



The Future is (Almost) Here

David A Rusling, CTO



“It’s just not very evenly distributed”



William Gibson, August 1993

What is this talk about?

- my career (sic)
- Linaro
- the future



Captain Hindsight by ianljort Zazzle

During this talk I highlight two agents of change - Open Source and the ARM partnership. I also talk about gateways, what they are and how we might build them

It's all about me

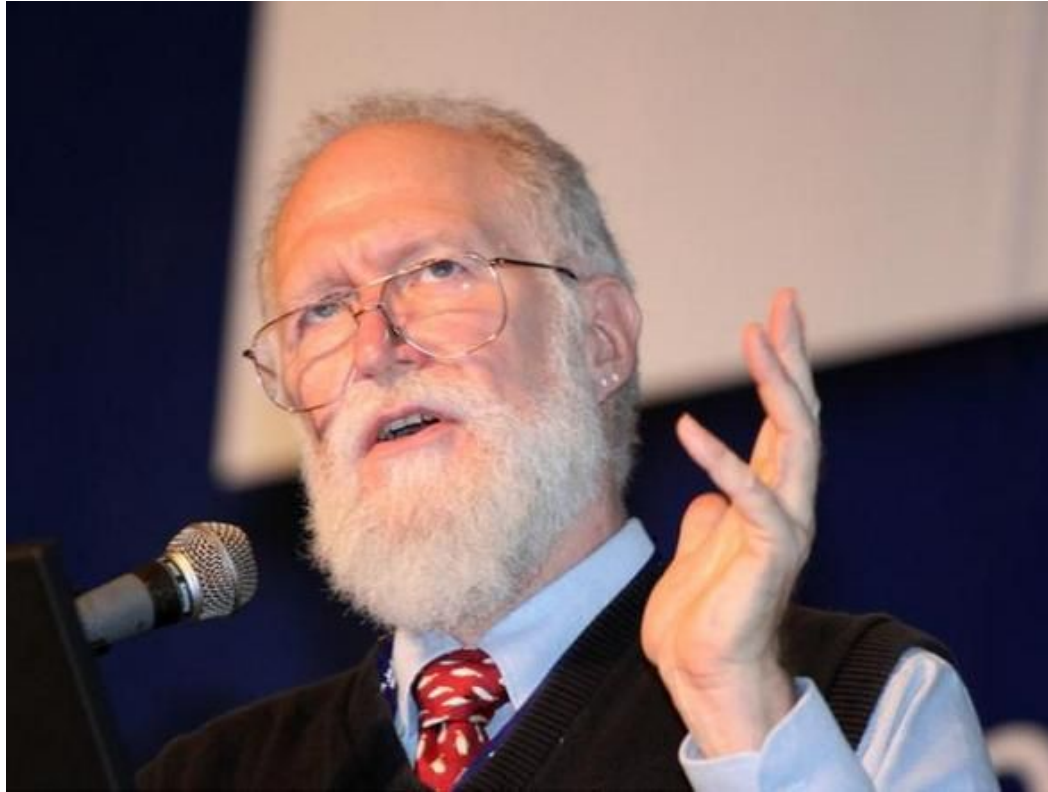


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ENGINEERS AND DEVICES
WORKING TOGETHER

It's all maddog's fault



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Short, well actually quite long, history

Always an **engineer**, **never** a physicist

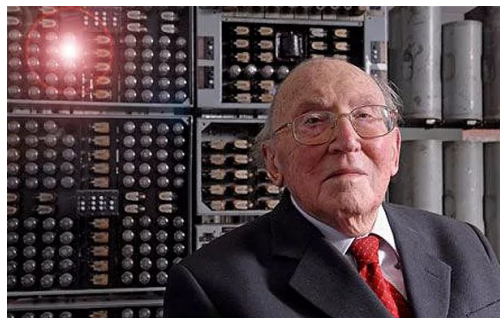
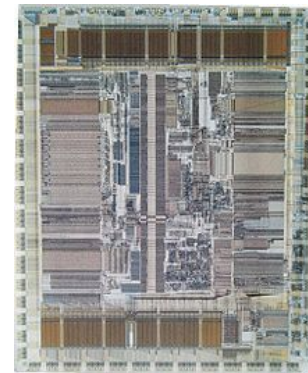
- Graduated in 1982,
BSc (Hons) Computer Science
- Worked at RAL on SNS as a student placement
for a year
 - Ported Adventure to the GEC 4070
 - More importantly, I worked out what an RTOS
actually is and does...

NOTE: The stuff that I worked on (8008 anyone?) is now in a museum



Linux and all that

- Met maddog early in 1995
- Started working on the port of Linux to the alpha
- Red Hat distribution 9 months later
- I gave a talk on the Alpha architecture in 1996, in this very room, and also at Cambridge Labs



“we can be heros”

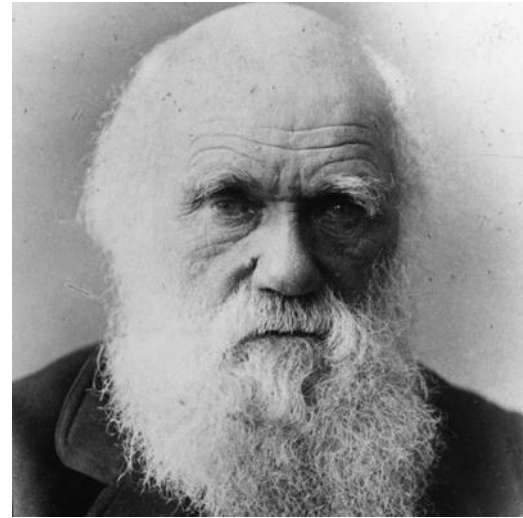
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ARM and Open Source

- An IP company is a reluctant bride of open source software
- Strangely, ARM started to use Linux from 1998 onwards
 - when I joined after part of Digital was acquired by Intel
 - we used it to validate cores - earliest was the ARM 920
- In the late OOs, Android rose to prominence and GPL 3.0 worried ARM
 - We decided to embrace GPL 2.0 and open source became key to ARM's strategy
- However, Intel was much better at open source than the ARM ecosystem which was horribly fragmented



NOTE: It turns out that the combination of ARM and Open Source is a **genius level move.**

The ARM Ecosystem

- ARM's core business model* is to create and license architecture
 - ARM's 64 bit architecture (aarch64) has been in development for a long time
 - RTL tools, software tools and models support that business
- ARM Ecosystem is made up of a lot of partners
 - Throughout all market segments - mobile, networking, automotive, embedded, home
- The ARM partnership is very, very competitive
 - this drives innovation, but also can lead to fragmentation
 - amongst other things, it is that fragmentation that Linaro seeks to avoid
- Learning fast
 - Very strong in mobile (phones, tablets)
 - Embedded, networking, automotive via Cortex-A, Cortex-R and Cortex-M
 - Enterprise has been a big learning curve for the ARM ecosystem; a lot has been achieved in a relatively short time

*ARM is a founding core member of Linaro

Linaro

ARM's embracing of open source led directly to the formation of Linaro

- May 2010, formation of Linaro
 - Legal framework designed by IBM (who know what they are doing)
 - Steered by the Technical Steering Committee*
- 2012 - first group (LEG) formed
- 2013 - LNG formed
- 2014 - LMG and LHG formed
- 2015 - 96Boards group formed
- 2016 - LITE formed, LEG HPC formed
- 2017 - quiet so far...



* with me in charge (and I have the best job in the world)

Office of the CTO (OCTO), What does it do?

- Coordinates strategy across all segment groups
 - Work directly with the segment groups
 - Technical detail is directly driven by the director, TL and committee
- Works directly with members
- Is small and contains bright young things that barely need direction (I call this 'nudging exocets')



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Linus Torvalds on ARM in Linux

2011

This whole ARM thing is a f*cking pain in the ass...
Somebody needs to get a grip in the ARM community...
Somebody in the ARM community really needs to step up and tell people to stop dicking around...

Source: LKML
<http://bit.ly/1NvpJdl>

2013

The ARM situation has just improved tremendously over the last several years. It used to be a major pain to me, it has gone to almost being entirely painless

Source: Softpedia
<http://bit.ly/1HdxvaV>

2015

What makes me happy is when some painful process issue gets resolved. For me, over the last year, it's been ARM who from a constant headache in every merge window has become an upstanding citizen in the Linux community

Source: YouTube
<http://bit.ly/1MfmZN6>



炬力
Actions

LEMAKER

Allwinner
Technology

WIND™

freescale™
semiconductor

IBM®

MontaVista

MEIZU

BROADCOM.

Google

THE
LINUX
FOUNDATION

facebook

CISCO

CAVIUM

NOKIA

ENEAA

MARVELL®

AMD

ERICSSON

hp

COMCAST

TINO®

apm
applied
micro

ZTE

SPREADTRUM®

MEDIATEK
everyday genius

redhat.

socionext™
for better quality of experience

ARM®

QUALCOMM
INNOVATION
CENTER, INC.
QuIC

ST
life.augmented

HISILICON

TEXAS
INSTRUMENTS

acer

Linaro

FUJITSU

Open Source Project Contributions





Linaro Technical Landscape

Core Technologies - Cross Linaro

- Kernel
 - Linux Real-time has been +20 years in the making. It's time to finish the job
- Power Management
 - Energy awareness across SoC and system, it's not just about the CPU core
- Security
 - Let's make OP-TEE the preferred industry-wide TEE
- Virtualization
 - We're now at parity with x86, let's pull away
- Tools - GCC, Clang, Debugging, IDE
 - GCC will be here for a long time but LLVM is the future
- Automation and CI
 - Automation is the only way to scale development, validation and certification

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Linaro Technical Landscape

- Servers - LEG
 - Working upstream is mandatory
 - ARM servers now just “work”, but that’s not enough
 - ARM servers have to bring innovation and benefit
Examples: High core counts, lower power/workload
 - Opportunity in both existing (datacenter) and in new markets
Examples: HPC, machine learning, innovative storage
- Accelerator standards - e.g. CCIX, Gen-Z
- Enterprise is an enabler for IoT, Smart Devices and Gateways
 - Linaro Core Engineering teams contribute



LEG
Server

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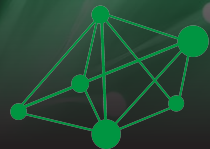
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Linaro Technical Landscape

- Networking - LNG
 - Dramatic IPsec RoI gains leveraging hardware accelerators (now)
 - Telecom Grade ODP and accelerated virtual Switching (SFO17)
 - Innovative networking virtualization technologies (2018)

 - vCPE opportunity - 5,000 VMs and 100Gbps on one server socket
 - CloudRAN opportunity - real-time guaranteed bandwidth above 50Gbps

 - Resistance to “platform distribution” vs embedded DIY
 - Increases costs of development, deployment and maintenance



LNG
Networking

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Linaro Technical Landscape

- Digital Home - LHG
 - Accelerated media on ARM should "just work" with any middleware
 - Build on FFMPEG, V4L2
 - Reference Secure Video Path with OP-TEE and 3rd party DRM
 - Reference set-top open source solution with RDK and OpenSDK
 - Best-in-class reference Android/AOSP TV experience
 - Leverage the work on unified accelerated media and secure video path
 - Focus on Premium Viewer Experience, not a cheap me-too clone
 - Target top-tier DRM-enabled official set-top platforms



LHG
Digital Home

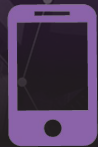
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Linaro Technical Landscape

- Mobile - LMG
 - Collaborate with the kernel community to extend Long Term Support (eLTS)
 - Continue backporting key SoC product features into LSK for Mobile
 - Continue reducing the gap between Android Common and mainline
 - Complete boot time optimization (20% speed up so far)
 - Investigate new opportunities with file systems, compression
 - Upstream all optimizations to AOSP
 - Improve CI Testing and Validation, improve base kernel quality, catch regressions faster



LMG
Mobile



Linaro Technical Landscape

- LITE - Embedded, Automotive, Gateway, IoT
- IoT client
 - Tens of RTOS, middleware and network options
 - Hundreds of Cortex-M MCUs and boards
 - Secure OTA update and secure sensor data connection to the cloud
 - Drive consolidation with a complete secure open source solution
 - Meet time-to-market schedule with a new code base in full development
- IoT Gateway
 - Different protocol and vendor lock-in gateways from each provider
 - Lead the development of a flexible unified open source gateway solution based on containers
 - Ally with the right Industry partners and consolidate across many ongoing gateway initiatives

96Boards

- Latest SoCs and MCUs being enabled on 96Boards
 - Other new boards are being previewed at the event

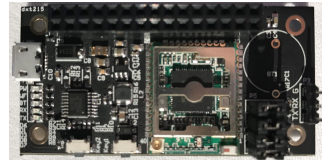
BlueSky IE with Zephyr

- RDA5981A
- Cortex-M4
- WiFi inc. PHY and MAC
- 64K ROM/8Mb NOR Flash
- 448KB SRAM/32KB cache
- Crypto security HW



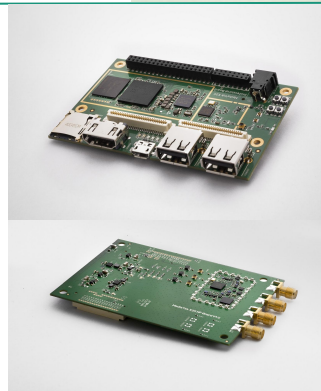
WRTnode IE with Zephyr

- Mediatek MT7697
- Cortex-M4, WiFi bgn and BT LE MCU
- 4Mb NOR Flash
- 353KB SRAM
- 64K ROM
- Crypto security HW



Archermind X20 Pro

- CE Spec
- Mediatek X20
- 10 core A72/A53
- Mali T880 GPU
- LTE radio module
- Available from AliExpress.com



ToCoding Neon 1.8V Mezzanine

- STM Cortex-M4 & LED controller
- Accelerometer/Gyro
- Magnetic/Pressure
- ALS/Proximity
- Microphone
- Temperature
- Humidity



Linaro Enterprise Group

- Moving into Enterprise / Data Center was a huge move for ARM, and Linaro
- Mobile has shaped the ARM ecosystem - it moves very quickly and, often, chaotically
- Working upstream has been a big challenge for the ARM ecosystem



Disruptive technology, engineering and business practices is flowing from mobile into all market segments

Why has the enterprise group been successful?

- Introduction of the ARMv8 architecture
 - Not as beautiful as the Alpha architecture, but lovingly and carefully designed
- The rise and rise of open source consortia driving open standards
 - [ACPI](#)
 - [PSCI ARMv8](#)
 - [SBSA / SBRR](#)
 - [UEFI](#)
- Open source cloud solutions
 - OpenStack

Open standards += open source

- Sound familiar? <https://home.cern/topics/birth-web>



And now enabling HPC

- The datacentre is evolving and HPC is becoming mainstream
- It's a natural progression for ARM to move into the world of supercomputing
- Easy journey? Doubt it but.....
 - Standardisation
 - Interoperability
 - Modularisation
 - Orchestration
 - Use case development... helps to lower barriers to deployment and management.
- We have CERN onboard!



ARM's Future is not Intel's Past

- Standards rule in the data center, the ARM ecosystem needs to embrace them
 - UEFI, ACPI ...
 - working upstream
- but the ARM ecosystem is different
 - It shaped the mobile market
 - It can innovate rapidly
 - What will it do to the data center? IoT? Networking?
 - How will these markets operate post-ARM?



Where's all this data coming from?

The Data Singularity

- Productivity tools no longer means 'Powerpoint', it means data sharing and social, for example salesforce.com
- Social is not just writing messages on walls, it is a means of sharing our interests and interactions
- IoT will generate vast quantities of data

Microsoft needs to try and reinvent the connective tissue of the enterprise
– *Microsoft CEO Satya Nadella*

We kill people based on metadata.
– *Gen. Michael Hayden, former head of the NSA and CIA*

Data analytics plus learning systems (AI) drive 'intelligent assistant' style interactions

IoT will Generate Vast Amounts of Data and Compute

- Data needs to be processed and protected
- Products are appearing
 - most are enhancements to existing mobile applications, tethered to your mobile
- Many 'walled gardens'
 - Little data traffic between them



Security

- Everybody wants our data
 - Mandated government back doors / keys
 - Cyberterrorism
 - Corporations
- Security not just about physical and electronic keys
 - Cloud gives more attack surfaces to exploit
 - Need to focus on detecting and responding to threats
 - User and entity behaviour analytics will allow adaptive behaviour



Glibc: Mega bug may hit thousands of devices
– *Dave Lee, BBC*

What does secure mean?

- Data kept where it should be
 - Virtualised and personalised
- Network traffic kept where it should be
 - Virtualised
 - Encrypted
- Security fixes
 - **Regular**, not every time you buy a car or fridge
 - Emerging standards and protocols



Welcome to mobile!

How to Hack Your Kettle

- Clone the network SSID
- Telnet to the iKettle with a default password of 000000
- List the iKettle's settings and it displays all known wifi passwords in plain text



Q: How many of you put your domestic appliances on a separate wifi?



How to Hack Your Child's Teddy Bear

- Web service (API) calls were not verifying the 'sender' of messages
- A would-be attacker to send bogus requests
- Attacker could find
 - Customer details
 - Child's name, age, gender



How To Hack Your Car

- Vulnerability in the mobile application
- Allows anyone to take control of your car using the last 5 digits of the VIN number
- Heated seats
- Air conditioning



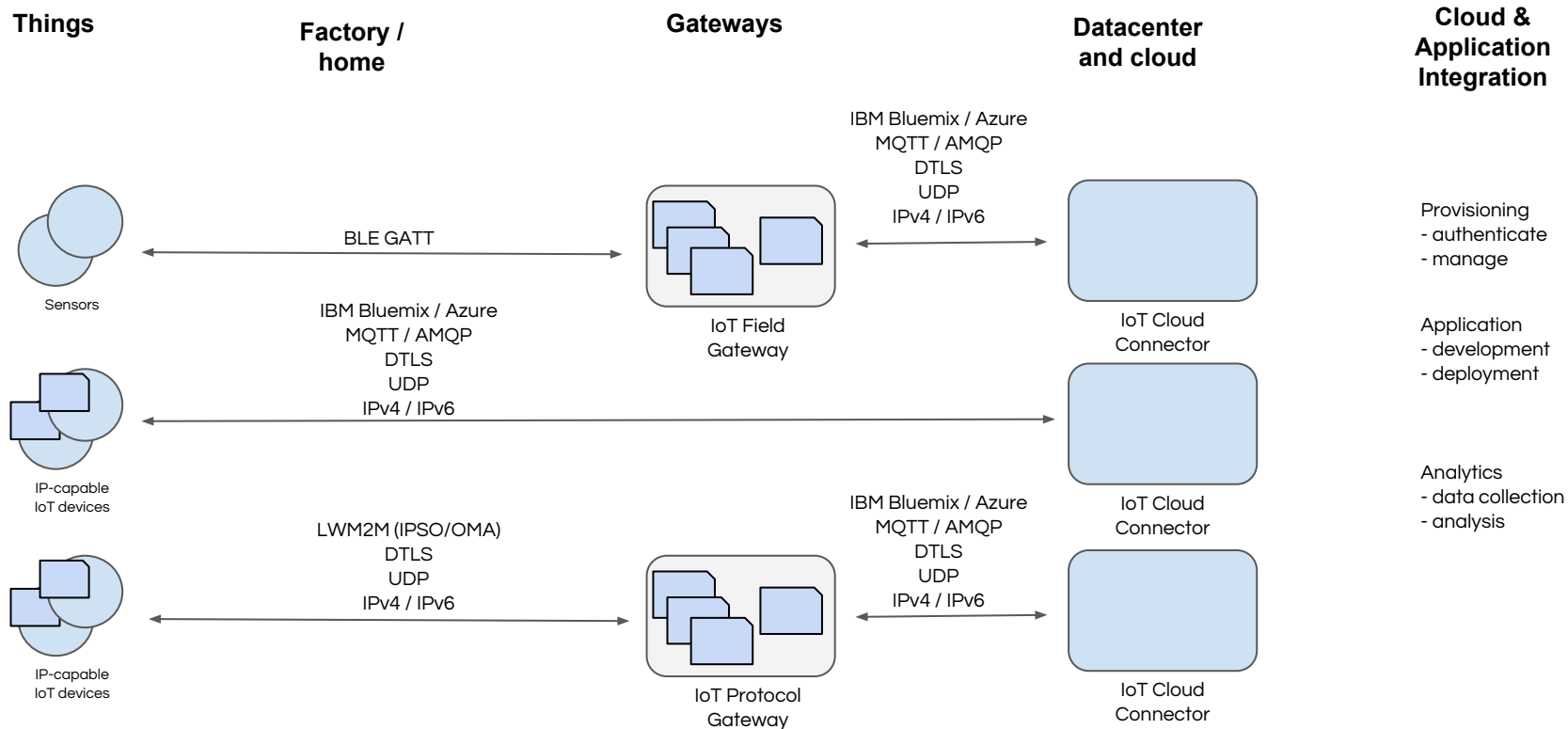
GET

[https://\[redacted\].com/orchestration_1111/gdc/BatteryStatusRecordsRequest.php?RegionCode=NE&lg=no-NO&DCMID=&VIN=SJNFAAZE0U60XXXXX&tz=Europe/Paris&TimeFrom=2014-09-27T09:15:21](https://[redacted].com/orchestration_1111/gdc/BatteryStatusRecordsRequest.php?RegionCode=NE&lg=no-NO&DCMID=&VIN=SJNFAAZE0U60XXXXX&tz=Europe/Paris&TimeFrom=2014-09-27T09:15:21)

IoT Terminology

- **Client / Device**
 - Hosts resources (objects) that represent a physical device, also known as **end points**
 - Devices are **IP capable** or **constrained**
 - Constrained devices are often referred to as **sensors**
- **Lightweight Machine 2 Machine (LwM2M Server) / Message Queue Telemetry Transport (MQTT) Broker**
 - Persistent **endpoint** through which devices and applications communicate with clients
 - Deployable in **gateways** and **clouds**
- **Bridge** - network infrastructure bridging networks
 - For example a bridge between Bluetooth and WiFi
 - May also be included functionality in a gateway
- **Gateway** - variety of devices that support connected devices
 - **protocol gateway** or **protocol adapter** - translates between object models and protocols
 - **field gateway** - supports constrained connected devices, such as sensors
- **Cloud connector**
 - Connection between devices and the cloud, also referred to as an **Hub** (Microsoft)

Gateway Examples



Gateway System Architecture

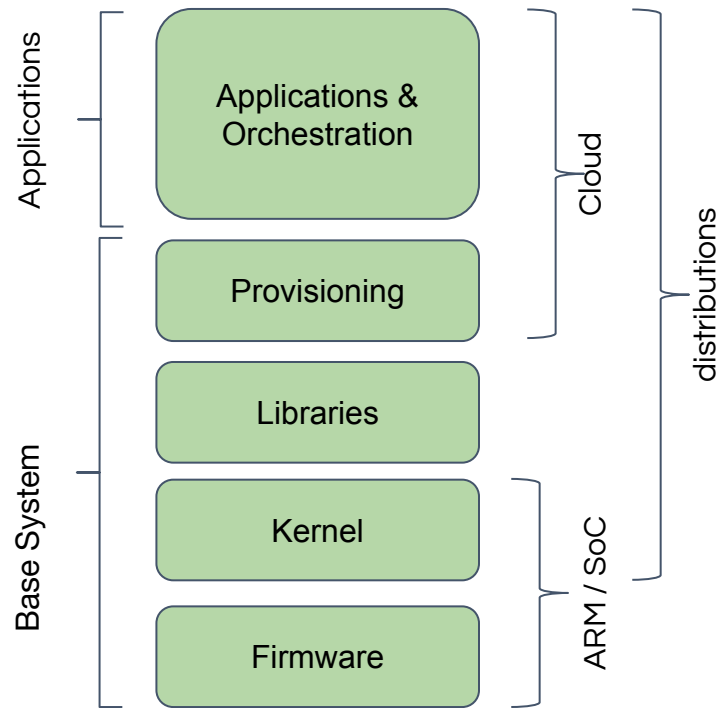
- Secure boot system capable of updating the kernel
 - Including rolling back kernel releases
 - It's called UEFI Secure Boot and we've been working on it for a while now
- Virtualization
 - 'bulletproof' separation of functions
 - static allocation of resources
- Minimal secure (signed) kernel
 - Signed modules versus no modules
 - The most secure kernel is the latest kernel
- Minimalist, transactional operating system
 - Applications isolated from each other
 - Several versions of applications (and kernel) can be installed / removed / rolled back
 - Suggest this is container based



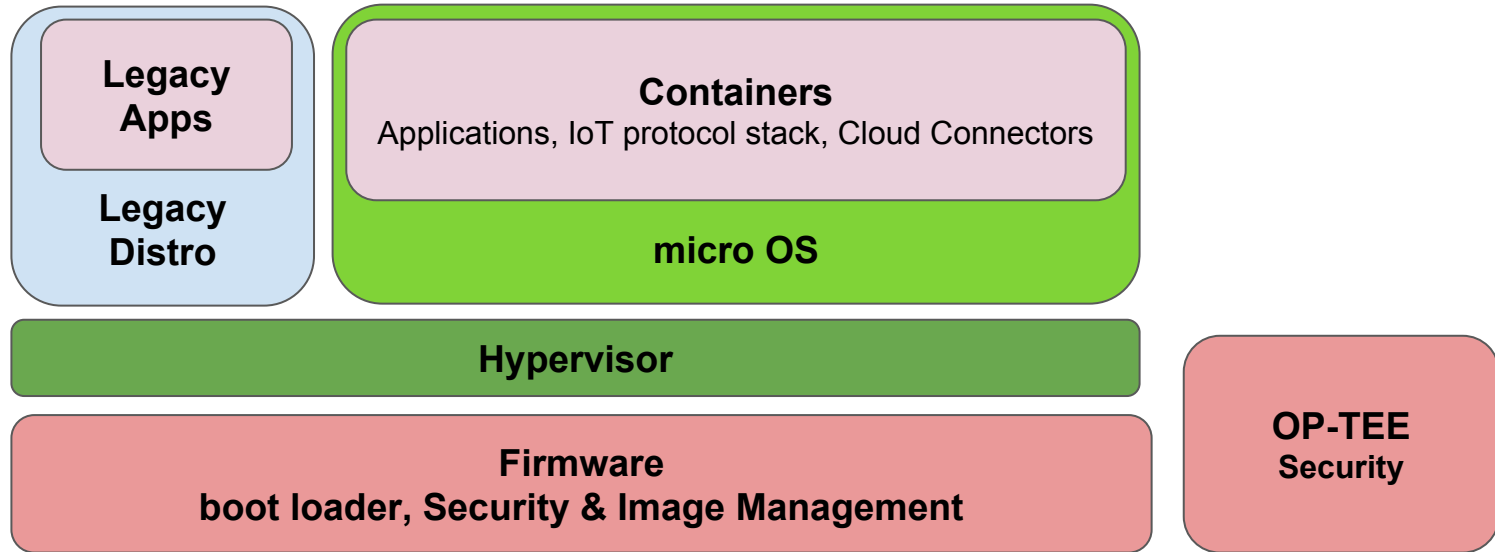
Greg Kroah-Hartman: You have to design your system so it can update itself.

21st Century Software Layers

- Applications & Orchestration
 - Installed locally or via an agent
 - Agents could be Ansible, Yast, Google Play ...
- Provisioning
 - Containers, for example etcd, systemd, dockerd
 - Package management, for example Debian
- Libraries
 - Run time libraries sufficient to run the provisioning layer
 - For example Debian docker-engine
 - Application libraries
- Kernel
- Firmware
 - Trusted boot agents, trusted execution environment etc

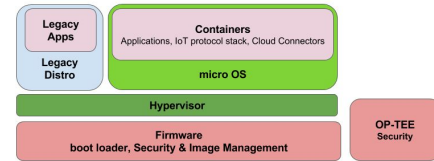


Gateway Simple Block Diagram



Implementation: Base System

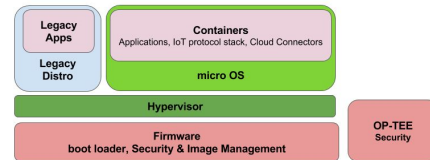
- Minimal, signed, kernel
 - Unified, binary kernel, runs on many platforms
 - Signed modules
- Base packaging technology
 - Used to provide key subsystems versus ‘built as a single base image’
 - Alpine commonly used in embedded systems suitable for IoT client and gateway
 - used by OpenWRT etc
 - minimal, stripped of documentation etc
- Key subsystems
 - systemd
 - etcd
 - container daemon (for example, docker, lxc)
 - update agent
 - would need ‘plumbing’ into remote device management (via IoT client / gateway support)



Implementation: Security

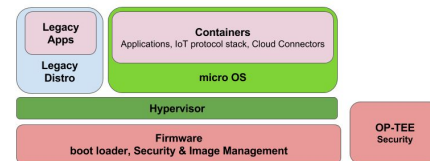
Depends on

- Secure boot loader supported by secure keys
 - UEFI etc
- VM
 - Isolate gateway / product subsystems
- Trusted Execution Environment
 - TrustZone
- Minimal attack surface transactional micro OS
 - Ubuntu Snaps, CoreOS, Atomic ...
- Minimal, isolated runtime components - containers
 - Signed
 - Minimal extraneous installed components
 - docker, rkt
- Secure communications
 - DTLS
 - Signed certificates



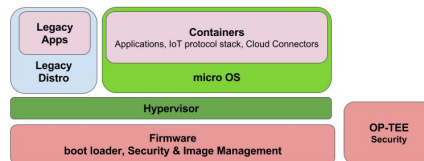
Boot Agents

- **Trusted boot agent can**
 - **verify** itself / boot options / installs
 - **install** new firmware base
 - **Remove** old firmware base
 - **Manage** security certificates
- The embedded world has not moved to UEFI etc
 - Networking, set top boxes etc
 - Moving (from U-Boot) to UEFI represents a significant cultural shift
 - Primary reasons for a shift
 - Security, including installing a trusted execution environment
 - This could be replicated with U-Boot
 - Support minimal transaction based operating systems
 - These use multiple boot partitions as part of their roll back mechanisms
- **Trusted protocol**
 - securely manages applications
 - for example, OpenTrust Protocol (OTrP)



Virtual Machines

- Lightweight virtual machine (VM)
 - Hypervisor envelope (KVM)
 - Machine Context (Qemu)
 - Jailhouse
- Hypervisor monitors behaviours of VMs
 - Static partitioning of system resources
 - cgroup-like mapping of functionality to behaviour
 - Devices
 - Memory
- Cost is low
 - Small memory footprint, 500μs
 - QEMU (Q-Boot) supports machine context (BIOS/UEFI, emulated devices, ACPI)
- Each VM runs a minimal base system (micro OS)
 - Capable of being updated
 - Supports containers



The Rise and Rise of Containers

Linux Containers enable you to run multiple isolated Linux systems on a single control host

Why have containers become popular?

- Containers build on reliable, established, Linux based technologies, for example systemd, namespaces, OverlayFS etc
- Container ecosystems, such as kubernetes and docker.com, have enabled easy application deployment
- Many choices...

Google: 'EVERYTHING at Google runs in a container'



Google: 'EVERYTHING at Google runs in a container'



Containers versus Contents

- A market for containers is evolving
 - Usually generated by the owners of that technology
 - For example, Debian containers, mysql etc
- Emerging standards
 - As the technology evolves so will naming, APIs etc
 - Right now there's a period of great experimentation
- Who supplies the containers?
 - Technologies are being increasingly bundled in containers (usually via open source projects and consortiums. For example
 - Debian, Alpine etc
 - Kolla - an open source project to package OpenStack clouds
 - Distributions
 - Seek to enhance their products and offer more services



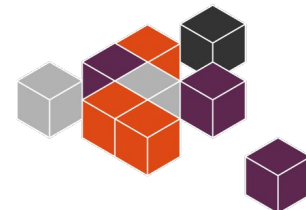
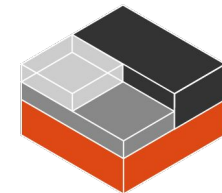
Container Implementations

Competing implementations

- CoreOS's Rocket (rkt) <https://coreos.com/blog/rocket/>
- Docker <https://www.docker.com/>
- Linux Containers (LXC) - <https://linuxcontainers.org/>
- Ubuntu Snaps - snapcraft.io
- Intel Clear Containers - <https://clearlinux.org>

Standards

- <https://www.opencontainers.org/>*
- App Container Specification @ <https://github.com/appc/spec/blob/master/SPEC.md#app-container-image>



* Linaro is a member

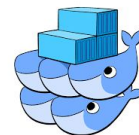


Container Deployment & Orchestration

- Orchestration tools
 - define containers and their inter-dependencies
 - manage the deployment (start up, shutdown, provisioning) of container based solutions
 - range from micro-services to planet-scale
- Examples are:
 - ansible - <https://www.ansible.com/>
 - swarm - <https://docs.docker.com/swarm/overview/>
 - fleet - <https://coreos.com/using-coreos/clustering/>
 - kubernetes - <http://kubernetes.io/>
 - mesos - <http://mesos.apache.org/>



ANSIBLE



kubernetes



Wait, aren't containers expensive?

- Cost of Docker on an ARM Debian system - ~9Mbytes
 - docker-engine
 - docker-py - enough to use ansible remotely
- Cost of installing a docker container image
 - Alpine based dnsmasq - ~10.7Mbytes (docker image claims 4.135Mbytes)
- Cost of running a docker container based image
 - Alpine based dnsmasq - ~8.8Mbytes
- Lightweight VM comparison point
 - Trimmed down 4.9 kernel ~2MB + standard debian libc ~8MB + app (a few MB)

debian/dnsmasq	259.4 MB
minideb/dnsmasq	48.5 MB
alpine/dnsmasq	6.5 MB

debian/python	508.3 MB
minideb/python	319.5 MB
alpine/python	126.9 MB

alpine/dnsmasq	4.1 MB
----------------	--------

alpine/go-hello	8.6 MB
alpine/go-gogs	35.0 MB

debian/emby-server	1.128 GB
minideb/emby-server	564.9 MB



How Does All This Come Together?

- It all comes together in the reference platforms, hardware and software
- Standard software is driven by standards
- Standards are driven by consortia
- Developing open source openly enables more players and creates better code
- Open source is now simply **the way that software is created and distributed**

It's the ARM ecosystem way




Told you it was all about me



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**Linaro is all about
collaborative software engineering
funded by members**



Base System: How Small is 'Small'?

- Debian based containers are quite large (although good for PoC)
 - Smaller alternative is minideb - stripped out debian
- Alpine is an apk based Linux distribution and is much smaller
 - apks used widely in embedded Linux, including OpenWRT
 - By far the smallest containers
 - Multiarch (armhf) tricky
- Development versus deployment
 - Build applications separately (build packages and install from them, for example)
 - Link statically (see `alpine/go-hello`)
- **Note:** using the same base images in all containers reduces overall memory footprint

<code>debian/dnsmasq</code>	259.4 MB
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Linaro

Hi Mum!



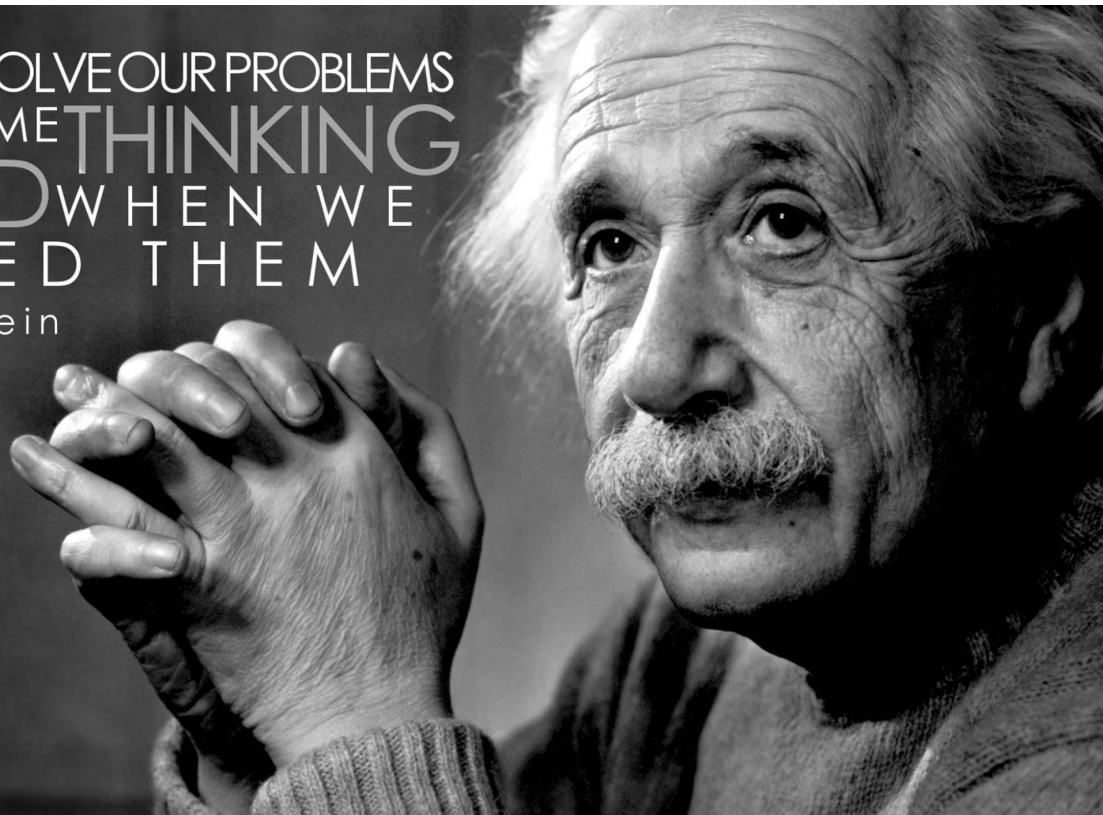
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Finally...

WE CANNOT SOLVE OUR PROBLEMS
WITH THE SAME THINKING
WE USED WHEN WE
CREATED THEM
-Albert Einstein



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Linaro Connect

Budapest 2017
#BUD17





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- IoT Gateway
 - Different protocol and vendor lock-in gateways from each provider
 - Lead the development of a flexible unified open source gateway solution based on containers
 - Ally with the right Industry partners and consolidate across many ongoing gateway initiatives

Linaro CTO, March 2017



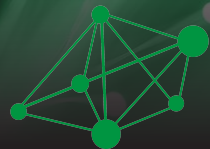
ENGINEERS AND DEVICES
WORKING TOGETHER

Linaro Technical Landscape

- Networking - LNG
 - Dramatic IPsec RoI gains leveraging hardware accelerators (now)
 - Telecom Grade ODP and accelerated virtual Switching (SFO17)
 - Innovative networking virtualization technologies (2018)

 - vCPE opportunity - 5,000 VMs and 100Gbps on one server socket
 - CloudRAN opportunity - real-time guaranteed bandwidth above 50Gbps

 - Resistance to “platform distribution” vs embedded DIY
 - Increases costs of development, deployment and maintenance



LNG
Networking

Linaro CTO, March 2017



ENGINEERS AND DEVICES
WORKING TOGETHER

Linaro Technical Landscape

- Servers - LEG
 - Working upstream is mandatory
 - ARM servers now just “work”, but that’s not enough
 - ARM servers have to bring innovation and benefit
Examples: High core counts, lower power/workload
 - Opportunity in both existing (datacenter) and in new markets
Examples: HPC, machine learning, innovative storage
- Accelerator standards - e.g. CCIX, Gen-Z
- Enterprise is an enabler for IoT, Smart Devices and Gateways
 - Linaro Core Engineering teams contribute



LEG
Server

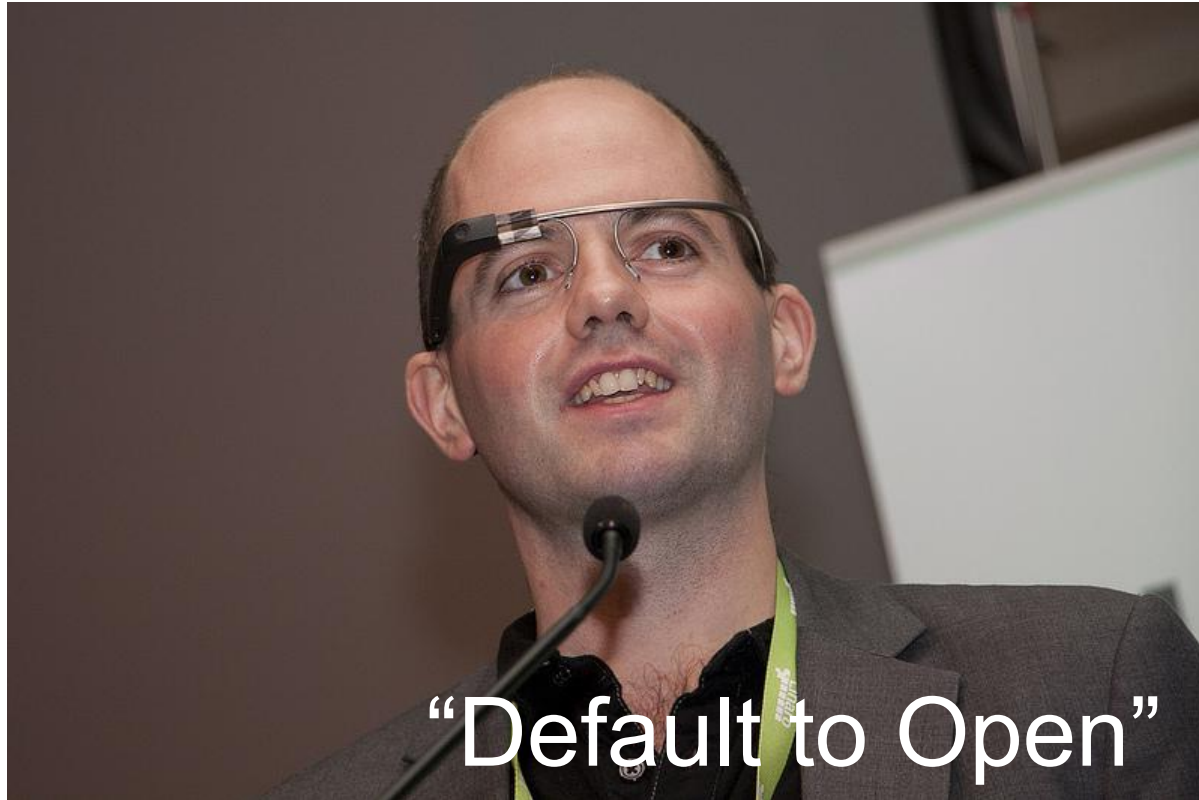
Linaro CTO, March 2017



ENGINEERS AND DEVICES
WORKING TOGETHER

Dispelling Myths

- Linaro is for ARM-only projects
- Linaro works collaboratively in upstream projects across the industry
- Examples of cross-architecture upstream work
 - Kernel
 - ODP.org
 - DPDK
 - UEFI/ACPI
 - Zephyr
- CI and testing on ARM and Intel platforms
 - kernelci.org



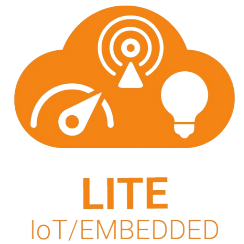
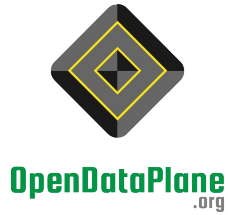
“Default to Open”

Firmware





Useful Logos



What is Linaro?

Collaboration amongst competitors

- Competitors take a risk coming together in Linaro to decide on common goals, code bases and technologies
- Linaro provides more than rooms in which to hold meetings....
 - Strategic coordination via closed open sessions with members
 - OCTO + Directors
 - Committees of domain experts driving each market segment with the TSC coordinating common core technologies and engineering teams
 - Lead Projects
 - Outside the firewall engineering
 - Allow member investment via assigned and member engineers
 - 6 monthly planning and engineering cycles underpinned by Linaro Connects
 - Lightweight engineering project coordination with transparency
 - Jira based requirements capture and delivery allowing operational coordination
 - **Mark O - the roadmap stuff, what do we call it?**





Linaro
connect

Budapest 2017

Thank You

For further information: www.linaro.org

