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A multi-objective genetic type-2 fuzzy logic based system for mobile field workforce area optimization

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ABSTRACT

In industries which employ large numbers of mobile field engineers (resources), there is a need to optimize the task allocation process. This particularly applies to utility companies such as electricity, gas and water suppliers as well as telecommunications. The process of allocating tasks to engineers involves finding the optimum area for each engineer to operate within where the locations available to the engineers depends on the work area she/he is assigned to. This particular process is termed as work area optimization and it is a sub-domain of workforce optimization. The optimization of resource scheduling, specifically the work area in this instance, in large businesses can have a noticeable impact on business costs, revenues and customer satisfaction.

In previous attempts to tackle workforce optimization in real world scenarios, single objective optimization algorithms employing crisp logic were employed. The problem is that there are usually many objectives that need to be satisfied and hence multi-objective based optimization methods will be more suitable. Type-2 fuzzy logic systems could also be employed as they are able to handle the high level of uncertainties associated with the dynamic and changing real world workforce optimization and scheduling problems.

This paper presents a novel multi-objective genetic type-2 fuzzy logic based system for mobile field workforce area optimization, which was employed in real world scheduling problems. This system had to overcome challenges, like how working areas were constructed, how teams were generated for each new area and how to realistically evaluate the newly suggested working areas. These problems were overcome by a novel neighborhood based clustering algorithm, sorting team members by skill, location and effect, and by creating an evaluation simulation that could accurately assess working areas by simulating one day's worth of work, for each engineer in the working area, while taking into account uncertainties.

The results show strong improvements when the proposed system was applied to the work area optimization problem, compared to the heuristic or type-1 single objective optimization of the work area. Such optimization improvements of the working areas will result in better utilization of the mobile field workforce in utilities and telecommunications companies.

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1. Introduction

For large companies with high numbers of mobile staff, efficiency can have a significant impact on many areas of the business, most importantly operation costs and revenue. This particularly applies to large utility companies that provide services such as water, electricity or telecoms.

One area of efficiency that is key is the optimization of allocating engineers to available tasks. Assigning each engineer the right set of tasks can be crucial in increasing the amount of tasks completed satisfactorily across the organization. The increase in completed tasks can lead to the improvement of customer satisfaction, as customers have to wait less time for services to be delivered to them. This also has the potential to increase revenue as there is more capacity to take on new customers. Furthermore, the increased utilization of the engineers has the potential to lower costs, as this will mean using the existing set of engineers to execute the given tasks within their working hours, rather than paying more money for overtime expenses or hiring external workforces to complete the given tasks [17,23].

A way in which the utilization of the engineers can be improved is by optimizing the area the engineers are assigned to. These areas, known as working areas (WAs) or work locations (WLs) [23] create the boundaries in which groups of engineers (teams) work within. These boundaries contain geographical areas and generate demand (tasks) for the engineers. However they also restrict the tasks that can be allocated to the engineers. If the WAs are not optimal, this will have a direct impact on the overall resource utilization.

In [17] the work revolves around a genetic fuzzy approach to assigning tasks to resources. However it does not look at the designs of the WAs the engineers work in. It does not generate new teams and it does not take into account factors such as travel or the imbalance of hours between the WAs. So this work greatly expands on the concept of workforce optimization but in a number of different ways, meaning the work noted in [17] could lead to sub-optimal solutions because it does not aim to optimize all the necessary factors that contribute to an engineer's utilization.

The overall structure and size of a WA can depend on the organization's management structure. As a number of WAs may be grouped together to form a region for the organization's higher level managers to oversee. This type of organization structure is a tree structure and is very common, as it is the same structure that is used in the military.

Fig. 1 illustrates an example of how the United Kingdom (UK) may be split up into areas and the management structure in place to oversee the operations of these areas. In this example, the director is responsible for 3 regional managers. The South UK regional manager has *N* number of sub-region managers (indicated by the dashed line) they are responsible for. A sub-region manager is responsible for *N* number of branch managers (indicated by the dashed line). Finally, the branch managers are responsible for a team of engineers which is divided into sub teams. These sub teams operate in their respective working areas, there can be between 1 and *N* number of WAs (indicated by the dashed line in Fig. 1).

The combination of the geographical working areas, the management structure and resource planning all contribute to the organization's efficiency and therefore needs to undergo an optimization process. This is to increase the efficiency with lower costs, as well as reducing travel costs or time dependent penalties and increasing the demand satisfaction. There are other secondary benefits involved with an optimized organizational structure, including the reduction of the organization's ecological impact (via less travel) and improved working conditions for engineers and managers.

Given the potential benefits of increasing an organization's efficiency, there have been a number of methodologies investigated to tackle the problem of optimizing workforce scheduling where heuristic techniques are widely applied. However a

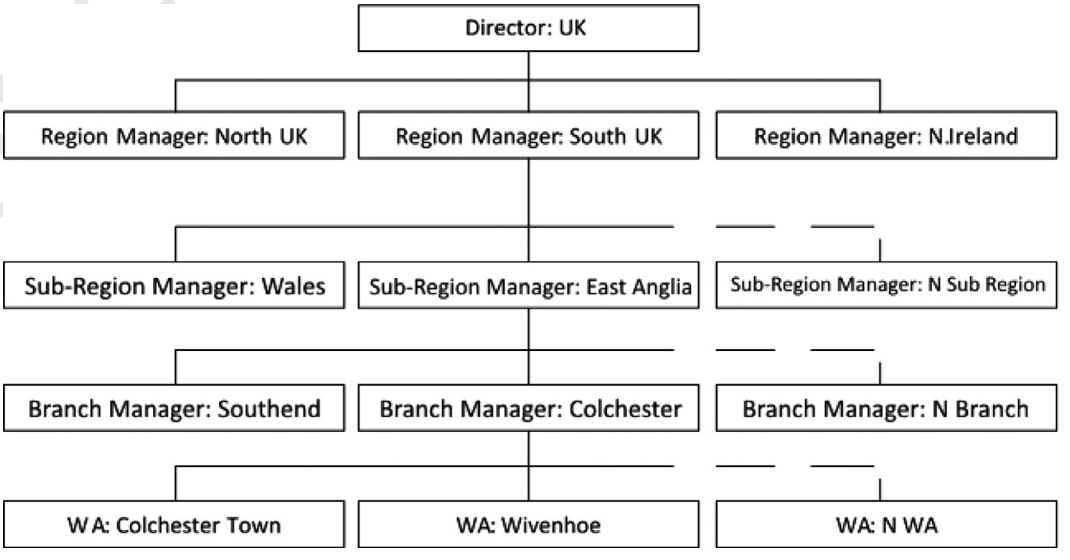

Fig. 1. Management tree structure example.

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