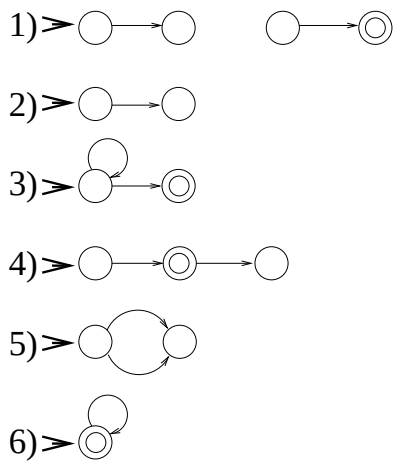
Computation, Information, and Intelligence (COMS/ENGRI/INFO/COGST 172), Fall 2005
8/31/05: **Lecture aid — Implicit Specifications**

Agenda: further discussion of general problem-space specifications; understanding how to give an implicit specification; reducing the size of problem space

Follow-up to last time: I should 'fess up about glossing over some issues when we discussed whether the farmer is "allowed" to begin by taking the wolf across the river, leaving the goat and hay un-chaperoned on the left bank. Summary: *In this case*, it is reasonable to interpret/translate the problem statement as disallowing the action (as many students seemed to), because the English statement was vague on this point. Some reasons I presented a specification containing states like "GH=FW" were to (a) show that dead states are allowed in specifications, and (b) exemplify the effort trade-off in deciding whether to remove them.[1]

Legal problem-space structures?



The course-requirements problem You are a student without any advanced-placement credit entering a very small Engineering college in the Fall. This semester's course roster is as follows:

Time	Courses available
9 MTWRF	ENGRI 111, MATH 171, MATH 191
10 MTWRF	CHEM 207, ENGRI 172
11 MTWRF	CHEM 211, MATH 191, MATH 192
12 MTWRF	ART 151, FWS 270, PHYS 116

Your goal is to fulfill college requirements by taking an ENGRI, a science class, and a math class by the end of the semester. You may not register for two class sections that meet at the same time. We assume that the category of each class (e.g., PHYS 116 is a science class) is known to the problem solver.

[1]The long story is: (1) *in general*, one shouldn't make assumptions that are not explicitly given in an English problem statement, because you might not know what the person who posed the problem really had in mind. (2) On the other hand, I admit that if one follows this logic to its end, one would also include states like "G=FW". But modeling transitions then involves issues that are out of the scope of this course, so I silently passed over this possibility.

(OVER)

Implicit specification #1. Explanations and motivations for each choice have been omitted for space. *Specifications you give on homeworks and exams must include this information.* Italics denote variables.

A. States: all possible "checklists" of the form [engri: x_{engri}; science: $x_{science}$; math: x_{math}; other: x_{other}] where

- each x_i is either a blank ("—") or a list of items of the form $course(time)$ such that $course$ is a class of type i that meets at time $time$;
- (no-conflict constraint) No time appears more than once among all the x_is; and
- (ordering constraint) if x_i lists multiple courses, they are listed alphabetically and then by ascending numerical order and then by ascending course-meeting time.

B. Initial state: [engri: —; science: —; math: —; other: —].

C. Goal states: those of the form [engri: x_{engri}; science: $x_{science}$; math: x_{math}; other: x_{other}] such that none of x_{engri}, $x_{science}$, or x_{math} has the value "—".

D. Actions: all pairs of the form $\langle course, time\rangle$ where $course$ is a class meeting at time $time$.

An action $\langle course, time\rangle$ applies to any state [engri: x_{engri}; science: $x_{science}$; math: x_{math}; other: x_{other}]. such that none of the x_i's lists a course time of time $time$. If the class $course$ is of type i, then the result of applying $\langle course, time\rangle$ to an applicable state is to transition to the state in which the pair $course(time)$ has been added to the appropriate location in the list x_i as specified by the state-set definition above. (Of course, if x_i is blank, then the new state has the blank replaced by $course(time)$.)

Implicit specification #2. Italics denote variables. This specification exhibits the minimum level of explanations and descriptions of motivation that we require of you.

A. The set of states consists of checklists of the form

$$[\text{engri: } x_{engri}; \text{ science: } x_{science}; \text{ math: } x_{math}; 9\text{: } t_9; 10\text{: } t_{10}; 11\text{: } t_{11}; 12\text{: } t_{12}]$$

where each x_i and t_i is either "—" or "✓". The intent is that $x_i = ✓$ if and only if a course of type i has been scheduled, and that $t_j = ✓$ if and only if a section that meets at time j has been scheduled.

B. The initial state is [engri: —; science: —; math: —; 9: —; 10: —; 11: —; 12: —].

C. The set of goal states is the set of states of the form [engri: ✓; science: ✓; math: ✓; 9: t_9; 10: t_{10}; 11: t_{11}; 12: t_{12}] where the t_i's can have any legal value.[2]

D. The set of actions corresponds to all pairs of the form $\langle course, time\rangle$ where $course$ is a class that meets at time $time$.

[2]It will turn out that some of our goal states, such as [engri: ✓; science: ✓; math: ✓; 9: —; 10: —; 11: —; 12: —], are unreachable, but nothing in the definition of problem-space specification requires the reachability of all, or even any, of the goal states.

An action $\langle course, time \rangle$ applies to any state [engri: x_{engri}; science: $x_{science}$; math: x_{math}; 9: t_9; 10: t_{10}; 11: t_{11}; 12: t_{12}] such that $t_{time} =$ —; that is, we disallow time conflicts, as required. The result of applying $\langle course, time \rangle$ to such a state is to transition to the state in which t_{time} has been changed from — to ✓, and, if $course$ is a class of requirement type i such that x_i is blank, then x_i in the new state is changed to ✓.