

Modelling Connectivity in the Work Place

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Abstract

This report summarises the Agent Based Modelling research carried out for the ICoSS project at London School of Economics. ICoSS used a number of tools including the Organisational Forms Simulator to investigate and apply Complexity thinking to organisations.

Objective

It is known that organisational forms and connectivity have a significant impact on an organisation's ability to:

- use its resources efficiently,
- improve its fitness for survival,
- exploit innovation, and
- co-evolve with the changing environment

This work is an example of the use of Agent Based Modelling mainly for

- gaining insights and information about Organisational Forms and Connectivity Patterns
- linking qualitative and quantitative properties organisations, and
- exploring new ways of organising

In summary it is part of an effort to develop tools for applying Complexity Thinking to organisations.

Connectivity, Agent Based Modelling and Social Networks

Previous work by Stuart Kauffman (1) describes abstract mathematical models of Connectivity and Fitness Landscapes in the NK model. Kauffman used a binary state network similar to a network of light bulbs going on/off depending on their connections with other nodes on the network.

Simulators built in the USA such as Swarm is also a platform for looking into the theoretical and abstract aspects of connectivity. TransSim, the first of its kind, modelled Albuquerque's highway transport system with a great detail. Interesting simulation work on social systems and strategies is described in SugarScape (2).

Agent Based Modelling and simulations, and the idea of using computer simulations as "laboratories" for many real life problems have been described elsewhere (3), and work such as SimStore supermarket simulator developed by SimWorld Ltd.

Recently, there is a growing interest on Social Networks and Network Analysis. Some of these ideas are described by Barabasi (4) and Buchanan (5).

Modelling Approach in ICoSS

We start by selecting a small business unit of 10 to 100 people as a pilot. This is preferably a relatively self-contained unit with little external connections. As we think that people working for an organisation have connections with others in different "modes" of behaviour. To begin with we broke the connection links as well as personal competencies into a number of "dimensions". To begin we started with "Team", "Business", "Technical" and "Social" aspects were the four dimensions of connectivity between people in

the workplace. In the questionnaires, we ask about individual preferences and opinions regarding these parameters as well as their connections with other individuals in these dimensions.

Then we prepare a web or email based questionnaire based on the questions identified as important by the company regarding informal networks. After a two-three weeks period we start processing the questionnaire results. We first obtain raw network files for each question as each question shows one informal network that we want to investigate. Using the organisational forms simulator, we then visualise the network and the quantitative measures such as most utilised nodes and most consulted people, calculated by the simulator. We then carry out some statistical analysis on the collected data present the network and results back to the organisation to stimulate discussion.

In discussion sessions we point out connectivity distributions and bottlenecks in communications. Using the simulator we can also modify the virtual organisation by trying out a number of possible configurations. At each step we focus on quantifying measures of connectivity. Some of the connectivity measures are

- total distance between nodes
- degree of separation between two nodes
- distribution of technical/social skills in clusters (teams)
- communications overloads (bottlenecks)

We also use the classical Network Analysis methods; when necessary we introduce new measures of connectivity and introduce new dimensions for connectivity and competencies. During this process we also attach (qualitative) expert opinions about the organisation using other ICoSS tools, and link them with quantitative data from connections and network analysis of what is known to be "good" patterns. We compare organisational structure with known structures such as flat, hierarchical or mixed organisational forms.

Using the simulator we can also look into the dynamic properties of organisational networks. For example we can test how long it would take for an organisation to spread an Epidemic of Innovation. To understand the speed of spreading ideas within an organisation, we use individuals as simple autonomous agents, and focus on communications efficiency and structure as well as fitness landscapes and organisational memory.

Organisational Forms Simulator

SimWorld Ltd (www.simworld.co.uk) has developed a simulator called Organisational Forms Simulator (organisation.htm) to be used by the ICoSS Project. The simulator is one of the tools for ICoSS Project applying complexity thinking to organisations. The main objective of the simulation is to visualise and observe informal networks within an organisation, aiming to stimulate discussion, improve communications and monitor changing patterns, as a result of modified team structures over time. It can also be used to select optimal team selections with given constraints, by testing out many combinations.

Organisational Forms Simulator is a generic tool capable of doing the following:

- 1 – Display a given network by spreading out the nodes and links.
- 2 – Visualise a given network of people and their connection links in a number of “dimensions”.
- 3 – Calculate a number of network properties, such as total distance, degree of separation
- 4 – Carry out what-if analyses by adding, deleting or moving nodes or links in the network
- 5 – Run what-if an epidemic of good ideas started from a person or a group of individuals. Would the network quickly spread the epidemic, or would the ideas die out where they originated?

The simulator runs as a Java Applet in a Java enabled Internet Browser. Once running, Load a network file by selecting a question from the "Q:" menu. The simulator then displays the network layout (not yet visually sorted). It calculates a number of statistics (described below in the Stats button section).

Question Files: Normally a question file is selected by using the "Q:" menu (the following question files organogram.sav, qx5a.txt, qx5b.txt, qx6.txt, qx7.txt, qx9.txt, qx10.txt, qx11.txt, qx12.txt, qx11-12.txt, qx13.txt, qx14.txt are available). Please see below for details of these questions.

- Load button: For each question there is a qx**.sav file with the layout already organised for better viewing. So press Load button to load qx**.sav file linked with that question. Alternatively LAYRUN button helps organise the layout.

The colour code on the nodes denotes the following: Colour red means 8 or more incoming connections to that node, other colours blue=7, magenta=6, orange=5, pink=4, green=3, yellow=2, cyan=1, finally grey means no incoming connections to that node.

- Conf button shows the network file processed from the questionnaires. The first name is the person who provided the other names for that question.

- Stats button shows some statistics of the network. These are:

1 - Gender Statistics. Connections based on gender, a breakdown of total Male to Male, Male to Female, Female to Male and Female to Female connections.

2 - Location Statistics. Connections based on locations of people, total number of connections between people on the same site location and connections across different locations are calculated.

3 - Connection Histogram (total incoming connections vs number of people). For example how many people have 1, 2, 3, ... incoming connections.

4 - Most Consulted Persons on the Network, Most consulted (incoming connections) on the network as a sorted list.

5 - Degrees of Separation and Most Used Nodes by all shortest connection pathways.

- Dual check box: We normally assume unidirectional connections as the questions often ask "who would you contact?". When the "Dual" checkbox is unticked, the system assumes all connections are unidirectional. All links on the display will have either a blue dot indicating the direction of the connection or a red dot in the middle showing the connection is bidirectional. The node closer to the blue dot has the incoming link. The bidirectional nodes consult each other. In the Dual mode where all connections are assumed bi-directional, all links have a red dot in the middle.

- Probe check box when ticked allows users to probe into nodes when clicked on them. This opens a new window showing relevant information.

- Note check box when ticked shows detailed information about nodes (people).

- Gender check box changes the colour code based on gender (cyan for male, and pink for female).

- Loc check box changes the colour code based on location. Nodes from the same location are shown as the same colour. One can only view nodes in Gender, Loc or the standard connection count colour codes in the Layout mode.

- Hide check box hides all people who did not take part in the survey but were named by others. Hide mode can be turned on and off to view the change on the network.

- LAY / EPI Menu changes the colour schemes used by the simulator. LAY option sets it for LAYRUN (Layout optimisation mode), and EPI option sets it for Epidemic run.

- LAYRUN organises the layout, it can be started with LAYRUN button. During the run, one can intervene manually by picking individual nodes and dragging on the screen to some other place.
- STOP button stops the LAYRUN.
- Scramble button shuffles the layout randomly.
- Shake button moves a number of randomly selected nodes.
- Jump check box, when ticked in the LAYRUN, a number of are selected and moved randomly.
- Dual check box makes all connections bidirectional when ticked.
- EPIRUN button helps to demonstrate the "epidemic of ideas" for the given network. When the network is triggered by one or more people with good ideas we can observe how ideas would spread. Graphically on the network, red coloured nodes indicate active status (or infected by the idea), and grey coloured nodes are inactive. Nodes go through intermediate stages ruled by the number of people in contact with them, and their state of activity. To start the epidemic with a certain node use RandState and Reset, and click on specific nodes to toggle their status. It can be observed that due to the connectivity characteristics of some networks, some ideas may never spread to the whole network.
- An EPIRUN can be stopped by the STOP button next to it.
- RandState button randomly sets the states of a number of randomly selected nodes as 1 (red, active), and the remaining nodes as 0 (grey or inactive). The random activity level can be selected by the help of the parameter next to the RandState button. This parameter is set to 5 (%) by default.
- Reset button on the other hand resets all nodes to 0. Having done that one can set or reset individual nodes to 1 or 0 (red or grey) by clicking on the nodes while in the EPI mode.
- Help button opens this help page.
- About button provides the version number of the simulator.

Future Work

Agent-Based Models could be used for Human Resource Management. We can simulate certain aspects of individuals in an organisation by defining a number of parameterised strategies to explore approaches to career development. We can simply run simulations with an open mind, and observe and investigate behavioural patterns for survival/success. This may be considered speculative but we can use results to stimulate discussion on to

- 1 - Qualify what is a "good" organisation in terms of informal network's structure
- 2 - Understand organisational properties by linking quantity with quality, good and bad practices

Using the simulator we can even try to grow virtual organisations with a given number of people, attributes and constraints. An interesting application of this is to set up a number of project teams with a good level of connectivity, minimum communications overloads, good distribution of social/business/technical-oriented individuals in project teams. This is in fact a combinatorial optimisation problem with a multi-dimensional objective function. But we can include fuzzy measures such as fulfilment, even happiness.

An additional benefit of ABM research methodology is that as we use data from interviews and questionnaires, this can be used to monitor changes in the organisation. We can then see the evolution of the pilot organisation, new and redundant connections, staff development through time, and perceptions.

References

1. Stuart Kauffman, **At home in the Universe**, Penguin Books, 1995
2. Joshua M. Epstein and Robert Axtell, **Growing Artificial Societies – Social Science from the bottom up**, 1996
3. John L. Casti, **Would-be Worlds**, John Wiley & Sons, 1997
4. Albert Laszlo Barabasi, **Linked – The new science of Networks**, Perseus Publishing, 2002
5. Mark Buchanan, **Small World: Uncovering nature's hidden networks**, Weidenfeld & Nicolson, 2002

Appendix - Application to Rolls Royce Marine

We have carried out a web-based questionnaire with RRM called 'Connectivity in the Work Place for RRM'. A total of 36 people completed the questionnaire. Please see below a summary of the answers to questions 5a, 5b, 5c, 6, 7, 8, 9, 10, 11, 12, 13 and 14 in the questionnaire.

All questions (except for question 5.c) asked details about the person, communications medium and preferred medium as below. People could choose a number of communications medium if they wished.

Name, Jobtitle, Relationship (line subordinate, line manager, functional manager, peer, other)
Medium used (telephone, e-mail, face-to-face, other) coded as (phone, email, face)
Preferred medium (telephone, e-mail, face-to-face, other) coded as (p_phone, p_email and p_face)

Question 5.c

How would you describe the process of taking your idea forward? (You can choose more than 1 option.)

	Total Preferred
a. an attempt to reach consensus amongst the people approached	21 people
b. a series of formal meetings	7
c. a series of informal meetings	20
d. prepare a business case and demonstrate it	13
e. get permission for any action I take in relation to getting support for my idea	8
f. approach a few select individuals	21
g. go straight to the most senior person I know	0
h. talk to/seek advice from friends outside the company about my idea	3
i. a combination of the above	7
j. this is not something I think I would initiate	0
k. no experience	0
l. other	0

Question 5.a

You have a good idea in relation to your job which you believe will benefit your business group. Who would you contact to discuss your idea?

People = 69
Male = 43
Female = 26

Links = 103
Male to male links = 42
Male to female links = 14
Female to male links = 34
Female to female links = 13

Are people happy with the comms medium they use?

Happy = 93 people
Unhappy = 10 people

Breakdown of comms medium used?

phone = 44
email = 38
face = 89
other = 0

Breakdown of comms medium used for relevant position?

	phone	email	face	other
linesub:	3	1	9	0
linemng:	6	10	29	0
funcmng:	11	6	10	0
peer :	16	13	25	0
other :	8	8	16	0
total:	44	38	89	0

Question 5.b

Initial conversations/feedback on your idea are positive.

Who would you then contact in order to get further support, in view of putting the idea into practice?

Total = 67
Male = 41
Female = 23
unknown = 3

Links = 81
Male to male links = 31
Male to female links = 6
Female to male links = 27
Female to female links = 14

Are people happy with the comms medium they use?

Happy = 71
Unhappy = 10

Breakdown of comms medium used?

phone = 38
email = 47
face = 62
other = 0

Breakdown of comms medium used for relevant position?

	phone	email	face	other
linesub:	2	0	4	0
linemng:	4	4	8	0
funcmng:	3	7	5	0
peer :	20	22	25	0
other :	9	14	20	0
total:	38	47	62	0

1

Question 6

You receive a request for some information. It's not your responsibility and you don't know whose job it is to provide the information. Who would you contact to find out who could deal with the request?

Total = 58
 Male = 28
 Female = 27
 unknown = 3

Links = 83
 Male to male links = 24
 Male to female links = 13
 Female to male links = 23
 Female to female links = 20

Are people happy with the comms medium they use?

Happy = 70
 Unhappy = 13

Breakdown of comms medium used?

phone = 38
 email = 32
 face = 53
 other = 0

Breakdown of comms medium used for relevant position?

	phone	email	face	other
linesub:	5	2	17	0
linemng:	3	2	7	0
funcmng:	4	5	3	0
peer :	14	16	16	0
other :	12	7	10	0
total:	38	32	53	0

Question 7

You are unsure about the business strategy or what the business objectives are. Who would you contact to find out?

Total = 67
 Male = 45
 Female = 21
 unknown = 1

Links = 84
 Male to male links = 37
 Male to female links = 4

Female to male links = 36
 Female to female links =6

Are people happy with the comms medium they use?

Happy = 69
 Unhappy =15

Breakdown of comms medium used?

phone =36
 email =27
 face =61
 other =2

Breakdown of comms medium used for relevant position?

	phone	email	face	other
linesub:	0	0	1	0
linemng:	9	7	22	0
funcmng:	7	7	9	0
peer :	15	9	18	0
other :	5	4	11	2
total:	36	27	61	2

Question 8

You have been away from the office for a couple of weeks on holiday. On your first day back you need to find out what you've missed in relation to work. Who would you contact to find out?

Total = 64
 Male = 32
 Female = 32

Links = 102
 Male to male links = 33
 Male to female links =18
 Female to male links = 23
 Female to female links =28

Are people happy with the comms medium they use?

Happy = 86
 Unhappy =16

Breakdown of comms medium used?

phone =27
 email =7
 face =74
 other =0

Breakdown of comms medium used for relevant position?

	phone	email	face	other
linesub:	4	0	23	0
linemng:	4	3	18	0
funcmng:	7	3	4	0
peer :	8	1	22	0
other :	4	0	7	0
total:	27	7	74	0

Question 9

You have been away from the office for a couple of weeks on holiday. On your first day back you need to find out what you've missed in relation to the social aspects of working life. Who would you contact to find out?

Total = 54
Male = 17
Female = 36
unknown = 1

Links = 77
Male to male links = 16
Male to female links = 18
Female to male links = 9
Female to female links = 33

Are people happy with the comms medium they use?

Happy = 72
Unhappy = 5

Breakdown of comms medium used?

phone = 8
email = 1
face = 71
other = 0

Breakdown of comms medium used for relevant position?

	phone	email	face	Other
linesub:	1	0	21	0
linemng:	0	0	3	0
funcmng:	1	1	2	0
peer :	5	0	30	0
other :	1	0	15	0
total:	8	1	71	0

Question 10

You are stuck with a problem and need some advice and support. Who would you contact to discuss your problem?

Total = 62
Male = 33
Female = 26
unknown = 3

Links = 89
Male to male links = 34
Male to female links = 7
Female to male links = 23
Female to female links = 22

Are people happy with the comms medium they use?

Happy = 78
Unhappy = 11

Breakdown of comms medium used?

phone = 48
email = 17

face =67
 other =0

Breakdown of comms medium used for relevant position?

	phone	email	face	other
linesub:	0	0	6	0
Linemng:	2	3	12	0
funcmng:	7	3	8	0
peer :	24	8	27	0
other :	15	3	14	0
total:	48	17	67	0

Question 11 (Only answer this question if you are in a CFBU.)

You get some marketing information which you think has an impact on R-R product development strategy. Who would you contact to share the information with?

Total = 34
 Male = 24
 Female = 9
 unknown = 1

Links = 26
 Male to male links = 11
 Male to female links = 1
 Female to male links = 13
 Female to female links =0

Are people happy with the comms medium they use?

Happy = 22
 Unhappy =4

Breakdown of comms medium used?

phone = 9
 email = 14
 face = 17
 other = 0

Breakdown of comms medium used for relevant position?

	Phone	email	face	Other
linesub:	0	0	1	0
linemng:	0	1	3	0
Funcmng:	0	0	0	0
peer :	4	7	8	0
other :	5	6	5	0
total:	9	14	17	0

Question 12 (Only answer this question if you are in an OBU.)

You get some product information which you think has an impact on the R-R market strategy. Who would you contact to share the information with?

Total = 28
 Male = 20
 Female = 8

Links = 22
 Male to male links = 6
 Male to female links =2
 Female to male links = 11
 Female to female links =3

Are people happy with the comms medium they use?

Happy = 21
 Unhappy =1

Breakdown of comms medium used?

phone =16
 email =14
 face =16
 other =0

Breakdown of comms medium used for relevant position?

	phone	email	face	Other
linesub:	1	0	1	0
Linemng:	2	3	5	0
funcmng:	1	1	1	0
peer :	7	6	4	0
other :	5	4	5	0
total:	16	14	16	0

Question 13

You are unsure about the process used to complete a task. Who would you contact to find out?

Total = 59
 Male = 30
 Female = 26
 unknown = 3

Links = 81
 Male to male links = 24
 Male to female links =15
 Female to male links = 23
 Female to female links =16

Are people happy with the comms medium they use?

Happy = 71
 Unhappy = 10

Breakdown of comms medium used?

phone =36
 email =24
 face =62
 other =2

Breakdown of comms medium used for relevant position?

	phone	email	face	Other
linesub:	4	3	16	0
linemng:	0	0	6	0
funcmng:	3	1	2	0

peer :	16	13	27	0
other :	13	7	11	2
total:	36	24	62	2

Question 14

Who do you generally go to the most for help and advice? Please list by order of preference.

Total = 69
 Male = 37
 Female = 29
 unknown = 3

Links = 117
 Male to male links = 45
 Male to female links =9
 Female to male links = 31
 Female to female links =29

Are people happy with the comms medium they use?

Happy = 104
 Unhappy =13

Breakdown of comms medium used?

phone =49
 email =40
 face =92
 other =0

Breakdown of comms medium used for relevant position?

	phone	email	face	other
linesub:	4	3	10	0
linemng:	5	5	20	0
funcmng:	7	5	8	0
peer :	19	17	35	0
other :	14	10	19	0
total:	49	40	92	0