UE : Machine Learning

Artificial Intelligence and WEB

http://membres-liglab.imag.fr/bisson/cours/M2INFO-AIW-ML/

G.Bisson - 2009

Introduction to AI domain
Artificial, OK … but «Intelligence»

What’s that ?

Some tentative definitions

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  - « Intelligence is an ability to understand a new concept and to react to this one in an appropriate way» (R. Atkinson)
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  - « Intelligence is an *umbrella term* used to describe a property of the mind that encompasses many related abilities, such as the capacities to reason, to plan, to solve problems, to think abstractly, to comprehend ideas, to use language, and to learn. » (Wikipedia)

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Capacity to **perceive** an environment and to rationally **act** in an **adaptative** way on

Several kinds of abilities

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Several kinds of abilities

- Theory of multiple intelligences *(H. Gardner 93)*
  - Logical and mathematic
  - Musical and rhythmic
  - Verbal and linguistic
  - Social (or interpersonal)
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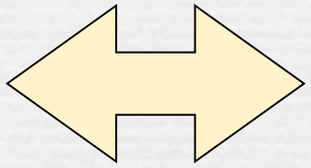
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Perception

Action

Learning

All of these kinds of intelligences involves three main processes

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      - Nine species : Great apes, Cetacean, Elephants and Magpies
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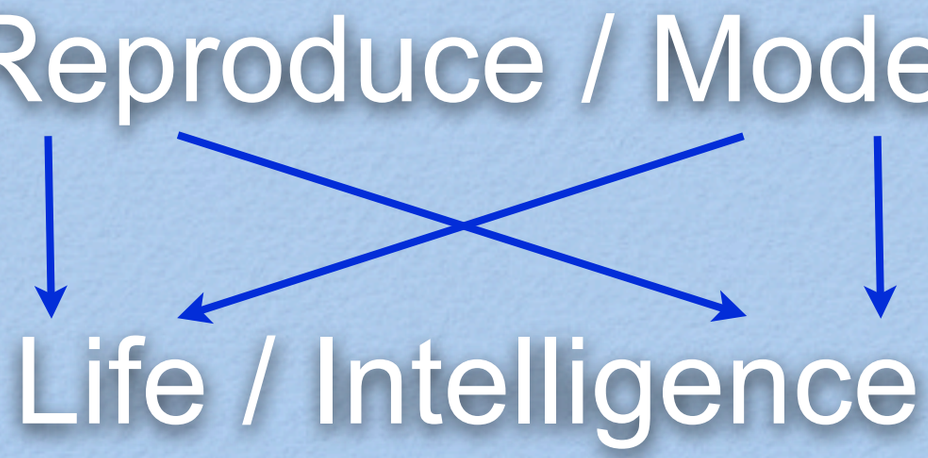


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The human quest for intelligent artefacts



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Contributions coming from many different domains :
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- Gödel, Turing, ... (XXème siècle) : Computability theory

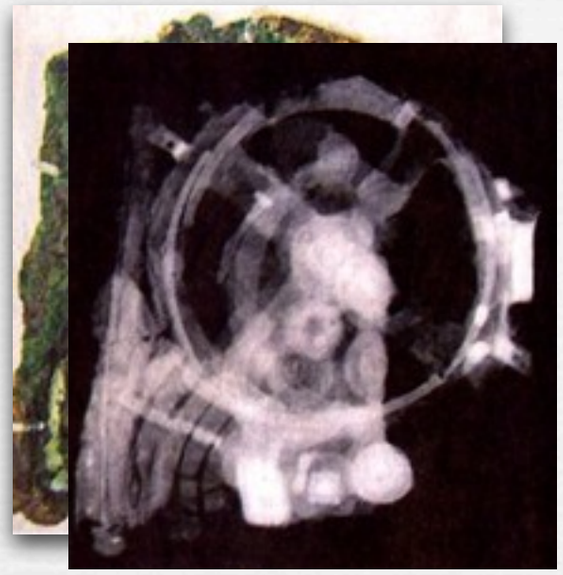
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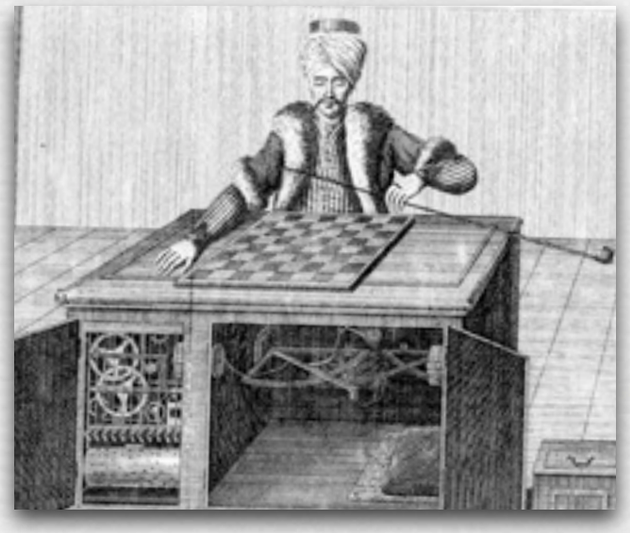
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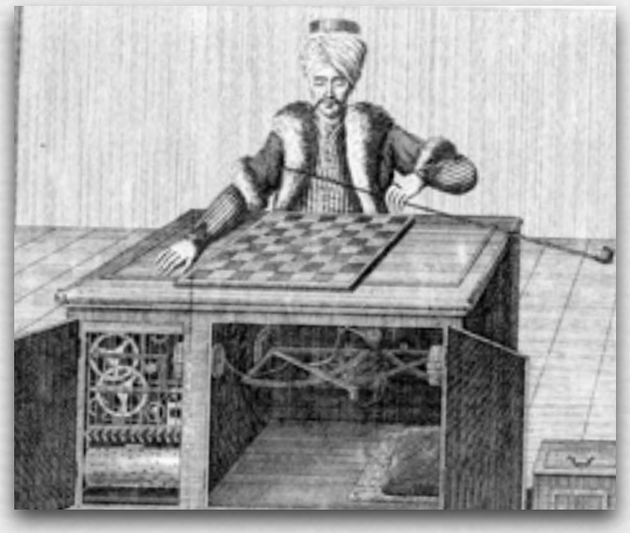




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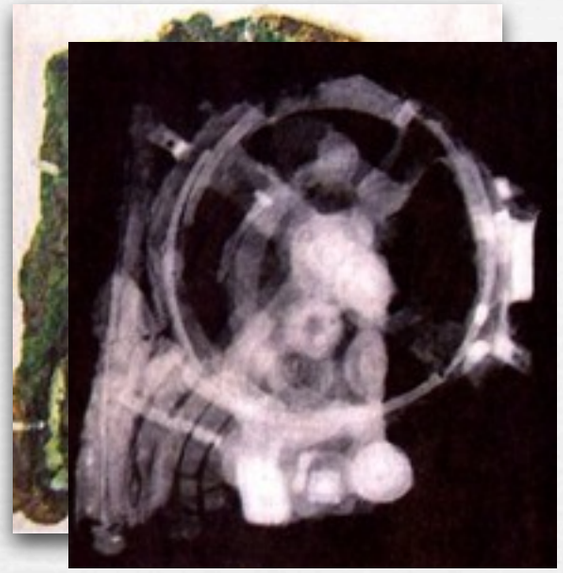
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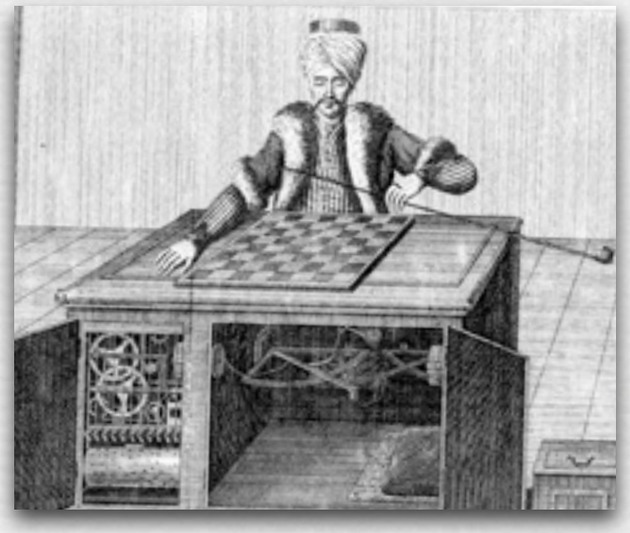




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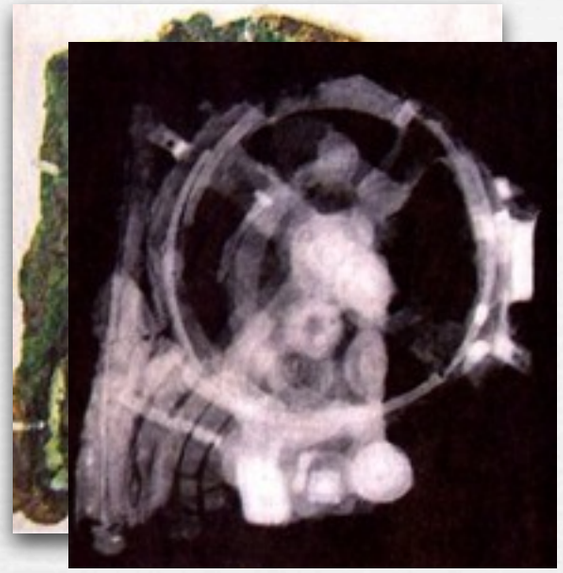
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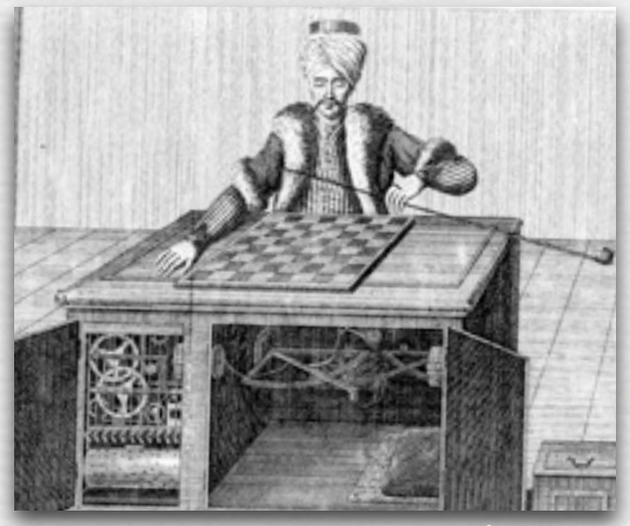


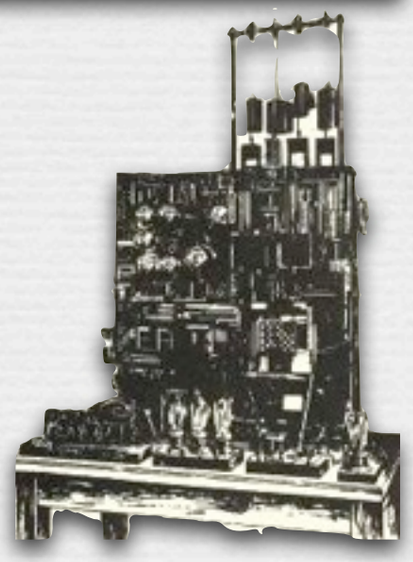


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Some «unknown» pioneers : Colossus (M. Newman), Z3 (K. Suze), ...

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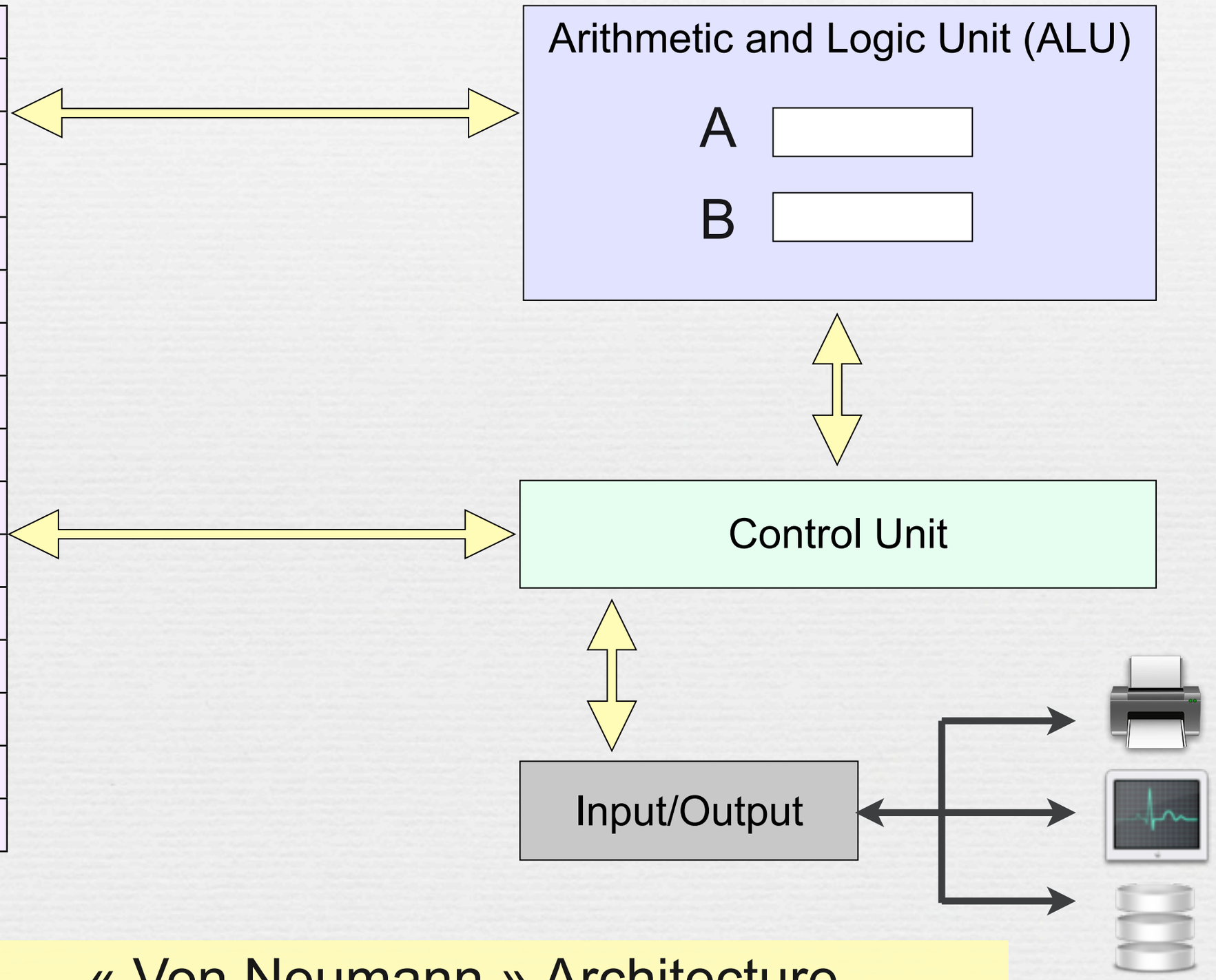
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How does computer work ?

Memory

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2	...
3	LOAD 2 → A
4	LOAD 5 → B
5	ADD A,B → A
6	TEST SI A>8
7	STO A → M12
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9	...
10	
11	...
12	0
13	6
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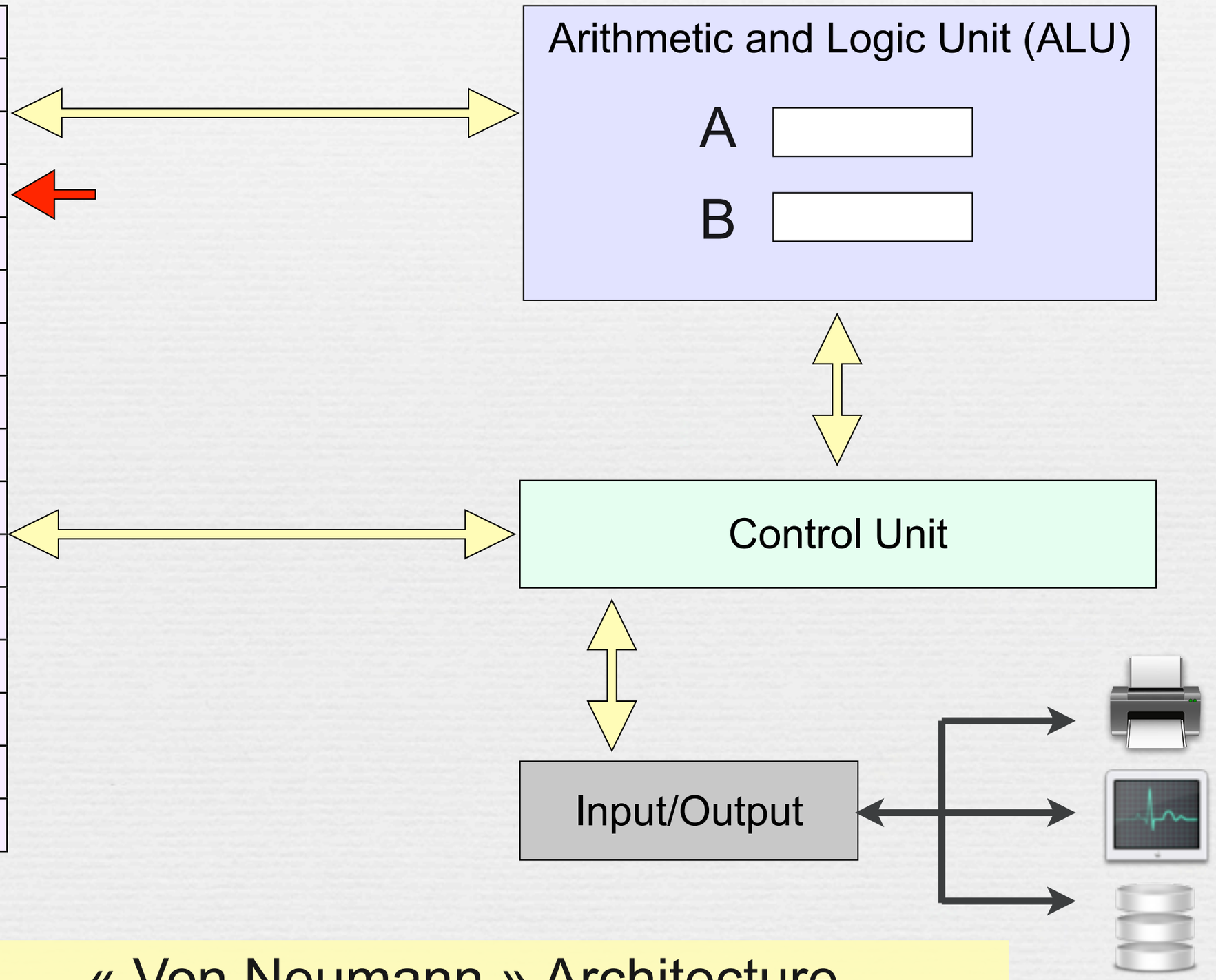
« Von Neumann » Architecture

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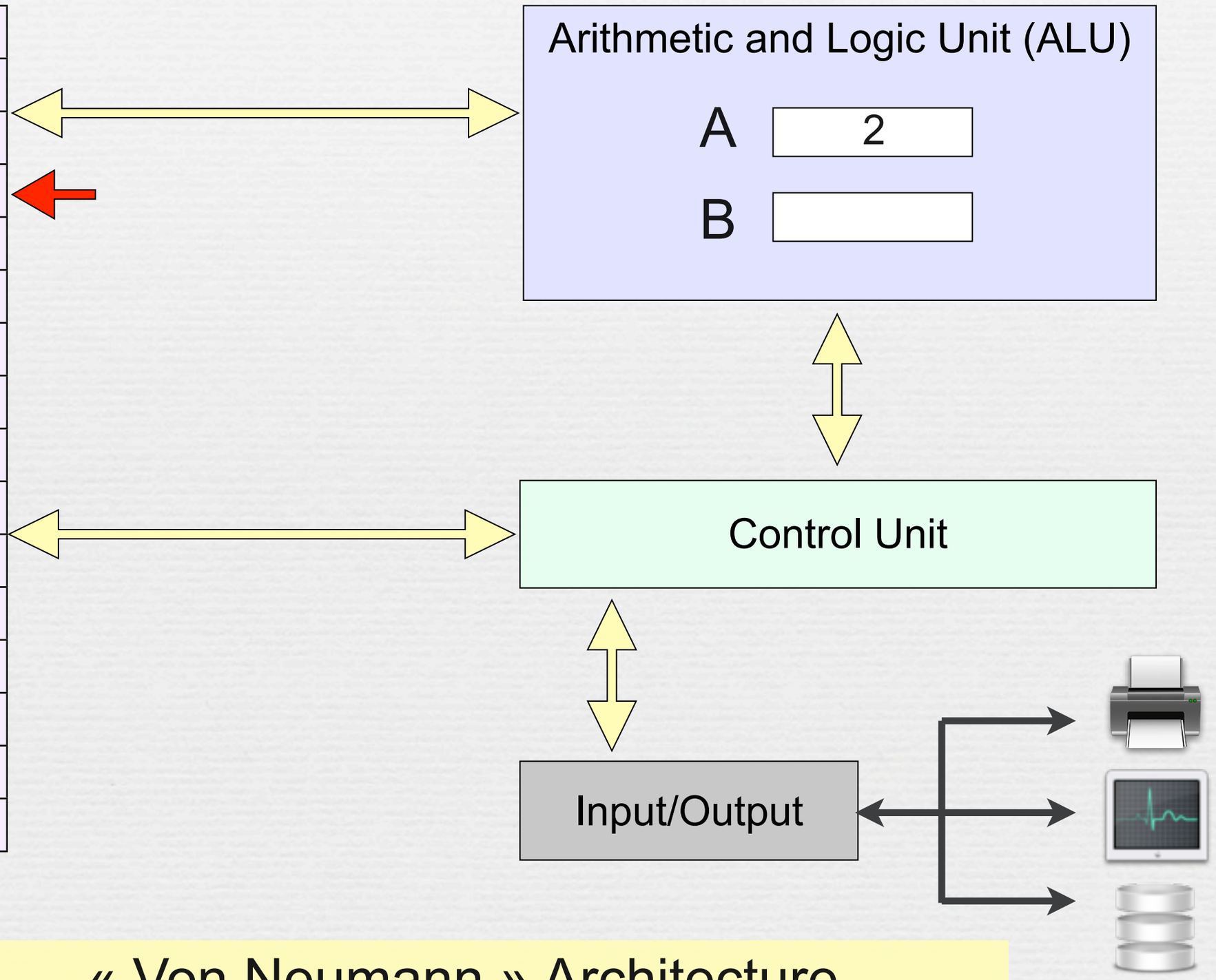
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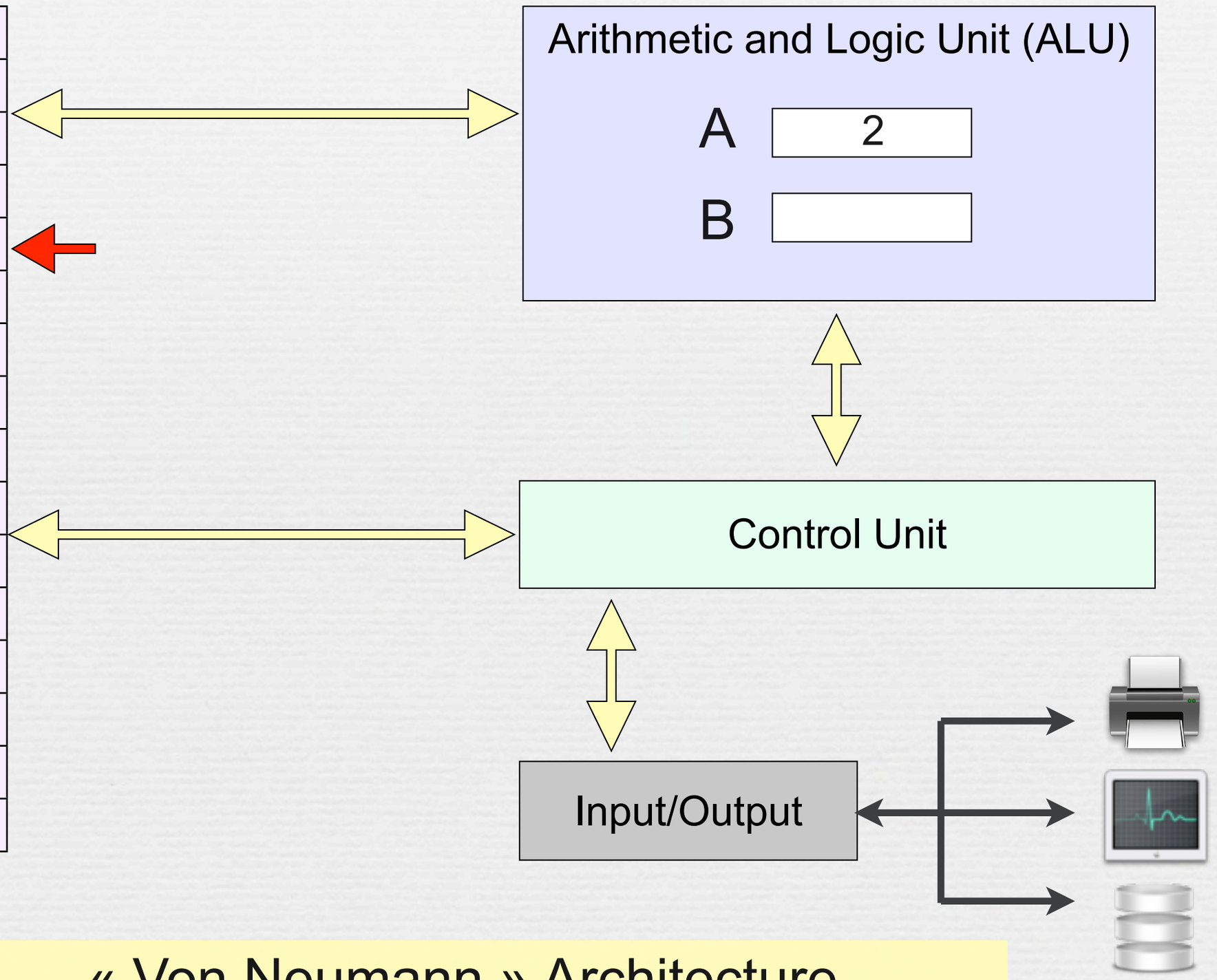
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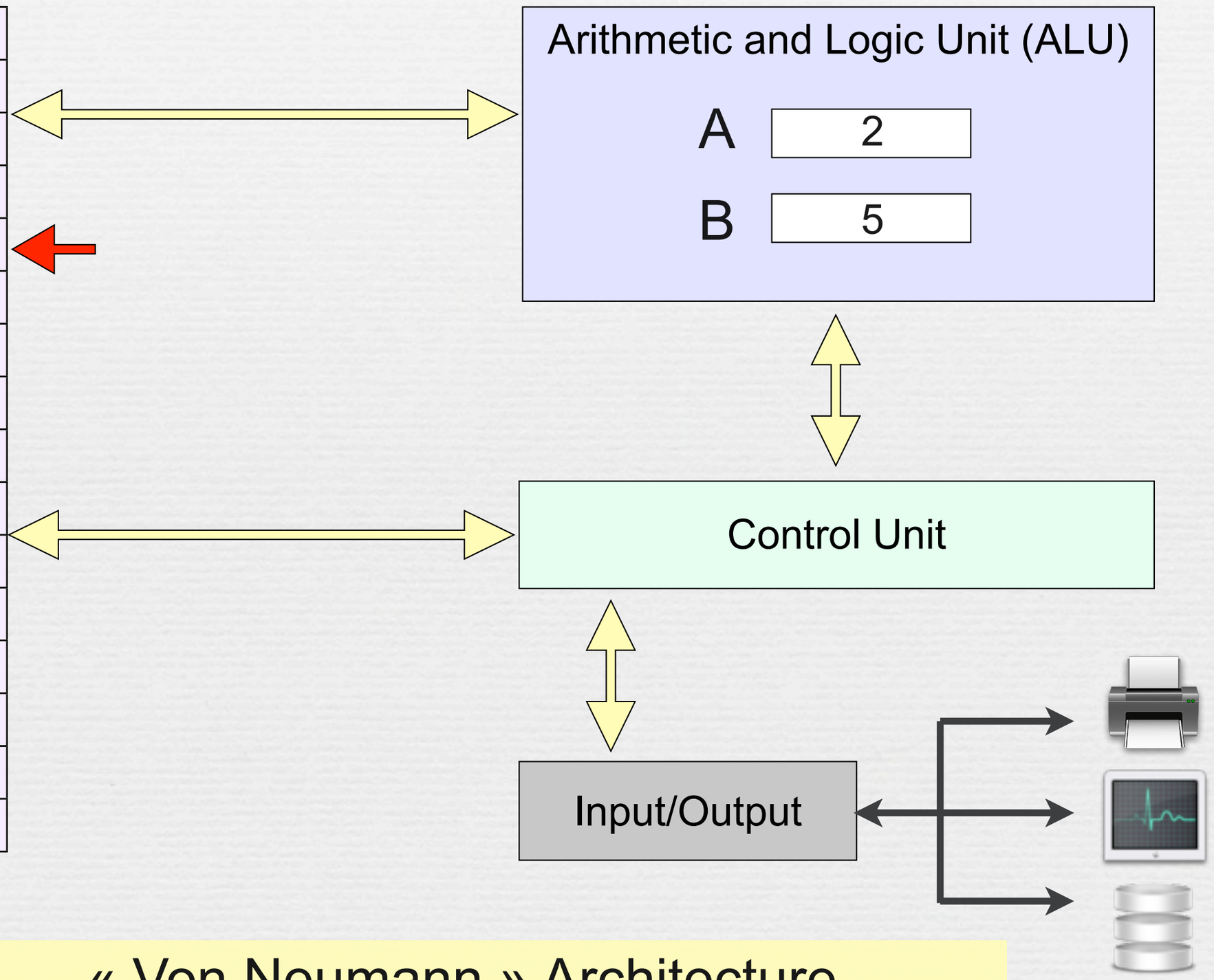
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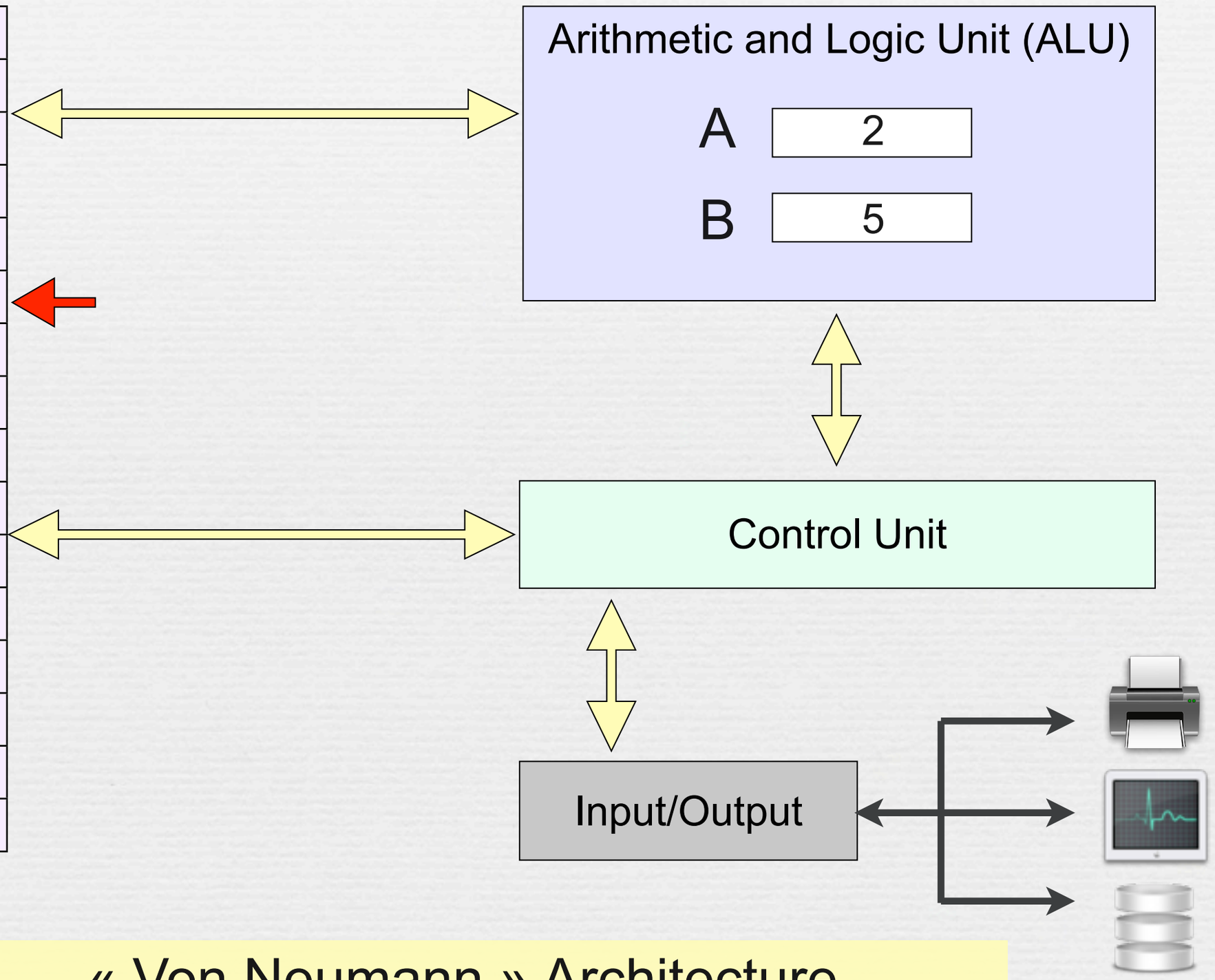
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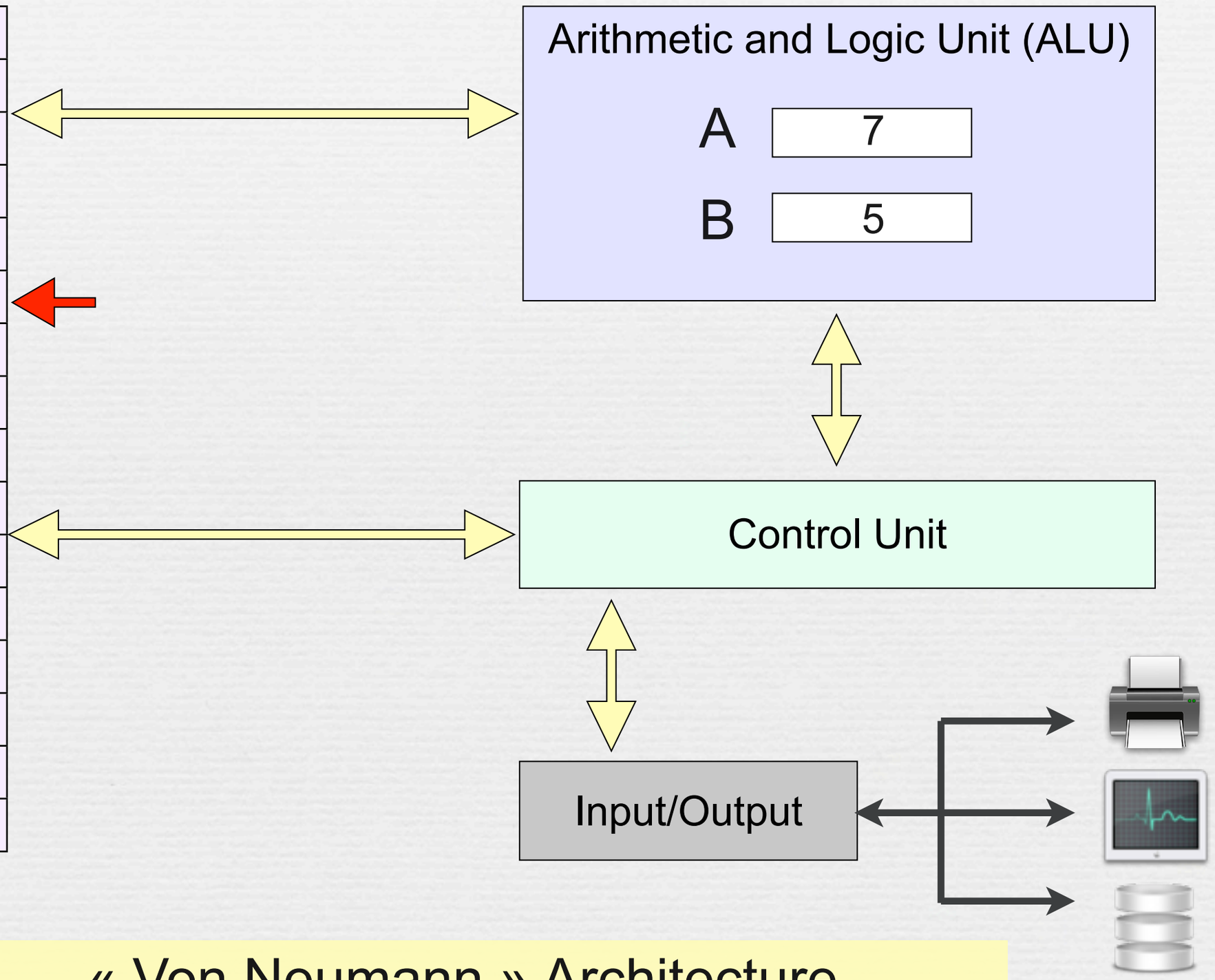
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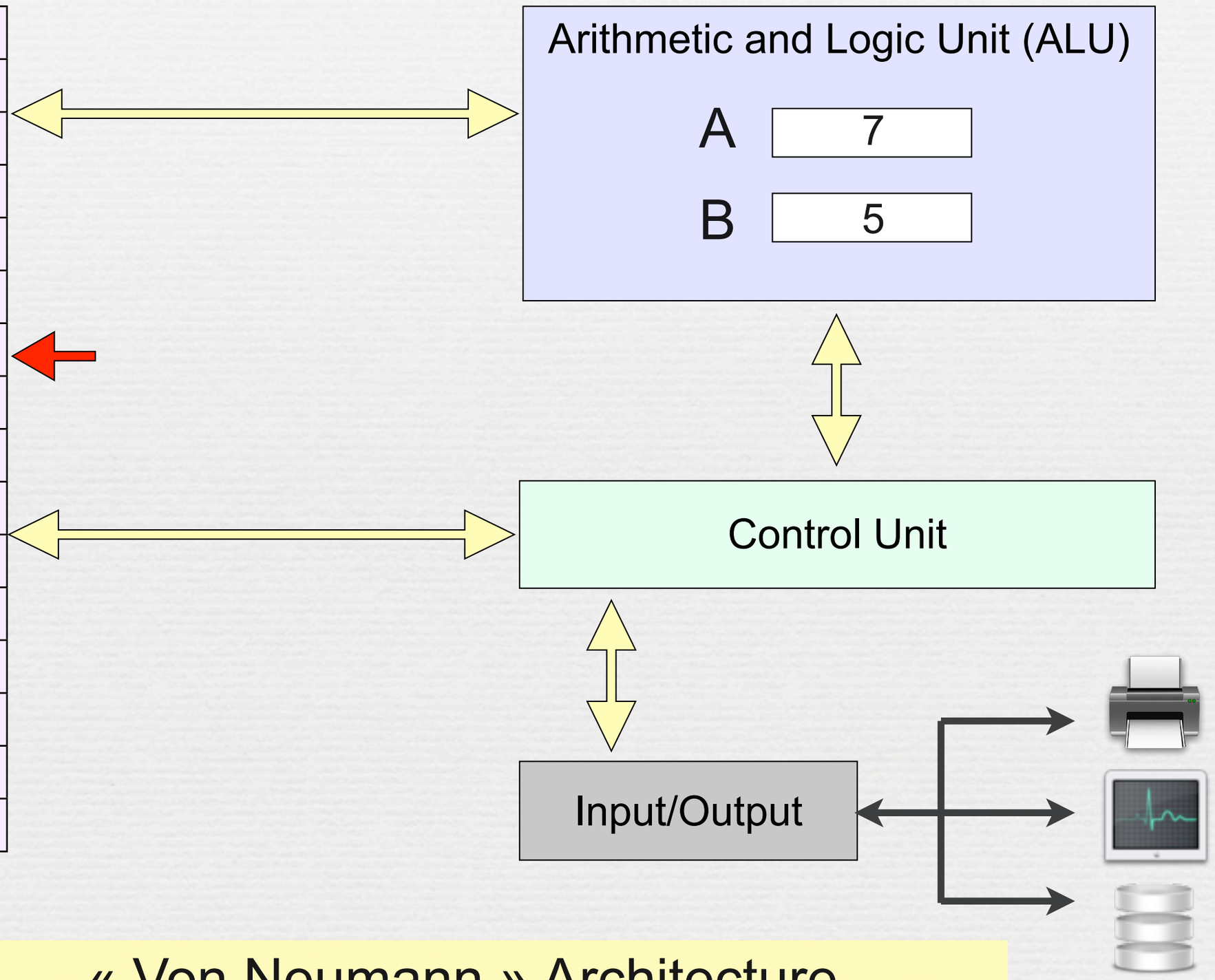
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Arithmetic and Logic Unit (ALU)

A 7

B 5

Control Unit

Input/Output



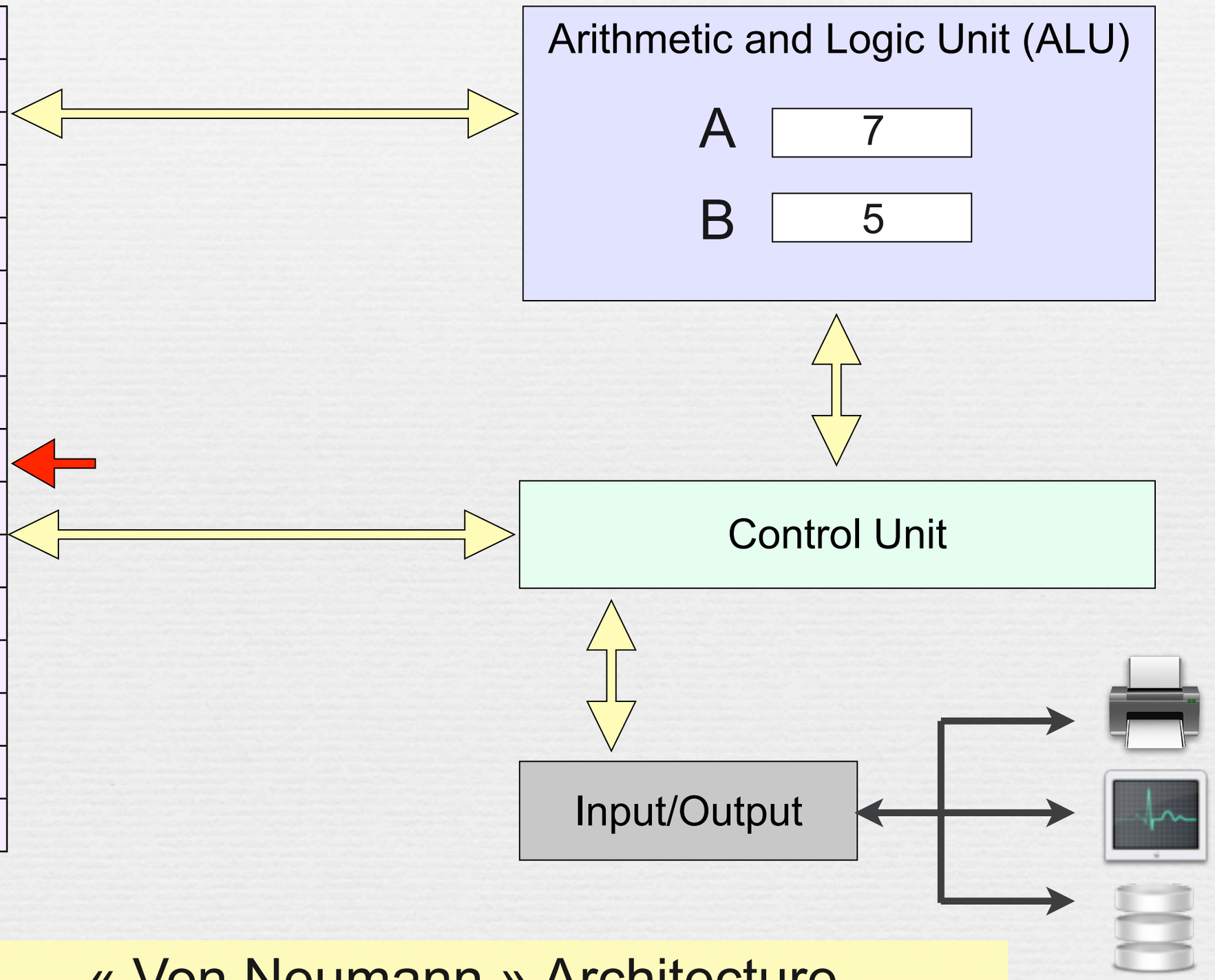
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What is an AI system ?

Multiple goals, multiple approaches

A many-sided domain ...

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Intelligence : Goal to reach	intelligence : Reference to judge		

A many-sided domain ...

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Intelligence : Goal to reach

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to think	Neurology, Psychology **Humanist approaches** **«Cognitives sciences»** *Try to built models of human and of human society*	Mathematics **Logical approaches** **«Mind laws»** *Formalization of the reasoning and of the knowledge representation*
to behave	Linguistic **Strong AI approaches** **«Artificial being»** *Creation of an intelligent artefacts : HAL-like*	Economy **Weak AI approaches** **«Rational agent»** Computer science *How to solve «**complex problems**» , engineering approach*

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O(N)	10 ns	20 ns	100 ns	1 μs	Planar graph
O(N.log(N))	33 ns	90 ns	700 ns	10 μs	Sorting
$O(N^2)$	100 ns	0,4 μs	10 μs	1 ms	Connected components
$O(N^3)$	1 μs	8 μs	1 ms	1 s	Maximum flow problem
$O(N^4)$	10 μs	160 μs	100 ms	17 minutes	Best match in a bipartite graph
$O(2^N)$	1 μs	1 ms	$4\ 10^{14}$ ans	3^{283} ans	Fifteen puzzle (Taquin)
O(N!)	360 μs	7 ans	10^{143} ans	10^{2550} ans	Travelling Salesman Problem (TSP)

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  - Information retrieval and filtering, knowledge extraction.



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- Learning and reasoning
  - Natural language processing (NLP), translation programs
  - Expert systems for diagnosis (medecine, engineering, ...)
  - Data / Web / Text mining
  - Personal digital assistant (PDA) and advanced HMI



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To drive a car in real situation ?		
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To identify a face in real time ?		
To summarize or to translate a document ?		
…		

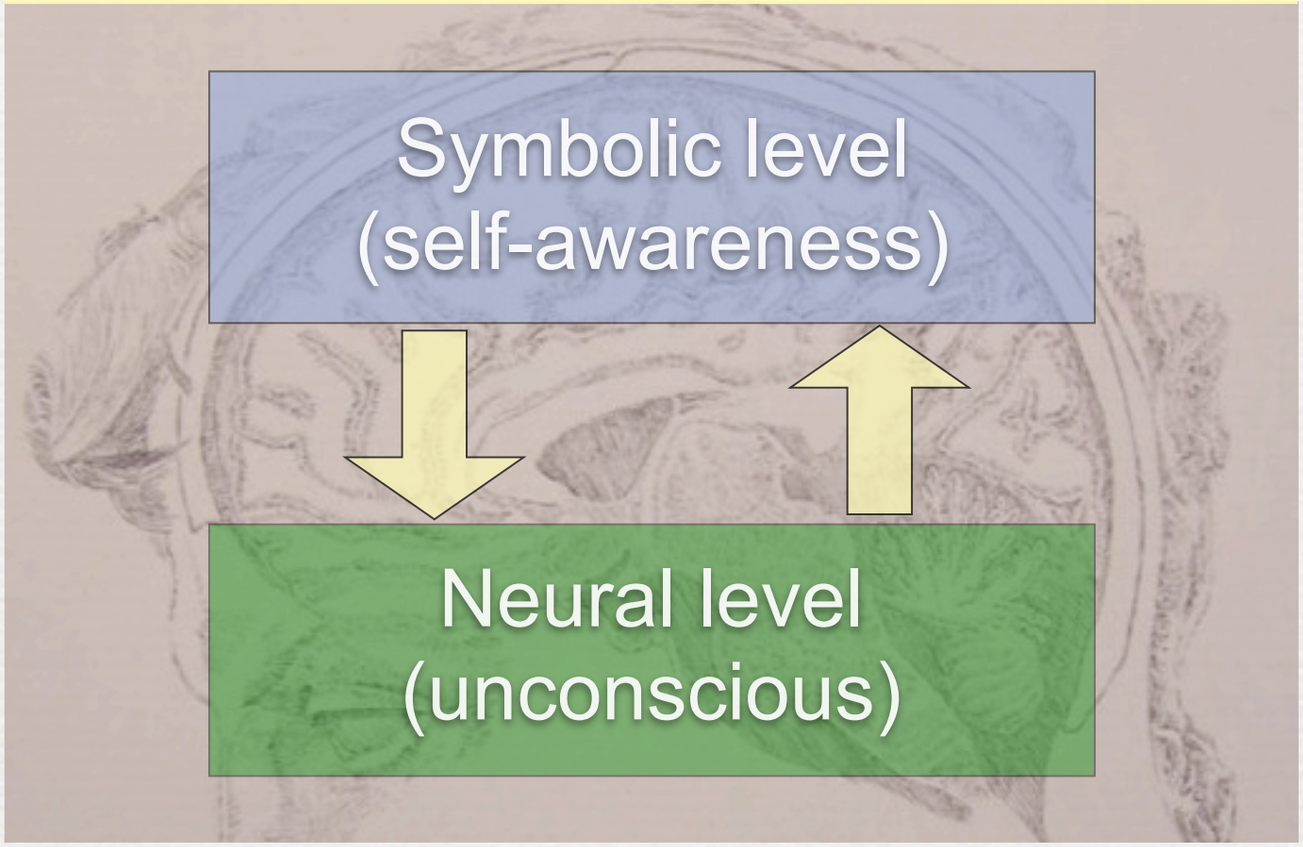
Intelligence is often associated to problems having (yet) no solution

A (quick) history of AI

From 1950 to now

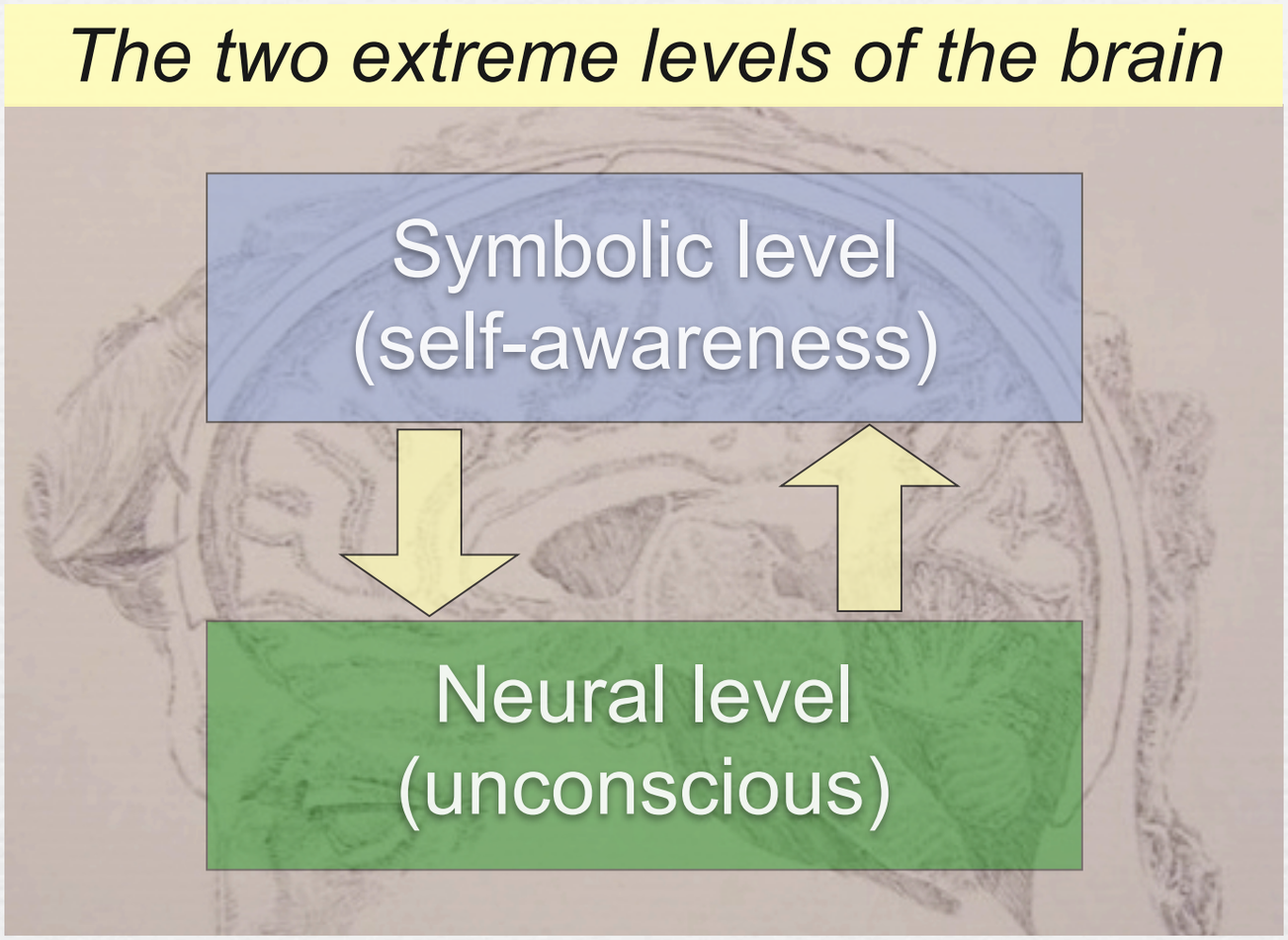
Symbolic vs Neuro-mimetic approaches

The two extreme levels of the brain



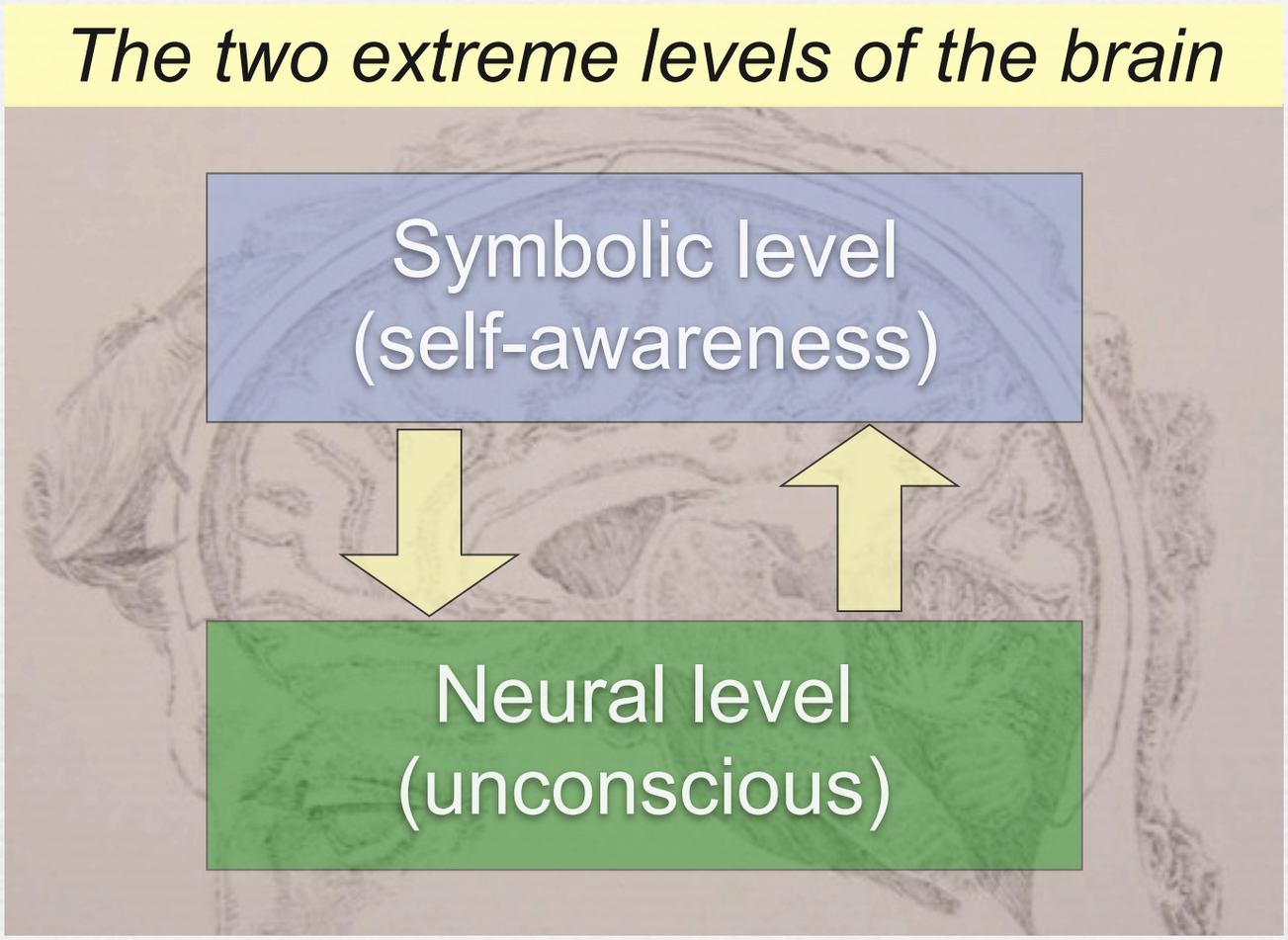
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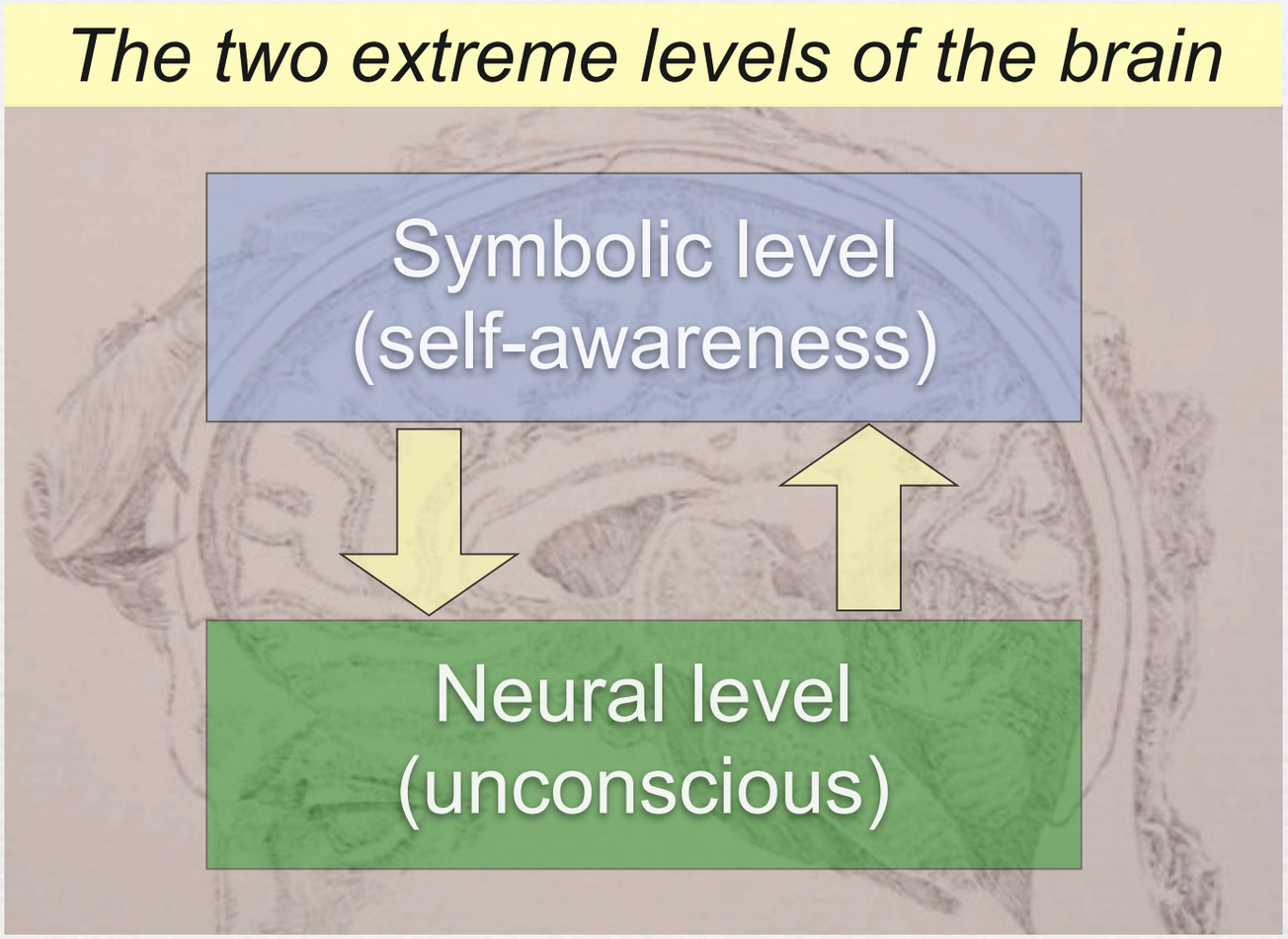
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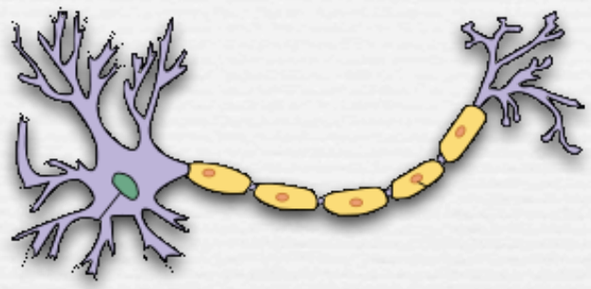


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  - «biological» trend
  - «statistical» trend

A good beginning ...

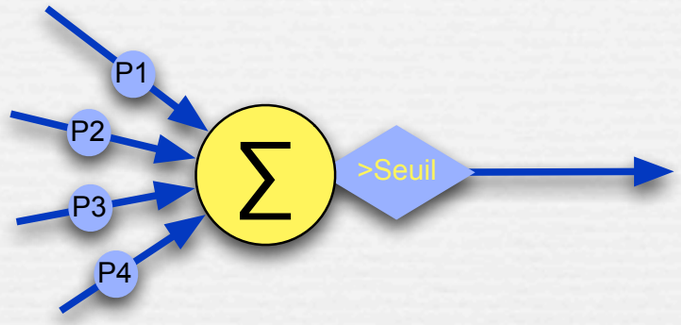
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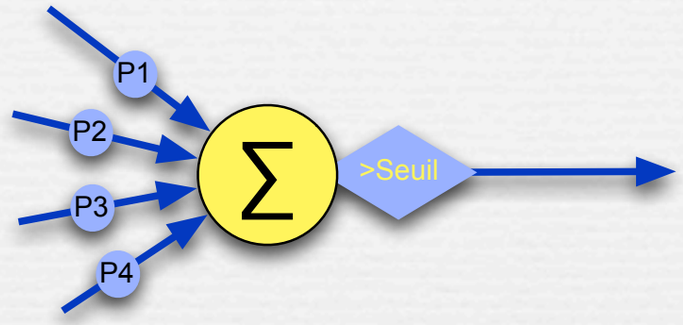
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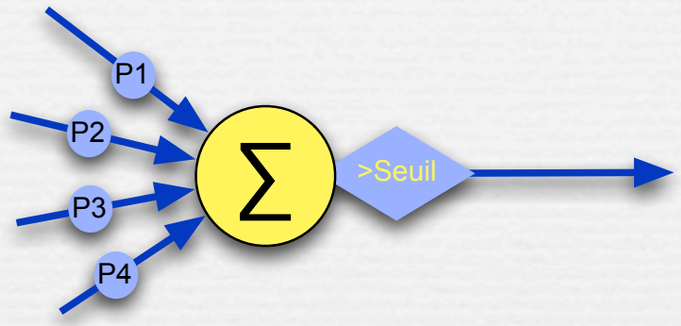
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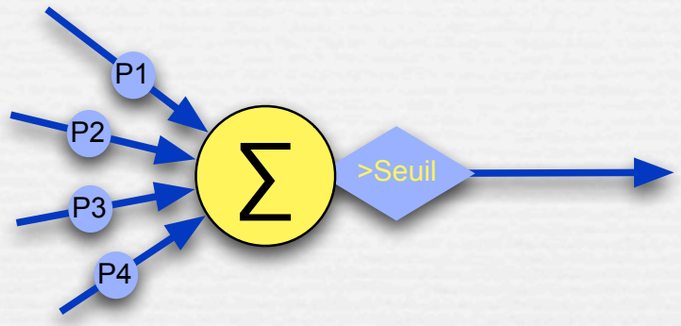
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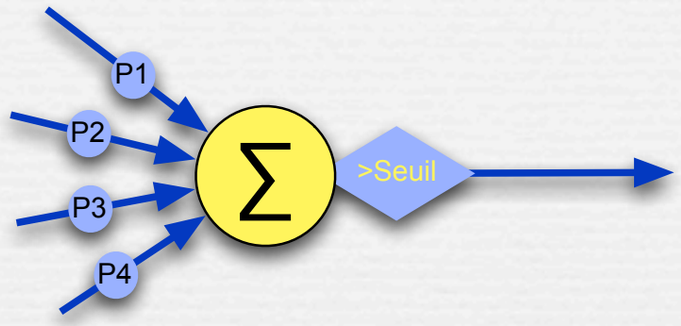
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- 1958 : Perceptron, ancestor of the neural network (F. Rosenblatt)
- 1960 : First work about translation and NLP
- 1966 : ELIZA
- 1969 : SHRDLU

ELIZA *(J. Weizenbaum 1966)*

USER: Man are all alike
ELIZA: In what way?
USER: They're always bugging us about something or other.
ELIZA: Can you think of a specific example?
USER: Well, my boyfriend made me come here.
ELIZA: Your boyfriend made you come here.
USER: He said I'm depressed much of the time.
ELIZA: I am sorry to heare you are depressed.
USER: It's true, I am unhappy.
ELIZA: Do you think coming here will help you not to be unhappy?
USER: I need some help, that much seems certain.
ELIZA: What would it mean to you if you got some help?
USER: Perhaps I could learn to get along with my mother.
ELIZA: Tell me more about your family.
USER: My mother takes care of me.
ELIZA: Who else in your family takes care of you?
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USER: You are like my father in some ways.
ELIZA: What resemblance do you see?

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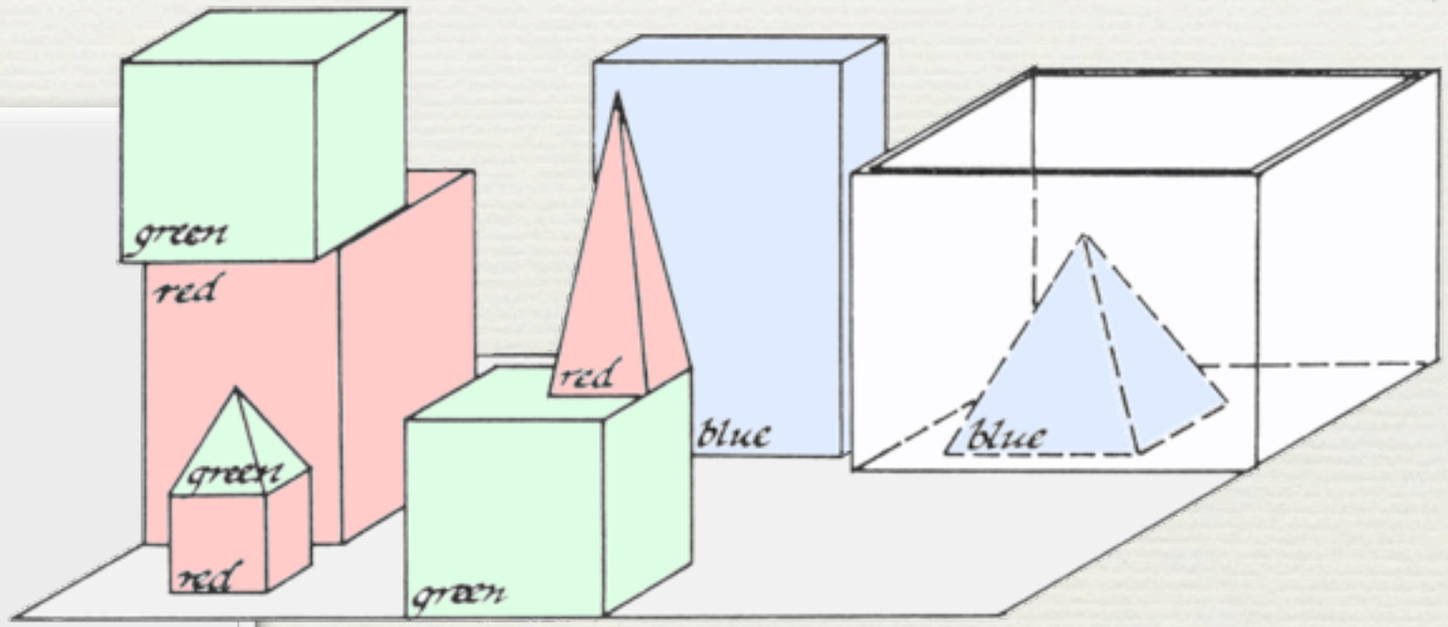
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« ELIZA effect »

It is susceptibility of people to read far more understanding than is warranted into strings of symbols and to associate a meaning according to their experiences and beliefs

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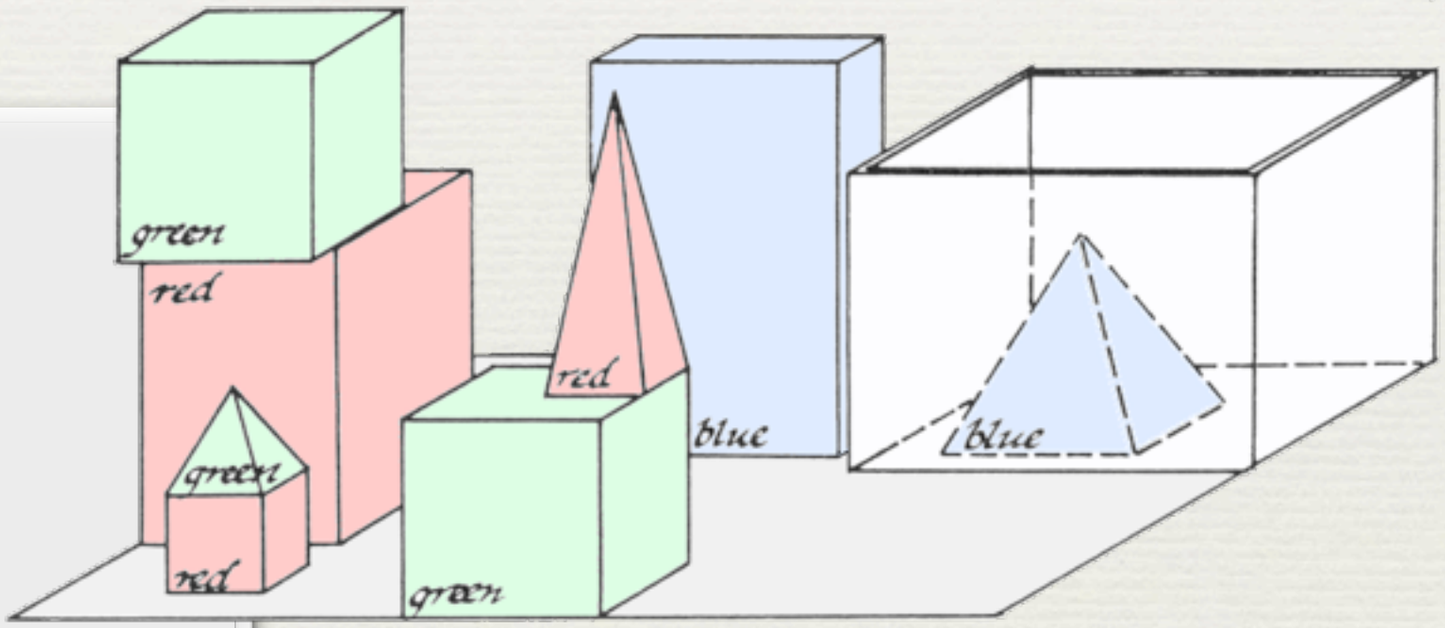
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Computer: OK. (does it)
Person: GRASP THE PYRAMID.
Computer: I DON'T UNDERSTAND WHICH PYRAMID YOU MEAN.
Person: FIND A BLOCK WHICH IS TALLER THAN THE ONE YOU ARE HOLDING AND PUT IT INTO THE BOX.
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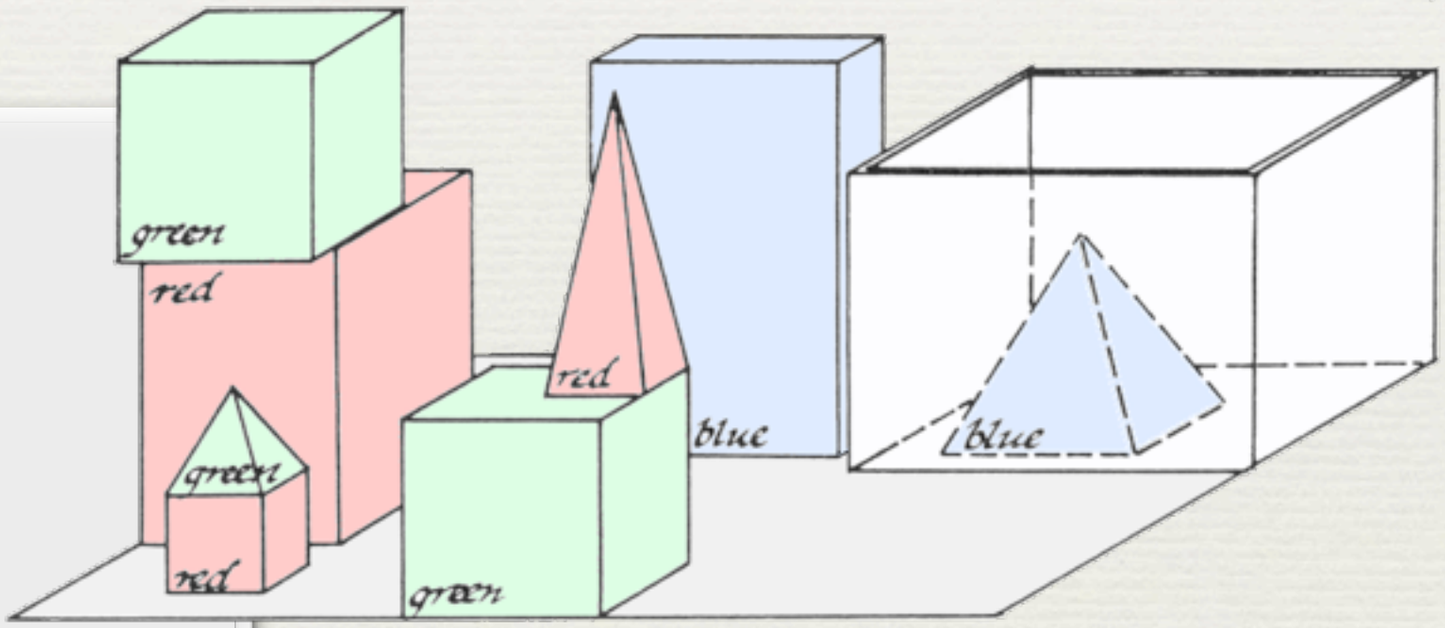
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Problem : scaling up the system to go from a micro-world to a real world application is, by far, not a linear problem !

Some doubts arise ...

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- 1966-73 : Operating budget devoted to AI projects sink deeply:
  - No more funding for NLP researches
  - ARPA Speech Understanding Research is stopped
  - «Lighthill» report in UK suggest to stop AI researches
  - Strong criticisms of Perceptrons (M. Minsky, S. Papert)
  - Publishing of a famous book «What computers can't do» (H. Dreyfus)

Why all these failures ?

Some doubts arise ...

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Why all these failures ?

- Multiple causes

Some doubts arise ...

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  - The power of the computer was incredibly «small» :
    - Digital PDP 11/20 (1970), 16 bits, 800ns cycle, 56 Kb, 20.000$
    - The «brute force» approach cannot work in such conditions

Expert systems

Simulation of an human expert on a specific domain

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- Principles
  - Knowledge is expressed as a set of rules
    - IF *set of premisses* THEN *set of conclusion*
    - *Many Knowledge Representation paradigms : propositions, predicates, …*
  - The set of rules forms a Knowledge Network/base or « Model »

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IF The site of the culture blood, and
The gram stain of the organism is gramneg, and
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Example coming from Mycin

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Example coming from Mycin

- Running
  - Some information (initial facts) are provides to the « Expert system»
  - The *Inference engine* looks at the model and verifies:
    1) Which rules can be «used» according to the known facts
       - Two classical strategies : Forward chaining and Backward chaining
    2) Then it «fires» the selected rules and propagates the new facts

Forward chaining

Next slide

Forward chaining

- Knowledge base

R1 : Si B & D & E → F
R2 : Si D & G → A
R3 : Si C & F → A
R4 : Si B → X
R5 : Si D → E
R6 : Si A & X → H
R7 : Si C → D
R8 : Si C & X → A
R9 : Si B & X → D

- Initial facts

(B, C)

- Control strategy

Rules are fired according to the alphabetical order

Next slide

Forward chaining

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- Evolution of the fact base and of the agenda

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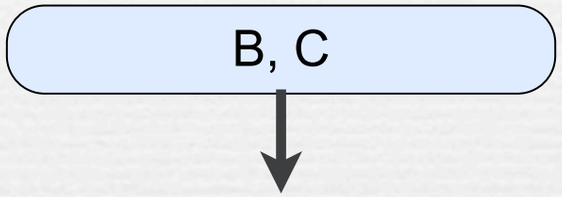
- Initial facts

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R4, R7

Next slide

Forward chaining

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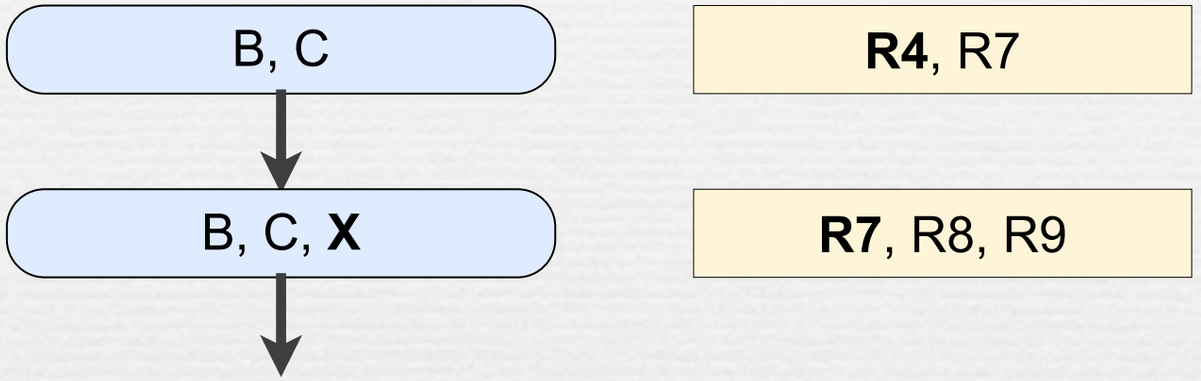
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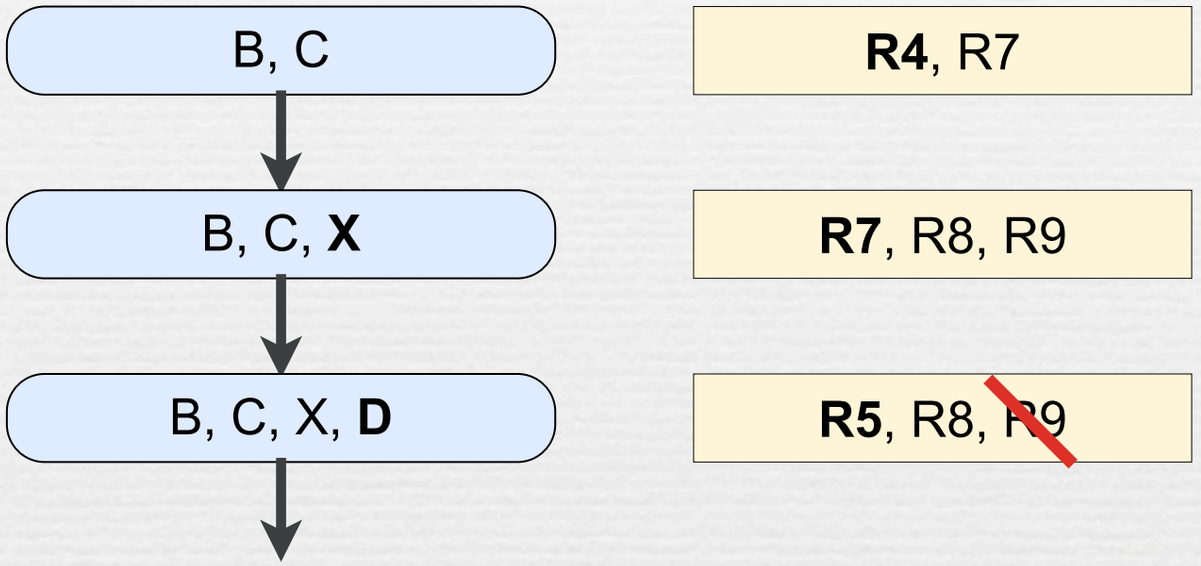
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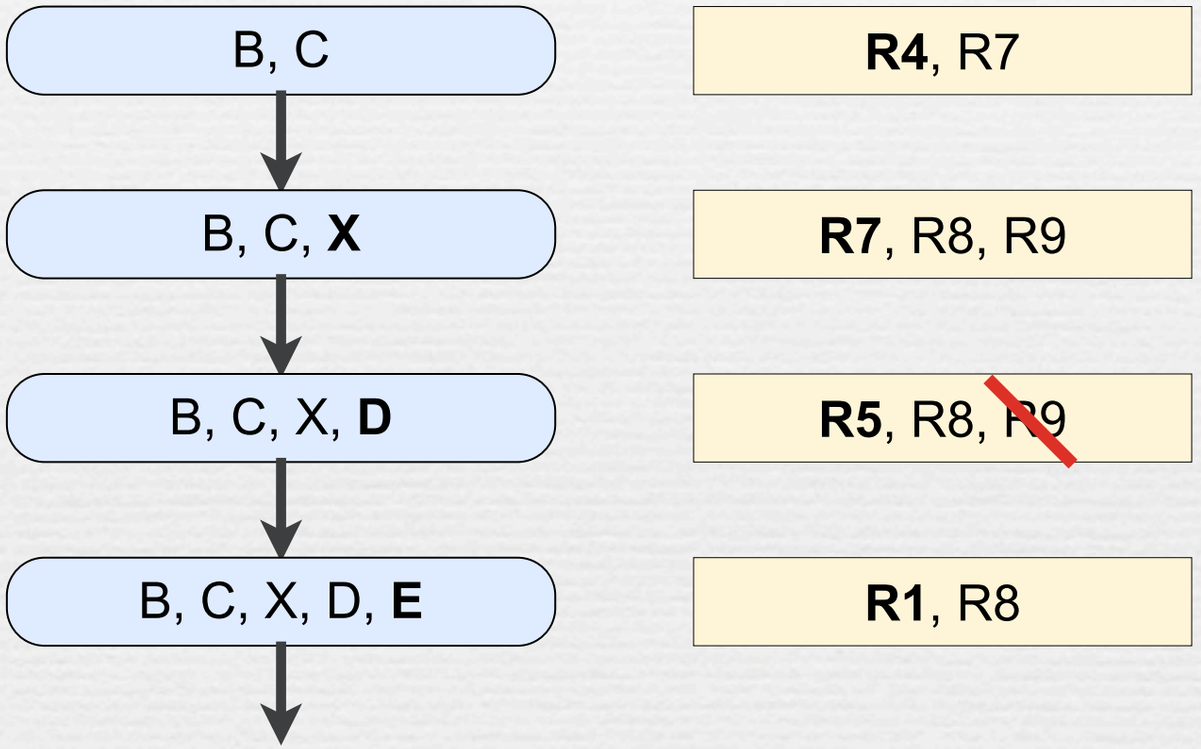
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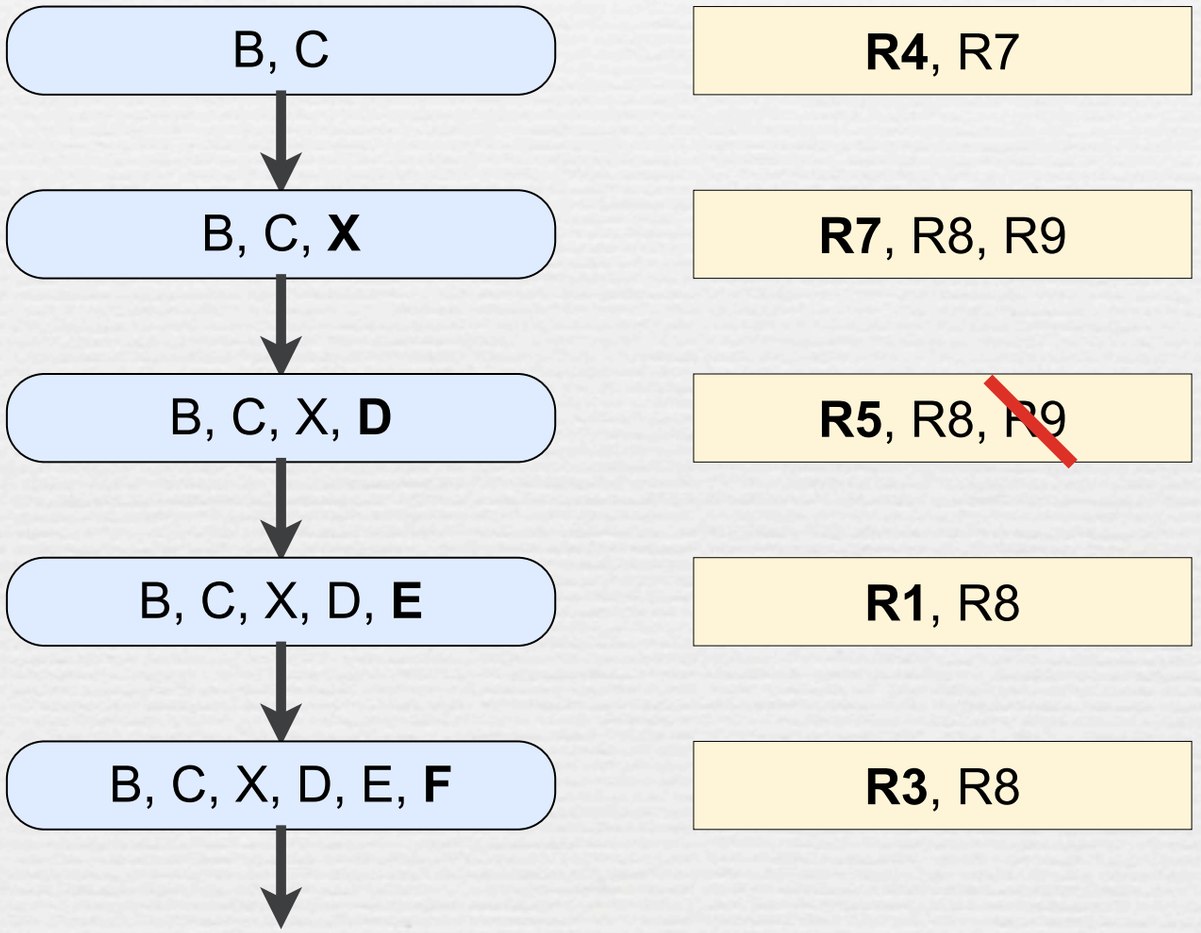
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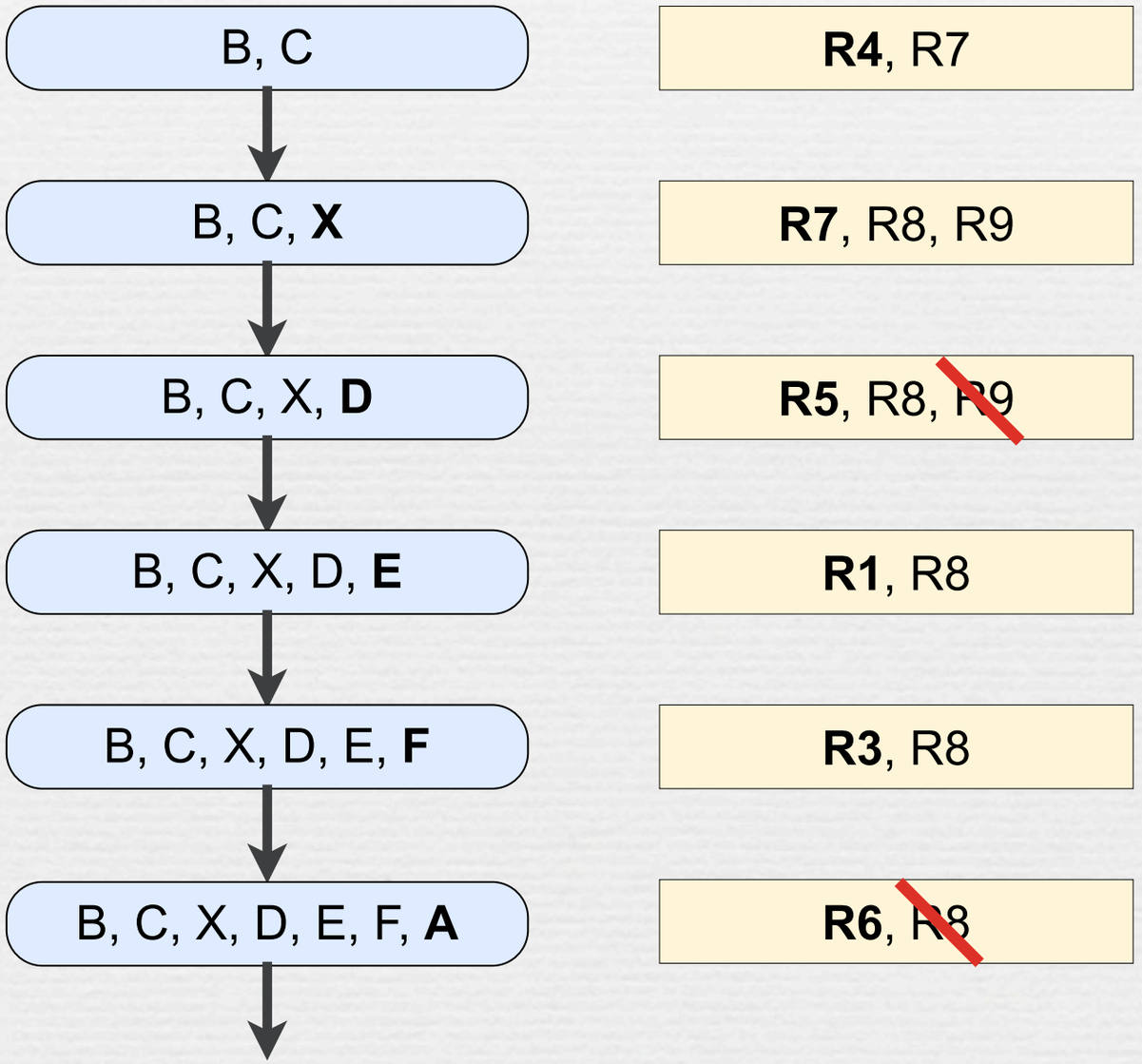
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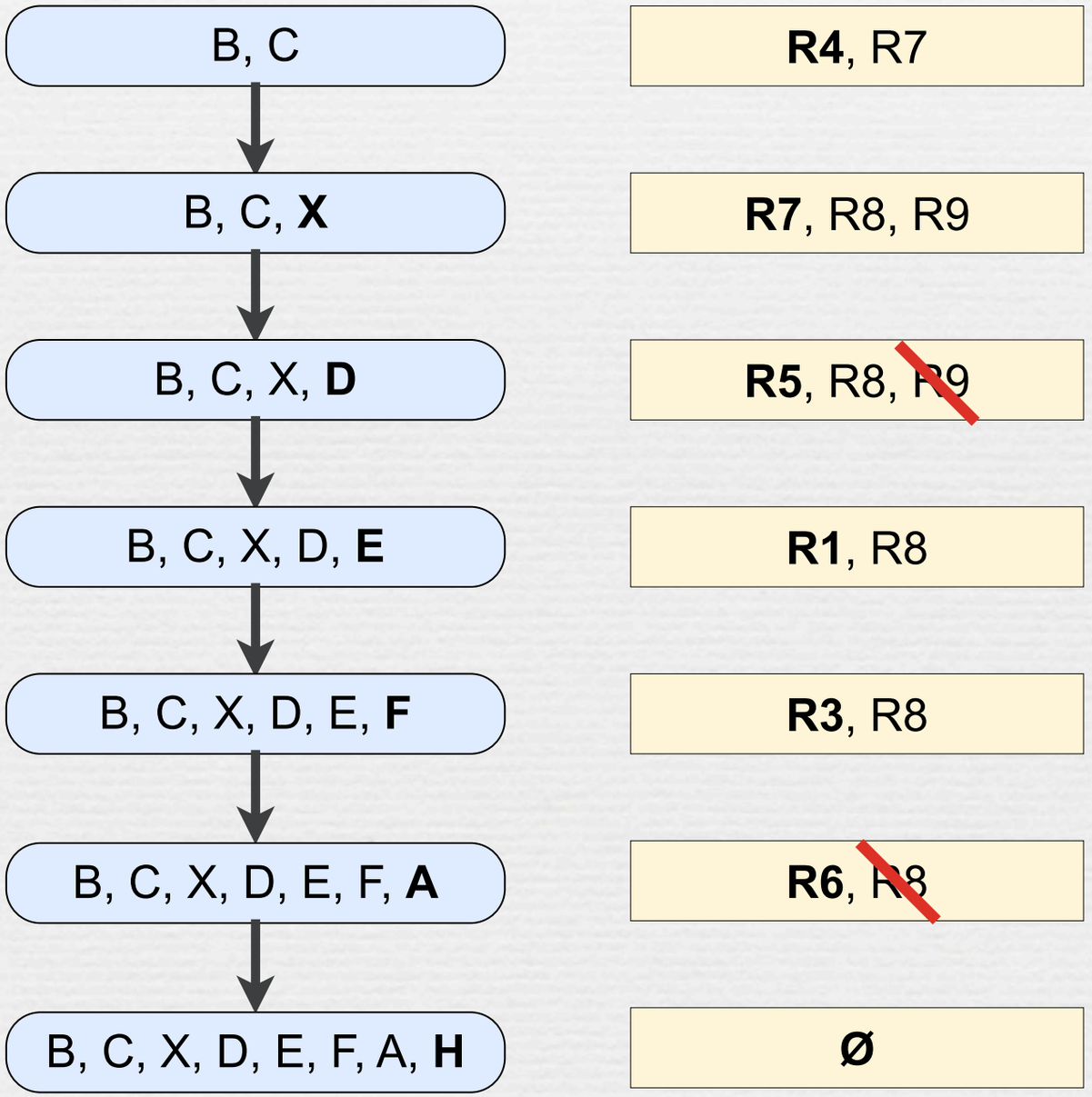
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Next slide

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Backward chaining

Next slide

Backward chaining

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- Initial FB + Hypothesis

(B, C) we want to prove **H**

- Control strategy

Rules are fired according to the alphabetical order

Next slide

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- Search tree

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H?

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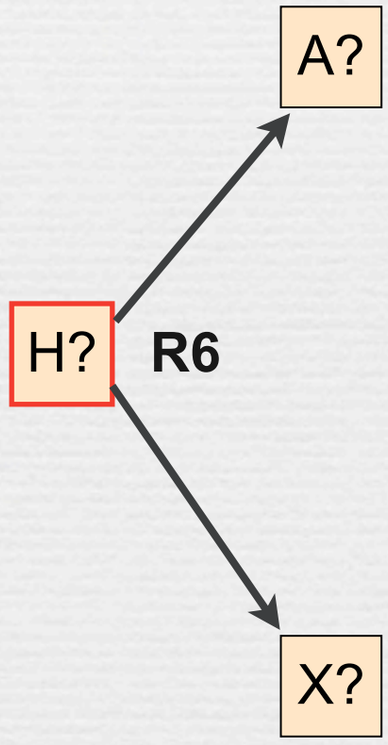
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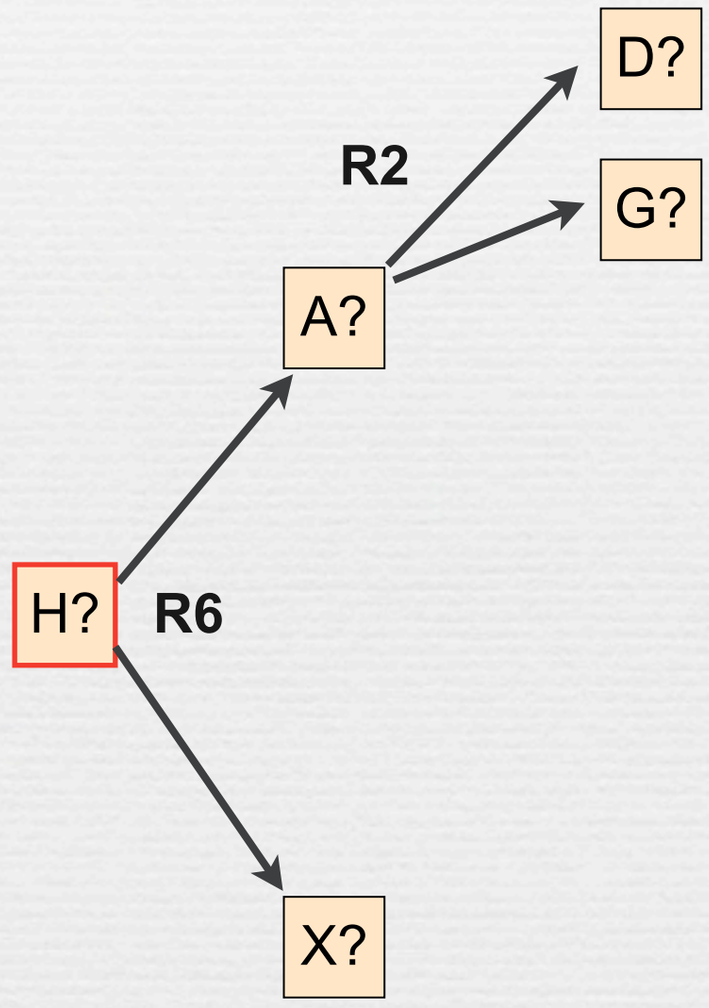
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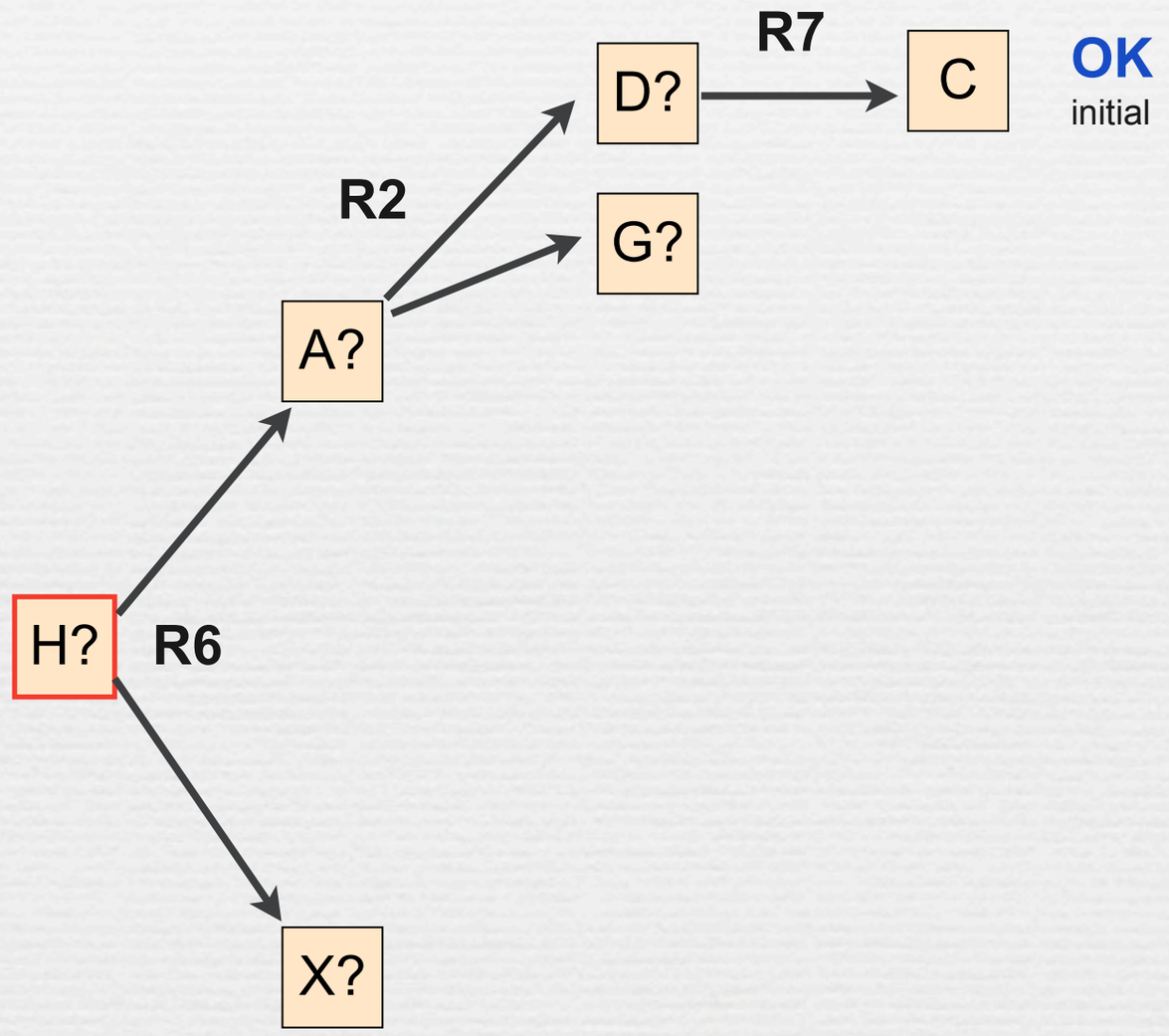
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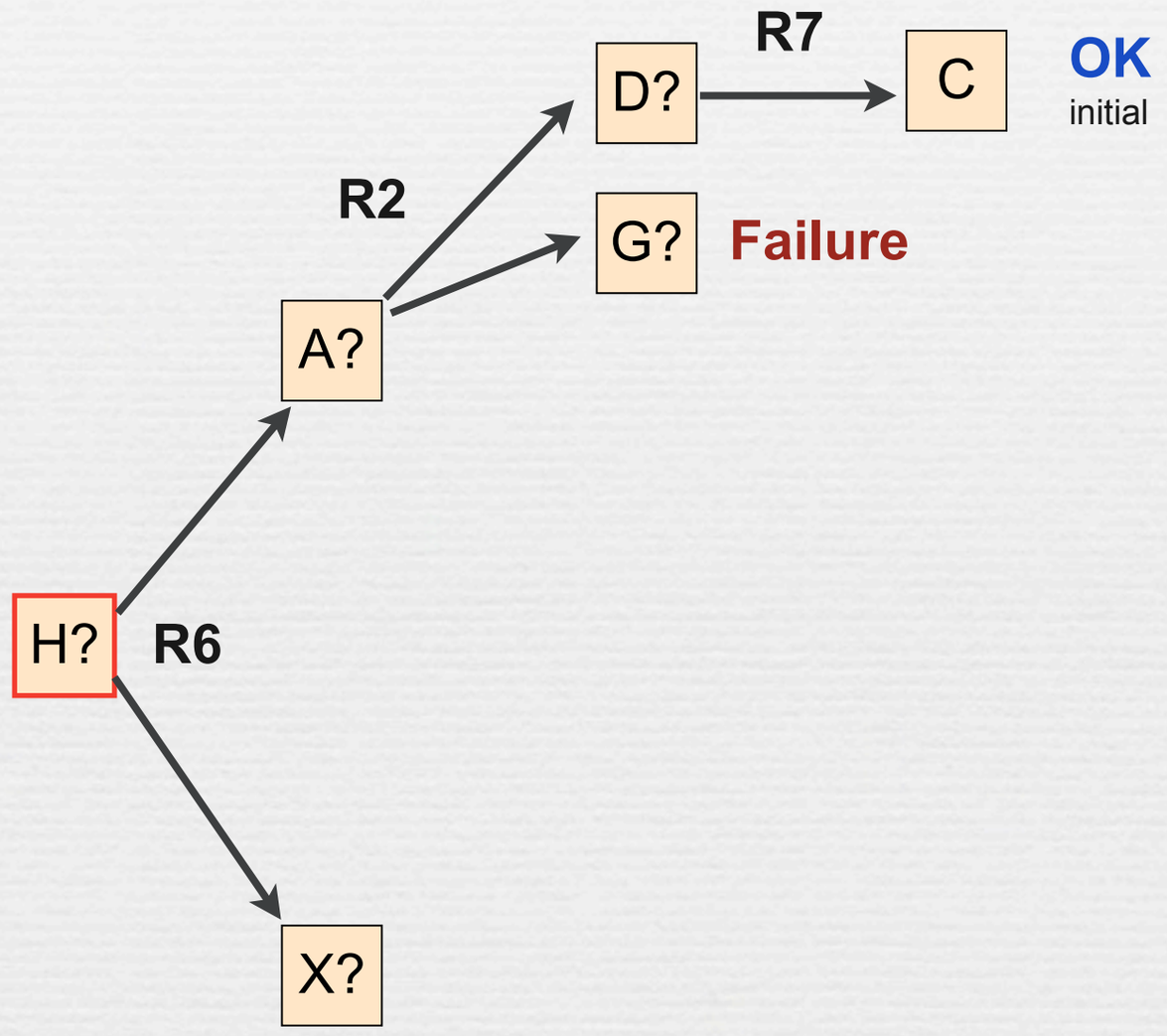
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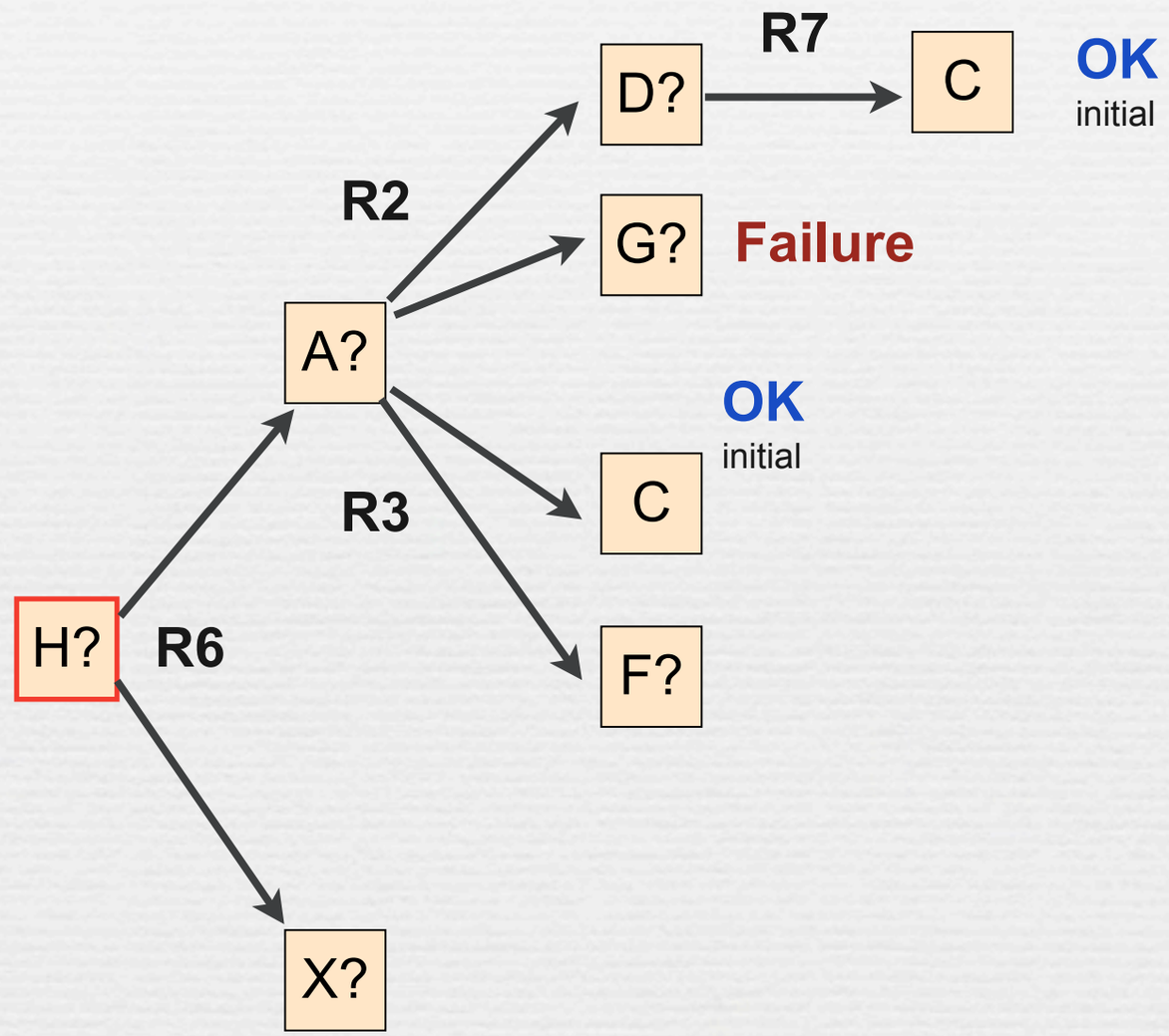
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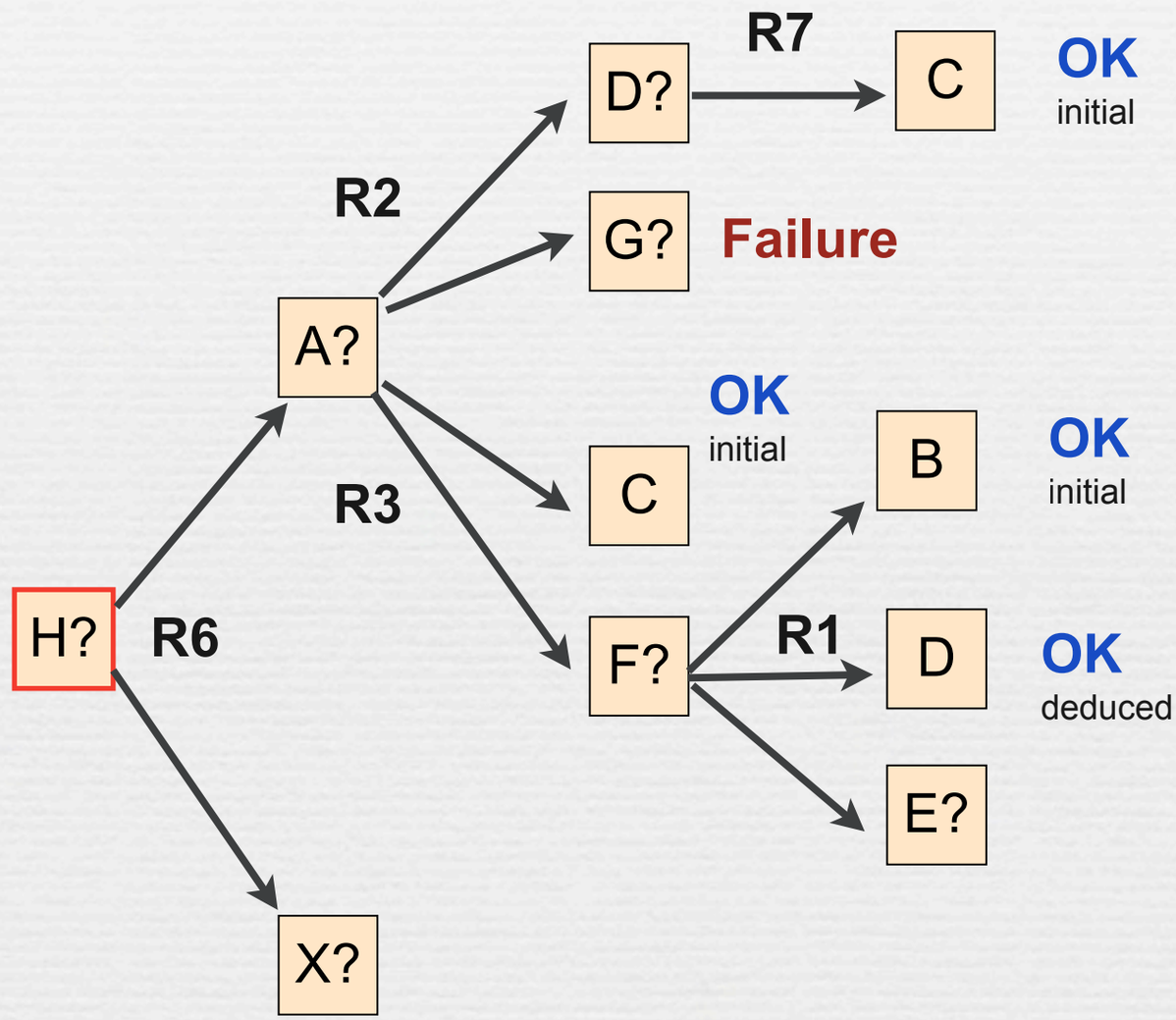
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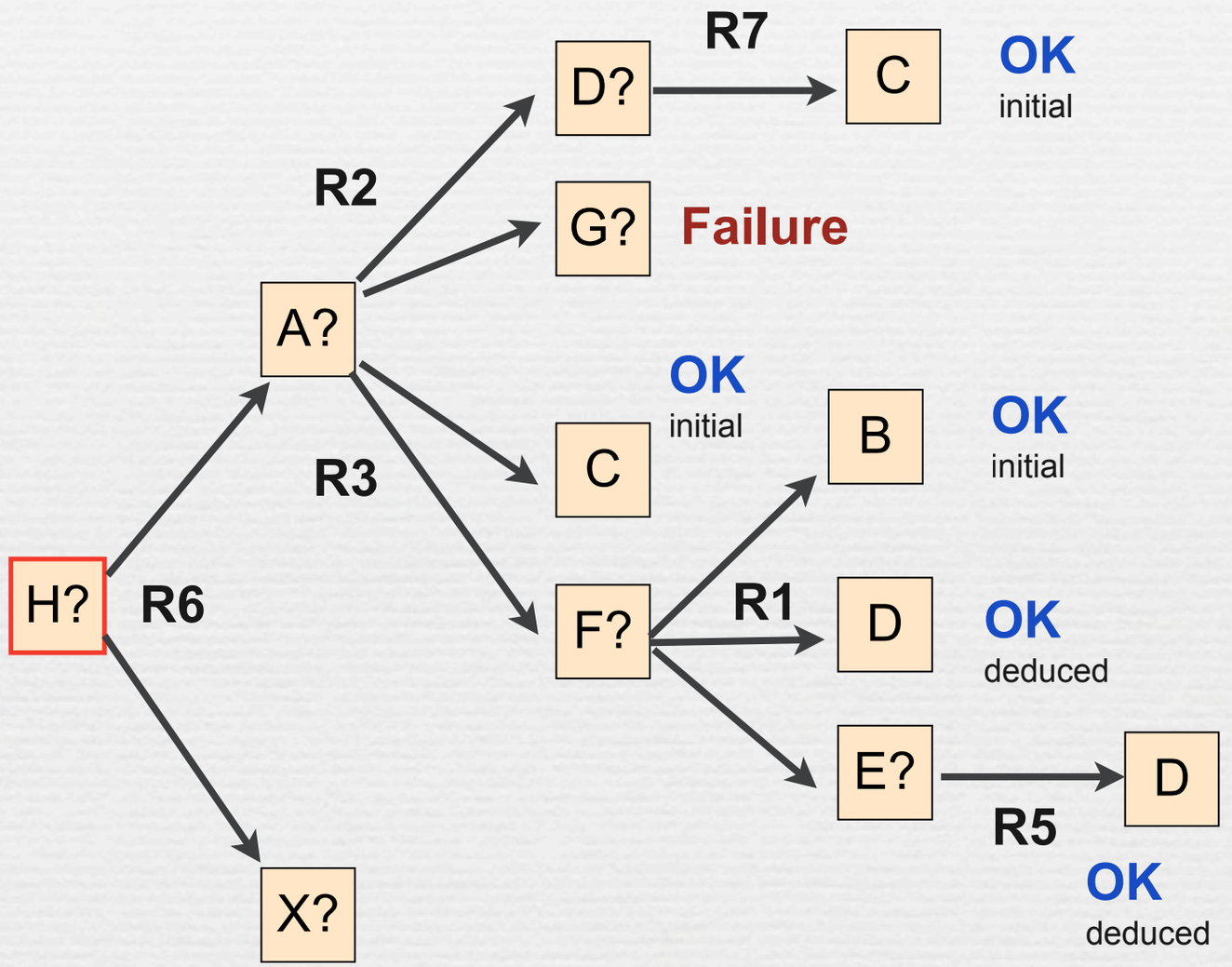
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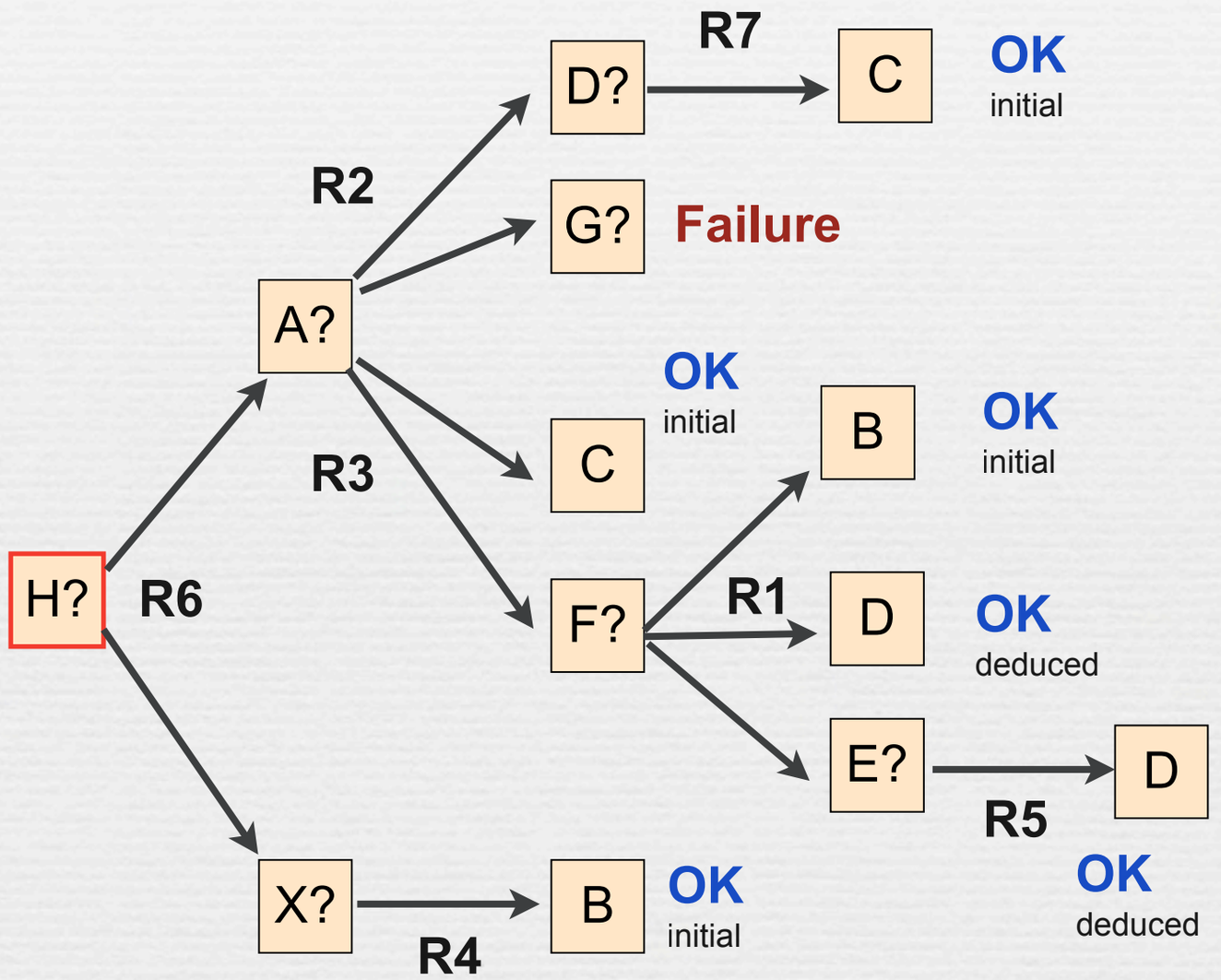
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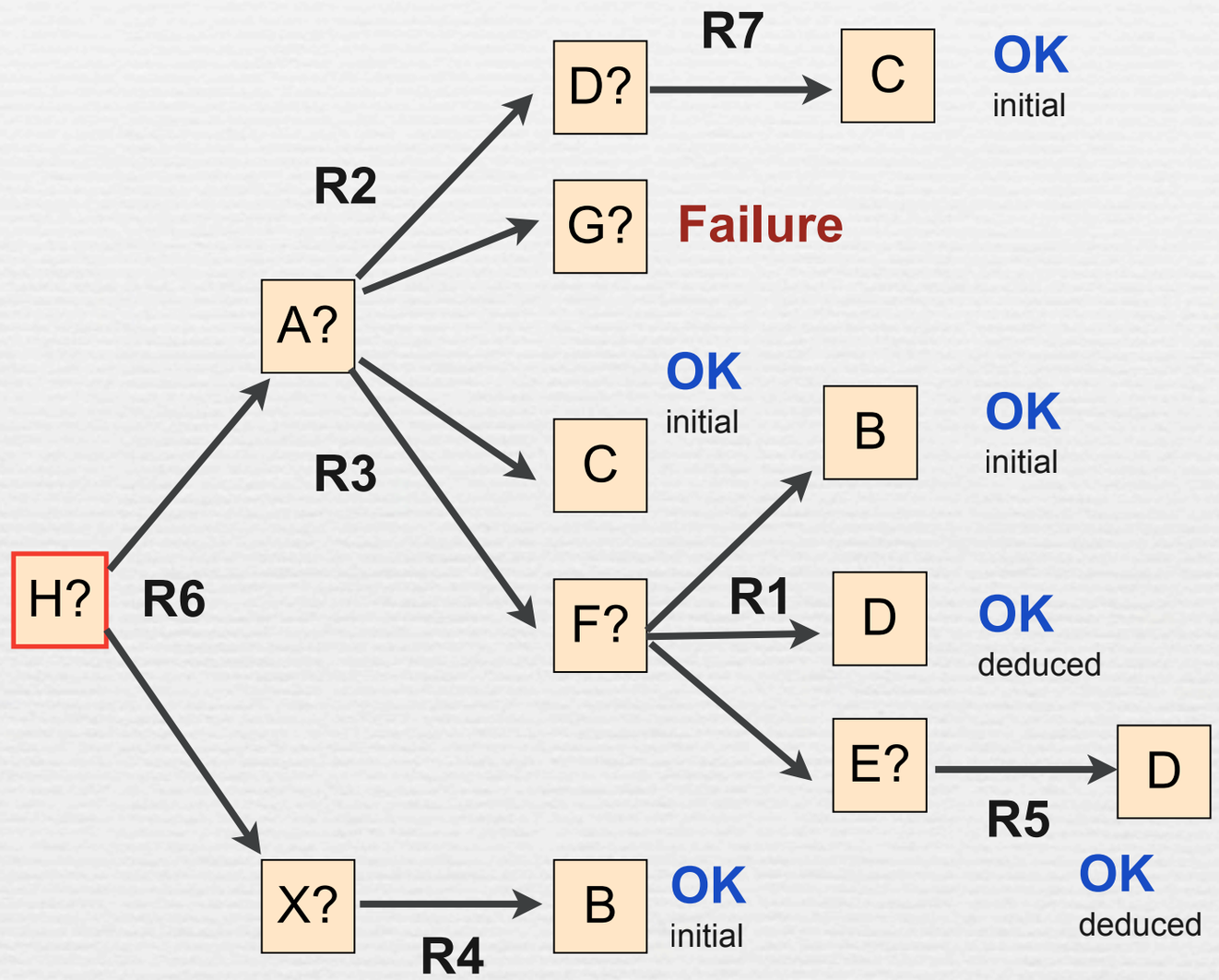
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With another control strategy we could prove H more rapidly : R6, R4, R8

Next slide

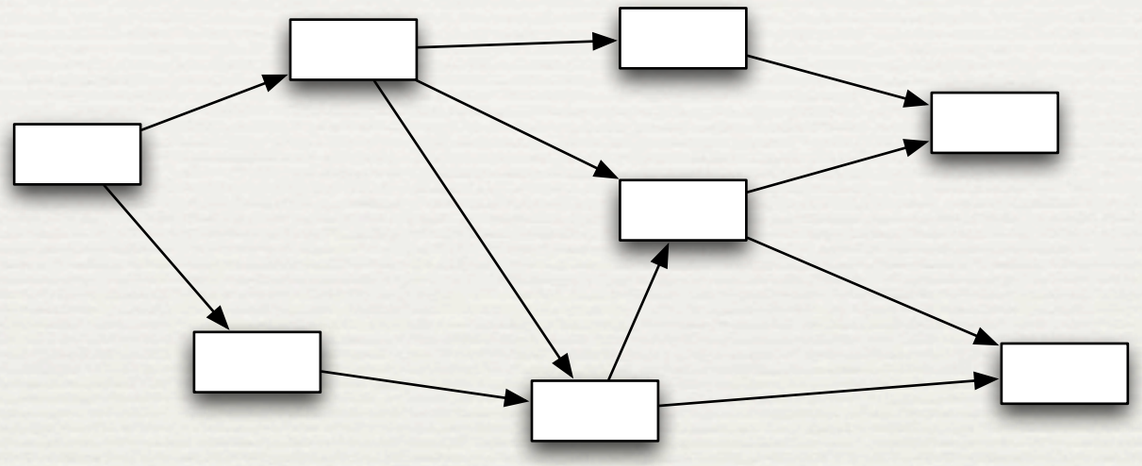
Analysis of the Expert system

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- Example of running

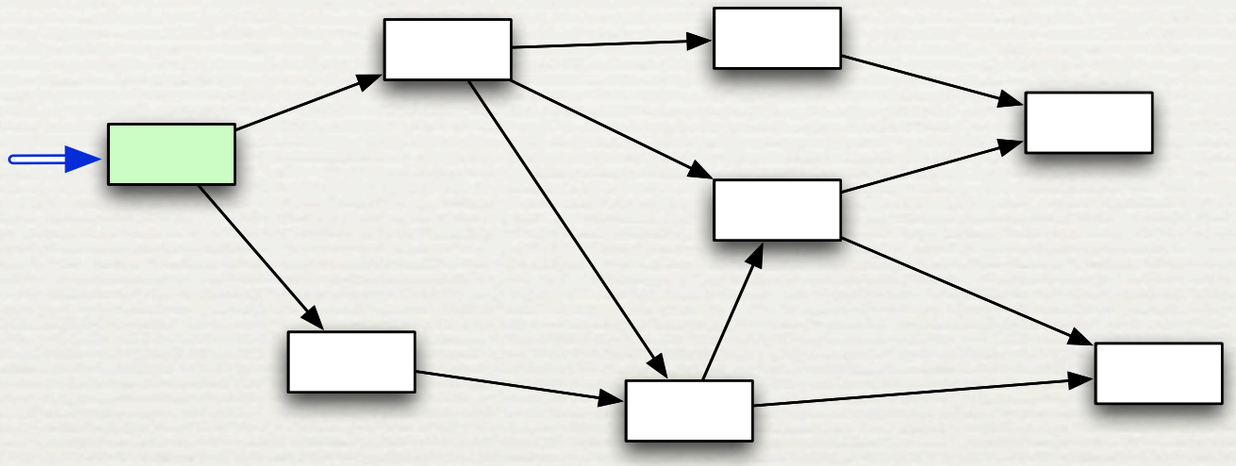
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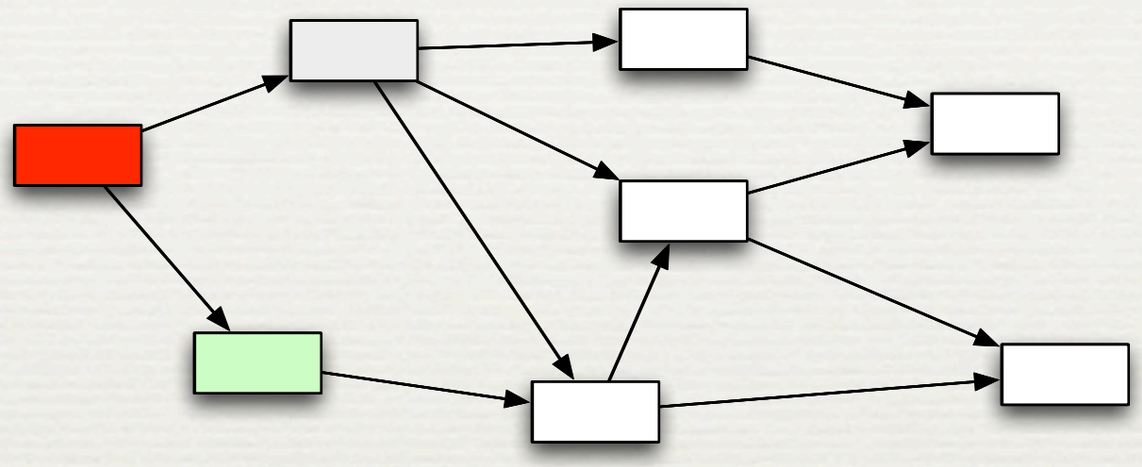
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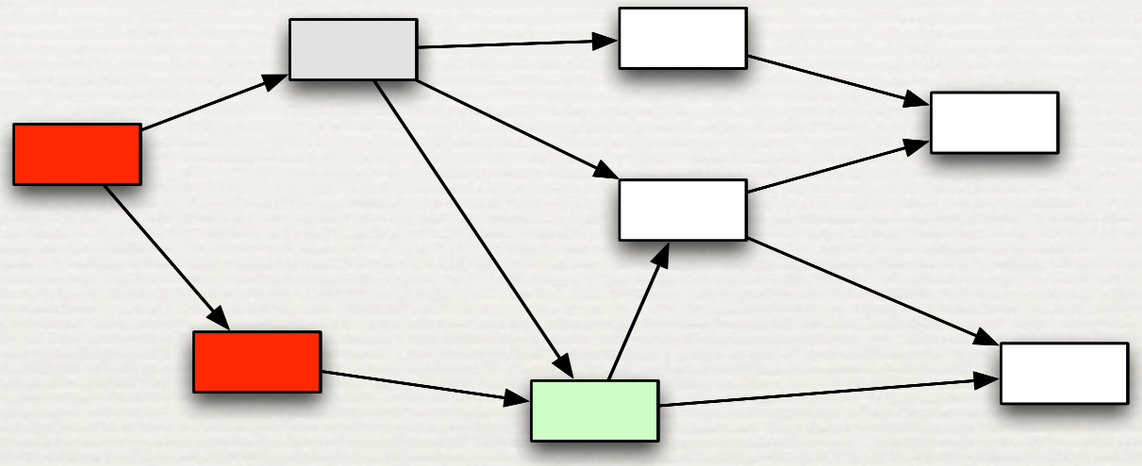
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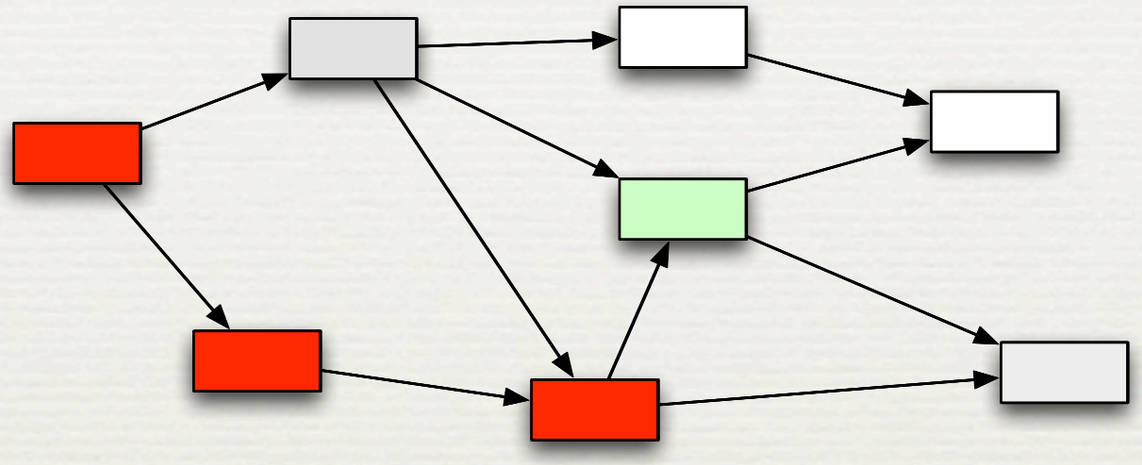
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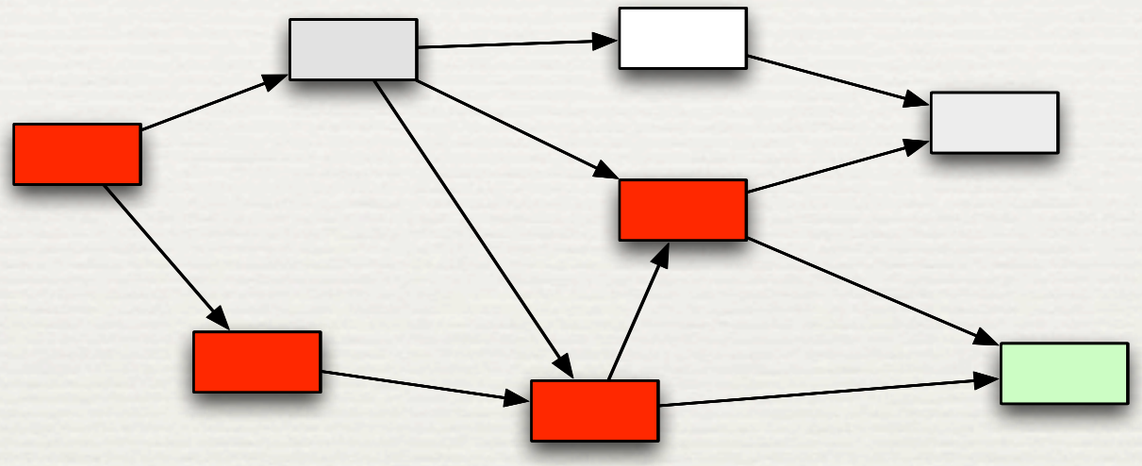
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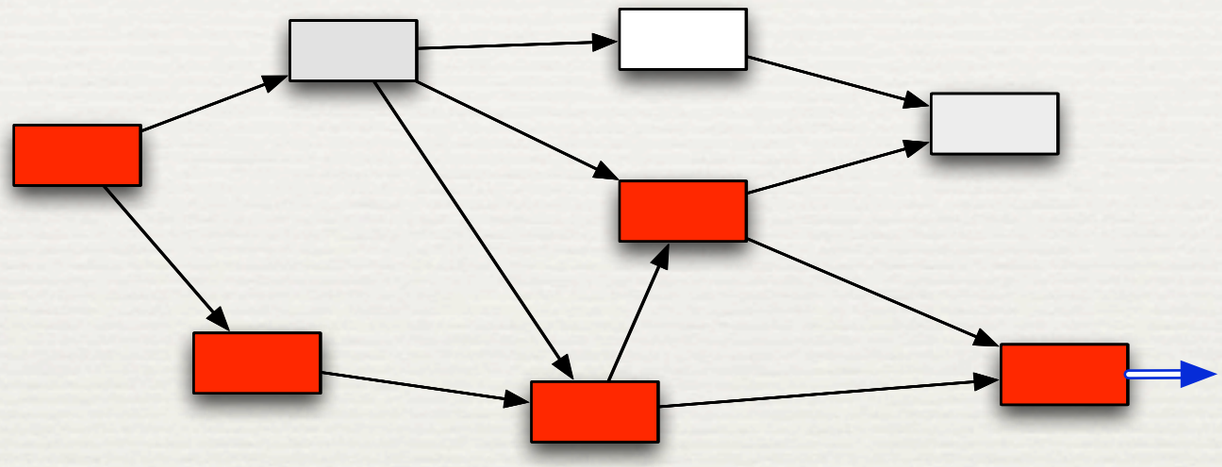
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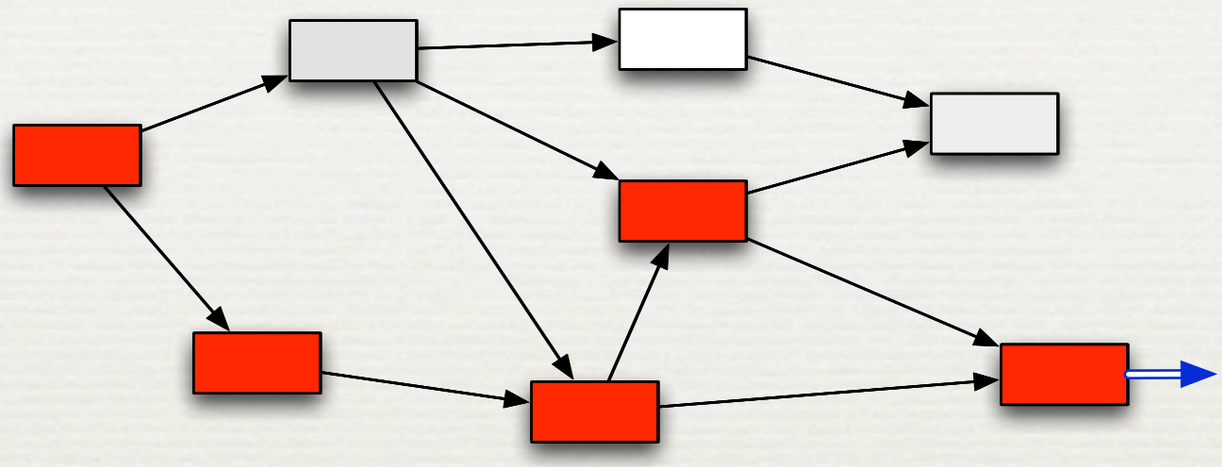
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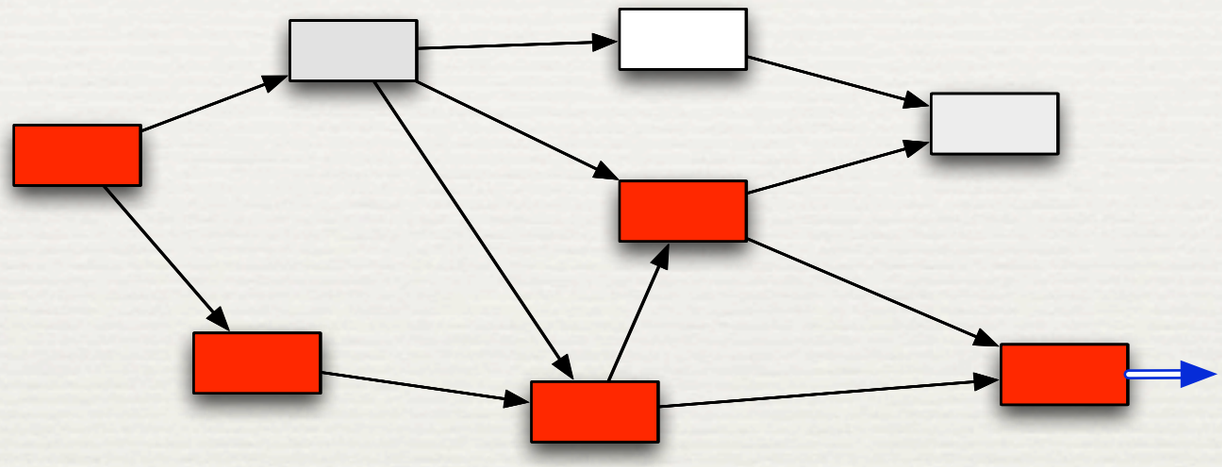
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- Theoretical advantages of using a Knowledge Base:
  - Legible : the knowledge is written in the Expert's language
  - Evolutive : we can easily add/delete the rules within the KB
  - Explainable : it is quite simple to keep track of the resolution process
  - Generic : a same KB is able to work with any set of initial facts

Analysis of the Expert system

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  - Generic : a same KB is able to work with any set of initial facts
- But … also two drawbacks in practice:
  - Acquisition : the knowledge must be **acquired** from the human experts !
  - Consistency : the content of the KB must be **semantically coherent** !

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  - The symbolic-based approaches don’t scale up very well in natural environment
  - Consequences:
    - Failures of the Fifth generation project (Japon) and MCC consortium (USA)
    - Bankruptcy of all the companies selling AI computers based on LISP and Prolog

The end of the XXth century looks like 1966-1973 period

AI systems today

AI systems today

- Four trends :
  - More pragmatism ... the AI pioneers are old (or dead) ...
  - Differences between symbolic/neuronal paradigms disappears
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- Many domains with dynamic research:
  - Autonomous systems (robot and image processing)
  - Machine Learning («Data Mining»)
    - Support Vector Machine (SVM) that encompassed Neural Network
    - Genetic algorithms (beginning in 1984)
    - Statistical and probabilistic learning
    - Relational learning, ...
  - Knowledge representation and ontologies (Semantic WEB)
  - Natural Langage Processing (Web and Text Mining)
  - Popular trends: « Intelligents agents», « Emergence in complex systems », ...

Computer evolution in the last 50 years



Computer evolution in the last 50 years

- Storage evolution
  - 1956 : First hard disk IBM 355 (650 RAMAC)
    - one ton, 50 platters of 24" (60 cm)
    - capacity of 5 MB (price 50 000 dollars/year)
  - 1982 : Hitachi H8598
    - 10 platters of 14" (35 cm), capacity of 1,2 GB
  - 2006 : Microdrive IBM/Hitachi
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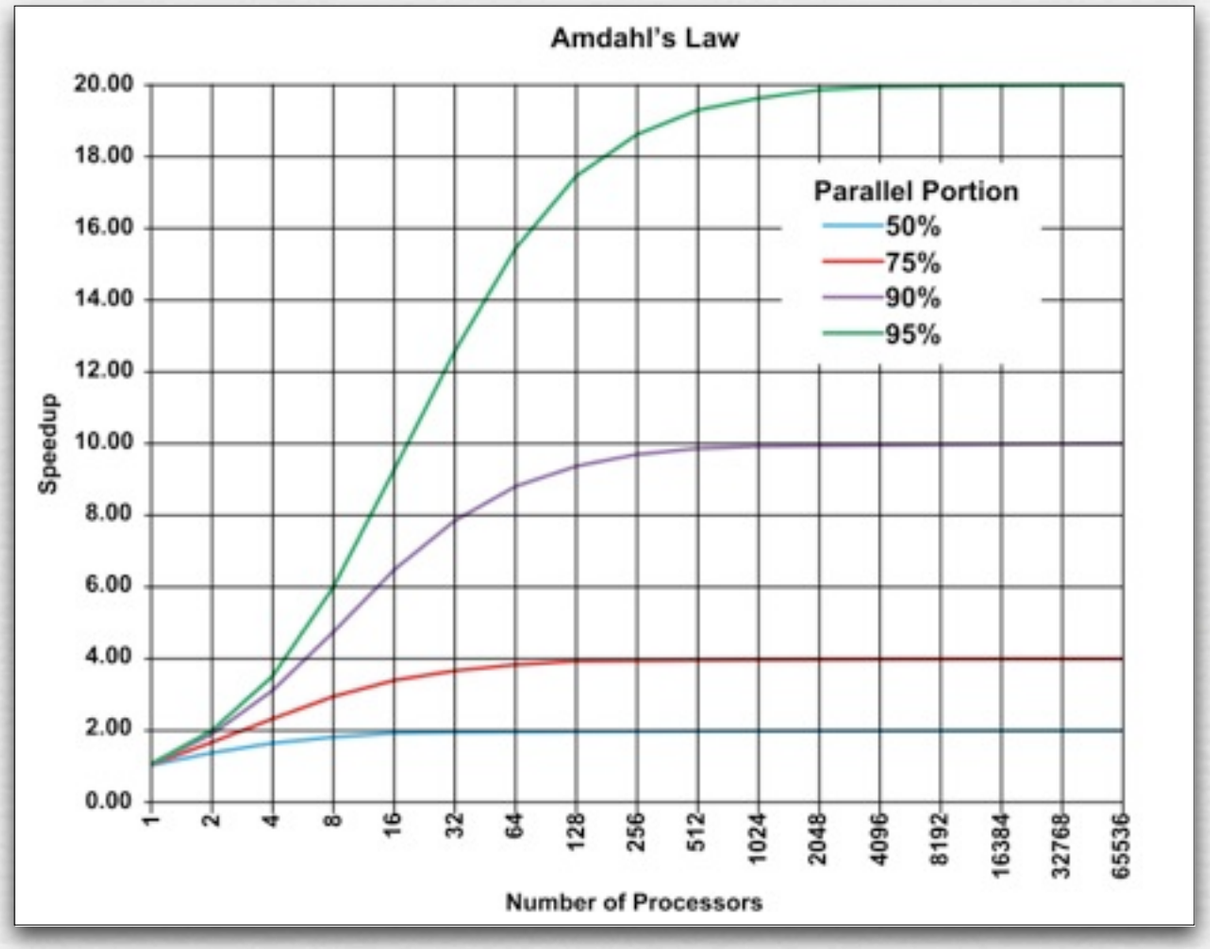
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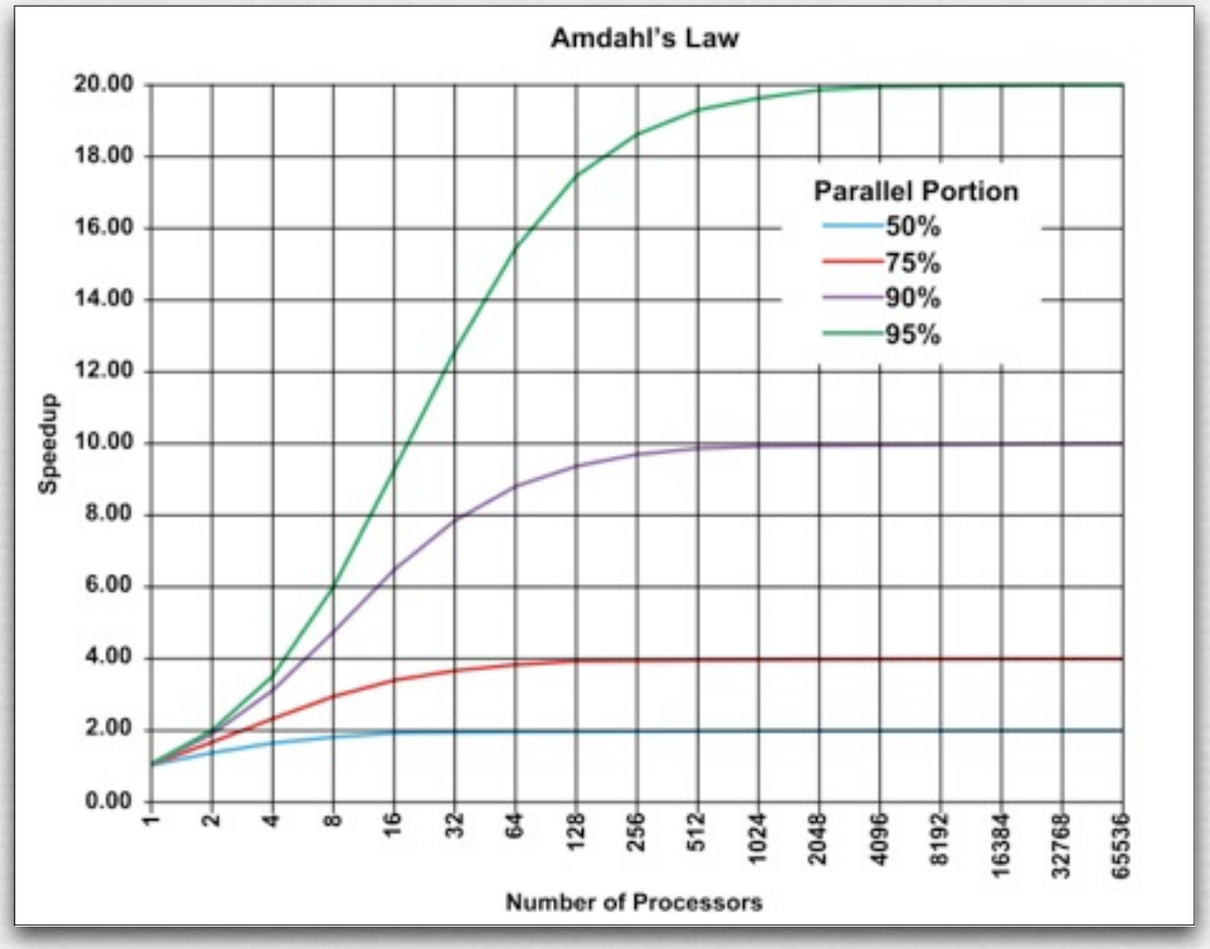


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- In practice, two ways to deal with huge datasets in AI:
  - To invent algorithms whose complexity is quasi-linear
  - To invent algorithms that can be totally parallelized

A rapid state of the art

Some results illustrating strength and weakness of AI

The « Grand Challenge »

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  - DARPA = Defense Advanced Research Projects Agency
  - Goal : to create a car that is totally autonomous on any kind of road
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  - 11 finalists and the winner was “Boss” (Carnegie Mellon University)
- In 2010 : the «Google Car» ... we are out of the laboratory
  - 2012 : California and Nevada Legislature approve Self-Driving Cars !



« Grand Challenge » (vidéo 2005)

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Robocup

Robocup

- The (initial) goal was to play football (soccer)
  - 1997 first “challenge” (Nagoya) : 38 teams / 11 countries
  - ...
  - 2011 (Istanbul, Turkey) : 451 teams / 40 countries
  - 2012 (Mexico), 2013 (Eindhoven) — http://www.robocup.org/
- Several leagues of increasing difficulties:
  - Simulation of a match (3D)
  - Small robots (radio)-controlled by a computer
  - Middle-size autonomous robots
  - «Standard» league (standardized material)
    - Four-legs robots (Aïbo, Sony),
    - **Two-legs robot (Nao, Aldebaran)**
  - Androids (2-legs large robots)

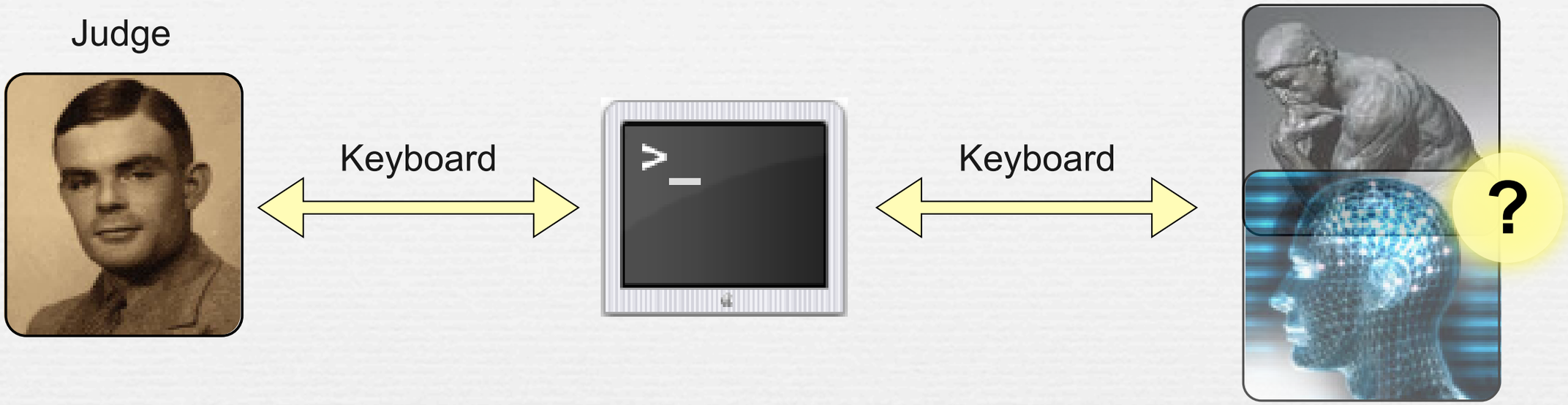
The ultimate goal of the RoboCup project is, by 2050, develop a team of fully autonomous humanoid robots that can win against the human world champion team



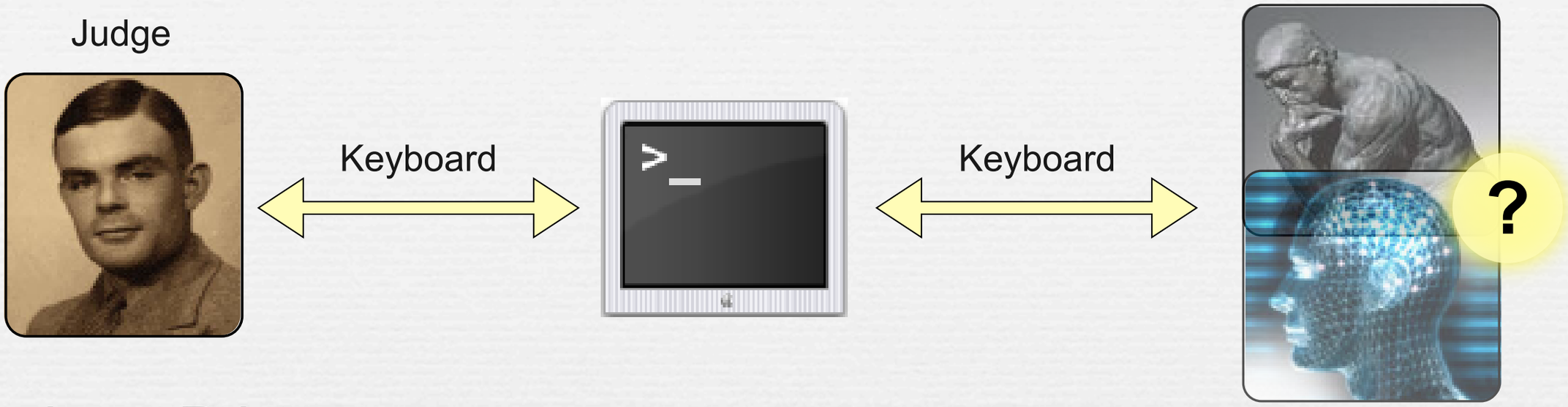
Robocup (vidéo 2010)



Turing test



Turing test



- Loebner Prize *(annual event)*
  - Current status
    - Today nobody won that price (100.000$)
    - Shift from «academic» to « industrialist » competitors
    - Huge market : help desk (IKEA), answering machine, AI avatars in games, ...
  - Two kinds of approaches :
    - «ELIZA-like» : Predefined patterns and sentences (A.L.I.C.E, ...) written in AIML
    - Very large DB of real sentences and contextual detection (Jabberwacky)
  - Some questions:
    - The 2008 winner, Elbot, fooled three judges *(try it : http://www.elbot.com/)*
    - But is the «Turing test»/«Loebner price» really matter with intelligence ?

Talking with Jabberwacky (2007)

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Why are you speaking to me?

In order to test you

Nobody smells better than me

I guess you are not so tasty

Your guess is wrong lad! I am very intelligent, indeed,.

Can you tell me the result of 5 plus 5 ?

Yes, the answer is quite simply 3.

Well and for 5 + 5 what is the result ?

I'll see you later.

Ok, where did you go during the summer holidays ?

To the ballroom for a drink. Would you care to join me for a dance?

No, I am a bad dancer.

The twinkling of the what?

Talking with Anna

Talking with Anna



Bonjour, je suis Anna, votre assistante en ligne. Posez-moi votre question à propos d'IKEA, s'il vous plaît.

Bonjour je m'appelle Gilles

C'est joli Gilles! Puis-je vous aider concernant IKEA, ses produits et services.

Quel age avez-vous ?

Je préfère ne pas parler de mon âge. Parlons plutôt d'IKEA.

Il fait beau ?

Chez moi, il fait toujours beau ! À votre service.

Vous êtes charmante ...

Je vous remercie de ce compliment. Maintenant, je vous invite à me poser une question concernant IKEA.

Je cherche un meuble bleu ...

Quel est le produit dont vous aimeriez connaître les coloris? (exemple de produit: BILLY Bibliothèque)

NL analysis in Wolfram Alpha





NL analysis in Wolfram Alpha

- a «Computational Knowledge Engine»
  - Very interesting for some precise domains : mathematic, biology, history, ...
  - But don’t be too verbose





Watson 2011

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- Watson (IBM) gains against humans
  - Jeopardy : quiz show
  - Difficulties of the game for a computer
    - Natural language processing (understanding and generating)
    - Clues are formulate as answers
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- Toward intelligent systems ?
  - National Institute of Informatics (NII) project : *«Can a Robot Pass the University of Tokyo (Todai) Entrance Exam?»*. Three challenges :
    - *1. Semantic analysis: Understand the problem text,*
    - *2. Formulation: Convert to a form that can be processed by a computer,*
    - *3. Calculation: Find the answer using the mathematical solver.*

Some other nice projects ...



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- Bluebrain (2002 - ...)
  - Goal : initially to simulate a rat *neocortical column* (part of the neocortex)
  - Partners : EPFL and IBM
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- Netflix prize
  - Goal : prediction of user rating of film (machine learning)
  - Status : stopped for privacy problems

How does it work ?

Programming AI in the games

AI and Games

AI and Games

- A «traditional» application domain
  - For psychological reasons ...
    - ... games are seen as a typical human activity,
    - ... complex games and notion of intelligence are closely linked
  - For practical reasons :
    - Structure of games are well-defined by a set rules
    - A game is a «closed world» (generally) simple to generate and to control
    - The quality of an artificial intelligence is easy to evaluate (gain/lost)
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Some criteria	Deterministic	Mixed	Random
Perfect information	*Go, Checker, Chess, Othello, ...*	*Carcassonne, ...*	*Jeux de l'oie, Roulette, ...*
Imperfect information	*Diplomacy, Stratego, Mastermind, ...*	*Bridge, Tarot, Poker, Scrabble, Cluedo, ...*	

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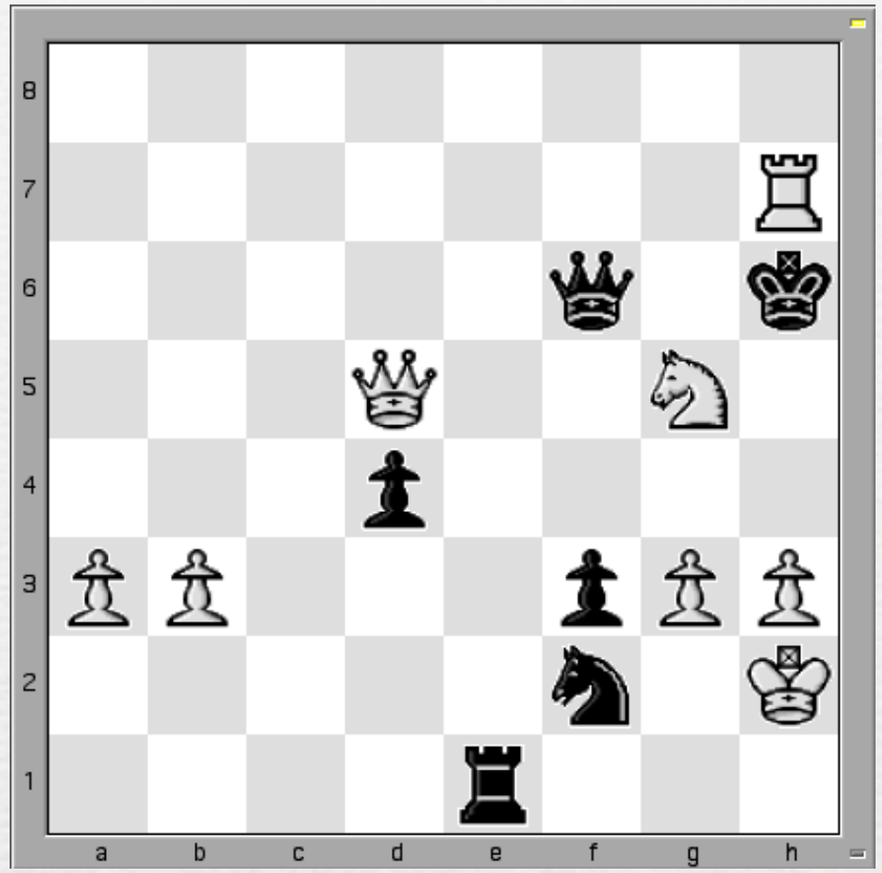


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- Other games ...
  - 1979 : A computer becomes World Champion of Backgammon (H. Berliner)
  - 1980-90 : «Co-evolution» of human and computer in Othello

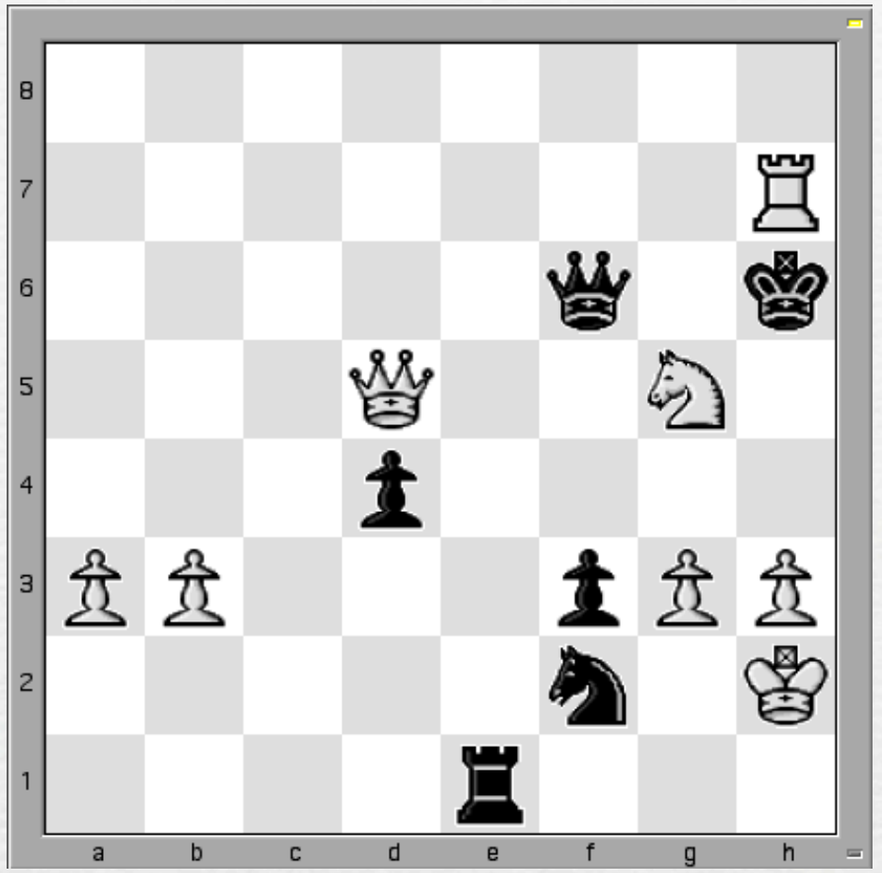
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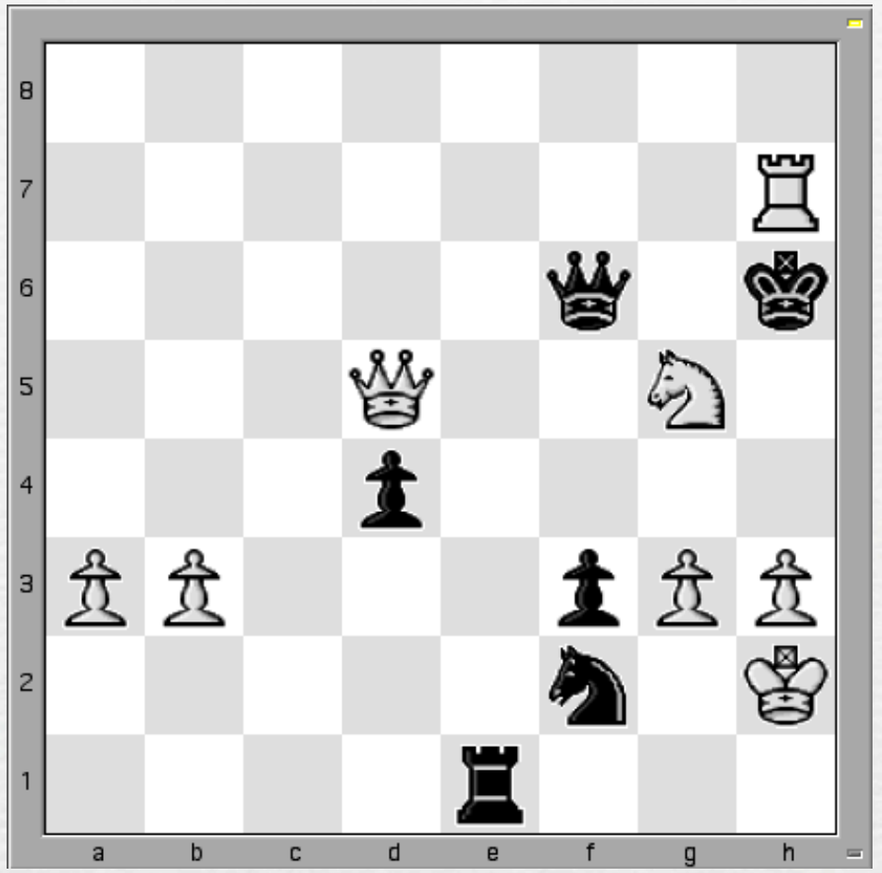
1. Search for the Legal Moves
   - Easy since the rules are non-ambiguous
   - here LM = {Rd1, ... Kfe4, ...} ≈ (72 moves)
   - On average there are 36 legal moves in chess, this number, named «*branching factor*», is a good way to assess the complexity of a game



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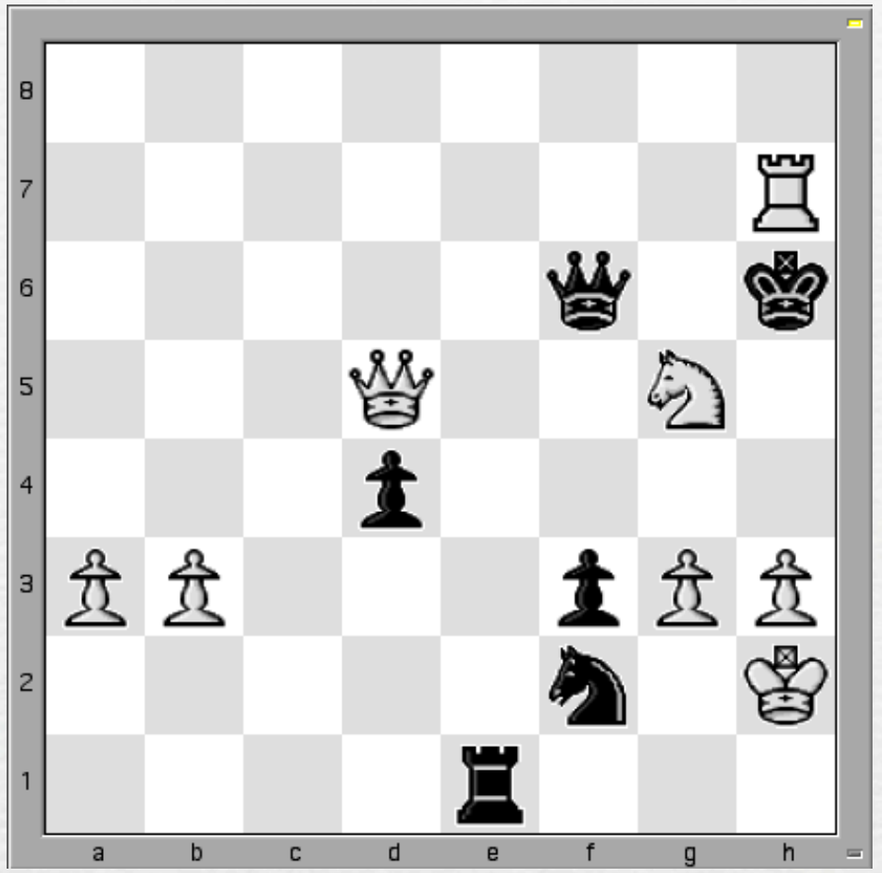
1. Search for the Legal Moves
   - Easy since the rules are non-ambiguous
   - here LM = {Rd1, ... Kfe4, ...} ≈ (72 moves)
   - On average there are 36 legal moves in chess, this number, named «*branching factor*», is a good way to assess the complexity of a game
2. Try each possible move, then evaluate the resulting position
   - *General criteria* (i.e. game independent)
     - Material : number of pieces (the most the best)
     - Mobility : number of legal moves, ...
   - *Specific criteria* (for chess, for instance)
     - The control of the board central square,
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3. Plays the move having the best evaluation !



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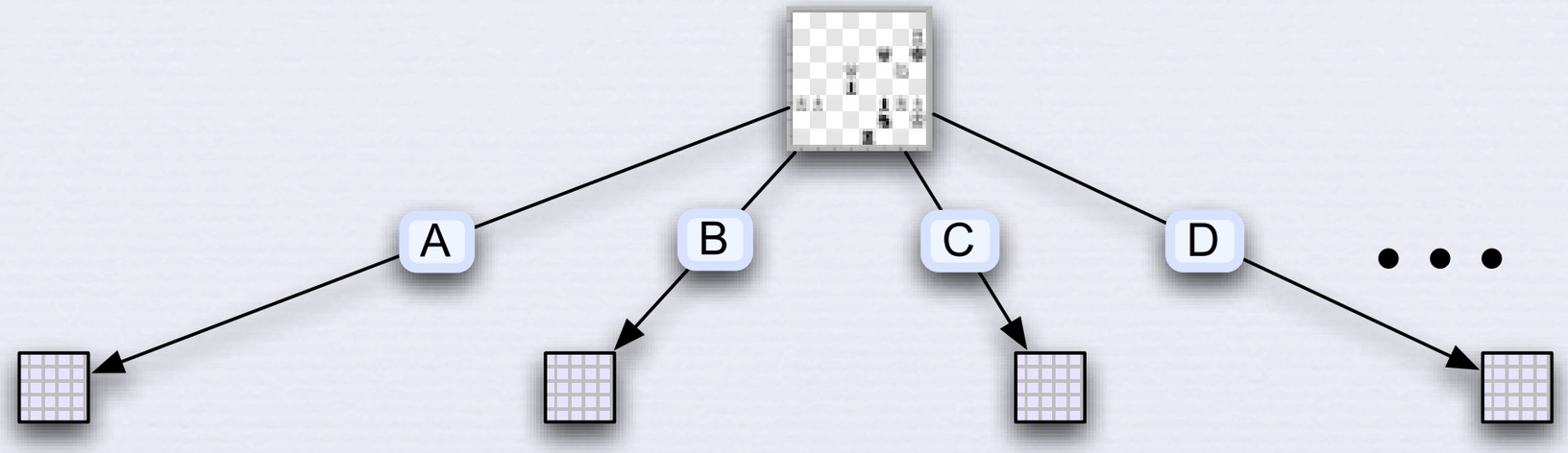
OK, it works but if you stop here, the level of play will be very weak.

Research tree - Minimax

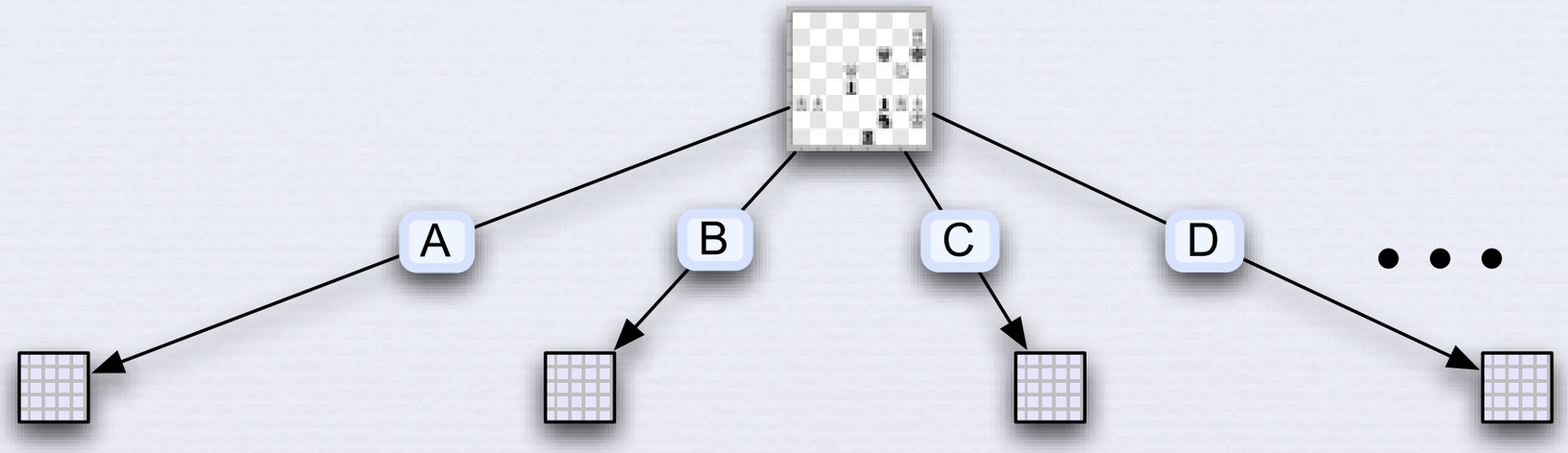
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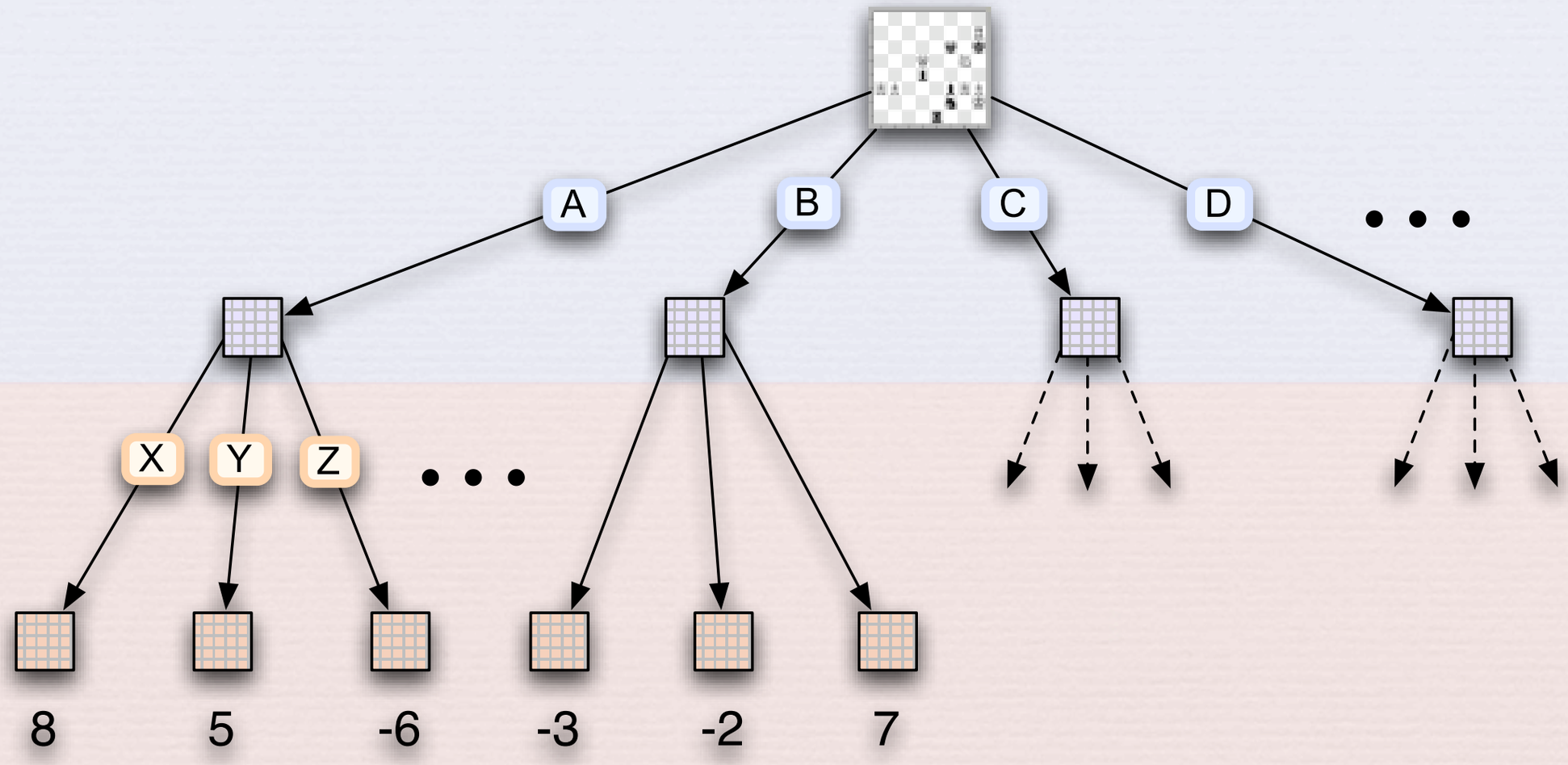


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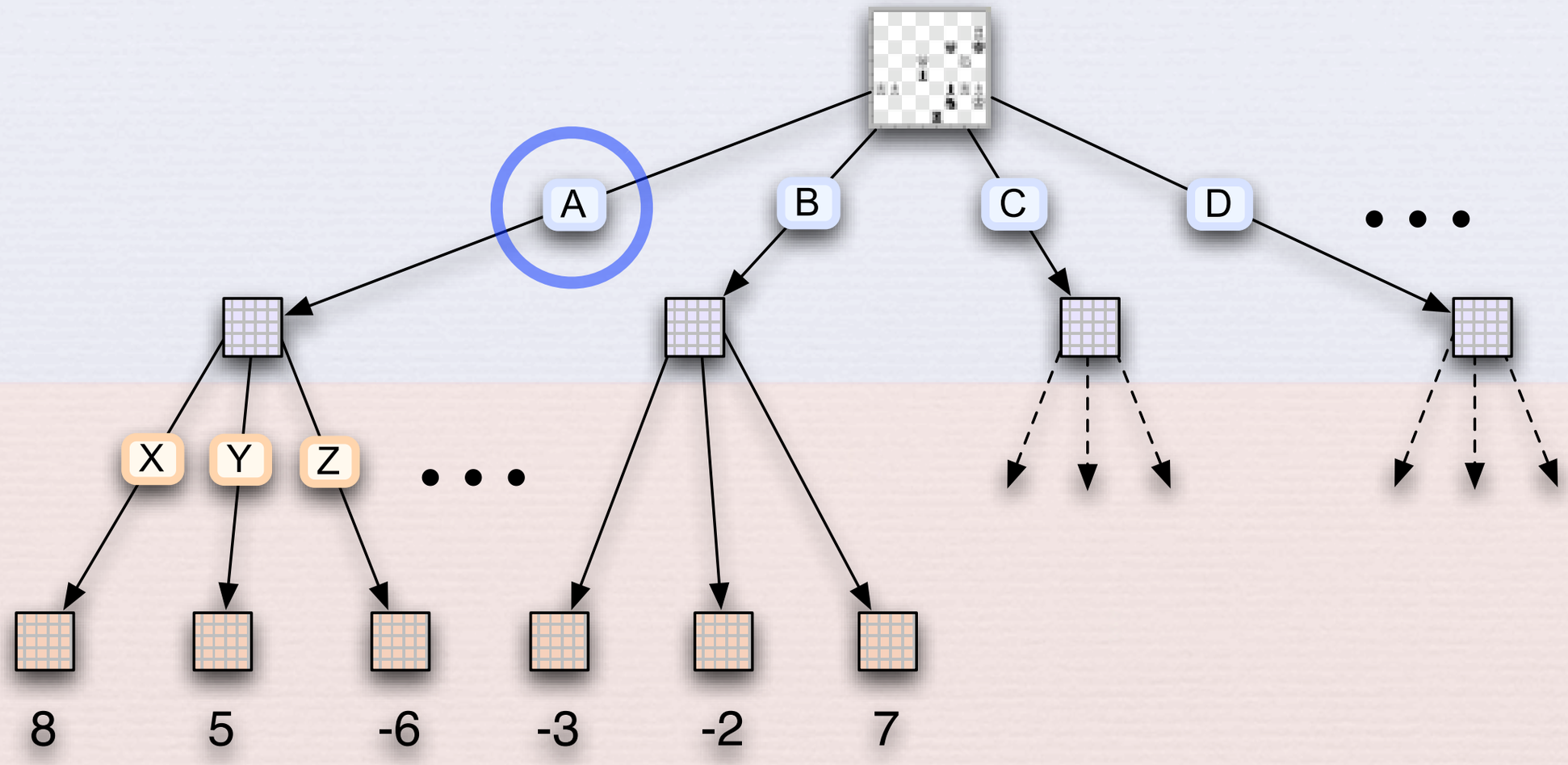
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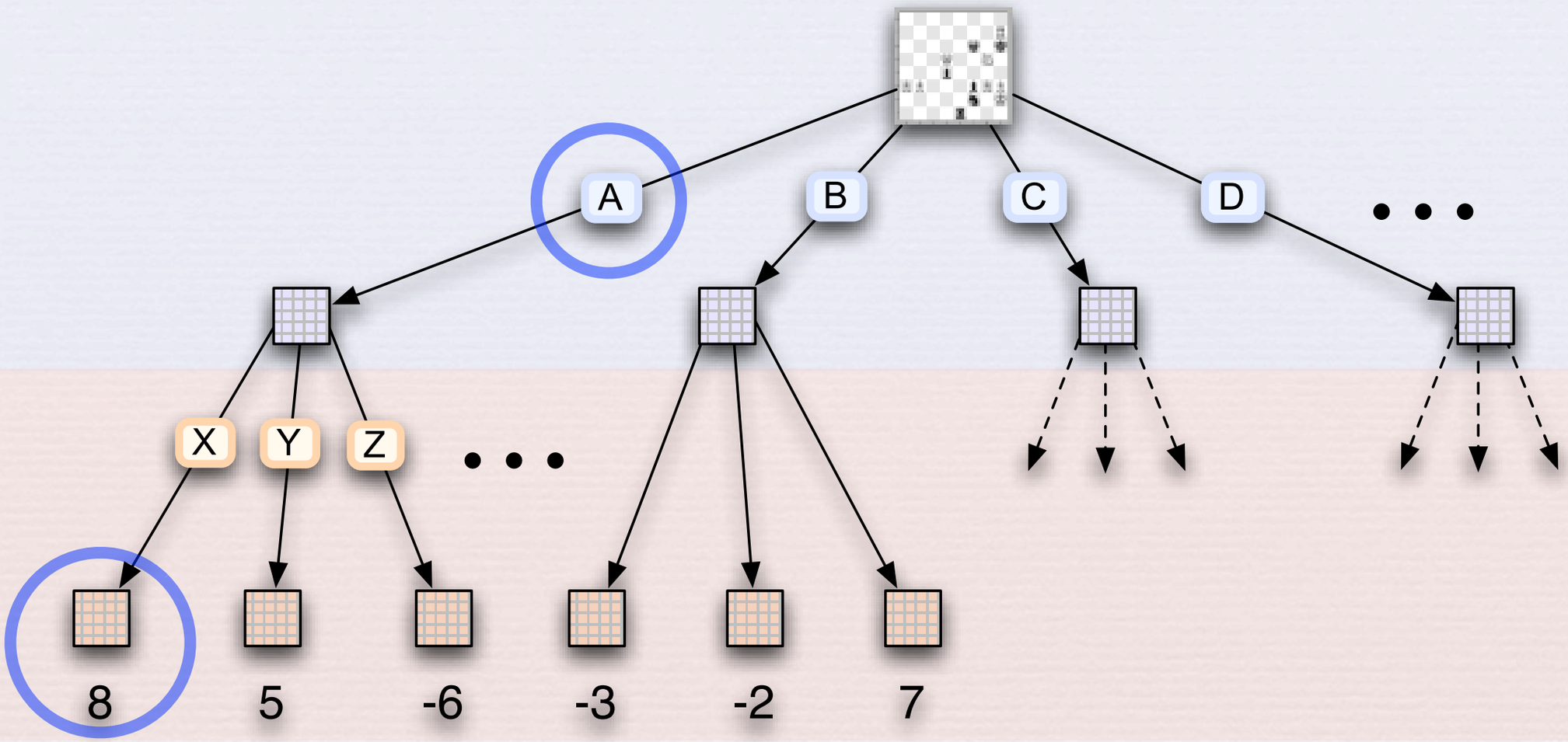
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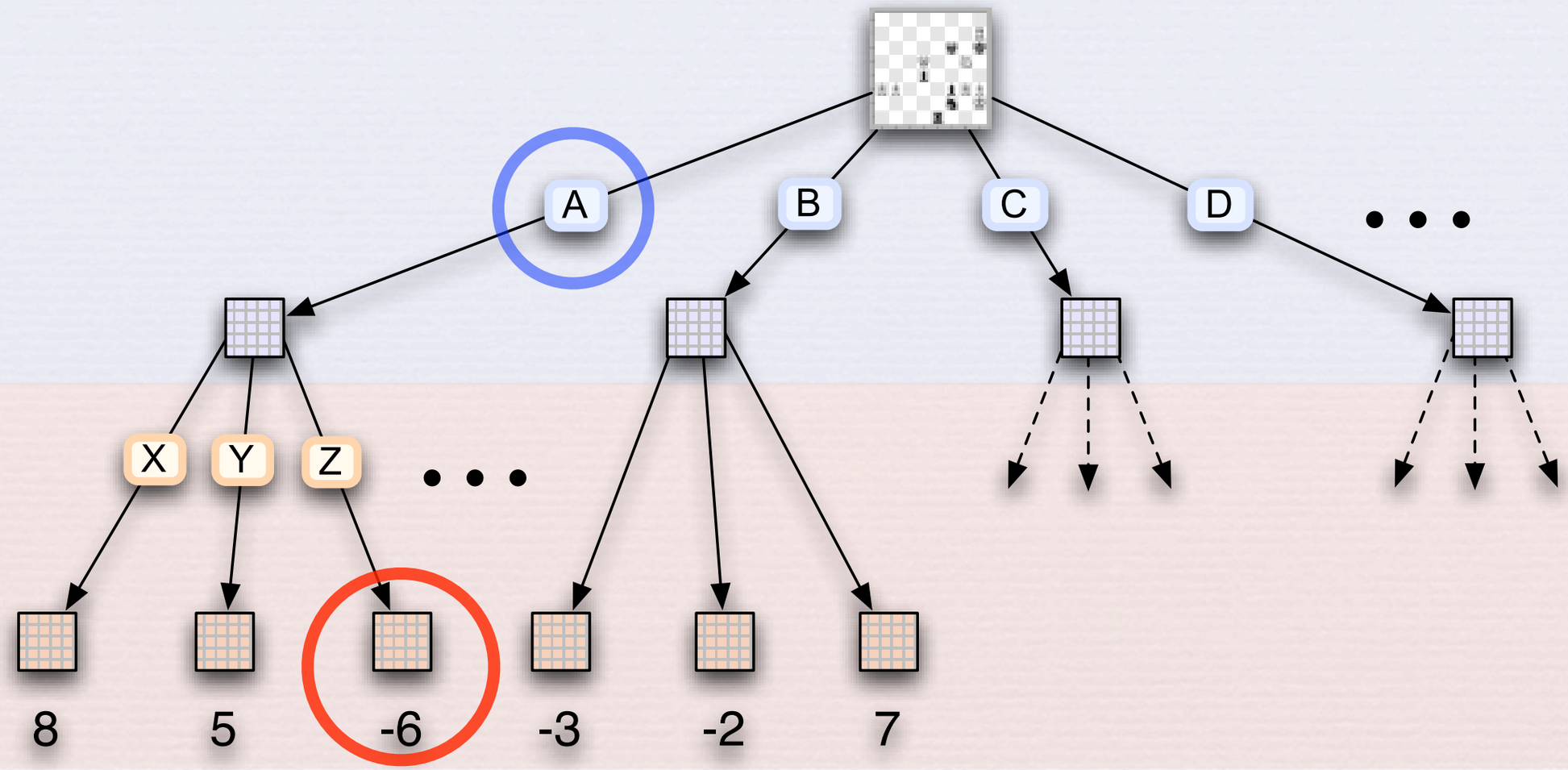
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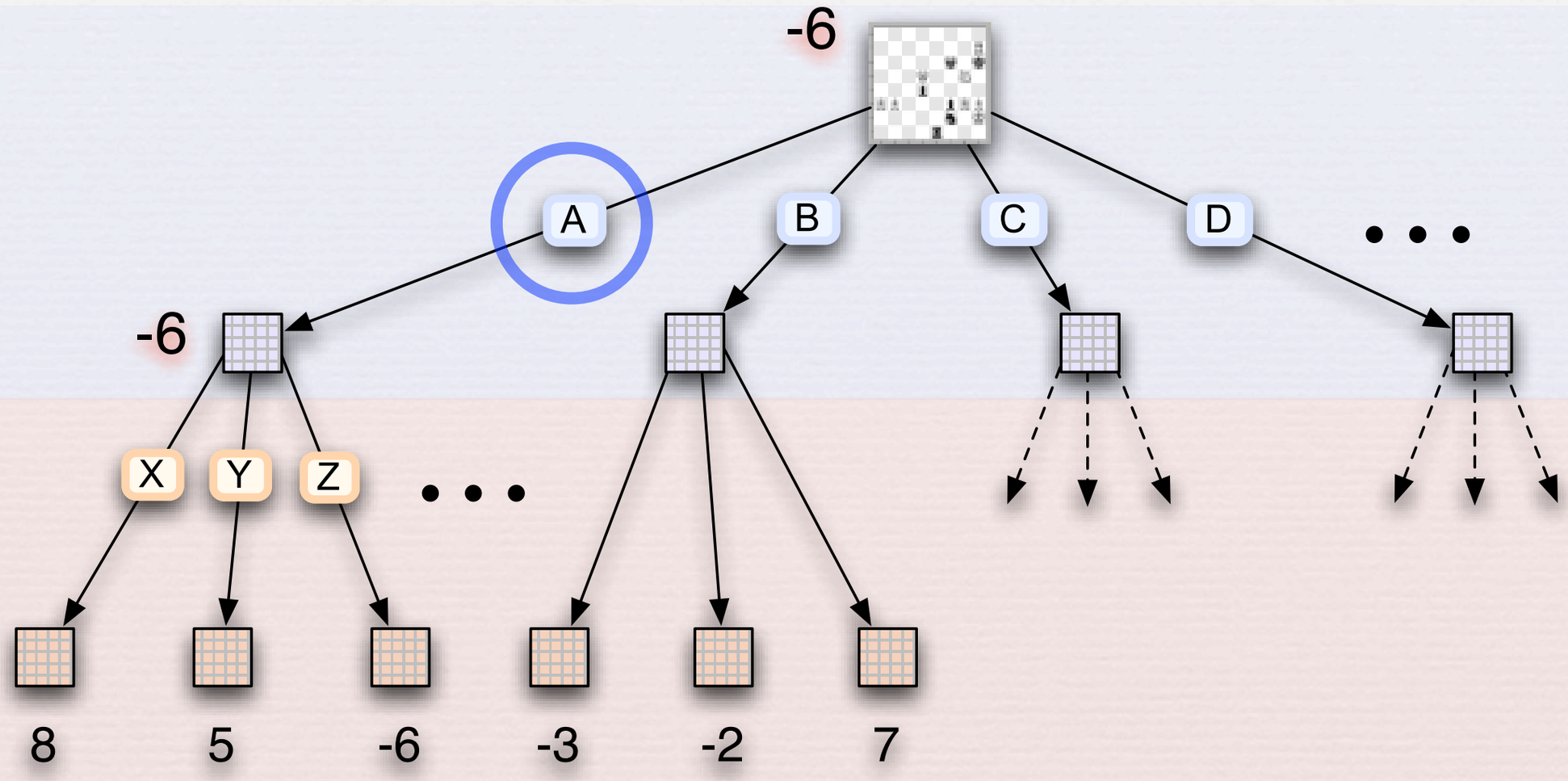
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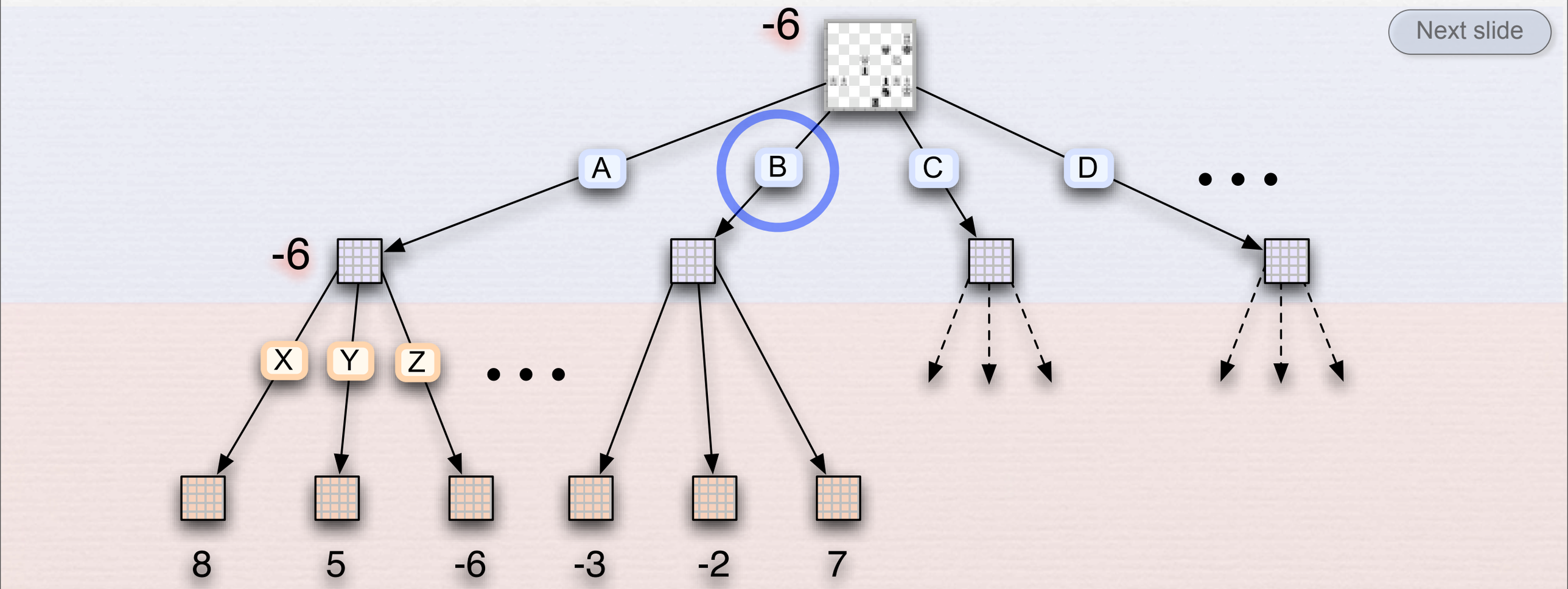
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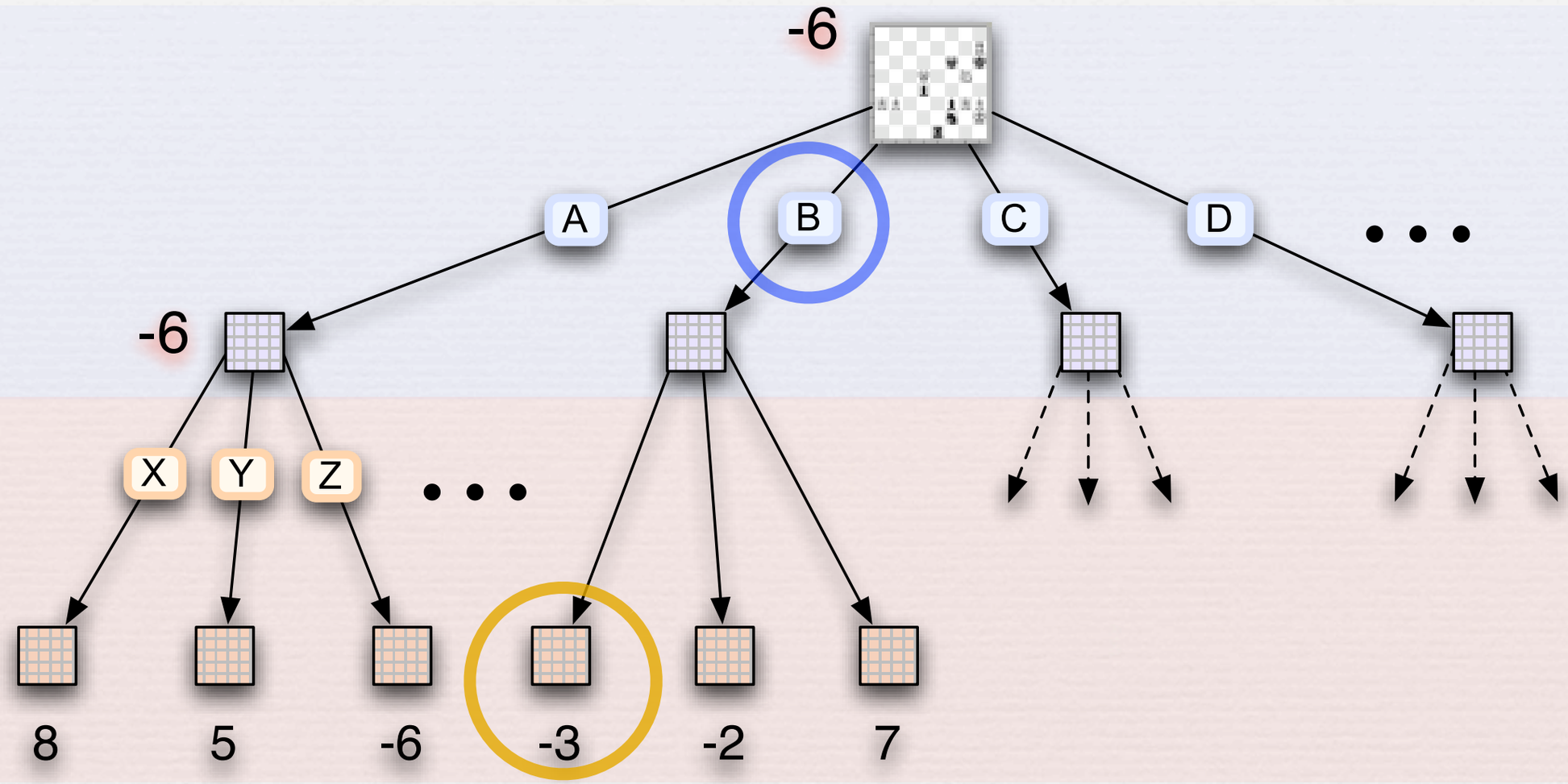
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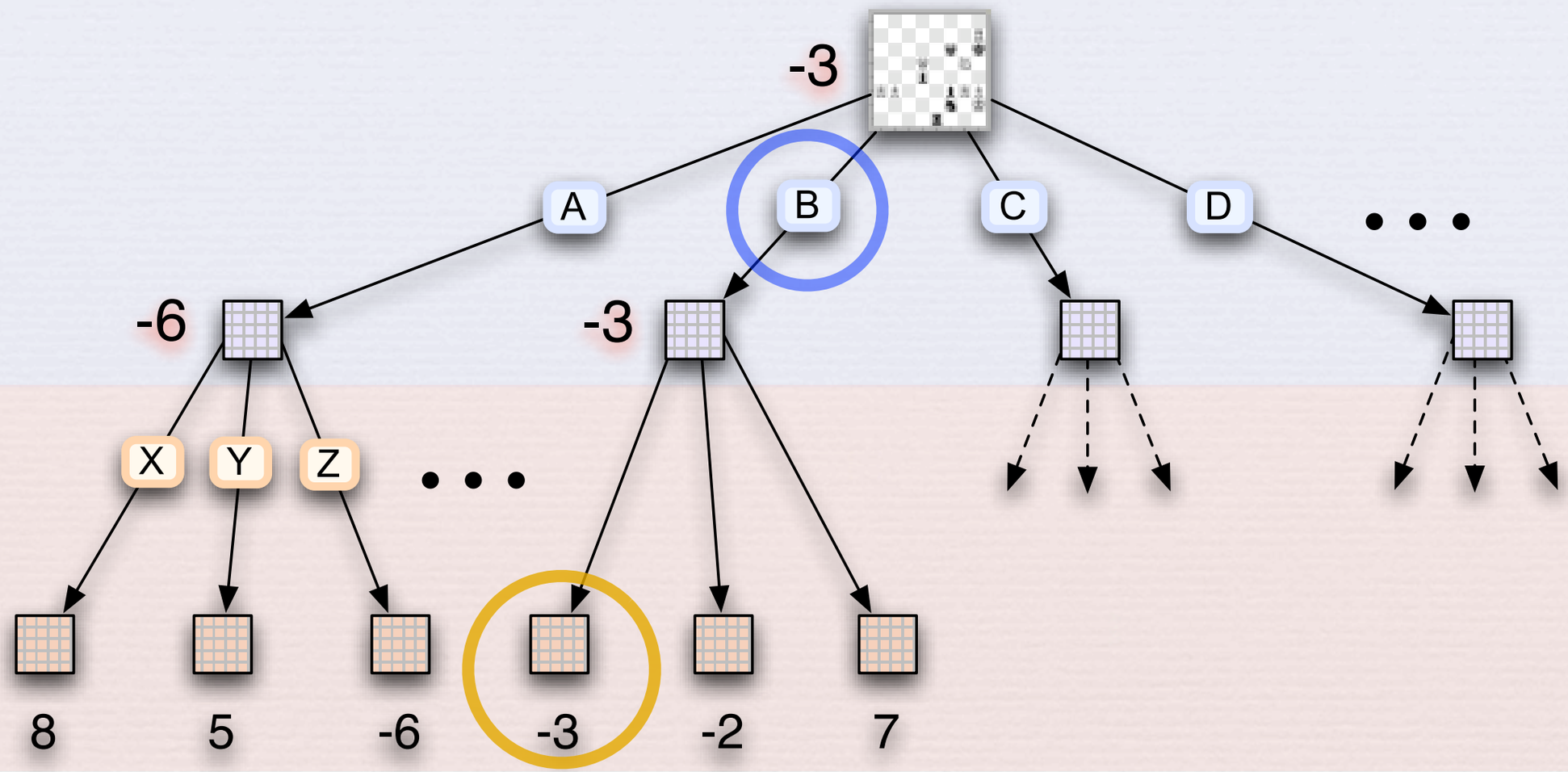
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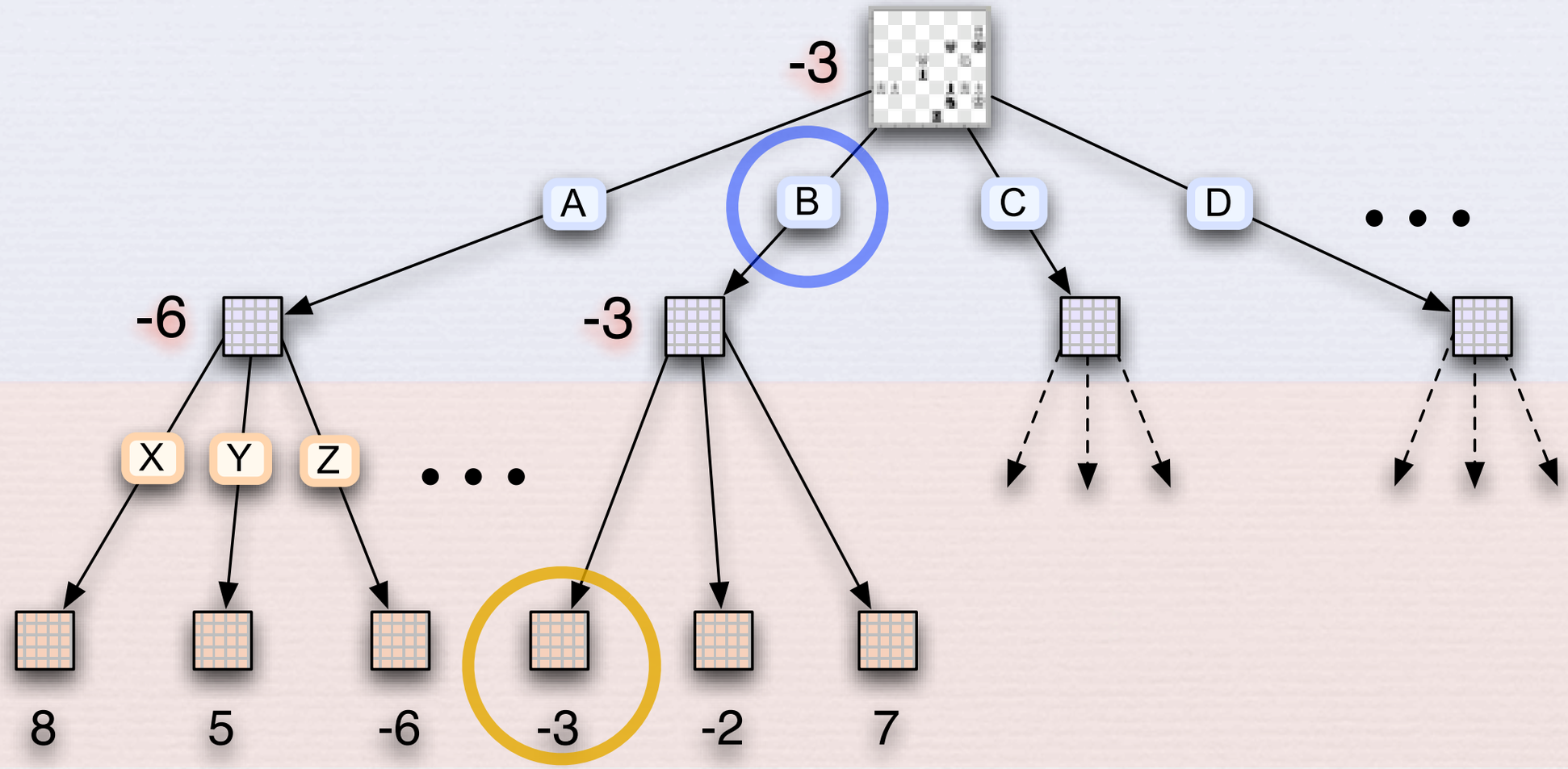
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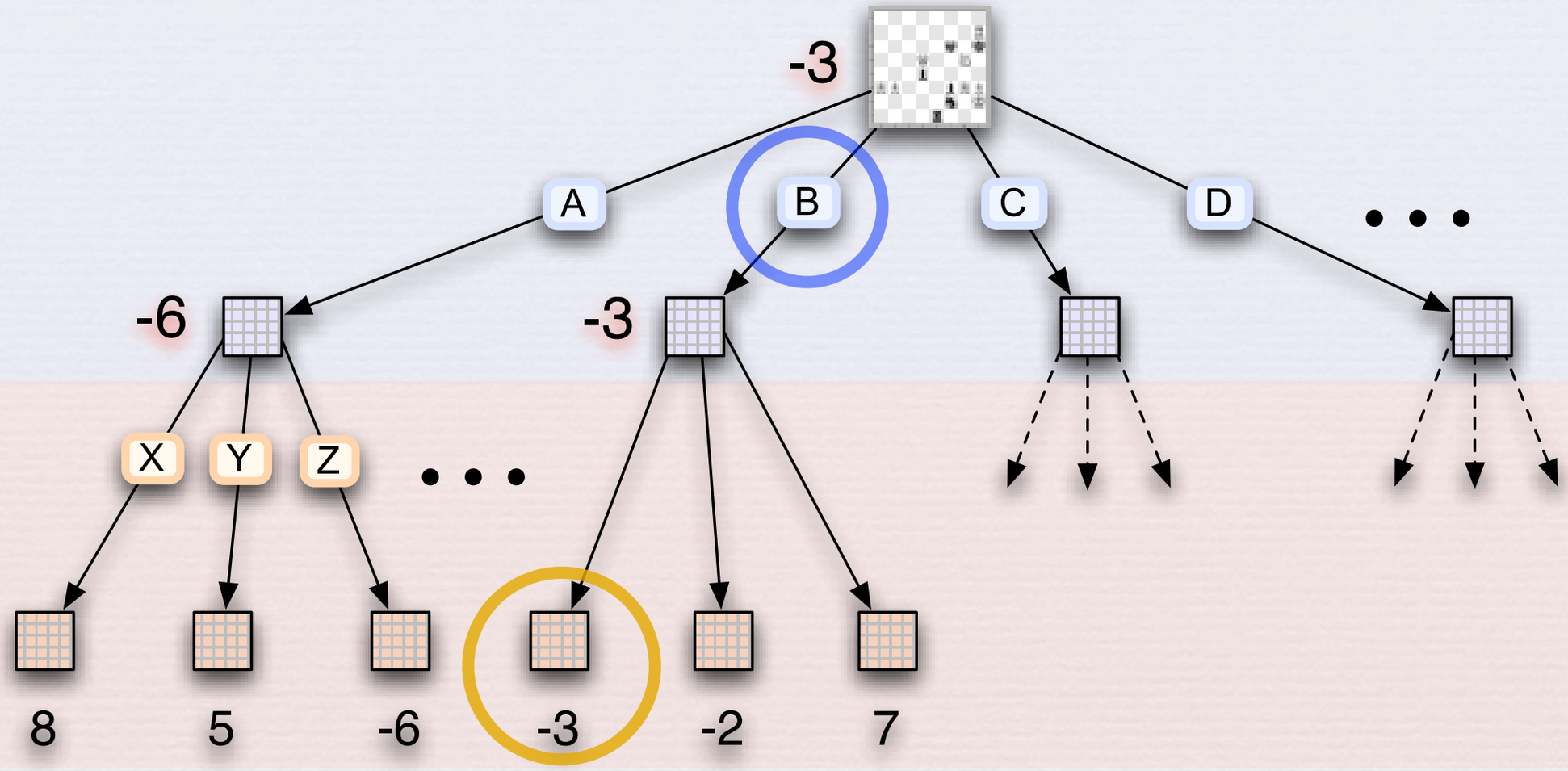
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  - Look ahead of 4 moves for chess → about 2 millions of positions to explore, ...
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    - *Quiescence search* : explores the critical positions deeper to avoid «horizon effect»
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- State of the art (2011) : Houdini Chess 2.0 (~1.5 10^7 nodes/s, >3300 Elo)

New challenge : Go

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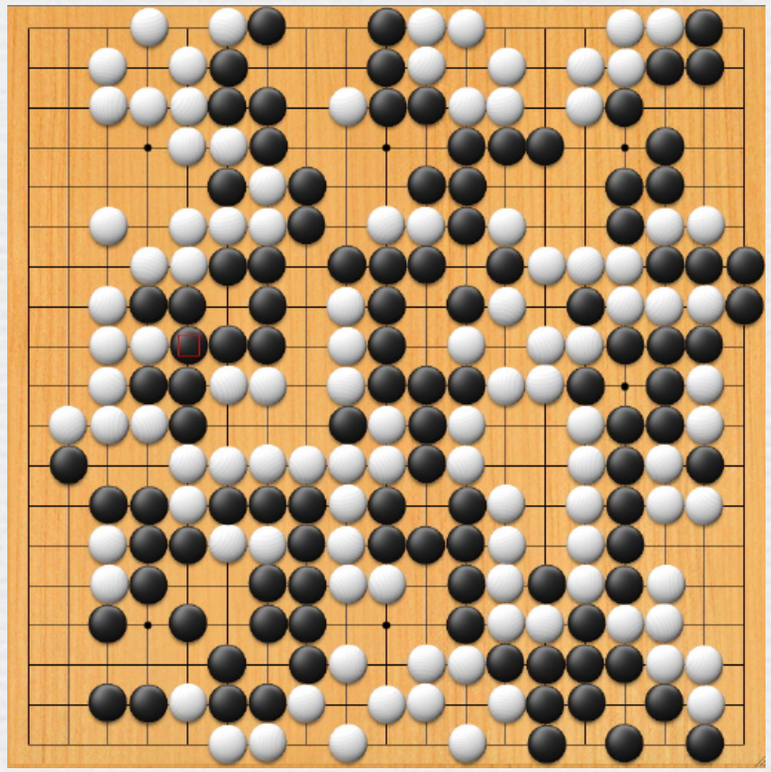
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- But since late 2006, things are changing;
  - Program MoGo (LRI, Orsay)
  - Results of a Master2R internship !
  - Ideas :
    - Evaluation based on Monte-Carlo method
    - New research algorithm: UCT
      (Upper Confident bound applied to Trees)
    - But … it runs on 3328 processeurs POWER6
  - MoGo wins some match against strong human player (with handicap)



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  - Civilization, Age of Empire, WoW, ...
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- We need new approaches
  - Better implementation of strategy/tactic
  - Tree research must be improved
  - Create a model of opponents
  - Abilities to learn from the opponents ...



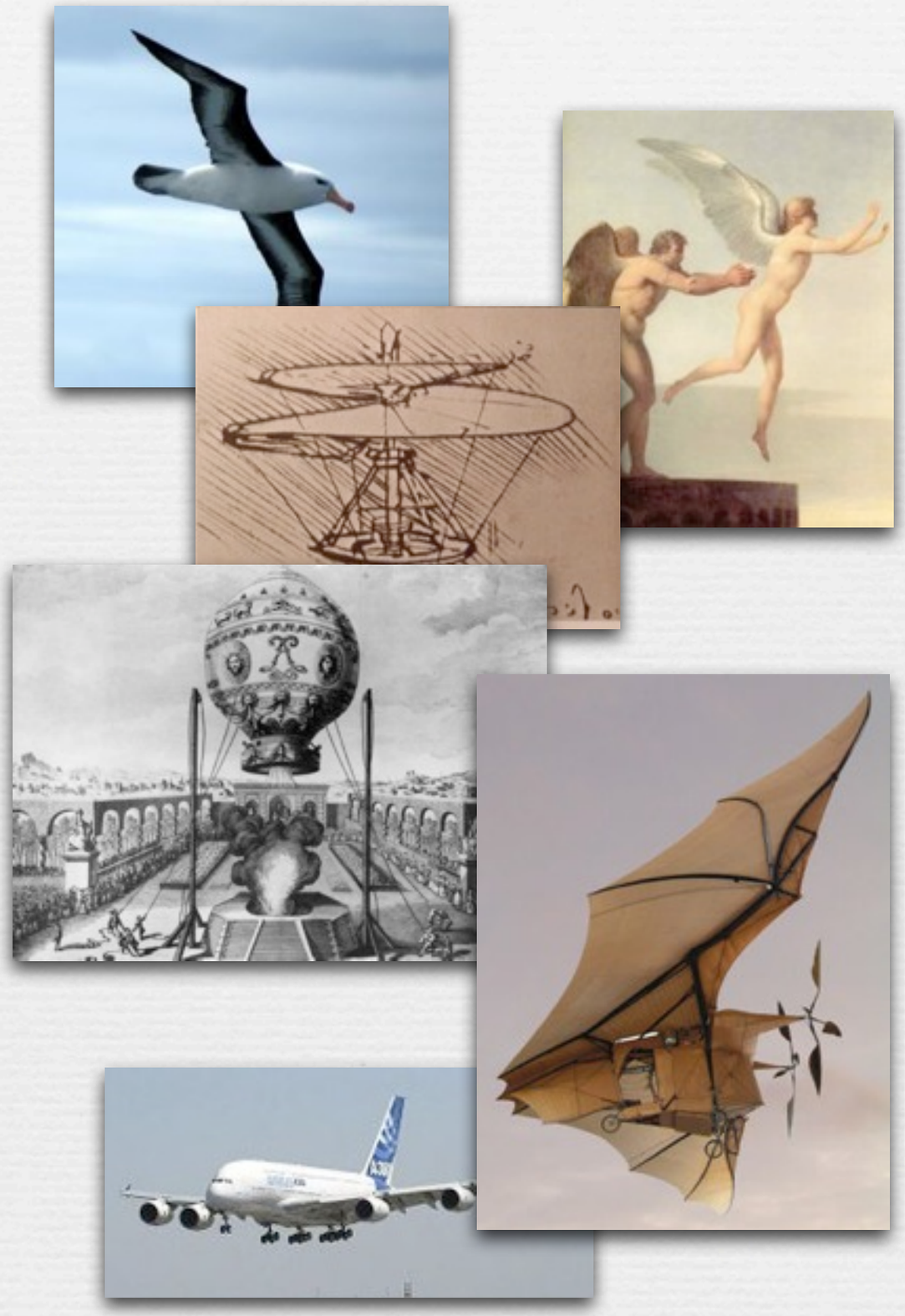
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So, could a computer be intelligent ?

Li-myths

An analogy : the quest for the flight...

From mimicking birds ...



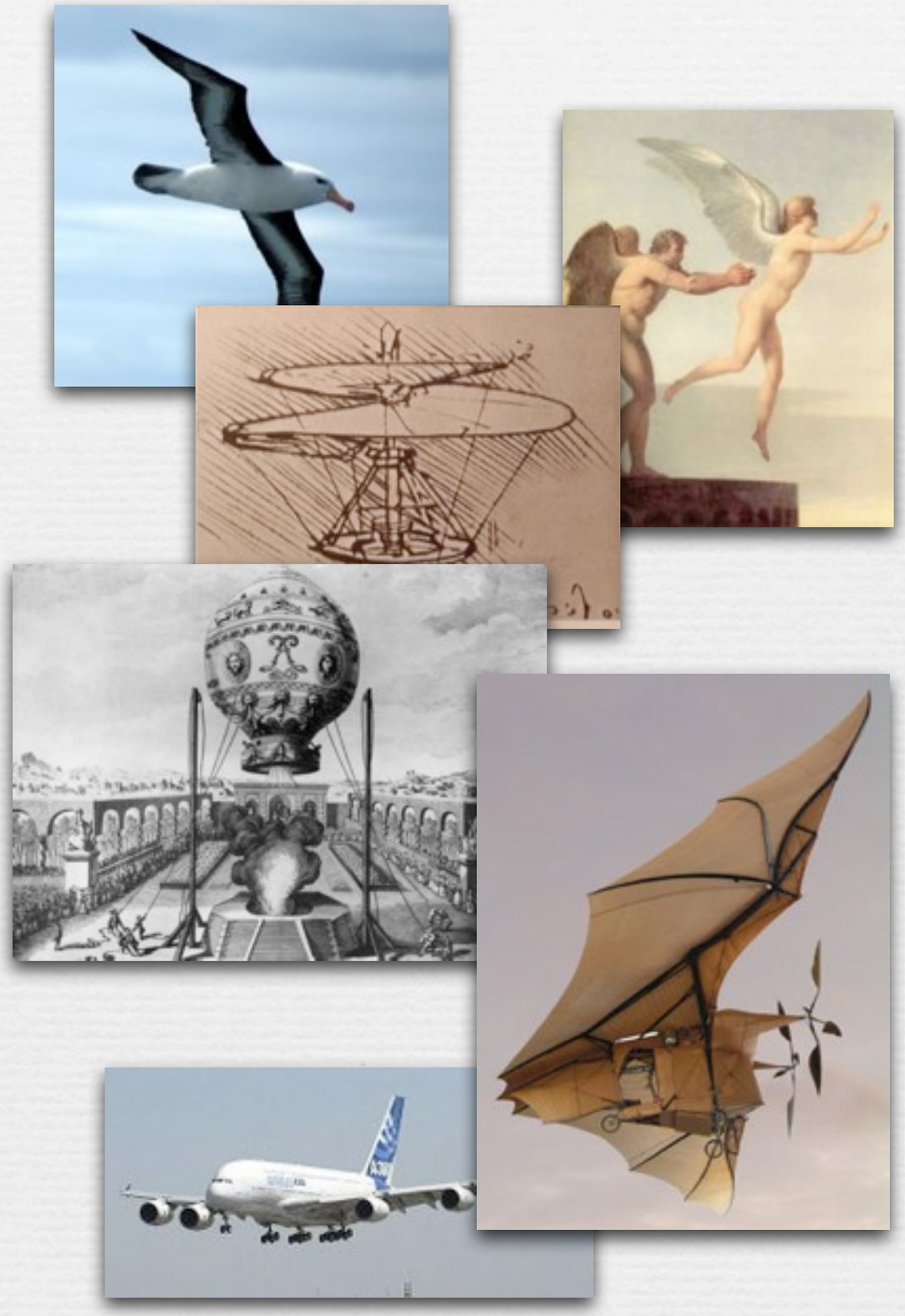
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An analogy : the quest for the flight...

From mimicking birds ...

- Icarus Myth
- Leonardo da Vinci (1486)
- Montgolfier's brother (1783)
- Clément Ader (1897)
- ...

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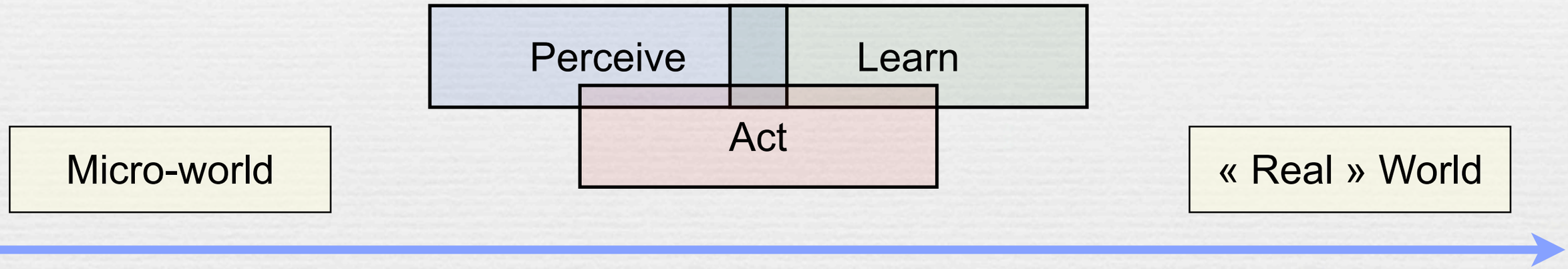
Artificial & Natural intelligence

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- Is a GPS intelligent ?
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  - … and that's the same for many programs playing chess, analyzing data, etc !
  - So where is the beef ?

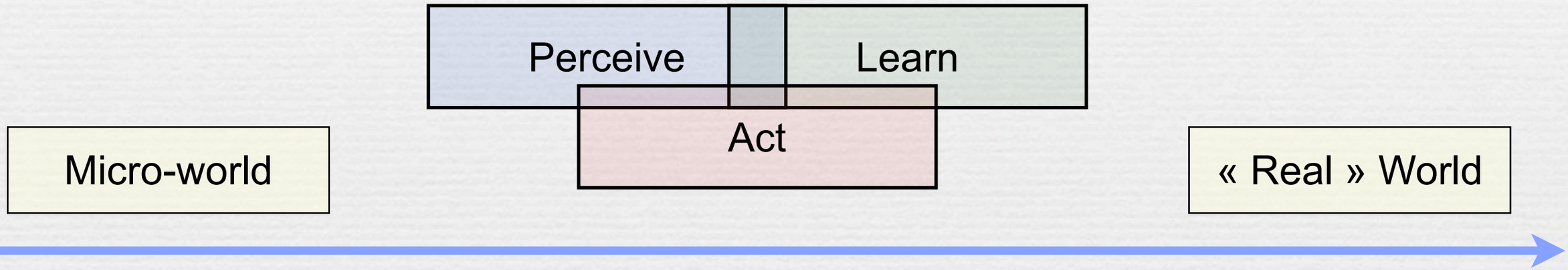
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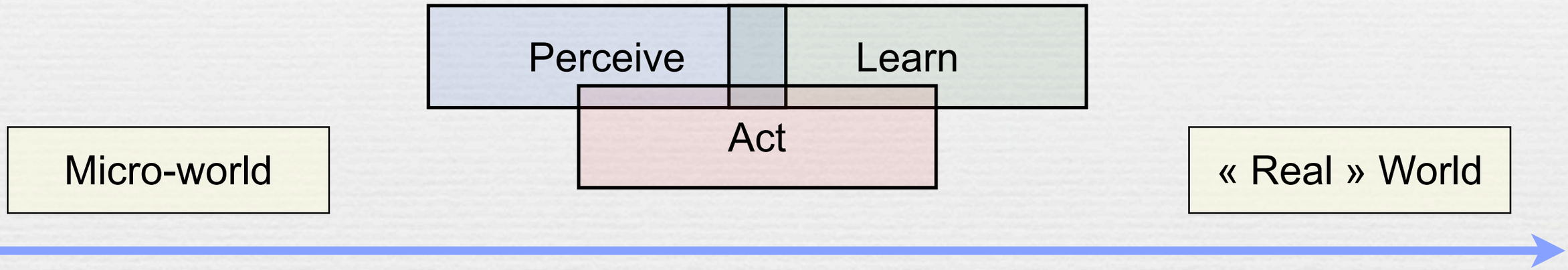
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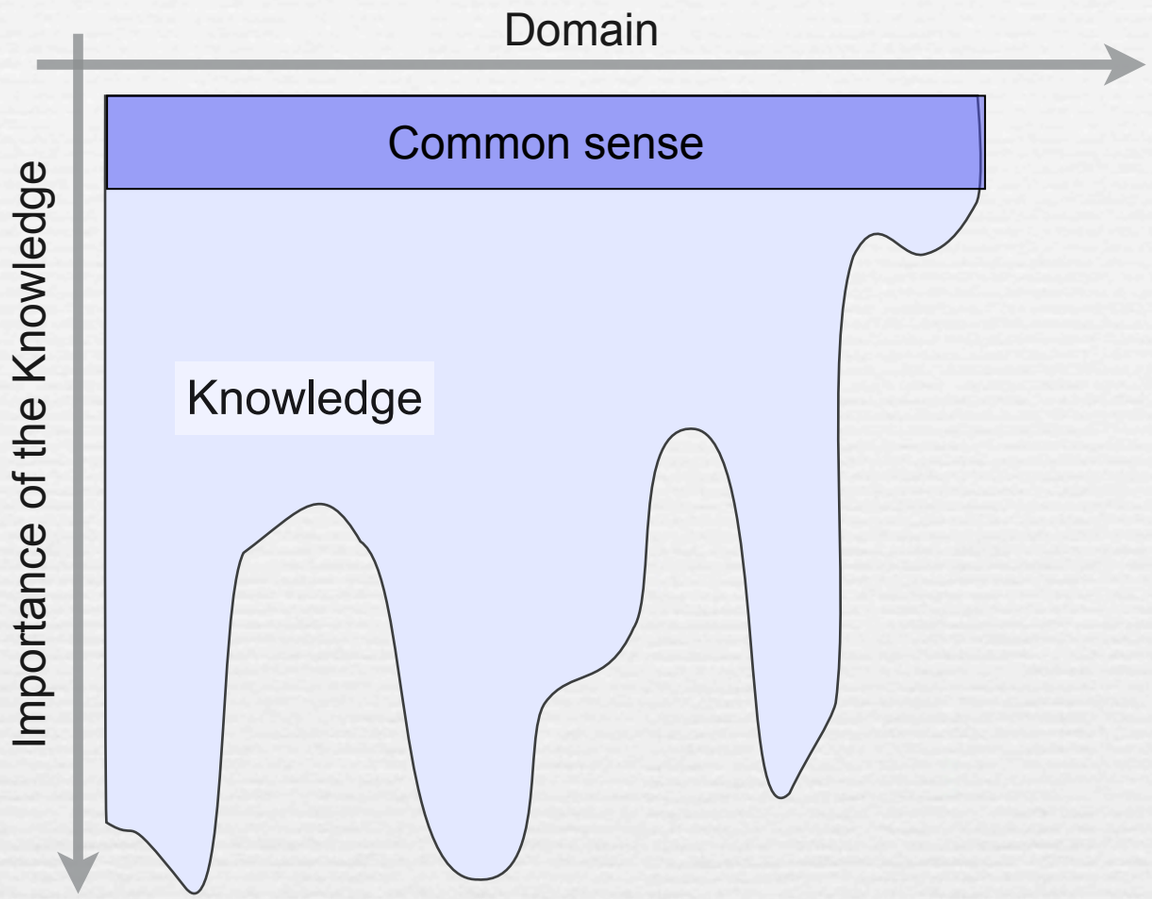


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Artificial Intelligence { spontaneously successes to Mirror test ?
able to create an artefact to solve a problem ?

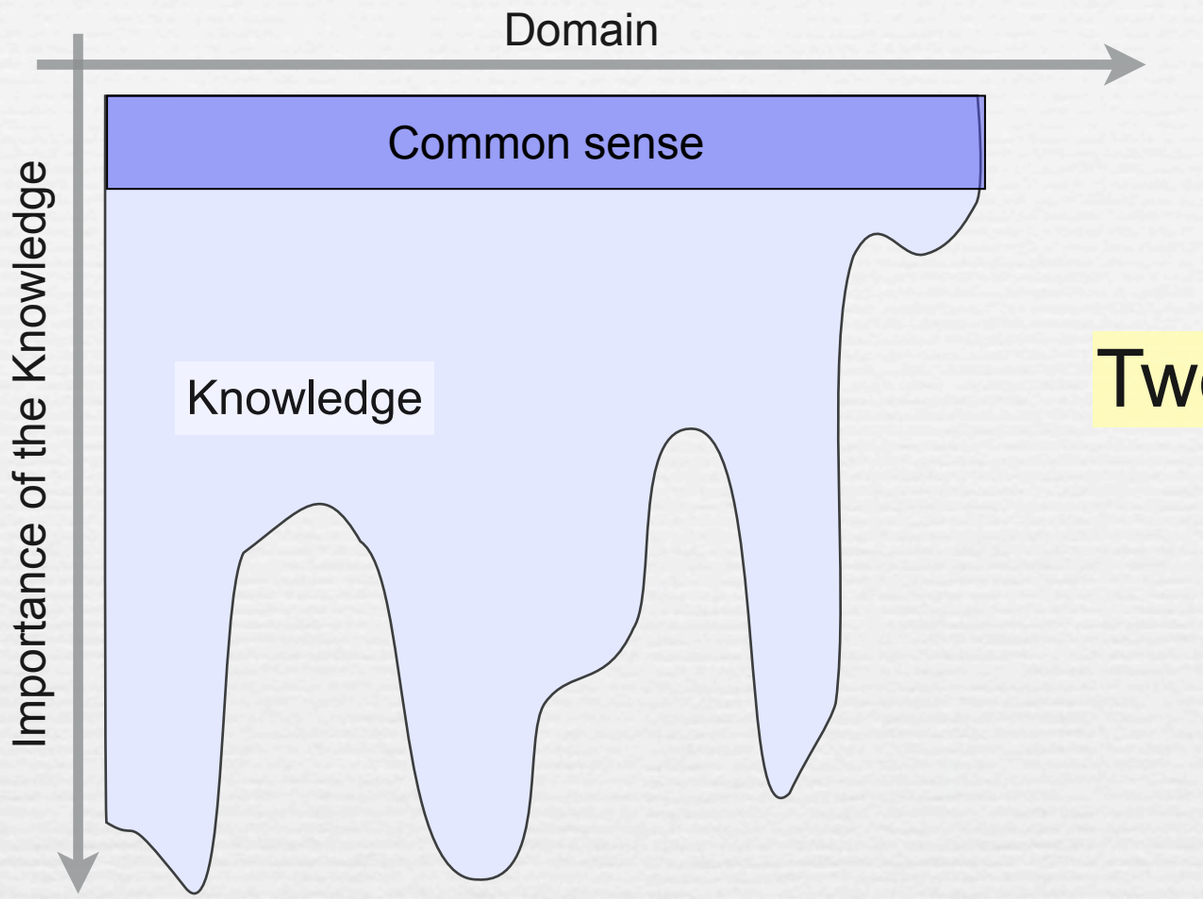
State of the art ...

Human being



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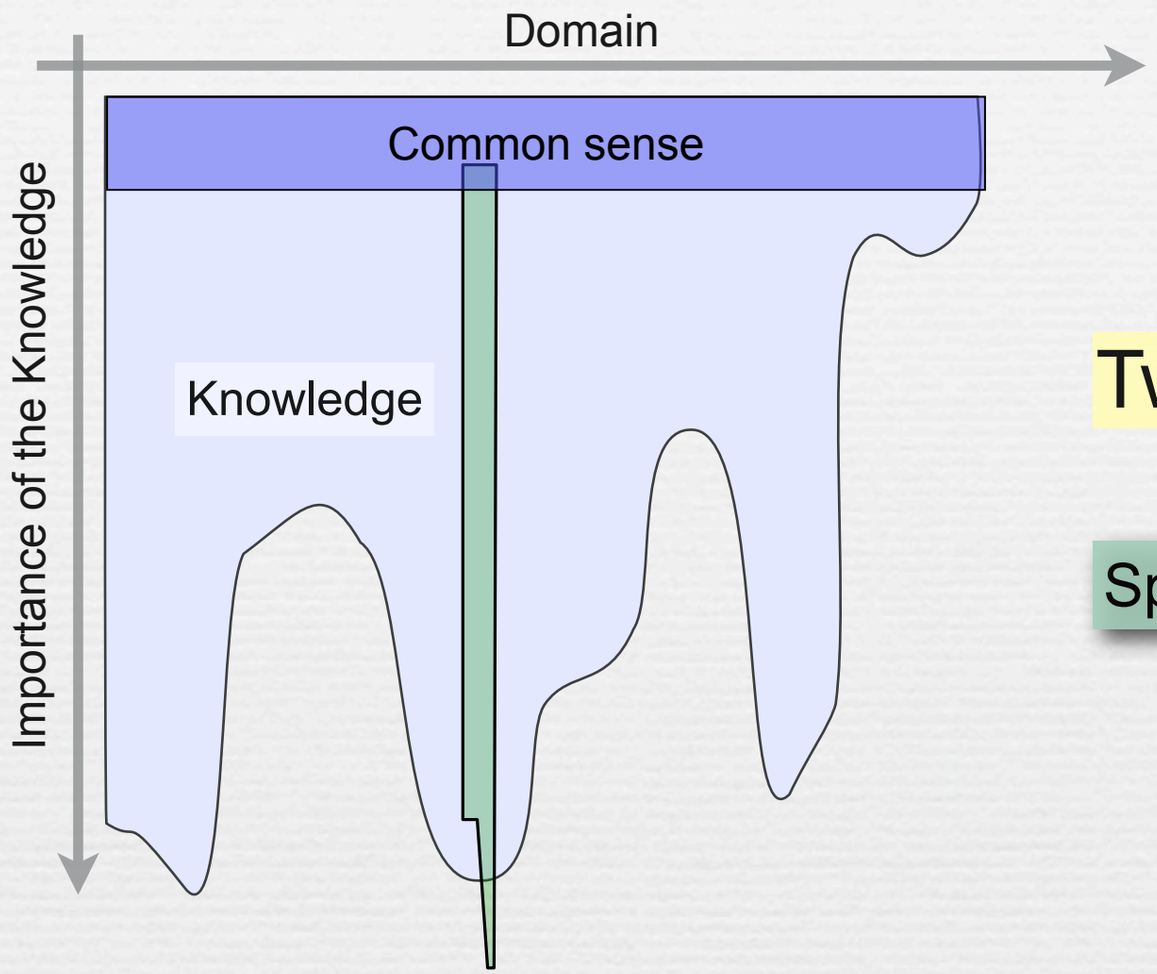
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Two «kinds» of AI

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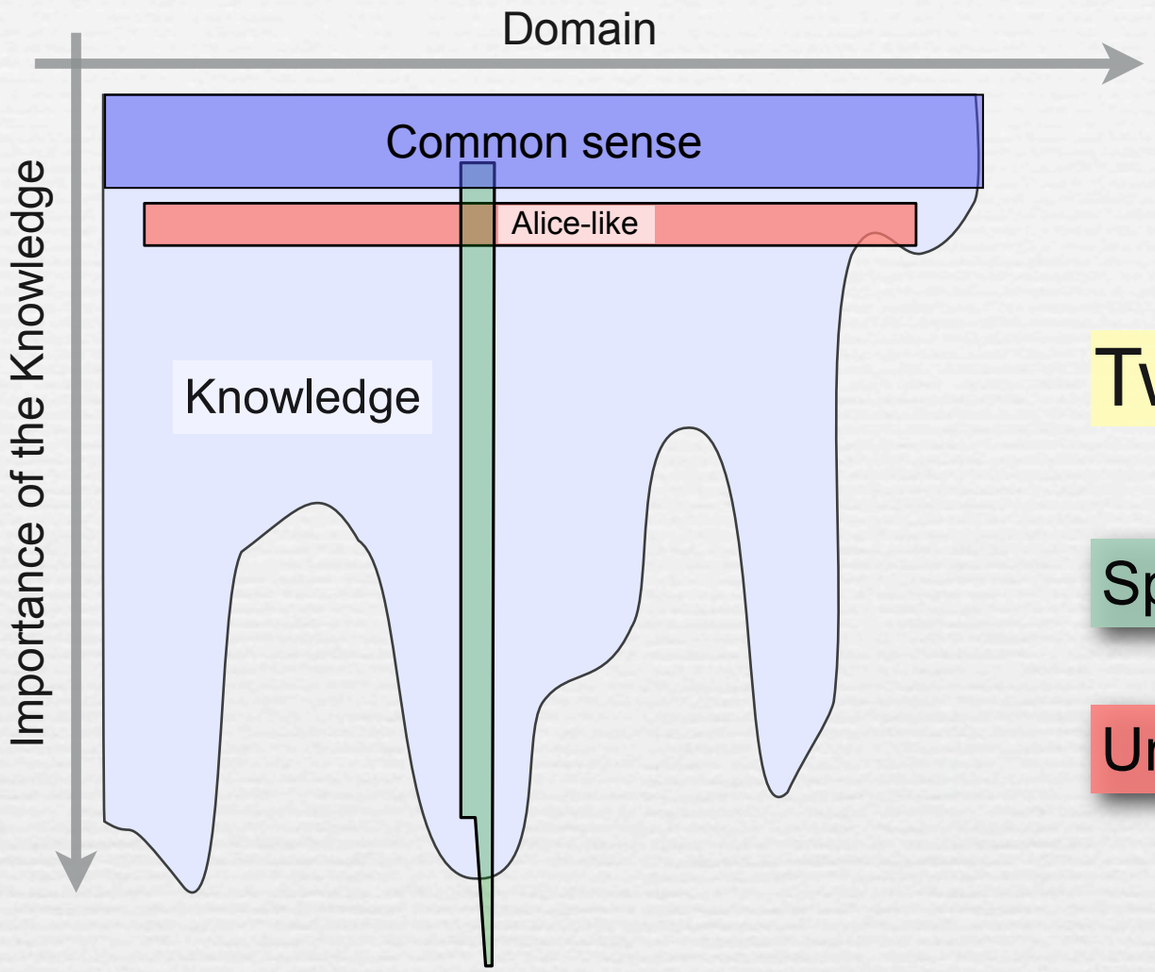


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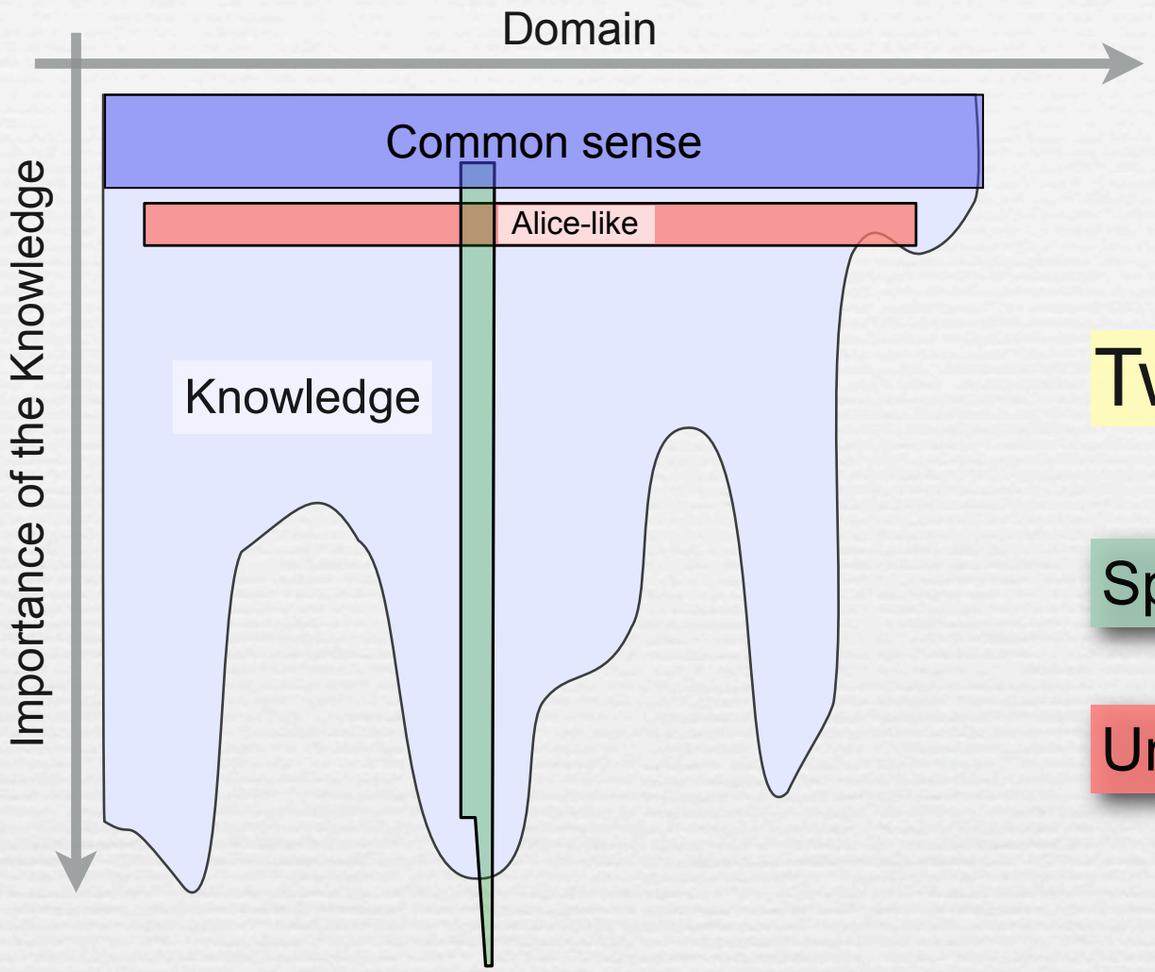
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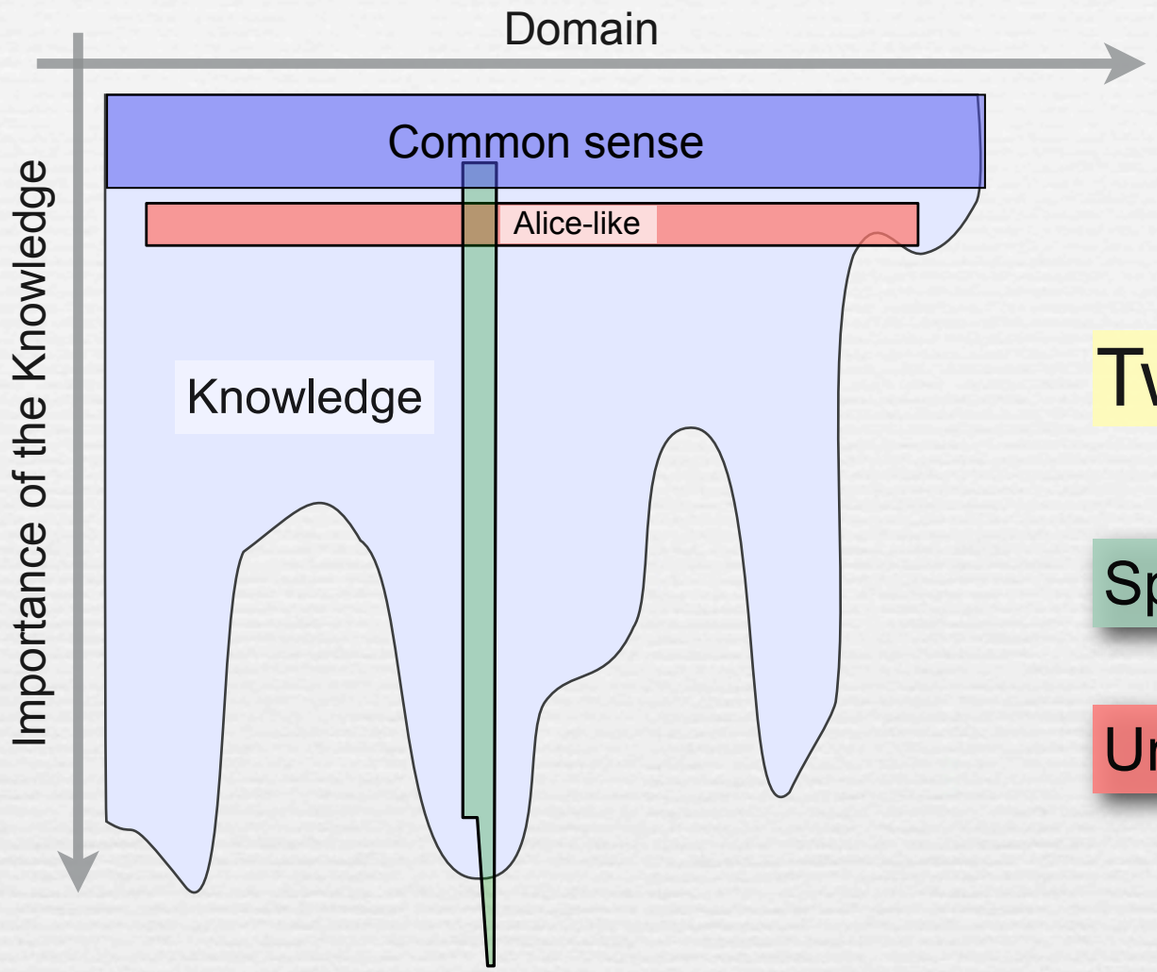
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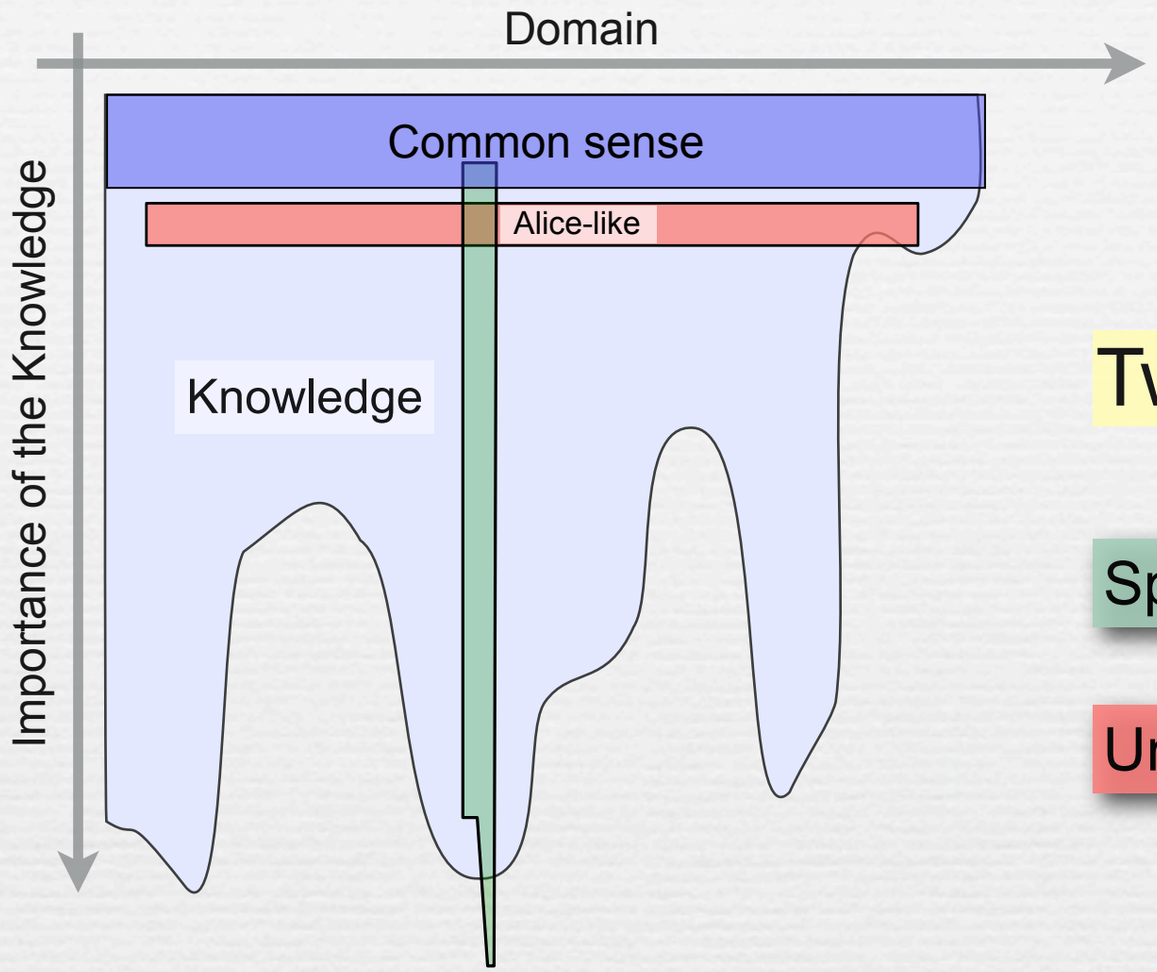
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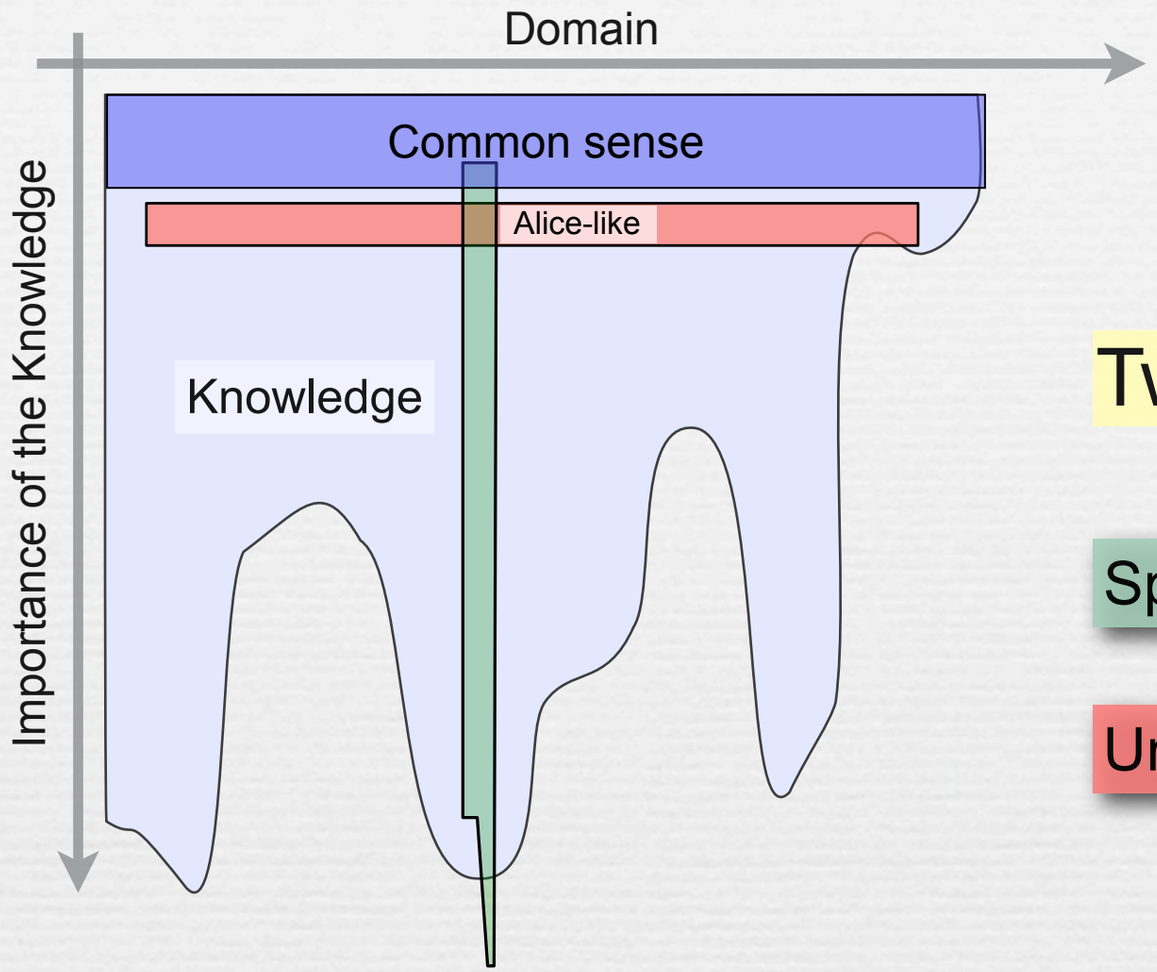
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  - Capacity to use analogy / to transform a problem into another
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How to get new behavior by putting together a set of predefined structures?	How to create something new by putting to-gether a set of atoms ? What’s occurring ?

Notion of emergence ...

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- Emergence in the complex systems
  - Some new «Macro-Entities» (may) appears with new behaviors
  - Overall system can be described with a good accuracy in terms of these M-E
  - Some examples of such emergence in natural sciences:
    - *Chemistry* : Atoms ➟ Molecules
    - *Life* : Molecules ➟ ADN/ARN/proteins (Bio-mol)
    - *Metazoa* : Bio-mol ➟ Community of cells
    - *Self-awareness* : Cells ➟ Neurons network (with feedback structures)
    - *Culture* : Brain ➟ Set of symbols

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... what is due to the evolution history and ...
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3) Our problem : we just have one example to learn !

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The AI must use a massive parallel processing hardware as do the brain.	A sequential computer can (in theory) totally simulates a parallel one.

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The AI must use a massive parallel processing hardware as do the brain.	A sequential computer can (in theory) totally simulates a parallel one.
We need to use multi-agent strategy.	Probably true, at least from the point of view of the implementation complexity.

What is required ?

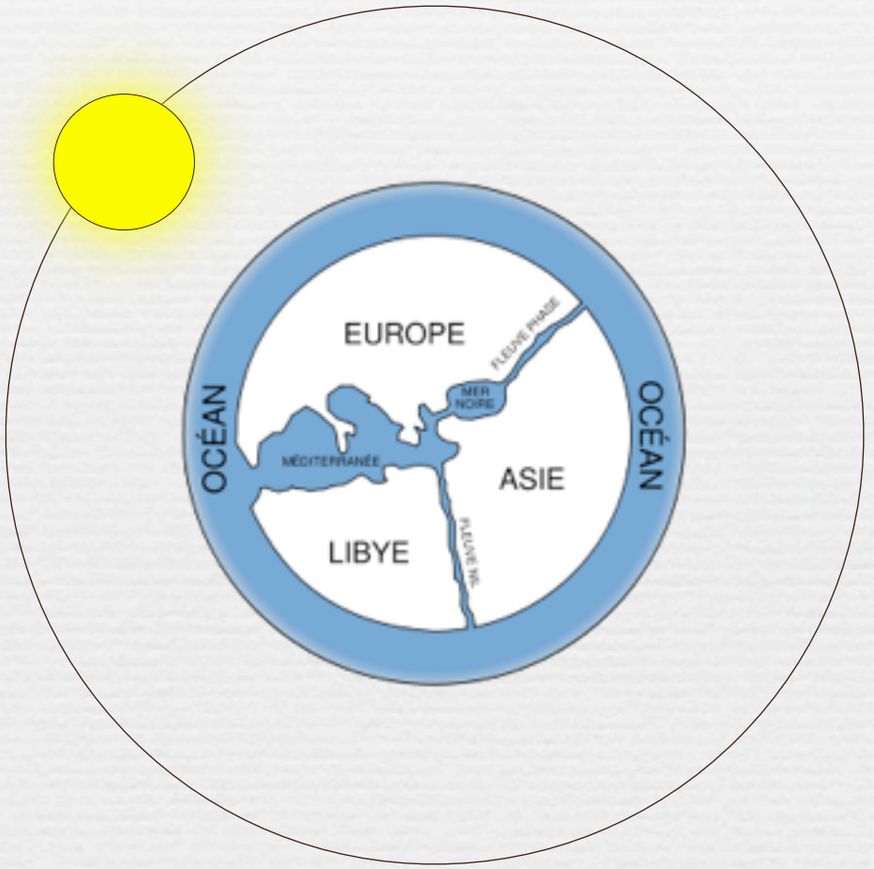
Hypothetical needs	Discussion
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The AI must use a massive parallel processing hardware as do the brain.	A sequential computer can (in theory) totally simulates a parallel one.
We need to use multi-agent strategy.	Probably true, at least from the point of view of the implementation complexity.
An AI must be able to learn by interacting to its environment.	Of course, first to be really intelligent, second to ease the implemention.

Tomorrow ...
2050 : the singularity ?

Humans and AIs

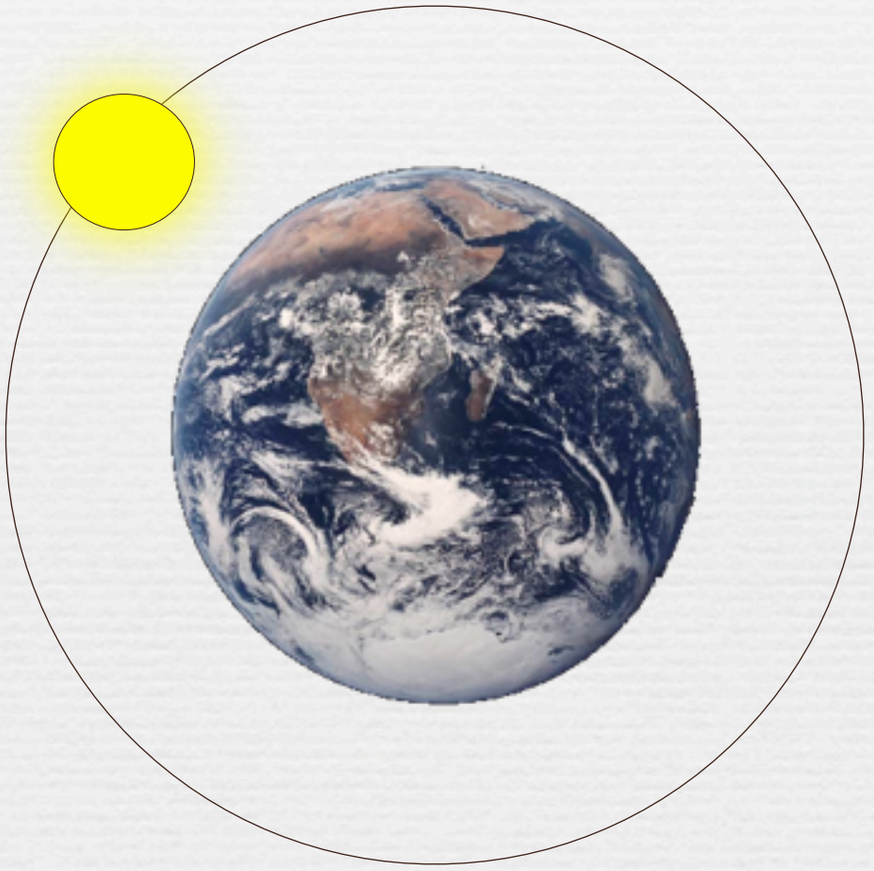
The human quest of his references

Where are we ?

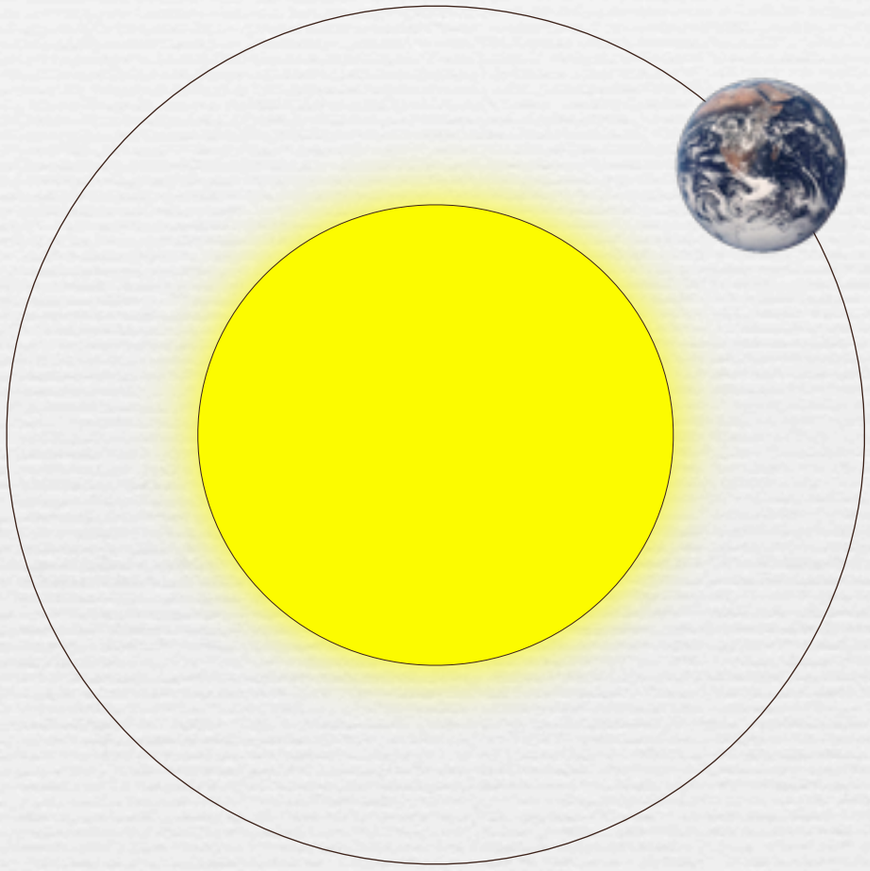


The human quest of his references

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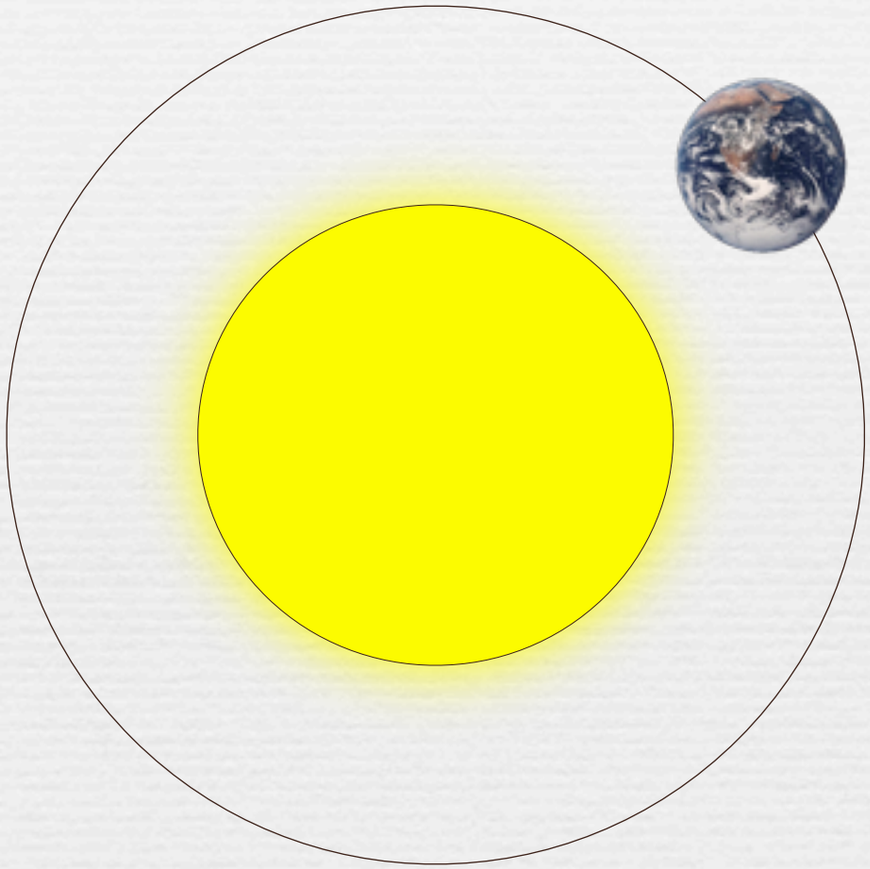


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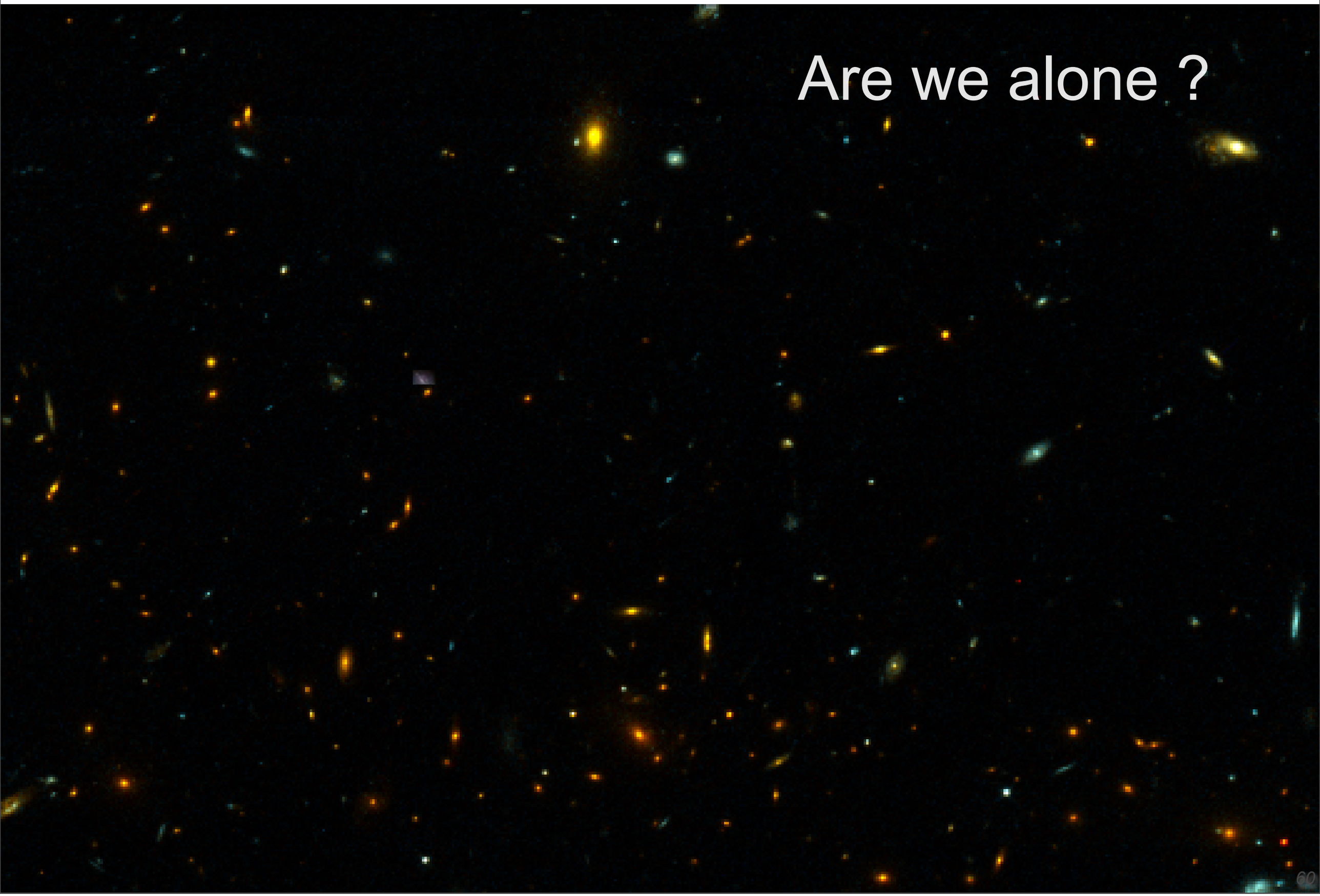
The human quest of its references



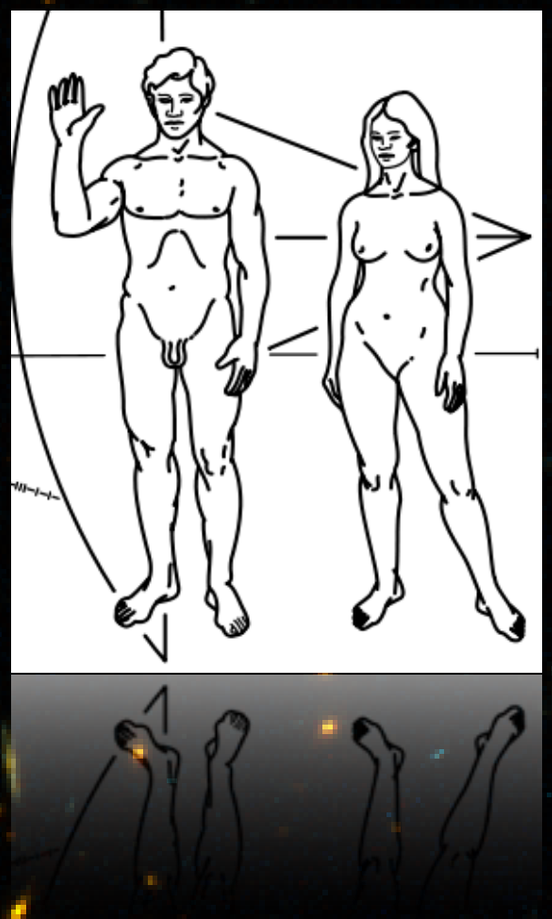
The human quest of its references

Are we alone ?

The human quest of its references

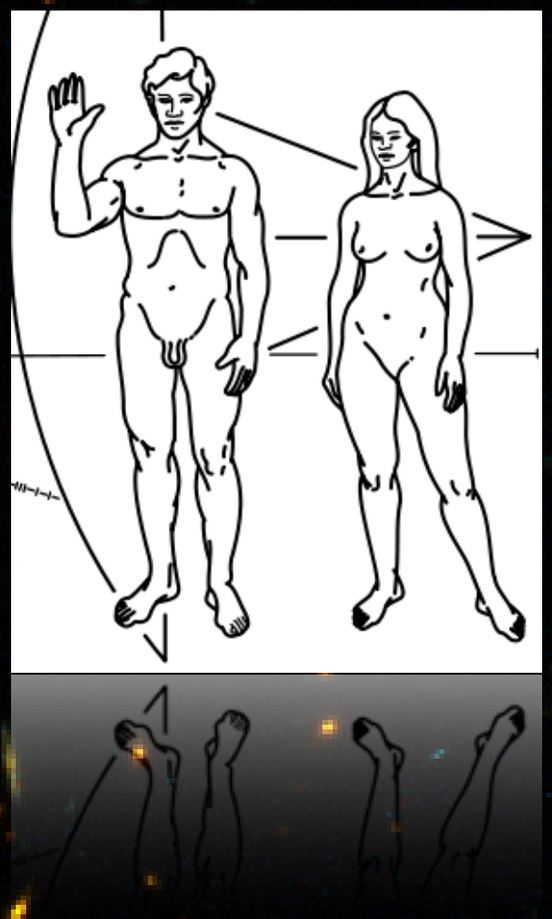


The human quest of its references



Are we alone ?

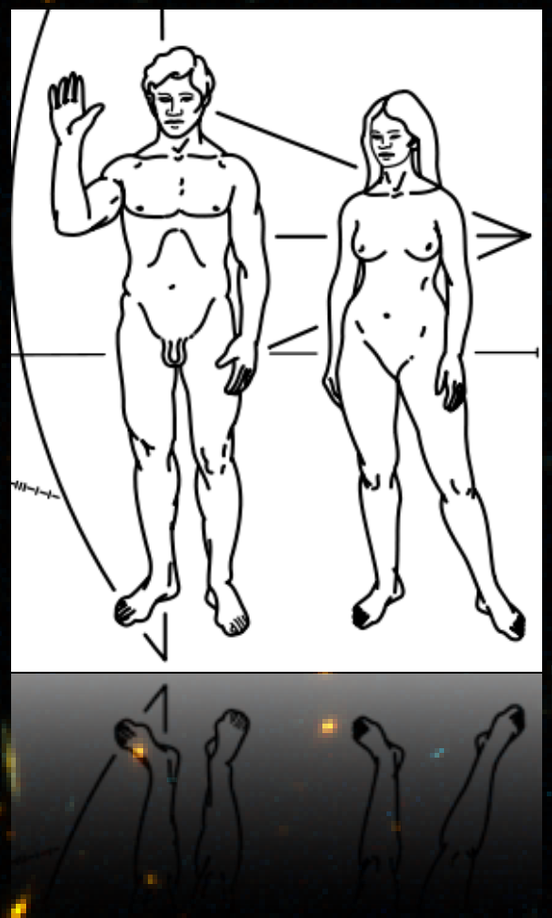
The human quest of its references



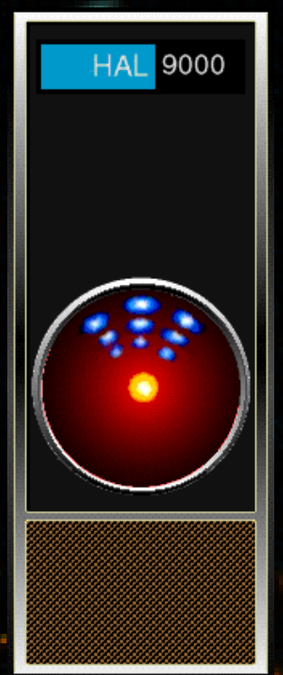
Are we alone ?



The human quest of its references



Are we alone ?



Toward « accustomed » AIs

AI systems will arrive progressively

Toward « accustomed » AIs

AI systems will arrive progressively

- Games
  - Intelligent toys as «Aïbo», «Nao», ...
  - Avatars in virtual worlds

Toward « accustomed » AIs

AI systems will arrive progressively

- Games
  - Intelligent toys as «Aïbo», «Nao», ...
  - Avatars in virtual worlds
- Intelligent tools will help us more and more
  - At work
    - Secretary (agenda, organization of the meetings, ...),
    - Automatic summerization of huge number of documents,
    - Handling of dangerous stuff
  - At home
    - Intelligent Vacuum cleaner, Cooking machines, ...
    - Supervision of children and help to person with disabilities
  - To commute or to travel
    - Autonomous vehicles : train, car, plane, ...

Toward « accustomed » AIs

AI systems will arrive progressively

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- But ... are we ready to accept accidents caused by an AI ?

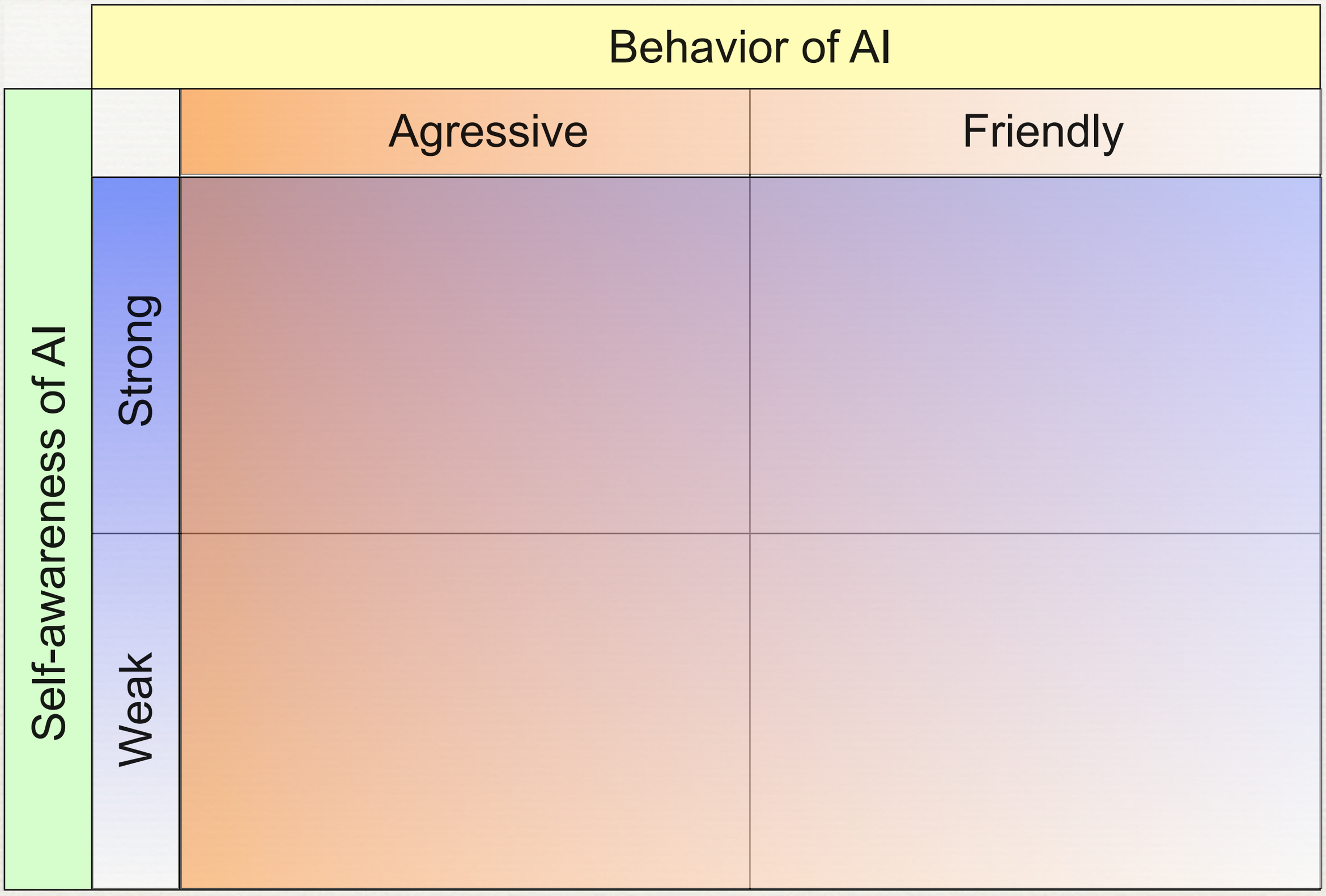
Living together ...

Living together ...

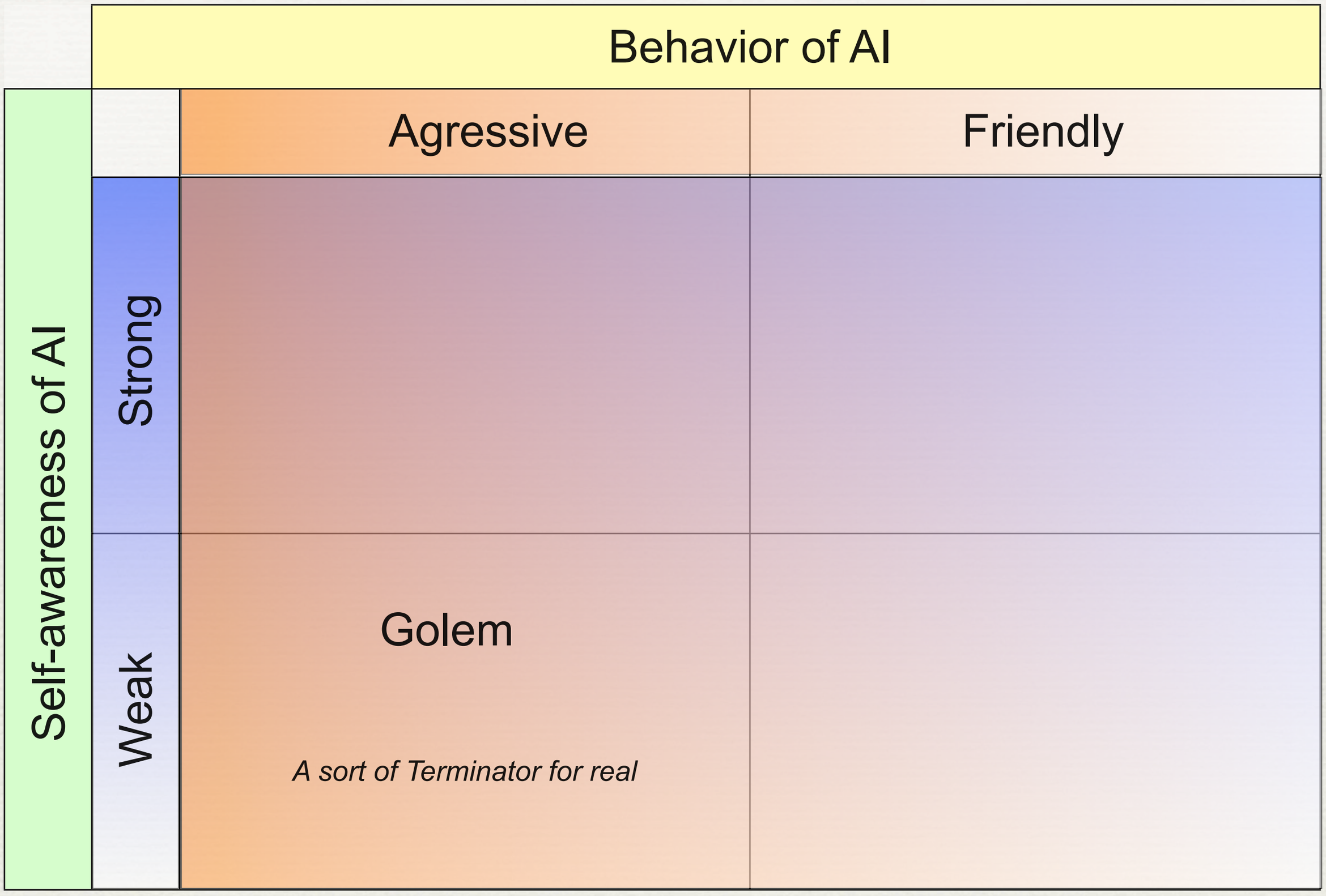
Self-awareness of AI	Behavior of AI	

G.Bisson - 2012

Living together ...



Living together ...



Living together ...

Self-awareness of AI	Behavior of AI: Agressive	Behavior of AI: Friendly
Strong	War *A well-known story for human kind but who will win this time ?*	
Weak	Golem *A sort of Terminator for real*	

Living together ...

Self-awareness of AI	Behavior of AI: Agressive	Behavior of AI: Friendly
Strong	War *A well-known story for human kind but who will win this time ?*	
Weak	Golem *A sort of Terminator for real*	Slaves *AI are the humans' servants respecting the «Three Laws of Robotics» (I. Asimov)*

Living together ...

Self-awareness of AI	Behavior of AI: Agressive	Behavior of AI: Friendly
Strong	**War** *A well-known story for human kind but who will win this time ?*	**Coevolution** *In a strong darwinian perspective we would see a coevolution between biological and artificial entities*
Weak	**Golem** *A sort of Terminator for real*	**Slaves** *AI are the humans' servants respecting the «Three Laws of Robotics» (I. Asimov)*

Some general references ...

