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

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Motivation

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

- Becoming in growing complexity day by day.

Motivation

- 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

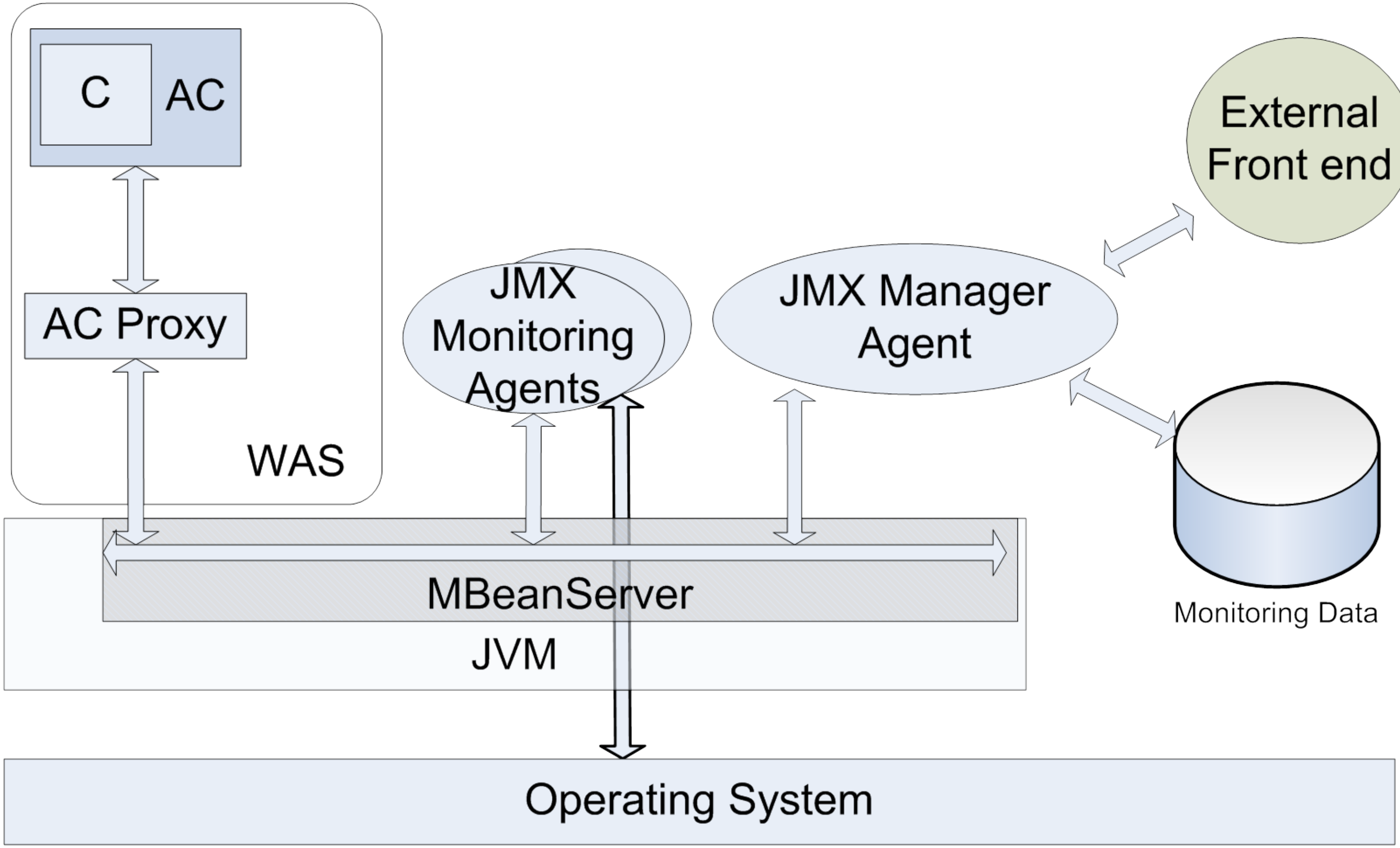
Our Contribution: Preliminary concepts

- 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

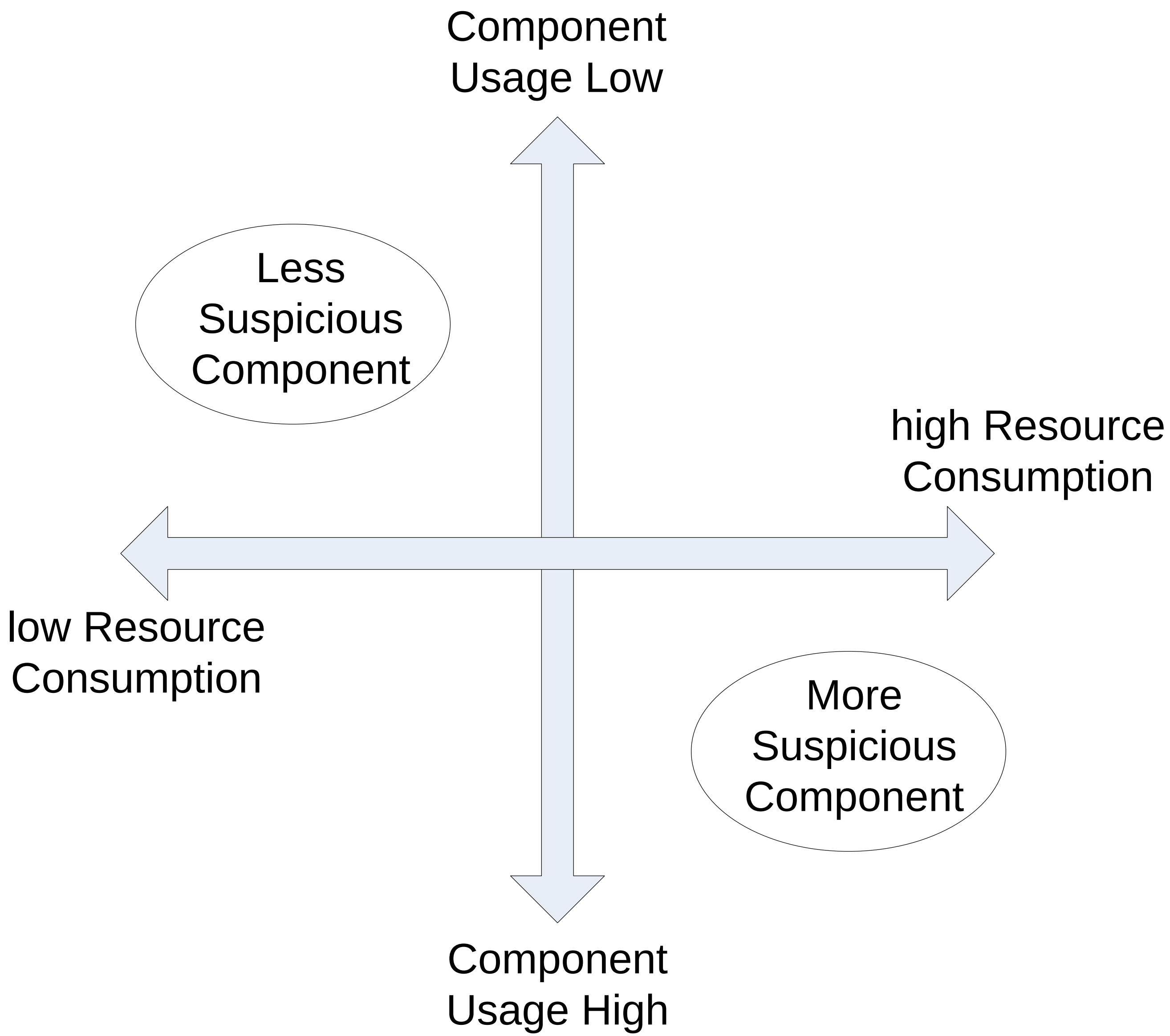


Our Contribution: Root cause determination strategy

- 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 priorize component “repair”

Our Contribution: Root cause determination strategy

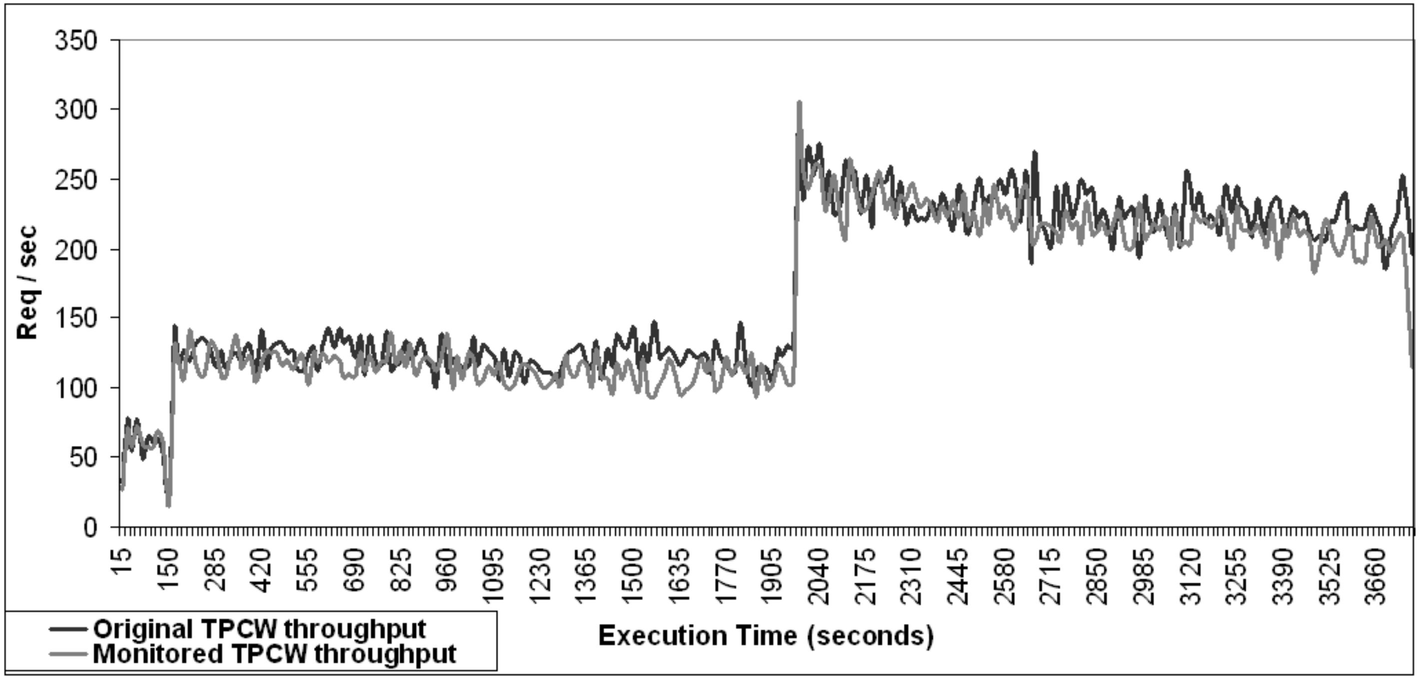


Experimental Case Study

- We have used TPC-W J2EE application to evaluate of 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.

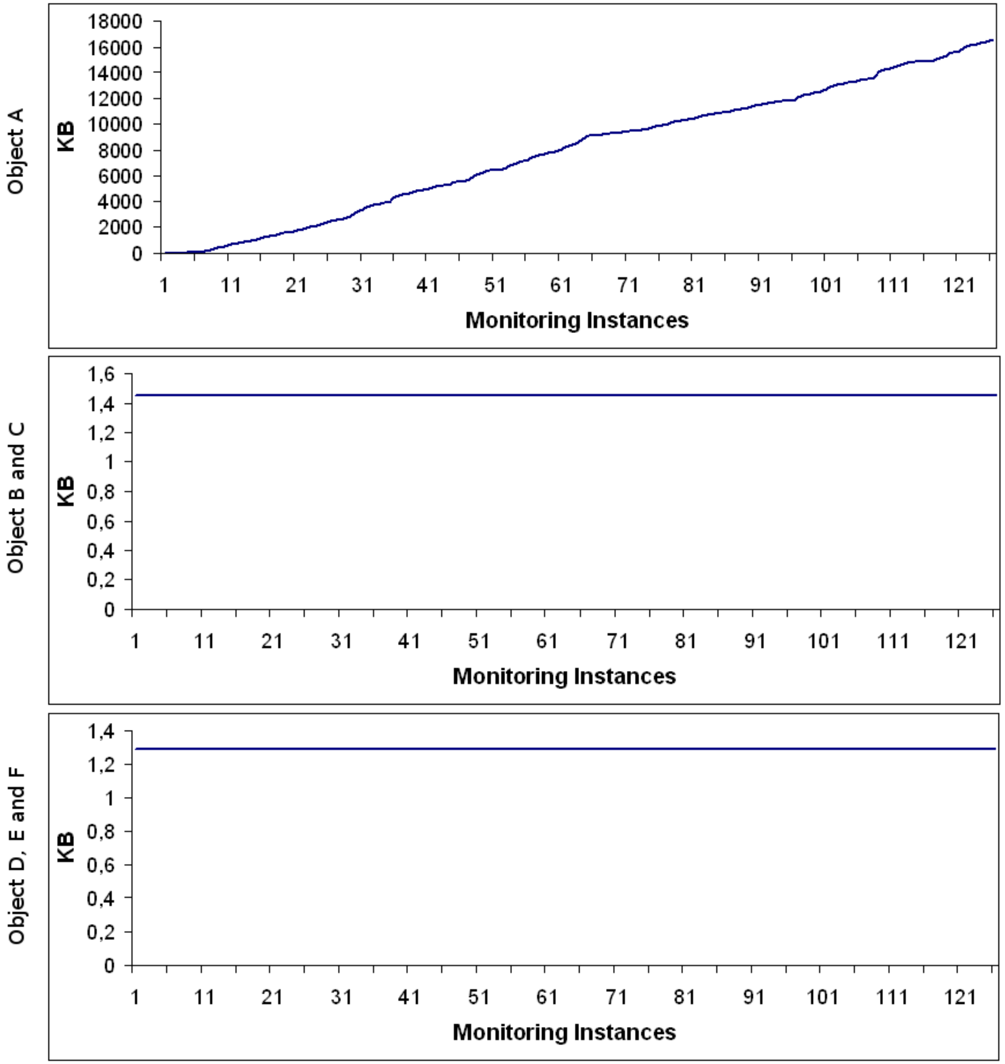
Experimental Case Study

- Overhead measurement:
  - Around 5% of overhead.



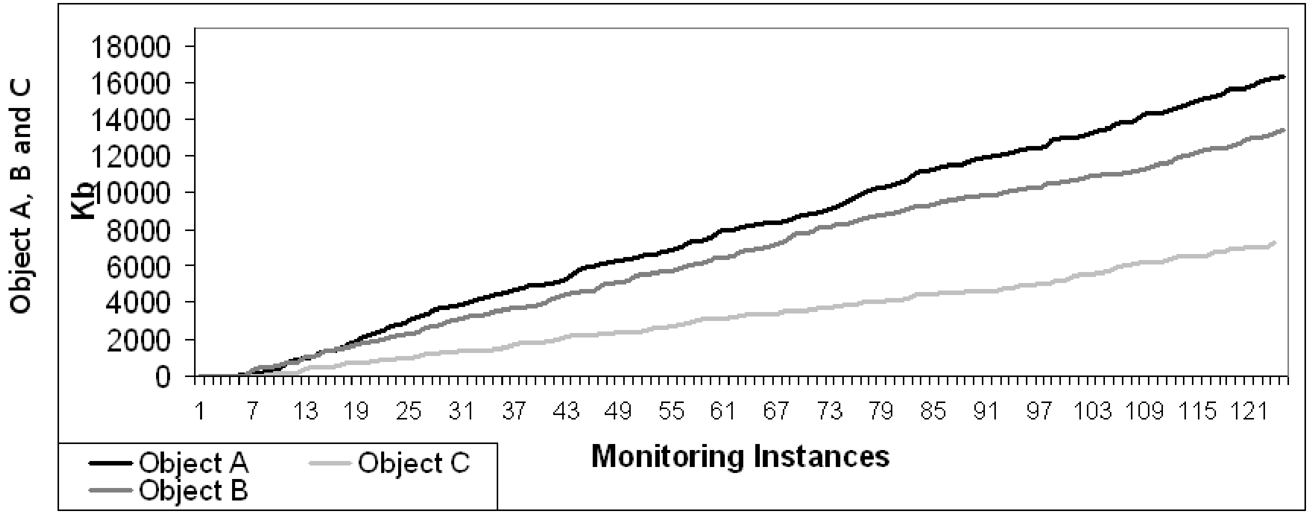
Experimental Case Study

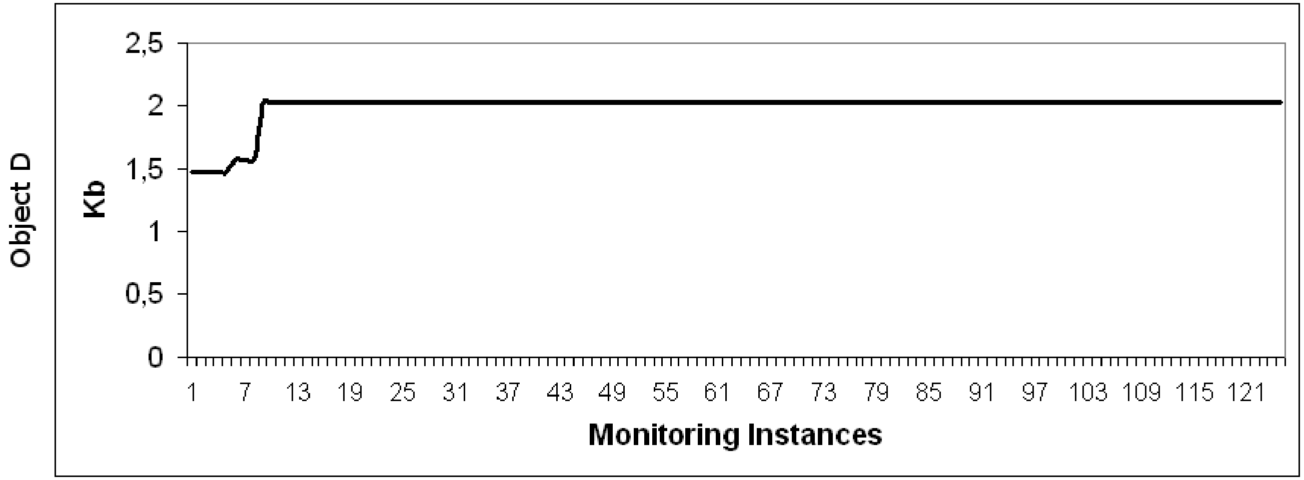
- Effectiveness to determine a memory leak:
  - Only one component injects a memory leak (100Kb every injection):



Experimental Case Study

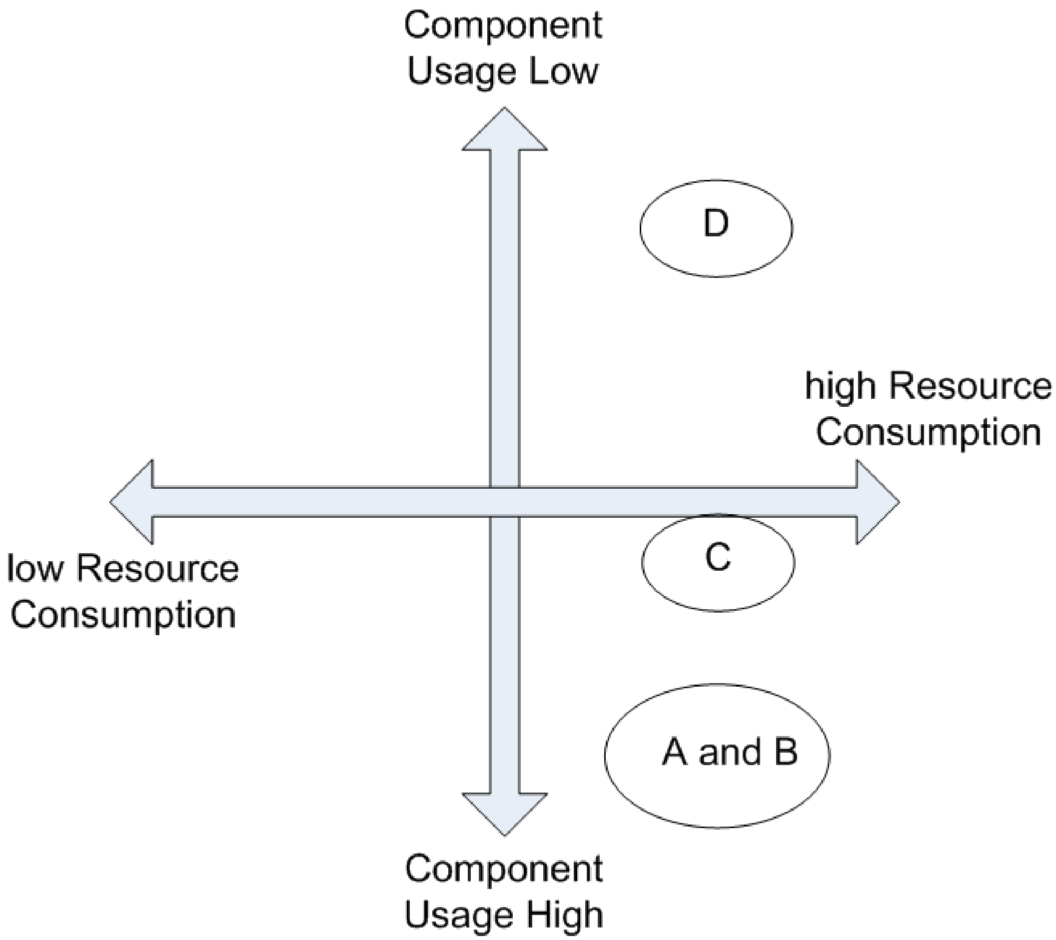
- Effectiveness to determine a memory leak:
  - Four components inject a memory leak (100Kb every injection):





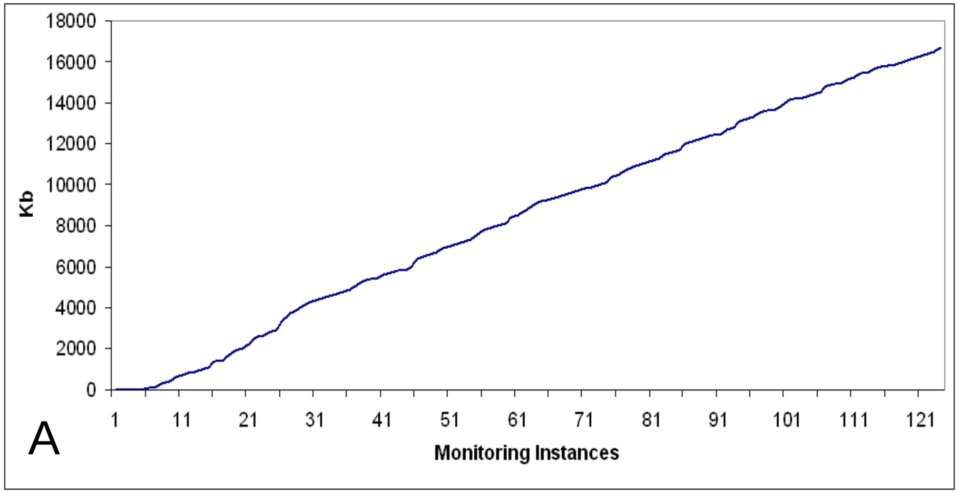
Experimental Case Study

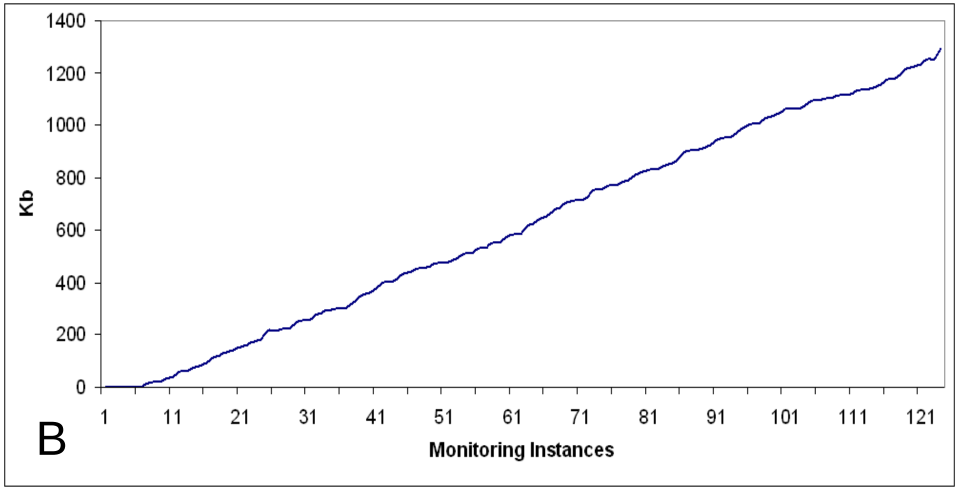
- The map built in the last experiment was:

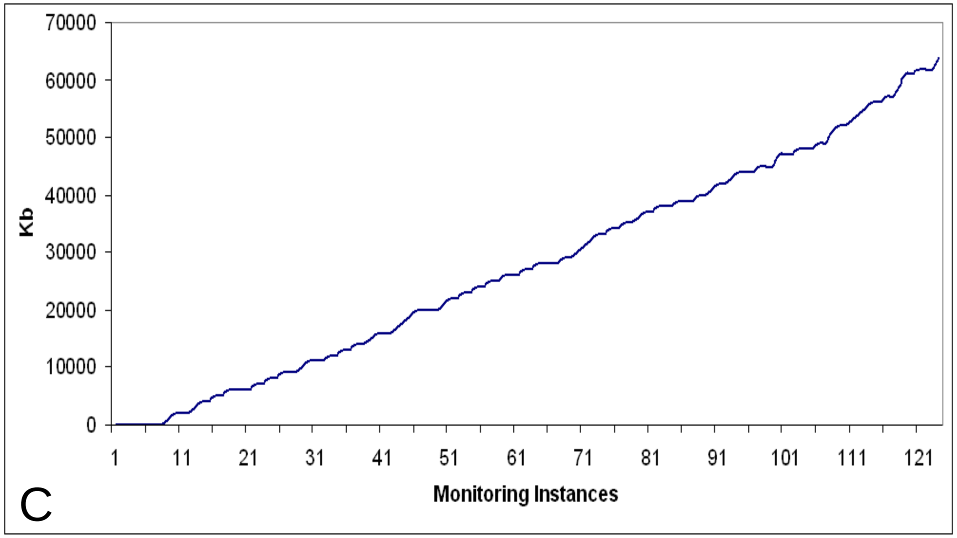


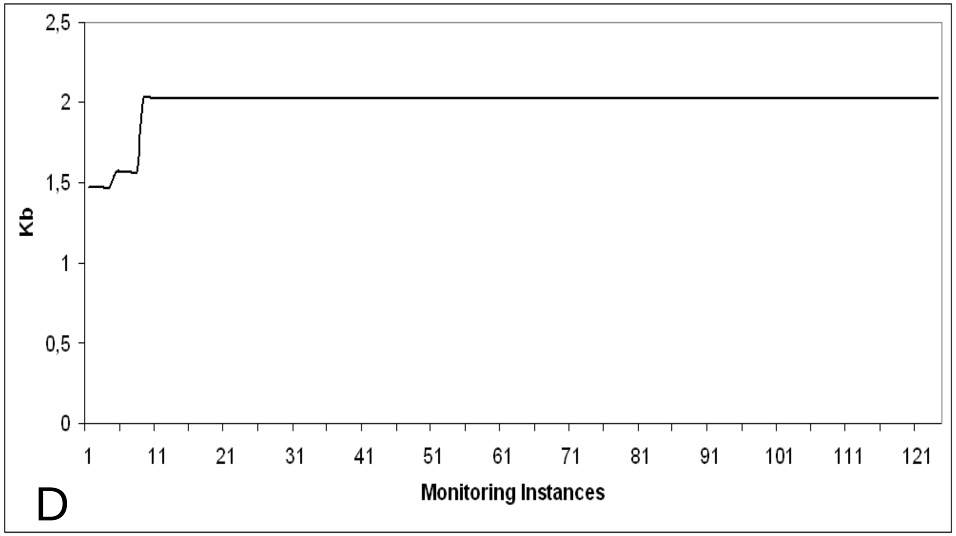
Experimental Case Study

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









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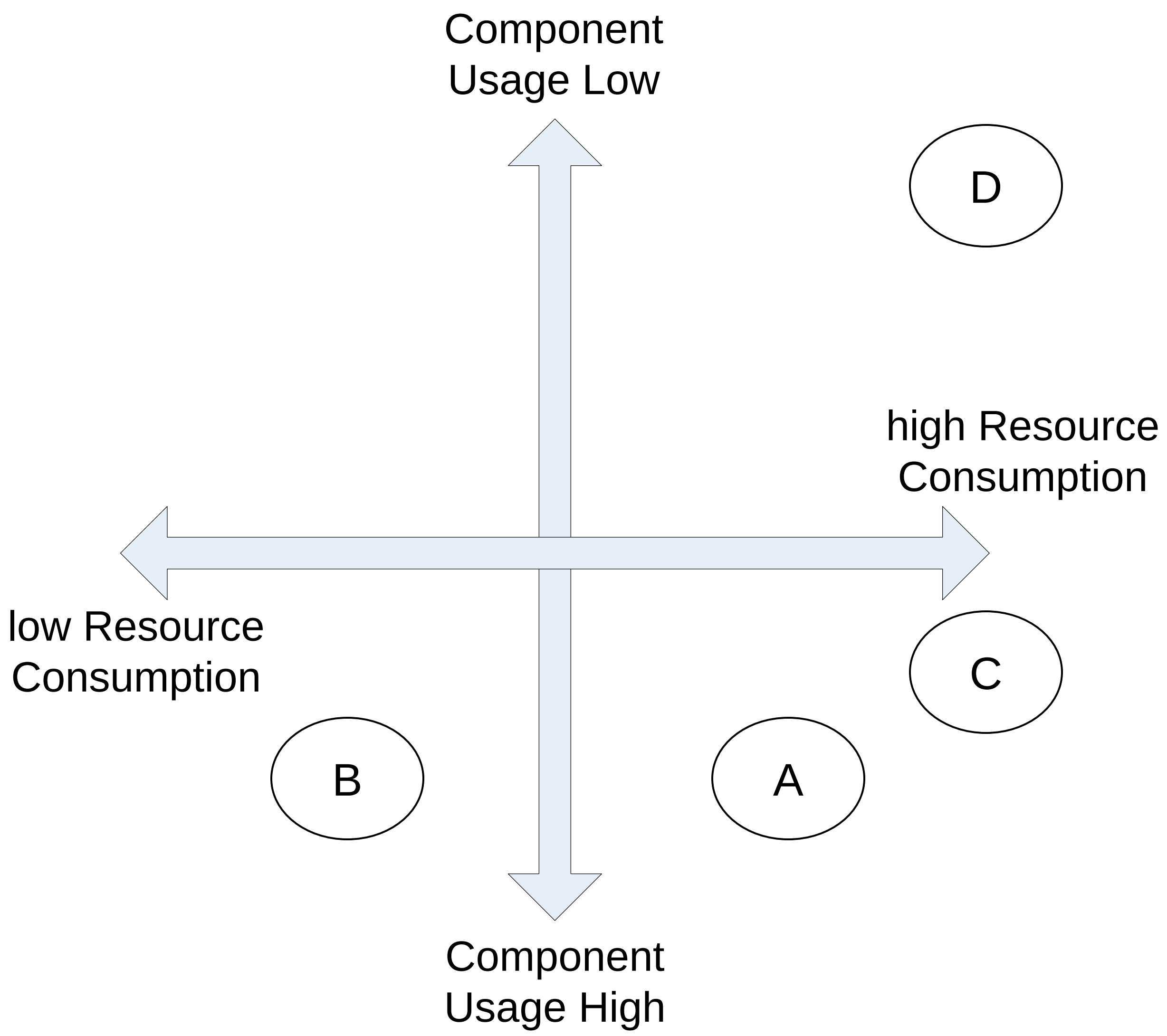

Conclusion & Future work

- 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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