

Collective Action Theory Meets the Blogosphere: A New Methodology

Nitin Agarwal^{1†}, Merlyna Lim², and Rolf T. Wigand¹,

¹ Department of Information Science, University of Arkansas at Little Rock,
2801 South University Avenue, Little Rock, AR 72204-1099, USA

² School of Social Transformation – Justice and Social Inquiry, Arizona State University,
1711 South Rural Road, Tempe, AZ 85287-4902, USA
{nagarwal, rtwigand}@ualr.edu, Merlyna.Lim@asu.edu

Abstract. With the advent of advanced yet exoteric ICTs, especially the social media, new forms of collective actions have emerged to illuminate several fundamental yet theoretically obscure aspects of collective actions. Existing computational studies focusing on capturing and mapping the interactions and issues prevailing in social media manage to identify the manifestations of collective actions. They, however, lack modeling and predictive capabilities. In this paper, we propose a new methodology to gain deeper insights into cyber-collective actions by analyzing issue propagation, influential community members' roles, and transcending nature of collective actions through individual, community, and transnational perspectives. The efficacy of the proposed model is demonstrated by a case-study on Al-Huwaider's campaigns consisting of 150 blogs from 17 countries tracked between 2003 and 2010. To the best of our knowledge, the proposed methodology is the first to address the lacking fundamental research shedding light on re-framing Collective Action Theory in online environments.

Keywords: collective action, methodology, blogosphere, social computing, social network analysis, community, influence, transnational, issue crawler.

1 Introduction

Social media have played a major role in the formation of collective actions. They are often hailed as having democratizing potential and portrayed as “important tools to replace authoritarian regimes and to promote freedom and democracy” [1]. However, despite the prominence of “Iranian Twitter revolutions” [2] and the “Egyptian Facebook protests” [3], there is very little research on cyber-collective actions. Mere journalistic accounts on such actions are inevitably based on anecdotes rather than rigorously designed research.

The study of collective action has a long established history. Collective Action Theory was developed, however, in the pre-Internet era. “As a result of emerging

[†] Corresponding author

information technologies, communication is not necessarily as costly, difficult, time consuming, or limited by the cognitive constraints of individuals as it once was” [3]. The availability of advanced information and communication technologies (ICTs) has “prompted a reassessment of collective action theory, shedding light on the benefits and costs for successful contemporary collective action efforts” [4](p.366). Simply put, “new forms of collective actions reliant on information technology illuminate several fundamental aspects of collective actions that have remained theoretically obscure” [4](p. 366). This shows a clear need for new and innovative approaches as well as methods to re-frame Collective Action Theory in online environments.

On the other hand, computational studies on social media, that have increasingly become popular, such as mapping the blogosphere, tend to focus on capturing the connections between social media users. They predominantly do not study processes involved in collective acts in online environment. They also are mostly based on either link-analysis or content-analysis. They lack insights from social science, such as collective action theories, where issues (shared narratives/repertoires) are important in shaping collective action. This paper addresses the need for new methods by taking advantage of emerging new tools and combining link and content analysis as well as meme (shared issues) tracking. Moreover, the paper attempts to develop methods permitting explanatory and predictive powers that goes beyond the mere description of the studied phenomena as has been traditionally practiced so far.

With the emergence of cyber-collective action, there are several plausible research questions: Do social media reduce transaction costs for contentious political action? Do social media reduce/remove geographical barrier of collective-actions? Do social media speed up the shaping of collective action (reduce time)? Do social media create “flat” rather than hierarchical networks of collective action? Do social media more effectively disseminate and diffuse cause? Do social media change political opportunity? Do social media create different collective understandings of the distribution of societal opinion (i.e., change beliefs about what others believe)? Do social media uses enable participants of collective action to gain deeper understanding on the issue?

In seeking answers to these questions, in this paper we develop a novel methodology that combines insights from Collective Action Theory and advanced computational mapping methods. This new methodology will enable us not only to explain but also to predict the evolution of cyber-collective actions.

2 Related Work

In this section, we present a brief review of collective action theory and an assessment of the various mapping efforts of the blogosphere. These reviews are necessary to gain an in-depth understanding on currently available methods and identify the need for a suitable methodology permitting the explanation and prediction of collective actions in the blogosphere.

2.1 Collective Action Theory

Theories of collective action have been intensively used to explain some aspects of human behavior [4]. [4](p.365) point out that perspectives on collective action have been useful in explaining “diverse phenomena”, including social movements, be it in real world [45] or virtual worlds [37], membership in interest groups [14][5], the operation of the international alliance [6], establishment of electronic communities [7], formation of inter-organizational relationships [8], formation of standards-setting organizations [9][10], and even bidding behaviors [11]. Further, [4](p.365) argue that “this range of actions accounted by collective action perspectives illustrates the centrality of this body of theory to social science”.

Collective action can be defined as “all activity involving two or more individuals contributing to a collective effort on the basis of mutual interests and the possibility of benefits from coordinated action”[44](p.9)[12]. The origin of collective action theory can be traced to Ronald Coase’s (1937) explanation on “how some groups mobilize to address free market failures” [43](p.2). However, many theories were developed before advanced communications such as the Internet are available [43][13]. New information and communication technologies (ICTs), especially the Internet, “have completely transformed the landscape of collective action” [43](p.2). In online environment, the cost of internal communication is no longer a barrier for groups to create collective actions [43][13]. All kinds of online platforms have enabled “efficient communication, organization, and even deliberation within collective actions of any size” [43](p.2) [14][39].

[43] point out that “some experts believe Internet-based collective action effects are overstated and may prove ephemeral”(p.2). For example, [15] “contends that easier international communication will not automatically translate into success for international collective actions because vital interpersonal networks cannot be adequately forged and maintained online” [43](p.2). [16] agree “that without face-to-face interaction, Internet communications cannot build the stable community a long-lasting movement requires” [43](p.2). And [17] argue “that virtual demonstrations cannot satisfy the protester’s desire for the emotional rush and thrill of real, physical action” [43](p.2). However, there are evidences of the successful uses of the Internet for collective action such as the 1996 Zapatista movement [18] and the 1998 Indonesian student movement [19][20]. “The operation of groups such as these has recently been characterized as something beyond traditional [collective action]” [43]. Such examples have stirred “debates about theories of collective action”, raising questions of whether collective action, profoundly dependent on the Internet and other new technologies, “is as effective or successful as collective action in more traditional” modes [4](p.2)[21][22][38]. Using both available successful and unsuccessful Internet-based collective actions, “research has now begun identifying aspects of the collective action process that can succeed online as well as shortcomings and disadvantages of online collective action” [4](p.366)[23]. However, such research has not answered many other questions related to the emergence of various forms of collective actions in the online world. One of the major questions is “to what extent the traditional collective action paradigm is even appropriate for explaining contemporary phenomena” [4](p.366). As alluded above, this paper attempts to fill this gap by developing a methodology demonstrating how Collective

Action Theory can be reframed and applied, in combination of computational mapping, for explaining collective actions online.

2.2 Mapping the Blogosphere

Social media allows individuals to share their perspectives and opinions on various events in vast social network. The diffusion of opinions can lead to the formation of collective actions [46]. One such form of collective actions, citizen journalism, has garnered interest from researchers and practitioners leading into many attempts to map issues in the blogosphere. However, a rigorous and fundamental analysis that explains cyber-collective action is not yet established. In this section, we assess some of these fundamental efforts to map the blogosphere that motivate the need for a more systematic and foundational analysis modeling collective action in the blogosphere or other forms of social media.

IssueCrawler [24] enables aggregating blogs and websites that mention issues of interest. Starting from a seed set of blog posts that contain the issue of interest, IssueCrawler crawls blogs and websites linked by at least two seed blog posts. IssueCrawler continues crawling the web resources that are three links away. For a good quality of crawl, it is imperative to start with a relevant seed set of blog posts, which are identified using Technorati search engine's results by using the issue as the search keyword.

Authors in [25] geocoded US blogs from LiveJournal and DiaryLand using city names and 3-digit ZIP codes specified by the bloggers in their postings. By identifying where people blog, local knowledge and culture can be gauged and certain behavior patterns could be identified, however, the geocoding mapping is not sufficient to explain why certain patterns exist and what they lead to. In essence, explanatory and predictive powers of such tools are missing. Authors in [40] mine blog content to identify local cuisine hotspots. In another study [26], authors mapped the US political blogosphere and observed the dichotomy between liberal and conservative blogs. Examining the link graph between and across these communities of blogs, authors observed certain interblog citation behavior patterns such as conservative bloggers tend to link more often than the liberal blogs, but there is no uniformity in the news or topics discussed by conservatives. However, the study fell short of suggesting a theory to explain these patterns.

Other studies such as [27] analyzed 60,000 blogs from the Iranian blogosphere using social network analysis and content analysis. A wide range of opinions representing religious conservative views, secular and reform-minded ones, and topics ranging from politics and human rights to poetry, religion, and pop culture were identified. In yet another study [28], authors analyzed the Arab Blogosphere consisting of 35,000 active blogs primarily from Egypt, Saudi Arabia, Kuwait, and other middle-east countries. The authors identified major clusters organized by countries, demographics, and discussion topics. The Arab Blogosphere primarily discussed domestic politics and religious issues with an occasional mention of US politics albeit in critical terms.

These and other similar studies clearly show that individuals discuss varied topics on various blogs, however, there is a lack of methodologies enabling the analysis of

how the discussions converge to central themes. In lieu of addressing this gap, we have specifically developed such a methodology (Section 3) enabling the use of Collective Action Theory and computational mapping in order to explain and predict the underlying processes involved in collective actions in the blogosphere.

3 Proposed Methodology

Scientific work typically aims at one (or both) of two things: (1) the precise, accurate and parsimonious description of some phenomena, and/or (2) the explanation of some phenomena, i.e. why does a phenomenon take place? These two questions need to be addressed carefully and well thought through in any piece of research. In this present area of research, it seems that considerable advancements may be made by taking the above two questions to heart. We argue that additional methodological rigor is needed to achieve the probably most important aim of theory, i.e. to explain and to predict. This is in addition to a theory being able to describe and to relate, prerequisites before explanation and prediction is possible. In general, a theory is designed to rationally and clearly explain a phenomenon. Moreover, a theory should be seen in light of the general nature of theory in that it should offer the following qualities and lend itself to be testable, falsifiable, generalizable, universal, and lasting over time.

In the following we will take a look at two broad methodological approaches permitting us to achieve the above stated aims of theory in relatively novel ways: (a) through relational or social network analytical approaches as well as (b) uniquely utilized tools enabling the capture and measurement of features within the blogosphere. Both approaches seem to be needed to achieve explanation and prediction in the context of Collective Action Theory.

The basic unit of analysis in social network analysis is a relationship between two system elements within the same system [29](p. 182). The term relationship deserves some specific attention: Generally, in social network analysis one is interested in dynamic, functional relationships, i. e. active interaction between the related elements. This kind of relationship, obviously, is of prime importance if one is to construct a network composed of relationships. Conceptually, the existence of a relationship between two elements is constituted by the recognition of some constraint, which restricts the behavior, at least minimally, of one or both of the elements [29](p. 182). Such a constraint suggests one other characteristic of a relationship, namely that of interdependence between the elements. Social scientists frequently have urged the need for relational analysis by emphasizing the importance to turn away from monadic and aggregate data [30][31][29]. The proponents of this approach to view 'reality' argue that the researcher not only manages to arrest data of two elements, A and B, as typically done in the monadic analysis, but that additional information is added to the recognition of constraints or, generally, a relationship between A and B. Four major properties of relational constraints can be identified: symmetry, strength, specificity and transitivity [29].

With regard to social network analytic purposes, a system is viewed as a set of elements embedded in a network of relationships. So far, the units of analysis, i.e. relationships, have been described and specified. Next, we offer a novel

methodological approach how we may go beyond the mere mapping efforts typically done in issue tracking in the blogosphere. Our aim is to strive toward the above-mentioned aims and features of theory, i.e. to develop predictive models, by combining social network analysis methods as well as focusing methodologically on information flows, issues and communities that, in turn, provide a deeper understanding of Collective Action Theory. In part this is accomplished via a mini-case study of the Weheja Al-Huwaider Campaign (in Section 4), illustrating the utility and strength of our novel methodological approach overcoming the previous limitations when looking at Collective Action Theory applied to research on the blogosphere and other social media or virtual world at large.

We have delved into emerging behavior patterns and their development into cyber collective movements from individual, community, and transnational perspectives, and in so doing delineate the challenges, propose an appropriate and fitting research methodology, evaluate various strategies, and analyze our findings. In order to cogently address the research questions posed in Section 1, we pursued a three-phased approach: phase 1, Individual Perspective; phase 2, Community Perspective; and phase 3, Transnational Perspective (see Fig. 1).

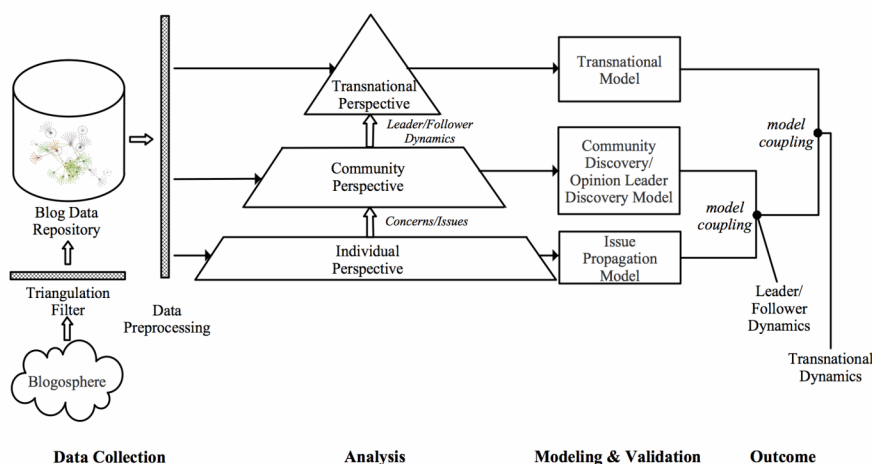


Fig. 1. Overall architecture of the research methodology.

3.1 Individual Perspective

It is observed that individual causes/issues can be transformed into collective cause. To understand and model this phenomenon, we need to study how personal issues and concerns evolve and propagate in social networks and how they converge and form collective concerns. We begin with preprocessing the blogs, identifying issues and concerns representing individual cause; and then modeling their diffusion in the network, and analyzing their convergence to collective cause. These steps are explained in further details next.

Preprocessing and extracting cause: For each new event that occurs, pre-event, during-event, and post-event blog reactions are analyzed. Probabilistic and statistical content analysis techniques such as Latent Semantic Analysis, Probabilistic Latent Semantic Analysis, and Latent Dirichlet Allocation assist in identifying, segregating, and teasing out relevant topics. Blog posts containing relevant topics are summarized to reduce off-topic chatter narrowing in on the key information [32]. The summarized text is used to extract representative keywords using tag cloud generator (Wordle.net). Starting from the seed blog, the above process is repeated for all other blogs that are connected to the seed blog. Blogs connected to the *seed blogs* are termed *adjacent blogs*. This demonstrates whether the issues and concerns mentioned in the seed blog were diffused to the adjacent blogs.

Modeling the diffusion of cause: We analyze the extracted issues and concerns representing a certain cause and study their propagation. Specifically, we explore how network ties affect an individual's concerns. The proposed diffusion model extends the existing information diffusion models (linear threshold, independent cascade, etc.) by considering concerns as the information chunks that propagate over the social network of bloggers. Since the underlying social network remains the same, the structural properties of the concern diffusion are no different than information diffusion characteristics. In other words, leaders of the community who are responsible for the fastest information diffusion also tend to be the major influencing factors on the individual's issues and concerns and hence the collective concerns of the community.

The finding from the individual perspective leads us to think about possible trajectories for future research. Beyond extracting issues and concerns, a similar approach can be used to extract individual sentiment and track how it is diffused into collective sentiment. The exploration of existing sentiment analyzers in combination with the use of sentiment word thesaurus, sentiwordnet [42], will enable us to label the polarity and degree of the opinion word. For the future research agenda, we propose to longitudinally analyze the extracted issues, concerns and sentiment and to identify the factors involved in their propagation. We also propose to utilize existing cognitive and behavioral theories to gain deeper insights into the adaptation of individual behavior stemming from social interaction and cultural ties. These theories will form the basis of our exploration, aided by the development of novel statistical and stochastic diffusion models focusing on the transformation and propagation of sentiments along network ties over time. The model will help in advancing sociological as well as computational understanding of how collective sentiment shapes and will be improved upon in later phases of the analysis by incorporating community and transnational factors.

3.2 Community Perspective

Community leaders often exert significant influence over fellow members in transforming individual opinion and shaping into collective sentiment. To model this phenomenon, we analyze the community of bloggers, and identify the opinion leaders of the community. This enables us to address the following issues: how decisions travel across the network from leaders to followers?; do followers consistently follow

the same leader(s) or is the influence of opinion leaders time-variant and/or topic-variant?; and is there a hierarchical structure in the rank of opinion leaders and can the model identify it? Lastly, can we evaluate the model objectively? To address these questions, first, we extract and analyze the community of bloggers and then, identify the opinion leaders.

Community identification: Often in the blogosphere users do not explicitly specify their community affiliation. The discovery of communities through network-centric approaches has been extensively studied [33]; however, as pointed out in [34], blogs are extremely sparsely linked due to the casual environment that does not necessitate users to “cite” the sources that inspire them. Moreover, spam links generated by malicious users could connect completely unrelated and/or irrelevant blogs, affecting the performance of community discovery process [47]. Further, spam may also adversely affect content-oriented community identification approaches [41]. We identify their implicit community affiliations and orientations leveraging the network structures (social ties, participation on other forms of social media) and issue/cause diffusion characteristics identified in the individual perspective phase.

Specifically, we explore both network and content-induced interactions between blogs to detect communities. The content-induced interactions approach, leveraging issues and concerns diffusion characteristics extracted from the individual perspective phase, not only guides the network-centric community extraction (while considering the relevant links and ignoring the spam/irrelevant links) but also complements it through revealing new potential links. Leveraging the insights from our prior study, the purpose of which is to identify communities from blog networks by examining the occurrence of shared concerns on particular events/causes, we unveil interactions through the observation of individual concerns. If the concerns of these blogs were similar we assume the blogs are themselves similar. Mathematically, the similarity between any two blogs can be computed using cosine similarity as follows,

$$Sim(B_m, B_n) = \frac{P_m \cdot P_n}{\|P_m\| \|P_n\|} \quad (1)$$

where, $Sim(B_m, B_n)$ is the cosine similarity between blogs B_m and B_n . The concerns of B_m and B_n on an issue is represented by the column vectors P_m and P_n , respectively. The data mining clustering algorithm, *k-means*, is used to extract communities.

Identifying Influentials: After extracting the communities from blogs, we set out to identify community leaders. Given the sparse network structure of blogs, we leverage both network and content information to identify influentials. We examine how social gestures of “influentials” could be approximated by collectable statistics from the blogs. We gather network-based statistics from the blog graph (e.g., inlinks, outlinks, blogger social network, comments) and content-based statistics from blog text and comments to map the social gestures. Knowledge from prior work on identifying influential bloggers, iFinder [35], enables us to model community leaders factoring in socio-cultural traits of the community that bootstraps our understanding of opinion leaders. The model analyzes how issues and concerns travel across the blogger network from leaders to followers and identifies if there exists a hierarchical structure in the rank of opinion leaders. Due to lack of the ground-truth or benchmark datasets, an objective evaluation of the proposed model is extremely challenging. Here we propose an avant-garde evaluation framework that leverages social media

sites such as Digg (www.digg.com) and blog search engines such as Technorati (www.technorati.com) as large-scale surveys to validate the model and identify opinion leaders. Details of this evaluation framework are given in [35].

The individual perspective phase provides an understanding of how issues and concerns propagate along the network. The outcome of the community perspective phase enlightens us with a deeper understanding of leader-followers dynamics. Together, outcomes from both phases lend insights into the emergence of cyber-collective movements in socio-culturally diverse environments. As a possible future direction, longitudinal analysis could be performed to address questions such as, whether followers consistently follow the same leader(s), or is the influence time-variant, offering deeper understanding of group dynamics.

3.3 Transnational Perspective

In this phase, we study and analyze whether collective concerns in communities transcend nation-state barriers and converge into transnational cyber-collective action or not. Analyzing the emergence of transnational actors and networks, structures relating to fluidity and boundless organizational architecture, is key to deeper understanding of the transnational underpinning of cyber-collective movements. Social networking platforms have undoubtedly intensified the degree of connectivity by building up capacity to circulate ideas and to transfer content very quickly across all barriers. An issue can be observed for a certain period of time and an issue-network can be constructed. The issue can be mapped periodically to detail the development of the issue-network. The mapping process can identify each blogger and classify her in one or more clusters (e.g., an Egyptian Canadian female blogger who resides in Arizona, United States belongs to three clusters: Egypt, Canada, and United States). The map of transnational collective movements then will show the overlap of various clusters and the expansion/evolution of networks.

This finding prompts us to seek answers for further questions such as the following: can transnational social movements be autonomous from national constraints in terms of discourses, strategies, and resources?; can the shifting scale (from local and national to global and transnational) also bring about a change of culture and identity of these movements?; with respect to outcomes and goals, can the transnational social movements deliver concrete strategies to overcome the unpredictability of their mobilizations?; with respect to their internal dynamics, can the transnational social movements encourage their perpetuation through mitigating the individual convictions of the collective actions/movements? Following we are presenting a brief case study illustrating how such research efforts can be accomplished methodologically.

4 Al-Huwaider Campaign Case Study

There are myriads of incidents and stories demonstrating the formation of collective causes and their manifestations in the form of cyber-collective movements. Among

aggregate the concerns from these three blogs (denoted in columns) for each cause/issue (denoted in rows).

Once communities of bloggers are extracted, our next step is to identify the influentials. We analyzed a community of 75 blogs that shared similar concerns for Al-Huwaider's campaigns and identified top ten influential blogs, as illustrated in Table 2. Due to space limitations we could not present the analysis of other blogs. However, all the 75 blogs had an average influence score of 198.306, a maximum influence score of 833, a minimum influence score of 1, and a standard deviation of 269.892. Representative tags extracted using Wordle are specified next to the blog posts to give contextual background.

Table 2. Top-10 influential blog posts discussing Wajeha Al-Huwaider's campaign along with their influence scores and representative tags extracted using Wordle.net.

Blog	Representative Tags	Influence Score
http://hotair.com/archives/2009/07/12/saudi-feminist-blocked-from-leaving-country/	Saudi, Al-Huwaider, Arabia, border, male, passport, permission, activists, rights, guardian	833
http://jezebel.com/5552458/japan-likely-to-reject-ban-on-sexualization-of-minors-playboy-model-jailed-for-boob+grope	Women, minors, drinkers, Japan, Yousef, freedom, infected, prisoners, police, jail, charges, allegations	824
http://volokh.com/posts/1245159018.shtml	Saudi, Arabia, HRW, Human, rights, links, mail, organization, government, Israel, workers	739
http://thelede.blogs.nytimes.com/2009/03/12/saudi-woman-drives-for-youtube-protest/	Saudi, Huwaider, driving, BBC News, Arabia, Arab, women protest, video, Fattah, car, youtube	702
http://www.memeorandum.com/100418/p4	Saudi, women, driving, Arabia, raped, reform, issues, populace	695
http://www.moonbattery.com/archives/2007/10/the_nobel_joke.html	Afghanistan, Navy, Murphy, bad, gore, Arafat, combat, killed, Marxist	690
http://latimesblogs.latimes.com/babylonbeyond/2010/06/saudi-women-use-fatwa-in-driving-bid.html	Women, Saudi, drive, Islamic, Wajeha, maternal, breastfeed, Obeikan, cars, ban, campaign	665
http://www.hrw.org/english/docs/2006/10/20/saudia14461.htm	Saudi, human, rights, police, detained, government, mabahith, Arabia, khobar, freedom	644
http://www.hrw.org/en/news/2006/10/30/saudi-arabia-lift-gag-order-rights-campaigner	Rights, al-Huwaider, Saudi, Arabia, human, september, mabahith, khobar, Abdullah, interrogated, police, officers,	644
http://globalvoicesonline.org/2008/08/12/saudi-arabia-bans-women-from-olympics/	Feminist, Burundi, Olympics, Wajeha, Macha, Women, muharram	627

4.3 Transnational Perspective

Analyzing the emergence of transnational actors and networks, structures relating to fluidity, and boundless organizational architecture, is key to deeper understanding of transnational underpinning of cyber-collective movements. One such actor identified in our analysis was Wajeha Al-Huwaider. Despite the cultural, ethnic, political, social, and geographical diversity of Al-Huwaider's supporters as illustrated in Fig. 3

below, the sense of community superseded differences and converged individual concerns into collective action.

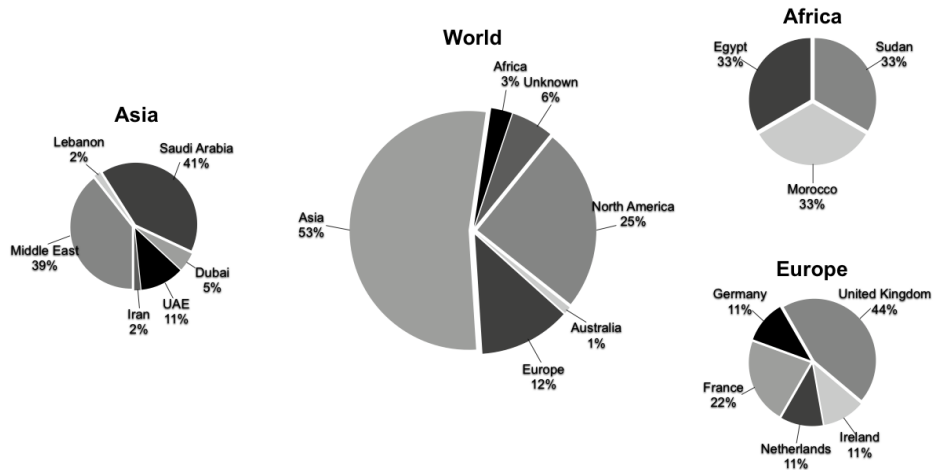


Fig. 3. Transnational support for Wajeha Al-Huwaider's campaign.

With access to more data, we can generate an issue network for Al-Huwaider's campaigns following our analysis in Fig. 3. Such issue networks can help decrypt the dimensions of: issues (on local, global, global-local levels), clusters (nation or content-based), political affiliations (conservative, liberal), time, and scale (network links, number of individuals, issue clusters) from actor and network perspectives.

This case study of the Wajeha Al-Huwaider campaign illustrates how our methodology enables the analysis of blogging behavior at the individual, community as well as transnational levels. In essence, our methodology illustrates how we can look at and explain collective actions in the blogosphere.

5 Conclusions

In this paper, we sought to understand the fundamentals, complexity, and dynamics of cyber-collective actions. By reaching out to existing social theories on collective action and computational social network analysis, we have proposed novel algorithms to model cyber-collective movements from individual, community, and transnational perspectives. The proposed methodology addresses the lacking fundamental research and re-framing Collective Action Theory in online environments making it the key contribution of this work. As utilized and illustrated in the mini-case study of the Al-Huwaider Campaign, our novel methodological approach convincingly overcomes the previous limitations when looking at Collective Action Theory applied to research on the blogosphere and other social media or virtual world at large. Further, our methodology goes beyond descriptive tendency of most computational studies on social media, such as mapping the blogosphere. By delving into the processes involved in collective acts in online environment and focusing on the formation of

issues (shared narratives/repertoires), our approach offers the predictive power. We also demonstrate that it is possible to develop predictive models of collective actions in blogosphere by combining social network analysis methods as well as focusing methodologically on information flows, issues and communities that, in turn, provide a deeper understanding of Collective Action Theory.

The findings in this paper also enable us to outline future research agenda that is geared towards the development of more advanced computational models. Such models would better our understanding of conventional social theories, assist in developing new ones, reinforcing the development of more accurate and efficient social interaction modeling algorithms for diverse environments allowing us to determine the trajectory of emerging cyber-collective movements.

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