

## ORIGINAL ARTICLE

**Networks of Networks: Changing Patterns in Country Bandwidth and Centrality in Global Information Infrastructure, 2002–2010**Hyunjin Seo<sup>1</sup> & Stuart J. Thorson<sup>2</sup>

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*Linkages between countries have changed significantly as the global information infrastructure has evolved over the past decade. We argue that communication infrastructure and political processes evolve together, and in this study we attempt to measure key structural changes in bandwidth and the centrality of digital nodes in Middle East and North Africa. Using a combination of bandwidth metrics and centrality indicators, we demonstrate how global information infrastructure evolved between 2002 and 2010, and how several countries in the Middle East rose to prominence as good nodes mediating strong intraregional networks.*

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Information communication technologies (ICTs) such as the Internet have enabled citizens to create and share information and content without having to rely on traditional intermediaries such as government and the press. By opening new communication channels, the Internet played a significant role in political and social movements (Benkler, 2006; Chadwick & Howard, 2009; Howard, 2010). The “Arab Spring” of 2010 and 2011 has raised questions about the role of ICTs and, in particular, social media. Some have argued that social media helped enable these uprisings whereas others disagreed arguing “the revolution will not be tweeted” (Gladwell, 2010).

As Kranzberg argued, “technology is neither good nor bad, nor is it neutral” (1985, p. 50). It is not only activists, but also dictators and oppressors who take advantage of new ICTs (Lichtenstein, 2010; Morozov, 2010). However, the fact that a system allows access to digital-based ICTs has significant implications for governance. For example, based on his empirical analysis of developing nations with significant Muslim communities, Howard (2010, p. 201) concluded, “increasingly, the route to

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democratization is a digital one.” Although it may be too strong to argue that global changes in information infrastructure should be credited—or blamed—for social unrest, it is also a misstep to argue that this infrastructure had no role in the evolution of political protest in the Middle East.

Accounts of contemporary political change increasingly make reference to new patterns of communication between key actors. The most common approach to studying these changes is through the systematic analysis of content, changes in the structure of social networks in a community, or changes in the behavior of large numbers of people. At a much deeper level, however, the information infrastructure that connects nations can be measured and is worthy of attention in its own right. Most countries have a few Internet exchange points that connect their national network infrastructure to global flows of information. Often these exchange points are operated by the state or the national telecommunications provider, but increasingly they are operated by private contractors. These exchange points relay traffic to similar infrastructure in other countries, connecting the network of domestic digital technologies to an international network of countries.

A behavioral approach to communicative phenomena is important, but so too is the infrastructure in which communication occurs. A reasonable discussion about social media and political change must begin with some analysis of how connectivity between countries and within regions has changed in recent years. First, we examine changes in Internet connectivity over the past decade. Understanding how the networks of information infrastructure have changed globally is a prerequisite to understanding regional changes. Second, we examine changes in the ways that countries in North Africa and the Middle East are connected with each other and the rest of the world. Analyzing cross-country Internet connections matters as communication networks are key factors for mobilization, organization, and diffusion of political movements, and the Internet has become an important communication conduit in many parts of the world (Bennett, 2004; Chadwick & Howard, 2009; Howard, 2010; Moezzi, 2009). In the case of recent uprisings, there is evidence that activists in different countries shared their experiences through social media (Kirkpatrick & Sanger, 2011). However, there remains a need for empirical analyses of how countries in the Middle East and North Africa (MENA) have become woven into the fabric of the Internet. This study contributes to our understanding of the evolution of the Internet as it relates to recent changes in the MENA and, more generally, political movements in the age of information technology and global networks.

### **Networked information society and political movements**

Facilitated by increasingly available and affordable digital network-based communication tools, the ways people and organizations connect with one another have changed dramatically over the past 2 decades (Benkler, 2006; Castells, 1996, 2000, 2004; Soete & Weel, 2005; Webster, 2002). Castells (1996, 2000, 2004) uses the term *network society* to describe the impact of new information and communications technologies on different levels of interactions in society. In a similar vein,

Benkler (2006) argues that new digital technologies have brought about a *networked information economy* characterized by decentralization, nonproprietary strategies, nonmarket mechanisms, and more effective large-scale nonhierarchical cooperation. This networked information economy has resulted in an environment for public discourse where traditional mass media no longer maintain near exclusive control over “filtering” and “accreditation” (Benkler, 2006, p. 12). Citizens have become increasingly empowered to participate actively in the public sphere.

These characteristics of the networked information society have important implications for political and social movements. Most of all, the Internet has helped change the balance of power and the levels of freedom among actors because it is more resistant to state control and censorship than most traditional forms of mass media (Benkler, 2006, 2011; Howard, 2010). This greatly helped activists mobilize and organize their movements (Bennett, 2004; Chadwick & Howard, 2009; Howard, 2010; Moezzi, 2009). Young Egyptians were able to circumvent the state control of information by resorting to social media such as Facebook, and the result was an alternative public sphere for them. It is a shift from “the mass-mediated public sphere to a networked public sphere” (Benkler, 2006, p. 10).

Political movements in the networked information age also benefit from non-market peer production wherein decentralized and self-organized collaborations of individuals produce goods and services that are often made freely available to others without an expectation of direct material compensation (Benkler, 2006). During the recent events in the Middle East people in other countries collaborated with in-country protesters through online communication tools to produce and share information about the protests.

In addition, the Internet helps sustain both strong and weak network links for political mobilization (Benkler, 2011; Watts & Strogatz, 1998). Transnational network ties are facilitated, as the Internet makes communication and connections between ordinary citizens in different countries more affordable and available. Social media such as Facebook and Twitter helped Egyptians protesting at Tahrir Square and those following the news through social media feel a sense of community (Kirkpatrick & Sanger, 2011).

### **Global Internet connectedness**

The Internet has become a fundamental information infrastructure for contemporary social movements. Activists use digital communication tools to build and maintain social relations with and learn from their counterparts in other countries. Protesters relied on social media to share information about protest tactics and to spread inspiring stories of success (Kirkpatrick & Sanger, 2011). Walid Rachid, a member of the April 6 Youth Movement, was quoted as saying, “Tunis is the force that pushed Egypt, but what Egypt did will be the force that will push the world” (Kirkpatrick & Sanger, 2011, p. 1). One of the latest examples in the United States is Occupy Wall Street Movement where protesters used various forms of social media to organize the movement and keep the momentum (Ngak, 2011).

Contagion, the diffusion of innovation, and protest waves all depend on the communication network among actors (Myers, 2000; Nickerson, 2008; Valente, 1993). Although networks may have been difficult to empirically study in the past, an ever-increasing number of online databases and significant improvements in computing power have enabled researchers to investigate complicated social networks. For example, Barnett (2001) conducted a longitudinal analysis of the international telecommunications network from 1978 to 1996. His analysis showed that the international telecommunications network has become denser, more centralized, and highly integrated over time. An updated picture of international telecommunications networks was provided by Lee, Monge, Bar, and Matei (2007). They found that the international telecommunication network has evolved toward a decentralized structure with increased clusters within the network and increasing connectivity within peripheral nations.

TeleGeography's published annual surveys of Internet traffic and capacity show that overall international Internet bandwidth has increased from fewer than 5 terabytes per second (Tbps) in 2005 to about 25 Tbps in 2009, with an annual growth rate of 10% in 2005 and more than 80% in 2009 (TeleGeography, 2009). International Internet bandwidth refers to the amount of data that can be transferred over the Internet, across national borders, in a given amount of time. International Internet bandwidth can be considered a useful indicator of global Internet connectedness, especially as previous research has shown that Internet bandwidth and Internet traffic tend to correlate (Barnett & Park, 2005).

Increasingly, scholars are using network analysis to identify the structure of Internet-based connections among countries. For example, Townsend (2001) analyzed Internet bandwidth to find that most countries have a direct Internet connection with the United States, and that U.S. Internet infrastructure functions as "a massive switching station for traffic that originates and terminates in foreign countries" (p. 1701). Barnett and Park's (2005) study on interdomain hyperlinks and Internet bandwidth between different countries showed similar results. The United States was the most central nation both in the hyperlink network and the international Internet bandwidth network in the early 2000s. In their analysis of the structure of international Internet traffic in 1998 and its correlations with other sociocultural networks, Barnett, Chon, and Rosen (2001) found that the international Internet traffic structure was significantly related to the structure of international telecommunications, trade, science, and asynchrony. Another study investigated the relationship between national culture and the structure of international Internet linkages (Barnett & Sung, 2005).

This article focuses on the structure of global Internet connectedness with the goal of providing a foundation for subsequent behavioral analyses of this topic. In this vein, the following research questions are investigated. How has the pattern of global Internet connections changed over the past decade? Have the centrality and degree of the MENA in the global Internet increased over the past decade in an absolute sense and in relation to countries outside the region?

## Methods

The structure of the Internet connectedness is examined using network analysis—a set of procedures used to identify and measure structural properties of social systems based on relationships among entities in the system rather than on characteristics of the individual entities (Monge & Contractor, 2003; Newman, 2010; Rogers & Kincaid, 1981; Wasserman & Faust, 1994). Scholars have applied the concept of the network in analyzing issues related to global connectedness, including civil society (Anheier & Katz, 2005), transnational activism (Carpenter, 2007), international terrorism (Stohl & Stohl, 2007), diplomatic recognition, trade (Hafner-Burton, Kahler, & Montgomery, 2008), and international communication networks (Barnett, 2001; Barnett & Park, 2005; Barnett et al., 2001; Lee et al., 2007).

A network can be thought of as a set of nodes together with connections or links between these nodes. In this case, the nodes are countries and the links are direct Internet connections between the countries. Networks are commonly represented as graphs. A graph is directed if the edges (links between nodes) have a specific direction associated with them. A graph is undirected if the edges have no direction associated with them. This article assumes that graphs representing direct Internet connections are undirected as IP packets can flow in either direction through the links. Strength indicates the magnitude of the relationship and in this research it is measured by the Internet bandwidth capacity of each link.

One property of a network is the number of direct links a given node has. This number is termed the degree of the node. So a node that is directly connected to five other nodes would have a degree of 5. The density of a network is a central concept for defining global connectedness. The density of a network attempts to capture how interconnected a network is by showing the ratio of actual network links to possible network links (Newman, 2010). In an undirected network, the density is calculated by this formula:  $2*M/(V*[V-1])$ . In this formula,  $V$  refers to the number of nodes and  $M$  refers to the number of links.

Centrality measures are used to identify the most important, or “central,” nodes in a network (Newman, 2010). Many different measures of centrality have been suggested, and they include degree centrality, eigenvector centrality, betweenness centrality, closeness centrality, Katz, and Page Rank centrality (for a very readable overview of centrality measures, see Newman, 2010). Degree centrality and eigenvector centrality are two of the most widely used measures. A node’s degree centrality refers to the number of edges connected to it, giving one centrality point for every network neighbor a node has. Thus degree centrality is a relatively simple measure of centrality. Eigenvector centrality is more sophisticated than degree centrality and takes into account the importance, not only the number, of edges connected to a node in determining the node’s centrality. So a node’s centrality score is proportional to the sum of the scores of its neighbors.

To describe the structure of the international Internet bandwidth network, the authors conducted longitudinal analyses of density, degree, and eigenvector centrality from 2002 to 2010. Graphs and statistics were calculated in R (R Development Core

Team, 2011) and networks were visualized using Gephi (Bastian, Heymann, & Jacomy, 2009).

Global Internet geography data obtained from TeleGeography were used to measure transnational Internet connections. Specifically, the authors analyzed country-to-country Internet bandwidth data from 2002 to 2010. Bandwidth refers to capacity and thus is an upper bound on actual bit flows. Given the time necessary to increase capacity, bandwidth also acts as a leading indicator for traffic. It is also important to remember that although the Internet is a packet switched network, the analysis in this article focuses only on direct connections between countries. The number of countries reporting Internet bandwidth greater than 0 was 187 in 2002 and 201 in 2010.

## Results

Analysis of Internet bandwidth data identified interesting characteristics of connections among countries. First of all, the total amount of international Internet bandwidth has significantly increased in a manner reminiscent of the familiar power law from 931,319 Mbps (megabytes per second) in 2002 to 37,424,671 Mbps (about 36 Tbps) in 2010. A graphic representation of the international Internet bandwidth network for 2002 and 2010 based on node eigenvector centrality scores is presented in Figures 1 and 2. For the brevity of presentation, only countries with connections of degree 4 or greater in each year are shown in the figures. In the graphs, the diameter of the node is proportional to the node's eigenvector centrality. To denote countries, ISO 3166-1 alpha-2 codes using the English short country names were used.

The United States was the most important country in the 2002 Internet network based on both eigenvector centrality and degree. The eigenvector centrality of the United States was 1 and the degree was 124 in 2002. Following the United States in terms of eigenvector centrality were the United Kingdom, Germany, France, Italy, Singapore, Netherlands, and China.

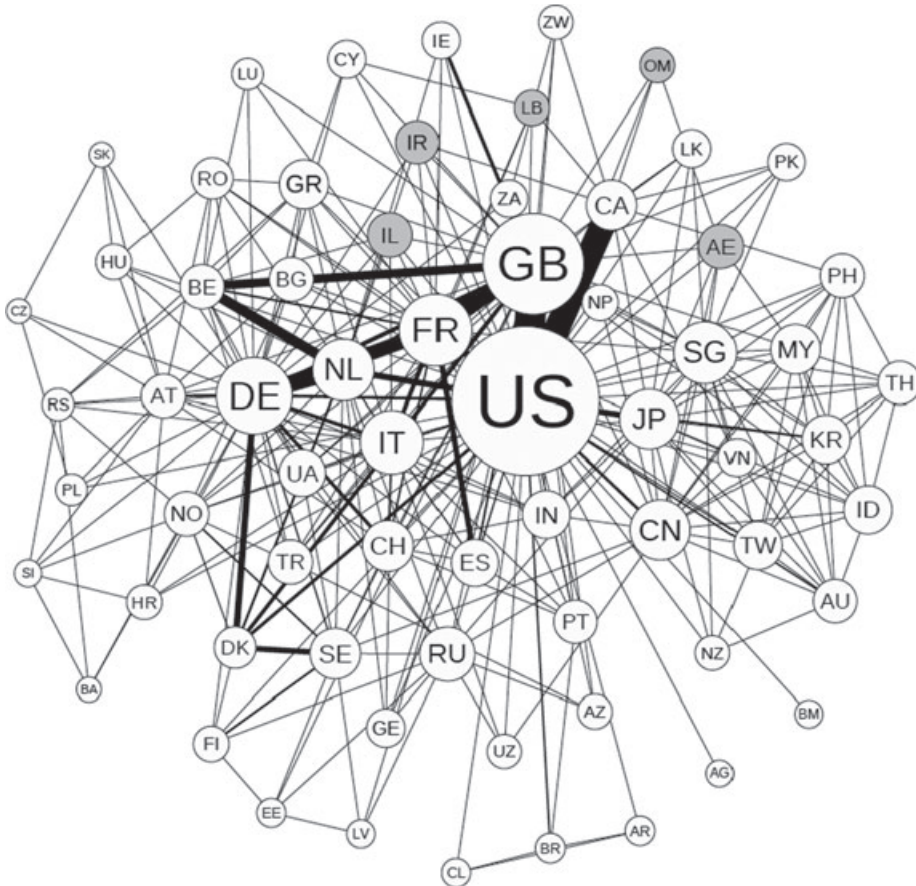
In 2010, the United States maintained the highest degree with 94, but its eigenvector centrality (0.970) was second to the United Kingdom (1). Germany, China, Singapore, and Italy followed the United States in eigenvector centrality scores. In addition, compared with the 2002 network, more countries with degree 4 or greater appeared in the 2010 network (Figure 2).

The density of the global Internet network was 0.030 in 2002 and it rose to 0.034 in 2010. Although the values are not much different, it is important to understand that the density was maintained at that level despite the increasing number of the countries in the global Internet network. This is perhaps especially interesting in that the overall density actually increased over time (with the exception of 2002–2003) even as more countries were reporting being connected.

### Middle East and North Africa

Total international Internet bandwidth within the MENA region has increased considerably between 2002 and 2010.<sup>1</sup> The total MENA bandwidth was 2,096 Mbps

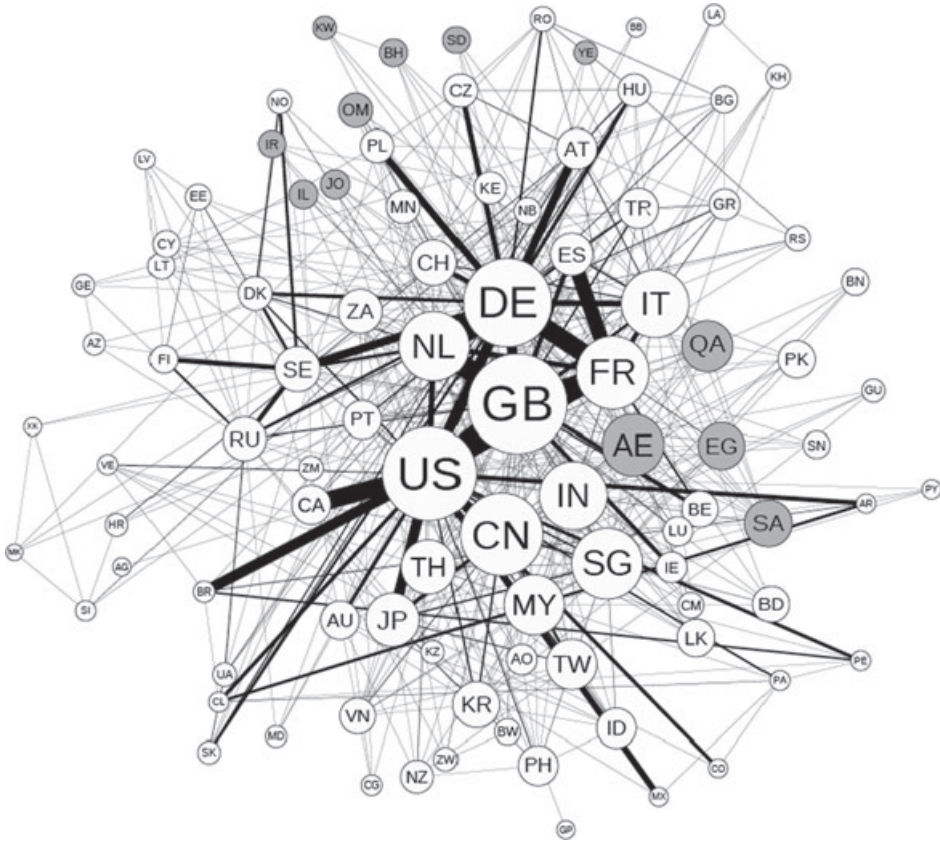




**Figure 1** Global Internet structure in 2002. For brevity of presentation, only countries with connections of degree 4 or greater are shown in the figure. The diameter of the node is proportional to the node’s eigenvector centrality. Nodes in gray represent MENA countries. To denote countries, ISO 3166-1 alpha-2 codes using the English short country names are used.

in 2002 and increased to 375,798 Mbps in 2010. The growth in the Internet bandwidth within the region showed a power-law pattern similar to that found in worldwide bandwidth capacity. As Figure 2 demonstrates, quite a few MENA countries moved toward the center between 2002 and 2010. These MENA countries include the United Arab Emirates, Qatar, Egypt, and Saudi Arabia.

Figure 3 displays eigenvector centralities of MENA countries in comparison with other countries between 2002 and 2010. In Figure 3, the dotted gray line indicates the overall mean eigenvector centrality score for the given year. As shown in Figure 3, eigenvector centralities of several MENA countries have increasingly gotten greater than the overall mean eigenvector centrality of the world in 2008, 2009, and 2010. The *x*-axis in this figure represents the countries (nodes) in each year’s dataset. The

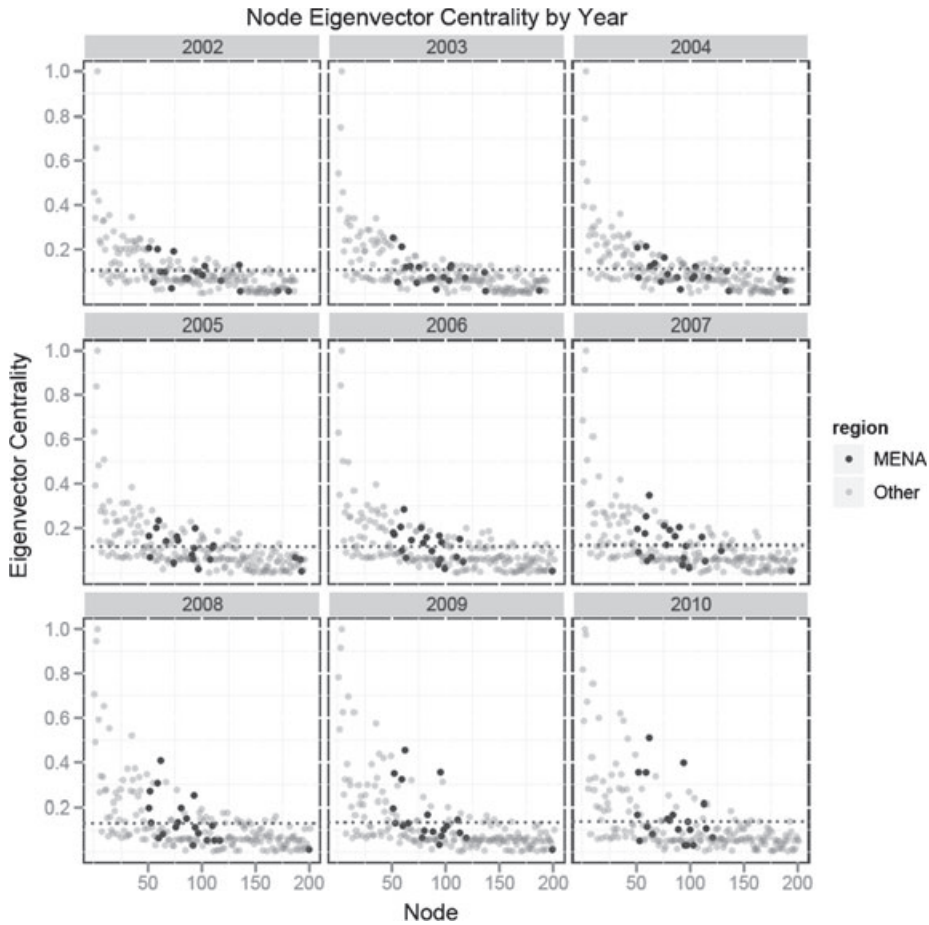


**Figure 2** Global Internet structure in 2010. For brevity of presentation, only countries with connections of degree 4 or greater in are shown in the figure. The diameter of the node is proportional to the node's eigenvector centrality. Nodes in gray represent MENA countries. To denote countries, ISO 3166-1 alpha-2 codes using the English short country names are used.

$y$ -axis represents eigenvector centrality scores. Dotted gray line indicates the mean eigenvector centrality score for all countries that year. Dots in black represent MENA countries. For the non-MENA countries, darker areas of gray reflect overlapping centrality scores. Figure 3 is interesting because it reveals that although the mean centrality score for all the countries in the sample has been fairly constant between 2002 and 2010, some MENA countries, such as the United Arab Emirates, Qatar, and Egypt, became more important nodes in the network over time.

In 2002, Israel showed the highest eigenvector centrality (0.207) among the MENA countries whose data were available. Israel was followed by the United Arab Emirates (0.202), Iran (0.192), Lebanon (0.130), Oman (0.126), Saudi Arabia (0.099), Egypt (0.099), Bahrain (0.099), Yemen (0.088), Kuwait (0.084), Qatar (0.072), Syria (0.070), Jordan (0.060), Morocco (0.052), Algeria (0.025), Libya (0.014), Palestine Territory





**Figure 3** Node eigenvector centrality 2002–2010.

(0.012), and Sudan (0.012). The United Arab Emirates showed the highest degree with 12, and the degree of Israel was 8. Data for Iraq and Tunisia were not available for 2002.

By 2010, the place of MENA countries in global information infrastructure had changed in interesting ways, both relative to the important information node of the United States and relative to each other. The United Arab Emirates emerged as the most important MENA country both in terms of eigenvector centrality (0.510) and degree (21). Moreover, Qatar (0.398) and Egypt (0.355) rose to become top three countries based on eigenvector centrality. They were followed by Saudi Arabia (0.354), Oman (0.215), Israel (0.167), Jordan (0.167), Bahrain (0.149), Iran (0.142), Sudan (0.136), Tunisia (0.113), Yemen (0.105), Kuwait (0.101), Lebanon (0.099), Algeria (0.080), Iraq (0.064), Morocco (0.050), Libya (0.030), Palestine Territory (0.030), and Syria (0.030). It is important to note that international Internet bandwidth for Egypt and Tunisia, at the forefront of the Arab Spring, has significantly increased during the period.

## Discussion

On the basis of an empirical analysis of global Internet connectedness for the past decade, this study has several important implications for research on social media and political activism. The structural analysis of the global Internet network in this study provides an important foundation for subsequent behavioral analyses of the role of social media in political movements. Although increased global connectedness through the Internet is a key assumption of many studies arguing the increased role of social media in political activism, few studies have tested the assumption empirically. This study's network analysis of international Internet bandwidth between 2002 and 2010 shows that global Internet connectedness has grown significantly during the period and has done so in an interestingly patterned way. Although there were variations in terms of countries positioned at the center of the Internet network, in general the countries that were central in the 2002 network generally remained so in 2010. These countries include the United States, the United Kingdom, Germany, France, China, Italy, and Singapore. It is likely that connections of those countries will grow faster than those in the periphery of the network.

The rich-getting-richer phenomenon is a commonly observed feature of naturally occurring networks (Barabási, 2002). This has important implications for diplomacy, trade, and global activism in the age of information technology and online social networking. For example, this suggests that countries that use these technologies effectively will, *ceteris paribus*, gain long-lasting and growing advantages if they do so sooner rather than later.

The results offer insights as to possible contagion effects of political movements. In this networked information society, behaviors of individuals and organizations are often facilitated by characteristics of ICTs systems within which they operate (Benkler, 2011). The fact that a system allows access to high-speed and relatively inexpensive networked ICTs has significant implications for governance and spread of movements within and across borders. Networked ICTs, in particular social media, played an important role in mobilization and spread of the Occupy Wall Street protests in the United States in 2011 (Ngak, 2011). Activists involved in the recent uprisings in the MENA region in 2010 and 2011 reported that they often relied on Internet-based communication tools to exchange ideas and discuss strategies with those in other countries (Kirkpatrick & Sanger, 2011).

Importantly, several countries in the MENA region have become more central in the global Internet network of 2010 than they were in 2002. These include the United Arab Emirates, Qatar, Egypt, and Saudi Arabia. In particular, it is important to note that Egypt has greatly increased its centrality in the network over the past decade. Egypt has become more connected with other countries (*degree*) and has become increasingly directly connected with important countries within the network (*eigenvector centrality*). In addition, Tunisia's international Internet bandwidth has grown considerably between 2006 and 2010. Does significantly increased Internet bandwidth in the MENA region have any direct correlation with recent uprisings in the region? This article does not test any correlational or causal claims regarding

the relationship between Internet connections and political movements. However, to the extent network structure enables or facilitates actions, perceptions, and policies, results reported here are consistent with arguments suggesting that more demands for political change may be expected to occur in MENA and that these demands may be patterned after demands expressed elsewhere. Understanding changes in the global Internet and how countries in the MENA region have evolved as part of the network is an important step toward understanding political movements in the region. The finding of the study that international Internet bandwidth within the region has increased provides an important clue as to possible contagion effects of political movements in the region.

The Internet has become an important tool for mobilization, organization, and diffusion of political movements in many parts of the world, and the system-level investigation of the structure of Internet helps researchers and scholars better understand changes in the global connectedness brought about by increasingly available and affordable high-speed networks. Network-induced changes have important implications for diplomacy, trade, and global activism. In addition, network concepts and analyses used in this study provide guidance for those wishing to analyze different types of transnational connections among countries and the resultant global network. As Slaughter (2009) puts it, "connectedness" is "the measure of power" in this world, and thus it is essential to understand how different types of connections are initiated, developed, and maintained in this network information age.

Although this analysis offers several new and interesting findings, it is important that readers be reminded of some limitations of the study. With regard to the analysis of international Internet bandwidth, it should be noted that TeleGeography's data set includes only countries whose transnational bandwidth data were available for a given year. This means that direct bandwidth connections between some small countries might have been left out. However, TeleGeography's data set is the most complete dataset available at this point and it includes most, if not all, major international bandwidth connections.

Future research must analyze relationships between patterns of international Internet bandwidth connections and amount and characteristics of political messages people in the MENA region exchanged via social media sites with people within the region and people outside the region. This will help us better understand possible direct connections between systems of ICTs and behavioral aspects related to social media and political movement. In addition, network analysis of individual-level ICTs connections of MENA activists with their counterparts within the region and outside the region will provide useful information to understand political activism in the networked information society.

An Internet is, of course, a network of networks. As countries develop, they make strategic choices about whether to invest in information infrastructure that routes traffic from their exchange points to those of their immediate neighbors, or whether to invest in information infrastructure that routes traffic from their exchange points to those of more distant countries. Sometimes these decisions are constrained by

available resources, and hooking up to an undersea trunk cable that connects to the United States, United Kingdom, or Europe is almost always a good way to improve the bandwidth available to users. But sometimes these decisions may also be political. The evolution of networks in North Africa and the Middle East suggests that over the last few years, governments have been improving the speed of connections between regional capitals. Where particular digital packets go in a network is almost randomly determined. But improving the bandwidth available between countries in this region, without having the United States, United Kingdom, or Europe as a mandatory point of passage, is evidence of the rising level of investment in an overall communication infrastructure for in-country and within-region use.

Changes in bandwidth and the linkage structure are observable of communication patterns. Knowledge of the content of such communication certainly reveals more about the ideas and norms being transmitted over networks, but comparing infrastructure reveals much about which communication links are valued. Understanding the pattern by which network relations change may also suggest how communication linkages may grow in the years ahead. Investing in new capacity is expensive and generally requires significant lead-time. In this way, investments in digital infrastructure provide the capacity to exploit new modes of communication, and the political or economic decision not to strengthen a tie or build a new node also reveals much about relations between countries. Communication behaviors must be interpreted in light of the structures within which they are manifested. Our analysis demonstrates that in the MENA, both the communication behaviors and structures have exhibited patterned changes over the past decade.

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## Note

- 1 The MENA countries analyzed in this study include Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine Territory, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, the United Arab Emirates, and Yemen.

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网络的网络：2002 至 2010 年国家带宽和中心地位在国际信息基础建设中的变化规律

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**【摘要：】**

由于国际信息基础建设在过去十年的发展，各国之间的联系已发生显著改变。本文认为传播基础设施和政治进程的发展同步。在本研究中，作者试图测量在中东和北非带宽和数字节点中心的关键结构性变化。本文通过带宽测量和核心指标的组合展示国际信息基础建设在 2002 年和 2010 年间是如何演变的，以及中东的若干国家如何异军突起成为优秀节点来调解强大的区域内网络。

Des réseaux de réseaux : les motifs changeants dans la bande passante et la centralité des pays  
dans l'infrastructure informationnelle mondiale, 2002—2010

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Les liens entre les pays ont changé de façon importante au cours de la dernière décennie, alors que l'infrastructure informationnelle mondiale évoluait. Nous soutenons que l'infrastructure de communication et les processus politiques évoluent ensemble, et dans cette étude nous cherchons à mesurer les changements structurels clés dans la bande passante et la centralité des nœuds numériques au Moyen-Orient et en Afrique du Nord. Par une combinaison de mesures de bande passante et d'indicateurs de centralité, nous démontrons comment l'infrastructure informationnelle mondiale a évolué entre 2002 et 2010 et comment plusieurs pays du Moyen-Orient sont devenus connus comme étant de bons nœuds médiant des réseaux intrarégionaux forts.

Mots clés : Moyen-Orient, Afrique du Nord, infrastructure informationnelle, bande passante, analyse de réseaux, Internet, effets de contagion

Netzwerke der Netzwerke: Die Auswirkungen von Veränderungen in den Bandbreite- und Zentralitätsmuster eines Landes auf die globale Informationsinfrastruktur zwischen 2002 und 2010

Verbindungen zwischen Ländern haben sich durch die Entwicklung der globalen Informationsinfrastruktur in den letzten Jahrzehnten dramatisch verändert. Wir argumentieren, dass sich Kommunikationsinfrastruktur und politische Prozesse parallel entwickeln und versuchen deshalb in dieser Studie Schlüsselinfrastrukturveränderungen in der Bandbreite und der Zentralität der digitalen Schnittstellen im Nahen Osten und Nordafrika zu messen. Wir nutzen eine Kombination aus Bandbreitenmetrik und Zentralitätsindikatoren und zeigen, wie sich die globale Infrastruktur zwischen 2002 und 2010 entwickelt hat und wie verschiedene Länder im Nahen Osten bedeutender wurden, weil gute Schnittstellen starke intraregionale Netzwerke begünstigten.

Schlüsselbegriffe: Naher Osten, Nordafrika, Informationsinfrastruktur, Bandbreite, Netzwerkanalyse, Internet, Ansteckungseffekt

네트워크들의 네트워크들: 2002-2010 년 사이의 글로벌 정보인프라에서의 국가 광역대와

중심성에서의 변화 형태들에 관한 연구

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요약

국가들간의 연계점들은 지난 10 년간 글로벌 정보 인프라가 진전되면서 커다란 변화를 겪어 왔다. 본 논문은 커뮤니케이션 인프라와 정치적 과정들이 함께 진전되었다는 것을 주장하였으며, 우리는 중동지역과 북 아프리카내에서의 디지털 노드의 광역대와 중심성내에서의 주요 구조적 변화들을 측정하려고 시도하였다. 광역대 매트릭스와 중심성 요소들의 조합을 통하여, 우리는 지난 2002 년부터 2010 년동안 어떻게 글로벌 정보 인프라가 진전되어 왔는지, 그리고 어떻게 중동지역의 여러 국가들이 지역간 네트워크를 형성하면서 현저하게 발전되어 왔는지를 증명하였다.



Las Redes de Redes: Cambiando las Pautas de Banda Ancha en el País y la Centralidad  
de la Infraestructura de la Información, del 2002 al 2010

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Resumen

Las conexiones entre los países han cambiado significativamente dada la evolución de la infraestructura global de la información en la década pasada. Argüimos que la infraestructura de la comunicación y los procesos políticos evolucionan juntos, y en este estudio intentamos medir los cambios estructurales claves de la banda ancha y la centralidad de los nodos digitales en el Medio Oriente y Norte de África. Usando una combinación de métricas de banda ancha e indicadores de la centralidad, demostramos cómo la infraestructura global de la información evolucionó entre el 2002 y el 2010, y cómo varios países del Medio Oriente alcanzaron prominencia como los nodos buenos mediando fuertemente en las redes intra-regionales.