Automation: Methodology and Technology

Panel Discussion 3

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November 4, 2022

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1 Background

2 Principles of Automation

3 Application

Compute

- “computer” $\leftrightarrow$ “person who computes”

Compute

- “computer” $\leftrightarrow$ “person who computes”
- complicated $\rightarrow$ methodology

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1 Background

2 Principles of Automation
- Abstraction
- Algorithms

3 Application

(Part of) Principles

- Abstraction
- Algorithms

Why abstraction?

To make problems clear

(I) To make problems clear.

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Example

A **farmer(P)** wants to cross a river and take with him a **wolf(W)**, a **goat(G)**, and a **cabbage(C)**.

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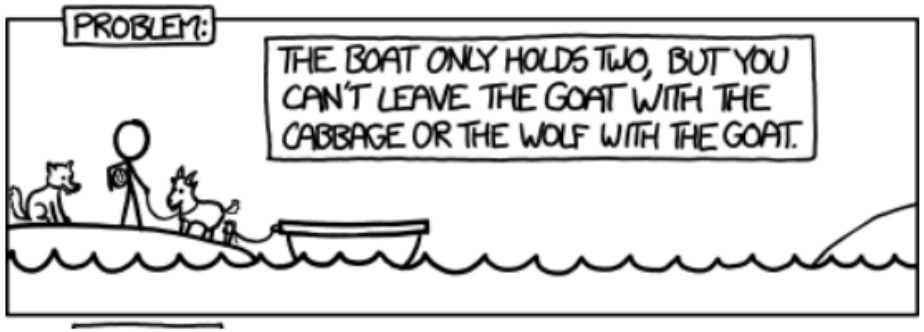
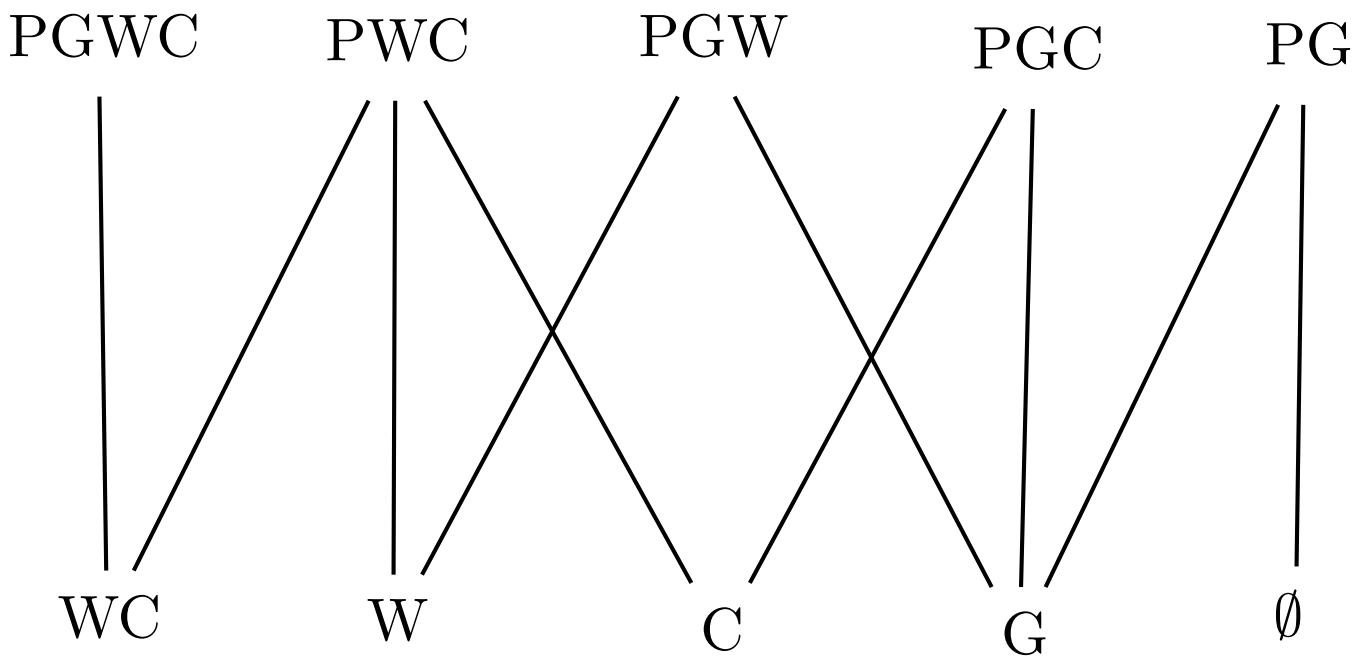


How can the farmer bring the wolf, the goat, and the cabbage across the river?

Why abstraction?

To make problems clear

Vertex = state of original shore.
Edge = Possible transition that can be made
Farmer=P, Wolf=W, goat=G, Cabbage=C.
That is, find the shortest path of the given graph.



And it's easy to solve now!

Why Abstraction?

Easy to Maintain

(II) Easy to Maintain
Black-box abstraction: What is it about.

Example

We have AND gates and NOT gates and so on...

Why Abstraction?

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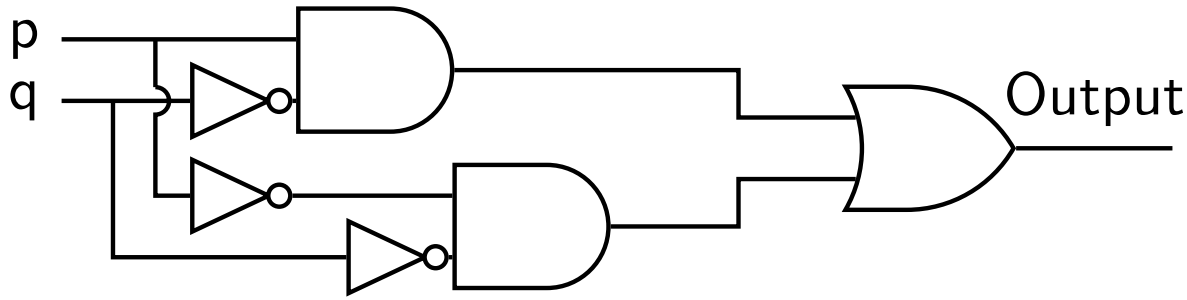
Example

We have AND gates and NOT gates and so on...
We have some wires to construct a functional logic gate.



Why Abstraction?

Easy to Maintain

Black-box abstraction: More precisely...

- Basic Elements: something that are pretty basic.(like sets in Maths)
- Means of Combination: may construct something rather complicated(composition of functions, etc.)
- Means of Abstraction: investigate how can we abstract things(like fixed patterns in math problems)
- Capturing Common Patterns: find how we make the abstractions (like reflection and summarizing after solving a problems)

The black-box abstraction uses the idea of abstraction itself!

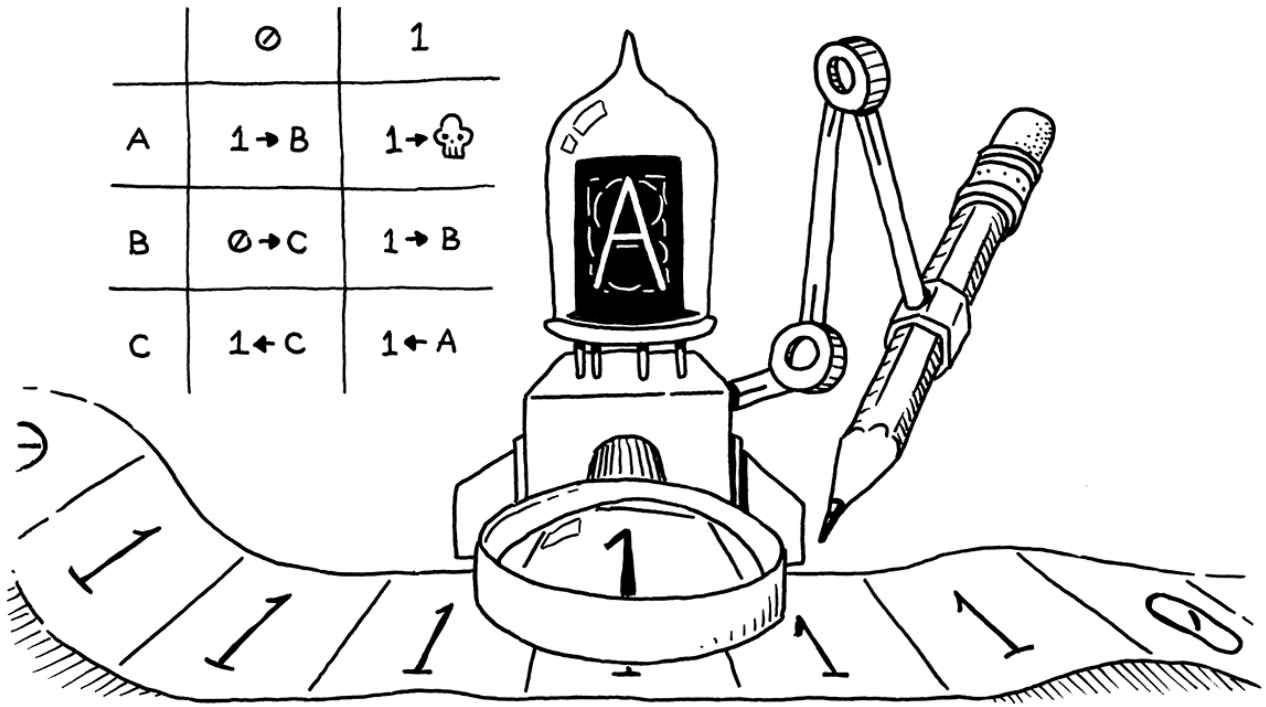
Why Abstraction?

Friendly to represent Data

(III) Friendly to represent Data

machine to automate things → computers

- state of **automation machine** is limited
- a "translation" from real-world problems to **automation machine**



How to Abstract?

Algorithms' Help

Make "abstractions" dynamic

Find the page of word s in *Oxford Advanced Learners' Dictionary*

Make "abstractions" dynamic

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Example (Find the page of word s(assuming no spelling mistakes) in OALD)

Algorithm 1.

for *word* in *dictionary*,
    if *word* is equal to s,
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Make "abstractions" dynamic

Find the page of word s in *Oxford Advanced Learners' Dictionary*

Example (Find the page of word s(assuming no spelling mistakes) in OALD)

Algorithm 1.
for *word* in *dictionary*,
    if *word* is equal to s,
        return the page of s

Algorithm 2.
find word in (*start page*, *end page*)
Open to the *middle*($\lfloor (startpage + endpage)/2 \rfloor$)
    Look at page
    If the word is on the page, return the page number.
    If the word is earlier in the dictionary, *find word* in(*start page*, *middle*)
    If the word is later in the dictionary, *find word* in (*middle*+1, *end page*)

That's it

But make sure that you have proved...

- your algorithm is correct
- your algorithm is (somehow) optimized

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ETC System

Efforts made in the field of abstraction and algorithms

- huge **database** system → Abstraction(II) (III)
  - data racing, concurrency problems → (Algorithm)
  - efficiency →(Algorithm)
- signals received by receiver → Abstraction(I), (III)

Automation Production in Factory

Efforts made in the field of abstraction and algorithms

- simulation process → Abstraction(I, II)
- stabilize the body of the robots → Algorithm

Dish washing

Efforts made in the field of abstraction and algorithms

- the "washing process" → Algorithm
- the construct of the machine → Abstraction(II)

Verify Mathematical Proofs

Efforts made in the field of abstraction and algorithms

- rules about logic $\rightarrow$ Abstraction(I)
  - if p is a prop. , $\neg\neg p \leftrightarrow p$
  - $A \wedge (B \wedge C) = (A \wedge B) \wedge C$
  - ...

Lean Theorem Prover

`http://leanprover-community.github.io/lean-web-editor`

Verify Mathematical Proofs

Example

```
variables A B C D : Prop
variable h1 : A -> B -> C
variable h2 : D -> A
variable h3 : D
variable h4 : B
#check h2 h3
#check h1 (h2 h3)
#check h1 (h2 h3) h4
```

More stuff: `https://leanprover.github.io/theorem_proving_in_lean4/title_page.html`

Data Providers on Web

gets information by...

- web crawler
- government files
- official dataset

before automatically process these data.

Summary and References

[1] *Problem Solving 2020*, Nanjing University.
[2] *Minecraft Logic Gates*, FandomWiki.
[3] *Structure and Interpretation of Computer Programs, 1986*, MIT.
[4] *CS50x 2022*, Harvard University.
[5] *Logic and Proof* by Jeremy Avigad, Robert Y. Lewis, and Floris van Doorn.

Thanks!