

that when the energy of the light and the wavelength of the sound match that of an excitation of the system, energy is absorbed. To detect this absorption, the authors monitor heating of the sample by looking at photoluminescence; they fire higher-energy photons at the sample and observe the spectrum of photons emitted.

One slight puzzle in the results of this technique relates to energy and momentum conservation. If the system absorbs the momentum of a sound wave, it should also absorb its energy. However, in the experiment, this does not seem to be happening. Nonetheless, cross-

checks on the experiment make a compelling case that the experiment does indeed measure excitations with the momentum of the sound and the energy of only the microwave.

The technique of using both light and sound seems sufficiently powerful that it should be extremely useful for measuring low-energy excitations of a wide variety of 2D electron systems, and maybe even for 3D systems. At this point, Kukushkin *et al.* can declare victory that the magnetoroton spectrum has finally been measured; with luck, this is only the first of many such victories.

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EPIDEMIOLOGY

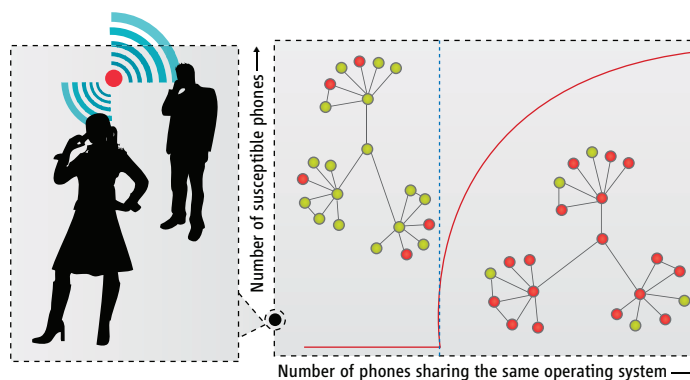
Phone Infections

Shlomo Havlin

In 1854, John Snow identified a water pump as the source of the cholera outbreak affecting the Soho district of London. This transformed the British physician into a public health giant, whose story is still celebrated in medical and public health history books. The weapon in his fight against cholera was a map of London on which he marked the residence of the individuals that had been infected by the disease. This enabled him to identify the Broad Street pump as the outbreak's source, allowing him to stop cholera proliferation in London. Snow understood the

spontaneous nature of epidemics and is regarded as a founder of modern epidemiology (1). Following in his footsteps, we understand today that the spread of infectious diseases follows reproducible patterns, whether they occur in the narrow streets of 19th-century London or along the digital highways of the 21st century. This is because diseases spread via networks of connections among individuals. On page 1071 of this issue, Wang *et al.* analyze the temporal and spatial spreading patterns of a new kind of virus—one that can spread through mobile phone networks (2).

Why, despite the more than 400 mobile phone viruses documented by cybersecurity organizations, is there no apparent serious concern about the prospect of viruses infecting mobile phones? By combining network science and percolation theory, Wang *et al.* examined mobility and communications data on the



Epidemics to come. Currently, very few smartphones are susceptible to a virus (red circles; nonsusceptible phones, green circles), a number that is below the threshold of transition to an epidemic (vertical blue line). In future epidemics, as the number of smartphones increases, the market share of a single operating system will reach a critical threshold and facilitate virus spread, potentially leading to a pandemic.

activity of more than 6 million individuals to study the speed and breadth of potential mobile phone virus outbreaks. Their conclusion is rather unexpected: Although mobile phone viruses do not pose a threat of spreading right now, the increasing market share of smartphones—mobile phones with computer-like operating systems and advanced features (such as electronic mail and Internet access)—will soon reach a phase transition point, beyond which mobile viruses could become far more damaging and widespread than current computer viruses (see the figure).

Mobile viruses are of two main types, Bluetooth and Multimedia Messaging Service (MMS), based on the communication protocol they exploit. Bluetooth is a short-range communication protocol that can transmit data between mobile phones within a 10- to 30-m radius. Thus, Bluetooth viruses spread among individuals like influenza virus, infecting only nearby Bluetooth-enabled phones. In contrast, MMS is a messaging protocol that

Is a mobile phone virus epidemic on the horizon?

allows sharing of media and programs between mobile phones within minutes and across the world. Thus, an MMS virus can send a copy of itself in a short time frame to all the phone numbers found in a phone's address book, resulting in a long-range spreading pattern that previously was common only in computer viruses.

Wang *et al.* discovered major differences in the speed and in the spreading patterns between Bluetooth and MMS virus outbreaks. The spread of Bluetooth viruses is relatively slow, as it is

driven by human mobility (3, 4) and will take days or weeks to reach a large fraction of mobile phone users. During this time frame, "infected" phones can be easily filtered out of that part of the network provided by mobile phone services that support Bluetooth technology.

The real danger is posed by MMS viruses (5, 6), whose spread is almost instantaneous. Wang *et al.* show that although MMS viruses can be transmitted quite rapidly, currently their spread is limited to small clusters of mobile phones due to the fragmentation of the underlying social networks (see the figure). This containment is due to different operating systems that various phones use.

Indeed, if all mobile phones had the same operating system, an MMS virus could instantaneously reach a large fraction of phone users. In reality, there are several competing operating systems in the mobile phone market, so the social network is separated into clusters of users with phones that use the same operating system, but who do not communicate with users in other

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clusters whose phones have a different operating system. As more and more users start using similar phones and operating systems, the size of these clusters will increase. Percolation theory predicts that once the market share of any operating system reaches a critical threshold, the system undergoes a phase transition and most of the isolated clusters will merge into a single large cluster containing a substantial fraction of mobile phone users. At that point, an MMS virus will be able to instantaneously reach most mobile phone users, and consequently, we'll become seriously concerned about mobile phone viruses. Wang *et al.* also show that this transition point can be accurately predicted by percolation theory (7). This transi-

tion also explains the relative absence of MMS mobile phone virus outbreaks: Currently, we are below the critical threshold, as smartphones still have a small market share, which is further fragmented by the large number of different operating systems competing in the market.

Yet, consolidation of the mobile phone industry is unavoidable, which means that the phase-transition threshold will be inevitably reached in the near future. Exactly when that happens depends less on network science than on market forces, i.e., the rate at which individuals switch to smartphones. However, some estimates indicate that within 2 to 3 years, there will be more smartphones than desktop computers. Thus, now is the time to

start preparing the theoretical knowledge and tools to deal with this expected major threat to mobile communications.

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AGRICULTURE

The Rubber Juggernaut

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Rubber plantations are expanding rapidly throughout montane mainland Southeast Asia (1–3). More than 500,000 ha may have been converted already in the uplands of China, Laos, Thailand, Vietnam, Cambodia, and Myanmar (see the figure, panel A). By 2050, the area of land dedicated to rubber and other diversified farming systems could more than double or triple, largely by replacing lands now occupied by evergreen broadleaf trees and swidden-related secondary vegetation (2). What are the environmental consequences of this conversion of vast landscapes to rubber?

The conversion of both primary and secondary forests to rubber threatens biodiversity and may result in reduced total carbon biomass (3–5). Negative hydrological consequences are also of concern—for example, in the Xishuangbanna prefecture of Yunnan province, China—but current data are too sparse to quantify the extent of the impacts (3, 6). The effect of conversion to rubber on catchment or regional hydrology depends, in part, on the water use of rubber versus that of the original displaced vegetation. Another factor is the degree to which rainwater infiltration



Swidden versus rubber. (A) Montane mainland Southeast Asia (green shaded areas) is defined here as the lands between 300 and 3000 m above sea level. (B) Most swidden fields and fallows on slopes near villages and roads in this area in Xishuangbanna have been converted to terraced rubber stands.



is reduced when terraces are constructed on sloping lands (see the figure, panel B). Unfortunately, a recent investigation into this issue in Xishuangbanna was terminated by regional authorities before sufficient data were collected (6, 7).

The rapid emergence of rubber is the hallmark of a larger land-cover transition that has been sweeping through montane mainland Southeast Asia in recent decades: the demise of swidden cultivation (also referred to as shifting or slash-and-burn cultivation) (8). Much of the upland areas that have been converted to rubber in the region are historically associated with swidden cultivation. Clinging to the perception that swidden cultivation is a destructive system that leads only to forest loss and degradation, governments in South-

The demise of swidden cultivation in Southeast Asia may have devastating environmental consequences.

east Asia have tried to control or terminate it through bans, declaration of forest reserves, forced resettlement, monetary incentives, and crop substitution programs (9, 10). The uncontrolled expansion of rubber in China was encouraged in part because it was seen as a favorable alternative to swiddening. Policies such as the Sloping Land Conversion Program supported the planting of rubber, because it counts as reforestation. Yet such policies have not always improved environmental conditions. In the case of rubber, homogeneous monocultures with myriad negative environmental consequences have emerged. This situation is not new or isolated. The permanent loss of forest cover through agrarian conversion to oil palm in insular Southeast Asia provides a parallel (11, 12).

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