BCM1101
Ethernet Enterprise IP Phone / Gateway Platform

Andy Fung
Senior Staff Engineer
afung@broadcom.com
Enterprise IP Telephony Topology

- Media Gateway Controller (PBX Function)
- PSTN Gateway
- 2-port IP Phone
- 1-port IP Phone
- 2-port IP Phone
- 2-port IP Phone
- WAN Router
- Data Server
- Other Call Domains

Call Domain: Wiring Closet

Other Call Domains:
- IP

Legend:
- IP
- Other Call Domains
IP Phone Chip Requirements

- **Single Chip Solution**
  - Integrate all key blocks for IP Telephony

- **Low cost**

- **Two External 10/100BASE-T Ethernet Ports**
  - One port to network, one port to PC

- **3 port 10/100BaseT Ethernet Switch**
  - Switch isolates IP Phone CPU core from PC<->network traffic
  - Hub solution floods CPU with PC<->network traffic, resulting in poor voice quality
IP Phone Chip Requirements

• Excellent Voice Quality
  – Wideband codecs
  – QOS
  – Low delay
  – Adaptive jitter buffer

• Support wide selection of vocoders:
  – Wideband: G.711, G.722, BroadVoice™

• Power over Ethernet
  – Built in support
  – Low power consumption
IP Phone Chip Requirements

• **Phone Application**
  - 3 wideband capable codecs (handset / handsfree / headset)
  - Half and full duplex speakerphone
  - 3 channel conferencing

• **Gateway Application**
  - Glueless interface to external SLICs
  - 2 wideband capable codecs (line 1 / line 2)
  - Line echo canceller
  - Fax relay / Voice band data
  - 3 channel conferencing
First Generation IP Phone

- CPU
- EEPROM
- LCD
- KEYPAD
- JTAG
- UARTs
- SDRAM
- Power Supply
- Switching Power Supply
- RJ-45
- Ethernet
- Switch
- CODEC
- DSP
- SRAM
- Magnetics
- Head Set
- Hand Set
- Spkr Mic
- Amps
- Head Set
- RJ-45 PC
- RJ-45 LAN
BCM1101 IP Phone

BCM1101

KEYPAD

JTAG

UARTs

SDRAM

Memory Bus

LED

Switching Power Supply

External Power Supply

Flash

LCD CTRL

EBI BUS

Amps

Hand Set

Amps

Head Set

Amps

Spkr Mic

Magnetics

RJ-45 PC

RJ-45 LAN

Hold

Redial

Mute

ABC

DEF

GHI

JKL

MNO

PQRS

TUV

WXYZ

0

*

#

F1

F2

F3

F4

KEYPAD

Character

LCD

BROADCOM CORPORATION
BCM1101

- Analog Processor Module
  - CODEC Channel 3
  - CODEC Channel 2
  - CODEC Channel 1
  - 16 bit D/A
  - 16 bit A/D

- MIPS32 CPU
  - + 8K I-Cache
  - + 4K D-Cache

- ZSP DSP

- 10/100BT PHY
- 10/100BT PHY

- 3 Port Ethernet Switch

- IPB Bridge

- High Speed Serial Port 2
- High Speed Serial Port 1
- TDM IOM-2 Port

- 50 MHz External Bus Interface
- SDRAM Interface

- DMA Arbiter
- SDRAM

- External Interrupt Controller
- 9x9 Keyscan Controller (or 18 GPIOs)

- UART 0
- Timers

- Watchdog Timer

- 48 KB Program Memory
- 32 KB Data Memory

- Master SPI Port
- Uart 0
- Uart 1

- 18 GPIOs

- External Interrupt Controller

- 100 MHz CPU System Bus
- 100 MHz CPU System Bus

- 10/100BT PHY port 0
- 10/100BT PHY port 1
- 10/100BT PHY port 2

- Ethernet LED Driver
- 64KB Buffer Memory

- External Bus Interface

- ZSP JTAG
- MIPS JTAG

- SPI Port

- 18 GPIOs

- SD Alliance

- CODEC Channel 2
- CODEC Channel 1

- 16 bit D/A
- 16 bit A/D

- 3 Port Ethernet Switch

- Ethernet LED Driver
- 64KB Buffer Memory

- DMA Arbiter

- SDRAM

- External Bus Interface
BCM91101 IP Phone Platform
BCM1101 Chip Features

• MIPS32 CPU (150 MHz / 165 DMIPS; 8kB I-cache, 4kB D-cache)
  – IP, RTP, UDP, VoIP protocol stacks (H.323, H.248/Megaco, MGCP, SIP)
  – Realtime OS

• ZSP DSP (140 MHz / 280 MIPS; 48kB Prog RAM, 32kB Data RAM)
  – 3 channel conference
  – Half & Full Duplex Speakerphone
  – Telephony algorithms: DTMF, Call Progress Tone Generation, etc.
  – Adaptive Jitter Buffer, Packet Loss Concealment
  – Framework (DSP ‘RTOS’)
BCM1101 Chip Features

• Three CODECS for simultaneous handset/headset/speakerphone
  – 16-bit, 8 kHz and 16 kHz (wideband) sampling

• Non-Blocking Managed Switch
  – 64 kB buffer enables Wire-Speed Non-Blocking - no dropped packets
  – 802.1p Prioritization ensures voice quality
  – 802.1Q VLAN tagging support for communications security
  – Switch solution is more robust than a repeater hub

• Two 10/100BASE-T Ethernet transceivers
  – Power Over Ethernet support (MLP method)
  – Auto MDIX support simplifies network installation
  – LED port for Ethernet status
BCM1101 Chip Features

• Peripherals
  – 9x9 key-scan supports standard and feature-phone keys
  – 2 UARTs and 2 High Speed Serial ports
  – 18 GPIO pins
  – TDM bus with IOM-2® support

• Physical Features
  – 0.18u process, 1.8/3.3V operation
  – 1.1W Peak, 0.3-0.8W Standby Modes
  – 256 pin PBGA package
    • Pin assignments designed to enable low cost, 4-layer PCB design

IOM-2 is a registered trademark of Infineon Technologies AG
DSP Memory Requirements

• Rich DSP functionality requires >200kB RAM
  – Jitter buffer
  – Tone generation / detection
  – echo cancellation (for handset / headset / line echo cancellation)
  – Full duplex speakerphone
  – Wideband audio

• Additional DSP memory needed for future expansion
  – ie. new codecs, speech recognition, MP3 player

• Internal SRAM is expensive
BCM1101 DSP Memory Reduction

- Distributed DSP Operating System
  - Portion of DSP Operating System runs on MIPS
  - Software developer can move non time critical tasks to MIPS (i.e. superpacketization, fax relay)

- Program Paging
  - DMA program and data tables from external SDRAM to DSP memory
  - Software development tools make paging transparent to programmer.
  - Programmer simply list functions to be paged
  - Function is stubbed out with code that sets up the DMA descriptor, pages function, transfer control to page

- Instance Memory Paging
  - DMA instance memory on demand from external SDRAM
  - Once processing is complete, instance memory DMA’ed back to SDRAM
BCM1101 DSP Memory Reduction

• BCM1101 has 80kB Internal DSP RAM
  – Traditional architecture requires >200kB
  – 48K Program Memory
  – 32K Data Memory

• Novel software and hardware architecture
  – Internal DMA controller is managed by software to page memory on demand
  – Minimizes memory footprint while supporting extensive DSP feature set
  – DSP feature set can be expanded without adding memory
  – No external expensive SRAM required for DSP core
  – Memory pages stored in SDRAM which is shared with MIPS core => no additional external memory needed for DSP
**802.1p Priority**

- Voice traffic receives priority treatment over data => reduce latency
- 3 bit 802.1p QOS field in Ethernet header
- Switch examines 802.1p field and queues packet into either high or low priority queue
- 2 priority queues per port
- Override mode retags 802.1p field from PC or Network port
• **802.1Q VLAN**
  - Allows network segmentation to increase security and decrease broadcast/multicast traffic
  - 12 bit 802.1Q VLAN ID in Ethernet header
  - Programmable VLAN ID on each of 3 ports
  - Packets only forwarded to port with matching VLAN ID
  - Optional VLAN ID removal on outgoing frames
  - Optional VLAN ID insertion/retagging on incoming frames
Power Over Ethernet (POE)

- BCM1101 supports MLP (Modified Link Pulse) method

![Diagram showing the connection between BCM1101, IP Phone, Filter, Network Switch, and Power Over Ethernet (POE) components.]
Power Over Ethernet

• Network switch supports POE
  – Phone is unpowered => BCM1101 relay closed
  – Network switch does not detect link, transmits link pulses (NLP, FLP, MLP)
  – MLP passes through filter
  – Network switch detected returned MLP, stops MLP tx
  – Network switch supplies power
  – BCM1101 relay opened

• Network switch does not support POE
  – Phone is unpowered => BCM1101 relay closed
  – Network switch transmits NLP (Normal Link Pulse) or FLP (Fast Link Pulse)
  – Filter blocks NLP and FLP => not looped back to switch
  – Network switch operates as normal
• **Wideband Telephony**
  
  – Conventional speech
    • 8 kHz (300 to 3400 Hz - dash curve)
  
  – Wideband speech
    • 16 kHz (50 to 7000 Hz solid curve)
    • Flat response and added bass and treble
    • More natural-sounding and intelligible
    • But higher bit rate required
    • Distinguishing feature for VoIP

• **BroadVoice™ was developed with the following goals**
  
  – Wideband and Narrowband modes
  
  – Low Complexity / Low Delay / Very High Quality
  
  – Free of third party IPR
BroadVoice™ Features

• Very high quality
  – Narrowband BroadVoice16 better than G.723.1, G.728, G.729, and G.729A
  – Wideband BroadVoice32 better than G.722 at 64 kb/s

• Very low coding delay
  – only 5 ms, versus 15 ms for G.729 and 37.5 ms for G.723.1

• Low codec complexity
  – 13 MIPS for narrowband BroadVoice16 codec
  – 19 MIPS for wideband BroadVoice32 codec
  – Low memory foot print

• Free of third-party’s intellectual property rights (Broadcom owns all IPR)
Summary

• Highly integrated single chip IP phone solution
  – MIPS32 CPU, ZSP DSP, DSP memory, ethernet switch / phy, 3 codecs

• Hardware/software designed to reduce DSP memory
  – DMA architecture for program and instance memory paging
  – Distribute DSP operating system allows tasks to run on MIPS
  – Paging allows rich DSP feature set on small memory footprint
  – No external SRAM required for DSP

• Features for IP Telephony
  – Wideband codecs
  – 802.1p / 802.1Q Priority support
  – Integrated power over Ethernet support
  – BroadVoice support