Communication Between Robots and a Computer via Lan

Interim Report

Andreas Bernhard Max Hofmeier

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Abstract

The proposed project is aimed to develop the software tool for the remote control of robots on the Internet

The feasibility of using the Internet to control robots will be studied. Functionality analysis of the system will be presented. Real-time accessibility to the remote side via the Internet is to be investigated.

The project develops a software platform in form of a library for GNU Linux, an user interface and an interface to the robot. A simulator of the robot will be developed to support the developing process of the whole system.

Up to now an initial structure of the system is developed. The aim, the objectives and the deliverables have been specified. An example test of the reliability and response time of some servers over the Internet has been done.

Contents

1 Introduction

Robots become more and more important because the technical progress allows economic and useful applications. Controlling robots over short distances with cable or wireless is not longer a problem, but more often robots need to be controlled far away. For example a robot as security guard or a pizza-robot is operating at home while controlled from the office. For this demand a public communication network has to be used.

One of the most flexible and economical possibilities is the Internet which works packet-oriented. All data has to be fragmented before it can be transfered. The transfer-process within the Internet can be compared with the postal service (Ball et al. 1999). “The packet should be there within two days” is a possible answer if the post clerk is asked how long the packet takes. This little word “should” is the problem. It should, but there is no guarantee. If many packets are handed in, it may take a week to deliver the packet. The Internet has the same problem even if a packet does not need a week, it cannot be predicted how long a packet takes to be delivered. Because of this random time delay the Internet has limits to which it can provide a platform to control robots (Elhaji et al. 2000).

Within this project the feasibility of remote control of robots over the Internet will be studied and a software platform on GNU Linux which provides this possibility will be delivered.

After the possibilities of the Internet are known the structure of a system which uses these will be designed. The main part of the system will be the library which is the software platform. For demonstrating and testing purposes it is necessary to develop a user interface (UI) which allows the user to control a robot. In one case the robot is a simulation and in the other case a real robot. It is necessary to develop an interface to the real robot and a simulator. These four parts has to be assembled together.

The description of the project is following, and follows this layout: Section 2, 3 and 4 define the aim, the objectives and the deliverables of the project. In the next two sections the requirements and the way for achieving the defined targets are discussed. The actual progress of the project is mentioned in section 7. In the last section the project plan is listed in form of an action plan and a Gantt-chart.

2 Aim

The aim of the project is to develop a software platform on GNU Linux systems (in the form of a library) for the communication between a server and robots to realise remote control of robots over the Internet. The communication between robots is allowed as well.

3 Objectives

1. (a) Feasibility study of real-time control of robots on the Internet.
   (b) Establishment of realistic levels according to the Internet overloading
   (c) Block diagram of the architecture of the software platform
2. (a) Developing the library
   (b) Developing the simulator and the user interface (UI)
   (c) Demonstrating the platform by using a simulation. Showing that it is possible to control the simulated robot over an Internet connection.
3. (a) Developing an interface to the real robot
   (b) Demonstrating the platform by means of the real robot. Showing that it is possible to control the real robot over an Internet connection.

4 Deliverables

1. The Library (the Software Platform)
2. Documentation of the Library (API; description of the functions; how to use)
3. User Interface
4. Documentation of the User Interface (User manual)
5. Simulator
6. Documentation of the Simulator (User manual)
7. Interface between Library and real Robot, for Demonstration.

8. Interim Report
9. Presentation
10. Final Report

5 Requirements to Meet Project Aim/Objectives

5.1 Resources to Meet Project Aim/Objectives

1. Time and Work

   The most important resource which is necessary to meet the project aims is time. According the unit guide at least 300 hours have to be spent on the project work. That are approximately 11 hours a week without Christmas and Easter. At least this time will be spent for project work.

2. Computer and Internet

   The second thing is access to a computer and the Internet. Computer are essential in this project because the project outcome is a peace of software and has to run on a computer. A computer will be used for developing and testing the software and is also necessary for using the Internet which is indispensable to getting information and testing the system. Computer and Internet access are available in the Learning Resource Centre.

3. Access to a Robot

   One Part of this project is to show the function of the system with a real robot. This robot is located in the laboratory T411 at the LSBU. For this reason access to this laboratory is necessary.

4. Library Access

   Another important source of information are books and journals which are located in a library, for example. The necessary access is possible in the Perry Library of the LSBU.

5. Supervisor

   The assigned supervisor has to be present to supervise the project.

5.2 Technical Requirements

1. According to the British Standard (1992) Industrial robots – Recommendations for safety, a single point of failure must not cause any hazards. The system have to be ensure that the robot stops if the control-connection is broken.

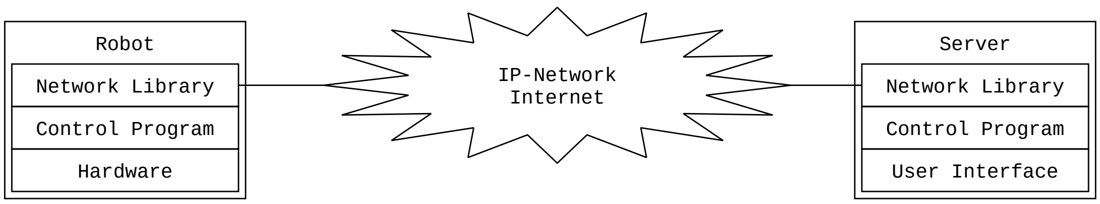
2. "A Linux system can actually be adapted to work with as little as 256 KB ROM and 512 KB RAM." (Addison, 2001) This network library has to run on such small embedded GNU Linux systems, as a consequence the library itself must be programmed very efficiently. Only the basic system library (g)libc-library[1] has to be used. According to Mitchell et al. (2001) the ld-linux-library is also necessary if the system has to deal with libraries dynamically (loading during the system runs).

6 Proposed Technical Approach

6.1 Basic Concept

The Library provides the communication tools to the robot and server control program. A command from a user goes the following way:

A user gives a command to the server control program on the user interface. The server control program evaluates the command and sends it throw the IP network (the Internet) by the functions in the Network Library. The Network Library on the robot's side receives the command and hands it over to the robot control program. The robot control program evaluates the command again and drives the robot.



This communication has to be bidirectional because it has to be possible to get data from the robot. This is important to get the acknowledgement for a command, get knowledge of the environment of the robot and to monitor the

[1]This library contains the commands for the C programming language

robot (for example, to know what the robot is doing now; energy repertoire and consumption).

6.2 Components of the Project

All phases that are mentioned (marked as **bold**) in the text bellow are referring to the Gantt-chart and action plan in section `Project Planning` on page **??**.

The project can only start after the aims and objectives are established. This was done in the **Clearing Project Aim/Objectives**-phase.

At first a **Feasibility Study** about how usable the Internet is for controlling robots has to be done. After this part of the project it has to be clear under which conditions the Internet can be used for real-time application.

After the **Feasibility Study** is carried out the **Design Structure**-phase begins. In this phase the design of the system has to be worked out. The design covers the internal design of the library and the design of the whole system (interaction between all parts: Library, UI, simulator and the real robot). Furthermore it has to be decided which protocol is used and which version of the Internet protocol (IP) is preferred. A choice has to be made among Transmission Control Protocol (TCP) streams, User Datagram Protocol (UDP), or an own protocol based on IP.

The **Literature Search** is carried out simultaneous to the **Feasibility Study** and the **Design Structure** because it is necessary to take other people's work into account.

Interface to Robot: In this part of the project an interface to the real robot is established. The aim of this part is to take control over of a robot. This is necessary for further stages of the project (**Interface between Robot and Library**) to demonstrate the system on the real robot. The library has to interact with the robot therefore this part is performed in an early stage of the project. All information gathered in this stage can help to ensure the match between the robot and the library.

When the structure of the system is figured out the library will be developed within the **Build Library**-phase. The documentation about the library has to be written simultaneous in the **Write Documentation (Library)**-phase. The last week of the documentation-phase is reserved for reviews.

After a basic version of the library is developed, the **Build User Interface** and the **Build Robot Simulator**-phase begins. During the development of the user interface and the simulator it is possible to find weaknesses of the system. Therefore these four stages are carried out simultaneously. The simulator is a simple model of the robot and is used to help develop and test the library. The user interface will be used to send commands to the robot or the simulator.

The documentation of the user interface and the simulator has to be written. This will be done within the **Write Documentation (UI/Simulator)**-phase of the project. The last week of this phase is reserved for reviews.

At the end of the project the **Interface to the Robot** will be completed to the **Interface between the Robot and the Library**. This phase is called **Interface between Robot and Library**. After this phase it will be possible to control the robot over the Internet by using the library developed before. This will be demonstrated.

6.3 Reports

All reports will be completed and handed in by their deadline. There are project-phases to write the reports before the deadline. The Interim Report was written in the completed **Interim Report**-phase.

The Final Report will be written during the whole project in the **Final Report**-phase because this report has to show the process of the project. Work on the Final Report will start after the **Feedback on Interim Report** is given.

Within the **Prepare Presentation**-phase the presentation will be prepared.

7 Technical Progress to Date

- Up to now the aims and objectives are clarified and the Interim Report has been written.
- About one third of the **Feasibility Study** is done by now. Within this phase a test of the reliability of the Internet is done. A script was written to test the response time of some servers on the Internet by using ping. A part of the **Literature Search** is done now to support the feasible study.
- In addition the basic structure of the system has been worked out.

- Reliability and safety of the robot control have been considered.
- Some enquiries about real-time GNU Linux on robots are done.

8 Conclusions

- The boundaries, aim, objectives and deliverables of the project are defined now.
- The interim report reflects the current project state, is written and handed in in time.
- A basic comprehension of the area needs to be enlarged.
- The structure of the system and of the library has to be considered and figured out.
- It has to be decided which protocol should be used for the communication. Choices are: TCP-socket streams, UDP, and a self-developed protocol based on IP. In addition the version of the Internet Protocol (IP) has to be considered.
- After the system works in the simulation it is necessary to demonstrate the operation on a real robot.
- The project has to be documented well. For this reason the documentation of the library, the UI and the simulator have to be prepared. To deliver an evidence of project progress the interim and final report have to be written. Additionally the project has to be presented in a presentation and questions have to be answered orally in the viva period.
- One of the main problems which has to be considered is the random time delay of an IP-Network. This is safety relevant because every robot has to have an emergency stop.

9 References

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10 Project Planning

10.1 Action Plan

Task		Estimated Duration in Weeks	Precedence
A	Interim Report	3	-
B	Final Report	15	Feedback A
C	Clearing Project Aim/Objectives	5	-
D	Literature Search	8	-
E	Feasibility Study	3	C
F	Prepare Presentation	2	-
G	Interface to Robot	4	C
H	Design Structure	4	C
I	Build Library	8	(G)
J	Write Documentation (Library)	9	(I)
K	Build User Interface	7	(I)
L	Build Robot Simulator	7	(I)
M	Write Documentation (UI/Simulator)	5	(K),(L)
N	Interface between Robot and Library	3	G,(M)

- Precedence:

  X: Task X has to be completed before the task can start.

  (X): Task X has to be semi-completed before the task can start. That means that task X has to be in a state in which is possible to start a new task simultaneous. Tasks which run simultaneous can have an influence among each other.

- Duration and Overlapping

  The weekly working time and effort is shared by overlapping tasks. For example the effort to write the final report will start at a lower level and increases during the project. On the other hand the effort on developing the library is decreasing. The main work will be done in the first three weeks. The last five weeks are planed for little changes to fit the library, the UI and the simulator together.

- Holiday Periods

  The holiday periods are not included in the calculation. It is planned to do all project work within the lecture time. The holidays are scheduled as a reserve in case that the project-work takes longer than expected.

10.2 Milestones

1. On Tuesday, 9 November 2004, the project is defined by now and has been started. This is reflected by the interim report which is completed and handed in.
2. At this point (9^{th} week of first semester) of the project it is possible to control the robot with a little experimental program. The interface to the robot is well understood.
3. In week 14 (first semester) an early simulation with library, user interface and simulator shows the basic function of the system.
4. At the end of week seven (second semester) the system works. It is now possible to control the robot over the Internet by using the library. This will be demonstrated. The simulation works as well.
5. On Tuesday, 26 April 2005, the project and final report are completed and handed in.

10.3 Project Schedule