A DECISION SUPPORT SYSTEM FOR HEALTHCARE OUTREACH TO A DISADVANTAGED COMMUNITY GROUP

McGrath, G. Michael, College of Business, Victoria University, Melbourne, Australia,
   michael.mcgrath@vu.edu.au

Abstract

Australia's Aboriginal and Torres Strait Islander people have very high levels of mental health (and related) problems but relatively few ever receive required treatment. This paper details the development and implementation of an agent-based decision support system, underpinned by dynamic network analysis models and technologies, aimed at assisting an agency concerned with improving outreach to members of this community most in need of help.

Keywords: Healthcare outreach, Decision support, Agent-based technology.

1   INTRODUCTION

There is a very significant gap between Aboriginal and Torres Strait Islander (Australia's First Nations) people and other Australians in infant mortality, disease, death rates, imprisonment and mental health (see e.g. ABS 2008). A lesson learned from studies addressing this issue (e.g. Fuller et al. 2008; Parker 2012; Price and Dalgliesh 2013) is that healthcare service providers need to understand how Aboriginal and Torres Strait Islander people communicate and prefer to interact with service providers.

This project is a component of a wider, joint endeavour between researchers at Relationships Australia Queensland (RAQ) and Victoria University, Melbourne. RAQ is a not-for-profit organization providing services to vulnerable clients in the areas of healthcare, family relationships, substance misuse and addictions, domestic family violence, gambling and dispute resolution. As noted above though, many of the most vulnerable clients may not access such services offered in their area. The overall aim of the wider project is to gain a much deeper understanding of the gaps and linkages in the service channels between healthcare service providers and the broader Aboriginal and Torres Strait Islander community. A major objective is to gain a deeper understanding of: i) the routes by which vulnerable groups access RAQ (and related healthcare service provider) services; ii) significant blockage points within the access networks and the reasons underpinning these; iii) alternative access routes that might be established; and iv) means by which access routes might be maintained and improved. In this paper, we report on an agent-based decision support system (DSS), underpinned by 'Dynamic Network Analysis' (DNA) models and technologies (Carley et al. 2012), aimed at supporting these objectives.

The paper is organized as follows: background to the project is provided in the following section and this is followed by a summary of a preliminary requirements elicitation workshop (held in late-2014), aimed at gaining a much deeper understanding of client help-seeking behaviour. The DSS design and specification is then overviewed and discussed and this is followed by concluding remarks.

2   BACKGROUND

As indicated in Figure 1, this research-in-progress project is a sub-project within a wider project conducted in partnership with RAQ, which commenced in 2009 and will continue on beyond this project. The major aim of this specific research project (i.e. the sub-project in Figure 1) is to produce an innovative DNA framework and an associated DSS that allows different aspects of a problem domain to be modelled using separate methods and for sub-models to communicate relatively seamlessly at simulation runtime. Thus, this particular project is primarily technical in nature and, by itself, it makes significant contributions to both DNA and information systems (specifically, DSS) research. However, once developed, the DNA framework and DSS will be employed in the wider (and ongoing) project, which is aimed at using the technical products of this research to improve access from Aboriginal and Torres Strait Islander healthcare service providers to vulnerable community members in need of care and support. Consequently, the outputs of this project may be viewed as having impacts and benefits at two levels: i) firstly, to DNA and DSS research as discussed below; and ii) secondly, to the wider community (specifically, the Australian indigenous community).

The principal output of this specific project is a DNA modelling and simulation architecture and associated DSS that extends traditional Social Network Analysis (SNA) approaches. Specifically, it allows: i) multiple modelling methods to be employed – particularly agent-based modelling (Borschev and Filippov 2004), system dynamics modelling and simulation (Maani and Cavana 2000) and traditional SNA matrix manipulation (Hanneman and Riddle 2007); ii) through simulation, studies of how dynamic networks evolve and behave over time; iii) models specified using different approaches

to be integrated and to share data; and iv) 'what if' type analysis, thus permitting the possible impacts of new policies and intervention strategies to be simulated and evaluated.
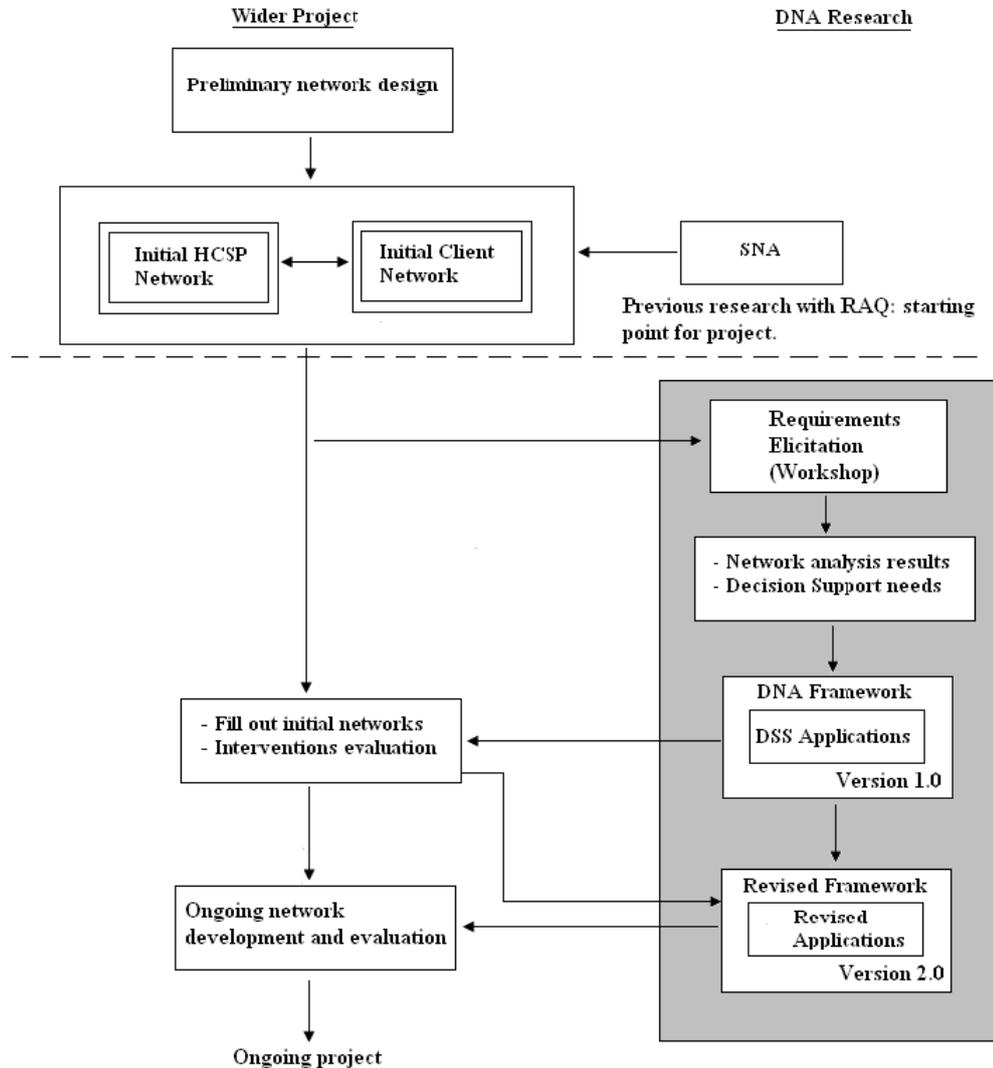

Figure 1.   Research design. Shaded area represents the scope of this project. Essentially, the software framework and tools developed in this work will be employed in social network specification and evaluation in the wider project.

The research plan for this project needs to be understood within the context of the wider project, concerned with the use of network analysis techniques in investigating the help-seeking behaviour of Aboriginal and Torres Strait Islander people with mental health problems (Biddle et al. 2004).

The life expectancy gap that exists between Aboriginal and Torres Strait Islander people and other Australians has remained unchanged since 2002 (ABS 2008). Nevertheless, indigenous Australians are twice as likely to report poor health than non-indigenous people, with approximately 32% of indigenous Australians from 18 years of age experiencing very high levels of psychological distress. From this population only 27% of Aboriginal and Torres Strait Islander people have visited a qualified professional and 38% were unable to function normally in their daily activities. The people that experienced high psychological distress also reported that either themselves or close friends and family members had experienced at least one stressor in the past year. Research conducted by Lock et al. (2011) determined the features of indigenous participation in an informal Australian Indigenous

health policy network. Results found that indigenous people had a high representation and interconnections between groups.

Thus, the wider project aims to deepen understanding of the complex relational ties that are implicated in the reasons for the choices made by Aboriginal and Torres Strait Islander people to access locally available health services. More specific aims are to: i) to discover the role of social networks, relational ties, trust and people of influence in decisions to seek help from health services; ii) to describe and model patterns of relationships using advanced SNA modelling techniques; iii) to develop a framework for participatory design of service models that meet cultural, spiritual and wellbeing needs informed by deepening theoretical understanding emerging from the lived experience of Aboriginal and Torres Strait Islander peoples; and iv) to create new knowledge of enabling mechanisms that will achieve recovery in the social and emotional strength of Aboriginal and Torres Strait Islander Peoples and communities. The DSS reported upon in this paper is a key tool in analyzing the changes in social networks over time (DNA) and in evaluating the possible impact of proposed policy interventions and new service models. At this point in the project, the initial DSS requirements elicitation workshop and system design have been completed and an initial prototype has been implemented. We report on these outcomes in the following two sections.

3   CLIENT HELP-SEEKING BEHAVIOUR

The initial requirements elicitation workshop was held in October 2014 and a key task was to gain a deeper understanding of RAQ client help-seeking behavior. Over a two-day period, some 6 RAQ counsellors and an equivalent number of clients (involved in the same cases) were interviewed in-depth in order to gain an understanding of both clients and counsellors' perspectives on how linkages were initially established. Initially, interviewees were asked to fill in questionnaires based on a style of instrument often used in SNA research but this was not well-received. Instead, counsellors were first engaged alone and then both counsellors and clients discussed their specific cases together over a period of about 4 hours. Together, and interactively and iteratively, networks were documented illustrating the content and quality of the relationship with providers of health and social care. White boards were used to both map the networks and evaluate relationship, trust, credibility and effectiveness in pairs of relational ties between service users and service providers.

Review of the white board documentation produced revealed that all case documentation conformed to a common, underlying, generic format and this was used to create a case documentation template within the process modelling tool *Optima!* (Micrografx 1997). All future case data collection within the project will utilize this template (which is, perhaps, more in keeping with the client community's cultural practices: in particular, a strong the community has a very strong visual arts tradition). An example (partial and a counsellor's view of one case) is presented in Figure 2.

In this particular example, the end-client had attempted suicide (unsuccessfully fortunately) and his sister, concerned about this and his general pattern of disruptive behavior, contacted the Queensland Suicide Prevention Bureau. Dissatisfied with their response, she confided in a friend who advised her to contact RAQ. She did this and the case was taken on by one of RAQ's specialist Aboriginal and Torres Strait Islander counsellors who, after initial discussions with her and her brother, mapped out, arranged and coordinated an intervention strategy centred on mental health treatment but also involving a number of other legal, counselling and mediation agencies. The case outcome is still uncertain but the RAQ counsellor believes that significant progress has been made and the more significant problems are, at least, under control.

Each of the cases analysed during the workshop had, of course, their own unique features. However, there was a degree of commonality in the linkage and referral processes. In only one instance was a linkage established as a result of an end-client contacting RAQ directly: in all other cases, RAQ were called in by a member of the client's immediate kin or non-kin networks or, at a level removed, through the social networks of the immediate client kin and non-kin network members. This led the

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research team to hypothesise that client-RAQ contact might occur through a limited number of generic path types: specifically, through *SN1* (at Level 1 - the client's immediate network), *SN2* (Level 2 - the set of networks for each member of the immediate network) and *SN3* (Level 3 - the set of networks for each member of the Level 2 networks). The team thought it unlikely that there would be a need to move out beyond three levels but more cases require investigation to confirm this view. In any event, this particular model was employed as the SNA model core around which the initial agent-based simulation was specified and constructed. This is discussed in more detail in the following section.
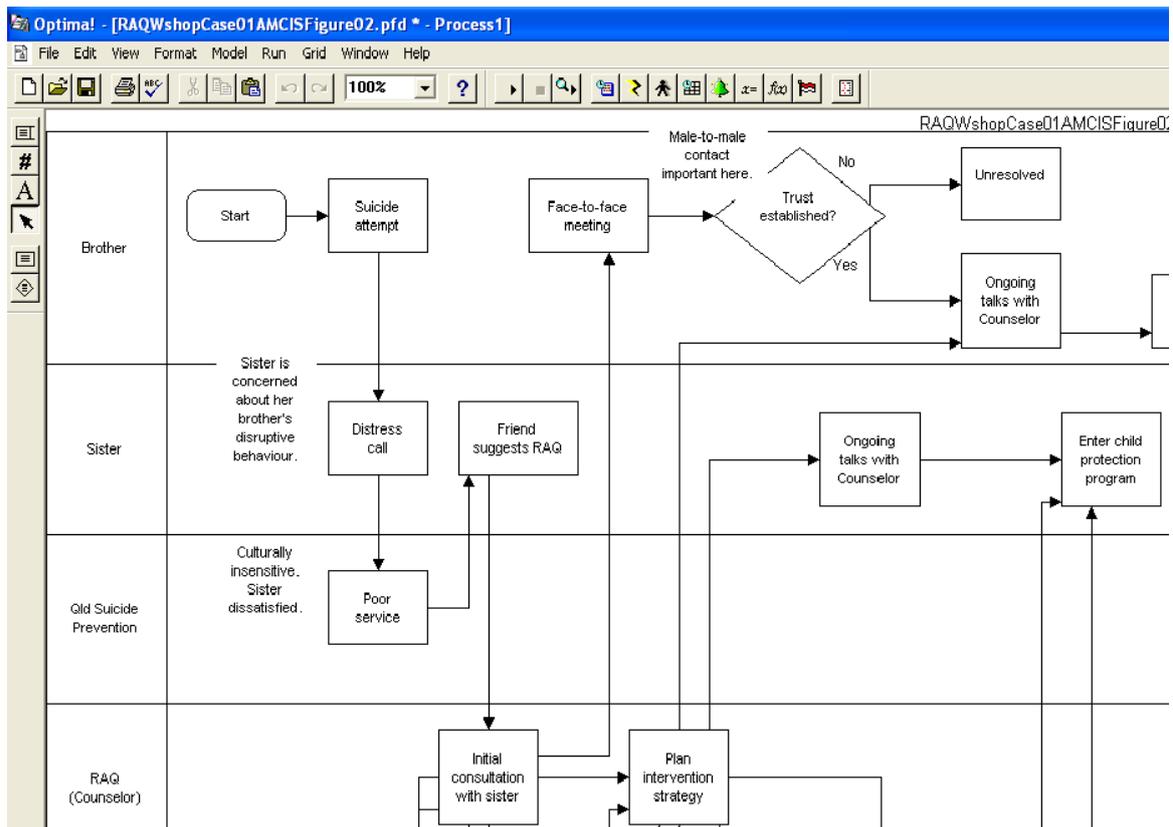

Figure 2.   Case specification example (partial).

4   DSS DESIGN

This DSS design overview is presented using the agent-based modelling specification approach recommended by Railsback and Grimm (2012). As noted by these authors (p.10), this approach is particularly appropriate for complex domains characterised by uncertain patterns of emergent behaviour (as was the case in this study).

4.1   Application Purpose

The model (and application) were designed to assist the Aboriginal and Torres Strait Islander unit of RAQ gain a better understanding of ways in which potential clients (individuals within their constituency requiring help) link up with their counsellors. RAQ provides counselling and healthcare support to those in need. The severity of clients' problems ranges from routine to severe. Severe problems may manifest themselves in mental illness and extreme anti-social behaviour, sometimes resulting in arrest, incarceration, injury (to self and others) and even death. Consequently, RAQ aims

to reach prospective clients before such extreme escalation occurs. The indigenous community is a particular concern as many people in need of help are not getting it. As far as RAQ is concerned, the social networks (breadth and strength of ties) of both its counsellors and clients appear to be a prime determinant of whether a link to a potential client is established. Ultimately, it is intended that the model will be employed to help simulate and evaluate impacts of policy interventions: e.g. if 5 new clients per week walk through the door, what impact might this have on counsellor needs, treatment quality and outcomes.

4.2   Entities, State Variables and Scales

The model has three basic types of agent, *counsellors, clients* and *socialNetworks.* Clients have three basic states: *inNeed* (in need of help), *inCounselling* (undergoing counselling and being helped) and *resolved* (problem resolved). Patches exist in a square grid with dimensions 100 x 100 and, in totality, are a virtual representation of an RAQ geographic region. Precise dimensions are unimportant for the purpose of the model, as agents move around the space randomly. A tick represents one week and a standard simulation run goes for 104 ticks (2 years).

Each client and counsellor exists within a *socialNetwork,* which must be one of 20 *socialNetworkTypes,* each of which has a *size* and a *reach.* Network size varies randomly around a mean of 9, a value based on an investigation of the social network characteristics of people with mental health problems[1] by Hamilton et al. (1989). In our model, network reach varies with size, determines how active a client or counsellor's social network is within the larger community and is the prime determinant of a client-counsellor link being established indirectly through a social network (rather than through a direct link with a client – see Figure 3). Each client and social network are linked with each other and with counsellors with a certain probability. The *UCINet* function, *Network/Cohesion/Distance,* can be employed to establish SNA *distance* as a link probability between clients, social networks and counsellors (directly and along intervening network routes) and *reach* is calculated as a random function of this SNA measure around a mean of 0.0001 for clients and 0.001 for social networks.

The model has been set up to simulate a region similar to Townsville (a northern-Queensland town), with a total population of 100,000 and an indigenous sub-population of 10,000. A scaling factor of 0.1 is employed (to make run visualization clearer) and the number of potential clients is set to 320: the assumption being that, 32% might have some sort of mental health problem (see above). Various studies on aboriginal and Torres Strait Islander wellbeing would seem to indicate that number is not extravagant and, indeed, might even be on the low side. Based on interviews with RAQ staff, the number of available counsellors has been set to 5.

4.3   Process Overview and Scheduling

The basic process in this model is movement of agents (potential *clients, socialNetworks* and *counsellors)* around the virtual region. At each time step (one week), each agent moves to a random spot. If, during any week, a counsellor and a client in need of help (or the client's social network) land on the same patch (or on patches within *reach* of each other), the client's state changes from *inNeed* to *inCounselling.* Finally, clients' problems are resolved at a rate specified by *resolutionRate* (a percentage of clients undergoing counselling between 1 and 100). When this happens, client status changes from *inCounselling* to *resolved.* Note that, in this initial version of the application, the naïve assumption is made that no regression (in the form of problem recurrence) occurs. This, of course, is

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[1] They found that the networks of those in their sample were significantly smaller than those of most people (about half the size) and were characterized by a relatively small number of intense, non-reciprocal ties (due largely to significant one-way dependence relationships).

much too simplistic and a more realistic representation of the actual process is specified in the state chart presented in Figure 3.
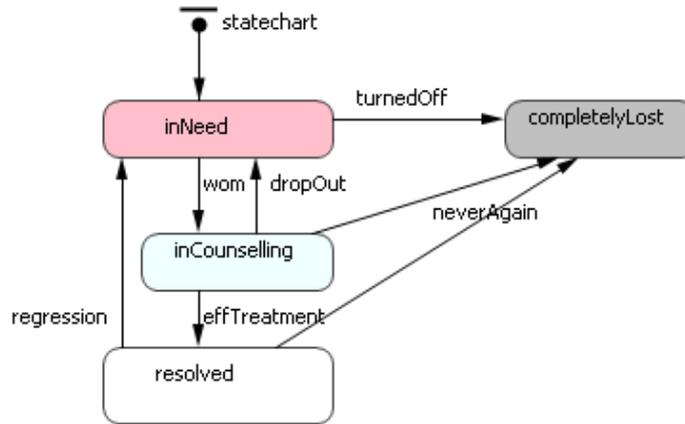

Figure 3.   Client state changes.

Apart from the three states introduced previously, as indicated in Figure 3, other state transitions are possible: specifically: i) clients may *dropOut* of treatment and revert to the *inNeed* state; ii) they may regress from *resolved* to *inNeed;* and iii) if completely turned off by their treatment, they may decide they will *neverAgain* utilize available services and, consequently, transition to a *completelyLost* state (the, perhaps unrealistic, assumption being made in our model that once a client is *completelyLost,* there is no way back). Data is currently being collected from RAQ which will enable us to instantiate *dropOut* (and related rates) rates in our initial, baseline application. It is important to note that drop-outs have significant (negative) feedback effects on future client contact, just as successful treatment experiences have a positive impact. This is discussed further below.

4.4   Design Concepts

The basic phenomenon addressed in this model (and associated DSS application) is the concept of people linking up (meeting) through their social networks and, more specifically, healthcare service providers reaching vulnerable community members in need of help. To a large extent, these linkages are established as a result of chance (thus the model is stochastic to an extent), plus the size and reach of parties' individual social networks (as discussed above). However, there are a number of other factors that have a significant impact on linkages. These include:

1. *Trust:* as noted above, successful treatments engender trust and this, in turn, results in a reinforcing feedback loop which may well increase the level of linkages. The converse, of course, also applies (Hunter 2007).

2. *Problem severity and awareness:* While not applicable in all cases (e.g. clients with major depression), social network members of a client with a severe problem will often become aware of this fairly quickly and, in addition, may well be motivated to seek help urgently (perhaps, for example, out of fear for their personal safety). This might mean that appropriate support (e.g. RAQ) might be called in earlier than is usually the case but it could also result in a disastrous outcome (e.g. suicide, assault etc.) before service providers have the opportunity to help.

3. *Demands on healthcare service providers:* if the service providers are successful in realizing their objective of reaching more clients, their load will increase and, if not resourced adequately, the quality of their work may suffer. In turn, clients become dissatisfied with

treatment, lose trust and advise their family and friends of this (a balancing feedback loop). As such, this represents a good example of a potential, significant network blockage point (and an unintended consequence).

4. *Demands on carers:* As noted by Hamilton et al. (1989), the social networks of those with mental health problems are characterized by one-way relationships where the individual with problems is highly-dependent on one or more carers within his/her network. In time, this may take a toll on the carer(s), with unfortunate consequences: including, for example, carers experiencing 'burn-out', illness and stress and isolation from their members of their own (other) networks. This could limit their opportunities to institute links with service providers.

During our requirements elicitation workshop, these factors were all identified as being important and, together, they constitute the core of a reasonably complex system that would appear to have the potential to generate some interesting and unintended consequences.

4.5   Submodels

The most significant submodel in the application is a system dynamics specification (Maani and Cavana 2000) of the factors (and the relationships between them) detailed in the Design Concepts sub-section). While development has not been completed as yet, the model (currently in causal-loop-diagram (CLD) form) will be converted to a stock-flow representation and implemented as a *NetLogo* submodel, so that changes in agent behavior and attributes will drive stock-level variations in the submodel and vice-versa.

It is anticipated that this CLD model may well have to be extended to take into account further factors critical to the behavior of the total system. Nevertheless, even as it currently stands, the complexity of this sub-model is evident and it may well be that the interactions of the various feedback loops may result in some interesting emergent system behavior. This particular sub-model is being implemented as a system dynamics (Maani and Cavana 2000) sub-system within the overall agent-based application. *NetLogo* supports both application types.

5   CONCLUSION

We have reported on the initial stages of the development of an agent-based DNA DSS aimed at gaining a deeper understanding of ways in which indigenous Australians access healthcare (and related) services and, eventually, at improving outreach to those most in need of help. At this point, following an initial requirements elicitation workshop, a preliminary DSS prototype has been developed and implemented. Work is currently progressing on extending this initial prototype with functionality designed to allow for some additional factors, identified as having significant impacts on service provider – client linkages during our workshop (summarized in the previous section). Once completed, the DSS will be field-tested at two client sites. As indicated in Figure 1, the DSS will then be revised and extended based on field test findings. Further iterations will follow and this will permit the investigation of one of the major, technical IS objectives of the project: specifically, we wish to determine the extent to which our development architecture permits both information interchange between applications and convenient maintenance.

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