J2EE Instrumentation for software aging root cause application component determination with AspectJ

Javier Alonso
Josep LL. Berral
Ricard Gavaldà
Jordi Torres

Technical University of Catalonia, Spain
• Motivation
• Our Contribution
  – Preliminary concepts
  – Architecture
  – Root cause determination strategy
• Experimental Case Study
• Conclusion & Future work
Motivation

• New challenges are demanded by the society.
  – Availability of the information
    • At any time
    • From everywhere

• Becoming in growing complexity day by day.
The growing complexity causes:

- Necessity for brilliant IT professionals.
- Increment of the Total owner Cost of the IT infrastructures.
- Increment of the faults/outages due to (directly or indirectly) the complexity.
Motivation

• These faults/outages have an important impact of the revenue of the companies:
  – Around US$125,000 per hour, direct impact
  – A part of the indirect impact

• Several studies show that the current system outages are more often due to software faults.
Motivation: Software Aging

• One of the most important reasons for software failures is the software aging phenomenon.

• The software aging
  – Accumulation of errors, usually provoking resource contention during long running application
  – Gradual performance degradation could also accompany software aging phenomena.
Motivation: Software Aging

• Software aging related with:
  – Memory bloating/leaks
  – Unterminated threads
  – Data corruption
  – Unreleased file-locks
  – Overruns
  – Potentially some of them together
Motivation: Software Aging

• The applications have to deal with software aging in production stage.
  – The **unaffordable and hardly cost** task to avoid all software bugs.

• What is it the solution?
  – **Software rejuvenation**
Motivation: Software Rejuvenation

- Software rejuvenation
  - Basically, reboot the system, although there are most sophisticated techniques like micro-rebooting.
  - There are two main strategies:
    - Time based strategy.
    - Proactive based strategy.
Motivation: Software Rejuvenation

• Time based strategies:
  – Rejuvenation is applied regularly and periodically.
  – Well-known used in web servers.

• Proactive based strategies:
  – System metrics are monitored continuously
  – The rejuvenation action is triggered when the system is near to the crash according to the system metrics.
Motivation: Software Rejuvenation

• The proactive approach is better because:
  – We can reduce the rejuvenation actions

• The effectiveness of the proactive approach depends on the accuracy of the monitoring metrics.
Motivation: Root cause rejuvenation

• However, traditional monitoring tools understand the applications as “black boxes”.

• This fact makes impossible to know what the *root cause* of the software aging is.
  – We understand as “root cause” the system component/s causing of the software aging.
Motivation: Root cause rejuvenation

- Monitoring tools do not offer enough clues about the root cause of failure.
  - The most used rejuvenation mechanisms are based on rebooting or application restarting.

- Rebooting implies also a reduction of availability
  - New more accurate techniques are proposed to reduce the Mean Time to Repair (MTTR), increasing the Availability.

\[
\text{Availability} = \frac{\text{MTTF}}{\text{MTTF} + \text{MTTR}}
\]
Motivation: Root cause rejuvenation

• Micro Rebooting
  – Apply the recovery technique only over the component of the application that causes the failure.
  – However, this technique needs a monitoring tool or detection mechanism that allow us to determinate the root cause of the failure.
Our Contribution

• We present a monitoring framework to help to determine the “root cause” of the software aging phenomena.

• Using technologies:
  – Aspect Oriented Programming (AOP)
  – Java Management Extensions (JMX)

• For J2EE infrastructures.
Our Contribution

• The idea:
  – Monitoring the resources consumed by every software component of a J2EE application
  – Monitoring the trend of the consumption
  – Allowing to build a resource-component consumption map.

• All of all:
  – Without modify the source code.
  – With low overhead.
Our Contribution: Preliminary concepts

• Aspect Oriented Programming:
  – Allows to isolate the main business logic of the application from secondary functions like logs or authentication.
  – The core of AOP: Aspects.
    • Aspects are composed by: Advices and Join Points.
  – AOP allows to inject code in compile, load or runtime without to know the source code.

• We are injecting our observers using AOP
Our Contribution: Preliminary concepts

• Java Management Extensions:  
  – a set of capabilities to manage and monitor any system component:
    • from devices to Java objects
  – is based on a 3-level architecture:
    • Probe level, Agent level and Remote Management Level.
Our Contribution: Architecture

• Aspect Component (AC)
  – Associated to every application component.
  – Manage the measurements of resource consumed and the trend.

• Aspect Component Proxy (AC-Proxy).
  – Creates a communication channel between the AC and the JMX Manager Agent.

• JMX Monitoring Agents
  – Access to the OS and collect system metrics for every component.

• JMX Manager Agent
  – Has the responsibility to collect the metrics of each component and build the resource-component map.
  – Activate and deactivate ACs on demand.

• External Front-end
  – Allow administrators to communicate with the JMX Manager Agent in real time or activate new ACs or new JMX Monitor Agents.
Our Contribution: Architecture

- AC Proxy
- JMX Monitoring Agents
- JMX Manager Agent
- MBeanServer
- Operating System
- External Front end
- Monitoring Data
- WAS
- C

Diagram showing the architecture involving AC, AC Proxy, WAS, JMX Monitoring Agents, JMX Manager Agent, MBeanServer, Operating System, External Front end, and Monitoring Data.
Our Contribution: Root cause determination strategy

- The JMX Manager Agent has a responsibility to build resource-component map:
  - The map is based on two axis:
    - Component usage
    - Resource consumption
- The map helps the engineers to prioritize component “repair”
Our Contribution: Root cause determination strategy

- Low Resource Consumption
  - Less Suspicious Component
  - Component Usage Low
- More Suspicious Component
  - Component Usage High
  - high Resource Consumption

- Less Suspicious Component
- More Suspicious Component
Experimental Case Study

• We have used TPC-W J2EE application to evaluate our approach.
• TPC-W simulates a on-line book store and uses Emulated Browsers (EBs) to simulate clients.
• The EBs calculate a thinking time to simulate the time used by a human to decide what will be his next step in the web.
• We have modified a set of TPC-W servlets to inject memory leaks at different ratios.
Experimental Case Study

• Overhead measurement:
  – Around 5% of overhead.
Experimental Case Study

- Effectiveness to determine a memory leak:
  - Only one component injects a memory leak (100Kb every injection):
Experimental Case Study

Effectiveness to determine a memory leak:

- Four components inject a memory leak (100Kb every injection):
Experimental Case Study

The map built in the last experiment was:

- Component Usage Low
- Component Usage High
- Low Resource Consumption
- High Resource Consumption

- D
- C
- A and B
Experimental Case Study

- Effectiveness to determine a memory leak:
  - Four components inject a memory leak (A = 100Kb every injection, B = 10KB, C and D = 1MB):
Experimental Case Study

• The map built in the last experiment was:

Component Usage Low

low Resource Consumption

Component Usage High

A

B

C

D

high Resource Consumption
Conclusion & Future work

• We have presented our framework and its utility and effectiveness to help to determine the root cause failure.
• We have focused on one type of software aging: memory leaks.
• The resource-component consumption could be an useful tool to help to determine the riskiest component
• We have to evaluate the effectiveness of that approach to determine other type of software aging due to different resources or even an interaction of more than one resource.
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