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Connection at Ewiiaapaayp Mountain

Indigenous Internet Infrastructure

CHRISTIAN SANDVIG

University of Illinois, Urbana-Champaign

It's a cloudy spring day in 2004 and Joseph is on top of a mountain on the Santa Ysabel Indian Reservation. He is climbing the tower that provides Internet service to the reservation. Joseph is a teenager and an apprentice network engineer, but it's a job he'll soon give up to become a valet at a nearby casino. As jobs go, it's not much of a comparison: As a casino valet he'll get tips, the chance to drive "some pretty nice cars," and the chance for promotions, while as a network engineer he gets a lower hourly wage and the chance to climb and maintain 80-foot towers with no ladder. The tower he's climbing today isn't normal as towers go—it was already erected and thrown away once (by a cellular telephone company) before Joseph got his hands on it. Joseph's brother Michael bought it in pieces from a salvage yard in El Centro and brought it here. "It was about what, 105 degrees, and we had to pick out all the bolts, the washers, and the nuts out of these 50 gallon drums . . . and count them all," Michael says. The tower adds its 80 feet to the top of this 5,400-foot mountain in the Palomar Mountains, part of the rugged Peninsular Ranges that extend north from Sierra de Juarez. Michael and his colleague Matt didn't just build the tower, they also built the road to get to the mountaintop. On the way there, "the brakes on the trailer started smoking," said Matt, "and we were saying, 'It shouldn't be this heavy.'" They had accidentally bought a steel tower instead of an aluminum one. "We had to get the whole foundation re-engineered," Michael said. Speaking of the broadband Internet system that they both run, Matt added, "We built the network before we knew how it worked exactly."

Back in 2004, Michael and Matt look on as Joseph nimbly scales the support struts to a height equivalent to the roof of a seven-story building. Matt comments, "We didn't get all the safety equipment that comes with these towers . . . like the ladders." Meanwhile, Michael crouches in a nearby plywood shed squinting into a magnifying glass held against the screen of a dusty laptop. For about an hour he rhythmically shouts out signal strength readings in isotropic decibels (dBi). He shouts, ". . . 70 . . . 70 . . . 71 . . . 70 . . . 70 . . ." as

Joseph, clinging to the tower on top of the world, repositions the giant metal bowl-shaped antennas by tiny increments. The monotony is occasionally relieved by Michael's joking and his infectious laugh. Joseph, Michael, and Matt are aiming invisible radio waves of wireless Internet at other distant mountaintops. The shed where Michael crouches is filled wall-to-wall with rows of car batteries connected to a solar array outside. The whole site is surrounded by chain-link to keep out the wild burros—they've roamed here ever since prospectors brought them in the 1850s, and they'll chew anything. Despite its scrapyard provenance, everything is well kept and looks professional, except that to a practiced eye it lacks a certain uniformity: each one of the four antennas bolted to the top of the tall tower came from somewhere else.

The tower is part of the Tribal Digital Village (henceforth, TDV), an innovative and successful solar wireless Internet distribution network that serves Indian lands in Southern California. This mountaintop has faster Internet service than my office at the University of Illinois, and it serves Indian reservations (some without phones, paved roads, or constant electrical power) where many residents now use the Internet every day, although some of them still may not have a phone. Matt, Michael, and Joseph's solar-powered metal towers—the way that the Internet is distributed here—form a system that is very different from one that a telecommunications company like AT&T would build, if they could ever be convinced to build here.

In 2010, the FCC estimated that 65 percent of American households had broadband Internet in the home. That is the proportion of Native Americans with basic telephone service. Statistics about Native broadband are largely unavailable or unreliable, but one unsourced US government estimate puts national broadband penetration on Native lands at well below 10 percent (Genachowski 2010). However, on some reservations served by Joseph, Michael, and Matt of the TDV, broadband penetration is 100 percent and every single resident reports using the Internet daily.[1] This chapter is, first, an attempt to explain the TDV's success and, second, to better understand the difference between the way AT&T might have done things and the way that the TDV has. On the way I will also explain how providing infrastructure on Indian reservations may be such a different problem than supplying it somewhere else. In this I will reflect on indigeneity, infrastructure, user-driven innovation, and appropriation—all discussed in detail later.

On the Reservations of Southern California

The TDV story began in the summer of 2000. At that time the Indian reservations in Southern California had little to no access to the Internet, and this was long after access to the Internet had become normal elsewhere. Although today we would consider it slow, virtually the entire US then had access to the Internet in some form if they chose to subscribe.[2] Almost all American Internet users (90 percent) then used "dial-up" Internet access that required the user to

place a call on a telephone line with a modem (NTIA 2000). Dial-up access was available across the US (via a metered telephone call charged by the minute), while more than 96.5 percent of the US population had access to cheaper dial-up Internet service via an unmetered local call (Downes and Greenstein 2002: 1035).[3]

On the reservations, while unmetered dial-up access was available to some places in 2000 (Downes and Greenstein 2002: 1042), on some reservations the poor quality of the telephone lines meant that a modem couldn't connect at all, or it could only connect at a very slow speed that was normal over ten years earlier (9600 bps). On one reservation the telephones themselves would not work when it rained. Other reservations had no telephone service (cellular or landline), and as of this writing they still do not. Some also lack paved roads and electrical power.

The poor state of basic infrastructure on these reservations is not unusual in "Indian Country" (a phrase referring to self-governing Native American lands in the US). By many measures, American Indians are the most economically disadvantaged group in America (Brescia and Daily 2007: 23). Those who self-identified as American Indian in the US Census's American Community Survey in 2007 are the least likely group to be employed, the least likely to hold a professional occupation if they are employed, the least likely to work in a technology-related field,[4] and the most likely to be below the poverty line (US Census Bureau 2008).

In 2000, the tribal governments in San Diego County estimated the overall high school graduation rate on San Diego area reservations at 15 percent and unemployment at 50 percent, and noted that 75 percent of primary school students qualify for free or reduced-cost school lunch programs (a common measure of poverty).[5] Michael, the Network Administrator for the TDV, explains reservations to outsiders using a comparison to the ghetto:

> Life is hard on the reservation; if you're from the inner city, you know what the ghetto is like and life is probably hard in the ghetto. Well, we're rural, but life is just like that on the reservation. You got drugs, you got alcoholism, you got all kinds of different types of abuse, the poverty, I mean, just like the whole thing.

There are few schools on reservation lands. Michael continues,

> When I was in high school, there were 26 of us that started as freshmen. We were bussed 45 minutes off the reservation to go to high school. There were 26 of us when I started, and there were three of us that finished.

The ghetto metaphor and its implicit comparison is probably helpful for Michael because he so often has to defend Native claims to poverty or need to a skeptical non-Native public. For example, online news stories about Native problems that appear on the *North County Times* or the *San Diego*

Union-Tribune Web sites always have their user-contributed comments turned off because the stories will so reliably attract slurs ("squaw," "redskin"). Articles about Native poverty or misfortune attract comments that state that "all Indians are rich" because of exorbitant welfare payments or casino revenues, or that "all Indians are drunk" or "lazy" and therefore deserve any misfortune that befalls them.[6]

Native Americans living in what is now called San Diego County are known as Mission Indians. "Mission" is a reference to place—it refers to groups that were living in the area upon the arrival of the Spanish Franciscans to colonize the region (Research Guide n.d.). In other words, Mission Indians are the people who hold the first known historical connection to the area: they are indigenous. They are often distinguished by language and descent into four groups: Kumeyaay (Diegueño), Cupeño, Luiseño, and Cahuilla (ibid.; see also Hyer 1999). These groups are further distinguished into federally recognized tribes that are sovereign and may hold land in trust. Research on disadvantaged groups that considers race may emphasize appearance, shared culture, or ancestry, but the registration (called "enrollment") in a federally recognized tribal group is a critical identity marker in Indian Country, as is evinced by its frequent discussion and the widespread logo merchandise worn by many enrolled members on every occasion—particularly baseball caps that say the tribe's name.

It would surprise most Californians that San Diego County has more distinct federally recognized Indian reservations than any other county in the United States (Sutton 2006). There are about 350,000 acres of reservation or "trust" lands in Southern California, and about 50,000 Indians living in the San Diego region (Sutton 2006: 75–76). About 8,000 Indians live on these reservations.[7]

Living on a reservation is hard to generalize about. As others have written (Sutton 2003), the details of a tribe's sovereign status and the history of the reservation lands are in each case very particular. Some San Diego area reservations were created after Luiseño leaders advocated for federal reservation status for the lands where they were already living.[8] In contrast, Cupeños from Agua Caliente (Warner's Ranch) were evicted from their homes and relocated by force to a site chosen by the US government, although some resisted and fled (Hyer 1999: 424).

The infamous forced marches from the US policy of Indian removal are usually taught in American History classrooms in units about "Westward expansion," and to the non-Indian (like me) they seem as though they are part of the distant past. (The infamous removal of the Choctaw Nation, for instance, known as the Trail of Tears, occurred in 1831.) But here in the mountains of Southern California the Cupeños were removed in the twentieth century, in 1903. Michael, a Luiseño Indian living on the Rincon reservation, comments:

> My great-great grandmother was a Cupeño—she was thirteen years old when they made the journey down to Rincon. I guess it's not that long

> of a hike. I mean, I wouldn't want to do it. But the time they chose for them to do it was really bad, and so a lot of people died.

(The march was about 39 miles over Palomar Mountain.)

As a result of the vicissitudes of history and the fluctuations of Indian policy, some Southern California reservations (such as Pala) are centrally located, reachable by existing roads, and contain arable land and ready access to water. Others are remote and virtually uninhabitable due to their mountainous terrain. Even land within a single reservation (e.g. San Pasqual) may not be contiguous and the individual parcels may not be connected by roads (Srinivasan 2006: 508). As a consequence some reservations are not inhabited, others are subject to land dispute, and some are inhabited seasonally (e.g. Ewiiaapaayp). The only common feature of the reservations in this area may be that they were lands that no one white wanted.

Offline by Design

Both in Southern California and elsewhere in the US, almost all Indian reservations were chosen as prisons. That is, the land was selected in order to isolate Native populations and to remove them from land that might ever be desirable. Today these places lack basic infrastructure like roads, power, and telephones, but ultimately infrastructure is difficult to provide in these areas by design—they are lands chosen to be inhospitable, and the residents were forcibly relocated there by the US government. For this reason, unlike other public policy initiatives that help the underserved and other rationales for telecommunications policy and universal service (see Sawhney 1994), programs like the Federal Indian Telecommunications Initiative and the FCC's Native Nations Broadband Task Force (FCC 2006, 2010) have a very different moral status. They can be conceptualized first as redress and second as a contractual obligation. Subsidizing infrastructure on Native lands is putting back something that the government earlier took away (or made much more difficult) by forced relocation. More broadly, the US government acquired most of its sovereign land area by promising a variety of benefits to Indians, sometimes in perpetuity, and infrastructure investment conceptually fulfills these treaty obligations. This is quite a different perspective than seeing these efforts as either social policy or welfare. For example, the 1851 Treaty of Temecula promises that the US will maintain shops, dwellings, and the services of schoolteachers, a carpenter, blacksmith, and wheelwright on Luiseño reservation lands in perpetuity.[9] Although clearly the technology of infrastructure has changed, the intent was to provision Native infrastructure in exchange for land. The US still has the land, but the reservations lack the promised infrastructure.

Of the eighteen reservations in San Diego County, at this writing only three contain areas that can obtain Internet service via traditional telecommunications companies. While the difficult terrain is one major obstacle, another major problem is the demographics of the reservations themselves which make them

uninteresting to corporate providers. As one network technician succinctly put it, "Not enough bodies, too much space in between." (He might have added: not enough money.)

Difficulties are also legal and institutional. As a consequence of the history of warfare between the US and Indian nations, Native sovereignty (the supreme, independent authority over a territory) is one of the most important legal features that define life on reservations. Native sovereignty includes most of telecommunications policy (see FCC 2000) and the details of sovereignty create significant legal and institutional barriers to many of the most basic forms of commercial activity as it is practiced off the reservation (for a review, see Bissell 2004).

The telecommunications industry in the US has evolved away from local efforts, and the accepted standard of service is now integration within a national oligopoly of a few companies (AT&T, Sprint, Verizon, Comcast, and so on). The demographics and geography of the reservations provide no incentive for these companies to engage with the complexities of Native legal exceptionalism. Property ownership is not possible on Native lands and digging may not be permitted—these are major obstacles to the normal approach of carriers like AT&T. A business venture always requires a negotiation with the tribal government, while any non-Native investments on Indian reservations may potentially be expropriated by the tribe. On some tribal lands, even access is forbidden without advance permission. (The reservation is surrounded by a fence, and the gate is locked.) In this institutional environment, only ventures with very high profit potential like casinos can entice non-Native investment into a reservation's collectivist (and mainly non-capitalist) economy.

Native investment by the tribes themselves is difficult because the history of neglect and poor service in telecommunications has been self-reinforcing, as tribal governments often lack technical expertise related to telecommunications. This leaves them both unlikely to succeed at self-provision and also at a serious disadvantage when negotiating with a large telecommunications corporation. One Southern California tribe granted Sprint a lien for the construction of a fiber optic backbone across reservation land, but the tribe did not realize that this was an advantageous negotiating position to ask for telecommunication services. Someone else's Internet thus transits the reservation but for the Indians there is no tap. On the surface just above the buried cable, the Indian telephones don't work.

The dismal state of telecommunications service on reservations has been an increasing source of embarrassment to the US government (US Congress Office of Technology Assessment 1995; FCC 2006, 2010). To improve the economic attractiveness of Indian populations, US subsidies on some reservations allow anyone to subscribe to telephone service for $1 per month if the service is offered, as the federal government will subsidize the rest (FCC 2006). Yet telecommunications infrastructure is still so rudimentary that telephone

service (much less Internet service) is not available to many Indian households, regardless of what they would be willing to pay. In the past, even where the telephone was available adoption rates remained remarkably low, suggesting some deeper and so far insoluble obstacles beyond cost.

TDV: The Genesis and Overview

It was in this challenging context that the TDV began and evolved from an experimental university project to an ongoing public service on tribal lands. In this section I will present the origin of the TDV and a sketch of its growth and evolution so that in later sections I can evaluate and generalize from some of TDV's particularities to the evolution of technological infrastructures generally. The TDV began with the serendipitous intervention of research scientist Hans-Werner Braun of the San Diego Supercomputer Center at the University of California, San Diego. A German-born engineer with a long and distinguished career in computer networking, Braun had designed and built Internet backbones as early as the 1980s.[10] When driving through the rural highways of northern San Diego County with his wife he had often noticed the highway signs demarcating Indian reservations. When he wrote a grant proposal to the US National Science Foundation to build a high-speed wireless network connecting remote Southern California academic research centers, he also had Native Americans on his mind.[11] Braun described the genesis by saying,

> Technology like . . . cell phones provides the illusion of reachability. Since you go out in rural areas and you often don't have connectivity, let alone high-speed connectivity. Yet many [research] centers are in very remote areas: out in the desert or on a mountaintop. When I submitted the original . . . grant proposal I wanted astronomy stuff and ecology stuff . . . and the seismic centers were all in the proposal already. Somehow I got the thought, for no good reason, wouldn't it be cool to involve Native Americans? And I put it into the proposal but I had no idea how to do it.

It turned out that the Pala Learning Center already had a grant-funded computer lab, but without broadband Internet connectivity the director has resorted to a sign on the single dial-up connected computer reading "Internet access is limited to 20 minutes." The Pala officials told Hans-Werner that on more distant reservations (like Rincon) school, library, and community center computers gathered dust because no Internet connectivity was available at all.

Thus commenced an almost textbook instance of technology transfer between Hans-Werner's university project and the tribal governments of Southern California. This technology transfer fits what the research policy literature has fittingly called "the mission paradigm" (Bozeman 2000) where government labs pursue topics of national interest with public funds, just as Braun pursued basic and applied research in wireless computing at the San Diego Supercomputer Center. As a policy goal, this public investment aims in part

to transfer both process and craft to commercial and educational institutions, ideally particularly benefiting underserved populations. Public money thus funds advanced wireless research at Hans-Werner's university and, eventually, the tribes of Southern California are the beneficiary, creating a spin-off: the TDV.

The TDV network is, at its base, also philanthropic. While initially providing university Internet connectivity to three tribes from his research project free of charge, Hans-Werner asked for installation help from tribal members and told his tribal contacts, "I'm not a service provider." A university/tribal partnership followed and eventually received a $5 million grant from Hewlett-Packard to develop the network on reservation lands, and thus was christened the "Tribal Digital Village" (the title of the grant proposal).[12]

Michael was at that time working at the Rincon Education Center as a youth counselor. When the Center was to be connected to Hans-Werner's university network, Michael participated in the day-long construction of the tower. It was a tricky enough job that each member of the team signed the inside of the radio box with black permanent marker when they finished. From this, a friendship between Hans-Werner and Michael eventually led Michael to the job of Network Administrator for the TDV, despite his lack of formal education in computing. Michael learned about networking on the workbench during visits to Hans-Werner's rural home. Michael reflects,

> we had to put IP addresses into our computers, but I didn't know what an IP address was. [Hans-Werner] just told me the numbers to put in and I put the numbers in. I had NO idea what they were for . . . [Hans-Werner] said, "When you get it set up, try to ping the other side." "Okay," I said, "what is ping?"

Experimentation quickly showed that Michael had a talent for wireless networking, a technical area where he was working with university researchers at near the state of the art. New radios, software, and network designs emerging at the time were invariably finicky, and in order to connect the reservations the TDV had to install equipment in some of the most inhospitable environments possible. Recall that most tower sites lacked power and water, and many were not accessible by road. Indeed, towers were surrounded by hostile thorny vegetation, and were subject to mudslides, rockfalls, washouts and wildfires. (Not to mention the burros.) Winds—the legendary Santa Anas—routinely topped 100 mph on tower sites, playing havoc with the delicate orientation of the antennas and solar panels, or simply blowing down entire structures during storms. Hans-Werner remembers:

> I told him . . . build a network on a bench first, and if you can make that work, you can make it work on a mountaintop. But if you start off on a mountaintop, you're not going to be able to make the network work . . . [When] Michael came online . . . suddenly there was a lot of interaction that resulted in expertise transfer, basically, by us educating them. Then

> they educate us as well about some improvements that they've made because they've improved on our design; they made it better. So there was a lot of interaction which ramped down over time as their expertise ramped up . . . initially we did the whole thing and transitioned the technology, transitioned the expertise, and it turned around after a while where we actually were being helped by [start air quotes] them [end air quotes], not only as people but also on the technology side.

The TDV developed by propagating new towers and moving bandwidth away from the university network, then it slowly grew more independent as expertise and funding increased. After three years the bandwidth used for TDV began to be reimbursed via the federal e-Rate program, a universal service initiative which subsidizes services to schools and libraries (for an overview, see Hudson 2004). With e-Rate funding, the TDV eventually stopped relying on university equipment and bandwidth altogether. Graduating from the university network had been a goal from the beginning, and Braun was delighted by this accomplishment. The TDV now exists as a government project of the Southern California Tribal Chairmen's Association, a federation of nineteen tribes.[13]

Although the build-out of TDV was challenging, some of the characteristics that made infrastructure difficult on these reservations made this wireless infrastructure ideal. As Michael says,

> You know, we were stuck on Indian reservations in the worst part of the counties. Well, guess what? Haha! We've got all the mountaintops and now we can create this cool wireless network that nobody thought we could do.

The tribes had been banished to the mountaintops, but now the mountaintops were the answer. The tribes controlled ideal tower locations and they also avoided paying rent or purchasing land by avoiding private property (TDV towers were constructed on reservation lands). Construction of these new towers on tribal lands could proceed much faster than off them, as the tribes perform their own environmental assessments. Obtaining permission for new construction is much faster from the tribal council than a building permit would be from the county.

A timeline of milestones for the TDV appears in the Appendix as Table 8.1. Over nine years the TDV grew from a connection to just one computer lab (the Pala Learning Center with the "Internet access is limited . . ." sign) to serve about 1,500 users on seventeen Indian reservations. It began as a way to provide service to government buildings (libraries, schools, fire stations, tribal offices, and community centers), as offering service to a central point in each community is common strategy for many broadband or Internet projects where resources are scarce. The start-up grant from Hewlett-Packard provided end-user equipment (like computers and printers) to jump-start the process. Almost ten years later,

a major problem for the network is now that it cannot grow fast enough to accommodate the many demands for new services on reservation lands.

To make all of this possible, Michael, Matt, Joseph, and others constructed twenty-three towers. These range from short rooftop masts to 80-foot steel and aluminum monoliths with elaborate outbuildings and poured concrete bases. As Matt explained it in 2009, TDV operates in a rectangle about 100 miles by 75 miles, spanning the area from the US–Mexico border up into Riverside County. It has 90 miles of backbone (point-to-point) links, and the backbone operates on solar power at 45 Mbit/sec, or about 800 times faster than the dial-up modem it replaced at Pala ten years ago.

This tale of continuous expansion hides important obstacles and strategies that explain infrastructure on Native lands. It also foregrounds a puzzle: How did the TDV succeed when similar initiatives on other tribal lands have not? The obstacles and strategies here concern the network of boxes, wires and waves, but also the residents and network builders. In the next section I will describe the TDV in more detail by considering the Internet users of Mesa Grande. Then in a subsequent section I will investigate the technological evolution of the devices and network engineers. The history of Native American engagement with technology makes the "missionary paradigm" for new technology more fraught than among other populations. That is, technology evangelists can remind San Diego tribal members of other sorts of missionaries.

Tribal Perspectives on the Internet

Without exception the staff of TDV explain its success as a human one. As Matt put it, in the world of tribal politics, just getting this many tribes to do anything together is a capital achievement. The TDV started by offering service to tribal government offices in part so that the first users would be the tribal leaders, who could then act as emissaries for the service to others. At the beginning of the TDV there was already a small population of Internet users on reservation lands using dial-up (as at the Pala Learning Center), and these were usually people with tribal government jobs related to education or administration. The government workers, then, were sometimes the easiest to convince as they were already users. After the TDV provided broadband service to community centers and government buildings the network builders hoped to expand the network to residences. But to do that they needed to encourage Internet use among a population that had little to no experience with Internet use.

Some of the Native perspectives on the Internet and computing generally were difficult for me to grasp because the Internet's promise of connectivity seems manifestly useful—especially in remote areas. There are a few narratives about Internet resistance (Wyatt *et al.* 2002), but these emphasize that being uninterested in using the Internet is very rare—about 2 percent of the US population was uninterested in 2009 and this is declining (Horrigan 2009). TDV staffers like Matt and Michael and outside collaborators like Hans-Werner

enthusiastically share the most optimistic view of the Internet and Internet connectivity. However, while the connotation of "new technology" for most readers will be positive, historically the interface between Native peoples and technology has often been negative (e.g. James 2006).[14] Even free Internet service can be seen as another intrusive government program that follows a stream of misguided past interventions, or as something that is potentially culturally dangerous.

The relatively short history of computing projects on Indian reservations has also produced as many warnings as successes. A project with one meaning off the reservation might find quite a different reception when brought to Indian Country. For example, one of the earliest successful educational computer games produced for use in public schools is "Oregon Trail." It was a blockbuster hit after its release in 1973 and it made the idea of educational computing on personal computers in classrooms mainstream. Although a simple game by today's standards, it is still used in elementary schools around the US. Schoolchildren play the role of white settlers colonizing the West in a manner that is quite alarming to Native users (Bowers *et al.* 2000: 194). As one instruction manual for a revised version (titled "Westward Ho!") points out dryly, as a player it is a valid move to kill both the hostile and the friendly Indians, but shooting the friendly Indians wastes bullets (Ahl 1986).

In the first blush of enthusiasm for the Internet (particularly in the 1990s) the Internet was celebrated by referring to the possibility of placelessness, or access to information without reference to place, and also to the excitement of anonymity or identity play—in utopian claims about the Internet every user could be equal. The state of indigeneity, in contrast, is a continual assertion of place and an affirmation of identity.

While past research on information and communication technologies has almost always explicitly acknowledged the problems of social justice that plague indigenous peoples, one persistent goal of researchers from this literature is to organize indigenous knowledge for its preservation and broad dissemination (e.g. Neeklmeghan and Chester 2007). But from a Native perspective the interconnection of knowledge is not read as neutral—it is read as extraction of valuable knowledge for use by others without compensation or control. As Howe writes, networked communication "condones equal and immediate access to information by all," but "this is antithetical to the social transmission of morally sanctioned tribal knowledge" (Howe 1998: 23–24).

Government agencies and foundations have promoted the use of computers for the purpose of cultural preservation among indigenous peoples (such as Roy 2006; Srinivasan 2007) and this was one of the justifications for the TDV's founding grant from Hewlett-Packard. Yet the codification of tribal knowledge has not served these nations well in the past, and to have more information available on the Internet can be seen as profoundly ignorant of the practices by which information is organized in these societies. Anthropologists have

analyzed today's taken-for-granted technological artifacts such as steel axes (Sharp 1952) and irrigation (Pfaffenberger 1988) and have found them to be implicated in the collapse of indigenous cultures and the impoverishment of Native peoples. Whatever obvious use these technologies seem to be designed for, they have also promoted genocide, forced assimilation, and dependency.

These connections between Internet evangelism and the technologically equipped missionaries of the past have not been missed by commentators: On the Internet, "tribal knowledge is usually treated as secular information with no restrictions on when it is broadcast and received, or who has access to broadcasting and receiving it" (Howe 1998: 24).

> That is, the Internet . . . is not merely the latest "foreign good"—such as cooking pots, firearms, and automobiles—to be adopted into tribal communities . . . until its universalistic and individualistic foundation is restructured to incorporate spatial, spiritual, and experiential dimensions that particularize its application, cyberspace is no place for tribalism. (Howe 1998: 26–27)

Recent Internet projects in the Navajo (Diné) Nation and the Hopi Nation found that those who participated were "concerned about the impact of the Internet on tribal members and tribal cultural knowledge" (Roy 2006: 529). From the perspective of the tribes, a critical challenge is to ensure it is still possible that "[t]ribal elders will act as gatekeepers of traditional knowledge" (Warner 1998: 77). One of the "primary ethical issues around the spread of technology in Indian Country" is "external users' access to a tribe or to an individual . . . and the impact of that interaction" (Warner 1998: 76). In other words, promiscuous connection is the problem, not the goal.

It could be easy to see this concern as exotic (or even as backwards or primitive), but reflecting on other nations quickly shows it to be quite common. France, Hungary, South Korea, Italy, and Spain have also placed legal restrictions on the media to ensure that domestic language and culture are not lost in a sea of imported content. A common approach is the screen quota (or programming quota) and domestic subsidy where a certain percentage of exhibitions are reserved for domestic languages or for domestically produced and subsidized content (Lee and Bae 2004: 164). Public debates about culture and programming quotas remain vibrant in many other countries (for Europe and the UK, see Galperin 2004: 134, 172) and are often an attempt to check or to be heard within the overwhelming flow of media from the US. In this, France and the Native sovereign nations of Southern California may be allies. Today, just as the TDV proposed a tribally separate Internet as a requirement for national sovereignty, the president of the national library of France proposed a similar effort to protect French culture from Google Books (Jeanneney 2006).

The TDV grant proposal went beyond Internet access, promising to fund the digitization of "historical photographs, songs, and spoken language," as well

as "digital storytelling," and "Web-based tools for language teaching and preservation" (for a similar project, see Srinivasan 2006, 2007). The grant also proposed a walled garden approach, including a separate e-mail system ("Rez-Mail"), e-greeting card system, and calendar to make "tribal and inter-tribal communication" easier than communication with the outside. But Native populations are not monolithic, and worries about cultural preservation and the dangers of assimilation divide sharply by class. In Eric Michaels's canonical narrative of the introduction of television production among the Warlpiri (Michaels 1994) tribal leaders speaks of the introduction of new media technology in terms of an ongoing cultural and language war between first nations and the dominant culture, and of unique first nations contributions to culture that should be subsidized and supported. But while the tribal leadership sees satellite television as a threat and part of a cultural war, the average Warlpiri television viewer in Michaels's account is thrilled by the chance to see live soccer matches for the first time. Indeed, concerns about assimilation are most often held by the cultural elite, while non-elites can be enthusiastic about new connections and the chance to use tools or see media that are common elsewhere.[15] (The same is true in France.)

Figure 8.1 The TDV services the Adams Drive backbone tower. (2008)
Photo credit: Matt Crain

Figure 8.2 Joseph climbs a backbone tower on the Santa Ysabel Indian Reservation to the height of a seven-story building. Matt comments, "We didn't get all the safety equipment that comes with these towers . . . like the ladders." (2006)

PHOTO CREDIT: Hope Hall

Figure 8.3 Ewiiaapaayp Indian Reservation has high-speed Internet access (from 1 to 45 Mbit/s) but no paved roads, electrical power, or telephones. (2008)

PHOTO CREDIT: Matt Crain

Figure 8.4 "Punky" at home with her laptop on the Mesa Grande Indian Reservation. The reservation has universal broadband adoption. (2008)

PHOTO CREDIT: Hope Hall

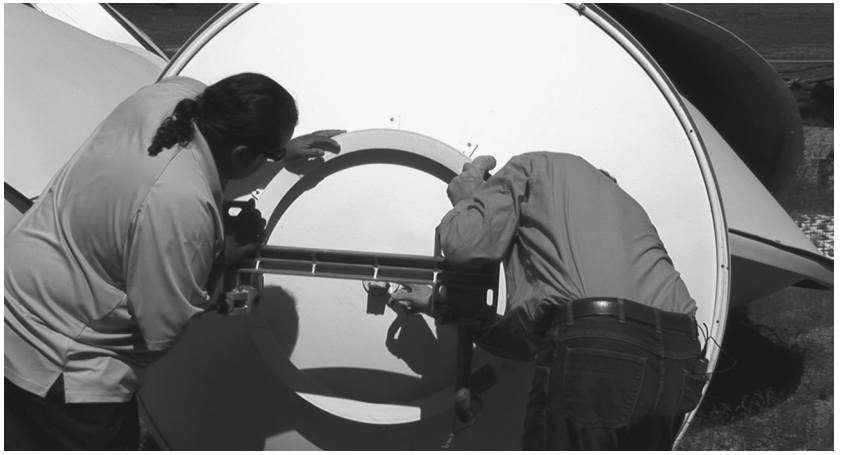

Figure 8.5 Michael and Hans-Werner examine the back of an antenna at the antenna graveyard in rural San Diego County. (2008)

PHOTO CREDIT: Hope Hall

Native Users Are Different; And They Are Required to Be

The TDV project emphasized the profoundly disadvantaged populations on the reservations and proposed the Internet as a tool for cultural preservation because the proposers were savvy about the politics of fundability. That is, funding rationales for the TDV emphasize technology transfer, poverty, and cultural patrimony rather than, say, the essential unfairness of everyone else in the US having the Internet (and telephones, roads, and electrical power) when Indians do not. The grant makes some worrying promises, however, because it implies that success for the TDV will lead to new technological developments, reduce poverty, and preserve culture. This is a serious disconnect between the everyday uses of the Internet and our usual reasons for subsidizing it. This is true for the TDV just as it is in most studies of Internet use in disadvantaged communities elsewhere: people use the Internet in a variety of ways—probably most prominently to entertain themselves and maintain their social connections. These uses conflict with the stridently instrumentalist approach of public policy and philanthropic subsidy. Our public policy assumes that users are working or educating ourselves all the time (e.g. Sandvig 2006). Thus the Internet, widely known to be a great source for pornography and idleness, can be subsidized as an educational and uplifting technological device only by developing a careful blindness about what people actually do with it.

In 2006, TDV expanded service to residential areas with a new connection to the Mesa Grande reservation. When drivers approach Mesa Grande on the only road, it jumps out of the mostly empty landscape as though it were an

oasis. Duane, a Mesa Grande resident, night watchman, and former minor-league baseball player, says, "We're out here in the middle of no place. We're 30 minutes either way from a paved road! . . . The milk man, cable man, post man don't come here." Duane's home is one of twenty-two on the reservation—all built by a 1992 grant from the US Department of Housing and Urban Development. The street of homes was built in two phases from generic plans. Architects praise a structure when it is integrated into its site and surroundings: These reservation homes are not. For the visitor, the street produces the distinctly odd effect of a stucco-walled California suburb that has been magically moved far away from its origin: the close-packed houses, streetlights, and the paved road (Hallyeyaaw Drive) start and stop abruptly, as though at a line on an unseen map. Beyond the limit, there is no paving and indeed no man-made structure of any kind. These twenty-two homes and the tribal hall are the only buildings on the reservation, although a nearby parcel is used to keep seventy head of buffalo. When the TDV first began serving residential homes instead of only government buildings (such as schools, libraries, community centers, and tribal offices), the Chairman of the Mesa Grande tribe volunteered this reservation, surely in part due to its extreme isolation.

In 2008 I visited these homes and talked with their occupants about the Internet. When I was invited into their homes I asked them to show me how they normally used it. None of the residents could recall ever attempting to use dial-up Internet, meaning that at the introduction of broadband TDV service in 2006 they went from Internet non-users to daily users. Penetration is 100 percent on the reservation, and all residents reported using the Internet daily. To spur use, residents were given free computers (though relatively simple and slow ones). Even with these incentives, the Internet's sudden popularity wasn't certain. Duane explains:

> When the computers were first given to us, a lot of people down here didn't [want them]. Either [they] weren't computer savvy or they just didn't know what to do with it, you know? Mesa Grande . . . although we're big in number, money-wise, we're probably one of the poorest tribes. And so for a piece of equipment like this to come into some of these houses, it's just a mind-blower. And it almost scares some people. [imitates others] "I don't want to break it." "I don't want somebody to find out I don't know how to use it."

Duane explains that universal adoption—suddenly every home had the Internet and a computer at the same time, and they had the same computer—helped the residents learn to use the Internet together via a mutually supportive experimentation. (Although the TDV did offer formal classes, none of the users we spoke with had taken them.) Duane says,

> I'm not the smartest bird in the world, but I can figure most things out. So I can get on a computer and send my [e-mail] and go through it.

> In fact, I can figure almost anything out. How long [it takes] is a whole different story!

All of the users of the TDV were at great pains to demonstrate the Internet's benefits for education and employment use, as this was the most readily accessible framing that would justify the existence of the network to me—and they knew the network was unusual. The moral burden of receiving free computers and not paying monthly charges meant that a frenzy of instrumental language was always deployed when I arrived, along with effusive praise of the TDV staff and government providers. The Internet was "educational," "for the children," "for the kids," "for homework," "for training," "for jobs," "for work," and "improves our opportunities." It was "a help." As Duane says, "The bottom line is it was a big help. And once people found out that it was help and not, you know, a hinder, I think, I don't think nobody down here disagrees with us being able to get it."

Of course the Internet is educational, but it is other things as well. After spending more time with the Internet users of Mesa Grande, it is clearer that they use the Internet mostly in the same way that anyone else would. Candice, a Mesa Grande teenager and casino worker nicknamed Punky, starts out with the justifications that were so familiar: "Lots of people, like, use the Internet to look into college and, you know, like, things you can do in the future. You know, and, how you can better yourself." After a longer interview, Punky admits that Mesa Grande teens use the network mostly as we would expect them to. She says,

> Oh yeah. Everybody does [use the Internet] here. Actually, you know, like, MySpace [laughs]. Lots of people down here have MySpace and talk to each other over the MySpace, chat, things like that [laughs] . . . Yeah, well, um, my cousin who I, um, I went to high school with I didn't see for a long time. And I went on her MySpace thing and found out she was pregnant, and so I congratulated her and, it's good to see that. And she had a baby, and it's a beautiful baby boy, so . . . I got to see that, and . . . she did [put the pictures online].

Again, undoubtedly Punky is right when she says that the Internet is used to "better yourself," but what is fascinating here is the moral burden—the requirement for utility—that subsidized Internet has put on Indian users. As mentioned above, providing Internet access here is one of the most difficult challenges in Internet provision anywhere. To justify their expensive and heavily subsidized use of the Internet they must perform difference—they must act like disadvantaged Indians who seek uplift and the preservation of their culture, despite the fact that (just as it was in Michaels's account of the Warlpiri), they may be more interested in MySpace or soccer games.

Duane uses the Internet for hours on almost every work day, and he was very clear about its place after he comes home from work.

> For me, I use it more as a toy than as a tool. I love the computer as far as just being able to get on it and just, uh, play on it; like I said, I mainly use it as a toy. That's my biggest thing: I'm not afraid to relax and enjoy things. I'm not one of them guys, or one of them people that have to go out and just [motions] . . . So I'll come home, eat something, and I'll come straight to my hole here [gestures at desk] and I'll turn on the TV. And the TV is nothing but noise most of the time; the computer is my main attraction. I'll turn on the TV or radio for the news and play—most the time—[online] poker, or a video baseball game [for] three or four hours at a time. You can buy a [CD-ROM game] . . ., but you buy a disc and it's just not live, you know? You play it once or twice, it's old news. Every time you get on the Internet it seems to be new, you know?

Duane also mentions keeping in touch with an old friend who travels avidly by receiving his e-mails from Amsterdam and New Mexico.

The difficulty of using public money to subsidize uses like Duane's has a long history in US policy. With the telephone, American legislators have long tried to separate the "useless" and "useful" and only subsidize the latter. For example, federal "Lifeline" subsidies have been designed to encourage telephone adoption so that the ability to call 9-1-1 would be universally available—potentially saving entire communities via the early reporting of fires before they spread. Yet this subsidy has often been structured so that the government cannot be accused of paying for talking on the phone for pleasure: by far the dominant actual use of the phone.[16]

Just as the TDV users are hesitant to admit they use subsidized MySpace and video baseball, the back-and-forth between what a technology "is designed for" vs "is used for" is obviously loaded and prescriptive in many settings. In the late 1980s French international aid agencies developed a solar-powered lighting kit for charitable export to rural Côte d'Ivoire (Ivory Coast) and other "less developed countries" (Akrich 1992). A lighting kit was chosen for charitable export because providing light is an uncontroversial use of charity. Indeed, the lighting kit itself was painstakingly designed to prevent its users from adapting it for any use other than lighting. In part the French designers restricted the system because they assumed that electricians in Côte d'Ivoire were not skilled enough to repair or modify it. (They would only break it.) Although the kit was "hardened" with non-standard plugs and wiring, in the end local electricians managed to successfully modify it to allow the solar panels to power television sets. (In international aid circles this use of charitably provided power systems is sometimes called "the television problem."[17]) Watching television was the use that the recipients of the kit most preferred, but that the designers and funders of the kit least preferred (Akrich 1992).

The TDV has avoided most controversy about the uses of these subsidies because they justifiably feel, when pressed about it, that they should be able to use the Internet "just like everyone else." While other wireless Internet Service

Providers that I have studied were justified by either straightforward profit on the one hand or transformative utopian claims on the other, the TDV was the only network that I've encountered whose most consistent internal justification is equality. While the users justify themselves by claiming educational benefits, the producers say things like "level playing field," "equality," "fairness," "getting what everybody else has." As Matt says, "It's not a money-maker. Nobody's gonna get rich." Michael makes a claim to entitlement: "It's what the people deserve."

As a provocative addendum, while the TDV may aspire to equality, the continuing mismatch of infrastructure development on reservations does make for some Internet uses that are quite unusual off Native lands, and it does provide circumstances where the TDV user is unlikely to look like anyone else. One of the earliest home users of the TDV, whom I'll call Chairman X, lived in an area without electrical power.[18] After the TDV service was installed, his new morning routine included going outside to start up his gasoline-powered generator so that he could check his e-mail. On the remote Ewiiaapaayp reservation, where there is no electricity or telephone service, communication with the outside required hiking on a footpath up a mountain to hope for a chancy cell phone signal, or a 20-minute drive to old Highway 80. The most important Internet use spoken about there was wildfire reporting and making calls to emergency services. Now Desi, an Environmental Program Manager for this Kumeyaay tribal government, has personally evolved a very distinctive communication system. He uses a solar-charged car battery to boot his laptop from the tribal hall. He then connects to the Internet via the TDV. In 2008 he had no phone service on the reservation but he was not (yet) familiar with Skype or Internet telephone services. He had a way around the problem. Once online, he bookmarked an SMS gateway Web page that allows him to send SMS (text) messages to cellular phones from the Web for free. When something comes up at Ewiiaapaayp he texts down the mountain. His texts always say, "CHECK YOUR E-MAIL."

Cloudy Days and Hard-Won Knowledge

Technologically, the challenges facing Matt and Michael differed from those of the university research network where the TDV started. The university network's backbone consisted of powered sites and used existing telecommunications towers, but the lands available for the TDV backbone were remote and often at high elevation—and they often had no infrastructure at all.

Even with $5 million in start-up funding it was clear that a traditional approach to infrastructure construction would still be too expensive. Contracting with a cellular tower construction crew that worked for Pacific Bell, for example, would quickly exhaust their budget and provide only a few installations. Matt and Michael needed to locate towers in locations where a new road or trail would have to be created for the occasion, and this created impressive new obstacles

even while it might save money on rent. Michael had the idea of enlisting his family members to carry bags of dry concrete mix and jugs of water in backpacks up steep hiking trails in order to stabilize the foundation of towers where no road could reach. Part of the unorthodoxy of Michael and Matt's approach was often the degree of risk that they were comfortable with. At one point, Michael built a tower by strapping the components onto the chassis of an ATV and driving it up the steep, rocky hillside. ("I thought [Michael] was insane," remembered Hans-Werner. "I got to the top!" replied Michael.) A later strategy of borrowing backhoes and building their own access roads was equally perilous. This is an area where a light rain can quickly turn the soil into impassable mud; the tight switchbacks and steep grades led to at least one Ready Mix Concrete Truck (bringing concrete for the tower foundation) sitting on the homemade road only to slowly lean over, with one wheel spinning in the air over a precipice. After these road-building adventures, a particularly difficult tower was constructed by dropping the equipment onto the mountaintop from a rented helicopter.

While one might think of the corporate engineers that developed and sold these towers, antennas, and radios as the experts on them, in fact the user of a device who is intimately familiar with its operation in their local context often has far more information about its performance characteristics and uses (von Hippel 1998, 2005). In this sense the TDV staff are users of the apparatus of wireless networking provided elsewhere.[19] In their construction of the TDV backbone network, Matt and Michael developed expertise with radios and antennas that made visits or phone calls with their vendors seem as though the chairs had been reversed. Matt and Michael could dictate the real performance characteristics of a given antenna or radio out of their long familiarity and the TDV's extreme conditions. To achieve connectivity in mountains across the North County and beyond, Michael and Matt often pushed beyond the limits (particularly range) listed on the specification sheets produced for their devices. In 2007, for instance, the San Diego wildfires destroyed two towers and came near a third tower at Adams Drive. The heat caused a pressure difference that exploded the glass membranes from all of the solar panels. The formerly drum-shaped, formerly airtight radio enclosures were left looking like sagging grey deflated balloons. The TDV was a kind of rugged technology sorting function: some devices continued to operate even when subjected to these terrific strains; others did not.

Matt and Michael readily acknowledge that they didn't know what they were doing, particularly in the early days. Michael jokes about their early network planning process by saying that they would get up on a mountain with a telescope and say,

> "That's the direction. Can you see this [other] mountain?" And we'd look, and we'd walk around, and we'd get under trees so we could find the way. "Yeah, we see that mountain. Okay, that's a good point." Now we'd walk

> over to the other side to the vantage point: "Now, can you see that mountain over there?" "No." "Well, let's go over here. Can you see it?" "Yeah."

Their approach provided some innovative engineering because they didn't know what kinds of configurations were off-limits or outlandish. It led to wasted efforts, to be sure, such as their foray into satellite-fed broadband backhaul (where the latency and asymmetry proved intolerable) that was later abandoned, or the network topography experiments that led to the later removal of four towers and the re-routing of the backbone itself. Yet they also gradually demonstrated the way to run a very high-speed wireless backbone completely on solar power, surprising their mentor Hans-Werner and later leading him to consult them on solar installations. During their first attempts, atypical strings of cloudy days over a few key relay towers would abruptly cut off all Internet access to most of the network. But in what economists have called learning-by-using (Rosenberg 1982: 122), recurring cycles of use, evaluation, and modification improved and then stabilized the TDV's use of solar power. As Hans-Werner said, "It's green. It's all solar powered in [TDV's] backbone. And I find that very impressive." They are now experimenting with wind.

The TDV embarked on what the business literature has called a series of "innovate-or-buy" decisions. In other words: Build my own custom wireless network infrastructure or hire consultants to do it for me. As mentioned above, the decisions seemed straightforward and were decided on cost—professional customization was too expensive. The tribes spent liberally from their initially unskilled labor instead of contracting for expensive outside expertise. But even if more funding had been available, this innovate-or-buy calculus is not always straightforward. As von Hippel writes,

> Some individual users . . . may decide to innovate for themselves rather than buy even if a traditional accounting evaluation would show that they had made a major investment in time and materials for an apparently minor reward in product functionality. The reason is that individual users may gain major rewards from the process of innovating, in addition to the rewards from the product. (2005: 61)

Von Hippel emphasizes "control over my own work" (2005: 61) as a psychological reason that individuals might invest huge sums in an innovation process rather than buying something, even something custom-made for them. However, the analog to "control over my own work" in the TDV case is tribal sovereignty, a collective overriding social goal and not a psychological one. Indeed, the technology transfer literature and public policy in this area assumes at least the learning rewards from innovation as given, and may assume that great sums should be spent on minor customizations in the hope of transferring tacit knowledge, skills, and social connections.

In this case the technology transfer rationale has carried the day, transforming Michael from an afterschool tutor to a skilled network administrator with

extensive professional connections across the forefront of wireless networking research and practice. The tribes themselves were transformed from users to producers: they now self-provide telecommunications services via TDV. In the process they have pioneered new configurations and assemblies of equipment and protocol stacks that are innovative among their peers, and copied. It is remarkable, then, that the academic rationale about the rewards of learning and control holds little weight with the people who lived through it.

Even though each struggle and setback was a chance to acquire new expertise, those involved in the project are now ready to give up their hard-won skills in exchange for normalcy. If we had the chance to do it again, they say, we wouldn't do it this way. Instead, they speak of spending their time writing more grants or raising more money to hire contractors who are already expert. Rather than delight in learning about tower construction, the expertise is a reminder that they had to do it themselves, and they didn't have the money or the status to have the same infrastructure as everyone else.

One extended foray with experimental mesh networking technology left a particularly bad taste behind. While the TDV received a grant to experiment with truly cutting-edge mesh protocols at Mesa Grande in the hope that meshing could reduce the overall system cost, they found the experimental equipment too temperamental, and soon abandoned the effort. While a successful new mesh deployment could pilot an innovative protocol suite for others, the TDV reasoned about this morally. Their users didn't deserve to be the guinea pigs of the networking world, and they aspired to "just plain Internet." Matt put it plainly: "No more experiments." Again, it's true that each trial by fire taught them something, but each piece of hard-won knowledge was still a reminder of their unusual status. Innovation, in this context, is both liberating and oppressive at the same time.

Joseph's tower climb at the beginning of this chapter provides a further example. Even though his work with Matt and Michael on the TDV surely taught him all about network engineering, the knowledge he gained was not sufficient for Joseph to pursue a high-tech, white-collar career in computing. Although he would be employable in such a job, no jobs like that exist anywhere near the reservations. (For example, almost all of the Mesa Grande reservation residents work for either casinos or the tribal government.) For Joseph, the technology transfer is a success (it developed his skills) but it doesn't take him anywhere worth going. Work in the casinos as a valet is the bottom rung of a defined career path. In contrast, a computing job is a dead end.

Appropriation Toward Parity: Understanding Difference in Technology

All of the differences between TDV and AT&T elaborated so far fit under the broad umbrella of the word "appropriation," one of the most intriguing concepts in the study of technology. Pronounced with a long second "a," to appropriate a technology literally means to possess it without permission—it denotes

ownership, control, and the ability to modify. People are generally fascinated by stories where a technology was intended to do one thing but then it was forcefully re-made in order to do something else, just as old cellular telephone towers, new wireless signals, car batteries and more were re-made to provide Internet service by TDV. Appropriation is almost never portrayed as a boring step in the development of technology–instead it is couched as a kind of noble resistance, a daring assault launched by an underdog on the powerful. (Michael: "haha! . . . nobody thought we could.") Accounting for appropriation is useful because it can free us from the assumption that technologies always unfold in the ways they are intended to, or that a particular technology necessarily produces particular consequences (technological determinism).

In cases like this one it is not helpful to think about technology as a single monolithic object (like "the Internet" or "electrical power") that diffuses (Rogers 2003) through cultures and societies. Instead the technology itself is always changing—it exists as a complicated network of interested parties who all work to achieve their own interests with and through it, changing it at every turn (Latour 2005). These changes to the technology are central in the study of appropriation. This is about more than making sense of a new technology (sometimes called domestication) and it is more than changing your life to fit a new technology into your habits and practices (sometimes called articulation). Appropriation appears in technology stories as the engine of difference (see Eglash *et al.* 2004): it's a concept that connotes virtuous inventors, hackers, tinkerers, phreaks, and colorful technical virtuosos who strive to change the sterile status quo by imprinting their countercultural ethos into the machines that they modify. Information and communication technologies are topics of special importance in the study of appropriation because they may be more easily designed to allow or forbid their own transformation and therefore appropriation (Hess [1995] terms this "flexibility," more recently Zittrain [2008] discusses this as "generativity"). Appropriation is also taken to be a significant source of innovation and creativity in the trajectory of technological design (von Hippel 1998).

I hoped, in the preceding text, to provide an introduction to the unusual challenges of infrastructure on Indian reservations, and an introduction to the unusual successes of the TDV. Yet this story has much larger implications. Like any appropriation story, the story of the Tribal Digital Village has underdogs and daring, but in the end I find it speaks for a very different perspective on appropriation than what has often been written: a perspective that I will call "appropriation toward parity." Rather than an engine of difference, in the case of the TDV it is clearer that some kinds of appropriation can be engines of *similarity* in the development of technological infrastructures, and that this asks us to reconsider the role of aspiration in the design of new technologies. In the scholarship of technology this aspirational component has largely been left out because appropriation is shown as an innovation—it leads to a technology that is culturally or technically a better fit with its users.

To recap, the TDV is a novel wireless Internet distribution network that provides Internet access to remote indigenous communities in Southern California. It was developed mainly by people with no experience in wireless technology or providing Internet service. While it is a technologically innovative system in many ways, the communities concerned would really rather have a more normal system—ideally provided by a more usual Internet provider. Matt, Michael, and everyone involved are justly proud of TDV's many achievements —it might be said it has succeeded against all odds, and although there are other efforts at tribal self-provision there is no clear competitor to TDV in terms of its technological daring, speedy rise, and universal adoption and use on some of its lands. Yet all of these achievements are also reminders of the odds and the obstacles. Matt, recall, would rather have had enough money to "just hire someone." The regrets of these reluctant innovators make their way into the design choices about the wireless system that they developed. Since ultimately their goal is to have the same Internet service as everyone else, this aspiration toward parity makes them cover up some of the novel features of their system, and (along with Native American identity and the funding models involved here) it provokes dissonance when their users need to be both exceptional and normal. Writing about appropriation has emphasized that different cultural (and geographic, and other) circumstances will produce different technological systems, just as the tribes of the Southern California mountains produced an Internet service that does not look like AT&T. Rather than celebrating the difference, it is worth noting that their different system may be striking and unusual only as a necessary step toward the ultimate goal of assimilation. (I mean assimilation both in a good and a bad sense—both as "fairness" and "sameness.") That is, appropriators may or may not produce difference by intent. The TDV is a wholly unusual distribution network elaborately built at great effort and expense using unorthodox means so that Punky can be an ordinary teenager. In circumstances of appropriation toward parity, you will design a system that is as different as it has to be so that you can be the same.

Technology tends to start with the powerful and then flows "downhill" to everyone else (see Eglash *et al.* 2004). Skilled technology designers are usually the ones who get to design and modify technology with permission, so most appropriation work involves users or otherwise non-traditional technology designers. If a relatively powerless or a marginal user is the one who ends up changing or controlling a widespread technological system this is seen by many writers as an opportunity for investigation and even celebration. Many of the most well-known writing about appropriation in the study of technology takes this template to heart as a way of understanding the forgotten or suppressed histories of technological innovation. If not handled delicately it can sound fatally patronizing, but handled well it gives students of technology and social justice a chance for celebration and optimism in a circumstance where these are rarely found. A popular current example of the genre is the blog Afrigadget (www.afrigadget.com/), where each entry chronicles examples of African ingenuity

and most of the ingenuity on display (but not all of it) involves duplicating a technological effect, function, or consequence with inferior materials. The more sophisticated researchers in this area are always keenly aware of the injustice that turns appropriation work a sour color if you look at it closely. As Eglash writes, "insofar as appropriation is a response to marginalization, we should work at obviating the need for it by empowering the marginalized" (Eglash *et al.* 2004: xvii). The TDV story shows us that there is a danger in cherishing the adaptability of the oppressed, who must adapt by necessity because they have no other choice.

In the standard view of user-driven innovation it is clear that appropriation is innovation-positive. The different user situations of the marginal and oppressed (or really, almost any diversity among users) can produce new designs and modifications, some of which may prove broadly valuable. In this view the TDV's evolution of its solar tower wireless Internet distribution system is potentially a model with wide application. The shortcuts and expediencies pioneered by TDV could be copied by other similarly constrained network builders. This view of appropriation invites us to consider the TDV as a site of innovation and perhaps a "best practice," as then-FCC Chairman Michael Powell did when he visited the TDV for a tour. However the particularities of the TDV case show that it is not a model for self-starting entrepreneurship or for a social policy.

While Powell toured Native lands to promote Native self-provision of telecommunications services and celebrate their promise and successes, he also advocated an overall do-it-yourself, entrepreneurial approach that mistakes the genesis of TDV, a project of massive subsidy. This was a well-justified subsidy, because it is not clear how an unsubsidized network would ever be viable in these areas with this population. While self-provision succeeded here, it did so because of the proximity of a major research university (a University of California campus), therefore this is not a model that can be duplicated across Indian Country. Indeed, traversing the history of TDV as we have done doesn't lead to a checklist of practices that will aid another provider to surmount the same challenges. Instead, it leads to a keen appreciation for the unique personalities, institutional factors, and luck that enabled the TDV to succeed with such an ambitious provision project. Indeed, the lesson of TDV for me has been the expensive and systemic attention that must be paid to Indian Country in order to reverse decades of neglect.

Recent research about computing and mobile phones demonstrates that there are many distinct strategies of appropriation. From Latin American culture, one is cannibalism, or appropriation through absorption and transformation. "We will swallow what they give us" and produce something else (Bar *et al.* 2007: 17). In contrast to cannibalism, another tactic is baroque infiltration, where new invasive forms of new technology are surrounded by exuberant contrasts and substitutes in order to render the new technology less effective or change the way it is used—a tactic pioneered by European Catholics to resist the culture of the Protestant reformation (20). I mean "appropriation toward

parity" as a goal and not a tactic per se, but it resonates most keenly where there is a specific history of injustice. It is impossible to know from one case study whether appropriation toward parity is a particularly Native American form. (I doubt it.) Yet in asking how appropriators like the TDV conceptualize difference in themselves and in their technology it provides us with a new way to think about technological change and human identity. It reminds us that having the Internet here at Mesa Grande or Ewiiaapaayp Mountain means something quite different than it does in the affluent suburbs of San Diego.

Appendix A: Note on Method

This chapter is an attempt at what Star (1999) has called an ethnography of infrastructure. Unlike other infrastructure studies (Jackson *et al.* 2007), learning from and with Indians is a serious challenge with unique problems and obligations (see Smith 2006). As Frank writes,

> At its deepest, the reticence by tribal . . . communities to allow non-members to undertake studies that document the issues and complexities of contemporary life combines the memory of the historical denigration of Native Americans through objectification and subjugation, often at the hands of "researchers." (Frank 2005: 13)

As a result, the research project as a whole was planned in partnership with the TDV organization, and grant funding for the project was jointly applied for and paid to the partnership. My goal as a researcher was to learn about the TDV, while the TDV's goal was to learn about itself.

Although I followed news of the TDV from 2002, I substantively engaged with TDV starting in 2003 when, along with graduate students, I interviewed the TDV directors at a variety of annual conferences and professional meetings (these interviews have continued through 2007). I also took four trips to California, one in 2004 (for one day), 2007 (two days), 2008 (for seven days), and 2009 (one day). Our interviews included tribal government staff, TDV staff, TDV users, and TDV collaborators. I have interviewed thirty-six people, some of them multiple times. At this writing I have studied the TDV for seven years (2003–2010) and amassed 380 recordings and over 1,000 photographs.

This study is then what Yin has called a longitudinal, embedded, single-case design selected for atypicality (Yin 2003: ch. 2). The method is primarily the ethnographic interview, with a variety of sources of documentation, including still photography, HD video recording, audio recording, and the collection of TDV documents intended for internal and external distribution (similar to Miller & Slater 2001). All recorded interviews were transcribed. I have also benefited from a cooperative agreement with another, related research project that has conducted other interviews independently of ours.[20]

I circulated a draft of this chapter to the community for comment (a process that ethnographers sometimes call participant validation). As our fieldwork was conducted cooperatively, our interlocutors also received copies of all of the photography, recordings, and transcripts that we produced. The response to the draft was uniformly positive. The only point of disagreement turned out to be the reasons behind the TDV's success when so many other similar projects have failed. This question "What's different about the TDV?" animated our research project, and in the end our interlocutors were as curious about it as we were. Several people who responded had different ideas and these also differed from my draft. This chapter was revised to incorporate these suggestions without altering the central argument.

AppendixB: Tables

Table 8.1 A Timeline of the Tribal Digital Village

2000	National Science Foundation awards Braun $2.3m via the University of California at San Diego to construct an experimental high-performance wireless research and education network First Indian site (Pala) added to university network
2001	Braun serves three Indian reservations and about twenty users Tribes receive $5m grant from Hewlett-Packard to expand network TDV founded by tribal governments TDV first offers service to tribal offices, libraries, and schools
2002	TDV begins experiments with solar power on mountaintops
2003	TDV bandwidth first subsidized by Federal e-Rate Program Chairman Powell of the US FCC visits to tour TDV
2004	TDV is first independent from university bandwidth
2006	TDV offers first widespread service to homes at Mesa Grande TDV begins experiments with mesh routing
2007	San Diego wildfires damage three TDV towers
2008	TDV rebuilds two damaged towers
2009	TDV serves seventeen Indian reservations and about 1,500 users

Table 8.2 Towers and Installations of the Tribal Digital Village

Year	*Tower Name*	*Function*	*Note*
–	Mt Whitney	Relay	
–	Mt Woodson	Relay	
–	Mt Laguna Observatory	Relay	University-owned Initially a telephone pole
2000	Pala	Feed	On the TDV office roof
2001	Adams Drive	Relay	Reprovisioned 2004 Melted by wildfire 2007 (but still working)
2001	San Pasqual	End	
2002	Pauma Valley	End	
2002	Rincon Reservation	End	
2002	Palomar Mountain	Relay	Wooden tower Route deprecated Tower now defunct
2002	Chairman's House	Relay	Route deprecated; defunct
2002	Los Coyotes	Relay	Route deprecated; defunct
2002	Santa Ysabel #1	Relay	Route deprecated; defunct
2002	La Jolla (a.k.a. Vallecitos Intermediate)	Relay	Previously university-owned Destroyed by wildfire 2007, rebuilt 2008

continued . . .

Table 8.2 Towers and Installations of the Tribal Digital Village . . . *continued*

Year	*Tower Name*	*Function*	*Note*
2002	Santa Ysabel Reservation	End	
2003	La Posta Intermediate	Relay	
2003	La Posta Reservation	End	
2003	Manzanita	End	
2003	Campo	End	
2004	Santa Ysabel Tract 2	Relay	
2004	Santa Ysabel Tract 3	Relay	
2005	Los Coyotes	End	
2005	Ewiiaapaayp Mountain	Relay	Infested by wasps
2006	Mesa Grande	Relay	Experimental mesh routing destroyed by wildfire 2007, rebuilt 2008
2007	Barona Library	End	
2007	Campo Intermediate	Relay	
2009	La Posta Intermediate	Relay	
TBD	Jamul	End	Planned expansion
TBD	Viejas	End	Planned expansion

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Notes

1 Mesa Grande, the reservation that first received broadband to the home from TDV.
2 About 44 percent of the US population used the Internet in 2000 (NTIA 2000).
3 This figure is from 1997 and would surely have been higher by 2000.
4 When Pacific Islanders and American Indians are both measured together.

5 These figures are taken from SCTCA grant application materials.
6 For example, "S.D. Indian Reservations Damaged by Wildfires," at: http://legacy.signonsandiego.com/news/metro/20071023–1752-bn23indian.html.
7 This estimate is from SCTCA documents submitted to the Hewlett-Packard Foundation in 2000 in the request for funding for the Tribal Digital Village Project.
8 These reservations represent a subset of the traditional lands historically associated with the Luiseño. Hyer (1999) argues that the tribally initiated creation of a reservation that included the lands that were already occupied by the tribe was attempted as an unusual strategy to prevent further white encroachment (188–189).
9 Southern California reservations were established by executive order, not by treaty. Although treaties promising compensation were negotiated and signed by the tribes and Indian agents, they were later disavowed by the US Senate and kept secret (Heizer and Elsasser 1980: 231–234). Some compensation has since been paid in the courts.
10 Actually, the NSFNET backbone. Braun was co-Principal Investigator for the NSFNET—the US National Science Foundation-funded network that succeeded ARPANET and was privatized to evolve into the broader public Internet in 1995.
11 This network became the UCSD High Performance Wireless Research and Education Network. See: http://hpwren.ucsd.edu/.
12 Half of the Hewlett-Packard grant consisted of Hewlett-Packard equipment, not cash.
13 Barona, Cahuilla, Campo, Chemehuevi, Ewiiaapaayp, Inaja, Jamul, La Jolla, La Posta, Los Coyotes, Manzanita, Mesa Grande, Pala, Pauma, Rincon, San Pasqual, Santa Ysabel, Sycuan, and Viejas.
14 In a small study of tribal high school and college students in South Dakota and Washington State, identification with American Indian identity was negatively associated with the idea that technology is a positive force.
15 Eric Michaels has since become a figure of controversy (O'Regan 1990, Ginsburg *et al.* 2002, Hinkson 2002, Deger 2006).
16 One of California's federally funded telephone LifeLine subsidies provides welfare recipients with a phone at home for $3.66 per month, but they may only make sixty local calls. For more information, see the California Public Utility Commission rate schedules: www.cpuc.ca.gov/PUC/Telco/Public+Programs/lifelinedetails.htm#discounts.
17 Thanks to Ethan Zuckerman for alerting me to this phrase.
18 Since this anecdote was narrated to me by others I do not have permission to use Chairman X's real name.
19 Both Hans-Werner and TDV mostly use commodity networking equipment, although TDV assembles its own towers and everyone involved experiments with software and configuration.
20 I would like to thank Ross Frank for his continuing assistance in this project.

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