RTC subsystem, recent changes and where it is heading

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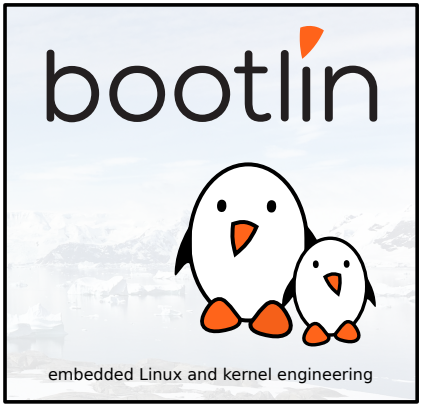


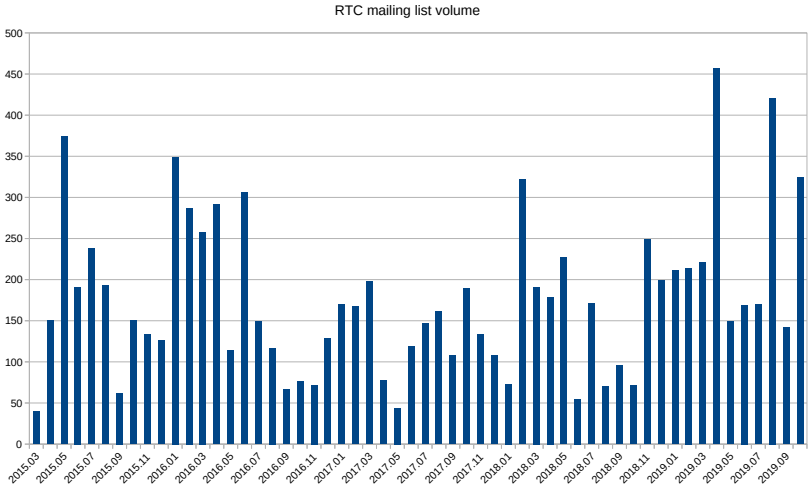
Alexandre Belloni

- Embedded Linux engineer at Bootlin
  - Embedded Linux **expertise**
  - **Development**, consulting and training
  - Strong open-source focus
- Open-source contributor
  - Maintainer for the Linux kernel **RTC subsystem**
  - Co-Maintainer of **kernel support for Microchip ARM SoCs**

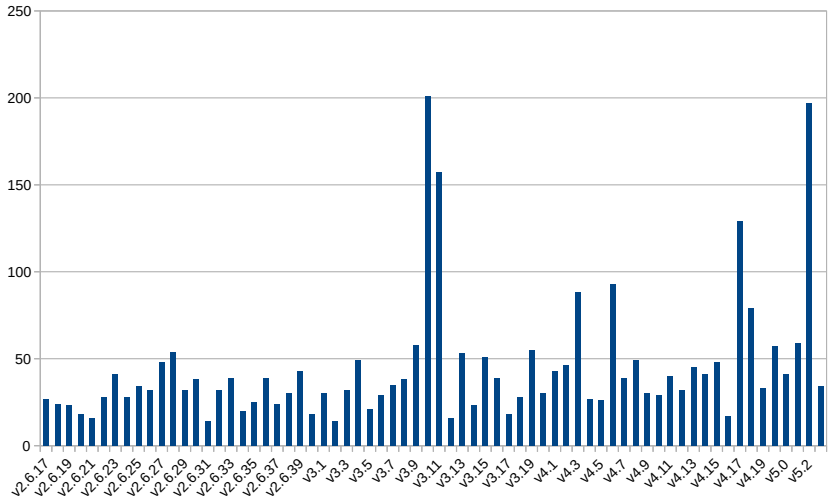
The RTC subsystem

- Introduced in 2.6.17 (March 2006) by Alessandro Zummo
- Taken over by Alexandre Belloni since 4.1 (April 2015)
- Mailing list was on googlegroups until Google decided that it was sending to much spam on the 4th of May 2017.
- linux-rtc@vger.kernel.org created on 11th of May 2017
- Archives are at `https://lore.kernel.org/linux-rtc/`
- Patchwork at `http://patchwork.ozlabs.org/project/rtc-linux/list/`
- git repository on kernel.org:
  `git://git.kernel.org/pub/scm/linux/kernel/git/abelloni/linux.git`

Mailing list statistics



Commits statistics



Recent changes: new drivers since 4.0

- Abracon AB-RTCMC-32.768kHz-EOZ9
- Alphascale ASM9260
- Amlogic Meson RTC
- Amlogic Virtual Wake
- Android emulator (goldfish) RTC
- Aspeed BMC SoC RTC
- Broadcom STB wake-timer
- Cadence RTC IP
- Chrome OS EC RTC
- Cortina Gemini
- Dialog DA9062
- Epson RX6110SA
- Epson RX8010SJ
- Epson RX8130CE
- Epson Toyocom rtc-7301sf/dg
- Freescale FlexTimer Module alarm
- Freescale i.MX system controller RTC
- Intersil ISL12026
- Maxim IC DS1308
- Maxim MAX77620
- Maxim MAX6916
- Mediatek MT6397
- Mediatek MT7622 RTC
- Microchip PIC32
- Microcrystal RV1805
- Microcrystal RV3028
- Microcrystal RV8803
- Motorola CPCAP PMIC RTC
- NXP i.MX53 SRTC
- NXP LPC24xx
- NXP PCF2127/PCF2129
- NXP PCF85263/PCF85363
- Realtek RTD1295
- Spreadtrum SC27xx PMIC RTC
- STMicroelectronics STM32
- Whwave sd3078
- Xilinx Zynq MP

Recent changes: crystal offset

- The RTC has either an in-package or external crystal, usually running 32kHz.
- There is variance in the exact frequency because of manufacturing, temperature and aging.
- Some RTCs can add or subtract correction pulses to make seconds quicker or longer.
- New sysfs interface `/sys/class/rtc/rtcX/offset`
- The unit is part per billion, positive value adds pulses and negative values subtracts pulses.
- The name is coming from the NXP datasheets, it is also called digital trimming.

Recent changes: crystal offset

- An other way to accommodate crystal variance is to change the load capacitance.
- Some RTC oscillators can change the apparent load on X1/X2
- New device tree property `quartz-load-femtofarads`
- It is also called analog trimming.

Recent changes: non volatile memory

- Some RTCs have a small amount of RAM.
- Because the RTC is always on, the RAM is non volatile.
- This memory is now exposed using the `nvmem` framework.
- New registration function: `int rtc_nvmem_register(struct rtc_device *rtc, struct nvmem_config *nvmem_config)`
- Multiple calls are allowed so if EEPROM is available, it can also be exposed through `nvmem`.
- `rtc->nvram_old_abi` handles the legacy ABI for drivers that were exposing a file named `nvram` in sysfs. It issues deprecation warning.

Recent changes: rtc registration

- With `devm_rtc_device_register`, it was difficult to write a probe function without race conditions.
- The registration is now split in two parts: `devm_rtc_allocate_device` and `rtc_register_device`.
- This allows to handle the `struct rtc_device` before registering it.
- Non devm managed registration has been removed from the driver API.

Recent changes: sysfs attributes registration

- sysfs attributes were created after `devm_rtc_device_register`. This opened up a possible race condition because the rtc folder appeared before the extra attributes.
- New functions: `int rtc_add_group(struct rtc_device *rtc, const struct attribute_group *grp)` and `int rtc_add_groups(struct rtc_device *rtc, const struct attribute_group **grps)`.
- Used between `devm_rtc_allocate_device` and `rtc_register_device`, they ensure all the RTC attributes are available at the same time.

Recent changes: RTC range

- New members of `struct rtc_device`: `range_min` and `range_max`.
- They allow the driver to declare the date and time range supported by the RTC hardware.
- No discontinuity is allowed in this range.
- The core will check `struct rtc_tm` is in the range before passing it to the driver.

Recent changes: RTC offset

- To solve RTC end of time issues, the core is now able to offset and window the hardware range.
- The offset is added or subtracted before calling the driver callbacks.
- Note that because the RTC time is always positive, there are almost no RTCs failing in 2038 (currently only 3). The most common failing date is 2100, followed by 2106.
- This is still useful to handle dates before 2000 as it seem to be mandatory for Android.
- New device tree property: `start-year`

Recent changes: other improvements

- New `%ptR` printk format
- Tracepoints
- `time_t` overflow is now properly handled in `rtc_hctosys` to avoid breaking 32bit platforms.
- `rtc-range` tool to test the continuous range of an rtc `git`: `//git.kernel.org/pub/scm/linux/kernel/git/abelloni/rtc-tools.git`
- Timestamping
- Trickle charging

Recent changes: cleanups

- Unnecessary `rtc_valid_tm` calls have been removed.
- `open`, `release`, `set_mmss` and `set_mmss64`, `read_callback` members of `struct rtc_class_ops` have been removed.
- `struct rtc_class_ops` are now `const` were possible.
- `rtc_control` API has been removed. It has been replaced by hrtimer.
- `rtc_irq_register` has been removed.
- Core files have been renamed for consistency.

Future changes: voltage detection

- Current voltage drop detection ABI is not working well for more advanced RTCs.
- `RTC_VL_READ` returns a currently undocumented value.
- There are different types of monitored voltages: main supply, battery or auxiliary supply.
- They can have multiple states: OK, low, low and functionalities are disabled, data lost.
- A new ioctl has to be developed.

Future changes: timestamping

- Some RTCs can store one or multiple timestamp when an event happens.
- Currently exposed through `/sys/class/rtc/rtcX/timestampX`
- This is open coded in each driver. There is room for factorization in the core.
- Timestamp events will probably need to be configured in the future (timestamp first event, last event, input pin).
- Not sure whether this will be using a new ioctl or more sysfs files.

Future changes: backup switch mode

- It is possible to select the backup switch policy for some RTCs.
- The common policies are:
  - disabled
  - direct (VDD $<$ VAUX)
  - standby
  - level (VDD $<$ threshold)
- This will be implemented through a device tree property because it directly depends on the type of auxiliary voltage provided by the board.
- It is necessary to avoid hardcoding in the driver because it may have been set properly by the bootloader.

Future changes: alarm handling

- Alarm support detection. Many drivers modify the `struct rtc_ops` when alarms are not present. This prevents constification.
- Alarms with minute granularity. Support is currently open coded in each driver.
- Wakeup support: many parameters have to be taken into account to know whether the RTC can wakeup the system, there is potential for factorization in the core.
- Alarm routing:
  - Some RTCs have multiple interrupt pins and can configure which interrupt goes to which pin.
  - This is useful to route alarms to a CPU (wakeup) or a PMIC (powerup)
  - Device tree properties will be used.

Future changes: BCD RTCs

- Many RTCs store the date and time in BCD in a somewhat common format.
- There is potential for code factorization, especially when using regmap to access the RTC registers.

Future changes: timers

- Some timers are now able to wakeup the platform.
- They don't actually handle the system time, either because the counter is too small or it is counting downward or it is impossible to read it.
- The drivers currently open code the dummy `read_time` and `set_time` to keep the RTC core happy.

Future changes: other topics

- Revisit the `RTC_EPOCH_READ` and `RTC_EPOCH_SET` to change the RTC offset. This will allow changing the RTC offset at runtime.
- Write documentation on how to write an RTC driver and avoid the common pitfalls.
- Split up the ds1307 frankendriver.

Questions? Suggestions? Comments?

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`https://bootlin.com/pub/conferences/2019/elce/belloni-rtc`