

Simulating the Emergence of the Organizing Structures of Work

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Abstract—This article is a first step toward a visualization and classification system for studying dynamic organizing structures of work. As a first step toward this research objective, this study brings together two active projects. One called “relatonics” studies work group formation and is primarily empirical and inductive. The other called “Human Interaction Dynamics (HID)” imports concepts, relationships and modeling from complexity science and is therefore primarily theoretical and deductive. The vision is to use social media, data gathering, and process simulation technologies to rigorously describe, systematically visualize, and validly model the complex dynamics of work processes of different types. This work will serve as a means to classify, study and improve the performance of work systems. We describe our progress to data and suggest further research.

I. INTRODUCTION

THIS paper is a starting point of a process aiming at building a tool for simulation of work activities in an organisation. It does so by merging the thinking from two different projects. The first is a series of studies which are developing the concept of “relatonics” and its visualisation. The second is a project that is developing a model of human interaction dynamics (HID) on a base of complex system theory.

After briefly describing the two projects, this paper discusses how one might use the HID-model to analyse empirical data that was collected in one of the relatonics projects. This study is the first bridge between the two projects, and it seeks to link findings from both theoretical and empirical based research in a general theory that classifies the mechanisms of organizing in human complex adaptive systems. The aim of the paper is to formulate a base for a discussion on how to simulate the emergence of the organising structures of work.

II. RELATONICS AND VISUALISATION OF AN ORGANISATION

Relatonics is here defined as the composite existence of relations in a workplace that are of importance in and for the performance of the core operational task [1]. A relatonic is charged with resources of significance for the core task, for example competence, information, and decision power, and thereby carries a capacity for action. A key determinant in differentiating relatonics from social networks in general, is that relatonics emerge in relation to shared work tasks, and

comprises the relations that are used to perform the task. Each core task of an organisation has different relatonics. The concept of *relatonics* lifts up the individual level concept *relation* to an organisational level. It is used to focus on the actors of a decisive organisational task and the dynamics of their interactions [2]. A specific relatonic may crisscross between several intra-organisational units, as well as external partner organisations [3]. A challenge for managers is how to understand and lead such dynamic and moving structures.

The relatonics project also examines organisation images to facilitate change [4]. It is based on the assumption that people, co-workers as well as managers and other agents of change, act and make decisions according to their own conceptions [5], [6]. Such conceptions are grounded in one’s understanding and are therefore largely dependent on context specific experiences and the images coupled to that understanding.

It is through interactions that the ongoing construction and reconstruction of a relatonic takes place, by means of either confirmation or change. The experiences of interactions that develop in an organization in the course of the performance of core tasks are of key importance to the relatonic in that they possess facilitating opportunities for future interaction of weight for operational tasks. Also, the opposite can apply; experiences of interaction within an organization may hinder future interactions.

Relatonics have process attributes as well as structural qualities. They are created and recreated in interaction, in interplay and action, and through conversation and co-acting. All this can be regarded as a process, since a relatonic is continuously created and recreated on the base of the current relatonic. At the same time, a relatonic can be regarded as a structure, since it is fairly stable, and exists as a multi-reciprocal experience pointing to future possibilities, even when it is not actively utilized. It may be said that the relatonic proceeds in more or less close interactive work processes, via which it both comes into being and is changed. The relatonic exists as a memory and a common experience, even when interaction temporarily comes to an end, and also as a potential for resumption of the interaction. In this way, the relatonic is durable, as a shared experience that intrinsically bears the possibility of future interaction.

Relatonics are path-dependent properties that emerge from of interactions between individuals in a specific context of tasks, available colleagues, constraints etc. Common experiences of interaction, and thereby the perceived

□ This work was financed by the KK Foundation and AFA Insurance of Sweden

potential for future interaction, exist as an intangible link between two persons, and as an intangible network within an organization. A mental map grows up along well-worn paths that lead to interaction with others [2]. It is thus possible, at least in theory, to understand how the structure of today's relations came to be if one has historical data about interactions and context. Consequently, it is also, in principle, possible to give prognoses for the relations of tomorrow for different changes in context. This software of the future would be a tool for practitioners to not only visualise the relations of today, but also simulate the relations of tomorrow. It would have 'sliders' to change the context, i.e., a new organisational structure, or a new design of the workplace. And it would be possible to see how such changes influence the relations.

There are at least two techniques that could be used for such a relations simulation tool. One way is to start with individuals and their interactions and use agent-based models (ABM). The goal of ABM is to simulate the collective behaviour of agents. Agents obey simple rules and can learn from experiences. Changes emerge iteratively at various stages. Different, simple rules of agents, their interaction with each other, and the context leads to the emergence of different collective behaviour, in this case relations. The other way is to start at the *system* level, with the relations. Human interaction dynamics (HID) is an analytical framework developed using information theory and mathematical models [7]. Structures at the collective level, like relations, which are called coarse-grained properties in HID, are described as categories. Drawing support from the category theory of mathematics, deductive logic can be used to predict the behaviour of coarse-grained properties

III. HUMAN INTERACTION DYNAMICS MODEL

The HID approach uses a complex systems theoretical framework to study human organizing as an emergent phenomenon. To do this, it looks at three levels: relations, information and action. Each level of the HID-model consists of a duality in each of these areas [7]-[9].

Relations focuses on the socio-emotional influences that constrain and enable the *integration* of individual choice and action into the collective. For example, Hazy and Silberstang describe organizing acts that integrate individual choices into collective action calling these "micro-enactments" [10], [11].

These relational "level 1 models" focus on the nature of *relations* among individuals and things and how these come together to form the understandable and predictable coarse-grain objects, for example recognizable variables such as the position "X", that define a community and its organizational identity [12], [13] and the capabilities of organizations [14]. Integration *with* the uncertainties of individual autonomy form an inevitable duality for agents within a complex adaptive system when recognizing and predicting the outcomes of social objects within organizations.

Information is created when surprising events unfold in an organizational context. In HID "level 2 models" describe how observers (whether inside of outside an organizational

boundary) recognize, interpret and use the information being created as events are observed and how this is used by individuals within the system to structure and execute complex action in the context of the changing relationships that were implied by the level 1 models that were described in the prior paragraph [15]. The level 2 models describe the information within the organizing structures and how this information flows to and among individuals through their interactions with others and the environment [16].

Treating the systems of interactions that use and create information as the unit of analysis, level 2 HID models are fundamentally about change, dX/dt . They explore the detail of both *convergence* and *divergence* within the changing micro-states recognized by individuals as coarse-grained properties during interactions—including the rules that govern these interactions, how they are enacted, and how they change. Convergence along some dimensions *with* divergence along others form another inevitable duality when gathering and processing information in a changing environment [17], [18]. This duality is acknowledged in the context of performance and learning. It is embedded in the action level as the balance between exploitation versus exploration.

Action, the third level, identifies organizations as entities and focuses on how they relate with one another as multi-agents and do so within ecosystems. These "level 3 models" enable individuals to *act* collectively in the context of the organization's objectives [19]. In this context individuals within organizations must *explore* for new information and use both it and other information that has been stored during past events available to *exploit* collective potentials even as these potentials are likewise changing. This is done by sharing and using level 3 models about the organization and how it interacts and exchanges resources within its ecosystem. Level 3 models help the organization as a whole as it both exploits its current resources and capabilities and at the same time explores the environment and innovates to improve its internal capabilities in an effort to sustain the organization in the face of forces of change impacting those potentials, d^2X/dt^2 .

In the context of level 3 models, individuals use level 2 models to predict the organization's changing properties and potentials in an effort to enable their own individual *potency* through collective action as they understand it in the context of their own interests as explicated through their level 1 models. To navigate this complexity, individual agents engage various dualities at each of these three levels in ways that empower them to act. At the same time, they learn to do so by thoughtfully and skilfully using the *constraints* that organizing places on others so they can to channel collective activity in ways that further each individual's personal agenda. They do this by leveraging effective coordinated action in service of their needs. Both potency and constraint are perceived in an efficacious balance.

IV. EMPIRICAL DATA ABOUT RELATIONS

The empirical material discussed in this paper is based on an on-going research and development project exploring

visualisations as a tool for organisational change and development [3]. In the municipality featured in the project, as in many other Swedish municipalities, there is an on-going struggle with increased expenditure and social costs due to high youth unemployment. Youth unemployment can be described as an ill-structured problem with few given means and ends [31]. Also, when working with youth unemployment, there are several stakeholders who need to be involved and who, by law, have different responsibilities. The senior management of the municipality initiated several efforts to change how work was organised by addressing the problem of youth unemployment from a more holistic perspective. Thus, during autumn 2012, they launched an *Employment Project* (EP) to work with this task. A core part of the EP was a small project team – the EP team – working with coordination and job coaching.

The empirical material consists of relational analyses of the task of ‘getting young people into work’ in a small Swedish municipality. Methods for data collection are two surveys, a couple of interviews with the senior management, and meetings with key people where network images have been presented. The visualisations of relational data was created by using the software Netdraw [20], based on a Multi-Dimensional Scaling (MDS) technique. MDS is a family of techniques that is used for information visualization to assign locations to nodes in multi-dimensional space (in the case of the drawing, a 2-dimensional space) such that nodes that are "more similar" are closer together. The algorithm used uses iterative fitting to locate the points in such a way as to put those with smallest path lengths to one another closest in the graph. This approach can often locate points very close together, and make for a graph that is hard to read. In the visualizations, we've also selected the optional "node repulsion" criterion that creates separation between objects that would otherwise be located very close to one another.

The relational analyses were done on the basis of a web-based survey covering three main areas, see Table 1: q1 frequency in interaction, q2 topic of interaction, and q3 experienced benefit of the interaction. q1 functions as a name-generating question, while q2 and q3 address certain qualities of the specific relations – the so-called name interpreter questions [21].

Three main steps were taken in our efforts to draw the map of relational data concerning the task of ‘getting young people into work’: 1) A senior manager – responsible for the newly started employment project in the municipality – identified three other key individuals in the task, two of whom worked within the municipality (one team leader in the employment project and one manager at the social welfare office). The third key individual worked at the local employment office. 2) Interviews were done with all four key individuals to map their network of people for the task. The interviews resulted in a roster consisting of 62 individuals. 3) A web-based questionnaire, using the roster, was distributed to the entire network. Additionally, when answering the questionnaire the respondents had the possibility of adding new people (with whom they interacted in the task).

TABLE I.
 QUESTIONS IN THE RELATIONAL SURVEY

No.	Questions	Response alternatives
q1	Which persons or functions are you in contact with, one way or the other, in the work task of getting young people into work?	Daily, weekly, monthly, rarely
q2	For what reason have you been in contact with X concerning the work task of getting young people into work?	Routine tasks, problem-related task, goal-oriented planning, strategic planning
q3	How much benefit have you had of person X in the work task of getting young people into work?	Rating between 1 (not at all) and 7 (very much)

The first questionnaire Q1 was distributed in December 2012, resulting in 48 full responses, a response rate of 77%, and was followed some six months later by a second identical questionnaire Q2. For the second questionnaire, the list of names was edited due to the fact that some people had turned out not to be relevant to the network. Also, a few people were added, including people that had changed job descriptions and who now potentially could be part of the network. The second questionnaire Q2 was distributed in June 2013 to a total of 59 respondents, resulting in 41 full responses, a response rate of 70%.

Some respondents were excluded to be able to better compare the results of the two questionnaires. Only organizational units included in both Q1 and Q2 were included in the comparison (5 units with a total of 8 respondents in Q1 and 1 unit with 1 respondent in Q2). For the comparison we thus have 40 respondents in both Q1 and Q2.

V. DIFFERENT KINDS OF ANALYSES OF THE DATA

Two different kinds of analyses of the relational data have already been used: Qualitative interpretation and Statistical reductionism. Some results from these analyses are presented below as illustrative examples. Two more kinds of analyses are planned to be used: Categorisations of actors and Agent based models. This paper is discussing these planned analyses.

A. Qualitative interpretation

In the qualitative interpretation approach people in the analysed organisation was asked to reflect about visualisations of their relational data [4]. The argument behind this approach is the assumption that people, including managers and other agents of change, act and make decisions according to their own conceptions. The aim was to explore and exemplify how work-integrated relations may be visualised, and to discuss qualities of three different types of

organisation image in terms of their potential contribution to an understanding that is useful for intended change. Mintzberg and van der Heyden [22], were pioneers in drawing alternative organisation images – organigraphs – showing how companies work. They identified four basic types of organigraph based on principles for managerial work: set, chain, hub and web, through which managers are respectively thought to allocate, control, co-ordinate and energise. This work aside, little attention has, in the research literature, been paid to problematizing visual organisation images and representations when it comes to their influence on change and development. This makes it relevant to use information visualization as a means to understand what is going on in an organization in terms of work-integrated relationships where expertise flows between people.

The visualisations of the relatronics as a network have been useful for the participating organisations as a mean for reflection. Participating managers, leaders and co-workers have seen the images as relevant to ongoing work where a new network is emerging for a new shared task. The images have, in some respects, confirmed senior managers' understanding of existing problems in patterns of interaction and collaboration. They have also challenged preconceptions about such patterns, e.g., by making hidden collaboration patterns visible.

One example of this is that the leader of the labour market project team observed how central she was in the relatonic of the task of 'getting young people into work' in the beginning of the project, see Fig 1. Then she sought to involve more people in the job and succeeded to do this, see Fig 2.

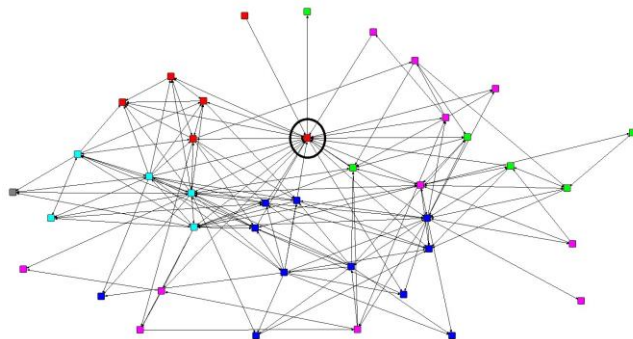


Fig. 1. The relatonic of the work task of 'getting young people into work' in December 2012 (Q1), with the team leader encircled. The small, colored squares represent people/functions (nodes). A node's color represents the organizational unit to which it belongs. The denser the work-integrated interaction, the more central the placement of the node. The lines between the nodes show that the individuals interact with one another at least once a week.

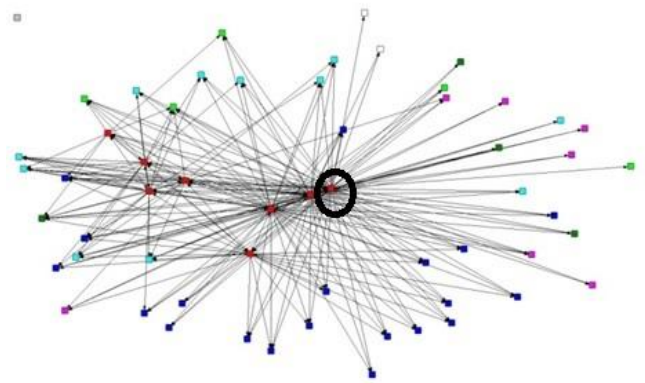


Fig 2. The same kind of picture as figure 1 half a year later, Q2 in June 2013.

Further, concepts from social network analyses such as cliques and bridges has been used to focus the on possibilities and weaknesses in the network structure [23], see Fig 3. Here, the efforts to use social network analysis as a tool for organisational development have been inspired by Cross, Gray, Cunningham, Showers, and Thomas [24].

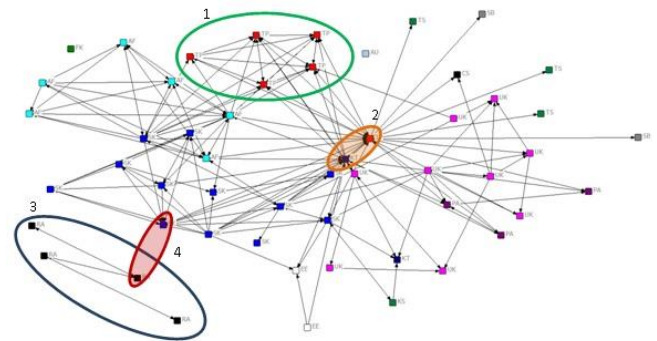


Fig. 3. The relatonic of the work task of 'getting young people into work'. The lines between the nodes show that the individuals interact with one another at least once a week. Encircled are phenomena focused in qualitative interpretations.

B. Statistical reductionism

In the statistical reductionism approach calculations on system level are used to summarize qualities of the relatronics. These analyses are on the system as a whole while the lower level structures of the relatronics are not included in the analyses.

Two measures have been used: Density and Centrality of the network. *Density* is the percentage of all realized talk connections among all possible. In a network with high density, many actors have direct contact with the other actors, and the flow is supposed to be high. In networks with low density, most actors have few direct contacts with others, and the flow is low. The *centrality of the network* is a measure of its overall structure. In a network with high centrality, one or few actors are in the center of the network, influencing most of the flow in the network, and the other

actors are in the periphery, with little influence of the flow. Such network is of a hierarchical type. In a network with low centrality, most actors have about the same influence of the flow. Therefore, this network is more equal. We use group closeness centralization as the measure. The calculation of it is based on the sum of the differences in individual centrality between the actors of the network. Individual centrality is a measure of how central or important a person is in the network. A person with high centrality, a broker, has direct contact with more of the others than a person with low centrality. Thus, he or she is able to influence the flow to a greater extent. We use Actor Closeness Centrality (ACC) to measure this. ACC is the inverse sum of the distances from the actor to all other actors. The centrality of the network is measured in percent, where 100 % is the highest possible centrality. The software UCINET 6 [25] was used for data management and analyses.

The results from our study for the relationalics of “*Interact at least once a week in the task of ‘getting young people into work’*” is showed as an example. For Q1 the density is 17% and the centrality 42% (December 2012). For Q2, half a year later, the density is 21% and the centrality 26%.

C. Categorizations of actors

The categorizations of actors approach is inspired by Backström, Hagström and Göransson [26]. They made classifications of actors are into a spectra of different categories: managers or non-managers respectively high, middle or low integration into to organizational culture. Analysis are made to see if these categories had systematically different positions in the pattern of interaction for different kinds of workgroups.

The HID-model includes six poles, a duality for each of the three levels. A first suggested operationalization of these poles when analysing the empirical data from the relationalics project are:

- *Integration* in the Employment project means that you are part of the relationalics of this work task.
- *Autonomy* from the project means that you are not part of it.
- *Convergent* information is operationalized as when you have strong ties in the network of talk about plans and goals of this task.
- *Divergent* information is that you have weak or no ties of this kind.
- *Exploit* and *Explore* will be decided using the interviews with senior managers about the action of the organization when it comes to this work task.

In the project we have data about the relationalics of the task of getting young people into work both before and after the Employment project. In the analyses we will try to understand mechanisms behind the emergence of relationalics. Some first hypotheses to be tested are:

H1. More people will be integrated into the task after the project.

H2. Since interaction about a subject triggers more interaction about the same subject, the frequency and density of interaction will increase.

H3. People included in the relationalics before the project will be more central in the relationalics after the project than newcomers.

Some first research questions to try to answer:

RQ1. If more people have been integrated into the task, is there a connection to this and the actions, is there for example a more of exploiting the resources?

RQ2. We have different data concerning the quality of the interaction, for example concerning the subject of the interaction and the perceived usefulness of it. Which qualities are most important for the emergence of the relationalics?

D. Agent based models

Agent-based models (ABM) [27] are unfamiliar for most of the authors of this paper. Attending to this conference is a starting point in learning how to use ABM to analyze empirical data about emerging phenomena. Simulation of organizational behaviors of a firm is a traditional approach in social simulation literature, see for example [28]. Our effort is a bit different in that it uses the human interaction dynamics as a base for the simulation. Further, we assume that a few order and control parameters [29] decides the general tendency of individual behavior in an organization [8]. The vision is to be able to simulate the emergence of relationalics in for example NetLogo using the six poles in the HID-model as global model parameters and sliders [30].

VI. CONCLUSION

One ambition of the municipal senior management included in the relationalic project was to organise the task of getting young people into work through boundary-crossing – not only working across unit boundaries in the municipality itself, but across to units in other organisations, especially the local employment office. However, the existing organisational structure and the image that represents it – the organisational chart – were described by leaders and managers as problematic, because of the influence both on how the work task was understood and on how resources were allocated. An additional problem that was identified by our research team was that the work task was defined and labelled differently within each unit, and was managed as if it were part of only a single unit, thus resulting in sub-optimisation and a lack of coordination. This made collaboration in the task more difficult.

Images of relationalics provide novel and richer pictures of organisation, and, for some of the interviewees, give a strong feeling of recognition and amazement. Network images do afford opportunities to understand the possibilities of intervening, for example, through appointing people to shared tasks, which means that there are possibilities to facilitate the emergence of changed structure. There are

empirical indications of the value of relational visualisations in modern organisations.

Complexity models of leadership and influence have the potential to classify visualizations of these structures. For example, Hazy [16]-[18], [32] describes the emergence of networks of influence based upon individual influence and leadership [17] and highlights the potential that emergent work structures might support organizational learning in a manner analogous to neural network learning models [33]. The assertion that work structures create network effects has also been explored in simulations related to boundary spanning [34]-[37].

This paper describes an ongoing project that is intended to add the dynamic visualization of work process to the analysis toolkit in support of organizational effectiveness. It is our hope that advances in complexity science bring with them additional analytical approaches and technologies as aids for the human project. We all, it seems, want to believe that “there must be a better way to do things.” In the end, we feel, it is this age-old expression of hopeful frustration that drives human progress.

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