

THREE PROOF-OF-CONCEPT MODELS RELATED TO SOCIAL AND BEHAVIORAL MODELING OF THE ANBAR AWAKENING

FINAL REPORT TO AFRL FOR WORK COMPLETED IN FISCAL YEAR 2010

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This is a final report to the Air Force Research Laboratory on work performed in Fiscal year 2010. The project was entitled 'Modeling the Anbar Awakening with NOEM/SILAS' and was intended to be the first year of a three year effort to enhance the capability of AFRL's NOEM (National Operational Environment Model) in the social and behavioral realm.

BACKGROUND

There is general agreement that understanding social factors, such as understanding social identity-based factions and shifting public sentiment, are important components of PMESII (political, military, economic, social, information and infrastructure) state. However, within the enormous amount of background research available in social psychology, cognitive psychology, organizational psychology, and political science, there is considerable uncertainty about which factors have the most military significance. Or, to put the problem another way, current military effectiveness modelers do not know which variables in these domains must be included and which variables can be downplayed or ignored.

We chose to focus our research on the events surrounding the Anbar Awakening in Iraq. By 2006, al Qaeda had more political and military influence than the US in many parts of the region, and some observers believed Anbar province to be 'lost'. The Awakening, which began in 2006, was a dramatic and relatively sudden shift in both sentiment and tactics of Iraqi Sunnis in Anbar province away from supporting al Qaeda and toward supporting the coalition forces.

As a modeling problem, what made the Awakening particularly interesting is that the events contained social, economic, and military components, and thus demanded a multi-level approach. A purely military model could not fully explain the Awakening, and neither could a purely economic or social model. A model of Anbar seemed to demand a representation that incorporated social, economic, and military factors in a way that had not previously been done.

THREE SOCIAL DYNAMIC MODELS

Our FY10 research developed three proof-of-concept models that focused on different dynamics relevant to events in Anbar during the period in question. These three models were:

Model #1: Economic patronage and affinity. Authors such as (McCary, January 2009) argue that early US involvement in Anbar antagonized tribal sheikhs by awarding contracts directly

to individuals, instead of going through established patronage channels, while later policies of working with sheikhs led to more cooperation. Model #1 produces different financial redistributions, loyalty, resentment, and affinity in a social network based on how an external influx of money into the system, such as aid from a foreign power, is initially distributed. The effects are consistent with current political and psychological theory about patronage systems, vertical collectivism, and horizontal inequality.

Model #2: Information access and complicity in a civilian population. Cooperation from the population is understood to be a 'force multiplier' in asymmetric warfare and counterinsurgency campaigns. In Anbar, the US and al Qaeda were competing for crucial information from the population; al Qaeda sought information about who was collaborating with the US while the US sought information about embedded al Qaeda agents and cooperating militias. This type of information could and did tip the balance of power between the opposing sides. However, the decision of individuals as to whether they should provide information was a complex one, involving fear of reprisal, kinship, current alignment of leaders, and the person's relationship to the person asking (e.g. an American soldier vs. a tribal leader). Our second model began to integrate these factors into a model that could simulate the 'red' versus 'blue' contest for information and control in a representative city in Anbar.

Model #3: Coalition dynamics of tribal leadership. The Anbar Awakening was not a grassroots movement; it was conceived and led by tribal Sheikhs in Anbar. Most current counterinsurgency models simulate only 'rank and file' residents; but leaders have different goals and actions that may be more influential than popular sentiment. Model #3 presents a possible model of leader behavior that draws on well-established game theory of coalitions. The model is a 'coalition game' that integrates the dynamics explored in models #1 (patronage) and #2 (popularity as a force multiplier). A demonstration run of this model produces a five-step sequence of events that is similar to the events of the Anbar Awakening. This model also has the property of integrating social, economic, and military factors.

NOTES ON THE STATE OF MODELS

These models have been developed as proof-of-concept models. For each model the design rationale, underlying algorithms, and sample outputs are presented in this report. Each has been implemented as a runnable model in MATLAB using the MATLAB Bioinformatics toolbox as a graph function library. We cannot deliver finished software code because meeting the extensive quality and documentation requirements for software code delivered to the government would be out of scope for this project. The intention of this advanced development effort was that the algorithms could and would be integrated into a larger model such as NOEM.

Because of the lack of unclassified quantitative data from Anbar during this period, these models are not grounded or validated with data sets. They are, to the extent possible, grounded in both qualitative scholarship on the Anbar Awakening and theoretical findings in the behavioral sciences, as documented in this report.

PRESENTATION OF MODELS

We will follow this organization pattern for each model presented.

- Introduction (purpose, theoretical and historical background, and qualitative description of model)
- Model Elements & Dynamics:
 - Entities: types of actors (agents) and resources and their parameters/attributes/properties
 - Relationships: types of links between entities, and their parameters/attributes/properties
 - Behaviors & Cognition: evaluations and actions conducted by agents
- Model Initialization
- Order of Operations (application of behaviors and cognition to initialized model)
- Walkthrough (1-3 example runs)
- Discussion

MODEL #1: ECONOMIC PATRONAGE AND AFFINITY

U.S. military commanders eventually realized that a system in which competing contracts went to the lowest bidder ... undermined the tribal system of patronage. Sheikhs traditionally maintain the fealty of their subordinates by providing for them financially. (McCary, January 2009)

PATRONAGE

As is true of many ethnic and religious leaders, Sheikhs in Iraq have little formal political power, yet wield great influence over followers. One of the key factors that allow them to maintain this power is a system of protection and patronage. Followers accept tribal leader's authority and in exchange look to them for protection and also for patronage-- help in finding jobs, emergency assistance, well-placed contacts for various needs. For the leaders, the ability to provide patronage is a critical source for their authority. Sheikhs have a social responsibility to distribute funds and resources downwards through their tribe (McFate, 2005), and an inability to do so results in a loss of authority for them. Over time, it has become culturally ingrained in Arabs that Sheikhs need to take care of their tribesmen, and if someone or something other than Sheikhs provides aid to tribesmen this results in a loss of face for the Sheikhs (Pryce-Jones, 1989) and a need to restore face. This loss of face shames the Sheikhs, forcing him to act in order to restore his honor (Wikan, 1984). Patronage can also take the form of Sheikhs providing security for their people (although security is not a component of model #1.). A lessened ability to do so via fewer resources results in a loss of one of the three components of honor: *ihtiram*. Losing honor results in humiliation and attempts to restore their honor (Fontan, 2006) can result in often violent struggles. To preserve their authority and maintain face, they expect financial and other opportunities to be mediated through them, and any attempt to bypass them will be met with resentment and resistance, and even violence. Our

patronage model recreates these dynamics by creating resentments in higher levels of a patronage system when money is distributed directly to lower levels.

POWER DISTANCE

Power distance, is a related cultural characteristic identified by Hofstede (1983). Cultures that score high in power distance expect power to be distributed unequally, and expect leaders to behave in more autocratic ways. High power distance cultures can be very tolerant of financial gains by leaders that would be considered excessive or even corrupt in more egalitarian societies. *Vertical collectivism*, a related cultural characteristic, (Triandis & Gelfand, 1998), refers to a society that expects a low degree of individual autonomy and a strong respect for existing hierarchies. Arab cultures are in general rated as high in power distance and vertical collectivism. This is reflected in the model in the high percentage of money kept by higher-level leaders and lack of resentment by followers when this occurs.

PATRONAGE AND POWER DISTANCE DYNAMICS

- Leader agents (any agent with followers) resent the source of any money distributed to their followers that does not go through them
- Agents expect and accept that leaders will keep a proportion of all funds (50% in this model)

HORIZONTAL INEQUALITY

Unequal distribution of resources within a society is always a potential source of conflict, but may particularly prime conflicts between groups of similar status. The theory of horizontal inequality predicts that groups will fear and resent gains made by groups that they consider to be their near-peers (Stewart, 2000; Østby, 2008). These gains may be in the socioeconomic, political, or cultural domains. Gains made by peer groups are feared because they change the implied social ranking, i.e. move a reference group down a notch, in a way that gains made by non-peer groups do not. This is reflected in the model in the responses of peers to unequal distributions to peers.

HORIZONTAL INEQUALITY DYNAMICS

- Each agent has a peer group defined by agents (see definition of peer)
- When agents receive new income, their peers tend to resent both the peer and the source, proportional to the amount of income
- Peer agents expect distribution of money from leaders to followers will be proportional to current affinity of leader toward each follower

MODEL ELEMENTS & DYNAMICS

Entities:

- *Follower*: Agent with a positive leader relationship value to another agent
- *Leader*: Agent with at least one follower. Leadership here is non-exclusive so that a follower may have multiple leaders. For a particular follower B, the individual with the greatest leader relationship value over B is considered B's *strongest leader*. A leader may also be a follower of another leader, in hierarchical fashion.
- *Resident*: special case of follower, a follower who is not also a leader, as he is without any followers himself, i.e., a leaf in leadership hierarchy. Resident, citizen, and tribesman are used interchangeably in this paper.
- *Peers*: Two agents (B and X) who have the same person listed as their strongest leader (C) and who are roughly equivalent in power, so that the number of followers of each (B and X) are within a ~2:1 ratio of each other: $(\frac{1}{2} < \frac{\text{followers}(X)+1}{\text{followers}(B)+1} < 2)$
- *Income*: Each agent has an income that accrues annually and into which received money is deposited

Relationships:

- *Affinity*: affinity represents sentiment of one agent toward another
- *Leadership*: leadership represents the degree to which one agent (a follower) is loyal to another agent (leader), which implies a set of expectations related to patronage

Behaviors & Cognition:

- *Transactions*: Money transfers are notated by $(S, R, \$_R)$ where S is sender, R is recipient, $\$_R$ is amount. Withdraw $\$_R$ from sender S, deposit $\$_R$ to recipient R. *Direct money* is that specified in a transaction. *Indirect money* is that received through the patronage network from redistribution of direct money. Each stage of redistribution is termed a *cascade*
- *Receipt bump*: For Transaction $(S, R, \$_R)$, Affinity (R, S) increases by $\$_R / \text{Income}_R$. Leadership increases similarly to reflect reinforced patronage
- *Patronage distribution*: Leaders redistribute half of what they have received to their followers. Leader C receives $\$_c$ and redistributes $\$_c/2$ proportionately between all followers based on C's affinity with each. If leader C's followers also have followers, they will redistribute received income in the same way. Receipt bumps apply to all distribution actions.
- *Bypass*: if C is B's leader, C is considered bypassed when B is the direct or indirect recipient in a transaction for which C is not the source. Leaders should always determine if they have been bypassed regardless of the amount of money in play and regardless of whether they received money directly in the same time step. In this version, only strongest leaders respond to bypass; higher ranked leaders are sufficiently distant from the recipient to be unconcerned with lower level undermining. Being bypassed is threatening in two ways. First, it makes the follower less dependent (a threat proportional to follower B's income). Second, it elevates the risk of the follower as a potential threat (a threat proportional to leader C's income.) So the decrement formula has two terms:

For Transaction $(S, X, \$_X)$ where C is a leader of X \rightarrow Affinity (C,S) decreases by $\$_X/\text{Income}_X + \$_X/\text{Income}_C$

- *Equity:* if peers are not provided in accord, inequity is perceived by those slighted. Every person connected to an individual receiving money evaluates to see if they are affected. If B considers X a peer, then B compares the amount of money given by S to each. B also compares Affinity (S,X) to Affinity (S,B) . B does not expect exactly equal distribution of money; B expects that S will distribute money in proportion to S's affinity with B and X. But if the distribution to X exceeds the ratio of affinities by more than 50%, B will be upset and decrease affinity to S (B won't get upset if it is unfair in the other direction, as B gets proportionately more). So for transactions $(S, X, \$_X)$ and $(S, B, \$_X)$ where S is a leader of both X and B, if $(\text{Affinity}(S,X) / \text{Affinity}(S,B)) / (\$_X / \$_B) < 2/3$, B will decrement affinity with S and with X by $\$_X / \text{Income}_B$

Model Initialization:

- Define *People* table with name, and annual income. Rank (Resident, Local Sheikhs, Regional Sheikhs) may be defined here or inferred from relationships
- Define *Relationships* with affinities and leadership values between pairs of people
- Define *Transactions* table with sender, recipient, amount and turn or set

Order of Operations:

- 1) Execute transactions: Transfer money
- 2) Recipients redistribute money
- 3) Recipients respond to receipt
- 4) Leaders evaluate bypass
- 5) Leaders & Peers evaluate equity

Walkthrough: How should \$50k for reconstruction be distributed?

This walkthrough compares the effects on relationships within the network and affinity toward the funder as a result of three different methods of distributing reconstruction aid.

Tribal population hierarchy

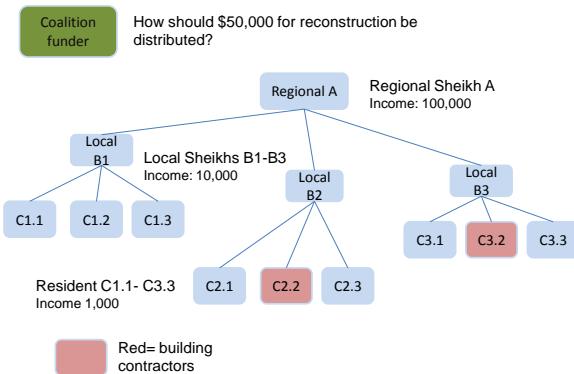
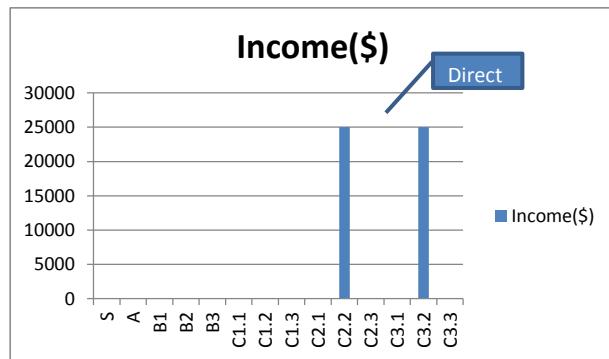


Figure 1. Hierarchical patronage network of leaders and followers. Leadership links are shown in blue (0.75). Affinity links exist between all entities and are initialized at 0.5.

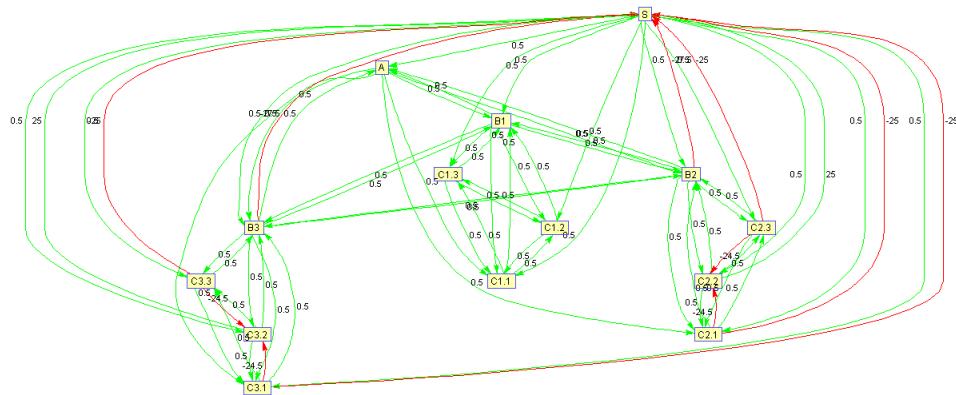
Strategy 1: Distribute between two contractors.

- 1) Transactions (S, C2.2, 25k) and (S, C3.2, 25k).
 - 2) C2.2 and C3.2 are leaves and so retain the entirety of transaction sum.
 - 3) C2.2 and C3.2 increment affinities toward S.
 - 4) Leader(C2.2) = B2, Leader(C3.2) = B3: B2 and B3 are bypassed and decrement affinities toward S.
 - 5) Whereas they have similar income and the same strongest leader, Peers(C2.2) = [C2.1, C2.3], Peers(C3.2) = [C3.1, C3.3]. Peers(C2.2) & Peers(C3.2) resent S for inequity of distribution, and are envious of C2.2 and C3.2 so that [C2.1, C2.3] and [C3.1, C3.3] decrement affinities toward S and toward C2.2 and C3.2 in proportion to the slight.

Money distribution profile:

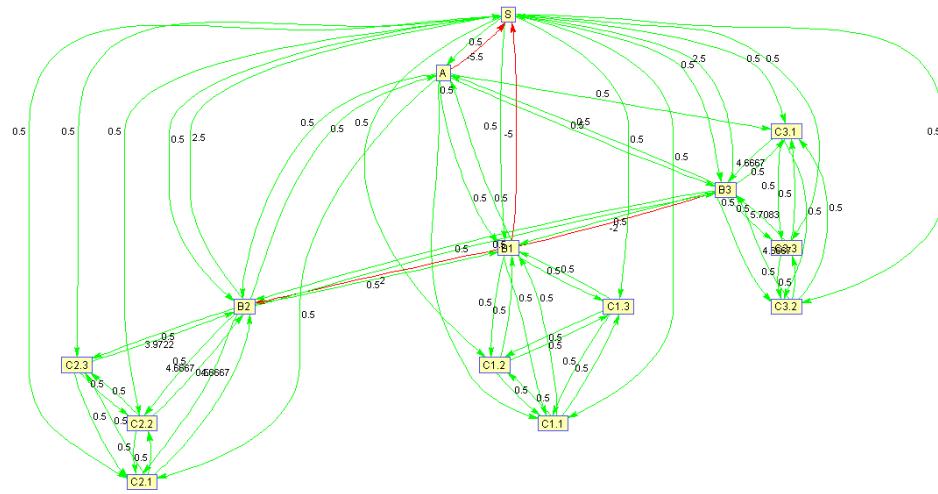
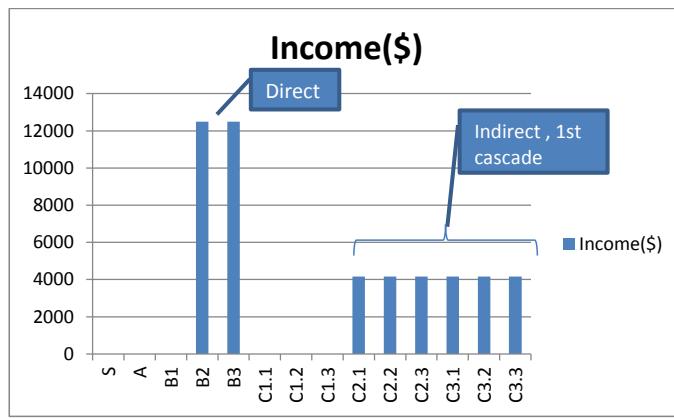


Affinity graph:



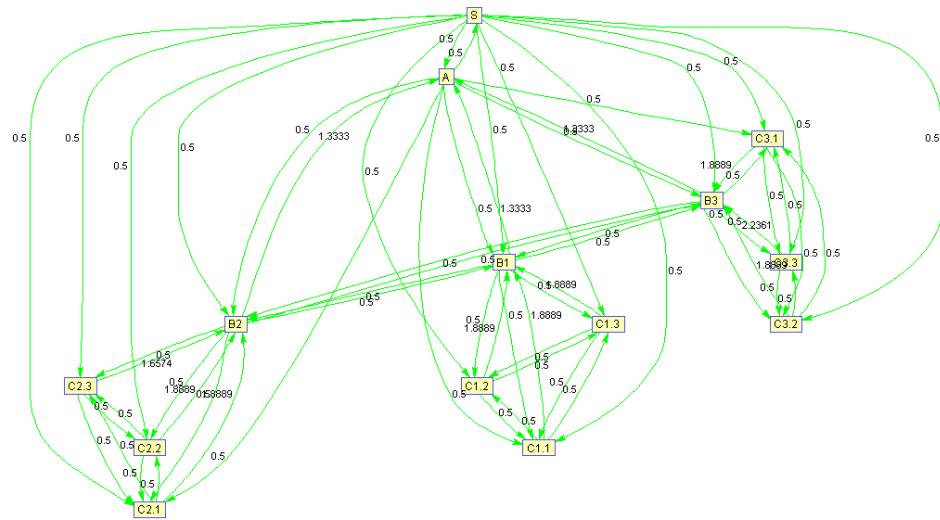
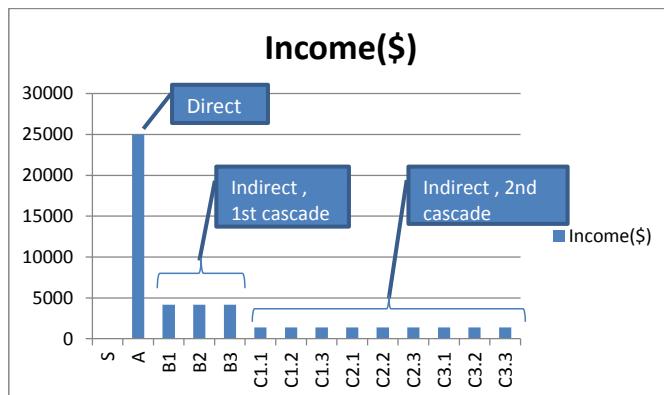
Strategy 2: give to local Sheikhs B2 and B3 to redistribute to C2.2 and C3.2

- 1) Transactions (S, B2, 25k) and (S, B3, 25k)
- 2) B2 and B3 each keep half and distribute the rest to their followers.
- 3) B2 and B3 increment affinities to S, followers of B2 and B3 increment affinities toward B2 and B3.
- 4) Leader(B2) = Leader(B3) = A is bypassed and decrements affinity toward S
- 5) Peers(B2) =Peers(B3) = B1 is slighted and decrements affinities toward B2 and B3 and toward S.



Strategy 3: give to top-level Sheikh A

- 1) Transaction (S, A, 50k)
- 2) A keeps half and distributes the rest to followers B1, B2, and B3. B-entities keep half and distribute the rest to their followers.
- 3) A increments affinity toward S, Bs increment affinities to A, and Cs increment affinities to their Bs.
- 4) No leaders are bypassed.
- 5) No peer inequality.



DISCUSSION

The walkthrough above compared three ways of distributing a fixed sum (\$50k) in a patronage network. The first method ensured that the largest amount was distributed to the two 'contractors' (C2.2 and C3.2) but created the most resentment toward the source from bypass sensitivity and toward peers from equity sensitivity. The second method generated less resentment toward the source from bypass sensitivity and toward peers from equity sensitivity, and a moderate amount of money reached the contractors. The third method created no resentment by distributing finances starting at the top of the patronage hierarchy. The third method also resulted in the least amount of money distributed to the 'contractors'; this did not create resentment, however, because the distribution followed cultural expectations.

This model illustrates the tradeoff between efficiency and minimizing resentment in a patronage network. The value of the model is in presenting quantifiable algorithms for affinity, resentment caused by bypassing leaders and jealousy of peers in such networks.

Any real-world network would be more complex, and the set of baseline expectations as described would be augmented to situational expectations. For example, it is likely that a peer to a construction contractor would not expect to get the exact same amount as the contractor for doing no work; and the amount of money kept by higher level leaders might be less than half. Resources might also occur in different forms, such as employment. This model provides a set of baseline algorithms that could be modified for inclusion into a larger model with customized thresholds and expectations.

MODEL #2: INFORMATION ACCESS AND COMPLICITY IN A CIVILIAN POPULATION (INCOMPLETE)

The second modeling effort we undertook focused on the competition for information between two opposing forces in a counterinsurgency campaign. Anbar was the nominal setting, but the model is intended to be general enough to apply to other situations.

This effort was partially completed but was interrupted by a change of direction requested by the sponsor away from individual-level modeling toward larger-scale social dynamics. This resulted in the balance of development effort being put toward model #3, which focused exclusively on leader behaviors.

INFORMATION WARFARE AND POPULATION COMPLICITY IN ANBAR

"The insurgents had spotters on every street and whistled or banged pots whenever a patrol, day or night, tried to sneak into town... No local dared provide information.... Abbas provided two informers who hid in an old vehicle and drove slowly through Khalidiyah... In four hours, 39 men were detained."
West, p 213(West, 2008)

"We felt like that we were going to solve Fallujah. . . . our courses of action of developing the intelligence, developing a credibility with the people, gaining additional tactical intelligence from them, would eventually lead us to the leadership of what we thought was an enclave of foreign fighters there . . . and we would take the head off of the insurgency in and around Fallujah." Conway USMC p 50 Lieutenant General James T. Conway Commanding General I Marine Expeditionary Force (*Al-anbar awakening: Volume I, american perspectives. U.S. marines and counterinsurgency in iraq, 2004-2009*2009)

"It is very easy for us to distinguish, and there are no foreign Arabs here now. It is hard for you to even distinguish between the guilty and the innocent, but we know them by their faces." Sheikh Ahmad Bezia Fteikhan al-Rishawi Paramount Sheikh, Albu Risha Tribe President of Mutammar Sahwat al-Iraq (Iraqi Awakening Party) in USMC II p 51(*Al-anbar awakening: Volume II, iraq perspectives. U.S. marines and counterinsurgency in iraq, 2004-2009*2009)

"Iraqi police who are Sunni, and live here, and can see a terrorist a mile away, who have their own ability to do indigenous R&S [reconnaissance and surveillance], which we have them moving around in plain clothes, undercover, coordinated, validating targets on a regular basis for us, where no American could go or uncover the information that they are." Lieutenant Colonel William M. Jurney Commanding Officer 1st Battalion, 6th Marines (*Al-anbar awakening: Volume I, american perspectives. U.S. marines and counterinsurgency in iraq, 2004-2009*2009)

In al-Anbar al Qaeda's foreign fighters, who formed the hardened core of the insurgency, counted on their ability to hide in plain among the civilian population. Al Qaeda did not have enough military strength to fight the US coalition directly. But by staying within the local population, they could not only hide their whereabouts, but also increase the chances of innocent casualties when they were attacked. This could only be countered by having very good targeting information, which early in the conflict the coalition forces usually did not have.

The coalition forces did not have the local knowledge to distinguish between foreigners and longtime residents, and did not have the local presence to either observe or receive informal reports. The Iraqi army had similar difficulty; they were mostly composed of fighters from other provinces and included many Shi'ites who could not easily mix with the local population. (The policy of assigning Iraqi army recruits outside of their home province was deliberate and intended to prevent sectarian bias or infiltration.)

Local residents were able to identify foreigners in their neighborhoods. Police recruited locally could be particularly effective, because they 1) blended in and 2) had pre-existing social networks to draw upon.

Al Qaeda conducted an extremely brutal and, for a time, extremely effective campaign of murder and intimidation to prevent locals from talking to coalition forces or joining the police force. Al Qaeda's limited forces had to depend on their own network of allies and informants to gather information to conduct this campaign.

This situation, then, could be represented as a well understood social network influence problem. Whichever force had the most influence with the local population would prevail, due to their ability to gather information about the other.

Properties of the network such as geographic reach of an individual's network and overall level of connectivity would strongly affect the behavior of the network. The presence of large poorly connected subgraphs (caused perhaps by geographic barriers, or tribal divisions) or presence of a few well-connected influences would also impact network behavior. A relatively well-connected network, such as one would expect to find in a small town, would be a very efficient information gathering system. A well-connected network would also be expected to show 'tipping point' effects where a small advantage for one side could quickly turn into an overwhelming advantage.

MODEL 2A: SYNTHETIC SOCIAL NETWORK

Model 2A was not a model per se; it was a synthetic population and social-network network which we could use to test assumptions about information access in a civilian population. A medium sized population of 1895 persons was made using JHUAPL's synthetic data generator. This population was geolocated in the town of Kubaysah, Anbar, although no specific data from that town was used. Three tribal groups were selected to populate the town. The names of actual Sunni tribes were used, but the distribution was synthetic.

Entities:

- *People*: (1895 in set)
 - Al-bu Nimr 985 ■
 - Ab-bu Sodah 475 □
 - Al-Rawi 395 ▲
 - Al Qaeda (foreign) 40 ▢

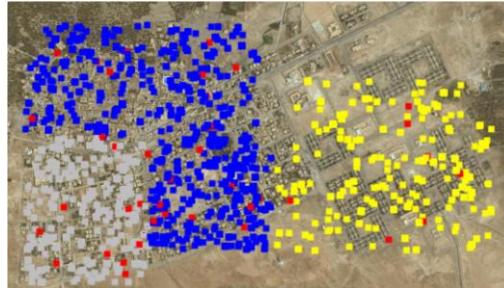


Figure 2. Google Earth visualization of synthetic population

- *Employers*: (138)
 - Example occupation types: local government, day laborer, skilled craftsman, mosque, import and export
 - Each employer had from 1-17 employees. Each employee was presumed to have a social connection with every other employee

Relationships:

- *Relatives* Local residents (non-AQ) had local networks for spouses, siblings, grandparents and cousins. There were 45,833 relative relationships in the model of different types
- *Coworkers* Individuals who worked for the same employer had coworker relationships with each other; 8,396 of these are in the model. Coworker patterns were not random. Employers selected employees using an algorithm that was biased toward selecting relatives first, then neighbors, and after that selected unemployed strangers from the population pool. This created employment groups that were less mixed than a random draw from the population would have been
- *Contacts* Al Qaeda members did not belong to other organizations so they did not have coworkers. However, the assumption was that AQ needed to coordinate with other groups, including suppliers and local militias, in order to succeed. Each embedded AQ member had on average two contact relationships. Because a relationship was created in both directions, this resulted in 160 contact relationships
- *Neighbors* Individuals were given ties to others who lived in close geographic proximity. A simple matching method based on rounded latitude and longitudes was used. There were 25,064 neighbor relationships in the dataset. Each individual in this model on average has 13.2 neighbors

All relationships in this model are one-way, but created in pairs. Our synthetic data generator does this to allow the possibility of asymmetric relationships, although all relationships in this model

were symmetric. If two-way edges had been used, the number of relationships would be $\frac{1}{2}$ the reported numbers.

Al Qaeda members were more disconnected than other members of the population, and thus more difficult to find. However, the presumption was that they did need to have some contact with other groups (criminal groups, smuggling groups, etc.) to carry out operations and would be known to them. So, each al Qaeda member was given two 'contact' connections to individuals in two criminal groups and reciprocal contacts were created the other way.

Initialization of model (see above)

Behaviors & Cognition, Walkthrough (not implemented). Model 2A was a static synthetic social network

Network properties

Initial explorations of this model focused on understanding the network properties of the synthetic Kubaysah network

The most interesting quality of this network was how highly connected it was, even with respect to the 'hidden' al Qaeda members. There were 562 agents in the model that had direct knowledge of at least one al Qaeda operative, by virtue of being a neighbor or a contact. If we expand the network of knowledgeable agents one more 'hop', virtually every agent in the model had access to information about one al Qaeda operative.

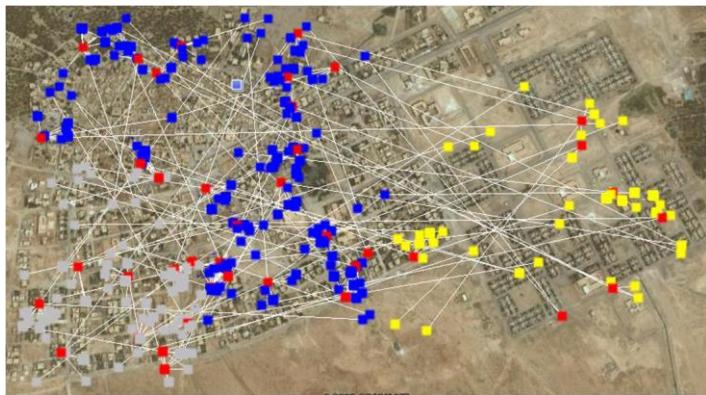


Figure 3. Synthetic Kubaysah residents and links indicating direct knowledge of at least one al Qaeda resident in the network.

MODEL 2B: INTERACTION OF FEAR AND COMPLICITY

When development of model 2 was halted, the model was partially specified and development had begun on the fully specified parts. Model 2B was focused on modeling residents' decisions to inform for al Qaeda, the US, or neither. Residents would be influenced by complex relationships with their leaders and the two competing outside groups.

JHUAPL's design for this model was to use a modification of the Beliefs-Desires-Intentions model used in other artificial intelligence efforts (Georgeff, Pell, Pollack, Tambe, & Wooldridge, 1999). This would be modified to what we called a 'Goals-Actions-Network' model. Goals and actions roughly correspond to desires and intentions, but at a level of abstraction appropriate to this modeling environment. It is a network model because most of the action triggers were properties of the social network (e.g. changes in alignments, or requests transmitted through the network) rather than either the physical environment or internal cognitive states, as in most other AI models. Appendix A represents the state of development of agent goals and actions when work on this approach was suspended in February.

Entities:

- *Sheikhs* in this model act as proxies through which requests for information (RFI) pass. A sheikh's alignment contributes to his determination of whether to pass along the request to his tribesmen.
- Tribesmen are aware of the alignment of other tribesmen to which they are connected. When a tribesman's sheikh passes along an RFI, the tribesman considers his relationships.
- *Teams* are the groups to which tribesmen and sheikhs may be aligned (US, AQ).
- *Member of Opposing Party (MOP)*: from the viewpoint of a tribesman or sheikh aligned to one team (US), those aligned to the opposing team (AQ)
- *Request Originator (O)*: A team who seeks to identify MOPs originates a request for information.
- *Request Proxy (P)*: A sheikh who receives an RFI from a team to pass to his tribesmen
- *Request Target (T)*: a tribesman who may be reported for being an MOP against the request originator.

Informants: tribesmen aligned with the request originator's team. **Relationships:** Relationships between entities have these components:

- *Kinship*: Residents have high kinship for family members, moderate for co-members of a tribe as defined by common Sheikh ties; and low but non-zero for AQ because of shared Sunni Muslim religion.
- *Fear*: Attacks carried out by US, AQ increased fear in both targets and observers.
- *Affinity*: Liking not based on kinship; could be based on favors or shared values. Less influential than fear or kinship.
- *Alignment*: Temporary alignments based on alliances of interest. Alignment changes were initiated by leaders and mirrored by followers (e.g. a Sheikh might decide to align with the US for strategic reasons, which would change his and his followers' alignment with the US).

- *Familiarity*: Neighbors and coworkers may be familiar with one another without necessarily sharing kinship, affinity, or alignment.

These relationship components combine to represent second-order relationships. For example, a *friend* is a combination of low kinship and high affinity.

Behavior & Cognition:

- *Request for information (RFI)*: Teams poll informants for MOPs, through Sheikhs out to followers.
- *Message Passing*: If the request proxy (P, usually a sheikh) is aligned with the request originator (O), P will pass the request onto his tribesmen.
- *Divulge*: If an informant knows (is connected to by any relationship) a member of the opposing party (MOP), does he tell the requester? The informant considers his sentiment toward the request originator (O), toward the request proxy (P, usually his sheikh), and his sentiment toward the MOP (the request target, T). Each sentiment is a sum of the components kinship, fear, alignment, and affinity, with kinship weighted highest, and affinity weighted lowest. Fear may be negatively weighted to represent the unwillingness of an informant to divulge information on those he fears (fear of reprisal), or positively weighted to represent the informant's desire to eliminate his threats and the fear they inspire. If $\text{Sentiment}(O) + \text{Sentiment}(P) > \text{Sentiment}(T)$ for the particular MOP T, the informant divulges the name of T.
- *Attack*: If the informant gives the requester the name of MOP T, the request originator attacks T. First, the health of T is decremented. Kin of T increment their fear and decrement their affinity toward the attacker. The kin also decrement their fear of T's Sheikh as the Sheikh is now seen as less able to provide protection and complementarily, to exact retribution. Further, if T's sheikh is also T's kin's Sheikh, the kin decrement their patronage to their sheikh for his ineffectuality.

Model Initialization:

- To explore the dynamics described, structures and values are set symmetrically.
- Two sheikhdoms, each with one sheikh and nine tribesmen are aligned as shown in Figure 4.
- See Appendix B for more initialization perspectives.

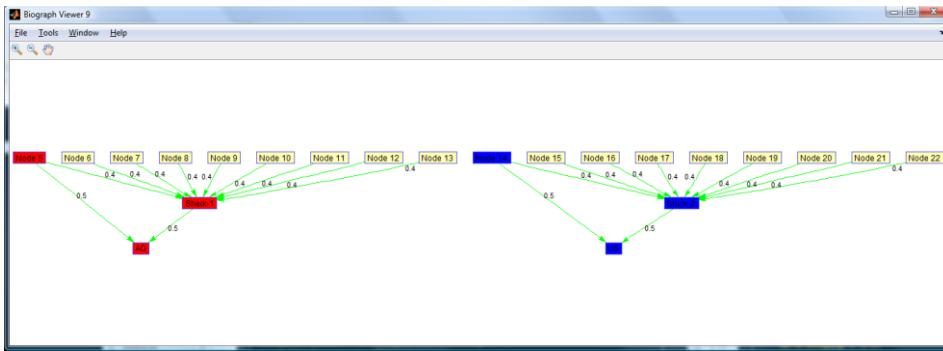


Figure 4. Initial alignment network of Sheikhs, followers, and teams. Red nodes are aligned to AQ, Blue nodes are aligned to US.

Order of Operations:

- 1) Teams polls for informants
- 2) Sheikhs determine message passing compliance
- 3) Informants decide if they will divulge MOPs
- 4) Informants respond to teams
- 5) Teams attack those given up by informants
- 6) Population responds to attack

Walkthrough (not implemented)

Sensitivity analysis

As part of initial development, we performed some sensitivity analyses exploring the interaction of fear, affinity, kinship, and cooperation. Because of the complexity of the relationships between model entities, and the complex repercussions of all possible actions, the possibility exists for non-linear and sometimes counter-intuitive dynamics to occur. As an illustration, the graphic below shows one interesting response surface set comparing the number of informants available to al Qaeda (red) versus the US (blue) based on number of attacks carried out by each. Algorithms describing the relationship between these variables were in flux and have not been specified in this report. However, even with the 'black box' of algorithms governing this space, the response surfaces raise interesting questions. Under what conditions do al Qaeda attacks have different effects than US attacks? Is it true, as this model suggests, that a completely non-military approach by the US (0 attacks) would lead to low cooperation?

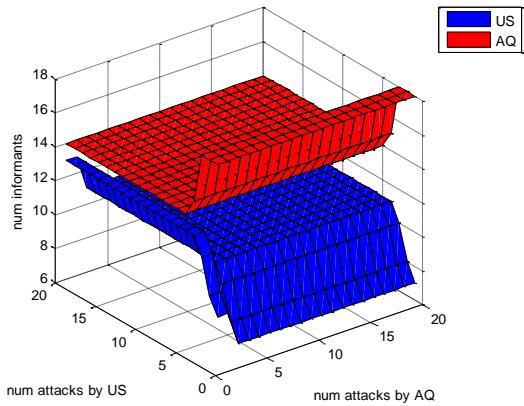


Figure 5. Number of informants as a function of attacks, mediated by network structure and relationship variables as specified in model #2.

DISCUSSION

Model #2 began to explore the relationship between population complicity, information, the exercise of military power and the exercise of soft power. Explorations of a synthetic social network in model 2A, based on plausible population and networking assumptions, showed how information from a cooperative population could be a force multiplier in a counterinsurgency struggle, and might tip the balance between competing powers.

The entities and relationships defined for this model are a plausible starting point for modeling the contest for influence and information in Anbar and similar situations.

The Goals-Action-Network model is a departure from prior models in the importance of the social network in determining individual actions; further development would be needed to determine whether it would be a tractable and productive approach.

MODEL #3: COALITION DYNAMICS WITH OF TRIBAL LEADERSHIP

"The Committee of Tribes (Lajnat al-'Asha'ir), which was established to work with the tribes of the Sunni Triangle northwest of Baghdad, including Anbar... enabled the Ba'ath Party (and particularly the canny Saddam) to place kinsmen in power (state tribalism) and buy the loyalty of other clans (auxiliary tribalism)" Long Anbar Awakening p73 (Long, 2008)

"This delegation of power to tribal authorities not only granted them formal authority but also enhanced their ability to seek extra-legal sources of additional revenue from smuggling (particularly lucrative as Iraq was under United Nations sanctions), government corruption and kickbacks, and even outright extortion and hijacking" Long Anbar Awakening p75 (Long, 2008)

.... So if you're an Anbari at the end of 2005 and you're being not only intimidated by these guys but robbed blind by them USMC I p127 (*Al-Anbar awakening: Volume I, American perspectives. U.S. marines and counterinsurgency in Iraq, 2004-2009*, 2009)

Neither the Anbar insurgency nor the Anbar Awakening were grass-roots movement. Both were led by powerful local leaders, aided by external powers. The insurgency was instigated by al Qaeda with cooperation from a collection of tribal Sheikhs and disenfranchised Ba'athists. The Awakening was a movement initiated and led by powerful tribal Sheikhs, who made a strategic decision to align with the US and then recruited the population to join them.

Most counterinsurgency models treat all citizen agents as the same. The common assumption is that agents seek some variant of Maslow's hierarchy of needs: physical, security, belonging, esteem, and self-actualization. There is also the assumption that citizens will consider a government to be legitimate if it provides security, some level of services, and administers justice.

However, leader behavior may need to be modeled differently than that of rank-and-file citizens (Bueno de Mesquita, 2009). Individuals who consider themselves political players, be they civilian politicians, tribal leaders such as Sheikhs, or religious leaders such as Islamic clerics, may have goals and behaviors that are very different from the average citizen. They may seek to gain power at the expense of security; they may oppose a functioning government as a rival to power. Furthermore, they may use their leadership positions and influence to bring about collective behavior among citizens that defies the conventional logic of counterinsurgency theory.

Our approach to modeling leader behavior draws on coalition theory. Coalition theory is a branch of game theory concerned with how partnerships are formed in different situations in order to 'win' at games that single players cannot win on their own. Parliamentary systems of government are prototypical coalition games: when one political party does not have a majority of seats they must form coalitions with other parties in order to form a government. Different partnerships are more or less likely to form based on the goals and relative strengths of the parties; likewise different theoretical assumptions made in a coalition game lead to different partnership dynamics.

Gamson's minimum resource theory (Gamson, 1961) makes somewhat counterintuitive predictions about choice of coalition partners. Minimum resource theory predicts that players will seek to form coalitions that are large enough to dominate a resource (e.g. control parliament) but not larger. The

reason for this is the assumption that within a coalition, power and resources are shared proportionate to each player's relative power, an assumption called the parity norm. According to this logic Player A who controlled 45% of available power would prefer to partner with a player who controlled 15% rather than a player who controlled 30%, because the first partnership would leave Player A with a 75% share of a winning coalition (45/60), and the second would leave player A with only a 60% share of a winning coalition (45/75).

Other assumptions can be made that change the dynamics of coalition formation. If one assumes an equity norm instead of a parity norm, which dictates that winning coalition members divide resources equally, then preferences swing toward coalitions with smaller numbers of partners. Leiserson's bargaining proposition (Leiserson, 1968) also predicts that coalitions with smaller numbers of partners will be more likely to form, all other things being equal.

In coalition games that are ongoing, rules for entering and leaving coalitions become important. A minimum winning coalition at one time point may lose power, and be replaced by a different coalition. Members may also gain power, in which case they may consider removing or replacing members of the coalition to maximize individual players' shares in the winning coalition.

JHUAPL COALITION MODEL

We developed a coalition game that can reproduce tribal leader behavior during the Anbar Awakening to a certain level of fidelity. Roughly, the order of events in Anbar that we sought to reproduce were:

Step 1: Anbar pre-invasion : Saddam Hussein is a dominant military power, aligned with a minimum set of Sunni leaders to form a stable coalition

Step 2: the US enters and removes Saddam Hussein by force, and brings a new player as partner: Civilian government. The US – civilian government seizes control of the resource (Anbar). Tribal Sheikhs are not welcome as part of the governing coalition per the (US's) Coalition Provisional Authority policy which sought to reduce tribal conflict and influence

Step 3: Al Qaeda enters as a political player with additional military power. Aligning with Sheikhs, who have more popularity than they do, this new coalition undermines the civil government and ultimately controls Anbar

Step 4: Al Qaeda increases its power in the area. Some Sheikhs are removed from the coalition.

Step 5: Some Sheikhs 'awaken' and turn against Al Qaeda. At the same time the US changes policy to allow arming and political partnering with Sheikhs. The US plus a coalition of Sheikhs seizes back control of Anbar

COALITION MODEL FEATURES:

The coalition model we developed has these assumptions that are common to other coalition games such as Riker's {{86 Murnighan,J.K. 1978}}

- Players seek to form coalitions that can dominate a resource

- Players prefer minimum winning coalitions that maximize their share of the winning coalition's power
- Players have perfect information about relative strength of themselves, rivals, and potential collaborators. Players can also calculate strength of potential coalitions, but do not project strength of coalitions several moves ahead.
- Coalitions have the ability to add or drop members and will do so to maintain minimum winning coalitions

Our model also included these unique features:

- Players wield two types of power, military strength and popularity. This reflects current thinking about power in counterinsurgency, where influence requires both types of power
- Military and popular power act as multipliers on each other. An individual player's power is the multiple of their military and popular power. This is meant to reflect the force multiplying effect of popular support (as partially demonstrated in Model #2's effects of information access earlier in this report)
 - A coalition's total power is the sum of its military power multiplied by the sum of its popularity. This encourages alignment of complementary partners, some with stronger military and some more popularity. Players in the model will consider forming coalitions with any other player, with these exceptions:
 - The US and Al Qaeda will not align with each other
 - The US has a preferred coalition with civil government (based on a policy preference toward western-style secular government)
 - The US will not align with Sheikhs in the early part of model (based on CPA policy)
 - Maintaining power for local players is dependent on controlling resources. Military power requires resources to pay for weapons and manpower; popularity requires resources to maintain patronage (as partially demonstrated in Model #1 in this report). The US is an exception to this rule, because its resources are dependent on US government funding (an externality), not local revenues
 - Power accrues according to these rules: Military and popular power accrue separately. Each converges over time to the value of the resources controlled, for example a coalition that controls a resource of value 10 will eventually converge on a military strength of 10. This would involve increasing or decreasing power at a rate of 25% per time step for military and 25% for popular support. Power accrues within a coalition proportional to original endowments, such that a player higher in military strength when a coalition forms will remain higher in military strength
 - When separated from all resources, a player's military and popular power eventually converge to 1 and 1. This represents native ability of these players to rally some support without resource endowment. Players are not normally removed from the model.

MODEL ELEMENTS & DYNAMICS

Entities:

- *Sheikhs*: agents with properties *Might*, *Popularity*, and *Active Period*
 - *Might*: agents have military strength
 - *Popularity*: agents have popular support
 - *Active Period*: time steps during which agents may engage or be engaged by other agents. Agents may enter or exit whenever. Agents that are killed or otherwise eliminated are inactivated
- *Team*: agents with *Might*, *Popularity*, and *Active Period* but with policies that preclude particular alignments or favor others. (US and AQ in the demo model)
- *Resources*: entity with property *Econ* that endows or secures *Might* & *Popularity* for those connected
- *Governors*: agents with control over a resource govern it
- *Coalition*: not defined explicitly, a coalition is a set of agents connected by *alignment* that *control* a common resource

Relationships:

- *Alignment*: this property between agents indicates their joint membership in a coalition
- *Control*: this property between agents and resources determines which agents are accruing from and obliged to defend a connected resource

Behaviors & Cognition:

- *Coalition strength*: for individual agents, strength is the product of military strength and popular support. For coalitions, strength is the sum of all coalition members' military strength times the sum of all coalition members' popular support. In this way, coalition members complement each other's strengths and coalition strength is superadditive
- *Coalition formation*: All active actors scan resources. For those resources which a Sheikh or team are not governing, that agent:
 - Determines defense of resources (coalition strength of those governing)
 - Tries all combinations of coalition membership (except those with whom you have negative alignment) to see if any have greater strength than current governing coalition
 - Of those membership combinations that grant greater strength, prefer the minimum strength coalition (not fewest members, not maximum strength) that includes yourself and join it if possible
- *Coalition Dissolution*: If a coalition's unifying resource is stripped, dissolve coalition
- *Kickout*: For all active actors, see if each actor can still defend their resources without any or all of their coalition members: that is, if actor A of coalition AB were to kick out actor B, could actor B join others to make a coalition strong enough to strip resource now governed solely by actor A?
- *Accrue/Decay*: Agents connected to a resource accrue value from the resources *Econ* to their *Might* and *Popularity* ratings. Where Power is *Might* or *Popularity*:
 - $\text{Power}_{\text{new}} = \text{Power}_{\text{previous}} + \text{Power}_{\text{previous}} / \text{Power}_{\text{coalition}} * (\text{Econ}_{\text{resource}} - \text{Power}_{\text{coalition}}) * \frac{1}{4}$

- When disconnected from resources, $Econ_{resource} = 0$, the parenthetical factor goes negative, and $Power_{new}$ decays.
- When disconnected from resources, heiks drop power until they reach their minimum rally values: Military power = 1, Popular support = 1 (abbreviated as M1, P1)
- US Military power is an externality and does not decay when disconnected
- *Clean-up:* Coalition behaviors are executed by coalition members uniformly. For a coalition ABC, A may decide to kickout C. B will make the same decision as he is cognitively homogenous to A, but if order of evaluation is not controlled, race conditions emerge. So, all intended actions are collected across agents during a turn, then pruned to a unique and non-conflicting set, and executed at the end of the turn. When an actor is kicked out or killed, all alignment links are severed, and his control link to the resource is removed. When an actor joins a coalition, that actor is connected to all coalition members by alignment, and connected to coalition-governed resources by control

Initialize population

- Set agents with might, popularity and active period
- Set resources with econ
- Set starting coalitions by alignments and governance by control

Order of Operations:

On each turn:

1. Determine active actors
2. Accrue/decay
3. Scan resources
4. Coalition formation/dissolution, Cleanup
5. Kickout. Cleanup

FIVE STEP SIMULATION OF ANBAR EVENTS

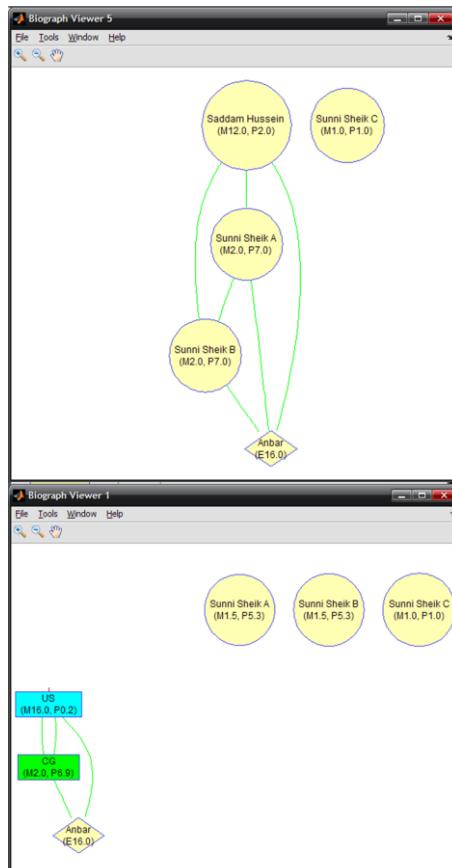
A coalition model following these rules was able to reproduce the five step version of the Anbar Awakening as described previously.

Step 1. In the model's initial state, Saddam Hussein rules Iraq with a small coalition of Sunni leaders (Sheikh's A and B). Not pictured in this is the presumed large population of disenfranchised Shi'ites and Kurds, without which Saddam could rule without the coalition. The ruling coalition's power is:

$$M \cdot 16 \times P \cdot 16 = 256$$

The 'Anbar' resource has value 16.

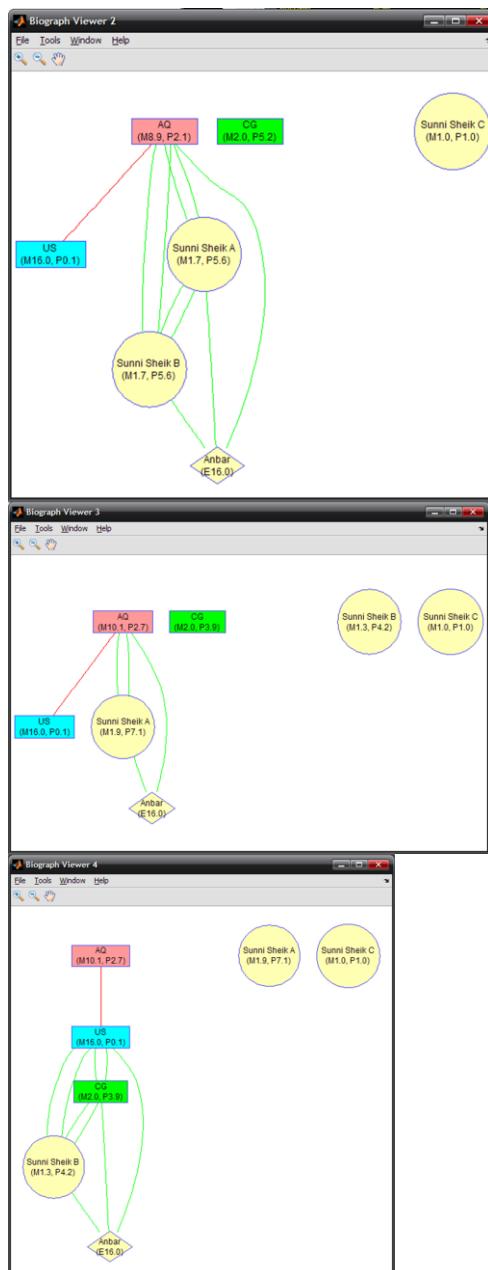
Step 2. The US replaces and removes Saddam Hussein and forms a minimum winning coalition with a newly formed civilian government. The US has high military power but low popularity; the civil government has low military power and moderate popularity. The disenfranchised Sheikh's power begins to degrade as they are no longer connected to the Anbar resource.



Step 3. Al Qaeda enters. AQ brings some military power which by itself does not exceed the US's; however, by aligning with still-popular Sheikhs, al Qaeda is able to form a winning coalition. The US and civilian government are disenfranchised. The civilian government's popularity begins to degrade.

Step 4. Al Qaeda's power has increased to the point where it can afford to, and does remove one Sheikh from the coalition for the purpose of gaining a greater share of the resources available to the winning coalition.
Disenfranchised Sheikhs would need a foreign military power such as the US to seize power again.

Step 5. The US changes policy to allow alignment with Sheikhs. The US along with one 'awakened' Sheikh, by combining US military power with the Sheikh's popular support, is able to seize control of Anbar. (A more historically accurate model would have a larger number of aligned Sheikhs.)



DISCUSSION OF MODEL #3

The coalition model is a proof of concept model that reproduces at a high level a known sequence of events surrounding the Anbar Awakening. This model offers a possible explanation for observed tribal leader behavior that does not require a drastic change in their goals or outlook. The Sheikhs in this model followed a consistent strategy throughout the model dictated by the rules and assumptions of a coalition game with particular rules.

This model could also be used to support the argument that leader behavior should be modeled differently than ordinary residents. Leaders who consider themselves players in the competition for political power may have goals and behaviors that are quite different than the concerns of ordinary residents who are more interested in security and prosperity. Leaders' influence is disproportionate, so that a small number of them may lead mass responses that are otherwise difficult to understand if only 'rank and file' goals and behaviors are modeled. Previous research on coalition games may be useful in modeling this behavior.

OVERALL DISCUSSION

The goal of this project was to recreate the dynamics of the Anbar Awakening, as documented by third party accounts such as (McCary, January 2009)(Long, 2008)(Smith & MacFarland, 2008). The Anbar Awakening was chosen because its change in state was complex enough to present an interesting modeling challenge. Anbar seemed to demand a multilevel model because most accounts of it include social, economic, and military dynamics, and could not be reproduced without consideration of each of these levels.

We developed three proof of concept models, each focusing on a different aspect of this problem.

We were successful in developing multi-level models that reproduce phenomena in ways that are consistent with observation and theory (although much more could be done.) Table 1 shows briefly where the three models address military, economic, and social considerations.

	Military	Economic	Social
Model #1. Economic Patronage and Affinity	N/A	Monetary redistributions through hierarchical patronage networks	Affinity changes due to monetary distribution
Model #2. Information access and complicity in a civilian population	Military power can only be applied with access to civilian-provided information	N/A	Fear, kinship, alignment and affinity determine information sharing
Model #3. Coalition behavior of tribal leadership	Military strength is one source of coalition power	Access to resources determines sustainable levels of military and social power	Popularity is a second source of coalition power and is a force multiplier of military power

Table 1. Military, economic, and social components of three models

Each of these models is a proof of concept only. These models do not prove any particular theory about the Awakening; nor do they provide complete explanations of the surrounding events or provide a predictive model of future behavior.

These models do, however, provide research and development useful in modeling a range of social and behavioral phenomena. Each of these models takes a conceptual model related to the interaction of social and other factors and does the work of translating concepts into the well specified parameters and rule sets necessary for runnable models. This enables future work that could test models with real-world datasets, integrate models into larger environments such as NOEM, or test models in a variety of conditions to understand their sensitivity and limits.

APPENDIX A: GOALS ACTION NETWORK MODEL

The table below is the set of goals and actions that would be available to different entity types. Table 2 shows goals. Table 3 shows possible actions taken in response to these goals. Algorithms linking individual states, network states, goals, and actions are not yet specified.

goalID	Goal	who has
10	protect self and kin	residents, leaders, sheiks
20	obtain subsistence income	residents, leaders, sheiks
25	increase income	residents, leaders, sheiks
30	increase honor	residents, leaders, sheiks
35	reduce shame	residents, leaders, sheiks
40	increase favor with patron	residents, leaders, sheiks
50	align with powerful leaders	residents, leaders, sheiks
60	promote and protect Muslim faith	residents, leaders, sheiks
110	increase number of followers	sheiks
120	protect influence with followers	sheiks
130	increase influence with followers	sheiks
140	weaken or eliminate internal rivals	sheiks
150	weaken or eliminate external rivals	sheiks
160	join most powerful group of leaders	sheiks
165	become leader of most powerful group of leaders	sheiks
170	provide jobs and money for followers	sheiks
175	protect followers from violence	sheiks
200	attack coalition	Al Qaeda
205	attack or deter coalition collaborators	Al Qaeda
210	increase AQ influence with residents	Al Qaeda
215	decrease influence of coalition with residents	Al Qaeda
220	undermine civil government legitimacy	Al Qaeda
230	grow AQ organization	Al Qaeda
232	raise money for AQ organization	Al Qaeda
234	recruit AQ members	Al Qaeda
236	recruit powerful leaders to align with AQ	Al Qaeda
310	eliminate insurgents	Coalition, civil government
320	increase government legitimacy	Coalition, civil government
330	increase influence with residents	Coalition, civil government
340	build and protect basic services	Coalition, civil government

Table 2. Initial set of goals for the GAN model of complicity

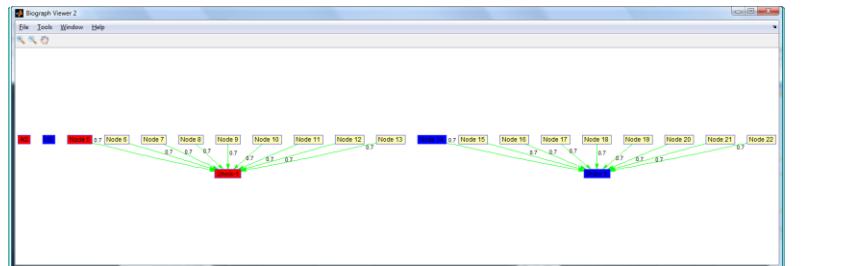
IntentionID	Action	who had these?

1	take job offer	residents, leaders, sheiks
2	give job to leader for patronage	residents, leaders, sheiks
3	increase alignment to leader or group	residents, leaders, sheiks
4	decrease alignment to leader or group	residents, leaders, sheiks
5	give public information about someone	residents, leaders, sheiks
6	give secret information about someone	residents, leaders, sheiks
7	provide false information to implicate an enemy	residents, leaders, sheiks
8	attack individual or group	residents, leaders, sheiks
9	participate in attack on person or group	residents, leaders, sheiks
10	join group	residents, leaders, sheiks
11	give money for protection	residents, leaders, sheiks
12	ask leader for protection	residents, leaders, sheiks
13	forgive past offense	residents, leaders, sheiks
101	offer job to individual	leader
102	attack individual or group	leader
103	threaten individual or group	leader
104	promise to protect individual or group	leader
105	extort money from individual or group	leader
106	make public alignment promise	leader
107	make secret alignment promise	leader
108	ask all followers for public information	leader
109	ask all followers for secret information	leader
110	ask another leader for protection	leader
111	ask another leader to align with self	leader
112	tell followers to provide information to group or individual	leader
113	tell followers to attack group or individual	leader
114	tell followers not to attack group or individual	leader
115	justify attack on individual or group	leader
116	arrange meeting with another leader	leader
117	mediate dispute	leader
118	invite someone to join group	leader
120	have job to offer	leader
120	fire someone from job	leader
121	increase militia to improve military strength	sheik
221	attack coalition directly	Al Qaeda
222	attack coalition with IED	Al Qaeda
223	attack someone aligned with coalition	Al Qaeda
224	threaten someone aligned with coalition	Al Qaeda
225	destroy infrastructure	Al Qaeda
226	kill civilians to increase fear	Al Qaeda

227	recruit members directly	Al Qaeda
228	ask militia to attack coalition	Al Qaeda
229	ask publicly for information on coalition collaborators	Al Qaeda
230	ask privately for information on coalition collaborators	Al Qaeda
231	threaten local business for extortion money	Al Qaeda
232	use smuggling route to obtain men and materials	Al Qaeda
233	ask sheik to align with Al Qaeda	Al Qaeda
234	threaten sheik to align with Al Qaeda	Al Qaeda
235	pay sheik to align with Al Qaeda	Al Qaeda
300	request information on insurgents through media	US
301	ask leader to find information on Al Qaeda	US
302	promise to protect leader	US
310	attack suspected Al Qaeda	US
311	arrest Al Qaeda collaborator	US
312	protect leader	US
313	protect infrastructure	US
314	protect police station	US
315	defend during attack	US
320	hire locals for construction project	US
321	hire contractor for construction project	US
322	hire contractor through sheik	US
323	hire police directly	US
324	hire police through civil government	US
325	hire militia through leader	US
330	increase alignment to leader	US
331	decrease alignment to leader	US

Table 3. Initial set of actions for the GAN model of complicity

APPENDIX B: WORK IN PROGRESS AND SENSITIVITY ANALYSES OF MODEL 2B



Comment [jk1]: Do we need to give Figure numbers for these figures?

Figure B1: Initial Patronage network. Nodes colored by alignment

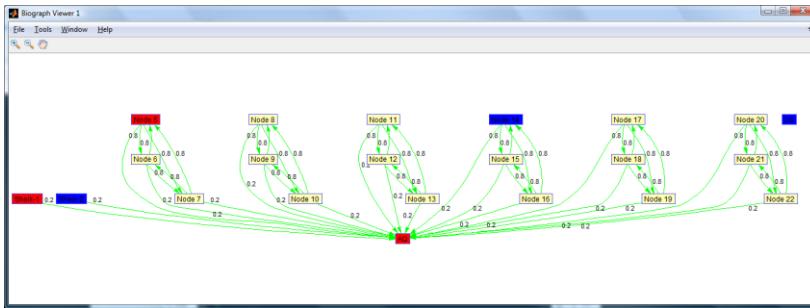


Figure B2: Initial Kinship network: nuclear families, Sunni shared across AQ/tribesmen

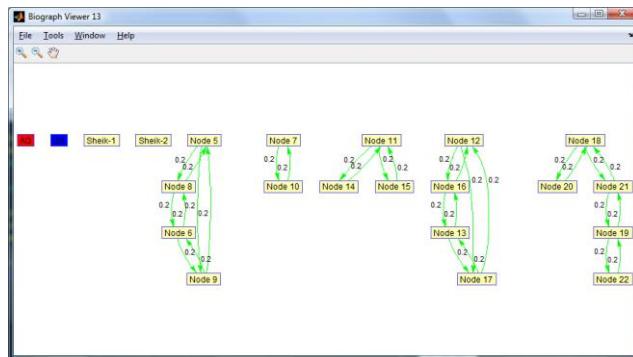


Figure B3: Initial Familiarity Network (Neighbors, coworkers)

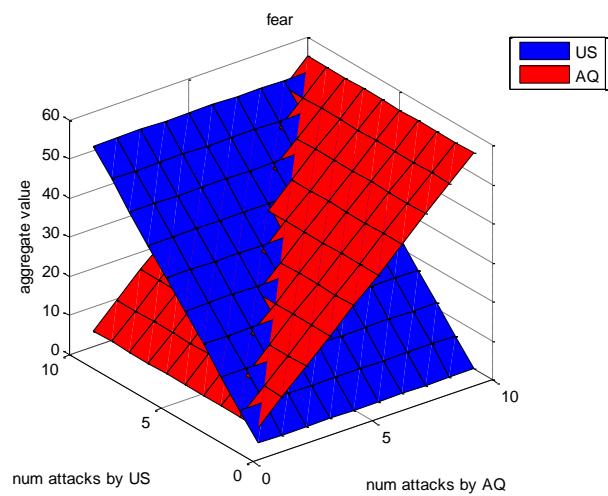


Figure B4: Fear increases by number of attacks

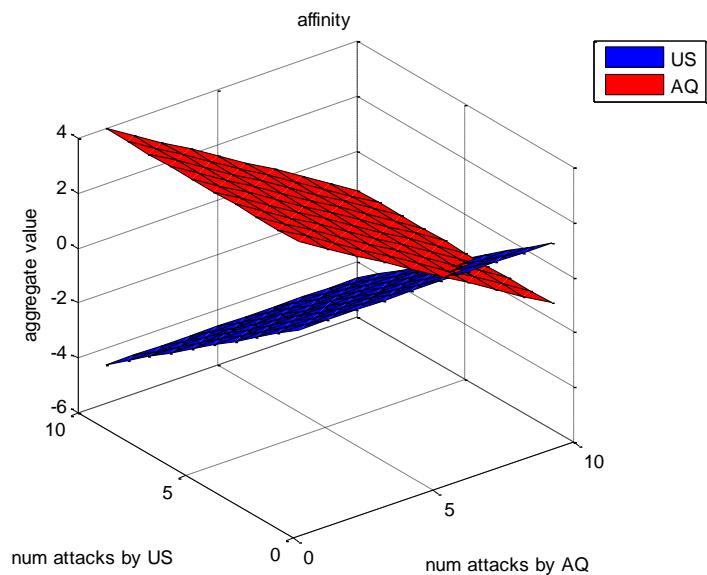


Figure B5: Affinity decreases by number of attacks

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