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Advanced Software Engineering

Problem Solving, Problem Frames

General Problem Solving Strategies

- Decomposition
- Aspects/Views
- Patterns and metaphors
- Taxonomy of problem classes
- Normal vs. radical design
- Means vs. end

The World and the Machine

- ❍ Why not just specify and design the machine?
- ❍ What does S, W |– R actually mean?
- ❍ Illustration: the turnstile problem

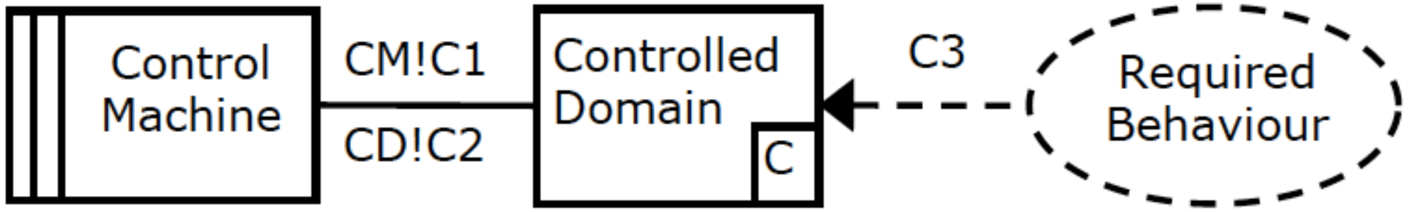
Problem Frames

- What is a problem frame?
- How / why do problem frames help?
- What kinds of frames are defined by Jackson?

The Required Behavior Problem

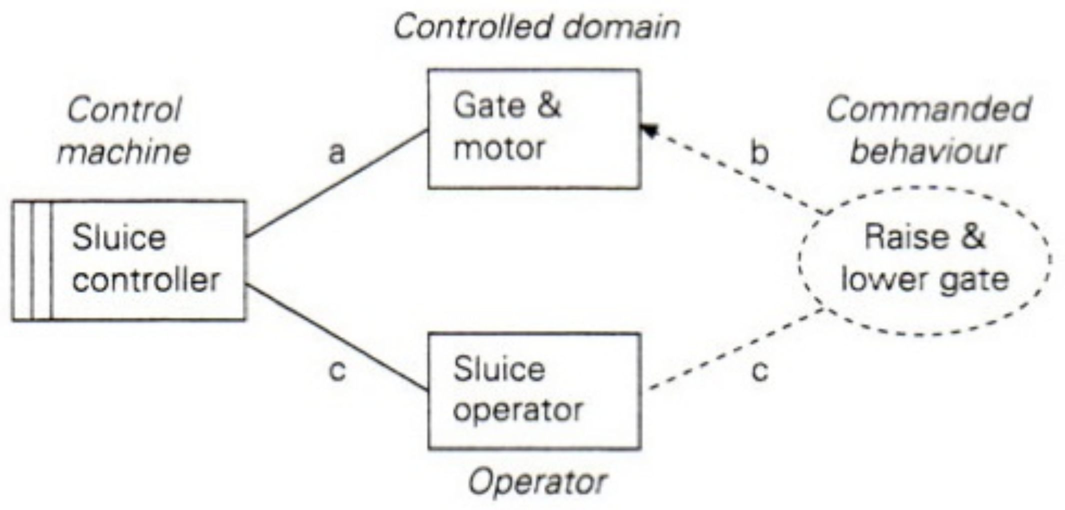
[Jackson 2006]

Application context:
Achieve/maintain a required behaviour in a given problem domain



The Commanded Behavior Problem

Application context:
Achieve a required behaviour in a given problem domain by commands issued by an operator



a: SC! {Clockw, Anti, On, Off} [C1]
GM! {Top, Bottom} [C2]
b: GM! {Open, Shut, Rising, Falling} [C3]
c: SO! {Raise, Lower, Stop} [E4]

[Jackson 2001, p. 112]

The Frame Concern

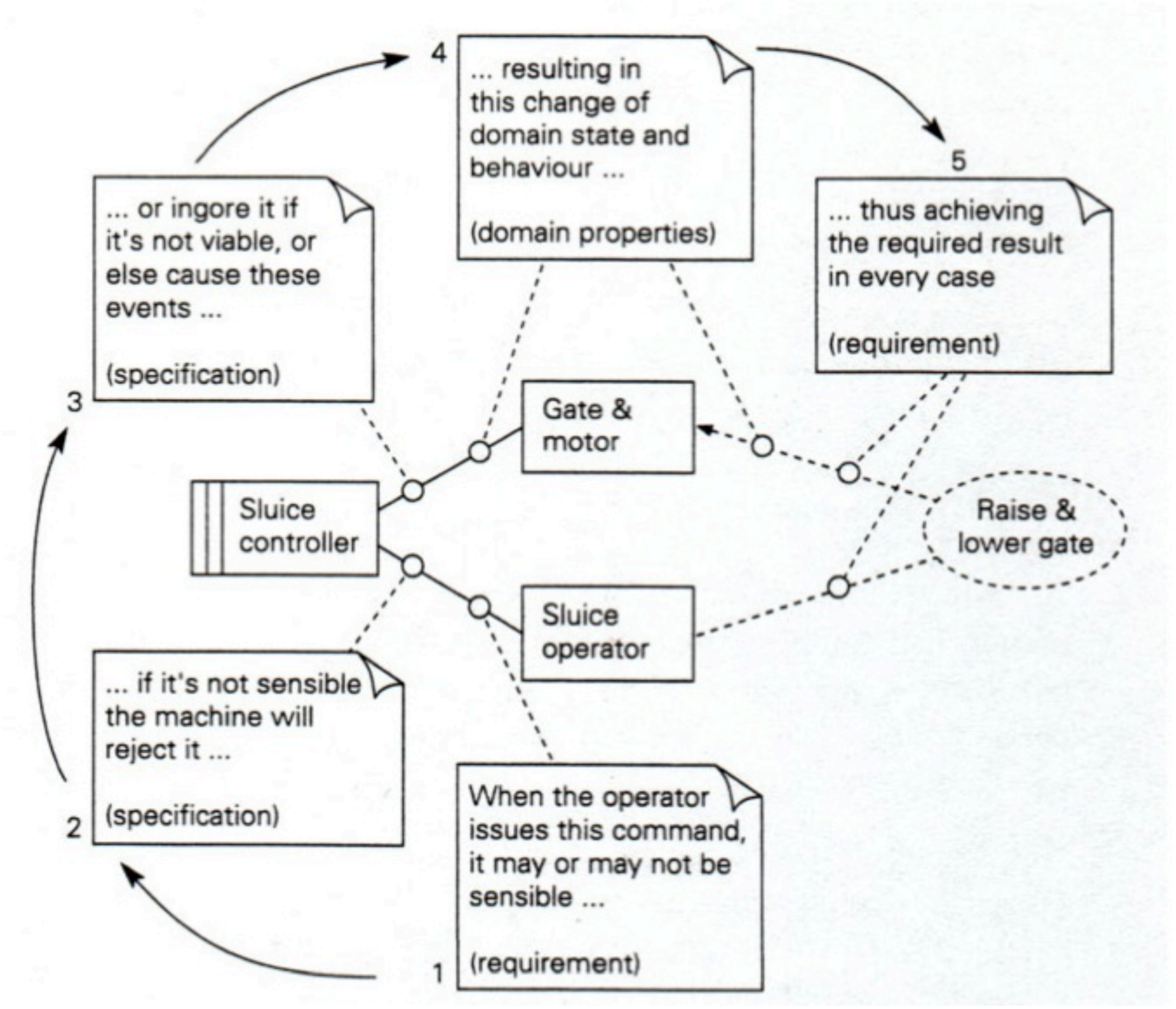
Arguing that

- the machine behavior

together with

- the domain properties

satisfy the requirements

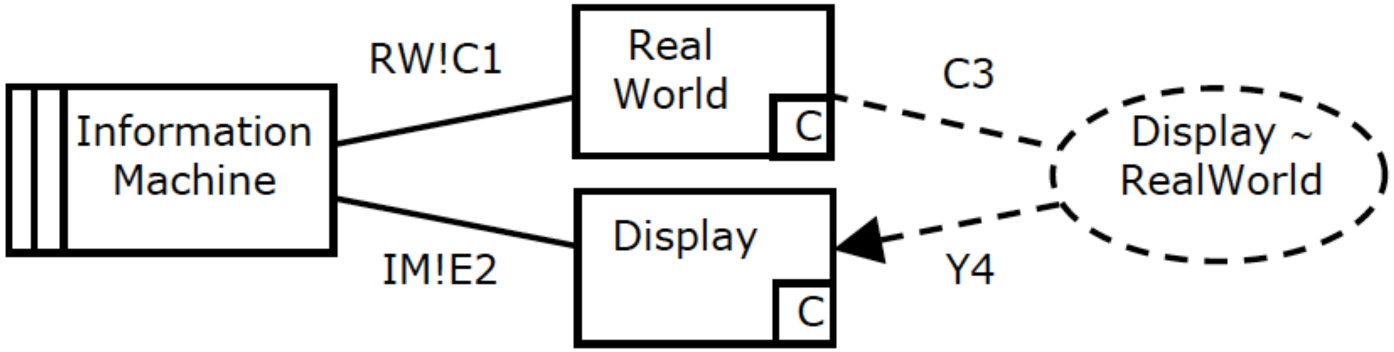

4
... resulting in this change of domain state and behaviour ...
(domain properties)
5
... thus achieving the required result in every case
(requirement)
... or ingore it if it's not viable, or else cause these events ...
(specification)
3
Gate & motor
Sluice controller
Raise & lower gate
Sluice operator
... if it's not sensible the machine will reject it ...
(specification)
2
When the operator issues this command, it may or may not be sensible ...
(requirement)
1

Commanded Behavior Frame Concern [Jackson 2001, p. 113]

The Information Display Problem

[Jackson 2006]

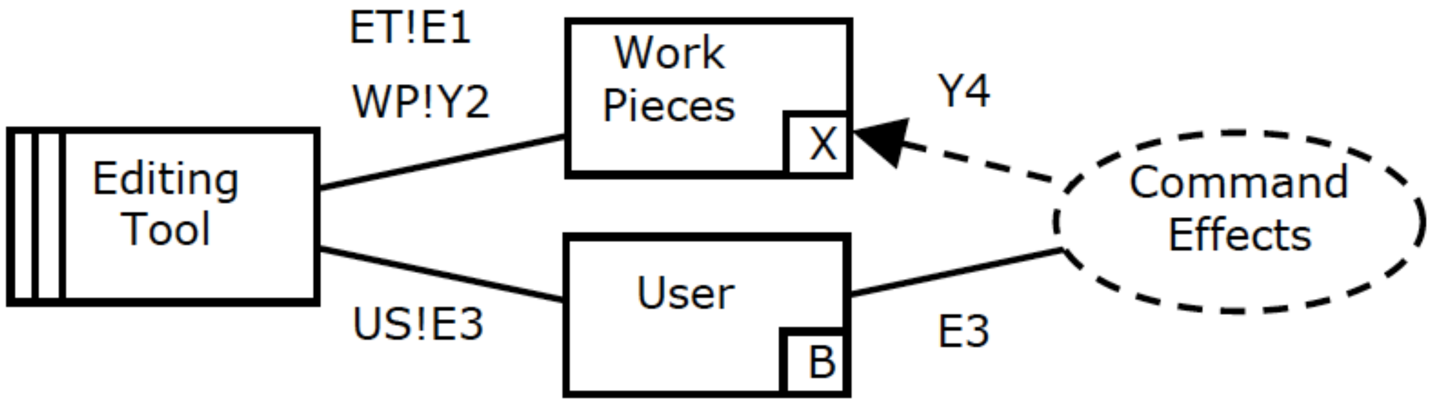
Application context:
Display information about a part of the world



The Workpieces Problem

[Jackson 2006]

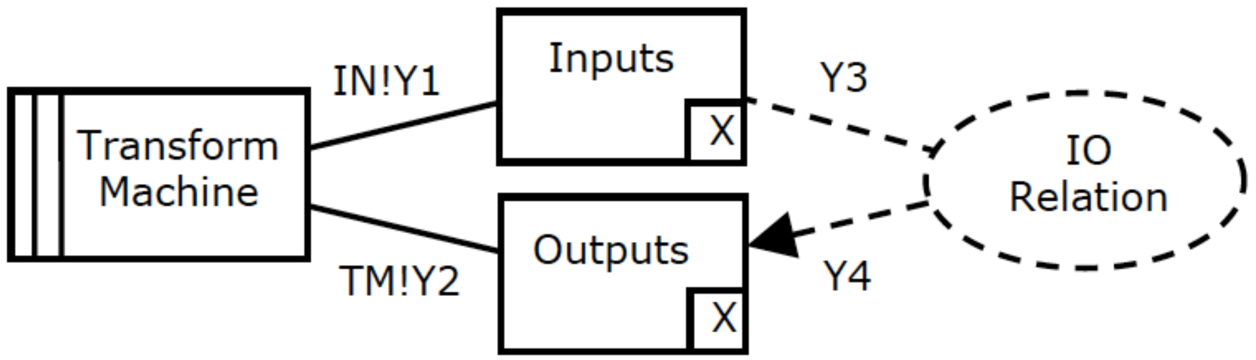
Application context:
Provide a tool for editing a work piece such as text, graphics, etc.



The Transformation Problem

[Jackson 2006]

Application context
Transform input data to output data



Decomposing and recomposing problem frames

- Separate the problem into individual frames
- Model the frames
- Address the frame concern
- Re-integrate the frames into a single design

A hard problem!

Other problem patterns: The four-variable model

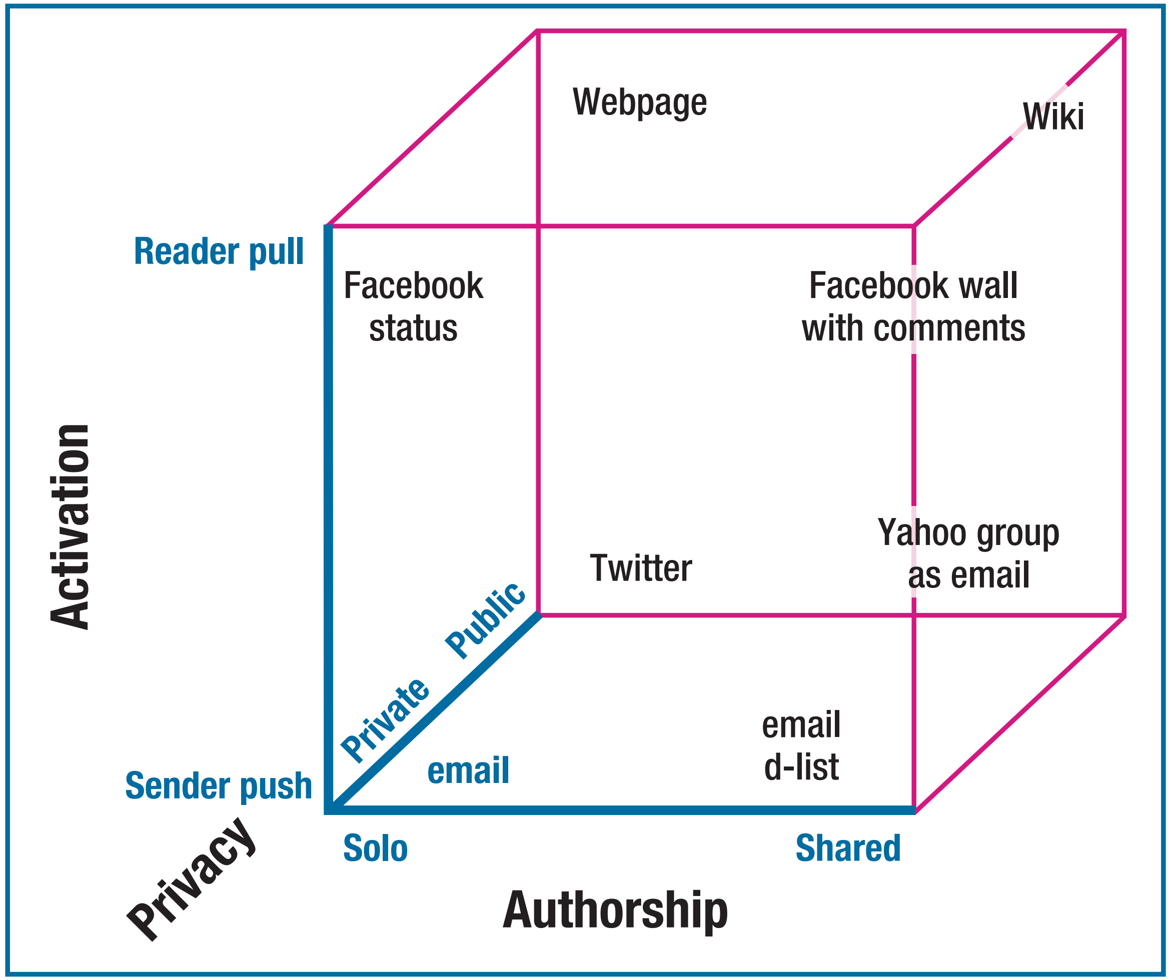
[Parnas and Madey 1995]

- Four variables: monitored, controlled, input, output
- Three relations: NAT (the constraints), REQ (the requirements), SOFT (machine input to machine output)
- Two mappings: MON → INPUT, OUTPUT → CON

$$\begin{tikzcd}
\text{MON} \arrow[r, "\text{REQ}"] \arrow[d, "\text{IN}"'] \arrow[r, leftrightarrow, bend left=60, "\text{NAT}"] & \text{CON} \\
\text{INPUT} \arrow[r, "\text{SOFT}"'] & \text{OUTPUT} \arrow[u, "\text{OUT}"']
\end{tikzcd}$$

Design Spaces

- What?
- Why?
- How?



[Shaw 2012]

Normal vs. Radical Design

P36 (1935)

P51 (1940)

Me 262(1942)

Design Process

- A rational design process?
- Innovation
- Mature systems

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