MANPOWER FORECASTING: A DISCRETE-EVENT OBJECT-ORIENTED SIMULATION APPROACH

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Abstract

Every organization needs a workforce suitable for its tasks in order to reach its business aims. To get insight into the quality and amount of staff needed in the future, human resource forecasting models are being used. This descriptive paper addresses a new way of human resource forecasting, based on simulation models of personnel movements in the organization. An example model is implemented in a simulation language in a project for the Royal Netherlands Navy. An important requirement in the design of the simulation model is that maintenance to keep it up to date with organizational changes should be possible without much effort. We describe what human resource forecasting is about. Next we describe what kind of models have been developed so far. In the third place we will give an overview of the type of information needed for manpower planning. Finally a new simulation based design will be presented.

1. Introduction

Nowadays organizations operate in ever changing environments. The impact of new technology, changing demands of customers, political factors and many others, lead to organizations that have to transform their products, their services, and their internal processes on a continuous basis. These changing policies imply new ways of working, new job contents and other qualifications needed to carry out the organization's functions [13, 17]. For an organization to survive in these dynamic circumstances, a long-term policy is needed. It is striking that when most organizations develop their long-term policy, they just focus on the products or services. Almost no attention is given to implications for the workforce or the allocation of employees to future tasks in the organization. When a new policy has already been carried out, many problems arise with staffing the new function structure with qualified employees.

The question is whether an organization that tries to implement a new policy has the right workforce to be able support and sustain that policy [2, 6]. Restructuring the workforce takes much more time than implementing changes in for instance technology, strategy, or the organization of work [15, 16]. In other words, having the right number of skilled employees at the right time to carry out the organizational policy is on the critical path. The success of an organization depends heavily on the availability of correctly qualified employees [7, 14]. According to this, it is of importance for an organization to have insight into the characteristics of its workforce and into the effects of changes in policy on its workforce.

It can therefore be easily seen that there will often be a mismatch between the business strategy of an organization on the one hand and an lack of support because of the organizational infrastructure on the other hand. Henderson and Venkatraman [8] address in their strategic alignment model the linkage between these factors as the strategic fit. Business strategy refers to business scope, business governance and the distinctive competencies of an organization, whereas organizational infrastructure consists of administrative structure, skills of employees and of processes. To improve the strategic fit more attention has to be given to strategic human resource planning methods.

Strategic human resource planning concerns all activities to provide the right number of employees having the right skills at the right moment in time, on the basis of the policy and plans of the organization [10, 22]. Within

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strategic human resource planning two tasks can be distinguished. First, manpower planning or short term planning, which answers questions about which employees will occupy what functions over the next couple of weeks or months. This paper is focused on the second task, human resource forecasting. This is defined here as a forecast of the number of people per function group within an organization, their skills, and the time path of their movements between these function groups over a longer period of time. These forecasts provide insight into the right quantity and quality of the workforce to carry out the proposed changes in the business strategy.

In contrast with the expanding line of forecasting techniques in general over the last few decades, human resource forecasting models have not changed fundamentally. These models can characterized by adding more and more sophisticated mathematical tools [1]. The basic assumptions of these tools have however not changed. These techniques are of no use as long as they cannot be converted into practical tools for human resource forecasting useable within organizations [4, 12].

From the fields of strategic human resource management and manpower planning it becomes very clear that the current approaches have several weak spots. New methods are hardly being developed and creative new techniques are lacking. The focus of this paper will therefore be on new simulation based concepts to develop *usable* tools, which provide new insights into the effects of a changed business strategy on the needed workforce of the organization. A case study at the Royal Netherlands Navy will be used to illustrate the current problems and the impact of the new way of modeling.

2. Current way of modeling manpower forecasting

Forecasting models of human resources did not evolve much the last decades. The methods and techniques used are well known [4, 6]. Within these models three parts can be distinguished: personnel supply, personnel availability and integration models. Two methods to estimate personnel buildup are used:

- Extrapolation;
  The assumption is that personnel supply can be derived from trends from the past. The main changing variable in these models is time.
- Correlation models;
  These models are based on relationships between personnel supply and explanatory variables such as turnover, sales volume, or production. If for example the turnover changes, the personnel supply will also change by a known factor.

The above models see employees just as numbers that are completely void in the models: only their quantity changes. Nothing can be said about the qualifications or functions the employees have over time. Furthermore these models give only the amount of employees that are needed at a moment in time. No information is provided whether this prediction can be met with the current workforce.

Personnel availability techniques add dynamics. Dynamic systems models "attempt to predict the life movements of people within a closed system and their interactions with other systems" [21].

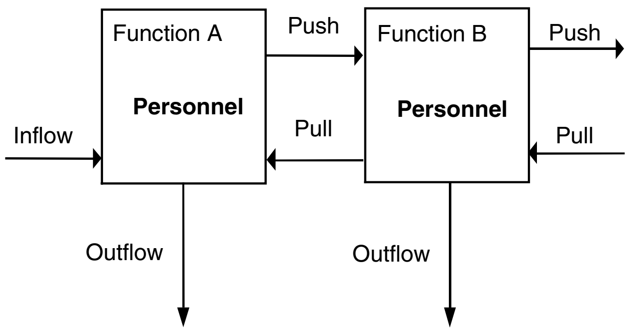

Figure 1. A flow-model

Two kinds of dynamics can be distinguished: a push-flow and a pull-flow, as is depicted in figure 1. In a push-flow, movements between cells occur regardless of a job opening existing in that cell. If the transition rate from first mate to skipper is 4 percent per year and the number of first mates is 50, each year two first mates will be promoted to skipper. The pull-model takes into account the availability of a job opening. If one skipper position is free and the transition rate is ten percent per year, then only 1 first mate will be promoted. In practice, the rates are calculated on the basis of historical data to forecast the flow of staff between the functions in the future.

The latest human resource-forecasting model (PBAS) used within Royal Netherlands Navy was based on these techniques. Within a model like this, movement of employees is based on past behavior of groups of employees. There is no matching between employees and functions in the system, but only a movement of groups of employees through predestined job ladders. Employee characteristics do not change over time in these dynamic models.

The third category of models consists of integration models such as goal models. These models are mainly based on linear programming methods. Based on constraints the model finds the optimal solution of the number of employees on functions, based on a goal function. This often takes personnel needs into account. The disadvantage of these models is that for reaching the optimal solution and the desired occupation of functions,

functions often have to be understaffed and overstaffed. This is often not applicable in organizations. Furthermore it shares the disadvantages mentioned before.

For an in-depth overview of the kind of models that have been developed over the last decades see Niehaus [11] and Ward et al. [19]. In the next section the manpower arrangement within the Royal Netherlands Navy will be examined. This will help to get an idea of the requirements that the new human resource-forecasting model must meet.

3. Manpower planning at the Royal Netherlands Navy

The main objective of the Royal Netherlands Navy personnel department is to provide the Royal Netherlands Navy with sufficient, competent and motivated personnel, who operate effectively in circumstances of war, crises and peace-operations now and in the future.

Inflow of new personnel occurs at two places in the Royal Netherlands Navy hierarchy, as a sailor or as an officer. After being contracted they follow initial courses, after which their naval career starts. The career path consists of a job ladder with corresponding ranks. Employees first get the required training before starting in a new function. Most of the functions require specific knowledge and skills only available within the Royal Netherlands Navy. There-fore the Navy is forced to educate their personnel on the job. The internal labor market arrangement provides an accumulation of knowledge and skills necessary for higher functions in the organization. For example, to reach the rank of captain, a career length of at least twenty years is needed.

The internal labor market within the Royal Netherlands Navy has enormous consequences for its personnel policy. It is not possible to enlist people on short notice on other than the entry positions, because new personnel lacks the knowledge and skills needed for other positions. Therefore a competent substitution should be enlisted early, for e.g. a captain twenty years in advance. This implies that a change in organizational policy, proposed for the future, which has implications for the job-contents or for the organizational structure, must be checked for its consequences on the occupation of the new set of functions. That is, the required qualifications for the (future) functions have to match the abilities of the employees who will be available at that time. Also, the effects on career possibilities of the current employees must be investigated. For example if a new ship is introduced in the Royal Netherlands Navy, new functions arise, functions disappear and job-contents change. Information is needed to indicate whether the ship can be crewed with enough skilled employees. A sailor-job will not change much, but an operator of a new rocket system needs new skills. Retraining is an option, but it is limited by the capabilities of the personnel. These changes affect the composition of the job ladder and can lead to the absence of promotion possibilities for a sailor to an operator due to lack of preparatory training or lack of adequate sub-sequent functions. Of course, this could have been foreseen in this example case.

The need to explore the different effects of proposed changes on structure, policy and job-contents of the organization, requires a modeling approach which provides insight into the dynamics of the system studied. Such a model should make it possible to detect pitfalls in long-term manpower planning. Furthermore, it must provide possibilities to evaluate different scenarios. The analytical models that were mentioned in section 2 oversimplify the dynamics involved. Simulation models do provides the needed functionality. Therefore, a simulation approach will be used to obtain the functionality needed. The outcome of the simulation(s) must provide information indicating whether proposed actions result in the desired effects or, if not, give insight in alternative measures that can be taken.

4. Requirements for a manpower planning model

The human resource-forecasting model has to operate within a staff division of the Royal Netherlands Navy to answer a large number of questions. Several of these questions are of the “what-if” type (the most simple one being the “what happens if we do not change anything”). Other questions are of the “how to” type.

After having made an inventory of questions the organization expects the model to answer, it turns out that the questions can be divided into the following categories:

- *Inflow questions*
  Example: Do we have the right kind of people in four years to crew a new ship?
- *Outflow questions*
  Example: What length of service is needed to reach a certain level of outflow, given that outflow depends on years of service?
- *Transition questions*
  Example: What effects occur if job promotions would be speeded up?
- *Occupation questions*
  Example: Where does the first shortage of employees occur if a vacancy freeze is in effect?
- *Personnel questions*
  Example: Are qualified employees available if the requirements for entering a certain function change?

The human resource forecasting simulation model must provide outcomes that can be used to answer these questions. In the next section an investigation will be carried out whether the layout and assumptions of the current models can do this.

5. Formulation of the new requirements

The Royal Netherlands Navy operates in a frequently changing environment. As a result of the changing circumstances, transition rates based on historical data need not at all be valid for the future [3, 7, 18]. After a change in the organizational structure, for example the introduction of a new set of functions, historical data to determine the accompanying transition rates between the new functions is not available. The normal practice is to estimate the needed rates to overcome this lack of data. The outcomes of the used model provide the users only with an answer how their own estimates of the forthcoming situation have worked out. We call this the prediction paradox: in order to provide transition rates, users should have insight into the results of changes in the organization, while, by means of the model, they try to gain insight in the personnel flows in the changed organization. The solution to solve this prediction paradox is that a human resource-forecasting model has to use other mechanisms, independent of historical data, to allocate employees to functions.

Thirdly, an implicit assumption is that when a transition between functions exists, the employees who flow between the functions are indeed qualified for their next job. If a function changes, requiring new qualifications of the employees, there is no possibility of accommodating these in the current models other than by a change of transition rates. The actual transition rate for the new situation will, however, depend on the qualifications of the employees in the functions that have a transition to the changed function. For the Royal Netherlands Navy it is important to know if employees are available within the organization, who satisfy the new required qualifications. The conclusion is that additional parameters are needed to match function requirements and employee qualifications, in order to be able to study the distribution of employees over the changed functions.

Fourth, through the explicit definition of push or pull transitions between functions, an inflexible model arises. Studying a possible change in the organization structure therefore will take a lot of effort, since changing the model is labor intensive. Related to this, because of the amount of changes in the Royal Netherlands Navy, the maintenance of the model will be very hard. The conclusion is that another method to allocate employees over functions is needed, as the information and flexibility, which the current models provide, are not sufficient in the context of the Royal Netherlands Navy. Consequently a new approach is proposed, where simulation models are used to provide the needed level of detail and accuracy. This approach has to provide better insight into the effects of changes in the organization on the occupation of functions, and on the enlisted employees with their characteristics over time.

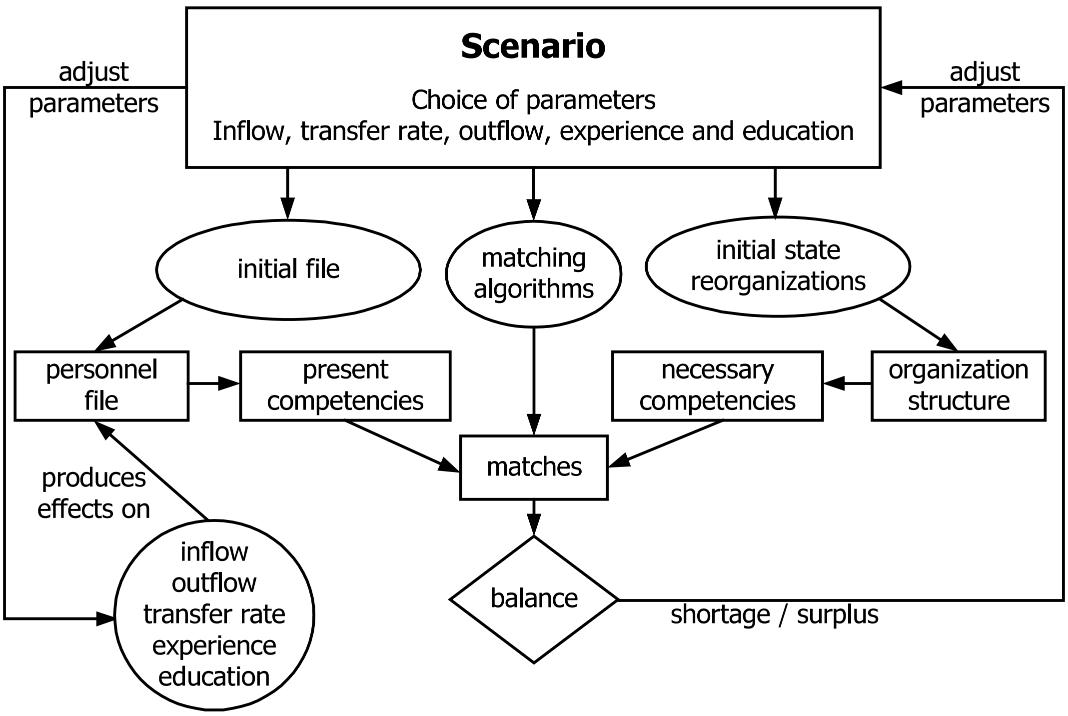

Figure 2. Dynamic competence model

6. A framework for human resource forecasting

As mentioned before the current models of manpower planning deal on a high level of abstraction with employee movements from function to function through the organization. As a consequence functions and employees are seen as numbers with no characteristics. Within the Royal Netherlands Navy the requirements of functions develop over time. As a result employees are needed with different competencies.

To decrease the level of abstraction we must avoid the pitfall of implementing too much behavior of employees. It is impossible to model the many interactions and career patterns of employees and the occupation of function in a very detailed manner. The modeling of "soft" factors such as preference, or dislike of specific functions by employees is therefore saved for later research.

Our approach is to first cover the "hard" factors of employee characteristics and function requirements, for example education, age, and experience based on earlier fulfilled functions. To model, verify, and explain these interactions patterns which will occur over time is the first aim. The objective of human resource forecasting is to give insight into the (mis)match between the competencies of the employees and the demand for competencies of the organization. A possible view on how to do this is given in figure 2.

The starting point has to be the demand of the organization, in terms of needed competencies, and based on the organizational goals. Therefore, the following information is needed of the organization with respect to competencies: first a characterization of the organizational infrastructure, which functions are available within the organization that are necessary to carry out the activities of the organization. Secondly, the organization must provide a characterization of required competencies for carrying out a function.

Together with the number of employees needed in the functions it defines the demand for competencies in the organization. To model the flow of employees through the organization, conditions for promotion such as a minimum time served in a function have to be determined. As mentioned earlier, education is important to develop the skills of the employees within an internal labor market. The possibilities to take courses are limited by the number of persons allowed and by the frequency the course is given.

The supply side for personnel forecasting consists of the set of competencies of the employees. Their competencies can change (and usually increase) continuously. The increase can have different causes. One cause for changes in the competencies of employees is gaining experience by working in a function. This competence growth through experience is an autonomous process. The organization can only influence it by changing the job-contents of the functions of the employees. Secondly, employees can be educated by taking internal or external courses. The knowledge of the employees increases, so the employee is prepared for more or other functions.

The competencies of the employees, which are useful for the organization, can also decrease by several causes. In the first place, after reorganization a shift in the competency demand of the organization arises. The number of employees stays the same, but the amount of competencies of the employees, which are still valid for the organization can decrease. As these competencies are no longer necessary for the organization, they are not taken into account anymore. Secondly, the employee's competencies get out of date after some time. Fighting obsolescence is a joint responsibility of the employee and the organization. Solutions can be to take courses or to change position in the organization to gain new experience. The factors mentioned here do not change the quantity of the employees, but just the set of available competencies.

Besides the mentioned processes, three other factors have an influence on the available competencies in an organization: inflow, outflow, and absence. The inflow of employees creates a growth in competencies available for the organization. The other two factors decrease the competencies. Insight into the trends of absence (through illness, vacation, and other causes), inflow and outflow can be gained by analyzing historical data and by looking at the developments on the labor market. These three factors change the obtainable competencies in the organization by changing the quantity of employees within the organization. Of course there is a difference between inflow in the 'lowest' functions in the organization and horizontal inflow in higher functions. In the latter case, one can expect the new employees to have a larger set of suitable competencies for the organization. In organizations with an internal labor market, employees usually only enter the organization at the bottom in a fixed set of functions. The inflow can be controlled by the organization, but it of course depends on the status of the labor market for the needed competencies. Outflow and absence can only be influenced indirectly.

This model covers the development of competencies within the organization over time and the way to influence them. Through defining functions as demands in competencies every function structure of an organization can be modeled. As function and employee are defined with the same variable (competencies) they can be compared directly. As demand and supply are integrated in one model, an overview of shortages and surpluses of competencies in the organization can be given easily.

Several outcomes can immediately be generated from this model:

1. functions that can be fulfilled;
2. functions with a shortage of employees;
3. employees who hold a function;
4. employees who do not hold a function;
5. employees with competencies that are not needed by the organization.

The decision-makers can immediately use this information. If function requirements are fulfilled, the organization has enough employees with the right competencies. The inflow question, e.g. do we have the right kind of people in four years to crew a new ship, can be answered now directly. Functions with a shortage of employees will cause serious problems with respect to the organization's objectives. In other words, the current manpower and inflow and education policies cannot provide the right amount of competent employees in time. The organization now has to study how to solve this shortage. The different solutions devised lead to new scenarios that can be tested with help of the simulation model. Example questions are: "What is the result if the inflow of employees is increased?" "Will a change in the competencies required for a function or changing the amount of courses employees take decrease the shortage?" Employees who occupy a function have competencies that are needed by the organization. If employees do not occupy a function this can have two reasons: their possible functions are occupied or they have a set of competencies that does not match the requirements of any function. Example questions are: "Are there any functions that aren't fulfilled?" "Is it possible to train the employees without a function for the vacant functions to make them useful for the organization?"

The third model in the framework is the matching model. Matching takes care of making a connection between supply and demand, according to some algorithm (see figure 2). This algorithm can be close to reality or it can be used for other purposes, such as checking if there is a theoretical possible fit between functions and employees, regardless of their current assignment. Parameters in matching are e.g. whether to start with employees or with functions, and the sequence of searching for possible assignments.

In the next section a simulation model approach is used to implement and to provide the needed level of detail and accuracy proposed above.

7. Functional specification

This section will give an outline of a way of implementing the employee model, matching model, and function model by adopting the object oriented modeling method. The choice for an object oriented simulation approach is based on the following:

First, a major requirement is that new tool must remain synchronized with the developments in the organization. Therefore the representation of the organization structure, policy and employees must not be directly fixed in the software code. An object oriented design gives the possibility to model autonomous objects with their own behavior that can be in several states [5]. The only interaction between objects is requesting information from or providing information to other objects [9].

Second, an employee, function or organization's policy have a certain behavior which changes over time. Modeling them as an object gives the possibility to allow changes in their characteristics over time. Third, the responsibilities they have must be modeled within the object [20].

These guidelines for designing an object-oriented simulation model provides a clear structure of objects which is easy to maintain. The possibility to model behavior and responsibilities of the independent objects gives room to create less abstract entities. In the following sections the three main objects will be described.

7.1. Employee object

The employee object forms the core of our simulation model. Instances of this object can be in several states. These states are depicted in figure 3 that summarizes the behavior of employees object instances.

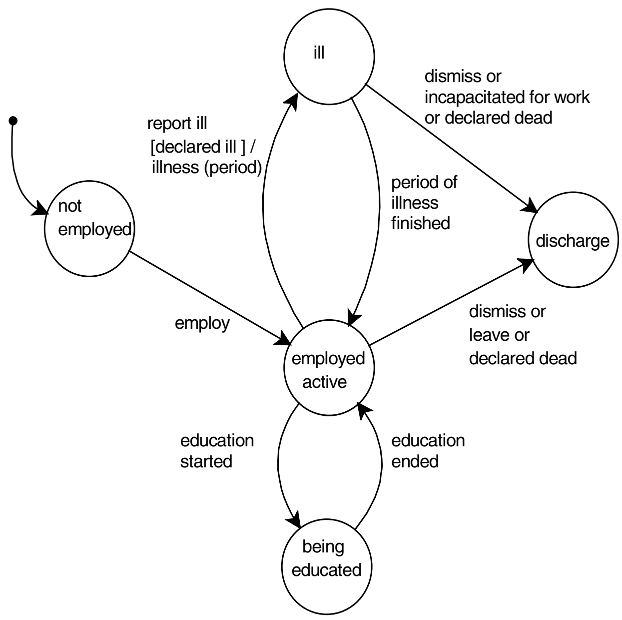

Figure 3. State-transition diagram for the lifespan of an employee-object

As is depicted, the employee object can be in five possible states. The first one, not employed, means the employee is not yet part of the organization. Within the Royal Netherlands Navy new sailors enlist and follow initial courses twice a year. The amount of sailors who enlist is based on historical data and labor market surveys. In the simulation these employees are created and have a date of enlistment equal to the starting date of their initial training. If the simulation clock reaches the enlistment date the state of each of these employees changes to "employed active". Moreover, an "employed active" employee is available for a function and will try to get one in the matching process. Over time, the characteristics of the employee will change, for example the function history and the time on function.

A third state is an employee who is "being educated" and therefore not available for a function. After the duration of the education, the state of the employee changes back to "employed active". Furthermore, the educational record of the employee is updated. Through this education, the employee might be more suited for other functions. State 4 "ill" is based on a chance for an employee to become ill. The illness chance and duration are derived from historical data and depend on the kind of occupied function, the age of the employee, and maybe other attributes. After the illness duration, an employee becomes "employed active" again. If the period of illness is too long, the employee will be dismissed as being incapable to do his job. It might also be possible that an employee dies after a term of illness.

The final state an employee reaches then is discharge. Several grounds for dismissal can be seen, such as end of contract, discharge by the organization, resignation by the employee, or long illness or death. The five states cover the complete real life of an employee. At every moment in the simulation an overview can be given of the states of the employees. For the Royal Netherlands Navy, this means that there are always about 15,000 employee objects active in the model.

The Superstate of "employed active" can be further broken down into three states, as shown in figure 4.

If an employee starts in an new function, he is supposed to stay a minimal period that depends on the function occupied. A change of function is not possible during this period. The employee is in the state "freeze on function". The employee knows his fixed period of stay. After serving the minimal period on the function, the employee changes to the state "free to change function". The employee is now free to obtain a new function and enrolls for matching, but actually getting a new function can take a lot of time An employee can become functionless through a change in available functions within the organization or a decrease in number of occupations in a function. If the employee becomes functionless he will enroll in the matching for a new function.

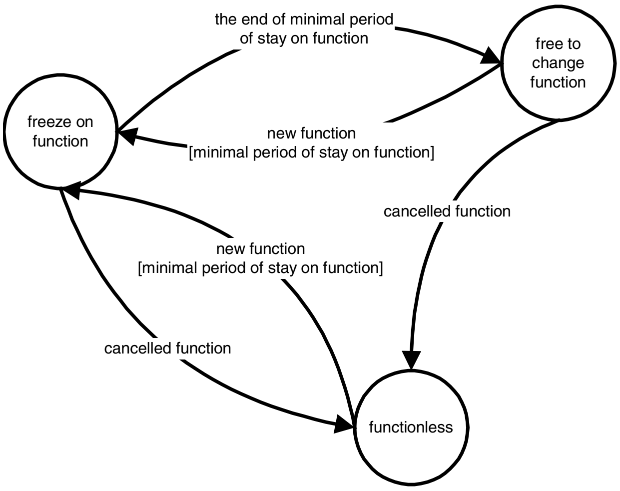

Figure 4. Superstate "employed active"

For creating the start file of employees for the simulation, the Royal Netherlands Navy has a database with the employee data of the current employees. These records will serve as data to create anonymous employee objects. The inflow of new employees in the future is based on estimates provide by the recruitment department.

7.2. Function object.

The function model consists of superstate "valid function". The "valid function" is known with the number of employees who are occupying the function, and the number of needed employees on the function. Three states can be discerned within the superstate. See figure 5.

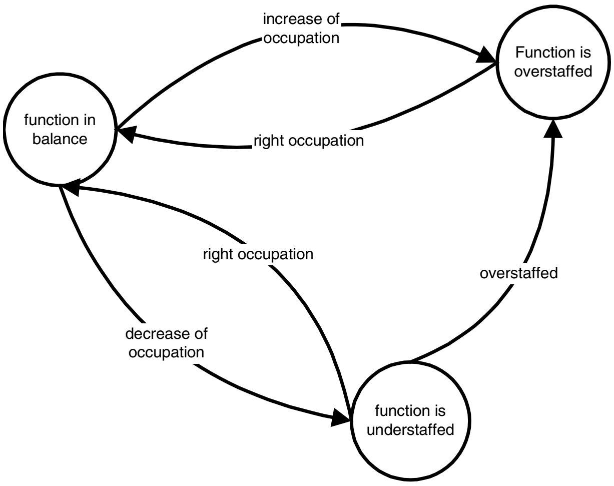

Figure 5. Superstate "valid function"

The first state into which a "valid function" can change, is "understaffed". The function has an certain demand of employees and has zero employees staffed on the function. The function will submit a request to matching for new employees, with specified competencies. If the requested employees are available the function will change toward the balanced state. The function remains passive until employees leave or enter the function.

A function can get overstaffed in two ways; first by decreasing the specified demand, which occurs in reorganization or downsizing. To cope with that, the function dismisses all employees because it knows only the number of employees and can not make a distinction between employees. The employees will enter the state of functionless and enroll for matching. The function is now understaffed and submits a request to matching with the new demand of employees. Some of the functionless employees or other jobless employees that match the requirements better, will occupy the function. The function will enter the balanced state again.

Secondly, employees can be promoted to a new function regardless of the function having an actual demand. An example is promotion on the basis of seniority. The function will change to the state of overstaffed. The only possibility to change the state toward balance is, that employees leave the function after finishing their minimal period of staying in the function.

To cover the actual functions in the Royal Netherlands Navy the "function" database is converted into function objects. Functions which become valid in the future will be derived from future plans or scenarios. In the Royal Netherlands Navy case, the available individual function database is converted into clusters of function objects for the simulation.

7.3. Matching object.

The current models match supply and demand in an implicit way by the transition rates between functions. The assumption is that the promoted employees always match the requirements of the next function. In this new model, the matching will take place explicit. A match will occur between the present competencies represented by the employees and the necessary competencies required by the organization to fulfill its business goals.

The objective of the matching is to avoid the rigid connections and placement of employees in the flows of the current models, and to allow for a flexible structure of matching supply and demand of competencies. For an overview or the matching process see figure 6.

Matching can be based on the scenario which can use different matching strategies to calculate if an employee and function match. We can even go as far as using different strategies for different functions. For example in higher management functions the education is less important than the type and number of functions that have been occupied in the organization. While for the function of torpedo-maker the only thing that matters is to have the right education and the ability to work secure. When employees or functions enroll in matching, their matching score will be calculated based on the current matching strategy. The matching object match the scores with the current available function or employee scores. If no match can be established, the score will be recorded and matched against future requests.

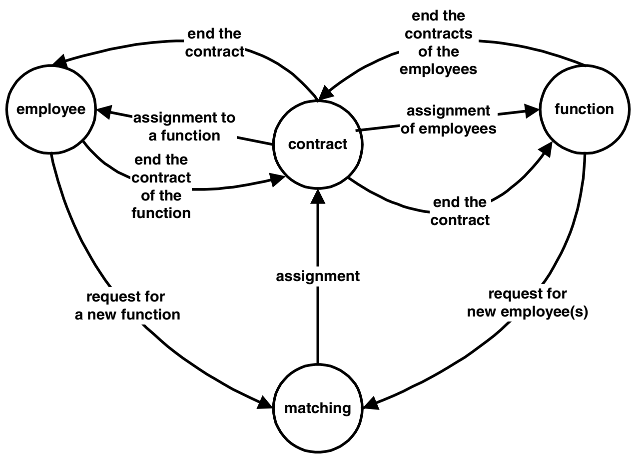

Figure 6. Matching process

The matching process can be viewed from two perspectives, employee and function. Both will be discussed. An employee triggers matching when it is in the state 'functionless' or 'free to change from function'. When an employee is functionless it transfers its particularly competencies. The moment matching finds a fit with the requirements of an function which is understaffed, a contract-object is created by the matching object. The contract is an intermediary object – and also the only connection – between the employee and the function. It provides the employee with data from the function by requesting it from the function object. This data contains for example function code, minimum time in function, and training that must have been received. The contract also informs the function after matching that it can increase the number of active employees with one.

Suppose an employee is 'free to change from function', and after a request to matching it is assigned a new function. When the new contract provides information on the new function, the employee realizes that he already has a contract. The employee will notify the current contract that the assignment has ended, which is allowed because the employee is 'free to change from function'. That contract will on its turn notified the old function. After that the new assignment can take place. Thus an employee can have only one contract at a time.

When a function becomes overstaffed it will terminate all its contracts. The employees will be notified by their contracts and become functionless. The function is now in the understaffed state and sends an request to matching. Another way for a function to become understaffed is when an employee finds a new function. When a function becomes understaffed it will send a request to matching with the requirements a potential employee must fulfill. If matching finds a employee a contract will be established. The employee will be notified by the contract which function it will occupy from now on. Furthermore the number of active employees on the function will be raised with one. In contrast with an employee, a function has more than one contract. The maximum for a balanced state is equal to the number of employees needed.

This design gives the possibility to implement many different types of matching objects with different matching algorithms to accurately model assignment in specific parts of the organization. The function and employee objects only communicate through the intermediary contract. They both can act independently of each other. No fixed connections exist. As a result, functions can become not valid and employees can be discharged without any trouble. The contract will be terminated and the involved function will become understaffed or the employee becomes functionless. Both will make a new request towards matching.

The first experiments with the described design show that the processing time of matching stays low.

8. Conclusions

A description has been given of the problems that arise within the Royal Netherlands Navy for getting insight in how to reallocate their manpower in the best way possible under changing circumstances. An overview has been given of current human resource forecasting models. The information the current models provide does not match the needs of the Royal Netherlands Navy. Current flow-oriented human resource forecasting models have several drawbacks:

1 They depend heavily on historical data to predict transition rates between functions, while this data may no longer be applicable in a changing world.

2 They lack data on transition rates when new functions appear in the organizational structure.

3 The model reports only on numbers of employees in a function.

4 Insight into the effects of new requirements to enter functions cannot be made visible.

Therefore it is impossible for the current models to give accurate insight in the future allocation of employees on functions.

This paper introduced a conceptual simulation based model that is matching-oriented. The observed inflexibility to make changes in the job-structure of a flow-model, through explicit specification of transitions between functions has disappeared in the matching model. Functions have no mutual relationships in the matching model. The matching between functions and employees is based on their respective properties.

The signaled impossibility to incorporate job contents, and thus changes in job contents in the flow-model also can be solved by specifying the requirements of a function, which an employee must match to obtain that function. New functions do not pose a problem, because the specifications of the function requirements are known in advance. Transitions take place automatically.

The only parts of the model for which historical data is needed are absence generators, the voluntarily outflow of employees, and, in case or organizations with an internal labor market like the Navy, the inflow. Therefore the matching-oriented model is less dependent on historical data.

For the functional specification of the matching concept, object orientated modeling proves to be useful. An example is the use of state transition diagrams. The different states an employee, function or matching object can be modeled together with the events that trigger the state changes. It proves to an be an good method to communicate with the content experts of the Royal Netherlands Navy. The results are that they have a good insight and confidence in the functional specification. The implementation of the system in the simulation language MODSIM III is being carried out at the moment.

To analyze the effects of different scenarios on the organization, only the set of new functions and their requirements needs to be known. The matching between employees and functions will now give the occupation of functions by employees automatically. Thus, the simulation itself generates the patterns of personnel flows through the changed organization.

The main conclusion of this project is that the matching-oriented approach for human resource forecasting promises to provide better insight in the dynamics of the occupation of functions and the allocation of employees on functions over time. Therefore organizations can get better insight into the impact of proposed changes in the organization, which leads to a more underpinned long-term human resource policy. As a consequence the Royal Netherlands Navy now has the possibility to investigate and evaluate the consequences of the proposed changes in strategy.

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