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Energy Efficient Wi-Fi for Industrial Automation


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Abstract

The energy demands of Ethernet links have been an active focus of research in the recent years. This work has enabled a new generation of Energy Efficient Ethernet (EEE) interfaces able to adapt their power consumption to the actual traffic demands, thus yielding significant energy savings. With the energy consumption of single network connections being a solved problem, in this paper we focus on the energy demands of link aggregates that are commonly used to increase the capacity of a network connection. We build on known energy models of single EEE links to derive the energy demands of the whole aggregate as a function on how the traffic load is spread among its powered links. We then provide a practical method to share the load that minimizes overall energy consumption with controlled packet delay, and prove that it is valid for a wide range of EEE links. Finally, we validate our method with both synthetic and real traffic traces captured in Internet backbones.

*Index Terms—**Network interfaces, Link aggregation, Optimization methods, Energy efficiency***

INTRODUCTION

In 2010, the Institute of Electrical and Electronics Engineers published the IEEE 802.3az amendment to the widespread Ethernet standard, commonly referred to as Energy Efficient Ethernet (EEE). The amendment introduces an optional Ethernet feature that allows to achieve power saving during periods of low network traffic. Basically, EEE allows an Ethernet link between two partners (either stations or network components like, for example, switch devices) to enter a new state in which link power consumption is considerably reduced with respect to that of its common idle state. The request to enter such a state may be issued by any of the two link partners.

The introduction of EEE was solicited by the observation that, even if practically all of the Ethernet links currently deployed operate with very low duty cycles, unfortunately their power consumption remains almost the same for all the time they are switched on. In other words, the power consumption of a link depends only slightly on the actual data traffic on the link itself. The power consumption, instead, strongly depends on the transmission rate and ranges, in general, from some hundreds of Milliwatt for 100 Mb/s links to some Watt for 10 GB/s. Considering that the assessment carried out in both and revealed an average utilization of Ethernet links below 5%, the expected overall power saving that could be achieved reducing the power consumption of idle links is potentially enormous.

The way in which power saving can be achieved has been the matter of a long debate in which two main options were considered. The first one, referred to as Low Power Idle (LPI) mode, allows to force Ethernet links in a specific state characterized by low-power

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consumption. The second option is represented by a reduction of the link transmission rate, which in turn limits power consumption. The final choice of the IEEE 802.3 committee has been in the direction of the LPI mode. Consequently, most manufacturers are currently implementing LPI on their products, so that EEE is rapidly becoming widely adopted. The EEE amendment, however, does not provide any indication on the power saving strategies to be implemented, leaving their definition be driven by the specific application scenarios. Such an aspect is a key issue currently addressed by the scientific community. Particularly, one of the most challenging problems is represented by the choice of the time instants to enter/exit the low-power state to achieve the greatest power saving while ensuring low packet transmission delays. Industrial versions of Ethernet networks are playing an ever more important role, thanks to their intrinsic valuable features that allow obtaining isochronous real-time communications. These networks usually referred to as Real-Time.

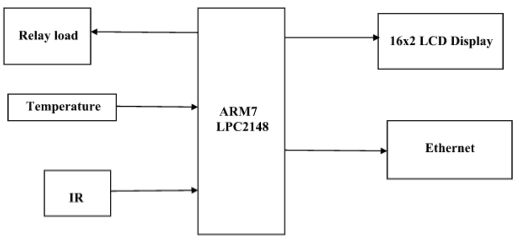

Fig 1.1 Block Diagram

Existing System:

In existing system they control only output loads. This gives us only controlling facility. There is no monitoring section is available here.

Proposed System:

In this project Ethernet module plays major role to control and monitor devices and sensors from any location. This entire process done by IP based.

Operation:

ARM7 – LPC2148 is connected Ethernet module and temperature, IR sensor loads are connected to controller. Also one output relay connected to control any device. This Ethernet module provides network communication from anywhere (if static IP available – user has to take care about this). Based on this Ethernet, user can control and monitor devices.

This project uses regulated 5V 500mA power supply. A 7805 three terminal voltage regulator is used for voltage regulation. Bridge type full wave rectifier is used to rectify the ac output of secondary of 230/12V step down transformer.

Instruction pipeline

The ARM7TDMI core uses a three-stage pipeline to increase the flow of instructions to the processor. This allows multiple simultaneous operations to take place and continuous operation of the processing and memory systems. The instructions are executed in three stages: fetch, decode and execute.

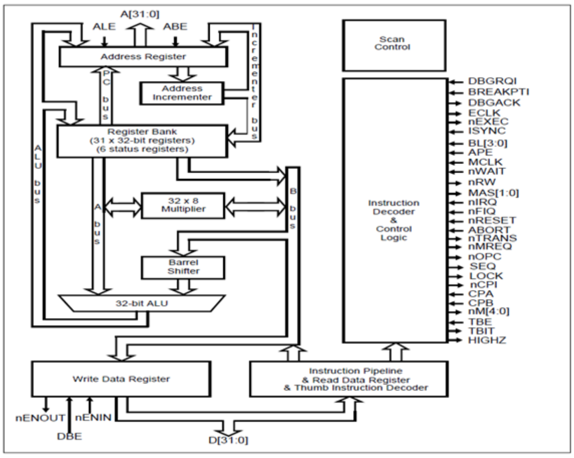

Fig 3.1 ARM7 TDMI Core Diagram.

Memory interface

The ARM7TDMI memory interface is designed to allow optimum performance potential and minimize memory usage. Speed critical control signals are pipelined to allow system control functions to exploit the fast-burst access modes supported by many memory technologies. The ARM7TDMI has four basic types of memory cycle: Internal, Non sequential, Sequential, Coprocessor registers transfer. There is also the option to use either a single bidirectional data bus or two separate unidirectional data input and output buses.

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LPC2148 Microcontroller Architecture

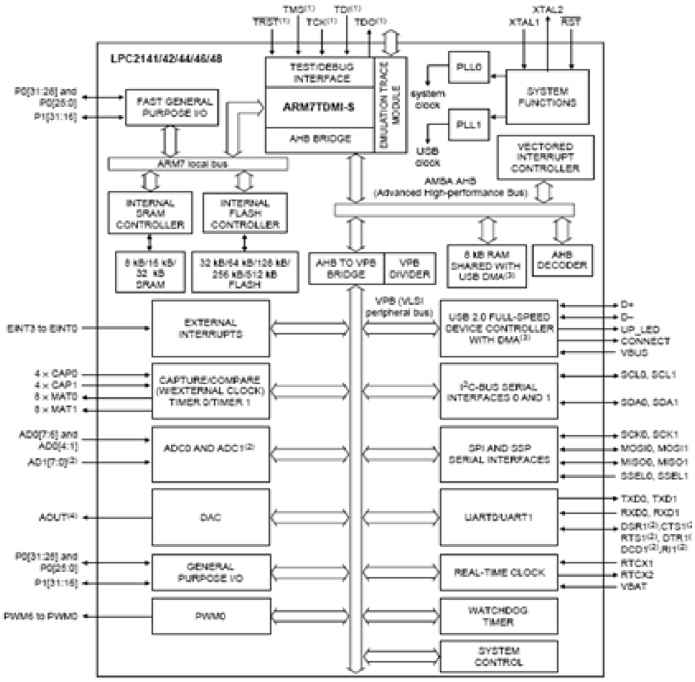

Fig 3.3 LPC2148 Microcontroller Architecture.

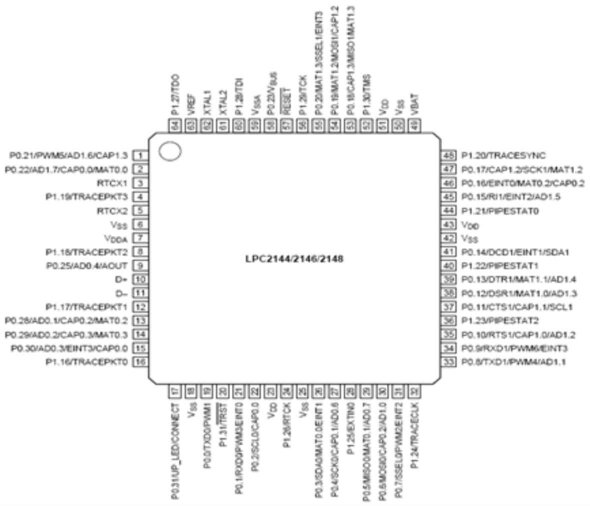

Fig 3.4 LPC2148 Microcontroller Pin Diagram.

Architectural Overview

Figure 3.1.3 shows the LPC2148 Microcontroller Architecture. The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. 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 (CISC). This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. The ARM7TDMI-S processor also employs a unique architectural strategy known as Thumb, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue.

IMPLEMENTATION PHASE & RESULTS

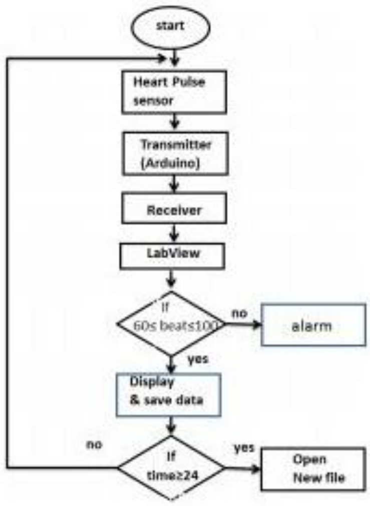

Fig 5.1 Flow chart

Advantages:

- Guaranteed bandwidth (WiFi is a shared, broadcast medium. Ethernet can be dedicated.)
- Physical security can be managed with "managed" switches (but security is layers - know the limitations.)
- PoE (Power over Ethernet): Using the ethernet cabling to deliver power for small routers/switches/devices so that electrical power wiring doesn't need to be delivered for the endpoint.
- Relative immunity to WiFi antagonistic environments (metal walls, etc.)

Disadvantages:

- Higher costs for provisioning in existing buildings
- Doesn't serve mobile devices
- Limited physical access (i.e.: ethernet ports in a room must be in specific locations.)
- Physical connectors can fail, especially if used (connected to, disconnected from) frequency
- Some bandwidth upgrades will require cable replacement. (I.e.: CAT-5e to CAT-6, etc,.)

Application:

- EEE to RTE networks.
- EEE for PROFINET IO.
- EEE for Ethernet POWERLINKS

Results:

Finally, it is worth observing that results from real applications of EEE are ever more necessary. Indeed, especially in the industrial communication field, even minimal differences from (theoretically) estimated behaviors could have dangerous effects on the behavior of plants/applications that use the networks. For example, if the activation delay of a path reveals, in practice, greater than the theoretically expected value, then the jitter of cyclic operations carried out on the path could increase. Consequently, the designed EEE strategies need to be validated by practical experiments.

In this way, the inevitable differences between theoretical models and real behavior may be evidenced, making possible an accurate tuning of the models themselves.

FUTURE SCOPE

We can implement further by using this project that, suitable EEE strategies have to be designed. As we have seen, such an activity is driven, on the one hand, by the characteristics of the (predictable) cyclic traffic, while on the other hand it has to take into account the negative impact deriving from the possible presence of acyclic data transmission requests.

CONCLUSION

In this paper, we provided an assessment of the issues concerned with the application of EEE to industrial networks. The analysis started with a description of the IEEE 802.3az amendment. Then, we actually addressed RTE networks and investigated how they could adopt effective EEE strategies. Specifically, we focused on some of the most popular RTE networks and provided practical examples of EEE application for typical industrial configurations. The analysis demonstrated that significant power savings can be achieved, actually maintaining the high-performance level these networks are requested to provide. Consequently, we believe the introduction of EEE in the industrial communication scenario is a promising research topic.

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