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Koichi Kurumatani
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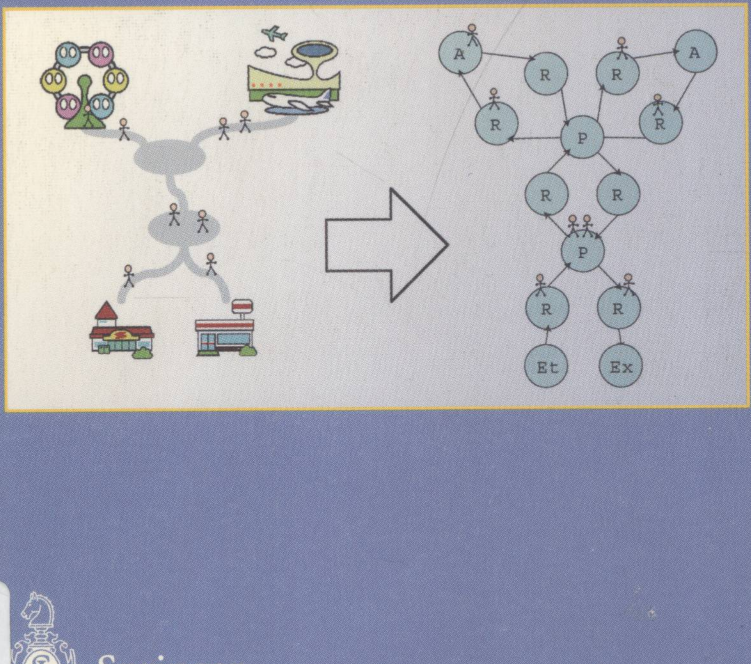
Multi-Agent for Mass User Support

International Workshop, MAMUS 2003
Acapulco, Mexico, August 2003
Revised and Invited Papers



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Preface

This volume is the postproceedings of the Workshop on Multiagent for Mass User Support 2003 (MAMUS 2003). It consists of revised papers presented at the meeting and invited ones based on the program committee's recommendation. The workshop was organized in association with the 18th International Joint Conference on Artificial Intelligence (IJCAI 2003), August 10, 2003, Acapulco, Mexico. The aim of the workshop was to investigate new directions of multiagent technology and its applications to support mass users and society by using social coordination mechanisms in both the artificial intelligence and social science senses.

Multiagent and agent-based simulations have been providing new methodologies and viewpoints for studying societies. They are becoming effective tools for modeling and simulating social systems. On the other hand, the rapid progress of IT (information technology) such as ubiquitous or pervasive computing is bringing changes to communications, decision-making processes, and even possibly to how people conduct themselves in their daily lives. People in a ubiquitous computing environment would be able to access information networks, communicate with each other, exchange information, and obtain sensing data on an everywhere, anytime basis. Such an information environment is expected to open up a new application field where each user's utility is increased and the efficiency of the whole system (society) is also improved. This is the objective of mass user support. In order to realize mass user support systems, we need to investigate the problem from the two viewpoints of social systems and information technology. By social coordination we mean analysis of social systems from the viewpoint of balancing the utilities provided to individuals and the whole system.

Papers included in this volume are categorized as follows. The *theoretical background* section includes two papers that characterize mass user support and social coordination. Kurumatani discusses the characteristics of the problem and gives its formalization and analysis. Chen proposes CE Lab, a platform where both human and software agents work together, especially to integrate experimental economics, behavioral economics, and agent-based computational economics.

The *resource allocation algorithms* section has three papers. Cheng proposes a market-based resource allocation algorithm for information collection in emergency scenario. Kawamura discusses the Theme Park Problem, in which he analyzes the effect of information provision on many users. Matsuo proposes story-based planning that generates visiting plans according to users' intentions and preferences.

Traffic systems is an important area of applications for mass user support. In the *Mass User Support in Traffic Systems* section, Yamashita proposes an algorithm for large numbers of users to exchange their driving plans in order to increase the utilities for individuals and the whole system. Shinoda analyzes the usability of dial-a-ride buses, especially their efficiency in large-scale towns.

Because mass user support essentially requires resource allocation among users, the problem can be formalized in the game theoretic sense as the simplest edge problem. The *game theoretic analysis* section includes two papers: Suzuki discusses role changes in the social dilemma game to manage limited common resources; Yamashita formalizes the dynamics of group formation mechanisms from the game theoretic viewpoint.

From the engineering viewpoint, it is crucial that we design large-scale systems that handle many communication and computation tasks in order to realize mass user support. In the section titled *Architectures for Social Coordination Mechanisms*, Amamiya and Pitt propose a multiagent system called KODAMA for managing individual digital rights for information trading. Murakami proposes Fairy Wing, which is a user profile accumulation system that works with RF-ID tags. Sashima proposes a multiagent architecture called CONSORTS for service coordination in a ubiquitous computing environment.

As the editors of this volume, we would like to thank the members of the program committee and the anonymous reviewers for their important contributions. We would also like to thank Akio Sashima for his typesetting of this volume.

Tokyo, February 2004

Koichi Kurumatani
Shu-Heng Chen
Azuma Ohuchi

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Mass User Support by Social Coordination among Citizens in a Real Environment

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Abstract. We propose the concept of mass user support realized by social coordination among citizens in a real environment. By real environment, we mean an environment integrating a world of abstract information such as the Internet with the physical world. Rapid progress in IT, especially ubiquitous or pervasive computing, is helping to bring about an environment where direct communication among citizens and realtime delivery of sensory information becomes possible not only within buildings but also in cities or in a driving environment. In the real environment, we can expect a new information service called mass user support that can be achieved by social coordination among users. An example of social coordination is dynamic resource allocation of spatio-temporal resources, i.e., traffic control for vehicles and pedestrians, by which the utility provided to both individuals and the whole system can be increased. In this paper, we first illustrate the concept of mass user support by giving several examples and then introduce a new kind of multiagent architecture called CONSORTS that is expected to be an infrastructure for social coordination. We analyze the characteristics of social coordination, compared with the conventional methods, and propose a course of software implementation to realize mass user support by coordinating users' intentions and preferences.

1 Introduction

We propose the concept of mass user support realized by social coordination among users in a real environment. By real environment, we mean an environment integrating an abstract information world such as the Internet with the real physical and spatio-temporal world where humans and physical objects exist. Rapid progress in IT, especially ubiquitous computing [1] or pervasive computing [2], is helping to bring about an environment where direct communication and delivery of sensory information can be done over wide areas, i.e., in buildings, cities, on roads, or nation-wide, rather than in a proximate environment shared by individuals.

In a real environment, we can expect a new kind of information service called mass user support that cannot be achieved by a simple combination of separate personal information services. For instance, let us consider a service to simultaneously help many vehicles and pedestrians to navigate. These days, many

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vehicles are equipped with car navigation systems that automatically make driving plans for the driver by using the current position of a vehicle and road maps in the car navigation system, and the system provides navigation service such as telling tuning direction at crossings to drivers during the trip. Some car navigation systems provide more sophisticated planning by using congestion information provided by VICS (Vehicle Information and Communication System) [3], i.e., these make plans to avoid congestion and to save total trip time.

We have, however, a question on the utility of such sophisticated services. What would happen when all drivers use such a congestion-avoiding planning strategy simultaneously? The answer is likely that many drivers would select roads that seem to be less crowded but in doing so make the roads crowded, which would in turn cause an oscillation in road traffic congestion that never converges. We can imagine the same situation in navigating many pedestrians in a building, theme park, or cities. It is quite possible that oscillation of congestion might occur if information about the current status of congestion were to be provided directly to pedestrians via information devices such as cellular phones or PDAs and then letting them choose the shortest path independently.

We need, therefore, some kind of coordination mechanism among users in order to provide good services under such situations, that is, we need to coordinate users' intentions and preferences socially. Mass user support is an information service that realizes such social coordination among users in daily lives by using cooperating software agents in a real environment. By social coordination, we mean automatic negotiation by software agents that work as proxies for users rather than explicit and verbal communication directly done by the human users themselves. The rapid progress of information network technology is expected to bring about a ubiquitous or pervasive network that will provide anytime, everywhere connectivity to information networks. In addition, we expect that mass user support will become one of the key services of the ubiquitous or pervasive network, besides the conventional information service images.

We have to pay attention to the difference between social coordination and collaboration. Collaboration is a highly organized activity done by human users in order to achieve goals, which usually needs long time before obtaining a solution. In contrast, social coordination requires realtime responses, e.g., drivers have to react rapidly to give a traffic lane to others. On the other hand, the best solution is not necessary in social coordination. If the best solution is unobtainable, the benefit may still be obvious; e.g., if we could reduce by only one percent of the total losses caused by a traffic jam in a city or in a country, it would bring much benefit to the economy and natural environment. Reflecting on the nature of the problem, social coordination requires different approaches from the ones developed for collaboration, e.g., CSCW (Computer-Supported Cooperative Work) [4], Collaborative Multiagent [5], conventional web-based meeting, and so on.

From the engineering viewpoint, we also introduce a multiagent architecture called CONSORTS, which is an infrastructure for electronic social coordination in a ubiquitous computing environment, by which software agents can trace users' movement histories, understand their intentions and preferences, construct user models, and negotiate with each other while protecting the users' privacy by using temporal identifiers. The functionality of mass user support is realized as a service agent in the architecture. The key functionality is realized by coordination of software agents, i.e., personal agents that serve as proxies for users, a service agent as the social coordinator, and a spatio-temporal reasoner.

After describing examples of mass user support and the CONSORTS architecture, we will analyze the characteristics of mass user support that cannot be formalized as a simple combination of personal services for individual users, and which consequently require coordination among users. We then compare various computational methods to realize the coordination. It seems useful to prepare some kind of standard problem in order to compare the methods in different environments.

2 Examples of Mass User Support

We can find many situations where social coordination is essential and a mass user support service would improve the efficiency and utility. In particular, mass user support is effective when we need to coordinate resources in a realtime manner, that is, realtime resource allocation is required. The aim of mass user support is to increase the efficiency of both individual users and the whole system simultaneously. Examples of application areas where social coordination is effective and mass user support is useful are as follows (Fig. 1):

1. Facility Usage and Layout Design:
   For pedestrian users, social coordination is expected to reduce waiting time in private or public facilities (e.g., at theme park attractions, or in stores, government offices, etc.), and also to increase the utility that each user may be seeking, e.g., fun, interest, or education. This kind of problem is called the Theme Park Problem [6][7].
2. Road Traffic:
   In the road traffic context, social coordination is expected to reduce traffic congestion and to shorten each driver's trip time, by coordinating users' driving plans according to their destinations and road constraints. The aim is not only to reduce congestion but also to increase each user's convenience and comfort. The problem is called the Car Navigation Problem [8]. Social coordination would also be effective to dynamically control driving plans of public transportation vehicles such as dial-a-ride buses [9].
3. Global Traffic Control:
   In addition to services for each driver and passenger, social coordination is also expected to control the global traffic system, e.g., to dynamically control intervals and durations of traffic signals, to change the direction of one-way streets, and to temporarily stop inflow to streets.
4. Supply Chain:
   Social coordination is useful to increase the efficiency of the supply chain by adapting it in a realtime manner to dynamically changing environments such as road traffic and whether, in contrast with conventional off-line scheduling.

Mass user support has different characteristics from conventional information services. The main difference is that mass user support is not just a combination of personal services for individual users. For instance, individually minimizing the waiting time for attractions in a theme park can result in an oscillation in queue length and waiting time, which consequently decreases total utility provided to each user. We should notice that utility means not only time efficiency but also convenience, comfort, fun, and so on. Methods to generate plans with several evaluation functions such as story-based planning [10] can be combined with dynamic resource allocation to generate several kinds of user utility for theme park, road traffic, and so on.

An example of mass user support for the Theme Park Problem is shown in Fig. 2 [6]. People tend to make reservations to a popular attraction regardless of the crowd in front of it, and they might forget attractions that are not crowded and yet ones that they are fairly interested in. By coordinating users' intentions and preferences about attractions, there is a possibility of controlling resource coordination while keeping user satisfaction.

3 CONSORTS – Architecture for Ubiquitous Agents

CONSORTS (Coordination System of Realworld Transaction Service) is a multiagent architecture for a ubiquitous computing environment, which is designed to 1) coordinate several kinds of services and 2) support social coordination by introducing mass user support services. The key concepts of CONSORTS are semantic grounding and cognitive resources. By using sensory information brought by the ubiquitous computing environment, agents have a grounding in the physical world and are conscious of physical resources (especially spatio-temporal resources) in a cognitive way, i.e., they can recognize, reorganize, and operate raw physical resources as cognitive resources. The services made possible by CONSORTS include 1) extension of conventional personal services using information about the physical world such as position and 2) forms of information provision and social coordination that go beyond personal support.

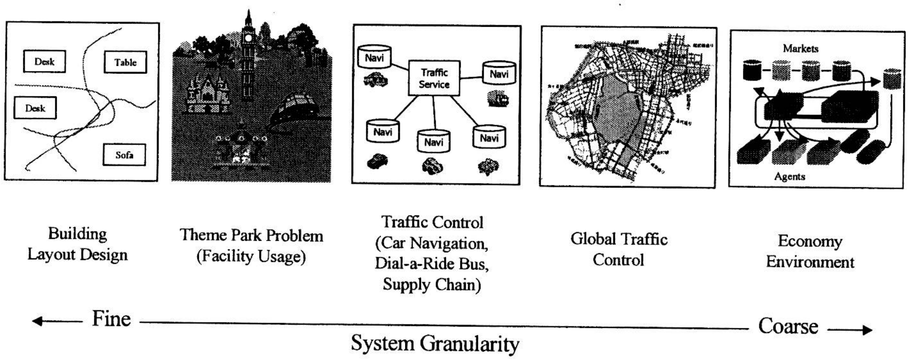

Fig. 1. Examples of Mass User Support

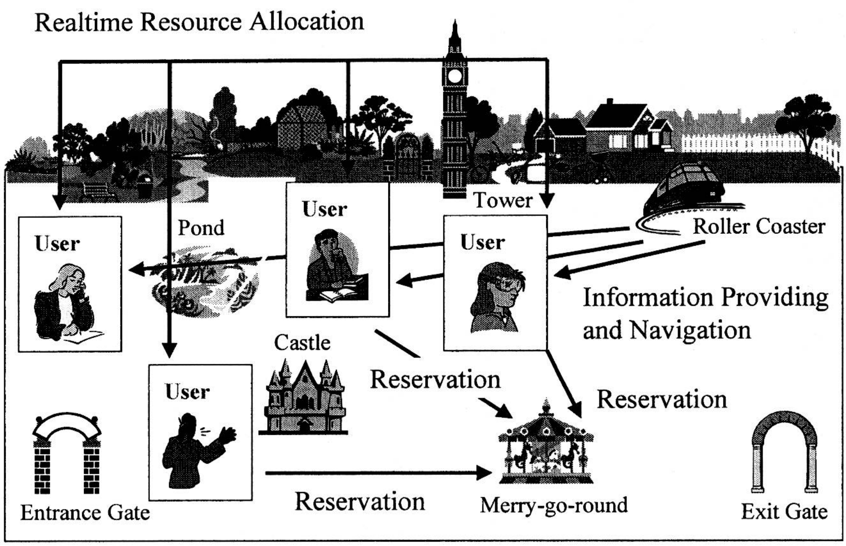

Fig. 2. Theme Park Problem

In the architecture, we assume that users have mobile information devices such as PDAs, cellular phones, and so on. We also assume that the users' positions are captured by sensors such as GPS, RF-ID tags, or wireless LAN and their tracks of moving history are also sensed and registered in the spatio-temporal reasoner. Service agents provide situation-based services that use information about a user's position and movement history. One such situation-based service is information provision according to the user's position. For instance, when a user is near an attraction that s/he might be interested in, a navigation agent tells the user about the way to get there (Fig. 3) [11, 12, 13, 14]. In version 1 of the architecture [14], all modules are designed and implemented as FIPA-Agents [15].

As an example of mass user support, let us again consider user navigation in a theme park, this time, one which coordinates many users' intentions and preferences about attractions. The service is implemented as follows. The first part is a personal service, which navigates users to their favorite places according to their intentions and preferences, i.e., maximizing the number of places they want to visit and minimizing moving distance and time, while obtaining the needed guidance information. The second one is a social coordination service, which tries to decrease the congestion degree and total movement distance and time of all users, by making plans for all the users while coordinating their intentions and preferences.

Another important part of this architecture is the model for describing the user, i.e., 1) intentions: goals that the user should be achieved during a period such as a day, 2) preferences: goals that the user expects achieve during the period, and 3) attributes: a static description about the user that can be used to retrieve suitable information.