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Social Modelling in Support of Planning and Intelligence

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Structure

- Research objectives and particular focus
- Social modelling
- An integrated spectrum of models
- Research Approach
- Examples of modelling techniques
  - Social Network Analysis
  - Stochastic Process Models
  - Bayesian Network Models
- Conclusion: A multi-disciplinary approach

Social Modelling Overview and Rationale for Research

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- Mathematical and computer models for optimised courses of action, conventional threat assessment and logistic planning support have become accepted tools in modern military headquarters.

- However, it is clear that many of the issues faced by planners and intelligence analysts require a better understanding of political, cultural and social issues.

- By this reasoning their support tool set should include a social modelling capability to represent and analyse social systems, relations and processes in the form of mathematical or conceptual models.

Modelling Social Phenomena: Research Approach

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- Modelling such processes is a complex enterprise that involves integration of mathematical methods and computational techniques with knowledge that is domain- and culturally-specific.
- This mathematisation of social phenomena also requires using different theories from social science, depending on the methodologies and approaches used.
- Development and interpretation of models has to be informed, on the one hand, by broader socio-cultural theories and, on the other hand, by general domain knowledge and specific case studies. Our research is therefore underpinned by social theory.
- The threats we currently face from global terrorism and unconventional warfare are not easily defined and are typically the result of many complex socio-cultural, political and military factors, pointing to the need for an **interdisciplinary approach.**

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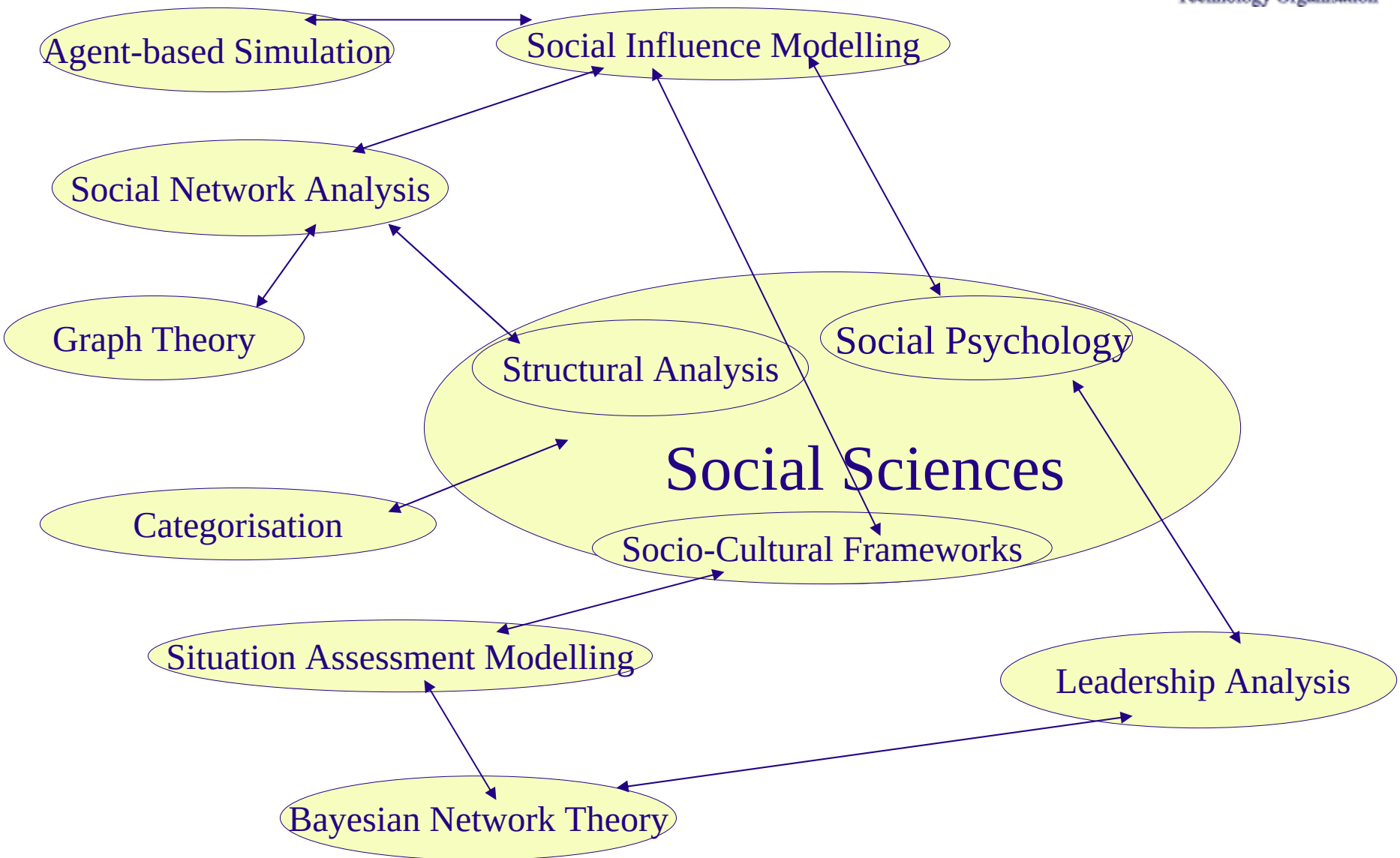
Conceptual View of Research Approach



Integrated Spectrum of Models

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We use an integrated spectrum of theoretical concepts and modelling techniques to analyse the following:

- Group or organisation types
- Coalition formations and factional splits
- Organisational structure – formal or informal
  - Internal groups, their structure and interrelationships
- Relationship types – kinship, economic, political – and their relative importance
- Actors' sociological profile
  - Roles and functions in the group, key players
  - Individual attributes (demographic, motivations etc)
- What determines the behaviour of the members (social and cultural norms and values; access to resources, power)
- What characterises terrorist activity
  - Underlying principles and modes of operation
- Social influence

Modelling Techniques

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Mathematical models of social phenomena are useful to investigate interesting aspects of social behaviour, such as conditions for instability in a population or the underlying structure of a system, rather than as accurate predictors of such behaviour or system manifestation.

- Social network analysis
  - *The network perspective conceptualises social organisations as a collection of individuals or actors and the relational ties among them* ;
- Stochastic process models
  - *They describe the development of a process over time according to probabilistic laws and form the basis of a computer simulation model;*
    - *Process models;*
    - *Spread of influence;*
    - *Alliance formation;*
- Bayesian network models
  - *They enable a visualisation and assessment of the overall situation based on gathered evidence and populated with subjective weighting; uncertainty is recorded and modelled explicitly.*

A crucial part of this work will be to develop specialised techniques for the analysis of sociological, socioeconomic, and demographic data.

Social Network Analysis

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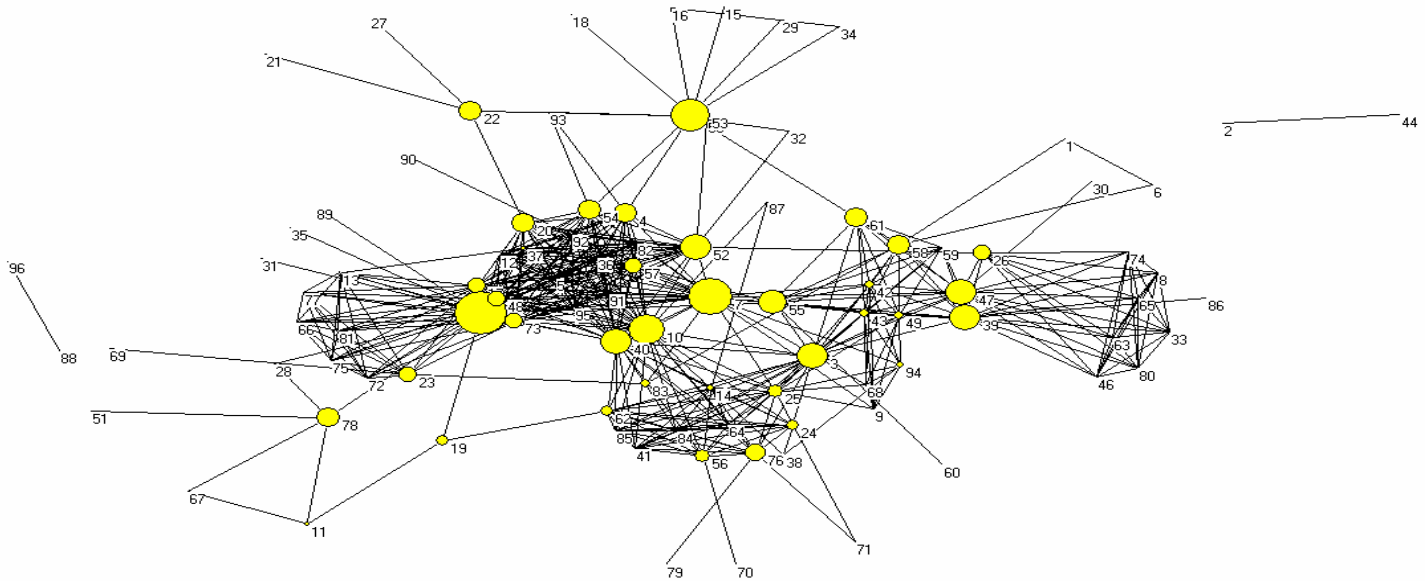
*"This perspective [of social network analysis] is not primarily a theory or even a set of complicated research techniques, but rather a comprehensive new family of analytical strategies, a paradigm for the study of how resources, goods, and even positions flow through particular figurations of social ties."**

A *social network* is simply a network consisting of a set of actors between whom relational ties are defined (Wasserman & Faust, 1994). It can be mathematically represented as a *graph* whose nodes and links correspond to actors and relational ties respectively. SNA utilises mathematical graph theory to represent and analyse the structural properties of networks.



*Emirbayer, M., 1997. Manifesto for a relational sociology. *The American Journal of Sociology*, 103,2: 281-317.

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Some Intelligence analysis questions*

- Who is central and peripheral in the network?
- What are the different roles within the network?
- What subgroups exist in the network?
- What are the important communications and methods of communicating?
- Which individuals could be influenced to best effect the network?
- What is the overall structure of the network?

* Adapted from McAndrew,D. *The Structural Analysis of Criminal Networks* in Canter,D. and Allison,L.J.(Eds),"The Social Psychology of Crime:Groups, Teams and Networks", Dartmouth Publishing Company, UK, 2000.

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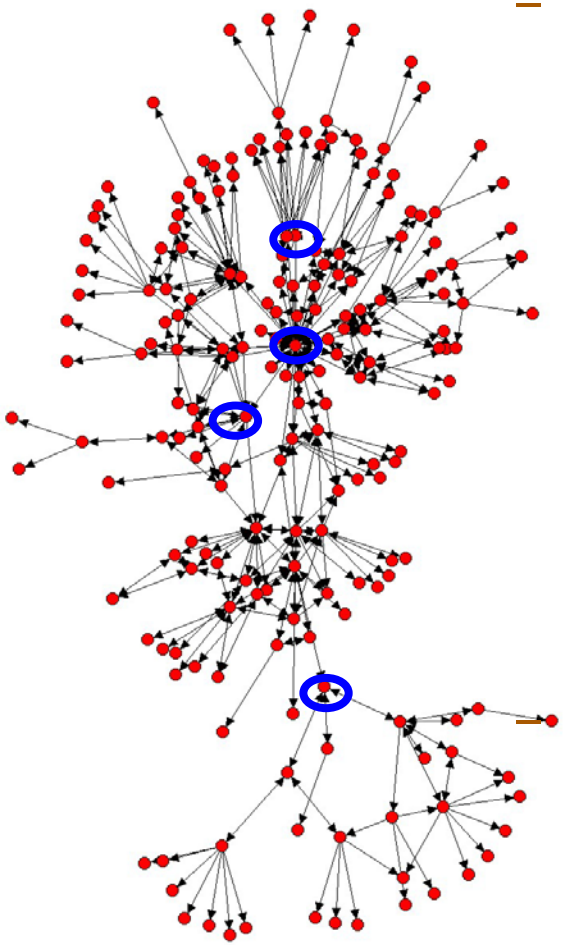
Social Network Analysis measures



- *Individual* measures include
  - centrality (or degree) - the number of direct connections an actor has to the other nodes in the network;
  - betweenness – the ability of an actor to act as a broker or conduit; and
  - closeness – the average number of links separating an actor from all other nodes in the network;
  - metrics from Borgatti's Key Player Problem (Borgatti, 2003).

  These measures help determine the key people in the network.
- *Network* measures might describe the clustering nature of the network; the redundancy of its connections; and its cohesiveness. They can tell us about a network's vulnerability to disruptions.

A Visual Representation of a Complex Network

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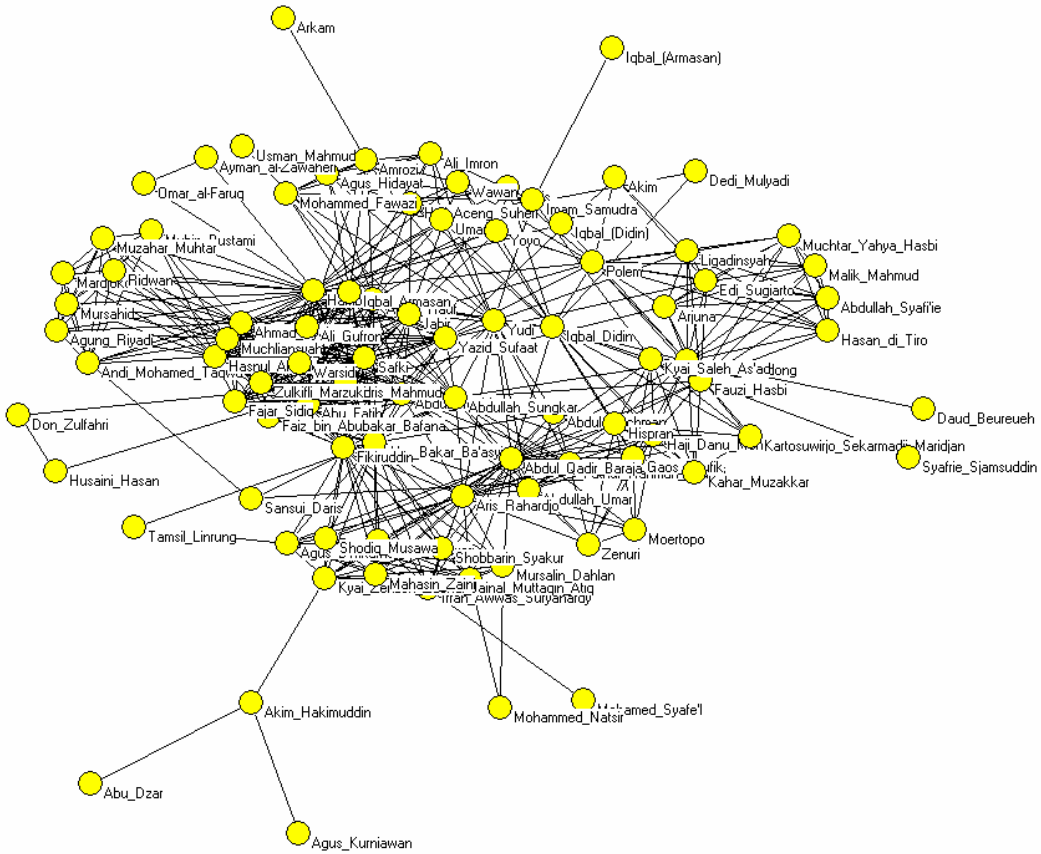

Although a network's visual representation might be complex and difficult to interpret, SNA can produce measures that tell us about individual actors and their roles in the network as well as measures that describe the network structure.

Making sense of a complex network

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Example: Exploring groups and factions

- The characteristics of social networks may relate to individual and group behaviour in complex ways;
- Important network characteristics might be determined from structural properties such as the similarity of network position of members or the presence of cohesive subsets or subgroups;
- The size and nature of these subgroups could help us to determine how fast and to what extent information or influence or even conflict might move across the network and they can tell us about the nature of group affiliations;

Cliques

- Social network researchers have made many attempts to formalise the group concept.
- A *clique* is defined as a maximal subnetwork containing three or more actors all of whom are connected to each other.
- Typically, an individual may belong to many different cliques, making the segmentation into subnetworks an almost impossible task, particularly, in dense and complex networks.
- Researchers have attempted to loosen the definition of a clique in order to describe subgraphs that are “clique-like”. These definitions have known graph theoretic properties while also capturing important intuitive and theoretic properties of cohesive subgroups.

Groups and Factions: How to make sense of a dense network

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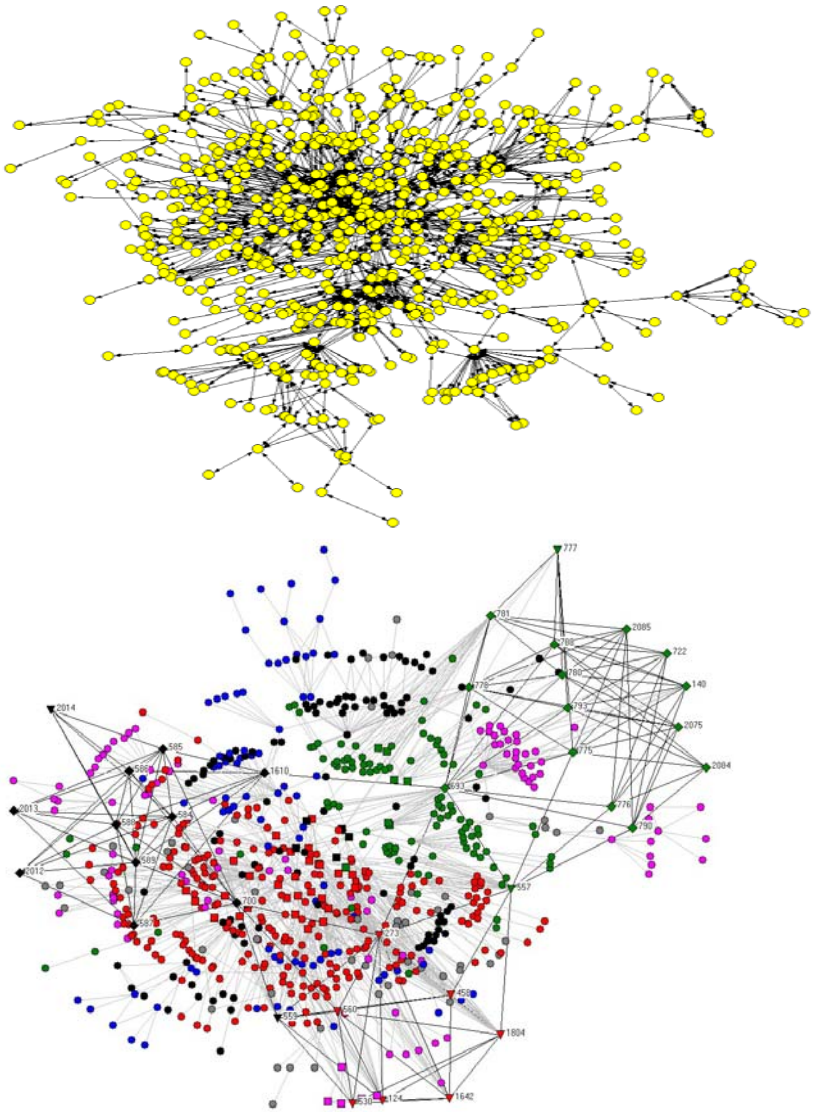

- 753 nodes, several have high centrality measures;
- Dense, complex network with highly overlapping clique structure;
- 169 cliques composed of 185 distinct nodes:
  - 50 of size >= 4 ;
  - 13 of size >=5;
  - 5 of size 6;
- Use less restrictive k-cores to determine cohesive groups;
- Use optimisation technique to identify factions
  - By trial and error chose to partition into six factions;

SNA Research Areas to be Explored

(Collaboration with University of Melbourne)

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Modelling the evolution of networks over time

- Probabilistic evolution of a network:
  - Outside events might result in a change in network structure and possibly a change in behaviour; nodes are added to the network as a result of 'world events' or changes in conditions among potential recruits;
  - Rules for evolution of the network, external impact on the network, and the spread of influence resulting in network growth can be derived from sociological and socio-psychological literature;
- Models for group dynamics including the evolution of interdependent beliefs, goals and interpersonal relationships within groups.

Inferences from incomplete network data

- Multiple networks with incomplete data
  - Inferring missing links
  - Inferring latent structures from observed data;
- Inferences for incomplete longitudinal network data;

Social Simulation Example:
Modelling Large Scale Opinion Formation

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The objective of social simulation is to enable a better understanding of a complex environment rather than to provide specific predictions.

Initial model based on Bibb Latané's Dynamic Social Impact Theory (1981)*

- To explain social influence Latané emphasised the importance of three factors in the source – target (speaker-listener) interaction:
  - Strength: the credibility or status of the source*
  - Immediacy: the distance (physical or psychological) between source and target
  - Number: the number of sources a target is exposed to.

* Latané,B. 1981."The Psychology of Social Impact". *American Psychologist* 36:343-356.

Simulating Social Influence

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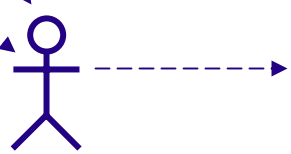
Media Influence

Influence of Other People

Every individual in the simulation is subject to social influence.

Whether an individual changes (or maintains) their opinion is calculated using Latané's (1981)† equation,

$$SocialImpact_i = -P_i\beta - O_iO_MS_M - \left[\sum_{j=1, j\neq i}^{N} \frac{P_jO_jO_i}{d_{(i,j)}^2}\right]$$



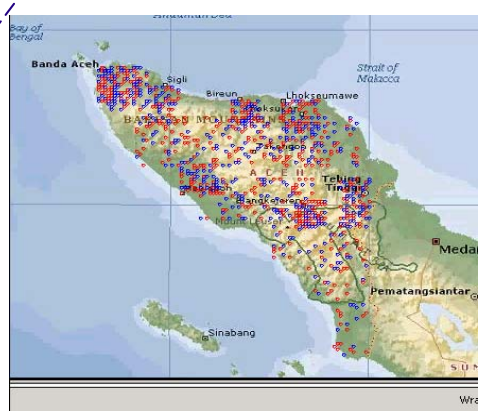
The influence of other individuals is attenuated by increasing social distance (d) and/or lower persuasiveness (P). If *SocialImpact* is great enough in the opposite direction, then the individual will change their opinion.

Key Individual Attributes

- Ethnicity
- Language
- Age
- Religion
- Education
- Occupation
- Gender

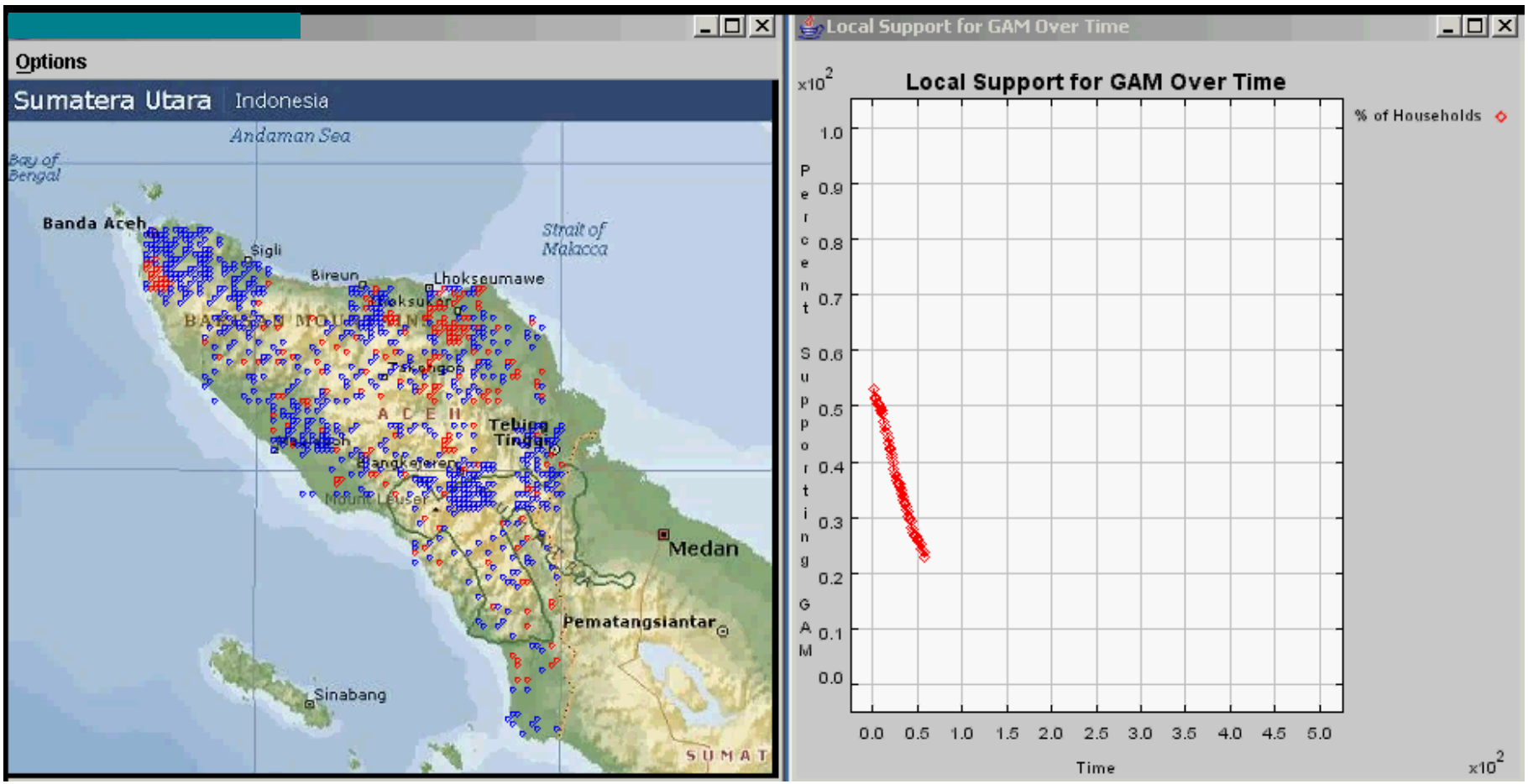
Persuasiveness (P)

- Media susceptibility (S_M)
- Resistance to change (β);
- Opinion (O)



† Latané,B. 1981."The Psychology of Social Impact". *American Psychologist* 36:343-356.

Example 1: Sample simulation output of public support for a separatist movement



Some lessons learned and obstacles to overcome

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- Quantifying Qualitative Data:
  - Geographic distance is easy to represent as it is numerical and can be represented by the grid spaces between source and target.
  - What about ethnic or religious distance?
  - If source and target have different religions what is the distance between them? How do we express it numerically and in a form that makes sense?
- Enormous effort needs to go into data gathering
- We want to include social network type models to include kinship links, etc.
- The rules that control interaction between agents need to be more realistic and verifiable
- It would be easier to focus on groups or societies where the rules of behaviour are very rigid

Bayesian Network Models for Situation Assessment:
What's the likelihood of conflict?

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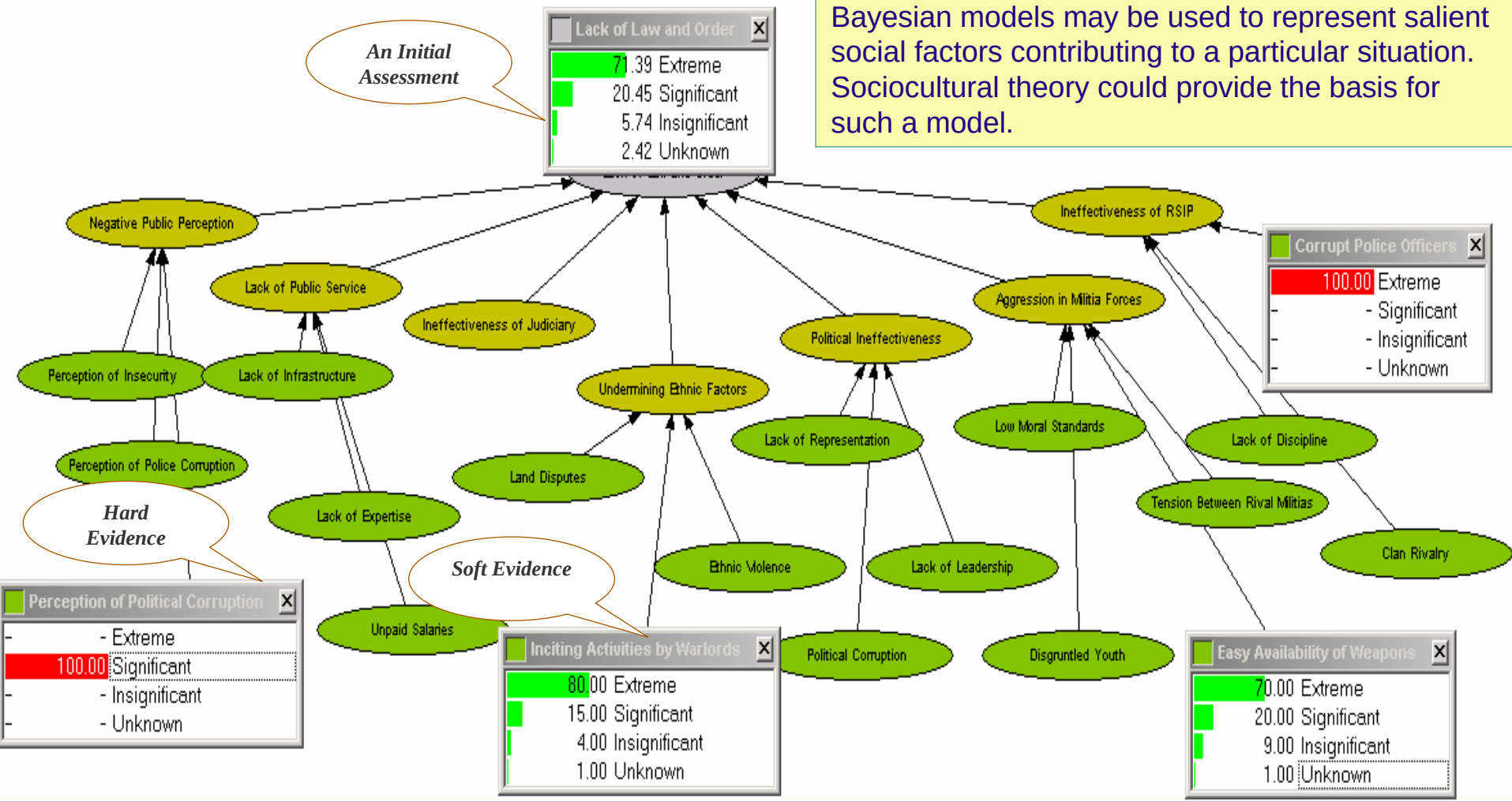
Bayesian models may be used to represent salient social factors contributing to a particular situation. Sociocultural theory could provide the basis for such a model.



Evidence injected into the network through the *leaf nodes* (*Secondary Causes*) provides an initial *situation assessment* and facilitates *what if experimentations*

A Possible Case Study: A multi-disciplinary approach

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Issue to investigate: the likelihood of social conflict in a society of interest. In particular we might want to find out:

– the key societal and situational factors driving this sentiment (including the relevant actors and organisations);

– the current status of this attitude;

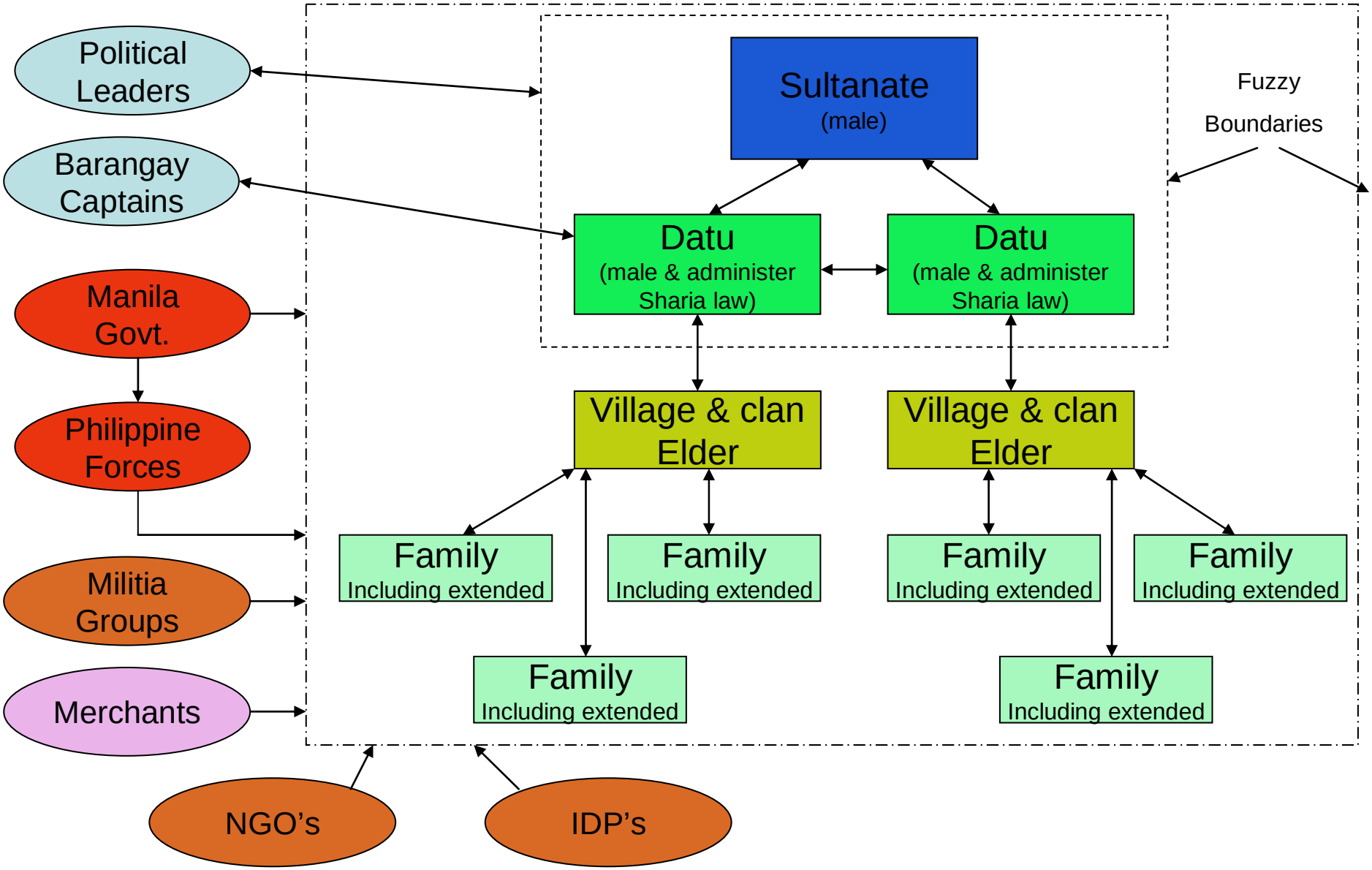
– the rate and extent of diffusion;

– the point at which stability is threatened;

Example: Context for social conflict

- Land conflict and displaced population
- Tribal loyalty outweighs loyalty to state
- Decentralised/diffused power and factionalism
- Surplus of educated youth
- Government alienation of tribal culture

Village Social Structure



A Multidisciplinary Approach

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Develop conceptual models of

- The social and cultural conditions of potential conflict;
- Key groups and organisations and their activities;

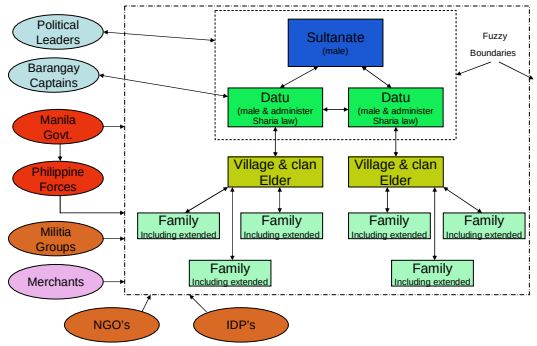
– Determine aspects that can be formalised for input into analytical and computational models;

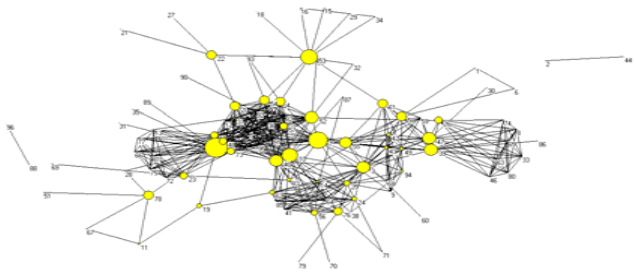
– Analyse raw data:

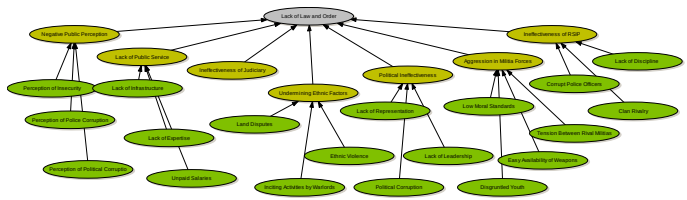
- Social network analysis from qualitative, and transaction data – static properties and network dynamics;
- Time series analysis of all timed data – pattern analysis etc;
- Stochastic characterisation and analysis of observed network flows, processes and behaviours;
- Structure, activity and behaviour hypotheses construction;
- Bayesian models for hypothesis testing;

– Identify gaps that still need to be addressed to develop a suite of models;

Village Social Structure







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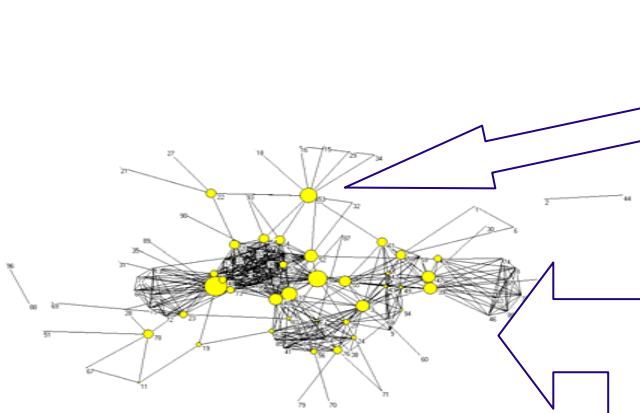
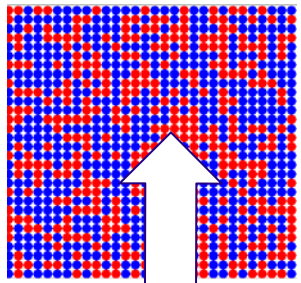
In Conclusion



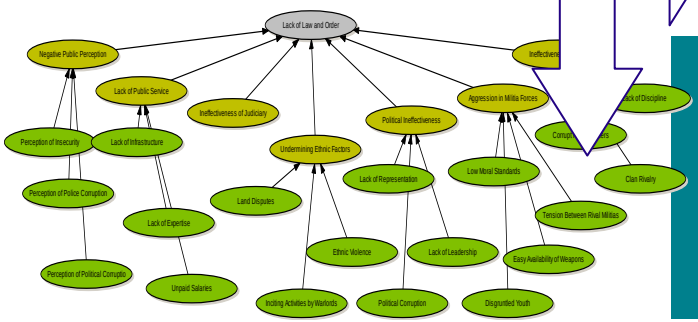


Structural Analysis

Social Psychology

Social Sciences

Socio-Cultural Theories



Regardless of the starting point:

- *Techniques used must fit the problem;*
- *The appropriate theories must inform the model development and the result interpretation*