Key Personnel: Identification and Assessment of Turnover Risk

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Abstract

Identifying and retaining key personnel is a major concern for knowledge-based enterprises. This paper applies social network criticality measures that take into account the knowledge, task and communication networks in order to identify key personnel. We then go one step further and perform a turnover risk analysis on the key personnel by way of simulation. Results show that the key personnel identified could impose a turnover risk if they are not replaced with others that have equal or greater expertise.

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Introduction

Intellectual work is the central commodity of any knowledge-based enterprise. Personnel are not simply brought in to run the assets of these companies as they are for more traditional manufacturing and service based enterprises. The personnel are the assets and as such, identifying and retaining key personnel is a major concern for knowledge-based enterprise.

Identifying key personnel in organizations has been a main topic of study for many social network researchers. Most of this work has focused on the centrality of actors and their immediate contacts (Freeman, 1979; Blau and Alba, 1982). More recent work has noted that the previous studies mostly take into account communication networks, which leaves other areas of criticality such as task assignment and knowledge distribution unaccounted for (Ashworth, 2003).

This work uses an extended notion of criticality that encompasses the communication, task and knowledge networks. Social network measures of criticality incorporating these dimensions are applied to empirical data collected from a small team.

But identifying key personnel is only the first step. Understanding turnover risk is the second step. This research extends the work on key personnel to include an assessment of turnover risk. The static nature of the cross-sectional data in this study tells us very little about the impact on team performance that may result from turnover of key personnel.

To understand turnover risk, simulation is used to estimate the performance impact of losing key personnel. Empirical data, including networks, are used as input into a simulation model, thus providing a representation of the team. This approach allows for the impact of turnover to be assessed before a key person is lost and can guide a knowledge-based enterprise to where they should focus retention efforts.

Methodology

Data and Context

Data was collected on Team X at NASA JPL. Team X is a concurrent engineering design team specializing in unmanned space missions. Team X for this particular mission design was composed of 20 personnel. Of the 20 personnel two were staffing the mission design position, the main mission design person and a support person. Only the main mission design person participated in the study thereby reducing the total number of personnel studied to 19. Data was collected from these 19 personnel.

Each person on the team is a functional expert and represents a unique functional area. The separation of the design team into functional areas forces knowledge distribution into specialized channels. Each functional expert is responsible for designing their particular subsystem of the spacecraft. The two exceptions to this responsibility are the systems engineer and the facilitator. The systems engineer is responsible for maintaining the central database for the group. The facilitator is responsible for overseeing the activities of the group and for assuring that design goals are accomplished.

The design process requires individually designed subsystems to be successfully integrated into one system. Knowledge must be shared among the subsystems in order to converge the multiple designs into one design. Consequently, there is an interdependent relationship between the functional experts (knowledge network), subsystem designs (task network) and information flows (communication network).

Due to task relevance and interdependence, data was collected on all three of these networks. The knowledge network was collected on a four point scale and measured the expertise of each person for each functional area (none, beginner, moderate, expert). The task network has two components. First is the task assignment network which is a binary matrix of the task assigned to each person. Second is the task requirement network which is a binary matrix of the knowledge requirement for each task. The communication network is a binary matrix of who talks to who.

Identification and Measures

ORA (Organizational Risk Analyzer) is used to identify the key personnel for Team X. The ORA tool takes relational data and outputs network measures for assessing the level of possible organizational risk and the factors that contribute to this risk. The knowledge, task and communication networks were input into ORA for analysis. The measures used for identifying key personnel in this study are knowledge exclusivity, potential workload, actual workload and cognitive demand (formerly called cognitive load). These measures are used because they take into account one or several of the networks collected from Team X and represent an extended notion of criticality. A full description of ORA and the measures, including equations, can be found at http://www.casos.cs.cmu.edu/projects/ora/index.html. Each of the measures used in this study are briefly described below

Knowledge exclusivity – measures the extent to which a person is the only one possessing particular knowledge. This measure uses the knowledge network.

Potential knowledge workload – knowledge workload that would result if a person was assigned all possible tasks. This measure uses the knowledge and task networks.

Actual knowledge workload – knowledge workload as a result of the tasks that a person is assigned. This measure uses the knowledge and task networks.

Cognitive demand – the amount of effort each person expends in performing actual tasks. This measure uses the knowledge, task and communication networks.

Risk Assessment and Computational Model

Based on the identification of key personnel using the social network measures in ORA, a virtual experiment is run to assess the risk of turnover. The networks of Team X were used as input which provided the model with a representation of the team. The simulation replaces the identified key personnel with agents of moderate expertise. The performance of the turnover group is compared to a baseline of the group as is.

Construct (Carley, 1990, 1991, 1995, 2002; Carley and Schreiber, 2002; Schreiber and Carley, forthcoming), which is a multi-agent model of the co-evolution of agents and socio-technical environments, is used to simulate the effects of turnover. Construct is used because it models information diffusion and group performance. Information diffusion represents the knowledge sharing and design convergence of Team X. Group performance is measured as task accuracy. In Construct, the agents perform the binary classification task, an intellective task. As more information is shared among the agents, group performance increases. In the Construct model, we can simulate the turnover effect of key personnel on group performance and estimate risk. Construct has been validated several times (Carley, 1990; Carley and Krackhardt, 1996; Carley and Hill; 2001; Schreiber and Carley, forthcoming). More about Construct can be found at http://www.casos.cs.cmu.edu/projects/construct/index.html.

Results

Identification of Key Personnel

The ORA measures indicate several critical personnel of Team X. Table 1 shows a list of the top three personnel for each of the knowledge exclusivity, potential knowledge work load, actual knowledge workload and cognitive demand measures.

Table 1 **Top Three Personnel by ORA Measures**

Knowledge exclusivity	Potential knowledge workload	Actual knowledge workload	Cognitive demand
4.5 (Thermal)	0.91 (Thermal)	0.048 (Facilitator)	0.23 (Thermal)
2.2 (Facilitator)	0.66 (Systems)	0.046 (Thermal)	0.20 (Facilitator)
1.8 (Mission)	0.63 (Facilitator)	0.041 (Systems)	0.20 (Systems)

Position name appears in parentheses

The thermal and facilitator personnel consistently fall within the top three rankings of each measure. The systems engineer is listed near the top in three of the four measures. Based on these measures, three personnel are identified as critical personnel – thermal, facilitator and systems engineer. These results indicate that Team X should protect against turnover of these personnel.

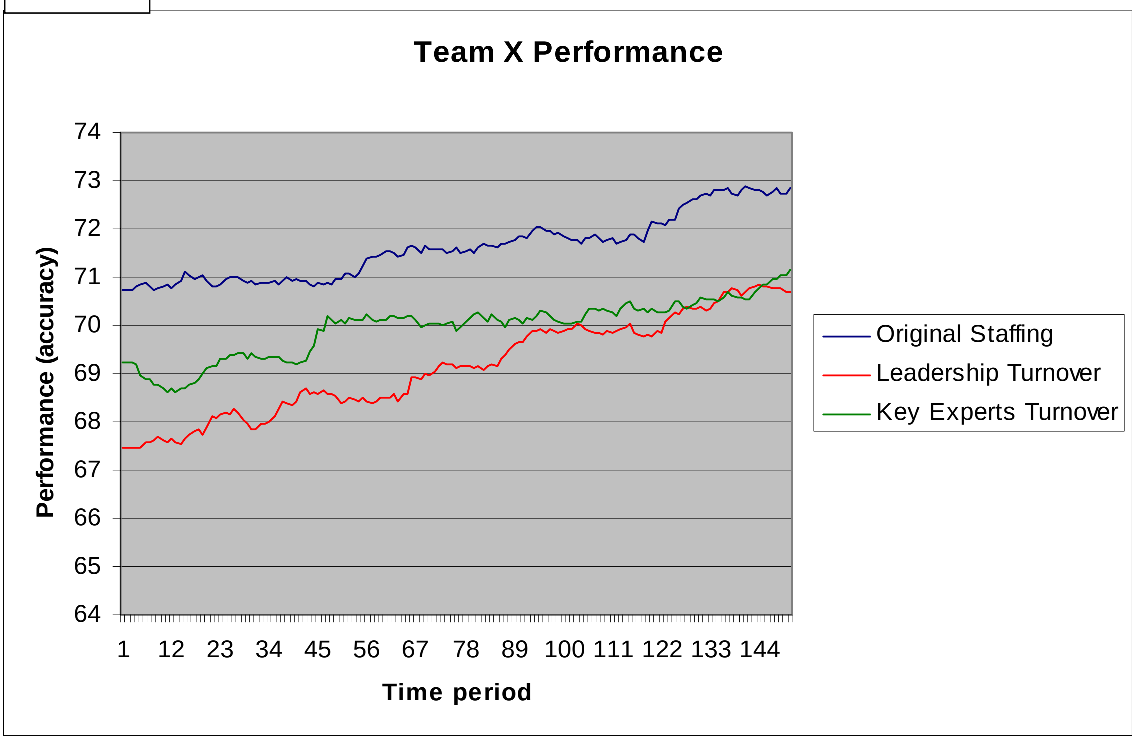
Assessment of Turnover Risk

Based on the identification of key personnel from the ORA analysis, a turnover risk virtual experiment was run. The critical personnel are thermal, facilitator and systems engineer. The following three conditions were run for the virtual experiment:

1) Original staffing (baseline) – the exact knowledge base from the data was used.
2) Leadership turnover – the knowledge of the facilitator reduced to moderate, lowering the expertise level. This represents someone with limited experience taking the role. All other staffing and knowledge base representations remain the same.
3) Key experts turnover – the knowledge of the thermal and systems engineer personnel were reduced to moderate, lowering the expertise level. This represents people with limited experience staffing these positions. All other staffing and knowledge base representations remain the same including the facilitator – there is no leadership change.

Performance accuracy for the team in each of the three conditions was compared to assess the turnover risk. Figure 1 reports the results of the experiment.

Figure 1



Team X relies heavily on key expert personnel. A key leadership turnover or key experts turnover negatively impacts the team. The turnover of the facilitator poses the most risk to Team X performance. The decrease in performance for the key leadership turnover was approximately equal to that of the key experts turnover. This is meaningful since there was turnover in only one position for leadership as compared to turnover in two positions for key experts. These results demonstrate the importance of leadership in this environment.

Conclusion

There is a turnover risk for Team X which has a reliance on key personnel. Three personnel were identified as being critical – facilitator, thermal and systems engineer. Identification of key personnel was accomplished with the use of social network measures in ORA. Virtual experiments were run to assess the impact of turnover on team performance because the static nature of the cross-sectional data does not allow for dynamic analysis of turnover risk. The Construct results show that key personnel turnover resulted in decreased team performance thereby imposing a risk. These results are reliant on the assumption that personnel of equal or greater expertise could not be hired to replace the lost experts.

Of particular interest in the assessment of turnover risk is the importance of leadership within Team X. The simulated impact of the leader is due to the reliance of the team on that person. There is a large requirement for this person to apply their knowledge to many tasks. This can be seen in the actual knowledge workload measure as the facilitator has the highest score. But this measure does not stand-out because there is not much of difference among the personnel, especially the top two. In contrast, the Construct model was highly sensitive to the interdependency of the knowledge and task networks.

Although the social network measures appear to identify key personnel as evidenced by the negative impact on performance under turnover conditions, they apparently are less sensitive to some features of leadership that are important to team performance. It is impossible to predict the much larger impact on performance that leadership turnover had by analysis of the social network measures. In fact, one could expect that turnover of the thermal person would have the larger impact.

References

Ashworth, M. J. (2003). Identifying key contributors to performance in organizations: The case for knowledge-based measures. In Proceedings of the First Annual Conference of the North American Association for Computational Social and Organizational Science (June 22-25, 2003), Pittsburgh, PA.

Blau, J. & Alba, R. (1982). Empowering nets of participation. *Administrative Science Quarterly,* 27: 363-379.

Carley, K. M. (1990). Group Stability: A Socio-Cognitive Approach. In Lawler E., Markovsky B., Ridgeway C., and Walker H. (Eds.) *Advances in Group Processes: Theory & Research.* Vol. VII. (pp. 1-44). Greenwhich, CN:JAI Press.

Carley, K. M. (1991). “A Theory of Group Stability.” *American Sociological Review*, 56(3): 331-354.

Carley, K. M. (1995). Communication Technologies & Their Effect on Cultural Homogeneity, Consensus, & the Diffusion of New Ideas. *Sociological Perspectives*, 38(4): 547-571.

Carley, K. M. (2002). Smart Agents and Organizations of the Future. In L. Lievrouw & S. Livingstone (eds), *The Handbook of New Media*, (pp. 206-220). Thousand Oaks, CA: Sage.

Carley, K. M. and Hill, V. (2001). Structural change and learning within organizations. In A. Lomi and E. R. Larsen (eds), *Dynamics of Organizations: Computational Modeling and Organization Theories*. Menlo Park, CA: MIT Press/AAAI.

Carley, K. M. and Krackhardt, D. (1996). Cognitive inconsistencies and non-symmetric friendship, *Social Networks*, 18: 1-27.

Carley K. M. and Schreiber, C. (2002). *Information Technology and Knowledge Distribution in C^3I Teams*, 2002 Command and Control Research and Technology Symposium, Monterey, CA.

Freeman, L. (1979). Centrality in social networks: I. Conceptual clarification. *Social Networks,* 1: 215-239.

Schreiber, C. and Carley, K. M. (forthcoming), Going Beyond the Data: Empirical Validation Leading to Grounded Theory. *Computational and Mathematical Organization Theory*.