

Technology-Mediated Social Arrangements to Resolve Breakdowns in Infrastructure During Ongoing Disruption

BRYAN SEMAAN, University of California, Irvine

GLORIA MARK, University of California Irvine

When societies experience disruption as caused by natural disasters, various official government agencies, relief organizations, and emergent citizen groups engage in activities that aid in the recovery effort—the process that leads to the resumption of normal life. In war environments however, societal trust can be affected and people may develop distrust of the institutions and associated individuals that provide and resolve breakdowns in infrastructure. This paper reports on an ethnographic study of the use of ICTs by citizens experiencing ongoing disruption in a conflict zone. We conducted 86 interviews with Iraqi civilians who experienced the 2nd Gulf War beginning in March 2003. We show how citizens used ICTs to continuously resolve breakdowns in infrastructure during ongoing disruption caused by the conflict by creating new, reliable technology-mediated social arrangements that enabled people to maintain daily routines for travel, education and obtaining information. We then discuss new ways to think about infrastructure and implications for the disaster relief effort.

Categories and Subject Descriptors: **K.4.3 [Computers and Society]:** Organizational Impacts – Computer-Supported Cooperative Work

General Terms: Human Factors

Additional Key Words and Phrases: Infrastructure, human infrastructure, trust, collaboration, crisis informatics, disrupted environments, routines, recovery, ontological security, empirical study

1. INTRODUCTION

One of the outcomes of natural disasters and war is the breakdown and destruction of infrastructures: physical, technical, educational, transportation, and others. Repairing infrastructure is a long and costly process and survivors may wait years for the government and institutions to repair and rebuild it. Daily lives of citizens can become a hardship as a result, affecting home life and travel, and the use of institutions such as schools and workplaces.

However, the increasing and widespread adoption of ICTs (Information and Communication Technologies) provide people with options on how they can respond to disasters. More and more, researchers are discovering how, through the use of bricolage using technology, people can find and provide assistance and information [e.g. Palen and Liu, 2007; Torrey et al., 2007; Sutton, 2008], and maintain situational awareness [Starbird and Palen, 2011], during disaster. It is critical during severe disruption that information be reliable and trustworthy, as people need access to information in order to take action. However, the official sources that people typically rely on for information may no longer be reliable during crises. Oftentimes, the information provided by official channels is too slow, or outdated [Hagar and Haythornthwaite, 2005]. In the most extreme cases, official governmental sources may be misleading [Tai and Sun, 2007]. There is evidence that technology has enabled people to obtain and provide information relevant to their situation from unofficial, or “back-channel” sources—by connecting with local citizens, as well as with people living outside of the affected area [Hagar and Haythornthwaite, 2005];

Author’s address: Department of Informatics, University of California, Irvine

e-mail: [bsemaan, gmark]@uci.edu

Permission to make digital or hardcopies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies show this notice on the first page or initial screen of a display along with the full citation. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credits permitted. To copy otherwise, to republish, to post on servers, to redistribute to lists, or to use any component of this work in other works requires prior specific permission and/or a fee. Permissions may be requested from Publications Dept., ACM, Inc., 2 Penn Plaza, Suite 701, New York, NY 10121-0701 USA, fax +1 (212) 869-0481, or permissions@acm.org.

Hughes et al., 2008].

In this paper we continue this research direction of how ICTs are used in disrupted environments, but shift the attention from information dissemination to focus on how citizens use ICTs to be able to use damaged infrastructure. We are interested especially in how people recover from a crisis in an environment where societal trust has eroded. In this paper we discuss how ICTs mediate the development of new social arrangements based on trusted networks, which, in turn, resolved breakdowns in the infrastructure that people rely on to maintain their daily routines. As we will describe in our research setting, a war zone, people could no longer depend on the people and institutions that maintained the infrastructure. Citizens took initiative to resolve breakdowns and make the infrastructure usable, as part of the recovery process from the ongoing crisis.

2. RETHINKING INFRASTRUCTURE

Infrastructure is the underlying foundation of a society [The American Heritage Dictionary, 2011]: the necessary equipment (i.e. buildings, roads, electric grids, or communication networks) that supports the *routine activities* of social systems. For example, people rely on the transportation infrastructure of road and highway systems, or the electric power grid to supply their homes and institutions.

Whereas infrastructure is generally regarded as physical or technical, some researchers have explored the notion of infrastructure from a more human-centered perspective [Star and Ruhleder, 1994; Bowker, 1994; Lee et al., 2006]. In this view, infrastructure is composed of various social, organizational and technical components, where the social and technical aspects are interwoven [Star and Ruhleder, 1994]. More recently, specific analytic attention has been given to the social, or human, element of infrastructure. Similar to physical infrastructure, human infrastructure is the underlying foundation of a system, in this case social, constituted by the pattern of relationships of people, through various networks and social arrangements [Lee et al., 2006]. Individuals in the human infrastructure can be central figures in one's social network such as family, friends and colleagues, less central but still key figures such as physicians or teachers, or persons outside of one's social network, such as taxi drivers or repairmen. When we use infrastructure, e.g. electricity, we generally do not think about the technologies working behind the scenes (i.e. the electric grid), the work that goes into maintaining the proper function of electrical systems, or the people involved in maintaining the systems that power our homes and work places (engineers, electricians). These members of the human infrastructure include what Bowker [1994] refers to as invisible workers, who are individuals that make the infrastructure work from "behind the scenes." These are people who are often unnoticed. A bus mechanic, for example, is an essential element of the human infrastructure as he supports people's ability to use a public transportation system. Thus, physical and technical infrastructures are largely dependent on the human infrastructure to function, and, in turn, social systems rely on the human infrastructure to support daily routines, such as travel, and receiving education.

3. INFRASTRUCTURE AND ONGOING DISRUPTION: RECOVERING FROM DISASTER

Infrastructure is relative to the situation and environment. In the event of a change or failure in the infrastructure, the inner workings, and also importantly, the social arrangements that comprise the infrastructure, may become visible [Bowker, 1994].

After a crisis event, restoration of infrastructure, in particular that which supports daily routines, is an integral part of the process of how societies adapt and

thus resume normal societal function. Star and Bowker [1999] describe how in the face of the unexpected, the human infrastructure engages in *articulation work*—the efforts required to resolve breakdowns. The articulation work that takes place after a crisis is integral to the resumption of normal life; it has been well documented in the case of hurricanes and tsunamis [e.g. Dynes, 1970; Hoffman, 1999].

The process of adaptation, characterized by the resumption of normal societal function, is known as the recovery phase of crises. Hoffman [1999] models the recovery process as taking place in three stages. Throughout the various stages, people adopt social arrangements to engage in articulation work that aids in the reconstruction of the physical and technical infrastructures.

In the first stage, it is often the case that the public engages in pro-social behavior. The individuals and groups who emerge and lead the initial response effort are typically not from the formal groups that we associate with the relief effort, such as the Red Cross, but rather are citizens from the surrounding or local community who help rebuild in the aftermath of a disaster. In the second stage, external relief organizations (e.g. The Red Cross) enter to help in the reconstruction effort. Local government agencies and other institutionalized social arrangements, such as the fire department, also work towards the common goal of maintaining and rebuilding the physical infrastructure so that people can maintain their daily lives. People also rely on kin during this period as a form of “self-help.” For example, friends and family often travel to visit their families in affected areas to provide them with monetary support. The third and final phase of recovery, known as the passage to closure, is marked by a return to normalcy where people resume their daily routines.

Throughout these phases, citizen and official groups that provide aid have proven to be highly creative and improvisational [Kendra and Wachtendorf, 2003]. Across several different crises, people have improvised by assuming and developing new roles [Webb, 2004], and by self-organizing to engage in non-routine activities [Kendra and Wachtendorf, 2003], to meet needs. For example, during Hurricane Katrina, U.S. citizens who owned boats conducted search and rescue missions.

An example of the interconnectedness of the human and physical infrastructures can be found in the case of the Northeast Power blackout of 2003, which affected approximately 55 million citizens of Canada and the U.S. The failure of the electric grid in this case, caused a chain reaction that affected other infrastructures, such as water, transportation, communications, and work places [CNN, 2003]. Traffic lights did not function leading to excessive traffic, public transportation was inoperable, electronics and air conditioners could not be powered and people could not receive up-to-date information from news networks. Here, while various elements of the physical infrastructure became visible, citizens also became aware of the human infrastructure. Emergency response units as well as representatives from local agencies, e.g. firefighters and police officers, provided evacuation assistance to citizens trapped in subway cars. Energy workers worked around the clock to restore the power grid. Thus, these official social arrangements engaged in work that made the infrastructure usable again. When power was restored, the physical and human infrastructure resumed their typical invisibility.

It is not always the case, however, that a disruption can be resolved in a timely manner where normal life and the reliance on infrastructure therein, can resume. External events in the environment can be so severe that they cause “slippages”—changes to a social system—to take place [Barley, 1986]. When slippages persist, they become replicated patterns that are counter to former practice, and people restructure their patterns of action accordingly to reconfigure to the setting’s revised institutional structure. Structural changes can emerge. A protracted disruption in an environment can cause recurring breakdowns in institutionalized infrastructure, and

may act as a catalyst for people to reconfigure their social arrangements and technical elements that comprise the infrastructure so that they can strive to maintain their routines. As with natural disasters, people living in a war zone may experience a breakdown in the infrastructure for a prolonged period of time. However unlike natural disasters, war can involve continuous disruptive events with cycles of infrastructure destruction and recovery. Hoffman's model is directed to natural disasters; with war, recurring threats and uncertainty of the environmental situation can make it challenging for citizens to meet physically.

4. SOCIETAL TRUST DURING CRISES: RESOLVING BREAKDOWNS WITH TECHNOLOGY

Trust has been investigated from several perspectives, e.g. morality [Uslaner, 2003], risk [Fischhoff et al., 1981], and confidence [Luhmann, 2000], and in various contexts: the public sphere [Miztal, 2001], organizations [Zand, 1972], distributed work settings [Handy, 1995], disaster [Weick, 1993] and war [Colletta and Cullen, 2000]. We define trust as *how people manage expectations of other individuals or institutions* [Handy, 1995]. Furthermore, trust carries the connotation of reliability based on those expectations [Giddens, 2000], as people are often dependent on others [Zand, 1972]. For example, ordinarily people generally expect societal institutions and individuals employed by them to provide and maintain reliable infrastructure. Interpersonal trust refers to how trust, on a more personal level, is made up of the expectations individuals have of other people [Abdul-Rahman and Hailes, 2000]. For example, when riding a bus in a normal environment, people trust that the bus driver will reliably deliver them to their stop. Impersonal trust, on the other hand, refers to the expectations that people have of institutions [Abdul-Rahman and Hailes, 2000]. For example, citizens of Chicago will likely have impersonal trust that the Chicago Transit Authority, a municipal corporation, will provide a reliable transportation system.

Giddens [1990] makes an important contribution to our understanding of trust. He argues that in the modern world, people have placed their trust in "abstract systems" (impersonal systems), which can include the infrastructure that people use daily. This is related to *ontological security*. Ontological security is a sense of order and continuity in regard to an individual's experiences that is produced and reproduced. Because people enact their routines by relying on abstract systems (the infrastructure and impersonal social arrangements) on a daily basis, they trust them despite not having the knowledge to create or maintain such systems on their own. Although we may not know how such systems work internally, or know the individuals who maintain such systems on a personal level, we have the expectations that such systems and social arrangements are reliable because we are able to reproduce our routines daily.

When disruption occurs, Weick (1993) argues that in order for people to overcome their situation, they must interact in a respectful manner, and trust one another. In other words, people must act in good faith. During disaster, people often engage in respectful interaction. For example, citizens who are not associated with the formal relief effort, and live within and outside the geographically disrupted area, converge on the site of disaster to aid others by helping them rebuild infrastructure (e.g. Dynes, 1970). During a war, however, trust in a society can break down [Colletta and Cullen, 2000], making it difficult for people to rely on the institutions or individuals that can enable normal societal function [Semaan et al., 2010]. When impersonal and interpersonal trust are lacking in a society, we contend that technology can mediate people's ability to resolve breakdowns and even create new infrastructure. If citizens cannot trust people in their local environment who maintain or allow them to use the

infrastructure, technology can equip people with the ability to construct new social arrangements, irrespective of distance, so as to make the infrastructure usable.

5. METHODOLOGY

Our data is based on interviews of Iraqi citizens who experienced ongoing disruptions to their routine lives, as caused by the second Gulf War beginning in March 2003. Our study is part of a larger research program where we are trying to better understand the role ICTs play in repairing people's daily practices when living in disrupted environments [e.g. Mark and Semaan, 2008; Semaan and Mark, 2011].

We conducted 86 semi-structured interviews in both English (67 interviews) and Arabic (19 interviews) with individuals who currently live, or had been living, in Iraq during the current conflict. Two members of our research team, both of which are native Arabic speakers, conducted the Arabic interviews. All interviews were then transcribed for analysis (interviews conducted in Arabic were first translated to English prior to being transcribed). The first phase of interviews, with 20 informants, began in September 2007 and ended in May 2008. The second phase of interviews, with 25 informants, originated in June 2008 and ended in December 2008. The third and most recent phase of interviews, with 41 informants, commenced in April 2010. By conducting an ongoing study over three separate time intervals, we were able to capture and document long-term, evolving technology use by Iraqi civilians.

In order to gain insight into how technology was being used to repair routine practices when living through ongoing disruption, we asked people to describe their lives before and after the war. Our first set of interviews focused on the use of ICTs for maintaining work and social collaborations. The second set of interviews focused on the use of ICTs for maintaining routine aspects of life. The most recent interviews focused on the impact of the war on societal trust, and implications for daily life. Though our interviews were conducted over a period of two years, researchers studying disasters using an interview methodology have found people's memory to be reliable long after a significant event [Rodriguez et al., 2006]. Additionally, it has been found that people can correctly report typical, recurring activities they engage in over time [Freeman et al., 1987].

We were unable to travel to the warzone to engage in observations and face-to-face interviews. Our presence in Iraq would put not only our own lives at risk, but would also put our informants' lives at risk. Militia and insurgent groups often targeted Iraqi citizens who were seen interacting with foreigners (especially Americans). We were also not able to send our informants camcorders to record their daily lives as this method would have posed several risks, as people were not allowed to record in public without their equipment being confiscated by both U.S. and Iraqi forces. Rather, we engaged in what anthropologists refer to as "ethnography at a distance" [Benedict, 1946]. First, we conducted interviews with people living in various cities ranging from southern to northern Iraq (i.e. Basra, Baghdad, and Mosul) using one or several technologies, e.g. the telephone, and Skype™. Second, we interviewed Iraqi émigrés to countries outside of the war zone, such as the United Kingdom and Sweden, using technology as well. Third, we conducted face-to-face interviews with local Iraqi refugees in the United States who immigrated to cities in southern California: San Diego and Los Angeles. We only recruited participants who had been outside of Iraq for two years or less to minimize issues related to the degradation of memory. Lastly, we collected archival materials in the form of written and video blogs, pictures from online photo-sharing sites, archives from online fora, Facebook data, and historical documents (i.e. news publications and books) which we triangulated with our interview data.

Two members of our research team are of Iraqi decent; one is part of the Iraqi community in San Diego, California, and the other left Iraq shortly after the first Gulf War in 1990. Both group members found informants through family and friend contacts. We also sought more Iraqis for interviews through Facebook. Additionally, our team member from San Diego located more informants through various refugee groups and Iraqi church organizations within Southern California. We utilized a snowball sampling approach [Biernacki, 1981], used in other HCI studies [e.g. Hagar and Haythornthwaite, 2005], using recommendations from our interviewees. Research participants were found via multiple seeds, which increased the chances that our population sample was diverse.

Interviews lasted anywhere from two to six hours in length and could span over multiple days and sometimes months. The majority of our interviews were conducted over the phone or Skype™, and we were highly limited by the technical infrastructure within Iraq. On average, per interview, our phone conversations would end abruptly between three and four times due to a mobile or Internet network failure. If we were unable to re-connect, rescheduling could take days, weeks, or even months. For our face-to-face interviews (15 informants), traditional Iraqi social protocols were observed. It is not polite in Iraqi culture to begin an interview right away; rather, it is appropriate to have a light discussion beforehand and drink tea or other beverages. After completing these in person interviews we were often invited to have lunch or dinner with our informants.

Our informants were diverse in age and education as well as professions. They ranged from 18 to 60 years of age. We interviewed high school students, as well as undergraduate and graduate students in various disciplines, ranging from engineering and medicine, to English literature and journalism. We also interviewed people in various professions such as professors, journalists, translators, and doctors.

We analyzed our data using a grounded theory approach [Strauss and Corbin, 1998]. Grounded theory foregrounds this data and helps create evolving hypotheses through systematic coding of data. In the course of this coding, patterns become visible giving rise to hypotheses that, in turn, can be validated and falsified through further coding.

6. RESEARCH SETTING

Our informants have been living in an environment disrupted by war for over eight years. While the conflicts that preceded it (the Iraq-Iran war from 1980-1988 and the first Gulf War in 1990) and the United Nations imposed embargo, weakened the infrastructure, the most recent war has done the most damage [UNHCR, 2010]. Prior to 2003, our informants described how the infrastructure supporting communication, such as telecommunications lines and the national power grid, functioned properly. However, though Iraqis had access to a functional landline telephone system prior to 2003, they were unable to call people living abroad. An Internet service became available in 2002, but many websites were blocked, and the government monitored online activities.

The embargo lifted after 2003, and several technologies entered the country. Although the landline telephone infrastructure was destroyed, today, all of our informants have integrated information technologies into their daily lives, ranging from mobile phones to various Internet-enabled applications, such as instant messenger and e-mail. Since 2003, militia attacks on power stations and other government operated sources of energy led to a discontinuous source of electricity. People often claimed that the government only provided them with electricity for four to six hours a day.

6.1 Damage to the Transportation Infrastructure

Before the war, the transportation infrastructure was intact and it was safe and easy for Iraqi citizens to travel and meet for social activities. There existed a constant flow of electricity, and traffic lights always functioned. Our informants expressed how travel was easy: traffic congestion was rare and they could safely drive their own vehicles. One informant explains:

“We used to travel everywhere in Iraq. We, as the locals... we used to drive our own cars and go to other provinces, and we used to spend more than one night outside of Baghdad... it was so easy and safe to do anything we wanted...”

Additionally, Iraqi civilians often relied on various forms of public transportation. First, when the Ba’ath party was governing Iraq (between 1963-2003), they developed a bus system that Iraqis used on a daily basis where people could easily travel within a city or to other governorates within the country (i.e. Anbar, Babil, Karbala). Second, people also used transportation organized by their workplaces (most organizations were sanctioned by the government). These organizations often made available what our informants have referred to as a “mini-bus” system, to transport people to and from work. Lastly, in Iraq, various locations existed where government-sanctioned taxis would congregate. Our informants reported they could rely on any taxi driver they could find. Thus, our informants could carry out routines with little unplanned disruption.

Today, Iraq’s citizens may no longer safely and easily travel with personal or public transportation. First, random bombings throughout the country make travel highly unpredictable. All of our informants have described at least one first-hand encounter with a bomb detonation in both public and private areas. Second, fighting often takes place throughout Iraq between various groups (i.e. competing sect-based militias, insurgent groups, the Iraqi army, and U.S. military forces). An average of 140 to 180 enemy-initiated attacks occurred per day between mid-2005 and 2007, which included attacks against Iraqi infrastructure and government organizations [Global Security, 2009]. Third, a newly implemented checkpoint system has also made travel complex. As people travel throughout the country, they must stop at multiple U.S. Army and Iraqi military enforced roadblocks where cars are searched, and people’s IDs are checked. While roadblocks were instituted as a safety precaution, they have also been used for harm. Militia and insurgent groups which are typically composed of individuals who align with one of the dominant sects of Islam—Sunni and Shiite—create fake checkpoints where they can then kidnap (for ransom) or kill innocent civilians who are of the opposite sect. Several American news outlets have reported the rise of fake checkpoints in Iraq and how they have contributed to the deteriorating security situation in the country [The New York Times, 2006]. One informant reports:

“OK, in 2006, mainly in 2006 to 2007, the major problem was the fake checkpoints by militia members and militants. We usually use the term militants for the insurgents, and militia for the religious groups. They were setting up fake checkpoints in these areas for a specific time, for 30 minutes to snatch up people from their car. First they would check their IDs and their tribal names, to have an idea about their sect or religious background. So if you are from the other sect or religious communities, they are going to snatch you up and kidnap you...”

Further, all of our informants claimed that they did not feel safe hailing a random taxi or riding in a bus as the drivers, as well as the other patrons, could be potential

sources of threat. This is explained in the following excerpt from one of our informants, a journalist in Baghdad:

“...public transit wasn’t quite reliable. Well you could get kidnapped. The people themselves would hurt you. Taxi drivers were kidnapping you, taking you to a neighborhood that was dodgy, and you may not survive. They would take your cellular phone from you and call your family members to ask for money. This happened to many people, and some people were returned to their families while other [people who were kidnapped] were killed after [the kidnapper] got what he wanted.”

6.2 Damage to the Educational Infrastructure

Before 2003, Iraqi citizens had impersonal trust in the government’s ability to provide an infrastructure that supported education. They also relied on the social arrangements (teachers, administrators) that made the educational system function. According to UNESCO [2003], prior to the first Gulf War in 1991, Iraqi higher education was of an international standard and staffed by high quality personnel. Although the UN embargo on the country, as well as attacks on the infrastructure leading up to the current war in March 2003, could be viewed as the beginning of the deterioration of Iraq’s educational infrastructure, the basic educational infrastructure remained intact. First, although approximately 30% of Iraq’s best trained educators left the country after the first Gulf War [UNESCO Fact Sheet, 2003], the majority of this group—e.g. medical doctors, and Ph.D. holders—continued to instruct the new generation of students. Second, several educational institutions ensured that students who could not travel to school due to family emergencies and illness could obtain photocopies of course materials.

The educational infrastructure has deteriorated significantly since March 2003 [UNHCR, 2010]. Our informants report negative expectations of the government’s ability to maintain the infrastructure supporting education. Initially following the war, lab equipment was stolen and not replaced. According to UNESCO [2003], following the onset of the current war, approximately 84% of Iraq’s educational institutions were burned, looted, or destroyed. Medical students who often needed practical lab experience by performing medical procedures on cadavers found that, whereas before the war began one cadaver was available for a set of two to four students, now two cadavers were available for an entire class. Textbooks were no longer up to date. Lecture notes were no longer made available for students who could not travel to the university. Additionally, academics, college students and educational institutions were targeted during the war. Whereas a minority of educators left after the first gulf war, the majority of those who remained were targeted and murdered, or fled the country following the current conflict [UNHCR, 2010]. Between 2005 and 2007, an estimated 340 academics and 446 students were killed, and between March 2003 and October 2008, 31,598 attacks were carried out on educational institutions in the country [UNHCR, 2010]. As a result, senior level graduate students and recent Master’s and Ph.D. graduates instruct the new generation of students.

6.3 Damage to the Information Infrastructure

Prior to 2003, the Iraqi government limited the flow of information into the country. The government regulated satellite television stations, and only five government operated news networks were available through official channels. Newspaper outlets, journalistic publications, and radio stations were also government operated. All of our informants claimed that the information provided to them was not trustworthy, but that it was their only option.

After the war began Iraqis faced a new problem: it became difficult to determine which sources of news are reliable. People now have access to official local government sources of information and global sources from other Arab countries, the U.S., and elsewhere. Our informants expressed that they believe the news provided by the Iraqi government is biased. Additionally, there is currently an information glut as many sect-based militias now own and operate various local news and media outlets, and people do not trust these information sources.

Thus, in addition to damage to the infrastructure, there is a deterioration of trust in Iraqi society due to the war. Interpersonal trust in others, particularly strangers, has declined. Impersonal trust in the human infrastructure especially, but not solely related to the government, has also lowered substantially. People do not feel safe utilizing public transportation, do not trust that the education system will deliver, and they do not trust information from official sources.

7. TECHNOLOGY AS A MEDIATOR IN RESOLVING BREAKDOWNS IN INFRASTRUCTURE

Star and Ruhleder [1996] describe how human infrastructure is interwoven with other infrastructures, e.g. technological and physical—the physical and technical infrastructures would not function without the support of the human infrastructure.

As discussed earlier, when breakdowns in infrastructure occur, the human infrastructure in charge of maintaining and repairing other infrastructures also becomes visible. Social arrangements of people in charge of maintaining the integrity of the infrastructure often engage in the necessary articulation work to restore the functioning of such systems. After a breakdown is resolved, the infrastructure and its associated social arrangements become invisible once again.

From our data, we discovered that when the war severely damaged the infrastructure used for transportation, education, and for relaying news information, the infrastructure became highly visible for a prolonged period of time. More importantly, the institutionalized social arrangements (i.e. in government) that typically engage in the necessary articulation work that ensures that the infrastructure operates reliably became exposed, and it showed that the human infrastructure was unable to provide and maintain working, reliable infrastructures for societal needs. Additionally, unlike disasters where citizens engage in pro-social behavior [Dynes, 1970], in this war environment people could not trust strangers. As our informants began to adapt to their environment, they became self-reliant. The slippages due to the infrastructure damage [Barley, 1986] served as an opportunity whereby they created their own social arrangements. ICTs, e.g. mobile phones and Facebook, equipped people with the ability to create social arrangements with others in their trusted social network who resolved breakdowns in the infrastructure, making it usable again—this was an ongoing process. Behavior became improvisational as people assumed new roles based on emerging needs. Figure 1 shows a model that illustrates this relationship between ICTs, social arrangements, trust, and resolving breakdowns in infrastructure.

Importantly, the technological infrastructure was *not* “always on.” The ICTs that people adopted following the war, because they were embedded in the technical infrastructure, did not always work. The severely damaged electric infrastructure affected people’s ability to use the technical infrastructure and communicate easily, as at times they could not power their computers, or use the Internet. Additionally, the mobile phone network did not always work. At times communication signals were jammed by the U.S. armed forces to prevent militia and insurgent groups from communicating when sensitive operations were taking place. In other cases, too many people were using the mobile phone network rendering it inoperable.

However, people were highly innovative and worked around the disruptions to the infrastructure by creating redundancy in their tools. First, everyone in our sample described how Iraqis have installed generators in their homes, and in other cases, large community generators have emerged providing electricity to entire neighborhoods, enabling people to continue powering their technological communications devices even when the power grid is off. Second, all of our informants now use from four to eight different communications technologies. Through our analysis we found that people are adept at switching between the different technologies when one is not working in order to maintain communication. For example, when the Internet is down and people are unable to communicate using Instant Messenger, Skype™, e-mail or Facebook, they will then switch to the mobile phone and use the voice or SMS capabilities provided by such technologies. In these cases, inherently, they are then not only switching from one technology to another, but also from one technical infrastructure to another (i.e. the Internet network to the mobile network). Half of our informants also use more than one mobile phone. A new practice has emerged where people now purchase mobile phones from more than one carrier to ensure that they can still communicate with people in the event that one mobile network is down.

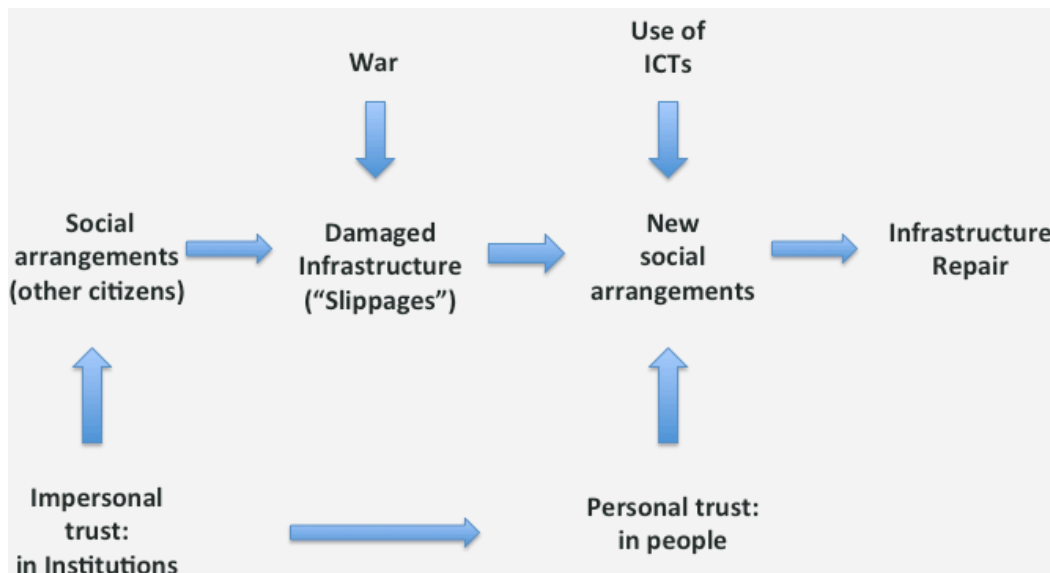


Figure 1: Social arrangements and trust related to infrastructure, before and during the war

We next present cases showing how ICTs mediated the development of new social arrangements that helped to resolve breakdowns in infrastructure vis-a-vis new collaborative practices and self-organization.

7.1 ICTs Supporting New Collaborative Practices with Trusted Networks

Studies of disruption have found that people often turn to family and friends [Hoffman, 1999], as well as community connections [Shklovski, 2010] like neighbors, school peers and work colleagues, for support in the aftermath of a disaster. This support is typically provided face-to-face. Hoffman describes how during the Oakland Fire Storm, family members and friends of affected victims often traveled to the site of physical destruction to provide monetary and emotional support. In an environment disrupted by violent conflict, however, it may be difficult for people to

provide support to one another in collocated settings. Although in some cases our informants created new technology-mediated social arrangements in collocated settings (i.e. at the university), various obstacles made it difficult to create new social arrangements face-to-face. Although family and friends may be living in the same country, they may be unable to travel to provide assistance. Also, people may flee the affected area and travel to safe countries. Lastly, community members are often separated during such events. For example, neighbors may move to other areas within the conflict zone making it difficult to reach these support networks in person.

Our informants reported that they created social arrangements that were comprised of strong ties—individuals within their kinship networks which consist of family members, close friends, work colleagues and school peers that are considered to be as close as familial links [Ebaugh and Curry, 2000]. These social arrangements were thus comprised of trusted networks where people reconnected across distance using ICTs. Nearly all of our informants claimed that they now communicate with people from their kinship networks more frequently than they did before the war, despite their inability to travel and visit people face-to-face. They cite the adoption of various ICTs, and the ease with which they can communicate when using these ICTs, as the main reason for the increased frequency in communication.

Additionally, our informants also constructed new social arrangements that consisted of weak ties: recommendations of people from their strong ties. Granovetter [1973] discussed how when the individuals who comprise one's closest group do not possess the information or social resources that one needs in order to conduct their daily life, weak ties can be invaluable resources. When a strong tie does not possess the necessary resources to provide a service for someone, they will often recommend an individual that is part of their network on which their strong tie can then depend. For example, from our data, we found that our informants often relied on both strong and weak ties for travel (as we will explain in more detail in subsequent sections). Thus, the articulation work that typically takes place in order to restore order when unexpected situations take arise, shifted from official to unofficial channels comprised of Iraqi civilians. We will now describe how our informants used technology to aid in the recovery process by developing new collaborative practices to resolve breakdowns in the transportation and information infrastructures.

7.1.1 Resolving breakdowns in the transportation infrastructure

In Iraq, the work involved in making the transportation infrastructure usable has transferred to unofficial citizen based networks. ICTs enabled people to obtain information regarding whether or not it was safe to travel to certain areas, and also to secure trustworthy drivers.

7.1.1.1 Travel safety information: "surveying the land"

Our informants reported that citizens are engaging in new collaborative practices for seeking travel information by using mobile phones, e-mail, and Instant Messenger, or by perusing their friend's Facebook status updates. They use ICTs to contact strong ties in their social network (family and friends) in the location to which they are traveling, to inquire about the local situation. If people do not have a close contact living in an area, they traverse their network of strong ties to seek recommendations of people who they could then rely on for vital travel information. The social arrangements people formed served an emerging need and created new roles for people: *travel information providers*. People utilized these new arrangements to obtain the knowledge they needed, in the form of safe and alternative travel routes.

One informant, an Iraqi translator for the U.S. army, refers to this process as "surveying the land." His daily work routine was such that he needed to travel to

various locations throughout Iraq. Prior to setting his travel routes for the day, he would contact his strong and weak ties at the various locations he was going to visit by using his mobile phone, e-mail, or Instant Messenger, to survey the traffic and security situation—he would contact family and friends, as well as people recommended by his close ties to obtain information about what was taking place at those locations to find out if roads were blocked, as well as if it was safe to travel. Via his peer-to-peer network he was able to determine which routes to take, as well as whether or not he was going to travel to certain locations for the day. His ability to connect with others was, in rare cases, limited by the technological infrastructure. In the event that the mobile phone networks were not working, he then relied on the Internet. However, not everyone in his social network could be contacted online at all times of the day. All but four of our informants engaged in a similar practice. In several cases, people felt that this new collaborative practice was a life-saving measure. One informant explained:

“My family calls me from Fallujah, I’m on the way back to Fallujah, they say turn around, there are too many car bombs that just exploded, so they will not allow you. In so many cases we had to wait long, long hours to be searched. There are so many incidents, where not only did it save my life, but it also saved me from possible danger.”

Additionally, with the aid of ICTs our informants collaborated with these new social arrangements to bypass the fake checkpoints that were being setup by militia and insurgents groups. Forty-five of our informants reported contacting their strong ties using the mobile phone, SMS, or instant messenger, prior to traveling to certain locations to inquire about fake checkpoints. In other cases, thirty of our informants discussed how trusted kinship members would contact friends and family members who they knew would be traveling to certain locations in order to warn them. For example, students who went to school together, or co-workers working for the same organization, would call their friends who they knew would be traveling the same route. One informant describes this new practice:

“For instance, I have a friend in Sadr city. He’s a very close friend of mine. One day I wanted to visit him and it was big risky move for a Sunni to travel to Sadr city. He called me and said the Mahdi army is checking for IDs, so turn around and return. It saved my life.”

In other cases, people who know one another from before the war who were of opposite sects could engage in this same practice to warn their family, friends, peers, and co-workers about impending dangers:

“For instance I have some Shia friends and they go to work and there might be some Shia militia, and they know I’m Sunni and they’ll call and warn me. And vice versa that would happen also. We would use SMS and voice...”

7.1.1.2 Private transportation networks

Our informants also reported that people have re-organized their roles within Iraqi society as a result of the war, where they have now become bus and taxi drivers. Forty-three of our informants engaged in new collaborative practices whereby they organized their own social arrangements for transportation composed of strong and weak ties. Our informants contacted people within their network of trusted contacts using various technologies, e.g. mobile phones, Yahoo Messenger, and e-mail, to hire a driver from a trustworthy contact or to seek a recommendation from an individual with whom interpersonal trust existed before the war (i.e. a weak tie). Thus, people

developed their own transportation systems; the social arrangements are now based on unofficial as opposed to official arrangements.

One informant, for example, was employed as a lecturer at a university in Baghdad. He is also a father and lives with his wife and his two younger daughters who are both still in high school. Whereas before the war they relied on public transit, he no longer trusted the people operating the bus system. He perused his personal network of contacts using his cell phone and found through word-of-mouth recommendations that a teenager in his neighborhood (who was the son of people he trusted) was now operating his own vehicle in order to drive people to school. He hired this young man to drive his daughters to and from school, as well as his wife to work. Every member of this family now owns and carries a mobile phone at all times, and they use their phones to keep one another up-to-date as to whether or not they arrived safely to school or to work, or back home.

Many of our informants developed a new collaborative practice where they used available ICTs to seek people from within their pre-existing network of trusted contacts who are taxi drivers, or to seek recommendations of trustworthy taxi drivers (weak ties). Some of our informants made exclusive deals with a single person to act as a personal taxi driver. Others compiled a list of people who they could depend on by leveraging their social networks. Once they created a list of trustworthy drivers, they would then traverse their list of contacts when they needed to travel.

One informant, an interpreter working for a large United States based organization, described this new practice as “phone hopping.” Whenever he needed to travel to and from work, he would essentially start “at the top” and work his way through his list of trustworthy taxi drivers until he found someone that was available. He owned one mobile phone, but carried two SIM cards from different providers. If one of the mobile networks was inoperable, he would switch SIM cards and use the other network.

7.1.2 Resolving breakdowns in the information infrastructure

Crisis situations are also information disasters, as information can be disseminated slowly, or can be inaccurate [Palen and Liu, 2007]. Despite the fact that our informants do not trust the news, the majority of our informants spent hours per day collecting information from various sources across multiple types of media, e.g. the satellite and Internet. People wanted to stay up to date on what was taking place in their country as well as abroad—this information often played a pivotal role in people’s lives as they used it to contact friends or relatives living in areas that were under duress to verify whether or not they were safe. However, the official social arrangements that people relied on to engage in the articulation work [Star and Bowker, 1999] proved to be unreliable. This signaled a shift whereby people developed new collaborative practices within their trusted networks in order to *obtain accurate information*.

7.1.2.1 Validating information sources through cross-checking

Eighty of our informants established new social arrangements consisting of strong ties whereby they could then validate information. Technology (i.e. mobile phones, instant messenger, and Facebook) enabled people to develop a new collaborative word-of-mouth practice on which they could rely to repair the information infrastructure via cross-checking in order to validate information. Thus, people were cross-checking against personal accounts of events by individuals with whom they have strong ties. Iraqi citizens assumed a new role, where they were acting as producers and disseminators of information that challenged the official control of information.

The majority of our informants reported contacting a relative or friend via technology, e.g. by sending a Facebook message, composing an e-mail, or sending an SMS, to verify what was being reported by Iraqi or foreign mass media outlets. They used technology to initiate discussions with people who could verify what was taking place across the country—people who were present at various locations throughout the country that could then confirm or contest what was being reported by official news sources. The news they were validating was typically local news about events taking place within Iraq (i.e. how many casualties were caused by a car bomb that was reported, or if an attack actually took place in a certain part of the country). The following is an excerpt from an informant, a journalist in Baghdad, that is a representative example of this:

“... I don't trust all the news that's available, or that's broadcast on satellite. I don't trust every channel; it's different on every channel. The news is different. Some say there were that many killed, and others say there were this many killed, and neither of them match up...I rely on people. I rely on the people who were actually there, where the disturbance occurred. Like when a bomb goes off, I rely on people who were actually in the place, or on site when the bomb happened, when the bomb went off. I also rely on word of mouth, and the news that is transferred from one person to the other. I feel that's a reliable source. You just believe... you disbelieve the news from regular sources, or official sources, but you rely on people that you know, and the news that they're telling you.”

7.2 ICTs Supporting Self-Organization

Another important theme from our data was that ICTs were used to support self-organization. Self-organization is a creative process whereby people engage in new patterns of action that were non-existent previously; people may form new relationships to support these activities (Kendra and Wachtendorf, 2003). We describe how ICTs mediated new self-organized patterns of action to resolve breakdowns in the infrastructure supporting education, thus aiding in the recovery process.

7.2.1 Resolving breakdowns in the infrastructure for education

The current institutional arrangements in Iraq are unable to provide educational resources. As a result, the work involved in restoring the educational infrastructure has shifted to unofficial, citizen-based groups. Using ICTs, a group of informants consisting of university students self-organized and *obtained updated education materials*, and also *created educational resources*, thus expanding their role within the educational system.

7.2.1.1 Updating educational materials

From our sample of eighteen informants who were medical school students in Baghdad, six self-organized whereby they engaged in a new ICT-mediated pattern of action to obtain new, updated books. Our medical school informants claimed that they could trust other medical students because they came from similar backgrounds. Utilizing an online forum, one medical student initiated a new social arrangement consisting of other students from the university. Once the new group was established, by continuing to use the forum, she coordinated and led private on-campus meetings. One of the members she recruited—who happened to be a partner in the OXFAM International Youth Partnership—connected the two groups via e-mail communication. Ultimately OXFAM provided the updated books they requested, which are now still being used by incoming students. As described by our informant who initiated the project:

“About the project, the first motivation is that we lived really hard times, and saw our country being destroyed, in many different aspects, and if you care about something, you just have the feeling that you should work to protect or fix what’s destroyed, or even try to be on the same level of development elsewhere in the world, we went far behind with this war, and it was the time to stand again and work together to fix and develop. The project was a chance to do something useful to our college, and... as a student, going to school despite the dangerous situation, its just life, we cant just stand still, we should move on, and continue what we are supposed to do...”

7.2.1.2 Peer generated physical and online educational resources

All our medical student informants (18 individuals) reported self-organizing to overcome the problems of missing lectures due to the travel difficulties. They formed new social arrangements that, in turn, created a robust educational infrastructure where students could maintain their educational practices even if they could not attend lecture or lab sessions¹. Thus, students expanded their role to become *educational curators*.

Our informants described a process where the student body took initiative to ensure that people who missed lectures and labs would stay up-to-date. Medical education in Iraq lasts five years, where each class (years one through five) is considered a cohort. One of our informants, a female medical student, described how students in each cohort now volunteer to take lecture notes. These students attend each lecture and either write or type the lecture notes for each course on a daily basis. The students have established contracts with several offices surrounding the campus, which reproduce these materials digitally on CDs, or make photocopies of handwritten notes, which are then made available to students in each cohort. Thus, when a student misses a lecture or an entire day of school, they may then obtain the materials by traveling to the office in charge of reproducing the materials.

It is also the case where students are self-organizing to make lab materials available to their peers. Using cameras and CDs, students coordinated new social arrangements that created academic resources so as to ensure that all students can access these materials if they cannot travel to the university. Students elected members from their cohorts to create these educational resources based on knowledge. They selected people who they considered to be experts using various technologies, e.g. digital cameras. One informant, a male medical student in Baghdad, described how students now use digital and video cameras during both Anatomy and Pathology labs. Students are taking pictures during their practical sessions with cadavers, and, more recently, they began to video record these sessions using their mobile phones (and later digital camcorders). Similarly, sets of students were elected by their peers to take pictures of slides during Pathology lab. In both of these cases, similar to the way in which lecture notes were distributed, contracts were created with bureaus surrounding the campus which reproduced these materials on CDs—students could then obtain these materials at a later date.

Additionally, our informants elaborated on how following the war, faculty never communicated with people outside of the classroom environment to provide people with updates, lecture notes, assignments, or grades. This was problematic, as students could not always travel to the university. The medical students self-organized to create online educational resources. These resources made the educational infrastructure more robust, as people could obtain pertinent information and materials online from any location with Internet access.

¹ This was not the case for all students in Iraq. We interviewed students studying a variety of subjects ranging from Engineering to English, who were unable to obtain materials when they missed lecture.

Initially after the war, our first set of interviews with medical students (beginning in September 2007) revealed that online fora were essential in mediating the new activities by the student population. One informant, a male medical student in Baghdad, created a web forum that could only be used exclusively by his peers at the university. Here, people created various forum topics where they discussed concepts they were learning, and asked questions that could then be answered by other members of the forum. Additionally, when the network infrastructure permitted, this individual would upload lecture notes to a server online and provide direct links to this vital information to his peers both using the forum and via e-mail. This took place to a lesser extent given the unreliable and slow Internet connection available in Iraq. Thus, the students constructed new communication channels about university courses using online fora.

More recently, social media has been more deeply integrated into the educational infrastructure by the student population. As described by all ten medical school informants that we interviewed since April 2010, Facebook was and continues to be instrumental in the way in which they resolve breakdowns in the infrastructure supporting education. One informant, a female medical school student in Baghdad, describes how a Facebook group now exists for each cohort of medical students. Here, a representative from each cohort is elected who maintains contact with the Dean of the medical school. This elected student official is in charge of communicating with the Dean via the Facebook group to receive and relay updates about exam schedules, or when the university will be closed as a result of the conflict.

Our informants described how they also use their respective Facebook groups to discuss and provide pertinent course information. Students now go online to seek and offer clarification on medical concepts from various courses, e.g. Pathology and Anatomy. They also share practice tests and study guides prior to exams. Medical students have also used Facebook to share course grades with their peers. Unlike universities in the United States, where grades are typically made available online, in Iraq, professors still post grades outside of their offices. As described by another informant, the security situation made it difficult for him to travel to the University to check his grades. However, another student from his cohort who lived near the university traveled to school, took a picture of the grade print-out, uploaded it to the Facebook group created for their cohort, and tagged everyone in the picture so as to make them aware of the availability of their grades.

8. DISCUSSION

This paper attempts to bridge different research streams. On the one hand, disaster researchers have studied how people cope with environmental disruptions [e.g. Dynes, 1970; Quarantelli, 1998], but have not focused on the use of information technology to a great extent. On the other hand, human infrastructure has been discussed as integral in maintaining and providing a working infrastructure [e.g. Bowker, 1994; Star and Ruhleder, 1994; Lee et al., 2006]. A third and emerging research stream is in understanding how people use information technology to recover from disruptive events [e.g. Palen and Liu, 2007; Mark and Semaan, 2008]. Our goal in this paper was to show how ICTs could support the recovery process in an environment where disruption was ongoing. We found that people developed new collaborative practices and self-organized in order to resolve breakdowns in the infrastructures supporting travel, education, and information. We contend that through their ability to resolve breakdowns with ICTs, people were, in turn, restoring ontological security.

8.1 Restoring Ontological Security with ICTs

Returning to Giddens [1990], *ontological security* is a sense of order and continuity in regard to an individual's experiences that is produced and re-produced. If this is compromised, the individual will attempt to re-establish or adapt their lives and viewpoints in order to cope.

The process of recovery is one marked by the non-routine activities various social arrangements engage in to restore societal function. It is typically the case that the groups that emerge in the aftermath of a disaster engage in the articulation work that resolves breakdowns in the infrastructure. After breakdowns are resolved, normal life resumes, and ontological security is restored as people are able to continue their routine lives.

In the context of our field site, an environment disrupted by war, breakdowns in the infrastructure were recurring; thus, recovery was an ongoing process. As such, the order and continuity that people typically produced and reproduced that provided them with ontological security was missing, as they could no longer reproduce their routines as they were accustomed to when their situation was "normal."

The new trust-based technology-mediated social arrangements that people developed, however, resolved breakdowns so as to make the infrastructure usable. In most cases, the breakdowns were only resolved temporarily, as the articulation work that people engaged in did not permanently repair the infrastructure. Rather, if we consider the infrastructure to be an open system, the articulation work that people engaged in temporarily closed the system so that people could then rely on it and enact familiar routines. For example, before traveling, people first had to resolve safety-related issues that limited their ability to utilize the travel infrastructure. They leveraged the unofficial social arrangements they developed in order to determine safe travel routes as part of the recovery process. After determining safe travel routes, they could then consider the travel infrastructure a temporarily closed system (or recovered system), and use it to enact familiar routines for travel. Similarly, people also created alternative infrastructure as part of the recovery process. For example, students self-organized to create ICT-based resources like CDs and online fora to resolve breakdowns in the infrastructure supporting education. These acted as supplemental or alternative resources that people could then rely on to maintain their educational practices. Thus, the social arrangements people relied on were resolving breakdowns in the infrastructure, which in turn, restored ontological security as people could engage in routine practices.

The new activities people developed were continually enacted and became integrated into people's daily lives. People developed robust practices on which they could rely in order to continuously make the infrastructure usable—people took "infrastructure-ing" [Star and Ruhleder, 1994] into their own hands. For example, students created new coordination structures and these eventually became embedded into the university practices. Trusted social networks became the backbone on which people could rely in order to maintain their routines. People were becoming more active participants in their society. Rather than being passive users of the infrastructure that supported travel, education, and information, people were restructuring their roles within society to adapt and resolve needs. Thus, in the context of an environment disrupted by war, the work involved in maintaining impersonal, abstract systems, became highly personalized.

8.2 Reconsidering Infrastructure: A disasters perspective

In the course of explaining the case of technology use by the Iraqi population, we have made considerable use of the concept of infrastructure. While infrastructure is comprised of physical, technical and social elements, we focused mostly on the social

element, or, the human infrastructure. Based on our results, we have identified new ways to view infrastructure from a disaster's perspective.

8.2.1 Creating ad-hoc social infrastructure with ICTs

The human infrastructure, unlike the physical infrastructure, which can be difficult or slow to change, is robust and expandable. In other words, the new social arrangements people were creating were not permanent, and people could add new contacts to their networks at any time after establishing trust through the use of technology. This adds an important element to our understanding of ICT use and, in turn, the human infrastructure, during crises. Despite the distance that often separated people, and the lack of trust in the environment, people were able to seek new trustworthy individuals that they could then rely on to repair the physical infrastructure. If one person was unavailable, people could then continue to use the technologies they had adopted to traverse their human network and search for someone else with the knowledge and expertise they needed in order to make the infrastructure usable again. For example, when traveling, people could rely on more than one person for travel safety information. They could also rely on more than one person to act as a taxi driver. Thus, the technology-mediated social arrangements were robust and expandable.

8.2.2 ICTs as a facilitator for improvisation

As we found in our study, the human infrastructure is highly adaptable during crisis events. In other words, people who were not accustomed to engaging in certain activities assumed new roles within the context of the ongoing disruption. During disaster situations, it is often the case that people improvise and assume new roles—expected organizational, group and individual functions [Weick, 1993]. In our study, we found that technology facilitated this form of adaptation during the war. For example, medical students expanded their roles within their respective educational institutions. They assumed a new role as educational *curators* where, using ICTs, they developed new educational resources that people could then rely on to continue their educational practices. Here, the role improvisations were enabled by the creative adaption of the ICTs at people's disposal, e.g. Facebook and digital cameras.

8.2.1 Building redundancy in ICTs

The social arrangements people created during the crisis were dependent on the technological infrastructure. On the one hand, if a technology was not working, then this could mean that a large portion of the human infrastructure was inaccessible. On the other hand, if people do not use a certain technology, if people within a human network are not connected via a certain technology (i.e. two people connect using mobile phones and not Instant Messenger), or if someone is not “online”, then this could limit people's ability to connect with those individuals with the knowledge and expertise required to engage in the articulation work to repair the infrastructure. For example, as was the case with our informant who was trying to determine safe travel routes, when the mobile network was down, he was unable to connect with people in his human infrastructure that would have the knowledge he needed in order to travel to certain locations. In other cases, people use various technologies and thus had various ways to communicate with people. When one technology was not working, they switched to another (i.e. from the mobile phone to instant messenger). This adds an important element to our understanding of how technology can serve as one of the key limiting factors during the recovery process from disruptive events. Many recent studies have explored the use of technology

during crisis events [e.g. Palen and Liu, 2007]. It is important that we understand that technology may not always work, and that people prepare redundancies in ICTs in the event of technological failure.

8.3 Implications for Disaster Relief

Our study also has implications for the field of disaster response. We used Hoffman's model to better understand how societies recover from disaster. The first two phases of recovery outlined by Hoffman are characterized first, by the emergence of new and old social arrangements to help repair infrastructure, and second, by the ability to converge in the physical space. The new social arrangements that emerged consisted of local and distant citizens that often came together on the site where the physical disruption took place. Additionally, local government agencies, e.g. the police department, also provide support during the recovery effort. Across the phases of recovery, altruistic behavior is often observed [Dynes, 1970]. This same philanthropic behavior has also been observed in an online context during disaster situations [Palen and Liu, 2007].

An environment disrupted by war leads us to alter this model. First, people may be unable to physically collocate in order to provide disaster assistance. Second, in war environments, people may no longer trust other people or the government to maintain as well as rehabilitate the infrastructure. Lastly, one key characteristic of a war zone is that disruption is ongoing. In this sense, when people are in a continual state of disruption, they may be engaging in recovery activities (i.e. repairing infrastructure) while engaging in routine activities in parallel.

In our field site, however, we showed that in spite of people's inability to collocate, of the mistrust that had developed in society, and of the ongoing disruption, *technology* aided people in their ability to resolve breakdowns as part of the recovery process. This in turn enabled people to enact familiar routines. Recovery was enabled via people's ability to use ICTs to create new social arrangements that were trustworthy across time and space. Recovery was also enabled via the resources created by trust-based social arrangements. In all of these cases, people assumed new roles, and improvised, developing a social infrastructure that they could then rely on to maintain routines for education, travel, and obtaining information.

How do we leverage this information to aid the disaster relief effort? The majority of studies looking at the use of technology during crises have not focused on trust. As we found in our study, an important requirement is to be able to trust others online. The ability to easily falsify online identity needs to be counteracted with better research on online identity verification, particularly for people to know who they are interacting with online. Our informants were selective in whom they interacted with online: they only contacted people within their kinship networks, and trusted recommendations of their kinship network. Technologies could offer better ways to provide people with an expanded and trusted social network (finding trusted friends of strong links) to help them navigate through a dangerous environment.

9. LIMITATIONS AND CONCLUDING REMARKS

We have several limitations to our study. First, all of our informants had access to, and were users of, technology. Thus, we cannot generalize our results to people who do not have technologies available that can be readily utilized. Second, the majority of our informants are highly educated yet are diverse in educational and professional backgrounds. They are also diverse with respect to age and gender. Third, by virtue of using the snowball sampling method our informants may have recommended people similar to them, and perhaps our informants were all proactive in their adoption and use of technology. However, the snowball sampling technique has been

used by other researchers who have studied similar situations [e.g. Hagar and Haythornthwaite, 2005]. We also found informants for interview through multiple seeds, which could help to diversify our sample. Last, another potential limitation is that our informants were reporting events from before the war, and because a lot of time has elapsed, we cannot rule out that their accounts may have inaccuracies. We have tried to reduce inaccuracies by comparing different informants' accounts. It has also been found that people can correctly recall recurring activities they engaged in over time [Freeman et al., 1987].

Our goal in this research was to better understand how technology can be used to repair infrastructure during ongoing conflict as inflicted by war. Amidst the turmoil in the physical environment, we found that citizens developed new ways to coordinate, interact, and assume new roles using ICTs. These social changes in turn helped them to repair the infrastructure and maintain their daily routines.

ACKNOWLEDGMENTS

This research was supported by the National Science Foundation under grants no. 0712876 and 0910640. This project was also funded in part by the Coalition Advocating Human Security, a program at the Center for Unconventional Security Affairs at the University of California, Irvine, and the Roberta Ellen Lamb Endowed Memorial Fellowship.

This is a revised and expanded version of a paper that appeared in the Proceedings of ISCRAM 2010, the 8th International Conference on Information Systems for Crisis Response and Management.

REFERENCES

- Abdul-Rahman, and A., Hailes, S. (2000). Supporting trust in virtual communities. *In Proceedings of the Hawaii International Conference on System Science (HIICS'11)*, 34, 1-9.
- American Heritage Dictionary, (2011). Retrieved from <http://dictionary.reference.com/browse/Infrastructure>.
- Barley, S.R. (1986). Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly*, 31, 78-108.
- Benedict, R. (1946). *The chrysanthemum and the sword*. Houghton Mifflin, Boston, MA.
- Biernacki, P. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods and Research*, 10, 2, 141-163.
- Bowker, G. (1994). Information Mythology: The World As/Of Information. In Bud-Frierman (ed), *Information Acumen: The Understanding and Use of Knowledge in Modern Business*, 231-247. London: Routledge.
- CNN, 2003. Retrieved from http://articles.cnn.com/2003-08-14/us/power.outage_1_outage-power-plant-lightning-strike?_s=PM:US.
- Colletta, N. J., and Cullen, M. L. (2000). *Violent Conflict and the Transformation of Social Capital*. Lessons, Washington DC, MD.
- Dynes, R. (1970). *Organized Behavior in Disaster*. Heath Lexington, Lexington, MA.
- Ebaugh, H. R., and Curry, M. (2000). Fictive kinship as social capital in new immigrant communities. *Sociological Perspectives*, 43, 2, 189-209.
- Fischhoff, B., Lichtenstein, S., Slovic, P., Derby, L., and Keeney, R. (1981). *Acceptable Risk*. New York, NY: Cambridge University Press.
- Freeman, L. C., Romney, A. K., and Freeman, S. C. (1987). Cognitive structure and informant accuracy. *American Anthropologist*, 89, 2, 310-325.
- Global Security, 2009. Retrieved from http://www.globalsecurity.org/military/ops/iraq_sigacts.htm.
- Giddens, A. (1990). *The Consequences of Modernity*. Stanford University Press, Stanford, CA.
- Granovetter, M. S. (1973). The strength of weak ties, *American Journal of Sociology*, 78, 1360-1380.
- Hagar, C., and Haythornthwaite, C. (2005). Crisis, farming and community. *Journal of Community Informatics*, 1, 3, 41-52.
- Handy, C. (1995). Trust and the virtual organization. *Harvard Business Review*, 73, 3, 40-50.
- Hoffman, S. (1999). The worst of times, the best of times: Toward a model of cultural response to disaster. In Smith and Hoffman (eds.), *The Angry Earth*, New York: Routledge.
- Hughes, A., Palen, L., Sutton, J., Liu, S., and Vieweg, S. (2008). "Site-Seeing" in Disaster: An Examination of On-Line Social Convergence. *In Proceedings of ISCRAM'08*.
- Kendra, J., and Wachtendorf, T. (2003). Creativity in Emergency Response to the World Trade Center Disaster. In J.L. Monday (ed), *Beyond September 11th: An Account of Post-Disaster Research*, 121-146. Boulder, CO: Natural Hazards Research and Applications Information Center.

- Lee, C., Dourish, P. and Mark, G. (2006). The Human Infrastructure of Cyberinfrastructure. *In Proceedings of the ACM Conference on CSCW (CSCW'06)*, 483-492.
- Luhmann, N. (2000). Familiarity, Confidence, Trust: Problems and Alternatives. In D. Gambetta (ed), *Trust: Making and Breaking Cooperative Relations*, 94-107. University of Oxford, UK: Department of Sociology.
- Mark, G., and Semaan, B. (2008). Resilience in Collaboration: Technology as a Resource for New Patterns of Action. *In Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW'08)*, 137-146.
- Mark, G. and Su, N. (2010). Making Infrastructure Visible for Nomadic Work. *Pervasive and Mobile Computing*, 6(3), 312-323.
- Misztal, B. (2001). Normality and Trust in Goffman's Thoery of Interaction Order, *Sociological Theory*, 19, 312-324.
- New York Times, The, 2006. Retrieved from <http://www.nytimes.com/2006/06/05/world/africa/05iht-web.0606iraq.1886908.html>.
- NPR, 2011. Retrieved from <http://www.npr.org/templates/story/story.php?storyId=134357847>.
- Palen, L. and Liu, S. (2007). Citizen Communications in Disaster: Anticipating a Future of ICT-supported Public Participation. *In Proceedings of the ACM Conference on Human-Computer Interaction (CHI'07)*, 727-736.
- Palen, L., Hiltz, S. R., and Liu, S. (2007). Online Forums Supporting Grassroots Participation in Emergency Preparedness and Response. *Communications of the ACM*, 50 (3), 54-58.
- Quarantelli, E.L. (1998), *What is a Disaster? Perspectives on the Question*, Rutledge, New York, NY.
- Rodriguez, H., Quarantelli, E. L., and Dynes, R. R. (2006). *Handbook of Disaster Research*, Springer, New York, NY.
- Semaan, B., and Mark, G. (2011). Creating a Context of Trust with ICTs: Restoring a Sense of Normalcy in the Environment. *In Proceedings of the ACM Conference on CSCW (CSCW'11)*, 255-264.
- Semaan, B., Mark, G., and Al-Ani, B. (2010). Developing Information Technologies for Citizens Experiencing Disruption: The Role of Trust and Context. *In Proceedings of the Conference on Information Systems for Crisis Response and Management (Of ISCRAM'10)*.
- Shklovski, I., Burke, M., Kraut, and R., Kiesler, S. (2010) Technology adoption and use in the aftermath of hurricane Katrina in New Orleans. *American Behavioral Scientist*, 53(8), 1228-1246.
- Star, S.L., and Bowker, G. (1999). The ethnography of infrastructure. *American Behavioral Scientist*, 43, 377.
- Star, S. L., and Ruhleder, K. (1996). Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces. *Information Systems Research*, 7, 1, 111-134.
- Starbird, K., and Palen, L. (2011). "Voluntweeters:" Self-Organizing by Digital Volunteers in Times of Crisis. *To appear in the Proceedings of the ACM Conference on Human-Computer Interaction (CHI'11)*.
- Strauss, A. L. and Corbin, J. M. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Sage, California.
- Sutton, J., Palen, L., and Shklovski, I. (2008). Back- Channels on the Front Lines: Emerging Use of Social Media in the 2007 Southern California Wildfires. *In Proceedings of the Conference on Information Systems for Crisis Response and Management (ISCRAM'08)*.
- Uslaner, E.M. (2003). *The Moral Foundations of Trust*. Cambridge, MA: Cambridge University Press.
- UNESCO Fact Sheet, 2003. Retrieved from http://portal.unesco.org/en/ev.php-URL_ID=11216&URL_DO=DO_TOPIC&URL_SECTION=201.html.
- UNHCR, 2010. Retrieved from <http://www.unhcr.org/refworld/docid/4b7aa9df5.html>.
- Webb, G.R. (2004). Role improvising during crisis situations. *International Journal of Emergency Management*, 2(1-2), 47-61.
- Weick, K. E. (1993). The collapse of sensemaking in organizations: The Mann Gulch Disaster. *Administrative Science Quarterly*, 38(4), 628-652.
- Zand, D.E. (1972). Trust and managerial problem solving. *Administrative Science Quarterly*, 17, 229-239.