'Is the Time Right Now?': Reconciling Sociotemporal Disorder in Distributed Team Work

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Temporal coordination endures as a central topic in computer-supported cooperative work (CSCW) because information systems still struggle to adequately support varying representations of time in the context of collaborations that are *both* temporally and geographically dispersed. Moreover, the adaptive practices of these broadly dispersed groups are still not well understood. We ask: *How do globally distributed teams temporally coordinate to accomplish their work?* We examine an extreme case of online temporal coordination: high-tempo information curation about the urgent humanitarian crisis following the 2017 Hurricane Maria landfall in Puerto Rico. Our analysis of synchronous chat transcripts and data artifacts produced by The Standby Task Force reveals how this digital humanitarian group establishes temporal coordination through different shared understandings of time relative to the crisis, the globally distributed work, and the collaborative information technologies. We make four contributions from our analysis: First, we developed a pluritemporal analytical framework that describes different forms of socially constructed time and disambiguates their meaning in talk. Next, we present empirical evidence of how this distributed team establishes shared temporal orders to collectively orient their work in time. Then, we describe how they reconcile multiple and conflicting instances of sociotemporal "disorder" to enable productive work. Last, we reflect on the design implications for collaborative information systems informed by this work.

CCS Concepts: • **Human-centered computing** → **Computer supported cooperative work**; *Human computer interaction (HCI)*; *HCI theory, concepts and models*; *Empirical studies in collaborative and social computing*;

Keywords: computer-supported cooperative work; crisis informatics; digital humanitarian; distributed work; pluritemporality; sociotemporality; temporal structures; time

1 AN UNPRECEDENTED DISASTER

In the aftermath of the catastrophic destruction of Puerto Rico by Hurricane Maria in 2017, volunteer *digital humanitarians* [34] from around the world came together online to help. At the request

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of the U.S. Federal Emergency Management Agency (FEMA), volunteers with The Standby Task Force (SBTF)[1] curated time- and safety-critical information about the highly fluid operational status of hospitals across the island. This type of globally distributed work presents multiple coordination challenges that arise from the almost invisible combination of *temporal orders*, or shared understandings of time within a group. Collective assumptions about time are characterized by shared rhythms, patterns, and reference points to which individuals orient their own experiences—in the natural world, through technology, and in society. The different representations of time that help people establish a shared sense of temporal order are quite diverse. For example, we all agree that *midday* can be represented by the regular diurnal cycles caused by the Earth's rotation, when the clock strikes 12 p.m., as a synonym for "lunchtime," and as the timestamp 2019-11-09T12:00:00Z. Here, this shared understanding of clock time leads to a *sociotemporal order*, a common framework for putting time into practice, which establishes that "midday" relates to the timing and context around a phenomenon in which both collective *agreement* and *organization* is needed in order to do something, like taking a break from work, eating lunch, or—as in our data—notating an event with a high level of precision.

These challenges are in full view in the following verbatim coordination chat transcript excerpt[2] between two SBTF volunteers:

> **Leia [2017-09-28T09:46:06Z]:** I *just* made sure all the hospitals the [Department of Health] says are up and running as of *yesterday* had at least 1 report that they were open. It certainly is confusing as there are social media reports *seemingly from the same time* saying they are not open.

> **Leia [2017-09-28T09:46:22Z]:** Hi Lexi, *good morning*, or almost *afternoon here.*

> **Lexi [2017-09-28T09:48:11Z]:** *Yeah* I found a lot of conflicting information *last night.* I think the best we can do it just get it all down and see if we can make some sense of it *prioritising* most reliable sources and *time stamps.* Thank you!

In the first turn-take, Leia engages with no fewer than three forms of time. First, she declares work she is doing relative to her own sense of time ("*just*", implicitly leaning on the chat platform timestamp to resolve any potential ambiguity about when she performed the work). Second, Leia refers to "*yesterday*" as a chronology of her work. Third, she refers to metadata from social media posted "*seemingly from the same time*" that she is using to derive information.

Leia then welcomes Lexi to the group chat. In her greeting, Leia establishes the local time as "*almost afternoon*" for both team members who reside one time zone apart.

Lexi responds in the last turn-take with three different time references after "*yeah*" to perhaps confirm the temporal agreement of the relative nature of their work. She refers to "*last night*" to situate the solar rhythm of her most recent work in contrast to re-entering the chat room now. Lexi describes "*prioritising*" as a time-relative strategy to evaluate the information the group has collected, thus far. She then, too, mentions metadata "*time stamps*"—drawing attention to how technology affects the product of their work: the creation of a chronology of available hospital resources to hurricane victims.

It is this wrestling with different temporalities—natural, social, and technological—that appears in the sometimes-convoluted discourse that this paper unpacks, theoretically describes, and then considers as grist for technology design for distributed, computer-supported collaborative work.

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[1]https://www.standbytaskforce.org
[2]Volunteer names are anonymized for privacy, and the sociotemporal discourse coded in our analysis is displayed in italicized text for clarity.

1.1 Overview and Contributions of this Research

Temporal coordination is fundamental to the functioning of society. Shared orientations to time shape rhythms, patterns of coordination, and interpretive frames for making our way in the world [67]. The creation of these shared orientations and the construction of a shared sense of "what time it is" [49, 67] is a form of work—temporal coordination work. However, temporal coordination endures as a central topic in computer-supported cooperative work (CSCW) because information systems still struggle to adequately support varying representations of time in the context of collaborations that are *both* temporally and geographically dispersed.

We present empirical evidence of how SBTF members use a variety of discursive temporal references to overcome instances of *sociotemporal "disorder"*—breakdowns in coordination caused by the inability to reconcile multiple temporal orders that they draw upon in the conduct of their work. For these digital humanitarians, temporal coordination is hampered by the chaos of incoming online information streams, varied metadata structures, widely dispersed workforce across numerous time zones, and inflexible technical tools that cannot readily handle other forms of temporal representations aside from clock time, e.g., shared interactions and turn-taking [26], cross-cultural notions of time [37], and qualitative experiences of temporality [47]. An analysis of the work of SBTF reveals that this temporal coordination work is complicated by the need to reconcile multiple different temporal orders—*what time it is relative to one another, to each piece of disaster-related information, and to the various collaborative information systems that each differently encode and display time.*

Here, we interrogate an extreme case of temporal coordination, a case in which the phenomenon of study is intense [45]: high-tempo digital humanitarian information work in the aftermath of the 2017 Hurricane Maria, one of the deadliest Atlantic hurricanes on record. In this context, the time-critical nature of the work further exposes and amplifies how temporal coordination must be achieved. Digital humanitarian workers—often volunteers [10, 40, 60]—are activated from around the globe as time and expertise allow. People join in anew with each event, putting further demands on the work that must be done to achieve temporal coordination.

Through an analysis of this case that foregrounds a nearly invisible substrate of the temporal coordination of distributed work, we make four contributions:

- A pluritemporal analytic framework to interrogate the forms of language that people employ to resolve their sociotemporal disorder;
- A descriptive account of the different temporal orders that our informants must reconcile, which was revealed by our application of the analytic framework;
- A theoretical description of how sociotemporal disorders are created and must be reconciled at the intersection of multiple, conflicting, temporal orders, including sociotemporal orders; and
- A suite of design implications for collaborative information systems to better support temporal coordination work.

There has been surprisingly little direct attention in the literature on exploring the temporal coordination practices of globally distributed digital humanitarian groups [10, 41] or the sociotemporal orders that influence their work [60], despite more than 10 years of partnership with the emergency response sector. Further, this ethnographic work helps to reveal a pathway toward understanding the larger and more complex practice of technology appropriation in CSCW [61]. This study is designed to help address these gaps.

2 TEMPORALITY AND WORK

Work—from interpersonal to institutional—depends on coordination with others [53], including temporal coordination. Technologies have been invented for the purposes of synchronization, such as the town center church clock to coordinate geographical communities [18] and the wristwatch to coordinate war maneuvers by people distributed over vast areas [32]. Temporal artifacts and new normative behaviors have in turn arisen because of technological innovation. The railroad gave rise to coordinated clock time across towns and cities, as well as to time zones across regions [68]. The precision of clock time on mobile phones, which reference essentially a single time source, means that "being late" is not a function of individually calibrated wristwatches, and therefore bears on temporal coordination behavior in new ways [28].

Temporal coordination relies on a shared knowledge of "what time it is" (and what day and date it is) [67, p. 65], as well as the capacity of people to act on that knowledge in a synchronized way [4], in due time [35], or across locally distributed groups [8]. We see this shared temporal knowledge in action when a small group imposes local meaning (e.g., the video conference is always at 2:00pm), a large group imposes structure on the year (e.g., a national holiday), or the community indirectly imposes the consequences of their coordinated habits (e.g., leaving work around the same time of day, which creates the traffic rush) [5, 21].

Recurrent collective activities give rise to the need for *social orders*, or a set of structures, systems, values, and norms that guide interactions. When a social order is coupled with shared temporal knowledge ("what time it is"), the resulting *sociotemporal order* [67] provides a common framework about how we think about time, ascribe meaning to it, and put shared temporal knowledge into practice. The seven-day week of a Gregorian calendar is an example of a conventional sociotemporal order that regulates social life. Sociotemporal orders are further elaborated by localized rhythms that are particular to smaller social groups (of the household, of religious groups, of a workplace's shift patterns, etc.) [67].

Sociotemporal orders are regulated by quantitative measures, typically clock-time or diurnal cycles, and qualitative features, such as social rhythms, patterns, routines, frames of reference, ephemeral states, and events [1, 18, 21, 26, 27, 37, 39, 56, 65, 67]. Sorokin and Merton [56, p. 623] describe features of qualitative time as "derived from the beliefs and customs common to the group and ... serve further to reveal the rhythms, pulsations, and beats of society in which they are found." Shared understandings of qualitative representations of time are relative, which can lead to confusion and discord—especially in diverse, globally distributed groups. Yet, these qualitative features are sometimes the only consistent or reliable sociotemporal information available to the group.

Grosz [20] describes how events can act as temporal ruptures of the past that transform the present and future in unpredictable ways. Here, Hurricane Maria caused a catastrophic rupture to the rhythms of life in Puerto Rico and elsewhere in the eastern Caribbean where the hurricane made landfall. The *sociotemporal disordering* of social institutions, infrastructures, and personal lives are experienced not only in the timing of disrupted daily routines according to the clock but the qualitative aspects of urgency, priority, and change in responding to the immediate post-hurricane reality. The resulting turmoil may play out for years to come.

Sociologists who study time have written about how historical events, theologies, technologies, and political systems have all shaped social constructions of time over thousands of years [2, 17, 26, 42, 56, 65, 69]. In this research, we examine how temporal coordination is negotiated in CSCW (see also [15, 27, 33, 46]), and geographically distributed CSCW, more specifically (see also [43]). The ubiquity of distributed teams is on the rise, made possible by (often) free software that enables synchronous and asynchronous collaboration through video conferencing, real-time messaging,

collaborative text editing, and shared information repositories. Yet, distributed work is a context in which we understand significantly less about how teams coordinate temporally to accomplish their work.

In the meantime, we look to adjacent high-tempo, information-centric coordination work for insights. Computer-supported temporal coordination in hospitals evokes a complex interleaving of quantitative and qualitative sociotemporal representations, including clock-time, scheduling, synchronization, and temporal allocation, in both patient care and staffing [4]. Moreover, temporal coordination requires significant support—whether through precise timekeeping in the case of a resuscitation team [24] or deep understanding of how temporal experiences influence work activities [46]. Reddy et al identify three qualitative sociotemporal features—trajectories, rhythms, and horizons—that contextualize and drive the coordination activities of complex information work across temporally-distributed staff on different shifts in a surgical intensive care unit (SICU) [46]. These sociotemporal features reflect how courses of action over time, patterns of activities in the unit, and future events are used by care teams to negotiate the subjective temporal relations necessary for effective collaboration. This framework, in particular, stands out for its thick description of the tensions of integrating qualitative temporal information into practice which is quite analogous to digital humanitarian work. However, the place-based nature of the coordination work by stable, professional teams makes it difficult to draw adequate comparisons for ad hoc, globally distributed volunteers with more constraints and fewer resources to achieve temporal awareness.

Recent work on the mediating role of technology on temporal coordination suggests that when people encounter multiple and recurring demands on their time, they adopt different approaches to enact a sense of sociotemporal order. Erickson and Mazmanian introduce the concept of *temporal entrepreneurship* to explore how some knowledge workers are pushing back against established norms of time. Here, they describe innovative ways people are using mobile technologies to characterize new qualitative forms of sociotemporal orders, such as: spectral time which describes how imprecise trajectories (borrowing the temporal arc concept from Reddy et al [46] are transformed to micro-coordinate brief, iterative activities; cohabited time that integrates multiple physical and distributed collaboration ecosystems of work and life; and porous time that simultaneously overarches multiple social contexts at once. [15]. These entrepreneurial practices are especially relevant to digital humanitarian work as SBTF volunteers also encounter multiple sociotemporal orders—in the crisis information that they collect, technologies that they use, and distributed social coordination processes they engage (see the next section for elaboration on these points). Likewise, SBTF volunteers attempt, with varying degrees of success, to innovate coordination practices and appropriate technologies as workarounds to sociotemporal breakdowns, though in a fast-paced, highly distributed, and large group context, in contrast to individual temporal entrepreneurs.

With so many different and simultaneous temporal factors at play, we look to the concept of *pluritemporality* [42] to explore the different ways that the SBTF volunteers talk about time to help reconcile sociotemporal disorder in their information work. Pluritemporality is a social construct that describes how people interpret and assign meaning to *modes of time(s) which may exist side-by-side* [42]. In this sense, adopting a pluritemporal framework helps to reveal the nearly invisible substrate of temporal language and representations that are necessary for shared understandings of time, and which ultimately help to support temporal coordination. Put into practice, Orlikowski and Yates [43] draw from pluritemporalism in their study of a geographically distributed work group and found that the use of recurrent temporal structures helps online communities-of-practice find a sense of symmetry—or, at least, a sense of quasi-agreement—around collective sensemaking [43]. This more expansive view of time provides a broader lens to examine the temporal affordances and constraints that continue to vex time-critical, globally distributed digital humanitarian work.

Further, pluritemporality makes visible the different modes of social time that are perceived, experienced, and enacted *alongside* those embedded in technology and artifacts [66]. As Adam [3, p. 601] notes:

> "[we] emphasize clocks and calendars or the qualitative experience of time and thus lose sight of the multiplicity of times inherent in any one social event."

3 DIGITAL HUMANITARIANS

Digital humanitarians [34] are globally distributed online workers, generally volunteers, who specialize in rapid, time-critical information monitoring, data collection, analysis, verification, satellite imagery analysis/mapping, and software development. These groups first came to notice as ad hoc volunteer teams in the wake of the 2010 Haiti Earthquake [59], emerging from the more formal Volunteer and Technical Communities (V&TCs) of emergency response professionals who work in collaboration with field-based humanitarian response efforts during large-scale calamities. During the same Haiti earthquake event, a group within the OpenStreetMap (OSM) geospatial data mapping community known as HOT (Humanitarian OpenStreetMap Team) populated a nearly empty base layer map for international responders to use [54].

Working as a network-within-a-network, the Digital Humanitarian Network (DHN)[3] is a member of the broader V&TC consortium. With the advent of online collaborative tools, social media, and camera-enabled mobile phones, people began to form virtual networks of "everyday analysts" [44, 60] to curate local, timely, and trustworthy information about distant emergencies to support humanitarian response in the crisis zone [10, 22, 23, 30, 40, 57, 60].

Some digital humanitarian organizations, such as SBTF, work in partnership with formal institutions including the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA), NetHope, World Health Organization, Mèdecins Sans Frontières (MSF), and the U.S. Federal Emergency Management Agency (FEMA), among others [58]. Digital humanitarian groups refer to their distributed online work as an *activation* to signal the call to action by their formal partners and to differentiate it from an on-the-ground deployment by emergency responders to the crisis zone.

In the context of distributed digital humanitarian work, time and temporality are often cited as important elements for sensemaking [44], decision support [19, 62], information sharing [11], and information quality [30]. This research in part responds to Crawford and Finn's call for critical data studies to consider the visible and invisible influences of temporality on disaster response and the ways that technologies can recursively shape crisis content [13]. We believe that an in-depth understanding of temporal coordination in digital humanitarian work provides a new opportunity to explore CSCW in distributed teams. In particular, describing the ways that time-critical collaboration is practiced in an entirely virtual space and how new sociotemporal orders emerge to help structure qualitative representations of time. As we explore in the empirical work that follows, temporal coordination is influenced by: how time is experienced within the context of an extreme event [1, 26, 39], how time is mediated by technology [2], and how time requires significant effort to reconcile shared understanding within a globally distributed team.

4 METHOD

To explore the temporal coordination challenges present in this distributed crisis information work, we conducted a content analysis of multiple text-based artifacts constructed through the work of SBTF during Hurricane Maria. The first author has been an SBTF volunteer for four years, has

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[3]http://digitalhumanitarians.com/

conducted long-term ethnographic work with SBTF for three years, and served as a coordinator managing information collection and verification efforts during the response to Hurricane Maria.

4.1 Research Context

4.1.1 2017 Hurricane Maria. The U.S. territory of Puerto Rico suffered catastrophic damage after a direct hit from Hurricane Maria in the early morning hours of Sept. 20, 2017. The Category 4 superstorm with peak 135-kt winds and 9-foot storm surge made landfall less than two weeks after the Category 5 Hurricane Irma caused mass destruction on the island. Casualty counts are disputed, but the government reports that more than 1.2 million residents were impacted [12]. Seven days after landfall, FEMA activated SBTF for two Hurricane Maria-related projects: first, to gather real-time intelligence on functional medical facilities, and second, to geolocate aerial infrastructure photos for damage assessments. The corpus of data for this study has been collected from the first activation, focused on healthcare system status. Fifty-five volunteers participated in this activation, which was conducted from September 27–29, 2017.

4.1.2 The Standby Task Force & Its Ecology of Information Systems. The Standby Task Force is staffed by 2,100 trained volunteers from 106 countries worldwide. SBTF is widely regarded for its capacity to deliver 24/7, rapid-response distributed work and information crowdsourcing expertise to support humanitarian crisis response. SBTF volunteers collect, verify, and synthesize public data from social media, news, official communications, and satellite/UAV imagery to produce situational awareness, remote damage assessments, and crisis maps (e.g., Figure 1) for use by emergency responders in the field [40].
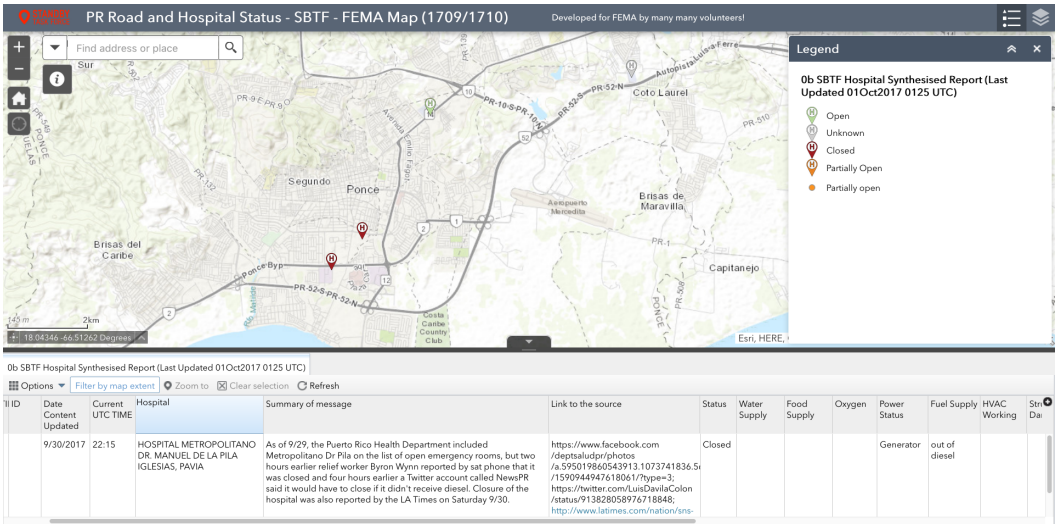

Fig. 1. A screenshot of the Hurricane Maria crisis map produced by SBTF with information collected by the volunteers and entered onto a corresponding Google Sheet.

SBTF, like many nonprofit organizations, appropriates assemblages of information systems to carry out their work [48, 64]. SBTF uses free, cloud-based systems in one of three contexts: (1) as the source material of their work, e.g., as volunteers comb through websites and social media feeds to identify relevant information about crisis-affected parties; (2) in the creation of new information artifacts to distribute externally, such as remote damage assessments; and (3) to coordinate that work, e.g., through Slack conversations.

We highlight here the most salient of these information systems, focusing, in particular, on each system's temporal features and affordances as it relates to SBTF work practices.

Fig. 2. An example of crisis-related social media posts (here, from Twitter) collected and aggregated by SBTF volunteers.

Social Media. For SBTF, social media is a key information source. SBTF volunteers monitor social media—primarily Twitter and Facebook—through hashtags, search keywords (e.g., disaster name, locations), and posts by users identified as being both trustworthy and relevant (Figure 2). The Twitter and Facebook platforms are both based on timeline interfaces (organized by default in the user-reader time zone) which users are normed to read as real-time observations and threaded posts. While often messy, incomplete, and needing verification, social media posts by crisis-affected people and emergency responders represent the information closest to the location. Thus, there is an assumption that these posts reveal the real-time nature of a disaster by eyewitnesses.

Google Drive & Google Apps Office Suite. The cloud storage platform, Google Drive, and the associated Google Apps Office Suite form the backbone of the SBTF information management system. The SBTF leadership drafts various information artifacts in Google Docs, such as task checklists for standing up an activation and after-action reports summarizing each mission. SBTF volunteers primarily work in Google Sheets, aggregating and organizing information in a proscribed, semi-structured template, referred to by the team as a datasheet (Figure 3). The datasheet is connected to and consumed by third-party data visualization tools, such as ArcGIS, to produce crisis maps and other real-time data visualizations. With dozens of volunteers simultaneously entering information into the datasheet, Google Sheet's data cell protection and custom/conditional formatting tend to fail. Therefore, on each activation, SBTF leaders create header notes on the datasheet (e.g., date of post, time, your time zone) to guide volunteers on manual entry of key temporal information, e.g., date-time formats, time zones, UTC offset lookup tables, etc.

Slack. SBTF uses the cloud-based, synchronous communication platform, Slack, to coordinate its work during activations. Slack's display of persistent conversations (cf. [16]) are typically presented as chronological, single stream dialogue timestamped in the user-reader's own time zone. For each activation, SBTF leadership creates a variety of invitation-only channels to manage the work activities of vetted volunteers (Figure 4) as well as a private back-channel for the leadership team

Fig. 3. A snapshot of a Google Sheet used by SBTF volunteers to collaboratively compile crisis-related information. In this Sheet, a team of volunteers is working to determine the operational status of various hospital facilities in Puerto Rico.

to coordinate the work. Other channels offer specialty "rooms" for specific types of tasks, such as GIS mapping or to provide emotional peer support by professional counselors. The Slack channels are also used as a communal notification board to convey information to volunteers through links to Google Docs and other artifacts "pinned" to the details pane of each channel. The primary activity takes place in the work channel. Here, volunteers dialogue with one another and the leadership team about information gathering and verification best practices and to announce their presence/departure. Archived Slack transcripts constitute an important temporal record of each activation for SBTF, as a means for producing an after-action report, evaluating its practices to inform future coordination work, and as historical artifacts.

4.2 Corpus

We compiled a corpus of all information artifacts generated as a result of the 2017 Hurricane Maria SBTF activation. The corpus includes the following texts: 1,549 Slack messages (107,054 words) of dialogue from the primary volunteer coordination channel transcript, 18,723 cells of information from 15 Google Sheets, and one Esri ArcGIS map containing 1,407 data points. We also refer to social media data as a supplemental source relative to the Slack dialogue.

For the analysis presented here, we rely primarily on the Slack messages to understand the temporal discourse, as this serves as the primary communication channel for the volunteers. The Google Sheets and ArcGIS map, as shared products of the collaboration, served primarily as referents to better understand what the volunteers were talking about in the Slack conversation. In addition, we also noted the ways that these production artifacts represented time; and when and where Slack-based discourse, discussion, and disagreement around time was linked to the representations of time in these artifacts.
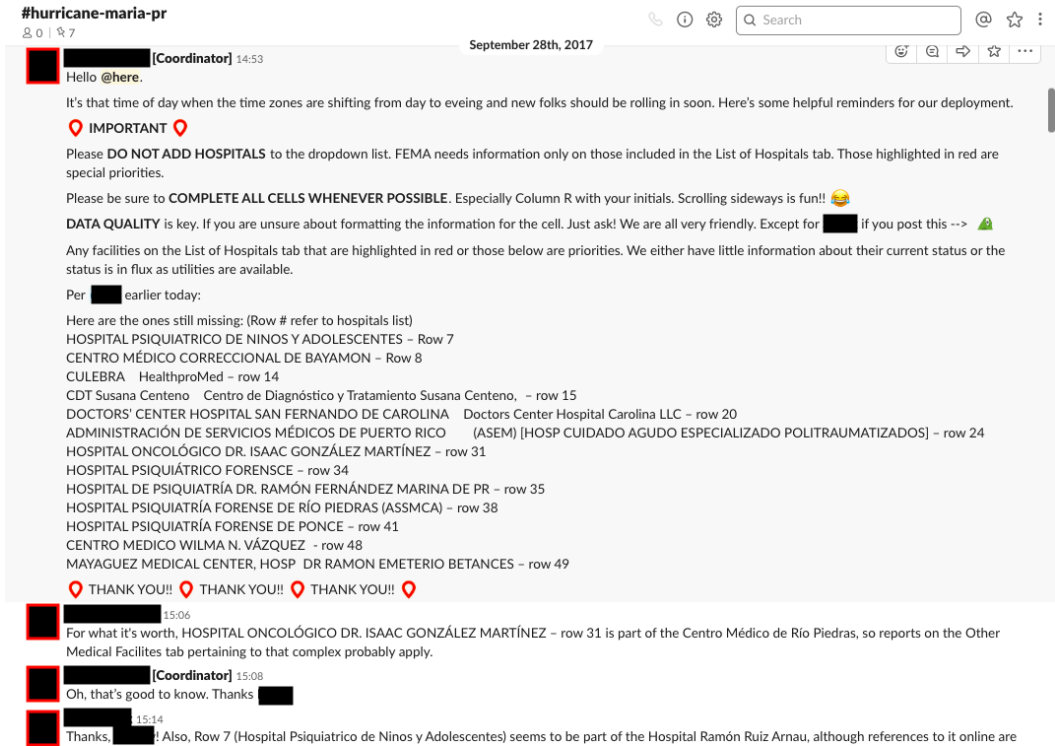
Fig. 4. A snapshot of the Slack channel used by SBTF volunteers to coordinate their distributed work. Posts in the private channel include task instructions, links to activation documents, and chat transcripts.

4.3 Data Analysis

We employed multiple phases of open, inductive *in vivo* and thematic coding and analytical memo writing [51] to interrogate the temporal work of SBTF volunteers. We imported the primary work coordination Slack channel transcript into MaxQDA[4]. Two researchers read through the entirety of the transcripts, independently identifying all instances of temporal discourse in the data (e.g., "*tomorrow*", "*quickly*", "*update*"). The analysis team met frequently to discuss differences in coding, and to arrive at a shared understanding of what constituted "temporal discourse" for this domain of work. Following this initial phase, the first author undertook multiple iterations of analysis, working through the data to code categories of temporal discourse; this coding was inductive but also informed by the sociology and linguistic literature on temporality [2, 25, 42, 67]. Notably, no one pre-existing temporal framework was sufficient for explaining or categorizing the diversity of temporal discourse present in our data. As a result, we inductively derived a temporal analytic framework, inspired by and in light of previous work in this area. In our initial coding passes, we grouped similar forms of language together, wrestling with how to understand the higher-level role that the language groupings played. Given the highly contextual nature of language use, some boundaries among categories were initially quite blurred. In subsequent iterations of analysis, we interrogated our data through the guiding question: "*What work is this language doing for the SBTF volunteers?*"' This guiding question helped to focus the boundaries of each of the six categories

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[4]https://www.maxqda.com/

and helped to offer language to better characterize each discourse category. This phase of analysis also helped us move to an understanding that various forms of temporal discourse are being used as a resource for reconciling multiple temporal orders. In section 6, we present a summary of these temporal orders and reflect more deeply about how SBTF volunteers use discourse, often in conjunction with features of their collaborative technologies, to construct a shared sociotemporal order in which their work can take place.

We also engaged in a continuous process of reflexive bracketing [63] through extensive memo writing and discussions during the research design, data collection, and analytical phases of the study. These interpretative exercises were employed to bracket, or set aside, preconceived notions about content reflected in the Slack transcript, as a method to draw awareness to the participant–researcher's close familiarity with the Hurricane Maria activation while mitigating against preconceptions about the emerging insights.

5 PLURITEMPORAL ANALYTIC FRAMEWORK

We found that our initial coding of the Hurricane Maria discourse from SBTF's distributed coordination work did not resonate well with existing temporal frameworks developed from co-located settings. For example, we detected a particularly unique coordination burden related to the volunteers lack of spatial awareness with one another that was not present in other frameworks. The need to simultaneously hold several types of quantitative and qualitative time in mind, such as global locations and time zones of the collaborating team members, pace of the information flow and its relative timeliness, social media timestamps, etc., demanded a new approach.

We draw on the concept of pluritemporality [42] to give voice to a more expansive view of the many different ways that time is perceived, experienced, enacted, and embedded in time-critical, distributed crisis information work. While informed by the existing research on temporality, our inductive analysis of data in the corpus advances a broader and more holistic analytic framework of temporalities. Taken together, the six forms of temporal discourse identified in our corpus illustrate the complexity of distributed temporal coordination work as well as the sophistication necessary to design potential process and technology improvements in a highly abstract and entangled domain, like time. Here, the different forms of qualitative temporality serve to provide shared meanings at the semantic level of coordination work [53]. In the excerpts below, words or phrases coded using the complete analytical framework appear in italicized text, while words and phrases specific to the pluritemporal type under examination are also shown in boldface type, for clarity.

5.1 Time as Standard

We coded language as *standard time* if dialogue referred to regulated, socially ordered formats that designate mechanized clock time. SBTF volunteers encountered several different types of time formats embedded in crisis data, including ISO-formatted timestamps in official public safety reports (e.g., `2017-09-27T15:02:19Z`), social media metadata (e.g., `3:02 PM -- 27 Sep 2017`), culturally-specific formats (e.g., "*9/27/17*", "*27/9/2017*", and "*2017/9/27*"), date-time expressions, and the informal, everyday language about time in social media posts by crisis-affected people (e.g., "*around 3 p.m.*").

We noted these instances of temporal standards present in our data corpus, as well as a number of meta-discussions *about* these standards, including negotiations about how best to address and embody standards in the organization's workflow:

> **Sabine [2017-09-27T22:48:53Z]:** Okay, question that might need to be standardized across deployments: When we post a *date* and *time*, no **time zone** is specified so we're probably getting a jumble of different **zones**. Thoughts?

5.2 Time as Interval

We coded language as *interval* if they referred to timespans, usually in relation to tasks, e.g., "*give me a sec*", "I had a conversation ... *a few hours ago*", "*morning*", "*around for awhile*", etc. Unlike formal ISO date/time *standards*, *interval* time is subjective and thus more likely to be susceptible to ambiguity and misunderstanding. Therefore, *interval* terms in our corpus tended to need additional explanation or elaboration as part of the workflow since they incorporated non-literal meanings and/or specific cultural contexts.

For example, SBTF volunteers extensively mined social media keywords and hashtags for information about hospital operating status in the aftermath of Hurricane Maria. Posts on both Twitter and Facebook (Figure 5) typically characterized the ground situation in terms of *interval* time, e.g., "*a while ago*" and "*when*". However, these mentions often lacked key information and needed additional temporal context. From the Facebook example, "*just*" is relative to the poster's time (who, in this case, is not in Puerto Rico but claims to relay information from the island). The grammatical context matters here. Using "*just*" as an adverb has a temporal connotation, in contrast to its use as an adjective, which conveys judgment. Further, the Facebook user also references "*2 hours*" as the interval of time over which the hospital could presumably continue to operate its generator. It was not unusual to see multiple qualitative temporal representations in a single social media post that volunteers had to evaluate for meaning.
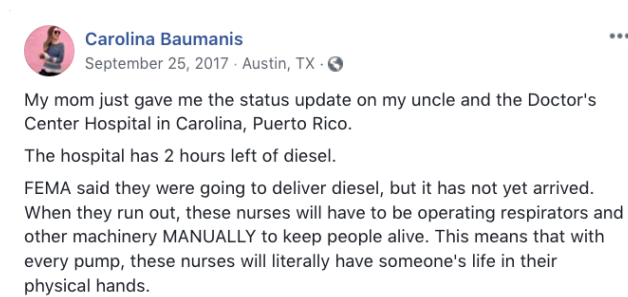

Carolina Baumanis
September 25, 2017 · Austin, TX ·

My mom just gave me the status update on my uncle and the Doctor's Center Hospital in Carolina, Puerto Rico.

The hospital has 2 hours left of diesel.

FEMA said they were going to deliver diesel, but it has not yet arrived. When they run out, these nurses will have to be operating respirators and other machinery MANUALLY to keep people alive. This means that with every pump, these nurses will literally have someone's life in their physical hands.

Fig. 5. *Interval time* example from Facebook.

5.3 Time as Chronology

We coded language as *chronological* if they referred to the linear past, present, and future perspectives of time, e.g., "*already*", "*now*", "*today*", "*new*", "*later*", etc. These terms capture an especially challenging temporal structuring problem for digital humanitarian work and information sensemaking since people use the present to base an understanding of past experience or anticipate near-future needs. This is often done to construct a timeline of events that are critical in the disaster event.

We encountered *chronology* words and phrases more frequently than any other pluritemporal mode. This makes sense, since the primary goal of digital humanitarian crowd work is to assemble situational awareness of on-the-ground conditions at a given moment in time. Therefore, SBTF volunteers are constantly negotiating between collective sensemaking and the need to gather additional context to discern the state of the present situation in light of the recent past. This dilemma is illustrated in the following exchange between Hera, an inexperienced volunteer and an SBTF leader, Rey:

> **Hera [2017-09-28T11:49:30Z]:** @Rey I'm stressing over the details. What *date* do I use? The *date* of the **original** post that stated that the hospital was open, or **right now**. Is the **time right now**, or the *time* from the post. What *time zone* do I use?

In this work, stitching together an event chronology from the cacophony of social media posts requires holding multiple temporalities in parallel—that is, the crisis time zone timestamps side by side with one's own relative time. Social media timestamped metadata used to curate information tends to reflect the volunteer's own device clock, time zone, stream settings, etc. Constructing a chronological timeline from individual social media posts means interrogating the context behind each potential data point.

> **Hera [2017-09-28T11:50:29Z]:** Okay *Just* seeing this **now**.

Hera then acknowledges her temporal relation to the social media post of interest as "*just*" and "*now*" implying that the information is new and presented to her in "real time":

> **Rey [2017-09-28T11:51:47Z]:** No please don't stress! *Date* of the **original** post please. *Time* from the post, I think as its from an entity within PR the *time zone* will be in *AST*, which is what PR follows. List the *time* from the post and put the *time zone* next to it.

The convoluted nature of assembling a chronology of events is evident in Rey's response to Hera. Rey, a highly experienced volunteer, also assumes the date-time of the post from "an entity within PR" is expressed in the local time zone, Atlantic Standard Time. Some volunteers achieve a sense of pseudo-agreement with local information sources on social media by tuning their own account settings to the disaster zone time to embed themselves in local time and avoid confusion around the need to manually convert time zone metadata. Based on Rey's advice to Hera, it appears Rey may have taken this settings approach without telegraphing it to Hera.

Piecing together a chronology of events from social media data is also challenging for the volunteers because the content and timestamps are often at odds. From this Twitter example (Figure 5), "*yesterday*" is relative since the timestamp on the tweet actually reflects the SBTF volunteer's Mountain Daylight Time zone and not the presumed Atlantic Standard Time of the crisis zone. However, the `10:46 PM 24 Sep 2017` timestamp, when taken at face value with the reference to "*yesterday*," would suggest that the author of the post is referring to the day before, September 23rd. However, once the timestamp is converted to the appropriate local Puerto Rico time, `12:45 AM 25 Sep 2017`, it becomes apparent that "*yesterday*" actually meant September 24th.

(a)

Fig. 6. *Chronology time* example from Twitter.

The additional cognitive overhead required of SBTF volunteers to discern the differences between relative and absolute times—in context and on the fly—is quite complex and introduces troubling time- and safety-critical risks.

5.4 Time as Tempo

We coded language as marked by *tempo* if they convey the speed or pace at which activities take place, such as "*pressing*", "*quickly*", "*moment by moment*", "*race against time*", etc. The rapid nature of time-critical digital humanitarian work often creates a sense of urgency for the volunteers that must also be balanced against the organization's commitment to assemble trustworthy information products for emergency responders that convey a reliable sense of ground awareness.

In this excerpt, *tempo* language appears more prominently when the mapping technology used to visualize the collected information interrupts the pace of Poe's work geolocating aerial images of hospitals taken by the Civil Air Patrol (CAP). Rey responds with "*wait*", "*slow*", "*speed*" to convey her shared experience about the image upload delays:

> **Rey [2017-09-28T17:24:46Z]:** So I put the coords as is, I ended up in Austria lol. But when I limited it to two digits after the decimal point, I ended up in Castaner, which is correct. Can you try using 18.18, -66.83 ?

> **Poe [2017-09-28T17:27:26Z]:** Hah! That seems to have worked - thanks @Rey! No CAP images *there*, unfortunately, at least on my view. :confused:

> **Rey [2017-09-28T17:31:14Z]:** *There* are! Just be sure to ***wait*** a *while*. Actually, just above the 'Powered by Esri' logo on the bottom right, there is the black circle that shows that the map is *still* uploading. Its real ***slow***, will check if something can be done about the ***speed***. Will keep you *updated*!

> **Poe [2017-09-28T17:31:48Z]:** Oh, I see! Alright, will do! #ivelearnedsomethingtoday

5.5 Time as Presence

We coded language as *presence* if time is framed in spatial terms, reflecting how time manifests in relation to a person's presence. This type of framing where time is represented as movement within a physical axis [25] is a common approach in the study of spatial metaphoric structures in linguistics [7]. In the world, time and space are socially intertwined as an expression of location [2, 50]. Here, *presence* takes on a host of qualitative textures that infer distance or movement as "*long time*", "*catch up*" and "*go ahead*":

> **Leia [2017-09-28T06:42:20Z]:** *Good morning*. It just took a ***long*** *time* to read and catch ***up*** but I rebooted and hope I can move a little *faster*. Is there anything special I should work on or just ***go ahead*** with a hospital that has no information *yet*?

5.6 Time as Ephemerality

We coded language as *ephemeral* if it acknowledged the fleeting or passing nature of time and the dynamic qualities of things happening in time. Ephemeral language often places specific emphasis on recognizing and responding to the idea that information and work practice are fluid—that everything is in motion. It also appears as an explicit acknowledgment that one is aware that others may have differing experiences of time, either based on their location or as mediated through the shared technologies.

Ephemeral language most often appears in dialogue about information *updates* or to signal the need to bring information *up to date* due to the rapidly changing ground truth at any given moment in time, irrespective of the *tempo* of the work. For instance, one hospital alone had 17 updates to its status over the activation.

Padme's reflection, below, about chronicling and *updating* the ever-changing hospital status is emblematic of the volunteers' discourse throughout the activation about the chaos in Puerto Rico:

> **Padme [2017-09-27T20:45:40Z]**: :sbtf: :sbtf: :sbtf: VERIFICATION is a key element for this deployment. Be sure to add the link to the *original* source when you add data. And double check to see if there are more **updated** information. In PR power is on and off, so an hospital that had power two *days ago* may not have it *today*. :sbtf: :sbtf: :sbtf:

Further, there is a texture to *ephemeral* time that is both relative and relational. In her post to the Slack channel, Padme concludes that the ephemerality of time complicates an already challenging task of discerning the relative currency of information (e.g., the mixed signals about whether a hospital is operating or not). Here, she alludes to the need to better align work practice and technology in their effort to achieve temporal coordination.

6 TEMPORAL ORDERS AND SOCIOTEMPORAL DISORDERS IN DISTRIBUTED CRISIS WORK

Our pluritemporal analytical framework provides a thick description of the ways that distributed SBTF volunteers use different qualitative aspects of time, in addition to standard clock-time, to coordinate their high-tempo, time-critical information work. These insights help scaffold a broader question that is the central thesis of this study: *How do globally distributed teams temporally coordinate their work?*

Here, we return to the concept of *temporal orders* introduced earlier that now come into view. We define temporal orders as shared understandings of time within a group. People use temporal orders to orient their experiences of time, which may originate in the natural world, technology or society. A natural temporal order, for example, describes the collective agreement that the lifespan of an Atlantic hurricane follows a regular pattern of formation from a rotating storm system off the coast of west Africa to potential landfall(s) to its eventual dissipation. Natural temporal orders tend to unfold as sequences in time, like a chronology, in a predictable linear path with a distinct beginning and end. Alternatively, a temporal order of technology assumes a more dynamic notion of time since computers can enqueue millions of real-time data points, label them with the platform's own interpretation of clock-time, (re-)structure the data at will, and then represent the data stream back to information consumers in any number of ways. Last, a sociotemporal order is a collective sense of time constructed by social norms and shared meanings that regulate activities. Put more plainly, a *temporal order* is a shared understanding of how different types of time manifest in our world, whereas a *sociotemporal order* places time into a shared social context and uses it in some form of collective practice.

Below, we interleave how the pluritemporal framework reveals the invisible work of these temporal orders in the Hurricane Maria activation—as well as highlighting the breakdowns, or *sociotemporal disorders* that the volunteers face in the course of their distributed coordination work. We present the results of our analysis of how work is accomplished in an environment where language about time punctuates most interactions, to understand *why* these different and often confusing discursive invocations of time are present in the first place. We begin by walking through an illustrative example that captures the confluence of multiple temporal discourses that shape and are shaped by temporal orders.

In the waning hours of the Hurricane Maria activation, a group is working at a fever pitch to wrap up the data collection. Two volunteers are in dialogue about how to resolve conflicting information: by recency of the timestamp, credibility of the information source, or relevance to the crisis. Note that the majority of the interaction occurs within 5 minutes, and so it is rapid-fire, with many issues being discussed at once:

>**Ben [2017-09-28T23:41:43Z]:** One of the critical things *at the moment* is to make sure we are only publishing one record about [each] hospital. The instructions will differ based on how many people have *an hour or so* to work on this. Can I get anyone who can work on this to yell out *here* and I'll create the instructions.

Here, Ben, an SBTF leader located in Oceania, puts out a call to volunteers for a quick side project to help validate previously collected hospital data that appears on the crisis map. He wants to ensure that the mapped information is timely and trustworthy—criteria that are sometimes at odds and require a fair amount of close evaluation by the volunteers that is difficult to achieve in the midst of a high-tempo activation. Maz, located in North America and one of the more experienced volunteers, responds to Ben's request within 30 seconds of his Slack channel post:

>**Maz [2017-09-28T23:42:17Z]:** Well, this is the problem with putting in *timestamps* that we see on our screens. The mayor made her statement at *16:51 Mountain*. The person posting about Damas said it at *10:46 Mountain*

While sorting out conflicting information is an everyday occurrence in digital humanitarian work, it is additionally complicated by the disunity between the information chronology and credibility of the source. Maz responds to Ben about this tension of privileging timestamps over other evaluation criteria. She points Ben to two Facebook posts about hospital status in Ponce that were previously recorded in the Google Sheet (Figure 7) that are at odds. Here, there is a clash of time, as standardized timestamps and pervasive technology-enabled timelines purport to offer 'real-time' chronologies of information. These structures hinder the volunteers' capacity to order, reorder, and reconcile a more nuanced temporal understanding of the information at hand. Maz in part resolves this by using a timestamp from her own local time zone of which she can be assured, talking about when the mayor at the disaster site and in a different time zone made her remarks. Maz is locking down details by making references to standard time, a commonly accepted timekeeping notation. Ben replies:

>**Ben [2017-09-28T23:43:33Z]:** We also can't just take the *timestamp* as even if a post is *older* but is from a better source with more credible info - that is the one that should be published first.

Ben concurs with Maz—acknowledging the dilemma of reconciling different information. This discursive exchange gives way to a shared understanding of how taking the chronology at face value is entangled with the need for a more sophisticated evaluation and verification of the content posted to Facebook. However, this does not merely entail a hierarchical ranking of the value of certain metadata over other descriptive attributes but a reckoning with the complexity of the information, the precision required to assess it, and how to parse it on the fly.

>**Maz [2017-09-28T23:44:15Z]:** The *later* record is the mayor. I have no idea who the other person is and how she would know about every hospital in Ponce

Within seconds, Maz replies to Ben, sharing her similarly aligned view: A Ponce elected official is a more trustworthy informant than a local Facebook user who posted a more recent but conflicting status report that lacked detail about the information's provenance. Thus, source credibility is assessed to supersede the social media timestamp as an evaluative judgment.

>**Ben [2017-09-28T23:44:33Z]:** We will have two layers in the map - one showing the most relevant info only and one showing all. So everything will be used but FEMA will just be able to use what they want easier.
>
>**Ben [2017-09-28T23:44:50Z]:** It's not just about this one example.

Having agreed about two dimensions of the information—recency of the timestamp metadata and credibility of the source—Ben introduces a new wrinkle: the relevance of the information to

the unfolding crisis. Here, he suggests generating map layers as a way to temporally arrange the information in ways that allows consumers of the information (in this case, FEMA) to decide what to prioritize: timeliness or dated-but-certified accuracy.

> **Maz [2017-09-28T23:46:33Z]:** I understand that but how do you propose finding the correct one *within* the *time* constraint? I found the "right" one by re-reading both the posts.

Maz pushes back on Ben's leap in adding relevancy as a new dimension for reaching agreement about the hospital status information. While they agree on the contextual precision needed to integrate clock time and credibility into their common agreement, she reminds him about the tempo of the work, which until this point in their dialogue was unacknowledged as a real tension and threat to the larger goal of producing timely and trustworthy information. She continues:

> **Maz [2017-09-28T23:58:53Z]:** The only way I can see these kinds of discrepancies to check these is to sort the data. I can copy the sheet into a separate workbook and sort by hospital name. But I don't think there's *time*, if we only had *an hour* to begin with. I have to be back on the fire in *an hour*. Let me know what you would like me to do

The SBTF Hurricane Maria project officially ends shortly after the discussion between Ben and Maz. However, a new problem is revealed about the Ponce hospital status discrepancy during the data verification process, where a small team of trusted volunteers spot check information entered onto the sheet at the conclusion of the activation. Upon further investigation, the SBTF volunteers discover that there are more than four hospitals in Ponce (in contradiction to the mistranslated statement attributed to the mayor in the sheet) and that the "other person" who posted on Facebook at 10:46 Mountain Time that two hospitals were closed is actually a Univision reporter based in Puerto Rico using her personal social media account to amplify her news reporting. So, in this case, both reports are correct and both sources are credible, but strictly relying on timestamps causes a misleading interpretation. To paraphrase Reddy et al. [46, p. 50], *While time is certainly important, context also matters.*

The tempo of digital humanitarian work varies considerably, adding yet another layer of complexity to distributed coordination work for ad hoc teams. Each activation establishes its own unique pace according to the complexity and urgency of the tasks, access to information, and, crucially, the availability of volunteers to coordinate with one another. Even with a globally distributed team, the nature of this work is still subject to the everyday work–life rhythms of the volunteers. As Maz notes, Ben's impromptu and quick-turnaround data validation side project runs headlong into the realities of a much more complicated, time-delimited task. She offers a data sorting workaround to speed up the task as a way to reconcile a temporal disruption in the work with her planned departure to attend to other work obligations.

In this rapid exchange covering a number of issues in digital humanitarian work, we see three primary temporal orders to which the pair attends:

- the **temporal order of the crisis** with respect to the damage it has done to hospital infrastructures and the constantly shifting state of operations caused by new natural hazards, e.g., flooding, mudslides, etc.;
- the **temporal order of the technologies**, which mediate the source information of their work—in this case, the timestamp metadata of social media posts about hospital status; and
- the **sociotemporal order of the distributed work** that influences the urgent pace of the coordination and the limited window of time that Maz can work on the task.

The remainder of this paper will discuss how SBTF is constantly undertaking temporal coordination work to establish some degree of workable and shared temporal agreement. But that work

Fig. 7. Conflicting hospital status reports.

begins from a state of temporal disorder by virtue of the arrangement of a globally distributed work team searching for information about a natural hazard event that runs on its own time and information that is mediated through technology platforms that associate their own temporal metadata with it.

6.1 Three Temporal Orders

We find three primary **temporal orders** present in distributed crisis work: (1) the *temporal order of the crisis*; (2) the *combination of temporal orders of the various technologies* being used; and (3) the *sociotemporal order of the distributed team*. These temporal orders vary from one another due to differences in the composition of the social groups implicated in each, as well as the nature of their relations to other temporal orders and markers of natural time. All three temporal orders manifest in the discourse that is central to distributed crisis work, particularly through the work required to orient team members to align the orders, and do so across the team. By revealing each of these largely tacit temporal orders, we are able to more specifically articulate and target those temporal features that provide the clearest opportunities to help resolve friction points and improve globally distributed team work practice and technology adaptation.

6.1.1 Temporal Order of the Crisis. The most foundational temporal order to the digital humanitarian work context is that of the crisis itself. Here, the shared understanding of crisis time within the group is dominated by timekeeping and the passage of time in a linear progression of crisis phases. For instance, the crisis event is located in a particular time zone—in this case, Atlantic Standard Time (AST). This includes communications about the hurricane landfall and other hazard-related events, the rescue phase activities, the recovery phase activities, and so on. Days and times in news reports and social media posts are often communicated with an implicit assumption of having taken place in the AST time zone. All of this necessitates frequent conversions between "crisis time" and the time zones in which the digital humanitarian work is being done. Further, temporal references in news and social media are often either implicit (e.g., "Hospital Meléndez Bayamon will run out of diesel ..."; Figure 8) or lack context that would facilitate precise organization or interpretation.

This problem increases volunteers' reliance on the timestamps of social media posts. However, media timestamps are typically displayed to reflect the time zone of the user-reader, not that of the user-poster who originated or shared the post (Figure 9). Although this design decision can facilitate rapid assessment of the recency or staleness of a post, it can also result in confusion. It is quite common for linguistic time references in the social media content to not align with the displayed time stamp.
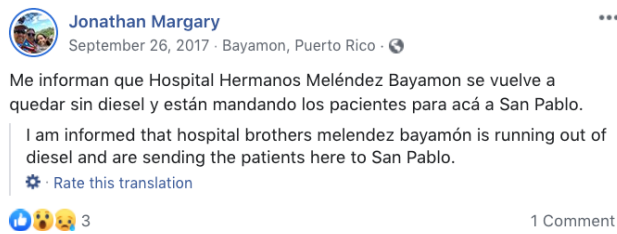
Fig. 8. Mentions of time in crisis-related social media posts are often implicit and/or non-specific.

(a)   (b)
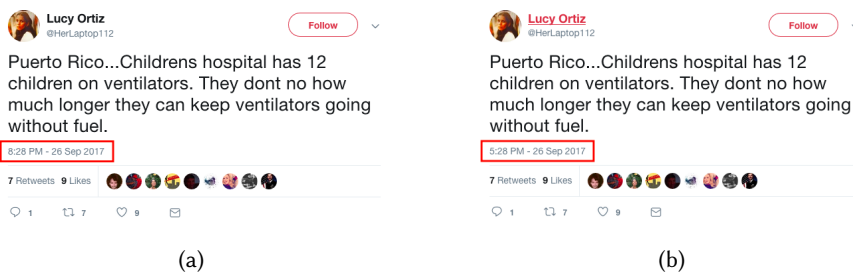
Fig. 9. The same social media post, as displayed in a browser with Twitter configured to display posts in the crisis time zone (AST, on the left) and as displayed in a volunteer's "home" time zone (MDT, on the right)

Natural disasters can additionally be divided into three broad, sequential phases: pre-impact, impact, and post-impact. Neal suggests that each phase is characterized by "a continuum of disaster," or period of time when the usual everyday rhythms of life are disrupted by the immediate priorities imposed by the disaster event [39]. Variations in individuals' experience of this facet of crisis time manifest in the content, tenor, and informational focus of their social media communications; characteristics that, then, affect the work that the distributed humanitarian team can accomplish.

6.1.2 Temporal Order(s) of the Technologies. In distributed humanitarian work, cloud-based tools and platforms are used to generate and synthesize information and metadata into temporal artifacts, such as datasheets, coordination transcripts, and crisis maps. Each of these tools imposes its own temporal order that is understood by SBTF volunteers as dynamic and malleable due to filtering, sorting, and layering, as well as algorithmic interventions. For example, when social media platforms control when posts appear (and in what order), they create their own sense of temporal organization. Information is made available based on inaccessible algorithms, internally-maintained clocks, and database schemas, all of which may introduce changes to the information's temporal metadata, divorcing the data from its original state. Additionally, by changing the ways that time is displayed to users, systems can either distort or clarify temporal relationships. In some cases, technologies can be configured to foster a sense of common ground among people [9] through shared representations of time. However, in most cases, these technologies are implemented according to commercial priorities.

Furthermore, the illusion of "real-time" is a source of significant tension in temporal coordination in distributed crisis work. These tensions manifest in two primary ways: 1) the false sense of immediacy embedded in technology-mediated information and 2) the limited ways that time is

represented in social and collaborative computing technologies. For example, synthesizing social media as a reliable, actionable, and timely information source for real-time situational awareness has proven to be quite challenging [55]. Social media platform infrastructures are not especially conducive to (nor founded upon an economic model that encourages) displaying an ordered real-time stream from the deluge of posts from and about the crisis zone.

Another key temporal disruption is the inability to represent different modalities of time in off-the-shelf, cloud-based collaborative technologies used to collect and synthesize qualitative crisis information. Although SBTF has, in the past, experimented with using customized collaboration support tools, the overhead of distributing, training, and provisioning long-term technical support for maintaining these tools is high (see also [64]).

As we noted in our pluritemporal framework, people employ multiple forms of time references side-by-side to construct a sense of order, as illustrated in this text message about the deteriorating conditions of a hospital posted to Twitter (Figure 10). Information about hospital status frequently inferred qualitative features of time, such as urgency, priority, and updates to previous information. Yet, data structuring tools, like Google Sheets, lack the extensibility to accommodate complex temporal sensemaking strategies, aside from storing different types of standardized timestamp formats. Instead, this crucial information gets lost in text fields, further degrading a shared understanding of "crisis time" by the SBTF volunteers.
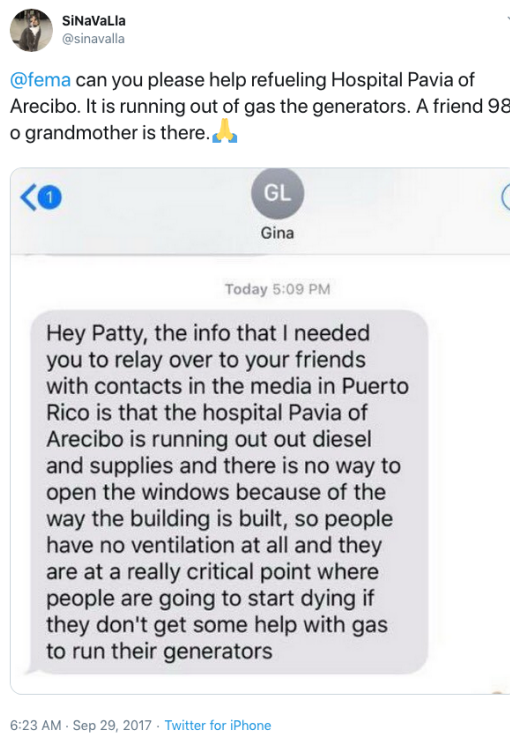

Fig. 10. Qualitative representations of time

6.1.3   *Sociotemporal Order of the Distributed Work.* Volunteers contributing to a globally distributed digital humanitarian endeavor are, by definition, spread out across immense geographical

space. As a result, they are also spread across time, joining into the collaboration from a variety of time zones, day and night, during breaks in daytime employment and in the midst of discretionary evening time. Not only do volunteers have to reconcile their own time to the duration of and milestones imposed by an SBTF activation, they also have to construct shared understandings of how to coordinate with one another to accomplish that work. The rapid micro-coordination [29] reflected in the exchange between Ben and Maz, above, illustrates how SBTF volunteers—one located in Oceania and the other in North America—are able to order and negotiate work within their shared, computer-mediated environment.

6.2   Temporal Coordination: The Work of Reconciling Sociotemporal Disorder

Breakdowns in finding adequate points of reference across the three temporal orders are the cause of much temporal discourse that we found and coded in our corpus. Instead of achieving an "order" in which they can organize their work from a shared understanding of time—their own sociotemporal order—they are instead working from a state of "disorder." SBTF volunteers must work discursively to reconcile temporal orders, both for themselves and collaboratively with others in their distributed work team to reach agreement about *what time it is where*.

The tyranny of clock time imposes deadlines, shift schedules, and production expectations on work. For broadly dispersed global teams, coordination must be negotiated across day/night rhythms, biological clocks, time zones, and localized sociotemporal orders, like periods designated for work and leisure. For 24/7 organizations like SBTF, which does not structure its work in shifts or formal units of time, this creates an additional layer of complexity added to temporal coordination. Volunteers come and go at will; therefore, the dynamic nature of what constitutes "work time" is sociotemporally disordered from the start. Erratic work rhythms and constantly evolving team formations hinder individuals' capacity to develop an awareness of what co-workers are doing and when.

The following exchange between SBTF volunteers illustrates sociotemporally disordered distributed teamwork. Early in the activation, the volunteers were provided inconsistent instructions about how to note on the Google Sheet which hospital, from a list supplied by FEMA, that they chose to search. The volunteers either did not see the instructions pinned in the Slack channel or were confused by the directions and forged ahead using previous practice that turned out not to apply in this case. At this point, seven days have passed since the hurricane first made landfall in Puerto Rico before FEMA activated SBTF. Hospitals and other major social institutions on the island remain in a state of chaos, which is uncharacteristic at the one-week mark of the disaster impact phase. Moreover, the information request by FEMA required a new, unfamiliar workflow for SBTF volunteers to collect highly targeted, real-time information about hospital status without duplications. Here, the disrupted temporal order of the crisis is out of sync with the typical rhythms of the sociotemporal order of the distributed work:

> **Sabine [2017-09-27T23:11:10Z]:** Guys, please sort this out, because the instructions on the sheet aren't clear, and there are initials columns in both the "list of hospitals" and the "social media sources" sheets.
> **Sabine [2017-09-27T23:12:41Z]:** I'm trying to point myself in a focused direction and hoping others know to do the same in whatever way is most coherent. :slightly_smiling_face: To be completely clear: Nothing is more frustrating to me than *wasting time* doing something someone else is *already* doing.

Here, Sabine complains about the lack of coordination among the team by specifically calling out "*time wasting*" as a threat to team productivity and shared understanding ("doing something someone else is *already* doing"). Absent a fix to the temporal disorder, she follows up a few minutes

later with a more urgent call to action for the community to clarify the parameters of the immediate, time-critical task, re-iterating time as a precious commodity:

> **Sabine [2017-09-27T23:17:01Z]:** Clues might be in the *version history*, @Rey, but for the *moment* I would just like some clarity so I can proceed in a *non-time-wasting* fashion. Pretty please, y'all. :slightly_smiling_face: Because we need everybody on the same page in order to *not waste time*, and that means everybody should be assigning themselves a hospital (or however many) from the list itself, if I'm understanding correctly.

Sabine's frustration boils over, which instigates a new strategy—peering back into the Google Sheet version history to resolve the confusion about the current, improvised work practice that deviates from previous hurricane activation instructions. Sabine suggests to Rey, an SBTF leader, to review the content timeline from the instruction-sharing tab in the Google Sheet to determine when the breakdown occurred. Here, the temporal order of the technologies is invoked to reveal the friction between the temporal order of the crisis and sociotemporal order of the distributed work that is driving the dispute.

> **Lexi [2017-09-27T23:17:07Z]:** I'm afraid *I'm off*, this is a *short* but tough one that has had to be be put together very *quickly*, with technical issues thrown in for extra fun! Have patience and work together! Love you all :heart_eyes: I will be *back* for the *last few hours tomorrow* :starspinning:

Lexi enters the conversation (though has been working steadily in the background) to offer missing temporal context about the behind-the-scenes tempo of the activation launch that likely caused the disruption. Note that she is also signalling the end of her own personal work shift, with some regret about the implications for collectively completing this task ("I'm afraid *I'm off*"). In urging the volunteers to be patient, Lexi draws attention to the need to slow their pace as a potential remedy to the unfolding temporal conflicts between the crisis and the work.

> **Rey [2017-09-27T23:19:27Z]:** Please *go ahead* and check the *history while* I check with the [activation coordinators] to get some *finality* on this matter.

> **Mace [2017-09-27T23:26:46Z]:** Hi Sabine, I hear where you're *coming from* but the hospital list tab is feeding a map. Too many people on that tab risks possible data corruption. How do you think we can *come up* with a way to stake claims on search terms without interfering with that tab?

Mace, one of the project coordinators, interjects herself into the continuing disagreement by using *presence* time references ("*come from*", "*come up*") to appeal for a new, agreed-upon workflow to leave the disordered temporal crisis, technology, and work rhythms behind.

7 DISCUSSION: DESIGNING TO SUPPORT TEMPORAL COORDINATION WORK

In this analysis, we highlighted how SBTF volunteers employ conversation to work through and around sociotemporal disordering and to establish some degree of sociotemporal agreement so their work can productively unfold. Much like other forms of articulation work (e.g., [52]), the negotiation about time and establishment of a shared understanding of *"what time is it?"* is carried out as an essential part of work practice but operates invisibly in the margins to support the functioning of the broader mission and aims of the organization. The diversity and scope of the discourse that transpires to support temporal coordination in this case is striking. The derivation of the pluritemporal framework presented in section 5 arose from our analysis of all the ways that people communicated the different modes of time that are at work in this problem space as they are perceived, experienced, and mediated via technology—often problematically. We use these

same pluritemporal categories to scaffold a set of design implications that could reduce the amount of discursive articulation work needed to overcome sociotemporal disorder, especially in time- and safety-critical events that are increasingly mediated by technology.

7.1 Designing for *Time as Standard*, *Time as Interval*, and *Time as Chronology*: Tools for automating timestamp management and providing data and metadata awareness

The prevalence of conversations around *standards*, the resolution of ambiguous or underspecified temporal *intervals*, and the reconstruction of a coherent *chronology*, highlights the dearth of useful information about temporality provided by current collaborative systems: timestamps—represented in varying base time zones—or vague characterizations of recency. Most temporal information with which the volunteers we studied were working is conveyed descriptively, embedded in the social media content itself. An accurate ordering of the social media content and the events that they describe has to be reconstructed manually—and has to be negotiated/aligned/ordered discursively among the volunteers. The implicit assumption embodied in these—admittedly mundane—facets of interface and infrastructure design is that [re-]presenting temporality with seemingly objective, but experientially indifferent timestamps, is sufficient.

Timestamps, however objective and reliable as they may appear, create problems of their own. Although SBTF coordinators currently attempt to pre-structure data collection sheets like the one appearing in Figure 3, the brittle nature of Google Sheets' automated formatting rules for dates and times regularly leads to breakdowns in the face of dozens of volunteers simultaneously editing the document. In the discourse under study, we observed, for example, comments about the interjection of different localized date representations when a row was added to a shared Google sheet, debates about the lack of uniformity in 12/24-hour time entries, and regular disagreement about whether timestamps should be conveyed in the local crisis time zone or a "universal" (e.g., UTC) time zone, given the lack of explicit conversion tools to and/or from the crisis-local time zone. These problems also raised questions about data trustworthiness, necessitating manual workarounds, such as continuous quality-control checks of the sheet by designated, experienced SBTF volunteers. These standards-oriented and temporal interpretation-oriented problems might be addressed by enhancing the time and date handling capabilities of tools like Slack and Google Sheets. Having the ability to globally specify—and lock down, for all but SBTF activation leadership—an expected timestamp format and timezone offset for a sheet or a conversation, and then providing the capability to automatically convert (or suggest conversion) to these shared norms would be an asset to large numbers of contributors working together to make sense of temporal sequences. The ability to quickly reveal relative time information (e.g., conversion of a time to UTC or to display a timestamp offset from one's local time zone or from a reference datum such as the time of crisis onset or the scheduled conclusion of an SBTF activation) would serve as useful informational resources for volunteers. This would reduce many of the questions about time zones and timestamp formatting that we observed in the Slack transcripts.

Another way that the collaborative computing platforms used by SBTF volunteers could better support adherence to *standards*, resolution of ambiguous *intervals*, and reconstruction of *chronologies* would be to provide better mechanisms for capturing and representing the provenance of the data upon which this work is based: when Facebook posts or Tweets are referenced, for example, the temporal and provenancial metadata surrounding those posts could be rendered visible, perhaps upon request, and it could be included as data are referenced, moved, and/or aggregated. What would it mean, for example, to be able to cut and paste a tweet into a spreadsheet and have the spreadsheet formulas and/or macros in that sheet have access to the temporal history of the post, as well as the ability to perform computation (e.g., conversion to standard time representations

and a primary time zone, validation or visualization of the recency of content, etc.) on that content on the user's behalf? What would it mean for "data detector"-like technologies [38] to be able to not only detect but also provide suggested resolutions for ambiguous mentions of time based on the known temporalities in which that information was constructed, propagated through a social media network, and then retrieved? What if this kind of rich temporal information were accessible to technology end-users instead of being relegated to esoteric JSON representations of the postings, intelligible only to sophisticated platform API users?

This kind of nuanced temporal information—ideally, pre-sorted chronologically by the platforms, themselves—might be embodied within specialized crisis-response "portals" that allow for more direct, comprehensive, and non-timeshifted access to social media streams in partnership with the major social media companies, themselves. Alternative approaches that would also address some of the shortcomings that we observed in our analysis include development of crisis-focused social media aggregation tools, in the vein of consumer-oriented apps like HootSuite[5] or TweetDeck[6], or the creation of browser plugins to allow for on-demand interrogation of the information provenance and in-depth metadata records associated with individual tweets accessed through a typical social media website.

7.2 Designing for *Time as Tempo*: Tools for promoting task and activity awareness

Technologies or interaction techniques to complement or obviate the need for volunteers' observed discourse about and around the *tempo* of the work (both relative to and in the context of the crisis and the SBTF activation) are more challenging to design for. Interfaces like Time Aura [31] suggest how real-time pacing indications can be ambiently added to a primary task interface and provide peripheral cues about how the pace of work is (or is not) matching expected norms or paced to meet an approaching milestone or deadline. However, these interfaces can also increase individuals' sense of time pressure and anxiety by rendering small deviations from temporal expectations or norms quite visible. Effective design solutions in this domain need to strike a subtle balance between providing the kinds of informative cues that are currently missing from shared tools like Slack. Likewise, doing so in a way that enables volunteers to support one another in settling into a sustainable pace that does not compromise the integrity of the shared output or the health and well-being of the volunteers themselves.

Implicitly, conversations about tempo and pacing also reflect a lack of strong shared awareness about how finer-grained activities and tasks fit into the larger picture of the crisis response activation. Feeling "rushed" or expressing concern about how the most important analysis activities will all be accomplished—at an acceptably high level of quality—within the 72-hour window that SBTF targets for completion of their intensive digital humanitarian response suggests that individual volunteers don't have a particularly clear sense of how or where their contributions fit into the bigger picture. Activity awareness tools and/or collaborative task-management dashboards (e.g., [36]) integrated into Slack or overlaid on the coordination-oriented communication channel might also help to address and mitigate these instances of uncertainty and anxiety.

7.3 Designing for *Time as Presence* and *Time as Ephemerality*: Tools for supporting sociotemporal and collaboration awareness

Temporal coordination work that is made visible through language that expresses features of *presence* and *ephemerality* in order to reconcile sociotemporal disorder—signals the presence of similar work coordination challenges that we see in CSCW work about remote co-presence

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[5]https://hootsuite.com
[6]https://tweetdeck.twitter.com

and awareness [14], with the added complexity of supporting a relatively large-scale team for a relatively short duration of time. Here, systems that provide increased situational and task awareness would help to off-load much of the temporal coordination work that we observed. Although the technologies employed by SBTF to coordinate and compile information—Slack and Google Sheets—do include representations of who is online, these representations provide little context besides indications of synchronous presence. Although techniques like media spaces [6] could implicitly provide better cues about activity and temporal constraints (e.g., time of day, location in which work in taking place), these approaches are generally not intended to scale beyond a few close collaborators. Other indicators of engagement, activity, and activity history in persistent conversational spaces have also been proposed (e.g., [16]). Adding similar visualizations— for example, the amount of time a volunteer has been active, their anticipated amount of time remaining available to participate in the current working session, a coarse representation of their current activity such as a link to the most recent contribution on the shared Google Sheet or the hashtags of the last social media post examined, and, as a counterpart, how recently a particular spreadsheet cell had been "updated" and by whom—might help to create a more tangible sense of "presence", cooperation, and coordination among volunteers.

Overall, exploring design implications through the lens of temporal discourse categories also suggests an initial design space for supporting temporal coordination work among globally distributed teams. Here, our pluritemporal framework helped us to identify several dimensions of automation and awareness support that SBTF's current toolset does not support well: automated timestamp management, data and metadata awareness, task and activity awareness, and sociotemporal and collaboration awareness. The emphasis here on supporting distributed work through different kinds of data, task, and collaboration awareness resonates well with prior CSCW research on design strategies for productively supporting group work without imposing formalized workflows. Additionally, the multiplicity of facets of awareness that we see emerging here suggests that facilitating other kinds of awareness might solve additional challenges beyond those that we uncovered by focusing specifically on temporal discourse. A more comprehensive design space analysis of the role of different kinds of awareness tools might be a valuable next step in designing to support these kinds of globally distributed collaborative teams.

8 CONCLUSION

Returning to the introductory excerpt in this article, we see once again how Leia is working to construct a legible chronology of a complex and dynamic crisis situation based on snippets of information originating in a distant part of the world, a region that is operating within its own temporal *dis*order in the wake of a disaster:

> **Leia [2017-09-28T09:46:06Z]:** I *just* made sure all the hospitals the [Department of Health] says are up and running as of *yesterday* had at least 1 report that they were open. It certainly is confusing as there are social media reports *seemingly from the same time* saying they are not open.

The pieces of information that Leia has found have been re-interpreted through the combined technological temporal order of the social media platforms that delivered them, adding layers of ambiguity about when the information was posted and making it difficult to interpret the apparent conflicts in hospital operational status. Leia uses language about time in a plurality of ways to articulate these tensions. She also uses language about time to signal where she is in the midst of completing this task, inviting an opportunity to reconcile temporal disagreement among the globally dispersed volunteers monitoring the shared chat channel. Language like this illustrates a

key challenge of distributed humanitarian work and highlights opportunities for directly addressing the breakdowns introduced by these competing temporal orders through design solutions.

This research has sought to understand how globally distributed teams temporally coordinate to accomplish their work by studying team discourse in high-tempo digital humanitarian information work. Our empirical analysis began with the development of a new pluritemporal analytic framework derived from the linguistic analysis. Subsequent analytical passes at a more macro level of analysis resolved how the discursive references were associated with the three different temporal orders that the team was invisibly wrestling with—the temporal order of the crisis, the combined temporal orders imposed by the technologies employed by the team, and the sociotemporal order that the team itself tried to construct in its own virtual workplace environment. Members of the Standby Task Force discursively worked toward shared temporal understanding to "order" the sociotemporal disorder (not once, but continuously throughout the activation) so as to achieve moments of temporal coordination. From these results, we, in turn, interrogated the technical origins that are in part attributable to these sociotemporal disorders.

The study of temporality in distributed work has taken on increased empirical and theoretical attention within the CSCW community—and with good reason. Temporality is an essential feature of technology, work practice, and human experience. And, as we have shown in this research, temporality and the alignment of temporal orders represents a significant challenge for individuals who are simultaneously distributed across time and space. Our work, bridging between the empirical and theoretical, also lays the groundwork for a more intentional shift towards designing for temporality within the CSCW community. Our contributions of a pluritemporal analytic framework, an articulation of the temporal orders implicated in this kind of distributed humanitarian work, and an initial discussion of design space axes that might serve as scaffolding for future design and implementation work all point towards opportunities for the community to continue to engage with these vital challenges.

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