Lecture 20:
Software Quality

Understanding Quality

Importance of Process Quality
    tools for improving process quality

Software Quality Attributes

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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?

Q1: What is Quality?

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"Quality is value to some person"

"Quality is fitness to purpose"

"Quality is exceeding the customer's expectations"

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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?)

Quality Assurance

V&V focuses on the quality of the product(s)

requirements, models, specifications, designs, code,…

QA focuses on the quality of the processes

How well are the processes documented?

How well do people follow these processes?

Does the organisation measure key quality indicators?

Does the organisation learn from its mistakes?

Examples:

ISO9001

TickIt

Capability Maturity Model (CMM)

Total Quality Management (TQM)

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Managing Quality (history)

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 and discard defective items

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: Total Quality Management

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.
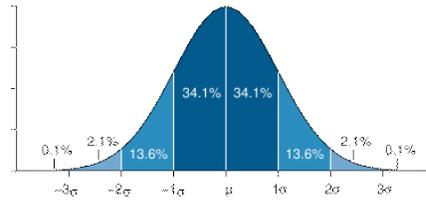
Instead, analyze the process and improve it

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Six Sigma

Key ideas:

Use statistics to measure defects

Design the process to reduce defects

Origin of the term

99.9999% 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 over the long term

So we really only get ±4.5σ = 3.4 defective parts per million
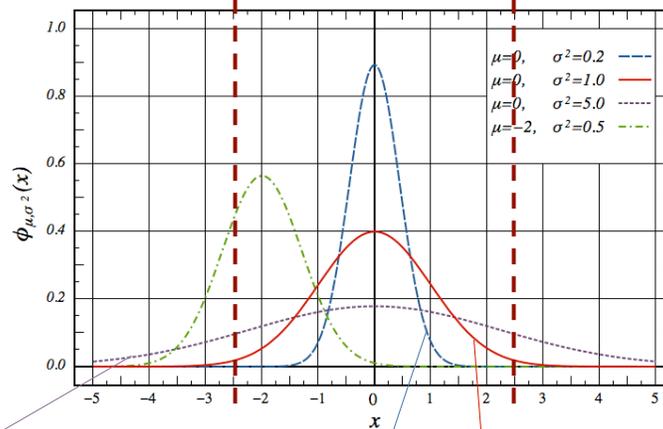
For complex devices

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**

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Explaining 6-sigma

Spec:

too little paint ← acceptable products → too much paint

$\mu=0, \quad \sigma^2=0.2$

$\mu=0, \quad \sigma^2=1.0$

$\mu=0, \quad \sigma^2=5.0$

$\mu=-2, \quad \sigma^2=0.5$

$\sigma = 2.24$ (32% will be defective)

$\sigma = 1$ (2% will be defective)

$\sigma = 0.45$ (0.0001% will be defective)

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Applying This to Software

Quality Management for Software

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

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

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Process Modeling & improvement

Process Description
    understand and describe current practices

Process Definition
    Prescribe a process that reflects the organization's goals
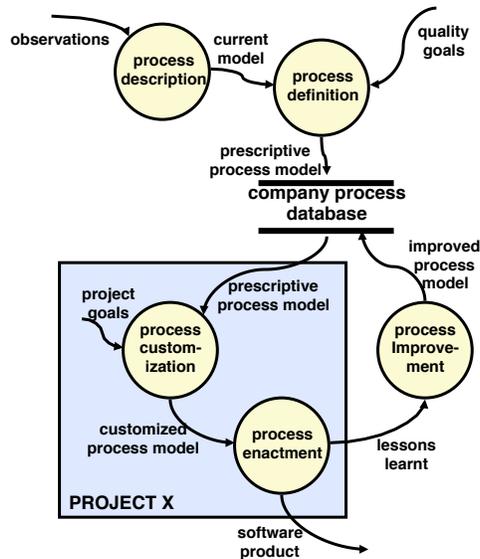
Process customization
    adapt the prescribed process model for each individual project

Process enactment
    Carry out the process
    (develop the software!)
    collect process data

Process improvement
    use lessons learnt from each project to improve the prescriptive model
    analyze defects to eliminate causes

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e.g. Capability Maturity Model (CMM)

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

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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 failures 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 (?)

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Arguments against QA

Costs <u>may</u> outweigh the benefits

> Costs: Increased documentation; more meetings; …
>
> Benefits: Improved quality of the process outputs (better software?)

Reduced "agility"

> Documenting the processes makes them less flexible

Reduced "thinking"

> Following the defined process gets in the way of thinking about the best way to do the job

Barrier to Innovation

> New ideas have to be incorporated into the Quality Plan and get signed off

Demotivation

> Extra bureaucracy makes people frustrated

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