Lecture 7: Requirements Modeling III

Last Week:
Modeling II
Information
Structure
Behaviour

This Week:
Modeling System Qualities
Non-functional Requirements
Satisficing Softgoals
Quality measures

Next Week:
Specification and Validation
Specification Languages
Documentation Standards
Reviews and Inspections

What are Non-functional Requirements?

- **Functional vs. Non-Functional**
  - Functional requirements describe what the system should do
    - things that can be captured in use cases
    - things that can be analyzed by drawing interaction diagrams, statecharts, etc.
    - Functional requirements will probably trace to individual chunks of a program
  - Non-functional requirements are global constraints on a software system
    - e.g. development costs, operational costs, performance, reliability, maintainability, portability, robustness etc.
    - Often known as the "ilities"
    - Usually cannot be implemented in a single module of a program
- **The challenge of NFRs**
  - Hard to model
  - Usually stated informally, and so are:
    - often contradictory,
    - difficult to enforce during development
    - difficult to evaluate for the customer prior to delivery
  - Hard to make them measurable requirements
    - We'd like to state them in a way that we can measure how well they've been met

Example NFRs

- **Interface requirements**
  - how will the new system interface with its environment?
    - User interfaces and "user-friendliness"
    - Interfaces with other systems
- **Performance requirements**
  - time/space bounds
    - workloads, response time, throughput and available storage space
    - e.g. "the system must handle 1,000 transactions per second"
  - reliability
    - the availability of components
    - integrity of information maintained and supplied to the system
    - e.g. "system must have less than 1hr downtime per three months"
  - security
    - E.g. permissible information flows, or who can do what
  - survivability
    - E.g. system will need to survive fire, natural catastrophes, etc
- **Operating requirements**
  - physical constraints (size, weight),
  - personnel availability & skill level
  - accessibility for maintenance
  - environmental conditions
  - etc
- **Lifecycle requirements**
  - "Future-proofing"
    - Maintainability
    - Enhanceability
    - Portability
    - expected market or product lifespan
  - limits on development
    - E.g development time limitations,
    - resource availability
    - methodological standards
    - etc.
- **Economic requirements**
  - e.g. restrictions on immediate and/or long-term costs.

Approaches to NFRs

- **Product vs. Process?**
  - Product-oriented Approaches
    - Focus on system (or software) quality
    - Aim is to have a way of measuring the product once it's built
  - Process-oriented Approaches
    - Focus on how NFRs can be used in the design process
    - Aim is to have a way of making appropriate design decisions
- **Quantitative vs. Qualitative?**
  - Quantitative Approaches
    - Find measurable scales for the quality attributes
    - Calculate degree to which a design meets the quality targets
  - Qualitative Approaches
    - Study various relationships between quality goals
    - Reason about trade-offs etc.

Software Qualities

- **Think of an everyday object**
  - e.g. a chair
  - How would you measure it's "quality"?
    - construction quality? (e.g. strength of the joints,…)
    - aesthetic value? (e.g. elegance,…)
    - fit for purpose? (e.g. comfortable,…)
- **All quality measures are relative**
  - there is no absolute scale
  - we can sometimes say A is better than B…
    - … but it is usually hard to say how much better!
- **For software:**
  - construction quality?
    - software is not manufactured
  - aesthetic value?
    - but most of the software is invisible
    - aesthetic value matters for the user interface, but is only a marginal concern
  - fit for purpose?
    - Need to understand the purpose

Fitness

Source: *Budgen, 1994, pp58-9*

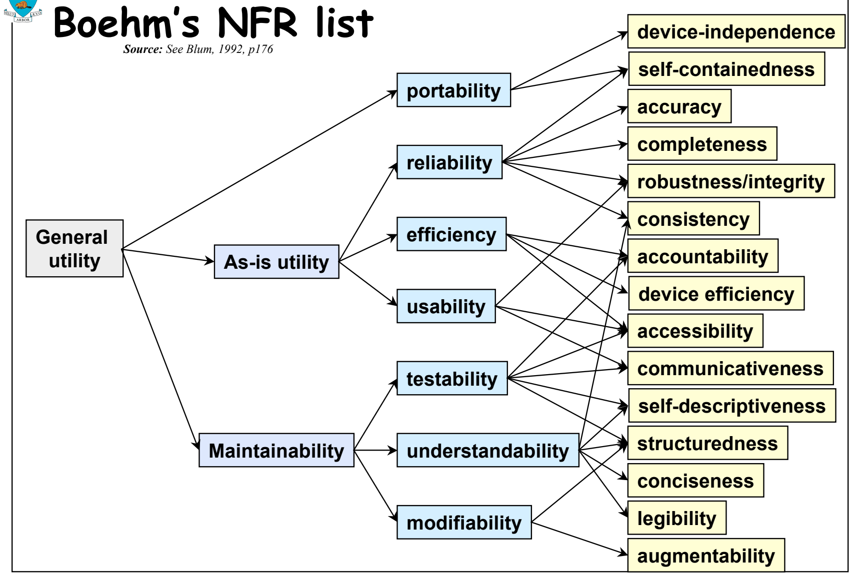
- **Software quality is all about fitness to purpose**
  - does it do what is needed?
  - does it do it in the way that its users need it to?
  - does it do it reliably enough? fast enough? safely enough? securely enough?
  - will it be affordable? will it be ready when its users need it?
  - can it be changed as the needs change?
- **Quality is not a measure of software in isolation**
  - it measures the relationship between software and its application domain
    - cannot measure this until you place the software into its environment…
    - …and the quality will be different in different environments!
  - during design, we need to *predict* how well the software will fit its purpose
    - we need good quality predictors (design analysis)
  - during requirements analysis, we need to *understand* how fitness-for-purpose will be measured
    - What is the intended purpose?
    - What quality factors will matter to the stakeholders?
    - How should those factors be operationalized?

Factors vs. Criteria

- **Quality Factors**
  - These are customer-related concerns
    - Examples: efficiency, integrity, reliability, correctness, survivability, usability,...
- **Design Criteria**
  - These are technical (development-oriented) concerns such as anomaly management, completeness, consistency, traceability, visibility,...
- **Quality Factors and Design Criteria are related:**
  - Each factor depends on a number of associated criteria:
    - E.g. correctness depends on completeness, consistency, traceability,...
    - E.g. verifiability depends on modularity, self-descriptiveness and simplicity
  - There are some standard mappings to help you…
- **During Analysis:**
  - Identify the relative importance of each quality factor
    - From the customer's point of view!
  - Identify the design criteria on which these factors depend
  - Make the requirements measurable

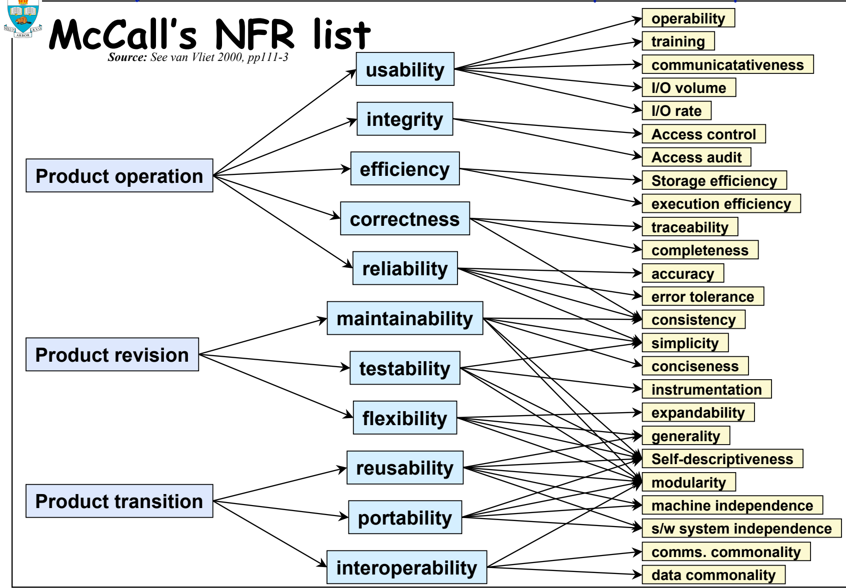
Boehm's NFR list

Source: *See Blum, 1992, p176*



McCall's NFR list

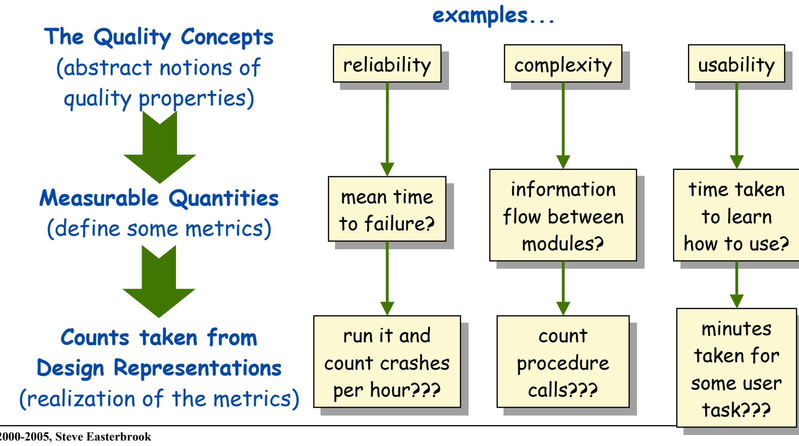
Source: See van Vliet 2000, pp111-3



Making Requirements Measurable

Source: Budgen, 1994, pp60-1

→ We have to turn our vague ideas about quality into measurables



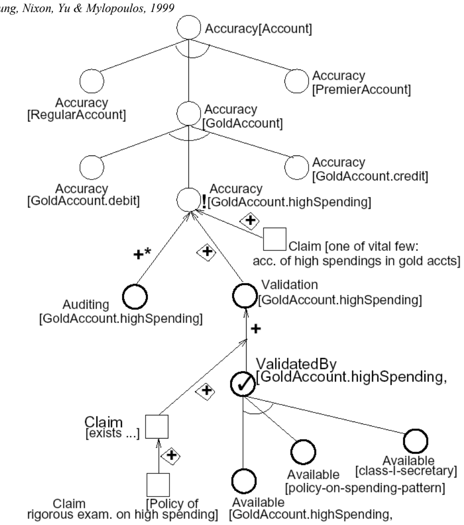
Making Requirements Measurable

- → Define 'fit criteria' for each requirement
  - ♦ Give the 'fit criteria' alongside the requirement
  - ♦ E.g. for new ATM software
    - ➢ Requirement: "The software shall be intuitive and self-explanatory"
    - ➢ Fit Criteria: "95% of existing bank customers shall be able to withdraw money and deposit cheques within two minutes of encountering the product for the first time"
- → Choosing good fit criteria
  - ♦ Stakeholders are rarely this specific
  - ♦ The right criteria might not be obvious:
    - ➢ Things that are easy to measure aren't necessarily what the stakeholders want
    - ➢ Standard metrics aren't necessary what stakeholders want
  - ♦ Stakeholders need to construct their own mappings from requirements to fit criteria

Softgoals: the NFR framework

Source: Chung, Nixon, Yu & Mylopoulos, 1999

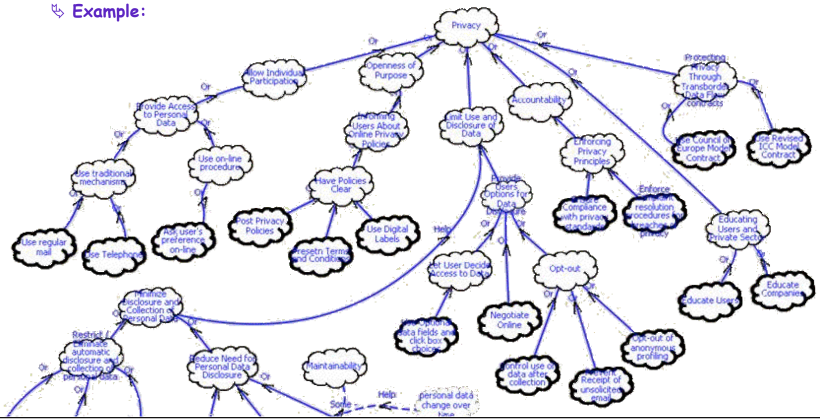
- → Goal types:
  - ♦ Non-functional Requirement
  - ♦ Satisficing Technique
    - ➢ e.g. a design choice
  - ♦ Claim
    - ➢ supporting/explaining a choice
- → Contribution Types:
  - ♦ AND links (decomposition)
  - ♦ OR links (alternatives)
  - ♦ Sup links (supports)
  - ♦ Sub links (necessary subgoal)
- → Evaluation of goals
  - ♦ Satisficed
  - ♦ Denied
  - ♦ Conflicting
  - ♦ Undetermined



NFR Catalogues

Source: Cysneiros & Yu, 2004

→ **Predefined catalogues of NFR decomposition**
- Provides a knowledge base to check coverage of an NFR
- Provides a tool for elicitation of NFRs
- Example:



Example: Reliability

→ **Definition**
- the ability of the system to behave consistently in a user-acceptable manner when operating within the environment for which it was intended.

→ **Comments:**
- Reliability can be defined in terms of a percentage (say, 99.999%)
- This may have different meaning for different applications:
  - Telephone network: the entire network can fail no more than, on average, 1hr per year, but failures of individual switches can occur much more frequently
  - Patient monitoring system: the system may fail for up to 1hr/year, but in those cases doctors/nurses should be alerted of the failure. More frequent failure of individual components is not acceptable.
- Best we can do may be something like:
  - "...No more than X bugs per 10KLOC may be detected during integration and testing; no more than Y bugs per 10KLOC may remain in the system after delivery, as calculated by the Monte Carlo seeding technique of appendix Z; the system must be 100% operational 99.9% of the calendar year during its first year of operation..."

Measuring Reliability…

→ **Example reliability requirement:**
- "The software shall have no more than X bugs per thousand lines of code"
- ...But how do we measure bugs at delivery time?

→ **Use bebugging**
- a number of seeded bugs are introduced to the software system, then testing is done and bugs are uncovered (seeded or otherwise)

$$\text{Number of bugs in system} = \frac{\text{\# of seeded bugs} \times \text{\# of detected bugs}}{\text{\# of detected seeded bugs}}$$

- ...BUT, not all bugs are equally important!

Other Reliability Metrics

→ **How to identify suitable metrics**
- Analyze the loss incurred by software system failure,
  - eg., destruction of the panet, destruction of a city, death of some people, injury to some people, major financial loss, major embarrassment, minor financial loss.
- Different metrics are more appropriate in different situations

→ **Example metrics**
- Probability of failure on demand.
  - measures the likelihood that the system will behave in an unexpected way when some demand is made of it. This is most relevant to safety-critical systems.
- Rate of Failure Occurrence (ROCOF).
  - measures the frequency of unexpected behaviour. For example, ROCOF=2/100 means that 2 failures are likely to occur within every 100 time units.
- Mean Time to Failure (MTTF)
  - Measures average interval between failures
- Availability
  - Measures the likelihood that the system will be available for use.
  - This is a good measure for applications such as telecommunications, where the repair/restart time is significant and the loss of service is important.