Investigating the Impact of Design Debt on Software Quality

Prioritizing Design Debt Investment Opportunities

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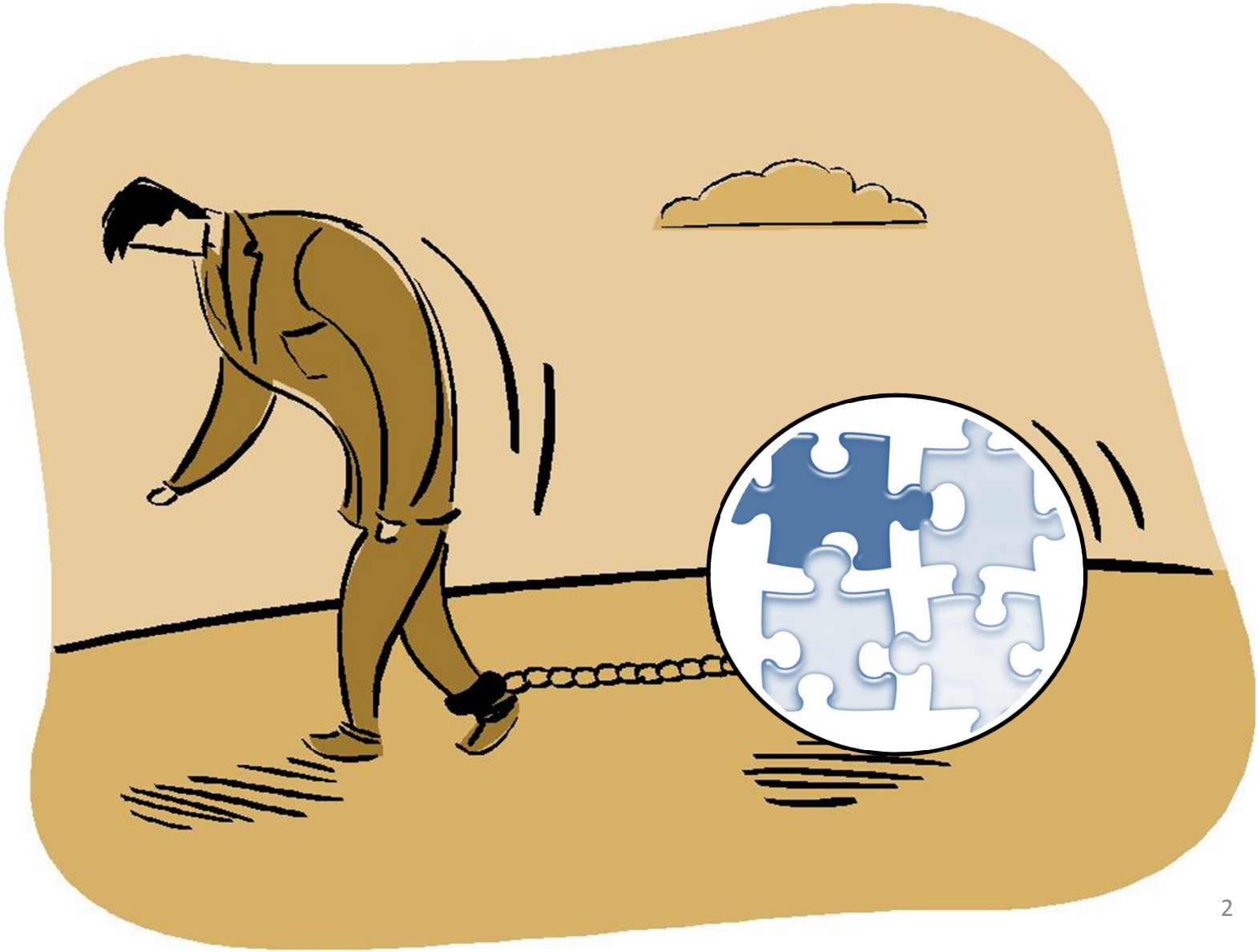
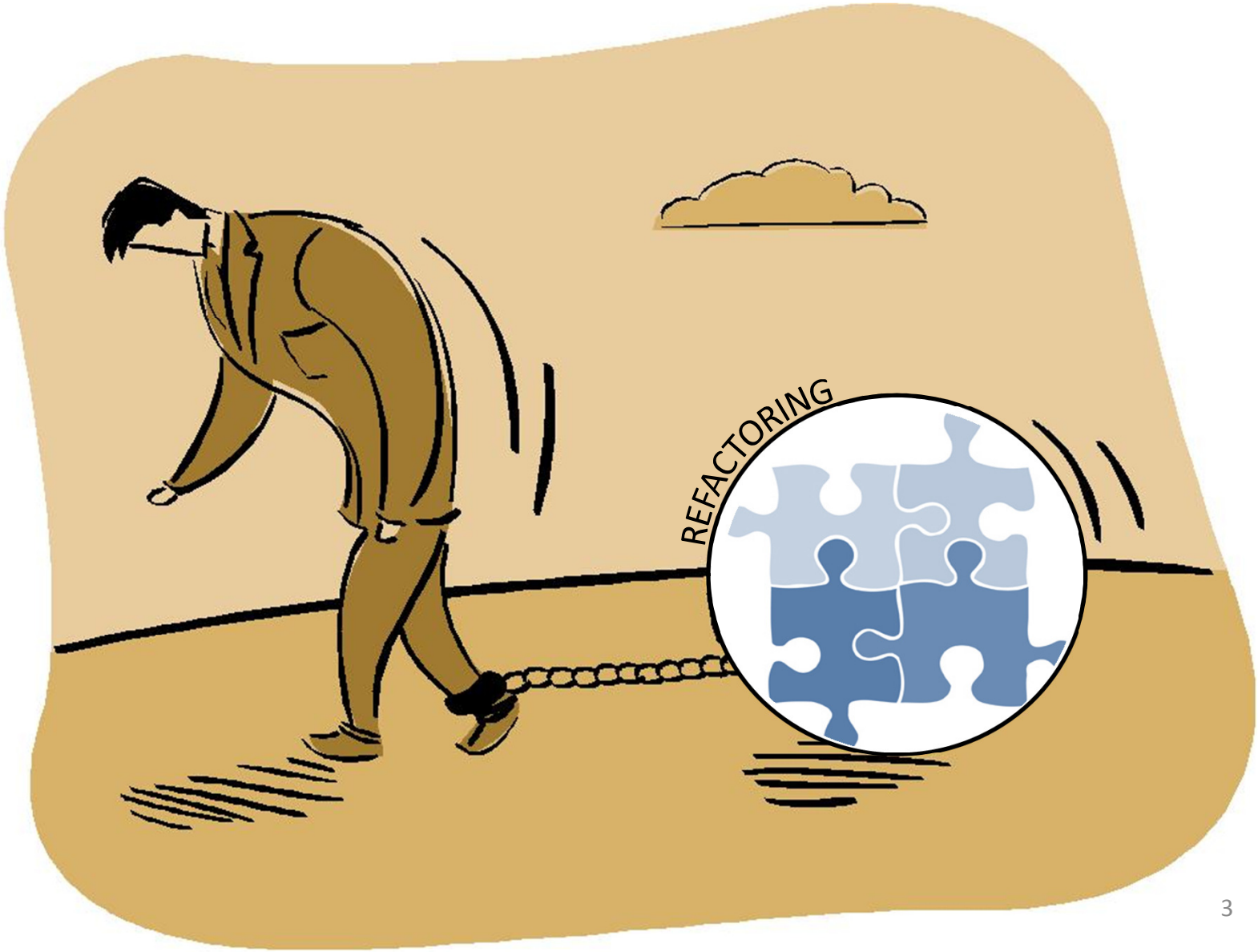
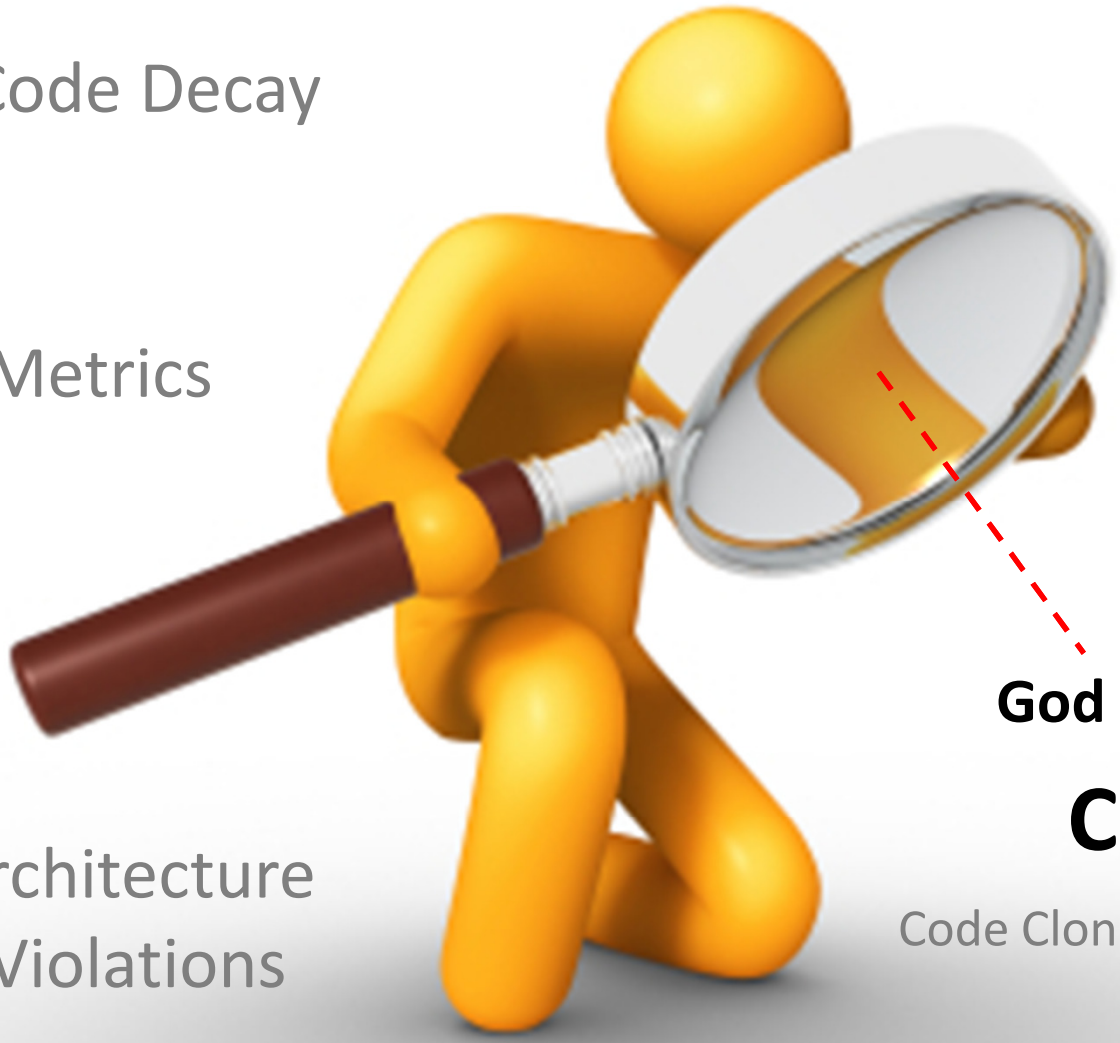
Design Debt



Design Debt



Potential Indicators



Code Decay

Lack of
Design Patterns

Code Metrics

God Class

Data Class

Code Smells

Architecture
Violations

Code Clones

Tradition Breaker

Intensive Coupling

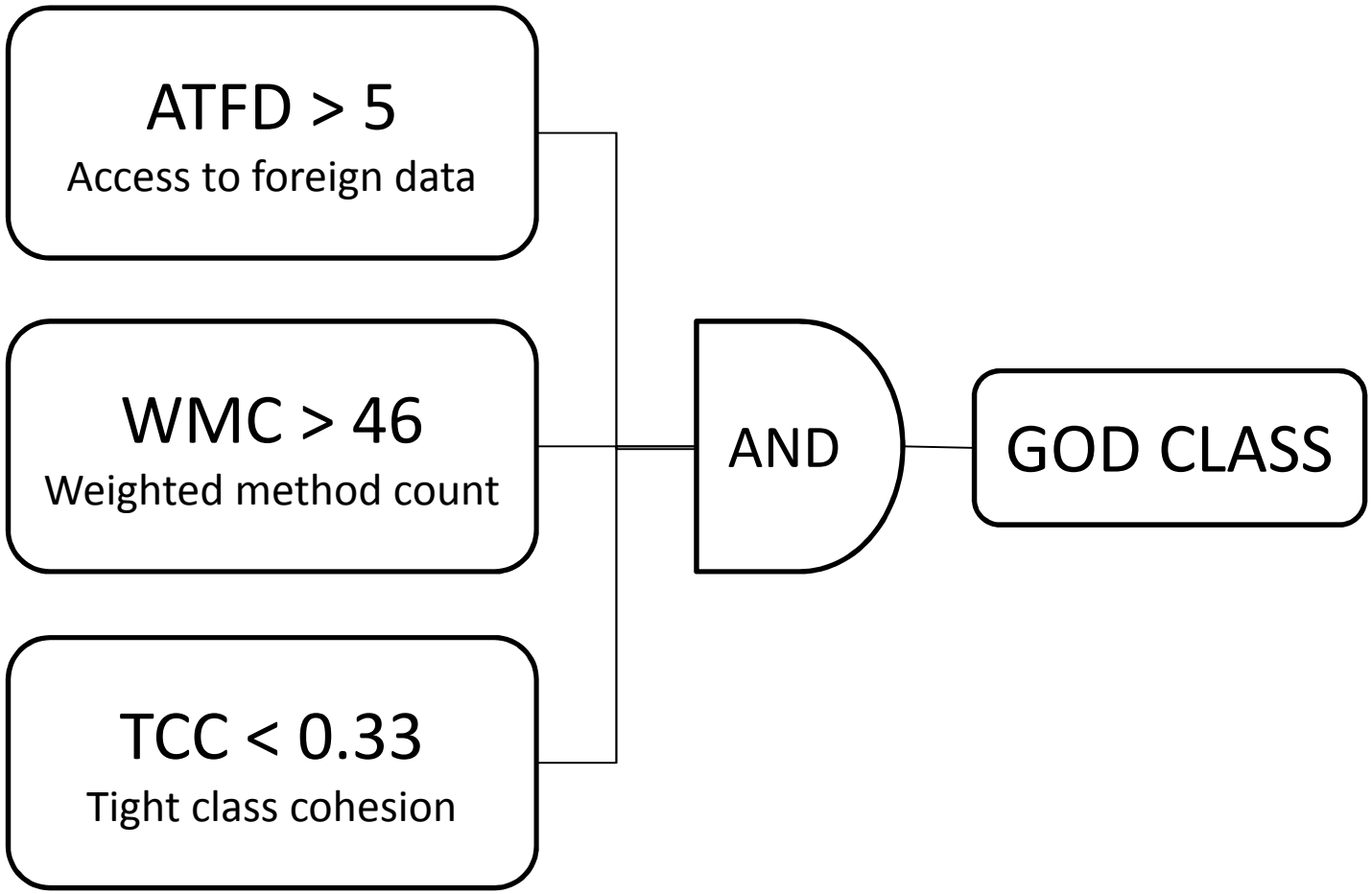
Research Questions

- Are Code Smells, i.e. God Classes, valid indicators for design debt?
  - Do God Classes have a negative impact on:
    - Maintainability and
    - Correctness
- Can we give advice on which design debt to pay first?
  - Which God Classes are easy to fix and promise high gain in software quality?
  - Which God Classes are hard to fix and promise low gain in software quality?

The God Class

- Also known as “Large Class” [Fowler99]
- Marinescu [Mar04]
  - Centralizes intelligence
  - Multiple responsibilities
  - Delegates minor detail
  - Uses data of other classes

God Class Detection



Case Study

- Small software development company
  - 30 employees: C# developers, web-designers
  - 2 active development projects
    - Project J: 35kLOC, 11 months, 4 developers
    - Project F: 45kLOC, 17 months, 4 developers
- Previously performed a code smell study in the same environment
- Small part of developers were familiar with technical debt metaphor
- Data: subversion repository and JIRA bug tracker

God Classes and Maintainability

- Assumption: maintainability can be estimated by investigating how often a class to be changed
  - Rational: classes that have to be changes too often, e.g. with each revision, are indicators for maintenance bottlenecks
- H1: The change likelihood of god classes is higher than for non-god classes

Revision	1452	1457	1471	1472	1424	Likelihood
Changed God Classes	0/4	1/4	1/4	2/4	2/4	0.300
Changed Non-God Classes	1/223	4/223	6/225	4/225	2/225	0.015

Example for change likelihood for god classes and non-god classes in project F

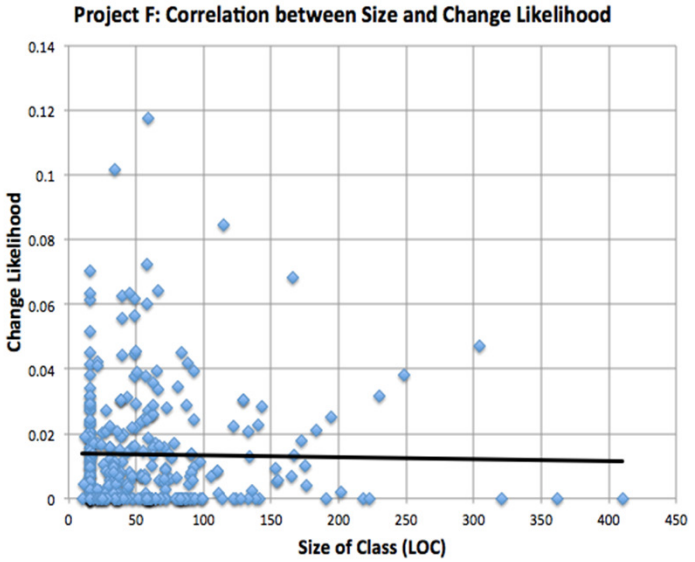
Maintainability Results

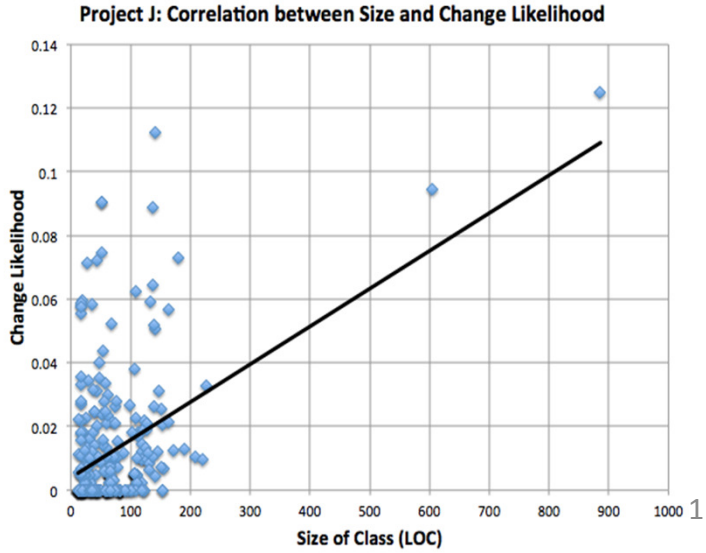
	Project F		Project J	
	God Classes	Non-God Classes	God Classes	Non-God Classes
N	545	658	282	328
mean	0.07848	0.01619	0.12565	0.01725
s	0.18448	0.03837	0.24754	0.02391
	p-value: 4.282e-14		p-value: 2.461e-12	

- God classes are 5-7 times more change prone
- Do we need to normalize this data by size?

Investigating Normalization

- Assumption: “A class that is twice as large, is twice as change prone.”
- Method: Measure correlation between:
  - Size (LOC)
  - Change Likelihood
- Results (Pearson CC):
  - Project F: **-0.029**
  - Project J: 0.42
- Dividing by LOC might over-normalize result
  - Project J normalized result still statistically significant





God Classes and Defects

- H2: The defect likelihood of god classes is higher than for non-god classes
- Data: JIRA bugs are linked to subversion change sets (=classes that were part of the bug fix)

Defect (JIRA issue)	J-166	J-161	J-377	J-396	J-228	Likelihood
Fix Revisions	9097, 9098	8939	11990	12842, 12844	10269	
God Classes	1/3	0/1	0/8	3/8	0/3	0.1417
Non-God Classes	0/94	1/94	1/156	0/157	1/101	0.0067

Example for defect fix likelihood for god classes and non-god classes in project J

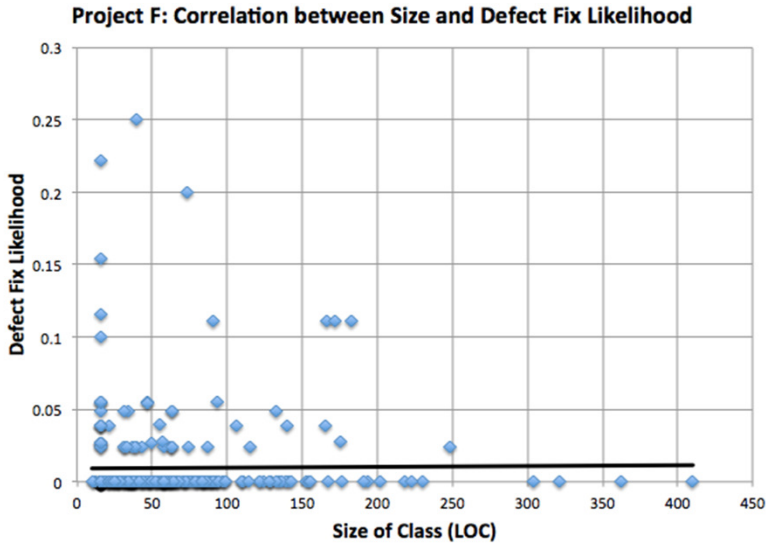
Defect Results

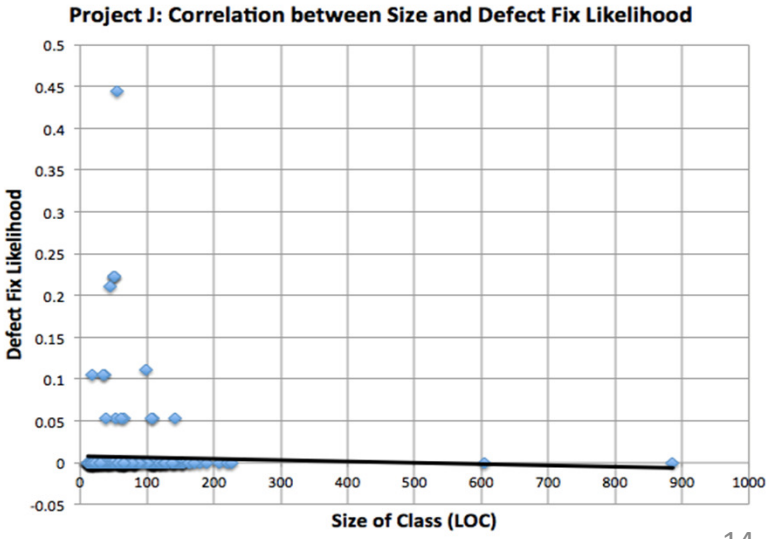
	Project F		Project J	
	God Classes	Non-God Classes	God Classes	Non-God Classes
N	32	32	17	17
mean	0.03939	0.00956	0.16911	0.00624
s	0.13669	0.01094	0.22266	0.00796
	p-value: 0.2276 (not sig.)		p-value: 0.008217	

- God classes are 4-17 times more defect prone
- Do we need to normalize this data by size?

Investigating Normalization

- Assumption: “A class that is twice as large, is twice as defect prone.”
- Method: Measure correlation between:
  - Size (LOC)
  - Defect Likelihood
- Results (Pearson CC):
  - Project F: 0.011
  - Project J: -0.018
- Dividing by LOC will over-normalize result





Related Research

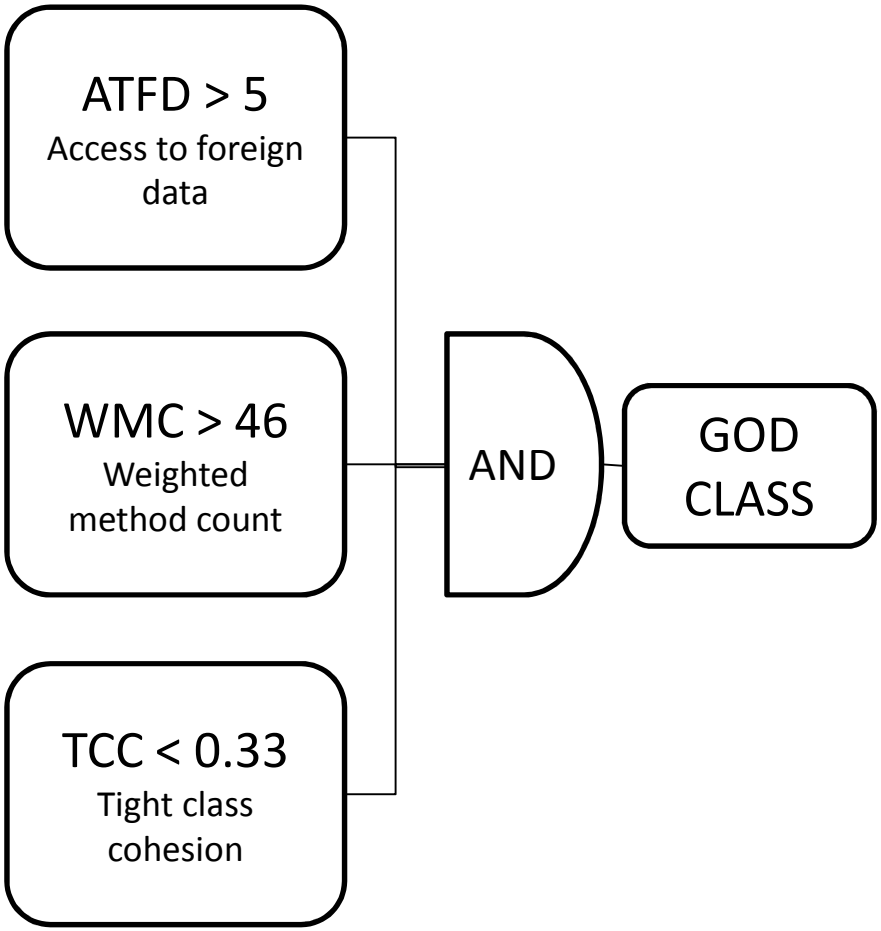
Related Work	Investigated Software	God classes more change prone if not normalized? (p<0.05)	God classes more change prone if LOC normalized? (p<0.05)	God classes more defect prone if not normalized? (p<0.05)	God classes more defect prone if LOC normalized? (p<0.05)
Li 2007	Eclipse				
Olbrich 2009	Lucene, Xerces				
Schumacher 2010	Two commercial applications				
Olbrich 2010	Lucene, Xerces, Log4j		 less change prone	 in 2 out of 3 cases	 less defect prone in 2 out of 3 cases
Khomh 2009	Azereus, Eclipse	 5 out of 10 releases			
Study results presented here	Two commercial applications		 in 1 out of 2 cases	 1 out of 2 cases	 in 1 out of 2 cases

Paying Design Debt

- Moving from identifying TD to **managing TD**
- Paying off debt is an **investment opportunity** with tradeoffs:
  - Value of debt (how much is it going to cost to fix it?)
  - Interest rate (how much does it slow down development?)
  - Probability (what is the chance that the debt affects productivity?)
- Goal: select the most profitable opportunities, ignore non-profitable ones.
- Profitable (good cost/benefit ratio)
  - Low value
  - High interest rate

Cost of Paying Debt

- Refactoring
- Idea: facilitate metrics in detection model
- Argument: a class being close to the thresholds will be easier to refactor than one that is multiple magnitudes outside.
- Method: rank god classes according to their distance to the thresholds



God Class Ranking: Cost

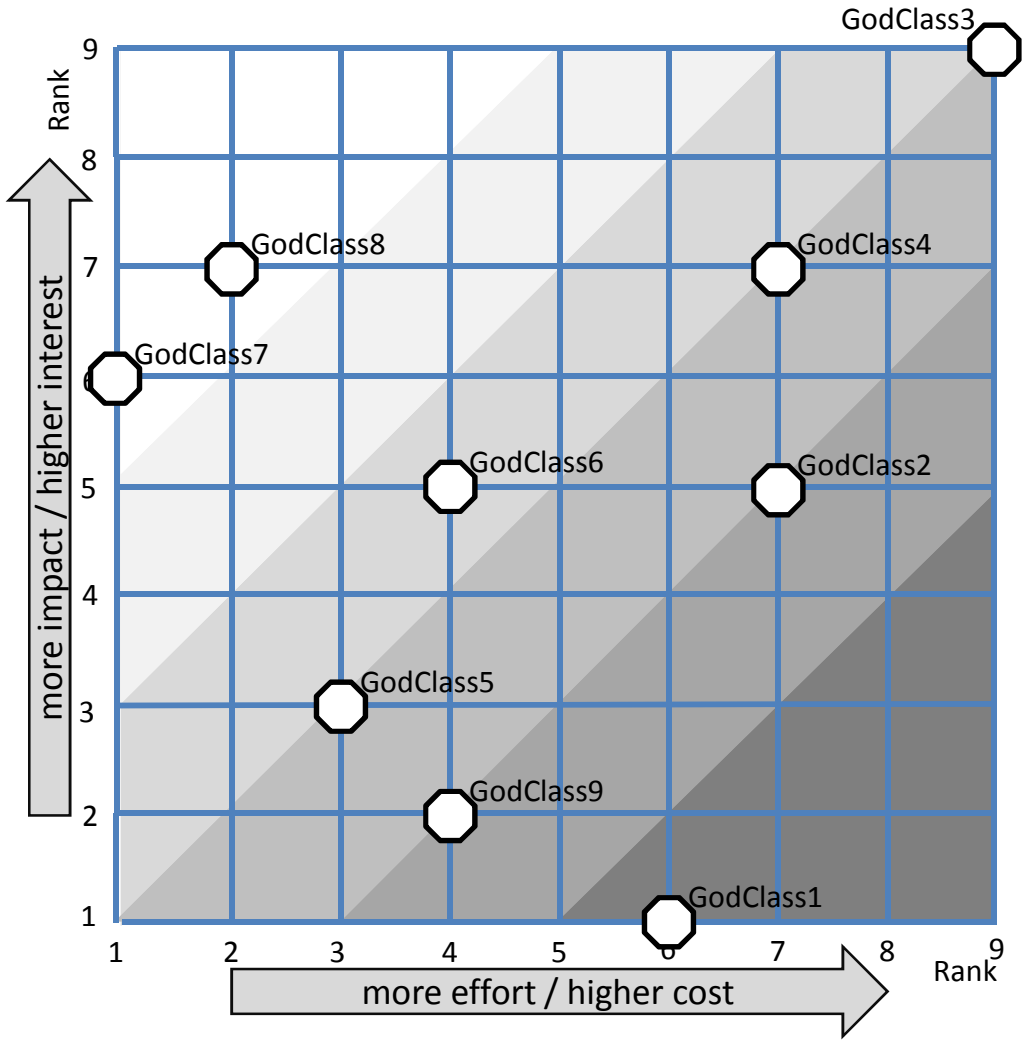
God Class Name	WMC (>46)		TCC (<0.33)		ATFD (>5)		Overall Score and Rank	
	Value	Rank	Value	Rank	Value	Rank	Sum Rank	Rank
GodClass1	49	3	0.0	8	20	6	17	6
GodClass2	87	8	0.005	7	28	7	22	7
GodClass3	107	9	0.0	8	28	7	24	9
GodClass4	69	7	0.026	6	34	9	22	7
GodClass5	49	3	0.065	5	9	3	11	3
GodClass6	60	5	0.177	4	19	4	13	4
GodClass7	47	1	0.219	1	7	1	3	1
GodClass8	48	2	0.199	2	7	1	5	2
GodClass9	61	6	0.192	3	19	4	13	4

God Class Ranking: Interest

- Interest: negative effect on software quality
  - Maintainability
  - Defects
- Method: use change and defect likelihood to estimate and rank impact

God Class Name	Change Likelihood		Defect Likelihood		Overall Score and Rank	
	Value	Rank	Value	Rank	Sum Rank	Rank
GodClass1	0.016	1	0.0	1	2	1
GodClass2	0.097	8	0.0	1	9	4
GodClass3	0.102	9	0.029	5	14	9
GodClass4	0.068	7	0.177	6	13	7
GodClass5	0.040	3	0.0	1	4	3
GodClass6	0.0455	4	0.133	7	11	5
GodClass7	0.0458	5	0.133	7	12	6
GodClass8	0.052	6	0.133	7	13	7
GodClass9	0.027	2	0.0	1	3	2

Cost/Benefit Matrix



Future Work

- Evaluation of other code smells and other indictors
- Empirical evaluation of cost/benefit model
  - Are our assumptions on correlation of metrics and refactoring cost true?
  - Are god classes after refactoring indeed less change and defect prone?
  - Can we advance from a ranking to a more precise prediction model?
- Managing design debt and god classes:
  - When should a god class be refactored?
  - When is it acceptable to introduce a god class for short term gains?

QUESTIONS?

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