Embedded Linux
Then and Now at iRobot

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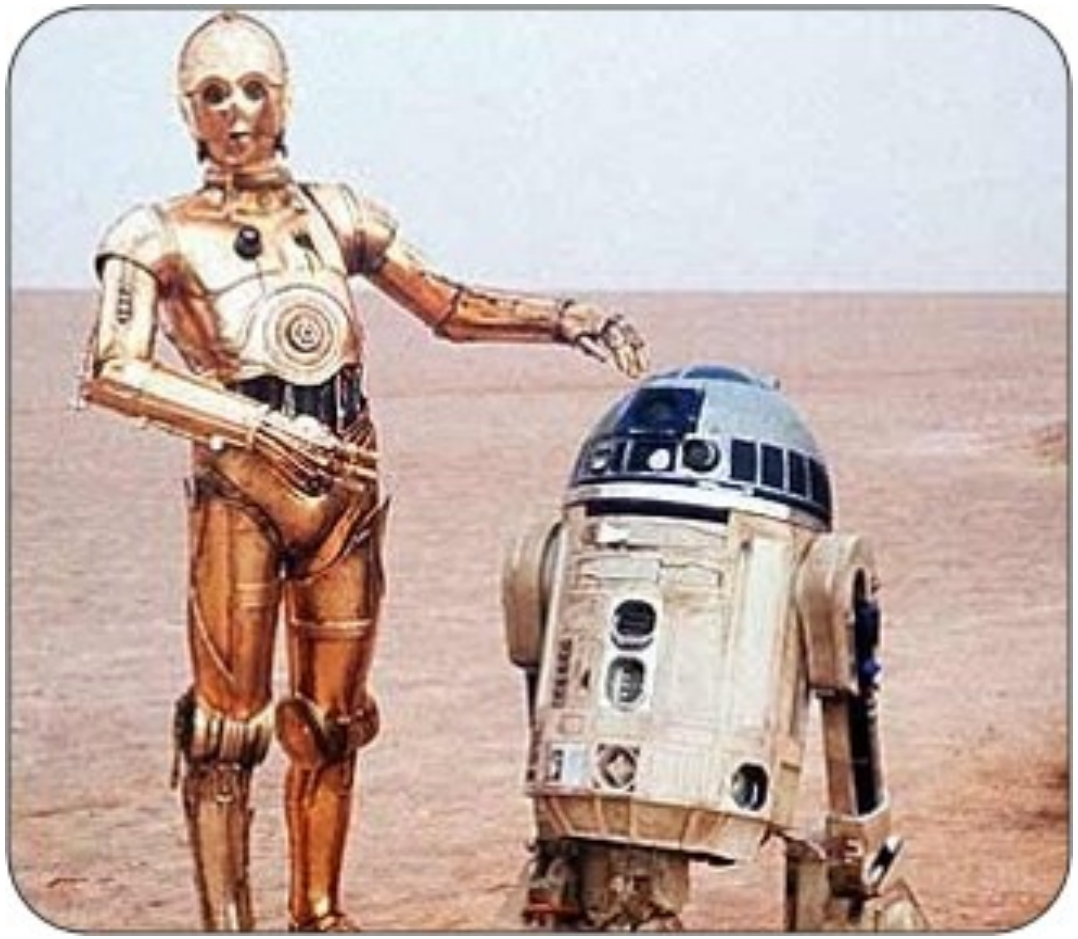
About Me

- Spent 25 years developing DoD and communications equipment
- 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

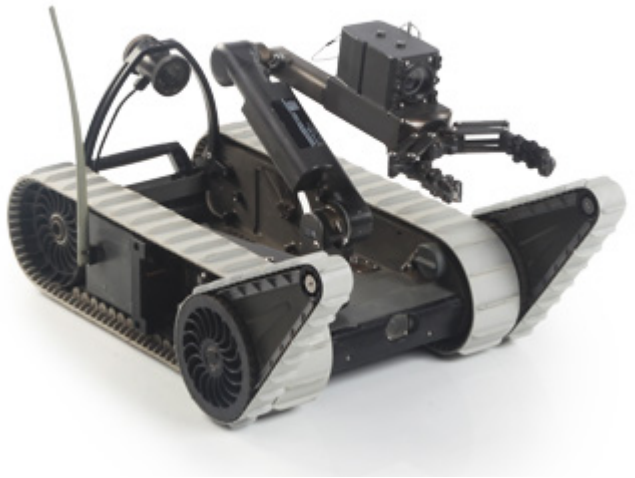
- Consumer Robots
- ARM processors
- Yocto & buildroot
  - With iRobot customizations

Packbot

- 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



Ava

- 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

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

Then What?

- Defense Group was 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 Processor from NXP
  - ARM9 SoC
  - 2 MByte FLASH
  - 16 Mbyte SDRAM
  - WiFi Connected via separate module
- New product developments considering SoCs such as the SAMA5 processor from Atmel
  - Cortex A5 SoC
  - 16 MByte FLASH (more on that in a bit)
  - 128 MByte SDRAM
  - WiFi Connected directly

New board /bin/sh in 8 days

- Received a board from the Electrical Designer on a Thursday afternoon in March
- Celebrated a "We 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
  - 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
  - Google Things
  - Stacks are provided, assume more resources
- GPL vs NDA
- Security, Security, Security
- STEM

Gratuitous iRobot Video

Thank you

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

iRobot Ventures: early stage investing program