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Ranking Terrorist Organizations Network in India using Combined Sna-Ahp Approach

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Abstract*: Terrorism is one of the major concern Worldwide. Many countries over the globe are developing strategies to fight with terrorism, either kinetically or non-kinetically. Terrorist Networks are often covert in nature, that's why also called Dark Networks. In this effort, Social Network Analysis (SNA) is a well-known technique among researchers analyzing these Dark Terrorist Networks. Various centrality measures of SNA have been evolved over time for targeting the key players in terrorist or covert networks and finding their ranking. On the other hand, Analytical Hierarchy Process (AHP), a multi-criteria decision making technique, enables subjective as well as objective choices of the decision makers over available criteria and makes decisions over various alternatives. Often, centrality measures of SNA result in different ranking and different set of key players, which makes terrorist targeting very tough. To deal with it, we propose a combined SNA-AHP approach for obtaining the consolidated/final/overall ranking of nodes in various terrorist networks. We consider a case study of a Network of various Terrorist Organizations involved in terrorist activities in India from 2000 to 2003. Final ranking of these terrorist organization is obtained using combined SNA-AHP approach. These rankings are compared with other rankings obtained from existing centrality approaches. To assess the robustness of our approach, sensitivity analysis is proposed and recommended. The results of this study show that the combined SNA-AHP approach delivers promising results in ranking and targeting dark/covert/terrorist networks.

***Index Terms*: Terrorist Network, Analytical Hierarchy Process (AHP), Social Network Analysis (SNA), Centrality Measures, Key Players, Ranking Terrorist Network, Terrorist Targeting, Dark Networks**

I. INTRODUCTION

In recent years, India has witnessed many violent terrorist activities. 26/11 Mumbai attack, Mumbai Metro Bombing, Parliament Attack etc. are the major terrorist attacks. Law-enforcements and intelligence agencies often try to figure out the connections between these various terrorist organizations involved in terrorist attacks and then neutralize them by disrupting terrorist networks. As these terrorist networks are covert in nature, they are also known as Dark Networks. After 9/11 terrorist attack in US, Social Network Analysis (SNA) became very popular technique among researchers involved in counter-terrorism and intelligence agencies worldwide.

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SNA is a graph theory based approach for studying social structure of individuals as nodes (i.e. person, organizations, events etc.) and connection among them (i.e. friendship, kinship, conversation, money transection, co-workers etc.). SNA has various applications in counter-terrorism and dark network disruption i.e. key-player identification, community detection, node discovery, link analysis, dynamic network analysis etc. SNA Centrality Measures [2] are popular in identifying the key players or leaders of terrorist networks and ranking them for targeting and network disruption. While disrupting the dark terrorist networks, different centrality measures result in different ranking, which makes it difficult for counter-terrorism and law enforcement agencies to develop strategies. To deal with this scenario, Analytical Hierarchy Process (AHP) can be devised with SNA centrality measures for better ranking and effective network disruption. Analytical Hierarchy Process (AHP) is a multi-criteria decision making technique, enables subjective as well as objective choices of the decision makers over available criteria and makes decisions over various alternatives.

In this paper, we propose a combined SNA-AHP approach for obtaining the consolidated/final/overall ranking of nodes in various terrorist networks. We took the case study of a Terrorist Organization Networks involved in terrorist activities in India from 2000 to 2003 [11], [12] to assess our proposed approach. Final ranking of these terrorist organization is obtained using our combined SNA-AHP approach. These rankings are compared with other existing rankings obtained from traditional centrality approaches. To check the robustness of our approach for subjective judgements, sensitivity analysis is proposed and recommended.

The paper is structured in following sections: The first section provides a brief introduction about SNA, Centrality measures and its limitations. The second section presents the related research and literature. The third section presents the objective of our research work. The fourth section presents our proposed combined SNA-AHP approach for effective ranking. The fifth section presents the data/model analysis for the undertaken case study of the terrorist organization networks of India during 2000 to 2003. The sixth section presents the result of the considered case study. The final section concludes the overall work and provide the scope for future research.

II. SOCIAL NETWORK ANALYSIS AND CENTRALITY

Social Networks are the representation of relationships among social entities (like, individuals, places, organizations etc.) in terms of Graphs. These Social Networks Graph can be undirected as well as directed in nature based on the relationship types.

Mostly these social networks graph data is represented in the form of Adjacency Matrix.

For example: Given a Social Network G = {V, E} with 7 nodes (V=7) and 8 edges (E=8) in Figure 1.

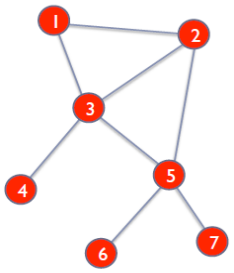

Fig 1 : Example Social Network Graph G

For finding key nodes in the network, SNA offers various measures, well-known as centrality measures. In covert and dark terrorist network analysis, mainly four centrality measures are widely used: Degree, Betweenness, Closeness and Eigenvector Centrality [2].

Degree centrality [2] of a node is the total direct links to other nodes in the network. A node with higher value of Degree Centrality is considered as most popular in the network. In counter-terrorism activities, this helps in identifying the key player or leader of the terrorist network.

Betweenness centrality [2] reveals the nodes, which act as a bridge in communication between other nodes or groups in the network. Betweenness is calculated as the number of times the node appear in communication between any other nodes. In terrorist networks analysis, nodes with high betweenness value reveals powerful and influencing nodes that contain maximum information.

Closeness centrality [2] is calculated as mean length of all the shortest paths from a node to other nodes in the network. In counter-terrorism, nodes with higher values of closeness reveals nodes that are much closer to other nodes and help in gaining information in more quickly.

Eigenvector centrality [2] is a variant of Degree Centrality, It is a measure of a node connected to other highly connected nodes in the network. In counter-terrorism, nodes with higher value of eigenvector centrality reveals most central nodes in the network, globally.

III. LITERATURE REVIEW

For identifying the key nodes in the network, various centrality measures have been evolved. Centrality Measures like Degree, Eigenvector, Betweenness and Closeness are most famous among them [2].

AHP [7], [8], [9] by Saaty was proposed as a multiple criteria decision making technique for solving decision problems, with various criteria (attributes), alternatives and subjective as well as objective judgements by decision maker.

Terrorist Organization Networks involved in various terrorist activities in India from 2000 to 2003 is gathered by Basu [11], [12] at IDSA's in-house utility, Terrorism Tracker (T2). Our review article [3] was focused on the role of SNA in Counter-Terrorism. Base for this research, our previous article about Ranking in 9/11 Terrorist Network using SNA and AHP [5] was presented at ISAHP 2016. Ranking in 26/11 Mumbai Terrorist Network using our approach [4] is another work in this sequence. The combined SNA-AHP approach was introduces in one of our article in press [6].

IV. METHODOLOGY: COMBINED SNA-AHP APPROACH FOR TERRORIST NETWORK RANKING

Analytical Hierarchy Process (AHP), proposed by Saaty [7] in 1977, is a multiple criteria decision making technique for organizing and analyzing decision problems, having various criteria (attributes), alternatives and subjective and/or objective judgements on them by decision makers. Many decision problems can be solved using AHP, for example, choosing the best alternative among set of alternatives, ranking alternatives, prioritization, conflict solving, business planning, government policy making etc.

AHP can be proved effective technique in addition with SNA, specifically for identifying key players/leaders and ranking of nodes in various social networks. Fox and Everton used AHP as a tool to identify key players in network and ranking of nodes [10].

The steps of combined SNA-AHP approach for finding the key nodes and their rankings in particular social network is outlined as follows,

Step 1: Develop the decision hierarchy according to the decision problem by dividing the problem into a hierarchy consisting a decision goal, various alternatives, and the some criteria and sub-criteria for these alternatives.

Step 2: Prioritize the decision criteria and sub-criteria either by using,

- Saaty's nine-point scale (in Table I) for making judgments based on pairwise comparisons between criteria and sub-criteria, or
- Objective values available for these criteria, sub-criteria and alternatives.

Table 1: Saaty's Nine Point Scale for Pairwise Comparisions

Intensity of Importance	Importance
1	Equal
3	Moderate
5	Strong
7	Very Strong
9	Extreme
2,4,6,8	Intermediate Values

It result in pairwise comparison matrix for criteria, sub-criteria and alternatives. For ensuring the consistency of judgements, this matrix must be stable according to consistency ratio (CR) defined by Saaty [15], [17].

The value of CR should be

less than or equal to 0.1 for pairwise comparison matrix.

Step 3: By using eigenvector method to estimate the weights of each criteria and sub-criteria, which result in comparative ranking of criteria and sub-criteria. Step 4: For m criteria and n alternatives, aggregate criteria weights (the m × 1 matrix) with values of alternatives with respect to each criteria (the n × m matrix), using matrix multiplication, in order to determine the final ranking of each alternatives (the n × 1 matrix).

V.DATA/MODEL ANALYSIS

Terrorist organizations networks can be represented very well using social network graph, as individual terrorist members as nodes and their relationships as edges often in the form of graph/network or adjacency matrix. Social Network Graph of Terrorist Organization involved in various terrorist activities in India during 2000-2003 [11], [12] is shown in Figure 2. This network consist of 34 Terrorist Organizations as nodes in the network.

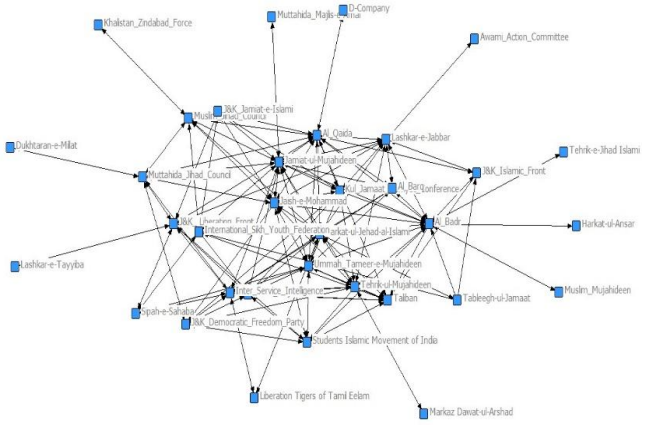

Fig 2: Social Network Graph of Terrorist Organizations in India

For finding key nodes and their rankings in the network, we used mainly six centralities: Degree, Eigenvector, In-degree, Out-degree, Closeness and Betweenness. Normalized values of these centrality measures for all 34 terrorist organizations in India are calculated and depicted in Figure 3.

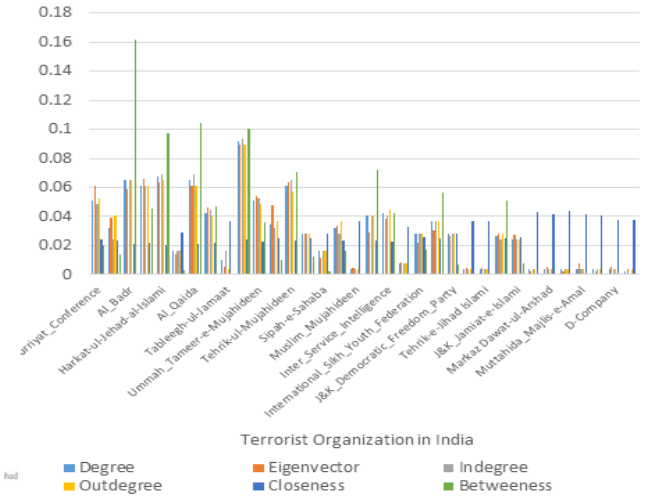

Fig 3 : Social Network Graph of 9/11 Network

For obtaining the overall ranking of terrorist organizations in India, we used our combined SNA-AHP approach. AHP decision hierarchy for ranking is shown in Figure 3. Above considered six centrality measures are considered as decision criteria and all 34 terrorist organization nodes are considered as alternatives.

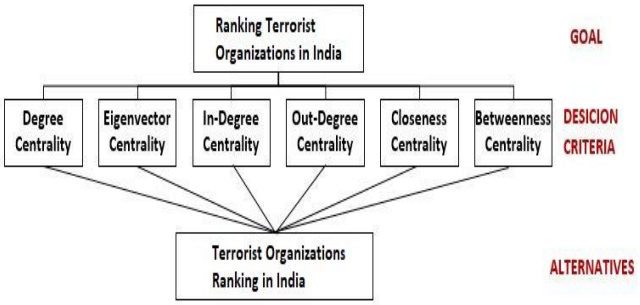

Fig 4 : AHP Decision Hierarchy for Terrorist Organizations in India

Criteria weights are calculated by using Saaty's nine point scale [7], [8] for pairwise comparison and subjective choices of the decision maker. Based on our subjective choices and various research articles, discussing the importance of centrality measures [4], [5] pairwise comparison matrix as shown in Table II, is produced for ranking terrorist organizations in India.

For ensuring the consistency of pairwise matrix, consistency ratio is calculated as per Saaty [7]. We found that pairwise comparison matrix is consistent, as the value of consistency ratio, CR is 0.021 (i.e. less than 0.1). Criteria weights are calculated using eigenvector method, as shown in Table III.

The final ranking of terrorist organizations is evaluated by aggregating criteria weights (6 X 1 matrix, in Table 3) with normalized centrality values of each terrorist nodes (as 34 X 6 matrix), using simple matrix multiplication.

The final AHP score values (34 X 1 matrix) of all terrorist organization nodes is depicted in Figure 4.

Table II. Pair wise Comparison Matrix for Criteria

	Degree	Eigenvector	In-Degree	Out-Degree	Closeness	Betweenness
Degree	1	1/4	2	2	1/2	1/4
Eigenvector	4	1	4	4	2	1/2
In-Degree	1/2	1/4	1	1	1/3	1/4
Out-Degree	1/2	1/4	1	1	1/3	1/4
Closeness	2	1/2	3	3	1	1/2
Betweenness	4	2	4	4	2	1

Table III: Decision Criteria Weights

Criteria	Criteria Weights
Degree	0.094
Eigenvector	0.269
In-Degree	0.062
Out-Degree	0.062
Closeness	0.169

Betweenness	0.341

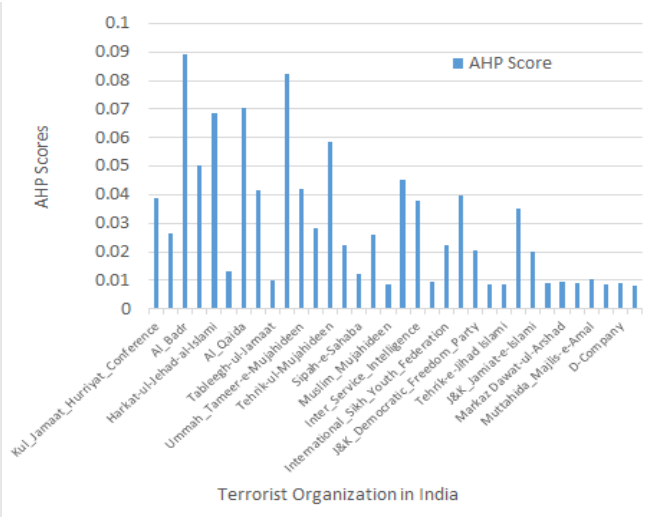

Fig 5: AHP Scores of Terrorist Nodes for 9/11 Network

Comparison of ranking of top 10 nodes based on centrality measures and our proposed AHP approach is shown in Table IV.

Table IV. Comparison of Ranking of Top 10 Terrorist Organizations Based On Centrality Measures and Proposed Combined Sna-Ahp Approach

Node Ranking	Degree	Eigenvector	Closeness	Betweeness	AHP Score
1	Jamiat-ul-Mujahideen	Jamiat-ul-Mujahideen	Jamiat-ul-Mujahideen	Jamiat-ul-Mujahideen	Al_Badr
2	Harkat-ul-Jehad-al-Islami	Jaish-e-Mohammad	Harkat-ul-Jehad-al-Islami	Al_Badr	Jamiat-ul-Mujahideen
3	Al_Badr	Tehrik-ul-Mujahideen	Al_Qaida	Harkat-ul-Jehad-al-Islami	Al_Qaida
4	Al_Qaida	Harkat-ul-Jehad-al-Islami	Al_Badr	Jaish-e-Mohammad	Harkat-ul-Jehad-al-Islami
5	Jaish-e-Mohammad	Al_Qaida	Tehrik-ul-Mujahideen	Al_Qaida	Tehrik-ul-Mujahideen
6	Tehrik-ul-Mujahideen	Kul_Jamaat_Hurriyat_Conference	Jaish-e-Mohammad	Tehrik-ul-Mujahideen	Jaish-e-Mohammad
7	Kul_Jamaat_Hurriyat_Conference	Al_Badr	Ummah_Tameer-e-Mujahideen	Kul_Jamaat_Hurriyat_Conference	J&K_Liberation_Front
8	Ummah_Tameer-e-Mujahideen	Ummah_Tameer-e-Mujahideen	Kul_Jamaat_Hurriyat_Conference	Ummah_Tameer-e-Mujahideen	Umma h_Tameer-e-Mujahideen
9	Lashkar-e-Jabbar	Al_Barq	Lashkar-e-Jabbar	Inter_Service_Intelligence	Lashkar-e-Jabbar
10	Inter_Service_Intelligence	Lashkar-e-Jabbar	J&K_Liberation_Front	Hizbul_Mujahideen	Muttahida_Jihad_Council

VI. RESULT AND DISCUSSION

Based on our study, it is found that Al_Badr, with highest AHP score key terrorist organization during 2000-2003. Other key players in top 5 ranking are Jamiat-ul-Mujahideen, Al_Qaida, Harkat-ul-Jehad-al-Islami and Tehrik-ul-Mujahideen. These ranking represents the key terrorist organizations based on the subjective judgments over six undertaken centrality measures as decision criteria.

These rankings often change with the change in subjective judgements at the time of pairwise comparison of decision criteria. Sensitivity analysis is recommended using controlled trial and error method for assessing the rank changing and evaluating sensitive criteria, which affect the ranking most.

For terrorist organization network, we performed the sensitivity analysis using trial and error method by increasing and decreasing weights of all six criteria, and then observing the rank changes for all nodes each time. Changes node ranking by increasing and decreasing criteria weights are shown in Figure 6 and 7 respectively.

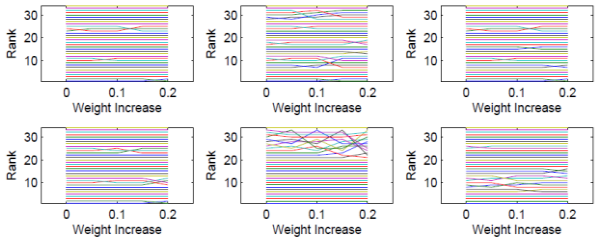

Fig 6 : Change in node ranks with increase in criteria weights (line graph)

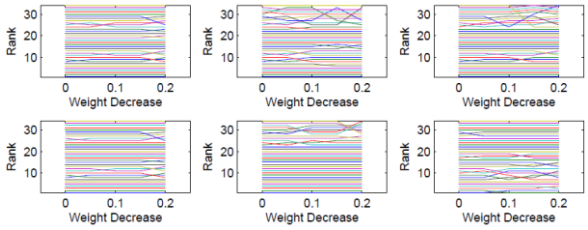

Fig 7 : Change in node ranks with decrease in criteria weights (line graph)

The results of this analysis reveals Betweenness as the most sensitive criteria in analysis, as it affects the ranking of nodes very quickly when priority changes (increase and decrease) in its decision weight. Other sensitive criteria is Eigenvector Centrality and Degree. Each time, is is essential to consider these sensitive criteria while making pairwise comparisons by decision makers.

VII. CONCLUSIONS AND FUTURE SCOPE

SNA is one of the most promising tool for studying and analyzing various dark terrorist networks and organizations. SNA Centrality Measures are most popular for identifying the key nodes and their ranking various terrorist networks. Analytical Hierarchy Process (AHP) can be proved effective tool while combined with SNA centrality measures for obtaining effective rankings

In our work, we analyzed terrorist organization network using combined SNA-AHP approach, for finding the ranking of all 34 terrorist organization involved in various terrorist attacks and revealing the key players among them. The calculated ranking is based on the subjective judgments over six centrality measures as our decision criteria. Sensitivity analysis with trial and error method is applied for identifying the sensitive decision criteria. The experimental results exhibit that the amalgamation of AHP with SNA centrality measures results in promising rank ordering in terrorist and criminal networks.

The work can be further extended by using other individual attributes of these terrorist nodes with considered centrality measures, to achieve more insightful ranking. Several decision-making units (DMUs) can be setup for dealing with subjective judgements and making pairwise comparison more robust.

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