Comparing performance of different organizational team structures by agent-based modelling

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Abstract. The research project "Determinants of resilience in organizational networks" investigates the socio-cognitive factors that make organizational adaptation to technology possible. The case study for this project is the maintenance department of a utility company responsible for district heating that recently started using drone-operated thermographic cameras for detecting leakages in their piping network. This paper presents a simulation model which investigates organizational resilience in the face of change. A team structure derived from the empirical case study is compared to three theoretically derived team structures, ranging from a traditional hierarchical structure to disorganization. Performance of the differently organized teams is measured by the speed of fixing leakages.

Keywords: Team performance, Team structure, disruptive events, organizational resilience

1 Introduction: organizational resilience

How does team structure and organizing flexibility shape organizational performance? Traditional teams are organized around a hierarchical order in which tasks are delegated by team leaders to subordinates. More recent approaches to studying team structure emphasize the benefits of *disorganization* for organizational performance [1]. *Disorganization* is the "[s]tochastic accumulation of varied entities within hierarchically ordered complex human structures" [8; 9, p.11]. It can refer to either planned or unplanned deviations from agreed-upon schemata of routines in a system. Empirical data on the structure of teams in organizations are likely to be in between the ideal types of strict hierarchy and complete disorganization. What is the impact of these different modes of team formation on an organization's ability to react to exogenous and potentially disruptive change? This raises the question of *resilience*, that is, how an organization continues to function and/or is capable of restoring its operations in the face of turbulent events and unexpected adversities [10]. Technological innovations are often an important source of such adversities [2] given that they have an impact on organizational routines in often unplanned or unanticipated ways. Yet, many technologies require slow adaptation and, thus, they elicit "soft" change which may spark a chain of unnoticed modifications in organizational practices, with important long-term implications for the workplace [3].

Since 2018, a large Danish utility company has been collaborating with an organization that specializes in the use of drones to detect leakages in heat pipes. These machines are equipped with thermographic cameras that detect sensible variations in surface temperature, hence indicating possible underground leakages. The organization specialized in drones provides thermographic imagery that aids the utility company in surveying thousands of kilometers of heating pipes that deliver district heating to private homes and businesses and institutions in the greater Copenhagen area. The thermographic data allows the utility company to map suspected leakages and organize their maintenance operations accordingly. The introduction of the new leakage detection system in the utility company's maintenance operations is a case of change in work and organizational practices brought about by technological innovation. The research project "Determinants of resilience in organizational networks" (DRONe) investigates the socio-cognitive factors [4,5] that make organizational adaptation to technology possible by employing an extensive ethnographical study [6,7] of the utility company's leakage detection and repair practices. Furthermore, the ethnographic data provide the input for building computational simulations of the work in the maintenance department. A first modelling framework is created where various aspects of team structure can be assessed and studied over the configuration of a generic organization.

2. Simulating organizational resilience

Using ABM for the study of organizational phenomena is still a niche in organizational research. However, since the garbage can model by March and Olson [12] and formalized into an ABM by Fioretti and Lomi [13] it is an established method and a growing body of research is devoted to modelling organizations [e.g. 14-18].

In the simulation – an agent-based model developed with NetLogo 6.3 – the baseline team structure derived from the empirical case is compared with three other theoretical structures (see Figure 1). *Option 1* (Figure 1a) is a standard hierarchical structure with all team members connected to one manager in a fixed layout. *Option 2* (Figure 1b) is still hierarchical but more flexible, in the sense that all agents are placed at random spots in the environment such that the different teams do not have the same number of members. *Option 3* (Figure 1c) is the organized anarchy or, in more modern terms, the disorganized way [1,9]. Not all employees are connected directly to a manager, and they connect to the ones closer to them. *Option 4* (Figure 1d) is the one derived from the actual maintenance department at the utility company and it is the baseline structure. The empirical evidence suggests that the mode of organizing at the maintenance department has some elements in common with *Option 2*, a standard hierarchical structure with some degree of flexibility. However, important deviations from the standard flexible hierarchical mode have been identified through the ethnographic case study. While formally being subordinated to a team leader, employees have a large degree of freedom in self-organizing their workload and significant linkages between teams can be found.

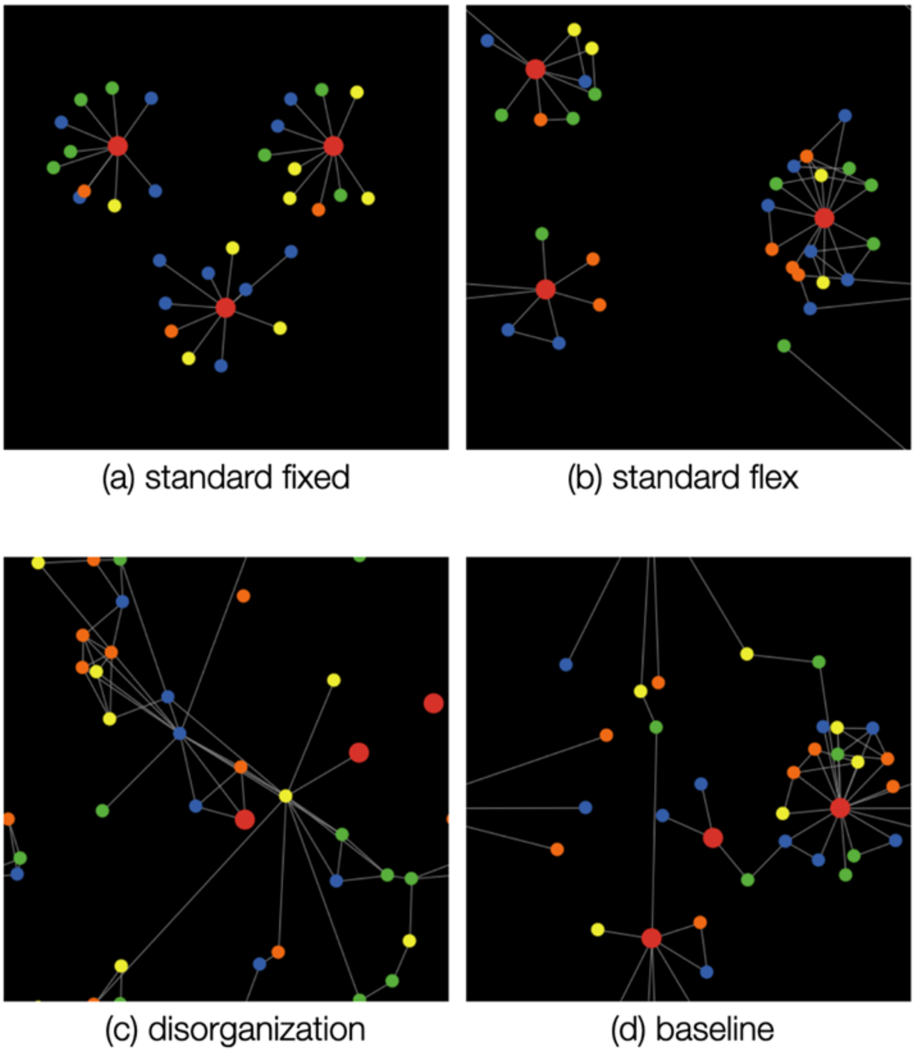
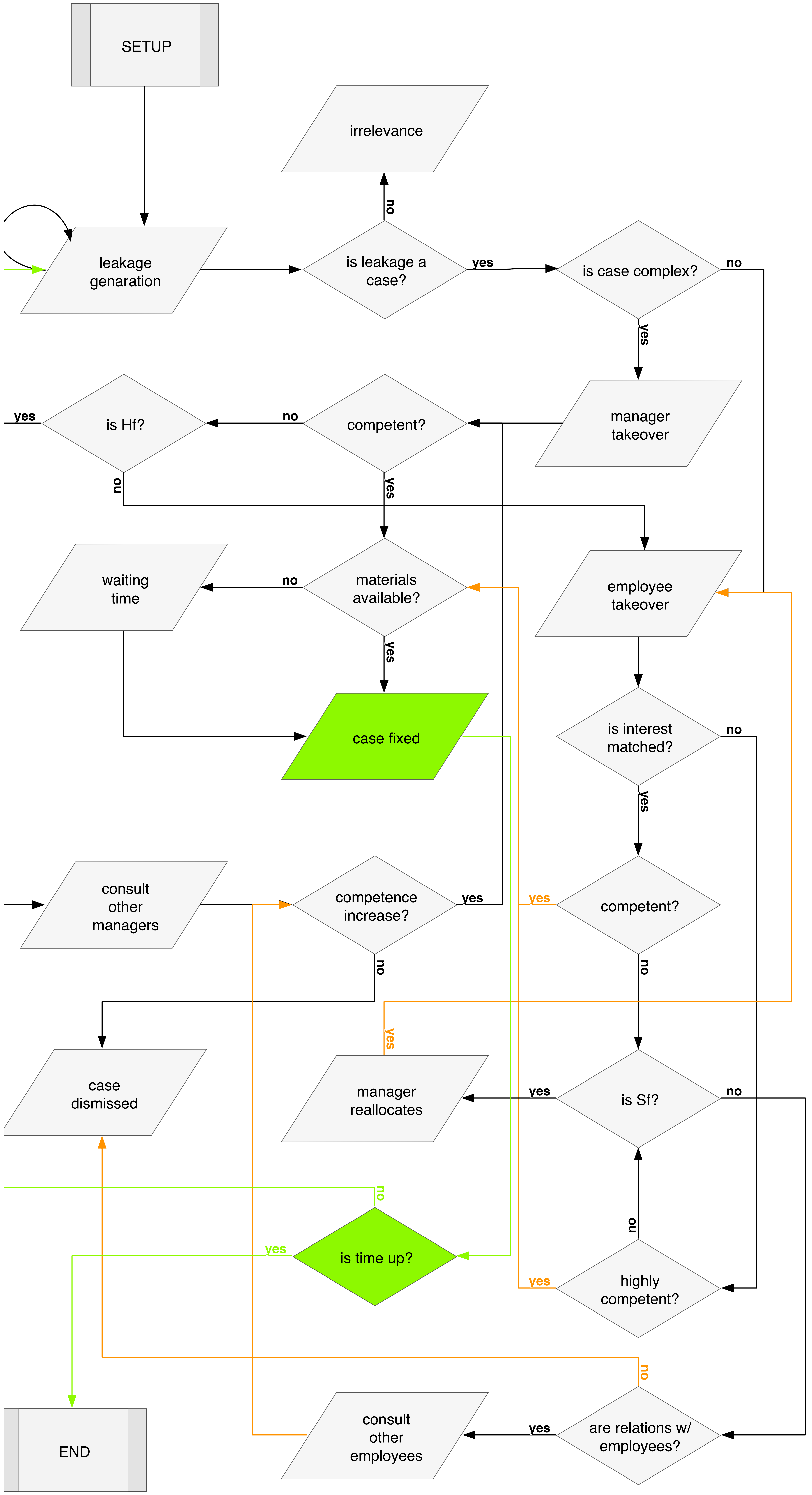


Figure 1. Alternative team structures

During the simulation, leakages – which are a type of agent in the simulation – are generated at random spots. If their severity exceeds a certain threshold, they become cases which need to be fixed, thus requiring action from the organization. They can be detected either by own employees, drones, alarm wires, or citizens. Other agent types are managers and employees. Cases are normally handled by employees; in order for this to happen, links appear between the agent which is fixing the problem and the case. When leakages are very complex, then responsibility is taken over by the managers. Complexity of cases is modeled by a Poisson distribution, i.e., it is a rare event that cases are complex. If a problem is fixed, both the case and the link disappear from the system.

Problem solving capacity is dependent on various factors. First, it depends on the *docility* of the agents [11], that is their willingness to give and/or listen to advice. Docility is randomly distributed among the agents. Second, materials (components, pipes) may be available or not. In the case that materials are not available, the case may be 'delayed' or 'severely delayed'. The ethnographic research conducted in the organization pointed at availability of materials as an important factor affecting the duration of case handling. However, it is assumed that this problem is not specific to this case, but that it is of general validity. The handling specificity of drone-related cases is one element that distinguished the empirical scenario from the theoretical scenarios. Whereas in the theoretical scenarios cases are randomly selected, in the empirical scenario drone cases are only selected when at least three drone cases are in close proximity. This is unless the severity of a case is reported as 'high' in the scale. Furthermore, the *time-to-completion* is dependent upon the competence of the employee handling the case. Competence is randomly distributed but agents can learn – i.e., become more competent – if they successfully fixed a case. If there is a mismatch between employee competence and the case they are handling, they might ask for help with a likelihood determined by their willingness to ask for advice (see *docility* above). In this case, they approach an employee randomly chosen from their network. In turn, the likelihood of support is determined by the willingness of this agent to give advice (still *docility*).

Competence is a crucial factor which distinguishes the empirical scenario from the theoretical cases: while competence is a general feature of employees in every setting, i.e., also in the theoretical cases, in the empirical scenario employees self–select the cases which they are handling. They choose a case that matches their interest and competence. By contrast, in the theoretical cases managers delegate cases randomly to the employees of their team. Choosing a case which matches the competence of the employee has the potential to increase the speed of case fixing. However, case self-selection might have the consequence that cases might not be chosen at all if they do not match the interest of any given employee. For this reason, in the empirical scenario the managers impose a trigger which counts the time a case remains untreated. Only if a certain threshold is reached, does the manager start delegating the case randomly to an employee. Figure 2 shows a flow chart of the model structure.


SETUP
irrelevance
leakage genaration
is leakage a case?
no
yes
is case complex?
no
yes
manager takeover
competent?
no
yes
is Hf?
yes
no
employee takeover
waiting time
materials available?
no
yes
case fixed
is interest matched?
no
yes
consult other managers
competence increase?
yes
no
competent?
yes
no
case dismissed
manager reallocates
yes
is Sf?
yes
no
no
is time up?
yes
no
highly competent?
yes
no
END
consult other employees
are relations w/ employees?
yes
no

The research question to be answered by this model concerns team performance, as measured by the speed with which cases are fixed. It will be compared how the different team structure affect the performance. Currently first simulation experiments are undertaken. First preliminary results of the model will be presented at the Social Simulation Conference 2023.

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