

A Visualized Tool of Role Transfer

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Abstract— When a crisis occurs, decision makers experience high tension and must make a decision in a short time. An automated tool with accurate analysis capability would help them make correct decisions. This paper presents a visualized tool to help a decision maker understand the structure of a group based on roles and agents (or people). The significant contribution of this tool is that it provides an exact solution to check if a group is workable, and if an agent (or a person) is critical for a group. It also suggests a role transfer scheme implementing time sharing mechanisms for when there are an insufficient number of agents (people) to complete a task simultaneously. Because role transfer is a fundamental problem in management, task assignment, and training, this tool can be used in many different ways, such as, training and management. It is also a direct assistance tool for crisis responses.

Keywords— Role, role transfer, visual tool, emergency management systems, and crisis responses.

I. INTRODUCTION

In emergency situations, decision makers experience high tension and must make a decision in a short time. It is dangerous for decision makers to make a critical decision based on proposals without accurate analysis results. Role assignment is one of the most important tasks in an emergency situation. Good role assignment often determines the success of a war, battle, project, task, rescue, etc. A group should work well after the group leader's role assignment commands are issued. The pre-assignment and re-assignment of roles are very important for a decision maker, such as, an organizer, manager or commander. To reassign roles, role transfer is required.

In reality, role transfer is a fundamental problem in organizations [1], emergency management systems [15] and highly-available systems. It is used to evaluate and check the flexibility of a group when its memberships and/or roles change. A group's workability is dependent on its organization and the relationships between roles and agents. To check if a group is workable, we need to find a successful role transfer. It is critical for a group of people to work together to approach the goal of a group. It is also a key problem in role-based collaboration. A decision maker should recognize this problem and quickly find a solution for a role transfer problem in order to make the group work well.

Our previous work [20, 21] demonstrates that a practical role-transfer algorithm can help decision makers of a group determine which agent (person) in the group is critical. A critical agent is an agent required for the group to be workable (role transfers might be required). In the following discussions,

agents may be people, system components and systems, while roles are composed of responsibilities or tasks.

To solve role transfer problems requires high intelligence. Especially in an emergency situation, a decision maker will benefit from an automated tool to help him/her reassign tasks and guarantee that a group works well. A visualized tool can help decision makers quickly understand the structure of a group and make correct a task/role reassignment based on the tool.

The rest of this paper is arranged as follows: Section II describes what a role transfer problem is; Section III demonstrates the functions of the tool. Section IV illustrates the architecture of the tool; Section V presents some examples of solutions provided by the tool; Section VI reviews the related work; and Section VII concludes the paper and discusses the future work.

II. ROLE TRANSFER

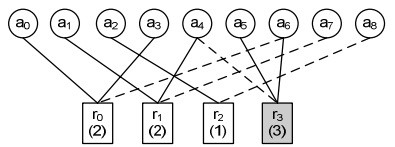
A role transfer problem can be formalized based on our previously proposed E-CARGO model and role-based collaboration [19]. In E-CARGO, agents are used to express entities possessing intelligent properties such as active, proactive, autonomous, and autonomic. For example, people are and some system components are agents. Roles are entities to express agents' rights, tasks, duties or responsibilities of agents. Roles can show the dynamic properties of agents.

A role (r) is assigned to one or more current and potential agents, where current agents are currently working for that role they are playing and potential agents possess the ability to play the role but not currently working for that role. A group (g) is built on an environment (e). An e confines a number bounds [l , u] for each role, meaning how many (l , called the lower bound) agents are required for this role to work properly and how many (u , called the upper bound) agents can be accommodated by this role. *A role works well when it obtains enough (l) agents to currently play it. A group is workable when all its roles work well.* A currently non-workable group may become workable after a role transfer. To simplify, in the following discussions, only l is considered.

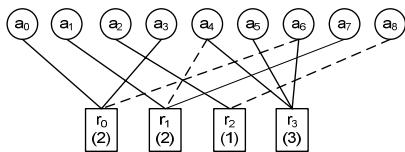
To understand the role transfer problem, we give examples as follows. In this discussion, we use \mathcal{A} to express all the agents and \mathcal{R} all the roles in a group. In the following figures, a circle is used to express an agent; a frame a role, a dark framed a role having not enough current agents; a solid line a current agent (role) and a dashed line a potential agent (role). We also use r_0, r_1, \dots to express role names and a_0, a_1, \dots agent names. A

number in a parenthesis in a frame is the required number (i.e., l) of current agents for this role.

Therefore, In Figure 1 (a), because role r_3 has only two current agents but requires three, the group is not in its working state and requires role transfer. Figure 1 (b) is one state after a successful role transfer, where, all the roles have enough current agents.



(a)



(b)

Figure 1. A Not Workable Group Becomes Workable

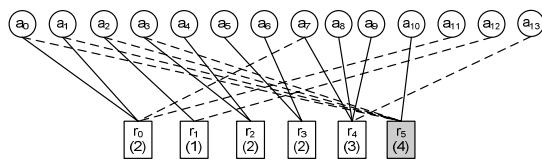
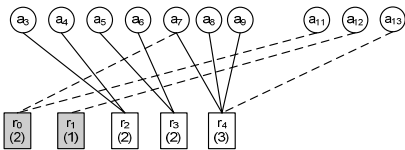
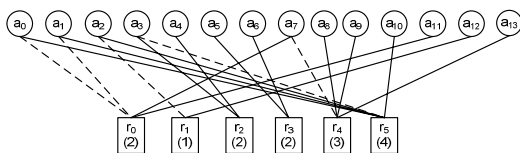


Figure 2. A Not Workable Group



(a)



(b)

Figure 3. The Solution to Figure 2

Let us consider a real-world case. Suppose a fire brigade (Figure 2) in an emergency situation where a building is on fire, r_5 is a role to rescue the people at the fifth floor. It requires 4 firemen. The commander finds that only role r_5 has not enough agents, then he commands some of those who are able,

to climb the building and rescue people on the fifth floor. However, after he has issued this command, he finds that both r_0 (the pumper operator) and r_1 (the fire truck driver) do not work well (Figure 3(a)). At this time, the situation worsens, i.e., two roles cannot work properly. He needs to issue more commands. Fortunately, he finally finds a solution as shown in Figure 3(b).

These two examples show that role transfer is a complicated problem. In a group, there may be many roles not workable; each of them may require one or more agents. The necessary condition for a group to be workable implies that there must be enough agents.

In a real emergency situation, scarcity often occurs more than sufficiency. It is required to repeatedly assign roles to an agent in different time segment due to the scarcity of agents. At one moment, there are many (>1) roles each of which loses many (>1) current agents; at the same time, $|A| < |R|$. To deal with this situation, we need a temporal role transfer scheme.

This problem may have two cases:

Case 1: Strong restriction. We need to find a scale s and a role transfer scheme to guarantee that in any interval T , every role has enough current agents in at least a period of time T/s . For example, to play a role of *piano mover*, four players are required. Hence, the *piano mover* works only when all four players are currently playing it.

Case 2: Weak restriction. We need to find a scale s and a role transfer scheme to guarantee that in any interval T , every role r_i must be played l time segments. For example, a role of *instructor* requires 4 people to offer 4 courses to students. The role works when 2 of them repeatedly offer 2 different courses. It is fine with the students as long as the schedule is not in conflict.

The role transfer tool should provide solutions for the above requirements.

III. THE FUNCTIONS OF THE TOOL

From the above discussions, we know that a group with roles and agents can be shown in a graph similar to Figures 1-3. Even though it is not very difficult to draw a graph with the current drawing tools, it is difficult to change and modify the graph for different situations and they do not tell if agents are critical and if a group is workable. Our tool provides an easy way to form a group, to express the assignment of roles to agents and to show the changes of a group. With the support of specially designed algorithms [20, 21], it can tell if a group is workable, if there is a successful role transfer in a group, if an agent is critical in a group, and if there is a scheduling scheme when there are not enough agents to play all the roles. These jobs are highly intelligent and the answers for these questions are required to be definite especially in an emergency situation.

The tool aims to assist decision makers to schedule personnel for different positions in a crisis situation. It must provide a list of functions of the management of a group. With the E-CARGO model for role-based collaboration [19], we designed the following functions for groups (G), agents (A), and roles (R), where, classes (C), objects (O) and environments

(\mathcal{E}) are the tool's internal components that are not visible to users.

Group:

- Create: create an empty group.
- Open: open an existing group.
- Save: save a group to a file.
- Print: print the current group.
- Check state: express whether the group is workable or not.
- Transfer: show the workable state of the group if there is a successful role transfer or a message if not.
- Temporal transfer: provide a temporal role transfer scheme when the agent number is less than the required number in a group.
- Critical agents: check if there are critical agents in the group.
- Zoom in/out: scale the size of the icons of agents and roles to accommodate the whole view of a group.

AGENT:

- Add: add an agent to the current group.
- Delete: delete an agent from the group.
- Change: change the property/profile of an agent.

ROLE:

- Add: add a role to the current group.
- Delete: delete a role from the group.
- Change: change the property of a role.

Role/Agent Assignment:

- Current role/agent: create a current assignment link between an agent and a role.
- Potential role/agent: create a potential assignment link between an agent and a role.
- Delete an assignment: delete the selected assignment link between an agent and a role.

IV. THE ARCHITECTURE ALGORITHMS OF THE TOOLS

By E-CARGO [19], a role-based system Σ can now be described as a 9-tuple. $\Sigma ::= \langle C, O, \mathcal{A}, \mathcal{M}, \mathcal{R}, \mathcal{E}, \mathcal{G}, s_0, \mathcal{H} \rangle$, where, C is a set of classes; O is a set of objects; \mathcal{A} is a set of agents who are representatives of human users; \mathcal{M} is a set of messages; \mathcal{R} is a set of roles; \mathcal{E} is a set of environments; \mathcal{G} is a set of groups; s_0 is the initial state; and \mathcal{H} is a set of users.

With the participation of users \mathcal{H} , e.g., logging in a system Σ , accessing objects of the system, sending messages through roles, and forming a group in an environment, Σ evolves, develops and functions. The results of interaction among

objects, agents, and human users are a new state of Σ that is expressed by the values of $C, O, \mathcal{A}, \mathcal{M}, \mathcal{E}, \mathcal{G}$, and \mathcal{H} . We include \mathcal{H} to emphasize a human-machine system. If we concentrate on the computer-based systems only, \mathcal{H} can be ignored. Actually in this paper, we do not include \mathcal{H} in the design of the tool. The initial state s_0 is expressed by initial values of all the components $C, O, \mathcal{A}, \mathcal{M}, \mathcal{R}$, and \mathcal{E} , such as, built-in classes, initial objects, initial agents, primitive roles, primitive messages and primitive environments.

The tool's internal architecture totally reflects the E-CARGO model. Our previously proposed kernel mechanism for RBC [19] can be directly applied in this tool. The major challenge is to link the kernel mechanisms to the Graphical User Interface (GUI) components (Figure 4). In the GUI part, we create lists of GUI objects such as agents, roles, connections, and groups. These GUI objects are all used to store the information for the GUI and each has a link with its corresponding internal component.

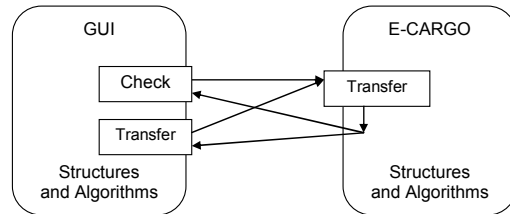


Figure 4. The Architecture of the Tool

To implement the tool of role transfer, a set of computational algorithms are required. Role transfer is in fact a search for enough agents to fill every specific role under some conditions. Therefore, the algorithms applied in this tool are mainly based on exhaustive searches. To implement these algorithms, matrices are applied to express a group [21]. Our early solutions [20, 21] only solved a special case of role transfer problems. This tool applies the newly developed algorithms which can be used to solve all the role transfer problems mentioned in this paper. The details of these algorithms will be discussed systematically in another paper.

V. EXAMPLES OF ROLE TRANSFER

With this tool, we can easily solve the fire brigade problem shown in Figure 2. The problem is expressed by the tool as shown in Figure 5 and the solution is in Figure 6.

Another example is a temporal transfer with the strong restriction. By temporal role transfer, we mean that there are not sufficient agents to fulfill each role and agents' time must be shared by the roles. As shown in Figure 7, the total number of agents required by the roles is 8, but the agent number is only 5.

Suppose that 5 professors are required to offer 3 courses (roles) (r_0, r_1 , and r_2) for 8 sections of students (Figure 7). Course r_0 has 3 sections at the same time, r_1 has 2, and r_2 has 3. Evidently, a professor cannot offer the different sections of the same course at the same time segment. Therefore, Figure 7 is not workable but Figure 8 is an acceptable schedule.

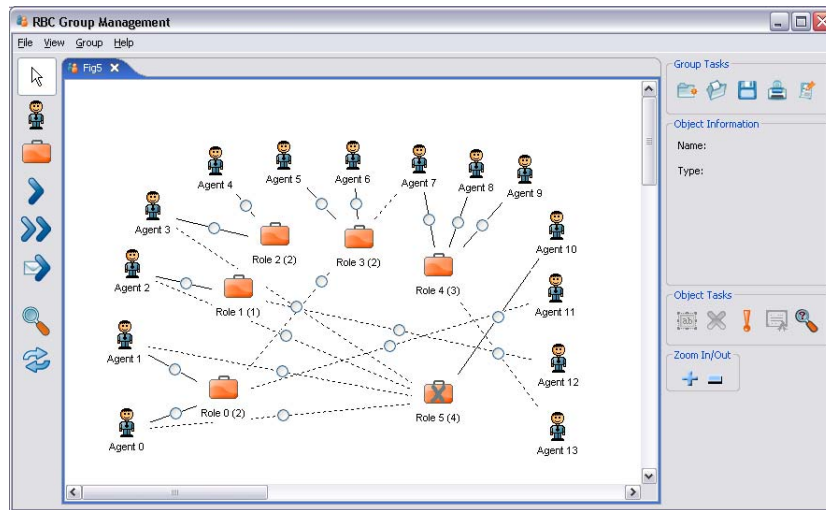


Figure 5. The fire brigade is not workable

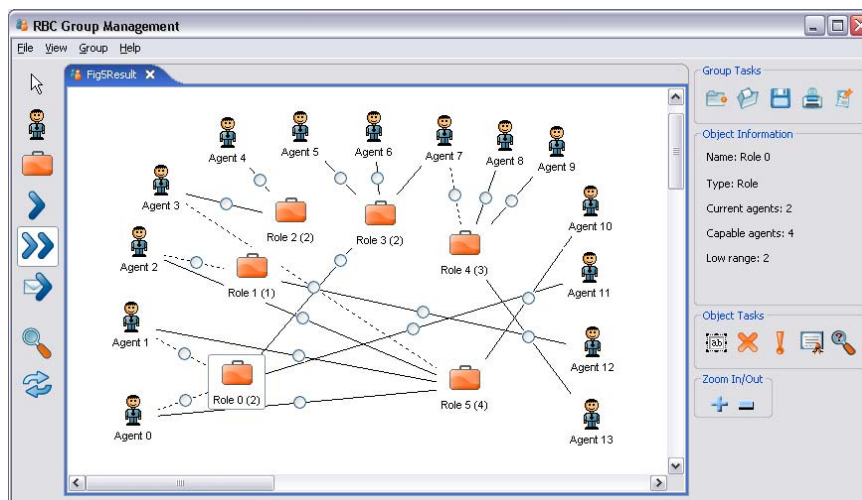


Figure 6. The fire brigade is now workable

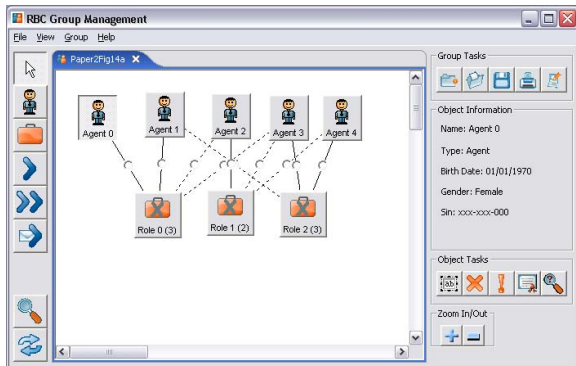


Figure 7. A Temporal Transfer Example

VI. RELATED WORK

Although role transfer is evidently a generally important problem in management [4] like, organizational behavior and performance [1, 3, 4, 11], system design [10], system construction [2], scheduling, training and commanding [15], there is no comprehensive research on role transfer theory and practice. Some related research regarding those in agent systems [5, 7, 13, 14, 16] and wireless communications using the term role assignment [9] and others mainly investigate people's or organization's behaviors when role transfer happens and they use the term role transition [1].

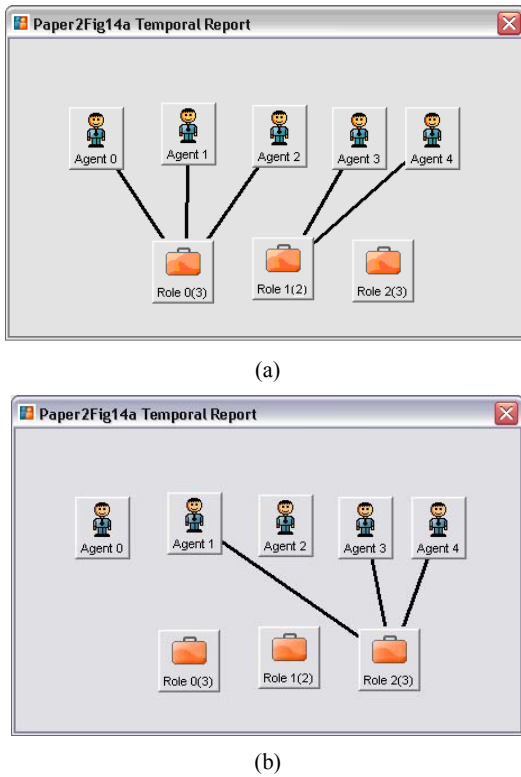


Figure 8. The Temporal Transfer Scheme with 2 Intervals (Strong restriction)

Some other relevant research is from psychologists and the major concerns are the behavior of people and organizational performance when role transition occurs [3, 11, 12].

Research on the delegation of rights (tasks, authorization, permissions, responsibilities, or even roles) [6, 8, 10, 17] also deals with the problem of transferring rights (permissions, responsibilities or roles) to neighbor agents or subordinate users. It mainly provides policies, rules or protocols to guarantee that the transfer (sometimes copy) process is possible, complete, trustable and secure. The results are mainly used for computer security.

In failure resilience [9], the concerned problem is how agents are designed such that they can dynamically join and leave an agent group to replace the faulty agents. Related research in this direction concentrates on providing algorithms and protocols to guarantee that the system still works when some agents do not behave properly.

All the above research shows that there are indeed strong needs to investigate role transfer problems and solutions. The results presented in this paper will find their applications in many different fields, such as, information systems, management, production, and manufacturing industry.

VII. CONCLUSIONS

A visualized tool for role transfer based on the algorithms we have proposed and implemented in our previous work [20, 21] is presented in this paper. Because role transfer is a fundamental problem for many applications, this tool may be applied in many fields, such as, management, commanding, task management, and training.

Another meaningful expansion is to check if a group of agents are critical to the group they belong to. In fact, this is more complicated than those solved by the presented tool. Suppose, in one group, there is not a critical agent. However, we still need to know if there are some agent combinations are critical to the group. By a critical agent set, we mean that a group cannot be workable after all the agents in the set leave the group, i.e., no successful role transfer exists. In such a case, we need to develop an algorithm to check agent combinations' critical properties, i.e., to deal with role transfer problems when many roles lose agents. Related HCI work to be done is designing some HCI operations on how to group agents together before checking with the proposed algorithms.

Other future work includes expanding this tool to support initial role assignment or pre-assignment, i.e., specifying agents with qualifications such as resume or curriculum vitae, specifying roles with requirements for skills and qualifications, and match agents and roles with the specified requirements. When a role assignment command is issued, the system will report if the agent is not-qualified, matching, or over-qualified. This function will give more assistance to decision makers. Last but not the least is to provide more usability by asking for users' opinions.

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