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REVEALING LINKS:
The Power of Social Network Analysis

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REVEALING LINKS: The Power of Social Network Analysis
An i2 White Paper

Drawing on insights of the intelligence experts at i2, this paper provides an overview of Social Network Analysis; how it can be used to enhance traditional analysis techniques and maximise the value of data; and its potential for use by a wide range of organisations to analyse and visualise a variety of network data.

Traditionally, intelligence analysts have employed link analysis to map associations among people, places and commodities, usually working backwards from a crime or terrorist attack to identify the perpetrators and their modus operandi. Today, however, the intelligence community faces a new kind of enemy – the asymmetric threat – that requires new approaches. When it is hard to understand where a threat may be coming from or in what form it will appear, analysts must take a much more proactive approach toward the information they collect, augmenting existing traditional qualitative-based link analysis methodologies with alternative, more quantitative analysis methods.

Social Network Analysis (SNA) is one of these alternative methods. Despite its title, SNA is not social networking like Facebook or Bebo (although the SNA methodology could be used to analyse that sort of information). Instead, SNA is a useful way for intelligence teams to analyse and understand complex networks of entities, such as individuals or organisations, by measuring or weighting the interactions between them.

Functions and Benefits of Social Network Analysis

Social Network Analysis provides both visual and mathematical analyses of complex human systems. This analytic approach has practical importance, because SNA tools combine data extraction, manipulation, and analytic and visualisation tools to distil massive databases into a visual representation of unusual linkages.

SNA methods provide some useful tools for addressing one of the most important (but also one of the most complex and difficult) aspects of social structure: the sources and distribution of power. It tells us who knows whom and who does business with whom.

By monitoring the communication patterns between network nodes, the network's structure can be established, which then enables identification of critical nodes and their relationships.

This mapping can help give an analyst insights into the performance of a network as a whole and its ability to achieve its key goals; characteristics of a network that may not be immediately obvious, such as the existence of smaller sub-networks operating within a larger network; the relationships between prominent people of interest who may wield the greatest influence over the rest of the network; and how directly and quickly information flows between people in different parts of the network. SNA also can help analysts predict a network's likely course of action or its intention in certain situations.

It is important to note, however, that SNA is not a silver bullet. It is one of the many tools in the intelligence toolbox that intelligence teams can use on their data. Wherever possible, users should corroborate their SNA findings with other relevant information.

Social Network Analysis in the Intelligence Community

Combining organisational theory with mathematical models, the Social Network Analysis methodology emerged from the academic field of social sciences. In social science research, SNA is generally applied against complete data sets, as social science researchers are usually very specific about the kind of data their research will capture and who the subjects are that they will collect information from.

The opposite is true for intelligence gathering organisations, as the data they usually work with is less complete. Often, operational teams are only able to hazard a guess about the sort of data or information that they will collect, and cannot predict its quality or completeness.

But SNA is being adopted by the intelligence community because it can help maximise the value of the information that operational teams are able to collect. On its own, traditional link analysis does not go far enough to definitively show why a network is shaped or operated in a specific way. SNA gives intelligence teams the capability to look beyond a network's collective links to focus on the links themselves – to determine why the links are links in the first place.

SNA is gaining adopters because it also helps overcome challenges that are part and parcel of the analyst's daily work:

- *Overcoming data deluge.* Too often, analysts are faced with data overload, a massive ball of string from which they must extract the most pertinent entities and connections; this is particularly challenging when it occurs during a live operation where dissemination requirements are very tight. SNA can help to unravel the ball by presenting key information in a clear format.
- *Working with limited resources.* Target networks are often dynamic. Analysts need tools that can help them quickly identify potential key individuals or groups so that resources can be more effectively focused on key players instead of on trying to target the entire network.
- *Uncovering hidden connections.* Analysts often need to look beyond the structure of a network into its dynamics – to identify characteristics that are not immediately apparent – and also to analyse how a network changes over time.
- *Finding it difficult to understand connections.* In social networks, not all connections are of equal importance or impact. Analysts need methods such as weighting relationships between entities to take account of how such links may affect a network.

SNA techniques can help overcome these and other issues by providing analysts with a higher level of understanding of the data that they are able to collect. With this understanding, they then can better evaluate future courses of action against target networks, such as how to best and most efficiently disrupt and destabilise them.

The Time Factor

Analysts can use Social Network Analysis to examine the activity of a communications network and its command and control elements across a broad time spectrum. For example, an intelligence team may want to examine the dynamics of the communications network leading up to, during and after an event. Analysts may then be able to use these findings to help predict what may happen in similar events.

One useful approach is to look at how a target network changes and grows over time. Which individuals are growing in importance and which are losing impact? Which parts of the network are driving decisions? Are key figures moving around the network? What happens if a key figure drops out of the network?

SNA can help point to the answers to these and many other questions, making it possible to identify the network's up-and-coming leaders and how their goals for the network may be shifting.

The Scope and Future of SNA

Social Network Analysis is proving useful in many different industries and situations, and is being used to analyse diverse types of networks. For example, military forces use it internally to identify and better understand communications hubs – not the formal one laid down in standard operating procedures, but the "real" communication network, the one that actually exists on the ground. Similarly, corporations and commercial enterprises employ SNA to look beyond the official organisational structure to uncover the real structure of their organisations: who serves as the font of all knowledge, who is the person that most others go to for information, etc.

SNA is also being used in the cyberworld to examine other types of networks, such as networked IP addresses that connect to form a hacker network. Other organisations are using SNA to monitor the movement of cattle to better understand the spread of foot-and-mouth disease. Previously, this type of monitoring may have been performed by laboriously drawing a visual representation of the network.

SNA provides analysts with deep understanding of data, a powerful graphical map, and fast, easily updated mathematical scoring. It holds enormous potential for any type of network analysis.

Appendix: Key Measurements of SNA

Centrality

Centrality is a key concept in Social Network Analysis. A highly centralised network is dominated by one person who controls information flow and may become a single point of communication failure. A less centralised network has no single point of failure, so people can still pass on information, even if some communication channels are blocked.

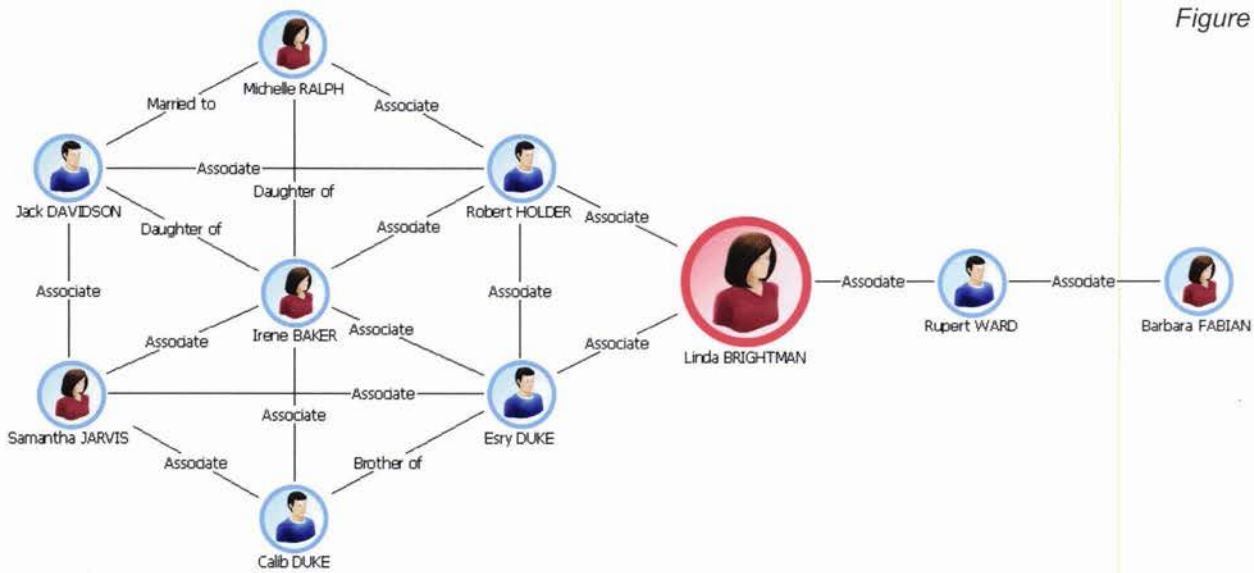
With SNA, an analyst can calculate several centrality measures – betweenness, closeness, degree and eigenvector (including hub and authority) - that offer different perspectives on the social relationships within a network. It is also possible to further refine centrality measures by taking into account the direction of links and the weightings applied to them.

Betweenness

Betweenness centrality measures the number of paths that pass through each entity. This measurement can help identify gatekeeper entities who have the ability to control information flow between different parts of the network. Gatekeepers may have many paths running through them, allowing them to channel information to most of the others in the network. Alternatively, they may have few paths running through them, but still play a powerful communication role, if they exist between different network clusters.

In the network represented in Figure 1, Linda BRIGHTMAN is the person with the highest betweenness score, as she is the link between two distinct parts of the network.

Figure 1

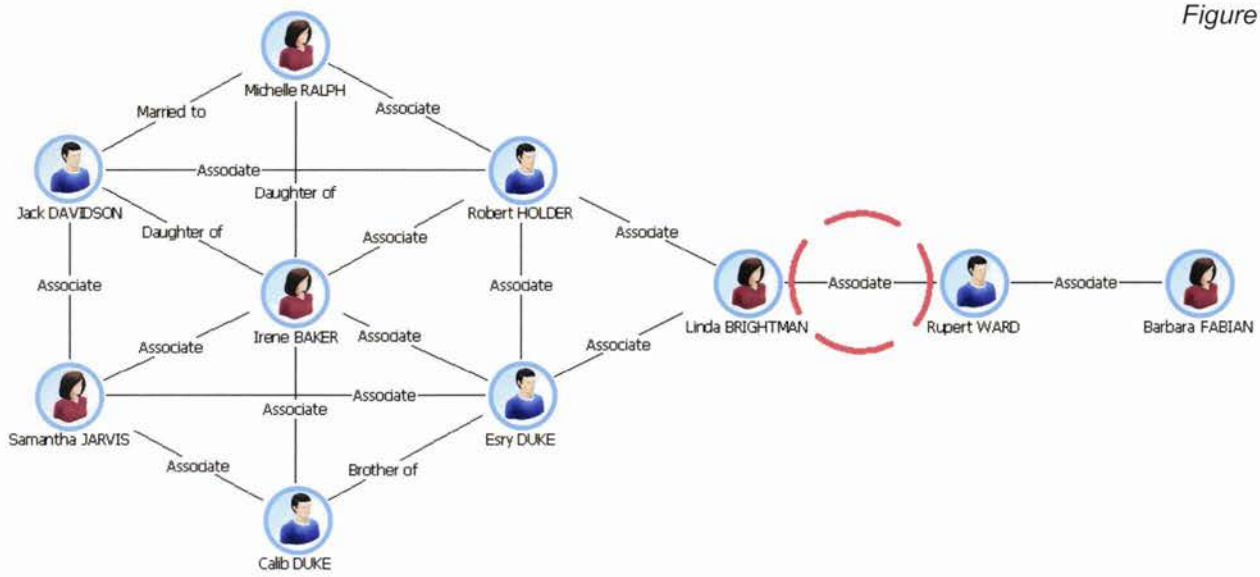


Link Betweenness

Link betweenness centrality measures the number of paths that pass through each link. This can help to identify key connections of influence within the network. A link through which many paths pass may be a significant route for information exchange between entities.

In Figure 2, the key connection of influence is Linda BRIGHTMAN. If this link were broken, a key channel for information exchange may no longer operate, and the network could be separated into two distinct parts.

Figure 2



Closeness

Closeness centrality measures the proximity of an entity to the other entities in a social network. An entity with a high measure of closeness centrality has the shortest path to other entities, allowing them to pass on and receive communications more quickly than anyone else in the organisation.

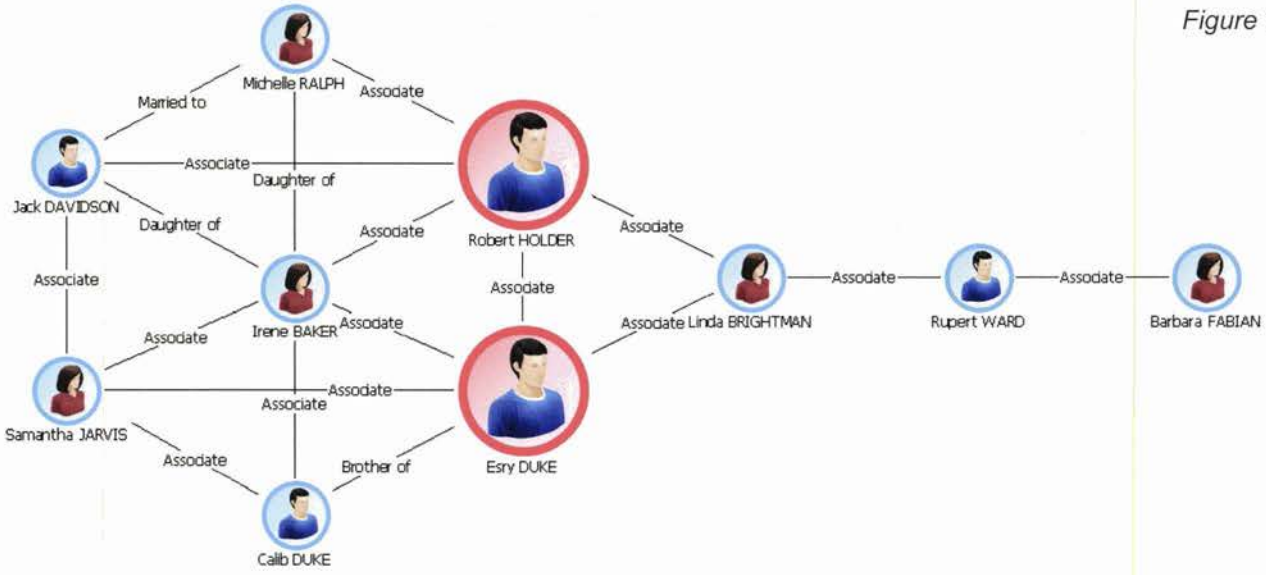
An entity on the edge of a network that is attached to few other entities will have a lower measure of closeness centrality, as information must travel much further to and from this network member.

Closeness centrality measures both direct and indirect closeness:

- *Direct closeness* means that two entities are connected by a direct link.
- *Indirect closeness* exists when information can only pass from one entity to another via a path that runs through one or more entities.

In Figure 3, Esry DUKE and Robert HOLDER have the highest closeness scores because they have the best access to the majority of other members in the network.

Figure 3



Degree

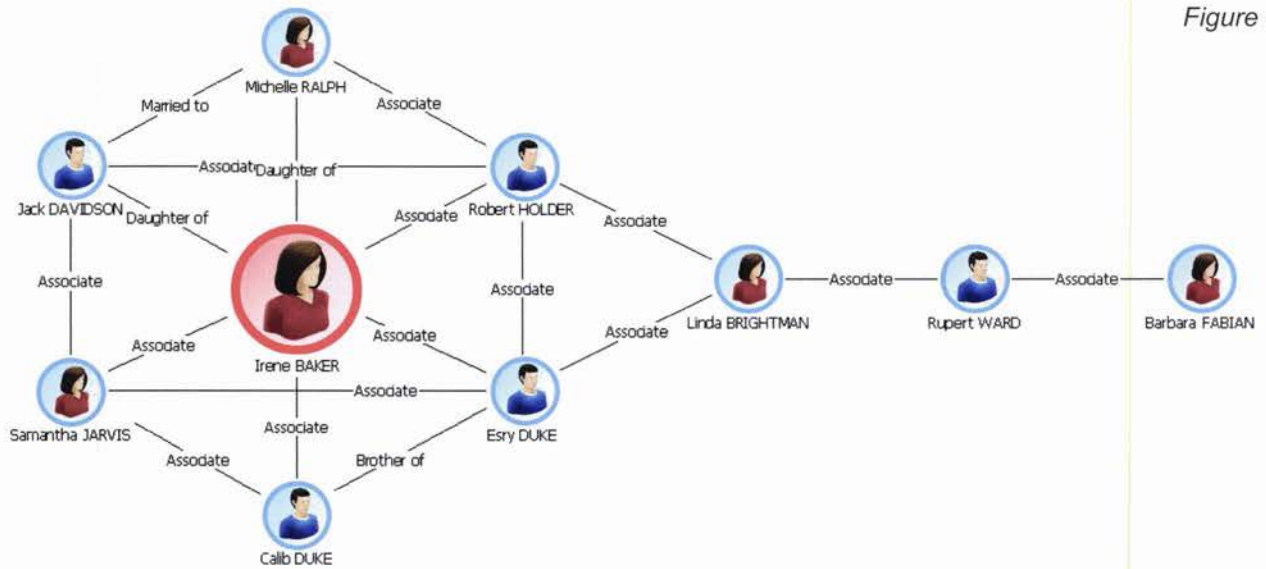
Degree centrality measures how well connected an entity is by counting the number of direct links each entity has to others in the network. This can reveal how much activity is going on and who are its most active members.

Degree centrality can be subdivided into in-degree and out-degree. In-degree centrality looks at who has the most incoming links (e.g., the most people contacting them); out-degree looks at who contacts the most other people. Nodes with high in-degree are highly sought after and have prestige. They may be subject matter experts, final approvers, advisors or have similar high-knowledge roles.

Nodes with high out-degree have visibility in networks as they reach out frequently. They may be new to the organisation, lack necessary knowledge, or be specifically tasked to spread information.

In Figure 4, Irene BAKER is the most central person in the network because she has the highest number of connections to other people in the network.

Figure 4



Eigenvector

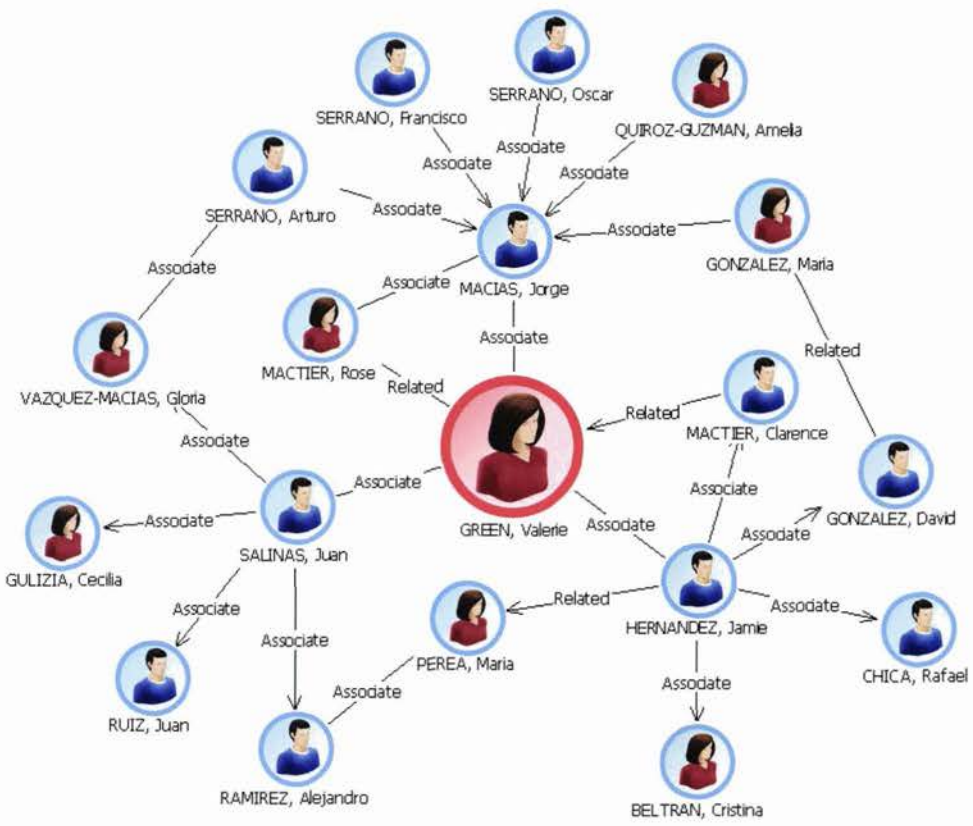
Eigenvector centrality measures how well connected a particular network member is and how much direct influence the member may have over the most active entities in the network. This measure is determined by looking at the centrality scores of the entities the network member is connected to.

For example, a person with high eigenvector centrality is likely to be at the centre of a cluster of key entities that also have high centrality. That person can communicate much more directly with those key entities than a person with a low eigenvector score on the periphery of the network.

Hubs and authorities are the terms used to describe the two eigenvector centrality scores calculated in networks containing directed links (see "Link Direction" below). Hubs refer to the scores for outbound links, and authorities refer to the scores for inbound links. There is a reciprocal relationship between the two; a high-scoring hub has many outbound links to high-scoring authorities, and a high-scoring authority has many inbound links from high-scoring hubs.

In Figure 5, Valerie Green has the highest measure of eigenvector centrality because she is connected to entities that are the most active in the network. Her position at the heart of the central cluster in the network means that she has more direct links to key entities than any other entity. She may exercise influence over them more quickly than anyone else.

Figure 5



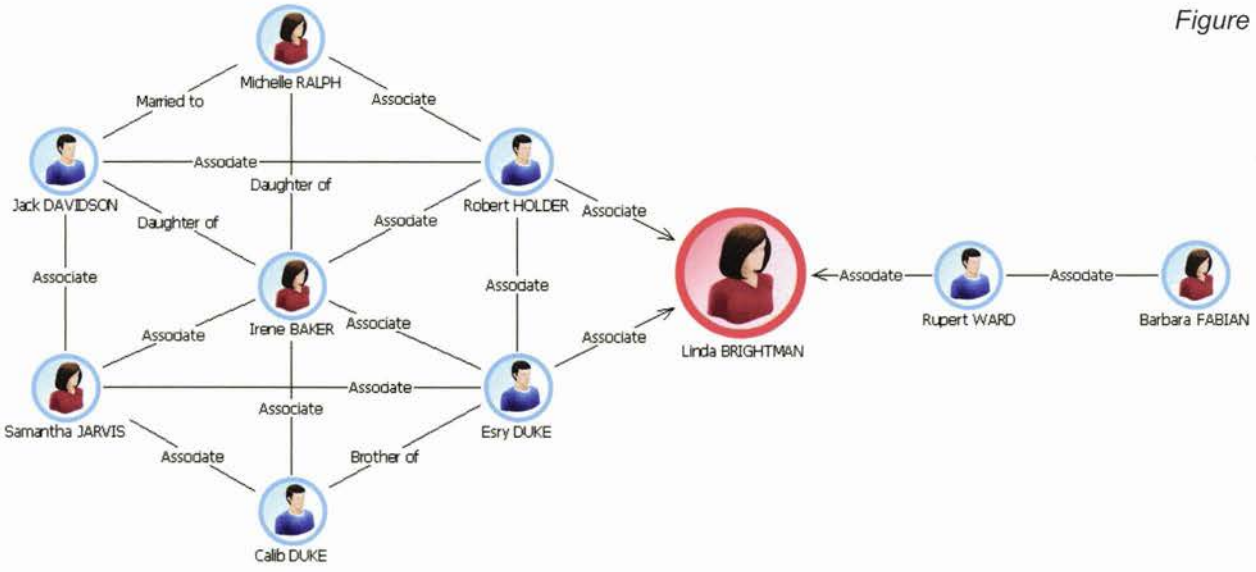
Link Direction

Using *link direction* on a chart is often helping in assessing how information and commodities flow through a network. A link with arrows added to it represents the directed flow of information between entities, either in a single direction or in both directions. This may have an important bearing on how quickly information is passed from one part of the network to another.

For example, a person may receive information from many others in the network but only send information to a select few. The centrality measures for an entity through which information is channelled in both directions will be higher than the measures for an entity through which information is channelled one way. Directed links can be included in the calculation of centrality measures against network charts.

In Figure 6, the arrows illustrate that while Linda BRIGHTMAN appears to be capable of receiving information from others, she is not passing it on to other parts of the network.

Figure 6

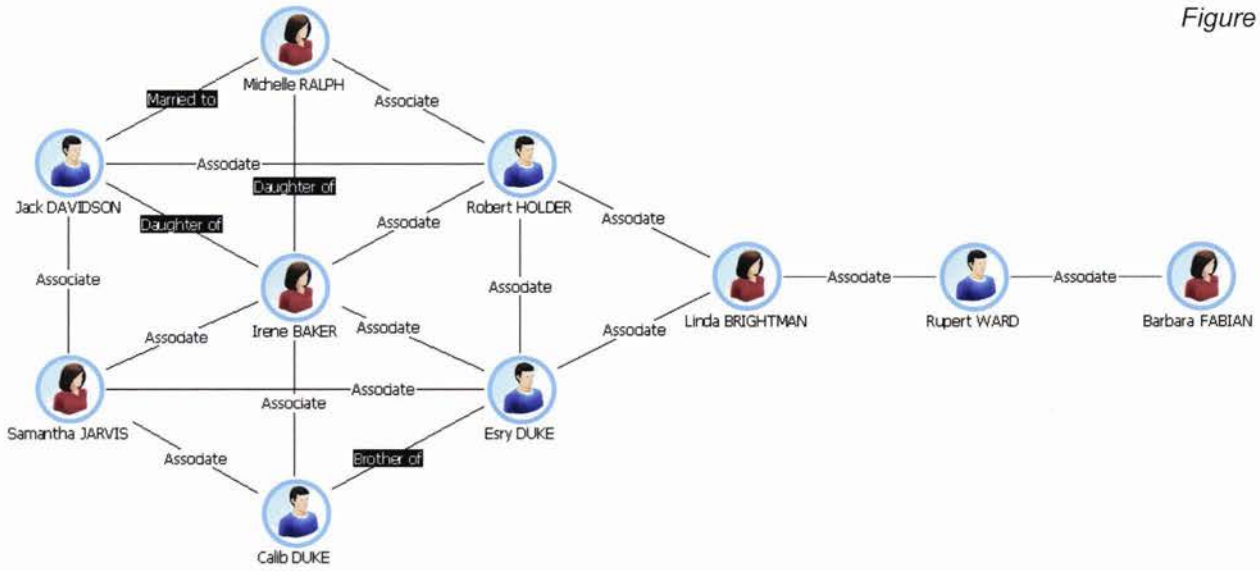


Link Weightings

Social Network Analysis can also be enhanced by the use of *link weightings* to indicate the strength of different relationships (links), which have an effect on a target network. This kind of analysis helps to deliver a more real-world indication of the dynamics and structure of a given target network.

As mentioned earlier, not all relationships in a network are equal. For example, qualitatively, the link between two people connected through a family relationship may be stronger than a link between two business associates. These links can be weighted so that they represent real-world strengths when carrying out Social Network Analysis. By weighting key paths, an analyst may also infer that the entities using them to channel information play important roles in the network. For this reason, centrality measure results are affected by link weightings.

Figure 7



i2 and Social Network Analysis

i2 has implemented Social Network Analysis capabilities within *Analyst's Notebook 8*, part of the i2 Intelligence-Led Operations Platform. The SNA measures can be used alongside existing *Analyst's Notebook* functionality to examine and analyse group structures and communication flows within networks, enabling users to better understand relationships between entities in *Analyst's Notebook* charts. *Analyst's Notebook 8* delivers powerful new assisted analysis and visualisation capabilities that increase analyst productivity and reduce the time required to deliver high value intelligence within quickly growing data sets. *Analyst's Notebook 8* is a major new product version that benefits from new functional requirements driven by the analytical community.

For more information, visit **www.i2group.com.**

About i2

i2 is the leading provider of intelligence and investigation solutions for defence, national security, law enforcement and commercial security. More than 4500 organisations in over 150 countries rely on the i2 Intelligence-Led Operations Platform to proactively deter, prevent, predict and disrupt the world's most sophisticated criminal and terrorist threats. i2 started the intelligence revolution in 1990 and continues to lead the industry in innovation with products like *Analyst's Notebook*® and COPLINK®. These solutions help public safety officers, analysts, managers, detectives and investigators uncover hidden connections faster, enabling collaboration and delivering critical information to the point of need.

For more information on *Analyst's Notebook* see:

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