Software Testing and Maintenance

CO6: Student will be able to apply testing and assure quality in software solution

Contents

- Testing: Software Quality, Testing: Strategic Approach, Strategic Issues- Testing: Strategies for Conventional Software, Object oriented software, Web Apps-Validating Testing- System Testing- Art of Debugging.
- Maintenance : Software Maintenance-Software Supportability- Reengineering- Business Process Reengineering- Software Reengineering- Reverse Engineering- Restructuring- Forward Engineering

Introduction

- A strategy for software testing integrates the design of software test cases into a well-planned series of steps that result in successful development of the software
- The strategy provides a road map that describes the steps to be taken, when, and how much effort, time, and resources will be required
- The strategy incorporates test planning, test case design, test execution, and test result collection and evaluation
- The strategy provides guidance for the practitioner and a set of milestones for the manager
- Because of time pressures, progress must be measurable and problems must surface as early as possible

A Strategic Approach to Testing

General Characteristics of Strategic Testing

- To perform effective testing, a software team should conduct effective formal technical reviews
- Testing begins at the component level and work outward toward the integration of the entire computer-based system
- Different testing techniques are appropriate at different points in time
- Testing is conducted by the developer of the software and (for large projects) by an independent test group
- Testing and debugging are different activities, but debugging must be accommodated in any testing strategy

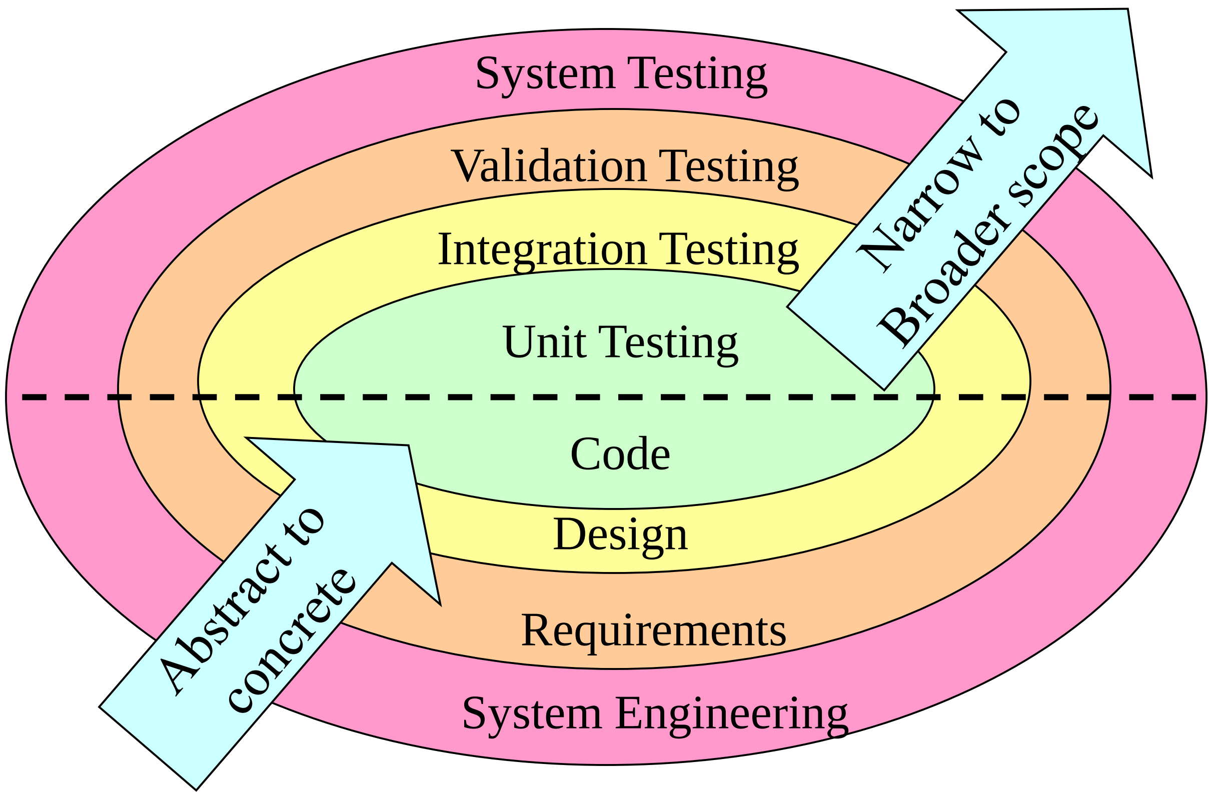
Verification and Validation

- Software testing is part of a broader group of activities called verification and validation that are involved in software quality assurance
- Verification (Are the algorithms coded correctly?)
  - The set of activities that ensure that software correctly implements a specific function or algorithm
- Validation (Does it meet user requirements?)
  - The set of activities that ensure that the software that has been built is traceable to customer requirements

Organizing for Software Testing

- Testing should aim at "breaking" the software
- Common misconceptions
  - The developer of software should do no testing at all
  - The software should be given to a secret team of testers who will test it unmercifully
  - The testers get involved with the project only when the testing steps are about to begin
- Reality: Independent test group
  - Removes the inherent problems associated with letting the builder test the software that has been built
  - Removes the conflict of interest that may otherwise be present
  - Works closely with the software developer during analysis and design to ensure that thorough testing occurs

A Strategy for Testing Conventional Software



Levels of Testing for Conventional Software

- Unit testing
  - Concentrates on each component/function of the software as implemented in the source code
- Integration testing
  - Focuses on the design and construction of the software architecture
- Validation testing
  - Requirements are validated against the constructed software
- System testing
  - The software and other system elements are tested as a whole

Testing Strategy applied to Conventional Software

- Unit testing
  - Exercises specific paths in a component's control structure to ensure complete coverage and maximum error detection
  - Components are then assembled and integrated
- Integration testing
  - Focuses on inputs and outputs, and how well the components fit together and work together
- Validation testing
  - Provides final assurance that the software meets all functional, behavioral, and performance requirements
- System testing
  - Verifies that all system elements (software, hardware, people, databases) mesh properly and that overall system function and performance is achieved

Testing Strategy applied to Object-Oriented Software

- Must broaden testing to include detections of errors in analysis and design models
- Unit testing loses some of its meaning and integration testing changes significantly
- Use the same philosophy but different approach as in conventional software testing
- Test "in the small" and then work out to testing "in the large"
  - Testing in the small involves class attributes and operations; the main focus is on communication and collaboration within the class
  - Testing in the large involves a series of regression tests to uncover errors due to communication and collaboration among classes
- Finally, the system as a whole is tested to detect errors in fulfilling requirements

When is Testing Complete?

- There is no definitive answer to this question
- Every time a user executes the software, the program is being tested
- Sadly, testing usually stops when a project is running out of time, money, or both
- One approach is to divide the test results into various severity levels
  - Then consider testing to be complete when certain levels of errors no longer occur or have been repaired or eliminated

Ensuring a Successful Software Test Strategy

- Specify product requirements in a quantifiable manner long before testing commences
- State testing objectives explicitly in measurable terms
- Understand the user of the software (through use cases) and develop a profile for each user category
- Develop a testing plan that emphasizes rapid cycle testing to get quick feedback to control quality levels and adjust the test strategy
- Build robust software that is designed to test itself and can diagnose certain kinds of errors
- Use effective formal technical reviews as a filter prior to testing to reduce the amount of testing required
- Conduct formal technical reviews to assess the test strategy and test cases themselves
- Develop a continuous improvement approach for the testing process through the gathering of metrics

Test Strategies for Conventional Software

Unit Testing

- Focuses testing on the function or software module
- Concentrates on the internal processing logic and data structures
- Is simplified when a module is designed with high cohesion
  - Reduces the number of test cases
  - Allows errors to be more easily predicted and uncovered
- Concentrates on critical modules and those with **high cyclomatic complexity** when testing resources are limited

Targets for Unit Test Cases

- Module interface
  - Ensure that information flows properly into and out of the module
- Local data structures
  - Ensure that data stored temporarily maintains its integrity during all steps in an algorithm execution
- Boundary conditions
  - Ensure that the module operates properly at boundary values established to limit or restrict processing
- Independent paths (basis paths)
  - Paths are exercised to ensure that all statements in a module have been executed at least once
- Error handling paths
  - Ensure that the algorithms respond correctly to specific error conditions

Common Computational Errors in Execution Paths

- Misunderstood or incorrect arithmetic precedence
- Mixed mode operations (e.g., int, float, char)
- Incorrect initialization of values
- Precision inaccuracy and round-off errors
- Incorrect symbolic representation of an expression (int vs. float)

Other Errors to Uncover

- Comparison of different data types
- Incorrect logical operators or precedence
- Expectation of equality when precision error makes equality unlikely
- Incorrect comparison of variables
- Improper or nonexistent loop termination
- Failure to exit when divergent iteration is encountered
- Improperly modified loop variables
- Boundary value violations

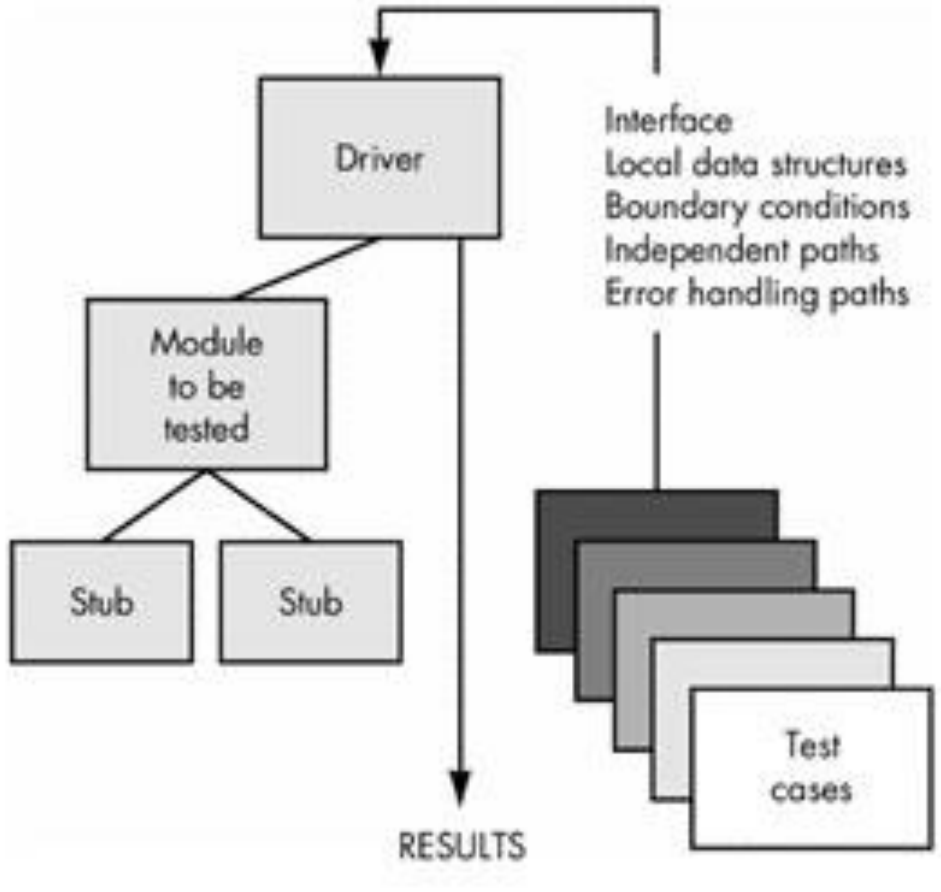
Problems to uncover in Error Handling

- Error description is unintelligible or ambiguous
- Error noted does not correspond to error encountered
- Error condition causes operating system intervention prior to error handling
- Exception condition processing is incorrect
- Error description does not provide enough information to assist in the location of the cause of the error

Drivers and Stubs for Unit Testing

- Driver
  - A simple main program that accepts test case data, passes such data to the component being tested, and prints the returned results
- Stubs
  - Serve to replace modules that are subordinate to (called by) the component to be tested
  - It uses the module’s exact interface, may do minimal data manipulation, provides verification of entry, and returns control to the module undergoing testing
- Drivers and stubs both represent overhead
  - Both must be written but don’t constitute part of the installed software product

Drivers and Stubs for Unit Testing



Integration Testing

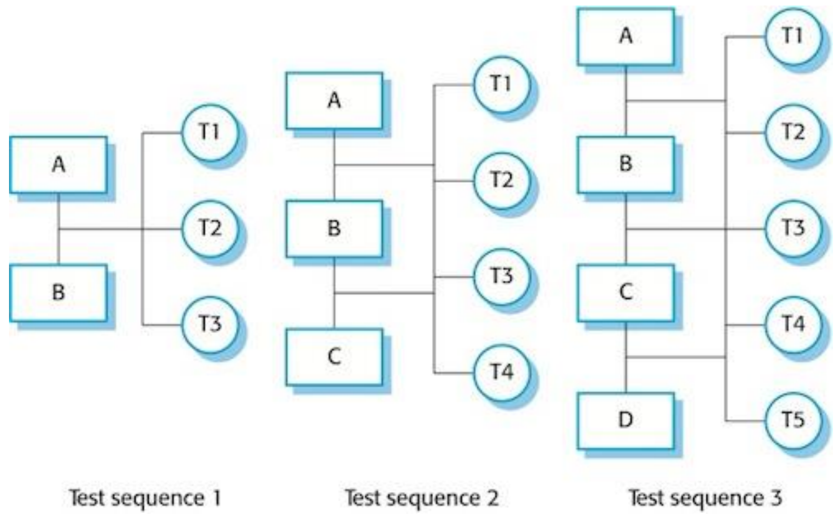
- Defined as a systematic technique for constructing the software architecture
  - At the same time integration is occurring, conduct tests to uncover errors associated with interfaces
- Objective is to take unit tested modules and build a program structure based on the prescribed design
- Two Approaches
  - Non-incremental Integration Testing
  - Incremental Integration Testing

Non-incremental Integration Testing

- Commonly called the “Big Bang” approach
- All components are combined in advance
- The entire program is tested as a whole
- Chaos results
- Many seemingly-unrelated errors are encountered
- Correction is difficult because isolation of causes is complicated
- Once a set of errors are corrected, more errors occur, and testing appears to enter an endless loop

Incremental Integration Testing

- Three kinds
  - Top-down integration
  - Bottom-up integration
  - Sandwich integration
- The program is constructed and tested in small increments
- Errors are easier to isolate and correct
- Interfaces are more likely to be tested completely
- A systematic test approach is applied

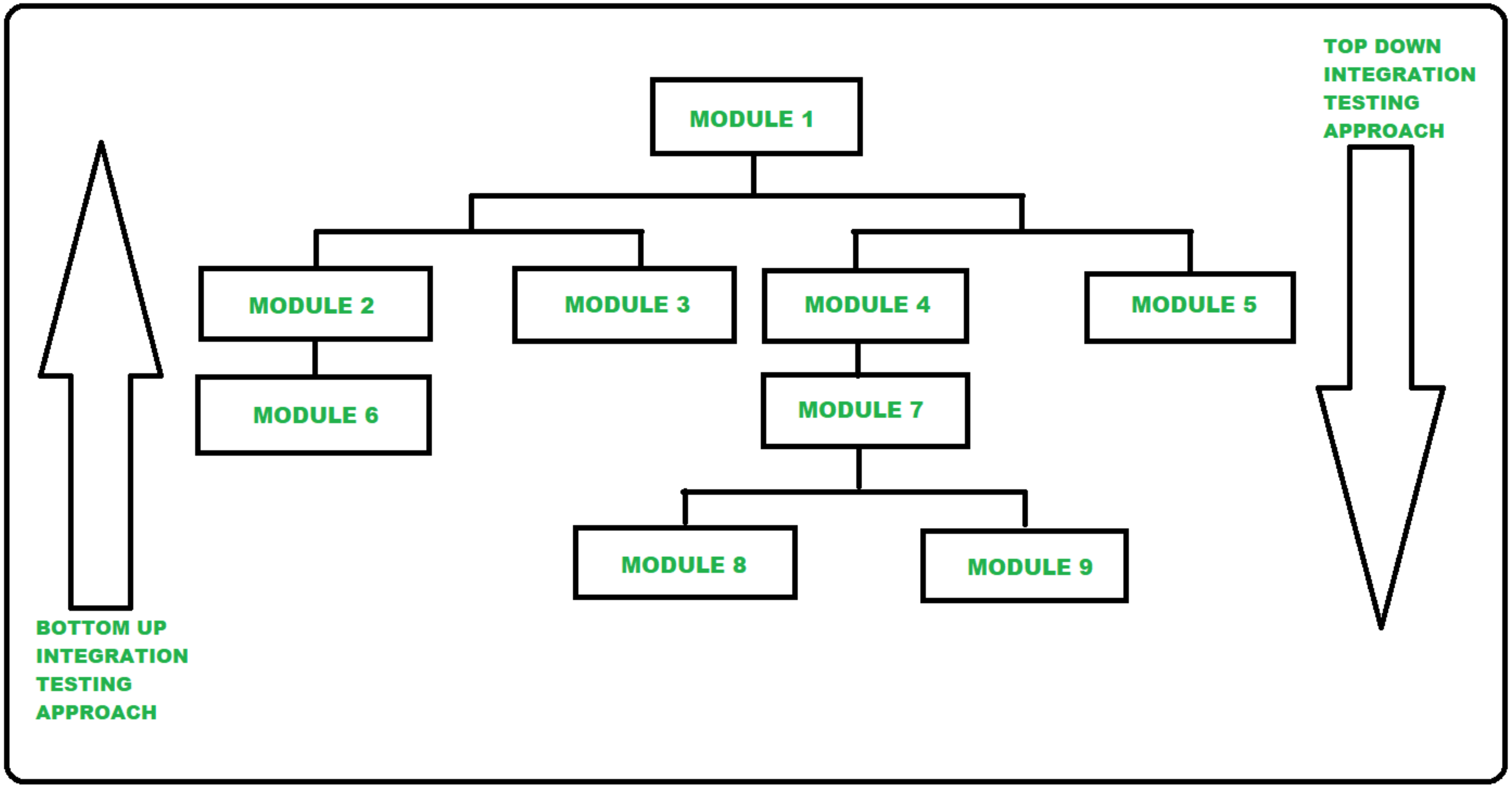


Top-down Integration

- Modules are integrated by moving downward through the control hierarchy, beginning with the main module
- Subordinate modules are incorporated in either a depth-first or breadth-first fashion
  - DF: All modules on a major control path are integrated
  - BF: All modules directly subordinate at each level are integrated
- Advantages
  - This approach verifies major control or decision points early in the test process
- Disadvantages
  - Stubs need to be created to substitute for modules that have not been built or tested yet; this code is later discarded
  - Because stubs are used to replace lower level modules, no significant data flow can occur until much later in the integration/testing process

Bottom-up Integration

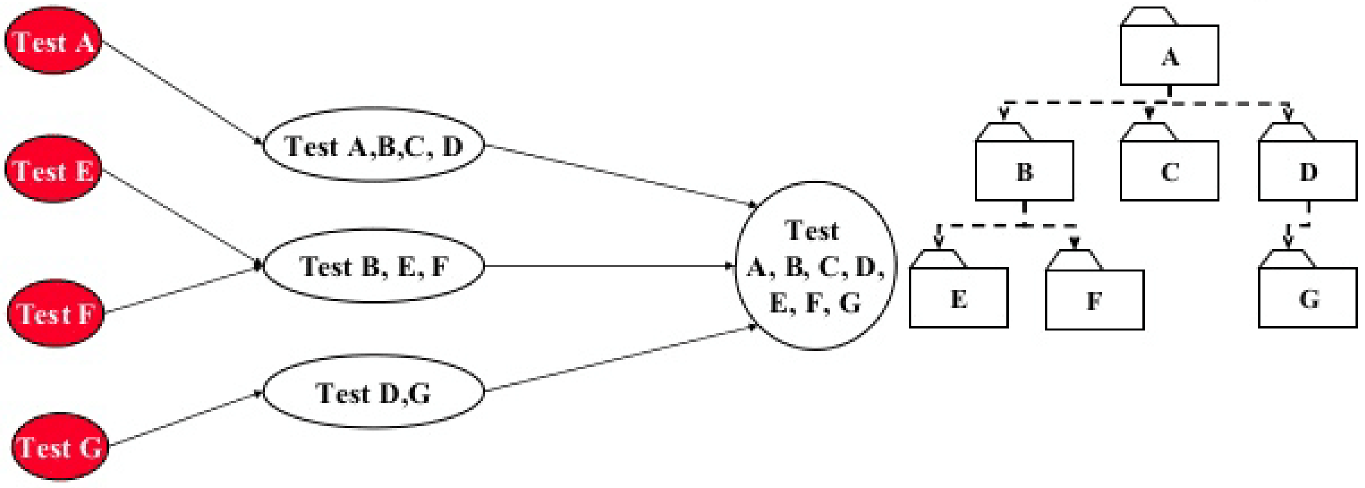
- Integration and testing starts with the most atomic modules in the control hierarchy
- Advantages
  - This approach verifies low-level data processing early in the testing process
  - Need for stubs is eliminated
- Disadvantages
  - Driver modules need to be built to test the lower-level modules; this code is later discarded or expanded into a full-featured version
  - Drivers inherently do not contain the complete algorithms that will eventually use the services of the lower-level modules; consequently, testing may be incomplete or more testing may be needed later when the upper level modules are available


TOP DOWN INTEGRATION TESTING APPROACH
MODULE 1
MODULE 2
MODULE 3
MODULE 4
MODULE 5
MODULE 6
MODULE 7
MODULE 8
MODULE 9
BOTTOM UP INTEGRATION TESTING APPROACH

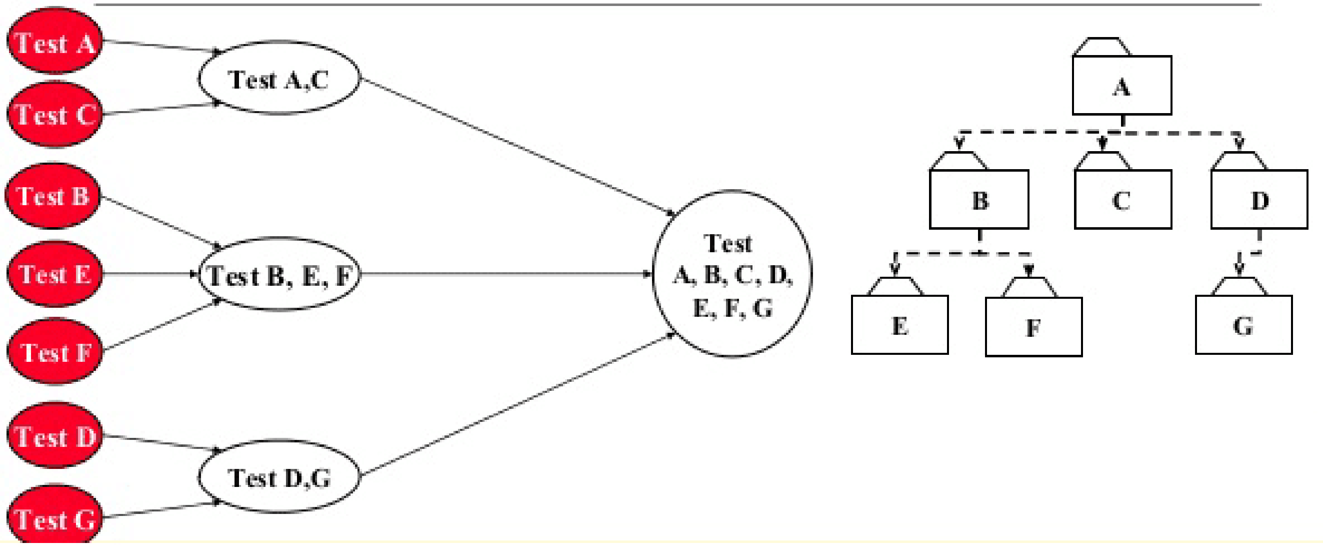
Sandwich Integration

- Consists of a combination of both top-down and bottom-up integration
- Occurs both at the highest level modules and also at the lowest level modules
- Proceeds using functional groups of modules, with each group completed before the next
    - High and low-level modules are grouped based on the control and data processing they provide for a specific program feature
    - Integration within the group progresses in alternating steps between the high and low level modules of the group
    - When integration for a certain functional group is complete, integration and testing moves onto the next group
- Reaps the advantages of both types of integration while minimizing the need for drivers and stubs
- Requires a disciplined approach so that integration doesn’t tend towards the “big bang” scenario

Sandwich Testing Strategy

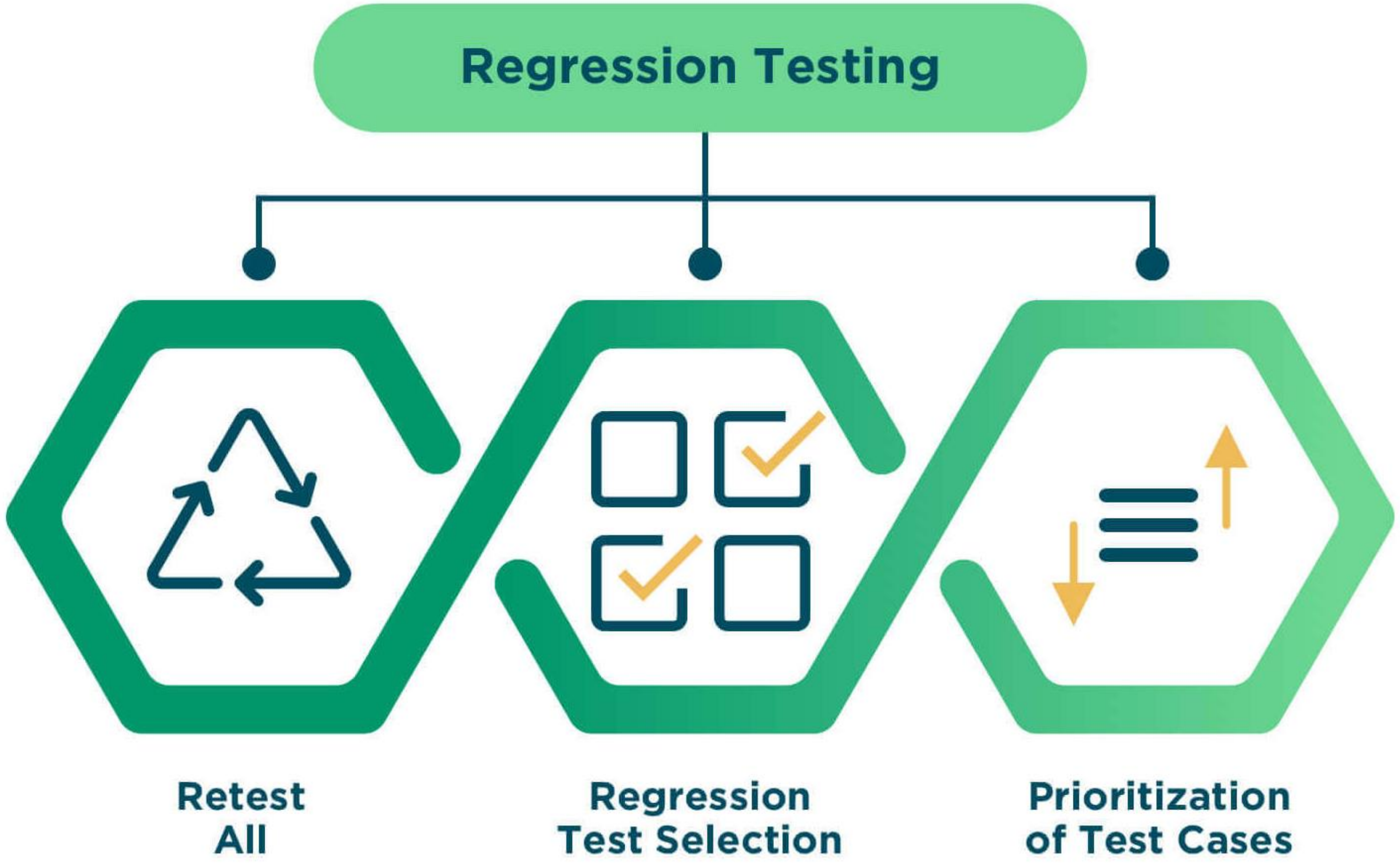


Modified Sandwich Testing



Regression Testing

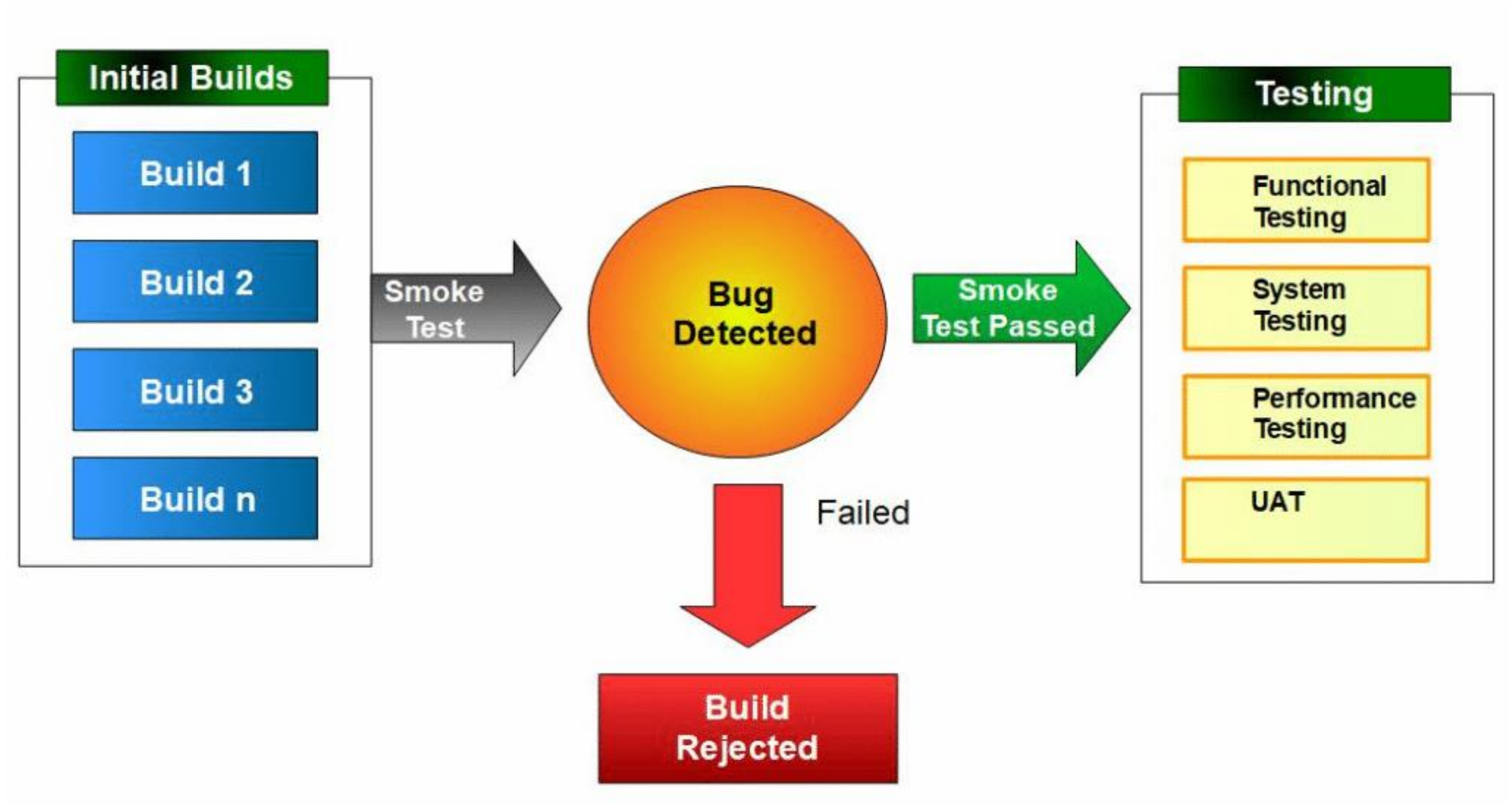
- Each new addition or change to baselined software may cause problems with functions that previously worked flawlessly
- Regression testing re-executes a small subset of tests that have already been conducted
    - Ensures that changes have not propagated unintended side effects
    - Helps to ensure that changes do not introduce unintended behavior or additional errors
    - May be done manually or through the use of automated capture/playback tools
- Regression test suite contains three different classes of test cases
    - A representative sample of tests that will exercise all software functions
    - Additional tests that focus on software functions that are likely to be affected by the change
    - Tests that focus on the actual software components that have been changed


Regression Testing
Retest All
Regression Test Selection
Prioritization of Test Cases

Smoke Testing

- Taken from the world of hardware
  - Power is applied and a technician checks for sparks, smoke, or other dramatic signs of fundamental failure
- Designed as a pacing mechanism for time-critical projects
  - Allows the software team to assess its project on a frequent basis
- Includes the following activities
  - The software is compiled and linked into a build
  - A series of breadth tests is designed to expose errors that will keep the build from properly performing its function
    - The goal is to uncover “show stopper” errors that have the highest likelihood of throwing the software project behind schedule
  - The build is integrated with other builds and the entire product is smoke tested daily
    - Daily testing gives managers and practitioners a realistic assessment of the progress of the integration testing
  - After a smoke test is completed, detailed test scripts are executed

Smoke Testing



Benefits of Smoke Testing

- Integration risk is minimized
  - Daily testing uncovers incompatibilities and show-stoppers early in the testing process, thereby reducing schedule impact
- The quality of the end-product is improved
  - Smoke testing is likely to uncover both functional errors and architectural and component-level design errors
- Error diagnosis and correction are simplified
  - Smoke testing will probably uncover errors in the newest components that were integrated
- Progress is easier to assess
  - As integration testing progresses, more software has been integrated and more has been demonstrated to work
  - Managers get a good indication that progress is being made

Test Strategies for Object-Oriented Software

Test Strategies for Object-Oriented Software

- With object-oriented software, you can no longer test a single operation in isolation (conventional thinking)
- Traditional top-down or bottom-up integration testing has little meaning
- Class testing for object-oriented software is the equivalent of unit testing for conventional software
  - Focuses on operations encapsulated by the class and the state behavior of the class
- Drivers can be used
  - To test operations at the lowest level and for testing whole groups of classes
  - To replace the user interface so that tests of system functionality can be conducted prior to implementation of the actual interface
- Stubs can be used
  - In situations in which collaboration between classes is required but one or more of the collaborating classes has not yet been fully implemented

Test Strategies for Object-Oriented Software (continued)

- Two different object-oriented testing strategies
  - Thread-based testing
    - Integrates the set of classes required to respond to one input or event for the system
    - Each thread is integrated and tested individually
    - Regression testing is applied to ensure that no side effects occur
  - Use-based testing
    - First tests the independent classes that use very few, if any, server classes
    - Then the next layer of classes, called dependent classes, are integrated
    - This sequence of testing layer of dependent classes continues until the entire system is constructed

Validation Testing

Background

- Validation testing follows integration testing
- The distinction between conventional and object-oriented software disappears
- Focuses on user-visible actions and user-recognizable output from the system
- Demonstrates conformity with requirements
- Designed to ensure that
    - All functional requirements are satisfied
    - All behavioral characteristics are achieved
    - All performance requirements are attained
    - Documentation is correct
    - Usability and other requirements are met (e.g., transportability, compatibility, error recovery, maintainability)
- After each validation test
    - The function or performance characteristic conforms to specification and is accepted
    - A deviation from specification is uncovered and a deficiency list is created
- A configuration review or audit ensures that all elements of the software configuration have been properly developed, cataloged, and have the necessary detail for entering the support phase of the software life cycle

Alpha and Beta Testing

- Alpha testing
  - Conducted at the developer's site by end users
  - Software is used in a natural setting with developers watching intently
  - Testing is conducted in a controlled environment
- Beta testing
  - Conducted at end-user sites
  - Developer is generally not present
  - It serves as a live application of the software in an environment that cannot be controlled by the developer
  - The end-user records all problems that are encountered and reports these to the developers at regular intervals
- After beta testing is complete, software engineers make software modifications and prepare for release of the software product to the entire customer base

System Testing

Different Types

- Recovery testing
  - Tests for recovery from system faults
  - Forces the software to fail in a variety of ways and verifies that recovery is properly performed
  - Tests reinitialization, checkpointing mechanisms, data recovery, and restart for correctness
- Security testing
  - Verifies that protection mechanisms built into a system will, in fact, protect it from improper access
- Stress testing
  - Executes a system in a manner that demands resources in abnormal quantity, frequency, or volume
- Performance testing
  - Tests the run-time performance of software within the context of an integrated system
  - Often coupled with stress testing and usually requires both hardware and software instrumentation
  - Can uncover situations that lead to degradation and possible system failure

Software Maintenance

Software Maintenance

- Software Maintenance is the process of modifying a software product after it has been delivered to the customer. The main purpose of software maintenance is to modify and update software applications after delivery to correct faults and to improve performance.
- **Need for Maintenance –**
  Software Maintenance must be performed in order to:
  - Correct faults.
  - Improve the design.
  - Implement enhancements.
  - Interface with other systems.
  - Accommodate programs so that different hardware, software, system features, and telecommunications facilities can be used.
  - Migrate legacy software.
  - Retire software.

Categories of Software Maintenance

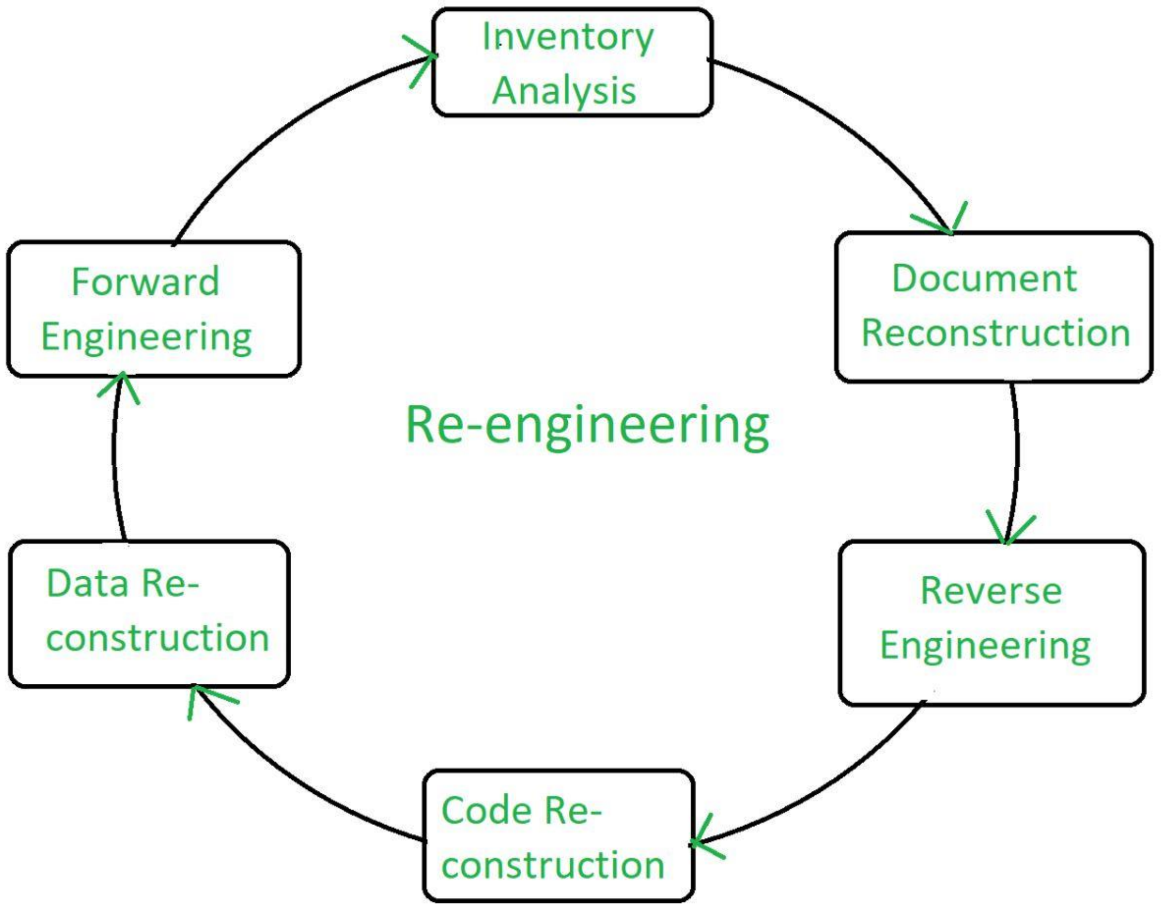
1. **Corrective maintenance**:
   Corrective maintenance of a software product may be essential either to rectify some bugs observed while the system is in use, or to enhance the performance of the system.
2. **Adaptive maintenance**:
   This includes modifications and updations when the customers need the product to run on new platforms, on new operating systems, or when they need the product to interface with new hardware and software.
3. **Perfective maintenance**:
   A software product needs maintenance to support the new features that the users want or to change different types of functionalities of the system according to the customer demands.
4. **Preventive maintenance**:
   This type of maintenance includes modifications and updations to prevent future problems of the software. It goals to attend problems, which are not significant at this moment but may cause serious issues in future.

Software Re-engineering

Software Re-engineering

- It is a process of software development which is done to **improve the maintainability of a software system**. Re-engineering is the examination and alteration of a system to reconstitute it in a new form.
- This process encompasses a combination of sub-processes like reverse engineering, forward engineering, reconstructing etc.

Steps involved in Re-engineering:

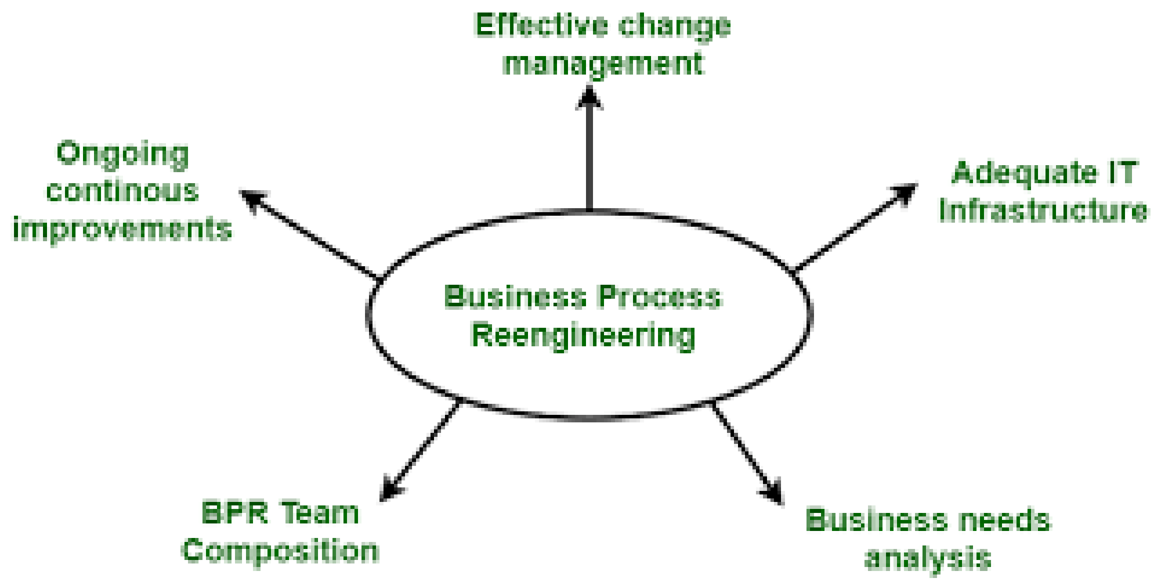


- **Advantages of Re-engineering:**
  - Reduced Risk
  - Reduced Cost
  - Revelation of Business Rules
  - Better use of Existing Staff

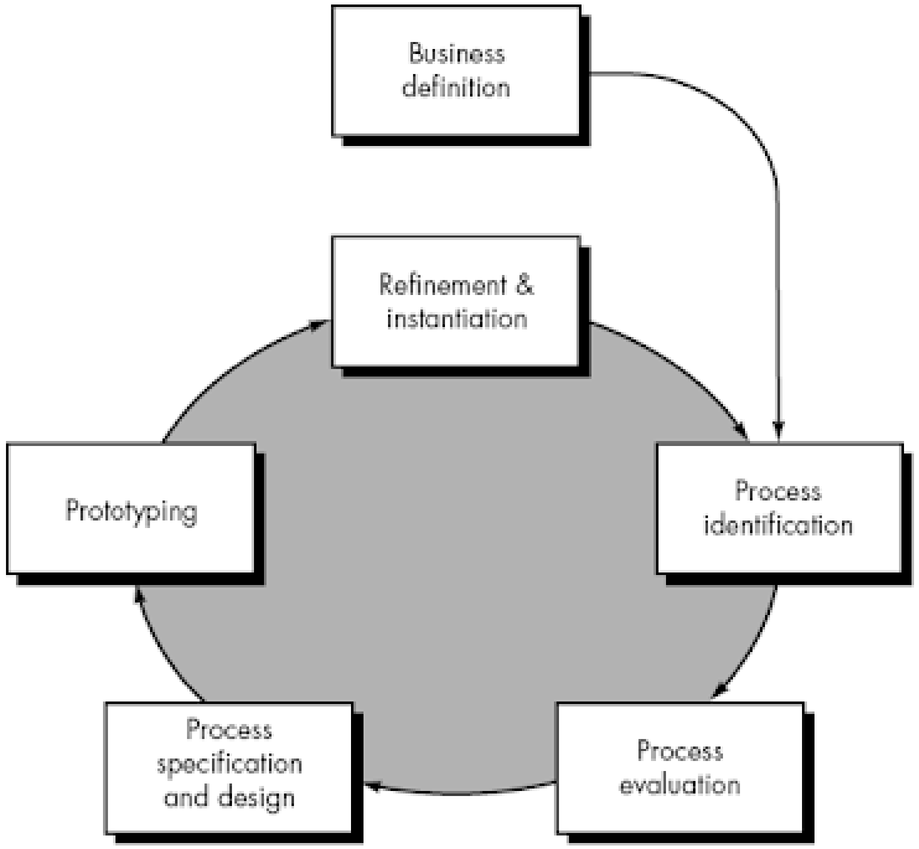
- **Disadvantages of Re-engineering:**
  - Practical limits to the extent of re-engineering.
  - Major architectural changes or radical reorganizing of the systems data management has to be done manually.
  - Re-engineered system is not likely to be as maintainable as a new system developed using modern software Re-engineering methods.

Business Process Re-engineering

- Business process engineering is a **way in which organizations study their current business processes and develop new methods to improve productivity, efficiency, and operational costs**.


Effective change management
Ongoing continous improvements
Adequate IT Infrastructure
Business Process Reengineering
BPR Team Composition
Business needs analysis

A BPR Model


Business definition
Refinement & instantiation
Prototyping
Process identification
Process specification and design
Process evaluation

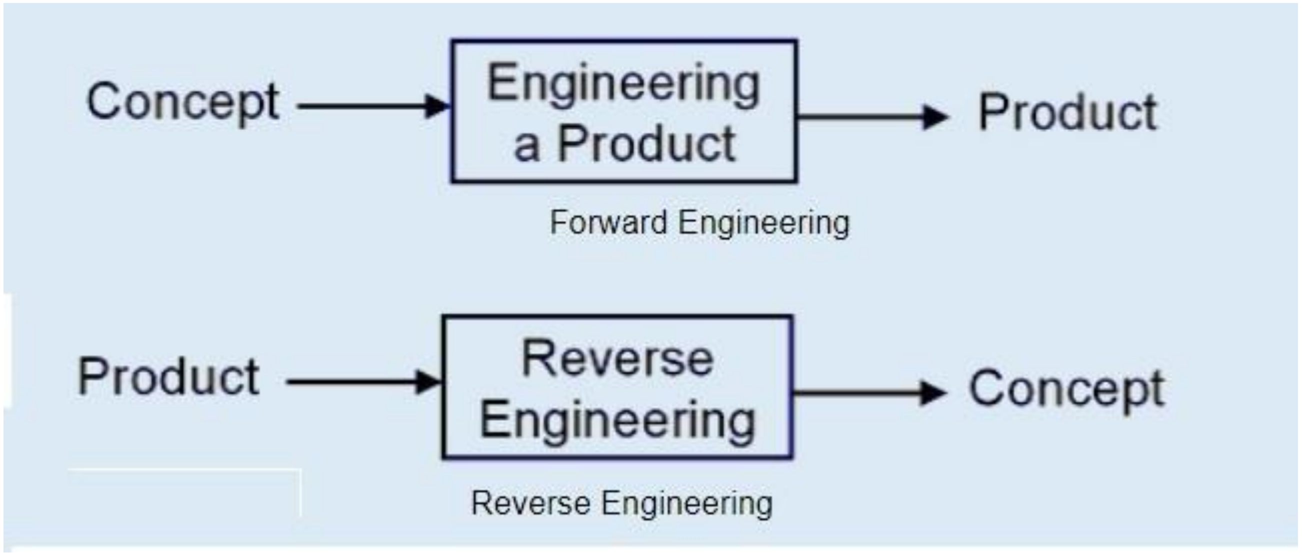
Software Reverse Engineering

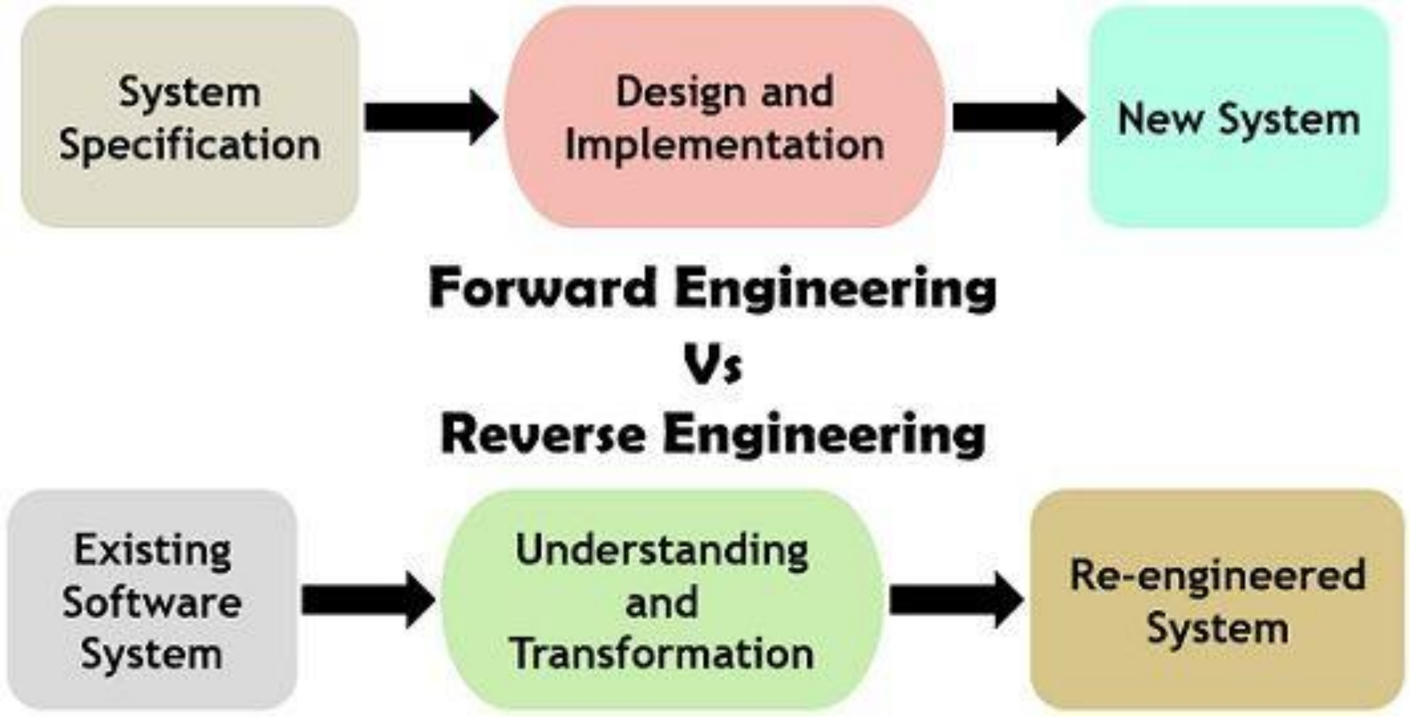
- Software Reverse Engineering is the process of recovering the design and the requirements specification of a product from an analysis of it’s code.
- Reverse Engineering is becoming important, since several existing software products, lack proper documentation, are highly unstructured, or their structure has degraded through a series of maintenance efforts.
- **Why Reverse Engineering?**
  - Providing proper system documentation.
  - Recovery of lost information.
  - Assisting with maintenance.
  - Facility of software reuse.
  - Discovering unexpected flaws or faults.

- **Uses of Software Reverse Engineering –**
- Software Reverse Engineering is used in software design, reverse engineering enables the developer or programmer to add new features to the existing software with or without knowing the source code.
- Reverse engineering is also useful in software testing, it helps the testers to study the virus and other malware code .

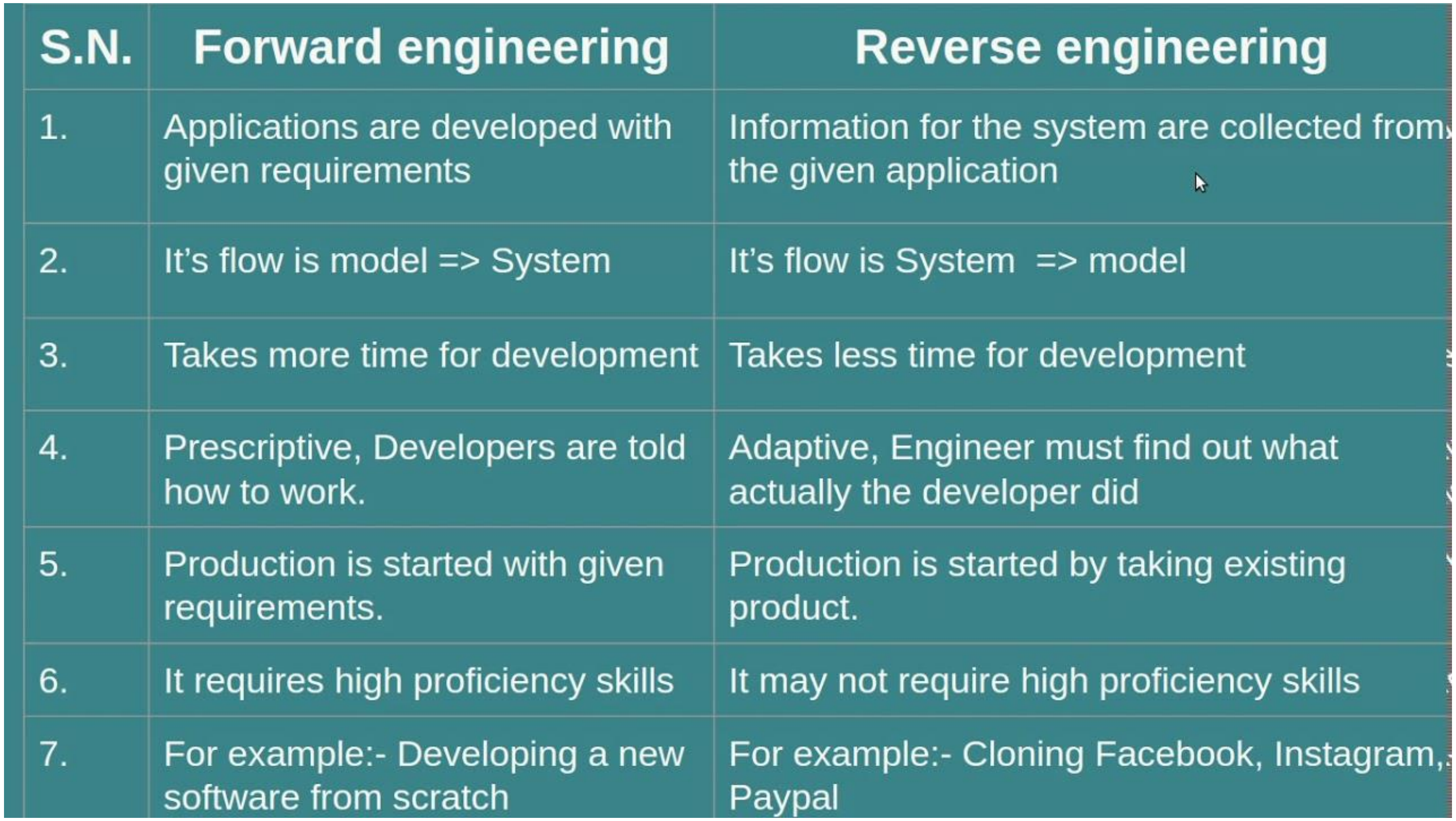
Forward Engineering

- Forward Engineering is a method of creating or making an application with the help of the given requirements.
- Forward engineering is also known as Renovation and Reclamation. Forward engineering is required high proficiency skills. It takes more time to construct or develop an application. Forward engineering is a technique of creating high-level models or designs to make in complexities and low-level information.
- Forward Engineering applies of all the software engineering process which contains SDLC to recreate associate existing application. It is near to full fill new needs of the users into re-engineering.


Concept
Engineering a Product
Product
Forward Engineering
Product
Reverse Engineering
Concept
Reverse Engineering


System Specification
Design and Implementation
New System
Forward Engineering
Vs
Reverse Engineering
Existing Software System
Understanding and Transformation
Re-engineered System

Difference between Forward Engineering and Reverse Engineering:



S.N.	Forward engineering	Reverse engineering
1.	Applications are developed with given requirements	Information for the system are collected from the given application
2.	It's flow is model => System	It's flow is System => model
3.	Takes more time for development	Takes less time for development
4.	Prescriptive, Developers are told how to work.	Adaptive, Engineer must find out what actually the developer did
5.	Production is started with given requirements.	Production is started by taking existing product.
6.	It requires high proficiency skills	It may not require high proficiency skills
7.	For example:- Developing a new software from scratch	For example:- Cloning Facebook, Instagram, Paypal