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Abstract:

Crisis response is the most critical stage in crisis management during which actors make important decisions on mitigating a crisis. However, the decision making in such situations is a complex sociotechnical phenomenon. The literature specifies crisis response to include four steps (i.e., observation, interpretation, choice, and dissemination) and suggests a sociotechnical approach for analyzing them. However, we still lack theoretical guidelines for conducting sociotechnical analyses of the complexity involved in the crisis response activities. To help fill this knowledge gap, we present an interpretive case study on Kathmandu Living Labs' (KLL) role in the response to the Nepal earthquake in 2015. We analyze the case using actor-network theory (ANT) and explore how a social entrepreneur from KLL enrolled different technical and human actors and mobilized them in the crisis response. We use ANT to explore the temporal and interdependent role of digital volunteers, local communities, and technologies in responding to the crisisWe demonstrate the usefulness of ANT's translation process in understanding the complex sociotechnical process of crisis response in disaster events.

Keywords: Crisis response, Actor-network Theory, Kathmandu Living Labs (KLL), Nepal.

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1 Introduction

Digital tools have increasingly proliferated and pervaded everyday life in recent years. They now play an instrumental role in shrinking time and space through offering improved channels for interaction and communication. At the same time, natural disaster events have grown in number globally. Recent incidents in both developed and developing countries such as the US (hurricanes), Haiti (earthquake), Philippines (flooding), West Africa (Ebola outbreak), and Nepal (earthquake) show their significant physical, social, and economic impact. Nevertheless, poor countries suffer more (Mechler, 2004). Hence, disaster management requires global attention to build resilient societies. The literature categorizes disaster management into four phases: mitigation, preparation, response, and recovery (Schmitt, Eisenberg, & Rao, 2007). The mitigation phase focuses on preventing and reducing the impacts of hazards, the preparation phase focuses on developing and improving the capacity to respond and cope with disasters, the response phase focuses on immediate emergency services to save lives and livelihoods, and the recovery phase focuses on restoring damage and returning to a proper level of functioning in the long term.

Today, we see a greater need to make disaster management more efficient and effective than ever, and the digital revolution can help organizations and countries do so. For example, as Schmitt et al. (2007) suggest, in the mitigation phase, one can use digital tools to collect and analyze data, create models for risk and vulnerability assessments, disseminate information, and monitor weather. In the preparation phase, one can use digital tools to raise awareness about response mechanisms and procedures. Similarly, in the response and recovery phases, they can support the flow of information between responders, the government, the public, local communities, aid agencies, and victims who reside in various locations. Indeed, after the 2015 Nepal earthquake, many such actors used digital tools to reach out to remote areas with poor communication systems. Finally, in the recovery phase, one can retrospectively analyze collected data to obtain insights on a disaster's impact and damage in order to reconstruct affected areas and prepare for future disasters.

In particular, we focus on the crisis response phase, which research considers the most critical of the four phases (Hale, Dulek, & Hale, 2005). Various attributes characterize this stage, such as short decision times and complexity, especially when coordinating and developing consensus among different actors. The advancement in technologies such as social media, mobile phones, and unmanned aerial vehicle (UAVs) allows crisis response teams to create digital crisis maps and analyze big data through crowdsourcing initiatives, which volunteer organizations such as The Humanitarian OpenStreetMap Team and Standby Task Force coordinate (Meier, 2015). Still, one cannot ignore the various challenges of deploying digital tools in a crisis response situation. In least developed countries in particular, poor infrastructure, inexperienced users, and sociopolitical dynamics represent barriers for efficient technology use. Studies show that crisis response activities comprise relationships among human capacities, big data, and software tools (Soden, Budhathoki, & Palen, 2014; Starbird & Palen, 2011). Meier (2015) also advocates the importance of digital volunteers, local communities, and governmental and non-governmental organizations and their mobilization during crisis response.

Scholars have specified that one should consider the following four steps in crisis response: observation, interpretation, choice, and dissemination (Hale et al., 2005). However, we still need to investigate what sociotechnical challenges occur in these four steps. Researchers in both information systems and crisis management have long promoted the importance of the sociotechnical perspective (Hanseth, Aanestad, & Berg, 2004; Palen & Liu, 2007; Shklovski, Palen, & Sutton, 2008; Tatnall & Gilding, 1999). However, we lack research that has systematically analyzed sociotechnical understanding related to crisis response. The immediate nature of crisis response, which involve data high in volume, variety, and velocity and the clustering and filtering of data to, among other things, determine its veracity, makes research in these settings challenging.(Comfort, Sungu, Johnson, & Dunn, 2001; Meier, 2015). Communication and coordination among different human actors with diverse cultural backgrounds also enhances the challenge. Some studies have examined the social aspects of crisis response and found evidence that supports the importance of social aspects such as social capital and collective action (Nakagawa & Shaw, 2004). However, these studies underplay the importance of the technical aspects, whereas studies that focus on the technical aspects (e.g., Huang, Chan, & Hyder, 2010; Zook, Graham, Shelton, & Gorman, 2010) only briefly consider the social aspects. As such, we have limited understanding of the holistic sociotechnical phenomenon of technology-supported crisis response. Thus, several questions remain, such as "how do actors problematize the situation?", "how are collectives being formed?", "what roles do the technical actors play?", and "how do focal actors enroll and mobilize different social and technical actors?".

To help fill this gap, we present a case study of Kathmandu Living Labs (KLL), which deployed digital tools and mobilized a social network in response to the massive earthquake disaster in Nepal in 2015. We apply actor-network theory (ANT) as an interpretive lens to explore the process by which KLL deployed digital tools vis-à-vis enrolled and mobilized individuals and organizational actors. As Latour (1994) states: "Boeing-747s do not fly, airlines fly". In the same way, crisis response does not concern only operationalizing social capital or deploying digital tools but both together.

This paper proceeds as follows: in Section 2, we introduce actor-network theory as our theoretical framework. In Section 3, we describe our research approach. In Section 4, we present the case description of KLL. In Section 5, we analyze the case. In Section 6, we discuss our findings and, in Section 7, conclude the paper.

2 Theoretical Framework

In this section, we briefly introduce ANT and explain its relevance in understanding sociotechnical processes of disaster management in general and crisis response in particular. By doing so, we relate social theories to crisis response research and practice.

2.1 Actor-network Theory

ANT was developed from the study of sociology and science at the Ecole des Mines in Paris (Callon, 1986; Latour, 2005; Law, 1992). It was derived the concept from Gabriel Tarde who, in his book *Monadologie et sociologie*, argues that the division between nature and society is irrelevant for understanding the world of human interactions (Latour, 2005). ANT includes actors (or actants) as its base concept. Fundamentally, the theory posits that both human beings and non-human objects (digital tools in this case) are actors and that social, technical, conceptual, and textual elements fit together in a process of heterogeneous engineering. An actor-network is a heterogeneous network of aligned interests, including people, organizations, and standards (Walsham, 1997). Researchers have criticized ANT on moral grounds for giving agency to non-human actors. In response, Latour (2005, p. 72) stated that ANT does not claim that objects do things "instead" of human actors; it simply says that no social science can even begin if one does not first thoroughly explore the question of who and what participates in the action even though it might mean letting elements in that, for lack of a better term, one would call non-humans (Latour, 2005, p. 72). We use ANT primarily to understand the process whereby KLL created and maintained a social network of aligned interests and mobilized the network in crisis response and recovery. Particularly, we use the ANT translation process to explore how focal actors identify relevant actors, align their interests, and mobilize networks (Callon, 1986). One advantage of using the ANT translation process compared to other theoretical lenses is that one can use it both as a theory and as a methodology and sensemaking tool. For example, in this paper, we analyze our data and describe the findings using ANT. As a theory, it explores the ontology of networking; as Cordella and Shaikh (2006, p. 8) state: "ANT tracks the process before the box actually gets closed rather than opening the black-box to study the process". In this paper, we apply the ANT translation process (Callon, 1986) as a guiding framework for to analyze data and make sense of it.

2.2 Translation Process

The translation process can help one more deeply understand the interplay among various actors by detailing all the strategies through which an actor identifies other actors and arranges them in relation to each other. This process requires one to focus on understanding how actor-networks are created, strengthened, and weakened rather than on causes and effects. As Table 1 depicts, the translation process has four phases: problematization, interessement, enrollment, and mobilization. These phases are not sequential and can overlap.

In the problematization phase, different actors define the problems and objectives that they need to solve. As the actors cannot achieve different objectives individually, they try to identify other relevant actors to do so together. After identifying the groups of actors, they select delegates that will represent them. A focal actor, in this phase, tries to convince different actors and define their roles and identities in such a way to establish itself as an obligatory passage point between the other actors and the network. The obligatory passage point refers to a common goal that benefits those involved in the network. As Callon (1986, p. 10) states: “This double movement, which renders him [the focal actor] indispensable in the network, is what we call problematization”. In the interessement phase, the focal actor attempts to negotiate and stabilize the identity of the other actors, whom it defines through its problematization process. During the problematization phase, different actors carefully define their allies' roles, responsibilities, goals, and inclinations. They can change these roles and goals based on their own competitive interests. After the interessement phase, the focal actor seeks through physical actions and negotiations to define and coordinate the roles of the other actors. It designates the device by which it defines and attributes a set of interrelated roles to actors who accept them. For all the groups involved, the device helps to create a favorable balance of power and corner the entities whom the focal actor wishes to enroll in the network. It attempts to interrupt all potential competing associations and to construct a system of alliances that comprise different sociotechnical actors (Callon, 1986). The successful enrollment depends on negotiation and consolidation among actors during the interessement phase. To describe enrollment is to describe the group of actors with various interests and the negotiations among them and synthesize their interests to make a common goal.

In the mobilization phase, the focal actor seeks to ensure that the other actors have chosen and accepted their specific representatives. All unions have their delegate(s) or spokesperson(s); even the IT artifacts have representation in project blueprints. Thereafter, the focal actor is accepted as the main voice or a delegate that speaks on behalf of all the actors in the network. The state when the actor network gets strong properties of irreversibility and effects that transcend time and place is known as immutable mobile (Callon, 1986). However, this consensus and the alliances that it implies can be contested at any moment and the translation can be turned into treason, known as dissidence (Callon, 1986). The lack of alignment is simultaneously a timely reminder that agendas and interests may be diverging, in opposition, or in competing directions. Focusing on the involvement of various ICT actors who formed and extended KLL, we use ANT as a sensemaking lens. More specifically, we use the lens to more deeply understanding how the sociotechnical interplay lead to the formation and extension of KLL and its crisis response activities.

Table 1. Four Phases of the Translation Process in ANT (Callon, 1986)

Problematization	In this phase, the focal actor(s) defines the problem that needs to be solved. Thereafter, they identify who the relevant actors are.
Interessement	In this phase, the focal actor(s) negotiates the terms of involvement with various interested actors.
Enrollment	In this phase, the focal actor(s) makes the actors accept the roles that have been defined for them during interessement.
Mobilization	In this phase, all unions select a delegate actor(s) in the network to adequately represent the masses.

Despite the relevance of ANT as an analysis tool, few studies have used it to understand crisis management (e.g., Sabou & Videlov, 2016). Thapa (2011) conducted research in Nepal and found evidence that ANT can help one understand the role of ICT in socioeconomic development (Thapa, 2011). For example, Thapa found how the team leader of a project called the Nepal Wireless Networking Project successfully established himself as an obligatory passage point in his community and involved various other actors such as Open Learning Exchange Nepal, thamel.com, Kathmandu Model Hospital, and local and national government agencies. Subsequently, the actors aligned and translated their diverse interests toward socioeconomically developing the mountain region in Nepal (Thapa, 2011). In contrast, Diaz Andrade and Urquhart (2010) used ANT to show that, when actors have misaligned interests and local people are unfamiliar with the network procedures that a project's sponsors define, a focal actor cannot establish the network. Hence, we argue that using ANT's translation process to explore crisis response projects adds value because it enables one to break up the process into temporal elements (i.e., four phases) to analyze the various phases of crisis response.

3 Research Approach

Given that we conducted explorative research, we consider research as “a continuous process of data collection, followed by analysis and memo writing leading to questions that lead to more data collection” (Corbin & Strauss, 2008, p. 76). We sought to obtain real-life experiences in real situations. Hence, we conducted an interpretive case study (Walsham, 1995) to understand how various sociotechnical actors interact during a crisis situation. We adopted the interpretive approach to obtain the views of the actors involved in the crisis response phase and to understand how KLL translated its objectives into a common goal. We selected KLL as the unit of analysis for this study due to its significance in the crisis response after the 2015 Nepal earthquake. KLL emerged as the only non-governmental organization that deployed digital tools and enrolled various governmental and non-governmental actors to respond to the earthquake. As we document in this paper, this complex sociotechnical process was not straightforward. To root the study further in the real situation, the second author was extensively involved in KLL activities, and we use his detailed narratives and direct observations to authentically recount how KLL responded to the earthquake. For example, we analyzed his Skype conversation logs from between 25 April and 30 May, 2015, which involved around 200 actors. In addition, we conducted interviews during November to December 2015 with locals from Kathmandu and volunteers from OpenStreetMap and Standby Task Force who were directly involved in the responding to the Nepal earthquake. We also talked to community members from the Timal village near Kathmandu and conducted an in-depth interview with a senior researcher from the Social Science Baha research institute who was doing case studies in Sindhupalchowk (one of the most affected areas). Table 2 overviews the interviews. Each interview lasted between 60-90 minutes. Additionally, an informal discussion with KLL staff was conducted. Most of the interviews were open-ended and conducted on site. In the interviews, we tried to acquire broader understanding of the phenomena, the interview questions were oriented towards who were involved in the crisis response activities, how the different actors responded to the situation, how the event changed their socioeconomic behavior, and what kind of digital technologies were used. We took detailed notes of all the interviews and discussions. The interviews were tape recorded and transcribed for analysis purpose.

Table 2. Overview of Interviews

Participants	Organization	Interview objectives
Informant 1 (specialist in using information and digital technologies such as mapping interventions to respond quickly to disasters)	OpenStreetTeam	To learn how OpenStreetTeam collaborated with KLL and what technical and human challenges they faced.
Informant 2 (leading expert in the field of digital humanitarianism; he had led several major international crisis-mapping efforts and research initiatives)	Volunteer in digital humanitarian	To learn how he deployed digital tools such as UAVs and how he involved community members along with KLL in the mapping process.
Informant 3 (executive director of KLL)	Kathmandu Living Lab (KLL)	To learn how crowdsourcing and social media can enhance civic engagement, collective action, and political and economic governance in poor countries.
Informant 4 (senior researcher, specialist in crisis management)	Social Science BAHA research institute	To learn how the earthquake affected the socioeconomic behavior of the people in remote villages.
Informant 5 (a local from Timal)	Timal village	To learn how the people in the village reacted to the earthquake and how the aid agencies and government organizations provided help.

We supplemented the primary interview data with secondary data such as news articles, government documents on the earthquake response, and former research papers on KLL (e.g., Anhorn, Herfort, & Albuquerque, 2016; Baharmand, Boersma, Meesters, Mulder, & Wolbers, 2016; Eckle & de Albuquerque, 2015; Soden et al., 2014).

We analyzed our data with guidance from the ANT's four phases of the translation process (Callon, 1986). From analyzing the Skype conversation, we identified the focal actors (e.g., KLL's director), the OpenStreetMap (OSM) groups, and digital humanitarians (see Appendix A for a graphical representation of the translation process). In the Skype conversations, several actors mentioned KLL as the hub for connecting the outside world to Nepal. KLL was the only visible organization equipped with digitals tools that crisis response team could use in responding to the earthquake. From the conversations, we inferred that KLL managed to establish itself as an obligatory passage point. Further interview analysis showed how various human and technical actors dealt with controversies and negotiations that took place among the various actors. For example, many governments and aid agency actors did not initially accept the digital maps that KLL created. However, later on, when KLL established itself as obligatory passage point, government agencies also started to use the digital maps of KLL. The interviews also provided a broader contextual picture of the crisis situation in Nepal. Throughout analyzing the data, we constantly compared data to hermeneutically understand how the parts related to the whole and the whole related to the parts as a sense making process (Urquhart, Lehmann, & Myers, 2010).

To discuss our findings, the first two authors attended a two-day workshop[1] titled “Digital Revolutions: Assessing the Role, Influence, and Potential of New Information Technology Tools in 21st Century polItics and Applied Research” at the University of Bergen, Norway, in November 2015. The workshop focused on understanding the affordances of various digital tools in affecting social and political behavior, including responding to crisis situations. Participants in the workshop also highlighted the importance of social networks, involvement of local communities and collective action. Various challenges of deploying digital tools in developing countries in the crisis response situation were raised during the sessions. The concluding remark of the workshop emphasized the importance of taking a holistic perspective of the complex sociotechnical phenomena. In line with this, our data analysis was mainly oriented towards unfolding such sociotechnical phenomena.

Finally, our different backgrounds (i.e., as insiders and outsiders to the research setting) helped our efforts to critically examine how people with different perspectives might interpret the research context. Interpretive researchers cannot claim that they report facts; rather, they report their interpretations of other people’s interpretations. Therefore, such researchers need to validate their process. In this context, we applied hermeneutic principles to conduct and evaluate the field research (Klein & Myers, 1999). One can use these principles as guidelines to evaluate the interpretive research process and, at the same time, analyze the interview data. These principles focus on the hermeneutic circle and help one to understand the complex phenomena that emerge out of the interaction between sociotechnical actors (Klein & Myers, 1999). With these principles, we could address criteria such as authenticity, plausibility, and criticality (i.e., the way in which the text probes readers to consider their taken-for-granted ideas and beliefs) when we validated our methodological approach (Walsham, 2006). Our diverse backgrounds helped us address criticality. To ensure authenticity, we mainly conducted the research on site in Nepal, and the second author was directly involved in the crisis response team. To enhance our findings’ plausibility, we presented them in a crisis management conference at the University of Agder, Norway.

4 Case Description

A social entrepreneur (“Nama”) founded KLL in 2013 to implement mobile and Internet-based technology solutions for to help governments and civic organizations innovate to enhance urban resilience and civic engagement. KLL has since grown into an active technology community that focuses on improving urban planning and management. The community comprises software start-ups, tech incubators, universities, and a local OpenStreetMap (OSM) chapter, which includes mapping volunteers from all around the world. With the motto “together we can do more”, KLL harnesses local knowledge, develops open data, and promotes civic technologies. Over the years, KLL has had to identify how to use technology to solve complex problems, such as responding to and recovering from emergencies.

On 25 April, 2015, a 7.8 magnitude earthquake hit Nepal, which caused widespread damage across fourteen districts. Later the same day, a powerful 6.9 magnitude aftershock hit. The earthquake directly or indirectly killed more than 8000 people and injured more than 21,000. The earthquake also damaged four out of the seven UNESCO World Heritage sites in Nepal. Amid this chaos and panic, KLL staff started their brainstorming session about how to respond to the earthquake. The next day, it established a situation room as the headquarters for its earthquake response. KLL staff started this situation room from the parking area because the earthquake had damaged the KLL office. Nama knew the organization could not do this work alone and locally; thus, in the same evening, he contacted volunteer digital humanitarians to seek help from the international OSM community. KLL received an unprecedented response from volunteer mappers. Within 48 hours, over 1,500 people began to remotely map the affected area in OSM using aerial imagery. To speed up their response program, they deployed QuakeMap volunteers to bridge the information gap between the quake victims and relief agencies.

KLL engaged and coordinated with mappers throughout the world using chat rooms. On 27 April, two days after the earthquake, KLL produced its first of many daily situation reports. The situation reports explained KLL’s actions in the relief effort and how others could help. Meanwhile, the demand for maps and data continued to grow. Individuals, volunteer groups, and humanitarian organizations began to request data and printable maps for relief operations from KLL. Around 2,200 volunteers have thus far contributed

[1] http://www.cmi.no/news/?1585=digital-revolutions

through remote mapping. In the course of extending their service, KLL established contact with the GIS division of Nepal's army. KLL received requests to map camps of internally displaced persons (IDPs). To handle this problem, KLL then asked volunteer mappers to assist in locating IDP camps with aerial imagery. KLL also involved doctors in these rescue operations, whom KLL members trained in how to use OSM and QuakeMap to determine what places needed their help. To meet the need for digital data and printable maps of the affected districts, KLL introduced QuakeRelief, a repository of printable maps that used the data mapping that volunteers had added to OSM Nepal. Considering the KLL's successful operations, *The New York Times* reported on KLL's earthquake response efforts (Sinha, 2015). The news helped to further spread the word about what KLL was doing. This report represented the first time KLL's work appeared in a major international news media after the earthquake. The international news also attracted the Nepal Government's attention, which consequently recognized KLL's work.

On 1 May, 2015, the National Information Technology Center (NITC) listed QuakeMap on its website as an important part of the local earthquake response initiative. KLL also began working with UNESCO and the Department of Archeology to document the condition of cultural heritage sites in the Kathmandu Valley. KLL developed a mobile data-collection app and held a training course to show volunteers how to report the conditions of sites in the mobile app. One of Nepal's leading journalists, Narayan Wagle, extensively covered crowdsourced mapping. He explained KLL's work (e.g., KLL's background, the way it coordinates thousands of international mappers, and users (various humanitarian agencies) of the mapped data). On 12 May, an aftershock of 7.1 magnitude further damaged the affected districts—a strong reminder of the importance of both recovering from disasters and preparing for future ones. The second earthquake made KLL's office too dangerous to enter; therefore, the office moved to another temporary location in a building at Kasthamandap School. From there, KLL continued its work. At this point, QuakeMap continued to be a vital tool in the earthquake response with 1,500 reports about the needs of earthquake victims and relief efforts. KLL used a team of 2,200 online/offline volunteers to analyze and classify the reports and to follow up the reports until they resolved them. Afterwards, on 18 May, a landslide blocked the Kali Gandaki River, which created a need for continued mapping. The blockage created a temporary dam that led to massive flooding upstream.

On 24 May, KLL moved to a new office in Chundevi, Kathmandu. On 7 July, because of KLL's expertise in mobile data-collection technology, the Department of Education and The World Bank collaborated with KLL to assess the damage to schools in affected zones. Similarly, KLL, the Harvard Humanitarian Initiative, and University of Colorado, Boulder, jointly held a workshop to discuss the role of data and technology in the relief efforts following the April earthquake. Along with Kathmandu University and UAViators, KLL co-organized a workshop on using UAVs, or drones, for humanitarian work. One can use the high-quality aerial imagery that UAVs collect cfor assessing damage and planning reconstruction. After it successfully completed the response program, KLL closed QuakeMap.org and moved its action zone from earthquake response to reconstruction. At the time we wrote this paper, KLL was involved in the work of school infrastructure damage assessment. The updated OSM data, created by the work of 9,000 volunteers from around the world, continues to serve as an important resource. KLL works continually in enrolling new actors and mobilizing the actors into other crisis management activities such as assessing housing damage. The assessment uses mobile data collection to assess housing damage through all earthquake-affected districts.

5 Case Analysis

In this section, we analyze the case using actor-network theory's four phases (see Section 2). The analysis demonstrates how one can use an ANT-based approach to reveal the complexity involved in crisis response.

5.1 Problematization

The ANT translation process starts with problematization. When the earthquake hit Nepal on 25 April, 2015, KLL focused predominantly on responding to this emergency situation. In this phase, KLL's founders—the focal actors in this case—focused on answering the following questions: "to make an effective crisis response, what problems do we need to solve?", "who are the relevant actors (social and technical)?", and "how can these actors be enrolled?". From an ANT perspective, they had to find out how to establish an obligatory passage point (OPP). When using ANT to analyze a case, one typically starts by tracing a focal actor to unfold the black-boxed network; hence, we started by tracing KLL. According to Latour (1994), the focal actor looks for "mediation" of various technical and social actors to translate their intention into action. The case shows that, even though KLL's office suffered damage and the organization had access only to basic Internet connections and a few laptop computers, it still wanted to respond to the crisis. The actor started brainstorming to find some solution, which led to its enrolling online communities in the digital humanitarian network, such as the Standby Task Force, through email and a chat platform. The following chat among various actors shows how the problematization phase started:

> *After Kathmandu/Nepal earthquake, which seems to have caused serious damage, opening this Skype room with some of my contacts, just in case it could be useful for exchanges.* (Budathoki)
>
> *…..Of course, feel free to add people, or remove yourself, or point to a more relevant room*
>
> *…renamed this conversation to "Nepal/Kathmandu earthquake".* (Jean-Guilhem)
>
> *…a quick heads up to say the Google Crisis Response team has activated for the Nepal Earthquake, and has launched a Person Finder instance to help track those missing/displaced*. (Jus Mackinnon)
>
> *…We're also working with the Skybox team on collects to support on the ground efforts (e.g. damage assessment), please let us know if there are specific areas we can help prioritize.* (Jus Mackinnon)

Within 48 hours, KLL received an overwhelming response from the volunteer communities. The focal actor's realizing it had enrolled various actors led to the possibilities for creating crisis response teams. Subsequently, KLL realized it needed to map the affected areas, which 2,200 volunteers helped it do using the OSM platform. However, he increasing volume of data challenged the volunteer efforts; for example, one of the volunteers stated:

> *It would be good for a plan on geolocating the images—there are 200 cities on the prompt assessment of global earthquakes for response impacted shake list, either geolocating them or pulling them into a single place is a challenge.*

5.2 Interessement and Enrolment

To coordinate between all these actors and analyzing the huge amount of data, someone needed to be accountable and responsible for integrating all the activities (i.e., the obligatory passage point in this case). For example, KLL gathered mapping information from different actors and provided them with compiled reports and local information. In the interessement phase, actors involved in a network negotiate and consolidate their roles and responsibilities and, furthermore, install a balancing device. Indeed, KLL established a situation room as a balancing device to coordinate all the volunteers, to integrate data they sent/received, and to verify/validate reports. Once it installed the situation room, KLL as the main facilitator established itself as an obligatory passage point for the entire crisis response team. In this team, KLL further enrolled Nepal's army, voluntary doctors, aid agencies, and community people. The publication about KLL in *The New York Times* and other national magazines also worked as a mediator to authenticate its role as an obligatory passage point. Meanwhile, the various actors in the network negotiated the roles and responsibilities according to their varying objectives. For example, the digital humanitarian team wanted to map and cluster the data, Nepal's army wanted to focus on sending the personnel to affected areas, aid agencies wanted to send their resources, and doctors wanted to volunteer to provide medical facilities. The local communities also wanted to work collectively to find out about the victims. The digital tools (technical actors) such as chat rooms, mapping tools, email systems, UAVs, GPS systems, and social media were mediating the actors' carrying out the rescue operations.

As we discuss in Section 2, the focal actor not only translates but also attempts to interrupt all potential competing associations to construct a system of alliances that comprises different sociotechnical actors (Callon, 1986). For example, in the beginning, the government organizations and aid agencies expressed skepticism about using KLL's mapping information and, instead, used their own authentic channels (i.e., traditional maps). This practice could have hindered KLL's crisis response team; however, after various national and international media and digital humanitarian communities recognized KLL's real-time mapping via crowdsourcing, KLL convinced the government and aid agencies that its mapping approach worked. Consequently, these agencies also enrolled in KLL's crisis response team. KLL not only negotiated with human actors but also appropriated non-human actors. For example, one of the main technical challenges at that time involved transmitting imagery data because the remote locations had low bandwidth. In response, the KLL team decided to compress the imagery files or send textual data instead. The following statement shows one instance of appropriation of a technical actor.

> *Kathmandu Living Labs has many requests for images for offline use in the field, so they'd like to download them. But their connection is limited (some 2 Mbps, shared between 30 to 40+ people; or some 200 MB/h for images). So it would be useful to compress the images prepared for visualization, and make them available for download.* (Caitlon)

Interruption of information flows in the crisis response came from nature as well. This is where the enrollment of army personnel and government agencies was required. One instance of natural obstacles was the following:

> *The main highways are narrower and the mountains rise to the north and so the roads are worse and worse in terms of grade and maintenance. Many are closed during the monsoon which is approaching in June. Already the weather has not been very good, unseasonal precipitation likely to cause instability and road closures.* (Guido Pizzini)

The following dialogues illustrate how sociotechnical actors mediated with each other to handle the obstacles:

> *We are still working on automatic landslide extraction from Moderate Resolution Imaging Spectroradiometer (MODIS) data (waiting for post event imagery) to provide a large scale guidance layer for detailed mapping with high resolution (HR imagery), but at this point we should consider start mapping it directly. We need to set up a visual tracing guide with examples and understand the level of experience needed to interpret landslides*. (Giovando)

> *…if anyone has already seen any from the new Google imagery, would be helpful to capture those examples in screenshots, to compile into a tracing guide.* (Giovando)

5.3 Mobilization

The mobilization phase concerns whether the main actor or actors in a project adequately represent the communities of interest. The focal actor in this case successfully identified and enlisted relevant actors. Within one month, KLL's network of crisis response connected more than 3,000 people across the world. At the time we wrote this paper, KLL still used the network and the data they collected for other purposes such as disaster measurement and recovery to benefit humanitarian and government organizations in the long run. The following statement shows an example of mobilization:

> *What I know is that in Nuwakot, just to the north and west of Kathmandu houses had fallen down…. If this is the case for all settlements north and west of there, and then radiating out from the epicenter then it is grave for many many people. Look at the map on this link when you scroll down. Twitter and facebook hashtags to look up #KathmanduQuake #Earthquakes #Kathmandu #Nepalquake #KathmanduEarthQuake.* (Daniel Pugh)

Finally, as Callon (1986) suggests, actors can contest the consensus and the alliances that can at any moment turn the translation into treason. Further, ICT actors can lack alignment, and interests may have diverged or started to oppose or compete with each other due to different social, human, physical, economical, and political factors. For instance, existing challenges such as lack of physical infrastructure, lack of coordination between various aid agencies and government agencies, misinterpretation of data, illiteracy with regard to use of digital tools, lack of political desire, and lack of government planning may hamper alliances and, consequently, the crisis response process in the long run. As the KLL director stated: "Successful implementation of a technology solution requires choreography of bringing together a number of elements forming an ecosystem".

6 Discussion

In this paper, we illustrate how successfully executing crisis response does not only depend on operationalization of digital tools or mobilization of human actors but also requires action and interaction between social and technical actors (Meier, 2015). Specifically, to analyze the intricacies of these complex sociotechnical phenomena, we propose using ANT as a lens. By applying ANT, we found that the process should start with a focal actor's identifying and enlisting key actors. The focal actor should be familiar with the local context. Thereafter, the focal actor should enlist all identified actors to achieve common objectives and mobilize them to pursue the end goal (e.g., responding to a crisis). As the KLL example shows, a collective of human and technical actors and not one single actor makes crisis response activities possible. KLL could not undermine technical actors' mediating role in this case. For example, KLL could not even have begun without the mediating role that OpenStreetMap, QuakeMap, UAVs, email, Facebook, and Skype played in its reaching out to various volunteers around the world. ANT provides an analytical lens for understanding such hybrid communities of sociotechnical arrangements in a crisis response situation. Through this study, we infer that one can use ANT to describe the how ecosystems form. Furthermore, the translation process of actor-network theory as a methodological guideline can help researchers to analyze and make sense of data in the crisis-management context.

However, using actor-network theory has its caveats. For example, ANT's proponents introduced it predominantly to understand networks of relations. In this paper, we extract some specific notions of the theory to understand the complexity of sociotechnical phenomena in a crisis response situation and, through empirical evidence, illustrate the theory's efficiency. However, one could argue that doing so violates ANT's original aim: Latour (2005) states that one should not use ANT as a framework for conducting such research (Latour, 2005). Yet, the theory's core concept—understanding the process of interaction between context (social) and content (technical) and their mutual influence—makes it an efficient tool to study sociotechnical phenomena in IS research (Heeks, 2007; Walsham, 1997). In using ANT in this way, our study follows the tradition of how IS research has used ANT and applies it to crisis response.

Theoretically, this paper contributes to how one can use actor-network theory to more deeply understand the roles that sociotechnical actors play in managing responses to crises. The detailed translation process describes how, even though the different actors may be separate to begin with, a common interest can unify them. Through our empirical case study, we examine how a focal actor, KLL's director, enrolled different actors, such as digital humanitarians, OSM mappers, community users, doctors, national and international volunteers, and government organizations through an enrollment process and successfully mobilized them. In turn, the mobilization facilitated the crisis response process.

The study has several practical implications. First, we show that digital tools can play a major role in how actors respond and recover from crises and in fostering an effective disaster-management process. For example, KLL functioned as an obligatory passage point to create a platform where people could access data resources and analyze it for mapping, clustering, and assessing earthquake-affected areas. KLL also offered training to cope with the crisis situation. One could locate people who lived in the remote affected zone in real time. However, the study also shows that local actors cannot respond to crises in isolation; they need to extend their social network in the form of bonding, bridging, and linking social capital (Nakagawa & Shaw, 2004). They should also be able to convince and enroll aid agencies and government organizations, exploit the affordances of existing digital tools, and provide training to enrolled actors as KLL did with doctors. Researchers have considered social capital as an important facilitating condition in disaster recovery (Nakagawa & Shaw, 2004), and we also see its relevance in the crisis response situations. Integrating actor-network theory with social capital can better explain how networks form, co-evolve, and respond to crisis situations.

For policy makers, our study shows how local knowledge gathering can enhance the deployment of digital tools by key actors in crisis situations. Thus, we should not neglect the potential of local communities to effectively mobilize for crisis response activities. However, our analysis also indicated that integrating digital tools sometimes can be challenging. Further, the tools need to be able to support a situation that changes all the time, and government should involve directly with local communities that can develop such digital tools (e.g., KLL in our context).

7 Conclusion

In this paper, we focus on understanding the complex sociotechnical phenomena involved in crisis response. To do so, we present an interpretive study of Kathmandu Living Lab in which we highlight the importance of technical and social actors and their roles and actions in responding to a large-scale crisis such as the 2015 Nepal earthquake. We apply actor-network theory and analyze how KLL went through various phases of identifying relevant sociotechnical actors and their roles and aligning their interests to effectively respond to the earthquake. We also highlight the roles that different digital tools as technical actors played in the crisis and the interconnection between social and technical actors that formed the sociotechnical network that facilitated coordination, communication, and integration.

Research classifies generalization through interpretive case studies into four types: developing concepts, generating theory, drawing specific implications, and contributing rich insight (Walsham, 1995). One can generalize our findings in the form of specific implications and rich insight. While one could regard our findings' contextual nature a limitation, we argue that our findings have relevance for any large-scale crisis response (especially in vulnerable, rural regions of the world). Finally, ANT cannot provide answers to some questions such as "why do the actors act the way they do?" and "what motivates or drives them?". Future research could, in addition to ANT, use other theories such as stakeholder theory or genres of communication to examine these issues. Similarly, by combining social capital approaches with actor-network theory, we can increase our understanding of the role that various stakeholders and technologies play in making crisis response more effective.

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Appendix A

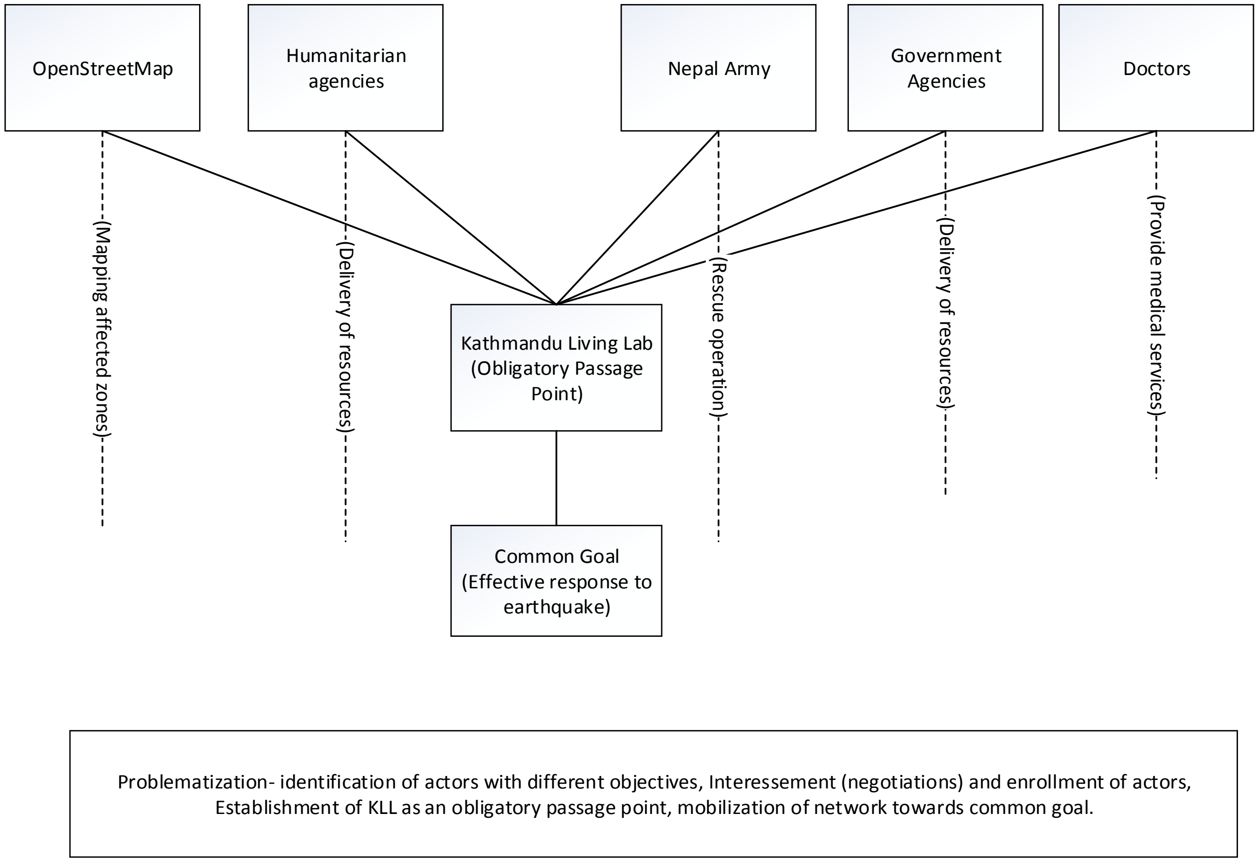

Figure A1. Enrollment and Mobilization of Crisis Response Team by KLL

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