# 1 Baseball Training Scheduling

You are in charge of scheduling for baseball teams that are going to practice on the next Tuesday, Thursday and Friday. There are six vacant stadiums on these days, and four teams are going to practice on those stadiums. You are constrained by the fact that each team can only practice at one stadium at a time. Let's assume each team has a private jet that can take them from each city to another city in no time.

The stadiums are:

1. $AT\&T\,Park$: available from 8:00 am - 10:00 am
2. $Fenway\,Park$: available from 9:00 am - 10:30 am
3. $Nationals\,Park$: available from 10:00 am - 12:00 pm
4. $Safeco\,Field$: available from 11:00 am - 1:00 pm
5. $YankeeStadium$: available from 12:30 pm - 1:30 pm
6. $Wrigley\,Field$: available from 12:00 pm - 2:00 pm

The teams are:

1. San Francisco Giants: comfortable practicing in the stadiums 1, 4, 5.
2. Boston Red Sox: comfortable practicing in the stadiums 2, 5, 6.
3. New York Yankees: comfortable practicing in the stadiums 5, 2, 3.
4. Washington Nationals: comfortable practicing in the stadiums 3, 1, 4.

**1.** Formulate this problem as a CSP problem in which there is one variable per stadiums, stating the domains, and constraints. Constraints should be specified formally and precisely, but may be implicit rather than explicit.

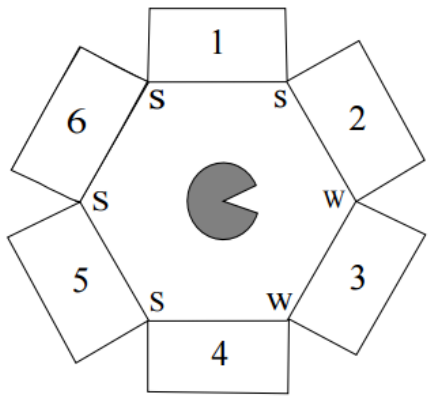
**2.** Draw the constraint graph associated with your CSP.

**3.** Your CSP should look nearly tree-structured. Briefly explain (one sentence or less) why we might prefer to solve tree-structured CSPs.

## 2 Trapped Pacman

Pacman needs your help! Poor guy is surrounded by mysterious corridors, each of which leads to either a pit (P), a ghost (G), or an exit (E). In order to escape, he needs to figure out which corridors, if any, lead to an exit and freedom, rather than the certain doom of a pit or a ghost.

The one sign of what lies behind the corridors is the wind: a pit produces a strong breeze (S) and an exit produces a weak breeze (W), while a ghost doesnt produce any breeze at all. Unfortunately, Pacman can't measure the strength of the breeze at a specific corridor. Instead, he can stand between two adjacent corridors and feel the max of the two breezes. For example, if he stands between a pit and an exit he will sense a strong(S) breeze, while if he stands between an exit and a ghost, he will sense a weak (W) breeze. The measurements for all intersections are shown in the figure below.




Also, while the total number of exits might be zero, one, or more, Pacman knows that two neighboring squares will not both be exits. He models this problem using variables $X_i$ for each corridor $i$ and domains $P$, $G$, and $E$.

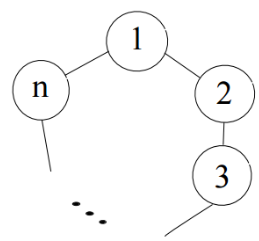
**4.** State the binary and/or unary constraints for this CSP (either implicitly or explicitly).

**5.** Cross out the values from the domains of the variables that will be deleted in enforcing arc consistency.

| | | | |
|---|---|---|---|
| $X_1$ | P | G | E |
| $X_2$ | P | G | E |
| $X_3$ | P | G | E |
| $X_4$ | P | G | E |
| $X_5$ | P | G | E |
| $X_6$ | P | G | E |

**6.** According to MRV, which variable or variables could the solver assign first?

**7.** Assume that Pacman knows that $X_6$ = P. List all the solutions of this CSP or write none if no solutions exist.




**8.** The CSP described above has a circular structure with 6 variables. Now consider a CSP forming a circular structure that has n variables (n ¿ 2), as shown below. Also assume that the domain of each variable has cardinality d. Explain precisely how to solve this general class of circle-structured CSPs efficiently (i.e. in time linear in the number of variables), using methods covered in class. Your answer should be at most two sentences.

**9.** If standard backtracking search were run on a circle-structured graph, enforcing arc consistency at every step, what, if anything, can be said about the worst-case backtracking behavior (e.g. number of times the search could backtrack)?