Embedded Linux
Then and Now at iRobot

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About Me

• Spent 20 years developing commercial and DoD embedded systems
• Spent 4 years working with a research group developing a retinal implant
• Spent the last 5 years playing with robots
• Rocket Scientist
• Brain Surgeon
• Roboticist
• Linux Enthusiast
  • Running Linux since 1995
Gratuitous Star Wars Reference
Agenda

Then
• DoD Robots
• x86 Processors (mostly)
• Open Embedded
  • With iRobot layer on top

And (almost) Now
• Consumer Robots
• ARM processors
• Yocto & buildroot
  • With iRobot customizations
Packbot

- 1999 - 2005
- x86 Pentium III
- Bluecat Linux
- Came up pretty easily
- Core problems:
  - RT characteristics
  - Terrible WiFi support
    - Hard to get AdHoc networking to work
One Linux to Rule them

• 2007 – 2010

• Multiple Hardware Platforms:
  • x86, ARM, PowerPC
  • Kernel was on a separate branch, not as well supported
  • Needed latest kernel
    – But older Wifi drivers needed older kernels

• Needed an embedded Linux Distribution

• "Common OS" project
  • IRobot Layer on top of Open Embedded
  • BSPs for various products
  • Common build system
  • Started with "OE Classic" migrated to Yocto/OE
Issues & Problems

• Compiler support was terrible
  • No scripts, no buildroot, had to buy cross compilers

• Backporting drivers is hard

• Various custom Linuxes for radios

• Boot time was minutes
  • Not good for military applications

• No good power management sleep/wake support
Ava

- 2011 - 2015
- Remote Presence Robot
- Off-the-shelf x86 COM Express module
  - running Ubuntu 12.04 (and then 14.04)
- ROS-like Robotics layer
- LIDAR used for mapping
  - Connected to CPU via Ethernet
- UART connection to mobility module
Then What?

• Defense and Remote Presence Groups were 100% Linux
• Home/Consumer Group was 100% NOT Linux
  • Minimal FLASH, RAM, processing power and cost!
Fast Forward to 2015

• Roomba 980 released
  • First product with vision based mapping
  • LPC3250 (ARM9 SoC) Processor from NXP
  • 2 MByte FLASH
  • 16 Mbyte SDRAM
  • WiFi Connected via separate module

• New product developments considering SoCs such as the SAMA5 product line from Atmel
  • Cortex A5 CPU
  • 16 MByte FLASH (more on that in a bit)
  • 128 MByte SDRAM
  • WiFi Connected directly
New board to /bin/sh in 8 days

• Received a board from the electrical engineer on a Thursday afternoon in March
• Celebrated a "I got the prompt" party the following Friday
• Customized Atmel's at91bootstrap bootloader to support our FLASH and SDRAM memory configuration
• Minor tweaks to U-Boot
• No modifications to Linux source tree
  • Except, of course for our custom device tree
  • And a few bugfixes/enhancements submitted upstream
• Second board came up in 2 days
  • But that one only had a FLASH change
  • WiFi took longer
Application Development Model

• Develop, debug and test the application on the Desktop
  • Using standard driver models (v4l2, USB, audio, network stack, etc...)  
  • Doesn't work so well for I2C, SPI, or GPIO devices

• Optional: Recompile natively on the target
  • Works if you have a native distribution such as Ubuntu running on the target

• Cross compile for the target
  • Linaro, Buildroot, and Yocto help a lot here!
  • Debug with gdbserver
  • Can use USB networking, or even PPP/SLIP!

• Fight to keep your boot console!
  • Don't let the hardware design take that from you
    — Perhaps adb can help here
Praise for (and a plea) to Chip Manufacturers

• SoC manufactures now maintain Linux kernels for their devices
  • And Yocto distributions as well

• Please work to get your kernel mainlined

• Please work to isolate your Yocto changes to a single meta package that can be dropped into the standard Yocto distribution
Going Forward

• More Cores
• More FLASH
• More SDRAM
• More Off-the-Shelf Software
  • Amazon Echo
  • Android Things
  • Stacks are provided, assume more resources
• GPL vs NDA
• Security, Security, Security
• STEM
Gratuitous iRobot Video

https://www.youtube.com/watch?v=oj3Vawn-kRE&t=7s
Questions?

Thank you

We’re hiring! (Software, Cloud, Mobile, IoT…)
http://www.irobot.com/careers

iRobot Ventures: early stage investing program