

FreeBSD SD/ MMC

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FreeBSD's SD/ MMC Implementation

<http://people.freebsd.org/~imp/bsdcan2007.pdf>

Overview

- Background
- MMC / SD card survey
- Motivation
- Embedded
- Standard's Device Model
- MMC / SD hardware details
- FreeBSD Implementation
- To do list

Background

- History
 - MMCA (1997 Siemens AG, SanDisk)
 - SDCA (1999 as secure MMC Matsushita, Toshiba, SanDisk)
- MMC Cards (1998)
 - 16MB to 4GB
- SD Cards (2000)
 - 16MB to 2GB (or 4GB)
- SDHC Cards (2006)
 - 4GB- 32GB, three speed classes
- SDIO Cards (2006)

MMC Cards

- MMCA (<http://www.mmca.org/>)
- Siemens AG and SanDisk 1997
- 1-bit 20MHz serial interface
- Multiple devices on bus
- Open standard, but expensive (\$1k)
- RS-MMC
- Current Version 4.x
- Wikipedia article excellent:
<http://en.wikipedia.org/wiki/MultiMediaCard>

MMC Cards (cont)

- MMC v1.0 (September 1996)
- MMC v2.11 (June 1999)
 - SD Card based on this standard
- MMC v3.31 (May 2003)
 - Dual Voltage Cards
- MMC v4.x (April 2005)
 - Smaller form factor
 - Larger bus (4 or 8 bits)
 - Faster bus (26MHz or 52MHz)
 - SecureMMC
 - MMCplus (> 4GB)
- eMMC (December 2006)

MMC Cards (cont)

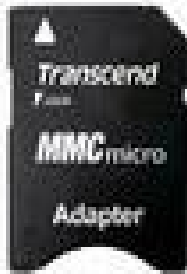
- Kinds of Cards
 - MMC / MMCplus
 - RS-MMC / MMCmobile
 - MMCmicro
 - eMMC



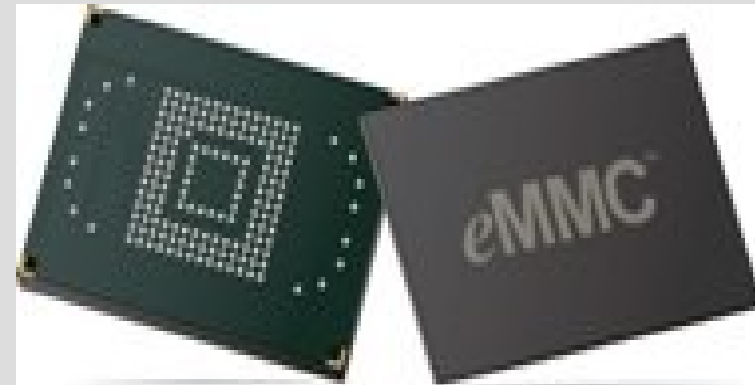
MMC



RS-MMC



MMCMicro



SD Cards

- SDCA (<http://www.sdca.org/>)
- Matsushita, Toshiba, SanDisk 1999
- MMC v 2.21
- 4bit Bus @ 25MHz
- Full Standard Closed
- Simplified Standard 1.01 and 2.0 (SDHC)
freely available
- Wikipedia Article:
http://en.wikipedia.org/wiki/Secure_Digital_card

SD Cards (cont)

- SD 1.0 (October 2001)
 - Complete Standard NDA & \$\$\$
 - Simplified Standard released 2005
 - Based on MMC Standard
 - One device on bus
 - 4bit 25MHz bus (12.5MB/ s)
 - Alternative SPI bus interface
 - 16MB- 2GB (4GB available)
- SD 2.0 (April 2006)
 - SDHC (4GB- 32GB)
 - Optional 8- bit bus
 - 3 speed classes(2MB/ s, 4MB/ s, 6MB/ s)

SD Card Examples

- SDHC
- SD
- MiniSD
- MicroSD



SDHC



SD



MiniSD



MicroSD

SD Card Caveats

- 4GB Card Issue

! CAUTION

About SDHC Memory Card

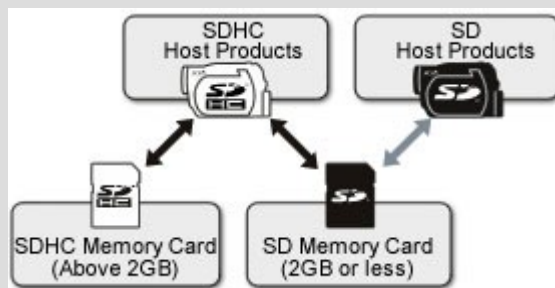
- Look for the SDHC logo when purchasing SDHC Memory Cards.
- The SDHC Logo is used for cards 4GB or larger.
- SD Speed Class is mandatory for SDHC Memory Card. It also appears on the card.

[more info](#)

Correct	Wrong
SDHC Logo	SD Logo
	CLASS 2 CLASS 4 CLASS 6
	SD Speed Class Logo

* SD Logo is a trademark.
* SDHC Logo is a trademark.

- SD vs SDHC Compatibility



SDIO Card

- SDIO 1.0 (October 2006)
 - I/O Cards for embedded/ consumer platforms
 - Simplified Spec
 - Mostly wireless cards
 - Also modems, FM radios, Bluetooth



Source: www.sdca.org

Motivation / Background

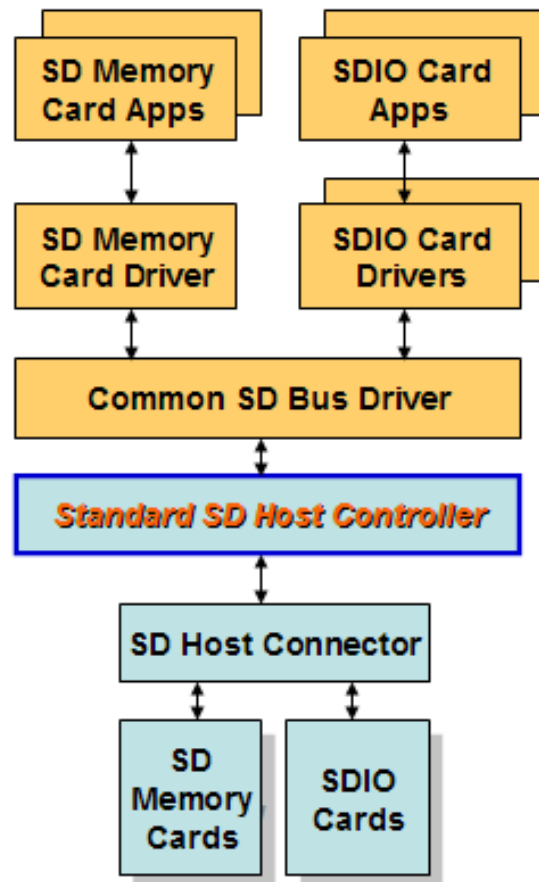
- Timing Solutions' AT91RM9200 Product
- SD Cards cheaper than CF cards
- Other products FreeBSD based
- SD Cards cheap and ubiquitous
- No SDIO cards support in SoC

Embedded

- SD Cards popular in embedded devices
 - low pin count
 - low cost
 - MMC/ SD dual solutions
 - SPI bus interconnect
- Each SoC has different SD/ MMC host adapter interface
- Host adapters typically very simple
- Software architecture must facilitate

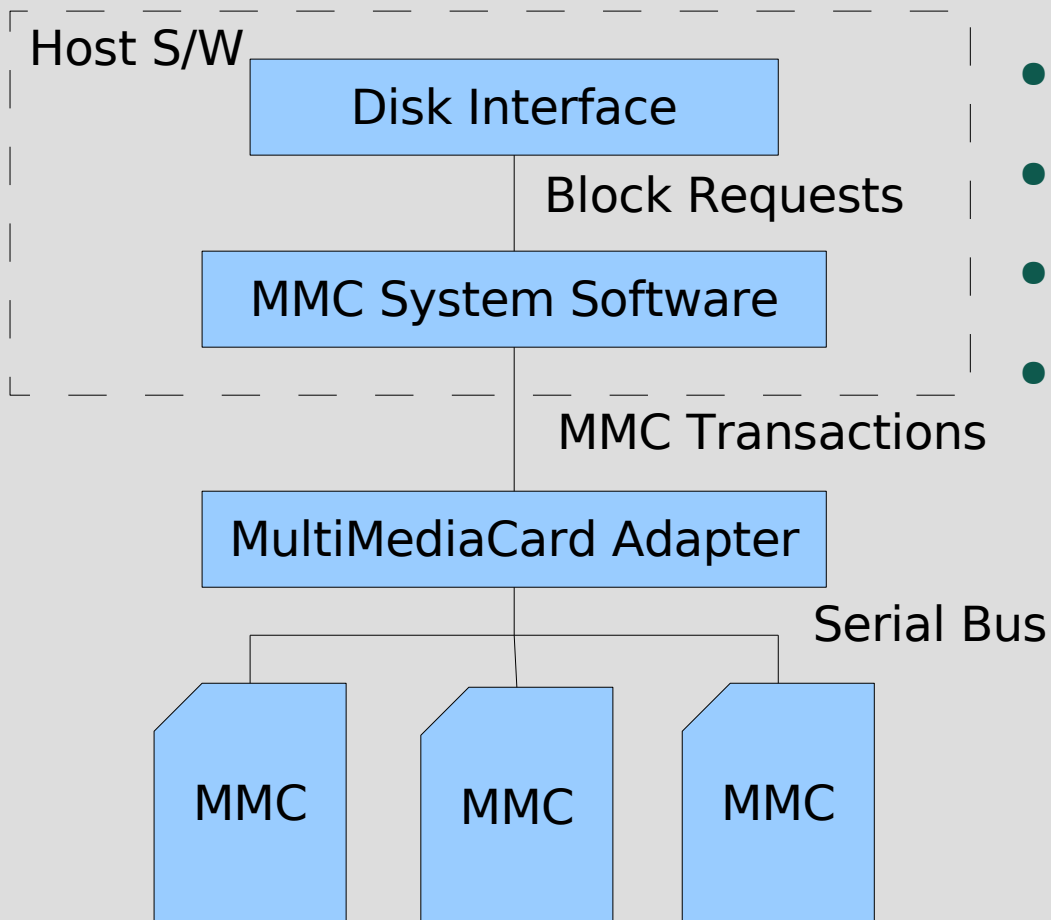
Idealized SD Device Model

What is the SD Host Controller?



- No MMC
- Standard SDHC not universally implemented
- Glosses over interaction with other OS subsystems

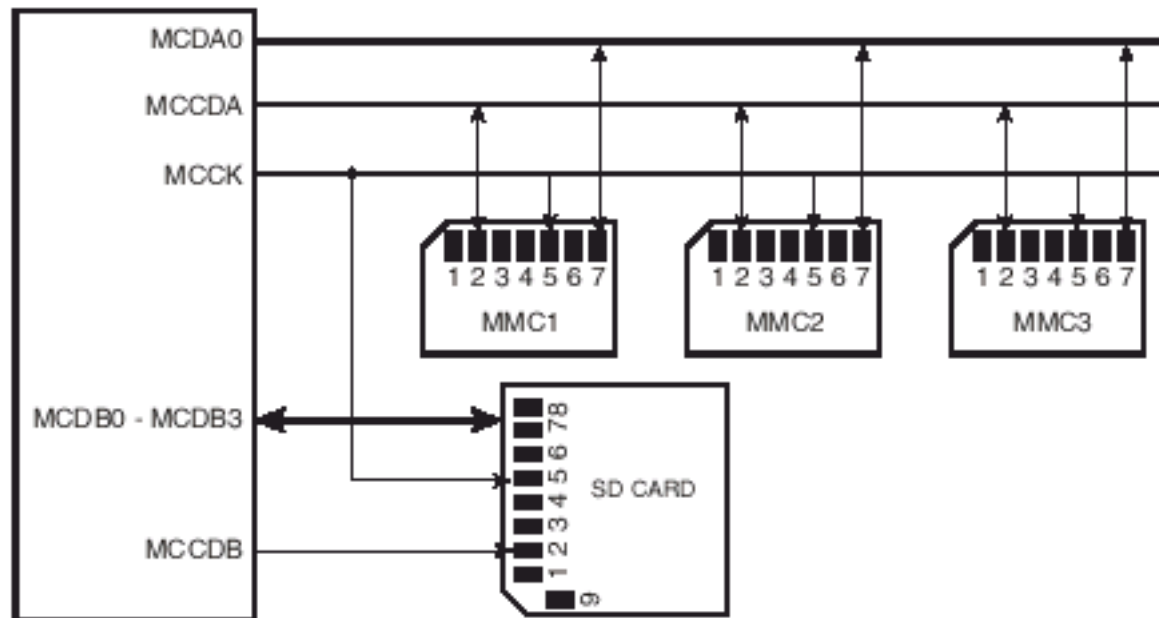
Idealized MMC Device Model



- Multiple devices
- No standard HC
- No I/O cards
- No SD cards
- A block device

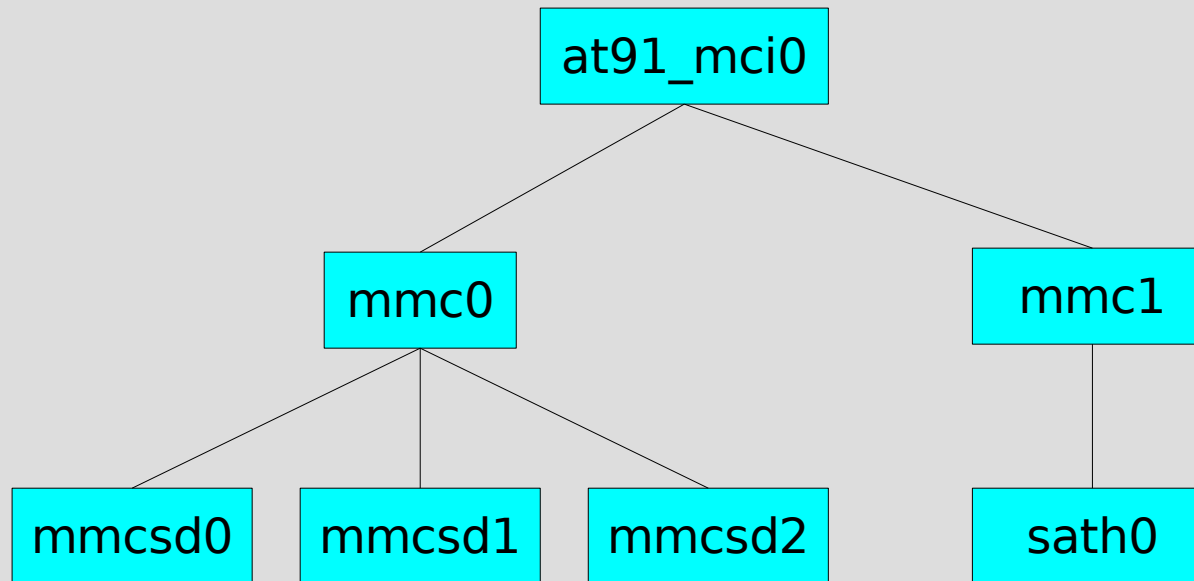
Real World Example

Figure 27-7. Mixing MultiMedia and SD Memory Cards



- Two different “slots”
- Signals shared between two buses

FreeBSD Device Tree



- at91_mci0 controller
- mmc0 and mmc1 are bus
- mmcsdX are MMC memory cards
- sath0 is SDIO hypothetical Atheros card

MMC: The details

- Pinout
- MMC Protocol
- MMC HC extensions
- SD Protocol
- SDHC extensions
- SDIO extensions

MMC Pinout

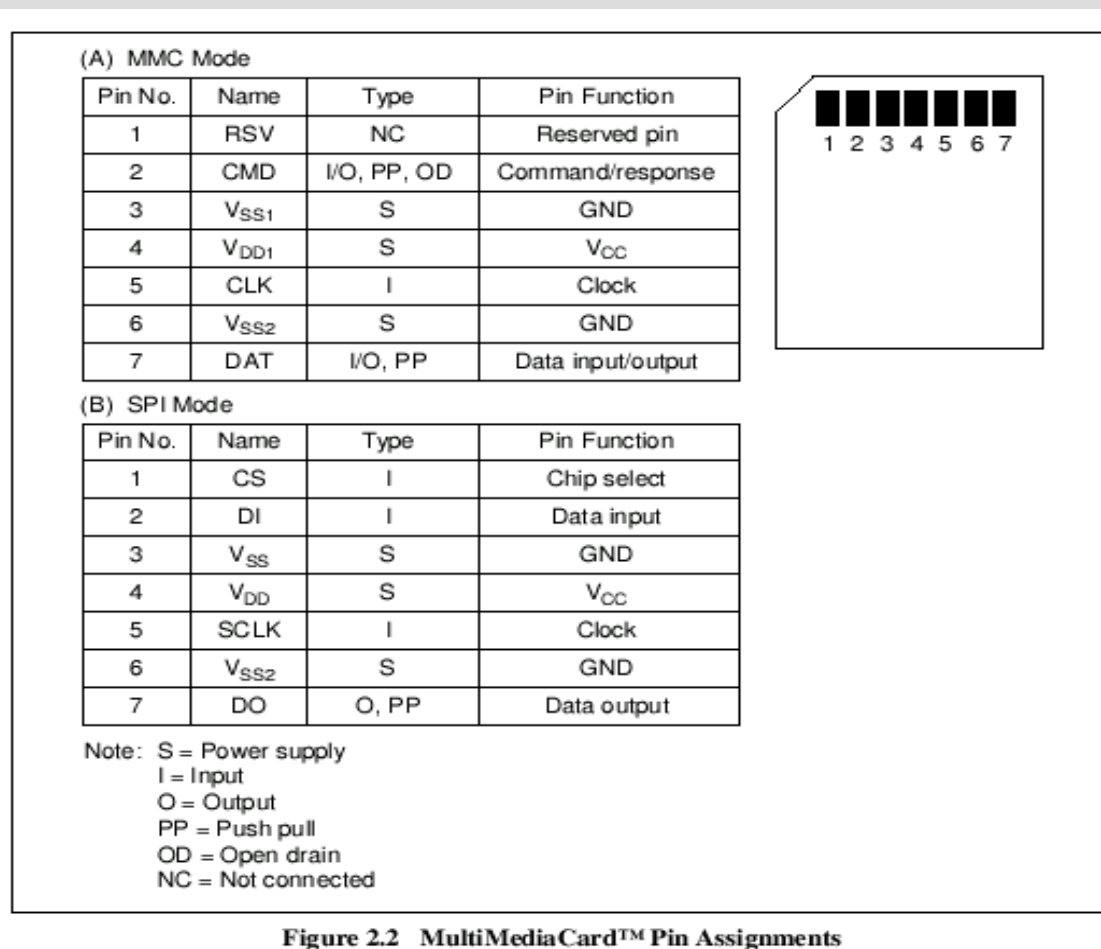


Figure 2.2 MultiMediaCard™ Pin Assignments

MMC Protocol

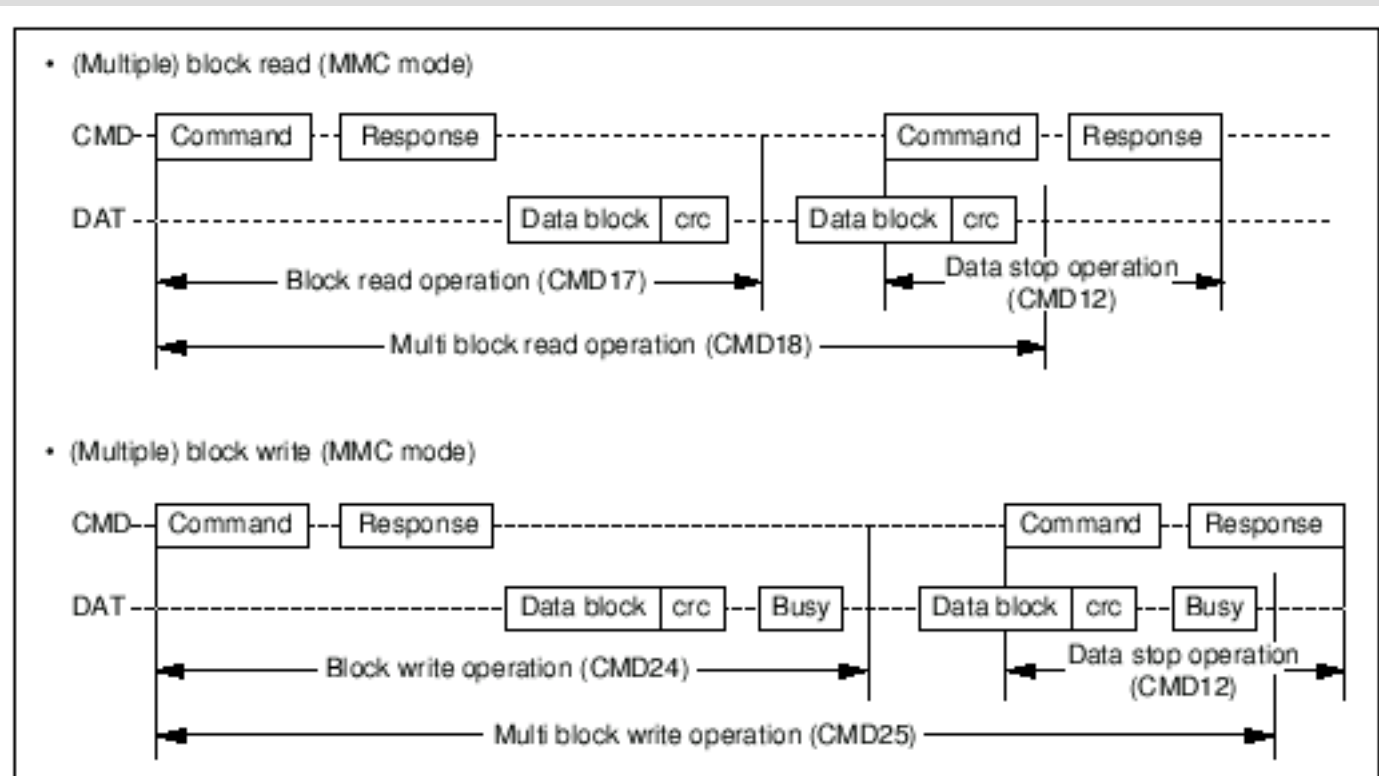


Figure 2.15 Examples of MMC Mode Read/Write Transfer

MMC Replies

- R1 (8) Command Status
- R1b (8) R1 with Busy
- R2 (16) SEND_STATUS reply
- R3 (40) SEND_OCR (R1 + 32bits of OCR)
- R4 & R5 SDIO replies
- R7 (40) SEND_IF_COND (SDHC ext)

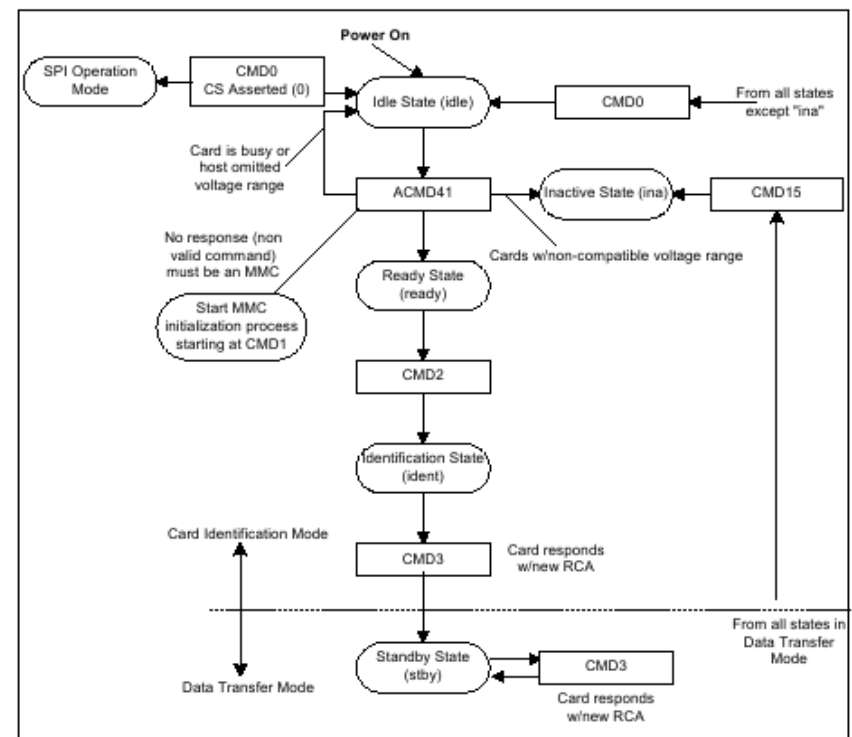
MMC Bus Enumeration

- Send GO_IDLE_STATE (CMD0)
- Send SEND_OP_COND (CMD1) w/ vdd
- Send ALL_SEND_CID (CMD2)
 - one card wins and sends its CID
- Send SET_RELATIVE_ADDRESS (CMD3)
- Get the CSD for card size, etc
- Loop until no card wins

SD Extensions

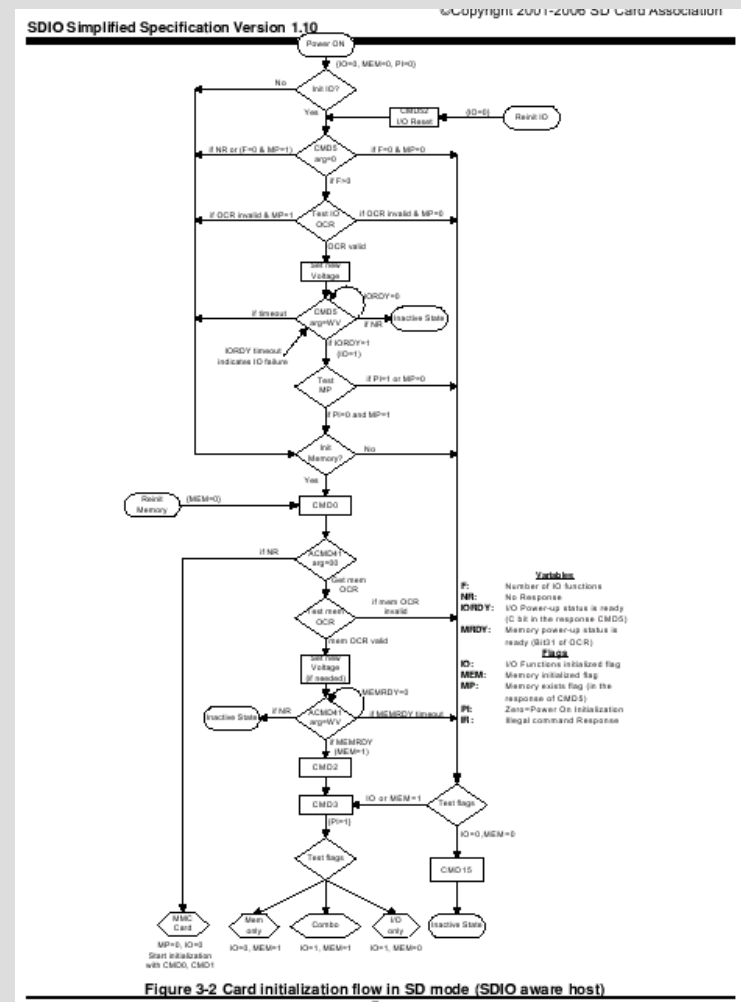
- SD/ MMC coexist
- 4bit vs 1bit bus
- Broadcast vs singlecast
- Try SD first, fallback to MMC
- SDHC complication
- SDIO adds much complication

Figure 4-7 SD Memory Card State Diagram—Card Identification Mode



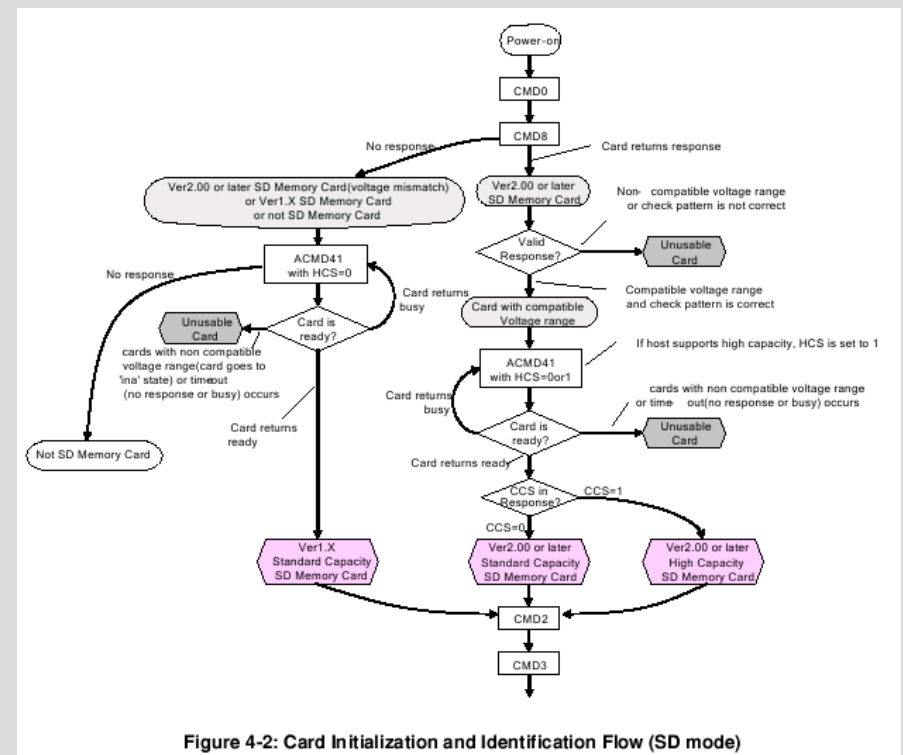
SDIO Extensions

- Additional ways to probe for SDIO cards
- SDIO cards have PCMCIA CIS for use in enumeration and configuration



SDHC Extensions

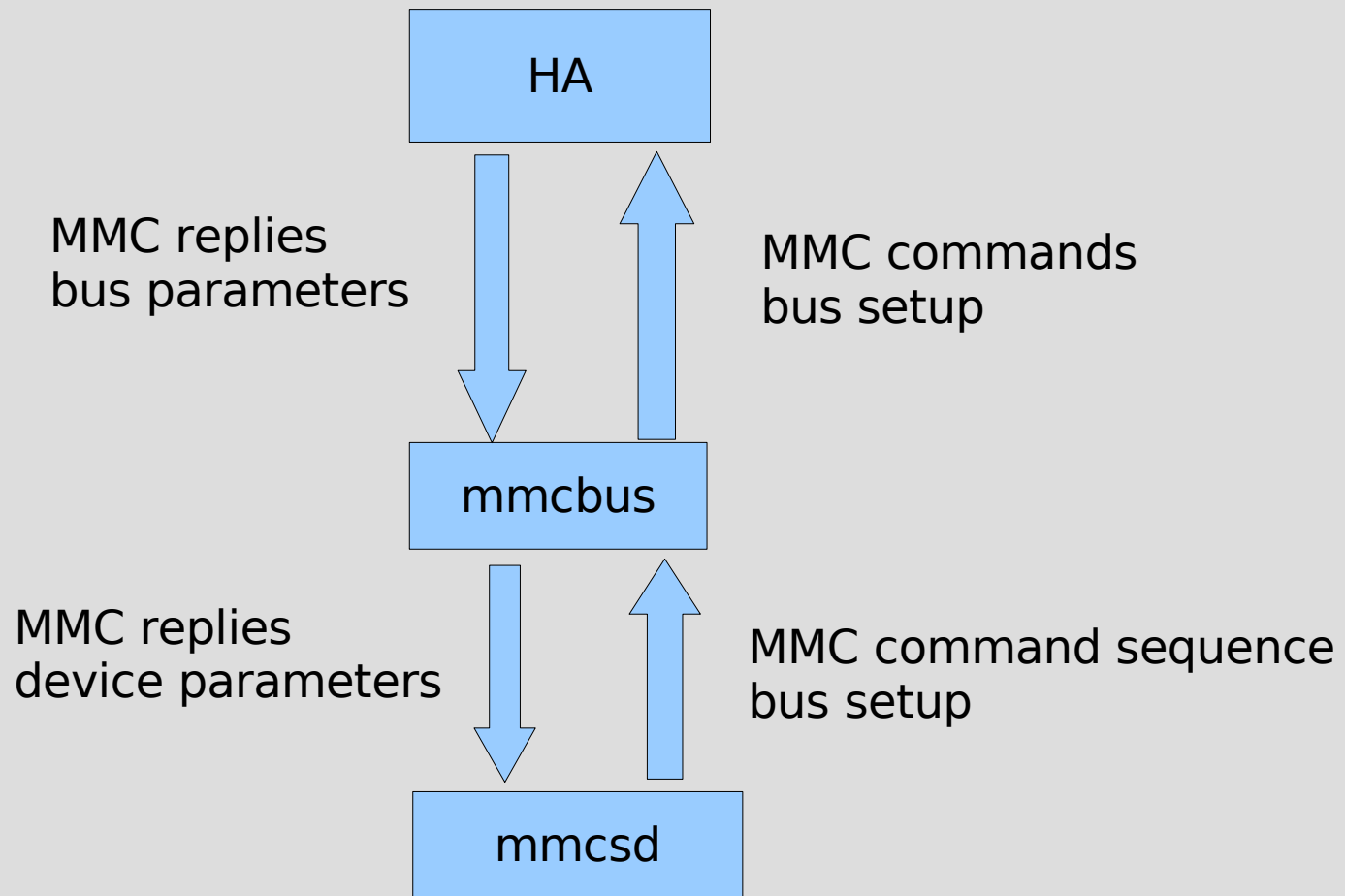
- SD/ MMC read/ write commands byte based.
- SDHC block (512 byte) based
- Different isolation sequence



FreeBSD Overview

- HA < - > MMC bus interface mmcbr_if.m
- MMC bus < - > MMC/ SD device (mmc_if.m)
- Why no port of OpenBSD mmc/ sd code
- Design details
 - Simple
 - Linux-like and OpenBSD-like interfaces
- To Do list

FreeBSD Data Flow



mmcbr Interface

- update_ios
- request
- get_ro
- acquire_host
- release_host

mmcbr ivars

- mmcbr sets/ gets ivars from mmcbr
 - mmcbr_get_bus_mode
 - mmcbr_get_bus_width
 - mmcbr_get_chip_select
 - mmcbr_get_clock
 - mmcbr_get_f_min
 - mmcbr_get_f_max
 - mmcbr_get_host_ocr
 - mmcbr_get_mode
 - mmcbr_get_power_mode
 - mmcbr_get_ocr
 - mmcbr_get_vdd

mmc bus Interface

- mmc bus has two sides to its interface
 - HA < - > mmc bus callbacks from HA
 - mmc bus < - > mmc/ sd device interface
- wait_for_request
- acquire_bus
- release_bus
- Needed: rescan_bus

mmc bus ivars

- mmc bus sets a common set of ivars in the devices can query
 - mmc_get_dsr_imp
 - Does this device implement SD's DSR register
 - mmc_get_media_size
 - Return the device's computed capacity
 - mmc_get_rca
 - Returns the 16-bit relative card address
 - mmc_get_sector_size
 - Sector size of the media (512)
 - mmc_get_tran_speed
 - Current bus clock rate

MMC Client Driver Interface

- mmcsd special for all memory cards
 - mmc bus needs to probe for what type
 - mmcsd handles all types
- SDIO cards need probe routine
 - Need implementation and cards
- MMC HC and SDHC cards
 - Need implementation and cards

TODO

- SDHC
- MMC cards (both HC and normal)
- SDIO
- Smarter transaction timeouts
- Improve mmcsd performance
- Add erase support
- More bridge/ HA drivers
- Integrate or reject Andrea Bittau's sdh
- SPI mode support
- Other kinds of cards: MS, SM, xD, etc?