GEMS Challenges—Sorting Networks

SUBJECT	**Suggested grades**	**Cautions / concerns**
Computer Science	3-12	You need outdoor or gym space. Or even a hallway.

The Challenge—Understand how computers sort data and information quickly

	LEADER ACTIONS	**GIRL ACTIONS**
INTRODUCTION	Present the challenge—computers sort data all the time—to make looking things up fast, to process data, to merge information. How do they do that?	Brainstorm options
BACKGROUND INFORMATION	Review as much of the Intro to Sorting document as you think you may need.	Think and talk about sorting
ACTIVITY	Follow the directions in the attached CS Unplugged Activity. Save time to try the optional networks so that it is not so clear cut.	Sort yourself according to the instructions.
CONCLUSION	Review why computers need to be able to sort. There are many kinds of sorting, which you won't have time for but need to be aware of.	
REFLECTION	Have 2-3 girls choose a reflection card and talk about her thoughts on this activity.	

Supplies

- Chalk or tape to mark squares and paths on floor.
- Cards on lesson plan—printed or hand-written
- Stopwatch or timer

Preparation needed

- Mark out sorting network on the large space—gym floor or playground
- Print or make cards
- Read over the activity from CS Unplugged and try it out.

Comments

This is a new and abstract concept for most girls. Be prepared to go over it several times, and come back to it later in the year to see if they have found examples.

CSunplugged.org

Activity 8

Beat the Clock—*Sorting Networks*

Summary

Even though computers are fast, there is a limit to how quickly they can solve problems. One way to speed things up is to use several computers to solve different parts of a problem. In this activity we use sorting networks which do several sorting comparisons at the same time.

Curriculum Links

- ✓ Mathematics: Number level 2 and up. Exploring number: Greater than, less than

Skills

- ✓ Comparing
- ✓ Ordering
- ✓ Developing algorithms
- ✓ Co-operative problem solving

Ages

- ✓ 7 years and up

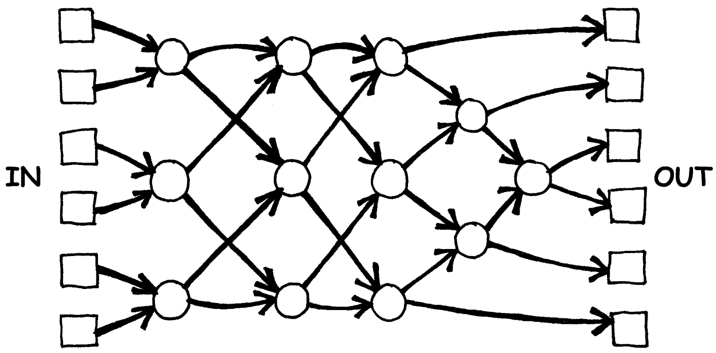
Materials

This is an outdoor group activity.

- ✓ Chalk
- ✓ Two sets of six cards.
  Copy Photocopy Master: Sorting networks (page 73) onto card and cut out
- ✓ Stopwatch

Sorting Networks

Prior to the activity use chalk to mark out this network on a court.

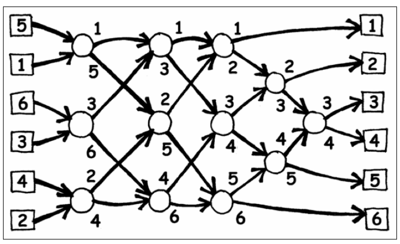


Instructions for Children

This activity will show you how computers sort random numbers into order using a thing called a sorting network.

1. Organise yourselves into groups of six. Only one team uses the network at a time.
2. Each team member takes a numbered card.
3. Each member stands in a square on the left hand (IN) side of the court. Your numbers should be in jumbled order.
4. You move along the lines marked, and when you reach a circle **you must wait for someone else to arrive.**
5. When another team member arrives in your circle compare your cards. The person with the smaller number takes the exit to their left. If you have the higher number on your card take the right exit.
6. Are you in the right order when you get to the other end of the court?

If a team makes an error the children must start again. Check that you have understood the operation of a node (circle) in the network, where the smaller value goes left and the other goes right. For example:



Photocopy Master: Sorting networks

1	2
3	4
5	6

156	221
289	314
422	499

Variations

1. When the children are familiar with the activity use a stopwatch to time how long each team takes to get through the network.

2. Use cards with larger numbers (e.g. the three-digit ones in the photocopy master).

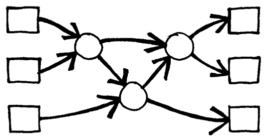
3. Make up cards with even larger numbers that will take some effort to compare, or use words and compare them alphabetically.

Extension Activities

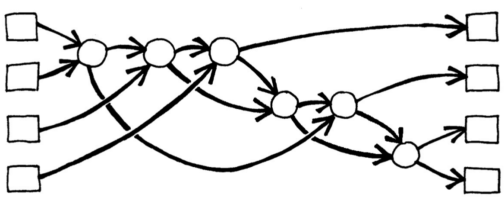
1. What happens if the smaller one goes right instead of left and vice versa? (The numbers will be sorted in reverse order.)

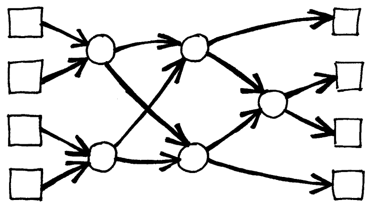
   Does it work if the network is used backwards? (It will not necessarily work, and the children should be able to find an example of an input that comes out in the wrong order.)

2. Try to design smaller or larger networks. For example, here is a network that sorts just three numbers. The children should try to come up with this on their own.



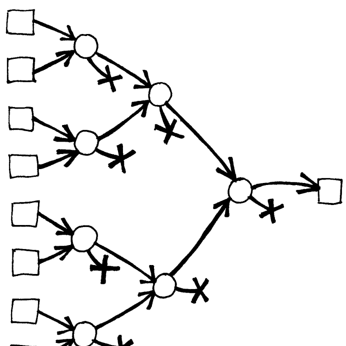
3. Below are two different networks that will sort four inputs. Which is the faster? (The second one is. Whereas the first requires all comparisons to be done serially, one after the other, the second has some being performed at the same time. The first network is an example of serial processing, whereas the second uses parallel processing to run faster.)





4. Try to make a larger sorting network.

5. Networks can also be used to find the minimum or maximum value of the inputs. For example, here is a network with eight inputs, and the single output will contain the minimum of the inputs (the other values will be left at the dead ends in the network).



6. What processes from everyday life can or can't be accelerated using parallelism? For example, cooking a meal would be a lot slower using only one cooking element, because the items would have to be cooked one after another. What jobs can be completed faster by employing more people? What jobs can't?

What’s it all about?

As we use computers more and more we want them to process information as quickly as possible.

One way to increase the speed of a computer is to write programs that use fewer computational steps (as shown in Activities 6 and 7).

Another way to solve problems faster is to have several computers work on different parts of the same task at the same time. For example, in the six-number sorting network, although a total of 12 comparisons are used to sort the numbers, up to three comparisons are performed simultaneously. This means that the time required will be that needed for just 5 comparison steps. This parallel network sorts the list more than twice as quickly as a system that can only perform one comparison at a time.

Not all tasks can be completed faster by using parallel computation. As an analogy, imagine one person digging a ditch ten metres long. If ten people each dug one metre of the ditch the task would be completed much faster. However, the same strategy could not be applied to a ditch ten metres deep—the second metre is not accessible until the first metre has been dug. Computer Scientists are still actively trying to find the best ways to break problems up so that they can be solved by computers working in parallel.

Intro to Sorting—a little background info
From: https://sites.google.com/site/childrenandtechnology/Home/presentation-4-sorting

Preparation

1. Have several sets of objects that can be sorted by various criteria. Each object should be on a separate card. For example:

- Numbers
- Dots representing numbers
- Squares with different degree of redness (white-pink -> bright red)
- Shapes with different degrees of roundness (flat oval -> perfect circle)
- Smileys (angry -> happy)

2. Have several sets of pictures (one set on one sheet of paper), to show kids examples of how to sort by various criteria, for example:

- Tiger, mouse, cat
- Sun, earth, moon
- Grapefruit, orange, lemon
- Motorcycle, car, bus, plain, boat
- Piano, drum fluite
- Lamp, candle, fire, sun
- Chair, Sofa, Carseat
- Pictures of somebody waking up, brushing teeth, having breakfast

3. Be clear about various sorting algorithms:

- Selection sort: find the biggest, put first in the resulting list, find the second biggest, put next in the resulting list, etc.
- Insertion sort: take the first element from the list, put it in the resulting sorted list. Take the next element and insert it into the right place in the resulting list. Continue for every element from the original list.
- Bubble sort: swap adjucent elements if the larger element is on the right to the smaller element. The big numbers "bubble up" to the head of the list, hence bubble sort.

For older (elementary school and up) kids try other sorting algorithms:

- Merge sort. Split into smaller groups, sort each group, then merge the sorted groups.
- Bucket sort. If numbers 1-N are sorted, create placeholders for every number. In this case sorting is just running to the placeholder where you belong. This is a good sorting algorithm if there are duplicate numbers.

Presentation

1. Why does computer care about sorting?
Computer likes things in order. If everything is in order, it's easy to find them.

- *Ask kids if they keep their toys in order, and vice versa, if they misplace a toy, how hard is it to find it?*

- In addition you may talk about why people sort. Here are some examples:

- o To find fast (page on a book, person in an ordered list)
- o To find the best match (what size of the bus is good to transport 20 kids)
- o To know which elements are near each other (whose birthday is next, which birthdays are adjacent, what activity to do next)
- o To know the first and the last elements (most favorite toy to play with, least favorite toy to give away)

2. How do we sort?

- o *Put several sticks of various heights in front of the kids.*In order to sort we need to compare two things.*Using selection sort arrange sticks in order - Find the largest stick, move it away, then put next to it the second largest, etc. Talk through the whole process.*

3. Ordering by various criteria

- o Now, ordering by size / length is not the only way to order things. We can order by ... Redness!
- o *Have the cards ready with various shades of red. This time choose a group of kids and give a card to each kid. Sort the kids using insertion sort, by picking the first kid and moving her away – she will make up the sorting list, then pick the next kid and have her "insert" herself into the ordered line based on her card. Once the kids are done have them raise their cards so that everybody see them ordered.*

- o Now, let's order by ... Roundness!*Do the same with a different group of kids and the cards of different roundness (flat oval till perfect circle). Sort the kids using bubble sort – have the kids with the rounder circle swap if they are out of order.*

- o You see, the rounder shape bubbles up, like a balloon, and the flatter shape goes down.*Again, have the kids raise their cards so that everybody sees that they are sorted*

But wait, you can even order by ... happiness!

- o *Distribute a set of smileys – from angry to happy and have the last group of kids sort them using selection sort – have the last child approach every other child and whoever has happier face continues to go through the kids, while the "angrier" one stays in the place of the happy one. Once the happiest is found, place him on the side and have the kids find the "happiest" among those left.*

At this point all kids should try sorting, have them seated.

4. Show example of ordering by various criteria, as well as ordering the same things differently.

- o Tiger, mouse, cat (order by size)
- o Sun, earth, moon (order by size, or by closeness to the Earth)
- o Grapefruit, orange, lemon (order by size or by sourness)
- o Motorcycle, car, bus, plain, boat (order by number of wheels, or by number of people that can be transported)
- o Piano, drum, flute (Order by loudness)
- o Lamp, candle, fire, sun (Order by brightness)
- o Chair, Sofa, Car seat (Order by size, or softness)