Technische Universität München
Lehrstuhl für Kommunikationsnetze
Prof. Dr.-Ing. Wolfgang Kellerer

Forschungsausschuss Münchner Kreis
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Software Defined Networking

Wolfgang Kellerer
wolfgang.kellerer@tum.de

Paradigm Shift

- Internet: basic economic factor for industries across all disciplines of our information society → new requirements
- Internet technology: too complex for changes, lacks proper resource management, scalability, flexibility, security, mobility, …

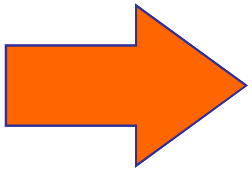
Need for dynamic control & management to support rapid innovation

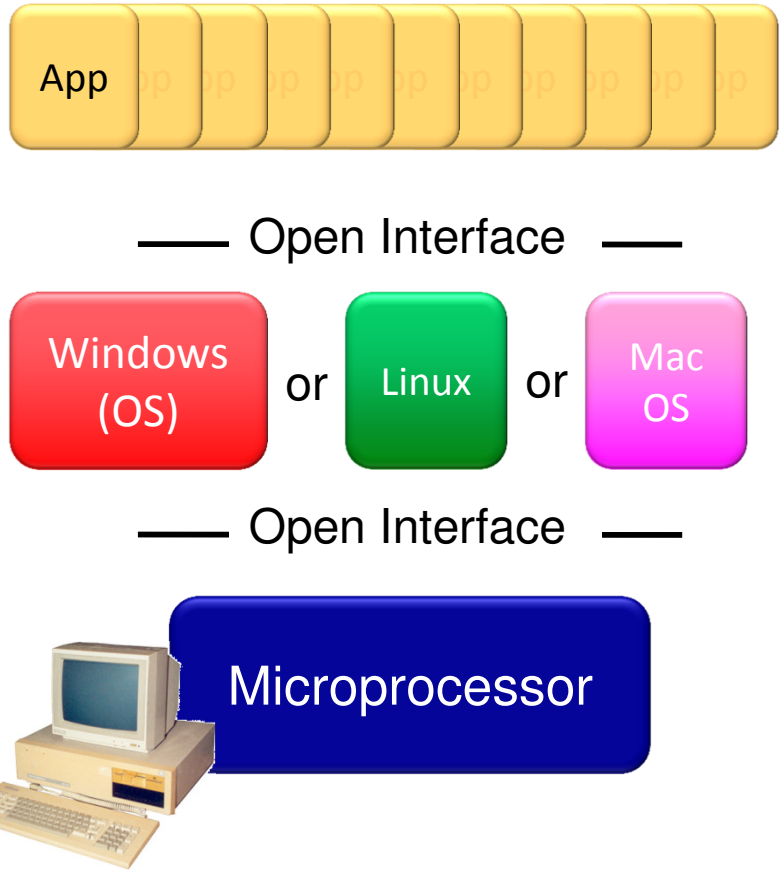
- Software Defined Networking (SDN) describes an abstraction to cope with the complexity in the network in a dynamic way

- Network virtualization describes a mechanism to manage network resources more dynamically and more efficiently (sharing!)

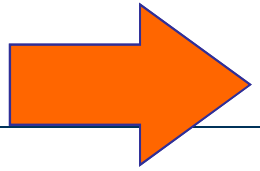
Paradigm shift in Computing

Vertically integrated
Closed, proprietary
Slow innovation
Small industry



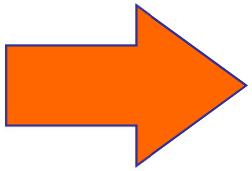


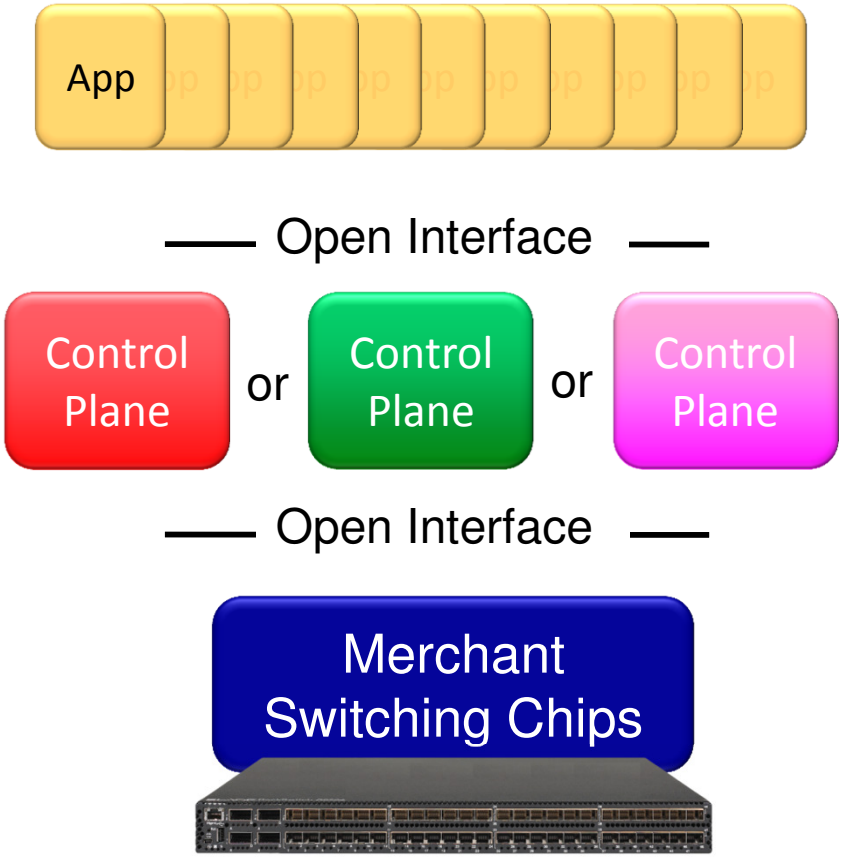
Horizontal
Open interfaces
Rapid innovation
Huge industry



From Nick McKeown, Stanford University, ACM SIGCOMM 2012

Can we do the same for networks?





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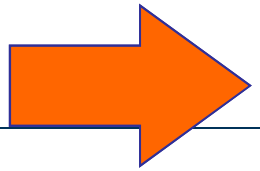

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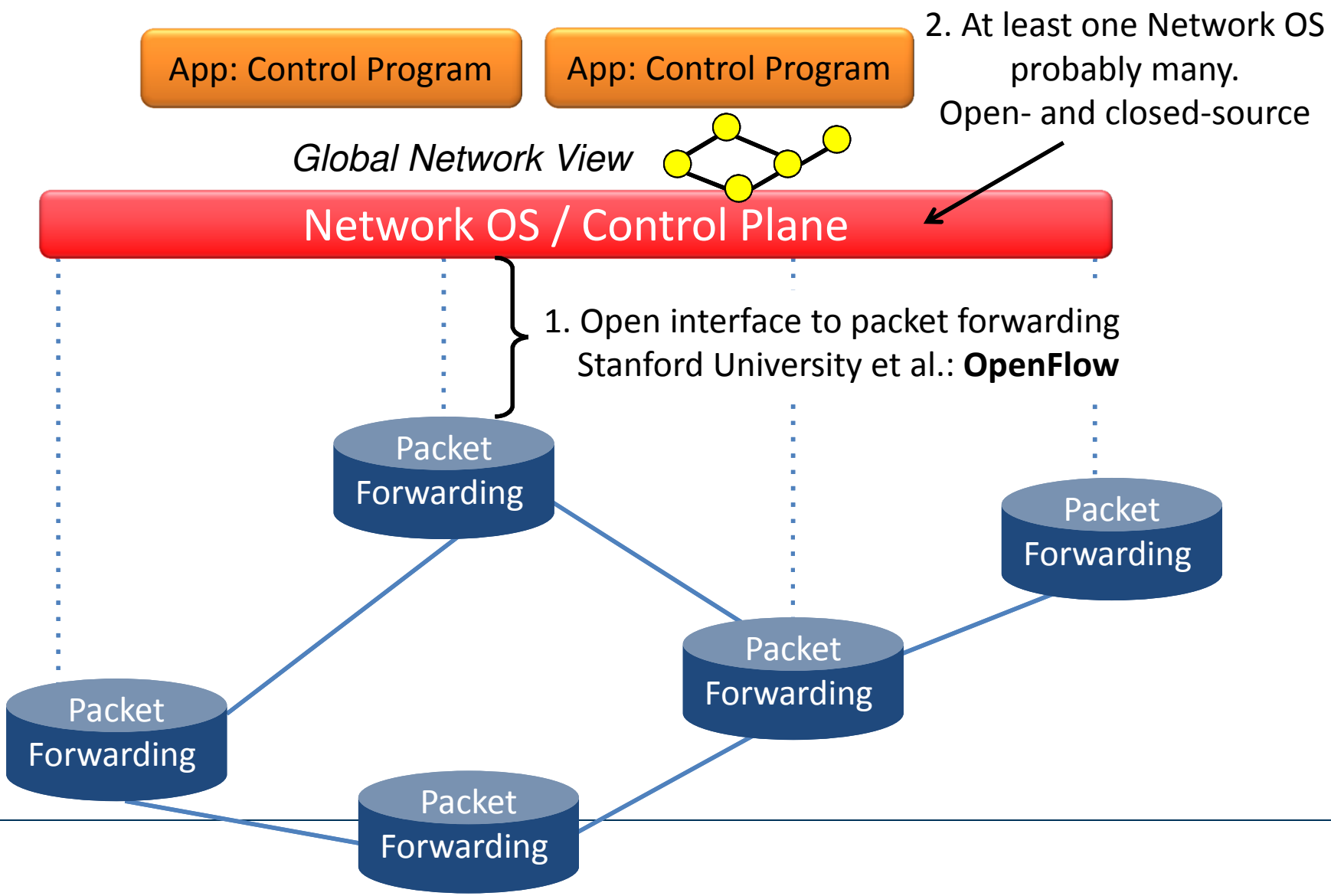
Software Defined Networking



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Opportunities

Programmability and Abstraction

- Customize networks: Introduction of new control architectures
  - centralized control
  - efficient operation: fault management, fast error recovery
- Reduce cost through competition: diversified supply chain
- Innovate faster and more efficiently
  - Fast innovation through open, standardized interfaces
  - Innovation inside the network rather than over the top
- Allow sharing among operators
  - Create virtual, isolated networks (slicing)

Context

- **Programmability and APIs**
  - Network APIs came up in 2000 to allow application innovation in the network
  - „Parlay API“ was outrun by *over the top* solutions

- **SDN allows to centralize intelligence in networks**
  - is network operators dream to provide QoS, mobility, reliability, AAA,…
  - „Intelligent Network“ (ITU Q.1200) in the 90ies
  - But: Internet is based on strict decentralization

- **Network virtualization** – a matter of abstraction level
  a. Use SDN abstraction to realize isolation and slicing of links (label switching)
  b. Virtualize/slice all network parts (incl. servers, nodes, “cloud“) and use SDN principle for the control of each part - towards a unified control plane

→ Network virtualization and SDN shall be considered jointly

Main Players & Status

- SDN idea emerged from Stanford University Clean Slate program
- SDN concept is an evolutionany apporach to today‘s networks

- Open Networking Foundation (since March 2011)
  - promoting the OpenFlow protocol for the SDN API
  - Members incl.: DTAG, Google, MS, Facebook, NTT, Verizon, Yahoo, CISCO,…

- Research has started by telcos, vendors, academia globally
  - Individual: DTAG, NSN, ALU, Ericsson, DOCOMO,…
  - EU projects: OFELIA, OASE, RESERVOIR, …
  - National projects: G-Lab
- Related experimental platforms: GENI, FIRE, G-Lab

- **Programmability of networks by software means independence from HW vendors (US origin): need for clever control software**

Challenges

- What is the right abstraction level?
- Scalability: central vs. distributed control? Coordination?
- Scalability: can we realize carrier grade core network transport?
- Dynamic network changes: embedding and re-embedding
- Security: How can we prevent misuse of critical infrastructure?
- (How fast) can we converge to a standardized API?
- Application-awareness

Danke für Ihre Aufmerksamkeit!

Prof. Dr.-Ing. Wolfgang Kellerer
Lehrstuhl für Kommunikationsnetze
Technische Universität München
wolfgang.kellerer@tum.de

Lehrstuhl für Kommunikationsnetze

Kommunikationsnetze als *die* Querschnittsfunktion
der Informationsgesellschaft …

(Neue) Prinzipien und Architekturen (Fest- und Mobilnetze)

- Software Defined Networking als Innovationsmotor
- Netzvirtualisierung
- Selbstorganisierte Netze
- Ressourcenmanagement in mobilen Netzen
- Optische Netze

Neue Anforderungen durch innovative Anwendungsfelder

- Energieeffizienz/Smart Grid
- Fahrzeugnetze
- eMobility
- Maschine-zu-Maschine Kommunikation
- Soziale Netze
- Sichere Kommunikation

Methodische Grundlagen

Architekturkonzepte – Selbstorganisation – Cross-Layer – Protokolle – Security Analyse – Optimierung – Fehlertoleranz – Leistungsbewertung – Simulation – Techno-Ökonomische Bewertung – Mobilitätsmanagement – Verteilte Systeme

Prof. Dr.-Ing. Wolfgang Kellerer

- 1996-2001: Promotion an der TUM
- 2001: Forschungsaufenthalt an der Stanford University, USA
- 2002-2012: DOCOMO Communication Labs Europe in München
  - Forschungsinstitut des japanischen Netzbetreibers NTT DOCOMO
  - Zuletzt: Leiter der Forschungsabteilung für Mobile Netze und Übertragungstechnik (ca. 30 Mitarbeiter)
  - Forschung zu Grundlagen für zukünftige mobile Netze: *Next Mobile Network* 2020
    - Signalisierungssysteme und Dienstplattformen
    - Peer-to-Peer Netze und Selbstorganisation
    - Mobile Breitbandkommunikation und Future Internet
    - Optische Netze und Fixed Mobile Convergence
  - Standardisierung in IETF (RFC5631) und 3GPP (IMS, traffic mgmt./QoE)
  - EU Projekte (EARTH, SAIL, METIS,…), BMBF G-Lab & SASER, ...
  - Kooperationen mit Universitäten und Industrie (NSN, ALU, E///, NEC,…)
  - > 100 Publikationen
  - > 40 Patentanmeldungen (25 erteilt)
- Seit Juli 2012: Professor an der TUM, Leiter Lehrstuhl für Kommunikationsnetze
- Mitglied in ITG/GI FA 6.4 (KuVS), Leiter ITG FG 5.2.4 (Mobility), Senior member IEEE