

CPSC 461

## Software Engineering Techniques

Ch.1 Software and Software Engineering

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## Ch.1 Software and Software Engineering

A framework for those who build computer software – people who must get it right

The framework encompasses a process, a set of methods, and an array of tools – software engineering

## Principles of Learning

- 5W1H
  - What
  - When
  - Where
  - Who
  - Why
  - How

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## What Is Software?

- **Computer software** is the product that software professionals design and build.
- It encompasses
  - Programs
  - Content
  - Documents

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## Who Does It?

- **Software engineers build it.**
- **Virtually everyone in the industrialized world uses it either directly or indirectly.**

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## Why Is It Important?

- Software affects **nearly every aspect of our lives.**

## What Are The Steps?

- You build software like you build any successful product, by applying a **process** that leads to a high-quality result.
- You apply a **software engineering** approach.

## What Is the Work Product?

- From the point of view of a **software engineer**, the work product is the **programs, documents, and content (data).**
- From the **user's** viewpoint, the work product is the **resultant information** that somehow makes the user's world better.

## The Product

- **Software** is the **engine** that drives business decision making.
- **Software** serves as the **basis** for modern scientific investigation and engineering problem solving.
- It is **embedded in systems of all kinds:** transportation, medical, telecommunications, military, industrial processes, entertainment, office products ...

## The Evolving Role of Software

- Software takes on a **dual role:**
  - A **product**
    - Delivers the computing potential embodied by computer hardware
  - The **vehicle** for delivering a product
    - Acts as the basis for the control of the computer (OS), the communication of information (networks), and the creation and control of other programs (software tools and environments)
    - The most important product: **Information**

## Evolution of Software

- **Software development** was **virtually unmanaged** - until schedules slipped or costs began to escalate.

## Software Maintenance

- As the number of computer-based systems grew, libraries of computer software began to **expand**.
- Most of software had to be
  - **corrected** when faults were detected,
  - **modified** as user requirements changed, or
  - **adapted** to new hardware that was purchased.

## Software Crisis

- Effort spent on **software maintenance** escalated **high**.
- Worse yet, the personalized nature of many programs made them virtually **unmaintainable**.

## Software-Related Problems

- **Hardware** advances continue to **outpace** our ability to build **software** to tap hardware's potential.
- Our ability to build new programs **cannot** keep pace with the demand for new programs, **nor** can we build programs rapidly enough to meet business and market needs.

## Software-Related Problems

- The widespread use of computers has made society increasingly dependent on reliable operation of software.
  - **Enormous economic damage and potential human suffering can occur when software fails.**
- We struggle to **build computer software that has high reliability and quality.**
- Our ability to support and enhance existing programs is **threatened by poor design and inadequate resources.**

## An Industry Perspective

- **In the early days** of computing, computer-based systems were developed using **hardware-oriented management**.
  - Project managers focused on **hardware**.
  - Project managers applied the controls, methods, and tools that we recognize as **hardware engineering**.

## In the early days ...

- **In the early days**, programming was viewed as an **"art form."**
- The programmer often learned his/her craft by trial and error.
- The software world was **virtually undisciplined**.

## Today ...

- Today, the distribution of costs for the development of computer-based systems has changed dramatically.
- **Software**, rather than hardware, is the largest single cost item.

## Questions

- For almost two decades **managers and many technical practitioners** have asked the following **questions**:
  - Why does it take so **long** to get programs finished ?
  - Why are development costs so **high** ?
  - Why can't we find all **errors** before we give the software to our customers?
  - Why do we continue to have **difficulty in measuring progress** as software is being developed.

## An Aging Software Plant

- Like the other industry, **we have an aging "software plant"** - there are thousands of critical software-based applications that are **in dramatic need of refurbishing**.

## Example: An Aging Software Plant Information System

- Information system applications **written twenty years ago** that have undergone many changes and are **now virtually unmanintainable**.
- Even the smallest modification can cause the entire system to fail.

## Example: An Aging Software Plant Engineering Applications

- Engineering applications that are used to produce critical design data, and yet, **because of their age and state of repair, no one really understands their internal structure**.

## Software Competitiveness

- **Software** is now an extremely **competitive business**.
- **Cost, timeliness, and quality** are **primary drivers** that will lead to **intense competition** for software work over the next few decades.

## Software Competitiveness

- Feigenbaum and McCorduck [1983]
  - "Knowledge is power, and the computer is an amplifier of that power ..."

## Software

- Software is
  - (1) instructions (computer programs) that when executed provide desired function and performance, (2) data (contents) that enable the programs to adequately manipulate information, and (3) documents that describe the operation and use of the programs.

## Software Characteristics

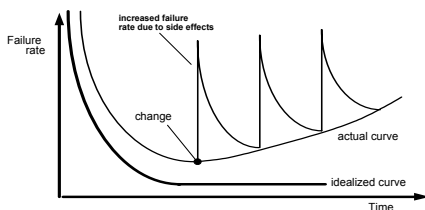
- To gain an understanding of SW, it is important to examine the characteristics of software that make it different from other things that human being built.
- When hardware is built, the human creative process (analysis, design, construction, testing) is ultimately translated into a physical form.
- Software is a logical rather than a physical system element.
- Therefore, software has characteristics that differ considerably from those of hardware:

## Software Characteristics

- Software is developed or engineered, it is not manufactured in the classical sense.
- Software does not wear out.
  - Figure 1.1 Failure curve for hardware
  - Figure 1.2 Failure curve for software (idealized and actual curves)
- Most software is custom-built, rather than being assembled from existing components.

## Software Characteristics

- Figure 1.2 Failure curve for software (idealized and actual curves)



## Software Components

- In the hardware world, component reuse is a natural part of the engineering process.
- In the software world, it is something that has yet to be achieved on a broad scale.
- Reusability is an important characteristic of a high-quality software component.
- A software component should be designed and implemented so that it can be reused in many different programs.

## Software Components

- In the 1960s, we built **scientific subroutine libraries** that were **reusable** in a broad array of engineering and scientific applications.
- These subroutine libraries reused well-defined algorithms in an effective manner, but had a **limited domain** of application.
- Today, we have extended our view of reuse to encompass not only **algorithms**, but also **data structures**.

## Software Components

- Modern **reusable components** encapsulate both **data** and the **processing** that is applied to the data, enabling the software engineer to **create new applications from reusable parts**.

## Examples: Software Components

- **Interactive interfaces** are built using **reusable components** that enable the creation of graphics windows, pull-down menus and a wide variety of interaction mechanisms.
- The data structures and processing detail required to build the interface are contained within a library of **reusable components** for interface construction.

## Software Applications

- Software may be applied in any situation for which a **pre-specified set of procedural steps (i.e., an algorithm)** has been defined.

## Information Content

- **Information content** and **determinacy** are important factors in determining **the nature of a software application**.
- **Information content** refers to the **meaning and form of incoming and outgoing information**.

## Example: Information Contents

- Many business application make use of highly **structured input data** (a database) and produce **formatted "reports"**.
- Software that **controls an automated machine** (e.g., a numerical control) accepts discrete data items with limited structure and produces **individual machine commands in rapid succession**.

## Information Determinacy

- **Information determinacy** refers to the predictability of the order and timing of information.

## Examples: Information Determinacy

- An engineering analysis program accepts data that have a predefined order, executes the analysis algorithm(s) without interruption, and produces resultant data in report or graphical format.

## Examples: Information Determinacy

- Example for the **indeterminate** application
- A multi-user OS accepts inputs that have varied content and arbitrary timing, executes algorithms that can be interrupted by external conditions, and produces output that varies as a function of environment and time.

## The Change Nature of SW Seven Broad Categories of SW

- System software
- Application software
- Engineering and scientific software
- Embedded software
- Product-line software
- Web-applications
- Artificial intelligence software

## The Change Nature of SW New Challenges

- Ubiquitous computing
- Netsourcing
- Opensource
- The "new economy"

## Software: A Crisis on the Horizon

- The term "**software crisis**" alludes to a set of problems that are encountered in the development of computer software.
  - The problems are **not limited to software that does not function properly.**
  - Rather, the affliction encompasses problems associated with how we develop software, how we maintain a growing volume of existing software, and how we can expect to keep pace with a growing demand for more software.

## Quality of Legacy Software

- Poor quality
  - Legacy systems sometimes have inextensible designs, convoluted code, poor or nonexistent documentation, test cases and results that were never achieved, a poorly managed change history, and etc.
  - An yet, these systems support core business functions and are indispensable to the business.
  - Nothing can be done until the legacy system must undergo some significant change.

## Software Evolution

- Regardless of its application domain, size, or complexity, computer software will evolve over time.
- Change (software maintenance) drives this process and occurs when errors are corrected, when the software is adapted to a new environment, when the customer requests new features or functions, and when the application is reengineered to provide benefit in a modern context.

## Software Evolution

A Unified Theory for SW Evolution [Lehman 1997]

- The Law of Continuing Change
- The Law of Increasing Complexity
- The Law of Self-Regulation
- The Law of Conservation of Organizational Stability
- The Law of Conservation of Familiarity
- The Law of Continuing Growth
- The Law of Declining Quality
- The Feedback System Law

## Software Myths

- Unlike ancient myths, **software myths propagates misinformation and confusion** that have caused serious problems for managers, technical people, and customers.

## 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
  - The book of standards may very well exist, but is it used? **Is it complete?** In many cases, the answer is **no**.

## Customer Myths

- Myth
  - Project requirements continually change, but **change can be easily accommodated** because software is flexible.
- Reality
  - It is true that software requirements do change, but **the impact of change varies with the time** at which it is introduced.



## Practitioner's Myths

- Myth
  - Once we write the program and get it to work, our job is **done**.
- Reality
  - "The sooner you begin writing code, the longer it'll take you to get done."
  - Industry data indicate that between 60 and 80 percent of all effort expended on software will be expended after it is delivered to the customer for the first time.

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## Summary

- **Software** has become the key element in the evolution of computer-based systems and products.
- **Software** is composed of programs, data (contents), and documents.
  - Each of these items comprises a configuration that is created as part of the software engineering process.

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## Summary

- Software has evolved from a specialized problem-solving and information analysis tool to an industry in itself.
- Yet we still have **trouble** developing high-quality SW on time and within budget.
  - Early programming culture and history have **created a set of problems** that persist today.

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## Summary

- The intent of **software engineering** is to provide a framework for building software with higher quality.

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## Stanzas To The Po

Time may have somewhat tamed them, - not for ever;  
Thou overflow'st thy banks, and not for aye  
Thy bosom overbills, congenial river!  
Thy floods subside, and mine have sunk away;  
But left long wrecks behind, and now again,  
Borne on our old unchanged career, we move;  
Thou tendest wildly onwards to the main,  
And I - to loving one I should not love.

George Gordon Byron (1788-1824)

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