Judges' Commentary: Managing Human Capital in Organizations

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Introduction

The topic area for one of this year's problems in the Interdisciplinary Contest in Modeling (ICM)® was network science. The problem involved measuring and modeling churn in an organization of 370 employees. This

The UMAP Journal 36 (2) (2015) 137–149.

issue is a hot topic in many business organizations. Too much turnover can ruin continuity of operation and leave organizations in a constant state of re-inventing themselves. The hope is that organizations "will find that treating workers as creative, social individuals instead of disposable assets can still be great for their bottom line" [Weathers 2015]. Abigail Whiffen, a human resources professional, wrote about the current situation in her profession:

> Human Resources as a function is consumed with data and metrics right now. Companies want to be sure that funding is used wisely and that programs are impactful. To that end, HR professionals across the globe are examining their programs and tools to assess whether they are measuring data that paints an accurate picture that the function and the business can in turn use to improve and change. But there is a fine balance. HR professionals want enough detail that they can make sense of people information, spot trends and analyze costs, but it needs to be in portions they can consume and utilize. Too much detail can be problematic. And if the detail cannot be simplified in ways that can be used to take outside of the HR function, that's also problematic, though an easier issue, as HR professionals can be accountable for that. So models, formulas, systems and mechanisms for understanding people initiatives, employee engagement, attrition and what's driving those factors are critical. [Whiffen 2015]

However, there are signs that when HR is considered too much like other capital assets, "humans were used as much as possible and discarded when they wore out or their usefulness came to an end" [Weathers 2015].

This year's problem attempted to get at some of the elements described by Whiffen and by Weathers. These items outline the way the judges viewed the tasks for the team members in this year's problem:

1. Do they build a simulation of the organizational model? Do they produce a good basic network model?
2. Do they develop a means for implementing network dynamics? (This was a demanding element of the model for this problem and may have separated the best papers from others.)
3. Do they display the network and its churn in some form so there is a visualization of their measure or model?
4. Do they produce budgets for training and recruiting based on the budget-related value of σ?
5. Do they answer the questions from Task 4: Can ICM sustain its 80%-full status for positions if the annual churn rate for all positions goes to 25%? How about 35%? What are the costs of these higher turnover rates? What are the indirect effects of these high churn rates?

6. Do they perform 25% and 35% churn simulations and make conclusions from their results?
7. Do they discuss team science and multilayer networks in the context of this organizational model?
8. Do they perform good modeling by discussing strengths, weaknesses, and sensitivity of their models?

Judges' Criteria

The general framework used to evaluate submissions is described below. The main thrust of ICM judging is finding and evaluating modeling that includes good science and leads to measurable outcomes and a viable solution.

Executive Summary

It was important in the summary that teams succinctly and clearly explained the highlights of their submissions. The executive summary should contain brief descriptions of both the problem and the bottom-line results. Better papers had a well-connected and concise description of the methodology, results, and recommendations.

Modeling

Well-defined measures of the organization's potential for performance and its costs to operate were needed to build a viable model. Many teams started with standard measures and modified them to produce more appropriate measures. Some teams used network analysis software packages for calculations and visualizations. No matter the modeling framework, the assumptions needed for these models and the careful and appropriate development of the dynamics in the models were important in evaluating the quality of the solutions. The better submissions explicitly discussed why assumptions were made and how their assumptions affected model development.

Science

ICM modelers were required to discuss team science and multi-layered network models. Some teams did effective background research and analysis and included elements in these areas in making strong, insightful connections between the mathematical measures and the more abstract notions of human capital. No matter what level of modeling was performed by the teams, the interdisciplinary nature of this problem was revealed in the science requirements and the background investigation performed by the teams.

Data Validity/Sensitivity

Sensitivity analysis to determine the effects of assumptions was empowering for some of the teams. Sensitivity analysis is especially important for highly-structured, data-rich models such as networks. Some network elements are robust while others are more fragile and sensitive to data errors or changes. Teams that did this well quickly rose to the top of judges' evaluations.

Strengths/Weaknesses

Discussion of the strengths and weaknesses of the models is where students demonstrate their deeper understanding of what they have created. The utility of a model fades quickly if team members do not understand the limitations or constraints of their assumptions or the implications of their methodology.

Communication/Visuals/Charts

To clearly explain their models, teams used multiple modes of expression including diagrams and graphs and clearly written English. Judges were often well informed through the amazing array of charts and graphs that explained both models and results. The graphics shown in **Figures 1–3** provide a glimpse of this kind of visual presentation.

Discussion of the Outstanding Papers

Despite the common background dataset and tasks, ICM teams used many different approaches to model various aspects of the problem. As a result, the submissions were varied and interesting. Overall, team modeling was often sound, with creative and insightful elements.

The papers that did not reach final judging generally suffered from shortcomings:

- Some lacked clear explanation of the structure of their model by providing only some details but not a complete description of their model and its purpose.
- Others failed to connect their models to the aspects and basic elements of the network or organizational science.

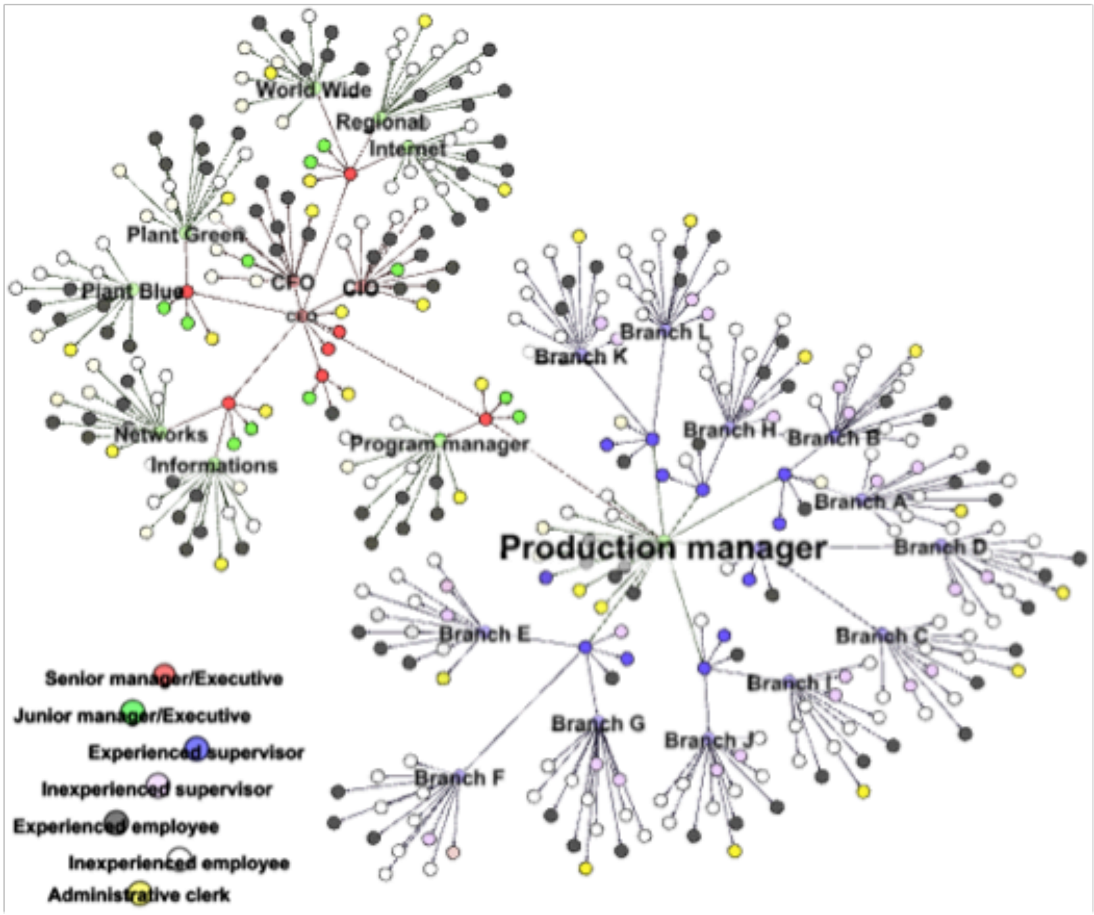

Figure 1. This is a common graphic for representing the organization as a network. This example is by a team from the University of International Business and Economics in Beijing, China.

- In general, communication was the most significant discriminator in determining which papers reached the final judging stage.

Although the five Outstanding papers used different methodologies, they all addressed the problem in a comprehensive way. These papers were generally well-written and presented clear explanations of their modeling procedures. In some papers, a unique or innovative approach distinguished them from the rest of the Finalists. Others were noteworthy for either the thoroughness of their modeling or the significance of their results. Summaries of the five Outstanding-rated papers follow.

National University of Defense Technology, Changsha, China

The team from National University of Defense Technology authored a report entitled "Human Capital Management in Organizations" that generated several networks from the information given in the problem on informal relationships and formal positional roles. By aggregating the data provided about formal and informal relationships, they developed a human

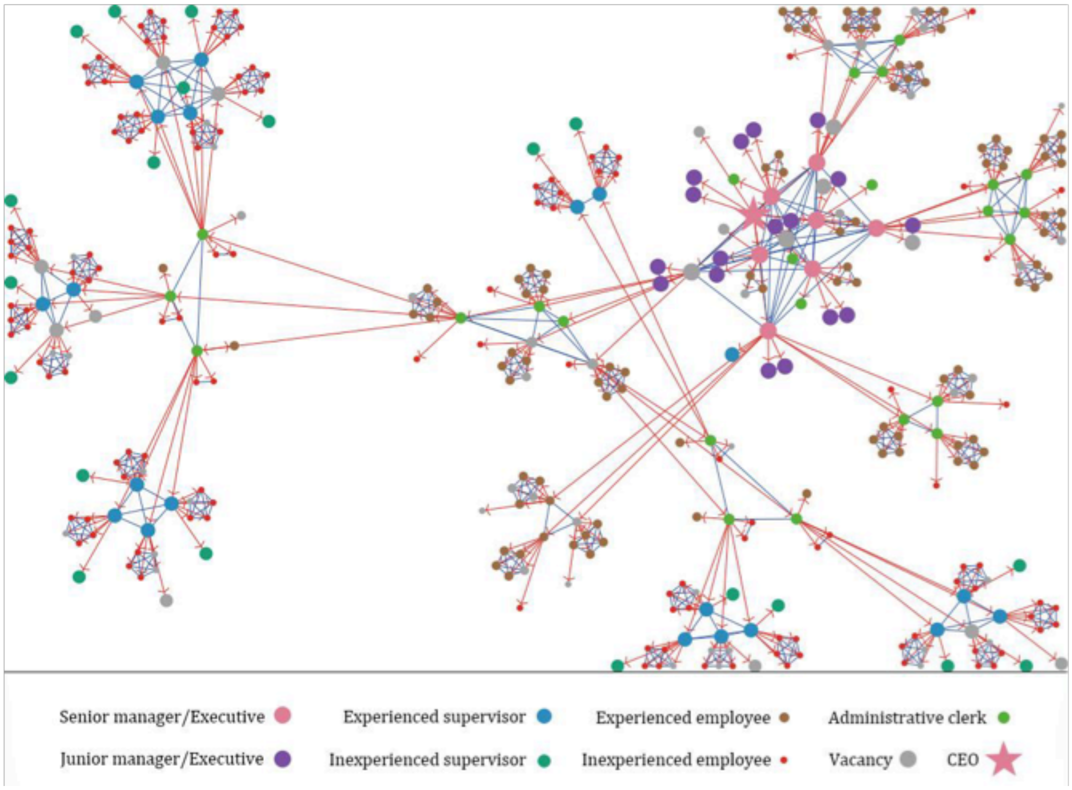

Figure 2. Many teams provided informative network graphs to show HR elements of the organization within their network model. This graphic is by a team from Harbin Engineering University in Harbin China.

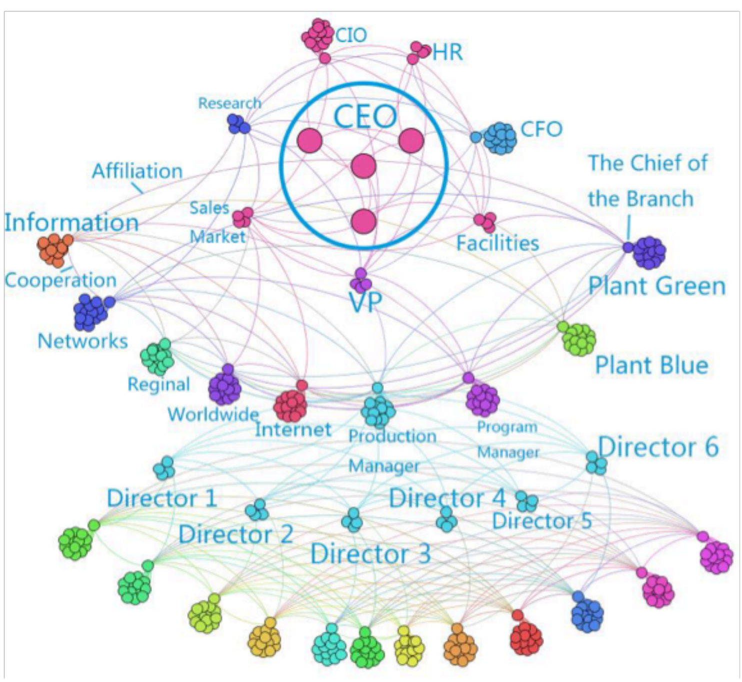

Figure 3. Some reports contained elaborate network diagrams like this one by a team from Huazhong University of Science and Technology in Wuhan, China.

capital network to reflect human relations and organizational stability. In order to capture influence among employees, the team developed two indices:

- **loyalty**, the intrinsic probability that a person will stay in the organization based on organizational culture and employees expectations; and
- **intimacy**, the extent to which a person was connected to others who have left the organization, weighted by the status similarity to those persons.

To account for change over time, the team modified a genetic algorithm to represent organizational human capital. This algorithm enabled the team to define the elements of the organization including power structure, promotion, churn and new hires. These analogies start with people as chromosomes; mutations equate to single-level promotions, while a crossover (analogous to genetic information being exchanged) is a two-level promotion. A diagram of the dynamics in their paper is shown in **Figure 4**. They use this algorithm to apply a fitness function, which translates to an optimal assignment model to generate values for churn, recruitment, cost of recruitment, and cost of training.

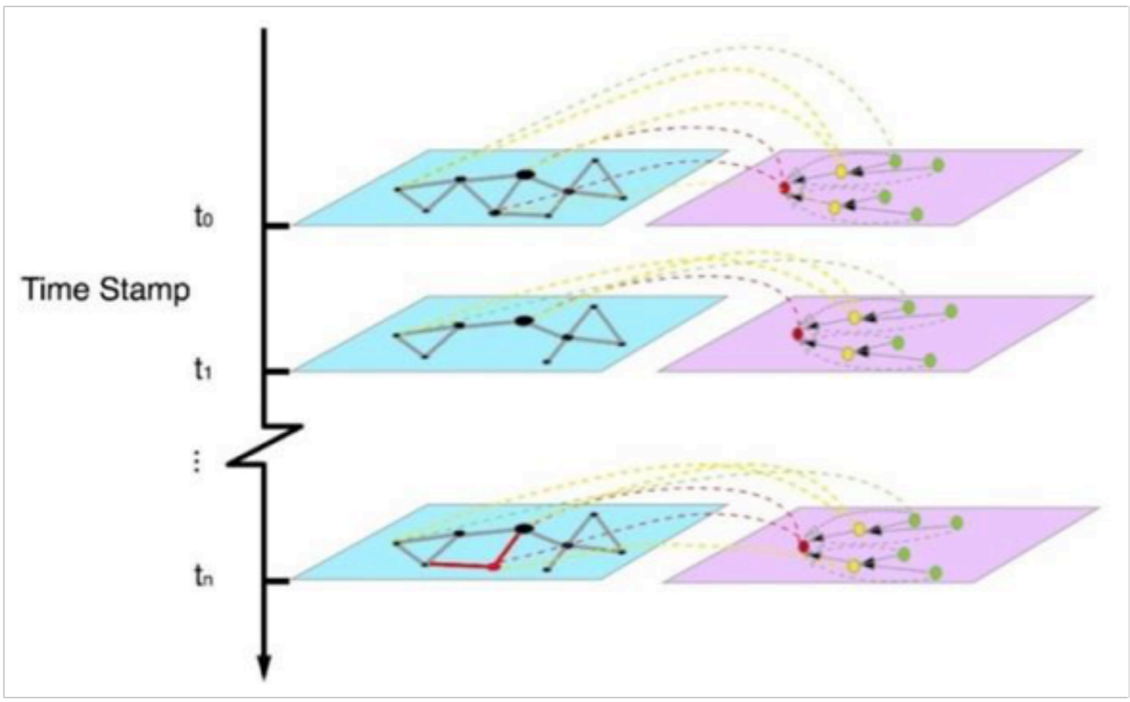

Figure 4. Schematic of the dynamics of the organizational network.

The team uses their model to simulate various conditions that the problem posed. For example, the cost of recruitment and training with no interventions would be 38σ and 127σ, respectively. To ensure that 80% of positions are filled with a churn rate of 25%, the team calculates that the recruitment rate should be 22% and would correspond to a direct cost is

618σ; while at a churn rate of 35%, recruitment should be 31% at a cost of 534σ.

Ultimately, the team defines an optimal point where the costs are the lowest while maintaining steadiness in the organization. They quantify the importance of stability at the lowest and highest level positions, but suggest that a higher churn rate among middle levels (junior manager and experienced supervisor) provides more chance for people to be promoted.

The team discusses some of the benefits that could be gained by analyzing this as a multi-layered system rather than simply aggregating the three networks into a single network. They mention the importance of negative ties, which were not considered in this problem. In addition, they discuss how local structures could be more rigorously defined and used to understand the influence of local leaders (heads of departments) and culture within the departments or other subgroups within the company.

Xi'an Jiaotong University, Xi'an, China

This team, winner of the first Leonhard Euler Award, combines their network model with elements of team science. They use a baseline network model with the ICM organization's 370 positions as nodes and the affiliations as edges. Their Post Archives Matrix (PAM) includes attributes for each position as a simulation for the real conditions. Their performance model combines affiliation and cooperative relationship to quantify team performance. In addition they add employees' demission (resignation), promotion, and recruitment to model churn in the company. Running their model, they determine that the recruitment and training costs are 26σ and 140σ. They also test churn rates of 25% and 35%, which ultimately produce negative effects such as declining performance. In their multi-layered network, they develop a model with friendship, competition, and their human capital as three network layers to describe the connection compactness in the whole team. This network provides the team even more analysis capability.

The team's report concludes with an assessment of the strengths and weaknesses of their model. The strengths include:

- Their network evolution is based on the connections and effects of their three algorithms—demission, promotion, and recruitment.
- They determine a set of strategies for churn and used the churn performance model to answer the requests in the task.
- They consider the effects of training and find that training can increase the working enthusiasm and performance, at the same time decreasing the demission probability. They list as a weakness that their model doesn't consider the effects of the employees who retire or leave their positions temporarily.

Shanghai Jiao Tong University, Shanghai, China

The team from Shanghai Jiao Tong University, in their paper titled "Analyzing Employee Turnover Using Dynamic Network," formed a human capital network consisting of two network models. The first model considers employees of the ICM as the nodes, with weighted edges connecting them based on their position in the company. The second model is of the organizational structure, where nodes are offices and divisions in the company and edges were weighted based on the proximity to other offices in ICM.

The team describes probabilistic models of turnover, promotion, and recruitment in order to create a dynamic simulation in MATLAB based on these network models. Measures they create for churn, productivity and cost are computed from a simulated two-year period. Some of the descriptions of portions of the models and how they are connected in their powerful dynamic simulation are lacking. However, the overall quality of the team's modeling impressed the judges. In particular, the team employs a genetic algorithm approach that determines optimal assignments of personnel to positions in the company based on the team's two network models. The algorithm maximizes a function of the four principles that they use to measure the most effective staffing. This innovative approach was attempted by a few other teams with less success.

An additional model using the Analytic Hierarchy Process (AHP) determines turnover intention based on factors such as salary, promotion potential, and measures of closeness to others who churned.

Xidian University, Xi'an, China

This team's paper entitled "Simulation Company: A Dynamic Model Based on the Multiplex Network" utilizes the information from the original problem and valid assumptions to extrapolate a model of the ICM company network and dynamics.

The team models the network as four sub-networks: department network, friendship network, leadership network, and information network. The department network consists of the organizational components of the ICM model in the problem statement with further subdivisions into an upper-level management layer and a lower-level executive layer. In this layer, the departmental influence is calculated using a vacancy ratio.

The team members recognize that other networks, not explicit in the problem statement, are also important to the dynamics of the company, so they construct through simulation an undirected friendship network, an undirected information exchange network, and a directed leadership network. Influence in the friendship network is related to node degree, the message influence of the information network is measured by page rank, and the leader influence is determined by a distance measure.

In the system dynamics, there are five different types of events that produced change in the discrete time simulation, with a monthly update period: demission, promotion, transfer, recruitment, and settlement. Demission rate of the middle management is modeled to be twice that of the rest of the employees due to the stresses at this level. Promotion to the next level is performed when there is a vacancy and the employee has minimum competence for the next level. Transfer to next higher or adjacent department is made in conjunction with promotion. Recruitment depends on cost of recruitment and a qualified person being available. The settlement phase calculates the various costs for the month, updates the experience and competency of employees, and updates other organizational parameters and attributes.

Using their dynamic model and simulation, the team analyzes the number of staff, the productivity of the organization, and the operational budget. **Figures 5** and **6** show some of the results of this simulation. Different churn rates are used in order to determine sensitivity and impact on the other HR measures.

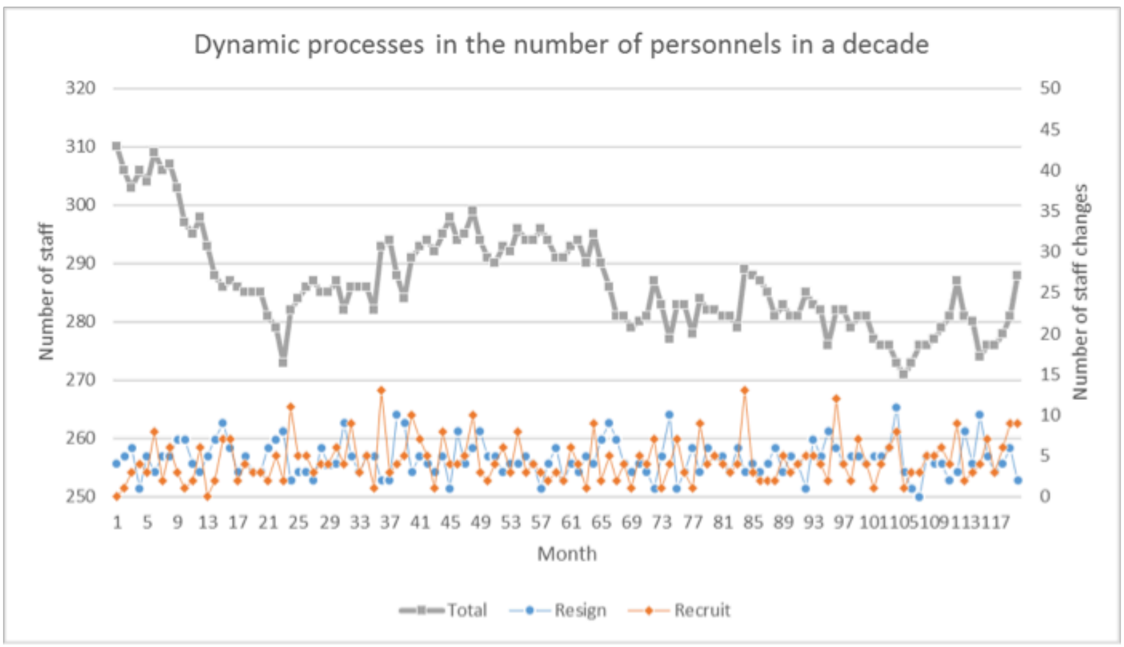

Figure 5. Numbers of recruits, resignations, and total employees by month for an 18% churn rate.

Tsinghua University, Beijing, China

The paper submitted by this team is entitled "Organizational Churn: A Roll of the Dice?" The team develops a Human Capital Network Relation where each node represents a position in the organization, and edges exist between positions within the same office, between senior managers, and between higher and lower members of the supervisory chain. The team

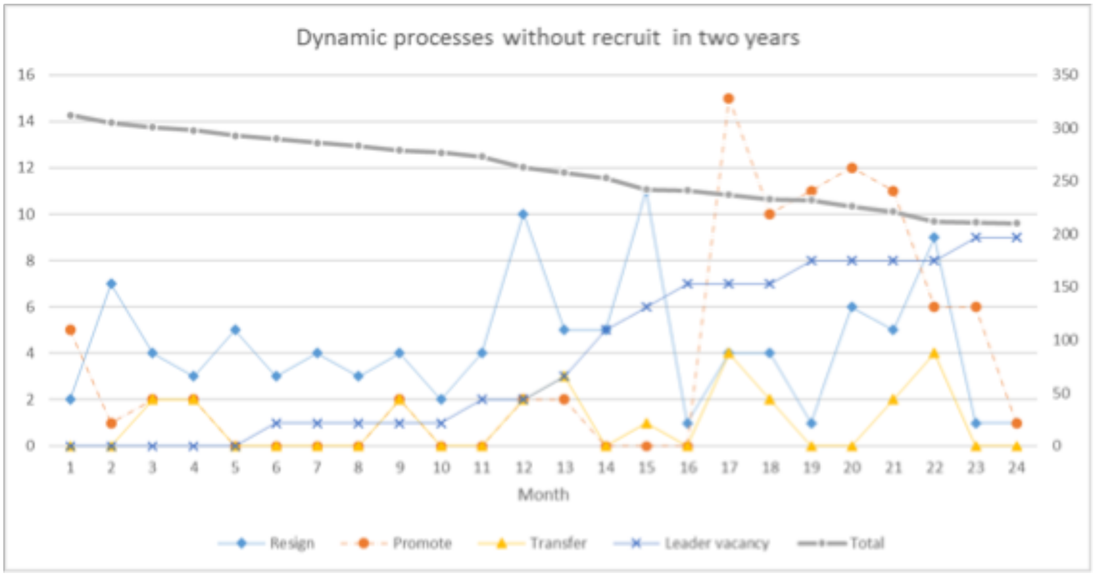

Figure 6. Numbers of employees resigning, being promoted, and transferring, with the resulting numbers of job vacancies and total employees.

then incorporates staff churn, promotion, and recruitment into the network to perform their analysis.

The team incorporates a unique approach to model the churn rate. They use a Bayesian learning process, which models the churn rate as a decision-making process influenced by decisions made in previous months. Their description of the process, determination of appropriate parameters, and implementation of the process is extremely well-developed. In addition, the team's modeling of promotion and recruitment process is thoroughly developed and incorporates well-thought-out assumptions and strategies. In particular, they lay out a very clear strategy for promotion within the organization, which targets experience, level of employee dissatisfaction, and level of centrality of the employee. After development of the model, the team runs a variety of simulations to capture the evolution of the model under various churn rates and promotion strategies. The team presents a strong analysis of the effects of these factors on organizational productivity, budget, and health of human resources.

The most impressive features of this paper are its extremely well-developed model and its creative utilization of the Bayesian learning process. In addition, the team utilizes excellent visuals and graphics to present the results of their analysis in a meaningful way. The paper is well-written, with comprehensive explanations of all parts of the process, and concludes with a meaningful discussion of the strengths and weaknesses of the team's analysis.

Conclusion

Among the 641 papers, there were many strong and innovative submissions that made judging both exciting and challenging. It was very gratifying to see so many students with the ability to combine modeling, science and effective communication skills in order to understand such large, complex datasets and build viable network models for their analysis.

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