Creating a Tiny Linux Distribution Using Yocto: petalinux-tiny Case Study

Alejandro Hernandez
Embedded Linux Conference Europe
Oct/2018
Agenda

> What is Poky-Tiny?

> DISTRO

> Poky-Tiny 2018
Agenda

> What Does petalinux-tiny Need?

> Creating petalinux-tiny DISTRO on Yocto
What is Poky Tiny?
Poky-Tiny

First Introduced in 2011 by Darren Hart at ELCE
- Kernel
- Eglibc
- Udev
- Login

Focused on explaining how to decrease size and boot time
- Remove or trim unnecessary components (userspace)
  - Switch to UClibc
  - Switch to Busybox
  - Remove Udev
- Remove Kernel drivers and modules
  - Drop networking support
  - “Cripple” busybox
  - “Cripple” kernel (acpi,smp,ipc,futex,printk)
Poky-Tiny

> Nothing in life is free

   >> Tradeoff between functionality and size + boot time

> Times Change 2011 -> 2018

> Decrease size and boot time (possible)

> Focus on creating a Tiny Distro
What is a DISTRO?
DISTRO

> DISTRO:

  >> The DISTRO variable corresponds to a distribution configuration file whose root name is the same as the variable's argument and whose filename extension is .conf [Yocto Reference Manual].
    - meta-poky/conf/distro/poky.conf
    - meta-poky/conf/distro/poky-tiny.conf

> poky-tiny.conf (trimmed):

```plaintext
require conf/distro/poky.conf
DISTRO = "poky-tiny"
DISTROOVERRIDES = "poky:poky-tiny"
TCLIBC = "musl"
PREFERRED_PROVIDER_virtual/kernel = "linux-yocto-tiny"
VIRTUAL-RUNTIME_dev_manager = "busybox-mdev"
VIRTUAL-RUNTIME_login_manager = "busybox"
IMAGE_FSTYPES = "cpio.gz"
```

> DISTRO !== Image
DISTRO

> **Poky + core-image-minimal**
  >> RootFS: 4 MB
  >> Kernel: 7 MB
  >> Boot time: 9.1 sec

> **Main Components:**
  >> Base-Utils: BusyBox
  >> C Library: GLIBC
  >> Dev manager: Udev/Eudev
  >> Other: Util-linux (sulogin, lsblk, umount, mkfs, fdisk, etc)
## Component size:

<table>
<thead>
<tr>
<th>Package</th>
<th>Arch</th>
<th>Version</th>
<th>Repository</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>packagegroup-core-boot</td>
<td>qemux86</td>
<td>1.0-r17</td>
<td>oe-repo</td>
<td>5.8 k</td>
</tr>
<tr>
<td>packagegroup-core-ssh-dropbear</td>
<td>noarch</td>
<td>1.0-r1</td>
<td>oe-repo</td>
<td>5.6 k</td>
</tr>
<tr>
<td>run-postinsts</td>
<td>noarch</td>
<td>1.0-r10</td>
<td>oe-repo</td>
<td>8.7 k</td>
</tr>
</tbody>
</table>

Installing:

- `packagegroup-core-boot`: qemux86 1.0-r17 oe-repo 5.8 k
- `packagegroup-core-ssh-dropbear`: noarch 1.0-r1 oe-repo 5.6 k
- `run-postinsts`: noarch 1.0-r10 oe-repo 8.7 k

Installing dependencies:

- `base-files`: qemux86 3.0.14-r89 oe-repo 13 k
- `base-passwd`: i586 3.5.29-r0 oe-repo 7.1 k
- `busybox`: i586 1.29.2-r70 oe-repo 111 k
- `dropbear`: i586 2018.76-r0 oe-repo 131 k
- `eudev`: i586 3.2.5-r10 oe-repo 149 k
- `initscripts`: i586 1.0-r155 oe-repo 22 k
- `libblkid1`: i586 2.32.1-r0 oe-repo 143 k
- `libfdisk1`: i586 2.32.1-r0 oe-repo 185 k
- `libmount1`: i586 2.32.1-r0 oe-repo 152 k
- `libncursesw5`: i586 6.1+20180630-r0 oe-repo 91 k
- `libsmartcols1`: i586 2.32.1-r0 oe-repo 93 k
- `v86d`: qemux86 0.1.10-r2 oe-repo 46 k
- `util-linux-cfdisk`: i586 2.32.1-r0 oe-repo 45 k
- `util-linux-fdisk`: i586 2.32.1-r0 oe-repo 57 k
- `util-linux-ionspace`: i586 2.32.1-r0 oe-repo 17 k
- `util-linux-sfdisk`: i586 2.32.1-r0 oe-repo 51 k
DISTRO

> **Poky-tiny + core-image-minimal**
  > RootFS: 1 MB
  > Kernel: 2.7 MB
  > Boot time: 5.2 sec

> **Main Components:**
  > Base-Utils: BusyBox
  > C Library: Musl
  > Dev manager: busybox-mdev
  > Other: busybox (sulogin, lsblk, umount, mkfs, fdisk, etc)
### Component size:

<table>
<thead>
<tr>
<th>Package</th>
<th>Arch</th>
<th>Version</th>
<th>Repository</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Installing:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>packagegroup-core-boot</td>
<td>qemux86</td>
<td>1.0-r17</td>
<td>oe-repo</td>
<td>5.7 k</td>
</tr>
<tr>
<td>run-postinsts</td>
<td>noarch</td>
<td>1.0-r10</td>
<td>oe-repo</td>
<td>7.4 k</td>
</tr>
<tr>
<td><strong>Installing dependencies:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>base-files</td>
<td>qemux86</td>
<td>3.0.14-r89</td>
<td>oe-repo</td>
<td>13 k</td>
</tr>
<tr>
<td>base-passwd</td>
<td>i586</td>
<td>3.5.29-r0</td>
<td>oe-repo</td>
<td>7.1 k</td>
</tr>
<tr>
<td>busybox</td>
<td>i586</td>
<td>1.29.2-r0</td>
<td>oe-repo</td>
<td>785 k</td>
</tr>
<tr>
<td>busybox-inittab</td>
<td>qemux86</td>
<td>1.29.2-r0</td>
<td>oe-repo</td>
<td>6.5 k</td>
</tr>
<tr>
<td>busybox-udev</td>
<td>i586</td>
<td>1.29.2-r0</td>
<td>oe-repo</td>
<td>6.5 k</td>
</tr>
<tr>
<td>musl</td>
<td>i586</td>
<td>1.1.20+git+6f9fa5d0c-rc</td>
<td>oe-repo</td>
<td>785 k</td>
</tr>
<tr>
<td>netbase</td>
<td>i586</td>
<td>1:5.4-r0</td>
<td>oe-repo</td>
<td>15 k</td>
</tr>
<tr>
<td>update-alternatives-opkg</td>
<td>i586</td>
<td>0.3.6-r0</td>
<td>oe-repo</td>
<td>8.5 k</td>
</tr>
<tr>
<td><strong>Installing weak dependencies:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>busybox-syslog</td>
<td>i586</td>
<td>1.29.2-r0</td>
<td>oe-repo</td>
<td>8.5 k</td>
</tr>
<tr>
<td>busybox-udhcpc</td>
<td>i586</td>
<td>1.29.2-r0</td>
<td>oe-repo</td>
<td>8.1 k</td>
</tr>
</tbody>
</table>
DISTRO

> DISTROOVERRIDES
  >> Enable us to use _poky-tiny
  >> Busybox defconfig:
     – meta-poky/recipes-core/busybox/busybox/poky-tiny/defconfig

  >> Kernel defconfig (not currently used)

> Busybox example configs diff:

```
+ CONFIG_FDISK=y
+ CONFIG_SWAPONOFF=y
+ CONFIGUnmount=y
- CONFIG_ZCAT=y
- CONFIG_BZCAT=y
- CONFIG_DIFF=y
- CONFIG_AwK=y
- CONFIG_SED=y
```
Poky-Tiny 2018
Poky-Tiny 2018

> core-image-tiny
  > Tiny RootFS but more functionality
  > Improve boot time
  > Boot to RAM

> Boot Process:
  > Load Kernel
  > Load Tiny RootFS to RAM : initrd=rootfs.cpio.gz
  > Load Tiny Init
    - Mount virtual filesystems
    - Start udev
    - Start dropbear (or other services)
    - Drop to shell before switching root
Poky-Tiny 2018

> **core-image-tiny**
  > core-image-tiny-initramfs: RootFS: 1.1MB (cpio.gz)
  > Kernel: 2.7 MB
  > Boot time: .93 sec (busybox-mdev)

> **Main Components:**
  > Base-Utils: Busybox
  > C Library: Musl
  > Dev manager: busybox-mdev / eudev
  > Other:
    - busybox (lsblk, umount, mkfs, fdisk, etc)
    - Dropbear (SSH)
    - No login
Poky-Tiny 2018

core-image-iiny

Boot Time

```
[   0.408480] Trying to unpack rootfs image as initramfs...
[   0.615349] Scanning for low memory corruption every 60 seconds
[   0.620084] workset: timestamp_bits=30 max_order=16 bucket_order=0
[   0.626754] io scheduler noop registered
[   0.626954] io scheduler deadline registered
[   0.627488] io scheduler cfq registered (default)
[   0.629278] efifb: probing for efifb
...  
[   0.669212] Serial: 8250/16550 driver, 4 ports, IRQ sharing disabled
...  
[   0.717234] Linux agpgart interface v0.103
[   0.731329] brd: module loaded
[   0.738554] i8042: PNP: PS/2 Controller [PNP0303:KBD,PNP0f13:MOU] at 0x60,0x64 irq 1,12
[   0.741451] serio: i8042 KBD port at 0x60,0x64 irq 1
[   0.742358] serio: i8042 AUX port at 0x60,0x64 irq 12
[   0.743569] mousedev: PS/2 mouse device common for all mice
[   0.746918] input: AT Translated Set 2 keyboard as /devices/.../input0
...  
[   0.751511] rtc_cmos 00:00: alarms up to one day, y3k, 114 bytes nvram, hpet irqs
[   0.756549] Using IPI Shortcut mode
[   0.756882] sched_clock: Marking stable (756175949, 0)->(859115222, -102939273)
[   0.756940] input: ImExPS/2 Generic Explorer Mouse as /devices/.../input2
[   0.904799] freeing unused kernel image memory: 324K
[   0.936327] Write protecting the kernel text: 2056k
[   0.936644] Write protecting the kernel read-only data: 860k
/init: line 43: --daemon: not found
/init: line 44: udevadm: not found
Poky Tiny Reference Distribution:
/#:
```
Pros and Cons

- Read Only RootFS
- Faster boot time

Example Applications

- Network devices
- Upgrade system
- Anything with that needs Linux, but requires to boot fast
Comparison

- Poky + core-image-minimal
- Poky Tiny + core-image-minimal
- Poky Tiny + core-image-tiny
petalinux -> petalinux-tiny
petalinux DISTRO on Yocto

> petalinux-image-minimal (From meta-petalinux, not to be confused with Petalinux Tools / BSP)
  > (Final PRODUCT)
  > Dropbear
  > Canutils
  > Pci-utils
  > Tcf-agent
  > Kernel-modules

> petalinux-image-full
  > QT
  > OpenCV
  > V4L
  > Gstreamer
  > MRAA
  > Python
petalinux

> petalinux + petalinux-image-minimal

  >> RootFS: 13MB (gz)
  >> Kernel: 15 MB
  >> Boot time: 42 sec

> Main Components:

  >> Base-Utils: BusyBox
  >> C Library: GLIBC
  >> Dev manager: Udev/Eudev
  >> Other: Util-linux (sulogin,lsblk,umount,mkfs,fdisk,etc)
>Petalinux

> Bootchart2:

>> On Image:

```bash
IMAGE_INSTALL_append = "bootchart2"
```

>> On Kernel cmdline (Run as pid 1):

```bash
append = initcall_debug printk.time=y quiet init=/sbin/bootchartd --init /tiny-init
```

>> After booting:

```bash
$ bootchartd stop
```

>> Create image file:

```bash
pybootchartgui bootchart.tgz
```
Creating petalinux-tiny

petalinux-tiny Goals:

- Reduce boot time - for testing and release
- Reduce Kernel Size
- Provide a more functional DISTRO than poky-tiny, still have features like FPGA manager
- Decrease filesystem size
- DON’T boot to RAM
petalinux-tiny

> Select userspace components

  >> musl
  >> BusyBox
  >> Udev
  >> Linux kernel

> Create a DISTRO.conf

```
require conf/distro/poky.conf
DISTRO = "petalinux-tiny"
TCLIBC = "musl"
PREFERRED_PROVIDER_virtual/kernel ?= "linux-xlnx"
VIRTUAL-RUNTIME_login_manager = "busybox"
VIRTUAL-RUNTIME_dev_manager = "udev"
```

[1] linux-xlnx github
petalinux-tiny

> petalinux-tiny + petalinux-image-minimal

  > RootFS: 11MB (gz)

  > Kernel: 15 MB

  > Boot time: 24 sec
petalinux-tiny

> petalinux-tiny + petalinux-image-tiny

  >> RootFS: 1.5 MB (gz)

  >> Kernel: 15 MB

  >> Boot time: 18 sec

> We should OVERRIDE linux-xlnx and BusyBox!
petalinux-tiny

> BusyBox's defconfig

+ CONFIG_FDISK=y
+ CONFIG_SWAPONOFF=y
+ CONFIG_UMOUNT=y
- CONFIG_ZCAT=y
- CONFIG_BZCAT=y
- CONFIG_DIFF=y
- CONFIG_AWK=y
- CONFIG_SED=y
Override `linux-xlnx` defconfig

Nothing in life is free

# DROP IO SCHEDULERS
- CONFIG_IOSCHED_DEADLINE=y
- CONFIG_IOSCHED_CFQ=y

# DROP IPv6 AND BLUETOOTH
- CONFIG_IPV6=y
- CONFIG_BT=y
- CONFIG_BT_RFCOMM=y

# DROP FILESYSTEMS SUPPORT
- CONFIG_EXT2_FS=y
- CONFIG_EXT3_FS=y
- CONFIG_FAT_FS=y
- CONFIG_MSDOS_FS=y
- CONFIG_ECRYPT_FS=y
- CONFIG_NFS_FS=y
Petalinux-Tiny

```
[ 2.25031] fpga_manager: FPGA: Xilinx ZynqMP FPGA Manager registered
[ 2.25947] ff000000.serial: ttyPS0 at MMIO 0xff000000 (irq = 38, base_baud = 10416666) is a xuartps
[ 2.35302] console [ttyPS0] enabled
[ 2.38320] ff010000.serial: ttyPS1 at MMIO 0xff010000 (irq = 39, base_baud = 2480158) is a xuartps
input:
gpio-keys as /devices/platform/gpio-keys/input/input0
hctosys: unable to open rtc device (rtc0)
of_cfs_init
of_cfs_init: OK
of_cfs_init: OK
clk: Not disabling unused clocks
Waiting for root device /dev/mmcblk0p2...
mmc0: Problem switching card into high-speed mode!
mmcblk0: mmc0:4567 QEMU! 39.8 MiB
EXT4-fs (mmcblk0p2): couldn't mount as ext3 due to feature incompatibilities
EXT4-fs (mmcblk0p2): mounted filesystem with ordered data mode. Opts: (null)
VFS: Mounted root (ext4 filesystem) on device 179:2.
Freeing unused kernel memory: 320K
mount: mounting none on /dev failed: Resource busy
udevd[1081]: error getting socket: Function not implemented
udevd[1081]: error initializing udev control socket
Booting Petalinux Tiny
Petalinux Tiny Test Distribution:
/
```
Petalinux-Tiny

- Petalinux-Tiny + Petalinux-Image-Tiny Final
  - RootFS: 1.5 MB (gz)
  - Kernel: 5.4 MB
  - Boot time: ~3.76 sec
DISTRO + Image Comparison

- petalinux + petalinux-image-minimal
- petalinux-tiny + petalinux-image-minimal
- petalinux-tiny + petalinux-image-tiny
Petalinux-Tiny

> What is next for petalinux-tiny?

>> Explore userspace component alternatives

  - Sbase
  - Toybox

>> Customize Kernel with Yocto Kernel Meta

  - Easily customizable by customers
  - Use MACHINE and DISTRO_FEATURES
Thanks!

Alejandro Hernandez
alejandr@xilinx.com