Software Product Lines

Concepts, Analysis and Implementation

TECHNISCHE UNIVERSITÄT DARMSTADT

Dynamic Software Product Lines

Dr. rer. nat. Malte Lochau
malte.lochau@es.tu-darmstad.de

Karsten Saller, MSc.
saller@es.tu-darmstadt.de
Tel.+49 6151 16 - 3776

ES Real-Time Systems Lab
Prof. Dr. rer. nat. Andy Schürr
Dept. of Electrical Engineering and Information Technology
Dept. of Computer Science (adjunct Professor)

www.es.tu-darmstadt.de

23.04.2014

Inhalt

TECHNISCHE UNIVERSITÄT DARMSTADT

I. Einführung

- Motivation und Grundlagen
- Feature-orientierte Produktlinien

II. Produktlinien-Engineering

- Feature-Modelle und Produktkonfiguration
- Variabilitätsmodellierung im Lösungsraum
- Programmierparadigmen für Produktlinien

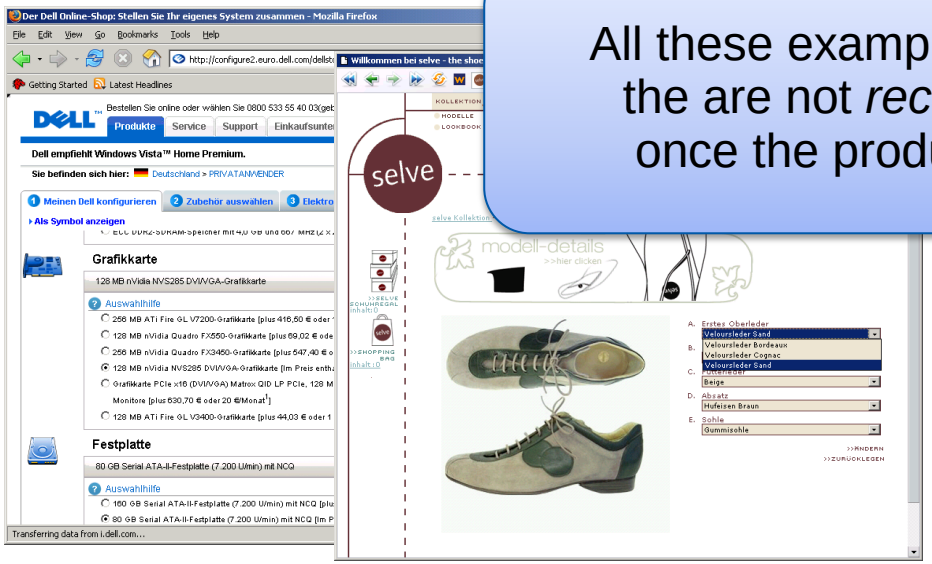
III. Produktlinien-Analyse

- Feature-Interaktion
- Testen von Produktlinien
- Verifikation von Produktlinien

IV. Fallbeispiele und aktuelle Forschungsthemen

- Adaptive Softwaresyteme
- Dynamische SPLs
- Zustandsbasierte Rekonfiguration
- DSPL & Forschung

Recap – Examples for an SPL

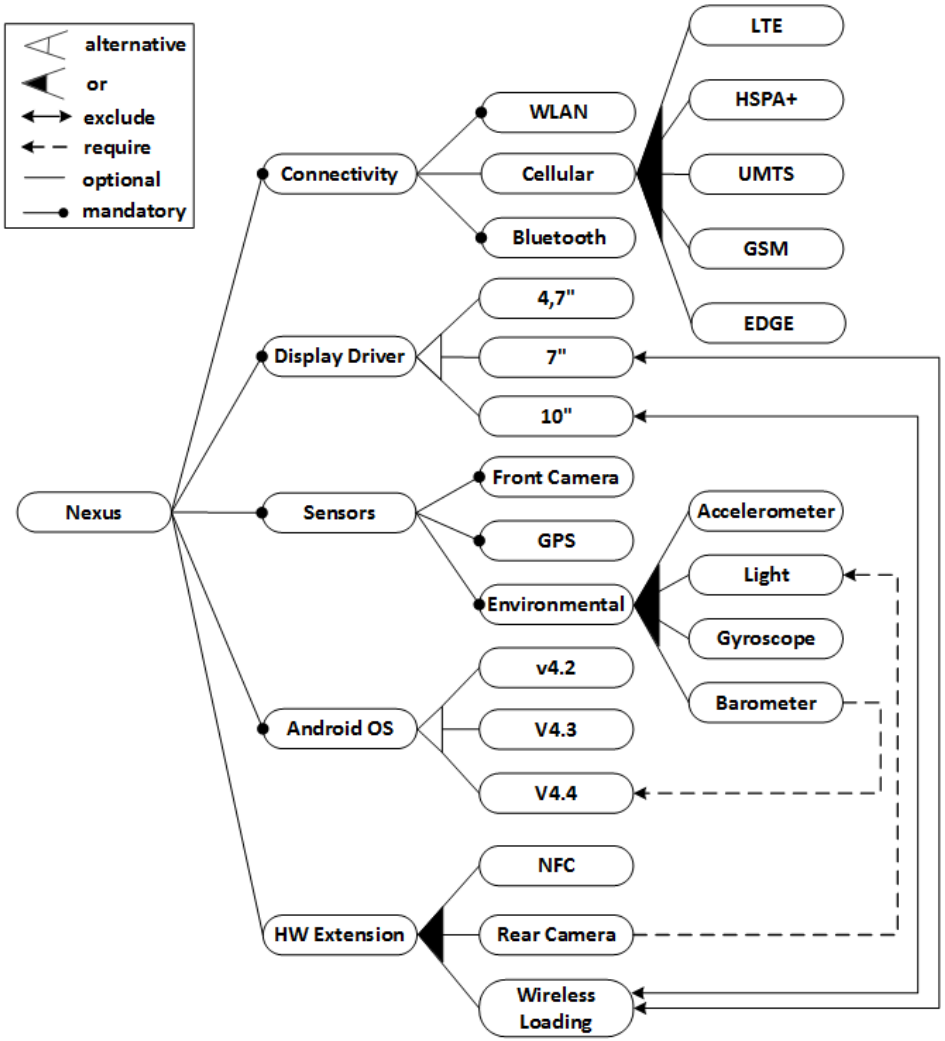


All these examples are *static* - the are not *reconfigureable* once the product is derived

Mobile Devices as an SPL, Google Nexus

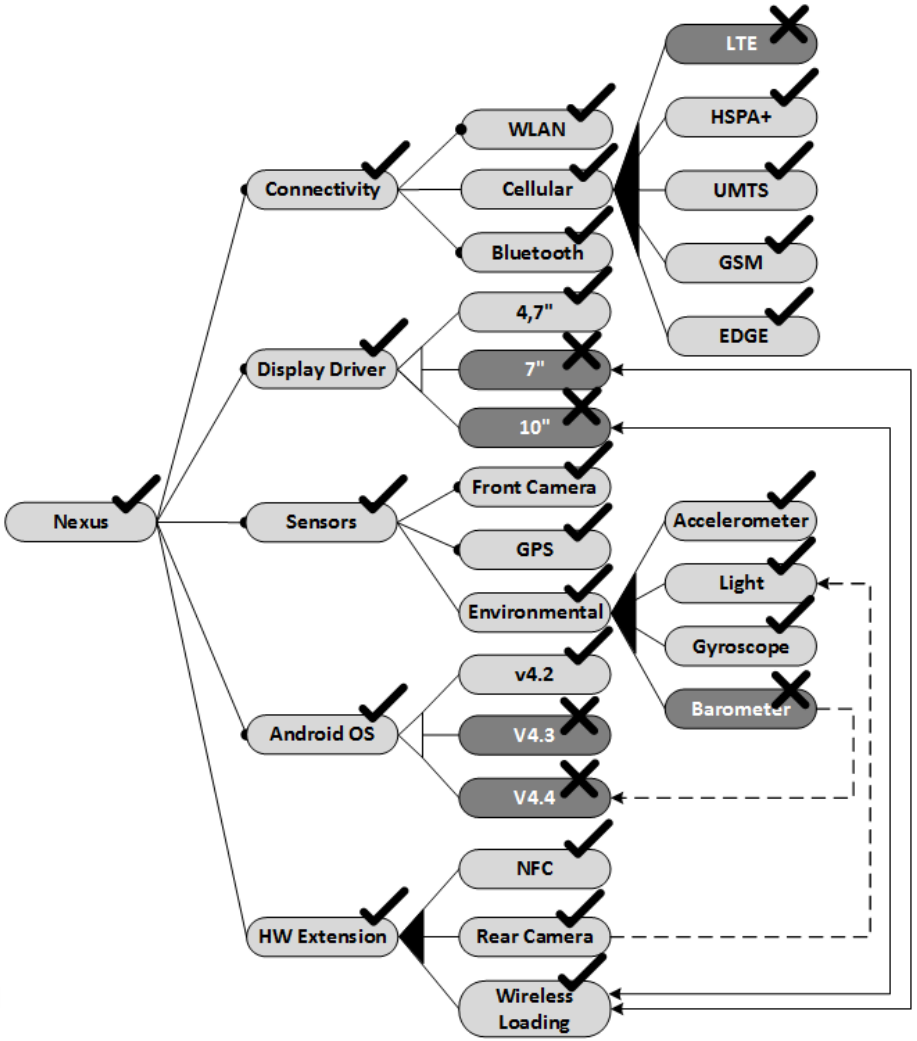
TECHNISCHE UNIVERSITÄT DARMSTADT

Mobile Devices as an SPL, Google Nexus

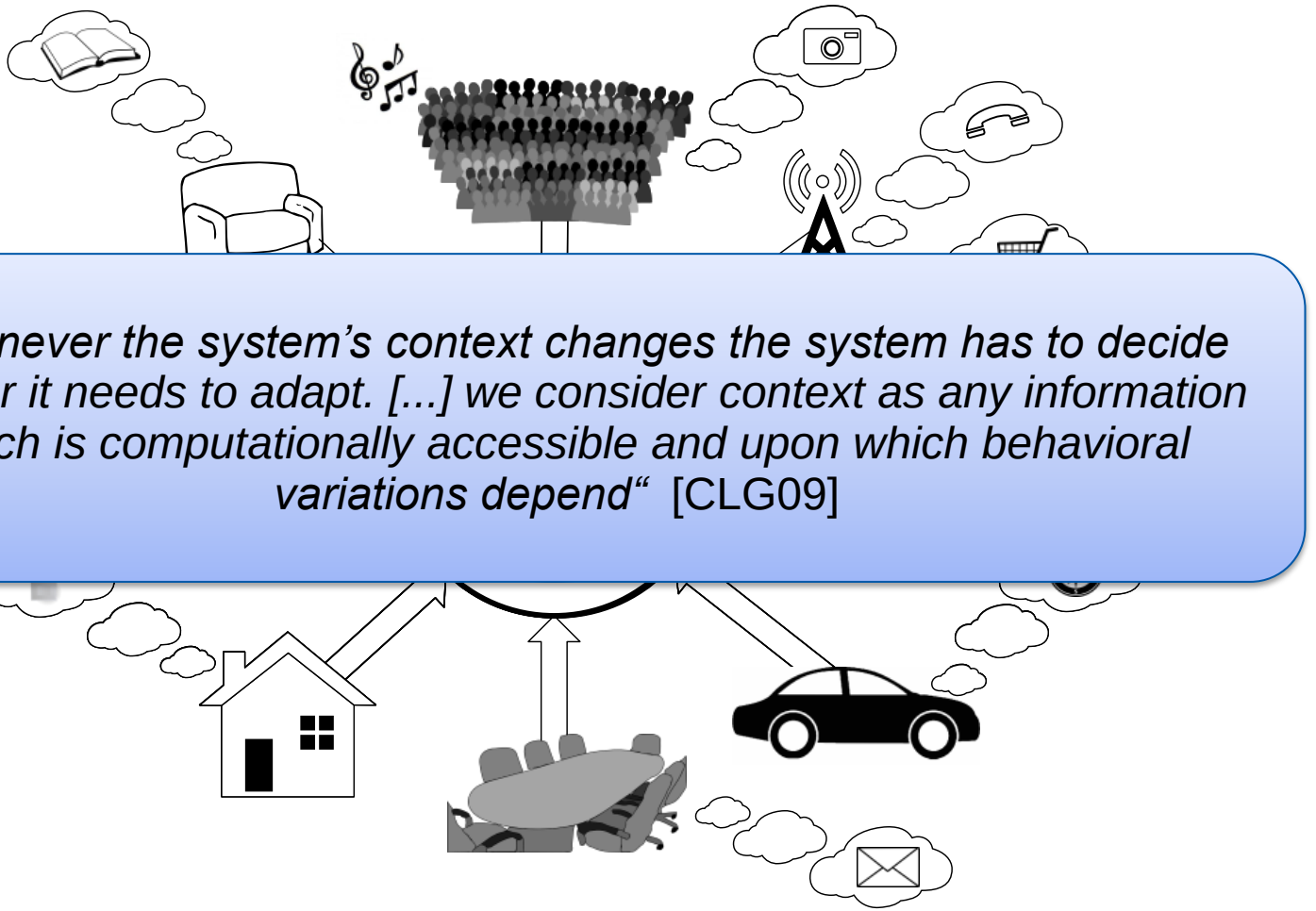


Mobile Devices as an SPL, Google Nexus

TECHNISCHE UNIVERSITÄT DARMSTADT



Mobile Devices in the Contextual Environments



"Whenever the system's context changes the system has to decide whether it needs to adapt. [...] we consider context as any information which is computationally accessible and upon which behavioral variations depend" [CLG09]

Self-Adaptive Systems

TECHNISCHE UNIVERSITÄT DARMSTADT

"self-adaptive systems" - systems that are able to adjust their behavior in response to their perception of the environment and the system itself [CLG09]

Application scenarios

- distributed systems,
- biologically inspired computing,
- distributed artificial intelligence,
- robotics,
- knowledge-based systems,
- machine learning, and
- control theory

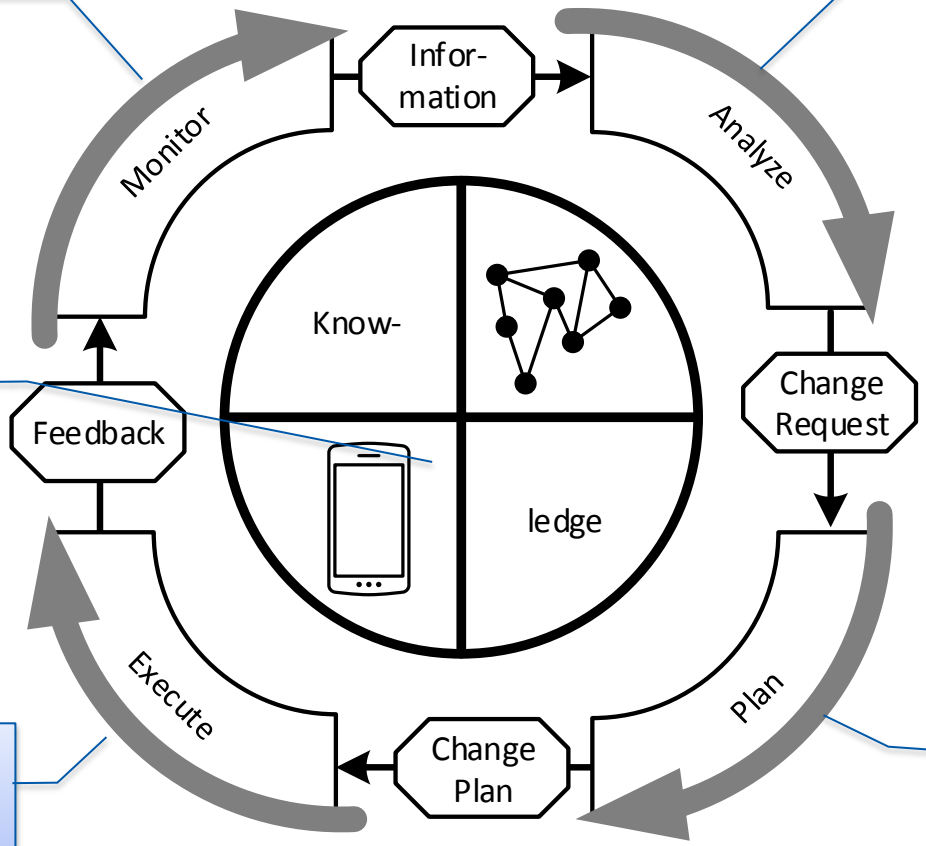
Traditional Concepts to Achieve Adaptivity

Adaptivity is Achieved by

- *rules*, e.g., event-condition-action
  - if <user is in office> then <switch to silent mode>
  - if <upload rate < 10kb/s> then <alternative different connection types>
- or by *goals*
  - video playback may not be interrupted
  - Stream always best quality

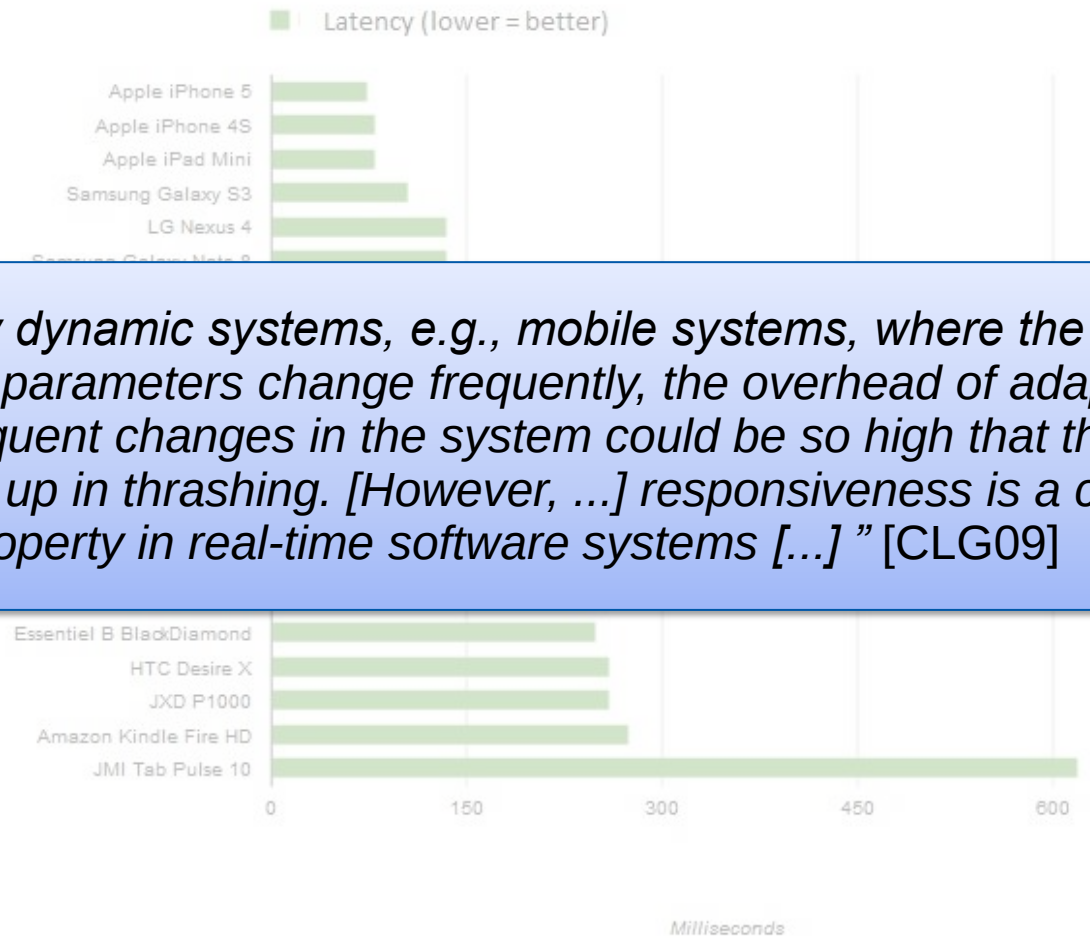
Self-Optimizing Systems are a special kind of self-adaptive systems

MAPE-K Feedback Loop [IBM06]



Challenges in Self-Adaptive Systems

TECHNISCHE UNIVERSITÄT DARMSTADT



"In highly dynamic systems, e.g., mobile systems, where the environmental parameters change frequently, the overhead of adaptation due to frequent changes in the system could be so high that the system ends up in thrashing. [However, ...] responsiveness is a crucial property in real-time software systems [...] " [CLG09]

Source: http://www.digitalversus.com/mobile-phone/new-touch-responsiveness-test-results-21-smartphones-tablets-n29229.html

Challenges in Self-Adaptive Systems

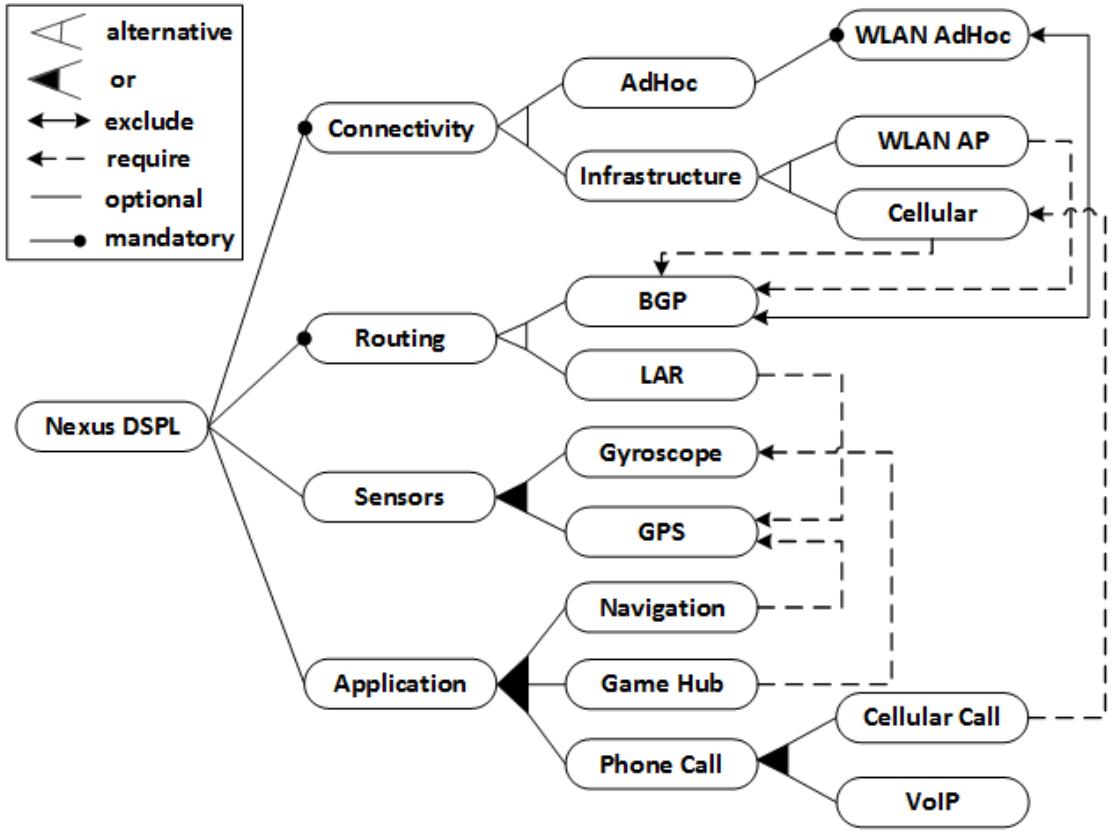
TECHNISCHE UNIVERSITÄT DARMSTADT

ISO 26262 – 6 Software Level Guidelines

- Modeling and Coding Guidelines (Page 16/17):
  - Language tailoring
    - Modeling language subsets & style guides
    - …
  - …
    - …
    - …
    - …
    - Support for traceability (Automotive SPICE, IEC 61508)
  - …

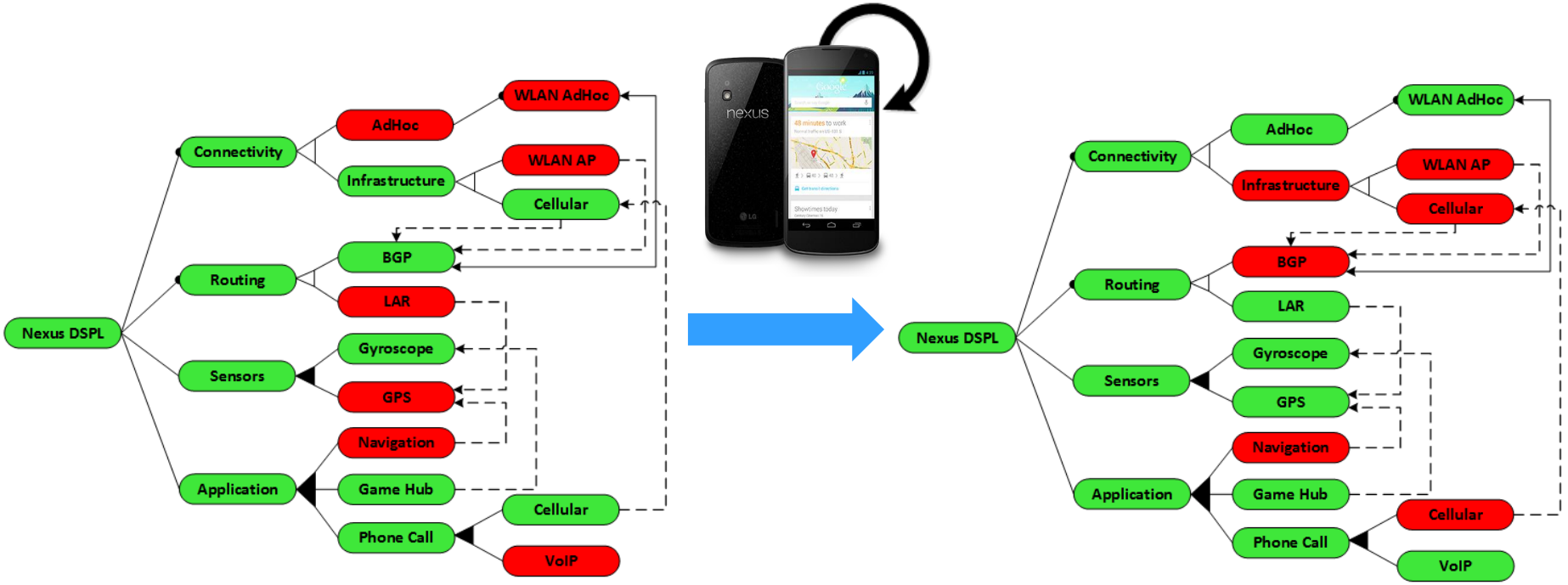
“A major challenge [...in the development of adaptation mechanisms ...] is to accommodate a systematic engineering approach that integrates control-loop approaches with decentralized agent inspired approaches.” [CLG09]

Mobile Devices as a (D)SPL



Mobile Devices as a DSPL

… the device is *continuously re*-configured



selected

deselected

DSPLs Suitable for Runtime Adaptations?

TECHNISCHE UNIVERSITÄT DARMSTADT

"A DSPL's strength is the systematic engineering foundations that it can bring to adaptive … g to higher reliability and pr…

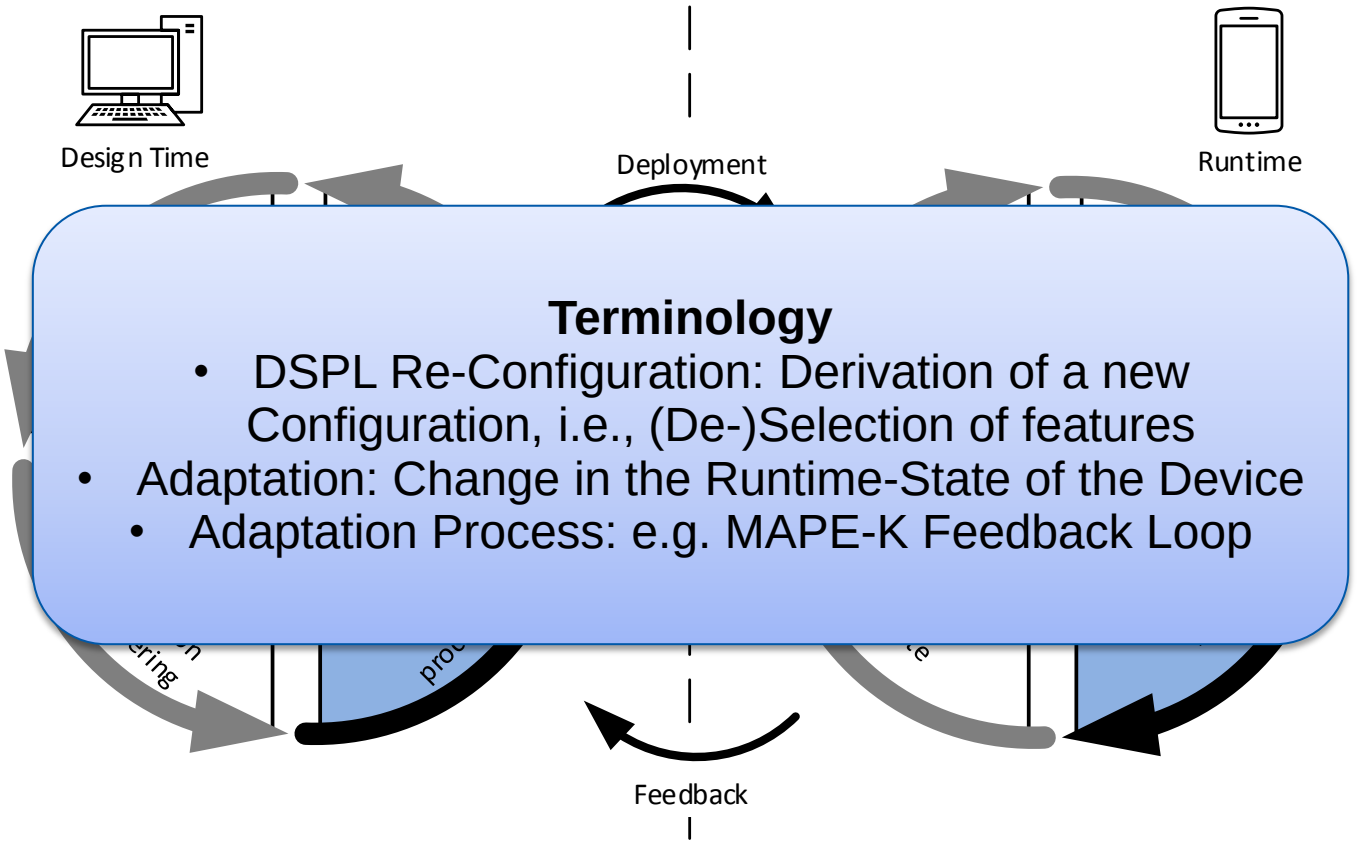
Reconfiguration can be planned and executed based on a formal model

"… the size of the … at can be exponential in th…

Complex Variability specification can lead to exponential overhead

How can a the resource consumption of DSPL reconfiguration be reduced?

Integrating a DSPL in the MAPE-K Loop*

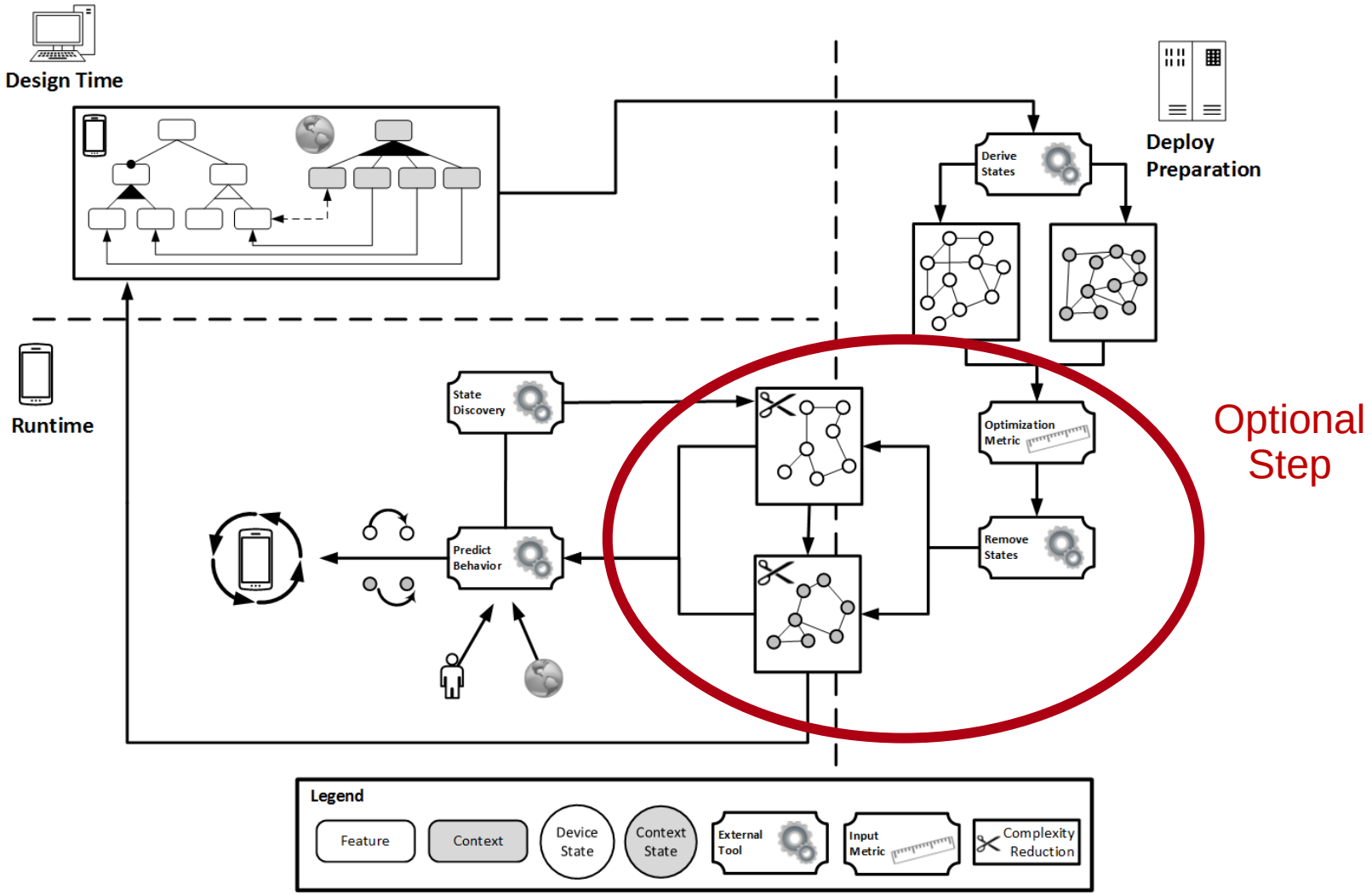


Terminology

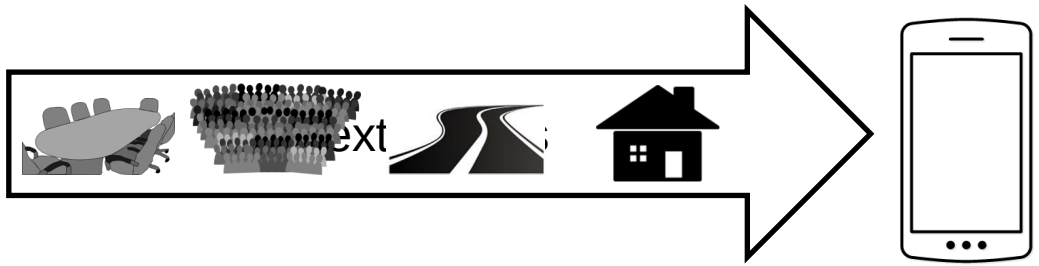
- DSPL Re-Configuration: Derivation of a new Configuration, i.e., (De-)Selection of features
- Adaptation: Change in the Runtime-State of the Device
- Adaptation Process: e.g. MAPE-K Feedback Loop

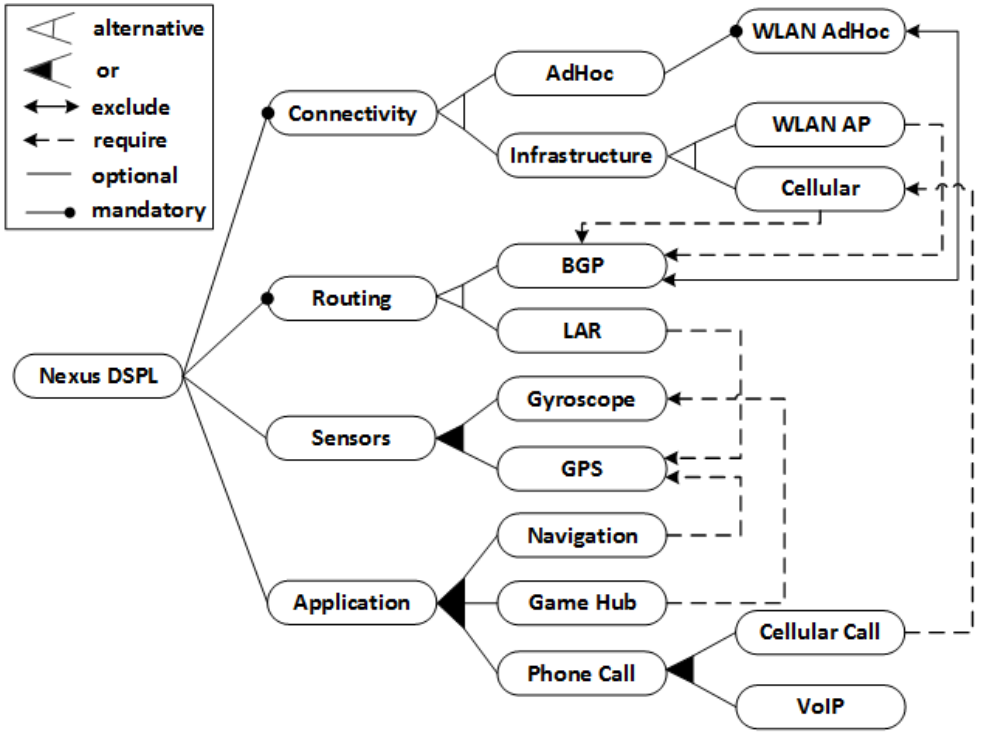
* Based on the concept proposed in [BHS12]

From Specification to Runtime Reconfiguration



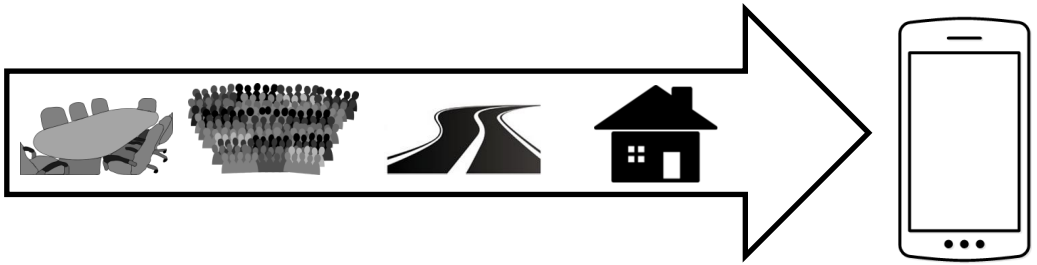
Context-Aware DSPLs [SLR13]

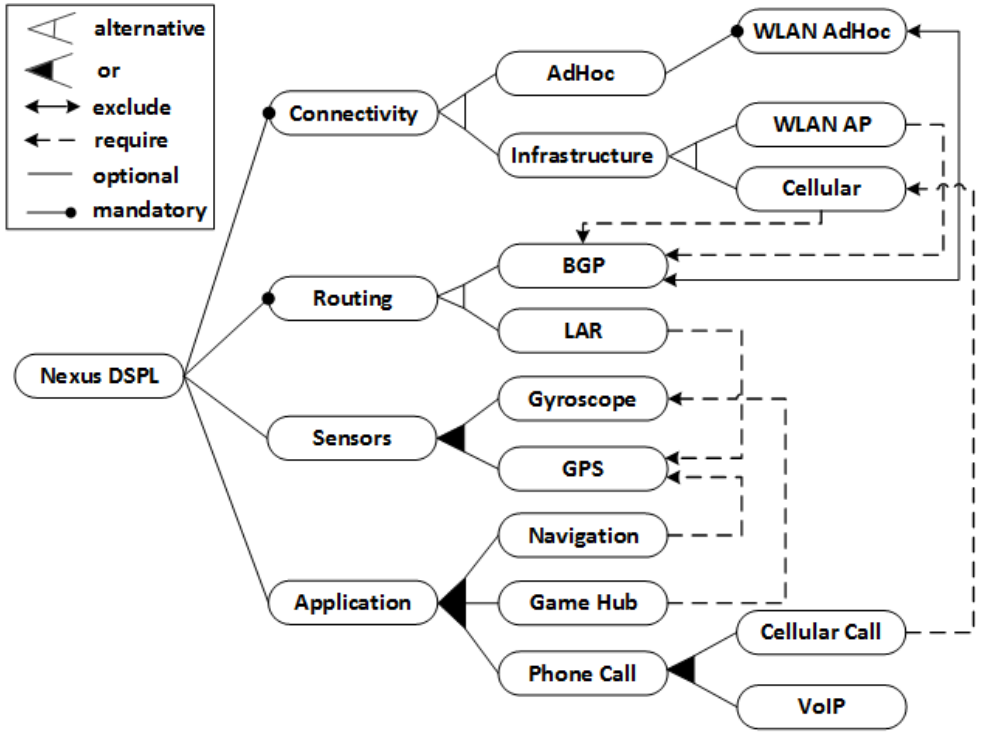




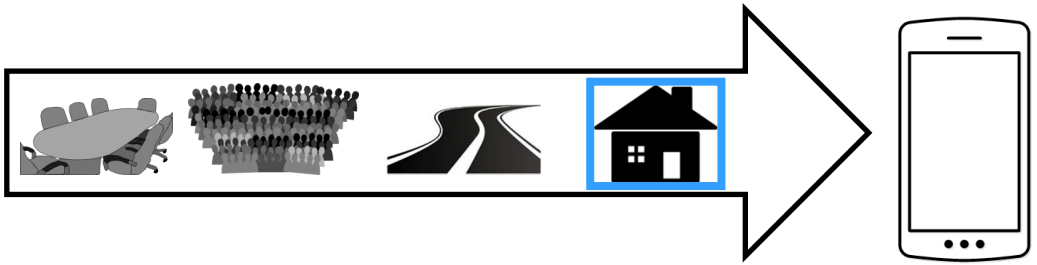
Adapt Feature-Configuration to new Context

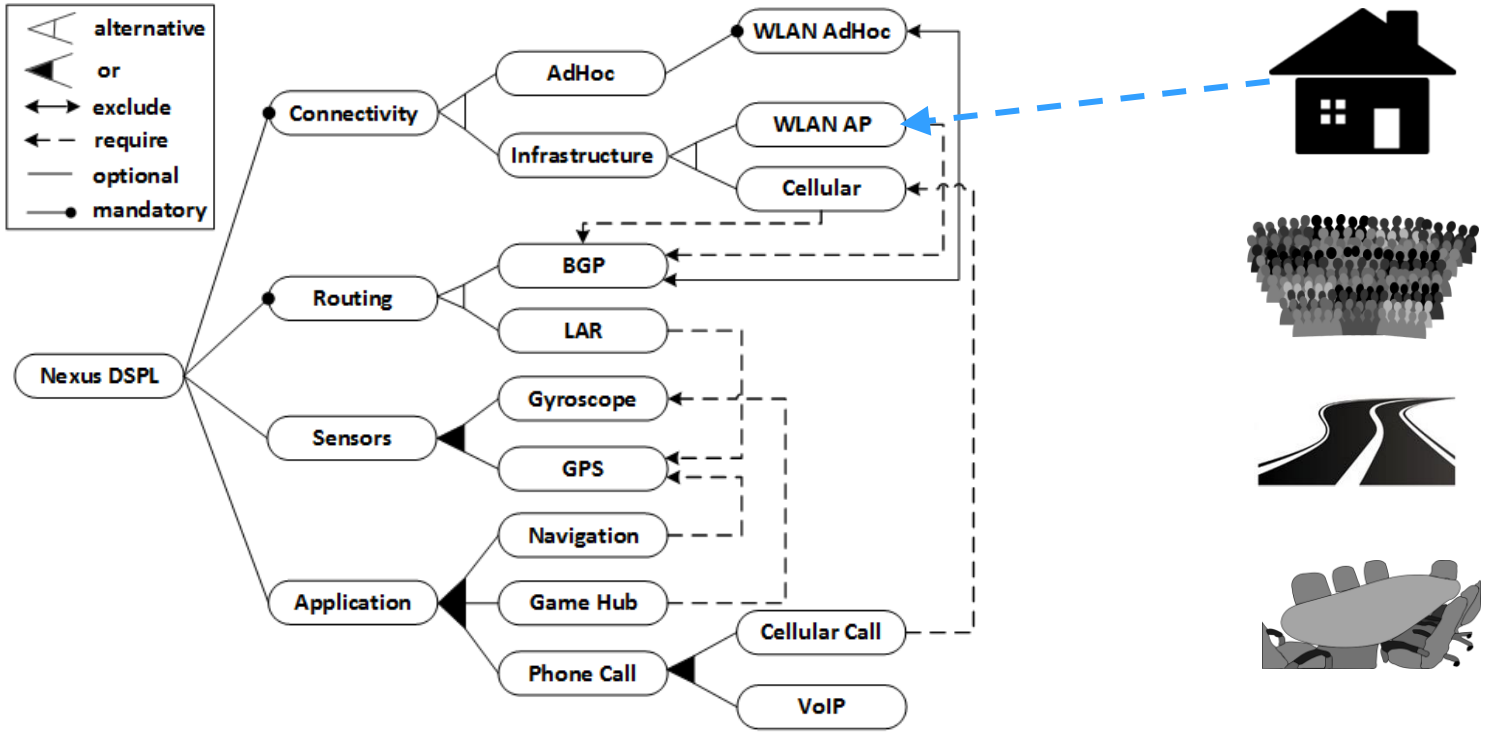
Context-Aware DSPLs



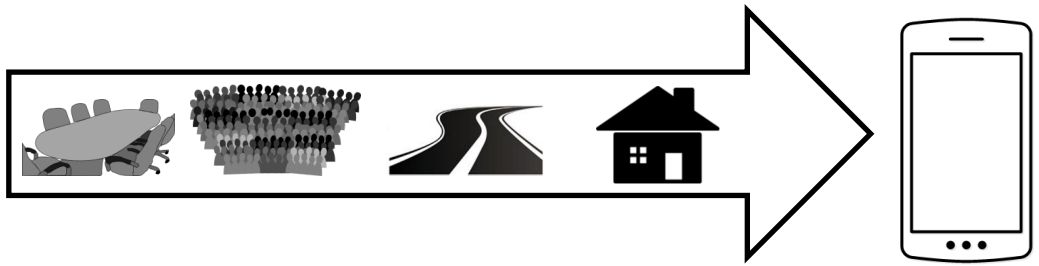


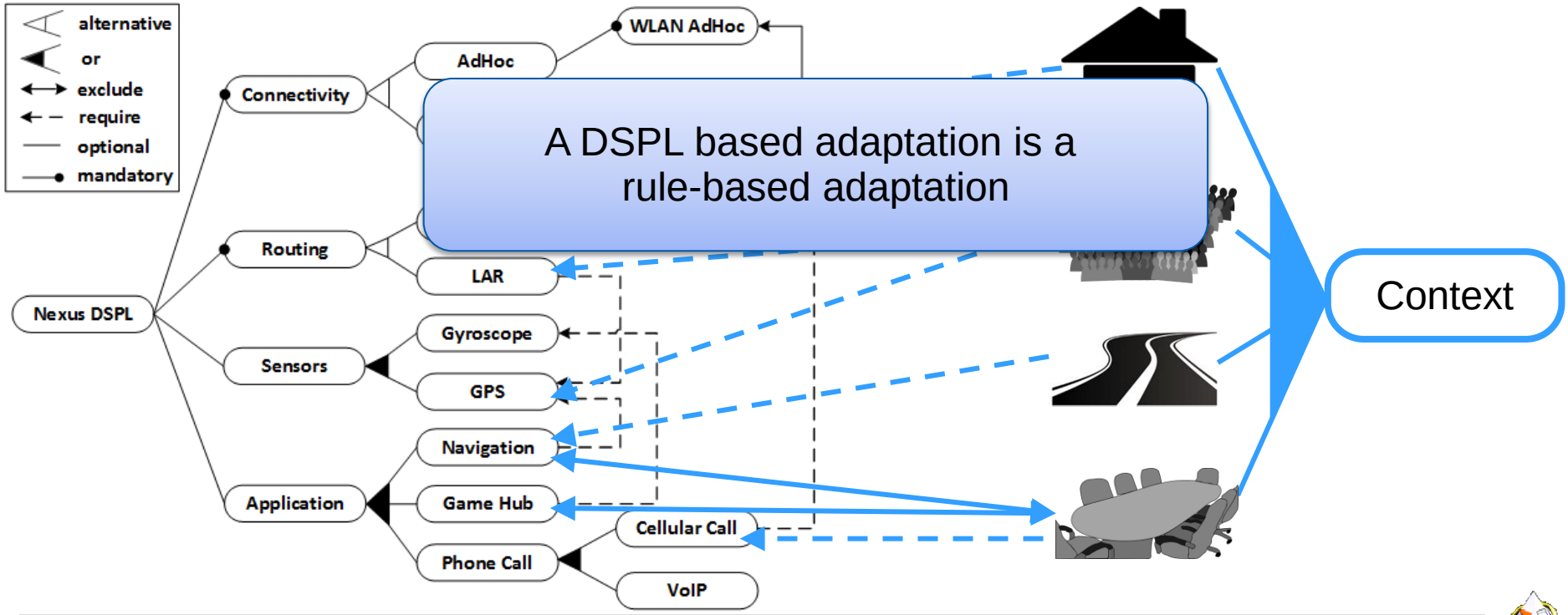
Context-Aware DSPLs



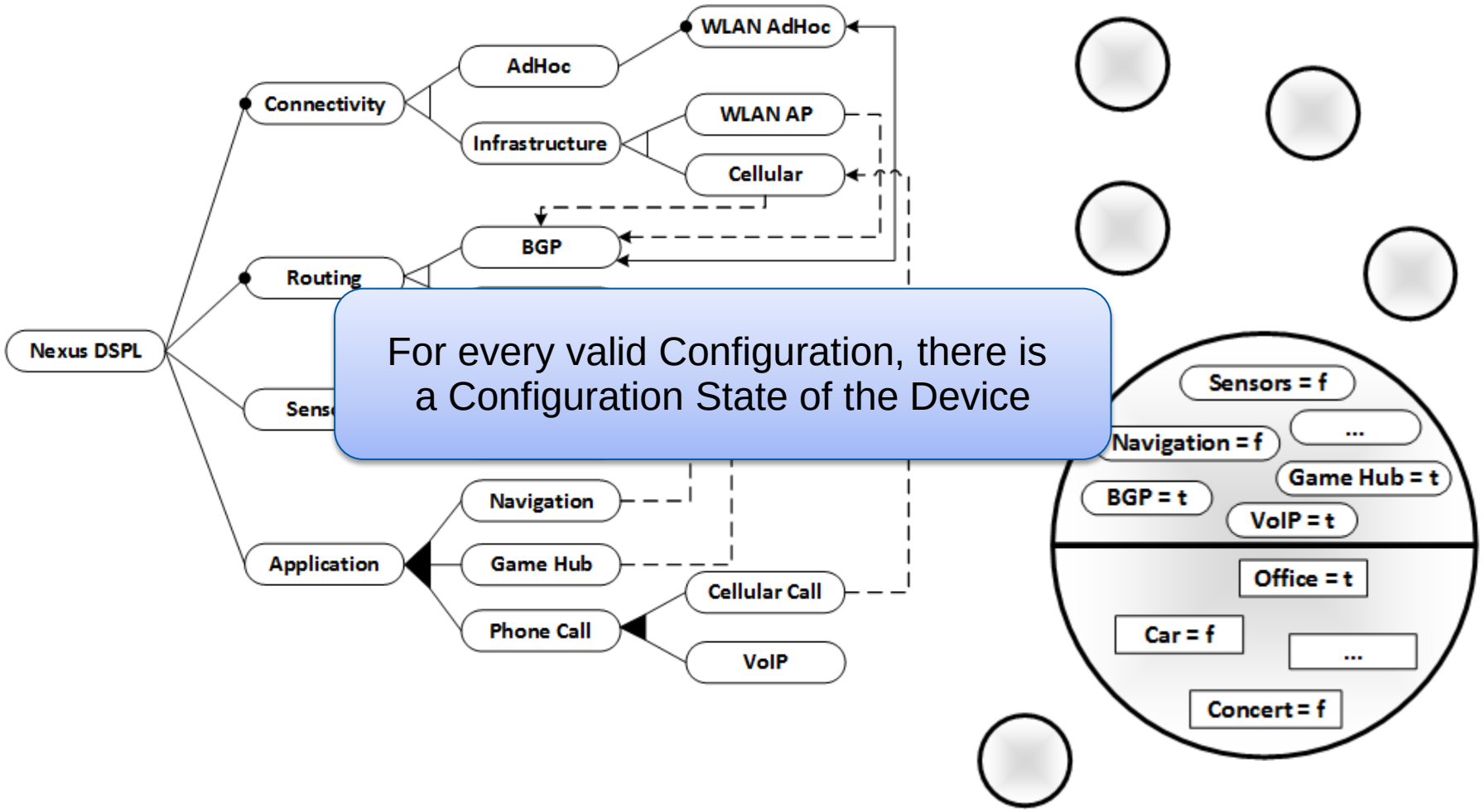


Context-Aware DSPLs

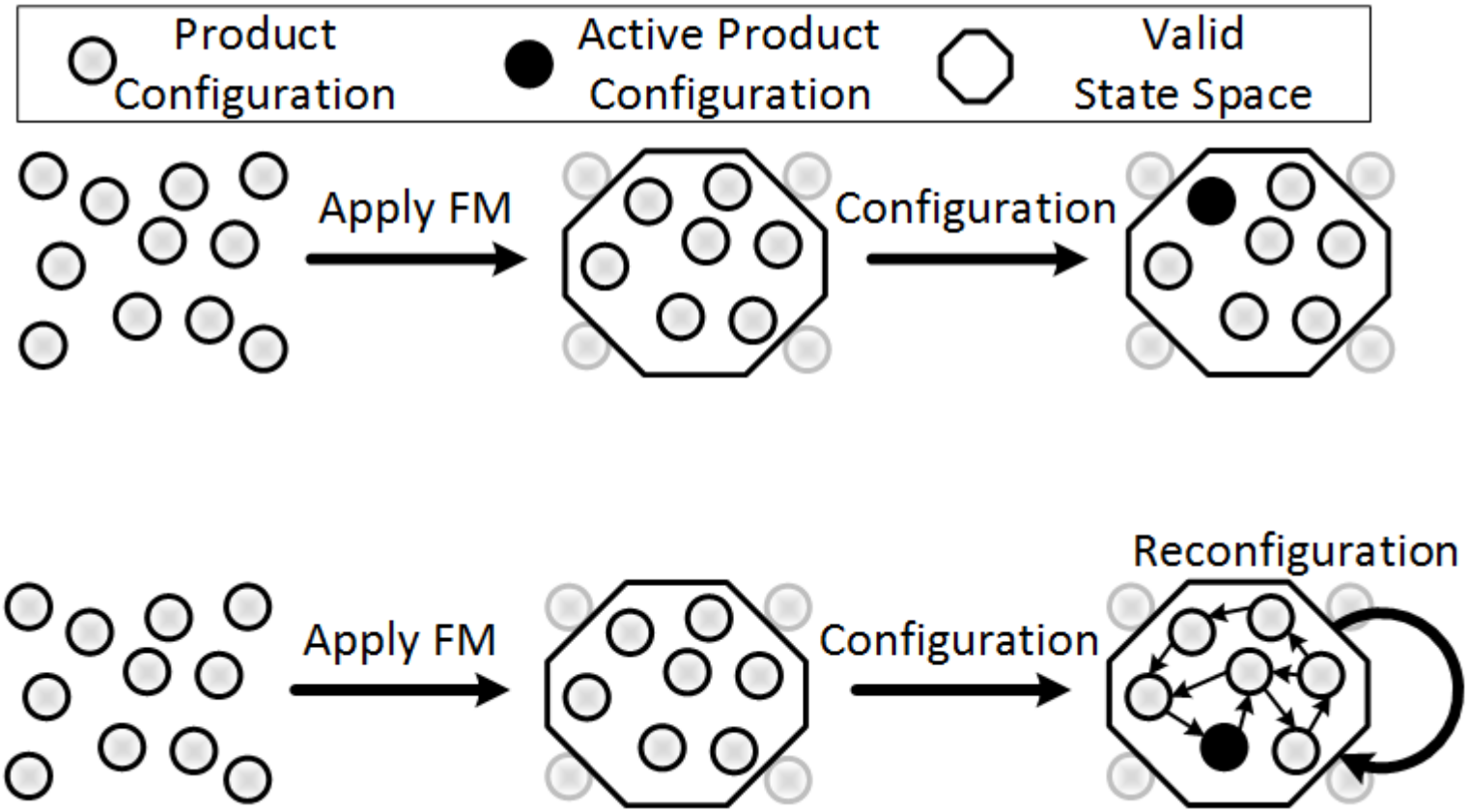




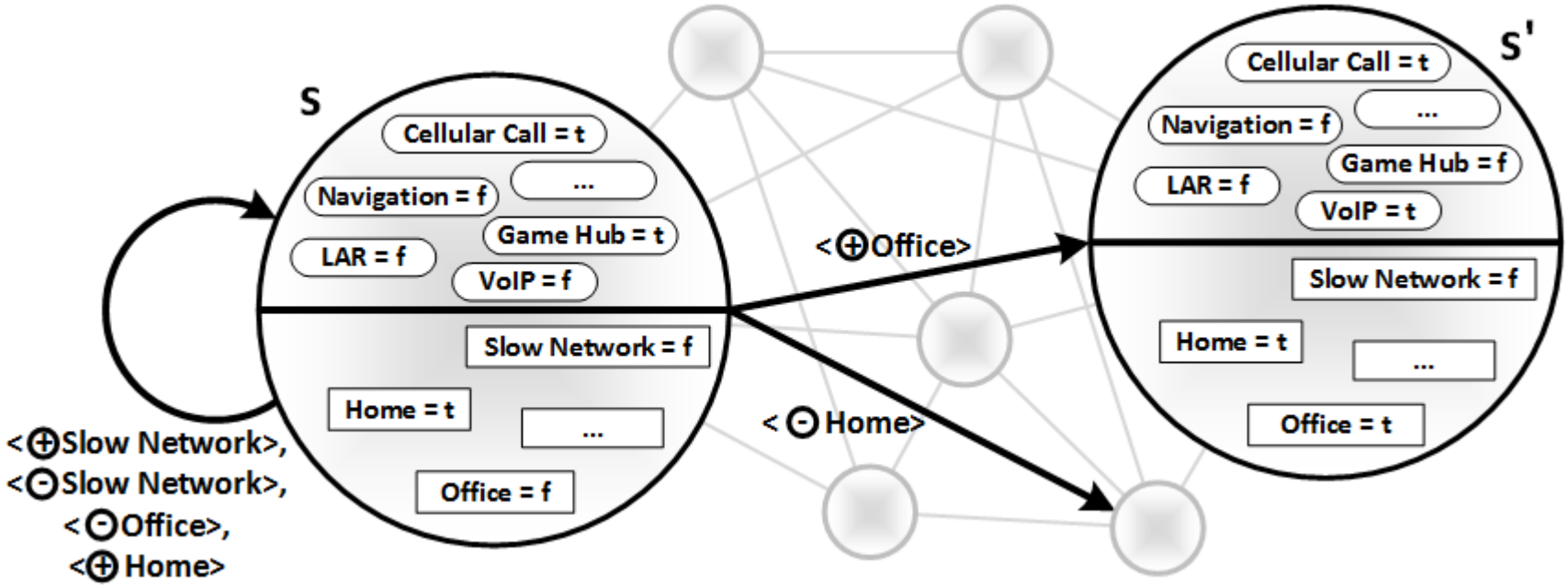
Configuration State



SPL Configuration vs. DSPL Reconfiguration



State Based Reconfiguration of the Device



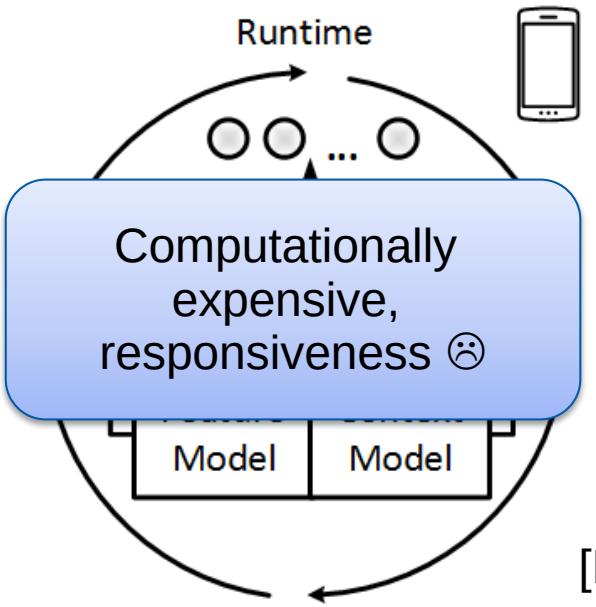
How To Reconfigure a DSPL

TECHNISCHE UNIVERSITÄT DARMSTADT

Consider the following:

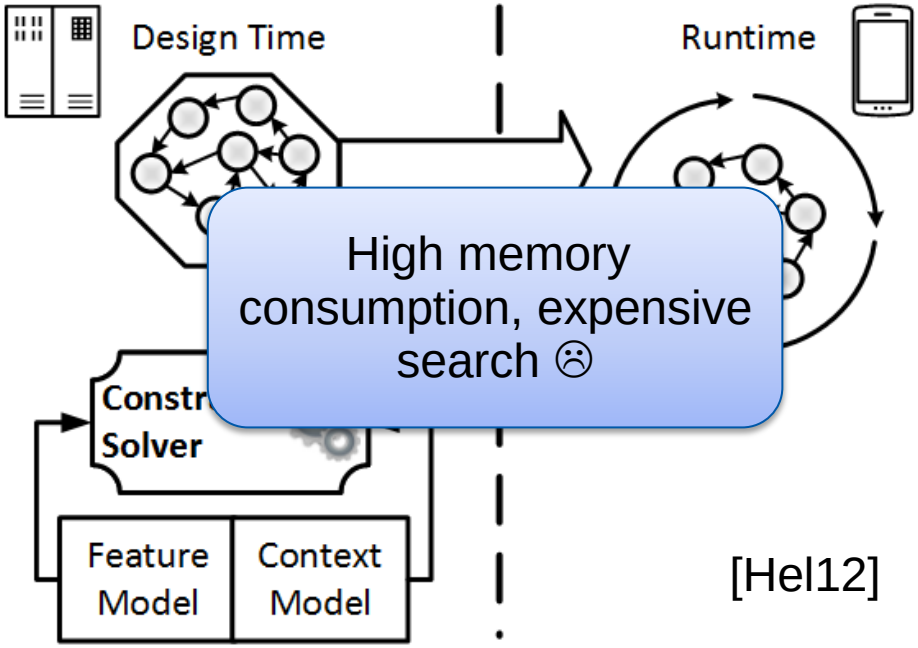
a DSPL with 14 features has, in worst case,

2^{19} = 524288 configuration possibilities



[FFF13]

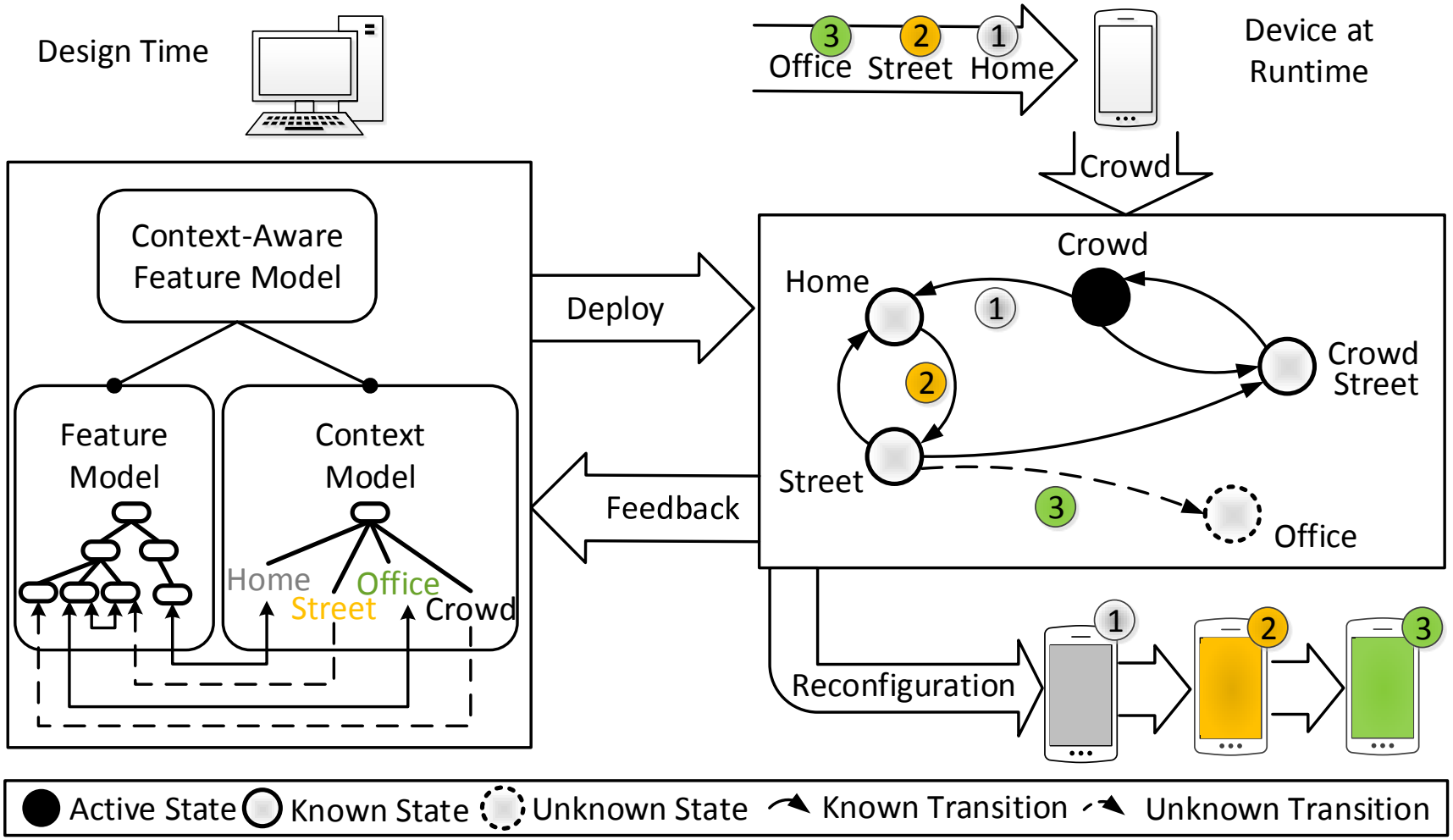
… on-demand derivation of configuration



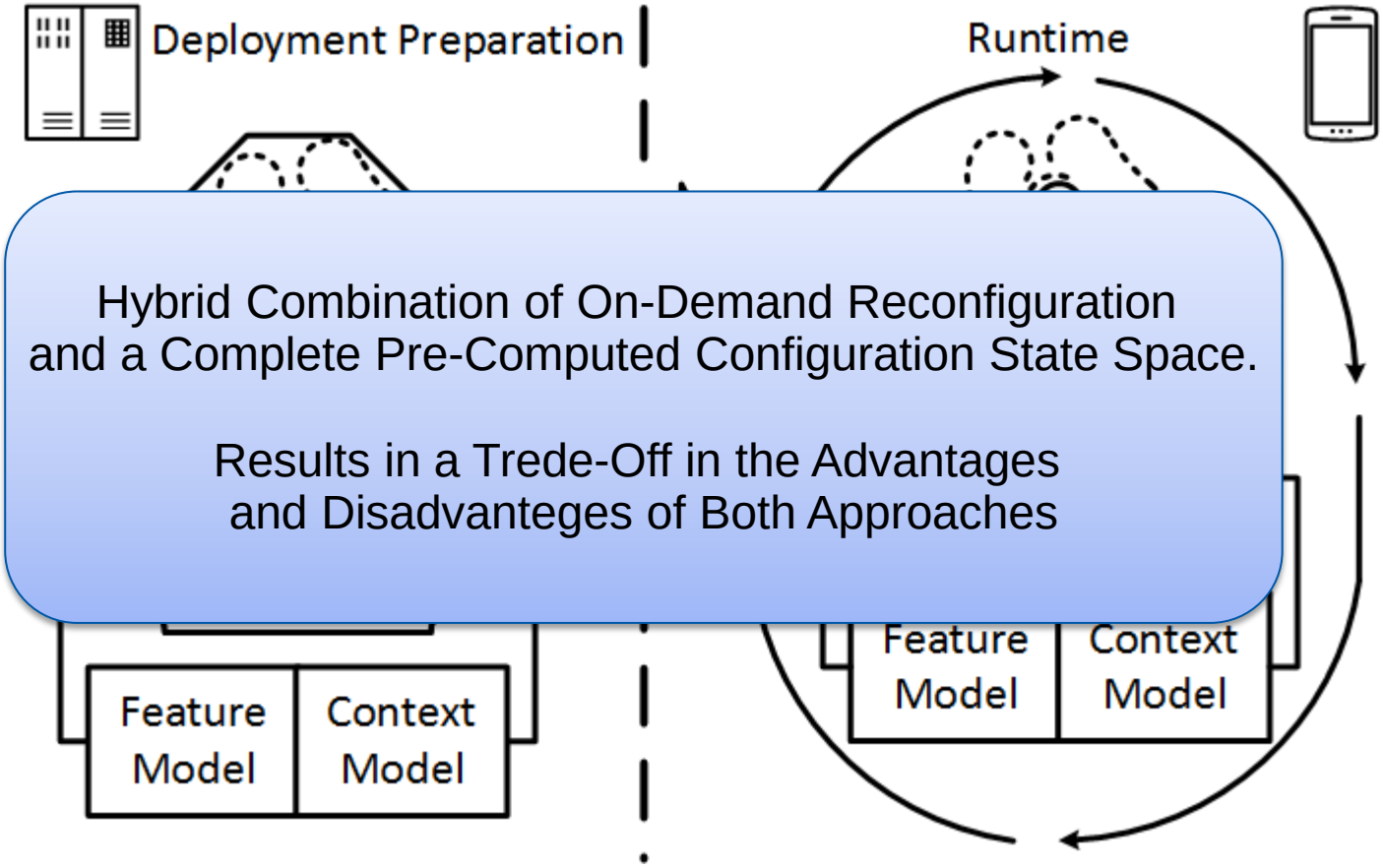
[Hel12]

… or all configurations are pre-computed

How To Reconfigure a DSPL



How To Reconfigure a DSPL



Currently Ongoing Research

TECHNISCHE UNIVERSITÄT DARMSTADT

Future Internet Challenges

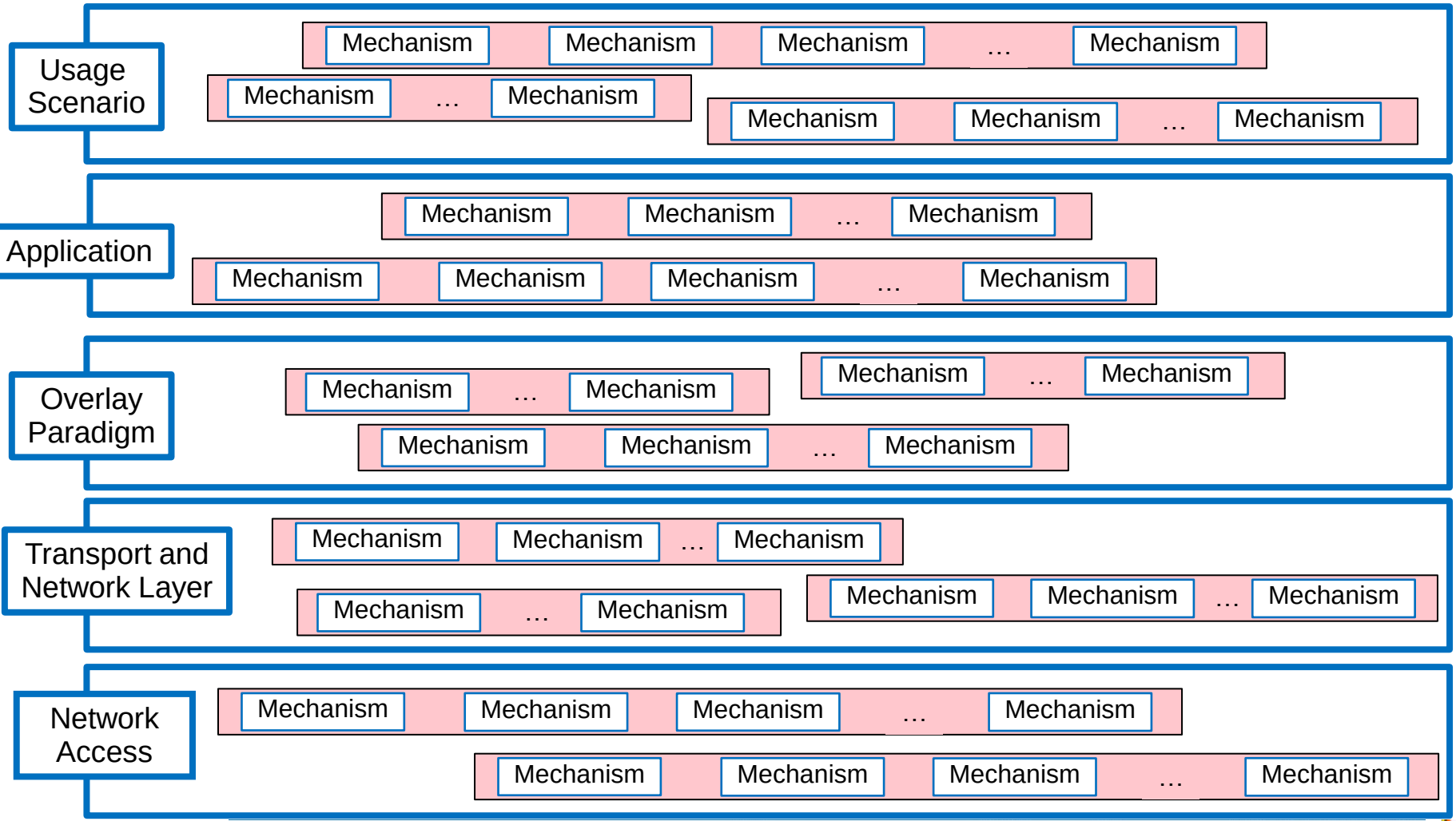
- everything is connected
- heterogenious network participants / software
- complex and large-scale systems
- ever-changing contextual situations

→ Tackle it with Dynamic Software Product Lines

Current Project: *MAKI – Multi-Mechanism Adaptation in the Future Internet*

- collaborative Research Center (SFB) 1053
- national project of the German Research Foundation (DFG)

Situation in the „Future Internet”

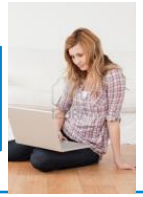


Concrete Situation in the „Future Internet“

TECHNISCHE UNIVERSITÄT DARMSTADT

Anywhere

Usage Scenario




...


...


Any size

Application


...

...

Any kind

Overlay Paradigm

PubSub

Event-based

RPC

Streaming

Transport- and Network Layer

Unicast

TCP

Broadcast

UDP

Multicast

SCTP

IPv4

IPv6

Network Access

Cellular

...

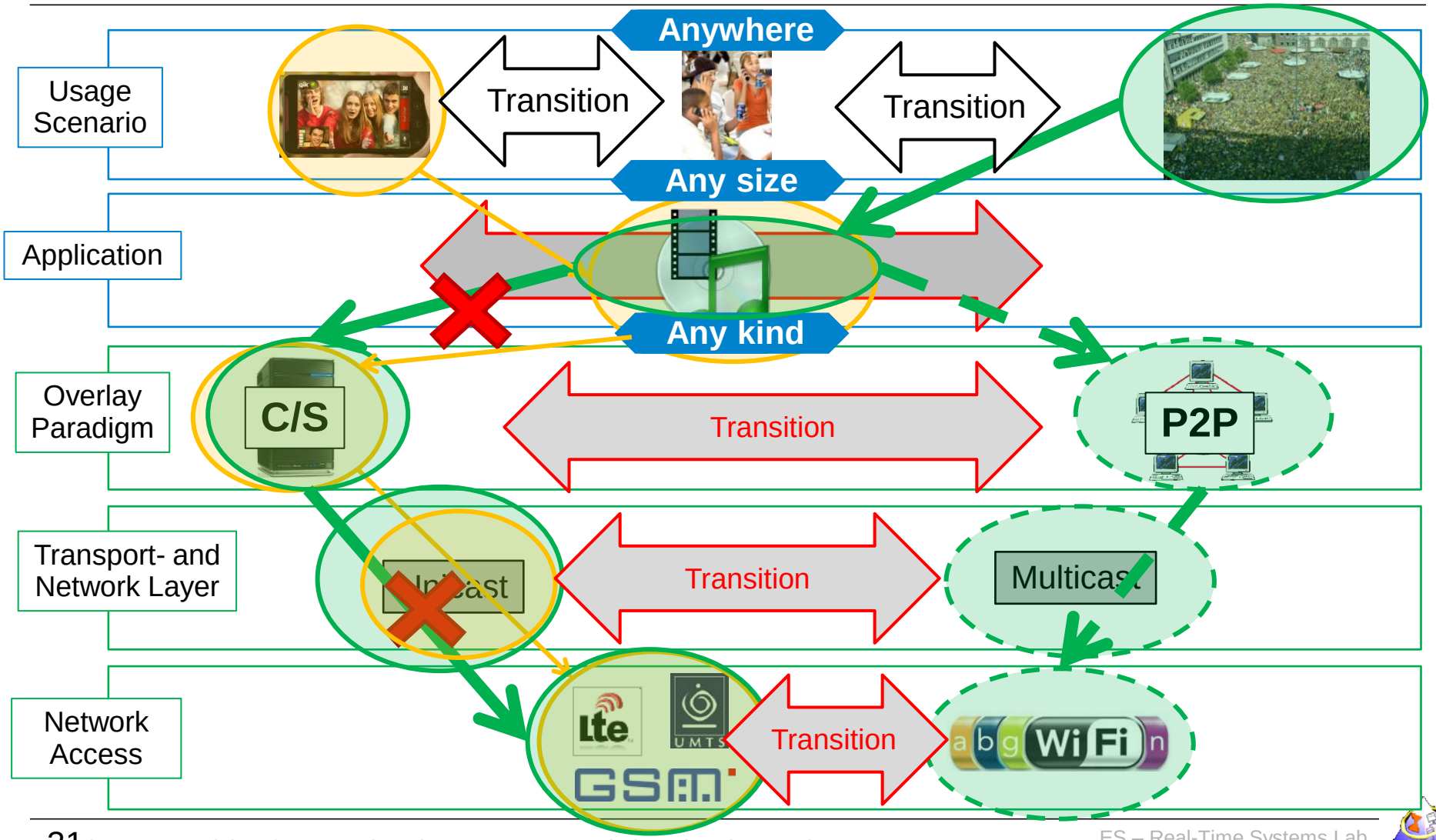
Mesh

...

Ad-hoc

...


Concrete Situation in the „Future Internet“

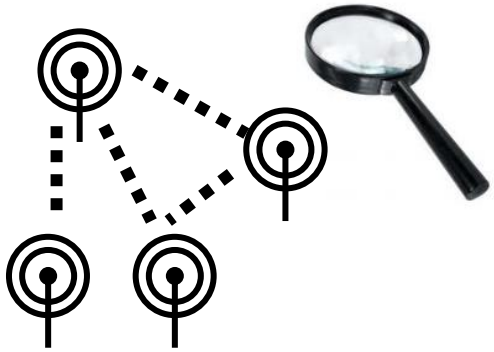


Dynamic Monitoring Product Line

TECHNISCHE UNIVERSITÄT DARMSTADT

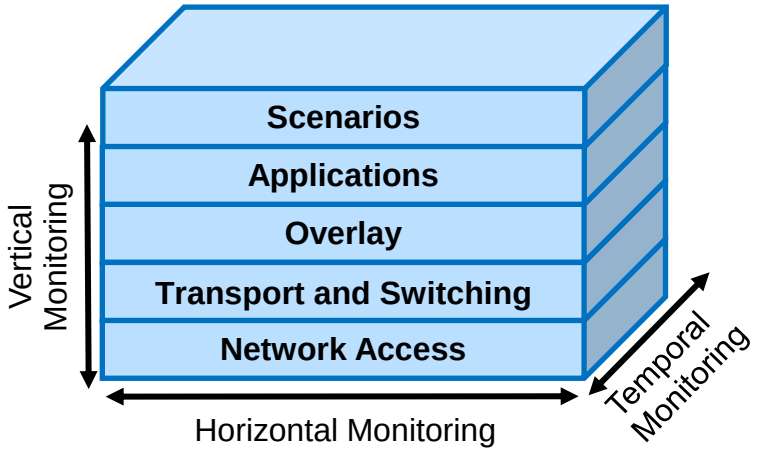
Monitoring and Analysis

- Data gathering
- State determination through data analysis
- Information provisioning to initiate the multi-mechanism adaption



Challenges

- Cross-layer interdependencies
- Transitions
- Strong heterogeneity
- Varying parameters



Dynamic Monitoring Product Line

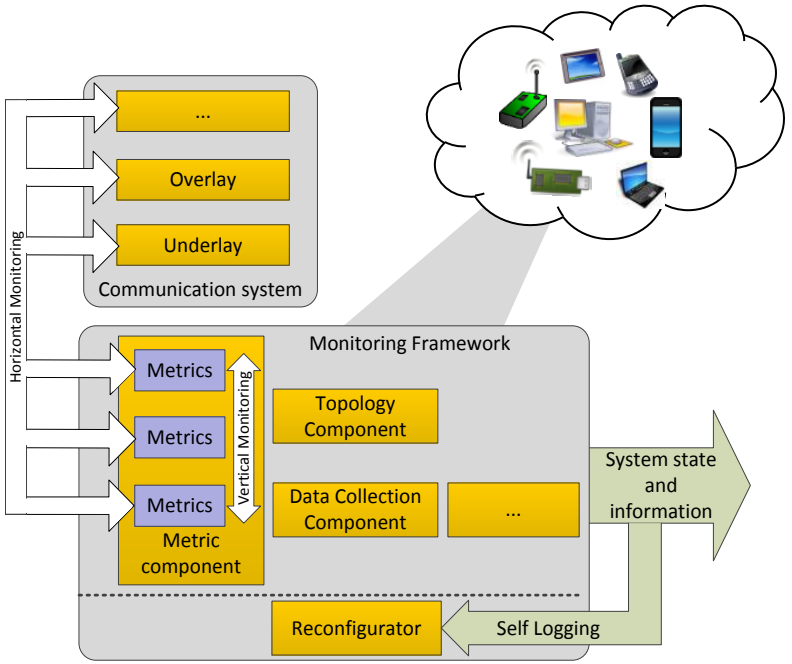
TECHNISCHE UNIVERSITÄT DARMSTADT

Goals of Monitoring Framework

- Cross-layer data collection and analysis
- Design and development of a modular adaptive monitoring framework
- Model-based configuration of the monitoring multi-mechanism at runtime

Approach

- Establish taxonomy
- Implement framework components
- Mapping to feature model and parameter specification
- Adapt constraint solver for (re-)configuration at runtime
- Extend dynamic adaptation beyond transitions
- Development and validation



References (only if you are interested)

TECHNISCHE UNIVERSITÄT DARMSTADT

[BHS12] N. Bencomo, S. Hallsteinsen, and E. Santana de Almeida, “A View of the Dynamic Software Product Line Landscape,” *Computer*, vol. 45, no. 10, pp. 36–41, 2012.

[BSB08] N. Bencomo, P. Sawyer, G. Blair, and P. Grace, “Dynamically adaptive systems are product lines too: Using model-driven techniques to capture dynamic variability of adaptive systems,” in *2nd International Workshop on Dynamic Software Product Lines (DSPL 2008), Limerick, Ireland*, 2008, vol. 38, p. 40.

[BSR10] D. Benavides, S. Segura, and A. Ruiz–Cortés, “Automated analysis of feature models 20 years later: A literature review,” *Inf. Syst.*, vol. 35, no. 6, 2010.

[CLG09] B. H. C. Cheng, R. De Lemos, H. Giese, P. Inverardi, J. Magee, J. Andersson, B. Becker, N. Bencomo, Y. Brun, B. Cukic, D. M. Serugendo, S. Dustdar, A. Finkelstein, C. Gacek, V. Grassi, G. Karsai, H. Kienle, J. Kramer, M. Litoiu, R. Mirandola, H. Müller, S. Park, M. Shaw, M. Tichy, M. Tivoli, D. Weyns, and J. Whittle, “Software Engineering for Self-Adaptive Systems : A Research Road Map” *Engineering*, pp. 1–13, 2009.

References (only if you are interested)

TECHNISCHE UNIVERSITÄT DARMSTADT

[FFF13] Jacqueline Floch, Cristina Frà, Rolf Fricke, Kurt Geihs, Michael Wagner, Jorge Lorenzo Gallardo, Eduardo Soladana Cantero, Stephan Mehlhase, Nearchos Paspallis, Hossein Rahnama, Pedro Antonio Ruiz, Ulrich Scholz, „Playing MUSIC - building context-aware and self-adaptive mobile applications“, *Softw., Pract. Exper*. 43(3): 359-388 (2013)

[Hel12] M. Helvensteijn, “Dynamic delta modeling,” in *Proceedings of the 16th International Software Product Line Conference*, 2012, vol. 1, p. 127.

[SOS12] K. Saller, S. Oster, A. Schürr, J. Schroeter, M. Lochau: "Reducing Feature Models to Improve Runtime Adaptivity on Resource Limited Devices", Proceedings of the 16th International Software Product Line Conference, 2012, ACM, Vol. 2, 135 - 142

[SLR13] K. Saller, M. Lochau, I. Reimund: "Context-Aware DSPLs: Model-Based Runtime Adaptation for Resource-Constrained Systems", *Proceedings of the 17th International Software Product Line Conference co-located workshops*, 2013, ACM, 106 – 113

Feel Free to Ask some Questions ☺

TECHNISCHE UNIVERSITÄT DARMSTADT

Department of Electrical Engineering
and Information Technology
Real-Time Systems Lab - ES

TECHNISCHE UNIVERSITÄT DARMSTADT

Karsten Saller, MSc.

Merckstr. 25
64283 Darmstadt
Germany
karsten.saller@es.tu-darmstadt.de

Telefon +49 6151/16 3776
Fax +49 6151/16 6942
http://www.es.tu-darmstadt.de

…then we are finished – have a nice week!