

# Linux Kernel ProCamp

## Presentation

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GlobalLogic

# Linux Usages

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# Linux Usages: Non-Embedded

Non-embedded systems:

- Servers
- Desktops
- Supercomputers



# Linux Usages: Embedded

## Embedded Systems:

- Mobile
- Automotive
- Networking
- Smart TVs, game consoles, set-top boxes
- IoT
- Medical
- Aerospace
- Industry



# Android Rise

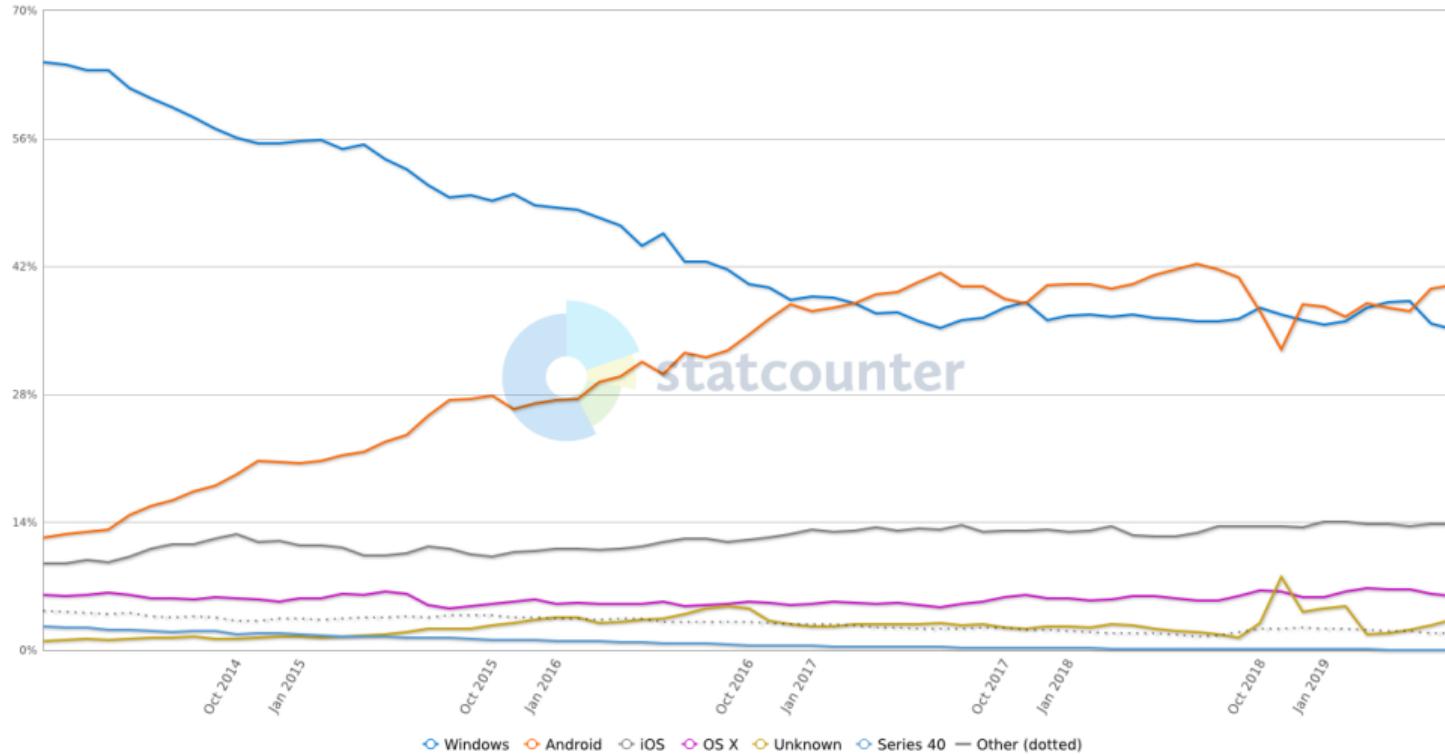


Figure 1: Operating System Market Share Worldwide

## Automotive Market Size

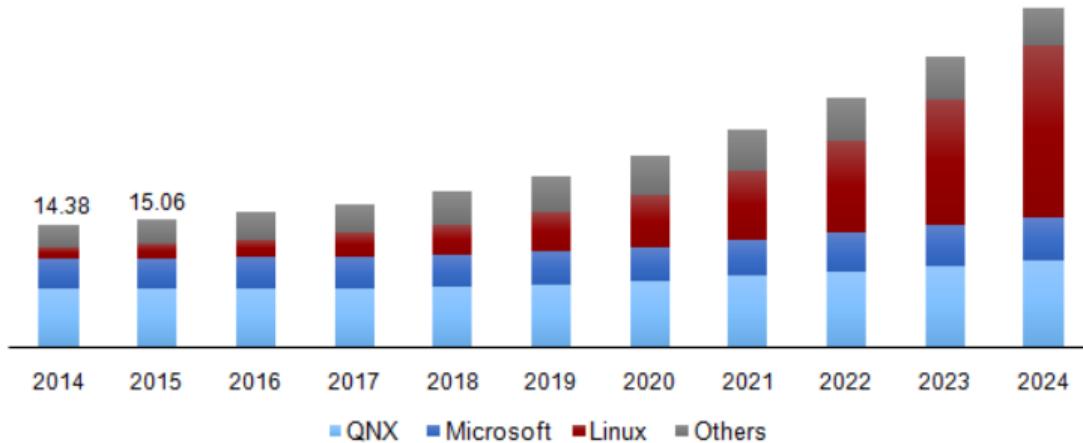
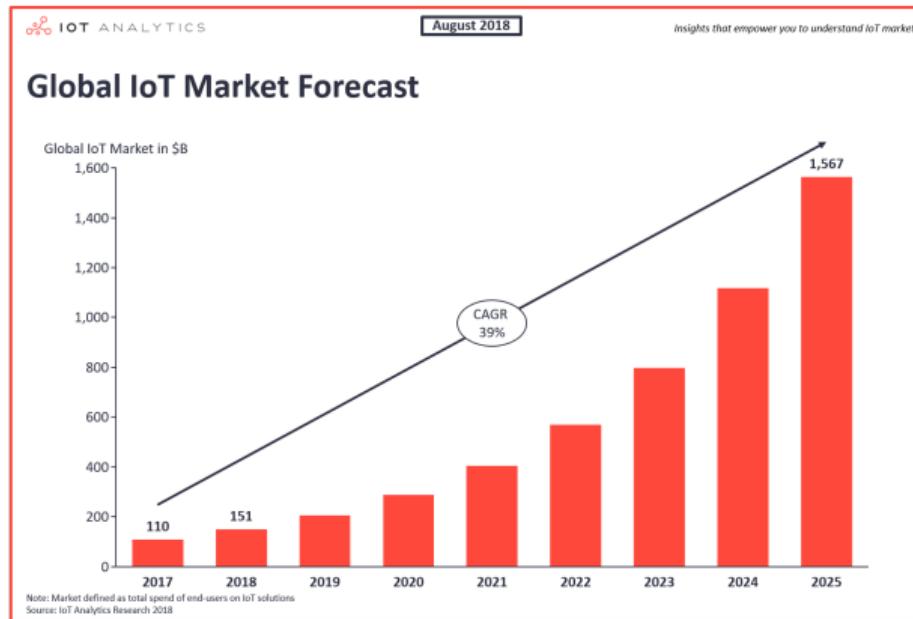


Figure 2: Global automotive infotainment market, by operating system;  
(2014 - 2024, USD Billion)

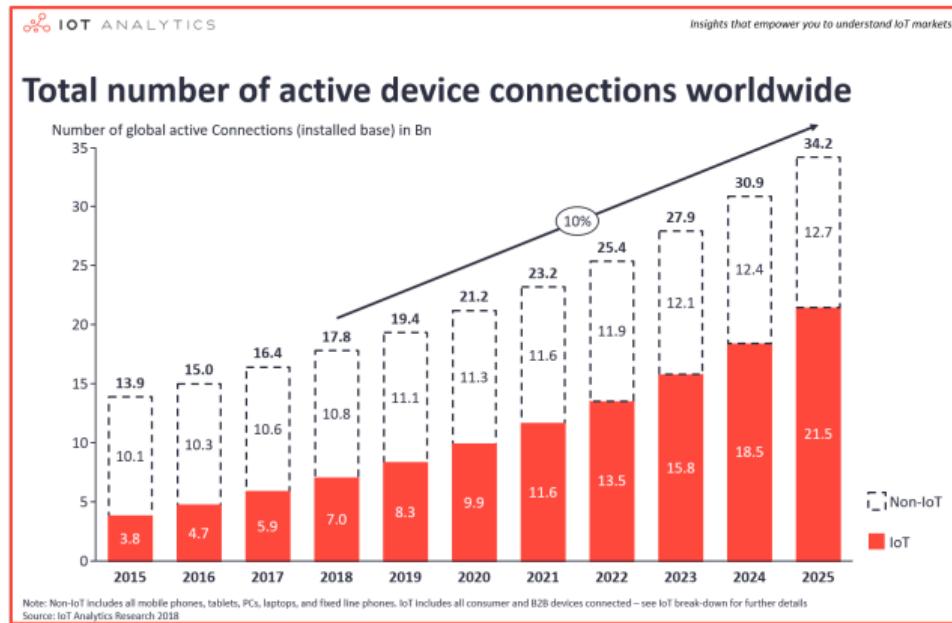
Source: <https://www.hexaresearch.com>

# IoT Market Size



Source: <https://iot-analytics.com>

# IoT Number of Devices



Source: <https://iot-analytics.com>

# How Linux kernel fits in?

## Good fit for embedded:

- Open-source (eases the collaboration)
- Supports a lot of architectures
- A lot of infrastructure exists (bootloaders, RootFS's, dev tools)
- Already widely used in Embedded world

# How Linux kernel fits in?

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## Recent developments:

- Reducing the kernel footprint (Nicolas Pitre)
- **PREEMPT\_RT** is being merged
- Xen
- OpenDataPlane vs DPDK
- RISC-V support
- Android kernel is mostly upstreamed now

# Embedded Linux Kernel Tasks

- Board bring-up (porting the kernel to a new board)
- Writing the drivers and device tree
- Migrating downstream kernel to a new version
- Bug fixing
- Boot time optimization
- Upstreaming
- Related work: bootloader, rootfs, hardware debugging

## My Experience

- Implementing the driver for automotive radio chip
- NOR flash support (XIP boot)
- Updating/upstreaming MAX732x driver
- Adopting upstream kernel VPN in Android kernel
- Fixing VPN protocols in kernel
- Implementing Android features (fastboot, boot flow, etc)

## Overture: Course Embedded Part

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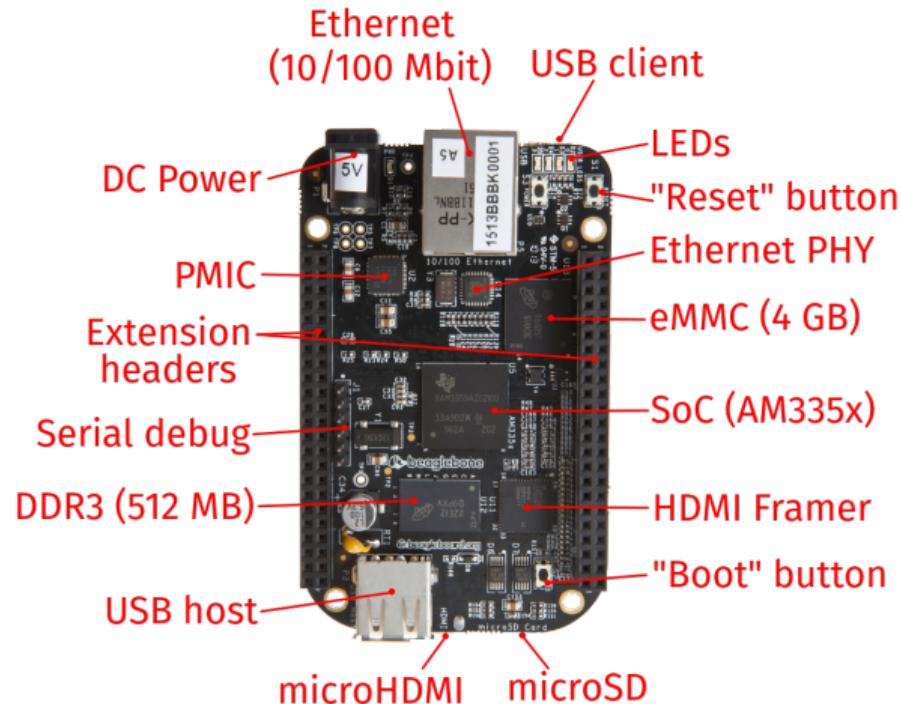
# Embedded Programming

Differences from regular system:

- Cross-compiling
- Flashing
- Serial console
- Testing concerns
- Working with hardware
- Non discoverable buses on board  
(device tree, platform drivers)



# BeagleBone Black



# AM335x SoC

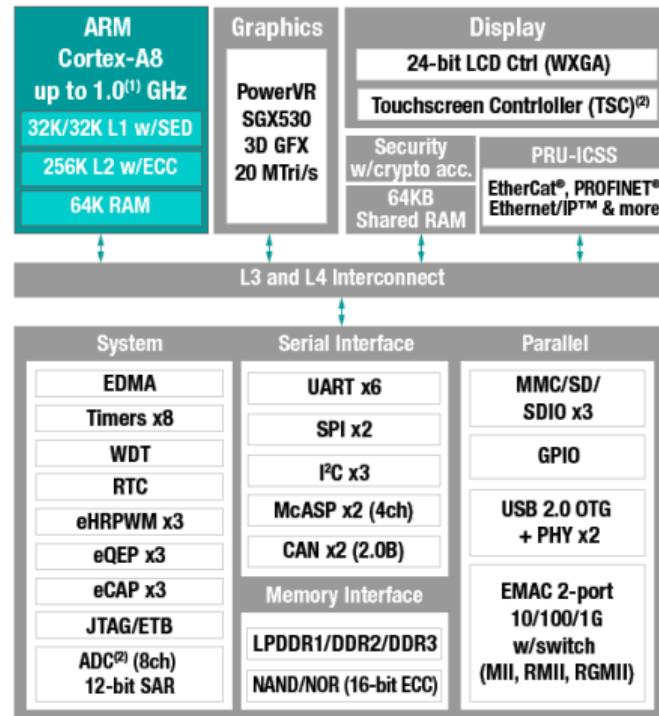


Figure 3: AM335x Functional Diagram

# BeagleBone Black: Pros and Cons

## Pros:

- Open Hardware
  - Public TRM
  - Schematic
  - PCB files
- Supported in upstream
  - Kernel
  - U-Boot
- Conventional ARM architecture
- Very popular
- Low cost (\$55)

## Cons:

- Old 32-bit architecture
- Single core processor
- Android is not supported officially
- No WiFi

# Embedded Topics

We will cover next Embedded topics during the course:

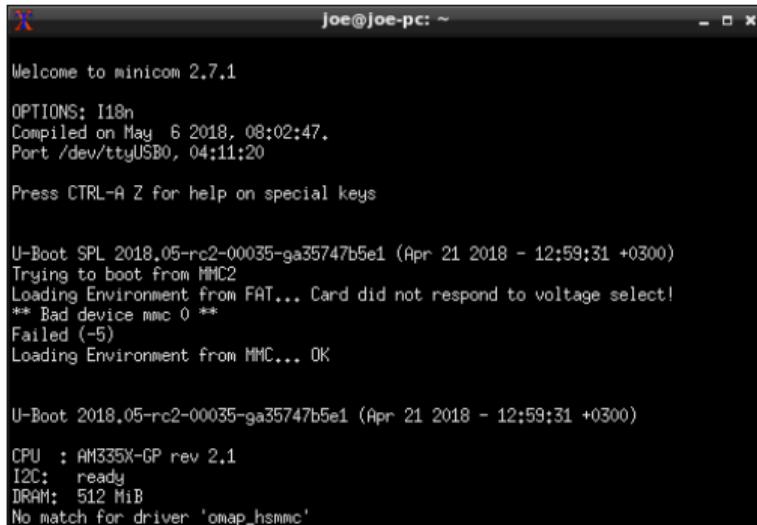
- Building, flashing and booting



# Embedded Topics

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- Bootloader and rootfs



joe@joe-pc: ~

```
Welcome to minicom 2.7.1

OPTIONS: I18n
Compiled on May 6 2018, 08:02:47.
Port /dev/ttyUSB0, 04:11:20

Press CTRL-A Z for help on special keys

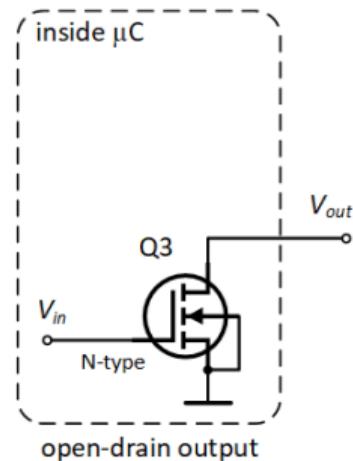
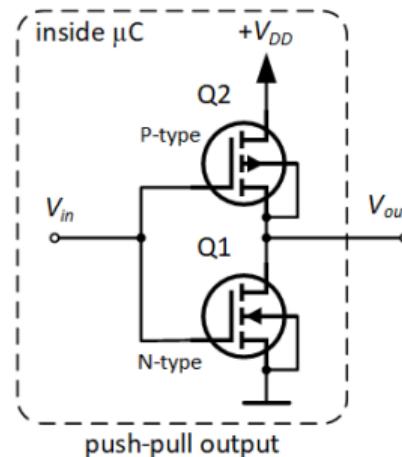
U-Boot SPL 2018.05-rc2-00035-ga35747b5e1 (Apr 21 2018 - 12:59:31 +0300)
Trying to boot from MMC2
Loading Environment from FAT... Card did not respond to voltage select!
** Bad device mmc 0 **
Failed (-5)
Loading Environment from MMC... OK

U-Boot 2018.05-rc2-00035-ga35747b5e1 (Apr 21 2018 - 12:59:31 +0300)
CPU : AM335X-GP rev 2.1
I2C: ready
DRAM: 512 MiB
No match for driver 'omap_hsmmc'
```

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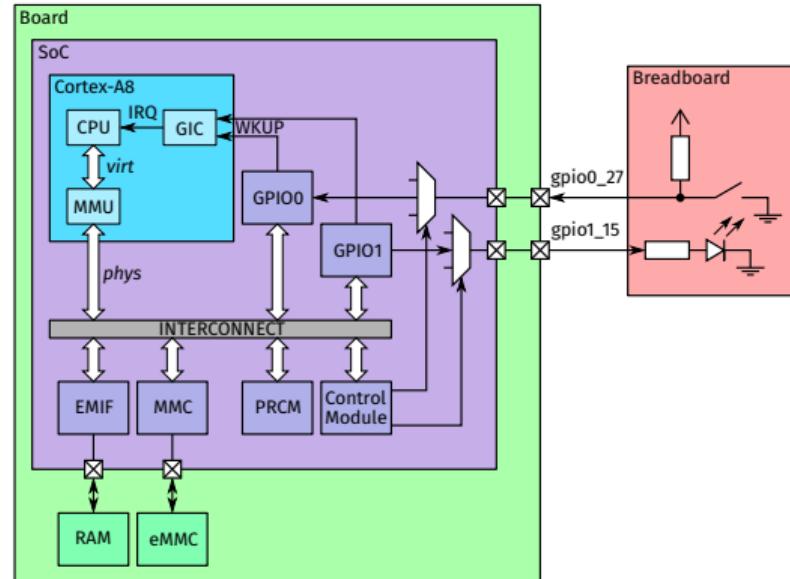
- Building, flashing and booting
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- Electronics basics



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We will cover next Embedded topics during the course:

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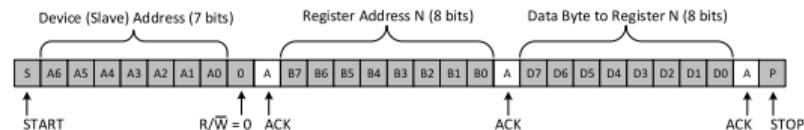


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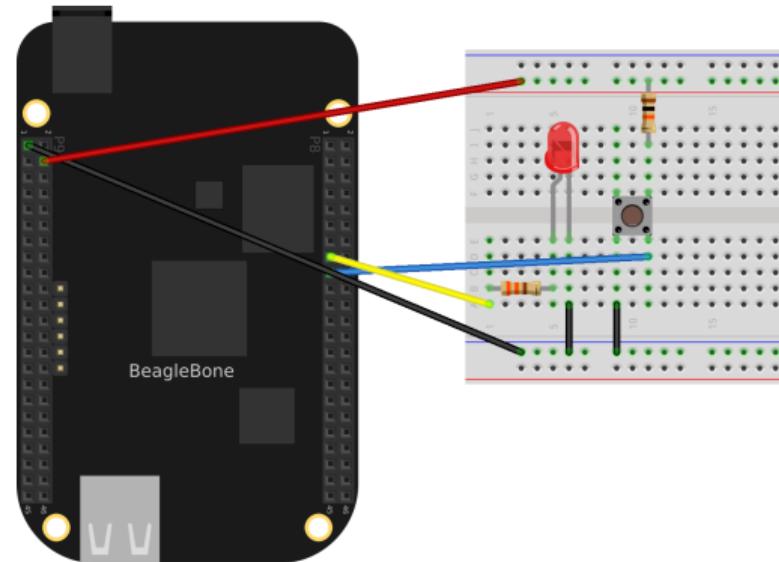
■ Master Controls SDA Line  
□ Slave Controls SDA Line



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- Writing the drivers

```
160 static const struct file_operations hw3_fops = {
161     .owner      = THIS_MODULE,
162     .read       = hw3_read,
163     .write      = hw3_write,
164     .poll       = hw3_poll,
165     .unlocked_ioctl = hw3_ioctl,
166     .llseek     = no_llseek,
167 };
168
169 static irqreturn_t hw3_btn_isr(int irq, void *data)
170 {
171     struct hw3 *hw3 = data;
172     unsigned long flags;
173
174     pr_err("### isr\n");
175
176     spin_lock_irqsave(&hw3->lock, flags);
177     hw3->data_ready = true;
178     hw3->btn_on = gpiod_get_value(hw3->btn_gpio);
179     if (hw3->btn_on && hw3->control) {
180         hw3->led_on ^= 0x1;
181         gpiod_set_value(hw3->led_gpio, hw3->led_on);
```

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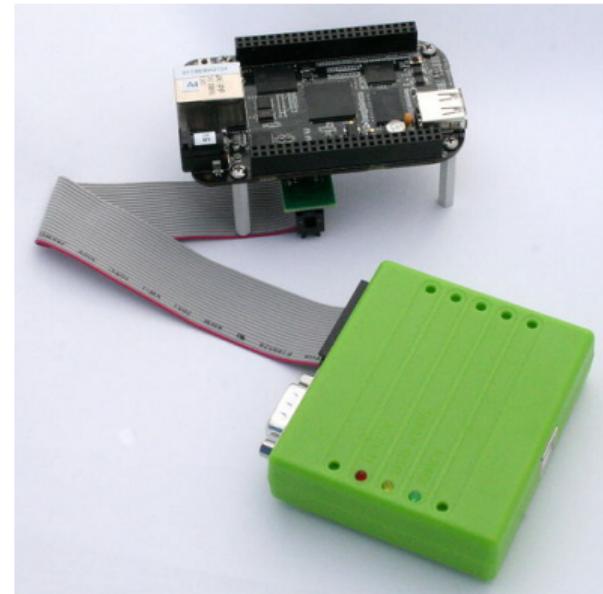
- Building, flashing and booting
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- Electronics basics
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- Writing the drivers
- Device Tree

```
249 &i2c2 {  
250     pinctrl-names = "default";  
251     pinctrl-0 = <&i2c2_pins>;  
252  
253     status = "okay";  
254     clock-frequency = <100000>;  
255  
256     cape_eeprom0: cape_eeprom0@54 {  
257         compatible = "atmel,24c256";  
258         reg = <0x54>;  
259         #address-cells = <1>;  
260         #size-cells = <1>;  
261         cape0_data: cape_data@0 {  
262             reg = <0 0x100>;  
263         };  
264     };  
265  
266     cape_eeprom1: cape_eeprom1@55 {  
267         compatible = "atmel,24c256";  
268         reg = <0x55>;  
269         #address-cells = <1>;  
270         #size-cells = <1>;  
271         cape1_data: cape_data@0 {  
272             reg = <0 0x100>;  
273         };  
274     };
```

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- Hardware debugging



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- Books: there are old ones and new ones; also LWN
  - ...but *practice makes perfect!*
- Working environment (IDE, toolchain, tools)
  - ...people matter even more; Linux is all about community

# UNIX/Linux History

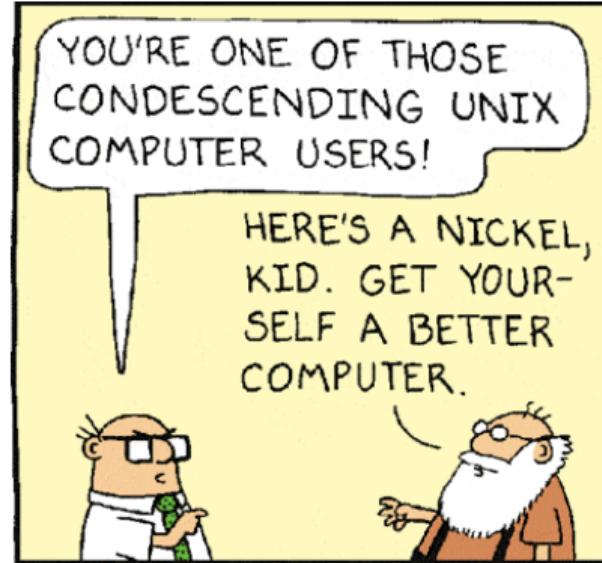
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# 2019: The Anniversaries

- 25 years: Linux kernel v1.0
- 30 years: WWW
- 50 years:
  - UNIX
  - Internet (ARPANET)
  - People walking on the moon
  - Linus Torvalds

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(Credits: Maddog presentation at FOSDEM 2019)

# UNIX

*“...When BTL withdrew from the project, they needed to rewrite an OS in order to play space war on another smaller machine (a DEC PDP-7 with 4K memory for user programs). The result was a system which a punning colleague called UNICS (UNiplexed Information and Computing Service) – an ‘emasculated Multics’; no one recalls whose idea the change to UNIX was.”*



## UNIX (cont'd)

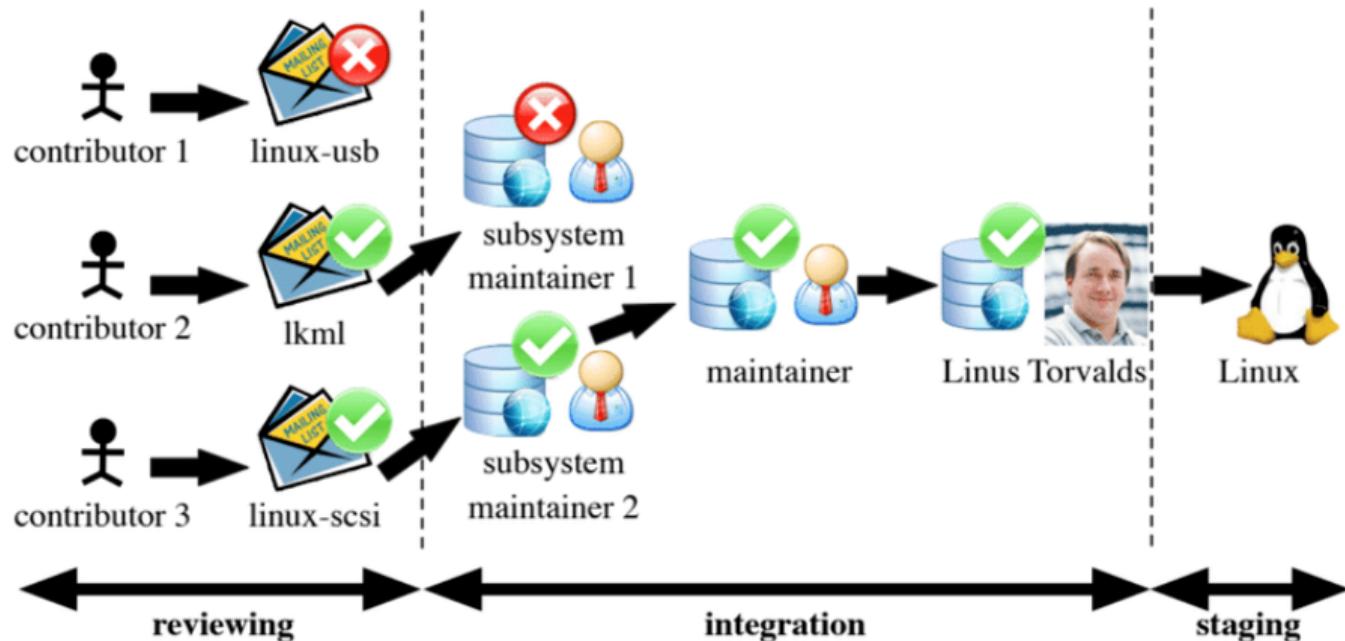
- 1969: UNIX development started (PDP-7)
- 1971: V1, written in assembler (PDP-11/20)
- 1973: **V4 was re-written in C**
- 1975: V6 was available outside of Bell Labs (basis for BSD)
- 1979: V7: K&R C, Bourne shell; ported to VAX (32-bit); kernel is only 40 KiB!

## GNU/Linux

- 1984: GNU is not UNIX
- 1991: LINUX v0.01
- 1994: LINUX v1.0
- 2005: **First Git release**

*"Hello everybody out there using minix - I'm doing a (free) operating system (just a hobby, won't be big and professional like gnu) for 386(486) AT clones. This has been brewing since april, and is starting to get ready."*

# Linux Development Process



## References

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## References

-  Eric S. Raymond.  
*The Cathedral and the Bazaar.*
-  Tracy Kidder.  
*The Soul of a New Machine.*
-  Steven Levy.  
*Hackers: Heroes of the Computer Revolution*, 25th Anniversary Edition.

Thank you!

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