Modularity Anomaly Types – Part II

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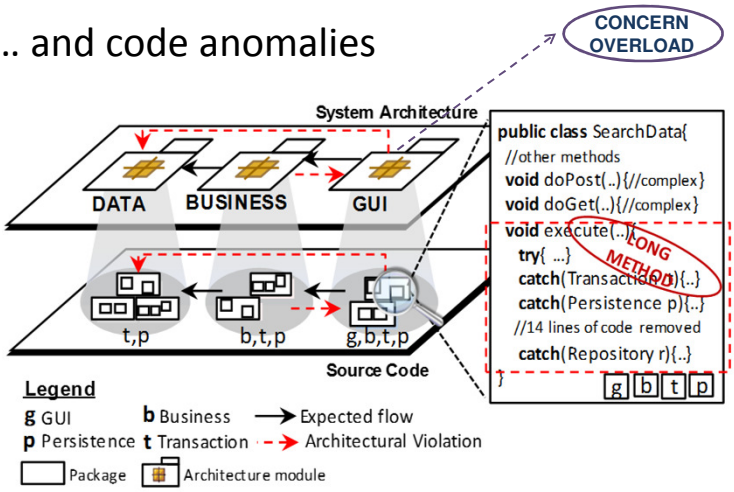
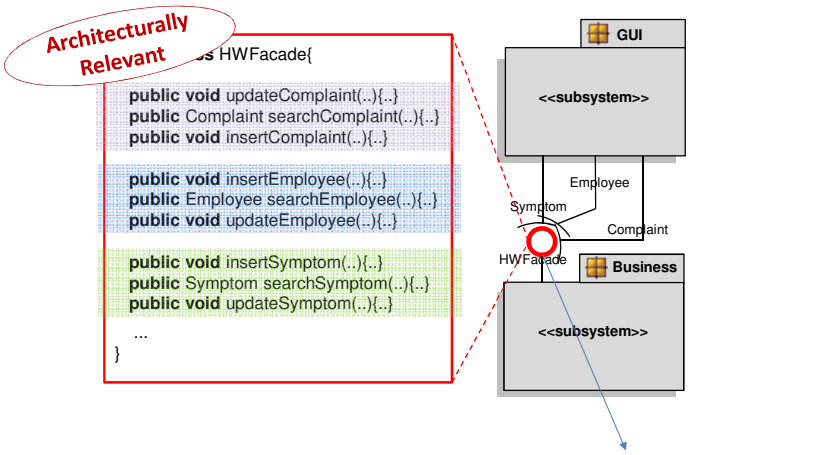
Relation between architectural problems…

- … and code anomalies

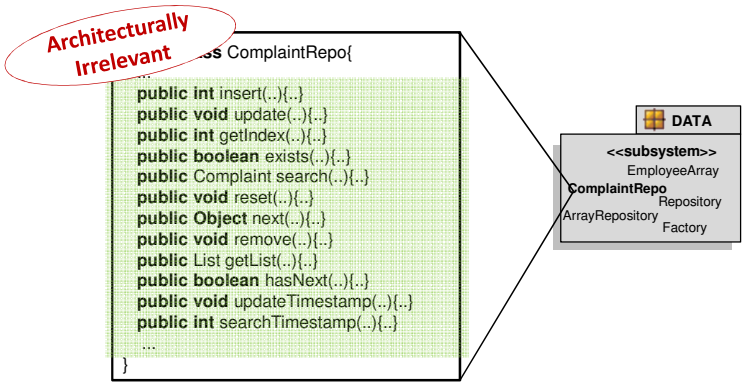


Relevance of Code Anomalies



Architectural Interface Bloat

Relevance of Code Anomalies



Three Questions

1 Are anomalous code elements and architecture problems related?

2 If so, which characteristics of the code anomaly are relevant for the architecture design?

3 To what extent the applied refactorings actually addressed architecturally-relevant code anomalies?

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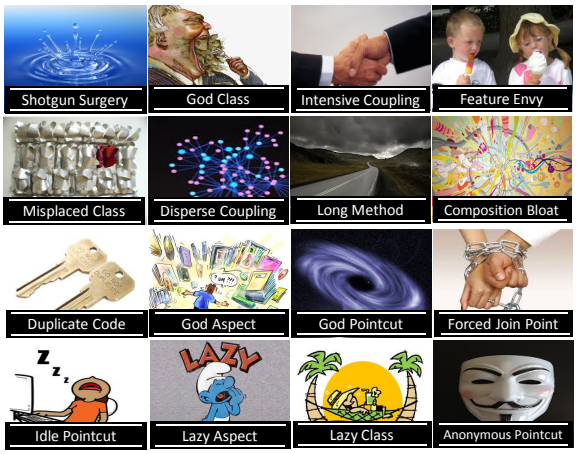
Target systems

MIDAS	Mobile Media
PDP	Health Watcher
	Aspectual Watcher
	Aspectual Mobile

Code anomalies



Architectural anomalies

Target Systems

MIDAS	MM	HW	PDP
C++	Java	Java	C#
76 KLOC	54 KLOC	49 KLOC	22 KLOC
111 anomalies	170 anomalies	252 anomalies	175 anomalies

- 6 different systems
- 40 revisions
- Architecture information available

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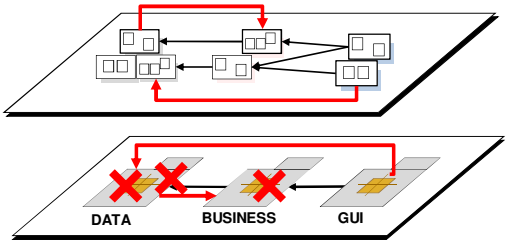
Analysis

- Recovering **Actual Architecture**
- Identifying Architecture Anomalies
- Detecting Code Anomalies
- Analyzing the Impact of Code Anomalies



Q1 Are anomalous code elements and architecture problems related?

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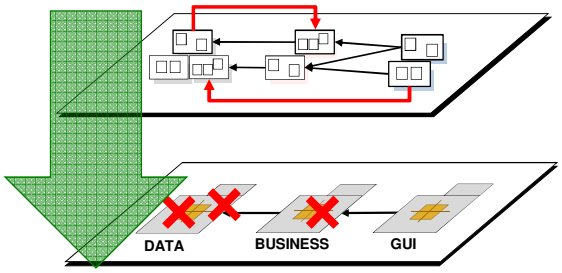
Analyzing the Impact of Code Anomalies

- Downstream Analysis
  - Which architecture problems are related to code anomalies



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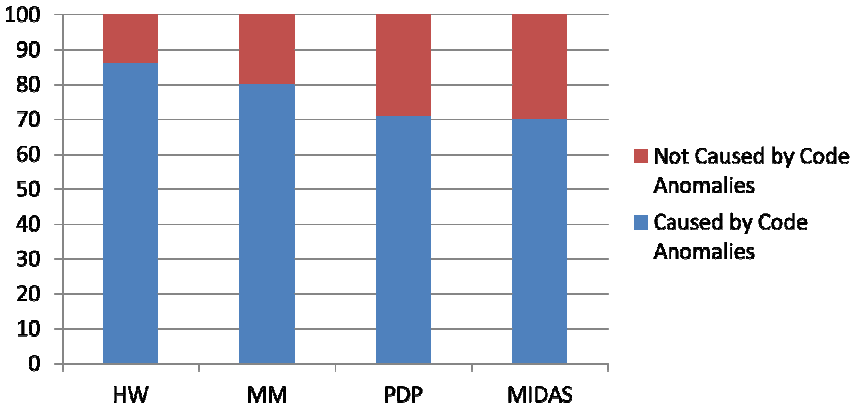
Analyzing the Impact of Code Anomalies

- Downstream Analysis



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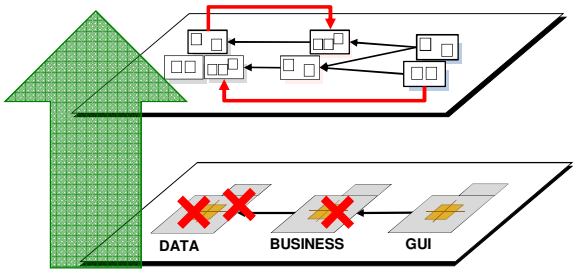
Analyzing the Impact of Code Anomalies

- Upstream Analysis
  - Which code anomalies are related to architecture problems



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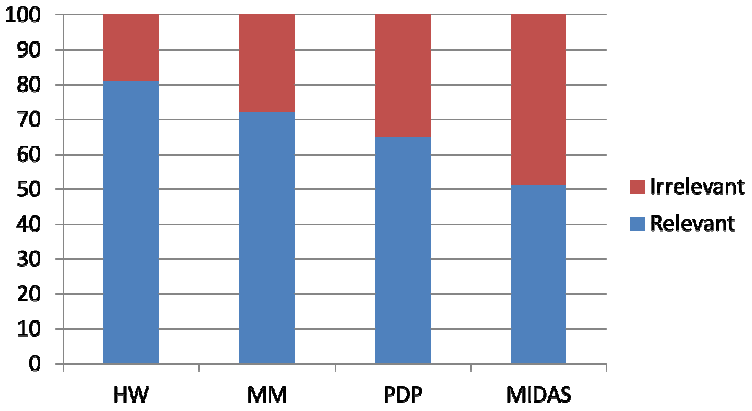
Analyzing the Impact of Code Anomalies

- Upstream Analysis



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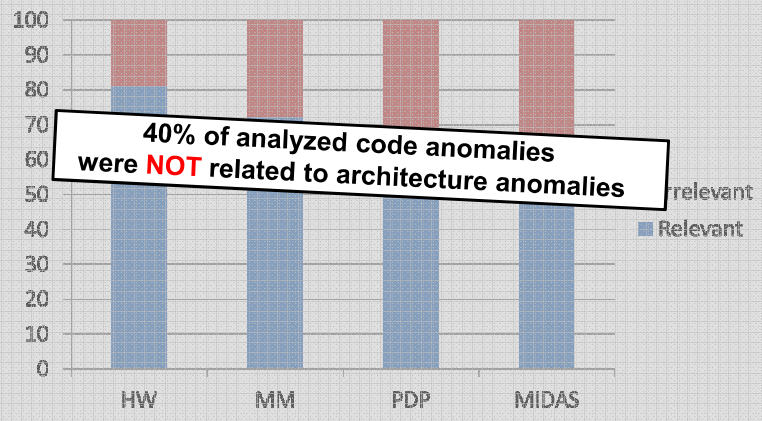
Analyzing the Impact of Code Anomalies

- Upstream Analysis



40% of analyzed code anomalies were NOT related to architecture anomalies

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Three Questions

1 Are anomalous code elements and architecture problems related?

2 If so, which characteristics of the code anomaly are relevant for the architecture design?

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Identifying Relevant Code Anomalies

- The following characteristics were analyzed:
  - **Code anomaly type**
  - Change density
  - Error density
  - Anomaly density
  - And others...

Q2 which characteristics of code anomalies are architecturally-relevant?

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Type of Code Anomaly

Kinds of Code Anomalies	AW	HW	AM	MM
Divergent Change	5	7	5	5
Feature	[illegible]	[illegible]	[illegible]	2
God Cl	[illegible]	[illegible]	[illegible]	5
Inappropriate Intimacy	6	[illegible]	[illegible]	8
Long Method	7	8	4	6
Long Parameter List	7	2	5	3
Misplaced Class	1	1	2	3
Shotgun Surgery	3	2	4	5
Small Class	4	7	3	6

None of the code anomalies was the best indicator across all analyzed systems

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Identifying Relevant Code Anomalies

- The following characteristics were analyzed:
  - Change density
  - Error density
  - Anomaly density

Q2 which characteristics of code anomalies are architecturally-relevant?

Studying prioritization models

- Which other characteristics could be explored for detecting architecturally-relevant code anomalies ?
  - Change density
  - Error density
  - Anomaly density

Q2 which characteristics of code anomalies are architecturally-relevant?

R. Arcoverde et al – **RSSE/ICSE 2012**: Automatically Detecting Architecturally-Relevant Code Anomalies

R. Arcoverde et al – **SBES 2013**: ***Prioritization of Code Anomalies Based on Architecture Sensitiveness.*** SBES'13) Brasília, Brazil, September 2013.

Prioritization heuristics

Change density

System	# of Ranked CE	Arch. Relevant	%
HW	14	10	71%
MM	10	7	70%
PDP	**10**	**10**	**100%**

Error density

System	# of Ranked CE	Arch. Relevant	%
HW	**14**	**12**	**85%**
MM	10	8	70%
PDP	10	8	70%

Anomaly density

System	# of Ranked CE	Arch. Relevant	%
HW	10	7	60%
MM	10	9	70%
PDP	10	8	70%
MIDAS	**10**	**6**	**90%**

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Priorization Factors

.. 1. **There is no 'universal' prioritization model**
2. **Prioritization models: satisfactory results too late**

May 16 20

Prioritization heuristics

Change density

System	# of Ranked CE	Arch. Relevant	%
HW	14	10	
MM	10	7	
PDP	**10**	**10**	**100%**

Version 12

Error density

System	# of Ranked CE	Arch. Relevant	%
HW	**14**	**12**	**85%**
MM	10	8	
PDP	10	8	

Version 9

Anomaly density

System	# of Ranked CE	Arch. Relevant	%
HW	10	7	
MM	10	9	
PDP	10	8	
MIDAS	**10**	**6**	**90%**

Version 10

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Earliness of Anomaly

- Early anomaly: appears in the 1st version of each system

18%

Of all architecturally-relevant code anomalies were identified as **early anomalies**

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Earliness of Anomaly

- Early anomaly: appears in the 1st version of each system

18%

Of all architecturally-relevant code anomalies were identified as **early anomalies**

and were related to more than

37%

of all architecture problems

However, we observed that...

- ... architecturally-relevant code anomalies tend to "flock together" even in the 1st version of each system:
  - anomaly agglomerations within a class or syntatically-related classes can be used as good indicator
- Continuous detection of emerging anomaly agglomerations?

Three Questions

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Refactoring of Relevant Anomalies

- 658 refactorings
  - 33% high-level
    - Move member (16%)
    - Extract class or superclass (12%)
  - 67% low-level
    - Rename (32%)
    - Extract local variable (16%)
- **37%** of all architecture-relevant anomalies were refactored
- Isolated versions concentrated most of the refactoring efforts

Q3 architecturally-relevant refactorings?

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Concluding Remarks

Most architecture problems are related to anomalous code elements

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Anomaly agglomerations are more frequently related to architecture problems

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Architecturally-relevant anomalies are not frequently refactored

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Concluding Remarks

Most architecture problems are related to anomalous code elements

Anomaly agglomerations are more frequently related to architecture problems

Architecturally-relevant anomalies are not frequently refactored

Detecting early code anomalies is a needed asset for assisting developers when prioritizing refactoring efforts

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