ARM Powered SoCs OpenEmbedded: a framework for toolchain generation and rootfs management

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12-2010

An overview on commercial ARM-Powered SOCs

Many low-cost ARM powered devices exists on the market nowadays.
They are usually designed around a **S**ystem **O**n **C**hip platform equipped with a Cortex-A ARMv7 main core such as

- Texas Instruments OMAP3:
  N900, Beagleboard, AI Touchbook, most of Apple's "i$SOMETHING" devices.
- Marvell ARMada (was 'Kirkwood'):
  Sheevaplug...
- Qualcomm Snapdragon
  Google Nexus One, Acer Liquid, HP Smartbook...
- Freescale i.MX51
  Efika, Sharp Netwalker...

Cortex-A8: More Specifications

All the previous platforms are built around the Cortex-A8 version of ARMv7 specifications. The Cortex processor series provides the following features:

- CPU Speed ranging from 600Mhz to more than 1Ghz.
- L1 and L2 cache (cache size is version dependent).
- NEON SIMD extension:
  Arithmetic instruction vectorization extension: parallel operates on multiple data arrays.
  Support for 64-128 bit instructions, for media codec and signal processing. Support in GCC is not fully available, "CodeSourvery G++" GCC based toolchain is more suited for NEON intensive applications.

Cortex-A8: More Specifications

- VFP (Vector Floating Point):
  Coprocessor extension for 16-32 bit instructions, handling floating and fixed point arithmetic, also on vectorized data but with no, or reduced, parallelism compared to NEON.
- Some other extensions such as xN memory protection ad TrustZone instructions subset.

OMAP3530: More Specifications

OMAP3530 is last one of the long OMAP3 TI processors line (dual core OMAP4 has been released some months ago).
OMAP3 is Texas Instruments proprietary version, and since is an hybrid processor featuring a Cortex-A8 GPP[1], includes a dedicated DSP for hardware signal and data processing.
DSP is 430Mhz C64x+ produced by TI. Other processor series, fully dedicated to image processing (DaVinci series) features a 1Ghz DSP, some other provides more than one DSP.

[1] General Purpose Processor

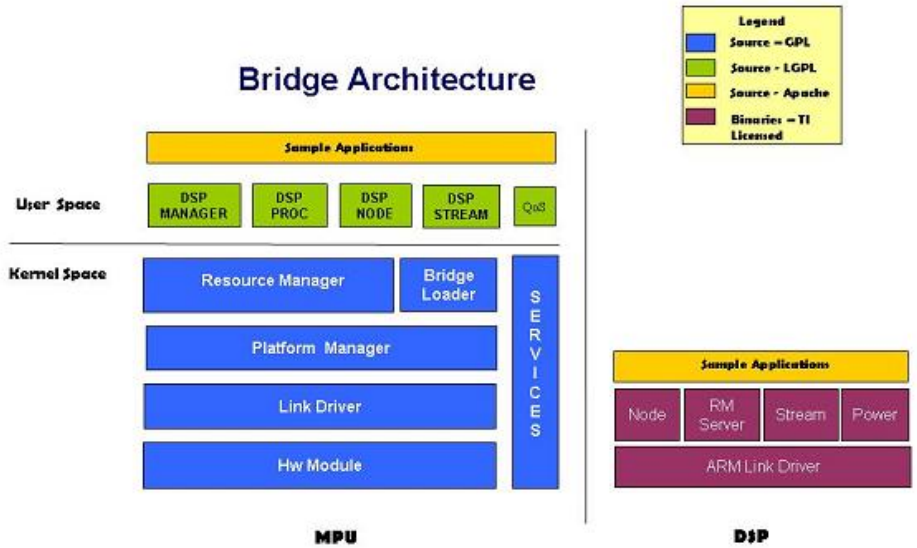
DSPBridge and DSP software support

Software support for DSP exploitation is provided by a cross-processor kernel modules, that gives access to DSP, called *DSPBridge*(now in staging also on Linus' tree since June 2010). Kernel module is used to dispatch instructions from Linux to DSP where a dedicated BIOS (not the one we are used too) runs and process incoming data in parallel to GPP processing.

DSPBridge and DSP software support

A dedicated toolchain for compiling codecs provided by TI is needed to develop DSP-specific software while the Linux counterpart is mainly FLOSS.
Some userspace utilities are used to communicate with BIOS-DSP via DSPBrisge.
The gst-dsp project aims to include native Gstreamer support for DSP infrastructure, in order to build cross-processors pipelines in a transparent way.

DSPBridge and DSP software support



OMAP3 based platforms

Commercial platforms available at a reasonable price found on the market are (random order):

- BeagleBoard (www.beagleboard.org)
- HawkBoard (www.hawkboard.org)
- Overo GumStix
- OMAP35 EVM
- More on http://processors.wiki.ti.com/index.php/OMAP3_Boards

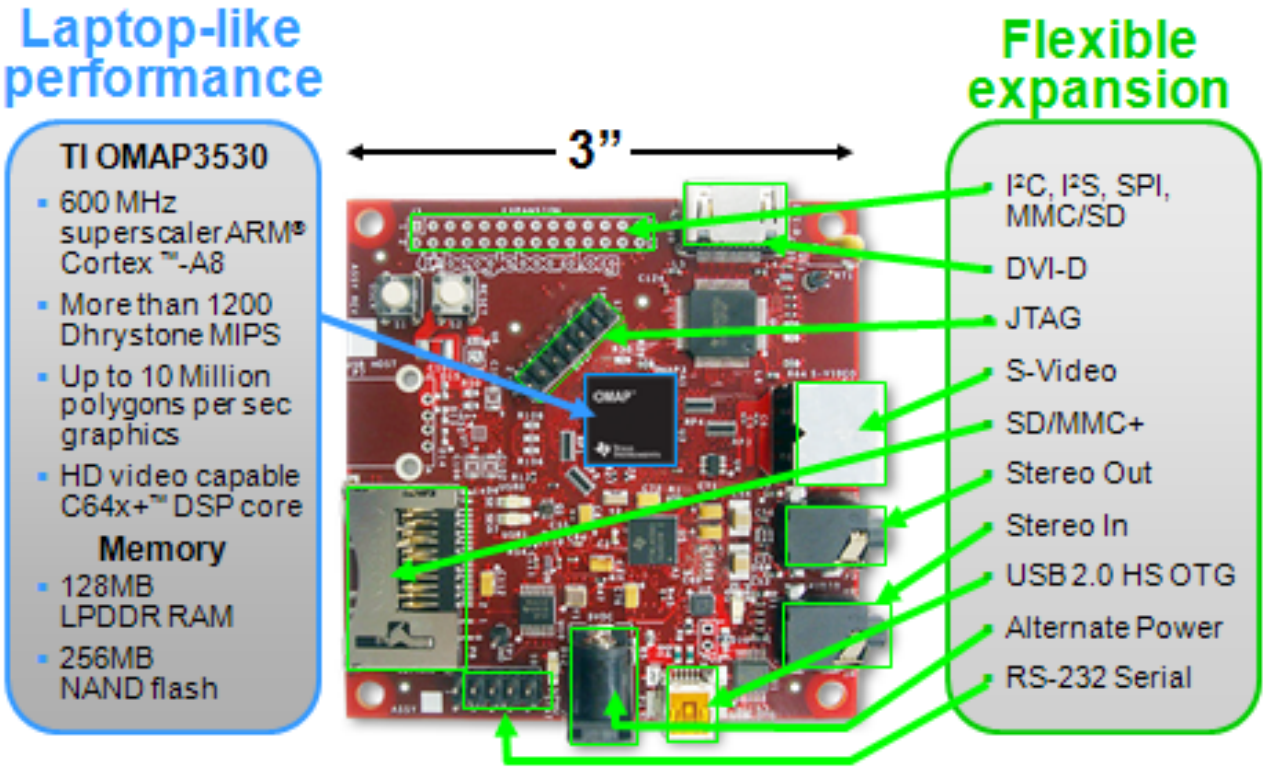
BeagleBoard: Versions

Beagleboard was a TI sponsored project, thought to provide an hobbyist low-cost platform.
After many years the project is self financed, and many beagleboard versions have been released.
Actually, two different releases are co-existing. The last incarnation of the classic beagle (BB-MB-C4) and the new kid on the blocks, the BB-xM version.
Price is 100$ for C4 version and $125 for xM version.

C4 version

The classic C4 version is equipped with TI OMAP3530 running at 600Mhz, 128Mb RAM, 256Mb NAND Flash Memory. Expansions connectors installed on the board are:

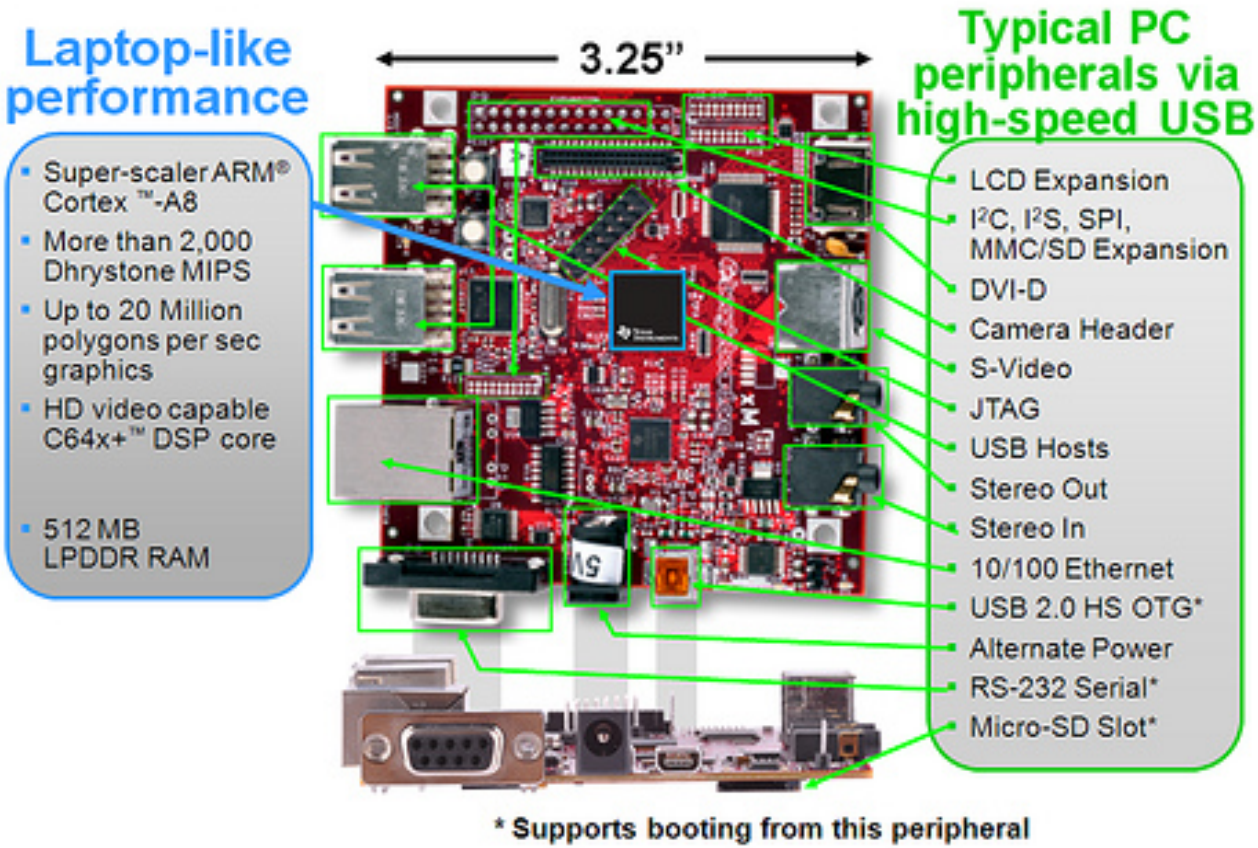
- DVI-D
- JTAG
- S-Video
- Stereo In/Out
- RS-232
- Power Jack
- MMC Card Slot
- 1 USB EHCI Host Port
- 1 USB OTG Port


Laptop-like performance
TI OMAP3530
600 MHz superscaler ARM® Cortex™-A8
More than 1200 Dhrystone MIPS
Up to 10 Million polygons per sec graphics
HD video capable C64x+™ DSP core
Memory
128MB LPDDR RAM
256MB NAND flash
3”
Flexible expansion
I²C, I²S, SPI, MMC/SD
DVI-D
JTAG
S-Video
SD/MMC+
Stereo Out
Stereo In
USB 2.0 HS OTG
Alternate Power
RS-232 Serial

xM Version

The new xM version (current release is A3) add a new Cortex-A8 OMAP implementation, clocked at 1.25Ghz, 512MB RAM, and substitutes the NAND memory with a 4Gb micro-SD card.
New expansions connectors have been added:

- 10/100 Ethernet Port
- 1 USB EHCI Host HUB with 4 USB connectors
- Micro-SD slot
- Header for camera input.


Laptop-like performance
Super-scaler ARM® Cortex ™-A8
More than 2,000 Dhrystone MIPS
Up to 20 Million polygons per sec graphics
HD video capable C64x+™ DSP core
512 MB LPDDR RAM
3.25"
Typical PC peripherals via high-speed USB
LCD Expansion
I²C, I²S, SPI, MMC/SD Expansion
DVI-D
Camera Header
S-Video
JTAG
USB Hosts
Stereo Out
Stereo In
10/100 Ethernet
USB 2.0 HS OTG*
Alternate Power
RS-232 Serial*
Micro-SD Slot*
* Supports booting from this peripheral

Expansions Connector

Both C4 and xM share an Expansion Slot and 2 LCD expansions slots, where additional connectors could be routed and physically installed.
Default behavior is General Purpose Input Output (GPIO), but many other connectors are available, such as I2C, PWM, SPI, additional USARTs and USBs.
That is possible thanks to the 'multiplexing' capabilities provided by OMAP3 chipset.

OMAP Multiplexing

Multiplexing and OMAP connectors means that same pin could perform (a maximum of) 4 different functions.
OMAP datasheet specify what are those functions, and how to set them.
It's possible choosing which role a pin must assume modifying bootloader or kernel startup routines. Preferred way is done by patching u-boot, since kernel is rapidly changing and kernel patching is not guarantee to work (the problem it's related to which bootloader-kernel combination is installed) [2]

[2] Code Example here: /home/jacopo/volta/kernel/patches/applied/u-boot_MUX_UART1_UART2/git/board/omap3/beagle

Software support

Yeah, beagleboard is a great pice of hardware, but without software, it would be just bare metal...
The first thing one must consider when approaching a new platform, is how to transfer code you write or you compile on the platform itself, and the first thing you want to transfer on the board is usually a bootloader, in order to bootstrap a fully-featured kernel. Before doing so, for OMAP platforms additional software is required...

x-loader, the meta-bootloader

X-Loader is a GPLv2 project by TI, and is a bootloader that boots a bootloader... Before launching the multi-platform fully featured u-boot, it's necessary to init some hardware related features, such as clocks, and processors registers.
I cannot say much more, since x-loader is written mostly in ARM assembly, maybe because is the software component closer to the bare hardware.

u-boot: a fully featured bootloader

X-Loader (aka MLO) launches the real bootloader: u-boot.
U-boot is a great project that realizes a small-fast-portable bootloader for various embedded platform.
It offers a fallback shell, that could be used for accessing the underlying memory, and transfer linux kernel images, new u-boot versions, and even new x-loader versions onto it.
As every bootloader does, u-boot launches the kernel, that is....

Linux (finally)

As we all know Linux runs on a incredible number of platforms, and of course OMAP is one of the supported ones... Many other operating systems support OMAP devices, but I could only talk about Linux, since I have no other experience.

Linux-omap

Two main branches of Linux kernel development tree are designed specifically for OMAP platforms.
As name suggests the *linux-omap* kernel tree integrate support for main OMAP features such as **Multiplexing, Dual Timing, Thumb support, NEON support, Musb**.

Linux-omap-pm

The other dedicated branch is *linux-omap-pm* that introduces advanced power management features such as *full sleep* while board is suspended and improves power retention for OMAP devices while halted or suspended.
The *pm* framework is an OMAP specific development branch, and some of its features have been included in main-line OMAP branch.

Linux: building

Configuring and compiling Linux kernel for ARM platforms is done in same way is usually done for other hardware platforms.
As for every cross-compilation environment it's mandatory to manually specify the cross-compilation-tools prefix and the architecture for which you are compiling.
The string for kernel compilation and configuration becomes something like:

make ARCH=arm CROSS_COMPILE=arm-angstrom-linux-gnueabi- -j3 INSTALL_MOD_PATH=‘pwd‘

Linux: issues

Some kernel features are not yet fully mature, and during different releases some regressions have been introduced and then fixed.
In my brief experience the weakest points for OMAP and beagleboard platforms are:

- USB OTG support (musb_hdrc):
  Support for dual role usb.
- NAND MTD support:
  In-device solid state memory, accessed through the *jffs2* filesystem.