Lecture 22: Software Quality

Understanding Quality

Importance of Process Quality

- tools for improving process quality

Software Quality Attributes

Challenge Problem

Context

- You built some software
- You tested it
- You shipped it

But:

- Is it any good?
- How would you know?
- Can you do a better job next time?

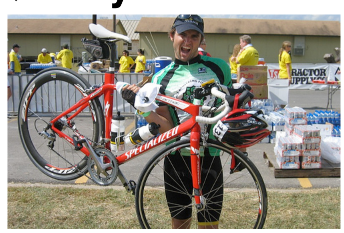
"Quality is value to some person"

"Quality is fitness to purpose"

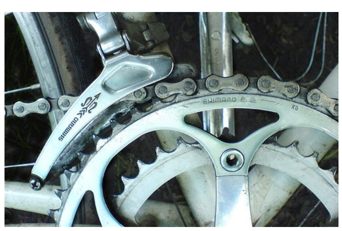
"Quality is exceeding the customer's expectations"

4 Views of Quality

Quality in Use
(What's the end-user's experience?)



External Quality Attributes
(Does it pass all the tests?)



Internal Quality Attributes
(Is it well-designed?)

Process Quality
(Is it assembled correctly?)

Importance of Process Quality

Cannot test-in software quality

- testing or inspection cannot improve the quality of a software product
  - (by that stage it is too late)

Defect removal

- Two ways to remove defects:
  - fix the defects in each product (i.e patch the product)
  - fix the process that leads to defects (i.e. prevent them occurring)
- The latter is cost effective as it affects all subsequent projects

Defect prevention (from Humphrey)

- Programmers must evaluate their own errors
- feedback is essential for defect prevention
- there is no single cure-all for defects (must eliminate causes one by one)
- process improvement must be an integral part of the process
- process improvement takes time to learn

Managing Quality (Background)

Source: *Adapted from Blum, 1992, p473-479. See also van Vliet, 1999, sections 6.3 and 6.6*

Industrial Engineering

- Product Inspection (1920s)
  - examine intermediate and final products to detect defects
- Process Control (1960s)
  - monitor defect rates to identify defective process elements & control the process
- Design Improvement (1980s)
  - engineering the process and the product to minimize the potential for defects

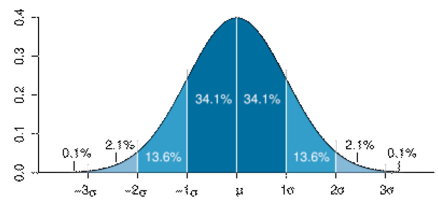
Deming and TQM

- Use statistical methods to analyze industrial production processes
- Identify causes of defects and eliminate them
- Basic principles are counter-intuitive:
  - in the event of a defect (sample product out of bounds)…
  - …don't adjust the controller or you'll make things worse.
  - Instead, analyze the process and improve it

Adapted to Software

- No variability among individual product instances
- All defects are design errors (no manufacturing errors)
- Process improvement principles still apply (to the design process!)

Six Sigma



Key ideas:

- Use statistics to measure defects
- Design the process to reduce defects

Origin of the term

- 99.999999% of all items are with ±6σ of the mean on a normal curve
- So a target of 6σ mean no more than 1 defective part per million
- In practice, must allow for ±1.5σ drift in the mean
- So we really only get ±4.5σ = 3.4 defective parts per million

For complex devices

- 100 parts: probability of a defective device is 0.0013
- 10,000 parts: probability of a defective device is 0.04 (I.e. 96% are okay….)
- ⇒ Design things to have fewer components
- ⇒ Control the manufacturing variability of the components

Counterpoint: 6 Sigma for Software?

Software processes are fuzzy

- Depend on human behaviour, not predictable

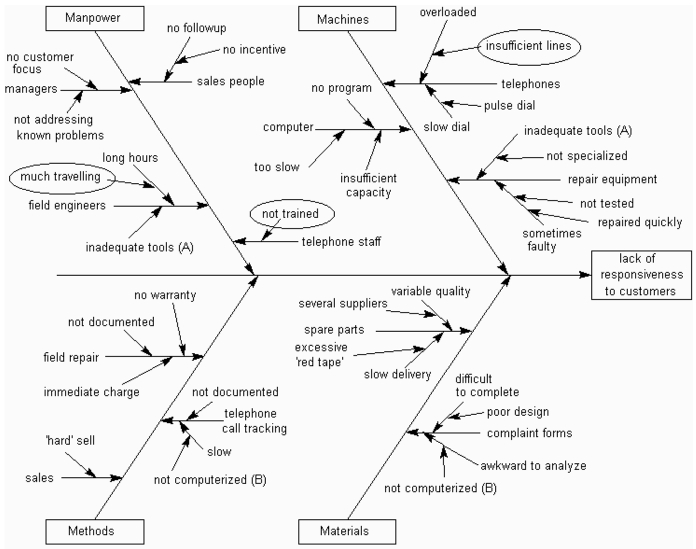
Software Characteristics are not ordinal

- Cannot measure degree of conformance for software
- Mapping between software faults and failures is many-to-many
- Not all software anomalies are faults
- Not all failure result from the software itself
- Cannot accurately measure the number of faults in software

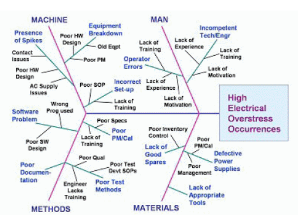
Typical defect rates

- NASA Space shuttle: 0.1 failures/KLOC (but it cost $1000 per line)
- Best military systems: 5 faults/KLOC
- Worst military systems: 55 faults/KLOC
- Six Sigma would demand 0.0034 faults/KLOC

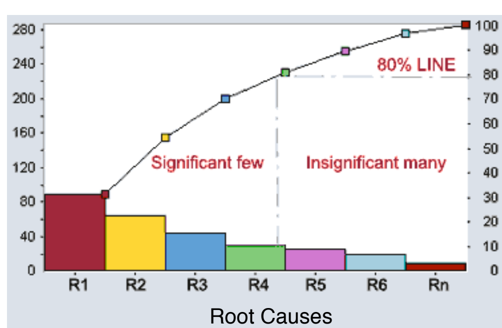
Ishikawa (Fishbone) Diagram



Pareto Chart



Measure frequency of each cause



"20% of the problem cause 80% of the defects"

Plot causes in order of frequency

Plot percentage contributions

Identify the top causes

Refresher: Capability Maturity Model

Source: *Adapted from Humphrey, 1989, chapter 1. See also van Vliet, 1999, section 6.6.*

Level	Characteristic	Key Challenges
5. Optimizing	Improvement fed back into process	Identify process indicators "Empower" individuals
4. Managed	(Quantitative) measured process	Automatic collection of process data Use process data to analyze and modify the process
3. Defined	(Qualitative) process defined and institutionalized	Process measurement Process analysis Quantitative Quality Plans
2. Repeatable	(Intuitive) process dependent on individuals	Establish a process group Identify a process architecture Introduce SE methods and tools
1. Initial	Ad hoc / Chaotic No cost estimation, planning, management.	Project Management Project Planning Configuration Mgmnt, Change Control Software Quality Assurance

Four Key Quality Concepts

Source: *Budgen, 1994, pp65-7*

Reliability

- designer must be able to predict how the system will behave:
  - completeness - does it do everything it is supposed to do? (e.g. handle all possible inputs)
  - consistency - does it always behave as expected? (e.g. repeatability)
  - robustness - does it behave well under abnormal conditions? (e.g. resource failure)

Efficiency

- Use of resources such as processor time, memory, network bandwidth
  - This is less important than reliability in most cases

Maintainability

- How easy will it be to modify in the future?
  - perfective, adaptive, corrective

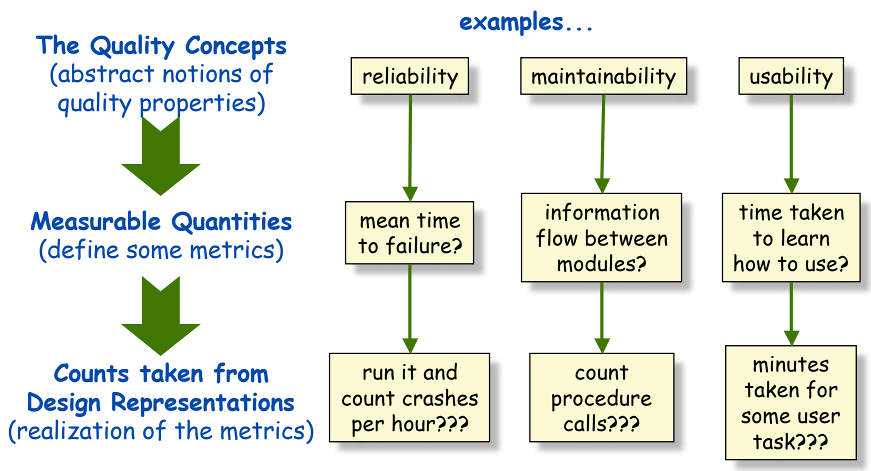
Usability

- How easy is it to use?

Measuring Quality

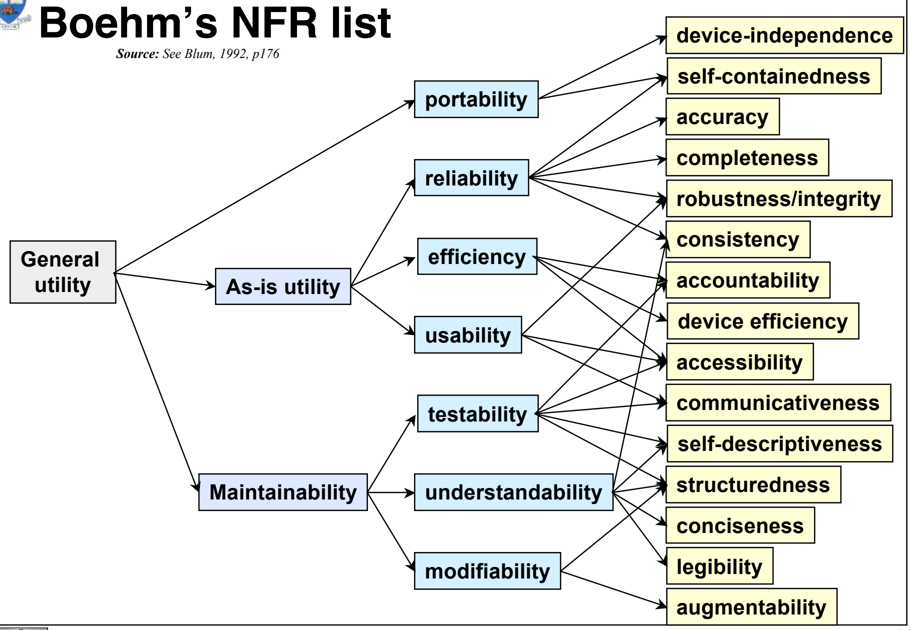
Source: *Budgen, 1994, pp60-1*

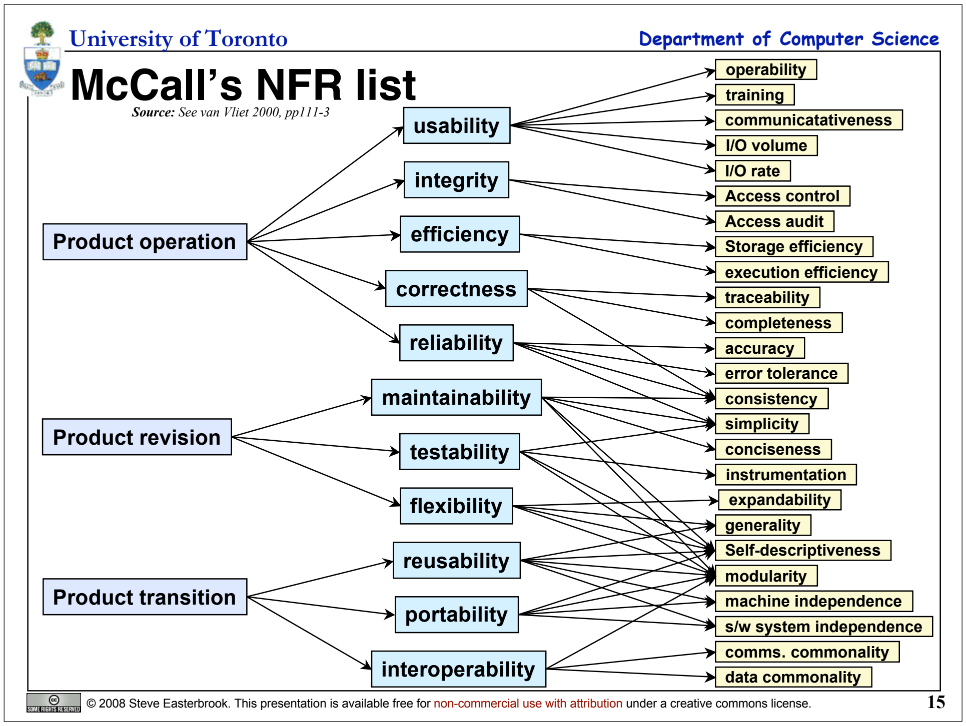
We have to turn our vague ideas about quality into measurables



Boehm's NFR list

Source: *See Blum, 1992, p176*




University of Toronto
Department of Computer Science
McCall's NFR list
Source: See van Vliet 2000, pp111-3
Product operation
Product revision
Product transition
usability
integrity
efficiency
correctness
reliability
maintainability
testability
flexibility
reusability
portability
interoperability
operability
training
communicativeness
I/O volume
I/O rate
Access control
Access audit
Storage efficiency
execution efficiency
traceability
completeness
accuracy
error tolerance
consistency
simplicity
conciseness
instrumentation
expandability
generality
Self-descriptiveness
modularity
machine independence
s/w system independence
comms. commonality
data commonality
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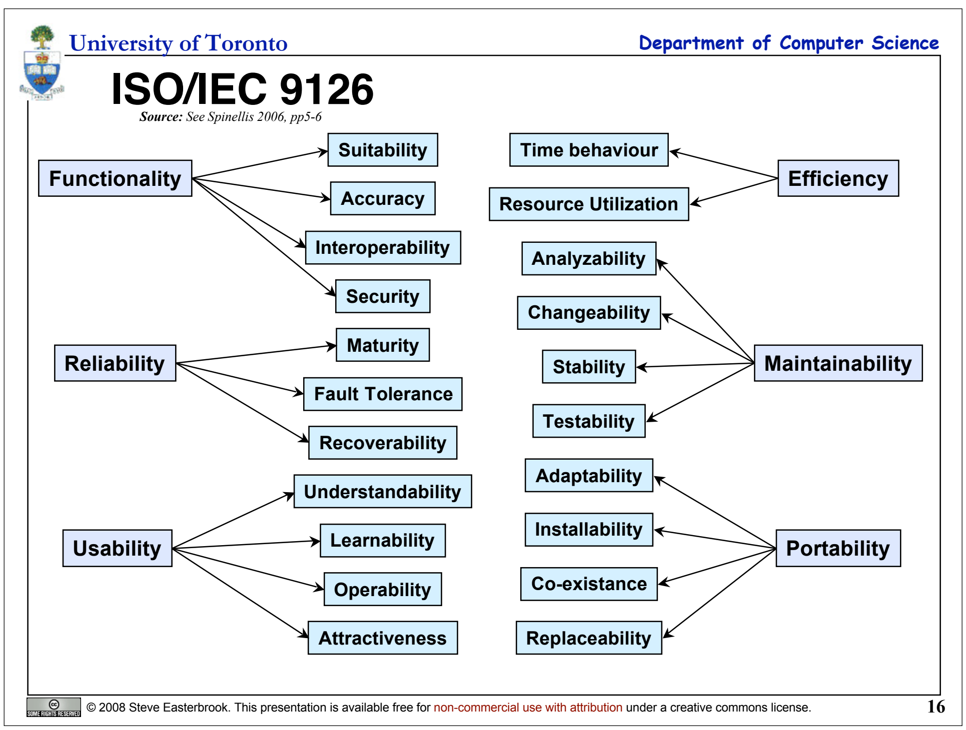
15


University of Toronto
Department of Computer Science
ISO/IEC 9126
Source: See Spinellis 2006, pp5-6
Functionality
Suitability
Accuracy
Interoperability
Security
Reliability
Maturity
Fault Tolerance
Recoverability
Usability
Understandability
Learnability
Operability
Attractiveness
Efficiency
Time behaviour
Resource Utilization
Maintainability
Analyzability
Changeability
Stability
Testability
Portability
Adaptability
Installability
Co-existance
Replaceability
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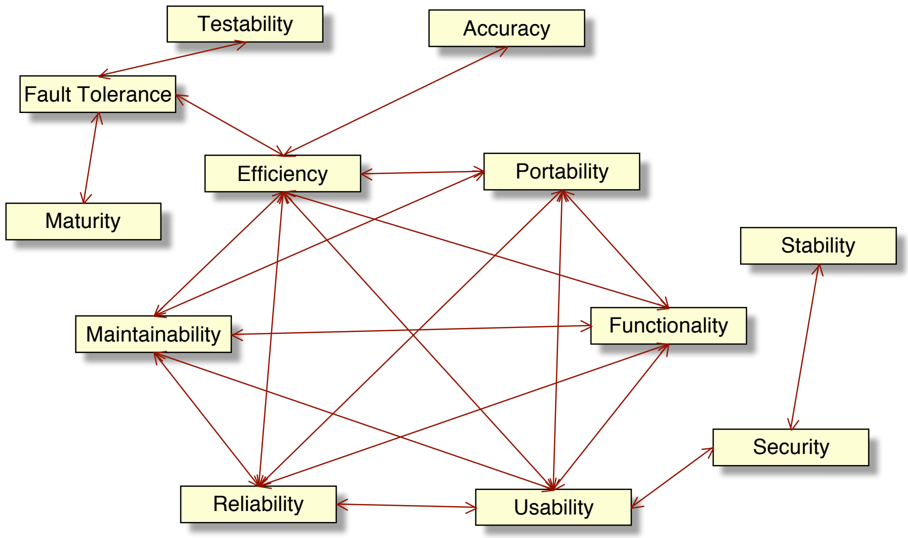
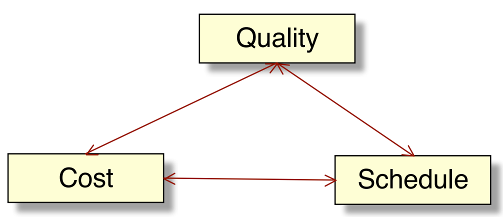
16

Conflicts between Quality factors



More abstractly…



"Better, Faster, Cheaper - pick any two"

Measurable Predictors of Quality

Source: *Budgen, 1994, pp68-74*

Simplicity

- the design meets its objectives and has no extra embellishments
- can be measured by looking for its converse, complexity:
  - control flow complexity (number of paths through the program)
  - information flow complexity (number of data items shared)
  - name space complexity (number of different identifiers and operators)

Modularity

- different concerns within the design have been separated
- can be measured by looking at:
  - cohesion (how well components of a module go together)
  - coupling (how much different modules have to communicate)

Wasserman's Steps to Maturity

Abstraction

- Allows you to focus on the essence of a problem

Analysis and Design methods and notations

- A shared language for expressing ideas about software

User Interface Prototyping

- Understand the user and evaluate the user's experience

Software Architecture

- Identify architectural styles and patterns

Software Process

- Identify appropriate processes and assess their effectiveness

Reuse

- Systematic ways to reuse past experience and products

Measurement

- Better metrics to understand and manage software development

Tools and Integrated Environments

- Automate mundane tasks, keep track of what we have done