Computation, Information, and Intelligence (ENGRI/CS/INFO/COGST 172), Spring 2007
1/26/07: **Lecture aid — Implicit specifications**

Agenda: finish discussion of benefits of complete specifications; implicit specifications; examples of the impact of making different design choices
Announcements: Reminder: Non-freshmen, please remember to fill out/drop off permission applications after class (students without permission will be dropped from the roster).

I. The "15 from 3" game (from Donald Michie, *Machine Intelligence and Related Topics: An Information Scientist's Weekend Book*, 1982) Start with 9 cards clearly labeled 1, 2, . . ., 9 on a table. Players take turns taking a card. The first player whose hand contains some set of three numbers adding up to 15 wins.

II. A version of the "$3x + 1$" (Collatz) problem [1] Here is an *implicit* specification.

A. States: all whole numbers

B. Initial state: 0

C. Goal state: 1

D. Actions: all operations taking one of the following forms, where x is always a positive whole number.

- "transition from 0 to x"
- "transition from x to $x/2$" where x is even
- "transition from x to $3x + 1$" where x is odd

III. The course-requirements problem You are a student without any advanced-placement credit entering a very small Engineering college. 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 (single) category of each class (e.g., PHYS 116 is a science class) is known to the problem solver.

[1] For more information, see Jeffrey C. Legarias's active bibliography, http://arxiv.org/abs/math.NT/0608208

(OVER)

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

A. States: all "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 all checklists of the form

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

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

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 $time$.

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 ✓.