



Software Engineering

Introduction

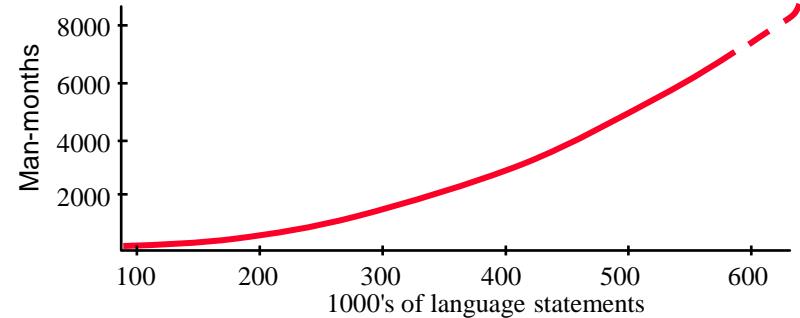


LEARNING OBJECTIVES

1. Appreciate that developing large software systems is a complex process.
2. Know some techniques for dealing with the complexity of software development.
3. Understand what is software engineering and why it is important in software development.

SOFTWARE IS COMPLEX TO DEVELOP

- Rome: Total War: 3 MLOC
- Boeing 787: 14 MLOC
- F-35 Fighter Jet: 24 MLOC
- Windows 7: ~40MLOC
- Windows 10: ~50 MLOC
- Facebook: 61 MLOC
- Mac OS X: ~90 MLOC
- Luxury passenger car: 100 MLOC



Development effort is not linear with respect to amount of code!

☞ **Software evolution (maintenance) is also complex and usually takes up the majority of the time of software developers.**

Source: <http://www.informationisbeautiful.net/visualizations/million-lines-of-code/>

SOFTWARE COMPLEXITY COMES FROM ...

- **Application domain**
 - The problems are often *very complex*.
 - The developers are usually *not domain experts*.
- **Communication among stakeholders (clients, developers)**
 - The stakeholders use different vocabulary:
domain experts ⇔ developers ⇔ developers.
 - The stakeholders have different background knowledge.
 - Human languages are inherently ambiguous.
- **Management of large software development projects**
 - Need to divide the project into pieces and reassemble the pieces.
 - Need to coordinate *many different parts* and *many different people*.
- **Coding software**
 - Creating useful software is a *complicated engineering process*.

SOFTWARE COMPLEXITY LEADS TO ...

1. Software quality problems

- unreliable → ARIANE 5 rocket
- unsafe → London Ambulance
- abandoned → London Stock Exchange
- inflexible → hard to change/maintain

For **large** software projects:

- 17% company threatening
- 45% over budget
- 7% over time
- 56% deliver less value

Source: McKinsey & Company in conjunction with the University of Oxford (2012).

2. Software development problems

- Over schedule and over budget *by an order of magnitude!*
- Does not meet user requirements.
- Development of *working code* is slower than expected.
- Progress is *difficult to measure*.

DEALING WITH COMPLEXITY: DESIGN GOALS

There are many desirable software quality characteristics:

correct	efficient	evolvable	interoperable	maintainable
portable	productive	reliable	repairable	reusable
robust	timely	usable	verifiable	visible

It is often impossible (or unnecessary) to achieve all of them simultaneously (time / cost / conflicting / not important).

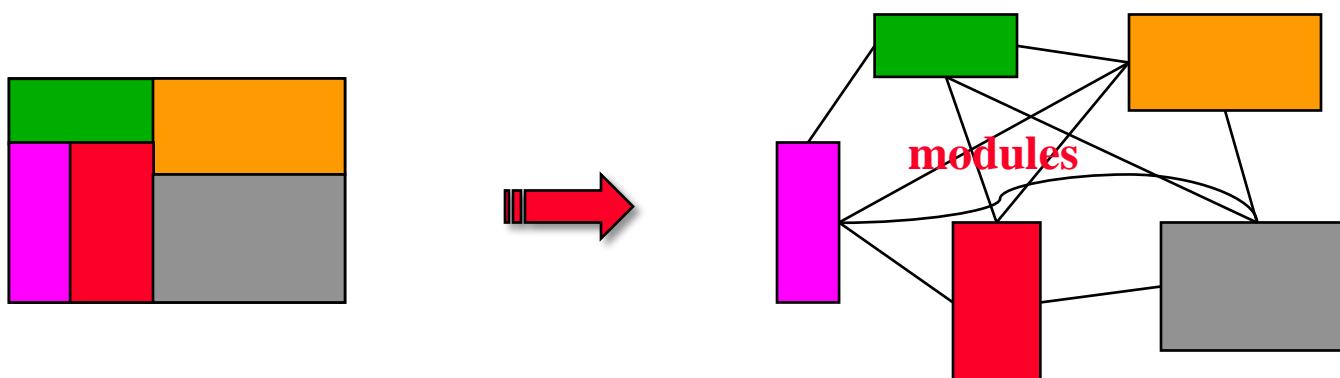
- ☞ Need to clearly understand the client's design goals!
- ☞ Need to prioritize the design goals (qualities) for a given project and base the development around these.

Having clear design goals reduces the complexity of designing the system!

DEALING WITH COMPLEXITY: MODULAR & INCREMENTAL DEVELOPMENT

There is a limit to human understanding.

DIVIDE AND CONQUER



module: A part of a system that it makes sense to consider separately.

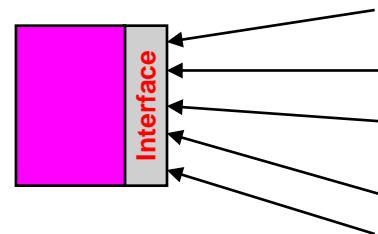
 **BUT** modules need to interact with each other.

DEALING WITH COMPLEXITY: MODULAR & INCREMENTAL DEVELOPMENT (cont'd)

There is a limit to human understanding.

USE INFORMATION HIDING

- 👉 Allow modules to interact *only* via interfaces.



- 👉 An interface abstracts and encapsulates a module thereby providing information hiding.

DEALING WITH COMPLEXITY: MODULAR & INCREMENTAL DEVELOPMENT (cont'd)

- An interface **abstracts** a module so the developer does not have to know how the module is implemented to use it.

☞ A module can be used by understanding **only its interface**.

This reduces the complexity of understanding the system!

- An interface **encapsulates** a module so the developer cannot use knowledge about how the module is implemented.

☞ A module can be changed (internally) without affecting the rest of the system.

This reduces the complexity of maintaining the system!

DEALING WITH COMPLEXITY: MODULAR & INCREMENTAL DEVELOPMENT (cont'd)

- Modular and incremental development using interfaces allows for:
 - more productivity in team development
 - fewer bugs in system development
 - more maintainable software
 - more reusable software
- resulting in more predictable software development.

This reduces the complexity of
cost and time estimates
for developing the system!

DEALING WITH COMPLEXITY: TRAINING SOFTWARE ENGINEERS

What do engineers do?

DEALING WITH COMPLEXITY: TRAINING SOFTWARE ENGINEERS

“programming-in-the-small” → **coding**

“programming-in-the-large” → **software engineering**

A software engineer needs to be able to:

- talk with users in terms of the application.
- translate vague requirements into precise specifications.
- build models of a system at different levels of abstraction.
- use and apply several software development processes.
- choose among design alternatives (i.e., make design tradeoffs).
- work in well-defined roles as part of a team.

This reduces the complexity of building the system!

WHAT IS SOFTWARE ENGINEERING ANYWAY?



I'm Chris

SOFTWARE ENGINEERING IS ...

“The establishment and use of sound **engineering principles** in order to obtain **economically** software that is **reliable** and works **efficiently** on **real machines**.”

— Fritz Bauer

“... **multi-person** construction of **multi-version** software.”

— Dave Parnas

- engineering principles → It is a disciplined development effort.
- economically...reliable...efficiently → It has built-in quality.
- real machines → It solves a real user problem (implied).
- multi-person → It requires a team effort.
- multi-version → It is not a “one-time” development effort.

SOFTWARE ENGINEERING INVOLVES ...

- **A modeling activity**
 - **requirements model** → models the **user requirements**
 - **solution model** → models the **system to be built**
- **A problem solving activity**
 - We search for an appropriate solution ***in the presence of change***.
 - Therefore, it is **not algorithmic**, but it should be **systematic**.
- **A knowledge acquisition activity**
 - Not a linear process → learn as you go, but ***may need to unlearn***.
 - Sometimes, you may even ***need to start over!***
- **A rationale management activity**
 - Our **assumptions** and **solutions** change → bugs, technology, etc.
 - Thus, we may **need to revisit decisions**.
 - Important to remember: ***Why did we make this choice?***

Need to
match!

INTRODUCTION: SUMMARY

- Dealing with **software development complexity** requires:
 - having appropriate design goals.
 - using modular and incremental development techniques.
 - using effective software engineering techniques.
- From a technical viewpoint, **software development** consists of:
 - **software engineering** (i.e., modeling and documenting system requirements and solutions—“**programming-in-the-large - **coding** (i.e., building the system—“**programming-in-the-small****

While coding is an important software development activity,
software engineering is **ESSENTIAL to help reduce complexity**
and **build high quality, more maintainable software systems!**

COMP 3111 SYLLABUS

- ✓ 1. **Introduction**
- 2. Modeling Software Systems using UML
- 3. Software Development
- 4. System Requirements Capture
- 5. Implementation
- 6. Testing
- 7. System Analysis and Design
- 8. Software Quality Assurance
- 9. Managing Software Development