

Real-time Network Middleware Supporting Fault-Tolerant Operations for Personal Robot System

Seongho Choo and Hong Seong Park

* Division of Electrical and Computer Engineering, Kangwon University, Chunchon, Korea
(Tel : +82-33-{251-6501, 250-6346}; E-mail: {somebody, hspark}@kangwon.ac.kr)

Abstract: By development of a robot technology, personal robot is being developed very actively. Various infra-technologies are accumulated in hardware and software how by internal a lot of research and development efforts, and it is circumstance that actual commodity is announced. But, personal robot is applied to be acting near human, and takes charge of safety and connected directly a lot of works of home security, gas-leakage, fire-warning facilities, or/and etc. So personal robot must do safe and stable action even if any unexpected accidents are happened, important functions are always operated. In this paper, we are wished to show design structures for supporting fault-tolerant operation from our real-time robot middleware viewpoint.

Personal robot, in being developed, was designed by module structure to do to interconnect and to interoperate among each module that is mutually implemented by each research facilities or company. Also, each modules can use appreciate network system that is fit for handling and communicating its data. To guarantee this, we have being developed a real-time network middleware, for especially personal robot. Recent our working is to add and to adjust some functions like connection management, distributed routing mechanism, remote object management, and making platform independent robot application execution environment with self-moving of robot application, for fault-tolerant personal robot.

Keywords: Personal Robot, Real-time network, Fault-tolerant system, Middleware

1. INTRODUCTION

Research and development are designed so that each modules that interior structure of personal robot system that is gone takes charge details function are linked and are applied to network system to country main subject in the abstract present South Korea.

There is big advantage that can plan division of labor and specialization of system development selecting module structure. Also, because function and bandwidth, real times of all communication networks that need in each module that do various function are different, each module must become to be linked to network system that is various.

We are developing network middleware that can support various hardware platforms and various network systems for many years for use of this interior network system.

Network middleware of structure was developed already being re for interlock use mutually between various selfishness species networks, and in various hardware platform and Operating System, data transformation and naming between selfishness species, routing etc.. is main function.

Guarantee for little more strong real-time and bug permission network system function strengthened this selfishness species liver communication support middleware by recent publication, and soft palate fit household mascot who is progressing present is object base real time network middleware that is based on this.

In existing in this treatise research and curt explanation about module base design of personal robot that develop present to tip of a writing development explain middleware rescue and implementation to part that is completed and describe contents that is applied present for guarantee for real time and bug permission network .

Also, wish to explain shortly about structure for object base real time middleware and design concept.

2. MODULE-BASED STRUCTURE FOR PERSONAL ROBOT

As see in module base personal robot structure picture, each module that present personal robot structure takes charge main function of robot addition, delete, exchange though do purpose put .

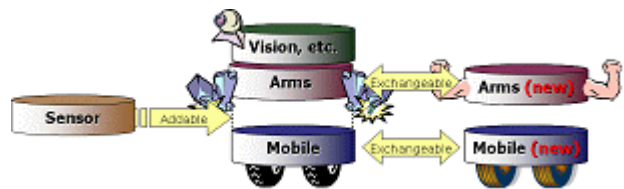


Fig. 1 The concept diagram of modularization

Physical, electrical, logical interface between module independent use surrounding and each module is important fairly for this.

2.1 Module-based structure

Robot that is developing module structure present is so that hardware/software multiple modules that take charge each details function interiorly with Fig. 2 may can be linked to each other various network.

It can seek various advantages modularizing rescue of robot interior.

Several technologies that is used to present robot are high-quality technologies that is much enough to can not be offered all by what organ or group.

This technologies are embodied separately by each one module and this modules in function suitable that, or there is effect that time and other resources that is cost in interface hardware enemy between each module as well as technologies of organ or group that have various technology if connect to network as long as unfold to develop more can amalgamate each other mutually and cause synergy effect decrease very.

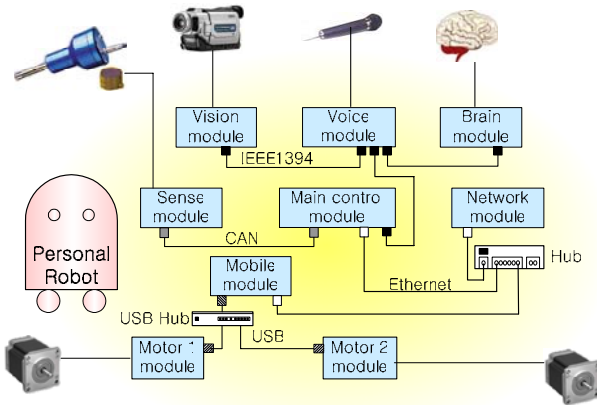


Fig. 2 The module-based structure of personal robot

Also, as well as independent modules do as can expect high productivity elevation capacitating division of labor evil in whole system development, technologies of more various field become base that can be applied to personal robot because doing not infringe base technology or Intellectual Property rights of technology possession subject.

Of course, shortcoming of when adopted decentralized structure of this network base can drop in whole system performance aspect than center concentrative simplex system structure, but this sees that network middleware that real time service is available is solved enough by is offered, and is open for robot application programs and offers interface that is object-oriented enemy.

However, can know that is contrary structure particularly to compete as after runner in world personal robot technology market that develop hour by hour if take into account many problem and so ones in side of system maintenance conservatism, correction of details function and difficulty of repletion, division of labor evil of development and cooperation development, Intellectual Property rights protection of each development subject of in case took simplex system rescue.

2.2 Networked structure

As describe network infrastructure before, each modules of interior are designed to be linked, and can communicate mutually each other through network that is various.

Can use selecting network system that network structure that is applied to personal robot present is suitable in details function that each module takes charge more than meaning of

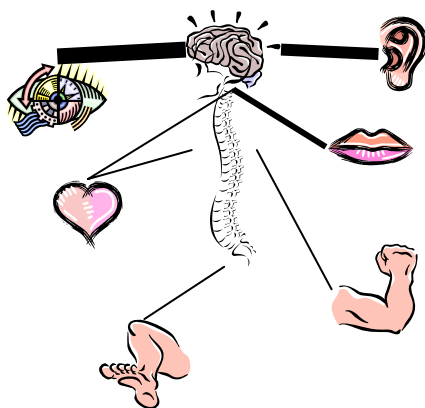


Fig. 3 A simplified nerverous system in human body

simple connection, and because this different all network systems are wormed mutually, is so that whole robot system may be applied.

It is device that this acts role such as human's nervous system in personal robot interior as real time middleware for personal robot that capacitate this.

Schematized whether expressed human's each organ and nervous system are applied being changed mutually to function how in personal robot interior shortly in figure 3.

Present structure is can be corresponded by human's body engine and one to one so, and can compose atomizing functions that each engine takes charge little more, and is supporting net structure (mesh topology) to supplement shortcoming of center concentrative connection structure through brain and central nerve.

If human's nervous system is central nerve but nerve connection part of brain is damaged, do not appropriate all body institutions that is coupled with there, but case of personal robot network system that have net structure can assume that have structure that improve more because can pass information using linked other roundabout way path if problem happens in one route.

Also, can apply suitable network in linked engine's function, nerve sheaf that is between eye and brain for sight connect by protocols such as IEEE 1394 (FireWire) that is proposed for multimedia appliances connection because it is inefficient that connect many network rail track physically, and comparative data quantity is few, but do so that appliances such as sensor and actuator that require real time can make use of field bus system of CAN and so on, and general connection is using by is simple and do so that can use TCP/IP of Ethernet base that is spread more effective information transmission plan ready, and offer ease of development and openness of composition.

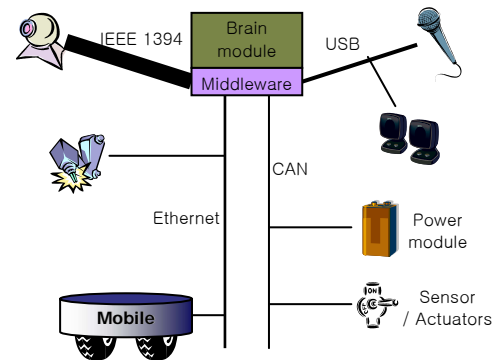


Fig. 4 A nervous system for personal robot

That is, as following, can be arranged.

- Eyes (Web Cam.) : the optic nerves → IEEE 1394 : large bandwidth multimedia communication
- Ears (Microphone) : hearing nerves → USB 2.0 : high speed multimedia communication
- General organs (Each modules) : central nerves → 10/100 Mbits Ethernet : General purpose communication network
- Real-time reactions organs (Actuator, advanced sensors, and etc.) : reflexes → CAN (industrial real-time network)
- Pain spots, pressure spots (simple switch or sensors) → end nerves (RS-232C or direct-line connections)

3. REAL-TIME NETWORK MIDDLEWARE

Each module of real time middleware personal robot interior for personal robot without different Operating System or Operating System in all different hardware environments is linked by various network protocols and is applied.

Developed real time middleware for personal robot that act as gateway to interlink this modules each other and do data transmission and conversion.[3 ~ 4] [6 ~ 12]

3.1 Supported operation systems

Operating System that real time middleware for support Operating System developed personal robot is supporting is Windows each version, Linux including Embedded Linux, PDA PocketPC 3.0, firmware and so on for baud that use Texas Instrument's DSP chip including Microsoft WindowsCE.

Time that can provide real time service that improve using real-time features that support in kernel 2.6 Linux case, and take in packet transmission in the case of experiment result ethernet shows Performance that satisfy comparative by average 0.013 ms.

3.2 Supported network protocols

Network protocol that is supporting support network protocol present is 802.11 (WLAN) for personal robot and connection between home-network, ethernet (TCP/IP) for general wire connection, USB for multimedia device connection and for urgency situation notice to CAN, RS-232C for general hardware connection, a person in house outside to connect IEEE 1394, Bluetooth for radio multimedia service, various real time low rank level devices SMS transmission through CDMA etc.[1]

Middleware itself improved openness being designed in hierarchical structure too and did so that can seek diversification of network path that describe before through itself Routing function.

Is progressing work that improve present interior structure in object-oriented type for function and preservation, administration who improve also more.

3.2 Layered structure and functions

Real time middleware interior structure and interior structure that is specific more than function are consisted of Streaming (SL), Network Adaptation Layer (NAL), Network Interface Layer (NIL) as see in Fig. 5, and each network protocols are linked on middleware lower part through commonness interface, and software modules for remote object administration service for breakup object service are composed with Streaming Layer.

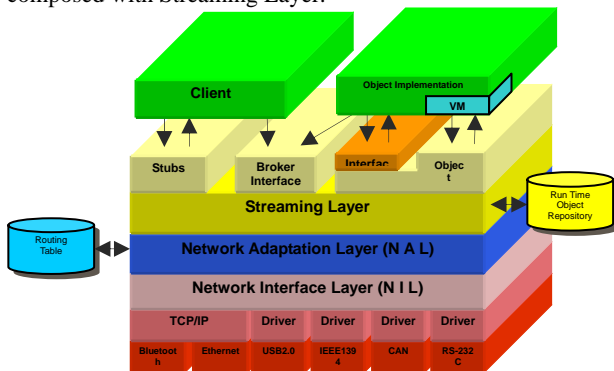


Fig. 5 The layered structure of robot middleware

Middleware that have data transmission function, Operating System network protocol rain dependence enemy through this real time service support, routing function that is network rain dependence enemy who use module name, conversion of data and suitable partition/reunion and execution environment, connection state watch hardware platform rain dependence enemy and function manager is situation that become actuality application to hardware that is developed various institution or research organization present and is verified function and Performance.

Robot application program (Robot Applications) that take charge task of real robot on object-oriented real time middleware that present development is gone rises and interrelation and form with middleware are same with that see in figure 6.

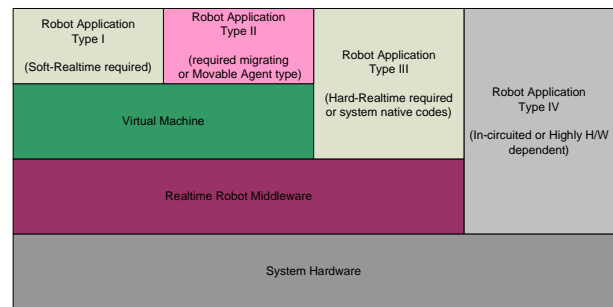


Fig. 6 Variances of robot application

Type I is application programs that mean general robot application programs and satisfy that is another thing soft real, type II moves to agent type of application programs to describe behind by other module through network and refers to application programs that can be executed.

Type I of something wrong, II application programs can be consisted of code that is system platform rain dependence enemy acting on all imagination machine (Virtual Machine)s.

Type III means form that can require that is another thing hard real or have network rain relativity through real time middleware as application program form that system native codes must come certainly.

Type IV means program form that is consisted of codes that correction has impossible software to change or highly hardware relativity because is fixed already to hardware and as long as this case is because can not use real time middleware spontaneously, several gains it can not be, and take charge role that service to middleware only passively. Softwares that include to camcorder or application of home network several units come in this case.

Object-oriented real time middleware that is becoming present development is designed by soft software platform (flexible software platform) rescue so that this various robot application programs may be able to achieve.

3.4 Development environment for robot application

Robot application programs that act in robot application program development environment each module can do to act down loading after is done in each module by structure such as Fig. 7, and application program can be transmitted by personal robot at any moment.

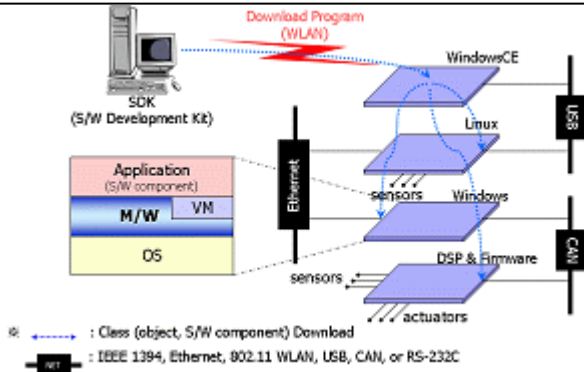


Fig. 7 Development environment of robot application

Of course, must acquire access privilege through suitable security certification before achieve program down loading function.

Personal robot is linked in home through radio internet device with radio internet AP (Access Point), and AP is linked to Internet through Home gateway.

Therefore, robot application programs can upgrade, and is downed and can install correct application program in confidence inclination through internet surfing that is robot master by Baroba when new version announced in the module development company.

Development market of human sea robot application program through this infra can plan virtue circle that more developers develop application program for open type robot structure and expect development of quality high application program more if is magnified.

4. AGENT-BASED FAULT-TOLERANT SYSTEM

4.1 Introduction

Because background personal robot contacts directly with a person within house, safety is very important.

Need stability of system and physical plan that make to be important but more reliable applying bug permission technology to secure safety.

Item that must consider some for this is as following.

First, importance control softwares that are acting in personal robot interior must perform safe action discontinuance going even if robot internal problem happens.

For example, even if what part of robot was damaged by outside invader, whole robot system has not suspended and phones function or expense company which notify minimum invasion to master, or function that do other protective device moving must run continuation.

Also, because aftereffect of this damage spreads by whole system in this case though case that what part is damaged in case of robot that is exposed for same reason in various environment through transfer always can happen frequently action case if occur resources waste .

In this case, damaged module or role of parts that is used until time that is repaired actually if other module or accessories can do alternate or imaginary simulation usability improve can.

Of course, to offer this functions each module different hardware and software to each problem situation person that awareness and processing functions are had basically desirable.

4.2 Schemes

Functions that consideration is possible are way and so on that use that secure a service control program or that do system control programs so that is removable through network because do type II's agentization, hardware and software composure quantity (redundancy), grafting of various kinds theory based on other safety engineering, several technologies about network security in present situation to embody way bug permission system.[5]

In the case of first method, present robot rescue consists of module structure of network base, and because remote object service through imagination machine will be offered, realization possibility is high.

Also, in case of service softwares of task facility of actual high position level, consist of codes that is hardware rain dependence enemy, and case that can act on imagination machine even if is not so is most, and actuality can say that is because is developing present object function manager.

Composure quantity security way of second is as following.

Composure quantity of network path is possible because go round network path that is cut through diversification of routing path and network connection state watch function that is supporting in current middleware as see in figure 7 and become so that can make path.[3]

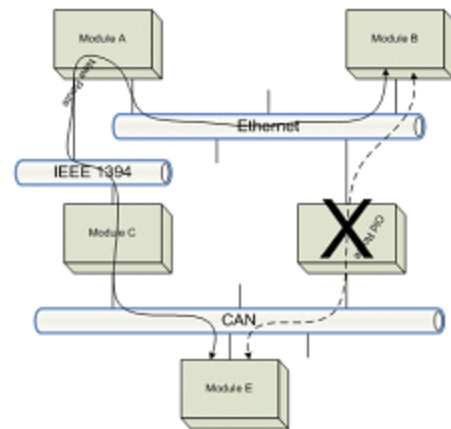


Fig. 8 A fault-tolerant scheme in the network route

Hardware composure quantity security must take into account well economic performance and efficiency justly, but ordinary each module do to act in other module through simple software transfer because case that possess all basis building blocks for general computing power, CPU, ROM, RAM etc. is much, or while is possessing hard copy already in other module more than doing to perform justly when happen more economically safety secure can.

Contents about several theory that allow fetters in safety engineering need that contents studied occasionally because is field that many parts are studied yet are reflected.

Because robot can not but communicate with outside through special quality upper radio network once at security connection measure, it becomes network security in this radio torso heftily.

Also, because present development environment structure takes rescue that robot application program that develop becomes down loading directly through this path, suitable authentication, access privilege grant and communication security of transmission data should be designed finely.

5. CONCLUSIONS

Described necessity and function etc. of real time middleware for personal robot with curt truth for personal robot that is developed by 1 step in treatise that see as more than conclusion, and proposed several ways about bug permission system implementation way to item that must apply this and consider when develop object-oriented real time middleware.

Object-oriented real time middleware for personal robot sees that thing which do to possess system extensity about bug permission function in design phase being situation that design is terminating almost is important present.

For front, demonstration room that actuality personal robot is applied along with implementation of object-oriented real time middleware will be distinct.

REFERENCES

[1] Seongho Choo, Hong Seong Park, et al., "Design for supporting interoprartion between heterogeneous networks in personal robot system," *Proc. Of 2004 Int'l Conf. of Control, Automation, and Systems*, ICCAS 2005, 25 Aug. 2004

[2] M. Kleinhagenbrock, J. Fritsch, and G. Sagerer, "Supporting Advanced Interaction Capabilities on a Mobile Robot with a Flexible Control System", *Proc of IEEE/RSJ Int'l Conf. on Intelligent Robots and System*, Sep. 2004.

[3] Geon Yun, Hyeong-Yuk Kim, Hong Seong Park, "Middleware structure for module based personal robot," *Journal of Control, Automation, and Systems*, Vol. 10, No. 5, pp. 464 – 474, May 2004

[4] Hong Seong Park, Seongho Choo, Hong-Seok Kim, Ho-Gil Lee, "Middleware structure for personal robot," *Korea Robotics Society Review*, Vol. 1, No. 1, pp. 69 – 81, Oct. 2004

[5] Barry W. Johnson, *Design and Analysis of Fault-Tolerant Digital Systems*, Addison-Wesley, 1989

[6] Hong Seong Park, Hyeong-Yuk Kim, "The middleware system for multiple homenetwork," *Journal of Control, Automation, and System*, Vol. 9, No. 7, pp. 24 – 31, Dec. 2003

[7] Tae-Kyu Park, Li Vitaly, Hong Seong Park, "CAN (Contoller Area Network) protocol for personal robot middleware," *Proc. of Information and Control symposium 2004*, pp. 80 – 82, May 2004

[8] Seongho Choo, Hong Seong Park, "A research of object-oriented middleware structure for personal robot," *Proc. of Information and Control symposium 2004*, pp. 83 – 85, May 2004

[9] Seongho Choo, Vitaly Li, Hong Seong Park, et el., "Heterogenous networks operation schemes for personal robot," *Proc. of Information and Control symposium 2004*, pp. 83 – 85, May 2004

[10] Ju-Seong Lee, Hong Seong Park, "A research of real-time communication for heterogeneous network environment in personal robot," *Proc. of Information and Control symposium 2003*, pp. 151 – 154, Dec. 2003

[11] Jung-Bae Lee, Gyun Yun, Hyeong-Yuk Kim, Hong Seong Park, "Middleware technology for heterogeneous interface home network," *Proc. of Information and Control symposium 2003*, pp. 159 – 162, Dec. 2003

[12] Ju-Seong Lee, Hong Seong Park, "A research of structure to support real-time service for module based

personal robot," *Proc. of Summer Conference in Korea Electronics Societies*, Vol. 26, No. 1, pp 278 – 281, June 2003