International Conference "Language, Metaphysics and Epistemology"

Faculty of Philosophy, University of Belgrade, 9-10 June 2016

Questions Regarding the Method?

Vladimír Marko, František Gahér

Department of Logic and Methodology of Science

Comenius University, Bratislava

Analytical Methods in Social Sciences and Humanities

Grant No. APVV-0149-12 · www.amesh.sk

Modern approach:
A method is component of the problem solving activity

- In the modern philosophical works it seems that the method is subject discussed in the context of *problem solving* (Agassi, Kuhn, Laudan, Hintikka, Nickles).
- **Laudan: „Science is essentially a problem-solving activity**.“ (*Progress and its Problems*, 1977)
- **Nickles: „The analysis of problems and of problem-solving behavior** constitutes, in my judgment, **the most promising approach to the general methodology of science today**.“ (What Is a Problem That We May Solve It?, 1981).
- **Mayer**: “Problem solving is **cognitive processing** directed at **achieving a goal** when **no solution method** is obvious to the problem solver.” (Mayer, 1992)

- Formulations emphasize that the method is particle of problem solving activity
- However, philosophical sources give us almost nothing about a structure of problem solving.

What is a problem?

- (Holyoak, 1995, p. 269): “a *problem* arises when we have **a goal** – a state of affairs that we want to achieve – and **it is not immediately apparent how the goal can be attained**”.

The most developed approach to problem solving in **philosophy of science(s) / methodology**

Problems are contradictions

- **Popper**:
  - scientific problems are largely of the character of **contradictions** between freely posited **theories** on the one hand, and **incompatible observations** or **experiments** on the other.

- **Hattiangadi**
  - a broadening of Popper's notion of a problem
  - all intellectual problems may be thought of as contradictions, and a solution as a resolution of the contradiction.
  - The new solution may give rise to new problems - new contradictions.

- **Nickles (and Battens)**
  - QA abductive approach; Q |- A & ~A;
  - “Try to **refine question** and search for **the best possible answer** (explanation)”

Some starting assumptions

(or maybe prejudices):

1. **All knowledge is propositional (or is transformable to propositional form).**

Problem 1: How problem is coded? Desires, skills, intuitions, insights, observations and perceptual knowledge, symbolical knowledge…

"Propositional tennis player"…

2. **Problem solver or agent in solving process is intentionally oriented subject.**

Problem 2: automated, semi-automated agents…
"Does mousetrap *intends* to kill a mouse?"

The theme concerning Problem Solving could be find under different names in different disciplines, from cognitive sciences, AI, practical use of knowledge in diagnostics and system management…

- General Problem Solving (GPS)
- Problem-solving Method(s) (PSM)
- Problem-solving Knowledge (PSK)
- Knowledge Base System (KBS)
- Expert Systems and Expertise Studies (ES)
- Task Analysis (TA)
- Hyerarchical Task Analysis (HTA)
- Cognitive Task Analysis (CTA)
- Task Solving Knowledge (TKS)
- Human Problem-Solving (HPS)
- …

The main aim of these disciplines is **the reuse of knowledge.**

=> probably, here we could find some kind of **generality** related to **an abstract notion of method**

A few observations:

- mostly **endemic** approach and not interrelated results;
- disciplines are **not** conceptually and terminologically synchronized.

Goal

Motivated subject of action

The CARRIER (or the subject) of problem solving

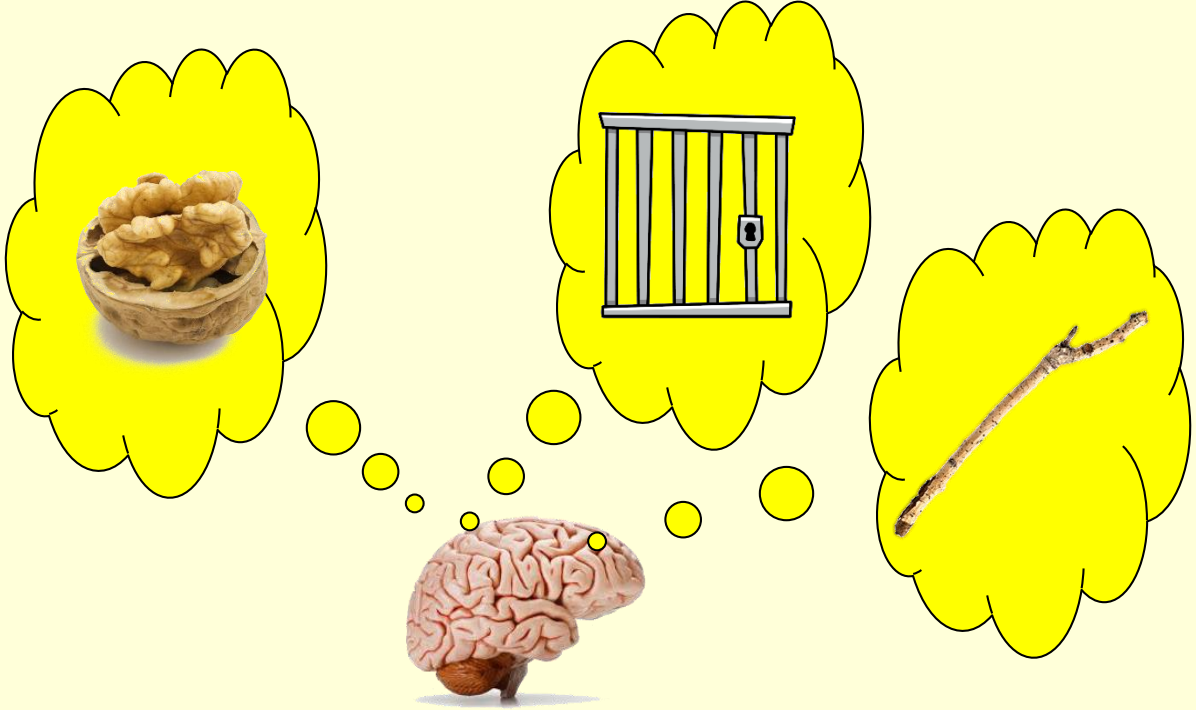
Neutral term: "Solver"

Operator or tool for putting action forward toward the problem solution

Obstacle

Rising of the problem

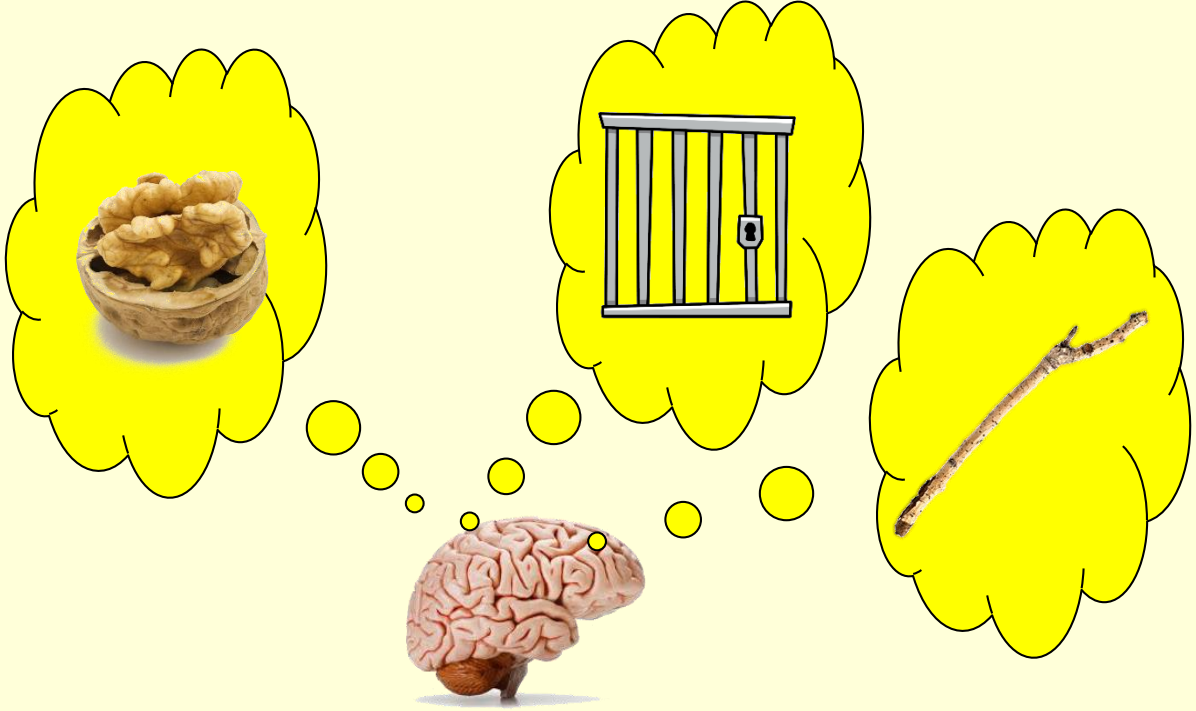
Gap in representation of obtaining the goal



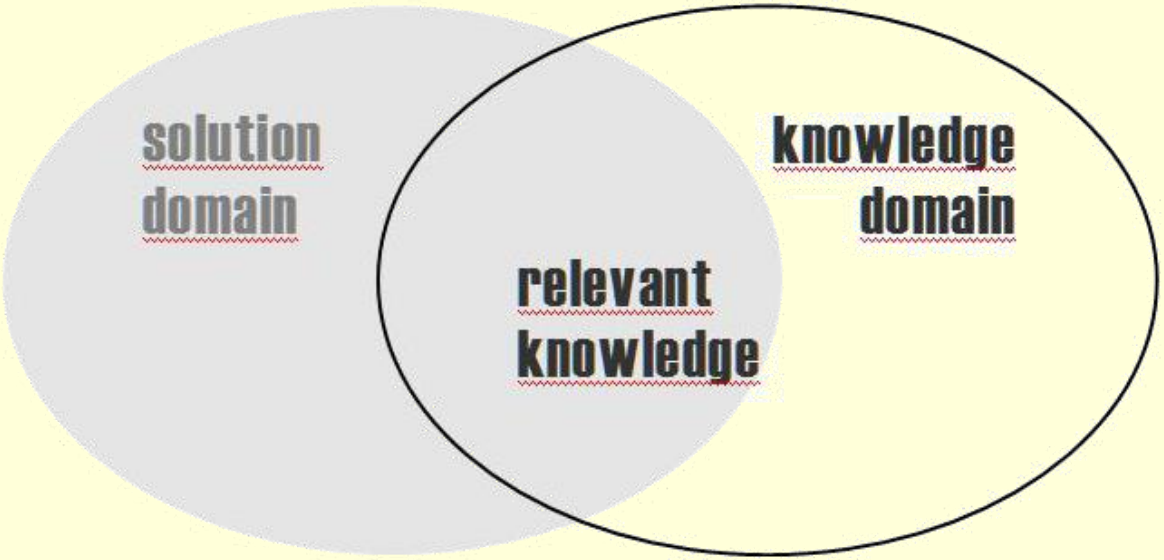
Abstract or representation level

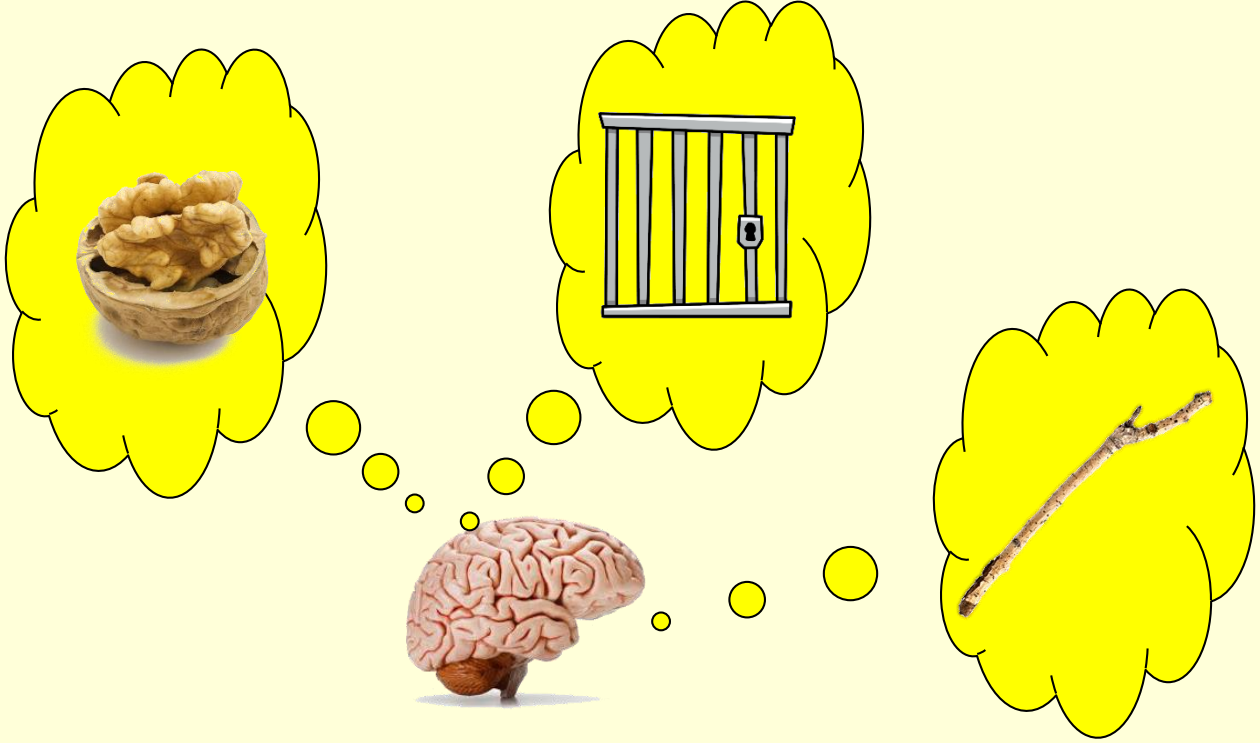
Problem space

Execution level



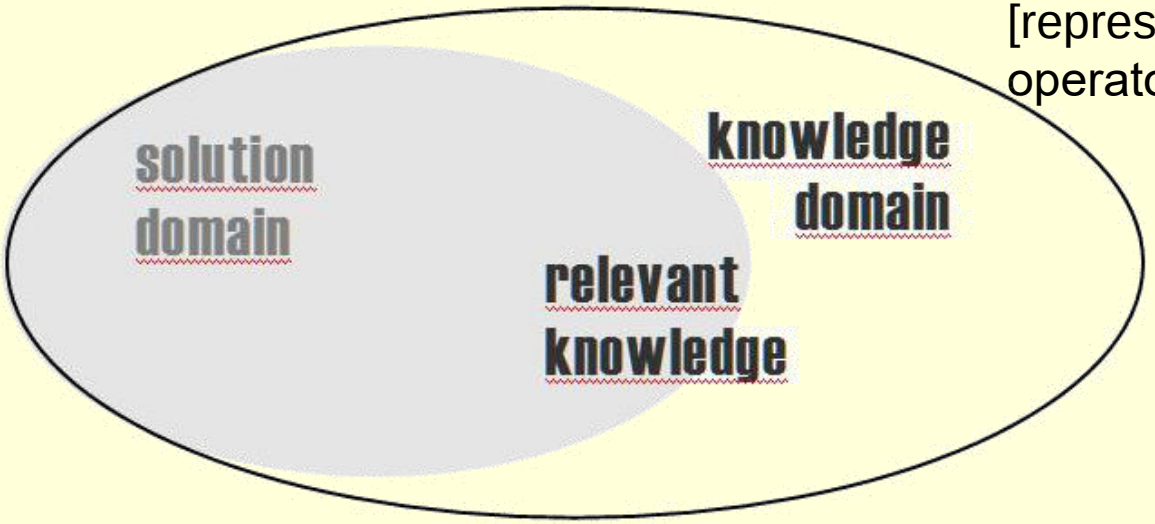
Problem space
How the problem is represented

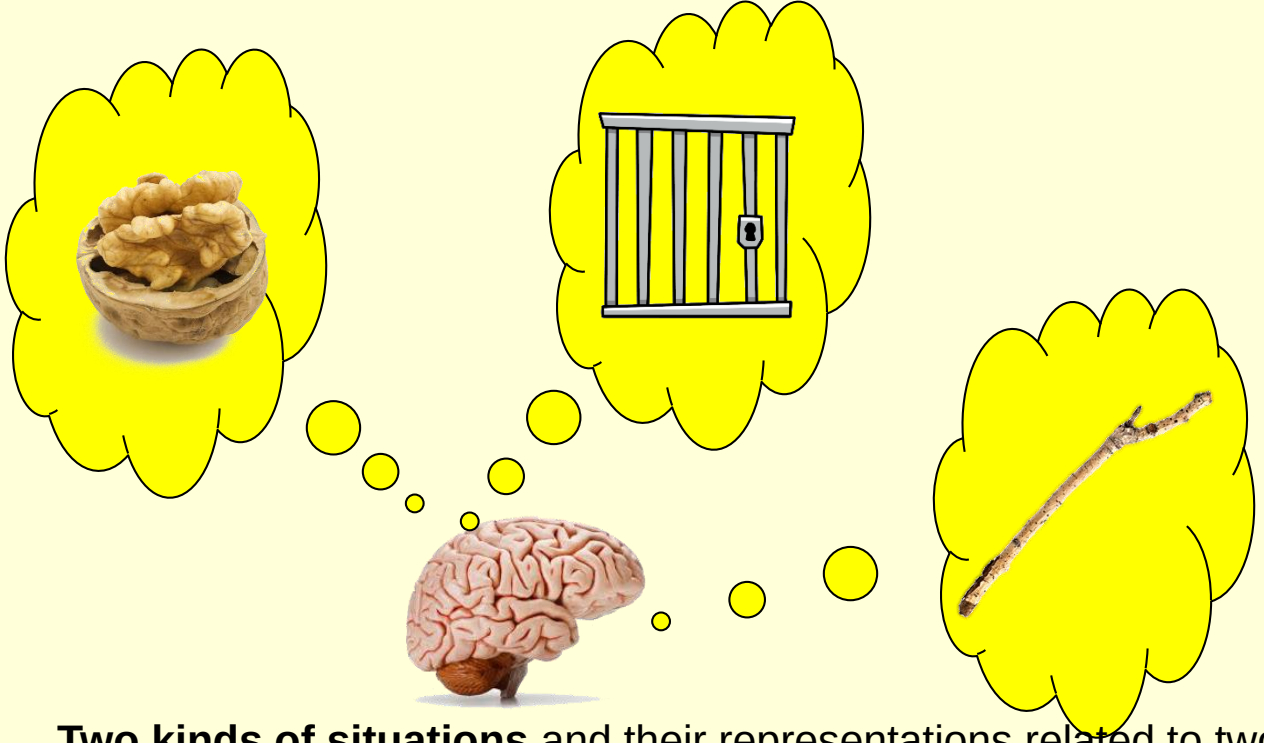




Problem space
How the problem is represented

Extending Searching space
(new evidence **or** new theory [representation, operator…]





Two kinds of situations and their representations related to two kinds of reaction to an impulse (the problem solution is intentional process!)

•Non-problematic situation

Identifying situation as known (confronting with **known obstacle** by **known means**)

Statical situation - there are no changes in background knowledge

Clear representation of the situation leads toward direct executing of the task plan

•Problematic situation

unsatisfactory gap, unknown obstacle (according to the background knowledge)

Unsatisfactory representation - problem with codification or with abridging rules

Dynamical situation – plan is developing during the process and problem representation is changing (make changes in the background knowledge)

A representation (symbolical, verbal, conceptual, visual, schematic, …) of situation is based on our background knowledge

Well-defined problem – known obstacle
adequate representation of the problem space → **task**

Ill-defined problem - unknown obstacle

- unsatisfactory representation of the problem space (sometimes unclear goal)
- problem with **codification** or with abridging **rules** (**new evidence** or revising **constrains**)
- searching space strategies (recursive, heuristics, analogy, abduction, …)

For a problem representation solver needs two kind of knowledge :

- **Declarative knowledge** (*knowing 'that'*, labeling the evidence)
- **Procedural knowledge** (*knowing 'how',* relating the problem particles)

Solving process:

1. **Analysis of situation**
    - **Identification** of situation particles (coding the situation), attributing the labels to problem objects and observations; descriptive level
    - **Searching** the solution that abridges (at least) two states – current and intended, searching for adequate **rules that relates two states;** reducing complex problem to **sub-problems**
    - Developing **a plan** of execution – putting together and chaining rules, inference process that transforms problematic to non-problematic situation (transforms problem to task)

2. **Executing the plan** (.exe of abstractly represented a procedure of task solving)

Wang & Chiew model of Problem Solving Process:

Definition 1. A *problem space* or *solution space*

$$(1) \qquad \Theta = \mathcal{X} \times \mathcal{P} \times \mathcal{G}$$

a nonempty set of **problem objects** $\mathcal{X}$,
a nonempty set of **paths** $\mathcal{P}$, and
a nonempty set of **goals** $\mathcal{G}$.

Definition 2. Assuming the layout of **a problem solving process** is **a function** f: X → ... →Y on Θ,

the problem *p* is the domain of f, X, in general, and a specific instance x, $x \in X$, in particular, i.e.:

$$(2) \qquad p = (\, X \mid f : X \rightarrow \ldots \rightarrow Y);\ p \in \mathcal{X}$$

Definition 3. **Problem solving** is an activity (a process) of searching or inferring a solution for a given problem in the form of ***a set of paths*** ($\mathcal{P}$) to reach a set of expected goals ($\mathcal{G}$).

Definition 4. ***A goal*** *G* in problem solving is **the terminal result *Y*** of satisfactory in the solution space of the problem p, which deduces X to Y by a sequence of inference in finite steps, i.e.:

$$(3)\ G = (\, Y \mid X \rightarrow \ldots \rightarrow Y),\ G \in \mathcal{G}$$

Definition 5. ***A path*** *P* in problem solving on Θ is a 3-tuple with a nonempty finite set of problem inputs *X*, a nonempty finite *set of traces* *T*, and a nonempty finite set of *goals* *G*, i.e.:

$$(4) \qquad P = (X, T, G) = X \times T \times G$$

where the *a trace* $t \in T$ is an internal node or subpath, t: $Xt \rightarrow Yt$, that maps an intermediate subproblem Xt to a subgoal Yt.

Two categories of problems in problem solving (according to Definitions 1–5):

(a) *the convergent problem* where *the goal of problem solving is given*, but the path of problem solving is unknown; and

(b) *the divergent problem* where *the goal of problem solving is unknown* and the path of problem solving are either known or unknown.

Definition 6. A *solution s* to a given problem *p* on Θ is an instance of a set of selected relation or function, *S*, which is **a subset of the solution paths in *P***, i.e.:

$$s \in S$$

$$S = (X, T, G) \subseteq P;\ X, T, G \neq 0$$

In case $\#X = 0$, $\#G = 0$, or $\#T = 0$, there is no solution for the given problem. For a convergent problem, i.e. $\#G \equiv 1$, the number of possible solutions is

$$\#X \bullet \#T.$$

- For our purposes we need to somewhat refine above Wang & Chiew model. Why?

There is **no explicit**:

- demarcation between procedural and descriptive knowledge (Ryle: knowing ‘that’; knowing ‘how’)
- VM: $\mathcal{X}$ above is a composite part of problem space
- demarcation of **the problem space** and **solution space** – it suggests recursive way of space searching and all possible solutions, so we need:
- demarcation of the relevant as part of complete knowledge
- Reasons for refinement additions:
  - saving of capacities, time and memory consumption;
  - transparency of explanatory reasons

This **calculation model is incomplete** – it shows us only size of the problem in respect to **all possible solutions** – no one is solving the problem in respect to all possible solutions

Solver		
Background knowledge (K)		
non-explicit	explicit	
	declarative (K-D)	procedural (K-Pr)
visual, motoric, capacities, etc.	Concepts, definitions, declarative propositions that are T $\vee$ F; awareness of surroundings and capacities	Rules, schemas, structures, macros, “matrix space”…

Relevant knowledge (K-Rel)
In the case of **problem** rising: K-Rel $\not\subset$ K
In the case of **task**: K-Rel $\subset$ K

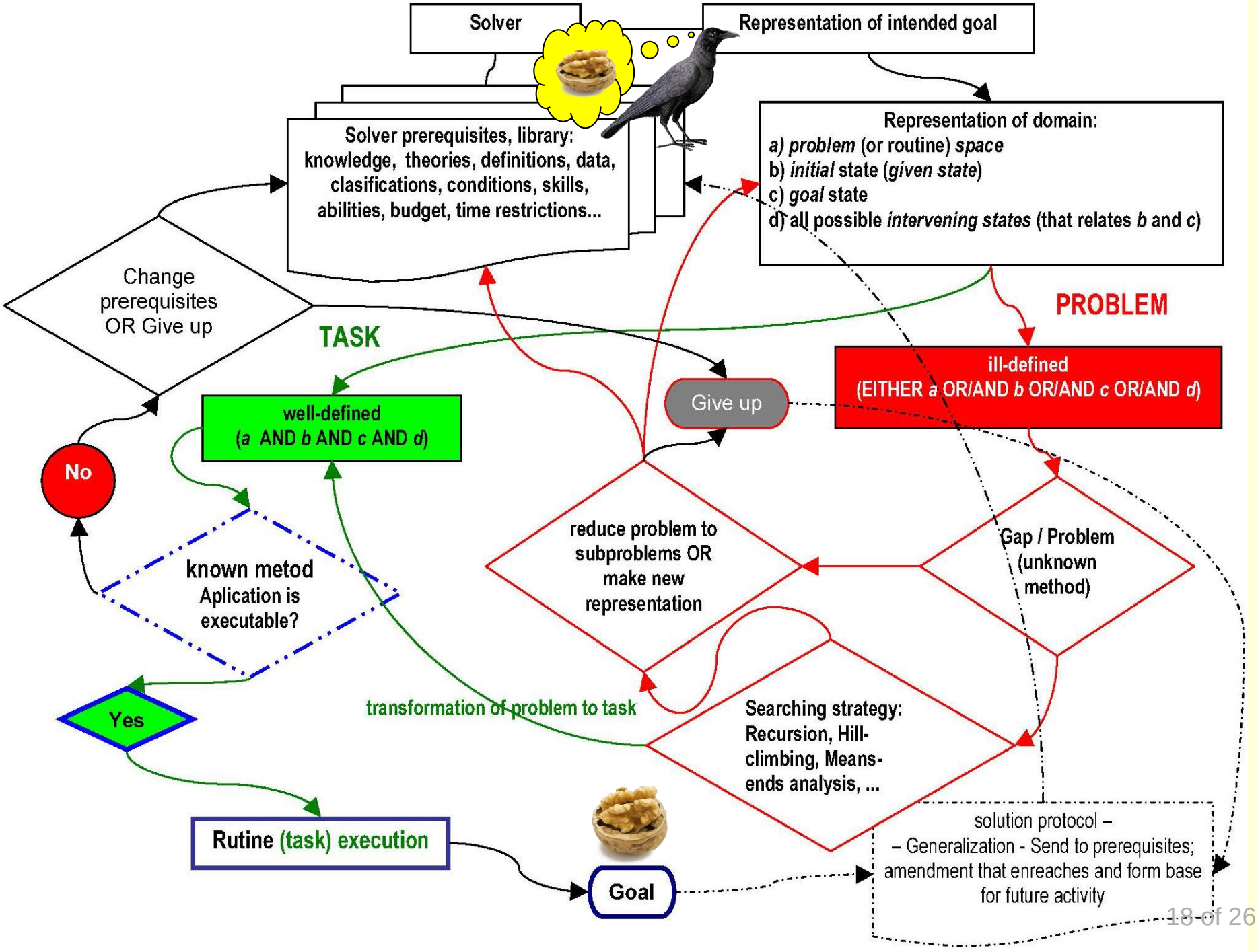
Some S.’s assumptions:
- **Represented goal (G);**
- **intentions, decisions, preferences** (**D**);
- **beliefs (B):** a gain is attainable

Problem solving process managing

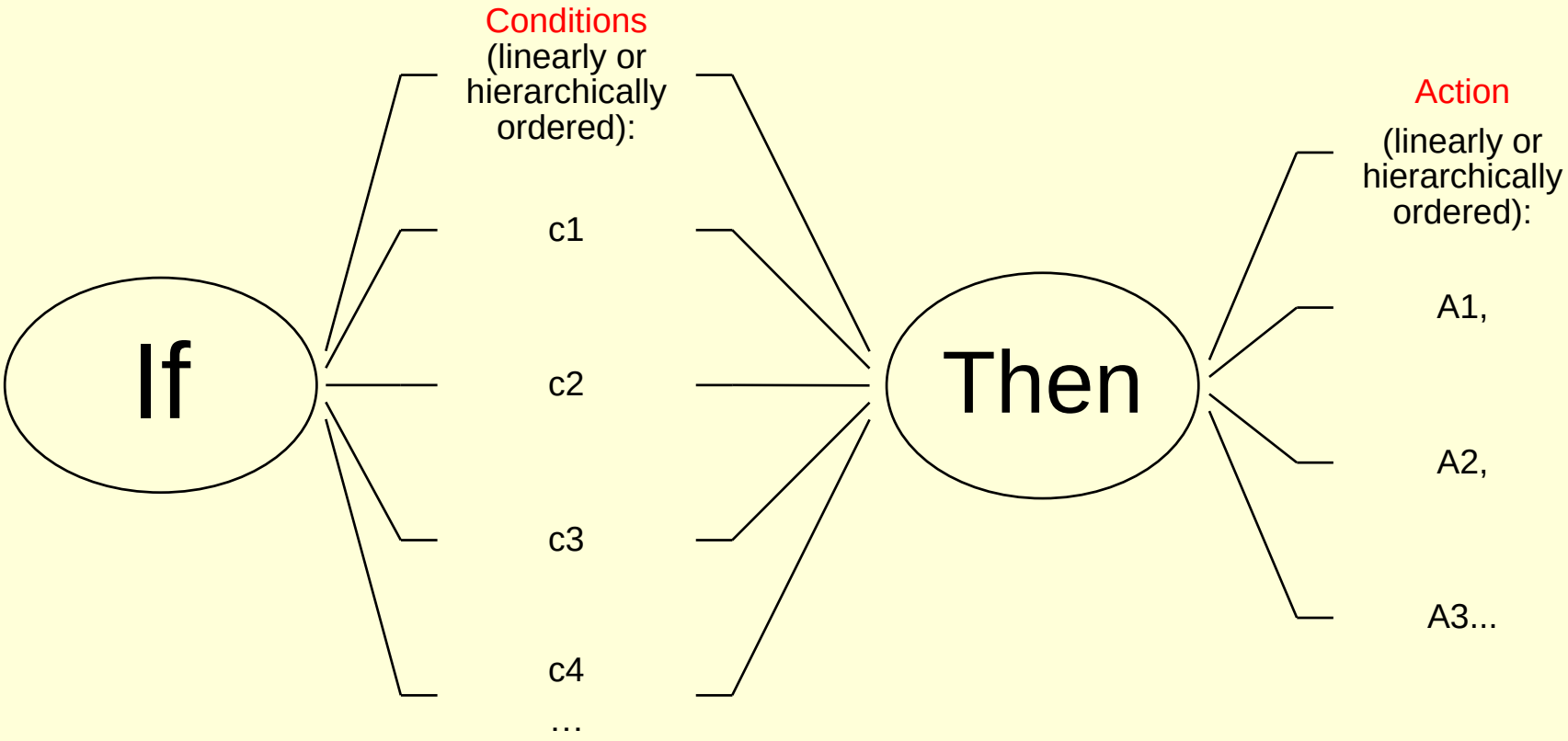
Background knowledge K (K-D & K-Pr)

Representation of goal (G), intention, decision, preferences (**D**) and **beliefs (B)**, that gain is attainable

representation, abstract levels, meta-domain				**grounded domain**	
analysis			**planning**		
t_1	t_2	t_3	t_4	t_5	t_6
problem	**unsatisfactory gap**		**task (hypothesis)**	**Task execution**	**Goal**
observation, identification and coding of elements of observation (K-D); rule of space transition is not part of knowledge, K-Pr $\not\subset$ K	problem space analysis **"Searching". Decomposition**; analysis of **conditions** + searching of appropriate **structures** (K-D + K-Pr); heuristics, reorganizing of knowledge, etc. Simon: "search in matrix space"	Problem space analysis **"Finding"** of relevant problem structure &/or Relevant conditions of rule (K-Pr)	**New representation**; **Well-defined problem** Transformation of problem to task	**Application of rule** or **fulfilling conditions** for rule application **Hypothesis testing**	**Outcome of application, valuation**
a shortage of relevant knowledge; relevant knowledge (K-Rel) is not part (subset) of knowledge (K): K-Rel $\not\subset$ K			relevant knowledge K-Rel is a subset of K; K-Rel $\subset$ K		

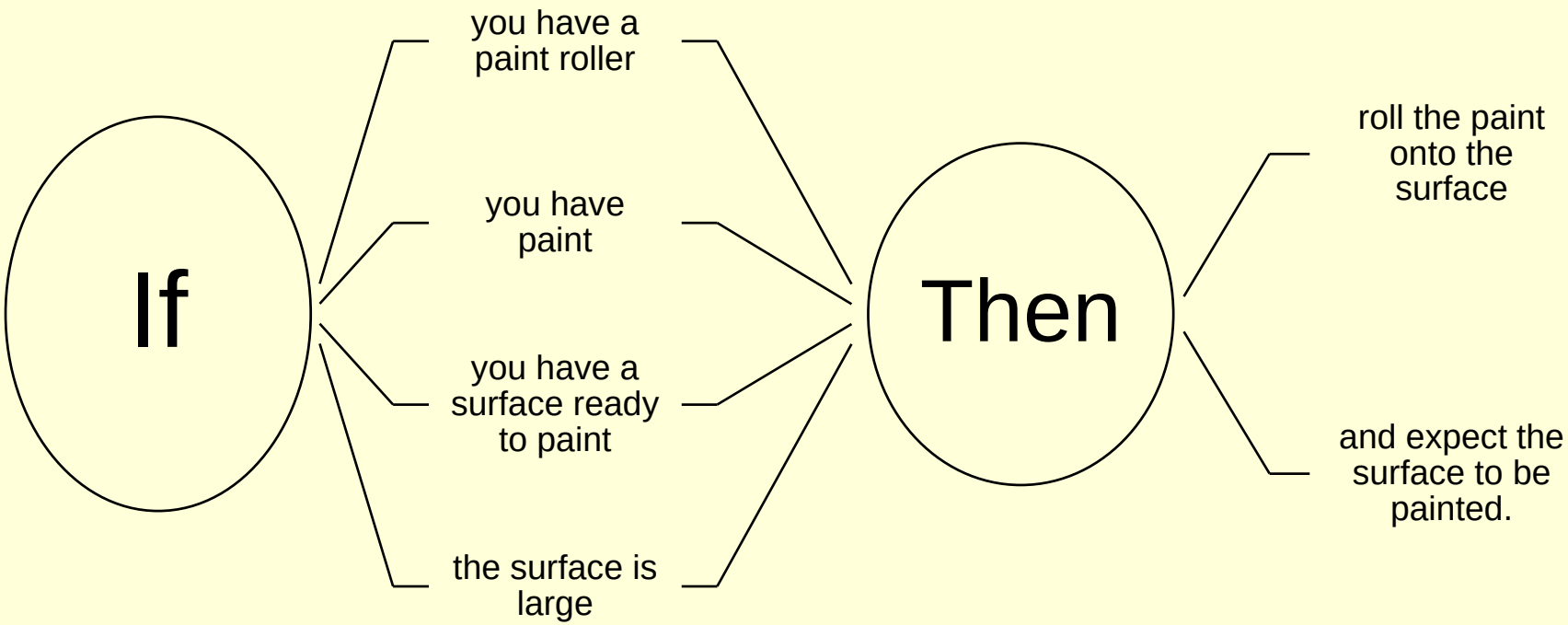

Solver
Representation of intended goal
Solver prerequisites, library: knowledge, theories, definitions, data, clasifications, conditions, skills, abilities, budget, time restrictions...
Representation of domain:
a) problem (or routine) space
b) initial state (given state)
c) goal state
d) all possible intervening states (that relates b and c)
Change prerequisites OR Give up
TASK
PROBLEM
ill-defined (EITHER a OR/AND b OR/AND c OR/AND d)
Give up
well-defined (a AND b AND c AND d)
No
known metod Aplication is executable?
reduce problem to subproblems OR make new representation
Gap / Problem (unknown method)
Yes
transformation of problem to task
Searching strategy: Recursion, Hill-climbing, Means-ends analysis, ...
Rutine (task) execution
Goal
solution protocol – – Generalization - Send to prerequisites; amendment that enreaches and form base for future activity

Production rule*
if conditions *then* action



*Set of *production rules* leads to *production system*

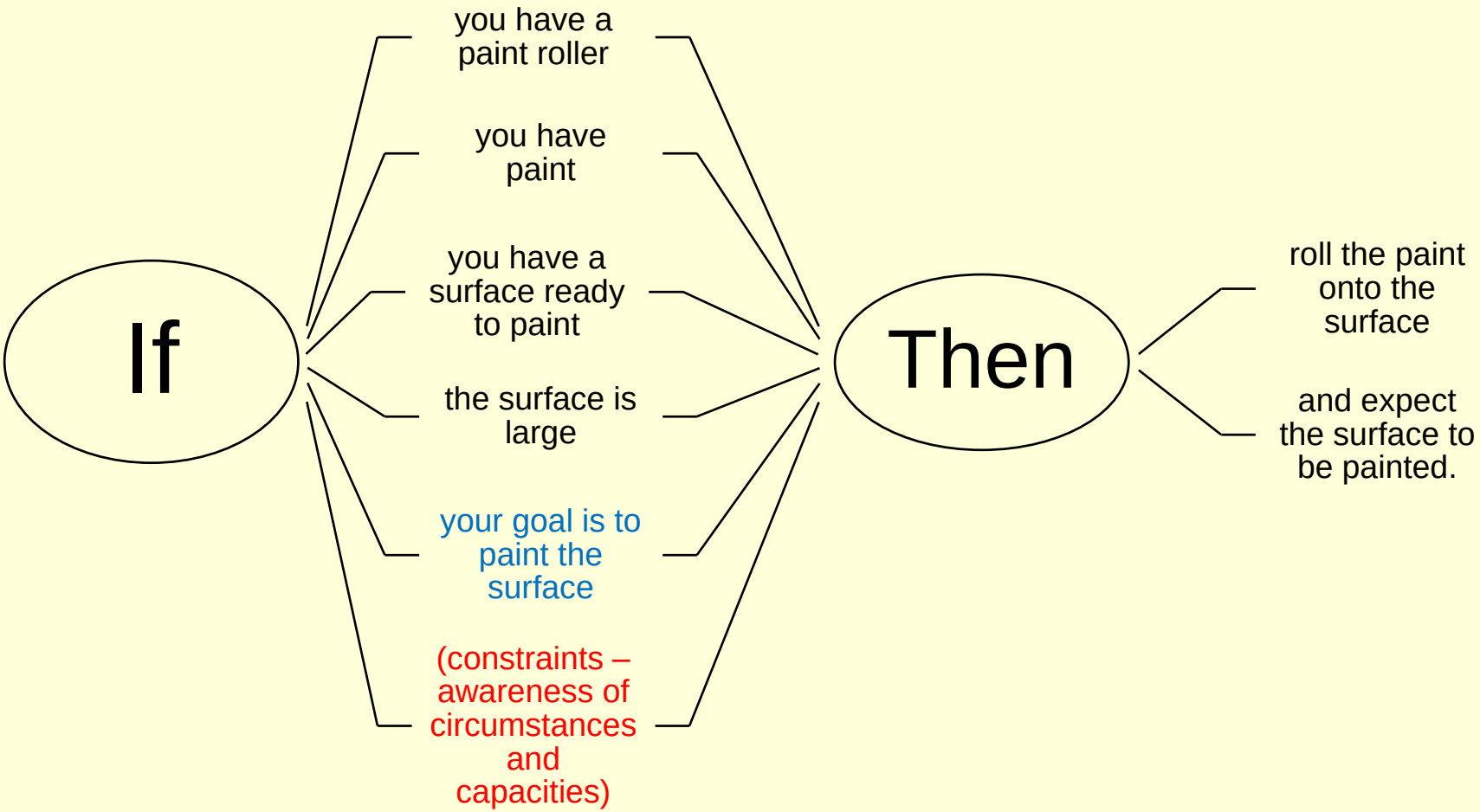
Production rules (production system)
if conditions *then* action



Production rules (production system)

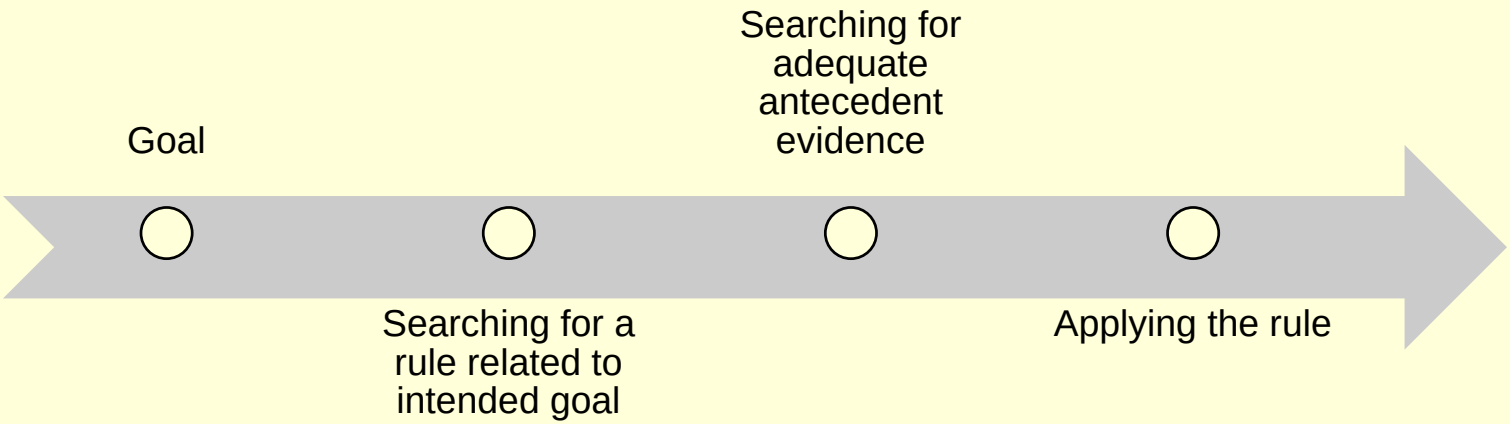
if conditions *then* action

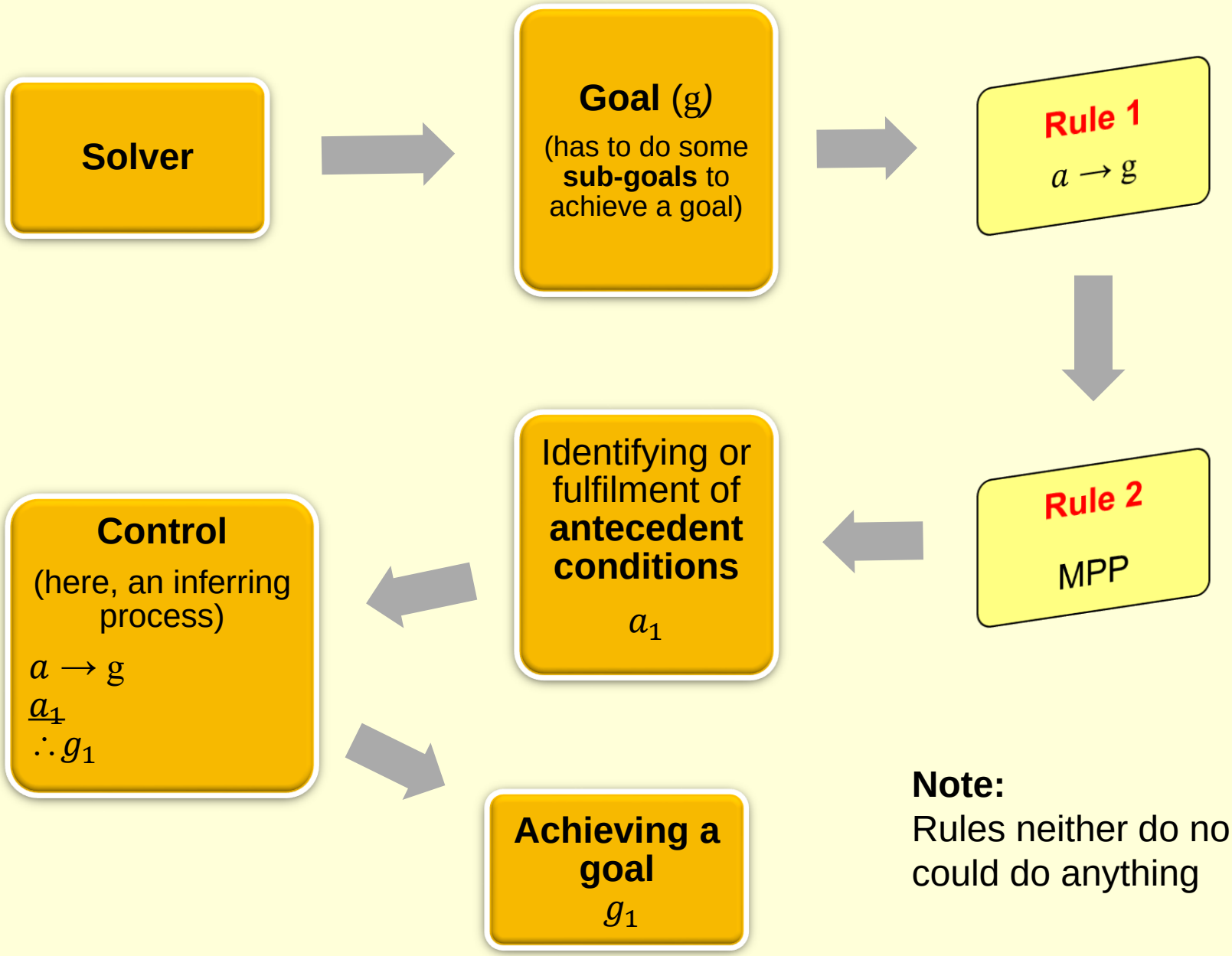
Problem solving is a type of *activity*



Abstraction and generalization

- Rules has form of generality and it claims a relation between/among some concepts. **Rule** ([natural] law, function, schema, matrix,…) alone, is **not a method for itself.**
  - Rules does not performs tasks
  - Rules has no own tasks
  - Rule cannot control own execution
  - Tasks, since they are indexed by goals, are always task of someone
- However, it could be used as a kernel of method and be **in function** of a method.
- Method is always **indexed** by **goal** and **carrier** of intended goal, it means
- **Agent** (goal + awareness of capacities and circumstances + ability of control) **+ rule + application of rule (controlling, kind of activity)**





Note:
Rules neither do nor could do anything

Abstraction and generalization

- **Generic method**:
  - a sketch of activity structure (“production rule”, procedure)
  - Different antecedent conditions determines different tools
  - Universal (abstract) method should cover disjunction of all conditions and related all tools?
  - typical aims requiring fulfilment of some typical antecedent conditions

- **Generalized method**: chained *generic methods* (procedures)

Kinds of methods in respect to level of their articulation (and reliability):

- **Layman**, folk method
- **Licensing** method (manual, expert experience, medicament prescription); it appeals to some authority
- **Scientific** method, full-fledged, capacity of scientific explanation

Summary: Task vs. Problem

- Agent is “performing a task” using some method
- “Method is way of performing a task” (on abstract and executive level)

- Agent is “solving a problem” by searching for (an unobvious) method
- If there is a problem there is no present an adequate method

- Solving a problem means to conceptually transform problem to a task and to perform a task by a solver

Thanks for Your attention