Parallelism in Nature - Thinking in Parallel

Goal:

This lesson gives students an opportunity to think and write about the parallelism that is inherent in nature, and to think and write about how parallel computing can be used to model that inherent parallelism.

Materials:

- Computers connected to the Internet, 1 per student, and 1 for the instructor.
- Websites with computational models, e.g.:
  - http://shodor.org/~aweeden
  - http://shodor.org/interactivate/activities/
  - Students' AgentCubesOnline and JavaScript projects
- Parallel Computing Notebook, 1 per student.

Activity:

1. Start with a discussion of parallelism in nature using a science example (e.g. stars in a galaxy interacting gravitationally). Identify the numerous objects that exist at the same time (e.g. stars) and the various behaviors of those objects that happen at the same time (e.g. movement - each star changes its acceleration based on forces from all the other stars, then changes its velocity based on its acceleration, then changes its position based on its velocity).
2. Introduce the concepts of **data** and **task** - the data are the different objects (or agents) that exist at the same time. The tasks are the behaviors of those objects/agents. Some data can exist in parallel, others cannot (e.g. an ice cube and a pool of water from the same melted ice cube cannot exist at the same time). Some tasks can happen in parallel; others cannot (e.g. a person cannot become sick and immune at the same time).
3. Introduce the concept of **parallel computing** - multiple computers interacting to solve the same problem at the same time. You can split up the problem among multiple computers, with each computer doing part of the work to solve the problem.
4. Identify how the example of parallelism in nature could be simulated using multiple computers, e.g. each computer can simulate a single star. Identify which data and tasks can be parallel, e.g. stars and the changes in position/velocity for each star. Identify which data and tasks cannot be parallel, e.g. there is only one galaxy; the position of a star in 10 time steps cannot be determined before knowing its position now.
5. Each student goes through the examples on the websites with computational models and writes out:
   - What data exist for the model
   - What tasks exist for the model
   - Which data can be parallel, and which cannot
   - Which tasks can be parallel, and which cannot

6. The class discusses the findings; students volunteer to read what they have written, and the instructors leads a discussion about how each model could be simulated on a parallel computer.

Questions to answer in your Parallel Computing Notebook:

1. What patterns do you notice in the types of data and tasks that can be parallel?
2. What patterns do you notice in the types of data and tasks that cannot be parallel?