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AWSM: Allocation of workflows utilizing social network metrics

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ABSTRACT

The primary contribution of this work is a methodology that serves as a decision support tool to create teams of human actors within an organization to perform workflows, based on optimizing social network (SN) measures of choice, such as group or team cohesiveness. Past literature shows that the constituent activities of the workflows will be performed with greater efficiency and/or effectiveness if the workgroup of actors is optimized along an SN measure such as group cohesiveness. The major contribution here is the creation and implementation of a formal generalized methodology we call AWSM (Allocation of Workflows with Social Network Metrics) that incorporates ideas from two diverse fields: social network theory and workflow modeling, and allows optimization of work groups along any SN metric. In order to implement this model we present newly created algorithms to structure and represent the problem so that standard integer programming solvers can be utilized to solve it. We also present a performance analysis of the AWSM methodology and empirically test its feasibility for solving real world sized problems.

1. Introduction

1.1. Motivating example

Jill is the CEO of ACME Bicycles. She supervises the daily work activities of over one hundred employees, where each can perform one or more of several roles such as finished goods inventory clerk, shipping clerk, lathe specialist, milling machinist, design engineer, engineering supervisor, product development manager, marketing manager, salesperson and so on. Several employees have been cross-trained in their roles, after a new enterprise information system was acquired and installed, that provided a uniform interface and data store for the entire organization. Like almost all organizations, the work load at ACME can be modeled using several workflow types. Examples of workflow types include ordering, receiving and stocking raw material, ordering, receiving and stocking outsourced manufactured goods material, building and storing finished bicycles, brainstorming over the next bicycle design, drawing out the strategic plan for the next 5 years and so on. Like most organizations, each workflow type at ACME can be decomposed into activity types performed in order to complete a workflow type. The overall workload at ACME over a time period consists of multiple instances of each workflow type to be executed within that time period.

Jill has observed that some instances of the same workflow type are performed more effectively or efficiently than other instances. She also understands that some groups of people work better together, and when these groups are allocated an instance of a workflow type, it tends to get done “better” (faster or more effectively) than another instance of the same workflow type allocated to another group. *She is wondering if there is a way to optimally allocate work amongst her employees, taking into account the knowledge of how well people work with each other.*

Business processes usually consist of a number of interrelated activities, performed by people with different skill-sets or roles. Recently, there has been extensive interest in the *workflow management systems* that provide a means of automating the allocation and scheduling of the interrelated activities that constitute the workflows. As pointed out in [22], most activities in an organization are executed by a number of agents, possessing different skill-sets. In their description of the dynamic allocation of workflows to agents, [34] point out several shortcomings with current allocation approaches. These limitations primarily stem from an inability to deal with uncertainty, and to incorporate knowledge about the organization into the allocation process. This lack of the incorporation of organizational knowledge is also recognized in other works such as [9,22,40]. Social networks in an organization constitute an important aspect of organizational knowledge [13], and are used explicitly in our work to help allocate workflows.

Workflow allocation has also been studied in the *job design* literature in human resource management [12,24,26,29,55]. Typical issues in this area include trade-offs between serial and parallel

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production, employee motivations and incentives management. However, studies in this area also have not typically considered relationships between agents when allocating workflows, which is the focus of this work.

A rich body of literature dealing with *social networks* (SN) exists in the social sciences. The sociocentric approach to SN [41,50,56] typically deals with measuring and quantifying the relationships between individuals in a group. The focus is on measuring the structural patterns of interaction and how these patterns can explain outcomes. According to [7], "The social network perspective assumes that actors (whether they be individuals, groups, or organizations; rational or political) are embedded within a web (or network) of interrelationships with other actors. It is this intersection of relationships that defines an individual's role, an organization's niche in the market, or simply an actor's position in the social structure." Graph based analyses in the area utilize measures like *centrality* and *network density* to characterize different groups, based on individual links between members (nodes) of that group. Centrality of each member can be characterized by the number of other nodes to which the member is linked [6]. Network density reflects how reachable a node is, on average, from any other node in the network.

In this work, we take a first step *towards incorporating ideas from SN to the problem of workflow allocation*. The primary contribution of this work is a methodology that creates workflow teams of human actors within an organization, based on optimizing a social network (SN) measure of choice *e.g.,* group or team cohesiveness. Past literature shows that the constituent activities of the workflows will be performed with greater efficiency and/or effectiveness if the social characteristics of the workgroup of actors are optimized along an SN measure, such as team cohesiveness [30,48,49,51]. Of course, metrics *other* than team cohesiveness may also drive efficiency and/or efficacy. For example, consider an allocation of workflows dealing with the planning of a major restructuring. These could conceivably require extensive working knowledge of and influence within the organization and may be performed more effectively if allocated to a group of actors that is maximized along the SN metric of *organizational centrality*, *i.e.* actors who are all central players in the organization.

Our contribution here is the development of a methodology and infrastructure we call AWSM (Allocation of Workflows utilizing Social Network Metrics), that can be used to allocate a generic set of workflows within an organization, to optimize workgroups along any SN metric chosen by the manager. The research paradigm we employ here is design-science based [25]. The artifact developed is the AWSM methodology, which is tested here under industrial strength loads. The theoretical contribution of the artifact developed is to allow the subsequent testing of theories linking social network measures to workflow performance.

The rest of this paper is organized as follows. In Section 2, we describe earlier work on workflow allocation amongst agents and the application of social networks to this allocation. Section 3 consists of a detailed description of the AWSM methodology, including the model, algorithms, an illustrative example and performance analysis. We discuss applications of AWSM in Section 4 and conclude with limitations and future research opportunities in Section 5.

2. Previous work

2.1. Workflow allocation

The allocation of resources to workflows has long been recognized as an important problem as highlighted in [4] where the middle level of process management is said to deal with this issue. Workflow allocation has been investigated in several different areas in the literature. In the automated workflow management systems (WFMS) area, attention has been paid to the dynamic allocation of activities. [22] points out that most WFMSs refer to underlying organizational role lists in order to allocate activities to machines accessible by agents who can perform these roles. [34] provides several shortcomings in the activity allocation methods of WFMSs, many of which can be attributed to a lack of organizational knowledge on the part of the WFMS. One of the pioneering attempts to overcome these limitations is presented in [34], with the use of object constraint language (OCL) to model teams of agents and their relationships in an organization. A limitation of this approach is that OCL does not support concepts that are usually used to characterize *organizational relationships*. Similarly, [40] uses an object-oriented language to model organizational constraints, with the same limitations. A third approach in [9] uses the event-condition-action framework to model organizational constraints. The AWSM methodology presented here complements these approaches in that it is a static methodology consisting of a series of calculations, which can be implemented alongside a dynamic selection scheme in a WFMS. Further, AWSM explicitly utilizes social network metrics, which traditionally have closer ties to organizational modeling than methods used in some of this earlier work.

In the human resource area, task or function allocation usually deals with the allocation of tasks to people versus machines, and to allocate tasks with a view towards maximizing employee satisfaction. The simplest allocation mechanism consists of a list of tasks that are more appropriate for people versus machines [17]. More recently, static and dynamic allocation schemes have been proposed that trade off criteria such as task criticality, job satisfaction, motivation, efficiency and training requirements [11,27]. [44] provides a list of requirements that allocation schemes should fulfill. Some requirements proposed that are relevant to our study include that the allocation scheme should be usable early in the work design process, should have a structured format and should be able to cover allocations between humans in different roles. In this context, the AWSM methodology described in this work is a static scheme that can be used by managers in the early stage of work periods. Further, the AWSM methodology caters to different roles amongst actors, and may be used to optimize a social network metric that has been shown to correlate positively with work efficiency, employee satisfaction, and other variables of interest in the human resource area. Hence, AWSM complements existing work in the human resource area on task allocation.

A third area that examines task allocation methods is in computer science, in distributed information systems, where tasks have to be allocated to multiple computer processors. The criteria in this domain include the minimization of communication costs [43] and the maximization of throughput. Both static and dynamic allocation schemes have been considered in this area, with the static schemes assuming knowledge of the characteristics of the workload [39]. Much of the emerging work in this area involves dynamic schemes that are heuristic based [38] rather than mathematical programming based, because of the real-time requirements of workload allocation for computer processors. A pricing scheme is proposed in [31], to improve the quality of service of Internet traffic. In the area of web services, a market based mechanism is proposed in [45], using the *DiffServ* architecture, so that quality of service for premium services is enhanced.

The AWSM allocation method is different because it uses mathematical programming for optimization, rather than heuristics, and models workflows linked to roles. This is very different from generic tasks or services performed by a computer processor (a single "role"). Finally, AWSM uses social network measures as the optimizing metric, rather than communication costs.

2.2. Social network measures

A social network is a structure whose nodes represent members in a social context and whose edges can represent interaction links,