A timeline for embedded Linux
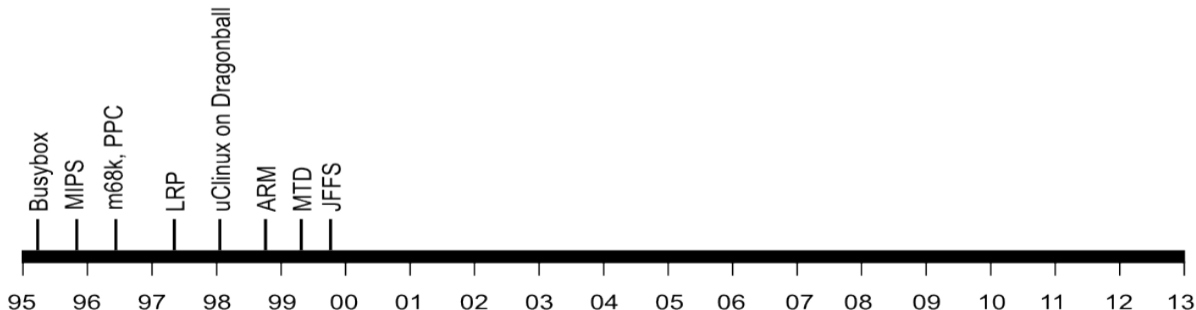
Chris Simmonds

2net Ltd.

24th October 2013

Chris Simmonds

- Has been using Linux as an embedded operating system since 1999
- Has been training others how to do the same since 2002
- Blog at `http://2net.co.uk/`

The early days: 1995 to 1999

- By 1995 Linux was already attracting attention beyond desktop and server
- It just needed a few more steps to make it a real contender...

A timeline showing:
- Busybox (95)
- MIPS (96)
- m68k, PPC (96)
- LRP (97)
- uClinux on Dragonball (98)
- ARM (99)
- MTD (99)
- JFFS (99)

Timeline axis: 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13

Making Linux small

1995
Busybox: a collection of command-line utilities

Created by Bruce Perens so that he could put the Debian installer on to a single 1.44 MiB floppy disk

Also ideal for embedded devices with limited storage

The Linux Router Project

1997
The Linux Router Project (LRP): Dave Cinege used Busybox to create a Linux distribution on a floppy disk that turns a PC into a router

1998
David Täht and Greg Retkowski publish the "Arlan Wireless Howto"
The first embedded Linux wireless router

Making the Linux code portable

1995: MIPS
1996: m68k, ppc
1998: uClinux for m68k Dragonball on 3Com Palm Pilot
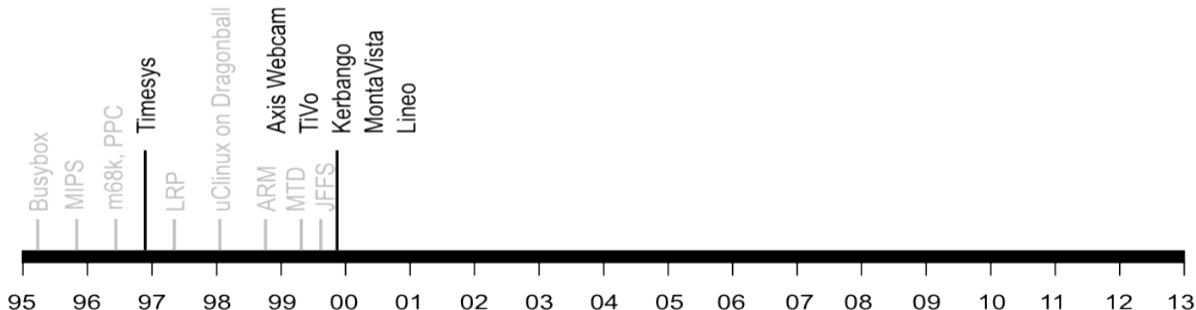*1999: ARM*

Flash memory

1999
David Woodhouse begins work on the Memory Technology Devices (MTD) layer

Axis create a robust file system for the flash memory in the AXIS 2100 Network Camera. It was called JFFS (Journaling Flash File System)

Things start to happen: 1999

- The first products based on Embedded Linux appear
- Embedded Linux software companies emerge

Things start to happen: 1999

AXIS 2100 Network Camera

TiVo DVR

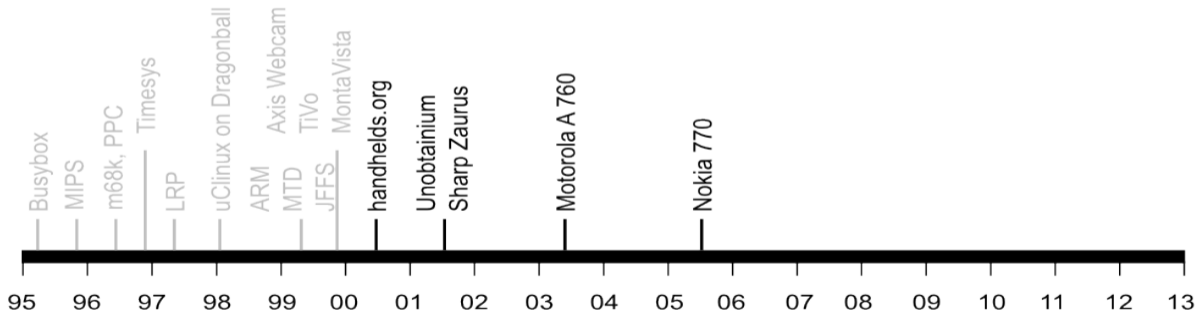Kerbango Internet radio

Professional help

1996: Timesys
1999: MontaVista
1999: Lineo
1999: Denx

Linux goes mobile: 2000 to 2005

- From early beginnings hacking on mobile hardware to a full mobile operating system

Timeline entries (early/grey, 1995–2000): Busybox, MIPS, m68k, PPC, Timesys, LRP, uClinux on Dragonball, ARM, Axis Webcam, MTD, TiVo, JFFS, MontaVista

Timeline entries (2000–2005): handhelds.org, Unobtainium, Sharp Zaurus, Motorola A 760, Nokia 770

Timeline axis: 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13
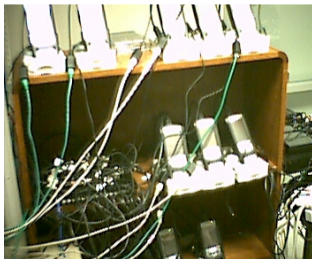
handhelds.org

2000
*handhelds.org was a focus for porting Linux to a variety of portable devices,
starting with the Compaq iPAQ H3600*

iPaq running X11

The build cluster

The unobtainium

2001
Project Mercury at Compaq put together a prototype mobile handset nicknamed the "Unobtainium"
*   iPaq 3600*
*   GSM/CDMA/802.11b/Bluetooth*
*   640x480 camera*
*   1 GiB of storage on an IBM Microdrive*

Zaurus

2001
Sharp create the Zaurus SL-5000D PDA running Linux 2.4.10 (provided by Lineo)

Motorola handsets

2003
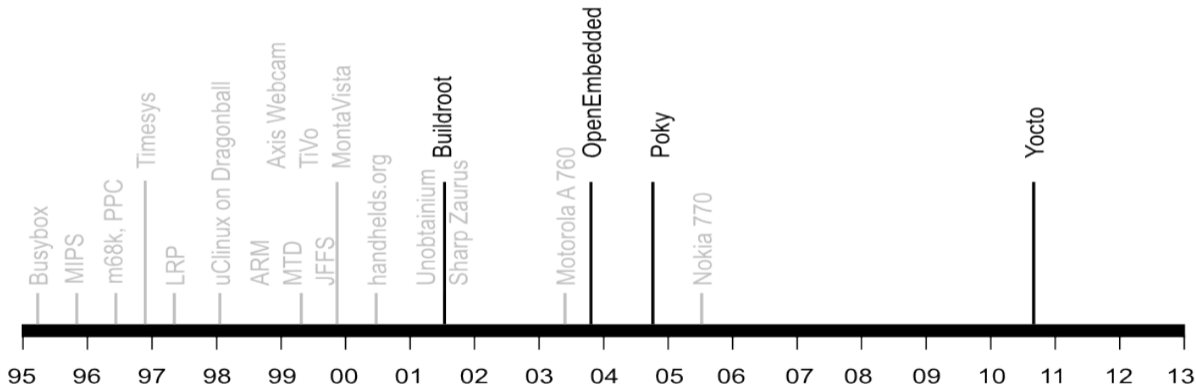*Motorola A 760 handset (MontaVista Linux)*

Nokia

2005
Nokia 770 Internet Tablet running Maemo Linux

Embedded Linux gets easier: 2001 onwards

- Move away from RYO (Roll Your Own) embedded Linux distributions

Timeline markers:

- Busybox — 95
- MIPS — 95
- m68k, PPC — 96
- Timesys — 97
- LRP — 97
- uClinux on Dragonball — 98
- ARM — 99
- MTD — 99
- Axis Webcam — 00
- TiVo — 00
- JFFS — 00
- MontaVista — 00
- handhelds.org — 01
- Unobtainium — 01
- Buildroot — 01/02
- Sharp Zaurus — 02
- Motorola A 760 — 03
- OpenEmbedded — 03/04
- Poky — 04/05
- Nokia 770 — 05
- Yocto — 10/11

95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13

Embedded Linux build tools

2001
Buildroot emerges from the uClinux/uClibc project

2003
OpenEmbedded Project is born, creating a common build system and code base for Familiar Linux, OpenZaurus and OpenSIMpad
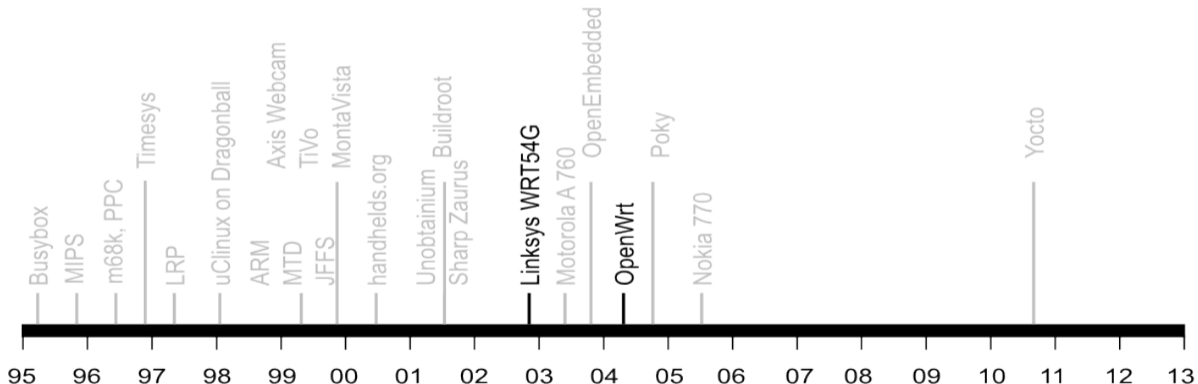
2004
OpenedHand employee Richard Purdie creates Poky Linux based on OpenEmbedded

2010
Intel spin off Poky Linux, acquired as part of OpenedHand, as the Yocto Project

Continuing the router story: 2002 onwards

- Linux becomes accepted in consumer WiFi routers

The WRG54G and OpenWrt

2002: December: Linksys release the WRT54G
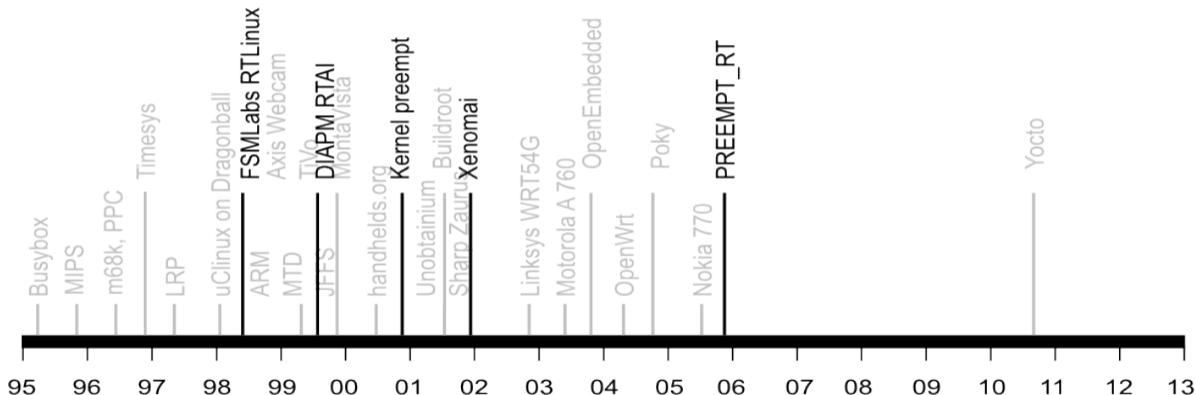*2003: July Linksys post GPL source components of the WRT54G firmware*
2004: OpenWRT project starts
2004 onwards: a large proportion of WiFi routers run Linux

Real-time: 1998 to present day

- Sometimes, real-world events require a deterministic response
- Early versions of Linux were not very good at real-time

Timeline markers:

Busybox, MIPS, m68k, PPC, Timesys, LRP, uClinux on Dragonball, FSMLabs RTLinux, ARM, Axis Webcam, MTD, TiVo, JFFS, DIAPM RTAI, MontaVista, handhelds.org, Kernel preempt, Unobtainium, Buildroot, Sharp Zaurus, Xenomai, Linksys WRT54G, Motorola A 760, OpenEmbedded, OpenWrt, Poky, PREEMPT_RT, Nokia 770, Yocto

95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13

Sub-kernels

1998: FSMLabs RTLinux
1999: DIAPM RTAI
2001: Xenomai
2002: DIAPM Adeos/RTAI

Patents
FSMLabs patented techniques used in both RTLinux and RTAI (associated with interrupt dispatching)
Adeos "nano kernel" implemented a different method, resolving the patent issue (probably)

Native real-time

2000: Timesys launch Linux/RT 1.0

2000: voluntary preempt patch (Ingo Molnar and Andrew Morton)
2001: kernel preemption patch (Robert Love)
2003: Linux 2.6 includes voluntary preempt and kernel preemption patches
2005: PREEMPT_RT kernel patch (Ingo Molnar, Thomas Gleixner and others)
2013: PREEMPT_RT still not in mainline kernel

Where are we today?

Android has 1.5 million activations per day, installed base 900 million

250 million set top boxes and smart TVs per annum

200 million WiFi routers per annum

Embedded Linux is the default OS

- Any questions?