

A Workbench for Creating & Running Qualitative Models

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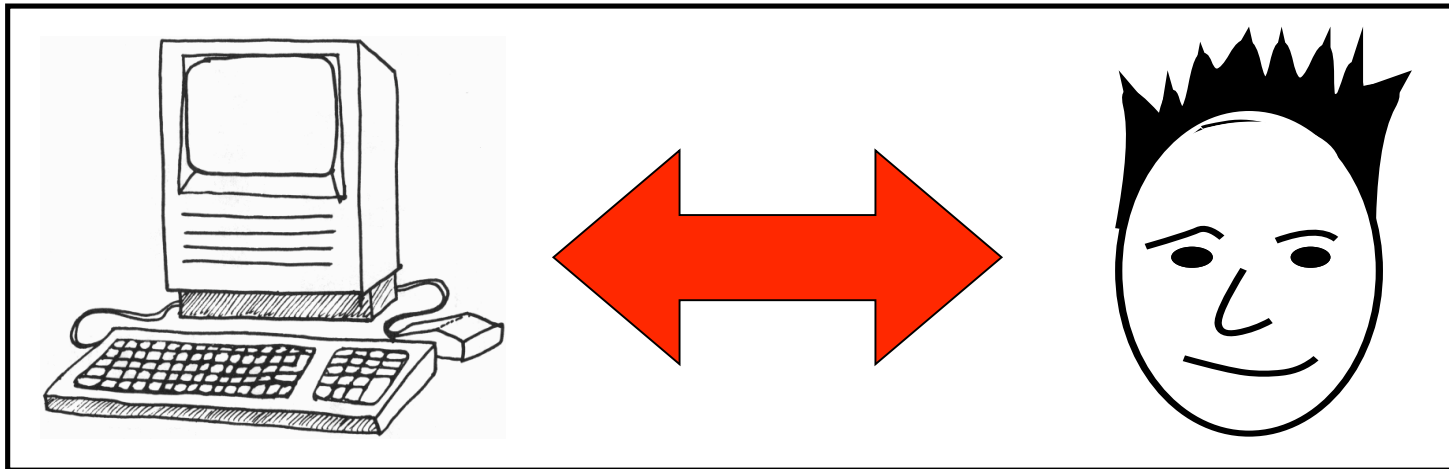
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Artificial Intelligence & Education

Using Qualitative Reasoning

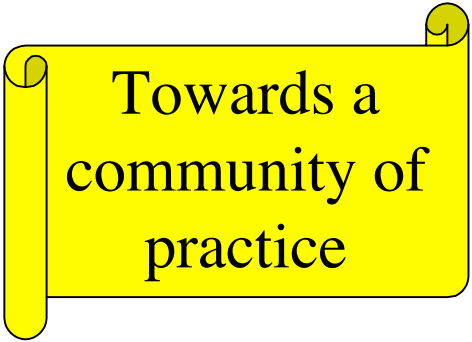


Research: *computational intelligence*

- Knowledge representation and reasoning
- Interaction, dialogue and interface
- Learner modelling


But not today...

Research issue




Towards a
community of
practice

to develop:

-  a workbench for creating, running, and inspecting models based on qualitative reasoning technology

in order to:

-  support domain experts in creating and capturing ecological knowledge
(*see also tomorrow's talk*)

Software

- **GARP**

the simulator, a qualitative reasoning engine

- **VISIGARP**

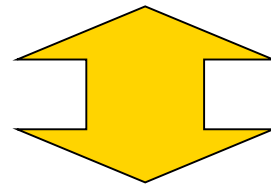
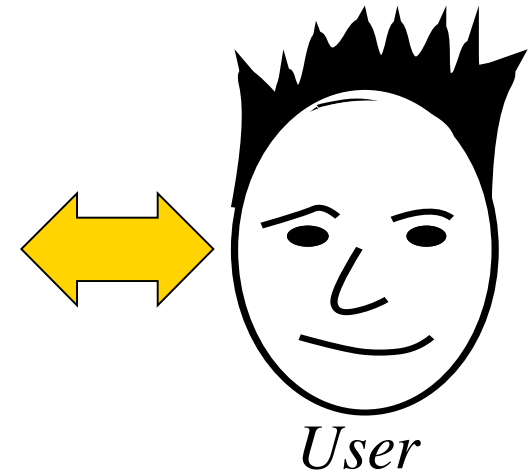
model inspection tool (runs on top GARP)

- **HOMER**

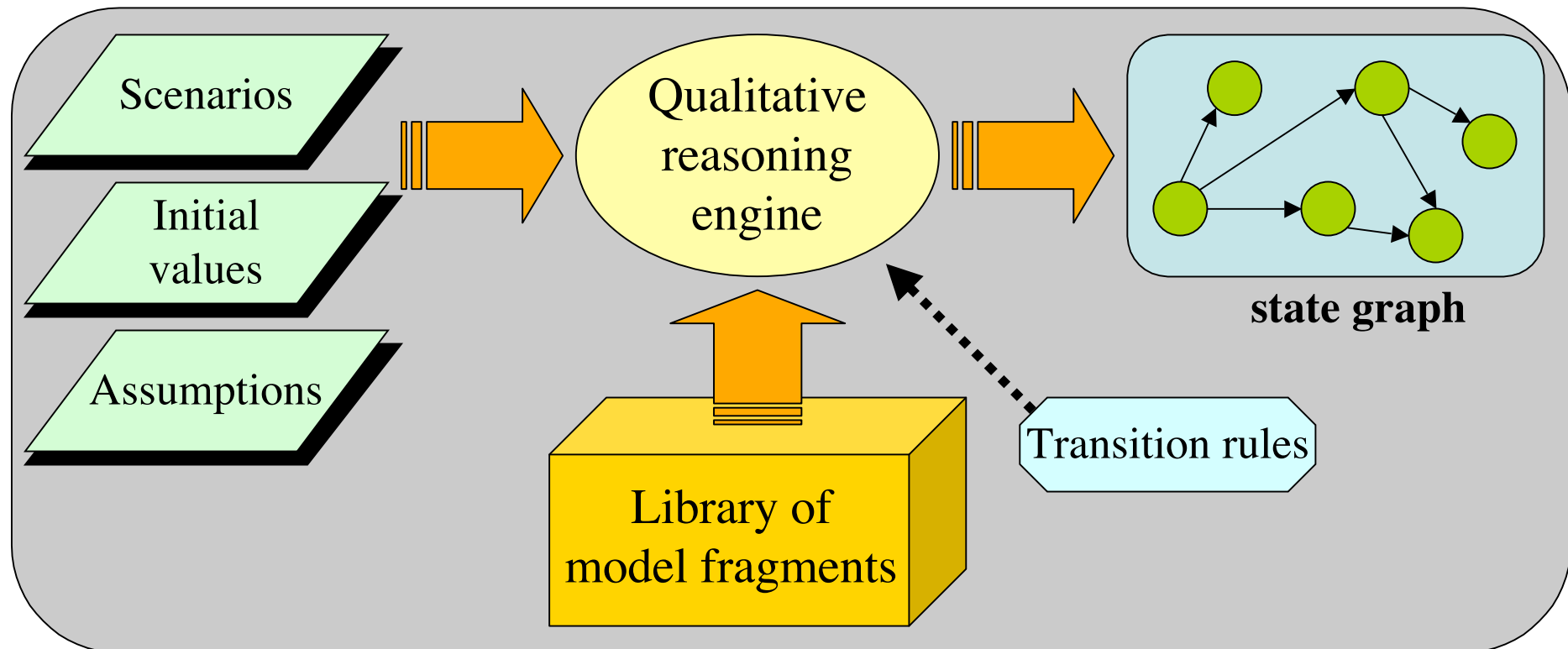
model building tool (produces input to GARP)

Software

*Using GARP
requires programming
skills in Prolog*



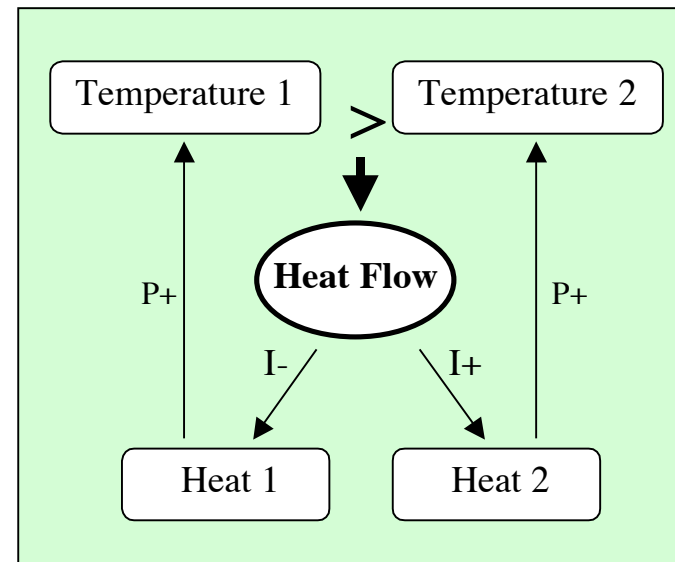
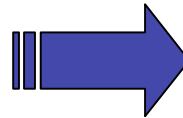
GARP



Diagrammatic representation

(Lisp / Prolog)

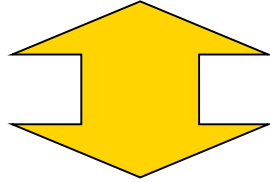
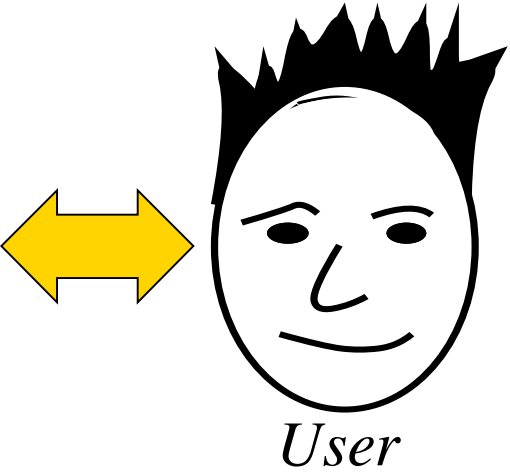
```
(defModelFragment heat-flow
:subclass-of (physical-process)
:participants ((the-src :type thermal-physob)
              (the-dst :type thermal-physob)
              (the-path :type heat-path
                        :constraints
                        ((heat-connection
                          the-path the-src the-dst))))
:conditions ((heat-aligned the-path)
            (> (temperature the-src)
               (temperature the-dst)))
:quantities ((heat-flow-rate :type heat-flow-rate))
:consequences ((Q= heat-flow-rate
               (- (temperature the-src)
                  (temperature the-dst)))
              (I- (heat the-src) heat-flow-rate)
              (I+ (heat the-dst) heat-flow-rate)))
```



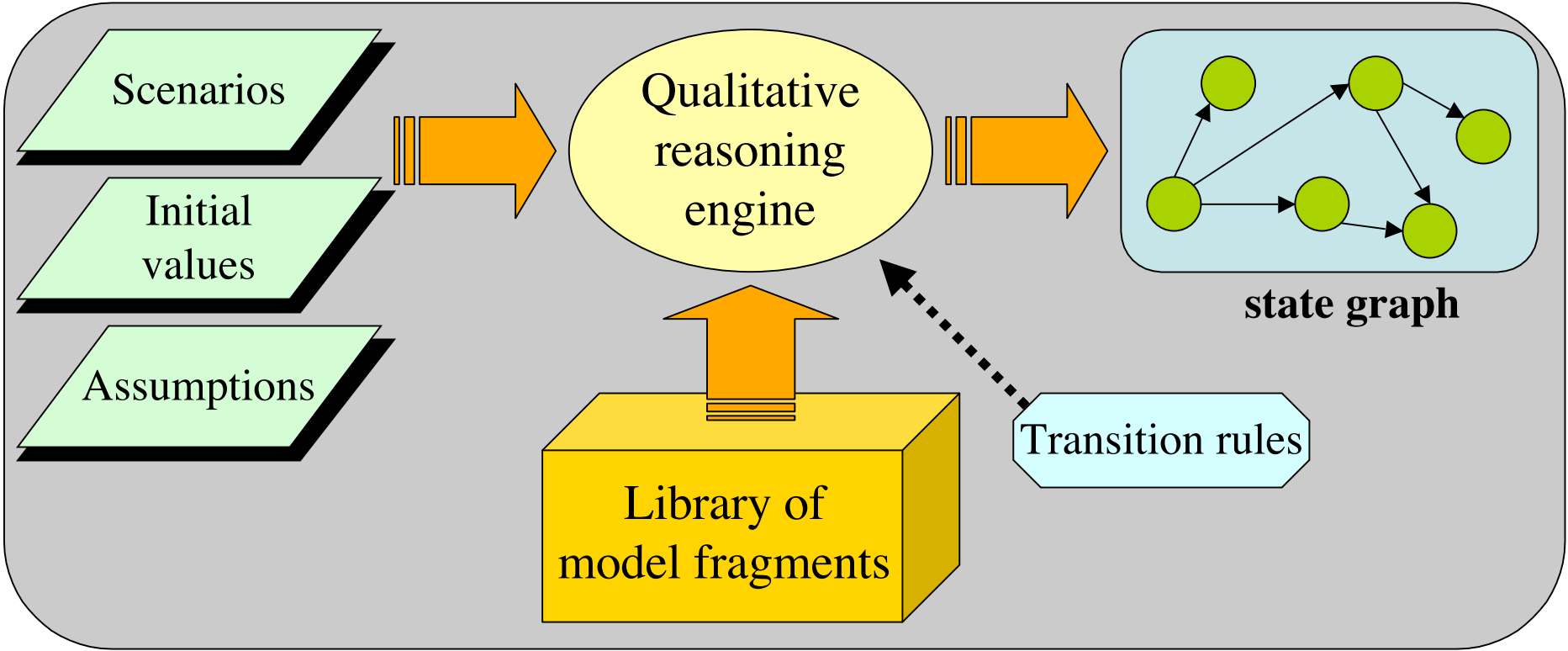
Software

VisiGarp

- Select scenario, ...
- Control reasoning engine
- Inspect state graph



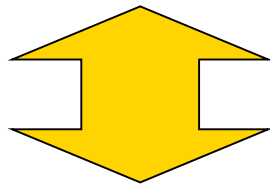
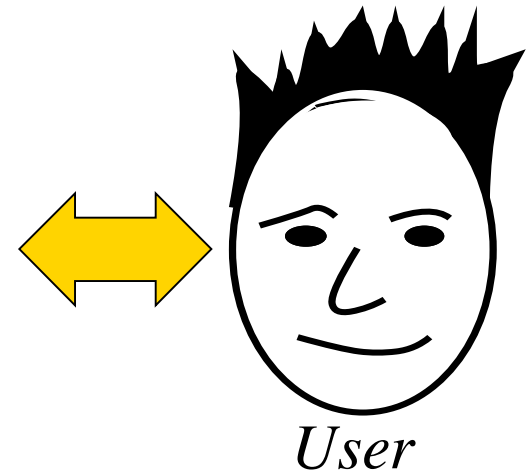
GARP



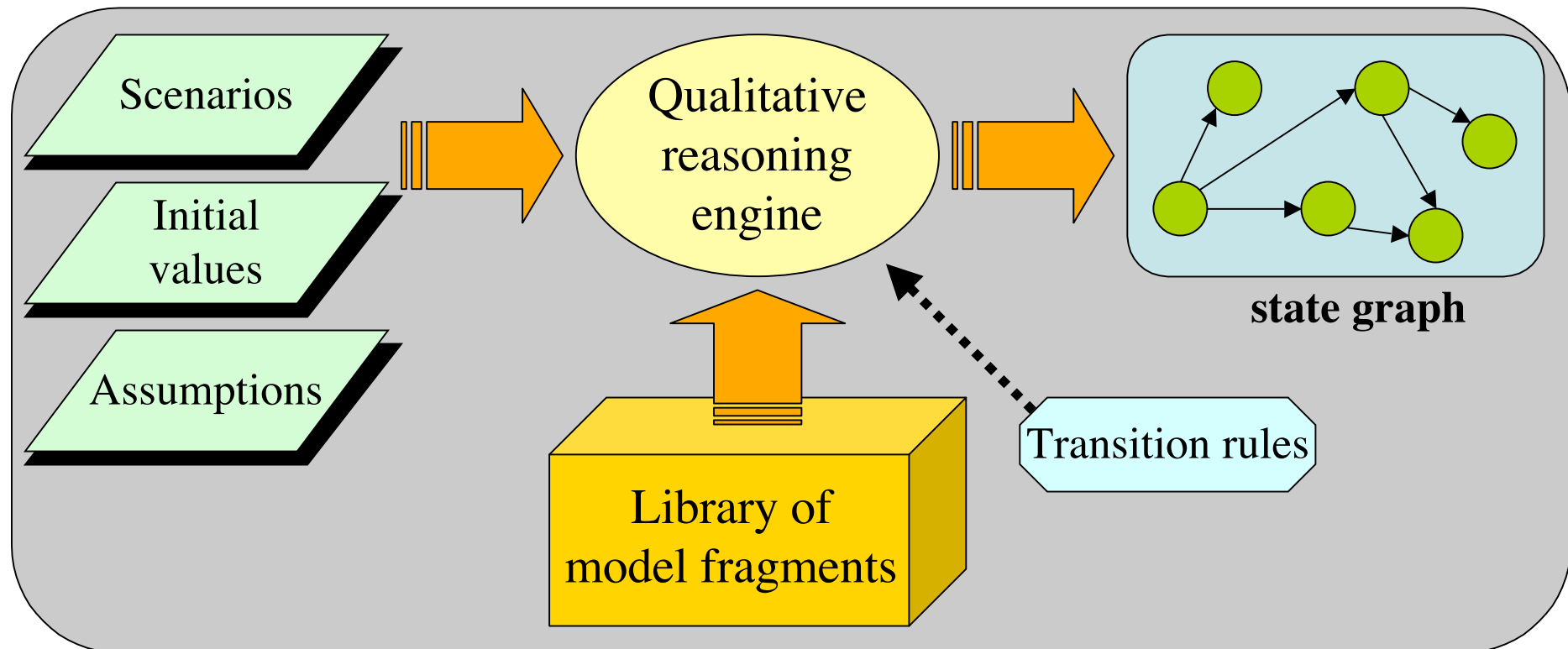
Software

Homer

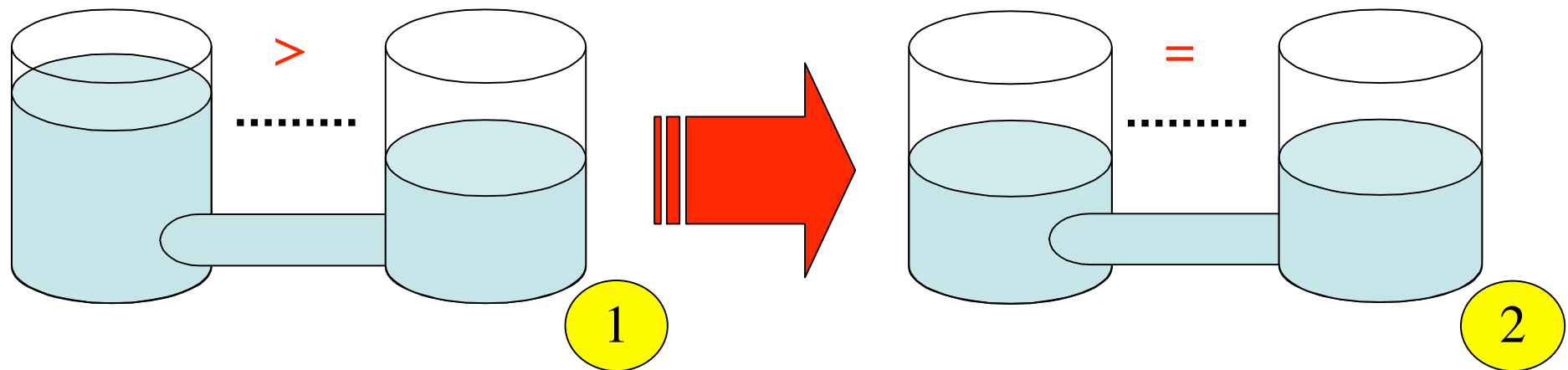
- Create scenario's, ...
- Create model fragments



GARP



Target system and behavior



A QR model captures knowledge that *explains* the system's behaviour
(a human interpretation of reality)

Assignment - Two-tank system

Construct the model ingredients that will allow you to run a simulation of the U-tube system. A U-tube, is a system consisting of two containers, filled with oil, which are connected via a pipe near the bottom of each container. Pressure difference near the bottom of the connected containers determines what will happen. From the container with the higher pressure, oil will flow to the container with the lower pressure. Assume that the pipe has no influence on the behaviour of the system except for facilitating the flow of oil between the two containers.

The following requirements should be addressed:

Construct a model fragment that is general for all kinds of containers filled with a liquid and that captures the quantities and their dependencies relevant for the typical U-tube behaviour. Do **not** include quantities that are not relevant for this behaviour.

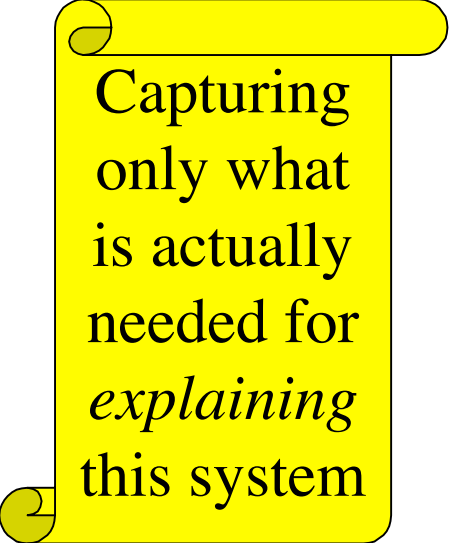
Construct a model fragment (a process) that captures the idea of a liquid flow between two containers filled with liquid. You may assume that the connecting pipe is always near the bottom and that the containers are always at equal height. Difference in pressure should trigger a flow. The flow should influence the amounts of liquids in each container.

Create a scenario's:

Create a scenario in which two containers exist, connected via a pipe, each containing liquid, for which a liquid flow will become active, because the levels of the liquid in the two containers are unequal.

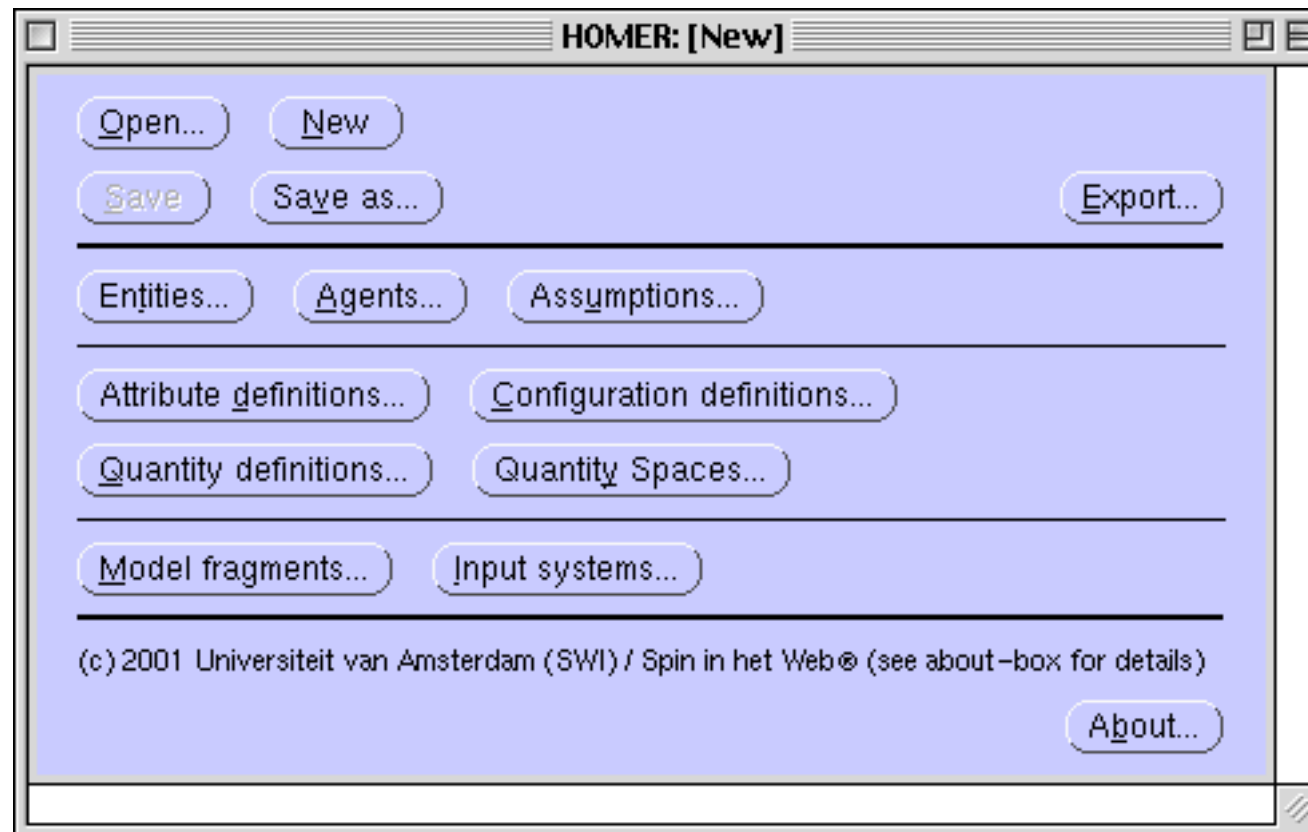
How to create the model?

- **B**uilding blocks
 - Entities
 - Structural relations
 - Quantities & quantity spaces
- **C**onstructs
 - Scenario
 - Model fragments
- **R**un simulation & test model results

A yellow sticky note with a black border and rounded corners, featuring a small circular tab at the top left and another at the bottom left. The text is written in black, with the word 'explaining' in italics.

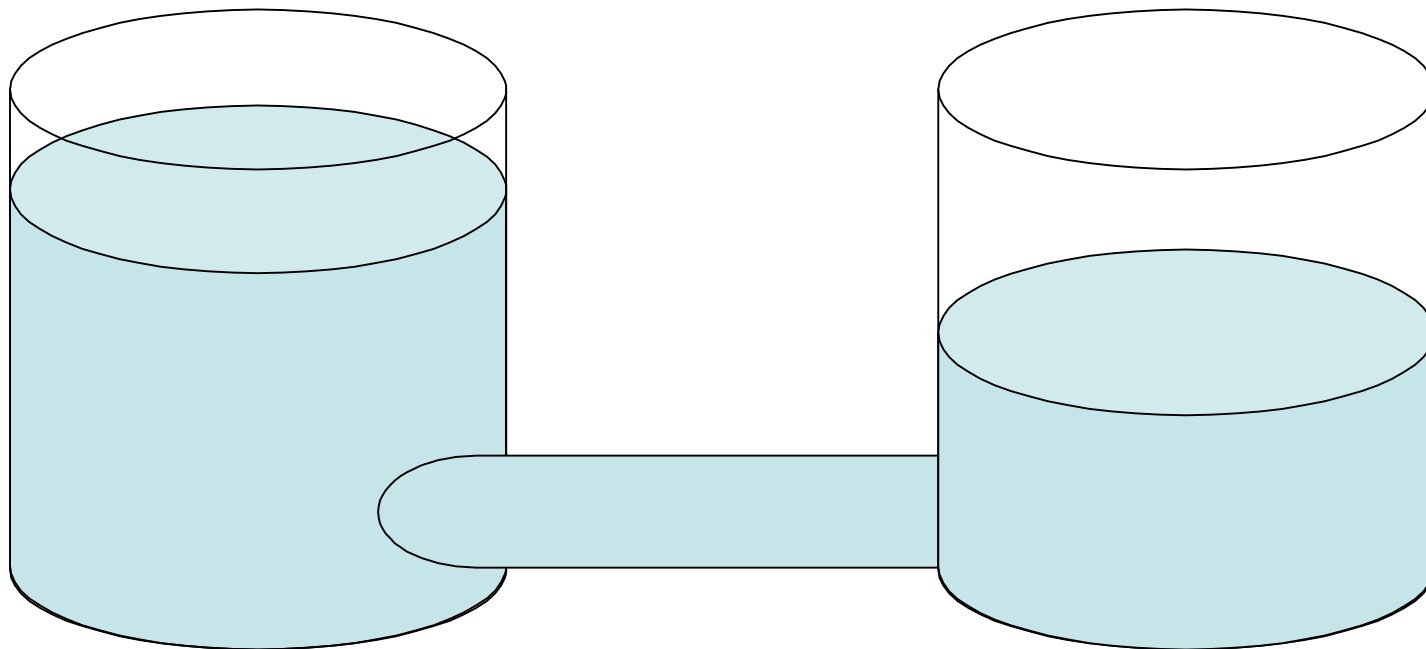
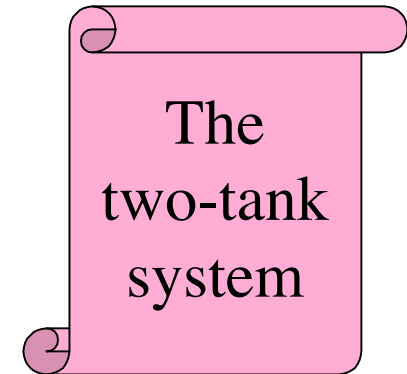
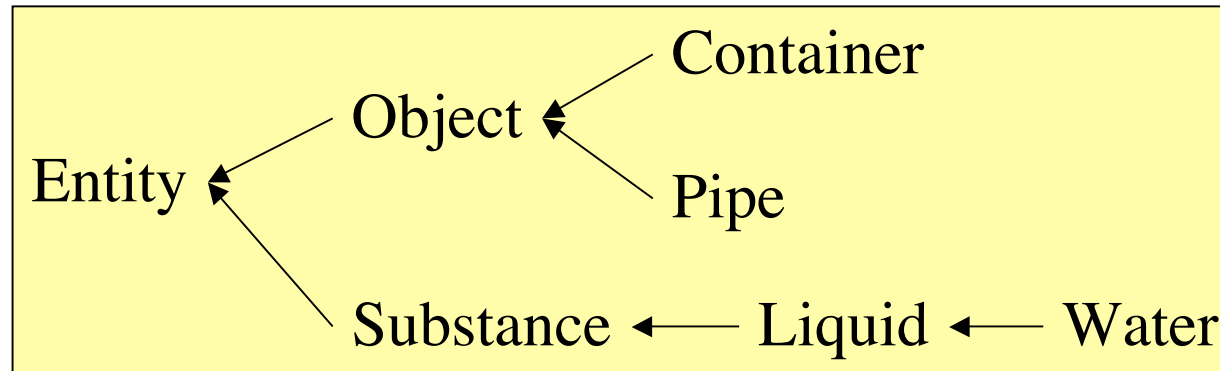
Capturing
only what
is actually
needed for
explaining
this system

HOMER *demo?*

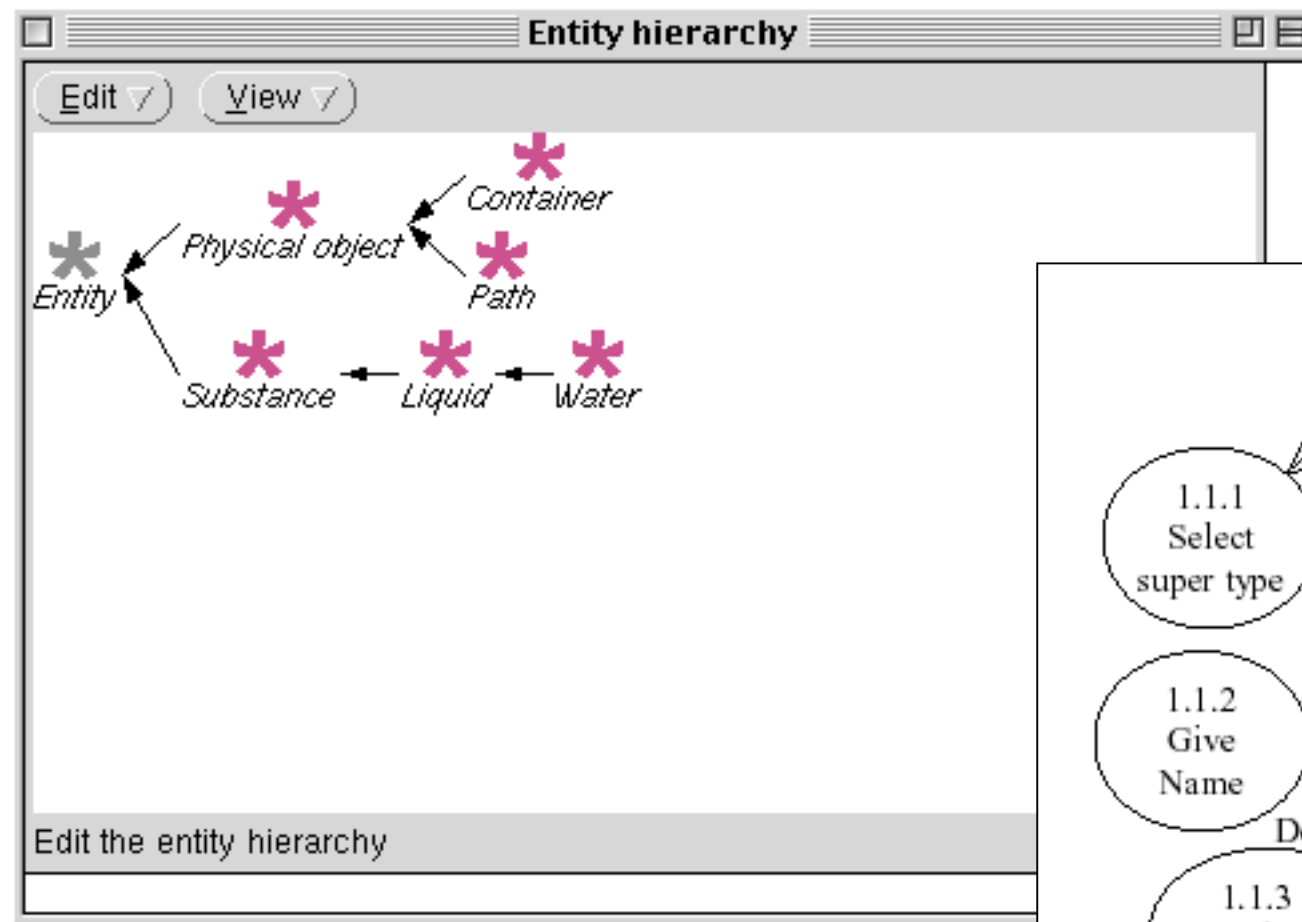


Which objects (& structural relations) ?

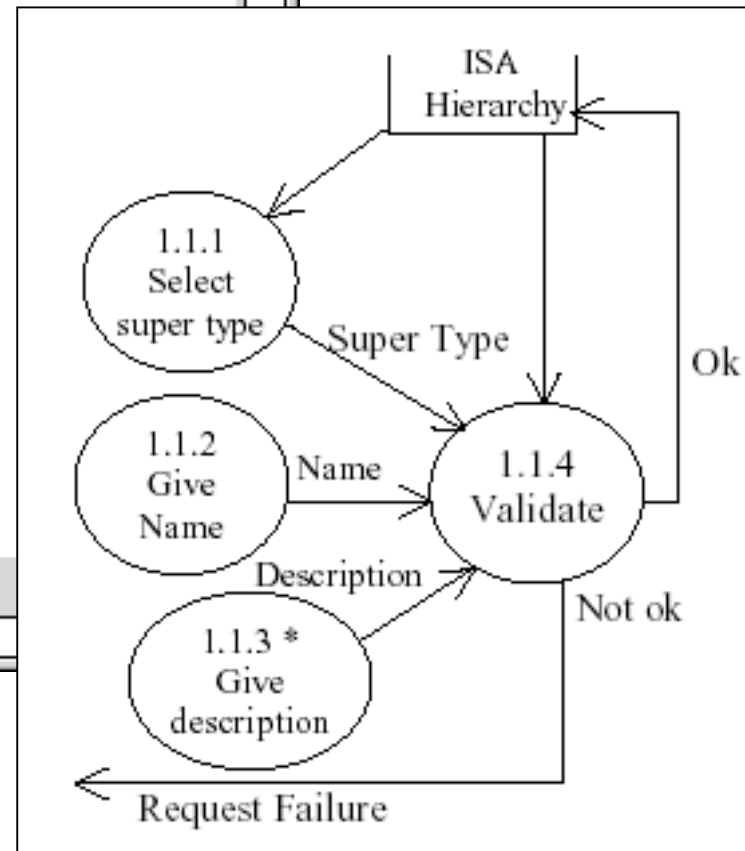
Subtype hierarchy



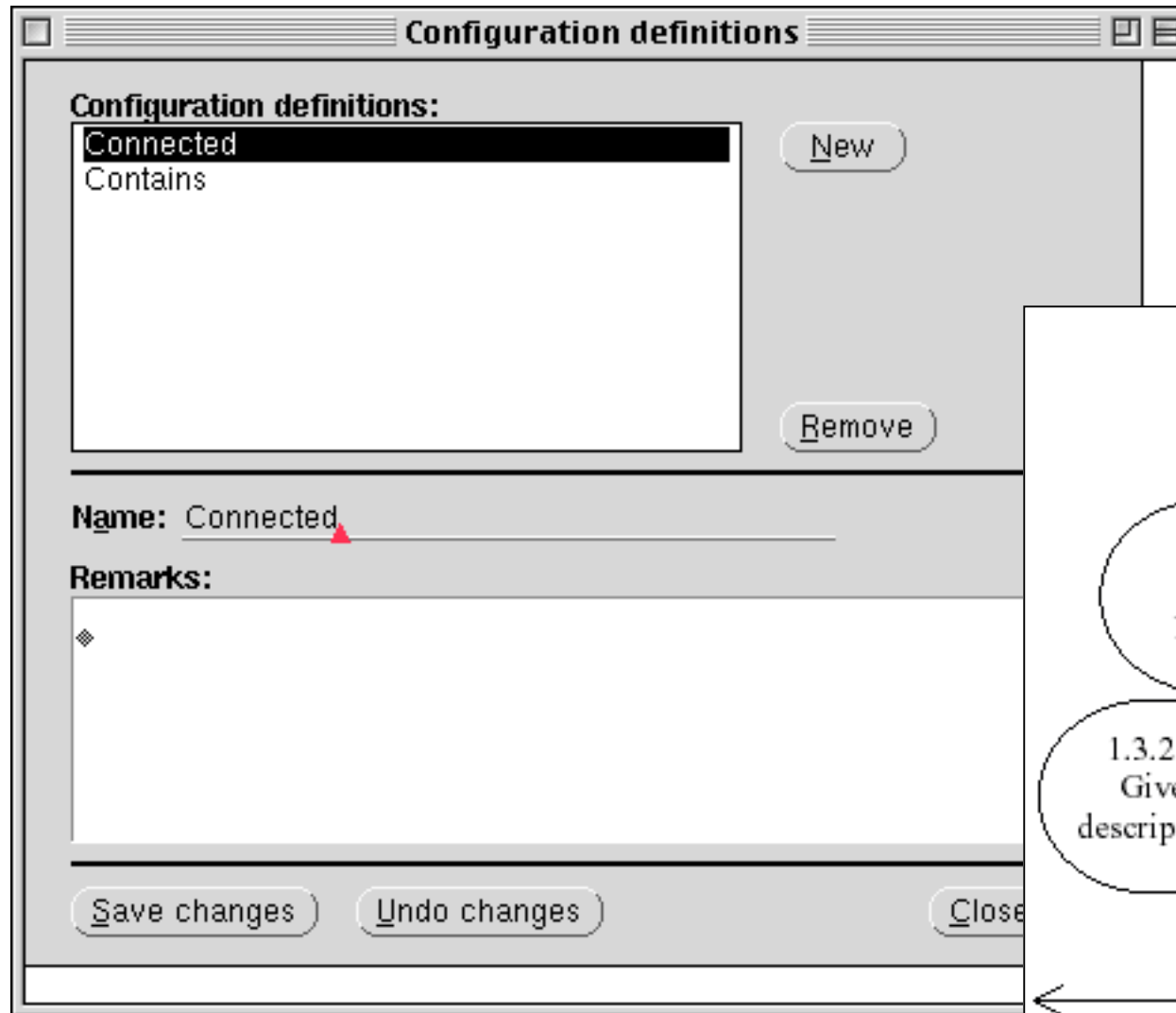
Constructing an entity hierarchy



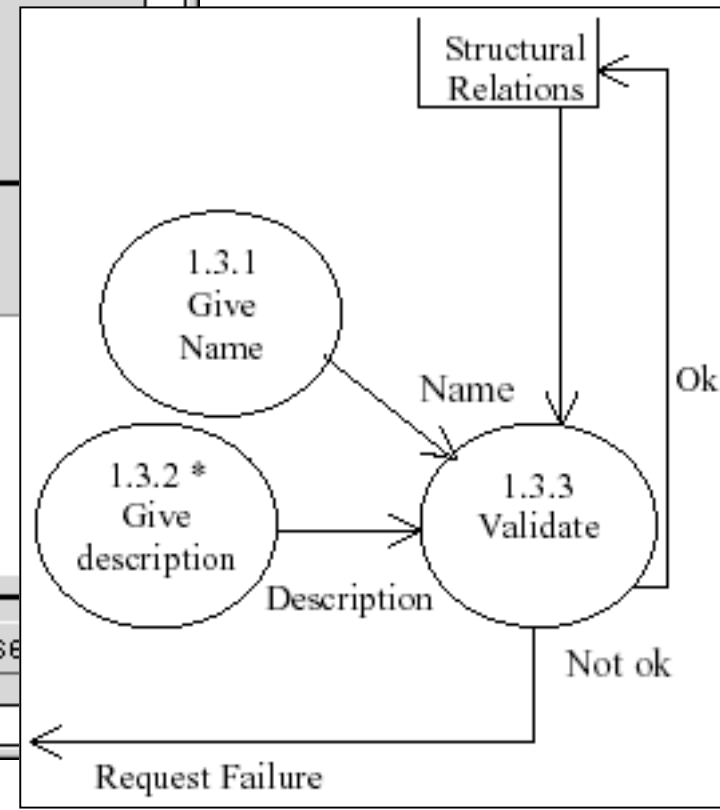
...*liquid* is
a kind of
substance...



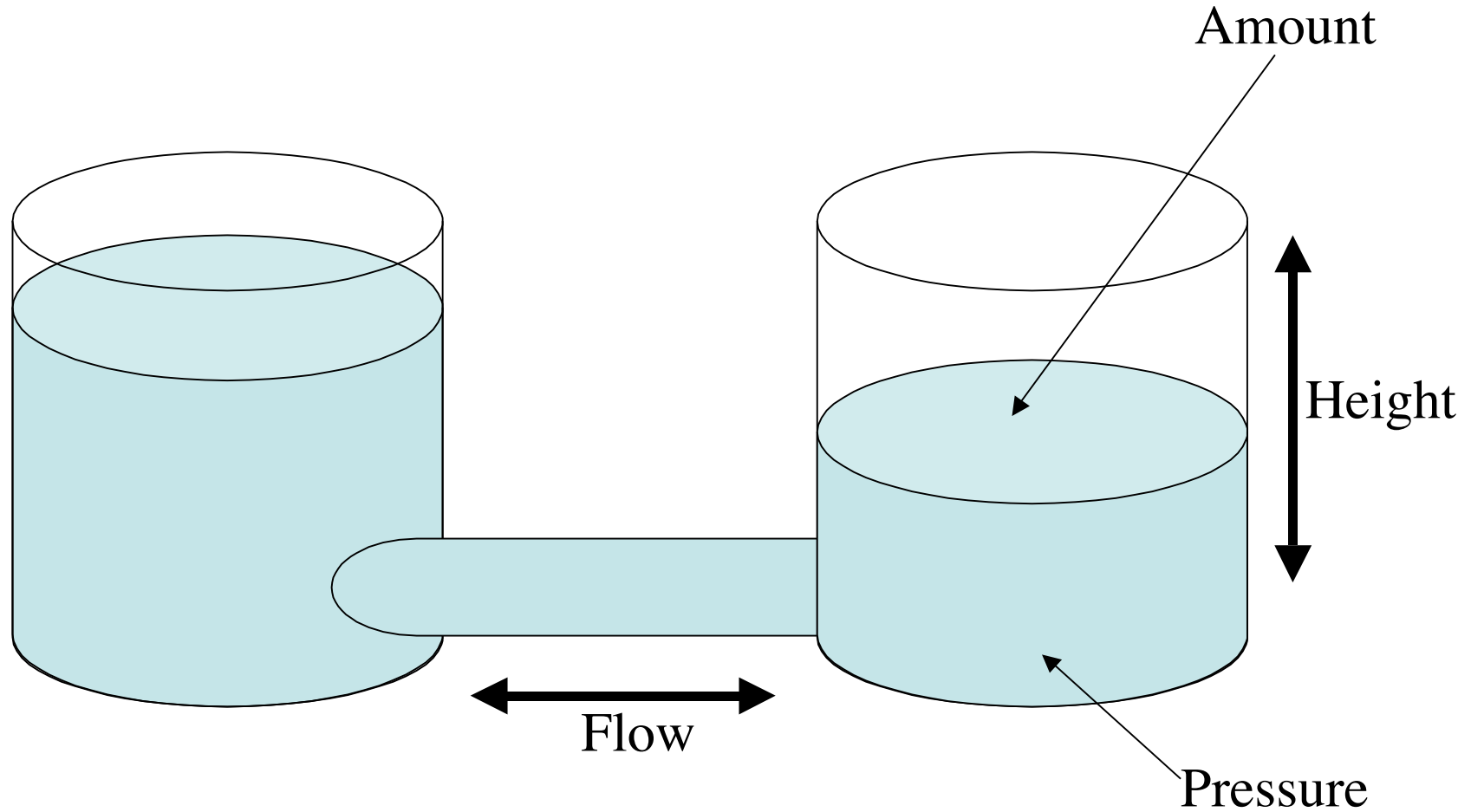
Specifying configurations



...container
contains
a liquid...



Which quantities ?



Quantity *value*=<magnitude,derivative>

Defining quantities

*To capture
the behaviour
of a system*

Quantity definitions:

Amount
Flow
Level
Pressure

Name: Amount

Allowed quantity spaces:

Zpm

All quantity spaces:

Mzp
Zpm

Preview:

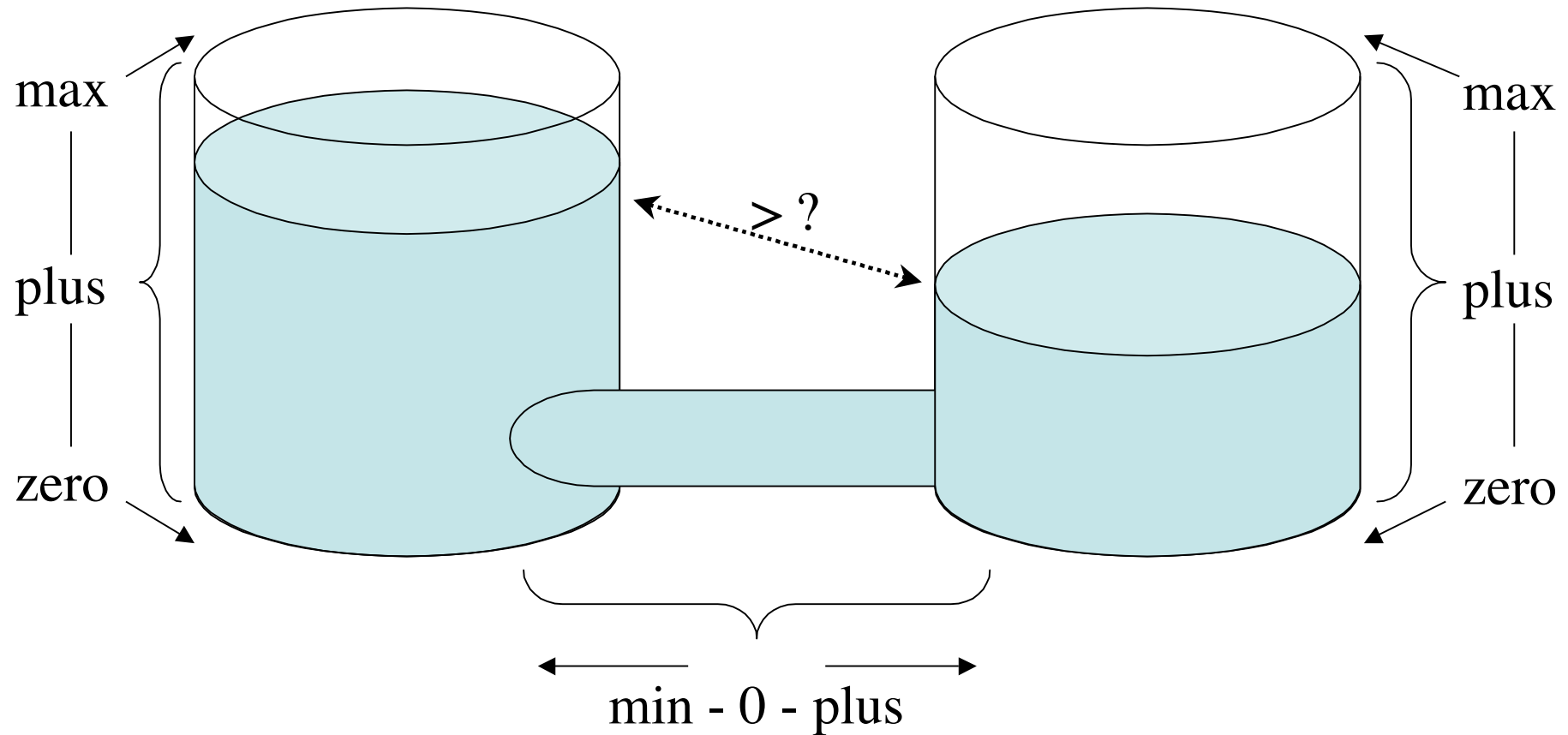
- Max
- Plus
- Zero

Remarks:

◆

Buttons: New, Copy, Remove, Remove QS, Edit quantity spaces..., Save changes, Undo changes, Close

Which quantity spaces?



Quantity spaces are unrelated (accept for 0)

Defining quantity spaces

The values
a quantity
can take on

What are the
important
landmarks...

The screenshot shows a window titled "Quantity spaces" with a list of quantity spaces. The list contains "Mzp*" and "Zpm", with "Zpm" selected. To the right of the list are buttons for "New", "Copy", and "Remove". Below the list, the "Name:" field is set to "Zpm". The "Definition:" section has a list of values: "Max", "Plus", and "Zero", with "Max" selected. To the right of this list are buttons for "Add high", "Add low", "Split interval", "Combine intervals", "Remove high", and "Remove low". Below the definition list, the "Value:" field is set to "Zero". At the bottom of the dialog is a "Remarks:" text area and three buttons: "Save changes", "Undo changes", and "Close".

Quantity spaces:

- Mzp*
- Zpm

New

Copy

Remove

Name: Zpm

Definition:

- Max
- Plus
- Zero

Add high

Add low

Split interval

Combine intervals

Remove high

Remove low

Value: Zero Max

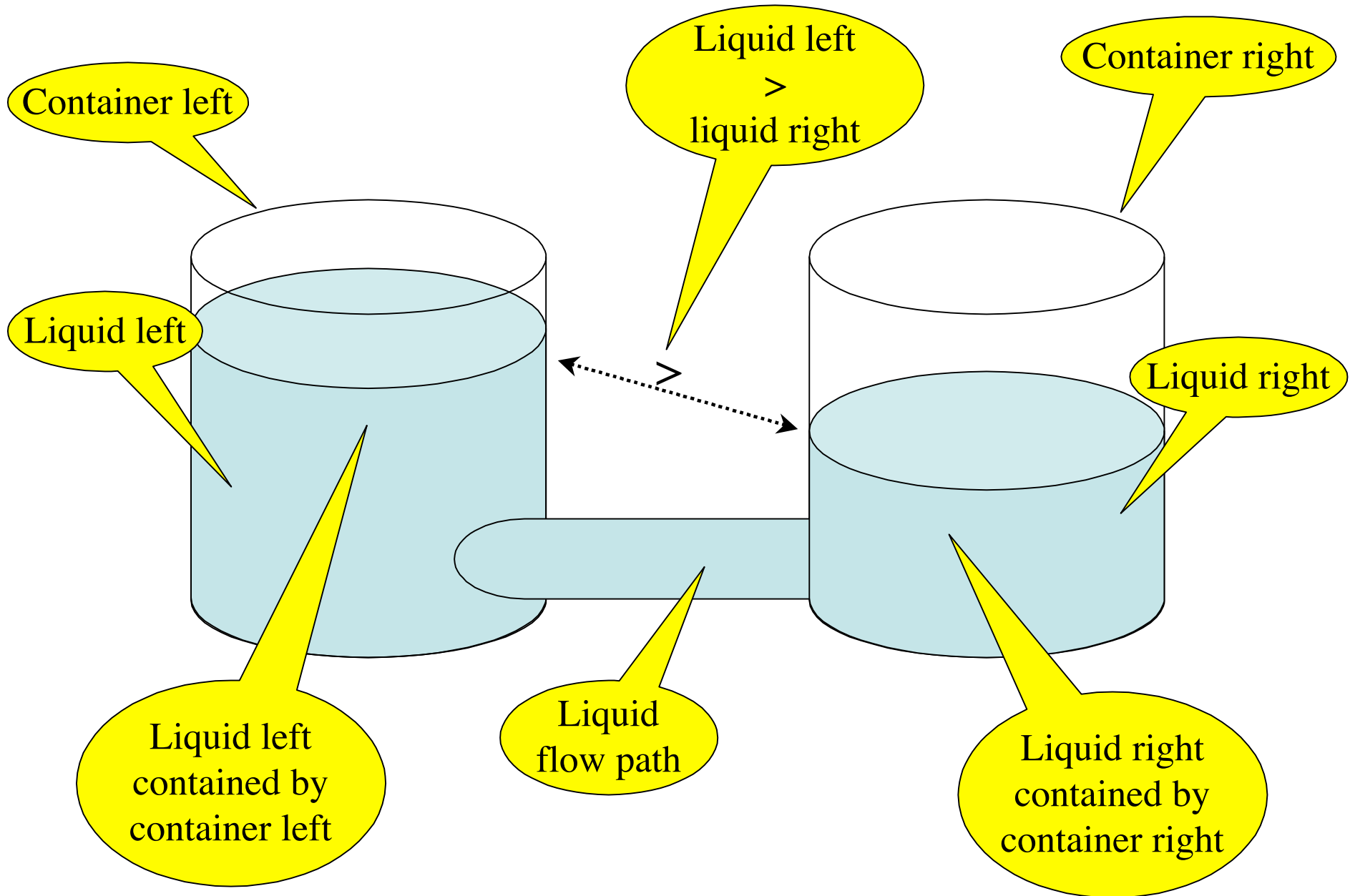
Remarks:

Save changes

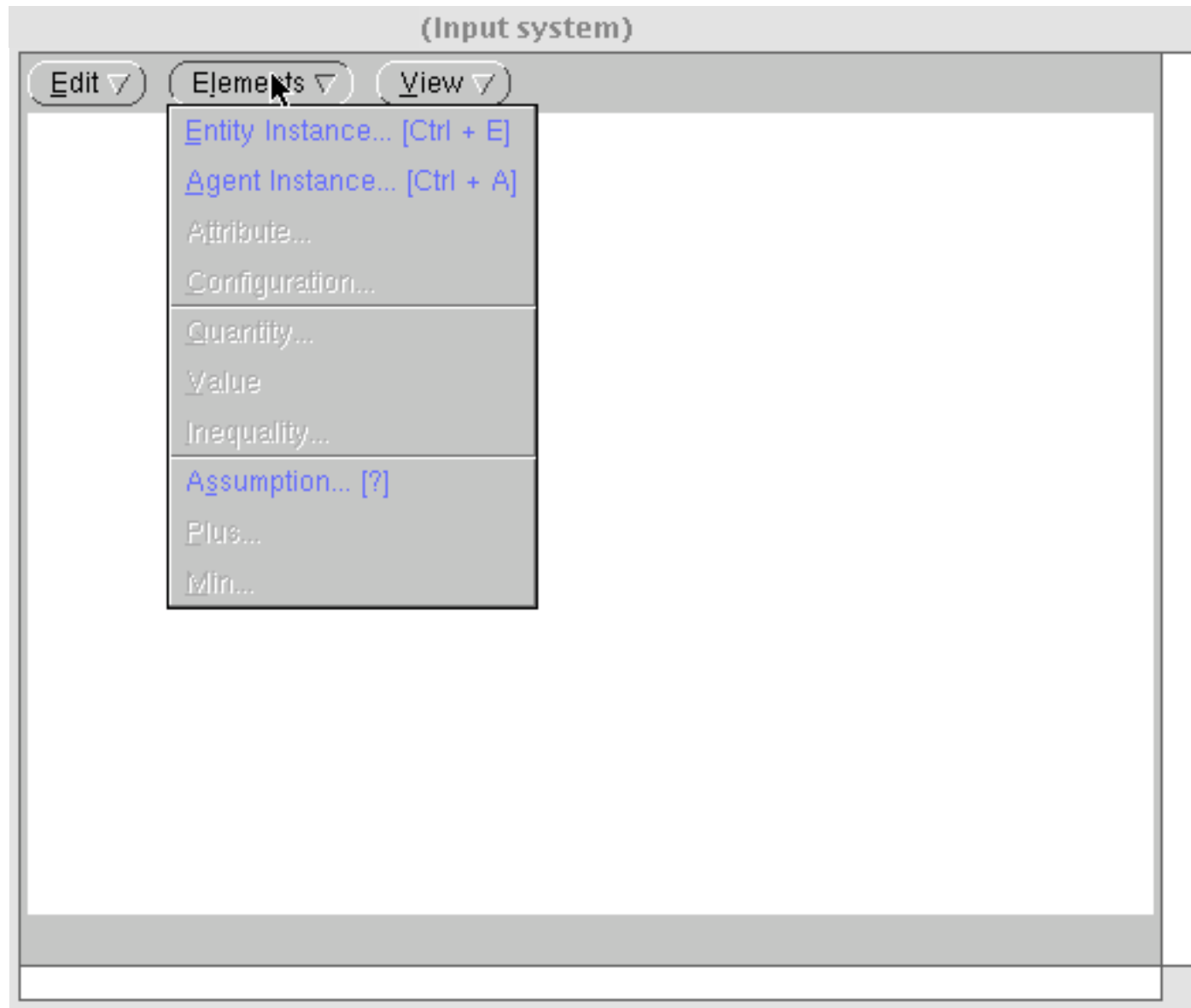
Undo changes

Close

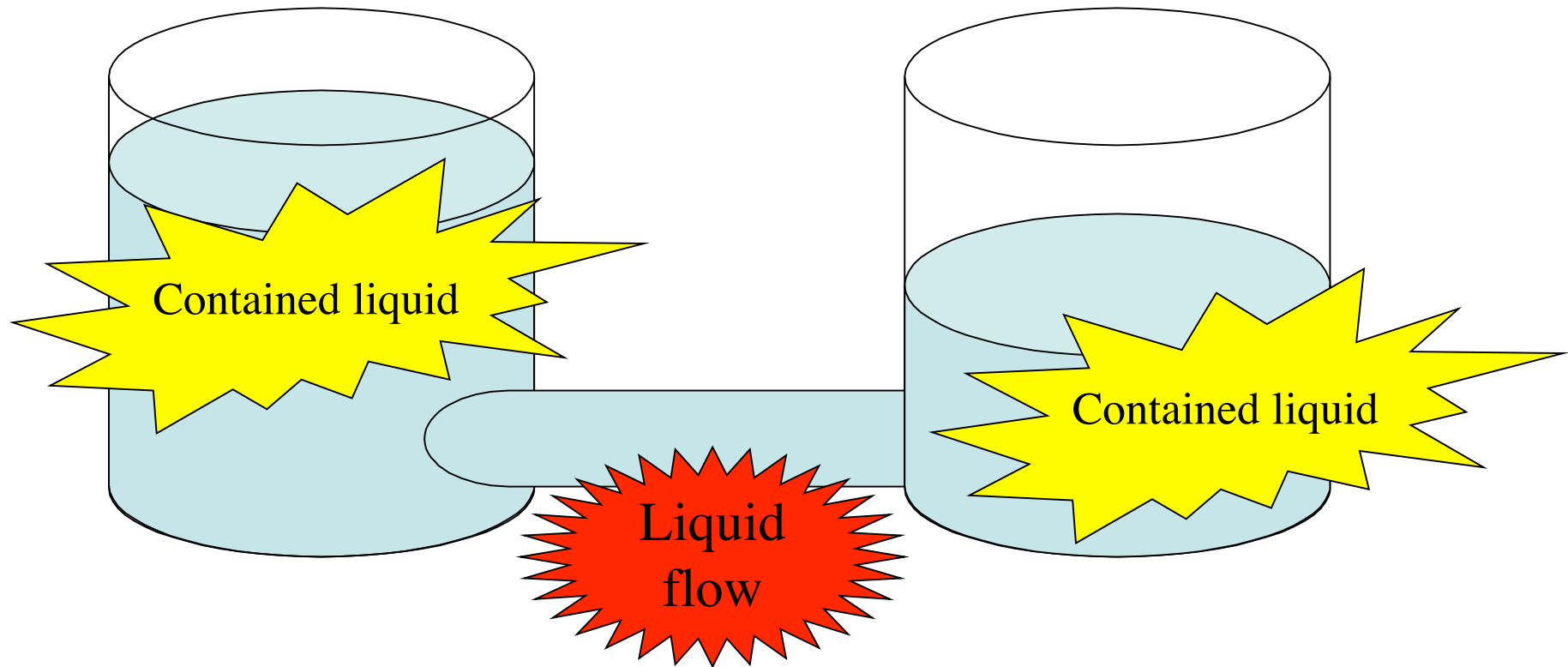
Scenario ?





The scenario editor

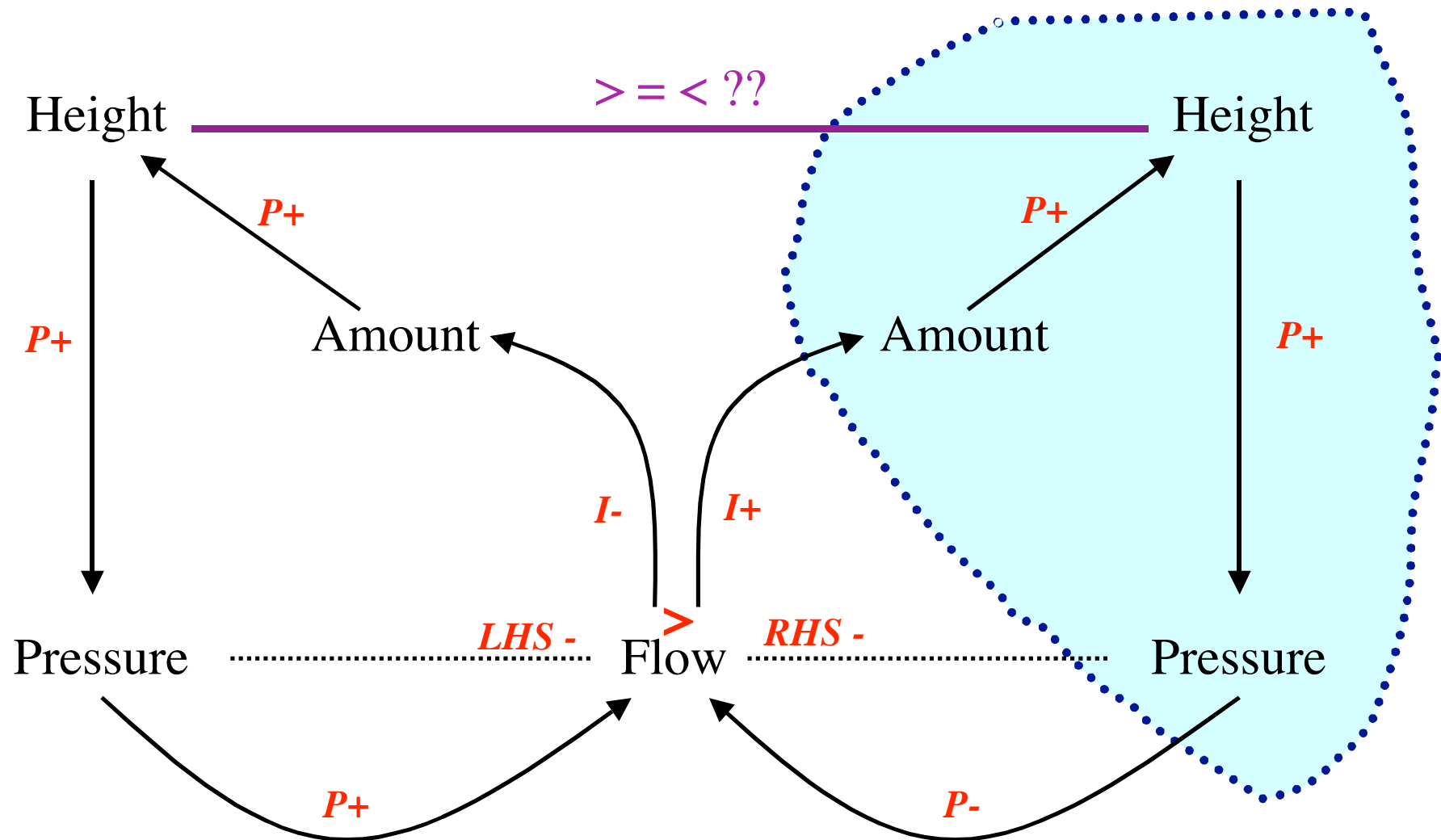


Model fragments



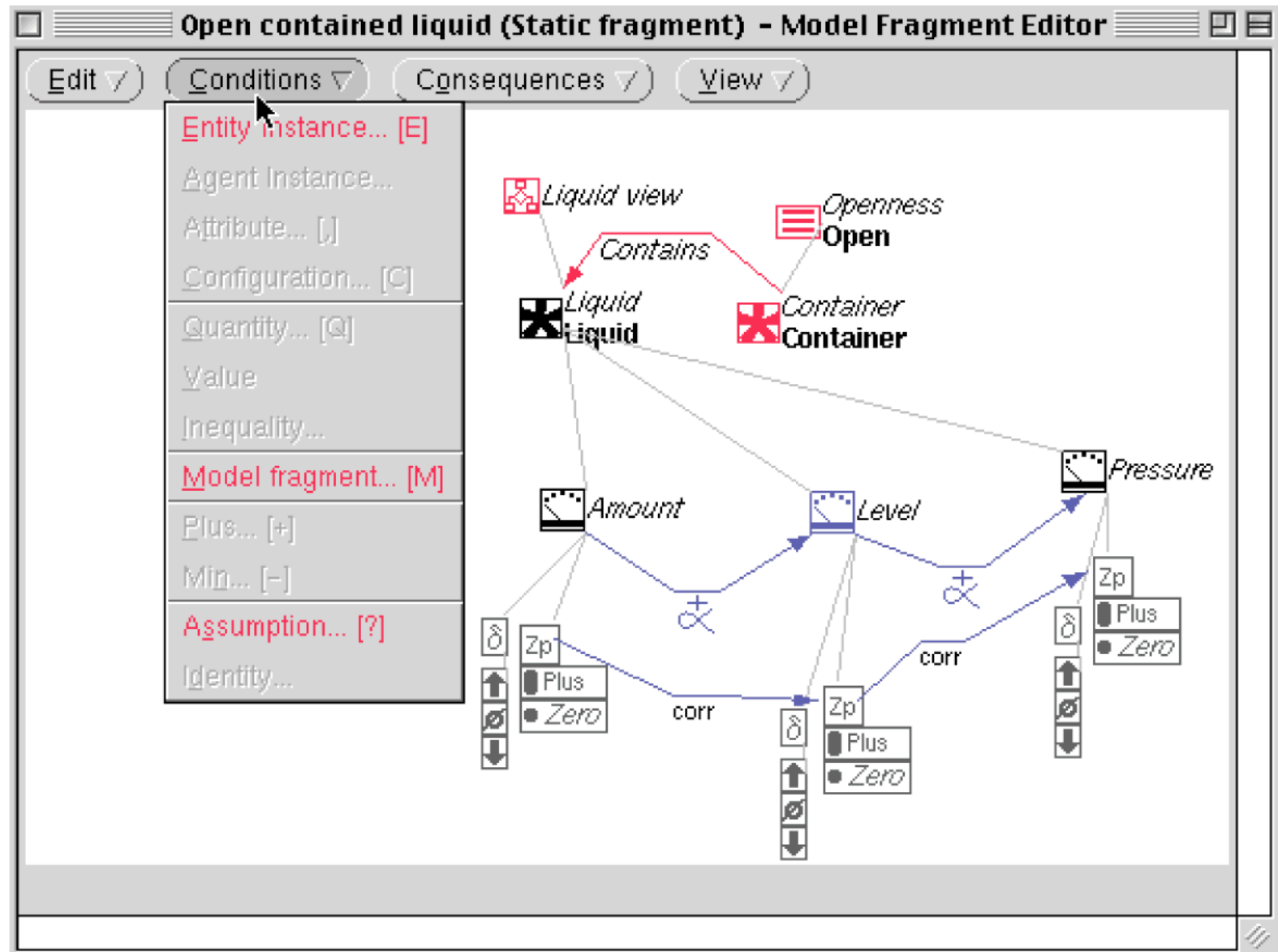
 = static MF  = process MF

Static MF: a contained liquid

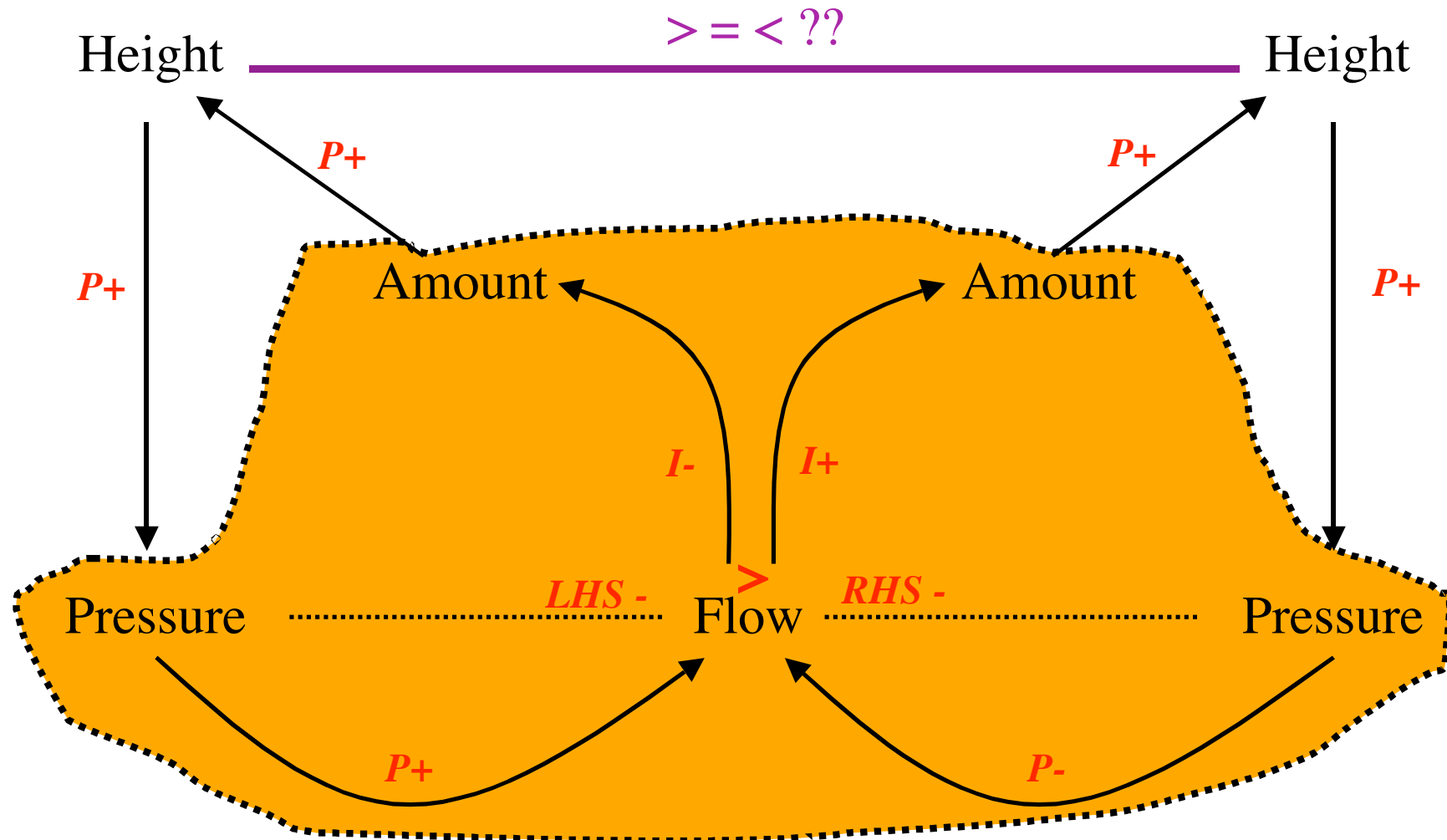


Model fragments

...what exactly is a 'contained liquid'?

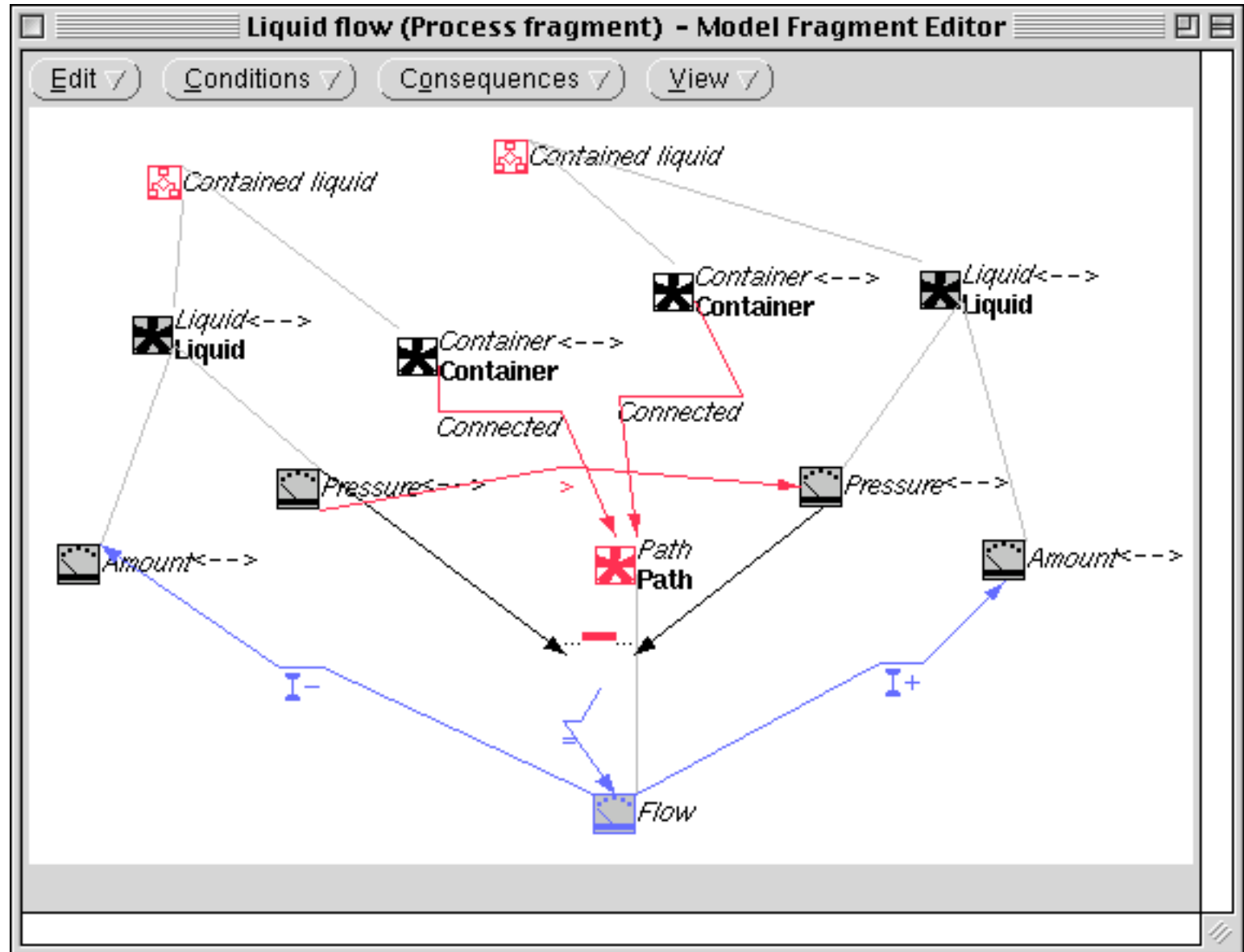
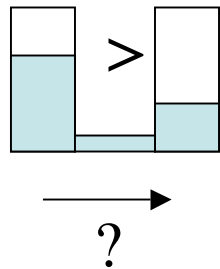


Process MF: a liquid flow



Processes (*a liquid flow...*)

...what exactly is a 'liquid flow'?



VisiGarp

State transition graph for scenario: Utube with unequal levels

File View Display Help

Select:

- States
- Path
- All

input → 1 → 2

Transition between state 1 and 2

```
1 -> 2:  from_greater_to_equal(level1, level2)
          from_greater_to_equal(pressure1, pressure2)
          merge_equal_correspondence((level1, level2), (p
```

Dependencies in state 1

View:

Entities	Relations
Spaces	Values
Derivatives	
All	None

Dependencies:

I+	I-
P+	P-
>	>=
<	<=
=	d=
d<	d>
d<=	d>=
Q	Q^
V	V^
All	None

water_left

water_right

level1
plus
zero

level2
plus
zero

amount1
plus
zero

amount2
plus
zero

pressure1
plus
zero

pressure2
plus
zero

flow1
plus
zero
min
= pressure1 - pressure2
path

Quantity

amount1(water_left)

amount2(water_right)

flow1(path)

level1(water_left)

level2(water_right)

pressure1(water_left)

pressure2(water_right)

Sort by:

- Quantity
- Entity

Select

- All
- None

Graph

- Draw

Show/hide:

- Inactive dependencies

Layout entities

Layout quantities

Zoom in

Zoom out

level2(water right)

Clear

Bouwer & Bredeweg, AIED 2001

Some recent developments...

- □ Question generation
- □ Event history
- □ Model building support

Concluding remarks



Knowledge
capture

- **H**omer: building QR models
(Bessa Machado & Bredeweg, QR2003)
- **V**isiGarp: running & inspecting QR models
(Bouwer & Bredeweg, AIED2001)
- **A**pplication to teaching: collaborative learning
(Salles & Bredeweg, AIED2003)
- **A**pplication to ecology: population & community dynamics
(Salles & Bredeweg, Ecological Modelling - in press)

Software can be found at:

<http://www.swi.psy.uva.nl/projects/GARP/>