Role Reassignment and Resource Management in Human Organizations

Melinda Robertson[1] and Chris Marriott[1,2]

[1]University of Washington, Tacoma, WA, USA 98402
[2]dr.chris.marriott@gmail.com

Abstract

We use an agent-based social simulation to study the effects of role reassignment on resource management in a human organization. As a model organization we use the 446 Force Support Squadron of the United States Air Force. We simulate different role reassignment policies where members of the organization can be reassigned at their request, at the request of the organization, or as a combination of both of these policies. We also consider at what point in an individual's career is the best time to change roles. We conclude that a compromise between organizational needs and individual needs results in higher productivity. In addition we conclude that mid-career reassignment is better for the organization than early or late career reassignment.

Introduction

Agent-based social simulation methods are often used to study human behaviors (Bonabeau, 2002). Agent-based simulation has been applied in many areas including biology (Marriott and Chebib, 2015), economics (Tesfatsion, 2003; North and Macal, 2007; Du and El-Gafy, 2012; Bullinaria, 2016), anthropology (Lake, 2014; Janssen and Hill, 2014), climate change (Balbi and Giupponi, 2010) as well as the military (Cioppa et al., 2004; Middleton, 2010; Scogings and Hawick, 2012). We will simulate the resource and personnel management of the 446 Force Support Squadron of the United States Air Force. Cioppa et al. (2004) survey the many potential applications of agent-based simulation to military scenarios. As examples Middleton (2010) applies agent-based simulation to better understand the "fog of war" created when soldiers face uncertainty where Scogings and Hawick (2012) use agent-based simulation to recreate the historical battle of Isandlwana in 1879.

Agent based models are commonly used to study the behaviors of human individuals and organizations. In Lim and Bentley (2012) the authors use an agent based model to simulate interactions between app developers and app users. Different app development strategies were simulated to see how they would adapt to the dynamic app ecology. A similar study (Fleurey et al., 2015) simulates web service providers and web service users. Providers must adapt to a dynamic demand for services and different strategies are tested.

It is common in agent-based simulation to simulate individual agents in an organization as they carry out their roles. For example, Du and El-Gafy (2012) simulate the different members of a construction company as they carry out their roles. Janssen and Hill (2014) simulate the foraging activities of the Ache, a hunter-gatherer population in Eastern Paraguay. Scogings and Hawick (2012) simulate the members of the Zulu and British armies as they engage in battle.

We model the role reassignment policies of the 446 Force Support Squadron (FSS) and the impact of these policies on resource management within the squadron. A Force Support Squadron is an organization of military personnel whose purpose is to support a particular squadron with all its needs while deployed. A FSS is an autonomous organization that must provide its members with basic needs, education, security and administration. The FSS in the US Air Force vary in number of support personnel and in internal organization. We selected the 446 FSS as an example organization because it is well established, proven to work and has an easily quantifiable structure. Although the model is based on a military organization it applies to any work environment that relies heavily on internal collaboration. Other organizations like bands of hunter-gatherers (Janssen and Hill, 2014), governments, corporations and universities all must manage human resources in order to provide for the needs of the organization.

The 446 FSS is a middle-tier organization based on performance with an award winning training program. Leadership tends to support employees desire to retrain to another career and tolerates low work quality in some employees. Most employees change careers at the third or fourth proficiency level after they have had some experience in their role.

Over the past five years, resources have become scarce due to budget cuts. This has affected employee moral and retention rates. New members have been gained but training cannot be conducted in a timely manner (Robertson, 2016), meaning that even though several employees are coming to work, they cannot contribute. This has led to a decrease in work quality, leaving some tasks incomplete or forgotten.

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,
(Cambridge, MA: The MIT Press, ©2017 Massachusetts Institute of Technology).

Even so, the 446 FSS has been able to continue at an acceptable output rate because of the high motivation of its employees. This high motivation can be attributed to leadership that is willing to be flexible for the sake of employee desires.

We can see the operation of the 446 FSS as a complex adaptive system (Lansing, 2003). As the resource needs and the availability of resources change over time the organization must react dynamically. The 446 FSS can react to changes by reassigning members to different roles. Older members retire and leave and new members are recruited and assigned according to need. The policies and procedures determining the assignment and reassignment of human resources determines the resource output of the organization and ultimately the success of the organization.

Agent-based simulation has been used to study role reassignment in other studies. In natural systems, like an ant colony, role reassignment is a emergent process (Marriott and Gershenson, 2011). In human organizations role reassignment can be emergent or be based on deliberate policies of individuals or organizations. Bullinaria (2016) studies gender inequalities in the workplace. In this simulation members of the organization can change roles in response to dissatisfaction with the work environment (due to discrimination). Members of the 446 FSS may request a change of role for many reasons. For simplicity, we will assume any such request demonstrates that a member has dissatisfaction with their current role.

We selected roles identified by the FSS. The parameters for training and impact of roles were derived from empirical data in military records, specifically the Career Field Enlisted Training Plan (CFETP). These roles are summarized in Table 1. We based the training model in our simulation on education in the US Air Force (USAF, 2013). The 446 FSS currently reassigns members upon their request (but not in order to cover areas without adequate coverage). They also only allow reassignment after the member has reached the third or fourth proficiency levels. Our goal was to build a simulation in which we could vary both the protocol used as well as at which proficiency levels a member can be promoted.

Our hypothesis has two parts. First, we believe that reassigning members when there is a need for the organization is important to the success of the organization. However, we also believe it is important that members are in roles that they prefer so that they are more motivated to perform at their best. We expect that a compromise between individual preferences and organizational needs will achieve the most productive organization.

Secondly, we consider the proficiency level at which members are allowed to be reassigned. Our expectation is that reassigning an agent earlier in their career would be better for an organization than reassigning later in their career. This avoids a highly proficient member from being reassigned to a role that they are not very proficient at.

Model

We simulate a population of agents comprising an organization. The organization consists of four units each with three roles. Agents are assigned to the roles and each role produces a different resource representing a public good. Agents have variable motivation and proficiency at their role and this impacts the quantity of resources produced. The success of the organization depends on meeting or exceeding the resource needs of the population from iteration to iteration.

An iteration of our simulation corresponds to one month. In each iteration an agent carries out four actions: consume resources, produce resources, train and update motivation. Resources are first consumed by the agents. Seven of the twelve resources are consumed by agents in this phase to produce output and one is consumed to train. The remaining four resources are consumed by the organization as a whole. Next agents produce resources according to their role. These resources are added to any resources not consumed in the last phase and are available for consumption in the next iteration. Following production the agents train in their role in order to improve their ability to produce resources. Finally, the agent makes updates to its motivation which may trigger a role reassignment.

Role reassignment is handled by the organization. If the available resources were enough to cover the demands of the agents then new agents may be added to the organization in this phase. Old agents may be retired (each agent has a fixed work lifespan). Depending on simulation settings agents may be reassigned. A reassigned agent is removed from their current unit and role and added to a new one.

Roles and Resources

The unit and role data used for the experiment is taken from military training documents, particularly the Career Field Enlisted Training Plan (CFETP). The CFETP's list the training requirements in number of tasks and length of time, so they were easy to translate into parameters for the simulation (see Table 1). The twelve roles selected are based on an Air Force Force Support Squadron (FSS). Many of the roles are functionally similar to one another in our simulation, though each is produced by a different role.

Seven of the resources produced are consumed by the agents as they perform their roles and directly influence resource output. For instance, to perform a role an agent must have their needs met (food, shelter, health care, security, and professional training) and have the appropriate support for their role (equipment and data). If an agent does not consume as much of these resources as it needs it will produce less than its maximum output.

The job training resource is consumed by agents to improve their proficiency in their current role. The formal

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,
(Cambridge, MA: The MIT Press, ©2017 Massachusetts Institute of Technology).

Role	Unit	Rank 1 (months)	Rank 2 (tasks)	Rank 3 (tasks)	Effects	Weight
Food	Services	4	35	96	Increases output.	0.88
Shelter	Services	4	35	96	Increases output.	0.89
Health	Services	4	35	96	Increases output.	0.92
Equipment	Tech Support	6	197	51	Increases output.	0.85
Data	Tech Support	6	246	71	Increases output.	0.85
Security	Tech Support	6	206	50	Increases output.	0.92
Formal School	Training	3	148	16	Increases agent acquisition rate.	0.99
Professional Training	Training	3	148	16	Increases output.	0.93
Job Training	Training	3	148	16	Increases task completion rate.	0.81
Acquisitions	Administration	2	60	3	Increases agent acquisition rate.	1.0
Management	Administration	2	60	3	Increases agent reassignment success rate.	0.99
Audit	Administration	2	60	3	Reassigns resources.	0.96

Table 1: Twelve roles and their units. Training time for each role and rank is derived from the CFETP. Weights were optimized to maximize organization success.

school and acquisition resources are consumed by the organization to recruit new agents to cover a lost agent or to accommodate growth. The management resource is consumed by the organization to assign and reassign agents to roles.

Finally the audit resource acts as a wild card resource that supplements resources that don't meet the organizational demand. At the end of the iteration the audit resource is distributed to the other resources in proportion to the need.

Proficiency

There are four proficiency levels, zero to three. Newly recruited agents begin at proficiency level zero in all roles. Agents at proficiency zero do not produce resources thus it is costly to retrain to a new role. Completing the first rank of proficiency in a role provides the first rank of proficiencies for all roles in the same unit. Training to the first level requires a fixed number of months (iterations) of training (indicated in Table 1).

Training to proficiency level two or three is on-the-job training. Agents produce resources while training at these levels. Training to the next proficiency level takes q tasks (see Table 1). In one iteration an agent can complete a number of training tasks equal to the amount of job training resource consumed by the agent that round, plus the number of available trainers. A trainer is a higher ranked agent in the same role. Under normal circumstances there is at least one trainer available. These training times were selected to match the data from the CFETP.

Resource Output

The resource output is affected by the agent's resource needs, the agent's proficiency level, and the agent's motivation. For resource i an agent has a desired consumption rate c_i. These consumption rates are assigned randomly to an agent when it is created and are in the range 0 to 5 (with values 1 to 3 being more likely). At the beginning of the iteration an agent will receive their share of available resources $r_i \leq c_i$. The ratio $\frac{r_i}{c_i}$ is combined in a weighted sum for the resources food, shelter, health, data, equipment, security and professional training.

$$S = \sum_{i=1}^{7} w_i \cdot \frac{r_i}{c_i}$$

Weights determine relative importance of the resources and are given in Table 1. These weights were hand tuned to maximize simulation run success as weights for the FSS are unknown.

The weights for equipment and data used in the sum are calculated by adding the weight in Table 1 to the proficiency level before being applied. This reflects that proficiency level is independent of how well fed you are but not independent of how well you use your equipment and data in your role.

The agent produces a number of resources equal to mS where m is the motivation level of the agent. An agent is assigned an initial natural level of motivation m. This value is set in the range 0.3 to 1 with values falling between 0.6 and 0.9 at least 85% of the time.

Agent motivation changes over time depending on if the agent's needs are satisfied or not. An agent that satisfies its needs will increase its motivation by 1% (that is $m_{i+1} = m_i \cdot 1.01$). If an agent has a resource shortfall then the total shortfall s is calculated (this shortfall is calculated for all resources not just those used for production of resources). As long as the agent is not in its preferred role then the agent will apply a penalty to its motivation equal to 1% of the shortfall s (that is $m_{i+1} = m_i - s * 0.01$). If the agent is in their preferred role they tolerate a resources shortage if it is beneath a threshold and no penalty is applied. Shortages above the threshold are still penalized.

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,
(Cambridge, MA: The MIT Press, ©2017 Massachusetts Institute of Technology).

Role Reassignment

Reassignment is triggered by the agent or by the organization depending on experimental settings. When an agent has low motivation the agent will request a transfer. If there is a great enough need for another resource then the organization will trigger a transfer to the needed role. Agents have a role they are naturally good at; if they are in that role their output is higher (because their motivation is higher). However, agents dont know what that role is. When they are asked what role to change to they randomly select a role. Over time their preferred role, and roles in the same unit as the preferred role, are given a higher chance of being selected as the agent learns what they are best at.

Initial assignment and reassignment of agents happen on the organizational level. When a new agent is added to the simulation the agent is either new and untrained or has previous experience. Ten percent of the time the new agent has experience and this is meant to simulate the transfer of an experienced member from outside of the organization (i.e. from another FSS). When an experienced member is added they are placed in their preferred role. When an inexperienced member is added they have proficiency in no roles and are placed in the role with greatest need to begin their training.

A new agent is available to be added only if enough resources are allocated to the roles of acquisition and formal school. Let c_a and c_f represent the organization's desired consumption rate for these two resources respectively. Let $r_a \leq c_a$ and $r_f \leq c_f$ represent the actual amount of resources consumed on this iteration. Then if an experienced agent is added it is added with probability $\frac{r_a}{c_a}$. If an inexperienced agent is added it is added with probability $\frac{r_a+r_f}{c_a+c_f}$.

When an agent has been flagged for reassignment a new role is selected for the agent based on the agent's desired role and/or the needed roles for the organization. Let c_m represent the organization's desired consumption rate for the management resource and let $r_m \leq c_m$ represent the actual amount of the management resources consumed in the last iteration. Then the role reassignment is successful with probability $\frac{r_m}{c_m}$.

Experimental Setup

Initial role assignments are made based on the needs of the organization. In the control run after initial assignment agents were not reassigned to other roles. Since agents have a fixed working lifespan agents would eventually be deleted. New agents were added to replace these agents or as the organization grows. In the control run this was the only mechanism the organization had available to adjust relative role assignments.

Our experimental runs consisted of three different reassignment priorities. The first priority mode is the *organization*. In this mode the organizational needs always outweigh the desires of the agent. When a resource experiences a shortfall beyond a threshold the organization will seek to supplement that role by reassigning an agent from a role with resource surplus. The second priority mode is the *agent*. In this mode the agents decide when to change roles. Agents with low motivation will select a new role that they wish to be reassigned to. The third priority mode is *compromise*. In this case the organization seeks to find an agent that wants to move from an overstaffed role to an understaffed role. If no such agent exists, agents that wish to be reassigned are reassigned so long as it does not conflict with organizational needs.

For each of these three priorities we considered different rules governing when reassignment can occur. At each proficiency rank a rule might permit or not permit agents at that rank to be reassigned. There are sixteen such rules with the rule that does not permit reassignment at any level being equivalent to our control conditions.

There are fifteen experimental rules that permit reassignment at at least one level. We ran experiments on all rules but for brevity in our analysis we will focus on the rules that permit reassignment only at a single level. There are three priorities and 15 different proficiency rules making a total of 45 different experiments plus one for the control. We ran each experiment 500 times for 1000 iterations. There were two trials run, the first to see how organizations would perform with limited resources and the second with sufficient resources. Data presented is from the high resources experiment.

During an experimental run it was possible for the initial population to fail to meet its needs. In these runs the population of agents did not survive. Survival rates were measured for all runs. The control run had a survival rate of 73%.

For convenience the experimental run is described by priority mode and the proficiency levels allowed to retrain. The proficiency levels are listed as a 1, if agents can be reassigned at that level, or 0, if agents cannot be reassigned. For example, if the priority mode is *organization* and agents can be reassigned at the second and fourth proficiency levels, the type is *organization0101*. Data was gathered for all experimental runs however we will focus on runs where the proficiency rule only has a single 1, that is, permits reassignment only at a single rank.

Data

The experimental runs differed in survival rate as well as in the total resources over time and in the final iteration. First we will present data on the survival rate for our experimental runs. Then we will look at the mean resources over time for the runs that survived.

Survival Rate

Figure 1 shows the survival rates for the experimental runs of focus. In these select runs we can see that the high-

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,
(Cambridge, MA: The MIT Press, ©2017 Massachusetts Institute of Technology).

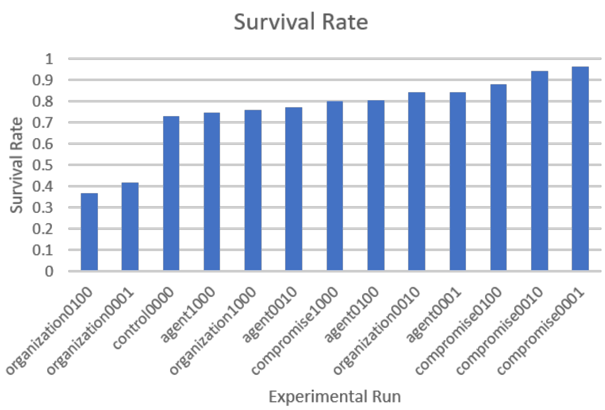

Figure 1: Survival rates of each experimental run.

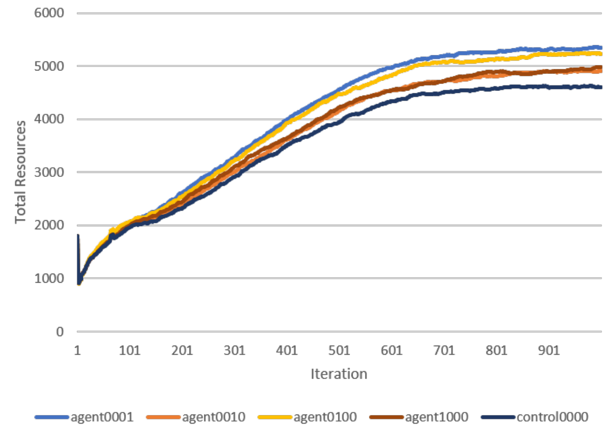

Figure 2: Mean total resources over time for select runs using the agent priority.

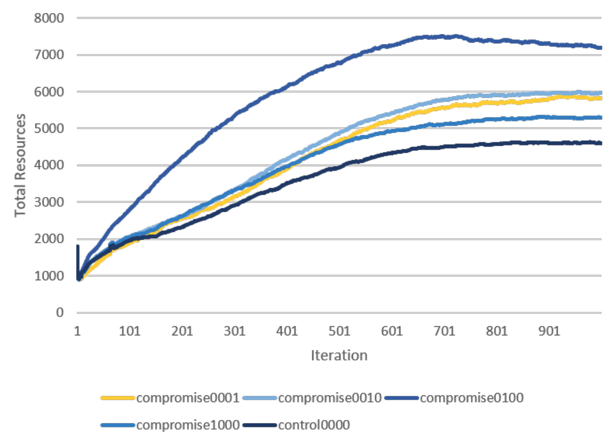

Figure 3: Mean total resources over time for select runs using the compromise priority.

est survival rates were achieved using the compromise reassignment priority. In particular the top three survival rates were for compromise0001, compromise0010 and compromise0100 with rates of 96.4%, 94.4% and 88% respectively. All four compromise runs shown in the figure exceeded the control run. This is true of all the compromise runs not shown as well. The top eleven runs in terms of survival all used the compromise priority. The worst performing run using the compromise priority was compromise1000 (shown in the figure) with a survival rate of 80%.

All of the runs using the agent priority (both shown and not shown) also exceeded the survival rate of the control run. As with the compromise priority the worst performing run using the compromise priority was agent1000 (shown in the figure) with a survival rate of 74.8%.

Not all of the runs using the organization priority exceeded the survival rate of the control run. Of the runs shown organization0100 and organization0001 had extremely low survival rates. Eight of the fifteen organization runs fall well below the control run with the highest surviving 53.2%. The other seven organization runs (two shown) exceeded the control run.

The organization strategy was more prone to failure because it does not consider the preferences of the individual agents. When the organization reassigns an agent the agent is likely to produce less than they were prior. The new role is not guaranteed to be the preferred role of the agent and is likely to be one in which the agent has low proficiency. This leads to situations where there are many agents assigned to roles in which they have low proficiency and in which agents are reassigned often to cover resource shortfalls.

Resource Output

Figure 2 shows the mean total resources for the runs of focus using the agent priority. For comparison the control run is included. All agent runs were able to produce more resources on average than the control run even if for some runs this was somewhat meager.

The two highest performing runs with the agent priority were agent0100 and agent0001. These were also the agent runs with highest survival rate. The other two runs agent1000 and agent0010 both outperformed the control run but with only a minor gain in resources.

Figure 3 shows the mean total resources for the runs of focus using the compromise priority. Again for comparison the control run is included. As with the agent runs all of the compromise runs were able to produce more resources on average than the control run.

The weakest performing compromise run, compromise1000, had comparable mean total resources to the best performing agent run, agent0001. The runs compromise0010 and compromise0001 outperformed compromise1000. The run compromise0100 was the best performing run in our focused runs. Of the runs not shown compro-

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,
(Cambridge, MA: The MIT Press, ©2017 Massachusetts Institute of Technology).

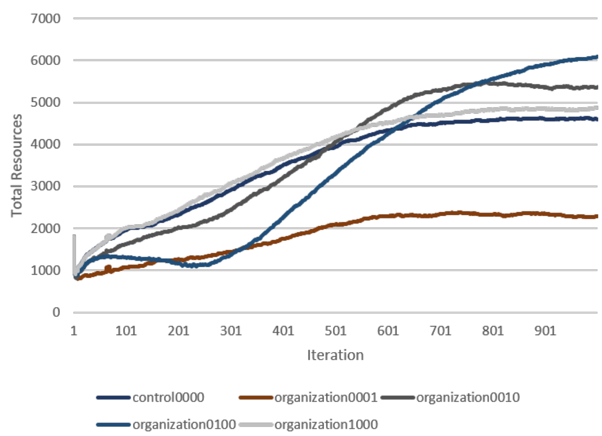

Figure 4: Mean total resources over time for select runs using the organization priority.

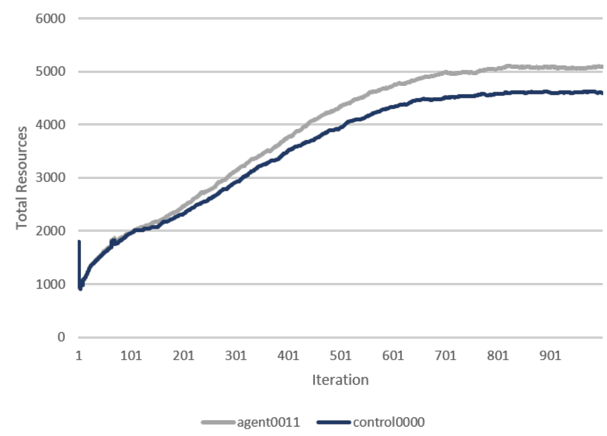

Figure 5: Mean total resources over time for run agent0011.

mise0100 was one of the top performers.

Compromise0100 had very little problem adjusting to initial conditions. Agents that were in non-preferred roles were more likely to request reassignment. After reassignment the agent was more likely to be in their preferred role (or at least unit) and/or in a role that supports the needs of the organization. This led to situations where many agents were in their preferred roles and there were few roles under producing resources. The agents were also more highly motivated and thus produced more.

Since reassignment only occurred at the second rank the reassigned agents had not invested much time in their roles. This meant they did not spend much time under producing due to low motivation. Instead they were reassigned to another role. If that role was in the same unit the cost of reassignment is almost nothing as the agent has already completed the first rank of training. If the role was in a different unit the first rank of training must be completed again, but as already mentioned, the agent is more likely to be better motivated in the new role.

Figure 4 shows the mean total resources for the runs of focus using the organization priority. Again for comparison the control run is included. Not all of the organization runs were able to produce more resources on average than the control run. Of the focused runs organization0001 performed very poorly. Not only did it have a survival rate of 41.8%, the runs that survived could only produce about half the resources produced by the control run on average. This strategy reassigns highly trained agents without regard for their motivation. This can lead to high ranked members returning to the lowest rank in a role they do not prefer.

The best performing run using the organization priority was organization0100. This run also had a low survival rate of 36.6%. The shape of this graph is indicative of this survival rate. Most of the runs of this type struggled in the early iterations to meet their resource needs. Those that managed to overcome this initial struggle however went on to be quite successful even outperforming the runs using the agent priority.

The run organization0010 has a similar shape but less pronounced. This run also had a much higher survival rate of 84.2%. Runs using this proficiency rule were more likely to survive through the initial struggle.

Finally, organization1000 has a performance close to the control run. This proficiency rule allows agents to be reassigned only after completely their initial training before they become productive members. This rule is very close to the control settings but gives a slight advantage of reassigning new members after initial training.

Discussion

Comparison

The 446 FSS allows employees to retrain similar to the *agent0011* run type. That is, employees in the 446 FSS are retrained at their own request, not to satisfy the needs of the squadron, and they are only allowed to retrain after reaching proficiency level two. There are a few exceptions, such as allowing an employee to retrain before reaching the first proficiency level if they are not making progress in training, but these are rare exceptions.

The survival rate of agent0011 was 80.4% better than the 73% of the control run. Figure 5 shows the results of our experimental run agent0011. The performance of agent0011 is slightly better than the control run in terms of mean total resources over time. The 446 FSS is middle-tier when compared to performance of other FSS's according to US Air Force evaluation.

Comparing this to the results we can see there is a slight correlation between the performance of the simulation and the performance of the 446 FSS. First run types with the agent choosing when to change roles tend to have a higher

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,
(Cambridge, MA: The MIT Press, ©2017 Massachusetts Institute of Technology).

survival rate, specifically in a low resource environment with a great deal of flexibility. The *agent0011* run type is also middle-tier for output. These results are not conclusive but provide a starting point for further research. For full validation more systematic comparisons need to be made with other squadrons.

The Effects of Mid-Career Reassignment

Most of the experimental runs with the highest survival and success rates had either the second or third proficiency rank open for reassignment. When restricting our attention to our focused runs this trend continues.

During the first priority rank agents cannot contribute to the organization, so if that were the only time that agents are allowed to retrain it would follow that those organizations would not do as well, since the agents do not get a chance to contribute before they are retrained. The data supports this interpretation.

The runs agent1000 and compromise1000 produce the fewest total resources on average within their respective priorities (including the data not shown). The run organization1000 was not the poorest performer among runs using the organization priority. However, among runs using the organization priority that had survival rates greater than the control run, organization1000 was the poorest performer.

Symmetrically the last proficiency rank contributes the most to the organization. When it is the only proficiency level that agents can retrain at, the organization loses a heavy contributor to the role they are leaving. This is especially evident in the organization priority mode because it could be forcing an agent away from the role they desire, which impacts motivation as well. The run organization0001 was a particularly good example of this. The survival rate was very low and surviving runs had a very hard time producing resources.

In contrast to this the runs agent0001 and compromise0001 both were better performers. When using the agent priority the run agent0001 performed as well as (a bit better than) the run agent0100. Likewise the run compromise0001 was a mid-range performer among runs using the compromise priority.

The second proficiency rank seems to be the ideal retraining time. It is just past the first proficiency rank where the agent begins contributing to the organization and is not yet at a rank where they are contributing so much the organization cannot afford to move them to another role.

When using the agent priority the run agent0100 was a top performer. When using the organization priority the run organization0100 was the top performer (though with low survival). Finally, when using the compromise priority the run compromise0100 was one of the best performers out of all runs.

Agents at the third proficiency rank contribute more to the organization than those at the second level but less than those that are fully trained. This might be why the third proficiency rank tends to lower output by itself when compared to the second rank. Agents are retraining at a point where they are becoming major contributors.

All three priority runs in which reassignment occurs only at the third proficiency are high performers. However, these runs do not perform as high as those in which reassignment happens only at the second rank.

Reassignment Priorities

The runs using the compromise priority had the highest survival rates. In addition, amongst the focused runs, the compromise runs all outperformed runs of any other type. Following the compromise priority the agent priority was the next best performer. Finally the organization priority was a good performer only rarely under some settings.

The differences in priority modes can be understood by looking at when agents are selected for reassignment and how their new role is chosen. This effects the motivation of agents and therefore their output. When agents choose when and how they are retrained they have a higher output because of a higher motivation, but do not necessarily fill the roles that are needed for the organization to do well. When the organization chooses, it does not take into account agent desires so agent motivation is lower. This can be seen in the low resources early on and how many of the organization run types die out. However, if the organization survives these initial difficulties, it does exceedingly well because it can rapidly switch agents that are qualified in several roles to compensate for low resources.

Finally, if there is a compromise between the two, the organization is more reliable because it manages low resources while taking into account the desires of the agents. Agent motivation is higher while lower resources are supplemented in a timely manner.

Further Research

After comparing the FSS's current reassignment model to our simulation results we have found that the reassignment strategy at the FSS was not among the best performing organizations, but also not among the worst. By looking to our best performing strategies we could offer some alternative strategies for the FSS.

The FSS uses the agent model of reassignment at this time, but this model was outperformed by the compromise model in our simulation. One benefit of the FSS's current model is that by allowing unmotivated members to request reassignment, the motivation levels of their members remains high. This suggests that if the FSS were to request reassignment of individuals into under covered roles they might better manage their resources.

The proficiency rank at which reassignment can be requested could also be varied. Allowing unmotivated workers to reassign earlier rather than later is better for two reasons.

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,
(Cambridge, MA: The MIT Press, ©2017 Massachusetts Institute of Technology).

By reassigning earlier the worker does not spend long under performing in their role and can move quickly to performing better in a role they (hopefully) are more motivated at. Workers at higher proficiency levels have invested a lot of time into building expertise and provide a lot to the organization. The cost of reassigning them to role they have little expertise in is a greater waste of resources.

Conclusions

We have created an agent based simulation of a self-sustaining organization modeled on the Force Support Squadrons in the US Air Force. In our model twelve different essential resources are produced by agents in twelve different roles. Managing the balance of resources available to the organization means managing the assignment of agents to roles and managing the agent's levels of motivation. We investigated different strategies for reassignment that consider the desires of the agents and the needs of the organization. We also investigated reassigning agents at different levels of proficiency.

Our simulation suggested that a reassignment strategy that takes into account both the needs of the organization and the desires of the agents is the most productive. This is because it allows the organization to be reactive to its collective resource needs while ensuring that agents are able to switch to roles where they might be more productive.

The simulation also suggested that reassigning agents earlier in their training is better than later. Reassigning agents of high proficiency means moving them from a position where they contribute a lot to the society into a position where, because of a lack of training, the agent will contribute less. On the other hand reassigning agents that are unsatisfied with their role early in their career means moving them from a position where they are likely under performing into a position where they will be more productive in the long term.

This conclusion comes with one exception at least in our model. Agents that are not yet productive to the organization should not be allowed to reassign. They should have the opportunity to contribute to the society for at least a short time before being reassigned. This is to avoid the additional cost of training agents in areas that they never contribute to.

References

Balbi, S. and Giupponi, C. (2010). Agent-based modelling of socio-ecosystems: a methodology for the analysis of adaptation to climate change. *International Journal of Agent Technologies and Systems*, 2(4):17–38.

Bonabeau, E. (2002). Agent-based modeling: Methods and techniques for simulating human systems. *Proceedings of the National Academy of Sciences*, 99(suppl 3):7280–7287.

Bullinaria, J. (2016). Population based simulation of gender inequality issues. In *Proceedings of the 15th Artificial Life Conference*, pages 452–459. MIT Press.

Cioppa, T. M., Lucas, T. W., and Sanchez, S. M. (2004). Military applications of agent-based simulations. In *Proceedings of the 36th Winter Simulation Conference*, pages 171–180.

Du, J. and El-Gafy, M. (2012). Virtual organizational imitation for construction enterprises: Agent-based simulation framework for exploring human and organizational implications in construction management. *Journal of Computing in Civil Engineering*, 26(3):282–297.

Fleurey, F., Baudry, B., Gauzens, B., Elie, A., and Yeboah-Antwi, K. (2015). Emergent robustness in software systems through decentralized adaptation: an ecologically-inspired alife approach. In *European Conference on Artificial Life 2015*.

Janssen, M. A. and Hill, K. (2014). Benefits of grouping and cooperative hunting among ache hunter–gatherers: insights from an agent-based foraging model. *Human Ecology*, 42(6):823–835.

Lake, M. W. (2014). Trends in archaeological simulation. *Journal of Archaeological Method and Theory*, 21(2):258–287.

Lansing, J. S. (2003). Complex adaptive systems. *Annual review of anthropology*, 32(1):183–204.

Lim, S. L. and Bentley, P. J. (2012). How to be a successful app developer: lessons from the simulation of an app ecosystem. *ACM SIGEVOlution*, 6(1):2–15.

Marriott, C. and Chebib, J. (2015). Finding a mate with no social skills. In *Proceedings of the 2015 conference on Genetic and Evolutionary Computation*. ACM.

Marriott, C. and Gershenson, C. (2011). Polyethism in a colony of artificial ants. In *Proceedings of the Eleventh European Conference on Artificial Life*, pages 498–505.

Middleton, V. E. (2010). Imperfect situation awareness: Representing error and uncertainty in modeling, simulation & analysis of small unit military operations. In *19th Annual Conference of Behavioral Representation In Modeling and Simulation (BRIMS), Charleston SC*.

North, M. J. and Macal, C. M. (2007). *Managing business complexity: discovering strategic solutions with agent-based modeling and simulation*. Oxford University Press.

Robertson, M. (2016). *446 Force Support Squadron Status of Training*. US Department of the Air Force.

Scogings, C. and Hawick, K. (2012). An agent-based model of the battle of isandlwana. In *Proceedings of the Winter Simulation Conference*, page 207. Winter Simulation Conference.

Tesfatsion, L. (2003). Agent-based computational economics: modeling economies as complex adaptive systems. *Information Sciences*, 149(4):262–268.

USAF (2013). *Air Force Instruction 36-2201: Air Force Training Program*. US Department of the Air Force.

Carole Knibbe et al, eds., Proceedings of the ECAL 2017, Lyon, France, 4-8 September 2017,