faces are publicly assumed, which then gives rise to the feeling that the new face and perhaps even the old face are false.[91]

Mizuko Ito pointed out to me that Goffman's theories of the link between identity construction and public performance are useful frames for looking at the people in public places engaged in conversations with people who aren't there: "The way mobile phones locate people in social groups is connected to the way the mobile phone operates in public space. To me these are interconnected points related to how people occupy technologically enhanced social space. The power of the mobile phone to allow people to be connected continuously with their virtual social group is what isolates them from co-present others in the public space, in other words, exclusion as the other side of the coin from affiliation."[92]

In Chapter 8, I'll take up the implications of the "always-on" nature of the mobile Internet, the effects of being continuously available to others, and the way all our formerly idle moments aboard public transit or while walking down the street are now filled with activity. If mobile telephony and texting alone were the only agents of change, the world's cultures would be facing a major shift in norms, relationships, and social power. Today's mobile devices, however, are only part of a larger smart mob infrastructure. "Peer-to-peer" methodologies like the one that made Napster possible are converging on mobile Internet devices, providing opportunities for massive device-to-device collective actions. The emergence of pervasive computation in smart rooms, wearable computers, and digital cities from laboratories into product lines are only beginning to transform today's telephones into the "remote controls for your life" envisioned by Hirschhorn, Linturi, and Natsuno.

The forms of collective behavior enabled or changed by smart mob technology go far beyond the etiquette of where and how to conduct mobile phone calls. The most radical changes are those possible at the level of entire societies. In order to make sense of the technologies I was seeing in media labs and the behaviors I was seeing on the streets, I looked for observers who focused not on small groups, but on the collective actions of entire societies. Fortunately, the years I had spent trying to make sense of virtual communities had led me to thinkers such as Marc A. Smith, now at Microsoft Research. After the streets of Helsinki and Tokyo, and the media labs of Cambridge and California, I headed for Redmond to try to see a bigger picture.

2

Technologies of Cooperation

Your corn is ripe today; mine will be so tomorrow. 'Tis profitable for us both, that I shou'd labour with you to-day, and that you shou'd aid me to-morrow. I have no kindness for you, and know you have as little for me. I will not, therefore, take any pains on your account; and should I labour with you upon my own account, in expectation of a return, I know I shou'd be disappointed, and that I shou'd in vain depend upon your gratitude. Here then I leave you to labour alone: You treat me in the same manner. The seasons change; and both of us lose our harvests for want of mutual confidence and security.

—David Hume, *A Treatise of Human Nature*, 1739

The Alchemy of Coopetition

Redmond, Washington, is headquarters of the world's most successful company, mother lode for the world's richest man, and home base of an army of carnivorously competitive software geeks. Despite this intense concentration of mojo, the Microsoft campus is also an unremarkable suburban office park with sidewalks, stands of fir, and lawns separating clusters of three-story buildings. Unlike Sanno Park Tower, the Microsoft campus displays few signifiers of power—aside from the wireless Internet antennae dangling discreetly from light poles. I wasn't sniffing for clues about the industry, although Microsoft might become the dominant player in the wireless Internet industry. I wasn't seeking a peek at future technologies, although the secret gizmos of tomorrow can be found within these buildings. I was searching for hints about the social forces at work in smart mobs.

What scientific knowledge can make sense of swarming teenagers in Finland and texting revolutionaries in Manila? Anthropologist Mizuko Ito and her Scandinavian counterparts helped me to understand group behaviors emerging from use of the mobile telephone. I needed to know more about what these activities could mean for entire societies, so I paid a pilgrimage to my guru in matters cybersociological.

In the ten years I've known him, Marc A. Smith had morphed from UCLA graduate student into Microsoft's research sociologist. In 1992, while I was trying to make sense of virtual communities, I heard about this fellow who had turned Usenet, the Internet's worldwide ecology of virtual communities, into an immense sociology laboratory. Since then, we've stayed in touch regarding social studies of cyberspaces. At Microsoft, Smith has refined the instrument he started building as a grad student—software that maps the social networks woven from a million electronic messages exchanged in 48,000 different conversation groups every day.[1] My question in 1992 was, What do people gain from virtual communities that keeps them sharing information with people they might never meet face to face?

Smith's answer was "social network capital, knowledge capital, and communion"—people can put a little of what they know and how they feel into the online network and draw out larger amounts of knowledge and opportunities for sociability than they put in.[2]

A decade later, I found myself trying to understand what happens when virtual communities migrate from desktop computers to mobile telephones. I wanted to visualize future social forms that could grow out of today's roving bands of mobile texters. How might the intergenerational power shifts illuminated by anthropologists affect power structures and social contracts? Will groups of people find it possible to draw out more than they put into mobile social networks? I was fortunate to be able to turn to someone who had studied both sociology and social cyberspaces. I arrived in Redmond on a rare clear winter day. We left our rain gear inside and engaged in a peripatetic interview. The Cascades sparkled visibly on the horizon. I explained the enabling technologies for smart mobs while we walked.

Smith escorted me into his company cafeteria for coffee—a company cafeteria with its own Starbucks. "The effects of mobile and pervasive technology will reach further into our lives than the Internet has," Smith said in a melodramatic voice, sweeping one arm through the air while

reaching into his back pocket with the other hand. Instead of paying cash for our coffees, he placed his wallet on a small pad next to the cash register, triggering a "beep." A chip on a plastic card in his wallet opens doors for Smith and pays for necessities of life within the Microsoft domain. We found a booth. I looked around with the knowledge that we were surrounded by some of the most intelligent and well-caffeinated people in the world.

Smith fell silent, sipped, and rolled his eyes toward the ceiling. "Does the new medium change the way people cooperate?" Smith stated his question again, rolling his gaze back down to eye contact. "That's the big question, and it's not a simple one. Sociologists have developed an entire vocabulary for arguing the technicalities of cooperation. To cast the impacts of mobile and pervasive media in terms sociologists know about, I'd ask how these tools might influence *collective action* and *public goods*." Marc is good at italicizing the spoken word. Another pause. Another sip.

"Do new modes of communication change the way we see ourselves and how others see us? If you follow the strands of cooperation, public goods, presentation of self, and reputation, you might find that they all tie together." He placed his Tall™ half-caf, hi-fat mocha on the table. "The same conundrum—cooperation exists, but it seems like it shouldn't—has infected discipline after discipline. Biologists, economists, even nuclear warfare strategists became interested in social games."

I asked him why he thought of cooperation when I described mobile and pervasive technologies.

"Whenever a communication medium lowers the costs of solving collective action dilemmas, it becomes possible for more people to pool resources. And 'more people pooling resources in new ways' is the history of civilization in . . . " Pause. ". . . seven words."

We ambled over to the company store, where we found Microsoft employees queued up. Marc queried one of the queued, a guy whose baggy jeans reminded me of Shibuya. "Waiting for new X-Box games," he answered with the happy fervor of a gamer. We skipped the company store and continued our conversation in the Microsoft museum, where we looked at antiques like the fabled Altair, the first personal computer kit. The most amusing exhibit was a photograph of the Microsoft staff in 1978, history's most motley group of billionaire nerds.

I interrupted: "What's a "collective action dilemma?"

"Collective action dilemmas are the perpetual balancing of self-interest and public goods." He held out his hands and made the universal gesture for "balancing."

"And public goods are . . . ?"

"A public good is a resource from which all may benefit, regardless of whether they help create it."

"For example . . . ?"

"For example, public television," Smith answered. "You know those pledge drives?" He dropped to a conspiratorial whisper. "Not everybody who watches public television sends a check." He returned to a normal speaking voice. "A lighthouse that a few build but all use for navigation is a classic example of a public good. So is a park. Breathable air. Sanitation systems."

Smith, at thirty-six, looks a bit like the actor Jeff Goldblum. He's lanky, brilliant, and passionate, and he can't refrain from doing stand-up comedy when he talks. He changes voices to create his own cast of characters. He'll present a case like a lawyer and then switch the imagined courtroom setting to an imagined vaudeville stage. Sometimes he appears to be asserting a hypothesis to his thesis committee. Occasionally, he sounds like he is defending his budget to Microsoft brass. No wonder he was drawn to the ideas of Erving Goffman—presentation of self, Goffman's material, is Smith's natural métier.[3]

I learned from ten minutes of shtick-laced pedagogy that the people who succumb to the temptation to enjoy a public good without contributing to its provision (or overconsume at the peril of depletion) are called, appropriately, "free riders." I recalled the people in Stockholm who cheat on subway fares by exchanging SMS messages about the location of fare police. Some smart mobs can be organized bands of free riders.

"Does it bother you when someone cuts in front of you at the grocery checkout?" Yes, of course it does. Smith explained that social disapproval of free riders changes the balance of cooperation dilemmas. The notion of reputation, the subject of Chapter 5, "The Evolution of Reputation," derives from the utility of knowing whom to trust in a cooperative enterprise and how to warn others about cheaters.

"If everyone, acting in their own interest, free rides, then the public good is never created, or it is overconsumed and goes away. Everyone suffers. There's your dilemma. What's good for *you* can be bad for *us*." Smith made the balancing gesture again and then adjusted his gesture to signify "out of balance."

We left the museum and cut across a lawn on our way to his office. "Many public goods, like public health, increase in value the more people share them. But managing collective action is always a struggle. Even where common resources occur naturally, like fishing grounds or pasturelands, free riding seriously threatens their continued sustainability. Most collective goods have a carrying capacity, a rate of consumption beyond which the resource cannot replenish itself. Collectively, groups of people have frequently rushed past this point to total ruin, often aware of exactly what they were doing when they did it. Fishing grounds were overfished, water tables dried up, pasturelands became desert because people faced complex multiplayer games that led each to act rationally for their own gain to the detriment of all."

"This field we're walking on might be a remnant of the first public good that humans found important," Smith declared enigmatically as we walked across a manicured lawn. I could see he was winding up for a story.

"When our ancestors descended from trees, they found themselves on an African grassland called a savanna. One of the things grasslands made possible were big game animals. Hunger drove our forebears to coordinate their actions to bring down animals so large that all the meat couldn't be consumed before it spoiled. In those circumstances, everyone in the group was free to eat—even those who didn't take the risk of hunting. The meat wouldn't be available in the first place unless a few people mustered the gumption to tackle large creatures, but the benefit of the cooperative activity of a few extended to all, even to those who had not participated in the hunt. I think Matt Ridley nailed it when he wrote, 'Big game hunting became the first public good.'"[4]

We entered Smith's office building. "Ridley pointed out in *The Origins of Virtue* that grasslands have been an ongoing theme in human history," Smith remarked in his "you have to read this" voice.[5] Talking with Smith always comes with a price—it can take weeks to finish his reading assignments. After I read the book Smith referred to, I began to see connections between our savanna origins and the desire to own a small lawn, the sport of golf, and the parks we create in the middle of cities. According to Ridley, it's not far-fetched to say that humans are still working out problems our ancestors first encountered on the African grasslands.

Smith held his wallet up to a pad next to the door to unlock the door to his part of the building. "The word *commons* originally denoted pastureland treated as a common resource, where individual herders were free to graze their sheep or cattle. The land can support a limited number of grazing animals. The temptation to graze more than one's share is a rational strategy for an individual herder. But if everyone succumbs to the same temptation, the grass ceases to grow, and the value of the pasture disappears."

I recognized this as the situation Garrett Hardin named in a much-debated article titled "The Tragedy of the Commons," in which Hardin concluded: "Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."[6] Hardin's article provoked a debate that continues to this day: In the face of temptation to behave selfishly, how do people manage to cooperate? Is it necessary to curtail their freedom through some kind of regulatory authority?

The debate surrounding Hardin's tragedy of the commons is a contemporary reprise of an older philosophical conflict. In 1660, Thomas Hobbes argued that humans are so competitive that the only way we can cooperate is for a more powerful competitor to impose a truce. Hobbes called this coercive authority *Leviathan;* subsequently, this logic supported arguments for a strong sovereign.[7] In conflicts over the provision or consumption of common resources, arguments continue to focus on the polarized viewpoints of centralized governmental regulation and decentralized, market-based self-regulation. However, the most salient counterargument to Hobbes is that humans obviously do agree to work together. Decades after Hobbes, John Locke, philosophical mentor to Thomas Jefferson, asserted that humans could govern through social contracts rather than coercive authority.[8]

Since the time of Hobbes and Locke, political philosophers, sociologists, economists, and candidates for public office have argued over the role of central authority in governance, markets, and human affairs. The argument became scientific as well as philosophical when researchers began to systematically observe the way people really do work together. Laboratory investigators began to formulate experiments to probe cooperative behavior. The experiments were based on simple games in which experimental subjects can win or lose money (more about game theory shortly). In the 1950s, economist Mancur L. Olson found that small groups are more likely to exhibit voluntary cooperation in these experimental games than larger groups and that cooperative behaviors increase when the games are repeated over and over with the same groups and when communication is permitted among the participants.[9]

In 1982, Olson wrote, "Unless the number of individuals in a group is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, rational, self-interested individuals will not act to achieve their common or group interests."[10] One unavoidable question remained. Clearly, some groups learn to solve collective action dilemmas to produce public goods or prevent overconsumption. How is this accomplished? Olson provided some hints when he noted that a prominent businessman might finance a lighthouse for the prestige and recognition such an act might win in the eyes of others. Reputation is a recurring leitmotiv in the discourse of cooperation.

In 1990, sociologist Elinor Ostrom argued that external authorities might not be necessary in governing what she called common pool resources (CPRs).[11] Ostrom studied the ways that people shared forestry resources in Japan, pasturelands in Switzerland, and irrigation arrangements in Spain and the Philippines. Ostrom provided examples of communities that have shared public goods for centuries and succeeded in not depleting them. She discovered that in Spanish irrigation-sharing *huertas*, "a portion of the fines is kept by the guards; the Japanese detectives also keep the sake they collect from infractors."[12] To facilitate cooperation, the Spanish synchronize schedules of adjacent water users so they can monitor each other, the Japanese reward those who report infractions, and most successful CPR groups impose social sanctions on cheaters.

In comparing the communities, Ostrom found that groups that are able to organize and govern their behavior successfully are marked by the following design principles:

- Group boundaries are clearly defined.
- Rules governing the use of collective goods are well matched to local needs and conditions.
- Most individuals affected by these rules can participate in modifying the rules.
- The rights of community members to devise their own rules is respected by external authorities.

- A system for monitoring members' behavior exists; the community members themselves undertake this monitoring.
- A graduated system of sanctions is used.
- Community members have access to low-cost conflict resolution mechanisms.
- For CPRs that are parts of larger systems, appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.[13]

In the weeks of reading that followed my visit to Redmond, I learned that Hardin has since stated that he should have called it "The Tragedy of the Unmanaged Commons."[14] I also discovered that research continues into the secrets of how successful commons are managed. Ostrom provided an ample and specific agenda for future research: "All efforts to organize collective action, whether by an external ruler, an entrepreneur, or a set of principals who wish to gain collective benefits, must address a common set of problems. These have to do with coping with free-riding, solving commitment problems, arranging for the supply of new institutions, and monitoring individual compliance with sets of rules."[15]

An interdisciplinary community of CPR researchers grew out of Ostrom's work, which built on the findings of Anthony Scott and H. Scott Gordon, who wrote about fisheries in 1954 and 1955.[16] In a paper about the application of CPRs to technology-based, human-created CPRs, such as the Internet, Charlotte Hess pointed out the significance of the emergence of a cross-disciplinary convergence:

> There are centuries of intellectual investigations into the nature of property rights, free riding, overpopulation, efficiency, participation, volunteerism, resource management, organizational behavior, environmental sustainability, social equity, self-governance, transboundary disputes, common fields, enclosure, communal societies, and the common good. What has remarkably changed is the merging of disciplines, the methodologies, the international cooperative approach, and the intentionality of the CPR literature.[17]

CPR research, still in early stages, might be a step toward the "empirically supported theory of self-organizing and self-governing forms of collective action" Ostrom called for in 1990.[18] If people start organizing new forms of collective action through the use of wireless devices, such theories as Ostrom's might help make sense of what we'll see around us.

When I had completed the reading assignments Smith had given me, I called him. The best way to reach Smith is through his mobile telephone. He was waiting to pick up his son from school, trying to log on to an open wireless node from the school parking lot. In addition to being a sociologist, Smith is a hardware and software geek. He pointed out, while walking back and forth in a Redmond parking lot with a handheld computer, that "Ostrom found that some system to monitor and sanction members' actions was a common feature of every successful community. Monitoring and sanctioning is important not simply as a way of punishing rule-breakers but also as a way of assuring people that others are doing their part. Many people are contingent cooperators, willing to cooperate as long as most others do."

Smith reminded me that commitment to cooperate is as important as temptation to free ride; threat of punishment can constrain, but it can't inspire. Something must motivate people to contribute to a public good. While we were talking on the phone, Smith sent me a paragraph from his Ph.D. thesis. He likes to do things like that from his palmtop in parking lots: "A commons can be more than physical resources like fish or pastureland," said his email. I read it while talking to him. Perhaps because I didn't grow up with it, such multitasking tends to require concentration: "A commons," continued Smith's message, "can also be social organizations themselves. Some goods are tangible, like common pastures or irrigation systems; others are intangible goods like goodwill, trust, and identity. Markets, judicial systems, and social capital in communities are all common resources. These resources must be actively reconstructed; where fish will remain in the sea whether they are fished or not, a judicial system or other social contract will not persist without the continued contribution of its participants."[19]

Smith added on the voice track that reputation and peer-to-peer social pressure pay a key role in maintaining CPRs: "Social pressure, from insult to incarceration, to make good on debts or obligations helps communities maintain the essential collective good of trust." Reputation, whether maintained by gossip, ritual behavioral displays, credit bureaus, or online reputation servers, appears to be one of the means by which people negotiate the day-to-day dance of self-interest and public goods.

Identity, reputations, boundaries, inducements for commitment, and punishment for free riders seem to be common critical resources all groups need in order to keep their members cooperatively engaged. These are the social processes most likely to be affected by technology that enables people to monitor reputations, reward cooperation, and punish defection.

The interdisciplinary study of CPRs and the continuing sociological debate about collective action turned out to be only one category of cooperation theory. Parallel inquiry came from different parts of the disciplinary spectrum. A mathematical approach took root in the 1950s and began to bear fruit decades later, when more powerful computers became available. Yet another discourse, which converged with computer modeling, grew up around issues in biological evolution. The surprising results might have remained hidden in think tanks and scientific journals if they had not generated such important implications for human group behavior.

It seemed as if the thread I had started following in Tokyo had turned into a whole ball of yarn by the time I returned from Redmond. My simple inquiry into existing knowledge that might make sense of smart mobs led me to a richer treasury of thinking tools than I had imagined that afternoon Mizuko Ito and I conversed about the thumb tribes of Tokyo.

Mutual Aid, Prisoner's Dilemma, and Other Games People Play

Does cooperation occur exclusively among people, making it the domain of psychologists, sociologists, and anthropologists? Is an emergent property of any population of interacting individuals, landing it in the domain of economists? Or could cooperation be a strategy that genes use to ensure their reproduction, which would make it the domain of biology? The answer to each of these questions appears to be "yes, in part." I caution against concluding that any theory or model will ever predict human social behavior; I recommend these inquiries from different disciplines as a means of understanding aspects of human social processes, not as oracles. Although the genetic influences on social dilemmas might seem distant from the impacts of smart mob technologies, certain motifs crop up at multiple levels when it comes to the tension between self-interest and collective action.

Biological arguments about the role of altruism and the origins of cooperation are rooted in Darwin's discovery of the mechanisms of evolution. If natural selection, a Hobbesian competition to transmit genes to future generations, is the force that sculpts species over millions of years, then genetic disposition toward cooperation should have been bred out of all species long ago. The philosopher who argued for the place of cooperation when evolutionary theory was first debated was a swashbuckling geographer and anarchist, Peter Kropotkin. Kropotkin, a Russian prince, was selected by the czar for elite training at an early age and later led a secret life writing pseudonymous anarchist pamphlets until he was arrested. After escaping czarist prison, Kropotkin ended up in London, where he contested the idea that competition was the sole driving force of evolution.

The naturalist Thomas H. Huxley championed Darwinian theory in Kropotkin's day, especially in his 1888 essay "The Struggle for Existence," which promoted competition as the most important driver of human evolution.[20] Kropotkin asserted that Huxley's interpretation of Darwinian theory was misconstrued and inaccurate. The publication of Huxley's essay was the impetus for Kropotkin to begin writing *Mutual Aid: A Factor of Evolution* as a reply to Huxley, and the subsequent series of articles that eventually made up Kropotkin's most famous book were originally published in the same journal, *The Guardian*.[21]

Cooperation, Kropotkin claimed, has been observed extensively in the animal kingdom. Horses and deer unite to protect each other from their foes, wolves and lions gather to hunt, while bees and ants work together in many different ways. Since Kropotkin's day, corroboration for some of his ideas has surfaced, and interest in Kropotkin's biological work, long eclipsed by his anarchist writing, was revitalized when biologist Stephen J. Gould concluded that Kropotkin had been onto something.[22] Symbiosis and cooperation have indeed been observed at every level from cell to ecosystem.

Kropotkin also contended that humans are predisposed to help one another without authoritarian coercion. A centralized government, he insisted, is not needed to set an example or to make people do the right thing. People were doing so before the rise of the state. In fact, Kropotkin maintained that it is government that represses our natural tendency for cooperation. His belief in the principle of grassroots power was strong enough to land him in the czar's prison.

Kropotkin wrote of the temporary guilds of the Middle Ages—cooperative, "just in time" groups formed by the union of like-minded individuals who shared a common goal and space. These groups could be found aboard ships, at the building sites of large-scale public construction projects such as cathedrals, and anywhere "fishermen, hunters, travelling merchants, builders, or settled craftsmen—came together for a common pursuit."[23] After leaving port, the captain of a ship would gather the crew and passengers on deck, tell them that they were all in this together and that the success of the voyage was dependent upon all of them working as one. Everyone onboard then elected a "governor" and "enforcers," who would gather "taxes" from those who broke the rules. At the end of the voyage the levies would be given to the poor in the port city.

Kropotkin's uncontestable observation that cooperation crops up all over biology eventually fomented a revolution in evolutionary theory in the 1950s and 1960s. Marine biologist George Williams stated the problem posed by the cooperative behavior exhibited by social insects: "A modern biologist seeing an animal doing something to benefit another assumes either that it is being manipulated by the other individual or that it is being subtly selfish."[24] If every organism seeks only to benefit itself against all, why would bees sacrifice themselves for the hive, as they clearly do?

In 1964, social insect specialist William Hamilton came up with an answer now known as "kin selection": Because bees are sisters (in fact, bees share more genes than sisters do), saving the life of several hivemates at the cost of one's own is a net gain in the number of the same genes transmitted to future generations.[25] The most radical interpretation of kin selection was popularized by Richard Dawkins's book *The Selfish Gene* in a startling formulation: "We are survival machines . . . robot vehicles blindly programmed to preserve the selfish molecules known as genes."[26]

The difference between predisposition and predestination is outside the scope of this book, but I recommend contemplating another of Hobbes's statements in regard to the behavior of insects versus that of humans: "The agreement of these creatures is natural; that of men is by covenant only, which is artificial; and therefore it is no wonder if there be somewhat else required."[27] The "somewhat else required" to achieve human cooperative behavior is as important as evolutionary influences and is the focus of its own discipline. And the bulk of the "artificial" part is what we now call "technology."

Those "covenants" mentioned by Hobbes turn out to be tricky because humans play elaborate games of trust and deception. Economists have long sought the mathematical grail that could predict the behavior of markets. In 1944, John von Neumann and Oskar Morgenstern's *Theory of Games and Economic Behavior* provided, if not a grail, a means of looking at the way people compete and collude, cooperate and defect, in competitive situations.[28]

John von Neumann was arguably the most influential but least-famous scientist in history, considering his fundamental contributions to mathematics, quantum physics, game theory, and the development of the atomic bomb, digital computer, and intercontinental ballistic missile.[29] Von Neumann was a prodigy who joked with his father in classical Latin and Greek at the age of six, was a colleague of Einstein at Princeton's Institute for Advanced Study, and was perhaps the most brilliant of the stellar collection of scientists gathered at Los Alamos to undertake the Manhattan Project. Jacob Bronowski, a Manhattan Project colleague, recounted that von Neumann had told him, during a taxicab ride in London, that "real life consists of bluffing, of little tactics of deception, of asking yourself what is the other man going to think I mean to do. And that is what games are about in my theory."[30]

Game theory is based on several assumptions: that the players are in conflict, that they must take action, that the results of the actions will determine which player wins according to definite rules, and that all players (this is the kicker) are expected to always act "rationally" by choosing the strategy that will maximize their gain regardless of the consequence to others. These are the kind of rules that don't fit real life with predictive precision, but that do attract economists, because they map onto the behavior of observable phenomena like markets, arms races, cartels, and traffic.

After World War II, von Neumann joined other mathematicians and economists to brainstorm game theory at a mundane building that still houses the same institution near the Santa Monica beach. The RAND Corporation was the first think tank, where intellectuals with security clearances thought about the unthinkable, as RANDite Herman Kahn referred to the craft of thermonuclear war strategy.[31] Because the arms race seemed to be closely related to the kind of bluff and counter-bluff described by game theory, the new field became popular among the first nuclear war strategists. In 1950, RAND researchers came up with four fundamental elements of Morgenstern- and von Neumann-style games: Chicken, Stag Hunt, Deadlock, and Prisoner's Dilemma. Keep in mind that although they can be described as stories, they are represented by exact mathematical equations.

Chicken is the game portrayed in movies about juvenile delinquents: two opponents rush toward oblivion, and the one who stops or swerves first loses. Deadlock is endless betrayal: Each player refuses to cooperate, ever. The next two are more interesting. Stag Hunt was first described by Jean Jacques Rousseau in 1755: "If it was a matter of hunting deer, everyone well realized that he must remain faithfully at his post; but if a hare happened to pass within reach of one of them, we cannot doubt that he would have gone off in pursuit of it without scruple and, having caught his own prey, he would have cared very little about having caused his companions to lose theirs."[32] Stag Hunt is a classic illustration of a problem of provisioning a public good in the face of individual temptation to defect to self-interest. Should a hunter remain with the group and bet on the smaller chance of bringing down large prey for the entire tribe or break away from the group and pursue the more certain prospect of bringing a rabbit home to his own family?

The fourth game hatched at RAND has grown into an interdisciplinary Schelling point. The game was invented in 1950 by RAND researchers Merrill Flood and Melvin Dresher.[33] A few months after Flood and Dresher invented the game, a RAND consultant named it at a seminar at Stanford University. Tucker described the game situation: "Two men, charged with a joint violation of law, are held separately by the police. Each is told that (1) if one confesses and the other does not, the former will be given a reward . . . and the latter will be fined . . . , (2) if both confess, each will be fined . . . . At the same time, each has a good reason to believe that (3) if neither confesses, both will go clear."[34]

Over the years, the popular version has changed Tucker's rendition of Prisoner's Dilemma. Threatening jail sentences is a better story than offering rewards. Remember that the prisoners are "held separately" and unable to communicate, so they can only guess what the other prisoner is likely to do. The prisoner who testifies against his partner will go free, and the partner will be sentenced to three years. If both prisoners decide to testify against each other, they will both get a two-year sentence. And if neither testifies, they will both receive a one-year sentence. Because this is game theory, each player is interested only in his own welfare. Rationally, each player will conclude that testifying will take a year off his sentence, regardless of what the other player does. Defecting will prevent a player from being a sucker—remaining loyally silent while the other player rats out. However, if they both refuse to testify, they could both get away with only one year. There's the dilemma: Each player, acting in his own interest, brings a result neither player prefers.

The mathematical version represents the results of the two players' strategies, pitted against each other in the form of a table. Each row represents a strategy for one player and each column represents a strategy for the other player. The pairs of numbers in the table cells represent the respective payoffs for the players. The payoffs are structured so that, in the RAND researchers' original terms, the *reward* payoff for mutual cooperation is greater than the *punishment* payoff for mutual defection; both are greater than the *sucker's* payoff for cooperating when the other player defects and less than the *temptation* payoff for defecting when the other player cooperates. All four of the RAND social dilemmas are variations of the same model: Reverse the sucker and temptation payoffs, and Prisoner's Dilemma becomes Chicken. Switch reward and temptation payoffs, and Prisoner's Dilemma becomes Stag Hunt.

	B cooperates	*B defects*
A cooperates	2,2	0,3
A defects	3,0	1,1

In 1979 political scientist Robert Axelrod grew interested in cooperation—a turning point in the history of smart mob theory:

> This project began with a simple question. When should a person cooperate, and when should a person be selfish, in an ongoing interaction with another person? Should a friend keep providing favors to another friend who never reciprocates? Should a business provide prompt service to another business that is about to be bankrupt? How intensely should the United States try to punish the Soviet Union for a particular hostile act, and what pattern of behavior can the United States use to best elicit cooperative behavior from the Soviet Union? There is a simple way to represent the type of situation that gives rise to these problems. This is to use a particular kind of game called the iterated Prisoner's Dilemma. The game allows the players to achieve mutual gains from cooperation, but it also allows for the possibility that one player will exploit the other, or the possibility that neither will cooperate.[35]

The Prisoner's Dilemma game takes on interesting new properties when it is repeated over and over ("iterated"). Although the players cannot communicate their intentions regarding the current move, the history of previous decisions becomes a factor in assessing the other player's intentions. In Axelrod's words, "What makes it possible for cooperation to emerge is the fact that the players might meet again. This possibility means that the choices made today not only determine the outcome of this move, but can also influence the later choices of the players. The future can cast a shadow back upon the present and thereby affect the current strategic situation."[36] "Reputation" is another way of looking at this "shadow of the future."

Axelrod proposed a "Computer Prisoner's Dilemma Tournament" pitting computer programs against one another. Each program would make a choice to cooperate or defect on each move, thus gaining points according to the game's payoff matrix. Each program could take into account the history of its opponent's prior moves. Axelrod received entries from game theorists in economics, psychology, sociology, political science, and mathematics. He ran fourteen entries against each other and against a random rule, over and over. "To my considerable surprise," Axelrod reported, "the winner was the simplest of all the programs submitted, TIT FOR TAT. TIT FOR TAT is merely the strategy of starting with cooperation and thereafter doing what the other player did on the previous move."[37] If the opponent cooperates on the first move, then TIT FOR TAT cooperates on the next move; if the opponent defects on the first move, then TIT FOR TAT defects on the next move. If the opponent switches from defection to cooperation, TIT FOR TAT switches from defection to cooperation on the following move, punishing the opponent but forgiving it.

Axelrod invited professors of evolutionary biology, physics, and computer science to join the original entrants on a second round. Designers of strategies were allowed to take into account the results of the first tournament. TIT FOR TAT won again. Axelrod found this intriguing:

> Something very interesting was happening here. I suspected that the properties that made TIT FOR TAT so successful in the tournaments would work in a world where any strategy was possible. If so, then cooperation based solely on reciprocity seemed possible. But I wanted to know the exact conditions that would be needed to foster cooperation on these terms. This led me to an evolutionary perspective: a consideration of how cooperation can emerge among egoists without central authority. The evolutionary perspective suggested three distinct questions. First, how can a potentially cooperative strategy get an initial foothold in an environment which is predominantly noncooperative? Second, what type of strategy can thrive in a variegated environment composed of other individuals using a wide diversity of more or less sophisticated strategies? Third, under what conditions can such a strategy once fully established among a group of people, resist invasion by a less cooperative strategy?[38]

Tinkering with the game simulation revealed an answer, at least on the game-theoretic level, to Axelrod's first question: Within a pool of entirely uncooperative strategies, cooperative strategies evolve from small clusters of individuals who reciprocate cooperation, even if the cooperative strategies have only a small proportion of their interactions with each other. Clusters of cooperators amass points for themselves faster than defectors can. Strategies based on reciprocity can survive against a variety of strategies, and "cooperation, once established on the basis of reciprocity, can protect itself from invasion by less cooperative strategies. Thus, the gear wheels of social evolution have a ratchet."[39]

Axelrod, a political scientist at the University of Michigan, wasn't a biologist, so he called "selfish gene" biologist Richard Dawkins in England, who told him to speak to William Hamilton, discoverer of kin selection in insects, who, unknown to Axelrod until then, was also at the University of Michigan. Hamilton recalled a Harvard graduate student, Robert Trivers, who had presented evidence for reciprocity as the mechanism that enables self-interested individuals to cooperate.[40] The "shadow of the future" enabled individuals to do favors for others, who would do favors for them in the future. Years before Axelrod and TIT FOR TAT, had Trivers uncovered the link between self-interest and cooperation? The publication of Axelrod's *The Evolution of Cooperation* ignited interest in the biological basis of cooperation.[41]

In 1983 biologist Gerald Wilkinson reported that vampire bats in Costa Rica regurgitate blood to share with other bats who had been less successful in their night's hunt and that bats played TIT FOR TAT, feeding those who had shared in the past and refusing those who had not shared.[42] Wilkinson suggested that the bats' frequent social grooming rituals furnished a means by which this social memory functioned.

In related research, Manfred Milinski performed a clever experiment with a species of small fish called sticklebacks.[43] Schools of sticklebacks send out scouting pairs to assess the danger posed by nearby predators. Why would an individual dart out from the safety of the school to probe the reactions of a fish that would like to eat it? Milinski noted that each pair of sticklebacks probing a predator took turns moving toward the larger fish in short darting movements. If the predator showed interest, the scouts scooted back to the school. Milinski proposed that the turn taking was an example of the Prisoner's Dilemma. He tested his hypothesis by putting a mirror near a predator in an aquarium. Lone sticklebacks reacted in a TIT FOR TAT–like manner when observing what their mirror image did; that is, when they darted forward or backward spontaneously, they repeated the action after seeing their image.

Later, when discussing zero-sum games versus non-zero-sum games, I'll point out the ways that cooperative and competitive behaviors are nested within one another. Recall the first public goods, where early hunters may have cooperated in order to bring down game but reverted to more competitive strategies such as dominance hierarchies when it came to allocating that meat (although one of the oft-quoted observations about the emergence of food sharing is that "the Inuit knows that the best place for him to store his surplus is in someone else's stomach"[44]).

Cooperation and conflict are both aspects of the same phenomenon. One of the important ways that humans cooperate is banding together into clans, tribes, and nations in order to compete more effectively against other bands. Cooperators can thrive amid populations of defectors if they learn to recognize each other and interact with one another. Are Ostrom's "clearly defined group boundaries" another way of cooperators learning to recognize each other? Cooperators who clump together can outcompete noncooperative strategies by creating public goods that benefit themselves but not the defectors. One time-tested way of inducing a group to work together is to introduce an external threat. Cooperative enterprise and intergroup conflict have coevolved because the ability to recognize who is inside and who is outside a group's boundaries is integral to both intragroup cooperation and intergroup conflict.

Reciprocity, cooperation, reputation, social grooming, and social dilemmas all appear to be fundamental pieces of the smart mob puzzle. Each of these biological and social phenomena can be affected by, and can affect, communication behaviors and practices. Prisoner's Dilemma and game theory are not "answers" to questions of cooperation; rather, they are tools for understanding human social dynamics. Together with CPR theory, game-theoretic and other computer-modeling approaches open windows onto the kinds of group behavior that might emerge with smart mob technologies.

Inventing the Innovation Commons

The most successful recent example of an artificial public good is the Internet. Microprocessors and communication networks were only the physical part of the Net's success formula; cooperative social contracts were also built into the Net's basic architecture. The Internet is both the result of and the enabling infrastructure for new ways of organizing collective action via communication technology. This new social contract enables the creation and maintenance of public goods, a commons for knowledge resources.

The personal computer and the Internet would not exist as they do today without extraordinary collaborative enterprises in which acts of cooperation were as essential as microprocessors. The technologies that support tomorrow's smart mobs were created over three decades by people who competed with each other to improve the value of their shared tools, media, and communities of practice. And for most of this era, "value" translated into "usefulness," not price per share of stock. A brief detour into the history of personal computing and networking illuminates more than the origins of smart mob technologies; the commons that fostered technical innovations is also the fundamental social technology of smart mobs. It all started with the original hackers in the early 1960s.

Before the word "hacker" was misappropriated to describe people who break into computer systems, the term was coined (in the early 1960s) to describe people who *create* computer systems. The first people to call themselves hackers were loyal to an informal social contract called "the hacker ethic." As Steven Levy described it, this ethic included these principles:

> Access to computers should be unlimited and total.
> Always yield to the Hands-On Imperative.
> All information should be free.
> Mistrust authority—promote decentralization.[45]

Without that ethic, there probably wouldn't have been an Internet to commercialize. Keep in mind that although many of the characters involved in this little-known but important history were motivated by altruistic concerns, their collaboration was aimed at creating a resource that would benefit all—starting with the collaborators who created it. Like other creators of public goods, the hackers created something that they were eager to use for their own purposes.

The Internet was deliberately designed by hackers to be an innovation commons, a laboratory for collaboratively creating better technologies. They knew that some community of hackers in the future would know more about networks than the original creators, so the designers of the Internet took care to avoid technical obstacles to future innovation.[46] The creation of the Internet was a community enterprise, and the media that the original hackers created were meant to support communities of creators.[47] To this end, several of the most essential software programs that make the Internet possible are not owned by any commercial enterprise—a hybrid of intellectual property and public good, invented by hackers.

The foundations of the Internet were created by the community of creators as a gift to the community of users. In the 1960s, the community of users was the same as the community of creators, so self-interest and public goods were identical, but hackers foresaw a day when their tools would be used by a wider population.[48] Understanding the hacker ethic and the way in which the Internet was built to function as a commons are essential to forecasting where tomorrow's technologies of cooperation might come from and what might encourage or limit their use.

Originally, software was included with the hardware that computer manufacturers sold to customers—mainframe computers attended by special operators. Programmers were required to submit their programs to the operators in the form of punched paper cards. When technology and political necessity made it possible for programmers to work directly with computers, an explosion of innovation occurred.

Credit Sputnik for the way computers changed. In 1957, motivated by the groundbreaking entry of Soviet technology in orbit, the U.S. Department of Defense created the Advanced Research Projects Agency. ARPA hired an MIT professor by the name of J.C.R. Licklider to lead an effort to leapfrog over existing computer technology. ARPA contractors created software that would display the results of computations as graphical displays on screens instead of printouts. Most importantly, they created software "operating systems" that enabled the community of programmers/users to interact directly with computers.

An operating system (OS) coordinates the interaction between a computer's hardware and application software. Early interactive operating systems were known as "time-sharing" systems because they took advantage of the speed of electronic computation to divide the computer's "attention" among groups of programmers. The computer's processor would switch between each user for a fraction of a second, giving each user the impression that he or she was the sole user. Because they were connected to the same computer, programmers working on ARPA projects quickly developed a sense of community. They started inventing ways to send each other messages from their individual terminals through the shared computer. Email and virtual communities are both rooted in the ancestral "hacks" the time-sharing programmers created to communicate among themselves.

The bill for these innovations was paid by ARPA grants. The hackers created tools for one another, competing to share the best hacks with the community, giving American taxpayers and the rest of the world an astonishing return on investment. At MIT in the early 1960s, inventing interactive computing was a collective enterprise. Essential programs were stored on punched paper tape and kept in an unlocked drawer; any hacker could use the program, and if he found a better way to do what the program was intended to do, he would revise the program, change the tape, and put it back in the drawer.[49]

In the late 1960s and early 1970s, several developments set off the next frenzy of innovation. Licklider and others started planning an "intergalactic network" to connect the geographically scattered ARPA computing centers.[50] From the beginning, the network's architects knew they were creating a communication medium as well as a means of connecting remote computers.[51] By the mid-1970s, government laboratories and big corporations were joined by a new player in the computer game: teenage hobbyists. In 1974, the Altair, the first personal computer kit, became available, and "homebrewing computing" hobbyists began meeting in Palo Alto. The Homebrew Computer Club received a famous letter in 1976 from twenty-one-year-old Bill Gates, complaining that homebrewers were using the programming tool that his new company, Microsoft, had created for the Altair without paying him for it.[52] Software, Gates declared, was not a public good you kept in a drawer, tinkered with, and shared; it was private property. Bill Gates stuck by his declaration, and by the 1990s he had become the world's richest man by selling the operating system used by 90 percent of the desktop computers in the world.

In 1969, AT&T Bell Labs pulled out of ARPA's Multics operating system project, and several Bell Labs programmers who missed the sense of community started working on their own unofficial OS project. Programmer

Ken Thompson created a game on a small computer that had come into his hands, in the process writing a "kernel" that would end up growing into the OS that collaborator Brian Kernighan named Unix in 1970. The name was a pun on the abandoned Multics project.[53] The Unix creators made their source code publicly available to other programmers and invited collaboration in creating software that could make Unix more useful, a decision that gave birth to a whole new way of developing software. Computer software is distributed for use in the form of "object code," a translation of the original ("source") program into a human-unreadable but machine-executable collection of zeroes and ones. By distributing the source code, the Unix creators made it possible for other programmers to understand how the software works and to make their own modifications—harking back to the days of the paper tape in the unlocked drawer. Ken Thompson started duplicating Unix source code and utilities on magnetic tapes, labeling and documenting them with the words "Love, Ken," and mailing the tapes to friends.[54]

Unix software became the OS of the Net. In turn, the Internet created a rich environment for Unix programmers to establish one of the earliest global virtual communities. Dennis Ritchie, one of the Unix creators, wrote: "What we wanted to preserve was not just a good environment in which to do programming, but a system around which a fellowship could form. We knew from experience that the essence of communal computing, as supplied by remote-access, time-shared machines, is not just to type programs into a terminal instead of a keypunch, but to encourage close communication."[55]

However, in 1976, AT&T halted publication of Unix source code; the original, eventually banned, books became "possibly the most photocopied works in computing history."[56] At around the same time the Unix community was coalescing, MIT's Artificial Intelligence research laboratory changed the kind of computers it used. This was a blow to the MIT hacker culture, because their software tools were rendered useless. At the same time, many of the early AI researchers were leaving for private industry to get involved in the techno-bubble of the time, the commercial AI boom and eventual bust. One holdout at MIT, deprived of his beloved programming environment, resistant to the commercialization of what he considered public property by AT&T and Microsoft, was Richard Stallman.

Stallman vowed to write an OS that would be as portable and open as Unix, but which would be licensed in a way that would maintain its status as public goods. Stallman, founder of the Free Software Foundation, started creating GNU—a recursive acronym that stands for "GNU's Not Unix." Stallman, who owns little property and has no home other than his office, devoted himself thereafter to what he called "free software" (and emphasized that he meant "free as in free speech, not free beer").[57]

Stallman hacked the legalities of the copyright system as well as created the first source code for a free OS. He released the software he created with a license known as the GPL (General Public License). The GNU GPL enables others to copy, distribute, and make changes to software, as long as innovators don't prevent others from doing the same thing. Stallman called the new kind of license "Copyleft."[58] Like the paper tape in a drawer at MIT, GPL software is free for anyone to use, and anyone is free to build on it, but only if they keep the source code of the software open for others to use and improve.

Creating an operating system is not a simple enterprise. By 1991, GNU was a complete OS, with the exception of its most essential part, known as the kernel. Linus Torvalds, a student at the University of Helsinki, started to write his own kernel. Based on GNU, all of Torvalds's code was open according to the GPL, and Torvalds took the fateful step of posting his work to the Net and asking others for help. The kernel, known as Linux, drew hundreds, then thousands of young programmers. By the 1990s, opposition to the monolithic domination of the computer operating system market by Microsoft became a motivating factor for rebellious young programmers who had taken up the torch of the hacker ethic.

"Open source" refers to software, but it also refers to a method for developing software and a philosophy of how to maintain a public good. Eric Raymond wrote about the difference between "cathedral and bazaar" approaches to complex software development:

> The most important feature of Linux, however, was not technical but sociological. Until the Linux development, everyone believed that any software as complex as an operating system had to be developed in a carefully coordinated way by a relatively small, tightly knit group of people. This model was and is typical of both commercial software and the great freeware cathedrals. . . . Linux evolved in a completely different way. From nearly the beginning, it was rather casually hacked on by huge numbers of volunteers coordinating only through the Internet. Quality was maintained not by rigid standards or autocracy but by the naively simple strategy of releasing every

week and getting feedback from hundreds of users within days, creating a sort of rapid Darwinian selection on the mutations introduced by developers.[59]

Software deliberately created as a public good is the reason you can type www.smartmobs.com instead of a string of numbers to see this book's Web site; the Internet's "domain name" system depends on BIND software, probably the most widely used software that nobody owns and everybody uses.[60] When it was time for the ARPAnet to grow into a network of networks, the programming wizards who created the Internet's fundamental protocols understood that decisions they made about this software would affect future generations of innovators. They created the first protocols for sending data around the network in a way that had profound social effects: "The basic argument is that, as a first principle, certain required end-to-end functions can only be performed correctly by the end-systems themselves. . . . The network's job is to transmit datagrams as efficiently and flexibly as possible. Everything else should be done at the fringes."[61] (Think of a "datagram" as a little chunk of content that has an address on it.)

By adhering to one of the principles Ostrom had recognized—in complex social systems, the levels of governance should nest within each other—Internet architects hit upon the "end-to-end" principle that allows individual innovators, not the controllers of the network, to decide what to build on the Internet's capabilities.[62] When Tim Berners-Lee created World Wide Web software at a physics laboratory in Geneva, he didn't have to get permission to change the way the Internet works, because the computers that are connected (the "fringes"), not a central network, is where the Internet changes. Berners-Lee simply wrote a program that worked with the Internet's protocols and evangelized a group of colleagues to start creating Web sites; the Web spread by infection, not fiat.[63]

In 1993, Marc Andreesen and other programmers at the U.S. National Center for Supercomputing Applications (NCSA) released Mosaic, the "browser" software that made the Web accessible through a point-and-click interface. Key Mosaic programmers moved from NCSA, a public institution that puts its software into the public domain, to Netscape, Inc., which "closed" the browser code. Marc Andreesen became a zillionaire when Netscape went public in 1994. As the Internet industry skyrocketed from nowhere to "the greatest legal accumulation of wealth in history,"[64] the Web was also emerging as a noncommercial effort by programmers who had not been born when the ARPAnet was invented. Volunteers started exchanging software to improve the Web server that NCSA programmers had created. Just as the browser is the software used to navigate the Web, the Web server is the software used to publish information on the Web. These volunteer programmers agreed that keeping free, open-source Web server software available was key to maintaining the spirit of innovation.

Brian Behlendorf cofounded the virtual community of volunteers who maintain the open-source software that still powers 60 percent of the Web servers in the world. Because the earliest noncommercial Web server software required many "patches"—additional software added to a program to fix a bug—Behlendorf organized an online coalition of programmers to share patches. Because it was a "patchy" program, they decided to call the software Apache. He's now the CEO of Collabnet, one of the rare surviving dotcoms that uses open-source methods for commercial software development. In 1998, IBM based its e-business product line on Apache and subsequently announced a billion-dollar budget to support open-source software development.

Perhaps the largest incubator of online social networks and the oldest global virtual community, Usenet, is also an example of a gigantic long-functioning anarchy—a public good that exists on minimum enforcement of cooperation. In 1979, Duke University grad students Jim Ellis and Tom Truscott, and Steve Bellovin at University of North Carolina, created the first link between Duke and UNC.[65] Unix-to-Unix copy protocol, a communication tool that came bundled with every copy of Unix, made it possible for computers to exchange files over telephone modem connections. Every day or hour, one computer would automatically dial the modem connected to another computer and exchange messages that had been composed by computer users at either end; each computer would relay messages that had been passed to them until they reached their destination, like a bucket brigade. This kind of public email, known as "postings," or "posts," is readable by anyone who subscribes to the appropriate topical interest group known as a "newsgroup." The self-organizing global conversation network began to spread among university and industry computer centers, relaying messages around the world through ad hoc dial-up arrangements.

To join Usenet, a computer system operator only needed to get a "feed" from another computer system that would transmit and relay messages to and from the system's users. That single agreement to send messages back and forth in an agreed format is the extent of Usenet's enforced cooperation. There is no central control, either technical or social. "Whatever order exists in the Usenet is the product of a delicate balance between individual freedom and collective good," is how Marc Smith put it.[66] This anarchy, now over twenty years old, became spectacularly successful after 1986, when the news feed began to propagate through Internet-linked sites with high-speed connections rather than ad hoc relay networks of dial-up connections. Usenet exchanged 151 million messages, contributed by 8.1 million unique identified users in 2000. Each day, more than 1 million messages are exchanged among more than 110,000 unique participants via 103,000 newsgroups.[67]

Will the Internet remain a decentralized, self-organized commons as the fixed network infrastructure upgrades to wireless connection technologies? Lawrence Lessig, distinguished professor at Harvard and Stanford law schools, is alarmed at technical and legal movements now underway that might change the characteristics that enabled the Internet to thrive. Intrigued by Lessig's book, *The Future of Ideas,* I talked with him directly in his office at Stanford's law school.[68] Lessig was dressed casually in black jeans and a blue cardigan sweater. I noticed five different coffee containers on his desk. I asked him whether it was proper to think of the Internet as the kind of common pool resource that Hardin and Ostrom had written about.

> Definitely! The resource that was held in commons was the right to innovate. That resource was held in commons because the architecture of the Internet prevented the owner of the network from vetoing innovations in content or applications that they didn't like. The end-to-end principle meant that the network itself had no power to discriminate. That meant anybody could take advantage of the commons created by connecting all these computers together to develop new ideas and applications that everybody could have access to. And that's what happened. The value of the Internet came from no single institution or company, but from the collective innovations of millions of contributors.

I asked Lessig why he is worried about the future.

> The innovation commons is being corrupted by changes that are being made at the architecture level. These changes are accomplished by allowing future versions of Internet software protocols to abandon the end-to-end principle, enabling the network owners to decide which applications will be permitted to run over the network and which applications won't. Coaxial cable owners that offer high-speed Internet access already prevent their users from running servers or hosting Web pages and are preventing content that competes with the cable owner's own content from running on their parts of the Internet. The AT&T–MediaOne merger created a huge cable infrastructure that AT&T controlled. AOL-Time-Warner created a huge cable infrastructure that AOL controlled, and now they're trying to put them both together into a single cable infrastructure for a large part of the Internet. As cable providers consolidate ownership, they are increasingly asserting their right to decide how people can use the network.

Four months after Lessig and I talked, the Federal Communications Commission launched a campaign to expand deployment of high-speed Internet access by reclassifying the cable modem business as an "information service" that would not require open access with the rest of the Internet to connect with their lines.[69] At the same time, the cable television industry pressed the FCC to prevent local governments from requesting that a portion of bandwidth be set aside for public, educational, and governmental uses.[70] In March, 2002, the FCC ruled in favor of the cable industry, dropping the requirement that cable operators allow competitors to use their networks and removing the power of local governments to request public resources in exchange for monopoly access to the local community.[71]

Lessig and I talked about technical and legal changes that might affect the wireless Internet of the future; that discussion continues in Chapter 6, "Wireless Quilts." He did have this to say in regard to the enabling technologies for smart mobs:

> New ways to think about connecting information services and people on the network now seem to be possible with wireless technologies, but what has to be preserved is the right to innovate about how these different ways of connecting to the Net can be used. The right to connect all sorts of devices to the network to do things that were never imagined by the people who built the network will assure a broad range of innovation around the mobile Internet. Are we going to move toward a controlled wireless world, where the equivalent of telephone companies or cable companies get to decide what we do on our wireless devices? It will be innovative relative to what wireless devices were five years ago, but still it will be innovative only as far as the controlling companies believe benefits them. Or will we adopt an architec-

ture for wireless where nobody gets to decide for everyone what the technology can and cannot be used for? Once we construct an innovation commons there, I think we could see the next great revolution of innovation in wireless Internet technology.

Who Knows Who Knows Who? Social Networks as Driving Forces

A few years ago, Marc Smith introduced me to his colleague Barry Wellman, a master of a discipline Smith knew would interest me—social network analysis. I learned that people were studying social networks decades before computer networks or mobile telephones were invented and that Wellman claimed that "computer networks are social networks."[72] His research and hypotheses about the connections between online and face-to-face social networks mapped perfectly onto many questions that had cropped up when I was investigating social cyberspaces. When Wellman visited California, he and I walked in an oak forest and chatted about the ways physical places and cyberspaces influence one another. Wellman has a quiet manner and a dry sense of humor, and he doesn't shrink from making bold claims. Wellman's claims came back to me when I looked for the social underpinnings of smart mobs.

Every time someone interacts with another person, there is the potential to exchange information about people they both know. The structure of everyone's links to everyone else is a network that acts as a channel through which news, job tips, possible romantic partners, and contagious diseases travel. Social networks can be measured, and interconnections can be charted, from relationships between interlocking boards of directors of major corporations to terrorist networks. One of Wellman's claims is that "we find community in networks, not groups."[73] He explained that "a group is a special type of network: densely-knit (most people are directly connected), tightly-bounded (most ties stay within the densely-knit cluster), and multistranded (most ties contain many role relationships)," and he challenged conventional thinking about how people cluster socially:

> Although people often view the world in terms of groups, they function in networks. In networked societies, boundaries are permeable, interactions are with diverse others, connections switch between multiple networks, and hierarchies can be flatter and recursive. The change from groups to networks can be seen at many levels. Trading and political blocs have lost their monolithic character in the world system. Organizations form complex networks of alliance and exchange rather than cartels, and workers report to multiple peers and superiors. . . . Communities are far-flung, loosely-bounded, sparsely-knit, and fragmentary. Most people operate in multiple, thinly-connected, partial communities as they deal with networks of kin, neighbours, friends, workmates and organizational ties. Rather than fitting into the same group as those around them, each person has his/her own "personal community."[74]

Does "personal community" remind anyone of those teenagers in Scandinavia and Pakistan, Tokyo and Manila, maintaining a stream of text messages with small groups of five to eight close friends as they go about their lives? I think Wellman's mapping of traditional social network analysis onto social cyberspaces can be applied to mobile cyberspaces, as well:

> Complex social networks have always existed, but recent technological developments in communication have afforded their emergence as a dominant form of social organization. When computer-mediated communication networks link people, institutions and knowledge, they are computer-supported social networks. The technological development of computer networks and the societal flourishing of social networks are now in a positive feedback loop. Just as the flexibility of less-bounded, spatially dispersed social networks creates demand for the world wide web and collaborative communication, the breathless development of computer networks nourishes societal transitions from little boxes to social networks. I define "community" as networks of interpersonal ties that provide sociability, support, information, a sense of belonging, and social identity. I do not limit my thinking about community to neighbourhoods and villages. This is good advice for any epoch and especially pertinent for the twenty-first century.[75]

Wellman foresees that "the person—not the place, household or workgroup—will become even more of an autonomous communication node" and points out that "people usually obtain support, companionship, information and a sense of belonging from those who do not live within the same neighborhood or even within the same metropolitan area. People maintain these community ties through phoning, writing, driving, railroading, transiting and flying. . . . The person has become the portal."[76] The Internet facilitates the creation and management of multiple, personal social networks.

What connects the technical properties of computer networks and the communication properties of social networks? When I started posing this question in my own social network, all the most interesting links led to Reed's Law, a mathematical formulation discovered by David P. Reed. When I educated myself about Reed, I knew I had to meet him. He had been one of the authors of the Internet's end-to-end principle; Reed had been the senior scientist of Lotus Corporation, and in affiliation with MIT's Media Lab, he has become one of the instigators of the "open spectrum" movement, a radical rethinking of the way wireless communications are regulated. When I visited Media Lab in the fall of 2001, Reed and I met at the lab and continued our conversation over lunch, where he recalled how he first discovered his law.

Reed's Law relating social networks and computer networks is the most recent in a series of fundamental discoveries about the driving forces of computers and networks. In the social sciences, prediction is necessarily fuzzy. In the economics of computer-mediated social networks, however, four key mathematical laws of growth have been derived by four astute inquirers: Sarnoff's Law, Moore's Law, Metcalfe's Law, and Reed's Law. Each law is about how value is affected by technological leverage.

Sarnoff's Law emerged from the advent of radio and television networks in the early twentieth century, in which a central source broadcasts from a small number of transmitting stations to a large number of receivers. Broadcast pioneer David Sarnoff pointed out the obvious: The value of broadcast networks is proportionate to the number of viewers.[77]

The often-cited Moore's Law is the reason electronic miniaturization has driven the hyper-evolution of electronics, computers, and networks. In 1965, Gordon Moore, cofounder of Intel and one of the inventors of the microprocessor, noted that the number of elements that could be packed into the same amount of space on a microchip had doubled every year. Moore forecast that the number of elements would double every eighteen months in the future.[78] Anything that doubles and redoubles grows large very quickly, from 2,250 elements in Intel's first microprocessor of 1971 to 42 million elements in the Pentium 4 processor thirty years later.[79] Computers and electronic components have driven industrial growth for decades because they are among the rare technologies that grow more powerful and less expensive simultaneously. Without the efficiencies described by Moore's Law, the PC, the Internet, and mobile telephones would have been impossibly large, unintelligent, and expensive.

What happens when you link devices based on Moore's Law? When ARPA wizards gathered at the Xerox Palo Alto Research Center (PARC) in the early 1970s to create the first personal computers, one of the engineering aces, Bob Metcalfe, led the team that invented the Ethernet, a high-speed network that interconnected PCs in the same building.[80] Metcalfe left PARC, founded 3Com, Inc., cashed out, and came up with Metcalfe's Law, which describes the growth of value in networks. The math is simple and is based on a fundamental mathematical property of networks: The number of potential connections between nodes grows more quickly than the number of nodes. The total value of a network where each node can reach every other node grows with the square of the number of nodes. If you have two nodes, each with a value of one unit, the value of joining them is four units. Four interconnected nodes, each still worth one unit, is worth sixteen units when networked, and one hundred nodes is worth one hundred times one hundred, or ten thousand. When value increases exponentially more quickly than the number of nodes, the mathematical consequence translates into economic leverage: Connecting two networks creates far more value than the sum of their values as independent networks.[81]

David Reed has a graying beard and a wicked twinkle in his eye. He's not the type of fellow to pound the table to make a point. He's more the kind of fellow who genially proves he is right with equations on a whiteboard. As we sipped lobster bisque in Kendall Square, I asked him what led him to Reed's Law.

"I had the first 'eureka' when I thought about why eBay was so successful."[82]

eBay, which has turned out to be the only hugely profitable e-commerce business, doesn't sell any merchandise; it provides a market for customers to buy and sell from each other.

> eBay won because it facilitated the formation of social groups around specific interests. Social groups form around people who want to buy or sell teapots or antique radios. At that time, I had been reading Fukuyama about social capital.[83] Fukuyama argues in his book *Trust* that there is a strong correlation between the prosperity of national economies and social capital, which he defines as the ease with which people in a particular culture can form new associations. I realized that the millions of humans who used the

> millions of computers added another important property—the ability of the people in the network to form groups. I remembered that when it became possible to send and reply to entire groups in email, it became possible to create ad hoc discussions. Since then, all sorts of chat rooms, message boards, listservs, buddy lists, auction markets, have added new ways for people to form groups online. Human communication adds a dimension to the computer network. I started thinking in terms of group-forming networks (GFNs). I saw that the value of a GFN grows even faster—much, much faster—than the networks where Metcalfe's Law holds true. Reed's Law shows that the value of the network grows proportionately not to the square of the users, but exponentially.[84]

That means you raise two to the power of the number of nodes instead of squaring the number of nodes. The value of two nodes is four under Metcalfe's Law and Reed's Law, but the value of ten nodes is one hundred (ten to the second power) under Metcalfe's Law and 1,024 (two to the tenth power) under Reed's Law—and the differential rates of growth climb the hockey stick curve from there. This explains how social networks, enabled by email and other social communications, drove the growth of the network beyond communities of engineers to include every kind of interest group. Reed's Law is the link between computer networks and social networks.

Reed, using his law to analyze the value of different kinds of networks, believes he has discovered an important cultural and economic shift. When a network is aimed at broadcasting something of value to individuals, like a television network, the value of services is linear. When the network enables transactions between the individual nodes, the value is squared. When the same network includes ways for the individuals to form groups, the value is exponential:

> What's important is that the dominant value in a typical network tends to shift from one category to another as the scale of the network increases. Whether the growth is by incremental customer additions or by transparent interconnection, scale growth tends to support new categories of "killer apps," and thus new competitive games.
>
> We can see this scale-driven value shift in the history of the Internet. The earliest usage of the Internet was dominated by its role as a terminal network, allowing many terminals to selectively access a small number of costly time-sharing hosts. As the Internet grew, much more of the usage and value of the Internet became focused on pairwise exchanges of email messages, files, etc., following Metcalfe's Law. And as the Internet started to take off in the early '90s, traffic started to be dominated by newsgroups, user-created mailing lists, special interest web sites, etc., following the exponential GFN law. Though the previously dominant functions did not lose value or decline as the scale of the Internet grew, the value and usage of services that scaled by newly dominant scaling laws grew faster. Thus many kinds of transactions and collaboration that had been conducted outside the Internet became absorbed into the growth of the Internet's functions, and these become the new competitive playing field.
>
> What's important in a network changes as the network scale shifts. In a network dominated by linear connectivity value growth, "content is king." That is, in such networks, there is a small number of sources (publishers or makers) of content that every user selects from. The sources compete for users based on the value of their content (published stories, published images, standardized consumer goods). Where Metcalfe's Law dominates, transactions become central. The stuff that is traded in transactions (be it email or voice mail, money, securities, contracted services, or whatnot) is king. And where the GFN law dominates, the central role is filled by jointly constructed value (such as specialized newsgroups, joint responses to RFPs, gossip, etc.).[85]

Reed believes that there is a direct connection between the kind of social capital that Fukuyama discusses and the way people use the Internet as a group-forming network. This connection is the reason why esoteric technical and legal arguments about the end-to-end principle and wireless regulation might have a large effect on everybody in the world. If the innovation commons is open to many in the future, as it has been in the past, a "cornucopia of the commons" could make it possible for many to benefit. Or those who have concentrated capital in existing infrastructures and corporations might manage to enclose the commons and reserve that power of innovation by technically excluding future innovators. The first battle has already been fought over Napster. The established interests won, triggering an effort by innovators to invent knowledge commons that can't be enclosed.

The "cornucopia of the commons" is a consequence of Reed's Law taking advantage of Moore's Law. My journey into the universe of peer-to-peer ad-hocracies that combine the powers of computation with the growth capabilities of online social networks started innocently enough, when I stumbled onto a plot to find life in outer space.