Requirements Engineering Lessons from House Building

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Acronyms

SW = Software

RE = Requirements Engineering

House Building vs. SW Building

Anyone who has built or remodeled a house and has developed or enhanced SW must have noticed the similarity of these activities.

Outline

This talk examines these processes from several points of view:

- **budgeting,**
- **scheduling,**
- **requirements creep,**
- **what vs. how, and**
- **how to be a customer.**

Basis for Talk

This talk is based on on popular perceptions and personal observation over small populations, i.e.,

- **houses I and some friends have remodeled and built**
- **SW projects in which I have participated as an analyst, designer, programmer, or consultant.**

The Two Activities

I give descriptions of the two activities worded so as to enhance the similarities of the house and SW RE activities.

First, I give each description in entirety.

Then, I give each *n*th sentence of each together.

House Building 1

When a customer wants to have a house built, she approaches an architect who puts his knowledge of house construction together with his creativity to try to come up with a plan for a house that will meet the customer's requirements.

The customer describes her dream house and the architect asks her questions, although not necessarily in that order.

House Building 2

The architect draws some possible plans or builds some models to show the customer his ideas.

The customer gives feed back on these plans or models to allow the architect to better understand her needs and desires.

House Building 3

Finally, the architect produces a final plan that meets the customer's requirements to her satisfaction and that is in a form that any builder will understand and will execute properly to build what the customer expects.

A budget and schedule for building the house are drawn up and are bound together with the plans in the house building contract.

Software Building 1

When a customer wants to have a program developed, he approaches a requirements engineer who puts her knowledge of SW construction together with her creativity to come up with a specification of a program that will meet the customer's requirements.

The customer describes his blue sky program and the requirements engineer asks him questions, although not necessarily in that order.

Software Building 2

The requirements engineer writes up some possible specifications or builds some prototype to show the customer some of her ideas.

The customer gives feed back on these specifications or prototypes to allow the requirements engineer to better understand his needs and desires.

Software Building 3

Finally, the requirements engineer produces a final specification that meets the customer's requirements to his satisfaction and that is in a form that any programmer will understand and will program properly to implement what the customer expects.

A budget and schedule for implementing the program are drawn up and are bound together with the specifications in the SW development contract.

Sentence 1

H: When a customer wants to have a house built, she approaches an architect who puts his knowledge of house construction together with his creativity to try to come up with a plan for a house that will meet the customer's requirements.

SW: When a customer wants to have a program developed, he approaches a requirements engineer who puts her knowledge of SW construction together with her creativity to come up with a specification of a program that will meet the customer's requirements.

Sentence 2

H: The customer describes her dream house and the architect asks her questions, although not necessarily in that order.

SW: The customer describes his blue sky program and the requirements engineer asks him questions, although not necessarily in that order.

Sentence 3

H: The architect draws some possible plans or builds some models to show the customer his ideas.

SW: The requirements engineer writes up some possible specifications or builds some prototype to show the customer some of her ideas.

Sentence 4

H: The customer gives feed back on these plans or models to allow the architect to better understand her needs and desires.

SW: The customer gives feed back on these specifications or prototypes to allow the requirements engineer to better understand his needs and desires.

Sentence 5

H: Finally, the architect produces a final plan that meets the customer's requirements to her satisfaction and that is in a form that any builder will understand and will execute properly to build what the customer expects.

SW: Finally, the requirements engineer produces a final specification that meets the customer's requirements to his satisfaction and that is in a form that any programmer will understand and will program properly to implement what the customer expects.

Sentence 6

H: A budget and schedule for building the house are drawn up and are bound together with the plans in the house building contract.

SW: A budget and schedule for implementing the program are drawn up and are bound together with the specifications in the SW development contract.

More Similarities

There are elements of similarity that run deeper and include:

- **the relationship between the customer and the architect/requirements engineer,**
- **the relationship between the customer and the builder/programmer,**
- **the relationship between the architect/requirements engineer and the builder/programmer,**

More Similarities, Cont'd

- **the importance of a graphical notation in the plans/specification, especially to the customer who is not in a building/programming profession,**
- **the importance of the client's understanding the plans/specifications in validating that the plans/specifications capture his/her intent,**
- **the usefulness of a model/prototype in the client's understanding the plans/specifications,**

More Similarities, Cont'd

- **the degree to which the reason that the house/program does not satisfy the client is in the plans'/specifications' not matching the client's intent or needs rather than in the house's/program's not matching the plans/specifications,**
- **the relative costs between changing the plans/specifications and changing the house/program,**

More Similarities, Cont'd

- **the propensity for the client to think of new requirements as the house/program is being built/programmed, and**
- **the debilitating effect of requirements creep on building/programming schedule and budget.**

Key Difference

Key difference between house and program construction:

It seems that building contractors routinely charge extra and announce schedule delays for changes in the plans requested by the client.

Key Difference, Cont'd

However, for some inexplicable reason:

It seems that we SW engineers are often reluctant to do either, ...

routinely promising to handle new requirements within the confines of the original contract's budget and schedule.

We're Being Had!

These are the immortal words of Tom DeMarco over this situation.

We have been conditioned by customers and programming managers

- **to accept utterly impossible schedules and budgets for SW production and**
- **to accept even adding more requirements to these schedules and budgets to make them even more ridiculously utterly impossible.**

We're Being Had, Cont'd

We act as if it would be

- **unpatriotic,**
- **unhumanly,**
- **unprogrammerly**

not to take on these few extra requirements or to insist on on a new contract, ...

especially if the new requirements are delivered, in the Salami Effect, a slice at a time.

We're Being Had, Cont'd

After all, SW is *so* flexible.

Contractors

In the house building trade, contractors are so confident that the client will change the requirements during the building that contractors routinely underbid both money and time on the original plans in order to win the contract.

They count on recovering costs and gaining time with inflated cost and time estimates for each change requested by the client during the building.

Contractors, Cont'd

Most clients accept without much argument, like sheep being taken to the slaughter, that changes requested during construction, are more expensive per unit of area and require more time than if they had been included in the original plans.

After all, the support structure of the building must be changed at the cost of much material and time, especially since already completed parts of the house must be torn away or changed.

Contractors, Cont'd

Even with this understanding, most clients push ahead with the changes regardless of the costs.

So, in house building, requirements creep is expensive for the client.

Obvious Question

Why don’t we SW engineers behave like house building contractors with respect to requirements creep?

I really don’t know the answer to that question.

House Building Experiences

I am aware of the costs of requirements creep in SW.

Using my knowledge, I managed to outwit two building contractors, one for a remodeling and one for a build from scratch.

I made sure before construction started that the plans both captured our (my family's) intent and were implementable.

House Building, Cont'd

We did numerous inspections and walkthroughs of the plans privately and with the architects.

We even made sure that the sums of distances along a wall added up to the length of the wall.

We resisted all temptations to change the plans once the construction started.

House Building, Cont'd

In the end, we finished within budget on both plans, although not on time.

Apparently, the contractors had bid impossible budgets and schedules.

While the contractual budget can be enforced, a schedule is, in the last analysis, unenforceable.

When the schedule slips, nothing can be done to recover, and stopping the building would only hurt us.

House Building, Cont'd

I did not act like the normal client

The contractors got stuck into an unrealistic contract, unable

- **to complete the building according to the schedule and**
- **to use a new requirement to excuse a slip in the schedule.**

Likewise, the contractor was unable to collect more money from us.

House Building, Cont'd

In both cases, soon after completing our construction, the contractors faced serious financial difficulties, ...

perhaps because they did not get from us the expected additional revenues that they had planned on assuming my behaving normally.

House Building, Cont'd

One contractor even went bankrupt, ...

because he got even less than contracted because they were assessed penalties against their income for being late.

I Wonder

I wonder if I have been blacklisted among Israeli contractors as a dangerous customer?

More Adventures

After moving to Canada, I bought a house.

Soon thereafter, I discovered some problems that required the expertise of professional builders and electricians to fix.

I prepared an RFP, a high-level requirements description in which I thought I had stated only requirements.

Maybe, *I* should have known better!

Request for Proposal

My shower stall is leaking and the plaster on the outside of the shower is crumbling. I guess I will need to have the showerstall [sic] rebuilt.

I would like to have the amperage of one outlet increased so that using the toaster at it does not dim the lights in the whole house.

The power to the baseboard heaters needs a bit of work. I think one of the heaters is malfunctioning.

One phone jack is dead; I would like the wire damage located and fixed.

Can you do these things?

If so, when can we meet?

Described Solution

I soon realized that what I described in fact bordered on being a description of a solution.

It was not really a pure requirements specification.

However, what I needed to do was clearly constrained by the existing house structures.

So I thought that what I described could be considered requirements.

Same as in Legacy Software

When one is enhancing existing SW, solutions to requirements are constrained by existing SW.

These solutions may be considerably different from those that would result if one could start from first principles.

Finding Contractors

I faxed or e-mailed the RFP to about 2 dozen remodeling contractors in the Kitchener-Waterloo area.

Some were recommended by friends.

Finding Contractors, Cont'd

In any case, each had either an e-mail address or a fax number listed in its Yellow Pages entry.

With an e-mail address or a fax number, I could communicate with each in textual form rather than voice.

Replying Contractors

Many contractors never replied.

In the end, I got replies from only three, hereinafter known as C1, C2, and C3, with the digit reflecting the order of replying to me.

I use these designations to refer to both the company and the representative person who dealt with me, the owner in each case.

Contractor C1

C1 faxed me a proposal to meet at my house for him to see the work sites.

He took my RFP as explicit requirements and discussed various implementations.

C1: Electrical

C1 proposed replacing existing wiring from fuse box to dinette outlet by heavier wiring so that he could put in a higher amperage fuse.

He noted that the living room and dinette were on the same fuse.

Allowing more current on the line would endanger the TV, VCR, and other entertainment appliances in the living room.

C1: Electrical, Cont'd

Thus, C1 said that we should split the line and fuse into two, one for the living room and one for the dinette, each with its own amperage.

However, there were no more slots in the fuse box.

I suggested attaching the living room line to the dining room line, to leave the former dinette–living room line for only the dinette.

C1: Electrical, Cont'd

Since the dining room had no appliances, the load on the new dining room–living room line should be fine.

C1: Shower

C1 proposed a three-piece unit with seams overlapping only downward, to prevent dripping leakage, rather than redoing the tiling.

No matter how well the tiling is done, tiles and grout eventually leak.

C1: Telephone

C1 said that fixing the phone line was trivial.

I agreed.

C1: Estimate

Two weeks later, C1 sent an estimate that covered all tasks in a complete middle-level requirements specification.

He said that if I chose him, he would produce detailed plans for the shower work.

Contractor C2

About a week after meeting with C1, but before C1 sent his estimate, C2 sent me a fax:

Mr. Berry;

...

We are happy to quote you a fixed price to repair and/or rebuild your shower as is found to be necessary. This is work we regularly do. Please visit our website at ... to see some of our work.

Also, we can service you [sic] 110 v.a.c. toaster outlet, service power to your electric baseboard heaters, and service your malfunctioning telephone jack. Our standard labour rate for such service is $39.00 per hour per service person, plus materials, plus applicable the taxes [sic].

If you choose to retain us for this service work, we will inspect your shower when we are on site, make recommendations, and follow up with a written proposal containing a stipulated price for the

decided upon shower work.

We shall look forward to receiving your written reply, and shall respond to you promptly via facsimile.

Thank you.

Extreme Programming?

When I read this fax, I thought, “My G-d! He’s proposing an XP approach for the electrical task followed by a waterfall approach for the shower task!”

He was not planning on ironing out requirements ahead of time.

Extreme Programming, Cont'd

He was planning to come, sit with me, get the four stories, and immediately begin implementing each of the stories.

I, the customer would be on site the whole time to make sure that the implementations proceeded to my requirements.

He might even have more than one of each craftsperson for the equivalent of pair programming.

Extreme Programming, Cont'd

Even the tests were effectively written before implementation, because

- **I could take a shower,**
- **I could turn on the toaster and watch the lights in the kitchen,**
- **I could turn on the heaters, and**
- **I could make a phone call.**

This is surely classic XP or perhaps XR (eXtreme Remodeling).

Extreme Programming, Cont'd

I immediately decided against C2, because I would be paying $39.00 per person hour plus taxes, ...

not only for the implementation of the electrical solution, ...

but also for on-the-fly requirements analysis and specification phases during which ...

all the electricians except the leader would be sitting, doing nothing but watch their leader and me haggle out the specifications.

Extreme Programming, Cont'd

I would be anxious to start the implementation as quickly as possible to avoid spending more than necessary on requirements specification.

I would be likely to accept the first workable specification produced and would not be interested in finding the best approach.

No to C2

I turned C2 down immediately because at least one contractor, C1, was willing to write requirements specifications for the electrical task at his own expense.

No to C2, Cont'd

I knew that the waterfall approach would be more to my advantage than the XP approach simply because ...

with the waterfall, I would pay only for implementation based on requirements that had been more thoroughly thought out and reviewed, all at the contractor's expense.

Contractor C3

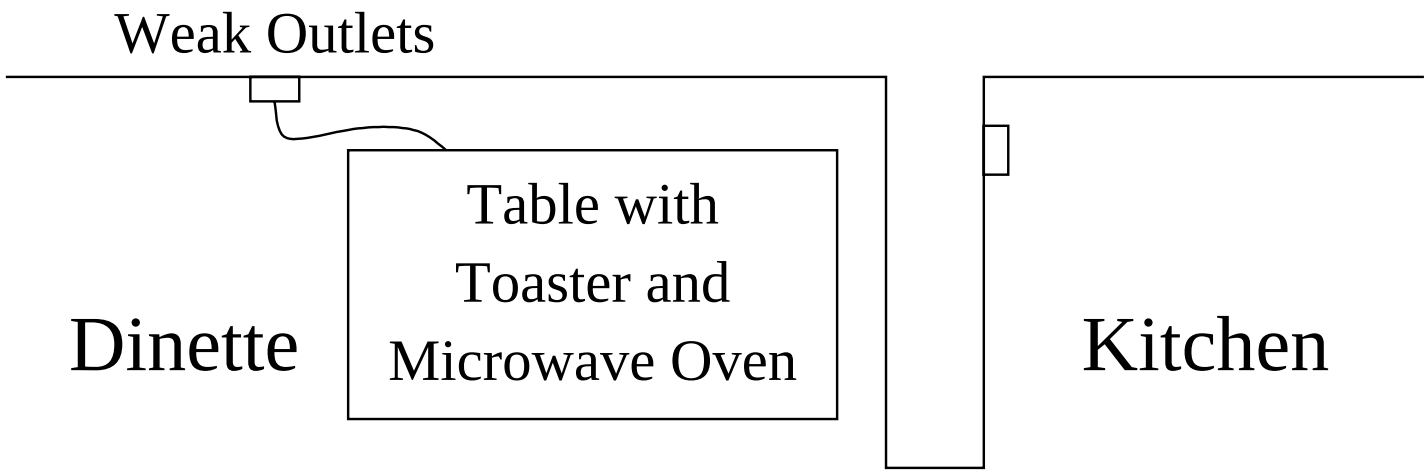
C3 came to my house and surprised me by doing real requirements engineering.

He thought that my so-called requirements for the electrical work were too complicated both as requirements and to implement.

C3: Electrical

He looked around in the kitchen that adjoins the dinette that needed stronger outlets:

C3: Electrical, Cont'd



C3: Electrical, Cont'd

He said that there is a better way to achieve what I *really* want, which is simply to have stronger outlets for the toaster and microwave oven.

I agreed that he captured my basic goal.

He showed me the wall that the kitchen and dinette shared and showed me a pair of outlets in the kitchen that were unused.

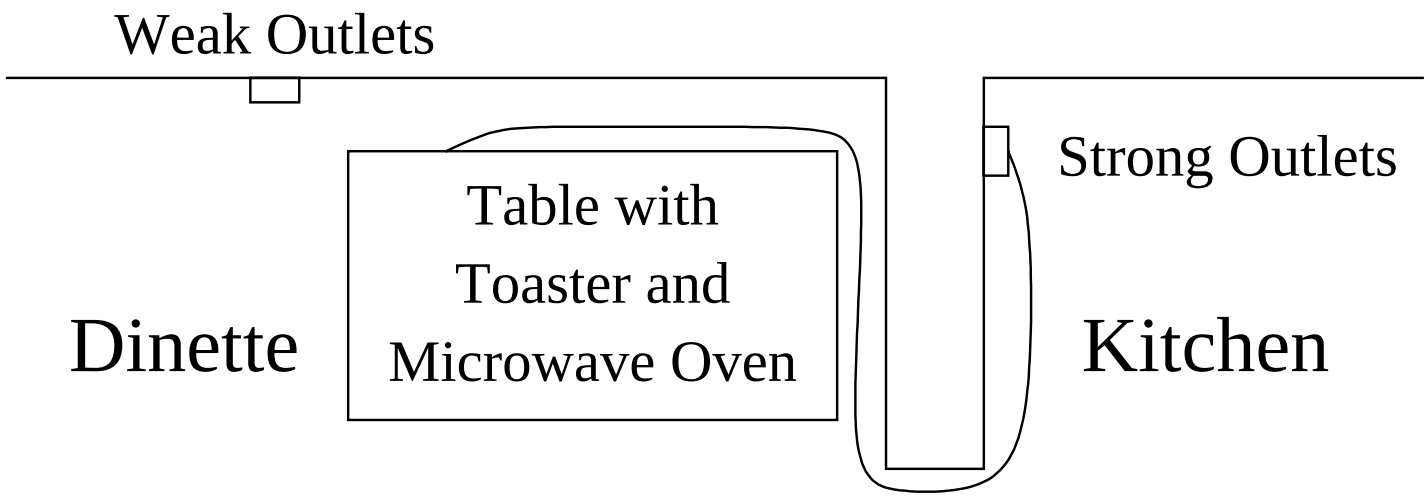
C3: Electrical, Cont'd

I did not know that they existed; I had never noticed them.

He explained that by the building code, kitchen outlets are already strong enough to support toasters and microwave ovens, two of the hungriest appliances in the house.

He asked, "So why not plug the toaster and microwave in those outlets in the kitchen?"

C3: Electrical, Cont'd



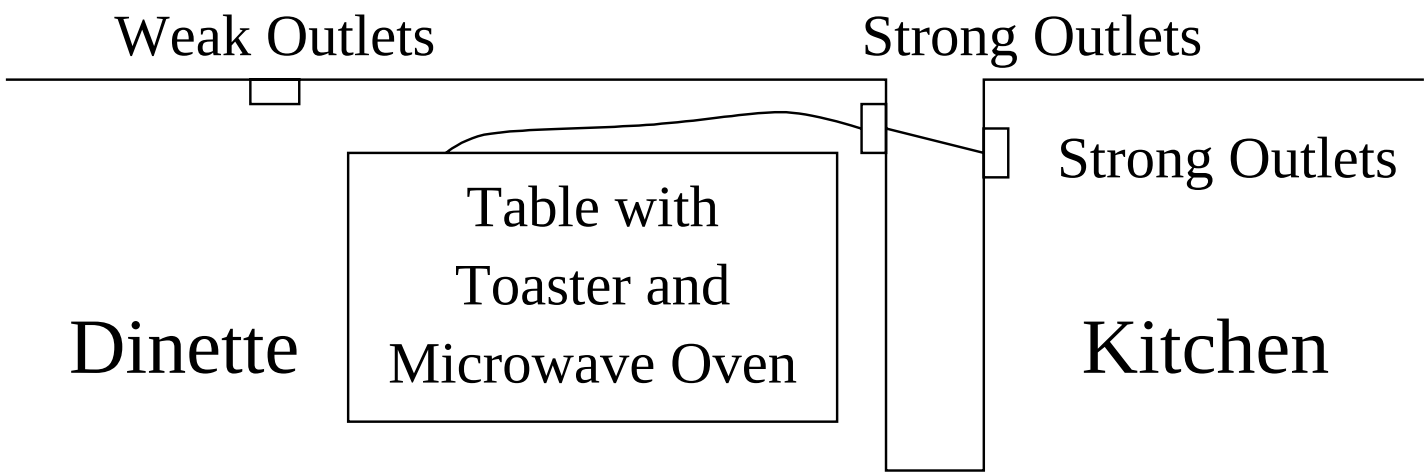
C3: Electrical, Cont'd

I explained that I did not want the cords running on the floor along the wall around the archway between the two rooms.

He explained how he could put in another pair of plugs on the other side of the wall, opposite the existing kitchen pair of outlets, ...

so that there would be a pair of outlets inside the dinette, coming off the existing strong line in the kitchen.

C3: Electrical, Cont'd



C3 Really Good

I was really impressed with C3.

He saw the real requirements.

He found two cheaper ways to implement them, one so cheap that he would not make any money at all on the electrical work.

C3 Really Good, Cont'd

That zero cost way, running the cords around into the kitchen, was ugly.

So, I opted for the other method, still quite a bit cheaper than what I had envisioned with my RFP.

C3: Shower

C3 then inspected the shower and proposed essentially the same as C1, right down to the brand of shower unit.

C3: Telephone

C3 said that fixing the phone line was trivial.

I agreed.

C3: Estimate

As expected, C3's estimate was considerably lower than C1's since the electrical work was relatively trivial.

The part of the estimate dealing with the shower was basically the same as that of C1's.

My Decision

I had C1's and C3's estimates in hand.

I knew that they were essentially equivalent with respect to the shower work

I asked each when he could begin.

C1 could start 2 months earlier.

I went with C1, but modified the electrical requirements in the way that C3 suggested.

My Decision, Cont'd

C1 lowered his electrical estimate.

I sent C3 a gift check for $50.00 for his time and the idea that led to the new electrical requirements and the lowering of C1's estimate.

Observations and Lessons Learned

- **Insisting on Waterfall**
- **Requirements, not Solutions**
- **Customer’s Duties**

Insisting on Waterfall

It was interesting to be on the customer's side of a requirements engineering effort with the knowledge of a requirements engineer.

As the customer, I firmly resisted working in any way in which implementation would start before the requirements and costs were agreed upon.

I did not want to pay for on-the-spot requirements analysis or prototyping.

Insisting on Waterfall, Cont'd

The building profession has a tradition of the contractor bearing the costs of RE.

Therefore, it was prudent for me, as a customer, to stick with the contractors that

- **followed the waterfall model completely and**
- **did the RE**
  - **up front and**
  - **at their own expense.**

Requirements, not Solutions

It is important to understand what the real requirements are and to specify requirements and not solutions.

Too often solutions are offered as requirements.

Requirements, not ..., Cont'd

On the other hand, it is the professional's job

- **to recognize that the customer has specified a solution and**
- **to ask questions that ferret out the real requirements.**

The professional has the domain knowledge necessary to make this recognition.

Requirements, not ..., Cont'd

In my case,

- **C3 knew enough about the building codes to know that there were strong enough outlets in the kitchen**
- **C3 knew, and could verify by observation, that the dinette would be near the kitchen.**

Thus, he was able to see an alternative implementation to the real requirements and then abstract to the real requirements.

Customer's Duties

It is essential for the customer of either a house building or a SW development to insist on following a full RE process, including

1. **goal identification,**
2. **requirements elicitation,**
3. **requirements analysis,**
4. **requirements specification, and**
5. **repeated validation of all of the above.**

Conclusions

We requirements engineers have a lot to learn about our own processes by being customers of a similar process.

For us to learn what it is really like to be a customer, it is necessary for us to be customers in a process, such as house building, not directly related to our own professional expertises, computer-based systems.

Conclusions, Cont'd

I have been a customer for SW construction (for ffortid, flo, and WD-pic).

it was not as difficult, anxiety producing, and educating as being a customer for a house building.

Perhaps, I know too much about SW development to be as mystified as most customers are!

Perhaps?

Teaching Customers

We need to write a manual to be given to potential SW construction customers and users explaining how to play their roles in a SW RE process.

It should tell them about all the processes involved and their roles in them.

Teaching Customers, Cont'd

It should admonish them

- **not to accept any attempt by us to pull the wool over their eyes,**
- **not to allow us to proceed to any next step until they have validated the work done up to then**
- **to bug us to death with questions about *any* thing that they do not understand about what we are doing.**

Teaching Customers, Cont'd

In other words, it should teach them how to be as good customers to us as I was to my contractors.

By "good" here, I mean for the customers' own benefits and not for the benefits of the requirements engineers' income or laziness.

House Building Customers

Perhaps, a slight variation of this manual could be written for customers of house buildings.

Would this book be blacklisted?

Acknowledgements

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