Evaluation of validity of verification methods

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Overview

Introduction

Background

- Circa 80 ECUs
- Millions of lines of code
- Vehicles become more and more complex
- More functionality
- Safety critical
- Testing more then half the production cost

Glossary

Functional Safety (according to ISO 26262)

Glossary

Functional Safety (according to ISO 26262)

ASIL (Automotive Safety Integrity Level)

Introduction

Objective

- Automation of tests of modules in AUTOSAR
- Examine if it is possible to reach the requirements for a higher ASIL classification, thus fulfilling more requirements within the concept of functional safety.

Watchdog Manager

AUTOSAR specification

"The Watchdog Manager supervises the execution of a configurable number of so called Supervised Entities. When it detects a violation of the configured temporal and/or logical constraints on program execution, it takes a number of configurable actions to recover from this failure."

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Functional Safety (according to ISO 26262)

ASIL (Automotive Safety Integrity Level)

Supervised entity (Critical section)

Checkpoint (Point in these critical sections)

Functions

Getters

- GetVersionInfo(VersionInfoType*)
- GetMode(ModeType*)
- GetLocalStatus(SupervisedEntityIdType, LocalStatusType*)
- GetGlobalStatus(GlobalStatusType*)
- GetFirstExpiredSEID(SupervisedEntityIdType*)

Setters (interesting)

- Init (ConfigType*)
- DeInit ()
- PerformReset()
- SetMode(ModeType, uint16)
- MainFunction()
- Checkpointreached(SupervisedEntityIdType, CheckpointIdType)

Supervision mechanisms

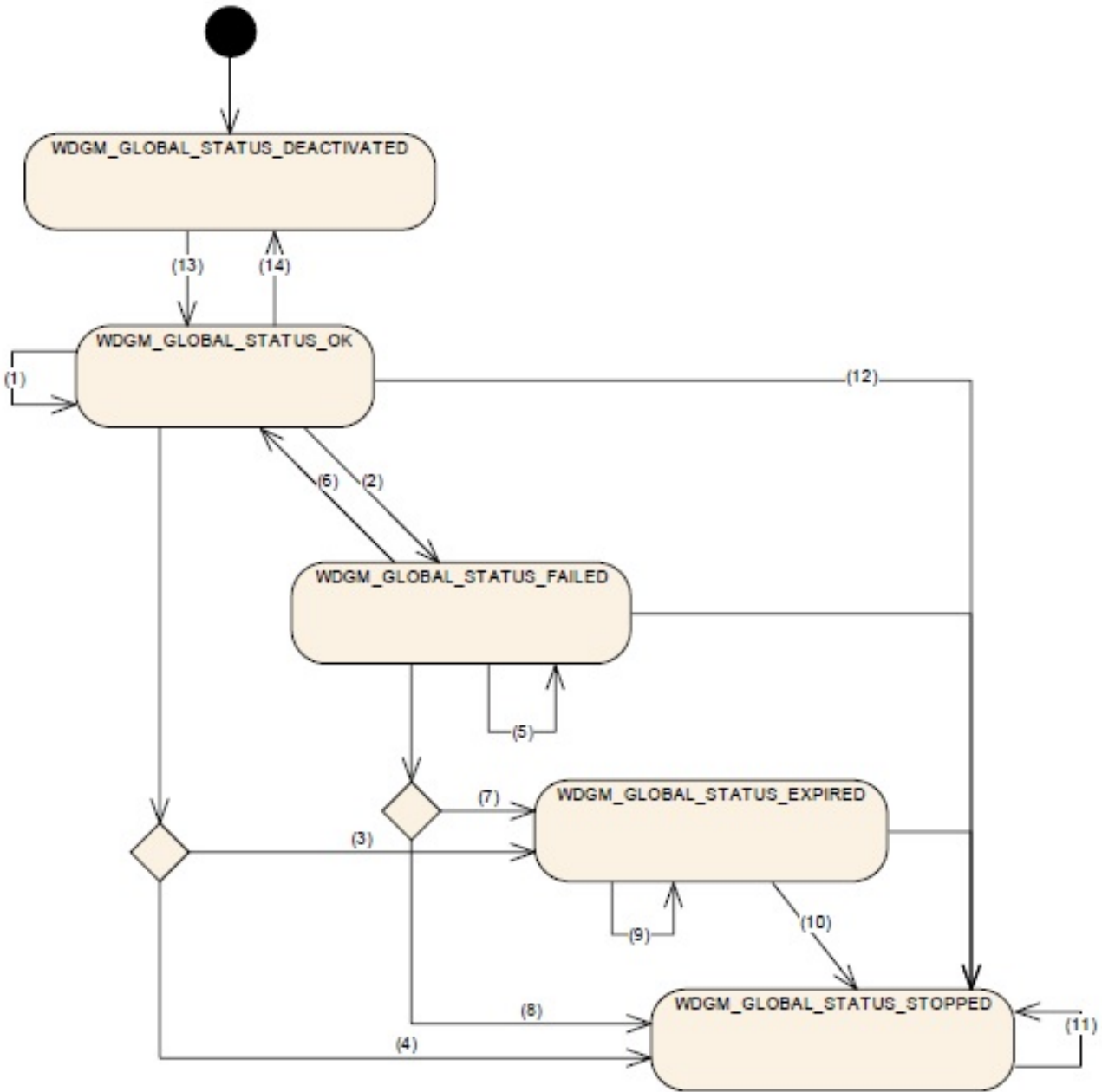
- Alive supervision
- Deadline supervision
- Logical supervision

The state machine

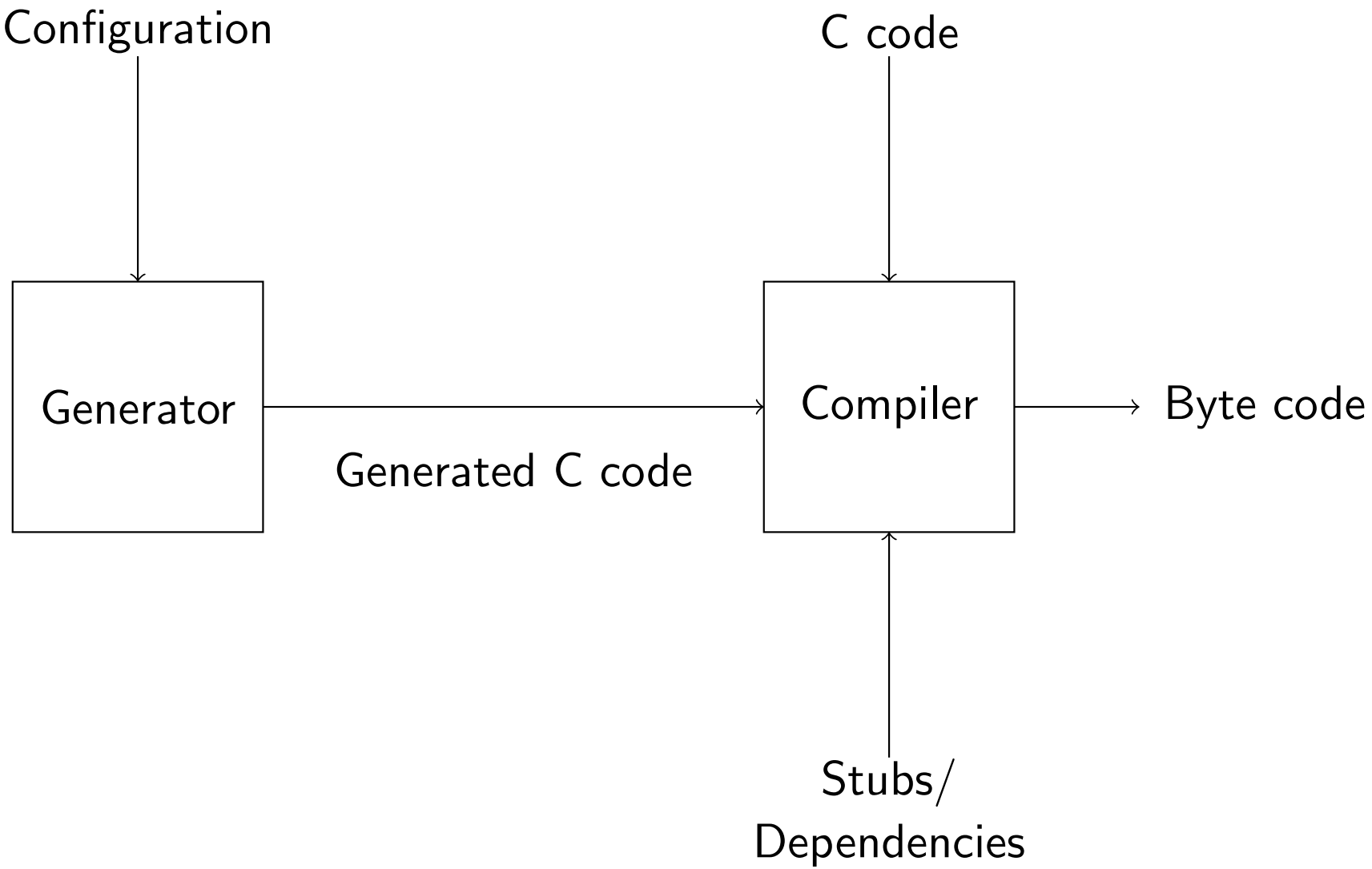
Global status (for the watchdog manager)

Local status (per supervised entity)

The state machine



Generating the C byte code



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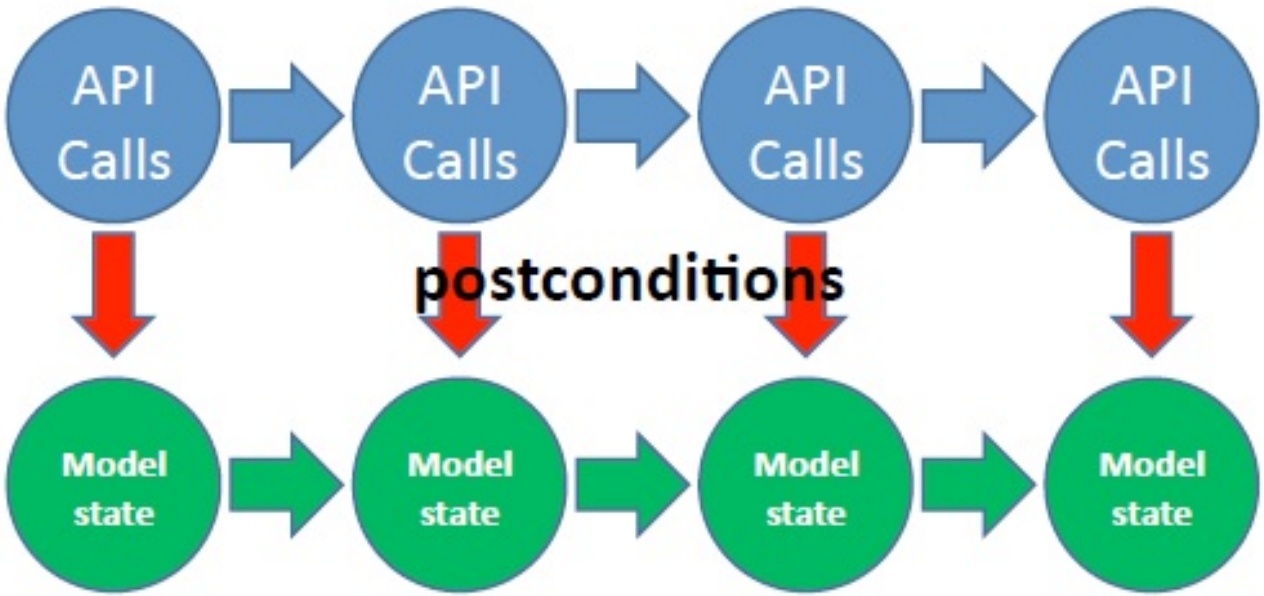
QuickCheck (A commercial testing tool)

QuickCheck

- Model based testing tool

How QuickCheck works



QuickCheck Properties

Properties

Quickcheck uses properties that can verify that AUTOSAR requirements are not violated.

Post condition example

```
getmode_post(S, [Is_Null], {Return_Value, Mode}) ->
  DevErrorDetect = S#state.originalCfg#wdgmgeneral.dev_error_detect,
  case Return_Value of
    0 -> Mode == S#state.currentMode; %% [WDGM170]
    1 -> DevErrorDetect andalso (Is_Null orelse %% [WDGM254]
                                 not S#state.initialized) %% [WDGM253]
  end.
```

Generating test cases

```
weight(S, _init) ->
  case S#state.initialized of
    true                          -> 1;
    _                             -> 200
  end;
```

Configurations

Three different configurations

BSI	minimal configuration
Example	complex configuration
Freescale	realistic configuration

Testing

Positive testing

- No absorbing state
- Correct arguments
- Correct command sequences

Negative testing

- Invalid arguments
- Null pointers
- Absorbing state

Bugs

- “Fix” the model
- Fix C-code
- Mocking function with bug

Bugs we found

C code

≈ 10

Generated C code

≈ 2

AUTOSAR complications

- ambiguous meaning
- conflicting requirements
- omitted requirements/explanations
- spelling of configuration parameters
- references

Coverage & Statistics

Coverage

- Line coverage of Erlang code (97.38%)
- Function coverage of the C code (100%)
- Condition/Decision coverage of C code (81%)
- State space coverage (100% of valid transitions, 0% of invalid transitions)
- Requirements coverage ($\approx$ 60%)

Statistics

- Generated command sequences of up to 120 commands (really no limit)
- 95% starts with the command `WdgM_Init`

Development Error Detection

Dangerous configuration parameter.

Our Testing Tool

- Automatically generates relevant test cases
- Combines requirements and tests them together
- Configuration independence
- Designed for integration with other modules

Future work

Integration testing.
More configurations = better test results.

Conclusions

- QuickCheck and functional safety.
- AUTOSAR as a standard.
- Complexity of configurations.
- Measurements of state space, and code coverages.
- Implementation time for finding bugs.

Questions?