Introduction to Software Testing Maintenance & Evolution Overview

Software Testing & Maintenance

SWE 437

http://go.gmu.edu/swe437

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(Dr. B for short)

Software Maintenance

"When the transition from development to evolution is not seamless, the process of changing the software after delivery is often called *software maintenance*."

Sommerville, 2004

Modifying a program *after it has been put into use*

Maintenance **does not normally involve major changes** to software architecture

Changes are implemented by *modifying existing components and adding new components* to the system

Maintenance **requires program understanding**

Why is maintenance important?

Organizations have **huge investments** in their software systems – they are critical business assets

To maintain the value of these assets to the business, they must be **changed** and **updated**

Large portion of software budget in large companies goes to modifying existing software

Also, software change is inevitable

We cannot avoid changing software

- *new requirements* emerge when software is used
- The business *environment changes*
- *Faults* must be repaired
- New *computers and equipment* is added to the system
- The *performance* or *reliability* may have to be improved

Software is **tightly coupled** with the environment.

A key problem for organizations is implementing and managing change to their existing software.

Management myths

Myth: We already have a book that's full of standards and procedures for building software, won't that provide my people with everything they need to know?

Reality:

- Book of standards may exist, but is it used?
- Are software practitioners aware of its existence?
- Does it reflect modern SE practice?
- Is it complete?
- Is it streamlined to improve time to delivery while still maintaining focus on quality?

Management myths

Myth: If we get behind schedule, we can add more programmers and catch up

Reality: Software development is not a mechanistic process like manufacturing. As Brooks said: "adding people to a late software project makes it later"

Myth: If I decide to outsource the software project to a third party, I can just relax and let them build it.

Reality: If an organization does not understand how to manage and control software projects internally, it won't be able to outsource effectively.

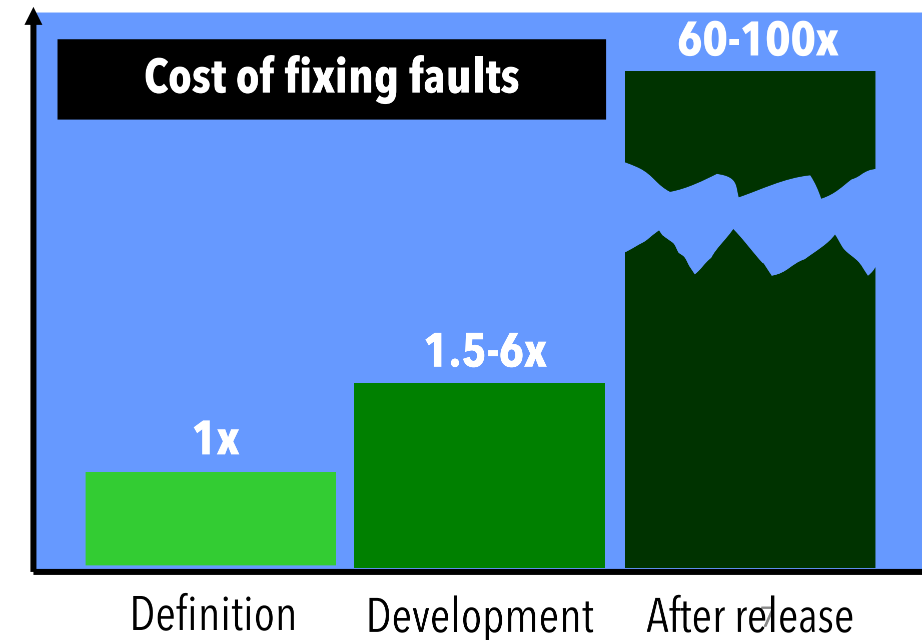
Customer myths

Myth: A general statement of objectives is enough to start writing programs – we can fill in the details later.

Reality: A poor upfront definition is the major cause of failed software efforts. If you don't know what you want at the beginning, you won't get it.

Myth: Project requirements continually change, but change can be easily accommodated because software is flexible.

Reality: It is true that software requirements change, but the impact of change varies with the time at which it is introduced.



Practitioner myths

Myth: Once we write the program and get it to work, our job is done.

Reality: Someone once said that "the sooner you begin 'writing code', the longer it'll take you to get done." Industry data indicate that 60-80% of all effort expended on software will expended after it is delivered to the customer.

Practitioner myths

Myth: Until I get the program "running" I have no way to assess its quality

Reality: One of the most effective software quality assurance mechanisms can be applied from the inception of a project – the formal technical review. Software reviews are more effective than testing for finding certain classes of software defects.

Myth: Software engineering will make us create voluminous and unnecessary documentation and will always slow us down

Reality: Software engineering is not about creating documents. It is about creating quality. Better quality leads to reduced rework. And reduced rework results in faster delivery times.

What makes maintenance hard?

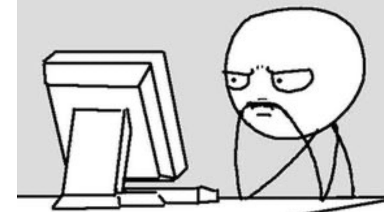
Most computer systems are **difficult and expensive** to maintain

Software **changes are poorly designed** and implemented

The repair and enhancement of software often **injects new faults** that must be repaired.

99 little bugs in the code,
99 little bugs.

Take one down, patch it around...
127 little bugs in the code!



Maintenance costs

Usually **greater than development costs** (2 – 100 times depending on the application)

Affected by both **technical and non-technical** factors

Increases as software evolves

Maintenance corrupts the software structure, making further maintenance more difficult

Aging software can have **high support costs** (old languages, compilers, etc.)

Maintenance cost factors

Team stability

Maintenance costs are lower if the same staff stay involved

Contractual responsibility

If the developers of a system are not responsible for maintenance, there is no incentive to design for future change

Staff skills

Maintenance staff are often inexperienced and don't have much domain knowledge

Program age and structure

As programs age, changes degrade the code, design, and structure and they become harder to understand and change

Additional maintenance terms

Maintainability: The ease with which software can be modified

Impact analysis: Understanding how changes in one software component can impact other components

Ripple effect: How changes transfer through the system, primarily through data and control flow connections

Traceability: The degree to which a relationship can be established between two or more software artifacts

Legacy systems: A software system that is still in use but the development team is no longer active

I'm sorry to say, but...

Much of the previous data comes from publications in the 1990s…

Based on knowledge from the 1980s…

When our software was "single-building size"!

How **out of date** is this information for building software of today??

VERY!!

Updated expectations

IEEE 1012-2016

IEEE Standard for System, Software, and Hardware Verification and Validation

Purchase

Access via Subscription

Active Standard

Verification and validation (V&V) processes are used to determine whether the development products of a given activity conform to the requirements of that activity and whether the product satisfies its intended use and user needs. V&V life cycle process requirements are specified for different integrity levels. The scope of V&V processes encompasses systems, software, and hardware, and it includes their interfaces. This standard applies to systems, software, and hardware being developed, maintained, or reused (legacy, commercial off-the-shelf [COTS], non-developmental items). The term software also includes firmware and microcode, and each of the terms system, software, and hardware includes documentation. V&V processes include the analysis, evaluation, review, inspection, assessment, and testing of products.

https://standards.ieee.org/ieee/1012/5609/

published in 2017

Getting in our own way

When considering the goal of **software maintainability**, it's important to not let **overconfidence** lead to **overengineering**.

Elegant, **well-designed** systems are easy to maintain.

Large, **unnecessarily complex systems** are not.

Maintenance vs. Evolution

Software **Maintenance**

Activities required to keep a software system operational after it is deployed

Software **Evolution**

Continuous changes from a lesser, simpler, or worse system to a higher or better system

Software evolution

"Software development does not stop when a system is delivered but continues throughout the lifetime of the system"

Sommerville, 2004

The system changes related to **changing needs** – business and user

The system **evolves continuously** throughout its lifetime

Modern agile processes emphasize getting a few (core) functionalities running, then adding new behaviors over time.

Lehman's Laws of Software Evolution

1. Law of **Continuing Change** (1974)

   Software that is used in a real-world environment *must change or become less and less useful* in that environment

2. Law of **Increasing Complexity** (1974)

   As evolving program changes, its *structure becomes more complex*, unless active efforts are made the avoid this phenomenon

3. Law of **Self Regulation** (1974)

   Program evolution is a *self-regulating* process. System attributes such as size, time between releases, and the number of reported errors are *approximately invariant* for each system release

Lehman's Laws of Software Evolution

4. Law of **Conservation of Organizational Stability** (1980)

   Over a program's lifetime, its *rate of development is approximately constant* and independent of the resources devoted to system development

5. Law of **Conservation of Familiarity** (1980)

   Over the lifetime of a system, the *incremental system change* in each release is *approximately constant*

6. The Law of **Continuing Growth** (1980)

   The functionality offered by systems has to continually increase to *maintain user satisfaction*

Lehman's Laws of Software Evolution

7. The Law of **Declining Quality** (1996)

    The quality of systems will appear to be declining unless they are *adapted to changes* in their operational environment

8. The **Feedback System Law** (1996)

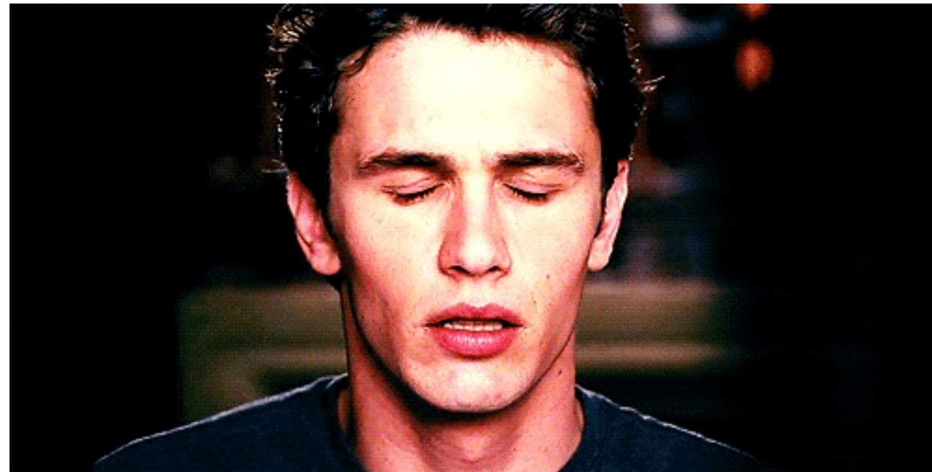
    Evolution processes incorporate *multi-agent, multi-loop feedback systems* and you have to treat them as feedback systems to *achieve significant product improvement*

    .

The pace of change is increasing

Hardware advances leads to **new, bigger software**

The **rate of change** (that is, new features) is **increasing**



How can we deal with the spiraling need to handle change??