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Research Article

An RTM based Distributed Simulation System for Guide Robot

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Abstract: In order to enhance the robot system integration and development for guide robot, a distributed simulation system was developed in this study using RTM (Robot Technology Middleware) technology, which is an open software platform for robot systems. The RT (robot technology) system of an adapter, a controller and the robot, together with other CORBA objects, was developed to connect the graphical programing interface with 3D simulator to set up an RTM based distributed simulation system. Simultaneously, the application of the distributed simulation system also confirms the controlling of the real robot utilizing the RT system. The proposed distributed simulation system based on RTM can obviously accelerate the software component development as well as the system integration for guide robot, which will certainly lower the cost of the development of new robot application systems.

Keywords: Distributed simulation system, graphical programming, RT component, RTM

INTRODUCTION

Recently, with the development of the Internet and communication technologies, the quantity of research and development projects which aim at making robots and robot systems more intelligent by distributing their necessary resources over a network, is increasing (Kim *et al*., 2004; Quintas *et al*., 2011; Zhang *et al*., 2009b). In the near future, human beings will live in a world where all objects such as electronic appliances are networked to each other and robots will provide us with various services by any device through network as we need (Kim, 2005). However, as the level of structural and behavioral complexity increases in robot systems, the need for technologies supporting the software module development and the integration of those systems has expanded (Mohamed *et al*., 2008). To the component development, a systematic methodology and infrastructure for the local and distributed composition of modular functional components is needed. And for the distributed simulation system integration, robot middleware technology enables the development of robot systems from the traditional close mode to an open, comprehensive and integrated mode. The standardization of components and a lot of underlying service will achieve the rapid development and maintenance of robot systems.

A distributed simulation system has been developed by our URPE (Ubiquitous Robotics and related Programing Environment) project since 2005 (Chen *et al*., 2009; Qiu *et al*., 2005). At the same time, we also developed hardware models, key technologies and implemented CORBA (Common Object Request Broker Architecture) based servers for the robot systems (Zhang *et al*., 2009a). In this study , in order to solve the increasing functional component development and the system integration of guide robot and take full advantages of the network and computer technologies, we use the RTM (Robot Technology Middleware) technology (Ando *et al*., 2005) to set up several key modular software components and build a distributed simulation system for guide robot. The distributed simulation system can help the developers improve the efficiency of functional component and application development.

ROBOT TECHNOLOGY MIDDLEWARE

RTM: Robot Technology Middleware (RTM) is developed in collaboration between the Japanese Ministry of Economy, Trade and Industry (METI), the Japan Robot Association (JARA) and National Institute of Advanced Industrial Science Technology (AIST), to promote the application of RT in various fields. To make robot systems be language and platform independent, RTM has been developed based on CORBA using a number of specifications at the distributed middleware interface level. A prototype implementation named Open RTM-aist (http: //www.openrtm.org/.) is released (Ando *et al*., 2008). The main goals of RTM are to build robots and their functional parts in a modular structure at the software

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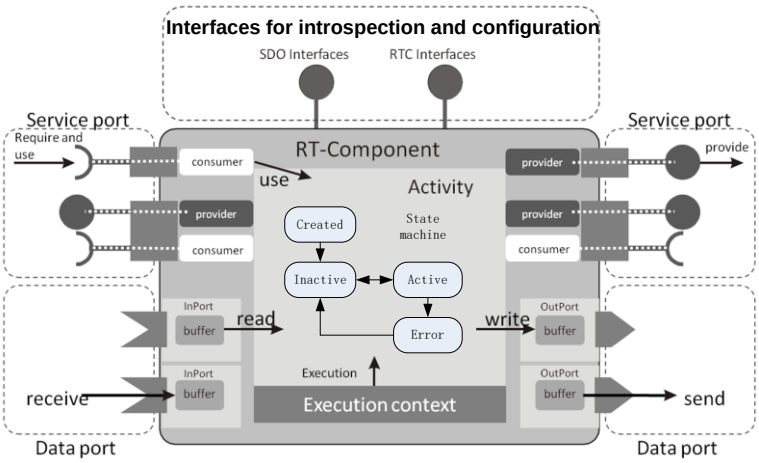


Fig. 1: RTC architecture (OpenRTM-aist official website)

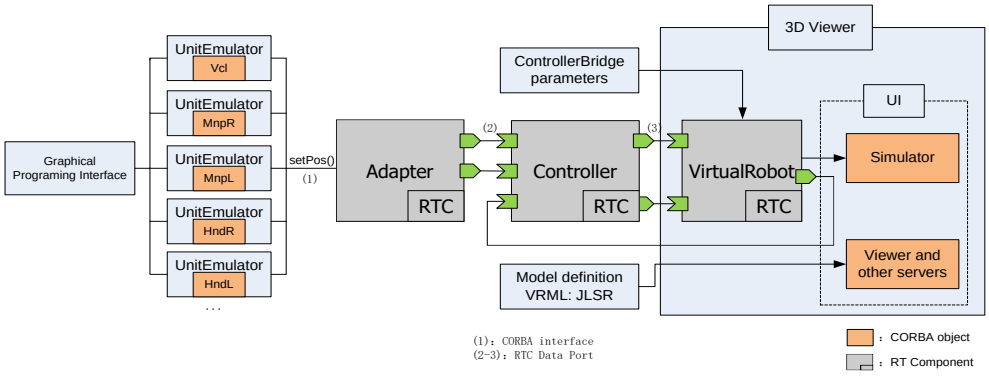


Fig. 2: System architecture of the distributed simulation system

level as well as to simplify the process of building robots by combining selected modules simply, which allow system designers or integrators to build customized robots for a variety of applications in an effective and efficient manner.

The RT-Middleware would support the construction of various networked robotic systems by the integration of various network enabled robotic elements, which are called RT-Components.

RT component: Towards robotic system development and modular design features, Japan has proposed the Robot Technology Component (RTC) (Ando *et al*., 2006), which is based on the CORBA specification and has made some simplifications and complementation. Using RT-Middleware to integrate different RTCs will speed up the robot system components integration from the module level.

RTC is the basic unit in a modular robot system. It is used for functional encapsulation of different hardware and software resources and provides CORBA-compliant RTC interfaces for the external and realizes plug and play system integration through the CORBA bus. Figure 1 shows the architecture block diagram of the RT Component.

RT Component standardizes interfaces, hides implementation and possesses network transparency and efficient communication channel. RT Component of the robot system can be implemented by different programming languages, run in different operating systems, or connected in different networks to communicate with each other.

SYSTEM ARCHITECTURE

For the purpose of making modular software components' development faster and robot system integration easier, we developed the distributed simulation system as shown in Fig. 2.

Graphical Programing Interface is a programing tool used to specify the robot's tasks by using a list of

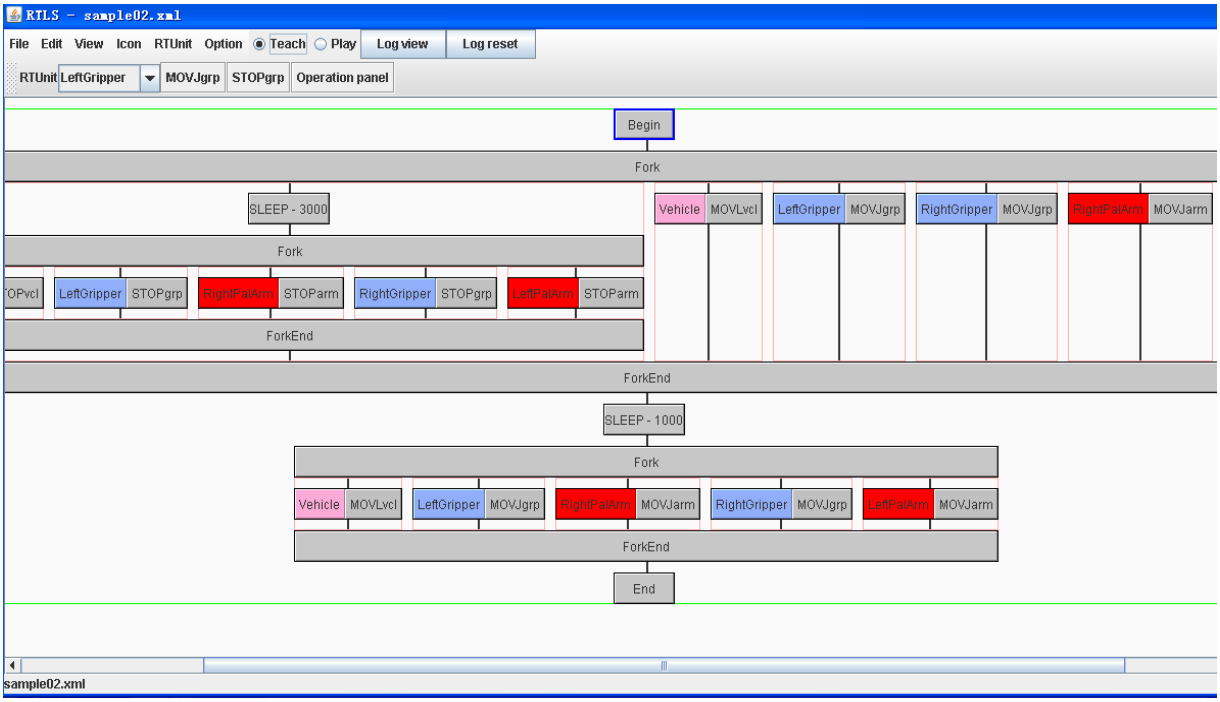


Fig. 3: Graphical programming interface

Table 1: Configuration of unit emulator

No	Parameter	Attributes
1	Name service IP	Local host
2	Name service port	2809
3	Unit name	MnpL
4	Viewer name	Sim3D.object
5	Segment period	100

motion icons (Fig. 3). Once an icon is programmed, it can be saved into an icon list. With this tool, the user can program the robot to complete multiple motion tasks. As a user-programming tool, it provides a user interface to send commands to the related units of the robot or even a networked sensor and integrates them with the user's commands to the RTCs via Unit Emulator.

Unit Emulator is a motion engine that can power on/off, servo on/off the robot units (such as Mobile Unit, Right Arm Unit, Left Arm Unit, etc.) and translate the commands from the graphical programing interface to the set Pos command. UnitEmulator is implemented as a CORBA object, as presented in Fig. 2. In a UnitEmulator server, we need to set the configuration of Unit Emulator, as shown in Table 1. In Table 1, we set the "NameService IP" to "localhost", "NameService Port" to "2809", "Unit Name" to "MnpL" (means left arm here), "Viewer Name" to "Sim3D.Object" and "Segment Period" to "100".

The RT Component of Adapter is developed to receive the commands and data from the UnitEmulator and transform them to a right format or order which the Controller RTC can use. In order to connect with UnitEmulator, we create CORBA interfaces which are defined in a IDL (Interface Definition Language) file (Aleksy *et al*., 2005).

In Controller RTC, some algorithms like path planning, motion planning can be implemented through using the data sent by the Adapter RTC and the sensors' feedback, furthermore, the results will be output to the VirtualRobot RTC in 3D Viewer part. The VirtualRobot RTC is set up by utilizing the Controller Bridge tool with the controller Bridge parameters in OpenHRP (Kanehiro *et al*., 2004) and connected to the Controller RTC at the same time.

In 3D Viewer part, there are other CORBA server objects, which could load in the robot and the environment as VRML models, display the simulation, calculate the collision detection, etc.

By using the RTM technology, we can focus on the developments of the modular components' functions, distribute them around a networked environment and integrate them as an RT system easily.

APPLICATION OF THE DISTRIBUTED SIMULATION SYSTEM

The distributed simulation system has been applied to a Guide Robot named Jiao Long Service Robot (JLSR) (Fig. 4). This robot is developed by Research Institute of Robotics, Shanghai Jiao Tong

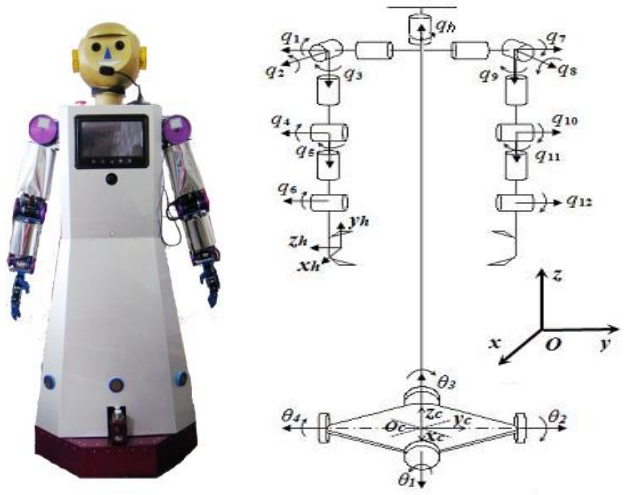


Fig. 4: JLSR robot and degree of freedom configuration

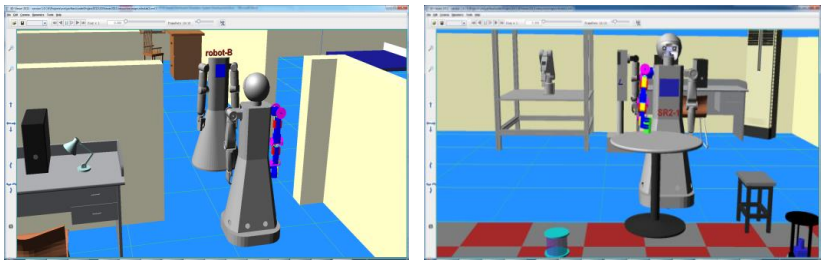
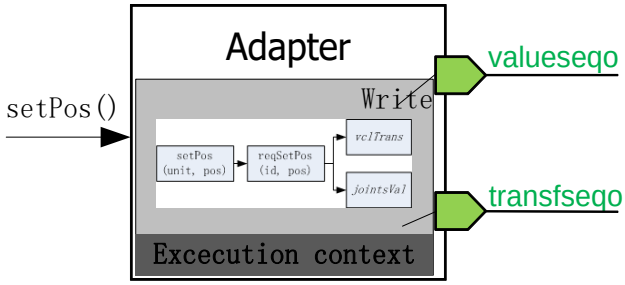
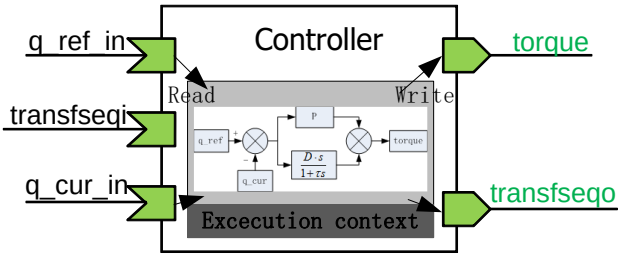


Fig. 5: JLSR robot welcomes a guest and picks up a cup of tea



(a) JLSRAdapter RTC



(b) JLSR controller RTC

Fig. 6: Structures of JLSRA dapter and JLSR controller RT components

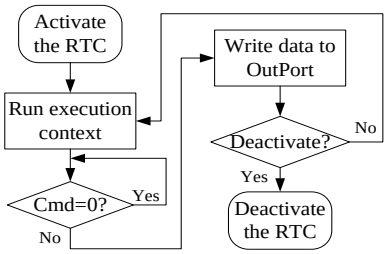


Fig. 7: Flow diagram of JLSRA dapter RTC's execution loop

University, for a robot restaurant. It has four omnidirectional wheels in the base, 6 DOFs (degrees of freedom) in one arm, one DOF in one gripper and one DOF in the head part. Take an application of this robot for example, when a guest comes, the JLSR will make a warm welcome firstly, then introduce the restaurant and pick up a cup of tea to the guest, as interpreted in Fig. 5. The two pictures in Fig. 5 illustrate the simulation of the JLSR robot that welcomes a guest (here we use another robot instead) at the door and picks up a bottle from a table.

In this application, there are three kinds of RT Components, which are JLSRA dapter, JLSR controller, JLSR robot. The structures of JLSRAdapter RTC and JLSR controller RTC can be seen in Fig. 6.

The JLSRAdapter RTC receives the command of setPos from UnitEmulator COBAR servers, which includes the unit name and its reference positions a current time and transforms them to the transformation matrix of the vehicle unit and the angles of all joints, after which it writes the data to its OutPort (transfseqo and valueseqo respectively). The flow diagram of the above procedure is shown in Fig. 7. In Fig. 7, after JLSRAdapter RTC is activated, it will run the execution context periodically. In one loop of the execution, it first check the value of "Cmd", it will write the data to "transfseqo" OutPort if "Cmd" equals to 1 and to "valueseqo" OutPort if "Cmd" equals to 2 and wait if the value of "Cmd" is 0.

The JLSRController RTC reads the data from its InPort which is sent by the JLSRAdapter RTC and JLSR robot RTC and transforms them to current torque values through a PD controller as its core logic, as shown in the equation (1). The JLSRController RTC then output the results to JLSR robot RTC for simulation:

$$\boldsymbol{\tau} = \boldsymbol{P}(\boldsymbol{q}_{ref} - \boldsymbol{q}_{cur}) + \boldsymbol{D}(\dot{\boldsymbol{q}}_{\text{ref}} - \dot{\boldsymbol{q}}_{cur}) \quad (1)$$

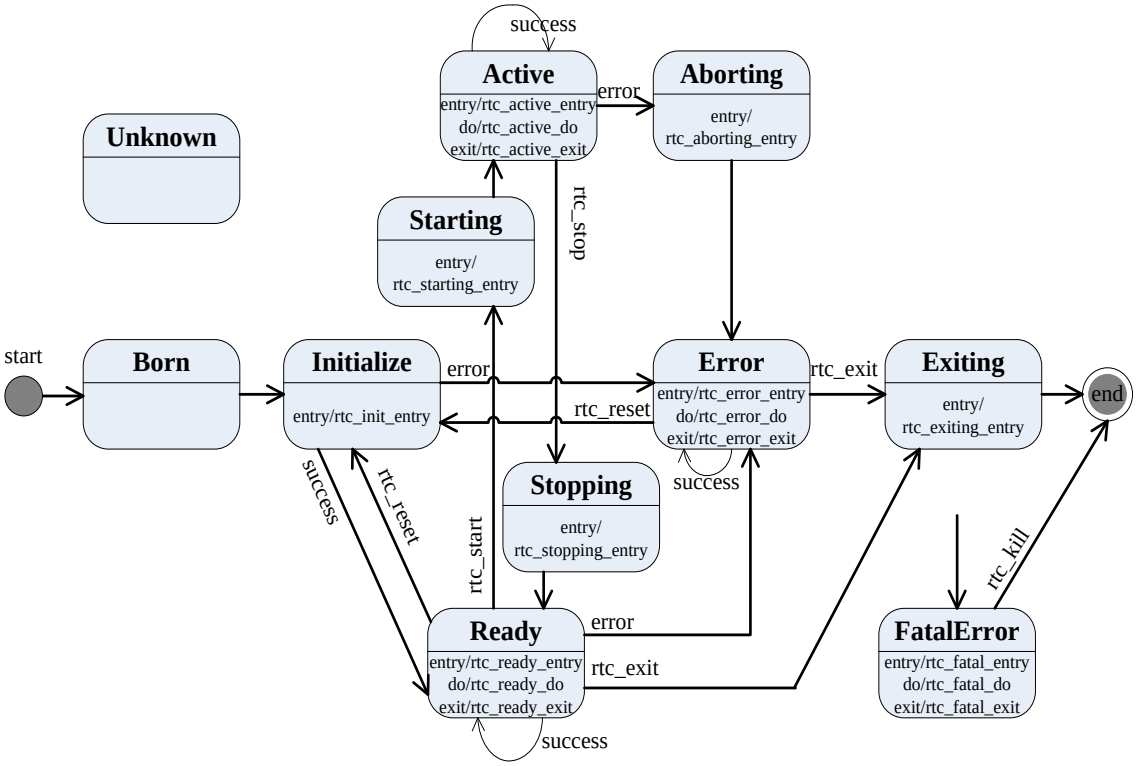


Fig. 8: JLSR controller RT component transition

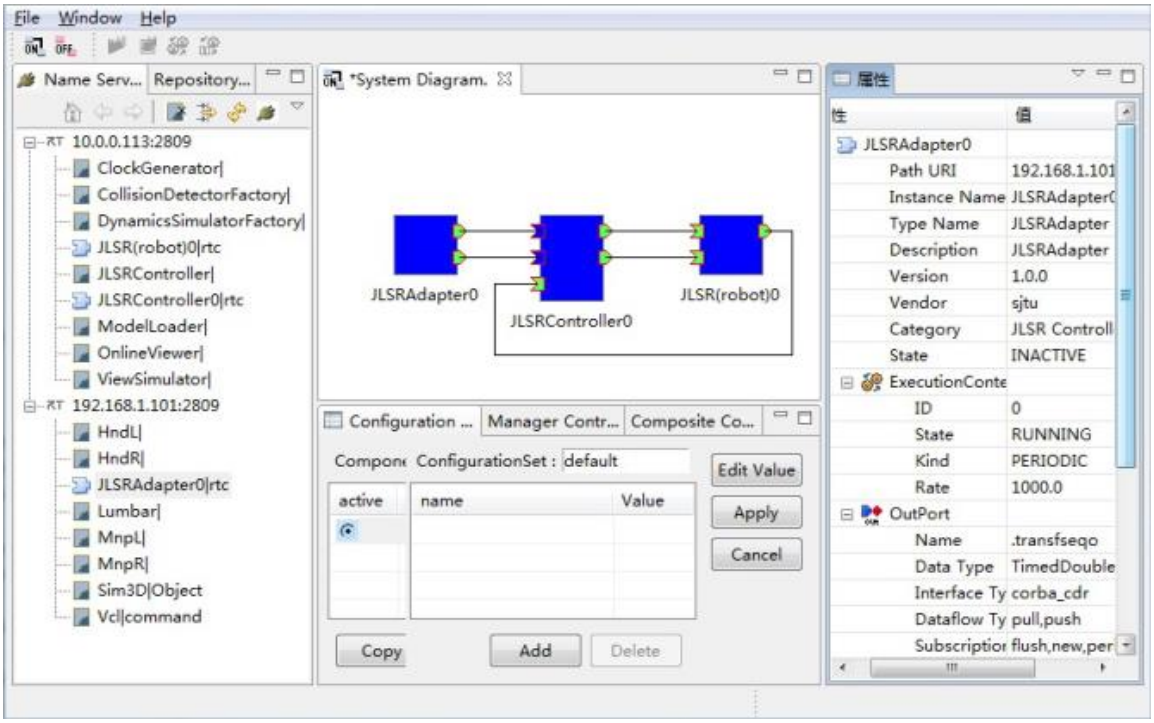


Fig. 9: RT system and CORBA servers of the distributed simulation system

Fig. 10: The JLSR robot picks up a cup of tea

where, $P \in i^{n\times n}$ and $D \in i^{n\times n}$ are the P/D gain parameters, $q_{ref} \in i^n$ is the reference (desired) joint values, $q_{cur} \in i^n$ is the current joint values and $\dot{q}_{ref} \in i^n/\dot{q}_{cur} \in i^n$ is the time derivative of q_{ref}/q_{cur}.

The transition process of JLSR controller RTC is shown in Fig. 8. It was developed based on RT middleware (Open RTM-aist 1.0.0) (Ando *et al*., 2005). The transition process includes:

- **Rtc-starting-entry:** JLSRController initialization read in PD gain values and the torque limit value.
- **Rtc-stopping-entry:** stop reading the InPorts of this RTC, calculating the toque values and writing to the OutPorts.
- **Rtc-active-do:** read in the values from JLSRAdapter RTC, calculate the output torque values and write to the OutPorts of this RTC.

We distributed the simulation system to be executed on two computers including a notebook with Linux Ubuntu 10.04 (2.20GHz, Core2, 4GB RAM) and a Dell desktop with Window 7 Professional (3.10GHz, Core i5, 4GB RAM). The notebook's IP is 192.168.1.101, while the desktop PC's IP is 10.0.0.113. The created RT system and other corresponding CORBA servers can be seen in Fig. 9.

After the setup of this distributed simulation system, the simulation result can be seen in Fig. 5. And the action of the picking task for the real robot could be seen in Fig. 10. The procedure of controlling the real robot is almost the same as the simulation.

CONCLUSION

Using RT-Middleware technology, the development of robotic systems could be divided into two parts, namely, component development and system integration. These two parts can be carried out independently, thus achieving a scientific division of labor: the component developer can concentrate on implementing the main logic and the integrator can concentrate on the design of the whole system without thinking about the detail of the implementations. We

develop robotic functional elements as RT Components for the guide robot, which make it easier to create the distributed robot simulation system by re-using existing modules and lower the cost of development of new robot application.

From the application of the distributed simulation system, we could also see that developing the software modules into RT Components and using RTM to integrate them into a robot system can achieve the reusability and interoperability of the modular components and make the robot system be network distributed easily. In the meanwhile, the distributed simulation system could be transferred and applied to the real robot system easily and quickly. So it can greatly improve development efficiency and adapt to rapid changes in demand.

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REFERENCES

Aleksy, M., A. Korthaus and M. Schader, 2005. Implementing Distributed Systems with Java and CORBA. Springer, Germany.

Ando, N., T. Suehiro, K. Kitagaki, T. Kotoku and W.K. Yoon, 2005. RT-middleware: Distributed component middleware for RT (robot technology). Proceeding of the International Conference on Intelligent Robots and Systems (IROS 2005), Edmonton, Alberta, Canada, pp: 3933-3938.

Ando, N., T. Suehiro, K. Kitagaki and T. Kotoku, 2006. RT (Robot Technology)-component and its standardization-towards component based networked robot systems development. Proceeding of the SICE-ICASE International Joint Conference, Bexco, Busan, Korea, pp: 2633-2638.

Ando, N., S. Takashi and K. Tetsuo, 2008. A software platform for component based rt-system development: Openrtm-aist. Proceedings of the International Conference on Simulation, Modeling and Programming for Autonomous Robots (SIMPAR 2008), Venice, Italy, pp: 87-98.

Chen, P.H., Q.X. Cao, C. Lo, Z. Zhang and Y. Yang, 2009. Robot Virtual Assembly Based on Collision Detection in Java3D. Artif. Intell. Comput. Intell., 5855: 270-277.

Kanehiro, F., H. Hirukawa and S. Kajita, 2004. Open HRP: Open architecture humanoid robotics platform. Int. J. Robot. Res., 23(2): 155-165.

Kim, J.H., 2005. Ubiquitous robot computational intelligence: Theory and applications. Proceeding of the Keynote Speech Paper of the 8th Fuzzy Days International Conference, pp: 451-459.

Kim, J.H., K. Yong-Duk and L. Kang-Hee, 2004. The third generation of robotics: Ubiquitous robot. Proceeding of the 2nd International Conference on Autonomous Robots and Agents, Palmerston North, New Zealand, pp: 2.

Mohamed, N., J. Al-Jaroodi and I. Jawhar, 2008. Middleware for robotics: A survey. Proceeding of The IEEE International Conference on Robotics, Automation and Mechatronics (RAM 2008), ChengDu, China, pp: 736-742.

Qiu, C., Q. Cao, N. Ikuo and Y. Kazuhiko, 2005. Graphical programming and 3-D simulation environment for robot. Robot, 27(5): 436-440.

Quintas, J.M., P.J. Menezes and J.M. Dias, 2011. Cloud Robotics: Towards Context Aware Robotic Networks. Proc. Robot, pp: 420-427. Retrieved from: www.meta-guide. com/ home/ bibliography /google.../cloud-robotics.

Zhang, Z., Q. Cao, L. Zhang and C. Lo, 2009a. A CORBA-based cooperative mobile robot system. Ind. Robot, 36 (1): 36-44.

Zhang, Z., Q. Cao, C. Lo and L. Zhang, 2009b. A CORBA-based simulation and control framework for mobile robots. Robotica, 27(3): 459-468.