university of groningen

On the Impact of Fault Tolerance Tactics on Architecture Patterns
An empirical study

Neil B. Harrison, Paris Avgeriou
University of Groningen

Uwe Zdun
Vienna University of Technology

Overview

Background

- Design measures for improving fault tolerance: tactics
- Tactics interact with architecture (patterns)
- Information of this interaction partly documented

Hypothesis testing

- How does the information support architects in better incorporating FT?

university of groningen

Background: Architecture Patterns

- Commonly used system-level designs
- Well-known, use common names:
  - Layers
  - Pipes and Filters
  - Model-View Controller
- An architectural aid AND a documentation aid:
  - Pattern descriptions document your architecture
- All systems have architecture patterns
  - Even if they weren't intentionally used

university of groningen

Fault Tolerance Tactics

- Reusable design solutions to support FT
- Categories (SEI):
  - Fault Detection
  - Fault Recovery: Preparation and Repair
  - Fault Recovery: Reintroduction
  - Fault Prevention

There are many more FT tactics and categories
e.g. Utas, Hanmer

university of groningen

Patterns and Tactics

- Tactics are implemented within an architecture
- Implementations of tactics and patterns interact:
  - Tactics may take advantage of patterns C&C
  - Or they need to add or significantly modify C&C
- Understanding these interactions is key to effectively selecting and implementing the tactics

university of groningen

Changes to Pattern Components

Type of change	*Description*	*Impact on Pattern*
Implemented in	Tactic at least partly implemented in existing component	No change to pattern structure
Replicates	Duplicates a component	Small changes; easy to implement
Add, In Pattern	Add component without changing basic pattern structure	Moderately easy to implement
Add, Not in Pattern	Add component that changes pattern form	Major changes; much work
Modify	Behavior of component changes	Impact varies; easy to hard

university of groningen

The Architectural Challenge

Incorporating tactics into the system architecture involves making tradeoffs:

- Selecting alternate tactics that fit the architecture
- Selecting a different architecture pattern (mainly early in the architecture effort)
- Implementing the tactic where it fits best in the architecture (which pattern to implement it in)
- Understand the implementation needed even if a tactic is not a good match for the patterns.

university of groningen

Research Questions

- Info on patterns-tactic interaction partly documented
- Does it help architects be more effective in:
  - Choosing tactics that satisfy FT requirements
  - Designing the tactics correctly – in the context of the architecture
  - Minimizing architectural impact by choosing appropriate pattern-tactic combinations
  - Understanding effort needed to implement the tactics

The Study: Design

- Exploratory Research
- Two teams, experienced professionals and academics
  - Moderate architecture experience
  - Light FT experience
- Study Team vs. Control Team:
  - Treatment: tactic-pattern information
- Each team received the same task
  - Initial architecture in place
  - Incorporate 4 FT requirements

Results: Satisfy FT Requirements

- Both teams satisfied FT requirements about the same; but control team had unclear solution to task 4
- Both had similar problems with task 3

Task	Study Team	Control Team
1	Yes	Yes
2	Yes	Yes
3	No: used exceptions	No: used exceptions
4	Yes	Probably, but key information missing

university of groningen

Results: Design Correctness

Study team's results were good. Control team's design missed essential information; appears not to have fully considered how to implement the tactics

Task	Study Team	Control Team
1	Correct	Connectors missing; "Voting" design wrong
2	Correct	Correct
3	Correct	Missing connectors for exceptions
4	Correct	Connection to redundant component entirely missing

university of groningen

Results: Optimal Tactic Selection

- Study team performed well, but control team over-engineered task 1, and under-designed task 4

Task	Study Team	Control Team
1	Heartbeat: good, Exceptions may be unnecessary	Used Heartbeat, Ping-Echo, Exception, and Voting. Much too complex!
2	Yes	Yes
3	Yes	Yes
4	Yes	Appeared not to understand the tactic's implementation

Results: Understanding Effort

- Teams estimated difficulty of implementing their solutions; scale of 1 to 5
- We also estimated the effort required to implement their solutions (not the optimal solution)
- Close agreement indicates good understanding of what is needed to implement the solution in the architecture
  - Study team's estimates closer to evaluators' estimates than the control team

university of groningen

Summary Observations

- Both teams solutions address the given FT requirements (exception: task 3)
  - Study team considered numerous alternatives
- Correctness: control team had several design issues
  - lower understanding of tactic-pattern interaction
- Both teams tended to over-engineer solutions
  - Control team over-engineered more
- Control team gave worse estimates of effort

Limitations

- Validity threats :
  - Small sample size (10 participants)
  - Limited FT experience
  - Limited time for the study
  - Analysis of results not blind
- Our observations partially support the hypotheses
- Further study required

Thank you for your attention