MediaTek Upstreaming

From Bring-up to Test Coverage

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Open First

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MediaTek, really?!

A little background

MediaTek, really?!

- OpenWRT people started upstreaming Ralink
  - MediaTek acquired Ralink in 2011
    - Router SoCs: initially MIPS, then ARM/ARM64
- A wild laptop appears: Chromebooks!
  - First MediaTek Chromebook: Acer Chromebook R13 (MT8173), year 2016
    - Almost fully upstreamed in year 2020
  - A Current MediaTek Chromebook: Acer Chromebook Spin 513, year 2022
    - Upstreamed. Currently misses external display support, nothing else!

MediaTek, Yes!

- MediaTek devices are everywhere!
  - You probably have a MediaTek smartphone somewhere
  - Chinese el-cheapo's: different name, same board
- MediaTek and upstream
  - Relatively small community around it
    - Vast majority on Qualcomm
  - More smartphones, please
    - Mythbusting: MediaTek SoCs are not slow!

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Bring-up: Hardware Tools

Chromebooks and Smartphones

Basic tools: power supply

Powering laptops/Chromebooks:

Embedded Controller (EC) takes care of everything

Basic tools: serial comms

Chromebooks make it easy (sometimes):

SuzyQable: Type-C → Type-A – triple UART, triple easy

Basic tools: Make your own!

Difficulties buying SuzyQable? No problem!

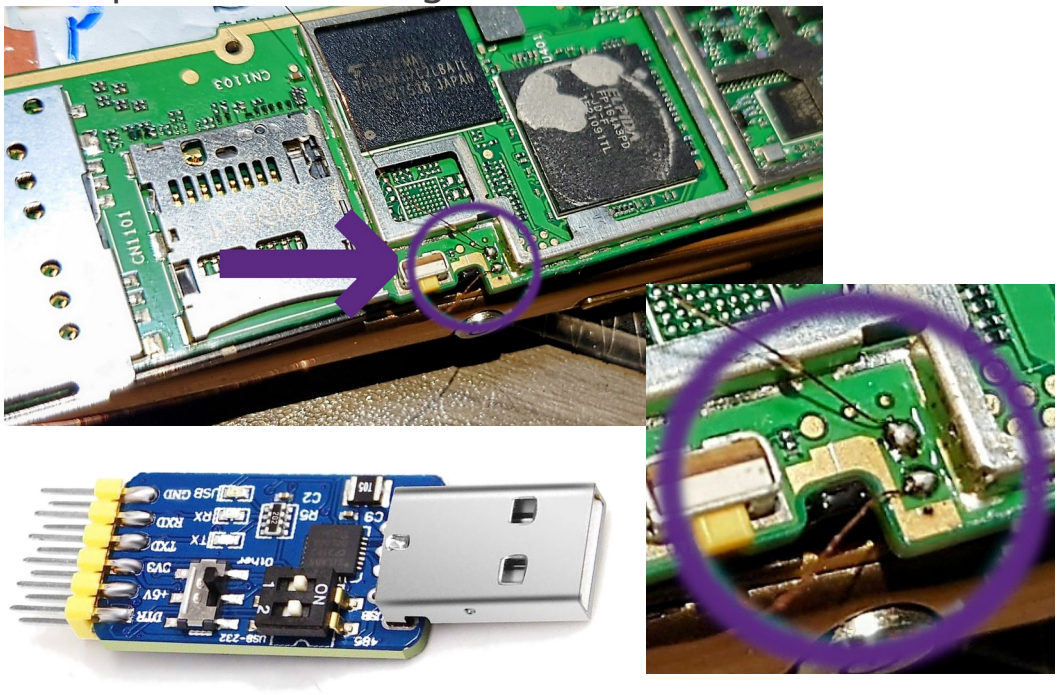
Type C Male	Other host (Type A Male)
A8 (SBU 1)	D+
B8 (SBU 2)	D-
A4, A9, B4, B9 (VBUS)	VBUS, 5V
A5 (CC1)	22 kΩ resistor to VBUS
B5 (CC2)	56 kΩ resistor to VBUS
A1, A12, B1, B12 (GND)	GND

Even debugging tools can be open source. Thanks, Google!

Ref.: Chromium - hdctools "Making your own SuzyQ".

Basic tools:
Patience.

Smartphones don't forgive:



Sony Xperia M5, MediaTek Helio X10 (MT6795) – UART Debug Port

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Bring-up: Software Tools

Chromebooks and Smartphones

Chromebook Bring-up Software Tools

- Reference Downstream Kernel Source Code
  - Usually not too old
  - Includes GIT history, you can see what's going on!
  - Publicly browsable at *chromium.googlesource.com*
- Recovery Images
  - Chromebook Recovery Utility: Windows and Mac only. (Yes, no Linux support...)
  - Chromium Dash: Manual download, *dd* on your own
  - Installation through USB Mass Storage (pendrives, HDDs, etc.)

Smartphone Bring-up Software Tools

- Reference Downstream Kernel Source Code
  - Usually very old (if you can find it, even)
  - Rarely includes GIT history, many times just a tarball drop
  - Rarely online browsable at <device manufacturer GIT>
- Recovery Images
  - Rarely, manufacturers make recovery tools available; if not...
  - Be prepared to browse potentially dangerous places to find a recovery image...
  - Installation through fastboot flashing
  - Disaster recovery: proprietary and confidential flash tool, not public

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Development Tools

Time to put our hands on it

Development tools: Global

- Obvious Basics
  - Your hands
  - Your favorite text editor
  - (cross-)Toolchain
  - Patience, people!
- Scripts and commodities
  - Never underestimate scripting
  - Scripts from the Linux kernel
  - External sources

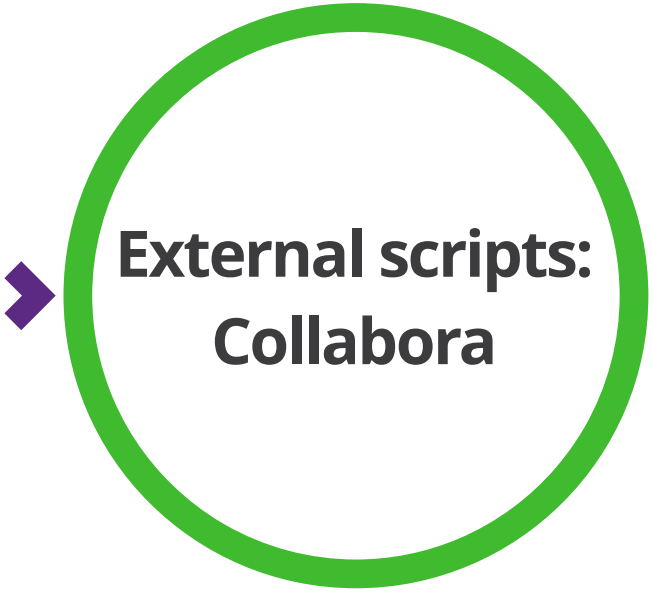
External scripts: Android

Obviously expects at least a boot.img

- There might be some commodity script around
- No MediaTek-specific mkbootimg to compose
- Know your bootloader's parameters
- Fastboot flashing (hopefully)

```
cat Image.gz mt6795-sony-xperia-m5.dtb > Image.gz-dtb;
mkbootimg --kernel Image.gz-dtb --ramdisk mt6795_android_ramdisk.gz --cmd
line "bootopt=64S3,32N2,64N2 console=serial0 earlycon=mtk8250,0x11002000"
 --base 0x40080000 --pagesize 2048 --kernel_offset 0 --ramdisk_offset 0x3
f80000 --tags_offset 0 -o xperia-m5-boot.img
```

P.S.: Newer devices need even more parameters...!



Chromebooks: rootfs and kernel

Public and open source

- Everything in one folder, no system-wide install
- Automatic toolchain download and setup
- Manage kernel configuration fragments
- Verify code/bindings, build and flash!

```
Commands useful for development workflow:

  deploy_kernel
    Compile the Linux kernel, its modules, the vboot image and deploy all
    on the storage device.

For example, to do everything on a SD card (format, repartition, flash the
rootfs, build and flash kernel) for the Acer Chromebook Spin 513 (ARM64):

  ./chromebook-setup.sh do_everything --architecture=arm64 --storage=/dev/sdX

or to do the same to use NFS for the root filesystem:

  ./chromebook-setup.sh do_everything --architecture=arm64 --storage=/srv/nfs/nfsroot
```

Available at: https://gitlab.collabora.com/google/chromebooks

Kernel scripts: checkpatch

Automate it!

```
echo '#!/bin/bash
exec git diff --cached HEAD | ' \
'scripts/checkpatch.pl --no-signoff --no-tree --strict -q -
exit 0 ' > .git/hooks/pre-commit
```

```
kholk@IcarusMOD ~/WORK/COLLABORA/mtk/linux-mtk $ git commit COPYING
WARNING: Possible repeated word: 'Kernel'
#7: FILE: COPYING:1:
+The Linux Kernel Kernel is provided under:

total: 0 errors, 1 warnings, 0 checks, 5 lines checked
```

P.S.: Make sure your hooks are executable!

Kernel scripts: bloat-o-meter

Trying to optimize code size?

- Build the kernel
- Save the old *vmlinux* or **.a* or **.o*
- Make your changes
- Build again
- bloat-o-meter!

```
kholk@IcarusMOD ~/WORK/COLLABORA/mtk/linux-mtk $ scripts/bloat-o-meter ../linux-mt
k-holly/drivers/clk/mediatek/clk-mux.o drivers/clk/mediatek/clk-mux.o
add/remove: 10/7 grow/shrink: 2/5 up/down: 458/-495 (-37)
Function                                     old     new   delta
```

...<snip>...

```
mtk_clk_mux_disable_setclr                   116      56     -60
mtk_clk_mux_is_enabled                       208     128     -80
mtk_clk_mux_set_parent_setclr_lock           428     288    -140
Total: Before=2359, After=2322, chg -1.57%
```

P.S.: Remember! Smaller is not always better!

External scripts: smatch

Static analysis helps a lot!

- Pointer initialization
- Variables usage
- Off-by-one errors, even!
- More life-savers

```
  CHECK   drivers/gpu/drm/mediatek/mtk_disp_color.c
  CHECK   drivers/gpu/drm/mediatek/mtk_disp_gamma.c
drivers/gpu/drm/mediatek/mtk_disp_gamma.c:192 mtk_gamma_set_common() error: we p
reviously assumed 'gamma->data' could be null (see line 120)
  CHECK   drivers/gpu/drm/mediatek/mtk_disp_merge.c
  CHECK   drivers/gpu/drm/mediatek/mtk_disp_ovl.c
120         if (gamma && gamma->data) {
121                 lut_diff = gamma->data->lut_diff;

192         if (gamma && !gamma->data->has_dither) {
193                 /* Descending or Rising LUT */
```

P.S.: Remember: always interpret and evaluate!

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Let’s bring it up!

The real deal.

Let’s bring it up: MediaTek SoC

- Basics...
  - Serial (UART)
  - Pinctrl
  - Clocks
  - Devicetree
- ...and more
  - PMIC / Regulators
  - eMMC/SD
  - Display

chromium / chromiumos / third_party / kernel / refs/heads/chromeos-5.10 / arch / arm64 / boot / dts / **mediatek**

42f8fc5	FROMGIT: arm64: dts: mediatek: mt8195: Add mediatek,broken-save-restore-fw to cherry by Douglas Anderson · 2 weeks ago
b3d9986	FROMGIT: arm64: dts: mediatek: mt8183: Add mediatek,broken-save-restore-fw to kukui by Douglas Anderson · 2 weeks ago
cc16f7e	CHROMIUM: Merge 'v5.10.173' into chromeos-5.10 by chromeos-kernel-auto-merge · 3 months ago
d7cf386	arm64: dts: mediatek: mt7622: Add missing pwm-cells to pwm node by AngeloGioacchino Del Regno · 3 months ago
717aa39	arm64: dts: mediatek: mt8183: Fix systimer 13 MHz clock description by Chen-Yu Tsai · 3 months ago
5a3143b	UPSTREAM: arm64: dts: mt8192: Fix CPU map for single-cluster SoC by Linux Patches Robot · 4 months ago
d7b105a	CHROMIUM: Merge 'v5.10.163' into chromeos-5.10 by William K Lin · 5 months ago

```
kholk@IcarusMOD ~/WORK/COLLABORA/mtk/linux-sony-hollyss-kernel-3.10/drivers/misc/mediatek $ ls
accdet          conn_md                 gpio                linearacceleration  pedometer       sync
accelerometer   cqdma                   gps                 m4u                 pick_up_sensor  sysenv
activity_sensor dbg_dump                gpu                 mach                pmic_wrap       systracker
aee             devapc                  gravity             magnetometer        pmt             thermal
almk            devinfo                 gud                 Makefile            power           tilt_detecto
alsps           dramc                   gyroscope           Makefile.custom     power_gs        trustzone
anc             dual_ccci               hdmi                Makefile.mt6795     power-loss-test uart
atf_log         dum-char                heart_rate_sensor   masp                pwm             usb11
auxadc          eccci                   hibcore             md32                ram_console     usb20
barometer       eemcs                   hwmon               mem                 rotationvector  usb2jtag
boot            eint                    i2c                 mjc                 rrc             vcorefs
boot_reason     emd_ctl                 imgsensor           mlog                rtc             vdec
bringtosee      emi_bwl                 in_pocket_sensor    mmc-host            sched           vibrator
```

Let's bring it up: UART

Knowing what's happening

Essential stuff

- Bootloaders usually leave UART pins configured
- Linux can use early console without HW setup
- No need for a full serial driver
- Slow, but effective raw prints

```
AP_UART0@0x11002000 {
        cell-index = <0>;
        compatible = "mediatek,AP_UART0";
        reg = <0x11002000 0x1000>;

chosen {
        bootargs = "earlycon=mtk8250,0x11002000";
};
```

Downstream node

P.S.: Only for early bring-up!

Let's bring it up: Pinctrl

Copy-paste or real work?

Hope to find a "modern" driver

- MediaTek kernel <=3.10: pain and suffering
- Modern era: Linux >=3.18: 60 minutes of work
- Essential for SoC integrated devices as well

```
if (pin == GPIO164) {          //ms0 DS
return (((GPIO_RD32(&reg->msdc0_ctrl4.val) & (1L << 2)) != 0)? 0: 1);
} else if (pin == GPIO165) {  //ms0 RST
return (((GPIO_RD32(&reg->msdc0_ctrl3.val) & (1L << 2)) != 0)? 0: 1);
} else if (pin == GPIO162) {  //ms0 cmd
return (((GPIO_RD32(&reg->msdc0_ctrl1.val) & (1L << 2)) != 0)? 0: 1);
} else if (pin == GPIO163) {  //ms0 clk
```

```
static const struct mtk_pinctrl_devdata mt6397_pinctrl_data = {
        .pins = mtk_pins_mt6397,
        .npins = ARRAY_SIZE(mtk_pins_mt6397),
        .dir_offset = (MT6397_PIN_REG_BASE + 0x000),
        .ies_offset = MTK_PINCTRL_NOT_SUPPORT,
        .smt_offset = MTK_PINCTRL_NOT_SUPPORT,
```

Let's bring it up: Clocks

Copy-paste or real work?

Hope to find a "modern" driver

- MediaTek kernel <=3.10: pain and suffering
- Modern era: Linux >=3.18: 60 minutes of work
- Essential for SoC integrated devices as well

```
static struct subsys syss[NR_SYSS] = {
    {
        .name = __stringify(SYS_MD1),
        .type = SYS_TYPE_MODEM,
        .default_sta = PWR_DOWN,
        .sta_mask = 1U << 0,
//        .ctl_addr = SPM_MD_PWR_CON,
        .ops = &md1_sys_ops,
    }, {
```

```
static int md1_sys_enable_op(struct subsys *sys)
{
    int err;
    err = spm_mtcmos_ctrl_mdsys1(STA_POWER_ON);
//    print_mtcmos_trace_info_for_met(); // XXX:
    return err;
}
```

```
static const struct mtk_gate mm_clks[] __initconst = {
        /* MM0 */
        GATE_MM0(CLK_MM_SMI_COMMON, "mm_smi_common", "mm_sel", 0),
        GATE_MM0(CLK_MM_SMI_LARB0, "mm_smi_larb0", "mm_sel", 1),
        GATE_MM0(CLK_MM_CAM_MDP, "mm_cam_mdp", "mm_sel", 2),
        GATE_MM0(CLK_MM_MDP_RDMA0, "mm_mdp_rdma0", "mm_sel", 3),
```

Let's bring it up: Devicetree

Copy-paste or real work?

Hope to find a "modern" driver

- MediaTek kernel <=3.10: pain and suffering
- Modern era: Linux >=3.18: 60 minutes of work
- Essential for SoC integrated devices as well

```
    M4U@0x10205000 {
cell-index = <0>;
            compatible = "mediatek,M4U";
            reg = <0x10205000 0x1000>;
            interrupts = <0 147 0x8>;
    };

    EFUSEC@0x10206000 {
            compatible = "mediatek,EFUSEC";
            reg = <0x10206000 0x1000>;
    };
```

```
disp_mutex_reg = <0x14020000 0x1000>;
g3d_config_base = <0x13000000 0 0xFFFF0000>
mmsys_config_base = <0x14000000 1 0xFFFF000
disp_dither_base = <0x14010000 2 0xFFFF0000
mm_na_base = <0x14020000 3 0xFFFF0000>;
imgsys_base = <0x15000000 4 0xFFFF0000>;
vdec_gcon_base = <0x16000000 5 0xFFFF0000>;
venc_gcon_base = <0x17000000 6 0xFFFF0000>;
conn_peri_base = <0x18000000 7 0xFFFF0000>;
topckgen_base = <0x10000000 8 0xFFFF0000>;
kp_base = <0x10010000 9 0xFFFF0000>;
```

```
iommu: iommu@10205000 {
        compatible = "mediatek,mt6795-m4u";
        reg = <0 0x10205000 0 0x1000>;
        clocks = <&infracfg CLK_INFRA_M4U>;
        clock-names = "bclk";
        interrupts = <GIC_SPI 146 IRQ_TYPE_LEVEL_LOW>;
        mediatek,larbs = <&larb0 &larb1 &larb2 &larb3>;
        power-domains = <&spm MT6795_POWER_DOMAIN_MM>;
        #iommu-cells = <1>;
};
```

Copy-paste or real work?

Hope to find a “modern” driver

- MediaTek kernel <=3.10: pain and suffering
  - Definitions scattered all around
- Modern era: Linux >=3.18: not too bad
  - A bit cleaner, more centralized
- Regulators required to get out of early porting
  - Think about eMMC voltage signaling!
- No optimizations yet! Get it working first.
  - Better working than fast....failures!
- It’s never just a copy-paste job anyway.

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Test coverage

More important than you think

Test coverage: how it helped me

- Kernel Test Robot (Intel 0-day)
  - Monitoring all (or most of) for-next branches
  - Promptly reporting build issues to you
  - Compiling your ARM64 code for other archs
  - Less work for you
- KernelCI
  - Monitoring Linux stable, linux-next and more
  - Collabora's MediaTek Integration Kernel
  - Testing on the real hardware!

Test coverage: Intel 0-day

Don’t be scared: it’s here to help you

...you shouldn’t feel annoyed!

- Catches issues before patches reaching -stable
- Goes straight to your mail inbox
- No action required to trigger tests

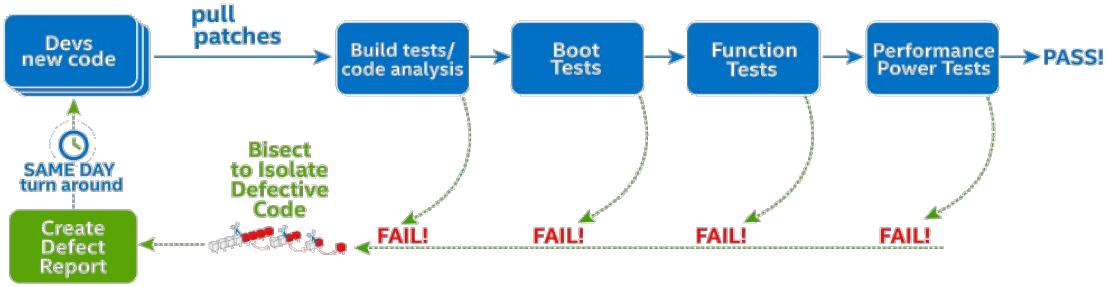


Image credits: © Intel Corporation, 01.org

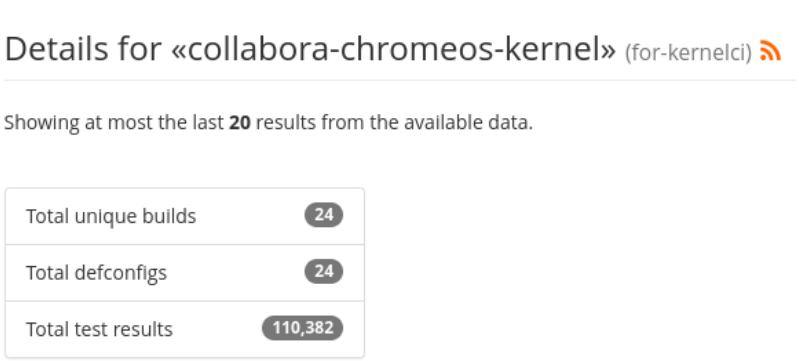
More info at: https://01.org/lkp/documentation/0-day-brief-introduction

Test coverage: KernelCI

Catching issues dynamically

Testing on the real hardware

- Static analysis can't catch all issues
- Tests on multiple devices / SoCs
- Also auto-bisects



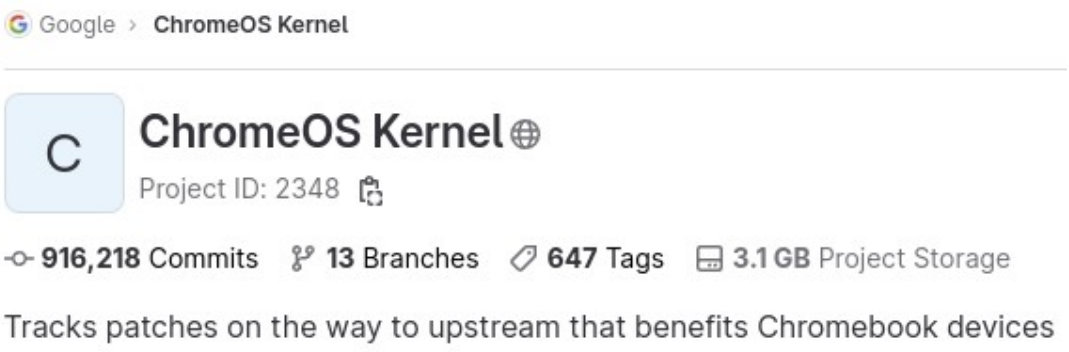
Check it out at: https://linux.kernelci.org and https://chromeos.kernelci.org

Test coverage: MediaTek Integration

Collabora's MediaTek Integration Kernel

Where everything goes together

- Mostly feature complete, always based on -next
- Testing all the pieces together on real hardware
- Our development kernel, KernelCI enabled
- Open to everyone!



Check it out at: https://gitlab.collabora.com/google/chromeos-kernel

Thank you!

We are hiring

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