Requirements elicitation/analysis

**Topics:**
- Problem statements, requirements, and elicitation
Cost of requirements errors by phase

- Analysis
- Design
- Testing
- Post-deployment
“Gulf” between client and developer perspectives on software requirements
“Bridging” the gulf

Customer → Requirements Specification → Developer
The requirements specification

Critical artifact, for many reasons:
- freezes “what” is to be developed
  - should be no new requirements added once development begins
  - equivalent to a “project handout” in a programming course
- part of the “contract” between client and developer

Two schools of thought on notion of “freezing” reqts
- It is a myth to think we can freeze requirements; therefore, we must develop software assuming new reqts will arrive after development begins
- It is vain to think we can develop a quality system if new reqts are added after development begins; therefore, the reqts spec should be thorough and subjected to quality assurance

Waterfall processes subscribe to the second view
Issues

Given the critical nature of the requirements specification, important to get it right!

Meta-requirements (i.e., reqts of a reqts spec):

- consistent
- complete
- understandable by both client and developer

Question: Why might these meta-requirements be difficult to satisfy?
Completeness/consistency problems

Consistency problems:

▪ Multiple interpretations of similar terms
  o developer’s vocabulary vs. client’s
▪ Concepts “built upon” undefined concepts/terms
  o E.g., scheduling system based on notion of “constraint”
  o But constraint never really defined
    ★ E.g., is a “recurring commitment” one or multiple constraints?

Completeness problems:

▪ Customer may have only a fuzzy understanding of what he or she wants
▪ Developer lacks “implicit knowledge” of client domain
Elicitation techniques
Client View of Domain

Clients cannot be expected to have rigorous or formal view of domain

Hence, cannot be expected to completely be aware of domain-problem relationship

Some knowledge is explicit
  ▪ Easier to get at...

Some knowledge is implicit
  ▪ Many constraints are implicit
  ▪ Hard to get at...
Technique: Initial client interview

Goal: Discover as many requirements as you can in a limited amount of time

Implications:

- Essentially an information-extraction process
- Ask open-ended questions
  - ask them in more than one way
- Your analysis should be very limited
  - OK to ask follow up questions, but don’t get bogged down analyzing one requirement, or you will run out of time
  - Never (during this interview):
    ★ suggest a “better way to think about it”
    ★ express opinions on answers
Question Structure is Critical

What is the client’s problem?
- what, precisely, is the problem to be solved?

When does the problem occur?
- what generates the problem?
- situations, are they new or old? Transient?

Where does the problem occur?
- what are the problem domain boundaries?

How is the problem handled now?

Why does the problem exist?

Remember, this is a diagnosis / information extraction process
Sample System: Smart Cruise Requirements

- **Safety zone**: About 400 ft - acquires target vehicle. Closing speed low enough to control.
- **Coast zone**: Starts coasting to match speed.
- **Safe zone**: Maintain proper trail distance - speeds match. This is what we want.
- **Closing zone**: Closing speed too high. Issues warnings to avoid this condition.
Closed-ended questions

Q: When a vehicle cuts in front of the car, you have to slow down quickly and not hit it, right?

A: Yes

**You learned absolutely nothing.**
**Q:** What happens when a car cuts in front of you?

**A:** Well, if the lead car is too close, the driver has to intervene or else a crash results. *I guess we need a warning light in this case.* If the car is moving faster, you don’t have to do anything. He’s pulling away. I guess the only time brakes are used is when the closing speed is too high for the distance and yet within the capabilities of the system to slow down. *But I guess if a collision is imminent, we should max out the braking.*
Dialogue with different responses

Q: Tell me what should happen if a car cuts in front of our car too close to avoid a collision?
A: I guess since there is nothing the system can do, turn off the controller and hope the driver brakes in time.

Q: What? Are you nuts? We should at least try to stop. Shouldn’t we?
A: Perhaps...

You are done at at this point, and still unresolved.

Q: We have quite a bit of braking power in the system. What would happen if we used it here?
A: Well, I guess it could avoid a collision and at least get the car slowed down but the attorneys tell me we don’t want the system active when a collision occurs.

Ah ha! Non-technical constraint
Your interview should result in a large volume of facts which must be analyzed to derive requirements

- Here “analysis” involves both analysis and synthesis
- Synthesis: attempt to compose a coherent “model” of the problem requirements

A model can be analyzed to:

- identify potentially inconsistent facts, and
- infer facts that should be true

Both of these issues must be clarified, often via a second client interview
Putative questions

Asks about a situation in a way that tests your model of the domain

**SWE:**
“If a lead vehicle turns, or otherwise is not in front of the car anymore, the car can resume the previous speed, correct?”

**CLIENT:**
“Yes, exactly.”

*Very specific question that tests the idea of cruise plus collision avoidance*
Sample Interview I

SWE:
Could you tell me about the cruise control system?

CLIENT
Yes, normal cruise control holds a fixed speed. What we want is to make the car "smart" so that it slows down when there is a vehicle in front of it.

SWE:
What does a driver currently do in this situation?

CLIENT
Currently, the driver can step on the brakes to disengage the cruise, or turn the cruise off completely. Or, not use the cruise.

SWE:
Why is turning off the cruise this way a problem?

i.e., Why do you need “smart” cruise? Try to get at the motivation for the problem.
In an urban environment, say I-75 in Detroit, using the cruise becomes irritating, but really we are more interested in avoiding collisions.

SWE: Tell me more about the collision avoidance aspect, please.

If we limit how close a lead vehicle can get, and control the speed while the car is in trail, the chances of a collision can be greatly reduced.

SWE: How would a system avoid a collision in a typical scenario?

Suppose the driver is following a truck, but at a higher speed than the truck. As the car closes, the system could alter the speed to match the speed of the truck.

SWE: What does the slowdown profile look like?
Sample Interview III

CLIENT
Well, we have discovered that slowing down linearly over a long distance can lead to other cars cutting in front of you. This is also not what a human driver does. Instead, we continue at our current speed and start a coast when we compute that we will get too close.

SWE: What is "too close"?
CLIENT: Oh, within 2 seconds of trail distance.

SWE: Does that mean at 60 mph, 88 ft/sec, too close is 176 ft?
CLIENT: Yes, closer than 176 ft is too close.
Sample Interview IV

SWE:
What if a car cuts in front of you within the "safe" 2 second distance?

CLIENT
I guess since there is nothing the system can do. Turn off the controller and hope the driver brakes in time.

SWE:
The specs indicate we have a fair amount of braking power available. What would be the problem with using it here?

CLIENT
The system does have access to the brakes, which are anti-lock. Technically, we could apply the brakes, but at the moment, our attorneys tell us we'd rather not have the system active if a collision is imminent.

A non-technical issue arises
Types of Questions as Tools

- **Why...**
  - Usually leads to deeper motivations, information on structure.

- **What...**
  - Usually leads to facts

- **How...**
  - Usually leads to a discussion of process, not structure

- **Could...**
  - Maximally open, might lead to no data
    - “could you explain why the safety zone is 2 seconds?”
Elicitation/analysis may require multiple interviews

- ask questions to obtain information
- build information into your “model”
- answer matches
- pose putative questions
- figure out where the ambiguity or problem is
- wrong answer
Summary

Elicitation is critical to:

▪ address the requirements-completeness problem
▪ support analysis, which aims to address the requirements-consistency problem

Client interviews are a useful tool, but:

▪ Must be carefully planned and orchestrated
  ○ Meetings should focus on a primary goal (e.g., information extraction vs. clarification)
▪ Big mistake to fail to plan for some iteration here