UNIVERSITÄT BERN

Introduction to Software Engineering (ESE : Einführung in SE)

1. Introduction — The Software Lifecycle

Prof. O. Nierstrasz

Herbstsemester 2010

ESE — Introduction

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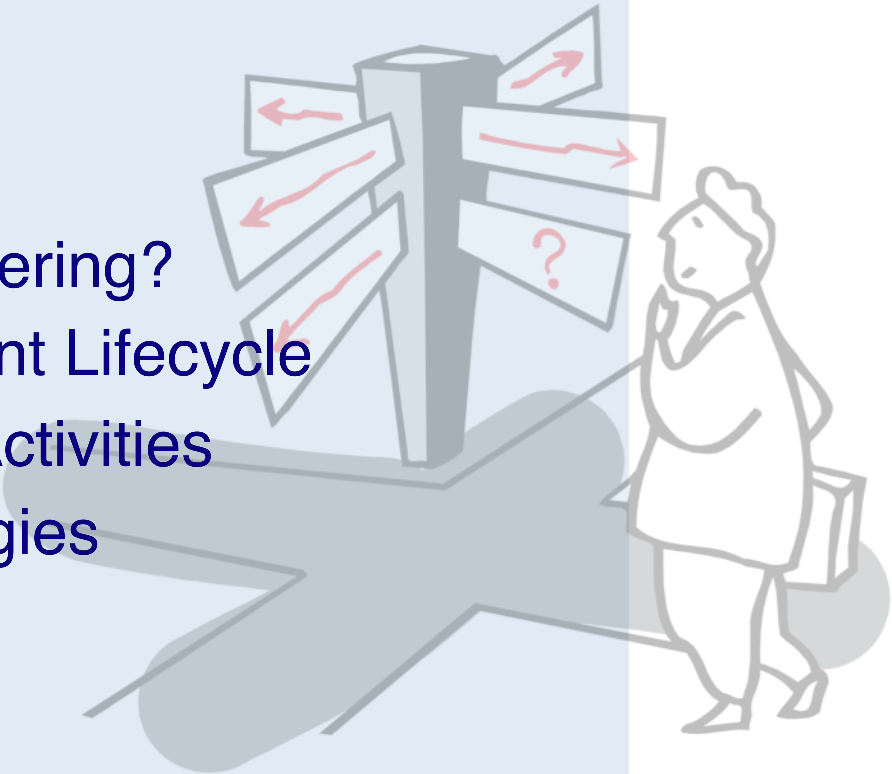
Lectures	Engehaldenstrasse 8, 001, Wednesdays @ 13h15-15h00
Exercises	Engehaldenstrasse 8, 001 Wednesdays @ 15h00-16h00
WWW	scg.unibe.ch/teaching/ese

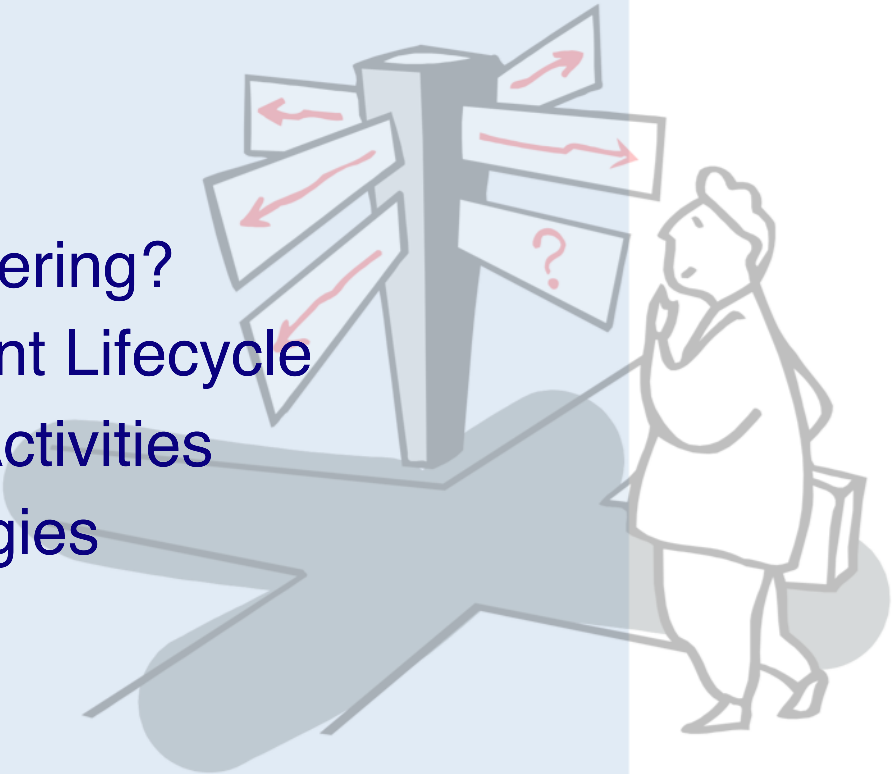
Selected material courtesy of Prof. Serge Demeyer, U. Antwerp

Roadmap



> Course Overview
> What is Software Engineering?
> The Iterative Development Lifecycle
> Software Development Activities
> Methods and Methodologies

Roadmap



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Principle Texts

- *Software Engineering*. Ian Sommerville. Addison-Wesley Pub Co; ISBN: 020139815X, 7th edition, 2004
- *Software Engineering: A Practioner's Approach*. Roger S. Pressman. McGraw Hill Text; ISBN: 0072496681; 5th edition, 2001
- *Using UML: Software Engineering with Objects and Components*. Perdita Stevens and Rob J. Pooley. Addison-Wesley Pub Co; ISBN: 0201648601; 1st edition, 1999
- *Designing Object-Oriented Software*. Rebecca Wirfs-Brock and Brian Wilkerson and Lauren Wiener. Prentice Hall PTR; ISBN: 0136298257; 1990

Recommended Literature

> *eXtreme Programming Explained: Embrace Change.* Kent Beck. Addison-Wesley Pub Co; ISBN: 0201616416; 1st edition (October 5, 1999)

> *The CRC Card Book*. David Bellin and Susan Suchman Simone. Addison-Wesley Pub Co; ISBN: 0201895358; 1st edition (June 4, 1997)

> *The Mythical Man-Month: Essays on Software Engineering.* Frederick P. Brooks. Addison-Wesley Pub Co; ISBN: 0201835959; 2nd edition (August 2, 1995)

> *Agile Software Development*. Alistair Cockburn. Addison-Wesley Pub Co; ISBN: 0201699699; 1st edition (December 15, 2001)

> *Peopleware: Productive Projects and Teams.* Tom Demarco and Timothy R. Lister. Dorset House; ISBN: 0932633439; 2nd edition (February 1, 1999)

> *Succeeding with Objects: Decision Frameworks for Project Management.* Adele Goldberg and Kenneth S. Rubin. Addison-Wesley Pub Co; ISBN: 0201628783; 1st edition (May 1995)

> *A Discipline for Software Engineering.* Watts S. Humphrey. Addison-Wesley Pub Co; ISBN: 0201546108; 1st edition (December 31, 1994)

Course schedule

Week	***Date***	***Lesson***
1	22-Sep-10	Introduction — The Software Lifecycle
2	29-Sep-10	Requirements Collection
3	06-Oct-10	The Planning Game
4	13-Oct-10	Responsibility-Driven Design
5	20-Oct-10	Software Validation
6	27-Oct-10	Modeling Objects and Classes
7	03-Nov-10	Modeling Behaviour
8	10-Nov-10	User Interface Design
9	17-Nov-10	Project Management
10	24-Nov-10	Software Architecture
11	01-Dec-10	Software Quality
12	08-Dec-10	Software Metrics
13	15-Dec-10	Software Evolution
14	22-Dec-10	Guest lecture — SE in practice
15	13-Jan-11	Final Exam — ExWi A6 @ 10h00-12h00

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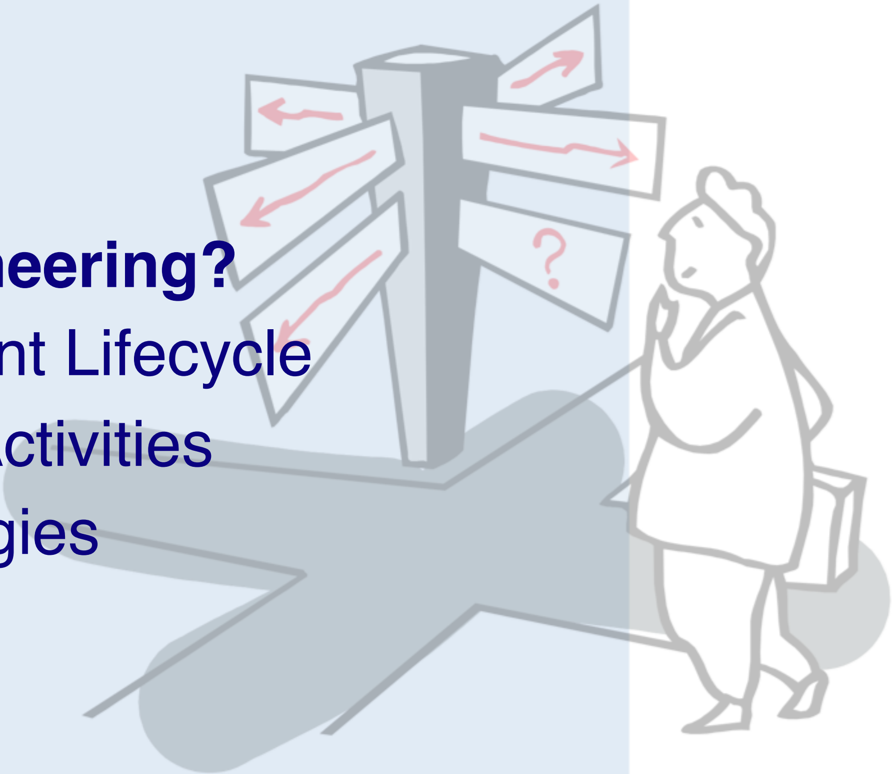

Why Software Engineering?

A naive view:

Problem Specification $\xrightarrow{\textit{coding}}$ Final Program

But ...

- Where did the *specification* come from?
- How do you know the specification corresponds to the *user's needs*?
- How did you decide how to *structure* your program?
- How do you know the program actually *meets the specification*?
- How do you know your program will always *work correctly*?
- What do you do if the users' *needs change*?
- How do you *divide tasks up* if you have more than a one-person team?

What is Software Engineering? (I)

Some Definitions and Issues

> *"state of the art of developing quality software on time and within budget"*

- Trade-off between perfection and physical constraints
  - SE has to deal with real-world issues
- State of the art!
  - Community decides on "best practice" + life-long education

What is Software Engineering? (II)

"multi-person construction of multi-version software"

— Parnas

- Team-work
  - Scale issue ("program well" is not enough) + Communication Issue
- Successful software systems must evolve or perish
  - Change is the norm, not the exception

What is Software Engineering? (III)

"software engineering is different from other engineering disciplines"

— Sommerville

> Not constrained by physical laws
>
> —limit = human mind

> It is constrained by political forces
>
> —balancing stake-holders

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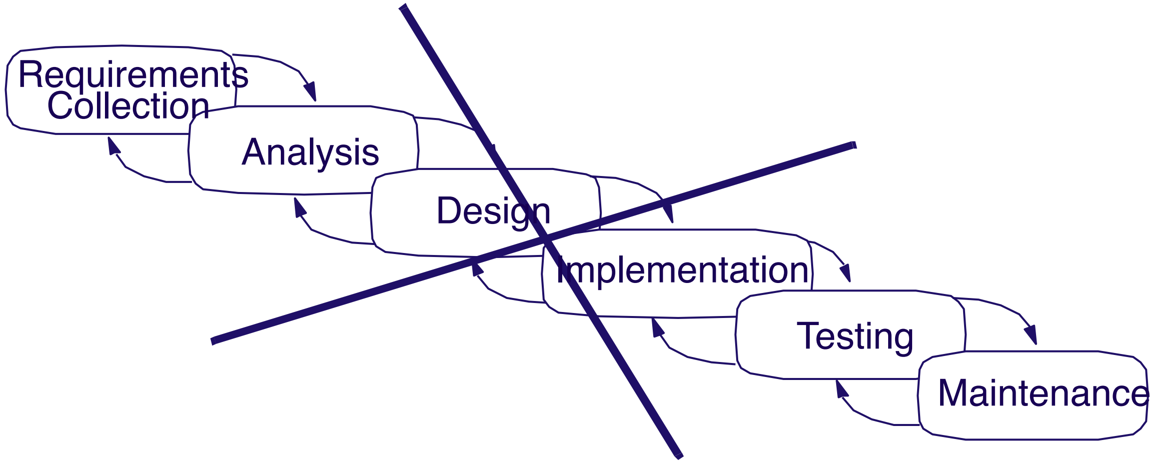
Software Development Activities

Requirements Collection	Establish customer’s needs
Analysis	Model and specify the requirements (“what”)
Design	Model and specify a solution (“how”)
Implementation	Construct a solution in software
Testing	Validate the solution against the requirements
Maintenance	Repair defects and adapt the solution to new requirements

NB: these are ongoing activities, not sequential phases!

The Classical Software Lifecycle

The classical software lifecycle models the software development as a step-by-step "waterfall" between the various development phases.



The waterfall model is unrealistic for many reasons:

- requirements must be *frozen too early* in the life-cycle
- requirements are *validated too late*

Problems with the Waterfall Lifecycle

1. "Real projects rarely follow the sequential flow that the model proposes. *Iteration* always occurs and creates problems in the application of the paradigm"

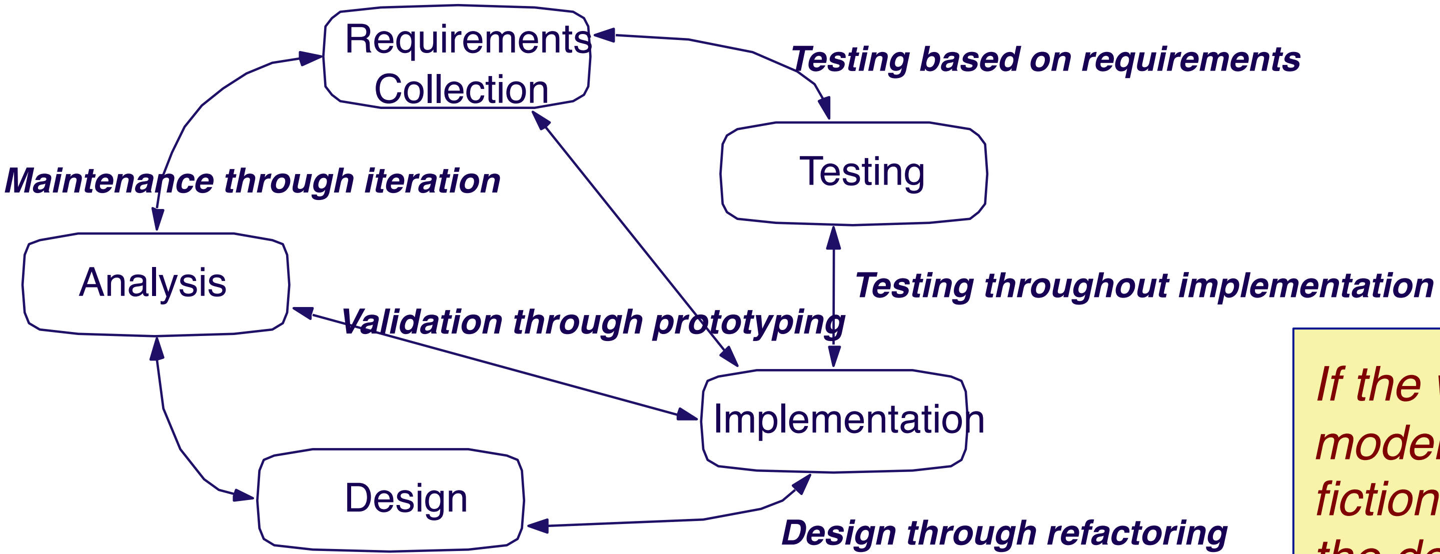
2. "It is often *difficult* for the customer *to state all requirements* explicitly. The classic life cycle requires this and has difficulty accommodating the natural uncertainty that exists at the beginning of many projects."

3. "The customer must have patience. A *working version* of the program(s) will not be available until *late in the project* timespan. A major blunder, if undetected until the working program is reviewed, can be disastrous."

— Pressman, SE, p. 26

Iterative Development

In practice, development is always iterative, and *all* activities progress in parallel.



If the waterfall model is pure fiction, why is it still the dominant software process?

Iterative Development

Plan to *iterate* your analysis, design and implementation.

— You won't get it right the first time, so *integrate*, *validate* and *test* as frequently as possible.

"You should use iterative development only on projects that you want to succeed."

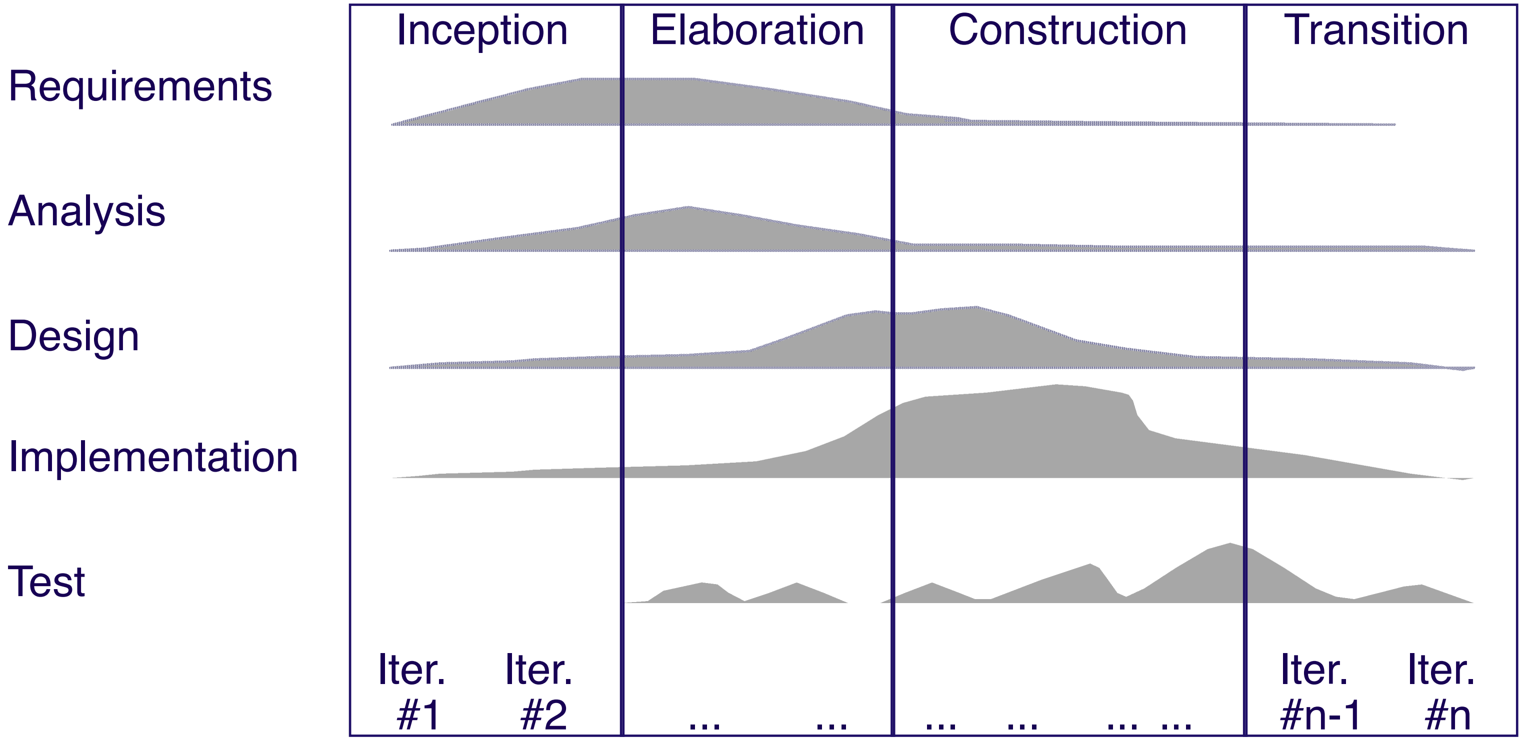
— *Martin Fowler, UML Distilled*

Incremental Development

Plan to *incrementally* develop (i.e., prototype) the system.

- If possible, *always have a running version* of the system, even if most functionality is yet to be implemented.
- *Integrate* new functionality as soon as possible.
- *Validate* incremental versions against user requirements.

The Unified Process



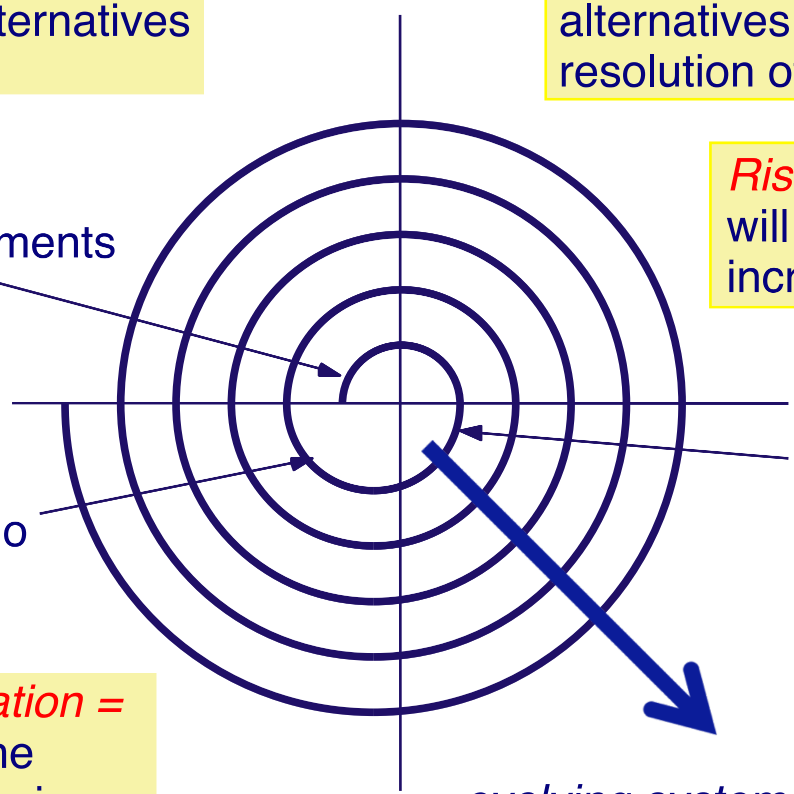
How do you plan the number of iterations?
How do you decide on completion?

Boehm’s Spiral Lifecycle

Planning = determination of objectives, alternatives and constraints

Risk Analysis = Analysis of alternatives and identification/ resolution of risks

Risk = something that will delay project or increase its cost



Customer Evaluation = Assessment of the results of engineering

Engineering = Development of the next level product

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Requirements Collection

User requirements are often expressed *informally*:

- — features
- — usage scenarios

Although requirements may be documented in written form, they may be *incomplete*, *ambiguous*, or even *incorrect*.

Changing requirements

Requirements *will* change!

- —*inadequately captured* or expressed in the first place
- —user and business *needs may change* during the project

Validation is needed *throughout* the software lifecycle, not only when the "final system" is delivered!

- —build constant *feedback* into your project plan
- —plan for *change*
- —early *prototyping* [e.g., UI] can help clarify requirements

Requirements Analysis and Specification

Analysis is the process of specifying *what* a system will do.

— The intention is to provide a clear understanding of what the system is about and what its underlying concepts are.

The result of analysis is a *specification document*.

Does the requirements specification correspond to the users' actual needs?

Object-Oriented Analysis

An *object-oriented analysis* results in models of the system which describe:

- *classes* of objects that exist in the system
  - *responsibilities* of those classes
- *relationships* between those classes
- *use cases* and *scenarios* describing
  - *operations* that can be performed on the system
  - allowable *sequences* of those operations

Prototyping (I)

A *prototype* is a software program developed to test, explore or validate a hypothesis, i.e. *to reduce risks.*

An *exploratory prototype*, also known as a *throwaway prototype*, is intended to *validate requirements* or *explore design choices*.

- UI prototype — validate user requirements
- rapid prototype — validate functional requirements
- experimental prototype — validate technical feasibility

Prototyping (II)

An *evolutionary prototype* is intended to evolve in steps into a finished product.

> iteratively "grow" the application, *redesigning* and *refactoring* along the way

First do it,
then do it right,
then do it fast.

Design

Design is the process of specifying *how* the specified system behaviour will be realized from software components. The results are *architecture* and *detailed design documents*.

Object-oriented design delivers models that describe:

- how system operations are implemented by *interacting objects*
- how classes refer to one another and how they are related by *inheritance*
- *attributes* and *operations* associated to classes

Design is an iterative process, proceeding in parallel with implementation!

Conway's Law

- "Organizations that design systems are constrained to produce designs that are copies of the communication structures of these organizations"

Implementation and Testing

Implementation is the activity of *constructing* a software solution to the customer's requirements.

Testing is the process of *validating* that the solution meets the requirements.

- The result of implementation and testing is a *fully documented* and *validated* solution.

Design, Implementation and Testing

Design, implementation and testing are iterative activities

- The implementation does not "implement the design", but rather the design document *documents the implementation*!

> System tests reflect the requirements specification

> Testing and implementation go hand-in-hand

- Ideally, test case specification *precedes* design and implementation

Maintenance

Maintenance is the process of changing a system after it has been deployed.

- *Corrective maintenance*: identifying and repairing *defects*
- *Adaptive maintenance*: *adapting* the existing solution to new platforms
- *Perfective maintenance*: implementing *new requirements*

In a spiral lifecycle, everything after the delivery and deployment of the first prototype can be considered "maintenance"!

Maintenance activities

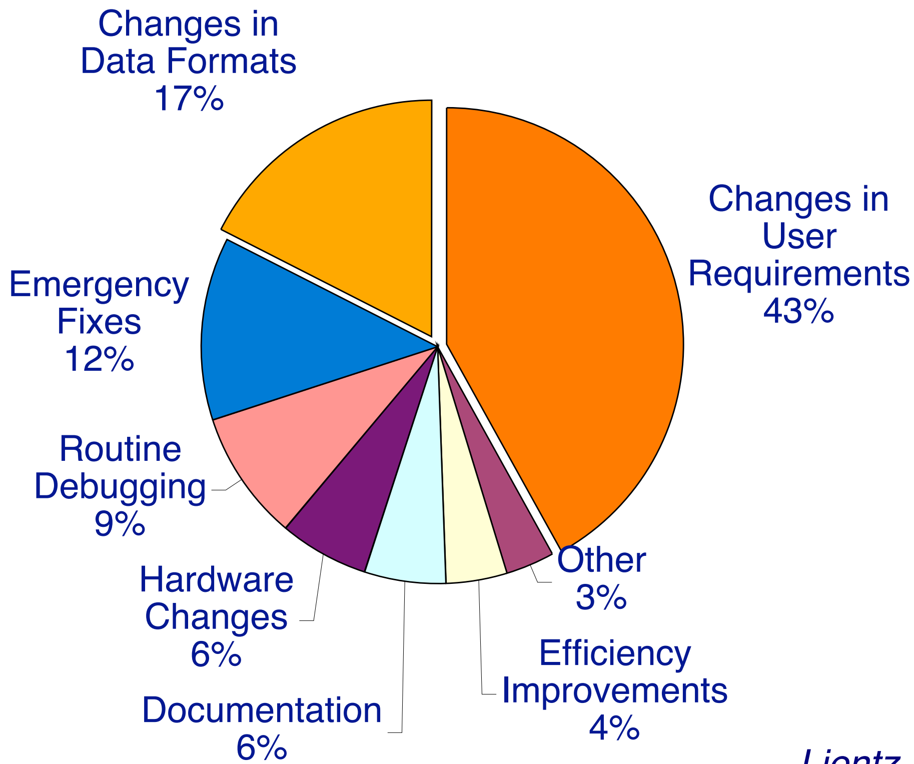
"Maintenance" entails:

> configuration and version management
> reengineering (redesigning and refactoring)
> updating all analysis, design and user documentation

Repeatable, automated tests enable evolution and refactoring

Maintenance costs

“Maintenance” typically accounts for *70% of software costs!*



– Lientz 1979

Means: most project costs concern continued development *after* deployment

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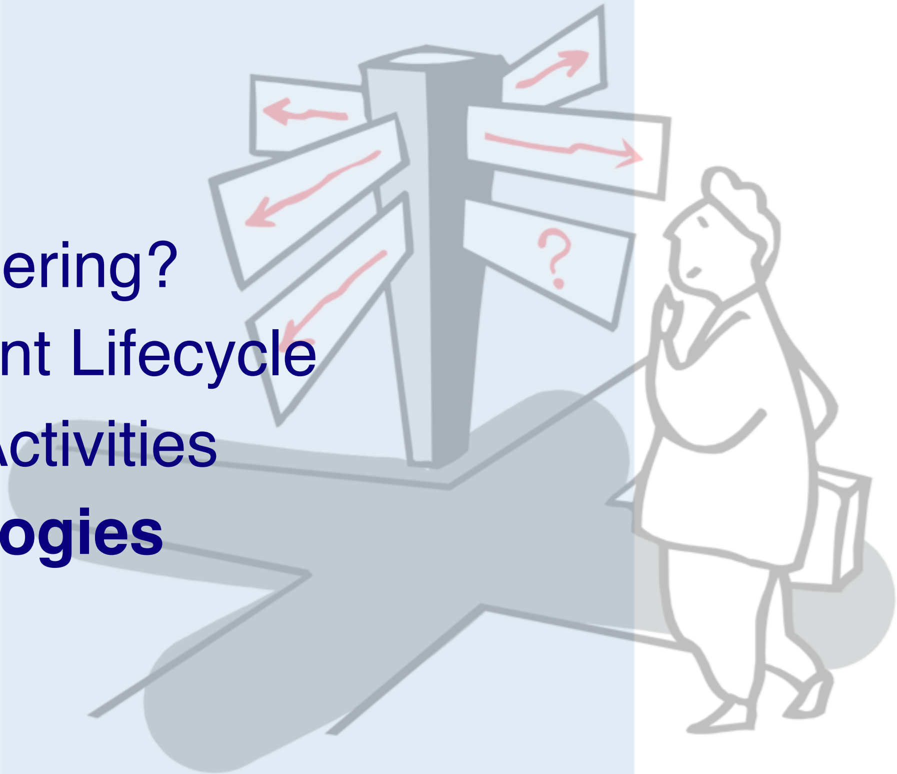
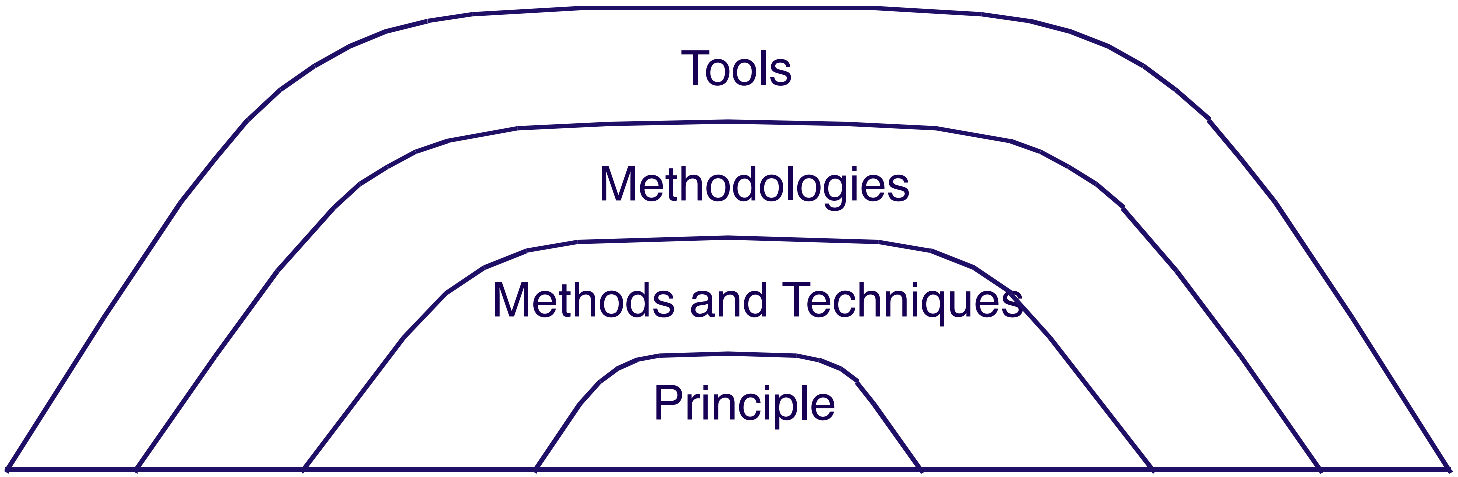


Methods and Methodologies

Principle = general statement describing desirable properties
Method = general guidelines governing some activity
Technique = more technical and mechanical than method
Methodology = package of methods and techniques packaged



— Ghezzi et al. 1991

Object-Oriented Methods: a brief history

- **First generation:**
  - Adaptation of existing notations (ER diagrams, state diagrams ...): Booch, OMT, Shlaer and Mellor, ...
  - Specialized design techniques:
    - *CRC cards; responsibility-driven design; design by contract*
- **Second generation:**
  - Fusion: Booch + OMT + CRC + formal methods
- **Third generation:**
  - Unified Modeling Language:
    - *uniform notation: Booch + OMT + Use Cases + ...*
    - *various UML-based methods (e.g. Catalysis)*
- **Agile methods:**
  - Extreme Programming
  - Test-Driven Development
  - Scrum …

What you should know!

> How does Software Engineering differ from programming?

> Why is the “waterfall” model unrealistic?

> What is the difference between analysis and design?

> Why plan to iterate? Why develop incrementally?

> Why is programming only a small part of the cost of a “real” software project?

> What are the key advantages and disadvantages of object-oriented methods?

Can you answer these questions?

- What is the appeal of the "waterfall" model?
- Why do requirements change?
- How can you validate that an analysis model captures users' real needs?
- When does analysis stop and design start?
- When can implementation start?
- What are good examples of Conway's Law in action?

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