

Analysis of Coupling Evolution on Open Source Systems



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Introduction

Software



Complexity

Evolution

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Quality

Coupling





Investigate how the internal structure and quality of Java software systems evolve in the aspect of coupling

Research Method





Research Questions

RQ1: How does coupling evolve in open source Java software systems?

RQ1.1: What kind of model better represents the coupling growth pattern in open source Java software systems?

RQ1.2: How does the relation between fan-in and fan-out behave throughout the evolution in open source Java software systems?

RQ1.3: What is the percentage of classes contained in the software that directly interfere in the coupling growth/decrease?



Comets Dataset

#	System Name	Description	Time Frame	# Versions
1	Eclipse JDT Core	Compiler and other tools for Java	07/01/2001 - 06/14/2008	183
2	Eclipse PDE UI	Set of tools to create, develop, test, debug and deploy Eclipse plug-ins, fragments, features, update sites and RCP products	06/01/2001 - 09/06/2008	191
3	Equinox Framework	OSGi application implementor	01/01/2005 - 06/14/2008	91
4	Hibernate Core	Database persistence framework	06/13/2007 - 03/02/2011	98
5	JabRef	Bibliography reference manager	10/14/2003 - 11/11/2011	212
6	Lucene	Search software and document indexing API	01/01/2005 - 10/04/2008	99
7	Pentaho Console	Software for business intelligence	04/01/2008 - 12/07/2010	72
8	PMD	Source code analyzer	06/22/2002 - 12/11/2011	248
9	Spring Framework	Java application development framework	12/17/2003 - 11/25/2009	156
10	TV-Browser	Electronic TV guide	04/23/2003 - 08/27/2011	221

[COUTO et al.]



Data Normalization

Data Modeling

Error Modeling

Models Evaluation

Global Measure



SUM

Data Normalization	Data Modeling	Error Modeling	Models Evaluation
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Linear Regression

Evaluated Models

- Linear
- Quadratic
- **Cubic**
- Logarithmic

Data Normalization	Data Modeling	Error Modeling	Models Evaluation

Autocorrelation Treatment

Durbin-Watson test

Autoregression



Wilcoxon signed-rank test



Time series Reorganization

Application of Trend Tests

Trend Identification

Trend Type Assessment

Removal of -1 values

Removal of ghost classes

Time series Reorganization	Application of Trend Tests	Trend Identification	Trend Type Assessment

Mann-Kendall

Cox-Stuart

Wald-Wolfowitz



Time series Reorganization

Application of Trend Tests

Trend Identification

Trend Type Assessment

Upward Trend

Downward Trend

Undefined Trend



RESULTS

RQ1.1. What kind of model better represents the coupling growth pattern in open source Java software systems?

Coupling Evolution in System Level

Carata and	Fan-in				Fan-out			
System	lin.	quad.	cub.	log.	lin.	quad.	cub.	o. log.
Eclipse JDT Core	0.973	0.989	0.992	0.908	0.978	0.993	0.994	0.907
Eclipse PDE UI	0.989	0.994	0.996	0.803	0.990	0.995	0.998	0.809
Equinox Framework	0.971	0.975	0.979	0.901	0.978	0.988	0.988	0.919
Hibernate Core	0.912	0.968	0.971	0.677	0.902	0.969	0.973	0.645
JabRef	0.932	0.988	0.995	0.971	0.921	0.988	0.996	0.971
Lucene	0.933	0.939	0.951	0.766	0.930	0.931	0.957	0.804
Pentaho Console	0.406	0.685	0.919	0.506	0.695	0.901	0.975	0.939
PMD	0.976	0.977	0.986	0.837	0.976	0.976	0.986	0.831
Spring Framework	0.842	0.995	0.996	0.928	0.770	0.997	0.997	0.938
TV-Browser	0.921	0.997	0.997	0.937	0.871	0.992	0.994	0.948

Coupling Evolution in System Level

Creations.	Fan-in				Fan-out			
System	lin.	quad.	cub.	log.	lin.	quad.	cub.	log.
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Coupling Evolution in System Level



RQ1.2. How does the relation between fan-in and fan-out behave throughout the evolution in open source Java software systems?

Evolution of Fan-in/Fan-out Relation

Concepts

$$fan-in$$

$$fan-out$$



fan-out

fan-in



Necessary Coupling

Unnecessary Coupling

Evolution of Fan-in/Fan-out Relation



RQ1.3. What is the percentage of classes contained in the software that directly interfere in the coupling growth/decrease?

Coupling Growth/Decrease Analysis



Coupling Growth/Decrease Analysis

System	i	ii	iii	iv
Eclipse JDT Core	15%	1%	2%	1%
Eclipse PDE UI	4%	1%	1%	0%
Equinox Framework	3%	0%	1%	1%
Hibernate Core	1%	0%	0%	0%
JabRef	5%	0%	1%	1%
Lucene	2%	0%	1%	1%
Pentaho Console	1%	0%	1%	0%
PMD	3%	1%	0%	0%
Spring Framework	5%	1%	1%	1%
TV-Browser	10%	1%	1%	1%





RQ1. How does coupling evolve in open source Java software systems?

Coupling Properties

- 1. Growth pattern modeled by a cubic function
- 2. Increasing complexity and declining quality are applied
- 3. Unnecessary coupling is greater than necessary coupling
- 4. Complexity is introduced into the first software version
- 5. A small group of classes influences the coupling
- 6. Legacy classes mainly contribute to the coupling evolution
- 7. The evolution of fan-in and fan-out are not associated

Conclusion

□ Focus: Investigate the evolution of software internal structure and quality based on coupling aspect.

Contributions

- Coupling evolution pattern in Java systems
- Coupling evolution properties

Future Work

- Define a global model to predict coupling evolution
- Replicate this study for other software aspects and metrics
- □ Investigate the metrics evolution in other systems domains

Propose a large time series dataset



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