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Performance Requirements: the Backbone of the Performance Engineering Process

Paper 1102

Session 601

Alexander Podelko

alex.podelko@oracle.com

@apodelko

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Introduction

- The topic is more complicated than it looks
- Performance requirements are supposed to be tracked through the whole system lifecycle
- Each group of stakeholders has its own view and terminology
- An overview of existing issues and an attempt to create a holistic view

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SDLC	Performance Eng Life Cycle
• Requirements	• Performance Requirements
• Architecture and Design	• Design for Performance and Performance Modeling
• Construction / Implementation	• Unit Performance Tests and Code Optimization
• Testing	• Performance Testing
• Deployment and Maintenance	• Performance Monitoring and Capacity Management

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Agenda

- Metrics
- Elicitation
- Analysis and Specification
- Validation and Verification

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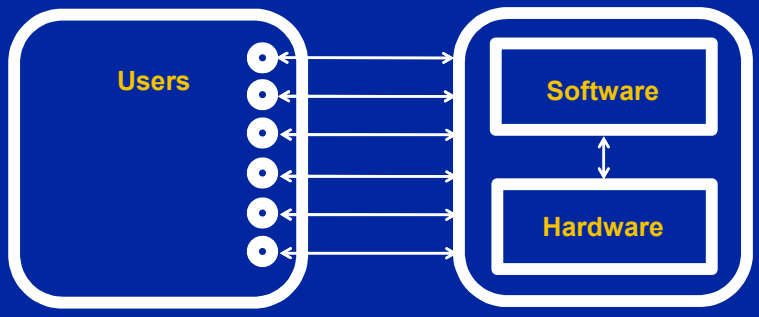
High-Level View of System



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Business Performance Requirements

- For today's distributed business systems
- Throughput
- Response / processing times
- All are important

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Throughput

- The rate at which incoming requests are completed
  - Usually we are interested in a steady mode
- Straightforward for homogeneous workloads
  - Not so easy for mixed workloads: mix ratio can change with time
- Varies with time
  - Typical hour, peak hour, average, etc.

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Number of Users

- Number of users by itself doesn't define throughput
  - Without defining what each user is doing and how intensely
  - 500 users running one short query each minute: throughput 30,000 queries per hour
  - 500 users running one short query each hour: throughput 500 queries per hour
  - Same 500 users, 60X difference between loads

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Concurrency

- Number of simultaneous users or threads
  - Number of active users
- Take resources even if doing nothing
- Number of named users
  - Rather a data-related metric
- Number of “really concurrent” users
  - Number of requests in the system
  - Not a end-user performance metric

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Response Times

- How fast requests are processed
- Depends on context
  - 30 minutes may be excellent for a large batch job
- Depends on workload
  - Conditions should be defined
- Aggregate metrics usually used
  - Average, percentiles, etc.

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Context

- All performance metrics depend on context like:
  - Volume of data
  - Hardware resources provided
  - Functionality included in the system
    - Functionality is added gradually in agile methodologies

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Internal (Technological) Requirements

- Important for IT
- Derived from business and usability requirements
  - During design and development
- Resources
- Scalability

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Resources

- CPU, I/O, memory, and network
- Resource Utilization
  - Related to a particular configuration
  - Often generic policies like CPU below 70%
- Relative values (in percents) are not useful if configuration is not given
  - Commercial Off-the-Shelf (COTS) software
  - Virtual environments

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Resources: Absolute Values

- Absolute values
  - # of instructions, I/O per transaction
    - Seen mainly in modeling
  - MIPS in mainframe world
- Importance increases again with the trends of virtualization, cloud computing, and SOA
  - VMware: CPU usage in MHz
  - Microsoft: Megacycles
  - Amazon: EC2 compute units

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Scalability

- Ability of the system to meet performance requirements as the demand increases
- Increasing # of users, transaction volumes, data sizes, new workloads, etc.
- Performance requirements as a function, for example, of load or data and configuration
  - No free / ideal scalability

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IEEE SWEBOK

- IEEE Software Engineering Book of Knowledge defines four stages for requirements:
  - Elicitation
    - Where come from and how to collect them
  - Analysis
    - Classify / Elaborate / Negotiate
  - Specification
    - Production of a document
  - Validation

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Where do performance requirements come from?

- Business
- Usability
- Technology

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Business Requirements

- Comes from the business, may be caught before design starts
  - Number of orders per hour
- The main trap is to immediately link them to a specific design and technology thus limiting the number of available choices
  - For example, it may be one page per order or a sequence of two dozen screens
  - Each of the two dozen may be saved separately or all at the end

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Requirements Elicitation

- ***Final*** requirements should be quantitative and measurable
- Business people know what the system should do and may provide some information
  - They are not performance experts
- Document real business requirements in the form they are available
  - Then elaborate them into quantitative and measurable

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Goals vs. Requirements

- Most response times "requirements" are goals
  - Missing them won't prevent deploying the system
- For response times, the difference between goals and requirements may be large
  - For many web applications goals are two-five seconds and requirements somewhere between eight seconds and one minute

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See The Whole Picture

- For example, the requirement is 10 seconds
- We got 15 seconds for peak load
- But what if
  - Only on busiest day of the year
  - All other days it will be below 10 seconds
  - It is CPU-constrained and may be fixed by additional hardware

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Determining Specific Requirements

- It depends
- Approach the subject from different points of view
- Just to illustrate here are 10 methods suggested by Peter Sevcik to find T in APDEX
  - T is threshold between satisfied and tolerating users; should be strongly correlated with the response time goal

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Methods 1-5 to Find T (by Peter Sevcik)

- Default value (4 sec)
- Empirical data
- User behavior model (# of elements/task repetitiveness)
- Outside references
- Observing users

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Methods 6-10 to Find T (by Peter Sevcik)

- Controlled performance experiment
- Best time multiple
- Find frustration threshold F first and calculate T from F (F=4T in APDEX)
- Interview stakeholders
- Mathematical inflection point

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Suggested Approach

- So Peter Sevcik suggests to use several of these methods: if all come approximately to the same number it will be T
- A similar approach can be used for performance requirements: use several methods to get the numbers – you get goal/requirement if they are close
  - Investigate / sort out if they differ significantly

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Usability Requirements

- Many researchers agree that
  - Users lose focus if response times are more than 8 to 10 seconds
  - Making response times faster than one to two seconds doesn't help productivity much
- Sometimes linked closely to business requirements
  - Make sure that response times are not worse than competitor‘s

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Response Times: Review of Research

- In 1968 Robert Miller defined three threshold levels of human attention
- Instantaneous 0.1-0.2 seconds
- Free interaction 1-5 seconds
- Focus on dialog 5-10 seconds

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Instantaneous Response Time

- Users feel that they directly manipulate User Interface (UI)
- For example, between typing a symbol and its appearance on the screen
- 0.1-0.2 seconds
- Often beyond the reach of application developers
  - System/UI libraries, client-side

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Free Interaction

- Notice delay, but "feel" the computer is "working"
- Earlier researchers reported 1-2 sec
  - Simple terminal interface
- For problem solving tasks no performance degradation up to 5 sec
  - Depends on the number of elements and repetitiveness of the task

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Does It Change with Time?

- Do expectations increase with time?
  - 2009 Forrester research suggests 2 second response time, in 2006 similar research suggested 4 seconds
    - The approach is often questioned: they just ask. It is known that user perception of time may be misleading
    - What page are we talking about?

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Focus on Dialog

- Users are focused on the task: 5-10 sec
- Half of users abandon Web pages after 8.5 sec - Peter Bickford, 1997
  - 2 min delay after 27 quick interactions
  - Watch cursor kept users 20 sec, animated cursor 1 min, progress bar until the end
- Users should reorient themselves after a delay above the threshold

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Technological Requirements

- Comes from the chosen design and used technology
  - We call ten web services sequentially to show a page within 3 sec. It translates into requirements of 200-250 ms for each web service
  - resource utilization requirements

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Analysis and Modeling

- Final requirements are elaborated from business requirements by applying usability and technological requirements
- Requirements traceability
  - Where it came from
- Input for Software Performance Engineering
  - For example, defining service / stored procedure response times by its share in the end-to-end performance budget

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Documenting Requirements

- Requirements / Architect's vocabulary
- Quality Attributes
  - Part of Nonfunctional Requirements
- Approaches
  - Text
  - Quality Attribute Scenarios (SEI)
  - Planguage

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Quality Attribute Scenarios

- QA scenario defines:
  - Source
  - Stimulus
  - Environment
  - Artifact
  - Response
  - Response Measure

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Planguage

- Tag: unique identifier
- Gist: brief description
- Scale: unit of measure
- Meter: how to measure
- Minimum / Plan / Stretch/ Wish : levels to attain
- Past / Record / Trend

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What Metrics to Use?

- Average
- Max
- Percentiles (X% below Y sec)
- Median
- Typical
- etc.

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The Issue

- SLA (Service Level Agreement)
  - "99.5% of all transactions should have a response time less than five seconds"
- What happens with the rest 0.5%?
  - All 6-7 seconds
  - All failed/timeout
- Add different types of transactions, different input data, different user locations, etc.

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Observability

- Four different viewpoints
  - Management
  - Engineering
  - QA Testing
  - Operations
- Ideal would be different views of the same performance database
- Reality is a mess of disjoint tools

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Metrics to Use

- Combination of percentile and availability metric works in many cases
  - 97% below 5 sec, less than 1% failed/timeout
- An example of another approach:
  - Apdex (Application Performance Index)
  - Objective user satisfaction metric
  - A number between 0 and 1
  - 0 no users satisfied, 1 all users satisfied

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Requirements Validation

- Making sure that requirements are valid
  - Quite often used to mean checking against test results (instead of verification)
- Checking against different sources
- Reviews, modeling, prototyping, etc.
- Iterative process
- Tracing
  - Tracing back to the original requirement

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Requirements Verification

- Checking if the system performs according to the requirements
- Both requirements and results should use the same aggregates to be compared
- Many tools measure only server time (or server and network)
  - End user time may differ significantly, especially for rich web clients or thick clients
- Both in load testing and production !

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Verification Issue

- Let's consider the following example
- Response time requirement is 99% below 5 sec
- 99% 3-5 sec, 1% 5-8 sec
  - Looks like a minor performance issue
- 99% 3-5 sec, 1% failed or had strangely high response times (more than 30 sec)
  - Looks like a bug or serious performance issue

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Requirements Verification: Performance vs. Bug

- Two completely different cases
  - Performance issue: business decision, cost vs. response time trade off.
  - Bug exposed under load: should be traced down first to make decision

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The equipment is not operating as expected, and therefore there is a danger that it can operate with even wider deviation in this unexpected and not thoroughly understood way. The fact that this danger did not lead to a catastrophe before is no guarantee that it will not the next time, unless it is completely understood.

Dr. Richard Feynman
Roger Commission Report on the Challenger space shuttle accident

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Summary

- Specify performance requirements at the beginning of any project
- What to specify depends on the system
  - Quantitative and measurable in the end
- Elaborate and verify requirements throughout Development – Testing – Production

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Questions ?

Alexander Podelko

alex.podelko@oracle.com
@apodelko

Links and references may be found in the paper and at www.alexanderpodelko.com

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