Karlsruher Institut für Technologie

Spontaneous Networks

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INSTITUT FÜR TELEMATIK – http://tm.kit.edu/

Applications, Applications, Applications … (I)

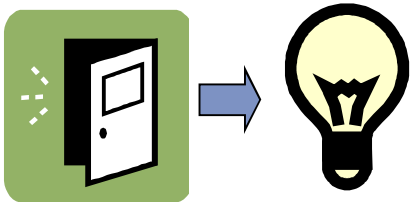
Social Networks

Mobile Applications

P2P Applications

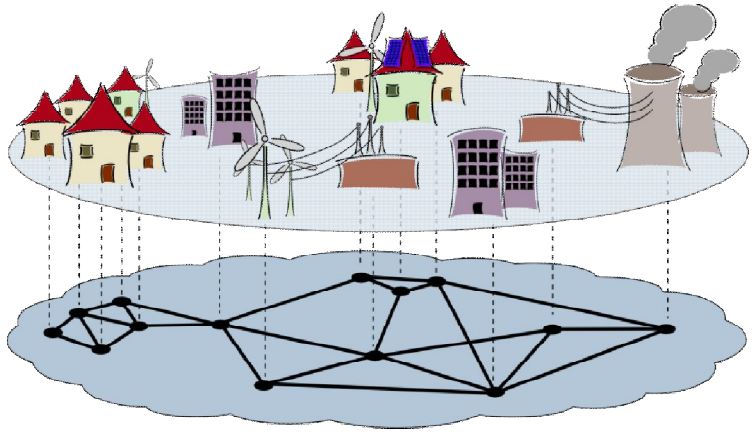
Applications, Applications, Applications … (II)

Networked Embedded Devices

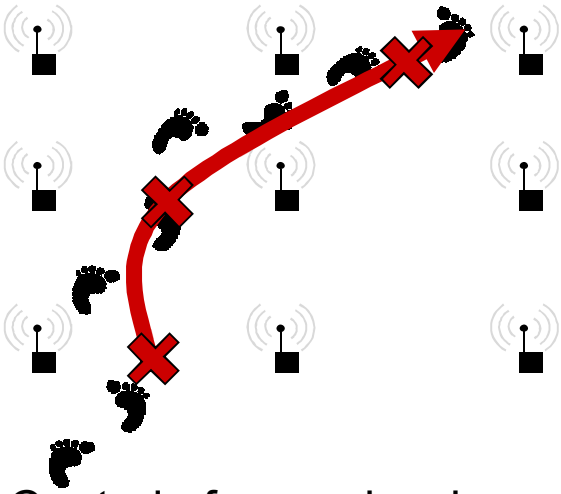


Home Automation

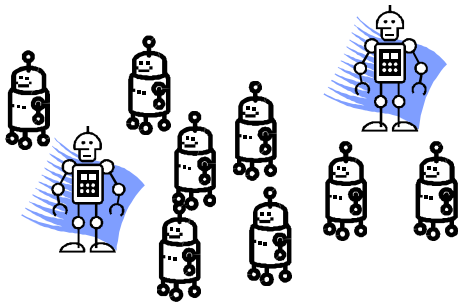
Internet of things



Future energy networks



Control of green borders



Swarms of robots

IP in/to/from the car

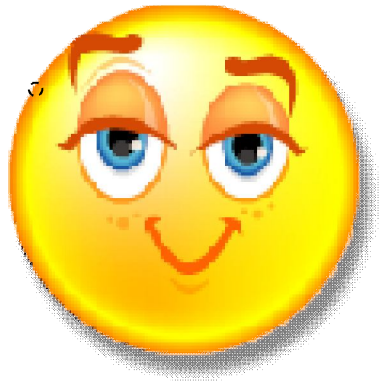
One Network Architecture for all Purposes?

Increasing Heterogeneity

- *Devices*
- *Networks/Protocols*
- *Requirements*

… what about
tailored networks
operating concurrently?

„Let 1000 Networks Bloom“



Overview

- Future Internet: Algorithms, Protocols, Architectures

Signalling, Virtualisation, Management	**Overlay Networks**	Network Security	Wireless Sensor Networks

- Methods and Tools: Evaluation, Design Process

Analysis & Simulations	Testbed Experiments	Systematic Design Process

Service Overlays

Allow spontaneous and easy creation of new services on top of existing networks

- Our solution
  - SpoVNet (Spontaneous Virtual Networks)
- Characteristics
  - Hides underlay difficulties from application and service developers
    - Multihoming, Mobility, (Protocol-)Heterogeneity, Middleboxes,…
  - Reacts autonomously to changes and required adaptations
  - Offers an easy-to-use application interface
  - Allows for fast and easy deployment of further higher level services

Service Overlays – Basic Scheme

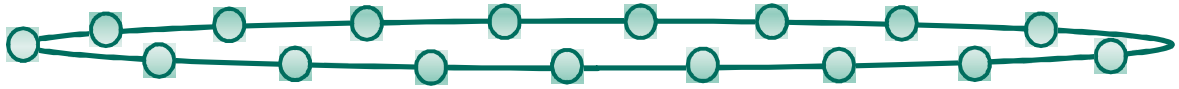
Applications

Application Example: Videostreaming

Higher Overlay-based Services

Higher Service Example: Application Layer Multicast

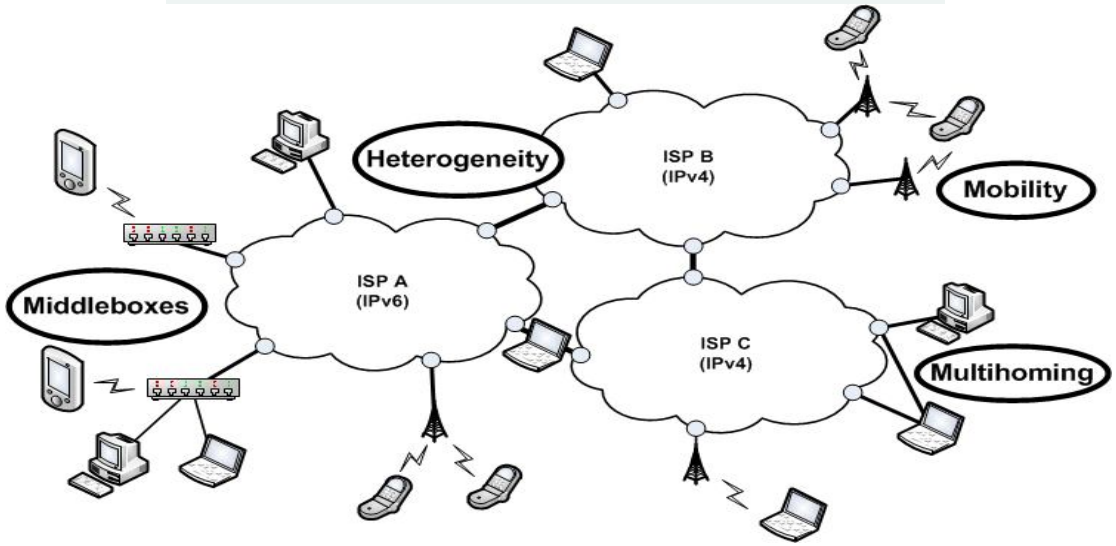
Service Overlay Base



Service Overlay

Service Overlay as Common Base

Heterogeneous Underlay



Application Interface

Base for Higher Services

Abstracts from Underlay Hassle

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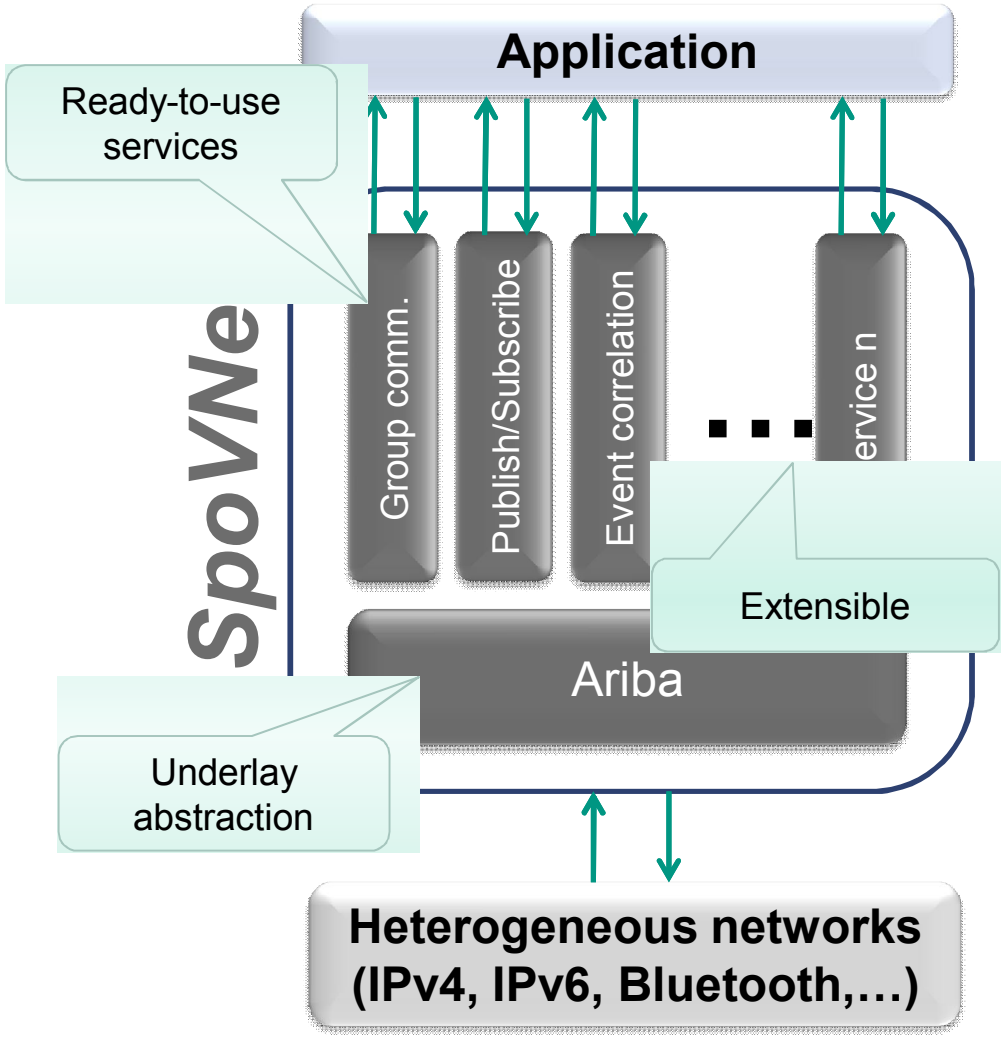
Service Overlays - SpoVNet



SpoVNet has been successfully presented at

ACM SIGCOMM 2009

Honorable Mention

and

IEEE INFOCOM 2010

Selected Aspects of SpoVNet

- **Connectivity management**

- Examples for service overlays
  - Event service
  - Multicast service
  - Attachment of sensor networks

  - **Connectivity for delay tolerant networks**

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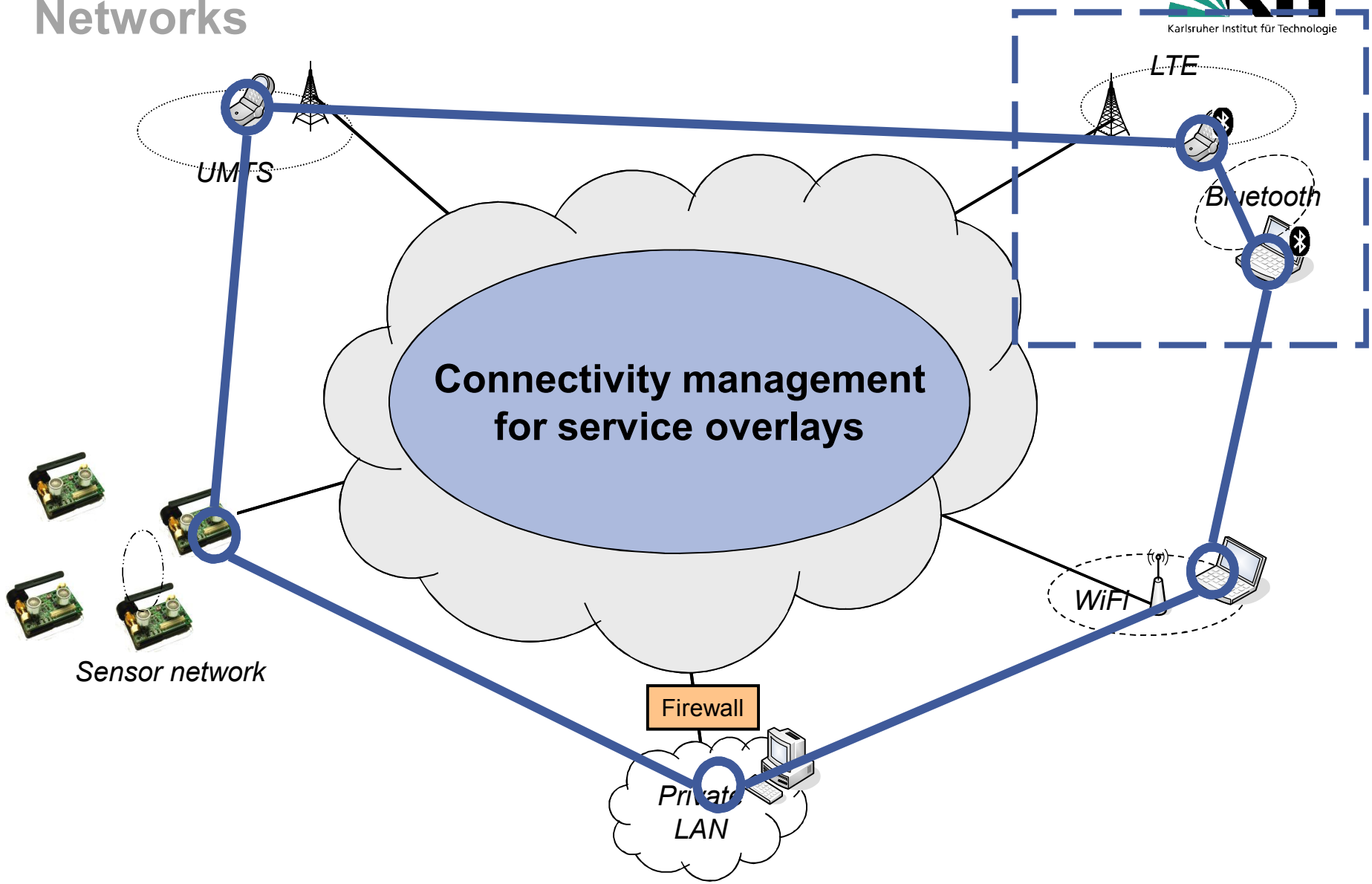
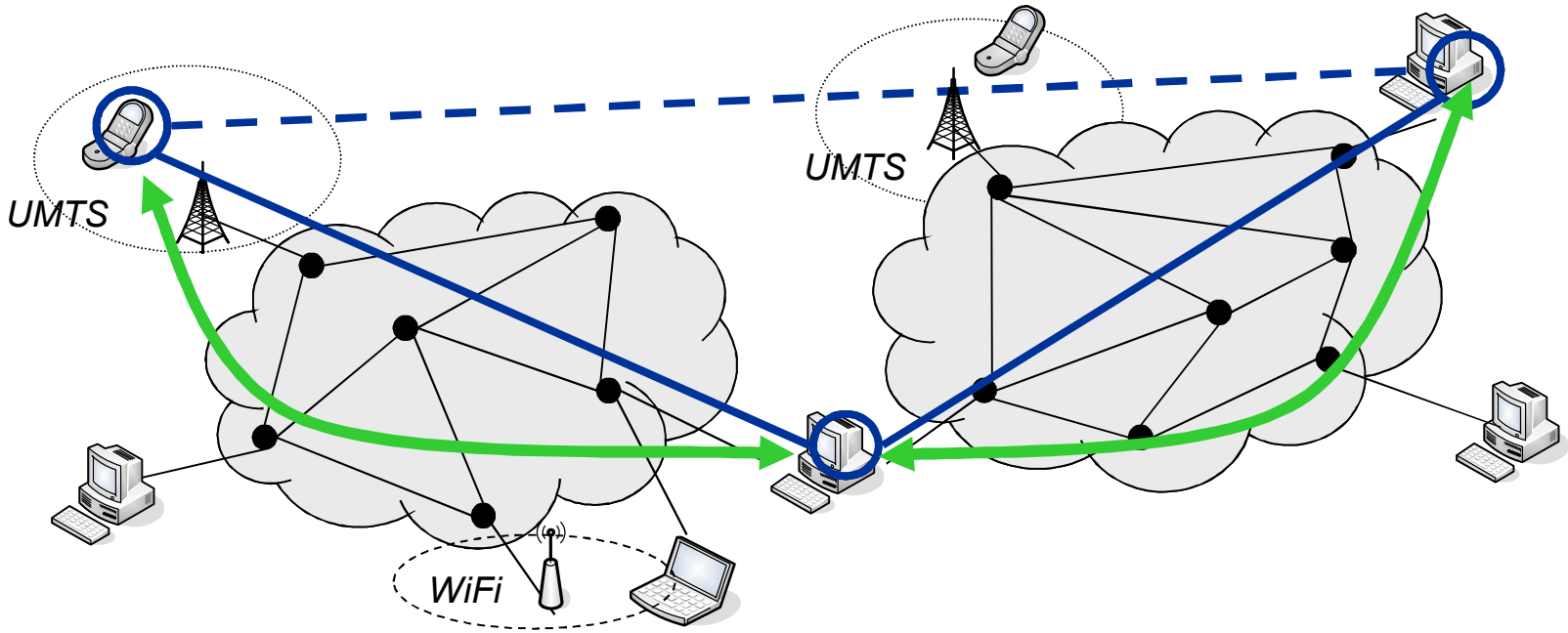
Overlay Construction across Heterogeneous Networks



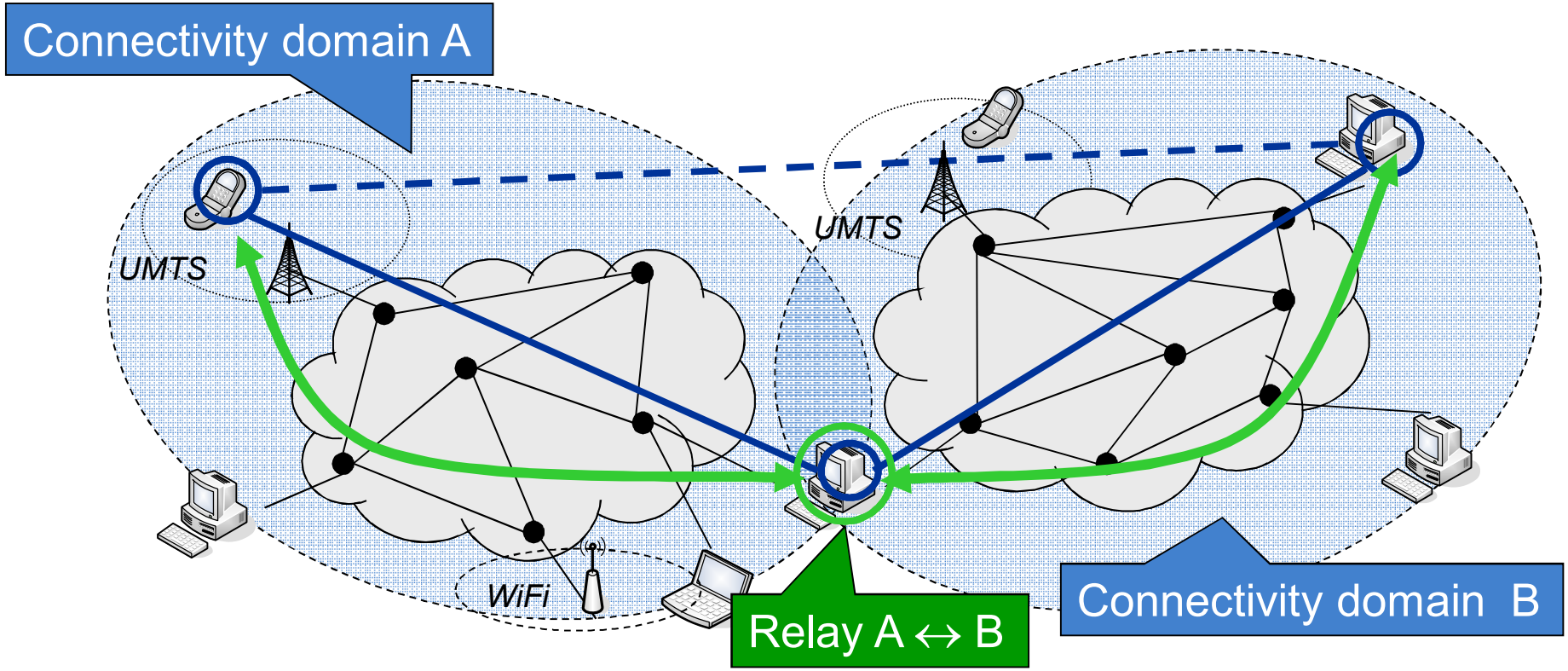
Overlay Connectivity



Often direct overlay connections not possible

- End systems serve as relay among multiple networks
- Overlay connection consists of sequence of multiple existing overlay connections

Connectivity Domains



Detect relay nodes

- Triangular tests

Assign unigque identifiers to connectivity domains

- Various algorithms supported

→ *autonomous, low overhead*

Selected Aspects of SpoVNet

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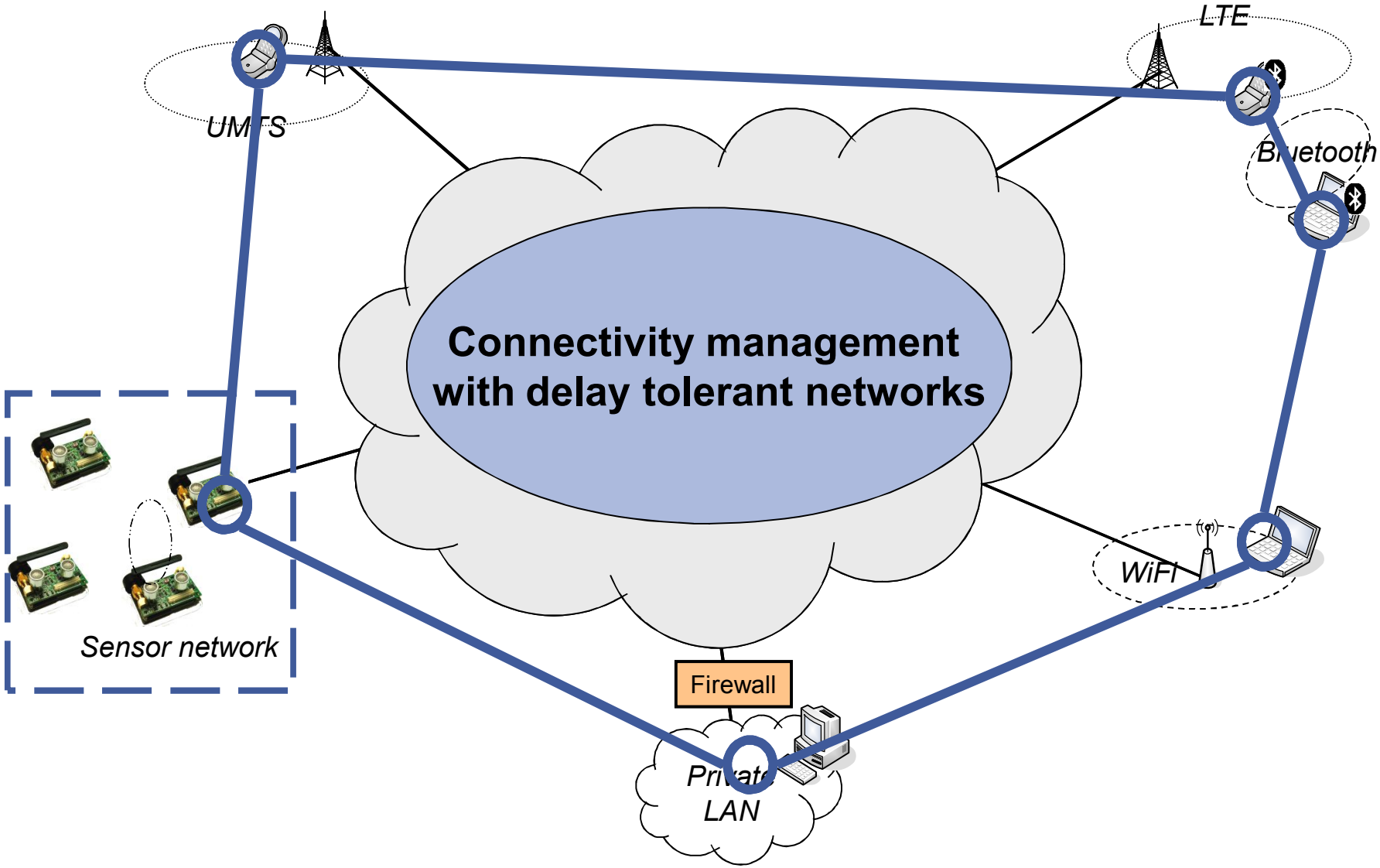
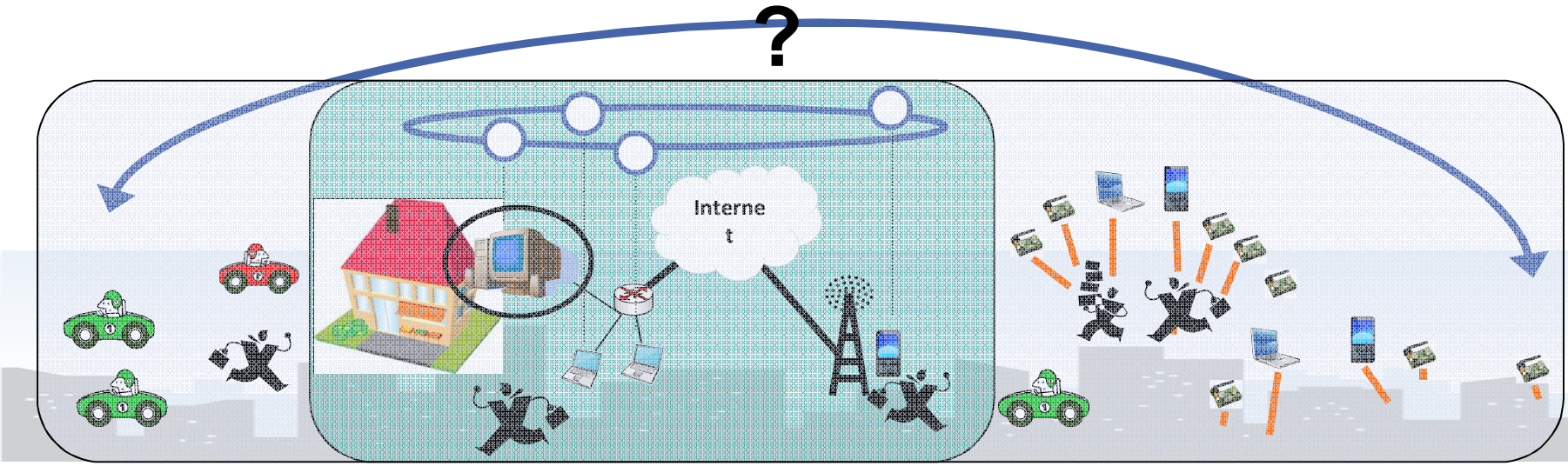
Overlay Construction across Heterogeneous Networks



Hybride Routing System



- Combined DTN and overlay routing
  - Structured overlay network
    - Closest match property
  - Delay tolerant forwarding
    - Based on relative ranks among devices (e.g., in social network)

→ Effective coupling of dis-connected devices, high impact of devices in infrastructure

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Overlay Networks

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Wireless Sensor Networks

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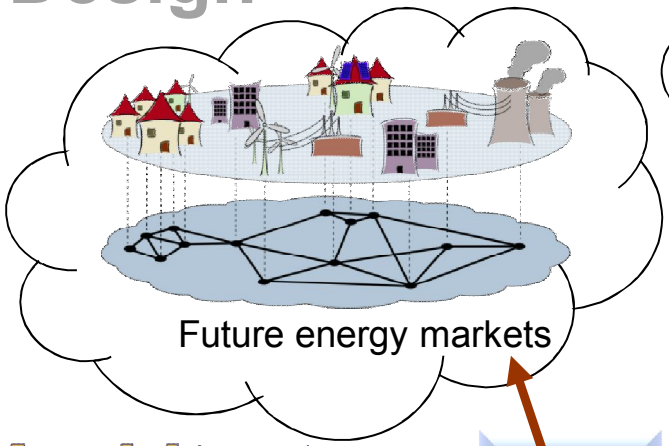
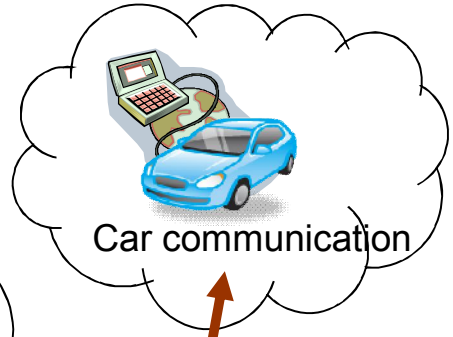
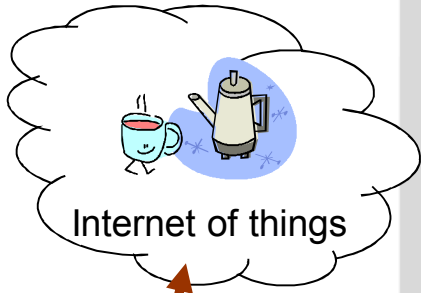
Systematic Design Process

Network Design

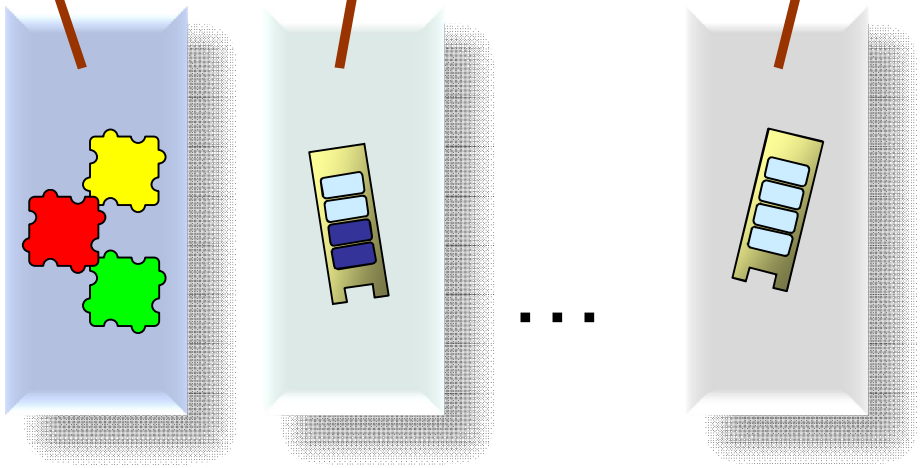






Network Architect

Tool support



Let 1000 Networks Bloom

SpoVNet/Ariba *or* Virtual Net

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Network Architect

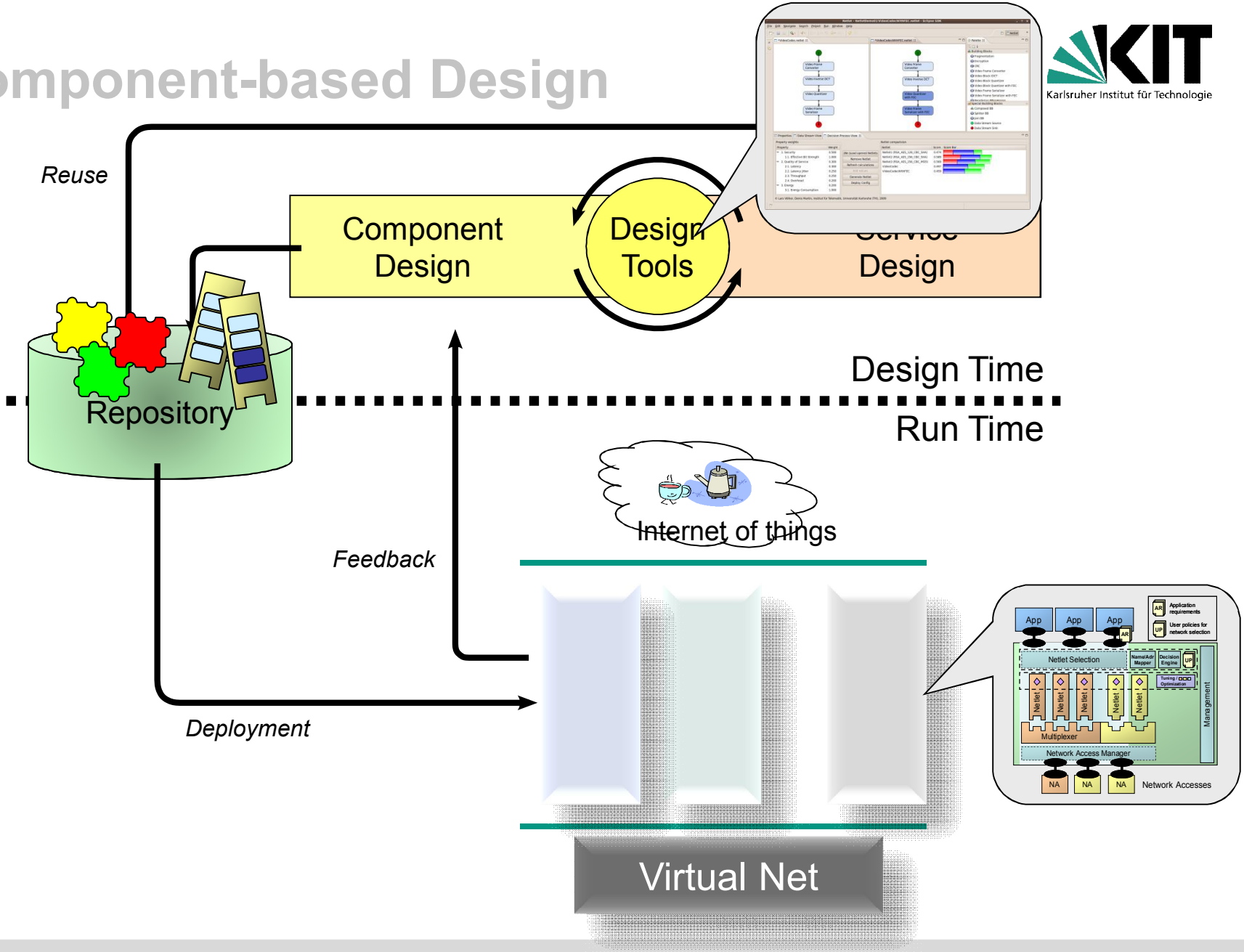
Tool support

How to compare protocols/ mechanisms?

Suited models? Best practices?

How to compose a complete system?

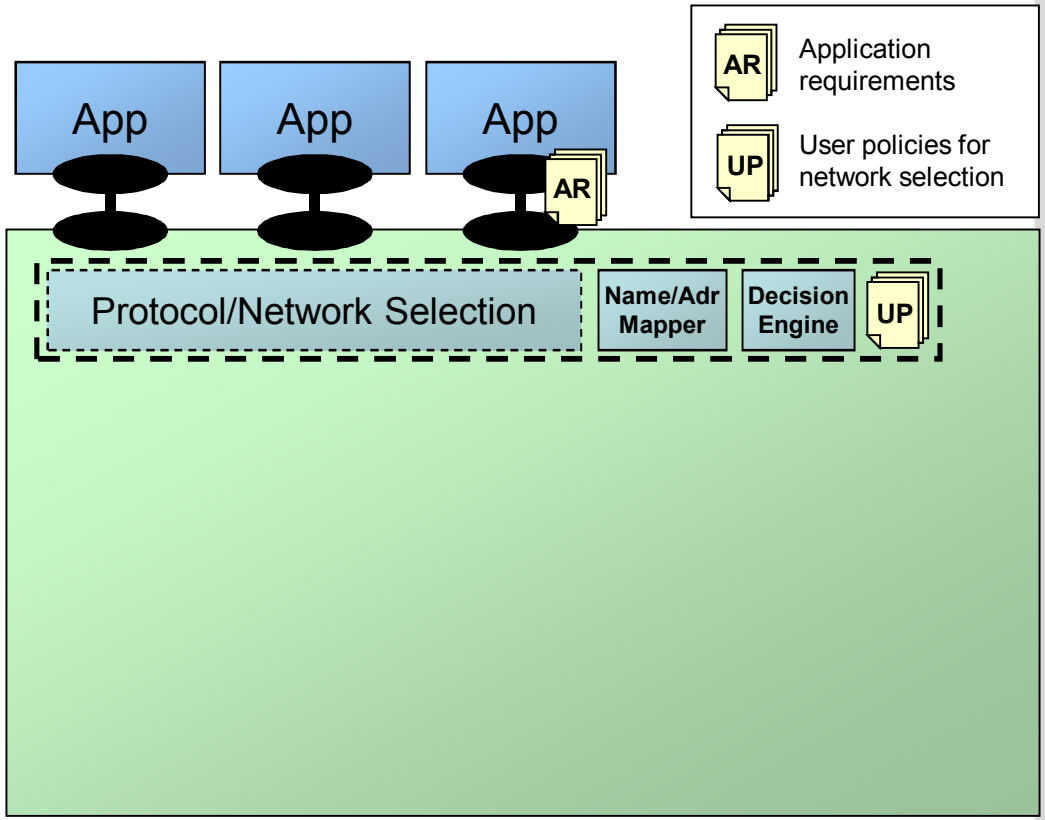
Component-based Design



The Node Architecture

Application Interface

- Innovations:
  - Move name resolver from application to system
  - Let the system choose the protocol, not the application
  - Allow application (and user) to influence choice of network and

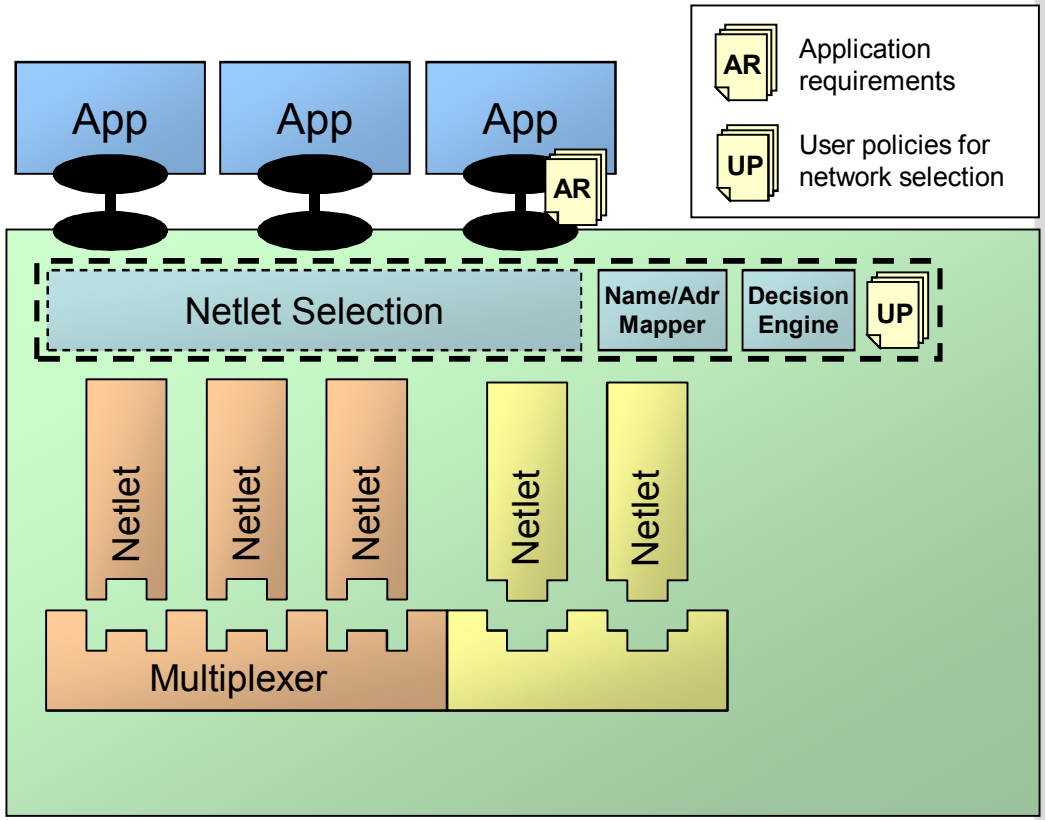


L. Völker, D. Martin, C. Werle, M. Zitterbart, I. El Khayat, ***Selecting Concurrent Network Architectures at Runtime***, IEEE International Conference on Communications (ICC 2009), IEEE Communication Society, Dresden, Germany, June 2009

The Node Architecture

Future Protocol Containers: Netlets

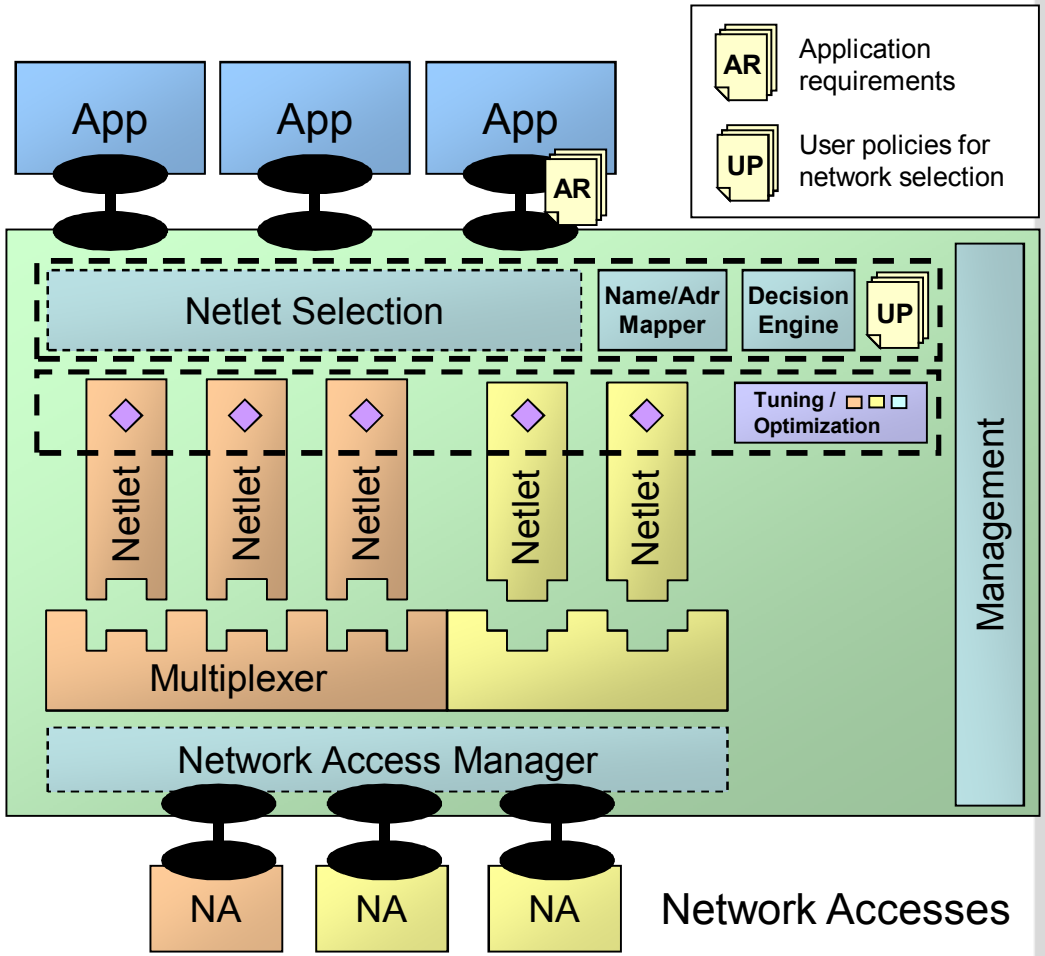
- Innovations:
  - Move app-layer protocols down to the system
  - Enable easy deployment for new lower-layer protocols
  - Architecture specific multiplexer for Netlets of the same family



The Node Architecture

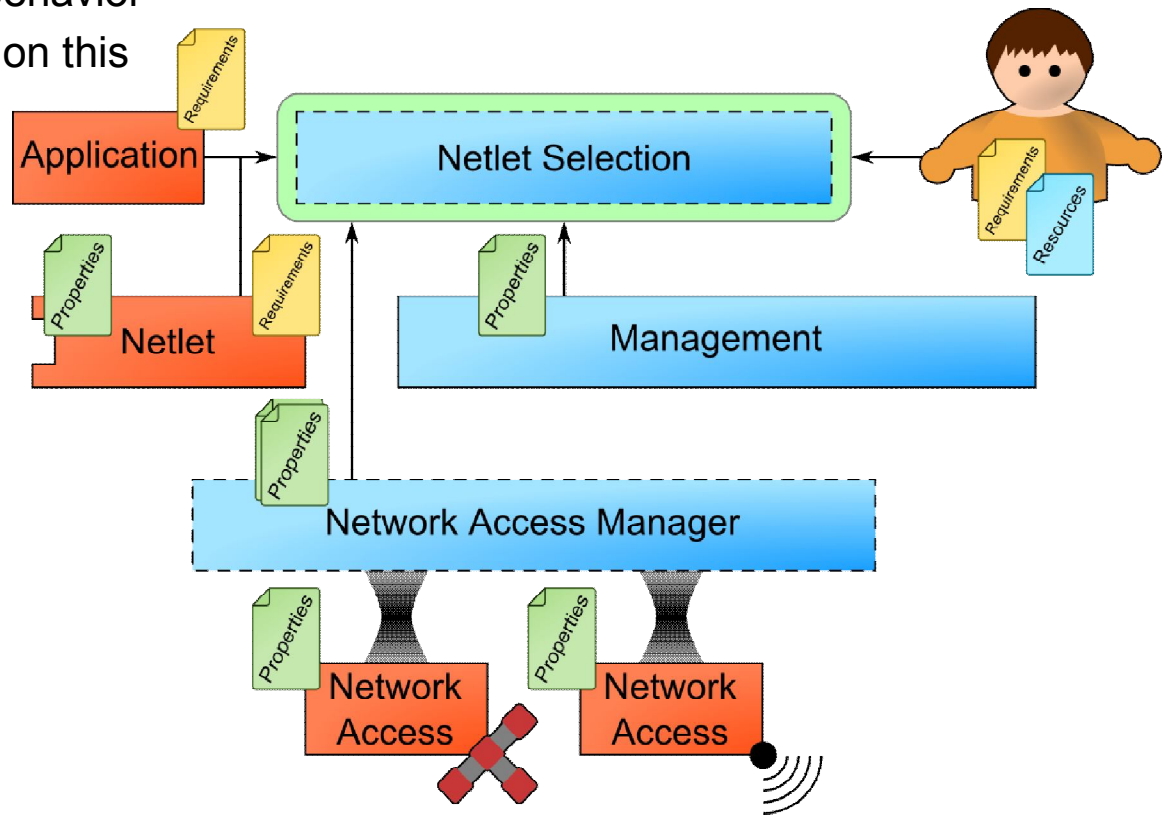
Tuning, Management, and Network Accesses

- Cross-“layer” optimizations
  - Tuning/adaptation according to network property changes
- Node Management
  - Network management functionality
- Network Accesses



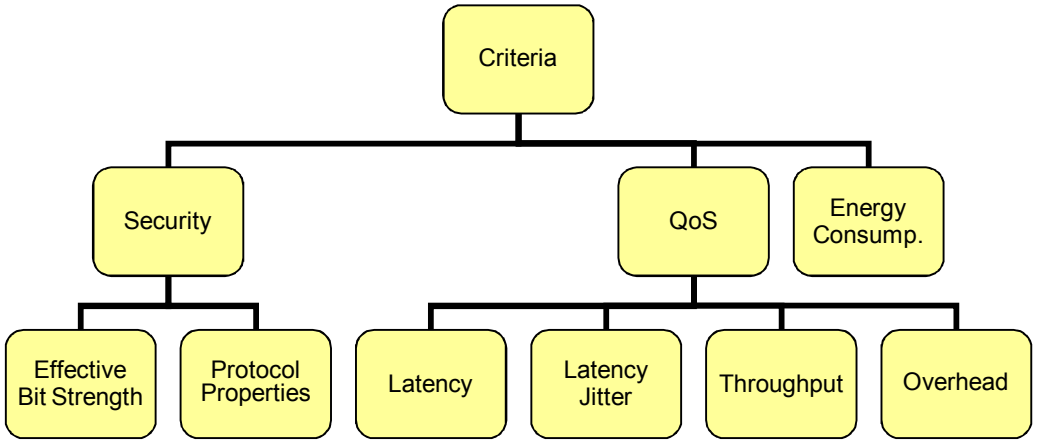
Netlet Selection

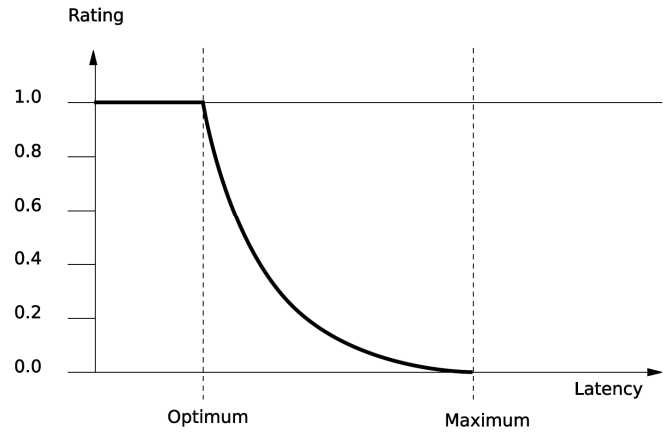
- Automatic selection
  - Let application, user, and administrator describe requirements/goals
  - Description of underlying network
  - “Estimate” the Netlet’s behavior
  - Rank the Netlets based on this



Netlet Ranking

Based on MAUT (Multi-attribute Utility Theory)



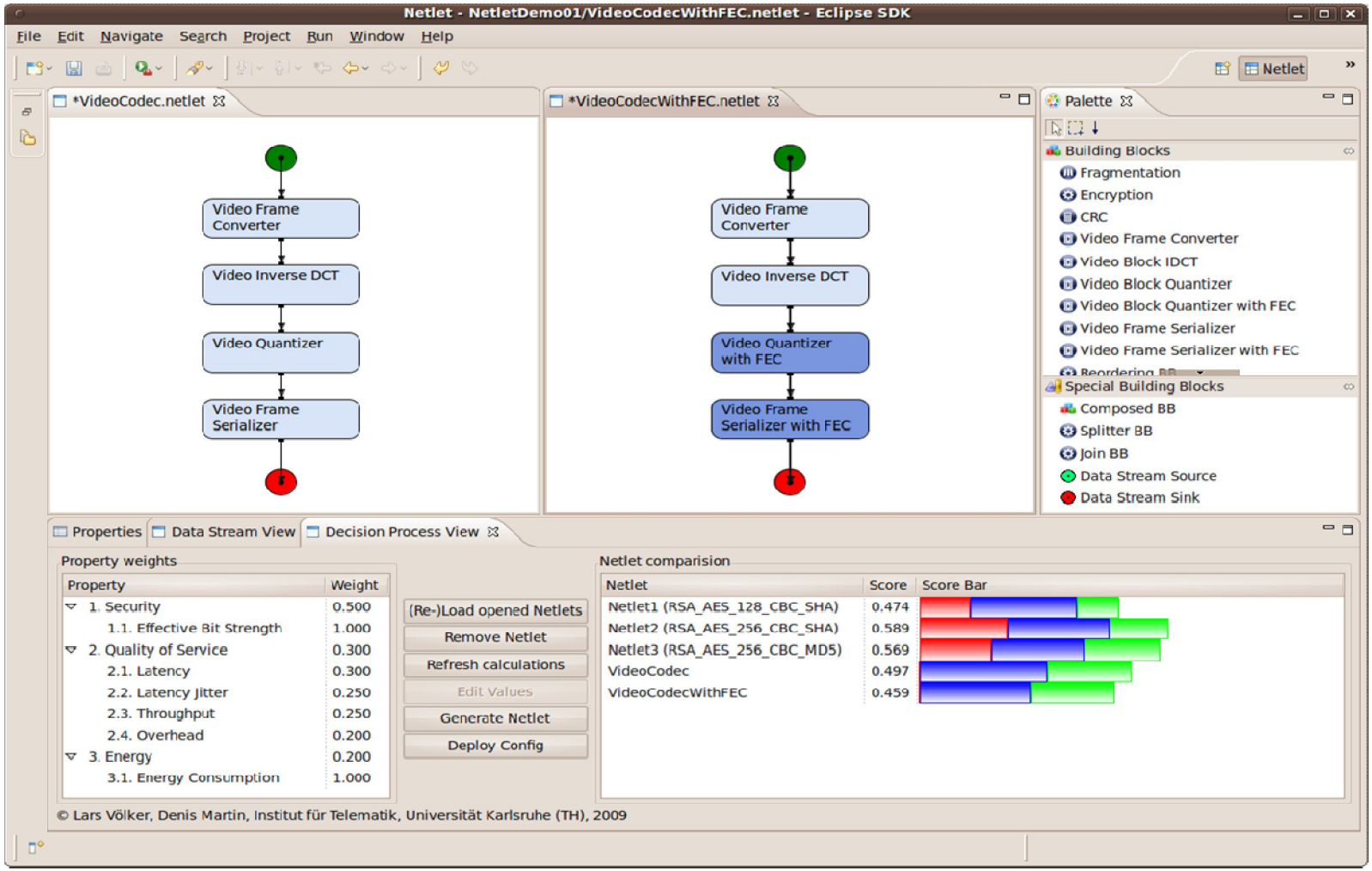


$$v(a_i) = \sum_{j=1}^{m} w_j * v_j(c_j(a_i))$$

Meaning	Abbreviation
Alternative i	a_i
Criterion j	c_j
Weight for criterion j	w_j
Attribute value of a_i with regard to criterion c_j	$c_j(a_i)$
Value function for criterion c_j	v_j
Total value of alternative a_i	$v(a_i)$

Lars Völker, Christoph Werle, Martina Zitterbart, ***Decision Process for Automated Selection of Security Protocols***, 33nd IEEE Conference on Local Computer Networks (LCN 2008), IEEE, p. 223-229, Montreal, QB, Canada, Oct 2008.

Design Tool


Netlet - NetletDemo01/VideoCodecWithFEC.netlet - Eclipse SDK
File Edit Navigate Search Project Run Window Help
Netlet
*VideoCodec.netlet
Video Frame Converter
Video Inverse DCT
Video Quantizer
Video Frame Serializer
*VideoCodecWithFEC.netlet
Video Frame Converter
Video Inverse DCT
Video Quantizer with FEC
Video Frame Serializer with FEC
Palette
Building Blocks
Fragmentation
Encryption
CRC
Video Frame Converter
Video Block IDCT
Video Block Quantizer
Video Block Quantizer with FEC
Video Frame Serializer
Video Frame Serializer with FEC
Special Building Blocks
Composed BB
Splitter BB
Join BB
Data Stream Source
Data Stream Sink
Properties
Data Stream View
Decision Process View
Property weights
Property
Weight
1. Security 0.500
1.1. Effective Bit Strength 1.000
2. Quality of Service 0.300
2.1. Latency 0.300
2.2. Latency Jitter 0.250
2.3. Throughput 0.250
2.4. Overhead 0.200
3. Energy 0.200
3.1. Energy Consumption 1.000
(Re-)Load opened Netlets
Remove Netlet
Refresh calculations
Edit Values
Generate Netlet
Deploy Config
Netlet comparision
Netlet
Score
Score Bar
Netlet1 (RSA_AES_128_CBC_SHA) 0.474
Netlet2 (RSA_AES_256_CBC_SHA) 0.589
Netlet3 (RSA_AES_256_CBC_MD5) 0.569
VideoCodec 0.497
VideoCodecWithFEC 0.459
© Lars Völker, Denis Martin, Institut für Telematik, Universität Karlsruhe (TH), 2009

Summary and Outlook

- Enabling technologies
  - Service Overlays and Virtual Networks
- Flexible and rapid prototyping/testing of network architectures
  - Component-based approach with proper tool support
  - Testbed experiments, simulations
- Some challenges
  - … new business models
  - … new ways of standardisation

Thanks!

Telematics team

P2P and Overlay Networks

- ***MEREGIO*** – „Towards Minimum Emission Regions"
  - More efficient decentralized energy systems by integrating advanced information and communication technology (ICT) into all levels of the energy supply chain
  - Focus on mobility in the companion project ***MEREGIOmobil***

- ***SpoVNet***
  - Spontaneous provisioning of application-and network-oriented services in heterogeneous networks by overlays
  - Enabling a seamless transition from current to future networks
  - Features
    - Network virtualization support
    - Internet of things integration
    - Overlay composition and configuration

SPOVNET spontaneous virtual networks

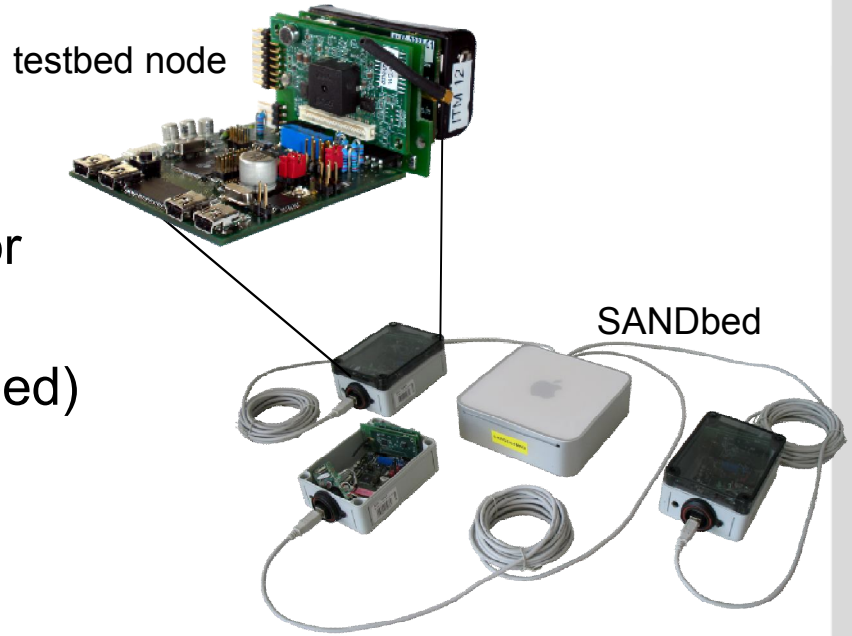
Architectures, Signaling & Management

- ***4WARD*** – „The Network of the Future“
  - New network architecture for a future Internet
    - Integration of Mobility, Quality of Service, and Security from the Beginning
- ***G-Lab***
  - Experimentally driven future internet research
    - Architectures, Virtualization, Management, Security
  - Establishing a German-wide experimental facility

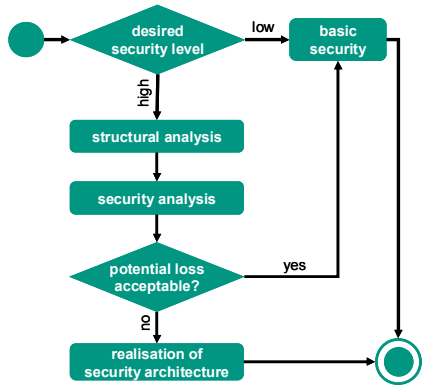
- ***SEIS***
  - Introduction of the Internet Protocol IP as convergence layer for In-car communications
  - Detect and resolve possible security issues related to the introduction of IP

Wireless Sensor Networks

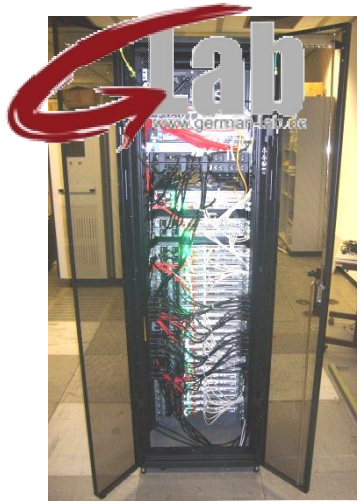
- ***ZeuS***
  - Research into security, safety, and energy-efficiency in wireless sensor networks
  - Setup of a flexible testbed (SANDbed) supporting energy measurements



- ***MoSe***
  - Developing an application aware security process for WSNs
  - Must be taken into account over entire development process



Testbeds and Labs



- **German-Lab (G-Lab)**
  - National research network for studies of new Internet technologies
  - Karlsruhe is one site
  - 25 Sun Fire X4150 Server
  - http://www.german-lab.org

- **GpENI**
  - International research testbed for the Future Internet
  - Part of the Geni project (http://www.geni.net)
  - https://wiki.ittc.ku.edu/gpeni/

- **Sensor Actuator Network Development Testbed (SANDbed)**
  - Platform for reproducible experiments without side-effects
  - Allows for precise analysis regarding energy efficiency and reliability
  - http://www.kit.edu/projects/sandbed

- **Simulation PCs and Router Testbed**
  - Simulation lab for evaluation of new network protocols and mechanisms
  - Test of real-world implementations on router testbed