An Cloud based IoT Controlled Robot Using ARM Cortex Controller For Critical Environments

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Abstract:
The electronics advancements and embedded technology advancements have become a challenging field in today's techno world. In paper, the diligent features of embedded systems are introduced. It deals about how a robot is controlled using embedded operating system and ARM. Based on the combination of ARM Cortex and Real time operating system (RTOS). This paper introduces development of embedded robot control system using Wi-Fi and also IOT. The embedded control system design includes four aspects. i.e., system structure, functions, hardware design and software design. By using these aspects (hardware and software adjustments), many robotic applications can be developed. Due to the fast execution speed and reasonable Ethernet speed in ARM processor, this system can be used in industrial oriented applications where there is very much necessity of safety and security.

Keyword: Wireless Technology, Robotics, Internet based Controlling(IoT), ARM Cortex, Real Time Operating System (RTOS), LM 393D.

1.Introduction

For the people who are indulged in electronics either as a hobby or as a profession who kind off happens to have more interest in robotics this project is the key in which most of precise work which humans cannot do repeatedly, this is where a robotic arm or we can say a pick n place robot comes into picture. Robotics is the branch of mechanical engineering, electrical engineering and computer science that deals with the design, construction, operation, and application of robots, as well as computer systems for their control, sensory feedback, and information processing. A Robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The internet of things (IoT) is the network of physical devices, vehicles, buildings and other items embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber physical systems, which also encompasses technologies such as smart grids, smart homes, intelligent transportation and smart cities. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure.

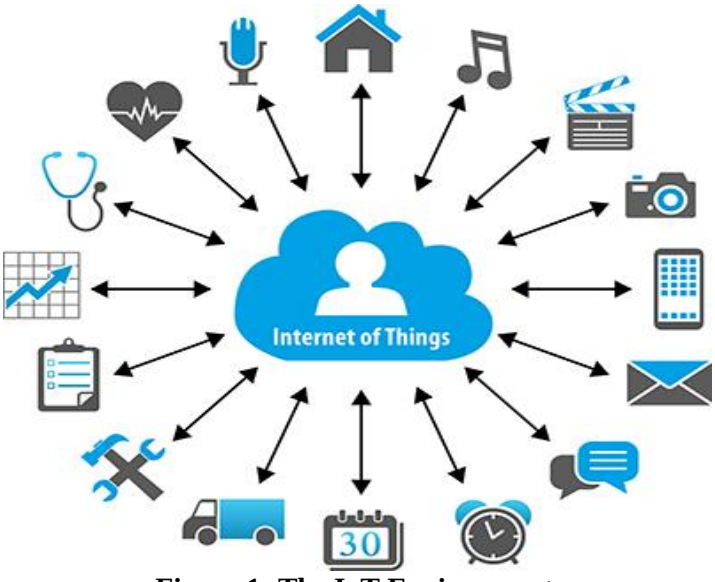

Figure 1: The IoT Environment.

An embedded operating system is an operating system for embedded computer systems. These operating systems are designed to be compact, efficient at resource usage, and reliable for many functions that non-embedded computer operating systems provide, and which may not be used by the specialized applications they run. They are frequently also referred to as real-time operating systems. An important difference between most embedded operating systems and desktop operating systems is that the application, including the operating system, is usually statically linked together into a single executable image. Unlike a desktop operating system, the embedded operating system does not load and execute applications. This means that the system is only able to run a single application. The advantages of embedded Linux over proprietary embedded operating systems include multiple suppliers for software, development and support, no royalties or licensing fees, a stable kernel, the ability to read, modify and redistribute the source code. The technical disadvantages include a comparatively large memory footprint (kernel and root file system), complexities of user mode and kernel mode memory access, and a complex device driver's framework. As more advanced control algorithms are becoming available for the control of robotic arms, traditional fixed controller boards and associated code generators are becoming less convenient way to test such control algorithms in real-time. The process of using such boards is complex, time consuming, and inflexible. By the advancement of electronics, embedded technology has become a challenging field in this modern age. The single functioned tightly constrained, reactive and real-time feature of these devices enhanced its importance in industrial, consumer applications.

2.Literature Survey

1.Alen Rajan in his paper [1] proposed that embedded technology is one of the emerging technologies in this most modern era. When networking technology is incorporated with the former, there is no doubt that the scope of embedded systems would be further more. 2. Alen Rajan has highlighted in the paper [2] that a robot arm is an Electro-mechanical device that performs various tasks ranging from simple mechanical jobs to highly complex tasks. It can be used to pick and place small parts on a production line. 3. Li Yanhong proposed that [3], it can replace the human operator in feeding industrial process with discrete components. 4. Reza Ezuan Samin in his paper [4] explained that, with the increase usage of wireless application, the demand for a system that could easily connect devices for transfer of data over a long distance - without cables, grew stronger. Robotic arms are used in diverse manufacturing processes including assembly, spot welding, laser processing, cutting, grinding, polishing, testing, painting and dispensing. 5. Tetsuya Akagia proved in his paper [5] that, Robots have proved to help automakers to be more agile, flexible and to reduce production lead times. The robot arm using in this paper was designed with DC motors which are driven by the driver circuit 6. V.Billy Rakesh Roy1, Sanket Dessai1, and S. G.Shiva Prasad Yadav in his paper [6] explained about The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers. This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and costeffective processor core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory ARM based embedded system will be more functional, reliable, cost effective, less in size and low power consumption. Microcontroller has low speed and poor memory, so it can only execute simple control tasks. 7. Mohd Ashiq Kamaril Yusoff in his paper [7] explained about a robotic arm saying that a robotic arm is a robot manipulator, usually programmable, with similar functions to a human arm. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The business end of the kinematic chain of the manipulator is called the end effectors and it is analogous to the human hand. The end effectors can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application. The robot arms can be autonomous or controlled manually and can be used to perform a variety of tasks with great accuracy. The robotic arm can be fixed or mobile (i.e. wheeled) and can be designed for industrial or home applications. The wireless mobile robots also have been developing in previous years. 8. Junhua Yang in his paper [8] explains that Since ARM is not directly connected with the Internet system. A kind intelligence monitoring system based on 32 bit ARM processor LPC2138 and information fusion technology was provided. ARM has advantages of high integration and powerful information processing capability. 9. K.Bharath reddy, Ch. Rajendra Prasad in their paper [9] explains about the system structure of embedded Web server. The entire system uses B/S mode. The client PC is connected to the Internet through a browser and then gets access to the embedded Web server. Through this way, remote login and operation are realized. Embedded Web Server (EWS) is a Web server that runs on an embedded system with limited computing resources and serves embedded Web documents to a Web browser. By embedding a Web server into a network device, it is possible for a EWS to provide a powerful Web-based management user interface constructed using HTML, graphics and other features common to Web browsers. When applied to embedded systems, Web technologies offer graphical user interfaces, which are user-friendly, inexpensive, cross-platform, and network-ready. A Web server can be embedded in a device to provide remote access to the device from a Web browser if the resource requirements of the Web server are reduced. The end result of reducing the resource requirements of the Web server is typically a portable set of code that can run on embedded systems with limited computing resources. 10. Vaishak N. L,C.G. Ram Chandra explained about ARM

processor in his paper[10] explained the software part was developed by using embedded C. Existing system robot generally works with microcontroller and it is basically wired robots which works on CISC microprocessor. Proposed System introduces the configuration of the embedded system, and then presents a robot control system based on an embedded operating system and ARM. Based on the combination of advanced RISC microprocessor (ARM), DSP and ARM-Linux, this project involves development of embedded robot control systems through Wi-Fi. Here we use ARM controller as the heart of the system. ARM has high speed of execution and powerful information processing capability. The capacity of multi-parameter execution, multi-level monitoring and networking of ARM processor makes it suitable for a wide variety of networking applications.

3.ARM Microprocessor

ARM Architecture ARM architecture is the most widely used 32-bit ISA in terms of numbers produced. They were originally conceived as a processor for desktop personal computers by Acorn Computers, a market now dominated by the x 86 families used by IBM PC compatible and Apple Macintosh computers. The ARM is a 32-bit reduced instruction set computer (RISC) instruction set architecture (ISA) developed by ARM Holdings. It was known as the Advanced RISC Machine, and before that as the Acorn RISC Machine. The relative simplicity of ARM processors made them suitable for low power applications. This has made them dominant in the mobile and embedded electronics market, as relatively low cost, and small microprocessors and microcontrollers. By systematic maintenance it is possible to achieve substantial savings in money, material and manpower as every effort is directed towards avoiding catastrophic failures 2.1 RISC Features 1. The ARM architecture includes the following RISC features: 2. Load/store architecture. 3. No support for misaligned memory accesses (now supported in ARMv6 cores, with some exceptions related to load/store multiple word instructions). 4. Uniform 16 × 32-bit register file. 5. Fixed instruction width of 32 bits to ease decoding and pipelining, at the cost of decreased code density. Later, "the Thumb instruction set" increased code density. 6. Mostly single-cycle execution. To compensate for the simpler design, compared with contemporary processors like the Intel 80286 and Motorola 68020, some additional design features were used: a. Conditional execution of most instructions, reducing branch overhead and compensating for the lack of a branch predictor. b. Arithmetic instructions alter condition codes only when desired. c. 32-bit barrel shifter which can be used without performance penalty with most arithmetic instructions and address calculations. d. Powerful indexed addressing modes. e. A link register for fast leaf function calls. f. Simple, but fast, 2-priority-level interrupts subsystem with switched register banks.

Conditional Execution

The conditional execution feature (called predication) is implemented with a 4-bitcondition code selector (the predicate) on every instruction; one of the four-bit codes is reserved as an "escape code" to specify certain unconditional instructions, but nearly all common instructions are conditional. Most CPU architectures only have condition codes on branch instructions. This cuts down significantly on the encoding bits available for displacements in memory access instructions, but on the other hand it avoids branch instructions when generating code for small if statements. One of the ways that Thumb code provides a denser encoding is to remove that four-bit selector from non-branch instructions.

Instruction Set

To keep the design clean, simple and fast, the original ARM implementation was hardwired without microcode, like the much simpler 8-bit 6502 processor used in prior Acorn microcomputers.

Pipelines and other Implementation Issues

The ARM7 and earlier implementations have a three stage pipeline; the stages being fetch, decode, and execute. Higher performance designs, such as the ARM9, have deeper pipelines: Cortex-A8 has thirteen stages. Additional implementation changes for higher performance include a faster adder, and more extensive branch prediction logic.

Coprocessors

The architecture provides a non-intrusive way of extending the instruction set using "coprocessors" which can be addressed using MCR, MRC, MRRC, MCRR, and similar instructions. The coprocessor space is divided logically into 16 coprocessors with numbers from 0 to 15, coprocessor 15 (cp15) being reserved for some typical control functions like managing the caches and MMU operation (on processors that have one).In ARM-based machines, peripheral devices are usually attached to the processor by mapping their physical registers into ARM memory space or into the coprocessor space or connecting to another device (a bus) which in turn attaches to the processor.

Debugging

All modern ARM processors include hardware debugging facilities; without them, software debuggers could not perform basic operations like halting, stepping, and break pointing of code starting from reset.

Jazelle

Jazelle is a technique that allows Java Byte code to be executed directly in the ARM architecture as a third execution state (and instruction set) alongside the existing ARM and Thumb-mode. Support for this state is signified by the "J" in the ARMv5TEJarchitecture, and in ARM9EJ-S and ARM7EJ-S core names. Support for this state is required starting in ARMv6 (except for the ARMv7- M profile), although newer cores only include a trivial implementation that provides no hardware acceleration

4.Internet of Things

An embedded web server is a microcontroller that contains an Internet software suite as well as application Code for monitoring and controlling systems. Embedded Web servers are integral part of an embedded network and Paves way for faster time to market products. “Fig 2”. Shows the general purpose web server where, it requires a huge amount of memory, special hardware, Software and an operating system. An embedded web Server can replace the “Fig 3.2” which is a single hardware With an RTOS and the application. Fig 3. Embedded Web Server Architecture The web server is the Board that has the application and the RTOS (µC/OS-II).

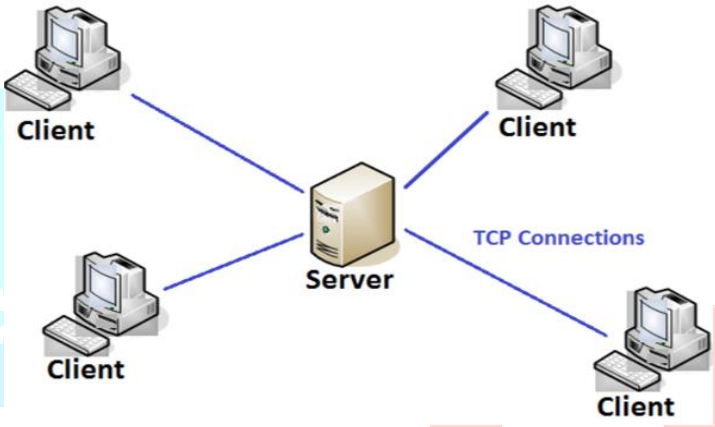

Figure 2: The client-server Architecture.

The operating system manages all the tasks such as sending the HTML pages, connecting to new users etc. The RTOS manages all the required tasks in parallel, and in small amounts of time. Web based management user Interfaces using embedded web servers have many Advantages: ubiquity, user friendliness, low development Cost and high maintainability. Embedded web servers have different requirements, such as low resource usage, High reliability, security and portability, for which general Web server technologies are unsuitable. There are also design issues such as HTTP and embedded API.

The Internet of things (IoT) is the internetworking of physical devices. The concept was simple but powerful. If all objects in daily life were equipped with identifiers and wireless connectivity, these objects could be communicating with each other and be managed by computers. The Three Cs of IoT: Communication -It is the interconnection between the user and system/device. Control and Automation - It is programmed once as if any changes in output parameter it will alert the uses and hence it can be control or it can be automated for any particular work. Cost Savings - Many companies will adopt IoT to save money.

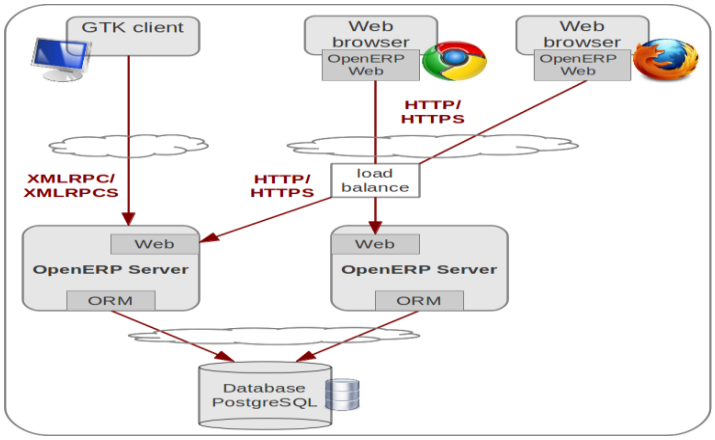

Figure 3: Embedded Web Server Architecture.

As when a machine loses to fulfill a company product on time the company will lose its money. With new sensor information, IoT can help a company to save money by reducing equipment failure and allowing the business to perform perfectly.

4.Project Implementation

ARM Cortex Controller(STM32F103C8)

Arm Cortex-A processors are at the heart of the most powerful and compelling technology products. They are deployed in laptop devices, networking infrastructure, home and consumer devices, automotive in-vehicle infotainment and driver automation systems, and embedded designs. Cortex-A processors power intelligent solutions, from edge to cloud, for next-generation experiences. The STM32F103xx medium-density performance line family incorporates the high-performance ARM®Cortex®-M3 32-bit RISC core operating at a 72 MHz frequency, high-speed embedded memories (Flash memory up to 128 Kbytes and SRAM up to 20 Kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses. All devices offer two 12-bit ADCs, three general purpose 16-bit timers plus one PWM timer, as well as standard and advanced communication interfaces: up to two I^2Cs and SPIs, three USARTs, an USB and a CAN.

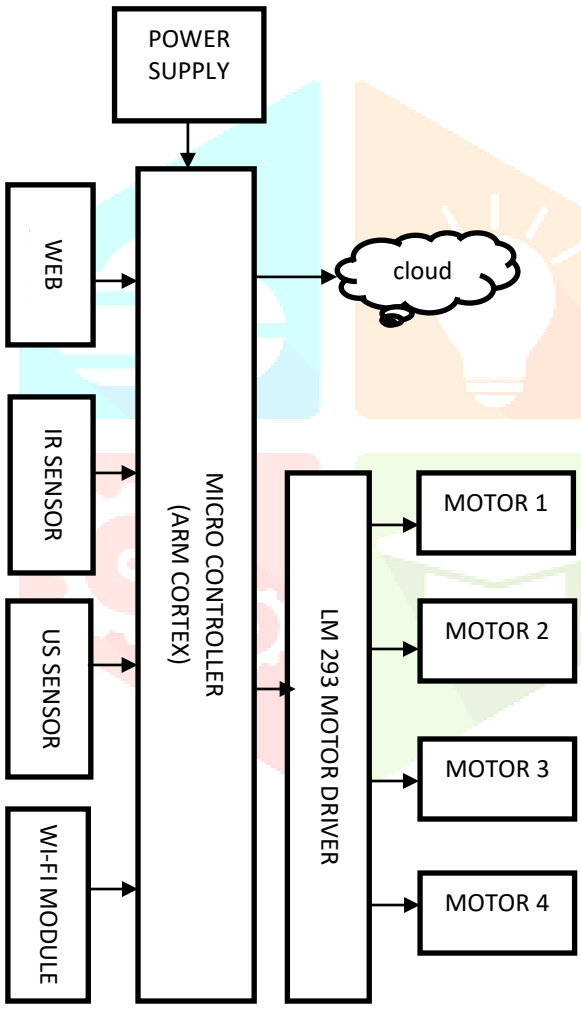

Figure 4: The Implemented Project Block Diagram.

Motor driver L293D

The L293 and L293D devices are quadruple high current half H-Drivers. The L293 is designed to provide bidirectional drive currents of upto 1A at voltage from4.5V to 36V. The L293D is designed to provide bidirectional drive currents of upto 600mA at voltages from 4.5V to 36V. both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high current/ high voltage loads in positive supply applications.

DC Motors

Almost every mechanical movement that we see around us is accomplished by an electrical motor. Electric machines are means of converting electrical energy into mechanical energy. Electric motor is used to power hundreds of devices we use in everyday life. An example of small motor applications includes motors used in automobiles, robot, hand power tools and food blenders. Micro-machines are electric machines with parts with the size of red blood cells and find many applications in medicine.

RTOS

A real-time operating system (RTOS) is an Operating system (OS) intended to serve real-time applications that process data as it comes in, typically without buffer delays. Processing time requirements (including any OS delay) are measured in tenths of seconds or shorter increments of time. A real time system is a time bound system which has well defined fixed time constraints. Processing must be done within the defined constraints or the system will fail. They either are event driven or time sharing. Event driven systems switch between tasks based on their priorities while time sharing systems switch the task based on clock interrupts.

ESP8266 Wi-Fi Module

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Systems. The chip first came to the attention of western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer, Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted.[2] The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation. The ESP8285 is an ESP8266 with 1 MB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.

IR Sensor

An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations are invisible to our eyes, that can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode. The resistances and these output voltages, change in proportion to the magnitude of the IR light received.

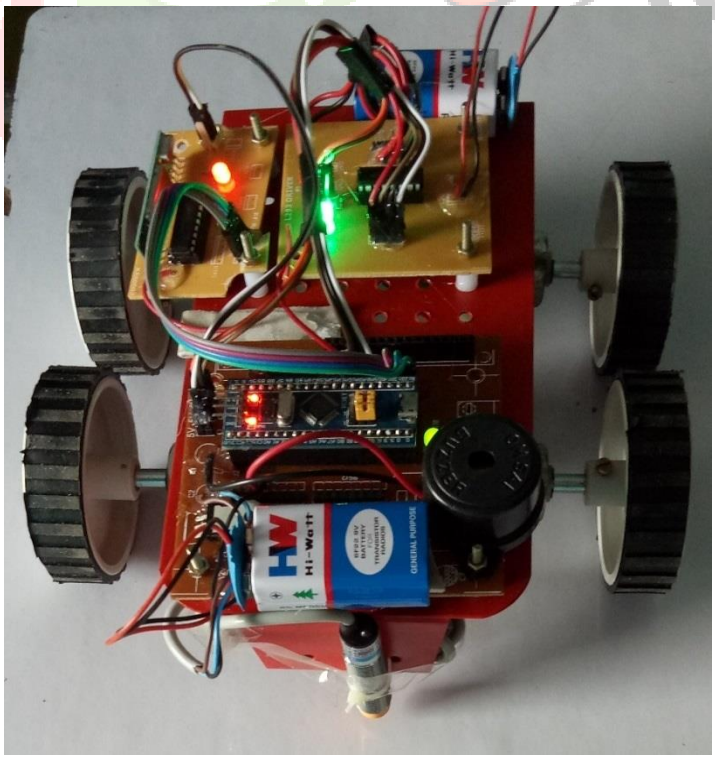

Figure 5: The Implemented Prototype Kit.

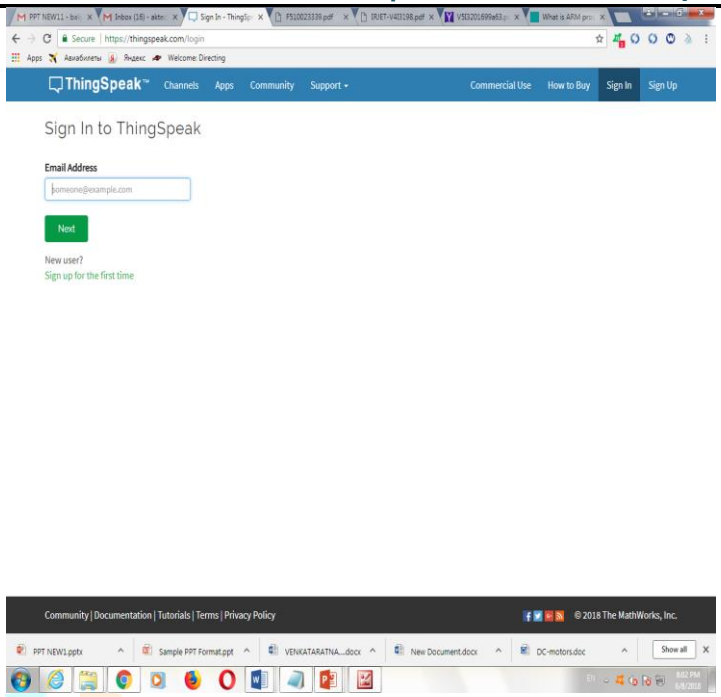

Figure 6: The IoT Cloud (Thingspeak).

Software development process based OS includes: the establishment of cross-compiler, the transplant of Boot loader, the transplant of embedded Linux, the development embedded Web server. To begin with, system cross-compiler environment using EABI-4.3.3 is established. Boot that developed by the German DEXN group is used as Boot loader. The function of Boot loader is to initialize the hardware devices, establish memory mapping tables, thus establish appropriate hardware and software environment and prepare for the final call to the operating system kernel. Besides, yaffs file system is made. Linux is used as operating system because Linux system is a hierarchical structure and completely open its kernel source, the important feature of Linux is portability to support a wide range of hardware platforms, can run in most of the architecture. Contains a comprehensive set of editing, debugging and other development tools, graphical interface, a powerful network supporting and rich applications. In addition, the kernel can be reduced by configuring.

5. Conclusion & Future Work

In this project we were able to control the Robotic arm not only using the wired controls but with the help of Internet of Things which is the growing technology in recent times we successfully controlled the robotic arm using the IoT interface. This can be useful to various industrial applications where machines need to be controlled from distant places. This project not only responds to the controls sent but also records the movements and can perform the same tasks repeatedly reducing human efforts.

When the case of monitoring multiple parameters comes, the EWS with integrated Ethernet is showing better performance when speed and reliability comes into picture. Thus, EWS with integrated Ethernet is suitable for real-time monitoring of Industrial appliances. More over this system has a wide variety of Industrial applications such as remote monitoring and controlling etc. Since ARM processor has fast execution capability and Ethernet standard can provide internet access with reasonable speed and this system is suitable for enhancing security in industrial conditions by remotely monitoring various industrial appliances where high safety and care is a necessity. Finally, this system will be useful for a wide variety of industrial applications.

Future Scope

This system can be extended with new web servers and by using Raspberry Pi and many applications can be developed. Medical Field where minor surgeries are required. Retrieving Suspicious objects without endangering humans.

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