Requirements—What are they?

WRSPM Readings

Topics of Today

• Requirements from 20,000 ft

• After this class you will know
  • What a requirement is (informally)
  • What a requirement is (formally)

The Importance of Good Requirements
Requirements Specification

- High-level description of what a system should do
- Must be detailed enough to distinguish between the “right” and the “wrong” system
- Capture the what not the how
- The specification process must involve all stakeholders
  - Customers
  - Engineers
  - Regulatory agencies
  - Users

The Cost of Req. Problems


Cost Overruns vs. Requirements Effort

Source: Werner Gruhl, NASA
Key Points

- Requirements capture what a proposed system shall do
  - But avoids design detail as much as possible
  - Written in the user’s language
- Poor requirements are the source of all evil
- Requirements problems are the
  - Most costly
  - Most difficult to correct (they are conceptual)

Requirements: What Are They?

What is a requirements document?
What is a requirement?

The Software Requirements Specification

- The SRS writer shall address the following
  - Functionality
    - What is the software supposed to do?
  - External Interfaces
    - How does the software interact with people, the system's hardware, other hardware, and other software?
  - Performance
    - What is the speed, availability, response time, recovery time of various software functions, etc.?
  - Attributes
    - What are the portability, maintainability, security, etc. considerations?
  - Design constraints imposed on an implementation
    - Are there any required standards in effect, implementation language, policies for database integrity, resource limits, operating environment, etc.?  

IEEE Std 830-1998
Requirements

Definition/Specification

- Market Requirements Definition (MRD)
  - Statements in natural language (plus diagrams) of the services the system provides and its operational constraints
  - Written for customers in their language
- Software Requirements Specification (SRS)
  - A structured document setting out detailed descriptions of the system services
  - Written as a contract between client and contractor
- Software Design Description (high-level design)
  - A detailed software description which can serve as a basis for a design or implementation
  - Written for developers

Requirements Readers

Market Requirements Definition
- Client managers
- System end-users
- Client engineers
- Contractor managers
- System architects

Software Requirements Specification
- System end-users
- Client engineers
- System architects
- Software developers

Software Design Description
- Client engineers
- System architects
- Software developers

Definitions and Specifications

- Market Requirements Definition
  - 1. One person must be able to load the boat on the car rack

- (Software) Requirements Specification
  - 1.1 The boat must be lighter than 100 lb.
  - 1.2 The boat must have handles to help one person lift it
  - 1.3 The car rack must be padded so the boat can easily slide into the rack
  - 1.4 Etc.
**Requirements, What are they really?**

- Two Good Models
  - The four variable model by David Parnas
    - Based on control systems
  - The WRSPM model by Michael Jackson
    - More general and the one I prefer (right now)
  - We will discuss both

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**Process Control**

- System Input
- System Output
- Controlled Variables
- Monitored Variables
- Actuators
- Sensors
- Computer (Controller)
- Command Signal
- Operator
Capture the Right Thing

- Requirements are always in the system domain
- Software specification is in the computer domain
- There are several levels of abstraction in between
  - Abstract away some details but not others

The WRSPM Model

- We want to make a change in the environment
- We will build some system to do it
- This system must interact with the environment

W – The World Assumptions (domain model)
R – The Requirements
S – The system specification
P – The Program (running on the machine)
M – The machine physically implementing the system
The Variables in WRSPM

Artifacts Related to Variables

Example—Patient Monitoring

- Requirement
  - A warning system that notifies the nurse if the patient’s heart stops
- Machine
  - A computer that can be programmed to use a microphone as a sensor and a buzzer as an actuator
- Specification
  - If the sound from the sensor falls below a certain threshold, the buzzer shall be actuated
- World knowledge
  - There will always be a nurse close enough to hear the buzzer
  - The sound from the heart falling below a certain threshold indicates that heart has (is about) to stop
e_h, e_v, s_v, and s_h???

Why Do We Care??

- Why is this important in requirements analysis?

- Why is this important from a safety critical systems point of view?
Patient Monitoring will Work

- If we take a computer that can be programmed to use a microphone as a sensor and a buzzer as an actuator,
- and if we program this computer to sound the buzzer when the sound from the sensor falls below a certain threshold,
- we will have a warning system that notifies the nurse if the patient's heart stops

- Because
  - There will always be a nurse close enough to hear the buzzer, and
  - the sound from the heart falling below a certain threshold indicates that the heart has stopped (is about to stop)

Example

- Requirement—R
  - Allow pedestrians to cross the road safely

- Specification—S
  - Show a red light to the cars and a green light to the pedestrians

- World Knowledge—W
  1. Drivers stop at red lights
  2. Pedestrians walk when green

W and S satisfies R
Example—Safety

Safety Requirement—R
Pedestrians and cars cannot be in the intersection at the same time

Specification—S
Never show a green light to both pedestrians and cars

World Knowledge—W
1. Drivers stop at red lights
2. Pedestrians stop at red lights
3. Drivers drive at green lights
4. Pedestrians walk when green

W and S satisfies R

World Knowledge is Essential

• This is the most error prone part of the requirements
  ♦ Most problems can be traces to erroneous assumptions about the environment
    ■ TCAS—transponder assumptions
    ■ NY subway—separation not enough
    ■ Patriot missile—clock drift
  ♦ Must be rigorously validated and continually questioned

In General We Want to Show

• The specification satisfies the requirements
  ♦ W and S satisfies R (W, S ⇒ R)
• The implementation satisfies the requirements
  ♦ W, M, P ⇒ R

This is the essence of any argument that your system is “right”

• The implementation satisfies the specification
  ♦ M, P ⇒ S
We Have Learned

- What requirements are (informally)
- What requirements are (more formally)
- The relationship between system and environment
  - The four variable model
  - The WRSPM model

Next time
- If you're not familiar with requirements writing, read the chapters in a textbook
- Modeling in practice
- Henninger SCR paper
- Leveson TCAS Paper