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Distributed Control of Robot Functions using RT Middleware

Kenichi Ohara[1], Takashi Suzuki[2], Noriaki Ando[3], Bong Keun Kim [3],
Kohtaro Ohba[3], and Kazuo Tanie[2]

[1]Systems and Information Engineering, University of Tsukuba, Tsukuba, Japan
(Tel : +81-29-861-3494; E-mail: k-oohara@aist.go.jp)
[2]System Design, Tokyo Metropolitan University, Tokyo, Japan
(E-mail: u6889523 ,ktanie@cc.tmit.ac.jp)
[3]Intelligent Systems Research Institute, National Institute of Advanced Science and Technology, Tsukuba, Japan
(Tel: +81-29-861-3494; E-mail: n-ando, k.ohba@aist.go.jp)

Abstract: In the ubiquitous robot system, various embedded elements (ex. sensors, actuators, and computers) are destributed and connected each other over network. Ubiquitous Functions Activation Module (UFAM) has been developped in our research group as one of key device for ubiquitous robots. UFAM can add wireless communication function into embedded elements. UFAM has a relatively low performance micro processor, therefore light weight middleware is needed for imploving reusability. RT Component Lite(RTC-Lite) has been developped as light weighted RT Component. In this paper, the application of RTC-Lite to UFAM is discussed. Some modifications of RTC-Lite are required for handling UFAM protocol by RTC-Lite. We discuss about this modificaton, especilly.

Keywords: Ubiquitous Robotics, Ubiquitous Functions Activation Module, RT-Middleware, RTC-Lite

1. INTRODUCTION

Ubiquitous computing is one of the key technologies to advance the robotics. Robots can easily control electric appliances(ex. TV, Video, Air conditionor) using this technology. However, robots are supported by only information in this scheme. To realize physical services, the physical functions(ex. actuator) should be embedded into spaces. A space becomes one of the robots to equip information functions and physical functions. We propose this type of the robot as "Ubiquitous Robot"[1].

To realize the Ubiquitous Robot, middleware technology is important to control these distributed devices, because each robot functions can be controlled by a common infrastructure. In the field of the ubiquitous computing, there are many kinds of middlewares. Especially, Echonet[2] and Zigbee[3] are good examples for household electric appliances. However, these middlewares are not mainly focused on the robot control. So, it is necessary to apply a middleware for robots. In this sense, RT-Middleware[4] is useful to control distributed robot functions. RT-Middleware is a software platform for component based robot system development. Since the current implementation of the RT-Middleware is based on CORBA, its execution needs a certain level of computational power. However, distributed robot functions are assumed to be embedded the micro computer, which has a poor resoueces less than PC, in ubiquitous robot space. So, RT Middleware is not applied to micro computers.

In this paper, distributed control method of robot functions using RT- Middleware is proposed. To realize the proposed method, RTC-Lite is focused. Moreover, Ubiquitous Functions Activation Module, which is one of the wireless sensor network node, is introduced. Finally, we disscuss the applied method of RTC-Lite for some ubiquitous robot functions.

2. UBIQUITOUS ROBOT

In the ubiquitous computing environment, many computers and sensors are distributed to spaces. In this environment, it is easy to get information at every time, everywhere based on the ubiquitous computing and the sensor network. These sensors and computers are very useful for robots, because information of the environment is very important to control them. For example, when the RFID tags included object information are attaced to some object, robot can easily understand object name, size, color, how to use or manipulate the object[5]. This is the one of the examples that ubiquitous computing is applied to the robotics. Robots have only actuated functions like manipulation and mobility using distributed computers and sensors.

Robots are basically composed of sensors, actuators, and controllers. So, if we extend this concept for physical space which has sensors, actuators and controllers, we can define this space as Ubiquitous Robot, which is shown in Fig. 1. Ubiquitous robot can provide various functions, which is not only informative service but also physical service. So, in this space, human and present robot, that most of functions is concentrated, can also control the door and blind attached some actuator, which is physical functions.

Commnication method between distributed robot functions is one of the problem, because robot function are distributed in the space. Additionaly, distributed functions must have some computers to controll them. In this sense, wileress sensor network node is one of the solution about this problem. Moreover, when developers sugest the modulality and reuserbility, communication protocol propers to be common. It is necessary for ubiquitous robot to solve these problem.

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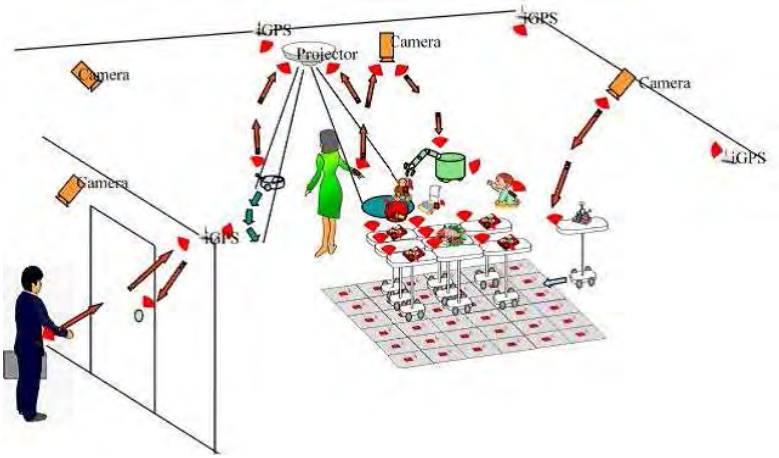


Fig. 1 Ubiquitous Robots.

Fig. 2 Ubiquitous Functions Activation Module.

Table 1 Specification of the UFAM

CPU	PIC16F627A
CLOCK	4MHz
Transmission/Receiver IC	TA32305FN
Frequency Band	303.2MHz
Baud rate	9600bps
Distance	about 10m
Free I/O port	I/O(4bit)
Battery	3V(Button Type)
Size	40*30*1[mm]

3. UBIQUITOUS FUNCTIONS ACTIVATION MODULE

To realize the ubiquitous robotics, communication method is very important, because these functions are distributed in the environment. Generally, there are two kind of communication methods. One is the wired, the other is the wireless. In the case of the ubiquitous robotics, wireless communication method is better than wired communication, because it is easy to add a new ubiquitous robot element into the target system (space). Moreover, ubiquitous robot element is controled by other functions, for example a sensor. So, each ubiquitous robot element need to equip control computer. Based on this discussion, we have developed the "Ubiquitous Functions Activation Module (UFAM)" as shown in Fig. 2. This module have objective to control ubiquitous robot element and to communicate other elements. In the Tbl. 3specification of the UFAM is shown. UFAM is superior to the general sensor network node, (ex. Mica mote etc [6]), in the point of power consumption. For example, when UFAM communicates in five seconds, this module can act for one year to use the button type buttery. Microchip PIC is apdapted to the CPU. And, to aquire the sensor information and control some actuator, UFAM has some digital I/O ports.

UFAM is very useful and powerful module compared to another sensor network node. However, memory resource is very poor. So, when users want to apply some middleware, it is necessary to optimize the protocol. Moreover, UFAM use the single band RF communication. So, multi access control(MAC) is necessary.

4. LIGHT WEIGHT RT COMPONENT: RTC-LITE

In the Ubiquitous Robotics, the embedded computer which has poor resources (ex. PIC, H8, AVR etc.) cannot be applied to RT-Middleware, because CORBA needs higher resources than these computers. New scheme is necessary which can combine the embedded computers to RT Middleware Network.

To realize this scheme, Ando et al. has proposed RTC-Lite[7], which is light weight component more than RT Component. RTC-Lite which consists of two parts as shown in Fig. 3. The first one is the proxy component which provides the bridge for other RT component. The other one is the RTC-Lite component, which has "activity" same as the RT component. Moreover, RTC-Lite component has a profile data about oneself.

After an RTC-Lite component is activated, the component sends its profile data to a proxy server. The proxy server instantiates a proxy component and bind it with the RTC-Lite component. If the proxy component can generate InPort/OutPort based on the profile data, developer need not to make the proxy component for each RTC-Lite component.

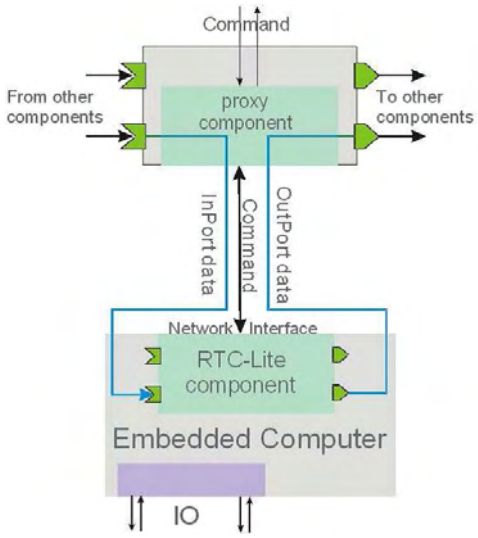


Fig. 3 RT Component Lite and Proxy Component

Table 2 RTC-Lite Protocol

Header	Protocol Header
Command0	Specify the RTC object
Command1	Actual Control Command
Command Data	Detail Data for Action Command
Checksum	Checksum of command 0,1 and command data

As shown in Fig. 4 and Tbl. 4, the protocol between an embedded computer and proxy component is decided by specification of the embedded computer. Generally, embedded computer is difficult to install CORBA. However, RTC-Lite is applied to common object model of RT component, because RTC-Lite aloso has InPort,OutPort and Activity. So, RTC-Lite protocol is better to support the RT component object model. Based on this discuss, RTC-Lite protocol as shown in Fig. 4, Tbl 4is sutisfied to requirement of the RT component.

In this protocol, RT component objects are spacified by command 0. At the next, actual control command is set at command 1. And, detailed control data toward to the command 1 is set. For example, if user want to change component's activity, user send the data as shown in Fig. 4.

In the RTC-Lite, the object model of RT Middleware should be satisfied with this protocol. To do this, RTC-Lite componet can be integrated to RT Middleware.

If UFAM is applied to this scheme, the following merits can be expected.

- Reusability of the distributed robot functions
- Easy plug and play to the RT Middleware
- Easy replacement of distributed robot functions with the same functions

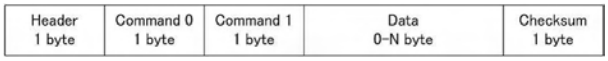


Fig. 4 RTC-Lite Basic Protocol

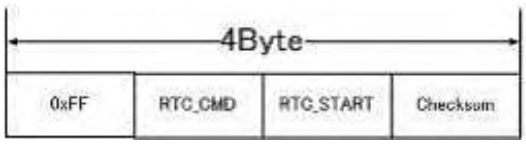


Fig. 5 RTC-Lite Protocol Example: Activity Change

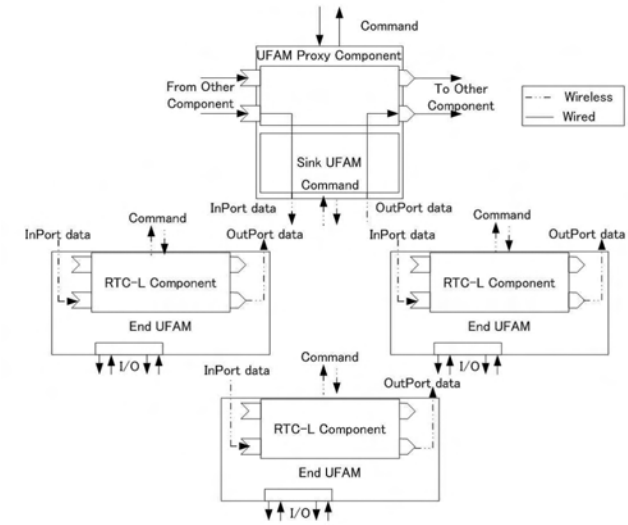


Fig. 6 Design of RTC-L for UFAM

5. RTC-LITE FOR UFAM

5.1 Concept

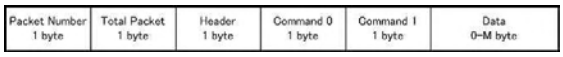
Generally, the wireless sensor network consists of two parts. One is sink node that is connected to PC or another sink node. Another one is the end node. The end node act standalone, and send some data to sink node with wireless communication. So, the component model of RTC-Lite using UFAM is shown in Fig. 6. The sink UFAM is included to the proxy component.

To apply RTC-Lite to UFAM, RTC-Lite need to append following new functions;

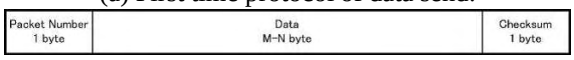
- Protocol length
- Judgement of disconnect

The protocol between proxy component and RTC-Lite component is very important, because the wireless communication is unstable. So, it is better to transmit short packet. Parity is newly appended in each packet increasing reliability of this packet. Moreover, the proxy component has to check the acknowledge information from UFAM. As this consideration, the reliability of a wireless communication can be improved by multiple checks.

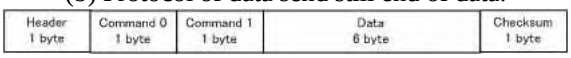
Moreover, the present RTC-Lite has no recovery methods when the communication between UFAM and proxy component is suddenly disconnected. This method is also necessary to improve the reliability of RTC-L with UFAM. Moreover, RTC-Lite can get the OutPort data, but cannot voluntarily send the data from UFAM. This is necessary functions when UFAM detects some event



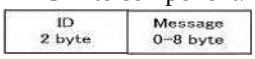
(a) First time protocol of data send.



(b) Protocol of data send still end of data.



(c) Protocol of regular state from proxy component to RTC-Lite component.



(d) Protocol of acknowledge message from RTC-Lite component to proxy component.

Fig. 7 Protocol of RTC-Lite for UFAM

from sensors.

Based on this disscussion, we have applied the scheme of the RTC-Lite for UFAM. To realize RTC-Lite for UFAM, it is easy and reliable for ubiquitous robot component to join the RT Middleware.

5.2 Protocol

Communication method of UFAM is single channel RF. So, when the several UFAMs send data at the same time, it is difficult for each node to get information. In this sense, protocol and maulti access control are important. In this part, protocol between RTC-Lite component and proxy component is focused.

Example of the protocol for RTC-Lite is shown in Fig. 4. However, when the data part is long, UFAM end node must send or receive long data. Generally, wireless communication is unstable. Therefore, data, which sends at the same time, is expected to be short. Based on this consideration, protocol of between proxy component and RTC-Lite component is designed as shown in Fig. 7. When RTC-Lite component starts, RTC-Lite component send own profile data. This profile data is long. So, in the case of sending profile, protocol (a), (b) are applied. Protocol (a) is used at first time, and at the next, protocol (b) is used still end of data. After receiving data, UFAM or proxy component combine several received packet following packet number.

In the regular communication, when the proxy component send some command, protocol (c) is used. And, to confirm the reception of the command, RTC-Lite component sends acknowledge message as shown in protocol (d).

In the experiment, we have decided 10 byte per a packet. To apply this protocol, as a result, RTC-Lite for UFAM becomes same style of general RTC-Lite. And, to use this protocol, UFAM can be join to the RT-Middleware network and developer can see these RTC-Lite component on the RTC-Link.

6. CONCLUSION

In the ubiquitous robot space, small computer, which is attached some robot functions, is distributed. To control these functions with same platform, RT- Middleware is one of the good platform. To join the UFAM to the RT-Middleware, we focus on the RTC-Lite, which is light component more than RT component.In this paper, we disscuss how to apply the RTC-Lite to the UFAM. Based on discusion, ubiquitous robot functions attached the UFAM can join to the RT-Middleware. Our approach is expected to apply another sensor network node, which has poor resources.

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