

Performance Monitoring of Database Operations

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July 29, 2015



1. Introduction
2. Approach
3. Implementation
4. Evaluation
5. Related Work
6. Conclusions & Future Work

- ▶ Performance of new or legacy software systems is insufficient
- ▶ Performance problems or bottlenecks are supposed or detected
- ▶ Often related to database operations

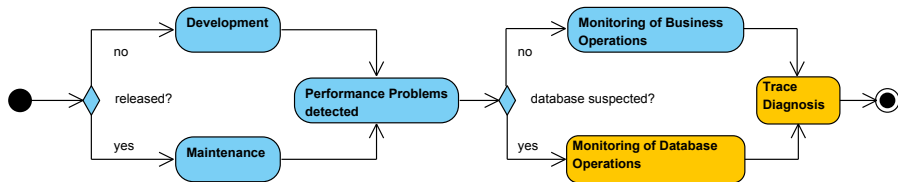


Figure: Enriched performance issue detection workflow

- ▶ Monitoring Component
 - ▶ executed SQL and prepared SQL statements
 - ▶ their call parameters
 - ▶ execution times
- ▶ Analysis & Visualization Component
 - ▶ analyzing recorded data
 - ▶ filtering, sorting, ...
 - ▶ grouping prepared statements

1. Identification of Performance Analysis Methods and Tools
2. Implementation of a Tool for Database Performance Analysis
3. Generic Monitoring Approach
4. Evaluation of the Developed Tool

Approach

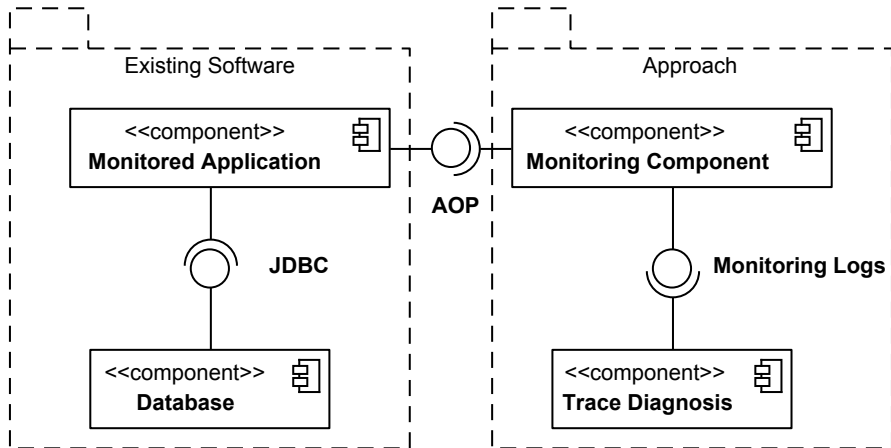


Figure: Architecture of our software system as component diagram

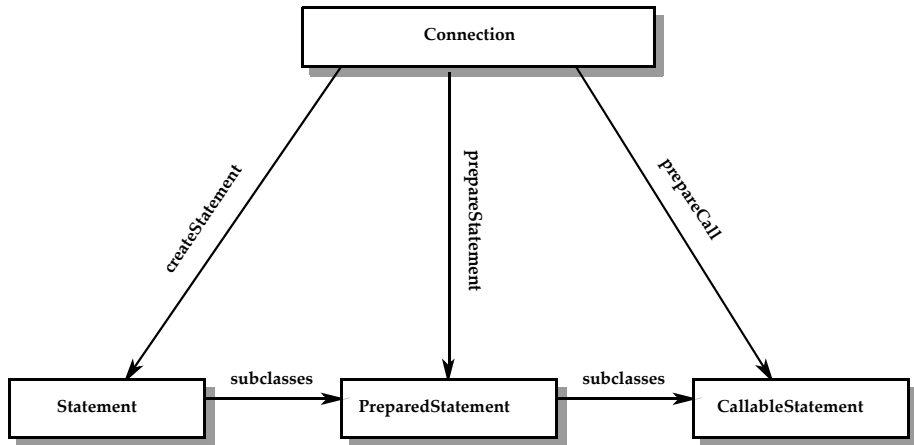


Figure: Relationships between major classes and interfaces in *java.sql*

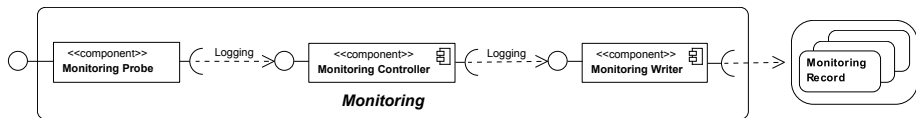


Figure: Monitoring components

- ▶ record type: differs between before or after event
- ▶ timestamp: represents date and time of the record
- ▶ operation name: full Java class name
- ▶ return type: e.g., ResultSet, boolean or int
- ▶ return value: e.g., number of affected database records
- ▶ operation arguments: e.g., SQL statement

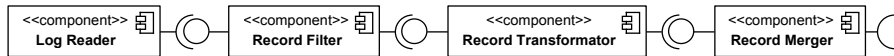


Figure: Generic Monitoring Record Processing based on P&F architecture

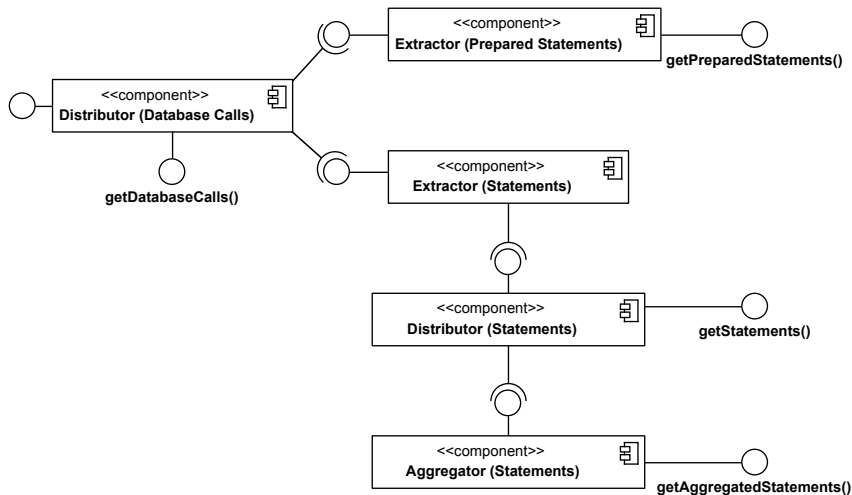


Figure: Specific Database Call Handling based on P&F architecture

Prepared Statements

Text filter...

Statement	Count	Total	Average	Minimum	Maximum
▽ SELECT itemid, name, price FROM item WHERE category = ?	3	3000ms	1000ms	500ms	1500ms
SELECT itemid, name, price FROM item WHERE category = cats		1500ms			
SELECT itemid, name, price FROM item WHERE category = dogs		1000ms			
SELECT itemid, name, price FROM item WHERE category = birds		500ms			
▶ SELECT quantity, price, discount FROM order WHERE customer = ?	7	15897ms	2271ms	320ms	4943ms
...

n Prepared Statements

Figure: Mock-up view based on *Call Tree Views* [De Pauw et al. (2002)]

Implementation

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Statement	ReturnValue	Total	Trace ID
DROP INDEX productName	null	3011932 ns	2
DROP TABLE lineitem	null	591418 ns	4
DROP TABLE orders	null	883278 ns	6
DROP TABLE profile	null	627339 ns	8

↑ Data Grid

← Detail Panel

Operation: boolean java.sql.Statement.execute(String)
Statement: DROP INDEX productName
Return Value: null
Total: 3011932 ns

← Footer 117 Statement(s)

Figure: Statement view screenshot

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Statement	Count	Total	Avg	Min	Max
SELECT itemid, productid, listprice FROM item	2	300008 ns	150004 ns	100004 ns	200004 ns
DROP INDEX productName	1	3011932 ns	3011932 ns	3011932 ns	3011932 ns

Operation: boolean java.sql.Statement.execute(String)
Statement: SELECT itemid, productid, listprice FROM item
Number of Calls: 2
Total: 300008 ns
Avg: 150004 ns
Min: 100004 ns
Max: 200004 ns

116 Aggregated Statement(s)

Figure: Aggregated statement view screenshot

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Statement	Count	Total	Avg	Min	Max	
▲ SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = ?	7	5445597 ns	777942 ns	501614 ns	1296373 ns	^
SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = EST-5		1296373 ns				
SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = EST-5		988476 ns				
SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = EST-5		503538 ns				
SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = EST-17		727726 ns				
SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = EST-17		610341 ns				
SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = EST-15		817529 ns				
SELECT QTY AS VALUE FROM INVENTORY WHERE ITEMID = EST-15		501614 ns				v
Operation:	PreparedStatement java.sql.Connection.prepareStatement(String)					^
Abstract PreparedStatement:	SELECT PRODUCTID, NAME, DESCN AS DESCRIPTION, CATEGORY AS CATEGORYID FROM PRODUCT WHERE CATEGORY = ?					v

13 PreparedStatement(s)

Figure: Prepared statement view screenshot

Evaluation

- ▶ Usability Test Experiment
- ▶ Based on a questionnaire, 36 participants
- ▶ Questionnaires have been used a long time to evaluate user interfaces [Root and Draper(1983)]

3 Statements

3.1 Name the Trace ID and response time (in ms) of the statement, that has the highest response time.

3.2 What is it's underlying calling Java operation?

3.3 What kind of SQL statement took the lowest amount of time?

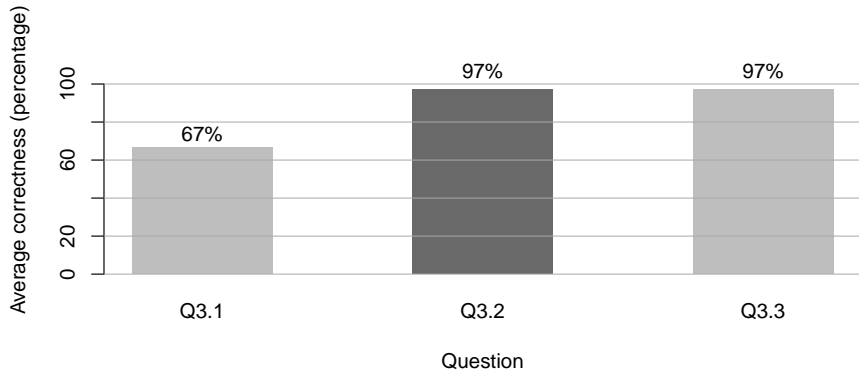


Figure: Average correctness per question within the statements part

6 Debriefing Questions

6.1 How difficult was it to **navigate** through the program?

very difficult very easy

6.2 How difficult was it to **filter** and **sort** database statements for specific problems?

very bad very good

6.3 Was the program **easy to use**?

very difficult very easy

6.4 How was your **overall impression** of the tool?

very bad very good

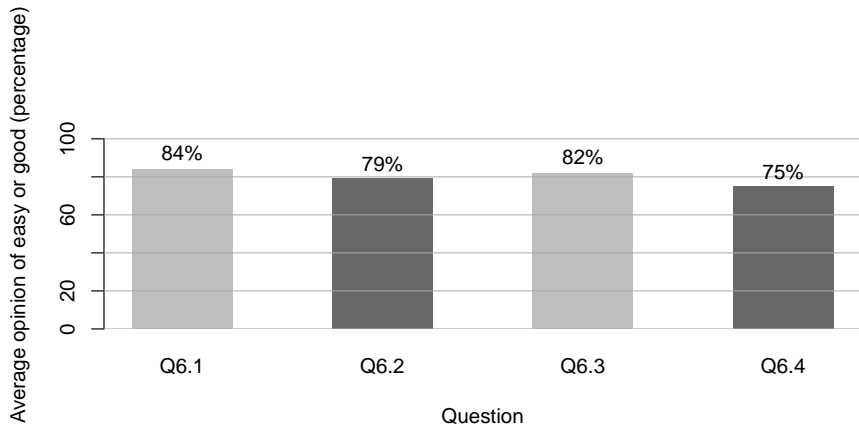


Figure: Average rating of easy or good per question within the debriefing questions

- ▶ Positive feedback from participants
- ▶ High average correctness rates
- ▶ Positive usability rating

- ▶ Cloud Monitoring [Ma et al. (2012)]



APPDYNAMICS



- ▶ Software supports performance analysis on database operations
- ▶ Monitoring component versatile (Kieker Trace Diagnosis and ExplorViz [Fittkau 2015])
- ▶ Approach validated through conducted experiment

- ▶ Easier filtering, e.g., based on substrings
- ▶ More visualization options, e.g., 3D visualizations
- ▶ Further experiments, e.g., controlled experiments similar to [Fittkau et al., May 2015a]



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