Democratizing Far Edge Networking: Journey of Mainlining Wired and Wireless in Linux Kernel

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Ideal software stack

- Current stable kernel
- Current OpenWrt release or distribution of choice
- No binary only drivers or tools
- Large selection of up-to-date packages

Traditional software stack

- Vendor provided reference SDK
- Usually based on old kernel versions
- Usually based on old OpenWrt versions (AP)
- Potentially number of binary only drivers or tools
- Outdated package versions, hard to update
- Possible security vulnerabilities, hard to mitigate

Upstream first development

- Approach targeting up-to-date upstream projects
- Kernel
- Distribution (OpenWrt, Debian, etc.)
- Userspace tooling (systemd, ModemManager, etc.)
- Upstreaming of features that may be missing

Downsides of upstream first development

- Usually takes longer for product to hit the market
- Potential rework of existing work required based on upstream feedback
- Missing prerequisite features in upstream that require development first

Upsides of upstream first development

- Public review of the code
- Feedback on aspects that can be improved
- More eyes on the same code
- Availability of modern kernel features
- Usually leads to simpler and cleaner code

Tips for upstream first development

- Development against linux-next
- Focus on sending small functional patch series
- Start sending patches as early as possible in the product development
- Try and avoid developing the whole product stack before upstreaming

Our experiences

Qualcomm IPQ40xx WiSoC

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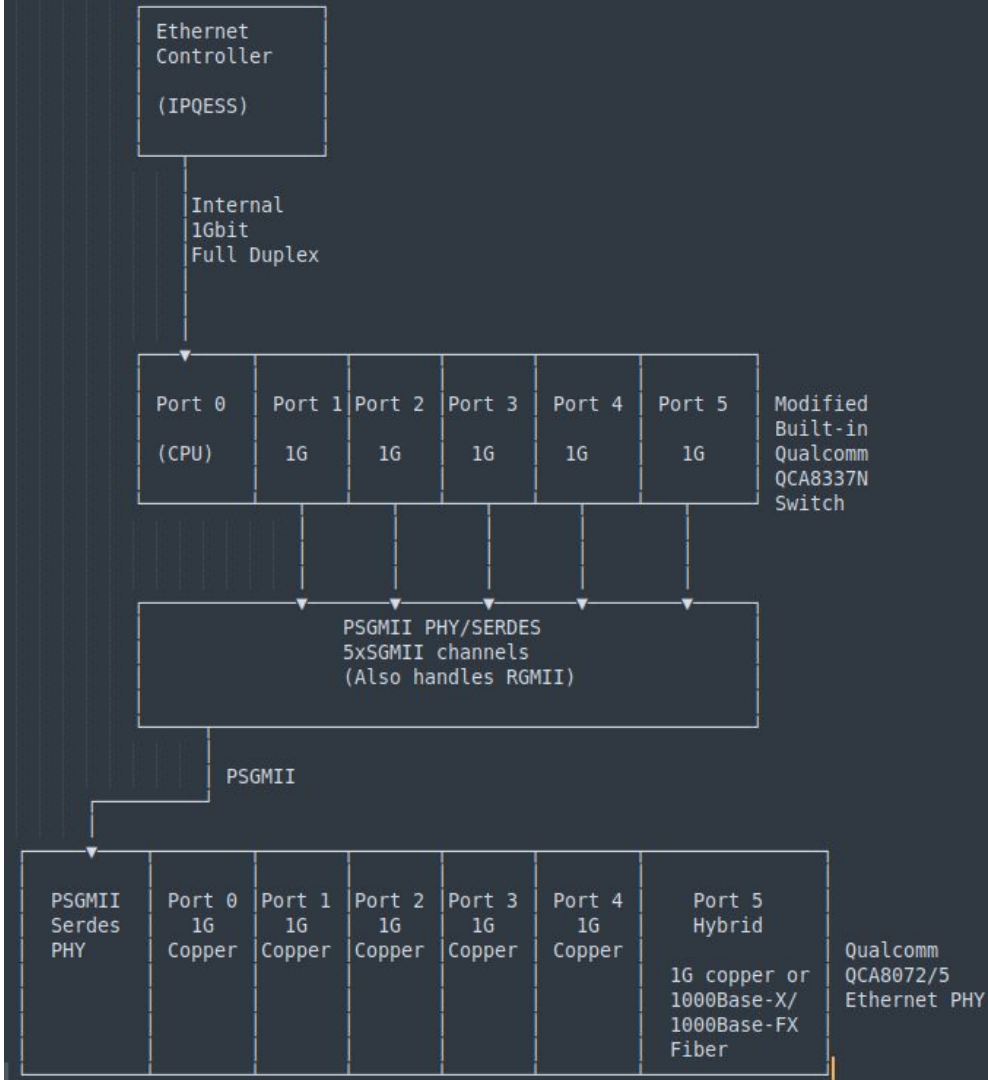
Existing state of support

- Quad Core ARMv7 Cortex-A7 with integrated dual-band 802.11ac radios
- Was already present in OpenWrt but mostly downstream patches
- Partial support in upstream kernel
- WLAN was supported in upstream kernel
- No wired networking support in upstream kernel
- No upstream U-Boot support

Challenges when upstreaming

- No HW level documentation
- Existing OpenWrt patches were mostly partially up-ported vendor downstream drivers
- Significant amount of code and magic values was relevant to the pre-production silicon
- Unusual networking subsystem with no upstream support
- Vendor kernel publicly available though heavily modified kernel 4.4

Wired networking subsystem



Wired networking challenges

- Internal switch based on QCA8337N but modified so unsupported by qca8k
- Use of Qualcomm specific Penta SGMII link
  - Mostly undocumented UNIPHY that handles RGMII or PSGMII, plenty of magic values
  - PSGMII link requires calibration between the UNIPHY and PHY-s, no support for anything like this in the kernel
- Switch tag tightly coupled to the HW, sent via DMA descriptor directly
- Companion Qualcomm QCA8072/5 PSGMII PHY-s
  - They contain 2 or 5 identical PHY-s in the same package
  - But also always contain one PSGMII SerDes PHY which requires configuration
  - PHY package support was minimal in the kernel

Current kernel upstream status

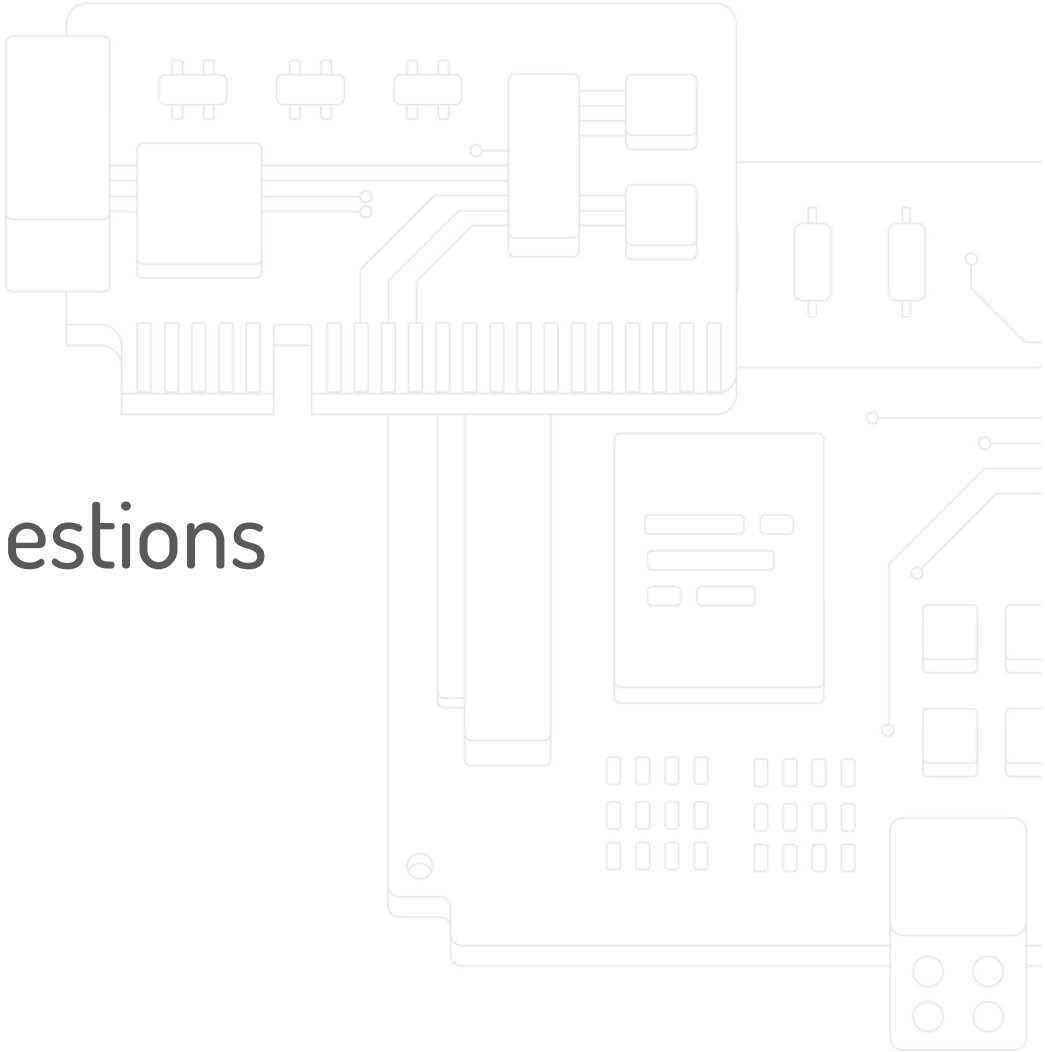
- SoC support has been upstreamed into kernel with the following exceptions:
  - LCD support (Lack of any HW actually using it)
  - I2S/TDM support (Lack of any HW actually using it)
  - Wired networking
    - Qualcomm IPQ8072/5 companion PHY support was upstreamed
      - Required expansion of the PHY package support
    - Upstreaming of the built-in ethernet controller and QCA8337N based switch was attempted
      - As a separate ethernet and DSA drivers
        - qca8k driver was refactored to split out common code
        - Out of band tagging support was used
      - As a single switchdev driver
        - Symbols were exported from the common qca8k code to try and avoid code duplication
      - Both efforts stalled

Current U-Boot upstream status

- Single core mode support
- UART (Including debug UART)
- Full pinctrl and GPIO support
- SPI support (NOR and NAND)
- USB3.0 and USB2.0
- OF_UPSTREAM support (Using Linux DTS)
- Partial network support (Missing QCA8072/5 support only)

Notable peripherals missing:

- NAND (Parallel ONFI)
- eMMC/SDIO



Questions