



Aalto University  
School of Science  
and Technology

# Directions for Energy Efficient Networking

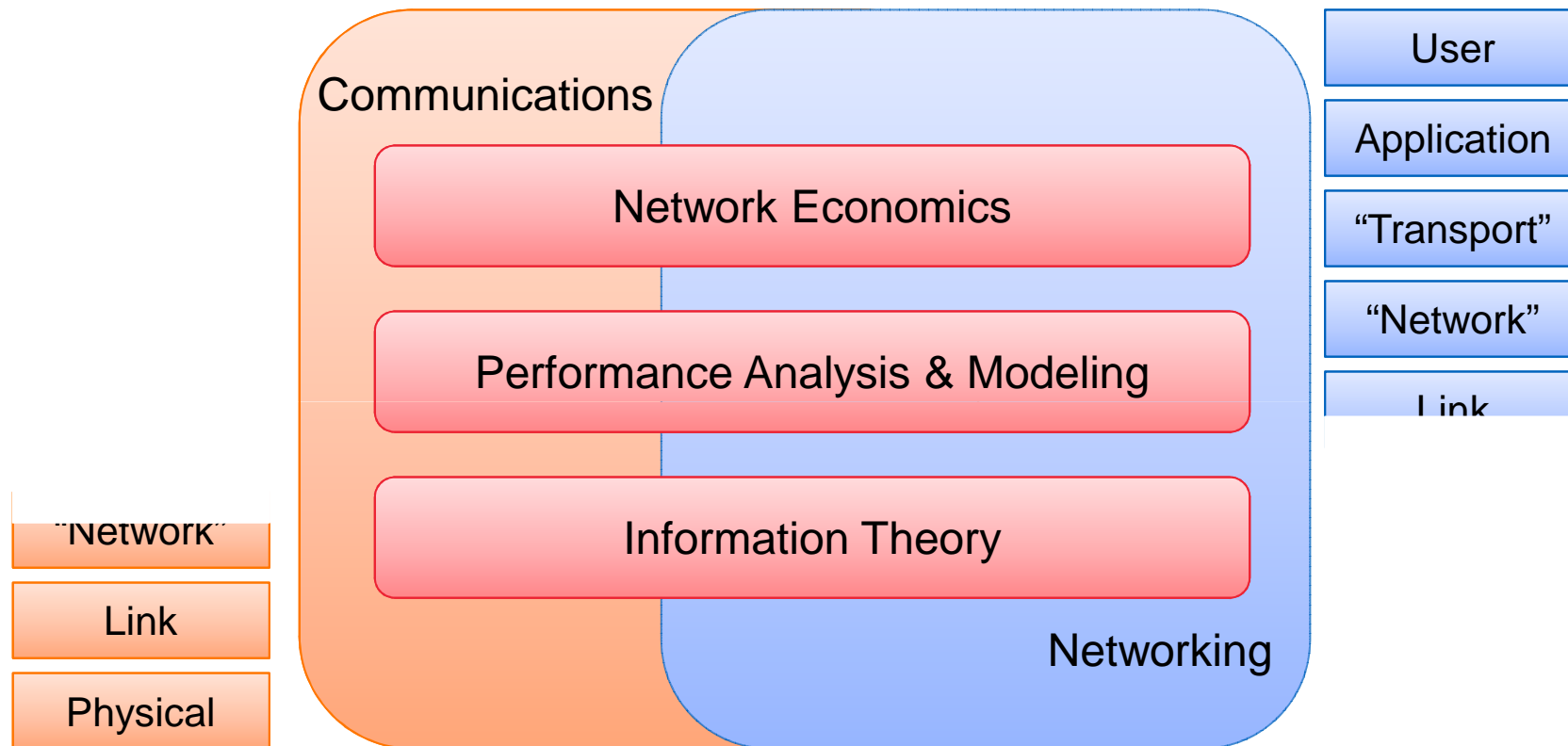
20 October 2010

Department of Communications and Networking (Comnet)

Raimo Kantola, Jörg Ott, Jukka Manner

[www.re2ee.org](http://www.re2ee.org)

# Comnet: Holistic Networking Research



# Premises for EE Networking

- IP Network power density, power consumption and CO<sub>2</sub> emissions will be unsustainable if we try to meet the traffic demand over the next 10 years with IP routing technology
- The higher up in the protocol stack switching takes place the more power is consumed
  - More program code need to be executed per packet → more transistors get involved → more power
  - Optical path switching may save up to 10 000 X vs. IP routing - CP
  - Carrier Grade Ethernet switching may save 20 X IP Routing
  - Deterioration of IP architecture has a price: more and more often packets are switched on application layer
- Power consumption grows relative to 2nd power of clock rate → MUST remove all complex functionality from the core to the edge where clock rates can be lower.

# Challenges in Addressing and Routing

- How to flatten the protocol stacks → Ethernet networking
- Addressing: globally unique addresses for every device leads to large routing tables and longest match prefix search → waste of energy → **look for alternatives**
  - Random rlocs in core RIB and FIB → reduces number of entries from >300k → <50k
  - Aggregateable rlocs → further reduction of the number of entries by about a factor of 10
- Next step is to remove Routing Tables from the Core nodes
  - Source routing (there are alternatives how....)
  - Should make route pin-down possible for TE
  - **Energy Efficient Routing** looks quite different from how we have been doing routing in IP networks so far

# Challenges in Access: Making Mobiles Reachable

- UNSAF – UNilateral Self Address Fixing for NAT traversal requires application specific code and continuous polling for staying reachable
  - Leads to fast battery exhaustion → can not have servers in mobiles → limited services
  - Leads to poor use of sleep mode in EEE transport
- Challenges
  - Interrupt driven reachability: mobile must sleep most of the time
  - How to make best use of EEE in mobile access
  - Supporting multi-homing with no impact on core routing
  - How to protect mobiles from DOS, other attacks and from unwanted traffic

# Challenges in Forwarding

- A uniform control plane for optical and electronic switching?
- How to isolate networks such that each network can choose its own technology
  - IP/MPLS , IPv4, IPv6 domains, Carrier Grade Ethernet domains
  - New forwarding modes optimized for energy efficiency
- Simplify multi-terabit core nodes and push complexity to the Edge

# Directions for joint EU-Japan Research

- New Energy Efficient Forwarding modes
- Energy Efficient Routing
- Hybrid opto-electronic architectures
- Scenarios for making use of EEE
- Energy dependent pricing for Internet services