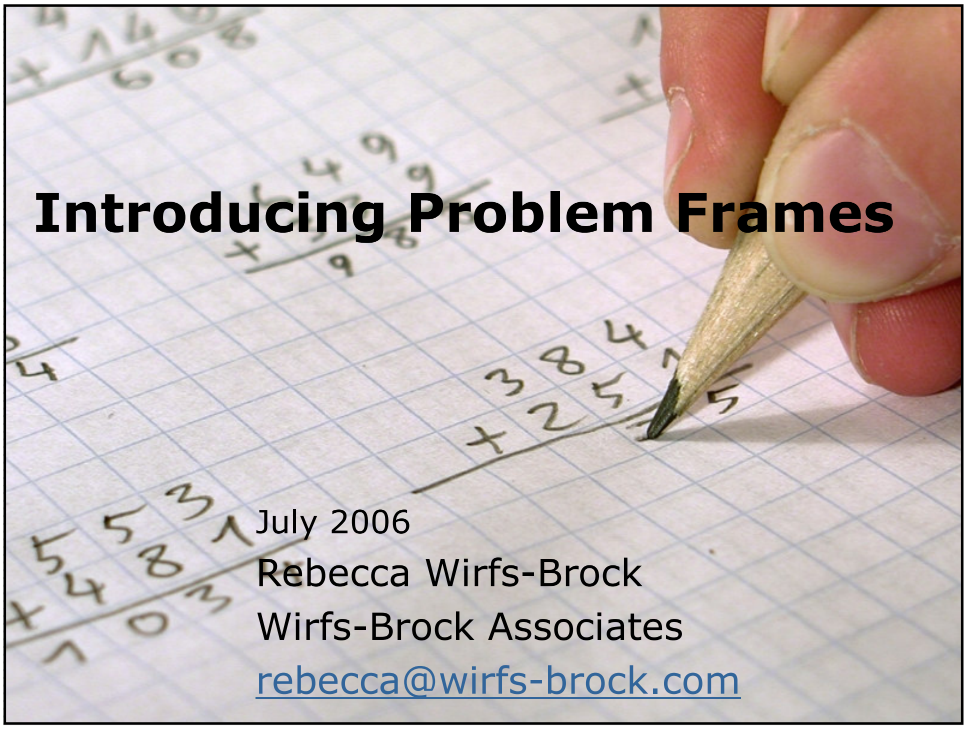

Introducing Problem Frames

July 2006

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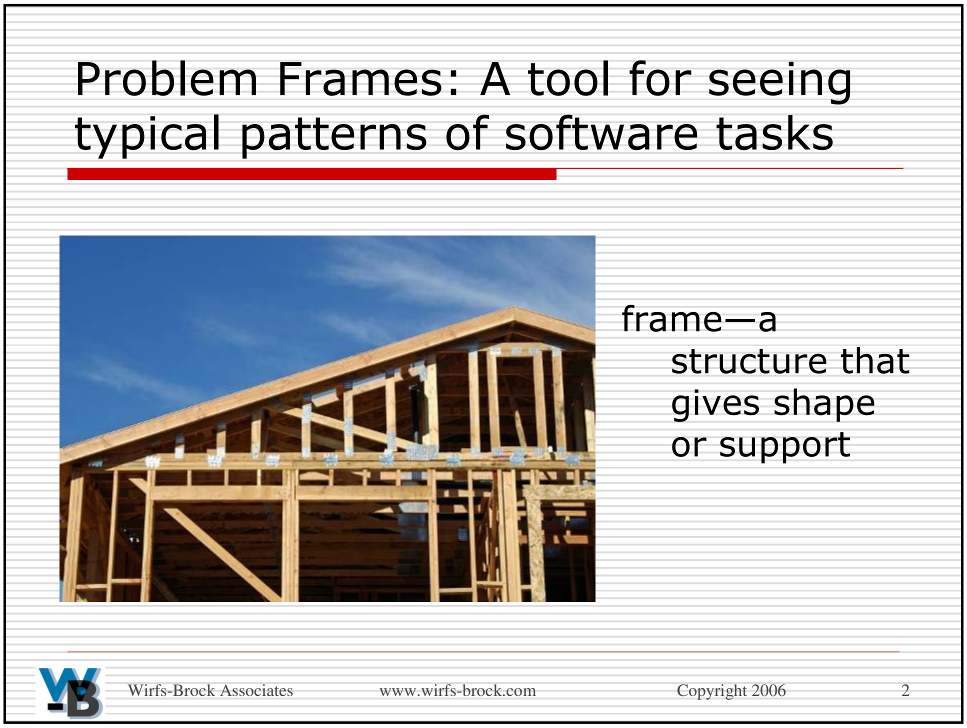
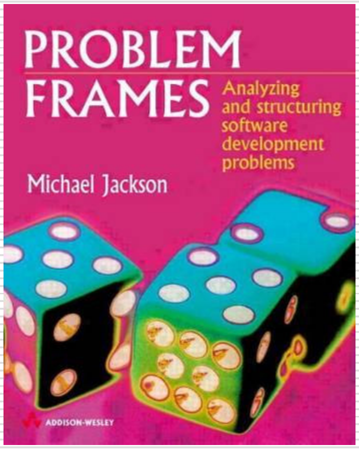


Problem Frames: A tool for seeing typical patterns of software tasks

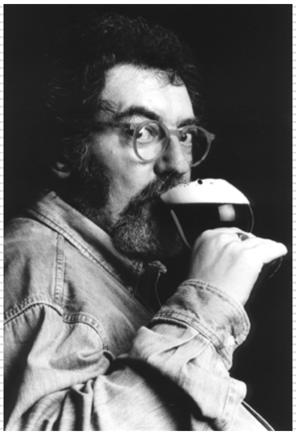
frame—a structure that gives shape or support

A Problem Frame…



"… defines the shape of a problem by capturing the *characteristics and interconnections of the parts of the world it is concerned with*, and the *concerns* and *difficulties* that are likely to arise. So problem frames help you to focus on the problem, instead of drifting into inventing a solution."

—Michael Jackson



Why frame problems?

"It's not easy to focus on problems in software development."

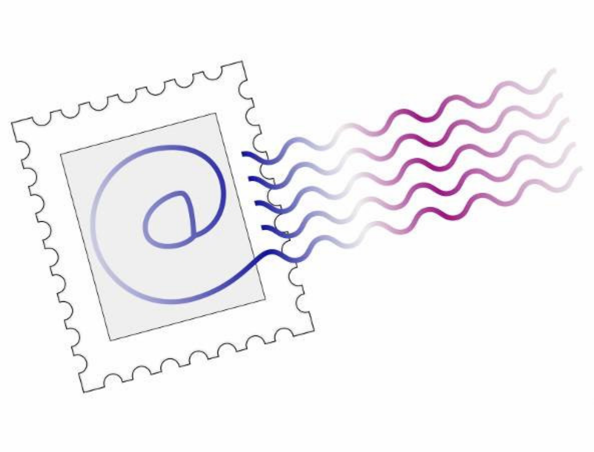
Problems:
Partly precise, partly imprecise

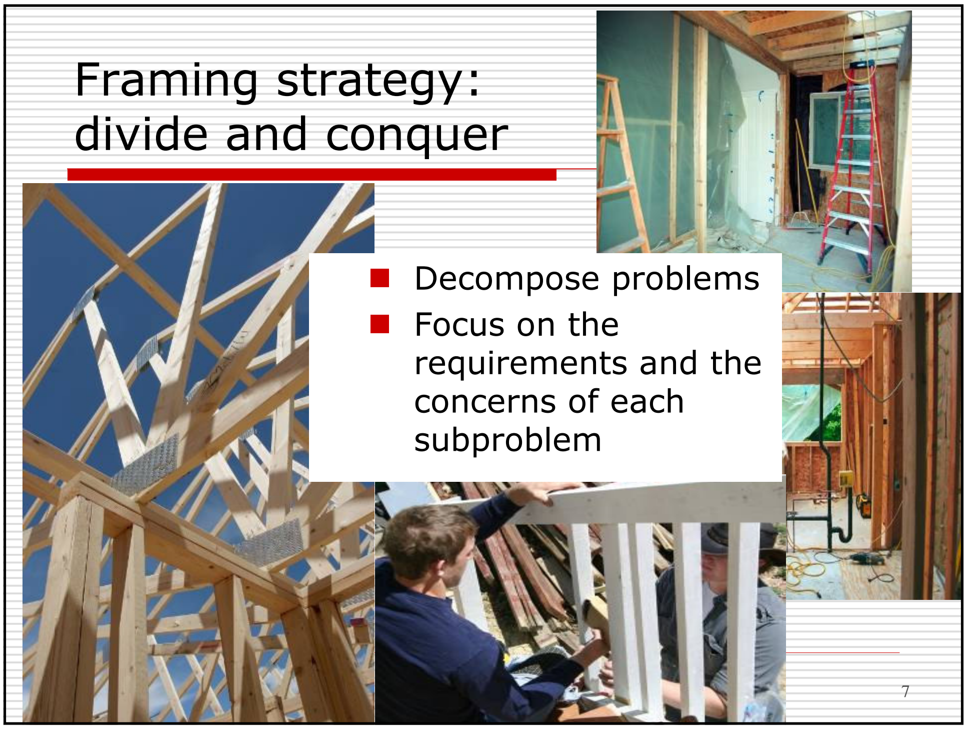
Scylla and Charybdis

Programming: Precise

Sociology, psychology:Imprecise

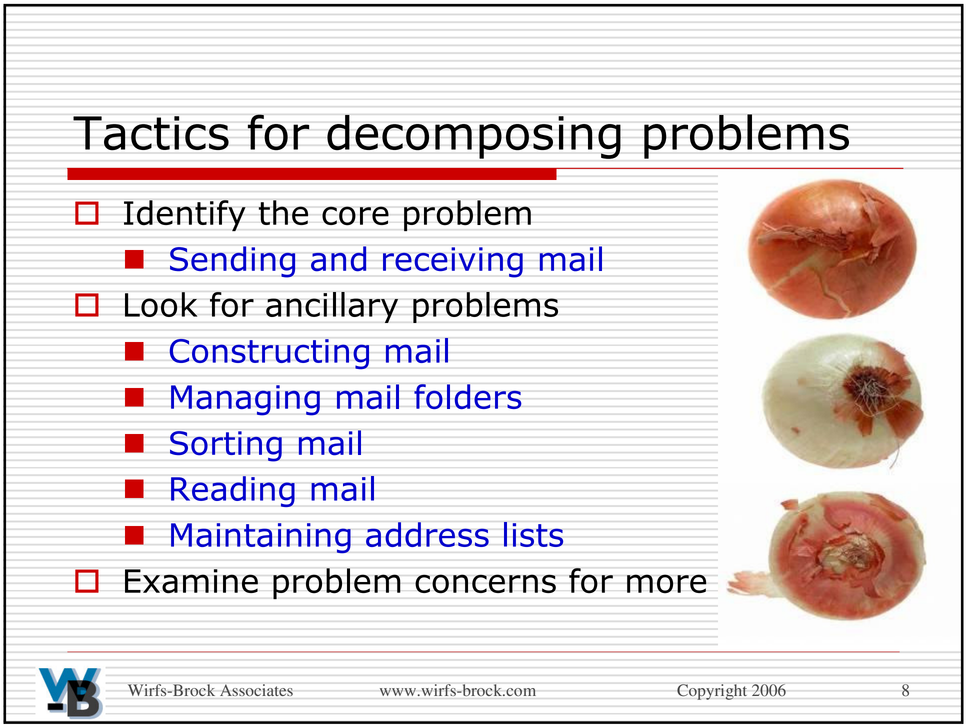
A case study: Email





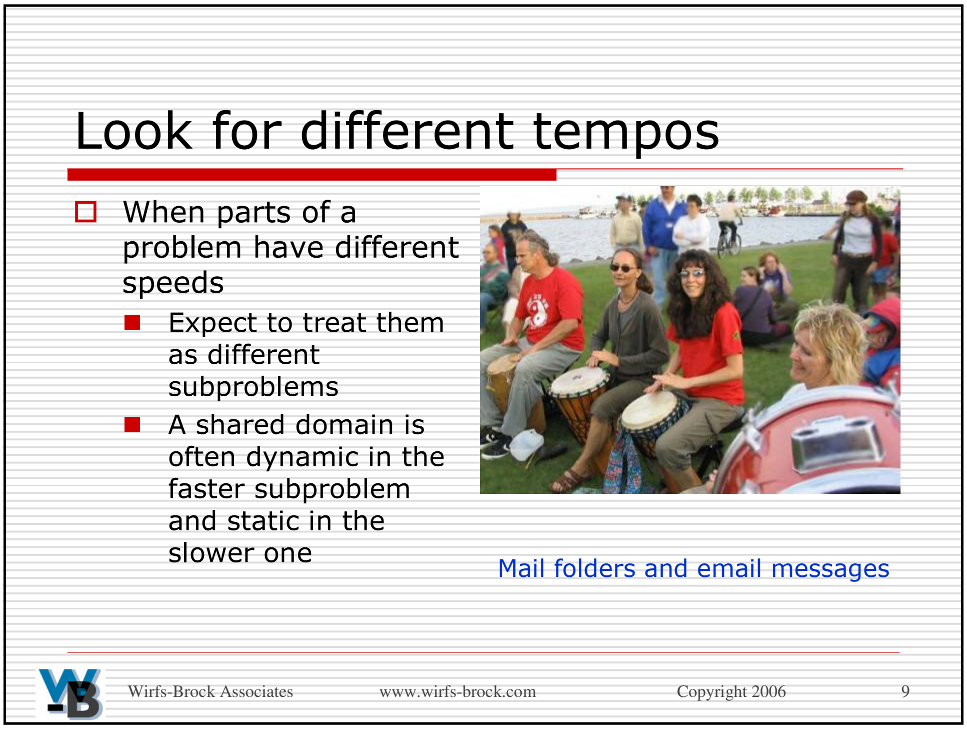
Framing strategy: divide and conquer

- Decompose problems
- Focus on the requirements and the concerns of each subproblem



Tactics for decomposing problems

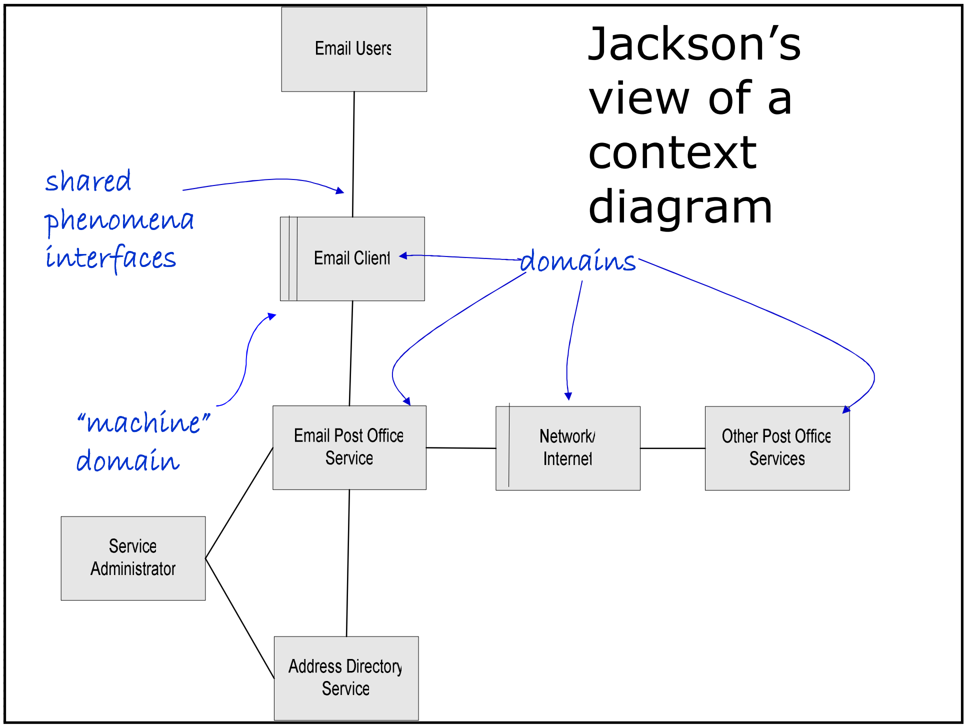
- Identify the core problem
  - Sending and receiving mail
- Look for ancillary problems
  - Constructing mail
  - Managing mail folders
  - Sorting mail
  - Reading mail
  - Maintaining address lists
- Examine problem concerns for more



Look for different tempos

- When parts of a problem have different speeds
  - Expect to treat them as different subproblems
  - A shared domain is often dynamic in the faster subproblem and static in the slower one

Mail folders and email messages



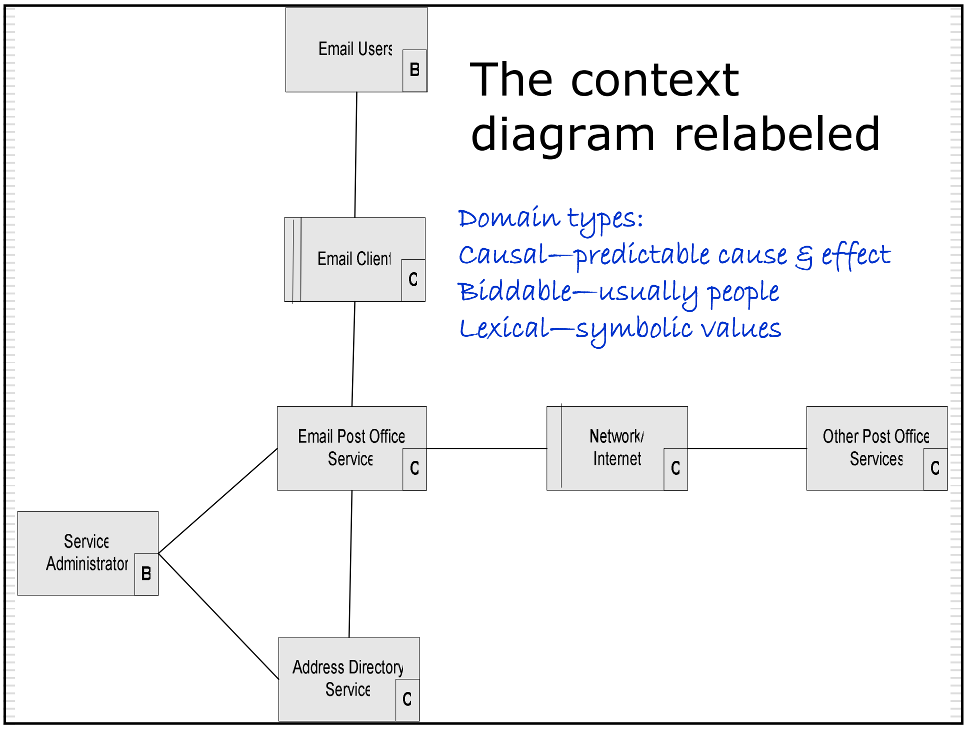
Jackson’s view of a context diagram

Email Users
Email Client
Email Post Office Service
Network/ Internet
Other Post Office Services
Service Administrator
Address Directory Service

shared phenomena interfaces

domains

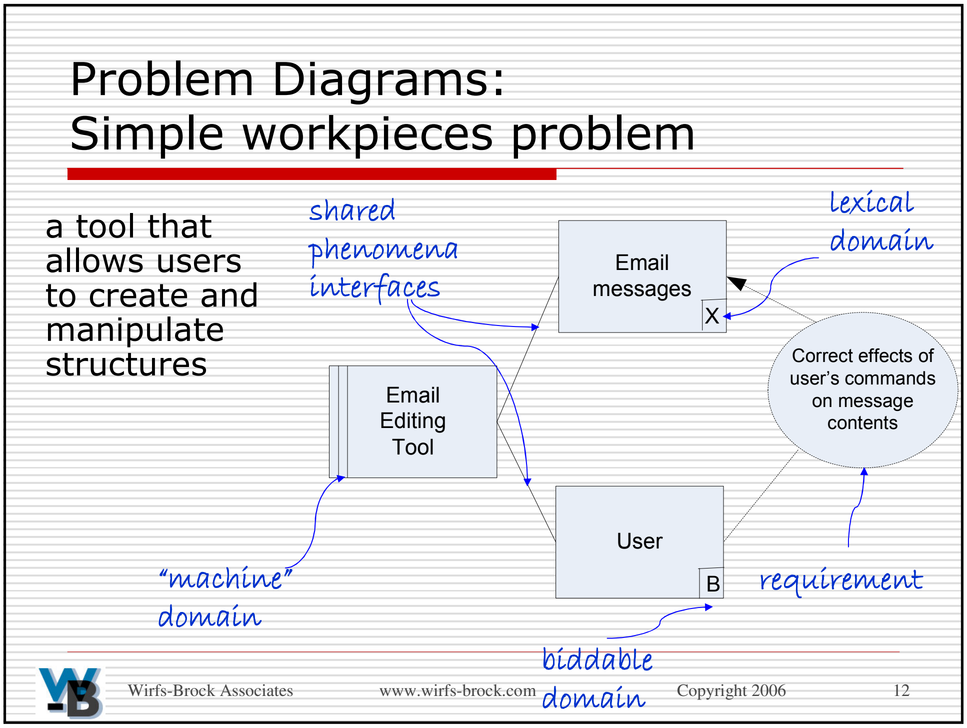
“machine” domain



The context diagram relabeled

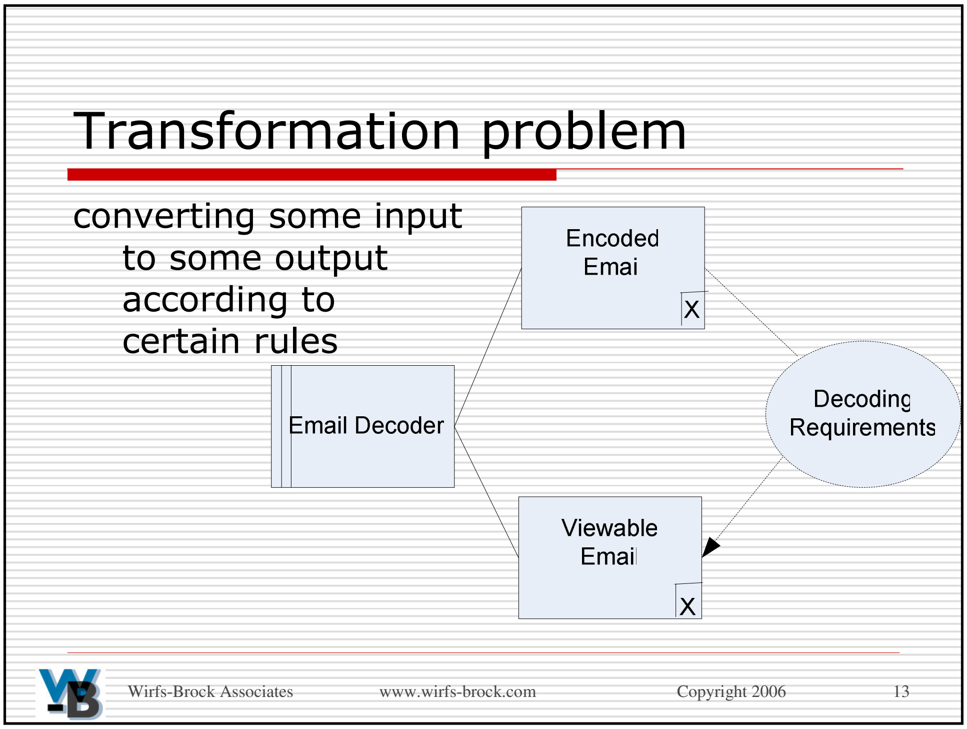
Domain types:
Causal—predictable cause & effect
Biddable—usually people
Lexical—symbolic values

Email Users
B
Email Client
C
Email Post Office Service
C
Network/ Internet
C
Other Post Office Services
C
Service Administrator
B
Address Directory Service
C



Problem Diagrams: Simple workpieces problem

a tool that allows users to create and manipulate structures



Transformation problem

converting some input to some output according to certain rules

Encoded Emai

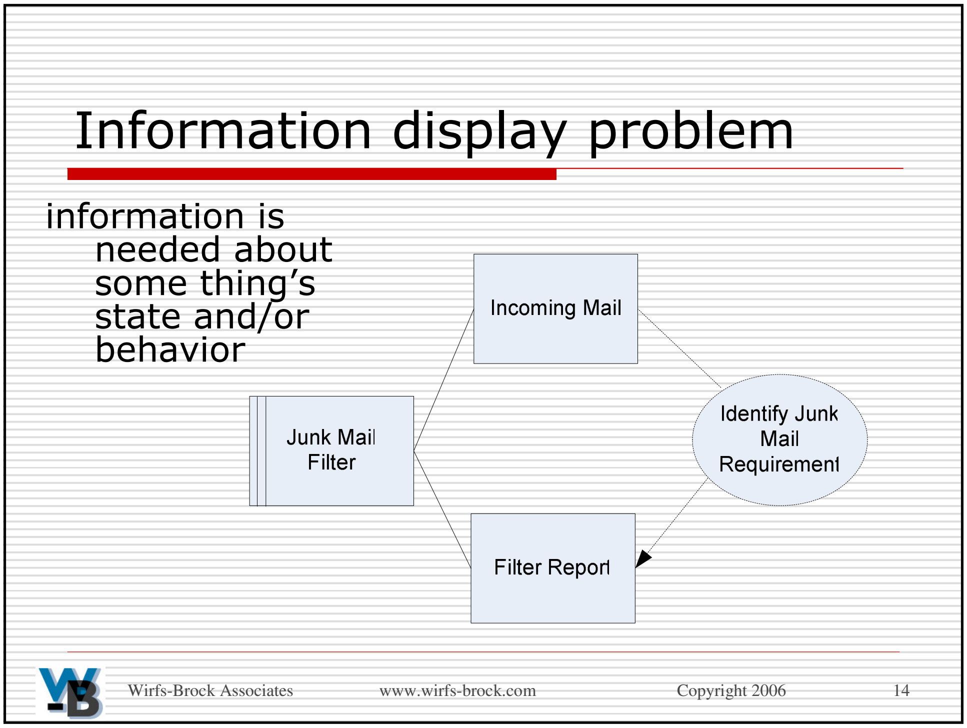
X

Email Decoder

Decoding Requirements

Viewable Email

X



Information display problem

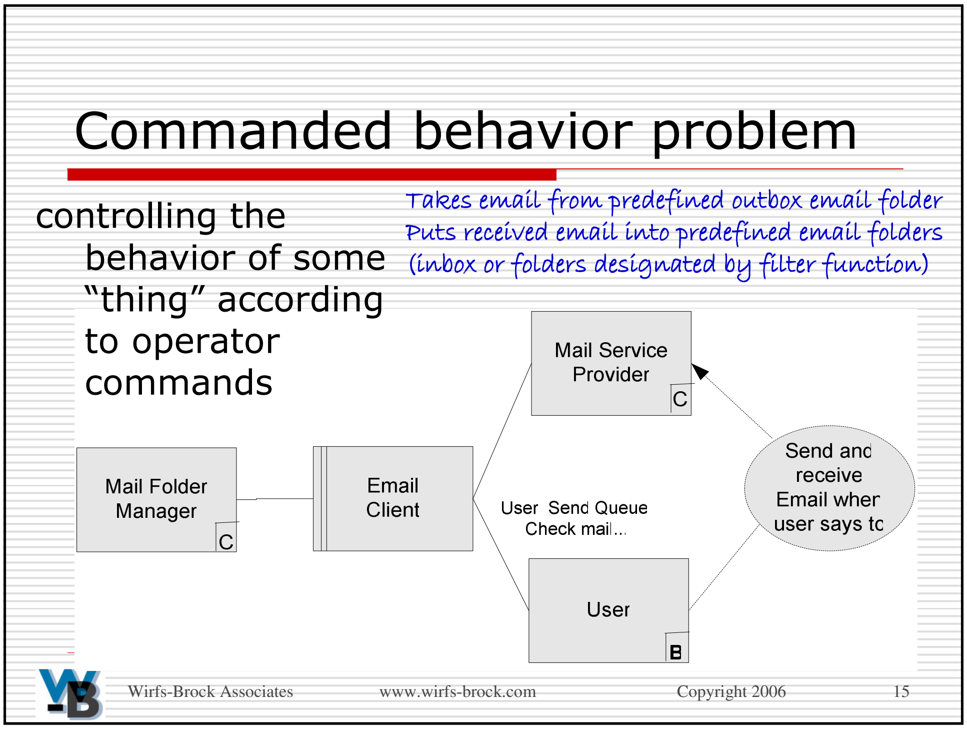
information is needed about some thing's state and/or behavior

Incoming Mail

Junk Mail Filter

Identify Junk Mail Requirement

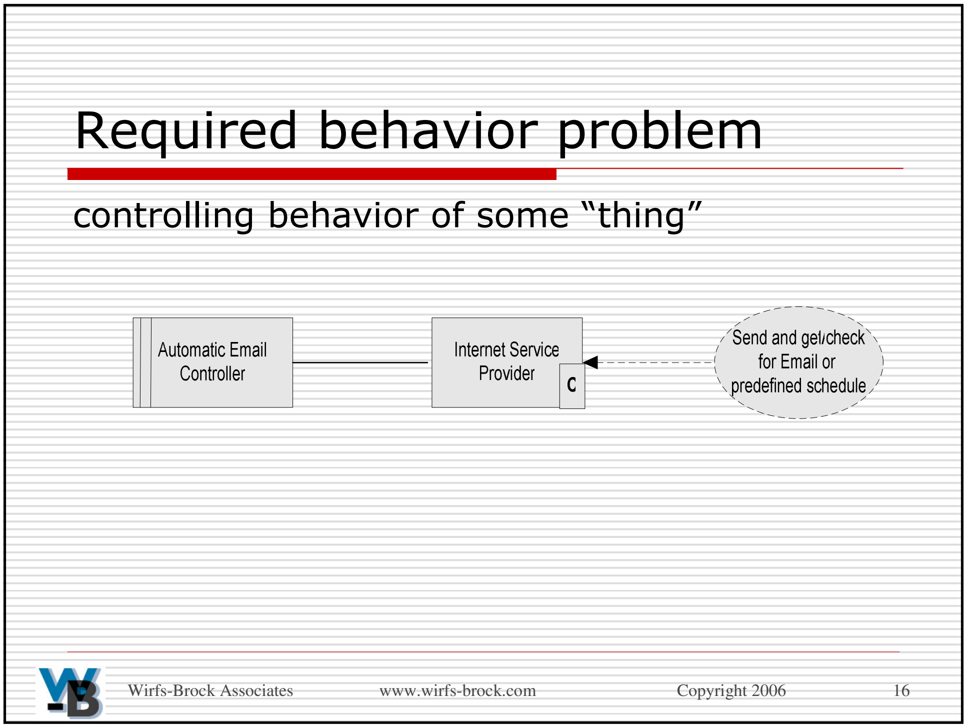
Filter Report



Commanded behavior problem

controlling the behavior of some "thing" according to operator commands

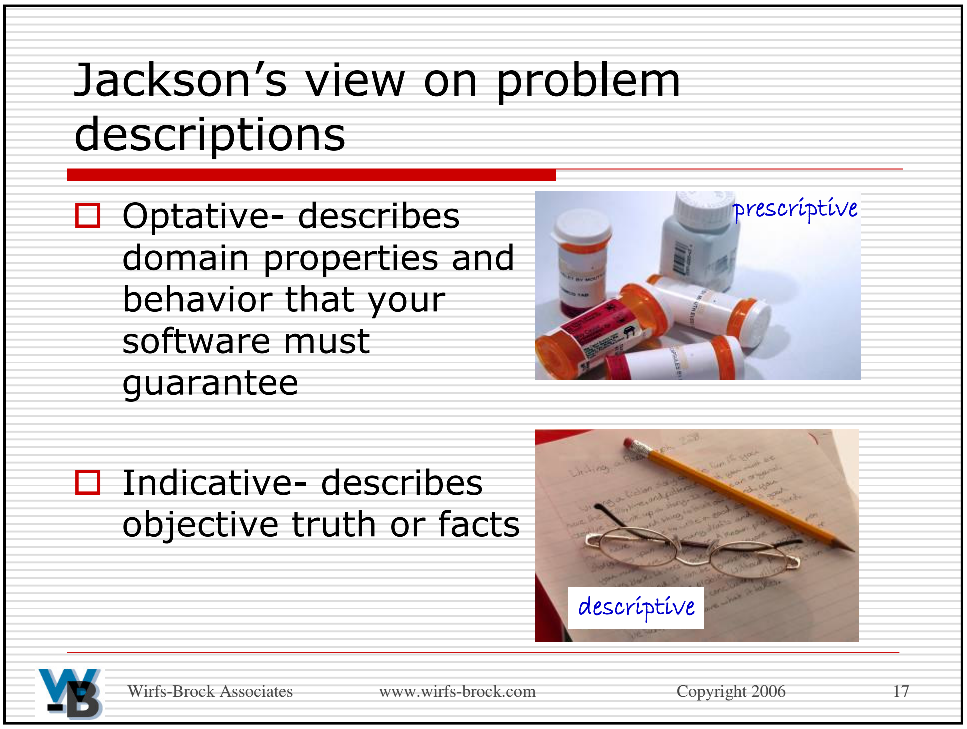
Takes email from predefined outbox email folder
Puts received email into predefined email folders
(inbox or folders designated by filter function)



Required behavior problem

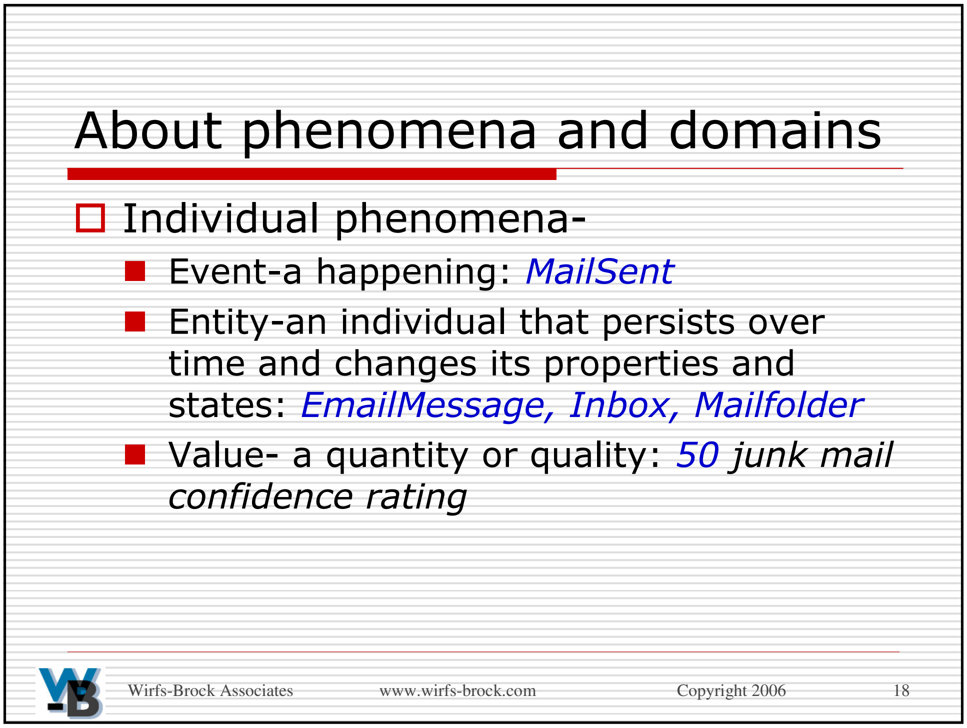
controlling behavior of some "thing"

Automatic Email Controller
Internet Service Provider
C
Send and get/check for Email or predefined schedule



Jackson’s view on problem descriptions

- □ Optative- describes domain properties and behavior that your software must guarantee
- □ Indicative- describes objective truth or facts



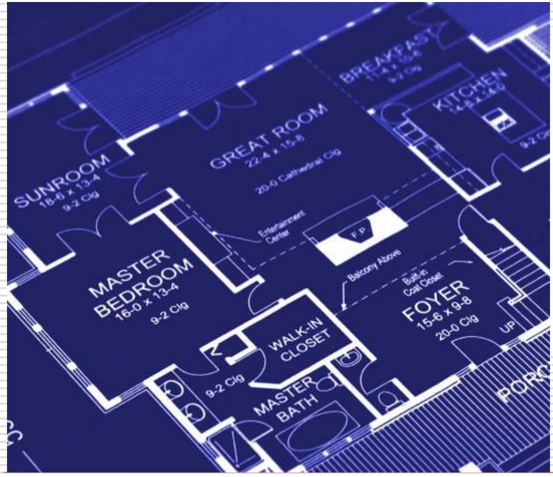
About phenomena and domains

- □ Individual phenomena-
  - Event-a happening: *MailSent*
  - Entity-an individual that persists over time and changes its properties and states: *EmailMessage, Inbox, Mailfolder*
  - Value- a quantity or quality: *50 junk mail confidence rating*

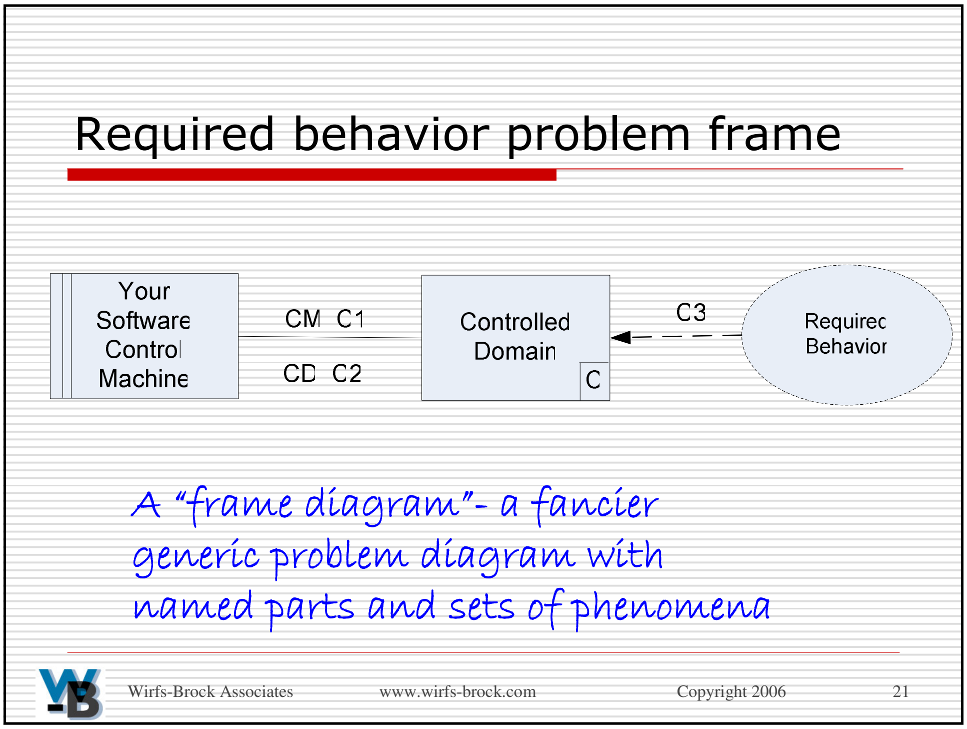
Relating phenomena

- State-relating values to entities *JunkMailRating(EmailMessagexxx,100)*
- Truths-a relation among individuals that cannot change *LaterThan(“timestamp: 07.19.2006”, “timestamp:1.1.2000”)*
- Roles-relation between an event and individuals *MailMoved(Inbox,ToDoFolder,EmailMessageyyy)*
- Cause and effect *MailRecieved(Inbox,EmailMessagexxx)* → *JunkMailRating(EmailMessagexxx,100)*

Shared Phenomena



Interfaces between domains are “direct”: Events, states, and values are shared between connected domains



Required behavior problem frame

Your Software Control Machine

CM C1

CD C2

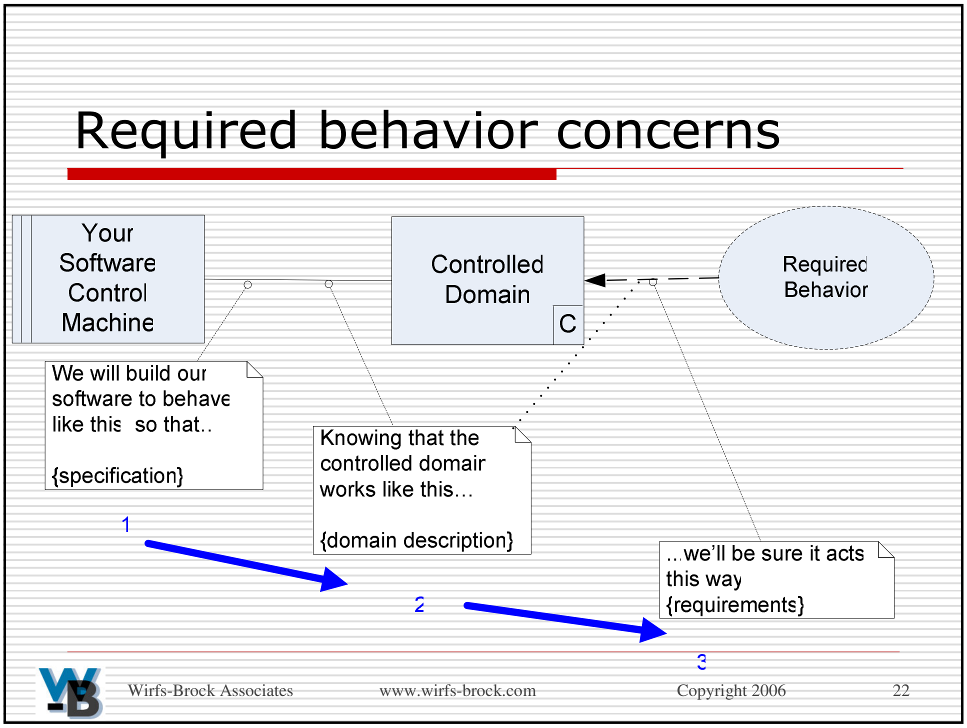
Controlled Domain

C

C3

Required Behavior

A "frame diagram"- a fancier generic problem diagram with named parts and sets of phenomena



Required behavior concerns

Your Software Control Machine

Controlled Domain

C

Required Behavior

We will build our software to behave like this so that..

{specification}

Knowing that the controlled domain works like this…

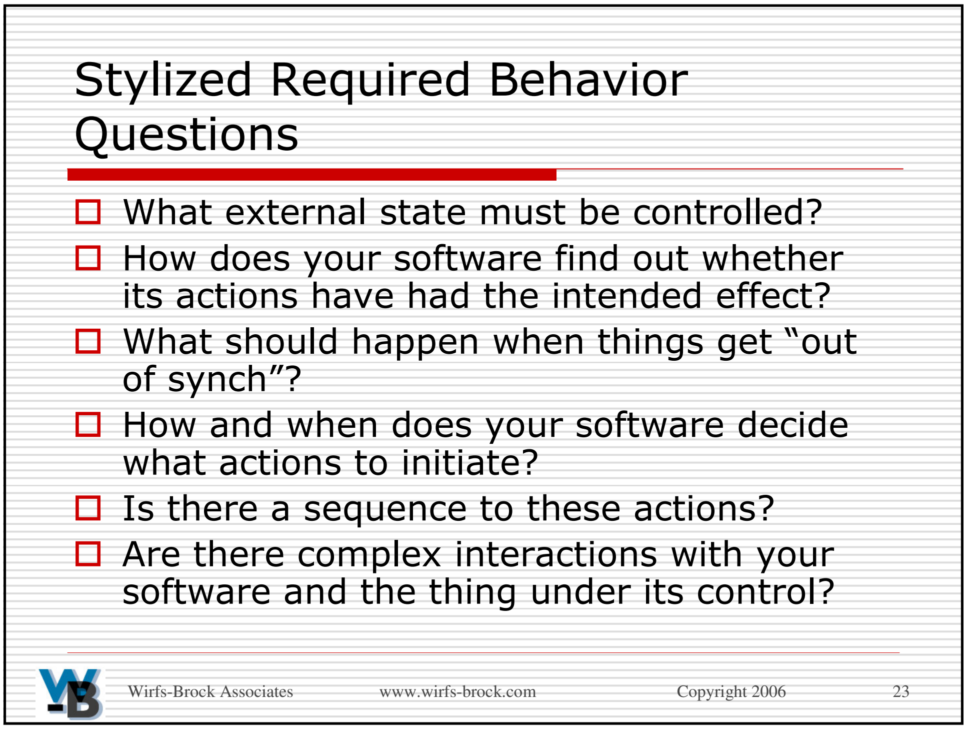
{domain description}

…we'll be sure it acts this way {requirements}

1

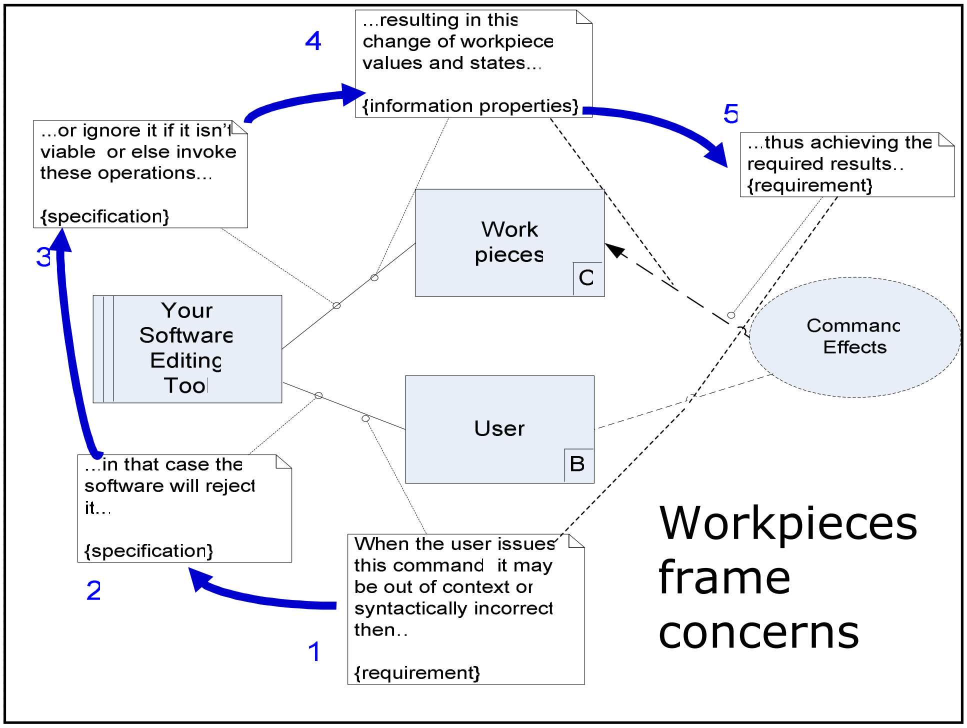
2

3



Stylized Required Behavior Questions

- □ What external state must be controlled?
- □ How does your software find out whether its actions have had the intended effect?
- □ What should happen when things get “out of synch”?
- □ How and when does your software decide what actions to initiate?
- □ Is there a sequence to these actions?
- □ Are there complex interactions with your software and the thing under its control?



Workpieces frame concerns

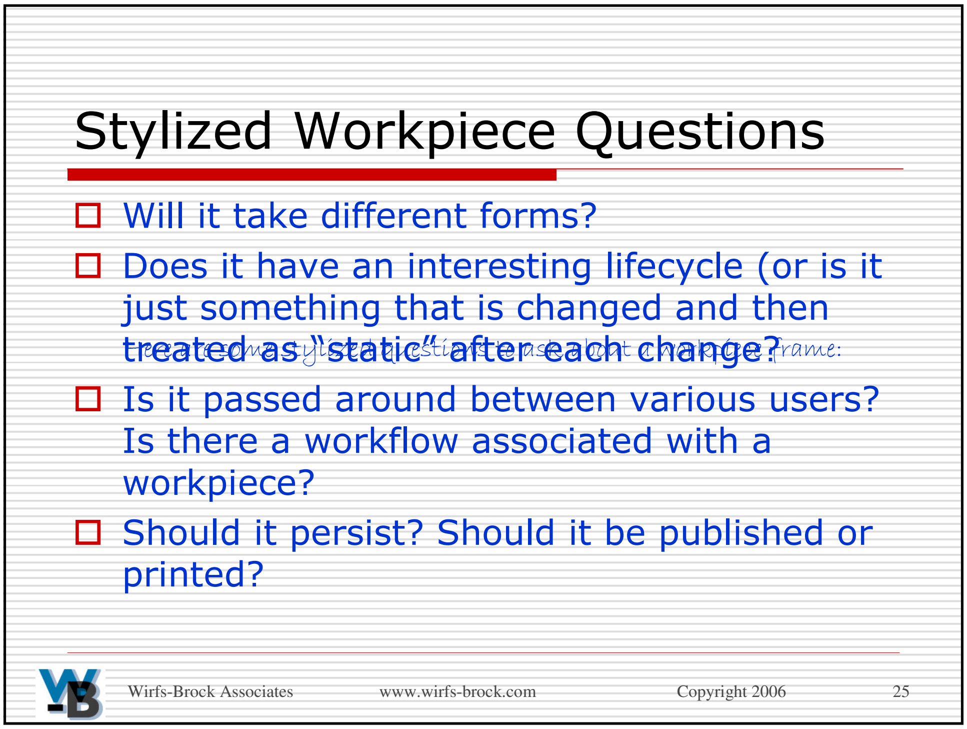
1 When the user issues this command it may be out of context or syntactically incorrect then..
{requirement}

2 ...in that case the software will reject it...
{specification}

3 ...or ignore it if it isn't viable or else invoke these operations...
{specification}

4 ...resulting in this change of workpiece values and states...
{information properties}

5 ...thus achieving the required results..
{requirement}



Stylized Workpiece Questions

- □ Will it take different forms?
- □ Does it have an interesting lifecycle (or is it just something that is changed and then treated as "static" after each change?
- □ Is it passed around between various users? Is there a workflow associated with a workpiece?
- □ Should it persist? Should it be published or printed?

Here are some stylized questions to ask about a workpiece frame:

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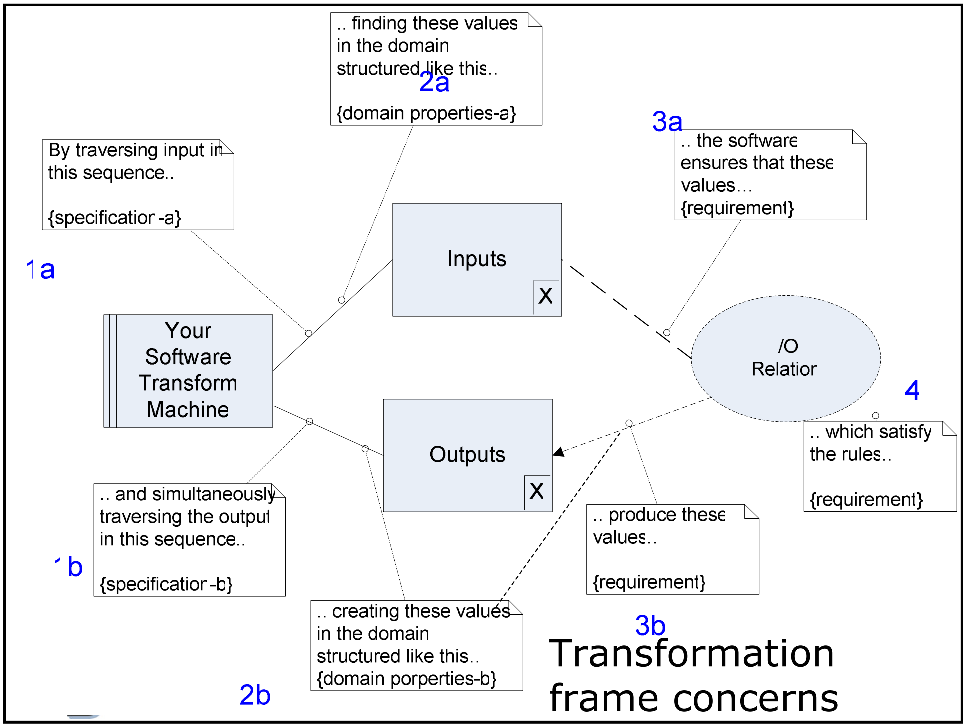
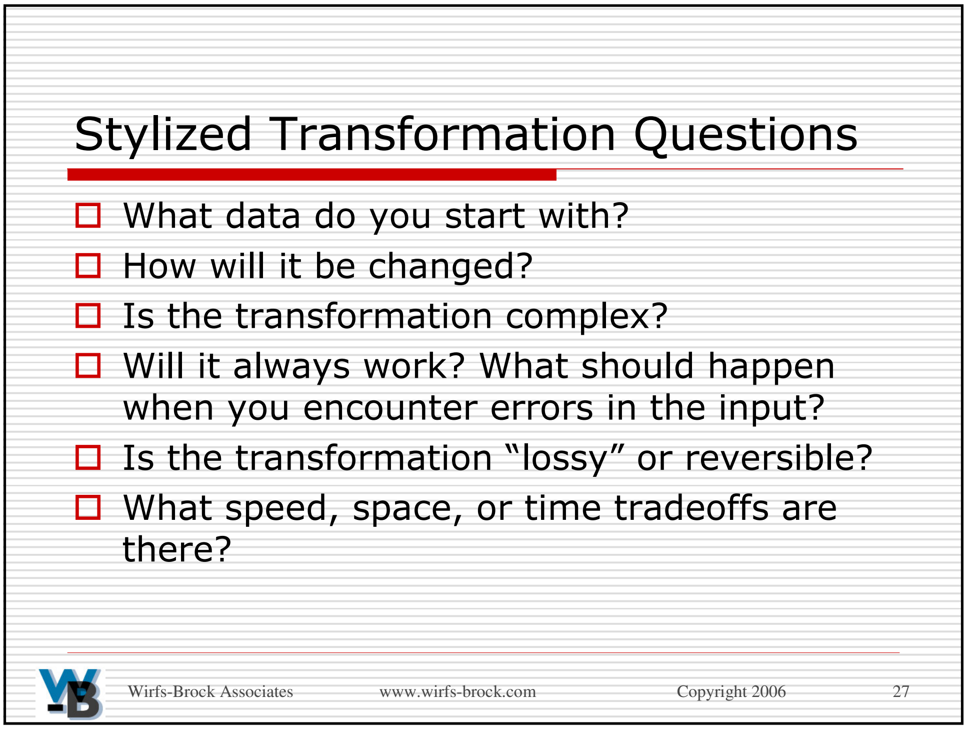


.. finding these values in the domain structured like this..
{domain properties-a}
2a
By traversing input in this sequence..
{specification-a}
1a
3a
.. the software ensures that these values…
{requirement}
Inputs
X
Your Software Transform Machine
I/O Relation
4
.. which satisfy the rules..
{requirement}
Outputs
X
.. and simultaneously traversing the output in this sequence..
{specification-b}
1b
.. produce these values..
{requirement}
.. creating these values in the domain structured like this..
{domain porperties-b}
3b
2b

Transformation frame concerns



Stylized Transformation Questions

- □ What data do you start with?
- □ How will it be changed?
- □ Is the transformation complex?
- □ Will it always work? What should happen when you encounter errors in the input?
- □ Is the transformation “lossy” or reversible?
- □ What speed, space, or time tradeoffs are there?

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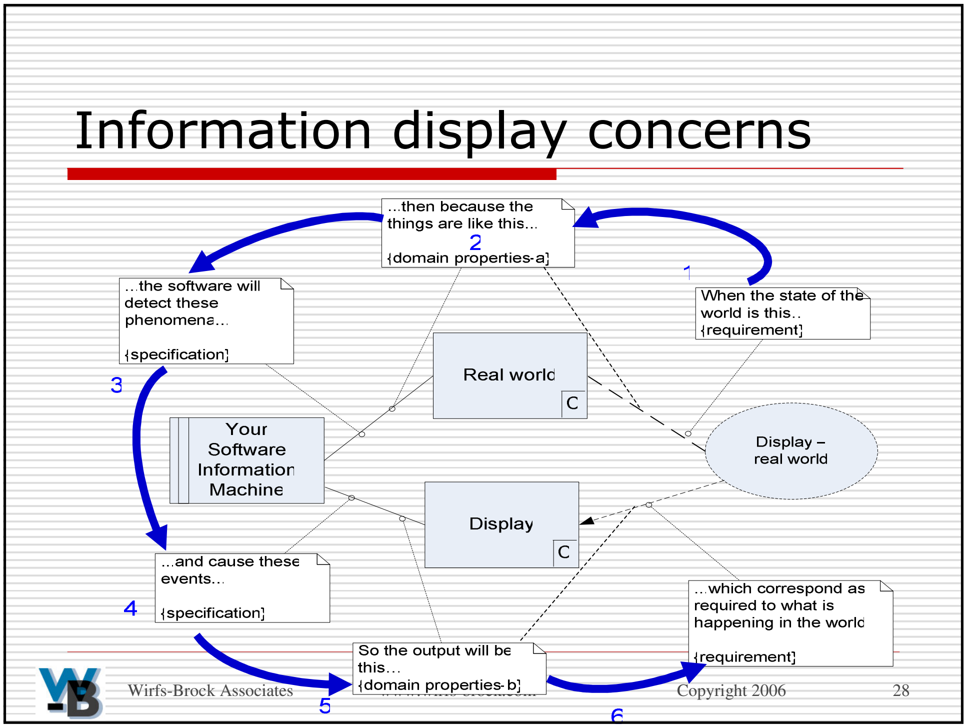

Information display concerns

1 When the state of the world is this.. {requirement}

2 …then because the things are like this… {domain properties-a}

3 …the software will detect these phenomena… {specification}

4 …and cause these events… {specification}

5 So the output will be this… {domain properties-b}

6 …which correspond as required to what is happening in the worlc {requirement}

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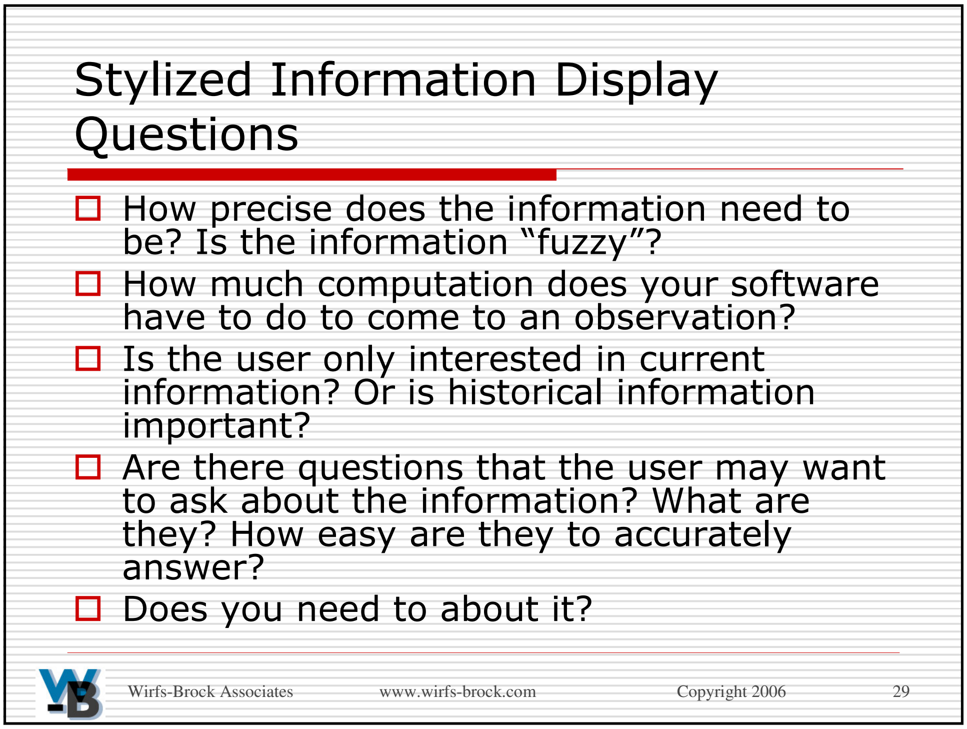

Stylized Information Display Questions

- □ How precise does the information need to be? Is the information "fuzzy"?
- □ How much computation does your software have to do to come to an observation?
- □ Is the user only interested in current information? Or is historical information important?
- □ Are there questions that the user may want to ask about the information? What are they? How easy are they to accurately answer?
- □ Does you need to about it?

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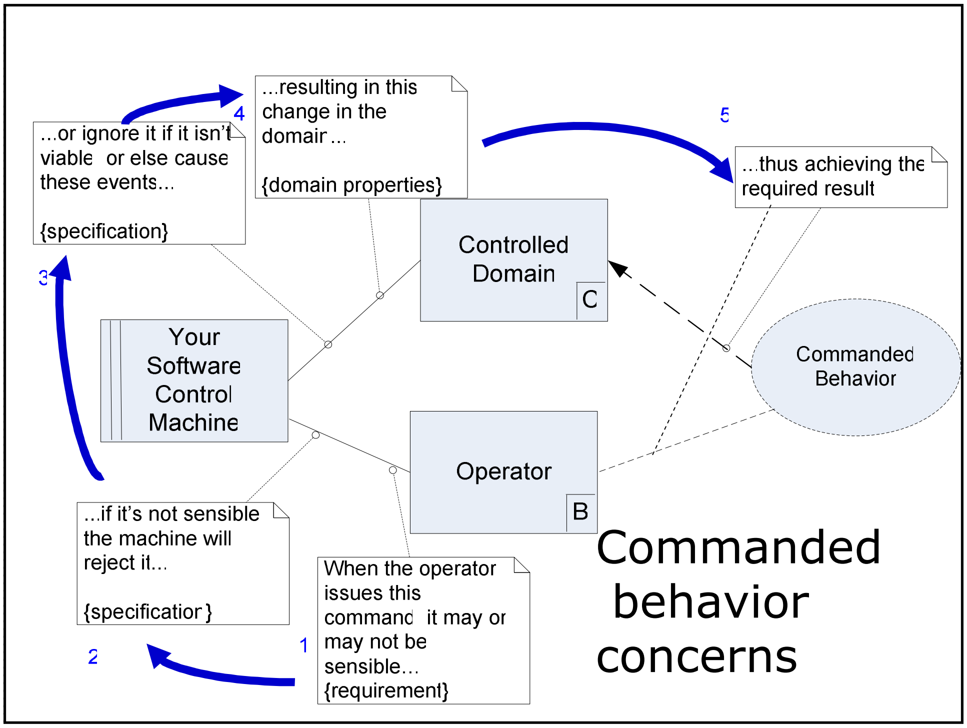


When the operator issues this command it may or may not be sensible... {requirement}

...if it's not sensible the machine will reject it... {specification}

...or ignore it if it isn't viable or else cause these events... {specification}

...resulting in this change in the domain... {domain properties}

...thus achieving the required result

Commanded behavior concerns

Stylized Commanded Behavior Questions

- □ What does the user need to know in order to “command” the system to do things?
- □ Do certain commands need to be inhibited? Do they always make sense?
- □ Is there a lag between issuing a command and the system performing the action?
- □ What happens when a command fails?
- □ Should certain commands be ignored?
- □ Do commands need to be reversible? logged? monitored or otherwise tracked?

Fitting problems to frames

The wrong frame will have some descriptions that don’t make sense and will leave out other necessary ones

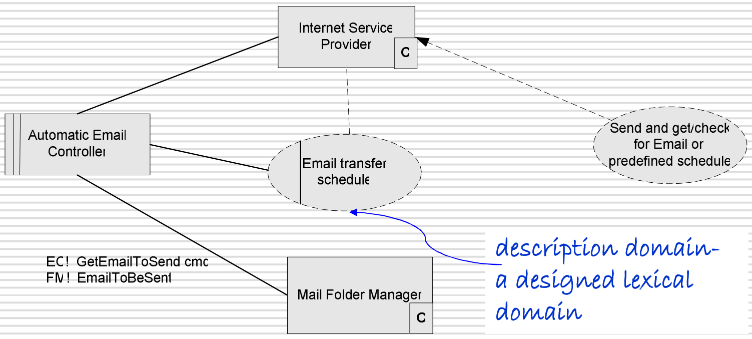
Problem frame expectations

- For each frame there is a clear expectation of the relative complexities

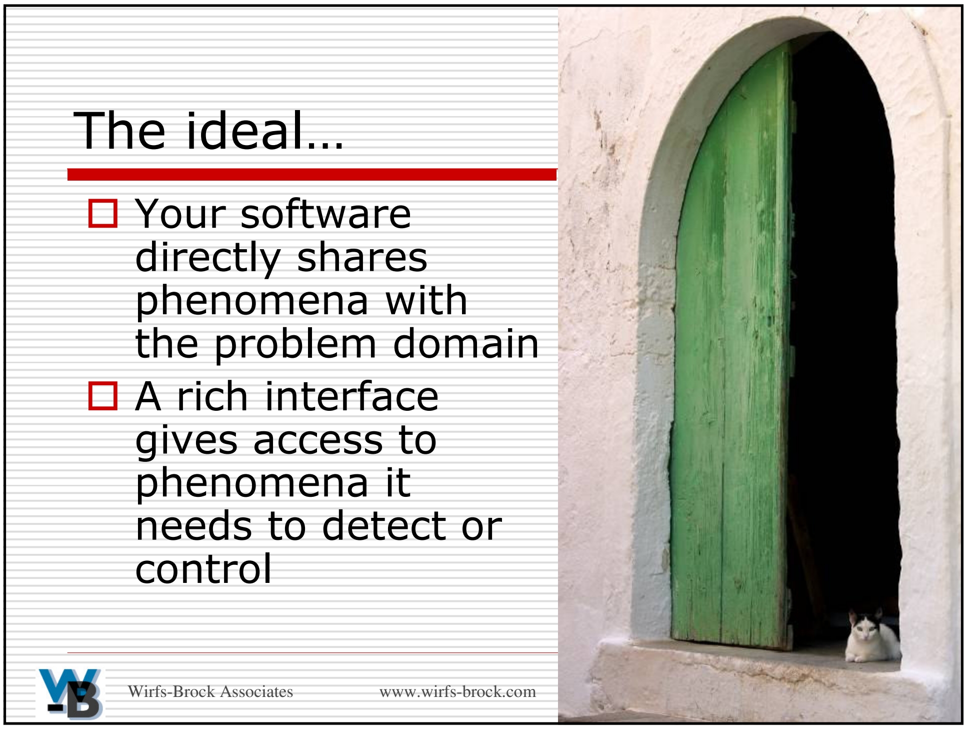
Frame	*Complex*	*Simple*
Required behavior	Controlled domain	
Commanded behavior	Controlled domain	Operator domain
Information display	Real world	Display domain
Simple Workpieces	Work pieces domain	User domain
Transformation	Input and Output domains	

Frame Variants:
Required behavior problem revisited

controlling behavior of some "thing"

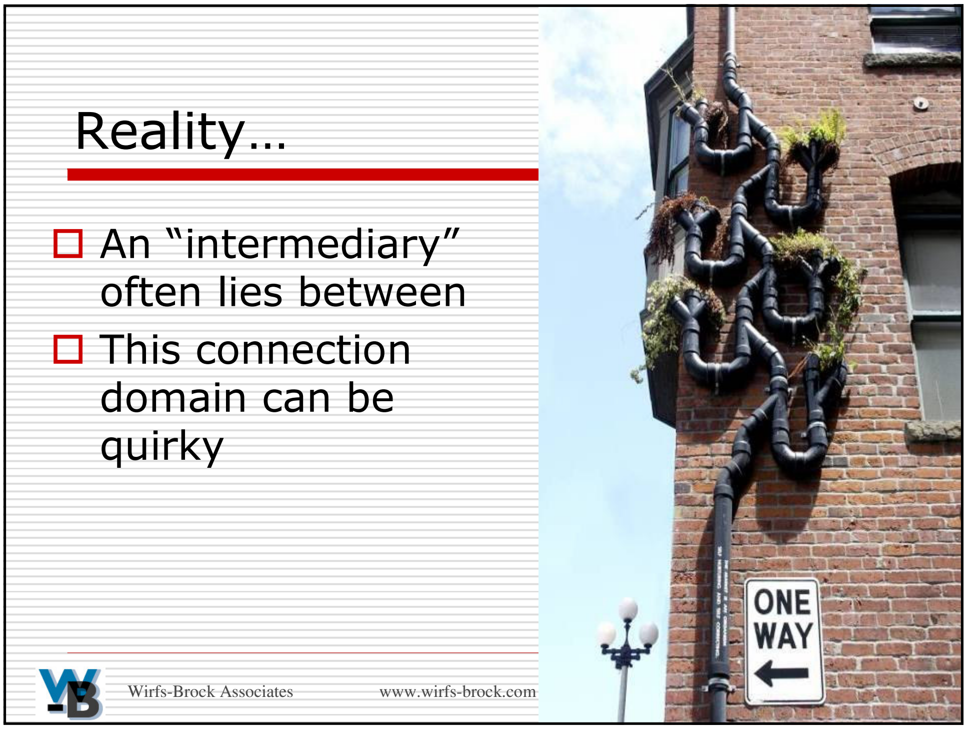

Internet Service Provider
C
Automatic Email Controller
Email transfer schedule
Send and get/check for Email or predefined schedule
EC! GetEmailToSend cmd
FM! EmailToBeSent
Mail Folder Manager
C

description domain- a designed lexical domain



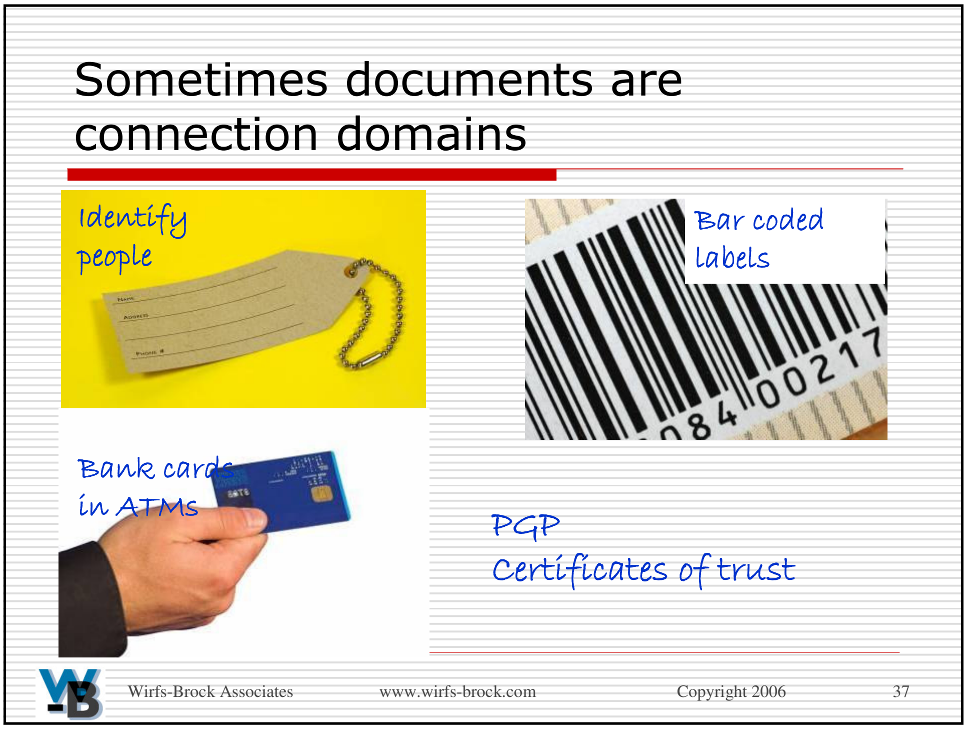
The ideal…

- □ Your software directly shares phenomena with the problem domain
- □ A rich interface gives access to phenomena it needs to detect or control



Reality…

- □ An “intermediary” often lies between
- □ This connection domain can be quirky



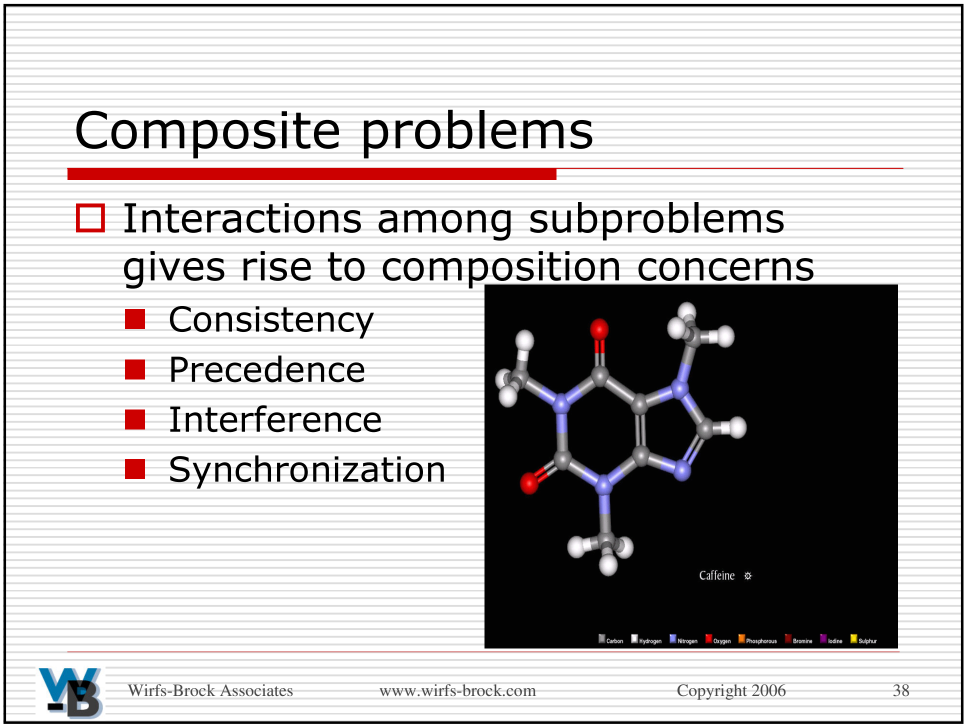
Sometimes documents are connection domains

Identify people

Bar coded labels

Bank cards in ATMs

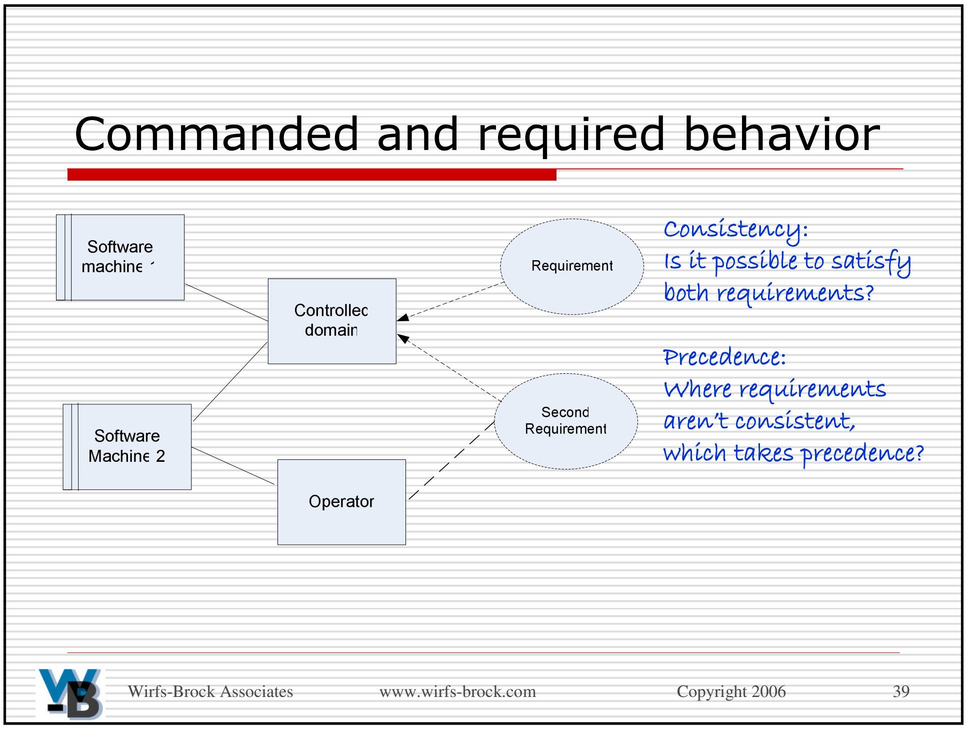
PGP
Certificates of trust



Composite problems

- Interactions among subproblems gives rise to composition concerns
  - Consistency
  - Precedence
  - Interference
  - Synchronization

Caffeine
Carbon
Hydrogen
Nitrogen
Oxygen
Phosphorous
Bromine
Iodine
Sulphur



Commanded and required behavior

Consistency:
Is it possible to satisfy both requirements?

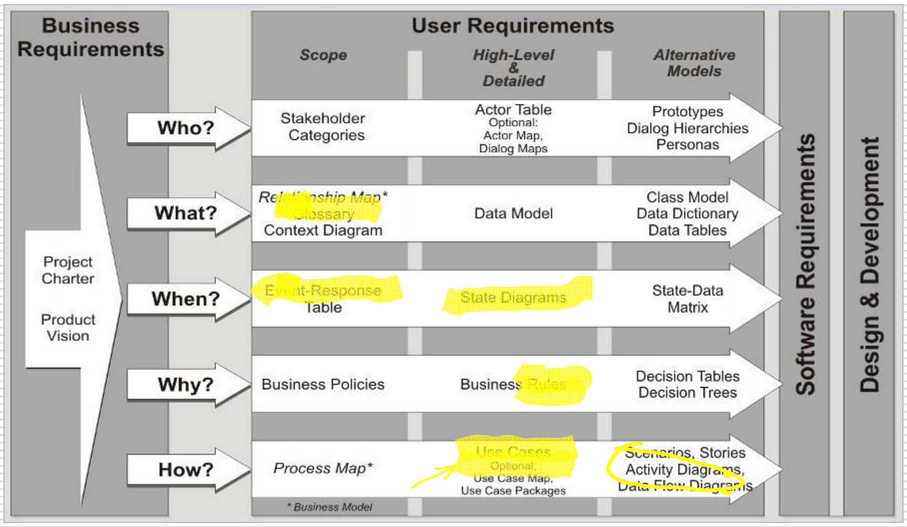
Precedence:
Where requirements aren't consistent, which takes precedence?

Integrating framing with other req'ts

- □ desired behavior and given domain properties can be missing or jumbled

Framing can help clarify

Requirements Roadmap



Business Requirements

Project Charter

Product Vision

User Requirements

	Scope	High-Level & Detailed	Alternative Models
Who?	Stakeholder Categories	Actor Table Optional: Actor Map, Dialog Maps	Prototypes Dialog Hierarchies Personas
What?	Relationship Map* Glossary Context Diagram	Data Model	Class Model Data Dictionary Data Tables
When?	Event-Response Table	State Diagrams	State-Data Matrix
Why?	Business Policies	Business Rules	Decision Tables Decision Trees
How?	Process Map*	Use Cases Optional: Use Case Map, Use Case Packages	Scenarios, Stories Activity Diagrams, Data Flow Diagrams

* Business Model

Software Requirements

Design & Development

Source: Ellen Gottesdiener, EBG Consulting

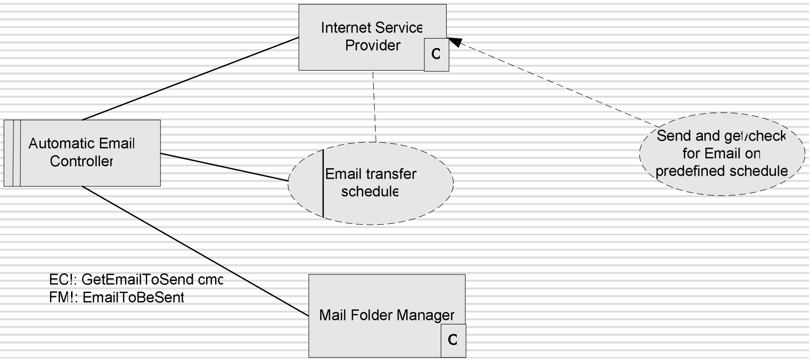
Where problem frames don't fit

- Framing's emphasis on phenomena doesn't help describe or understand:
  - Mathematical computations or algorithms
  - Graphics user interfaces
  - Compilers
  - …

What about a more agile world?

- □ Jackson advocates fully understanding problems before starting design
- □ Agile developers expect to incrementally discover requirements. Framing
  - …can focus design spikes
  - …can lead to deeper understanding of user stories and their dependencies

How do Problem Frames Relate to Sprints and Story Cards?



Internet Service Provider C

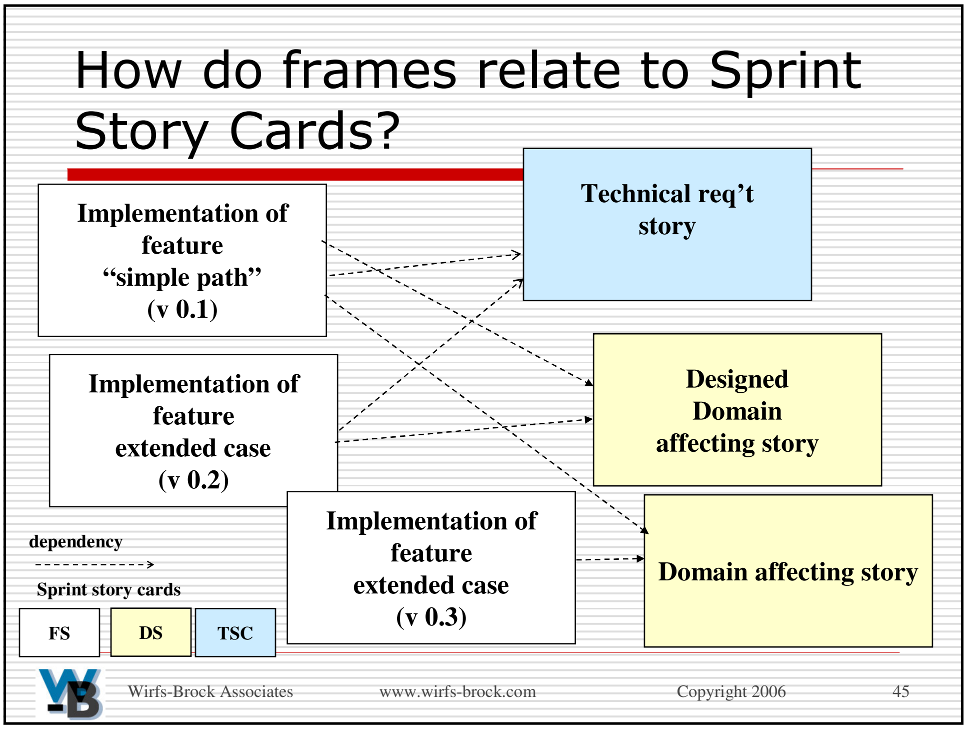
Automatic Email Controller

Email transfer schedule

Send and get/check for Email on predefined schedule

EC!: GetEmailToSend cmd
FM!: EmailToBeSent

Mail Folder Manager C



How do frames relate to Sprint Story Cards?

Implementation of feature "simple path" (v 0.1)

Implementation of feature extended case (v 0.2)

Implementation of feature extended case (v 0.3)

Technical req't story

Designed Domain affecting story

Domain affecting story

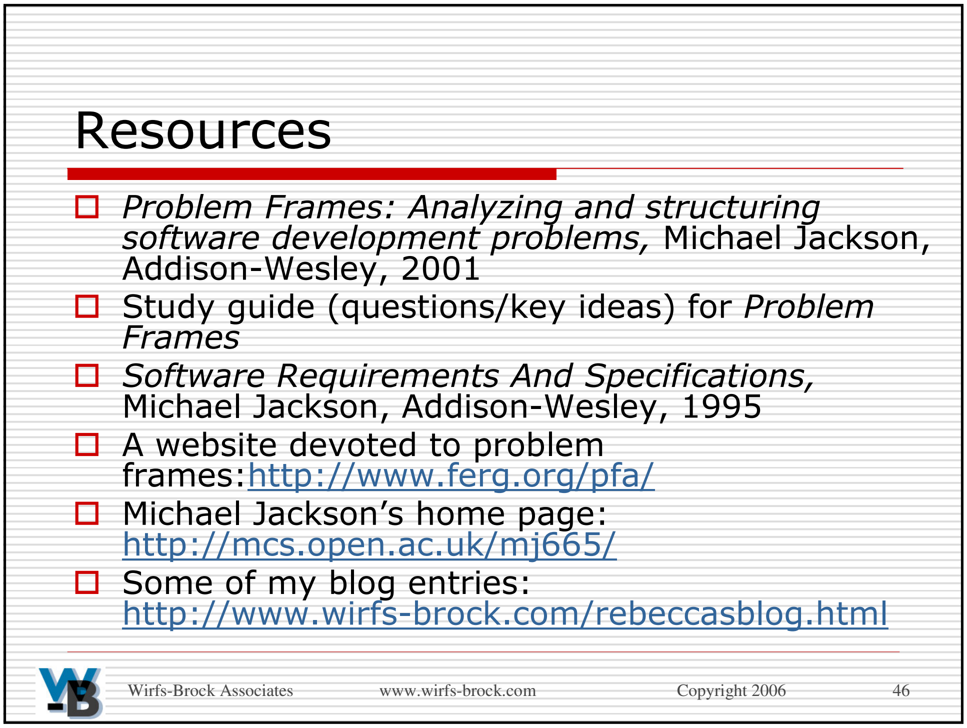
dependency

Sprint story cards

FS

DS

TSC



Resources

- *Problem Frames: Analyzing and structuring software development problems,* Michael Jackson, Addison-Wesley, 2001
- Study guide (questions/key ideas) for *Problem Frames*
- *Software Requirements And Specifications,* Michael Jackson, Addison-Wesley, 1995
- A website devoted to problem frames:http://www.ferg.org/pfa/
- Michael Jackson's home page: http://mcs.open.ac.uk/mj665/
- Some of my blog entries: http://www.wirfs-brock.com/rebeccasblog.html

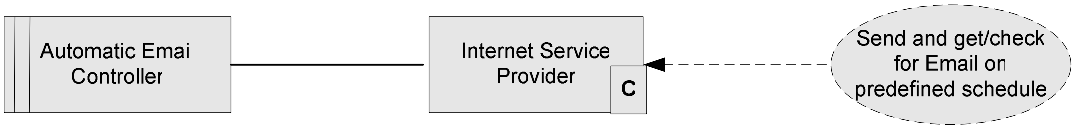
Introducing Problem Frames

Rebecca Wirfs-Brock
Wirfs-Brock Associates, www.wirfs-brock.com

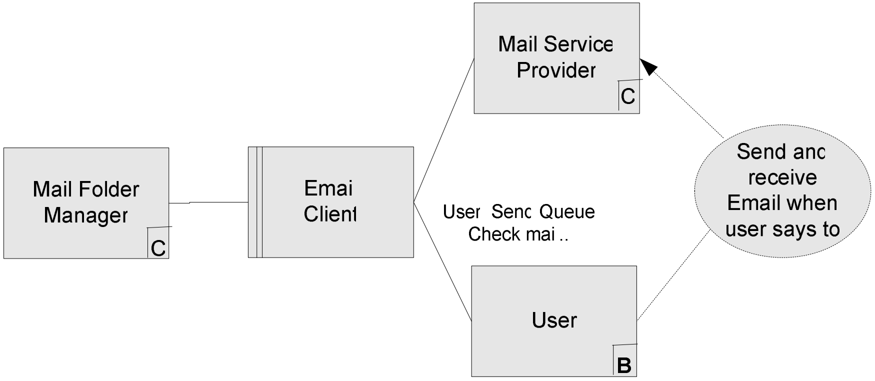
Problem frames are a way of mentally dividing our software's purpose into manageable chunks. Software systems can be thought of as a set of sub-problems or "problem frames". By breaking down a problem into its constituent problems, you can consider a large system one smaller piece at a time. Michael Jackson, who invented the notion of problem frames, writes about them in *Problem Frames: Analyzing and structuring software development problems.* Jackson suggests that because software serves so many purposes that software developers start by describing and structuring their problems in a way that, according to Jackson, is "rarely necessary in other engineering disciplines, where the diversity of problems to be solved is much smaller." As software analysts, developers or agile designers must become adept at asking: What kind of problem is this? What is our software all about? What purpose does it serve? What behavior and properties must our software have to achieve that purpose?

Each different class of problem frame has specific concerns and issues. When you think about a problem, if you can "fit your problem (or a piece of it) into a relevant frame" then it will lead you to ask appropriate questions and make appropriate tradeoffs. Here are definitions of Jackson's five problem types or frames and example frame diagrams:

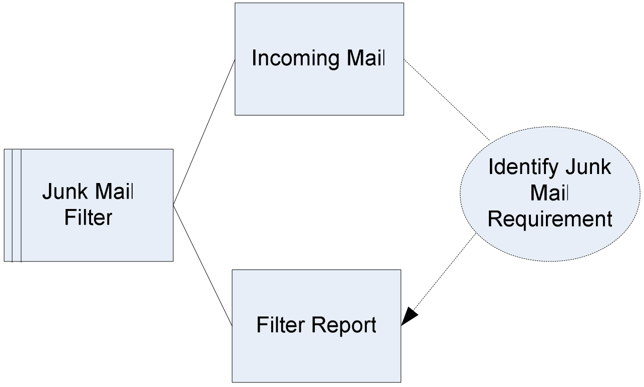
- Required behavior—controlling state changes of something outside your software machinery according to specific requirements.


Automatic Emai Controller
Internet Service Provider
C
Send and get/check for Email or predefined schedule

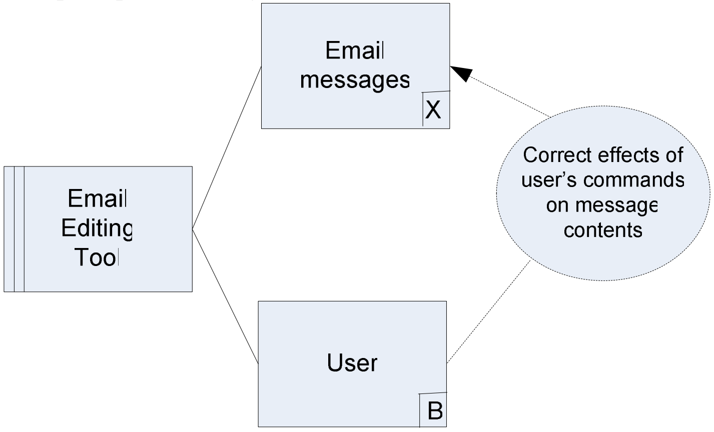
- Commanded behavior—controlling changes based on an operator or user's commands


Mail Service Provider
C
Mail Folder Manager
C
Emai Client
User Senc Queue Check mai ..
Send anc receive Email when user says to
User
B

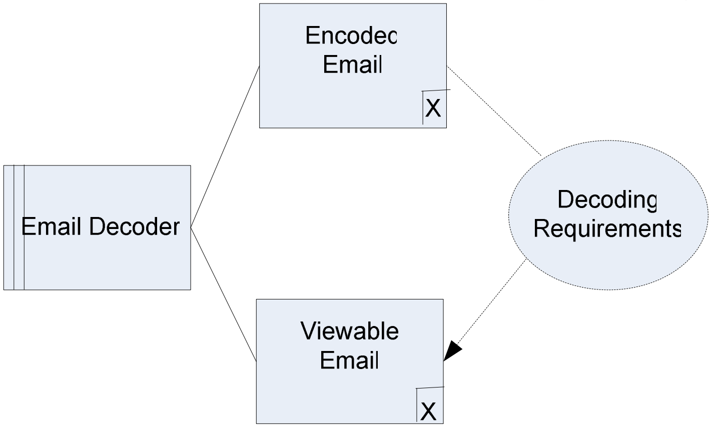
- Information display—produce information about some observable phenomena



- Simple workpieces—a tool that allows users to create and manipulate structures, so that they can be copied, printed, analyzed, or used



- Transformation—convert input to one or more outputs according to specific requirements



Frame diagrams are just a convenient iconic way to represent the structure of a problem, but they are secondary to the real value of framing—a tool to help you gain understanding and focus requirements and design activities. If you understand the nature of the problem your software needs to address, you can ask relevant questions that help shape and focus your work. You can use problem framing in many different situations even if you don't adopt Jackson's formal approach.

- In more traditional development processes
    - To enhance requirements descriptions and artifacts with richer descriptions. For example, if you are aware that a connection domain sits between your software and a "controlled domain", your requirements can be beefed to describe exceptional conditions and how they should be addressed and possibly, to model that connection domain's properties.

    - To distinguish truths or facts (indicative qualities) from desired (optative) behavior which is often imprecisely expressed as statements beginning with “shall” or “should”.
    - To help you recognize where state models are appropriate to more precisely model complex behaviors.
- In agile development:
    - To initially brainstorm what kinds of design challenges will predominate and what parts of your software they are likely to impact. In all but the simplest system there are usually multiple problems (and frames) that are evident. Problem framing is a good way to get teammates acquainted with upcoming design work and identify the potentially hard parts.
    - As you discuss specific user stories with your customer. While I don’t even mention problem frames to customers, I keep them in mind as we discussing any issue. I use them as a mental tool to sharpen my thinking. If you think about which problem frame is relevant (and what concerns there are) you will find yourself asking questions that buy you more information. And you can have more meaningful discussions with your customer about what your software should or shouldn’t do.
    - To assess additional work during a design spike. As you dig deeper into implementation you need to rethink and occasionally reframe the problems you are solving. A design spike happens whenever something is more complex than you had thought. It could be that reframing the problem might bring clarity.

Frame Concerns. Your goal is to design and build software that will behave appropriately and solve the customer’s problem. Jackson advocates that you convince yourself and your customer that your proposed software will tackle the right problem by writing an appropriate set of descriptions about the problem domains. As a problem framer, your central task is to investigate and describe problem domain properties. Each class of frame has a different set of concerns that are typically addressed.

This is one area where Jackson and agile developers diverge on their approaches (and value equation). While I may advocate for formal descriptions *when they add value*, I find Jackson’s insistence on writing descriptions of various domain properties to be a difficult task for most developers whether they are agile or not. I find these formalisms to be less valuable than knowing what questions to ask and what issues are commonly encountered in particular problem frames. So instead of going formal, I find myself asking probing questions about a particular frame. Once I’ve framed a problem, I can start asking questions. Or conversely, as I am asking questions I’m exploring what frames seem to fit and push harder to gather appropriate requirements.

Here are some stylized questions to ask about a workpiece frame:

- What are the basic elements of the workpiece?
- Will it take different forms?
- Does it need to be shared? If so, how?
- Does it have an interesting lifecycle (or is it just something that is changed and then treated as “static” after each change?
- Is it passed around between various users? Is there a workflow associated with a workpiece?
- Should it persist? In what forms? Should it be published or printed?

Here are some questions to ask about required behavior problems:

- What external state must be controlled?
- How does your software find out whether its actions have had the intended effect? Does it need to know for certain, or can it just react later (when the state of some thing is not as expected)? What should happen when things get “out of synch” between your software and the thing it is supposedly controlling?
- How and when does your software decide what actions to initiate?
- Is there a sequence to these actions? Do they depend on each other?
- Are there complex interactions with your software and the thing under its control?
- Can you view the connection between your software and the thing under control as being direct (easier) or do you have to consider that it is connected to something that transmits requests to the

thing being controlled (and that this connection can cause quirky, interesting behavior)? If so, then you may need to understand the properties of this "connection domain" that stands between your software and the thing being controlled?

Here are some questions to ask about transformation problems:

- What data do you start with?
- How will it be changed?
- Is the transformation complex?
- Will it always work? What should happen when you encounter errors in the input?
- Is the transformation "lossy" or reversible?
- What speed, space, or time tradeoffs are there for performing any transformation?

Here are some questions to ask about commanded behavior problems (in truth these are only the tip of the iceberg):

- What's a good model of user-system interaction?
- What does the user need to know in order to "command" the system to do things?
- Do certain commands need to be inhibited based on the current state of the system? Do they always make sense? Does a sequence of actions make sense?
- Is there a lag between issuing a command and the system performing the action? Is that a problem?
- What happens when a command fails? How should users be involved in "steering" the software when a command fails?
- Should certain commands be ignored (e.g. how many times do you need to press the elevator button to call the elevator to your floor)?
- Do commands need to be reversible? logged? monitored or otherwise tracked?

Here are some questions to ask about information problems:

- What is the form of "observation" that the software must make about some event or fact or thing? Is it difficult to ascertain when an event has occurred? (For example, if your software is trying to record how many "vehicles" passed over sensors place on the road it may be very difficult to characterize what constitutes a vehicle—is it two axles passing within a time period, but what about motorcycles, backed up slow traffic, etc., etc.)?
- How precise does the information need to be? Is the information "fuzzy"?
- How much computation does your software have to do to come to an observation? (For example, consider assigning a "junk mail rating" to an email, based on Bayesian analysis of the contents of the current message based on sample data currently loaded into the junk mail box?
- Is the user only interested in current information? Or is historical information important?
- Are there questions that the user may want to ask about the information? What are they? How easy are they to accurately answer?
- Does your software need to construct a "model" of the phenomena being observed in order to answer questions about it?

Additional Resources

Two books by Michael Jackson

Problem Frames: Analyzing and structuring software development problems, Michael Jackson, Addison-Wesley, 2001

Software Requirements and Specifications, Michael Jackson, Addison-Wesley, 1995

A website devoted to problem frames and their application: http://www.ferg.org/pfa/

Jackson's home page: http://mcs.open.ac.uk/mj665/

Some of my blog entries are about framing: http://www.wirfs-brock.com/rebeccasblog.html

If you are interested in a copy of some study questions for Jackson's book or wish to pursue practical hands on framing activities contact me at rebecca@wirfs-brock.com