CITIES ON THE MOVE:

How Global Solution Networks are Transforming Urban Mobility

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Catalyzing urban mobility in an era of mega-urbanization, economic austerity, and climate change demands new approaches to transportation planning and policy, especially in the megacities of the Global South. Tackling traffic problems will require marshaling untapped resources and recruiting unlikely allies.

In this context, global solution networks are emerging around what has been called the "new mobility"—a shift away from private motor vehicles toward multi-modal networks mediated by information. The world needs bold new approaches leveraging contributions and resources from all sectors of society—new global solution networks to design and implement sustainable transportation solutions.

GLOBAL SOLUTION NETWORKS

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The Idea in Brief

Catalyzing urban mobility in an era of mega-urbanization, economic austerity, and climate change demands new approaches to transportation planning and policy, especially in the megacities of the Global South. Tackling traffic congestion in such cities as Nairobi, Manila, Delhi, and Mexico City is essential to reducing carbon emissions while increasing the scope of inhabitants opportunities and quality-of-life.

Tackling traffic problems will require marshalling untapped resources and recruiting unlikely allies. Conventional transportation planning by public and private sector actors alike ignores the informal transportation networks ferrying millions of commuters daily, whether they're dollar vans in New York or matatus in Nairobi. New technologies and services will play a pivotal role in discovering, integrating, and delivering more inclusive, more fluid, and less polluting transportation networks comprising existing modes, from metros and bus rapid transit (BRT) to rickshaws and unlicensed jitneys.

In this context, global solution networks are emerging around what has been called the "new mobility"—a shift away from private motor vehicles toward multi-modal networks mediated by information. Some of these networks are generating and safeguarding the new data standards and protocols enabling these networks; others are introducing and lobbying for more sustainable and more equitable transportation policies around such networks; and still others are delivering services that are neither traditional public transit nor private operations, but a more resilient hybrid.

Hot, Broke and Gridlocked

Mobility and congestion have become paramount issues for cities facing an unprecedented wave of rural-to-urban migration. More than half the world's population—3.5 billion people—now live in cities, and their numbers are expected to nearly double by 2050[1] at a rate of more than a million migrants weekly.[2]

An enormous quantity of infrastructure is required to house, employ, and transport these new arrivals—an estimated $350 trillion worth, of which $84 trillion should be earmarked for moving people and goods.[3] Arguably, transportation is the most important investment cities can make, given its impact on land use, labor mobility, energy consumption, and air pollution, all of which in turn have profound implications for both accessibility and sustainability.

The speed and scale of mega-urbanization—and with it, epic traffic congestion and its accompanying climate impact—has overwhelmed policymakers. They struggle to understand new patterns of informal transit,

> *"Manila's traffic is considered so intractable that policymakers and business leaders alike have impractically called for "decongesting" (i.e., de-populating) the megacity."*

are unable to finance large investments due to austerity, and have largely been unable to reach consensus on how to integrate existing investments into a more coherent mobility system.

An example: Brazilian officials were dumbstruck last year when a $.09 increase in São Paulo's transit fares triggered months of violent demonstrations. President Dilma Rousseff's pledge to spend $22 billion on improving the nation's transit infrastructure failed to mollify protestors and triggered a slide in the Brazilian real on fears of a widening budget deficit.[4] Nor is money a sufficient answer—a lack of political will, a shortage of experienced project managers, and unrealistic financial expectations have prevented the construction of high-speed rail between Rio de Janeiro and São Paulo despite existing financing. That may be for the best—*The New York Times* reported in April that, despite billions spent, Brazil is littered with unfinished infrastructure projects in the wake of hosting the FIFA World Cup.[5]

Meanwhile, Manila's traffic is considered so intractable that policymakers and business leaders alike have impractically called for "decongesting" (i.e., de-populating) the megacity[6] (a call echoed in Nairobi).[7] This is impossible. Urbanization has historically been driven by the desire for economic opportunity. Cities began as nodes of exchange and trade and today they might functionally be defined by the size and scope of their labor sheds, i.e., the ability to live and work anywhere within them.[8] For this reason, efficient transportation systems are vital to residents' health, wealth, and well being, whether measured in terms of productivity, income, or social mobility. Polycentric cities such as Manila feel the strain of congestion acutely, as traditional linear public transit systems (e.g., metros and BRT) are ill suited for lower-density sprawl.

Instead, residents have turned to informal and semi-regulated transit services such as auto-rickshaws and motorcycles. Manila, for instance, is home to an estimated 3.5 million "trikes"—motorbikes with metal passenger sidecars welded to their sides.[9] Dangerous, noisy, and dirty, such vehicles are also among the most polluting on a per-passenger-mile basis.[10] This is especially significant in that the Intergovernmental Panel on Climate Change has found transport to be responsible for 23% of world energy-related greenhouse gas emissions, with about three quarters coming from road vehicles.[11] Transport has been the fastest growing energy sector for twenty years, relying on a single fossil fuel for 95% of its energy.

With oil prices hovering around $80 per barrel[12] despite hydraulic fracking and new fields coming online in Iraq and elsewhere, it would appear ground transportation faces persistently high (and eventually higher) fuel costs for the foreseeable future. If that weren't enough, the IPCC's increasingly dire warnings about climate change[13] have reinforced the need for more sustainable forms of transportation. As events like COP 15 and Rio+20 have demonstrated, nation-states and traditional political actors have made little headway on addressing the underlying issues of climate change, leaving it to local forms of governance and non-traditional actors to adopt and implement policies for sustainable transportation.

As with other global issues such as climate change, gender-based violence, and the prevention and management of global health pandemics, the gridlock plaguing urban centers will not be solved by governments alone. Nor can it be satisfactorily addressed by individual private enterprises or non-profit organizations. Instead, the world needs bold new approaches leveraging contributions and resources from all sectors of society. In short, new global solution networks are needed to design and implement sustainable transportation solutions, transfer knowledge and best practices, and bridge the governance gap between governments, corporations, and citizen stakeholders.

As defined by the GSN program, a global solution network consists of diverse stakeholders, organized to address a global problem, making use of transnational networking, with a membership and governance that are self-organized. Given the lack of leadership and funding across much of the Global South, GSNs have a significant role to play in designing, advocating for, and delivering inclusive, low-carbon transportation schemes. Aiding them are new technologies—from smart phones to electric vehicles to low-sulfur fuels—to compensate for a lack in traditional infrastructure investment.

This report is an analysis of four such GSNs to illustrate how traditional approaches to transportation planning and transit are changing. Nairobi's Digital Matatu effort mapped the city's semi-formal bus networks, providing the information for what has become an entire generation of real-time transit apps.

G-Auto has reinvented auto-rickshaw service in five Indian cities using call centers, text messaging and apps. Drivers joining its network are held to higher performance standards in exchange for health insurance, access to credit, and educational allowances for their children. The net result is better service for passengers, a higher quality of life for drivers, and fewer empty rickshaws, which in turn reduces congestion and emissions. G-Auto is the 2014 winner of the Grand Mobi Prize recognizing innovation in sustainable transportation.

The prize, in turn, is the creation of SMART (Sustainable Mobility & Accessibility Research & Transformation), a GSN at the University of Michigan that is creating knowledge and building capabilities around what it calls the "new mobility ecosystem."

The fourth example is EMBARQ, an initiative of the World Resources Institute operating five research centers around the world that are drafting and implementing sustainable transportation policies, including Mexico City's BRT system and national fuel efficiency standards.

In the taxonomy of GSNs (see box below), Digital Matatu is a hybrid of a Global Standards Network and Knowledge Network; G-Auto is an Operational and Delivery Network; SMART is a Knowledge Network; and EMBARQ is a hybrid of Policy, Advocacy, and Operational and Delivery Networks. Considering each example in turn, this report will explore the

ramifications of GSNs when it comes to urban mobility and congestion, concluding with lessons for network leaders.

The Ten Types of Global Solution Networks

1. Knowledge Networks develop new thinking, research, ideas and policies that can be helpful in solving global problems. Their emphasis is on the creation of new ideas, not their advocacy.
2. Operational and Delivery Networks actually deliver the change they seek, supplementing or even bypassing the efforts of traditional institutions.
3. Policy Networks create government policy even though they are not networks of government policy makers.
4. Advocacy Networks seek to change the agenda or policies of governments, corporations or other institutions.
5. Watchdog Networks scrutinize institutions to ensure they behave appropriately.
6. Platforms create the capability for other networks to organize.
7. Global Standards Networks are non-state-based organizations that develop technical specifications and standards for virtually anything, including standards for the Internet itself.
8. Governance Networks have achieved or been granted the right and responsibility of non-institutional global governance.
9. Networked Institutions provide a wide range of capabilities even similar to state-based institutions but with a very different modus operandi.
10. Diaspora Networks pursue problem solving through kinship and ethnicity connections.

"Their relative invisibility—partly a product of government neglect, and also corruption—means they're often ignored by the government's transportation planners, despite a modal share nearly four times larger than private vehicles."

Case Study: Digital Matatus

The Digital Matatus team studies the maps designed by MIT's Sarah Willams (center).

In Nairobi, "Hitler," "Gangsta," "Psycho," and "Gucci" aren't the nicknames of aspiring hip-hop artists or criminals, but of local bus routes.[14] The buses in question are matatus, garishly decorated 14-seaters infamous for their speed, recklessness, and cash-only operation. They became essential to the daily commutes of nearly a third the city's 3.5 million inhabitants[15] after the city's regularly-scheduled bus service collapsed in the 1990s.[16]

Despite frequent newspaper editorials fulminating against the "matatu menace," the operators aren't technically outlaws—most are registered, bearing a yellow stripe along the sides of the buses indicating their route number and destination. The problem is that no one knows how many matatus there really are, or how many riders. Their relative invisibility—partly a product of government neglect, and also corruption—means they're often ignored by the government's transportation planners, despite a modal share nearly four times larger than private vehicles.

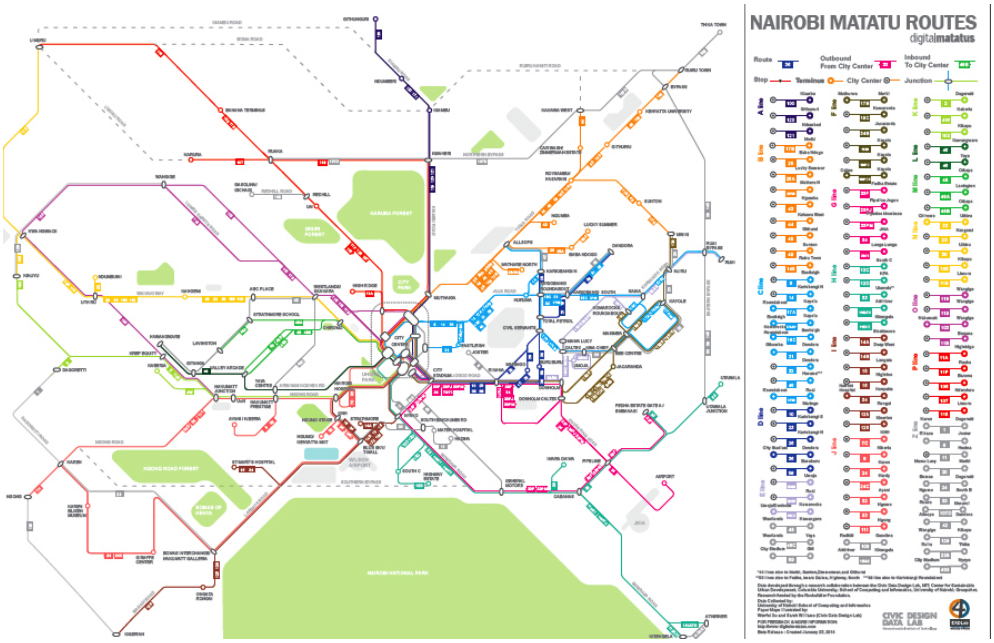
That's because unlike the centrally-planned and easily understood London Underground, "Nairobi's subway system"[17] is a chaotic one whose routes and schedules are "in many, many heads, but fragmented," says Columbia University researcher Jacqueline Klopp, who set out in 2011 to unify them with the Digital Matatus project. Klopp was working in Nairobi at the time on mapping and collecting urban data with her then-colleague Sarah Williams, now the director of MIT's Civic Design Lab. They recruited a third partner in Adam White, a Boston-based designer who was also no stranger to Nairobi and the conundrum posed by matatus—how to render an immense, complex, opaque system transparent.

White's colleagues at the University of Nairobi's C4D lab of computing and informatics, led by the data mining and mapping expert Peter Waiganjo Wagacha, had struggled to create even basic maps of matatu routes. Together, the foursome realized that mobile phones and GPS devices could capture each stop as a set of coordinates, and those coordinates could in turn be compiled into a dataset that could act as both a map and a platform

"You can make data open, but if they can't plug into computer models, it isn't of much use to anyone."

for building the matatu equivalent of popular traffic apps such as Waze (see sidebar below). "The project always revolved around the data set," says Williams. "How can we collect it? How do we create it? And how should we use it?"

They began with Wagacha and eight of his students riding matatus for months, taking care to log each of the city's 130 routes using Huawei IDEOS smart phones and Garmin GPS units. Coordinates were collected by hand and translated into data compatible with the General Transit Feed Specification (GTFS). Originally developed by Google at the request of Portland, Oregon's transit agency, GTFS has become the *lingua franca* of transit data thanks to both the ease of integration with open source tools such as Open Trip Planner, and the scale of Google Maps.[18] Working with Google engineer Brian Ferris—whose personal free transit app One Bus Away had drawn 50,000 users in Seattle—the team labored to ensure the data was both accurate and user-friendly. "You can make data open, but if they can't plug into computer models, it isn't of much use to anyone," says Williams.



The matatu route map created by the Digital Matatus team in late 2013

Williams and her colleagues at MIT used it to produce intricate yet elegant maps of the matatu system, depicting both its far-flung stops outside the city and multiple hubs in its core. It wasn't until they made the maps, however, that what began as a straightforward research project morphed into a standards network. The unveiling in Nairobi in January 2014 was a local sensation, with matatu drivers and riders alike taking pride in a map depicting them on a par with world-class transit systems in New York and London.

“There are limits to transparency, however, when it conflicts with local norms and compensation systems, also known as corruption.”

The maps made enough of a splash that the group began adding stakeholders and quickly became a global solution network, with diverse stakeholders (public, private, academic, and citizens), transnational partnerships (more on which below), progressive goals (lower emissions and greater inclusion), and technology-enabled networks. As a cross between a global standards network and a knowledge network, Digital Matatus has created a framework for common operations, transparency, and interoperability across private and public sectors when it comes to informal transportation, and has led the dissemination of that framework.

In Nairobi, the sudden existence of Digital Matatus placed the government in a bind. Confronted with proof of matatus’ existence, officials rushed to recognize the team’s map as legitimate. “People were up in arms about the government not doing it, but no one was ever worried about our being involved in such an important planning project,” says Williams. “It might have been more surprising if the government had been doing something,” because that would have implied responsibility for the matatu system as a whole, rather than as a source of official licensing revenue and unofficial kickbacks.

This created a dilemma: now that a map existed, who would own, host, and maintain it? The GSN soon expanded to add another partner, the Kenya Institute for Public Policy Research and Analysis (KIPPRA),[19] an autonomous think tank created by the federal government. Once ensconced at KIPPRA, the data was quickly incorporated into local private traffic navigation apps such as Ma3route and FlashCast’s Sonar. It also became part of the Nairobi’s transportation planning apparatus. Whereas once the city built highways without bothering to collect traffic data, Klopp notes, “If [the data is] open, you can test it.”

There are limits to transparency, however, when it conflicts with local norms and compensation systems, also known as corruption. In 2011, Kenya’s Equity Bank partnered with Google to create BebaPay, a cashless transit payment pass designed to streamline and formalize the matatu payment process, making tax collection automatic and preventing drivers from both over-charging passengers and bribing police. (Its secondary purpose was to break M-Pesa’s stranglehold on small payments.[20]) Despite a federal mandate to go cashless by July 1, 2014, drivers continue to openly flout the law.[21] Adam White predicts the pass will ultimately fail: “There’s a disconnect between Google and the informal systems in place.”

The Digital Matatus project has ended in Nairobi, but the global standards networks around open transit data continue to expand. In November 2013, representatives for Mexico City, Dhaka, Manila, and a trio of cities in China joined the matatu team at the World Bank’s headquarters in Washington DC for a bank-sponsored workshop discussing how best to promote GTFS as the global standard for transit data, especially when it comes to mapping unscheduled informal transit.[22] The designers at Urban Launchpad had taken a similar approach to create the first map of Dhaka’s bus routes earlier that year, and were already at work on one for Mexico City.[23] “We’re creating an alternative policy network,” says Klopp. “It’s not about a technology, but a

> *Real-time information about transportation has become more important than the actual vehicles.*

system,"—one that can be implemented using similar technologies adapted to local contexts.

Klopp is correct, to a point. The first lesson of Digital Matatus is that a global standards network could only have formed around Nairobi's informal transit system with the enabling technologies of open source standards (e.g., GTFS), software (Ma3route), and hardware (Android smartphones). Armed with these tools, a small team of academics, designers, and students created a proprietary dataset free from private or institutional claims or interference that then became the glue for gradually incorporating matatu riders, drivers, and owners, a government-chartered think tank, Google, the Rockefeller Foundation, and the World Bank into a broadening GSN.

The second lesson is that real-time information about transportation has become more important than the actual vehicles. It is leading to connected and orchestrated transportation systems, with the whole more powerful than any single mode within it. The ability to connect disparate modes and resources onto a single platform underlies both Uber's $18 billion valuation,[24] and Helsinki's ambitious plans to create a public "mobility-on-demand" utility by 2025.[25] This is a common theme among nearly all of the GSN examples mentioned in this report, whether they are creating or promoting standards, such as Digital Matatus, delivering services, drafting policy, or re-imagining what transit can be.

Finally, the combination of these factors presents an opportunity for GSNs to plug information and governance gaps between modes, jurisdictions and the formal versus informal sectors. An example is the Bangalore Transport Information System, which combines mobile phone traffic, GPS data and video feeds to create a real-time congestion map of the city regardless of vehicles, departments, or municipal boundaries.

Created in 2007 by former NASA scientist Ashwin Mahesh and his non-profit group MapUnity, the BTIS reflects his belief that, "If I sense some incompleteness in government, it's not the government's fault, it's my fault." Mahesh continues, "If you constantly remind yourself that you, as a citizen, have set up the government, something interesting happens. The pieces that don't exist must be created by me. Work not done by any department becomes my responsibility." Although typically unspoken, this is the credo of many GSNs.

Waze is one of the world's most popular GPS-enabled smartphone navigation apps, with nearly 50 million users at the time of its acquisiton by Google in June 2013 for a reported $1.3 billion.[26] What sets it apart from Google Maps and previous mapping efforts is Waze's ability to crowdsource information from users in real time—information including traffic events, road closures, congestion, and police stops.

Waze has been a hit with commuters, but also with governments. In 2013, Rio de Janeiro began incorporating Waze data into Centro de Operacoes Rio (COR),[27] a city-wide control room built by IBM in 2010 for $14 million.[28] On an average day in the summer of 2014, Rio's transportation planners could observe 110,000 drivers reporting nearly 60,000 incidents, from traffic jams to road hazards.

"Waze gave the COR a deeper understanding of real-time conditions," Pedro Junqueira, the operations center's chief executive, has said in statements released by the company. "Road sensors and cameras are cost-prohibitive and can't scale to every corner of our city. The context of why traffic has occurred, in addition to specific incident reports, is invaluable."

In October, Waze announced its "connected citizens" program, expanding its partnerships to ten cities and states—including Barcelona, Jakarta, the state of Florida, and the New York Police Department (NYPD).[29] The hope is to create a three-way sharing of information between users, governments, and Waze to decrease congestion and improve responsiveness.

"What this points to is how we can save you time every day," says Di-Ann Eisnor, global head of growth at Waze. "What if we saved you 60 hours a year, which is significant? Imagine that at the city level or the national level—that's billions of hours and tons of CO_2. How would it change the way we plan our schedules? What if we could plan for abundance rather than scarcity? It can only happen in conjunction with cities and governments."[30]

Operational & Delivery Networks

Case Study: G-Auto

G-Auto founder Nirmal Kumar (foreground) poses with a just few of the 6,000 auto-rickshaws in its Ahmedabad network.

The Indian Institute of Management in Ahmadabad is regarded as the subcontinent's best business school—The Economist ranks it among the top 50 in the world.[31] Its graduates typically have their pick of executive job offers, which makes Nirmal Kumar's decision to earn less than $10,000 per year[32] managing India's largest auto-rickshaw fleet all the more puzzling.

Kumar was still a student at IIM Ahmadabad in 2008 when the idea for G-Auto came to him. Returning to campus one night in an auto-rickshaw, Kumar was exorbitantly overcharged by his driver, in defiance of the posted fare and despite extensive haggling. Although the experience left him seething, this was simply how the system worked.

First introduced to India in the 1950s,[33] the three-wheeled taxis doubled in numbers between 2003 and 2010 in tandem with private vehicle ownership, generating a combined total of more than 110 million vehicles on the roads.[34] Meanwhile, public transportation's share of trips declined precipitously, falling between 20% and 70%[35] in Indian cities. In many places, auto-rickshaws are fast becoming commuters' first option, a preference vehicle manufacturers hope to export across the Global South.

"What sets G-Auto apart from Uber is social and political innovations, not just technological ones."

Transportation experts see auto-rickshaws as a double-edged sword. On the positive side, they are safer and ultimately less polluting than private vehicles (insofar as they have a lower-than-private-vehicle collision rate and replace the need to own such vehicles); they are often used as a first- and last-mile supplement to mass transit in addition to door-to-door service; and they are a vital source of employment, with more than half of all drivers supporting families ranging from five to eight members.

On the flip side, the typical auto-rickshaw's two-stroke engine produces more pollution and carbon emissions per kilometer than automobiles,[36] and poor customer service is rampant, as Kumar's unpleasant experience suggests. The majority of drivers are either single-vehicle owners or renters, which means they're incentivized to both aggressively compete for passengers and then over-charge them. (Even official fare hikes usually translate into corresponding increases in rental fees).

Just as Uber and Lyft would later integrate thousands of independent livery cabs and private drivers into city-wide ride-sharing networks, Kumar had the insight in 2008 that rapidly proliferating mobile phones would enable a new type of auto-rickshaw service. Instead of hailing rides and haggling over fares, passengers would call, text or use a mobile app to contact a central dispatcher and arrange the fare and pickup in advance. Drivers would operate under its brand umbrella, conforming to strict rules governing appearance, amenities, and customer service. Starting with fifteen drivers who regularly waited outside the university's gates, G-Auto grew to include more than a thousand auto-rickshaws across Ahmadabad within months.

What sets Kumar's idea apart from Uber—and from Indian competitors such as AutoRaja, Rickshawale.com, and EasyAuto—are social and political innovations, not just technological ones. Kumar didn't just build a company, but a social enterprise conglomerate under the umbrella of the Nirmal Group, which includes three organizations,[37] one of which is the non-profit Nirmal Foundation. The foundation, in turn, operates the for-profit G-Auto. While the latter is devoted to bettering the lives of customers through increased safety and efficiency, the foundation exists to provide drivers with security, prosperity, and dignity. "How do you convince drivers that once they are in the network, they are safer?" asks Kumar.

In practice, it means drivers receive an unprecedented array of benefits, including health insurance, life insurance, educational stipends for their children, and access to credit and banking services. They also retain the right to sell passengers newspapers and refreshments, and they can sell advertising space on their vehicles (which G-Auto helps broker). Financial security extends to higher wages, more regular incomes, and less time spent idling or seeking fares—which in turn has the bonus of lessening traffic congestion and emissions.

As hybrid social enterprises tackling multiple social, economic, and environmental problems through the use of mobile networks, G-Auto and the Nirmal Foundation represent a fledgling operational and delivery network—one that could become the template for providing last-mile

"G-Auto's determination to scale internally may be its biggest constraint."

connectivity to public transit—an alternative to voracious enterprises such as Uber. Operational and delivery networks (ODNs) harness technology and multi-stakeholder partnerships to deliver services and drive change, often supplementing or even bypassing the efforts of traditional institutions. ODNs improve on the old model of service delivery, where companies, governments, NGOs, and foundations work in isolation from each other, and where data, expertise, relationships and resources are perceived as assets that should be protected from other people and groups working on similar goals. Instead, these networks combine the skills, knowledge, assets, and capabilities of states, corporations, foundations, NGOs, and individual citizens to devise and implement effective solutions to major challenges such as climate change, corruption, poverty, or the lack of adequate health care in developing countries.

G-Auto is not yet there, as its operations are still confined within India, and the network Nirmal Kumar envisions is still emerging. But he has taken care to position G-Auto at the nexus of the public, private, and philanthropic sectors. He raised early capital from local companies looking to fulfill their corporate social responsibility obligations; after he had tapped those streams he appealed to then-Gujarat chief minister (and now Indian prime minister) Narendra Modi, who swiftly allocated public funds in support.

As G-Auto has grown to encompass 15,000 drivers in five cities, including Delhi and four cities across the state of Gujarat (Ahmedabad, Gandhinagar, Rajkot, and Surat), the company has sought to strengthen its integration with public transit networks, signing memorandums of understanding with municipal transportation corporations to share real-time vehicle information. Kumar has been hampered to date by Ahmedabad's lack of open transit data. "I'm asking them for the same data they use to plan their own routes," Kumar says. "We'll send SMS messages to customers to book G-Auto service for last mile and first mile connectivity. I am not yet successful, but it will be done, as it is going positively."

The first step will be installing counters at bus stops, trains stations, and airports where passengers might seamlessly switch modes to waiting auto-rickshaws, which will have been alerted by customers' phones. "These are the points where we want to organize the system," Kumar says. "We want to have a network of thousands of such places across India."

From here, one can begin to imagine how a full-fledged ODN might form, as G-Auto effectively becomes the delivery arm of the global standards and knowledge networks initiated by the Digital Matatus project. Using the General Transit Feed Specification (GTFS), G-Auto could quickly expand or franchise its model to such cities as Nairobi or Dhaka or Manila, internalizing the semi-formal matatu or auto-rickshaw or trike networks into its service. Franchising could be accomplished through partner knowledge networks, whether SMART (described below), or Volvo (which works with EMBARQ, described below, and which awarded G-Auto the 2014 Volvo Sustainable Mobility Award).[38]

Reorganizing the mobility patterns of India's 340 million urban residents—a population McKinsey expects to reach 590 million by 2030—is a challenge of tremendous scale. While G-Auto's fleet is the country's largest, it still represents just a fraction of the market in each of its five cities. In Ahmedabad, for example, G-Auto drivers comprise just 6,000 of an estimated 70,000 auto-rickshaws. This is also an opportunity; Mumbai alone has 150,000 auto-rickshaws still waiting to be networked.

G-Auto offers several lessons for operational and delivery GSNs, most notably its determination to reward both the service provider and the recipient, designing its offering in such a way that the initial profits from networked coordination (e.g. more fares and less idling) could produce a virtuous circle addressing externalities (such as congestion) while delivering social benefits.

But its untapped potential outside of India demonstrates the importance of aligning ODNs with standards and knowledge networks, which can respectively provide the frameworks on which to scale (such as GFTS), and through which to disseminate successful models, such as G-Auto itself. Kumar's determination to grow the service in the name of quality control may be the biggest constraint on its growth and evolution into a full-fledged ODN.

At present, Kumar is simultaneously searching for venture capital and beseeching the prime minister to make G-Auto the template for auto-rickshaws services across the country. "I want to expand to twenty additional cities in next five years, with [100,000] auto-rickshaw drivers in the network," says Kumar. "I have a plan; I just need the resources to do it."[39]

"SMART starts from the proposition that there isn't a lack of innovation, but too much of it."

Case Study: SMART

Participants of a SMART workshop in Metro Manila map transportation assets using colored stickers.

In February 2012, thirty-eight local businessmen, government officials, open data experts, academics, planners, architects, and high school students filed into a room in Quezon City—the most populous arm of Metro Manila—to map out their small corner of the mega-city.[40] They had just finished a walking tour of Quezon's central business district, paying particular attention to the northern terminus of Manila's rapid transit system, where a chaotic mix of taxis, buses, and "jeepneys" (vintage US Army Jeeps retrofitted into matatu-like mini-buses) swirled around. Sorted into small groups and armed with multi-colored stickers, participants traced the points at which all of these systems intersected, seeking spots at which to combine modes and forge new connections between the assembled stakeholders.

Although organized by Ateneo de Manila University's School of Government, the workshop's methodology had been developed halfway around the world by the SMART Initiative in Ann Arbor, Michigan. Founded in 2004[41] as a collaboration between Ford Motor Company, the University of Michigan Transportation Research Institute, and the university's Taubman College of Architecture and Planning, SMART is a global knowledge network and self-described "link tank" catalyzing what managing director Susan Zielinski calls "the new mobility"—the emerging "system of systems" defining new patterns of movement and accessibility.

Knowledge networks support the development of evidence-based policy, empower advocates with access to timely information and help drive mass-market awareness and adoption of policy solutions. As discussed in the GSN report on the topic, knowledge networks are "the origination points for disseminating new thinking to other GSNs, and the broader world."[42] Like so many other GSNs, effective knowledge networks foster a culture of openness and inclusion; their methods are transparent; and their activities typically involve multiple stakeholders across multiple regions of the world. Knowledge networks harness technology and social media to collaborate, share data, and generate and test new ideas.

SMART starts from the proposition that the problem for sustainable transportation isn't a lack of innovation, but too much of it. There are too many modes (e.g., BRT, autonomous cars), too many services (Uber, Lyft, bike-sharing), too much open data and too many new technologies for any one planning agency or freshly hatched startup to make sense of the bigger picture. Rather than stump for any particular transit mode or service, SMART's mission is to "connect the dots," generating new knowledge, services, and business models along the way.

In practice, this typically takes the form of a four-step process that begins with convening local workshops such as the one in Manila. Zielinski stresses the importance of going beyond the "usual suspects," i.e., city and transportation planners, and bringing a diverse network of public and private interests to the (literal) table. In many cases, the organizers lack experience altogether—past workshops have been organized by a physicist in Chennai, an advertising executive and filmmaker in Los Angeles, an academic in Atlanta, and a group of entrepreneurs in Cape Town.

Once assembled, these groups map (again, literally) the assets, systems, resources, services, corridors, and amenities—in most cases using stickers to identify each. The hope is that a pattern will emerge. Rather than build new transportation modes or services, simply bridging the gaps on the ground between the public and private sectors, and between organizations, will catalyze opportunities. "I call it 'public-private innovation,'" says Zielinski, "because it's many, many steps before a partnership. It's people working out what will happen."[43]

The Vytilla multi-modal transportation hub on the outskirts of Kochi, India

This usually leads to the third step, which is to implement a pilot project realizing one of the group's ideas. In the case of the Manila workshop, this led to redesigning pedestrian areas around the transit station. Other pilots are more ambitious, including a multi-modal transportation hub in Kochi, India, and an electric vehicle network in Seattle. Finally, as a coalition of stakeholders forms around these pilots, a new, localized link tank is created. To date, there are 22 cities in SMART's global network of "New Mobility Hubs" (yet another example of Zielinski's unique terminology), which started with an invitation to Bangalore, then to Cape Town ahead of the 2010 FIFA World Cup, then to Brazil and beyond. Just as workshop participants share their individual perspectives in search of a larger vision, SMART coordinates the exchange of knowledge and best practices between nodes in the larger network.

In Kochi, this process has led to a long-proposed bus terminal on the edge of the city blossoming into a hub for rail, auto-rickshaws, and even small boats. (The hub abuts a lake.) But it wasn't until D. Dhanuraj hosted the first SMART-inspired workshop on behalf of Kochi's Center for Public Policy (of which he is chairman) that anyone thought to bring the relevant stakeholders together. "The equivalent of New York City's Metropolitan Transportation Authority doesn't exist here," he says. "Even now, in most cities in India, the public transportation stakeholders all act independently."[44] In 2009, he met Zielinski in Chennai through SMART's work with the Chennai Connect Foundation, where she suggested he adopt the link tank strategy as well.

SMART's activities as a knowledge network go beyond simply convening. SMART also presents the annual Mobi Prize, awarded to cities and companies that best represent new mobility principles. The 2014 Grand Mobi went

"Sustainable transportation's most successful formula? Avoid, Shift, Improve."

to G-Auto;[45] runners-up included Moovit, a free transit trip-planning app analogous to Waze, and Divvy, Chicago's bike-sharing system.

As Zielinski notes, the roots of the "new mobility" aren't especially new. The notion of a multi-modal system integrating transit, taxis, and bicycles with a single fare collection system can be traced to Bremen's groundbreaking "Mobil Punkts"[46] program in the mid-1990s. While smart phones and open transit data have been instrumental in integrating modalities at an informational level (as Moovit does), knowledge networks such as SMART will remain necessary to join stakeholders on the ground.

What SMART hasn't done, however, is produce a large-scale operational and delivery network. What does a city-wide implementation of a new mobility network look like? Who takes the lead in orchestrating it? Zielinski's ultimate goal, befitting a GSN based in Michigan, is to build a new transportation industry around these principles, but realizing the new mobility at scale has proven elusive. Uber's success indicates the technology for coordination across multiple modes and stakeholders is ready, but so far only G-Auto and a handful of others hint at what's possible.

Case Study: EMBARQ

Passengers board a bus along Line 4 of Mexico City's Metrobus bus rapid transit network.

When Mexico City's first bus rapid transit (BRT) route was still in the planning stages a decade ago, the Metrobus represented one of the earliest

"Having a story to tell makes it easier to create relationships. Metrobus was one."

sustainable transportation projects to follow what has since become a globally successful formula: avoid-shift-improve. Avoid moving; shift people from cars to transit, and improve the quality of the transit in question. In choosing the Avenida de los Insurgentes—Mexico City's longest and busiest avenue—as its first corridor, the city ensured growth along the route would be dense and mixed-use, thus avoiding the need for longer trips. By deploying BRT to accommodate transportation growth rather than increased use of cars, it has successfully shifted 444,000 daily passengers[47] onto public transit. And through replacing 350 polluting buses with 97 new ones equipped with state-of-the-art exhaust systems and running on ultra-low sulfur diesel fuel, BRT dramatically improved the per-capita emissions attributable to those commuters by saving an estimated 47,000 tons of CO_2 annually.[48]

Today, Metrobus comprises five lines carrying 855,000 daily passengers,[49] and BRT routes running in nine cities across Mexico carry 800,000 more. The clean fuels originally mandated for the buses led in time to Mexico's first fuel-efficiency standards for cars and other light vehicles, which were passed into law in 2013.[50] And the avoid-shift-improve paradigm has become standard policy everywhere from Belgrade to Guangzhou to Paris.[51] What's most remarkable about the project, however, is that it was primarily designed, financed, and implemented not by the city or the ministry of communication and transportation, but by a Washington DC-based think tank and its partners.

EMBARQ is a hybrid of policy, advocacy, and operational and delivery networks devoted to sustainable transportation, most commonly in the form of BRT. EMBARQ's operations span the globe, working with diverse sets of stakeholders in six nations where it maintains a permanent presence, and anchors a worldwide network of partners including fellow NGOs such as the Institute for Transportation and Development Policy (ITDP) and the Partnership on Sustainable Low Carbon Transport (SLoCaT), institutions such as the World Bank and Inter-American Development Bank, universities (e.g., MIT, the Pontificia Universidad Católica de Chila), corporate foundations (Shell, Volvo), and governments.

As in the case of Metrobus and its successors, EMBARQ helps governments conceive pilots, builds technical capacity, acts as a trusted intermediary between stakeholders, and assists in project implementation. From there, it works to draft and enact policies drawn from these projects (such as avoid-shift-improve or fuel-efficiency standards), and then advocates for these policies internationally, using its global network of research centers. In doing so, it has helped scale BRT from a Brazilian curiosity to 186 cities carrying 31 million daily riders worldwide[52]—nearly two-thirds of them are in Latin America.

EMBARQ began life in 2002 as an initiative of the World Resources Institute, a self-described "activist research center"[53] for environmental issues founded twenty years earlier. Still operating as an NGO, over time EMBARQ has evolved into a network of five affiliated research centers in Mexico, Brazil, India, China, and Turkey. But to understand how it truly operates, it's

necessary to consider its activities in turn as aspects of an operational and delivery, policy, and advocacy network.

Operational and Delivery

As noted earlier, ODNs harness technology and multi-stakeholder partnerships to fill gaps in service provision—gaps that traditional institutions have either ignored or failed to adequately respond to. The Mexico City Metrobus was EMBARQ's first test, and soon after became its calling card. Invited by Mexico's National Environmental Ministry (SEMARNAT), which had already launched a study with citizen groups in an effort to mitigate air pollution, EMBARQ initially worked with the World Bank, the Hewlett Foundation, and its own principal backer, the Shell Foundation, to fund the project. But its role quickly expanded to include the creation of a new political institution—the Metrobus Decentralized Public Organism (DPO)—reporting directly to the mayor and thereby sidestepping bureaucratic turf warfare.

EMBARQ was also critical in convincing 200 bus drivers to pool their interests into a single entity, and subsequently into a single firm for each route. Later, its experts helped solicit bids for buses, chose the low-sulfur fuel, and established a trust to manage fare collection and pay for ongoing operations. The Centre for Sustainable Transport in Mexico (CTS-México), EMBARQ's local affiliate, remains involved in monitoring and planning the system's expansion.

Having successfully delivered BRT in the capital, the next step was to start and scale similar programs in cities such as Guadalajara and Puebla. The success of those municipal projects granted EMBARQ the legitimacy to take the next step and enshrine best practices as national policy. Having a story to tell makes it easier to create relationships, says Adriana Lobo, director of CTS-México. "It was very clear our role in implementing Metrobus was a high one."[54]

Policy

Policy networks are "internet-enabled networks of participants that contribute a broad range of skills, experiences, perspectives and resources to constitute an effective policy-making unit."[55] The goal of policy networks is not necessarily to wrest control of the policy making process from governments, but rather to supplement traditional top-down policy process and to engender a greater degree of transparency, consultation, and collaboration.

CTS-México is doing just that by leveraging its relationships with municipal policymakers to help draft Latin America's first fuel-efficiency standards.[56] Its credibility and technical expertise enabled CTS-México to bridge the gulf between the government and auto industry by presenting its partners at SEMARNAT with a complete draft regulation. That draft became the basis for a law passed in June 2013 mandating a new vehicle fleet average of 14.9 kilometers per liter of gasoline (35 miles per gallon) by 2016, which is expected to reduce Mexico's carbon emissions by 170 megatons per year.[57]

As an acknowledgement for its contributions, CTS-México was awarded a voting seat on the National Standardization Committee of Environment. Lobo and her team are currently working to pass a new national road safety law—an issue of global interest[58] to EMBARQ.

Advocacy

A pair of Metrobuses traveling in opposite directions along Line 4 in Mexico City

Advocacy networks seek to change the agenda or policies of governments, corporations, or other institutions, typically mobilizing large numbers of diverse participants with Internet-fueled campaigns. EMBARQ is perhaps less populous than the average campaign on Avaaz.org, but it nevertheless plays an important role in advocating for the adoption of sustainable transportation solutions around the world. For example, in addition to implementing projects at the municipal level and drafting policy at the national one, EMBARQ's international network of research centers seeks to leverage past successes in new contexts. For example, CTS-México was able to transfer its experience in organizing Metrobus drivers to Rio de Janeiro, Brasilia, and Belo Horizonte where EMBARQ Brazil assisted in launching 154 km of BRT[59] in time for this year's World Cup. Similarly, the lessons learned in tendering and contracting for new buses have been well received in India.

EMBARQ has also played a pivotal role in advocating for BRT and sustainable transportation. It frequently hosts webinars and online platforms to build awareness of successful projects, and is a founding member of the BRT Centre for Excellence,[60] a knowledge network based in Santiago, Chile comprising four universities and the Volvo Research and Educational Foundations (VREF).

But it cannot be everywhere. EMBARQ offers several lessons for operational and delivery networks. As an NGO with limited funding, it is careful to vet potential partners and projects. "We do a basic assessment on three levels," says Dario Hidalgo, the organization's director of research and practice. "One, is there the political will? Because it's so important that the decision-makers are committed to sustainable mobility. Two, there must be some basic technical capacity—at least a middle management willing to move things forward. And three, there must be viable opportunities to finance the project. It's very difficult to align all three."

Failure to do so has led to setbacks in Delhi, where a BRT pilot succumbed to political apathy, in Porto Alegre, Brazil, where committed municipal leaders were unable to secure federal funding, and in Guadalajara, where the project fell victim to political infighting. That said, EMBARQ's outsider status remains its greatest strength as a GSN. "We don't really care about government, even when it changes," says Hidalgo, "because we are an independent organization and externally funded."[61]

Another lesson for Policy Networks is the importance of bringing technical expertise to partners, "because it allows you to play an intermediary role of interest to the other parties," explains Lobo. Maintaining that expertise requires building yet another network of transportation engineers and specialists, internally (within its five global research centers) and externally through the knowledge networks in which it participates.

In the case of drafting Mexico's fuel standards, CTS-México was able to build a coalition of stakeholders beginning with the health ministry, only later adding transportation officials and other stakeholders. "We asked for the next meeting even as we presented the proposal," Lobo adds. "With these kinds of projects, if you don't have the partners, they aren't working. If you don't have the partners, you have to build them."

Implications for Network Leaders

As Silicon Valley's interest in Uber, electric and autonomous cars, and even the "Hyperloop" attests, there is tremendous potential to use networked transportation as a means to increase urban accessibility and productivity while decreasing congestion and emissions. But network leaders must understand that the real opportunities lie in illuminating, brokering, and integrating existing transportation systems (which are typically fractured across bureaucratic lines), with officially invisible informal ones, whether matatus or jeepneys. Some points for network leaders to keep in mind:

It's about integration, not infrastructure. According to Global Infrastructure Basel, 75 percent of the infrastructure that will be in place in 2050 doesn't

exist today.[62] This assumes governments and capital markets will find the aforementioned $84 trillion necessary for moving people and goods by that time. Despite Nobel Laureate economist Paul Krugman's arguments[63] for increased infrastructure spending by the US (and other economies with slow growth, low interest rates, and high corporate savings), the political logic of austerity means funding for large-scale transportation projects will be hard to come by. Even high-growth nations such as the Philippines are turning in desperation to public-private partnerships, which have been slow to materialize.[64] The opportunities for network leaders lie in recognizing gaps between existing assets and systems and deploying lightweight, low-cost strategies to bridge them.

SMART recognized this early on, creating a knowledge network before the information and communication technologies necessary to flexibly recombine nodes had entered widespread adoption. The Digital Matatus team demonstrates what only now has become possible, transforming an outlaw bus network that nonetheless transports 40% of the city's commuters into a more legible network using little more than smart phones, GPS units, and an open transit data format.

In fact, GSN research has consistently demonstrated that high-impact innovations—whether in mobile health applications or in crowdsourced disaster relief maps—do not necessarily have a high price tag. Innovation is about identifying ways of doing business more effectively and efficiently, and well-executed projects can often help networks save money.

"Disruption" isn't necessary. Uber is the poster child for Silicon Valley's cult of disruption, which the new Silicon Valley site Pando Daily translates as,[65] "Let us do whatever we want, otherwise we'll bully you on the Internet until you do." Uber's hostility toward regulation has forced many cities into a visceral fight-or-flight reaction to networked transportation. But it doesn't have to be that way. As seen in the case studies above, there's tremendous value to be realized for all stakeholders—public entities, private firms, and passengers and drivers alike—from creating new services at the edges of existing transportation systems. Rather than simply networking informal resources for profit, as Uber has done, mutually beneficial models are possible.

G-Auto is an exemplar of what Uber could be: a genuinely disruptive force whose only real trick is aggregating existing resources (e.g., Auto-rickshaws) on its smartphone-enabled platform. But whereas Uber is determined to consign as much as possible as external to the firm—including driver insurance and passenger safety—G-Auto has vertically integrated both driver and passenger welfare instead. This has smoothed the way for expansion and greater integration with Indian cities' transit systems as their last-mile provider of choice. That doesn't mean it isn't still disruptive—what Nirmal Kumar calls the "auto mafia" of angry auto-rickshaw owners temporarily drove the company out of Ahmedabad's airport. But network leaders should focus, first and foremost, on adding value by working with existing stakeholders rather than disrupting them.

Orchestrate a multitude of network types and solutions to address complex issues. The case studies reviewed above demonstrate the value of mobilizing a variety of network types to reduce urban congestion and build sustainable transport solutions. Operational and delivery networks address gaps in existing infrastructure by harnessing the resources and competencies of multiple partners to build new transportation services. Policy networks foster the transparency and collaboration required to forge more progressive and effective regulatory frameworks. Knowledge networks generate and disseminate the data and insights that help transfer knowledge and best practices among disparate actors working to achieve similar objectives. A similar logic applies to climate change, and indeed most complex global problems where a diversity of actors and solutions is needed. The most effective solutions to global problems will involve the orchestration of multiple network types working in tandem.

Replicate local successes in other regions to make the leap from local to global. The jump in scale from local to global is important in the context of addressing urban congestion. As with other problems addressed by GSNs, the problems of urban congestion inherently cross jurisdictional boundaries. But as SMART's global network of "New Mobility Hubs" shows, there is tremendous value in creating a network that identifies local innovations that could be applied elsewhere. Of course, replication of local successes often entails constraints. It takes significant investment to replicate networks in different languages, for example, and local or national actors, who are less interested in seeing congestion reduced outside their own country, may not invest in the time required to make sharing their experiences easy. There are, however, enormous missed opportunities when local innovators and network leaders fail to replicate models and aggregation information across countries. These aggregations and replications, pushing toward truly global solution networks, represent important investments for network leaders in the coming decade.

Tap the power of informal networks. New York's semi-legal dollar vans carry an estimated 120,000 passengers per day—enough to make this America's 20th largest[66] bus service, if it were to be recognized as such. As the example of Digital Matatus demonstrates, the lowest-hanging fruits for network leaders are the informal and semi-formal transit systems that exist in every city—whether they're dollar vans, matatus, jeepneys, or auto-rickshaws—but are kept separate from both riders and official transportation planning due to their outlaw status. Incorporating them into formal systems requires multi-stakeholder networks on the ground (both at a political and infrastructural level) and in the cloud. At the same time, the growing power to organize locally may lessen the need for their services. Network leaders will need to consider how they can best add value in a world where bottom-up problem solving is increasingly the norm. Otherwise they risk falling into the same trap that many international organizations and public sector entities have encountered—that ensuring their own sustainability could become more important than actually solving the problem.

Which brings us to…

As with other global issues, the most transformative transportation technology of our time is the smartphone. Whether for Uber or G-Auto, the phone has become the focal point for first- and last-mile door-to-door service, or what EMBARQ labels "intermedia public transportation." Simultaneously, apps such as Moovit, RideScout, Citymapper, and even Google Maps (which has added the ability to hail an Uber from within the app after Google Ventures invested $268 million in the company) are rapidly becoming a unified interface for commuters. Even the most progressive city leaders have been slow to recognize[67] this—shockingly, only Helsinki has announced a municipal government-led initiative to build an app including these capabilities.

One reason networks fail to harness mobile technologies is that they lack the competencies to build mobile applications internally and they just don't know where to start. However, other GSN case studies suggest that a lack of mobile capability is by no means a show-stopper. Application development contests have offered numerous networks a means to incentivize and surface new mobile innovations, and have demonstrated that a relatively small amount of prize money can yield a significant investment in innovation.[68] Another means to take advantage of the mobile technologies and capabilities is to partner directly with the companies and university research labs at the cutting edge. Universities such as MIT are well known for their numerous research labs chock full of eager grad students who are pioneering public-good applications of advanced technologies. Most students would like nothing better than the opportunity to get involved in real fieldwork. Technology companies like Google, Facebook, HP, Intel, and Cisco have demonstrated similar enthusiasm for getting engaged in global problem solving initiatives that showcase the social and environmental promise of their latest wares.

The most important transportation mode matters less than the information about that mode. Indeed, as an enabler of transportation innovation, smart phones are next to useless without open, real-time transit data. Unsurprisingly, transit data has become the glue for combining existing systems. As the Digital Matatus case demonstrates, where transit data doesn't exist, it becomes necessary to create it. Perhaps the greatest threat Uber et al. pose to government isn't their threatening posture toward taxis and public transit, but their refusal to share their data. In exchange for allowing them to operate more or less according to their own rules, cities should extract their data in return.[69]

Network leaders operating across a variety of domains are finding that open data is a highly effective means to aggregate knowledge and attract a larger and more diverse network of problem solvers to the cause. By open sourcing their approach, and particularly their data, network leaders can stay more attuned to emerging issues and social expectations and can also leverage the complementary resources and capabilities needed to address them. For example, a larger external audience may spot opportunities or challenges in the data that your internal team doesn't have the expertise to recognize

or act on. Whether building a network of Digital Matatus in Nairobi or using a mobile phone to source advice on how to safely administer OxyContin to a mother in the midst of childbirth, the capacity to harness creativity of networked crowds is among the most important skills for network leaders to hone in the years to come.

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nutritional data from growth monitoring clinics in developing countries to government and UNICEF databases, while providing instant feedback to mothers on the changing status of their child's growth and nutritional needs. Second and third place prizes were no less transformative. The runner-up was a health diagnostics application that connects health care workers in under-served regions to medical specialists and collects real-time data for interventions in areas such as maternal mortality, cancer or AIDS. Third place went to Ushahidi, the crisis reporting application.

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About Global Solution Networks

Global Solution Networks is a landmark study of the potential of global web-based and mobile networks for cooperation, problem solving and governance. This research project is a deliverable of the GSN program, offered through the Martin Prosperity Institute at the Rotman School of Management, University of Toronto.

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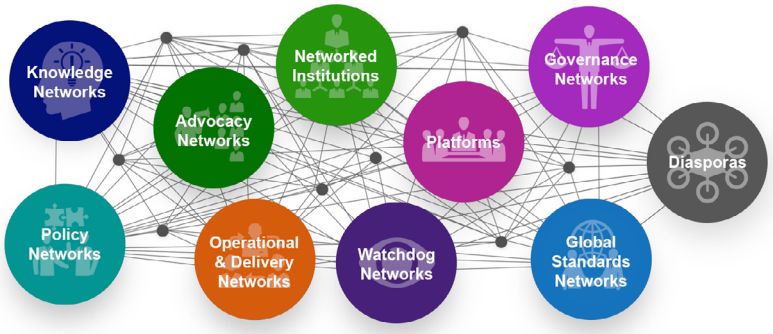

Ten Types of Global Solution Networks

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