Future Networks – Design Goals and Challenges

A viewpoint from ITU-T

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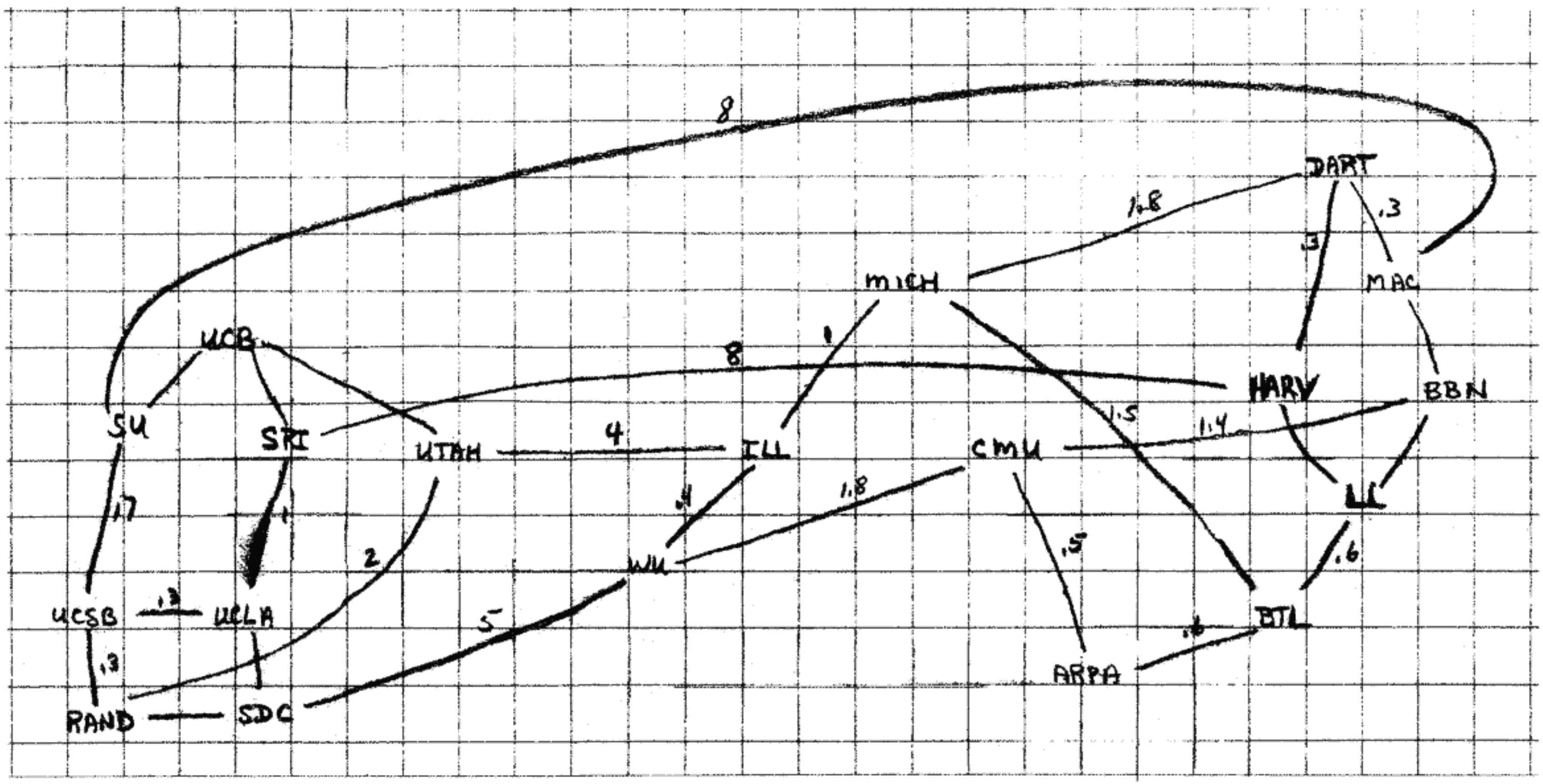
ARPAnet Plan – late 1960s

Rough sketch by Larry Roberts



Internet 1973-74

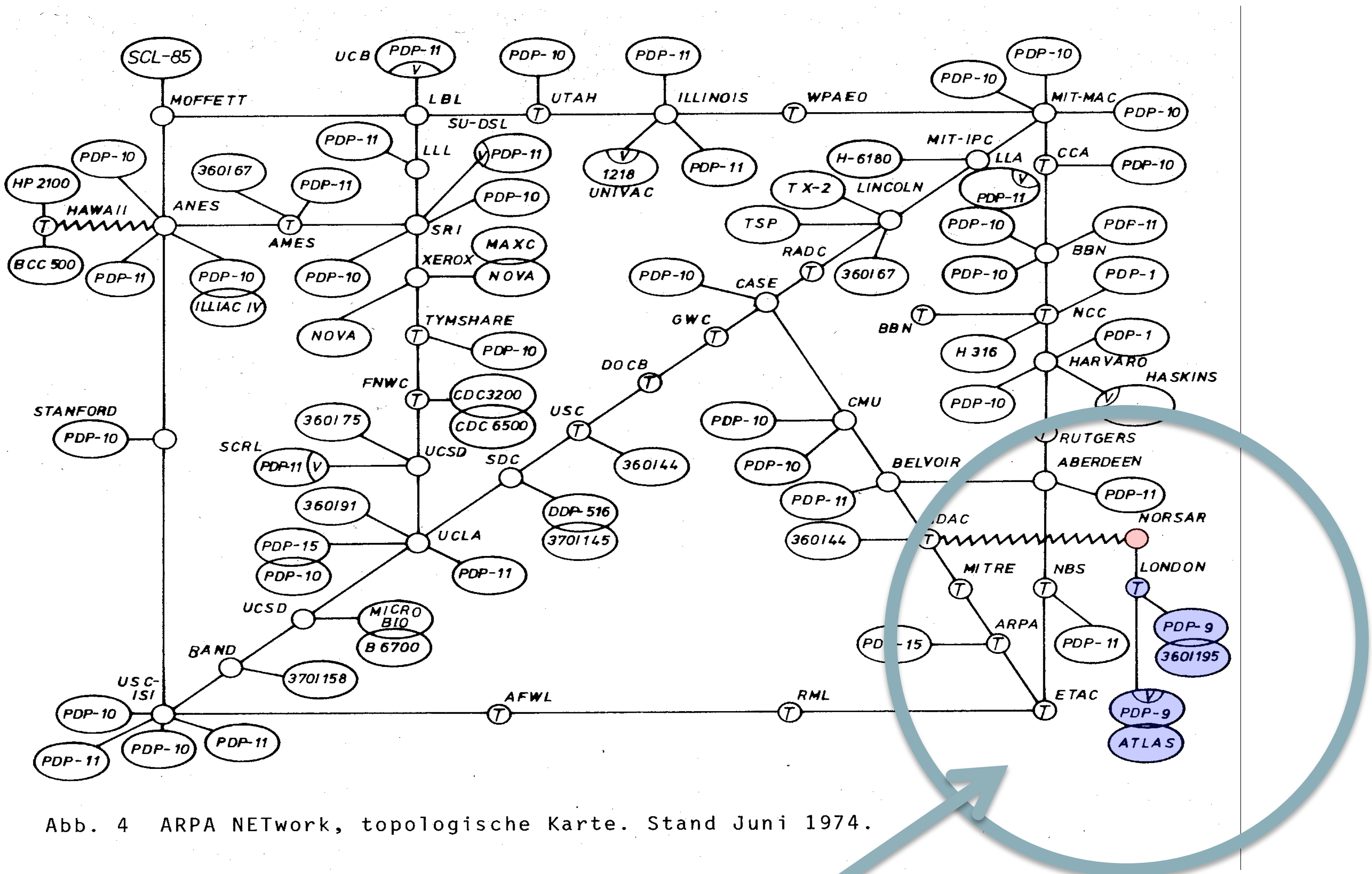
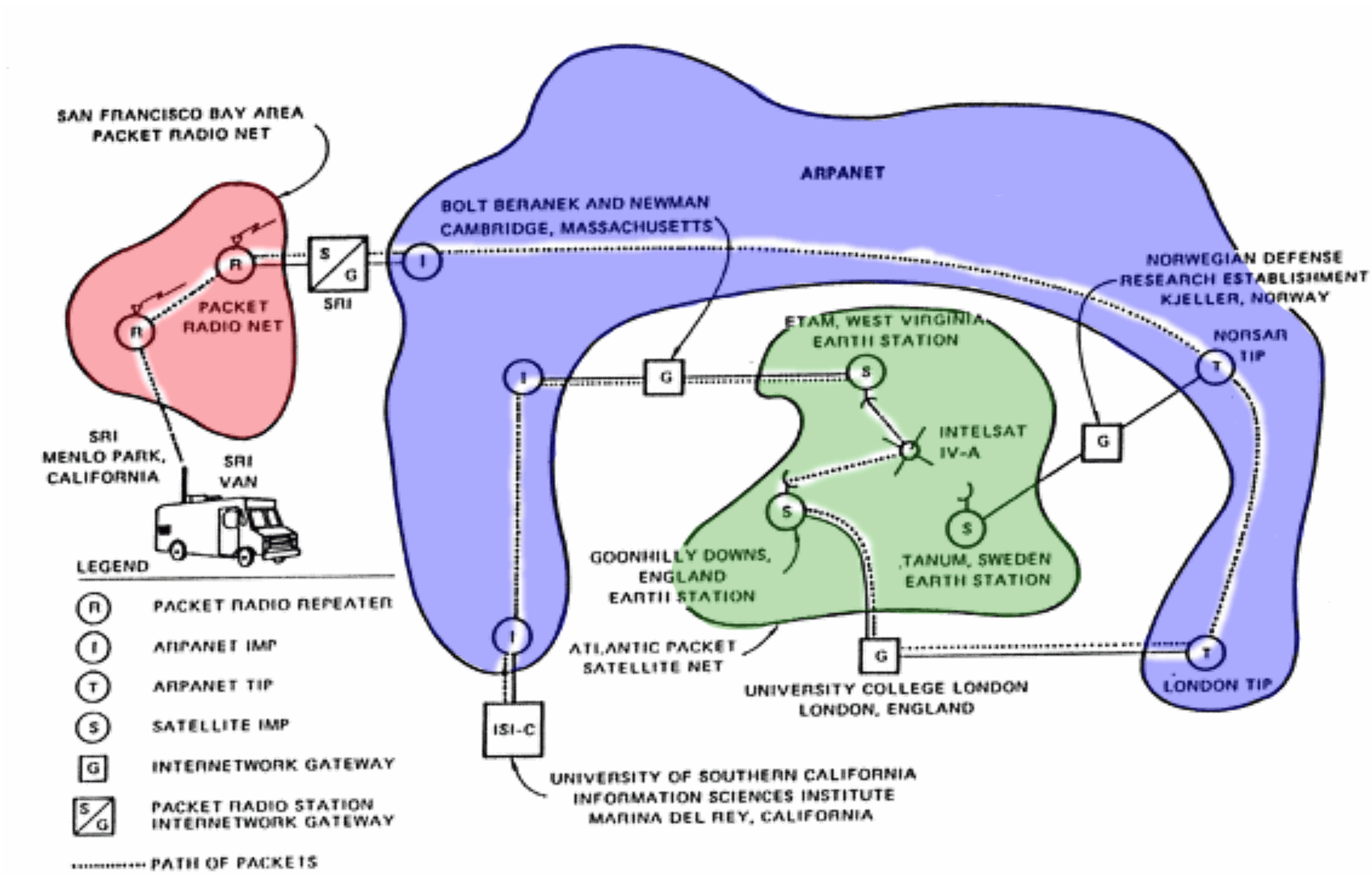


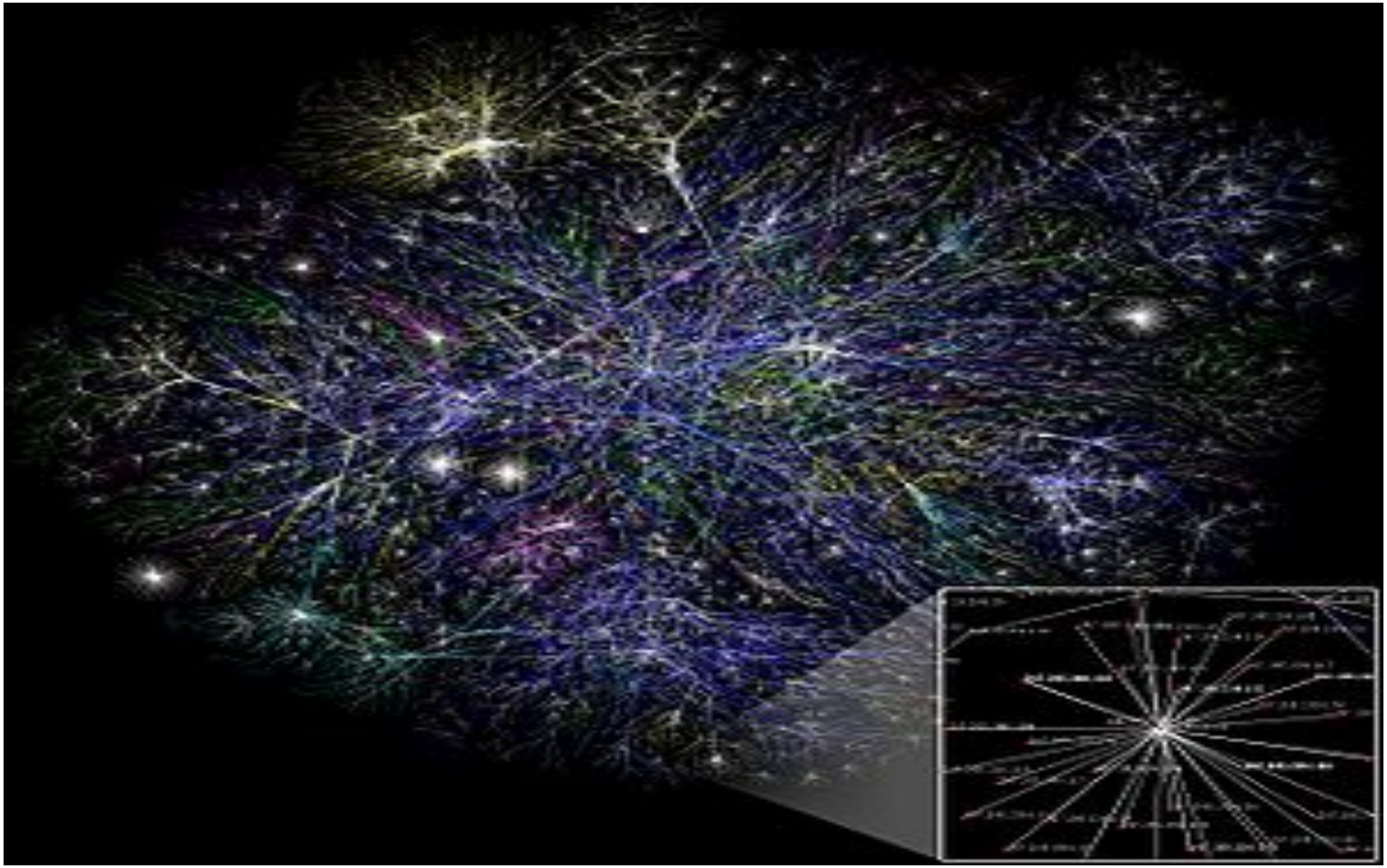
Abb. 4 ARPA NETwork, topologische Karte. Stand Juni 1974.

UCL connected in July 1973 to ARPAnet

Inter-networks Demonstration 1977



Internet 2011



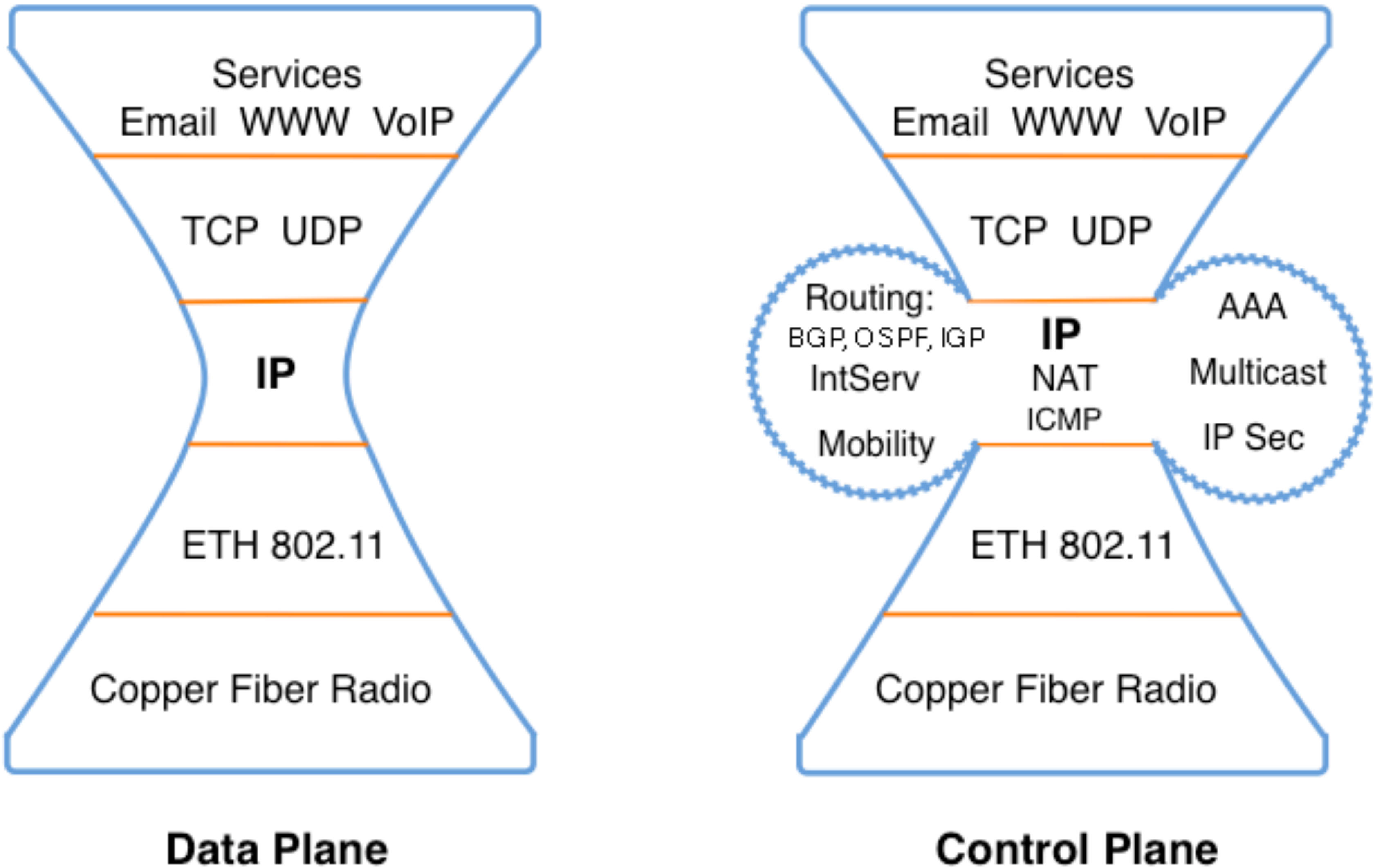
Current Internet

- The Internet plays a central and vital role in our society
  - Work and business, education, entertainment, social life, …
- Victim of its own success, suffering from ossification
  - Innovation meets natural resistance (e.g. no IPv6, no mobile IP, no inter-domain DiffServ, no inter-domain multicast, etc.)
- Services such as P2P, IPTV, Cloud services, emerging services, pose new requirements on the underlying network architecture
- Big growth in terms of the number of inter-connected devices but slow growth in innovation and new services

Key Changes in Internet - History

- Changes were possible when the Internet was still an academic research network (i.e. until 1993 when the WWW turned it to a commercial)
- Inter-network that underpins the "information society"
- Key changes in that period were the following: 1982 DNS, 1983 TCP/IP instead of NCP, 1987 TCP congestion control, 1991 BGP policy routing, 1991 SNMP
- No significant changes since then apart from MPLS which has been deployed in addition to plain IP
- Research efforts towards the Future Internet: evolutionary & clean-slate approaches, evolutionary changes, autonomic management

Internet Hour-glass Model



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Future Internet – some differences

Current Internet = Network of Interconnected uncoordinated networks

Future Internet

- Unlike the original Internet set of standards, which merely focus on technical connectivity, routing, and naming, the scope of the Future Internet recommendations, standards, and guidelines should encompass all levels of interfaces for Services as well as technical resources.
- They should further support the complete lifecycle of applications and services that are primarily constructed by recombining existing elements in new and creative ways.

Why to change

- **Disappearance of the 'End-host only' concept** (i.e. edge networks; new nodes : sensors, mobile devices;)
- **Lack of in-system management** (i.e. information, decision, implementation – closed control loops for realizing management requirements)
- **Trustworthy User / Network / Service (**i.e. end-host protocols can and are altered → many security issues)
- **Best effort service delivery**
- **No explicit media & content handling**
- **Size & Costs:**
  - N X 10^9 connectivity points - status: reaching maturity and maybe some limits
  - N X10^5 services /applications - status: fast growing
  - N X10^3 Exabyte's content - status: fast growing
  - Cost structure: 80% (→90%) of lifecycle costs are operational and management costs - status: reaching crisis level
- **Ossification:** reaching crisis level
  - A lot of missing and interrelated features; missing enablers for integration and orchestration of Nets, Services, Content, Storage
  - Substantial barriers to innovation with novel services, networking systems, architecture and technologies

How to change

Approach:

- Parallel Internets; Progressive changes; “Clean” slate and evolutionary
- Network of networks → system of coordinated service networks
- Virtualization of resources (Networks, Services, Content, Storage)
- Programmability
- Increased self-managebility as the means of controlling the complexity and the lifecycle costs

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Research Initiatives

1. Korea - Future Internet Forum - http://fif.kr/
2. Asia Future Internet - http://www.asiafi.net/
3. Japan - AKARI Future Internet - http://akariproject.nict.go.jp/eng/conceptdesign.htm
4. USA - Global Environment for Network Innovations (GENI) - http://www.geni.net
5. European Union - Future Internet Assembly (FIA) www.future-internet.eu

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ITU-T

- ITU-T FG FN - Focus Group Future Networks

Period: July 2009 – March 2011

Objective: document results that would enable development of Recommendations for future networks

www.itu.int/en/ITU-T/focusgroups/fn/Pages/Default.aspx

Results:

- **ITU-T Recommendation Y.3001 " Future Networks- Objectives and Design Goals"**
- **FNs Vision Document + 3 Supporting Technologies**

With contribution - concepts & references from FIA MANA & FP7 projects: AutoI, RESERVOIR, 4WARD, Univerself

Chairman:	Takashi Egawa (NEC, Japan) - 2010
	Morita Naotaka (NTT, Japan) - 2009
Vice-Chairman:	Hyoung Jun Kim (ETRI, Korea)
Vice-Chairman:	Alex Galis (University College London, UK)

Future networks

ITU-T started pre- standardisation activities with identification of FNs requirements

– **new application areas (e.g., IoT, cloud, smart grid)**

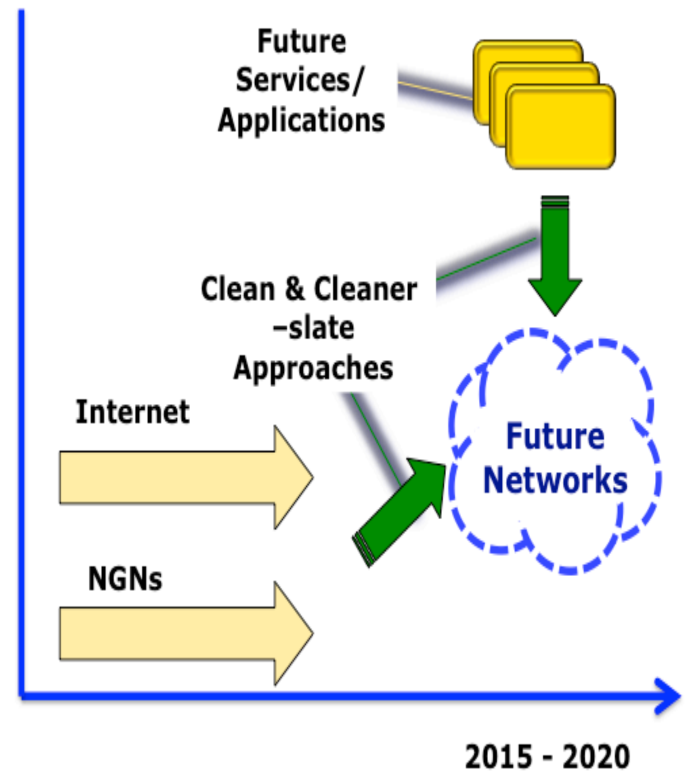
→Introduction of new network architectures; call this Future Networks

ITU is not R&D body. Direction is find by analysing existing activities (Asia, EU, USA)

Produced document Future Networks: Objectives and Design Goals is first "guidance" – ITU-T Recommendation Y.3001

FN - Appropriate timeframe for prototyping and phased deployment is 2015 - 2020

Next phase is to find the best answers on requirements.



Definition - Future networks

Future Networks (FNs):

A future network is a network which is able to provide revolutionary services, capabilities, and facilities that are hard to provide using existing network technologies. A future network is either:

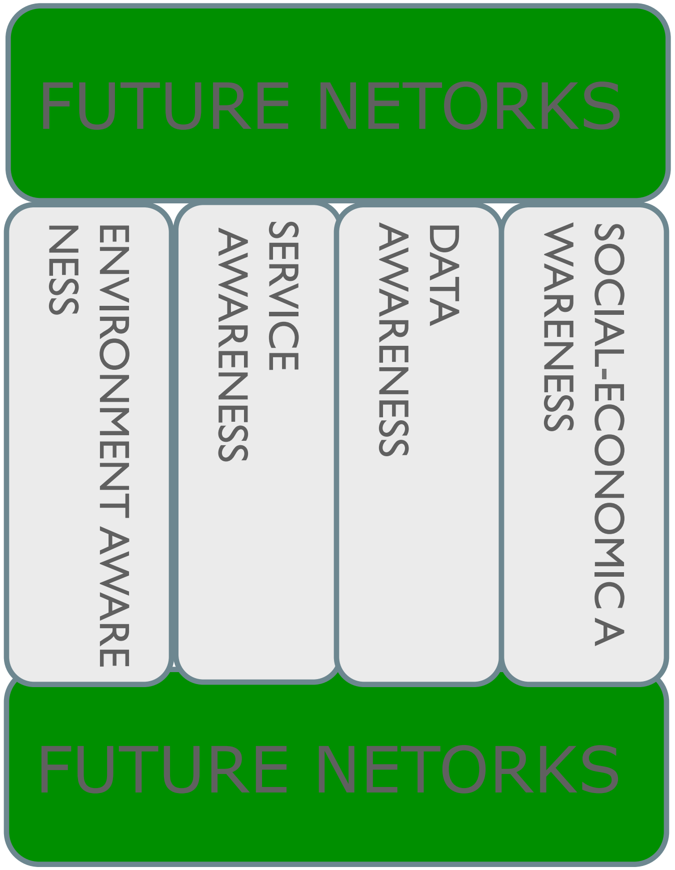
- **new component network or an enhancement to an existing one;**
- **federation of new component networks or federation of new and existing component networks.**

ITU-T FG FN - Vision document

- **fundamental issues that are neglected in designing today's networks as 'objectives',**
- **capabilities that should be supported by future networks as 'design goals',**
- **ideas and research topics of future networks that are important and may be relevant to future ITU-T standardization as 'promising technologies'.**

Future Networks - Four Objectives

- **Environment awareness**
  - FNs should be environmental friendly.
- **Service awareness**
  - FNs should provide services that are customized with the appropriate functions to meet the needs of applications and users.
- **Data awareness**
  - FNs should have architecture that is optimized to handling enormous amount of data in a distributed environment.
- **Social-economic awareness**
  - FNs should have social-economic incentives to reduce barriers to entry for the various participants of telecommunication sector.



Future Networks - 12 Design Goals

International Telecommunication Union

① (Service Diversity) FNs should accommodate a wide variety of traffic and support diversified services

② (Functional Flexibility) FNs should have flexibility to support and sustain new services derived from future user demands

③ (Virtualization of resources) FNs should support virtualization so that a single resource can be used concurrently by multiple virtual resources.

④ (Data Access) FNs should support isolation and abstraction FNs should have mechanisms for retrieving data in a timely manner regardless of its location.

⑤ (Energy Consumption) FNs should have device, system, and network level technologies to improve power efficiency and to satisfy customer's requests with minimum traffic

⑥ (Service Universalization)FNs should facilitate and accelerate provision of convergent facilities in differing areas such as towns or the countryside, developed or developing countries

FNs - 12 Design Goals (Cont.)

International Telecommunication Union

⑦ (Economic Incentives) FNs should be designed to provide sustainable competition environment to various participants in ecosystem of ICT by providing proper economic incentives

⑧ (Network Management) FNs should be able to operate, maintain and provision efficiently the increasing number of services and entities.

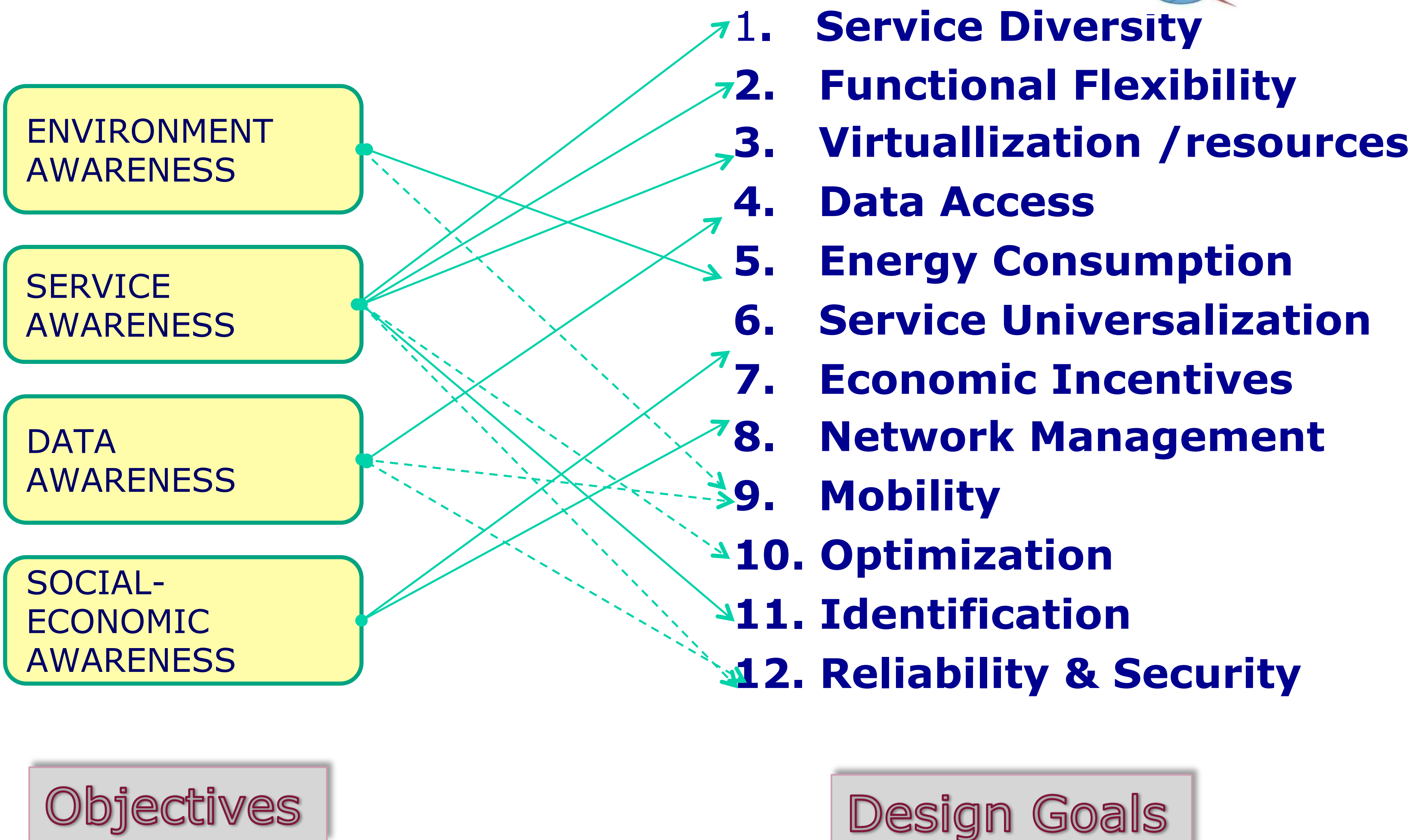
⑨ (Mobility) FNs should be designed and implemented to provide mobility that facilitates high levels of reliability, availability and quality of service in an environment where a huge number of nodes can dynamically move across the heterogeneous networks.

⑩ (Optimization) FNs should provide sufficient performance by optimizing capacity of network equipments based on service requirement and user demand.

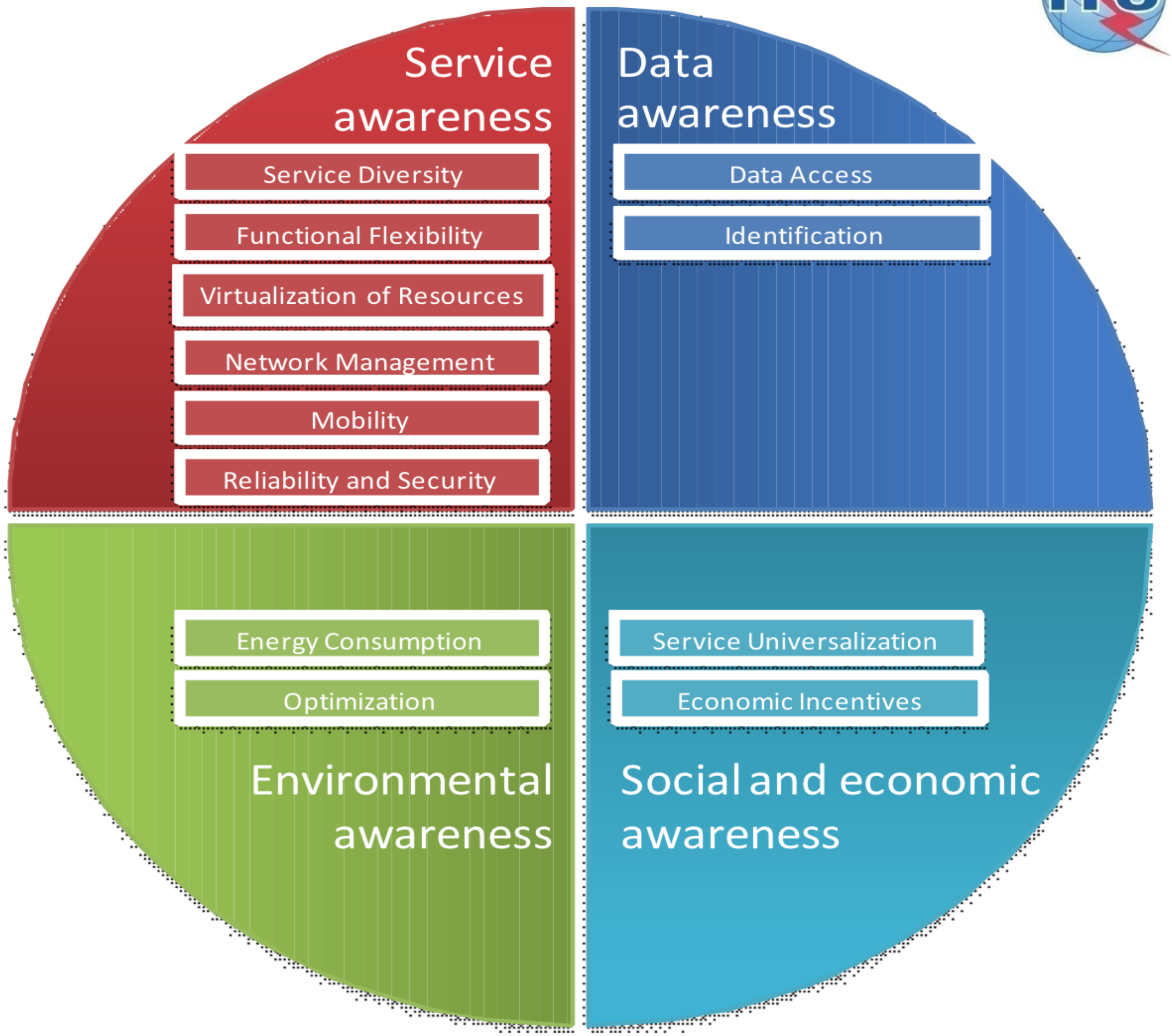
11 (Identification) FNs should provide a new identification structure that can effectively support mobility and data access in a scalable manner.

12 (Reliability and Security) FNs should support extremely high-reliability services

Future Networks : Objectives Vs. Design Goals



Future Networks : Objectives Vs. Design Goals



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Technologies - achieving the design goals

- **Virtualization of Resources (Network Virtualization)**
  - Enables creation of logically isolated network partitions over shared physical network infrastructures so that multiple heterogeneous virtual networks can simultaneously coexist over the shared infrastructures; it allows the aggregation of multiple resources and makes the aggregated resources appear as a single resource
- **Data/Content-oriented Networking (Data Access)**
- **Energy-saving of Networks (Energy Consumption)**
  - Forward traffic with less power
  - Control device/system operation for traffic dynamics
  - Satisfy customer requests with minimum traffic
- **In-system Network Management (Network Management)**
- **Distributed Mobile Networking (Mobility)**
- **Network Optimization (Optimization)**
  - Device / System / Network level optimization (Path optimization, Network topology optimization, Accommodation point optimization)

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Filling in the Research Challenges

UniverSelf FP7 Project

Federating

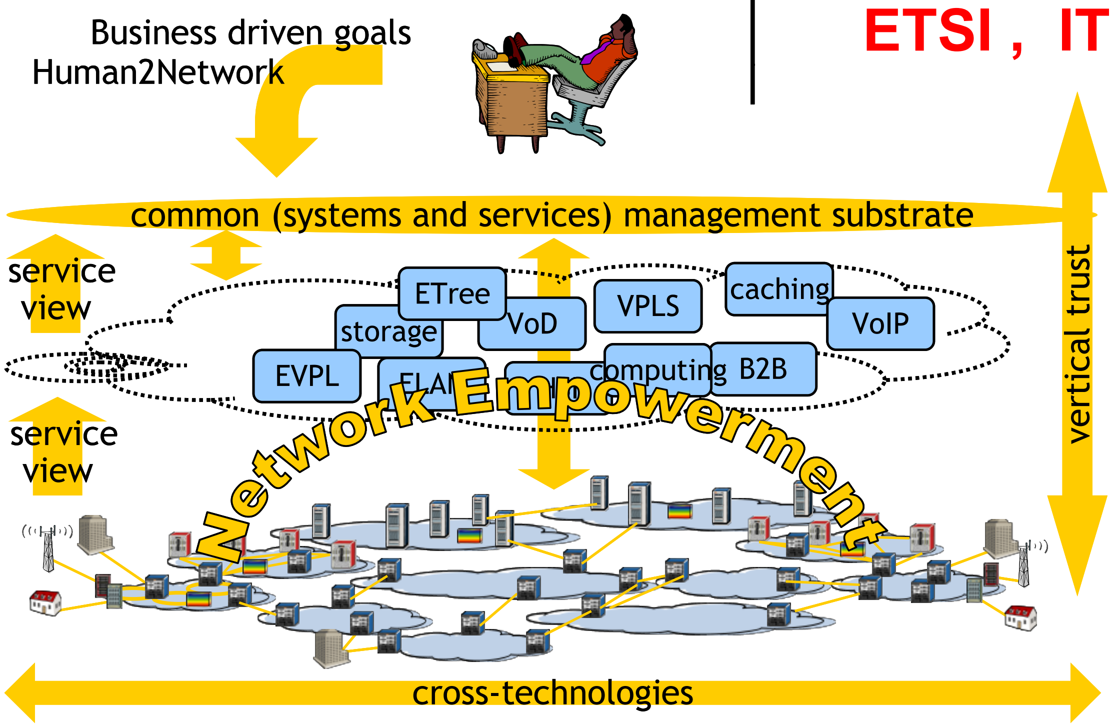
- Self-* has been a major focus, time to consolidate achievements
- Both systems and services need to be managed
- Services span multiple technological domains (wireline and wireless)

Impactful

- Driven by scenarios identified by service and network providers, solving live-networks manageability bottlenecks
- Trust, certification/labeling and validation to foster deployments
- Standards for industry wide adoption

"Cleaned state not clean slate"

ETSI , ITU-T, ..



Multi-faceted Unification

Network Empowerment

Impact the telecommunication industry

Foster adoption by means of trust and confidence

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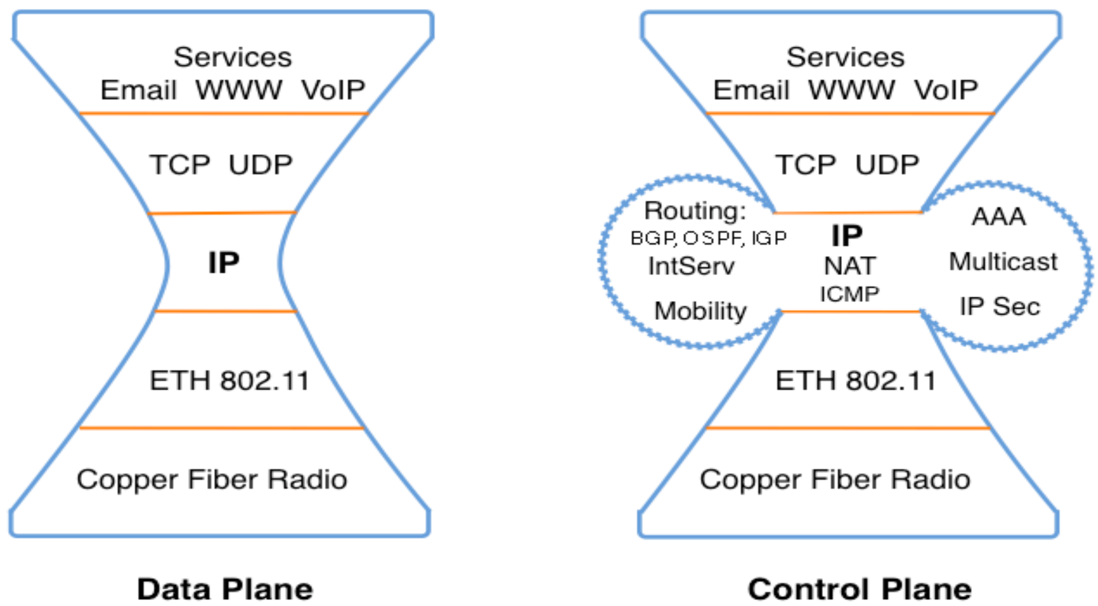
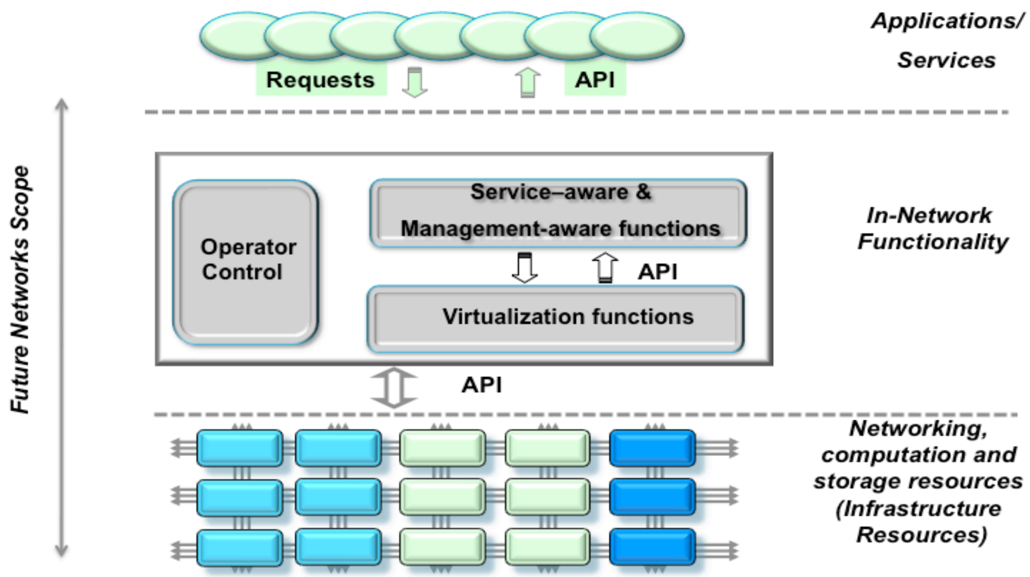
Towards a new Network Model

- **Current Internet = Network of Interconnected uncoordinated networks – “infrastructure where intelligence is located at the edges”**
- **Simple network layer ;Services are realised at the end-hosts**
- **KISS Principle : “Keep it Simple, Stupid” (i.e. today optimisation is tomorrow’s bottleneck) source: D. Isenberg**



Towards a new Network Model



- ❑Future Internet/Networks = Unlike the original Internet infrastructure set of standards, which merely focus on technical connectivity, routing, and naming, the scope of the Future Internet recommendations, standards, and guidelines should encompass all levels of interfaces for Services, Manageability and Technical Resources (networking, computation, storage, control)

- ❑ Infrastructure where the intelligence is embedded and enabled

Software Defined Networks

- ❑Substitute KISS principle with KII principle : "Keep it intelligent" (i.e. today fundamental is tomorrow's secondary) source A. Galis