

# Summary

In this report the researchers focus on identifying important individuals in terrorist networks. First because such individuals pose a threat to Dutch society. Second, due to the scarceness of resources of intelligence and security agencies it is possible to focus only on a limited part of a network.

Does there exist a decision support methodology in the quantitative domain that identifies important individuals in terrorist networks? And how can such a methodology be used to allocate scarce observation resources and to destabilize terrorist networks? These questions are at the heart of this report. To provide an answer to these questions the researchers applied centrality analysis from graph theory (i.e. social network analysis) as well as power indices from cooperative game theory to two case studies of terrorist networks: the operational network of Jemaah Islamiyah during the Bali bombings and Al Qa'ida's 9/11 network. The centrality analysis consists of standard centrality measures *degree*, *betweenness* and *closeness*. Degree centrality measures the number of direct relationships that an individual holds with other individuals in the network. Betweenness centrality measures the amount of network connectivity an individual enables, i.e. it measures whether an individual functions as a gatekeeper in the network. Closeness centrality reflects how close an individual is to others in the network. Next to these standard centrality measures two game theoretic centrality measures were developed and applied to the aforementioned two case studies.

Analysis shows that standard centrality measures focus on the network *structure*. However both case studies show that in reality often additional information on individuals in the network as well as on relationships between these individuals is available. Standard centrality measures are not able to model this additional information. Cooperative game theory provides a platform to develop centrality measures to analyze terrorist networks based on power indices that do take this additional information into account. This is due to the fact that cooperative game theory assigns a value to each possible coalition of individuals. Thus cooperative game theory enables the analyst to develop specific centrality measures on a case to case basis. Analysis of both case studies showed

that rankings based on cooperative game theory have a higher resolution than rankings based on standard centrality measures. In addition the researchers acknowledge that multiple rankings based on both standard centrality measures and game theoretic measures provide a more detailed account of and insight in the individuals within a terrorist network. Such an analysis thus allows for the optimal allocation of scarce observation resources and the destabilization of terrorist networks by removing the highest ranking members.

The data set used to analyze the Jemaah Islamiyah case has been obtained from scientific literature. This data set contained information about the network structure as well as information about the frequency and duration of interaction between individuals in the network. The standard centrality analyses that have been implemented so far only consider network structure. In this report it is shown how interaction related data (frequency and duration of interaction) can be used to develop rankings of individuals by the use of game theory. Both the standard and game theoretic centrality analysis of Jemaah Islamiyah's operational network in Bali identify the same individual as the most important person within the network. This individual acted as a gatekeeper between two clusters that were preparing the attack. The removal of this individual from the network would have resulted in a highly destabilizing effect on the network. In addition it is shown that the 5 highest ranking persons according to game theoretic centrality differ significantly from the 5 highest ranking persons according to standard centrality. Moreover, the game theoretic centrality measure is more suitable to distinguish between individuals. In addition it is shown that one of the suicide attackers is identified by game theoretic centrality as one of the 3 most important individuals. This in contradistinction to standard centrality that does not identify this individual as being important. In hindsight the researchers conclude that identification of this suicide attacker would have at least resulted in a disruption of the operational network. The combination of standard centrality analysis with game theoretic centrality analysis provides a more detailed account of the importance of persons in Jemaah Islamiyah's operational network during the 2002 Bali bombing.

The data set used to analyze the 9/11 case has been obtained from scientific literature as well. In addition, the researchers show how information tied to individuals, abstracted from the 9/11 commission report, can be quantified and used in a game theoretic centrality analysis. As in the Jemaah Islamiyah case, the 9/11 case shows how game theoretic centrality is more suitable to distinguish among persons in the network. If the most important individual according to standard centrality would be removed the resulting destabilizing effect on the network would be minimal. In contrast, game theoretic cen-

trality does not even identify this particular individual as being a member of the top 5 of most important persons. It turns out that the most important individual according to game theoretic centrality is the crucial link between the American Airlines flight 11 hijackers and the rest of the network. Removal of this individual would have had a highly destabilizing effect on the network.

The findings in this report exhaustively illustrate how centrality analysis based on game theoretic methodology can aid in identifying important persons in terrorist networks. Based on such quantitative methodology it is possible to develop a decision support system that can aid decision makers and politicians in the realm of counterterrorism. Both the Jemaah Islamiyah case and the 9/11 case show that game theory provides a relevant addition to analyzing and identifying important persons in terrorist networks. In addition, the researchers conclude that observing or isolating individuals in a terrorist network based on game theoretic methodology has a highly destabilizing effect on the network. Both in the Jemaah Islamiyah case and the 9/11 case game theoretic centrality identifies the backbones of the network. Among others this is due to the fact that cooperative game theory takes each possible coalition of individuals into account. Standard centrality measures such as degree, betweenness and closeness only model pairs of individuals. Additionally game theoretic centrality enables the possibility to model extra information such as information tied to individuals (for instance signs of radicalization) and information related to the interactions between individuals (for instance frequency and duration, type of communication).

To operationally implement the quantitative centrality analysis that is developed and analyzed in this report a protocol has to be developed to quantify the qualitative data. Both domain specialists as well as scientists versed in the quantitative methodology should participate in this endeavor. In addition, the game theoretic centrality measure has to be defined by domain as well as methodological specialists in order to fit to the context of the operational problem. The authors state that quantitative centrality analyses provide a valuable contribution to the identification of important persons in terrorist networks and henceforth are useful in combating the violent and disrupting phenomenon called terrorism.