Embedded Storage Management

What to Expect?

- W's of Memory Technology Devices
- MTD Subsystem
- MTD related Drivers
- Flash File Systems
- Flash Tools

Storage Timeline

- Traditionally (for most of past 20+ years)
  - ROM – For read-only storage
  - NVRAM – For read-write storage
- Equating with today's technology
  - Low-density
  - Costlier
- Latest trend is flash technology devices
  - More commonly referred as MTD
  - Comes as NOR, NAND, some exotic varieties
  - Best suited for Embedded Systems

What are Memory Technology Devices?

- Embedded Flash Memory
- Contains Large Erase Blocks
  - 32KB to 128KB
- Maintains three main Operations
  - Read, Write, Erase from Erase Block
- Bad Erase Blocks to be dealt by software
- Erase Blocks get worn out after some erase cycles

NOR Flash

- Reading like RAM
  - Random Access
  - Execute Code (XIP)
  - Could be replacement for ROM (but slower)
- Manufacturers
  - Intel, AMD, Fujitsu and Toshiba
- Capacity
  - Typically from a few KBs to 64MB

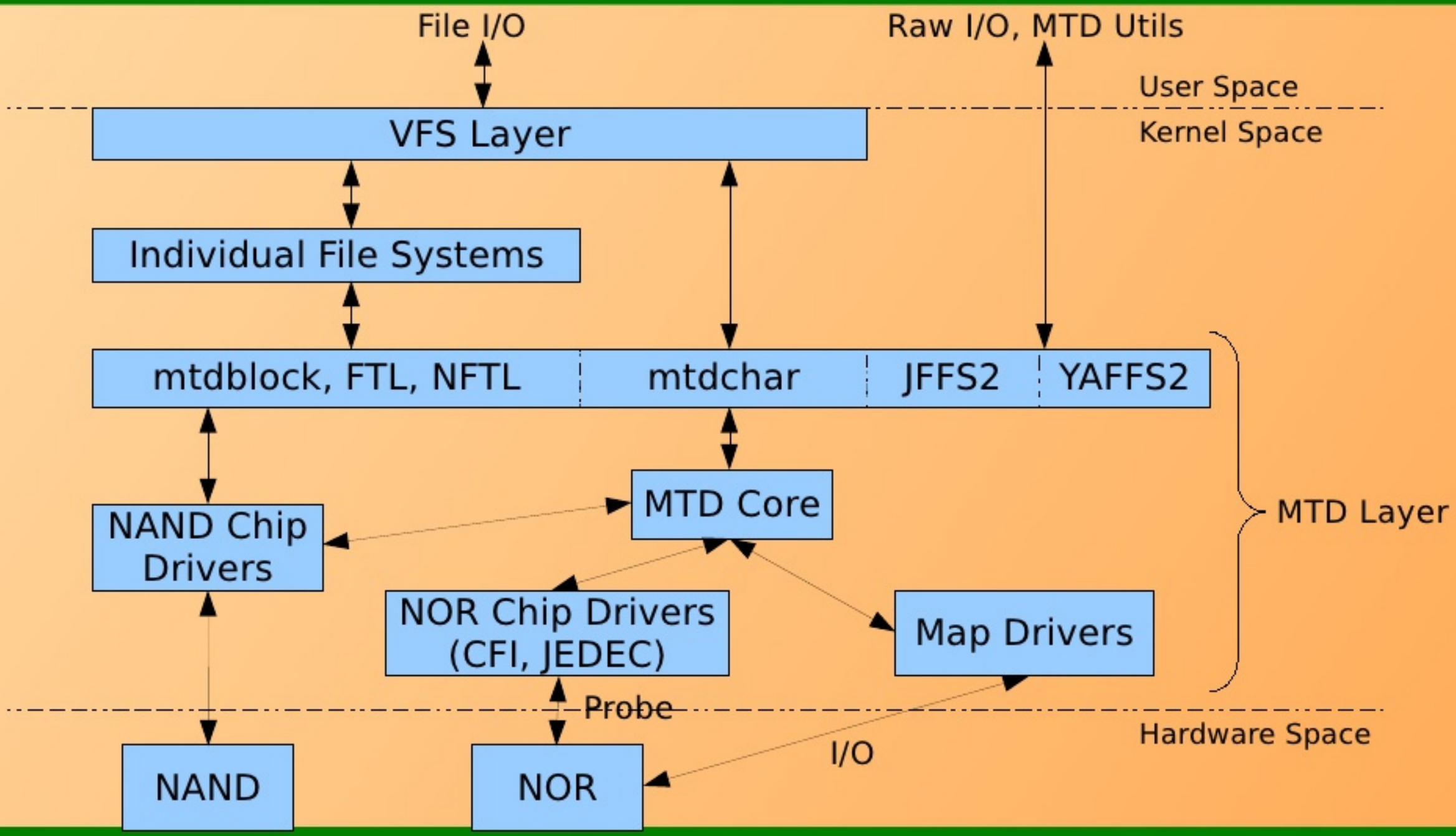
NAND Flash

- Reading like Hard Disk
  - Multiples of 512 bytes at a time
  - No XIP
- Higher Density & Cheaper than NOR
- Highly prone to errors at the bit level
  - Needs software to handle bad blocks
- Manufacturers: Samsung and Toshiba
- Capacity: Typically from 8MB to 1024MB. Today, even more

Writing into Flash

- Same for both NOR and NAND Flash
- Sequence of Steps needed
- Almost always involve an erase cycle
- As Writing of Data means
  - Flipping a bit to "0" or leaving it as a "1"
  - Flipping a bit to "1" needs an erase cycle

MTD Subsystem



Map Drivers

- Drivers to Map
  - Flash Memory Range for CPU access
  - Mark the Storage Partitions in the Kernel
    - As no partition table on flash
    - Shows up as /dev/mtd*
- Example
  - Browse the drivers/mtd/maps/ folder
- Data Structures
  - struct mtd_partition (Header: <linux/mtd/partitions.h>)
  - struct map_info (Header: <linux/mtd/map.h>)
- Header: <linux/mtd/mtd.h>
- APIs
  - int add_mtd_partitions(struct mtd_info *, const struct mtd_partition *, int);
  - int del_mtd_partitions(struct mtd_info *);

NOR Chip Drivers

- NOR Chip Drivers
  - CFI specification
  - JEDEC specification
- CFI Command Sets
  - 0x01 – Intel & Sharp flash chips
  - 0x02 – AMD & Fujitsu flash chips
  - 0x03 – ST flash chips
- All three are configurable in kernel

NAND Chip Drivers

- Drivers for NAND Controller to access NAND
- Sources: drivers/mtd/nand/
- A NAND Drive should do the following
  - Add an entry to nand_flash_ids[] in drivers/mtd/nand/nand_ids.c
  - Entries being
    - Id Name, Device Id, Page Size, Erase Block Size, Chip Size, Options like Bus Width, ...
  - As, no automatic configuration support
  - Specify its out-of-band (OOB) spare area layout through the “struct nand_ecclayout” (Header: <mtd/mtd-abi.h>)
    - For ECCs, to implement error correction & detection
  - Enable Error Management, in case NAND Controller doesn't do it
    - Software ECC is implemented in drivers/mtd/nand/nand_ecc.c

Kernel Configurations for MTD

- CONFIG_MTD should be enabled
- And whatever required under it, should be enabled, e.g.
  - Required NAND Driver, Or
  - Required NOR Protocol
  - etc

File Systems for Flash

- Typical Requirements
  - Flash wear-levelling
  - Less Writes / Erases
  - Protect Data during Erase Cycles
  - Bad Block Management (esp for NAND)
  - Possibly compression (though preferred on read-only file systems only)
- File Systems handling these
  - JFFS2 (log-structured design & garbage collection)
  - YAFFS2 (specifically designed for NAND constraints)

Flash Tools

- Useful tools to work with MTD layer
  - flash_erase, flash_eraseall
  - flash_lock, flash_unlock
  - nanddump, nandwrite
  - sumtool
  - ...
- Download from ftp://ftp.infradead.org/pub/mtd-utils
- Tool to construct a JFFS2 file system image
  - mkfs.jffs2

What all have we learnt?

- W's of Memory Technology Devices
  - About NOR & NAND
- MTD Subsystem
- MTD related Drivers
  - Map, NOR Chip, NAND Chip
- Flash File Systems
- Flash Tools

Any Queries?