Requirements elicitation/analysis
Part I: Elicitation

Topics:
- Problem statements, requirements, and elicitation

"Because computers can serve so many purposes, the practice of sw development is less specialized than the established engineering disciplines. That's why [software engineers] should start by describing the problem in a way that's rarely necessary in other engineering disciplines, where the diversity of problems to be solved is much smaller. The automotive engineer designing a sports car does not need to ask whether the car must be capable of carrying 15 people, traveling underwater, carrying a ten ton load, or moving backwards at 100mph."

-- Michael Jackson

Cost of requirements errors by phase

"Gulf" between client and developer perspectives on software requirements

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
1. It is a myth to think we can freeze requirements; therefore, we must develop software assuming new reqts will arrive after development begins
2. 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 subject 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
  - developer's vocabulary vs. client's
- Concepts "built upon" undefined concepts/terms
  - E.g., scheduling system based on notion of "constraint"
  - 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

Addressing obstacles

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Elicitation</th>
<th>Analysis/ synthesis</th>
<th>Writing/ rhetoric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consistency</td>
<td>X</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td>Completeness</td>
<td>XX</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Readability</td>
<td></td>
<td>XX</td>
<td></td>
</tr>
</tbody>
</table>

Elicitation techniques

Client View of Domain

Clients can’t be expected to have rigorous or formal view of domain

Hence, can’t 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, if 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
Achieve desired trail distance

Closed zone

Closing zone

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

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.

Open-ended questions

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.

Now, we learned something...

Closed-ended questions

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: 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.

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.

Much better

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.

An fatal Non-technical constraint

Not good
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 all unresolved.

From elicitation to analysis...

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
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?

CLIENT: I.e., Why do you need “smart” Cruise? Try to get at the motivation For the problem

Sample Interview II

CLIENT: 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.

CLIENT: 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?

CLIENT: 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.

Great insight

Very specific, to resolve ambiguity in domain terms

Time for a putative theorem to verify current model that resolves ambiguity

Verification

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.

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

Usually leads to a discussion of process, not structure.

"Could you explain why the safety zone is 2 seconds?"
Elicitation/analysis structure

Elicitation/analysis may require multiple interviews

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