roomComputers – Bridging Spaces

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Abstract

Cooperative Rooms (COR) is an interdisciplinary research and development program of GMD in collaboration with partners. Its objective is to design, develop and investigate future workspaces by bringing together information and communication technology, architecture, design and management of buildings, and new flexible forms of individual and joint work. This paper concentrates on bridging the gap between physical and virtual work environments by the development of an innovative device, called roomComputer. The roomComputer is an embedded system and as such offers unprecedented chances to administer distributed physical work environments of people from virtual ones and vice versa.

1 Introduction

There is an increasing need for environments where people can closely collaborate although they may be physically far away from each other. Many Computer Supported Collaborative Work (CSCW) and Teamware systems deal essentially with virtual worlds, while physical work rooms are traditionally managed by Facility Management systems. The Cooperative Rooms (COR) research and development program takes an integrated approach to develop the work environments (real and virtual) which we will need for collaborative work in the future. It is located at the intersection of information technology, work organization and architecture [1].

COR addresses any collaboration which is characterized by a group of geographically distributed people teaming up to work on a specific project for a fixed time. Their work environments will consist of both physical and virtual rooms. The main topics covered by COR are: creating virtual offices, accessing physical locations from them, customizing such collaboration environments to specific projects, running them within a given project and (re)configuring them dynamically as need arises.

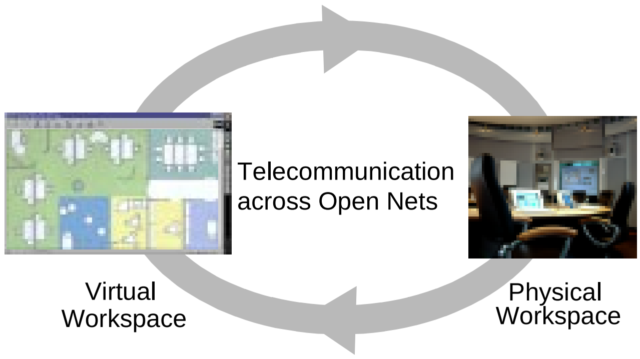

Figure 1 Cooperative Rooms

In our ongoing research we are addressing the need to integrate both, the virtual workspaces together with the physical ones [2]. On the one hand, the Virtual Project Office gets input from and adapts to physical rooms as locations of people and resources. On the other hand, physical rooms can be reserved and configured from within the Virtual Project Office. Real and virtual rooms are combined under a common metaphor, so that one can act equally in either one and make a seamless transition from one to the other.

This paper focuses on the development of an innovative device, called the roomComputer, which serves to bridge physical and virtual work environments.

In the following section we introduce the World Wide Facility Management (WWFM) project, which is part of the COR R&D program and is motivated by the realization that modern forms of work and organization require frequent and dynamic reconfiguration of physical work environments and easy adaptation of rooms to varying requirements. The main part of the paper describes the roomComputer which can be easily installed in any room and gives access to a full set of services for that room. Integrated security features provide means for the secure identification and authentication of people, e. g. entrance and access rights can be defined by means of role based access control. With the introduction of JINI (JAVA Intelligent Network Infrastructure) the development of a distributed system and therefor the usage of interconnected devices and services will become more simplified. The paper closes with a short conclusion.

2 WWFM – World Wide Facility Management

Present-day office buildings often house a larger number of companies and organizations, and must thus be capable of adapting the floor plan, technical facilities, and organization to changing uses and changing tenants on short notice and at no great expenses. Due to increasing economy pressure, the use of office space will become more diverse and intense in the future. This makes it necessary that buildings take over services which are presently rendered by traditional facility management systems, information systems, and various specialists. It is also required that these services be offered to users in an integrated and intuitively usable form.

Facility Management (FM) is the practice of coordinating the physical workplace with the people and work of the organization. It integrates the principles of business administration, architecture and the behavioral and engineering sciences. Although the facility management profession has been in existence for many years, only in recent time has it received worldwide recognition. Business entities have come to realize that maintaining a well managed and highly efficient facility is critical to success.

The term facility management is often used to refer to a variety of activities ranging from control of facilities within in individual rooms up to the management of buildings, business plants, real estate etc. Here, we mainly address the management of facilities in buildings and rooms, which is traditionally backed by (more or less centralized) systems and data bases. Within our ongoing research work, we are following a different approach, namely an approach from the side of data communication and data networks, such has Internet/Intranet. It is based on the availability of ubiquitous universal networks (such as Intranet/Internet) and inexpensive computing power (e.g. provided by embedded systems).

Within the COR R&D program WWFM project integrates physical work-spaces (rooms) and physical objects into virtual work environments. It is motivated by the realization that modern forms of work and organization require desk sharing by different users, frequent and dynamic reconfiguration of workplaces and easy adaptation of rooms to varying requirements. Offices need to be equipped with information and communication technology, devices to be located, rooms to be reserved, furnished, set up for a specific meeting, or re-set to a previous state.

The WWFM project develops strategies to link up buildings which differ in construction, technical infrastructures, work and organization forms, by means of unified, state-of-the-art technologies such that they can be organized and run world-wide like a single building. Moreover, WWFM investigates how users could implicitly take over typical functions of facility management themselves by organizing their personal work in the context of a virtual office.

The main objective is to make it possible to monitor, control, and manage both old and new buildings on a unified world-wide platform, irrespective of any particular local technology. WWFM creates the preconditions for locating, adjusting and administering physical objects such as rooms, equipment, and other resources in a given work context. It implements a distributed application, which provides room services like

- control of light, heating, ventilation, air and climate,
- communication facilities like telephone, fax, etc.
- Internet/Intranet access,
- reservation of rooms and required resources,
- localization of persons and equipment within rooms and buildings,
- organization of maintenance and house keeping,
- accounting and billing.

The first approach was to develop a device which can be easily installed in any room and gives access to a full set of services for that room: the so called *roomComputer*. With roomComputers, a facility management system would simply be a network of rooms, each of which has its own roomComputer, linked together via the Intranet or Internet to form a central building management system. An expansion to include more rooms and resources can easily and inexpensively be done by adding roomComputers and connecting them to the Intranet or Internet.

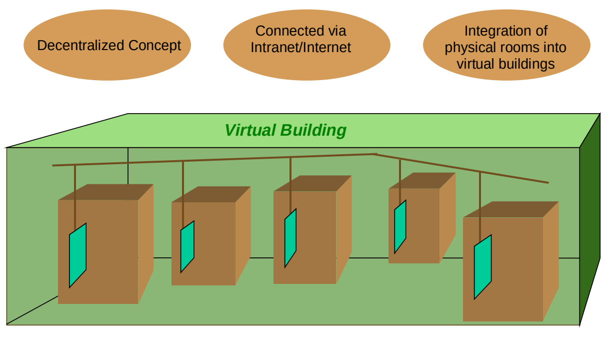

Figure 2 World Wide Facility Management

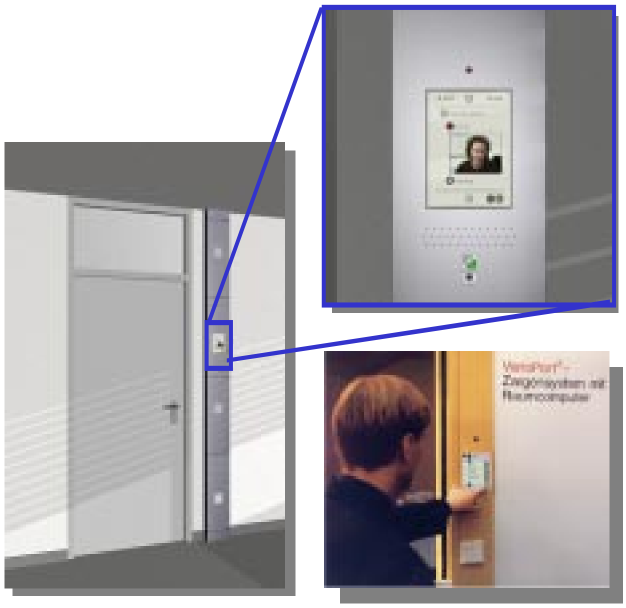

Figure 3 The roomComputer

3 The roomComputer

In the old days, room control simply meant a couple of switches. Today's definition of room control encompasses a surplus of advanced pieces of environmental and multimedia equipment ranging from e. g. lighting control systems to VHS players, LCD projectors and others. Of course, simply equipping a room with advanced electronics is not enough. Making a room that is easy to use and versatile enough to keep pace with quickly evolving technology has become the ultimate goal.

The roomComputer is specifically designed to meet this goal. It has an advanced and simple to use graphical user interface. Its openness and expandability allows technological advances to be incorporated quickly, and it is easily mastered by everyone. It is an embedded system and as such offers unprecedented chances to administer distributed physical work environments of people from virtual ones and vice versa. Since each individual room has its a roomComputer of its own assigned to it, this makes it possible to autonomously control a room and all its devices in an efficient way. Several of these roomComputers can be net-worked via the Intra-/Internet, which makes it possible to administer a set of rooms, or buildings, and to cluster them into a virtual building under a unified application view. All the steps required to set up the appropriate work environments and to establish the necessary network links between distributed users are automated in a way that communication and collaboration in virtual teams is just a mouse-click The roomComputer is an autonomous installation unit (typically located in the doorframe of the room) which is connected to the Intranet/Internet. It is based on a modern Handheld PC with a touch sensitive LCD display as local interface and has integrated loud speakers and a microphone. A Smartcard reader, and so-called Single-Chip-PC's are being attached to it. The roomComputer provides a flexible distributed framework architecture implemented by means of JAVA and Web technology which can easily be tailored to the needs of its users. Through a standard Web-browser any roomComputer may be accessed remotely in the same way as locally The Web-based user interface shows a simple and easy-to-understand, graphical user interface (GUI). Each of the icons on it leads to one of the software modules that make up the system. When an icon is selected either an action is immediately initiated, or a control panel opens to allow the selection of options.

Some sample screenshots of the user interface are shown in figure 5. For example, users can control room

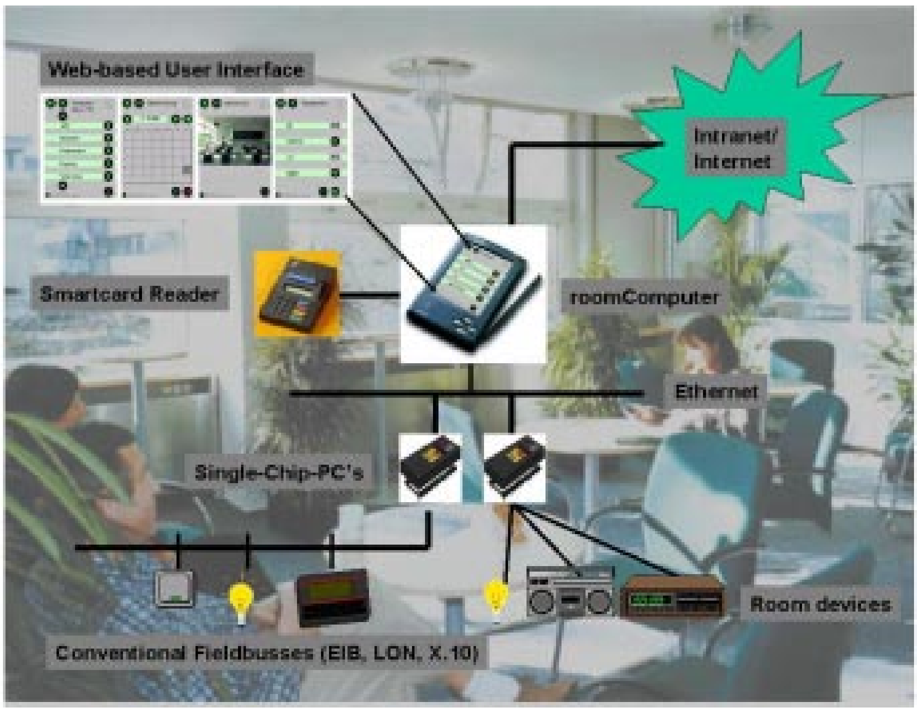

Figure 4 Overall Architecture

Figure 5 Web-based User Interface

devices like blinds (open, close, move up and down). A calendar is provided so that rooms (e.g. meeting rooms) can be reserved. The panoramic view is a very intuitive user interface element. Users can easily select the room devices they want to interact with, by simply pointing to them on a full 360 degrees panoramic photograph (see fig. 5).

4 The Single-Chip-PC's

The different functions in a single room (e.g. light, climate, heating) are controlled via so-called Single-Chip-PC's, which are connected to the roomComputer via a local Ethernet. These Single-Chip-PC's are small innovative and low-cost devices which combine all components of a PC on just a single chip. They provide digital and analog I/O interfaces, serial interfaces and timers.

These days the (traditional) field-bus world is being turned on its head. Recently the "new" Ethernet field bus is the subject of discussion in building automation systems. Ethernet is not new, of course. It is a comparatively old technology that has been tried, tested, and used in millions of applications and is also extremely practical. However, Ethernet recently seems to have gained in popularity in building automation technology.

As a communication protocol, TCP/IP has become widely accepted. It is available and may also be used in building automation technology, so that the same infrastructure could be used for operation and control of room devices as well as for exchanging data with facility management systems or for accessing the functions and services of room devices from any computer on the Intranet or the worldwide Internet, wherever this may be required.

Connecting the Single-Chip-PC's to the Ethernet allows access to all room devices connected to it by using the TCP/IP protocol. Everything a roomComputer connected to the same network needs to know, is the IP address of a specific Single-Chip-PC. A roomComputer can then download programs to it and activated them, monitor variables and thus the status of room devices. Data can be send from the roomComputer to a Single-Chip-PC, which can be used by all types of operators in the Single-Chip-PC, e.g. inputs, outputs, flags, registers, timers and counters.

The Single-Chip-PC's are using a specific TCP/IP stack together with the necessary software to realize a Web-server. Of course, this is not an Internet server with MBytes of memory and simultaneous access by thousands of users as is required with Internet Providers. On the contrary a small web server is provided with a maximum of about 5 to 10 simultaneous accesses and, as the "disk space" access to the I/Os as well as, if appropriate, flags or registers of a subordinate software program.

The services provided by the Single-Chip-PC's (e.g. switching the light on or off) can then be accessed from the roomComputer via a standard Web-browser by using HTML, CGI scripts or JAVA programs. Service providers for underlying devices and networks translate the high-level operations on the Single-Chip-PC's into corresponding commands sent to the connected room devices.

The advantage to the developer is that the way an application accesses a room device is always the same, regardless of the underlying protocol that is used to talk to the device. By shielding applications from the underlying heterogeneity of building automation components and protocols and providing a Web-based interfaces for controlling room devices, the Single-Chip-PC's will help get applications that use room devices developed quickly and easily.

5 Security Aspects

Connecting the roomComputers together with its Single-Chip-PC's to a Intranet or the Internet raises some security issues. The services provided by the Single-Chip-PC's (i.e. controlling the room devices) could thus be accessed from any computer on the same Intranet or Internet. However, it has to be prevented that users or computers may access such services, without having the proper rights. Access to a single room should only be granted under specific circumstances and with prior authorization by the associated roomComputer (i.e. services in a room must only be accessible via the associated roomComputer, which encapsulates them). Direct access to the roomComputers and Single-Chip-PC's is prevented by applying standard procedures such as local "Firewalls", mutual authentication and securing the communication channels (e.g. by using the Secure Sockets Layer, SSL).

Beside unauthorized access to the room services , unauthorized access to a room itself must be prevented under certain circumstances. Therefore measures for the secure identification and authorization of people are foreseen.

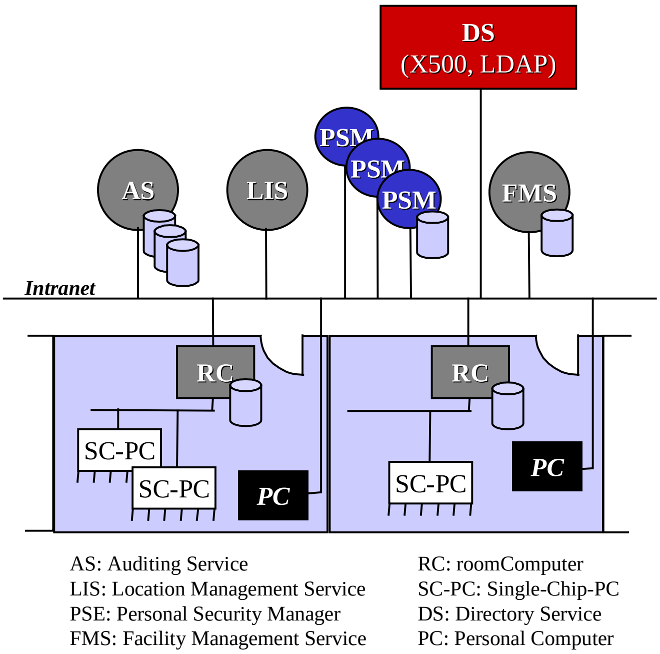

Figure 4 Security System Architecture

For that purpose, we have developed a digital identity card (DIC) as a secure means for identification, authentication and authorization of people together with privacy enhanced auditing, and location management.

The implementation of personal security managers (PSM), local and central location managers in conjunction with appropriate public key cryptography methods serves to handle privacy protection, e.g. to prevent unauthorized knowledge about where people are located and/or have been located in the past, the resources they are using and/or have been using in the past etc.

A smartcard reader connected to the roomComputer in combination with security policies implement means for controlling the access to a single room (locking/unlocking doors), access to the services provided by the roomComputer (as well as their appearance to the outside).

We will make use of digital identity cards (DIC) which are based on the specification of identity cards for the public sector and government departments[3]. As a technological basis we have chosen dual-interface smartcards (offering two interfaces, one with contacts, the other one contactless) with an integrated crypto-controller. They provide means for the secure identification and authentication of people, allow the secure storage of important data (e.g. private signature keys) and the secure performance of crypto-graphical functions (e.g. data encryption).

Basically, the DIC has the same functions as a paper-based identity card. For example, it contains information about its cardholder, his citizenship, his name, date of birth, department information, a unique card number, and period of validity. Furthermore, it carries digitized pictures of the cardholder and of his signature. On the other hand, authentication data is being stored on the card. Such authentication data consist of the roles of the cardholder together with the implicitly assigned authorizations to such roles. These authorizations can be granted permanently or temporarily.

In addition to the pure identity card functions and the authorization information, the DIC provides signature functionality according to the DIN specification for digital signatures [4]. For example, this would allow a cardholder to access electronic documents from a roomComputer and sign them by using his digital signature.

Location management plays an important role in our work. In the facility management context it splits up into two fields, location management for fixed and mobile devices (e.g. locating a specific device within a building) and location management of persons (e.g. locate teammates in order to communicate with them). A specific security problem of location management is that of allowing the subjects of such a system to retain control over the distribution of the information about their location, e.g. in order to prevent others from location tracking. We have developed a concept for controlling personal reachability while maintaining a high degree of privacy and data protection.

The information about the location of a person is sent via the Intranet from the RoomComputer to the location information server (LIS). The LIS hands over the data to personal security managers (PSM) of the respective person. The PSM of a person then stores the location information cryptographically so that only this person can read it. A request about the current location of a person within a building can be handled only via the LIS, and the respective PSM.

6 Advanced Architecture

The deployment of roomComputer networks and smart controllable room devices will enable the development of compelling new facility management applications that moves us closer to the vision of the “cooperative building” that enhances users’ comfort, convenience, and ease of use.

However, one problem in developing such applications is that there are numerous competing building automation protocols (e.g. X.10, LON, EIB) and different application programming interfaces (APIs) for accessing room devices. Since building automation systems are likely to remain heterogeneous, with multiple incompatible protocols used to discover and control different types of devices, application programmers are faced with the prospect of using multiple protocol-specific APIs with no common underlying programming model.

In addition, electrical installations in rooms and buildings are getting more and more complex these days. In the past it was often sufficient, to switch on and off devices. Today developers of facility management applications have to deal to much with the protocol-specific details of the room devices and networks that application uses. Furthermore, when new room devices are being installed, developers have to modify their application and/or install the appropriate drivers to use them, i.e. there is no standard software infrastructure to shield applications from these low-level details.

To control the different devices in a room (such as light, blinds or heating) there are at present many conventional island solutions which require great effort of wiring (with a great number of cables) and configuration. Moreover, these systems can often not being installed, configured and managed independently from each other. Changes in the usage of rooms and buildings often require rewiring and reconfiguration of existing technical components which results in great efforts and expenses.

In addition, in modern facility management systems it is nowadays unavoidable to also provide functions for operating, controlling and managing as well as for reporting, billing and accounting.

The usage of JINI (JAVA Intelligent Network Infrastructure) is intended to change this by providing a set of services that will make it easy to develop applications that discover and control room devices.

With JINI [5], the development of a distributed system (like ours) and therefor the usage of interconnected devices and services will become more simplified. JINI brings to the network the facilities of distributed computing, network-based services, seamless expansion, reliable smart devices, and ease of administration. Connecting a JINI-capable device (like our Single-Chip-PC’s or the roomComputer) to the network, switching it on, and starting a JINI service allows direct access to this service or device from virtually everywhere in the Intra-/Internet.

The usage of JINI will result in the roomComputer appearing as a set of distributed service. Its interfaces will always be present, simply and uniformly, regardless of how they are implemented or where they are physically located. Thus, adding new devices and services to the roomComputer simply means plugging them in. JINI will not only simplify connecting the Single-Chip-PC’s to the roomComputer, but also the interconnection of the roomComputers themselves (e.g. to manage a set of rooms or buildings). JINI will make it possible to create a powerful infrastructure of interconnected distributed devices and services, which is very robust, flexible and scalable.

7 Conclusion

The COR research and development program takes an integrated and systematic approach to support various aspects of collaboration among distributed people. The emergent need to integrate the physical workspaces with the virtual ones is addressed by the development of a roomComputer. This device will shortly be (commercially) available. COR is carried on by GMD in cooperation with development and application partners. Interested parties from users, industry, and research are invited to contribute to COR and to use its results.

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