Past and future of reflective middleware

Towards a corpus-based impact analysis

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The best and safest method of *philosophizing* seems to be, first to *inquire diligently into the properties of things*, and to establish those properties by *experiences* and then to *proceed more slowly to hypotheses* for the explanation of them. For hypotheses should be employed only in explaining the properties of things, but not assumed in determining them; unless so far as they may furnish experiments.

Isaac Newton
Abstractions and Paradigms
Reflective Middleware

- Computational reflection proposed in the 80s
  - approach to organise software to ease adaptation

- Growing influence
  - Popular languages at least partially reflective
  - AOP

- Reflective middleware
  - proposed en of the 90s
  - strong impact (JBoss, …)

- How to assess value of reflection for middleware?
The (difficult) Art of Abstractions

- Reflection is an example of programming paradigm
  ➔ These are key part of middleware research

- We endeavour to be scientists, and apply a scientific approach to our work

- How can we assess the value of a paradigms?
Assessing a paradigm

development process

software (product)

programming paradigm (reflection)
Homo Faber

programmer (human)  paradigm (tool)  software (matter)
How well does reflection fit the human brain?
Assessing a paradigm

- **Case studies**
  - show feasibility
  - not controlled conditions

- **Controlled experiment**
  - experimental software engineering
  - compared to psychology still coarse (ICSE)
  - but much better that nothing

- **Measurements of real artefacts**
  - necessary to construct hypothesis
Measurements of real artefact

- First 'humans' to be in contact with a new abstraction = researchers
  - How did we researchers react to reflection?
  - Future of reflection?
  - Research gaps?
  - Better understanding of middleware paradigms?

Chart research trajectory of reflection
Experiment
Where to start?

Choice of papers (Corpus)

The 40 most quoted papers among those citing [Blair]
Representativeness

Seems so in terms impact (# citations)
Keyword analysis

- One of the key tools of corpus-based linguistics
  - compares word frequencies between two sets of text

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\[P_1(c) = \frac{3}{58} = 0.0517\]

\[P_2(c) = \frac{8}{40} = 0.2\]

Log-likelihood = 4.59 > 3.84

(significant, 95% confidence level)
Keywords

Middleware (5153.9)
application (3484.6)
component (2593.4)
applications (2182.3)
distributed (2167.4)
components (2150.1)
object (2142.6)
interface (1681.7)
mobile (1627.8)
orb (1476.0)
reflective (1459.0)
adaptation (1404.4)
objects (1373.4)
architecture (1343.6)
dynamic (1336.8)
implementation (1320.8)
corba (1304.6)
systems (1284.2)
reflection (1250.3)
model (1187.4)
QoS (1169.8)
system (1134.5)
network (1014.3)
service (981.3)
resource (976.2)
configuration (958.0)
binding (957.0)
resources (928.1)
interfaces (907.8)
invocation (889.5)
code (843.8)
(can) (827.1)
management (824.5)
client (814.7)
framework (801.7)
context (801.1)
protocol (797.4)
(e.g.) (777.2)
support (746.3)
devices (742.5)
dynamically (737.1)
requirements (728.8)
(=) (718.0)}
communication (713.3)
(C) (710.5)
(such_as) (709.8)
services (703.4)
Correlations

- Each keyword → vector of values

| Application | 16  | 15  | 11  | 12  | 26  | 30  | 4   | ...
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Architecture| 20  | 13  | 20  | 36  | 20  | 13  | 0   | ...

- Each pair of keywords → correlation factor
  - close to 1 or -1: strong linear correlation
  - close to 0: weak or no correlation

- All keywords → correlation matrix
  - can be represented as a graph
Positive correlations

network 0.69
middleware 0.69
wireless 0.77
scalability 0.69

system 0.78
distributed 0.77

mobile 0.72
energy 0.72

reflection 0.72

interface 0.77
device 0.77

management 0.7
grid 0.7

resource 0.76
context 0.72

client 0.68
corba 0.75

interoperability 0.75
embedded
Service vs. context

- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004

Linear (context)
Interpretation

- Not directly linked to web-services and context-awareness
- Cover many different contexts
  - From scheduling (execution context)
  - To context-awareness
- Hypothesis: Highlight recurring ingredients on encapsulation / interactions
  - Service: what is being offered (internals)
  - Context: environment, conditions
Negative correlations

-0.34
-0.38
-0.29
-0.29
-0.31
-0.28
Architecture vs. Application

![Graph showing word count for 'architecture' vs. word count for 'application' for different years (1998-2004). The graph includes data points for each year and a linear trend line labeled 'Linear (architecture).']
Application vs. architecture

![Graph showing the comparison of application and architecture in terms of word density over the years 1998 to 2004. The graph depicts an increasing trend in application % from 1998 to 2004, while the architecture. * % shows a decreasing trend during the same period.](image-url)
Interpretation

- **Hypothesis**
  - Away from completely generic platforms
  - Closer to higher level services and hence applications
    - AOP, weaving
  - Trend to more domain-specific work
  - Focus on mechanisms rather than general platform

- **Other possibilities**
  - Keyword fashion
  - Refinement (e.g. *framework* rather than *architecture*)
What we’ve learnt
Conclusion

Very preliminary

- Selection of **corpus** questionable
- **Statistical** approach coarse
- **Sensitivity** analysis: what happens when we change
  - the article we started from
  - the mode of selection (i.e. all ARM papers for last 7 years)
  - the baseline to select keywords

- key step **interpretation**: on-going / manual
  - how to help?
Future

- Address **representativeness**
- Work on **interpretation**
- **Looping back**
  - Confirm hypothesis
  - What does it mean for reflection? dying? morphing?
  - Why was it successful?
- **Opportunities**
  - Application to other textual artefacts
  - Development mailing lists (e.g. JBoss)
Past and future of reflective middleware: Towards a corpus-based impact analysis *François Taïani, Paul Grace, Geoff Coulson, Gordon Blair*, 7th Workshop on Adaptive and Reflective Middleware (ARM'08), December 1st 2008, Leuven, Belgium, (6p.)