In groups of 2-3 for two minutes: various (mis)interpretations of these signs at the foot of an escalator.

Shoes Must Be Worn

Dogs Must Be Carried

CSE403: Software Engineering

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Well?

- Must I carry a dog?
- What about the shoes I just bought that are still in my shopping bag?
- Do dogs have to wear shoes?
- What does it mean to wear shoes?
- What are shoes?
- What are dogs?

"dog" (noun)

- OED has 15 definitions, Webster's 11
  - a highly variable domestic mammal closely related to the common wolf
  - a worthless person
  - any of various usu. simple mechanical devices for holding, gripping, or fastening that consist of a spike, rod, or bar
  - FEET
  - an investment ... not worth its price
  - an unattractive girl or woman

"shoe" (noun, Webster's)

- Six definitions including
  - an outer covering for the human foot usu. made of leather with a thick or stiff sole and an attached heel
  - another's place, function, or viewpoint
  - a device that retards, stops, or controls the motion of an object
  - a device (as a clip or track) on a camera that permits attachment of accessory items
  - a dealing box designed to hold several decks of playing cards

How about formalizing?

```
∀x•(OnEscalator(x)→
  ∃y•(PairOfShoes(y)∧
      IsWearing(x,y))

∀x•((OnEscalator(x)∧
     IsDog(x)) →
       IsCarried(x)
```

- Why do the formalizations say "dogs are carried" and "shoes are worn" while the signs say "must be"?
  - The formalizations are in indicative mood
  - The signs are in optative mood

Formalization: quick aside

- We will return to formalization later on, primarily with respect to precise definitions of program specifications
- `∀i,j | 0 ≤ i,j ≤ N • i < j → A[i] ≤ A[j]`
- `top(push(S,e) = e`

- But for requirements, it's far beyond the scope of the course (and perhaps, indeed, to some degree beyond the scope of formalization)
- Michael Jackson: "It is not too much to say that in dealing with the physical world formal reasoning can show the presence of errors, but not their absence."

Optative vs. indicative mood

- Indicative: describes how things in the world are regardless of the behavior of the system
  - "Each seat is located in one and only one theater."
- Optative: describes what you want the system to achieve
  - "Better seats should be allocated before worse seats at the same price."

Principle of uniform mood

- Indicative and optative properties should be entirely separated in a document
  - Reduces confusion of both the authors and the readers
  - Increases chances of finding problems
- If the software works right, both sets of properties will hold as facts

"Will" and "Shall"

- Some government groups write requirements with specified meanings for "will" and "shall" and "may" and such
  - "shall" is a requirement
  - "may" is an optional requirement
  - "will" describes something not under control of the system
- Generally unclear
  - Related to mood mixing

Structured natural language

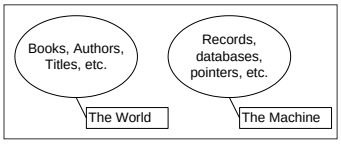
- I
  - I.A
    - I.A.ii
      - I.A.ii.3
        - » I.A.ii.3.q
- Although not ideal, it is almost always better than unstructured natural language
  - Unless the structure is used as an excuse to avoid content
- You will probably use something in this general style

"what vs. how": it's relative

- "One person's what is another person's how."
  - "One person's constant is another person's variable." [Perlis]
- Parsing is the what, a stack is the how
- A stack is the what, an array or a linked list is the how
- A linked list is the what, a doubly linked list is the how

The machine and the world Repeat

- Michael Jackson suggests a more fundamental distinction between requirements and program
  - The requirements are in the application domain
  - The program defines the machine that has an effect in the application domain
  - Ex: Imagine a database system dealing with books



Not a perfect mapping

- There are things in the world not represented by a given machine
- Examples might be
  - Book sequels or trilogies
  - Pseudonyms
  - Anonymous books
- There are things in the machine that don't represent anything in the world
- Examples might be
  - Null pointers
  - Deleting a record
  - Back pointers

Use cases: a very quick preview

Repeat

- A use case is a description of an example behavior of the system as situated in the world
  - Jane has a meeting at 10AM; when Jim tries to schedule another meeting for her at 10AM, he is notified about the conflict
- Similar to CRC (class responsibility collaborator) and eXtreme programming "stories"

Alert!

- I'll give some fairly specific details about what use cases are
- But there is no reason to follow the details precisely: they are just guidelines (you needn't even use them)
- Cockburn distinguishes
  - **Brief use case**: a few sentences that can be easily inserted in a spreadsheet cell, allowing other columns in the spreadsheet to record priority, etc.
  - **Casual use case**: a few paragraphs of text that summarizes the use case.
  - **Fully dressed use case**: a formal document with well-defined fields

Use cases and actors

- *Use cases* represent specific flows of events in the system
- Use cases are initiated by *actors* and describe the flow of events that these actors are involved in
  - Anything that interacts with a use case; it could be a human, external hardware (like a timer) or another system

Use case description

- How and when it begins and ends
- The interactions between the use case and its actors, including when the interaction occurs and what is exchanged
- How and when the use case will need data from or store data to the system
- How and when concepts of the problem domain are handled

Jacobson example: recycling

The course of events starts when the customer presses the "Start-Button" on the customer panel. The panel's built-in sensors are thereby activated.

The customer can now return deposit items via the customer panel. The sensors inform the system that an object has been inserted, they also measure the deposit item and return the result to the system.

The system uses the measurement result to determine the type of deposit item: can, bottle or crate.

The day total for the received deposit item type is incremented as is the number of returned deposit items of the current type that this customer has returned...

Use cases vs. scenarios

- Even though Jacobson invented use cases, I don't like this last example as a sample use case
- The reason is that it's really pretty long
- I think of this as more of a *scenario*, which strings together a set of use cases
- But the key point is fine: describe how the system behaves with respect to the users

An apparent aside

- In the process of defining a bunch of use cases, you will develop a set of entities in your system
  - Some of these are actors
  - Some of these are parts of your system
    - Remember, we're still not talking about implementation, but about requirements
- Collectively, these entities form something usually called your *data dictionary*

Data dictionary

- Basically, a list of the entities with descriptions of what they are

- *Account*: a single account in a bank against which transactions can be applied. A customer can hold more than one account.
- *Customer*: the holder of one or more accounts in a bank. A customer can consist of one or more persons or corporations. The same person holding an account at a different bank is considered a different customer.
- *Transaction*: a single integral request for operations on the accounts of a single customer...

Due to Jacobson

Designations vs. definitions [M. Jackson]

- *Designations* are the atomic phenomena
  - e.g., genetic mother
- *Definitions* define terms using designations and other definitions
  - e.g., genetic child of
- Refutable descriptions can in principle be disproven
  - $\forall m,x \bullet Mother(m,x) \rightarrow \neg Mother(x,m)$
  - Can't do this with definitions
- So, the data dictionary should rather include designations

How are the entities related?

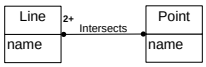
- The sample ATM definitions showed some relationships among the entities
  - "A customer can hold more than one account"
- There are many such relationships among the entities in a system
- These are often captured in a diagram usually called an *object model*

Object models

- There are many "languages" for defining object models
  - All object-oriented modeling techniques have such a language (OMT, UML, Booch, etc.)
- But the heart of these is basically Chen's entity-relationship diagrams (ERDs)
- Basically, boxes represent entities and connectors represent relationships
  - Logic can be used too, but isn't common

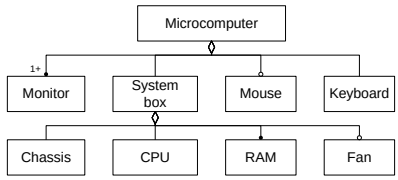
Trivial example

- Each of the two entities has a single attribute
  - This is similar to an instance variable
- There is a relationship (or association) named *Intersects* between the entities
  - This reads "2 or more Lines intersect in 0 or more Points"
  - Different notations do this in different ways
  - Make up your own if you need!



Note: OMT is perhaps the simplest of these models. There are lots of web pages about such models

Aggregation



- Aggregation represents an *is-part-of* relationship

Whence inheritance?

- OMT and other notations indeed support the representation of the inheritance relationship
- However, it's quite unusual for a good requirements object model to include inheritance relationships
  - Why is this?
  - Ones' design documents might do so, however

Another Example: buy a product

http://ontolog.cim3.net/cgi-bin/wiki.pl?UseCasesSimpleTextExample

1. Customer browses through catalog and selects items to buy
2. Customer goes to check out
3. Customer fills in shipping information
4. System presents full pricing information, including shipping
5. Customer fills in credit card information
6. System authorizes purchase
7. System confirms sale immediately
8. System sends confirming email to customer

- Alternative: **Authorization Failure**
  - At step 6, system fails to authorize credit purchase
  - Allow customer to re-enter credit card information and re-try
- Alternative: **Regular Customer**
  - 3a. System displays current shipping information, pricing information, and last four digits of credit card information
  - 3b. Customer may accept or override these defaults
  - Return to primary scenario at step 6

Another example: ATM

http://courses.knox.edu/cs292/ATMExample/UseCases.html

Recap I

- Use use cases to define instances of the behavior of the system
  - Beware: it's very hard to show completeness of your large collection of use cases
  - Scenarios are useful because they represent larger actions that users might perform

Recap II

- A data dictionary captures the entities and actors in a system, quite precisely
- An object model defines the relationships among those entities
- Together, these three elements define the basic requirements of a system: what's there, what the stuff is, and how it gets used

Questions?