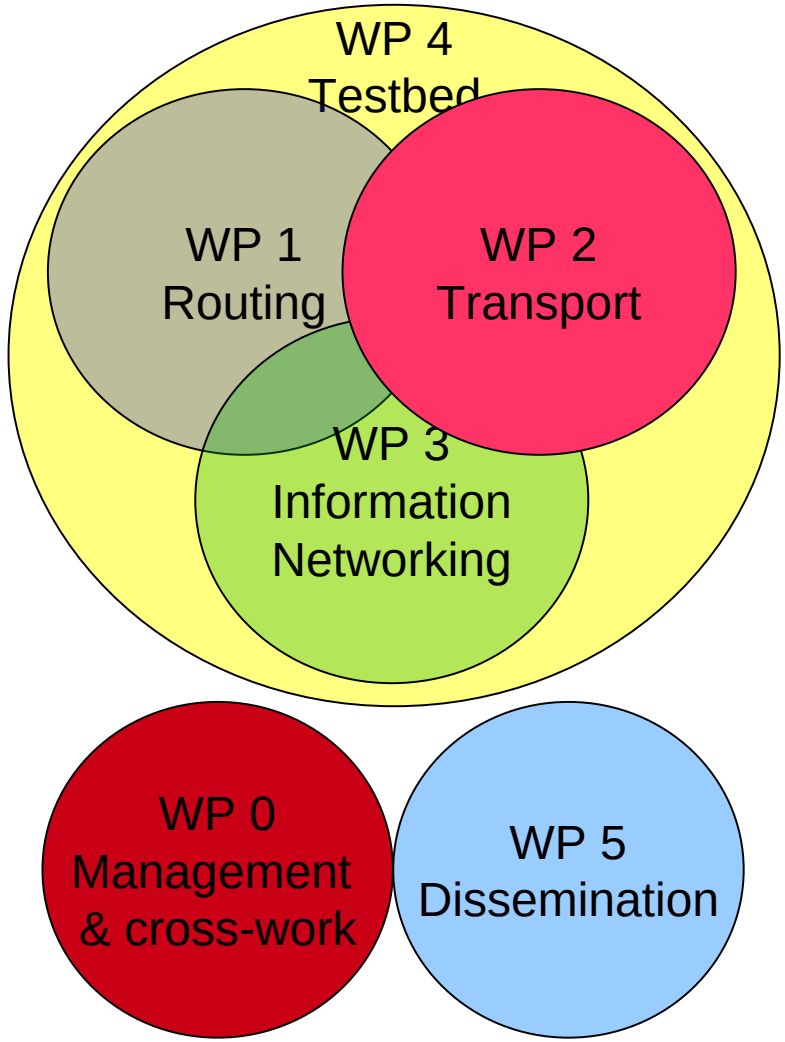
FP7/Call5 will open in June 2009 and the proposals have to be submitted in September 2009

- Call4 will include research areas which are relevant for FI :
  - Future Internet Architectures and Network Technologies
  - Service Architectures and Platforms for the Future Internet
  - Architectures and technologies for an Internet of Things
  - Future Internet based Enterprise Systems
  - Trustworthy Network Infrastructures
  - Trustworthy Service Infrastructures
- Building up the consortiums will be started in Apr-May 2009
- Projects will start in Summer 2010 and end in Summer 2012

Mission:

Enhance the Internet technology and ecology as a *platform for innovation* while providing strong governance over the use of the network resources and information in such a way that especially mobile use of the network and its services will be natively supported

www.futureinternet.fi



- Start: April 2008
- 50 person years/year
- + SMEs

Major national (Tekes) initiative to create competencies, technologies and business opportunities in Finland

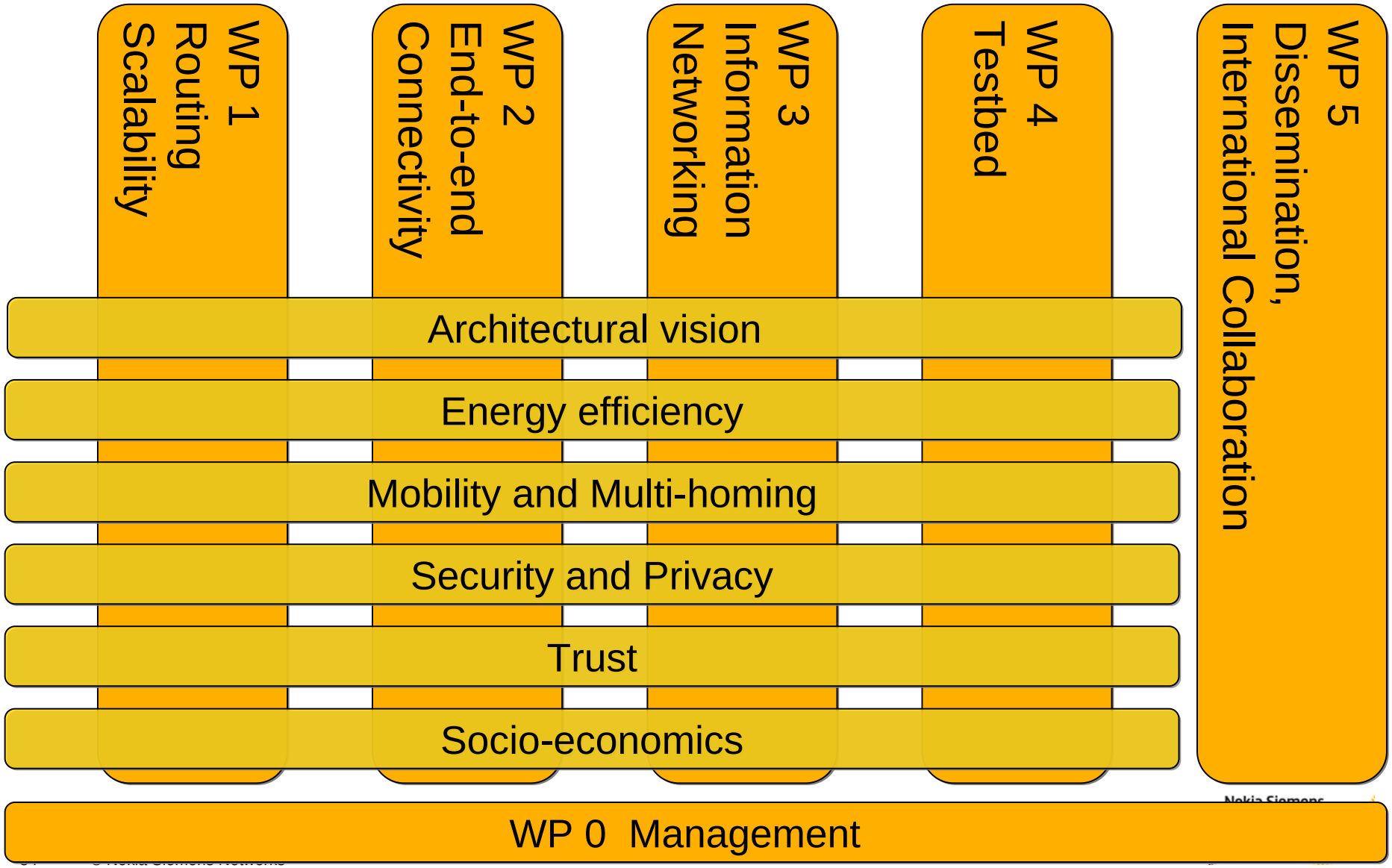
WP 1: Routing Scalability
- New ways to manage the increasing size and complexity of routing tables
- Investigate addressing structures, aggregation methods, performance characteristics, etc.

WP 2: End-to-end Connectivity
- Energy efficient communications
- Transport over challenged environments
- New abstractions to manage end-to-end performance and resource control
- Concept/framework development for policy based network resource management and access network selection

WP 3: Information Networking
- How and where the information is stored and managed in the network?
- How information is discovered and retrieved?

WP 4: Testbeds
- Set up Finnish testbed for experimenting with Future Internet technologies

WP 5: Dissemination, International Collaboration


WP 1
Routing
Scalability
WP 2
End-to-end
Connectivity
WP 3
Information
Networking
WP 4
Testbed
WP 5
Dissemination,
International Collaboration
Architectural vision
Energy efficiency
Mobility and Multi-homing
Security and Privacy
Trust
Socio-economics
WP 0 Management

Conclusion

- Internet is a critical backbone of the society and continues to be so
- Internet has grown out from its original design specifications
  - The core of the Internet hasn’t changed in a decade or more
- New terminals, network technologies and usage modes are driving the Future Internet
- Several international, EU and national initiatives are exploring and developing the foundation for the Future Internet, and more activities are under planning

References

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Nokia Siemens Networks

Nokia Siemens Networks:

Reinventing the connected world