New Media Solutions in Nonproliferation and Arms Control: Opportunities and Challenges

Bryan Lee & Margarita Zolotova

2013

CNS James Martin Center for Nonproliferation Studies

This report was prepared with the financial support of the United States Department of State,
Bureau of Arms Control, Verification and Compliance (AVC),
through the Key Verification Assets Fund,
Contract number SAQMMA12M2340

Acknowledgements

The authors would like to thank Lisa Donohoe Luscombe for her editorial assistance with this project. We are grateful for the helpful comments and discussion provided by William Potter, as well as those of Erica Briscoe, Jessica Bufford, Frank Pabian, Kevin Whattam, and Daniel Wurmser. We also appreciate the research assistance of Helen Kei and Andrea Todd, the contributions regarding satellite imagery and machine learning from Melissa Hanham, and insight into the NPT Preparatory Committee process from Gaukhar Mukhatzhanova and Amanda Moodie. Finally, David Steiger provided expert guidance and assistance with R programming and debugging efforts. The contents and conclusions, as well as any errors or omissions, remain the responsibility of the authors.

Photo credits:
On the cover (top to bottom):
U.S. Department of State Official Blog, jamesjustin: Flickr

James Martin Center for Nonproliferation Studies
Nonproliferation.org

The James Martin Center for Nonproliferation Studies (CNS) strives to combat the spread of weapons of mass destruction by training the next generation of nonproliferation specialists and disseminating timely information and analysis. CNS at the Monterey Institute of International
Studies is the largest nongovernmental organization in the United States devoted exclusively to research and training on nonproliferation issues.

Monterey Institute of International Studies
www.miis.edu

The Monterey Institute of International Studies, a graduate school of Middlebury College, provides international professional education in areas of critical importance to a rapidly changing global community, including international policy and management, translation and interpretation, language teaching, sustainable development, and nonproliferation. We prepare students from all over the world to make a meaningful impact in their chosen fields through degree programs characterized by immersive and collaborative learning, and opportunities to acquire and apply practical professional skills. Our students are emerging leaders capable of bridging cultural, organizational, and language divides to produce sustainable, equitable solutions to a variety of global challenges.

James Martin Center for Nonproliferation Studies
Monterey Institute of International Studies
460 Pierce St., Monterey, CA 93940, U.S.A.
Tel: +1 (831) 647-4154
Fax: +1 (831) 647-3519

New Media Solutions in Nonproliferation and Arms Control: Opportunities and Challenges

Monterey Institute of International Studies
A Graduate School of Middlebury College

Table of Contents

Executive Summary

The world first learned of the horrifying chemical weapons attack near Aleppo in Syria from an eyewitness report. It was not CNN or the *New York Times* that broke the news, however. On August 21, 2013 Syrian opposition groups began to post a series of videos showing the victims of the attack on the video sharing website YouTube. Within hours, traditional media outlets around the world published the reports and governments around the world began to issue official statements. Although the investigation as to what exactly happened and who is responsible for launching the attack against civilians in Syria is under way, it is the first time that average members of the general public, not industry scientists or government defectors, had shown themselves to be a critical element in the battle to prevent the proliferation and use of weapons of mass destruction.

The large numbers of global users of social networking sites together with the rise of smartphone technology has led to renewed interest in the concept of societal verification or "inspection by the people" as a method to address persistent nonproliferation and arms control challenges. Despite the intuitive appeal of this idea, the nonproliferation community has little understanding of the dynamics of the online world in such a context. Fully anonymous reporting or whistleblowing, for example, is virtually impossible online. At the same time, advances in computer aided analysis have made it possible to explore large amounts of publicly available data to draw conclusions that do not rely on information from any individual person. Given the capabilities and limitations of these new technologies, how can the nonproliferation and arms control community effectively tap into this rapidly growing new media field?

This paper presents our findings and recommendations, but also highlights the evolution of the authors' thinking about new media and its potential to advance nonproliferation and arms control strategies. As we began this project, the major focus of our discussions was the verification potential of new media technology in arms control and nonproliferation. As our research progressed, however, we concluded that the possibilities of using this evolving communication ecosystem for global security are much broader than merely verifying compliance with key arms control and nonproliferation regimes. We suggest that among the potential applications of new media are: arms control verification; broad confidence building; increasing global transparency; and combatting the proliferation of weapons of mass destruction.

We believe that new media has the potential to significantly enhance current practices in the field of nonproliferation and arms control. However, we also stress that it is critical to approach anything that is so new and fluid with caution and flexibility as technologies that might be effective today for solving a particular nonproliferation or arms control problem might not work or require a major redesign in the future.

This study presents an extensive review of the research literature on social media, including topics such as crowdsourcing, social network theory, privacy and security, and state censorship. Additionally, we examined four real-world case studies of how internet-enabled technologies have been used in a variety of situations with nonproliferation and arms control applicability. Finally, this research outlines our vision related to five proposed major new media categories and how they might be employed in nonproliferation and arms control. We attempt to capture the developments and key characteristics of each category to contribute to a better understanding of new media. This paper aims to start a conversation within the nonproliferation and arms control community about future directions and the challenges of adopting new media technologies for solving long-standing security challenges.

With regards to the specifics of new media, there is much confusion in the terminology describing internet-enabled technologies, and capabilities frequently overlap. To clarify this, we propose a framework which we believe will assist in understanding the nature and connections between the terms "new media," "web 2.0," and "social media." Regardless of the software platform or how it is accessed, all new media technologies offer several potential advantages over traditional means of arms control and nonproliferation monitoring, verification, and public diplomacy efforts. First among these is reach and speed. The social networking site Facebook, for example boasts more than a billion users. However, unlike traditional media outlets, social networks allow individual users to identify and reach out to specific members of an audience based on demographics or shared interests, and to do that in real time.

The ability to foster two-way communications is another fundamental advantage of new media. Although user input from society at large is critical, managers of a new media effort must incorporate those inputs and share the results. This generates a response, which leads to more interpretation and sharing. Done properly, this two-way communication model greatly accelerates the traditional information/intelligence cycle (plan-collect-process-analyze-disseminate).

The cycle of ever increasing inputs brings two additional advantages common to new media: data availability and scale. Most new media technologies share the "open source" ethos of Silicon Valley. Companies such as Facebook and Google readily provide to the public a great deal of access to user information or user-developed content. When such open information is aggregated, the enormous scale allows the use of so-called "big data" analytical techniques. Because the data often include known relationships it is possible to understand patterns better, whether between people, organizations, or some combination of the two.

Cost, ease of use, and rapid improvement are the final hallmarks of new media. To take one example, high-resolution commercial satellite imagery may be purchased from online vendors for a few hundred dollars and processed with freely available state-of-the-art analysis software. Technical or analytical assistance is also provided free of charge in numerous online discussion forums. And, ideas or suggestions for improving the software or the service are collected and frequently responded to in almost real-time. By way of comparison, the U.S. currently spends more than $400 million dollars for a single satellite, and untold millions more for the supporting infrastructure to manage the asset.

Although we emphasize new media's capabilities, we also identified several common limitations. Despite growing numbers of online users, internet access remains a concern, especially in non-Western countries. Those actors who do have access might not have good intentions. The openness of new media systems makes them especially vulnerable to malicious behavior. Data quality is also a concern. Unreliable observers can overwhelm a system with misleading or incorrect information, and critical data may be simply missing. Even when human error is removed, new media still faces the familiar difficulties of software and data format compatibility. Data availability also may not always be assured. Corporations such as Google or Twitter own the most relevant data, and access to it is provided (or not provided) as these companies see fit.

In developing a model for addressing arms control and nonproliferation challenges, we have identified the major new media functions and further explored their potential for solving global security problems.

Gaming: Applying game elements and game design techniques to engage users in play behavior.

Content creation: Applying new media for collecting, managing, and publishing information in any form and through any medium.

Social: Using new media technologies for creating social environments in which individuals can communicate, form relationships and share information.

Problem solving: Employing new media techniques and technologies to bring people together, online or offline and often under time constraints, to find solutions to a particular problem.

Data mining: The process of extracting knowledge from data – finding, pre-processing, managing, analyzing, and visualizing extracted knowledge in a way that is useful for decision making.

These new media categories represent loosely defined, fungible functions that new media can perform. Based on design solutions, resources, and other considerations, any given challenge can be potentially addressed using various combinations of these tools. Elements from each function can, and in some instances *must,* be combined to create effective new media solutions.

Other key findings are summarized below:

- The potential of new media in nonproliferation and arms control is much broader in scope than traditional societal verification, encompassing activities beyond monitoring and reporting to include analysis, public diplomacy efforts, confidence building, and combating the spread of weapons of mass destruction.

- Deliberate online "whistleblowing" is likely to be only one of many potential applications of new media in the field of arms control and nonproliferation. Monitoring and verification will increasingly involve information that was shared without the source being aware of its potential nonproliferation significance.

- Data mining combined with further analysis by experts will contribute to increasing transparency in nonproliferation and arms control on a global scale.

- Effective use of new media in nonproliferation and arms control is not only feasible, but is already taking place. Non-governmental groups, businesses, and academic researchers have already laid much of the technical groundwork for implementation and demonstrated the basic capabilities of new media in addressing various security challenges. For example, think tanks such as the Institute for Science and International Security or academic researchers affiliated with Johns Hopkins University have conducted and shared open source analysis that provided major insights into the clandestine nuclear activities of Iran and North Korea.

- An open, creative, and flexible approach is a must in incorporating new media tools in nonproliferation and arms control research and policy-making. Social media is only one of a wide range of internet-enabled technologies that may be applicable to nonproliferation challenges. Nonproliferation and arms control solutions are most likely to result from exploiting several "new media" functions.

- The principle barriers to adopting new media for arms control and nonproliferation purposes are not technical. Social factors such as cultural attitudes, illiteracy, and access to technology must be addressed. Additionally, legal and policy issues will need to be better understood and resolved before the maximum benefits of employing the new media solutions can be realized.

- Any new media effort is likely to be resource intensive and require a substantial planning and management commitment. The most successful examples follow a deliberate design model, and do not rely on random inputs from unsolicited crowds.

Building on our research, we have developed a guide to using new media tools for nonproliferation. To ensure the efficient incorporation of these techniques into future arms control and nonproliferation monitoring and verification efforts, we offer the following recommendations.

Recommendations

- Policy makers and the staffs that support them should receive familiarization training on the major new media platforms and functions to better understand the capabilities and limitations of the technology.

- Public cooperative projects in the nonproliferation sphere should be encouraged to help government officials become familiar with the dynamics and potential of the new media environment.

- Policy makers should consider developing procedures to incorporate public participation into government verification and compliance deliberations.

- Governments should encourage openness and standardization of nonproliferation-relevant data to facilitate public access and analysis.

- Policy makers should designate select individuals at the Senior Executive Service level as new media leaders and ensure those individuals receive the training and skills necessary to plan and manage future technology-based efforts.

Introduction

The idea of engaging the general public in monitoring and verifying nonproliferation and arms control agreements has been around since the dawn of the nuclear age. Lewis Bohn and Seymour Melman advocated for "inspection by the people" in the late 1950s, arguing that the involvement of civil society in compliance monitoring would improve the formal inspection process (Melman 1958); (Bohn 1961) and allow for verification when on-site inspections were not feasible. The basic concept was refined and expanded by authors such as Grenville Clark and Louis Sohn who tried to establish some form of whistleblowing protection for "citizen inspectors" as part of international law (Deiseroth 2000). In the 1990s, physicist Joseph Rotblat famously proposed to add whistleblowing protections to every country's domestic laws, thus paving the way for societal verification to form an integral part of a global treaty to ban nuclear weapons (Rotblat, Steinberger et al. 1995).

While appealing in theory, traditional societal verification has proven unworkable in practice. States are reluctant to grant blanket whistleblower protections to individuals working with state secrets and national security issues, and citizens are equally reluctant to inform on their own countries, either out of loyalty or fear of reprisal. In order to break the impasse, some new method of reporting violations is required.

In a 2012 Speech at the Moscow State Institute of International Relations Acting Under Secretary for Arms Control and International Security Rose Gottemoeller proposed one such method:

> *Our new reality is a smaller, increasingly networked world where the average citizen connects to other citizens in cyberspace hundreds of times each day. They exchange and share ideas on a wide variety of topics, why not put this vast problem solving entity to good use?*
>
> *Today, any event, anywhere on the planet, could be broadcast globally in seconds. That means it is harder to hide things. When it is harder to hide things, it is easier to be caught. The neighborhood gaze is a powerful tool, and it can help us make sure that countries are following the rules of arms control treaties and agreements (Gottemoeller 2012).*

In other words, might the tools and techniques used by hundreds of millions of people every day to create, collaborate, and communicate online be employed to address the challenge of the proliferation of weapons of mass destruction? What follows is our attempt to answer this question.

To begin, we assert that the new media enabled verification is much broader in scope and method of application than traditional societal verification. When Bohn and Melman were discussing "inspection by the people," the presumption was the people in question would have physical access to the item in question. That presumption does not hold for today's new media environment. Observation of a treaty violation could be reported directly by an individual on the ground, but could just as easily be determined by analyzing aggregated data provided in a public forum and not attributable to any one person. In fact, a violation could be determined through analyzing publicly available commercial satellite imagery, thus removing the individual whistleblower from the equation entirely. In this context we no longer limit the sources of relevant information to individual whistleblowers and public activists, but rather open up the term of societal verification to include governments, NGOs, international organizations, and online users as potential beneficiaries and designers of any new media solutions aimed at solving the nonproliferation and arms control challenges.

We believe the nonproliferation and arms control potential of new media is defined not by technique, but by intention.

Commonly used models such as crowd-based sensor->internet communication->crowdsourced analysis (Zerbo 2013) are inadequate to describe the capabilities of new technologies and their possible application to nonproliferation and arms control challenges. We also find many such descriptions ignore the technical and theoretical underpinnings of online technologies. This leads to a situation where policy makers see the technology as a "black box" offering unverified solutions, thus creating a reluctance to embrace the opportunities presented.

The focus of this paper is on the new media potential for solving global security issues. We assume the reader has a basic familiarity with arms control and nonproliferation practices, and is interested in learning more about the opportunities and challenges provided by internet-enabled technologies. The remainder of the paper is organized into four sections: a literature review and typology of online technologies; case studies and lessons learned; navigating the new media; and some concluding remarks.

The literature review provides some definitions of easily confused terms and traces a brief history of the growth of online social networking sites. It also describes a typology of internet-enabled technologies and defines the term *new media* as the top-level category of these technologies. It follows with an overview of the foundations of network theory and explains what network science has to say about online interactions, including a discussion of popular concepts such as "six degrees of separation," "virality," and "tipping points." The section also examines the "crowdsourcing" phenomenon and explains the prerequisites for crowdsourcing success as well as some pitfalls. Last, the literature review looks at the dual issues of state censorship and privacy and anonymity, finding that both are likely to be larger barriers to adopting the new media strategies than is generally supposed.

We provide four case studies to illustrate various applications of new media in real-world situations. The first explores grass roots efforts to use web and mobile applications to monitor elections in Russia. Key features examined include geo-tagging, "gamification," and crowdsourcing. The second is an example of how the data from online social media websites can be combined with simple data mining techniques to strengthen public diplomacy efforts and aid in identifying key people within a community. The third case describes the online version control system GitHub and looks at how such systems enable collaboration without coordination. Finally, we examine the use of commercial satellite imagery and show how it can be combined with crowd-based expertise to provide real-time analysis of events on the ground.

The final analytical section returns to the typology provided in the literature review to offer some insights into navigating the new media. For each of the five identified new media functions, we provide a description of capabilities and some examples of common ways they are currently used. We also describe some of the challenges and advantages particular to each function. To conclude, we present the conceptual approach to using new media to design nonproliferation or arms control solutions. To demonstrate its potential, we develop several sample ideas and offer general guidelines for employing new media to address global security challenges.

Web 2.0, Social Media, and the "New" Media

Brief history and definitions

Web 2.0

Describing the interactive online universe is complicated because of the different terms used to describe similar things. One of the most common is "Web 2.0," which was popularized by computer book publisher Tim O'Reilly at a conference his company hosted in 2004 (Graham 2005). At the time, O'Reilly used it to mean a World Wide Web environment where the web pages acted as platforms to deliver content instead of static repositories. This definition has since evolved until it is generally understood to mean web-based technology that allows the user to interact in some way with the content.

Even this loose definition is controversial, however. The inventor of the World Wide Web, Tim Berners-Lee says Web 2.0 is “of course a piece of jargon, nobody even knows what it means” (Laningham 2006). Berners-Lee insists that the point of the World Wide Web has always been people-to-people interaction; therefore there is nothing new or revolutionary about sites that facilitate that. Recent trends in usage seem to be on his side. One researcher has found Google searches for the term peaked in 2007, possibly due to a growing familiarity with the technology (Naughton 2011).

New media

A term that is frequently used synonymously with social media is “new media.” This phrase was coined by media scholar Paul Levinson in his 2009 book of the same name, and usage has grown rapidly since then. Levinson rejects the equivalence of social media and new media, finding the second qualitatively different than the first. For Levinson, media and communication have always had a social aspect. For example, teenagers have always discussed their taste in music or books with friends, whether in person or in writing. Therefore, the focus on the social component of today’s interactive technologies is not sufficient to describe them. He also insists social media is an inadequate description because the factor of the consumer becoming a producer is also left out. For Levinson, the broad category of new media shares five essential characteristics: 1) every Consumer is a Producer; 2) the media are free to the consumer and sometimes to the producer; 3) the media products both compete and act as catalysts for each other; 4) they are more than simply e-mail and online searches; and 5) the underlying software platforms are beyond the control of the individual users (Levinson 2013). New media can therefore be understood as the top level or broadest categorical term to describe interactive online activities.

Social media and social networking sites

The struggle to define the elements of new media becomes more complicated when so-called social networking sites such as Facebook or LinkedIn are included. An influential distinction was offered by danah boyd [who spells her name in lower case like e. e. cummings] and Nicole Ellison: “We define social network sites as web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site.” (boyd and Ellison 2007) Crucially, boyd and Ellison distinguish between social “network” sites and “networking” sites. The difference is many sites allow networking in the classic sense, i.e. allowing users to meet new people, but that is not what makes them a social network site. Instead, it is the ability of the users to “articulate and make visible their social networks,” that makes a social network site different from other forms of social media, such as blogs or wikis (boyd and Ellison 2007). This definition in turn has been criticized as too broad (Beer 2008), too technology focused (Stenger and Coutant 2009), or in a comment posted to danah boyd’s blog in January 2008, as conflating sites with services.

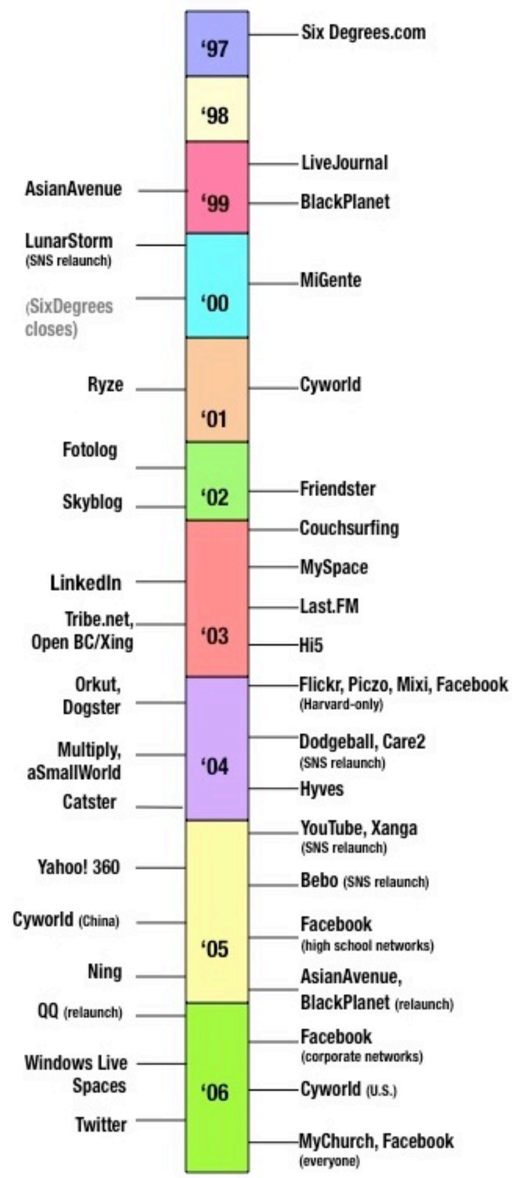


Figure 1: Launch Dates of Major Social Networking Sites (boyd and Ellison 2007)

Growth of social networking sites

Although it often seems as if the social networking world began with the 2006 launch of Facebook, social networking sites have been in use since

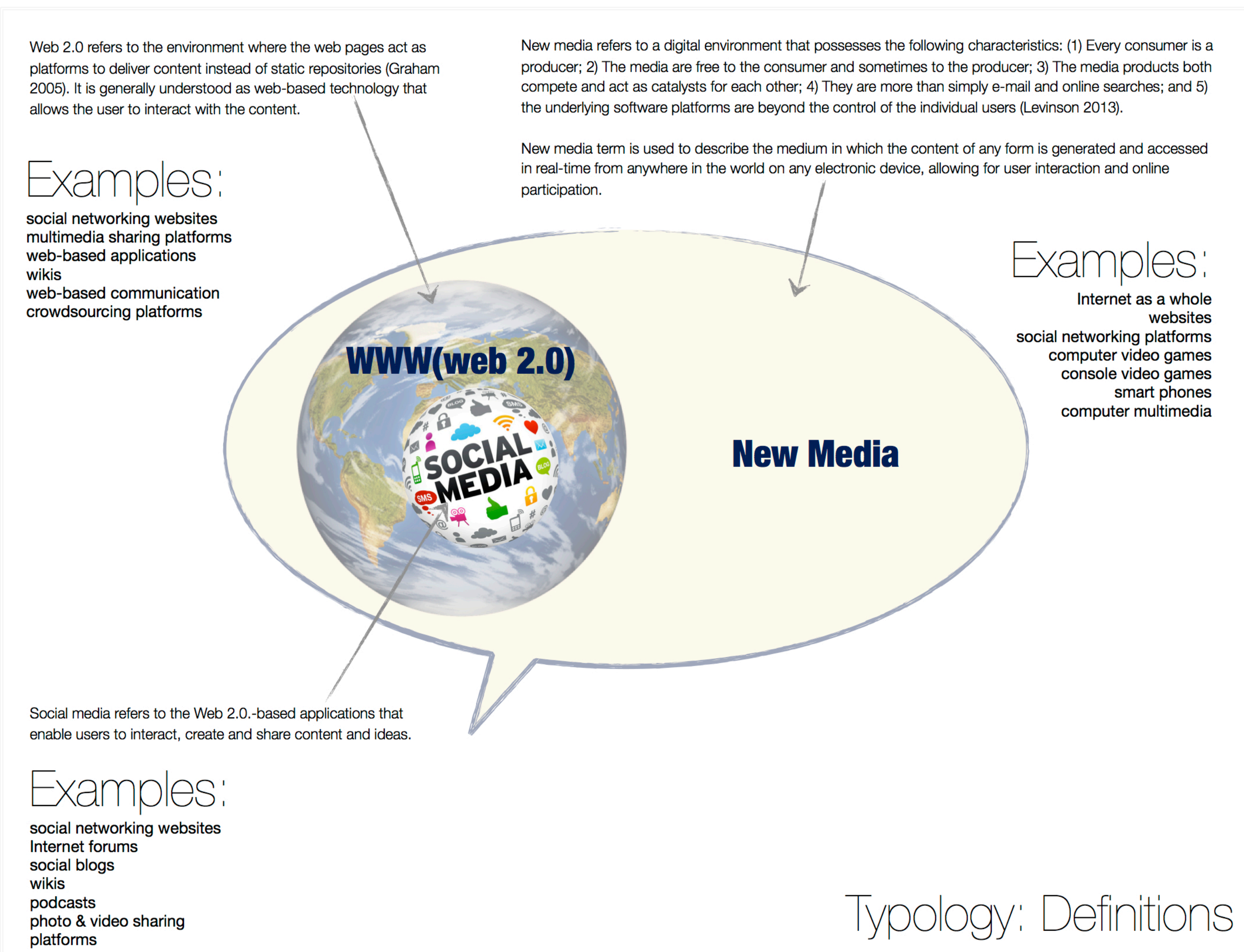
1997 when the aptly named SixDegrees.com was first introduced. Prior to this, dating sites allowed users to create profiles, and services such as AOL instant messenger allowed the creation of friend lists, but SixDegrees was the first service that combined all of these features. Though it attracted millions of users, it ultimately closed in 2000. The founder felt that it was simply ahead of its time (boyd and Ellison 2007).

Today, Wikipedia lists close to 200 "notable, well-known" social networking sites (Wikipedia 2013), and further lists 13 "virtual communities" with more than 100 million active users. Of these, six are U.S. based, including Facebook and LinkedIn, four are in China, and the remaining three are in Russia. *Social Media Today* claims there are at least 40 major social networking sites, with many catering primarily to non-English or non-US based audiences, or focused on niche user groups such as movie fans or the online gaming community (Jain 2012).

A New Media Typology

The project attempts to develop a true typology as opposed to a simple classification system. We draw this distinction based on Doty and Glick's assertion that classification systems are organized around "mutually exclusive sets" while typologies refer to "interrelated sets of ideal types," (Doty and Glick 1994). Towards this end, we prioritized broad functional categories over specific software platforms. We also attempted to situate social media within a broader hierarchy of modern communication technologies (Figure 2, see Annex 1 for enlarged version).

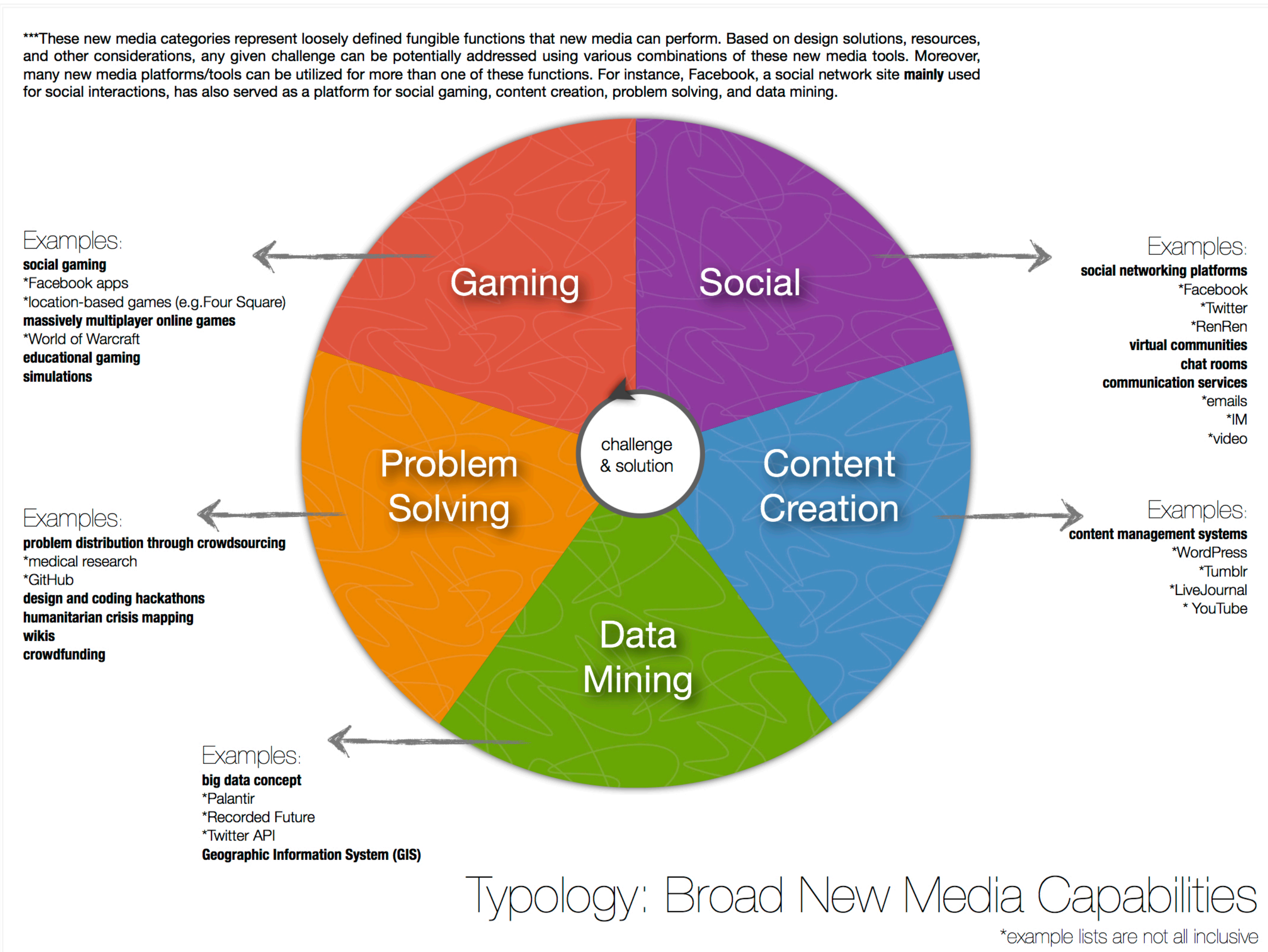
Figure 2



We found the works by Kietzmann and Hermkens (Kietzmann, Hermkens et al. 2011), boyd and Ellison (2007), and Levinson (2013) particularly relevant for our effort. Because business and marketing practitioners are the dominant users of social media, we also reviewed classification examples designed by prominent internet commentators, including those by Brian Solis,[1] Ross Dawson,[2] and Tim O'Reilly.[3] Additionally, we consulted with representatives and experts at several social media and internet technology companies to better understand how industry views the field. These conversations confirmed our earlier findings that practitioners are struggling to define and categorize a myriad of functions and capabilities. Because the research field is new and subject to much confusion regarding terminology, we decided a "new media" rubric presented the most comprehensive viewpoint for understanding this dynamic subject.

After reviewing the literature and designing a hierarchy, we went through several iterations of identifying the functions and categories of new media. These were further refined and combined to produce a final list of five new media types. For each type, the team then selected common examples of functionality and specific software platforms, resulting in the typology depicted in Figure 3 (See Annex1 for enlarged version).

Figure 3

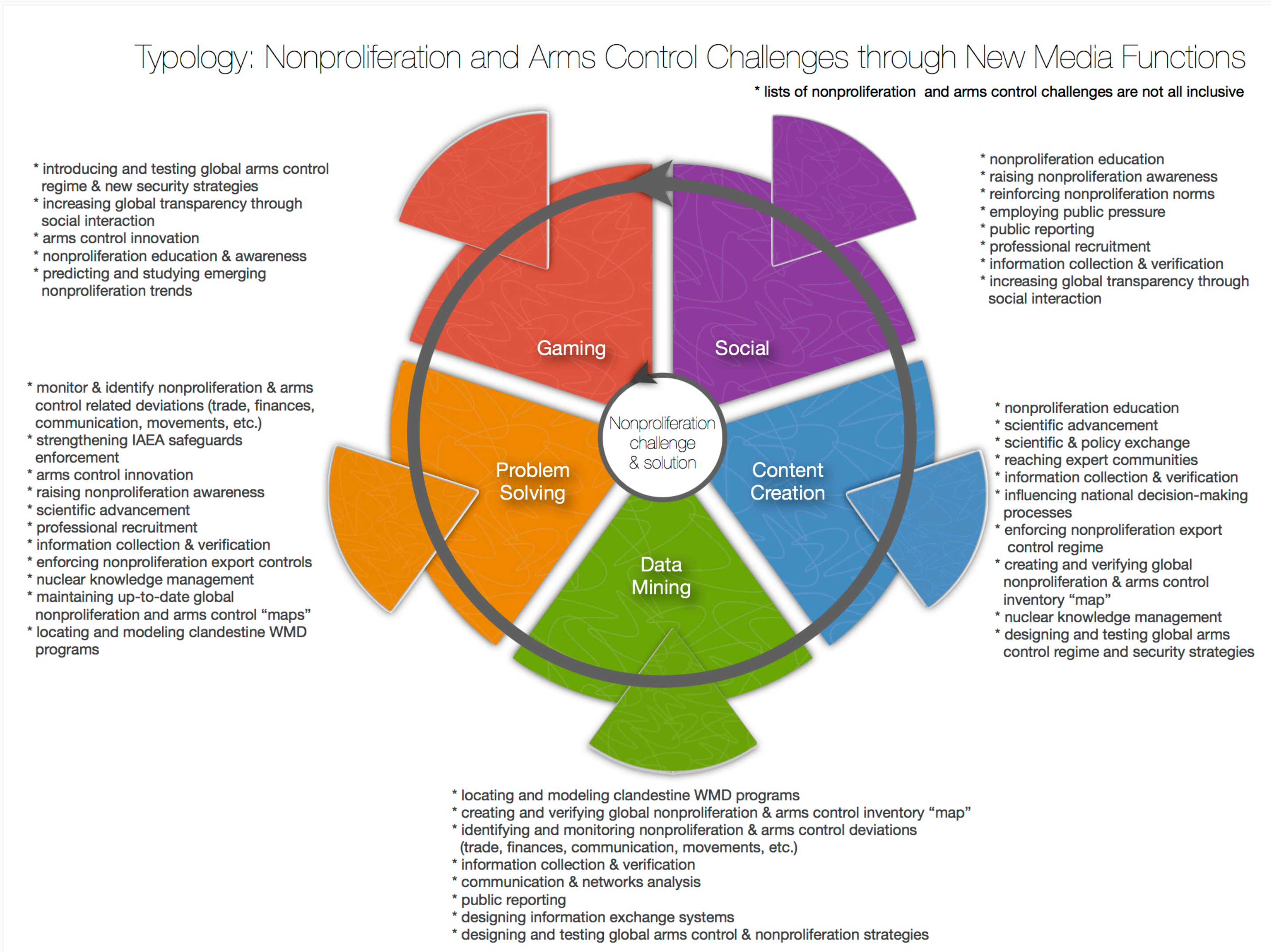


[1] http://www.theconversationprism.com/
[2] http://rossdawsonblog.com/weblog/archives/2007/05/launching_the_w.html
[3] http://oreilly.com/web2/archive/what-is-web-20.html

New media and arms control and nonproliferation challenges

Once the new media types and common functionalities were identified, we arrayed them against an illustrative set of arms control and nonproliferation challenges. This produced a diagram similar to the previous example, but highlights the manner in which the ideal types merge together in actual use (Figure 4, see Annex for enlarged version). In the section *Navigating the New Media* we further examine each of these new media capabilities, including their key components, current major applications, challenges and advantages of employing a particular technology, as well as their potential for nonproliferation and arms control.

Figure 4



The Diffusion of Information: An Overview of Thinking and Research Related to New Media

Foundations

Theory of social structures

Sociologists had long been fascinated with the idea that society could be best understood by analyzing its root structure. Initially, most theory began at the individual level of relationships. Family relations such as father-son were one example, but there were also economic relations such as employer-employee, or the political relations of sovereign-subject. By the 1930s, however, sociologists had begun to step away from the individual relationship as the basis of society and began to focus more on the role of the institution.

In 1937, Talcott Parsons published his landmark *The Structure of Social Action* which tried to show that the structural basis of society lay with its institutions and not with its individuals. His approach was heavily influenced by the new field of systems theory, and by 1951, he extended his analysis in *The Social System* to show the value of a systems approach to a variety of large-scale societal interactions. His development of this analytical approach soon became intertwined with the new field of systems theory.

Parson's structural ideas were refined by the British anthropologist S.F. Nadel. His 1957 *Theory of Social Structure* returns to the earlier idea of the importance of individual roles, but expands the analysis to also look at how those roles relate to the surrounding environment. His descriptions of the complex interactions that result were influential in later developments of a network approach to social theory.

It was another British anthropologist, John Barnes, who is credited with the first scientific application of a "social network" analysis to social structure. He coined the term in 1954 to describe the complex interactions he observed during a study of a Norwegian fishing village (Barnes 1954). Academics from a variety of fields quickly grasped the utility of the concept, and by the early 1970's, social networks were being studied by anthropologists, sociologists, psychologists, and political scientists (Mitchell 1974).

Although the benefits of using social network analysis in terms of understanding social structures and interactions were clear, the underlying causes of the interactions remained a mystery. The new tool seemed to give rise to the old individual-institution question but in a new form. Did the network structure arise from the choices and behaviors of the individuals, or did the structure itself somehow govern the choices and behaviors? To answer the question, the theorists began to experiment.

Group connections

Perhaps the most well-known concept in social networking today is the idea of "six degrees of separation," meaning that no person is ever more than five people away from being acquainted with anyone else. This is known as the "small world" theory and was popularized by Stanley Milgram (Milgram 1967). As one of the world's leading social psychologists, Milgram was interested in the idea of social gaps, that is the implausibility that a very wealthy person would be acquainted with a very poor person, or (at the time) that an African American would associate with a white person. Some argued that the structure of any large network would make such overlaps inevitable, while others held that social circles were essentially closed, and that contact would not happen.

Proof for the argument had to wait for a breakthrough by mathematicians Ithiel de Sola Pool from MIT and Manfred Kochen of IBM who calculated the odds of acquaintanceship based on research that showed the average number of friends and acquaintances a person had was approximately 500. Based on this, Pool and Kochen estimated the odds of any two of these acquaintances knowing one another as better than 50-50 (Milgram 1967). Milgram seized on this and decided to test the results empirically.

Milgram decided to try an experiment to see whether a random person in the Midwest, chosen because, from the Harvard campus in Cambridge, “these cities seem vaguely ‘out there,’ on the Great Plains or somewhere,” could send a document to a pre-selected person in Cambridge using only his chain of acquaintances (Milgram 1967). Most memorably, a wheat farmer in Kansas was able to get the document to Milgram’s target, the wife of a Divinity School student in Cambridge, in only four days and crossing only two intermediaries. Most of the remaining chains were longer, however, and Milgram determined the median number of intermediaries required was five, leading to the “six degrees of separation,” idea so well-known today. Perhaps more important, the experiment also proved it was possible to navigate a large social network even if a person could not observe the whole thing.

Usually forgotten in discussions of Milgram’s study is his finding that one of his targets, a stockbroker in Sharon, Massachusetts, received almost half of his documents from just three people. This suggests that the social circle plays a larger role than is usually understood by the term “six degrees of separation.” Indeed, Milgram himself says the degree of separation should not be thought of as five people, but “five circles of acquaintances (Milgram 1967).”

Although Milgram’s work looms large as a concept in social networking and forms the basis of much of the popular notion of social media, later researchers have questioned both his methodology and his findings. Judith Kleinfeld examined his original research notes and found that the number of completed chains hovered at approximately 30%, and even that number was probably high due to Milgram’s recruiting of unusually connected people as his starting points (Kleinfeld, 2002). In an overall assessment of small-world empirical findings, Sebastian Schnettler also found the number of completed chains to be low, and suggests high completion rates are improbable because even a small attrition rate at each step will compound as the length of the chain increases (Schnettler, 2009). Most importantly, critics assert that even if the “six degrees of separation” theory is correct (and data scientists at Facebook believe it is), overcoming the social gap that first motivated Milgram’s study is very difficult in practice (Backstrom, Boldi, Rosa, Ugander, & Vigna, 2011).

Extra-group communication

If Kansas farmers are only six degrees away from Massachusetts stockbrokers, why don’t they vote alike? The answer, according to Elihu Katz and Paul Lazarsfeld, is that communications are transmitted via two steps, and not six (Katz and Lazarsfeld 1955). The theory was first put forward as a refinement to Lazarsfeld’s earlier discovery that voters are influenced less by the mass media than by certain “opinion leaders” (today often referred to as influentials) (Lazarsfeld, Berelson et al. 1944). These are people who are seen by others as better informed and better connected than average, and therefore voters turn to them to mediate the information provided by the mass media.

Subsequent research provided additional support for the theory, but in all cases it has been difficult to disentangle whether the influence comes from a true “opinion leader,” or whether the opinion leader is really just the person who best embodies the group’s existing preferences (Katz 1957). This “birds of a feather” tendency, or *homophily,* and the difficulty of distinguishing the influencer from the influenced in a group setting has been the chief methodological problem with the theory and has resulted in mostly mixed evidence in later attempts to verify it (Watts 2007). And, while the concept of the “opinion leader” is still very much alive, the “two-step” theory of communication has been mostly supplanted by a much more complex theory of the “diffusion of innovations.”

Information diffusion

Everett Rogers theorized that a two-step communication process was too simplistic to represent the degree of interaction between people when processing new information. Motivated by studies of how and why firms adopt new technologies, Rogers explored the process of how information flows through a social network. His theory, first published in 1962, resulted in a continuing flood of research devoted to what he termed the "Diffusion of Innovations" (Rogers 1995).

Unlike many theoretical works, Rogers strove to base his theories on case studies and empirical evidence largely drawn from actual experiences in the corporate world. The result was a model that defined four elements in the diffusion of new ideas: "(1) an *innovation*, (2) which is *communicated* through certain *channels*, (3) over *time*, (4) among the members of a *social system"* (Rogers 1995).

Since Rogers was concerned with the real-world applications of diffusion, he devoted much of his research to how information moves through a network. Interestingly, his findings tend to support the idea of an opinion leader, but he finds it is the leader's role as the holder of group norms that makes him important. In Roger's view, this can lead equally to a situation where the leader facilitates or stymies the flow of information: "When the social system is oriented to change, the opinion leaders are quite innovative; but when the system's norms are opposed to change, the behavior of the leaders also reflects this norm." (Rogers 1995).

There is also a homophily paradox in network diffusion. Rogers holds with the common sense notion that information is most likely to be shared by like-minded individuals. This also means that opinion leaders would have the most influence within small groups where everyone already shares very similar opinions. Obviously, this leads to a situation where information simply circulates rather than propagates through the network. In order for information to move beyond a small circle, there must be some element of *heterophily*, a bridging between groups. This heterophily cannot be too pervasive, however, because people will not have the same degree of trust in these different individuals, and therefore will be less likely to share information with them.

Inter-group communication

One effort to explain this balance between homophily and heterophily was a 1973 paper by Mark Granovetter called "The Strength of Weak Ties." As part of his PhD research in the late 1960's, Granovetter explored how job seekers use their networks to find jobs. His research led to the discovery that the bulk of his subjects found their positions through acquaintances or friends of friends. Surprisingly, most reported they did not even know the acquaintance at all beyond the work context (Granovetter 1973). This counterintuitive result led him to apply the tools of social network analysis to refine his understanding of the role of acquaintances in a social network.

A key hypothesis of social network analysis is the "balance theory," which says in part that if A has strong ties to B (e.g. they are good friends) and A also has strong ties with C, then B and C will form a connection as well. This is because people tend to associate with like-minded people (homophily), so a friend of yours becomes a friend of mine. Granovetter exaggerates the hypothesis by suggesting it is impossible for B and C not to be connected in this situation. The result is there is never a situation when there is only one possible path between two of the three points. Granovetter's major insight was to combine the idea of these multiple paths with the idea of a bridge. In network analysis, a bridge represents the ***only*** path between two points. Since the balance theory says that can never happen when strong ties are present, it follows that the only connection that can be a bridge is a weak tie.

The implications for this are profound. Contrary to the common assumption that information diffuses through a network via strong ties, Granovetter's idea is that it can only flow in the presence of weak ties. He uses the example of a rumor. If a rumor starts among friends and is passed to other friends, many will hear the rumor repeated because of mutual friendships and it will eventually trail off because it has lost its novelty. If however, the rumor is passed to an acquaintance (a weak tie), who shares it with his group of friends, the rumor gains new life.

For information diffusion then, Granovetter's theory holds that it is not the strong ties that matter most, but the much more numerous weak ties. They function as bridges between social groups and offer access to information that is unlikely to be found among a person's strong ties. Those people with numerous weak ties, then, should be in the best position to both receive and send novel information. And, networks that are composed of numerous weak ties should be better at spreading information and reacting to new information.

Modeling network behavior

As interesting as many of the ideas and theories of social networks were, they were in most cases too mathematically complex to test empirically. The foundations of the mathematical field of graph (network) theory were laid by Leonhard Euler in a 1796 paper, which solved the famous "Seven bridges of Königsberg" problem. The German city of Königsberg (today Russian Kaliningrad) had seven bridges connecting various islands across the Pregel River. Was it possible to walk across all seven bridges without crossing the same one twice? Euler proved it was not possible mathematically. In so doing, he devised a technique of representing the islands as "nodes" and the paths connecting them as "links."

Graph theory remained a relatively obscure field of mathematics until a theoretical work by Dénes Kőnig was translated into English in 1956, leading to rapid growth in applying graph theory as a model for social networks (Prell 2011). A significant breakthrough came when Paul Erdős and colleague Alfréd Rényi demonstrated how to construct a random network mathematically (Erdős and Rényi 1960). Researchers finally had an adequate representation of a random network and could begin to study how a network's structure was related to its function. Erdős and Rényi also used their model to show how a simple network could grow over time. Surprisingly, the random growth model demonstrated an unusual characteristic. Nodes would send out links to other nodes in a haphazard fashion, leading to some nodes being connected and others remaining cut off. This progressed until the network reached a certain threshold, then it suddenly underwent a "phase transition" or complete change from one state to another. In the new state, the network exhibited a so-called "giant component," where all of the nodes were suddenly connected to all of the other nodes. What this meant was that, mathematically at least, a network structure was highly efficient. In other words, the larger a network is the fewer links are required proportionately to connect all of the nodes together.

Despite the results from the mathematicians showing the power of using graph theory to analyze networks, empirical research lagged far behind theory for the next two decades. It turned out that the models being developed were too simplistic to represent real network behavior, but too computationally complex to use on real social network data. It wasn't until the early 1980s that computing power and software advanced sufficiently to attempt to build more realistic representations of social networks (Freeman 1988).

As software became more capable, researchers turned again to the task of building better models. Erdős had shown that a network was an efficient way to spread information, and Milgram had shown that points within the network should be able to communicate with other points. What remained was a model that could show both, and explain how that came about. The breakthrough came in 1998 when Duncan Watts and Steven Strogatz devised a random network model that had properties usually found in real-world networks (Watts and Strogatz 1998). Watts later explained the significance: "What it told us was that small-world networks arise from a very simple compromise between very basic forces—order and disorder—and not from the specific mechanisms by which that compromise is brokered. At that point it dawned on us that small-world networks should show up not just in the social world, from which the idea originated, but in all kinds of networked systems," (Watts 2004).

While Watts and Strogatz were able to show how most networks would likely show some small world properties, the models still lacked some obvious features found in real-world networks. First is the phenomenon of growth. How does a network such as the World Wide Web grow exponentially if the growth has to take place page by page? Second is the idea of hubs. As any high school student can attest, some people are more popular than others, and people tend to form groups or "clusters" in network terms. None of the models presented so far could account for those two facts. It was left to a physicist, Albert-László Barabási, to build a model that more closely resembled the real-world networks we are all familiar with.

What Barabási and his colleague Réka Albert demonstrated was that by making a subtle shift in the rules of network growth, the resulting model closely resembled the properties of a real world network (Barabási and Albert 1999). By assuming new nodes had a slight preference for linking to earlier nodes, the network could still grow rapidly, but now clusters began to form around the earlier nodes. Mathematically, this "rich get richer" effect is known as a power law distribution. Barabási and his colleague described networks that show this property as "scale free" and showed how the growth and form of a network like the internet could arise from very simple starting conditions.

With these mathematical models in place, the data scientists joined the earlier band of social scientists in the interdisciplinary quest to understand how structure informs and is informed by the individual. The rapid growth of social media on the internet is today seen as an ideal test-bed for exploration of these ideas.

Networked intelligence

The idea of collective intelligence is not as recent as some internet visionaries would contend. Adam Smith described it in 1776 as the "invisible hand" behind market economics, and Friedrich Hayek argued forcefully for the superior intelligence of the aggregate of individuals over any centralized problem solver in 1945 (Hayek 1945). A more concrete example was offered by Leonard Read's memorable essay "I, Pencil" in 1958, where the author showed that manufacturing an object as simple as a pencil is beyond the capability of any single individual (Read 1958). What is perhaps new in the internet age is the shift of the concept of collective intelligence away from the economic sphere and into other areas of cooperation.

As computer systems have become more advanced, theorists have tried to combine these ideas with the possibilities implied by the new technologies. Hungarian theorist George Pór in his 1995 "Quest for collective intelligence" says that collective intelligence is based upon network structures, and further defines four enabling functions, communication, coordination, memory, and learning. Only when the network is robust enough to support these four functions can any collective intelligence be said to take place. Going further, French philosopher Pierre Lévy describes a "universally distributed intelligence" which will transform the social order and promote the growth of democracy and civil society.

The combination of theories and applications that take advantage of them was termed the "Wisdom of Crowds" phenomenon by James Surowiecki in his 2004 best-selling book of the same name (Surowiecki 2004). Collective efforts such as Wikipedia and the Linux computer operating system are today widely publicized as archetypical examples of the possibilities of collective intelligence. Perhaps less well known, however, are the qualifications that Surowiecki himself identified. First, the intelligence of the crowd is generally best applied to problems that have one correct answer. Surowiecki cites Francis Galton's discovery that the crowd could accurately guess the weight of an ox at a county fair as a classic example of the best use of collective intelligence (Surowiecki 2004). Also the *structure* of the group matters. In an interview describing his book, Surowiecki said the ideal problem-solving group "needs to be diverse, so that people are bringing different pieces of information to the table. It needs to be decentralized, so that no one at the top is dictating the crowd's answer. It needs a way of summarizing people's opinions into one collective verdict. And the people in the crowd need to be independent, so that they pay attention mostly to their own information, and not worrying about what everyone around them thinks," (Surowiecki 2004).

Online data and network analysis

The rise of social networking sites has brought with it an equally rapid rise in research interest. Partly this is due to the relative ease with which massive amounts of user and network data can be gathered and analyzed. Indeed, the bulk of research in the new media field is focused on social networking sites, largely to the exclusion of more comprehensive research into the new media phenomenon. Among the studies dealing with social networking sites, the majority are focused around research questions dealing with the experiences and interactions of individual users, and not how the users interact in the network or react to outside stimuli.

Since Facebook is the most popular social networking site for both users and researchers, a recent analysis of peer-reviewed studies dating back to 2005 provides a good illustration of the current research focus (Wilson, Gosling et al. 2012). In their review, researchers examined more than 400 articles and determined that research interests fell into five broad categories: descriptive analysis of users; motivations for using Facebook; identity presentation; the role of Facebook in social interactions; and privacy and information disclosure. Despite the avalanche of popular press articles about the marketing and advertising value of Facebook, there were very few studies looking into this aspect of individual use. Perhaps most striking given media descriptions of Facebook's role in aiding organizers of the Egyptian revolution, researchers found no studies at all looking at its role in fostering or hindering collective action, and only three exploring the use of Facebook as a collaboration platform.

It is understandable that a gap between academic research on social networking sites and practical application of the research exists because social networking sites themselves are such a recent development. Thus far, most of the published studies involving the application and use of social networking sites are descriptive in nature (Goolsby 2010), (Martin, Allan et al. 2011), and/or involve niche segments of the population (Gold, Pedrana et al. 2011). An important exception to this trend is seen in the marketing and business community, where considerable effort has been made to use data from social networking sites in studies of marketing influence (Leskovec, Adamic et al. 2007);(Watts, Peretti et al. 2007) and predicting consumer behavior (Chang, Chen et al. 2012); (Kwok and Yu 2012).

Moving beyond a narrow focus on marketing, Francesco Bonchi proposes applying known techniques of data mining and social networking analysis to common business processes in general, including vision and strategy development, customer service, and human capital (Bonchi, Castillo et al. 2011). Although the paper uses a business context, several applications of the social network research are more widely applicable. For example, the research indicates analysis of social network data can be used to identify trustworthy individuals or news sources. It can also be used to create an expert-finding system, or even aid in the assembly of an expert team. Community detection is another application that has been used successfully, most famously as the basis for recommendation lists on e-commerce sites such as Amazon.com. In their overview of viral marketing and influence propagation, arguably the most important from both a business and strategic communication perspective, the authors remain cautious: "Although there has been some interesting work in this direction, this is by far the area of which we know the least: it is largely unclear why certain information propagates while other information does not, measuring influence remains a difficult task (in large part because all social network data is partial), and successful application of models depends on a number of external factors that are difficult to quantify." (Bonchi, p. 22:29)

Social media as a network

How close are social media networks to real life?

There are two largely unstated assumptions underlying the majority of research into real-world applications of social media technologies. The first is the audience of social media is representative of the broader population, and the second is largely theoretical models of network and media functions hold true in the face of observed user experiences. These are fundamental issues facing all social science, so it is perhaps not surprising to find them arising in this new context. In general, however, research into social media usage and application tends to be focused on the users and functions of specific software, thereby avoiding the larger questions. This may be appropriate for individual studies, but anyone trying to understand the broader topic must keep these unresolved issues in mind.

Consider first the most basic question of who uses social media. According to Facebook, the social networking site boasts more than a billion active users, or an astonishing 14% of the global population of seven billion (Facebook 2013). Further, Facebook states that approximately 82% of those users are outside of the U.S. and Canada. At first glance, Facebook would seem to be an ideal platform to interact with the global community. Yet, a closer examination tells a different story. In his cautionary overview of psychology research, Joseph Henrich points out that the overwhelming number of published studies focus on WEIRD subjects, i.e. people who come from Western, Educated, Industrialized, Rich, and Democratic countries and cultural backgrounds (Henrich, Heine et al. 2010). Henrich's WEIRD description could be fitted just as well onto social media users.

A prime example of the WEIRD phenomenon can be seen in Facebook's user demographics. Advertising researchers looked at self-identified information from Facebook profiles, and concluded that almost 60% of users come from just ten countries, and six of those are members of NATO. (Carmichael 2011). The age split is also unrepresentative, with about 40% of Facebook users being between the ages of 14-25 as opposed to 17% of the world population falling into that age category according to U.S. Census office figures. These basic age and geographic splits hold true across the majority of the most popular social networking and media sites. Research firm Beevolve in its 2012 Twitter statistics report finds 74% of Twitter users are younger than 25, and 50% of the estimated 170 million active Twitter users reside in the United States (Beevolve 2012). Photo sharing service Instagram reports 100 million active accounts (Instagram 2013) but the Pew Internet research center found that here too the majority are young users (Duggan and Brenner 2013).

Given the availability of data and the obvious conclusion that the Western world is both more active on social media sites and more likely to be home to social media companies, it is unusual that more cross-country or cross cultural comparisons of social media usage have not been conducted. The few that have, however, support the conclusion that national culture matters in online interactions as much as it does in the physical world.

Cross-cultural comparisons of social media usage generally support the idea that different nationalities approach social media in different ways. Asian cultures, for example, tended to approach new media technologies with more apprehension than Western users (Yoo and David Huang 2011). Others have found differences in topic selection (Chapman and Lahav 2008), privacy settings (Marshall, Cardon et al. 2008), and usage in learning environments (Park, Mohan et al. 2009).

One of the earliest studies to look at this phenomenon in a broader context was Suely Fragoso's study of the Brazilian "takeover" of Google's Orkut social networking site (Fragoso 2006). Launched in 2004, Orkut is one of the second wave of social networking sites and was originally based in Google's California headquarters. Like most social networking sites, Orkut experienced a period of explosive growth in membership and currently boasts approximately 37 million users (Orkut 2013). Yet a little more than a year after its founding, Brazilian users began to create forums pledging to "take" Orkut from the Americans and by early January 2006, Brazilians outnumbered U.S. users by a factor of 7 to 1(Fragoso 2006). Fragaso attributes this success to the interplay between Orkut's membership rules and the different ways the Americans and Brazilians interpreted them. The only way to become a member of Orkut was to be invited by a current member, thus reinforcing an impression of exclusivity. The American audiences more or less followed along with that practice, restricting their invitations to people they knew well enough to want to invite into the "club." The Brazilians, on the other hand, "understand, however, that as frequently happens in the world 'outside the screen' of their computers, the law can be forgotten, or at least limited in effect, so as not to apply in their case." (Fragoso 2006). Their strategy was to ignore the intended exclusivity of membership, and they were therefore able to rapidly build a critical mass of Portuguese speaking users that quickly overwhelmed the American user base.

An equally important consideration of social media usage that is often overlooked is the divide between rural and urban users. In most countries, rural inhabitants tend to be poorer, and therefore lack the means to purchase the computers or the internet connections that will allow them to participate in new media activities. In some countries, lack of foreign language skills prevent access, as does high amounts of illiteracy (Wasserman 2007). In poorer regions such as Africa, the relatively few rural inhabitants who can access the internet tend to be highly atypical: young, educated, male, and comparatively wealthier than his neighbors (Furuholt and Kristiansen 2007). The divide persists in wealthy countries as well. Rural social media users in the United States have fewer online friends, have less interaction online, are more likely to be female, and are much more likely than urban dwellers to connect to people from the local geographical area (Gilbert, Karahalios et al. 2008).

Mobile phones are sometimes mentioned as the internet access point of the future for rural areas, but the evidence is mixed. Technology consulting firm Accenture found that 69% of all internet users do so over a mobile device (Accenture 2012), but academic researchers have noted that cell phone penetration into rural areas and developing nations continues to lag (Fong 2009); (Ruth 2012). In rural India, for example, there are only 39 phones per 100 inhabitants, while Burma claims only 2 (ITU 2012). An exception to this rule seems to be in Africa, where some nations report overall cell phone penetration at close to 100% (ITU 2012). This is likely to be more indicative of growing urbanization than it is of cell phone usage in rural areas.

How networks work

It would seem to be a fair conclusion that the users of social media tend not to be particularly representative of their broader societies. Moreover, users in one culture may interact with new media technologies differently than users in another culture. Given this reality, what does the research say about the second common research assumption that media and social networks largely function according to existing theoretical models? The evidence for this assumption is on generally firmer ground.

Today's social networking sites are providing researchers with the raw data to test the basic ideas of social networks, and it is not at all uncommon to see researchers conducting network analysis on data sets containing tens of millions of online social relationships. The results are broadly supportive of what Charles Kadushin calls the "master ideas" of social networks, and include:

1. Social networks are fundamentally about interaction and interrelatedness.
2. Social networks can be graphically displayed and mathematically described.
3. The effect of homophily within a network is not fully understood.
4. Position in a social network is important.
5. Real world networks exhibit a "small world" tendency.
6. Diffusion or flow from one node to another is the basis of any network (Kadushin 2012).

Since actual social networking sites are proving to function in line with theoretical concepts, researchers are beginning to turn their attention to practical applications. Of these, information diffusion, mobilization, and crowdsourcing are the most relevant to the nonproliferation and arms control field.

Because of the obvious connection to business advertising, information diffusion through social media has received the lion's share of research attention. Popular works such as *The Tipping Point* (Gladwell 2006) and *Contagious* (Berger 2013) demonstrate the appeal of the notion that people's behavior can not only be influenced, but that there is a recipe to do so. Given that social media provides easy access to a potential audience of millions of people, there is a rich body of research testing this essential idea.

Unfortunately for the world's advertising executives, information flows across social media networks are much more difficult to predict than expected. In one of the best known experiments, Matthew Salganik and his team built a music website where users could download music and vote on the most popular songs. The expectation was that the crowd would come up with a common definition of quality, and those songs would consistently rise to the top of the rankings. Additionally, since all voters could see the results of previous votes, the researchers wanted to see how this social influence would play out in the rankings (Salganik, Dodds et al. 2006). Instead of clearly tracing the role of influence, the experiment showed the song selections became more random and unpredictable as social influence was increased. In other words, the interplay between music voters' own preferences and their desire to respond to the preferences of others creates a dynamic system that leads to generally unpredictable results.

Many researchers make an even stronger statement, especially with respect to so-called information cascades or "viral" effects. One widely cited study examined 4 million users of a retail web site and compared their product recommendations on 500,000 products with subsequent purchases (Leskovec, Adamic et al. 2007). The results found the vast majority of recommendation chains terminate after a short number of hops, and the few that go on to become very large are essentially random. Even more importantly, the study goes on to say that highly connected individuals do not have as much influence as theory suggests, largely due to a saturation effect when people simply stop listening to recommendations once a threshold has been reached. Still, the research did find one interesting anomaly: recommendations had a much higher chance of being accepted if they took place within an organized social context. For example, doctors would follow the recommendations of other doctors on purchasing a medical text, or orchid specialists would listen to like-minded specialists when purchasing gardening books.

The idea persists, however, that certain individuals carry outsized influence in any network. Katz and Lazarsfeld called these people "opinion leaders," (Katz and Lazarsfeld 1955) but the more familiar term today might be Gladwell's "Mavens." Perhaps the most prominent critic of the "influentials" idea and the individual's role in viral propagation is Duncan Watts, the same data scientist who demonstrated that small world networks should be everywhere. His criticism centers on the lack of empirical evidence to back up the claim (Watts 2007). Moreover, Watts finds that most studies suffer from a variety of methodological issues, including overreliance on anecdotal evidence, poor survey design, and failure to define how any influence is to be measured. Famously, Watts has concluded that the viral effects often ascribed to influential individuals in today's new media world are most similar to forest fires:

> *Some forest fires, for example, are many times larger than average; yet no one would claim that the size of a forest fire can be in any way attributed to the exceptional properties of the spark that ignited it or the size of the tree that was the first to burn. Major forest fires require a conspiracy of wind, temperature, low humidity, and combustible fuel that extends over large tracts of land. Just as for large cascades in social influence networks, when the right global combination of conditions exists, any spark will do; when it does not, none will suffice. (Watts and Dodds 2007)*

His study concedes that influentials may exist, but their influence effects are likely to be small, unique to the situation, and impossible to predict.

As is to be expected, the influentials hypothesis continues to be debated. More recent work has argued that influence exists, but is best understood when it is combined with others' susceptibility to influence (Aral and Walker 2012); fast information diffusion can be triggered by using incentives to target highly connected individuals (Stephen and Lehmann

2012); and individuals are highly influential primarily among their closest friends, a situation that holds true in online networks (Bond, Fariss et al. 2012).

One distinction that is necessary to draw out is influencing someone to take an action as opposed to influencing someone to share information. A study of 253 million Facebook users (Bakshy, Rosenn et al. 2012) found that weak ties (i.e. online acquaintances) were very important to spreading information. The authors conclude this is likely the result of the fact that there are so many of them, and that the cost of disseminating information in online environments is extremely low. These findings seem to be strongly reinforced when compared to a number of studies examining the microblogging platform Twitter.

Interaction between users on Twitter is fundamentally different from other social networking sites when viewed from a network analysis perspective. It has a shorter diameter (meaning users are "closer" together), low reciprocity, and does not have a "winner take all" follower distribution among users. The conclusion is that Twitter is best understood as a type of mass media instrument, and not a social networking site (Kwak, Lee et al. 2010). In fact, in an analysis of 106 million tweets conducted over a two-month period, 85% of the topics were news related. Even more surprising, a comparison with topics gathered from CNN Headline News coverage showed that CNN was ahead of Twitter more than half the time (Kwak, p 6.). Twitter showed an advantage in live-event coverage however, suggesting that it might be useful for breaking news.

Underscoring the Twitter-as-mass-media description is another study by Yahoo! Research which found that 50% of the total links clicked on by Twitter users were generated by just 20,000 Twitter accounts—out of 42 million registered users (Wu, Hofman et al. 2011). On Twitter, there seems to be good evidence that information diffuses quickly, and that it follows the classic "two-step" flow of opinion leader to masses as described by Elihu Katz (Katz 1957). Oddly, the information shared by these opinion leaders tends to die out quickly, probably because it is more topical in nature. The longest-lived content tended to be multi-media such as music or videos that were continually "rediscovered" by non-elite Twitter users and reintroduced into the Twitter system. Opinion leaders in a Twitter context are most likely to be mainstream news organizations. Bloggers or others who gained a large following tend to do so through long and concerted effort and narrow topical focus (Cha, Haddadi et al. 2010).

Returning to the effectiveness of social media as a platform for mobilizing action in the offline world, the jury is still out. Prominent journalists and internet observers have criticized social media campaigns as "slacktivism" (Morozov 2011) or as "good at things like helping Wall Streeters get phones back from teen-age girls," (Gladwell 2010). And even the highly touted success of social media in helping to coordinate protests during the Arab Spring turns out to have been not as clear cut as analysts first believed. Social media played an important part in the Egyptian uprising for example, but the real work was done over a period of years as activists steadily built vocal online communities of like-minded individuals (Lim 2012). And, while Twitter and Facebook receive the bulk of attention, a much more pivotal role was played by long-established technologies such as landline and mobile telephones (Zhuo, Wellman et al. 2011).

Beyond comparative discussions of the role of traditional versus online activism in the Arab Spring, our review finds very little empirical research on the effects of social media information sharing on subsequent real world behavior. This may be because of the methodological difficulties involved in untangling influence from homophily or in obtaining accurate information about reported but unobserved behavior. The Bond study mentioned earlier is one of the few that did manage to track Facebook user actions offline, but it was in the limited context of U.S. voter behavior. The study nonetheless found influence was transmitted online, but the influence was largely restricted to people who were friends in an offline context as well. Furthermore, the effect, though statistically significant, was small in real terms. Given the enormous total number of Facebook users, however, the researchers conclude that even this minor effect resulted in a large number of voters (an estimated 340,000) casting votes who might have otherwise stayed home.

How crowdsourcing works

The term "crowdsourcing" was first popularized by Wired Magazine contributing editor Jeff Howe in a 2006 blog post (Howe 2006), but it took an additional two years for the scholarly community to come up with an appropriate definition. Daren Brabham's description of crowdsourcing as "online, distributed problem solving" is generally accepted (Brabham 2008), but still leaves some room for interpretation. At issue is the confusion between crowdsourcing as an approach to solving discrete problems (often in comparison to an expert-provided prediction) and crowdsourcing as a goal-seeking process.

The problem solving aspect of crowdsourcing was clearly articulated by James Surowiecki in his best-selling book The Wisdom of Crowds (Surowiecki 2004). Surowiecki was primarily concerned with situations where a non-expert crowd could provide a solution with a precision that rivaled experts. In a wide-ranging survey of historical cases, Surowiecki concluded that not only did crowds outperform experts, but they did so routinely. However, his findings included the certain caveats mentioned earlier in our discussion of Collective Intelligence. More recent research has re-visited the issue in light of these restrictions (a discrete problem with a factual answer, independent individuals, crowd diversity) and tried to answer how good crowdsourced results might be expected to be.

Not surprisingly, the answer is very good under the right conditions. In fact, provided the crowd meets Surowiecki's conditions, it only takes a crowd of 30 to start to deliver expert levels of performance (Wagner and Vinaimont 2010). Performance increases with crowd size, and once the crowd approaches 1000, it will likely outperform most experts almost 9 out of 10 times (Wagner, p. 729). While these results are impressive, it is important to keep two cautions in mind. First, there is a difference between outperforming an expert and getting the answer right. No studies claim crowds can magically deliver the solution, only that the crowd solution is frequently as good as or slightly better than an expert's. Next, the crowd does not always outperform. Expert advantage over novices has been demonstrated in domains ranging from computer science (McKeithen, Reitman et al. 1981), to physics (Larkin, McDermott et al. 1980), to music composition (Colley, Banton et al. 1992). If the expert's advantage is large enough, the crowd will lag. Still, this performance advantage largely disappears when experts compete against semi-expert groups or reasonably sophisticated statistical models (Camerer and Johnson 1997).

Crowdsourcing as a goal-seeking process is probably the most common and widely used sense of the term, and can be applied to the output of online reference works such as Wikipedia or Yahoo! Answers, as well as to collaborative business concepts such as Threadless.com or community developed software programs such as Linux. It is the process element of crowdsourcing rather than the outcome that distinguishes it from more familiar team or committee based approaches. The crowdsourcing process can be roughly defined as a combination of four elements: crowd pre-selection; accessibility of peer contributions; aggregation of the contributions; and some form of remuneration (Geiger, Seedorf et al. 2011). The process sequence is not important, but each element forms an essential part of any crowdsourcing effort.

Beyond identifying the process elements, several researchers have attempted to identify key factors in crowdsourcing success. As could be expected, the question of incentives and their effects on worker motivation has received the most attention. In general, the evidence suggests a role for both monetary and non-monetary awards. Some crowdsourcing platforms such as Amazon's Mechanical Turk are set up for workers seeking money. In fact, one survey showed that 91% of surveyed workers cited a desire to make money as their primary motivation for using the system (Silberman, Irani et al. 2010). Even more surprising, fully 13% of the U.S. respondents claimed Mechanical Turk provided their primary income. While there are many examples of websites such as YouTube which offer no direct monetary compensation and argue powerfully for the power of reputational incentives (Huberman, Romero et al. 2009), monetary incentives can still strongly influence task performance (Harris 2011). Moreover, the belief that the average crowdsourcing participant engages in a task mostly out of intrinsic motivation is at odds with the demographic reality of the global online community.

Mechanical Turk is intentionally designed for low-skill, high repetition tasks such as categorizing photographs. As the skills required to accomplish a task become more complex, so does the optimal mix of incentives. In fact, complex incentives are almost certainly warranted for the majority of crowdsourced applications, as new research shows most crowdsource workers are not hobbyists or amateurs but are largely professionals and experts (Brabham 2012). For highly skilled computer programmers, reputation seems to play a role, though size of monetary incentive is still highly predictive of outcome quality (Archak 2010). Additional research supports the idea of combining incentives, with some evidence that the simple existence of a reward system (e.g. top 10 list, most popular list) encourages the majority to participate (Antikainen and Vaataja 2010).

One of the more rigorous studies of incentives was conducted by Thomas Walter and Andrea Back. In addition to the expected importance of blended incentives, they found poorly designed incentives can harm participation (Walter and Back 2011). Interestingly, there can be a negative correlation between monetary reward and outcome. Higher rewards tend to increase the quantity of entries, not their quality. They also found that brand identity is a significant factor in attracting participants. Hence, some element of brand building and market research can have a positive impact on crowdsourcing efforts.

The majority of crowdsourcing research tends to examine the worker side of the equation. Management schools have recently begun to take a closer look at the organizational side in search of insights into the process. A common element to these studies is the insistence on alignment; that is the crowdsourcing goals of the organization must be such that the crowd can be seen as a partner in the effort. In order to be successful, organizations might have to create training programs, public affairs campaigns, and invest significant resources in articulating a vision and building trust with the targeted community (Sharma 2010). MIT researchers suggest that crowdsourcing efforts work best "in situations where *the resources and skills needed to perform an activity are distributed widely or reside in places that are not known in advance,*"[italics in original] (Malone, Laubacher et al. 2009). They find that crowdsourcing performance can be improved when organizations follow a simple task matrix to help determine answers for what the goal is; who will conduct the task; how it will be structured; and why people would participate.

Because the ethos of crowdsourcing is one of cooperation, there has been almost no research exploring when crowds do not cooperate. There has been some effort to study methods to improve crowdsource worker quality (Downs, Holbrook et al. 2010, Kapelner and Chandler 2010), but few attempts to look at the broader scope of competition versus cooperation in a crowdsourcing environment. This is an important oversight, because high stakes crowdsourcing initiatives are subject to malicious attacks and vandalism. For example, the winners of the highly publicized DARPA red balloon challenge had to devote a considerable amount of their time filtering fake submissions containing individuals disguised as DARPA officials (Tang, Cebrian et al. 2011) and social mapping platform Ushahidi might have contributed to violence among ethnic groups during Kenyan elections as opposing sides infiltrated the platform (Chohan 2009). Despite the benign expectations of crowdsourcing, it turns out that in competitive situations "malicious behavior is the expected behavior, not the anomaly," (Naroditskiy, Jennings et al. 2013). Using a game-theoretic approach, the research team believes the behavior gets worse in multi-player environments and attacks are basically unavoidable. More research is needed to confirm these initial findings, but it seems reasonable that any crowdsourcing effort should be designed with the expectation of malicious behavior in mind.

State control of networks

Although the ethos of the internet purports to be freedom of information, the reality is states exert a tremendous amount of control over the content of information that is permitted. It is counterintuitive, but the majority of such censorship takes place under commonly accepted civil and criminal law. For example, many courts aggressively enforce copyright law against software and music piracy, and most would agree that using the web to transmit child pornography is rightly prohibited. Even democracies sometimes censor political speech, with both France and Germany prohibiting online (and offline) speech that is against the constitutional order (Zittrain and Palfrey 2008). For societal verification purposes, however, the focus is usually on authoritarian regimes and here the conventional wisdom holds: all 12 countries rated as “Enemies of the Internet” by information freedom watchdog Reporters without Borders (Borders 2012) are also listed as “Not Free” by democracy watchdog Freedom House (House 2013).

While authoritarian nations have strong incentives for censorship, any effort to do so must take into account the increasing dependence on the internet for commerce, communications, and information sharing. When they do censor, states tend to do so selectively. This is partly due to the availability of technical solutions such as internet protocol (IP) blockers or domain name server (DNS) tampering, but is also because a more wide-spread (and effective) approach such as disconnecting internet service trunk lines would downgrade the entire system and prevent the government in question from using the internet as well (Howard, Agarwal et al. 2011). Nonetheless, the leaders of authoritarian regimes are willing to take even this extreme measure if the perceived threat to the regime is urgent enough (Singel 2011).

Censorship efforts by states such as China are frequently downplayed as ineffective (O'Carroll 2012) and easily bypassed by even moderately sophisticated users (Vitaliev 2008). This is at best an incomplete assessment. The reality is the success of anti-censorship efforts largely depends on the cost-benefit determination of the state. States monitor and block access to certain sites, and motivated actors frequently discover effective methods to get around the censorship. On balance, the side with the most resources tends to prevail (Zhu, Phipps et al. 2012).

Unlike most of the other research in the field of social media, which tends to concentrate on its technical aspects, research on state control of social media takes a broader view. From this perspective, censorship of social media has three components, technical, social, and political (Howard, Agarwal et al. 2011). The technical component receives the most attention but is the least important aspect of censorship.

As the internet matures, so too does the sophistication of all of its users. This shows itself very clearly in the growing importance of the social and political components of internet censorship. China for example has enforced its censorship rules though economic pressure, forcing both Google and Yahoo to comply or lose access to one of the most lucrative advertising markets in the world (Wright 2013). In practice, internet technology has not been able to undermine the authoritarian state, because so much of the internet infrastructure remains under state control. In China, many users access the internet through internet cafes. Rather than block the cafes or shut them down, Chinese authorities installed cameras that observe both the users and their computer screens (Goldsmith and Wu 2006). The idea that content providers could bypass these state-controlled intermediaries to reach enormous numbers of users turns out to be false.

Some users do access some sites, but surveillance and censorship do not have to be perfect to be effective. This is especially the case as sophisticated regimes begin to shape the internet environment to their own purposes. The users of the Weibo microblogging platform are adept at using homonyms and nicknames to discuss censored terms or to refer to political personalities (Lewis 2012). But any code is necessarily restricted to the small group of users. And, how can this small group compete against the enormous amount of state fostered conversations about China’s greatness or the latest Japanese outrage (Goldsmith and Wu 2006)?

This sophisticated censorship has been termed “networked authoritarianism” by Rebecca MacKinnon. Her examination of Chinese internet censorship shows a regime that is absolutely aware of both the benefits and the danger of the technology. Eschewing the “great firewall” metaphor common in the West, Chinese officials liken their system to a waterworks. The government must maintain a constant balance between drought and flood, and it cannot rely on a simplistic method to do so (MacKinnon 2011). The combination of technical means and social controls is ultimately leading away from freedom of expression and towards the authoritarian dream: effective self-censorship.

Sophisticated state internet usage is not restricted to China. The nations of the former Soviet Union are also evolving in this direction. Russia in particular was quick to grasp the importance of the internet to the state, and President Putin participated in one of the first online chats between a head of state and voters back in 2006 (Schwirtz and Philips 2006). Today, 49% of individuals are connected to the internet (ITU 2012) and Russia's homegrown search engine Yandex garners as many hits in Russia as Google (LiveInternet 2013).

These developments have not gone unobserved by governments. Ronald Deibert and Rafal Rohozinski surveyed the post-Soviet countries and found only Turkmenistan and Uzbekistan still practice what they call "1st Generation Controls," or using technical means to block access to sites (Deibert and Rohozinski 2010). Instead, they assert the majority are following in China's path and implementing "2nd Generation Controls." By this they mean tools such as a carefully defined legal structure that prohibits certain activities, and requires providers to register with authorities or face sanctions. They also highlight an expanded use of defamation and slander law to deter bloggers and independent media. Even more controversial, they find some evidence of states conducting or sponsoring hacking and other malicious online attacks aimed at certain users.

Deibert and Rohozinkski very much see an evolutionary trend in authoritarian states to what they call "3rd Generation Controls," or those where the state seeks to "compete, engage, and dominate opponents in the informational battle space through persistent messaging, disinformation, intimidation, and other tactics designed to divide, confuse, and disable," (p. 29). The authors believe the growing emphasis on cyber security and the internet as a domain for military action will accelerate the tendency.

Privacy and anonymity in networks

The chief obstacle to any social-media based form of societal verification is likely to be security. Poor security practices are so common that some cyber security experts now claim that it is better to follow yesterday's bad security practice of creating a complicated password and writing it down because it will be safer than most passwords that are easily remembered (Cheswick 2013). This faulty human element means that any attempt at widespread societal verification would inevitably expose a citizen to the dangers of reprisal, even if there were a perfect technical solution. Beyond human error, all computer systems are subject to malicious attacks and hacking. It is bad enough when the perpetrators are criminals, but state security services have equally high incentives to snoop on users computers, especially in authoritarian regimes.

The Syrian uprising provides a case study of state-based hacking. Syrian dissident Taymour Karim was arrested and tortured but refused to divulge the names of his fellow dissidents. After a brutal beating, his interrogators confronted him with their evidence: over 1000 pages of transcripts from his encrypted Skype sessions with other dissidents. The security forces had infiltrated his hard drive with a program that allowed them to remotely monitor his actions. "My computer was arrested before me," he later explained to a reporter (Faris 2012).

Research into social network privacy and anonymity demonstrates that there is no reliable method to ensure user security from determined attackers. In fact, the very nature of social media, with its multiple overlapping friendship networks, means that establishing identity is easier than ever. In one U.S. based study, researchers found under certain circumstance they could predict a person's entire social security number an astonishing 60% of the time by training a basic machine learning algorithm and applying it to online databases and social media sites (Acquisti and Gross 2009).

Even the data used in research is subject to exploitation. Social media sites such as Twitter and Facebook make their data available for research after anonymizing it – that is, removing names, addresses, and other identifiable information. Previous researchers have found that individuals can be uniquely identified with small amounts of publicly available data such as zip codes and birth dates (Sweeney 2000). At issue now is the availability of much of this data online and the ability of machine learning algorithms to combine it and process it (Ohm 2010). As more users have multiple social media accounts, anonymized data can be de-anonymized easily, with accuracies approaching 90% (Narayanan and Shmatikov 2009).

In addition to the clandestine ability of states or other bad actors to learn user identities, social media data can also be extracted at the source. According to the Google Transparency Report, the corporation responded to almost 2,000 requests from governments and legal authorities to remove postings or provide information on users in the first six months of 2012 (Google 2012). Foreign equivalents of Google and Facebook, such as Russia's Yandex and Odnoklassniki are located on national territory, and presumably must comply with the same types of government or legal requests (Rispoli 2013). The next section of this paper describes, among other things, how citizens overcome these obstacles.

Applications of New Media Technology: Case Studies and Lessons Learned

Introduction

In the course of this study, we have placed great emphasis on understanding how new media have been used in various contemporary projects. We studied and debated cases of employing technology in different parts of the world – including humanitarian crises in South East Asia and Latin America, political campaigns in the U.S. and Russia, use of geospatial analysis around the world, and creating the online movements to address human trafficking and extremism to name just a few. Ultimately, we have chosen the following examples to demonstrate the depth and the breadth of new media potential: (1) Use of web and mobile applications during political protests in Russia 2011-2012, (2) Data mining for public diplomacy and expert identification, (3) Open source collaboration and version control—negotiating via GitHub, and (4) Satellite imagery and crowdsourcing – Tomnod rescue operation.

The stories of these very different cases are told in dramatically distinct ways – some explore the exact flow and details of a particular instance of using new media while others take a broader look at how various actors have turned to a specific technology to accomplish their goals. We suggest that it is as important to understand the technology and its challenges, as it is to approach new media creatively, learning from cases in which the same means are used to accomplish various purposes. The lessons learned from studying these cases lay out the foundation for our conceptual approach to using technology in nonproliferation and arms control which we explore in more detail in the *Navigating the New Media* section.

1 Use of web and mobile applications during political protests in Russia 2011-2012

Background

Traditional media in Russia are primarily controlled by the government or its affiliates, an arrangement that impedes the airing of oppositional points of view on national television. Such a media environment has driven many opposition groups and their leaders towards online media as the only domain of free information available to them.

On September 24, 2011, then-President of Russia Dmitry Medvedev announced his intention to stand aside in favor of former President Vladimir Putin. For many Russians, this decision meant that the upcoming Presidential elections would become simply a formality to legitimize this political "switch."

That December's parliamentary elections, preceding the Presidential campaign, sparked enormous protest when reports of ballot stuffing and other fraudulent voting activities began to surface. These reports were quickly seized upon by opposition groups and shared via social media. More than a dozen grassroots application projects designed to provide a venue for voters to report, investigate, and verify instances of election fraud were "born" online on December 4, 2011. Most of these applications, whether web-based or mobile, were accessed primarily through smart phones during 2011 - 2012. Although the use of mobile phones and social media in a political process did not initially appear to be an organized effort, the impact of nearly instantaneous sharing of possible cases of corruption and voter misconduct with large groups of people could not have been predicted.

What were the key features of the online effort?

For this case study analysis, we examined various web and mobile initiatives designed to monitor elections in Russia (2011-2012) and publicize the results. Based on an assessment of more than 15 crowdsourcing and social media projects, we identified the major functions and features of these election-focused initiatives as: crowdsourcing, user-centered approach, personalization, geo-tagging, and gamification.

Crowdsourcing

Mobile and web applications served as a central operational hub for collecting the voters' grievances, monitoring the elections, and providing legal information and advice to observers in case of confrontation with election officials or police. To gather and vet all of the information, organizers relied on crowdsourcing (Figure 5).

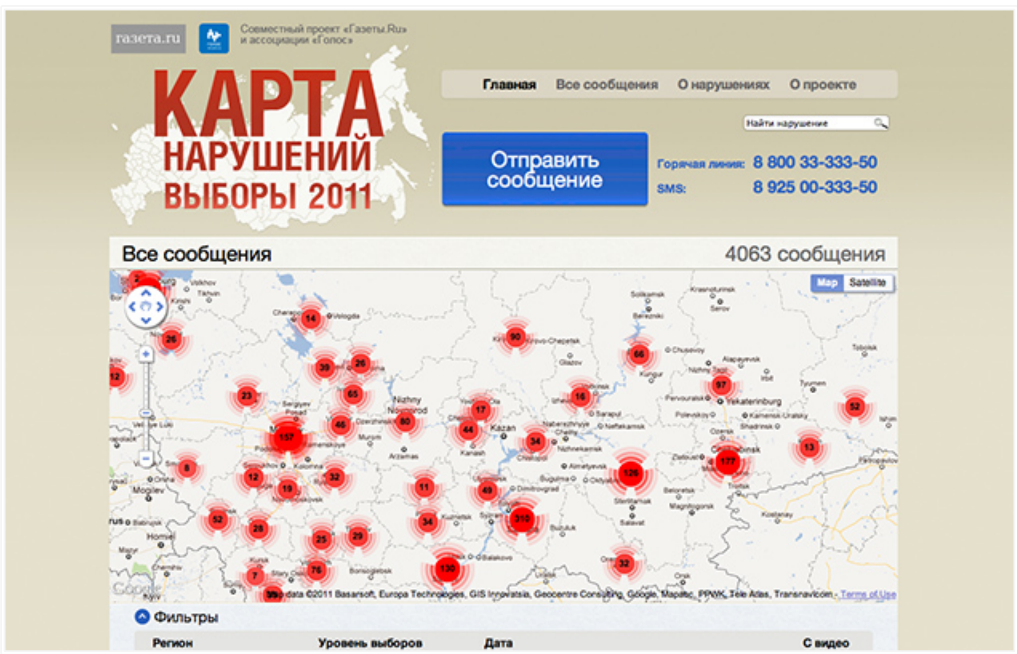


Figure 5: Example of visualization of voter grievances during the 2011 elections in Russia

For instance, a joint project of the Association "VOICE" and "Gazeta.Ru", *Karta Itogov,* was designed as a parallel process of counting the ballots in both parliamentary and presidential elections by analyzing the official results and identifying the protocols modified or rewritten by election officials after all votes were cast. This web-based initiative identified the differences in the content of copies of the protocols submitted by the observers and the official data. *Rosvibory* was another project that employed crowdsourcing as the main tool to simplify the registration process for those willing to volunteer as observers at the polling stations. In this case, crowdsourcing took the form of soliciting help to monitor the elections from a large online community. It provided a legal framework and formal training to anyone ready to participate in the political process.

User-centered interaction and personalization

Many election-focused web-based projects demonstrated a good understanding of user interaction in developing websites or mobile applications, as well as a strong orientation towards engaging with users and their input. As a result, some projects effectively capitalized on their design strategy to create an online conversation to counteract the government's effort to quash any opposing political agenda. For instance, a project named *Grakon* managed to collect 2.3 million page views, 350,000 unique visitors, and about 1,000,000 Rubles in donations through its crowdfunding effort in just two weeks. All collected data on election violations was immediately made available online to view or download.

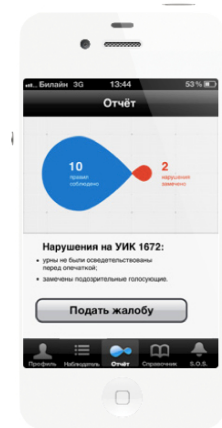


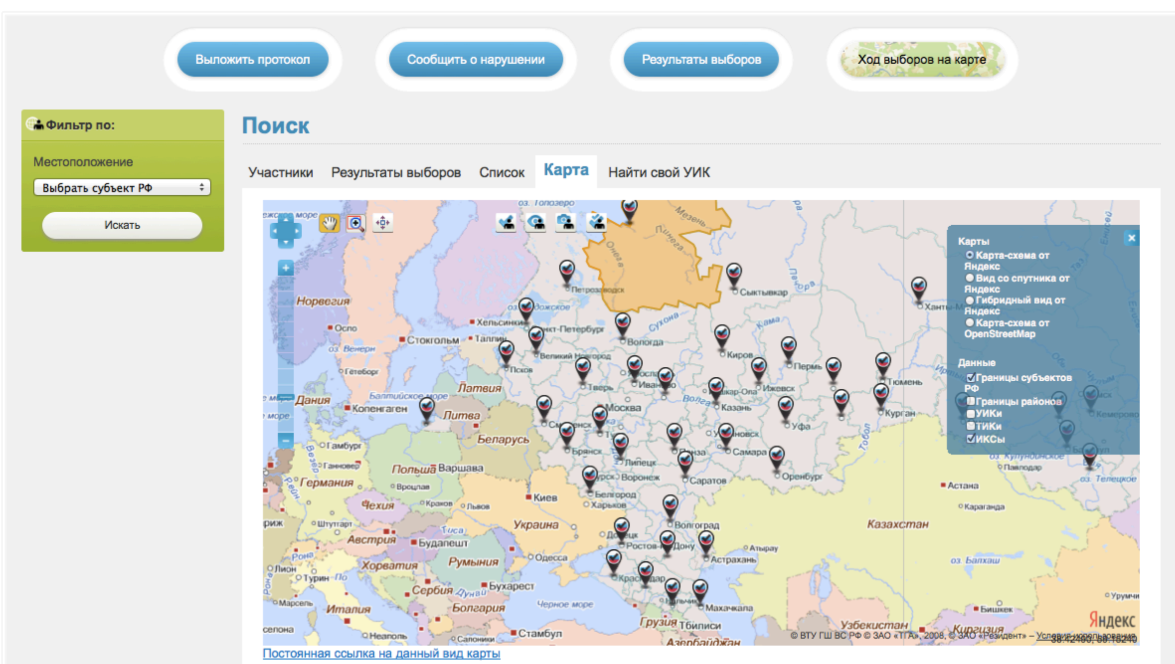
Figure 6

Another example is WebNabludatel (Web-watcher), built primarily for mobile users. This application helped observers see in real-time any violations reported at a particular local polling station. They could also file a photographic, video or text complaint, and receive legal help and tips about how to proceed in case of conflict with election officials (Figure 6). The Web-watcher allowed users to login via Facebook and Twitter to share the election reports through their social networks, thus multiplying the effect of this public awareness campaign. The application used the open source model, making the code freely available for any further improvements and add-ons. Interestingly, regardless of its usability and effective design vision, this initiative reached only a little more than 6,000 users, likely due to being drowned out by dozens of other web platforms addressing the same issues during 2011-2012 political processes.

Geo-tagging

Allowing users to map their reports by adding geographical identification metadata became a key feature for many new media projects focused on monitoring the elections (Figure 7). It was a major contributor to creating and maintaining the national database of reports and grievances coming from the polling stations. In addition, it provided users with visual feedback and enhanced the sense of community by highlighting activities in familiar locations and neighborhoods.

Figure 7: Locator for precinct polling stations in Russia



Gamification

In a highly competitive environment where new media projects struggle to retain users, gamification became one of the distinctive features drawing people to a particular web ecosystem. For instance, *Grakon* used a ranking system in which the most active users earned points by participating in the political process. When a sufficient number of points was collected, a user gained a new "status": online activist - for adding the most useful information to the election database; offline activist - for participating in offline political events; and organizer/leader - for organizing offline events. *Grakon* took user status into account when sorting the lists of participants to display on the website. It would also give the status owners extra "powers" to use on the platform, such as the ability to moderate pages and do mass mailings to users located in the same electoral districts. The idea behind using the game design elements in this project was to create a virtual space in which the most proactive participants were recognized and encouraged to become new civic leaders at local and state levels.

Lessons learned

The power of technology and the need for integration

The use of technology and new media during the political campaign of 2011-2012 in Russia appears to have been greatly effective in reaching an audience that is normally on the margins of political discourse and processes – young online users. The many web and mobile projects directed to this segment of the Russian electorate affected how it sees its own role in the political process. The effort has evolved into hundreds of emerging web platforms aimed at solving major social and political issues – from humanitarian online movements helping orphanages across the country to crowdfunding initiatives providing legal and financial assistance to protesters charged with violations of public order during the opposition marches in May 2012. Although a majority of the Russian people is still influenced by traditional media, especially the older population and those living in smaller towns, it is now clear that technology can provide an extremely effective tool for organizing an internal dialogue within online communities and mobilizing groups for action.

Yet, the political events of 2011 – 2012 have also revealed the importance of integrating disparate efforts with similar goals. The fact that so many platforms had identical objectives and features might have contributed to limiting the effect of some new media initiatives. Some ideas, regardless of how well designed and promoted they were, were drowned out by so many similar projects. To mitigate this challenge, one might suggest a process in which all of the human and social capital is directed towards a single or very small group of platforms. This approach would combine the efforts of developers and media enthusiasts to strengthen the idea and its implementation.

Although the election results remained legally unchallenged, most political experts and media analysts point out that social reaction amplified through technology has made the political process overall more transparent and has elevated the urgency of changing the existing political system.

Crowds as arms control and nonproliferation observers

The case of employing crowdsourcing in a political process to collect and verify large amounts of data from thousands of polling stations across the country in a very short period of time demonstrates that scale is not a major limiting factor. The key is to design an effective algorithm that encompasses all relevant parameters to derive information needed for the purposes of these new media projects. In other words, the quantity of data is not as important as the quality of models developed to identify and analyze valid discrepancies between official election results and information supplied by the crowd.

Based on this case study, one could draw a parallel between the goals and objectives of election-focused new media initiatives in Russia and the challenges facing the nonproliferation and arms control community. In some cases, one of the biggest problems during the 2011 - 2012 political campaigns was information discovery and its verification. Through crowdsourcing, people could publicize and assess the credibility of a particular report or official election result. Similarly, arms control decision-making often depends on detecting deviations in states' behavior and the official records related to verifying the implementation of arms control agreements. A combination of crowdsourcing and big data applications can be successfully employed for creating and maintaining a parallel data bank on all nuclear-related objects around the world and the movements around those objects, which could significantly reduce the time and cost of initial detection and verification of possible discrepancies. Although, the scale of such effort is massive, the major challenge in developing this platform will be a thorough examination of a great number of diverse parameters and their relationships to devise an algorithm capable of processing the data and users' inputs accurately and efficiently. Finally, the social sentiment and sense of community that has ultimately become a foundation for a strong opposition movement in Russia suggests the possibility of employing social media ideas to strengthen arms control and nonproliferation norms among a particular target audience.

2 Data mining for public diplomacy and expert identification

Introduction

Societal verification is based on people being aware of their obligations

A basic awareness of what must be verified is the first requirement for any societal verification effort. In the arms control and nonproliferation arena, while experts such as scientists or government officials may be aware of what constitutes a treaty violation, the same cannot be said of everyone who may be a potential source of information. For this reason, governments must not only make an effort to inform and educate individuals about treaty obligations, they must also be involved in public diplomacy efforts that can engage audiences in a discussion of arms control and nonproliferation norms and behaviors in an effort to win public support for arms control and nonproliferation goals.

Social media technologies can play a useful role in public diplomacy efforts. Many platforms have a large and educated user base, and social media users in general tend to be more politically involved and motivated (Allstate 2012). The networked nature of the platforms allows for rapid and efficient information propagation, and the information can be prepared and transmitted without a huge staff overhead. Also, since all social media is by definition a two-way communication channel, the sense of engagement is higher than with traditional media. This means there is a greater opportunity to gain support for a cause from the audience.

Power can be enhanced with targeting select audiences

Social media activity can be easily recorded and analyzed, allowing public diplomatic efforts to better and more quickly identify important audiences and key individuals. It also allows users to determine topics of interest and respond or adapt to changing audience sentiment. Since social media platforms are virtual representations of real-world social networks where friends are known to influence friends (McPherson, Smith-Lovin et al. 2001), engaging audiences via social media allows governments to establish norms of behavior that will tend to reinforce themselves within a peer group.

Twitter Glossary

Tweet: The basic communication entry on Twitter. Tweets may be no longer than 140 characters.

User: A holder of a Twitter account. Users may be individuals (e.g. @Gottemoeller), or joint (e.g. @BulletinAtomic) accounts.

Re-Tweet: A tweet received by one user and subsequently shared with others.

Mention: A tweet that references a specific user.

Hashtag: A method of categorizing tweets. Indicated by the symbol "#" followed by a subject term (e.g. #prepcom)

Follow: To subscribe to the tweets of another user.

Follower: A user who subscribes to the tweets of another user.

Background of Prepcom effort

What is Prepcom?

The parties to the *Treaty on the Non Proliferation of Nuclear Weapons* (NPT) meet once every five years to discuss the implementation of the treaty and, since 1995, identify objectives for the future. For three years prior to this review conference, representatives meet annually for the Preparatory Committee (PrepCom) sessions to build consensus among States Parties, address relevant procedural and substantive issues, and develop recommendations for the review conference. Non-governmental organizations (NGOs) participate in PrepComs and review conferences as observers, often host side events – independently or in cooperation with states parties, and provide updates on and analysis of proceedings to interested audiences. During a formal session of the plenary devoted specifically to NGO statements, select NGOs also address the delegates. NGO participation is very important in the PrepCom process, because many state delegations do not have a large pool of arms control and nonproliferation experts and rely on analysis and advice from NGOs to augment their own assessments.

What is CNS's involvement?

In order to share CNS analysis and assessments with a larger group of interested participants as well as increase outreach efforts, CNS decided in 2010 to use the microblogging platform Twitter to do live updates of event proceedings. In 2013, CNS expanded this effort to include archiving all Twitter activity related to the 2013 PrepCom meeting.

What were the goals of the effort?

CNS established three related goals for the 2013 campaign. First, CNS wanted to use its existing Twitter network to publicize its involvement and participation at the PrepCom. The PrepCom meeting is an important and popular professional development opportunity for graduate students, and publicizing CNS involvement aids in student recruiting efforts. CNS also wanted to highlight the extensive collection of PrepCom and NPT resources such as fact sheets, background information, and analytical research reports prepared by staff and made available to support meeting attendees and interested observers on the CNS website. In addition, CNS intended to use Twitter to further its educational mission by encouraging followers to raise questions and start discussions about arms control and nonproliferation topics of concern.

Metrics to verify progress towards these CNS goals were straightforward. CNS would measure its publicity effort by tracking how many Twitter accounts it reached during the campaign, using the previous year's less focused effort as a baseline for comparison. It would assess how successful the campaign was at creating demand for CNS analytical resources by measuring the number of hits on the CNS website over the time period. And it would measure engagement by counting the number of "re-tweets" and "mentions" CNS accounts generated.

Although these traditional campaign goals were laudable, CNS decided it would also use this opportunity to explore the Twitter data itself as a source of information about the network of users and PrepCom-related topics of discussion. Since previous experience demonstrated that the number of tweets would be too large to analyze manually, the campaign team decided to use the open source software package R (R_Core_Team 2013) to conduct textual analysis. The team selected NodeXL (Smith, Milic-Frayling et al. 2010) as the Social Network Analysis platform because it is also open source and maintains an active user support group.

Designing and implementing the Twitter PrepCom campaign

The PrepCom campaign effort began with the CNS team deciding on goals and appropriate metrics. The team held its first discussion in early February, but immediately ran into resistance from staff members who were unfamiliar with social media. Some staff were concerned that the project would emphasize online social interaction at the expense of more traditional analytical research. Others felt uncomfortable with the technology or had never established a Twitter account. And almost all of the non-technical staff felt the time commitment would be too large.

Figure 8

To address these concerns, the team identified select staff members to act as Twitter "reporters." These were principally younger staff and graduate students who were familiar with Twitter and committed to using the technology to share their PrepCom experiences and impressions online. This relieved the staff who were uncomfortable with Twitter from participating in that aspect of the campaign. For those who would be participating, the technical staff provided a main point of contact to provide training and resolve technical issues which helped remove concerns over time commitments. In order to resolve questions about the emphasis on analysis, the technical team also re-designed CNS's PrepCom web page to stress research and analytical efforts (Figure 8).

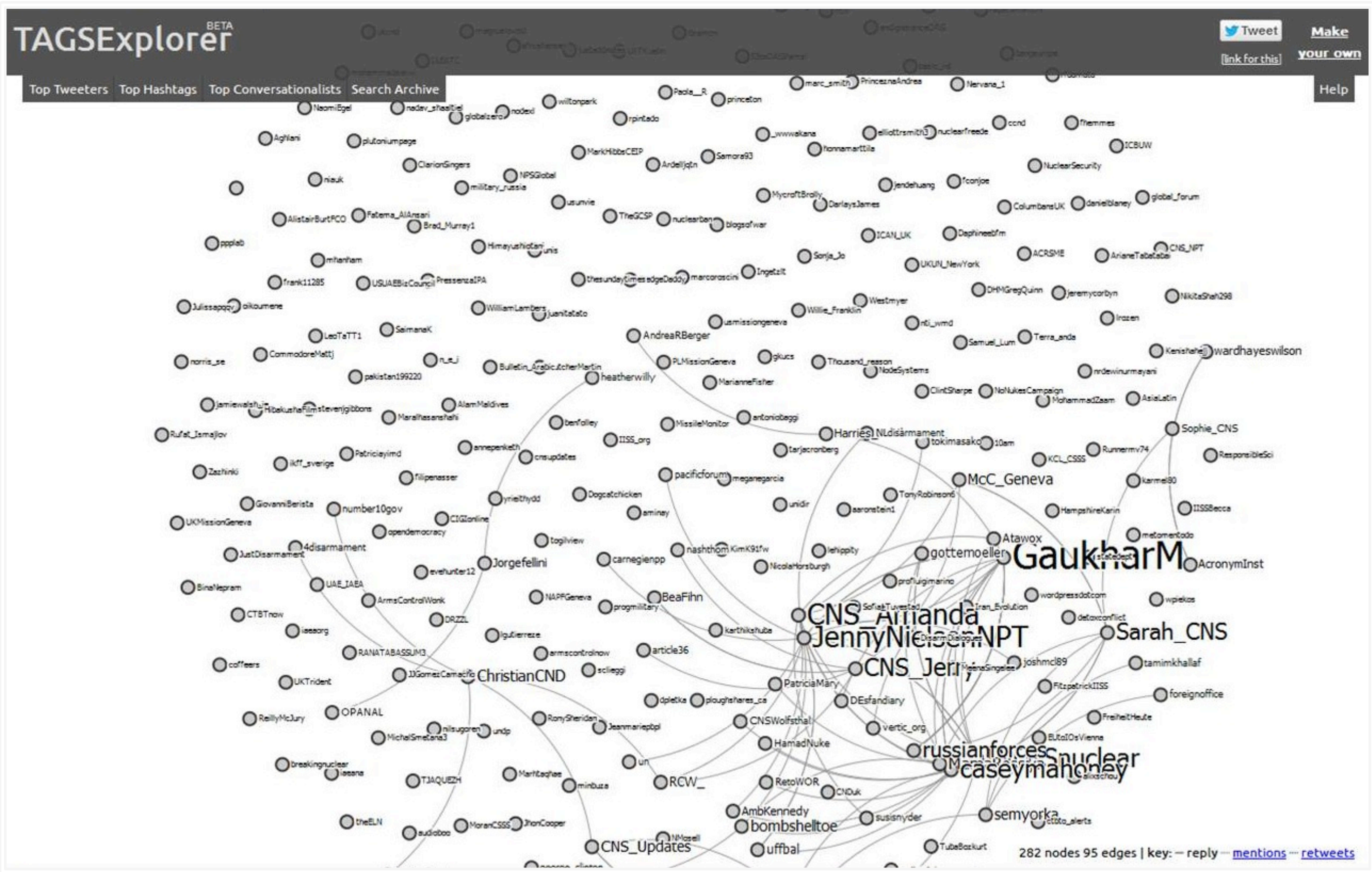
Team preparations continued with regular meetings with both the reporters and the technical staff. Of a total of 12 CNS students and staff PrepCom attendees, six would be reporters. The team briefed these individuals on expected PrepCom themes of interest and provided a list of Twitter users who followed the @CNS_Updates account and who were identified through social network analysis as occupying central positions within the follower graph. Reporters were instructed to watch for opportunities to engage with these individuals on the expectation that they would exercise the most influence within the network and therefore cause the most re-tweets or mentions. Once the reporters were trained, attention turned to technical staff preparations.

Since the PrepCom campaign was conceived as an experiment in social media outreach, the team wanted to capture as much information as possible from Twitter during the course of the PrepCom. One way to capture information on Twitter is to apply a "hashtag" to each tweet. Hashtags identify the tweet as pertinent to a particular subject and can be used later to find relevant tweets for analysis. The team adopted the established hashtag "#prepcom" to identify the tweets to be analyzed. This decision necessarily excludes some unknown number of tweets that were marked with a different hashtag such as "#NPTPrepcom" or "#prepcom2013." Unfortunately, many commercial web sites that purport to analyze Twitter metrics are essentially black box operations, in which the user has no insight into how the metrics are collected and prepared. Even Twitter's own internal sampling algorithm frequently provides results that differ greatly from the true population of tweets (Morstatter, Pfeffer et al. 2013). Judging from past observations, the team realized the total number of tweets would be on the order of several thousand, and thus decided to collect the tweets in real time rather than rely on sampling or outside analysis.

In order to capture all of the #prepcom tweets, the team created a simple Google spreadsheet using the freely available "Twitter Archiving Google Spreadsheet" (TAGS) template (Hawksey 2013). This spreadsheet takes advantage of

Google's built-in data-capturing capability to read and record information provided by Twitter's API. The team configured the spreadsheet to query the Twitter site continuously for all tweets containing the #prepcom hashtag. Additionally, the spreadsheet data was fed to the included TAGSExplorer website, which creates a network visualization of the Twitter conversation in real time (Figure 9).

Figure 9



The team completed its final technical preparations 10 days prior to the beginning of the PrepCom and also provided a final briefing to the reporters at that time. The campaign went live with the initial tweet on 12 April, and received its first re-tweet by the Danish Ambassador for Disarmament, Non-proliferation, and Arms Control 17 hours later. Tweeting remained sporadic until the opening day of the PrepCom, when the team recorded more than 500 tweets with the #prepcom hashtag. Table 1 summarizes the overall campaign statistics.

Table 1

Dates	Users	Tweets	Re-tweets	Mentions	Maximum Users Reached
4/12/13-5/5/13	229	3,681	884	245	1,401,125

What were the results?

Upon the completion of the PrepCom meeting, the team gathered and analyzed the available information. A comparison of campaign results to the goals and metrics mentioned above showed mixed results. In terms of publicizing CNS's PrepCom involvement measured by total Twitter accounts reached, the campaign was a success. Analysis provided by Topsy.com showed that approximately 1.4M users had at least one #prepcom tweet appear in their timeline. This number is an improvement of 42% over 2012 campaign results and is the result of both CNS and non-CNS users using the *prepcom* hashtag. Efforts at generating engagement were also a qualified success. Although the top three CNS-affiliated Twitter accounts boast more than 7,600 followers, only 229 of those followers (33%) sent a tweet with the #prepcom identifier. This relatively low participation rate, however, is a 789% improvement over 2012 numbers. Moreover, the information flow was decidedly two-way, with close to one-third of tweet volume consisting of re-tweets or mentions of other users. The campaign was much less successful in generating interest for CNS analysis, however. In fact, comparing the 2012 results to 2013, the team found visits to the analysis pages were down by 35%, although visits to the CNS main web page were up slightly.

Content analysis

Archiving the tweets produced over the course of the campaign allowed the team to conduct additional analysis on both the content of the PrepCom Twitter discussion and the community involved in the discussion. This analysis was computer assisted and conducted using the open-source statistical analysis software program R (R_Core_Team 2013) and the Social Network Analysis program NodeXL (Smith, Milic-Frayling et al. 2010). The R analysis required the use of the supplemental packages *ggplot2* (Wickham 2009), *qdap* (Rinker 2013), *twitteR* (Gentry 2013), *tm* (Feinerer and Hornik 2013), and *wordcloud* (Fellows 2013) and followed procedures described by Yanchang Zhao (Zhao 2012).

The advantage of computer-assisted analysis is that it allows the analyst to scan large amounts of data quickly to retrieve useful information. In particular, computer-aided analysis allows for visual exploration of the data, which is most useful when the data are large and unstructured or when the exploration goals are vague (Keim 2002). In this instance, the total number of tweets was 3,681. While by no means a large data set, to read through it manually and record the relevant information would require tens of hours.

The first visualization the team attempted was a word frequency analysis. Using the R program, commonly used words (e.g. “and”, “the”) and words that have low meaning in this context (e.g. “nuclear”, “prepcom”) were filtered out to determine the top 25 terms that were used in tweets over the duration of the observation period. The results are shown in Figure 10. One can immediately see that the proposed Middle East (Mideast) Nuclear Weapon Free Zone (wmdfz), humanitarian, and Disarmament (disarma) were all popular terms. Among countries, only China, Egypt, France, Iran, Russia, and the UK, generated enough discussion to make it onto the list of top 25 terms.

Figure 10

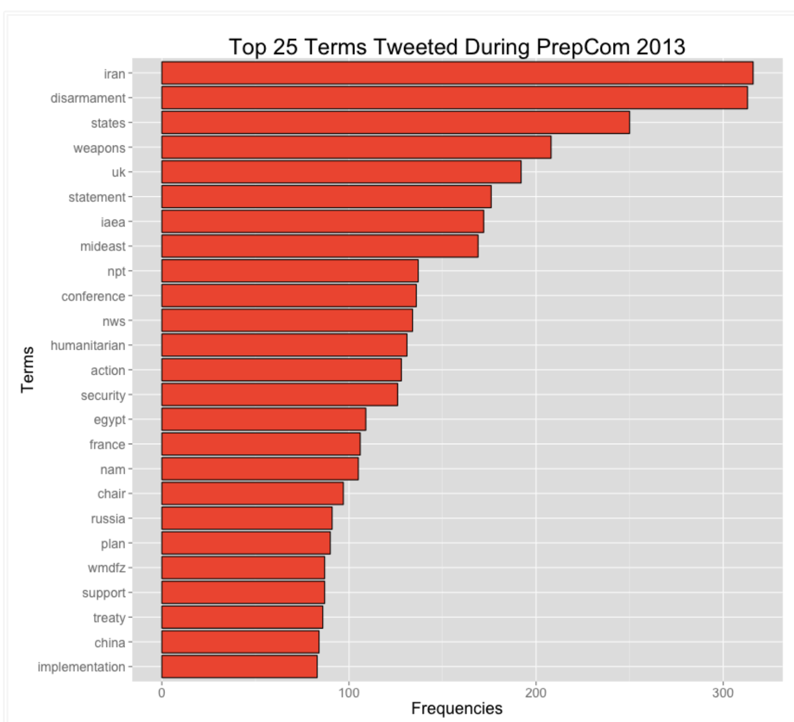
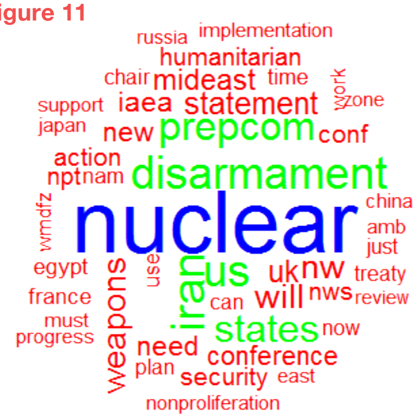


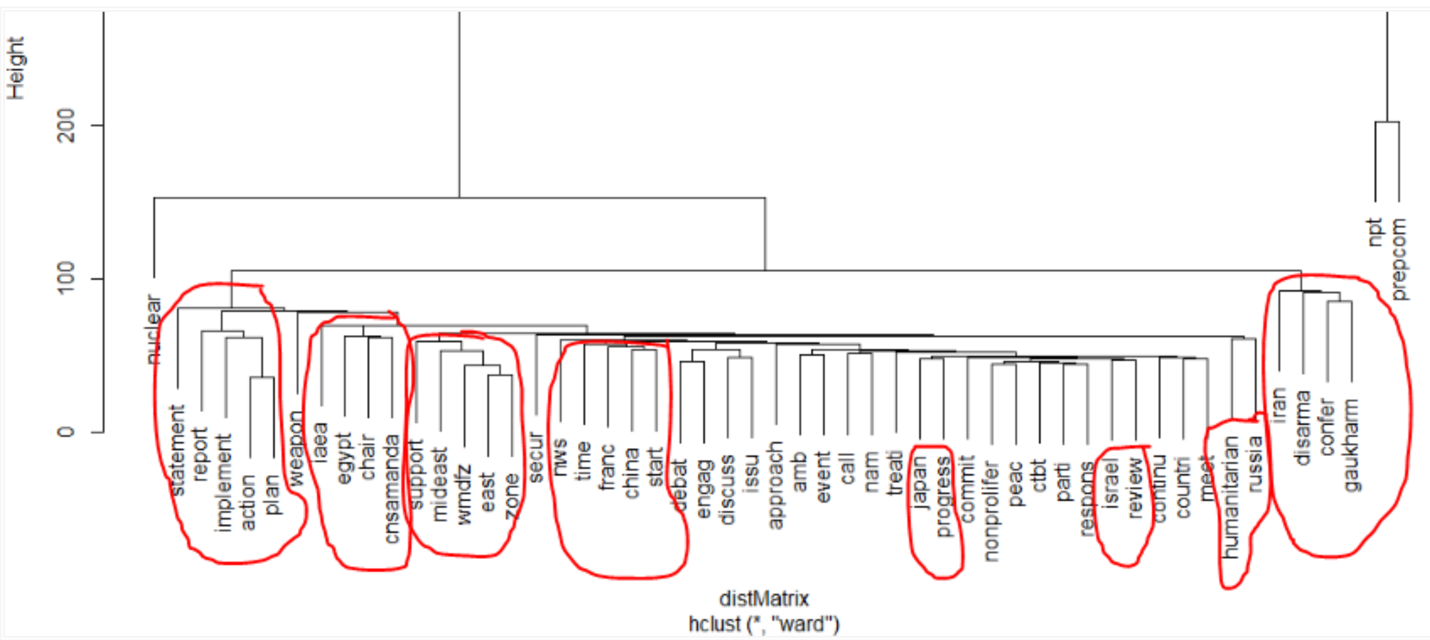
Figure 11



Another way to visualize the content of the tweets is to use the R software to create a word cloud based on word frequencies. In this case all words were considered except for common English prepositions, and we limited the search to terms appearing at least 75 times. The most frequently used words appear towards the center of the cloud and are of larger size than less frequent words (Figure 11). Again, with little effort, it is immediately clear that words such as Mideast, Iran, humanitarian, and disarmament frequently came up in Twitter conversations during the PrepCom.

While individual word frequency gives some indication of what subjects participants found important or interesting, the software can also be used to infer what the conversations were about. One method of doing this analysis is to use an algorithm to retrieve and display words that appear together. The R software has several of these clustering algorithms built in and allows for the rapid generation of a basic cluster dendrogram or tree diagram showing which terms are related to each other. The results of this analysis are shown in Figure 12.

Figure 12

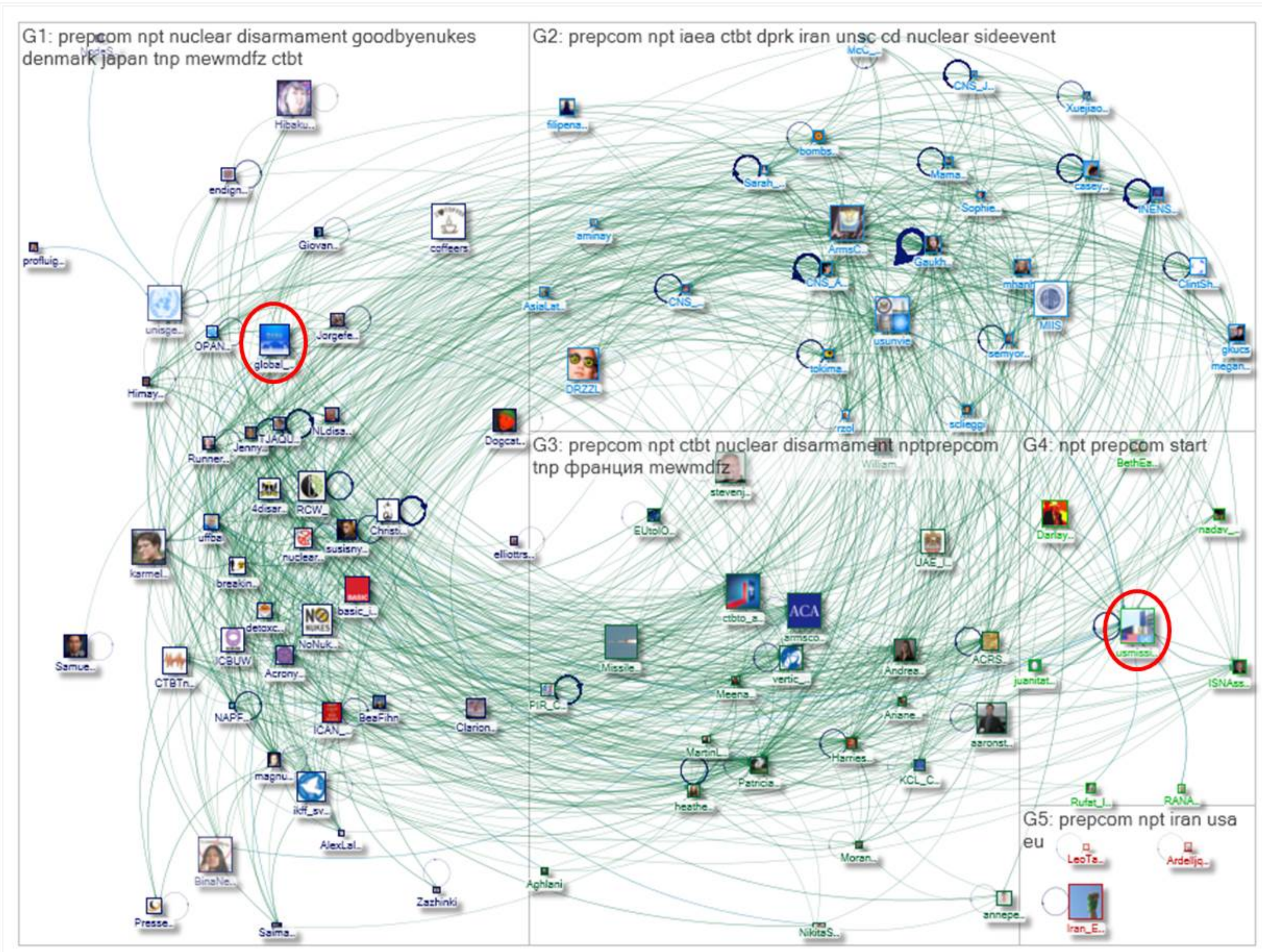


Clearly, Twitter users were eagerly discussing statements about the 2010 NPT Action Plan, as shown by the first cluster on the left. On the far right is a group of tweets that discussed Iran and disarmament. Again, this interaction was likely in the context of Iran's efforts to remind participants that the 2010 Action Plan calls for current nuclear weapons states to pursue a world free of nuclear weapons. The cluster containing the words "Egypt" and "Chair" likely indicates discussion over Egypt's abrupt withdrawal from the conference in protest over the failure to implement parts of the action plan. A related topic is the Middle East nuclear weapon-free zone, which also generated a cluster of tweets for discussion. The relationship between France and China or Japan and "progress" is less clear, highlighting the fact that visual analysis is most helpful as a first step in sorting large groups of data.

The PrepCom social network

The Twitter API provides a rich array of metadata for each individual tweet. Accordingly, in addition to tweet content, the CNS team recorded user names, time and geo-locational data, and basic twitter network information such as number of followers and who follows whom. Several free and open-source software packages are available to process this information to generate a basic network visualization and network statistics. The creator of the NodeXL social network analysis program, Dr. Marc Smith, used a sample of the CNS PrepCom data to produce the visualization seen in Figure 13 (Smith 2013).

Figure 13



The network diagram uses Twitter account icons to represent the graph vertices (nodes). Each vertex is sized relative to its number of followers. There is one vertex for each of the 104 users whose tweets contained "#prepcom" over the period of April 24-April 29, 2013. The lines (edges) between the vertices are connections, representing either a follower relationship, or a response or mention relationship. The circles near some icons represent "self-loops" or tweets that did not generate any replies. The graph is laid out using the Harel-Koren Fast Multiscale layout algorithm (Harel and Koren 2001) and uses the Clauset-Newman-Moore clustering algorithm (Clauset, Newman et al. 2004) to group the vertices together. The diagram also shows the most frequent terms used by each group.

Exploring network visualization can be more art than science, but figure 10 immediately offers some useful observations. First, the graph's density is only .16, which means that only 16% of the potential connections in the graph are actually connected. This is not a particularly high density for such a small network, but consistent with the temporary nature of the PrepCom event and the ad hoc nature of the network surrounding it. Next, the graph layout shows an "in-group" pattern (Smith 2013), with few isolates or unconnected vertices, indicating the PrepCom topic has limited appeal outside of the defined groups tweeting about it. Finally, the clustering algorithm found four main groups, with one isolate. The extent of NGO involvement is clear from the groupings, with G1 mostly representing several prominent disarmament organizations (i.e. IKV Pax Christi or Reaching Critical Will), G2 representing the CNS community, and G3 loosely representing arms control groups (i.e. Arms Control Association or the Comprehensive Nuclear Test-Ban Treaty Organization).

Group G4 in Figure 13 bears special mention, because its hub is U.S. Mission Geneva, the organization charged with representing the United States government at the United Nations in Geneva (red circle in G4). Despite the prominence of the mission and the importance of the U.S. in the PrepCom process, the grouping algorithm assigns the mission to the periphery of the network. This indicates that mission communications and engagement on Twitter are perhaps less influential or effective than those of more centrally positioned government organizations such as the Japanese foreign ministry's "Disarmament Now" education office (red circle in G2, Figure 13).

Lessons learned

Twitter as an arms control and nonproliferation awareness platform

Twitter use and popularity has exploded since the platform was opened to the public in 2006, with analysts reporting the company hosts more than 500 million user accounts (Lunden 2013). This rapid growth and general excitement over the social media phenomenon has led many companies and organizations to try to reach this growing online audience. CNS's 2013 PrepCom Campaign effort showed some of the strengths and weaknesses of Twitter as a platform for generating awareness about arms control and nonproliferation topics.

The first lesson to take away from the experience is that the best results will continue to depend on traditional awareness campaign behaviors. Although Twitter is a media platform, success in "getting the message out" still requires knowledge about the audience, the development of a campaign theme, and an understanding of the resources available to commit to the campaign. The CNS campaign was able to increase the number of people engaged in the PrepCom conversation because the team established who the relevant Twitter users were and made the effort to reach out to them. The team also identified likely topics of interest in advance so it was ready to take advantage of conversations as they developed. And last, CNS prioritized the effort and assigned members of the staff to report and communicate about PrepCom themes for the duration of the meeting.

With respect to specific lessons for Twitter campaigns, the team confirmed much of what the research literature has shown. Credibility grows slowly. Tweets by CNS experts were re-tweeted at 9-10 times the rate of those of our graduate student reporters. The search for credibility together with Twitter's network properties combine to create a winner-take-all market. Just three PrepCom tweeters generated fully 40% of the tweets. And as is the case with all social networks, there is a strong tendency for groups to huddle together. Although PrepCom tweets reached a potential audience of 1.4 million users, fewer than 300 participated in the conversation, and almost all of those were users with some pre-existing connection to the arms control and nonproliferation community. Even with the reach and communications advantages of social media, it is extremely difficult to break out of a subject-specific niche.

Twitter as an analytical data source

A hallmark of social media is the abundance of publicly available data generated by its users. Twitter is a particularly good source of this data because it is generated in a public forum with the expectation that it will be shared with others. This expectation is encouraged by Twitter, which makes the data freely available and easily recordable. The downside to data availability, however, is analysts can quickly become overwhelmed by information. The CNS PrepCom campaign was a small-scale and experimental attempt to gather and assess Twitter data within a limited timeframe. Yet, even this effort resulted in more information (3,500+ tweets) than could be efficiently digested by the analytical team. Fortunately, a host of simple to use tools is available to make the information available and usable to analysts and policy makers.

Martin Hawksey's Twitter Analysis Google Spreadsheet (TAGS) was easy to set up and allowed the team to generate a running archive of all the tweets containing the #prepcom hashtag. Even more helpful, the spreadsheet could be linked to the TAGSExplorer visualization engine simply by entering the spreadsheet's uniform resource locator (URL) code into a field on the TAGSExplorer website. The result is a surprisingly rich real-time visualization of the Twitter conversation, including top tweeters, the most frequently used terms, who is responding to whom, and a listing of all the tweets by each user. The team used this tool to observe campaign progress and to encourage further participation by publicizing the information (e.g., top tweeters) found there.

One step above the TAGSExplorer, the R programming language allowed the team to rapidly generate data visualizations based on the actual content of the tweets. The language was relatively simple to learn, and the tool creates diagrams that are easy to interpret but statistically rigorous. Outputs such as frequency charts, word clouds, and dendrograms require little effort to create but provide important insights about the content of the Twitter conversation—important aids to analysts who need to assess a large amount of information rapidly and communicate it in a way that is informative, accurate, and unbiased. The team's analysis showed, for example, that concerns about the Middle East and Iran dominated the PrepCom Twitter discussion, while equally important issues such as North Korea and tightening the NPT withdrawal clause were barely touched upon. It also showed that relatively arcane topics such as nuclear weapons-free zones were frequently discussed, pointing to the likelihood that the participants were largely members of the arms control and nonproliferation community of experts and practitioners.

Twitter offers another advantage for public information campaigns in that user networks are easy to identify and explore. Again, simple and freely available software such as NodeXL allows analysts to gather this information and create useful visualizations of the user social network. The software also allows for easy calculation of network metrics and applies sophisticated mathematical algorithms to aid in complex tasks such as community identification.

Using the NodeXL software, the team was able to show that the PrepCom Twitter conversation largely conformed to an "in-group" model, where experts shared knowledge with other experts. The network analysis also showed that certain users were more central to the conversation, and had a higher likelihood of having their information shared by others. Surprisingly, even though the U.S. Mission in Geneva has a high number of Twitter followers, its location at the periphery of the network meant its communication efforts were not as effective one would expect. Additionally, the network visualization provides ample evidence of the key role non-governmental organizations play in promulgating information, and gives some hints as to how to better orchestrate a future awareness campaign.

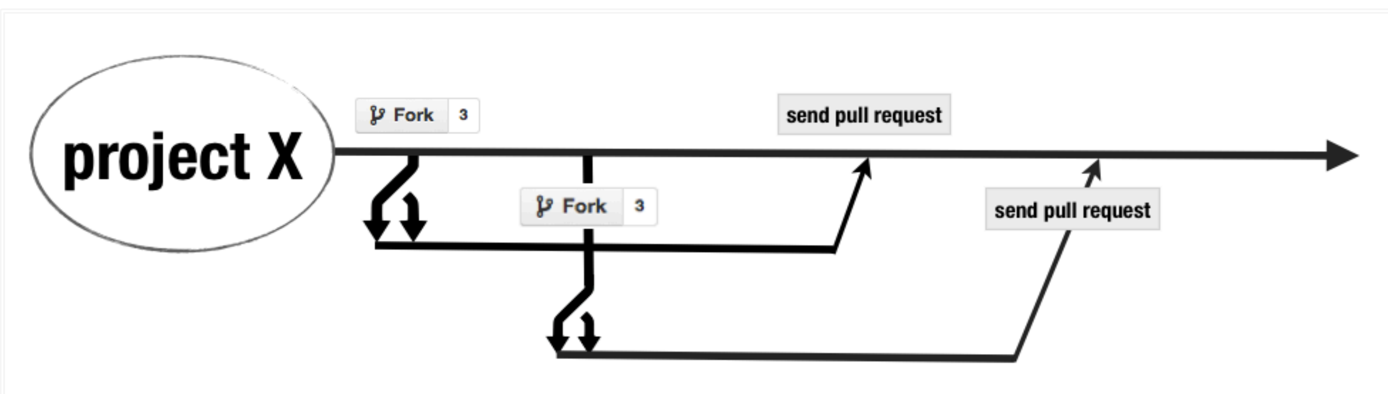
3 Open source collaboration and version control—negotiating via GitHub

Introduction

The idea of creating an open source version control system was first established by the founder of the computer operating system Linux, Linus Torvalds. Git is a version control and source code management system designed to make project collaboration more efficient. In line with the open source culture of the programming community, any Git is a full-fledged repository with complete history and version tracking capacity. Complex and decentralized, the system allows anybody working on a project to have access to all parts of the project at all times.

One of today's most successful open source code repositories and web-hosting services for software development was founded in 2007. GitHub is a web-hosted version of Torvald's git which allows managing and storing multiple versions of a project, and improving upon the system with an online interface, access control and the ability to see users' profiles and project history. A user "forks," or copies, a repository to his or her account, makes revisions and modifications to the code, then submits a "pull request" to the original owner, who can decide whether to merge those changes with the original code (Figure 14). The platform allows for real-time discussion about proposed modifications to a project.

Figure 14



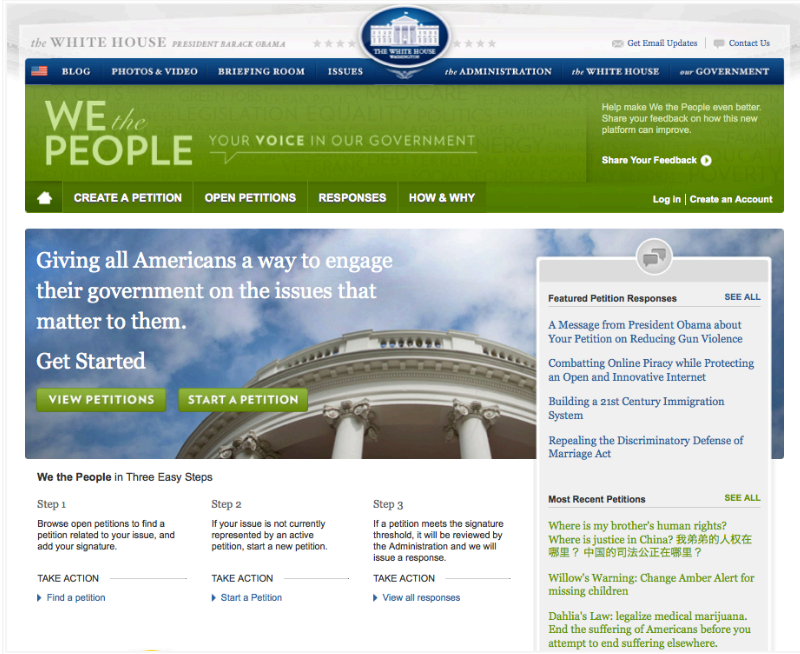
? How and why do people use Github?

Although the Github platform is used predominantly by software developers, it has started to attract users involved in various political, legal, and social projects drawn by the promise of an open, distributed version control system available in full to anyone anywhere in the world. Having analyzed various open source initiatives focused on using Git for political and legal purposes, we have identified the following elements and features shared by the majority of projects built on GitHub:

Crowdsourced contributions

Crowdsourcing is at the heart of the GitHub phenomenon. With more than 3.5 million users and more than 6 million repositories, the power of the crowd is made more visible and effective for solving complex issues. For instance, the White House petition platform *We the People* is built on GitHub. The U.S. government opened up the application programming interface (API) to developers interested in helping to improve the functioning of government for citizens around the world (Figure 15). Similarly, Twitter has opened its source code and invited GitHub users to work on various applications and provide feedback on the company's products. The mere fact of being present on GitHub has a profound meaning for its community: *this project and the organization that is hosting it on GitHub are open for collaboration*.

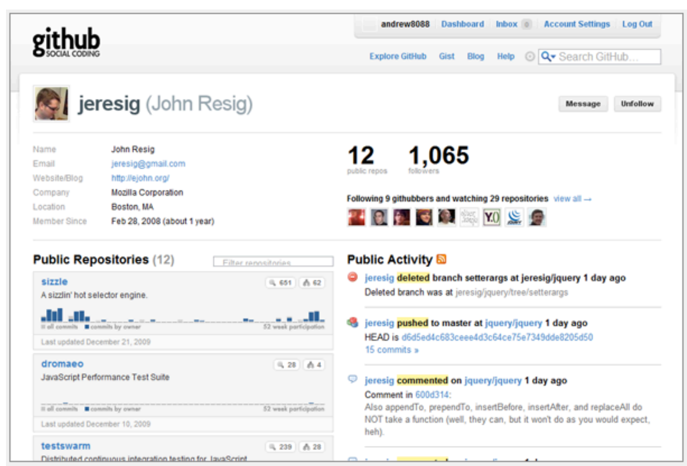
Figure 15: *We the People* petition platform built on GitHub



Open source approach

At the core of the global programming culture is the notion that all information and knowledge should be freely available on the Web. As an example, Ruby, one of the most popular programming languages presently in use, is available to be modified and improved by ***anyone*** on GitHub. Another project built on this platform is PublicMarkup of the Sunlight Foundation. It is designed to solicit public comment and contributions in drafting legislation by allowing bills to be marked up and modified within a certain timeframe in a legislative process.

Figure 16: An example of GitHub user profile



Reputation system

GitHub platform enables participating programmers to join in a "reputation system" that rewards users for working on projects and contributing to others' ideas and improving on them (Figure 16). Various levels of privacy can be maintained, however, from complete anonymity to full disclosure of one's identity through social media and other web credentials. Interestingly, an anonymous reputation system based on a user alias allows reliable contributors to be identified without revealing anything about their actual identity.

Distributed version control

Managing changes in large projects with multiple contributors is extremely difficult. The GitHub system manages to solve this problem by emphasizing cooperation without coordination. One example of how the principle of distributed version control works in the public sector is the open source initiative of the New York State Senate. Through opening the API and the proposed legislation to the public online, the Open Legislation Service permits citizens of New York to review and propose amendments to pending legislation. It also allows the online community to track, comment on, and publicize representatives' voting records and their positions related to the proposed bills. All comments and ideas are tracked and merged through the GitHub platform and algorithms. The idea behind this project is to create an environment in which users do not necessarily have to interact and communicate with each other in order to work towards the same goal or on the same legislative proposal.

Lessons learned

Facilitate small contributions

GitHub-built projects give anyone on the web the power to create a unique product without having to build it from scratch. It allows users to create a small piece – document, code, or multimedia – and then merge that change with those of thousands of other users who have worked on the same idea. As we have seen from various public service or legislative initiatives on GitHub, this approach does not reduce the overall complexity of drafting national laws or generating workable policies. Yet, it creates an environment where even a small idea can find followers willing to invest their time in improving the initial concept.

One might argue that this collaboration mechanism is only accessible to the technical community that shares the expertise and understanding of how to use the distributed version control systems. However, this barrier appears to be less relevant as more government agencies and civic start-ups turn to GitHub and other platforms in search of ways to increase government transparency and improve citizen participation in the democratic process. The White House's Project Open Data is one of these initiatives, it allows anyone to "fork" (or copy) the *Open Data Policy*, make changes, and submit them for approval (Figure 17). To take part in this open source policy-making experiment, no technical skill is required, as the editing process resembles using a word processor. Proposed changes are not made public until the policy "owner" approves the proposed modifications, and then the results are shared with everyone, spurring further improvements. The distributed version control systems offer a built-in feedback mechanism that allows for an easy transition from open information to collaborative problem solving. Among topics opened for online collaboration on GitHub are more and more non-technical and socially-focused ideas – from policy, law, and budgets, to city planning and using big data.

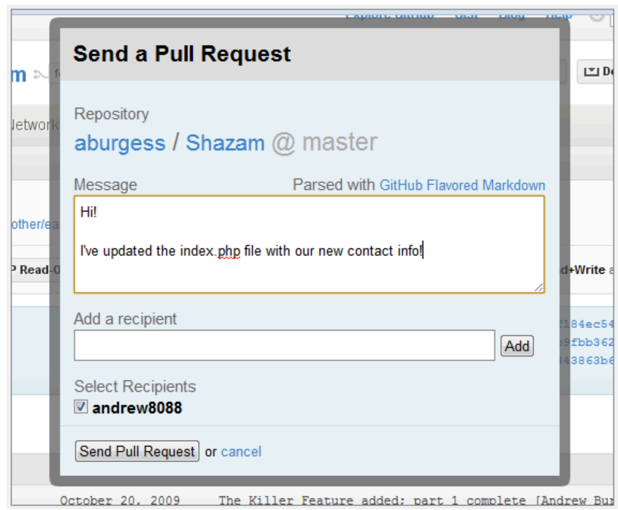


Figure 17: A Pull Request form

Focus on cooperation, not coordination

The complexity of large software projects with hundreds of dependency levels is very similar to that of global security and arms control challenges. Designing a policy approach in which collaboration does not require coordination can help to address similar challenges facing the nonproliferation and arms control communities: the need for agreement, norm maintenance, verification and stewardship. Distributed version control frees users to develop the best ideas incrementally, without being constrained to finding a comprehensive solution. Moreover, as teams naturally collaborate, the arms control and nonproliferation community will benefit by receiving inputs from both experts and the general public. In the case of an arms control treaty, for example, this public participation can provide a solid foundation for official negotiations on these matters. In other words, to lay groundwork for future official arms control discussions, interested states can initiate an online exercise and invite a wider audience to brainstorm on the ideas and technology that might become a part of bilateral or multilateral agreements. Participating groups and individuals will likely embrace the decisions and the strategies created within the virtual negotiations as a result of having been involved in their formulation. This can lead the groups to offer greater political support for their ultimate adoption. In addition, as the nonproliferation community faces the need to collect and verify information on state and non-state actors' activities related to WMD materials and technology, platforms like GitHub offer a mechanism to manage and vet citizen reports. This open process can minimize the risks of false information as well as provide better protection for whistleblowers.

4 Satellite imagery and crowdsourcing

Introduction

Satellite imagery has been a mainstay of arms control monitoring since it was first incorporated into the Strategic Arms Limitation Treaty (SALT) in 1971. It presented numerous advantages to arms controllers, not the least of which was the ability to remotely monitor changes on the ground. Unlike On-Site inspections, which are difficult to organize and contentious to implement, satellite imagery offered a mutual monitoring capability without the security risks assumed to accompany On-Site inspections (Croft 1996).

The deliberate lack of any specificity as to types or capabilities of satellites meant that both sides could improve satellite technologies without impediment, which created further disincentives to cheating. Satellites were always watching, and the technology was always improving. When the U.S. launched its first imagery satellite (code named CORONA) in 1958, it took film photographs and could only clearly determine objects on the ground larger than 12 meters (Clarke 1999) 1999). Today, images are digital and transmitted in real time, and it is commonly understood that military satellites can identify individual objects smaller than .4 meters.

The familiar pattern of military technologies working their way into the civilian world held true with satellite imagery as well. Responding to a need for scientific study of the earth's environment, NASA launched the Earth Resources Technology Satellites in 1972 (renamed LANDSAT in 1975) and made the imagery available to both governmental and non-governmental researchers. Russia's decision to market its military satellite imagery to the public in 1992 caused the U.S. to respond in 1994 with a Presidential Decision Directive encouraging commercial companies to develop and sell satellite imagery. As the Russian imagery was initially restricted to a 2 meter resolution, the U.S. initiative allowed for 1 meter resolution. The Russians responded in kind, spurring greater competition and leading to today's market where .5 meter resolution is the commercial standard (Lavers 2013).

Usage may have remained restricted to large industries without the introduction of Google Maps and its related service Google Earth in 2005. Suddenly, the average person had access to high quality and inexpensive satellite imagery. The new access created an explosion of interest among hobbyists and businesses in using satellite imagery for various commercial and private applications, and companies such as Tomnod.com were created to respond to the demand.

Given its roots in arms control, it was only natural that nonproliferation researchers outside of government would be eager to apply the tools so long used by their colleagues in the intelligence community. The results have been very impressive. For example, a CNS-affiliated graduate student named Tamara Patton was able to use publicly available satellite imagery and modeling tools to create a three dimensional model of Pakistan's Khushab Plutonium Production Complex (Patton, 2012). Researchers at CNS have also used the tools to produce site diagrams, interactive facility maps, and walk-through models of nuclear facilities around the world on behalf of the Nuclear Threat Initiative.[4] David Albright and his team at the Institute for Science and International Security (ISIA) routinely make global headlines with their analysis of Iran's Parchin Military Complex (Albright & Avagyan, 2012). And, the Wall Street Journal used satellite imagery analysis conducted by CNS's Jeffrey Lewis for Johns Hopkins University's U.S.-Korea institute to break news about North Korea's likely reconstruction efforts at its Yongbyon nuclear facility (Gale, 2013).

As impressive as these analyses are, they are to a large extent duplicative of existing efforts in the intelligence community. Presumably, analysts at the National Geospatial Intelligence Agency (NGA) have been conducting the same type of analysis for years. It is also important to note that although access to satellite imagery has greatly increased, there has been no such democratization of analytical tools and techniques. Patton, Albright and Avagyan, and the Johns Hopkins team (38North.org) all bring highly developed and specialized imagery analysis skills to their task. In fact, our

[4] http://www.nti.org/country-profiles/

research failed to find a single example of non-specialists using satellite imagery to uncover significant arms control and nonproliferation relevant information.

However, as we have seen from the previous case studies and the research literature, unskilled crowds can frequently equal or outperform experts in performing certain tasks. Generally, if the crowd is large, diverse, and allowed to make independent decisions (Surowiecki 2004), it can find a solution to a discrete problem with an accuracy equal to a qualified expert. Since satellite imagery interpretation is a discrete problem (i.e. there is one true answer), a properly organized crowdsourcing effort should be able to accurately perform imagery analysis. Besides matching the level of accuracy, we can expect a crowdsourced imagery analysis attempt to benefit from the advantages inherent to crowdsourcing, including speed, distributed workflow, and rapid feedback loops.

What is Tomnod?

Tomnod – the name means “big eye” in Mongolian – was a commercial imagery analysis company based in San Diego and founded by Albert Yu-Min Lin and four other PhD engineers in 2010. In 2013, it was acquired by the leading commercial satellite imagery provider, Digital Globe. The company described itself as “founded to meet the needs of a growing digital world, where the size and complexity of digital data sets continue to increase exponentially and new analytical methods are required to realize their potential. We specialize in data improvement, machine learning/ automated computation, and human generated analysis (crowdsourcing).” Among its clients were National Geographic, Amnesty International, and the Government of New Zealand (Tomnod 2012).

Figure 18
Search timeline

In addition to having engineering backgrounds, all of Tomnod’s employees considered themselves “explorers, and adventurers,” and founder Lin had received the “2010 Adventurer of the Year” award from National Geographic Adventure magazine. His staff actively participated in hobbyist and professional graphical imaging system (GIS) online forums, and the company also established a large and well-connected network on both Twitter and Facebook. Tomnod was also an eager supporter of using satellite imagery to aid in disaster relief operations, and the company had numerous personal contacts with technically savvy enthusiasts at organizations such as Crisismappers.org and Amnesty International. Moreover, as one of the very first companies to market the commercial potential of satellite imagery analysis, Tomnod had unusually good working relationships with the two largest vendors of satellite imagery, DigitalGlobe and Geo-Eye.

How did Tomnod get involved in a satellite search?

On July 25, 2012, Tomnod employees received an e-mail from family members of Gil Weiss and Ben Horne, two men who formed part of a group of local mountain climbing enthusiasts. They had been attempting to scale the south face of Palcaraju Oeste, a 20,000 foot Andean peak approximately 300 miles outside of Lima, but failed to check in when expected. Since the Tomnod employees were avid climbers themselves, the report immediately caused concern. Weiss and Horne were personal friends, and Tomnod President Shay Har-Noy didn’t hesitate in deciding to help (Figure 18). Within four hours, Tomnod searched through online information, maps, and global positioning data to confirm that the hikers were indeed missing and had never made it to their rendezvous destination (Har-Noy, 2012). Shortly thereafter, Tomnod requested archival and current satellite images of Palcaraju Oeste from DigitalGlobe and GeoEye. Both companies immediately agreed and began to search their archives. Recognizing that time would be a limiting factor, Tomnod also made contact with U.S. Embassy representatives and search team members in Peru to help prioritize the search area.

Satellite imagery analysis is usually conducted on archival images because orbiting satellites can see only a portion of the earth's surface at any one time. It is possible to shift a satellite's orbit or reprioritize its coverage schedule, but it is expensive and time-consuming. In this instance, the imagery companies agreed to reschedule their satellites, but providing new imagery would take up to 72 hours.

The search team contacted Tomnod to inform them that they had found the climber's base camp, but that Weiss and Horne were not there. They also provided new information: they had discovered tracks on a ridge in a descent from the mountain. The team had to call off the search because of darkness. Four hours later, Tomnod received the first batch of archival imagery taken one week before the climbers departed. The company immediately published it to its website to publicize the search, and the publicity led to renewed urgency at DigitalGlobe and GeoEye to provide current images.

The next morning, DigitalEye provided Tomnod with previews of unprocessed satellite images taken the day before. The team immediately recognized that the coverage area was too vast for their internal assets to handle and that they would need to activate a crowdsourcing portal. At this point, approximately 50 hours had elapsed since Tomnod first learned that Weiss and Horne were missing.

Tomnod employees had experience with crowdsourcing, and fully implemented what in hindsight can be seen as best practices (Malone, Laubacher et al. 2009). They created a software platform to collect crowdsourced information; they identified specific tasks for the crowd such as searching for people, snowtracks, camp locations, or avalanche evidence; and they narrowed the search to a specific location. Only after all of these parameters were defined and planned out did they start to build their crowd.

The pre-planning turned out to be essential. When the full delivery of that day's imagery arrived, Tomnod found itself with 2.4 gigabytes of digital photos of Peruvian wilderness. Tomnod processed the images into "tiles" that were small enough to be transmitted quickly over the internet and manipulated by a standard personal computer then posted them online on a crowdsourcing portal set up specifically for the search. It also pushed out the link to the portal through its social media networks on Twitter and Facebook. Significantly, Tomnod did not completely rely on these online networking sites. It also targeted expert users groups using an e-mail listserv and personal e-mail lists and posting information about the search to online discussion forums.

The crowdsourcing strategy was to ask participants to "tag" anything that looked relevant in the images with a location and brief remarks. Tomnod would then aggregate these tags and solicit further analysis of the targeted areas from in-house and outside experts. Images that passed this scrutiny were labeled and shared with the online group and the local search and rescue team in Peru. Remarkably, 90 minutes after the crowdsourcing portal was activated, the crowd identified the tracks of the rescue team in the snow (Figure 19).

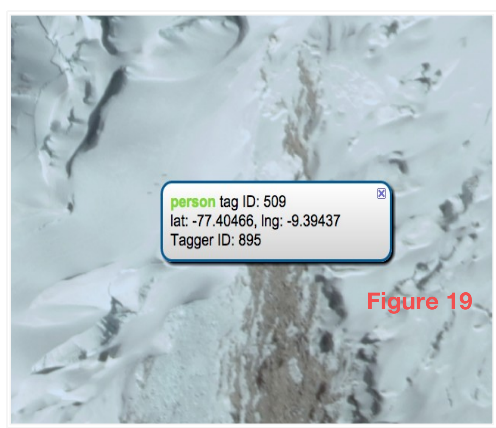


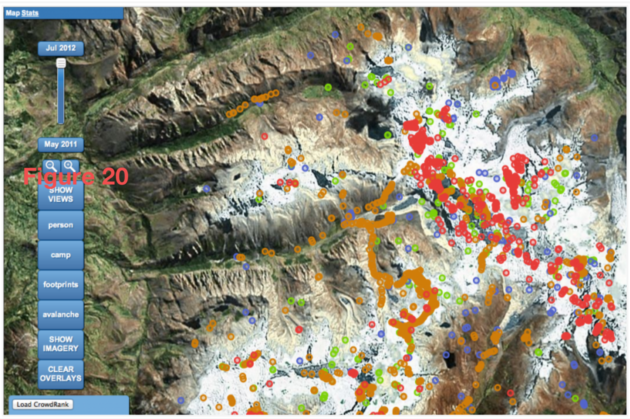
Figure 19

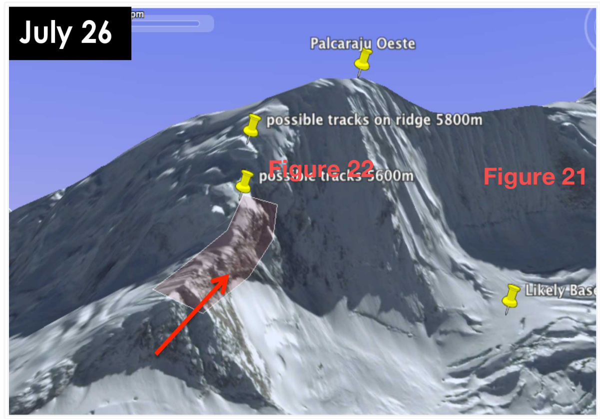
The crowd continued to work rapidly, and within hours more than 100 users had identified more than 1,000 clues to evaluate. Tomnod expert analysts used the clues, a comparison of before and after imagery and their own mountain climbing expertise to prioritize the three most likely locations of the climbers. Once they had their analysis, they further leveraged the crowd by sending out a request on Facebook to translate the company's report into Spanish so the Peruvian search team could use it. In one hour, 73 volunteers completed the translation and the Tomnod report was sent to the rescue team. The ground search crew returned to the base camp to continue the search that night while the aerial team prepared for a daylight search based on the Tomnod report. Two hours after the search plane departed Peru, the ground team located the bodies of Weiss and Horne at the bottom of a ravine.

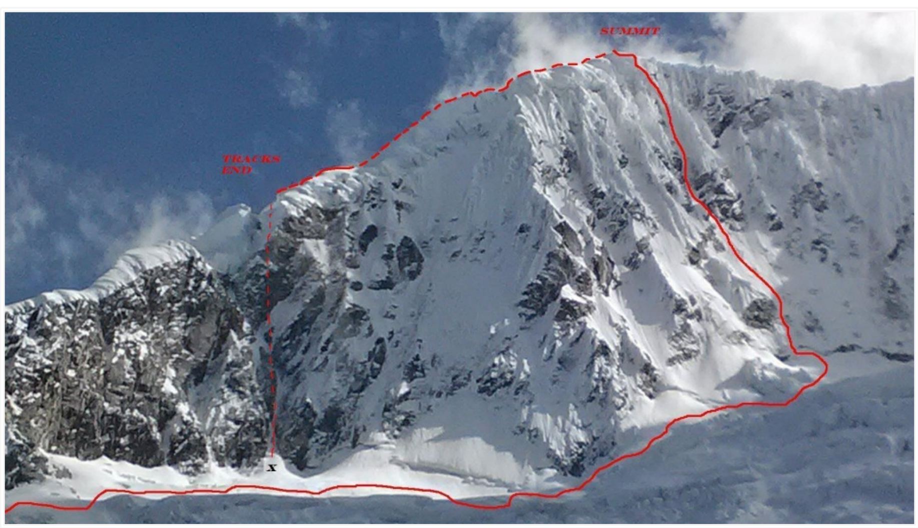
Shay Har-Noy summarized the search effort:

> *"In a very short time, a dedicated community sprang up and searched a huge area of satellite imagery to find meaningful clues that successfully pinpointed the final tracks of the missing climbers. Once we acquired current imagery, the analysis time was incredibly fast with answers emerging in just a few hours," (Barrington 2012).*

The tragedy of the deaths likely caused Har-Noy to understate Tomnod's success. In 76 hours, 288 people were mobilized to search through 2.5 gigabytes of satellite imagery. Collectively, the group generated 4,946 descriptive tags for further processing (Figure 20). Experts in turn analyzed those tags and locations and the most likely location of the climbers was determined (Figure 21). In the end, using information generated by analysts sitting 4000 miles away, the ground search team discovered the bodies approximately 1000 feet from where the crowd had identified the final tracks in the snow (Figure 22) (Barrington 2012).







Lessons learned

Commercial satellite imagery

Although this case study provides an unusual instance of near real-time satellite imagery analysis, Tomnod and its analytical team did not divulge their particular analytic methodology. Presumably, that is because there is already an extensive body of literature on the topic (Lillesand, Kiefer et al. 2004) and there is little in this case study that adds to the technical understanding of satellite imagery usage or analytical methods. While there may be few concrete lessons learned from Tomnod's search, the case does highlight some important implications about the future of commercial satellite imagery.

Satellite imagery has clearly come of age, and its uses will continue to grow. This realty seems to be manifesting itself most in the business sector, but there is no reason to expect nation states to remain on the sidelines. If a five-person team in San Diego can locate footprints in the snow in Peru, non-friendly countries can just as easily examine U.S. military or nuclear facilities within the safety of their borders. Indeed, the fact that the Tomnod team was able to execute this task demonstrates that many terrorist cells now have a satellite capability equivalent to the best U.S. military technology of the 1990's.

With respect to arms control and nonproliferation, this explosion in capability is at once helpful and problematic. It is helpful in that it allows for a degree of independent verification that was never before available. Treaty violations or other concerns may be shown publicly and confirmed by neutral observers or states which no longer have to rely on images provided by one side or the other. This capability increases confidence in conclusions and can bolster U.S. efforts by openly demonstrating a case for proliferation concern. On the other hand, having such a capability so widely available means that the amount of wrong or misleading information will also rise. For example, debate over a Georgetown University report that used commercial satellite imagery to estimate the size of the Chinese nuclear arsenal was later referred to in the *Asia Times* as a "battle between sensationalizing amateurs and incensed arms control professionals," (Lee 2011). Clearly, easily available imagery technology can complicate U.S. nonproliferation and arms control efforts by providing readily available material for counterfactual explanations or analysis.

One final implication of Tomnod's experience is the expectation for satellite technology to provide ever more near-real-time capability. Because of its special relationships with Digital Globe and GeoEye, Tomnod was able to request and receive imagery less than 24 hours after it was shot. Mapping software company MapBox recently announced plans to offer satellite imagery within 6 hours of being shot, and will bundle that with professional imagery analysis (Herwig 2013). In the same manner that Tomnod was able to provide guidance and assistance to the ground search team in Peru, verification experts can monitor on-site inspection teams using near-real-time satellite imagery: either in a formal inspection environment or in reacting to *ad hoc* tasks such as searching for a lost radiological source or stolen nuclear materials.

Crowdsourcing

Tomnod's impressive success in the finding of the lost climbers provides several lessons about how to harness the power of crowdsourcing. Even though the incident was a life-or-death situation, the Tomnod team members still took the time to think carefully through their crowdsourcing plan. They identified a select audience and gave it a defined task. They chose the proper incentive by appealing to user emotions instead of finances. And, they kept the crowd large and independent enough to ensure the benefits of crowd diversity, leading to a group composed of imagery enthusiasts, family members, mountain climbers, and Spanish speakers. Most important, Tomnod had previous experience combining crowdsourcing and imagery analysis, so the company was virtually certain that crowdsourcing would be appropriate and useful for this task.

Tomnod made some important decisions that helped with this task. It recognized that its crowd was likely to be small and close-knit, so it did not waste time creating measures to prevent sabotage or misleading information. It managed the initial task-generation process, breaking the imagery into defined areas for the crowd to analyze. It also chose the appropriate model for decision-making: the crowd could contribute and would receive feedback, but the final solution would be determined by Tomnod.

Despite Tomnod's past experience, the crowdsourcing effort was still exhausting. While the crowd was able to vastly reduce the size of the area that had to be searched, its efforts were still not a substitute for expert-level analysis. The crowd provided a series of highly relevant clues, but ultimately it was a handful of imagery analysts and mountaineering experts in the Tomnod headquarters that provided the final site list to the ground search team. Besides Tomnod's own analytical efforts, the crowd also required constant management and guidance from the Tomnod team. New information had to be reviewed and circulated within the group, and new tasks such as Spanish translation had to be devised and distributed. The crowd eagerly and effectively accomplished its task, but it was able to do so only because Tomnod provided the feedback and assistance to keep it on track.

Navigating the New Media

Introduction

What this section is and what it is not

Coming to terms with the arms control and nonproliferation implications of new media technologies is no easy task. As we have shown in our typology and case studies, the new media landscape is dynamic; companies are constantly developing new technologies, and users are constantly developing innovative ways to take advantage of them. Nevertheless, our research has begun to uncover some signposts to help guide us along the way.

It is not too much of an exaggeration to say that new media is still in the exploration phase. The "Web 2.0" concept of integrated and real-time two-way communication on the World Wide Web is only 9-years-old, and definitions are still open for debate (Madden and Fox 2006). For that reason, the conclusions we offer are preliminary. There is no one recipe for new media success, and if there were it would quickly become obsolete due to changes in technology. Still, we approach our task very much as an explorer would, beginning with some planning considerations that apply to new media usage in general. We then provide a description of the technologies available and offer common ways they are used as well as some advantages and disadvantages. With a final glance at previous attempts to use the tools in other contexts, we will move out into the uncharted territory of nonproliferation and arms control applications. In the end, we will provide a summary of lessons learned and suggestions on how to use the information provided here as a toolkit to develop additional ways to apply the technologies to nonproliferation and arms control challenges.

New media commonalities

Regardless of the platform, all new media technologies offer several potential advantages over traditional means of arms control and nonproliferation monitoring, verification, and public diplomacy efforts.

First among these is the potential reach of any new media-based effort. Media experts estimate the Arabic language television programs of Qatar-based news organization Al Jazeera have a maximum potential reach of approximately 50 million viewers (Auter, Arafa et al. 2004). By comparison, the Dubai School of Government (2011) estimates there are already 36 million Facebook users in the Arab world and projects the growth trends to match or exceed those in the West. In Asia, Facebook claims more than 200 million users (Lim 2012), and country-specific social media platforms such as China's Sina Weibo reports more than 400 million registered accounts (Millward 2012). What makes these large potential audiences substantially different from those of traditional media such as Al Jazeera is the ability to identify and reach out to specific members of that audience based on demographics or shared interests and to do that in real time (Johnson 2013).

Common Advantages

- Reach
- Speed
- Two-way engagement
- Data Availability
- Scale
- Simplicity and Cost
- Continuous Innovation

Related to speed and reach, another fundamental advantage of new media is the ability to use it to foster two-way communications. The defining characteristic of all new media is that it requires some degree of user participation. In this sense, any public attempt to use new media technologies to aid in arms control and nonproliferation monitoring efforts can be seen as a type of societal verification even if it does not involve a formal whistleblowing function because it is based on user inputs from society at large. Inputs do not stop with the user, however. The managers of a new media effort must in turn incorporate those user inputs and share the results. This in turn fosters more inputs, which leads to more interpretation and sharing. Done properly, as seen in the Russian Elections and Tomnod case studies, this two-way communication model greatly accelerates the traditional information/intelligence cycle (plan-collect-process-analyze-disseminate).

The benign cycle of ever increasing user inputs leads to two additional advantages common to new media: data availability and scale. Most new media technologies were born in the “open source” era of software development (Raymond 1999) and at least publicly support an ethos of sharing. This attitude, coupled with users’ expectations of some degree of ownership to their inputs, means even aggressively commercial firms such as Facebook and Google willingly provide a surprising amount of access to user information or user developed content to researchers, product developers, and the general public. For example, anyone with internet access can read what Twitter users in Russia are saying about President Putin’s scheduled visit to Iran using Twitter’s advanced search feature. When such open information is tied to other data routinely collected by social media sites (e.g. location, biographical information, personal and professional network connections), the enormous scale allows the use of so-called “big data” analytical techniques. Because the data are about known relationships, it is possible to understand patterns better, whether it is between certain people, certain organizations, or some combination of people, organizations, and specific technologies such as nuclear power facilities (Boyd and Crawford 2011).

One of the most frequently celebrated aspects of new media tools is their low cost and ease of use. Traditional monitoring and verification technologies such as satellite imagery or on-site inspections require a large amount of resources. New media tools on the other hand are less costly in terms of money and manpower. For example, the Pentagon budgets approximately $468 million for a single satellite launch, and this does not include the cost of the satellite itself (Shalal-Esa 2013) or any of the associated infrastructure or operating costs once the satellite is in orbit. A new media equivalent would involve the purchase of a .5 meter resolution satellite image from Mapmart.com for $350. The image processing and analysis software is free, and analysts can share their assessments and rapidly refine them on social websites such as LinkedIn or gis.stackexchange.com.

The final common advantage of new media technologies is their rapid development. New applications of the technologies are generated daily, and the technologies themselves are constantly being updated and improved. A July search of the U.S. Patent and Trademark Office database of patent applications containing the term “social media” revealed 2013 has already seen close to 100 unique inventions. The pace of innovation and the speed with which new media technologies are adopted mean planners can expect almost constant improvement in capabilities over the next several years.

Like any other set of technologies, new media has its share of limitations. The first one that should be of concern with respect to arms control and nonproliferation monitoring and verification is access. Paul Butler sampled 10 million Facebook accounts and totaled the numbers of friendship pairs, plotting each pair in its respective geographic location (Figure 23). The result is a surprisingly detailed map of the world with the borders delineated by relationships (Butler 2010). For all the beauty of this map, it is important to notice what is not there. Vast swaths of Africa are dark, as is most of Brazil and virtually all of Russia, China, and the Middle East. While it is true that mobile telephones are the platform of choice for internet access for much of the world, it is equally true that less than one third of the world's population accesses the internet at all; only 9% of Pakistan's population is online, and tech powerhouse India barely surpasses the 10% hurdle (WorldBank 2013).

Figure 23

In some sense, it is a relief that only one third of the world's population is online, because the internet is loaded with bad actors. The very openness of new media systems make them especially vulnerable to malicious behavior, and recent research tends to show that such behavior is the norm and not the exception (Naroditskiy, Jennings et al. 2013). It does not require much imagination to envision criminals generating false distress reports to lure unsuspecting aid workers to a remote location in the chaos of a relief operation (Gao, Barbier et al. 2011), and even less to picture terrorists groups using the same type of tactics. Any effort to capitalize on the benefits of new media must keep this fact in mind.

Even if the goodwill of everyone involved in a new media effort is assumed, this will still not overcome the limitation of data quality. A tenet of crowdsourcing is that errors will tend to cancel each other out if a large enough crowd is used. While this is true in theory, in practice time constraints often force decision makers to rely on information that has not yet been corrected. Good intentioned but unreliable observers can overwhelm the system with misleading or incorrect information. Human error can lead to improper analysis or coding of the data. And, as in any other information seeking effort, a lot of the data are simply missing. Once human error is removed, new media still faces the familiar difficulties of software and data format compatibility. The Haitian earthquake relief effort, often cited as the archetype of the successful use of crowdsourced social mapping, required experts to enter mapping data twice because Google's Map Maker could not interface with maps created by OpenStreetMap (Zook, Graham et al. 2012).

Stuart Brand, futurist and founder of *The Whole Earth Catalog* unwittingly summarized new media's next limitation when he said "Information wants to be free. Information also wants to be expensive." Most new media observers concentrate on the first statement, but the largest new media companies are obsessed with the second. Friendship networks, search records, imagery archives, and question and answer forum postings are very much treated as proprietary information by companies such as Google, Facebook, Twitter, and Yahoo. The value of these corporations in the new media world lies in their roles as data gatekeepers, literally and figuratively selling access to the highest bidder (Battelle 2005) (Carlsson 2010). As any new media attempt at societal verification relies on unencumbered access to the data, any limitations imposed by the gatekeepers are critical.

Common Limitations

- Access
- Bad Actors
- Data Quality
- Gatekeepers
- Anonymity

Corporations are not the only gatekeepers. States such as Syria, Egypt, and Burma have shut down the entire internet infrastructure at various times, and the so-called "great firewall" of China has become symbolic of modern political repression. Optimists downplay the effectiveness of such state control, citing the pluck and technical savvy of a determined internet public. Nonetheless, such technical capability is the exception and not the rule among the population of general internet users. Moreover, State internet censorship is not restricted to technical approaches. The legal system, trade policy, and traditional police-state tactics have all been used to restrict and control who does what online. Any new media based arms control and nonproliferation effort must be reconciled to this basic restriction.

Related to state control is the question of user anonymity. Societal verification efforts predicated on the anonymity of whistleblowers likely are not feasible in the new media environment. MIT researchers put it most bluntly after their research found 95% of mobile telephone users could be individually identified just from the cell phone tower location data: "These findings represent fundamental constraints to an individual's privacy…." (de Montjoye, Hidalgo et al. 2013). New media monitoring or verification efforts that rely on citizens of states that are opposed to the effort almost certainly will place those citizens at risk of retaliation.

New media and arms control and nonproliferation: Towards a model of application

A brief explanation of the models

The literature review and case study sections of this paper demonstrate the variety of ways new media technologies have been adopted by various fields – from business and marketing to medicine and computer science. We have used the five major capabilities of new media discussed in section 2 (gaming, social, content creation, data mining, and problem solving) to create models of potential applications for nonproliferation and arms control. As mentioned earlier, the major capabilities represent loosely defined and fungible functions that new media can perform. It is important to realize that a particular arms control and nonproliferation challenge can be addressed using various combinations of these new media tools depending on design solutions, resources available, and other considerations. For instance, Facebook, a social network site mainly used for social interactions, can also serve as a platform for social gaming, content creation, problem solving, and data mining.

As we move into more detailed analysis of each of the new media capabilities and their potential for solving nonproliferation and arms control issues, it is helpful to understand the nature of this technology and the ways it is used in various fields. To illustrate that, each function is described using a standard list of relevant considerations: (1) key components; (2) advantages and disadvantages; and (3) common approaches to using the function with specific examples of either products or technological solutions. The key components are essential ingredients for each new media technology. They are identified based on existing research referred to in the literature review section of this paper. The challenges and advantages of using a particular new media solution are general characteristics that one should consider when using a particular form of technology.

Following the overview of each of the functions, we attempt to apply our model to specific categories of nonproliferation and arms control problems such as: (1) locating and modeling clandestine WMD programs, (2) designing and testing global arms control and nonproliferation strategies, and (3) enforcing export controls and safeguards. For each of these global security issues, we identified potential roadblocks and benefits for employing a particular new media technology. At the conclusion of this section, we use our models to develop new ideas that demonstrate how new media technologies can be included in to advance nonproliferation and arms control goals.

Gaming

In the context of this study, gaming refers to applying game elements and game design techniques to engage users in play behavior. Gaming-focused strategies can be used for various purposes, including: pure play – online or offline, education, problem solving, and engaging an audience through "gamification." (For visualization see Figure 24)

The following are identified as the major elements of a successful gaming solution:

- Storytelling
- Competition
- Achievement/Reward System
- Status
- Self-Expression
- Altruism
- Closure

Challenges and advantages

Designing a strategy that includes gaming involves several common challenges. Among the most significant is building an effective feedback structure that provides the right combination of extrinsic rewards (e.g., points, status, and virtual or real money) and intrinsic rewards (e.g., positive emotions, relationships, meaning, and accomplishment, etc.). Game designers recognize that participants are more likely to internalize the skills they learn through gameplay when they receive intrinsic rewards. If the major focus is on extrinsic rewards, participants tend to enjoy gaming less and are less likely to return to that activity in the future (Pittman, Emery et al. 1982).

As the online audience continues to grow worldwide, so too does the gaming community and the time it spends playing. According to Jane McGonigal, a prominent game researcher and designer, as of January 2013, people around the world spend on average 7 billion hours a week playing online games (McGonigal 2013). Such a massive scale offers the possibility for companies to reach a vast audience. The constant accumulation of information about a diverse group of users and their behaviors also affords a unique opportunity for A/B testing[5] for new ideas and products (Kohavi, Longbotham et al. 2009). On the other hand, that global market is also multicultural and multilingual; a certain level of customization to create an appropriate cultural context is a must for any gaming-based initiative in today's online environment.

The potential of using gaming as a mechanism for modeling and testing new ideas is potentially a key advantage of employing this form of new media. Gaming has been successfully employed in this capacity in various fields – military, business, and medicine, to name just a few examples. For instance, HopeLab[6] has developed Re-Mission, a game designed to experiment with new approaches to shaping children's perception of chemotherapy. According to their study, patients who played the game have demonstrated a significant improvement in "key behavioral and psychological factors associated with successful cancer treatment" including "faster acquisition of cancer-related knowledge" and a more consistent compliance with a treatment plan (Kato, Pamela et al. 2008).

Rapidly expanding mobile connectivity has been a key factor in boosting the number of people online globally. However, the combination of bandwidth issues and mobile devices as the primary access to the web in certain regions of the world imposes some limitations on the kind of gaming environment that can be delivered. Moreover, with gaming becoming one of the most effective methods of engaging audiences in a desired activity, it is crucial to also appreciate

---

[5] A/B testing refers to a methodology of using randomized experiments with two variants, A and B, which are the control and treatment in the controlled experiment. It is used extensively in consumer preference testing.

[6] http://www.hopelab.org

legal limitations that may apply. Such restrictions may be related to data privacy, labor regulations, data mining, and virtual currency exchange, among others.

Common approaches

The ways that gaming is employed in various fields – from education and medical research to military and politics – are unlimited. For the purposes of this paper, we have identified the following applications as the major common approaches to using the gaming capability of new media:

1. Simulations. As technology grows more accessible and more actors come to appreciate its potential to immerse their target audiences in a particular environment, simulation exercises are becoming more widely used for training and education. Among the very first successful commercial simulations was the 1982 release of Microsoft Flight Simulator, with a level of detail that made it "realistic enough to be used for real-flight training," (Lackey 2006). Today, technology-based simulations are used in medicine to allow students to practice procedures before using them on real patients and in education to recreate the environments students are studying (Tech 2010).

2. Social Network Games. With rapidly expanding user bases, social networks offer an effective platform for online games played through virtual communities. In many cases, the social element not only provides a marketing channel to attract new users but is also a major factor in retaining existing players. Among the most successful examples of social network games are FarmVille[7], Dragons of Atlantis[8], and FourSquare[9].

3. Massively Multiplayer Online Games. MMOGs are games capable of supporting multiple players simultaneously online through any Internet-capable device or platform. As of July 2013, the world's most subscribed MMOG, World of Warcraft, had 7.7 million players (Karmali 2013). However, this mass-market approach has spread well beyond pure gameplay. The U.S. military has been exploring these game technologies and their capabilities for training, recruitment, and public relations purposes (Macedonia 2002). One of the publicly accessible examples of online gaming by the military is the tactical America's Army game. The game has a ranking system entitled "Honor" and includes virtual medical training that simulates real-world combat situations.

4. Gamification. Applying game elements and digital game design techniques in a non-game context, gamification uses play and game thinking to increase user engagement and customer loyalty, to name just a few functions. Transforming user experience through gamification has found its way into medicine, education, marketing and political campaigning. The University of Washington created the puzzle video game FoldIt[10], which gamifies crowdsourcing to engage users in finding various protein structures to fit the research criteria. In just 10 days the FoldIt community achieved a major breakthrough by modeling the structure of an AIDS-related enzyme that scientists were unable to unlock for a decade (Peckham 2011). The strategy of engaging online students in learning, mastered by Khan Academy[11] and its integration of a badge system and social networking, demonstrates how gamification can significantly improve education. Numerous examples of using game mechanics are present in consumer loyalty campaigns to enhance user interaction with various brands and organizations.[12]

[7] www.farmville.com/
[8] http://dragonsofatlantis.com/
[9] https://foursquare.com/
[10] http://fold.it
[11] https://www.khanacademy.org
[12] As an example, the Badgeville, as a gamification platform, allows for designing and building a gamification strategy for consumer products or organizations.

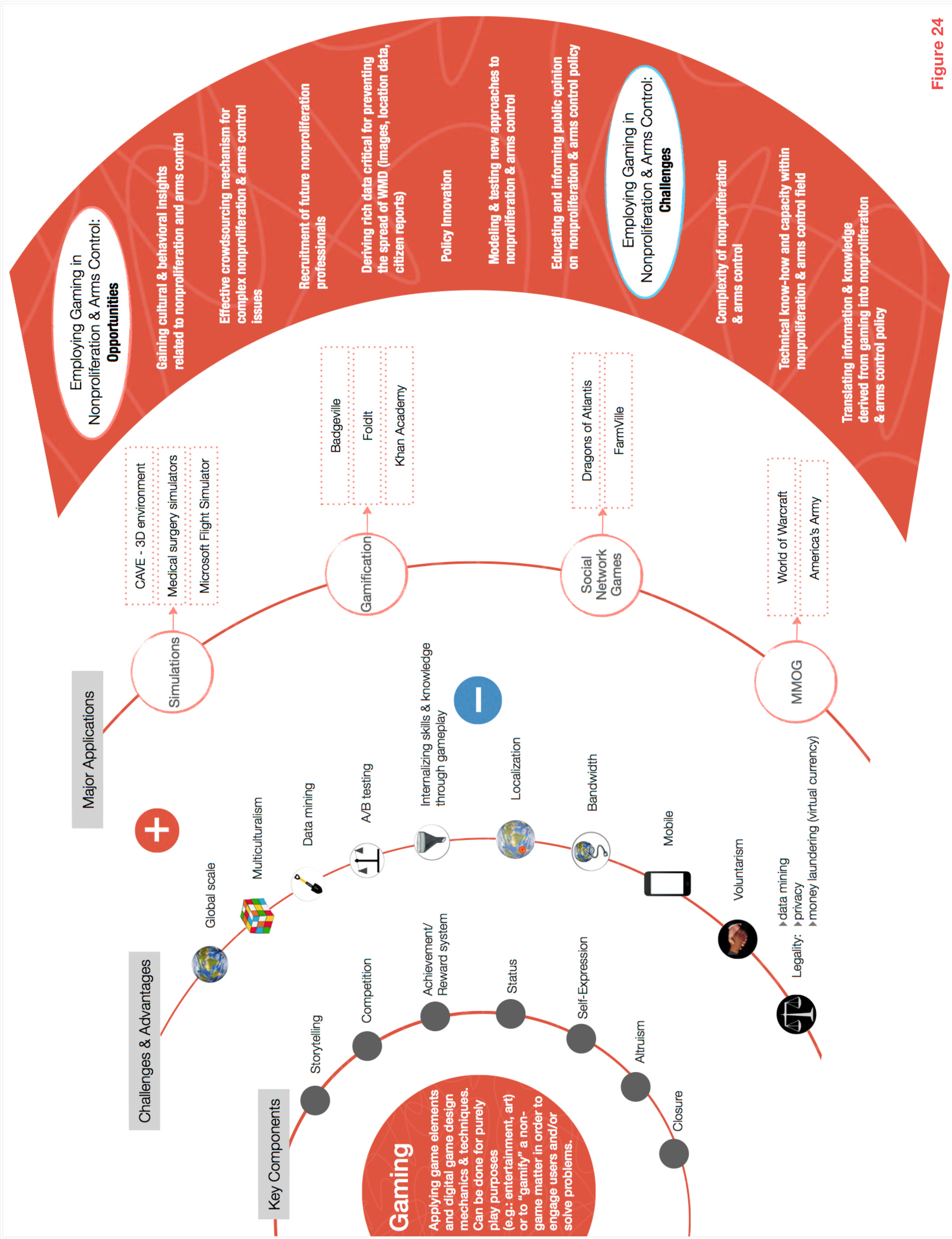

Gaming
Applying game elements and digital game design mechanics & techniques. Can be done for purely play purposes (e.g.: entertainment, art) or to "gamify" a non-game matter in order to engage users and/or solve problems.
Key Components
Storytelling
Competition
Achievement/ Reward system
Status
Self-Expression
Altruism
Closure
Challenges & Advantages
+
Global scale
Multiculturalism
Data mining
A/B testing
Internalizing skills & knowledge through gameplay
Localization
Bandwidth
Mobile
Voluntarism
Legality:
data mining
privacy
money laundering (virtual currency)
−
Major Applications
Simulations
CAVE - 3D environment
Medical surgery simulators
Microsoft Flight Simulator
Gamification
Badgeville
FoldIt
Khan Academy
Social Network Games
Dragons of Atlantis
FarmVille
MMOG
World of Warcraft
America's Army
Employing Gaming in Nonproliferation & Arms Control: Opportunities
Gaining cultural & behavioral insights related to nonproliferation and arms control
Effective crowdsourcing mechanism for complex nonproliferation & arms control issues
Recruitment of future nonproliferation professionals
Deriving rich data critical for preventing the spread of WMD (images, location data, citizen reports)
Policy Innovation
Modeling & testing new approaches to nonproliferation & arms control
Educating and informing public opinion on nonproliferation & arms control policy
Employing Gaming in Nonproliferation & Arms Control: Challenges
Complexity of nonproliferation & arms control
Technical know-how and capacity within nonproliferation & arms control field
Translating information & knowledge derived from gaming into nonproliferation & arms control policy

Figure 24

Employing Gaming in Nonproliferation & Arms Control: Opportunities

- **Educating and informing public opinion on nonproliferation and arms control policy;**
- **Effective crowdsourcing mechanism for complex nonproliferation and arms control issues:** The environment created through gameplay can be used to introduce various problem-solving challenges to all players or a particular group within the medium.
- **Deriving rich data critical for preventing the spread of WMD** (e.g.: images, geo specifics, citizen reports, etc.): When designing a project that uses gaming elements, one might think about building in such capabilities to receive input from the participants as geo-tagging, image submission, text-messaging as a form of reporting on real-world events, etc.
- **Gaining cultural and behavioral insights related to nonproliferation and arms control among players:** The interaction among users within the designed gaming environment (whether it is MMOG, simulation, or elements of gamification built into a project) can provide a great deal of information on how players form groups, how they build consensus, what ideas tend to win the majority support, where the most dominant players come from, etc.
- **Potential for policy and technology innovation emerging from gameplay:** If watched carefully, it is possible to identify the ideas that have potential to re-shape the way the nonproliferation and arms control policy is currently approached. It is likely that players that are not vested in current global security paradigms can offer insights and new ideas that the expert community has not yet explored.
- **Modeling and testing new approaches to nonproliferation and arms control issues:** Presently, nonproliferation and arms control scholars and experts have very limited capacity to test new concepts in real time. Although it might be very challenging to model the complex global environment we operate in, it is even more difficult to imagine testing new nonproliferation and arms control ideas in real-world situations – the stakes are simply too high. Thus, gaming applications might be the exact type of solution capable of affording the means to experiment with innovative policy and technical ideas. For instance, in light of recent developments in the Middle East, identifying possible scenarios for disarmament strategies involving Syrian chemical weapons can take the form of an online simulation game. It can allow for exploring various strategies and potential challenges facing the arms control and nonproliferation community, particularly UN inspectors.
- **Recruitment of future nonproliferation professionals:** Through gaming, it is possible to appeal to a certain audience to attract it to joining the nonproliferation and arms control field. In addition, participating individuals, based on demonstrated agility dealing with the game challenges, can be offered real-world professional opportunities in the global security area.

Employing Gaming in Nonproliferation & Arms Control: Challenges

- **Complexity of nonproliferation and arms control concepts for translating into gameplay;**
- **Technical know-how and capacity within nonproliferation and arms control community;**
- **Translating information and knowledge derived from gaming into nonproliferation and arms control policy:** Within the constraints of current nonproliferation and arms control regimes, it appears challenging to "legitimize" and make use of information derived through such novel mechanisms as gaming environments. Moreover, as new media technology is only starting to demonstrate its effectiveness in global political and security spheres, many might still have concerns, misunderstanding and, as a result, mistrust towards the information obtained from observing and analyzing the players' behavior and ideas.

Social

In describing the social functions of new media, we refer to applying new media technologies for creating social environments in which individuals can communicate, form relationships and share information. In the context of this paper, we do not limit the social dimension of new media to the existing social networks; it includes any applications aimed at fostering communication and building communities. (For visualization see Figure 25)

Taking advantage of the social capability of new media requires considering its key elements:

- Identity
- Trust
- Recognition
- Two-way conversation
- Immediacy

Challenges and advantages

Adoption of new media technologies and the growth of global connectivity have been occurring at an unprecedented speed. As of 2013, more than 2 billion people are connected to the Internet and more than 6 billion are mobile users (Schmidt and Cohen 2013). Such a scale makes it possible to reach a truly global audience, empowering anyone with a cell phone to have a voice on any social or political issue and potentially leverage social connections to trigger a message to go viral.

The Internet has spurred activities and interactions among online audiences that generate enormous amounts of data. The development of social network sites means that the social graph of many of these users is now available to study behaviors, sentiment, social influence dynamics, and other types of information. For instance, it is possible to take a quick snapshot of how users within a network feel about a particular matter and track how emotions and opinions change depending on various factors.

Such capabilities come with legal limitations that must be considered when privacy issues are in play. Although the user bases of many networks are not integrated with one another, the amount of personal information that can be aggregated on any given user is quite substantial. Moreover, the sharing of personal information online has brought questions of how protected the data actually is and how it could be used by criminals, corporations, and, potentially, governments.

Indeed, the publicized role of social media communication in recent political changes across the Middle East and in Africa makes the potential of online communication platforms clear to governments worldwide. They can be powerful tools to spark a global conversation and facilitate the creation of a social movement. Consequently, some states choose to block their citizens from the web completely, or censor particular topics or user groups. Thus, any design solution involving social instruments should consider the challenge of working within a set of imposed technical and legal restrictions applied by governments. In addition, as with gaming, it is important to remember that the global nature of the web implies the need to customize any new media strategy to fit a particular cultural and political context.

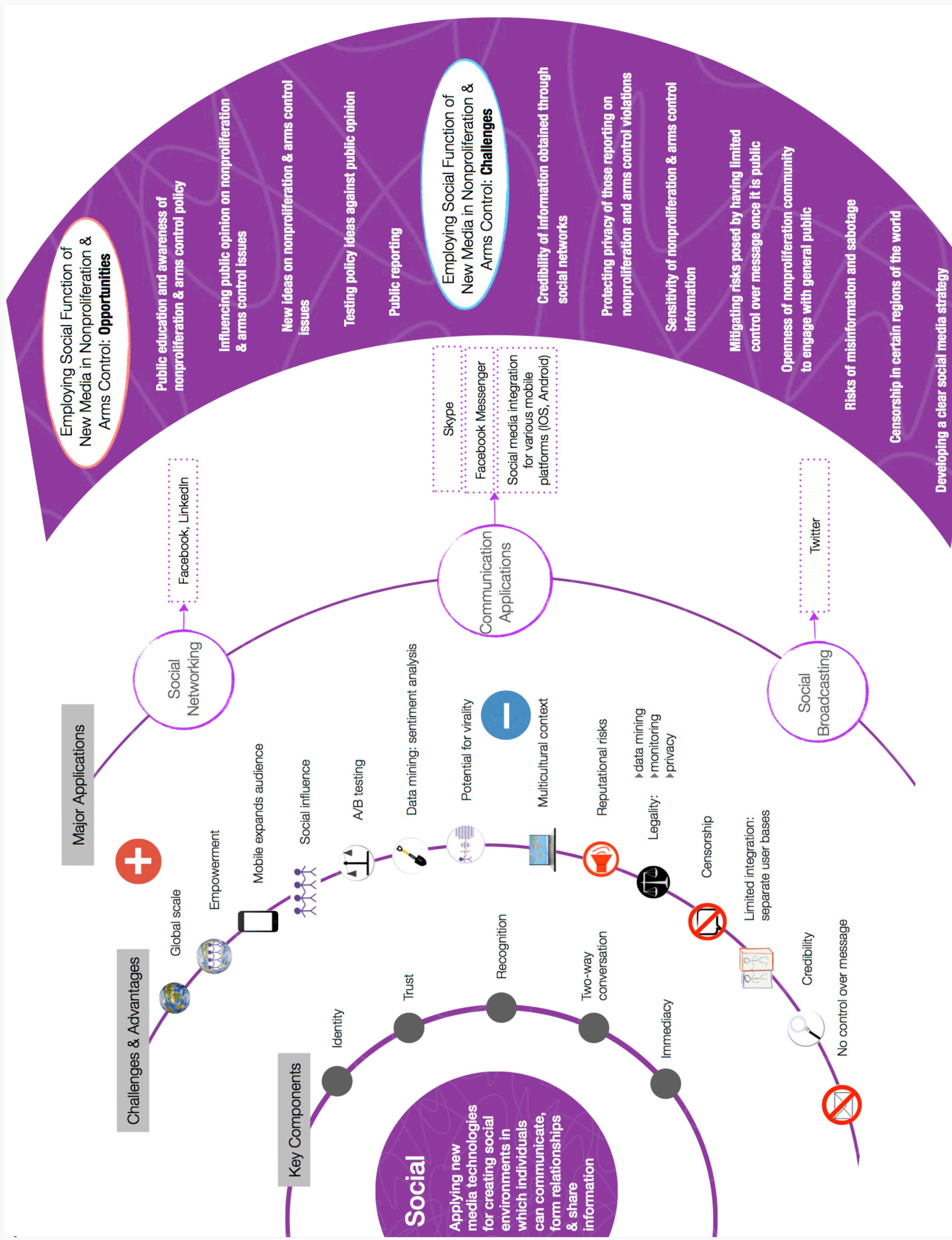
Common approaches

Although the boundaries between various ways of employing social technology are blurred, it is helpful to categorize the various forms of using the social functions of new media into three major approaches:

1. Social Networking. This category refers to the application of new media instruments to build social connections among people who share personal and professional interests, backgrounds, and real-life relationships. Among the existing social online communities are Facebook, the professional network LinkedIn, Renren of China, Orkut (with the majority of users in Brazil) and VKontakte (in Russia). Most of these networks serve more than merely a social function; they have become platforms for political campaigning, marketing, and data mining. Yet, it is possible to build these various extensions only on a developed network of people willing to come online to share and connect with one another.

2. Social Broadcasting. As users express their opinions and interests online, all the while developing more digital content, they look for ways to communicate with and distribute content to a broader audience. Twitter, with almost 500,000,000 users worldwide, is perhaps the best-known example of this use of the technology. It has become an excellent push-and-pull mechanism for efficient communication of information to and from users.

3. Communication Applications. As more people come online through their computers or mobile devices, more communication services and platforms are developed to compete for this rapidly growing pool of online citizens. Connectivity becomes more affordable and practical (Schmidt and Cohen 2013). In parallel, the experience that technology applications offer grows richer every day – from video communication (Skype, G-chat) and photo editing and sharing (Flickr, PicMonkey) to social media integration algorithms (Hootsuite, TweetDeck).


Employing Social Function of New Media in Nonproliferation & Arms Control: Opportunities
Public education and awareness of nonproliferation & arms control policy
Influencing public opinion on nonproliferation & arms control issues
New ideas on nonproliferation & arms control issues
Testing policy ideas against public opinion
Public reporting
Employing Social Function of New Media in Nonproliferation & Arms Control: Challenges
Credibility of information obtained through social networks
Protecting privacy of those reporting on nonproliferation and arms control violations
Sensitivity of nonproliferation & arms control information
Mitigating risks posed by having limited control over message once it is public
Openness of nonproliferation community to engage with general public
Risks of misinformation and sabotage
Censorship in certain regions of the world
Developing a clear social media strategy
Major Applications
Social Networking
Facebook, LinkedIn
Communication Applications
Skype
Facebook Messenger
Social media integration for various mobile platforms (IOS, Android)
Social Broadcasting
Twitter
Challenges & Advantages
Global scale
Empowerment
Mobile expands audience
Social influence
A/B testing
Data mining: sentiment analysis
Potential for virality
Multicultural context
Reputational risks
Legality:
data mining
monitoring
privacy
Censorship
Limited integration: separate user bases
Credibility
No control over message
Key Components
Identity
Trust
Recognition
Two-way conversation
Immediacy
Social
Applying new media technologies for creating social environments in which individuals can communicate, form relationships & share information
Figure 25

Employing Social Function of New Media in Nonproliferation & Arms Control: Opportunities

- **Public education and awareness on nonproliferation and arms control policy;**
- **Influencing public opinion on nonproliferation and arms control issues:** By tapping into social media conversation on global security it is possible to influence the way public discourse on nonproliferation or arms control is shaped.
- **Testing policy ideas against public opinion:** With more people using social networks for communication, news consumption and broadcasting, the data is accumulated on online users. By employing basic social networking analysis tools, we can test various policy ideas and approaches to media messaging related to nonproliferation and arms control.
- **New ideas on nonproliferation and arms control emerging through social networks:** Similar to gaming, an extensive pool of social media users from various regions in the world, having different skills and cultural backgrounds offers a potential for creative ideas on how to approach nonproliferation and arms control to emerge within networks.
- **Public reporting:** Social networks can be seen as a mechanism for retrieving information in various forms (text and multimedia) on nonproliferation and arms control from the public. This can be done by actively soliciting such information from the users, or by analyzing the social media-originated data using available data mining techniques.

Employing Social Function of New Media in Nonproliferation & Arms Control: Challenges

- **Credibility of information obtained through social networks;**
- **Protecting privacy of those reporting on nonproliferation and arms control violations through social networks:** The social capability of new media allows for empowerment and enabling people from anywhere in the world to share information that might be relevant for nonproliferation or arms control verification. Yet, it also creates risks of exposing these users to governments that might not be willing to make such information public. Therefore, in designing projects using social media to gather on-the-ground reports, it is critical to carefully develop mechanisms to protect the sources of information obtained through societal verification means.
- **Sensitivity of nonproliferation and arms control information:** Global security and political limitations as to how the information regarding nonproliferation and arms control should be handled requires developing a sound policy approach to employing social networks as a means to both gather and disseminate a particular message.
- **Mitigating risks posed by having limited control over message once it is public:** Operating in a social media environment entails understanding that it is always a two-way conversation in which there is no guarantee for a particular reaction to a message or the direction a conversation might take. As one develops a new media strategy using its social dimension, a full engagement and flexibility are required for a successful outcome.
- **Openness of nonproliferation community to engage with general public;**
- **Risks of misinformation and sabotage;**
- **Censorship:** As more people worldwide turn to social networks as a means to share information on various topics, including sensitive areas, governments also learn to mitigate the risks of having such content revealed online. The Internet censorship employed by certain governments aims at making it more challenging to communicate sensitive materials, particularly information related to nonproliferation and arms control issues.
- **Developing a clear social media strategy** including the nonproliferation or arms control message it is intended to communicate to the public.

Content Creation

Although many new media platforms and mechanisms enable users to produce digital content, in this section we focus on the process of content creation. In the framework of this paper, we refer to content creation as applying new media for collecting, managing, and publishing information in any form and through any medium. (For visualization see Figure 26)

Challenges and advantages

As more actors with various levels of technical ability join the Internet, they begin not only consuming the information, but also seeking ways to create new content in different forms and for different purposes. Our research has found that users who invest time and other resources in creating digital content in a systematic fashion are more likely to be producers of high-quality information. Yet, the scale of the Internet and easy access to uncomplicated publishing mechanisms causes information overflow and, as a result, it becomes difficult to find this quality information and to establish the credibility of content sources.

The global reach of the web affords an extremely efficient way for distributing digital material hosted on open platforms. The massive amount of data produced by the global online community provides an opportunity for opinion and sentiment analysis among these semi-professional content creators. It is now possible to take an emotional 'pulse' of a particular group of users in response to an external factor.

Through our research, we have identified the following key elements present in a successful content creation solution:

- Storytelling
- Self-Expression
- Sharing

Just as new media is exposing billions of consumers to new content, it is also exposing billions of content creators to new means of publishing and managing digital content. Emerging content creation and management tools offer a variety of UI (user interface) solutions – from simple text-focused platforms and video hosting services to complex collaboration projects and open education hubs.[13] In addition, the expansion of mobile connectivity has accelerated the development of applications that enable low-cost content creation on the go in the most remote areas of the world. The result is a creative environment where content can be delivered in a staggering variety of ways. This opens new avenues for reaching an audience, but also complicates the content consumption process due to information overflow.

Last, there is a seemingly insatiable demand for new content. The constant pressure to maintain an online presence and to engage with audiences in order to remain relevant is a major challenge. That level of connectivity becomes even more difficult in a medium where creators have very limited control over their message once it is published.

Common approaches

There are numerous models describing various methods of content creation. Here we concentrate on the major applications for, and approaches to, the production of digital material.

1. Content Management Systems. This category refers to online platforms that allow users to create, modify, and publish content through a central interface. Popular examples include the Wordpress blogging platform[14], Tumblr's visually oriented equivalent[15], and YouTube[16]. The key feature of any platform of this type is the diversity of hosted material – from multimedia to text and from expert opinions on economic development to rock music performances.

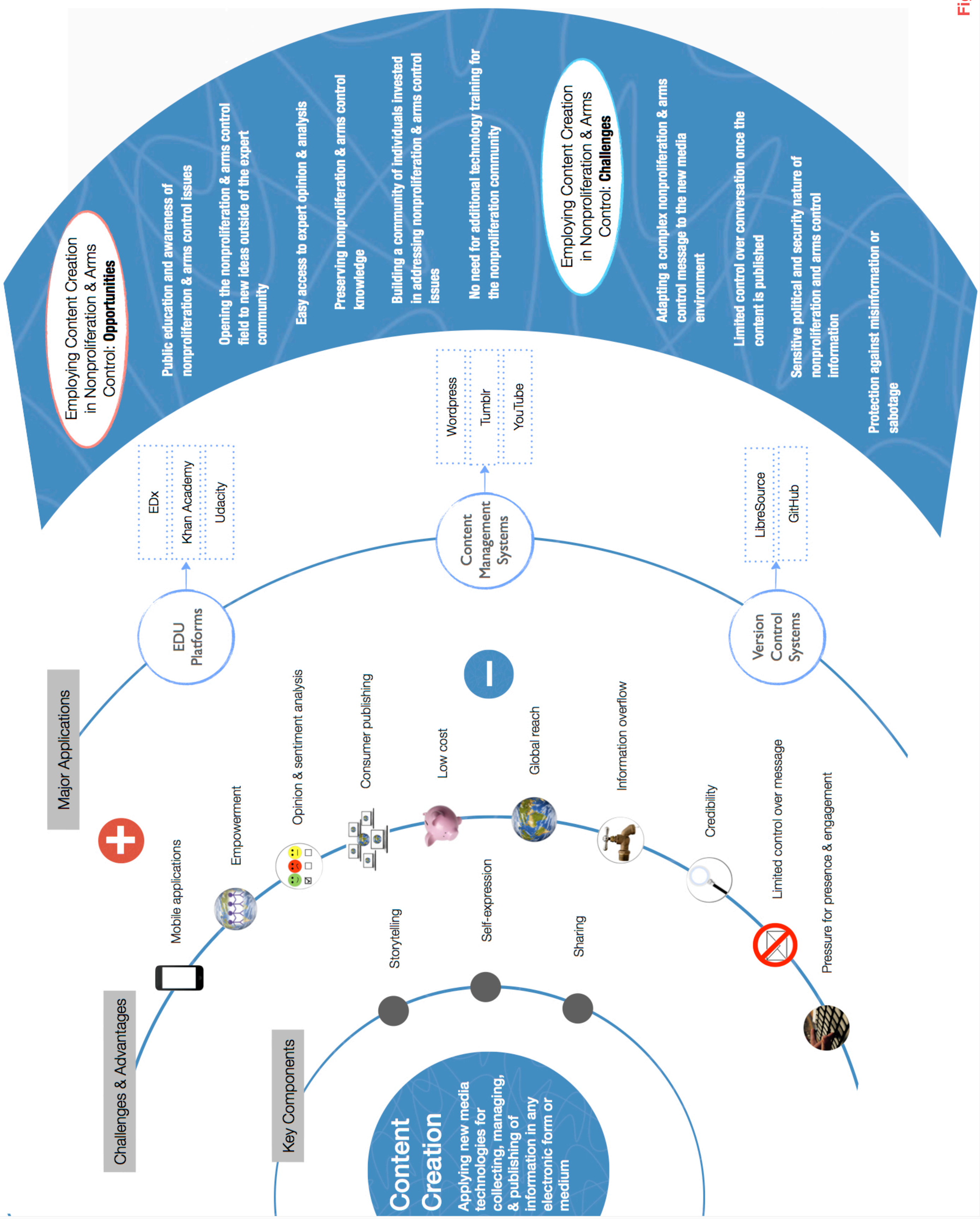
[13] User Interface refers to the mechanisms that enable users to interact with a machine, including hardware and software.
[14] http://www.wordpress.org
[15] http://www.tumblr.com

2. EDU Platforms. Leveraging Internet connectivity to provide anyone in the world with a quality education has become a powerful online movement. The audience for this effort ranges from those living in remote areas who have never had access to prominent thinkers and teachers, to students in the developed world who struggle with traditional education. Among the most effective and naturally developed initiatives is the Khan Academy, which provides millions of people on the web with thousands of short interactive video lessons on a host of topics. Another model being actively explored today is the so-called massive open online courses (MOOCs), mainly for college-level users. The Center for Nonproliferation Studies is developing one such course in the field of nonproliferation export controls. In addition to traditional institutional actors, many individual teachers and companies have invested resources in designing new ways to approach online learning in subject areas ranging from computer science and mathematics to policy analysis and gardening.

3. Version Control Systems. In this category we refer to the systems that allow for hosting and managing of complex projects with many contributors and that provide a central, straightforward interface for manipulating different versions of the same content. Whether they are working on extremely complex tasks from various locations in the world or from the same location, the need for an effective, low-cost collaboration mechanism has inspired the emergence of hundreds of different platforms and approaches to organizing such work. Today, not only programmers and engineers, but also artists, legal scholars and policymakers populate distributed version control platforms like Git and LibreSources. Such mechanisms afford collaboration without coordination. In other words, through clear user interfaces, anyone on the web can create one's own version of a product and then merge the changes with those of thousands of other users who worked on the same product.

[16] http://www.youtube.com

Figure 26


Content Creation
Applying new media technologies for collecting, managing, & publishing of information in any electronic form or medium
Key Components
Storytelling
Self-expression
Sharing
Challenges & Advantages
Mobile applications
Empowerment
Opinion & sentiment analysis
Consumer publishing
Low cost
Global reach
Information overflow
Credibility
Limited control over message
Pressure for presence & engagement
Major Applications
EDU Platforms
EDx
Khan Academy
Udacity
Content Management Systems
Wordpress
Tumblr
YouTube
Version Control Systems
LibreSource
GitHub
Employing Content Creation in Nonproliferation & Arms Control: Opportunities
Public education and awareness of nonproliferation & arms control issues
Opening the nonproliferation & arms control field to new ideas outside of the expert community
Easy access to expert opinion & analysis
Preserving nonproliferation & arms control knowledge
Building a community of individuals invested in addressing nonproliferation & arms control issues
No need for additional technology training for the nonproliferation community
Employing Content Creation in Nonproliferation & Arms Control: Challenges
Adapting a complex nonproliferation & arms control message to the new media environment
Limited control over conversation once the content is published
Sensitive political and security nature of nonproliferation and arms control information
Protection against misinformation or sabotage

Employing Content Creation Function of New Media in Nonproliferation & Arms Control: Opportunities

- **Public education on nonproliferation and arms control issues:** The content creation capability of new media as it requires presenting the knowledge in a more digestible form creates an opportunity for the public to become interested and familiar with such complex fields as nonproliferation and arms control.
- **Opening the nonproliferation and arms control field to new ideas outside of the expert community:** Alongside policy makers and scholars, any individual can now meaningfully contribute ideas and opinions regarding nonproliferation and arms control issues. Such a communication environment, in which people of different backgrounds and skills can share their views with one another, allows for open discussion on global security.
- **Easy access to expert opinion and analysis:** Through content creation, experts can establish their web presence in ways that attract the public to subject matter shaping an online conversation on nonproliferation and arms control. That, in turn, creates an opportunity for policy makers to validate their initiatives against expert analysis.
- **Preserving nonproliferation and arms control knowledge** (Knowledge Management mechanisms);
- **Building a community of individuals invested in addressing nonproliferation and arms control issues;**
- **No need for additional technology training for the nonproliferation community:** The majority of content management platforms and instruments offer intuitive and effective user interface that allows individuals with minimal technical knowledge to freely create, modify and publish their work online.

Employing Content Creation Function of New Media in Nonproliferation & Arms Control: Challenges

- **Adapting a complex nonproliferation and arms control message to the new media environment to make it relevant to people's lives;**
- **Limited control over conversation once the content is published;**
- **Sensitive political and security nature of nonproliferation and arms control information;**
- **Protection against misinformation or sabotage.**

Data Mining

The term ***data mining*** commonly refers to one of several steps in a process called Knowledge Discovery in Databases, and it implies applying specific algorithms for extracting patterns from data (Fayyad, Piatetsky-Shapiro et al. 1996). In its traditional definition, data mining does not include data collection, pattern analysis, visualization or other components of manipulating information. For the purposes of this paper, in which the new media field is presented through its major functions, we will use *data mining* and *knowledge discovery* interchangeably to refer to the complete process of extracting knowledge from data – that is, extracting and pre-processing data and feeding it into databases, managing database systems and extracting information (clusters, patterns and connections), analyzing the extracted information, and finally visualizing extracted knowledge in a way that is useful for a client. (For visualization see Figure 27)

Due to the statistical and computer science nature of data mining capabilities, the key components of this technology will not be a part of our discussion. The technical elements that comprise the process of knowledge discovery do not lend themselves to the scope of this paper.

Challenges and advantages

The global nature of the Internet makes it easy to access staggering amounts of raw data from any region of the world, and the expansion of mobile connectivity further enhances the amount of data available. However, like with other new media technologies, it is a challenge for analysts to place the information derived from low-level data collection into cultural, geopolitical and linguistic contexts. Blindly applying data mining techniques without this context can lead to extracting invalid conclusions (Fayyad, Piatetsky-Shapiro et al. 1996).

The interviews conducted to inform this research have revealed challenges that are particularly relevant to predictive data mining. Presently, as accuracy of big data analysis tends to fluctuate around 70-80%, traditional analysts can be reluctant to embrace the so-called *big data* tools. It is important to understand that data mining cannot be a silver bullet solution; it is rather a valuable supplement to traditional analysis. It allows analysts to review and digest unprecedented amounts of data in real time to provide evidential support for the overall analytical effort.

Although the availability of open source data has spurred a great number of consumer applications focused on assisting businesses and governments in gaining a better understanding of their customers or constituencies, building a reliable data mining operation is still a complex undertaking. It typically means, among other requirements, having access to great computational power, a thorough grounding in computer science and advanced statistics, and a solid understanding of the various legal and privacy limitations that must be overcome in order to collect, process and make sense of data. However, as technology evolves, one can expect many "big data" companies to offer increasingly sophisticated applications with user-friendly interfaces directly to businesses and consumers.

Common approaches

Data mining capabilities can be employed for countless purposes, becoming a natural extension of any new media application. Among the areas in which it is most commonly used are: consumer marketing, mapping and spatial analysis, scientific information discovery, political campaigning, and surveillance for national security and law enforcement. Although not required, visualization of extracted information and knowledge can facilitate and significantly enhance the data discovery process. The statistical and computer science concepts behind many of the "machine learning" algorithms that power data mining processes (Witten, Frank et al. 2011) are beyond the scope of this paper. In general terms, however, we have identified the following major approaches to data mining:

1. Predictive Data Mining. This category refers to the capacity to extract patterns and forecast their developments. For example, it is possible to diagnose emerging trends based on available open source information – social media, traditional media, government reports, business news and economic indicators. Once gathered, the data are divided into two categories, a training set and a test set. Algorithms are used to draw correlations and build a model to predict outcomes. Perhaps the best known example of this type of data mining is Google Trends, which has shown the capability to detect an influenza outbreak 7-10 days before conventional Centers for Disease Control and Prevention surveillance systems (Carneiro and Mylonakis 2009).

2. Clustering and Classifying. Data mining is frequently used to cluster items into similar groupings or to decide if something belongs to one category or the other. For example, this function might allow a researcher to identify consumer groups with similar health behaviors, and classify them into risk categories. In the nonproliferation arena, clusters of trading partners can easily be determined, and classification algorithms can be applied to aid in determining countries at higher risk for illicit smuggling. People and opinions can be clustered and classified as well. As explained in the case study “Public Diplomacy and Expert Identification,” Twitter is frequently mined to identify advocacy or expert groups. For instance, in a case study of tweets relating to the 2011 Wisconsin union protests, Moritz Sudhof identified user groups based on “their general attitude towards the topic and the medium through which the attitudes are expressed,” (Sudhof 2012).

3. Relationship Discovery. Relational information in the form of correlations forms the basis of most data mining modeling. What makes the data mining approach different from traditional statistics is the use of large, frequently unstructured data sets; the search for unknown or unsuspected correlations; and a general disinterest in determining causation (Anderson 2008). In today’s social online environment, the links and correlations between users may hold valuable information about political, economic, and cultural events. As was mentioned in the data-mining case study, Twitter information may be mined to discover correlations among users based on a particular topic or region. Through applying openly available social networking analysis tools, it is possible to identify the opinion leaders, trigger events, and other insights into information distribution and communication dynamics on Twitter. Facebook’s Open Graph allows a person to search within his or her own network, and also shows information about the non-human objects — photos, web pages, events — that people interact with. The major challenge with extracting relations from online data sets is the limits of the network from which the data was retrieved. In other words, in analyzing the social graph of a particular group of users on Facebook, we can see only a partial picture of the user’s connections. Offline connections, as well as online connections that take place on a different network, remain mostly invisible to the researcher.

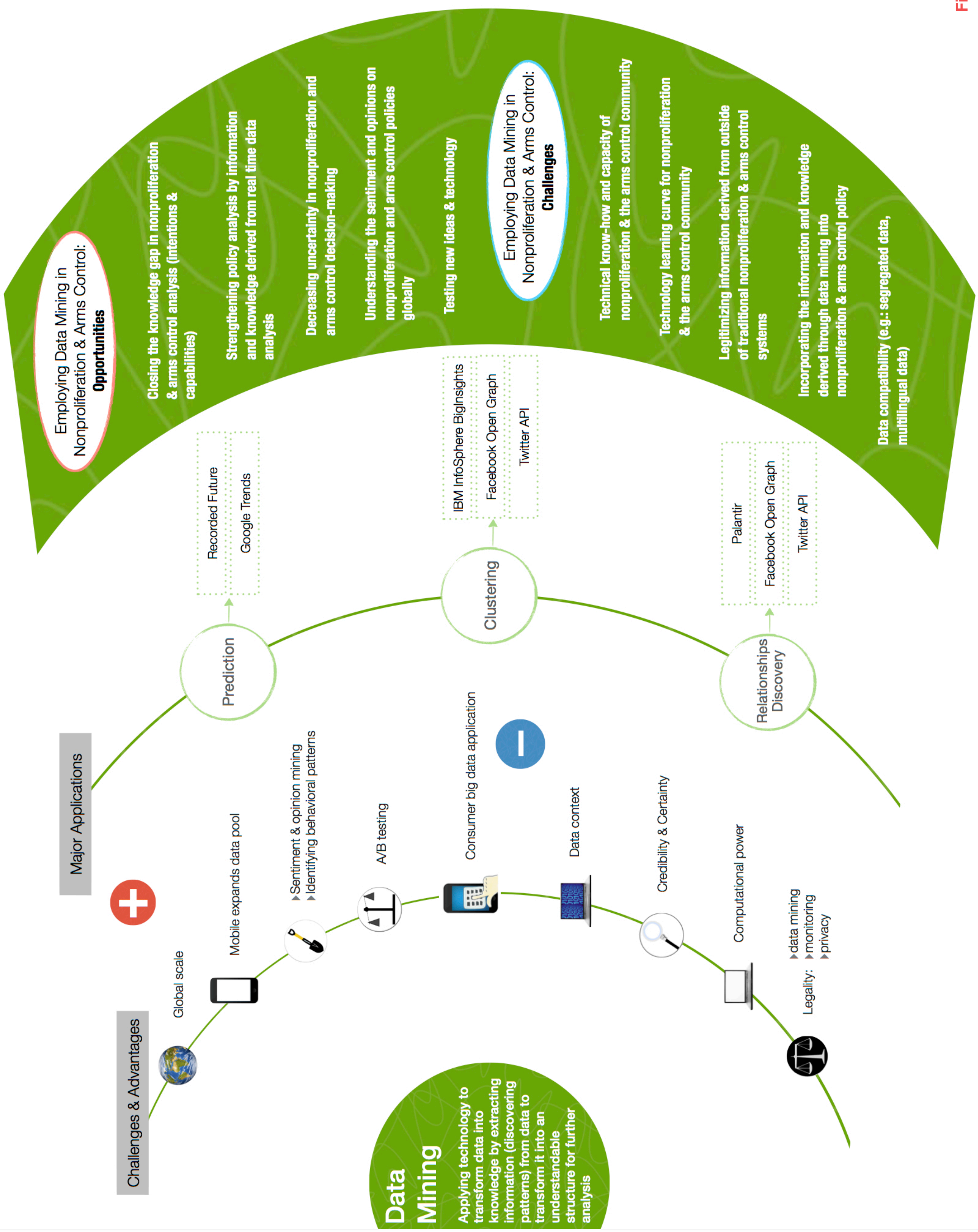

Data Mining
Applying technology to transform data into knowledge by extracting information (discovering patterns) from data to transform it into an understandable structure for further analysis
Challenges & Advantages
Global scale
Mobile expands data pool
Sentiment & opinion mining
Identifying behavioral patterns
A/B testing
Consumer big data application
Data context
Credibility & Certainty
Computational power
Legality:
data mining
monitoring
privacy
Major Applications
Prediction
Recorded Future
Google Trends
Clustering
IBM InfoSphere BigInsights
Facebook Open Graph
Twitter API
Relationships Discovery
Palantir
Facebook Open Graph
Twitter API
Employing Data Mining in Nonproliferation & Arms Control: Opportunities
Closing the knowledge gap in nonproliferation & arms control analysis (intentions & capabilities)
Strengthening policy analysis by information and knowledge derived from real time data analysis
Decreasing uncertainty in nonproliferation and arms control decision-making
Understanding the sentiment and opinions on nonproliferation and arms control policies globally
Testing new ideas & technology
Employing Data Mining in Nonproliferation & Arms Control: Challenges
Technical know-how and capacity of nonproliferation & the arms control community
Technology learning curve for nonproliferation & the arms control community
Legitimizing information derived from outside of traditional nonproliferation & arms control systems
Incorporating the information and knowledge derived through data mining into nonproliferation & arms control policy
Data compatibility (e.g.: segregated data, multilingual data)

Figure 27

Employing Data Mining in Nonproliferation & Arms Control: Opportunities

- **Closing the knowledge gap in nonproliferation and arms control analysis:** Although nonproliferation and arms control regimes have developed procedures for monitoring the compliance with international regulations, they both heavily rely on member-states submitting their reports. Assuming these reports are comprehensive and always accurate and timely, the sheer amount of data that needs to be processed and analyzed from both national reports and open source makes it challenging to construct a full picture of the nuclear world. Data mining capability of new media allows for automating the process so that analysts can focus on only those areas that need particular attention and human judgment. For example, Norman White has developed an automated tool that uses control lists to crawl the World Wide Web to discover web pages indicating interest or research relevant to producing weapons of mass destruction. The tool then ranks the web pages according to relevance and presents the prioritized results to a human analyst (White, 2006).
- **Strengthening policy analysis by information and knowledge derived from real time data analysis;**
- **Decreasing uncertainty in nonproliferation and arms control decision-making:** Although data mining might not guarantee 100% accuracy of its findings, it offers a potential to support other forms of policy analysis to improve its overall credibility. For instance, a group of researchers have developed a data mining project that used social network analysis techniques to examine incidences of nuclear smuggling in Russia. The results were supportive of the thesis that several incidents were related to a single large-scale theft of material, demonstrating that improving security at major Russian nuclear facilities would be a worthwhile policy initiative (Cook, Holder, Thompson, Whitney, & Chilton, 2009).
- **Understanding the sentiment and opinions on nonproliferation and arms control policies globally;**
- **Testing new ideas and technology.**

Employing Data Mining in Nonproliferation & Arms Control: Challenges

- **Technical know-how and capacity of nonproliferation and the arms control community;**
- **Technology learning curve for nonproliferation and the arms control community**;
- **Legitimizing information derived from outside of traditional nonproliferation and arms control systems:** Both nonproliferation and arms control have developed mechanisms for collecting and analyzing information related to treaties' compliance. Incorporating information obtained through new sources beyond traditional procedures might require additional effort to mitigate legal and political concerns related to legitimizing such information.
- **Incorporating the information and knowledge derived through data mining into nonproliferation and arms control policy;**
- **Data compatibility:** Data that can be used to advance nonproliferation and arms control come from various sources, often in different media formats and languages. To take advantage of such segregated information, it is important to develop effective means to unify the data.

Problem Solving

As the number of people coming online exceeds 2 billion users globally, social networks remain the most popular activity; however, people are exploring other ways to use new media to engage with one another in a meaningful fashion. Collective problem solving has become one of the most promising functions of new media. Ranging from crowdsourcing and crowdfunding to civic hacking, web-based problem solving allows millions of users to direct their time and skills to help tackle the world's most pressing problems. In this section we look at applying technology to bring people together, online or offline and often under time constraints, to find solutions to a particular problem. (For visualization see Figure 28)

Challenges and advantages

Easy access to a global pool of potential collaborators stimulates innovation and new solutions for long-standing unsolved challenges. One example is the crowdsourcing and gaming application that led to the discovery of the structure of an AIDS-related enzyme that scientists had been unable to unlock for a decade (Peckham 2011). In addition to addressing "old" issues, technology allows for the emergence of new paradigms that have a potential to mitigate new problems – from environmental and security threats to global development and education. One such novel approach is the so-called *sharing economy*, an economic system that, through technology, empowers individuals, businesses and governments to distribute, share, and reuse excess capacity in goods, services, data, and talent (Sundararajan 2013).

Tapping into global intelligence from users with a diversity of skills and experiences allows analysts to approach any issue efficiently and immediately, at extremely low cost. However, that is possible only if the crowd is motivated enough to collaborate on a particular task and organized to effectively deliver the solution. In some cases, the immediacy of problem solving efforts on the Internet impedes the thorough implementation and sustainability of solutions produced under time pressure. Because the collaboration is often ad-hoc among a self-selected mix of people coming together online or offline to find a remedy for a particular issue, the organizational mechanisms and approaches to creating a sense of purpose among participants must remain flexible to adapt to a changing environment.

The following components and characteristics are likely to be present in a successful problem-solving initiative:

- Storytelling
- Sense of purpose
- Altruism
- Clear problem statement
- Openness

Although the technical threshold can be an obstacle to problem solving for some users, it is becoming less so with more collaborative applications developing simpler and more intuitive interfaces. Quick prototyping and testing for non-tech communities and projects are frequently incorporated into the design of problem-solving platforms. The data used in such problem solving are also becoming increasingly "liberated," or saved in non-proprietary and easy to share formats which makes distributed problem solving even easier (May 2010).

In order to solve some issues, it is invaluable to sift through information and knowledge derived from raw data. That, in turn, poses some challenging legal questions that should be addressed prior to engaging the online "crowd." Among such issues are privacy and restrictions on the release of some types of data. Additionally, "anonymization" of data is often required by law in order to make it available to the public. Anonymization can be problematic, because it might make it difficult for problem solvers to derive actionable information from the data while at the same time implying a degree of privacy and safety for data contributors that often is not there.

Common approaches

The capability of users to facilitate problem solving through new media has found its way into a variety of domains, including humanitarian relief, business, investigative journalism, and science. The process can take many forms and occurs in different ways. For the purposes of this paper, however, we have identified three major applications:

1. Crowdsourcing. Although crowdsourcing and its applications are not the only forms of problem solving through technology, it is important to appreciate the revolutionary potential crowdsourcing offers to many fields faced with complex challenges. One widely accepted definition of *crowdsourcing* describes it as "the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call (Howe 2006)." Among the most successful crowdsourcing platforms is Ushahidi, which was initially developed to track violence reports in the aftermath of the 2008 Kenyan elections (Ushahidi 2013). Since then, it has been used for hundreds of projects worldwide – the relief effort after the Haitian earthquake in 2010, recovery after the earthquake in Japan in 2011, rescue work during wildfires in Russia in 2010, and the tracking of war crimes in the ongoing conflict in Syria.

In assessing the impact of crowdsourcing, many point to ethical questions posed by low monetary compensation paid to crowd "workers." Although that is a valid criticism, compensation applies only to those crowdsourcing tasks that focus on extrinsic rewards since workers with intrinsic motivations receive other kinds of rewards, like personal satisfaction or social reward. One example of crowdsourcing with extrinsic rewards would be Amazon's Mechanical Turk[17], for which users receive modest rewards for mostly simple and tedious tasks. As to the value of work received from the crowd, it can vary dependent on compensation, how well the workflow is organized and whether the purpose of the crowdsourcing effort resonates with the values and aspirations of the participants. It is also worth considering that the crowd itself can consist of various types of collaborators – from amateurs and hobbyists with a great desire to help but without specific skills or knowledge, to expert communities willing to donate their time and expertise to a mission they believe in. Therefore, with crowdsourcing of any form, the challenge is to have a clear understanding of the desired outcome and which communities might be the most effective in achieving that goal.

2. Crowdfunding. Often seen as a form of crowdsourcing, crowdfunding refers to the collective effort of individuals and organizations to financially support the initiatives of others, usually through the Internet. In the context of this paper, however, we believe it should be considered separately as one of the most rapidly developing forms of problem solving. Crowdfunding is becoming the mechanism that validates new ideas – political, business, or social—enabling the most promising of them to get fully funded without going through a traditional fundraising process. In many cases, this new media capability has empowered innovation, political competition and economic development. Through crowdfunding sites Kickstarter[18] and Indiegogo[19], thousands of large and small projects presented through storytelling have been funded. Among the most recent crowdfunding success stories is the Moscow mayoral campaign for which the opposition leader Alexey Navalny raised a record $1 million in just two weeks (Navalny 2013). That trend in the Russian public sphere is the newest to tap into the country's fast-growing online population for social and political purposes.

3. Civic hacking. In this category we refer to the process in which people with various backgrounds – from software development and design to entrepreneurship and government – come together to brainstorm, invent and build new solutions using publicly released data and technology. Hackathons, intensive events designed to bring people together offline or online to innovate using technology, are becoming one of the most effective forms of problem solving. The Random Hacks of Kindness (RHoK) initiative, founded by NASA, Microsoft, Google, Yahoo, and the World Bank, organizes global software development sessions in which participants respond to challenges in regions with a high risk

---

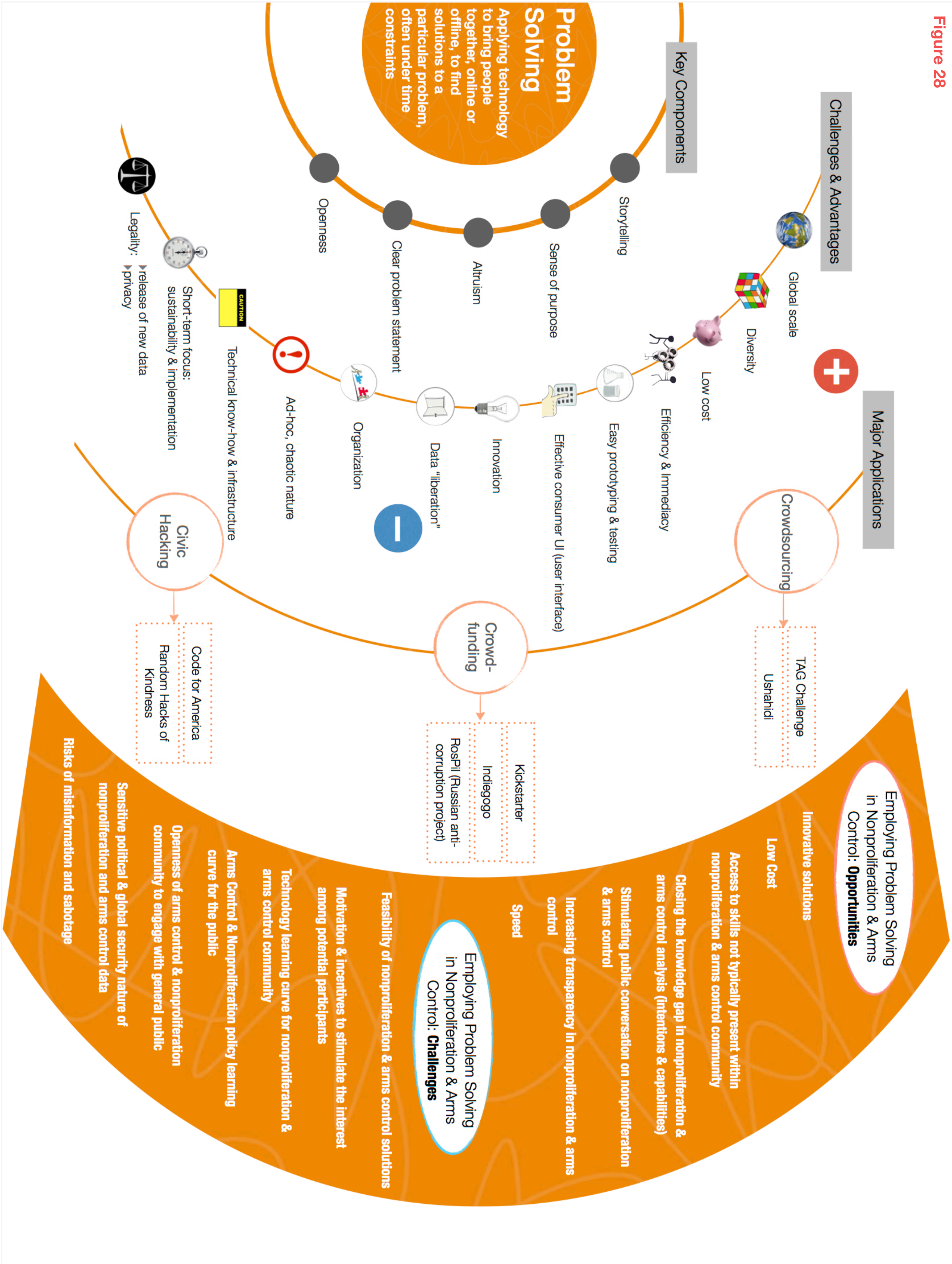
[17] https://www.mturk.com/mturk/welcome
[18] http://www.kickstarter.com/
[19] http://www.indiegogo.com/

of natural disaster. Code for America's National Day of Civic Hacking[20] engages civic activists and computer programmers to tackle major humanitarian, economic, and political issues. Among examples of civic hacks are: a mobile application that alerts citizens about cities' dangerous potholes; projects that help to coordinate access to shelters or fresh, affordable food, for homeless people; and a website that helps citizens understand how local politicians vote on specific legislation.

One of the common criticisms of civic hacking is its often chaotic nature, which can result in a short-term focus at hacking events and generate ideas that are not particularly sustainable. Yet, civic hackathons do have a benefit of engaging people outside of government agencies in public service and showing governments the potential of using their data for social good. The growing interest in employing this form of intense problem solving among non-profits and international organizations also stimulates openness and encourages data providers to allow public access to their information.

[20] http://hackforchange.org/

Figure 28


Problem Solving
Applying technology to bring people together, online or offline, to find solutions to a particular problem, often under time constraints
Key Components
Storytelling
Sense of purpose
Altruism
Clear problem statement
Openness
Challenges & Advantages
Global scale
Diversity
Low cost
Efficiency & Immediacy
Easy prototyping & testing
Effective consumer UI (user interface)
Innovation
Data "liberation"
Organization
Ad-hoc, chaotic nature
Technical know-how & infrastructure
Short-term focus: sustainability & implementation
Legality: ▸release of new data ▸privacy
Major Applications
Crowdsourcing
TAG Challenge
Ushahidi
Crowd-funding
Kickstarter
Indiegogo
RosPil (Russian anti-corruption project)
Civic Hacking
Code for America
Random Hacks of Kindness
Employing Problem Solving in Nonproliferation & Arms Control: **Opportunities**
Innovative solutions
Low Cost
Access to skills not typically present within nonproliferation & arms control community
Closing the knowledge gap in nonproliferation & arms control analysis (intentions & capabilities)
Stimulating public conversation on nonproliferation & arms control
Increasing transparency in nonproliferation & arms control
Speed
Employing Problem Solving in Nonproliferation & Arms Control: **Challenges**
Feasibility of nonproliferation & arms control solutions
Motivation & incentives to stimulate the interest among potential participants
Technology learning curve for nonproliferation & arms control community
Arms Control & Nonproliferation policy learning curve for the public
Openness of arms control & nonproliferation community to engage with general public
Sensitive political & global security nature of nonproliferation and arms control data
Risks of misinformation and sabotage

Employing Problem Solving Capability of New Media in Nonproliferation & Arms Control: Opportunities

- **Access to skills not typically present within nonproliferation and arms control community;**
- **Speed;**
- **Low cost;**
- **Closing the knowledge gap in nonproliferation and arms control analysis** (states' intentions and capabilities);
- **Innovative solutions;**
- **Stimulating public conversation on nonproliferation and arms control matters;**
- **Increasing transparency in nonproliferation and arms control.**

Employing Problem Solving Capability of New Media in Nonproliferation & Arms Control: Challenges

- **Feasibility of nonproliferation and arms control solutions;**
- **Motivation and incentives to stimulate the interest among potential participants in problem-solving effort;**
- **Technology learning curve for nonproliferation and arms control community;**
- **Arms control and Nonproliferation policy learning curve for the public;**
- **Openness of arms control and nonproliferation community to engage with general public;**
- **Sensitive political and global security nature of data related to nonproliferation and arms control;**
- **Risks of misinformation and sabotage.**

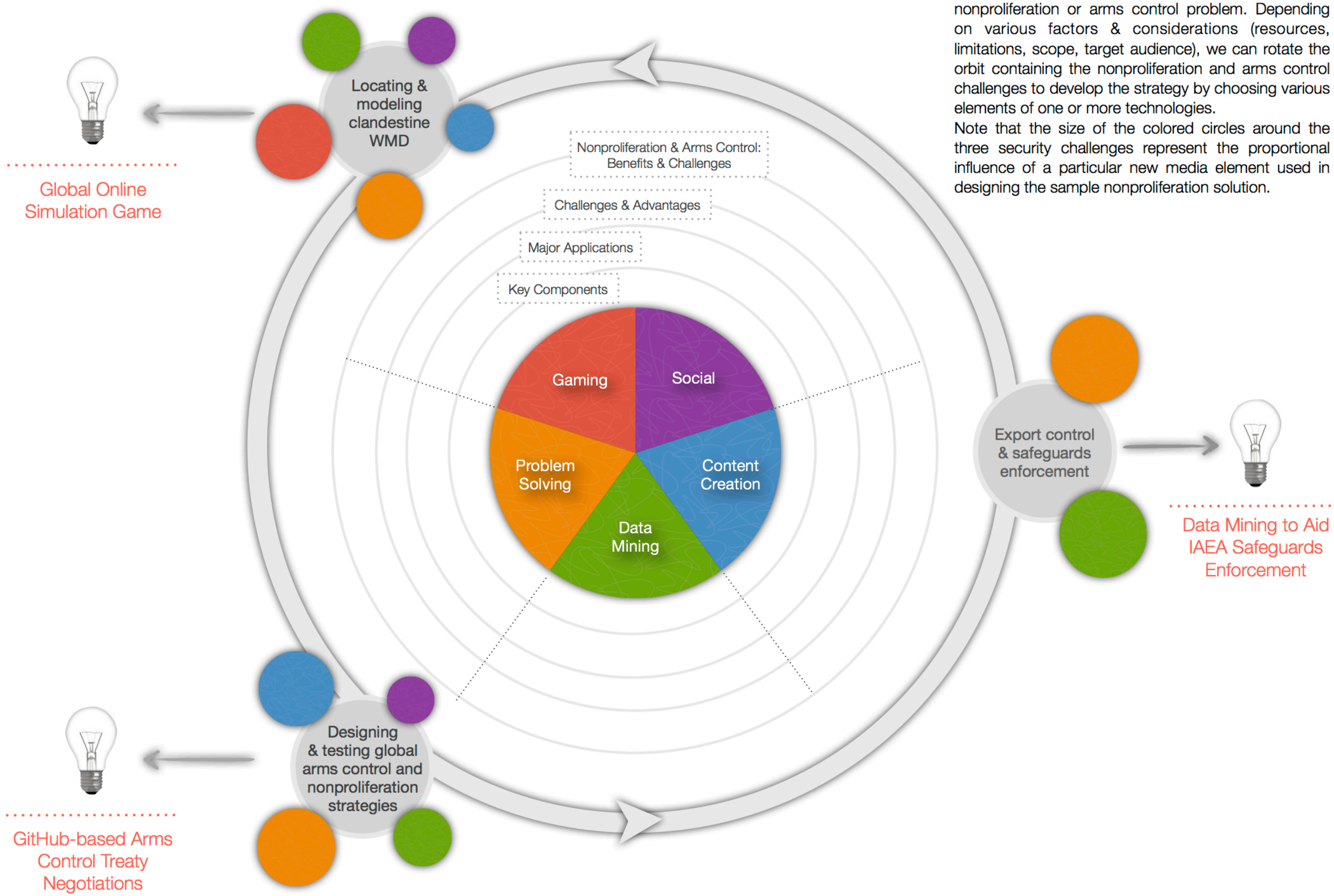
New ideas

As shown in this study, the rapidly evolving and fluid new media ecosystem has seen tremendous transformations over just the last decade. The global online community has crossed its 2 billion users Rubicon. Yet, many of these online citizens still remember the world without the Internet today's common capabilities. The stark change in how society communicates and shares ideas reveals major characteristics of the new media environment. It is volatile, adaptable, open, and customizable. Thus, it is challenging to imagine a situation in which a generic new media recipe can solve a specific nonproliferation or arms control problem. Instead, we propose a broader and more conceptual approach.

Based on our research, we believe it is crucial to realize that the nonproliferation and arms control potential of new media lies not in technology itself, but rather in how we take advantage of it. Although there are cases where social media, online mapping, or other means have been successfully employed by self-organized members of the general public to address a particular issue, we argue that deliberate design and development can yield much more workable and sustainable results. For instance, in the case of the terrorist attack in Boston in 2013, the role of new media can be best understood in the context of how effectively law enforcement tapped into social media and "big data," rather than how the online crowd struggled to identify the terrorists on its own.

As we show in the concluding diagram of this paper (Figures 29, 30), designing a strategy to address a nonproliferation or arms control problem requires a holistic approach. One should first examine the five new media capabilities explored in this study - their key components, major ways of employing the technology, its advantages and disadvantages. We then suggest assessing one's goals and limitations, resources and scope against the opportunities and challenges of using a particular new media function in nonproliferation and arms control. It is important to realize that a solution does not necessarily have to be built on just one of these five new media capabilities (gaming, social, content creation, data mining, and problem solving). Depending on various factors and considerations, one can "rotate" the orbit with nonproliferation and arms control challenges to create or customize the strategy by choosing elements of one or more technologies.

To illustrate this approach, we have developed three preliminary ideas addressing current global security issues: export control and safeguards enforcement; designing and testing global arms control and nonproliferation strategies; and locating and modeling clandestine WMD programs. As the visual shows, all sample ideas are designed using various combinations of new media tools. These examples of new media solutions for nonproliferation and arms control challenges serve to demonstrate how one might employ the conceptual design approach proposed in this paper (Figures 29, 30). As we applied each of the challenges to the new media categories, it became clear that many of the functions of these technologies, their features, and the scope of a particular project determine potential remedies for each security issue. In designing the final graphs (Figures 29, 30), we use colored symbols to emphasize the proportion of influence of a particular new media feature in developing sample solutions to nonproliferation and arms control challenges. These precursory concepts are not intended to provide a full description of a particular new media solution to a nonproliferation or arms control issue, but rather to demonstrate the potential of employing our design strategy to develop a technology application in this global security realm.



***This graph represents a conceptual approach to understanding & designing new media solutions to a nonproliferation or arms control problem. Depending on various factors & considerations (resources, limitations, scope, target audience), we can rotate the orbit containing the nonproliferation and arms control challenges to develop the strategy by choosing various elements of one or more technologies.
Note that the size of the colored circles around the three security challenges represent the proportional influence of a particular new media element used in designing the sample nonproliferation solution.

Figure 29

Global Online Simulation Game

Audience
- Global gaming community

Goals
- Create a mechanism for safe citizen reporting
- Promote nonproliferation norms
- Gain insight into cultural & behavioral patterns
- Public education
- Innovation emerging as a result of crowdsourcing specific nonproliferation issues

Mechanics
- Emulate real world nonproliferation environment
- Provide real-world baseline knowledge (access to resources: maps, legal information, etc)
- Players choose a country to play for
- Update of gaming environment based on real-world developments & testing objectives
- Game levels represent players' progress
- Game challenges present specific nonproliferation problems to solve

Challenges (factors to consider)
- Game design due to complexity of nonproliferation universe
- Sensitive nature of nonproliferation & arms control information
- Cybersecurity & protection of whistleblowers
- Technical know-how and capacity within nonproliferation community: data mining (monitoring, testing) & game development
- Risk of misinformation & sabotage
- Using the outcome of gameplay in policy-making

GitHub-based Arms Control Treaty Negotiations

Audience
- Broad expert community: scientists, scholars, policy-makers, technology specialists

Goals
- Solicit new ideas related to technical & policy aspects of arms control verification
- Build a foundation for future arms control negotiations
- Test new ideas and verification concepts with various audiences
- Engage a wider audience in building political consensus
- Public education & awareness

Mechanics
- Issue an open call to all interested parties
- Provide technical training as to how operate within the distributed version control systems
- Provide baseline knowledge to the participants outside of arms control community
- Divide the participants into teams
- Call for ideas within teams to shape the states' negotiation positions
- Begin the GitHub online negotiations

Challenges (factors to consider)
- Technical know-how & capacity within nonproliferation and arms control community
- Translating complex arms control policy and history to provide an adequate background for the participants
- Sensitive nature of arms control
- Incorporating solutions generated as a result of online negotiations into policy

Data Mining to Aid IAEA Safeguards Enforcement

Audience
- IAEA analysts, nonproliferation expert community

Goals
- Create a holistic picture of a state's nuclear program
- Improve efficiency of safeguards compliance assessment
- Create mechanism for timely detection or prediction of states engaging in clandestine nuclear activities

Mechanics
- Aggregate nuclear data in one database
- Identify nonproliferation attributes to develop templates of a nuclear facility
- Map out existing known facilities
- Design the algorithm for searching for undeclared nuclear facilities and activities
- Apply algorithm
- Analyze specific areas of concern

Challenges (factors to consider)
- Technical capability within nonproliferation field
- Identifying the relationship between various nonproliferation and other geopolitical and industrial factors for developing the templates
- Designing effective algorithm capable of analyzing dozens of parameters, including GIS signatures to reach high level of certainty
- Timely access to imagery and other data

Figure 30

Global online simulation game

Until recently, the nonproliferation and arms control community had limited opportunities to develop and test new ideas and strategies on a global scale in real-world settings. With internet connectivity and new media technologies becoming more accessible to people around the world, it is now possible to design an open online platform to simulate the international nonproliferation and arms control environment. An online simulation game can become a vehicle for international security scholars and policy makers to test new nonproliferation theories and approaches by observing and analyzing creative thinking and behavioral patterns among players from various regions of the world. It can also offer an educational platform for players to familiarize themselves with the international security realm and global nonproliferation norms.

The goals of using gaming in global security context can vary dramatically, from public education and raising awareness, to recruitment or problem solving. The implementation can be adjusted to target specific regions and audiences. Developing this security simulation can be done through creating an independent game environment or by cooperating with one of the MMOG environments to add nonproliferation and arms control aspects to an existing game. Any of these missions can be accomplished if gaming techniques and mechanics are aligned with a purpose of the game and its target audience.

Due to the complex nature of the global security environment, the participants can be offered access to a complete suite of reference resources, including maps, legal databases, nonproliferation export control practices, communication tools, and other related applications. The players will have to make a choice for which country they would like to play before starting the game. That decision will determine the game settings for them, such as the country's political structure, socio-economic conditions, military and nuclear capabilities, and the state's legal obligations. The players will then enter the game having basic capabilities and operating under rules emulating real world situations.

The gaming environment will be continuously updated based on actual nonproliferation and arms control developments. The levels within the game will represent the progress players make successfully completing challenges presented within the simulation. To do so, users will work on building-up their expertise, reputation and resources. The game challenges with various difficulty and complexity can focus on solving global diplomatic dilemmas related to arms control negotiations, export control issues, and disarmament verification. For instance, players can be presented with a challenge to virtually assist UN inspectors in verifying and transporting stockpiles of chemical weapons for destruction. The game could also include elements designed to emphasize peaceful use of nuclear materials, including materials protection, control, and accounting (MPC&A). Such tasks might be designed as long-term assignments or challenges that must be completed within certain time limits. Upon successful completion of a task, players win rewards - transition to the next more advanced level within the game or additional points. The more successful the players are, the more options they have to advance, including such "powers" as individual political positions, virtual financial recourses, leverage over competitors, etc.

The users and the nonproliferation and arms control community can be a source of ideas for game challenges. In other words, individual players, global security think tanks can be invited to incorporate their ideas into the gameplay for the participants worldwide. The open nature of this gaming project will ensure an unlimited supply of creative ideas coming from the nonproliferation and arms control community making the game a global laboratory for testing new security ideas.

Assuming a wide variety of players with different motivations could play the game, the simulation could help to reinforce nonproliferation norms while also providing a valuable resource to explore attitudes and incentives for proliferation and nonproliferation. Researchers and policy-makers would have a real-time universal research lab and survey mechanism to test various hypotheses about nonproliferation and examine behavioral patterns and deviations. New media technologies applied to engaging large online audiences can model real world behavior and perhaps supply new insights for advancing future nonproliferation and arms control strategies.

Data mining to aid IAEA safeguards enforcement

Identifying undeclared nuclear facilities is a key to stopping the vertical and horizontal proliferation of nuclear weapons and fissile material to state and non-state actors. Geographical information systems (GIS) and imagery analysis can aid in that effort, but resource constraints hamper the effort. While the quality of satellite imagery and GIS information is better than ever before, the sheer amount of data that needs to be processed is daunting. Automating the early stages of analysis by employing data mining techniques can improve efficiency and possibly increase the likelihood of states engaging in clandestine nuclear activities.

In this example, we will illustrate the potential of using data mining to aid in the search for undeclared nuclear facilities and activities. Through developing a machine-learning algorithm to screen for the likely presence of a nuclear facility based on GIS signatures, it is possible to create a holistic picture of a state's entire nuclear program. This algorithm can process various remote sensing capabilities, such as Visible and Near Infrared spectrum light (VNIR), Synthetic Aperture Radar (SAR), Thermal Infrared (TI), and Hyperspectral sensors to develop templates with weighted attributes for any existing type of nuclear facility.

Attributes can be weighted according to how common they are in indicating a facility, as well as filtering out features that are less important. For example, light water reactors **always** need access to cooling; **usually** have domed reactor cores; and **occasionally** are co-located with Surface to Air Missiles. This approach will allow running incoming data (manual search queries or a stream of new incoming data) against the trained machine learning algorithm, outputting a confidence level that the area contains a facility, and reducing the amount of area for the analysts to search manually. Employing data mining techniques in this fashion will not only improve the efficiency of safeguards compliance assessment; it will also contribute to a broader understanding of signatures of nuclear facilities. Additionally, research into this area could encourage the development of new technologies in image processing and other forms of unstructured data analysis directly related to the nuclear nonproliferation field.

Some of the attributes that could be considered are:

- Distance from a cooling water source
- Distance from population centers
- Electricity grids
- Road and rail networks
- Terrain variations
- Steam or water disturbances
- Heat plumes
- Trace gasses
- Security perimeters
- Vehicle activity
- Specialized equipment, vehicles (grinders, crushers, elevators)
- Surface to Air Missiles

GitHub arms control treaty negotiations

As mentioned in the case study section, distributed version control systems have been successfully employed in software development to organize collaborative work among engineers from around the world. It allows large complex projects to be built without direct coordination. If applied to arms control, this approach could facilitate the groundwork for future bilateral or multilateral negotiations. The initial preparation for an arms control deliberation process can be crowdsourced through one of the distributed version control platforms, like GitHub. Invited global security specialists, scientists, policy makers and the general public could engage in contributing their ideas and skills, knowledge and viewpoints to what can become the next international arms control agreement. This intellectual exercise can focus on any aspect of arms control policy – bilateral or multilateral negotiations, verification and compliance mechanisms, or implementation procedures.

For instance, employing distributed version control in developing a joint U.S.-Russian initiative to engage interested individuals and groups can facilitate shaping the direction of the future arms control strategy. This project will create an opportunity for people with different backgrounds from anywhere in the world to become a part of the arms control dialogue. Through observation of the brainstorming and negotiation process within the online environment, U.S. and Russian moderators will be able to test new policy ideas and technology solutions while educating the audience on international security matters.

To launch the GitHub-based arms control project, both sides will issue an open call to potentially interested audiences – scientists, engineers, military scholars and policy makers, the NGO community – to become part of a national negotiation team. As the goal of this project is to explore ideas for arms control verification through online deliberation, it is critical to establish a baseline for understanding the current state of legal, technical and political limitations in the area of arms control and nonproliferation under consideration. For that purpose, organizers will provide the participants with resources on challenges facing the arms control community in both Russia and the United States.
As teams generate ideas, they submit them to their moderators for consideration and possibly for open discussion. Accepted proposals will shape the negotiation positions of the states and can ultimately become a part of a virtual bilateral agreement on arms control and nonproliferation between Moscow and Washington. An open negotiation project based on a platform with built-in mechanisms for undirected collaboration offers the potential for groundbreaking ideas to emerge as many participants, while may be experts, will have no vested interest in a particular outcome of such experiment. If designed properly, the innovative environment will offer a low cost efficient way to investigate potential roadblocks and possible verification scenarios essentially building a foundation for arms control and nonproliferation progress.

Guidelines for using new media to address arms control and nonproliferation challenges

The overview of technologies and their functions together with the lessons learned from the case studies can be combined to provide some basic guidelines when approaching new media for arms control and nonproliferation challenges. These guidelines are based on our assessment of new media best practices and offer considerations for application and research.

Plan

Planning is the starting point for any new media effort. A structured and deliberate planning approach will ensure resources are aligned with goals and that both management and staff share a common understanding of the intent of the project (Mintzberg and Waters 1985). Team based planning is often an effective method to develop creative problem solving approaches and the basic steps of problem identification, knowledge exploration, priority development, program development, and program evaluation (Delbecq and Van de Ven 1971) apply in the new media environment as well.

At a minimum, a new media effort must explicitly define the goals it wants to achieve, the intended audience (in an outreach effort) or customer (in an information gathering or analytical effort), and resources available. Defining the goal will greatly assist in identifying appropriate success metrics and feedback mechanisms, ensures unity of effort, and allows managers to determine the overall level of effort. Understanding the audience clarifies the appropriate technology to use and also helps to frame the type of output required, e.g. a real-time data stream, a collection of processed data, or a finished analytical product. Finally, determining the resources required ensures continuity of the project for the duration of the effort and also provides a discrete planning step to evaluate and finalize the choice of new media technology.

Know and understand the tools

Understanding the "how" and the "what" of new media greatly increases the chances for successful application. Unfortunately, reliable information on new media is difficult to come by as businesses and marketers attempt to take advantage of the "buzz" surrounding the new technologies. In order to avoid getting caught up in the hype, some understanding of the theories behind the technology is useful. Serious users should be familiar with the "small world" theory and the importance of weak ties, have some grasp of the mechanics of information diffusion, and know the basis for the success of collective intelligence. A basic understanding of key sociological and communication concepts such as *homophily*, *influencer,* and *opinion leader* is also important because these underlie much of the current research and practice of new media.

Of course, the "how" of new media is still only one half of the equation. The "what" is equally important. It is critical that new media practitioners understand the specifics of the chosen technology, and, more importantly, how to combine that technology with other platforms or methods to develop a complete solution. For a simple example, it is inappropriate to rely on Twitter for detailed location information because Twitter does not offer a reliable and widely used method of tying tweets to location. On the other hand, Foursquare was specifically designed to track and report user locations. Therefore, the best solution for a new media effort might be some combination of the two.

Users must also stay abreast of changes to the technologies in general, or to platforms in particular. Since its founding in 2004 for example, one researcher has documented well over 100 changes to Facebook's look, feel, and functionality (Loomer 2012). Another example of new media dynamism is to be found on Wikipedia's listing of the top social media sites. Between May and July 2013, the talk page records more than 25 requests to add, remove, or update social media website information (Wikipedia 2013). For this reason, it is important that planners take the time to review the current technologies before embarking on a new media effort.

Take limitations seriously

New media have enormous potential to contribute to solving nonproliferation and arms control challenges. In order to realize that potential, however, users must anticipate its limitations. Some of these are technical, such as the resolution of commercial satellite imagery; others are theoretical, such as the difficulty distinguishing between influence and homophily in social networks; still others are based in culture or law, such as censorship of certain online content. All of these limitations can be addressed or mitigated if they are identified in advance. Ignoring or downplaying them, even if it does not immediately ruin the project in question, will always lead to sub-optimal results.

Integrate

The best new media efforts take advantage of a variety of platforms, technologies, and techniques. It makes no more sense to rely on a single source in the new media world than it did with traditional media. Planners and users must be prepared to integrate inputs from all of the sources available to them as well as select and combine the outputs to create a useable end result.

Be prepared to manage

Successful new media initiatives require a substantial management effort. This is not to say that a traditional hierarchical management structure is required, but there must be some mechanism in place to coordinate and supervise activities. Furthermore, someone must be available and authorized to decide appropriate responses to changes in the information, often in real time. Additionally, the manager needs to be able to interpret the results of the effort, both to superiors and subordinates, but also in some cases to the user base at large. Finally, as techniques and methods for using new media develop, a manager must be able to conduct after-action analysis to document successful practices for future use.

Conclusion

> *"The great thing in the world is not so much where we stand, as in what direction we are moving."*
>
> -Oliver Wendel Holmes

When Lewis Bohn and Seymour Melman formally proposed "inspection by the people" in the 1950's, few would have believed it would still be a topic of discussion in the 21st Century. Yet, the institutional challenges of legal protections, state secrets, treaty obligations, and norms of international behavior are just as much an obstacle to societal verification today as they were then. What has changed is the ability of the average person to bypass these institutional barriers and take the case directly to the public, as well as the abilities of any online actor, including governments and international organizations to take advantage of a whole host of data sources and technology-based analytical tools to advance nonproliferation and arms control goals.

As we have shown, the use of new media in global security brings its own challenges. Some are conceptual. Today's online environment offers much broader opportunities to enhance nonproliferation and arms control strategies than the 1950's whistleblower concept, and enables security practitioners to tap into virtually any form of behavior that uses publicly available internet-based information in the service of nonproliferation and disarmament norms. However, the present verification and compliance infrastructure is not prepared to receive, analyze, or act on such information. In order to take full advantage of the possibilities of new media, governments and international bodies will need to become much more willing to engage with non-expert members of the public, to include "liberating" much of their own government data in the interest of transparency and public trust.

In addition to questions of international law, concerns about privacy and the government's role in data acquisition and analysis still need to be addressed. Just as copyright law is struggling to come to terms with digital publishing, legal and administrative rules will likely lag behind developing online verification practices. As monitoring and verification efforts move into the public arena, it will be crucial that states maintain the public trust.

Technical challenges remain as well. The question of anonymity seems to be the most important and also the least likely to be solved. Put simply, new media efforts cannot guarantee anonymity of reporters. A determined government security service or even a dedicated research team is likely to be able to trace a report back to its source. For this reason, nonproliferation and arms control advocates should place most of their emphasis on better use of existing publicly available collections of information. Detecting and analyzing the signals coming from various new media platforms and potentially relevant to nonproliferation or arms control removes the emphasis on individual whistleblowers. For example, during the U.S. raid on the Osama Bin Laden compound, a computer consultant living nearby unwittingly alerted the world to the activity by tweeting "Helicopter hovering above Abbottabad at 1AM (is a rare event)," (BBC, 2011). Data mining Twitter archives or crowdsourcing commercial satellite image analysis would seem to provide a better risk-benefit ratio than encouraging electronic "see something, say something" campaigns in politically repressive regimes.

Beyond solving technical challenges, supporters of the idea of using new media in nonproliferation and arms control should work to develop a better understanding of the science underlying the technology. In a commercial culture dominated by reports of the rapid growth and amazing success of companies such as Facebook or Google, the desire for a good headline sometimes obscures the full story. Anyone who has watched an internet cat video has certainly encountered the idea of something "going viral," and a Google search on "how to go viral" reveals 92 million hits. But, few if any of those web pages will note that science has already answered the question: there is no way to predict what will "go viral," just as there is no way to predict who will win the lottery (Salganik et al., 2006). Likewise, there is no reliable way to harness a social network to influence others to do something (D. Watts, 2007), rapidly gain a large online following (Cha et al., 2010), or guarantee a helpful and cooperative crowd in a crowdsourcing effort (Naroditskiy et al., 2013).

None of this should imply that the use of new media is impossible or has limited real-world application. Our case studies have shown just the opposite. In fact, events unfolding in Syria as this paper is being written may accelerate the trend. What would new media applications look like there? It is possible that technological capabilities explored in this paper will assist in mitigating the risks related to conducting UN inspections, as well as verifying and securing the stockpiles of chemical weapons currently possessed by Syria. Crowdmapping, social media, and commercially available satellite imagery could be used to ensure the safety of UN inspectors by determining areas with heavy fighting. Beyond safety and access, social media could help the inspectors prepare for their work. In the period before they enter Syria, they could familiarize themselves with various sites based on open source information and three-dimensional visualizations. Crowd sourcing photographs of buildings of interest may be extremely useful in determining what kind of inspection team and equipment will be needed to carry out the first phase of any work in Syria. Finally, social media efforts do not have to be one way. We have already seen Syrians establish social media networks to warn residents of Aleppo and other cities of Scud launches. Using these tools to help share updates on the status of UN inspections may help reassure Syrian civilians that international efforts are working.

We believe our paper provides a starting point for the arms control and nonproliferation community to explore the opportunities and challenges of employing new media in the global security realm. The term *Online Societal Verification* might be appropriate to summarize the broad idea of using new media for addressing various interrelated security issues – from arms control verification, to global transparency and confidence building, to preventing the spread of WMD. Regardless, re-thinking the idea of societal verification to include the possibilities offered by a rapidly expanding online environment provides a promising avenue of future research.

We believe new media applications for arms control and nonproliferation continue to emerge, just not in the tidy package once envisioned by the arms control and nonproliferation community. Taking advantage of the opportunities presented by new media will require learning new technical skills as well as developing new attitudes. The new media environment is a place where collaboration is frequently more valuable than individual expertise or rank, and openness is often seen as the highest good. Such an environment will occasionally be at odds with the instincts of both governments and their national security experts. The benefits for everyone interested in the goals of nonproliferation, however, seem to be well worth this risk.

Annex

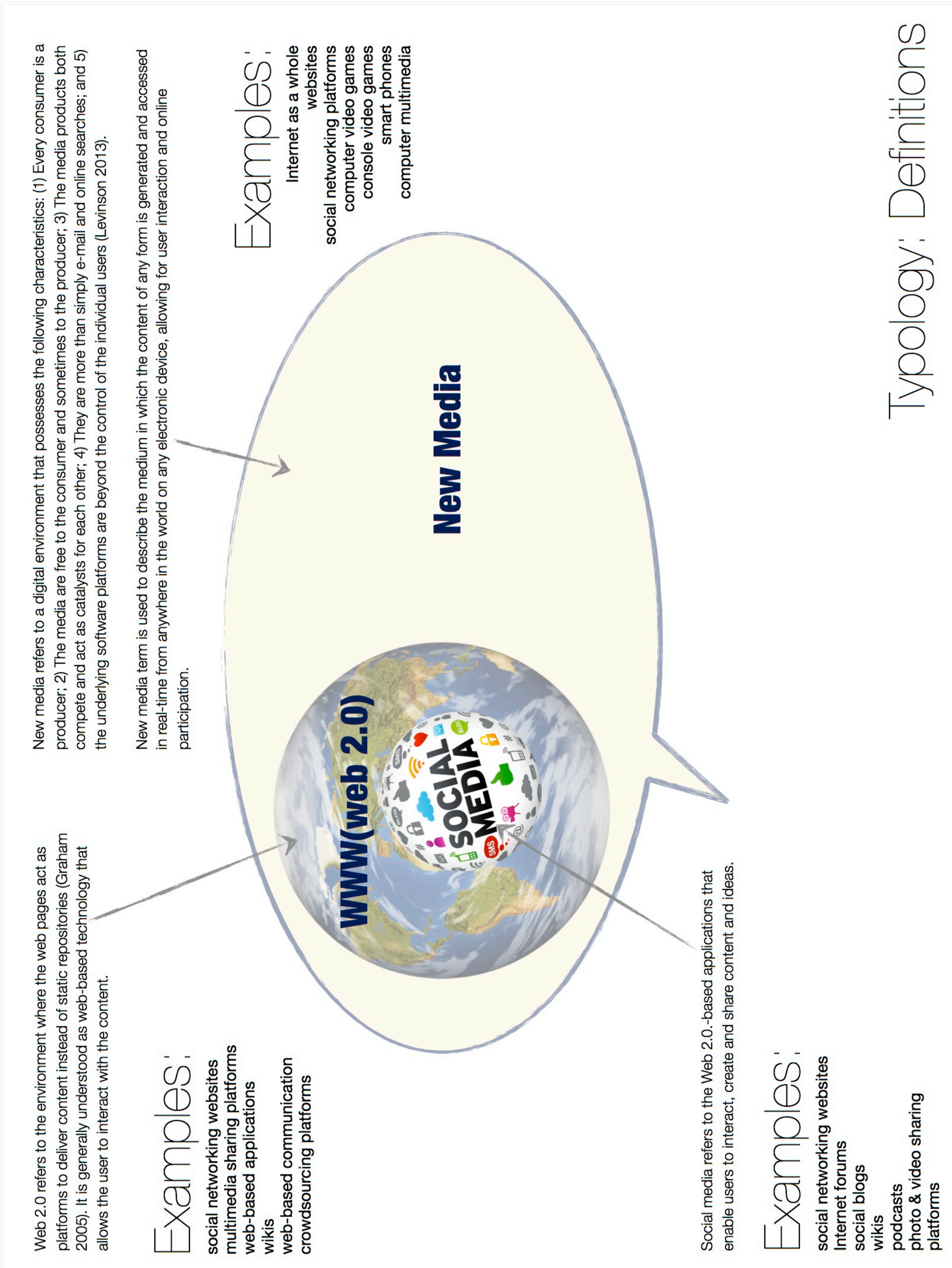


Figure 31

***These new media categories represent loosely defined fungible functions that new media can perform. Based on design solutions, resources, and other considerations, any given challenge can be potentially addressed using various combinations of these new media tools. Moreover, many new media platforms/tools can be utilized for more than one of these functions. For instance, Facebook, a social network site **mainly** used for social interactions, has also served as a platform for social gaming, content creation, problem solving, and data mining.

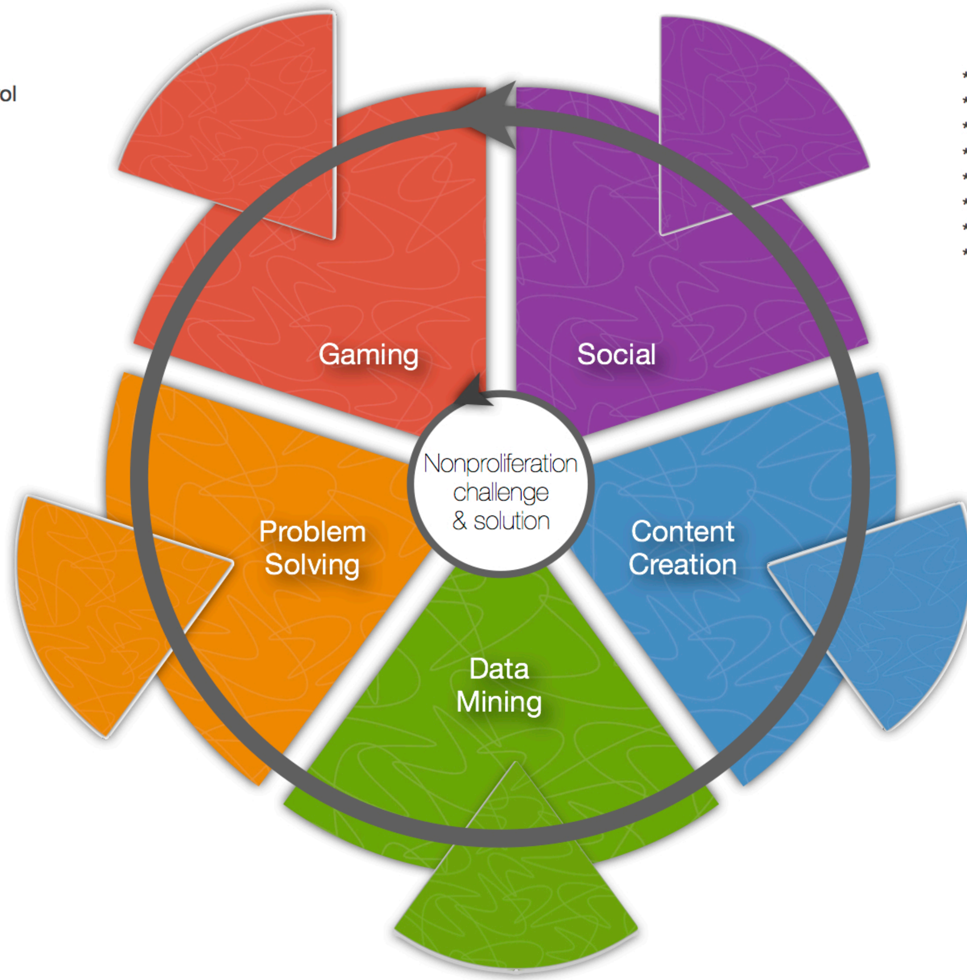
Typology: Broad New Media Capabilities

*example lists are not all inclusive

Figure 32

Typology: Nonproliferation and Arms Control Challenges through New Media Functions

* lists of nonproliferation and arms control challenges are not all inclusive



Gaming

* introducing and testing global arms control regime & new security strategies
* increasing global transparency through social interaction
* arms control innovation
* nonproliferation education & awareness
* predicting and studying emerging nonproliferation trends

Social

* nonproliferation education
* raising nonproliferation awareness
* reinforcing nonproliferation norms
* employing public pressure
* public reporting
* professional recruitment
* information collection & verification
* increasing global transparency through social interaction

Problem Solving

* monitor & identify nonproliferation & arms control related deviations (trade, finances, communication, movements, etc.)
* strengthening IAEA safeguards enforcement
* arms control innovation
* raising nonproliferation awareness
* scientific advancement
* professional recruitment
* information collection & verification
* enforcing nonproliferation export controls
* nuclear knowledge management
* maintaining up-to-date global nonproliferation and arms control "maps"
* locating and modeling clandestine WMD programs

Content Creation

* nonproliferation education
* scientific advancement
* scientific & policy exchange
* reaching expert communities
* information collection & verification
* influencing national decision-making processes
* enforcing nonproliferation export control regime
* creating and verifying global nonproliferation & arms control inventory "map"
* nuclear knowledge management
* designing and testing global arms control regime and security strategies

Data Mining

* locating and modeling clandestine WMD programs
* creating and verifying global nonproliferation & arms control inventory "map"
* identifying and monitoring nonproliferation & arms control deviations (trade, finances, communication, movements, etc.)
* information collection & verification
* communication & networks analysis
* public reporting
* designing information exchange systems
* designing and testing global arms control & nonproliferation strategies

Figure 33

References

Accenture. (2012). *Mobile Web Watch Internet Usage Survey 2012 - Accenture - Accenture-Mobile-Web-Watch-Internet-Usage-Survey-2012.pdf*.

Acquisti, A., & Gross, R. (2009). Predicting Social Security numbers from public data. *Proceedings of the National academy of sciences, 106*(27), 10975-10980.

Albright, D., & Avagyan, R. (2012). *Further Activity at Suspected Parchin Explosive Testing Complex: Two Small Buildings Razed*: Institute for Science and International Security.

Allstate. (2012). Allstate/National Journal NEW POLL: Americans Using Social Media Are More Engaged Consumers and Citizens, But...

Anderson, C. (2008). The end of theory. *Wired Magazine, 16*.

Antikainen, M. J., & Vaataja, H. K. (2010). Rewarding in open innovation communities–how to motivate members. *International Journal of Entrepreneurship and Innovation Management, 11*(4), 440-456.

Aral, S., & Walker, D. (2012). Identifying influential and susceptible members of social networks. *Science, 337*(6092), 337-341.

Archak, N. (2010). *Money, glory and cheap talk: analyzing strategic behavior of contestants in simultaneous crowdsourcing contests on TopCoder. com.* Paper presented at the Proceedings of the 19th international conference on World wide web.

Auter, P., Arafa, M., & Al-Jaber, K. (2004). Who is Al Jazeera's audience? Deconstructing the demographics and psychographics of an Arab satellite news network. *Transnational Broadcasting Studies, 12*.

Backstrom, L., Boldi, P., Rosa, M., Ugander, J., & Vigna, S. (2011). Four degrees of separation. *arXiv preprint arXiv:1111.4570*.

Bakshy, E., Rosenn, I., Marlow, C., & Adamic, L. (2012). *The role of social networks in information diffusion.* Paper presented at the Proceedings of the 21st international conference on World Wide Web.

Barabási, A. L., & Albert, R. (1999). Emergence of scaling in random networks. *science, 286*(5439), 509-512.

Barnes, J. (1954). Class and Committees in a Norwegian Island Parish. *Human Relations, 7*, 39-58.

Barrington, L. (2012). Timeline of Satellite Search and Rescue | Tomnod, *tomnod blog*.

Battelle, J. (2005). *The Search: How Google and Its Rivals Rewrote the Rules of Business andTransformed Our Culture*: Portfolio.

Beer, D. (2008). Social network(ing) sites…revisiting the story so far: A response to danah boyd & Nicole Ellison. *Journal of Computer‐Mediated Communication, 13*(2), 516-529.

Beevolve. (2012). *An Exhaustive Study of Twitter Users Across the World - Beevolve, Social Media Analytics Platform*, from http://www.beevolve.com/twitter-statistics/

Berger, J. (2013). *Contagious: Why Things Catch On*: Simon & Schuster.

Bonchi, F., Castillo, C., Gionis, A., & Jaimes, A. (2011). Social network analysis and mining for business applications. *ACM Transactions on Intelligent Systems and Technology (TIST), 2*(3), 22.

Bond, R. M., Fariss, C. J., Jones, J. J., Kramer, A. D. I., Marlow, C., Settle, J. E., et al. (2012). A 61-million-person experiment in social influence and political mobilization. *Nature, 489*(7415), 295-298.

Borders, R. W. (2012). *Enemies of the Internet*: Reporters Without Borders.

Boyd, D., & Crawford, K. (2011). *Six Provocations for Big Data*.Unpublished manuscript.

boyd, d. m., & Ellison, N. B. (2007). Social Network Sites: Definition, History, and Scholarship. *Journal of Computer‐Mediated Communication, 13*(1), 210-230.

Brabham, D. C. (2008). Crowdsourcing as a model for problem solving an introduction and cases. *Convergence: The International Journal of Research into New Media Technologies, 14*(1), 75-90.

Brabham, D. C. (2012). The Myth of Amateur Crowds. *Information, Communication & Society, 15*(3), 394-410.

Butler, P. (2010). Visualizing Friendships, *Facebook Engineering* (Vol. 2013).

Camerer, C. F., & Johnson, E. J. (1997). 10 The process-performance paradox in expert judgment: How can experts know so much and predict so badly? *Research on judgment and decision making: Currents, connections, and controversies*, 342.

Carlsson, J. (2010). *An Assessment of Social Media Business Models and Strategic Implications for Future Implementation.* Oxford (Saïd Business School).

Carmichael, M. (2011). The Demographics of Facebook, LinkedIn, MySpace and Twitter | Ad Age Stat - Advertising Age, *AdAge blogs*.

Carneiro, H. A., & Mylonakis, E. (2009). Google trends: a web-based tool for real-time surveillance of disease outbreaks. *Clinical infectious diseases, 49*(10), 1557-1564.

Cha, M., Haddadi, H., Benevenuto, F., & Gummadi, K. P. (2010). *Measuring user influence in twitter: The million follower fallacy.* Paper presented at the 4th international aaai conference on weblogs and social media (icwsm).

Chang, K. T. T., Chen, W., & Tan, B. C. Y. (2012). Advertising Effectiveness in Social Networking Sites: Social Ties, Expertise, and Product Type. *IEEE Transactions on Engineering Management, 59*(4), 634-643.

Chapman, C. N., & Lahav, M. (2008). *International ethnographic observation of social networking sites.* Paper presented at the CHI'08 Extended Abstracts on Human Factors in Computing Systems.

Cheswick, W. (2013). Rethinking passwords. *Communications of the ACM, 56*(2), 40-44.

Chohan, R. (2009). Madagascar: an SMS away from the news, *The Ground Floor*.

Clarke, K. (1999). *Project CORONA, Clandestine Roots of Earth Science*, from http://www.geog.ucsb.edu/~kclarke/Corona/Corona.html

Clauset, A., Newman, M. E., & Moore, C. (2004). Finding community structure in very large networks. *Physical review E, 70*(6), 066111.

Colley, A., Banton, L., Down, J., & Pither, A. (1992). An expert-novice comparison in musical composition. *Psychology of Music, 20*(2), 124-137.

Cook, D., Holder, L., Thompson, S., Whitney, P., & Chilton, L. (2009). Graph-Based Analysis of Nuclear Smuggling Data. *Journal of Applied Security Research, 4*(4), 501-517.

Croft, S. (1996). *Strategies of arms control: a history and typology*: Manchester University Press.

de Montjoye, Y.-A., Hidalgo, C. A., Verleysen, M., & Blondel, V. D. (2013). Unique in the Crowd: The privacy bounds of human mobility. *Scientific reports, 3*.

Deibert, R., & Rohozinski, R. (2010). Control and subversion in Russian cyberspace. *Access Controlled: The Shaping of Power, Rights, and Rule in Cyberspace*, 15-34.

Delbecq, A. L., & Van de Ven, A. H. (1971). A group process model for problem identification and program planning. *The Journal of Applied Behavioral Science, 7*(4), 466-492.

Doty, D. H., & Glick, W. H. (1994). TYPOLOGIES AS A UNIQUE FORM OF THEORY BUILDING: TOWARD IMPROVED UNDERSTANDING AND MODELING. *Academy of Management Review, 19*(2), 230-251.

Downs, J. S., Holbrook, M. B., Sheng, S., & Cranor, L. F. (2010). *Are your participants gaming the system?: screening mechanical turk workers.* Paper presented at the Proceedings of the 28th international conference on Human factors in computing systems.

Duggan, M., & Brenner, J. (2013). *The Demographics of Social Media Users — 2012 | Pew Research Center's Internet & American Life Project*.

Erdős, P., & Rényi, A. (1960). On the evolution of random graphs. *Magyar Tud. Akad. Mat. Kutató Int. Közl, 5*, 17-61.

Facebook. (2013). *About*. Retrieved 9/5/2013, 2013, from https://www.facebook.com/facebook

Faris, S. (2012). The Hackers of Damascus. *Bloomberg Businessweek*.

Fayyad, U., Piatetsky-Shapiro, G., & Smyth, P. (1996). From Data Mining to Knowledge Discovery in Databases, *AI Magazine*: American Association for Artificial Intelligence.

Feinerer, I., & Hornik, K. (2013). tm: Text Mining Package (Version 0.5-9.1).

Fellows, I. (2013). wordcloud: Word Clouds (Version 2.4).

Fong, M. W. (2009). Digital divide between urban and rural regions in China. *The Electronic Journal of Information Systems in Developing Countries, 36*.

Fragoso, S. (2006). WTF a crazy Brazilian invasion. *Proceedings of CATaC*, 255-274.

Freeman, L. C. (1988). COMPUTER PROGRAMS AND SOCIAL NETWORK ANALYSIS. *Connections, 11*(2).

Furuholt, B., & Kristiansen, S. (2007). A rural-urban Digital Divide? Regional aspects of Internet use in Tanzania. *The Electronic Journal of Information Systems in Developing Countries, 31*.

Gale, A. (2013). Satellite Images Suggest North Korea Reactor Activity, *Wall Street Journal Asia* (Vol. 2013).

Gao, H., Barbier, G., & Goolsby, R. (2011). Harnessing the crowdsourcing power of social media for disaster relief. *Intelligent Systems, IEEE, 26*(3), 10-14.

Geiger, D., Seedorf, S., Schulze, T., Nickerson, R., & Schader, M. (2011). *Managing the crowd: towards a taxonomy of crowdsourcing processes.* Paper presented at the Proceedings of the 17th Americas Conference on Information Systems, Detroit.

Gentry, J. (2013). twitteR: R based Twitter client (Version 1.1.7).

Gilbert, E., Karahalios, K., & Sandvig, C. (2008). *The network in the garden: an empirical analysis of social media in rural life.* Paper presented at the Proceedings of the twenty-sixth annual SIGCHI conference on Human factors in computing systems.

Gladwell, M. (2006). *The tipping point: How little things can make a big difference*: Little, Brown.

Gladwell, M. (2010). Small change. Why the revolution won't be tweeted. *The New Yorker, 4*.

Gold, J., Pedrana, A. E., Sacks-Davis, R., Hellard, M. E., Chang, S., Howard, S., et al. (2011). A systematic examination of the use of online social networking sites for sexual health promotion. *BMC public health, 11*(1), 583.

Goldsmith, J., & Wu, T. (2006). *Who controls the Internet?: illusions of a borderless world*: Oxford University Press, USA.

Google. (2012). *Google Transparency Report*, from http://www.google.com/transparencyreport/removals/government/

Goolsby, R. (2010). Social media as crisis platform: The future of community maps/crisis maps. *ACM Trans. Intell. Syst. Technol., 1*(1), 1-11.

Gottemoeller, R. (2012). Arms Control in the Information Age.

Graham, P. (2005). *Web 2.0*. Retrieved 2/8/2013, from http://www.paulgraham.com/web20.html

Granovetter, M. S. (1973). The strength of weak ties. *American journal of sociology*, 1360-1380.

Harel, D., & Koren, Y. (2001). *A fast multi-scale method for drawing large graphs.* Paper presented at the Graph drawing.

Harris, C. (2011). *You're hired! an examination of crowdsourcing incentive models in human resource tasks.* Paper presented at the WSDM Workshop on Crowdsourcing for Search and Data Mining (CSDM).

Hawksey, M. (2013). Twitter Archiving Google Spreadsheet (TAGS) (Version 5.0).

Hayek, F. A. (1945). The use of knowledge in society. *The American Economic Review*, 519-530.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world. *Behavioral and Brain Sciences, 33*(2-3), 61-83.

Herwig, C. (2013). Real Time Imagery via MapBox Satellite Live, *MapBox Blog*.

House, F. (2013). *Freedom in the World 2013*: Freedom House.

Howard, P., Agarwal, S., & Hussain, M. (2011). *When Do States Disconnect Their Digital Networks? Regime Responses to the Political Uses of Social Media*.Unpublished manuscript.

Howe, J. (2006). Crowdsourcing: A Definition, *Crowdsourcing*.

Huberman, B. A., Romero, D. M., & Wu, F. (2009). Crowdsourcing, attention and productivity. *Journal of Information Science, 35*(6), 758-765.

Instagram. (2013). *About Us*. Retrieved 9/5/2013, from http://instagram.com/about/us/#

ITU. (2012). *Yearbook of Statistics - Telecommunication/ICT Indicators - 2002-2011* (38th ed.): International Telecommunication Union.

Jain, S. (2012). *40 Most Popular Social Networking Sites of the World | Social Media Today*. Retrieved 2/11/2013, from http://socialmediatoday.com/node/195917

Johnson, J. P. (2013). Targeted advertising and advertising avoidance. *The RAND Journal of Economics, 44*(1), 128-144.

Kadushin, C. (2012). *Understanding Social Networks:Theories, Concepts, and Findings: Theories, Concepts, and Findings*: Oxford University Press, USA.

Kapelner, A., & Chandler, D. (2010). *Preventing Satisficing in online surveys.* Paper presented at the Proceedings of.

Karmali, L. (2013). *World of Warcraft Down to 7.7 Million Subscribers*, from http://www.ign.com/articles/2013/07/26/world-of-warcraft-down-to-77-million-subscribers

Katz, E. (1957). The two-step flow of communication: An up-to-date report on an hypothesis. *Public Opinion Quarterly, 21*(1), 61-78.

Katz, E., & Lazarsfeld, P. F. (1955). *Personal influence: The part played by people in the flow of mass communications*. Glencoe, IL: Free Press.

Keim, D. A. (2002). Information visualization and visual data mining. *Visualization and Computer Graphics, IEEE Transactions on, 8*(1), 1-8.

Kietzmann, J. H., Hermkens, K., McCarthy, I. P., & Silvestre, B. S. (2011). Social media? Get serious! Understanding the functional building blocks of social media. *Business Horizons, 54*(3), 241-251.

Kleinfeld, J. S. (2002). The small world problem. *Society, 39*(2), 61-66.

Kohavi, R., Longbotham, R., Sommerfield, D., & Henne, R. M. (2009). Controlled experiments on the web: survey and practical guide, *Data Mining and Knowledge Discovery*. Berlin: Springer.

Kwak, H., Lee, C., Park, H., & Moon, S. (2010). *What is Twitter, a social network or a news media?* Paper presented at the Proceedings of the 19th international conference on World wide web.

Kwok, L., & Yu, B. (2012). Spreading Social Media Messages on Facebook: An Analysis of Restaurant Business-to-Consumer Communications. *Cornell Hospitality Quarterly*.

Lackey, J. (2006). *Microsoft Flight Simulator X Review*. Retrieved 8/23/2013, 2013, from http://www.gamespot.com/microsoft-flight-simulator-x/reviews/microsoft-flight-simulator-x-review-6159886/

Laningham. (2006). IBM developerWorks Interview: Tim Berners-Lee [Podcast Transcript]: IBM.

Larkin, J., McDermott, J., Simon, D. P., & Simon, H. A. (1980). Expert and novice performance in solving physics problems. *Science, 208*(4450), 1335-1342.

Lavers, C. (2013, 1/24/2103). The Origins of High Resolution Commercial Satellite Imagery. *Directions*.

Lazarsfeld, P. F., Berelson, B., & Gaudet, H. (1944). The people's choice: How the voter makes up his mind in a presidential election. *New York: Duell, Sloan and Pearce*.

Lee, P. (2011). *Asia Times Online :: China tunnel and nuclear warhead follies*, from http://www.atimes.com/atimes/China/ML10Ad01.html

Leskovec, J., Adamic, L. A., & Huberman, B. A. (2007). The dynamics of viral marketing. *ACM Transactions on the Web (TWEB), 1*(1), 5.

Levinson, P. (2013). *NEW NEW MEDIA* (2ND ED. ed.). Upper Saddle River: PEARSON.

Lewis, L. (2012, 5/19/2012). How China's 300m microbloggers are shaking the system*,* p. ASIA.

Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2004). *Remote sensing and image interpretation*: John Wiley & Sons Ltd.

Lim, M. (2012). Clicks, cabs, and coffee houses: Social media and oppositional movements in Egypt, 2004–2011. *Journal of Communication, 62*(2), 231-248.

Lim, Y.-H. (2012). Facebook in Asia: Growth Deceleration Continues [Latest Stats], *Forbes Tech* (Vol. 2013).

LiveInternet. (2013). *LiveInternet.ru Site Statistics*. Retrieved 4/18/2013, from http://www.liveinternet.ru/stat/ru/searches.html?slice.ru

Loomer, J. (2012). Detailed History of Facebook Changes 2004-12 [Research], *Jonloomer.com* (Vol. 2013).

Lunden, I. (2013). Analyst: Twitter Passed 500M Users In June 2012, 140M Of Them In US; Jakarta 'Biggest Tweeting' City | TechCrunch, *Tech Crunch*.

Macedonia, M. (2002). Games, Simulation, and the Military Education Dilemma.

MacKinnon, R. (2011). China's Networked Authoritarianism. *Journal of Democracy, 22*(2), 32-46.

Madden, M., & Fox, S. (2006). Riding the waves of "Web 2.0.". *Pew Internet & American Life Project*, 1-6.

Malone, T., Laubacher, R., & Dellarocas, C. (2009). *Harnessing Crowds: Mapping the Genome of Collective Intelligence*.

Marshall, B., Cardon, P., Norris, D., Goreva, N., & D'Souza, R. (2008). Social networking websites in India and the United States: a cross-national comparison of online privacy and communication. *Issues in Information Systems, IX, 2*, 87-94.

Martin, D., Allan, J., Newton, J., Jones, D., Mikulak, S., Mayorga, E., et al. (2011). *Using web-based and social networking technologies to disseminate coastal hazard mitigation information within the Pacific Northwest component of the Integrated Ocean Observing System (IOOS).* Paper presented at the OCEANS 2011.

May, R. (2010). *The Data Liberation Movement*. Retrieved 9/2/2013, 2013, from http://www.technewsworld.com/story/70844.html

McGonigal, J. (2013). IBM Connect 2013 Session on Gamification. Youtube.

McKeithen, K. B., Reitman, J. S., Rueter, H. H., & Hirtle, S. C. (1981). Knowledge organization and skill differences in computer programmers. *Cognitive Psychology, 13*(3), 307-325.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual review of sociology*, 415-444.

Milgram, S. (1967). The small world problem. *Psychology today, 2*(1), 60-67.

Millward, S. (2012). *8 Facts About Sina Weibo Users That All Marketers Should Know*. Retrieved 7/29/2013, 2013, from http://www.techinasia.com/sina-weibo-users-facts-marketers/

Mintzberg, H., & Waters, J. A. (1985). Of strategies, deliberate and emergent. *Strategic management journal, 6*(3), 257-272.

Mitchell, J. C. (1974). Social Networks. *Annual Review of Anthropology, 3*(ArticleType: research-article / Full publication date: 1974 / Copyright © 1974 Annual Reviews), 279-299.

Morozov, E. (2011). *The Net Delusion: How not to liberate the world*: Penguin.

Morstatter, F., Pfeffer, J., Liu, H., & Carley, K. M. (2013). Is the Sample Good Enough? Comparing Data from Twitter's Streaming API with Twitter's Firehose. *arXiv:1306.5204*.

Narayanan, A., & Shmatikov, V. (2009). *De-anonymizing social networks.* Paper presented at the Security and Privacy, 2009 30th IEEE Symposium on.

Naroditskiy, V., Jennings, N. R., Van Hentenryck, P., & Cebrian, M. (2013). *Crowdsourcing Dilemma*.Unpublished manuscript.

Naughton, J. (2011). We're going to miss you, Web 2.0. You've been the perfect host*. The Observer,* p. 21.

Navalny, A. (2013). Vashington ili Chukotka [Washington or Chukotka], *Navalny*: LiveJournal.

O'Carroll, L. (2012, 2012-10-26). NYT's little problem in big China*. The Guardian*.

Ohm, P. (2010). Broken promises of privacy: Responding to the surprising failure of anonymization. *UCLA Law Review, 57*, 1701.

Orkut. (2013). *orkut - About*. Retrieved 8/22/23, from http://www.orkut.com/Main#About?page=keep

Park, E., Mohan, R., & Ponnusamy, V. (2009). *Facilitating Learning Through Web 2.0 Collaboration-Cases Across the Culture.* Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications.

Patton, T. (2012). Combining Satellite Imagery and 3D Drawing Tools for Nonproliferation Analysis: A Case Study of Pakistan's Khushab Plutonium Production Reactors. *Science & Global Security, 20*(2-3), 117-140.

Peckham, M. (2011). Foldit Gamers Solve AIDS Puzzle That Baffled Scientists for a Decade, *Time Magazine*: Time Inc.

Pittman, T. S., Emery, J., & Boggiano, A. K. (1982). Intrinsic and extrinsic motivational orientations: Reward-induced changes in preference for complexity. *Journal of Personality and Social Psychology, 42*(5), 789.

Prell, C. (2011). *Social Network Analysis: History, Theory and Methodology*: Sage Publications Limited.

Raymond, E. (1999). The cathedral and the bazaar. *Knowledge, Technology & Policy, 12*(3), 23-49.

Read, L. (1958). I, Pencil: My family tree as told to Leonard E. *Read. Irvington-on-Hudson: Foundation for Economic Education*.

Rinker, T. W. (2013). qdap: Quantitative Discourse Analysis Package (Version 0.2.3). Buffalo, New York: University at Buffalo.

Rispoli, M. (2013). Blog | Access, *Access* (Vol. 2013).

Rogers, E. M. (1995). *Diffusion of Innovations, Fourth Edition* (4th ed.): Free Press.

Ruth, S. (2012). Is There a Digital Divide? Check the Numbers. *Internet Computing, IEEE, 16*(4), 80-83.

R_Core_Team. (2013). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Salganik, M. J., Dodds, P. S., & Watts, D. J. (2006). Experimental study of inequality and unpredictability in an artificial cultural market. *science, 311*(5762), 854-856.

Schmidt, E., & Cohen, J. (2013). *The New Digital Age: Reshaping the Future of People, Nations, and Business*. New York: Knopf.

Schnettler, S. (2009). A small world on feet of clay? A comparison of empirical small-world studies against best-practice criteria. *Social Networks, 31*(3), 179-189.

Schwirtz, M., & Philips, J. K. (2006). Putin Goes Online for Chat, and Russians Want to Know*. The New York Times*.

Shalal-Esa. (2013). Pentagon sees doubled cost for rocket launch program*. Reuters*.

Sharma, A. (2010). Crowdsourcing Critical Success Factor Model: London School of Economics.

Silberman, M., Irani, L., & Ross, J. (2010). Ethics and tactics of professional crowdwork. *XRDS: Crossroads, The ACM Magazine for Students, 17*(2), 39-43.

Singel, R. (2011). Egypt Shut Down Its Net With a Series of Phone Calls. *Wired*.

Smith, M. (2013a). *NodeXL Graph Gallery*. Retrieved 4/29/2013, 2013, from http://nodexlgraphgallery.org/Pages/Graph.aspx?graphID=4383

Smith, M. (2013b). Structures of Twitter Crowds and Conversations: Social Media Research Foundation.

Smith, M., Milic-Frayling, N., Shneiderman, B., Mendes Rodrigues, E., Leskovec, J., & Dunne, C. (2010). NodeXL: a free and open network overview, discovery and exploration add-in for Excel 2007/2010: Social Media Research Foundation.

Stenger, T., & Coutant, A. (2009). *Social Network Sites (SNS): do they match? Definitions and methods for social sciences and marketing research.* Paper presented at the Sunbelt XXIX, Annual Conference of the INSNA.

Stephen, A., & Lehmann, D. (2012). *Using Incentives to Encourage Word-of-Mouth Transmissions that Lead to Fast Information Diffusion*: Columbia University.

Sudhof, M. (2012). Politics, Twitter, and information discovery: Using content and link structures to cluster users based on issue framing, *Stanford Undergraduate Research Journal*.

Sundararajan, A. (2013). From Zipcar to the Sharing Economy, *HBR Blog Network*: Harvard Business Review.

Surowiecki, J. (2004). *Q & A with James Surowiecki*. Retrieved 2/7/2013, from http://www.randomhouse.com/features/wisdomofcrowds/Q&A.html

Surowiecki, J. (2004). *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations*: Knopf Doubleday Publishing Group.

Sweeney, L. (2000). Uniqueness of simple demographics in the US population. *LIDAP-WP4. Carnegie Mellon University, Laboratory for International Data Privacy, Pittsburgh, PA*.

Tang, J. C., Cebrian, M., Giacobe, N. A., Kim, H.-W., Kim, T., & Wickert, D. B. (2011). Reflecting on the DARPA red balloon challenge. *Communications of the ACM, 54*(4), 78-85.

Tech, V. (2010). *Visionarium VisCube*, 2013, from http://snoid.sv.vt.edu/visionarium/

Tomnod. (2012). *About*. Retrieved 8/14/2013, from http://www.old.tomnod.com/?q=about

Ushahidi. (2013). *About Us | Ushahidi*, from http://ushahidi.com/about-us

Vitaliev, D. (2008). Vaulting the great firewall*. The Guardian*.

Wagner, C., & Vinaimont, T. (2010). Evaluating the Wisdom of Crowds. *Issues in Information Systems, XI*(1), 724-731.

Walter, T., & Back, A. (2011). *Towards Measuring Crowdsourcing Success: An Empirical Study on Effects of External Factors in Online Idea Contest.* Paper presented at the Proceedings of 6th Mediterranean Conference on Information Systems (MCIS'11).

Wasserman, H. (2007). Is a New Worldwide Web Possible? An Explorative Comparison of the Use of ICTs by Two South African Social Movements. *African Studies Review, 50*(1), 109-131.

Watts, D. (2007). Challenging the influentials hypothesis. *WOMMA Measuring Word of Mouth, 3*(4), 201-211.

Watts, D., & Strogatz, S. (1998). Collective dynamics of'small-world'networks. *Nature, 393*(6684), 440-442.

Watts, D. J. (2004). *Six degrees: The science of a connected age*: WW Norton.

Watts, D. J., & Dodds, P. S. (2007). Influentials, networks, and public opinion formation. *Journal of consumer research, 34*(4), 441-458.

Watts, D. J., Peretti, J., & Frumin, M. (2007). *Viral marketing for the real world*: Harvard Business School Pub.

White, N. E. (2006). *The use of textual data mining in the detection of the proliferation of weapons of mass destruction.* George Mason University.

Wickham, H. (2009). *ggplot2: elegant graphics for data analysis*: Springer Publishing Company, Incorporated.

Wikipedia. (2013). *List of social networking websites - Wikipedia, the free encyclopedia*. Retrieved 8/5/2013, 2013, from http://en.wikipedia.org/wiki/Social-networking_sites

Wilson, R. E., Gosling, S. D., & Graham, L. T. (2012). A review of Facebook research in the social sciences. *Perspectives on Psychological Science, 7*(3), 203-220.

Witten, I. H., Frank, E., & Hall, M. A. (2011). *Data Mining: Practical Machine Learning Tools and Techniques: Practical Machine Learning Tools and Techniques*: Elsevier.

WorldBank. (2013). *The Little Data Book on Information and Communication Technology 2013*: World Bank Publications.

Wright, M. (2013). Google shows China the white flag of surrender (pp. BLOG). London: The Telegraph.

Wu, S., Hofman, J. M., Mason, W. A., & Watts, D. J. (2011). *Who says what to whom on twitter.* Paper presented at the Proceedings of the 20th international conference on World wide web.

Yoo, S. J., & David Huang, W.-h. (2011). Comparison of Web 2.0 Technology Acceptance Level based on Cultural Differences. *Journal of Educational Technology & Society, 14*(4), 241-252.

Zhao, Y. (2012). *R and Data Mining: Examples and Case Studies*: Academic Press.

Zhu, T., Phipps, D., Pridgen, A., Crandall, J. R., & Wallach, D. S. (2012). Tracking and Quantifying Censorship on a Chinese Microblogging Site. *arXiv preprint arXiv:1211.6166*.

Zhuo, X., Wellman, B., & Yu, J. (2011). Egypt: The First Internet Revolt? *Peace Magazine, 27*(3), 6-10.

Zittrain, J., & Palfrey, J. (2008). Internet filtering: The politics and mechanisms of control. *Access denied: The practice and policy of global internet filtering*, 29-57.

Zook, M., Graham, M., Shelton, T., & Gorman, S. (2012). Volunteered geographic information and crowdsourcing disaster relief: a case study of the Haitian earthquake. *World Medical & Health Policy, 2*(2), 7-33.

JAMES MARTIN CENTER FOR NONPROLIFERATION STUDIES
Monterey Institute of International Studies
460 Pierce Street
Monterey, CA 93940
USA

tel: 831.647.4154
fax: 831.647.3519

New Media Solutions in Nonproliferation and Arms Control: Opportunities and Challenges

Bryan Lee & Margarita Zolotova

2013