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The Chair of **Future Communication:** Organization and Medium Term Perspective

Prof. K. Tutschku (kurt.tutschku@univie.ac.at)

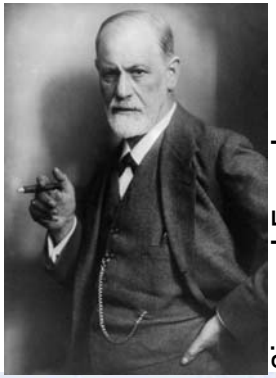
The Chair of Future Communication:
Organization, Research and Teaching Perspective
(November 2010)

The University of Vienna

Kurt Gödel

Erwin Schrödinger

Konrad Lorenz



Sigmund Freud

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Departments

Distributed and Multimedia Systems

Chairs

Distributed Systems:	Prof. G. Haring
Future Communication:	Prof. K. Tutschku
Multimedia Information Systems:	Prof. W. Klas
Software Architectures:	Prof. U. Zdun
Theory and Applications of Algorithms:	Prof. M. Henzinger

Knowledge and Business Engineering

Workflow Systems and Technology:	Prof. S. Rinderle-Ma
Knowledge Engineering:	Prof. D. Karagiannis

Scientific Computing

Data Analysis and Computational Sys.:	Prof. W. Winiwarter
Software Science:	Prof. S. Benkner

Additional Centers:

Computational Technologies and Applications	(Dr. W. Gansterer)
Didactic Center for Computer Science	(Prof. E. Neuwirth)
Computational Science Center	(Prof. O. Scherzer)

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Group Members

Head

Kurt Tutschku (since 01.09.2008)

Administration

J. Baier-Mathews (secretary)

O. Michel (system admin.)

Full Time Scientific Staff (senior staff and Ph.D. students)

Florian Metzger (from 01.05.2010)

Albert Rafetseder (from 01.03.2009)

David. Stezenbach (from 01.10.2010)

N.N. (advertised)

Student Helpers

M. Alberer, B. Grubor, A. Lukovics, L. Pühringer, S. Seebacher, C. Vorhemus

Post-Graduates (temporary scientific staff, Ph.D students)

Dominik Klein (Univ. of Würzburg, Germany, Mar. 1st – Aug. 31st, 2009)

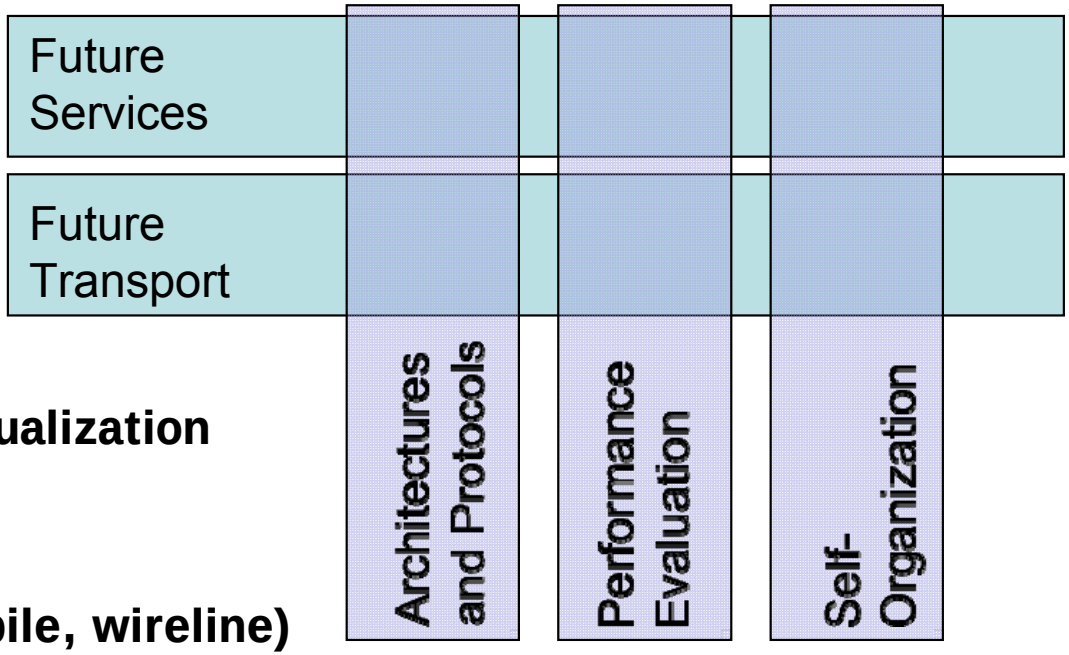
Ricardo Matos (Univ. of Aveiro, Portugal, Apr. 1st – Jul. 15th, 2009)

Christian Schwartz (Univ. of Würzburg, Germany, Mar. 1st – Sep. 31st, 2010)

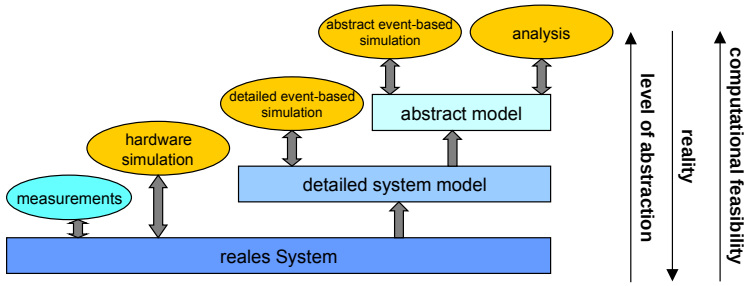
Collaboration with external Ph.D. students

Thomas Zinner (Univ. Würzburg)

Research Topics



- **Future Internet, network virtualization**
- **Future network control plane**
- **P2P content distribution (mobile, wireline)**
- **Quality-of-Service and Quality-of-Experience**
- **Future Internet services, service virtualization and Internet of Things**
- **Traffic-oriented network management**
- **Performance evaluation (Event-based Simulation, Analysis)**
- **P2P algorithms (mediation, resource exchange), self-organization**



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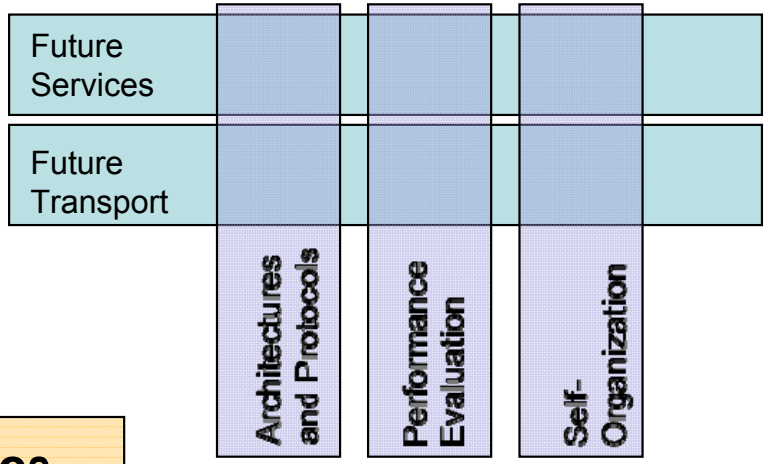
Partners

Milestones (2008-10)

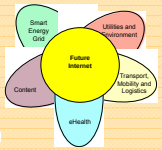
- Renewal of Endowment by Telekom Austria
- Research contract with NSN
- 2009: two journals, four conf. papers
- 2010 (so far): one journal, one book chapter, two conf. paper
- First EuroNF Specific Joint Development and Experimentation project
- Demo at GENI Engineering Conference 7 (Mar.'10)
- WWTF project on NV, Federation and Optimization (3years)

Research and Teaching Instruments



Future Transport Lab

Future Services Lab (planed)



Vienna Think Tank for Future Communication

- Focus on industry collaboration
- Endowed by Telekom Austria

Academic Excellence

- Complementing courses in Bachelor prog.
- Ph.D. courses
- School of Internet Architects?

Milestones

- **Two EuroNF funded Ph.D. courses (Simulation, 2009; Network Virtualization, 2010)**
- **(Re)-engineering of 5-6 lectures (Rechnernetze, Netzwerktech. f. MA,, Simumlationstechnik, OS & Algo. f. VNS, Sys. Arch f. zukünftige Netze)**
- **17 Bachelor theses in 2009-10**
- **Contribution to curricular program**

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Involvement in Future Internet Activities

Collaboration with the following Future Internet projects:

- Akari (Japan, K. Tutschku was member of NICT)
- EuroNF (Europe, Strategic Officer, WP leader)
- G-Lab (Germany, application and association)
- OneLab2 (Europe, association)
- GENI/PlanetLab (USA, listener/member, participant to GEC3/4/6/7)
- Setup of first GENI/GpENI-Nodes in Austria (subproject of GENI)
- Invited talk on Network Virtualization at Future Internet Cluster (FIC 2010)
- Advisory board European PPP project "Future Internet"
- Invited talk on Comparison FI Architectures at EU-sponsored Future Internet Assembly (FIA 2010)
- Invited talk on Network Virtualization at DFN-Forum 2010
- Co-Lead in Austrian FI PPP application
- Member of EuroNF steering board

Lead or participation in the following Future Internet workshops

- 20th ITC Specialist Seminar on Network Virtualization (TPC Chair)
- Network virtualization workshop at KIVS'09 (TPC)
- Network virtualization (VISA) workshop at Sigcomm'09 (Reviewer)
- VISA workshop at Sigcomm'10 (TPC)
- Track Chair for Network Virtualization at the Future Internet Symposium (FIS 2010)
- Reviewer for EU FP7 program for Future Internet projects

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Chair for Future Communication
Prof. Dr. K. Tutschku
Institute for Distributed and Multimedia Systems
Faculty for Computer Science

How to Evaluate and Compare Architectures: State of the Art and Beyond

K. Tutschku (kurt.tutschku@univie.ac.at) and G. Haring (guenter.haring@univie.ac.at)

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Overview

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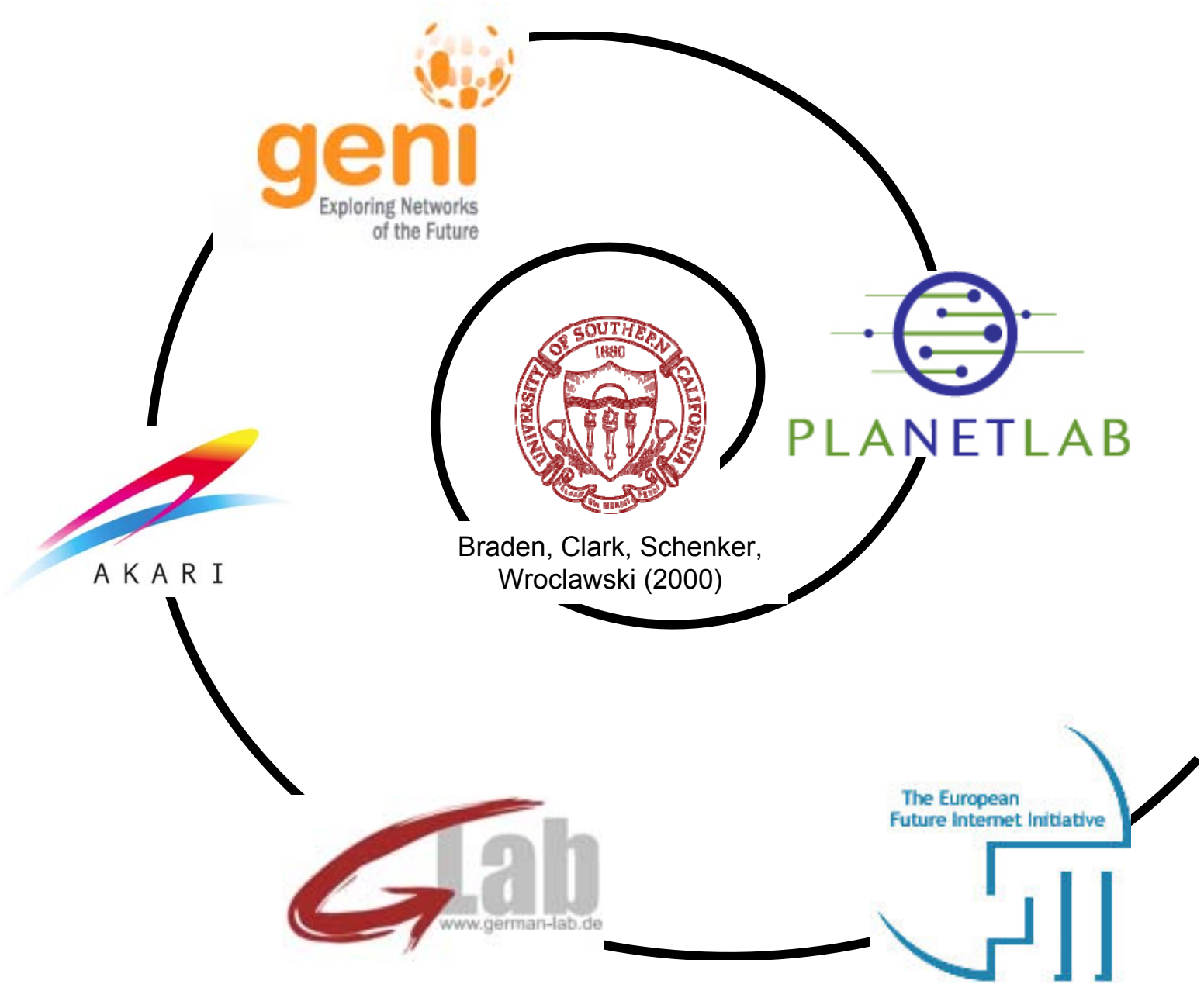
- Introduction: the Internet and Future Internet
- What is an architecture?
- Comparison and evaluations of architectures
  - Structure, comparison, and quality
  - Formulation of metrics
  - Relation of attributes and milt-dimensional evaluation
  - An evaluation recipe
- Conclusion

The Future Internet Architecture?



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IP „Hour Glas“ Architecture and other Reference Concepts

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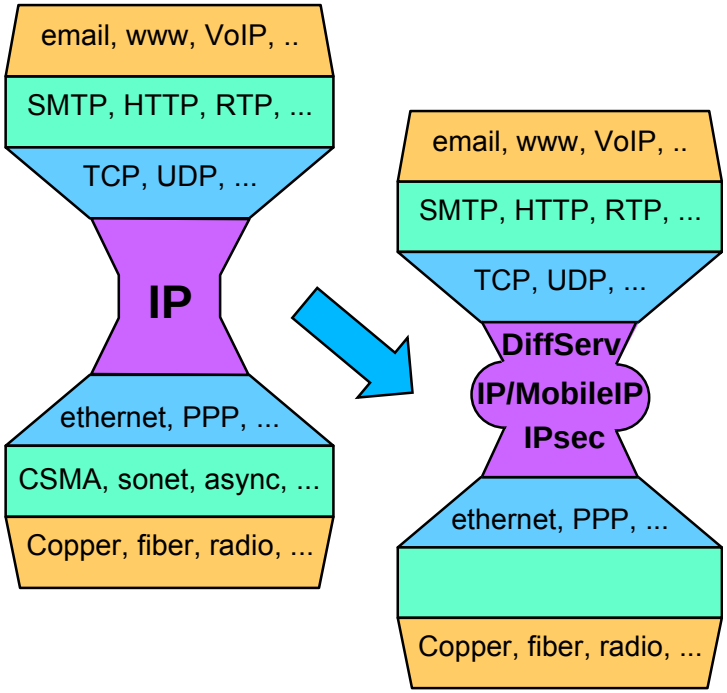
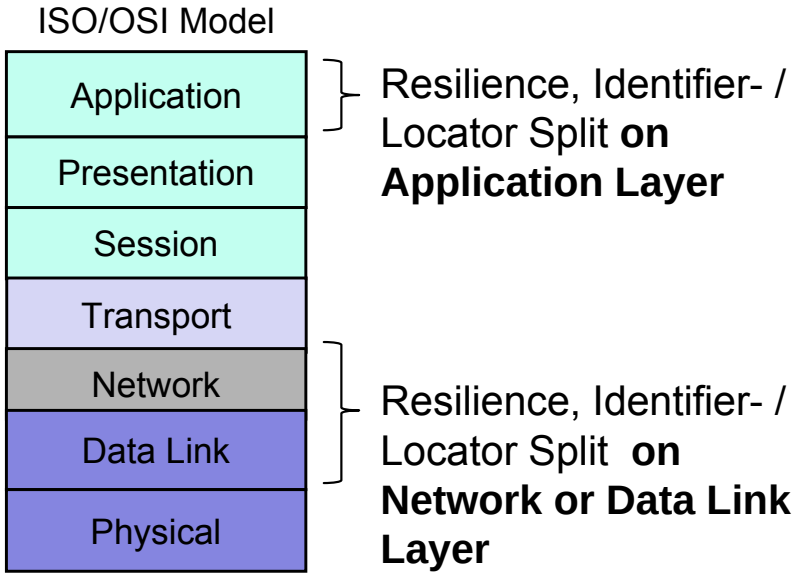
Functional Overload



Functional Ambiguity



- We probably **need** a new reference architecture!
- How to separate fcts? An where to place fcts?
- Which architecture is **„better“**, i.e. **„A > B“**
  - Mapping to a numerical scale?
- What is an **architecture reference model?**

What is Architecture?

Museums

Churches

Train Stations

- Each architecture/system has a specific purpose!
- Louis Sullivan: **“Form** (ever) **Follows Function”** → set of requirements (multi stakeholder goals)
- Is it possible/feasible to to compare architectures for different purposes? Or different views of one architecture?
- If yes, under which which circumstances, constraints, conditions, … ?
- Normalization/coordination is required! What are the interfaces?

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What is Architecture?

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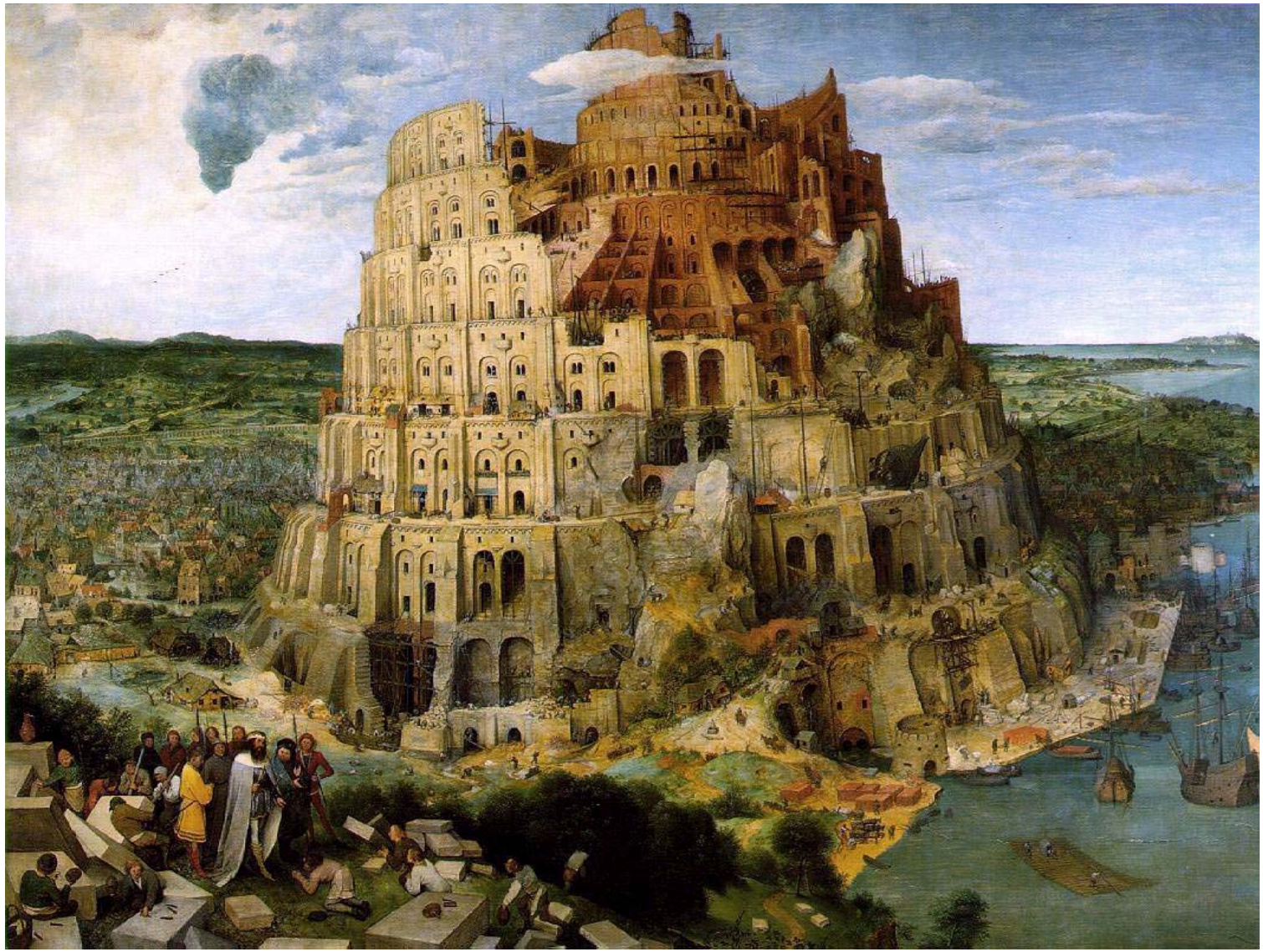
Tower of Babel



What is a Reference Model?

- From software architecture: OASIS (Organization for the Advancement of Structured Information Standards, 1993-2009): *Reference Architecture Foundation for Service Oriented Architecture* (Version 1.0)
  - Abstract framework for understanding **significant relationships** among entities of some environment
  - Consists of a **minimal set** of unifying concepts, axioms and relationships within a particular problem domain
  - Is **independent of specific technologies**, standards, implementations, or other concrete details.

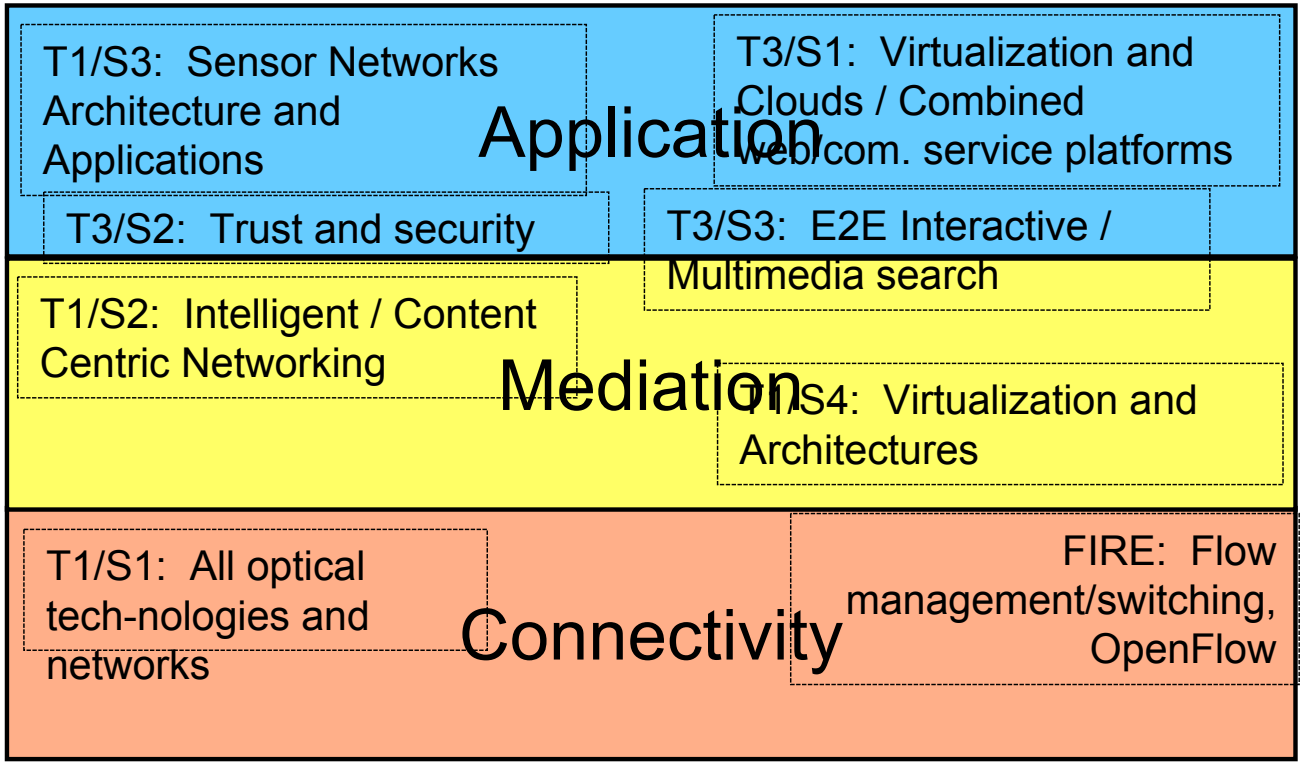
Structure and Comparison

- **Separation of Concerns** (E. W. Dijkstra, 1974; C. Reade, 1989)
  - **Concern**: any piece of interest or focus in a program
  - Process of separating a computer program into distinct features that overlap in functionality as little as possible
  - "… isolation for the sake of its own consistency …"
  - Achieved by **modularity** and **encapsulation;** facilitated e.g., by layered designs; other concept possible ("heaps" instead of "stacks", e.g. Braden, Faber and Handley, ACM Sigcomm CCR, Jan. 2003)

→ How does this relates to reality?

Example: Separation of Concerns

- **Is a simple three-layer architecture suitable?**
  - Classification of project sessions at 3rd EU-Japan Symposium on Future Internet (Oct. 2010)



→ At least suitable for strategic decisions

→ Concerns guide also selection of **quality attributed**

Compare Quality of Architectures

- **Quality** (from Latin *qualitas*): an attribute or a property. Attributes are ascribable (by a subject), whereas properties are possessable.

→ Depends on criteria applied to it.

- **Quality** as defined **by ISO 9000:** "Degree to which a set of inherent characteristics fulfills requirements"
- **Quality of Architectures**
  - Non-functional quality: how an architecture is **supposed to be**
    - Fault-tolerant, backward compatibility, extensibility, maintainability, availability, security, usability, flexibility (e.g. for the **Polymorphic Internet**) …
    - ***Hard to quantify***
  - Functional quality: what a architecture is **supposed to do**
    - Fast, efficient, required/consumed resources
    - ***Easier to quantify***

How to Measure and Evaluate Quality?

- Basis: **measurable quality attributes for architectures (features)**
  - Various characteristics, metrics, dimensions, …
  - For example: load, throughput, MTBF, …

→ In general two alternatives:

  - feature **is measurable** or
  - feature **can be made measurable**

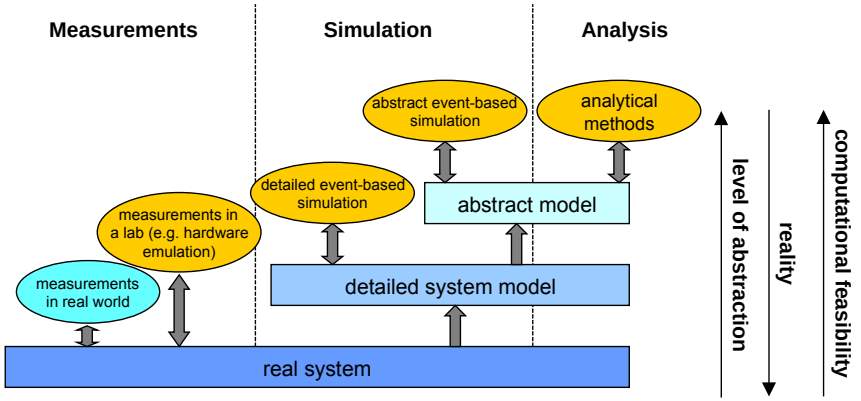
→ Overall **quality model**: *systematic (e.g. weighted , normalized) combination of quality features*

  - Quantification of obligatory, mandatory, or elective features

→ **Formulation of axioms for quality metrics**

Formulation of Quality Metrics

- Relatively easy: **numerical performance evaluations** of architectures wrt QoS (loss, delay) and eventually QoE (MOS)



- Problem: **vaguely defined quality attributes for architectures,**
  - Example “maintainability” → **In general:** which measurable attributes determines the quality subject and in which way they related with the subject?

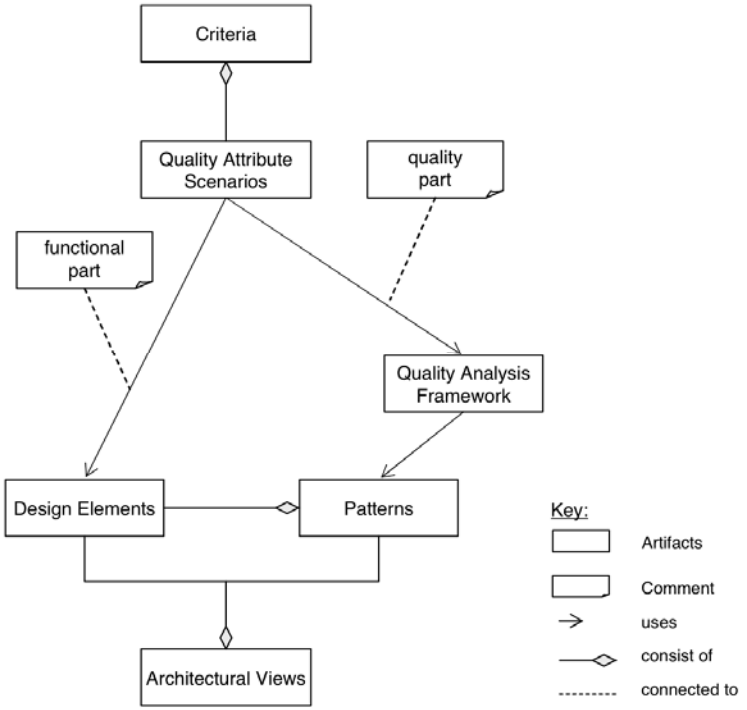
→ Need: **Goal-oriented derivation of appropriate metric** (with minimization of the cardinality of the attribute set)

  - Be appropriate for the context! → Context may vary

Formulation of Quality Metrics

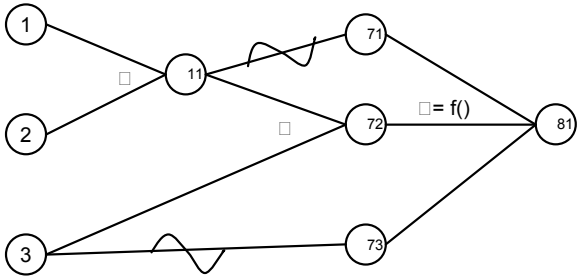
- From software design and evaluation: **SACAM framework**(Software Architecture Comparison Analysis Method; C. Stoermer, et al., 2003)
  - *Reasoning as to whether quality attributes are satisfied by an architecture candidate*
  - Assistance in searching for particular indicators in the architectural documentation

→ **Score each architecture on a scenario basis**

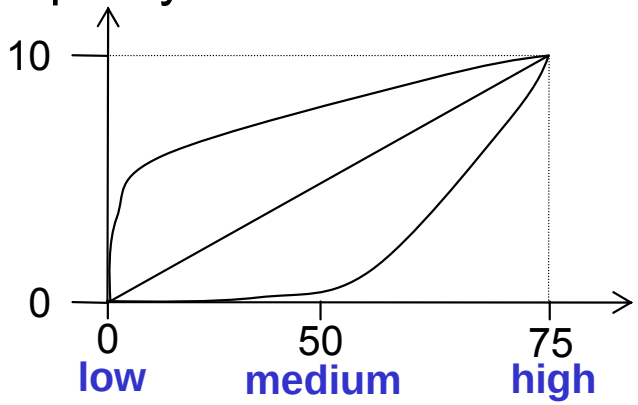


Relation of Quality Attributes

- **Cause-and-Effect Graph**
  - Separation into measurable sub-metrics
  - Specify causes and effects for sub-metrics (Div&Conq)



  - Various relationships: arithmetic/geometric mean, etc.
- **Identify functional relationships**
  - Define **Score Functions**, e.g. with normalized value range [0…10], for score of quality attributes
    - Numerical values
    - Properties



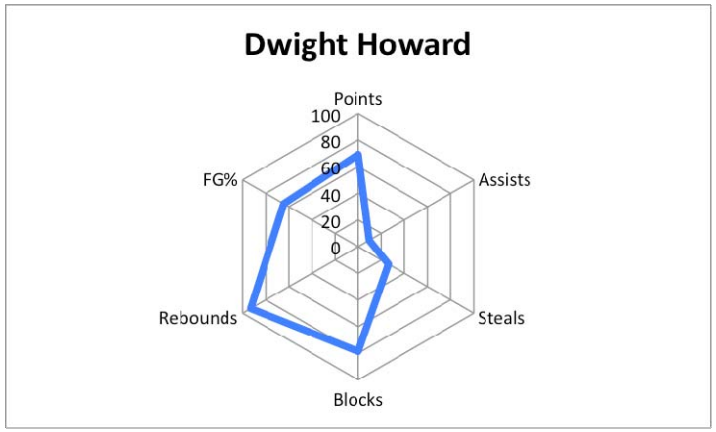
Multi-Dimensional Evaluation

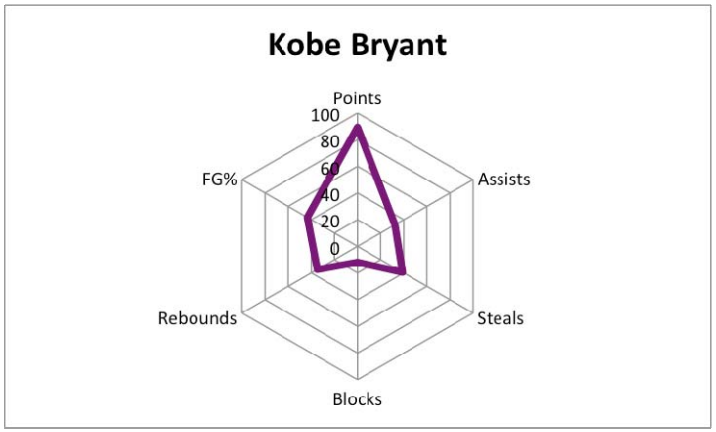
- Problem: **Comparison of scores N dimensions**

→ **Radar (Kiviat) graphs** or **star plots** (Chambers, 1983)

  – Displaying multivariate data, each star represents a single observation.

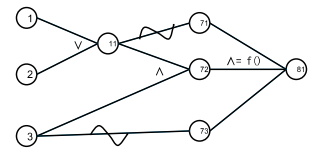
  – Typically, multi-plot format with many stars on each page and each star representing one score with many dimensions

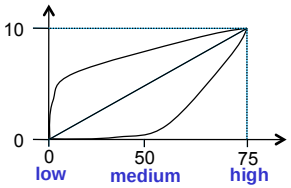


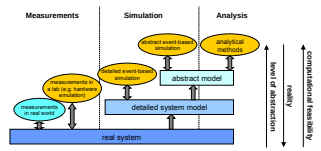


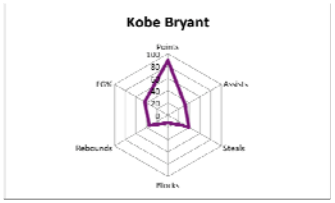
A First Architecture Evaluation Recipe

- **Acknowledge the plurality of Future Internet** architectures
  → define and apply *comparison scenarios*
- Make **causally determined decisions on**
  - Cause-and-effect graphs
  - Specify scoring dimensions and scoring functions and determine weights
  - Compute base quality/performance attributes by mathematical performance analysis
  - Use multivariate comparison









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Conclusion

- **Presentation of various comparison methods from a variety of disciplines**
  - Network design, software design, operations research, ...
  - Comparison based on scenarios **(= no unified architecture?)**

→ **Identify causal relationships (= multi-disciplinary modeling)**

- **Many open questions**
  - Specification of metrics, e.g. for dynamic networks with node churn
  - Which and how many quality dimensions are needed?
  - Is relative comparison sufficient? (no absolute values)
  - How to do **sensitivity analysis?**
    - **May improve the "separation of concerns"!**