SARS, Terrorism and Knowledge Management

By Patrick Lambe

The Power of Maps

One evening in the second half of August 1906, the well to do Warren family, vacationing in Oyster Bay, Long Island, had their favourite dessert: fresh sliced peaches, served with ice cream. It was a speciality of their cook for the summer, Mary Mallon. Ice cream was still a small luxury, and August had been hot. The temperature in central New York had peaked in the mid-thirties Celsius at the start of the month, and it had been thundery and humid, with frequent storms, followed by a prolonged dry spell. It was much healthier to be out of the city in such weather – typhoid, an endemic disease in the United States at that time, was particularly active in the hot summer months, and it thrived in urban environments.

A few days later, on August 27th, Warren's daughter fell sick with symptoms of typhoid. The local doctors were bemused: typhoid was rare in the resort, and there were no known problems with the water and sewerage systems, a known cause of the disease. Over the next six days, five other members of Warren's household fell sick, including his wife and second daughter.

The family called in a sanitation engineer named George Soper, who had had extensive experience with typhoid outbreaks. First he ruled out the water supply and sewerage as possible causes. The other known major route of contamination was through the handling of food by typhoid sufferers. His attention turned to the Irish cook, Mary Mallon, who had left the family three weeks after the outbreak, when her summer contract had ended. She had not come down with typhoid symptoms, but Soper was aware of cases emerging from Europe of so-called "healthy carriers" – people who harboured small reservoirs of typhoid bacilli in their gall bladders, and periodically shed them in their faecal matter. Poor hygiene assured inadvertent transmission while preparing food… particularly uncooked food like the Warren family's favourite dessert.

Soper got to work, and over several months traced the past six years of Mary Mallon's employment history through her agency. He found seven cases of typhoid outbreaks in the families of Mary Mallon's employers over that period. Twenty-two people had been struck by the disease, and one had died. Soper tracked Mallon down to her current employers in New York, in March 1907. He told her, somewhat undiplomatically, that she was spreading typhoid through poor hygiene, and asked her to supply samples of faeces and urine for examination.

In 1906, the germ theory of disease was still not well known in non-medical circles. Much of the previous century's concern with hygiene had been fixed on locating the places where disease transmission took place – filth and putrid air were the commonly believed sources of disease, and so civic efforts had focused on building sewerage infrastructures to remove waste, and on guaranteeing clean water supply.

So Mary Mallon, quite understandably took offence. Not only was this man accusing her of being filthy, he was crazy to suggest that she was spreading typhoid, when she had never (to her knowledge) been ill of the disease herself. And of the people who kept falling ill around her, well, typhoid was an endemic disease. People got it all the time.

After several unsuccessful attempts to persuade her, Soper finally asked the local public health authorities to issue a warrant for her arrest and forcible examination. In a country much concerned with civil liberties, this was no small step. The crucial thing that persuaded the authorities to arrest Mallon, was his detective work. In his detailed chronology, Soper had created a map, and that map showed all too clearly the likely correlation between Mallon and the disease.

Maps are extremely effective, where lots of data confuse. They make visible what the density of information conceals. Mallon was arrested, and was in fact found to shed substantial quantities of typhoid bacilli. She was America's first documented healthy carrier.

Maps of contagion were not completely new. One of the most celebrated deployments of mapping a disease outbreak was that of John Snow, a London doctor, who obtained the addresses of cholera victims from the August 1854 epidemic, and showed brilliantly how the infections all converged on a contaminated water pump in Broad Street.

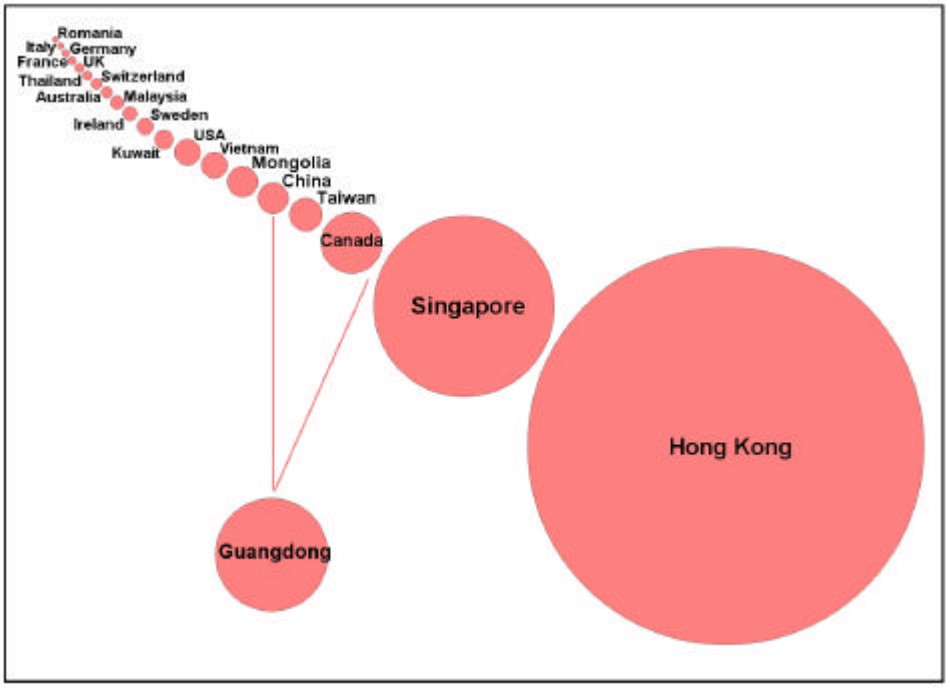
But where Snow's detective work was pre-germ theory, and focused on the place of infection, Soper's detective work had shifted from mapping *places* as disease harbourers, to mapping *people* as disease carriers. The basic principle was the same. The Broad Street pump was indeed infected. When it was shut down at Snow's insistence, the epidemic ceased. Mallon was interned, and infected no more people, until she was released and years later, returned to cooking as her only means of livelihood. She was subsequently arrested after a typhoid outbreak in a hospital where she was working as a cook, spent the rest of her life in forced isolation, and is better known to posterity as the much-maligned "Typhoid Mary".

Mapping Carriers

Until the SARS outbreak, Soper's method of mapping people to people contacts has predominated in the analysis and tracing of infectious diseases. The early 20th century discovery of the "healthy carrier" has shifted slightly in the SARS case, to the notion of the "super infector", but both, essentially, focus on locating the carrier as the prime means of locating and isolating the disease. It now seems that there may also be healthy (asymptomatic) carriers of SARS, which is an added complication, but we still focus more on people than on places. The map of SARS transmission in Singapore published in *The Sunday Times* on April 13, retains this focus on linking people to people, and identifying the "super infectors".

Worryingly, however, there are signs that place also plays a role in SARS, a role we may not be adequately mapping. In practice, we recognise the importance of place in the measures we take. We are told that the corona virus spreads most readily in airborne water droplets, and cannot survive for long outside the body. But we stay

away from infected areas. Amoy Gardens in Hong Kong was the first clear incidence of possible – and unsatisfactorily explained – environmental contagion. We disinfect lifts and doorknobs. We close schools and avoid crowds. On a larger scale, the WHO has a list of SARS affected areas that when mapped, starts begging interesting questions about contributory factors for contagion. The map below indicates the proportion of probable SARS cases per million members of the population. Suddenly Hong Kong's role as a key incubator of the virus, despite its small size, springs into prominence.



Probable SARS cases per million population 19 April 2003. Data source: WHO

The spread of SARS is certainly conditioned by the complex interactions of numerous factors, such as population density, density of air transport connections, population mobility, and healthcare policies. But countries like the UK, with high urban density and air travel connections into Hong Kong, seem to incubate the SARS virus slower than places like Singapore or Canada. Hospitals are seeing the highest incidence of SARS cases by location – not, as one might fear, other crowded places such as airplanes, schools and cinemas. That's also curious, because while we can understand that there is close proximity to sufferers during treatment, hospital staff also tend to be more aware of infection control than people in airplanes, schools and cinemas.

Maps such as these allow you to ask interesting questions, and isolate individual contributing factors for further investigation. In conditions of high uncertainty, when you don't really know what the contagion factors are, it's important to keep asking novel, different questions. Like Snow's cholera map, or Soper's healthy carrier map, you are only likely to discover new things if you ask different questions from the past.

But maps can mislead. While they can throw significant causal factors into striking relief so that you can take action and navigate your way through the problem, every time you make features of the landscape visible in a map, you conceal other features. It's important that our maps not become too simplistic, and focus on too few features.

For example, the labelling and mapping of AIDS as a "gay disease" in the 1980s played a large part in creating a false sense of security among the heterosexual population. Awareness of safe sex practices grew in the homosexual population, and the disease shifted ground to where it was least visible. While male to male transmission is still significant in the Americas, Europe and East Asia Pacific, in most other regions, heterosexual transmission is a major cause. 53% of people living with AIDS are women and children, and that proportion is on the rise.

Maps built around single features are too simplistic, just as tracing contacts for the latest infections in a disease is too simplistic. Contact tracing is retrospective. At best it keeps you one step behind the disease, at worst is simply a reactive containment measure enacted more in hope than certainty of success. What we really need are tools for getting further ahead of the disease, of mapping the next place it's likely to hit, and cutting off the transmission vectors by whatever means we can. The invisibility of the disease means the actual infection networks are opaque until full symptoms emerge.

In the second part of this article next week, I will examine some of the ways that a knowledge management technique called social network analysis has been used to map another kind of opaque and dangerous network – the terrorist network. There are lessons there that can be brought back to how we map contagious diseases like SARS, and ultimately how we get ahead of them.

Patrick Lambe is Principal Consultant of Straits Knowledge (www.straitsknowledge.com), a Singapore-based firm that focuses on how organizations use their knowledge. His articles can be read at www.greenchameleon.com.

Terrorism and Social Network Analysis

By Patrick Lambe

In the first part of this article last week, I looked at how contact tracing can help you to build network maps of how a contagion spreads, and to try to figure out the mechanism by which it spreads. But contact tracing may be too limited a view to give us a real insight into how it spreads, and the difficulty with diseases like SARS is that infection is not always visible until it's already been communicated to other people. In other words, the infection network is opaque until it's already too late to act pre-emptively.

Interestingly, there is another context where mapping opaque contact networks is critical, but often retrospective and incomplete, just like SARS. Criminal and terrorist networks are also notoriously difficult to map, and they more often mapped after a crime than before. Terrorists have a vested interest in concealing their relationships, they often emit confusing or misleading information to throw you off the scent, and they operate in self-contained cells for much of the time. But just as in disease prevention, it's important to be able to map the connections in a terrorist network ahead of the strike.

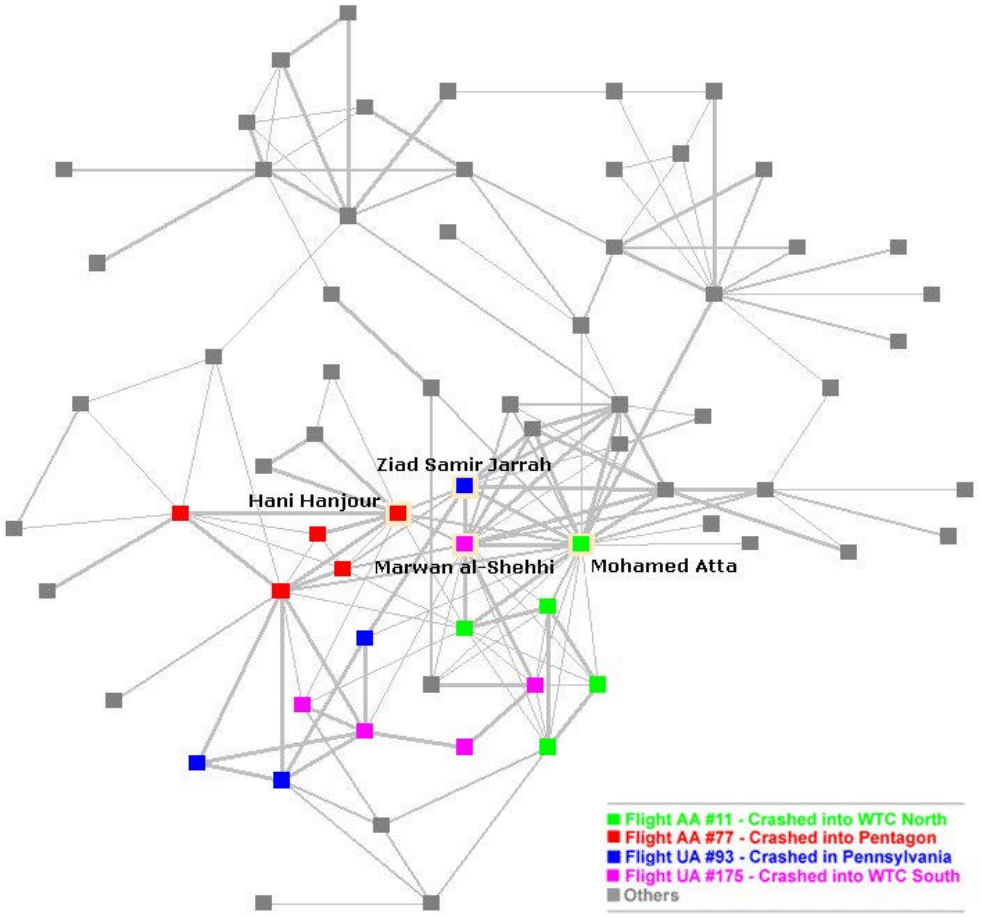
In a striking March 2002 article for *First Monday*, an internet-based journal, social network analysis expert Valdis Krebs unpacked the issues involved in mapping covert terrorist networks. In the months following the 911 terrorist attacks, and using publicly available information, Mr Krebs had painstakingly built a social network map of the al-Qaeda hijackers using his proprietary mapping software InFlow.

InFlow is more commonly known as a popular social network mapping tool used in knowledge management projects to map communication flows, informal communities of practice, and enablers or barriers to tacit knowledge transfer. It can identify key knowledge players in a network, as well as diagnose knowledge silo problems, or incipient knowledge communities. Its use to visualise covert networks, and contact tracing for infectious diseases (it is used to track TB contagion by the Center for Disease Control and Prevention in the USA) is a more compelling reminder of how important yet how complex are our social interconnections, not just for knowledge transfer, but also for disease and conspiracy transfer.

Mr Krebs' analysis of the 911 hijacks strikingly showed the central, connecting roles of hijackers Nawaf Alhamzi and Mohammad Atta. Beyond that, it became more evident that Atta was the most externally connected of the group. By taking him out of circulation, the ability of this particular group of cells to connect with wider networks might have been at least temporarily degraded.

Terrorist networks are very secretive, and so they operate in small cells that interconnect only intermittently, and through limited numbers of people. Interestingly, our response to an epidemic is to do something very similar – we avoid crowds, and many companies and hospitals are breaking workgroups up into small independently

operating teams to assure business continuity in case one team is infected. Infectious disease teaches us the same tactics that terrorists use.



Social Network Map of the 911 Hijackers Source: Valdis Krebs, 2002

It follows that if you can identify key connectors in the terrorist network, and take them out of commission, you can do much more harm to the covert network than if it were more densely interconnected. This is a device very much in evidence in the Israeli intelligence community. Their unparallelled surveillance and intelligence capabilities in the West Bank help them map crucial nodes in the Palestinian terrorist networks they seek to disrupt. Nodes become targets, for arrest or attack.

But here also, simple contact tracing is not enough. Terrorists have lots of innocent contacts as well as sinister ones. Their sinister connections are invisible or dormant for much of the time. In his *First Monday* article, Krebs recommends a more multi-layered mapping approach, looking at a number of possible networks, mapping people to people, but also people to places, times and resources:

Trust networks: prior contacts in personal history, often going back many years - family, neighbourhood, school, military, club or organization.

Task or activity networks: Intelligence services note that activity and connections within a covert network often spike in the prelude to an attack. They monitor communications such as logs and records of phone calls, electronic mail, chat rooms, instant messages, web site visits. Place is also important. If different members of the network all appear to have been in Kabul at the same time, there's a good chance that they connected.

Money and resource networks: Money and resources flow along network links just like communications and travel. Bank account and money transfer records, the pattern and location of credit card use and observation of visits to alternate banking resources all provide clues.

Strategy and goal networks: planning and coordination of an attack involves many of the previous activity types: travel, meetings, attendance at common events, web site visits, postage of documents or videotaped instructions, money transfers.

Social Network Mapping Applications

So what can the use of such mapping techniques teach us about mapping disease or knowledge flows?

First, in opaque networks, such as terrorist networks, contagion networks, and most informal knowledge networks within organizations, it's important to use multiple mapping criteria, and not to rely on single, retrospective, criteria.

Valdis Krebs summarises the similarities thus: "Whether it is knowledge networks, virus outbreaks, or terror networks, we are always looking for: 1) key players; 2) emergent community structures; 3) boundary-crossing ties (those that connect the communities). In knowledge networks we want to support/reward the key players, in terror/criminal networks we want to monitor and then remove the key players, and in contagion networks we want to heal and isolate the key players."

Secondly, it follows that used intelligently, tools like Mr Krebs' InFlow software can help anticipate emergent or incipient features of a network, things that have not yet been actualised. Let's take the phenomenon of the "super spreader" as an example. Most of the medical literature on "super spreaders" has focused on their individual clinical characteristics: for some unknown reason, they carry a high viral load, and shed their virus more readily. Hence they infect more people. This is useful to know, because it can help specify a test that will diagnose such super spreaders very early.

However, as Valdis Krebs points out, different people also have different intensities of people to people contacts. Some have relatively small social circles, others, whom Mr Krebs terms "social butterflies" have wide ranging and very active social networks. These people can also be incredibly important in the early spread of a disease, even if they are only moderately infectious. In an early 1980s gonorrhea epidemic in Colorado Springs, epidemiologist John Potteratt found that fewer than 0.2% of the population were responsible for the majority of new infections. Worst of all, says Valdis Krebs, is when infectiousness and connectedness converge in the "social butterfly" who is also highly infectious.

Network mapping tools such as InFlow can be used to identify "social butterflies" in a community. As soon as they emerge in the contact network of a known infected person, these highly connected people and their own contact networks can be given extra attention, in an attempt to get further ahead of the disease, faster.

In knowledge management, "social butterflies" have more benign effects in facilitating and accelerating "knowledge infections". Spotting these people, and the people who connect different networks, allows you to see opportunities for improvement. In one project in a major pharmaceutical company that had been formed through a series of mergers, InFlow was used to map knowledge sharing practices across departments and disciplines. The maps made it clear that most people were still sharing knowledge based on their original company affiliations, and that the innovation opportunities of the new merged entity were not being fully leveraged.

My firm Straits Knowledge has used InFlow in Singapore to identify knowledge champions within a company seeking to start up a knowledge management project. Mr Lim Chon-Phung, vice president and head of regional sales for HP Services Asia Pacific, used it to identify structural holes and new connection opportunities in his sales organization, in the wake of the HP-Compaq merger last year. All these maps, and the questions that lie behind them, are designed to provide actionable insights that get you ahead of the game.

Thirdly, as we saw from the issues around terrorist networks, as well as from the uncertainties around the spread of SARS, wherever networks are opaque and dynamic, it's not enough to map people to people in a one dimensional fashion. It's important to take a multi-facetted approach. The hidden, actionable characteristics of networks can also be displayed by mapping people to places, times, activities and resources.

We have, for example, taken the results of an information audit, and mapped documents to departments. The resulting maps identified the most informationally active departments, as well as the most intensively traded documents across the company. What can you do with this? We used it to prioritise the migration of content onto a new shared portal, as well as to prioritise document types for workflow support within the portal.

In mapping immediate contagion risks that are actionable, it may be wise to take a leaf from the knowledge management and terrorist tracking manuals. Maps of places, disease resources (where it flourishes most) and environmental factors, and the activities in which contagion occurs most frequently, are also critical. A versatile approach is crucial in a complex, poorly understood environment. The beauty of maps, however, is that when you manage, finally, to map the landscape well, suddenly the actionable details spring into luminous focus. Fresh sliced peaches prepared at the hands of an Irish cook acquire a significance they could never have had before.

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