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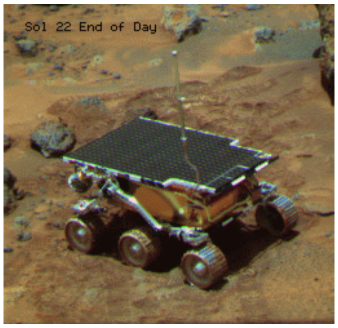
The Pods Are Coming!



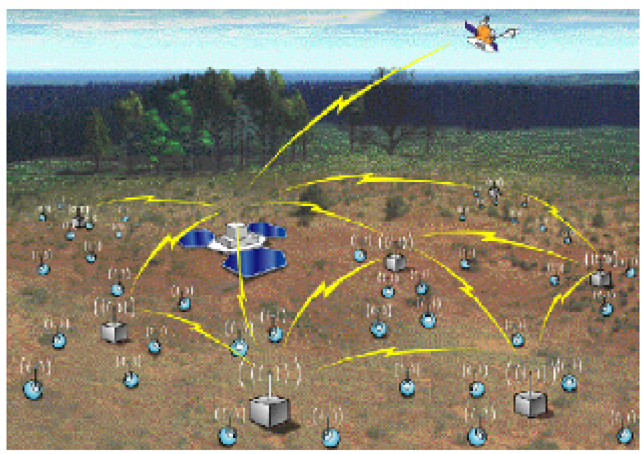
Mars Pathfinder mission's Sojourner rover on Mars.

On July 4, 1997, the Mars Pathfinder Sojourner rover bounced to a safe landing on the surface of Mars and began investigating that alien world. The first robotic rover of its kind, Sojourner didn't roam very far from its base station. However, some future missions to other worlds will carry even more capable rovers. Some will be able to roam on their own for several kilometers. They will be able to analyze the composition of the soil and rocks, take pictures, and make all kinds of other measurements. They will also be able to transmit the data long distances back to a base station or orbiter, which will then relay the information to Earth.

These rovers will be designed to take complicated measurements over a fairly small area. But what if scientists want to measure conditions over a large area all at the same time? For example, here on Earth, if scientists put together all the information from many weather stations, they can track regions of high and low pressure, precipitation (rain or snow), and temperature. They can then draw the boundaries of weather fronts, atmospheric pressure changes, and temperatures, and track these boundaries to help predict what the weather will do next in a given area.

So, a unique way to study a large area all at once is with a whole flock of sensors scattered all over the place. Each "sensor pod" takes a number of measurements (for example, temperature, wind speed, and atmospheric pressure), then relays the results to a nearby "sensor node." The node puts that information together with information from other nearby pods and transmits it to a distant base station or to the information's final destination. This "web" of sensors could repeat the same measurements again and again to see how conditions vary from place to place over time.

The National Aeronautics and Space Administration (NASA) is developing technologies to put all the instruments necessary to make and transmit valuable measurements into very tiny, very tough, yet quite inexpensive packages. This way, many of them can be scattered around to check out conditions in any number of strange places.



A sensor web made of scattered sensor pods, sensor nodes, a base station, and an orbiter.

Sensor pods could be dropped from a plane (on Earth) or a spacecraft (on some other planet) to take and transmit measurements in the atmosphere as they drift down, perhaps slowed by balloons or parachutes.

Sensor pods can be used in studies of climate on Earth. Have you heard the term "global warming"? It's all about how much

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Sensor webs can work with satellite imaging of Earth to keep track of the carbon cycle.

carbon dioxide is in the atmosphere. Carbon dioxide holds the heat close to Earth, like a greenhouse. Plants take carbon from the air and return oxygen. As forests are destroyed, less carbon is held in plant form and more is held in carbon dioxide form. Too much carbon dioxide will make Earth too hot for life, so we want to keep a close watch on carbon dioxide levels. Sensor webs measuring carbon dioxide over wide areas and compared with satellite images of plant growth will help us understand the important carbon cycle.

Sensor pods can be quite small and still contain several measurement instruments and communication capability.

Some of the sensor pods now under study are not even as large as a golf ball. They use parts that are already available for other types of electronic devices--parts such as thermometers, light detectors, tiny computer chips, and transmitters and receivers--and, of course, ordinary batteries!

The Rover Plays the Web

Try this demonstration to see how a sensor web would work.

You can do this activity in your classroom, if your seats are arranged in rows. If they are not (for example, if you sit at tables or in a circle), find a way to group yourselves into columns and rows. For example, if there are 30 students in the class, the arrangement might look something like this:

Every student gets five small pieces of paper. If they can be five different colors, great. If not, just label the upper right hand corner of each piece A, B, C, D, and E.

Trial A: The Rover Rolls

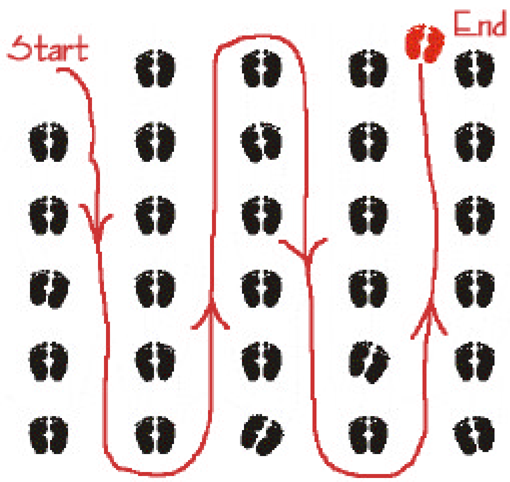
Choose one person to be the “Rover.” The Rover stands next to one of the corner people. Choose another person with a watch having a second hand to be the “Timekeeper.” The Timekeeper stays where he or she is.

Everyone except the Rover takes the same color of paper (or the paper marked A) and marks their answer in the form of 0 (zero) or 1 to the following multiple choice question:

Which book would you rather read:

(0) *A story about space travel in the future.*
(1) *A story in which the main characters are dogs and cats.*

Now, the Timekeeper keeps track of the elapsed time as the Rover collects the pieces of paper one at a time. The Rover should go down one row and up the next at a normal pace. *It's not a race!*



When the Rover has collected all the pieces of paper, he or she sits or stands at a table or desk and sorts the papers into piles of 1's and 0's. Then the Rover counts the number of 1's and the number of 0's, and writes it on the board or a full-sized piece of paper for Trial A.

Just as the Rover writes the number on the board, the Timekeeper reports the elapsed time and the Rover also writes that time (minutes and seconds) on the board beside Trial A.

The data sheet might look something like this:

Trial	No. of 0's	No. of 1's	Elapsed Time
A	21	9	5 min. 30 sec.

Trial B: The Web Works

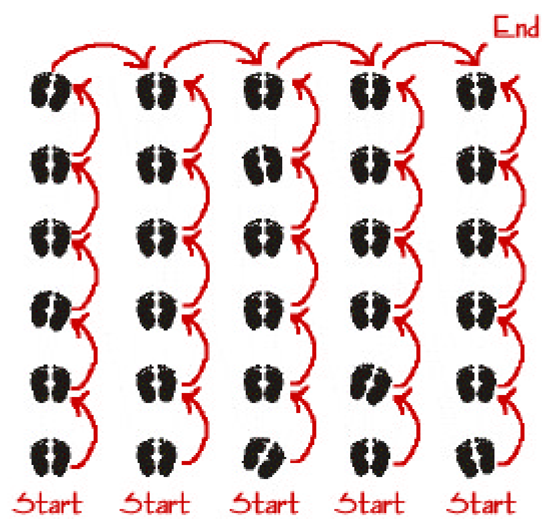
This time, the person at the front of each row will act as a "Node." In addition to being a Node, the person on one of the front corners will act as the "Base Station Keeper." A real sensor web doesn't really need a base station, but for the purpose of our demonstration, we'll appoint one. The same or another Timekeeper is appointed.

This time, everyone takes the same color of paper (or the paper marked B) and marks their answer in the form of 0 or 1 to the following multiple choice question:

Which type of place would you rather go for a vacation:

(0) *A tropical island paradise.*
(1) *A piney forest in the mountains.*

Now, the Timekeeper keeps track of the elapsed time as everyone passes their paper to the Node person at the front their row. Then the Nodes pass the papers over to the Base Station person. *Again, it's not a race*.



When the Base Station Keeper has collected all the pieces of paper, he or she sorts the papers into piles of 1's and 0's, then counts the number of 1's and the number of 0's and writes it on the board for Trial B.

Just as the Base Station Keeper writes the number on the board, the Timekeeper reports the elapsed time and the Base Station Keeper also writes that time (minutes and seconds) on the board beside Trial B.

Trials C, D, and E: Seeing the Trend

Repeat the Trial B process three more times, using the remaining three colors (or letters) of paper. Use the following questions:

C. *If you had to be either a foot taller than average height for your age and gender or a foot shorter, which would you choose?*

(0) Taller
(1) Shorter

D. *If you had to choose, would you rather be a brilliant and famous scientist or a brilliant and famous artist?*

(0) Scientist
(1) Artist

E. *If you had to choose, would you rather be breathtakingly beautiful/handsome or very, very rich (but not very good looking)?*

(0) Beautiful/handsome
(1) Rich

Evaluating the Techniques

Compare the times required to gather one piece of data from each person using the single Rover method and the Sensor Web method. How many pieces of data per person could you gather using the Sensor Web method during the time it took to gather one piece of data using the Rover method?

Which would be the better approach for taking measurements in the following situations? ("Better" in this case means getting the most information that you really want with the least expense.)

- Measuring how much pollution is coming out of a factory smoke stack.
- Measuring how much pollution from that smoke stack is reaching the town one mile downwind.
- Measuring how much oxygen is in the water in your 10 gallon aquarium.
- Measuring how much salt is in the Great Salt Lake in Utah.
- Measuring how much the Earth moves during an Earthquake in Los Angeles.
- Sampling and analyzing what kind of materials are in the soil in a Martian crater.

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