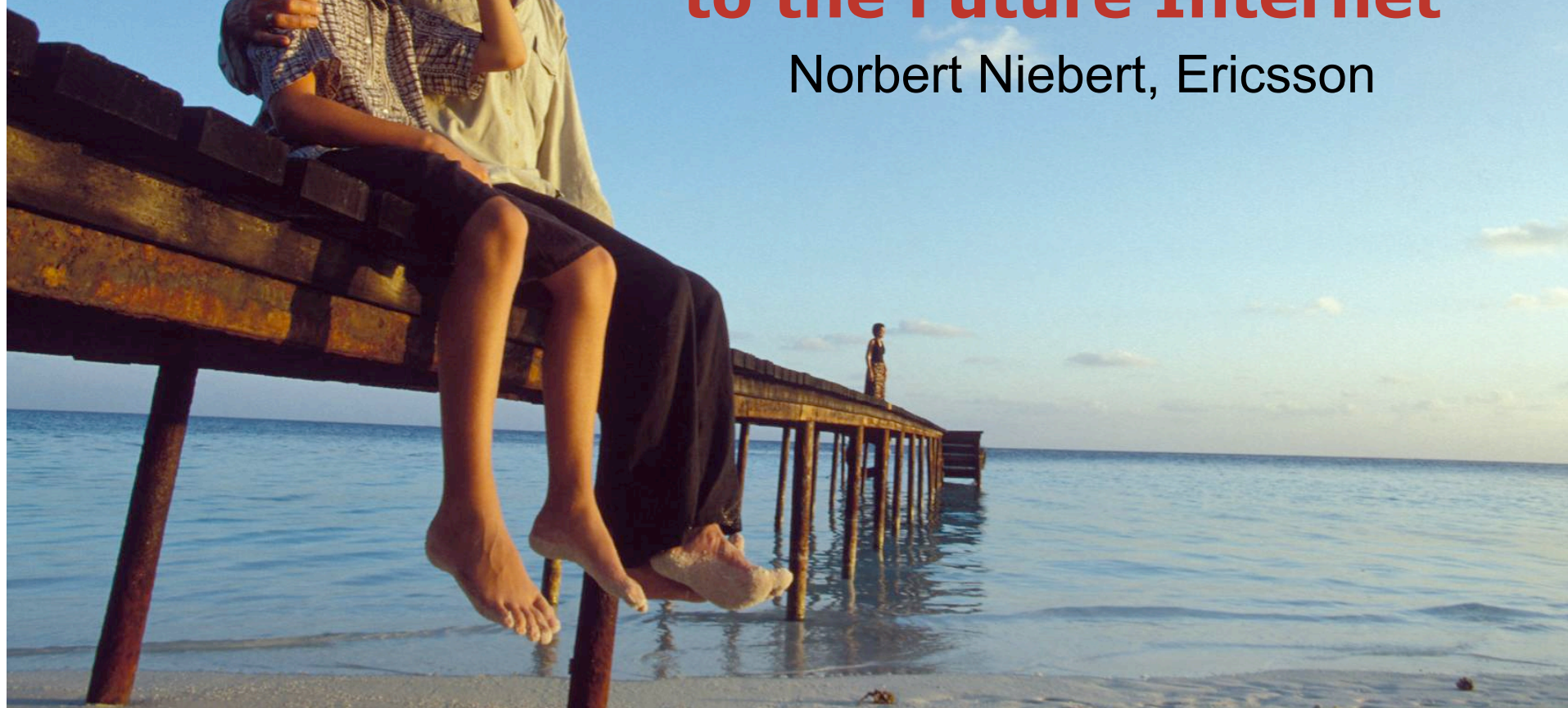




Looking 4WARD to the Future Internet

Norbert Niebert, Ericsson





Why a clean slate network approach?

- ❖ "Nobody changes basic technology for less than a ten-times improvement [over existing technology]" (Mike O'Dell)
- ❖ Improvement of cost, capacity, bandwidth, reliability?
- ❖ Do we need that?
- ❖ Can we do that?
- ❖ Should we give it a try?

- ❖ If so, we have to reset our brains and start from scratch again
- ❖ ... and then connect with what we have created so far



Network (R)Evolution – How?

- ❖ Is it just IPv7 or creating an alternative?
- ❖ By adding and patching we run into the risk of obesity and a weak immune system
- ❖ Or should we even dare to think of tailor-made networks, fit for the purpose and reliable?
- ❖ Than migration will not be the major headache
- ❖ But then, „the value of a network is proportional to the square of the number of users of the system” (Metcalfe’s law)
- ❖ How to solve this?





Network Virtualisation – Main Innovations

- ❖ Network virtualisation as a meta-architecture in a *commercial* setting
 - Enable *co-existence* of diverse network architectures
 - Enable *deployment* of innovative approaches
 - Enable *new business roles and players*
 - Allow split of infrastructure-/network-/service-providers
 - Lower barriers of entry
 - „Market place“ for shareable network resources

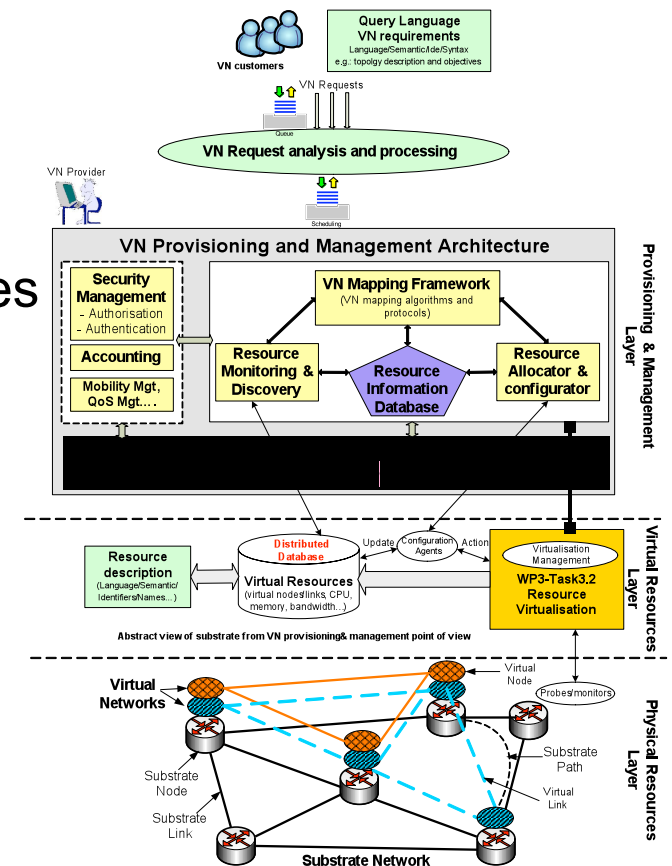
- ❖ Provisioning and virtualisation management framework
 - *On-demand instantiation* of virtual networks at large scale

- ❖ Virtualisation of diverse resources in a *common framework*
 - Routers, links, servers – can all be done today but need a unifying e2e approach
 - Extension on the virtualisation of the wireless infrastructure and spectrum
 - Folding points providing interworking between virtual networks



How far have we come?

- Draft architecture
- Scalable mapping algorithms using data mining technology
- Initial definition of signaling and control interfaces
- First version resource description language
 - Modelling of resources and networks
 - XML-based
 - Used for request and offer
 - Additional query language for complex requests
- Early prototyping and testbeds
- Controlled Interworking concept
- Virtual Radio concept





But how to design a network architecture?

- ❖ By reusing and patching existing protocols we forgot to develop tools for clean slate design esp. for the more detailed network architecture specifications
- ❖ Can such a design toolkit and process be easily developed and used?
- ❖ Where can we find reusable components other than protocol specs and implementations?
- ❖ How can we ensure interoperability?





Network Design: What is needed?

Network customisation

Virtualization technologies will allow the concurrent deployment of multiple specialised networks (the best network for each task, device and technologies) → A good **toolkit to preserve principles** (such as interoperability) **and to meet multiple requirements is envisioned**



Efficient Design Process to reduce the time to deploy new services

To develop an **innovative model-driven design process** able to minimise the time requested to develop new network solutions that are able to meet the desired requirements.



No more patchwork design in the network ...

... To minimise the risk of obesity the approach must include **efficient ways to compose functionalities in order to meet the desired requirements (e.g., QoS, Mobility, Security)** ... operational costs should be considered



Assured Interoperability and different Business Models

Solutions are explored to preserve the interoperability among the different designed networks (if needed) and the support for multiple business models (**advanced interconnection models**)





What a new network architecture could interconnect

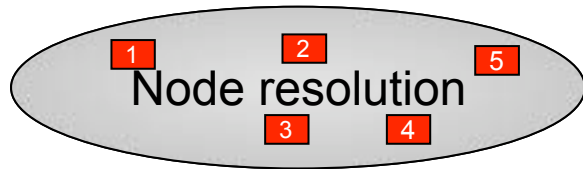
- ❖ We are used to think a network consisting of nodes (end + forwarding) and links
- ❖ What if we start to network the information we are looking for?
- ❖ Triggered by Van Jacobsen and others a new view on interconnecting information has emerged...
- ❖ that would change the way we engineer networks fundamentally
- ❖ The Future Content Centric Internet...





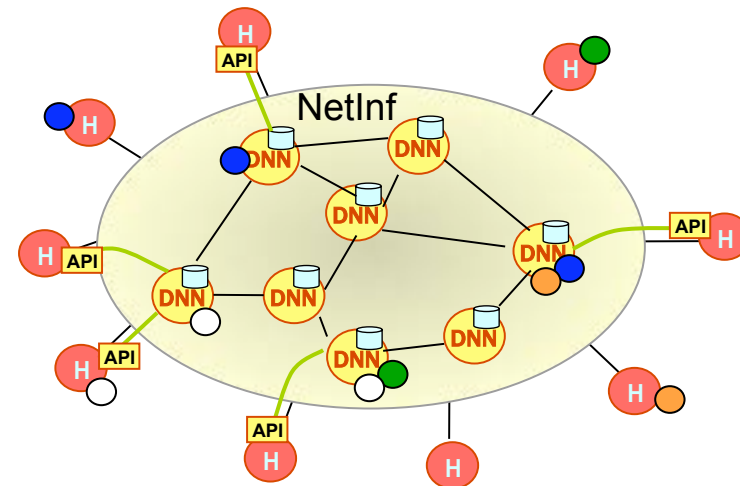
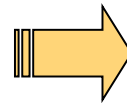
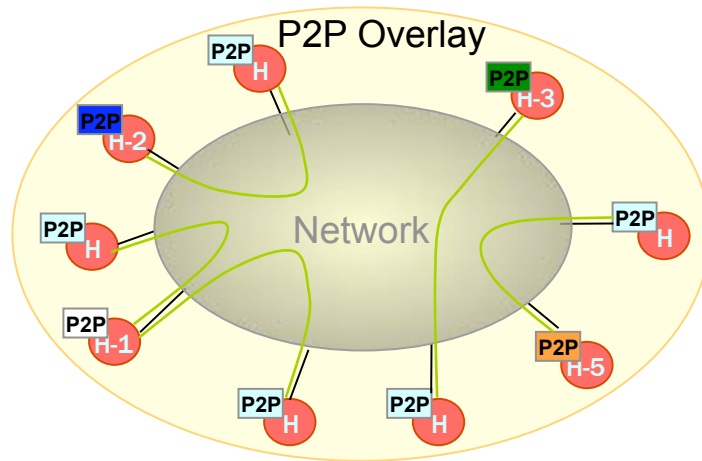
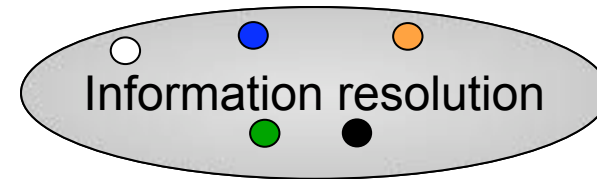
NetInf compared with p2p overlay networking

Internet



Addressing

Information centric network



- ❖ Common dissemination infrastructure for all applications (peer-to-peer, IPTV, Voice, etc.), including network support for caching and transcoding
- ❖ Network awareness of application needs
- ❖ Can use several underlying network technologies



How to transport?

- ❖ Can we assume that turning wireless and optical media into copper will work forever?
- ❖ And why is it efficient to do transport innovations only as overlays?
- ❖ What can be gained with a completely fresh view on transport mechanisms?
- ❖ The Generic Path is an answer to these questions...

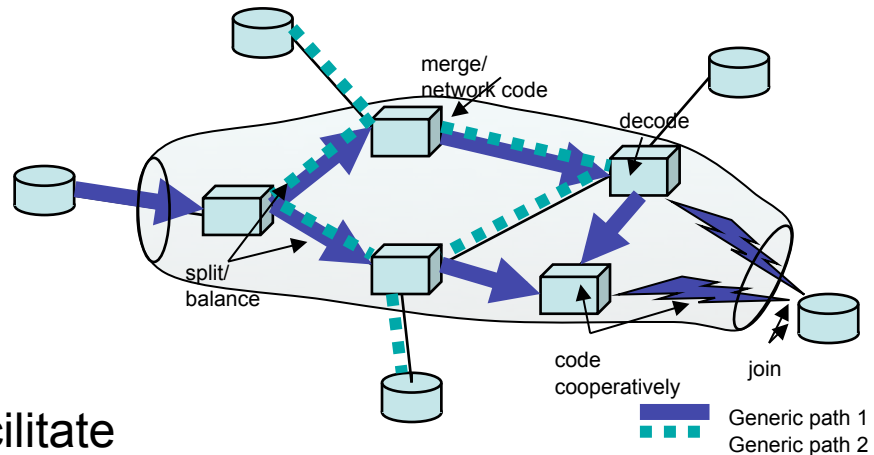




A transport architecture and a set of mechanisms

❖ The *Generic Path* architecture

- a much richer class of data flows, beyond TCP, UDP
- minimal state within the network
- common management interfaces, to set up and tear down flows and to query their status
- explicit identification, notably to facilitate control of multi-flow applications like videoconferencing



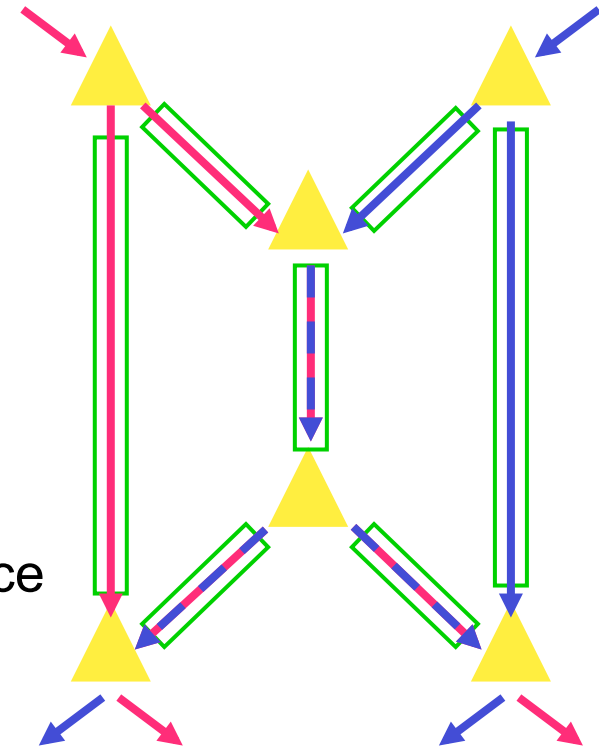
❖ Mechanisms for assured performance and efficient operation

- to exploit techniques like network coding and cooperative transmission
- to choose the "best" paths for the considered transport
- to ensure resource sharing is "fair" and meets application requirements
- to manage the mobility of users, networks and information



Novel transport mechanisms

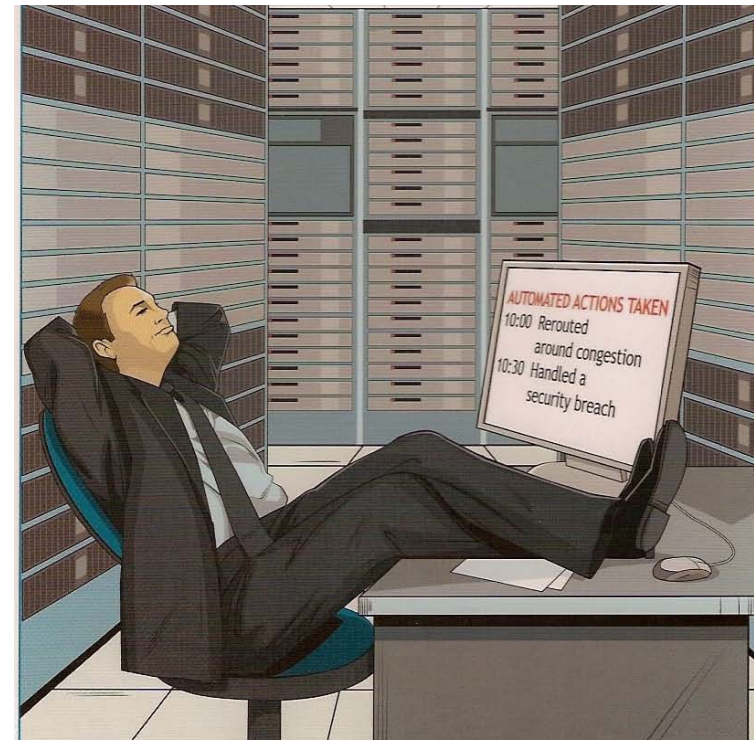
- ❖ a coding and cooperation framework
 - e.g., to realize the gains of "butterfly" coding
 - with adapted signalling and flow routing
 - ...
 - but also, coding of chunks in swarms, coding and cooperation for wireless
- ❖ routing in a network of information
 - choosing the "best" copy of a data object
 - incorporating swarm-like transport
 - using network caches to enhance performance
 - ...
 - but also, multi-path, multi-layer and multi-technology routing





Management?!

- ❖ The most urgent need in a dynamic world is Self-Management
- ❖ Automation of Management is a research topic since many years
- ❖ Does it provide in practice more than automated settings on FI routers?
- ❖ Can we rely on this?
- ❖ What are the new approaches in this area?

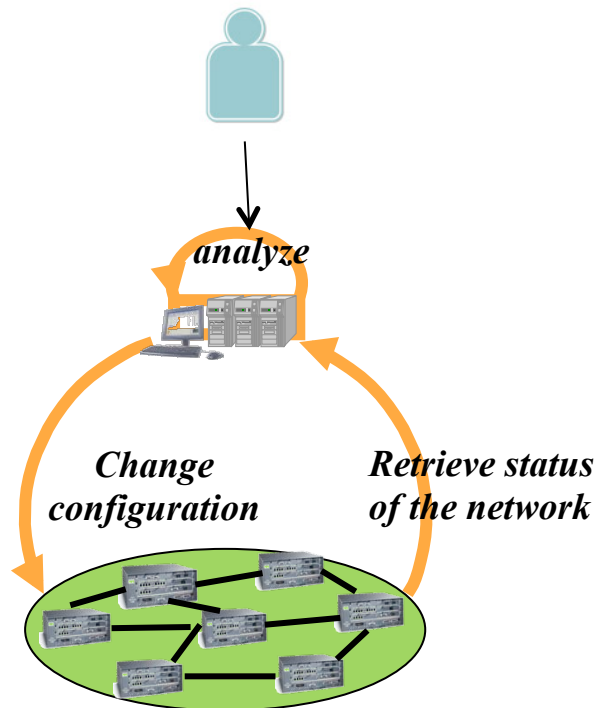




In-Network Management: a new paradigm

Limitations of today's approach

1. Network infrastructure is developed and deployed first
2. Management functions are added as **separated functions**. Examples:
 - because it is **not supported** by the network:
 - e.g. test capability at different layers
 - because it is **not accessible** for management:
 - e.g. congestion control of transport layer



In-Network Management (INM)

1. Built-in at design time
2. Monitoring and optimization functions as **embedded capabilities** of network components
3. Rather co-design than retro-fit

→ Supports self-management with reduced integration costs and shortened service deployment cycles



A first summary

- ❖ 4WARD follows a number of technical innovation approaches in all areas of the network
- ❖ They all start from a clean-slate perspective, defining radically new solutions for the Network of the Future
- ❖ Concrete results have been achieved and it looks promising
- ❖ Now the hard work of refining and integrating is going on towards a new

Network of the Future
as a family of networks

