Product Quality Engineering

Objectives

- Identify aspects of quality beyond functionality and few defects/failures
  - Performance, availability, usability, etc.
- For selected quality attributes
  - Define the concept
  - Identify engineering practices to provide the attribute
  - Identify testing and other measures to gather indicators of the attribute

Q vs q

- Quality includes many more attributes than just absence of defects:

Features
Performance
Availability
Safety
Security
Reusability
Usability

Evolvability
- Extensibility
- Modifiability
- Portability
- Scalability

Cycletime
Cost

Q vs q

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Features
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Security
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Addressed in lecture

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ISO9126 Attribute Classification

ISO/IEC 9126 Software engineering -- Product quality

Reliability
- Maturity
- Fault-tolerance
- Recoverability

Functionality
- Suitability
- Accurateness
- Interoperability
- Compliance
- Security

Usability
- Understandability
- Learnability
- Operability

Portability
- Adaptability
- Installability
- Conformance
- Replaceability

Efficiency
- Time behavior
- Resource behavior

Maintainability
- Analyzability
- Changeability
- Stability
- Testability

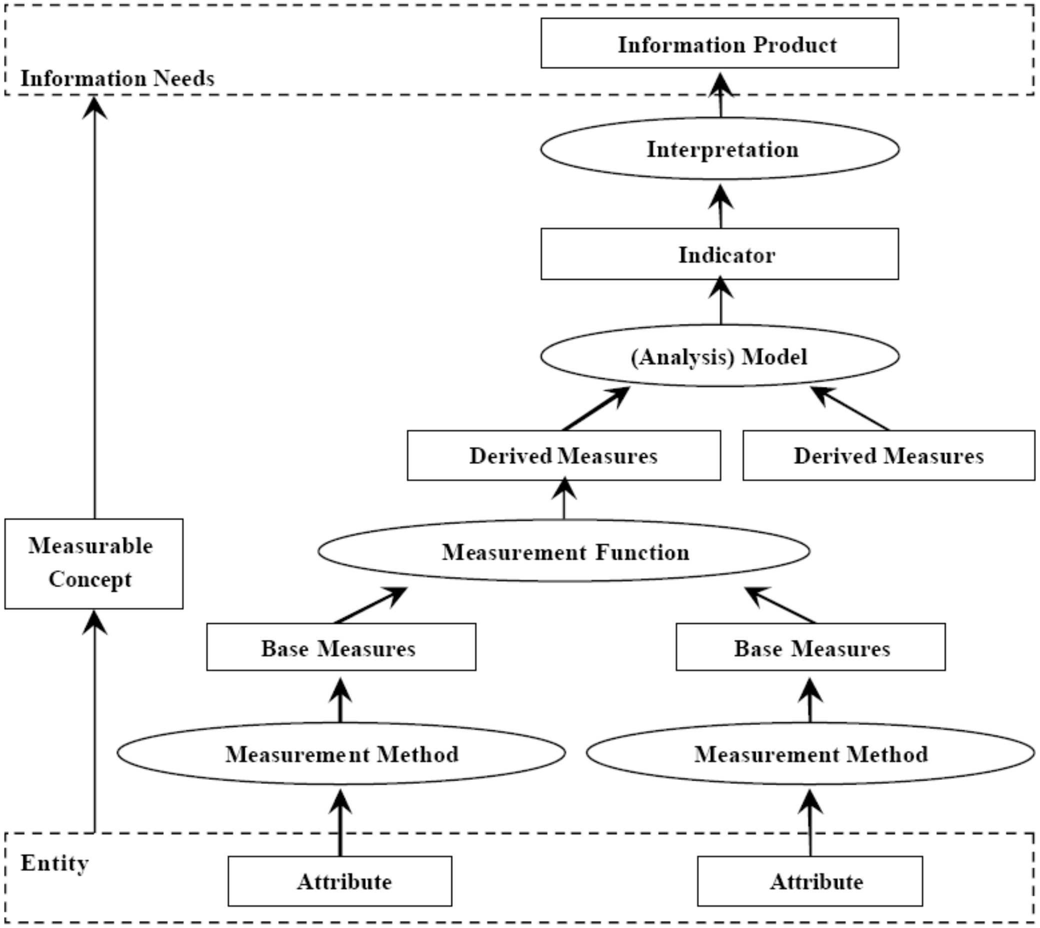
Measurement Information Model

[From ISO 15939 (2002) – Software Measurement Process]

Data Analysis

Data Preparation

Data Collection



Product Quality Engineering

Objectives

Design

Analysis

Development

Measurement

- Attribute goals
- Criticality of goals
- Preferred tradeoffs

- Quantitative / Qualitative
- Fidelity varies with effort, available info

- Testing & Field Data
- Customer Feedback

Functionality (Features)

- Requirements process defines objectives
  - Includes decisions about release phasing
  - Also address interoperability, standards compliance, …
- Requirements quality engineering practices
  - Prototyping, customer interaction for early defect detection
  - Requirements checklists (and templates) for defect elimination
  - Domain modeling for completeness and streamlining
  - Feasibility checking is a preliminary analysis step
- Analysis at requirements and design time
  - Sequence/interaction diagrams for use cases
  - Exploring alternative scenarios
  - May use formal methods to analyze consistency & completeness
- Acceptance testing measures success in feature delivery
- Customer satisfaction is the ultimate measure

Performance Engineering Practices

- Specify performance objectives
  - Even where user does not have specific requirements, useful to set performance targets
- Analyze designs to determine performance
  - Use performance benchmarking to obtain design parameters
  - Performance modeling and simulation, possibly using queuing and scheduling theory, for higher fidelity results
- Performance testing
  - Benchmarking (individual operations), stress testing (loads), soak testing (continuous operation)

Performance Objectives: Examples

- Response Time
  - Call setup: < 250 ms
  - System startup: < 2 minutes
  - Resume service within 1.5 sec on channel switchover
- Throughput
  - 1000+ call requests /sec
- Capacity
  - 70+ simultaneous calls
  - 50+ concurrent users
- Resource Utilization
  - Max 50% CPU usage on full load
  - Max 16MB run time memory
  - Max bandwidth: 96 kb/sec

Performance Analysis

- Example: Spell checker
  - If you were building a spell checker that searched words in a document against a wordlist, what will be its performance?
- Gives very approximate results
- Useful to get an idea of whether the performance goals are:
  - Impossible to meet
  - A significant design concern
  - A “don’t care” (can be met easily)
- Helps to identify bottlenecks: which parts of the design need to worry most about performance?

Metrics for Performance

- Within project:
  - Performance targets (requirements)
  - Estimated performance (design)
  - Actual performance (testing)

- Across projects:
  - Metrics available for some domains
    - For example, polygons/sec for graphics, packets/sec for networks
    - Can measure performance on “standard” benchmarks
  - But overall, no general performance metrics

Measuring Performance

- Benchmarking operations:
  - Run operation 1000s of times, measure CPU time used, divide to get average time
    - Need to compensate for system effects: load variations, caches, elapsed vs. CPU time, etc.
- Performance testing:
  - Execute operations using applications – benchmark performance
- Performance is very sensitive to configuration
- Load testing: performance testing under typical and high-use operating conditions, where there may be multiple concurrent requests active simultaneously

Availability Engineering Practices

- Defining availability objectives similar to reliability
  - Based on cost impacts of downtime
- Design techniques for availability
  - Implement fault-tolerance at software and hardware levels
- Availability analysis:
  - Fault trees to determine possible causes of failures
    - FMEA: Failure modes and effects analysis
    - Sort of like fishbones!
  - Attach MTBF numbers to entries and propagate up the tree
  - Combine with recovery times to get estimated downtime

Availability Testing & Metrics

- Availability testing:
  - Fault injection: introduce faults, study recovery behavior
  - Fault injection capabilities built into code
  - Study failure behavior during system tests: reliability & availability
- Availability metrics:
  - % of time system needs to be up and running (or)
  - % of transactions that must go through to completion
- Availability goals of 99.9% not unusual
  - 8 hours of downtime per year
- Availability goal of 99.999% (“5 NINES”) for telecom etc.
  - Less than 5 minutes downtime per year, including upgrades
  - Requires upgrading the system while it is operational

Usability Engineering Practices

- Specify usability objectives
  - Often internal to development team
  - May be either quantitative or qualitative
- Workflow observation and modeling, user profiles
- Create interface prototype, analyze for usability
  - Interface concept has primary impact on usability
  - State machine models for navigation design and analysis
- Add usability "widgets" to improve usability properties
- Analysis and testing:
  - Assess usability based on operational profiles
    - Keystrokes/clicks/number of steps for frequent operations
  - Assess usability using surveys: SUMI standardized survey tool
  - User observation testing: watching actual users try to get work done
- Alpha/beta testing

Usability Objectives: Examples

- Usability:
  - User types: Administrators & Operators
  - Look and feel same as Windows packages (compliant with Windows Style Guide)
  - Server invocation in < 60 ms
  - Invocation command shall have < 5 Command line arguments
  - Expert user should be able to complete the task in < 5 sec
  - New users to start using the system in one hour without training
  - Context sensitive help for most of the common operations
  - SUMI rating of 48 or higher

SUMI: Software Usability Measurement Inventory

- SUMI is a survey-based approach for usability analysis
  - Standard user questionnaire – 50 questions
  - Pre-calibrated response analysis tool
    - Constantly calibrated against 100s of major software products
    - Score is relative to state-of-the-art
  - Score of 0-10 along five dimensions: efficiency, learnability, helpfulness, control, affect
- Inputs: Actual interface and software behavior, prototypes
- SUMI score is a metric for usability

- http://www.ucc.ie/hfrg/questionnaires/sumi/whatis.html

Usability: Quality Engineering

- Various guidelines on what to do, not to do:
  - User Interface Hall of Shame, Hall of Fame
  - http://homepage.mac.com/bradster/iarchitect/shame.htm
- Focus on eliminating various kinds of problems:
  - Widget choices to eliminate input errors
    - Such as a calendar to choose date instead of typing
  - Graying out to eliminate invalid choices
  - Input validation
  - Fault detection & handling model to eliminate crashes
  - Standardized libraries of UI widgets within applications, to eliminate inconsistencies

Quick Summary of Usability Engineering

- UI design needs to focus first on the basics, then on the cosmetics
- Focus on user characteristics, expectations and the operations they want to perform
- Consistent interface concept is the most critical part of UI design
- “Obvious” behavior is good!
- Need to figure out and use the right widgets for each UI task
- Cosmetic aspects are nice add-ons after the basics in place
- Usability is about users getting things done and feeling comfortable using the software, not about impressing them!

Evolvability Engineering

- Identifying evolvability objectives:
  - Likely types of future changes
- Designing with evolvability in mind:
  - Most design patterns focus on evolvability
  - Note tradeoffs: designs that increase evolvability along one dimension may reduce evolvability along others
    - For example, with OO, easier to add classes & behaviors, harder to make some types of changes to operations (affects multiple classes)
- Evolvability analysis with SAAM:
  - SAAM: Software Architecture Analysis Method
  - Review-based technique that analyzes the architecture to determine how hard it is to make certain types of changes
  - It is possible to analyze for subjective/qualitative attributes!

Evolvability Objectives: Examples

- Portability
  - Application should run on Windows 7 as well
  - Should be able to use different databases Oracle/SQL Server/...
- Scalability
  - Increase the number of state vectors in the space communications network from 66 to 110
- Extensibility
  - Should be easy to incorporate password protection
  - Medium effort to add context sensitive help feature to the GUI
  - Diagnostic monitoring tool should be extensible with respect to analysis capabilities for monitored data
- Maintainability
  - The tool should allow easy addition of new message formats
  - The tool should be customizable for new business processes

Evolvability Engineering Practices

- Addressing (only) those types of changes that are likely
  - Avoiding over-engineering
  - Refactoring approach from agile processes
- Generating multiple design options and comparing their quality attributes
- Matching concerns with solutions: design patterns thinking
- Design-by-contract, built-in self-tests, test suites
  - To provide early detection of failures due to changes
- Changes during development itself provide feedback on evolvability

Product Quality Data Chart

Key Product-Quality Attributes(Performance, Usability…):

Paramater	Goal	Arch/Design based Projection	Test Results	Benchmark Value

Availability Goal

Nines goal	
Nines Estimated	
Nines Achieved	

Product Evolution Goals:

Evolution Req	Goal	Arch/Design based Projection	Action plan

Usability score from SUMI (if used):

Overall Score	
Efficiency	
Affect	
Helpfullness	
Control	
Learnability	

Summary

- Product Quality encompasses a number of attributes: “ilities”
- It is possible to systematically focus on each attribute
  - Specify objectives, analyze designs, measure results during testing
  - Specific engineering practices to achieve given quality attributes
- Objective metrics exist for some attributes but not others
  - But subjective data is also useful