# Feature-Oriented Software Evolution
(Vision paper)

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**The Seventh International Workshop on Variability Modelling of Software-intensive Systems**

Software evolves…

# Example

Automotive embedded software:

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Automotive embedded software:

- Changing regulations

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  - ABS is now mandatory in the EU

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## Example

Automotive embedded software:

- Changing regulations
  - ABS is now mandatory in the EU
- Market differentiating enhancements
  - Electronic stability control (SC) improves ABS by preventing skidding
- New technology availability
  - Laser-based distance sensors are more precise than radio-based ones

Understanding the evolution in place is not easy…

# Scenario

$$\mathrm{ABS} + \mathrm{SC}$$

# Scenario

- Integration can scatter different artifacts

## Scenario

- Integration can scatter different artifacts
- Different levels of abstractions not mastered by all stakeholders

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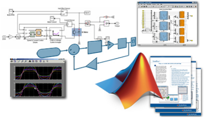
Management level

System level



Code level

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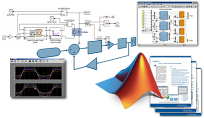

Code level

⇐ Developers

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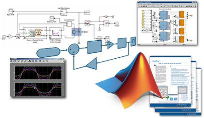

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Code level

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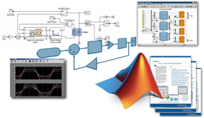
⇐ Project managers

System level



Code level

In practical settings. . .

# In practical settings...

Complex and large software systems have:

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Complex and large software systems have:

- Diverse set of stakeholders

## In practical settings. . .

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Complex and large software systems have:

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- Different stakeholders have particular "views" over the software

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Stakeholders need a common meeting point

Otherwise. . .

(no common meeting point)

# Otherwise. . .

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Ineffective communication

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Ineffective communication    Software flaws

# Otherwise. . .
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Ineffective communication

Software flaws

Architecture decay

# Otherwise. . .

(no common meeting point)

Ineffective communication Software flaws

Architecture decay Higher maintenance costs

# Hypothesis

## Hypothesis

*Managing evolution at the level of features can address the challenges describe above*

# Hypothesis

Arguments favouring the hypothesis:

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- Feature = cohesive requirements bundle

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Arguments favouring the hypothesis:

- Feature = cohesive requirements bundle
- Requirements are a common point among all stakeholders
- Features are more coarse-grained than individual requirements
    - Facilitates understanding
- Evolution can be put in simple terms
    - Add new feature, retire old ones, etc.

# Our vision

(Assuming the validity of our hypothesis)

# Feature-oriented evolution based on:

**Tracing**

# Feature-oriented evolution based on:

**Tracing**

**Analyses**

Feature-oriented evolution based on:

**Tracing**

**Analyses**

**Recommendations**

# Purpose of our work

## Research agenda based on our vision for feature-oriented software evolution

This presentation covers part of that agenda
(see paper for more details)

# Motivating example

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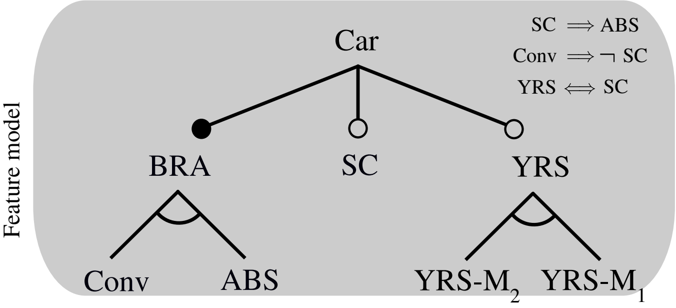

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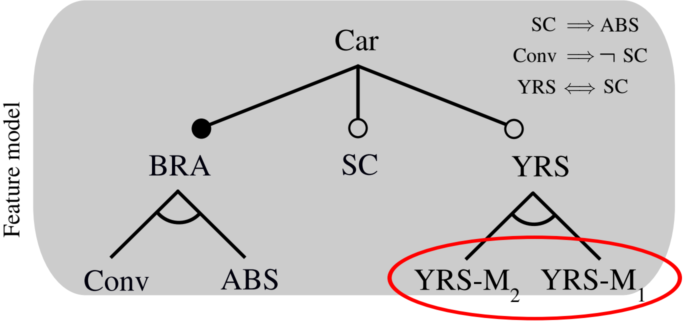
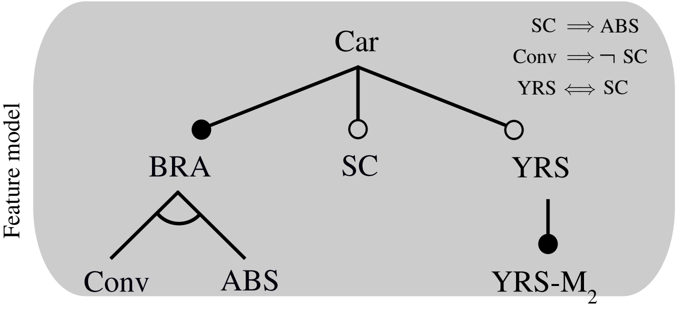



Merge + clone yaw rate prediction

# Motivating example



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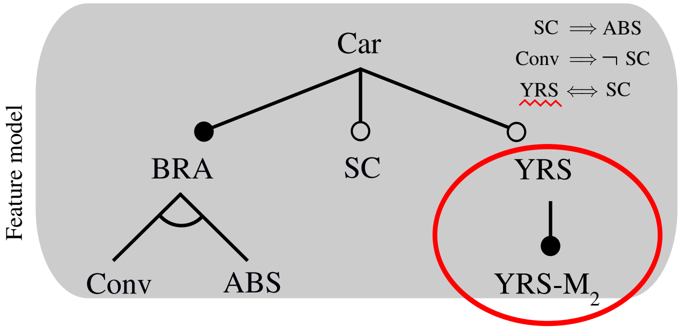
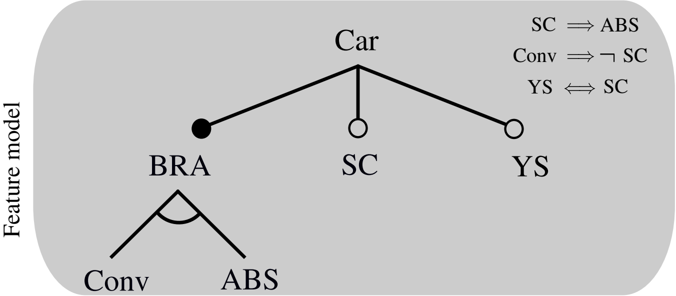



Merge YRS-$M_2$ into YRS + rename YRS to YS

# Motivating example



# Tracing

# Tracing

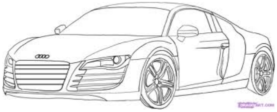
$(t_1)$

YRS-$M_1$ YRS-$M_2$

$(t_2)$

YRS-$M_2$

$(t_3)$



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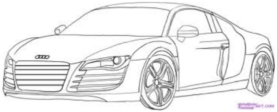
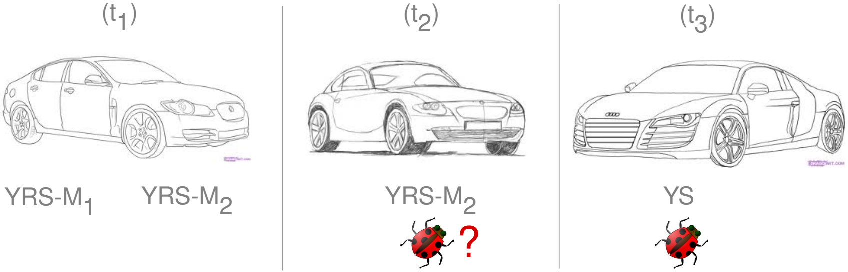


YS

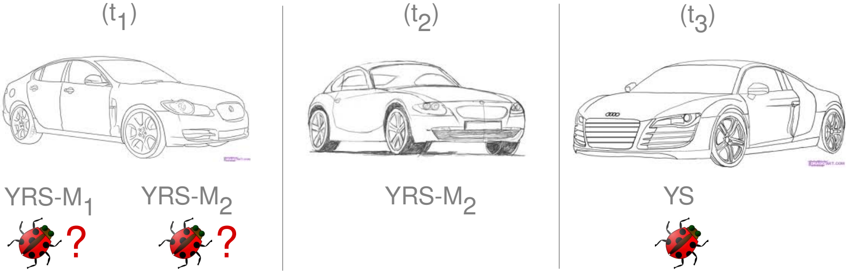
Bug found in YS

# Tracing



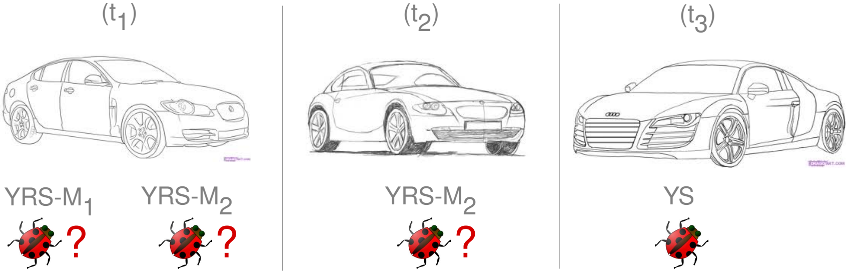

Does the bug exist in YRS-$M_2$ ($t_2$)?

# Tracing



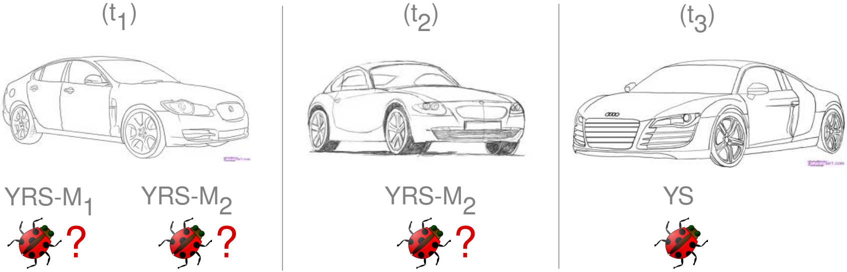

Does the bug exist in YRS-$M_{1/2}$ $(t_1)$?

# Tracing




Does the bug exist in both $t_1$ and $t_2$?

# Tracing




Answering requires tracing the evolution of single features

## Tracing

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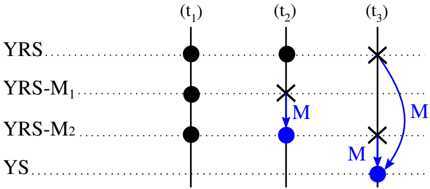

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(Research questions)

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**RQ: How to recover traceability links in build files and source code in variability-aware systems?**

# Tracing (Research questions)

- Tracing certain artifacts can be daunting
  - Individual build rules in build files (e.g., *make* is Turing-complete)
  - Fine-grained variability analysis in code is costly

**RQ: How to recover traceability links in build files and source code in variability-aware systems?**

**RQ: Once recovered, how to update them to reflect the temporal evolution in place?**

## Tracing (Research questions)

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**RQ: Which sources are trustworthy?**

# Analyses

# Analyses
(Back to the motivating example)

## Analyses

After the evolution of the SPL, stakeholders noticed that:

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Well-known phenomena of *software aging*

## Analyses

We envision three analyses to prevent aging:

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# Analyses
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Goal: prevent inconsistencies in different artifacts

# Analyses (Consistency checking)

## Goal: prevent inconsistencies in different artifacts

abs.c (1)

```
...
#ifdef Conv
   // switch
   // to Conv
   // if ABS
   // fails
#endif
...
```

abs.c (2)

```
...
sensor_data_t data ;
#ifdef SC
  data = get_value(data) ;
#endif

if (data->check_oversteering())
   react_oversteering() ;
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```

abs.c (3)

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...
#ifdef SC && YRS_M1
   double predicted_value
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abs.c (4)

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#ifdef SC && YRS_M1
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Dead code

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Null pointer exception

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Syntax error

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Other types of analysis exist: e.g., model-checking

# Consistency checking

(Research questions)

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# Consistency checking (Research questions)

- Variability aware-analysis is costly.

  **RQ: Do existing approaches for variability-aware type-checking, flow-analysis and model-checking scale to large systems?**

- Existing flow-analysis is intra-procedural.

  **RQ: How to adapt existing inter-procedural analyses to handle variability?**

# Analyses
(Impact analysis)

## Impact analysis

Goal: assess impact of changes

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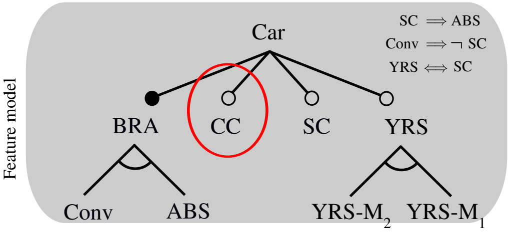

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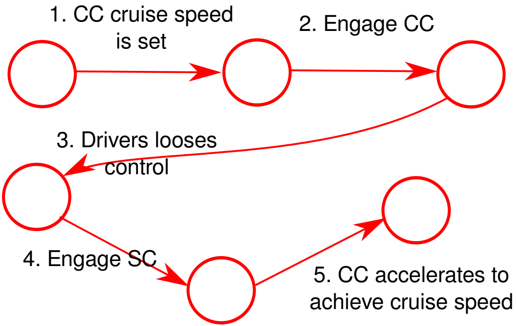

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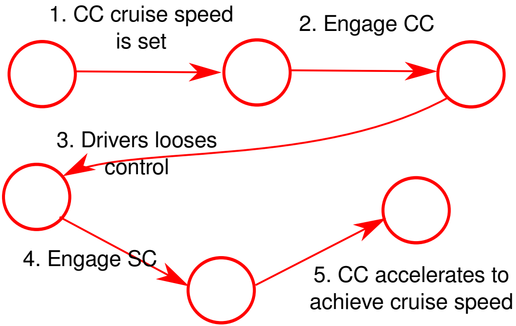


Adding CC violates the given property

# Impact analysis

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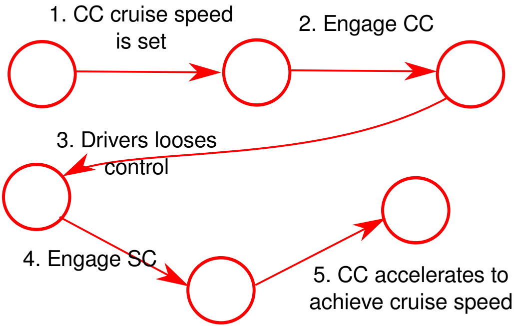


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(Impact analysis aims to detect that promptly)

# Impact analysis (Research questions)

- Currently, consistency between implementation assets (code) and the system's specified property is mostly intractable.

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  **RQ: How to verify that the system implementation does not break its specified properties?**

# Analyses
## (Architectural analysis)

## Architectural analysis

- Feature model = view of the system architecture
- From the recovered traces, one can track the "health of the system"
- Different indicators can be collected to assess the system evolution:
  - code metrics
  - process metrics
  - feature-based metrics
  - feature-model based metrics
  - product-line based metrics

## Architectural analysis

- Evidence relating scattering and defects is rather preliminary.

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  **RQ: Can we provide more evidence for the relationship between scattering and defects?**

# Recommendations

# Recommendations + research question

Suggestions for:

## Recommendations + research question

Suggestions for:

- Consistency analysis

## Recommendations + research question

Suggestions for:

- Consistency analysis
- Impact analysis

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## Recommendations + research question

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- Fix recommendations for different artifacts types

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Impact analysis:

- Point which features are more likely to have defects after a change

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- Fix recommendations for different artifacts types

**RQ: How to devise a fixing recommender integrating different artifacts, with different abstraction levels?**

Impact analysis:

- Point which features are more likely to have defects after a change

**RQ: Which feature-based metrics are good defect predictors?**

# Recommendations + research question

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**RQ: Which scenarios should be supported (are required in practice)?**

# Conclusion

- We hypothesized that feature-oriented evolution can mitigate existing challenges in evolving large-complex systems
- From that hypothesis, we presented our vision based on tracing, analyses and recommendations
- We are have started working on the realization of that vision

# Thanks for listening!