AN EMBEDDED WEB SERVER-BASED REMOTE MONITORING SYSTEM

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Abstract

To design and develop an embedded web server using 8-bit microprocessor and TCP/IP Ethernet connection for office/home automation applications. In this project, the controller developed is based on Rabbit microprocessor and its core module model RCM 3700. Controlling the motor and others I/O like sensor and also alarms through a website base controller. Showing the I/O data through RCM 3700 with the TCP/IP Ethernet connection to personal computer in webpage. The webpage and firmware will be done in Dynamic C programming language.

For a controlling system, most of last time technology is on short distance controlling system, for example, a control system that builds in a system like a car manufacture system at 1970th. The use of internet and local area network at that time is not common so the range control system is quite difficult at that time. For the present day, the long range control system is become very common. Many types of controlling system are developed for long range control system. For example, the controlling of the Lander Beagle 2 (a remote control car that send to the Mars). At the future, this long range control technology may be developing in the speed of communication. The controlling reaction time may be become as fast as the speed of light or may be faster than the light speed.

For the hardware development, I have to do the connection to connect the I/O like motor to the RCM 3700 board. For the software part, I have to develop the embedded webpage base software enable personal computer to communicate with RCM 3700 board.
Abstrak


Untuk bahagian perkakasan, saya akan membuat perikatan dengan I/O untuk menghubungi RCM 3700 board. Untuk bahagian perisian, saya membuat develop dengan embedded laman web software untuk membolehkan computer peribadi bercommunikasi dengan RCM 3700 board.
CHAPTER 1

INTRODUCTION

Nowadays, controlling a system via PC is very common. A web base control and monitoring system can make us control a system without distance. So developing a cost effective, programmable and high efficiency controller webpage is necessary for the world competition.

This project is titled as “An Embedded Web Server-based Remote Monitoring System”. The propose of this project is to build a remote control system through a webpage. And this system is controlled through local area network by using an embedded TCP/IP Rabbit Core Module 3700. The RCM 3700 is chosen because of have easy Program download utility, ideal for network-enabling security and lots of storage.

This project is divided to hardware and software part. The hardware part is building up an I/O that can connect to the RCM 3700. The connection between the Input/output is connected by a converter that can convert the hardware like sensor and motor signal for RCM 3700.

For the software part, webpage base embedded software will be build for enable personal computer to communicate with RCM 3700 by using Dynamic C. The changing in the I/O will be shown in the personal computer by accessing the webpage.
1.1 Objectives of the project

1. Controlling and monitoring a control system through webpage.
2. A personal computer will become a client and the rabbit microprocessor will be a server.
3. Controlled through local area network by using embedded TCP/IP Rabbit Core Module 3700 RCM 3700 as a server.
4. Design and develop an I/O interface for extended device connection to the RCM3700.
5. Develop Webpage application software will run at the PC platform.
6. Develop Webpage base embedded software will be design and develop for communication between personal computer with RCM 3700 by using Dynamic C via local area network (LAN).
7. Controlling and monitoring the I/O like motor, sensor, relay and led via webpage for distance control.
1.2 Project scopes

1. Study the architecture design and technical specification of embedded Rabbit microprocessor base controller.
2. Study the TCP/IP connection protocol.
3. Study the Dynamic C programming language environment.
4. Develop web server program.
5. Develop firmware for RCM 3700.
6. Design and develop I/O interface for devices connection like relay, sensor and motor.
7. Run the prototype controller in real-time and debug.

1.3 Problem statement

1. Controlling a system via PC is very common but PC is too expensive and cannot work continuously for long working time.
2. A web base controlling system can make us control a system without distance.
3. Controlling a webpage use the PLC based controller is very difficult because the programming language too complex.
4. Developing a cost effective, programmable and reliable embedded web controller webpage is necessary for the world competition.
5. The Rabbit microprocessor is chosen because it provide embedded based for remote automation applications like office or factory application controller that can provide good environment for webpage controlling system.
6. Integrated hardware and software development and build in with TCP/IP capabilities.
### 1.4 PERANCANGAN PROJEK  
**PROJECT PLANNING**

List major activities involved in the proposed project. Indicate duration of each activity to the related month(s).

<table>
<thead>
<tr>
<th>Aktiviti Projek</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study the architecture design and technical specification of Rabbit microprocessor.</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Study the TCP/IP connection protocols.</td>
<td>/ / / / /</td>
<td></td>
</tr>
<tr>
<td>Study the Dynamic C programming language and programming environment.</td>
<td>/ / / / /</td>
<td></td>
</tr>
<tr>
<td>Develop web server program.</td>
<td>/ / / / / /</td>
<td></td>
</tr>
<tr>
<td>Develop firmware for RCM 3700.</td>
<td>/ / / / / /</td>
<td></td>
</tr>
<tr>
<td>Build up I/O interfaces.</td>
<td>/ / /</td>
<td></td>
</tr>
<tr>
<td>Functional testing of the prototype controller in real-time and debug.</td>
<td>/ / /</td>
<td></td>
</tr>
<tr>
<td>Final report PSM I &amp; II</td>
<td>/ / / / / / /</td>
<td></td>
</tr>
<tr>
<td>Presentation PSM I</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>Presentation PSM II</td>
<td>/</td>
<td></td>
</tr>
</tbody>
</table>

*Table 1.1 The Gantt chart shows the project planning of the major activities in PSM1 and PSM2.*
CHAPTER 2

LITERATURE REVIEW

2.1 Remote Monitoring System

The remote and monitoring system can be control by many kind of different technology. The progress can be control and monitor system via field bus, and Ethernet, power line carrier, SMS, EPRS, ADSL, GPRS, CDMA-Based, 3G-Based wireless network, telephone control and other communication means are applied to realize data transmission between data acquisition modules and data collection center. The remote and monitoring able system can be the temperature control and monitoring system, streetlight monitors and control system, remote monitoring of air-quality system, online power system, crop field remote monitoring system, remote measurement and control system for greenhouse, home automation system and some other system that will appear on our living life.

2.1.1 Embedded Web-server-monitoring System and CDMA Service (Crop Field Remote Monitoring system)

Remote monitoring systems based on web-server-embedded technology and mobile telecommunication will become a core node technology in sensing network construction because of a great deal of mobile users and spreads of digital services in next generation telecommunication in the world. Soil, environmental, and crop information monitoring are important in production management and decision-making in precision agriculture. Therefore, reliability, security and inexpensive characteristics required will be essential in the crop field information monitoring. Three improved field monitoring servers (FMS) using code division multiple access
(CDMA) services combined with IPSec-based virtual private network (VPN) function have installed to two rice practical fields in Shanghai and one maize experimental field in Beijing for constructing a remote wireless sensing network. [1]

This crop field remote monitoring system as a ubiquitous node infrastructure in wireless sensing networks is useful and powerful to collect soil, environment, and crop information in remote for precision agriculture. The real-time soil and environment data, and crop images can be dynamically collected in remote area by the crop field monitoring systems in remote. This crop field remote monitoring system using web-server-embedded technology and CDMA service with IPSec-based VPN function as a node infrastructure is powerful and useful to construct a ubiquitous wireless sensing network in low-cost and high-security for crop production. [1]

2.1.2 GSM-SMS Based Remote and Control System for Greenhouse Application

GSM (Global System for Mobile Communications), SMS (Short Message Service).

Global System for Mobile communications is the most popular standard for mobile phones in the world. Its promoter, the GSM Association, estimates that 82% of the global mobile market uses the standard. GSM is used by over 2 billion people across more than 212 countries and territories. Its ubiquity makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM differs from its predecessors in that both signaling and speech channels are digital call quality, and thus is considered a second generation (2G) mobile phone system. This has also meant that data communication was easy to build into the system.

Short Message Service (SMS) is a communications protocol allowing the interchange of short text messages between mobile telephone devices. The SMS technology has facilitated the development and growth of text messaging. The connection between the phenomenon of text messaging and the underlying technology is so great that in parts of the world the term "SMS" is used colloquially
as a synonym for a text message from another person or the act of sending a text message. SMS as used on modern handsets was originally defined as part of the GSM series of standards.

As a new planting mode, modern greenhouse installations are marked by their high efficiency and uniformity in production of vegetable, fruitage, flower, medicinal materials, and others. The new mode breaks the restriction of region, environment, climate and other factors, and has become an incomparable planting mode. It can efficiently improve the agriculture ecology and production condition while promoting the scientific exploitation and reasonable use of agriculture resource. Moreover, output rate of earth as well as working efficiency is enhanced, and good social and economic benefits are received. Survey and control of greenhouse environment parameter is the key part in the realization and development of greenhouse installations. [2]

A greenhouse environment measurement and control system based on GSM-SMS was developed. The system adopted mobile communication between computer and microcontroller; it comprises a centre station and some base stations. The central station consists of a server together with its application software, a GSM module and a database system; the base station consists of a microcontroller, sensors, actuators and a GSM module. Modularization design procedures were taken in hardware and embedded operating system in software development, which make it easy to extend, maintain and update the system. [2]

2.1.3 The 3G-Based Wireless Networked & Intelligent Monitoring System (Pharos Management)

An intelligent monitoring system of pharos based on GSM/GPRS, GPS and GIS short message service is introduced. For the data collection, data treatment and GSM/GPRS-base data communication are implemented via field instrument. The working states and messages of pharoses, including working current and voltage, unloading voltage, GPS parameters and other environment information, are sent by SMS on GSM/GPRS system. All the information can be sent to control and management center and the mobile telephone of manager on the watch. So the
central computer of the system is able to carry out centralized management of data and remote control for wireless remote monitoring of pharoses. [3]

In practical application of pharos management system, the information transferred via SMS include parameters like location of pharos, charging current, battery cell voltage, load current and other working states. The implementation of intelligent management on pharos with GSM & SMS technology, as a wireless remote monitoring system, it is of wide application. In the navigation channel management, pharoses spread widely in inland and near-sea. To check the status of these pharoses artificially not only cost a great deal of man power and material resources, but the inspection cannot be done in time. Even worse, sometimes the artificial operation may endanger man's life. It has gear significance to apply wireless monitoring system of pharos for improving the management level & quality of pharos and navigation. [3]

2.1.4 Remote Telephone-Controlled System (Home Automation)

Home Automation System using telephone lines, will be consists of two subsystems. One is the Remote Control system. The other one is the Phone Monitoring system. The Remote Control system used the Dual Tone Multi-frequency signals to control the operations of various appliances. The hardware and software are designed based on the standard telephone system. The Phone Monitoring system provides convenient services for the user to better monitoring the usage of their phones. [4]

The systems can be installed for public use widely. Both systems were designed based on the DTMF (Dual Tone Multi-frequency) signals that are produced by the telephone system. The DTMF signals were sent from the user end to the destination end. The RC (Remote Control) system detects the number of phone ring and a set of defined codes to determine if a remote control signal has been sent out to control the operation of target appliance. If the control signal is confirmed by the system, the system will send out a control signal to initiate the operation of the appliance. The PM (Phone Monitoring) system will send out a warning signal and
automatically record the content of the conversation if it detects an in or out call of the phone.

The remote control system provides a couple of convenient services to promoting the living lives of families. The users have better control on their home appliances. This is especially important if they need such a control when they are far away from the location of their homes. This remote control style can also be applied to the control of factories. A careful design can possibly reduce the operation cost. The phone monitoring system can record the conversation on the phone. The circuit is quiet small and can be insert in telephone set easily. The circuit can be installed in series with the phone lines. The serial resistance is below 100 ohms. Therefore, the circuit will not affect the performance of telephones. [4]

The circuit extracts the power from the phone line directly and has low power dissipation. Therefore, there are no battery and antenna in the circuit. The user can listen to the conversation far to 25 meters. A commercial cascade player can record the conversation easily. The parents can use the utility to better understand the development of their children. By the way, the bulb wills turn on automatically when the phone is ringing. This function will be helpful in lighting up the room for picking up the phone when a deep night call is coming. The design of a remote control system and a phone monitoring system. Both systems are operated based on the standard telephone lines. People can have better control on their house and their lives even they are traveling in another country. [4]

2.1.5 Remote Monitoring over Internet (Air-Quality)

Air-quality remote monitoring systems, consists of monitoring controllers, monitoring agents, MNIB (MoNitor Information Base), protocols and the Internet. The air-quality monitoring systems will in 4 models: organization model, information model, communication model and functionality model. The information model deals with monitoring information structure and MNIB. The basic unit of monitoring information is a monitored object with 6 attributes. MNIB takes a tree-like structure and its leaves store a monitored object. The communication model discusses how the monitoring information is communicated between monitoring
controllers and monitoring agents. The system devise a proprietary network application layer protocols, termed as ARMP (Air-quality Remote Monitor Protocol), dedicated to air-quality remote monitoring systems. ARMP operates in four modes: monitor, monitor-next, set and trap. [5]

In Monitor mode, a monitoring controller will send a request to monitoring agents, and specify the pollutants. The Set mode is designed for a monitoring controller to write values to monitored objects in a monitoring agent. After Set operation, the monitoring agent will return to the monitoring controller for response with the same value in the object-bindings and with status information indicating whether the Set operation is successful in addition. It should be noted that the monitoring agent, instead of the monitoring controller, is active in the Trap operation. The monitoring agent initiates a communication session with a monitoring controller when any emergency occurs. [5]
2.2 Computer network

A computer network is an interconnection of a group of computers. Networks may be classified by what is called the network layer at which they operate according to basic reference models considered as standards in the industry such as the four-layer Internet Protocol Suite model. While the seven-layer Open Systems Interconnection (OSI) reference model is better known in academia, the majority of networks use the Internet Protocol Suite (IP) as their network model.

2.2.1 LAN (Local Area Network)

![Figure 2.1 LAN connection flow](image)

A local area network (LAN) is a computer network covering a small geographic area, like a home, office, or group of buildings. The defining characteristics of LANs, in contrast to Wide Area Networks (WANs), include their much higher data transfer rates, smaller geographic range, and lack of a need for leased telecommunication lines. [6]

Ethernet over unshielded twisted pair cabling, and Wi-Fi are the two most common technologies currently, but ARCNET, Token Ring and many others have been used in the past. Although switched Ethernet is now the most common data link layer protocol and IP as a network layer protocol, many different options have been
used, and some continue to be popular in niche areas. Smaller LANs generally consist of one or more switches linked to each other - often with one connected to a router, cable modem, or DSL modem for Internet access.

Larger LANs are characterized by their use of redundant links with switches using the spanning tree protocol to prevent loops, their ability to manage differing traffic types via quality of service, and to segregate traffic via VLANing.

LANs may have connections with other LANs via leased lines, leased services, or by 'tunneling' across the Internet using VPN technologies.
2.2.2  WAN (Wide Area Network)

Wide Area Network (WAN) is a computer network that covers a broad area (example: any network whose communications links cross metropolitan, regional, or national boundaries). Or, less formally, a network that uses routers and public communications links. Contrast with personal area networks (PANs), local area networks (LANs), campus area networks (CANs), or metropolitan area networks (MANs) which are usually limited to a room, building, campus or specific metropolitan area (e.g., a city) respectively. The largest and most well-known example of a WAN is the Internet.

WANs are used to connect LANs and other types of networks together, so that users and computers in one location can communicate with users and computers in other locations. Many WANs are built for one particular organization and are private. Others, built by Internet service providers, provide connections from an organization's LAN to the Internet. WANs are often built using leased lines. At each end of the leased line, a router connects to the LAN on one side and a hub within the WAN on the other. Leased lines can be very expensive. Instead of using leased lines, WANs can also be built using less costly circuit switching or packet switching methods. Network protocols including TCP/IP deliver transport and addressing functions. [6]
### 2.2.2.1 WAN connectivity options

Several options are available for WAN connectivity: [1]

<table>
<thead>
<tr>
<th>Option:</th>
<th>Description</th>
<th>Advantage/s</th>
<th>Disadvantages</th>
<th>Bandwidth range</th>
<th>Sample protocols used (application)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leased line</strong></td>
<td>Point-to-Point connection between two computers or Local Area Networks (LANs)</td>
<td>Most secure</td>
<td>Expensive</td>
<td></td>
<td>PPP, HDLC, SDLC, HNAS</td>
</tr>
<tr>
<td><strong>Circuit switching</strong></td>
<td>A dedicated circuit path is created between end points. Best example is dialup connections</td>
<td>Less Expensive</td>
<td>Call Setup</td>
<td>28 Kb/s - 144 Kb/s</td>
<td>PPP, ISDN</td>
</tr>
<tr>
<td><strong>Packet switching</strong></td>
<td>Devices transport packets via a shared single point-to-point or point-to-multipoint link across a carrier internetwork. Variable length packets are transmitted over Permanent Virtual Circuits (PVC) or Switched Virtual Circuits (SVC)</td>
<td>Shared media across link</td>
<td></td>
<td>X.25 Frame-Relay</td>
<td></td>
</tr>
<tr>
<td><strong>Cell relay</strong></td>
<td>Similar to packet switching, but uses fixed length cells instead of variable length packets. Data is divided into fixed-length cells and then data is transported across virtual circuits</td>
<td>Overhead can be considerable</td>
<td></td>
<td>ATM</td>
<td></td>
</tr>
</tbody>
</table>

*Table 2.1 WAN connectivity*
2.2.3 Client/Server Networks

The client/server paradigm requires some computers to be dedicated to serving other computers. A server application waits for a client application to initiate contact.

<table>
<thead>
<tr>
<th>Client Software</th>
<th>Server Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>An arbitrary application program that becomes a client when a remote service is</td>
<td>A special-purpose, privileged program dedicated to providing one service. It can</td>
</tr>
<tr>
<td>desired. It also performs other local computations.</td>
<td>handle multiple remote clients at the same time.</td>
</tr>
<tr>
<td>Actively initiates contact.</td>
<td>Passively waits for contact.</td>
</tr>
<tr>
<td>Invoked by a user and executes for one session.</td>
<td>Invoked when the system boots and executes through many sessions.</td>
</tr>
<tr>
<td>Capable of accessing multiple services as needed, but actively contacts only</td>
<td>Accepts contact from an arbitrary number of clients, but offers a single service</td>
</tr>
<tr>
<td>one remote server at a time.</td>
<td>or a fixed set of services.</td>
</tr>
<tr>
<td>Does not require special hardware or a sophisticated operating system.</td>
<td>Can require powerful hardware and a sophisticated operating system, depending on</td>
</tr>
<tr>
<td></td>
<td>how many clients are being served.</td>
</tr>
</tbody>
</table>

*Table 2.2 The Summary of Differences between Client and Server [7]*
2.2.4 Port Numbers

Port numbers are the mechanism for identifying particular client and server applications. Servers select a port to wait for a connection. Most services have well-known port numbers. For example, HTTP uses port 80. When a web browser (the client) requests a web page it specifies port 80 when contacting the server. Clients usually have ephemeral port numbers since they exist only as long as the session lasts. [7]

Some of the common well-known TCP port numbers are listed in the table 2.3.

<table>
<thead>
<tr>
<th>Port Number</th>
<th>Listening Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Echo request</td>
</tr>
<tr>
<td>20/21</td>
<td>File Transfer Protocol (FTP)</td>
</tr>
<tr>
<td>23</td>
<td>Telnet</td>
</tr>
<tr>
<td>25</td>
<td>Simple Mail Transfer Protocol (SMTP)</td>
</tr>
<tr>
<td>53</td>
<td>Domain Name Server</td>
</tr>
<tr>
<td>80</td>
<td>HTTP Server</td>
</tr>
</tbody>
</table>

*Table 2.3 TCP port number [7]*
2.2.5 TCP/IP protocol

The Internet protocol suite is the set of communications protocols that implement the protocol stack on which the Internet and most commercial networks run. It has also been referred to as the TCP/IP protocol suite, which is named after two of the most important protocols in it: the Transmission Control Protocol (TCP) and the Internet Protocol (IP), which were also the first two networking protocols defined.

The Internet Protocol suite—like many protocol suites—can be viewed as a set of layers. Each layer solves a set of problems involving the transmission of data, and provides a well-defined service to the upper layer protocols based on using services from some lower layers. Upper layers are logically closer to the user and deal with more abstract data, relying on lower layer protocols to translate data into forms that can eventually be physically transmitted. The TCP/IP reference model consists of four layers.

The TCP/IP flow that I use for my PSM is from the application layer (HTTP) then the data will send to the transport layer (TCP) and go to the network (IP) and lastly go to the data link (the Ethernet). : - [HTTP → TCP → IP → ETHERNET]

![Figure 2.2 TCP/IP protocol flow](image_url)
2.2.5.1 Network Protocol Layers

Computers on a network communicate in agreed upon ways called protocols. The complexity of networking protocol software calls for the problem to be divided into smaller pieces. A layering model aids this division and provides the conceptual basis for understanding how software protocols together with hardware devices provide a powerful communication system.

2.2.5.2 Layering Models

In the early days of networking, before the rise of the ubiquitous Internet, the International Organization for Standardization (ISO) developed a layering model whose terminology persists today.

<table>
<thead>
<tr>
<th>Name of Layer</th>
<th>Purpose of Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 7</td>
<td>Application</td>
</tr>
<tr>
<td></td>
<td>Specifies how a particular application uses a network.</td>
</tr>
<tr>
<td>Layer 6</td>
<td>Presentation</td>
</tr>
<tr>
<td></td>
<td>Specifies how to represent data.</td>
</tr>
<tr>
<td>Layer 5</td>
<td>Session</td>
</tr>
<tr>
<td></td>
<td>Specifies how to establish communication with a remote system.</td>
</tr>
<tr>
<td>Layer 4</td>
<td>Transport</td>
</tr>
<tr>
<td></td>
<td>Specifies how to reliably handle data transfer.</td>
</tr>
<tr>
<td>Layer 3</td>
<td>Network</td>
</tr>
<tr>
<td></td>
<td>Specifies addressing assignments and how packets are forwarded.</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Data Link</td>
</tr>
<tr>
<td></td>
<td>Specifies the organization of data into frames and how to send frames over a network.</td>
</tr>
<tr>
<td>Layer 1</td>
<td>Physical</td>
</tr>
<tr>
<td></td>
<td>Specifies the basic network hardware.</td>
</tr>
</tbody>
</table>

*Table 2.4 ISO 7-Layer Reference Model [7]*

The 7-layer model has been revised to the 5-layer TCP/IP reference model to meet the current needs of protocol designers. [7]
<table>
<thead>
<tr>
<th>Name of Layer</th>
<th>Purpose of Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 5</td>
<td>Application</td>
</tr>
<tr>
<td>Layer 4</td>
<td>Transport</td>
</tr>
<tr>
<td>Layer 3</td>
<td>Internet</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Network</td>
</tr>
<tr>
<td>Layer 1</td>
<td>Physical</td>
</tr>
</tbody>
</table>

Specifies how a particular application uses a network.

Specifies how to ensure reliable transport of data.

Specifies packet format and routing.

Specifies frame organization and transmittal.

Specifies the basic network hardware.

Table 2.5 TCP/IP 5-Layer Reference Model [7]

### 2.2.5.3 Application layer

HTTP – Hypertext Transfer Protocol is a communications protocol used to transfer or convey information on the World Wide Web. HTTP is a request/response protocol between clients and servers.

FTP – File Transfer Protocol is used to transfer data from one computer to another over the Internet, or through a network. FTP is a commonly used protocol for exchanging files over any network that supports the TCP/IP protocol.

SMTP – Simple Mail Transfer Protocol is the standard for e-mail transmissions across the Internet. SMTP is a relatively simple, text-based protocol, where one or more recipients of a message are specified and then the message text is transferred.

DNS – Domain Name System. Domain names are significant because they guide users to where they want to go on the Internet. It stores other information such as the list of mail exchange servers that accept email for a given domain. In providing a worldwide keyword-based redirection service, the Domain Name System is an essential component of contemporary Internet use. The most basic use of DNS is to translate hostnames to IP addresses. It is in very simple terms like a phone book. For example, if you want to know the internet address of www.uiten.edu.my, the Domain Name System can be used to tell you it is 60.125.130.10.
DHCP – DHCP (Dynamic Host Configuration Protocol) is a protocol used by networked computers (clients) to obtain IP addresses and other parameters such as the default gateway, subnet mask, and IP addresses of DNS servers from a DHCP server. DHCP is a more advanced protocol based on BOOTP, but is far more complex to implement. Most DHCP servers also offer BOOTP support.

BOOTP – short for BOOTstrap Protocol is a UDP network protocol used by a network client to obtain its IP address automatically. This is usually done in the bootstrap process of computers or operating systems running on them. The BOOTP servers assign the IP address from a pool of addresses to each client. BOOTP enables 'diskless workstation' computers to obtain an IP address prior to loading any advanced operating system.

2.2.5.4 Transport layer

TCP – The Transmission Control Protocol (TCP) is one of the core protocols of the Internet protocol suite. TCP provides reliable, in-order delivery of a stream of bytes, making it suitable for applications like file transfer and e-mail. It is so important in the Internet protocol suite that sometimes the entire suite is referred to as "the TCP/IP protocol suite."

The Internet Protocol (IP) works by exchanging groups of information called packets. Packets are short sequences of bytes consisting of a header and a body. The header describes the packet's destination, which routers on the Internet use to pass the packet along, in generally the right direction, until it arrives at its final destination. The body contains the application data.

TCP Connection/Socket

A TCP connection is done with a 3-way handshake between a client and a server. The following is a simplified explanation of this process.

- The client asks for a connection by sending a TCP segment with the SYN control bit set.
• The server responds with its own SYN segment that includes identifying information that was sent by the client in the initial SYN segment.

• The client acknowledges the server's SYN segment.

The connection is then established and is uniquely identified by a 4-tuple called a socket or socket pair:

• (destination IP address, destination port number)

• (source IP address, source port number)

During the connection setup phase, these values are entered in a table and saved for the duration of the connection. [7]

Example:

1. The initiating host (client) sends a synchronization (SYN flag set) packet to initiate a connection. Any SYN packet holds a Sequence Number. The Sequence Number is a 32-bit field in TCP segment header. For example let the Sequence Number value for this session be x.

2. The other host receives the packet, records the Sequence Number of x from the client, and replies with an acknowledgment and synchronization (SYN-ACK). The Acknowledgment Number is a 32-bit field in TCP segment header. It contains the next sequence number that this host is expecting to receive (x + 1). The host also initiates a return session. This includes a TCP segment with its own initial Sequence Number value of y.

3. The initiating host responds with the next Sequence Number (x+1) and a simple Acknowledgment Number value of y + 1, which is the Sequence Number value of the other host + 1.
UDP – User Datagram Protocol (UDP) is one of the core protocols of the Internet protocol suite. Using UDP, programs on networked computers can send short messages sometimes known as datagrams (using Datagram Sockets) to one another. UDP is sometimes called the Universal Datagram Protocol. Unlike TCP, UDP supports packet broadcast (sending to all on local network) and multicasting (send to all subscribers).

Common network applications that use UDP include the Domain Name System (DNS), streaming media applications such as IPTV, Voice over IP (VoIP), Trivial File Transfer Protocol (TFTP) and online games.
2.2.5.5 Network layer

IP – IP address (Internet Protocol address) is a unique address that certain electronic devices use in order to identify and communicate with each other on a computer network utilizing the Internet Protocol standard (IP)—in simpler terms, a computer address. Any participating network device—including routers, switches, computers, time-servers, printers, Internet fax machines, and some telephones—can have their own unique address. An IP address can also be thought of as the equivalent of a street address or a phone number (compare: VoIP (voice over (the) internet protocol)) for a computer or other network device on the Internet.

ARP – The Address Resolution Protocol (ARP) is the standard method for finding a host's hardware address when only its network layer address is known. ARP is not an IP-only or Ethernet-only protocol; it can be used to resolve many different network-layer protocol addresses to hardware addresses, although, due to the overwhelming prevalence of IPv4 and Ethernet, ARP is primarily used to translate IP addresses to Ethernet MAC addresses. It is also used for IP over other LAN technologies, such as Token Ring, FDDI, or IEEE 802.11, and for IP over ATM.

2.3 Embedded Web Server

An embedded HTTP server is a component of a software system that implements the HTTP protocol. Examples of usage within an application might be:

- To provide a thin-client interface for a traditional application.
- To provide indexing, reporting, and debugging tools during the development stage.
- To implement a protocol for the distribution and acquisition of information to be displayed in the regular interface — possibly a web service, and possibly using XML as the data format.
- To develop a web application
There are a few advantages to using HTTP to perform the above:

- HTTP is a well studied cross-platform protocol and there are mature implementations freely available.
- HTTP is seldom blocked by firewalls and intranet routers.
- HTTP clients (e.g. web browsers) are readily available with all modern computers.
- There is a growing tendency of using embedded HTTP servers in applications that parallels the rising trends of home-networking and ubiquitous computing.

### 2.3.1 Typical requirements

Natural limitations of the platforms where an embedded HTTP server runs contribute to the list of the functional requirements of the embedded, or more precise, embeddable HTTP server. Some of these requirements in random order

- "Small" RAM and ROM foot print. The exact number depends on the system, but in many cases anything above single digits MB is not embeddable.
- Low CPU consumption.
- Cross compilation support for multiple CPU + OS combinations.
- C implementation (compare with C++/Java/C#).
- Easy integration with existing application, including static link with the OS and application.
- Serving pages from the RAM if there is no file system.
- Modularity.
- Single thread and multi-thread support.

For every specific project requirements can vary significantly. For example, ROM and RAM footprints can be very serious constrain and limit the choices of the system designer. C++ or JVM availability for the CPU/system can be another constrain. Frequently performance is an issue, because typical embedded system runs multiple simultaneous tasks and WEB server is only one of them and usually is a low priority task.