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Remote Control of Devices using an 8-bit Embedded XML & Dynamic Web-server in a Smarthouse Environment

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Abstract

This paper focuses on an Embedded System known as "TCP/IC" and its role in the "house of the future" – the SmartHouse.

Overall, the aim of the TCP/IC was to design a device which could interact with a user (or AI control system) and allow for the control various attached peripherals remotely.

Although such a device could well be used as a standalone device to aid in home-automation, this paper focuses on its use in a SmartHouse environment – one where a number of these devices are networked and controlled by a central AI.

The different technologies and protocols involved in the implementation of the TCP/IC, along with its two primary interfaces, namely HTML (used for user interaction) and XML (used for machine interaction) are also discussed.

The reader will also be introduced to Embedded Systems and the various design principles involved in the creation of quality Embedded Systems. Core-concepts of home-automation and its logical extension, the SmartHouse are also covered in detail.

Various additional interfaces (e.g. Web, XML, custom-formatted text) are also discussed and compared, as are the result of my work and some ideas for future implementations.

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List of Abbreviations

AI	Artificial Intelligence
ALU	Arithmetic and Logic Unit
ARP	Address Resolution Protocol
AUSART	Addressable Universal Asynchronous Receiver Transmitter
BIN	Binary (access file)
CCP	Capture/Compare/PWM
CGI	Common Gateway Interface
CMOS	Complementary Metal-Oxide Semiconductor
CPU	Central Processing Unit (including ALU)
DIP	Dual Inline Package
DOS	Disk Operating System
EEPROM	Electrically Erasable Programmable Read Only Memory
EPROM	Erasable Programmable Read Only Memory
FAT	File Allocation Table (referring to a File System)
FIFO	First-in, First-out (Abstract data type – e.g. a queue)
FSM	Finite State Machine
FTP	File Transfer Protocol
GSM	Global System for Mobile communication
GUI	Graphical User Interface
HTML	Hyper-Text Mark-up Language
HTTP	Hypertext Transfer Protocol
I/O	Input / Output
I ² C	2-wire Inter-Integrated Circuit
ICD	In-Circuit Debugger
ICMP	Internet Control Message Protocol
IP	Internet Protocol
IR	Infrared (communication)
IrDA	Infrared Data Association
ISA	Industry Standard Architecture (AT bus architecture)
ISO	International Standards Organisation
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LIFO	Last-in, First-out (Abstract data type – e.g. a stack)

LLC	Logical Link Control (layer)
MAC	Medium Access Controller
MIPS	Million Instructions per Second
MPFS	Microchip File System
MS	Microsoft
MSS	Maximum Segment Size (typically 576 or 1500 bytes)
MTU	Maximum Transmission Unit (typically 576 or 1500 bytes)
NIC	Network Interface Card
OS	Operating System
OSI	Open Systems Inter-connection
PC	Personal Computers (a.k.a Desktop Computer)
PCI	Peripheral Communication Interface
PVR	Personal Video Recorder
PWM	Pulse-Wave Modulation
RAM	Random Access Memory
RFC	Request For Comments (Internet Standards)
ROM	Read Only Memory
SBC	Single-Board Computer
SGML	Standardised General Mark-up Language
SLIP	Serial Line Internet Protocol
SMS	Short Message Service (relating to GSM/ Mobile Networks)
SOC	System-on-a-Chip
SPI	Serial Peripheral Interface
SSI	Server Side Includes
TCP	Transmission Control Protocol
TUI	Text User Interface
TV	Television
UDP	User Datagram Protocol
VCR	Video Cassette Recorder
W3C	World Wide Web Consortium (Internet Standards Committee)
WAN	Wide Area Network
WIFI	Wireless Fidelity (refers to RFC 802.11)
XML	eXtensible Mark-up Language

Chapter Summaries

Chapter 1 – Embedded Systems

This chapter introduces the reader to the Embedded Systems and show the significant role Embedded Systems play in our daily lives. By comparing Embedded Systems to the *Personal Computer* and detailing their design requirements, it shows that Embedded Systems have requirements that differ significantly in detail and in scope from the *Personal Computer*. It also includes examples of Embedded Systems.

Chapter 2 – Home Automation & The SmartHouse

This chapter introduces the concept of home-automation and the ideas it aims to incorporate. The social impact that home-automation has on society is also been briefly discussed.

The idea of a SmartHouse, a house where automation technology has been integrated with various AI techniques to help make life easier, safer and more enjoyable for its occupants, is introduced. The chapter concludes by introducing the SmartHouse project currently under development at Massey University along with the role the device outlined in this paper, the TCP/IC, plays in this project.

Chapter 3 – The TCP/IC

This chapter introduces the TCP/IC, an *Embedded System* used to remotely switch and monitor, in real-time, connected devices. It outlines the various design options available, ranging from serial and parallel based systems to Ethernet based systems.

It goes on to describe the various options made available by using an Ethernet based system and the advantages, and problems encountered when using this approach.

It also briefly introduces the concept of rapid prototyping and further details the rapid-prototyping board used in the construction of the TCP/IC prototype.

Chapter 4 – Protocols & Standards

This chapter formally introduces protocols and explains how protocols are used in network communication.

The OSI model for a protocol stack is then introduced along with each of the involved protocols, namely ARP, IP, ICMP, TCP, UDP and DHCP were implemented on the TCP/IC.

Chapter 5 – Interface Options and Implementation

This chapter introduces the various interface options available when dealing with remote devices along with the advantages each offer, focusing on the two interface options chosen for the TCP/IC, namely HTML and XML.

It describes what each interface offers to Embedded Systems and details how they were implemented on the TCP/IC.

Alternative interfaces are also discussed and compared with the two interfaces used by the TCP/IC. The chapter concludes by showing how although other, seemingly more efficient interfaces are available, in practice they may not be.

Chapter 6 – Results & Conclusion

This chapter discusses the results obtained when the TCP/IC along with its interfaces were developed and tested.

It goes on to discuss ideas for possible future work, and concludes by summarising the ideas and their implications that are outlined in this paper.