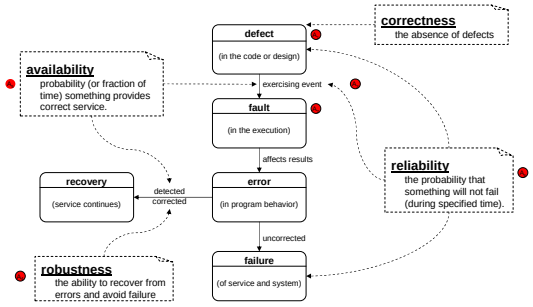
Software Robustness

- terminology
  - phases of failures, measuring goodness
- developing robust software
  - philosophy and general approach
  - planning for error management
    - enumeration, prioritization
    - detection, diagnosis, containment
    - handling, reporting
- Failure Mode Analysis exercise

Taxonomy of not-working



why Software fails so often

1. we implement functionality incorrectly
   - often, because we don't understand correctness
   - we make mistakes without realizing they are wrong
2. we make optimistic assumptions
   - valid inputs, good data, successful requests
   - allowing errors to cascade to greater failures

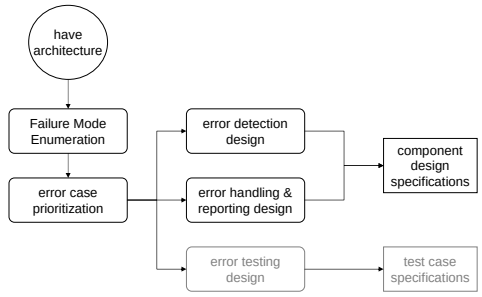
solution:

1. completely define correctness
2. explicitly state all assumptions
3. review these along with the design
4. use them to guide the implementation

why Software fails so badly

- error handling is seldom well specified
  - requirements seldom enumerate error cases
  - specifications seldom describe handling
- architecture often ignores error handling
  - errors are difficult to diagnose & contain
- error handling is seldom well tested
  - we test against the specifications ☺
  - we can't reliably cause most errors
- bottom line – because we have let it do so

Designing for Robustness



Failure Mode Enumeration

- enumerate all likely external errors
  - services: resources, access, ...
  - hardware: transient and persistent
  - data: bad configuration, corrupt data, ...
  - communication errors: protocol, link, node, …
- and general classes of internal errors
  - resulting from failures of our own components (may be easier to focus on symptoms here)
- include problems reported to support
  - involving similar products

Error Prioritization

- assess likelihood (common, occasional, rare)
  - based on prior experience w/such services
  - based on estimated transaction rates
  - based on intrinsic risk (novelty, complexity)
- assess impact (serious, moderate, minor)
  - serious: loss of service or data
  - moderate: a few brief and isolated failures
  - minor: user can easily work around problem
- rank all of the errors on a priority ladder
  - from <common,serious> to <rare,minor>

Exercise

- Consider proj #1b (architecture development)
- Perform a Failure Mode Analysis
  - enumerate likely errors that can happen in system
    - more interesting one than bad user input
  - rank them by likelihood and impact
  - describe how we can recognize each case
    - symptoms and/or test to confirm
    - source, scope, impact, containment
  - describe how to handle the problem
- gather in your project teams
  - identify and analyze 2-3 good problems (per group)
  - you have ten minutes

Error Detection

- to handle an error we must first detect it
  - in most cases, by adding error detection code
    - checking return codes, testing pre-conditions
  - some errors may be quite difficult to detect
- general principles of error detection
  - close as possible to errors first appearance
  - general checks that find many problems
  - simple w/high probability of correctness
  - low overhead – this stuff executes often

Difficult Error Detection

- some errors may be hard to detect
  - symptoms are very subtle (not total failures)
  - may involve relationships among transactions
- some may be hard to discriminate
  - the symptoms could indicate many problems
  - each of which requires very different handling
- this may indicate problems w/architecture
  - if likely/severe errors are hard to detect, consider changes that would make them easier to find

Diagnosis and Containment

- diagnosis
  - source: where did the error originate
  - impact: recoverable, degraded, failed
  - persistence: transient, chronic, permanent
  - much diagnosis is done at design time
- containment
  - which components have actually failed
  - which components have been affected
  - much containment is dictated by architecture

handling well-contained errors

- can we correct the error and continue?
  - error may not stop us from fulfilling request
  - retry request, perhaps from a new server
- can we inform requestor and continue?
  - return an error code identifying the problem
  - let your caller decide how to handle problem
- can we continue with reduced capability?
  - fail requests needing compromised resources
  - continue fulfilling other types of requests

handling poorly-contained errors

- assume entire component is compromised
  - may be unsafe to continue providing service
  - this is a correctness/robustness trade-off
- options
  - refuse all further requests to this component
  - shut down this component component
  - shut down the entire system
- architectural fault containment domains
  - limit potential spread of the damage
  - obvious units of shut-down/restart

Error reporting

- what to report, and to whom
  - explain what went wrong to the user
  - log incidents that require corrective action
  - record information to help establish trends
  - record information for post-mortem analysis
- reporting mechanisms
  - detailed error codes (for software)
  - error messages/dialogs (for users)
  - system error log (for support)
  - automated reporting and diagnosis services

For Next Lecture

- Usability.net: User Centered Design Principles
  - good set of basic principles
- Talin: Principles of U/I design
  - good discussion of philosophy of U/I design
- Nielsen/Butler: Web vs GUI design issues
  - how Web apps are similar and different from GUIs
- Kampe: Content Architecture & Navigation
  - an introduction to designing content structure
- Wikipedia: Usability Testing
  - good overview, ignore stuff sample sizes/statistics
- Kampe: Command Line Interfaces
  - there are actually principles to guide these interfaces

Supplementary Slides

Don't trust other components

- explicit return code checking
  - always check return codes from all requests
- assertion checking parameters & returns
  - sanity check input parameters
  - sanity check results returned from requests
- detect network/IPC no-response errors
  - choose a time that is clearly too long to wait
  - set timer at start of request, cancel at end
  - if timer goes off, something is wrong w/server

Don't trust yourself

- in-line consistency assertions
  - sanity check results of our own computations
  - find errors before we return them to others
- periodic consistency audits
  - scan and sanity check persistent resources
  - find errors we missed when they happened
- exception handling (for very serious errors)
  - catch, report, and handle all exceptions
  - these may happen long after original error

Don’t trust your error detection

- external health monitoring
  - independent program, maybe another system
  - sending periodic test transactions
  - checking responsiveness/reasonableness
- provides end-to-end testing
  - network links, front-end, system, application
- very general health monitoring
  - will find a very wide range of failures
- requires 3rd party error report mechanism