Global Networking versus Networking-on-Chip

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- Preliminary Version -

Our Research Profile

Research Group

Ambient Technologies

ZigBee

Sensors/ Actuators

Bluetooth

Embedded Devices

Quality-of-Service

Robustness

Overlay-Networks

Security

Peer-to-Peer

Self-Organization

Programmable Networks

Internet Technologies

IPv6

NSIS

Ad-hoc

Mobile / Ubiquituous Computing

Current Project Partners

ALCATEL

T

LANDESSTIFTUNG Baden-Württemberg

DFG

German National Science Foundation

bmb+f

German Research and Education Ministry

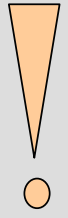
SIEMENS

NTT DoCoMo

About Terminologie …

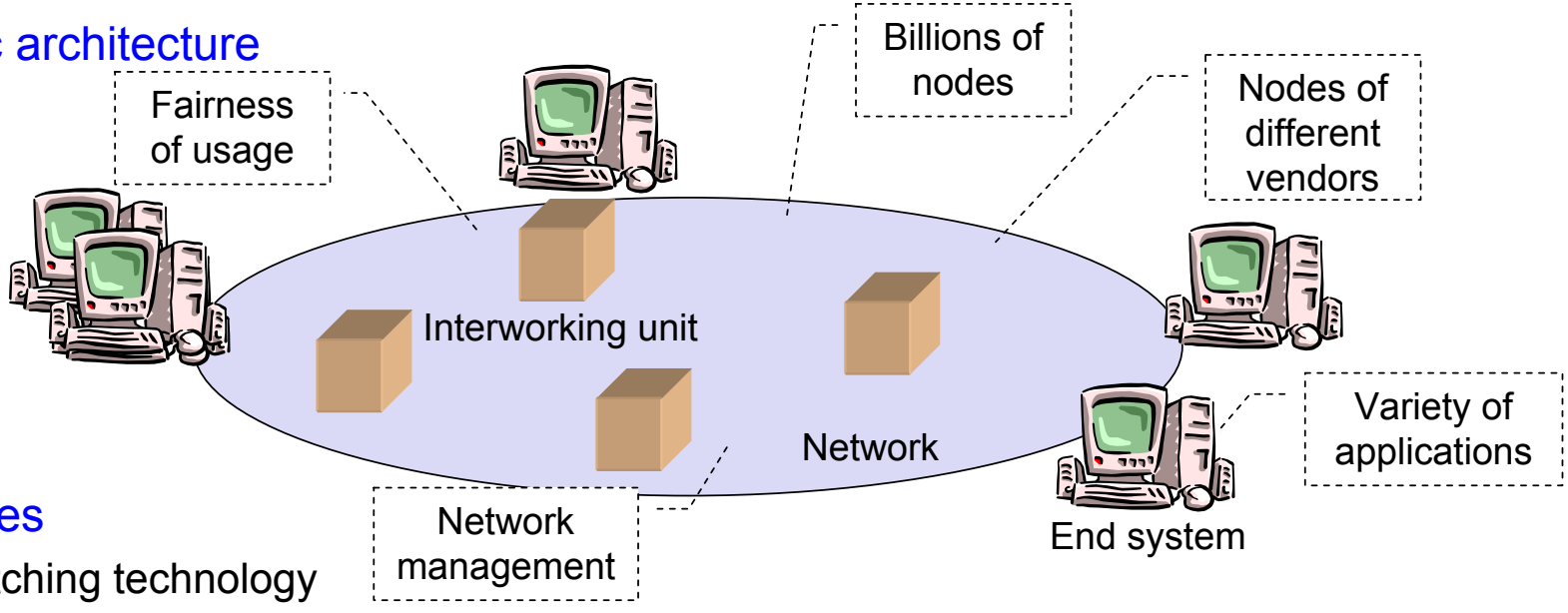
IP …

- Networking Community
  - Internet Protocol
- Systems on Chip
  - Intelectual Property



Global Networking

Very basic architecture

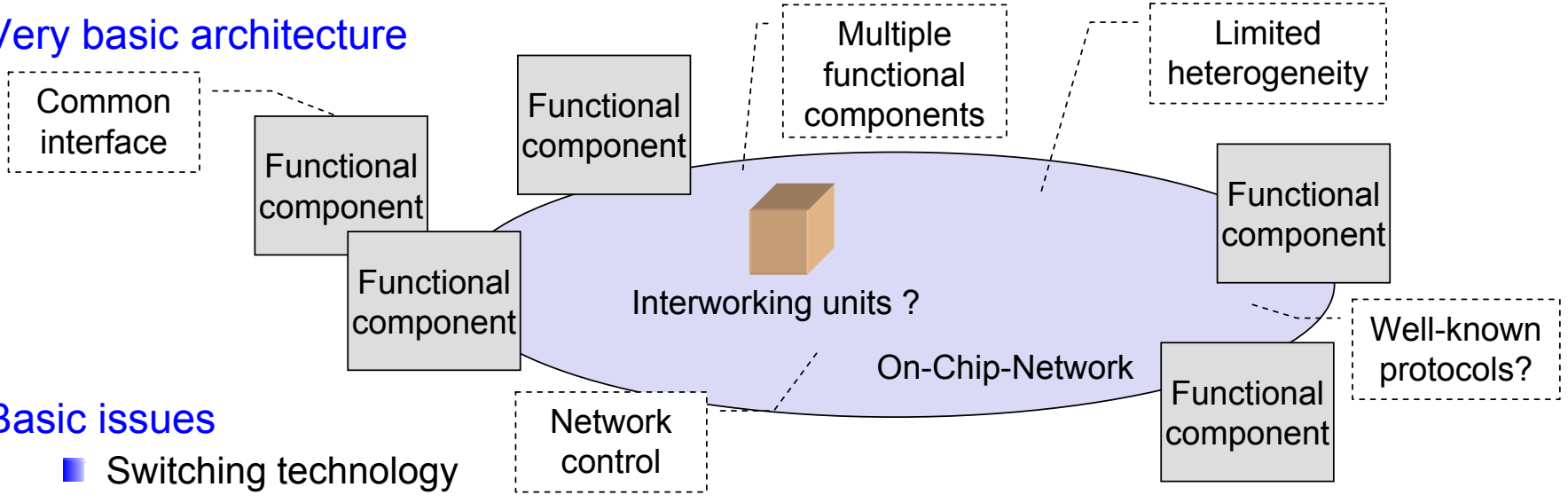


Basic issues

- Switching technology
  - Packet switching (Internet), line switching (ISDN), fast packet swichting
- Openess
- Scalability
- Flexibility
- Robustness
- Quality of Service
- Security

Networking-on-Chip

Very basic architecture



Basic issues

- Switching technology
  - Packet switching (Internet), line switching (ISDN), fast packet swichting
    - „Route packets not wires“
- Asynchronous versus synchronous
  - Globally asynchrounous locally synchronous?
- Low power
- Flexibility
- Robustness
- Quality of Service
- Security

Global networking imposes

new challenges

- Increasing heterogeneity and mobility
  - Flexibility is needed
- Robustness
  - In case of changing requirements
- Security

on Networking-on-Chips

but keep in mind …

- Networking
  - Globally vs.
  - On-Chip

Similar Constraints?

→ Similar basic architectures but different constraints in detail

Global Networking … Next Generation Networks

are …

Networks of Networks

providing

(Broadband) Always On /
Seamless Services /
Context Awareness

High bandwidth,
low latency,
ubiquituous,
flexible,
adaptive

requiring

Fixed/Mobile
System Solutions

Next Generation Networks are Heterogeneous

Core network

- Homogeneous, IP-based

Network access

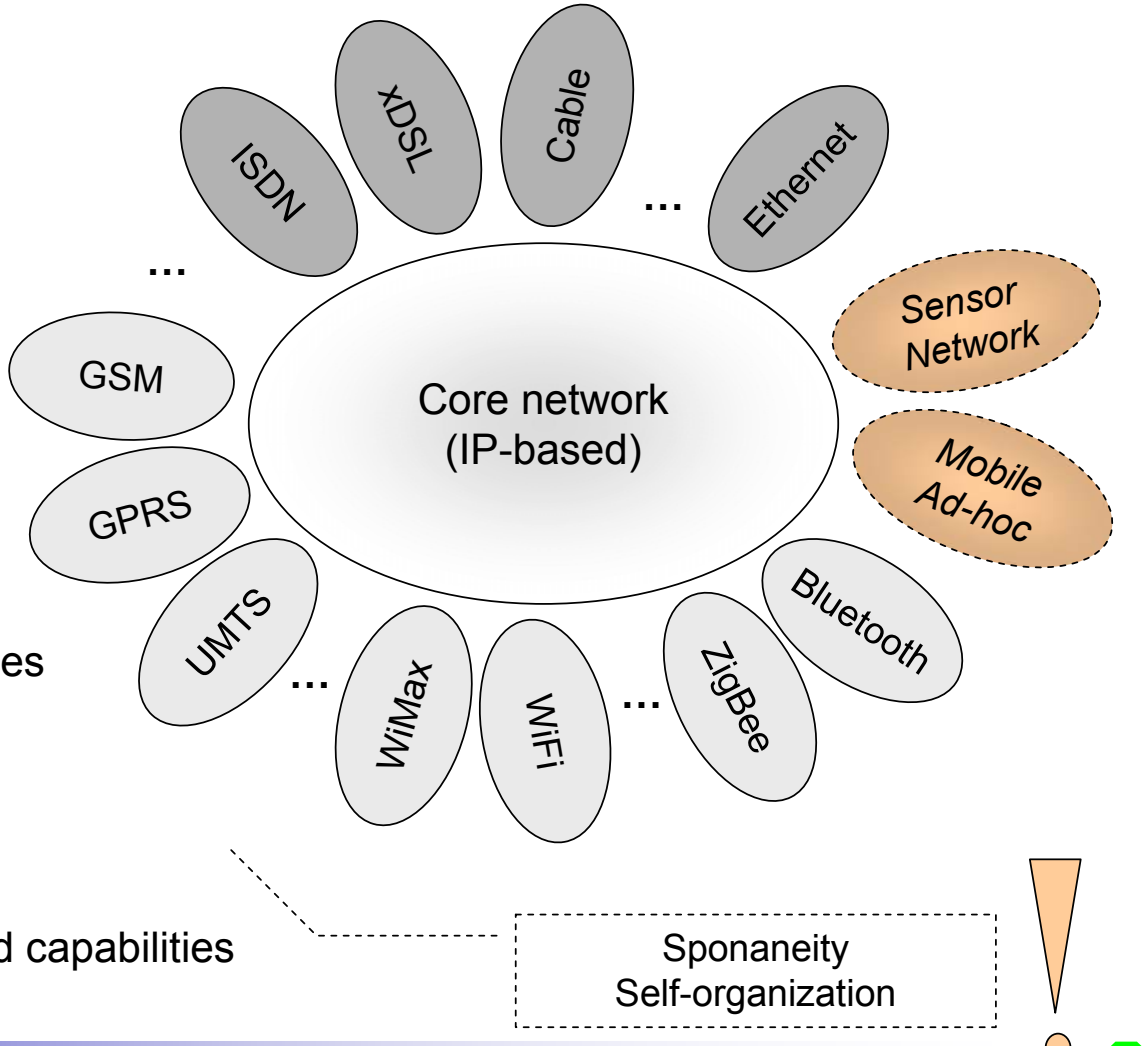
- Heterogeneous
  - Wireless, wired
  - Infrastructure-based, infrastructure-less
  - Reliable, non-reliable

Mobile ad hoc networks

- Enable spontaneous communication and services
- Self organized

Sensor networks

- Self-organized
- Network nodes with limited capabilities



Increasing Interest …

Sensor networks

- Increased number of networked nodes
- Really ubiquituous
- Self-organized
- Power constraints

Similarity between global networking and networking-on-chip?

Sensors - Ubiquituously Embedded / Networked

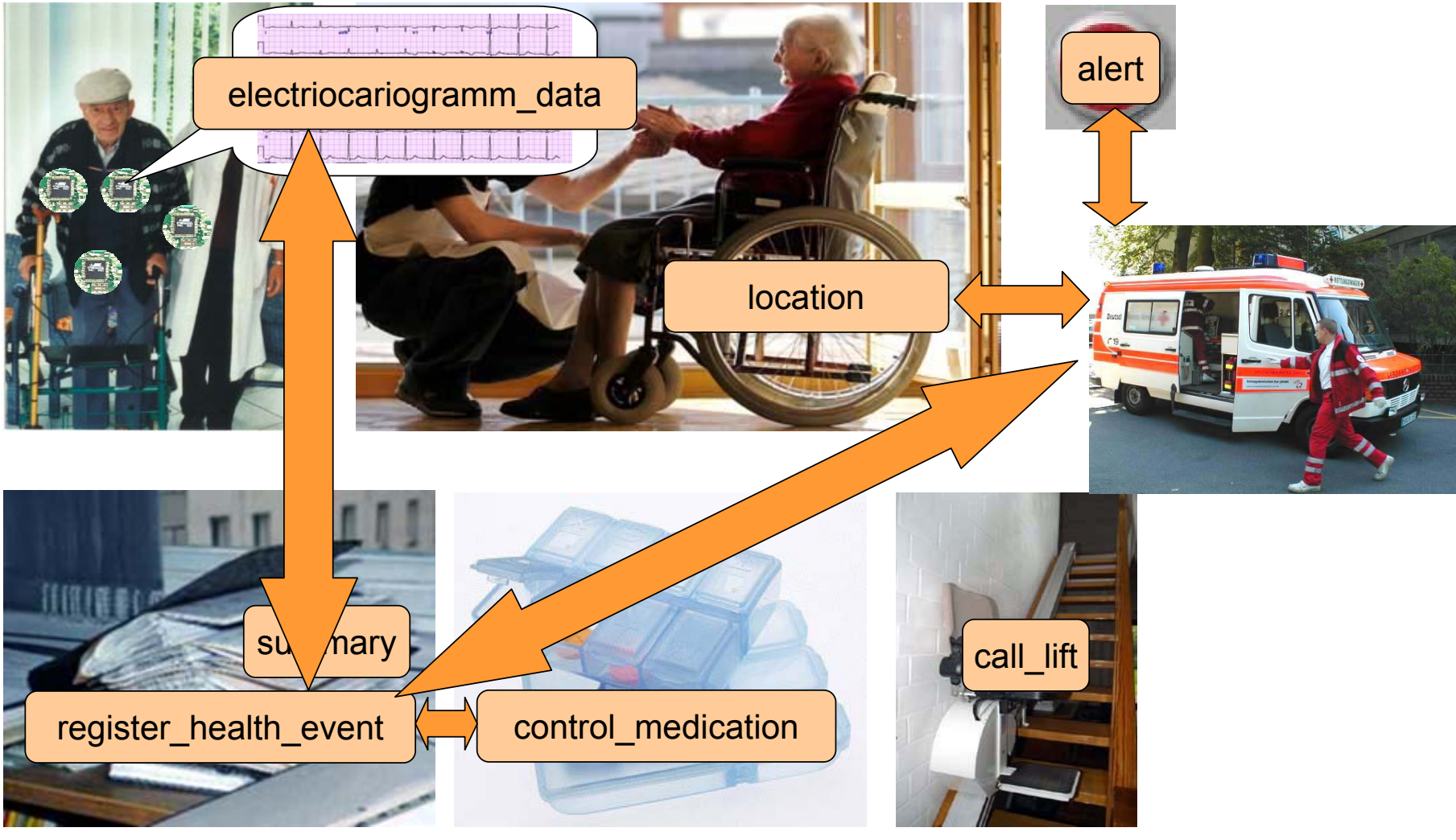
Examples

- Hospitals
- Office environments
- Assisted living
- Home environments
- …

Goal

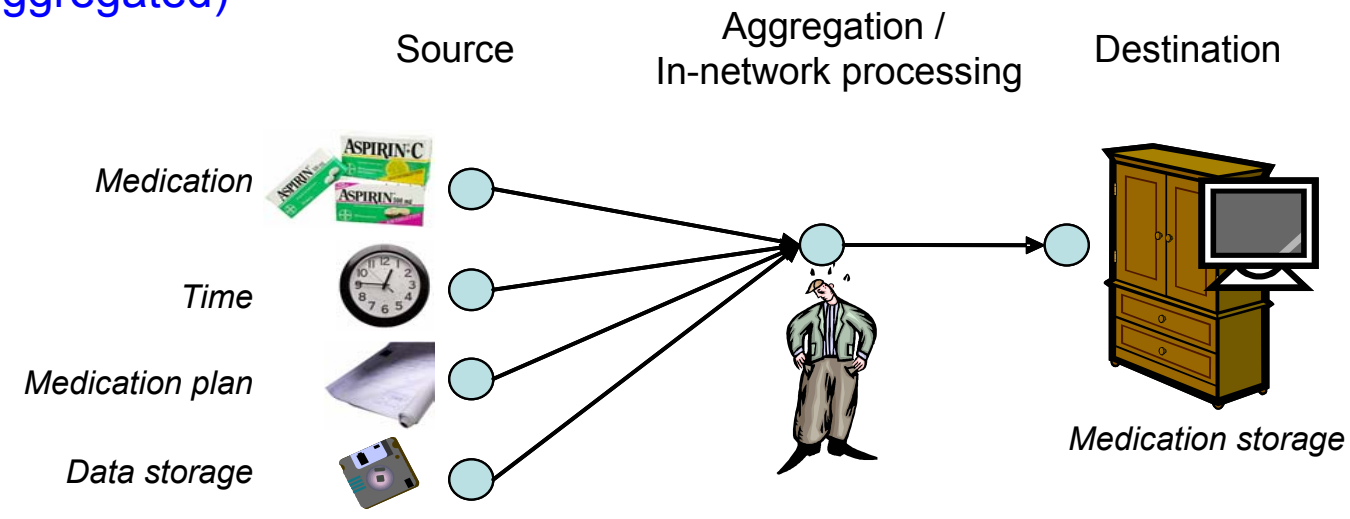
- Provide services that improve quality of living seamlessly in different scenarios
- … high requirements regarding robustness and security

Assisted Living: Networked Sensors are Part of it



Example: Secure Data Transport in Sensor Networks

Typically, in sensor networks, data are processed within the network (e.g., aggregated)



Problem: How can data transport be secured in the context of in-network-processing?

- Secure sensible data with respect to interception, confidentiality, integrity …
- Provide authenticity, …
- Efficient solutions required due to very limited resources

Interplay between global networking and networking-on-chip?

… general observation

Self-organization

- Traditional management approaches not feasible
- Administrators?
  - For a single chip?
  - For my living room?
  - …

Both:
global networking as well as networking-on-chip require self-organisation

Global Networking Example

Project IPonAir bmb+f

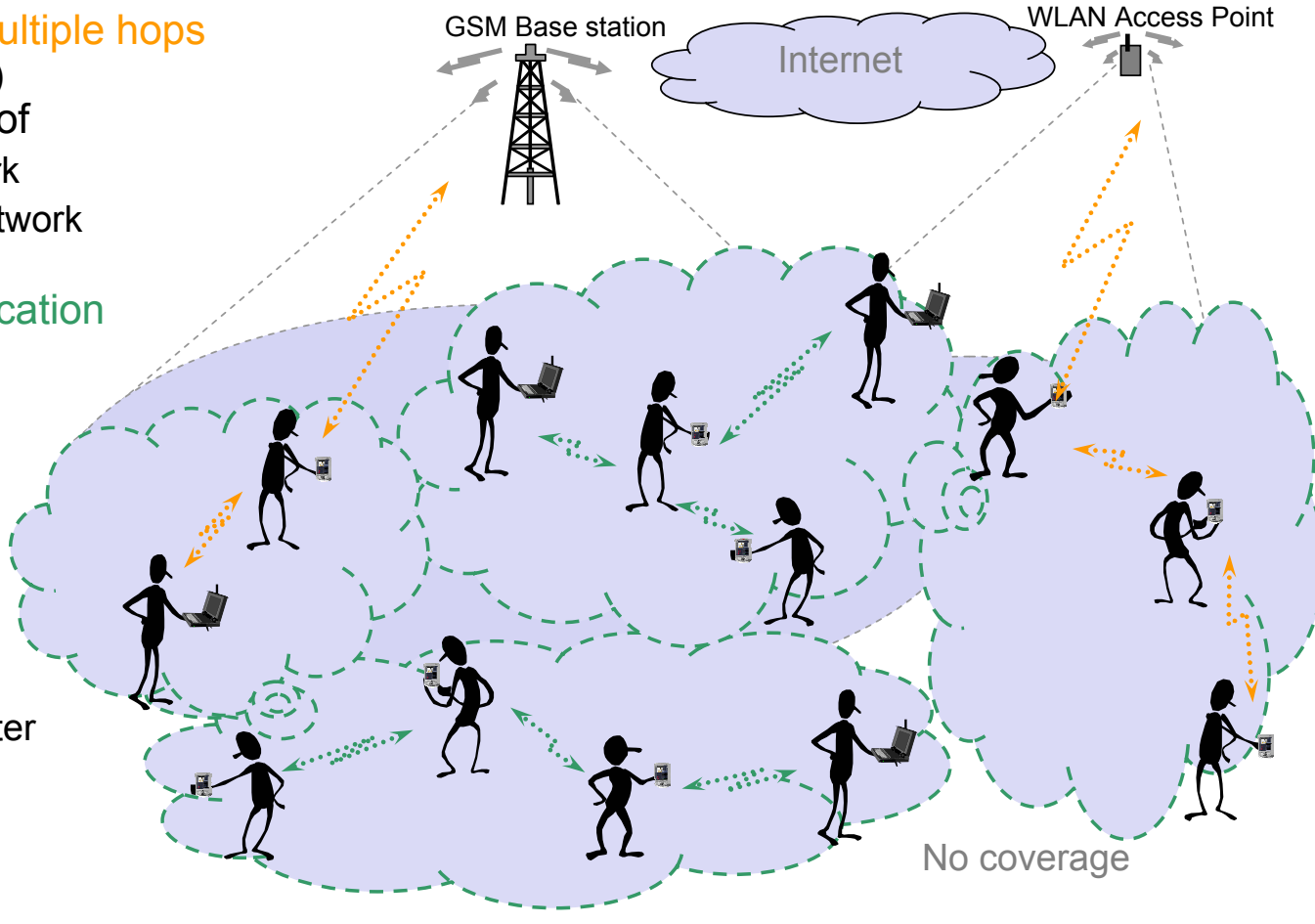
Internet access over multiple hops
(e.g., for Web, EMail...)
for nodes out of range of

- Any access network
- Desired access network

Peer-to-Peer communication
(e.g., for file exchange
or multiplayer games)

Mobile Ad-hoc
Networks (MANETs)

- Wireless links
- Infrastructure-free
- Each device is router
- Dynamic topology
- Self-organizing



Mobile Ad-hoc Networks

Network of mobile devices without fixed infrastructure

- No base stations/access points, no backbone, no central components

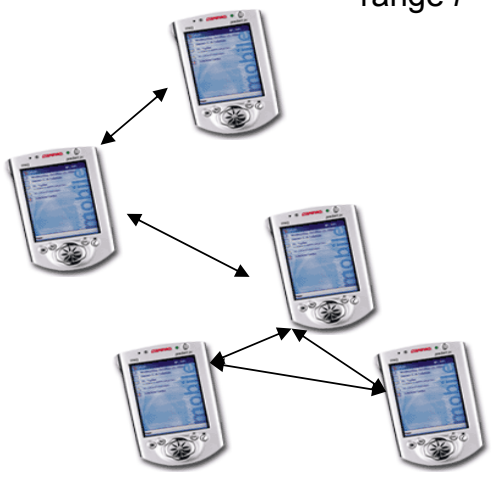
Packet switched network

- Routes among devices can consist of multiple hop

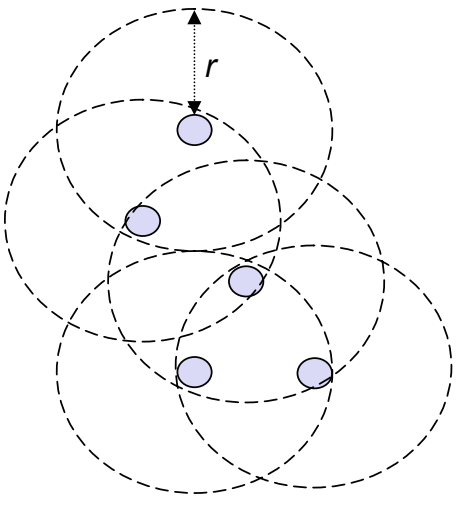
Each device operates as a router

→ self organized

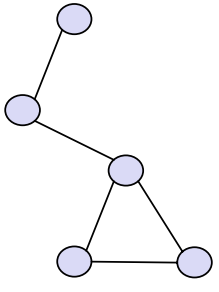
Example



Transmission range *r*



DFG-Schwerpunktprogramm SPP 1140
„ Middleware for self-organized networked mobile systems"
(2002 – 2008) (12 Universities)



BMBF-Projekt IPonAir (2001 – 2005)
(Alcatel, Ericsson, Lucent, NEC, Nokia, Siemens, T-Systems + Universities)

Autoconfiguration in MANETs

Autoconfiguration

- Essential component of self organized networks

Routing protocols assume unique addresses. But how are they provided?

- Pre-configuration often not possible
- No network administrator
- No infrastructure components (DHCP servers)

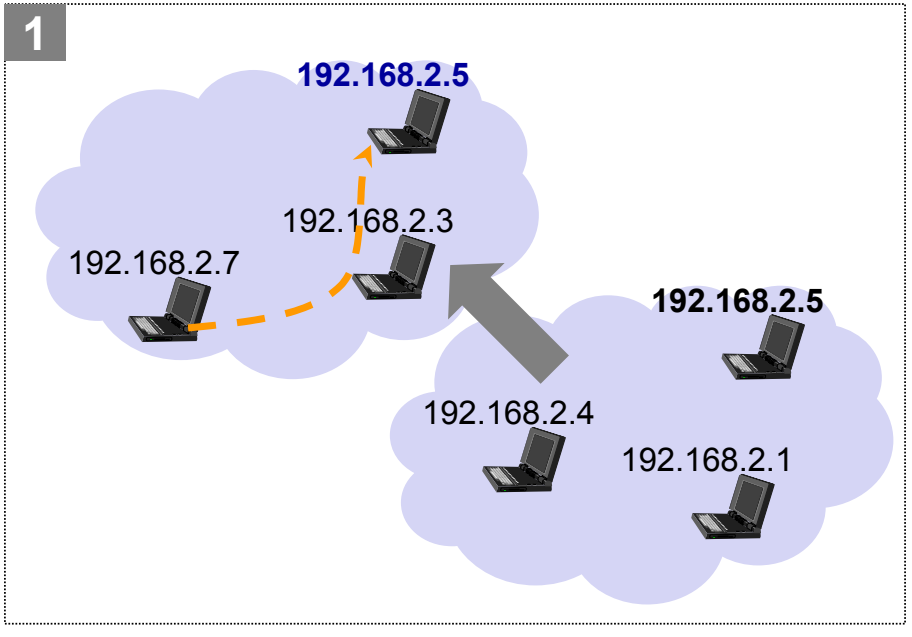
Address autoconfiguration in MANETs is challenging

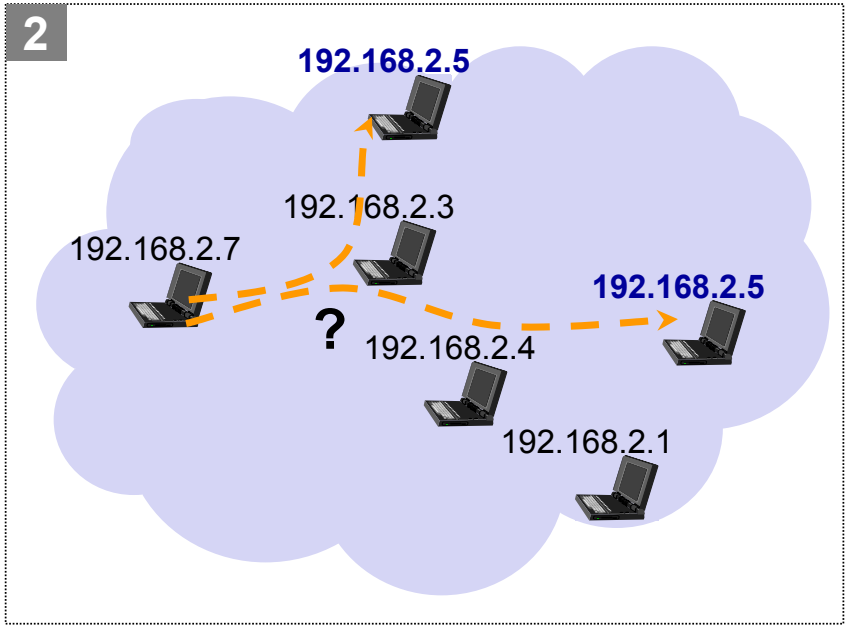
- *Distributed* and *efficient* due to bandwidth and energy constraints
- *Dynamic multi-hop topology* and frequent *network partitioning & merging*

K. Weniger, M. Zitterbart
Address Autoconfiguration in Mobile Ad Hoc Networks: Current Approaches and Future Directions
IEEE Network Magazine, Juli 2004

Problem: Merging of Networks

Example: data stream 192.168.2.7 → 192.168.2.5





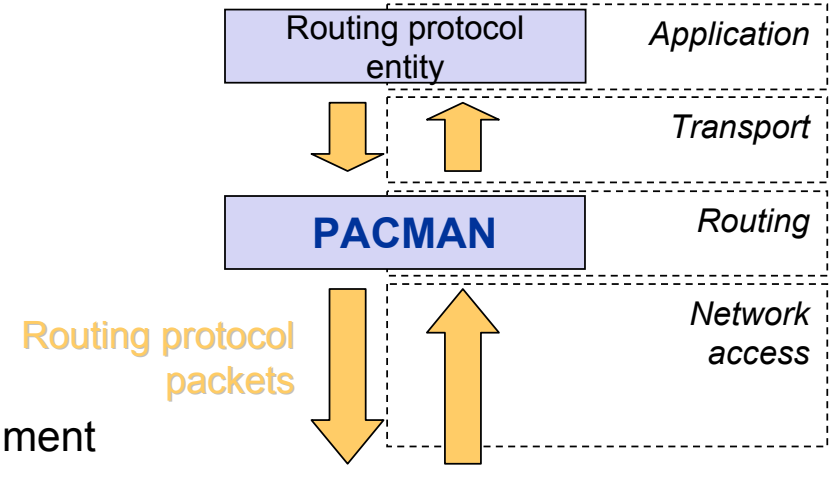
- → Merging of networks can lead to address conflicts
- → Problem Routing: Forwarding of data packets to „wrong“ nodes!
- → Autoconfiguration needs to be an ongoing process

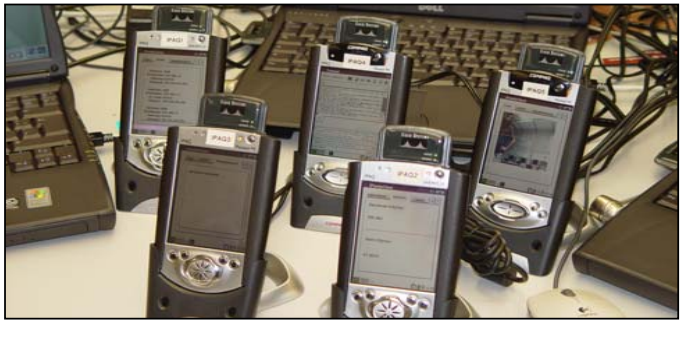
Passive Autoconfiguration for MANETs (PACMAN)

Modular architecture for efficient distributed address autoconfiguration of MANETs

Features

- Cross-protocol & cross-layer design
- Passive Duplicate Address Detection
  - Based on anomalie detection in routing protocol traffic
- Compression of IP addresses
  - Reduction of routing protocol overhead
- Probabilistic algorithm for address assignment
  - Conflict probability can be adjusted
- Support for hierarchical addressing
- Implemented on Linux-based iPAQs





Demonstrator of PACMAN

Protoypical implementation of the concepts

- IP- auto configuration
- Service discovery with anycast routing
- Multicast routing

for mobile ad-hoc networks

Plattform

- Linux-based HP iPAQs.
- IEEE 802.11b

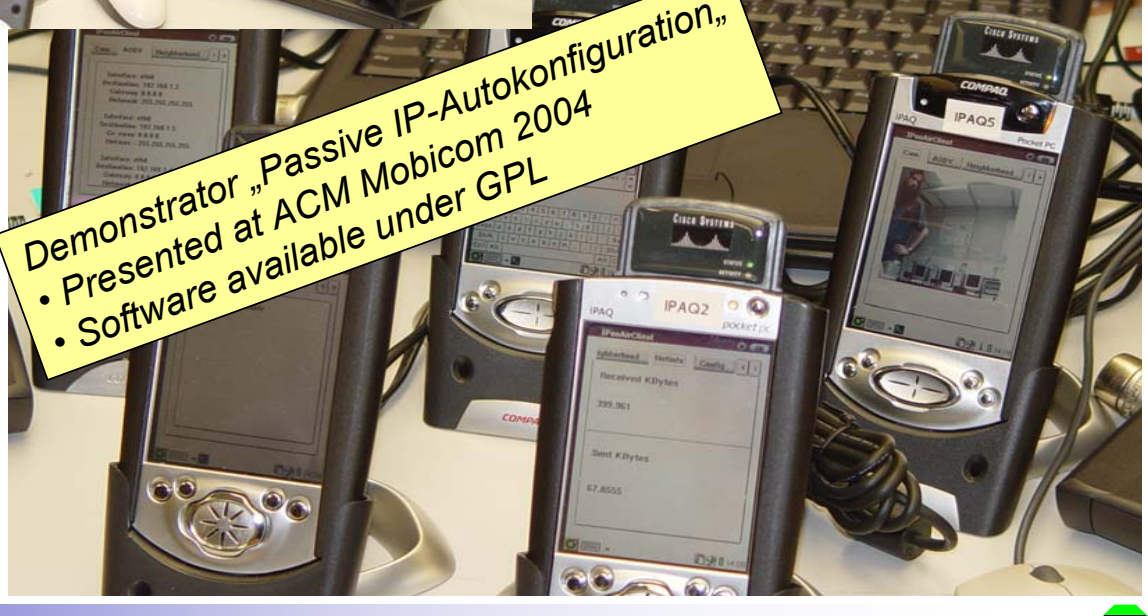
Applications

- Live-Webcam
- Instant Multicast-Messaging

For demonstration purpose

- Multi-hop-Topology emulated with MAC filters

Tested in „real“ multi-hop ad-hoc network !



Some Experiences …

Protocols for mobile ad-hoc networks differ significantly from protocols for fixed networks

- Adaption of protocols for fixed networks not suitable in most cases
- Intensive inter layer / inter protocol communication
- No strict seperations between protocol layers
  - Save restricted resources, such as energy and bandwidth
  - Increased dependence among protocols and increased complexity

Cross-Layer Design

→ High adaptivity

- Performance highly dependent of network situation (e.g., routing protocols)
- Adaptive protocols are needed
  - Monitoring of network situation required

Adaptivity

MANETs require decentralized approaches

- Auto configuration
- Multicast communication
- Quality of service, energy efficiency
- Security, privacy, billling

Self organisation ! Usage of overlay networks?

→ Approaches for Networking-on-Chip should be aware of these experiences

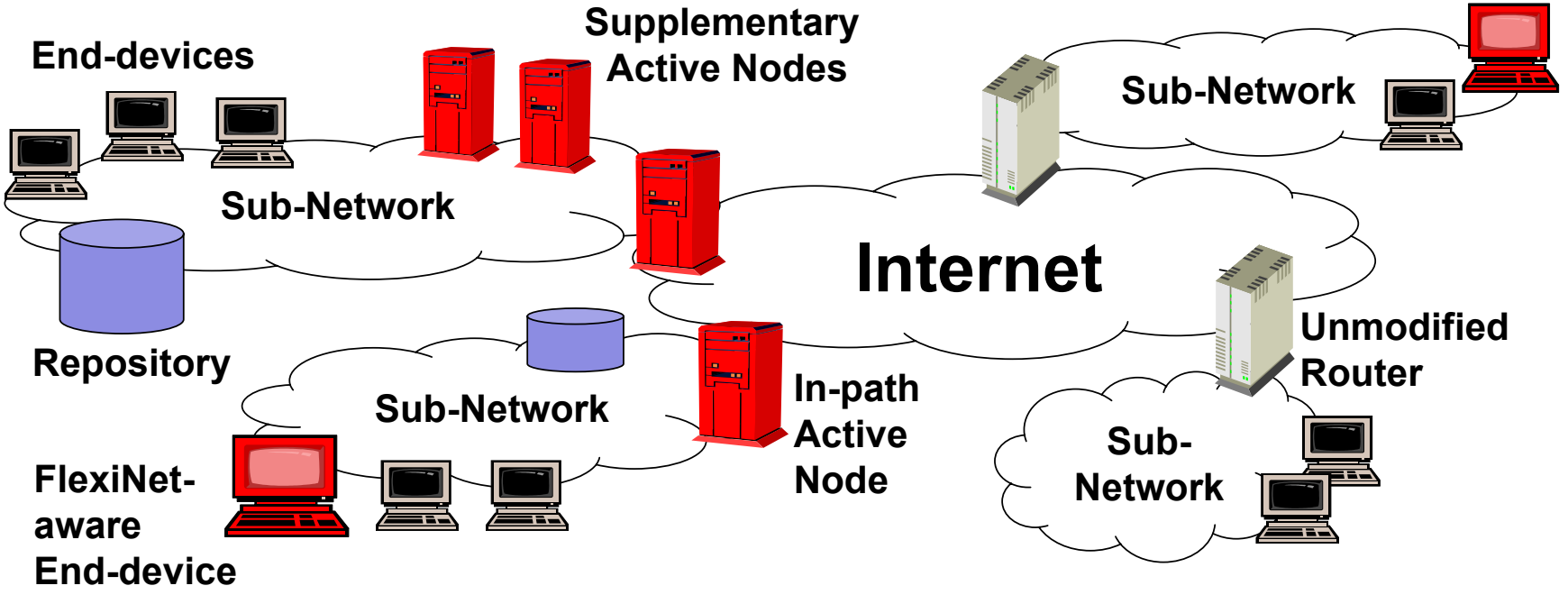
Flexibility

- Changing requirements
- Mobile communication
- Heterogeneous environments

- … always provide best solution

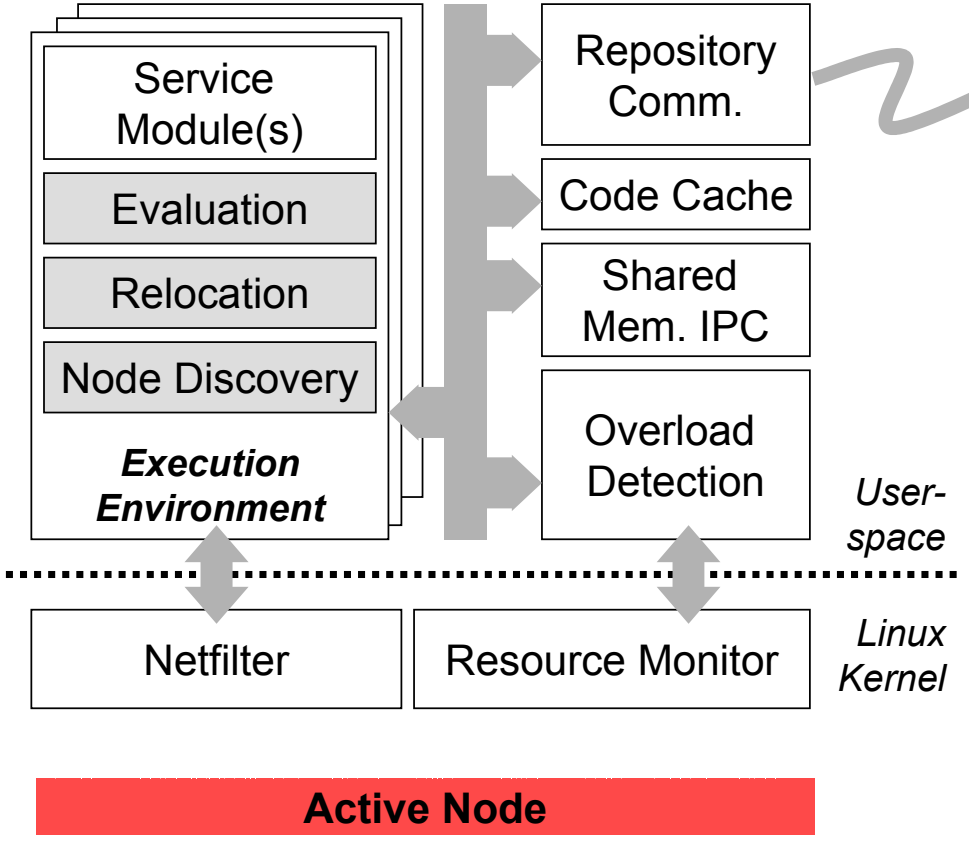
Programmable networks
versus
software-defined radio

Example: Programmable Networks



FlexiNet creates a programmable network architecture for the Internet edge. Both, in-path and off-path nodes flexibly extend the network with new services: Benefit from the first node on. End-devices don't even need to be FlexiNet-aware.

The FlexiNet Architecture



Repository

Organized in hierarchy (cf. DNS)
- **Service module code**
- **User profiles**
- **Authentication, authorization, accounting**

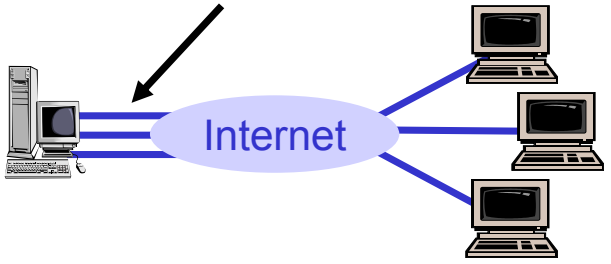
Front-end to the FlexiNet System (local domain only)
- **Network monitoring**
- **Node management**
- **User management**

Management GUI

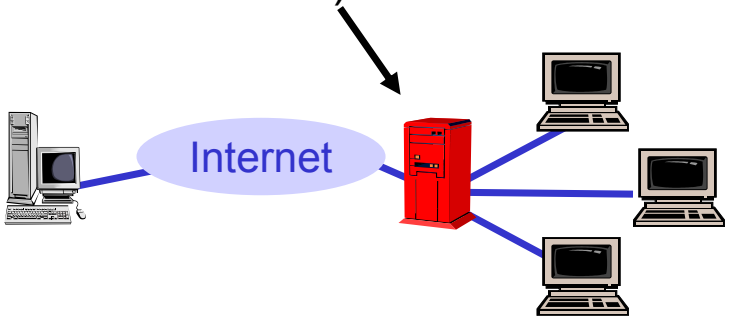
Sample Services in FlexiNet

Example 1

Problem: Typically, Internet streaming uses unicast.



FlexiNet: A FlexiNet node dupli-cates data stream. (Works with unmodified server and client!)



Example 2

Problem: End-devices have varying capabilities concerning video codecs.

FlexiNet: Video is transcoded to specifically match Palm-OS.

Services and Service Modules

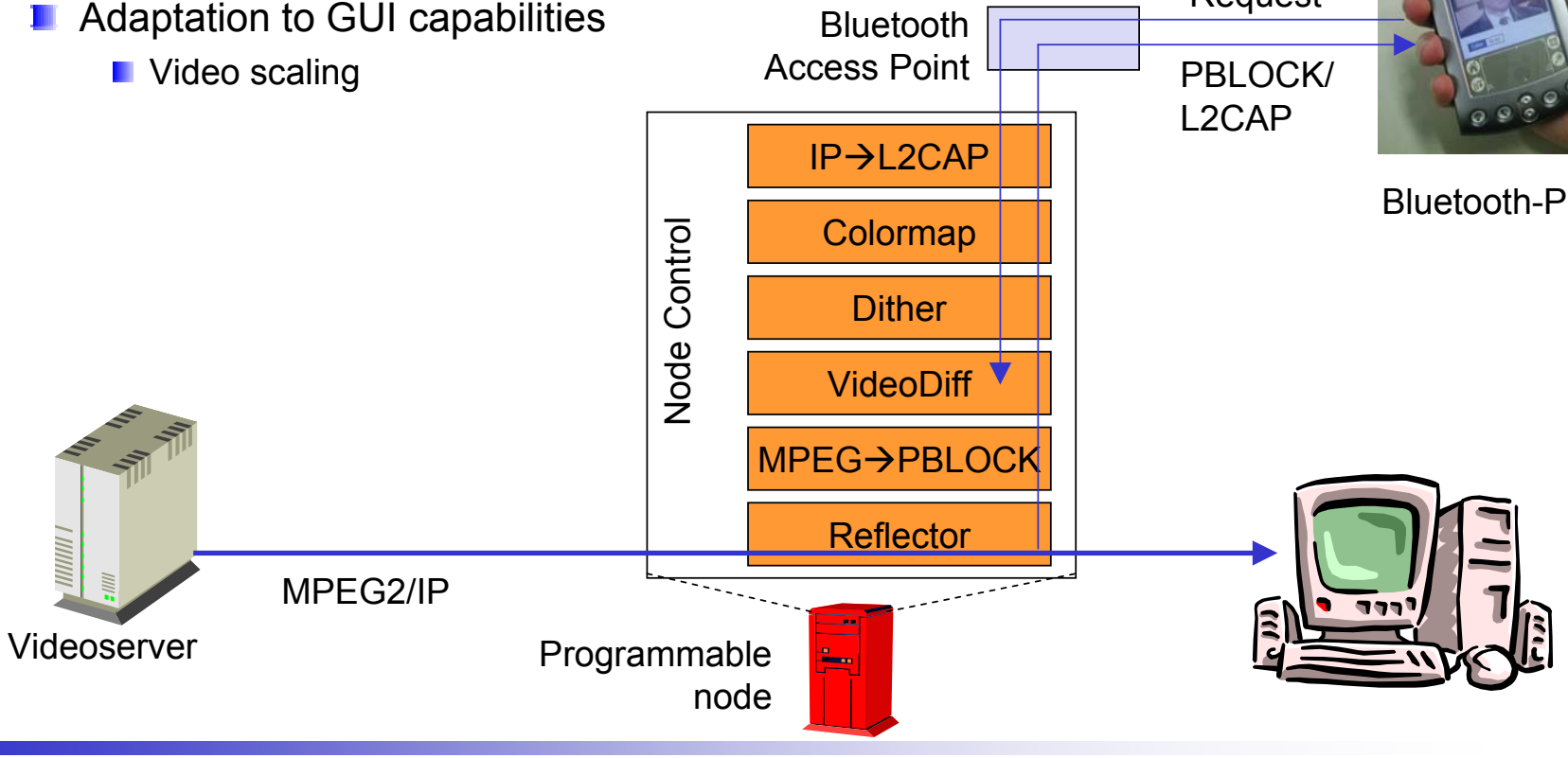
Service Modules

- Provide simple services
- Can be combined to complex services

Example

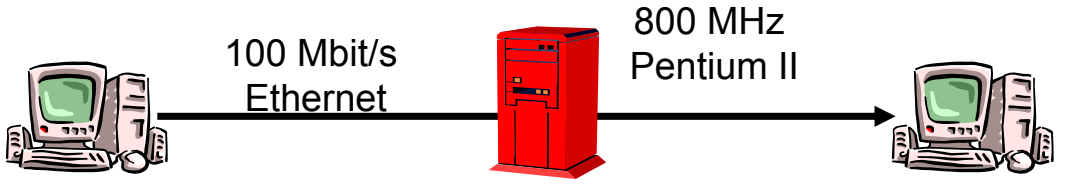
- Adaptation to GUI capabilities
  - Video scaling

Bluetooth-PDA

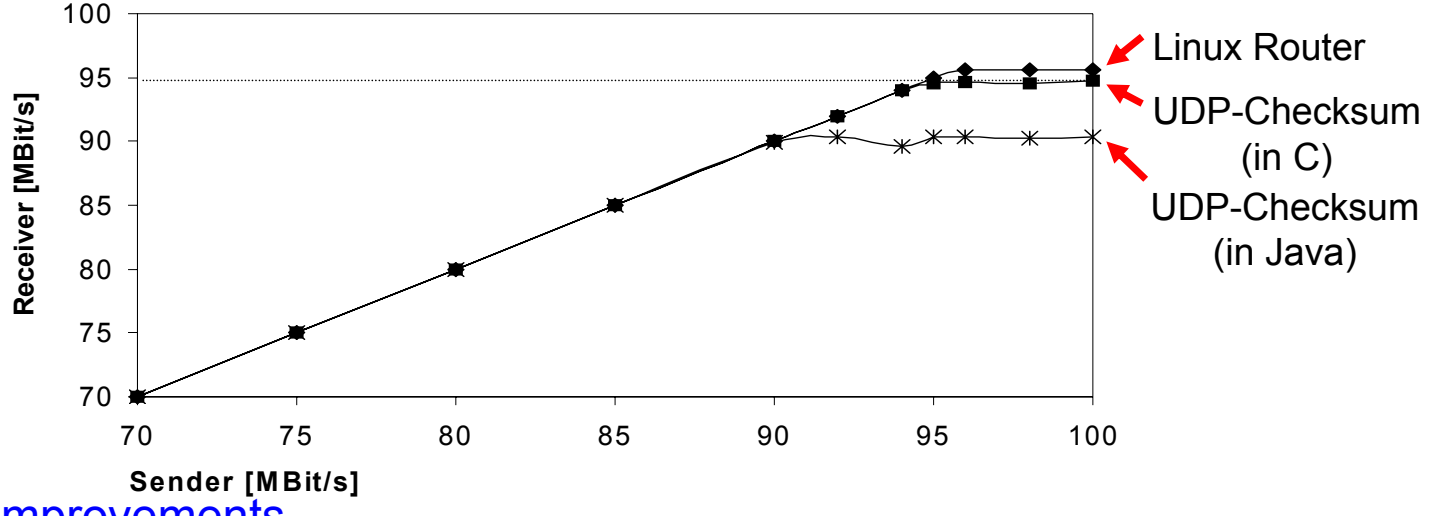


... Performance?

Measurement Scenario



Throughput



Possible Improvements

- Network processors
- Off-path programmable nodes

Let´s go for …

- Zero-touch networks (off-chip, on-chip)
  - Self-organized
  - Flexible
- Seamless global networking vs. Networking-on-chip
- Cross-layer !!
- Many open questions

Learn …
but take into account the specific situation!

Don´t do the same mistakes again and again!

Personalization

Location

Privacy

Billing and Accounting

Context