DataCenter 2020.
Data Center Management and Efficiency at Its Best.
OpenFlow/SDN in Data Centers for Energy Conservation.

Dr. Rainer Weidmann, DC Architecture & DC Innovation

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Deutsche Telekom.
Partner for connected life and work.

Deutsche Telekom delivers one-stop services and solutions:
for all customer communications needs – at home, on the move and at work.

T-Mobile

T-Mobile offers cell-phone solutions in the Netherlands, Austria, and the Czech Republic.

T Mobile

Telekom

The Telekom subsidiaries provide products and services for the fixed network, mobile communications, the Internet and IPTV in Europe.

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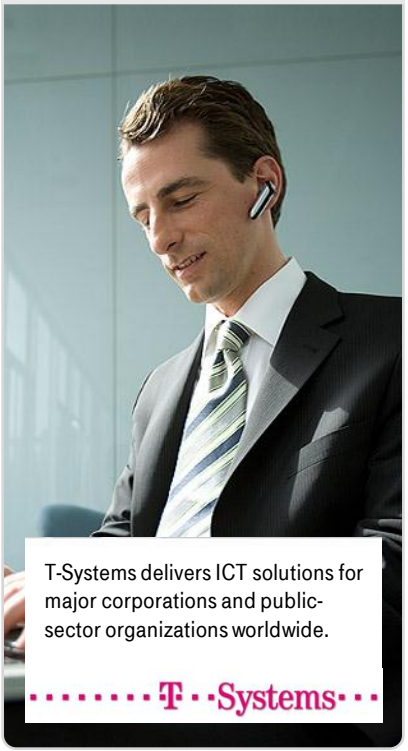

T-Systems delivers ICT solutions for major corporations and public-sector organizations worldwide.

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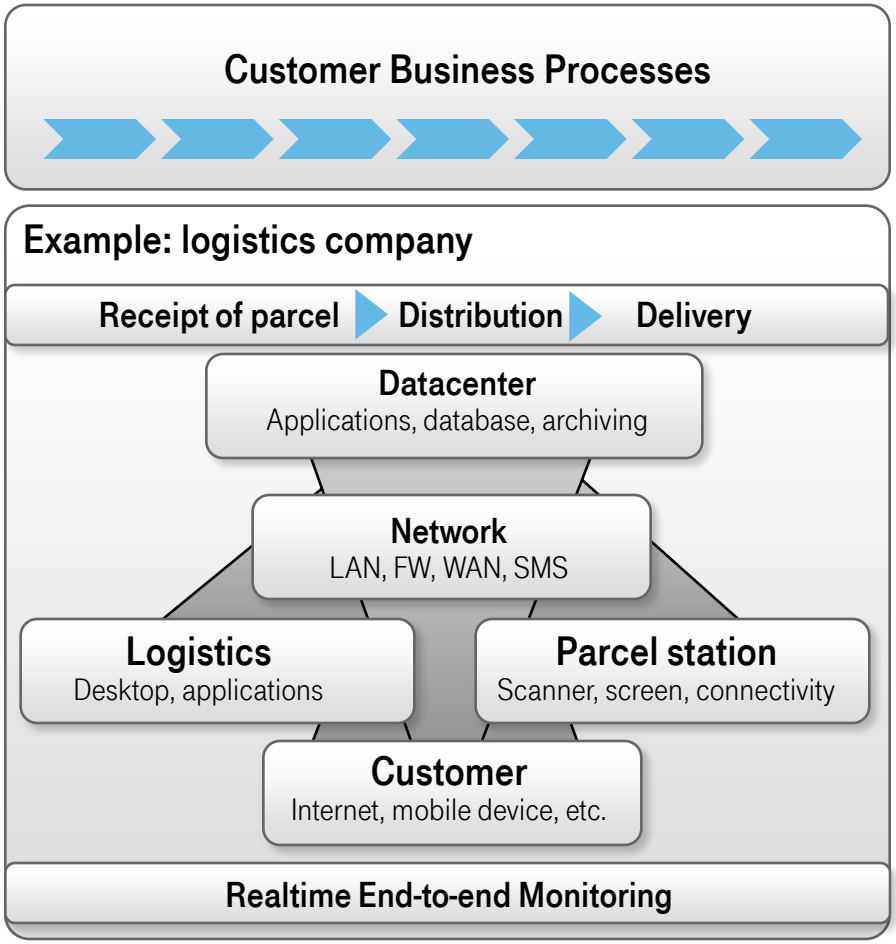
T-Systems delivers ICT:
End-to-end IT and telecommunications services.

Design – Implementation – Operation
Integrated ITIL Processes



End-to-End Monitoring
End-to-End Service Levels

ICT expertise.

- a single point of responsibility
- customer-specific price models, e.g. Price per desktop
- dynamic services with flexible up- and down scaling
- replacement of up-front investments with monthly costs
- cost savings of up 30 percent
- easy integration of new technologies
- greater transparency and security
- more growth thanks to new business models

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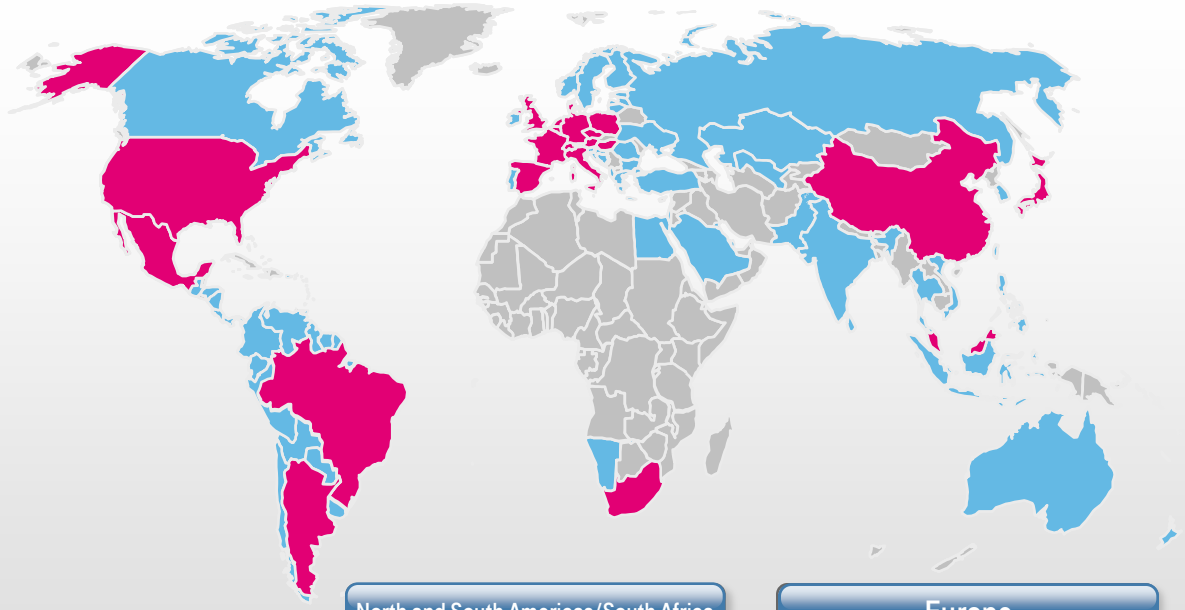
Scalable platforms: unmatched IT infrastructure skills.

IT Infrastructure.



T-Systems
Partners

Facts and figures

- 119,900 m^2 data center space
- 91 Data Center managed by T-Systems
- 118,600 MIPS
- 58,000 open systems server
- 23.6 m installed SAPs
- 3.2 m named SAP user
- 1.5 m managed seats
- 2,343 service desk agents
- 556,551 exchange mailboxes
- 276,697 notes mailboxes

North and South Americas/South Africa	
Data center m^2	19,800
DC managed TS	17
MIPS	11,100
Open systems server	11,400
Installed SAPs	3.2 m
Named SAP user	186,700

Europe	
Data center m^2	96,200
DC managed TS	67
MIPS	106,900
Open systems server	44,700
Installed SAPs	24.4 m
Named SAP user	3.0 m

Asia Pazific	
Data center m^2	3,900
DC managed by TS	7
MIPS	600
Open systems server	1,900
Installed SAPs	45,700
Named SAP user	14,000

As of May 2011

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DC2020 - Motivation/General Duties

Observations & Responsibility

Operational

- Steadily increasing power consumption of Data Centers
- Steadily increasing density in Data Centers

Environment

- Climate Change Group (DTAG)
- T-Systems' Core Beliefs: Sustainability & Corporate Responsibility.

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CO_2

Infrastructure Test Lab

- "Closed Shop" / No limits
- Testbed for benchmarking

Optimize Energy efficiency

Definition: energy efficiency of a DC
(PUE, Power Usage Effectiveness, the green grid™)

$$PUE = \frac{\text{total Facility Power}}{\text{IT-Equipment Power}}$$

(average value 1 year)

Fields for improvement

- Legacy DC
- Blueprint for DC 2020
- CFD Models

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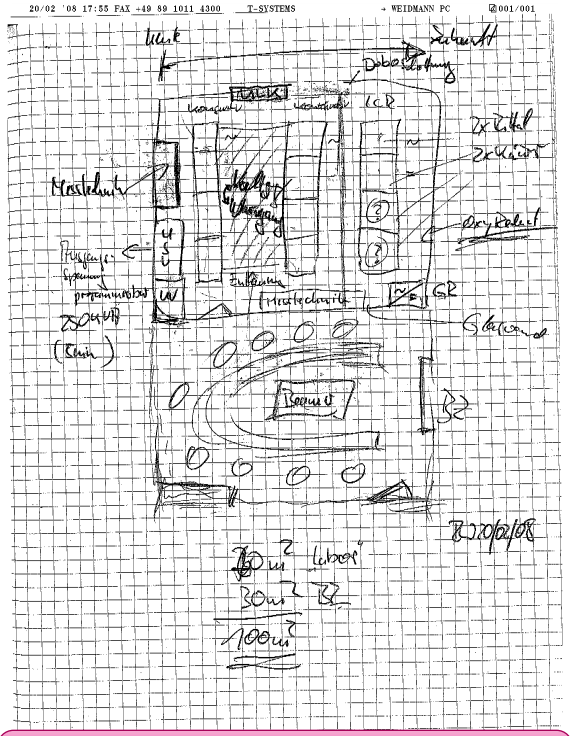
DC2020.
Technical Features.

- Floor space 67 + 67 m²
- Raised Floor 80cm
- 190 real Servers
- 8 Racks & 1 liquid cooled rack
- AC-UPS (250kVA)
- DC-Supply (48V, 600A)
- Adjustable ceiling
- Coated walls
- Smoke generator

- Cold water supply (290kW)
- Free cooling capability
- Plate Heat Exchanger
- CRAC EC
- CRAC FT
- CRAC Humidity
- Cold aisle containment
- Hot aisle containment
- Building mgmt. system (1800 Datapoints)



Basic Idea 2008

- Permanent inertization

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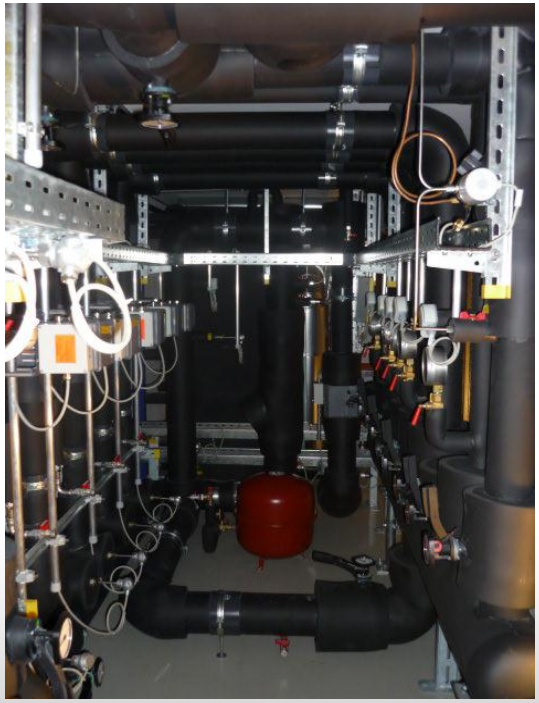
DC2020.
Pictures.

Top view from meeting room

Raised Floor

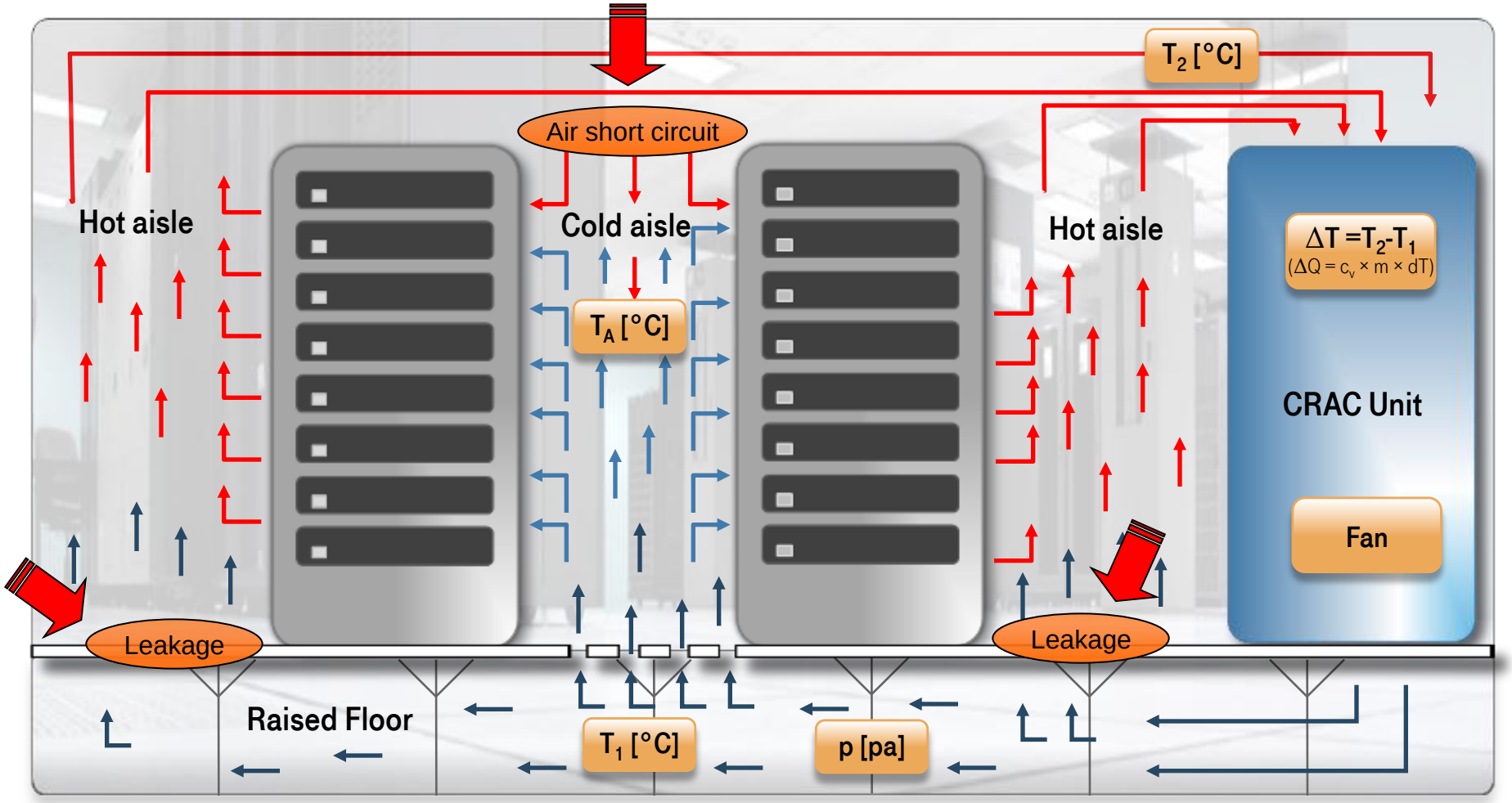


Cooling equipment

Smoke Generator

Enclosure and "Cooltrans"

Hot/Cold Aisle Room Layout.
General. Hot-/Cold-Aisle.



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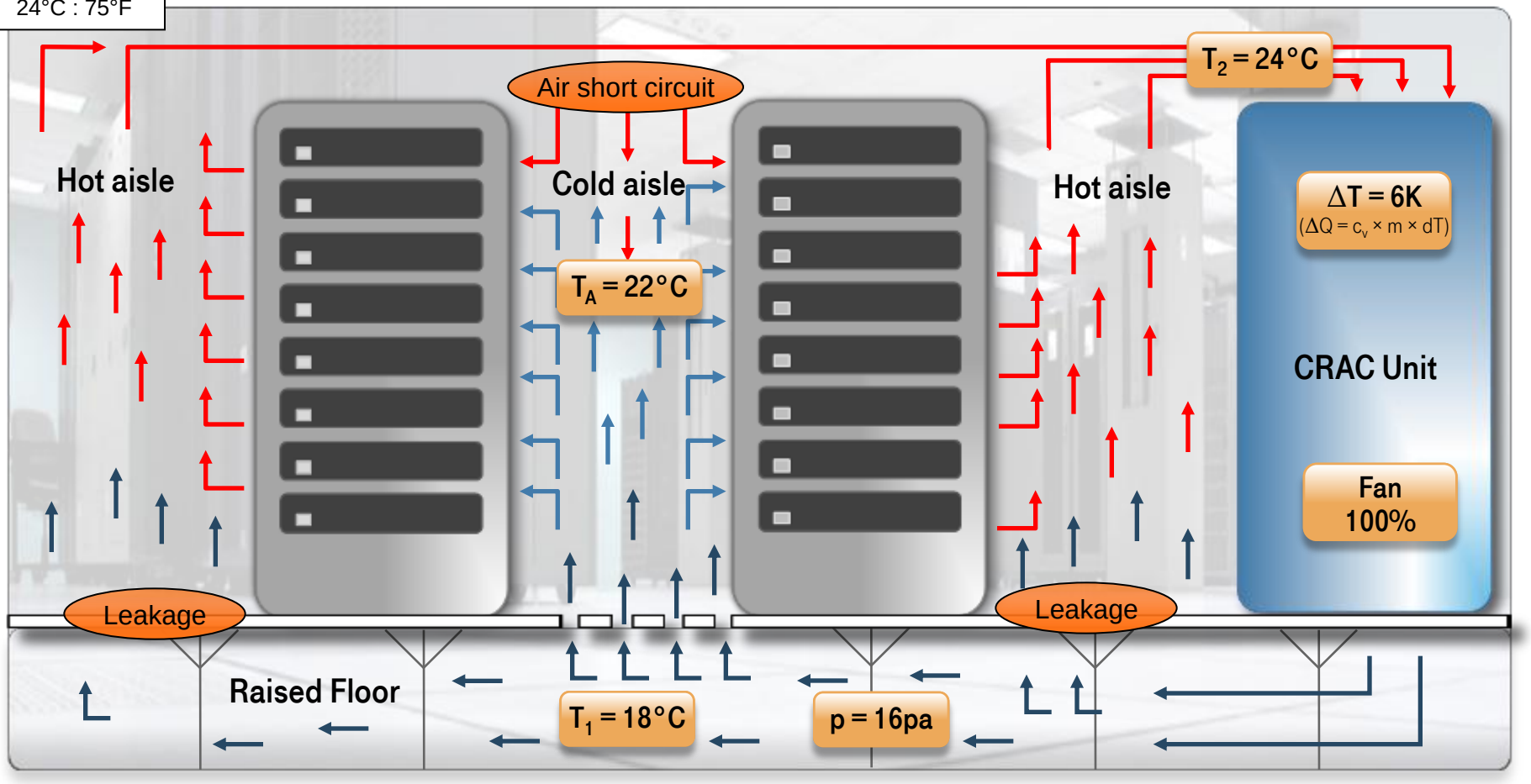
Hot/Cold Aisle Room Layout – Status Quo.

PUE_{typ} =2,20 …1,80

18°C : 64°F
22°C : 72°F
24°C : 75°F



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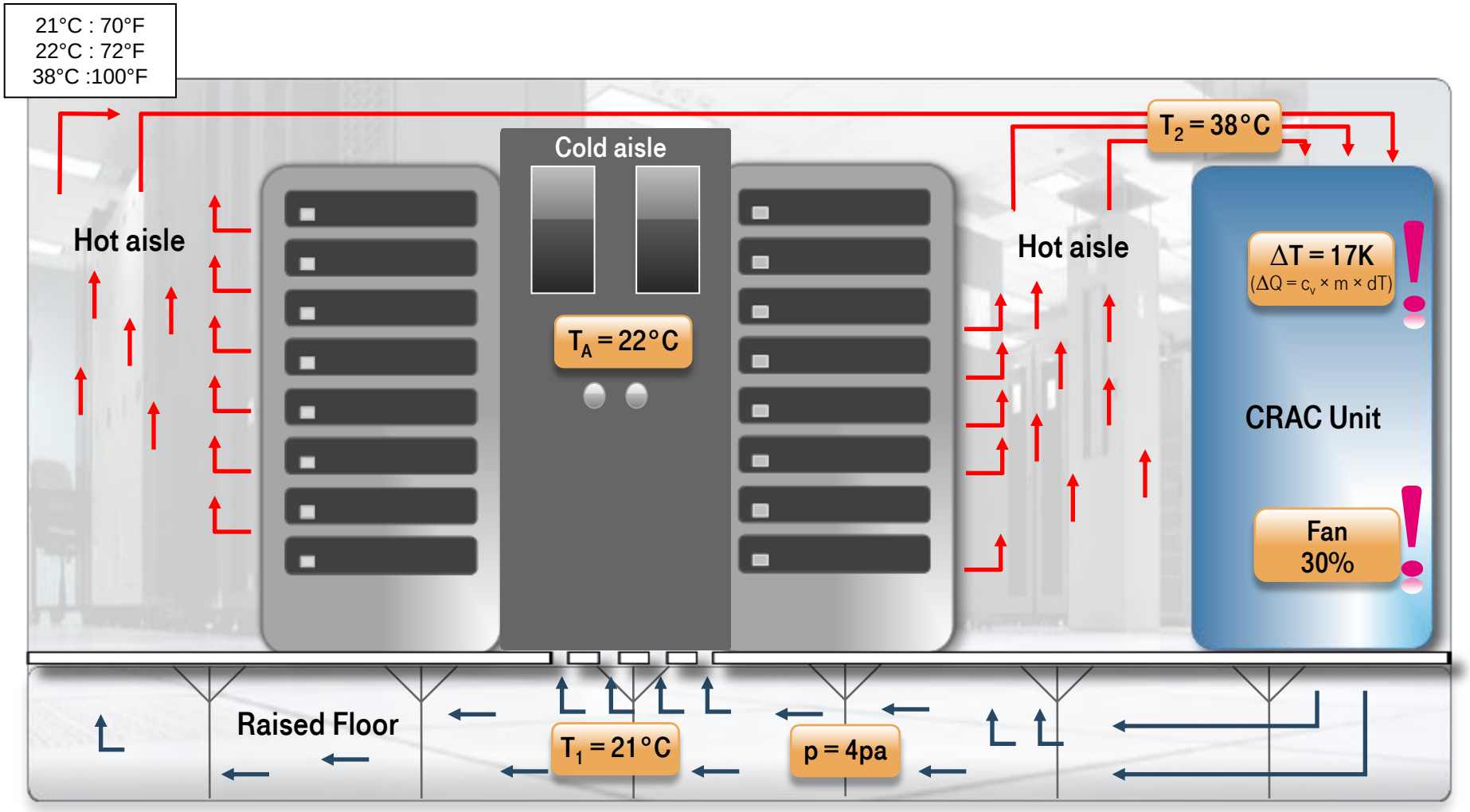
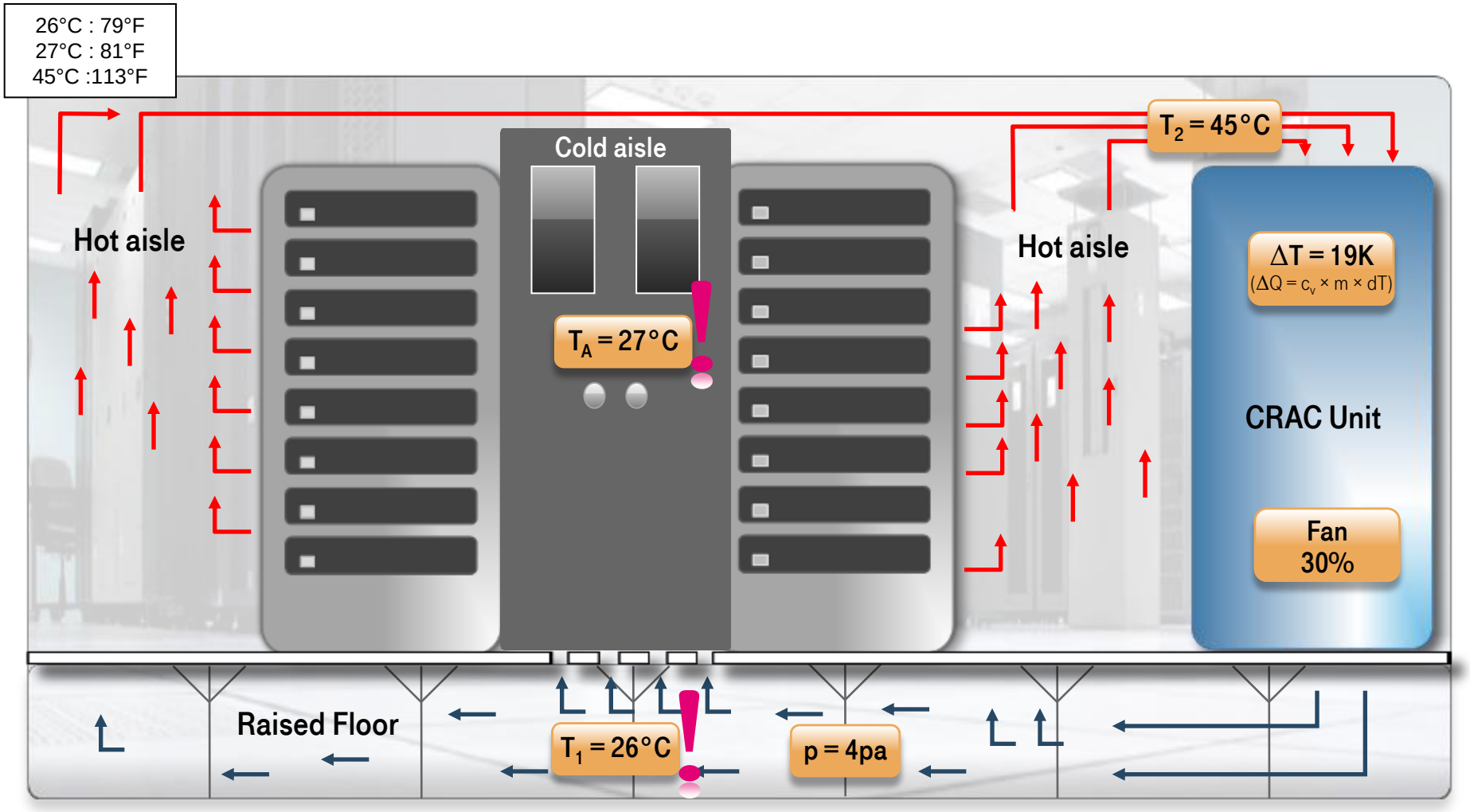
Hot/Cold Aisle Room Layout – Improvement I.

Leakage Reduction – **Cold-Aisle Containment** – Fan Speed Adjustment.



Hot/Cold Aisle Room Layout – Improvement II.

Leakage Reduction – **Cold-Aisle Containment** – Fan Speed Adjustment – Temperature.



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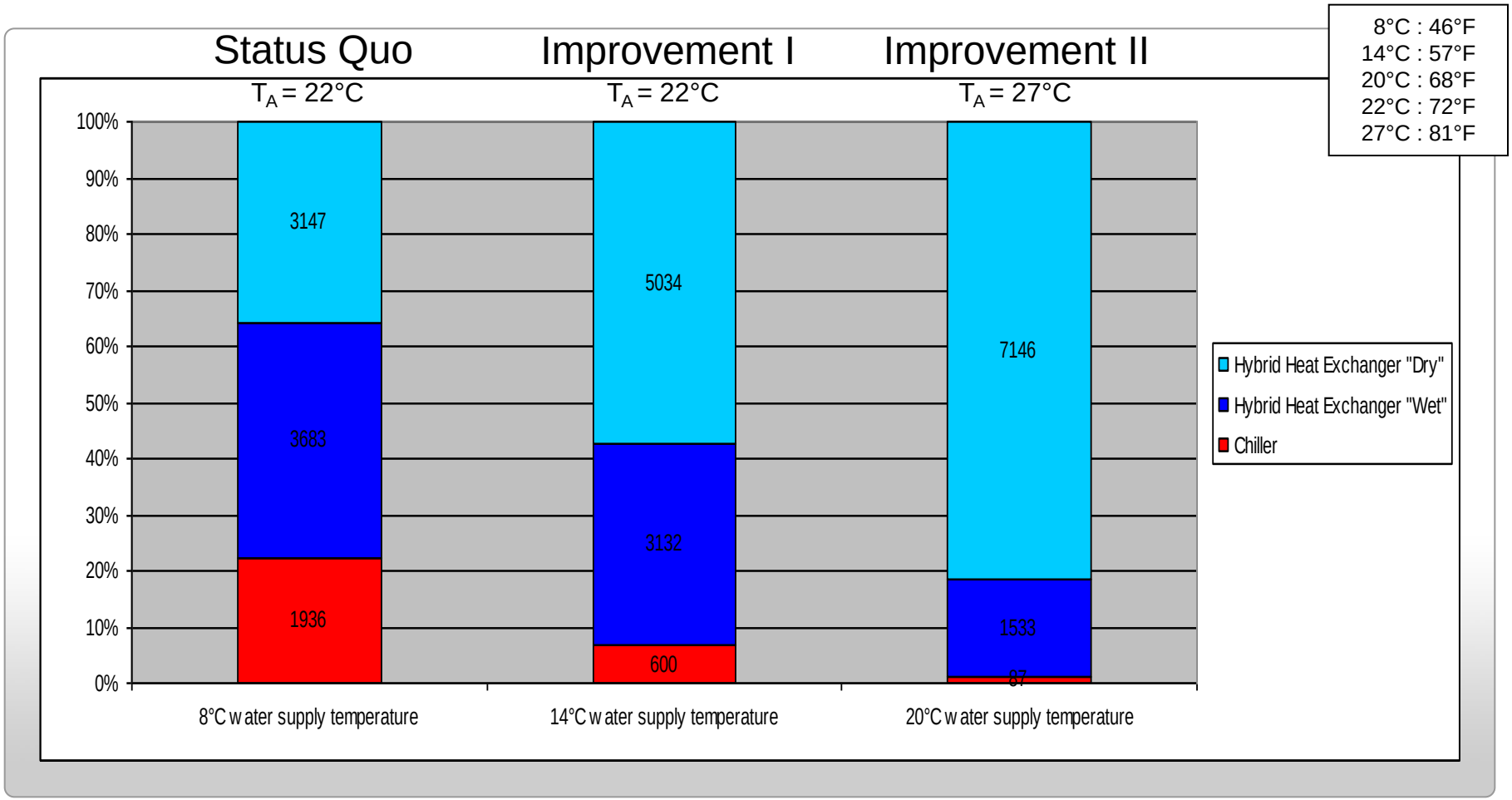
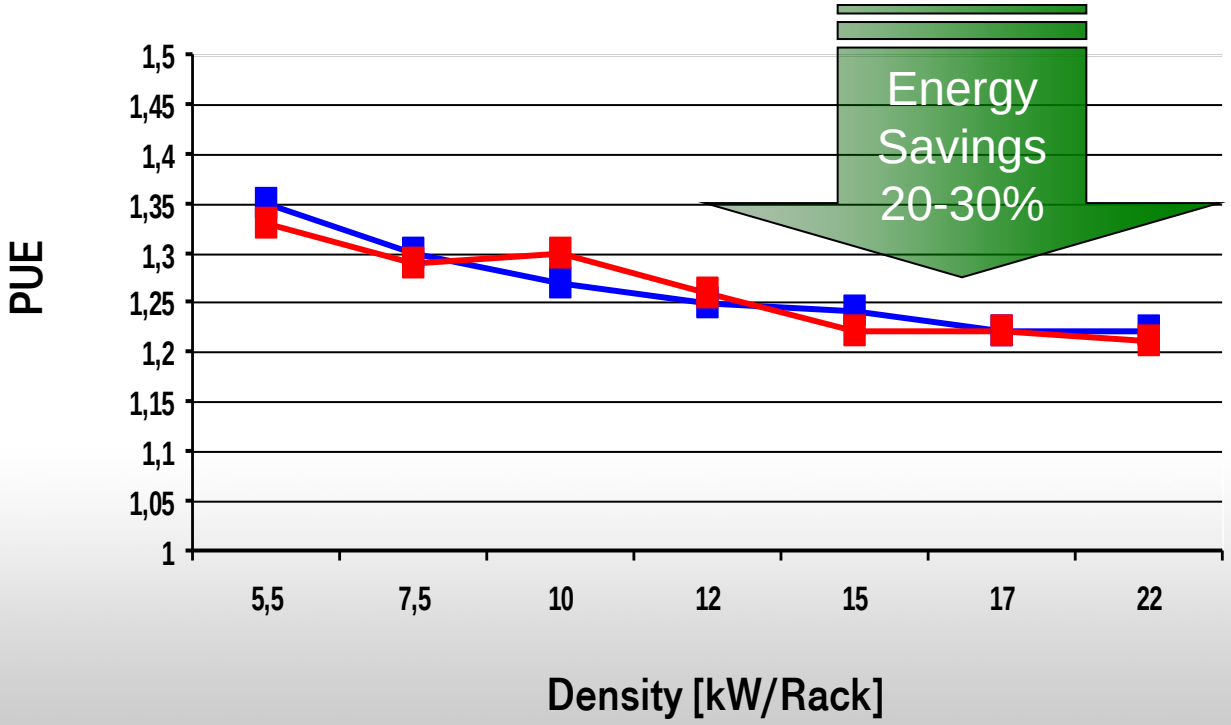
Overview – Free Cooling Period.
Hours of Operation (Loc. Munich).

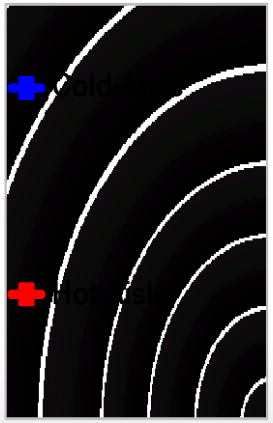


Cold- vs. Hot-Aisle Containment.
PUE Improvement I.

14°C : 57°F
22°C : 72°F

22°C Server Inlet Temperature ; 14°C Water Supply Temperature

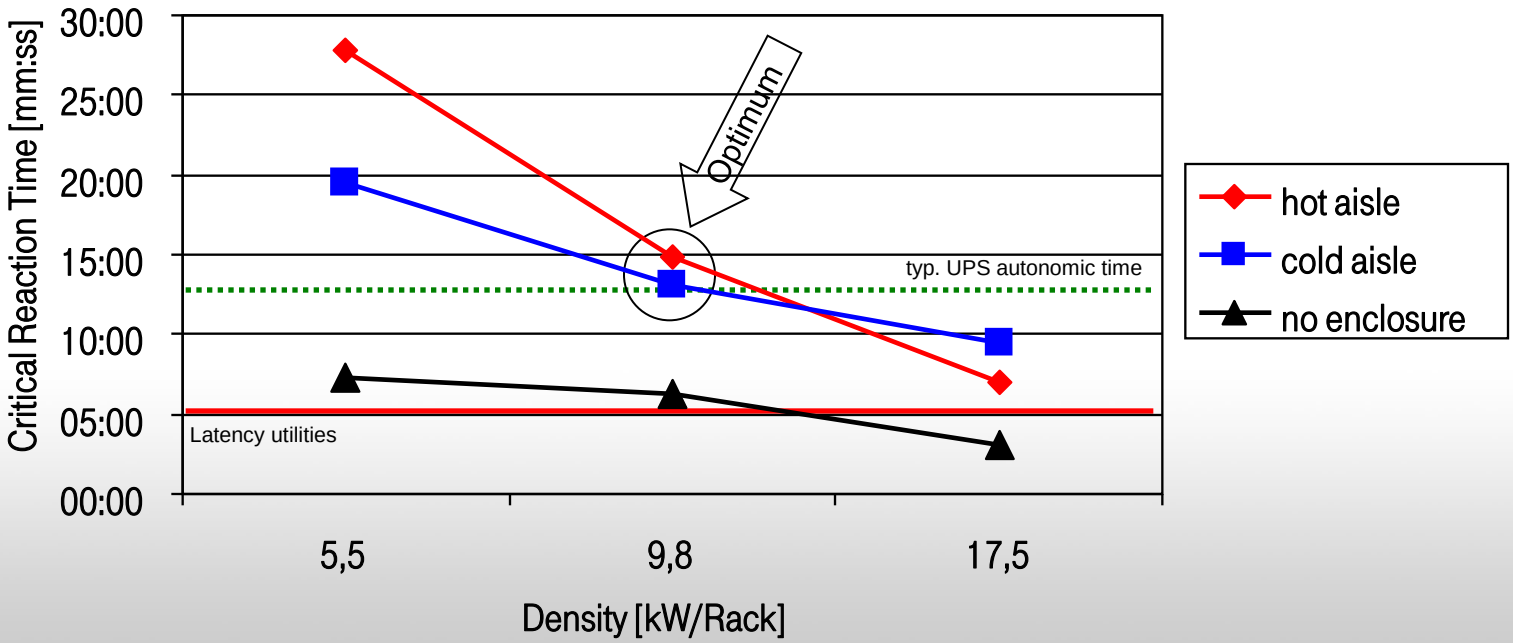




Cold-/Hot-Aisle Containment
Total Outage of Airconditioning.
Critical Reaction Time vs. Density.

22°C : 72°F
35°C : 95°F

22°C →35°C Server Inlet Temperature T_A



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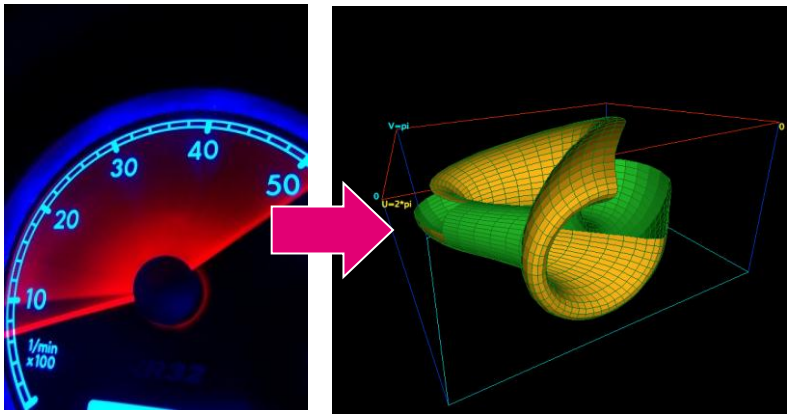
Lessons Learned Phase 1.

- PUE of 1.3 or better possible with standard techniques already available
- Leakage Reduction and Enclosures necessary (Cold-/Hot-Aisle enclosure)
- Homogenous airflow very important (flow direction, air velocity, pressure)
- Standardized Hardware useful ("Dynamic Services")
- Room height is of minor interest (in case of enclosures no influence)
- Increase of DC-Availability with Enclosures
- Savings increase with increase of power density in Datacenters

Recommendations

→ Reduce Fan speed in CRAC Units
→ Increase Temperatures (ASHRAE 2008)
→ Infrastructure „on demand" (IT leading)

→ Increase Density to > 10kW/Rack (avg)
  → Increase average CPU utilization
  → Dynamic Load sharing



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Next steps for DC2020 - Phase 2
Focused on end-to-end enterprise load management

- Upgrade the data center to use:
  - Private cloud application stacks
  - Equipment: latest CPU generation utilizing Intel Node Manager/Data Center Manager (blade level density)
- Considering infrastructure is already in place to measure power, investigate effectiveness of strategies for server and network power conservation:
  - Power capping vs. other forms of load limiting and distribution
  - Enable power conservation in computing resources
  - Reduce idle power consumption

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Potential of OpenFlow/SDN for energy conservation.

- Server level:
  - Caching/Proxying requests until wake-up
  - Mapping services to servers in an energy-aware manner
  - Migration and consolidation across 1 or more data centers
  - Workload allocation can be over a limited physical space so as to conserve cooling energy
- Network device level:
  - Using centralized control to coordinate across 1 or more data centers such that energy proportionality or multiple energy states at device level (e.g., IEEE 802.3AZ) is effectively used:
    - ElasticTree is an instance where we have only 2 modes: on/off.
      - Pack workload efficiently using OpenFlow/SDN
      - Turn off/on links/switches using config protocols
    - For each workload, move traffic away from elements at high energy mode

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DC server power management.
Energy-aware server provisioning and consolidation.

- Many existing ideas, on energy-aware provisioning, load consolidation and migration, for web services hosted across a collection of data centers:
  - Provisioning: NSDI 2008
  - Server consolidation: HotPower 2008
  - Load migration: SIGCOMM 2009

- SDN can enable these actions seamlessly without causing disruption:
  - VM migration without dropping existing sessions
  - Allocate load in a power-aware manner
  - Triggering power on/off of computing nodes

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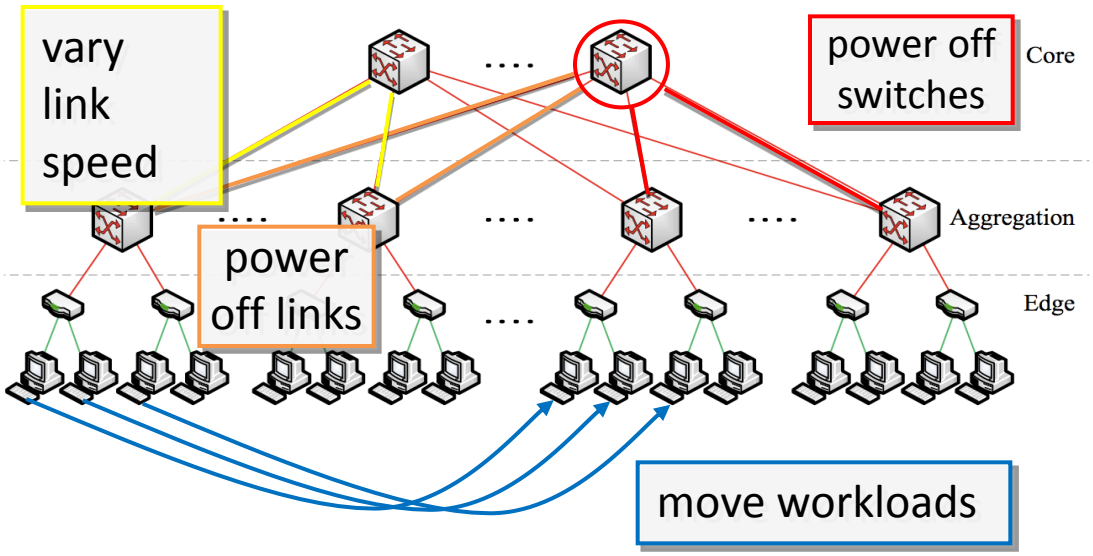
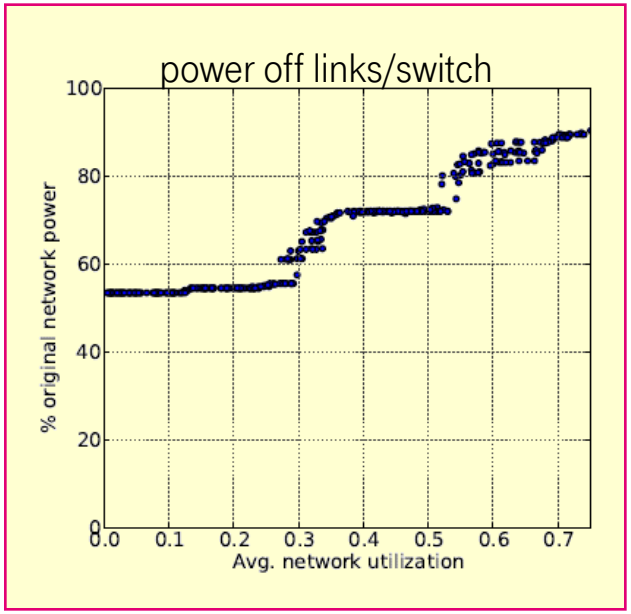
DC network power management.
Simple strategy with interesting power savings.

- ElasticTree work in collaboration with HP and Stanford University
  - Simple topology control can produce noticeable energy savings; savings increase with decrease in load.





Summary

- OpenFlow/SDN has potential to:
  - Intelligently trade-off power, redundancy, workload and performance.
  - Enable Dynamicity, automatic management and evolvability of the DC.
- DC2020 will help evaluate the potential in realistic environments and explorate to the desired scale
- How should the data center network look like, if energy-awareness is enabled by SDN, for maximum energy conservation?

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Thank you for your attention!

http://www.datacenter2020.de
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