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Capability-based architecture for automated vehicles in urban environment

Tamara Hofmann, PROSTEP AG

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Placement in V&V Assurance Framework





Overview





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Why capabilities



Performing in open context VERIFICATION Why capabilities VALIDATION METHODS ك °O §35 StVO



Understanding the problem



- > Our current traffic system is an open system
- > We have to deal with **uncertainty** and **incompleteness**
 - Today the human driver must be capable to deal with these
 - In Future the ADS equipped vehicle must be capable to operate in this open context
- How to **span the problem space** if the human fallback level is removed?
- How to argue that safety case will remain valid, even if system context changes.
- > The expected behavior has to be addressed also in systems architecture



 \rightarrow Modeling capabilities as an approach to enable argumentation on an abstract level

Addressing the different levels

Why capabilities VERIFICATION VALIDATION METHODS



Addressing the different levels

Why capabilities



Capability-based Architecture of the System



- What shall the System capable of?
- Starting point are expectations towards the system (target behavior)
- Capabilities can be decomposed (hierarchical structuring)
- Capabilities do not have inputs and outputs





Target behavior and Capabilities



Target behavior to capabilities

Orange: signal and known facts

-?üQr1F

?üQr1P

Light blue: measurement

?üQr1P

!-?+Bb1P

?üQr1P

Measurement

Eao movement and position

?+Bb1P

Measurement

cyclist at r1

!-?üQr1P

?rQr1P

rQr1F

Measurement

crosswalk

+Bb1P

Green: fact

+Bb1F

Red. Actio

concluded fact:

Ego moves

crosswalk at r1

Benavioraltule

+Br1P

Grev: structure

üQr1P

+Bb2P

rQg2P

Crosswalk

Ego

Cyclist



Necessary capabilities can be derived from an analysis of the target behavior

Capabilities can **bridge the gap** from required target behavior (in certain quality) to the functions needed

Capabilities are the result of an orchestration

-> focus on emergence of systems (emergent behavior)

System capabilities are specified to achieve specific outcomes required by society, laws, regulations, enterprises, ...

✓ rQg1P

?rQg2P

Measurement cyclist at g2



Capabilities in FUC2-3

Target Behavior and Capabilities

- What shall the System capable of?
- Starting point are expectations towards the system (target behavior)
- Capabilities can be decomposed (hierarchical structuring)
- Capabilities do not have inputs and outputs
- Capabilities can be used to define a concept for validating the system behavior





Capabilities and functions



Capabilities and Functions in FUC2-3





Connecting capabilities and functions



- Functions contribute to certain system capabilities
- A system capability can be realized by multiple functions (for example, at a higher level of abstraction)
- A function can contribute to the realization of several system capabilities (-> modularity in architecture)
- Capabilities and functions are represented at different levels of abstraction

- System Capabilities:
 - Based on expectations of the target behavior of a vehicle
 - Describe on an abstract level preconditions to make target behavior possible
- Functions:
 - Definition of in- und outputs
 - Describe actions within the system at different levels
 - Can be mapped to logical parts of the system



Capabilities and Requirements





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Conclusion



Key aspects



- > The concept of capabilities taken from enterprise architecture can be applied to other systems
- Capabilities are understandable across organizations and remain stable
 - Capabilities are persistent across the PLC, even if the targets change
 - > They are independent of technologies and system functions
- Capabilities offer the possibility to bridge the gap between target behavior and function up to requirements
 - Capabilities can be derived from a target behavior specification, and these become measurable via capability targets
 - Capabilities have structuring characteristics
 - \rightarrow Objectify the problem and validate the behavior
 - > Used for structuring requirements for automated driving (appropriate behavior in traffic)



Thank you!

Tamara Hofmann, PROSTEP AG



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