SW Development & QA

CSH6 Chapter 39

"Software Development and Quality Assurance"

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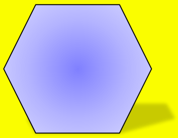
Topics

- Introduction
- Goals of SW QA
- SW Devt Lifecycle
- Types of SW Errors
- Designing SW Test Cases
- Before Going Into Production
- Managing Change
- Sources of Bugs & Problems

Introduction

- Development potentially affects all 6 elements of Parkerian Hexad
- Usually affects
  - ❑Integrity
  - ❑Availability
  - ❑Utility



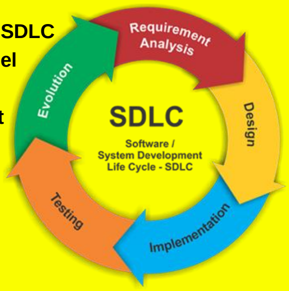
- COTS (commercial off the shelf) software often needs to be customized
- Many programs still developed from scratch
- Project managers typically underestimate
  - ❑Effects of errors
  - ❑Time required to get project right

Goals of SW QA

- IEEE definition of quality: *"degree to which …[x]… meets customer or user needs or expectations."*
- Uncover All Program Problems
  - ❑Assume they are there – TEST to find them
- Reduce Likelihood that Defective Programs Enter Production
  - ❑Costs escalate (~10x) with every stage through which problems are undiscovered or ignored
- Safeguard Interests of Users
  - ❑No point in having software that is irrelevant
  - ❑SQA should report at same mgmt level as SW development
- Safeguard Interests of SW Producers
  - ❑Avoid legal liability for failures, damages

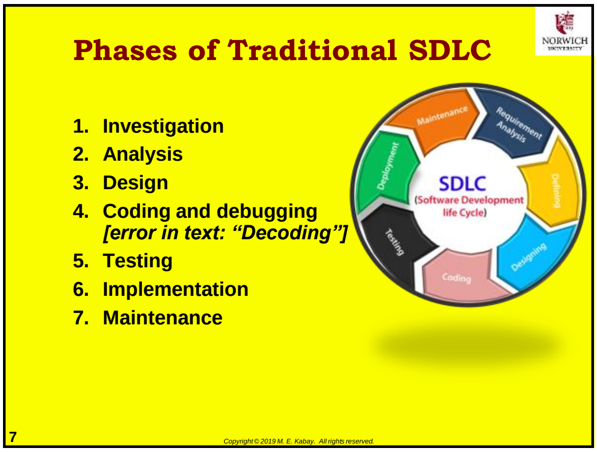
SW Devt Lifecycle (SDLC)

- Overview of SDLC
- Phases of Traditional SDLC
- Classic Waterfall Model
- RAD & JAD
- Integrating Security at Every Phase



Overview of SDLC

- SW devt projects often large
  - ❑Need orderly process to coordinate efforts
- Phased approach defines milestones
  - ❑Often defined using specific documents
  - ❑But in reality, development does not match strict step-by-step progression
  - ❑Often have overlapping stages in different sections of project
- Different models for development co-exist
  - ❑Useful in different contexts
  - ❑Adapt to needs for rapid access to early productivity vs rigid demands for strict controls



Phases of Traditional SDLC

1. Investigation
2. Analysis
3. Design
4. Coding and debugging *[error in text: "Decoding"]*
5. Testing
6. Implementation
7. Maintenance

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SDLC
(Software Development life Cycle)
Maintenance
Requirement Analysis
Defining
Designing
Coding
Testing
Deployment

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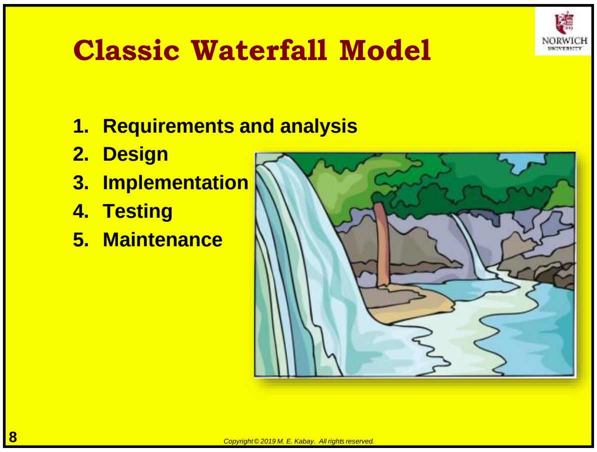

Classic Waterfall Model

1. Requirements and analysis
2. Design
3. Implementation
4. Testing
5. Maintenance

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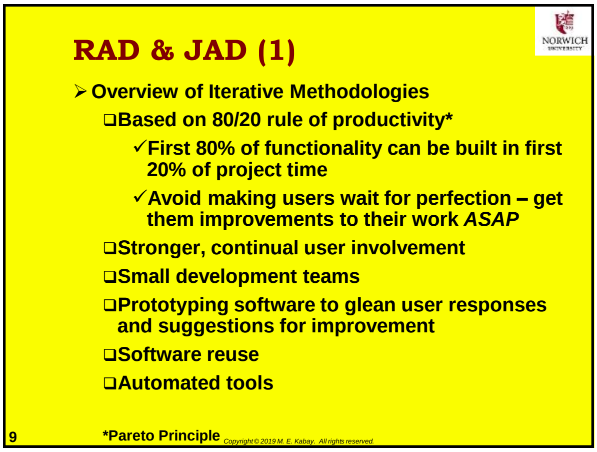

RAD & JAD (1)

- Overview of Iterative Methodologies
  - ❑Based on 80/20 rule of productivity*
    - ✓First 80% of functionality can be built in first 20% of project time
    - ✓Avoid making users wait for perfection – get them improvements to their work *ASAP*
  - ❑Stronger, continual user involvement
  - ❑Small development teams
  - ❑Prototyping software to glean user responses and suggestions for improvement
  - ❑Software reuse
  - ❑Automated tools

*Pareto Principle

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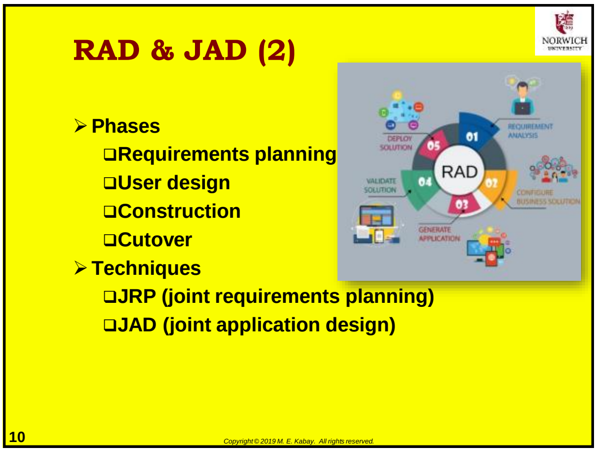

RAD & JAD (2)

- Phases
  - ❑Requirements planning
  - ❑User design
  - ❑Construction
  - ❑Cutover
- Techniques
  - ❑JRP (joint requirements planning)
  - ❑JAD (joint application design)

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RAD
01
REQUIREMENT ANALYSIS
02
CONFIGURE BUSINESS SOLUTION
03
GENERATE APPLICATION
04
VALIDATE SOLUTION
05
DEPLOY SOLUTION

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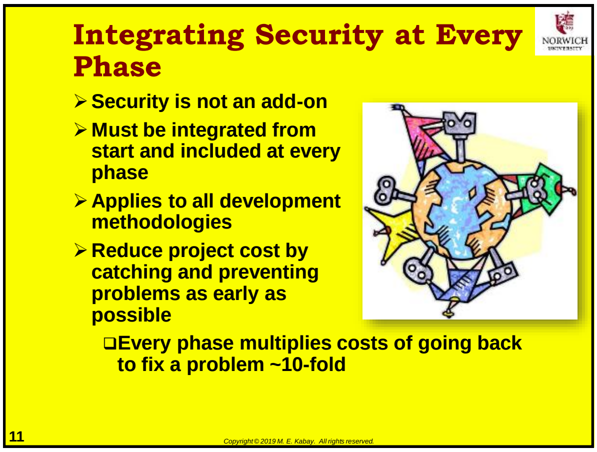

Integrating Security at Every Phase

- Security is not an add-on
- Must be integrated from start and included at every phase
- Applies to all development methodologies
- Reduce project cost by catching and preventing problems as early as possible
  - ❑Every phase multiplies costs of going back to fix a problem ~10-fold

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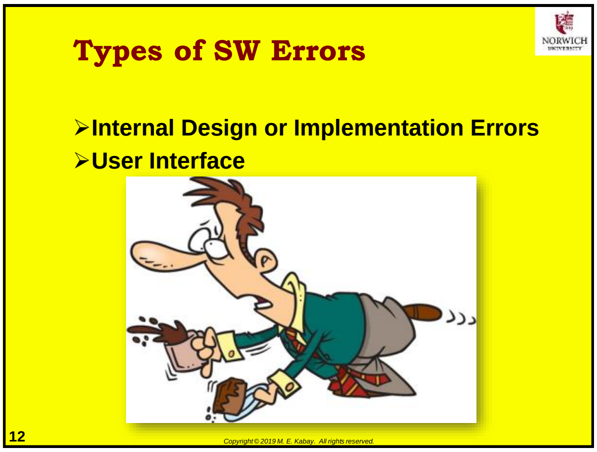

Types of SW Errors

- Internal Design or Implementation Errors
- User Interface

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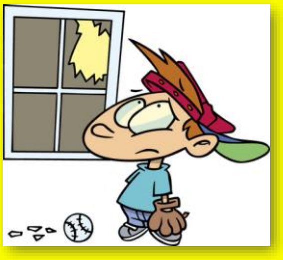
Internal Design or Implementation Errors



- Initialization
- Logic Flow
- Calculation
- Boundary Condition Violations
- Parameter Passing
- Race Conditions
- Load Conditions
- Resource Exhaustion
- Interapplication Conflicts
- Other Technical Errors
- Regulatory Compliance Considerations

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Initialization Errors

- Difficult to find
- Programmer forgets to save initialization data to disk BEFORE trying to run program
  - ❑So program fails on first run
  - ❑But works on second try
- Or program may leave out only certain initial values, causing funny results on first run or loop

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Logic Flow Errors

- Error when control passes to wrong routine or module
- Can happen when a conditional statement either
  - Looks at wrong variable or
  - Looks at right variable but has bad value
- Can also happen when execution falls through a missing end-of-routine marker (e.g., RETURN)

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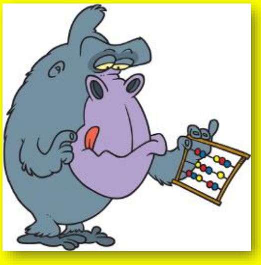
Calculation Errors



- Wrong formula
- Roundoff errors when programmer forgets precision of data fields
  - ❑E.g., multiplies a long-real by a short-real variable
  - ❑Thus loses precision in product
- Variables may be defined with wrong precision
  - ❑E.g., 16 bits instead of 32 bits

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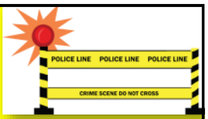
Boundary Condition Violations



- Attempting to read or write beyond the end of an array is viewed as a sign of serious corruption by most operating systems
  - ❑Call a hardware *halt* instruction – e.g., HP3000 *suddendeath()* with parm for type of error
- Arrays defined with wrong number of maximum values
  - ❑E.g., “year” array with only 365 values
  - ❑In leap year,
    - ✓December 30 is #365
    - ✓Next day tries to roll to 366 > limit
    - ✓Causes process or system crash
- But going under or over any limits can cause problems

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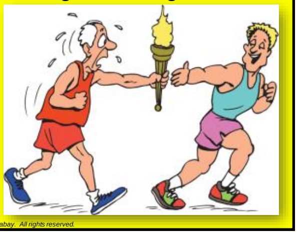
Parameter Passing Errors

- Modules / routines / objects must respect expected / defined variables passed among them
  - ❑Passing wrong types or contents may cause serious errors
- Can corrupt data (e.g., writing into wrong area of memory or disk)
- May affect logical flags
- Can switch execution into aberrant paths



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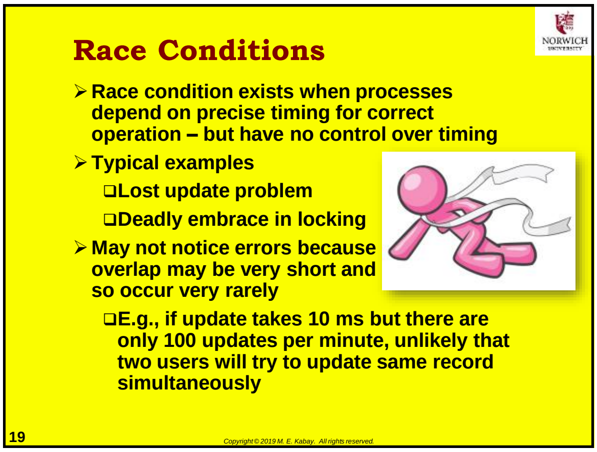

Race Conditions

- ➢ Race condition exists when processes depend on precise timing for correct operation – but have no control over timing
- ➢ Typical examples
  - ❑Lost update problem
  - ❑Deadly embrace in locking
- ➢ May not notice errors because overlap may be very short and so occur very rarely
  - ❑E.g., if update takes 10 ms but there are only 100 updates per minute, unlikely that two users will try to update same record simultaneously

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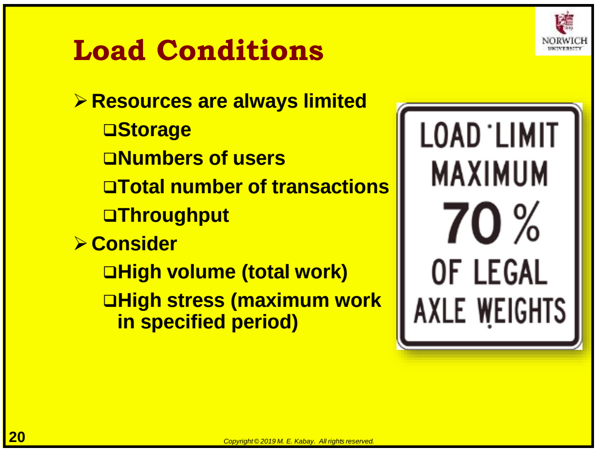

Load Conditions

- ➢ Resources are always limited
  - ❑Storage
  - ❑Numbers of users
  - ❑Total number of transactions
  - ❑Throughput
- ➢ Consider
  - ❑High volume (total work)
  - ❑High stress (maximum work in specified period)

LOAD LIMIT
MAXIMUM
70 %
OF LEGAL
AXLE WEIGHTS

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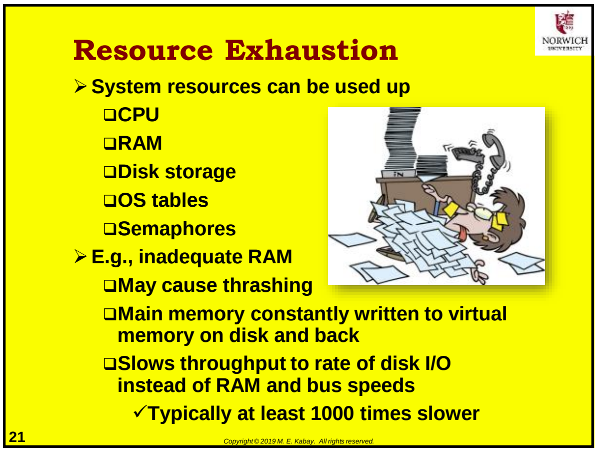

Resource Exhaustion

- ➢ System resources can be used up
  - ❑CPU
  - ❑RAM
  - ❑Disk storage
  - ❑OS tables
  - ❑Semaphores
- ➢ E.g., inadequate RAM
  - ❑May cause thrashing
  - ❑Main memory constantly written to virtual memory on disk and back
  - ❑Slows throughput to rate of disk I/O instead of RAM and bus speeds
    - ✓Typically at least 1000 times slower

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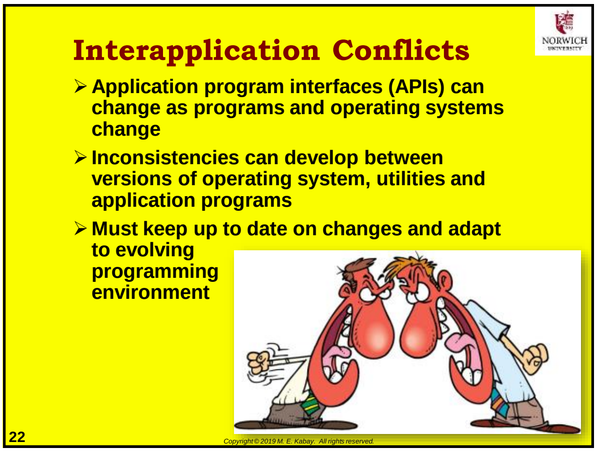

Interapplication Conflicts

- ➢ Application program interfaces (APIs) can change as programs and operating systems change
- ➢ Inconsistencies can develop between versions of operating system, utilities and application programs
- ➢ Must keep up to date on changes and adapt to evolving programming environment

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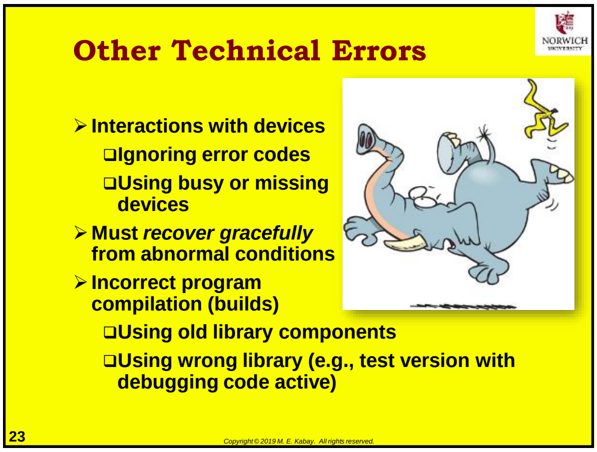

Other Technical Errors

- ➢ Interactions with devices
  - ❑Ignoring error codes
  - ❑Using busy or missing devices
- ➢ Must *recover gracefully* from abnormal conditions
- ➢ Incorrect program compilation (builds)
  - ❑Using old library components
  - ❑Using wrong library (e.g., test version with debugging code active)

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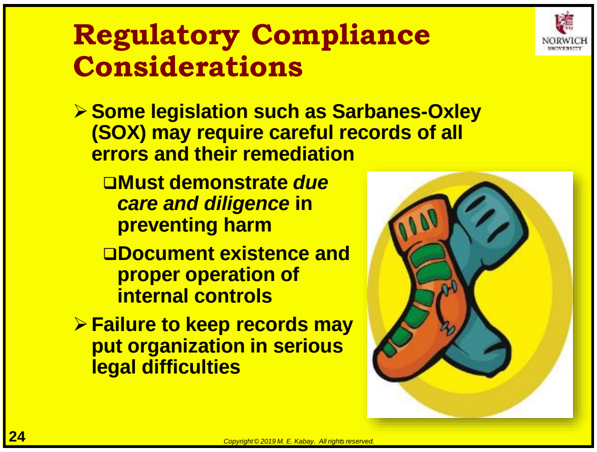

Regulatory Compliance Considerations

- ➢ Some legislation such as Sarbanes-Oxley (SOX) may require careful records of all errors and their remediation
  - ❑Must demonstrate *due care and diligence* in preventing harm
  - ❑Document existence and proper operation of internal controls
- ➢ Failure to keep records may put organization in serious legal difficulties

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User Interface Errors

- ➢ Overview of User Interface
- ➢ Functionality
- ➢ Control (Command) Structure
- ➢ Performance
- ➢ Output Format

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Overview of User Interface

- ➢ UI: all aspects of system relevant to user
  - ❑UVM: *user virtual machine*
  - ❑Screens, mouse movements, keyboard functions, print outputs, sounds, colors….
- ➢ Problems arise when developers fail to consider users' perspective
  - ❑"Who could possibly have thought of doing *that*???"
  - ❑"Why can't the **** users figure that out themselves???"
- ➢ Documentation is essential to support users
  - ❑But also for management and audit purposes

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Functionality Problems (1)

- ➢ Confusing, awkward, difficult, impossible
- ➢ Function is missing
- ➢ Undocumented features
- ➢ Required information is missing
- ➢ Program fails to confirm / respond to valid input
- ➢ Errors in output
- ➢ Conflicting names for features
- ➢ Too much information

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Functionality Problems (2)

- ➢ Cursor disappears or appears in wrong place
- ➢ Screen displays are wrong
- ➢ Instructions difficult to find or read
- ➢ Identical functions require different operationsScreens don't match expected format
- ➢ Passwords or other confidential data unprotected
- ➢ Impossible to trace data entry or changes (bad audit trails)
- ➢ Segregation of duties not enforced

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Control (Command) Structure Errors

- ➢ Sequence of operations determined by control structure
- ➢ Errors can confuse users or cause data loss; e.g.,
  - ❑Impossible to move between menus
  - ❑Confusing, repetitive, contradictory menus
  - ❑Inadequate command-line entries
  - ❑Requiring non-intuitive command-line entries
  - ❑Deviating from operating system conventions
  - ❑Failure to show correct error messages
  - ❑Contradicting standard keyboard function keys
  - ❑Omitting required commands
  - ❑Violating privacy and other security constraints

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Performance

- ➢ Quality of service (QoS) or service-level agreements (SLA) may define required throughput
  - ❑Maximum response times
  - ❑Minimum data throughputs
  - ❑Minimum transaction rates
- ➢ Rigid designs may impede rapid response to changing requirements
  - ❑E.g., programming business rules in code instead of in database metadata

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Output Format

- Printed or screen outputs must be controllable by user
- Fonts
- Emphasis (bolding, underlining, italics…)
- Spacing
- Tables, graphs,
- figures….
- Precision of numeric data
- Output device

Designing SW Test Cases

- Good Tests
- Emphasize Boundary Conditions
- Check All State Transitions
- Use Test-Coverage Monitors
- Seeding
- Building Test Data Sets

Good Tests

- Impossible to test program to perfection
  - ❑Too costly and lengthy
- But good testing finds *most* problems
  - ❑Emphasize eliminating *serious* errors
- Full-disclosure debate
  - ❑Should researchers announce bugs and vulnerabilities to the world immediately?
  - ❑Or should they tell developers first and give time to fix problems?
- Equivalence classes important
  - ❑Define tests that can be considered equivalent
  - ❑Examine design
  - ❑E.g., a program may treat all data < boundary same → an equivalence class "less than lower limit"

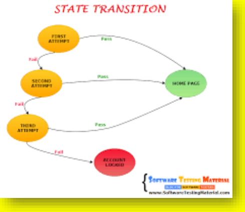
Emphasize Boundary Conditions

- Especially important to check boundary data
  - ❑Below, at and above boundaries
- Also test using different user categories
  - ❑Admin
  - ❑Root / super-user
  - ❑Data entry
  - ❑Read-only

- Be especially careful to test for buffer overflows
  - ❑Widely used by criminal hackers
  - ❑Can insert code into stack of interpreter in long data input strings
  - ❑Execute unauthorized code

Check All State Transitions

- Every change in data constitutes a state transition
- Map probably state transitions
  - ❑Transition probability matrix: from A to B
  - ❑Menu maps show exactly where user can go in program from each menu
- May not be able to test all possible transitions
  - ❑But can test most likely transitions first
- Test every limit
  - ❑Tools available for certain applications such as Web code
- Test for race conditions
  - ❑Use multiple clients executing automated scripts



Use Test-Coverage Monitors

- Difficult to track execution of program during test to identify which modules being run
  - ❑Primitive hand-coding writes log records
  - ❑Call print function with parameter for each routine
  - ❑Conditional compilation can allow debugging statements to remain or not
- Better: test-coverage monitors track every line of source code
  - ❑Show reports of how often every line used
  - ❑Thus can spot holes in testing
  - ❑Or holes in logic – code impossible to reach
  - ❑Or unauthorized code (Trojan horses, logic bombs)

Seeding

- Add known bugs to program
- Run test
- See if you catch the bugs
- Can also estimate approximate *rate* of capture by looking at proportion of known bugs spotted

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Building Test Data Sets

- DO NOT USE ACTUAL PRODUCTION DATA IN TESTING!
- You may extract sample data sets from production data for testing
  - ❑But keep confidentiality considerations in mind
  - ❑May have to anonymize or randomize some fields (e.g., for Health Insurance Portability and Accountability Act – HIPAA)
- Ideally, use completely separate test system
  - ❑Can use historical data with due attention to security / privacy
  - ❑Also supports compliance issues (HIPAA, SOX…)

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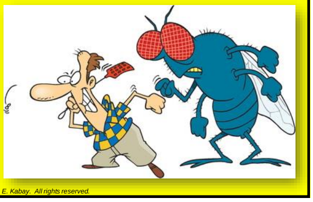
Before Going Into Production

- REGRESSION TESTING!!
  - ❑Testing everything you have done before
  - ❑Done after every change
- AUTOMATED TESTING!!!
  - ❑Repetitive testing difficult for people to monitor effectively (eyes glaze over)
  - ❑Automated testing far more efficient
  - ❑Can keep track of all errors
  - ❑Provide detailed report
- Tracking Bugs from Discovery to Removal
  - ❑*Fix* the bug
  - ❑Find out *why* there was a bug
  - ❑Fix the underlying *cause(s)* of the bug



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Managing Change

- Change Request
  - ❑Organized documentation of *who* wants *what why when*
  - ❑Allows prioritization
- Tracking System
  - ❑Make sure that bugs are not forgotten
  - ❑Also gather statistics about where bugs are being found and of what type – helps diagnosis
  - ❑Essential for continuous process improvement
- Regression Testing – as mentioned, always required after every bug fix
- Documentation
  - ❑Essential for continued smooth operations
  - ❑Required for compliance with legal, regulatory standards

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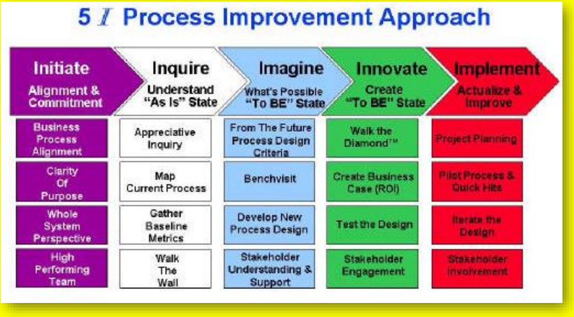
Continuous Process Improvement



5 *I* Process Improvement Approach

Initiate Alignment & Commitment	Inquire Understand "As Is" State	Imagine What's Possible "To BE" State	Innovate Create "To BE" State	Implement Actualize & Improve
Business Process Alignment	Appreciative Inquiry	From The Future Process Design Criteria	Walk the Diamond™	Project Planning
Clarity Of Purpose	Map Current Process	Benchvisit	Create Business Case (ROI)	Pilot Process & Quick Hits
Whole System Perspective	Gather Baseline Metrics	Develop New Process Design	Test the Design	Iterate the Design
High Performing Team	Walk The Wall	Stakeholder Understanding & Support	Stakeholder Engagement	Stakeholder Involvement

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Sources of Bugs & Problems

- Design Flaws
- Implementation Flaws
- Unauthorized Changes to Production Code
- Insufficient or Substandard Programming Quality
- Data Corruption
- Criminal Hacking

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Design Flaws

- Poor communication between users and designers
  - Keep good documentation throughout development process
  - Helps identify breakdown in communication
- Trying to meet unrealistic delivery schedules
  - Managers must resist pressure to rush
  - All of the development stages are important
  - Rushing may lead to serious errors later

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Implementation Flaws

- Time pressure a major problem
  - Developers, testers skimp on documentation and *testing*
  - End up with unrecognized flaws
- Allocate sufficient time to avoid blunders

**Rule of thumb:
~60% of software project should be devoted to *TESTING***

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Unauthorized Changes to Production Code

- Any unauthorized change to production code is a serious violation of standard policies
- Should be viewed as sabotage
- Critically important to determine who did it and why
- Find out how programmer got *access* to production code

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Insufficient or Substandard Programming Quality

- Testing and support records may identify who causes most of the problems in code
- Or possible that entire team needs coaching – or replacement
- Screen programmers carefully before placing on critical projects
- Use *independent team* for QA
  - Do NOT report QA team to programming director!
  - Avoid serious conflict of interest

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Data Corruption

- Logical corruption
  - Poor programming
  - Invalid data entry
  - Bad locking during concurrent access
  - Illegal access to other process' data stack
- Physical corruption
  - Hardware failure
- Analyze all data corruption cases thoroughly
  - Document
  - Fix underlying problems

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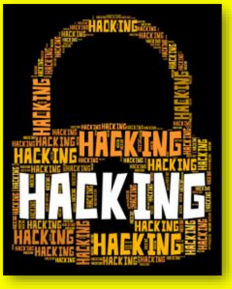
Criminal Hacking

- Audit trails (logs) essential tool for analysis of problems
  - Conforming to regulatory & legal requirements
  - Incident response
  - Research
- Policies
  - Archiving – how long to keep?
  - Security – e.g., chained checksums, encryption
  - Intrusion detection systems



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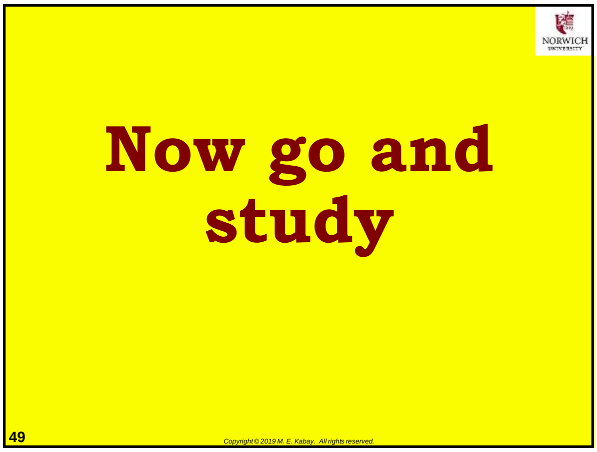

Now go and study

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