VEMU Institute of Technology

Dept. of Computer Science & Engineering

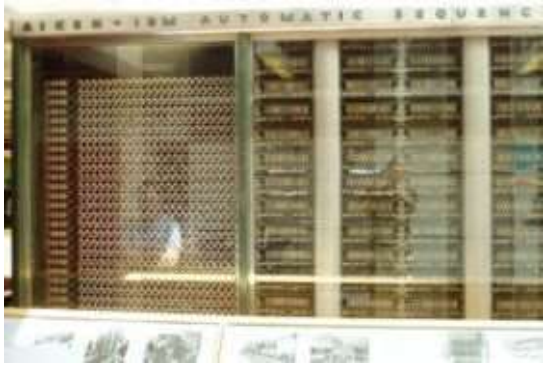
Software Testing PPTs

Class : IV year **Sem : I**

2022-23

Introduction to Software Testing

What is a computer bug?



- In 1947 Harvard University was operating a room-sized computer called the Mark II.
  - mechanical relays
  - glowing vacuum tubes
  - technicians program the computer by reconfiguring it
  - Technicians had to change the occasional vacuum tube.
- A moth flew into the computer and was zapped by the high voltage when it landed on a relay.
- Hence, the first computer bug!
  - I am not making this up :-)

Bugs a.k.a. …

- Defect
- Fault
- Problem
- Error
- Incident
- Anomaly
- Variance
- Failure
- Inconsistency
- Product Anomaly
- Product Incidence
- Feature :-)

Defective Software

- We develop programs that contain defects
  - How many? What kind?
- Hard to predict the future, however… it is highly likely, that the software we (including you!) will develop in the future will not be significantly better.

Sources of Problems

- **Requirements Definition:** Erroneous, incomplete, inconsistent requirements.
- **Design:** Fundamental design flaws in the software.
- **Implementation:** Mistakes in chip fabrication, wiring, programming faults, malicious code.
- **Support Systems:** Poor programming languages, faulty compilers and debuggers, misleading development tools.

Sources of Problems (Cont'd)

- **Inadequate Testing of Software:** Incomplete testing, poor verification, mistakes in debugging.
- **Evolution:** Sloppy redevelopment or maintenance, introduction of new flaws in attempts to fix old flaws, incremental escalation to inordinate complexity.

Adverse Effects of Faulty Software

- **Communications:** Loss or corruption of communication media, non delivery of data.
- **Space Applications:** Lost lives, launch delays.
- **Defense and Warfare:** Misidentification of friend or foe.

Adverse Effects of Faulty Software (Cont'd)

- **Transportation:** Deaths, delays, sudden acceleration, inability to brake.
- **Safety-critical Applications:** Death, injuries.
- **Electric Power:** Death, injuries, power outages, long-term health hazards (radiation).

Adverse Effects of Faulty Software (Cont'd)

- **Money Management:** Fraud, violation of privacy, shutdown of stock exchanges and banks, negative interest rates.
- **Control of Elections:** Wrong results (intentional or non-intentional).
- **Control of Jails:** Technology-aided escape attempts and successes, accidental release of inmates, failures in software controlled locks.
- **Law Enforcement:** False arrests and imprisonments.

Bug in Space Code

- Project Mercury's FORTRAN code had the following fault:
  DO I=1.10 instead of ... DO I=1,10
- The fault was discovered in an analysis of why the software did not seem to generate results that were sufficiently accurate.
- The erroneous 1.10 would cause the loop to be executed exactly once!

Military Aviation Problems

- An F-18 crashed because of a missing exception condition:
  if ... *then* ... without the *else* clause that was thought could not possibly arise.
- In simulation, an F-16 program bug caused the virtual plane to flip over whenever it crossed the equator, as a result of a missing minus sign to indicate south latitude.

Year Ambiguities

- In 1992, Mary Bandar received an invitation to attend a kindergarten in Winona, Minnesota, along with others born in '88.
- Mary was 104 years old at the time.

Year Ambiguities (Cont'd)

- Mr. Blodgett's auto insurance rate tripled when he turned 101.
- He was the computer program's first driver over 100, and his age was interpreted as 1.
- This is a double blunder because the program's definition of a teenager is someone under 20!

Dates, Times, and Integers

- The number 32,768 = 2^{15} has caused all sorts of grief from the overflowing of 16-bit words.
- A Washington D.C. hospital computer system collapsed on September 19, 1989, 2^{15} days after January 1, 1900, forcing a lengthy period of manual operation.

Dates, Times, and Integers (Cont'd)

- COBOL uses a two-character date field …
- The Linux **term** program, which allows simultaneous multiple sessions over a single modem dialup connection, died word wide on October 26, 1993.
- The cause was the overflow of an `int` variable that should have been defined as an `unsigned int`.

Shaky Math

- In the US, five nuclear power plants were shut down in 1979 because of a program fault in a simulation program used to design nuclear reactor to withstand earthquakes.
- This program fault was, unfortunately, discovered after the power plants were built!

Shaky Math (Cont'd)

- Apparently, the arithmetic sum of a set of numbers was taken, instead of the sum of the absolute values.
- The five reactors would probably not have survived an earthquake that was as strong as the strongest earthquake ever recorded in the area.

Therac-25 Radiation "Therapy"

- In Texas, 1986, a man received between 16,500-25,000 rads in less than 1 sec, over an area of about 1 cm.
- He lost his left arm, and died of complications 5 months later.
- In Texas, 1986, a man received at least 4,000 rads in the right temporal lobe of his brain.
- The patient eventually died as a result of the overdose.

Therac-25 Radiation "Therapy" (Cont'd)

- In Washington, 1987, a patient received 8,000-10,000 rads instead of the prescribed 86 rads.
- The patient died of complications of the radiation overdose.

AT&T Bug: Hello? ... Hello?

- In mid-December 1989, AT&T installed new software in 114 electronic switching systems.
- On January 15, 1990, 5 million calls were blocked during a 9 hour period nationwide.

AT&T Bug (Cont'd)

- The bug was traced to a C program that contained a `break` statement within an `switch` clause nested within a loop.
- The `switch` clause was part of a loop. Initially, the loop contained only `if` clauses with `break` statements to exit the loop.
- When the control logic became complicated, a `switch` clause was added to improve the readability of the code ...

Bank Generosity

- A Norwegian bank ATM consistently dispersed 10 times the amount required.
- Many people joyously joined the queues as the word spread.

Bank Generosity (Cont'd)

- A software flaw caused a UK bank to duplicate every transfer payment request for half an hour. The bank lost 2 billion British pounds!
- The bank eventually recovered the funds but lost half a million pounds in potential interest.

Making Rupee!

- An Australian man purchased $104,500 worth of Sri Lankan Rupees.
- The next day he sold the Rupees to another bank for $440,258.
- The first bank’s software had displayed a bogus exchange rate in the Rupee position!
- A judge ruled that the man had acted without intended fraud and could keep the extra $335,758!

Bug in BoNY Software

- The Bank of New York (BoNY) had a $32 billion overdraft as the result of a 16-bit integer counter that went unchecked.
- BoNY was unable to process the incoming credits from security transfers, while the NY Federal Reserve automatically debited BoNY’s cash account.

Bug in BoNY Software (Cont'd)

- BoNY had to borrow $24 billion to cover itself for 1 day until the software was fixed.
- The bug cost BoNY $5 million in interest payments.

Discussion …

- Have you heard of other software bugs?
  - In the media?
  - From personal experience?
- Does this embarrass you as a future software engineer?

Specification

"if you can't say it, you can't do it"

- You have to know what your product is before you can say if it has a bug.
- A *specification* defines the product being created and includes:
  - Functional requirements that describes the features the product will support. E.g., on a word processor
    - Save, print, check spelling, change font, …
  - Non-functional requirements are constraints on the product. E.g,
    - Security, reliability, user friendliness, platform, …

A software bug occurs when at least one of these rules is true

- The software does not do something that the specification says it should do.
- The software does something that the specification says it should not do.
- The software does something that the specification does not mention.
- The software does not do something that the product specification does not mention but should.
- The software is difficult to understand, hard to use, slow …

Most bugs are not because of mistakes in the code …

- Specification (~= 55%)
- Design (~= 25%)
- Code (~= 15%)
- Other (~= 5%)

Relative cost of bugs
"bugs found later cost more to fix"

- Cost to fix a bug increases exponentially (10^x)
  - i.e., it increases tenfold as time increases
- E.g., a bug found during specification costs $1 to fix.
- … if found in design cost is $10
- … if found in code cost is $100
- … if found in released software cost is $1000

Bug Free Software

- Software is in the news for the wrong reason
  - Security breach, Mars Lander lost, hackers getting credit card information, etc.
- Why can’t software engineers develop software that just works?
  - As software gets more features and supports more platforms it becomes increasingly difficult to make it create bug-free.

Discussion …

- Do you think bug free software is unattainable?
  - Are their technical barriers that make this impossible?
  - Is it just a question of time before we can do this?
  - Are we missing technology or processes?

Goal of a software tester

- … to *find* bugs
- … as *early* in the software development processes as possible
- … and make sure they get *fixed*.

- **Advice:** Be careful not to get get caught in the dangerous spiral of unattainable perfection.

What to look for when interviewing someone for the position of software tester

- Are they explorers?
- Are they troubleshooters?
- Are they relentless?
- Are they creative?
- Are they perfectionists (within reason)?
- Do they exercise good judgment?
- Are they tactful and diplomatic?
- Are they persuasive?

You now know …

- … what is a bug
- … the relationship between specification and bugs
- … the cost of a bug relative to when it is found
- … the unattainable goal of perfect software
- … the goal of the software tester
- … valuable attributes of a software tester

The Software Development Process

[Reading assignment: Chapter 2, pp. 23-36]

Software is …

- requirements specification documents
- design documents
- source code
- test suites and test plans
- interfaces to hardware and software operating environment
- internal and external documentation
- executable programs and their persistent data

Software effort

- Specification
- Product reviews
- Design
- Scheduling
- Feedback
- Competitive information acquisition
- Test planning
- Customer surveying
- Usability data gathering
- Look and feel specification
- Software architecture
- Programming
- …

Discussion …

- What is software engineering?
- Where does testing occur in the software development process?

Customer requirements

- *The software development team must determine what the customer wants.*
- How can you do this?
  - Guess?
  - Collect detailed information from surveys?
  - Get feedback from a previous version of the software?
  - Read reviews in magazines?
  - Get information about the competition?
  - Other ways?
- The collected data is used to guide the specification effort.

Specification

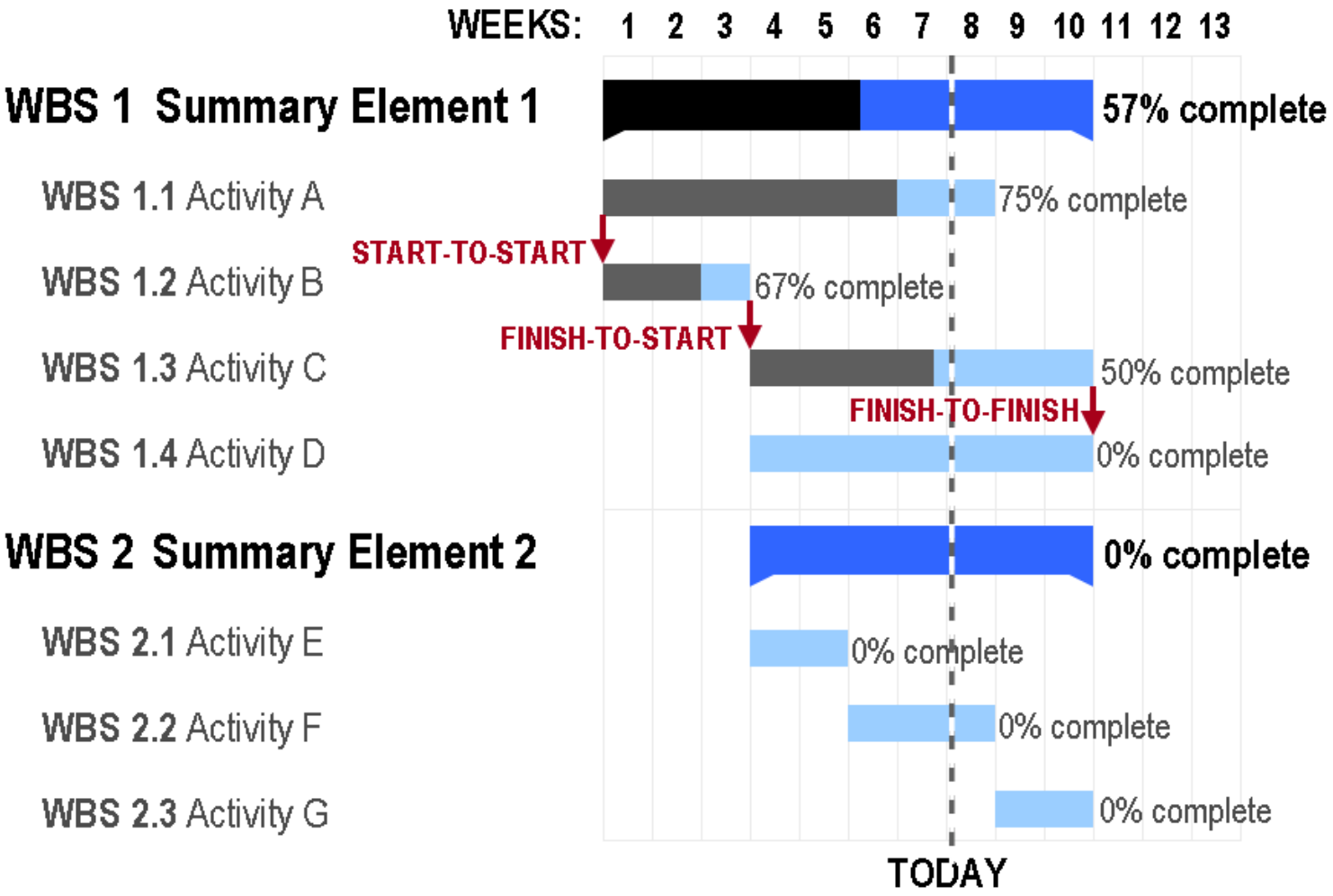
"If you don't know where you're going any road will take you there"

- The specification takes the data from the customer requirements and other sources and defines:
  - The features of the software (functional requirements).
  - The constraints on these features (non-functional requirements).
- Specifications can be:
  - formal (e.g., aerospace industry), rigid
  - informal (e.g., a .com start up), on a cocktail napkin or a whiteboard.

Schedules

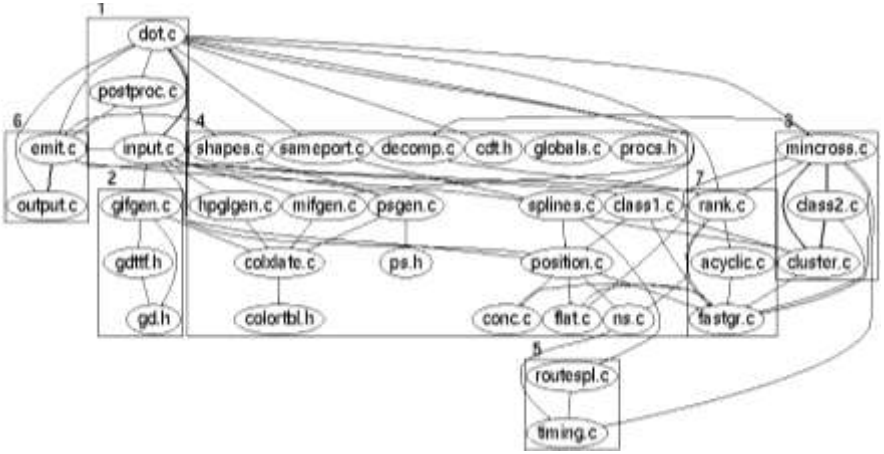
- The goals of scheduling are to know:
  - What work needs to be completed?
  - How much work is left to do?
  - When will the work be finished?
  - Who will finish each task?
  - Other measurable queries.
- A **Gantt chart** is a popular type of bar chart that illustrates a project schedule.

Gantt Chart


WEEKS: 1 2 3 4 5 6 7 8 9 10 11 12 13
WBS 1 Summary Element 1
57% complete
WBS 1.1 Activity A
75% complete
START-TO-START
WBS 1.2 Activity B
67% complete
FINISH-TO-START
WBS 1.3 Activity C
50% complete
FINISH-TO-FINISH
WBS 1.4 Activity D
0% complete
WBS 2 Summary Element 2
0% complete
WBS 2.1 Activity E
0% complete
WBS 2.2 Activity F
0% complete
WBS 2.3 Activity G
0% complete
TODAY

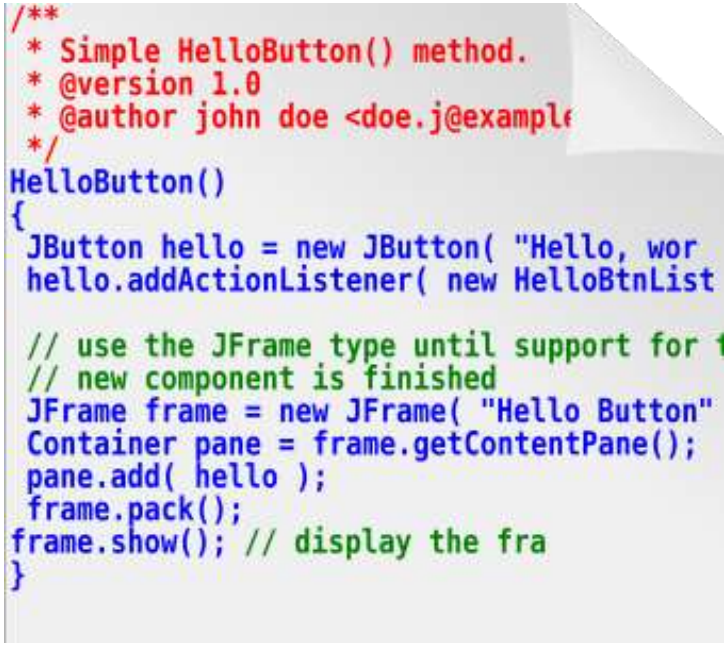
Design

- Before coding begins on non-trivial software projects, a set of design documents are created to serve as blueprints.
  - Software Architecture
  - Data flow diagram
  - State transition diagram
  - Flowchart
  - Commented code



Source code … of course

- The ultimate specification of the software!
- ‘Code is king’ philosophy still prevalent.
- Many programming languages and tools to choose from.



```
/**
 * Simple HelloButton() method.
 * @version 1.0
 * @author john doe <doe.j@example
 */
HelloButton()
{
 JButton hello = new JButton( "Hello, wor
 hello.addActionListener( new HelloBtnList

 // use the JFrame type until support for t
 // new component is finished
 JFrame frame = new JFrame( "Hello Button"
 Container pane = frame.getContentPane();
 pane.add( hello );
 frame.pack();
frame.show(); // display the fra
}
```

Test documents

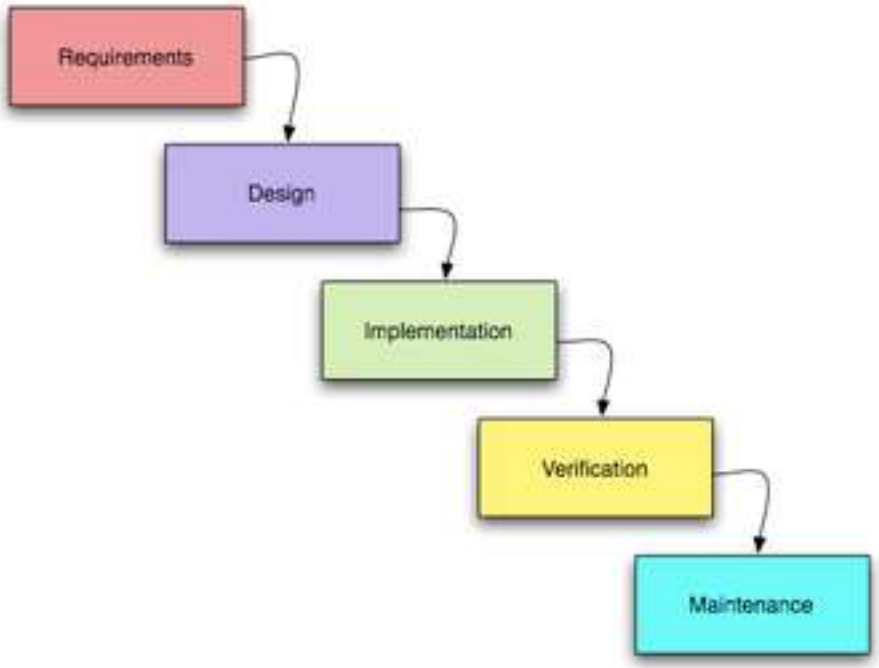
- Test plan
  - Quality objectives, resource needs, schedules, assignments, methods, etc.
- Test cases
  - Inputs and expected outputs.
- Bug reports
  - E.g., the Bugzilla web-based bug tracker.
- Test tools and automation
- Metrics, statistics, and summaries
  - Number of unresolved bugs, mean time to repair a bug, etc.

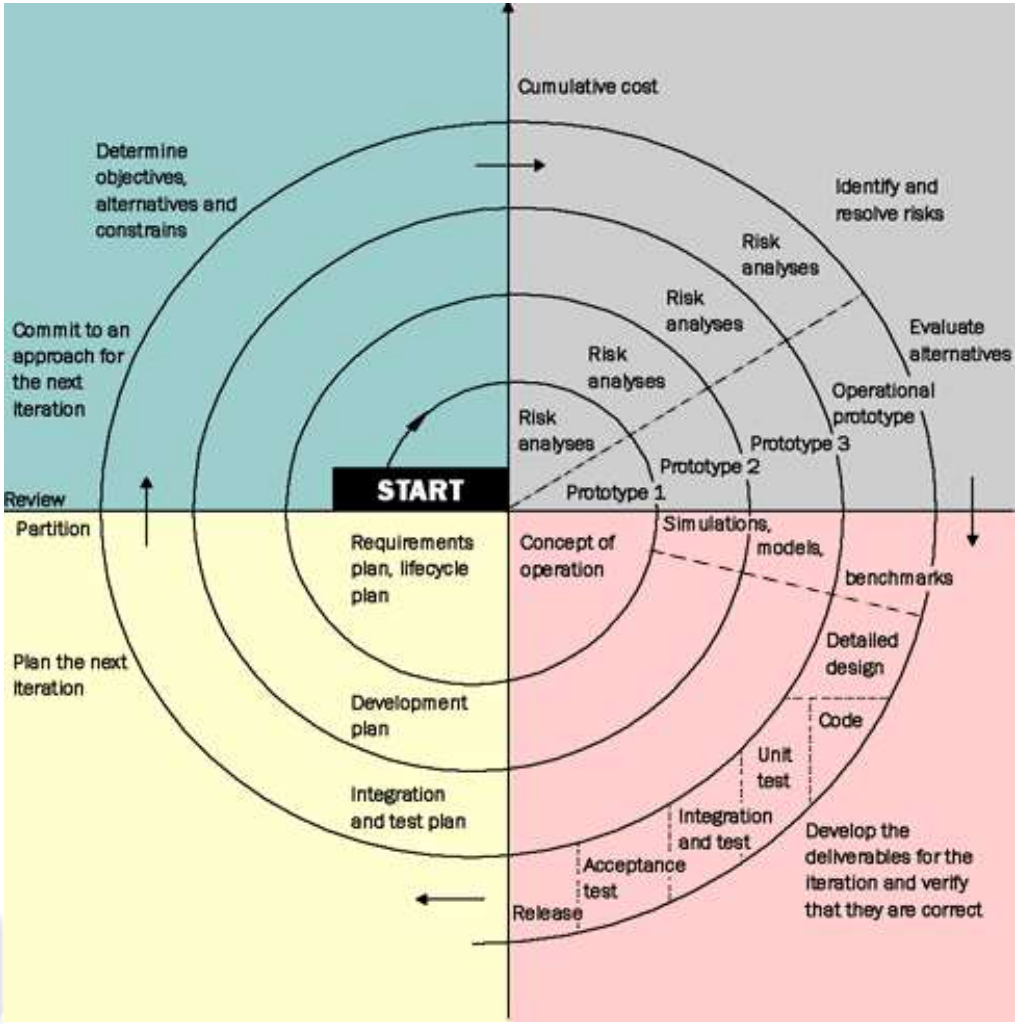
Software Project Staff

- Project managers
  - Write product specification, manage the schedule, critical decision tradeoffs
- Software architects, system engineers
  - Design the software, work closely with programmers
- Programmers, developers, coders
  - Write code, fix bugs
- Testers, quality assurance staff
  - Find bugs, document bugs, track progress of open bugs
- Technical writers
  - Write manuals, on line documentation
- Configuration managers, builders
  - Packaging and code, documents, and specifications

Software Development Lifecycles

- Code and Fix
- Waterfall
- Spiral





You now know …

- … what is software
- … what is software engineering
- … what is the composition of a software development organization
- … what are the major phases of a software development project
- … how major phased are organized