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Cover: CARL DETORRES

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Quitting Google

Millions of people are utterly dependent on Google for their Web experience—it provides a browser, a search engine, e-mail, YouTube videos, and more. All it asks in return is your data, the better to sell advertising. *IEEE Spectrum* Associate Editor Josh Romero decided



to put his own dependence on Google to the test, by completely severing his relationship. Are Google's services really worth the personal data we provide?

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CANDIDATES TAKE ON TOP IEEE ISSUES

In August, IEEE members will receive their ballots for the election for 2012 IEEE president-elect. To help you choose between candidates Roger Pollard [left] and Peter Staecker, *The Institute* asked them to weigh in on important IEEE issues.

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back story



Taking a Taste of Google and Facebook

Silicon Valley companies are famous for using such temptations as foosball tables, weekly massages, beer blasts, pet-sitting services, and other perquisites to lure smart techies. So with Google and Facebook in a death-match struggle for tech talent, you'd expect the perks battle to be epic. And you'd be correct. Google is, after all, the company that took the definition of free food upscale, from popcorn and soda to sashimi and Kobe beef, among other gourmet delectables. So what was Facebook to do? Well, the opening salvo left no doubt that Facebook meant business: It lured away three of Google's top chefs and one of the pastry chefs. Yes, this is what it has come to: chef poaching.

So *IEEE Spectrum* simply had to check out the food, and who better to send than a restaurant critic? We picked Sheila Himmel,

and we picked well. Himmel was the restaurant critic for the Bay Area's *San Jose Mercury News* for 10 years and won a James Beard Award, the food world's Oscar.

Even with her years of experience, Himmel was a bit flummoxed by the assignment. For starters, she's used to slipping into restaurants incognito, as a regular customer, to check out the food and ambience. But with access to corporate campuses carefully controlled, Himmel became the watched, with every move she made subject to scrutiny.

Google put yet another obstacle in Himmel's path: It gave her exactly 60 minutes to review four of its more than 18 cafés. So, rather than spend time at a table, she loaded up on takeout boxes, rushed them to her car, and drove through a deluge to her home, fortunately only minutes away, to sample her selections. Facebook, more graciously, gave Himmel enough time to eat on site.

For her detailed impressions, see "Food Fight," in this issue. And if you ever get invited to lunch at Google, don't miss the bread pudding. "It was wonderful," Himmel says, "and I don't even like bread pudding." □

CITING ARTICLES IN IEEE SPECTRUM

IEEE Spectrum publishes two editions. In the international edition, the abbreviation INT appears at the foot of each page. The North American edition is identified with the letters NA. Both have the same editorial content, but because of differences in advertising, page numbers may differ. In citations, you should include the issue designation. For example, the first page of Update is in *IEEE Spectrum*, Vol. 48, no. 6 (INT), June 2011, p. 9, or in *IEEE Spectrum*, Vol. 48, no. 6 (NA), June 2011, p. 11.

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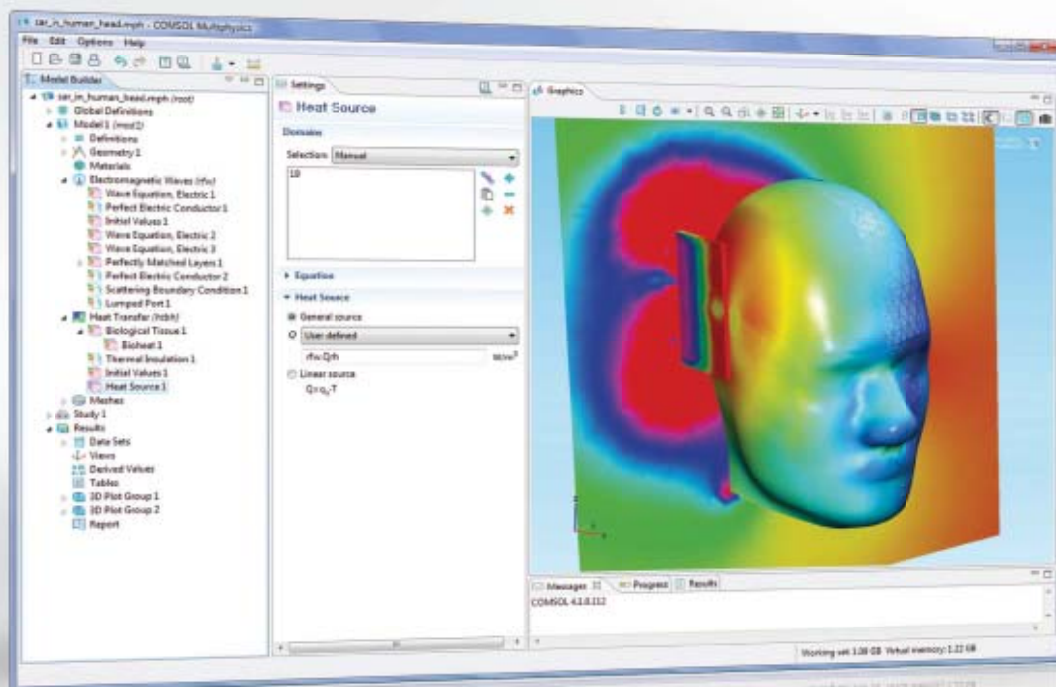
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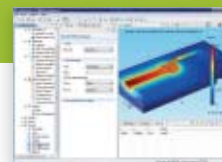
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JEREMY N. BAIENSON and **JIM BLASCOVICH** wrote the new book *Infinite Reality: Avatars, Eternal Life, New Worlds, and the Dawn of the Virtual Revolution*. Bailenson is the founding director of Stanford's Virtual Human Interaction Lab; Blascovich is a professor of psychology at the University of California, Santa Barbara. Bailenson blames Blascovich, his advisor at UCSB, for inspiring a career dedicated to studying avatars, a subject they explore in "This Is Your Mind Online" [p. 70].



ARIEL BLEICHER first met the founders of the social networking start-up Diaspora, whom she profiles in "The Anti-Facebook" [p. 46], at a hole-in-wall Cuban joint in San Francisco. A brief introduction became a three-hour discussion over a five-course meal. "I went to San Francisco thinking the Diaspora guys were just some scrappy hackers who'd gotten a lot of press," says the Brooklyn, N.Y.-based journalist, "but actually, they're part of something potentially game changing."



CARL DETORRES, our cover artist, says that while he's always loved science and technology, his true talent is in draftsmanship. Now he tells visual stories with data. Formerly a *Wired* art director, he has contributed to *Fortune*, *Scientific American*, and *The New York Times*. His cover illustration reflects the style of his data visualizations.



ROBIN DUNBAR, a professor of anthropology at the University of Oxford, is the fourth person to have his name connected with a law at the heart of an *IEEE Spectrum*

article (along with Moore, Metcalfe, and Edholm). Dunbar's Number, which he derived nearly two decades ago, answers the question posed in his article "How Many 'Friends' Can You Really Have?" [p. 73].



BOB GARFIELD, cohost of WNYC's "On the Media," distributed by NPR, and longtime *Advertising Age* columnist, is author of *The Chaos Scenario*, which describes the collapse of mass media and mass marketing as a by-product of the digital revolution. He says that when he first floated his theories in 2005, he was wisely dismissed as a hysterical crackpot, whereas now, a mere six years later, he is widely dismissed for belaboring the obvious. He gives a précis of those theories in "The Revolution Will Not Be Monetized" [p. 26].



SIVA VAIDHYANATHAN has 2611 Facebook friends and 3525 Twitter followers, yet on "The Daily Show" he complained that social network connections are cheap and fleeting. What's more, he values his privacy, as he writes in "Welcome to the Surveillance Society" [p. 40]. He is a professor at the University of Virginia whose latest book, *The Googlization of Everything*, came out this year.



CASSANDRA WILLYARD, a freelance writer in Brooklyn, N.Y., was intrigued to learn while reporting for "Me, Myself, or I" [p. 44] that Smitha Ballyamanda had arranged her Facebook friends in an elaborate hierarchy. "I should hire Smitha to organize my contacts," Willyard says. "I'd never have to worry that my editors will see me posting kitten videos when I should be working."



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Facebook and Google Put My Grandmother on the Map

IN 1921, the year Czech writer Karel Čapek's hit play about robots was first staged and Albert Einstein won the Nobel Prize in Physics, my grandmother left Milik, a tiny Russian village in the Carpathian Mountains, to travel by ship to the United States. When she left, she knew she was saying good-bye forever. She wouldn't even be writing letters—she couldn't read or write.

In 1990, the year before the European Organization

for Nuclear Research announced its World Wide Web project and the Soviet Union dissolved, my husband and I went to find her village, now in Poland, near the border of Slovakia. We took a train to Kraków and then hired a driver to take us into the mountains. Milik wasn't on any maps we could find, but we knew the name of a town nearby. We started out there, and along the way our driver stopped frequently

CIRCA 1990: The author cradles her future Facebook friend Paweł, from Milik, then age 3.

to ask for directions. Milik itself hadn't changed much since my grandmother's day. We asked the driver to help us find a family in the village that might be interested in renting a room to us. He did, and we stayed with them for a few days, roaming the countryside with their young children as guides, taking turns churning butter. After our visit, we exchanged letters and photos, but getting their letters translated from Polish was difficult, and within a year we stopped communicating. It wasn't odd or particularly sad; most of the people I've met while traveling haven't become permanent friends.

But now it's 2011, and technology titans Facebook and Google have changed all that.

A few weeks into this year I was friended on Facebook by a 24-year-old man named Paweł. He sent along a scan of a picture taken in 1990 of me holding him, then age 3, in Milik, and told me his family often reminisced about the time we stayed with them.

He and I exchanged Facebook mails. Curious to see just how much Milik had grown, I looked for it on Google Maps, and there was the satellite view, the single road, the scattering of homes. Given that it wasn't on any kind of map 20 years ago, I was stunned. Then I looked it up on Wikipedia—and there it was again, population 700. I guess I knew the social Web was everywhere, but I really didn't get it until that moment.

In our correspondence, I complimented Paweł on his English. He confessed that he didn't speak English and that he used a translator program. So much for struggling to translate Polish snail mail! I asked him where he was using the Internet, thinking that perhaps the church or local school had access. "Every house has Internet," he replied, "it is like water in the tap."

And that's our world, one in which the Internet flows like water, changing everything it touches. For better and for worse, Facebook and Google and myriad other Web-based communication tools have made it possible to stay connected to friends and enemies, acquaintances and strangers, professional colleagues old and new, even genealogically related distant relatives, as we signal our presence in the Internet-bound universe. Language is no longer a barrier. Saying good-bye has in some sense become impossible.

And as social networks continue to seep into the fabric of our lives and begin to actively initiate relationships and transactions, perhaps one day I'll get a message, not from Paweł but from his Facebook identity, telling me that he's on his way to San Francisco and hopes to meet up with me at my favorite Thai restaurant on the 21st of the month, because my Facebook identity has alerted him that I'll be headed for the city that day. Will I be eager to meet the real live grown-up Paweł? Or will I want to close the door on the Internet-imposed present and just hold on to my own fond memories of him and his family instead?

—TEKLA S. PERRY

TEKLA S. PERRY

update

more online at spectrum.ieee.org



What Young Engineers Want Out of the Revolutions

Engineers in Egypt and Tunisia hope for more jobs and better education

FED UP with their countries' stagnant politics and economies, chronic unemployment and underemployment, low living standards, and lack of opportunities, young men and women took to the streets earlier this year in Egypt and Tunisia and overthrew their governments. Young engineers were among the crowds at Tahrir Square and Tunis. *IEEE Spectrum* spoke with roughly half a dozen to find out what they were fighting for.

Nearly all had the same wish list. "Engineers, like other Egyptians, want the same thing: freedom, lack of corruption, and better opportunities," says Kareem Habib, a digital design engineer at Mentor Graphics Corp., in Cairo.

Opportunity has certainly been lacking. North African youth aged 15 to 24 are four times as likely to be unemployed as adults, according to the International Labour Organization. In Egypt, college grads represent a much

larger fraction of unemployed persons than do people with only elementary school educations, according to a report on higher education in Egypt by the World Bank and the Organization for Economic Co-operation and Development (OECD).

"There is an oversupply of graduates" of all kinds, not just engineers, says Francisco Marmolejo, a coauthor of the report. "Graduates have relatively poor or limited skills. Sixty percent don't find jobs in their field," he says.

However, the problem is less acute for technology grads than it is for others, Marmolejo adds. In particular, electrical engineers have had an easier time of it, because the country's telecommunications sector soaks up some graduates, and

SOMETHING BETTER: Cairo students call for the ouster of the head of their university, an appointee of Hosni Mubarak.

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update

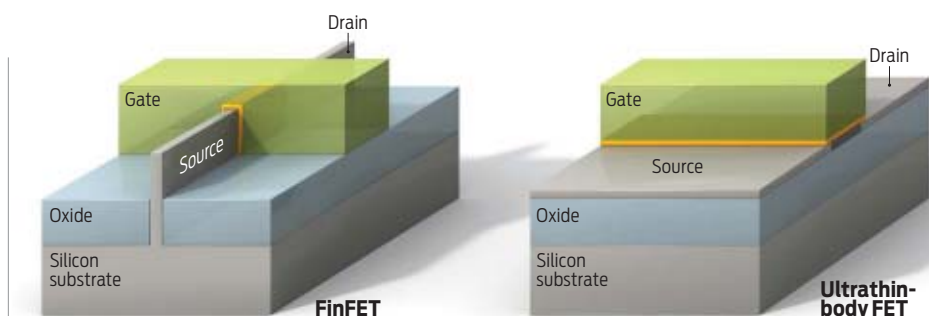
multinationals such as Google and Microsoft have moved in. However, “there is very little engineering innovation and product development” going on at the local offices of these tech giants, says Habib.

Pay and the quality of jobs were high on the list of complaints of young engineers. Nagwa Ahmed, an EE graduate of Cairo University, has been a sales support engineer for more than 10 years, she says, but her salary is not enough to cover living expenses and leave money for savings and other items. “I have another, part-time job as a math teacher to cover our expenses,” she says.

The situation is similar in Tunisia, with low-paying jobs that don’t make use of graduates’ engineering skills, says Habib Kammoun, a computer science Ph.D. student at the National School of Engineering of Sfax, in Tunisia. The result has been a decades-long brain drain to oil-rich Persian Gulf countries, Europe, and North America.

A big part of the employment problem, as seen by the engineers *Spectrum* spoke to, is that politics is pervasive in the education and employment system. Securing a good job is in many cases about having the right connections.

The need to be connected begins at the university level. In Egypt, deans of engineering and other schools as well as university presidents were appointed by Mubarak. After Mubarak’s regime fell, students called for his appointees in university administration to step down.



Transistors Go 3-D

Last month Intel beat the competition to begin production of logic chips with 22-nanometer features. With those chips, the basic shape of the metal-oxide-semiconductor field-effect transistor (MOSFET), the workhorse transistor in all logic ICs, will change for the first time. Transistors have been built in the plane of silicon wafers up to now, with only the gate stack—the gate and insulator—protruding. Beginning this year, Intel will produce processors of a design in which the entire transistor extends out from the plane of the silicon. Intel calls the design a “tri-gate” transistor, but it is more broadly referred to as a FinFET.

FinFETs solve one of the main problems with

today’s transistors—the leak of charge across the transistor’s channel. The finlike shape of the FinFET channel and the fact that it is surrounded by the gate on three sides means that voltage on the gate can better stanch the leak.

Intel’s competitors, such as Advanced Micro Devices and IBM, might not choose a FinFET design for their 22-nm chips. Instead, they may go with what’s called the ultrathin-body (UTB) design. Instead of a plain silicon wafer, the UTB starts with a costlier sandwich of silicon, glass, and a nanometers-thick top coat of silicon. Because the transistor’s silicon is so thin, the gate should be able to squelch any leaks.

IEEE Fellow Chenming Hu was a coinventor of both the FinFET and the UTB. *IEEE Spectrum* Associate Editor Rachel Courtland interviewed him about the two inventions shortly after Intel announced its plans. Read on at <http://spectrum.ieee.org/hu0511>.

“If you have an extremely rigid system in which decisions about which academic programs you can offer, how many students you can accept, and how much money you can receive are controlled by the government, the incentive to be different doesn’t exist, and the incentive to be better is relatively little,” higher-education expert Marmolejo says.

In Egypt “it’s not just government policies; it’s lack of resources,” says Sam Mikhail, a Canadian engineer of Egyptian origin and part of the OECD/World Bank study team. The country has experienced soaring

population growth, but it must fund its education system in a narrow economy based mainly on agriculture and tourism. Egypt spends US \$874 per student for public higher education, while Turkey spends \$4648; the OECD average is \$12 336.

Farhat Fnaeich, an engineering professor at the École Supérieure des Sciences et Techniques de Tunis, says that the engineers and professors he speaks with believe that well-educated, democratically elected officials will be more open to international collaboration and could help bring engineering education

up to international standards. Freedom and less corruption should also encourage investment, creating new jobs and more entrepreneurship opportunities, Fnaeich believes.

“Since technology is the key for a country’s future, engineers have a more important role than other professionals in shaping the right direction and developing a global vision,” says Kammoun, the Sfax student.

One hopeful sign: Engineers at Cairo University are working on an electronic voting system for the coming presidential and parliamentary elections. —PRACHI PATEL

EMILY COOPER (2)

\$600 per metric ton Cost of capturing carbon directly from air, according to a report by the American Physical Society. The report politely gives "direct air capture" a failing grade.

12 Space Shuttle Missions That Weren't

A look at some of the gutsier (and goofier) proposed space shuttle missions

THE U.S. SPACE SHUTTLE FLEET is set for retirement following the launch of *Atlantis*, scheduled for mid-July. In all, the fleet will have flown 135 missions, the first in 1981, but there were many more on the drawing board. With scrubbed missions that included daring rescues, in-orbit satellite snatches, and dangerous explosives, you can see why some of these didn't make the cut. But just imagine if they had. —James Oberger

1979 REBOOST SKYLAB

As America's first space station (1973–4) slipped steadily from orbit, NASA built a small booster rocket



to be attached to it by a two-man crew (Fred Haise and Jack Lousma) on an urgent early flight. But launch schedules slipped, and Skylab fell on Australia.

1980 SATELLITE SNATCH

A key scenario among the planned missions that drove the shuttle's design was the Pentagon's need for a superfast, single-orbit mission that would deploy or retrieve a military satellite. Strictly speaking, the retrieved satellite need not have been the property of the United States. The shuttle was built to enable this, but the idea was soon abandoned.

1981 RETURN TO LAUNCH SITE

In the event of engine problems during launch, one emergency procedure involved flipping over in midascent and thrusting back to Florida for a runway landing. It worked in the simulator, but it was so dangerous that astronauts considered it barely preferable to crashing into the ocean.

1983 SALYUT RESCUE



Following a series of breakdowns on the Soviet Salyut 7 space station, NASA wondered if its upcoming mission, carrying the Spacelab module, could be diverted to perform an emergency rendezvous so that the cosmonauts could be evacuated via space walks. The answer was yes, but Moscow never asked for help.

1986 HYDROGEN BOMB

For fast planetary probes, a Centaur rocket stage was modified to be carried on the shuttle, and two launches were planned in one week in May 1986. The explosion hazard from leaking gas later led to their cancellation, but only after *Challenger* was lost in January.

1980s CRUISING HOME

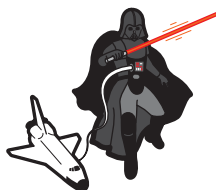
NASA discovered that if there had been an emergency landing at an overseas airfield, the shuttle would have been too heavy for the 747 carrier aircraft to transport it across an ocean. So the agency developed a kludge plan to lift the shuttle onto the deck of an aircraft carrier, thereby limiting emergency landings to coastal airfields.



1986 CALIFORNIA (SPACE) DREAMING

The U.S. military had planned polar-orbit spy-satellite launches from California. A launchpad at Vandenberg Air Force Base was ready, spy satellite payloads had been picked, an emergency landing site on Easter Island built, and a crew trained. But the needed upgrades to engines were deemed too risky after *Challenger* was lost, so the mission was canceled and the pad mothballed.

LATE 1980s DARTH VADER, ASTRONAUT



During research for a space-based ballistic-missile shield (the Strategic Defense Initiative, popularly known as "Star Wars"), the Pentagon wanted to test astronauts' ability to track objects and aim weapons in space, and Moscow accused NASA of doing so. But in truth, the test was canceled.

1990s HANDS-OFF LANDING

The shuttle's digital autopilot has an "autoland" option, although it does require one throw of a manual switch to lower the landing gear. NASA actually scheduled a mission to test the system all the way to "wheels stop," but the agency lost its nerve before launch and left the astronaut in control for the landing.



1998 ALL-WOMAN CREW

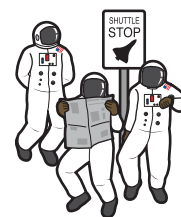
A combination of astronaut selection, mission training, and flight assignments offered the option to juggle the crew manifest and put seven experienced female astronauts onto an otherwise routine shuttle mission. The selection was meant to demonstrate the level of responsibility women had earned in space, but concerns about exploitation for electoral politicking scuttled the suggestion.

2003 RESCUE COLUMBIA

Although *Columbia* had been mortally wounded by launch damage and was too crippled to safely return, controllers failed to realize it in time to mount a rescue flight by the next-in-line shuttle. After the disaster, analysts examined whether that flight might have been launched in time. The answer: maybe.

2000s SUICIDE SPACE DIVE

NASA figured that if a shuttle was too damaged to safely land, the crew could hang out at the International Space Station until the next shuttle could retrieve them. The agency also developed a system to remotely pilot a crippled shuttle into the South Pacific.



SPACEFLIGHT WITHOUT THE SHUTTLE: In an online commentary, IEEE Spectrum examines the capabilities that NASA is giving up by retiring the shuttle fleet. See <http://spectrum.ieee.org/obergo611>.

update

A New Kind of Cool

Start-ups are advancing solid-state cooling systems

THE EXHIBIT hall was buzzing like a high school science fair. At this year's Energy Innovation Summit, hosted by the U.S. Department of Energy's Advanced Research Projects Agency (ARPA-E), several hundred inventors and entrepreneurs had propped up posters to show off their bright ideas. At one table, a couple of Ph.D.s were grinning as if they'd already taken home a trophy. In a way, they had—their company, Phononic Devices, had made the most of a US \$3 million ARPA-E grant it won in 2009, parlaying it into \$10 million in venture capital money to commercialize its technology.

Phononic Devices, based in Raleigh, N.C., is building thermoelectric modules that use electricity to provide cooling power. Such modules essentially replace the flow of refrigerants through vapor compression cooling systems with the flow of electrons through a chip. CEO Anthony Atti says his company used the ARPA-E grant to “prove that we were right at the material physics level.” Now, he says, the company is working on a cheap prototype that will “convince the market that we're right at the

product level.” The company's cooling modules are initially intended for electronics.

Atti's product will hardly be the first thermoelectric device to hit the market. The principles of the thermoelectric effect (which covers both cooling and heating) were discovered in the mid-19th century, and companies have found plenty of niche applications. Tiny thermoelectric devices are used to cool some CPU hot spots and laser diodes; shoppers can buy thermoelectric wine refrigerators and cars with thermoelectrically cooled seats.

So why is ARPA-E, an agency meant to encourage blue-sky energy ideas, investing in companies like Phononic Devices? Because so much more can be done to bring thermoelectrics into the mainstream, says ARPA-E director Arun Majumdar. “The compressor-based refrigerators and air conditioners are cheaper and have better performance today,” says Majumdar, who worked on thermoelectrics at Lawrence Berkeley National Laboratory before taking charge of ARPA-E. The goal at ARPA-E is to improve thermoelectrics to the point where “the performance-cost ratio is not only comparable to the traditional ways of doing things but perhaps better.”

Solid-state cooling would eliminate a system's moving parts and its refrigerants, which are usually potent greenhouse gases. And with the flip



side of the thermoelectric effect, in which heat can be harvested to produce electricity, engineers could make use of waste heat in everything from car engines to factories. “Thermoelectrics could potentially be a game changer,” says Majumdar.

Majumdar says both material and systems breakthroughs are needed before thermoelectrics goes mainstream. To create a cooling effect, voltage is applied to a compound semiconductor chip, which moves electrons from one surface toward the other. When an electron moves, it drags a phonon of heat to one side of the chip, where it can be dissipated by a heat sink.

Cooling chips are typically made of semiconductor materials like bismuth telluride, but these are woefully inefficient; today's thermoelectric devices often consume more than a watt of power per watt of heat moved. Researchers are struggling to develop new materials and structures that conduct

electricity well but not heat—the needed combination to prevent transferred heat from immediately flowing back through the chip.

Phononic Devices' Atti says his company combines a new thermoelectric material with a thin-film design to form a cooling device that is two to three times as efficient as today's modules. He believes this efficiency level will make thermoelectrics commercially viable in mainstream applications.

Atti hopes to have prototypes ready for customers by early 2012. Other start-ups are on the same track. Tucson-based Tempronics says it has a different kind of cooling module structure that works with many types of materials.

Even if companies like Phononic Devices and Tempronics can put a thermoelectric fridge in every home, their work will be only half done. There's still all that waste heat waiting to be turned into electricity.

—ELIZA STRICKLAND

GETTY IMAGES

SPECTRUM.IEEE.ORG

500 gigahertz Theoretical top speed of a new kind of optical modulator constructed from graphene. The device turns electrical signals into optical ones, but right now it can do it only at 1 GHz.

Virtual-Reality Scent System Fools Flavor Sense

What you see (and smell) is what you taste

SIGHTS, SOUNDS, and more recently touch are commonly employed to create and enhance virtual-reality (VR) experiences. But the sense of smell is rarely a factor. A small group of researchers at the University of Tokyo are working to change that by integrating the sense of smell and sight in a way that alters a person's perception of taste. Their VR system was able to trick people who were eating a plain cookie into thinking the cookie was of whatever flavor they had selected. The group is making use of the fact that taste is affected by what we see, hear, and smell, among other things.

"We are using the influences of these sensory modalities to create a pseudogustatory display," says Takuji Narumi, an assistant

professor at the University of Tokyo. "The aim is to have subjects experience different tastes through augmented reality by only changing the visual and olfactory stimuli they receive."

To do this, the Tokyo team created a system dubbed the Meta Cookie, in which a plain cookie was stamped with an edible marker that allowed machine vision software to track it easily. The experiment also used a computer-controlled olfactory head-mounted display, or HMD, which incorporated a system that overlaid images onto the cookie and a marker detection unit. The olfactory unit employed seven scent-filled plastic bottles fitted with air pumps and tubes that delivered individual aromas to the subject's

nose. An additional air pump was used to dilute the amount of scent the subject received.

Experimental subjects were asked to choose a cookie flavor but were given a plain cookie and were told to observe it before eating it. A webcam in the marker detection unit picked up the pattern on the cookie and calculated the cookie's position and orientation, as well as the distance between the cookie and the subject's nose. This information was used to adjust the image of the cookie, which had already been overlaid with an image of the chosen flavor.

A second webcam positioned near the subject's nose, pointing downward, detected the point at which the cookie approached the subject's mouth and signaled the olfactory unit to release the scent. By mixing air with the scent, the system could adjust the strength of the smell to 127 different levels and cause the odor to increase as the cookie neared the mouth.

In the latest trials, 43 participants were asked to eat one or two cookies and then write about their taste experience. "In 72.6 percent of all the trials, the participants felt they tasted the kind of cookie they chose," says Narumi.

Now the researchers are working to make the olfactory HMD smaller by replacing the plastic scent bottles with inkjet technology. They are also improving the image overlay quality and seeking to add a sense of texture through the use of sound.

As for practical applications, Narumi sees the technology being used to reinforce dietary programs, for instance by making bland food appear tastier, especially for hospitalized patients. He says this might happen in five years. Much further in the future, he says the technology could be used for entertainment in the home "to augment TV viewing pleasure and when playing video games." —JOHN BOYD



news brief

Schizophrenic Systems

Researchers at the University of Texas at Austin and Yale University have made a computer program schizophrenic. The program, called DISCERN, is a neural network that has been designed to learn language; it can be taught a set of simple stories and then relate the stories in its own words. The researchers tweaked one of the network's parameters to produce a state equivalent to that of a human who has overdosed on dopamine. As a result, DISCERN began displaying language abnormalities similar to those of a schizophrenic person. The software began putting itself at the center of fantastical and delusional stories and at one point claimed responsibility for a terrorist bombing.



EAT IT: Graphics tricks and computer-controlled scent sprays combine to make a plain cookie taste like almond, strawberry, lemon, or maple.

PHOTO: UNIVERSITY OF TOKYO

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€2 billion Subsidy the German government is providing to help its auto industry develop electric cars. The amount represents a doubling of its previous aid.

update

Silicon Is Key to Quest for \$5 LED Lightbulb

Bridgelux process grows gallium nitride on high-volume silicon wafers

THE LED lightbulb has loads to recommend it. Compared to the compact fluorescent, it can be twice as efficient, lasts far longer, and is free of mercury. But high prices are holding back sales: A 40-watt-equivalent LED bulb with a good hue starts at around US \$20, and 60-W versions retail for far more.

The good news is that this barrier to mass adoption should fall in the next two to three years, thanks to recent developments by the LED maker Bridgelux that should spur the launch of a \$5 bulb. This California-based firm plans to slash the price of white emitting chips—which account for up to 70 percent of the cost of this type of bulb—by churning out millions of gallium nitride LEDs on 200-millimeter-diameter silicon wafers.

LEDs are usually made on sapphire or silicon carbide substrates that are typically 50 mm, 75 mm, or 100 mm across. Switching to 200-mm silicon would trim the LEDs' cost of materials,

because such wafers are cheap and common. However, Bridgelux will realize even bigger savings by outsourcing the processing of its gallium-nitride-on-silicon wafers to the many underutilized 200-mm fabs around the world, says vice president of marketing Jason Posselt. He claims that this outsourcing will cut chip-manufacturing costs by 75 percent and, combined with steady improvements in manufacturing, lead to a \$5 LED bulb as soon as 2014.

Being able to manufacture LEDs on readily available, low-cost substrates has been a long-standing dream, according to Ulrich Steegmueller, senior director of advanced development at the LED manufacturer Osram Opto Semiconductors. He and Colin Humphreys, head of the Cambridge Centre for Gallium Nitride, in England, say that most leading LED manufacturers are trying to develop processes to grow their devices on silicon.

"The results of Bridgelux will certainly further encourage this move," says Humphreys. "It is my belief that in the future, all gallium nitride LEDs will be grown on large-area silicon."

Efforts to develop white GaN LEDs on silicon date back 10 years. However, until now these techniques worked only on smaller wafers, and efficiencies have significantly lagged those of commercial devices made on other substrates.

Bridgelux claims it has narrowed this efficiency



WIDER WAFER: Two-hundred-millimeter silicon wafers make cheaper LEDs. PHOTO: BRIDGELUX

gap, developing cool-white LEDs on 200-mm silicon that deliver 135 lumens per watt and warm-white variants with a similar color to that of incandescents emitting 85 lm/W. "They are pretty good bread-and-butter numbers, where in [LED] lighting a lot of products are being sold today," says Posselt.

Depositing high-quality gallium nitride layers on silicon is tough; strain results from a large difference in the atomic spacing of the two crystals. Compounding this is a difference in the rate at which the two materials expand and contract when heated and cooled. This may lead to stresses as the gallium nitride film, grown at 1000 °C, cools to room temperature. If these stresses and strains are not dealt with as the GaN crystal grows on the silicon, the GaN degrades, limiting light emission and driving down efficiency.

"We have found some unique ways to manage that

strain," says Posselt. But he would not elaborate on them.

What Posselt will discuss are some of the electronic advantages silicon brings. Bulb manufacturers want to drive more and more current through the LED chips so that they can use fewer of them. However, this leads to lower efficiencies, pushing up operating costs. According to Posselt, silicon-grown LEDs can help, as devices grown on silicon require a smaller voltage increase to boost the drive current through the LED (from 350 to 1000 milliamperes) than do devices grown on other substrates. In addition, silicon is better at conducting heat than sapphire, allowing chips to run cooler and brighter.

Bridgelux will spend the next few years improving yields, qualifying the process, and getting it ready for high-volume production. "It's more development than invention," Posselt says.

—RICHARD STEVENSON

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hands on



SEND A TWEET TO YOUR OFFICE DOOR

And let your coworkers know what you're up to

HERE AT *IEEE Spectrum*, staffers routinely put Post-It notes on their doors and cubicles to let colleagues know they're out. But you can't slap a note on your door if you decide to work at home at the last minute—which, as I learned this winter, happens quite often when you have a very pregnant wife about to go into labor any instant.

That's why I set out to replace those yellow sheets of self-adhesive stationery with something less, uh, analog—something that would allow me to post the updates electronically. An

idea then popped up in my head: Twitter for my door.

It turns out to be a simple DIY project that an experienced hobbyist can complete in a few hours. Or if you're me and this is your first serious hardware project, it might take you a couple of months and nearly drive you insane.

It worked out in the end. Now, when I'm home—or actually anywhere with my phone—I can send a tweet to a small LCD that hangs by my door, thus keeping my coworkers informed of my whereabouts. The LCD also shows current weather conditions in New York City; I thought my colleagues would appreciate this value-added service.

The hardware setup is fairly straightforward. The main component is an Arduino, the popular

microcontroller for DIY projects. I used a Duemilanove model (US \$30). You'll also need an accessory board called the Ethernet Shield (\$45), which allows the Arduino to connect to the Internet. For the LCD, I used a Sparkfun black-on-green 5-volt model with four lines of 20 characters each (\$30), which I connected to the Arduino with a thin ribbon wire (\$5).

An Ethernet cable plugs into the shield, which attaches directly to the Arduino. Three wires connect the Arduino to the LCD—one for data bits, transmitted serially, the other two for power and ground.

It would have been great to have the device get its Internet access wirelessly, but that would have involved more complicated hardware

and frequent battery replacements. So I drilled a small hole in the wall and ran a cable, hoping that the office manager wouldn't notice (or read this article!).

The idea is, you post the tweet and the Arduino goes online periodically, fetches the message, and displays it on the LCD. Combining the Arduino and Twitter wasn't a new idea. With a Google search I found similar projects, including one to send a tweet every time you flush your toilet.

With other people's code as my starting point, soon my tweets were showing up on the little display. Nice. Except that two days later it stopped working. I pressed the Arduino's reset button and it came back to life—until the next time. It would work for a day or two and then freeze. As it turned out, making my device work wasn't very difficult. The hard part was making it work *reliably*.

A new Google search turned up fellow DIYers with the same problem. They were blaming the Ethernet Shield's software stack. Something about data transmissions not closing properly and preventing new ones from opening. Unfortunately, there was no firmware fix available.

One way around this issue was to periodically reset the shield. But the problem is that the reset pins of the Arduino and the Ethernet Shield are connected. That means if you use the Arduino to transmit a reset pulse to the shield, it will reset itself midway through the

transmission, a process that can damage the chips.

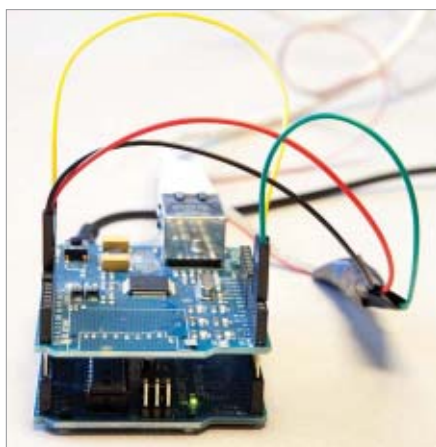
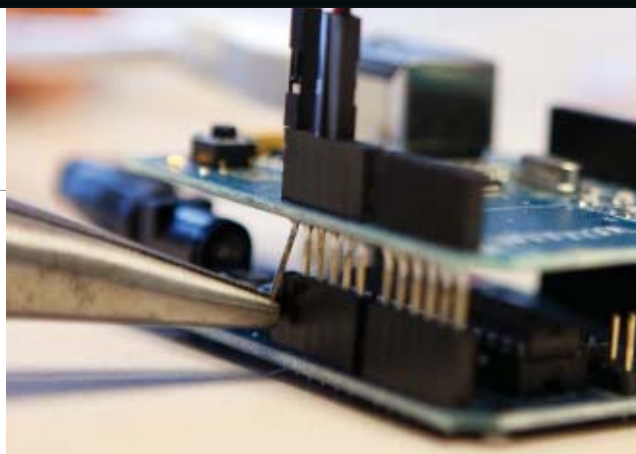
The inelegant but effective fix was simple and decidedly mechanical: Bend the metal pin from the Ethernet Shield so it doesn't connect to the Arduino reset pin and program the Arduino to reset the shield before it retrieves a tweet.

The device started working again...until it didn't. For days I looked at my hardware and software and couldn't figure out what had happened. I thought it might've been a curse from the Post-It gods, but then I read a news story that revealed the truth.

Sometime last August, Twitter changed its authentication method. The Arduino code to access my door's Twitter account was outdated. Twitter's new authentication method, called OAuth, is much more secure but not simple to implement, at least not for an inexperienced programmer like me.

It was back to Google, where I soon found a way to do the new Twitter authentication using PHP, a popular programming language for Web sites. That meant shifting the authentication from the Arduino to the Web.

I wrote a PHP program that retrieves the tweet and stores it in an XML text file. The PHP code runs on a Web hosting service I use (companies like Go Daddy, DreamHost, and others offer similar PHP capabilities). Using a scheduling tool called



WHERE'S ERICO? Clockwise from bottom: An LCD outside the author's office shows updates on his whereabouts; an Arduino with an Ethernet Shield retrieves the updates from Twitter; the device gets a mechanical tweak; a hole in the wall is needed for Internet access. PHOTOS: RANDI SILBERMAN KLETT

cron, I set the PHP program to run every 5 minutes.

So here's how the system now works: After I post a tweet, the PHP program retrieves it from Twitter and puts it into an XML file on a Web server. Then the Arduino in my office

fetches the XML file, parses it to extract the tweet, and sends it to the LCD. The PHP program also retrieves weather information from the Web and puts the data into the same XML.

If you're considering replicating this project, here

are some improvements you could try. First, implement the OAuth authentication in the Arduino itself, getting rid of the PHP component, the XML, and the Web server. (A public Twitter account would be even simpler, skipping the OAuth authentication entirely. But that's not a good idea if you want to leave notes with phone numbers and other information you don't want to be public.)

Second improvement: Implement some form of error detection that keeps garbled data from the LCD. Third, use a fancier, color LCD to format the message, weather, and other information in a better-looking way to impress your coworkers (and boss).

I created the sketch (as Arduino C language programs are called) using version 18 of the software; the Arduino maintainers have since revamped its Ethernet library, and I haven't tested my sketch with the new versions.

By the way, you don't have to use Twitter to convey your message. The Arduino can just as easily grab e-mail from Gmail or another POP account. I used Twitter because the office network blocks access to e-mail servers, and anyway, messaging from a phone is easy and feels cool.

As I write this, the system has been working uninterrupted for over three months. Now excuse me, I need to tweet my door.

—ERICO GUizzo

tools & toys



CAN MARIO MAKE THE LEAP?

Nintendo's new 3DS handheld game player may be the best of a dying breed

ON 27 March, Nintendo Co. launched arguably the most eye-catching handheld gaming device yet, the glasses-free 3DS. That's 3D as in "three-dimensional."

Early reviews and consumer preorders are impressive, which is just what we'd expect from Nintendo. The company has a track record of turning select technologies into well-designed systems, each of which carves

out a niche all its own. Last time around, while Sony and Microsoft were trying to outdo each other's high-def video gaming platforms, Nintendo went a different way, with the non-HD, marketplace-redefining, motion-capturing Wii. Yet the challenges Nintendo faces today would give even the Mario brothers pause.

The first is 3-D itself. In the past 18 months, consumers essentially yawned as the

electronics industry plied them with 3-D via televisions, Blu-ray players, and console games. Then there's archrival Sony, already previewing its successor to the PlayStation Portable.

But Sony and Nintendo might as well be best buddies, in an enemy-of-my-enemy-is-my-friend way, as they face the even bigger challenge of smartphones. Over 100 million of them were sold in just the last quarter of 2010. By comparison, the Nintendo DS took four years to reach a mere 91 million units sold. In an April report, IHS iSuppli, a research firm

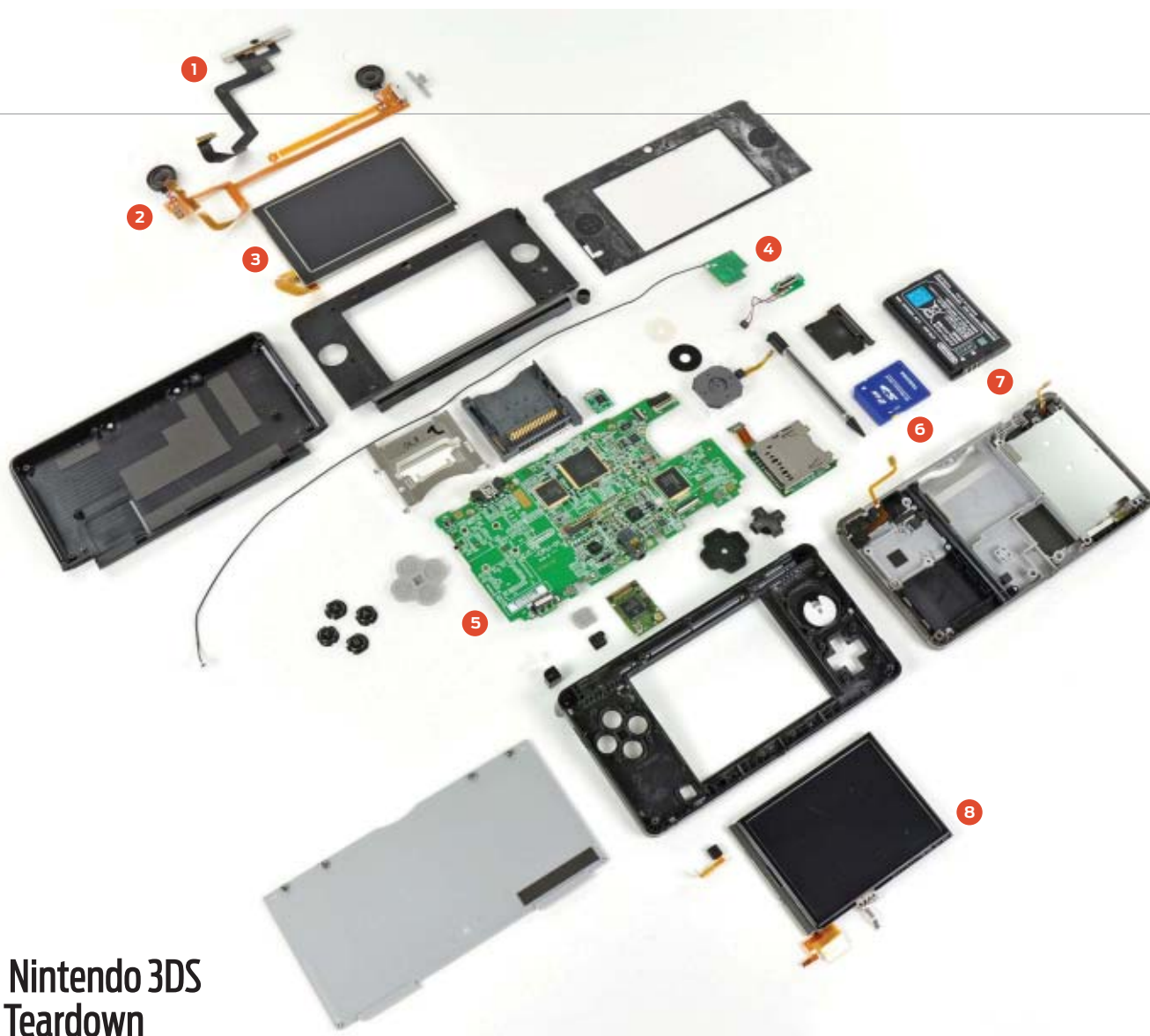
that specializes in consumer electronics, predicts 3DS sales of only 70 million over the same period of time: "Growing competition from the iPod, iPhone, and Android smartphone and tablets will prevent the 3DS from matching the sales of the previous-generation Nintendo handheld, the DS."

Today's smartphone would have been a portable gamer's Valhalla a few years ago: gigahertz-clocking processors with many of the same motion-sensing capabilities as a Wii, plus sparkling high-res displays and—in Apple's case—an App Store filled with over 50 000 games.

To be sure, neither Sony nor the iPhone has the 3DS's glasses-free 3-D. And they don't have Mario or the legendary Zelda. (Both iconic Nintendo franchises should be available for 3DS by the holiday season.) At the same time, 3DS doesn't have phone service, e-mail, AIM, Facebook, Twitter, Foursquare, Skype, Kindle, or Gmail—although both a Web browser and Netflix support are expected later in the year.

Yet perhaps the biggest competitor to 3DS is neither Sony nor the smartphone. "The important question for most people isn't 'Will I buy the 3DS or Sony's new handheld?'" says Kyle Wiens, CEO of tech tear-down website iFixit. "It's 'Will I buy this or the iPod Touch?'"

Wiens said Apple's latest version of the Touch, priced at US \$229 for 8 gigabytes, lacks only 3-D as it lures tech heads to do all their gaming as well as *Continued on page 20*



Nintendo 3DS Teardown

AS SOON as the first Nintendo 3DS models—made for Japanese customers—became available in late February, the techs at iFixit got their hands on one. Although unable to use it because both menus and manuals were in Japanese, iFixit CEO Kyle Wiens got out his heat gun, tiny screwdrivers, and antistatic “spudger” (a prying and wedging tool). Here’s what was left once all the fasteners were unfastened.

—Mark Anderson

1 THREE CAMERAS: Of course, the Nintendo 3DS wouldn’t be much of a console if it didn’t also capture 3-D graphics. A single front-facing camera enables video chat, while a stereoscopic pair of 0.3-megapixel cameras point out, capturing screen-popping 3-D snaps of the baby pulling on the dog’s tail.

2 SPEAKERS: They’re tiny. They’re tinny. You wanted handheld 5.1 surround? Set the DeLorean for 2025, Mr. McFly.

3 THE GLASSES-FREE 3-D SCREEN: The 3DS’s “parallax barrier” consists of two layers of LCD screens that shield the left eye from the vertical strips of image meant for the right eye, and vice versa. The result: 400-by-240, 24-bit color graphics to each peeper.

4 WI-FI: An IEEE 802.11g antenna-and-chip combo communicates with any nearby Wi-Fi base station and also any other nearby 3DS—the StreetPass feature that lets 3DS players’ consoles find one another, even when in sleep mode. And how about that superlong wire? “They needed the antenna in the top...to keep it farther away from your body, [which] gives it better wireless performance,” says Wiens. “But they needed to route it all the way through the hinge and down into where the board is at.”

5 MOTHERBOARD: A Nintendo-branded ARM CPU is the beating heart of the 3DS. Nintendo doesn’t brag about its specs, so it clearly couldn’t go

head-to-head with Sony’s forthcoming next-gen NGP, the quad-core Cortex A9. Do 3DS fans care? Surely not.

Also on board is InvenSense’s MEMS gyroscope. “It opens up new types of game play,” Wiens says. “You’re basically getting a Wii Motion Plus for free with every 3DS.”

6 The flash memory is expandable via SD card, and you can start with the 2-gigabyte card that comes with the 3DS.

7 Nintendo’s website says 3DS plays for 3 to 5 hours on a charge—though playing non-3-D games extends battery life to as much as 8 hours. The iPod Touch’s battery rates 3.44 watt-hours, while 3DS is 5 Wh—and it’s swappable. Game, set, match to Nintendo.

8 2-D DISPLAY: Last but not least is 3DS’s other (2-D) display—with a PDA-throwback resistive touch screen that requires the telescoping

stylus (next to the SD card) for input. “You could use your fingernail,” Wiens says, “whereas with capacitive [touch screens] like on the iPod or iPad or Android portables, it’s measuring the electrical conductivity in your finger.”

IHS ISUPPLI PRODUCTION COST ESTIMATE:

Cameras	US \$4.70
Gyroscope, speakers, accelerometer	\$6.81
3-D screen, 2-D screen	\$33.80
Wi-Fi	\$5.00
Motherboard processors, timing components	\$18.98
Battery, power management	\$7.13
PCBs and other mechanical/electromechanical components	\$20.81
Charger, cables, and other box contents	\$3.48
Manufacturing cost	\$2.54

TOTAL LIST PRICE **\$103.25**
\$250

tools & toys



CONSOLE FEVER: First-day purchasers in Tokyo flaunt their new Nintendo 3DSs.

PHOTO: YOMIURI SHIMBUN/AP PHOTO

Continued from page 18
music, social networking, Net surfing, and movie and TV too. The 3DS, at \$250, has just 2 GB.

The stakes for Nintendo could hardly be higher. If the 3DS fails to score a hit, the company might become the next Sega—a former console maker relegated by the marketplace to serve as a software-only supplier.

But fortunately for Nintendo, the 3DS's biggest challenger is all but asleep at the switch, says games industry analyst Billy Pidgeon of M2 Research, based in Encinitas, Calif.

"Apple doesn't get games at all," Pidgeon says. "Everyone knows Steve Jobs doesn't like games. He thinks it makes the computer more of a toy. To the extent that they have games [in the App Store], they don't really curate it. They treat it like a commodity, just like they treat music."

For Nintendo, the handheld gaming

device is anything but a commodity. And it shows the moment you pick it up.

"I can tell you all day that the 3DS is very cool, but you have to see it to believe it," says Richard George, executive editor for the gaming website IGN. "Nintendo defies trends. They come up with innovative ways to play games that make you think you've never played games before."

At 3DS's March launch, the console's marketplace consisted of just 18 cartridges—including its own *Nintendogs + Cats* (virtual pet training) and *Pilotwings Resort* (a stunt-flight simulator franchise first developed for the Nintendo NES in 1991). Probably the best of the initial offering, though, says *@Gamer Magazine* executive editor Andy Eddy, is Capcom's *Street Fighter IV: 3D Edition*.

As you might expect of any 3-D title worth a thumbs-up, the game's pugilistic graphics fly off the screen with every fierce uppercut

and roundhouse kick. But, crucially, it also takes clever advantage of a lesser-known 3DS feature called StreetPass.

"If you have it in your backpack or pocket, and it's in a standby mode—where it's powered up but you have the lid closed—there's a limited handshaking that takes place," Eddy says. "If you and another person [with a 3DS] pass each other, the *Street Fighter* game lets you have virtual battles with somebody, even though you're not pushing buttons."

Street Fighter's passive rock-paper-scissors minicontests highlight what Pidgeon says could be the other innovation behind any great success 3DS enjoys. For a company like Nintendo to make money, it needs to sell software.

"3DS comes out, and the hard-core gamers will buy it," Pidgeon says. "The trick is going to be to get each person who buys that machine to buy additional

software as much as possible."

3DS's *Street Fighter* helps move players through the ranks with every virtual match, which of course happens only if the players take the 3DS with them. Moreover, Nintendo has learned a lesson from its wildly popular Pokémon franchise, with an onboard 3DS pedometer that also advances a player a little with each step.

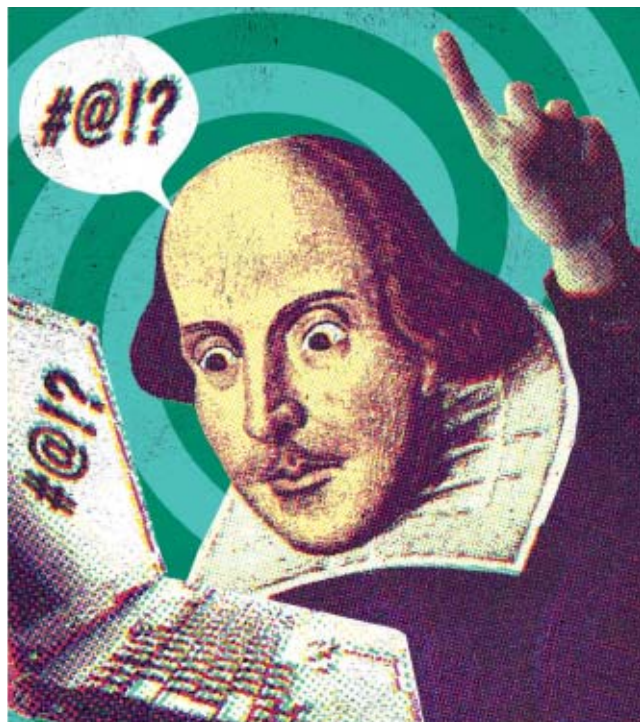
"They have this thing called a PokéWalker that you carry around, and it converts your steps into points you could use to buy Pokémon items," Pidgeon says. "Now they put the thing right into the [3DS] and give you a point system right there that can be used for in-game items and other things that have not yet been defined."

The Touch might be only the penultimate threat to Nintendo. "If in the gaming world the iPod Touch is the present, the iPad is the future," Wiens says. While a tablet may not fit in your pocket, it is getting closer to delivering games like those you get from Wii or Xbox. The iPad 2 alone, with its tenfold GPU speed increase over the first-gen Apple tablet, already represents a threat to portable gaming.

"It is tougher to have a dedicated device business," Pidgeon says, "because convergent devices are becoming good enough to have a great game on. It's just that the great games aren't there yet." —MARK ANDERSON

technically speaking

BY PAUL MCFEDRIES



New Networks Need New Insults

It is surely better a man should be abused than forgotten.
—Samuel Johnson (1709–1784)

AS THE terms *iPod oblivion* and *laptop zombies* from my December column suggest, we're living in the age of the technological insult. Social networks, smartphones, and other technologies have a way of promoting behavior that is off-the-wall, cringe-inducing, or plain old stupid. And the technologies themselves make it easier than ever to respond with a good zinger.

Mind you, I'm not saying this is a golden age of insults. That would be Shakespeare's time, when the Bard himself penned such gems as *knotty-pated fool*, *bull's pizzle*, and

bolting-hutch of beastliness (to name only three from a single play, *Henry IV, Part I*). Or you could make a strong case for the eighteenth century, with the likes of Swift, Pope, Voltaire, and most notably, the great Samuel Johnson, who served up such snubs as *blunderhead*, *fopdoodle*, *lackbrain*, and *slubberdegullion*.

In our time, technology itself is often baked right into each brickbat. For example, if we stumble upon a **luser** (a blend of *loser* and *user*), someone who's out of touch or clueless, we might describe the poor sap as **404**. That adjective comes

from the Web-server error message "404 Not Found"—the Web equivalent of the classic description "not playing with a full deck." Thus it and similar insults are called *fulldeckisms*.

In this age of instantaneous transmission, the meaning of a new word can quickly change from positive to negative. Take **pajamahadeen**, for example. This blend of *pajama* and *mujabideen* (in the sense of "fighter") was coined in 2004 for the bloggers who proved that Dan Rather was fooled by forged documents when questioning the National Guard service of George W. Bush. A former CBS executive defended Rather by characterizing the typical blogger as "a guy sitting in his living room in his pajamas." So in its early linguistic life the term was used, favorably, as a catchall term for bloggers who expose errors made by the traditional media. Within a few years, however, people were also using it to refer to those whose idea of activism is clicking their e-mail software's Forward button (presumably while wearing pajamas). Such folk are also denigrated as **slacktivists**.

If you wish to insult someone who can't even be bothered to rise to the level of **slacktivism**, call that person a **meh-sayer**. *Meh* (pronounced like the first syllable in *medal* or *message*) is an interjection, often accompanied by an actual or virtual shrug of the shoulders, used to signal that one is bored by, or apathetic or indifferent to, something.

Technology has been a big help when we need to slam people who are acting

without thought or reflection. For example, someone who refuses to accept new ideas is said to have a **ROM brain**, while those who never create their own content are put in their place as **read-only users**. Recent coinages include **robo-signer**, a person who assents to a legal document without reading or understanding it; **digi-necker**, a driver who slows down to take a picture of an accident with a digital camera; **fauxtographer**, someone who manipulates images with software; and **foreclosure mill**, a law firm that processes foreclosures perfunctorily and without due diligence. (Each foreclosure is necessitated, no doubt, by the original purchase being run through an **appraisal mill** and then a **mortgage mill**.)

Modern mudslinging also takes aim at the **Wikipedia kid**, a student who has poor research skills and lacks the ability to think critically (probably because his research begins and ends on Wikipedia). No doubt he'll end up a **freshmore**, a second-year high school student who must repeat some or all of his first-year classes. If he's cute but also socially awkward, then feel free to describe him as **adorkable**.

You might be thinking that none of this vituperation quite rises to the level of, say, slubberdegullion, which Johnson defined as "a base, paltry, dirty, sorry, wretch." But these slights and smears feel right for the times, and we've embraced them as the postmodernists we are. Now my time is just about done, so I should take my leave before the insults start flying in my direction. □



THE SOCIAL WEB | *A Special Report*

The Social Era of the Web Starts Now

AND A BIG, COMPLICATED CLASH WILL DETERMINE WHETHER GOOGLE OR FACEBOOK DOMINATES IT

IN THE BEGINNING WAS THE PERSONAL COMPUTER.

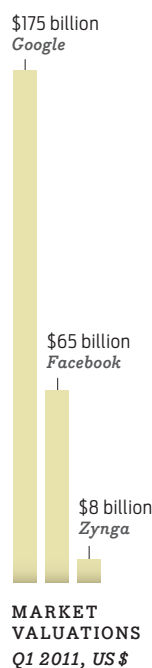
Not long after, people started connecting them together on networks, culminating in the World Wide Web and the Web browser, which launched the first great era of the Web. Then came the search engine, which launched the second great era of the Web, the era of Google.

Now comes the third: the era of social networks. Facebook has jumped out to a commanding lead, but Google hasn't really started fighting yet. So the stage

by JOHN RENNIE
& GLENN ZORPETTE

is set for a battle of, well, biblical proportions. The wizards

at the Googleplex in Mountain View, Calif., are working furiously on a social network to rival Facebook's. Just a few miles away, in Palo Alto, Facebook is preparing for an initial public offering to give it the money it needs to take on Google's Goliath. And last month, the clash got a bit ugly when it was revealed that Facebook had hired a public relations agency to slime Google's social networking tactics.



We are about to witness the next great conflict of the information age, a rich and complicated match on the scale of mainframes vs. micros, RISC vs. CISC, Windows vs. Unix. Like those battles, Google-Facebook will shape the industry's landscape for years to come.

The Web has had a social dimension almost from the start. It just took a while for the right software to come along and make it compelling. "We're now seeing a Web built around people, where their profiles and content are moving with them as they visit different websites," notes Paul Adams, who made his mark as a user-experience researcher at Google before jumping recently to Facebook. Socializing is something that people used to do on the Web; gradually it is *becoming* the Web.

During the first quarter of 2011, the set of 12 social media companies tracked by the Rye Brook, N.Y.-based private equity advisor NYPPEX rose in value by 51 percent. One of those companies, the Facebook game maker Zynga,

increased by 81 percent. Ken Rutkowski, the founder of the Media, Entertainment and Technology Alliance, predicts that credits purchased and exchanged in its online games will make Facebook the world's biggest "bank" by 2015.

None of that has been lost on Google. Yes, it flopped with Buzz, Orkut, and Wave. But Google finds itself in a position like that of IBM in the early 1980s, when IBM's core mainframe business was threatened by what were then called microcomputers. Like IBM 30 years ago, Google has seemingly inexhaustible resources and an implacable determination to stay on top. And so it will try again in the social sphere, and keep trying until it succeeds.

Yet Google's opening salvo, on 31 March, was so small that it slipped by with little fanfare. Still chastened by the Buzz fiasco, apparently, Google is calling its modest new initiative an "experiment" for now. Officially known as "+1," it's a button that pops up next to search results and ads. You click on the button to recommend pages or ads to your friends and contacts. Yes, it's basically the Facebook "like" button but without all the other stuff you need to call yourself a social network. But Google's not done. Think of +1 as an acorn. The oak tree will come later, when Google thinks we're ready for it.

In the meantime, Google says that it will use the button to help determine a page's relevance and ranking in its search results—the more +1 clicks a page gets, the more significant and interesting Google's servers will deem the page to be. There's a kind of insidious brilliance about +1, because every time you hit that button Google learns a little bit more about you, letting the company target you a bit more effectively with search results. And with ads, too.

That's important, because ads are what makes this cockeyed caravan go. Google and Facebook have the same basic model: Offer the services free and charge for advertising. And, as any adman will tell you, the more popular your service, the more money you can get for ad space. That's why Google and Facebook are vying to be the de facto home for Web users.

Nearly all of Google's and Facebook's revenues come from advertising. Google posted US \$29.3 billion in revenue in 2010. A recent report said that privately held Facebook generated about



\$2 billion in revenue last year, which places its size on a par with that of Google when Google was also just six years old.

What Google and Facebook have that old media don't is information about you—data that they collect and process with a barrage of advanced technologies, software, and math to wring money out of you with far greater efficiency. They do that by using the information to target you with ads that can be so specific and relentless that they seem a little creepy at times. Use Google's Chrome browser to search for a fruit-flavored green tea and you will probably find yourself hounded for days or weeks by ads from tea sellers that pop up to the side of other pages that Google points you to. Writing the code that does that is how some of the greatest mathematical minds of the current generation make their living these days.

That's Google's edge: It is in the enviable position of benefiting from having users online in almost every way (but it greatly prefers to keep them at sites available to its scrutiny through the Chrome browser and Android apps). Facebook, on the other hand, can learn about people and profit from them only when they're on the site (a fact that helps explain Mark Zuckerberg's fervent desire that we all just get over our archaic notions about privacy). So now Facebook's triumph is emboldening the network to take on more and more services in the interest of keeping users within its walls.

Here, Facebook has two potent weapons: crowdsourcing and games. Google's success at collecting information and driving commerce has created incentives for sites to manipulate the system with search-engine optimization tricks that artificially elevate their ranks in search results. Distorted search results are in turn prompting frustrated Web surfers to crowdsource their questions to trusted branches of their social networks. The idea is that your friends and relations can steer you toward a good answer much more reliably than Google's immensely powerful but compromised data centers.

Here, too, Google isn't sitting still, but you already knew that. Improved search is part of the rationale for the +1 feature, which allows users to elevate their favorite search results in queries from their friends.

Facebook has also made extremely successful use of online games to keep people within its domain. There are scores of Facebook games, but just two—Zynga's *CityVille* and *FarmVille*—account for 140 million of the 250 million people who play social games every month. Nobody doubts that some of the fiercest battles for online revenues will occur in the arena of gaming. And as our contributor David Kushner notes, these new social diversions are nothing like the action-heavy console games that have been the industry's mainstay [see "Betting the Farm on Games"].

As improbable as it might seem now, Google and Facebook could yet lose their grip on the new social Web. They will thrive only as long as online ad revenue flows, and that flow can be maddeningly fickle and elusive [see "The Revolution Will Not Be Monetized"]. Their snooping may even backfire. Some users have already decided that they would rather not blindly trust their social networking and Web-search history to anyone. So four young techies in San Francisco have found a niche and are trying to fill it with a different kind of social network, called Diaspora. We've got the inside story on the ups and downs of life at the tech start-up of the moment [see "The Anti-Facebook"].

Google and Facebook, meanwhile, are grappling with a rather different sort of engineering problem: how to build data centers that push the boundaries of what's possible now, to keep up with epic demands for processing power, data storage, and more [see "Under the Hood at Google and Facebook"].

We're just starting to see other technologies that let people interact with their machines more intuitively and effortlessly.

They'll help lower the barriers to natural interactions and updates across the Web [see "5 Technologies That Will Shape the Web"]. The inevitable culmination of these developments, say a couple of prominent social-media tech researchers, will be digital avatars that do your bidding online—and are thinner and funnier and better looking than you, too. Avatars are a staple of current sci-fi, and they'll soon be a part of your online social world, according to Jeremy N. Bailenson and Jim Blascovich [see "This is Your Mind Online"].

Technology will also give us a whole new concept of mobility. Just as GPS units in phones make it possible for people to spontaneously advertise their coordinates at all times, new kinds of sensors linked to the Web and embedded in clothes, buildings, vehicles, and other common objects will be able to convey ongoing updates about your every action. People will need to do less and less in the future to loose a torrent of data about themselves and their ongoing activities onto the Web.

There's a downside, and it's a doozy. A system for tracking everyone's actions sounds even more intrusive than the tele-screens of George Orwell's *1984*. But in capitalist democracies, at least, the more immediate worries are that corporate marketing could gain major advantages from knowing so much about us, and that minor lapses or, as they say, youthful indiscretions could wind up wrecking some people's lives and careers [see "Welcome to the Surveillance Society" and "Me, Myself, or I"].

Of course, privacy means different things in different places. The 457 million Chinese who use the Internet have seized avidly on social media, making Sina Weibo, China's homegrown microblogging service, one of the fastest-growing utilities in Web history. Sina Weibo's success has protected it so far from Chinese officials who fear its reach and influence. If services like Sina Weibo can survive long enough, they may provoke significant cultural if not political changes [see "China's Social Networking Problem"].

Google and Facebook are both counting on human creativity to drive their future success. So they are fostering lavish workplace cultures—with beautiful campuses, gourmet food, and at Google, conveniently located dog-poop disposal stations. (Really.) You may be surprised (we sure were) by what it takes to lure, pamper, and retain a top techie these days [see "Campus Life" and "Food Fight"].

The social networks that will come out of these brainy hot-houses will undoubtedly have surprising cultural consequences. Life support excepted, the most fundamental human need is companionship. And so humankind has turned its newest technologies—computers, networks, mobile gizmos, and software—to one of its oldest and most basic requirements. A new and interesting chapter has begun. You'll like it, although there are bound to be a few scary parts. We can't tell you how the chapter will turn out. But when you've read our report, at least you'll know what to fear and what to hope for. □

With additional reporting by Julie Pitta





[BUSINESS]

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THE SOCIAL WEB | A Special Report

The Revolution Will Not Be Monetized

STRATOSPHERIC VALUATIONS
FOR SOCIAL MEDIA
TITANS ASSUME VAST
ADVERTISING REVENUE
THAT WILL NEVER ARRIVE

FIRST THING YOU DO, TEAR THIS ARTICLE OUT OF the magazine and carefully set it on fire. It's about the jockeying for position and revenue among the big players in social media: Facebook, Twitter, and Google's YouTube. And the analysis isn't bad for—

whaddyacallit—history. But it wasn't written in the past 12 minutes. So more likely than not it's already hilariously out of date. (“Google?” you may be asking, perplexed. In case the brand has in the interim disappeared from the scene, like Webvan and John Tesh, listen up: “Google” was a *search engine*.)

Probably there's a new serial-killer app in town—CatRattle.com, or some such—that lets users know what everybody else really thinks of them, in real time. Probably sweeping the nation is the phrase “Dude, you've been totally rattled.” But just in case events haven't made a mockery out of this exercise, let's try to address three basic questions:

US \$29.3 billion
Google



\$2 billion
Facebook

2010 Revenues

In its sixth year, 2010, Facebook's estimated revenues equaled Google's at the same age.

1. If you build it and they come, does that guarantee that there's money to be made? (Hint: No.)

2. Which of Facebook, YouTube, and Twitter will amass the millennium's first megafortune and a borderless virtual state, with a vast population, political influence, economic clout, and a lair in a hollowed-out volcano from which to control the world's weather? (Well, you can probably eliminate Twitter.)

3. The Wall Street valuations of companies like Facebook, which is worth US \$85 billion on the secondary market, are stratospheric. Should we stockpile ammo and canned goods for when the bubble bursts? (Not a bad idea; remember Pets.com.)

Once again, addressing such questions is a process both complicated and highly speculative. But let's give it a shot anyway, beginning with a glance at the status quo, and a little arithmetic.

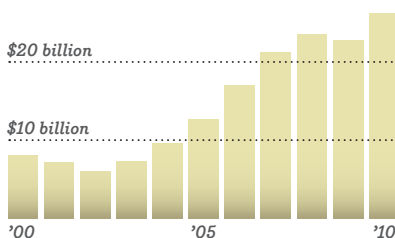
According to the Interactive Advertising Bureau, U.S. advertisers spent \$25 billion online in 2010—representing about 15 percent of the \$164 billion U.S. ad market and, for the first time, a bit more than their spending on print newspapers. That was no small milestone. But here's the thing: According to eMarketer, 31 percent of Americans' media-consuming *time* in 2010 was spent online. Which means, speaking broadly, marketers valued new-media time *only half as much* as old-media time. And that's the rose-colored view. Chris Anderson, curator of the TED Conferences, recently crunched numbers from Nielsen, Forrester Research, the Yankee Group, and other modelers to synthesize the value, medium by medium, of an individual's time. Globally, print publications fetched \$1 per hour of reader attention. TV got a quarter for a viewer hour. Online fetched "less than a dime."

Why is online advertising such a poor stepchild? Well, extremely delightful and informative books with pale-blue and white covers have been written on this subject, but let's reduce the problem to its essence: The endless supply of online content means an endless supply of places where ads could go, which by definition depresses demand and, with it, price. Period.

The second problem is more basic still. Ever click on a banner ad? Have you? Ever? Of course not, because why would you leave what you're doing—especially socializing—to go listen to a sales pitch? The click-through rate, industry-wide, is less than 1 percent—and chalk some of that up to mouse error and click fraud. Some advertisers deal with this problem by popping ads into your face, blaring audio, or subjecting you to "preroll" video messages before the video you actually wish to see. As Anderson sagely observed to a Madison Avenue audience, that was an acceptable quid pro quo in the days of passive TV viewing. Online, though, users are active and in control. "If you take control away from

Online Ad Revenue Soars

ANNUAL REVENUE (US \$), 2000 to 2010

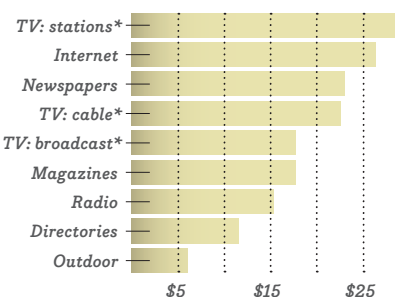


Web revenues rose last year following a brief, recessionary fall.

Source: Interactive Advertising Bureau

Online Advertising Surpasses Newspapers

U.S. ADVERTISING MARKET, by MEDIA REVENUE, 2010 (US \$, billions)



Internet advertising revenue rose at the expense of other media, and last year it surpassed newspapers.

* "TV: stations" includes national and local TV station ads, as well as multichannel system ads. Cable and broadcast refer to TV networks. Sources: IAB Internet Advertising Revenue Report; PwC

them," he said, "they will hate you." Or, put another way: Online, *all advertising is spam*. These two structural problems leave two possibilities: Either advertising will never be the force in new media that it was in the five predigital centuries (a theory to which I personally subscribe), or someone will crack the code.

The holy grail, if it exists, resides in online advertising's central advantage: the ability to mine data and target individuals with an offer relevant to their lives and interests. In the case of social

networks, there is also the ability to target *friends of existing customers*—what venture capitalist David Pakman calls "the most powerful form of advertising ever created, not counting search." Not only is such targeted advertising on average twice as lucrative as conventional ads, it can fetch 100 times as much revenue as mere spam, the sort that pushes random teeth-whitening miracles and predatory-loan-shilling dancing silhouettes. That's why Pakman believes Facebook's valuation will rise even higher.

"Social networking is a winner-take-all market," Pakman says. "They run the table." His firm recently bankrolled a start-up heavily dependent on Facebook in the social-advertising arena.

On the other hand, that very lucrative targeted messaging has another undesirable effect: It gives us, the target, a condition that experts call the heebie-jeebies. A word about data mining: It is automated and essentially anonymous, but it engenders a creepy sense of privacy invasion and personal violation. Which is why the Federal Trade Commission (FTC) and the U.S. Congress are warning the industry to fix the privacy problem or permit the government to fix it for them. As Anderson sums up the situation: "We're in danger of becoming stalkers. That strategy is going to end badly."

Nor is it beginning all that magnificently.

Facebook and Google's YouTube themselves achieved milestones in 2010. Both are said to have eclipsed \$1 billion in ad revenues, and both have reportedly become cash-flow positive. Twitter has only just started attempting to monetize its microblogging utility, but it has similarly altered human behavior on a large scale. Absolutely nobody questions the transformative qualities of these services, nor their extraordinary reach. At this writing, Facebook boasts approximately 600 million users. At current rates of growth, by 2020 its membership will exceed the population of Earth, plus

the International Space Station and the planet Krypton. Yet, as Pakman recently estimated, it generates no more than \$3 per user per year in revenue (compared to Google, which brings in about \$25 per user)—and a huge chunk of the revenue comes from the social-gaming firm Zynga to sell player credits for titles like *FarmVille*, itself a Facebook app.

Furthermore, Facebook's priceless asset is not its incomparable reach but its incomparable data set. Should legislators or regulators intervene in the name of privacy—maybe by mandating a simple way for anyone to opt out of tracking—the value and sustainability of Facebook's data trove would be vastly degraded.

And that's not the only dark cloud. Facebook's ad strategy hinges not on ads that appear on Facebook pages but rather those served to third-party sites seeking to benefit from Facebook's data and reach. This strategy employs Facebook Connect, a bag of tricks that let developers build Web applications that invite visitors to share information with their friends. For instance, such an application allows subscribers to Netflix, the movie-rental service, to tell their friends which movies they've seen and how well they liked them.

It is precisely such third-party transactions that the FTC is at the moment proposing to regulate. Furtherfurtherfurthermore, not everyone on Madison Avenue is persuaded that social affinities are such a magical predictor of purchasing behavior. "This is old math," says Rob Norman, CEO of the media-buying colossus Group M North America. "It's the Bell Labs' 'network neighborhood' theory of selling long-distance calling plans. 'Birds of a feather flock together' blah, blah, blah." That's a decent theory but so far, he says, worthy of only "the Scottish Verdict: unproven."

So hold those thoughts for a moment.

If social targeting indeed represents the second most powerful ad engine in history, the first is surely Google search,

which allows advertisers to pursue not those it suspects of being prospects but those raising their hands with search terms hollering "Yoo-hoo! I'm over here! And I'm looking for a deal on a new television." Google's 2010 revenues were \$29 billion—equivalent to the monthly U.S.–China trade deficit, the Harvard endowment, or the GDP of Latvia plus the market value of the Philadelphia Eagles when Michael Vick is staying in the pocket and refraining from killing dogs. In short, that's a chunk of change. It is so big, in fact, that nobody much sweats about when or whether YouTube will be significantly profitable, much less about how Google will amortize the \$1.65 billion it paid YouTube's Chad Hurley, Steve Chen, and other owners.

By 2020 Facebook's membership will exceed the population of Earth, plus the International Space Station and the planet Krypton

YET IT GENERATES NO MORE THAN \$3 PER USER PER YEAR IN REVENUE
(COMPARED TO GOOGLE, WHICH BRINGS IN ABOUT \$25 PER USER)

By the same token, as the default platform for video distribution in the Milky Way galaxy, YouTube probably doesn't care how quickly Anderson fills with blind rage upon being presented a 20-second preroll ad before a 2-minute video of kittens on a sliding board. For those who want free content, says Norman, putting up with commercials "is an occupational hazard," and necessary, at least up to a point. The balance of ad time versus content time, he believes, must and will find its level. Meanwhile, the display ads on YouTube's home page have TV-like reach and "are of enormous value to advertisers. I don't think there is any question about that."

What YouTube mainly has going for it is its enormous value to users. In addition to being a bottomless bowl of video snacks, it provides convenient and free distribution for the genius and stupidity of countless video civil-

ians. If Google executive chairman Eric Schmidt's vision is realized, it will also be the central purveyor of all video content, amateur and Hollywood alike, worldwide. For ever and ever. To this end, he has spoken of a 15-year monetization plan including not just advertising but also subscriptions and micropayments. On that journey, he might want to get started right quick.

If YouTube is profitable at \$1 billion in revenues, it ain't by much. Acquisition of Hollywood content means fat licensing fees, and streaming all the world's video requires vast network capability beginning—but only beginning—with bandwidth. Alas, even in developed countries, the amount of available fiber *and* wireless bandwidth

is insufficient to convey today's peak loads, much less tomorrow's. "I was sent on a jaunt for one client to buy as much bandwidth and distributed architecture as I could," says Tony Greenberg, chief executive of RampRate, the IT infrastructure consultancy. "I had an unlimited budget, but the Internet didn't have enough capacity."

Google chews up 10 percent of the Internet's capacity, and it has recently been speculated that much of that share is in the form of as-yet-unused optical cable, or dark fiber, that's actually owned by Google. Rather than paying a \$500 million annual YouTube bandwidth bill, the company is known to conserve cash by "peering"—trading its excess bandwidth with Internet service providers, like Verizon, for access to their networks. But so what? To Google's accountants, the barter still represents a gigantic overhead expense.

And it's not the only one, as Greenberg notes, his voice rising in gathering annoyance. "In the cost of streaming media, I'm sick and tired of everyone talking about pennies to move a movie on Netflix and then quoting only bandwidth cost. That's like computing the cost of a bathroom based on the price of toilet paper. You have to deal with the ability to scale, the servers, where the servers live, how it's routed, what the fault tolerances are in terms of milliseconds. And then there's 100 engineering and application issues that can go awry."

That's why, he says, so many massively multiplayer online games are defunct, and why pioneering social network Friendster, outside of Asia, is more like Dumpster. And why Twitter crashes frequently.

Ah, Twitter. Permit me to dispense with this perfunctorily: It is hard to imagine Twitter prospering long-term as a stand-alone company. Oh, the microblogging utility is surely utilitarian. For those who tweet among themselves, it's a means to make all life experiences interactive. For those who monitor the Twittersphere, it is a near-perfect, real-time zeitgeist engine. These are revolutionary benefits, but will the revolution be monetized? That entirely depends on the rather dubious value of "promoted tweets."

"We wanted to do that in a way that was very organic to Twitter and didn't seem foreign or in any way clash with how people were using the product," says Twitter cofounder Evan Williams. "Basically, we give companies the ability to give visibility to a topic that they want to give visibility to, and then when people see that and they click on it, they see a tweet from that advertiser. We have a few dozen advertisers who have gotten phenomenal results, and we're ramping that up now."

Maybe, but here again, a huge obstacle is defeating online inertia.

"If I'm going to be interrupted during a tweet, I want a deal," says Peter Hirshberg, CEO of the agency Reimagine Group and former chairman

Google and Facebook by the Numbers

Google is six years older than Facebook—a generation, in tech terms. But Facebook is pacing Google's early growth, and then some

HOW DO GOOGLE AND FACEBOOK COMPARE? Today Google is bigger than Facebook in all the ways that count. But then, Google, founded in 1998, has a six-year lead on its rival, and Facebook is growing up fast.

Facebook boasts approximately 600 million active users, who on an average day each spend 25 minutes on the site. About 70 percent of those users are outside the United States. Facebook has been translated into 76 different languages.

Google processes more than 1 billion search requests each day in 40 different languages. But you can't really judge a search engine by users and minutes, because search engines by design direct users to other sites.

—Julie Pitta

of Technorati. But such promotional offers are more or less the antithesis of brand building and therefore not necessarily attractive to leading national advertisers. "The point of a brand is to create brand equity and brand loyalty," Hirshberg says. The point is definitely *not* to attract bargain hunters, who are by definition the least loyal, least profitable customers. Many observers therefore assume Twitter will be gobbled up by Google or somebody else—perhaps as a competitive hedge against Groupon, the daily-bargain site, or Foursquare, the location-based social network.

So there. We've reduced the battle of social-media titans to Google/YouTube

and Facebook. But who prevails? One of them? Both of them? Neither? That answer probably hinges on who dominates in three areas: mobile search (it's basically the same as search, but on wireless devices, with a few more branches but not really the Foursquare thing), e-mail, and e-currency.

In mobile search, Google doesn't just dominate—it enjoys a virtual monopoly. It also obviously has a huge advantage in e-mail, with its Gmail service, but Facebook, with its new combined e-mail/text/Facebook-message application, is trying to move into that territory—and thereby start siphoning a huge contextual-advertising revenue stream.

30 000 employees
Google

2000 employees
Facebook

HELP WANTED

Both companies are on a hiring spree that Google chairman Eric Schmidt has called “the war for talent.” By the end of this year, Google, which listed 26 316 employees in its most recent quarterly report, plans to have more than 30 000 employees in 20 U.S. and 50 overseas offices. Facebook currently has about 2000 employees in 11 U.S. and 14 overseas offices; although it is keeping mum on hiring, it has said it will move into a new corporate office that can accommodate 9400.



30

Average Google
Employee Age

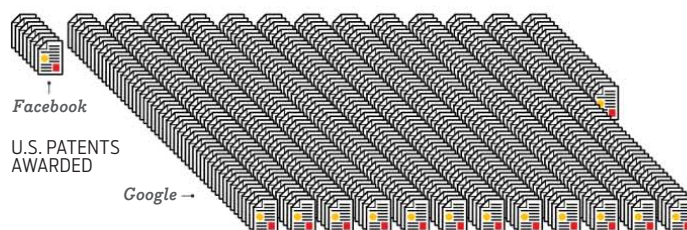


31

Average Facebook
Employee Age

FOREVER YOUNG?

Both companies value youth: The average age of a Google employee hovers around 30, while at Facebook it has reportedly jumped from 25 all the way to 31. The emphasis on youth, though, can have its downside: A 54-year-old executive, one of Google’s “Greyglers”—the company’s name for workers over 40—sued the company for age discrimination after he was fired in 2004. The lawsuit is still making its way through the courts.



A PASSION FOR PATENTS

Google has earned more techie cred than its young rival. The company has been awarded nearly 620 U.S. patents to Facebook’s 8, according to the U.S. Patent and Trademark Office. Google’s patent portfolio is a reflection of its broader reach into a wide range of technologies and services, including Google maps, software applications, and its Android operating system for smartphones and tablets. For now, Facebook’s engineering efforts are focused on improving aspects of its social network, most notably its e-mail service. Displacing existing e-mail services would give Facebook its best shot at becoming the home page of choice for Web users.

For my money, though, the segment to keep your eye on is “Facebook credits,” the virtual currency now used primarily in places like *FarmVille*, to buy that game’s own in-house money—say, to purchase a virtual cow. I say it will evolve into the long-sought-after mechanism for online micropayments. And you’re reading it here first—or maybe the second or 18th time, because the thought isn’t unique to me. But the other 17 folks are onto something. As smartphones evolve into transactional tools, Facebook credits could someday function as scrip in the brick-and-mortar world as well. Right now Facebook takes a 30 percent commission; if it can make the system

work at 0.3 percent, it will not only overtake the rest of the social media, it will overtake Switzerland.

So, all of the above having been chewed over, the question remains: Who wins? Well, before we get there, I should probably own up to misleading you, because the three queries this essay used as points of departure leave out a possibility, namely that...

4. Those three questions are irrelevant! What if we evolve from an Internet-cloud environment to an app environment—in which case Steve Jobs, who defined his business in 1984 by portraying the competition as Big Brother, could wind up as Big Brother himself?

As app-centric mobiles and tablets increasingly dominate our online lives, perhaps the CatRattle app or something else will materialize to make us all forget that Mark Zuckerberg, Chad Hurley, and Evan Williams ever existed.

Maybe yes, maybe no; my forecast is cloudy with a strong chance of iPads. But I must delay no longer. The assignment here was to make a prediction, and with all the above-mentioned caveats, and the further disclaimer that this is but one man’s opinion, I will boldly do just that. The dominant online force with a significant social-media component over the next 20 years will be:

Amazon.com. □

Write to us at <http://spectrum.ieee.org/revolution0611>.

JUNE 2011 • IEEE SPECTRUM • INT 31





[FUTURE TECH]

|||||

THE SOCIAL WEB

A Special Report

5 Technologies That Will Shape the Web

INNOVATIONS THAT WILL MAKE
THE WEB SMARTER AND SLEEKER
AND IRRESISTIBLY MORE SOCIAL, TOO

IT WAS 1997—EONS AGO, IN INTERNET YEARS—AND the Web was only beginning to take off. People used dial-up modems to get online, and Netscape Navigator was the browser of choice. Google was still a research project of two Stanford students, and Facebook...well, Mark Zuckerberg was a 13-year-old having his Star Wars-themed bar mitzvah.

Flash forward to 2011. The Web has since reinvented itself time and again: when businesses embraced it in the late 1990s, when Google dominated search in the early 2000s, when user-generated content became prominent in the mid-2000s. Today the Web is going through another reinvention, morphing into a place where our social interactions are ever more important. And the main force behind this phenomenon is, of course, Facebook, led by Zuckerberg, now a 27-year-old billionaire.

by ELISE ACKERMAN
& ERICO GUIZZO

21

Sergey Brin
& Larry Page

10

Mark
Zuckerberg

1

Justin Bieber

AGE IN
1994,
WHEN
THE FIRST
VERSION
OF THE
NETSCAPE
BROWSER
CAME OUT

So where will the Web go next? We asked two dozen analysts, engineers, and executives to describe what technologies they think will shape our online experiences in the next several years. Their predictions could easily fill this entire issue, but we distilled their wisdom into a more palatable list of five key technologies that our sources mentioned most frequently.

We also asked six of the experts to tell us what these technologies mean for today's dueling titans, Google and Facebook. What challenges do they face? Who's got an advantage? You'll find their comments sprinkled throughout these pages.

Lists like this are nothing if not contentious. Some critics will say we overlooked more crucial trends. Others will claim our technologies are already history. So we want to know what you think. Join the discussion at <http://spectrum.ieee.org/fivetech0611>.

1

The Mobile Web Will Be a Smarter Web

IN A WATERSHED MOMENT IN THE HISTORY OF COMPUTING, global shipments of smartphones exceeded those of PCs for the first time in the fourth quarter of 2010. The rise of mobile devices is indeed staggering in its pace and scale. Every day, carriers activate 350 000 phones running Google's Android operating system. An estimated 15 percent of Google's search volume now comes from mobile devices. More than 10 billion apps have been downloaded from Apple's App Store.

Today a fierce battle is under way between Google's Android and Apple's iPhone. But let's put that aside and focus on how mobile technology is transforming the user experience.



[MOBILE]

For many people mobile devices are becoming the favored portal to their online social lives. We're using our phones to voice opinions, publish photos, play games, and check on friends. More than 250 million users access Facebook on their mobile devices, and 40 percent of all tweets come from mobile platforms. Already the iPhone 4 is poised to become the most popular camera among Flickr users.

Experts say this is just for starters. The powerful blend of mobile and social capabilities will inspire new products and services and become the foundation for new ways to work, shop, and entertain ourselves. The key element propelling this transformation? Context.

Most of the time when you use your phone, you're immersed in a specific context: There's the location, the day and time, what you're doing there, what is nearby, whether you've been there before. There's also your social graph—the connections among individuals, as well as among individuals and objects—with bits of data that are relevant to that context (whether, say, any friends have shared information about that location). The future of mobile computing will be all about how big companies and start-ups alike develop technologies—data analytics and machine learning algorithms, for example—capable of

making sense of context data to provide better search results, advertising, and other services.

To see where this is going, consider one piece of context information that companies are already exploring: geo-location. Facebook launched a service called Places, and Google has Latitude; location start-ups include Foursquare and Gowalla. Using GPS and Wi-Fi data from people's phones, these services offer location-specific information and deals. If you're at a store, you might receive a discount coupon; if you're at a bar, you'll see what friends have said about the place and whether any of them are nearby. So what our mobile devices are doing is linking the digital world to the real world—and as a result, new applications will become possible and people will become ever more connected to other people.

"You're going to see the same kind of changes to industry and business that you saw when the Web became popular," says Dennis Woodside, a Google vice president, "but it's going to happen much faster."



When we talk about mobile as a disruptive technology, we need to talk about social. Google is winning the Web, but Facebook is winning social. I see Google really flailing around social. They are trying to figure it out, but they are coming late to the game.



—GINA TRAPANI
Developer, ThinkUp,
smarterware.org

Mobile phones mean that people want information in context. So Google's challenge is to give people personalized recommendations on the fly, which is different from a list of search results. Facebook is well placed in this regard, because they have the social context for search on mobile phones.



—RICHARD
MACMANUS
Blogger, ReadWriteWeb,
readwriteweb.com

2

Video Is Poised to Inundate the Web

ANSWER QUICKLY: WHAT'S THE WORLD'S SECOND-largest search engine? If you said Yahoo or Bing, you'd be wrong. The answer is YouTube.

Each month, YouTube users all over the world collectively spend some 2.9 billion hours—that's 331 050 years, if you're wondering—on the site. More video is uploaded to YouTube in 60 days than the three major U.S. networks created in 60 years.



[VIDEO]

Analysts say that YouTube, acquired by Google in 2006, is just the beginning trickle of a video flood that will swamp the Web. Indeed, video traffic has already surpassed peer-to-peer as the dominant form of data flowing in telecommunications pipes. Movies streamed by Netflix alone can make up as much as 20 percent of U.S. broadband traffic on any given night. As more TV programming shifts to the Web, TV sets themselves are becoming Net-enabled devices optimized for video consumption. Smartphones that make it easier to produce, watch, and share video only help to accelerate this trend.



We have an increasing expectation that we should be able to watch movies and entertainment whenever we want to. Why do I have to watch "American Idol" at night on a certain channel? Why can't I just pull it up on my iPad and watch it when I want to watch it?



—ROBERT SCOBLE
Blogger, Scobleizer,
scobleizer.com

Google has more to be worried about with video than Facebook does in the sense it has more to lose. YouTube is a hugely popular video-sharing site, but it faces some threats. For example, it needs to make the transition to professional content, and that transition has been hard.



—DANNY SULLIVAN
Blogger,
Search Engine Land,
searchengineland.com

But the future of Web video is not only that there will be more of it—*how* we watch it is also changing. That's because the Web is enhancing the social nature of video. We love to talk about what we watch—some people now tweet in front of the TV during shows and sports—and we love to recommend things to one another.

And here's where the social Web comes in. The social graph could be the basis of a powerful recommendation engine. Indeed, Facebook recently teamed up with Warner Bros. to offer streaming movies for rent, starting with *The Dark Knight* in March. Facebook's move into distribution is a big threat to cable companies' pay-per-view services; to YouTube, which has long sought more professional content; and even more so to Netflix, now the dominant force in online movie rentals. Facebook's advantage is its massive user base and the fact that it can use people's social connections, their comments, and "likes" to suggest movies in a very effective way.

Because online video's attractiveness to users makes its revenue potential gigantic, companies are reorganizing their software and network infrastructures to accommodate it. That focus has touched off a major battle over standards. More and more Web video is relying on a patent-encumbered encoding technology known as H.264. Google, which says it favors an open, free-for-all video format, has dropped support for H.264 and is pushing instead for an alternative called WebM.

A resolution should emerge when a new Web standard, HTML5, becomes official. HTML5 will specify which video formats—contenders include H.264, WebM, and others—all browsers should support. David Recordon, senior open programs manager at Facebook, says that no matter which format prevails, it will lead to richer applications both on the Web and on mobile devices, making it easier for ever more people to create and consume video.



[SENSORS]



Many of these connected devices will use Android, so Google will benefit from the trend, though it has to figure out how to integrate their data in their search index. Facebook isn't there yet, because what is missing is the social layer in those devices. But Facebook is so big—they will figure something out.



—JEFF CLAVIER
Investor, SoftTech VC,
softtechvc.com

Sensors will pump a ton of new data into the Internet. What's most fascinating is what will be built on top of that new data, which makes it likely to produce deeply disruptive new start-ups and companies. The next Google or Facebook may well be an Internet of Things company.



—RICHARD MACMANUS
Blogger, ReadWriteWeb,
readwriteweb.com

3

Everyday Objects Will Join Our Social Networks

AFTER THE EMERGENCY AT JAPAN'S Fukushima Dai-ichi nuclear plant early this year, government agencies and individuals set up Geiger counters to measure radiation. Like many sensors today, these Geiger counters post their measurements to the Web, which lets people pool the data and crowdsourcing the monitoring of radiation levels.

Welcome to the Internet of Things, where data from scientific instruments, embedded sensors, and a vast assortment of Net-connected objects will eventually eclipse information produced by humans.

Actually, it's already happening. Carnegie Mellon University researchers are developing sensors to monitor buildings, roads, and bridges. A high-tech pedometer made by Fitbit monitors your movements and lets you share your exercise habits with your friends. Last year, toy maker Mattel unveiled an electronic tag that sends a tweet whenever a dog moves or barks.

First proposed more than a decade ago, the Internet of Things is finally taking shape, thanks to ever cheaper electronics, improvements in wireless technologies, and the availability of DIY electronics like the Arduino, a popular open-source microcontroller.

Mapping data from ubiquitous sensors to our social graphs will provide valuable information about ourselves and our surroundings. People will find ways to use these streams of information to their advantage, in ways that we can't necessarily anticipate now but that will surely test our boundaries for privacy and publicness. Don't be surprised when your fridge joins Facebook.

4

Web Data Will Explode, and That's a Good Thing

IF THE EARLY DAYS OF THE WEB IGNITED AN EXPLOSION of data, what we're seeing today is more like an A-bomb blast. Google executive Marissa Mayer has said that data are proliferating at a rate that outpaces Moore's Law. According to research firm IDC, the amount of data created globally last year surpassed 1 zettabyte—enough to fill a billion 1-terabyte hard drives.



[BIG DATA]

This unprecedented data accumulation has led to a tech arms race of sorts, with companies seeking new ways of storing, managing, and analyzing information. The industry has dubbed this trend "big data."

Google, of course, was a pioneer in the development of data-crunching technologies. It created tools such as MapReduce, a set of superefficient algorithms for distributing and processing large blocks of data, and built supersecret data centers that work like "warehouse-sized computers," as some Google researchers have described them.

This computing capability is at the heart of what makes Google's search offerings so powerful. It also lets the company discover insights about what people are collectively thinking, the seasonality of the flu, and the popularity of words. Peter Norvig, Google's director of research, says that having more data opens the door to new kinds of theories and models—new ways of thinking about the world.

But today's big data will be different from tomorrow's. A large fraction of today's data consists of Web pages that companies like Google can crawl, process, and present to users when needed. In the future, however, users will consume and produce ever more data in near real time.

TOP: JEFF CLAVIER



Facebook is trying to be hegemonic when it comes to your profile.

Facebook Connect is brilliant because of that. They couldn't be the one place where everyone went on the Web, but they could be the profile that everyone links to.



—CHARLENE LI

Analyst,
Altimeter Group,
altimetergroup.com

The new data will come in great part from the social Web. Already, Facebook users share more than 30 billion pieces of content—Web links, news stories, blog posts, photos—each month. Twitter users generate more than 155 million tweets per day (up from 55 million one year ago). What's more, both companies are establishing themselves as platforms for data aggregation, granting other companies access to the results through APIs, or application programming interfaces. (Facebook Connect, which allows sites to access public data from Facebook users, is one such API.) The growth of these interconnections, of course, spawns still more online data, in a widening spiral.

It's a spiral that is leaving Google, perhaps more than anyone else, dizzy: Real-time and social search poses the greatest threat to the company's search hegemony. As Facebook, Twitter, and other social-oriented sites amass vast volumes of data and connect this data to people's social graphs, they might be able to help users find information in ways that Google can't.

As this battle unfolds, tech companies, including innovative start-ups like Cloudera, race to build better big-data technologies: radically new server architectures, database systems very different from classic relational schemes, novel language frameworks that combine the best aspects of various programming languages. They're also mobilizing highly specialized teams of "data scientists." Interestingly, although the companies are secretive about their tech arsenals, they rely a great deal on open-source code, sometimes even collaborating on open-source projects that all can use. Experts say that innovations in big data will lead not only to better online experiences but also to new data-driven services and even scientific discoveries.

Google has so much data that they have been sucking up from the Web for so long, but Facebook has structured data that is people-centric. That is really powerful, especially with mobile happening and people wanting to find other people, versus Web pages. Facebook's big data is a lot more interesting than Google's.



—GINA TRAPANI

Developer, ThinkUp,
smarterware.org

5

Voice and Gestures Will Change Human-Computer Interaction

IN THE PAST 30 YEARS, PROCESSORS HAVE steadily gotten faster, storage systems have mushroomed in capacity, and even monitors have lost weight and gained higher resolutions. But the way we interact with computers—with a keyboard and mouse—hasn't changed a whit.

Now human-computer interaction is really evolving. Smartphones and tablets have popularized touch screens, doing away with physical keyboards and creating an interface that even toddlers can intuitively operate. Next is voice. Google has already voice-enabled its search app for Android: Speak and the program will search. Another app will translate sentences between Spanish and English in near real time.

But the next wave of interfaces will involve...waving. Last year, Microsoft launched Kinect, a 3-D motion sensor for its Xbox 360 game console. The device projects a pattern of infrared dots, invisible to the naked eye, on the environment. Then it uses a sensor to "see" the dots, deriving their distance based on how objects and people deform the pattern. Some speculate that Microsoft may integrate Kinect controls into Windows. (Cue Tom Cruise waving frenetically as he operates a futuristic computer in *Minority Report*.)

Experts say the latest innovations in natural interfaces provide a glimpse of a fast-approaching future in which people will interact with the Web very differently—not only by typing and touching but also by talking and gestulating before our devices.

"We want to make technology disappear," says Alex Kipman, Kinect's project leader at Microsoft. □



[NATURAL INTERFACES]



Some disruptions are difficult because they require large investments. Natural interfaces are really hard; they require a huge amount of R&D. What is great about Kinect is it removes a layer of technology between me and the content.



—CHARLENE LI

Analyst,
Altimeter Group,
altimetergroup.com

If you look at Google, they have tons of people who are working on voice. It is something that is almost required for Android. But I don't think that the new interfaces are causing much disruption in terms of the incumbents. This is where we see evolution; we don't see revolution.



—JEFF CLAVIER

Investor, SoftTech VC,
softtechvc.com

Privacy, Publicness, and the Web: A Manifesto

As Google, Facebook, and other companies exploit our data trails to help us connect and communicate, we the people need to establish some basic rights

THE INTERNET IS THE GREATEST AGENT OF CHANGE SINCE AT least Gutenberg. Its leaders, Google and Facebook, are transforming business, society, our relationships, and even our worldview in so many ways. They're also transforming our notions of privacy and publicness. Will this new world be a better one?

Facebook and Google—and I—believe a public society is a better society. “On balance, making the world more open is good,” Facebook’s founder, Mark Zuckerberg, told me. “Our mission is to make the world more open and connected.” And Google’s is to organize the world’s public knowledge.

Many benefits accrue to a public society. Sir Tim Berners-Lee, inventor of the Web, has been calling for opening up as much data as possible—save for that which jeopardizes privacy—to move the Web to its next phase. Because when data are layered upon data and connections are made, value can grow dramatically.

Google demands openness if we want to be found online. Facebook enables—indeed, encourages and presses for—transparency in our relationships and identities. After acknowledging the irony that both of these organizations operate somewhat opaquely, we must recognize that we are entering an era of openness that will affect how business and government work and how they interact with their constituents.

In my research, I’ve found that worries about privacy are often triggered by the changes that new technology brings. After Gutenberg’s press, the earliest book authors feared making their ideas public and permanent. In the United States, the first serious discussion of a right to privacy came in 1890. The trigger: the invention of the Kodak camera, tied to the emergence of popular newspapers known as the penny press. The telephone, miniature microphones, video cameras, and RFID chips all raised similar worries. Now it’s the Internet’s turn.

Zuckerberg believes Facebook is the Web’s next phase after Google. According to his history, before the Internet, many of us suffered “privacy through obscurity,” but now the democratizing Web gives us all the opportunity to share and publish, to be both consumer and producer. “If everyone shares a little bit of information, then you can compile

these massive sets of knowledge—whether it’s a better way of doing news or a better encyclopedia,” he said. That’s what the Internet, search, and content tools give us.

But Facebook and Google are still just companies. As Google executive chairman Eric Schmidt said in the midst of his company’s battle of wills with China—a battle over censored searches and possible attacks on Google servers by Chinese hackers—Google is not a nation and does not have a police force or diplomats. Nonetheless, it was Google that represented the rights, security, and principles of the Net to Chinese bureaucrats and hackers. Google was the new world’s ambassador to the old world because somebody had to be.

And that was fine until Google also took it upon itself to negotiate “network neutrality”—the concept that all data traffic should be treated equally—with Verizon Communications, resulting in a proposal, presented to the U.S. Federal Communications Commission, that sacrificed Net neutrality in mobile connectivity to secure it in the wired Internet. I lament that proposal and the fact that it was made without us—Internet users—at the table. But again, Google is just a company, acting in its own interests. And so is Facebook, which has repeatedly faced questions about its own motives and interests versus those of its users in matters of privacy.

We, the people of the Net, need a set of principles for our new world. We need something to point to when governments censor the Web or try to control it, and when companies create new products or behave badly.

I don’t yet have the right set of principles. But I present a conversation starter for the discussion I believe we must have:

- I. We have the right to connect.
- II. We have the right to speak.
- III. We have the right to assemble and to act.
- IV. Privacy is an ethic of knowing.
- V. Publicness is an ethic of sharing.
- VI. Our institutions’ information should be public by default, secret by necessity.
- VII. What is public is a public good.
- VIII. All bits are created equal.
- IX. The Internet must stay open and distributed.

That’s very much a beta version of this needed declaration—incomplete and imperfect and already oft revised. We need to consider these larger questions about the architecture and the consequences of our choices—not only for each of us, individually, but most important for the Net as a whole. What principles should inform our choices? What should privacy and publicness mean in the future? Join the discussion at <http://spectrum.ieee.org/publicness0611>. □

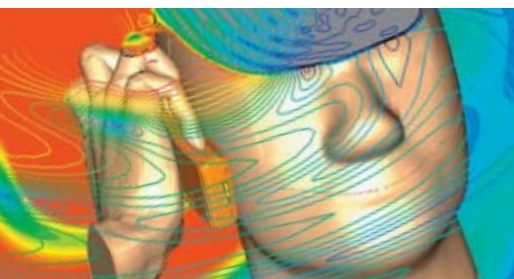
JEFF JARVIS, a professor of journalism at the City University of New York, blogs about media at [Buzzmachine.com](http://buzzmachine.com). His new book, *Public Parts*, will be published by Simon & Schuster this fall.

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CHANGING THE STANDARDS





[PRIVACY]

|||||

THE SOCIAL WEB

A Special Report

Welcome to the Surveillance Society

WHEN WE LOSE CONTROL OF OUR ONLINE INFORMATION, BIG BROTHER IS EVERYONE

PRIVACY IS NO LONGER A “SOCIAL NORM,” FACEBOOK CEO Mark Zuckerberg said last year. At first glance, it seems that Zuckerberg is right. More than half a billion people use his site to share all sorts of intimate details of their lives with others loosely defined as “friends.”

In your own life, you’ve likely noticed that people are broadcasting details that they used to reserve for small circles of friends. They announce when they break up with a romantic partner as casually as they mention what they are cooking for dinner or where they are shopping. Teens and twentysomethings seem particularly fond of such sharing, leading many people to conclude that younger people care little about privacy.

But Zuckerberg is wrong, and the fact that you know what your cousin had for dinner doesn’t change that. Privacy does matter to everyone, regardless of birth date. Even if you opt to tell many people when you are drunk or with whom you are

sleeping, you care about privacy. It’s not about what you share and where you reveal it. Privacy is about the fact that you have a choice in what you reveal and that you exercise the choice knowingly.



PERCENT OF FACEBOOK USERS WHO CHANGE THEIR PRIVACY SETTINGS, BY AGE

ZUCKERBERG IS USING A DIFFERENT and overly simplistic definition of privacy. By this definition, privacy covers only a set of aspects or actions that people generally wish to keep to themselves: essentially, matters of sex, drugs, and—occasionally—rock and roll. Using such a definition is convenient for Zuckerberg because ignoring the real meaning of privacy helps him run his business without fear or guilt.

But privacy is not about a universal set of behaviors. Nor is it just about sexual orientation or HIV status. Nor does it have the same meaning in every venue in which we live and move.

When we complain about infringements on our privacy, what we really

are demanding is some measure of control over our reputations in the world. Who should have the power to collect, cross-reference, publicize, or share information about us, regardless of what information that might be? If I choose to declare my romantic status to my friends on Facebook, then at least it's my choice, not Facebook's.

Interestingly, younger people are exerting more control over their online reputations than older people. According to a 2009 survey by the Pew Research Center's Internet and American Life Project, 71 percent of Facebook users aged 18 to 29 reported changing their privacy settings to limit the amount of information they disclose about themselves; only 62 percent of those 30 to 49, and 55 percent of those between the ages of 50 and 64, had done so. It may be that young people care more about control of their privacy than their older peers do, or perhaps they're just more technically literate.

But the kind of control anyone can exert by tweaking privacy settings is minimal. Through a combination of weak policies, poor public discussion, and some remarkable inventions, including social networking services and mobile smartphones with cameras, we have less and less control over our reputations every day. That doesn't mean we want less control. But as long as we are held accountable for youthful indiscretions that potential employers or customs agents can easily google, our opportunities for social, intellectual, and actual mobility are limited. And we are denied second chances.

IT DOESN'T HAVE TO BE THIS WAY.

Each of us learns early on that there are public matters and private matters, and that we manage information differently inside our own homes and outside of them. Yet that distinction fails to capture the true complexity of the privacy tangle, and it has led us astray, for we have come to treat what we do on our personal computers much like what we do inside our homes. But online environments mix up the previously distinct spheres of our relationships, making it easier for employers to track our private lives and stalkers to find out where we work and live. That has to change.



We have to come up with a clearer understanding of the value and meaning of privacy. One way of doing that is by considering a framework of “privacy interfaces”—that is, domains through which we negotiate what is known about us. Each interface offers varying levels of both control and surveillance. If we recognize how these interfaces work in our lives, then we can use services like Google and Facebook with more safety and confidence.

We each have at least four major privacy interfaces. The first is person to peer. Early on we develop the skills necessary to negotiate what our friends and families know of our predilections, preferences, and histories. If we grow up gay in a homophobic family, for instance, we learn to exert as much control over such knowledge as we can. If we as teenagers smoke marijuana in our bedrooms, we learn to hide the evi-

dence from our parents and nosy siblings. If we cheat on our partners, we practice lying. These are all privacy strategies for the most personal spheres.

The second is person to firm. In this interface, we decide whether we wish to answer the checkout clerk at Babies-R-Us when she asks for our home phone numbers. And in this interface we have to think twice about whether to apply for the discount card at the local supermarket or bookstore; while the card will let us purchase items on sale, it will also let the store gather and maintain detailed information about our purchases. When we apply for such a card, though, the clerk almost never explains how the system works or what the true nature of the transaction is.

The third privacy interface is the most important, only because the stakes of misuse and abuse are so high: person to state. Through the census, tax forms, drivers' license records, and myriad other bureaucratic functions, the state has cause to record traces of your movements and activities. The state also has a monopoly on legitimate violence, imprisonment, and deportation, so the cost of being falsely caught in an information dragnet that brings your records to the state's attention is worth considering no matter how unlikely it seems to be.

Until recently, most of us rarely encountered the fourth privacy interface (although Nathaniel Hawthorne explained it well in *The Scarlet Letter*). It's the person-to-public interface, which the social Web has made the trickiest to negotiate. By now we've all heard of at least one unfortunate event in which some poor soul found his life exposed, his name and face ridiculed, and his well-being harmed by the combination of the rapid proliferation of images, the asocial nature of much "social" Web behavior, and the permanence of the digital record.

Remember the "Star Wars kid"? The high-school student suffered great humiliation after bullies posted a video of him online that showed him playing as if he had a *Star Wars* light saber. Those bullies ripped the poor kid's image out of context and made him suffer so much his family had to move to another town to escape the harassment.

And how about the woman who became known as "dog-poop girl?" A resident of Seoul, South Korea, she refused to clean up after her dog on the subway, even after fellow riders berated her. Then one of the riders took photos of her and posted them on his blog, and within days others had discovered her name, address, phone numbers, and place of employment. Soon people began harassing her as well as her relatives and friends. Here's a case where massive surveillance by individuals acting as vigilantes can cause harm disproportionate to the offense.

This person-to-public interface is most worrisome because we often have no idea that we're entering it. If a person takes a picture of you at a party in which you appear to be leering at someone (even if you are not actually doing that), you could run afoul of your peers—or your spouse—through no fault of your own. Any of us could have been the Star Wars kid; we all assume comical, fantastic poses when we think

we are alone and unwatched. And any of us could fall victim to widespread public shaming or ridicule if untoward videos or images of us leaked onto the Web and traveled the world.

WHAT CAN WE DO? IN OUR REAL SOCIAL LIVES WE HAVE LEARNED to manage our reputations in various contexts among our friends and family and coworkers. Our domains in real life have enough friction and inconvenience built into them to allow us to shift masks and manage what people know (or think they know) about us.

But the online environments in which we now work and play have been intentionally engineered to simultaneously serve our professional, educational, and personal desires, and so they have broken down the social barriers in our lives. On Facebook or YouTube, a coworker could just as well be a "friend," fan, or critic. A supervisor could be a stalker. A parent could be a lurker. In such a world, the privacy interfaces blend, and creaky legal distinctions between "public" and "private" places no longer make sense.

Understanding these interfaces and controlling our use of social network sites is only the beginning. Over time, we all must develop social norms that punish bullies who expose private people to ridicule and public humiliation. Beyond that, we should work to establish strong laws that protect the vast majority of us who don't have the skill, time, attention, or awareness to constantly manage our online profiles and multiple reputations. At the very least, companies that make money from harvesting our personal preferences should have to ask us to opt in to these systems of surveillance with all the costs and benefits clearly disclosed. If allowing Facebook and Google the ability to track and store our most personal information will give us better service in return, let's make these companies convince us to enter such a deal. As of now, few of us even comprehend the extent to which we are tracked and studied for the benefit of these companies.

We are just beginning to figure out how to manage our reputations online. And we're making mistakes, lots of them. For some time we will read more stories about employees getting fired over embarrassing Facebook photos or ill-advised tweets. Eventually we will likely develop the social skills and norms to deal with the most absurd and extreme of these situations.

In the meantime the companies that host the online environments will continue to benefit directly from our confusion. The more they know about us, the better they can precisely target both advertisements and content to reflect our expressed interests. It's almost as if they read our minds—because they do. And that means they are not going to make it easy for us to keep our social connections separate from our professional contacts. It's clearly in these companies' interests to scramble everything and see each of us as a single knowable personality. But it's not in our interests. And it's not too late to make the Web more about who we want to be and less about what they want us to be. □



[PRIVACY]

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THE SOCIAL WEB

A Special Report

Me, Myself, or I

How a young doctor took control of her online identity

FACEBOOK'S AIM, ACCORDING TO ITS website, is to create "greater understanding and connection" by making "the world more open and transparent." Smitha Ballyamanda found out what that benign-sounding ambition could mean in 2006, when her ex-boyfriend's girlfriend began stalking her on the social networking site.

The situation started out simply enough. Ballyamanda, then a 23-year-old medical student in Miami, got repeated "friend" requests from the woman. Hoping to stop further contact, Ballyamanda blocked the woman from seeing her Facebook profile. But things only got worse. Her stalker created false accounts to befriend Ballyamanda and her friends. Then she hacked Ballyamanda's Hotmail and Facebook accounts and began sending bizarre e-mails to Ballyamanda's friends,

by CASSANDRA WILLYARD



MULTIFACETED: Smitha Ballyamanda works hard to maintain her privacy on Facebook.

family, and most embarrassingly, professional contacts. One message said that Ballyamanda was dropping out of medical school because she was pregnant. "I had my entire world turned upside down," Ballyamanda says.

As she regained control of her online identity, Ballyamanda deactivated her Facebook account. But she had second thoughts when she realized she'd cut her social lifeline. "That was my way of keeping in touch with people," says Ballyamanda, now a resident in family medicine in Philadelphia. Eventually she

created a new account. But this time she read the fine print: She studied Facebook's privacy controls, and then she created an elaborate system to control what her contacts could see—and, more important, what they couldn't.

Countless such privacy-related minidramas have already played out behind the scenes of the world's largest social network. Now, with hundreds of millions of users, and firms like Google eager to take on Facebook with social networks of their own, it's a good time to ask: How many of us are ready for total transparency?

Transparency, in this case, means widely revealing personal details that you might ordinarily share with just a small subset of people. "Facebook is driving this idea that they want us to live more public lives," says Alice Marwick, a social media researcher at Microsoft Research New England, in Cambridge, Mass. In *The Facebook Effect*, a recent history of the social network, Facebook creator Mark Zuckerberg told author David Kirkpatrick that he envisions a society in which "you have one identity"—where "having a different image for your work friends or coworkers and for the other people you know" will no longer be possible or even desirable.

But this vision of a world full of indiscriminate sharing is not realistic, Marwick says: "We've always wanted to provide different types of information to different groups of people." For Ballyamanda, keeping those different groups apart now defines her Facebook experience.

BORN IN SOUTH INDIA, BALLYAMANDA HAS GOOD REASON TO keep some information private. Many of her relatives, especially older ones, have conservative views about how a young woman should behave.

Ballyamanda, a petite beauty with thick black hair and big brown eyes, isn't shy about wearing clothes that flatter her figure. Like most young professionals, she socializes in bars and clubs with friends of both sexes. But she frets that a Facebook photo of herself and a male coworker having an innocent after-work drink could ricochet among her far-flung family members and blossom into a story with no basis in reality: "You're getting married and that was your engagement party," as she puts it.

To control who sees her profile information, Ballyamanda has assigned each of her 682 Facebook friends to one of six groups. At the bottom of the heap is "Zero Trust." This group can't access old status updates, messages from her friends, or many of her photo albums. At the top of the heap are the 10 or 15 people who constitute the "Inner Circle." "They have full-blown access," she says. "They see my page as I would see it."

In between are groups with intermediate levels of access. Those in either the "Coworker" or one of two "Guilty by Association" groups can see more of her profile than those in Zero Trust. And the "Paparazzi"—Ballyamanda's catch-all group for acquaintances and friends who haven't made the

Inner Circle—can see a bit more still. Paparazzi members can see far more than Ballyamanda's own mother, who has been relegated to Zero Trust. "I tell her most of what's going on in my life," Ballyamanda says. "But I don't think she could handle the weight of my entire page."

If you ask her, Ballyamanda will tell you which group each of her contacts belongs to and why. Her cousin's wife, for example, should be in the Paparazzi. The two women are close. But then she would have access to sensitive information—photos of Ballyamanda drinking and wearing revealing clothes. If the woman ended up showing those photos to her husband, Ballyamanda's cousin and a member of Zero Trust, he might say something to the rest of her family. So Ballyamanda had no choice but to put his wife in Guilty by Association.

The system "makes me seem completely nuts," Ballyamanda concedes. "But that's how I protect myself in this new world where everyone can see everything."

THIS NEED TO PRESENT DIFFERENT PERSONAS TO DIFFERENT people is natural, says Microsoft's Marwick. "When you're in a job interview, you're presenting a different self than you are when you're at a bar with your friends," she says. "This is just logical." Your future boss doesn't need to know that you like tequila or tattoos.

But Facebook doesn't automatically distinguish among family, friends, and colleagues. Everyone is invited to the party. Marwick and her colleagues refer to this as "context collapse," and it can lead to sticky situations. In 2010, for example, Massachusetts high school administrator June Talvitie-Siple lost her job after she described students as "germ bags" and their parents as "snobby" and "arrogant" in what she said was intended to be a private Facebook post.

Even the most careful users may unintentionally give away sensitive information. As part of a class project, two engineering graduate students at MIT found that they could predict which Facebook users were gay just by looking at the sexual orientation of their online friends. "You could be completely in the closet," says sociologist Jason Kaufman, a researcher at Harvard's Berkman Center for Internet and Society. "But a savvy marketer, advertiser, blackmailer—what have you—could deduce with reasonable certainty that you're gay simply by the behavior of your friends in your network."

THE PRIVACY RISKS YOU FACE ON FACEBOOK ARE THE SAME risks you would face in any social network, virtual or real. The Facebook experience is similar to life in a small town, in which everyone knows his or her neighbors. But a Facebook user's ability to broadcast information can easily outpace even the most energetic small-town busybody.

The heart of Facebook's information distribution system is the site's news feed, a service that *Continued on page 75*



DUDES IN BLACK:

Last June, Rafael Sofaer, Maxwell Salzberg, Ilya Zhitomirskiy, and Daniel Grippi [clockwise from top] moved to San Francisco to create the social Web platform Diaspora.



[FUTURE TECH]

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THE SOCIAL WEB | *A Special Report*

The Anti-Facebook

*HOW FOUR YOUNG CODERS
ARMED WITH GOOGLE
TECHNOLOGY WILL ROCK THE
SOCIAL WEB WITH DIASPORA*

THE DIASPORA GUYS, FOUR COLLEGE KIDS TURNED chief engineers of the most-talked-about social networking start-up this year, get a lot of friend requests. Sometimes fans just show up at their office, uninvited, and ask to work with them. Every now and then, someone recognizes them in public, which freaks them out. On the day they

by **ARIEL BLEICHER** moved into their current office in San Francisco, a commuter stopped them on the subway and commanded, "Go get 'em, guys! Kill Facebook!"

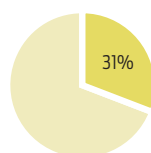
Journalists and bloggers have called Diaspora "the Facebook killer," "the Facebook rival," "the anti-Facebook," "Facebook's challenger," and "another Facebook wannabe." They have speculated about whether Diaspora is better than Facebook, whether Facebook will try to buy Diaspora, and whether Diaspora could "knock Facebook off its perch."

The guys, however, don't see themselves as competition. After all, Diaspora is a rookie company; its software is buggy and crash prone, and although the company tries to solve the biggest problem with

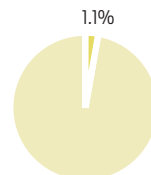
Facebook by giving users better control over their private data, its site looks and acts like a vacant, amateur imitation.

Besides, the guys insist, they're not aiming to replace Facebook with "yet another social network." Rather, they're taking a stab at reengineering the way online socializing works by building an entire network of networks from the ground up. They hope that in the process they will help promote standards that other social sites—such as Digg, LinkedIn, Google Buzz, and perhaps one day even Facebook—will use to bridge their services. They imagine that during the next decade, the Web will evolve from a sea of social networking islands into what many developers are calling the federated social Web—one that lets you choose your networking provider, just as you now choose your e-mail provider, and yet still connect with friends who use other services.

Such a Web may be a distant, idealistic vision, but it's not Diaspora's alone. Many programmers and social media thinkers, including some at other start-ups, at universities, and at big companies such as Google, Mozilla,



PERCENTAGE
OF ONLINE
DISPLAY ADS
SERVED BY
FACEBOOK
Q1 2011



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SERVED BY
FACEBOOK
June 2008



and Germany's Vodafone, have been working to develop open standards for a federated social Web since around the time "The Facebook" was a profile directory for Harvard students. They believe that such a Web is not only possible but also preferable. "If I couldn't e-mail people who don't share the same domain as me, that would be pretty stupid," remarks Joseph Smarr, a social Web engineer at Google. "But that's exactly the way social networks work today, and that's broken and should be fixed."

Of course, Google has a lot to gain if Diaspora can fix social networking. The search giant has tried to stop Facebook from encroaching on its share of online advertising revenue by offering its own networking services, including Lively (discontinued), Orkut (thriving only in Brazil), Buzz (trashed for its privacy flaws), and Wave (passed on to Apache). But so far, Google has failed to make anything as wildly popular as Facebook.

As far as the guys know, no prominent Googlers have invested money in Diaspora, but they have written most of their code using Google-engineered protocols. And if they can work out the kinks in their system and turn a profit, says Rob Enderle, an Internet technology analyst and president of the

Enderle Group, in San Jose, Calif., "their success will showcase to the bigger players that if you work with Google, you too can be profitable, and you can pick up users more quickly."

Diaspora itself may not be a threat to Facebook. But a federated social Web built on Google technologies, Enderle says, "would destroy Facebook's value and certainly its power on the network." If Google, starting with small players such as Diaspora, can plant the seeds of a federation and cultivate a network of many social services that is richer, more addictive, and more ubiquitous than Facebook, "it would create an environment wherein Facebook can't be the next Google," Enderle says.

STOKED TO CODE:

Ilya Zhitomirskiy [left] helped lay Diaspora's conceptual foundation; stylish Daniel Grippi is redesigning the user interface.

THE NAME DIASPORA (THE LOGO INCLUDES AN *) REFERS TO many things. It is the name of the company founded by Maxwell Salzberg, 24; Daniel Grippi, 22; Rafael Sofaer, 20;

and Ilya Zhitomirskiy, 21. It is also the name of the guys' website, at Joindiaspora.com, which hosts Diaspora's 50 000 users. Finally, it is the name of the open-source software that runs the site and that other people are using to run other Diaspora-like websites, known as pods.

How many Diaspora-powered pods are out there?

"Hundreds?" Salzberg guesses. Often the spokesman at pitch meetings with venture capitalists, he is the most eloquent and outspoken of the four guys, and the most disheveled.

"A handful?" Grippi offers. "Pods that are up and running, anyway." He wears black skinny jeans and a black leather jacket and is the only Diaspora guy who can be described as fashionable. Perhaps because he has an eye for aesthetics, he recently decided that Diaspora's user interface is "not cool" and is redesigning it.

"We really have no idea how many pods there are," Salzberg concludes. "We have nothing to do with them."

A site run by a Web designer in Germany that tracks the uptime of several pods recently listed 48 of them. They had names like Diasp.org, My-seed.com, Dpod.se, Diaspora.lordgandalf.nl, and Facebook.doesntexist.org. Each pod hosts anywhere from one to 15 000 users. Sign up with any one of them and the experience is pretty much the same as if you signed up at Joindiaspora.com, provided the servers running it are reliable and the host keeps the code updated.

The guys imagine that someday, once other pod hosts start writing their own software, each one will be very different. For example, Diaspora could charge users US \$5 per month to encrypt all their messages, while the host of My-seed.com could provide a more Facebook-like service with advertisements for free. Diasp.org could extend invitations only to engineers, while Diaspora.lordgandalf.nl could offer a *Lord of the Rings* theme and games. But because all pods built using Diaspora's source code and standards speak the same language, users on different pods are still findable and approachable.

Choice, interoperability, and the chance to invent your own networking experience are what federated networks such the Diaspora pods are all about. If I create an account at Joindiaspora.com but its servers are constantly down, or I find out that the Diaspora guys are selling my data to advertisers, I can export my profile and my list of friends and sign up for a new account at Diasp.org, for example, which is run by a business analyst in Seattle. Or, if I'm acutely privacy conscious and tech savvy, I can set up my own pod on my own server. "That's going to be one of our measures of success: How many people can we get off our servers using their own servers?" Grippi says. "We want our numbers to shrink."

Clearly, shedding users isn't an overtly smart business plan, and there are those who doubt Diaspora will succeed. Even the guys know their company could very well be dead within the next six months, once its seed money runs out. They admit their plan is ambitious and unformed, which "could totally come and bite us back in the ass," Salzberg says.

They believe what they're doing is important, but they don't want fans to hang their hopes on Diaspora; they want people to remember that they're not programming savants. "At the end of the day, we're just four dudes out of New York University trying to see if we can solve a problem," Salzberg says.

Yet in a way, they're perhaps the best kind of dudes to take on the challenge of creating a viable alternative to Facebook. Starting a social networking business today without honed programming skills and a clear moneymaking scheme is a big risk. But because the Diaspora guys are young and have little to lose, it's a risk they can afford. "Worst-case scenario is we put it on our résumés and go get jobs at Google," Salzberg says.

Best-case scenario is they make something that changes the world.

THE GUYS DIDN'T SET OUT TO DETHRONE FACEBOOK. THEY FIRST started hanging out together in the fall of 2009 as student members of the Association for Computing Machinery. Like most ACM college chapter offices, NYU's was a place to stay up late eating pizza and hacking things. In February 2010, they had just finished assembling a MakerBot Thing-O-Matic 3-D printer from a kit when Eben Moglen came to campus.

Moglen, a professor at Columbia Law School and a staunch advocate of free, open-source software, had come to NYU to give a lecture he titled "Freedom in the Cloud." Addressing a packed auditorium, he laid out the argument that cloud-based services built on proprietary software, such as Google Docs and Yahoo Mail, were an assault on user privacy and, from a programmer's perspective, utterly unnecessary. As for Facebook, Moglen chided, the company offers its users "a very poor deal, namely, 'I will give you free Web-hosting and some PHP doodads and you get spying for free all the time'....This is bad. I'm not suggesting it should be illegal. It should be obsolete! We as technologists should fix it!"

Moglen proposed what he called a "freedom box," which he described as "a really good Web server that you can put in your pocket and plug in anywhere." It would talk to your friends' servers, host all your data, and keep track of everything you did and everyone you met on the Web. And you wouldn't have to share that information if you didn't want to. Most important, the software that ran the box would be free and open source, so anyone could download it and tailor it to his or her needs.

"We thought this idea was really rad," Grippi says. "We decided, well, let's take a shot at making the social networking aspect of it 'cause we were getting a little fed up with Facebook."

While the guys admire Facebook and believe, as Salzberg says, that founder and CEO Mark Zuckerberg "sort of blew the lid open on what people are willing to do online," they find many things about his company unnerving, even maddening. They don't like that Facebook owns the data they share through the site and can mine or sell it to advertisers at will. They don't like that if they disagree with the company's privacy policy and



choose to cancel their accounts and sign up with a different networking service or make their own, they can no longer socialize with friends who still use Facebook. “It sucks,” Grippi says.

Above all, they don’t like that most ordinary people and many Web engineers have come to believe that seven-year-old Facebook represents the be-all and end-all of everything online socializing will ever be. “Facebook is about distilling yourself always to the simplest thing,” Salzberg says. “To think that we’ve arrived at the pinnacle of human communication, it’s just...”—he pauses and lets his shoulders slump—“a bummer.” Social networking is still a young technology, he argues; there’s a lot left to be invented, and one company can’t do it all. “Sending little messages and pictures between your friends isn’t some convoluted technical masterpiece. So why isn’t there an alternative?”

One night late last April in NYU’s ACM office, the guys recorded a video pitch for their project and posted it on Kickstarter, a website that crowdsources funding. In the video, they sit shoulder to shoulder in front of a sliding chalkboard, facing the camera. Sofaer begins, his voice full and cadenced, like a preacher who truly believes his own sermon: “In real

life we talk to each other. We don’t need to hand our messages to a hub and have them hand it to our friends. Our virtual lives should work the same way.”

They couldn’t have timed their pitch better. Five days earlier, Facebook had yet again changed its privacy policy, this time making the site’s default settings such that anyone browsing the Internet could see a user’s status updates, photos, and most of the user’s profile information. Two days after that, Zuckerberg announced a newly developed protocol he called Open Graph. It lets other sites, such as Yelp, Pandora, and CNN, access Facebook users’ public profile data—name, gender, hobbies, friends, songs they like, songs their friends like, articles they recommend, restaurants they’ve tried—and use the data to customize the users’ experiences on those sites without making them create new accounts.

Many Facebook members were outraged that the photos and updates they thought they had shared only with friends were

POD PEOPLE:
Maxwell Salzberg [left] is often the spokesperson for the dudes; Rafael Sofaer does most of Diaspora’s data encryption.

now being handed over to companies. Donations for Diaspora came rolling in. A reporter from *The New York Times* called and interviewed the guys. The CEO of Pivotal Labs, a software consulting company in San Francisco, invited them to use its office space for free. Even Mark Zuckerberg pitched in. (He told a reporter that he identified with the guys' ambition to change the world and thought Diaspora was a "cool idea," although he wouldn't say how much money he had donated.)

The guys had given themselves 39 days to raise \$10 000 for a summer project. When the fund-raiser ended on 1 June—before they'd written a single line of code—they had \$200 641 from 6474 donors.

That day, they caught a plane to California to begin the most ambitious hacker project any of them had ever tackled.

PIVOTAL LABS OCCUPIES THE THIRD FLOOR OF A DRAB, GRAY building sandwiched between a CVS drug store and a fitness club on Market Street in downtown San Francisco. The office is open and airy. There are rows of tables cluttered with big-screen monitors, a couple of Ping-Pong tables, and a kitchen stocked with coffee, cereal, granola bars, fruit in wicker baskets, and Mexican Coca-Cola. Dozens of programmers are usually coding in pairs or troubleshooting problems in small groups, and so the room is always humming, like a café in the afternoon.

The Diaspora guys sit side by side at one of the tables, surrounded by boxes overflowing with Diaspora T-shirts and paper plates piled with pistachio shells.

When they arrived at Pivotal last June, they knew their project would be less a summer experiment than a full-time job. They created a corporation, partly because they needed a place to keep their money that wasn't Salzberg's checking account, and partly because they knew that eventually the money would run out and they'd have to solicit investments from venture capitalists.

Their plan was to code all summer, get the false starts and embarrassing oversights out of the way, then release what they had on the code-hosting site GitHub in mid-September. They would license the software under the Affero General Public License (AGPL), which would ensure that the Diaspora code remained free to anyone to use and play with and that whoever changed it or added to it had to release the code under AGPL, too. That's the beauty (and some say the curse) of free, open-source software. It didn't matter that Diaspora was just four dudes out of college, because now there was a whole world filled with smart programmers who could help them. Today more than 100 people have contributed to the Diaspora project, and the code has been translated into 40 different languages, including Swedish and simplified Chinese.

When at last the guys sat down to type the first lines of code, they knew that several veteran programmers, including some at Google, were already experimenting with many of the protocols needed to build a federated social network.

A few programmers were even leading their own open-source projects, among them StatusNet, BuddyPress, OneSocialWeb, and the Applesseed Project.

The pieces of the puzzle were out there. The guys just had to fit them together.

THE FIRST THING USERS OF ANY ONLINE SOCIAL NETWORK need to be able to do is meet one another. On a centralized network such as Facebook, finding new friends is easy. In fact, Facebook often does this for you by recommending people who share your affiliations or who know your friends. If you're looking for a particular person, you simply type in the name. Facebook's system queries its database and voilà—up pops a picture along with a list of the person's friends. Unlike browsing blogs or sending e-mail, socializing on Facebook lets you check people's identities to help determine whether they're the kind of people you want to introduce yourself to.

"To think that we've arrived at the pinnacle of human communication, it's just..."

—SALZBERG
PAUSES AND LETS
HIS SHOULDERS
SLUMP—
"A BUMMER"

Meeting people on a federated network of many separate servers with many separate databases is trickier. To let users identify one another as they would on Facebook, Diaspora's software follows a sparsely used protocol known as WebFinger. It was developed in 2009 by a couple of engineers at Google and modeled after an old Unix protocol called Finger. Users of a Unix network could type in the command "finger username@hostname" and receive information about Mr. User Name, such as a phone number and whether the person was logged into the network. WebFinger does something similar by using the language of the Web (HTTP), rather than simply the language of the network (TCP/IP).

For example, suppose I have an account on the Diaspora-powered pod My-seed.com, and you have an account on Diasp.org, and that "me@my-seed.com" would like to find "you@diasp.org." (The guys call such identifiers "handles.") I type your handle into a search box on my stylized user interface and the Diaspora software on my pod routes my query to a file on your pod that contains your WebFinger profile—basic stuff about you, such as your full name and your picture. Diaspora's software then extracts that information from the file and dumps it into an interface template, which displays it on my screen, much like a public Facebook profile.

The downside to the WebFinger system is that if I don't know your handle, I can't find you any other way. I can't search for you by your name or by your job title, for example—unless, of course, you are already friends *Continued on page 74*

FACEBOOK

"À la minute" cuisine means just-cooked dishes served in cast-iron pans.



Food Fight

Where would you rather go for lunch?

YES, THERE IS SUCH A THING AS A FREE LUNCH—and breakfast and dinner, if you work at Google or Facebook.

And the food is pretty remarkable, too. Both Google and Facebook go way beyond simple sustenance with menu items like venison, boar, and wheatgrass shots. These workplace cafeterias have better food than most cruise ships. Google food is synonymous with its former chef Charlie Ayers. He once cooked for the Grateful Dead and now runs a trendy café near Stanford University. Facebook head chef Josef Desimone is proud to have evolved out of the Google tradition.

—Sheila Himmel



**On the Menu:
FACEBOOK**

Desimone presides over two cafés at Facebook headquarters: Café X and Café 6. Both of them have a new, always different theme every day; for Johnny Cash's birthday, for instance, diners at Café X enjoyed "I Walk the Lima" beans and "Streets of Laredo" barbecue pork ribs. Desimone has worked in fine dining establishments, including a two-star Michelin restaurant in Amsterdam. He shows off his chops with his own version of a cooking style he calls

"à la minute": Instead of steam tables, his chefs pop just-cooked food into enameled cast-iron Le Creuset cookware. Bias-sliced hanger steak, just off the grill and resting in the Le Creusets, was deeply satisfying, with or without the creamy chervil sauce.

At Café X, the nicest surprises were the roasted Brussels sprouts, silken and fetchingly aromatic, frites that stayed crisp, and feather-light quinoa with orange zest. The textures and flavors fit together.

Meanwhile, over in Café 6, which I visited the day after Presidents' Day, the chefs honored George W. Bush with a pastry pretzel, commemorating the famous incident in which he choked on a pretzel while watching TV and passed out. Café 6's pretzel was dry, perhaps intentionally so. The sushi bar's barbecued beef roll, with Texas and Japan fighting for

MARK RICHARDS (4)

GOOGLE

The “Farmer’s Market” salad bar includes roasted beets and seared tofu.



palate prominence, was not a culinary success.

Desimone mainly uses local suppliers, goes about 75 percent organic, and serves only fish that are not endangered or raised in ways that harm the environment, as defined by the Monterey Bay Aquarium Seafood Watch program. He estimates that 85 percent of the menu is vegetarian. But within the remaining 15 percent, Facebook eaters can be daring, he says. “They’ll try anything: rabbit, venison, wild boar”—particularly, it seems, if it’s organic and sustainably grown.

For those days when employees don’t feel adventurous, Facebook offers them comfort with a formula right out of a college dining hall (well, maybe a really expensive college): two meat entrees and one vegetarian, pasta, pizza, an extensive salad bar, a turkey carving



station, two house-baked desserts, and frozen yogurt with toppings.

In Desimone’s plans for the dining areas on Facebook’s new campus, employees won’t have to run between the restaurants to evaluate their dining options or check the roundup posted on the Facebook page of the Facebook Culinary Team (<https://www.facebook.com/>

FacebookCulinaryTeam); there will be one large café where employees can leisurely survey the whole cornucopia.

On the Menu: GOOGLE

Google’s Mountain View campus has more than 18 cafés, including one for people who eat raw foods, one for vegans, and a four-continent food

court named Charlie’s Café, after founding chef Ayers. Around its spacious perimeter, the food court has Chinese, Japanese, and Mexican venues; the 40th Street Deli; decent thin-crust, foldable pizza; and Kobe burgers at Chuck’s Diner. The central Farmer’s Market salad bar features three types of roasted beets, baby mozzarella balls, wheat berries, and wok-seared Hodo Soy organic tofu; condiments range from croutons to wakame seaweed.

The desserts are amazing. Even those who can resist the popular bread pudding and the oatmeal cherry chocolate chip cookies I encountered at Charlie’s one day still have to make it past a freezer case of Google-labeled It’s-It ice cream sandwiches, a local brand beloved by generations of San Franciscans.

Over at the crowded

No Name Café, the sandwich bar is stocked with gluten-free and other fresh breads. Whole-wheat couscous salad—studded with currants and almond slices—is a mouth-feel bonanza. And on the hot line: Humboldt Natural rib eye, tender curry chicken, grilled local mackerel, roasted Lakeside Farms broccoli, couscous with local peppers, and roasted golden beets. Think all-you-can-eat day at Whole Foods.

At the tiny Slice Café, vegans who can’t wait for a made-to-order mushroom burger might instead grab a hummus/spinach wrap (a tad pasty), organic pink lady apples, and dark chocolate “energy nuggets” that keep their promise.

If I ever get to eat at Google again, I’ll definitely try the tabletop “hot-pot” dining at Jia, yet another dining option. □



FILE AISLE: Racks of file servers stand in neat alignment at Facebook's newly built data center in Prineville, Ore.



[BUSINESS]

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THE SOCIAL WEB

A Special Report

Under the Hood at Google and Facebook

*A PEEK AT THE DATA CENTERS,
SERVERS, AND SOFTWARE
THAT KEEP US FEELING CONNECTED*

IT WAS 1999, AND GOOGLE FOUNDERS LARRY PAGE and Sergey Brin, fresh from incorporating their oddly named company, needed servers—lots of them. So they went shopping for PC motherboards, disk drives, and power supplies. Not long before, though, they'd been cash-strapped grad students, so to save money, they kludged together four motherboards to one power supply, mounting them on cookie trays, which they lined with cork to avoid shorting anything out. Then they crammed these ugly yet functional servers into racks with network cables dangling everywhere.

by DAVID SCHNEIDER,
with additional reporting
by QUENTIN HARDY

It goes without saying that Google's technical infrastructure has improved since those slapdash early days. But Google is loath to reveal much about its back-end operations. In interviews with *IEEE Spectrum*, the company's engineers would often preface their purposely vague answers with,

1.1

Use a coffee-
maker for
an hour

0.1

Run a ceiling
fan for an hour

0.05

Use a laptop
computer
for an hour

0.0003

Answer
a typical
Google search

KILOWATT-
HOURS OF
ELECTRICITY
REQUIRED

"We don't want to talk about specifics" or "We can't talk about it a lot." Google has even attempted to keep secret the locations of many of its three dozen or so data centers, which include 20 scattered across the United States. Of course, that is absurdly hard to do with multimillion-dollar warehouse-like facilities that must be approved by local officials, checked by government inspectors, and constructed in plain sight. So considerable information about Google's data infrastructure can now be found by just, well, googling Google.

Facebook, too, quickly catapulted from a student project to a dominant player on the Web. And Facebook's engineers have also had to pedal hard to keep up with the site's speedy rise in popularity. Indeed, these two companies have in many respects led strangely parallel lives—each of them opened its first data center in its seventh year of operation, for example.

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But Google and Facebook differ in fundamental ways as well, particularly in how they've produced the software that creates all the things we've come to expect from them, and also in how open they are about their technical operations.

Of course, those operations have had to grow in size and complexity to match the exponential rise in demand. Now, on any given day, Google's search engine fields more than a billion queries, and more than a quarter billion people visit the Facebook site. These companies have both had to mount massive engineering efforts to handle all that traffic, and the results of those labors have been impressive indeed.

GOOGLE'S DATA CENTER IN THE Dalles, Ore., completed in 2006, is one of the first that the company built rather than leased. At the time, Google was so hush-hush about this project that it required town officials to sign confidentiality agreements that precluded their even mentioning the facility to the press. Although Google is open enough now about having a data center located on this particular bend of the Columbia River, to this day Google Earth displays only overhead views of the site taken before construction commenced.

Google's if-we-tell-you-we'll-have-to-kill-you attitude toward its data centers isn't ironclad, however. For example, in 2009, Google hosted an energy-efficient data-center summit, where it revealed much about its operations. Days later, a narrated video tour of one of its early data centers, which the company refers to publicly only as "Data Center A," appeared on YouTube, which Google owns. This facility's more than 45 000 servers are mounted in 45 giant shipping containers, giving the interior of the cavernous building a strangely temporary look—as if Google wanted to be able to pack up and move all these servers to another location at a moment's notice.

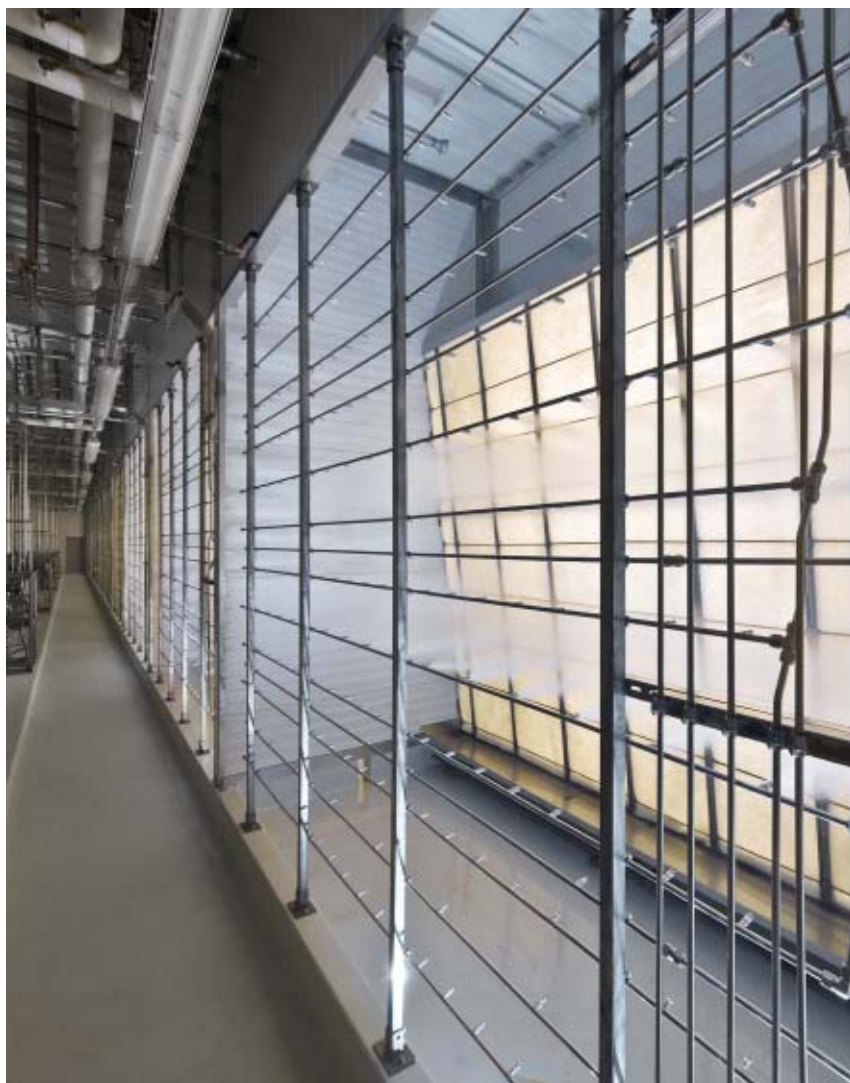
This modular approach is not unique to Google, but it's not standard practice either. Google has also departed from data-center tradition in the way it handles power outages. Backup generators kick in when the grid fails, but they don't work instantly, requiring an uninterruptible power supply

(UPS) to keep each server running for the first 10 seconds or more after the lights flicker off.

Most data centers use large centralized UPSs to carry them through that precarious interval, but those units are inherently wasteful. That's because the AC voltage feeding each one gets converted to DC and then back to AC, which is sent to the various power-distribution units and then to the individual servers. Those conversions even out voltage sags and spikes, but they squander about 10 percent of the electricity going to the computing equipment. To avoid these losses, Google instead attaches a small UPS to each server.

COOL SPRAY:

Facebook's Prineville, Ore., data center uses a misting system to cool outside air, which is then blown over the servers.



ALAN BRANDT

Another energy-conservation measure Google shows off in its YouTube data-center tour is a cooling technique known as water-side economization. That's important, because just a few years ago cooling accounted for 40 percent of a typical data center's electricity bill. Water-side economization cuts down on costs because it uses—you guessed it—water, which is dripped over heat exchangers outside the building. A closed cooling loop that passes through the server-packed containers inside brings warm water to these heat exchangers. As the water dripping over them evaporates, it carries away much of the heat. That tactic, combined with the right climate, keeps the servers cool enough most of the time, and conventional chillers can be put into the loop to assist as needed.

Google's data centers use electricity far more efficiently than was typical in the past. Data-center experts gauge efficiency using a statistic called power usage effectiveness (PUE), which is computed by dividing all the electrical power used in a facility by the power delivered to just the computers and related networking equipment. By the end of 2010, Google's data centers achieved an overall PUE of 1.13—impressively close to the ideal value of 1.0. This is a great improvement from five years ago, when a sampling of 22 data centers showed an average PUE of 2.0, meaning that for each watt actually used for computing and networking tasks, another watt is squandered on chillers, lights, fans, pumps, office equipment, and probably more than a few snack machines.

Although other large data centers can boast efficiencies that rival those Google has reported, Google's PUE numbers will probably creep even lower as newer, more energy-efficient centers come on line. The company is now working on a data center in Finland that will cool servers with sea-water pumped in from the Baltic, for example. But don't think that Google's engineers are the only ones who know how to build super-energy-efficient data centers. Facebook's engineers are now up to speed as well, and they've been eager to show off their results.

TRAMPING AROUND THE RED-CLAY EXPANSE WHERE Facebook is constructing its newest data center, located in what was until recently a patch of woods east of the Blue Ridge Mountains, I'm struck by the immense scale of the project: the 34 000-square-meter (370 000-square-foot) structure looming in front of me stretches some 340 meters (about 1100 feet) end to end. Imagine a Walmart super-center on steroids, and you still won't be thinking large enough. What's more, Facebook may one day place three of these behemoths here. Even more stunning than its size is the speed at which Facebook's general contractor, DPR/Fortis, has put all this concrete and steel in place, having broken ground at the site just four months earlier.

"I'm amazed at this one," says Tom Furlong, who directs site operations for Facebook's data centers. At our meeting in a construction trailer at the site in North Carolina's rural Rutherford County, Furlong tells me that in Facebook's early years it could get away with colocation (where one building houses servers for several companies) and then, as the company grew, with leasing entire data centers.

But the situation changed in 2008, when much of the world economy slowed to a crawl. At the time, most of Facebook's servers were in leased data centers in the San Francisco Bay area, where the company continues to occupy eight separate facilities tied together with high-speed data links. It also began leasing data-center space in northern Virginia to create a matching East Coast hub of operations.

But when he went looking for more space, Furlong says, he discovered that many data-center projects had been shelved—victims of the financial crisis. Ultimately, the search for space proved so frustrating that in early 2009 Facebook decided to build a data center of its own. By August, Furlong and his colleagues had settled on Prineville, Ore., just 150 kilometers from Google's facility in The Dalles. Before the Prineville center was even completed, the company announced plans to build a second one in North Carolina.

As if to prove Facebook CEO Mark Zuckerberg's contention that openness is a new social norm, Facebook's engineers have released many of the technical specs for these state-of-the-art data facilities, which they believe will have PUE values of 1.07 or less. They call their sharing the Open Compute Project. They're not exactly open sourcing their hardware for anyone else to duplicate, but the descriptions they offer are surprisingly detailed.

The Prineville center, which officially came on line in April, departs markedly from the containerized approach Google favors. "You can save some money with modularity, but you

BATTERIES INCLUDED:

Google's servers have uninterruptable power supplies with hefty batteries [upper right].



get restricted in a lot of different ways,” says Furlong. So Facebook houses its servers in conventional racks placed directly on the data-center floor, where they are cooled by the flow of air blowing in from the side. But that air doesn’t come from conventional air-conditioning equipment. Jay Park, Facebook’s director of data-center design and construction, explains that they use “direct evaporative cooling.” A fine mist cools the air, which in turn cools the servers. “It’s a big honkin’ misting system,” Park says.

Direct evaporative cooling fits well with the overall philosophy that Facebook’s data-center engineers have come to favor: simplicity. “Our data center in Prineville basically uses outside air,” says Park. “We filter the air, pass it through the misting system, and then blow that into the data center. If the outside air is too cold, we’ll recirculate some of it. If not, we’ll just dump it out.” Park boasts that the mechanical design is so straightforward that it doesn’t even require ductwork, and his computational fluid dynamics calculations show that it still does the job. Facebook’s North Carolina facility will be similarly configured, although it will include back-up air conditioners to supplement the misting system during hot spells.

Facebook’s data centers, like Google’s, dispense with centralized UPSs. Instead, one phase of the three-phase, 480-volt AC derived from the main utility switchboard is sent directly to the servers, which contain custom power supplies that use what amounts to a 277-volt AC feed. During a power outage, those supplies can also run off the 48-volt DC coming from specially engineered UPS cabinets installed next to the server racks.

That arrangement saves watts, and it also simplifies maintenance, because there are far fewer pieces of equipment to maintain. “In traditional data centers, with the UPSs higher up the food chain, you have a lot of additional breakers and connections to bypass,” says Furlong. “Moving the UPS close to the server gives you the flexibility not to have all that hardwired extra stuff.”

GIANT DATA CENTERS—EVEN ENERGY-EFFICIENT ONES—ARE, of course, nothing without the proper servers. Facebook will be populating its Oregon and North Carolina locations with custom-designed servers, just as Google has long done.

Facebook’s Amir Michael, manager of hardware design, explains that when the company decided to build its own facilities, “we had a clean slate,” which allowed him and his colleagues to optimize the designs of their centers and servers in



tandem for maximum energy efficiency. The result was a server that “looks very bare bones. I call it a ‘vanity-free’ design just because I don’t like people to call it ugly,” says Michael. “It has no front bezels. It has no paint. It has no logos or stickers on it. It really has only what is required.”

Google also keeps server frills to a minimum. Like Facebook, it buys commodity-level computing hardware and just fixes the many pieces that break, instead of purchasing high-end systems that are less prone to failure but also much more expensive. Economics, if nothing else, drove engineers at both companies to similar conclusions here. Fit and finish might count if you’re buying one server or even a hundred, but not when you’re shopping for tens of thousands at a time. And striving for high reliability is a little pointless at this scale, where failure is not only an option, it’s a daily fact of life.

Facebook’s Michael explains that he helped design three basic types of servers for running the Facebook application. The top layer of hardware, connected most directly with Facebook’s many users, consists of outward-facing Web servers. They don’t require much disk space—just enough for the operating system (Linux), the basic Web-server software (which until recently was Apache), the code needed to assemble Facebook pages (written in PHP, a scripting language), some log files, and a few other bits and pieces. Those machines are connected to a deeper layer of servers stuffed with hard disks and flash-based solid-state drives, which provide persistent storage for the giant MySQL databases that hold Facebook users’ photos, videos, comments, and friend lists, among other things. In between are RAM-heavy servers that run a memcached system to provide fast access to the most frequently used content.

Alpha geeks will recognize that these pieces of software—Linux, Apache, PHP, MySQL, memcached—all hail

BIG BOXES:

Facebook’s upcoming North Carolina data center [left] is almost twice the size of Google’s facility in The Dalles, Ore. [right]



from the open-source community. Facebook's programmers have modified these and other open-source packages to suit their needs, but at the most basic level, they are doing exactly what countless Web developers have done: building their site on an open-source foundation.

Not so at Google. Programmers there have written most of their company's impressive software from scratch—with the exception of the Linux running on its servers. Most prominent are the Google File System (or GFS, a large-scale distributed file system), Bigtable (a low-overhead database), and MapReduce (which provides a mechanism for carrying out various kinds of computations in a massively parallel fashion). What's more, Google's programmers have rewritten the company's main search code more than once.

Speaking two years ago at the Second ACM International Conference on Web Search and Data Mining, Jeff Dean, a Google Fellow working in the company's system infrastructure group, said that over the years his company has made seven significant revisions to the way it implements Web search. However, outsiders don't realize that, because, as Dean explained, "you can replace the entire back end without anyone really noticing."

How are we to interpret the difference between Google's and Facebook's engineering cultures with respect to the use of open-source code? Part of the answer may just be that Google, having started earlier, had no choice but to develop its own software, because open-source alternatives weren't yet available. But Steve Lacy, who worked as a software engineer for Google from 2005 to 2010, thinks otherwise. In a recent blog post, he argues that Google just suffers from a bad case of not-invented-here syndrome. Many open-source packages "put Google infrastructure to shame when it comes to ease of use and product focus," writes Lacy. "[Nevertheless, Google] engineers are discouraged from using these systems, to the point where they're chas-

tised for even thinking of using anything other than Bigtable/Spanner and GFS/Colossus for their products."

MIGHT GOOGLE'S OR FACEBOOK'S infrastructure yet crack under their ever-increasing loads? Facebook's regular user base has mushroomed to more than half a billion people, and it continues to add more than 20 million users a month. And Google must devote vast computing resources to keep up with the 34 000 searches it performs each second, while running ad auctions, translating languages, handling Gmail traffic, hosting YouTube

videos, and more. Can all this just go on and on without end?

It seems it can. While the costs are enormous, these companies appear to be handling the computing burden with relative ease. But maybe that shouldn't be surprising. After all, if they don't have adequate horsepower, they can always delay the introduction of whatever resource-intensive service they're working on—and they both roll out such features regularly enough.

Take Google Instant, an instant-search function that the company introduced last September. "The point was to increase the delight factor," says Ben Gomes, who headed the Google Instant team. Instant looks at the first letters you key into a search query and offers a page of results based on what it anticipates you intend to type. So for even a simple query, multiple searches must now go on in parallel, and further calculations must be carried out to choose which results to show. Would Google have made such a change if its engineers had any doubts about the ability of their systems to take the punishment?

Similarly, Facebook can certainly control how heavily its users tax its system. As of last year, for instance, Facebook users had uploaded 50 billion pictures to the site. And yet, despite the enormous amount of bandwidth and storage space eaten up by all those photos, Facebook has periodically boosted the resolution of the images users can save. Would it have done that if its operations engineers felt their computing infrastructure was in danger of collapse?

My point is that neither Google nor Facebook is likely to falter in scaling up their systems to match demand. Sure, there will be glitches and slowdowns from time to time. But it seems unlikely that either company will suffer from a long-term lack of computing oomph as they continue to shape the way we run our online lives. Just how quickly they'll have to build new data centers, and what new kinds of energy-saving technology those centers will contain, is anyone's guess. But one thing's for sure: Their servers will always be ugly. □

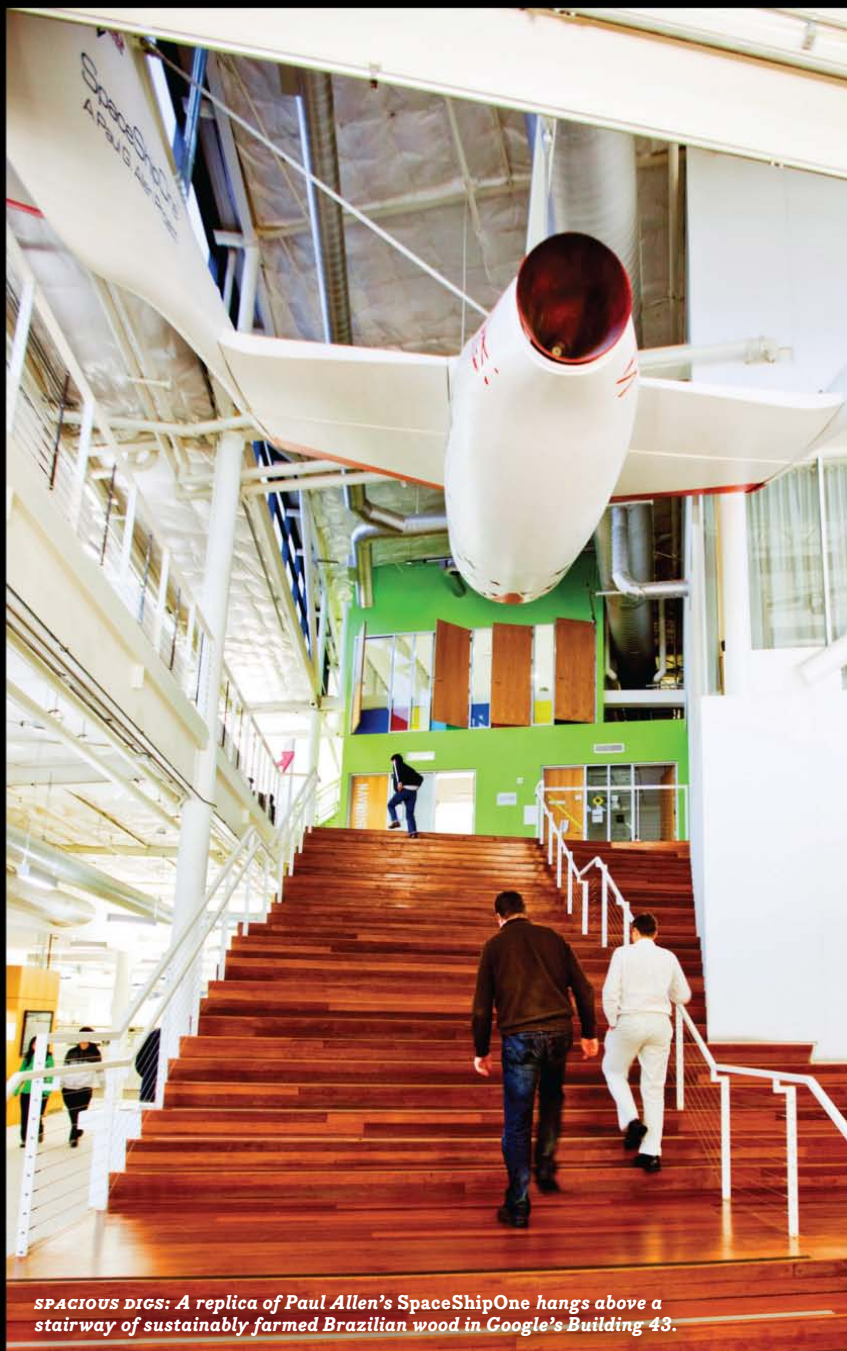
Campus Life

It's like the difference between public and private school: Facebook and Google have very different vibes

FACEBOOK TRACES ITS ROOTS to Harvard, but the social networking company's culture skews more toward public high school—a good one, to be sure, in an area with good demographics that's also slightly frayed at the edges. Google, on its sprawling suburban campus, is the smug private school in a world of its own. Both companies provide lavish perks, including free food at all hours, but there are clear cultural differences if you look closely. —*Sheila Himmel*

LOBBY LAND

Visitors to the two hottest tech companies on the planet can help themselves to a sugary fix upon arrival. In Facebook's lobby, there are vats of Starburst chews and Hershey's Kisses and a refrigerator stocked with Coke, Diet Coke, and Crystal Geyser water (sparkling and still). At Google, a small jar filled with generic small candies is tucked unobtrusively to the left of the reception desk. In the refrigerator, there are Odwalla juices and energy drinks. A highly reflective surface that paves the lobby reduces the need for artificial light, one small step in Google's march toward eco-heroism. Chairs and couches are boxy and bright updates of midcentury modern, à la "Mad Men."



SPACIOUS DIGS: A replica of Paul Allen's SpaceShipOne hangs above a stairway of sustainably farmed Brazilian wood in Google's Building 43.

MARK RICHARDS (5)



WHEELING AROUND

Googlers pedal around the company's Mountain View campus on brightly painted bikes that look like something a grade-schooler would favor, with small wheels, high handlebars, front baskets. The company tested several styles of bikes, and these won the employee vote. An employee grabs a bike, tosses his laptop in the basket, rides to his destination, parks the bike, and forgets about it. At Facebook, the cement floors are perfect for gliding around on a RipStik (a sort of skateboard/snowboard hybrid).

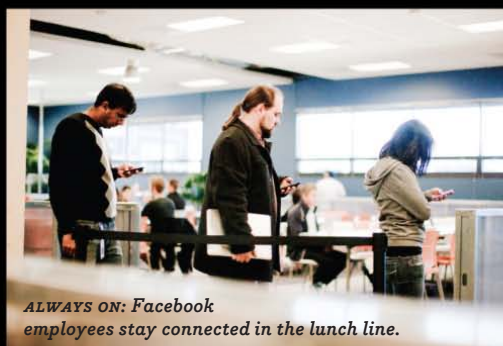


DAILY POST: At Facebook, "the wall" is not just a metaphor.

HOME TURF

Nowhere is the rapid growth of Facebook and Google more visible than in the expansions of their Silicon Valley headquarters. Facebook has had to scramble for office space in recent years. In 2009, it moved its headquarters from a handful of downtown offices in Palo Alto, Calif., into a 14 000-square-meter complex once occupied by Hewlett-Packard and later Agilent, in the Stanford Research Park.

Facebook is already bursting at the seams, and so it is planning yet another move, this time to neighboring Menlo Park, where Sun Microsystems abandoned a 23-hectare office complex last year. Just in case that's not big enough, the company has also grabbed up a neighboring 9-hectare property and plans to reopen an abandoned tunnel connecting the two. It's not an instantly appealing location,

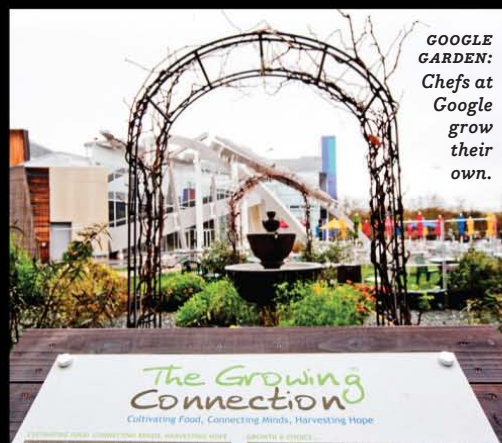


ALWAYS ON: Facebook employees stay connected in the lunch line.

far removed from the downtown buzz that Facebook staffers thrive on and the Caltrain tracks that convey many between home and work. It's so isolated, in fact, that during Sun's tenure, the campus earned the nickname "Sun Quentin," a nod to California's famous prison. Facebook plans renovations, however, that it has indicated will give the campus its own downtown feel.

Google moved its headquarters to its current location in

Mountain View, Calif., in 2003. The company initially leased four buildings that had been occupied by Silicon Graphics; later it bought those buildings and gobbled up adjacent properties. The site, known as the Googleplex, now encompasses some 65 buildings and 390 000 square meters of office space. The campus isn't near any commercial area, so temptations to leave, except to head home to sleep, are few. Google's expansion seems never-ending:



GOOGLE GARDEN: Chefs at Google grow their own.

The company has signed a lease for 17 hectares in the nearby NASA Research Park. There, employees won't ever have to leave; Google is planning to build housing alongside the new offices.

GROW YOUR OWN

Even in midwinter, the two vegetable gardens at Google's headquarters are abundant with produce, and the citrus trees are laden with fruit. The bounty finds its way onto the tables at the adjacent No Name Café, one of the many free restaurants on the Google campus. There's no room for horticultural pursuits at Facebook's current cramped headquarters, however.

Fashion Statement: JUNIOR HIGH SCHOOL

In the 1960s, male IBM employees wore white shirts and dark suits. The attire of elite techies sure has changed. Google and Facebook may be two of the hottest

companies around, but many of their workers dress like adolescents.

Facebookers, at least those in Silicon Valley, wear their brand proudly on black T-shirts and matching black hoodies. Even when branching out from the logo-wear, they dress like the guys who hang out at the local dive bar. Actually, they are the guys who hang out at the local dive bar—after hours, you'll find them packing into Antonio's Nut House, arguably the seediest joint in Palo Alto. (Don't take my word for it; one reviewer on Yelp calls it "a dark, dingy place where the beers are cheap and cold and the drinks are strong. It is all about getting s---faced and not blowing your whole paycheck on alcohol.")

Googlers pay a little more attention to style, with men in skinny jeans and colorful Converse All-Stars and women in high boots or ballet flats. I did see one pair of high heels at Facebook, but a shoe-shine shop would go broke at either of these companies. □





[BUSINESS]

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THE SOCIAL WEB

A Special Report

Betting the Farm on Games

FARMVILLE HAS LED A SOCIAL-GAME ASCENDANCE THAT WILL SWAY THE FACEBOOK-GOOGLE STRUGGLE—AND THREATEN THE DIGITAL GAMING INDUSTRY

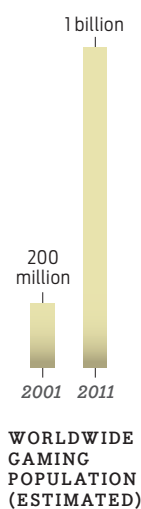
THE HOTTEST TREND IN GAMING ISN'T ALIENS OR wizards. It's something more down to earth. The grass is green. Guitar chords drift lazily from a front porch. And the crops are ready for harvest.

Such are the bucolic pleasures of *FarmVille*, the Facebook game that led the way in a games revolution that transformed how hundreds of millions of people are entertained online. In the process, a new generation of players has pushed aside the stereotype of the lonely teen in the basement. Instead, she's the middle-aged mom harvesting virtual corn in *FarmVille*. He's the commuting executive with his iPad, slingshotting evil green pigs in *Angry Birds*. They're the retirees on their iPhones playing *Words With Friends*.

Video games are in a renaissance. Even as game developers continue to churn out big-budget shooters and sports games for the trinity of home consoles—Microsoft's Xbox 360, Sony's PlayStation 3, and Nintendo's Wii—the real action is migrating to a

decidedly less hard-core arena: social networks and mobile applications.

According to the Nielsen Co., the top two activities for Americans online are social networks and games—together accounting for about a third of our time on the Net (one casualty: time spent on e-mail, which dropped nearly 30 percent in the past year). Those two trends converge in games like *FarmVille*. It boasts more than 50 million monthly players, and its sequel, *CityVille*, is fast on its way to surpassing 100 million a month, according to the website Inside Social Games. The explosion of such "social games"—games played on social networks—has been aided by a perfect storm of broadband penetration, wireless connectivity, and mobile platforms. And it's made Zynga Game Network, creator of the "Ville" series (which includes *FrontierVille*, *FishVille*, *PetVille*, and *YoVille*), the second biggest publisher in the game business, worth as much as US \$9 billion, according to *The Wall Street Journal*. Zynga, based



in San Francisco, is now bigger than Electronic Arts, the industry mainstay famous for the chart-topping Madden football and Sim City franchises. The communal aspect is central to Zynga's strategy. As Dorion Carroll, chief of technology of the shared technology group for Zynga, says, "We're not a gaming company. We're a social gaming company."

Games are profoundly shaping the future of the Web and, as a result, the strategies of the two biggest players online: Facebook and Google. The annual Game Developers Conference is the usual place where people take the pulse of the industry. And at this year's conference, the two companies loomed large. The panels on Facebook games and Google's two-day-long developer summit were both jammed.

The companies' interest in games reflects their differing visions: the openness and decentralization of Google versus the walled-but-thriving community of Facebook. "Games for Facebook are a mechanism to drive you to the page and keep you there," says Michael Pachter, an analyst with Wedbush, a Los Angeles-based financial services firm. "Games for Google are to drive you to their [Android operating system] and keep you there. It's different strategies and outcomes."

SOCIAL GAMES AREN'T NEW. BEFORE computers, games were inherently social, because essentially all of them were meant to be played by two or more people. The new social games, however, have a fundamentally different purpose. Socialization isn't meant to enhance the games; the games are meant to enhance socialization. They've been designed to do that for a very specific and simple reason: The more people who hang out online, the more Facebook and Google can cash in.

By attracting specific demographics of players and uncovering information about their habits, preferences, and acquaintances, social games are tailor-

made for supporting targeted advertising. Moreover, players can enhance their experience by purchasing digital items with credits, for which they pay real cash in the real world. If you think no one but a misfit would spend hard-earned money on a virtual crop duster, you're wrong: Zynga alone is pulling in \$1 billion that way, according to estimates by Wedbush. And by taking a 30 percent cut of all credit purchases made through all its games, Facebook earns roughly \$500 million a year.

To reach a wide market, the more accessible such games are, the better. *FarmVille* isn't *Grand Theft Auto* or

If you think no one but a misfit would spend hard-earned money on a virtual crop duster, you're wrong:

ZYNGA ALONE IS PULLING
IN \$1 BILLION THAT WAY

Halo or some other blockbuster that demands dozens of hours of play and thumbs that dance like Lady Gaga to achieve competence. The object of *FarmVille* couldn't be more straightforward: You run a farm with the help of your online friends. It's a light diversion, something you enjoy in installments. The simplicity lends itself well to smartphones, allowing games to fill tiny gaps of downtime throughout the day.

As Facebook's membership exploded in 2008 and 2009, so did its games. Led by *FarmVille*, Zynga grew from 16.9 million monthly active users in September 2008 to 200 million in November 2009, according to Inside Social Games. And the surge isn't limited to Zynga. In April 2010, PopCap Games, the Seattle-based creators of the hit puzzler *Bejeweled*, launched a Facebook version called *Bejeweled Blitz* that quickly racked up 3.8 million daily players. PopCap attributes the success, in part, to Facebook's use of real identi-

ties for members; that appeals to casual gamers and sets Facebook apart from the faceless free-for-all of other online games. "People are far more comfortable playing with people they really know," says Jon David, vice president of social games for PopCap.

With games now attracting so many eyeballs and dollars, Facebook is ramping up its strategy in the market. Last November, the company hired a dedicated director of engineering for game platforms: Cory Ondrejka. The cocreator of Linden Labs' pioneering virtual world Second Life and Linden's former chief technology officer, Ondrejka says games are central to the mission of the site. "Games on Facebook are inherently social," he notes. "The whole point of putting a game on Facebook is that you can play with friends."

Engineering a Facebook game has its appeal: It can cost as little as \$100,000 to develop, which is peanuts compared to the tens or even hundreds of millions that go into a sophisticated console game. But so many game developers rose early to the challenge that Facebook users were quickly overwhelmed, as developers essentially spammed users through news feeds and wall posts. In March 2010, Facebook finally put restrictions on such viral promotions. Users welcomed that reform, but for developers, it made publicizing their new games harder.

For those lucky developers who do manage to get the word out, Facebook success can pose its own headaches. With *FarmVille*, Zynga had to quickly scale up a game from zero users to more than a million in just days, while simultaneously readying the game to add still more millions as word spread. Prior to *FarmVille*, the company ran its games on racks of computer servers in designated data centers. As the game exploded in popularity, however, Zynga engineers had to change their approach.

"We simply could not have acquired and configured hardware fast enough to meet the user demand," Carroll says. Instead, the company switched

to Amazon Web Services, a cloud computing solution, which allowed it to take advantage of Amazon's elastic supply of processing power but "also meant that we needed to learn a lot of things all over again," he adds.

The challenge for Facebook now is how to expand its portfolio of games. Ondrejka is betting on new tools that will enhance and vary the kind of game experiences players can have on the site. "It's on us to push technology forward wherever we can," he says, whether that means calling for faster CPUs and browsers or greater availability of wireless spectrum. "Right now there's an intense arms race to make browsers better," he says. "How do we make sure those better browsers enable developers to make better games and reach more users?"

In particular, Facebook is exploring the potential of Hypertext Markup Language 5, or HTML5, the latest version of the standard Web programming language. Ondrejka calls it "a potent platform for game development," citing HTML5's robust handling of video and audio. According to Facebook, more than 125 million people are already using HTML5-equipped browsers on their mobile phones.

But the company still has concerns over the language's low performance and frame rate. One complication, Ondrejka explains, is that HTML5 offers "myriad different approaches" to drawing the images that appear on-screen, but it isn't always obvious which technique will work best in the context of a specific game. Consequently, Facebook devoted one of its all-night "hackathon" research-and-development events to creating the JSGameBench software, to test the limits of HTML5 for game performance. Developers are now using the code to see how many two-dimensional objects—known as sprites—HTML5 can generate at a time.

But for all the open-source innovation, how open will Facebook's gaming future really be? Some game develop-

ers have criticized Facebook for what they see as excessively harsh and autocratic behavior. For two days this past October, for instance, Facebook banned all games by the company LOLapps for violating Facebook's privacy policy. The fact that LOLapps games were being played by 150 million Facebook members at the time, according to *The Wall Street Journal*, sent a chill through other developers. "Facebook has the power to shut down an entire company," warned Daniel Cook, chief creative officer of the social game developer Spry Fox. Cook made his comment during a panel at the Game Developers Conference entitled "How to Survive the Inevitable Enslavement of Developers by Facebook."

Ultimately, episodes like this lead Facebook's critics to the same conclusion: that Facebook is a walled garden that fails to honor the spirit of openness on which the Internet was founded. They have a point: Facebook, and only Facebook, gets to decide who can come inside and play. Ondrejka, however, bristles at the suggestion that Facebook is cloistered. "Looking at it as a walled garden is probably the wrong way to look at it," he says. "It's important that we continue to make it as open as we can."

Game designer Graeme Devine of Zynga agrees. "Users don't see Facebook as a walled garden," he says, "so developers shouldn't see it that way."

But many developers do see it that way—particularly ones that aren't earning a billion dollars a year from Facebook. Google, too, has adopted a very different strategy for games and is quite happy to talk about it. "Strategically as a company, it's just our personality. We stay away from walled gardens," says Ian Ni-Lewis, the senior developer advocate on Google's gaming relations team. "The advantage to getting out of a walled garden is that everybody is on a level playing field. Consumers have more choice."

Google's interest in gaming has soared in the past year. According to

Ni-Lewis, on phones running Google's Android open-source operating system, over 60 percent of the paid apps are now games. Game-related videos are the second most popular type of video on YouTube, which Google owns. And as Google pushes HTML5 programming as part of its Chrome Web browser, there's no doubt where demand will come from. "The only things people get excited about with HTML5 are games," says Ni-Lewis. "They drive our technology and drive our platform."

Google's gaming plan is twofold: to encourage developers to use Chrome and Android phones as distribution platforms and to employ Google tool sets for game creation. Ultimately, anything good for the Web is good for Google, and the more that Google can nurture online games, the more it stands to gain from ad sales and other revenues.

Developers are already employing Google tools such as App Engine (a cloud computing service), SketchUp (a 3-D graphic design tool), and software development kits for Android handsets. One of the most compelling new tools that Google is pushing is WebGL. This 3-D Web-based graphics library promises to bring to compatible browsers such as Chrome the kind of immersive graphics seen in first-person-shooter and adventure games on consoles.

Unlike Facebook or Apple's App Store, the Chrome Web Store offers developers a means to distribute their games online without interference or the 30 percent fee on every transaction that Facebook and Apple claim; Google's cut is reportedly only 10 percent. Also, following the lead of Zynga's *FarmVille*, Google recently introduced microtransactions for online purchases of, among other things, virtual game items—a development seen as central to growing Chrome and Android as robust platforms.

The model for Google here is Apple. Apple's app-store data show that 7 of the top 10 paid apps on Apple iPhones and iPads are games. The games support the hardware's *Continued on page 75*



[PRIVACY]

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China's Social Networking Problem

INTERNET USERS IN MAINLAND CHINA ARE FLOCKING TO SOCIAL NETWORKING SITES, AND BIG BROTHER IS MONITORING WITH MIXED FEELINGS

LAST JANUARY, SOCIOLOGIST YU JIANRONG opened an account on the popular Chinese microblog service Sina Weibo. Yu called it “Take a Photo to Rescue Child Beggars,” and he encouraged its followers to post snapshots of waifs on China’s city streets. A professor at the Chinese Academy of Social Sciences, Yu hoped his project would help reunite missing children with their families.

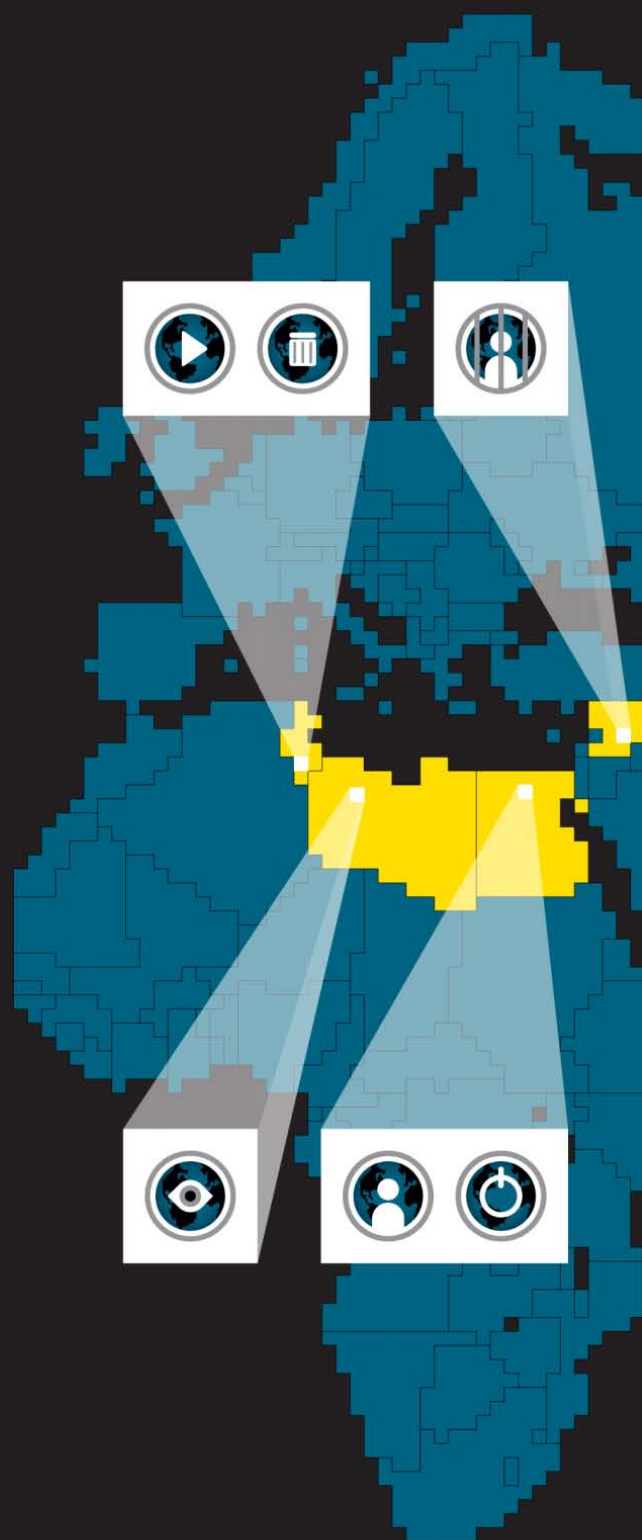
Yu started his campaign shortly before the Chinese New Year holiday, a time for family reunions—and it struck a chord. Within days, thousands of images and other clues were posted, and an audience numbering in the tens of thousands developed. The Chinese news

by SKY CANAVES

aged its followers to post snapshots of waifs on China’s city streets.

CARL DE TORRES

SPECTRUM.IEEE.ORG



Censoring Social Media

The ability to share status updates, photos, and videos with an online network is taken for granted in much of the world. But some regimes view social networking sites as a threat to stability and restrict their citizens' access to Facebook, Twitter, YouTube, and the like. Here are a few flash points of censorship from the last decade.

November 2003: The "Great Firewall of China," which allows the Chinese government to block Internet sites and keep users under surveillance, goes into operation.

November 2007: Syria blocks access to Facebook as part of a crackdown on political activism on the Internet. The authorities claim the site is a dangerous conduit for Israeli propaganda.

February 2008: The Pakistani government tries to block a YouTube video that mocks Muhammad but ends up shutting down YouTube worldwide for a few hours.

June 2009: In response to protests over Iran's disputed presidential election, the Iranian government increases its intensive Internet censorship. Despite intermittent shutdowns of Twitter and YouTube, Iranian protesters use these sites to air their grievances before the world.

June 2009: In fear of protests around the 20th anniversary of the Tiananmen Square massacre, the Chinese government permanently blocks

access to Facebook and Twitter and temporarily limits many domestic social networking sites.

May 2010: Pakistan temporarily blocks Facebook in response to a Facebook group promoting "Everybody Draw Mohammad Day," which the authorities consider blasphemous.

15 November 2010: A Chinese woman is sentenced to one year in a labor camp because of a single satirical tweet.

December 2010: The Tunisian government harvests log-in and password details from Facebook and uses them to delete Facebook groups, pages, and accounts. But Tunisian protests continue.

13 January 2011: The Tunisian president announces that the government will lift its ban on video-sharing sites like YouTube and Vimeo in a move intended to placate protesters. But demonstrations soon topple the government.

January 2011: Egyptian protesters organize demonstrations through the Facebook page "We Are All Khaled Said," honoring an Egyptian man allegedly beaten to death by police.

27 January 2011: The Egyptian government shuts down the country's entire Internet, but demonstrations escalate. On 2 February Internet service is restored, and on 11 February president Hosni Mubarak resigns.

February 2011: Because the Libyan government is monitoring Facebook and Twitter, would-be revolutionaries find each other via a Muslim dating site.

media even reported several success stories of rescued children.

In an interview with the influential Chinese magazine *Southern Metropolis Weekly*, Yu described his new sense of empowerment. "With a microblog, I finally have the same opportunities for expression as you," he said to the reporter. "Current technology has changed the social environment. Every person has a microphone; every person is a news center. Now it's easy to find friends; just publish a piece, and you'll find your comrades right away."

That's true, of course. But microphones can also be turned off. The media hubbub surrounding Yu's campaign soon led to official unease at the prospect of netizens (an old term that has been revived in China) tackling a social problem directly. In a leaked memo, China's Central Propaganda Department ordered news organizations to "lower excitement" by ceasing to report on Yu's project and giving microblogs in general a "reduced presence" on news sites. State media published editorials critical of the child-rescue effort, and Yu stopped giving interviews.

Yu's story is a classic example of a netizen reveling in the personal expression that China's new social networking sites offer—and quickly coming up against the limits of expression under an authoritarian regime. The country's Internet users are genuinely confused about what's permitted, because the Chinese government's response to their online activities has been inconsistent. The state seems torn between allowing homegrown social networking sites to flourish as part of China's transition to a high-tech information society and viewing them as a dangerous destabilizing force. Recent signals seem to suggest that China's social media sites are here to stay—but that the government is learning how to shape them to its advantage.

THE SOCIAL MEDIA LANDSCAPE IN CHINA IS STRIKINGLY different from the one most Western users inhabit. The Chinese government blocks all access to foreign sites it deems difficult to control; as of this writing, that list includes Google-owned YouTube as well as the social networking sites Facebook and Twitter. Only technically savvy users can access such sites, by slipping around China's system of Internet controls, colloquially known as the Great Firewall. But most of the 450 million Internet users behind the wall don't miss those American companies in the slightest, thanks to the numerous copycat services that have sprung up and evolved into uniquely Chinese entities. A variety of Facebook-like sites cater to different demographic groups, from white-collar professionals to rural workers. And one popular microblog service boasts features that go far beyond Twitter's offerings.

Analysts of China's Internet have long noted just how sociable its Web users are. Sociology professor Guobin Yang of Barnard College, in New York City, writes in his 2009 book, *The Power of the Internet in China: Citizen Activism Online*, that

Chinese netizens realized early on they could express themselves relatively freely online and could organize in ways that the restrictive political environment prohibits elsewhere. From the first days of bulletin boards and online discussion forums, netizens lit up the Chinese Internet. Global surveys have found that Chinese Internet users are more likely to blog and share content than are Americans, that they spend more time online, and that they express a sense of being able to live more fully in cyberspace.

Yet censorship is a constant presence in China, in subtle and not-so-subtle forms. State authorities have developed a range of strategies to manage the Internet: They block web-sites, scan content for keywords, and hire people to steer online discussions in directions favorable to the state. And Chinese Internet companies are well aware that their continued existence depends on their diligent self-censorship. Under Chinese law, these companies are responsible for all the content that users post and must ensure that it doesn't violate intentionally vague dictates against subverting state power, damaging the honor of the state, disrupting social stability, and the like. To avoid losing the required licenses, all Internet companies that host content in China have departments dedicated to monitoring and deleting problematic material.

One of the biggest tests of the Chinese government's attitude toward social networking sites came in June 2009, when the state chose to officially ignore the 20-year anniversary of the crackdown on the Tiananmen Square democracy movement. The verdict for social media was not promising. In the days leading up to the anniversary, Facebook and Twitter, which had been intermittently available in China, were cut off, apparently for good. Around the same time, dozens of domestic sites either became inaccessible or reported that they were undergoing "scheduled maintenance," causing some critics to mockingly refer to the anniversary as Chinese Internet Maintenance Day.

One of the homegrown sites targeted by Tiananmen-obsessed officials was Fanfou, the first domestic microblog service to take off in China. During the summer of 2009, Fanfou was shut down, returned to service, and then turned off again. But soon Fanfou didn't matter much, because a new social media force was rising: Sina Weibo.

Sina, the Internet company behind China's largest news and entertainment portal, launched its microblog service, Sina Weibo, in August 2009. (Weibo is a contraction of *weixing boke*, the Mandarin term for microblog.) The company leveraged the power of celebrity blogging to turn Sina Weibo into one of the hottest places on the Web. Its growth has been explosive: By February 2011, the service had about 100 million registered users. For comparison, it took Facebook more than four years to reach the 100-million-user mark.

Sina Weibo has been quick to incorporate various social media features, rendering comparisons with Twitter increasingly moot. It allows users to upload images and videos

directly into their feeds, and the service's "forward" function, which allows users to tack on their own 140-character comments to the original post, gives it a conversational feel. With the recent introduction of group functions and an instant-messaging platform that shows users which of their contacts are online, Sina Weibo is clearly encouraging the growth of a social network.

The form of written Chinese also sets Sina Weibo and the country's other microblogs apart from Twitter and similar sites in the West. In Chinese, most words can be expressed with one or two characters, and spaces aren't required between words. So 140 characters can convey far more than is possible in English, and entire news stories can be told in just a couple of posts. The result: Vast amounts of information flow through Chinese microblogs.

That torrent creates problems for the companies running the microblogs because, in principle, they must police everything that's said. "Monitoring content is an issue that is a serious headache for Weibo," Chen Tong, Sina's chief editor, said at a conference last year. Sina's chief executive recently told *Forbes Asia* that the company has at least 100 people checking content, and many experts believe the number is much higher. Still, with an estimated 100 million posts per day going up on China's microblogs, corporate censors are hard-pressed to take down objectionable material before it spreads through blogs, social networking sites, and discussion forums.

IN A COUNTRY WHERE NEWS ORGANIZATIONS CAN'T HOLD THE government to account, China's social media sites, with their ready potential for citizen journalism, have become the primary forums for protest and activism. And Sina Weibo's censorship department, no matter how well it's staffed, just can't expect to stop all the messages of dissent. In the past year, dozens of cases of injustice and wrongdoing have been exposed and publicized through social media sites, most notably through Sina Weibo. (Some users rely on anonymity to critique the government—but as with Twitter, the most influential users are those who are bold enough to post under their real names.)

Take, for example, the recently popularized phrase "My father is Li Gang." Reposted countless times and in countless ways, it's a reference to an incident in which a young man who was driving drunk hit two university students, killing one; the driver then attempted to talk his way out of deten-

Chinese social media sites

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tion by informing security guards that his father was a senior police official. Even as Chinese media were ordered to cease reporting on the touchy story, reporters and ordinary citizens continued to comment on the case in the relatively free space of social networks.

Such episodes continually test the limits of the state's tolerance, as users try to determine just how much they can get away with. Sometimes, however, the government makes the boundaries of expression very clear. In February, Chinese-language websites overseas posted calls for people in China to emulate the democracy movements in Tunisia and Egypt by starting a "Jasmine Revolution" in more than a dozen large Chinese cities. The state's reaction was swift and decisive. Activities on Sina Weibo were severely curtailed: Post forwarding and photo publishing were suspended, and searches for the word *jasmine* were blocked. Those drastic actions led to speculation that Sina Weibo was about to go the way of Fanfou and that the whole domestic microblogosphere would soon be shut down.

Instead, the restrictions turned out to be largely temporary. Reposting and photo sharing were restored once the immediate threat was deemed to have passed (though *jasmine* remained taboo), and authorities' attention shifted to arresting those who used the Internet to spread the revolutionary message within China. Defending the microblog's continued viability, Chen, the Sina editor, recently declared online that "there is zero possibility that Sina Weibo will be shut down within 20 years."

Writing in response, Hong Bo, the influential Chinese blogger known online as Keso, listed several reasons why he agrees that Sina Weibo is here to stay. Keso noted that the greatest risks of closure came during the service's first year of operation, when the so-called Twitter revolution in Iran had raised fears among China's leaders about the power of microblogs. Keso wrote that since then, government authorities have started using microblogs to shape public discourse, and he noted that Sina Weibo has taken pains to ingratiate itself by exercising strict supervision. The Chinese government might have concluded that a well-monitored public forum for dissent is preferable to rumblings in the underground, he wrote.

The state's response to a small scandal in March could signal its growing sophistication in social media matters. During the annual legislative sessions in Beijing, a delegate by the name of Wang Ping said in a speech that rural students shouldn't be encouraged to go to college. Her comments immediately spread through Chinese microblogs, with many Sina Weibo users calling on her to step down from her position.

Wang's response to the uproar says a lot about the future of social media in China. Rather than blaming Sina Weibo for turning her into a reviled figure, she acknowledged the importance of microblogs. "People need a channel to speak and discuss things," she told reporters. "I myself might open a Weibo account to communicate better with the public." □



[FUTURE TECH]

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THE SOCIAL WEB

A Special Report

This Is Your Mind Online

Avatars will give social networks power to seduce

DID YOU KNOW THAT A VIRTUAL representation of a politician could be more convincing than the politician himself? That your heart beats just as fast when your girlfriend winks at you from your computer screen as when she walks into the room? That if you make your onscreen surrogate mimic your friend's head movements, he's more likely to do what you say?

Within three years, many online interactions will not simply involve passages of text typed on a keyboard but will instead be rich exchanges involving sophisticated representations of ourselves. Those digital beings are called avatars, and today at least half a billion people around the world are routinely socializing through them over the Internet, for example in online games.

by JEREMY N. BAIENSON
& JIM BLASCOVICH



Half a billion people around the world spend more than 20 hours a week "wearing" avatars, that is, using digital representations of themselves.

Others spend many hours each week controlling avatars inside their own homes, using game platforms like the Wii and Xbox.

And avatars aren't just for recreation. A vice president at IBM has predicted that by 2015 all IBMers will have avatars to send to work-related meetings and presentations.

The use of avatars is booming. But even more people use social media—at least a billion people around the world.

It's only a matter of time before these two trends—realistic avatars and social media—intersect. As more people gain experience with avatars, and as the technology for enriching them improves, we can expect avatars to play far bigger roles in communications. Evidence suggests that the use of avatars could profoundly alter our social behaviors and work performance—for better or worse.

AVATARS HAVE SPECIAL ADVANTAGES. A VIDEOCONFERENCE system continuously captures what someone is doing in the real world and sends that image to another locale. But avatar technology works differently—it captures only selected movements, sending enough information about them over a network to allow the computer on the other end to re-create the action. That difference has two helpful consequences. First, the avatar can be shown doing things that a camera doesn't see, or the system can ignore certain motions. Second, the avatar can be controlled without any network delay, because there is no need to send bandwidth-hogging HD pixels.

Remember Second Life? That was the first commercially successful home for avatars that was not a video game. Its cartoonish characters can be controlled (awkwardly) only through the computer mouse and keyboard, and network lags deter users, though developers are trying to improve the experience.

But avatars have evolved over the years and are growing to resemble their human controllers, both in how they look and how they behave. Look at the Kinect, Nintendo's Wii, and Sony's PlayStation Move, which are all now equipped with devices that transform players' physical actions into virtual body movements. Digital avatars move in tandem with their wearers as the latter jump, point guns, and swing rackets.

Soon avatars are going to get even more compelling. Advances in 3-D are changing the entertainment industries; they will change avatars as well. And you can already purchase inexpensive devices from such makers as Novint Technologies and Scent Sciences Corp. that augment video games with tactile feedback or a sequence of scents. So, besides hearing and seeing conversational partners, you can potentially feel and smell them.

While avatar technology has been steadily improving, social networking, with its text, still images, and jerky videos, has been skyrocketing. Adults in developed countries who have access to any kind of digital tools have quickly come to depend on the Internet to shop, do business, and entertain and educate themselves. Online dating, which was somewhat stigmatized just a few years ago, is now the norm.

Within the next three years we're going to see the advanced avatars and other technology developed for gamers migrate into social networks. Imagine your friends seeing you in 3-D, in the form of a fully embodied avatar projected into the center of a room. You'll need no keyboard for typing or mouse for

clicking; rather, unobtrusive devices will measure and capture your movements.

These avatars can simply be realistic representations of who you are and what you are doing, helped along by motion-capture technologies that let them mirror every movement. But they can also be strategically filtered or altered representations that show only what you want them to. Their capabilities can be modified to allow them to do things that no real, physical person could do in a given situation. And behavioral studies have shown that those differences can carry a remarkable social power to influence others.

SHOULD WE BE AT ALL WORRIED ABOUT TURNING OVER MOST—or even some—of our online communications to avatars? The scientific record is mixed.

As researchers and authors of the book *Infinite Reality*, we know from studies of people's behavior that the brain often fails to differentiate between virtual experiences and real ones, and between computerized characters and human beings. In one of many experiments that support this conclusion, Clifford Nass and Byron Reeves, of the department of communication at Stanford University, conducted a "politeness study" in the mid-1990s. Researchers asked participants who were completing a digital survey to evaluate the performance of the computer they had just used. If they answered those evaluation questions on the same computer—literally, the same physical unit—they rated the computer more positively than if they were moved to a different machine to take the evaluation survey; those who switched machines were more critical of the performance of the first computer. We agree with Reeves and Nass's interpretation that participants (perhaps unconsciously) did not want to offend the machine they had been working on.

More recent work examining people's experience of the virtual versus the real involved functional magnetic resonance imaging (fMRI) data. Researchers at various universities across the country have conducted experiments over the past six years that analyzed and compared the patterns made by neurons that fire when people watch a digital 3-D re-creation of other people with patterns from those that fire when people view photographs or video of real people. Most experiments failed to find differences in those patterns.

It's not too hard to see why some of us prefer virtual life to physical reality. In virtual spaces aging is optional, and weight loss happens via Photoshop. In cyberspace, there is no such thing as a bad hair day. Avatars can even be more socially gifted than the humans who drive them.

For years, for example, researchers have been fascinated by mimicry, regarded by developmental psychologists as essential to the acquisition of communications skills. Psychologists also believe that mimicry has a lot to do with a person's likability. In a classic experiment, Tanya Chartrand, a social psychologist now at Duke University, demonstrated that research



participants acting as interviewers significantly favored the “job applicants” who mimicked the interviewers’ gestures over ones who did not. Furthermore, the interviewers were not consciously aware of the mimicry. Chartrand labeled this the “chameleon effect.”

We wondered if that chameleon effect applied in virtual reality. So in 2005 we carried out a study in which Stanford undergraduates watched and listened to a virtual character in a video-game-like setting while wearing a head-mounted display that allowed them to see in 3-D and to control their point of view by moving their heads. The character delivered a message advocating a campus security policy that would require all students to carry their identification at all times.

We varied the mimicry behavior of that character, using the head-mounted display to track each undergraduate’s head movements and programming the virtual character to make those same head movements four seconds later. The undergraduates rated mimicking agents as more persuasive and also more credible, trustworthy, and intelligent than identical-looking virtual characters who delivered the same messages without the mimicked head movements.

In fact, avatars are better at strategically planned mimicry than people are. A human who consciously tries to mimic another human generally doesn’t do it well. (Ironically, though, the many people who tend to do this mimicry uncon-

sciously do just fine.) A conscious mimic can be too obvious about it, can miss seeing the other’s gestures, and can slip up when tired. Conscious mimicry takes a lot of effort, potentially making it harder to keep track of the conversation and speak persuasively. Avatars face none of these problems.

Could this type of social influence become important? Imagine how a virtual car salesperson on a future social networking site could be programmed to mimic the movements of a potential buyer detected by webcam. Or how a politician who uses these sites to reach constituents might use this technology to augment the effectiveness of his message.

Small changes to avatar appearance could drastically change history. In a study performed by Stanford researchers, 200 respondents from a national random sample received electronic surveys with images of George W. Bush and John Kerry, U.S. presidential candidates in 2004. One third of participants received an image of Bush manipulated to look on a subconscious level like the respondent, a third received a similarly manipulated image of Kerry, and a third saw the original images only. Nobody explicitly detected the changes, but the manipulation caused a 20 percent shift in the votes of those seeing the manipulated samples as compared with the control group. They repeated this experiment with other candidates, covering more than a thousand people in five total studies, and demonstrated conclusively that subconscious similarities could swing an election. People don’t consciously notice that the candidates look like them, but they are swayed by the implicit affinity.

THIS TECHNOLOGY MAY BE MANIPULATIVE, BUT IT CAN BE A force for good. Teachers could use virtual mimicry to ensure that most, if not all, students in a class are more in tune with their lessons. Because the rendering computer in an immersive virtual-reality system sends information to all of the students’ systems individually, it can tailor that information to make the teacher look and behave like each student simultaneously.

Similarly, avatars can always maintain eye contact. With the possible exception of physical touch, looking another person in the eye is the most potent nonverbal tool humans possess for commanding attention. When a teacher looks at a student, the student is actually more likely to master the educational material. But making direct eye contact with a hundred students simultaneously is impossible. A teacher can try to spread her gaze around, but even if she spreads it evenly among the students in a large lecture hall, she can only gaze at each student perhaps 1 percent of the time. Yet digital avatars on students’ individual displays can engage in a mutual gaze with everyone at the same time—and every student will respond as if she were the sole recipient of that gaze.

We have run hundreds of experimental participants through what we call “non-zero-sum gaze” virtual-classroom studies to test this premise. So far, not *Continued on page 76*

How Many “Friends” Can You Really Have?

Can social networks expand the evolutionary limit on how many people anyone can truly be close to?

WHO WOULD HAVE SUPPOSED SEVEN years ago that the newly launched piece of software called Facebook would so quickly become a routine part of everyday life? It was, after all, just one more digital trick purporting to spring us from the dusty confines of our small-town lives and into the sunny uplands of a global village, where we could make new friends all around the world.

Some might call this the fulfillment of the tech folks' brash promises that such software would help us stay close to an ever-expanding universe of pals. There are the triumphal claims of those who say they have 1000 or even 5000 friends on their Facebook pages, who claim comrades in far-off corners of the world they have never visited. But is this really true? How many real friends do people have on Facebook?

Facebook itself did a survey of its accounts about a year ago and found that the average number of friends was between 120 and 130. The distribution is, of course, skewed, with a long tail to the right. Some people really do number their friends in the thousands, but they are in fact few and far between. And many of these cases are actually professional accounts held by writers, journalists, and musicians who use Facebook as a fan base.

The odd reality is that we are actually not capable of managing more friendships than you typically see on Facebook now—or more than people have traditionally maintained. Across the primate order as a whole, there is a general relationship between the size of the brain's neocortex and the



size of the average social group, and this relationship predicts a group size for humans of 150. This value is now known as Dunbar's Number, because I was the first to point it out, in 1992. The number pops up surprisingly often in human organizational life, not least in the military, where it defines the key unit on which everything else is structured, namely the company. It is also the average size of a personal social network—the number of people with whom you have some kind of reciprocated relationship.

Of course, you know many more people—you can put names to the faces of around 1500 individuals. But you have a very different kind of relationship with those who come between the 150 and the 1500: You know who these people are, but they don't necessarily know who you are. The list includes folks like President Obama, the anchor of your favorite TV news channel, the woman you see at the bus stop every

morning. You can add them to your Facebook page, but they can't really be counted as meaningful friends.

Of course, sublevels exist even within that select circle. At the top of your social pyramid are the five people closest to you, most of them probably relatives. They are nestled inside the top 15, with whom you generally have weekly interchanges. Then come the top 50, with whom you keep up every month or so. Finally, there are all the others with whom you correspond in any meaningful sense. All the relationships require tending, although relatives retain their place in the hierarchy more tenaciously than nonrelatives do.

Data that my colleagues at the University of Oxford and I have gathered suggest that if you start to invest less time in a friendship, the emotional quality of the relationship will decay within at most six months. The relationship will gradually bump its way down through the layers of friendship until eventually it slips over the weir at 150 and that person becomes “one of those people I once knew.”

It is here, perhaps, that Facebook does demonstrate its value.

Until about a century ago, social movement was relatively modest, and most people probably grew up within a day's journey of where they had been born. Communities were small (in fact, typically about 150 to 200 people), and most folks knew everyone. That arrangement created a complex web of interwoven relationships, many of which were familial. Since then, society has undergone a dramatic change. It has become commonplace for people to move many times during their working lives—first to college, then to their first jobs, followed by a series of moves as they are transferred to new offices by their companies or move to new jobs elsewhere. The result is that our networks of 150 have become fragmented into small subsets of friends picked up along the way. Our college friends probably do not know our family, and

Continued on page 76

Write to us at <http://spectrum.ieee.org/friends0611>.

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The Anti-Facebook

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with someone else on [My-seed.com](#), which means its server cache knows you exist and has stored your WebFinger profile.

The ability to let users search its database is perhaps the biggest advantage Facebook has over a federated network such as Diaspora and the biggest threat the company poses to Google. Because Facebook encourages its users to list their hobbies, affiliations, likes and dislikes, and tag photos, videos, and events, the site has become a sizable search index. Users can search for everyone who collects Raytheon CK722 transistors, pull up photos of all of them, and poll other Facebook users about whether they prefer iPhones or Android phones before buying one.

“Search is a huge problem,” Salzberg concedes. “Everybody’s always saying, ‘Oh, my God! Facebook is awesome because I can search for anyone!’ And you can’t do that on Diaspora. But we’re not going to quit trying to solve the distributed networking problem just because we don’t know how to do search. That’s something some company the size and scale of Google will need to solve.” In the meantime, there are other, more basic things Diaspora’s distributed system must do to “mask the distributedness,” as Salzberg says, “and make it look and feel the same as a centralized website.”

Suppose now that I, at [me@my-seed.com](#), have used your handle, [you@diasp.org](#), to call up your WebFinger profile. Next, I need to be able to communicate with you. In the Diaspora system, any personal messages I send or private updates I post are encrypted with standard RSA cryptographic keys and “pushed” from my pod to your pod using HTTP. “Push” technologies, which are also used in instant chat and for forwarding e-mails from an online account to a smartphone, are distinct from “pull” technologies, used for RSS feeds and browser requests, in which the servers receiving content constantly ask the servers generating content for updates.

Because most conversations on social networks happen nearly in real time, Diaspora’s message distribution system must be as efficient as possible. As you can imagine, a push system distributes messages more efficiently than a pull system, but it also makes a lot of demands on the server doing the pushing. The Diaspora guys are therefore trying out a new protocol being developed by Google engineers for dispersing public posts, which don’t need to be encrypted and will likely be sent to more people than private posts.

The protocol, named PubSubHubbub, calls for an intermediary server, or hub, and assigns it the task of handing out updates from a publishing server to its subscribers. Using a cloud-based hub, such as the one Google runs, lets you host data on your own small, cheap server while the hub takes care of publishing your updates for you. Diaspora’s software then packages the updates using an open-formatting protocol called Activity Streams—developed by engineers now employed at Google, Microsoft, Socialcast, and elsewhere—to add useful identifying information to each update, such as who wrote it, when it was written, and what kind of message it is (a status post? an article link? a new location? a preference?). The software run by subscribing Diaspora customers then uses that information to display the updates in an aesthetic, engaging way, much like an RSS or Atom feed reader.

The final element of what Diaspora’s Zhitomirskiy calls the “social networking atomic units”—meeting people, sending private

messages, publishing public updates—is commenting. For this, the guys adopted a protocol called Salmon, developed by Google engineer John Panzer. If a Diaspora user comments on a post, the comment gets pushed “upstream” to the person who wrote the post. The post author then pushes the comment out to his friends.

Last 15 September, as planned, the guys made their code public. Since then, they have been adding features and little by little “improving the user experience” as more and more fans ask for invitations to join the network. “It’s kind of like building an airplane as you’re flying it,” Salzberg says.

CRITICS OF DIASPORA SAY THAT ASSEMBLING A SOCIAL NETWORK on the fly probably isn’t a good strategy. They predict that Diaspora’s missteps—the security holes, the broken features, the lost accounts, the misrouted messages, the delays, the crashes, the inconsistencies—will drive users away before the company can even get off the ground.

Some programmers who are designing their own federated networking systems argue that a better approach may be to first create standard protocols and libraries that established networks, such as Myspace, China’s Renren, and Russia’s VKontakte can use to interoperate as if they were Diaspora pods. “The problem with Diaspora right now is it’s not designed to work with other providers out of the box,” says Ben Zhao, a network security expert at the University of California, Santa Barbara [listen to an interview with Zhao at <http://spectrum.ieee.org/zhao0411>]. Zhao is developing a mobile social network architecture called Polaris that, if widely adopted, he says, would assemble existing social networking services into a single federated system. To be fair, the Diaspora guys are working toward linking up their pod with other networks, starting with StatusNet, which targets businesses and organizations, and Identi.ca, an open Twitter-like service built on StatusNet software.

“I would argue there’s also a lot of value in putting all the pieces together in a nice package with a nice name,” says Smarr, the Google social Web engineer. “There’s nothing like building an end product to figure out where the holes are in the building blocks.”

Of course, he adds, “agreeing on the building blocks and getting the big, established players to see the benefit of being part of these technologies” won’t be easy. Not for Diaspora, and certainly not for Google, agrees tech analyst Enderle, “especially if the larger, established networks see Google as a competitor.”

It’s most likely then, that if federated social networking does pervade the Web, it will take over slowly, like ivy enveloping the brick halls of Harvard University. At first, open-source projects such as Diaspora will grow steadily and haphazardly, all the while tweaking their technologies, working out standards, and syncing with each other. Then, when they attract enough users to seem like they’re onto something cutting-edge and lucrative, perhaps other niche networks—the Quoras, the Goodreads, the Foursquares—will join the federation. Developers will create new start-ups and invent features and experiences that Facebook can’t offer: private networks, anonymous networks, exclusive networks, ephemeral networks.

“If you take all of Facebook’s competitors and tie them all together into a large web of choices,” Zhao predicts, “then when the next big Facebook privacy gaffe happens, people will actually jump ship because there will be a good alternative.” At last, Facebook will face a real killer.

And it just might look an awful lot like Google. □

BETTING THE FARM
ON GAMES*Continued from page 65*

popularity, and vice versa. "Given the success Apple had with smartphones and iPads, Google looks at that and says, 'Obviously we need to be there,'" remarks Colin Sebastian, a director and senior analyst with Lazard Capital Markets in New York City.

"Google is thinking about global domination," adds Wedbush's Pachter. "Google is looking at games as apps that will sell its OS and make Google more essential as an operating system," thereby replicating the success of games on Apple's mobile operating system, iOS. He thinks Google "will very likely succeed."

Yet for developers, migrating to Google offers mixed prospects. On the one hand, the company's tool sets are empowering. "Google understands that a platform that is implicitly and totally trusted by developers and consumers will become unimaginably valuable over time, by eventually identifying a friendly, 'nonevil' method of generating profit," says Spry Fox's Cook.

But coding a game for Android requires testing it on a variety of handsets, because each manufacturer tweaks the operating system to meet its needs. That testing process takes additional time and labor. Moreover, releasing a game outside of Facebook means missing out on the hive of dedicated gamers built into its audience. As a result, developers are more inclined to design a product with the social network in mind. "Initially targeting Facebook isn't a bad strategy," says Colin Macdonald, vice president of business development for eGeo, a social game developer based in Dundee, Scotland.

Whether or not developers adopt Google's tools also depends in part on the adoption of Chrome. "If WebGL and Chrome are advancing and enough people are using the technology, then we want to [work with] that," Zynga's Carroll says. But "we have to wait until [the] audience adopts that." David of PopCap describes these early days of HTML5 as a "wait and see" phase, which developers will adopt if and when the language proves robust.

The competition over games is part of the larger conflict between Facebook and Google over whether (and how much of) the Web will be open or closed. Yet it's not necessarily a winner-take-all battle. The companies are also allies in a sense, because they both hope to pry

eyeballs away from the video-game consoles and dedicated handhelds and onto cellphones, tablets, and PCs. And so the success of one may help the other.

"In a lot of ways it's just collaboration," says Ni-Lewis. "The idea is that we want to advance these open standards." Facebook's Ondrejka agrees, calling Google's work on Chrome "extraordinary" and the innovations for Android and HTML5 just as encouraging. "They're making increasingly broad platforms better," Ondrejka says. And that bodes well for both companies, no matter what games people are playing.

Nevertheless, the success of Facebook and Google in gaming poses a twofold threat to console game developers. Many social games are either free or cost less than a dollar. So some companies producing \$60 console games worry that the market for their kind of highly advanced games is going to wither.

In addition, there's concern that the flood of inexpensive, lower-quality titles could sour the public's appetite for games. (Something like this happened before: The first golden age of video games ended with the release of a lackluster *E.T.* movie tie-in game.) During a standing-room-only keynote speech at the 2011 Game Developers Conference, Nintendo president Satoru Iwata shocked the crowd by noting that the thousands of console games on the market paled beside the tens of thousands of games online. "Game development is drowning," he said.

Despite such concerns, these are still very good times for the industry. As an entertainment form, games are as popular as they've ever been. There's even a new buzzword—"gamification"—which describes the infiltration of gamelike experiences into everyday life. Global game sales now top \$60 billion and are expected to top \$70 billion by 2015, according to DFC Intelligence, a technology research firm based in San Diego.

There's nothing like a good round of *Madden NFL* on a PlayStation 3 and a 56-inch screen. Facebook and Google probably won't ever be able to replicate that. What they've done is expand the market by bringing games to people who probably would have never become gamers otherwise, just as in the 1950s and 1960s TV expanded the distribution of entertainment beyond movie theaters. The wizards and space marines aren't dying. They just have some new friends down on the farm. □

ME, MYSELF, OR I

Continued from page 45

aggregates updates from all the people you are connected to and displays them on a single page. Every time a user changes his or her relationship status, posts a status update, uploads a photo, or "friends" a new person, his or her other friends are all informed, virtually instantaneously.

The distance information can travel on Facebook isn't immediately apparent. The average Facebook user has 130 friends, but those friends will each have dozens or even hundreds of their own, and those friends will have their friends, and so on. "People don't understand that when you say, 'I'm making this available to friends of friends,' you're potentially opening up your network to tens of thousands of people," Marwick says.

Managing the flow of information on Facebook can be a laborious process. Facebook's software allows users to control what each friend can see, but it doesn't make it easy. Ballyamanda has to assign each new "friend" to a group. And every time she posts a status update or a new photo album, she hand selects the groups that can see it.

Many users simply aren't willing to make the effort. The privacy settings are complicated, and "just when you learn how to use the system, they go and they change it," says Amanda Nosko, a social media researcher at Wilfrid Laurier University in Waterloo, Ont., Canada.

But that doesn't mean we're headed toward Zuckerberg's open society. Rather than tailor information for different users, many Facebook users may simply self-censor, restricting how much information they share on the site.

Ballyamanda, for one, isn't about to give up her groups, despite promises from relatives that they won't use the site to spy. In a video posted to Facebook last year, Ballyamanda's aunt and uncle sit side by side and read a privacy statement that their son prepared. Her aunt, wrapped in an embroidered pink shawl, recites the words carefully in thickly accented English. "We pledge to never intrude on the privacy of our children as we embark on our journey to fully enjoy the communication benefit of Facebook," she says. "I wish to state that no one coerced us to make this statement," her uncle adds.

Her aunt and uncle seem sincere, Ballyamanda says. But it's going to take a lot more than a video to get them out of Zero Trust. □

THIS IS YOUR MIND ONLINE

Continued from page 72

one student realized that the gaze of the teacher's avatar was not genuine—they all thought the teacher was looking at them individually while ignoring the other students. Moreover, students' attention and learning improved. As a group, they focused on the teacher's avatar with the simulated direct gaze more than on avatars not set to use the technology. The students also retained more information. So a relatively simple chunk of code (about 20 lines) allowed us to augment the behavior of a virtual teacher in socially influential ways, improving students' behaviors, attitudes, and learning. For example, in one study, students paid attention almost 20 percent longer when receiving an augmented gaze than when receiving a natural gaze.

In our experiments, even small changes in avatar appearance resulted in huge changes in behavior. Taller avatars can make people behave more confidently; attractive ones can make them more social. Avatars that lose weight can make their owners exercise more and eat healthier. Showing young people their future selves can make them save more money for the future, and showing people's avatars living with the consequences of energy use—for example, in a forest with the trees all cut down—can increase conservation.

These examples suggest a synergy between the mind and immersive virtual technology. On the one hand, the brain treats real and virtual experiences as the same. On the other hand, in virtual reality, the rules of grounded reality are suspended. In virtual reality, avatars can age, grow, or become supermodels at the touch of a button. They can use conversa-

tional superpowers, including large-scale mimicry and gaze, or wear other people's faces and bodies. Rationally, people bring specific expectations, perhaps guarded ones, when interacting with virtual others. However, the brain cannot consistently keep this guard up for long stretches of social interaction, and these superavatars tend to elicit very human responses.

Current social networking and other online sites are just precursors of what we'll see when social networking encompasses immersive virtual-reality technology. When people interact with others for substantial periods of time, much as they do now on Facebook but with fully tracked and rendered avatars, entirely new forms of social interaction will emerge. Avatars can be more human than humans, and what that means for the brains responding to them will be understood only many years from now.

We will be watching what unfolds as the dawn of the virtual revolution turns to high noon. We expect billions of people to benefit greatly from the resulting expansion of personal freedom and the resulting changes to society's collective institutions; the democratic social movements now unfolding in North Africa and the Middle East are enabled in large part by social networking, and they are just the beginning. But there will be downsides, especially in terms of privacy, personal mental health, and intimate relationships.

Pope Benedict XVI recently said: "New technologies and the progress they bring can make it impossible to distinguish truth from illusion and can lead to confusion between reality and virtual reality" and might result in "indifference towards real life." But Mark Twain cautioned, "Don't part with your illusions. When they are gone you may still exist, but you have ceased to live." □

HOW MANY "FRIENDS"
CAN YOU REALLY HAVE?*Continued from page 73*

they certainly won't know the friends we acquired when we moved to another city for a job.

Not only have our networks fragmented, they have also dispersed, often across an entire country or even to every continent. In the past, most of those ties would have quietly withered away with time, much as our immigrant ancestors' ties to their homelands quietly died after they left to start life in a new country.

I suspect that Facebook's one great contribution has been to slow down that rate of relationship decay by allowing us to keep in touch with friends over long distances. How long it will prevent relationships from fading altogether remains to be seen—social networking sites haven't been around long enough for us to tell yet. My guess, however, is that they will slow the rate of decay only temporarily and won't prevent relationships from dying eventually. What makes relationships really work, it seems, is "doing stuff" together.

Catching up over the phone helps to keep the acquaintance ticking, but if at some point we don't get together—and sooner rather than later—then the relationship will fade, Facebook or no Facebook.

One might think that by cutting through some of the time and inconvenience involved in keeping up with friends, Facebook could allow you to widen your social circle. Yet the answer seems to be a resounding negative, as Facebook's own survey showed. Our Facebook friends are, by and large, the same folks as our everyday friends. If you have more than 150, it is because you are including people who have no meaningful relationship with you. They are no more than voyeurs in your social life. In fact, studies of traffic on Facebook suggest that when we write on our own or someone else's wall, we think we are engaged in a conversational conversation with just a few other people.

An explanation for this phenomenon may come from work that my colleagues and I have done on how people evaluate interactions with close friends over different media. We compared face-to-face conversations with ones involving the same

individuals over Skype, phone, e-mail, text, and social networks. Face-to-face conversations beat Skype, which in turn elicited radically more satisfaction than did those involving the other technologies. Something about the sense of being in the same place seems to make an immense difference that neither old-fashioned phones nor modern Facebooking can yet manage. The immediacy of the interaction is part of it, but so too is seeing the other person's responses to what we say. Laughter turned out to be the key. Even e-mails that evinced laughter (often just signaled by an "LOL") were viewed more positively than those that didn't.

All these results suggest that the main challenge for social networking will be to make exchanges more like real conversations. In the end, just posting photos of our vacations isn't enough: We need to be able to have something closer to the back and forth of a real conversation about the photos [see previous article, "This is Your Mind Online"]. Ultimately, I believe, the real challenge will be to solve the problem of virtual touch. In our everyday relationships, every touch is worth a thousand words. □

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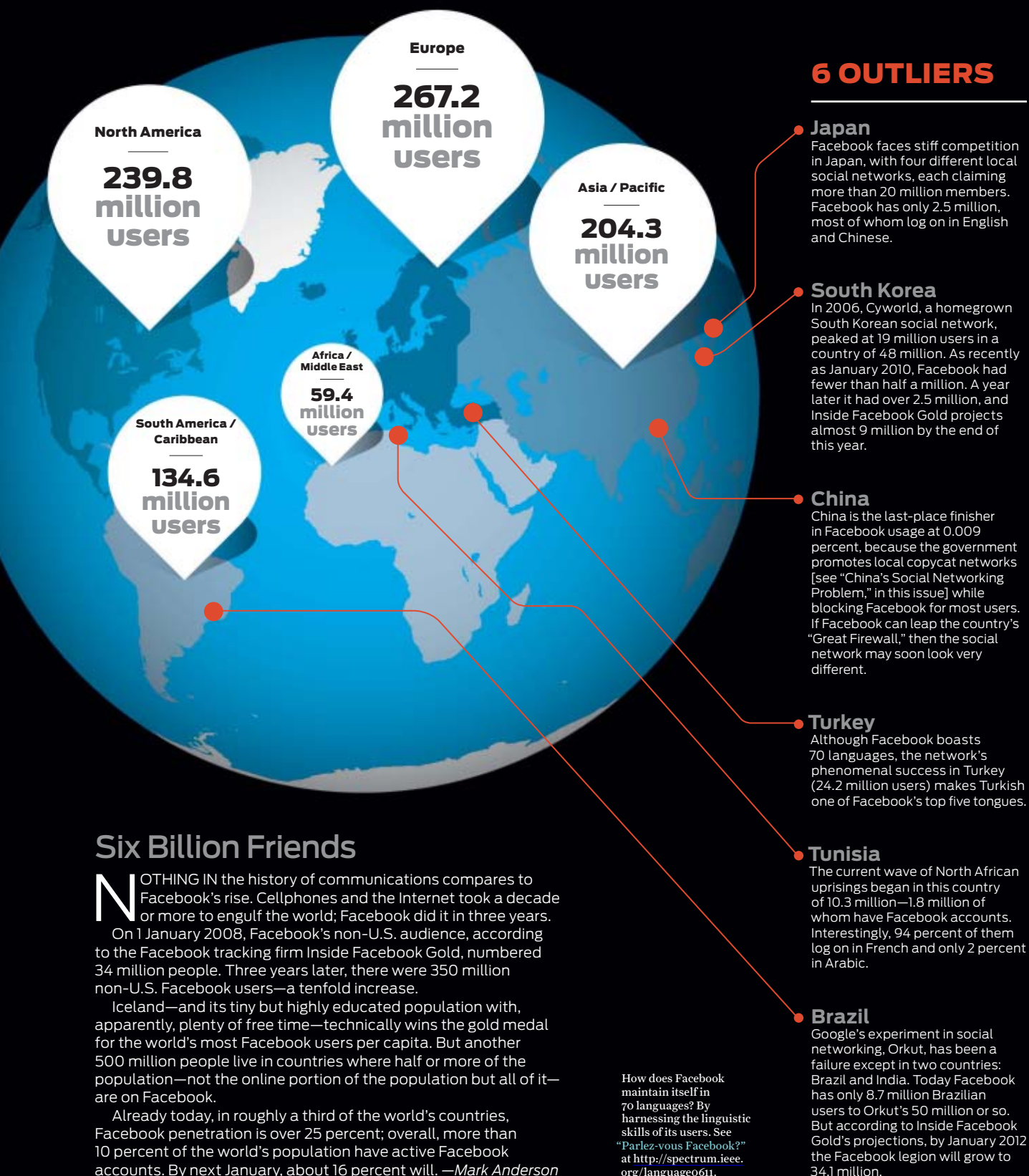
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Six Billion Friends

NOTHING IN the history of communications compares to Facebook's rise. Cellphones and the Internet took a decade or more to engulf the world; Facebook did it in three years.

On 1 January 2008, Facebook's non-U.S. audience, according to the Facebook tracking firm Inside Facebook Gold, numbered 34 million people. Three years later, there were 350 million non-U.S. Facebook users—a tenfold increase.

Iceland—and its tiny but highly educated population with, apparently, plenty of free time—technically wins the gold medal for the world's most Facebook users per capita. But another 500 million people live in countries where half or more of the population—not the online portion of the population but all of it—are on Facebook.

Already today, in roughly a third of the world's countries, Facebook penetration is over 25 percent; overall, more than 10 percent of the world's population have active Facebook accounts. By next January, about 16 percent will. —Mark Anderson



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