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SOFTWARE ENGINEERING
CS 487

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Computer Science

Summer '19

Homework #3

- Consider a fish tank's control system which:
  - Keeps the water within a user-set temperature range
  - Monitors the cleanliness of the water and initiates cleaning when necessary
  - Feeds the fish and turns the lights on/off according to user-set schedules
  - Interfaces with sensors and systems as needed
- Deliverable requirements:
  1. Draw a context model
  2. Draw a state-transition diagram
  3. Depict a user interface / control panel
  4. Write pseudo-code to support your design
  5. Write a set of test cases to verify proper operation
- Submit to Blackboard by 7/27/19

Lecture 6 Dependability and Reliability

Lesson Overview

- Dependability and Reliability
- Reading
  - Ch. 9 – Software Evolution
  - Ch. 10 – Dependable Systems
  - Ch. 11 – Reliability Engineering
- Objectives
  - Understand the concepts of dependability and reliability in the context of systems
  - Examine approaches for developing better systems, where better means dependable and reliable
  - Discuss assessment approaches for measuring these factors
  - Discuss system reengineering as a means for gaining insight into the design of legacy systems

Dependability Considerations

- Repairability
  - The ability to recover from failure
  - Diagnosis, analysis, “surgical” repair, etc.
- Maintainability
  - Economical adaptation to new requirements
- Survivability
  - The ability to withstand “attack”
  - Recognize, resist, and recover
- Error tolerance
  - Avoid or at least tolerate user errors
  - Autocorrect if possible
  - Teach the user along the way

Specification

- Types of specification
  - Risk-driven – avoid hazards
  - Reliability – measurable performance standards
  - Security – authorization and protection
- Formal specification
  - Human communication is complex and error prone
  - Formality seeks to simplify and reduce the opportunity for error
  - Unfortunately formality has had limited effectiveness in practice to date

Risk Management

- Assessment
  - Identify assets requiring protection and value
  - Identify threats and likelihood of occurence
  - Assess exposure (likelihood X impact)
  - Consider mitigation possibilities and costs
  - Mitigate where feasible
- Life-cycle risk assessment
  - Secondary assessment following system and data architecture decisions

Failure Categories

- Hardware failure
  - Design errors
  - Component failure
- Software failure
  - Requirements issues
  - Design errors
  - Coding defects
- Operational failure
  - User misuse

Safety Critical Systems

- Primary safety-critical systems
  - Embedded system controllers
  - Failure of the controller leads to failure of the system it is controlling
- Secondary safety-critical systems
  - Failure of this system will not directly cause harm
  - However such a failure could lead to harmful situations (e.g., CAD or CASE tools)

The Need for Security

- Openness has many benefits
  - Data sharing
  - Remote user access, etc.
- But also introduces vulnerabilities
  - Unauthorized access
  - Denial of service
  - Exposure of sensitive data, etc.
- Security engineering attempts to develop systems that minimize the exposure
  - Application security is a software engineering problem
  - Infrastructure security is a systems engineering problem

Security Management

- Access
  - User and permission management
  - Restrict users' access
- Deployment
  - Control installation and configuration
  - Patching
- Attacks
  - Monitoring, detection and recovery

Security Concepts

- Asset – system resource that must be protected
- Exposure – potential loss/harm
- Vulnerability – exploitable weakness
- Attack – exploitation of vulnerability
- Threats – circumstances under which attacks can occur
- Control – a protective measure that reduces vulnerability

Design for Security

- Architectural design
  - Protect critical assets
  - Distribute assets to minimize the effects of an attack
  - Analogous to a medieval castle
- Design guidelines
  - Establish and adhere to policies
  - Minimize impact through distribution, redundancy, compartmentalization, etc.
  - Recoverability, failing securely, safe deployment
  - Maintain usability
  - Validate inputs

Design for Deployment

- Include support for viewing and analyzing configurations
- Minimize default privileges to only those that are essential
- Localize configuration settings
- Make it easy to fix vulnerabilities

Dependable Programming

- Control the visibility of information
- Check all inputs for validity
- Handle all exceptions
- Avoid error-prone code constructs
- Provide recovery and restart capabilities
- Check array bounds
- Include timeouts when interfacing with external components
- Name all constants that represent real-world values

Risky Programming

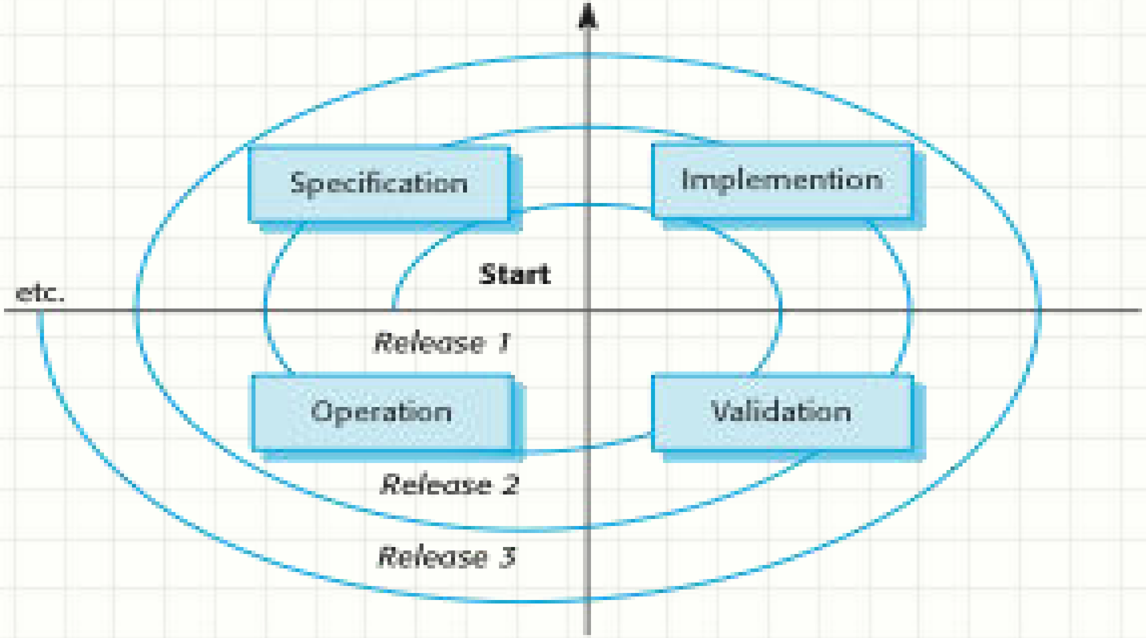
- Unconditional branching (go-to’s)
- Floating point numbers
- Pointers
- Dynamic memory allocation
- Parallelism
- Recursion
- Interrupts
- Inheritance
- Aliasing
- Unbounded arrays
- Default input processing

Survivability

- Design to minimize vulnerabilities and their effects,
- but just in case, design to withstand attacks
- This is critical for critical systems
- Multiple strategies
  - Resistance to attacks
  - Recognition of the type of attack
  - Maintain adequate operation during an attack and then recover to full operation

Software Evolution

- Manage the inevitable change
  - Support and facilitate business growth
  - Take advantage of technology innovation
- Evolve-release-evolve-release-…



Evolution Dynamics

- Grow or progressively lose value (e.g., user satisfaction, perceived quality, etc.)
- Evolution tends to increase complexity
- Bigger systems tend to resist evolution
- Organizational bureaucracy dampens evolution
- The bigger the evolution the greater the number of associated problems

Managed Change

- Formal change requests/proposals
  – Purpose and priority
  – Cost and effort
  – Risk assessment
- Change review and authorization
  – Change control board
- Change implementation
  – Software engineering
  – Planning and management
- Change release
  – Communication
  – Rollback planning

Program Evolution Dynamics

- Change is inevitable
  - As long as the system is used there will be demand to correct imperfections, improve shortcomings and add functionality
- Change increases complexity
  - Adding to an existing structure tends to degrade stability
  - New functionality may bring new defects
- Change tends to be regulated by factors such as system and organization size
  - Big systems are more difficult to change
  - Bureaucracies impede change

Maintenance

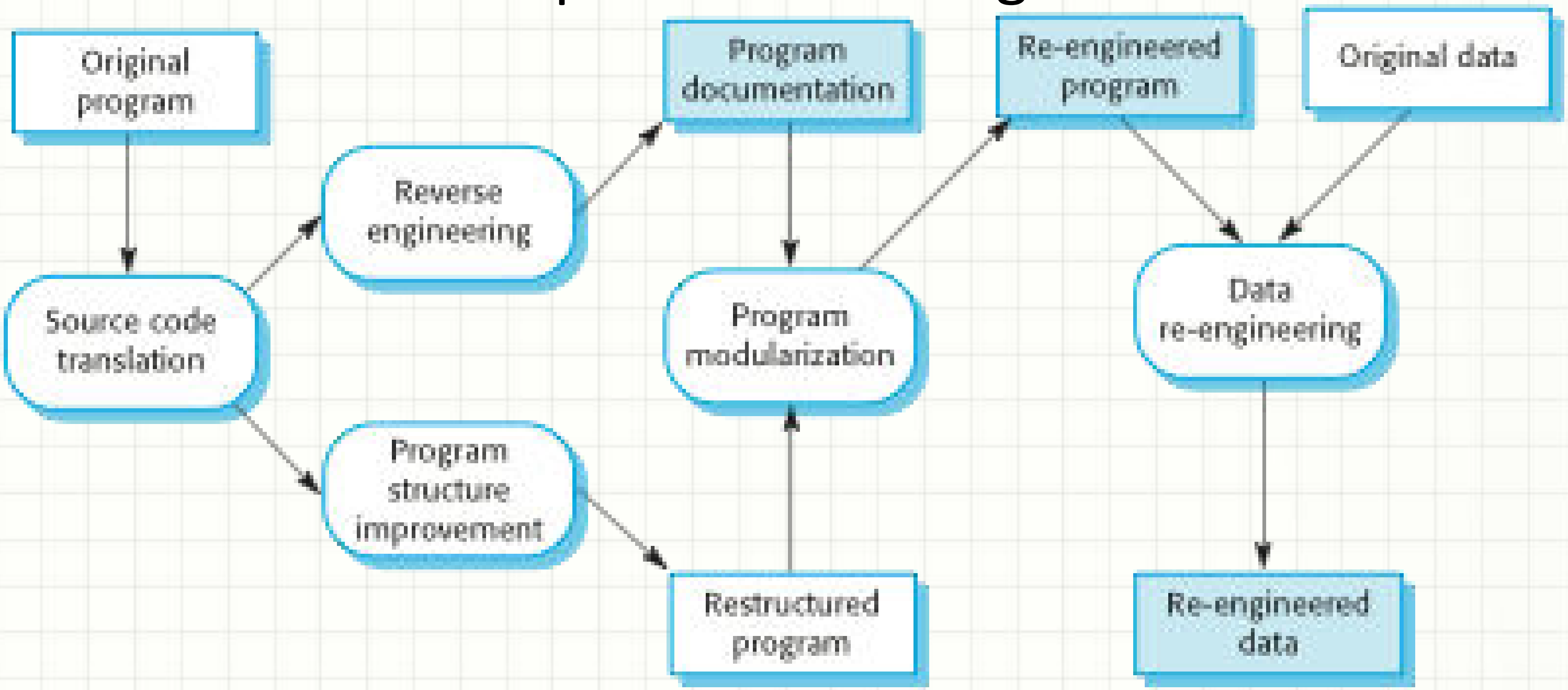
- Development effort and discipline should reduce maintenance effort and cost
  - Better analysis will result in a better alignment with user needs
  - Better design and implementation will reduce defects (including user confusion, etc.)
  - More thorough QA will minimize defects in production
- The evolutionary approach can result in higher maintenance costs
  - Adding functionality to an existing system is more difficult
  - This issue should be countered by planning evolutions well in advance where possible
- Change should be managed with discipline
  - Defect removal
  - Enhancements

Drivers of Maintenance Activity

- Interfaces
  - Number and complexity matter
  - User and system interfaces
- Information
  - Number of data sources
  - Data structure complexity
- Volatile requirements
  - Policies and procedures
  - Business rules
  - Technology
- Processes utilizing the system
  - The more users, the more demand for change

Reengineering to Gain Understanding

- Benefits
  - Creates a newer, more maintainable version
  - Faster and cheaper than building brand new



Refactoring

- Preventive maintenance thru occasional touching up to stave off degradation
  - Improve structure and performance
  - Reduce complexity
  - Improve understandability, etc.
- Improve what's already there, don't add new functionality
- Targets for refactoring improvement
  - Removal of duplicate code
  - Decomposing long methods
  - Simplify or replace "switch" statements
  - Encapsulate recurring "clumps" of data
  - Remove speculative generality

Legacy Systems

- Systems supporting critical business systems may hang around for a while
  - Change is risky
  - Need downtime to switch over
  - Domain knowledge seeps away over time
- Possible next steps
  - Scrap it
  - Leave it as is and maintain
  - Reengineer it to improve maintainability
  - Replace all or at least some of it
- Assess business value vs. system quality

Legacy System Evaluation