MDC and MiniPCI modem/LAN combo design for notebooks

Aureus H.L. Shum
Senior Applications Engineer
Software Products Division
Motorola Semiconductors HK Ltd.

Abstract
Mobile Daughter Card (MDC) provides a mobile form-factor module and interface for audio and modem solutions based upon AC'97 Rev. 2.1. It is particularly suitable for modem-alone or audio/modem combo solution. MiniPCI, on the other hand, is designed mainly for communication solution because it is an industrial internal expansion card standard for notebook and is functionally equivalent to PCI rev. 2.2 with sideband I/O signaling like LAN I/O, and AC'97 AC-Link. This paper describes the technical challenge of designing software modem and modem/LAN combo for notebook based on these two new platforms. Both modem hardware and software architecture will be discussed. The advantages of cost, development and homologation cycle, as well as variety of choice of vendors will be presented too.

1. Introduction

In this section, we will introduce the MDC modem, the MiniPCI modem-only and the MiniPCI modem/LAN hardware architecture. The software modem architecture will be presented next. Here, we will use Motorola software modem as an example for discussion. For LAN architecture, interest parties can refer to those papers or documentation published by some LAN solution providers like Intel, Realtek etc.

A. Hardware Architecture

The AC Link (ACL) software modem solution provided by some wireline communication industrial leaders like Motorola based on the mobile audio/modem daughter card (MDC) specification 1.0 has the integrated architecture shown in Figure 1. Rather than using digital signal processor (DSP) or a dedicated hardware on the add-in card, the software modem is host signal processing (HSP) based, with both controller and datapump functions executing on CPU. The core hardware component left is the MC'97 modem codec that operates over a 5-pin serial link called AC-Link on one end, while it couples with a silicon Digital Access Arrangement (DAA) to complete the simplified MDC on the other end. The core logic on the host side can be from Intel, Via, Sis and Ali chipsets that have provided AC link interface. Usually, the modem codec is configured as the secondary codec because notebook manufacturers tend to build the audio codec on board with the host processors and core logic. Therefore, the modem codec is operating under slave mode with the 12.288MHz bit clock coming from the audio codec, and the whole hardware is driven by the software modem stack.

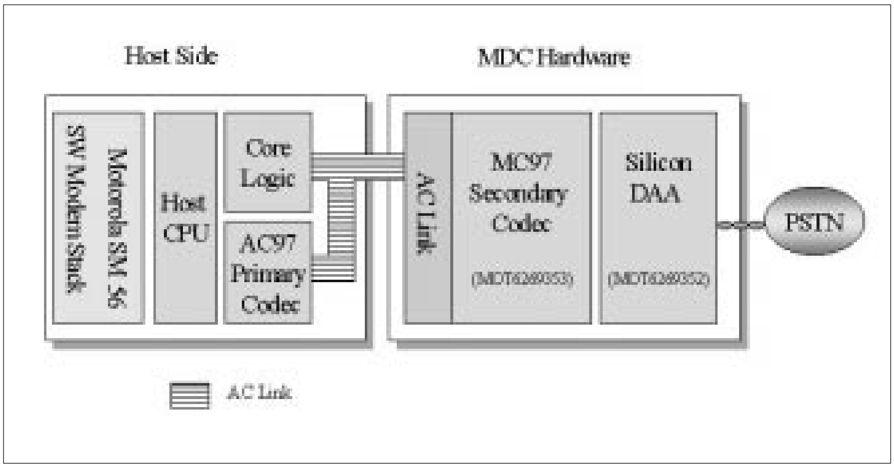


Figure 1: MDC SM56 Architecture

Alternatively, the modem in a notebook can be implemented based on MiniPCI specification 1.0, which uses a subset of the same signal protocol, electrical definitions, and configuration definitions as the PCI local bus specification 2.2. The major difference of a MiniPCI card and the standard PCI expansion card is the use of standard sideband signals for audio and communication. Based on this, Motorola has provided two suggested solutions: MiniPCI modem-only card and the modem/LAN combo card. They are shown in Fig. 2 and Fig. 3 respectively.

The first solution is much suitable for host that has MiniPCI slot but does not support AC link. The 3.3V TQFP PCI ASIC used has the PCI 2.2 compliant interface, four bus buffered DMA channels (modem data transmit, modem data receive, handset mic/line input and handset speaker/line output) with four FIFOs.

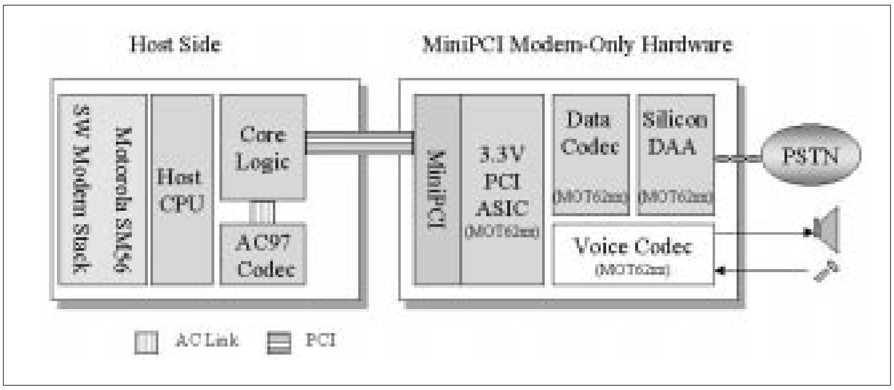


Figure 2: MiniPCI Modem-Only System Architecture

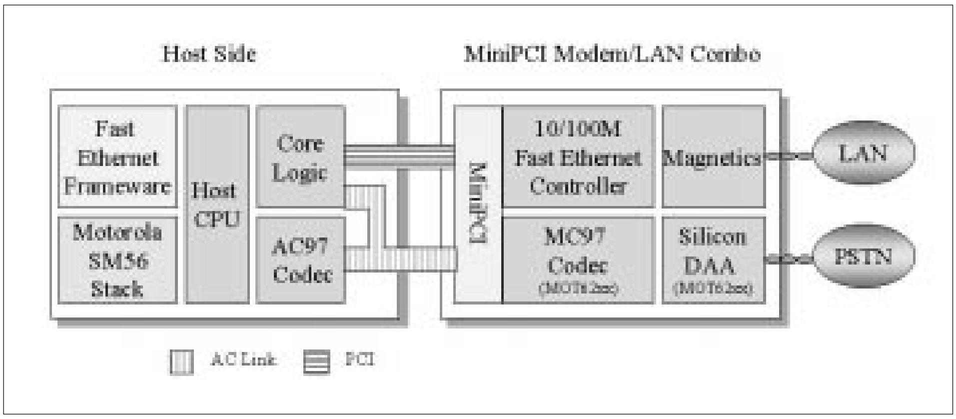


Figure 3: MiniPCI Modem/LAN Combo System Architecture

The depth of the FIFO is selected so the modem can provide long enough latency time such that concurrency operation with other devices is possible while minimizing interrupt overhead.

The second solution is so similar to the MDC but has the modem connected to the AC link that built over the MiniPCI interface. Together with the 10/100Mbps Fast Ethernet Controller and the Magnetic, it forms the modem/LAN combo solution. The software modem stack is designed in such a way that it can operate mutually independent with the LAN frameware and thus, there will be no drivers conflict.

B. Software Architecture

The software modem architecture based on Window 95/98 OS is shown in Fig.4. Motorola provides three virtual drivers:

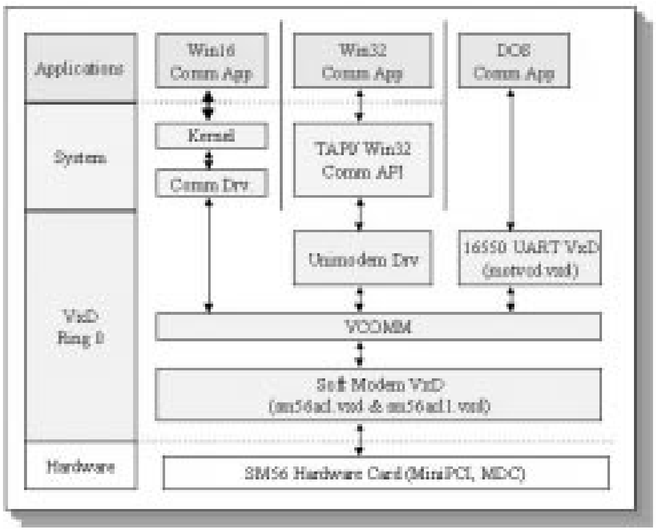


Figure 4: SM56 software architecture

sm56acl.vxd, sm56acl1.vxd and motvcd.vxd. The sm56acl.vxd contains the controller which deals with those functions like AT command interpreter, error correction, data compression and modem control. The sm56acl1.vxd contains the datapump for data modulation and demodulation, line probing, DTMF/pulse dialing, ring detection etc. Both of these virtual drivers register in the VCOMM as serial communication device so that it can operate under the operation system infrastructure. They also register in Unimodem driver as data/fax modem. High level application functional calls, thus can then be translated into specific modem AT commands with the service provided by TAPI, which is in turn, served by the Unimodem driver. The third virtual driver is a virtual UART, called motvcd.vxd, which is implemented to make the modem compatible with DOS application program. It traps the DOS communication I/O and directs the stream to soft modem driver through VCOMM. However, only one interrupt and one memory mapped base address are required, which is different from traditional UART that uses 8 I/O addresses.

2. Hardware Design Challenge

In this section, we will discuss the challenge we shall face during the design of the MDC and MiniPCI modems.

A. Form Factors Selection and Component Layout

Designers of the suggested modem solution should decide which form factor they are going to use first before starting any layout process. There is only two form factors for MDC modem (outer edge placement or not), but for MiniPCI, there are three types grouped according to whether the cards shall place at the notebook outer edge or not, and to the shape of the MiniPCI connector. i.e. miniature stacking connector or SO-DIMM connector. Then each type is further separated to “A” and “B” forms, according to the board height level. Designers should refer to the dimension in the MiniPCI specification for a best choice. However, most of the notebook manufacturers will have their own definition of the connector to suit their component placement requirement. Specific design for a particular customer may be resulted finally.

Layout is very important on MDC and MiniPCI modem to get a high performance design, as well as to pass country-specific Telecom, EMC and Safety requirement. Different from the desktop design, for portability, the MDC and MiniPCI modems should better use international DAA. Design should be able to pass some basic international telecom standards like FCC part 68 for North America and some Asian countries, CTR21 for Europe, JATE for Japan and ACA for Australia. Fortunately, in these modem solution, the modem under design, rather than using transformer for isolation, has its barrier crossed by using high voltage capacitor and signal is passed digitally over the link as shown in Fig. 5. The DAA behavior is simply

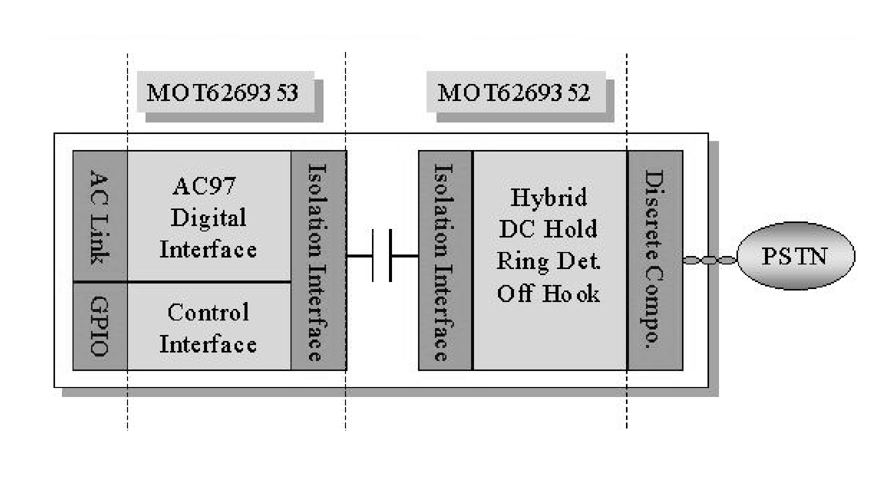


Figure 5: AC-L SM56 Building Block

changed by programming new coefficients inside the register memory; thus it can adhere to global telephone line standards without hardware changes. With a few of external passive components, the silicon DAA can perform functions such as DC holding, hook switch, AC impedance matching, 2-4 wires conversion, ring detect, DTMF or pulse dialing and caller ID detection and storage as good as using discrete DAA. The design should also be EMI compliant and follow safety standards. For example, it should meet FCC part 15 requirement and get CSA and UL 1950 certificate. Layout skill like careful grounding, power supplies decoupling, limiting crosstalk with trace spacing, reduce reflection by termination, limiting of outband noise by component selection and placement, as well as high/low voltage separation become important. Some typical tips related to our layout that the designer can follow are:

- MiniPCI clock signal CLK is limited to 1.0 inch rather than 2.5 inches in standard PCI as stated in the MiniPCI specification.
- Height of modem above motherboard is designed to be greater than 3mm.
- RJ11 jack is mounted on a separate PCB with the surge protection circuitry and is connected to the modem by a 28 AWG cable that is less than 4 inches in length to meet the specification.

There are a lot of other design rules that should be followed and designers should refer to the specification or other PCB layout reference book.

B. Power Consumption and Management Consideration

MiniPCI has 3.3V signaling only so the ICs used should support this. Also, although 5V-power supply is available, it is limited to 100mA, so a 3.3V to 5V DC converter is needed if there are any device, such as the fast ethernet controller, that require 5V supply present on the MiniPCI card. The limitation on total power consumption is 2.0W for MiniPCI compared with 25W on standard PCI. Our software modem part has a power consumption of below 200mW because the algorithms are implemented in software while the ethernet part is around 1.5W. The total consumption is still within limit.

MiniPCI provides PME# and 3.3Vaux for power management. This allows the solution to support ACPI wake up on ring from D3 cold power state. Thus, even Vcc and clock are removed, the ring still can generate an interrupt on the modem, as long as the 3.3V Vaux auxiliary power is supplied. This initiates system wake-up and the restore of register states by the software driver is followed. It should be noted that since it is a software modem, during normal operation, full system performance control should be set active. The CLKRUN# protocol defined by PCI Mobile Design Guide should be implemented by software too, to indicate that the clock cannot be stopped.

MDC has 1.65W as the limitation on total power consumption. Even for an audio-modem combo design, it can hardly excess this limit. To support wake up from sleeping state like S3 or S4, the MDC modem must be powered by the 3.3Vaux/dual supply. Instead of providing any PME# pin, the modem is waken up by the transition of SDATA_IN pin from 0 to 1 as defined in AC97 components specification.

3. Software Design Challenge

Besides the challenges we faced while designing the software for coexistence with other concurrent application during the ISA and PCI era, we shall discuss the new challenges on designing software for MDC and MiniPCI modem.

A. Core Logic and OS Variety

Drivers designed for the MDC and MiniPCI ACL modem should be able to work under different core logic from Intel, Via, Sis and Ali. These controllers usually have different I/O registers and PCI configuration space definition.

Drivers should also support different Microsoft OS such as Win95/98, WinNT4.0, as well as Win2000, like that in desktop, for meeting PC99 requirement and getting Window logo. Since the OS are of different architecture and different registration methods, usually, three different drivers are necessary.

B. Homologation Consideration

Worldwide homologation capability is extremely important on mobile design because the notebook is a portable device.

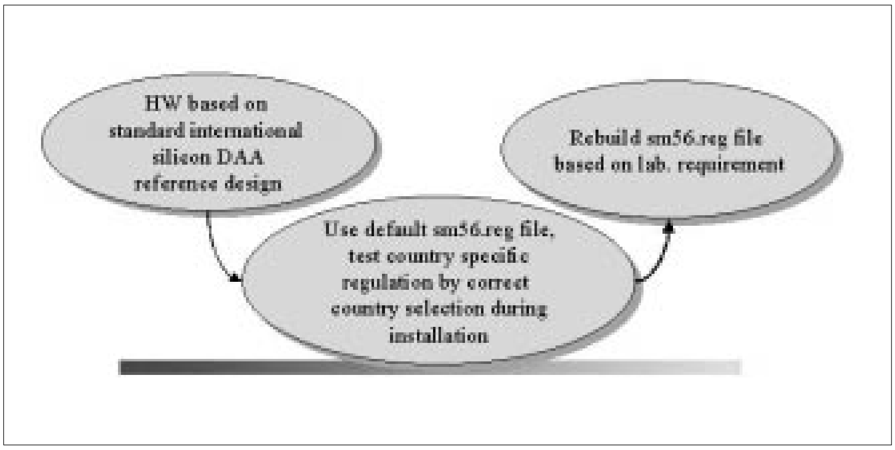


Figure 6: Simple homologation cycle

Silicon DAA hardware implementation has helped a lot to alleviate the burden on return loss and DC characteristics tuning as we discussed in section 2. Beside this, a software utility has been developed which allows software parameters such as DTMF level, dial tone detect and blacklisting requirement to be adjusted "on the fly" in the regulatory compliance laboratory. The homologation cycle becomes as simple as in Fig. 6.

C. Voice Implementation

To kick the voice codec out of the MDC/MiniPCI modem to save cost and space further, another element to support Microsoft's DirectX is required. Thus, we implemented a dynamic link library (DLL) to link the DirectX library and our own modem codes together. Such architecture is shown in Fig. 7. Remote voice data will be demodulated by the modem first, and then will be collected by the DirectX components through the service provided by the TAPI layer. Buffered data will then be playback through the sound card using DirectSound that is serviced by the hardware abstraction layer (HAL). In turn, local microphone data collected through the sound card can go a way in reverse to the remote side. The voice codec can be eliminated then.

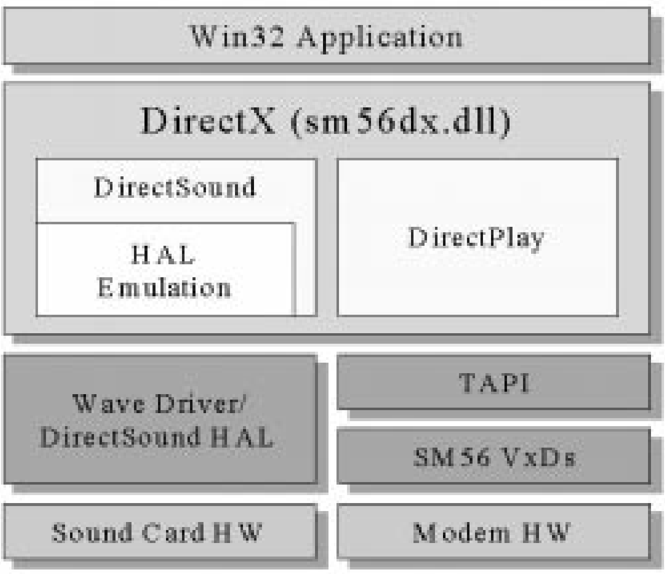


Figure 7: Architecture showing the modem voice implementation using DirectX

4. Conclusion

In this paper, we go through the hardware architecture and design challenge of the MDC and MiniPCI modem, as well as the MiniPCI modem/LAN combo card. The simple MC97 modem codec, the silicon DAA and the highly integrated network controller has yielded great benefits on board design, which in turn, favors the development cost, power consumption and portability that are the key factors related to the notebook design. Together with the distributed software architecture and universal driver stack, it provides a low loading, easily upgradable, low cost modem solution for high performance mobile world.

5. References

[1] Motorola: Softmodem White Paper: Comparison Between Software, Controllerless and Hardware Modems.

[2] Motorola: Motorola Technology Brief: Host-Based Software Modem Technology

[3] PCISIG: MiniPCI Specification 1.0

[4] Intel: MDC Specification ver. 1.0

[5] Motorola: ACL SM56 RDK

[6] Microsoft Press: Inside DirectX

[7] Realtek: Single Chip Fast Ethernet Controller with Power Management RTL8139L Specification.

[8] Intel: 82559 Fast Ethernet Multifunction PCI/CardBus Controller Specification

Contact Persons

Mark Dolan
7/F, No. 296, Sec. 4, Jen-Ai Road, Taipei, Taiwan
Phone: 886 2 2326 6342
E-mail: v10115@email.sps.mot.com

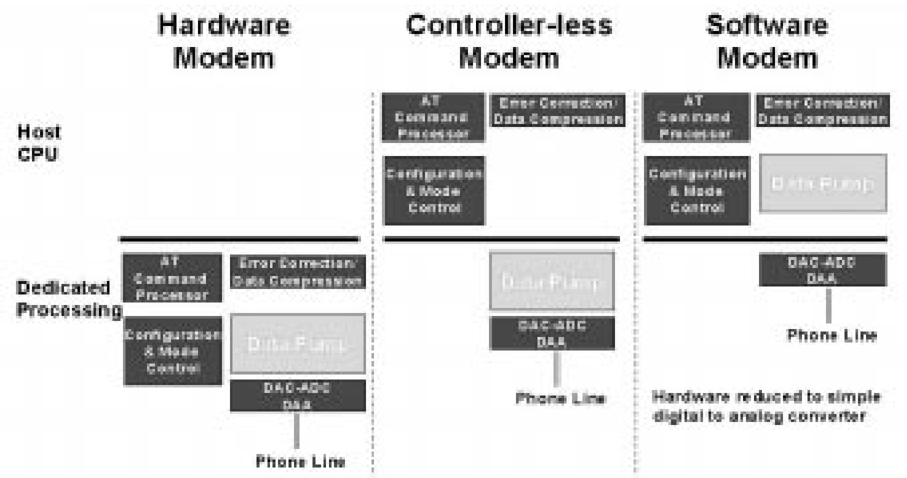
George Chiang
7/F, No. 296, Sec. 4, Jen-Ai Road, Taipei, Taiwan
Phone: 886 2 2326 6236
E-mail: c22203@email.sps.mot.com

Aureus, Hoi Leung Shum
2 Dai King Street, Tai Po Industrial Estate
Tai Po, N.T., Hong Kong
Phone: 852 2680 7185
Fax: 852 2662 3277
E-mail: R29117@email.sps.mot.com

Introduction: Softmodem

- Host Signal Processing Based
  - controller & datapump executed on CPU
  - CPU loading should be less than 30% under Pentium 200MHz
- Bus interface can be PCI, MiniPCI, AMR, MDC and USB
- Main focus for this presentation: Softmodem for Notebook
  - MDC modem-only
  - MiniPCI modem-only
  - MiniPCI modem/LAN combo
- Hardware and Software Architecture will be discussed

Definitions



What is AC Link?

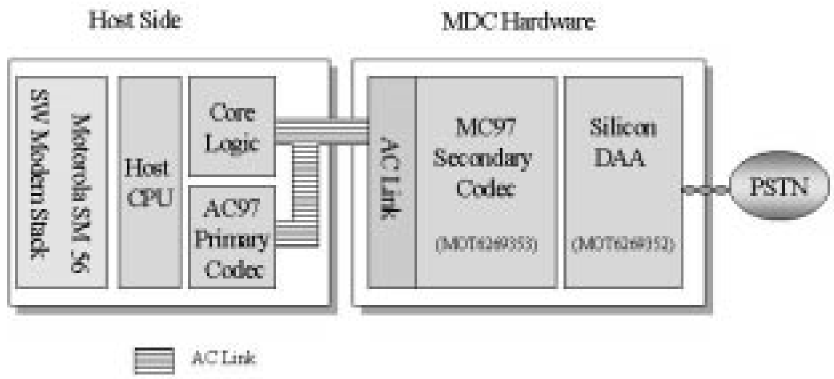
- AC '97 = Audio Codec
- Electrical specification defined by Intel to standardize the audio codec interface
  - 5-wire interface
  - Supports chaining of multiple codecs
- Intel has expanded this specification to encompass modem codecs: AC '97 version 2.1
- It is now established as an industry standard
  - Codec vendors now make audio and modem codecs compliant with the AC '97 v 2.1 specification
  - For more info: http://developer.intel.com/pcsupp/platform/ac97/
- MDC is Modem Daughter Card for notebook

What is MiniPCI?

- Defined by PCISIG
  - Specification 1.0
  - subset of PCI Spec. 2.2
  - with standard sideband signals for audio and communication
  - for notebook
- It is now established as an industry standard
  - For more info:
    - http://www.pcisig.com

Hardware Architecture

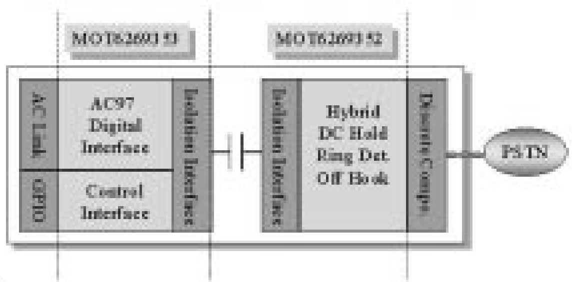
1. Motorola MDC SM56 Hardware Architecture



MDC Hardware: MC97, Silicon DAA, Simple discrete components

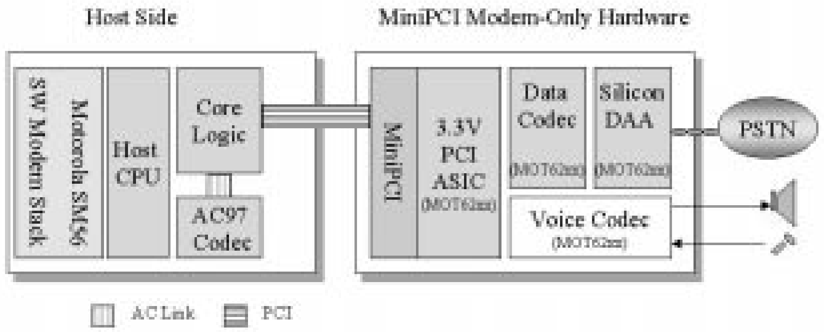
Host Side: CPU, Core Logic, AC97, Softmodem Stack

Example: Motorola MDC building Block



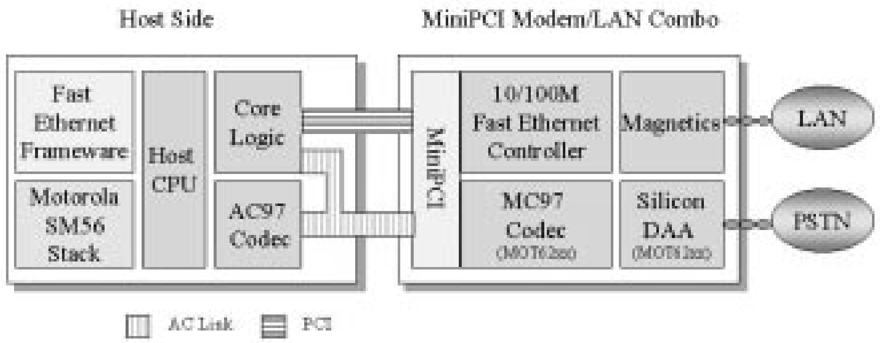
- MC'97 Chip
  - MC'97 Modem Codec with 5-pin AC-Link Interface
  - Set to secondary mode: bit clock and synch. supplied by split onboard AC'97 Codec.
  - Isolation Interface to receive coupled digital data from front end chip.
- Front End Chip
  - Isolation Interface: replaced transformer to high voltage capacitor
  - Hybrid / DC hold / Ring Detection / On/off Hook
  - Programmable registers for global telephone line characterisation

2. Motorola MiniPCI Modem-Only SM56 Hardware Architecture



- **3.3V PCI ASIC**
  - **four bus buffered DMA channels: data tx/rx, voice tx/rx**
  - **four FIFOs: take care latency time for software concurrency**

3. Motorola MiniPCI Modem/LAN Combo Hardware Architecture



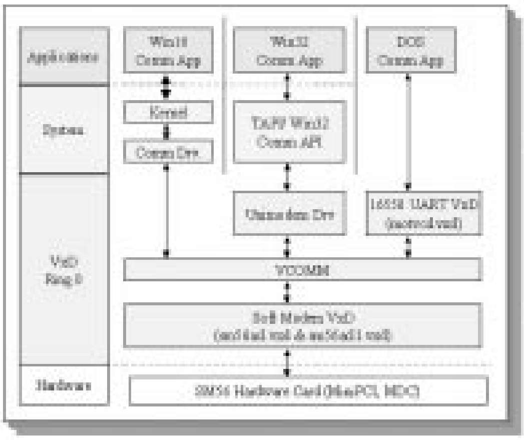
Modem Components Vendors

- MC97, SiliconDAA: Motorola 62032, 62033.
- PCI ASIC, Data Codec, Voice Codec: Motorola 62xxx
- Single Chip Fast Ethernet Controller: Intel 82559, Realtek 8139L
- Magnetics: Pulse etc.
- AC97: ADI 1881, Sigmatel

Core Logic Vendors

- Core Logic:
  - Intel Desktop
    - 810 & 820 Southbridge
  - Intel Mobile
    - 440MX - integrated Northbridge & Southbridge
  - SIS
    - 960 Southbridge (Motorola SM56 AC-L does not support this chipset)
    - 630 - integrated Northbridge & Southbridge (Intel CPUs)
    - 540 - integrated Northbridge & Southbridge (AMD CPUs)
  - VIA
    - 686A Southbridge - part of chipset called MVP4
  - Ali (Acer Labs Inc.)
    - 1535 (Not currently supported)
    - 1563 (Not currently supported)

Software Architecture



- Three Virtual Drivers
  - sm56acl.vxd: AT command interpretator, error correction, data compression and modem control
  - sm56acl1.vxd: datapump for data modulation and demodulation, line probing, DTMF/pulse dialing, ring detection as well as voice functions
  - motvcd.vxd: simulate virtual UART to support DOS application

SM56 Software Architecture (Con't)

- Three levels of priority for task execution
  - Highest: hardware level interrupt like time-critical signal processing & FIFO data transfer
  - Middle: software interrupts from communication application for timer management and I/O transfer
  - Background: error correction and data compression processing

Hardware Design Challenge

- Form Factors Selection
  - MDC: internal & outer edge placement
  - MiniPCI:
    - Miniature stacking connector or SO-DIMM connector
    - "A" or "B" type according to board height level
- Component Layout
  - according to International Telecom, EMC and Safety standard
    - Telecom: FCC part 68, CTR21, JATE, ACA
    - EMC: FCC part 15
    - Safety: CSA, UL1950
  - Layout skill: grounding, power supplies decoupling, crosstalk reduction, line termination, outband noise limitation.

Hardware Design Challenge (Con't)

- Power Consumption Consideration
  - MDC: 1.65W limitation. Hardly can exceed specification even for Audio/Modem combo
  - MiniPCI:
    - 3.3V signaling
    - 5V supply limited to 100mA
    - Total power consumption limited to 2.0W
  - Example: Motorola MiniPCI
    - modem part: below 200mW
    - LAN part: around 1.5W

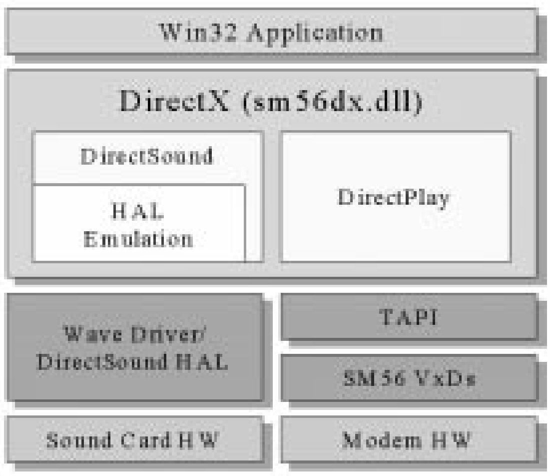
Hardware Design Challenge (Con't)

- Power Management Consideration
  - MDC:
    - Wake up from S3, S4 sleeping state
    - powered by 3.3Vaux/dual supply
    - controlled by SDATA_IN pin transition
  - MiniPCI:
    - Use PME# pin and 3.3Vaux
    - Full system performance control should be active all the time during normal operation
    - CLKRUN# protocol to indicate clock cannot be stopped

Software Design Challenge

- Core Logic and OS Variety
  - Intel, Via, Sis, Ali: Diff. I/O registers and PCI config. Space
  - Win95 OSR2, Win98, Win98 SE, WinNT4.0, Win2000: Diff. Architecture and registration method
  - Hard to have a universal driver
- Homologation Consideration

Software Design Challenge (Con't)



- Voice Implementation
  - use DirectX to replace modem voice codec

Conclusion

- Benefits:
  - Low Cost Modem and Combo because of usage of simple, highly integrated chipsets
  - Low power consumption:
    - <1.7W for MiniPCI modem/LAN
    - <0.2W for MDC modem only
  - Low loading, easy upgradable
  - Quick international telecom certification
  - Excellent portability
  - Designed for notebook world

Reference

- Motorola site: http://www.mot.com/softmodem
- Intel web site: http://www.intel.com
- Microsoft site: http://www.microsoft.com
- PCISIG site: http://www.pcisig.com