



# Requirements Engineering (Summer 2021)

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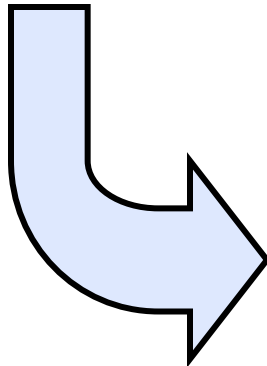
<https://github.com/nanniu/RE-Summer2021>



# Today's Menu

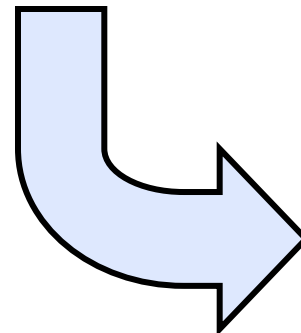
Wednesday (July 14)

"req.s", "why", & "RE"



Thursday (July 15):

Meaning of Req.s  
ASN1 Release







Friday (July 16):

Req.s Elicitation  
Functional Req.s & NFRs



# Course website updates

➤ Please check on a daily basis  
& let me know if there're any  
questions.

	Assignments
	Audios
	Readings
	Slides

➤ My original needs & desires:  
"Share the lecture videos"

➤ GitHub file upload limit:  
25MB

➤ I had to *adjust* my desire due  
to this *environmental* condition



## Yesterday's take-aways

→ What're requirements?

↳ Stakeholders' needs & desires

→ Why're requirements important?

↳ Because doing requirements right saves money

→ What's requirements engineering (RE)?

↳ A set of activities (elicitation, modeling, prioritization, realization, evolution, etc.) aimed at communicating and adjusting requirements



## Today's take-aways

- What's the meaning of requirements?
- Why're the implications of the "meaning of requirements"?
- What's ASN1 about?



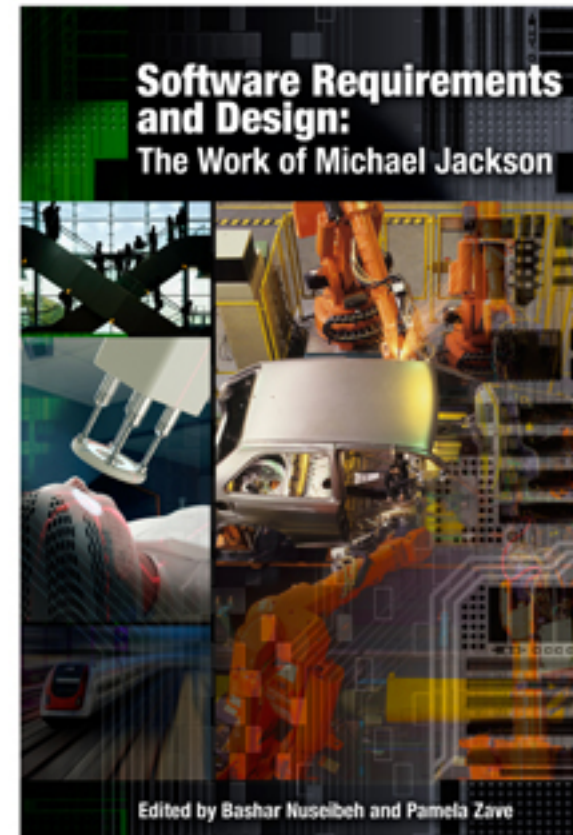
# The Meaning of Requirements

## Software Requirements and Design: A Tribute to Michael Jackson



**Michael Jackson (not the singer)**

$\mathcal{E}, S \vdash R$





## The req.s concerned in Jackson's paper

- The computer must not weigh more than 0.25 Kg.
- The system must be completed by 1st January 1998.
- The programs must be written in Ada.
- The system specification must be formally accepted by the steering committee.
- The operator interface must be easy to learn.
- The system must produce a monthly report of outstanding debts.
- If passenger in the lift presses the *open-doors* button while the lift is stationary at a floor, the doors should begin to open within 0.5 secs.

### → Functional requirements

↳ Real-time response

↳ Those properties (of operational safety that) can be *precisely* stated in terms of system behavior



## Requirements are in environment

→ Environment = the part of the world

↳ into which the machine will be installed

↳ with which the machine will interact

↳ in which the effects of the machine will be observed and evaluated

→ Machine = software-to-be

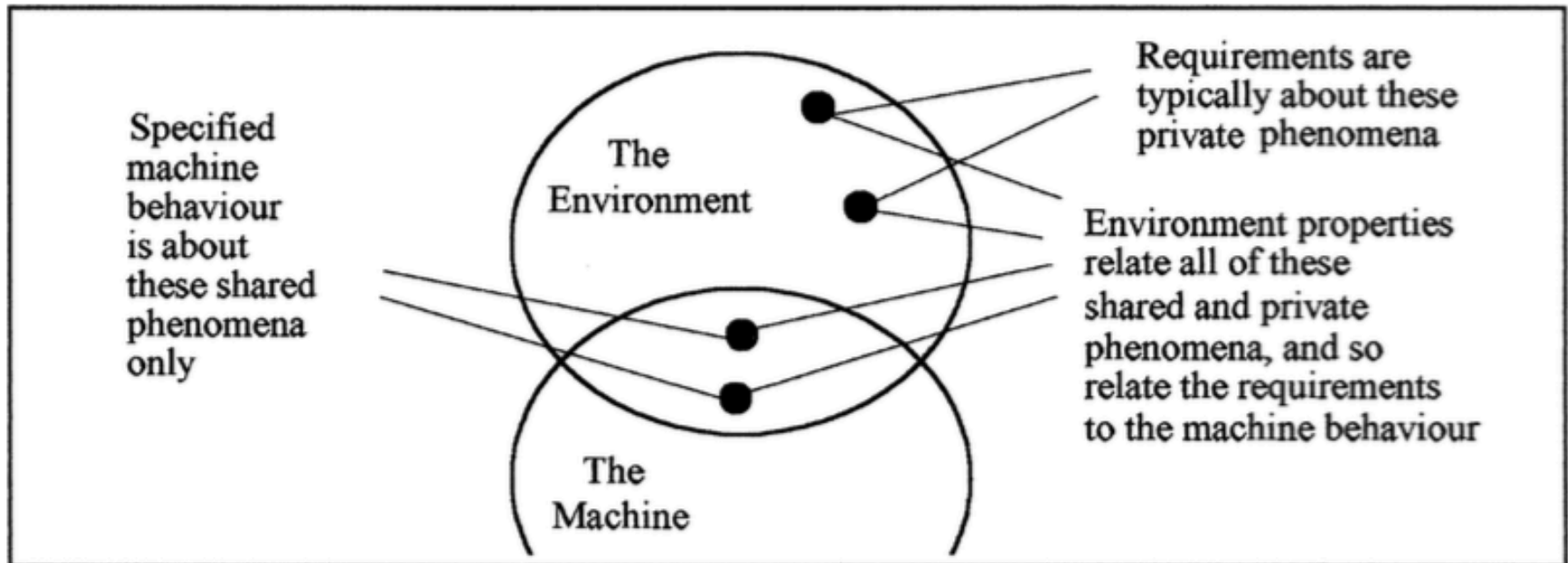
↳ with which programmers do programming

↳ sth. that we transform a general-purpose computer into in order to satisfy stakeholder needs & desires

We want to do programing/transformation without further environment knowledge. ← What RE is for.



# Understanding R, $\mathcal{E}$ , S



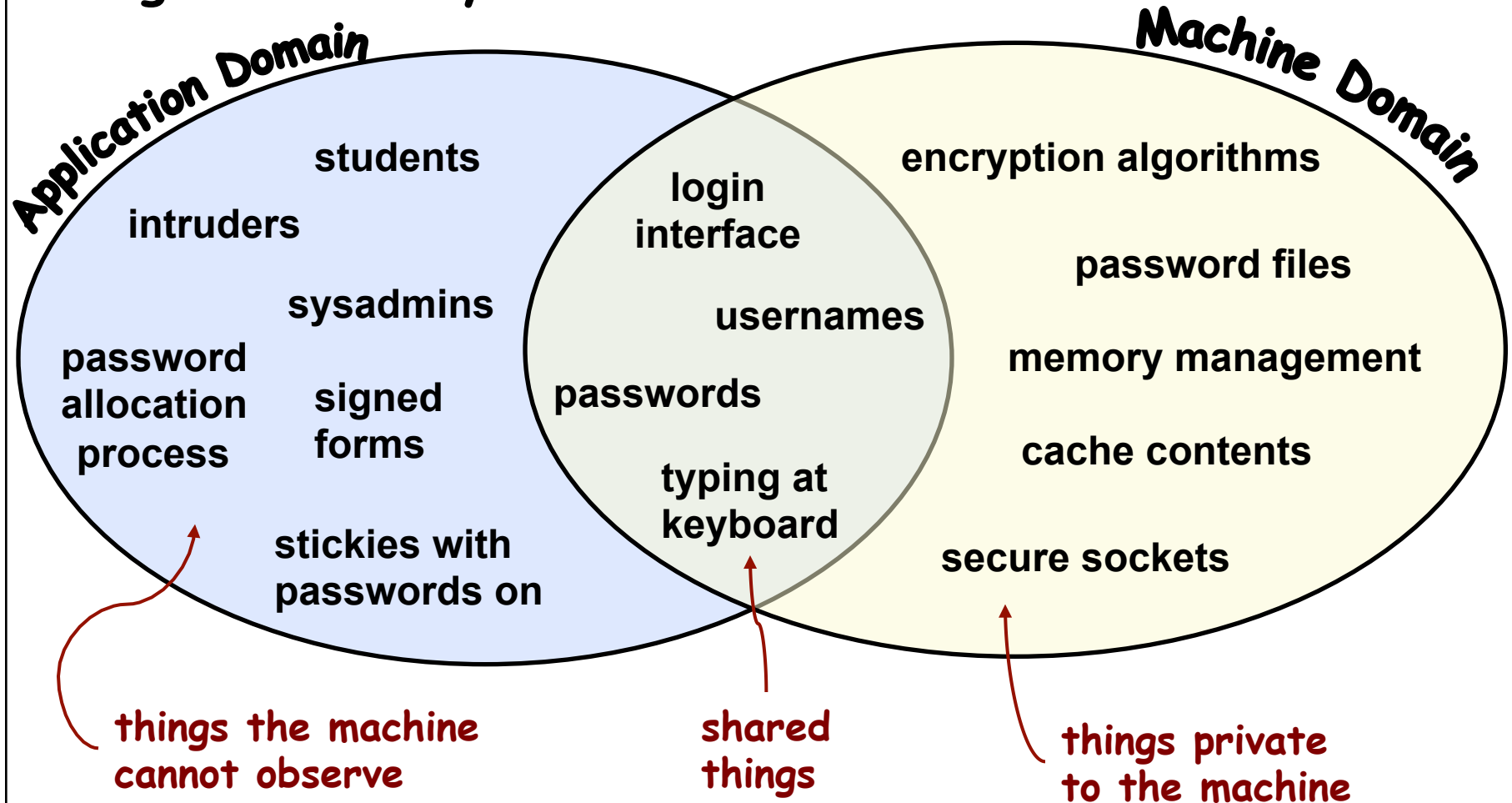
**R:** requirements (optative/desired)

**$\mathcal{E}$ :** environmental assertions (indicative/given)

**S:** specifications (optative/desired)

# Software is a **science** of description

→ E.g. “allow only authorized access to lab machines”





## To be more specific

### → Requirement R:

↳ "The lab machine shall be accessible by only authorized personnel"

### → Domain Properties E:

↳ Authorized personnel have usernames

↳ Authorized personnel have passwords

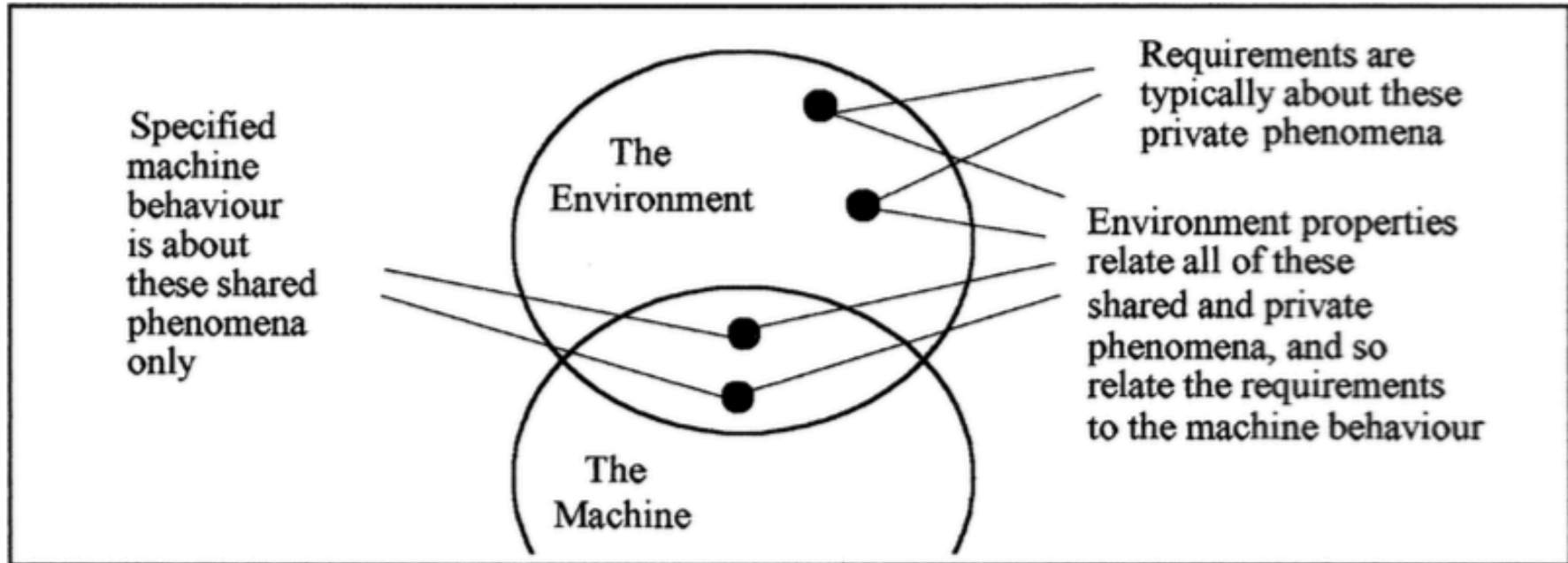
↳ Passwords are never shared with non-authorized personnel

### → Specification S:

↳ Access to the lab machine shall be granted only after the user types an authorized "username, password" pair

→  $S + E$  entail R

# Req.s = Stakeholders' needs & desires



A library system allows its member to renew books.

An auto-pilot helps the pilot to fly the plane safety & efficiently.

An elevator controller provides safe & convenient transport from floor to floor in a tall building.



## Req.s are **OUTSIDE** the machine

A library system allows its member to renew books.

An auto-pilot helps the pilot to fly the plane safety & efficiently.

An elevator controller provides safe & convenient transport from floor to floor in a tall building.

If the software-intensive system fails, **where** are the complaints?

*"The true subject matter of the software development is not the computation performed inside the computer, but the desired behavior that these computations evoke and control in the world outside."*

## In-Class Exercise #1: Group

- I'll randomly assign you to a breakout room
- Instantiate  $R$ ,  $\mathcal{E}$ ,  $S$  for the elevator system such that your instantiated  $R$ ,  $\mathcal{E}$ ,  $S$  satisfy " $\mathcal{E}, S \models R$ ".



## Requirements

- R: “attend a class at a different floor”
- Requirement is in the OPTATIVE mood, expressing a wish
- Requirement can (and SHOULD) be stated entirely without reference to the machine
  - ↳ Private phenomena of the environment
  - ↳ Requirements are located in the environment
- The GOAL (needs & desires) of stakeholders

## Environmental Assertions

- R: “attend a class at a different floor”
- $\mathcal{E}$  is in the **INDICATIVE** mood, expressing what is claimed to be a known truth
- Instances of  $\mathcal{E}$ : knowing ...
  - ↪ “different floor of the SAME building”
  - ↪ “LOCATION of the elevator inside the building”
  - ↪ “DIRECTION ('up' or 'down') to go”
  - ↪ ...



## Finally: " $\mathcal{E}, S \vdash R$ "

- $R$ : "attend a class at a different floor"
- $\mathcal{E}$ : ..., "press the right button", ...
- $S$ : "button → sensor → controller → move"
- Specification
  - ↳ Optative
  - ↳ Shared phenomena of environment and machine
  - ↳ A nexus of constraints and causal chains

The meaning of requirements: " $\mathcal{E}, S \models R$ "

This one is also true: " $P, C \models S$ "



## → Implications

- ↪ RE, in its simplest form, shall (1) elicit R, and (2) derive S such that " $\mathcal{E}, S \models R$ "
- ↪  $\mathcal{E}$  should act as a sufficient faithful approximation to the informal environment
- ↪ We want to do programming without further environment knowledge. ← What RE is for.

# Environment & machine

→ relationship of formal models to physical reality

Radiation therapy



Passenger lift



Rotterdam barrier



Car parking



Flight control



Cruise control



# Software-intensive systems

→ are engineered to fulfill the requirements that are located in the environment

Industrial press



rapy



Vending machine



r lift



Medical Records



rrier



Lending Library



king



ontrol



ontrol



# Jackson's own conclusion

Requirements engineering is not a branch of pure mathematics or logic: the meaning and applicability of an environment description depends crucially on its reliable interpretation in the environment. In requirements engineering we may not postpone interpretation until description is complete: without its interpretation a description at any level is literally meaningless.

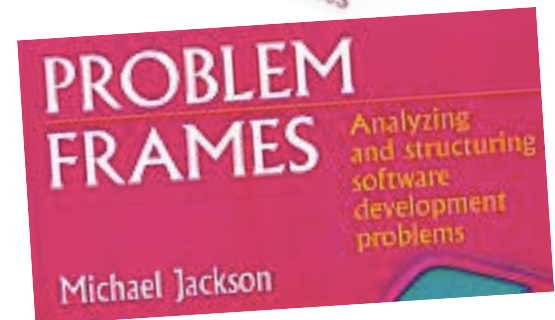
$\mathcal{E}, S \vdash R$



## Beauty in Software Engineering

Jon G. Hall and Lucia Rapanotti  
*The Open University*

Software Requirements & Specifications  
*a lexicon of practice, principles and prejudices*



# ASN1: Meaning of Requirements

## → What?

↪ WebEx: Three (or more) tuples of  $\langle R, E, S \rangle$  such that "E, S entail R"

↪ GitHub: same as above

↪ "R", "E", and "S" are expressed in English

- Expressing "R" *without* referring to the machine
- Making sure "E" is *relevant*; note that "E" can be a *set* of environment assertions
- Including the *machine* in "S"

We have two machines: (1) WebEx, (2) GitHub



# Example: Elevator is the machine

## → Tuple #1

↳ R: "A student carrying a heavy bag to attend a class at a different floor"

↳ E: "different floor of the SAME building", "pressing UP/DOWN button means the intention to move UP/DOWN", "social distancing in an elevator", ...

↳ S: "button pressed → request sent to the elevator controller  
→ triggering the motor or opening the door"

## → Tuple #2 / #3

↳ R: "A student carrying a heavy bag (lab kit / lunch box) to attend a class at a different floor"

↳ ...

**BAD**

Don't Do This

NOT  
COOL



# ASN1: What?

## → Tuple #2

↳ R: "A technician helps move hazardous materials to a new lab space"

↳ E: "safety protocols", "wrapping", "masks", ...

↳ S: "button pressed → request sent to the elevator controller  
→ triggering the motor or opening the door"

## → Tuple #3

→ (at least 3 tuples for WebEx; at least 3 tuples for GitHub)

→ Optional: rationale & reasoning





# ASN1: When & how to submit?

- Before 9am on Monday (July 19)
- Email your ASN1 solution in one PDF file to [nan.niu@uc.edu](mailto:nan.niu@uc.edu)

# Meaning of Requirements

THE WIZARD OF ID PARKER & HART

