University of Würzburg
Institute of Computer Science
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Pathways towards Next Generation Networks

Prof. Phuoc Tran-Gia
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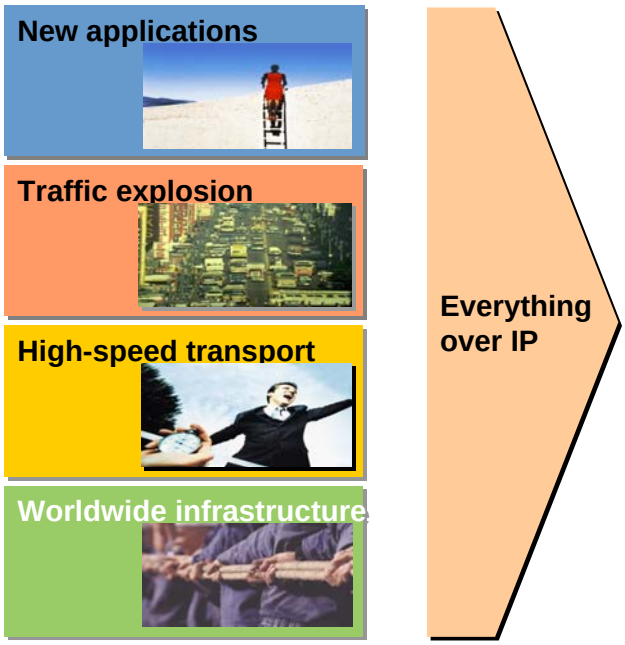
Würzburg, Germany

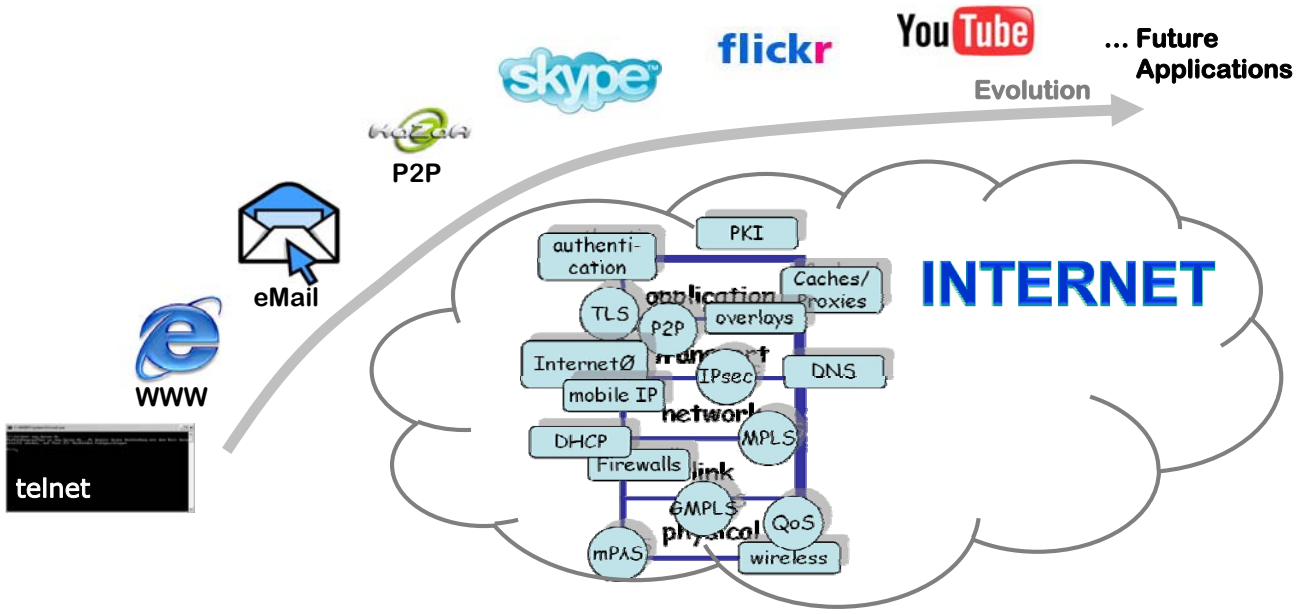
Pathways towards Next Generation Networks

1. **Trends and observations**
   - Multi-Network Service & Edge-based Intelligence
2. **Service Evolution**
   - Overlay and self-organizing networks
   - Changing user traffic behavior and Quality of Experience
3. **Future Network Projects**
   - USA and Asia Pacific
   - European Union& Germany NGI Projects
4. **Quo vadis**
   - Pathways and funding issues

The IP bottleneck

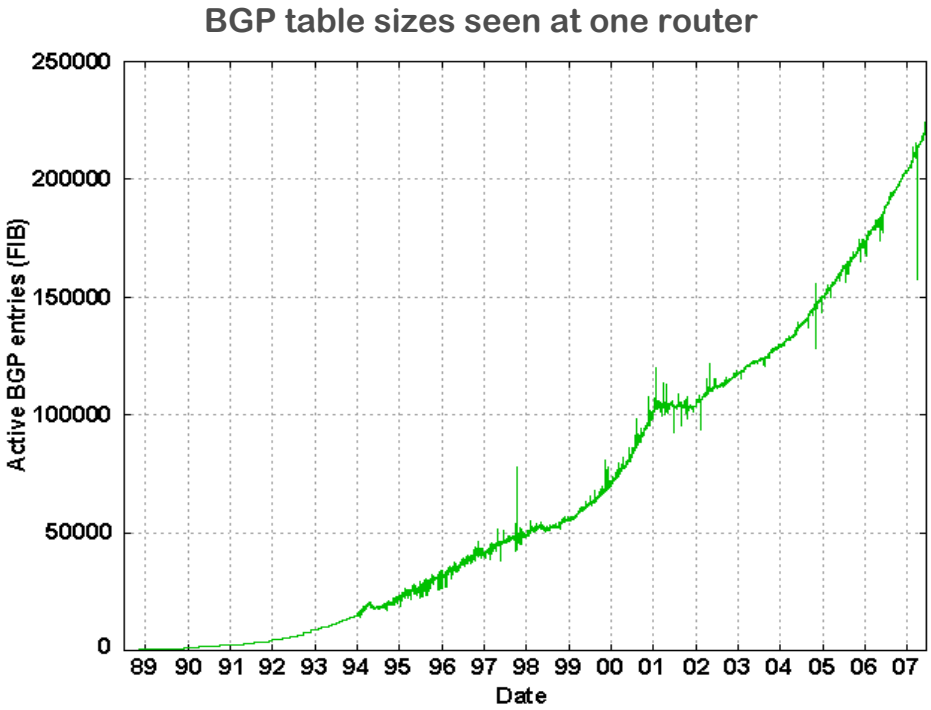


Usage (service?) evolution



Internet evolution is mainly driven by innovative usages (or services)

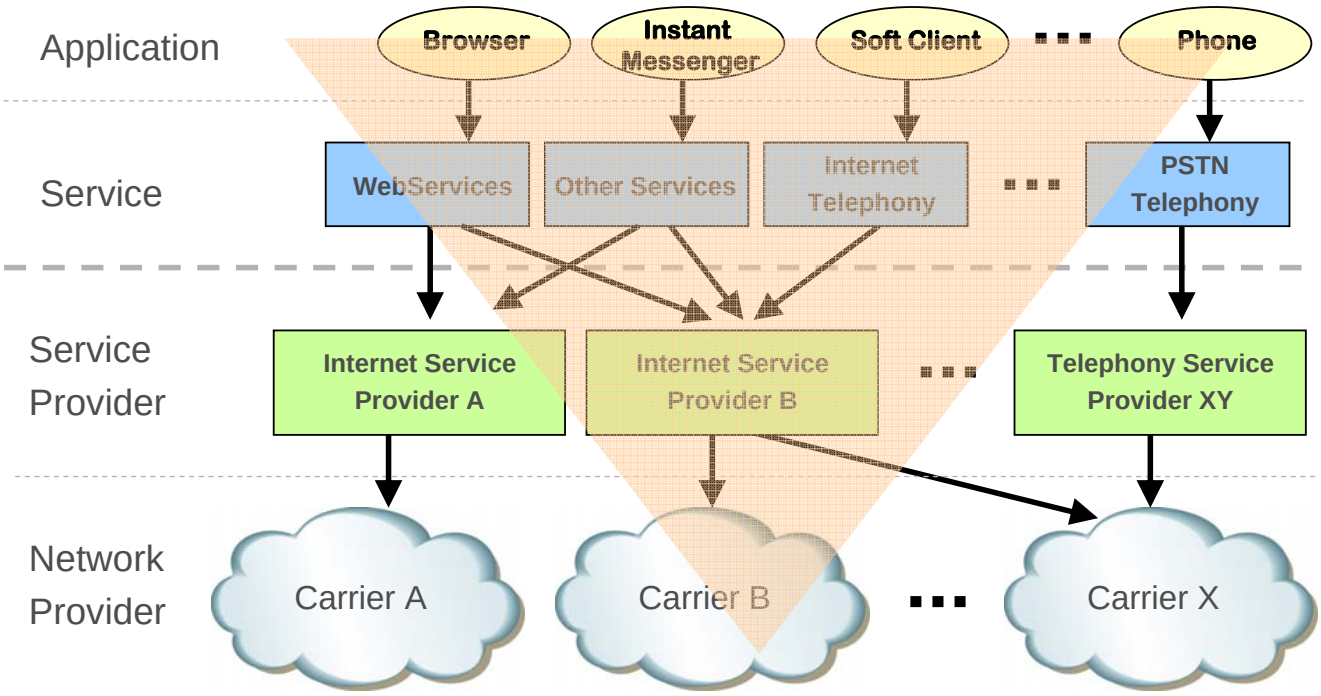
Why do we need a new Internet routing?



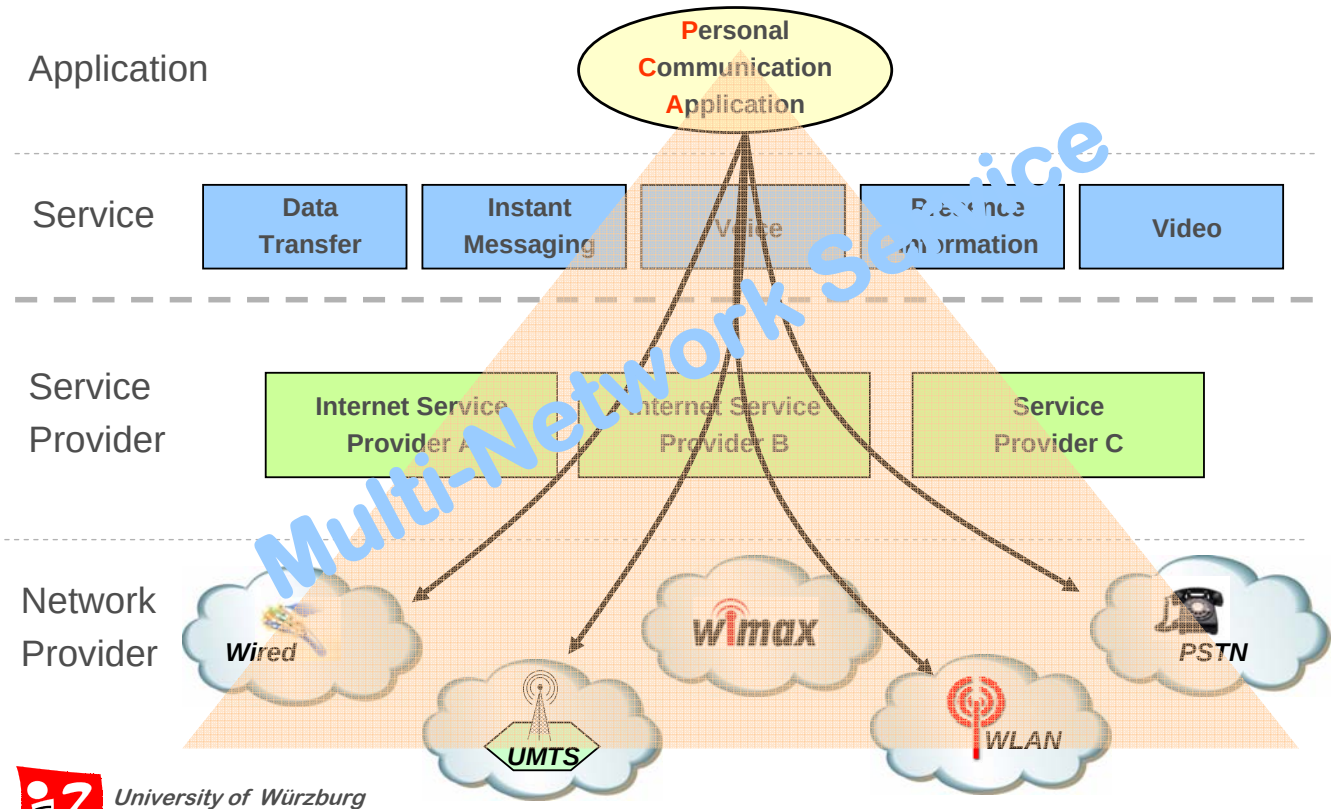
[*Source*: CIDR Report IPv4 – http://www.cidr-report.org]

Trend:
Multi-Network Services & Quality of Experience

Network-centric: Multi-Service Networks

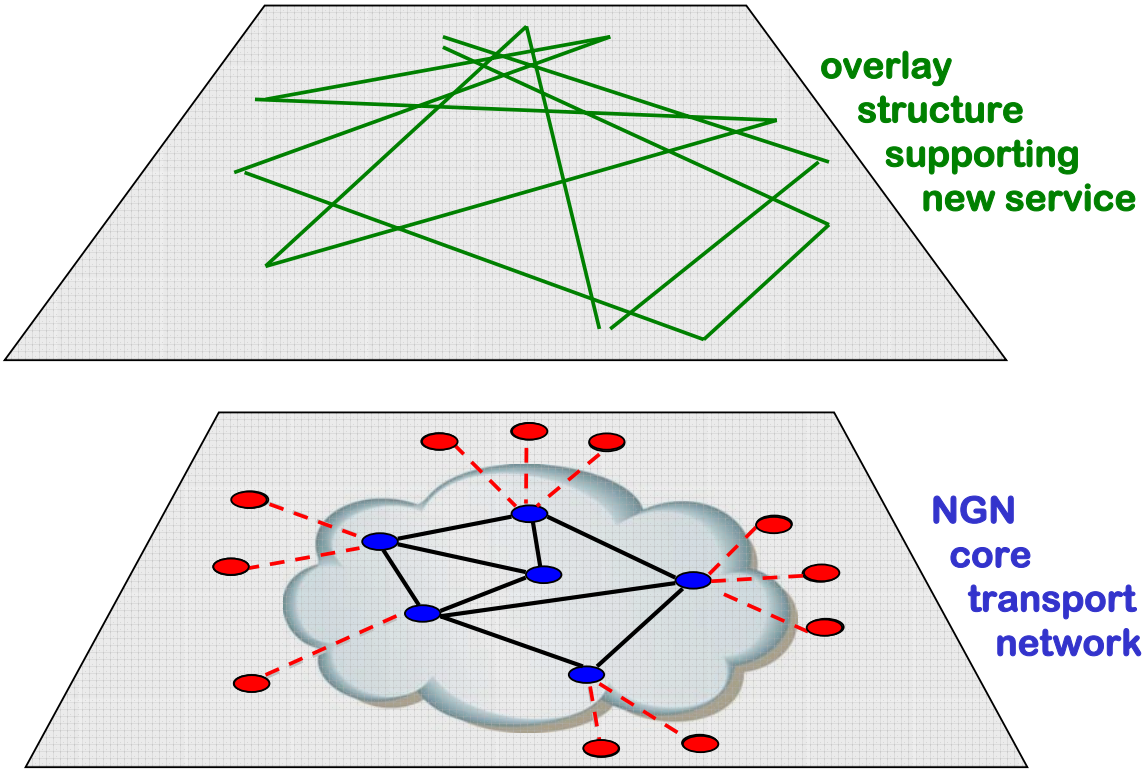


Application-centric: Multi-Network Service



Trend:
Edge-based Intelligence and Overlay Networks

Overlay Control Structure



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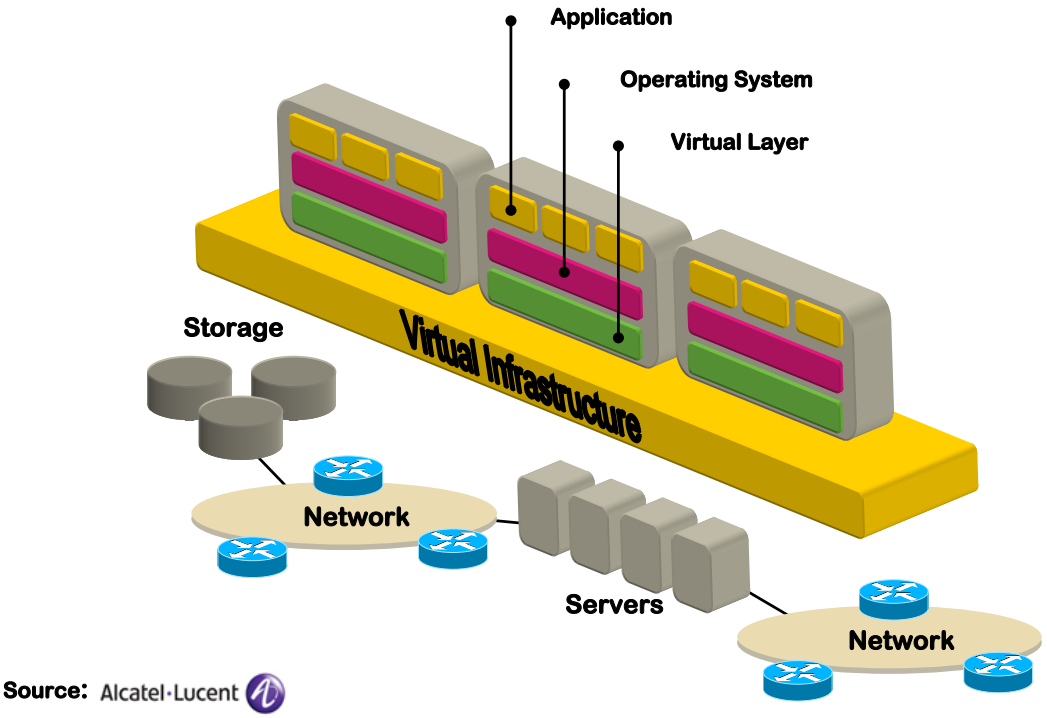
Everything virtualized !
(including virtual things)

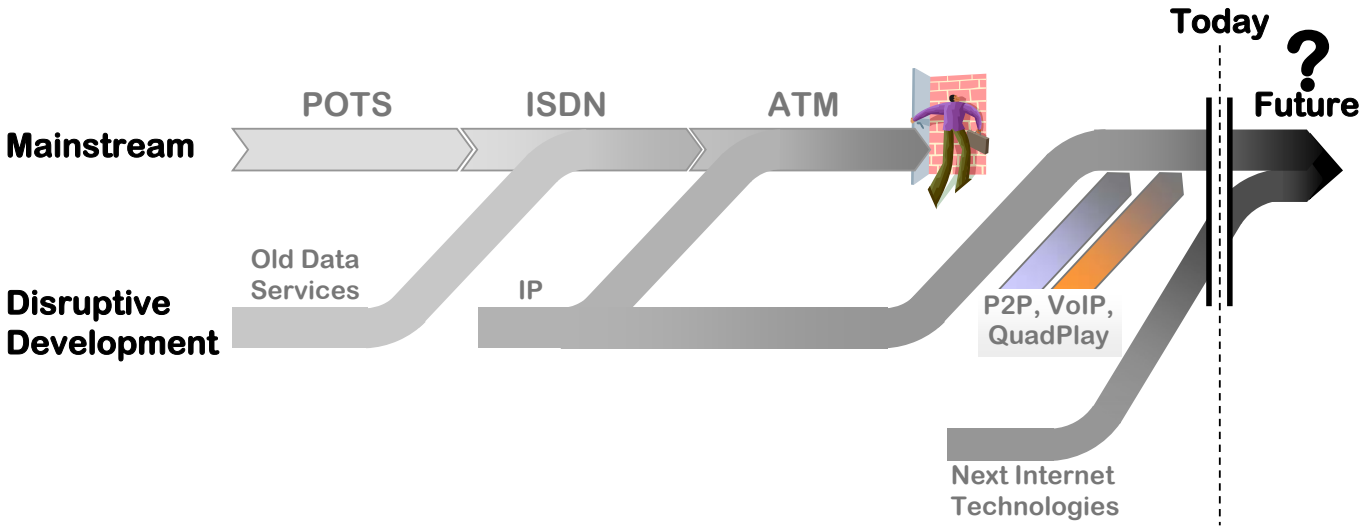
Virtualization of the Network



Source: Alcatel·Lucent

Next Generation Networks: Disruptive Development & Mainstream

Disruptive Delelopment & Mainstream



Which path to go: Clean-Slate or Evolutionary Approaches ?

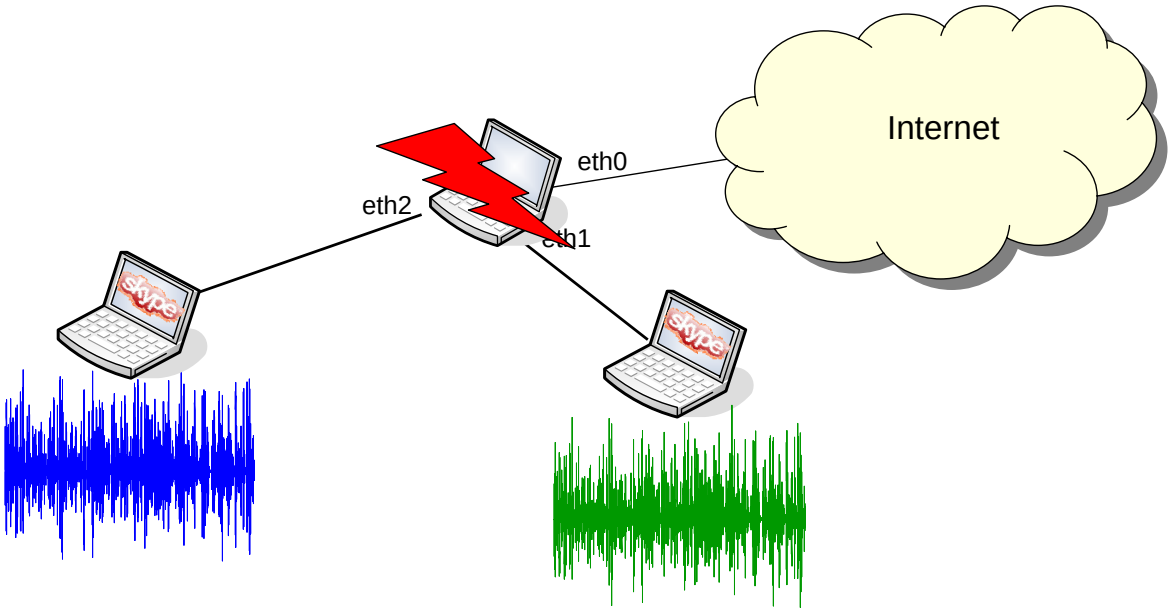
Future Network: Clean-slate or Evolutionary?

- **Clean-Slate Approach**
  - **start new network design from scratch**
  - Pros:
    - don't bother legacy network, forward-looking
    - don't get trapped by repair shop
    - clearer vision what we really need
  - Cons
    - "academic approach", deployment unrealistic
    - acceptance of component vendors and network provider questionable
- **Evolutionary Approach**
  - **try to find out emerging paths from today's network**
  - Pros:
    - pragmatic, CAPEX-oriented
    - High acceptance level from main players
  - Cons
    - legacy technology, repair-shop approach

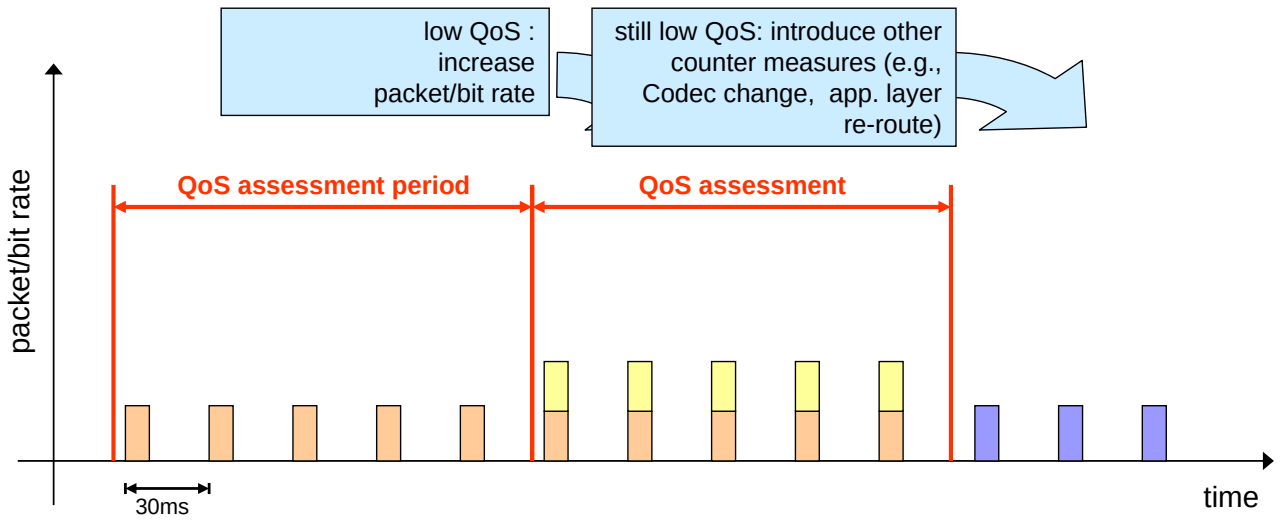
Quality of Experience
Example:
Skype Measurement

Emulating Dynamic Changes

packet loss

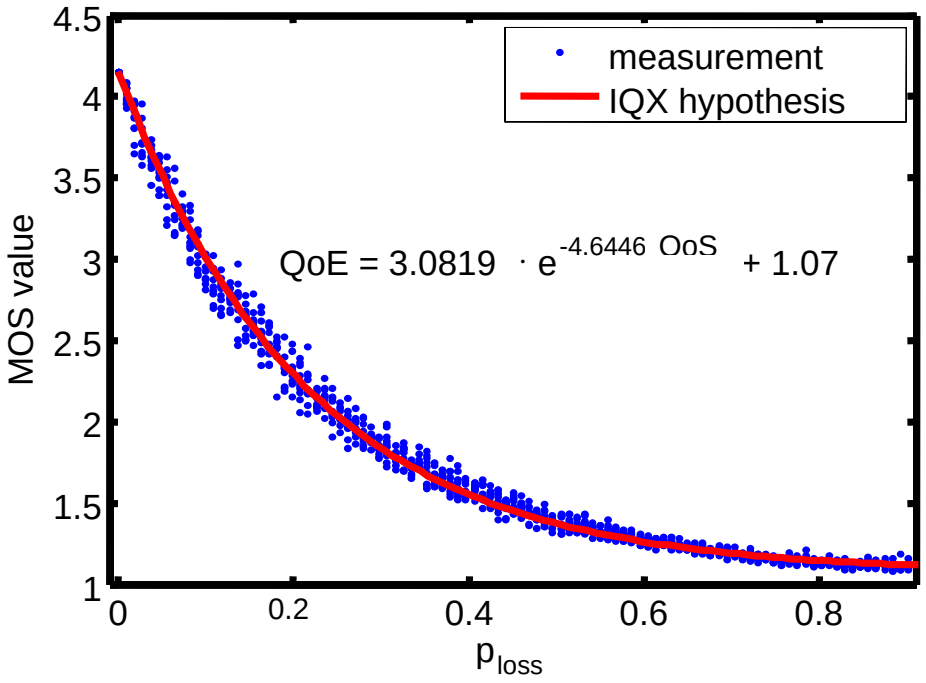


Selfish application: positive feedback bitrate



Quality of Experience: Exponential Relationship between QoE and QoS

IQX Hypothesis : Exponential Relation between QoE and QoS



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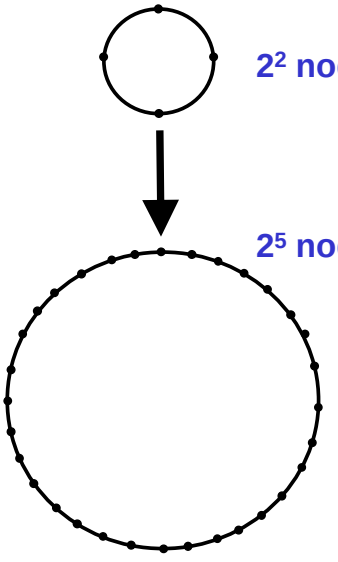
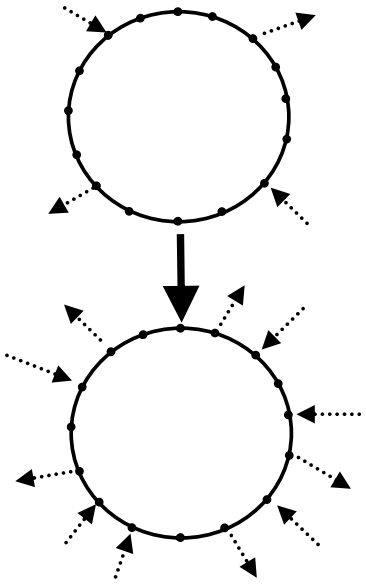
Functional Scalability
& Stochastic Scalability

Functional Scalability & Stochastic Scalability

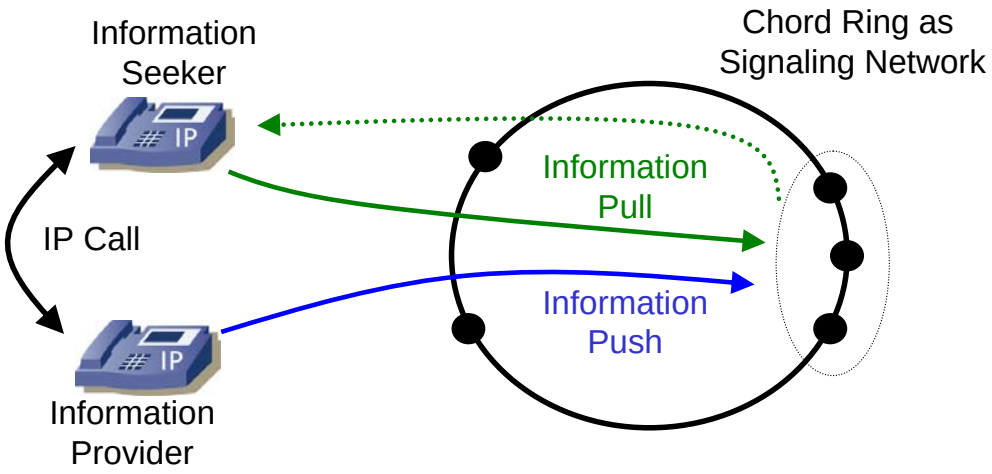
Functional Scalability



Stochastic Scalability



Example: P2P Voice-over-IP Signaling using Chord



Information:
- nick-name
- current IP-address
- user profile

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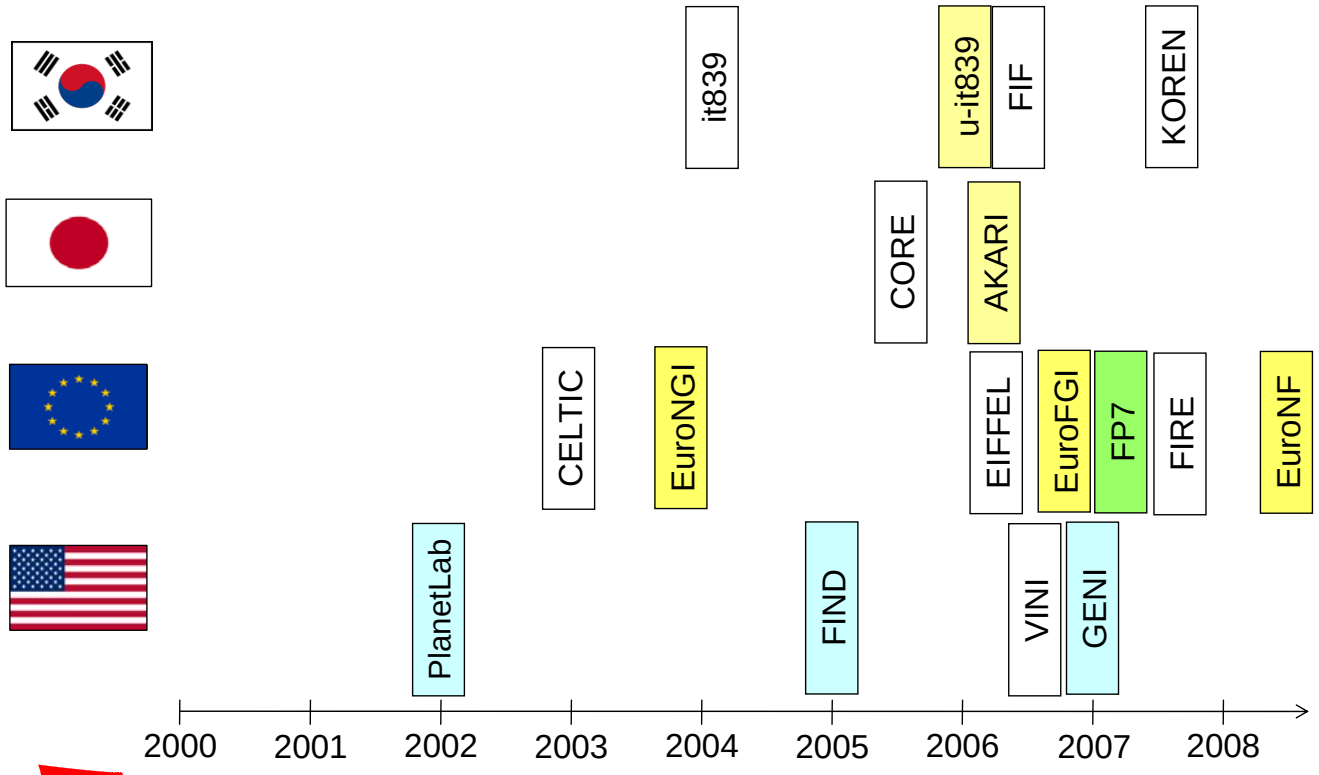
NGI everywhere

Where, When, What? (not completed)

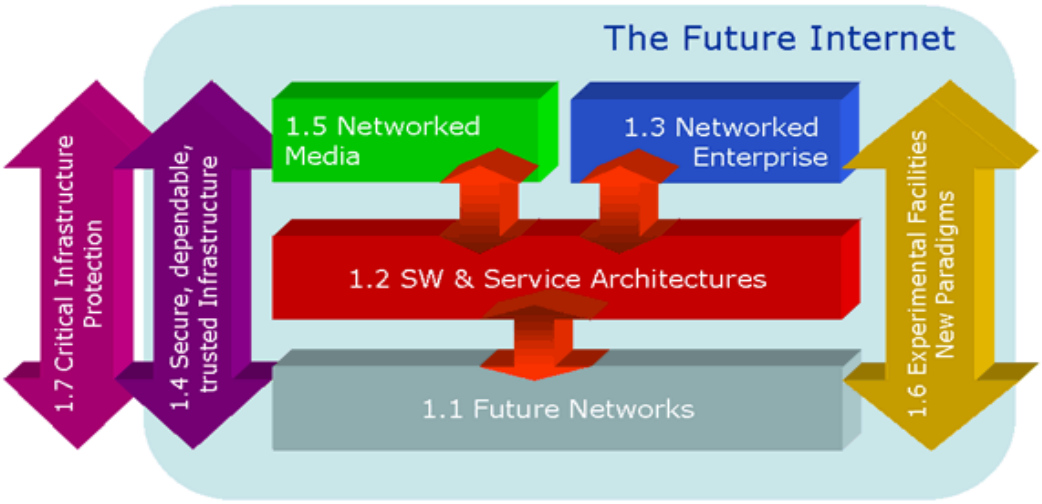


NGI project examples

European Union

EU FP7-ICT Work Programme 2007-2008

- Challenge 1 „Pervasive and Trusted Network and Service Infrastructures“



[*Source*] http://cordis.europa.eu/fp7/ict/prgraomme/challenge1_en.html

FIRE – The International Context



FIRE

FIND

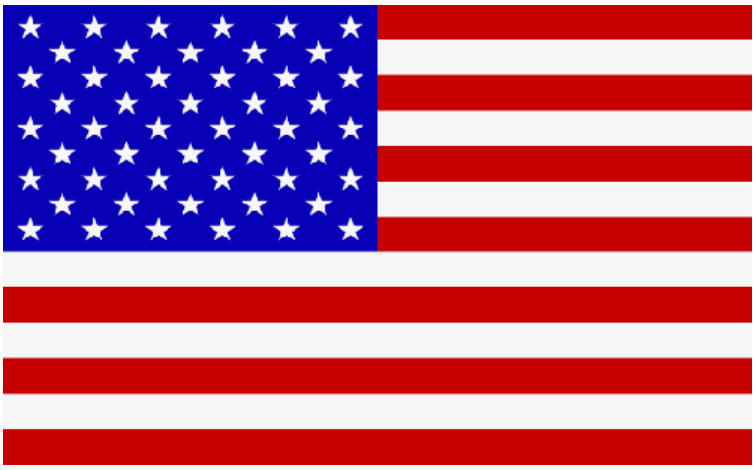
AKARI

New approaches to the Internet

GENI

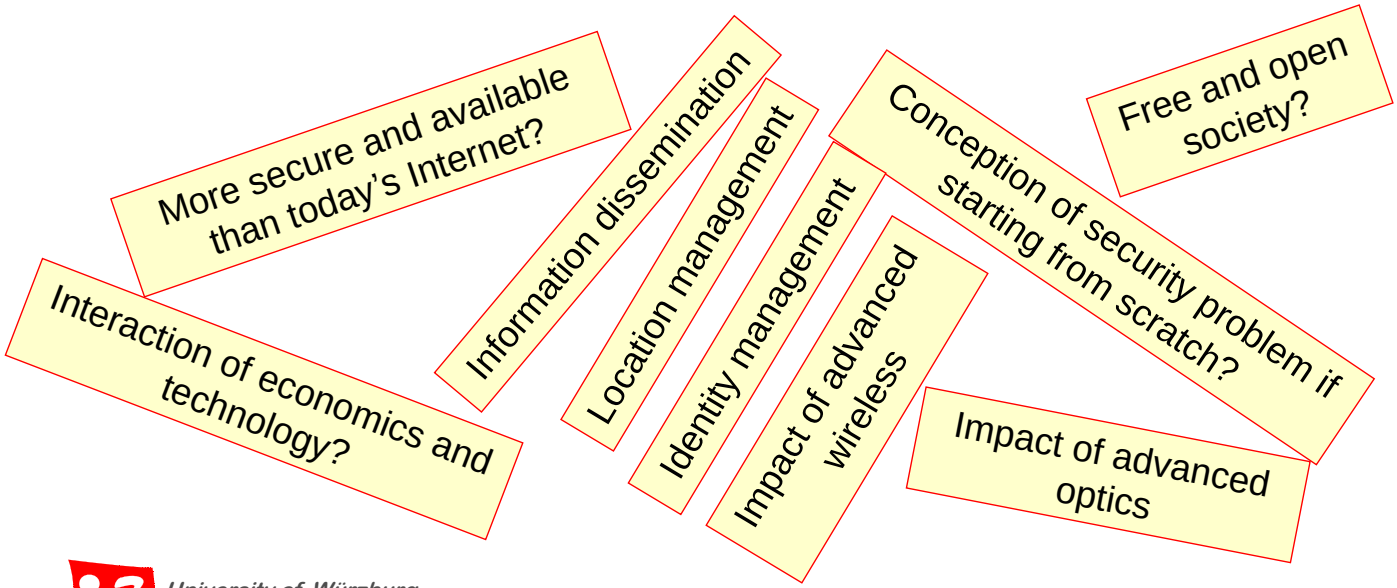
Large-scale experimental facility

United States



NSF NeTS FIND – The Goal

"[…] what the requirements should be for a global network of 15 years from now, and how we could build such a network if we are not constrained by the current Internet"



NSF NeTS FIND – The Projects

- Projects funded in 2007: 38 funded projects (13,276,253 USD)
- Topics (*):

Security: 3

Architecture basics: 10

Economical impact: 3

Diagnosis and Troubleshooting: 2

Availability and Robustness: 2

Routing: 7

Sensors: 3

Location Management: 3

Management: 4

Identity Management: 4

Privacy: 3

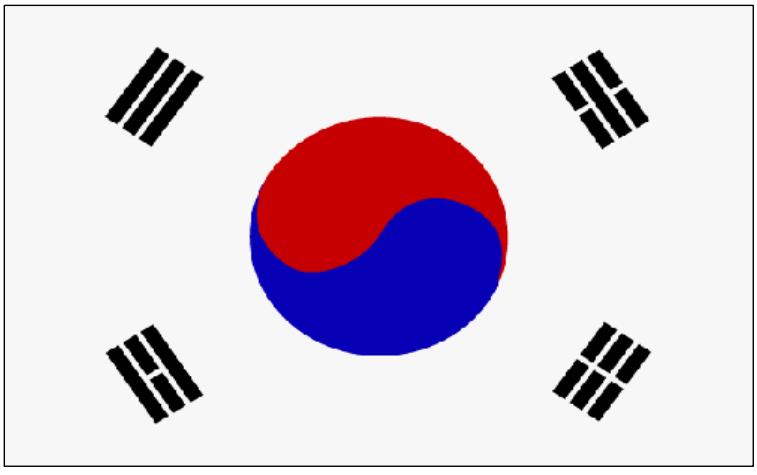
Advanced wireless: 7

Virtualization: 3

Advanced optics: 2

(*) multiple categories per project possible

Korea



u(biquitous)-IT839

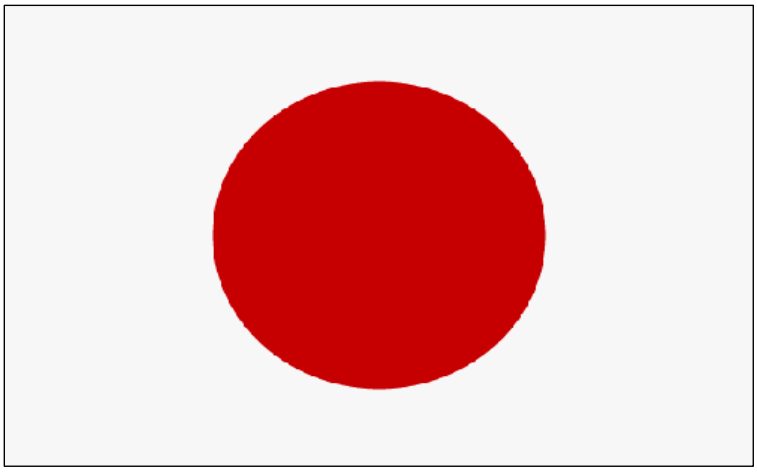
- 2004: IT839 by Korean Ministry of Information and Communication (MIC), Institute for IT Advancement (IITA) – growth strategy to nurture
  - eight new services
  - three infrastructures
  - nine hardware-related businesses
- 2006: u-IT839 – streamlined long-term plan, rearranged portfolio

8
HSDPA/W-CDMA
WiBro
BcN service
DMB/DTV service
u-Home Network service
Telematics/LBS service
RFID/USN service
IT service

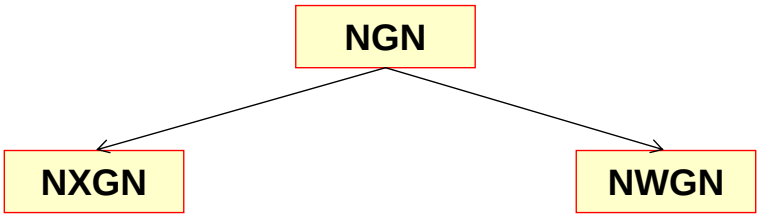
9
MobileCommunication/Telematics
Broadband Home Network
Digital TV/Broadcasting
Intelligent Service Robots
Next Generation PCs
IT SoC
Embeded SW
RFID/USN devices
Digital content and SW solutions

3
Broadband convergence Network (BcN) [IPv6]
Ubiquitous Sensor Networks (USN)
Soft Infraware

Japan



The Japanese Vision on NGN



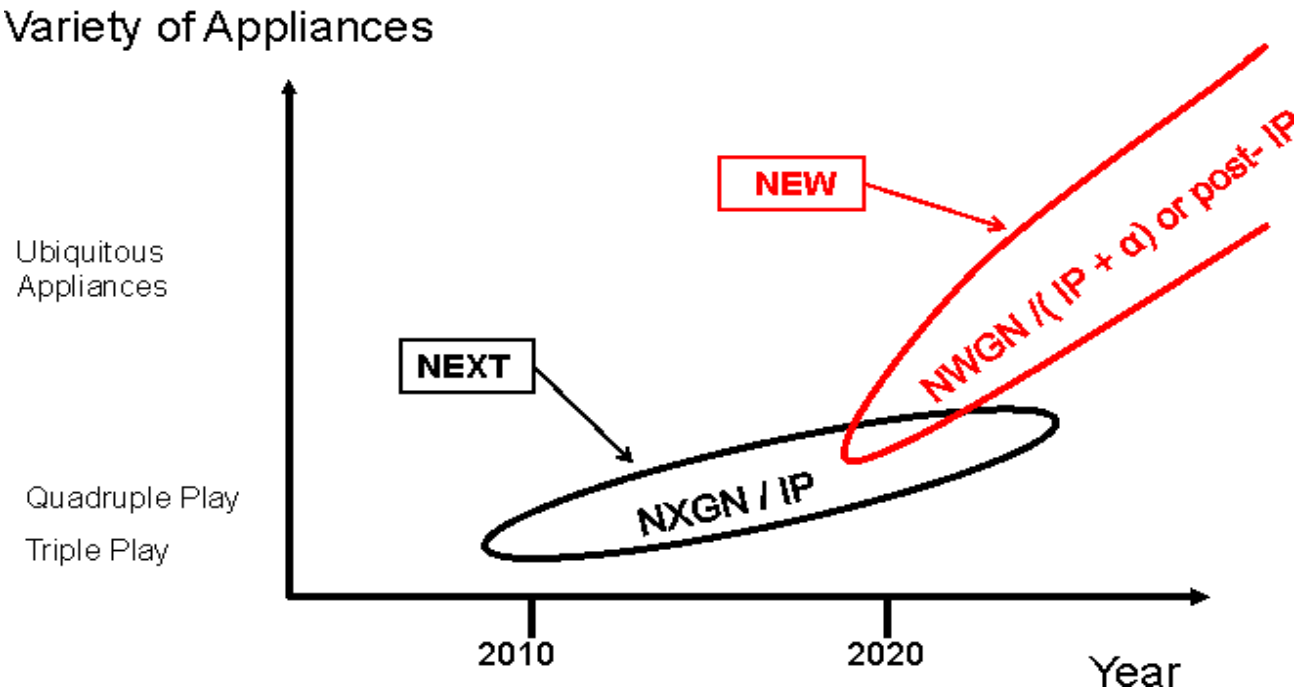
NeXt Generation Network

Replacement of legacy telephone networks using IP-based networks

NeW Generation Network

Clean slate architectures and main protocols different from IP networks

The Japanese Vision on NGN



AKARI

AKARI project
"A small light in the dark pointing to the future"
(AKARI (jap.): small light)

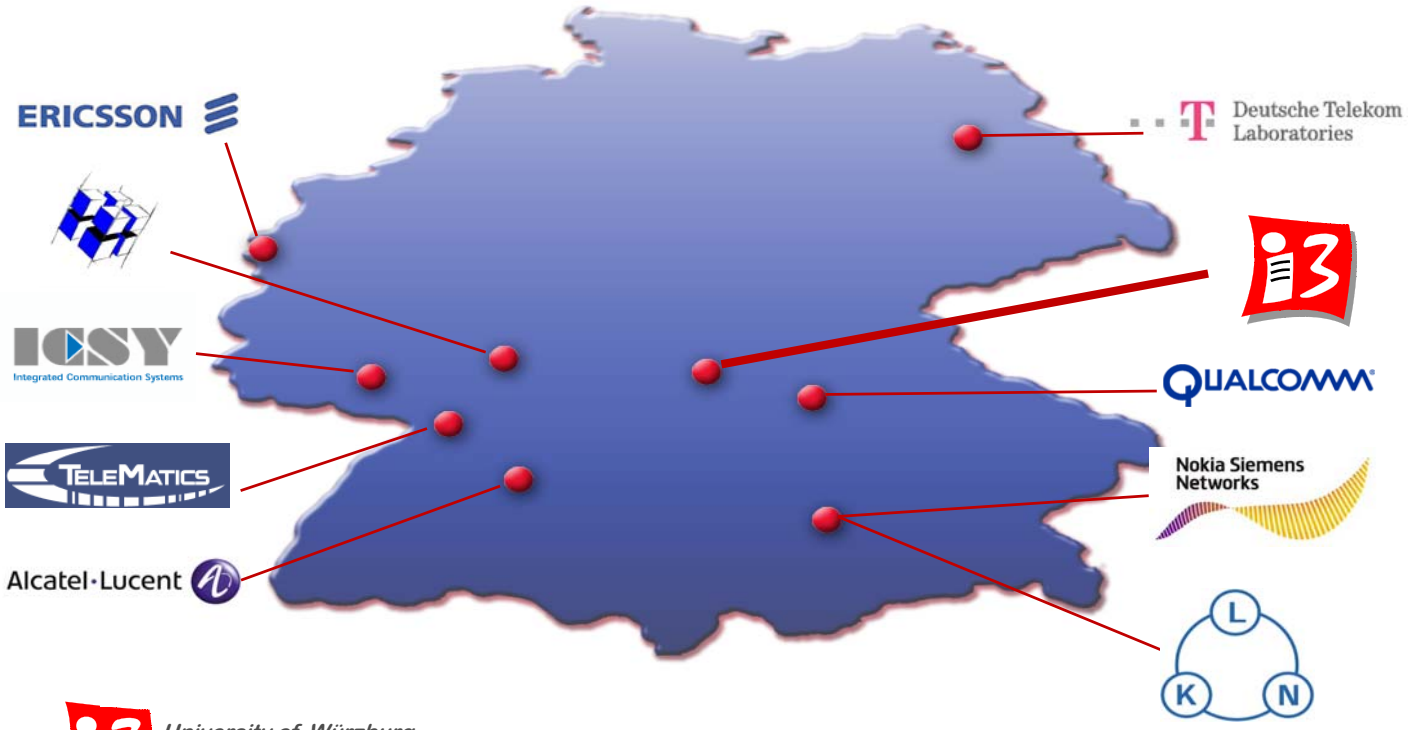
Research	NWGN architectures and key technologies
Testbed	JGN2 → JGN2+ → JGN3 (JGN: Japan Gigabit Network)
Funding	for projects in universities and/or industry

The AKARI Architecture Design Project aims to implement a new generation network by 2015

Germany

Germany: The G-Lab Project

G-Lab Partner

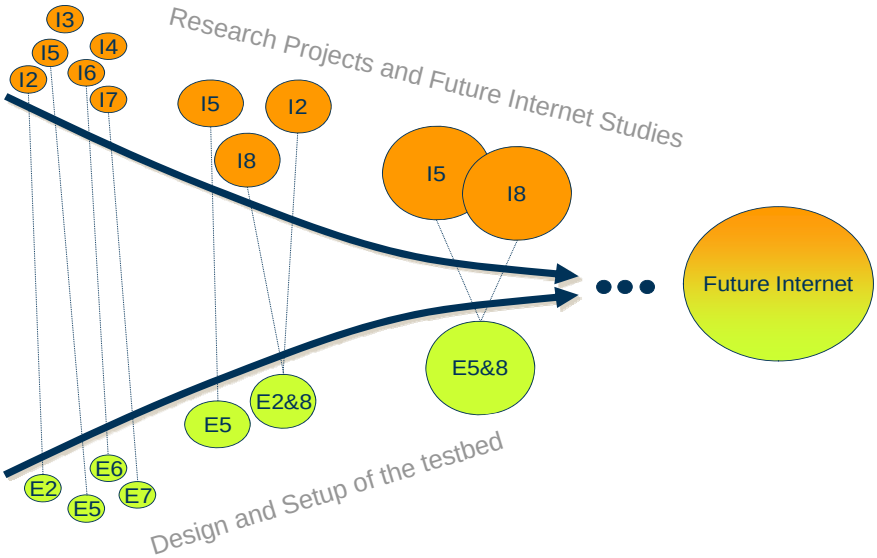


Consortium

- Industries
  - Alcatel-Lucent Germany, Stuttgart (Peter Domschitz)
  - Deutsche Telekom T-Lab, Berlin (Anja Feldmann)
  - Ericsson Lab. Germany, Aachen (Ralf Keller)
  - Nokia Siemens Networks, Munich (Andreas Kirstädter)
  - Qualcomm Germany, Nuremberg (Hans Schotten)

- Universities
  - Technical University of Darmstadt (Ralf Steinmetz)
  - University of Kaiserslautern (Paul Müller)
  - Technical University of Karlsruhe (Martina Zitterbart)
  - Technical University of Munich (Jörg Eberspächer)
  - University of Würzburg (Phuoc Tran-Gia, coordinator)

Vision of the Future Internet



- G-Lab Aims:
  - Provide an experimental platform for studies on mechanisms, protocols and applications towards Future Internet
  - Investigate interdependency of theoretical studies and prototype development

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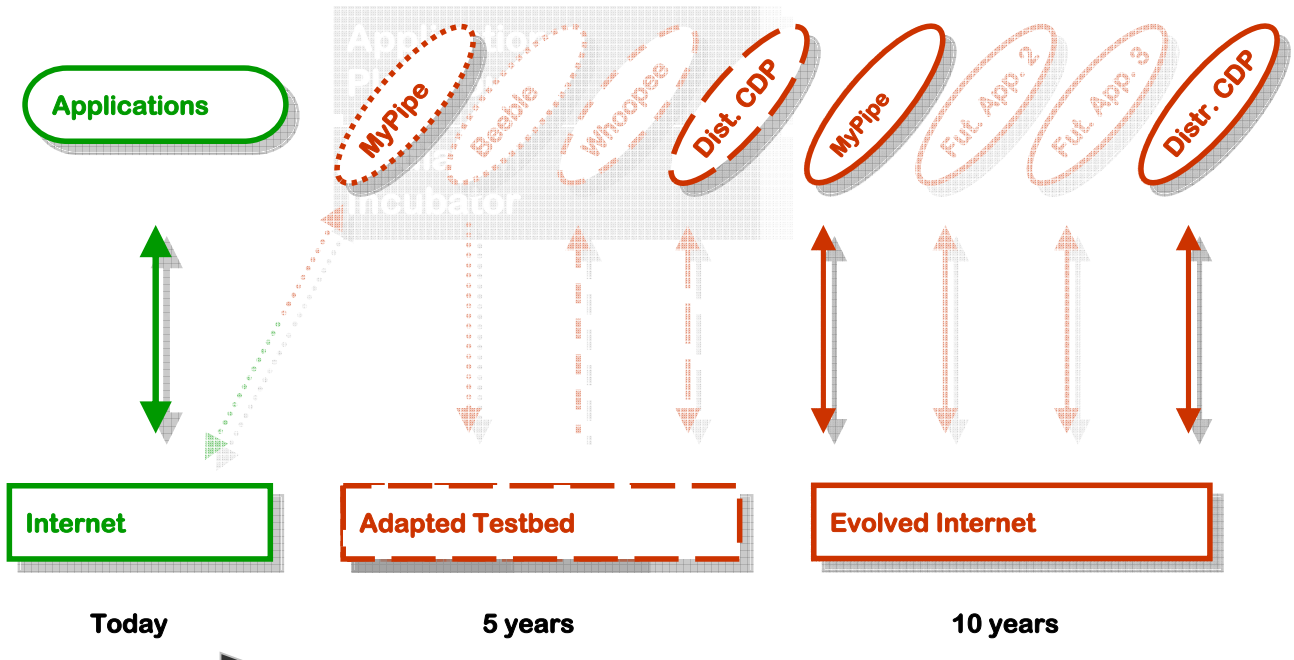
Service Evolution and Testbed



End of Talk

Thank you !