Embedded Linux Conference
Europe

OpenIoTSummit
Europe

The Industrial IO Subsystem after 10 Years!

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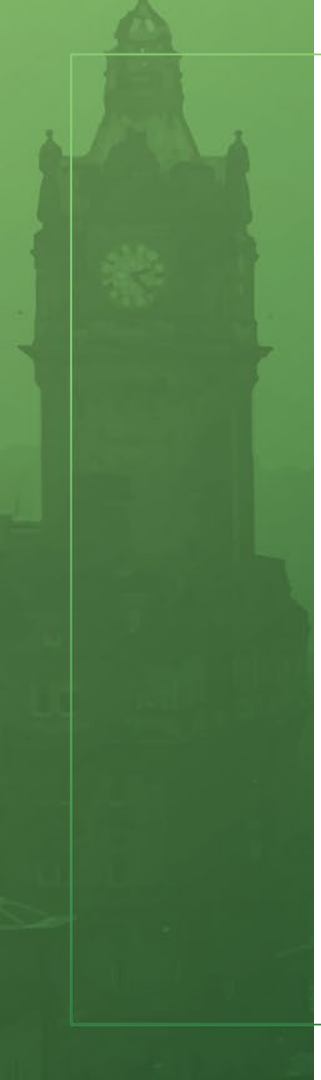
THE LINUX FOUNDATION

Outline

1. History – where we came from
2. Interface principles
3. IIO architecture
4. Some of our mistakes!
5. Community



First some history

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My personal itch…

- The SESAME project
  - Sensors on athletes
- Linux platform
  - Intel Research IMote2
- Sensor drivers
  - Accelerometers, ADCs
  - Upstream, but as what?

Designed by Vexels.com

Requirements…

- Simple interface option (hwmon?)
- Efficient streaming option (Input?)
- So what to do?
  - Ask the Linux Kernel Mailing List!
    - Back then people actually read it.
  - Answer – **You'll need to do something new.**

    https://lore.kernel.org/lkml/4832A211.4040206@gmail.com/

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- Issue 1: My requirements are not always your requirements.

So what is IIO?

Backwards definition: What is it not?

- Not a replacement for hwmon
- Not a replacement for Input
- These both do what they do well

IIO is broad

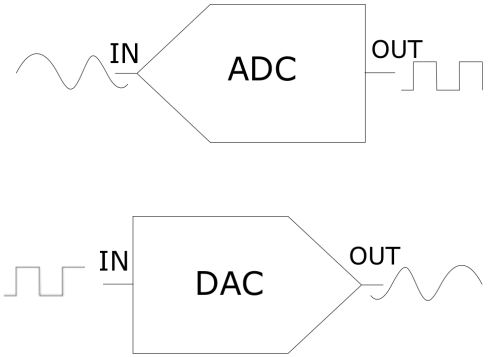
- Small focused subsystems?
- We tried that first!
  - /sys/class/als

“…I _do_ think that it's crazy to start doing new subsystems for every little thing. That way lies madness.”

- Linus

So what devices do we support?

- Anything that is at heart an:
  - Analog to Digital Convertors (IN)
  - Digital to Analog Convertors (OUT)
- ADCs, Accelerometers, Gyroscopes, Magnetometers, IMUs, Light, Chemical, Health, Rotation and many others.
- DACs, DPOTs



What is the interface?

- IIO's most important characteristic is it's user-space interface
- Allows generic user-space code
  - libiio, iio-sensor-proxy, android-iio-sensors-hal
- Must be consistent
  - Ideally should not 'need' to read the docs

Interface Principles

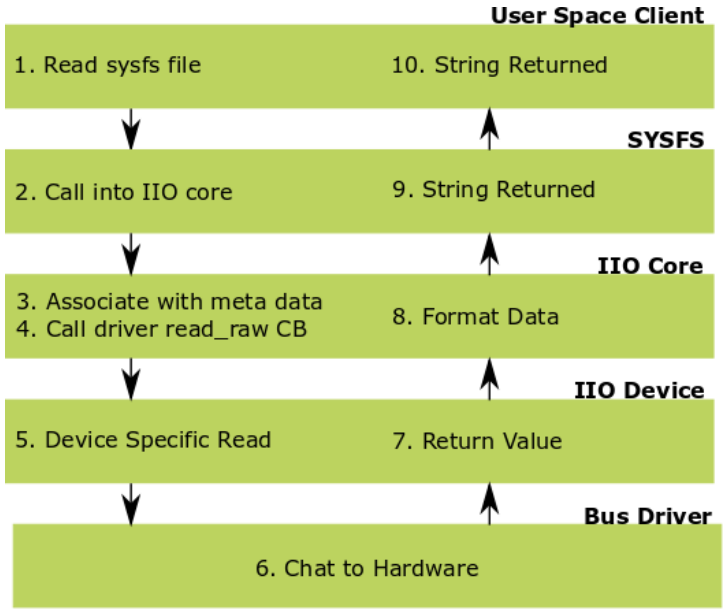
- All control and metadata via SYSFS
  - Human readable – no magic!
  - Consistent and predictable
- Single channel polled read via SYSFS
- Chrdev based FIFOs
- Chrdev based Events

The architecture

- Simple polled read, or…
- Trigger / Buffer (push) concept
  - ‘Concurrent’ samples from enabled channels
  - Buffers used to allow asynchronous reads

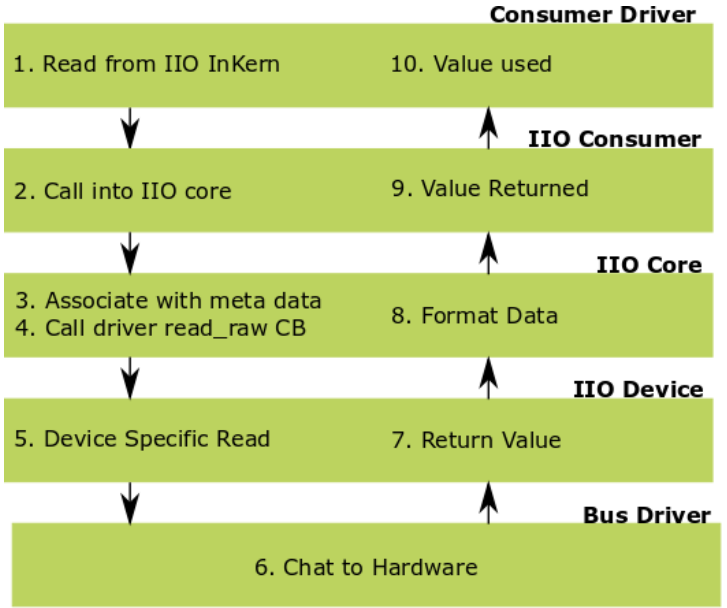
Synchronous Read / SYSFS

- Straight forward.
- Why is the core there?
  - Enforces ABI
  - Alternative interfaces!

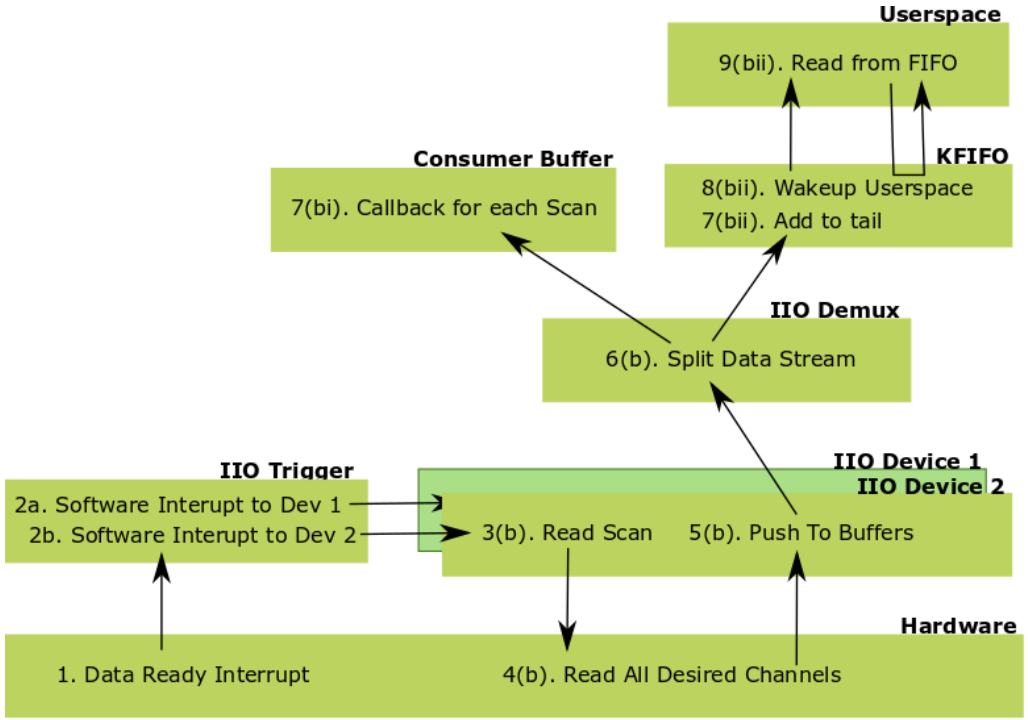


Synchronous Read / Consumer Driver

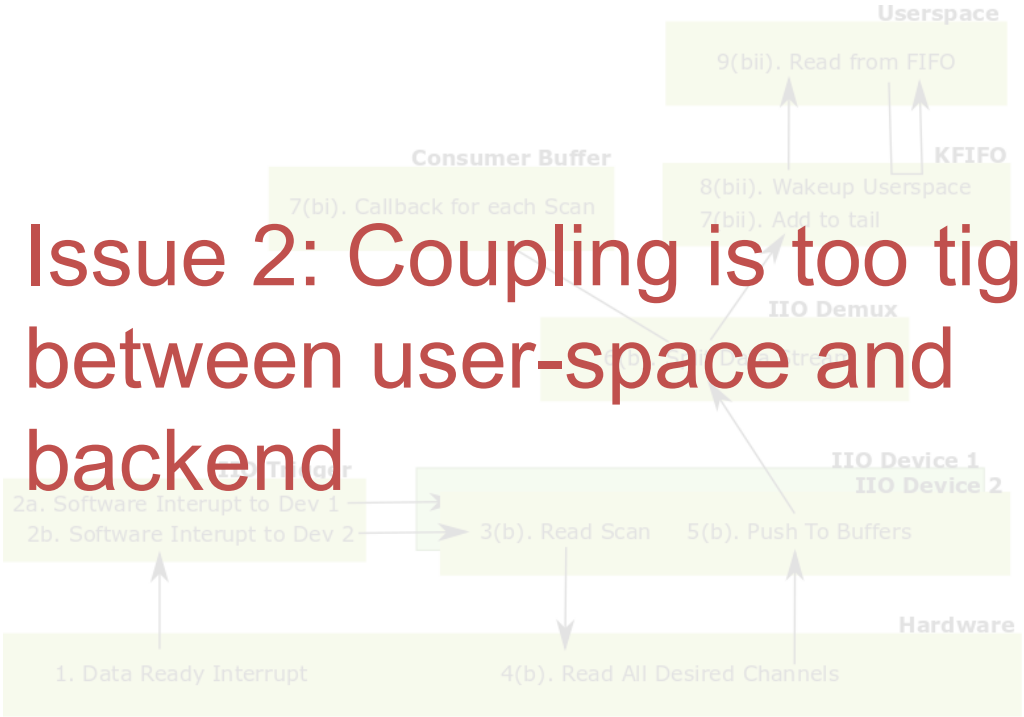
- Service provider.
- Use cases:
  - hwmon
  - Thermal
  - Battery
  - Other IIO devices



Push Data Flow



Push Data Flow



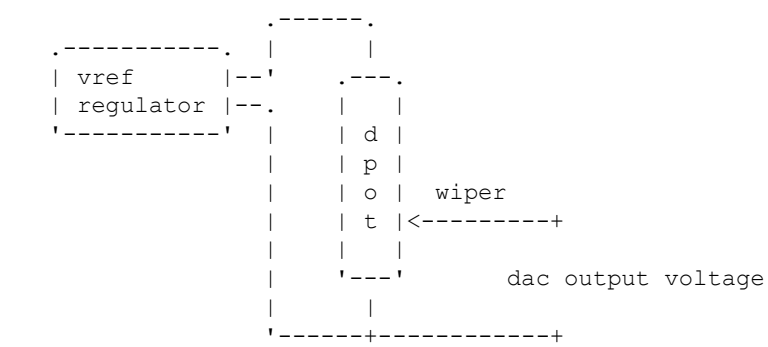
- Issue 2: Coupling is too tight between user-space and backend

Why so complex?

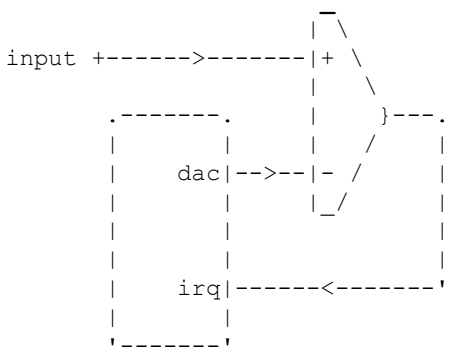
- Flexibility
  - Not all devices have to do it all
  - Multiple devices can do different parts
  - One device can feed multiple data users
  - IIO user-space is just another in kernel user

Lets us do cool things!

- Generic ADC touch screen driver
- Chained IIO devices



Peter Rosin: 7fde1484af21
("iio: dpot-dac: DAC driver based on a digital potentiometer")



Peter Rosin: b475f80b354a1
("iio: envelope-detector: ADC driver based on a DAC and a comparator")

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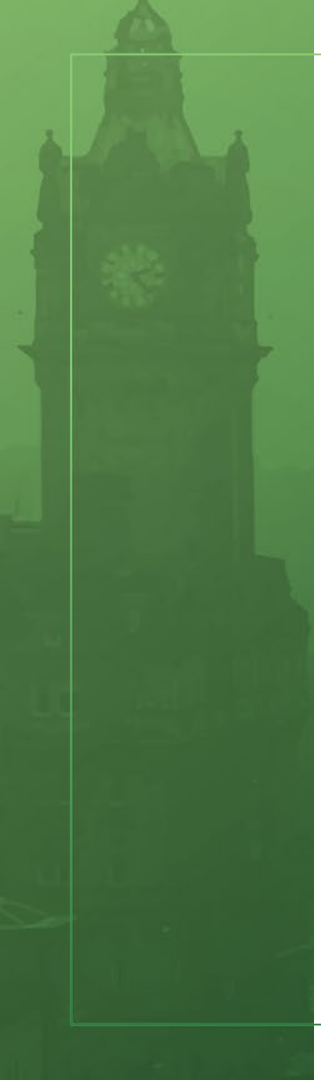


Issue 3: It is very difficult to predict the future

ABI ‘mistakes’

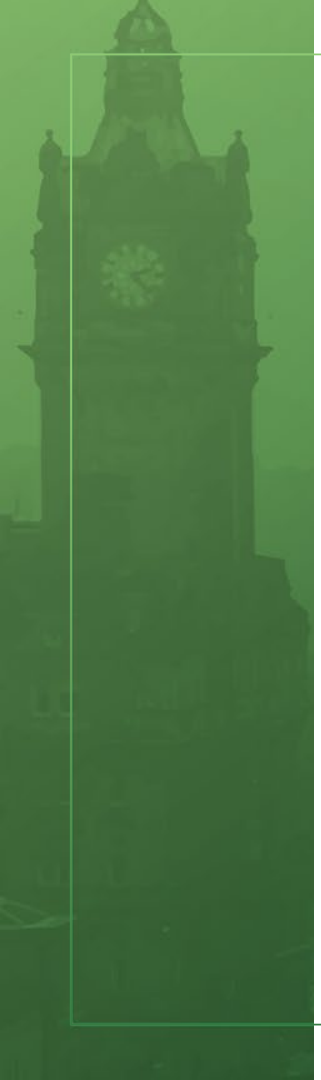
- Generalized simplicity over local simplicity.
  - in_accel_x_raw vs in_accel_x0_raw
- Compatibility with existing ABI nice, but don’t try too hard
  - Unit choices of hwmon weren’t good to copy

ABI ‘mistakes’

- Abstraction doesn’t always map well
- Counter drivers moving out of IIO to own subsystem.
  - Cleaner abstraction
  - Appropriate flexibility
  - Historic ABI has to be maintained.

Missing “indication of interest”

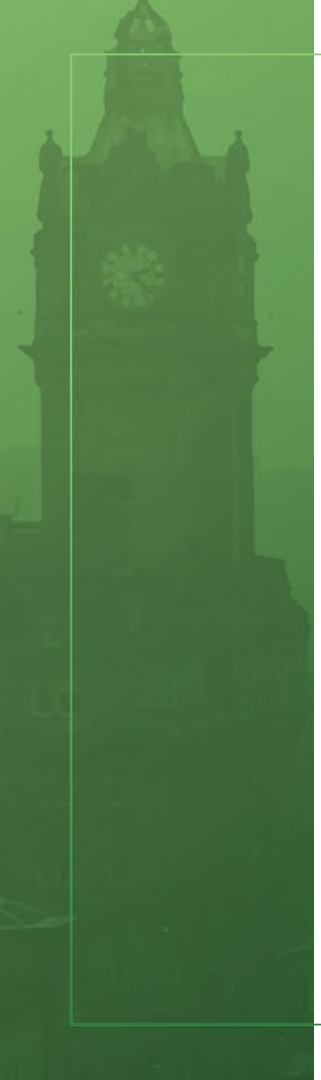
- Normal SYSFS flow provides no ‘I will read this shortly’.
- It is costly to stop triggered flow and read an ‘extra’ channel.
- No solution yet!



Issue 4:Where does high performance fit?

Issue 4: Mapping to High Speed

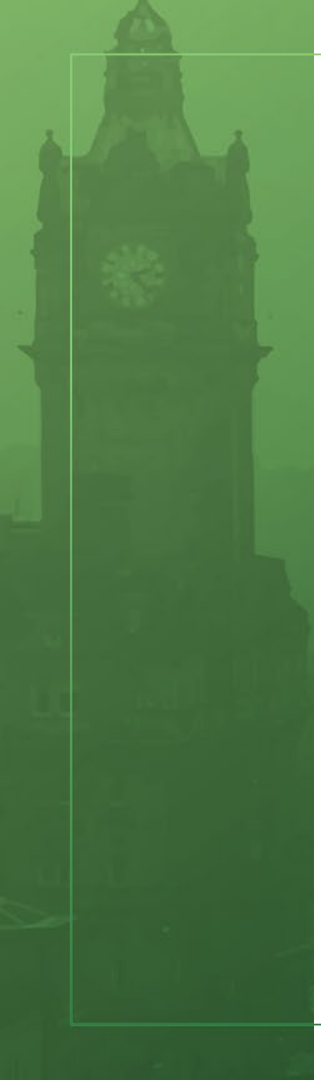
- High speed devices needs
  - DMA buffers (done for some time)
  - Handling of Complex multi sample triggering and state changes
  - Inline meta data, alignment tags etc
  - Often self describing flows
- These are not yet handled in mainline



Issue 5: Complex devices with proprietary user-space

When generalization breaks…

- Some sensors e.g. Pulse Oximeters need complex post processing to provide useful output.
- So far we have
  - Mapped to generic interfaces at boundary
- Is this always possible?

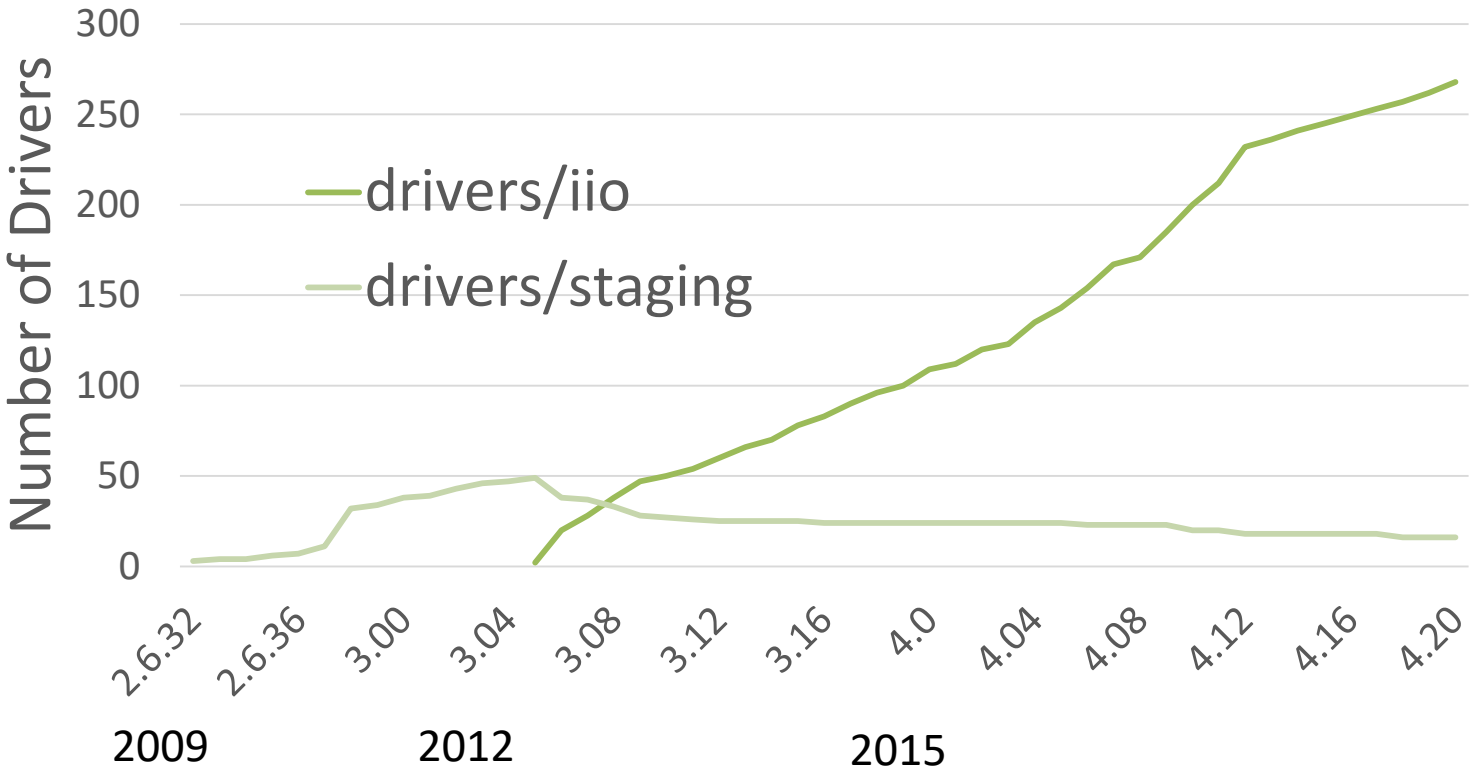


Building a Subsystem
Building a Community

Route to success!

- Posts to LKML
  - Some good feedback – slow progress
- Staging
  - Unusual route for a subsystem
  - It let us work out where we were going
  - Great feedback
- Making that jump
  - Need to reach ABI Stability

Growth of a subsystem



So who wrote all these drivers?

- Certainly not me!
- Companies (20+)
- Hobbyists
- Students
- Outreachy / GSOC students

Turn to gitdm

Developers with the most changesets

Jonathan Cameron	845	(15.8%)
Lars-Peter Clausen	641	(12.0%)
Peter Meerwald-Stadler	235	(4.4%)
Michael Hennerich	166	(3.1%)
Brian Masney	164	(3.1%)
Sachin Kamat	162	(3.0%)
Srinivas Pandruvada	97	(1.8%)
Lorenzo Bianconi	86	(1.6%)
Matt Ranostay	81	(1.5%)
Linus Walleij	80	(1.5%)
Hartmut Knaack	77	(1.4%)
Daniel Baluta	75	(1.4%)
Alison Schofield	62	(1.2%)
Irina Tirdea	53	(1.0%)
Fabrice Gasnier	49	(0.9%)
Dan Carpenter	48	(0.9%)
Arnd Bergmann	45	(0.8%)
Cristina Opriceana	39	(0.7%)
Eva Rachel Retuya	36	(0.7%)

Developers with the most changed lines

Jonathan Cameron	61209	(16.8%)
Lars-Peter Clausen	38921	(10.7%)
Barry Song	23246	(6.4%)
Michael Hennerich	21217	(5.8%)
Peter Meerwald-Stadler	10953	(3.0%)
Srinivas Pandruvada	8949	(2.5%)
Linus Walleij	8405	(2.3%)
Sonic Zhang	7859	(2.2%)
Daniel Baluta	7660	(2.1%)
Matt Ranostay	7037	(1.9%)
Lorenzo Bianconi	5768	(1.6%)
Denis Ciocca	4505	(1.2%)
Fabrice Gasnier	4401	(1.2%)
Brian Masney	4173	(1.1%)
Irina Tirdea	3939	(1.1%)
Gregor Boirie	3405	(0.9%)
Jon Brenner	3269	(0.9%)
Akinobu Mita	3081	(0.8%)
Tiberiu Breana	2971	(0.8%)

It’s all about the long tails!

Patches	Authors
P > 200	3
P > 100	6
P > 50	14
P > 25	27
P > 10	78
P > 5	143
P > 2	229
P ≤ 2	512

Lines	Authors
L > 10,000	5
L > 5,000	11
L > 2,500	23
L > 1,000	65
L > 500	112
L > 250	158
L > 100	205

Aspects of a good community

- Reviewers are the life blood of a kernel sub-system!
- Mentorship of new contributors
  - Including organised schemes and ad-hoc
- Willingness to engage and explain or be persuaded!

Why we get so many new contributors?

- Tangible things
- Cheap devices
- Can start simple
- History of new contributors
- (It’s certainly not our quality documentation!)

Outreach-Y / GSOC

- Great mentors
  - Daniel Băluță, Octavian Purdilă, Alison Schofield, Greg KH
- Great students!
  - (see reference list)

Getting involved

- Subscribe to linux-iio@vger.kernel.org
- Pick up one of the infrequent ‘todo’ items that get posted to the list.
- Pester me to send a todo if there isn’t one open.
- Grab a cheap bit of HW and see if it works.
- Develop a new driver. The various intern blogs are great to get you started.

- Whilst I naturally like keeping things on list, I don’t mind PMs to jic23@kernel.org

Reference list - talks

Industrial I/O and You: Nonsense Hacks
Matt Ranostay (ELC 2017)
https://elinux.org/images/b/ba/ELC_2017_-_Industrial_IO_and_You-_Nonsense_Hacks%21.pdf

LIBIIO – Access to sensor devices made easy
Lars-Peter Clausen (ELC 2016) https://www.youtube.com/watch?v=CS9NuRBzN5Y

IIO Industrial Input-Output
Linus Walleij (Lund Linux Conference 2016)

Android IIO sensors HAL
Daniel Baluta (Lund Linux Conference 2016)

Software Defined Radio using the Linux Industrial IO framework
Lars-Peter Clausen (FOSDEM 2015) https://archive.fosdem.org/2015/schedule/event/iiosdr/

Industrial I/O Subsystem: The Home of Linux Sensors
Daniel Baluta (LINUXCON Europe 2015)
https://events.static.linuxfound.org/sites/events/files/slides/lceu15_baluta.pdf

High-speed Data Acquisition using the Linux Industrial IO framework
Lars-Peter Clausen (ELCE 2014)
https://events.static.linuxfound.org/sites/events/files/slides/iio_high_speed.pdf

IIO, A New Subsystem For I/O Devices
Maxime Rippard (FOSDEM 2012) https://bootlin.com/blog/bootlin-fosdem-2012/

Reference list – This Week!

Drone SITL Bringup with the IIO Framework

Brandan Das (OSSE 2018!)

Introduction to IIO and Input Drivers

Matt Porter (OSSE 2018 E-ALE)

Outreachy Linux Kernel Internship Report

Various including Georgiana Chelu (OSSE 2018)

Reference list – Intern blogs

- Kristina Martšenko 2013 https://kristinamartsenko.wordpress.com
- Zubair Lutfullah 2013 http://beagleboard-gsoc13.blogspot.com/2013/
- Roberta Dobrescu 2014 https://iiobits.wordpress.com/
- Christina Moraru 2015 https://kernelsense.wordpress.com/
- Alison Schofield 2016 https://amsfield22.wordpress.com/
- Narcisa Vasile 2017 https://narcisaam.github.io/
- Georgiana Rodica Chelu 2018 https://giach.github.io/
- Himanshu Jha 2018 https://himanshujha199640.wordpress.com/

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