

**Table 1– Measurement results for source code examples before and after applying Aspect-Oriented Refactoring Methods**

Aspect- Oriented Refactoring Method		Aspect Name	Inheritance		Coupling		Cohesion	Size and Complexity		
			DIT	NOC	CBC	RFC	LCOO	WOC	NOA	LOC
Change Advice Kind from Around	Before	InterAdvicePrecedenceAspect	1	0	1	3	1	3	2	15
	After	InterAdvicePrecedenceAspect	1	0	1	4	2	4	2	16
Extract Method from Advice	Before	SubjectObserverProtocol	1	1	2	6	1	6	8	27
	After	SubjectObserverProtocol	1	1	2	7	3	7	8	30
Merge Advice Bodies	Before	SaveEnergyAspect	1	0	1	4	0	4	0	15
	After	SaveEnergyAspect	1	0	1	3	0	3	0	14
Inline Method into Advice:	Before	GetInfo	1	0	1	3	1	3	2	26
	After	GetInfo	1	0	1	2	0	2	2	23
Generalize before or after Advice to around Advice	Before	Tracer	1	0	1	2	0	2	2	12
	After	Tracer	1	0	1	1	0	1	2	11
Delete Unreachable Advice	Before	OptimizeFactorialAspect	1	0	1	4	4	4	3	22
	After	OptimizeFactorialAspect	1	0	1	3	2	3	3	19
Change Advice kind from Before to After	Before	CallRecipe	1	0	1	1	0	1	1	11
	After	CallRecipe	1	0	1	1	0	1	1	11
Separate pointcuts	Before	PointcutsAspect	1	0	1	1	0	1	2	10
	After	PointcutsAspect	1	0	1	1	0	1	3	12

Table 1– Continued

Aspect- Oriented Refactoring Method		Aspect Name	Inheritance		Coupling		Cohesion	Size and Complexity		
			DIT	NOC	CBC	RFC	LCOO	WOC	NOA	LOC
Introduce Aspect Protection	Before	SecurityAspect	1	1	2	2	0	2	2	11
	After	SecurityAspect	1	1	2	2	0	2	3	16
Replace List Statement with Method Call	Before	DBConnectionPoolLoggingAspect	1	0	2	3	0	3	1	18
	After	DBConnectionPoolLoggingAspect	1	0	2	3	0	3	1	16
Pull Up Pointcut		ObservingRelationships	1	2	2	2	0	1	0	18
	Before	ObservingOpen	2	0	2	3	0	3	5	28
		ObservingClose	2	0	2	3	0	3	5	27
		ObservingRelationships	1	2	2	2	0	1	2	22
	After	ObservingOpen	2	0	2	3	0	3	3	24
		ObservingClose	2	0	2	3	0	3	3	23
ObservingRelationships		1	2	2	5	0	4	1	31	
Pull Up Advice	Before	ObservingOpen	2	0	2	4	2	4	5	30
		ObservingClose	2	0	2	4	2	4	5	29
		ObservingRelationships	1	2	2	6	2	5	1	34
	After	ObservingOpen	2	0	2	3	0	3	5	27
		ObservingClose	2	0	2	3	0	3	5	26
		ObservingRelationships	1	2	2	6	2	5	1	34

Table 1– Continued

Aspect- Oriented Refactoring Method	Aspect Name	Inheritance		Coupling		Cohesion	Size and Complexity			
		DIT	NOC	CBC	RFC	LCOO	WOC	NOA	LOC	
Push Down Advice	Before	ObservingRelationships	1	2	2	6	2	5	1	34
		ObservingOpen	2	0	2	3	0	3	5	27
	After	ObservingRelationships	1	2	2	5	0	4	1	31
		ObservingOpen	2	0	2	4	0	4	5	30
Pull Up Declare Parents	Before	ObservingRelationships	1	2	2	5	0	4	1	31
		ObservingOpen	2	0	5	3	4	3	7	29
		ObservingClose	2	0	5	3	4	3	7	29
	After	ObservingRelationships	1	2	5	5	0	4	3	33
		ObservingOpen	2	0	2	3	4	3	5	27
		ObservingClose	2	0	2	3	4	3	5	27
Push Down Declare Parents	Before	ObservingRelationships	1	2	5	4	3	4	2	33
		ObservingOpen	2	0	2	3	4	3	5	27
	After	ObservingRelationships	1	2	2	4	3	4	1	31
		ObservingOpen	2	0	5	3	4	3	6	29
Push Down Pointcut	Before	ObservingRelationships	1	2	2	2	0	1	4	24
		ObservingClose	2	0	2	3	0	3	3	26
	After	ObservingRelationships	1	2	2	2	0	1	3	22
		ObservingClose	2	0	2	3	0	3	4	28

Table 1– Continued

Aspect- Oriented Refactoring Method	Aspect Name	Inheritance		Coupling		Cohesion	Size and Complexity			
		DIT	NOC	CBC	RFC	LCO	WOC	NOA	LOC	
Pull Up Inter-Type Declaration	Before	ObservingRelationships	1	2	2	5	0	4	1	31
		ObservingOpen	2	0	3	4	2	4	6	30
		ObservingClose	2	0	3	4	2	4	6	30
	After	ObservingRelationships	1	2	3	6	3	5	1	34
		ObservingOpen	2	0	2	3	0	3	6	27
		ObservingClose	2	0	2	3	0	3	6	27
Push Down Inter-Type Declaration	Before	ObservingRelationships	1	2	3	6	2	5	2	35
		ObservingOpen	2	0	2	3	0	3	5	27
	After	ObservingRelationships	1	2	2	5	0	4	2	31
		ObservingOpen	2	0	6	4	0	4	5	31
Eliminating Duplicated Pointcut	Before	HomeSecurityAspect	1	0	1	2	1	2	4	12
		SaveEnergyAspect	1	0	1	2	1	2	4	12
		DuplicatePointcutsAspect	-	-	-	-	-	-	-	-
	After	HomeSecurityAspect	1	0	1	2	1	2	2	8
		SaveEnergyAspect	1	0	1	2	1	2	2	8
	DuplicatePointcutsAspect	1	0	2	0	0	0	2	6	

Table 1– Continued

Aspect- Oriented Refactoring Method	Aspect Name	Inheritance		Coupling		Cohesion	Size and Complexity			
		DIT	NOC	CBC	RFC	LCOO	WOC	NOA	LOC	
Eliminating Borrowed Pointcut	Before	HomeSecurityAspect	1	0	3	2	1	2	4	12
		InfoAspect	1	0	1	1	0	1	1	5
		SaveEnergyAspect	1	0	2	2	1	2	3	9
		BorrowedPointcutAspect	-	-	-	-	-	-	-	-
	After	HomeSecurityAspect	1	0	2	2	1	2	3	10
		InfoAspect	1	0	1	1	0	1	1	5
		SaveEnergyAspect	1	0	2	2	1	2	3	9
		BorrowedPointcutAspect	1	0	4	0	0	0	1	3
Move static introduction	Before	HashablePoint	1	0	2	3	3	3	3	24
		CloneablePoint	1	0	1	2	2	2	2	21
	After	HashablePoint	1	0	1	2	2	2	3	16
		CloneablePoint	1	0	1	3	3	3	2	23
Delete Unreferenced Named Pointcut	Before	MinimumBalanceRuleAspect	1	0	2	2	1	3	3	16
	After	MinimumBalanceRuleAspect	1	0	2	2	1	3	2	14

Table 2– Aspect-Oriented Refactoring methods classification based on internal software quality attributes

Aspect-Oriented Construct	Aspect- Oriented Refactoring Method	Inheritance		Coupling		Cohesion	Size and Complexity		
		DIT	NOC	CBC	RFC	LCOO	WOC	NOA	LOC
<b>Advice</b>	Change Advice Kind from Around	-	-	-	↑	↑	↑	-	↑
	Extract Method from Advice	-	-	-	↑	↑	↑	-	↑
	Pull Up Advice	-	-	-	↓	↓	↓	-	↓
	Push Down Advice	-	-	-	↓	↓	↓	-	↓
	Delete Unreachable Advice	-	-	-	↓	↓	↓	-	↓
	Inline Method into Advice	-	-	-	↓	↓	↓	-	↓
	Merge Advice Bodies	-	-	-	↓	-	↓	-	↓
	Generalize before or after Advice to around Advice	-	-	-	↓	-	↓	-	↓
	Replace Statement List in Advice with Method call	-	-	-	-	-	-	-	↓
	Change Advice kind from Before to After	-	-	-	-	-	-	-	-
<b>Pointcut</b>	Separate Pointcuts	-	-	-	-	-	-	↑	↑
	Pull up Pointcut	-	-	-	-	-	-	↓	↓
	Push Down Pointcut	-	-	-	-	-	-	↓	↓
	Delete Unreferenced Named Pointcut	-	-	-	-	-	-	↓	↓
	Eliminating Duplicated Pointcuts	-	-	-	-	-	-	↓	↓
	Eliminating Borrowed Pointcuts	-	-	↓	-	-	-	↓	↓



Table 3– Aspect-Oriented Refactoring Methods classification based on External software quality attributes

AO Construct	Aspect-Oriented Refactoring Method	Maintainability	Reusability	Flexibility	Understandability	Testability	Reliability
<b>Advice</b>	Change Advice Kind from Around	↓	↓	↓	↓	↓	↓
	Extract Method from Advice	↓	↓	↓	↓	↓	↓
	Push Down Advice	↑	↑	↑	↑	↑	↑
	Pull Up Advice	↑	↑	↑	↑	↑	↑
	Generalize before or after Advice to around Advice	↑	↑	↑	↑	↑	↑
	Delete Unreachable Advice	↑	↑	↑	↑	↑	↑
	Merge Advice Bodies	↑	↑	↑	↑	↑	↑
	Inline Method into Advice	↑	↑	↑	↑	↑	↑
	Replace Statement List in Advice with Method call	↑	↑	↑	-	-	↑
	Change Advice kind from Before to After	-	-	-	-	-	-
<b>Pointcut</b>	Separate Pointcuts	↓	↓	↓	-	-	↓
	Push Down Pointcut	↑	↑	↑	-	-	↑
	Pull up Pointcut	↑	↑	↑	-	-	↑
	Eliminating Duplicated Pointcuts	↑	↑	↑	-	-	↑
	Delete Unreferenced Named Pointcut	↑	↑	↑	-	-	↑
	Eliminating Borrowed Pointcuts	↑	↑	↑	↑	↑	↑



Table 3– Continued

AO Construct	Aspect-Oriented Refactoring Method	Maintainability	Reusability	Flexibility	Understandability	Testability	Reliability
<b>Inter-Type Declaration</b>	Move Static Introduction	↑	↑	↑	↑	↑	↑
	Pull Up Inter-Type Declaration	↑	↑	↑	↑	↑	↑
	Push Down Inter-Type Declaration	↑	↑	↑	↑	↑	↑
<b>Declare Clause</b>	Pull Up Declare Parents	↑	↑	↑	↑	↑	↑
	Push Down Declare Parents	↑	↑	↑	↑	↑	↑
	Introduce Aspect Protection	↓	↓	↓	-	-	↓

**Table 4– Aspect-Oriented Refactoring methods classification based on internal software quality attributes**

Aspect- Oriented Refactoring Method	Inheritance		Coupling		Cohesion	Size and Complexity		
	DIT	NOC	CBC	RFC	LCOO	WOC	NOA	LOC
Change Advice Kind from Around	-	-	-	↑	↑	↑	-	↑
Extract Method from Advice	-	-	-	↑	↑	↑	-	↑
Pull Up Advice	-	-	-	↓	↓	↓	-	↓
Push Down Advice	-	-	-	↓	↓	↓	-	↓
Delete Unreachable Advice	-	-	-	↓	↓	↓	-	↓
Inline Method into Advice	-	-	-	↓	↓	↓	-	↓
Generalize before or after Advice to around Advice	-	-	-	↓	-	↓	-	↓
Merge Advice Bodies	-	-	-	↓	-	↓	-	↓
Separate Pointcuts	-	-	-	-	-	-	↑	↑
Introduce Aspect Protection	-	-	-	-	-	-	↑	↑
Pull Up Declare Parents	-	-	↓	-	-	-	↓	↓
Push Down Declare Parents	-	-	↓	-	-	-	↓	↓
Pull Up Inter-Type Declaration	-	-	↓	↓	↓	↓	-	↓
Move Static Introduction	-	-	↓	↓	↓	↓	-	↓
Push Down Inter-Type Declaration	-	-	↓	↓	↓	↓	-	↓

Table 4– Continued

Aspect- Oriented Refactoring Method	Inheritance		Coupling		Cohesion	Size and Complexity		
	DIT	NOC	CBC	RFC	LCOO	WOC	NOA	LOC
Pull up Pointcut	-	-	-	-	-	-	↓	↓
Push Down Pointcut	-	-	-	-	-	-	↓	↓
Delete Unreferenced Named Pointcut	-	-	-	-	-	-	↓	↓
Eliminating Duplicated Pointcuts	-	-	-	-	-	-	↓	↓
Eliminating Borrowed Pointcuts	-	-	↓	-	-	-	↓	↓
Replace Statement List in Advice with Method call	-	-	-	-	-	-	-	↓
Change Advice kind from Before to After	-	-	-	-	-	-	-	-
Extract Superaspect	↑	-	-	↓	↓	↓	↓	↓

**Table 5– Aspect-Oriented Refactoring methods classification based on External software quality attributes**

<b>Aspect- Oriented Refactoring Method</b>	<b>maintainability</b>	<b>reusability</b>	<b>Flexibility</b>	<b>Understandability</b>	<b>Testability</b>	<b>Reliability</b>
Change Advice Kind from Around	↓	↓	↓	↓	↓	↓
Extract Method from Advice	↓	↓	↓	↓	↓	↓
Pull Up Advice	↑	↑	↑	↑	↑	↑
Push Down Advice	↑	↑	↑	↑	↑	↑
Delete Unreachable Advice	↑	↑	↑	↑	↑	↑
Inline Method into Advice	↑	↑	↑	↑	↑	↑
Generalize before or after Advice to around Advice	↑	↑	↑	↑	↑	↑
Merge Advice Bodies	↑	↑	↑	↑	↑	↑
Pull Up Declare Parents	↑	↑	↑	↑	↑	↑
Push Down Declare Parents	↑	↑	↑	↑	↑	↑
Pull Up Inter-Type Declaration	↑	↑	↑	↑	↑	↑
Move Static Introduction	↑	↑	↑	↑	↑	↑
Push Down Inter-Type Declaration	↑	↑	↑	↑	↑	↑
Eliminating Borrowed Pointcuts	↑	↑	↑	↑	↑	↑
Separate Pointcuts	↓	↓	↓	-	-	↓
Introduce Aspect Protection	↓	↓	↓	-	-	↓

Table 5– Continued

Aspect- Oriented Refactoring Method	maintainability	reusability	Flexibility	Understandability	Testability	Reliability
Pull up Pointcut	↑	↑	↑	-	-	↑
Push Down Pointcut	↑	↑	↑	-	-	↑
Delete Unreferenced Named Pointcut	↑	↑	↑	-	-	↑
Eliminating Duplicated Pointcuts	↑	↑	↑	-	-	↑
Replace Statement List in Advice with Method call	↑	↑	↑	-	-	↑
Change Advice kind from Before to After	-	-	-	-	-	-

**Table 6– Classification of the aspect-oriented refactoring methods within aspects based on their effects on the external quality attributes**

<b>Aspect-Oriented Refactoring Method</b>	<b>Maintainability</b>	<b>Reusability</b>	<b>Flexibility</b>	<b>Understandability</b>	<b>Testability</b>	<b>Reliability</b>
Change Advice Kind from Around	↓	↓	↓	↓	↓	↓
Extract Method from Advice	↓	↓	↓	↓	↓	↓
Introduce Aspect Protection	↓	↓	↓	-	-	↓
Separate Pointcuts	↓	↓	↓	-	-	↓
Generalize before or after Advice to around Advice	↑	↑	↑	↑	↑	↑
Delete Unreachable Advice	↑	↑	↑	↑	↑	↑
Merge Advice Bodies	↑	↑	↑	↑	↑	↑
Inline Method into Advice	↑	↑	↑	↑	↑	↑
Replace Statement List in Advice with Method call	↑	↑	↑	-	-	↑
Delete Unreferenced Named Pointcut	↑	↑	↑	-	-	↑
Change Advice kind from Before to After	-	-	-	-	-	-

**Table 7– Classification of the aspect-oriented refactoring methods within aspects based on their effects on the external quality attributes**

<b>Aspect-Oriented Refactoring Method</b>	<b>Maintainability</b>	<b>Reusability</b>	<b>Flexibility</b>	<b>Understandability</b>	<b>Testability</b>	<b>Reliability</b>
Move Static Introduction	↑	↑	↑	↑	↑	↑
Pull Up Inter-Type Declaration	↑	↑	↑	↑	↑	↑
Push Down Inter-Type Declaration	↑	↑	↑	↑	↑	↑
Pull Up Declare Parents	↑	↑	↑	↑	↑	↑
Push Down Declare Parents	↑	↑	↑	↑	↑	↑
Push Down Advice	↑	↑	↑	↑	↑	↑
Pull Up Advice	↑	↑	↑	↑	↑	↑
Eliminating Borrowed Pointcuts	↑	↑	↑	↑	↑	↑
Eliminating Duplicated Pointcuts	↑	↑	↑	-	-	↑
Pull up Pointcut	↑	↑	↑	-	-	↑
Push Down Pointcut	↑	↑	↑	-	-	↑