Oh, What a Tangled Web We Weave

Francis Sullivan, Editor in Chief

NOT LONG AGO, A FRIEND HAD AN EXPERIENCE THAT SOME MIGHT CALL A "POST-MODERN, SOCIAL NETWORK/COMPUTER NETWORK CROSSOVER EVENT." SHE WORKS AT A LARGE RESEARCH LAB, AND ONE DAY SENT AN EMAIL LETTER OF ACCEPTANCE TO A PROSPECTIVE SUMMER STUDENT. TWO days later, my friend got email from her sister, who has no connection to my friend's lab and lives in Europe. Amazingly, the second email contained a copy of the acceptance letter. The explanation for this happening that first comes to mind is probably some sentence containing the phrases "degrees of separation" or "connectivity of the Web." I suggest that as scientists, we might not want to accept these buzzwords as an explanation and, more to the point, that these phenomena raise important and exciting computational issues.

Steve Olson wrote an article describing Joseph Chang's work at Yale University in the May 2002 *Atlantic Monthly* that seems to go in the right direction toward an explanation. Chang claims that everyone currently living is descended from Nefertiti, the Egyptian queen. Why? Briefly, because as we walk back in time, the number of ancestors increases like 2^g (where g means generations), but the population of the planet decreases like e^{-t} where t is time. Hence, family trees must intersect. Observation of population data plus mathematical models of the dynamics of population movement patterns give us information on when and how they do.

Nothing is ever completely new. More than 20 years ago, while living in the Netherlands, I heard a story of the rise and fall of the Dutch Charlemagne Club. To be a member, you had to have some plausible claim to descent from Charlemagne. The club dissolved when members discovered it to be highly likely that *everyone* of European descent in the Netherlands was, in fact, a relative of Charlemagne. In another direction, members of all scientific subdisciplines are fond of tracing lines of academic descent. I used to have a lot of contact with a small physics department where the entire faculty was descended from Christian Doppler.

So far, this seems easy. However, what about more specific questions? How, exactly, am I related to Nefertiti? We don't look that much alike. What's the expected number of generations before I find a common ancestor with my boss? The computational problems associated with these more detailed kinds of questions are often stated in terms of graphs, appear to be discrete and combinatorial rather than continuous and analytic, and could be hard—in fact, probably very hard.

One example is network reliability. Assume that the edges of a graph have some probability p_f of failing. What is the probability that the graph will disconnect? (To add some drama, replace "graph" with "national electrical power network.") Even getting an approximate value for the probability is hard because we would need a good estimate of the number of different sets of edges that cut the graph, meaning a set whose removal disconnects it. In its raw combinatorial form, the problem is impossible. Things get better if we can reformulate the problem in a way amenable to the methods of statistical physics. The computation is still formidable but closer to doable. Not surprisingly, use of statistical physics in combinatorial work is a growing research area.

Large graph problems are another case where we do well to look for interesting computing problems, provided we're willing to use any tools we have!

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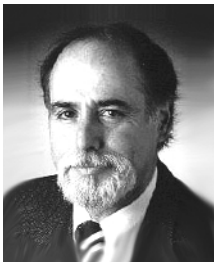

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Correction

In the May/June 2002 issue, we inadvertently stated that David Beazley received his PhD from the University of Utah. He actually received it from the University of Oregon. We apologize for any confusion this error might have caused.

Henrik Schmidt is a professor and associate department head of the Department of Ocean Engineering at the Massachusetts Institute of Technology. His research interests include underwater acoustic propagation and signal processing, in particular, the interaction of sound in the ocean with seismic waves. He has an MSc and a PhD, both in structural engineering, from the Technical University of Denmark. He is a member of the Danish Center of Applied Mechanics and Mathematics and the Society of Exploration of Geophysicists. Contact him at Rm. 5-204, MIT, Cambridge, MA 02139; henrik@keel.mit.edu; http://acoustics.mit.edu/faculty/henrik/henrik.html.