# CS1632, LECTURE 3: REQUIREMENTS & DEFECTS

Bill Laboon

# What are requirements?

- The specifications of the software
  - *Often collected into a SRS, Software Requirements Specification*
- That is, the finished software is required to meet the requirements
- This is how developers know what code to write, and (more importantly for this class), testers know what to test

# Requirements Example – Bird Cage

- The cage shall be 120 cm tall.
- The cage shall be 200 cm wide.
- The cage shall be made of stainless steel.
- The cage shall have one dish for food, and one dish for water, of an appropriate size for a small bird.
- The cage shall have two perches.
- At least 90% of birds shall like the cage.

# Problems With Our Requirements?

- What if the cage is 120.001 cm tall.. OK?
- What if the cage is 120 km tall.. OK?
- Food dishes are steel... OK?
- The perches are steel... OK?
- 2 cm gaps between cage wires... OK?
- 60 cm gaps between cage wires.. OK?
- What kind of birds should like it?
- How can we know the birds like it?
- How many birds should it support?
- Cage has no door... OK?
- Cage has 17 doors, all of which are opened via elaborate puzzles... OK?
- Cage weighs 100 kg... OK?

Most software is more complex than a picture of a cat or a bird cage!

# You need to understand requirements!

- Why?  Because they (or something like them) describe the expected behavior!
  - *Remember, expected behavior vs observed behavior is the foundation of testing software*
- Software that does not meet requirements does not do what it is supposed to do!

# Verification vs Validation

- Verification – Did we build the ***software right***?
  - *Ensure that requirements are met*
  - *Ensure that there are no unexpected failures, output is correct, edge cases handled, etc. (implicit requirements)*
- Validation – Did we build the ***right software***?
  - *Ensure that the software does what the customer/user actually wants*

# Requirements say WHAT to do, not HOW to do it!

- **GOOD:** The system shall persistently store all logins for future review.
- **BAD:** The system shall use an associative array in a singleton class called AllLoginsForReview to store all logins.
- **GOOD:** The system shall support 100 concurrent users.
- **BAD:** The system shall use a BlockingQueue in order to support 100 concurrent users.

# From a requirements perspective, we care about WHAT the system does, not HOW

- We want to know – does the system do X in situation Y, under circumstances Z?
- Black-box testing can be impossible if we need to know implementation details
- Specifying implementation details restricts designers and developers from implementing better solutions

# TESTABILITY

- Requirements should be testable.  What this means, exactly, will vary, but we have some guidelines.
- GOOD: The calculator subsystem shall include functionality to add, subtract, multiply, and divide any two integers between MININT and MAXINT.
- BAD: The calculator subsystem must be awesome. Like, seriously awesome.

*Requirements should be…*

- Complete
- Consistent
- Unambiguous
- Quantitative
- Feasible to test

# COMPLETE

- Requirements should cover all aspects of a system.  Anything not covered in requirements is liable to be interpreted differently!
- If you care that something should occur a certain way, it should be specified in the requirements

# CONSISTENT

- Requirements must be internally and externally consistent.  They must not contradict each other.
- Req 1: "The system shall immediately shut down if the external temperature reaches -20 degrees Celsius.“
- **BAD:** Req 2: "The system shall enable the LOWTEMP warning light whenever the external temperature is -40 degrees Celsius or colder."
- **GOOD:** Req 2: "The system shall turn on the LOWTEMP warning light whenever the external temperature is 0 degrees Celsius or colder."

# Internally and Externally Consistent

- **BAD:** The system shall communicate between Earth and Mars with a round-trip latency of less than 25 ms.
- **GOOD:** The system shall communicate between Earth and Mars with a round-trip latency of less than 42 minutes at apogee and 24 minutes at perigee.

# UNAMBIGUOUS

- **BAD**: When the database system stores a String and an invalid Date, it should be set to the default value.
- **GOOD:** When the database system stores a String and an invalid Date, the Date should be set to the default value (1 Jan 1970).

# QUANTITATIVE

- BAD: The system shall be responsive to the user.
- GOOD: When running locally, user shall receive results in less than 1 second for 99% of expected queries.

# FEASIBLE TO TEST

- **BAD:** The system shall complete processing of a 100 TB data set within 4,137 years.
- **GOOD:** The system shall complete processing of a 1 MB data set within 4 hours.

# FUNCTIONAL REQUIREMENTS AND QUALITY ATTRIBUTES (NON-FUNCTIONAL REQUIREMENTS )

- **Functional Requirements** – Specify the functional behavior of the system
  - *The system shall do X [under conditions Y].*
- **Quality Attributes** – Specify the overall qualities of the system, not a specific behavior.
  - *The system shall be X [under conditions Y].*
- Note “do” vs “be” distinction!

# FUNCTIONAL REQUIREMENT EXAMPLES

- **Req 1:** The system shall return the string "NONE" if no elements match the query.
- **Req 2:** The system shall turn on the HIPRESSURE light when internal pressure reaches 100 PSI.
- **Req 3:** The system shall turn off the HIPRESSURE light when internal pressure drops below 100 PSI for more than five seconds.

# QUALITY ATTRIBUTE EXAMPLES

- **Req 1** - The system shall be protected against unauthorized access.
- **Req 2** - The system shall have 99.999 (five 9's) uptime and be available during that same time.
- **Req 3** - The system shall be easily extensible and maintainable.
- **Req 4** - The system shall be portable to other processor architectures.

# SOME CATEGORIES OF QUALITY ATTRIBUTES

- Reliability
- Usability
- Accessibility
- Performance
- Safety
- Supportability
- Security

*You can see why quality attributes are sometimes called "-ility" requirements!*

Quality attributes are often more difficult to test than functional requirements.

*Solution: agree upon quantifiable requirements.*

# Why?

- Can be very subjective
- May relate back to functional requirements
- It's easy for contradictions to arise
- Often difficult to quantify
- No standardized rules for considering them "met"

# Solution

*Agree with stakeholders upon quantifiable requirements.*

# Converting Qualitative to Quantitative

- **Performance:** transactions per second, response time
- **Reliability:** Mean time between failures
- **Robustness**: Amount of time to restart
- **Portability:** Number of systems targeted, or how long it would take to port
- **Size:** Number of kilobytes, megabytes, etc.
- **Safety:** Number of accidents per year
- **Usability:** Amount of time for training
- **Ease of use**: Number of errors made per day by a user

# EXAMPLE

- **BAD:** The system must be highly usable.
- **GOOD:** Over 90% of users have no questions using the software after one hour of training.

# How to think about it…

- FUNCTIONAL REQUIREMENT - The system must DO something.
- QUALITY ATTRIBUTE - The system must BE something.

# What do we mean by “defect”?

***Bug, n.:*** An unwanted and unintended property of a program or piece of hardware, esp. one that causes it to malfunction. Antonym of feature.

-Eric S. Raymond, The Jargon File

# Better definition:

Some condition in a system which does one of the following:

1. Violates a requirement
2. Violates end-user expectations
3. Causes the program to malfunction or end prematurely
4. Produces an incorrect result

# Where do defects come from?

- Gaps or mistakes in code
- Gaps or ambiguity in requirements
- Other:
  - *Compiler broken*
  - *Bad hardware*
  - *Broken operating system*
  - *Gamma rays from space*
- Guess which are the two areas on focus on?

# A Defect Is Visible to the User!

```
// Program shall always print out “wombat”
// Program shall never print out “cephalopod”
// Is there a defect in this code?
int k = 4;
if (k > 100) {
   System.out.println(“cephalopod”);
} else {
   System.out.println(“wombat”);
}
```

# Bad Code != Defect

- This does NOT mean that it’s a good thing to have bad code!
- Don’t tell people Laboon is saying that it’s OK to have ugly code if it’s not visible to the user
- But from a definitional perspective, a defect is something that impacts the functionality of the program

If the behavior of a system under test does not meet the requirements (implicit or explicit), or the expectation of a user, it can be considered a defect.

- A user may have expected an error message when a string is entered when an integer was expected.
- A user may not have cared whether a word is capitalized or not.
- A user may want negative numbers to be treated as positives.
- You may need to have a discussion with systems engineers or requirement analysts if the behavior of the system as defined by the requirements is not what the user expects.
  - *Remember verification vs validation!*

# Defects vs Enhancements

- If the software does not meet the requirements, or is unstable (which is an implied requirement), then there's a DEFECT.
- If the user wants to ADD or MODIFY a requirement/feature/etc, that's an ENHANCEMENT request.

# A defect does not have be severe to be a defect

- Images are sized 1 pixel too small
- Delays are 1 ns longer than required
- Upon shutdown, typo in final statement
- Seldom-used feature does not work correctly
- Background color is slightly off
- There should be three periods in an ellipsis, not two..

# Defects can be ambiguous

- Communication
- Communication
- Communication

# Defect Reporting Template

- SUMMARY
- DESCRIPTION
- REPRODUCTION STEPS
- EXPECTED BEHAVIOR
- OBSERVED BEHAVIOR
- IMPACT
- SEVERITY
- NOTES

# Summary - *A succinct (one-sentence or so) description of the problem.*

- Title does not display after clicking "Next“
- CPU pegs after addition of any two cells
- Total number of widgets in shopping cart not refreshed after removal of more than one
- Page title is "Alll Entries", should be "All Entries“
- If timezone is changed during execution, idle tasks never wake up

# DESCRIPTION - *A more detailed explanation of the problem.*

- If more than one widget is removed from the shopping cart, the number of widgets is not changed from the initial value.  This value is updated if the widgets are removed one at a time.

# DESCRIPTION

Be careful not to overgeneralize (or undergeneralize, but this tends to be less of a problem) here.

# REPRODUCTION STEPS - *Specify an EXACT SEQUENCE OF STEPS to reproduce the problem.*

- Make sure you give:
  - *Exact values*
  - *Exact steos*
  - *Exact manner of execution*
- It’s usually better to err on the side of overspecificity

# REPRODUCTION STEPS

- BAD: Put some things in the shopping cart.  Take a couple things out.
- GOOD:
  - *1. Add three widgets to shopping cart*
  - *2. Note number of widgets listed is 3*
  - *3. Remove two widgets from shopping cart*
  - *Observe number of widgets listed*

# EXPECTED AND OBSERVED BEHAVIOR

- EXPECTED BEHAVIOR: This should note, as precisely as possible, what you expected to see according to the requirements.
- OBSERVED BEHAVIOR: This should note what you ACTUALLY saw.

# BAD EXAMPLE

- Expected Behavior: Number is correct.
- Observed Behavior: Number is incorrect.

# GOOD EXAMPLE

- EXPECTED BEHAVIOR:
  The number of widgets in the shopping cart is 1.
- OBSERVED BEHAVIOR:
  The number of widgets in the shopping cart is 3.

# EXPECTED VS OBSERVED BEHAVIOR

- What you saw versus what you expected to see is the CRUX of a bug report.
- Make sure you get it right!
- Be as PRECISE as possible.

# IMPACT – How does this defect impact the user of the software?

BAD:The user will hate this because everything is wrong!

GOOD:The user will see an incorrect number of widgets in their shopping cart, meaning they could purchase fewer widgets than they expect.

# SEVERITY – how severe is the problem?

*Note that this differs from PRIORITY, the ordering of which defects should be worked on first. However, the two are not orthogonal; ceteris paribus, a higher-severity bug will take precedence over a lower-severity one.*

# SEVERITY

Severity is a combination of several factors:

1. How bad is the problem when it does occur?
2. How often does it occur?
3. Is there a workaround?

# LEVELS OF SEVERITY (Bugzilla)

- BLOCKER
- CRITICAL
- MAJOR
- NORMAL
- MINOR
- TRIVIAL

# NOTES – Technical and detailed notes that can help understand and fix the problem.

- Stack traces
- Log file excerpts
- Environment
- Anything that may be helpful to a developer fixing this defect