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The N.S.A.'s Math Problem

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By Jonathan David Farley

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NEWS that AT&T, Verizon and BellSouth gave customer records to the National Security Agency has set off a heated debate over the intricacies of espionage law. But legal or not, this sort of spying program probably isn't worth infringing our civil liberties for — because it's very unlikely that the type of information one can glean from it will help us win the war on terrorism.

If the program is along the lines described by USA Today — with the security agency receiving complete lists of who called whom from each of the phone companies — the object is probably to collect data and draw a chart, with dots or "nodes" representing individuals and lines between nodes if one person has called another.

Mathematicians who work with pictures like this are called graph theorists, and there is an entire academic field, social network analysis, that tries to determine information about a group from such a chart, like who the key players are or who the cell leaders might be.

But without additional data, its reach is limited: as any mathematician will admit, even when you know everyone in the graph is a terrorist, it doesn't directly portray information about the order or hierarchy of the cell. Social network researchers look instead for graph features like "centrality": they try to identify nodes that are connected to a lot of other nodes, like spokes around the hub of a bicycle wheel.

But this isn't as helpful as you might imagine. First, the "central player" — the person with the most spokes — might not be as important as the hub metaphor suggests. For example, Jafar Adibi, an information scientist at the University of Southern California, analyzed e-mail traffic among Enron employees before the company collapsed. He found that if you naïvely analyzed the resulting graph, you could conclude that one of the "central" players was Ken Lay's . . . secretary.

And even if you manage to eliminate all the "central players," you may well still leave enough lesser players that the cell retains a complete chain of command capable of carrying out a devastating terrorist attack.

In addition, the National Security Agency's entire spying program seems to be based on a false assumption: that you can work out who might be a terrorist based on calling patterns. While I agree that anyone calling 1-800-ALQAEDA is probably a terrorist, in less obvious situations guilt by association is not just bad law, it's bad mathematics, for two reasons.

The simplest reason is that we're all connected. Not in the Haight-Ashbury/Timothy Leary/late-period Beatles kind of way, but in the sense of the Kevin Bacon game. The sociologist Stanley Milgram made this clear in the 1960's when he took pairs of people unknown to each other, separated by a continent, and asked one of the pair to send a package to the other — but only by passing the package to a person he knew, who could then send the package only to someone he knew, and so on. On average, it took only six mailings — the famous six degrees of separation — for the package to reach its intended destination.

Looked at this way, President Bush is only a few steps away from Osama bin Laden (in the 1970's he ran a company partly financed by the American representative for one of the Qaeda leader's brothers). And terrorist hermits like the Unabomber are connected to only a very few people. So much for finding the guilty by association.

> Phone records are unlikely to help us combat terrorists.

A second problem with the spy agency's apparent methodology lies in the way terrorist groups operate and what scientists call the "strength of weak ties." As the military scientist Robert Spulak has described it to me, you might not see your college roommate for 10 years, but if he were to call you up and ask to stay in your apartment, you'd let him. This is the principle under which sleeper cells operate: there is no communication for years. Thus for the most dangerous threats, the links between nodes that the agency is looking for simply might not exist.

If our intelligence agencies are determined to use mathematics in rooting out terrorists, they may consider a profiling technique called formal concept analysis, a branch of lattice theory. The idea, in a nutshell, is that people who share many of the same characteristics are grouped together as one node, and links between nodes in this picture — called a "concept lattice" — indicate that all the members of a certain subgroup, with certain attributes, must also have other attributes.

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For formal concept analysis to be helpful, you need much more than phone records. For instance, you might group together people based on what cafes, bookstores and mosques they visit, and then find out that all the people who go to a certain cafe also attend the same mosque (but maybe not vice versa).

While researchers at Los Alamos National Laboratory have used this tool to sift through hundreds of terrorism-related reports — and find connections that human analysts could not have found easily — it's still dangerous to rely on the math.

This is because, as Kennedy and Lincoln assassination buffs know, two people can be a lot alike without being the same person. Even if there is only a 1 in 150 million chance that someone might share the profile of a terrorist suspect, it still means that, in a country the size of the United States, two people might share that profile. One might be a terrorist, or he might be Cat Stevens.

This isn't to say that mathematicians are useless in fighting terrorism. In September 2004 — 10 months before the bombing of the London Underground — Gordon Woo, a mathematician and risk-assessment consultant, gave a speech warning that London was a hotbed of jihadist radicalism. But Dr. Woo didn't anticipate violence just using math; he also used his knowledge of London neighborhoods. That's what law enforcement should have been doing then and should be doing now: using some common sense and knowledge of terrorists, not playing math games.

Math is just a tool. Used wisely, math can indeed help in warfare: consider the Battle of Britain, won in part by breaking the German codes. But use it unwisely — as seems to be the case here — and your approval ratings might just hit a new all-time low. □