

What Are Design Patterns Good for?

Foutse Khomh
Yann-Gaël Guéhéneuc

Department of Computer
Science and Operations Research
University of Montreal

foutsekh@iro.umontreal.ca
guehene@iro.umontreal.ca

QAOOSE
31/07/07

Hypothesis and Objective

- Design patterns have been said to have a positive impact on quality attributes
 - Expandability
 - Reusability
 - Understandability
- Hypothesis: "Design patterns have a positive impact on quality attributes"
- Objective: prove or disprove the hypothesis with concrete evidence

Choices

- Quality characteristics related to design, implementation, and runtime
- Empirical study
 - ≠ Absolute, with theory
 - ≠ Relative, with data mining
- Development and maintenance are foremost carried out by people, an empirical study reports better on their perception

Method

- Choice of design patterns of interest
 - 23 design patterns in the GoF book
- Identification and definition of quality characteristics of interest
 - 10 characteristics
 - Implementation
 - Design
 - Runtime
- Definition of a scale
 - Likert scale of 5 points + "I don't know"

Data Collection

- Questionnaire send out to colleagues between January and May 2007
- Questionnaire posted on three lists:
refactoring, patterns-discussion,
and gang-of-4-patterns

Data Processing

- Number of received questionnaires: 30
- Number of complete questionnaires: 12
 - For the other 18, some answers missing or "I don't know"
- Number of kept questionnaires: 20
- Answers A and B aggregated in Positive, C in Neutral, and D and E in Negative

Results

Design Patterns	Expendability(%)			Simplicity(%)			Generality(%)			Modularity(%)			Modularity at runtime(%)		
	G	N	B	G	N	B	G	N	B	G	N	B	G	N	B
A.Factory	100.0	0.0	0.0	53.33	13.33	33.33	78.57	21.43	0.0	85.71	7.14	7.14	46.15	38.46	15.38
Builder	90.91	9.09	0.0	54.55	27.27	18.18	54.55	9.09	36.36	90.91	0.0	9.09	45.45	36.36	18.18
F.Method	75.0	8.33	16.67	58.33	25.0	16.67	58.33	33.33	8.33	66.67	16.67	16.67	45.45	45.45	9.09
Prototype	58.33	33.33	8.33	53.85	30.77	15.38	76.92	15.38	7.69	38.46	53.85	7.69	53.85	38.46	7.69
Singleton	7.69	30.77	61.54	92.86	7.14	0.0	30.77	38.46	30.77	15.38	46.15	38.46	16.67	50.0	33.33
Adapter	53.85	38.46	7.69	46.15	38.46	15.38	61.54	30.77	7.69	76.92	15.38	7.69	58.33	33.33	8.33
Bridge	83.33	16.67	0.0	18.18	27.27	54.55	70.0	0.0	30.0	75.0	16.67	8.33	50.0	33.33	16.67
Composite	100.0	0.0	0.0	69.23	15.38	15.38	76.92	15.38	7.69	71.43	21.43	7.14	53.85	38.46	7.69
Decorator	91.67	0.0	8.33	27.27	45.45	27.27	90.91	9.09	0.0	72.73	18.18	9.09	72.73	18.18	9.09
Facade	53.85	23.08	23.08	83.33	8.33	8.33	50.0	33.33	16.67	50.0	16.67	33.33	36.36	27.27	36.36
Flyweight	22.22	44.44	33.33	0.0	22.22	77.78	11.11	44.44	44.44	33.33	33.33	33.33	11.11	66.67	22.22
Proxy	41.67	50.0	8.33	61.54	23.08	15.38	61.54	30.77	7.69	76.92	15.38	7.69	38.46	53.85	7.69
Ch.Of.Resp	91.67	8.33	0.0	72.73	9.09	18.18	81.82	18.18	0.0	66.67	16.67	16.67	54.55	27.27	18.18
Command	69.23	15.38	15.38	46.15	15.38	38.46	61.54	23.08	15.38	64.29	21.43	14.29	41.67	41.67	16.67
Interpreter	66.67	25.0	8.33	50.0	16.67	33.33	64.29	14.29	21.43	58.33	33.33	8.33	41.67	41.67	16.67
Iterator	92.31	7.69	0.0	69.23	15.38	15.38	72.73	27.27	0.0	57.14	28.57	14.29	50.0	41.67	8.33
Mediator	58.33	25.0	16.67	27.27	36.36	36.36	45.45	36.36	18.18	50.0	25.0	25.0	33.33	50.0	16.67
Memento	30.0	50.0	20.0	50.0	30.0	20.0	40.0	50.0	10.0	11.11	66.67	22.22	12.5	75.0	12.5
Observer	86.67	6.67	6.67	64.29	21.43	14.29	78.57	7.14	14.29	73.33	20.0	6.67	69.23	23.08	7.69
State	72.73	18.18	9.09	63.64	9.09	27.27	63.64	18.18	18.18	63.64	9.09	27.27	54.55	18.18	27.27
Strategy	78.57	14.29	7.14	66.67	26.67	6.67	71.43	21.43	7.14	85.71	7.14	7.14	78.57	14.29	7.14
T.Method	80.0	20.0	0.0	66.67	20.0	13.33	73.33	20.0	6.67	33.33	53.33	13.33	28.57	64.29	7.14
Visitor	66.67	6.67	26.67	7.14	14.29	78.57	78.57	7.14	14.29	73.33	13.33	13.33	57.14	21.43	21.43

Design Patterns	Learnability(%)			Understandability(%)			Reusability(%)			Scalability(%)			Robustness(%)		
	G	N	B	G	N	B	G	N	B	G	N	B	G	N	B
A.Factory	35.71	28.57	35.71	38.46	30.77	30.77	50.0	42.86	7.14	21.43	64.29	14.29	0.0	72.73	27.27
Builder	54.55	18.18	27.27	81.82	9.09	9.09	36.36	45.45	18.18	0.0	81.82	18.18	0.0	90.0	10.0
F.Method	50.0	33.33	16.67	41.67	33.33	25.0	63.64	18.18	18.18	27.27	54.55	18.18	0.0	88.89	11.11
Prototype	46.15	23.08	30.77	53.85	23.08	23.08	58.33	8.33	33.33	33.33	50.0	16.67	9.09	90.91	0.0
Singleton	85.71	14.29	0.0	92.86	7.14	0.0	15.38	53.85	30.77	35.71	57.14	7.14	15.38	69.23	15.38
Adapter	69.23	7.69	23.08	46.15	23.08	30.77	69.23	23.08	7.69	0.0	45.45	54.55	0.0	58.33	41.67
Bridge	27.27	36.36	36.36	50.0	33.33	16.67	41.67	16.67	41.67	10.0	30.0	60.0	10.0	80.0	10.0
Composite	76.92	7.69	15.38	69.23	15.38	15.38	61.54	23.08	15.38	41.67	41.67	16.67	8.33	91.67	0.0
Decorator	41.67	25.0	33.33	41.67	8.33	50.0	33.33	25.0	41.67	18.18	36.36	45.45	0.0	77.78	22.22
Facade	66.67	25.0	8.33	75.0	25.0	0.0	33.33	41.67	25.0	25.0	50.0	25.0	22.22	77.78	0.0
Flyweight	0.0	20.0	80.0	0.0	10.0	90.0	37.5	12.5	50.0	77.78	0.0	22.22	22.22	66.67	11.11
Proxy	46.15	38.46	15.38	30.77	46.15	23.08	50.0	33.33	16.67	27.27	36.36	36.36	10.0	80.0	10.0
Ch.Of.Resp	63.64	36.36	0.0	33.33	33.33	33.33	54.55	27.27	18.18	10.0	50.0	40.0	25.0	58.33	16.67
Command	38.46	30.77	30.77	30.77	30.77	38.46	33.33	16.67	50.0	25.0	33.33	41.67	33.33	58.33	8.33
Interpreter	66.67	0.0	33.33	66.67	0.0	33.33	54.55	0.0	45.45	27.27	18.18	54.55	8.33	83.33	8.33
Iterator	50.0	33.33	16.67	50.0	42.86	7.14	69.23	15.38	15.38	16.67	41.67	41.67	45.45	54.55	0.0
Mediator	54.55	9.09	36.36	58.33	25.0	16.67	20.0	50.0	30.0	25.0	41.67	33.33	9.09	81.82	9.09
Memento	40.0	30.0	30.0	40.0	50.0	10.0	37.5	37.5	25.0	0.0	50.0	50.0	12.5	62.5	25.0
Observer	50.0	14.29	35.71	40.0	33.33	26.67	50.0	28.57	21.43	16.67	50.0	33.33	9.09	63.64	27.27
State	54.55	18.18	27.27	54.55	0.0	45.45	20.0	40.0	40.0	18.18	45.45	36.36	10.0	60.0	30.0
Strategy	73.33	20.0	6.67	64.29	28.57	7.14	46.15	30.77	23.08	21.43	42.86	35.71	33.33	58.33	8.33
T.Method	53.33	33.33	13.33	37.5	37.5	25.0	57.14	28.57	14.29	23.08	61.54	15.38	16.67	75.0	8.33
Visitor	14.29	21.43	64.29	20.0	20.0	60.0	26.67	26.67	46.67	25.0	33.33	41.67	0.0	72.73	27.27

Composite

Attributes	Positive	Neutral	Negative
Expandability	100.0	0.0	0.0
Simplicity	69.23	15.38	15.38
Generality	76.92	15.38	7.69
Modularity	71.43	21.43	7.14
Modularity at Runtime	53.85	38.46	7.69
Learnability	76.92	7.69	15.38
Understandability	69.23	15.38	15.38
Reusability	61.54	23.08	15.38
Scalability	41.67	41.67	16.67
Robustness	8.33	91.67	0.0

- Overall positive impact on quality attributes
- Modularity at runtime and robustness not so positively impacted

Abstract Factory

Attributes	Positive	Neutral	Negative
Expandability	100.0	0.0	0.0
Simplicity	53.33	13.33	33.33
Generality	78.57	21.43	0.0
Modularity	85.71	7.14	7.14
Modularity at Runtime	46.15	38.46	15.38
Learnability	35.71	28.57	35.71
Understandability	38.46	30.77	30.77
Reusability	50.0	42.86	7.14
Scalability	21.43	64.29	14.29
Robustness	0.0	72.73	27.27

- Overall neutral impact on quality attributes
- Expandability, generality, and modularity as expected
- Robustness surprising

Flyweight

Attributes	Positive	Neutral	Negative
Expandability	22.22	44.44	33.33
Simplicity	0.0	22.22	77.78
Generality	11.11	44.44	44.44
Modularity	33.33	33.33	33.33
Modularity at Runtime	11.11	66.67	22.22
Learnability	0.0	20.0	80.0
Understandability	0.0	10.0	90.0
Reusability	37.5	12.5	50.0
Scalability	77.78	0.0	22.22
Robustness	22.22	66.67	11.11

- Overall negative impact on quality attributes
- Positive impact only on scalability as expected

Reusability

Patterns	Positive	Neutral	Negative
A.Factory	46.15	46.15	7.69
Builder	36.36	45.45	18.18
F.Method	60.0	20.0	20.0
Prototype	63.64	0.0	36.36
Singleton	18.18	54.55	27.27
Adapter	66.67	25.0	8.33
Bridge	41.67	16.67	41.67
Composite	58.33	25.0	16.67
Decorator	36.36	18.18	45.45
Facade	36.36	45.45	18.18
Flyweight	37.5	12.5	50.0
Proxy	45.45	36.36	18.18
Ch.Of.Resp	54.55	27.27	18.18
Command	30.0	20.0	50.0
Interpreter	50.0	0.0	50.0
Iterator	72.73	9.09	18.18
Mediator	20.0	50.0	30.0
Memento	28.57	42.86	28.57
Observer	53.85	23.08	23.08
State	20.0	40.0	40.0
Strategy	41.67	33.33	25.0
T.Method	58.33	33.33	8.33
Visitor	28.57	28.57	42.86

- 10 positive impacts
- 6 neutral impacts
- 7 negative impacts

Expandability

Patterns	Positive	Neutral	Negative
A.Factory	100.0	0.0	0.0
Builder	90.91	9.09	0.0
F.Method	72.73	9.09	18.18
Prototype	63.64	27.27	9.09
Singleton	9.09	27.27	63.64
Adapter	50.0	41.67	8.33
Bridge	83.33	16.67	0.0
Composite	100.0	0.0	0.0
Decorator	90.91	0.0	9.09
Facade	58.33	16.67	25.0
Flyweight	22.22	44.44	33.33
Proxy	45.45	45.45	9.09
Ch.Of.Resp	91.67	8.33	0.0
Command	66.67	16.67	16.67
Interpreter	63.64	27.27	9.09
Iterator	90.91	9.09	0.0
Mediator	58.33	25.0	16.67
Memento	33.33	55.56	11.11
Observer	85.71	7.14	7.14
State	72.73	18.18	9.09
Strategy	76.92	15.38	7.69
T.Method	84.62	15.38	0.0
Visitor	71.43	7.14	21.43

- 19 positive impacts
- 3 neutral impacts
- 1 negative impact

Understandability

Patterns	Positive	Neutral	Negative
A.Factory	38.46	30.77	30.77
Builder	81.82	9.09	9.09
F.Method	45.45	27.27	27.27
Prototype	58.33	16.67	25.0
Singleton	91.67	8.33	0.0
Adapter	50.0	25.0	25.0
Bridge	50.0	33.33	16.67
Composite	75.0	16.67	8.33
Decorator	45.45	9.09	45.45
Facade	81.82	18.18	0.0
Flyweight	0.0	10.0	90.0
Proxy	33.33	50.0	16.67
Ch.Of.Resp	33.33	33.33	33.33
Command	33.33	33.33	33.33
Interpreter	63.64	0.0	36.36
Iterator	50.0	41.67	8.33
Mediator	58.33	25.0	16.67
Memento	33.33	55.56	11.11
Observer	42.86	35.71	21.43
State	54.55	0.0	45.45
Strategy	69.23	23.08	7.69
T.Method	38.46	38.46	23.08
Visitor	21.43	21.43	57.14

- 15 positive impacts
- 3 neutral impacts
- 5 negative impacts

Preliminary Conclusion

- Globally, design patterns have a positive impact on quality characteristics
- Pattern by pattern, their impact on quality varies and includes negative impact!

Help Wanted

- Please help us refine this study by downloading and filling in the questionnaire

<http://www.ptidej.dyndns.org/downloads/>