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STUDYING COMMUNICATION NETWORKS WITH AGNA 2.1

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ABSTRACT
This paper gives a general description of the functionality and use of Version 2.1 of an application employed in the study of communication networks called Applied Graph and Network Analysis. Along with some elementary notions related to this field, the graphical user interface and the main tools available in Agna are presented. Various computational commands, such as network transformations or analyses, are described in the second part of the article.

KEY-WORDS: *communication networks, social networks, behavior analysis software*

Social Networks Analysis (henceforth SNA) is a powerful methodology that has known tremendous developments in the past decades (for a general-scope introduction to SNA, see Hanneman, 2005; Watts, 2003; Barabasi, 2002; Scott, 2000; Wasserman, 1994; Hoffman, 1992; Knoke, 1982). It has emerged from the studies in the social psychology of small groups done by Alex Bavelas, Harold Leavitt, Harrison White, and Claude Flament in the 50s and 60s coupled with the techniques employed in the sociometry school. More recently, SNA techniques have begun to be applied to studying non-human social behavior, particularly social structures and communication networks in mammals (see, for example, Newman, 2004; Lusseau, 2003; McComb, 2001; Wells, 1987).

The main assumption of the SNA framework is that the systemic and sub-systemic properties of a communication group—be it a human, an animal, an institutional, or an economic relational structure—depend to a large extent on the topological and quantitative descriptors thereof. In other words, the shape of a group communication structure determines such attributes of the group as the efficiency in performing a given task, the degree of moral satisfaction of its members, or the chances of a given member to reaching a leadership position.

SNA has developed its specific terminology largely borrowed from graph theory. Accordingly, a *network* is a set of *nodes* (or *actors*) connected among them

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by *ties* (or *edges*). The *size* of a network is the number of its nodes. A network is *valued* (or *weighted*) when each of its edges has an associated numeric value and *binary* when its edges merely reflect the presence of connections between nodes.

For instance, Figure 1 represents a binary network with six actors (John, Liz, Alice, Phil, Yvonne and Mike).

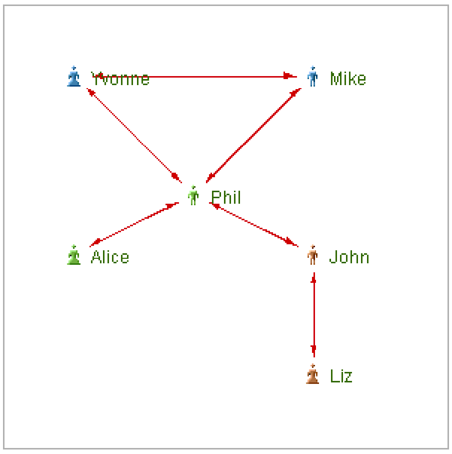


Figure 1. A simple network of six actors

An important concept in SNA is that of *sociomatrix*. The sociomatrix of a network of size n is a square matrix (n x n) whose elements represent the ties. The sociomatrix associated to the network in Figure 1 is shown in the following table:

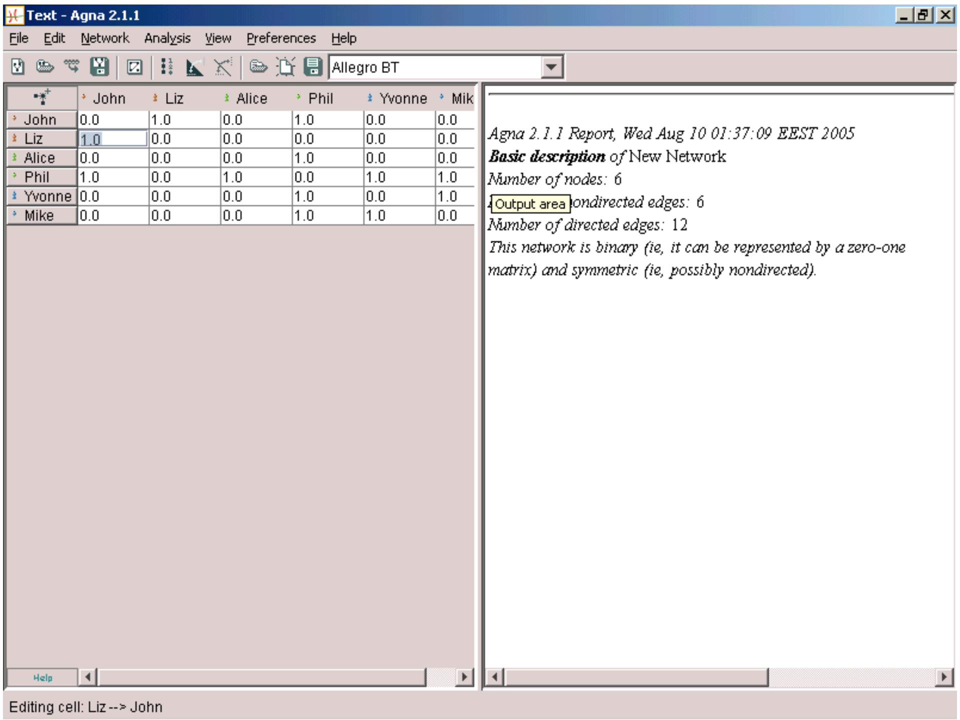
	John	Liz	Alice	Phil	Yvonne	Mike
John	0	1	0	1	0	0
Liz	1	0	0	0	0	0
Alice	0	0	0	1	0	0
Phil	1	0	1	0	1	1
Yvonne	0	0	0	1	0	1
Mike	0	0	0	1	1	0

Networks can also be *directed* or *undirected*. In an *undirected network*, the communication link between two actors is represented by a single, non-oriented tie, whereas in a *directed* network the communication relations between two actors are represented by oriented arcs.

The User Interface

Agna is a general SNA desktop application for small and medium sized networks. It is a platform-independent framework and allows creating, editing, and analyzing social networks, as well as producing text and graphical output.

The main window (or the Main Frame, see Figure 2) of the Agna graphical interface contains a spreadsheet-like grid, which allows the user to easily enter and modify sociomatrix data. Agna always stores the sociomatrix data of a network as real numbers. Also, Agna always forces diagonal elements to zero, which means that self-connections are never allowed. The decision whether a network is binary, valued, directed, or non-directed is made by the application at run time.



	John	Liz	Alice	Phil	Yvonne	Mik
John	0.0	1.0	0.0	1.0	0.0	0.0
Liz	1.0	0.0	0.0	0.0	0.0	0.0
Alice	0.0	0.0	0.0	1.0	0.0	0.0
Phil	1.0	0.0	1.0	0.0	1.0	1.0
Yvonne	0.0	0.0	0.0	1.0	0.0	1.0
Mike	0.0	0.0	0.0	1.0	1.0	0.0

Agna 2.1.1 Report, Wed Aug 10 01:37:09 EEST 2005
Basic description *of* New Network
Number of nodes: 6
ondirected edges: 6
Number of directed edges: 12
This network is binary (ie, it can be represented by a zero-one matrix) and symmetric (ie, possibly nondirected).

Editing cell: Liz --> John

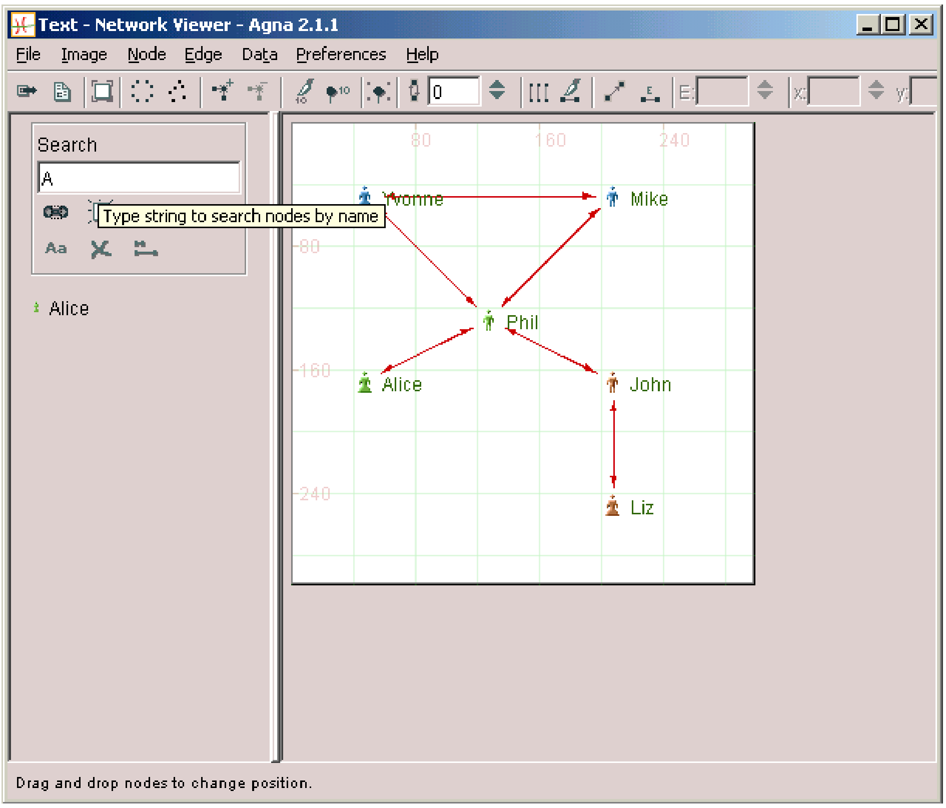
Figure 2. Agna 2.1 main window

Data can be entered by clicking on the desired cell or by keyboard arrow movements. The grid also allows selecting ranges of data, as well as exchanging data with other applications (such as Microsoft Excel) via copy and paste functions. Clicking on the left-side vertical header allows the user to edit the names of the actors.

The Main Frame contains a basic text editor (the Output Area), which provides some functionality in manipulating the reports that Agna generates automatically when the user selects a command from the Analysis menu.

The File menu in the Main Frame offers three options to saving the currently open network: Agna Data Format (.agn), Text Tab-Separated (.dat or .txt), and Comma Separated Values (.csv). The native Agna file format (.agn) contains all the information related to a network created with this application, including the graphical information. The CSV format only saves sociomatrix data and node names, while TTS saves nothing but the sociomatrix.

The secondary window of the application is a visual network editor (the Network Viewer), which is by default inactive and can be made active by pressing Ctrl + Z (see Figure 3).



A

Type string to search nodes by name

Drag and drop nodes to change position.

Figure 3. The visual network editor

The Network Viewer offers various capabilities to editing networks (the Data menu), to modifying their graphic appearance (Image, Node, and Edge), and to exporting the images thus created (the File menu). It also allows the user to search actors by their name.

Connections among nodes can be created or edited in the visual network editor by clicking successively on two nodes then pressing Ctrl + E. New nodes can be added to the network by double-clicking anywhere in the free area; existing nodes can be removed, isolated, or cloned using the commands from the Data menu.

Every data change performed in the Network Viewer will automatically be reflected in the sociomatrix grid and vice-versa.

Transforming Networks

Once a network has been created, several transformations can be applied to it. Network transformations can be accessed from the Network Menu in the Main Frame, and the most frequently used are:

- Remove Outsiders: deletes from current network all isolated nodes (i.e., nodes completely disconnected);
- Scalar Multiplication: multiplies every connection value in the current network by a given number;
- Transpose: reverses the arrow orientation of every tie in the network;
- Symmetrize: transforms the current network into a symmetric network following a symmetrization criterion, such as: Minimum, Maximum, Below Diagonal, Above Diagonal, Sum, Mean, etc.
- Binarize: transforms the current network into a binary network by replacing every non-zero connection value with 1.

Analyzing Networks

The Analysis menu in the Main Frame provides several options to performing SNA-specific computations over the currently open network. The results are generated into the Output Area, which is a very simple text editor provided with an HTML export function (File | Save Output As…).

Apart from Basic Description, which produces elementary information about the current network—such as type, size, and number of edges—, Agna can compute two categories of parameters: centrality coefficients and sociometric indexes, and can perform some distance-related analyses.

Centrality

This is one of the first concepts to have been studied in SNA experiments. Centrality as an *actor-level* coefficient reflects the degree of access to information (or resources) of an actor and hence the probability of that actor to acquire a leadership position in the group.

For instance, by visually inspecting the network we have built earlier (Figure 1), one can easily infer that Phil enjoys the most central position, while Liz is the most peripheral actor. Selecting the option Analysis | Centrality | Bavelas-Leavitt will produce the following results:

Node	Bavelas-Leavitt Centrality
John	3.38
Liz	2.25
Alice	2.70
Phil	4.50
Yvonne	3.00
Mike	3.00

Indeed, Phil has the highest score (4.50), which gives him the highest chances to becoming the leader of the group, whereas Liz (2.25) appears to cast the least influence over the network.

We were able to disclose the centrality positions of the actors within this network at a glance because the network only has six members. In the case of larger networks, however, visual estimations are much more difficult if not impossible, and the use of computed centrality estimates is obviously required.

As a *network-level* coefficient, centrality measures the distribution of information (or power) within the group. In a highly centralized network, information is localized in a single actor or in a small number of actors. For the network in Figure 1, the Freeman General Coefficient computed for the Bavelas-Leavitt centrality coefficients has the value of 1.15, whereas in a six-actor network in which everyone is connected to everyone this coefficient has the value 0.0 because all the actors have equal centrality coefficients.

Given that they account for the degree of uniformity/non-uniformity in the distribution of information within a group, the various measures of network-level centrality can be thought as different versions of entropy. For this reason, Agna computes the informational entropy itself as a network-level property apart from Freeman General Coefficient. In particular, the relative entropy can be an efficient centrality measure, as it ensures comparability among networks of different size.

It is important to note that centrality operations only apply to binary networks. If applied to valued networks, Agna tacitly converts the connection values to binary data.

Sociometric Coefficients

In a communication network, actor-level sociometric coefficients measure the level of communicational activity of a specific actor. Unlike centrality coefficients, sociometric coefficients do take into account the weighting information contained in a network. On the other hand, the sociometric coefficients of an actor only take into account the information about connections with its immediate neighbors.

Among various sociometric coefficients, the emission degree and the outdegree indicate the level of information emitted by an actor. The reception degree and the indegree reflect quantitatively the informational input of an actor. The emission and reception degrees give absolute values, whereas the indegree and outdegree are relative to the size of the network. The sociometric status and the determination degree are also relative measures. While the sociometric status reflects the overall communicational activity of an actor, the determination degree is an index of the influence or dominance an actor receives from the other members of the network. The latter index can have both positive and negative values. When the determination degree is positive, the actor is mostly a dominated actor or a consumer of information. When this degree is negative, the actor is a rather dominating agent or a producer of information.

At network level, Agna computes density and cohesion. Density refers to the degree of connectedness of a network; in different words, it shows if a network is dense in connections or scarce. Cohesion is an index that measures the amount of symmetry contained in a directed network.

Distance-Related Coefficients

This category of measures is based on the concept of *geodesic distance*. Given two nodes of a network, say node A and node B, the geodesic distance from A to B is the length of the shortest possible path from A to B. The length of a path is computed as the number of edges that comprise it. Just as in the case of centrality, weighting information is here ignored: only the existence or absence of a connection is taken into consideration. In theory, if there is no path between two nodes, their geodesic distance is said to be infinite; in practice however, Agna will signal this fact by a zero-value geodesic distance.

Agna can also find the *diameter* of a network (Analysis | Distance | Diameter), which is the length of the longest geodesic path to be found in that network. The network used in our examples has the diameter 3 because the longest geodesic path is the one connecting Yvonne and Liz through Phil and John. Also, Agna can identify the shortest paths between any pair of actors in a network, and can generate a matrix containing all the geodesic distances of a network.

Conclusion

Being an extremely dynamic and evolving field of research, SNA has not reached a unanimous level of standardization yet. A wide range of new techniques and concepts are being studied and proposed every year, and many new computer technologies keep being developed. In this context, instead of competing among them, these different technologies rather complement each other.

Compared to other applications, Agna is a friendly and easy to learn software, and can provide an intuitive framework for grasping the concepts and the philosophy that underlies SNA. Through its export and import functionality, Agna allows researchers to employ it in conjunction with other software existing on the market and to facilitate the access to a rich and diverse source of technology.

The main purpose of this paper was to give an overview of Agna 2.1 and to explain briefly the meaning of the main coefficients that it provides. A more extensive description of Agna functionality together with mathematical formulas for all the computational options available to the user can be found in the application manual and the menu reference (Benta, 2003).

REFERENCES

Barabasi, A.-L. (2002). *Linked—The New Science of Networks*. Cambridge, MA: Perseus Publishing.

Benta, M. I. (2003). *Agna 2.1 User Manual*. Retrieved August 2nd, 2005, from http://www.geocities.com/imbenta/agna/doc/User_Manual.htm.

Hanneman, R. A. & Riddle, M. (2005). *Introduction to Social Network Methods*. Riverside, CA: University of California.

Hoffman, C., Wilcox, L., Gomez, E., & Hollander, C. (1992). Sociometric Applications in a Corporate Environment. Journal of Group Psychotherapy, Psychodrama & Sociometry, 45, 3-16.

Knoke, D. & Kuklinski, J. H. (1982). Network Analysis, Sage University Paper, 07-028.

Lusseau D. (2003). The Emergent Properties of a Dolphin Social Network. Proceedings of the Royal Society of London Series B-Biological Sciences, 270, S186-S188.

McComb K., Moss C., Durant S.M., Baker L., & Sayialel S. (2001). Matriarchs as Repositories of Social Knowledge in African Elephants. Science, 292, 491-494.

Newman M.E.J. & Girvan M. (2004). Finding and Evaluating Community Structure in Networks. Physical Review E, 69, 026113.

Scott, J. (2000). *Social Network Analysis: A Handbook*. London: Sage Publications.

Wasserman, S. & Faust, K. (1994). *Social Network Analysis: Methods and Applications*, Cambridge, MA: Cambridge University Press.

Watts, D. (2003). *Six Degrees: The Science of a Connected Age.* New York: W.W. Norton and Company.

Wells R.S., Scott M.D. & Irvine A.B. (1987). The Social Structure of Free Ranging Bottlenose Dolphins. In H. H. Genoways (Ed.), *Current Mammalogy* (pp. 247-305). New York: Plenum Press.