Total Cost of Ownership:
Cloud-based vs. Onboard Vehicle Software Components

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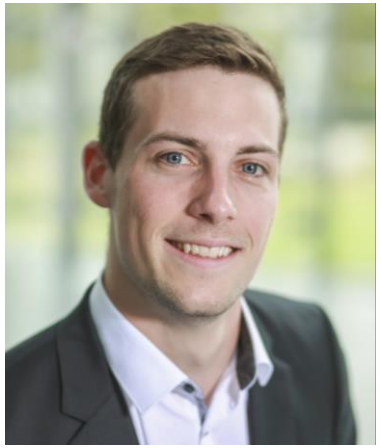
Bio

Daniel Baumann (M. Sc.)



- Studies in Electrical- and Information Engineering
- PhD Candidate at the Institute für Technik der Informationsverarbeitung (Institute for Information Processing Technology)
  At Karlsruhe Institute for Technology
- Project OTrace: Over the Air Communication for sustainable Energy Management of Fleets

Agenda

- Motivation
- E/E Architecture
- Total Cost of Ownership Model
- Case Study
- TCO Reduction Options
- Conclusion and Future Work

Motivation

- Vehicle has fixed hardware & software during production
  - Limited capacity in terms of functionality, storage space and computing capacity

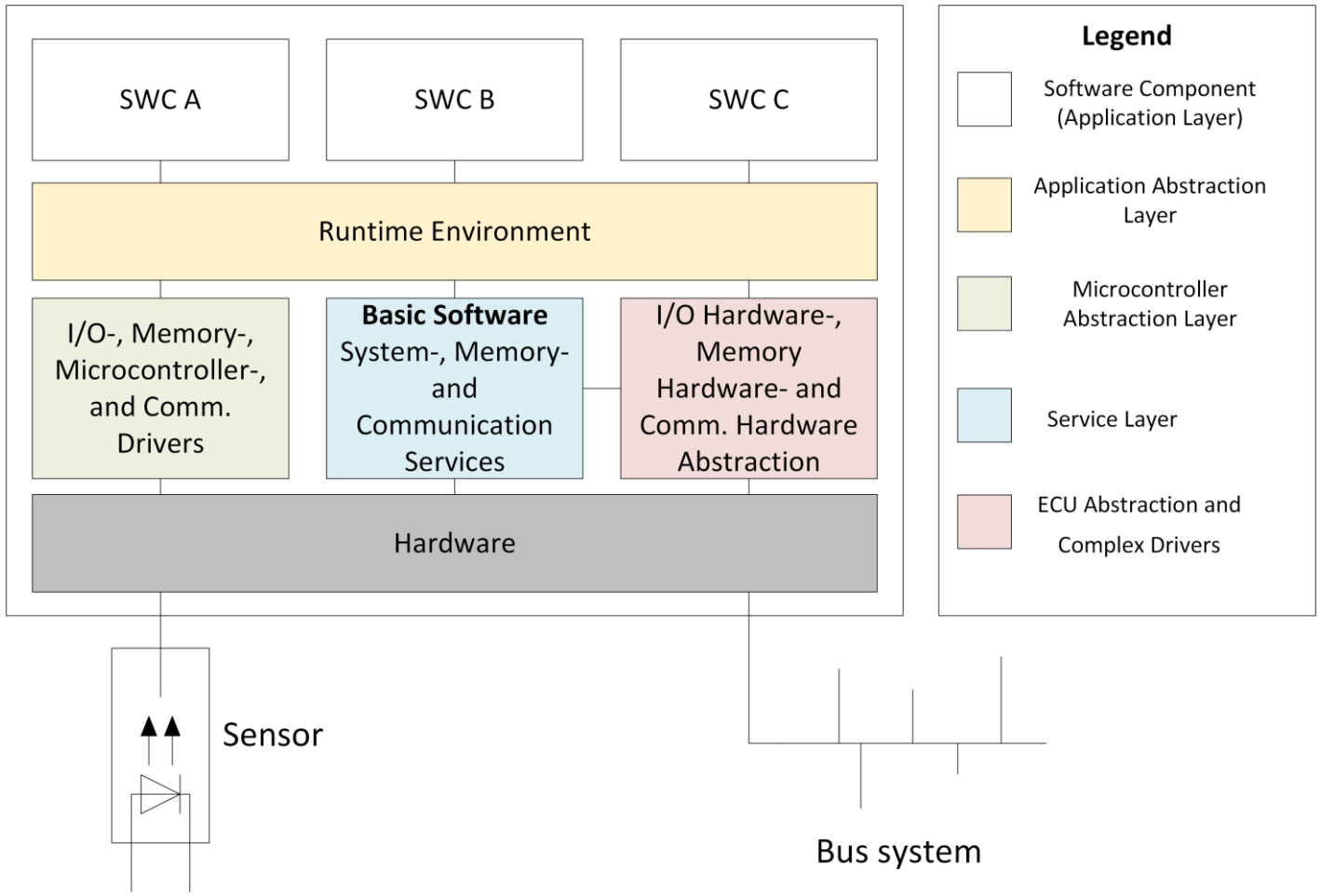
- Customers want vehicles that are state of the art and meet the driver's requirements
  - Currently, vehicle updates are only possible via OTA or workshop visits

→Expansion of the E/E architecture into the cloud

→But does it make sense from an economic point of view?

E/E Architecture

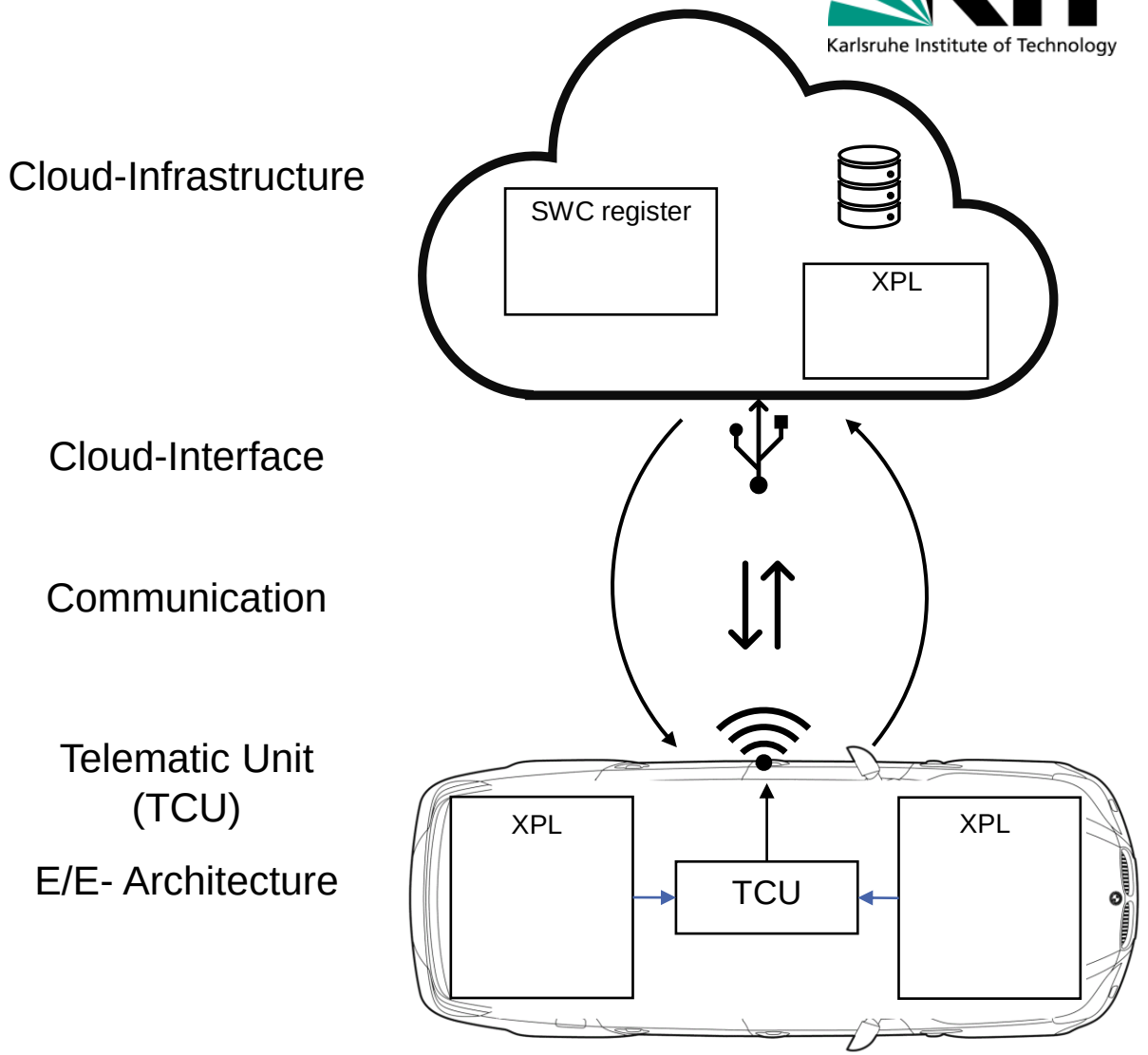
Architecuture of vehicles



E/E Architecture

Architecture for cloud-based SW

- Definition of cloud-based software component[1]:
  - Vehicle application that runs temporarily or permanently in the cloud
  - Use of cloud capacities (computing and/or storage resources) instead of the vehicle's own capacities
  - Functions can use both data from the vehicle (e.g. sensors) and external data (e.g. weather service)



XPL: e**X**ecution **PL**atforms

[1] F. Milani and C. Beidl, "Cloud-based Vehicle Functions: Motivation, Use-cases and Classification," 2018 IEEE Vehicular Networking Conference (VNC), Taipei, Taiwan, 2018, pp. 1-4, doi: 10.1109/VNC.2018.8628342.

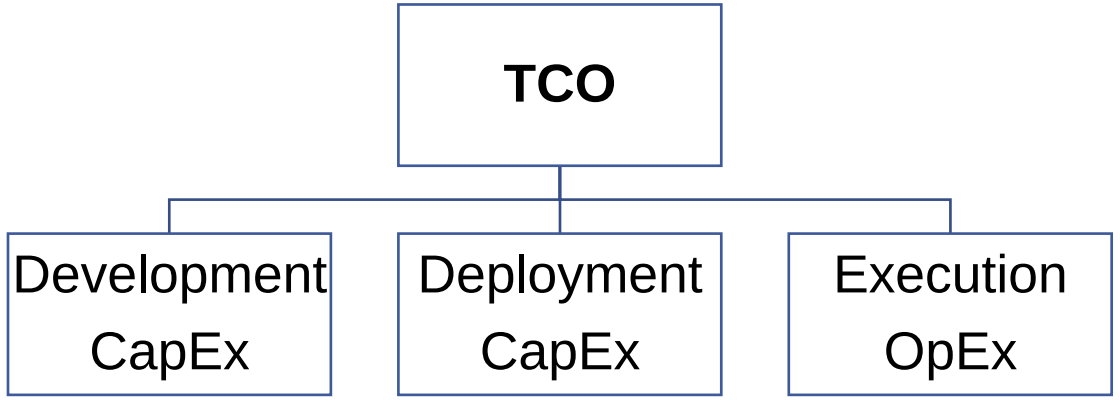
Total Cost of Ownership

Definition

- Total Cost of Ownership (TCO) is a financial estimate of the total costs of a product over its entire service life

- TCO includes
  Capital Expenses (CapEx)
  and Operating Expenses (OpEx)

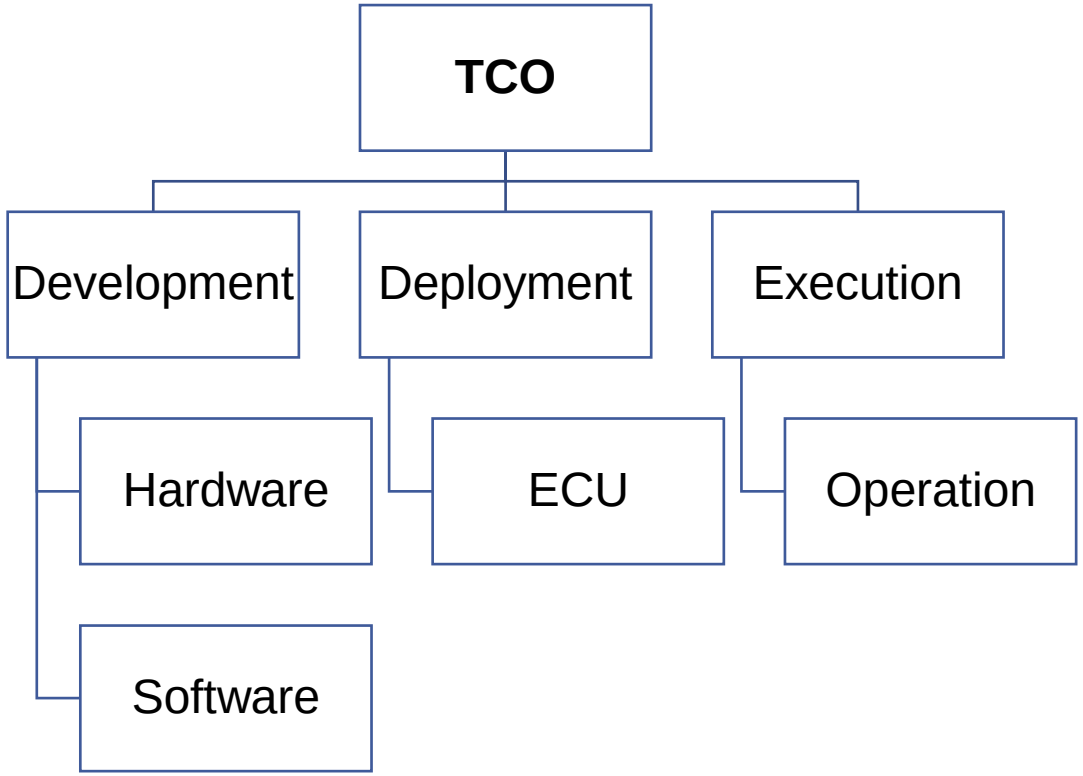
$$TCO = CapEx + OpEx$$



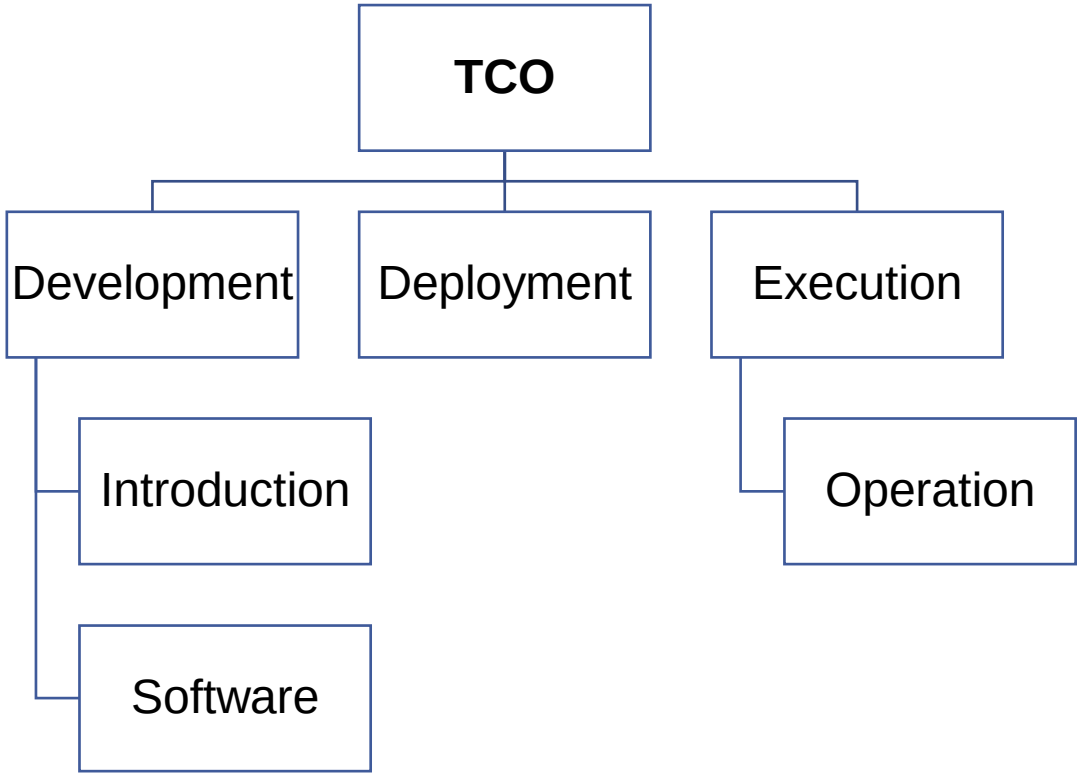
Total Cost of Ownership

TCO Model for onboard vs. cloudbased SWC

- Onboard SWC



- Cloudbased SWC

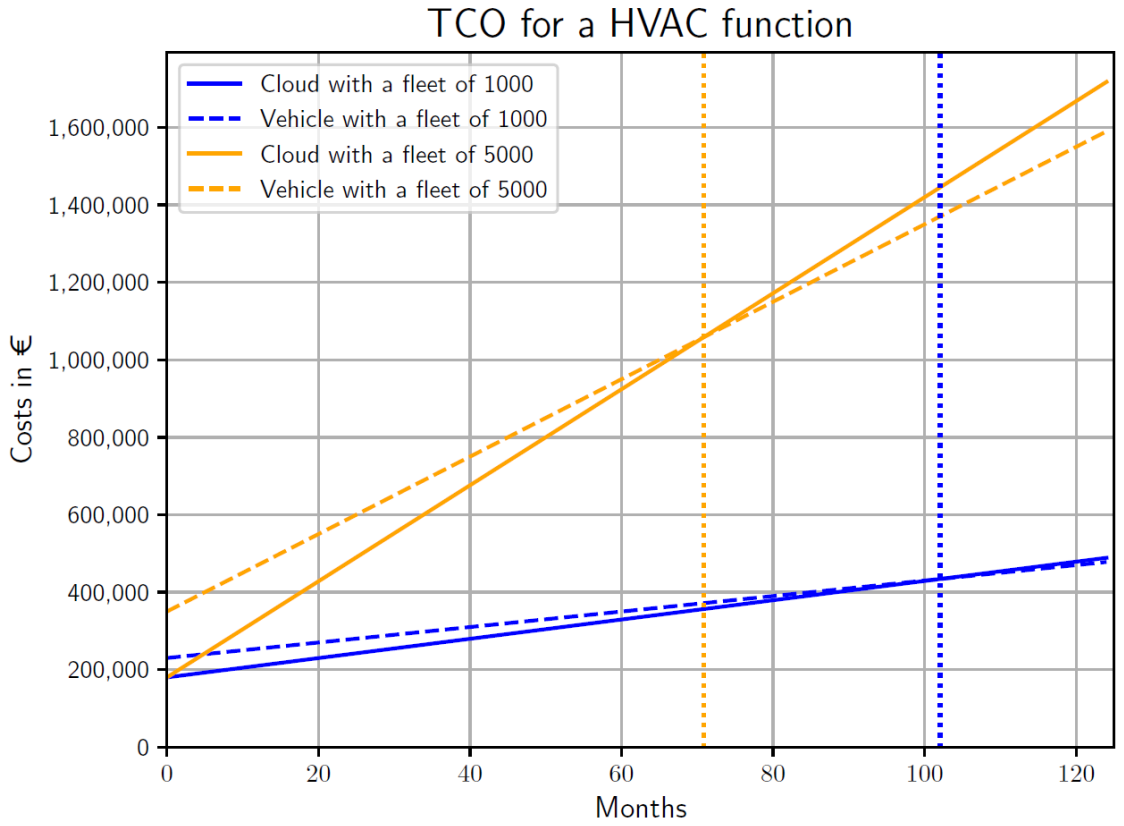


Case Study

Results of the total cost of ownership mode

- Case study of an SWC for the setpoint temperature specification of a heating, ventilation and air conditioning system (HVAC) for a city bus

TCO	Onboard SWC	Cloudbased SWC
Development	200.000€	180.000€
Deployment	30€ per ECU	0€
Execution	1€/month	2,49€/month



→ Outsourcing to the cloud makes sense

TCO Reduction Options

1) Saving of a complete ECU in an existing E/E architecture

2) Downsizing of an ECU in an existing E/E architecture

3) The cloud as a new execution platform alternative for new E/E architectures

Discussion

- Cloud Computing in the automotive sector is becoming increasingly important
- Downsizing a current ECU by moving SWC to the cloud only has a small financial effect
- The most likely use case: the cloud as a new execution platform
- While comfort functions are not considered safety-critical
  → network failures can still result in a negative user experience

Conclusion and Future Work

- Approach to gain an overview of the costs to be expected when applying a cloud or an onboard SWC
- Three cost reduction options
- Cloud based vehicle functions are becoming increasingly important
- Validate the model with additional case studies

Questions?

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