III. Software Lifecycles

Software processes and lifecycles
Relative costs of lifecycle phases
Examples of lifecycles and processes
Process maturity scale
Information system development lifecycle
Lifecycle phases

The Software System Lifecycle

- A **software process** is a partially ordered collection of actions, carried out by one or more software engineers, software users, or other software systems in order to accomplish a (software engineering) task..
- The **software system lifecycle** is a software process by which a software system is developed, tested, installed and maintained throughout its useful history.
- The concept of software lifecycle is a useful project management tool. A lifecycle consists of **phases**, each of which is a software process.
- Think of lifecycles as coarse-grain software processes. There is a lot of work on fine-grain software processes, such as fixing a bug, extending a module, testing a module, etc.

We focus here on
information system development lifecycles

The Software Lifecycle

- For large software systems, involving >10K lines of code (LOC), the breakdown of costs between different phases is as follows:

Requirements Analysis	5%
Design	10%
Programming-in-the-small	15%
Integration	10%
Maintenance and Evolution	60%

- The breakdown of costs per phase for small software systems (<5K LOC) has as follows:

Specification	10%
Decomposition	20%
Coding	20%
Optimization	15%
Testing	25%
Validation	10%

Systems analysis and design more important than coding!

What is Described by a Lifecycle?

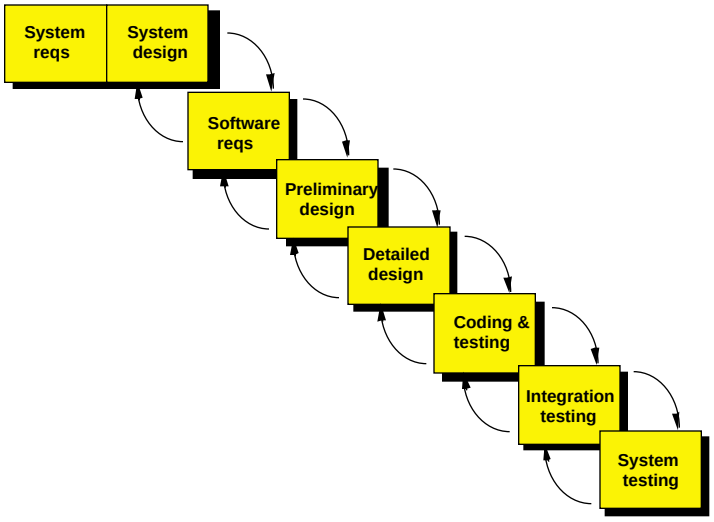
- The lifecycle describes the temporal, causal and I/O relationships between different lifecycle phases
- The lifecycle concept includes the concept of feedback (returning to a previous phase) as well as moving forward to the next phase
- In the past, the lifecycle concept was applied to the management of complex systems that had some sort of physical hardware as their end product, e.g., missiles, communication networks, spacecraft, etc.
- However, for hardware systems there is a tangible end product that can be measured and observed,...

It is not as easy to measure and observe
the results of information systems analysis and design

Lifecycle Models

- History of lifecycle models
  - Stage-wise (Benington, 1956)
  - Waterfall (Royce, 1970)
  - Transformational, automatic (Balzer, 1973; Balzer, Cheatham and Turner, 1983)
  - Evolutionary (Basili & Turner, 1975)
  - Transformational, specification to implementation (Lehman, Stenning and Turski, 1984)
  - Spiral (Boehm, 1986)
- Benefits of lifecycle models
  - Process awareness and understanding
  - Order of global activities
  - Improvement in product quality
  - Reduction of software costs
- Deficiencies of lifecycle models
  - Too coarse-grained -- they hide important process detail

The Waterfall Lifecycle Model



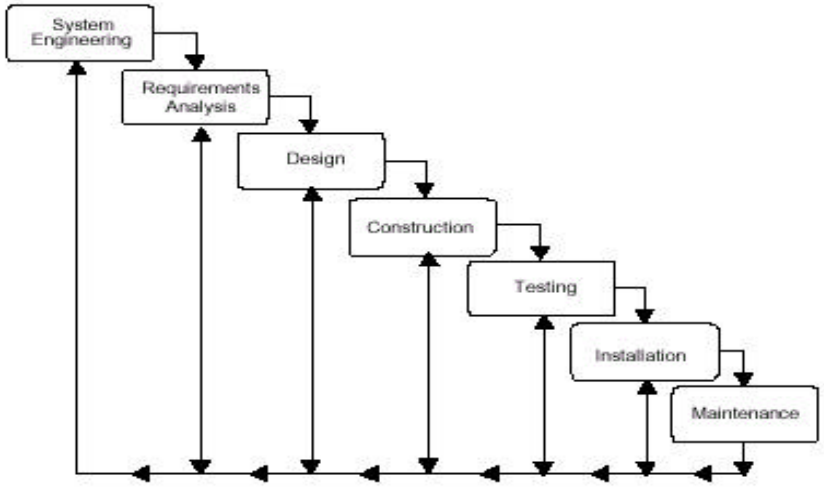
Waterfall Life Cycle Deliverables

Phase	Output deliverables
System Engineering	High level architectural specification
Requirements Analysis	Requirements specification Functional specification Acceptance test specification
Design	Software architecture specification System test specification Design specification Sub-system test specification Unit test specification
Construction	Program code
Testing	Unit test report Sub-system test report System test report Acceptance test report Completed system
Installation	Installed system
Maintenance	Change requests Change request report

Criticisms of the Waterfall Life Cycle Model

- Advantages
  - ✓ The tasks of a step may be assigned to a specialized team;
  - ✓ The progress of the project can be evaluated at the end of each phase and an assessment made as to whether the project should proceed;
- Criticisms
  - ✓ Inflexible partitioning of the project into distinct steps -- real projects rarely follow it!
  - ✓ Iterations are inevitable;
  - ✓ It may take too long;
  - ✓ Difficult to respond to changing customer requirements.
- Generally, this lifecycle model is appropriate when the requirements for a given system are well-understood.

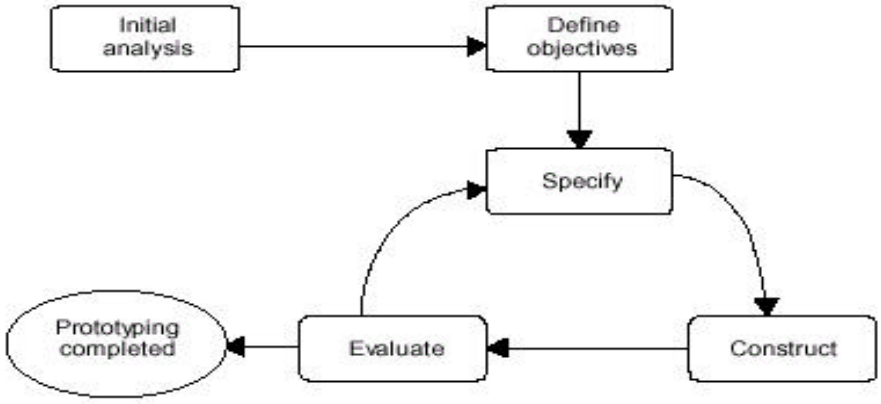
The Waterfall Life Cycle with Iteration



Prototyping

- Built something quickly to explore some aspect of the systems requirements
- The prototype is not intended as the final working system; among other things, it may be incomplete. less resilient (ex. poor performance) than a production system.
- In building a prototype, the objective is to investigate user requirements, in particular:
  - ✓ What data should be presented and what data should be captured;
  - ✓ To investigate suitable forms of interfaces;
- Also to determine whether a particular implementation platform is appropriate, as well as the efficacy of a language, DBMS or communication infrastracture.

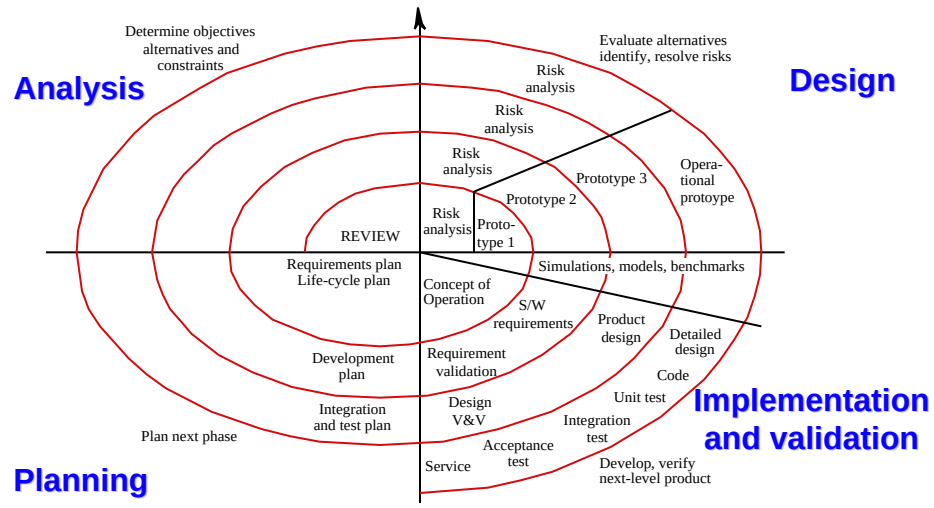
Prototyping



Evaluation of Prototyping

- Advantages
  - ✓ Early demonstrations of system functionality help identify any misunderstandings between developer and client;
  - ✓ Helps identify missing client requirements;
  - ✓ Problems with user interfaces can be identified;
  - ✓ Early testing of feasibility and usefulness of the system (partially)
- Problems
  - ✓ The client may not understand the extra effort needed to produce a working production system;
  - ✓ May divert attention from functional to solely interface issues;
  - ✓ Requires significant user involvement;
  - ✓ Managing the prototyping life cycle is not easy;
- Applicability
  - ✓ For small or medium-size interactive systems
  - ✓ For parts of large systems (e.g. user interfaces)
  - ✓ For short-lifetime systems.

The Spiral Lifecycle Model



Software Processes: Fixing a Bug

Step 1: Problem identification

/* During testing, a problem is identified */

- A problem report is created, including problem identification, responsible personnel etc.
- Responsible personnel is notified

Step 2: Problem analysis

- Perform problem description evaluation, evaluation of software component etc.
- Propose solutions and describe technical and operational implications

Step 3: Cost analysis

- Project manager decides whether to use cost analysis routine
- If so, perform cost analysis to determine impact in work-months

Step 4: Schedule analysis...

Step 5: Perform change process...

Step 6: Close problem report...

Software Process Programming

A Testing process

```
Function AllFunctionsnsOK(executable,tests);
  declare executable executableCode,
            tests testSet,
            result derivedResult;
  /* executableCode etc are types, undefined here */
  All-fn-OK := true;
  For case := 1 to #tests do
      derive(executable, tests[case].input, result)
      if ~resultOK(result, testcase[case].output)
            then All-fn-OK := false; exit;
  end loop;
end All-Fn-Perf-OK
```

This only works for highly structured or automated processes

[Osterweil87]

Software Process Maturity

Level	Characteristic	Key challenges	Result
5 optimizing	improvement feedback into process	maintain organization at optimizing level	Productivity & quality
4 managed	process defined quantitatively and measured	changing technology; problem prevention	
3 defined	process defined and institutionalized	process measurement and analysis	
2 repeatable	intuitive process, dependent on individuals	training, process focus	
1 initial	ad hoc/chaotic	project and configuration management	risk

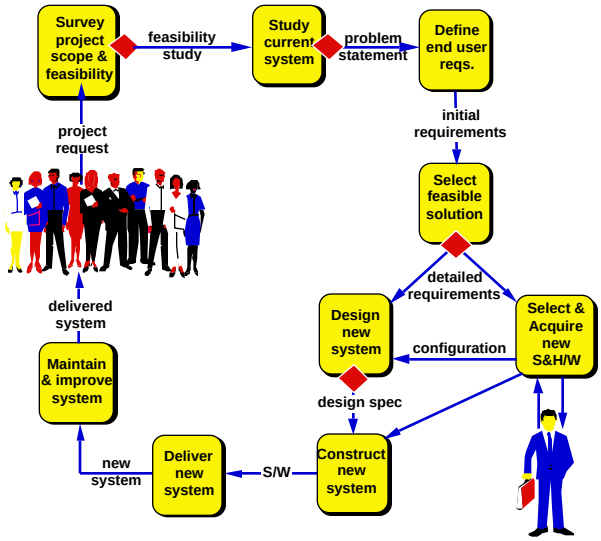
Software Process Maturity: Field Study (early '90s)

Level	USA (167 cases)	Japan (196 cases)	Result
5 optimizing	0%	0.5%	Productivity & quality
4 managed	0%	0%	
3 defined	1%	0.5%	
2 repeatable	13%	1%	
1 initial	86%	98%	risk

Information System **Development** *Phases*

- We focus now on the development part of the software lifecycle.
- There are many ways to divide up an information system development into phases
- For this course, we identify four major phases: **feasibility study**, **requirements analysis**, **system design** and **implementation**.
- All activities associated with each phase must be performed, managed and documented.
- **Development support** -- tools and methodologies that support the performance, management and documentation of all four phases

The Information System Lifecycle Phases



Who Are the Players ("Stakeholders")?

- **Management** -- for initiation, approval, control, possibly as users
- **End-users** (persons who actually use the system on a day-to-day basis) -- they provide input during requirements definition and testing, participate in committees and final system evaluation
- **Developers** (analysts and programmers)
  - **Analysts** -- serve as project leaders, perform information analysis, create system requirements and design
  - **Programmers** -- program, test, document, maintain
- **System support group** -- they are responsible for system maintenance
- **Database administrator** -- responsible for design and control of one or more databases
- **Program librarian** -- keeps track of all program files, documentation
- **Steering committee** -- oversees project to ensure that objectives have been met

Phase I: The Feasibility Study Phase

Deciding What to Do:

- Confirm that a problem exists
- Carry out a study to determine if a system can be developed to solve the problem (2 days - 4 weeks)

- A feasibility study looks at the problem at a high level (only takes into account few details)
- The study provides cost and savings estimates for the proposed solution.
- The feasibility study is reviewed by the customer (usually through a manager) and if the review is positive, then a more detailed requirements study is undertaken.

Phase II: The Requirements Analysis Phase

- **Study** existing procedures and computerized information systems in detail and document them.
- **Define** goals to be achieved by the new system
- **Propose** alternate (possibly several) business processes that might better fit organizational goals and objectives. Discuss these with the customer and get feedback on what is the most desirable alternative.
- **Define** the boundaries of the information system to be built as part of the collection of business processes.
- **Define** non-functional requirements on the proposed system, including input/output requirements, response requirements, file requirements, etc. Collect statistics on volumes, amounts of data handled by the system.

Phase III: The Design Phase

- Specify an architecture and a detailed design for the proposed information system
- Ideal system specified first, meeting all functional requirements, then modified to meet non-functional requirements and other constraints
- Resources allocated for hardware equipment, personnel tasks and programming tasks
- Technical specifications are prepared for: system architecture (components, system interfaces to existing systems), processing logic (how does the system do what it is supposed to?), database design (what information does the system handle?), input/output (what do the users see?), platform requirements (on what systems does the system run?) and manual procedures (how do people use the system?)

Phase IV: The Implementation Phase (Not Covered in this Course)

- The system is implemented on the basis of the design specification.
- Programming of the system is carried out
- Testing of the system, both as individual parts and as a whole, are conducted (acceptance test)
- Equipment is acquired and installed
- Procedures, system manuals, software specifications and documentation are completed
- Staff is trained

Additional Readings

[Humphrey89] Humphrey, W. and Kellner, M., "Software Process Modelling: Principles of Entity Process Models", Proceedings Eleventh International Conference on Software Engineering, Pittsburgh, May 1989.

[Humphrey90] Humphrey, W., *Managing the Software Process*, Addison-Wesley, 1990.

[Osterweil87] Osterweil, L., "Software Processes are Software Too", Proceedings Ninth International Conference on Software Engineering, Monterey, 1987.