Mathematics

Fractal models for data traffic

In an industrialized country, telephone service is sufficiently reliable and efficient that, under normal circumstances, a caller will nearly always get a dial tone. On the collection of computer networks making up the Internet, however, connecting to a particular World Wide Web site can be much more of a hit-or-miss proposition.

The comparatively erratic service on the Internet reflects a significant difference between the structure of voice-carrying and data-transmitting networks. In the case of voice traffic, the telephone network behaves as if it were providing a direct and continuous circuit from the caller to the receiver. In contrast, digital information is sliced up and transmitted as self-contained data packets. Those packets compete for a path to their intended destination with all the other packets traversing the network. If there is little competition along a particular path, the trip can be very fast. On the other hand, high packet traffic means congestion and overloaded links, which slow down data transmission.

Measurements of data traffic indicate that it is much less steady and predictable and more variable in duration and rate than voice traffic. Data traffic is often characterized by sudden bursts of activity with lulls in between (SN: 7/26/97, p. 53). This difference means that mathematical models used with great success for the design, control, and management of traditional telephone systems don't apply to data-transmitting networks.

In the September NOTICES OF THE AMERICAN MATHEMATICAL SOCIETY, Walter Willinger of AT&T Labs-Research in Florham Park, N.J., and Vern Paxson of the Lawrence Berkeley (Calif.) National Laboratory suggest that the mathematics underlying so-called fractal behavior could serve as a basis for new, superior models of data networks. A geometric object has fractal characteristics if a magnified piece of the object resembles the original pattern (SN: 8/17/96, p. 104). In the case of data traffic, bursts of activity show roughly the same spiky pattern over a wide range of time scales. In other words, the activity pattern of spikes and lulls evident over a period of a few seconds resembles the fluctuations taking place in just milliseconds.

"The finding of the fractal nature of Internet traffic can be viewed as a promising start toward solid characterizations of Internet traffic," Willinger and Paxson conclude. However, factors such as the rapid growth of the Internet "make it immensely difficult to characterize and understand the Internet in any sound fashion." —*I.P.*

Picking off more pieces of pi

The number pi represents the result of dividing a circle's circumference by its diameter. Starting with 3.141592653 . . . , its digits go on forever. So far, researchers have computed the first 51.5 billion decimal digits of pi (SN: 8/9/97, p. 92). Using a remarkable formula discovered in 1995, they can also determine specific, individual digits of pi without computing and keeping track of all the preceding digits. The catch is that the formula works for binary, but not decimal digits (SN: 10/28/95, p. 279). Expressed in binary form, pi starts off as 11.0010010000 . . . .

Now, Colin Percival, a 17-year-old student at Simon Fraser University in Burnaby, British Columbia, has calculated the five-trillionth binary digit, setting a record for the highest known digit of pi. Percival needed 5 months and the help of 25 computers in six countries to complete the calculation. He reported his feat on the World Wide Web at http://www.cecm.sfu.ca/projects/pihex/announce5t.html. However, there is no way to convert that result, 0, into decimal form without knowing all the binary digits that come before the one of interest.

Percival says his next challenge is to finish calculating the 40-trillionth binary digit. The ongoing calculation is distributed among more than 200 computers throughout the world. Beyond that, the quadrillionth binary digit beckons. —*I.P.*

Paleontology

Wyoming wonder: Tiniest mammal ever?

Paleontologists have discovered the fossilized jaw of a mammal so tiny that the entire animal would have tipped the balance at only 1.3 grams. "That's about the weight of a dollar bill," says Jonathan I. Bloch of the University of Michigan in Ann Arbor. "This represents the smallest known mammal."

Bloch and his colleagues discovered the Lilliputian lightweight, named *Batodonoides vanhouteni*, in 53-million-year-old limestone nodules from Wyoming. Distantly related to shrews, *B. vanhouteni* had teeth only a fraction of a millimeter wide, the researchers reported at an October meeting of the Society of Vertebrate Paleontology in Snowbird, Utah. The paleontologists estimated the weight of the animal from the size of its lower first molar, which typically gives a good indication of total body size, says Bloch.

The discovery challenges scientists' ideas about the lower limit on the size of mammals. The smallest known living mammal is the 2.0-gram bumblebee bat. Researchers had estimated that mammals could not get any smaller because they would lose too much body heat. The planet was warmer, however, during the Eocene epoch, which may explain how smaller animals could have flourished then, says Bloch.

John J. Flynn of the Field Museum of Natural History in Chicago says there is some uncertainty in estimating body weight, but he agrees that the *B. vanhouteni* jawbone is smaller than that of any other mammal known. —*R.M.*

Questions raised about oldest animal

Headlines earlier this month trumpeted the discovery of the oldest evidence of animal life, but new research challenges the reported age of these fossils from central India.

The specimens in question are a series of squiggly grooves in sandstone dated to be 1.1 billion years old. Adolf Seilacher of Yale University and the University of Tübingen in Germany and his colleagues last year described these marks as fossilized worm burrows, making them nearly twice as ancient as the oldest animal remains (SN: 11/1/97, p. 287). They formally reported their findings in the Oct. 2 SCIENCE.

If confirmed, the purported worm tracings would eat holes through ideas about animal evolution. An Indian scientist, however, has found evidence that the worm tracks could be far younger, according to Martin D. Brasier of Oxford University in England, who wrote a commentary in the Oct. 8 NATURE. R.J. Azmi of the Wadia Institute of Himalayan Geology in Dehra Dun, India, has found shelly fossils of animals in limestone above the sandstone containing the worm impressions. Scientists had formerly dated both the limestone and sandstone to be about 1.1 billion years old, but the shells in the limestone indicate that this layer is only about 540 million years old.

That opens the possibility that the underlying sandstone formed at about the same time, when worm burrows were quite common, according to Brasier. On the other hand, he says, there could be a big gap in age between the sandstone and the limestone above it, which would make the tracks much older than 540 million years. The difference would affect the standing of Brasier's own discovery. In January, he and a colleague reported finding 600-million-year-old fossil worm tracks, the oldest known prior to Seilacher's report.

Samuel A. Bowring, a geochronologist at the Massachusetts Institute of Technology, offers a way to reconcile the relatively young fossils found within rocks that appear quite old. When scientists dated the Indian deposits, they may have calculated the age of 1.1-billion-year-old rock grains that washed into the ocean and became incorporated in much younger limestone and sandstone. Further dating work is needed, he says. "Whenever we find fossils like this that seem to rewrite the book, it's critical to have unequivocally precise ages." —*R.M.*