Dynamic Network Analysis in Information Operations: A Process for Near Real-time Assessment of Atmospherics, Socio-Political Landscape, and Leverage Points

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Abstract: In the weeks leading up to the Iraqi elections, our team worked with open source material collected in the Baghdad region. While open source material is, as indicated by its name, unclassified, the physical collection of newspapers, flyers, bulletins, etc does come with some personal risk to the collectors. That risk is justified when the open source material is rapidly transitioned to near real-time navigable data and exploitable information by Information Operations analysts and operational commanders. This report is a demonstration of a Dynamic Network Analysis approach to open source material collection, database creation, and situation understanding. In addition to supporting qualitative assessments, Dynamic Network Analysis provides quantitative metrics to assess the socio-political situation and policies affecting the socio-political system. Dynamic Network Analysis goes beyond the traditional Social Network Analysis by considering multiple types of relationships, multiple types of entities, and the temporal aspects of the resulting network. This report uses three cutting edge tools developed by the Carnegie Mellon CASOS Laboratory, Automap, ORA, and DyNet. Process, product and future directions for the Information Operations community are explained and explored.

Introduction

The military's newest battlefield operating system, Information Operations, has become a hub of operational decisions in the US military's global war on terror (FM 100-6). In Iraq, the Balkans, Africa and other hot spots, Information Operations is faced with describing the current status of the socio-political landscape, population characteristics, insurgent atmospherics, and leverage points (Kuehl, 1997; Siegel, 1998). These loosely defined atmospherics support the commander's operational situation understanding and leverage point identification.

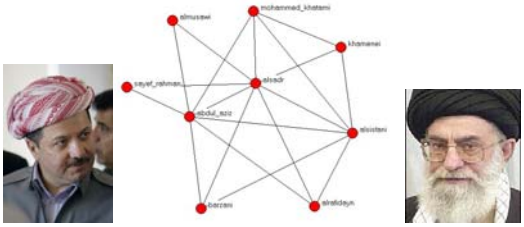
In too many cases, the atmospherics and assessments are based on gut intuition of a single IO analyst. To rectify this weakness, Information Operations has key leaders and conferences (MORS, Dec 2004; IOWG, Sept 2005) seeking standardized metrics to assess the battlefield

atmospherics. If successful in developing standardized metrics, IO can temporally assess the reverberations of activities and policies on the socio-political systems of interest.

One type of metrics available to IO is provided by Social Network Analysis. Social Network Analysis (SNA) is useful in uncovering & understanding hidden relations and informal organizations (Krebs, 2002). SNA has been gaining increased use by the intelligence community in their effort to understand the hidden structure of terrorist and insurgent networks. This report uses Dynamic Network Analysis, an advanced form of Social Network Analysis, to develop useful standardized metrics and an operational process. On the battlefield, Dynamic Network Analysis is gaining exploratory use by select units that are interested in studying the same hidden and informal structures on a temporal basis. What follows is a description of Social Network Analysis, Dynamic Network Analysis, and their application to open-source media evaluation.

Social Network Analysis

The social network graph is the building block of social network analysis. A social network is a graph consisting of individuals and connections between them. In a social network graph, individuals are represented as nodes and relationships between individuals is represented by links between the nodes (Figure 1) (Borgatti, 1994; Scott 1992).



Barzani Khamenei

Figure 1. A simple social network graph of key individuals and relationships in the Baghdad socio-political landscape on 4 December 2005.

SNA allows for the quantification of dyadic ties that exist within a graph. In any socio-political system people influence each other, the ideas being exchanged, and the flow of information (Borgatti, 2002). SNA seeks to quantify this relationship. People or organizations are represented as nodes in a network and the relationships (e.g. potential information flows) between people are represented as lines drawn between these nodes.

Thus, a social network is not just a description of who is in the socio-political system but how they are put together and how they interact with one another (Borgatti, 2002). Social Network Analysis allows the decision-maker to understand individual and system performance simultaneously. In addition to the relationships described above, social network analysis allows for values to be attached to these relationships to represent strength of the relationships, information capacity, rates or flow of traffic, distance between nodes, and probabilities of information being passed (Borgatti, 2002). It is these values that allow social network analysis to quantify the relationships, thus presenting a means for mathematically testing the network.

However, traditional social network analysis does not adequately address the dynamic nature of socio-political systems such as populations, terrorist networks, and insurgencies. Traditional social network measures such as betweenness (Freeman, 1979), cohesion (Frank, 1995), structural equivalence (Lorainne & White, 1971), etc, are designed to explain an organization in terms of a single data collection or single point of time. These metrics do not take advantage of temporally spaced data collections and the effect of a previous state of the socio-political system.

Dynamic Network Analysis

As a result, Dr Kathleen Carley (1998), Dr Jeffery Johnson (1998) and others have developed the concept of dynamic network analysis. Dynamic network analysis considers the factors that lead to temporal change in network structure and performance. Dynamic network analysis considers the population, terrorist network, or insurgent organizational form to be a living entity capable of shifting form and structure.

Dynamic Network Analysis also encompasses a methodology to mathematically represent the temporal shift in nodes and edges. At the lowest level, Dynamic Network Analysis is entities and relationships. This taxonomy is an extension of the nodes and edges that are the building blocks in social network analysis. However, entities, in Dynamic Network analysis go beyond just people and include organizations, knowledge, resources, tasks, locations, etc. Relationships are the available edges between all types of entities and can include who communicated with who, who knows what, what knowledge is related to what tasks, what organizations have what resources, etc.

Entities and relationships are assembled under the concept of the meta-matrix (Table 1). The meta-matrix allows for understanding and measurement of relationships not considered relevant in the social network approach. Meta-Matrix: Carley (2002) combined knowledge management, operations research and social networks techniques together to create the notion of the meta-matrix. The Meta-matrix is an extension and generalization of the PCANS approach forwarded by Carley and Krackhardt (1999) that focused on people, resources and tasks.

	People / Agents	Knowledge / Resources	Tasks / Events	Group/ Organizations
People / Agents	Social Network	Knowledge Network	Assignment Network	Membership Network
Knowledge / Resources		Information Network / Substitutes	Needs Network	Core Capabilities
Tasks / Events			Precedence Ordering	Institutional Relation
Group/ Organizations				Inter-organizational Network

Table 1. Meta-matrix approach in Dynamic Network Analysis. The People x People approach is typical of traditional Social Network Analysis. Understanding the temporal aspects of multiple types of relationships and nodes (knowledge, events, organizations, etc) is germane to Dynamic Network Analysis.

Dynamic Network Analysis allows for different data aggregation strategies to study different levels of the organization. Individual roles can be studied by extracting the behaviors and tasks performed by the individual participant. Cells and ad-hoc organizations can be studied by aggregating the behaviors of the individual members. The entire population and network can be studied by aggregating the activities of the individuals, cells, and ad-hoc organizations.

Dynamic Network Theory is relatively young and unexplored. Information Operations as a battlefield operating system is young and emerging. It appears that it is just the problems that Information Operations is facing that is spawning the rapid development and practice of Dynamic Network Analysis. This paper demonstrates an application of dynamic network analysis into the Information Operations environment and develop new Dynamic Network-based measures for the Information Operations context.

Open Source Intelligence

This report uses open source material for demonstration purposes. Open source material is the fastest growing area of operational analysis. Open source material is collected by soldiers on patrol, web surfing, and deliberate collection at newsstands. Nearly every Brigade-level and above tactical command center monitors local television broadcasts to understand what is being discussed and make inferences about how the news reports will affect area atmospherics and population activities.

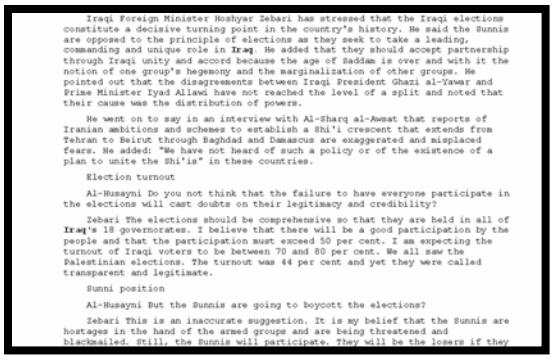
Open Source (OSINT) is defined as publicly available information. I.E., any member of the public could lawfully obtain the information by request or observation. Open source information includes any information that may be used in an unclassified context without compromising national security or intelligence sources and methods (NATO Director of Central Intelligence Directive (DCID), March 1994). Available open source material tends to explode with the advent of democracy. For instance, there were some 1,700 newspapers published in the former Commonwealth of Independent States that were not present before the fall of the wall.

In the weeks leading up to the democratic Iraqi elections, our team was given the opportunity to work with open source material collected in the Baghdad region. The data is arbitrarily grouped by five collection time spans: 19-25 Nov, 25-30 Nov, 3-10 Dec, 10-17 Dec, 17-24 Dec (Table 2). The elections were held on 30 January 2005, thirty days after the last collection.

Time Period	Inclusive Dates
1	19-25 Nov
2	25-30 Nov
3	3-10 Dec
4	10-17 Dec
5	17-24 Dec

Table 2. Open Source media collection dates and arbitrary material groupings

Files are all .txt or .rtf format after translation (Figure 2). The material for each time period ranged in file size from .25M to 1.5M. All figures, pictures, and tables were removed from the material prior to processing.



Iraqi Foreign Minister Hoshyar Zebari has stressed that the Iraqi elections constitute a decisive turning point in the country's history. He said the Sunnis are opposed to the principle of elections as they seek to take a leading, commanding and unique role in **Iraq**. He added that they should accept partnership through Iraqi unity and accord because the age of Saddam is over and with it the notion of one group's hegemony and the marginalization of other groups. He pointed out that the disagreements between Iraqi President Ghazi al-Yawar and Prime Minister Iyad Allawi have not reached the level of a split and noted that their cause was the distribution of powers.

He went on to say in an interview with Al-Sharq al-Awsat that reports of Iranian ambitions and schemes to establish a Shi'i crescent that extends from Tehran to Beirut through Baghdad and Damascus are exaggerated and misplaced fears. He added: "We have not heard of such a policy or of the existence of a plan to unite the Shi'is" in these countries.

Election turnout

Al-Husayni Do you not think that the failure to have everyone participate in the elections will cast doubts on their legitimacy and credibility?

Zebari The elections should be comprehensive so that they are held in all of **Iraq's** 18 governorates. I believe that there will be a good participation by the people and that the participation must exceed 50 per cent. I am expecting the turnout of Iraqi voters to be between 70 and 80 per cent. We all saw the Palestinian elections. The turnout was 44 per cent and yet they were called transparent and legitimate.

Sunni position

Al-Husayni But the Sunnis are going to boycott the elections?

Zebari This is an inaccurate suggestion. It is my belief that the Sunnis are hostages in the hand of the armed groups and are being threatened and blackmailed. Still, the Sunnis will participate. They will be the losers if they

Figure 2. Example .rtf file translated from Arab-language media available in the Baghdad region in the time period leading up to the Iraqi national elections.

While open source material is, as indicated by its name, unclassified, the physical collection of newspapers, flyers, bulletins, etc does come with some personal risk to the collectors. That risk is justified when the open source material is exploited. Optimal exploitation occurs when open source material is rapidly transitioned to near real-time navigable data and exploitable information by Information Operations analysts for operational commanders.

Traditional Intelligence Analytic Process

However, the traditional analytic process developed by the intelligence community is not suitable for rapid turnaround of the large body of OSINT material. The traditional intelligence analytic process is cumbersome, inflexible, and not tied to action (Figure 3). The process can take up five to seven days before material is first assessed. As a result, the assessments, once complete are 'yesterday's news'.

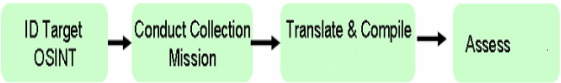


Figure 3. analytic process developed by the intelligence community (as simplified for this presentation)

The collections conducted for intelligence analysts can be overly routinized. Collections may come from the same sources every time. This can induce inherent bias in the collected material and miss the fact that the material is overly representing one area of the socio-political system over others.

Translation time for collected material remains an issue and is not addressed in this proposal. Each region may have open source material in multiple languages and dialects that needs to be translated into English. Multiple software packages have been developed to rapidly translate material, however, there is no agreement on best of breed as this area needs further research and development.

Intelligence analysts produce assessments by reading all of the material translated. The assessment process requires extensive note-taking, cross referencing, and organization based on the constructs envisioned as important by the analyst. The goal is to find patterns that are not readily available from a surface skim of the material. Essentially, the goal is to find a needle in a haystack, but the definition of a needle is amorphous.

Because raw text material analysis is a deliberate, high cognitive demand activity, assessment is done once enough material has been collected to produce a large, noticeable change. The rule of thumb is between 3 and 7 days between assessments. The assessment techniques and the categorization processes are inherently human. On the plus side, this develops expertise, on the negative side, the analysis given to the commander can vary in presentation and metrics based on the capabilities and whims of the analyst.

Lastly, collections and assessment are generally not tied to the activities of the commander. In fact, many in the intelligence community consider 'actionable intelligence' to be a dirty word. Reasoning about how an action will affect a large system such as atmospherics is difficult. There are many first, second and third order effects that should be considered in determining the socio-political dynamics. Currently there is no way to simulate and project how an action will affect the network. With a time lag of 5-7 days before the next analysis, the current feedback loop is excessively time-lagged and unable to capture the important temporal reverberations of an action in the socio-system.

DNA & IO Processing

Information Operations cannot be limited by a set of processes optimized for traditional intelligence assessments. Information Operations needs actionable information, near real-time monitoring, a feedback system. In addition, the decision maker requires metrics that describe the collected material serving as the foundation of analysis.

We propose altering the traditional intelligence community approach to incorporate Dynamic Network Analysis (Figure 4). The additional steps will better serve a process oriented on the Information Operations community needs. Consistent metrics that describe the temporal state of the socio-economic system provide the type of observations required to implement the OODA (observe, orient, decide, act) loop that has become the hallmark of good command (Col John Boyd, USAF).

Further, we argue that the additional steps will speed up the analytic process to near real-time. By incorporating feedback loops from the rapid analysis, the collection, translation, and the compilation steps can all be accelerated. Eliminating the time lag between action and observations allows for understanding the feed-forward characteristics of the Socio-Political system. A commander can potentially observe the impact of a policy, press release, arrests, and other operations.

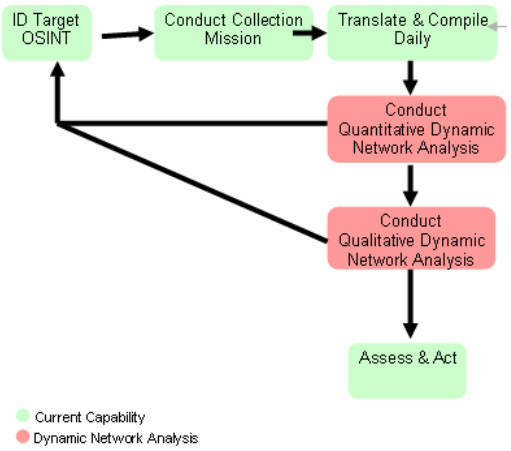


Figure 4. Proposed Information Operations OSCINT Analytic Process Incorporating Dynamic Network Analysis.

An Example Analysis

Many approaches to analysis disregard the sheer amount of human effort and time to turn raw material into navigable datasets. They will develop outstanding analytic tools that only work on datasets which could be notionally collected under optimal conditions. In fact, most traditional social network analytic packages only work if the organization is willing to expend significant resources to expand their collection procedures.

Considering a requirement for additional long term organizational analytic resources unacceptable, CASOS Dynamic Network Analysis incorporates a rapid database tool, Automap (available for free download at www.casos.cs.cmu.edu). The goal is to minimize the material-to-database time and incur little short term organizational analytic resources (start-up cost) and no long term organizational analytic resources.

The Automap software is a network text analysis tool that works with an analyst to rapidly extract meta-matrix formatted datasets from raw txt files. Dynamic Network text analysis is a specific text analysis method that encodes links between words in a text and builds a network of the linked words in terms of the Dynamic Network Meta-matrix structure shown previously in Table 1(Diesner & Carley, 2004). Somewhat similar text analysis tools include CETA (Ridder, 1998) and KEDS (Kovar etal, 2000).

We applied Automap to the earliest OSINT material, 19-25 Nov, to establish a thesaurus and categorization schema. The thesaurus is critical to identifying alias' and alternate spellings. Particularly in the translation from Arabic to English there are multiple spellings for the same Arabic name. For instance, Mohammed can be alternately spelt as Mohamed, Mohammad, and Mohamad.

Also, in the case of terrorists from Egypt and other countries outside Iraq, many will assume an alias when they enter Baghdad to signify their origins and identify themselves as a mujahideen. Further, there can be many ways to refer to a significant leader. For instance Al Sistani, a major religious leader is often alternately referred to as the Most Revered Sistani, Grand Ayatollah Ali Sistani, or Reverend Mohamed al Sistani. If any aliases are missed, they will show up as separate people in the database and are typically caught during the analysis phase.

In terms of initial start up overhead, the thesaurus itself does take approximately six hours to set up with the first set of .txt material. The process itself should include an area expert that can identify the alternate spellings and has some knowledge of the well known alias. This is the major cost in adopting a Dynamic Network Approach in Information Operations. However, updating the thesaurus in subsequent collections becomes exponentially faster.

The categorization schema is used to determine whether a word or set of words in a .txt will be

labeled as people, places, organizations, resources, knowledge, events etc. This process can be initially as tedious as the thesaurus. However, most Information Operation cells already have information to speed the process. For instance, most IO cells already maintain a list of key persons of interest, key towns and districts, holidays and events, etc. We were able to construct our categorization schema in approximately four hours for the first set of collected material. Updates to the categorization schema in subsequent collections were accomplished in minutes.

With the thesaurus and categorization schema complete we constructed the metamatrix for each of the .txt collection sets. On a typical Pentium-based laptop, each .txt set required four to eight minutes of runtime. The output is a completed metamatrix in dynetml format. Dynetml is an xml-based language to describe the multiple sub-matricies in the metamatrix and easily ports into the Organizational Risk Analyzer (ORA) software.

While much of the data analysis could have been done on the small dynamic network analysis package included in Automap, we used ORA to harness the full capabilities of Dynamic Network Analysis. ORA is a risk assessment tool for locating individuals or groups that are potential risks given social, knowledge and task network information. Essentially, first you use information about people to "connect the dots." Then, ORA examines this network and finds those dots, those people, who represent a threat to the overall system. Individuals are risks, e,g,, if their removal from the network would debilitate it (the critical employee) or if they were to feed false information to others they could create havoc (the rumor monger).

Based on network theory, social psychology, operations research, and management theory, a series of measures of "criticality" were developed at the Carnegie Mellon University CASOS Laboratory. Just as critical path algorithms can be used to locate those tasks that are critical from a project management perspective, the ORA algorithms can find those people, types of skills or knowledge and tasks that are critical from a performance and information security perspective. Each of the measures we have developed are calculated by ORA on the basis of network data like that in the Table 1.

ORA can be applied both within a traditional organization, on covert networks, or socio-political systems. Applying ORA to an organization, we identify key actors who, by virtue of who they know, what they know, and what they are doing, are potential risks to the security of a company. Applying ORA to a covert network, we can identify key actors whose removal will damage the adaptability or performance of the covert network. Applying ORA to a socio-political system, we can identify key leverage points such as relationships, ad-hoc groups and informal organizations, meeting places, resources and knowledge. By temporally displaying this analysis, the leader gets feedback on how actions (arrest of key people, redistribution of resources, etc) have reverberated on the socio-political landscape.

Iraqi Elections Database

In the course of our analysis we identified over 550 different people referenced in the open source data collected in the Baghdad region leading up to the Iraqi national elections. Some datasets ranged from 152 to 230 individuals present. New entries to the Socio-political landscape are as important as those that have departed or disappeared. Therefore, every one of those people is critical to track and understand their roles, knowledge, events associated with, etc.

However, to provide a tractable demonstration for this paper, only the 22 individuals that were consistently present in all five collection periods are considered (Table 3). While this was an arbitrary decision to fit the size of this paper, the number and membership is significant to the socio-political landscape under study. For instance, while the number of people mentioned in any given data set fluctuates up and down, these twenty-two individuals had a consistent presence in the open source material.

1. abdul_aziz	9. alramadi	17. barzani
2. adnan	10. alsadr	18. george_bush
3. alasad	11. alsamarrai	19. khamenei
4. alhakim	12. alsistani	20. mohammed_khatami
5. al-hayat	13. altaakhi	21. said_mujahed
6. allawi	14. ariel_sharon	22. sayef_rahman
7. almusawi	15. ayyar	
8. alrafidayn	16. bahman	

Table 3. Twenty-two individuals consistently present in the open source material available in the Baghdad region between 29 November and 24 December.

Therefore, fluctuations in the relationships between these core individuals can tell a story on their own. Further, fluxuations in the relationships with other meta-matrix entities (events, locations, tasks, etc) will potentially expand and explain that story. Note also that the list contains members that are not located in Baghdad. For instance President George Bush (USA), President Mohammed Khatami (Iran), Prime Minister Ariel Sharon (Israel) and Grand Ayatollah Al Khamenei (Iran) are not in Baghdad, but they are part of the socio-political landscape with resources, relationships, and actions affecting perceptions and information operations in Baghdad.

While the twenty-two individuals were consistently present in all datasets, the relationships were in flux. A relationship is signified as an edge or line between two people nodes (Figure 5). In the example below, the relationships for the twenty-two are displayed for the first and the fifth (last) data sets.

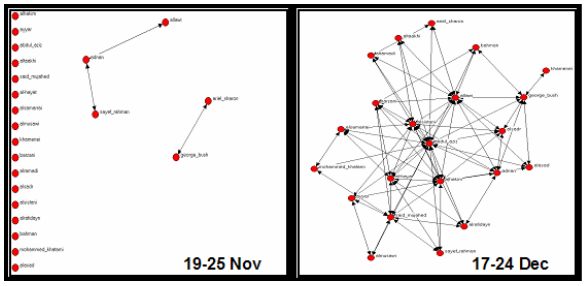


Figure 5. Network graph for the first and last datasets from the open source media material.

Clearly there is change in relationships over time. The nodes on the left side of the first graph are considered isolates that have no connections, while the five nodes with lines between them have an identified relationship with another node. In the first dataset (19-25 Nov) we can see few relationships exist between the twenty-two people. However, in the second network graph, one month later, and closer to the Iraqi national elections, the twenty-two all have at least one relationship to another member of the twenty-two.

Graphs that have more relationships between nodes are considered more connected. The more people are connected in a socio-political system, the more likely they are working toward or competing for a common goal. New relationships indicate new alliances or competitors entering the landscape. Creation of new relationships alters the structure of the landscape and the positioning of the individual nodes.

Rather than counting the relationships, we identify how connected a set of people are based on the group's density. Density is the total number of edges divided by the total number of possible edges. In our graph of twenty-two individuals, the total number of possible edges is 231 if every node is connected to every other node.

A graph of change in density over time provides some concept of the dynamic aspects of relationships. Figure 6 is a graph of the temporal relationship density for the five collections between 19 November and 25 December 2005. The first time period shows the lowest density with only five nodes of the twenty-two connected. However, as time progresses, and the elections near, the group is increasing its connectivity. It appears that as the elections approach, the open source information is picking up on the alliances and competitions between these twenty-two actors on the socio-political landscape.

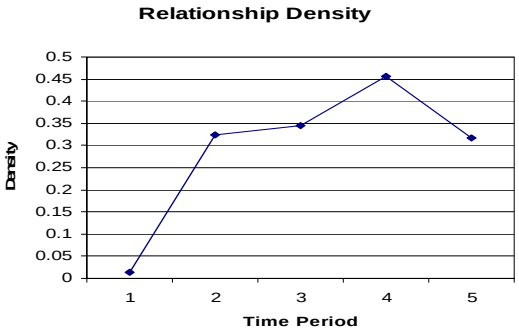


Figure 6. Temporal graph of network density for the twenty-two key individuals in the Baghdad open source material

However, there is an alternate analysis based upon the collection methodology. It is possible that the media collected during the first and inaugural time-period was narrow in scope. The collection team may not have had conducted enough insight as to where and when to collect material to get the widest range of material. Further the last time period, that shows a dip in density, was collected during a holiday period where less material may have been published and therefore available. Both of these insights should serve as drivers to adjust collection procedures and temper the findings from analysis.

Another way of viewing the temporal nature of the network is through a time-series correlation of the networks (Figure 7). In performing a correlation we are seeking to understand whether there is a relationship between a edge existing in one time period being repeated in the next time period. Essentially, we are describing the stability of relationships between people in the open source material.

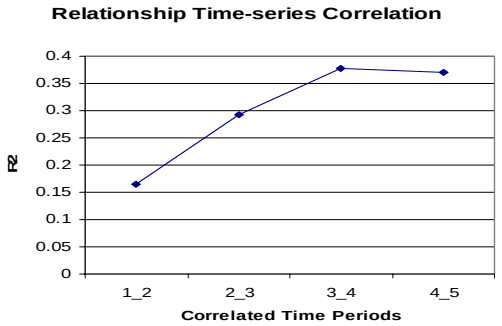


Figure 7. Graph of Time-series correlation for relationships between the twenty-two key individuals over five time periods of the Baghdad open source material.

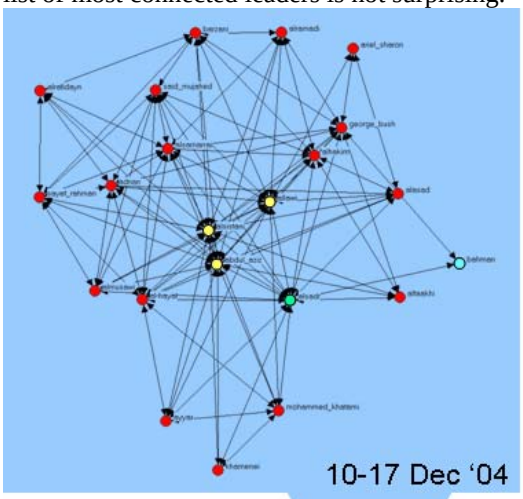
The trend in figure 7 indicates that the relationships between the twenty-two key individuals becomes more stable over time. Initially, there is only a r =.17 (p<.01) correlation between the relationships that exist in time period one and time period two. By the last time period, the correlation between time period four and time period five relationships increases to r=.37 (p<.01). A correlation of r=1.0 would indicate unchanging relationships between these twenty-two people.

While the correlations are significant and become more positive over time, they are not particularly high. There is still a great deal of variance in the relationships between time periods. Armed with this information, Information Operations analysts can now focus on the consistent relationships and the fluctuating relationships to better understand how the key players are changing position within the network. If the commander has taken an action (arrest of a key member) the Information Operations analyst will focus on fluctuations precipitating from the action.

Leverage Point Identification

The structure of the network uncovers leverage points. One key element of socio-political network structure is the people serving as the hubs in the system. One common identifier of 'hubness' is a mathematical quality called the eigenvector centrality. The eigenvector centrality metric identifies the people that are connected to the people that are also most connected. This identifies the leaders among leaders.

In Figure 8, King Faud Abdul Aziz (Saudi Arabia), Grand Ayatollah Ali al-Sistani (Iraqi Shiite Leader), and Interim Prime Minister Iyad Allawi (Iraq) were the key members of the group of twenty-two. Given the upcoming elections, positioning of the Shiite majority in preparation for the elections, and the beginning of the Hajj (annual Muslim pilgrimage to Mecca in Saudi Arabia) this list of most connected leaders is not surprising.



1	2	3	4	5
adnan	abdul_aziz	alsistani	abdul_aziz	abdul_aziz
allawi	alramadi	abdul_aziz	alsistani	alhakim
sayef_rahman	adnan	alsadr	allawi	allawi

Figure 8. Key actors by time period as identified by the eigenvector centrality, 'leader among leaders'. Network graph identifies key actors for time period 4 (10-17 December)

The least connected person of the twenty-two is Bahman Ghobadi, an Iranian Kurd who had just released a movie about an Iraqi village's efforts to obtain a TV satellite dish. From his position in the network he appears to be the least important member on the socio-political landscape. However, his quick rise to fame provided him access and perceived relationships to Al Sadr, a radical mullah stirring the pot in the time leading up to the elections. Exploiting that linkage might

have been a profitable route for the responsible Information Operations cell.

Beyond the Core Twenty-Two

While we have demonstrated the gains from a temporal approach to understand the dynamics of the socio-political system, we have not yet taken full advantage of the power of the Dynamic Network Analysis meta-matrix. Recall the meta-matrix in Table 1 with multiple sub matrices. Table 4 below is a partial expansion of a few sub matrices in a data set collected 8-10 January 2005. Note that the example includes people beyond the twenty-two discussed up to now. The remainder of the analysis will look at the full data set (people, events, locations, organizations, actions etc) collected for that time period.

Person	Location	Organizations	Actions
alialsistani	*Karbala, Baghdad, Al Najaf*	*governorate, Shiite, Iraq*	*against, bitter, asserted, boycott*
alialara	*Karbala, Iraq*		
bremer	*kurdistan, Kirkuk*	*administration*	*arabized*
altahrir	*baqubah, Iraq*	*Iraq*	
alhakim	*Iraq*	*Sunni, Iraq*	*added, assassinated*
abdalrahmanal uh	*amman, jordan*	*Jordan, commission*	
alchalabi	*iraq*	*i_n_s, assembly, Iraq, Iran*	*appointed, attacked, authorized*
khan_ansari	*jawawla, iran*	*Iran, British*	
abdul_aziz	*karbala, jordan*	*consulate, commission*	*buried, agree, asserted, came*

Table 4. Partial expansion of the metamatrix data for 8-10 January data set.

The 8-10 January 2005 dataset contains 172 People, 22 Organizations, 16 Actions, 32 Roles, and 10 Knowledge/Resource nodes for a total of two-hundred and fifty-two entities in the meta-matrix. Between all of the nodes there were a total of 906 edges or relationships within and between the sub matrices. The density of the total meta-matrix is .0017.

Note that the density for the meta-matrix is (.0017) is significantly smaller than the densities charted earlier in Figure 6. In general, a lower density indicates a lower amount of connectivity in the graph. However, in the case of the meta-matrix, as the number and type of nodes increases, the ration of connections naturally decreases. For instance, while a person may have high connectivity on the agent x agent matrix, they may one of the few people with a linkage to Jordan in the agent x location matrix. The low connectivity to specific locations, organizations, etc leads to a lower overall density.

Leveraging the additional data provided in the meta-matrix is advantage of Dynamic Network Analysis. Table 5 (below) is a comparison of the top three results for each of six measures. Each measure takes advantage of different elements of the meta-matrix. The outcome is a set of slightly different or completely different perspectives on the same socio-political landscape.

Centrality-Betweenness	Centrality-Eigenvector	Centrality-Total Degree	Clique Count	Cognitive Demand	Exclusivity-Knowledge
alialsistani	aldustur	alialsistani	alialsistani	abuhilalah	alfayiz
alchalabi	alialsistani	salahaldin	salahaldin	alialsistani	alshuhada
alnasiri	alkinani	alnasiri	alchalabi	alazzawi	alsharqiyah

Table 5. Six Dynamic Network Analysis measures of the 8-10 January 2005 data set.

Betweeness Centrality, Eignevector Centrality, Degree Centrality, and Clique Count take advantage of the agent x agent sub matrix. Betweeness centrality determines which person or entity is most likely to be on a path between any two other actors in the landscape. In an information system, this person is most likely to know what is going on and who knows what. Eigenvector Centrality is the person or entity connected to the most connected people. These people can exert overt and covert pressure on the socio-political system to their benefit. Degree Centrality is the person or entity with the most in and out direct connections. They can reach the most people in the organization faster than others in the network. Clique count identifies people or entities that are in a large number of tight knit groups. These people have a large amount of close relationships.

Note that in my explanation I used people and entities as interchangeable. This is because entities such as knowledge, location, organization, etc can be high in centrality or clique count. For instance, the reference to 'salahaldin' in Table 5 is actually a small, inconspicuous town in northern Iraq. The surprise is that this town appears to have been a meeting and reference hub for a wide range of key actors during the 8-10 January 2005 time period. Google the town and we quickly learned that Salahaldin was a hub of Kurdish activity during Saddam's reign and was gaining new importance with the upcoming elections and the Kurdish delegates.

Cognitive Demand takes advantage of the Agent x Agent, Agent x Knowledge, Agent x Action

matrices. By crossing the number of relationships by the number of knowledge items by the number of actions, we get a good sense of who is working harder in the socio-political landscape. In Table 5, note that Cognitive Demand extracted a different key individual than the other measures, Abu-Hilalah. As it turns out, Yasir Abu-Hilalah is a correspondent for Al Jeezera TV with high access and as a result, high knowledge. An Information Operations analyst would be foolish not to continue to track this individual as he moves through the Iraqi Socio-political landscape to obtain breaking news (On 25 March 2005, open source media reported that Al Jezeera and Yasir Abu-Hilalah were ejected from Iraq). Only a Dynamic Network Analysis Measure that takes advantage of the full meta-matrix would uncover these type of key individuals.

Knowledge Exclusivity takes advantage of the Agent x Knowledge matrix. By studying this matrix, we can discover which knowledge is prolific and which knowledge is low density. The low density knowledge is exclusively held by few members of the socio-political landscape, which in some cases is a form of power. In Table 5, Prime Minister Al Fayez of Jordan holds the highest knowledge exclusivity position. At the time, he was a significant member of the Iraqi socio-political landscape as his country was accused of allowing terrorists to pass into Iraq, which he denied.

Leverage Points

Even without the measures and metrics, we can use a visual representation of the full Dynamic Network. Given the size of the representation, it is best to use an interactive visualizer such as Social Viz that comes with the ORA software. To simplify the visualization for this paper, I removed all isolates and pendants to shrink the graph. As a result, Figure 9 (below) represents a very small percentage of the actual meta-matrix for 8-10 January 2005.

The first point to take from this visualization is that there are seven distinct and separate sub networks in the data set. Each group has been marked with a color for reference: red, yellow, grey, turquoise, green, purple, and black. Red, the largest group is explored for leverage points. Each transparent blue circle identifies a node that, if removed, would isolate significant portions of the entire matrix from the rest of the socio-political landscape.

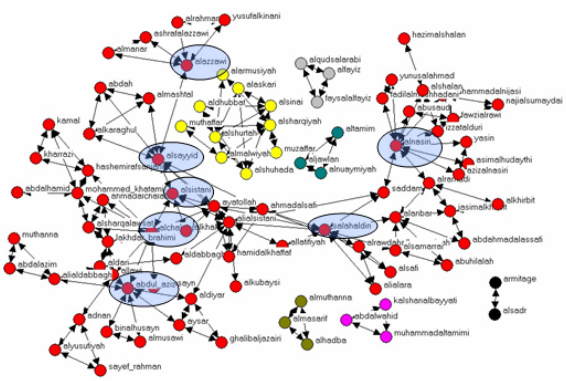


Figure 9. Visualization of the reduced metamatrix for 8-10 January 2005. Blue circles represent proposed leverage points.

Returning to our discussion of the town of Salahaldin, we can see that controlling access to the town could cut the red group into two distinct halves. Further, if we could concurrently eliminate the influence of Al Azzawi, Al Sayyid, Al Sistani, Al Chalabi, Al Nasiri, and Abdul Azziz Sayn the red landscape would be compartmentalized until new linking agents could be installed. These individuals are considered weak boundary spanners. Weak boundary spanners lie on network cut points, which if removed, dismember a connected group into sub groups.

The Road Forward

While Open source intelligence is considered unusable by many in the intelligence community, it is extremely valuable to the emerging information operations community. Open source material is clearly useful to understand the operating environment and socio-political landscape. Open source analysis can provide insights and metrics to know how the socio-political landscape is organized, when the socio-political landscape is stable, and when it is undergoing significant change. Further, open source material should not be discounted as valuable for coo berating classified sources and developing actionable intelligence.

Dynamic Network Analysis provides a quick method, with little overhead to sift through and organize the amount and complexity of open source datasets. We were able, with one person, twenty-four working hours, and one week's worth of data, to establish a process that could be iteratively applied to the next weeks' data sets. This was achieved despite the disparate collection schemas and formats.

Dynamic Network Analysis does not preclude traditional analytic methods developed by the intelligence community. However, Dynamic Network Analysis can stand on its own or serve as a complement to the traditional analytic methods. Further, we argue that because of the speed of categorization inherent in a Dynamic Network Analysis-based feedback system, we see an immediate efficiency gain for the traditional analytic methods.

Part of the reason Dynamic Network Analysis is so powerful is its immediate acceptance by Information Operations personnel and operational commanders. Dynamic Network Analysis is based on categories (people, places, events, resources etc) that are readily understood and fit into an analyst's existing schemas. The concept of relationships between entities has been trained into the minds of everyone already using the older tools such as I2 and Analyst Notebook. Lastly, the Dynamic Network Analysis metrics and ontology (hubs, key leaders, leverage points, low density information, etc) are within the intuitive framework of a practicing Information Operations analyst.

As much as Dynamic Network Analysis' success is reflecting what the Information Operations operator is prepared for, the process also pushes the operator towards new insights not previously possible. The new metrics and ontology are within the intuition of the operator, but not previously apparent. The speed at which initial insights are gained supports further, intelligent exploration of the landscape. Further, for the first time, an operational commander has a feedback system to understand how policies, actions, and events impact his operating environment.

Dynamic Network Analysis can provide the metrics that are sorely missing in the emerging practice of Information Operations. However, Dynamic Network Analysis is a young theoretical field of research as well as a existing field of practice. There is still room for metric development and process improvements. A focused effort to combine Information Operations and Dynamic Network Analysis would accelerate both fields.

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