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Yocto Project on the Gumstix Overo Board

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***Abstract*—Ångström Linux is no longer supported for the Gumstix Overo Board. Therefore, Yocto Project is used to build a custom Linux distribution. The changes between the old operating system Ångström Linux and the new Yocto Project will be elaborated in this paper. The most significant advantage of the Yocto Project is its ability to port the customized Linux distribution on many different platforms and to create customizable distributions. Furthermore, Yocto Project has a newer kernel than Ångström Linux. Unfortunately, with the high flexibility of Yocto Project distribution, the complexity of the build process to build the distribution is also increasing.**

***Keywords*—Gumstix Overo Board, ARM, Linux, Yocto Project, Ångström Linux**

I. INTRODUCTION

LINUX is a commonly used operating system for embedded systems. In addition, to support more computer architectures than any other operating system, it is lightweight and cheap (mostly open source), making it a perfect platform for embedded systems.
Two primary factors contributing to embedded developers choice of operating systems in their designs are cost and the availability of source code. These factors have contributed to the explosion of demand for Linux in embedded devices [1]. There are different operating systems for the Gumstix Overo Board (described in section II). The best supported operating system for this platform is Linux.
Ubuntu, Ångström Linux or Yocto Project are the common operating systems for the Gumstix Overo Board [2]. Unfortunately, Gumstix does not support Ångström Linux anymore and Ångström has been replaced with Yocto Project as the recommended alternative.

> "...Ångström images are no longer in development, as Gumstix Software Development is currently transitioning from the classic OpenEmbedded build system to the Yocto Project build system." [3]

Yocto Project builds a customized Linux distribution with all required packages for the Gumstix Overo Board. Furthermore, it is also possible to download the latest version of a pre-build Yocto Project distribution from www.gumstix.com.
The major difference between Ångström Linux and Yocto Project is that Ångström is a distribution and Yocto Project is a build system like OpenEmbedded. It can generate many different Linux distributions, including the Ångström distribution. Figure 1 shows the build process for a Linux distribution with Yocto Project or OpenEmbedded. Both build systems are using the same build tools and receipts to build a Linux distribution.

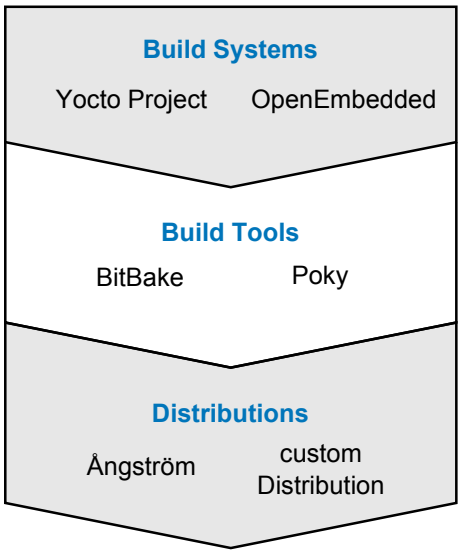

Fig. 1. Build process of a Linux distribution

The Gumstix Overo Board is used together with the ePuck Robot in the project "Nexting on the ePuck Tabletop Robot" [4]. The two-wheeled ePuck robot is a small coffee mug sized robot with integrated sensors like proximity sensors, ground sensors, camera, microphone and IR communication. The communications structure of the ePuck robot is shown in Figure 2. On the Gumstix Overo Board runs the Linux distribution which

communicates via two 70-pin AVX-Connectors with a PIC30 microcontroller. This microcontroller controls the wheels and reads the sensor data. The recorded data from the robot is transmitted over the WLAN-USB stick to a host computer. On the Gumstix Overo board, which runs on top of the Linux distribution, is a nexting algorithm. The nexting algorithm predicts how the sensor input will change in the future. Nexting is a kind of reinforcement learning.

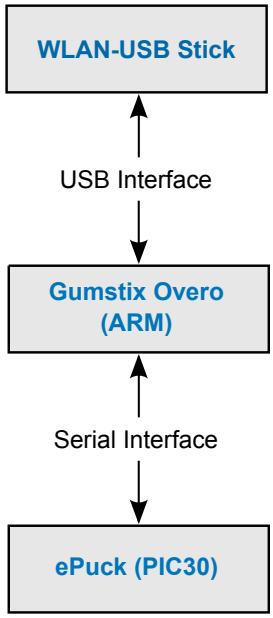

Fig. 2. System structure of the ePuck robot

II. Gumstix Overo Board

The Gumstix Overo Board is a small and powerful embedded system. The name Gumstix comes from the size of the board which is comparable to the size of a stick of gum. Figure 3 shows the different components of the Gumstix Overo Board. Due to its different components ARM Processor, microSD card slot and an optional WiFi-antenna, the Gumstix Overo Board is also called a Computer-on-Module (COM).

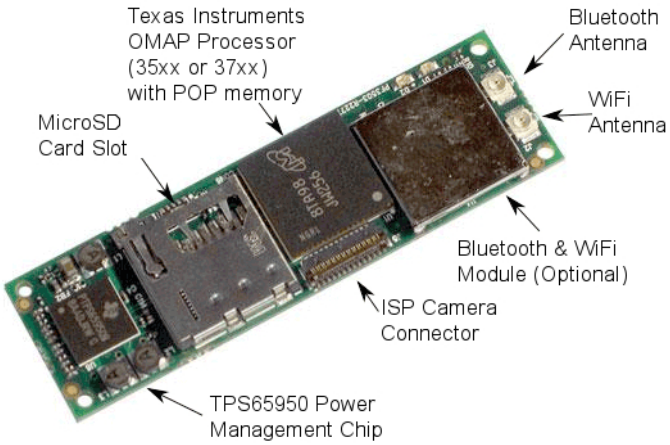

Fig. 3. Gumstix Overo Board Earth [3]

Gumstix Overo Board specifications [5]:

- ARM Cortex-A8 Core (OMAP3503)
- Max CPU Clock 600 MHz
- DRAM: 512 MiB
- NAND: 512 MiB
- Wireless: optional 802.11b/g and Bluetooth
- On-board: microSD slot
- Dimension 58mm x 17mm x 4.2mm

The ARM Cortex-A8 (OMAP3503) is a processor from Texas Instruments, which is designed for video, image, and graphics processing. In this project, the Gumstix Overo Board is used to run the Linux distribution and the nexting algorithm.

III. Ångström Linux

Ångström is a Linux distribution which is built with Open Embedded. The developers of Ångström Linux worked on the OpenEmbedded, OpenZaurus and OpenSimpad projects to unify their effort to make a stable and user-friendly distribution for embedded devices like handhelds, set top boxes, network-attached storage devices, and more [6]. OpenEmbedded is used to create Ångström Linux but Ångström is not called "OpenEmbedded Ångström" [7].
Ångström is also officially "Yocto Project Compatible" and "Yocto Project Participant" [6]. This means, Yocto Project can be used to build an Ångström distribution.

IV. YOCTO PROJECT

The Yocto Project is an open source project and not a stand-alone Linux distribution; instead, it creates a custom Linux-based distribution [8]. It is focused on the development of embedded Linux distributions for embedded systems and was founded in 2010. Yocto Project is similar to OpenEmbedded [9], because it has integrated recipes, tools and other build metadata from the OpenEmbedded project. The nature of open source allows users to modify the operating system to the specific requirements as well as development by low cost. Yocto Project is also hosted by the Linux Foundation.
Furthermore, the commercial software from "Wind River Linux" and "MontaVista" are also based on the Yocto Project. Therefore, it is possible to switch from Yocto Project to commercial software without major problems [10].
The most important build tool from Yocto Project is the Poky build tool. It contains the BitBake tool, which allows platform independent cross-compiling. Furthermore, BitBake manages all configuration files and recipe data and tries to reduce the build time by using all the available processing resources.

OpenEmbedded-Core provides the support for the five different processor architectures (ARM, x86, x86-64, PowerPC and MIPS) and supports also QEMU (Quick EMUlator), shown in Figure 4. OpenEmbedded-Core is also a collection of metadata, which provides the engine of the Poky build tool.

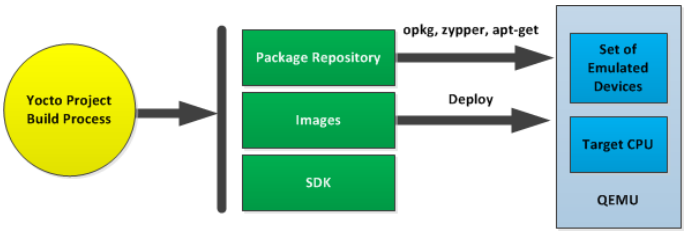

Fig. 4. Build process of Yocto Project [11]

There are several different types of metadata in the Yocto Project. The metadata are based on a mix of Shell- and Python-scripts. Another layer of the metadata is meta-yocto. This layer provides both the default and supported distributions.
The last layer is the meta-yocto-bsp (Board Support Packages) layer. It provides the hardware specific board support for the Poky tool.
The recipes manage one or more packages which should be installed on the distribution. It also provides instruction on configuring and compiling the source code from the kernel and the packages.
The whole build process with input and output files is shown in Figure 5.

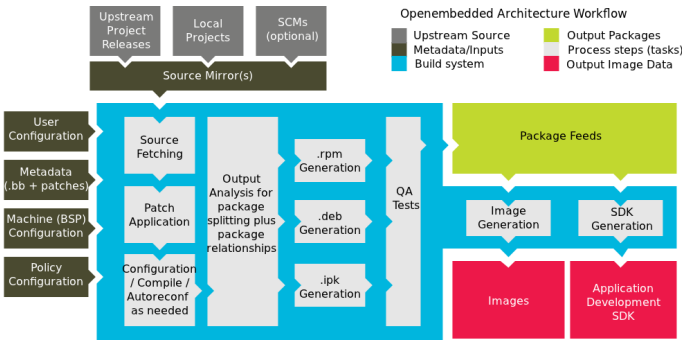

Fig. 5. Yocto Project build process and dependencies [12]

Running BitBake or Hob (graphical user interface for BitBake) yields a customized Linux distribution. The results of the BitBake process are a boot loader, a root filesystem (rootfs) and the Linux kernel [13].
Yocto Project uses the open source U-Boot boot loader which is used in many embedded Linux projects. U-Boot provides a simple command line interface (CLI), usually over a serial console port. The smallest footprint of the Yocto Project could be achieved by using poky-tiny results in a usable system under 1 MByte.

V. Yocto Project vs. Ångström

The Yocto Project distribution and the Ångström distribution are both based on Linux. They have some common properties, including a Linux kernel, package management, disc space usage and boot time. Below is a comparison of both distributions according to these properties:

- **Disk space usage:** Two partitions are needed, the first for the boot loader and the kernel. The remaining space is needed for the root-filesystem.
  The Yocto Project distribution needs 511 MBytes common amount of disc space and on the Ångström distribution 524 MBytes.

- **Linux kernel:** The Linux kernel is the basis for every Linux distribution. The kernel is the interface between the hardware and the application. The Linux kernel contains the drivers for the hardware and peripherals. Therefore, it is important that the kernel is not too old for the hardware being used. The latest Linux kernel in November 2014 is the 3.17.1 kernel. Every three months there is a new release of the Linux kernel.
  The Ångström distribution produced by Gumstix does not support Linux kernel versions beyond 2.6 (2011) [3].
  The Yocto Project framework uses the kernel 3.5.7 (Oct. 2012). It is also possible to build a customized kernel through the Yocto Project framework.

- **Boot time:** The boot-time is mainly determined by the size of the Linux distribution.
  The Yocto Project distribution needs 28 seconds whereas the Ångström distribution requires 42 seconds. One reason that the Yocto project boots faster than Ångström is because the Yocto Project offers a custom-sized operating system which loads only the needed peripheral devices.

- **Support for Gumstix Overo:** The user support for a software is one of the most important issues for the success of a project. The support includes the documentation of the software and fixing bugs.
  The Yocto Project provides a documentation for every used tool and also a guide for professional developers and for beginners (Quick Start). There is also an IRC-Chat and a mailing list where individual support can be found. Furthermore, the wiki gives a structured documentation about common problems and workflows.
  Ångström Linux just gives support in a user forum.

- **Package Management:** The package management is used to install software for the Linux distribution. For example, the GCC compiler can be installed, updated or removed using the package management system.
  The Ångström distribution uses the *opkg* package management (latest version September 2014). The *opkg* package manager is not user-friendly and does not give

a warning when important packages are deleted.
The Smart Package Manager (latest version October 2011) can be found on the Yocto Project distribution. The Smart Package Manager is written in Python and works in all major distributions. The benefit of the Smart Package Manager is that it does not leave the system in an unrecoverable state, if anything goes wrong with an update. The usage of multiple packaging systems like rpm and dpkg at the same time is possible but not recommended. Yocto Project allows also to install packages during the build process with the tool BitBake by using recipes which defines the packages. BitBake is also used in the OpenEmbedded project, the same recipes from OpenEmbedded are compatible with Yocto Project.

Ångström images produced by Gumstix are stable, but they do not feature Linux kernel versions newer than 2.6. [3]. Due to the fast changes of hardware in the embedded system industry, it is more important to have a portable software like Yocto Project. The Board Support Packages manage the specific configurations for different hardware platforms. Hence, the same Yocto Project distribution for a different hardware platform can be easily built by changing Board Support Packages.

Ångström Linux's g++ and clang++ do not support C++11 yet and the libraries enabling threading without C++11 are only available on Ångström in depreciated versions.

Yocto Project has a stable release every 6 months. The latest version of Yocto Project for the Gumstix Overo Board can be downloaded from Github [14].

VI. CONCLUSION

Table I shows the summary of the comparison between Yocto Project and Ångström Linux.

	Yocto Project	**Ångström**
Disk space on SD-Card	511 MByte	524 MByte
Boot time	28 seconds	42 seconds
Latest Linux kernel	3.5.7	2.6
Supported Architectures	ARM, PPC, MIPS, x86, and x86-64	ARM
Partners	Intel, Huawei, Texas Instruments, Wind River, MontaVista	Sharp Zaurus family, PocketPC and Windows Mobile family, Archos 5 and 7, Beagle Board
Support for Gumstix	Documentation, IRC-Chat, mailing list, wiki	user forum
Package Management	Smart Package Manager, recipes	opkg

Table. I. COMPARISION OF YOCTO PROJECT AND ÅNGSTRÖM

The major advantage of Yocto Project is that it offers support for a wide range of platforms, processor architectures (ARM, PPC, MIPS, x86, and x86-64) and hardware. Yocto Project is a very powerful tool for creating a custom Linux distribution. Though it requires a lot of time to understand and use Yocto Project as it is a complex tool, the result generated is a small-sized custom-fit Linux distribution for specific requirements. The difficulty is not to create a single product, but to manage and control changes of the hardware and software during the life cycle through all of the products versions and variations. Ultimately, Yocto Project is the best tool for creating a custom Linux distribution for the Gumstix Overo Board.

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