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COALITION COMMAND AND CONTROL IN THE NETWORKED ERA

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Constructing Social Networks on the Basis of Task and Knowledge Networks using WESTT

Topics: Social Domain Issues / Cognitive Domain Issues

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Abstract

In this paper, we propose that it is possible to combine conventional Human Factors approaches to task analysis and crew models to the study of covert networks. The intention is to add to the debate and methods that surround the study of covert networks. We suggest that it is possible to use Human Factors methods to both inform Social Network Analysis approaches, and to provide representations by which intelligence can be shared and explored. The paper is couched in terms of the WESTT approach, which assumes that any given organisation requires social, task and knowledge descriptions in order to submit to analysis.

Introduction

This paper contributes to the current debate on how covert networks can be studied. It will be argued that much of the current work concentrates of social network analysis, and that, while the SNA approach is very useful in the analysis of such networks, it can also focus analysis on specific features at the expense of others. The paper does not argue for a rejection of the SNA approach, but rather proposes that, in order to make sense of network structures, an approach that overlays three forms of representation is necessary. In this sense, the approach is similar to that advocated by Carley and her colleagues at the 2003 ICCRTS conference. However, a key difference lies in the manner in which we arrive at our network definitions and the way in which we represent links across networks.

Following the logic of the WESTT software tool (as presented at the 10^{th} ICCRTS conference by Houghton et al., 2005), we assume that any organisation can be considered in terms of a set of three interconnected network descriptions, i.e., social, task and knowledge. We further propose that the point of interest lies in the intersection of pairs of these networks. This is illustrated by figure 1.

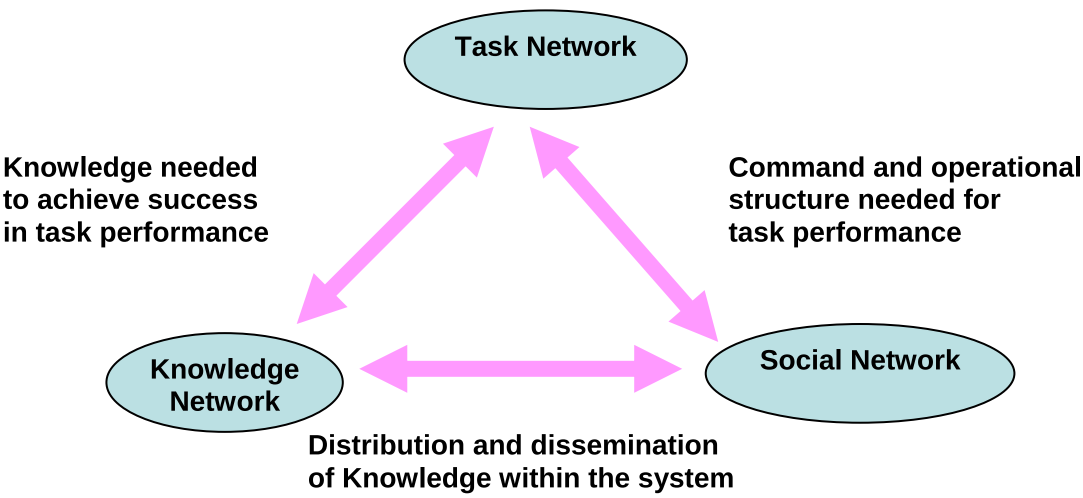


Figure one: WESTT triangle

Of particular interest to this paper is the manner in which the different networks in figure 1 can be described through a variety of operations, and the manner in which these interconnections can be used to hypothesise different social networks. An initial attempt to consider these relations was reported by McMaster et al. (2005) through analysis that manipulated roles and functions within police command and control to produce different network structures. To achieve this goal, it is necessary to create network representations that are appropriate to the focus of task, knowledge or social factors. It is proposed that relying solely on one form of network description might lead to omission of data that do not comply with the representation. This means that we would expect to represent task factors in the form of a task network, knowledge in the form of a knowledge network and social factors in the form of a social network. This is in contrast to assuming, for instance, that social or knowledge factors can be 'bolted' onto task models, or that task or knowledge factors can be adequately represented by social networks. Such an approach recognises the challenge inherent in describing social networks that have been created for the performance of a specific objective. As Richards (2001) pointed out, in her consideration of a related phenomenon, "…despite the empirical prevalence of coordination problems, we have failed to achieve a full theoretical account of coordination. The theoretical cul-de-sac arises because coordination problems by definition have multiple equilibria, resulting in indeterminate predictions." (p.259). Her solution was to describe coordination networks as a combination of communication (via a network of connected individuals) and shared knowledge (through the use of the concept of mental models, with elements that several people might use). Taking the lead from this work, it is proposed that covert networks require some sharing of knowledge and that communication could represent a minimal means of managing network activity. For example, studies by Banks and Calvert (1972) indicate that it is possible to manage sharing of knowledge through exchange of representations (A is like B) rather than direct comment (I choose A). The implication of this, and similar studies, is that a focus on communication between agents might skew the analysis inappropriately. In order to illustrate this point, we take as a starting point the bombing of two pubs in Birmingham by the IRA (Irish Republican Army) in 1974. This case is particularly noteworthy not because there was any attempt to use social network analysis but because the verdict was over-ruled and discredited some 20 years (?) later. This case has become infamous as the 'Birmingham Six'.

Using Social Networks to Represent Covert Cells

The use of 'cells' (small units of 3-5 operatives with minimal connection to other cells) was used effectively by the IRA during the 1970s (Robertson, 1987; Rosen, 2004). It is likely that this form of organisation was used by the Viet Cong, but the structure of the IRA has been more readily adopted by other urban terrorist groups. A challenge, therefore, to the network analyst is to define membership and association with such cells. Such an effort is confounded by the apparent lack of direct association between cell members prior to operations. It is also complicated by the observation that such cells tend to perform specific functions within the organisation as a whole, e.g., one cell might assume responsibility for logistics, another for operations, another for communication etc. This suggests that each cell would be closed, insular and protected. These various cells connect together to form a scale-free network that has a dynamic membership, non-hierarchical structure and ill-defined connections.

A key paper in the SNA of covert structures, in recent years, has been Krebs (2002) work on analysing interconnections between people in the cells responsible for 9/11. He begins by recognising Sparrow's (1991) observation that covert (criminal) networks will, by definition, by incompletely specified (in terms of available intelligence), exhibit fuzzy-boundaries between other networks and across particular activities, and by highly dynamic (with membership being subject to change). Krebs (2002) solution to these problems was to explore the connections between people who were likely to be involved in the activity. This led to the development of a series of social networks as information became available.

The Birmingham Six

In November 1974, two bombs exploded in Birmingham, killing several hundred people, making it one of the worst terrorist acts on the UK mainland during the IRA's campaign. Police and Security Forces were under intense pressure to bring about arrests and, within a few hours of the explosions, had arrested six men who were believed to be the perpetrators. They were arrested, subjected to interrogation and forensic analysis and then charged. After appeal, some 20 (?) years later, all charges were quashed and they were released. The actual bombers have not been arrested.

Reading through accounts of the trial, it is possible to identify links between individuals and to define these links in terms of strength of tie. Figure two shows a Social Network Analysis diagram in which strength of tie is defined by the number of unique points of association between individuals, i.e., if they were at school together, if they worked together, if they drank in the same pub etc. From this it is possible to create a total score of 5.

Figure Two: Social Network Diagram showing people mentioned in Birmingham Six trial

What is evident from this diagram is that four individuals stand out visually as key in this network. Applying analysis for Status and Bevalis-Leavitt Centrality allows us to further quantify membership of the network. Table one shows the analysis for

Status.[1] Following the logic that a node is significant if it exceeds the mean score (in this case, Mean: 0.64), then 7 people are 'key'. These are the Birmingham Six and James McDade (whose funeral they were travelling from Birmingham to Northern Ireland to attend). In terms of Centrality, an agent is deemed to be most central if it has the lowest score. Ranking these nodes in descending order of centrality suggests that the most central node is James McDade, and he is the person who links the other agents. This is because it was his funeral that the other were attending (and he was also associated with some of the other people through frequenting the same pub).

Of course, this diagram is based on consideration of evidence presented in Court – but an important point to note is that constructing a network on the assumption that people are guilty will support the assumption rather than provide an alternative perspective. What is, perhaps, more pertinent to the discussion in this paper is that a 'covert' network will (by definition) be likely to resist scrutiny by network analysis. The fact that six people are so prominently connected ought to raise some concern as to whether or not these connections are suspicious. Indeed, one of the arguments used to campaign against the convictions was that the arrest of these six people on the way to the funeral of an IRA member (who had blown himself up some seven days earlier while planting a bomb in a Telephone Exchange in Coventry), should either have raised some questions – either they would not have gone directly from an IRA bombing to an IRA funeral, or this represented some elaborate double-bluff.

Status	*Node*	*Centrality*	*Node*
1.67	*John_Walker*	4.76	*James_McDade*
1.25	*William_Power*	5.41	*Paddy_Hill*
1.08	*Hugh_Callaghan*	5.41	*Hugh_Callaghan*
1.0	*Gerry_Hunter*	5.41	*Gerry_Hunter*
0.92	*Paddy_Hill*	5.67	*William_Power*
0.75	*James_McDade*	5.67	*Thomas_Watt*
0.75	*Dick_McIlkenny*	5.95	*McDade_family*
0.33	*Thomas_Watt*	6.26	*Michael_Murray*
0.25	*Michael_Murray*	7.0	*John_Walker*
0.08	*Michael_Sheehan*	7.0	*Michael_Sheehan*
0.08	*Kenneth_Littlejohn*	7.0	*Sandra_Hunter*
0.08	*McDade_family*	8.5	*Dick_McIlkenny*
0.08	*Sandra_Hunter*	119.0	*Kenneth_Littlejohn*

Table One: Calculations of Status and Centrality for people mentioned in accounts of the Birmingham Six case

In their paper, Carley et al. (2003) follow the observation that covert networks are cellular and distributed, and propose the need to develop a dynamic network analysis. This offers a means of addressing Richards (2001) 'multiple equilibria' problem, by

[1] All SNA calculations in this paper has been performed using the WESTT software and validated using Agna.

developing a meta-matrix of people, resources and tasks. In this paper, our approach is to explore task models through conventional Human Factors methods, and then to consider knowledge through the use of propositional network analysis.

Task Networks

Much of the focus on media attention relating to terrorist activity has been on the outcome of particular activity, or the question of what motivates someone to engage in such actions. Less attention is given to the more prosaic questions of what actions are required to perform and support the activity. Drawing an analogy with traditional Human Factors domains, we can begin to develop notions of these actions through task models.

Annett et al (2000) argued that team goals must share common performance criteria (i.e., the team product) with which the success or failure of the team can be judged against. Team processes normally stress the importance of communication and co-ordination activities. Annett at al (2000) propose that it is important that the task analysis captures the three principle components of team work, namely the communication, co-ordination activities as well as team goals. The team work descriptions are rather more complicated than task work description, because of the interdependences and synchronisation of work between, rather than within, individual agents. Gramopadhye & Thaker (1998) illustrate how team tasks can be represented by allocation of function, interaction, error analysis, and knowledge requirements. Team performance requires an understanding of the team competencies, the communication and task requirements, the team environments, and the team objectives and mission (Salas, 2005). Therefore, we can assume that a network exists to achieve some goal (even if that goal is not concrete for a given network at the time of its formation). As Baker and Faulkner (1993) point out in their analysis of criminal networks, the purpose of the network is to achieve some goal. To our knowledge, the question of how tasks are managed within a covert networks has received less attention than the social and organizational structure of such networks. Jenkins (1987) suggested that, "Six basic tactics have accounted for 95 percent of all terrorist incidents: bombing, assassinations, armed assaults, kidnappings, hijackings, and barricade and hostage incidents. Looking at it another way, terrorists blow up things, kill people or seize hostages." (p.154). Approaching this argument from a human factors point of view, it ought to be possible to develop task models for each basic tactic, and for the approaches of different groups to be represented as low-level variations in these task models.

With regards to the roles that teams take within systems, Cooke (2005) suggests that teams are required to detect and interpret cues, remember, reason, plan, solve problems, acquire knowledge and make decisions as an integrated and co-ordinated unit. Team-based activity in complex systems comprises two components: teamwork and taskwork. Teamwork refers to those instances where actors within a team or network co-ordinate their behaviour in order to achieve tasks related to the teams goals. Taskwork refers to those tasks that are conducted by team members individually or in isolation of one another. Team-based activity involves multiple actors with multiple goals performing both teamwork and taskwork activity. The activity is typically complex (hence the requirement for a team) and may be dispersed across a number of different geographical locations. Having developed a high-level task model, the next step is to considering how it can be 'crewed'. This is similar to defining roles for members of a cell, and allocating duties to these roles. Sullivan and Bunker (2005) noted that “Linking network structures to network roles offers better insights into how networks form.” (p.185). In his analysis of transnational criminal networks, Williams (2001) suggested six basic roles for such networks:

- Organizers – provide steering mechanisms for network
- Insulators – protect core from infiltration
- Communicators – ensure communication flows between nodes
- Guardians – security enforcers
- Extenders – recruitment
- Monitors – report weaknesses

Within the IRA in the 1970s, cells tended to consist of 3-5 people and to be organised with an Officer in Charge (who would most likely assume the Organizer and Communicator roles), a Quartermaster (whose role was to source and supply guns, explosives and other requirements), an Intelligence Officer (whose role was, amongst other things, the evaluation of targets), and other Operatives (Mullins, 1987). The Officer in Charge would be appointed because of previous experience, and would most likely be the single point of contact between the Cell and other higher authorities (who would be responsible for funding, organization, strategy etc.). However, links to these higher authorities would be minimal and the Cell would, to a large extent, be autonomous. The Quartermaster would need to manage storage and distribution of materials, which would be potentially the most risky operation. The Operatives will be trained and tasked to perform specific actions, which might not require knowledge of the overall objective or other people’s actions. This leads to a clear allocation of function within and across Cells, and possible duplication of effort to ensure continuity.

According to Steiner (1972), tasks can be divided into five basic types: additive, compensatory, disjunctive, conjunctive or discretionary. These task types differ in the degree to which effective performance depends upon the "richness" of information transferred between individual group members. McGrath and Hollingshead (1994) proposed that they differ in the amount of additional information they require. Simple, low ambiguity tasks e.g. additive tasks require no additional information beyond the acquisition of facts, and indeed any evaluative or emotional information may be a hindrance to effective performance. In contrast complex, high ambiguity tasks, such as disjunctive tasks, where there are conflicting interpretations about the situation, do require additional information in order to resolve disagreements through the exchange of subjective views. In addition some tasks will comprise of a combination of these task types. Therefore the effectiveness of the group will be determined by how well the interaction of its members fit the requirement of the task.

We propose that it is possible to recruit work from the area of task analysis for team performance to gain some insight in this question. In order to pursue this question, we take the position that a network is set up in order to achieve a specific goal and that allocating personnel to achieve this goal is analogous to crewing problems that are traditional in human factors.

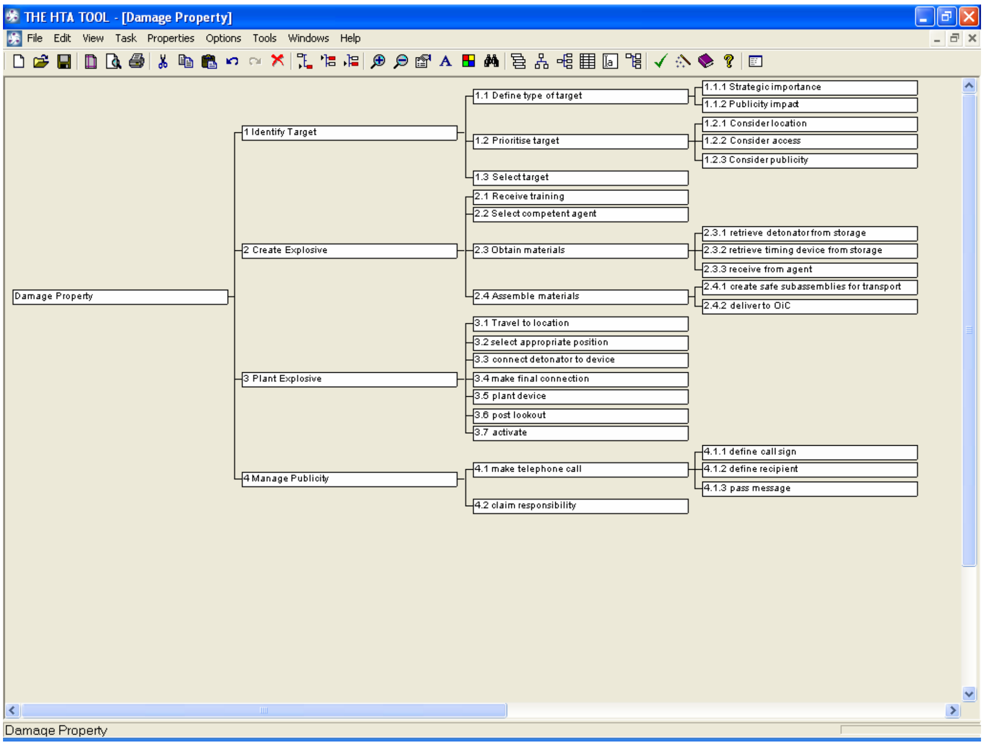


Figure Three: Proposed task model

From figure three, one might ‘crew’ the mission with four primary agents {Officer in Charge, Quartermaster, Intelligence, Explosives}, with links to higher Command and (possibly) to ‘outside agents’. This would follow the sort of cell structure adopted by the IRA in the 1970s. Table two shows how one might begin to create such a crewing model for the mission. For each task, we assume that it can be classified as either strategic, tactical or operational. there is a possible member of the cell who would be likely to take responsibility, and (if necessary) some agents external to the cell who would be involved. This information is sufficient to produce the Sequence Diagram in figure four and the social network in figure five.

During his investigations, Mullins (1986) reported an account of the Birmingham bombings from someone he identified as X. Table two also includes a column that maps X’s account of events onto the task model. This leads to the production of the social network in figure six.

Task	Type	‘Crew’ in Cell	External	X’s account
Identify target	strategic		Command	
Define type of target	strategic		Command	
Strategic importance	strategic	Officer in Charge		
Publicity impact	strategic	Officer in Charge		
Prioritise target	tactical	Officer in Charge		
Consider location	tactical	Intelligence Officer		
Consider access	tactical	Intelligence Officer		
Consider publicity	tactical	Command		
Select target	tactical	Officer in Charge		any
Create explosive	operational	Explosives		x
Receive training	strategic		Outside agent	
Select competent agent	tactical	Officer in Charge		
Obtain materials	operational	Quartermaster		?

Retrieve detonator	operational	Operative		a
Retrieve timing device	operational	Operative		a
Receive materials	operational	Explosives	Outside agent	x
Assemble materials	operational	Explosives		x
Create safe subassemblies	operational	Explosives		x
Deliver device	operational	Explosives		x
Plant device	operational	Operative		a, b, c
Travel to location	operational	Operative		
Transport device	operational	Officer in Charge		oic
Select appropriate position	tactical	Operative		?
Connect detonator to device	operational	Operative		a
Make final connection	operational	Officer in Charge		a
Post lookout	operational	Intelligence Officer		oic
Activate device	operational	Operative		a
Manage publicity	tactical	Officer in Charge		
Make telephone call	tactical	Officer in Charge		x
Define call sign	strategic		Command	
Define recipient	strategic		Command	
Pass message	tactical	Officer in Charge		
Claim responsibility	strategic		Command	

Table two: Mapping of task model onto task types and roles

Having tentatively assigned roles to tasks, it is a simple matter to relate this to a sequence diagram. We can assume that some tasks will be dependent upon others, and this determines the sequence shown in figure four.

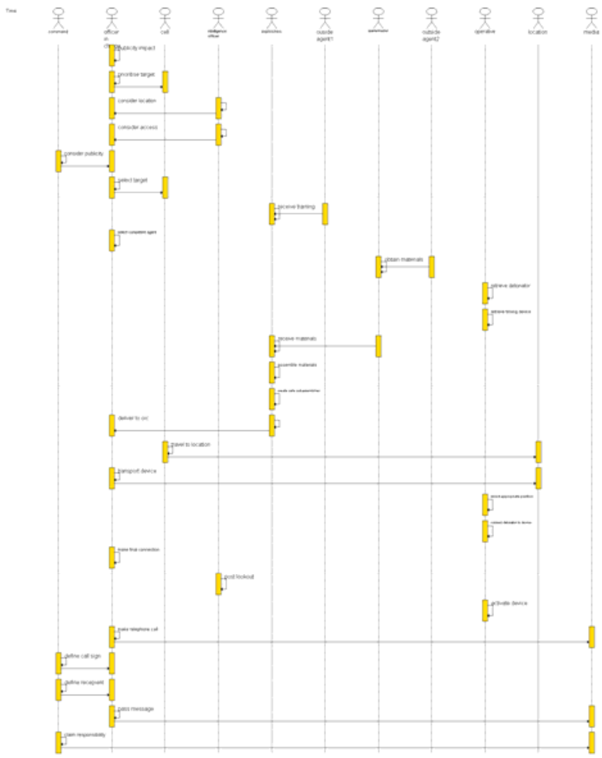


Figure four: Proposed crew for task model shown in figure three

Figure four represents a fairly large collection of individuals. This could represent a problem for coordinating activity, and could also provide several potential points of fracture in the network. Figure five shows the social network that reflects this description.

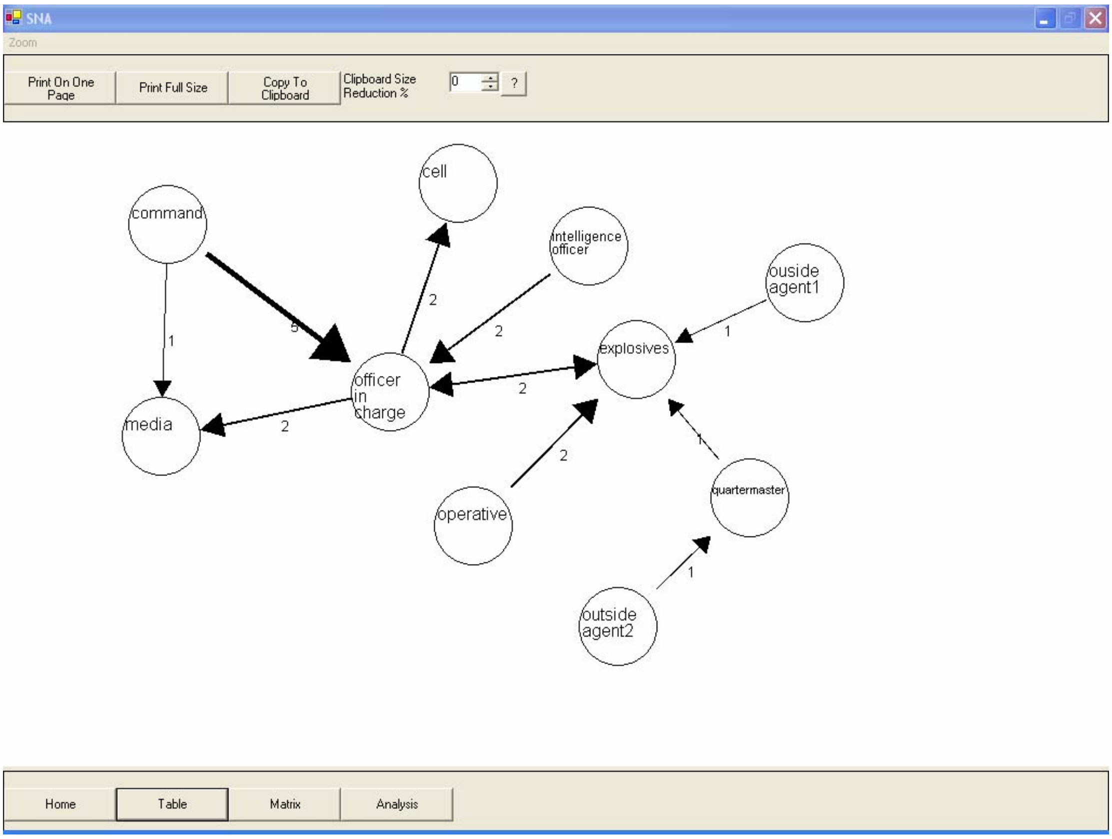


Figure five: Social Network Derived from Task Model

In crew studies, the primary concerns are to allocate function to appropriately skilled individuals so as not to overload them. This means that workload and skill-level of key concerns. One can assume that similar concerns arise in the 'crewing' of covert cells. Indeed, "Removal of high cognitive load individuals tends to be more disruptive than the removal of individuals high in degree centrality." (Carley et al., 2003). One reason for this could well be that removal of individuals whose actions lie on the critical path of the mission (irrespective of their place in a social network) could lead to delay or termination of the mission. As Sullivan and Bunker (2005) note, "While individual hubs are important, and hubs with high capacity…are critical, the workload must be distributed across the network to optimize resilience. Multiple hubs, reinforced by clusters of nodes with distributed capabilities, can absorb both random failure and intentional attack." (p.195). This suggests the need to optimise the size of the 'crew' in terms of skill, workload and resilience. One might argue that X's account of the Birmingham bombings reflects a cell that had a specific skill (X's work on explosives), together with a division of labour: 'a' fetched the detonator and timing device, and passed these to the 'Officer in Charge', who had received the device from 'X'.

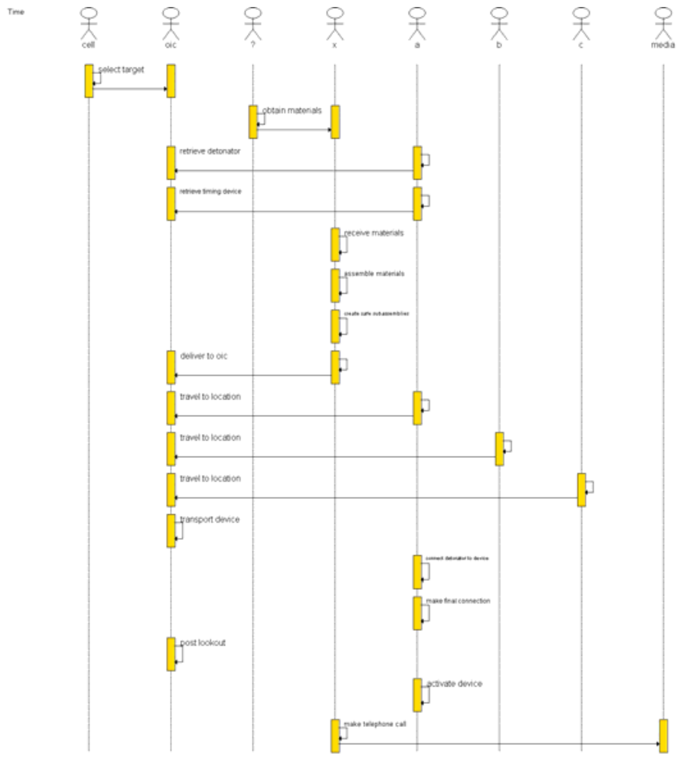


Figure six: Sequence diagram of X’s account

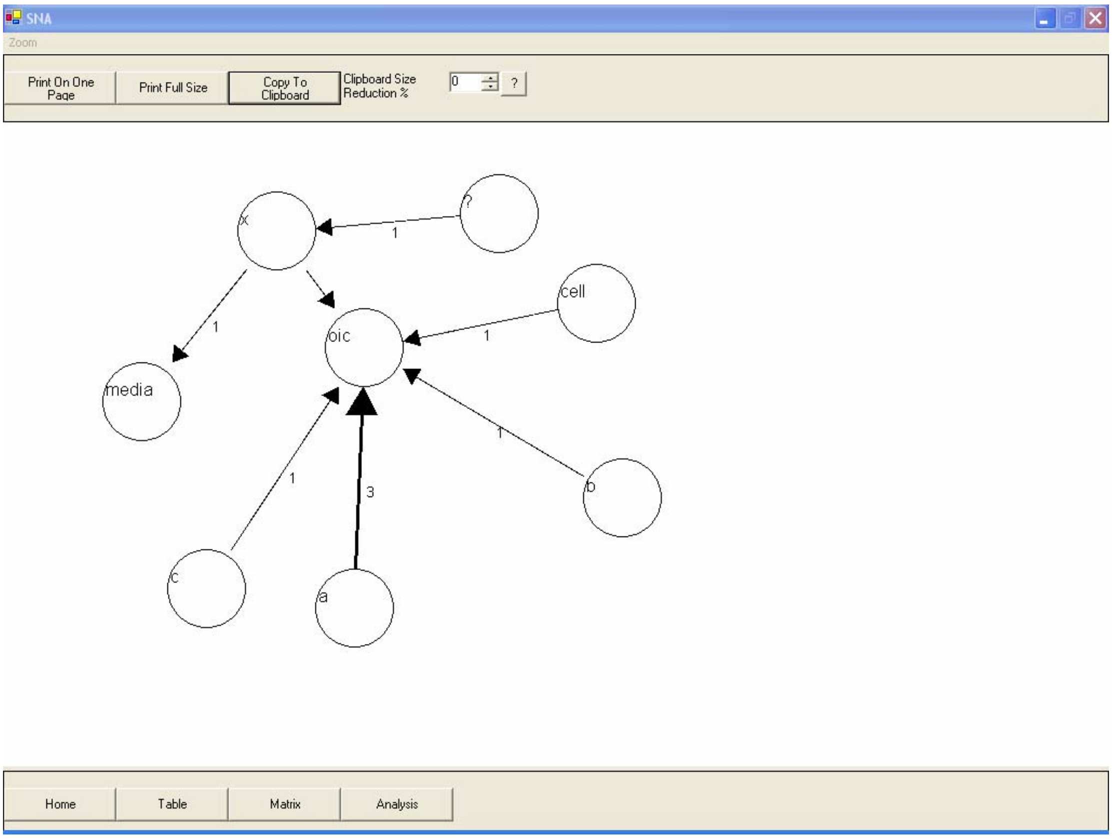


Figure seven: Social network of X’s account

Some of the difference between figures five and seven simply reflect the fact that X's account does not cover all elements in the task model. A further difference lies in allocation of duties. For example, the OiC was supposed to make final preparations of the device but, ultimately, this was done by 'a'. Comparison of these two network diagrams is interesting. Both show a central role of the Officer in Charge (OiC) and links from the Explosives (x) agent to other agents. This implies that '?' in figure seven could be the Quartermaster, and that a, b, c are Operatives. It is tempting to also assume that at least one of the Operatives could correspond to X and the other to the Quartermaster (which would better align the diagrams, and is possible, given the inconsistencies in X's account).

How do social network analysts deal with knowledge?

There has been a long tradition in the social networks community to assume that 'knowledge' was owned by an individual, and that linking to this individual would provide access to this knowledge. By implication, this would mean that sharing of knowledge would require other individuals to link to this specific individual. In a similar vein, contemporary notions transactive memory (Wenger, 1987; Borgatti and Cross, 2003) assumes that knowledge is distributed across agents and that, in order to use such knowledge effectively, individuals need to know who knows what. While this looks like a promising line of enquiry for networks that are relatively stable, static and well-defined, it becomes particularly problematic for the analysis highly dynamic networks, such as covert networks. A review of the social network literature suggests that the interaction between individuals (or groups/entities) and knowledge is typically represented in three different ways:

1. Social network structure

The first approach to combining social networks and knowledge is to not represent knowledge explicitly but rather to draw conclusions largely from the structure of the network. In such an analysis one may, for example, identify clusters of individuals. Either on the basis that they are grouped together, or more usually with reference to an informal understanding of those individuals' job description or interests, they may be identified as a *community of practice* (Wenger, 1998). Communities of practice have three defining qualities: First, they have a domain; they are about something such development of a new product or information technology support. Second, they are constructed from relationships between individuals and it possible to note boundaries between being within and outside a community. This identification of boundaries naturally lends itself to the techniques used in social network analysis; we may for example define group membership in terms of either a clustering or in terms of a statistical criteria of *geodesic distance* between nodes or the values/weightings of edges connecting nodes (i.e., frequency of communication between nodes or other measure of strength of connection). It might also be possible to, in terms of network metrics, identify other roles with relation to a community of practice, for example individuals who connect various groups, and may act as gatekeepers or facilitators. Third, communities of practice have a body of practice which differentiates them from groups who merely have a passive interest in a topic; this might be indicated by the shared use of common tools, ideas, documents or other artefacts to pursue goals (see Wenger, 2004). Communities of practice are autonomous and may exist across organisations or across demarcations made in organisational charts: on this basis they should not be confused with *teams* or *functional groups* (O'Hara et al., 2002). Notably in this network-centric approach, the actual objects of knowledge are not themselves closely identified, indeed some authors argue that communities of practice generate and organise their own knowledge and that attempting to objectify knowledge would be to miss the exchange of tacit or implicit knowledge between actors (Wenger, 2004). None the less, the transition from identifying a cluster to identifying it as a community requires at least the subjective assessment that they have commonalities and given that this becomes an inductive process once the cluster is identified, there may be instances where researchers search for tenuous confirmatory evidence of commonalities rather than contradictory evidence. Clearly there may be cases when such groups are falsely identified on the basis of spurious epiphenomenal statistical patterns (i.e., statistical type I errors) or otherwise not noticed (i.e., statistical type II errors).

2. Knowledge category tracks

A second approach is to use social networks normally but to categorise individual nodes formally in terms of a classes of knowledge they use. This produces a visualisation of the network that is reminiscent of the London Underground map where different tracks (e.g., the Bakerloo line) represent different classes of group membership or knowledge (e.g., “has expertise in demolitions”, “has access to security briefings”, “has a degree in a scientific subject”). An alternative but equivalent visualisation is to produce separate social networks for each type of knowledge as a subset of a larger network. Social network analyses can then be carried out to measure and then compare the qualities of each network. Again, communities of practice can be identified (a class of knowledge may be restricted to a limited part of the network) and gatekeeping roles identified (individuals may be connected to multiple tracks). A notable use of this approach has been in the mapping of terrorists following 9/11 in terms of which group of hijackers they belonged to or which function they undertook (e.g., Krebs, 2002). One drawback of this technique for knowledge representation (rather than solely group membership) is that it is typically limited to a small number of types of knowledge and fails to capture relationships and overlaps between different types of knowledge itself. The decisions made by the analyst in grouping various types of expertise or knowledge may have a distorting effect upon the ensuing analyses. Further, whilst we might understand socially mediated connections between different types of knowledge, the nature of that knowledge itself is not explored.

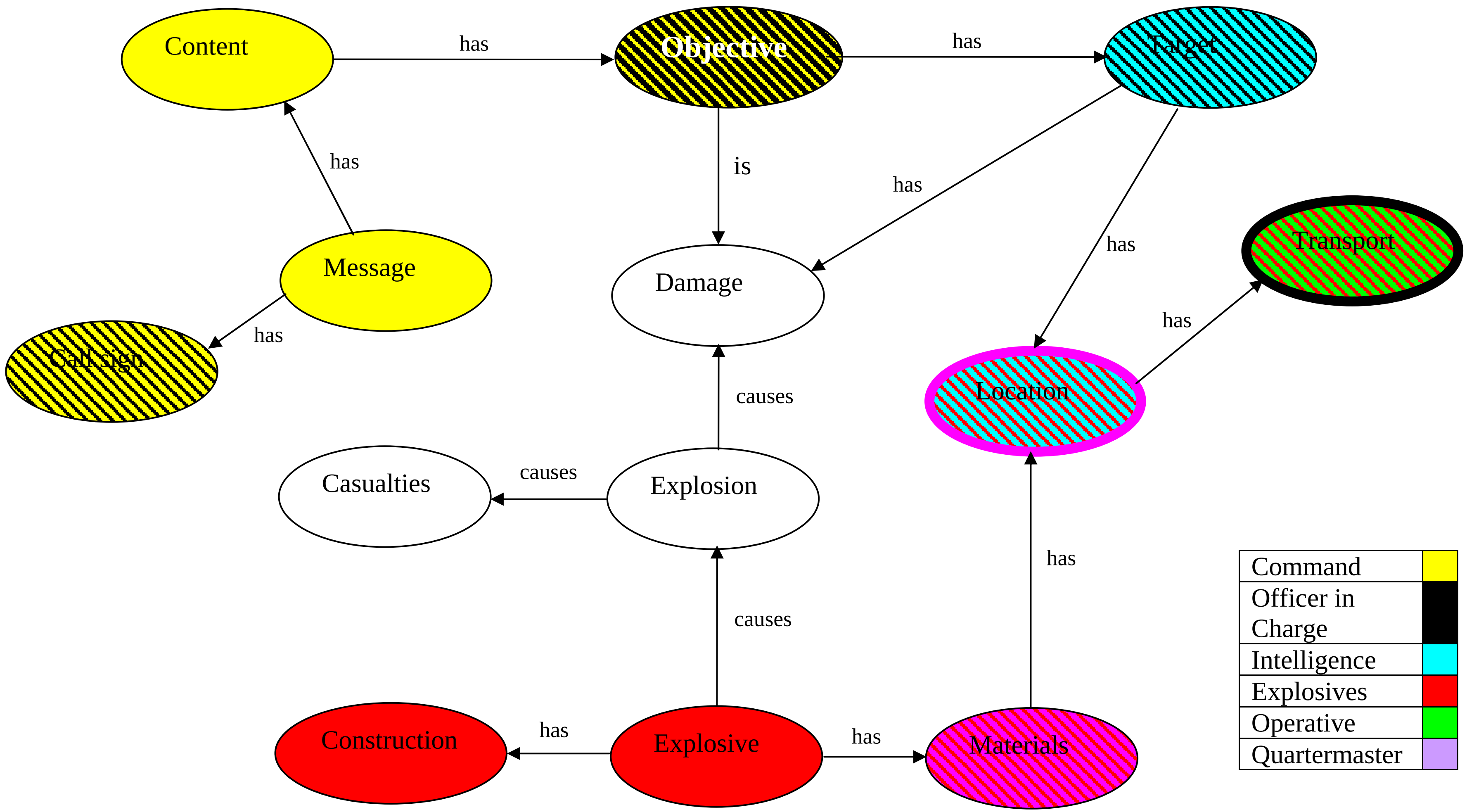
3. Combined social and knowledge networks

The third kind of approach, which WESTT and its related methodology are a part, is to take social networks as above and link them to networks of knowledge. There are various approaches to the mathematical construction of such networks; one may construct two different networks of knowledge and social actors respectively, and then link and compare across the two matrices or else adopt a “flat” structure and put both knowledge and actors into the same matrix. In the general case, these two approaches should be formally equivalent although it will depend on the exact nature of the analyses produced. This approach to combining networks appears to most popular where researchers are interested in web-based applications of social network theory and knowledge is generated from automated “screenscraping” or textual analysis of webpages and then linked back to the individuals who own, are mentioned in or perhaps have used those webpages. For example, O’Hara et al. (2003) report success in binding social networks to a network that depicts a knowledge ontology based on automated analyses of webpages. This allows the generation of analyses which suggest, for example, which specific research interests individuals have in common. The signal advantage of this approach is that by making a closer-grained analysis of knowledge this provides a richer understanding of the nature of connections between individuals. For example, if we see a cluster or clique of individuals in a social network, there may be a similar clustering in terms of the knowledge they utilise, which would present strong evidence of the existence of a community of practice. However, if there was not this clustering in the knowledge itself we might instead suggest that the clustering is a result of some other factor, for example a diktat of the organisation or mere geographical proximity of the actors in their workspace.

Propositional Networks and Role

From the description of activities considered previously, it is possible to identify core topics about which people need to discover and share knowledge. We term these topics ‘knowledge objects’ and claim that they can be represented, at a system level, in a simple network diagram. Relations between knowledge objects are defined in terms of propositions, i.e., a <building> <has> <location> (where building and location are knowledge objects, and has is the association between them).

The basic concept is that each knowledge object is used by specific agents. If more than one agent makes use of a knowledge object, then it is represented as a striped node in the network. Thus, in figure eight, there are six knowledge objects that are used by more than one agent. The essential point to note is that this does mean that this does not mean continuous communication between the agents. Rather, it means that some of the knowledge objects have the potential to be ‘shared’. Thus, <Location> refers to both the <target?> and <materials>, and is used by Quartermaster, Explosives, Intelligence in different ways.. Likewise, <transport> is used by explosive, operative, Officer in Charge. The implication is that the Explosives could know <location> without needing to inform the others until they had reached it.


Content
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Explosion
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causes
Construction
has
Explosive
has
Materials
Command
Officer in Charge
Intelligence
Explosives
Operative
Quartermaster

From the Propositional Network, it is possible to construct another Social Network Diagram (figure nine). In this diagram, we assume that agents are linked if they 'share' knowledge. Thus, knowledge objects with more than one agent associated with them imply communication. It is not claimed that the communication need always be direct, e.g., the knowledge object 'Materials' could imply that two agents know the location of the 'materials' but could travel there at different times without any explicit communication.

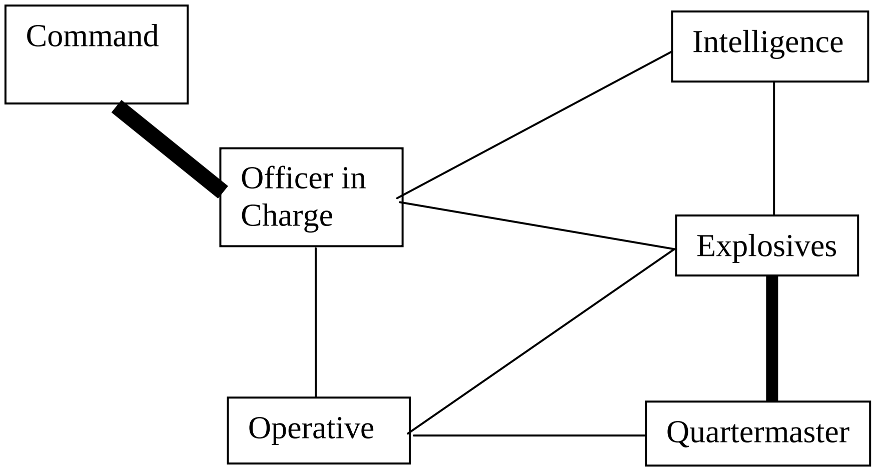

Figure Nine: Social Network reflecting Propositional Network

Figure nine implies more communications than the other Social Networks, although it still places the Officer in Charge in the centre of the network and still suggests strong links between Explosives and Quartermaster.

Conclusions

In this paper, we have asked the question can social networks be constructed on the basis of task and knowledge networks? We demonstrate that, for the example used in the paper, they can. We suggest that the networks exhibit some interesting similarities. The implication is that the conventional Human Factors methods can be beneficially applied to Social Network Analysis, to capture the question of how tasks are performed and how knowledge is used.

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