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Author(s)	Corcoran, Peter M.; Desbonnet, Joe
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System Architecture and Implementation of a CEBus/Internet Gateway

Peter M. Corcoran and Joe Desbonnet.

Dept. of Electronic Engineering, University College, Galway

Abstract

Class structures and an object-oriented software framework to facilitate Internet access to CEBus networks are described. The Internet/CEBus Gateway consists of a server application (CEBusd) and dynamic data structures which provide a real-time representation of a CEBus network. CEBus network traffic is continually monitored and interpreted and these data structures updated accordingly.

In addition the creation of "virtual" CEBus devices is supported. These "virtual" devices can interact with the real CEBus network. This allows the creation of "new" device personalities whose behaviour can then be characterised through interaction with a real CEBus network.

1. Introduction

The Consumer Electronic Bus (CEBus®) is a multimedia LAN standard developed for home automation applications [1]. In earlier work we discussed some of the issues involved in providing access to a CEBus network from a conventional Web browser and Java® virtual machine JVM [2]. The aim was to demonstrate that WAN access to a local control network was practical and broadened the scope and range of applications of CEBus networking technology.

However we note that the market penetration of CEBus technology has remained slow, apart from certain niche applications. The authors feel that this is largely due to a combination of the end-user perception of the benefits of home networking and a reluctance on the part of consumer electronics manufacturers to apply the technology in unproven markets.

Further, drawing on the recent example of the mass public acceptance of the Internet, we argue that the lack of a usable and readily available user-interface to CEBus networks is a key reason for poor user perceptions and lack of market penetration. In this and a companion paper [3] we offer a preliminary approach to the design of an architectural framework to allow the inter networking of CEBus and TCP/IP networks. We also describe a class framework for implementing virtual CEBus networks and devices. The issue of providing a suitable user-interface to CEBus networks is covered in a companion paper [3].

2. Philosophy and Design Goals.

A central theme in our implementation of an Internet/CEBus gateway is that the system architecture should be lightweight and platform independent.

We see two distinctly different approaches emerging in the field of home automation: one approach is to incorporate TCP/IP networking functionality into even the simplest of consumer appliances; the second approach, which we feel is more realistic, is to integrate existing established technologies, such as CEBus with the TCP/IP infrastructure.

2.1 Scalability of the Gateway Architecture

The prototype gateway has been developed on a standard desktop PC platform. However to support scalability it has been almost entirely implemented in the Java language. This should greatly simplify the porting of the gateway to low-end embedded applications such as Set-Top-Boxes and Web-TV appliances.

2.2 Cross-Platform Portability

Again, as the core software components of the system are implemented in Java it should be readily portable across a broad range of desktop and embedded platforms. Some low-level interface drivers may need to be written, but as the system is built around TCP/IP network socket concepts and CEBus devices compliant with the common application language (CAL) the necessary low-level software hooks should be quite generic.

2.3 Independent User Interface Modules

A further strategy to keep the gateway lightweight and scalable is the approach to user-interface issues. These are covered in more detail in a companion paper [3], but essentially the gateway interface only supports a simple device browsing service. Independent user-interface elements for each network device are loaded from external network URLs - typically in the form of interface applets.

Thus the gateway can support a practically unlimited range of user-interface components.

2.4 Internet and CEBus Standards

As was mentioned above the gateway is built on TCP/IP and CEBus standards. This ensures that it has a broad applicability in both industrial and home network applications.

3. Implementation Issues

In this section we describe some of the practical issues which arise in the practical implementation of a lightweight Internet/CEBus gateway system.

3.1 Virtual CEBus Network

One of the key problems in accessing a local control network from a WAN is the difficulty of knowing what devices are available on the network. In a TCP/IP WAN, for example, network nodes use the DNS network mechanism to identify and locate other network nodes. Such search mechanisms are not available over a lightweight Internet/CEBus gateway.

To overcome this difficulty we have implemented the concept of a local CEBus device registry which is maintained on the local gateway. This allows external TCP/IP applications to determine the devices present on a local powerline network.

3.2 CEBus Device Simulator

A second problem we encountered was a shortage of available CEBus compliant devices. Furthermore many of the available devices are partly proprietary and as such are not fully CEBus compatible.

To overcome this problem and assist in testing and debugging our prototype gateway we set up a second desktop PC with a virtual network of CEBus devices. Network traffic from this device simulator was broadcast over the powerline network, appearing to the gateway system as if a real powerline CEBus actually existed.

4. Software Architecture

A central theme in our implementation of an Internet/CEBus gateway is that the system software architecture should be lightweight and platform independent. To achieve these goals most of the key system components have been implemented in Java.

4.1 CEBusd

CEBusd (CEBus 'Daemon') is a Java application that acts as an intermediary between applications and the CEBus network. CEBusd communicates to the CEBus network via a proprietary monitor device. CEBusd provides several services to connecting applications including full packet dump, filtered packet dump and network statistics. Applications request services from CEBusd in a manner similar to that of a HTTP server. Packets can also be sent into the CEBus network.

4.2 Class Libraries for a Virtual CEBus Network

A Java class library provides all the necessary tools to construct CEBus devices and network. The network can be run a standalone simulation on a computer or bridged to other virtual or real networks.

4.3 Bridge/Router

The bridge/router is another Java application allowing the interconnection of two or more real or virtual CEBus networks, *eg.* linking buildings in university campus via its TCP/IP infrastructure.

5. Conclusions & Future Work

A working Internet/CEBus gateway system for AC powerline medium has been developed. The system has been designed to allow the inter networking of CEBus and TCP/IP networks. We also describe a class framework for implementing virtual CEBus networks and devices.

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