A Plague of Viruses: Biological, Computer and Marketing[1]

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Abstract
We analyze the transfer of biological, computer and marketing viruses. Despite differences between these three types of viruses, network structure affects their spread in similar ways. We distinguish between two forms of networks – densely knit and ramified – and show that biological, computer and marketing viruses all behave in similar ways depending on the form of network. Densely knit networks promote the quick dissemination of a virus, and increase the odds that many of the members will become infected. Ramified networks allow a virus to disperse widely, jumping between different milieus. In the end, the spread of viruses in the real world involves a combination of both densely knit and ramified networks, which we call "glocalization".

Viruses Thrive on Networks

As the twentieth century becomes the twenty-first, biological viruses have been joined by two other types: computer viruses and viral marketing. Are there similarities between biological viruses, computer viruses and viral marketing other than the common term in their names?

All three depend on networks for their spread rather than growing *in situ*. A virus spreads through contact, be it purposeful or unaware juxtaposition. Without networks, viruses would lead lonely lives without affecting anyone except for the original hosts. For example, biological viruses do not come from toilet seats: They are transmitted person-to-person (or at least species-to-species). Computer viruses almost always flow between human beings. Viral marketing, where Harry tells Sally what cool brand to buy or what Internet petition to sign, is inherently and consciously person-to-person. Even at its weakest form, viral marketing is by observation, as when one high school student observes the star quarterback wearing Fubu (last year) or Ecko (last month) clothing.

Just as viruses differ, so too do the networks of biological, computer and marketing viruses. One similarity is that frequent contact increases the likelihood of "catching" a virus. Another is that densely knit groups accelerate the spread of a virus but keep it within a confined population. By contrast, viruses spread more slowly in sparsely knit networks but will jump to new milieus and ultimately spread more widely. We examine here all three kinds of viruses – biological, computer, and marketing – their similarities and their differences. We are especially interested in how different kinds of networks affect how such viruses operate.

Before we compare these three kinds of viruses according to network structure, we first compare them:

[1] We appreciate the advice of Alden Klovdahl and Martina Morris with respect to biological viruses, Danyel Fisher and Douglas Tygar with respect to computer viruses, and Eszter Hargittai, Valdis Krebs, Bill Richards, Emmanuel Rosen, Patrick Thoburn and Matthew Stradiotto with respect to viral marketing.

Biological Viruses: Biological viruses have been the best studied of the three[2]. Please note that our comments here refer to bacteria as well as viruses, but we use the term "biological virus" to preserve the literary conceit that organizes this issue.

The preponderance of biological viruses need contact with humans or other animals to be transmitted, although some may be transmitted indirectly by human-aided contact (biological warfare; tainted animal feed). Transmitter and receiver must be near each other, but they need not have any social contact (see Table 1). The need for social proximity or contact means that the speed by which these viruses spread is low. In many cases, the young are the most vulnerable.

Biological viruses frequently mutate. Preventing their spread requires physical isolation, tracing the spread of the viruses is hard, and eradication and healing is accomplished with great difficulty by medical personnel. Widespread prevalence can have important second-order consequences, with the debilitation of a population through disease and the desire of apparently-healthy individuals to flee the infected area and quarantine the ill.

Computer Viruses: Computer viruses are not born but deliberately made by either hackers or cyber-warfare experts. They are commonly transmitted by the Internet, although file-sharing is another vector just as needle-sharing is for biological viruses. Like biological viruses, transmission often occurs without deliberate human intent (after initial creation).

Transmitter and receiver need not be physically proximate, but must have connected communications, most typically the Internet. The transmitter must minimally have awareness of the receiver's Internet address. In many cases, social ties are vectors. Friends and acquaintances inadvertently infect friends by sending viruses that have been hiding in one system as attachments to an existing file: Strongly tied close friends are especially apt to do this because they have the most contact. In other cases, the virus ransacks the host transmitter's Internet address book: The greater number of weak ties in such books means that more acquaintances will be infected than close friends.

Children and teenagers are probably the most vulnerable because of their general reluctance to take protective measures. Although one might think that corporate executives, protected by well-organized information technology units, would be the least vulnerable, large organizations have repeatedly suffered virus attacks because of their reliance on Microsoft Outlook, a favorite target of hackers (Taylor, 1999).

Computer viruses transmit at hyper-speed. The Nimda worm spread so fast that the New Brunswick (Canada) provincial government had to shut down their computer systems for a day, September19, 2001 and use "old-fashioned" techniques. "We're using phones; we're typing; we're conducting a lot of business face-to-face and by fax," reported Susan Shalala of the Supply and Services Department (Canadian Press, 2001). Viruses mutate readily, as hackers obtain the original virus and use "script kits" to modify it. Dealing with computer viruses has itself created sizable corporations providing anti-virus solutions (e.g., www.symantec.com). Anti-virus measures include interception programs to recognize and neutralize viruses as they enter a system and reverse path tracing to identify a virus's origins.

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[2] See also Ellen Gee's and Maticka-Tyndale's papers in this issue.

The social consequences of a virus attack range from the annoyance of having to maintain up-to-date anti-virus software and backups, through the personal difficulties of losing information on one's hard disk, to serious organizational disruption. The embedding of the Internet in the developed world's everyday life means that large-scale or well-placed attacks might cause societal paralysis and the resulting socioeconomic isolation of units within the society.

Viral Marketing: Although the practice has been around for millennia, viral marketing, sometimes called "buzz marketing" is the newest recognized type of virus. Viral marketing refers to the marketing of a product or service by word of mouth. It dates back to Biblical days, as when Jesus said to his disciples, "Go ye into all the world, and preach the gospel to every creature" (Mark 16:15). Unlike biological and computer viruses, many people welcome viral marketing because it gives them new information, a chance of feeling socially accepted, being in the know, and following the latest fashion. Although this form of marketing tends to be overlooked because it is not easily traced, word of mouth may make or break any product, despite formal advertising (Rosen, 2000).

The idea of having commercial viral marketing campaigns was not introduced until 1940's (Rosen, 2000), and corporations rarely choose it as their primary mode of advertising. Diffusion can be through strong ties who are trusted with their opinions, or through weak ties who observe the tag lines appended to messages. But the virus can also spread merely through observation of physically-proximate role models / "aspirational leaders" – such as the stars of high school sports teams (Thorburn, personal communication, 2001). It flexibly supplies needed and wanted information at low cost. The interpersonal nature of viral marketing means that it conveys information more precisely and efficiently than the mass media to people who have higher probabilities of wanting the information.

In the 1950's, Elihu Katz and Paul Lazarsfeld (1955) created the classic concept of the "two-step flow of communication": persuasive communication diffused through the mass media (step one) as interpreted by influential people through their interpersonal relationships (step two). In *Medical Innovation: A Diffusion Study*, James Coleman et al. (1966) showed how knowledge about drugs spread informally among physicians[3]. He found a snowball effect where well-connected doctors act as early adopters and then influence non-adopters.

A research field soon developed, "the diffusion of information" (Rogers and Kincaid, 1981; Rogers, 1995). Perhaps its greatest proponents were public health officials, who soon became persuaded that health information about contraception use was best given to Third Worlders through interpersonal ties (Valente, 1995; Valente and Watkins, 1997). It might be said in such cases that viral marketing is used in such situations to combat biological viruses. Yet, the most extensive use of viral marketing has not been to prevent disease but to promote various forms of contraception.

The Internet has brought its own novel forms of viral marketing because the technology makes it easy to pass on messages – to one or one hundred closest friends. Computer-based viral marketing takes several forms:

1. There is the conscious circulation of petitions or similar appeals to do something. For example, a petition for the United Nations to look into the possibility of

[3] Also see Van den Bulte and Lilien's critique (2001).

election fraud during the 2001 presidential election in the United States. We have received similar petitions several times in the past month, and many times in the past decade.

2. There is the forwarding of rumors and humorous stories. Many people, for example, maintain “joke lists” which circulate purported humor for short or long periods. For example, one of us has received the story about the Nieman Marcus cookie recipe twenty-seven times in the past eight years.[4]

3. There has been quite successful latent viral marketing by taglines to email. For example, some Internet service providers such as Hotmail and Yahoo provide free email to users who agree to have a phrase added to every mail telling the receiver that they can get free email by going to http://explorer.msn.com. We will say more about this later.

4. There is a movement now in the computer game industry to use the Internet as a vehicle for promotion. "Many of the new games are viral, meaning that they permit players to spread the games by e-mail to friends." (Marriott, 2001: D1)

Viruses as Social Networks: Densely Knit Groups and Ramified Networks

The spread of viruses is shaped by both the nature of interpersonal relationships and the composition and structure of the interpersonal networks of which these ties are a part. Social network analysis has developed concepts and procedures for analyzing such networks (Marsden and Laumann, 1984; Wasserman and Faust, 1994; Wellman, 1988; Wellman 1997; Garton et al., 1997). We use the social network approach here to compare the similarities and differences in the forms of ties and networks that shape the movement of biological, computer and marketing viruses. In doing so, we show how the structure of social networks – the pattern of relationships that connect people and their computers – has important consequences for the spread of viruses: how much of the population is infected and how fast this infection takes place.

There are two structural archetypes. In ***densely knit groups,*** most members know each other, are in frequent contact with each other, but have little contact with outsiders (Figure 1). In network analytic terms, such groups are densely knit and tightly-bounded (Garton et al., 1997; Wellman 1997). By contrast, in ***ramified networks,*** few members are in contact with each, and a large portion of interactions are with outsiders. Such networks are sparsely knit and loosely-bounded. Reality, of course, often occurs in the continuum between these archetypes. A common one in contemporary societies is ***glocalization***: rather densely knit clusters of relationships (usually at home, at work, and with kin) that also have many ramified ties to other people and groups (Wellman 1999; Hampton 2001). For the sake of clarity, we concentrate here on two ideal types: densely knit groups and ramified networks.

[4] See www.neimanmarcus.com/about/cookie_recipe.jhtml; www.urbanlegends.com/food/two-fifty/neiman-marcus.html.

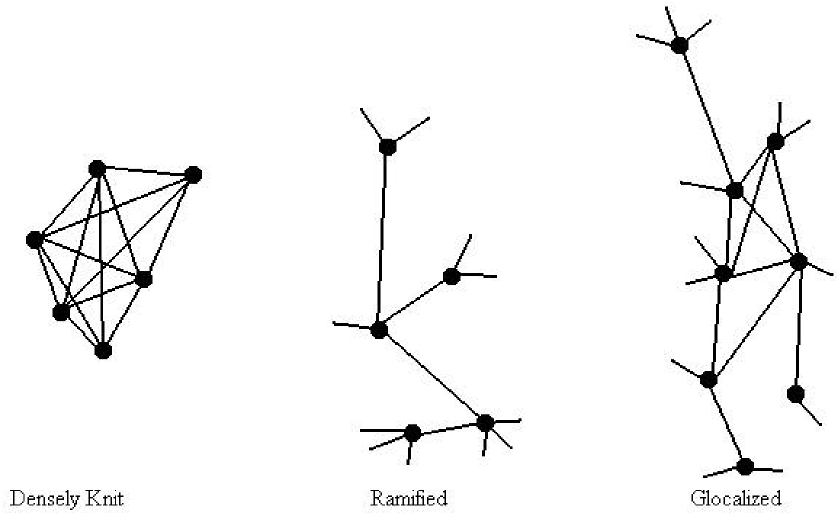

Figure 1: Three Models of Network Structure.

Densely Knit Groups

A virus can move quickly within a densely knit network because almost every member has frequent contact with every other member. This is true for all kinds of viruses. Densely knit groups allow for synergy, in which a particular group member is often exposed to a virus through frequent contact with other group members and, in turn, exposes and re-exposes other group members to the same virus.

"Homophily," birds of a feather flocking together (McPherson et al., 2001; McPherson and Smith-Lovin, 1987), increases the likelihood that biological, computer and marketing viruses will spread even more quickly through a densely knit group. Not only are people in densely knit groups in direct contact with each other, they also tend to share common characteristics, such as socioeconomic status, tastes, or attitudes (Erickson, 1988; Feld 1981, 1982). They are also have considerable influence over each other's decision processes (Cross et at., 2001). This increases the likelihood that they will have similar patterns of behavior and hence be more likely to be exposed to the same virus.

Biological Viruses: Consider how the AIDS-causing HIV biological virus may have spread in the San Francisco Bay area by this kind of group synergy in the late 70's and early 80's. During this time the gay community there was a closely knit group, with frequent unprotected sex between members. The ideology of sexual freedom as having multiple partners and the relatively bounded structure of the group meant there was often overlap between sexual partners (Rotello, 1997). Overlap caused the virus to spread quickly within the group.

Computer Viruses: There is reason to believe that computer viruses spread within densely knit groups of computers in much the same way. A computer virus is a file which has the ability to attach itself to other files (Aunger, 2001). Once these files are modified , they will carry out a list of instructions called a protocol. If a virus lies latent until a certain date or a trigger event, it is called a "trojan" after the Greek legend of the Trojan Horse.

Both biological and computer viruses are most successful at spreading if they do not rapidly destroy their hosts. This is the "stickiness factor" (Gladwell, 2000: 200). A living host will better allow the virus to spread to other computers before it is caught by another person or computer, replicate itself, and continue the chain migration process. If the virus cannot execute its protocol because of incompatible software, then it does not stick to the computer. If it does not stick, it does not have the opportunity to spread. This is why a virus which does not completely wipe out an entire computer hard drive tends to spread widely. Leaving most of the operating system intact allows a virus to spread itself to even more computers. This was the case with SirCam (Vamosi, 2001), which may lie dormant until October 16, 2001 when it may "awake" to erase hard drives or fill them with garbage. SirCam was the most widely distributed worm or virus in July, infecting many FBI computer systems (Dlunginski, 2001: 30).

Before the Internet became a popular way to share data files, computer viruses were usually transmitted by floppy disk from computer to computer. It is no surprise that group members who are frequently sharing files are also likely to share viruses. If Monika, Uyen and Uzma are all working on different parts of a research proposal, a virus on Monika's computer can be transmitted to Uyen's computer when she shares her spreadsheet analysis. As with transmission of a human virus, overlap in contact increases exposure to the virus. The odds that Uzma will get the virus on her machine doubles if both Monika and Uyen have the virus.

Today, computer viruses usually spread through email. Unlike the earlier days, contemporary viruses do not have to wait until a user contacts another person. Many viruses are designed to read an infected user's address book and use it to transmit the message to those on the list. For example, the SirCam "worm" virus itself does not "know" in advance what computers to infect, it obtains a list of email contacts from the host's address book. Using this list it will disperse email to all list members, attaching itself as a file. If the recipient opens the file, the cycle will continue again (Johnston, 2000).

Those in densely knit groups will be especially open to the resulting synergy. This means that if even a few people in the group have the virus, everyone in that group will be emailed the virus several times. The more it is emailed to the group, the more likely it is that others in the group will open it and send it to the group yet again. Consider the email address book of someone who is only involved in one densely knit group of six persons. Everyone in this group knows everyone else, and they all have each other's email addresses. If one member of this group has a virus, the virus will use his address book to send itself to everyone else in the group. Keeping in mind that everyone else in the group also has each other's email address, the virus will set off a chain reaction where each person in the group will receive the same virus a total of five times. In effect, the virus will have been transferred a total of thirty-six times. Even if one person in the group catches the virus with a virus checker, each person will still receive the same virus four other times. In computers as well as biology, overlap in contact between group members allows a virus to spread quickly within the group.

As of now, the August 2001 "Code Red II" virus has been one of the most destructive viruses to date. Code Red II was designed to use homophily to aid its spread. As Valdis Krebs explained to the Social Network Analysts' listserve (2001), this virus "seeks out clusters of nearby systems, knowing that pockets of Internet addresses will often use the same software. Birds of a feather flock together, and so do servers running the same OS." Having access to common software allows Code Red II to use just one simple protocol. This protocol can take advantage of a system's weakness, then spread through computer networks to similar systems (Aunger, 2001). Because these similar systems tend to be in dense networks, the resulting synergy increases the rate of infection[5].

One rumor has it that Code Red "was part of a bigger scheme that was orchestrated by the Russian Mafia to rob a bunch of banks electronically during all the confusion." (Dvorak, 2001: 71) The discovery of the Nimda virus/worm exactly one week after the Sept 11 2001 attack on the World Trade Center and Pentagon spurred fears that the virus was the next phase of the attack.

Viral Marketing: In the case of viral marketing, densely groups would lead to a fashion developing among a small group of people. It would be persistent, because it would be mutually reinforcing, but it would not spread widely.

Homophily is important when trying to understand viral marketing. Because people within these groups have similar tastes, they are likely to buy similar products (Rosen, 2000). Once something is introduced into a densely knit group, everyone in the group is sure to find out about it quickly (Rogers, 1995). Furthermore, they are likely to buy the same product themselves. As Emanuel Rosen (2000) points out, this can have either positive or negative consequences for a producer. If a product is accepted into such a group, then the producer is likely to maintain that market. However, if the product is not accepted, the producer will have a very difficult time breaking into that market.

A product requiring cooperating others to have the same product can gain wide acceptance within a densely knit group when a sizable plurality start using the it. Such "network externalities" occur when a product becomes more valuable as more people use it (Haruvy and Ashutosh, 2001; Van Hove, 1999). For example, PayPal facilitates the transfer of money over the Internet to pay for purchases. To use PayPal, both parties must have accounts. Once a few members of a densely knit group are using PayPal, other group members will be tend to use it for the sake of simplicity (Bodow 2001; Van Hove, 1999).

The Pox video game also uses this principle. The games operate by allowing users to battle others within a radius of a few meters (Tierney, 2001; Heinzl, 2001). Once a few (teenage) users have the game, others in their group see them playing it and want in on the action. As with computer and biological viruses, once access to a densely knit group is obtained, the marketing virus quickly infects many of its members.

The telephone and the Internet are classic examples of how network structures affect flows of information. As each telephone or Internet account is useless unless others can be reached, universal standards allow global connectivity. By contrast, Microsoft and AOL have competing standards for instant messaging. Their two systems are mutually unintelligible, so that all persons in a densely knit group are impelled to all adopt one instant messaging product or the other, in contrast to the variety of personal computers they own.

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[5] Computerization facilitates the construction of animated maps describing the spread of computer viruses (CAIDA, 2001).

Ramified Networks

If a virus could only spread within a densely knit group, then it would remain isolated and not spread on such a large scale. Ramified networks do not spread viruses as thoroughly within a defined population as within a densely knit groups. However, they reach out to a larger and more heterogeneous population. Viruses diffuse through a population in a curve that spreads rapidly when it moves to additional social circles. Eventually, diffusion levels off as friends of friends turn out already to have been virally infected by carriers who are more proximate in their social networks (Rapoport and Yuan, 1989).

"Structural holes" (Burt, 1992) between groups are filled by people who are connected to more than one group. These key gatekeepers and brokers are the means by which a virus spreads out through ramified networks. Through the use of brokers – those who have membership in many different groups and thus link groups – a virus can travel between groups and spread throughout an entire population. Often, those linking two groups have "weak ties" with members of either or both groups. While strong ties stay within groups and thus circulate the same information and viruses (Granovetter, 1982), weak ties are more apt to have different social characteristics than the core members of a group (Feld, 1982). Hence, weak ties are more likely to spread the virus to new social milieus.

Biological Viruses: With respect to the HIV biological virus**,** the brokers have included men who are sexually active, and had sex outside their group. These outsiders brought the virus to other groups, which eventually led to the emergence of HIV in the population at large (Rotello, 1997). A more recent example is the epidemic of syphilis in Baltimore during the mid-1990s. Although syphilis was already prevalent in the low socioeconomic housing projects of East and West Baltimore, it spread throughout the city when these housing projects were torn down, and its residents moved to other parts of the city Moving to different parts of the city led former project residents to have more sexual contact with others, thereby dispersing the virus throughout the entire city (Potterate 1985; Gladwell, 2000).

Computer Viruses: Just as the spread of biological viruses depends on the patterns of human contact networks, the spread of computer viruses depends on how computers are networked, or linked to each other. Computer viruses spread differently on Local Area Networks (or LANs) than on Wide Area Networks (WANs). LANs have the ability to share designated files called broadcast packets with *all* of the computers on the network. If one computer has a virus, then it is likely that all computers on that network have the virus which was sent in the form of a broadcast packet. This is an extreme version of a densely knit network, because all computers are connected and communicate with each other. By contrast, WANs have a dedicated "router" that takes apart all computer files that have been sent and then directs them to a specific destination. This means that a virus may be caught and isolated before it is transmitted to an entire network of computers.

The way in which computers are connected is only one aspect of viral spread. A virus can also spread through email by using certain well connected individuals as brokers. Recall how computer viruses, such as SirCam, have the ability to read email address books and send virus-bearing messages to those listed in the address books.

People who only have membership in one or two dense groups are at high risk of receiving a virus common to those particular groups. But brokers have the additional problem of being exposed to an eclectic variety of viruses from the many different groups in which they are involved. This also means that they are the ones who are more likely to introduce new viruses to a group.

For example, let us assume that one member of a six-person group is a broker. This broker is connected to one other densely knit group of ten people in each group. In a worst case scenario the broker would receive the virus five times from the one group. Each time she would send it to the other groups of ten, sending the virus a total of fifty times. The broker would also have the added risk of receiving different viruses from the other groups. So not only would the broker send and receive more viruses than the people of only one group, she would also have the extra risk of sending and receiving new and different viruses. It is not difficult to see why brokers play prominent roles in spreading a virus far and wide.

Viral Marketing: Because the Internet amplifies the effects of viral marketing, it speeds up the proliferation of "buzz" across groups. Weak ties play a key role in the spread of word of mouth through ramified networks because the Internet allows people to maintain their weak ties with little effort. Instead of contacting weak ties with the telephone, people can use email to drop a quick line to a sizable list. As new information often comes from socially heterogeneous weak ties, there is ample evidence of the usefulness of acquiring new information from weak ties on the Internet (Wellman and Gulia, 1999). For example, singer Alanis Morrissette believes that file sharing programs such as Napster can give musicians useful exposure. In her words "Mp3.com and Napster and companies like them established a link between artist and audience that hinted at a world without barriers." (*Toronto Computes!*, 2001: 26)

Marketers tell us that viral marketing has been especially used in persuading teenagers to adopt new fads. For example, a sports shoe company hired a viral marketing firm to identify admired role models in high schools. These "aspirational leaders" (the marketers' term) gave free shoes to teens leaders. By wearing these and talking about them, the teen leaders create a persuasive demand for the new product.

The free email service, Hotmail (and similar ones such as Juno and Yahoo Mail), successfully use viral marketing to promote its service. In exchange for getting Hotmail's free email service, account holders must agree to have a tagline automatically added to the bottom of all messages, "Get your FREE download of MSN Explorer at http://explorer.msn.com". Two months after their launch, Hotmail had over 100,000 registered users (Rosen, 2000). Their messages – and the accompanying Hotmail ads – go to all members of their ramified networks, intimates and acquaintances alike. Thus viral marketing is used to advertise the Hotmail service without any overt action on the part of the sender. Moreover, there is a modeling effect: Harry the recipient observes that Sally the sender uses Hotmail, and may think "if it's good enough for Sally, it's good enough for me." Hotmail makes it easier to sign-up, because it includes in each tagline a clickable web address for new subscriptions.

Viral marketing can be used to sell ideas as well as products (Chattoe, 1998). Many readers have been asked to sign petitions, passed on electronically from hand-to-hand. More immediately, we are writing this the day after airplanes crashed into the World Trade Center and the Pentagon in the United States. We have already received two political statements – one calling for attacks on "Muslim terrorists" and one asking us to persuade people to avoid war. Someone we do not know wrote each statement, but close friends forwarded them to us – and to others on sizable lists of friends.

The structural position of people in networks affects how information will flow. Those who are especially well connected (network analysts say they have "high degree") or connect different groups (high "betweeness") spread information the most rapidly (Wasserman and Faust, 1994). Brokers are important for viral marketing because of their structural position.[6] Or as Everett Rogers puts it, "diffusion campaigns are more likely to be successful if change agents identify and mobilize opinion leaders" (1995, p. 354; see also Valente and Davis, 1999; Weimann, 1994).

At times marketing agents can use these brokers to their advantage. In "leapfrogging", a marketer finds a person who is well connected to several groups and then gives that person a free product (Rosen, 2000). The marketer does this in hopes that the chosen broker will spread the word about their product to their multiple groups. The fad "leaps" between different group and social milieus, spreading the word far and wide. According to Gladwell, "one of these exceptional people found out about the trend, and through social connections and energy and enthusiasm and personality spread the word." (2000: 22). Leapfrogging brokers have the ability to make a buzz about a product through their personality, social capital and structural position (Frank, 1998).

The cultural element of viral marketing sets it apart from biological and computer viral exchange. With almost any product, there will always be trendsetters. Trendsetters are the few people who will seek out new products and essentially decide whether or not they are "cool". Cool products will be adopted by this group before they become popular, and will be abandoned once they become too mainstream. Unlike a computer or human virus, a buzz about a product will only occur if it fits into this cultural construct of "cool".

Social networks are doubly important for bringing products from small groups of trendsetters to the wider public. This is because they convey both sheer awareness and cultural approval. Trendy fashion companies, such as Reebok and Nike, have "coolhunter" employees. Coolhunters seek the new fashions of trendsetters, and they then act as brokers, by bringing these trends back to their company designers and eventually to stores (Gladwell, 1997). In this way brokers are important not only in bringing a product into the market as in leapfrogging, but also in bringing the market to a product.

Killing a Virus

Until now, controlling computer viruses has mostly depended on anti-virus software checking suspected viruses against known templates. This does nothing to protect against new viruses. However, the control of biological and computer viruses may be converging. IBM and Symantec are jointly mounting an effort "to create a full biology-inspired immune system for computer protection, so systems can deal with invaders as automatically as your body deals with microorganisms." (Dlunginski, 2001: 30).

Brokers can be important for stopping the spread of viruses as well as for fostering their spread. A traditional method for dealing with a virus has been to quarantine it. In this situation all people afflicted with a virus are isolated from outside

[6] Such brokers are referred to in marketing as "cosmopolites", "hubs" or "opinion leaders" (Rosen, 2000).

contact. In effect, they are not allowed to come in contact with people who might act as brokers and take a virus to new groups. Through quarantine either the virus dies out on its own or the hosts die. In either case, the removal of weak ties means that a virus stays confined within a few groups.

The quarantine method is not always possible. People who obtain a computer virus are not likely to forgo their Internet access, just as those who have obtained a biological virus are not likely to become isolated from their social ties. There is also the further problem that often people are not aware that they have a virus until it has already spread. For these reasons, precautions must be taken to limit the spread of a virus before it has even been contracted. For people, proper hygiene, eating habits, and safe sex practices help limit the contraction of viruses. In the case of computers, virus checkers and firewalls must be in place. This is especially important for brokers who may come into contact with carriers from a variety of groups.

While prevention by means of genetic alteration is still a possibility, this option still has questionable moral considerations (Burfoot, 1999). Inadvertent prevention may also occur with the spread of biological viruses. Brokers who have passed the primary infection stage of HIV and still have functioning antibody responses inadvertently act as firewalls or buffers which isolate HIV to a number of small clusters. People in this stage of HIV infection are not as likely to pass the virus on to those outside the infected group, because they do not have a very high rate of infection (Friedman et al., 2000).

Conclusion: Understanding the Glocal Habitat of a Virus

To say a virus is transmitted through a network is a useful beginning, but the real questions are what kinds of viruses and what kinds of networks? Although biological, computer and marketing viruses have different constituent elements and processes, they all are bound by the realities of social network transmission. By using two contrasting ideal types of networks, we have shown how network structure can shape the movement of three different kinds of viruses.

Densely knit networks, in which contact is frequent among all members, increases the potential that an infected group member will transmit a virus to almost all of the group. The quick spread within a densely knit group is amplified by the tendency of these groups to be in similar milieus: be they places they go to, computer platforms, or fashion sense.

Ramified networks stand at the other structural extreme and have different consequences for a virus. These networks have infrequent contact between members, and no two members will be in contact with a similar set of people or machines. These networks provide a bridge in which a new virus can travel from one group to the next, allowing many different kinds of viruses to reach many different kinds of people. Not all members of a ramified network are likely to have the same virus at a given time, since not all members are in contact.

Of course, these are only ideal types: Reality is messier. The actual world is a combination of both forms of networks (see also Kadushin 2001). People and their computers often belong to densely knit networks while at the same time maintaining ramified ties. We have termed this fusion of local and global connection, "glocalization". In a glocal situation, biological, computer and marketing viruses use ramified networks to introduce themselves into pockets of densely knit groups. Once viruses get inside a group, members will have much exposure to them and thus a greater likelihood of being infected by them.

Thus the structure of contact allows a commonality in the life and death of viruses that must be taken into account in understanding how they - and all sorts of networks - operate.

Table 1: Comparing Biological, Computer and Marketing Viruses

Type	***Biological***	***Computer***	***Marketing***
		Basics	
Source	Animals, Bio-Warfare	Hackers, Cyber-Warfare	Marketers, Activists
Nickname	Bug, Germ	Virus, Worm	Buzz, In-Crowd
Life-Course	Very Young (except AIDS)	Corporate Execs.,Teens	Teens
Media	Physical Contact, Transport	Computer Network, FD2FD*	Internet, F2F*
	**F2F = Face-to-Face*	*FD2FD = Floppy Disk to Floppy Disk*	
		Spread	
Prob. of Infection	Frequent Contact	Frequent Contact	Frequent Contact
Propogation	Local, Airplanes	Social Networks	Social Networks
Transmission	Knowns, Unknowns	Lists, Address Book	Known & Trusted
Diffusion	No Social Link	Weak & Strong Ties	Strong Ties
Acceleration	← Sparsely-Knit, Loosely-Bounded Networks Accelerate All →		
Speed	Slow	Hyper-Speed	Slow to Medium
Spread of	Disease	Destruction	of Fashions
		Control	
Recognition	Symptoms, CDC	Scripts, Template Match	Trendies, Chain E-mail
Tracing	Very Difficult	Reverse Messaging	Financial Reward
Mutations	Natural	Deliberately Created	New Business Model
Prevention	Condoms, Long Sleeves	Anti-Virus, Firewall	Voice-Mail
Eradication	Drugs, Sanitation	Anti-Virus	Do Your Own Thing
Healing	Medical	Reformat	Cut Up Charge Card
		Consequences	
Latent	Resistant Viruses	Hacker Prestige	Reinforces Status Order
Economic	Population Explosion	Anti-Virus Industry	Free Sites Disappear
Worst Case	War, Starvation	Societal Paralysis	Distrust of Friends
Networking	Physical Isolation	Social Isolation	Network Overload

Trojans	Protect against Infection	Form of Computer Virus	Brand Name

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