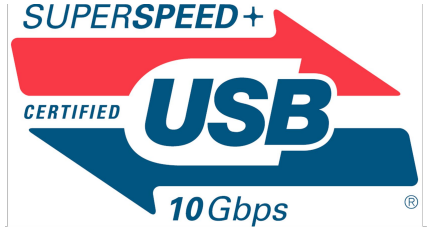

Nifty Type-C Features and Optimizations

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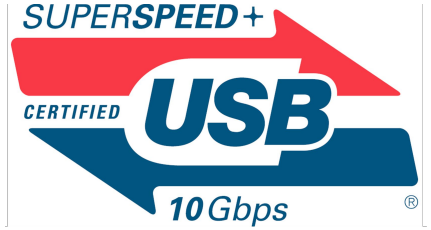
October 24 – 25, 2017

Chromebook/USB-C: State of the union is good

- All new chromebooks (even low cost ones) have USB-C™
  - Power sink: wide input range (5-20V on most, 5V-PDP limit on others)
  - Power source: min 7.5W, some 15W
  - USB Data
  - DP Alt mode video
- Most devices have 2xUSB-C: normally one on each side
  - Good to also have USB-A if it fits in the device
- Still mostly USB PD 2.0: focus has been on adoption and cost
- Just started on PD 3.0: FRS, PPS, Power adapter info, Battery info

Nifty New USB-C Features

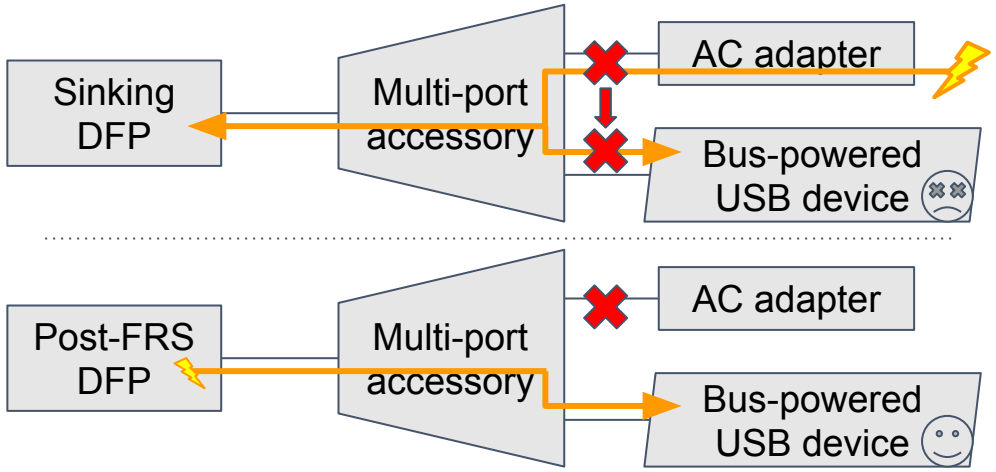
- Feature: Fast Role Swap
- Architecture: Mux and TCPC integration
- Architecture: Power Integration Part
- Feature: Programmable Power Source
- Feature: Vconn-powered Devices (VPDs)



Fast role swap and TCPC integration drive the need for a power front-end chip

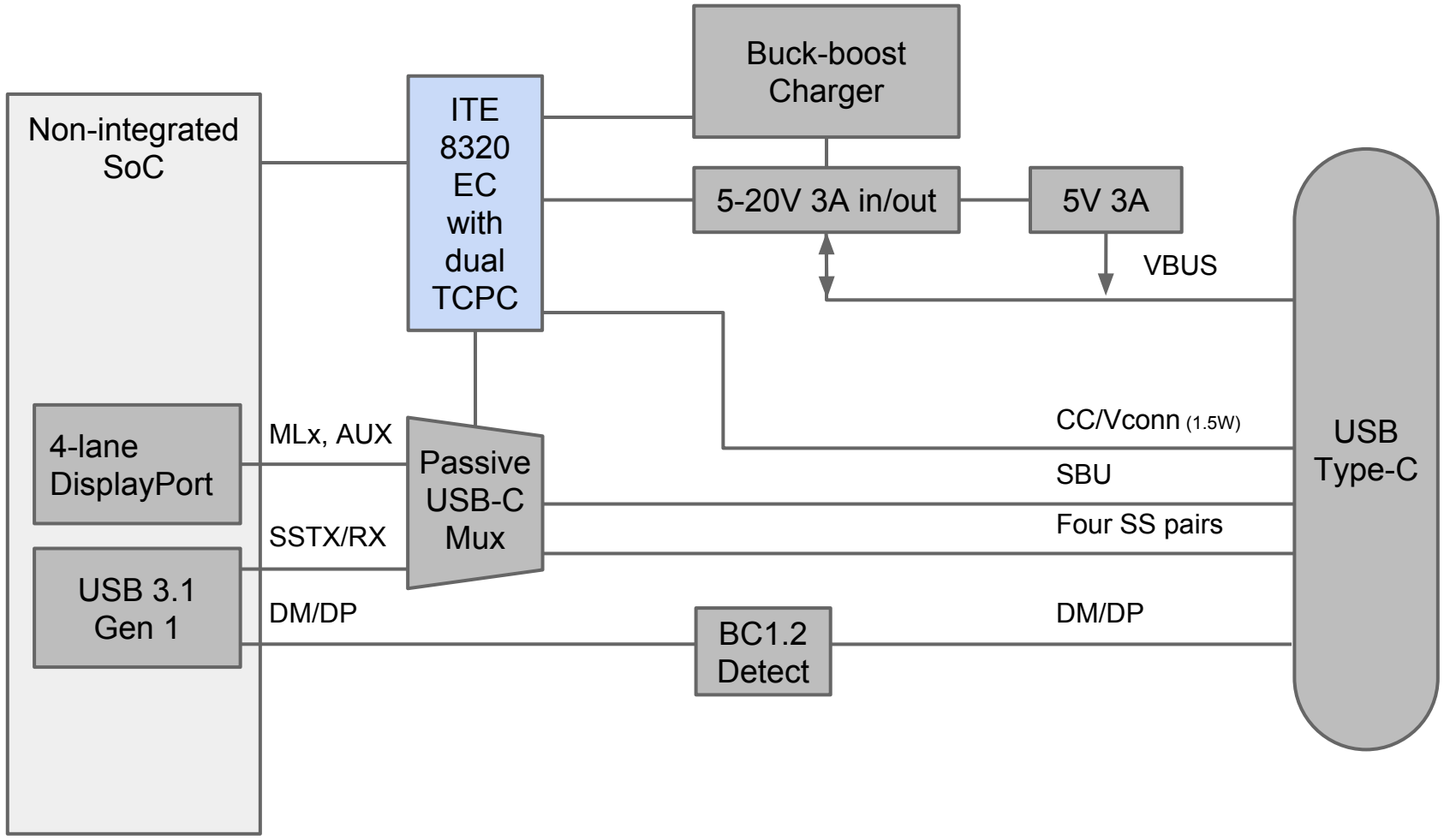
Fast Role Swap

- Fast Role Swap added to USB-C / PD 3.0 to improve user experience
- Problem (in 1000 words):
- Solution: FRS
  - Detect on accessory
  - Signal on CC
  - Device switches sink to 5V source in 150µs
  - Protocol catches up
  - Vconn makes surviving the transition a bit simpler, but it's not mandatory
- Supporting parts becoming available for laptop and accessory



Integration already here: IT8320

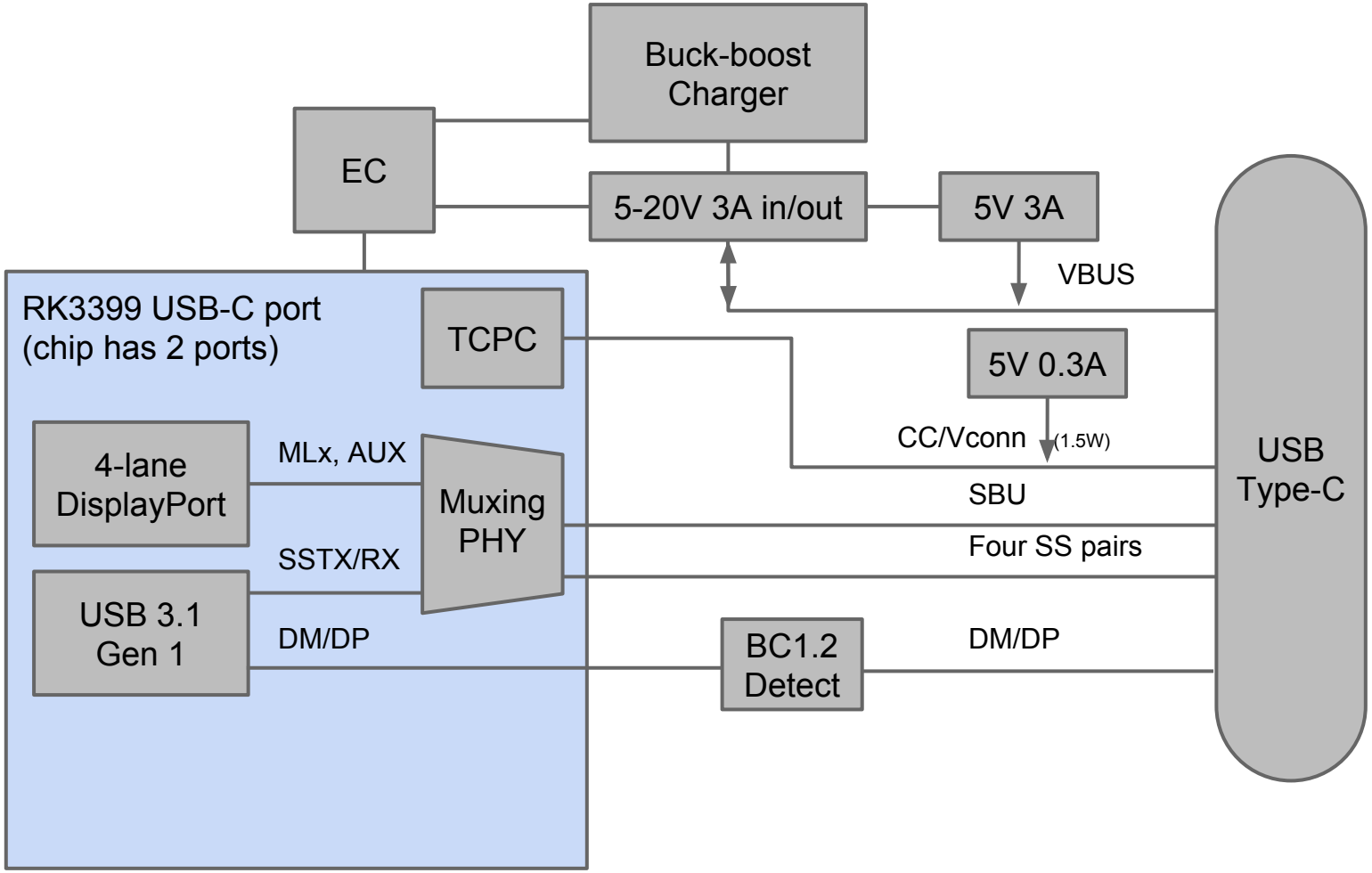
- ITE integrated in EC
  - 2x TCPC



Integration already here: RK3399

Rock-Chip integrated in SoC

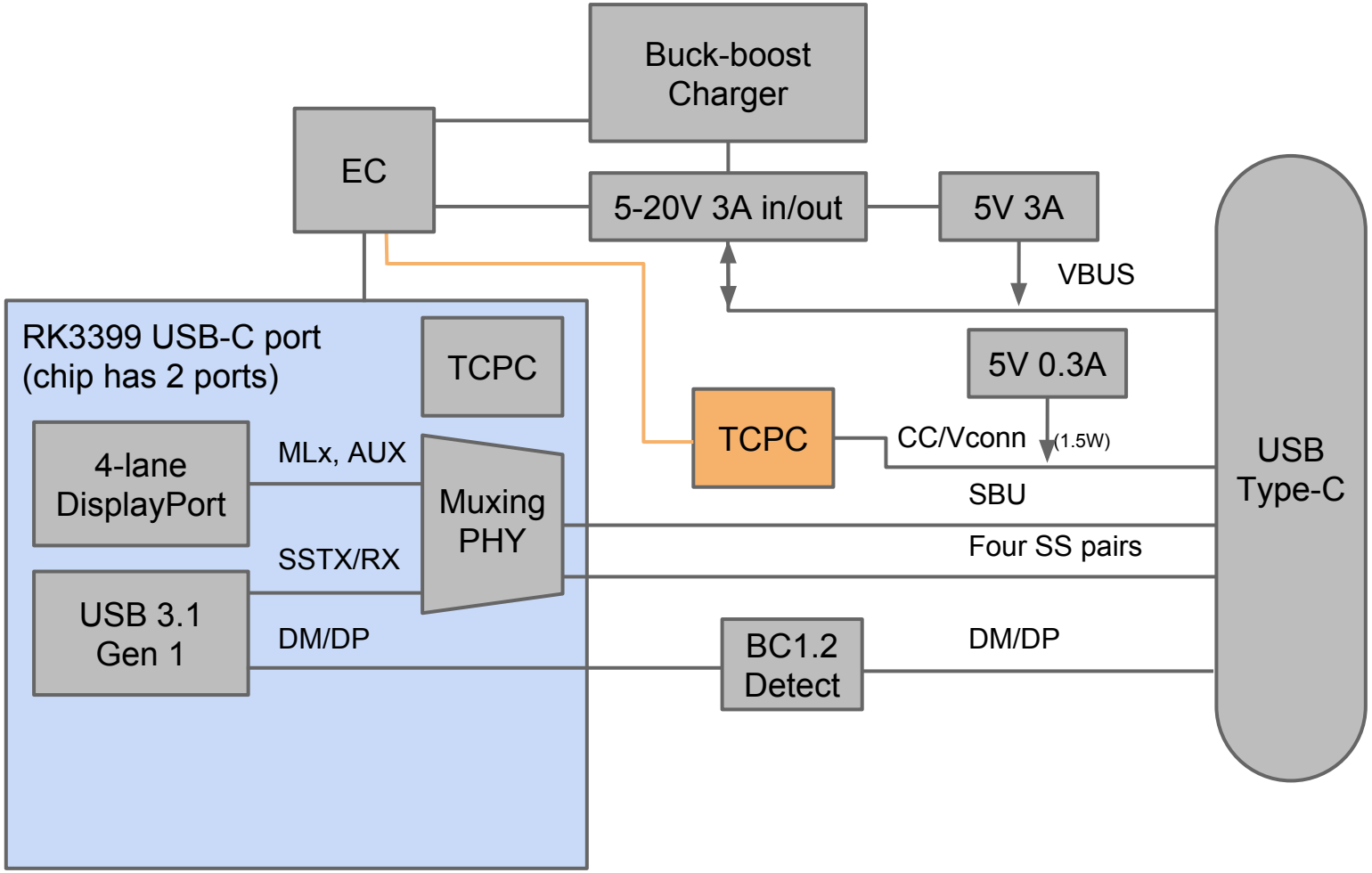
- Superspeed Mux
- TCPC
- Android makes good use
  - USB PD in kernel



Integration already here: RK3399

Rock-Chip integrated in SoC

- ChromeOS today controls TCPC from the EC
- Mux is controlled from kernel



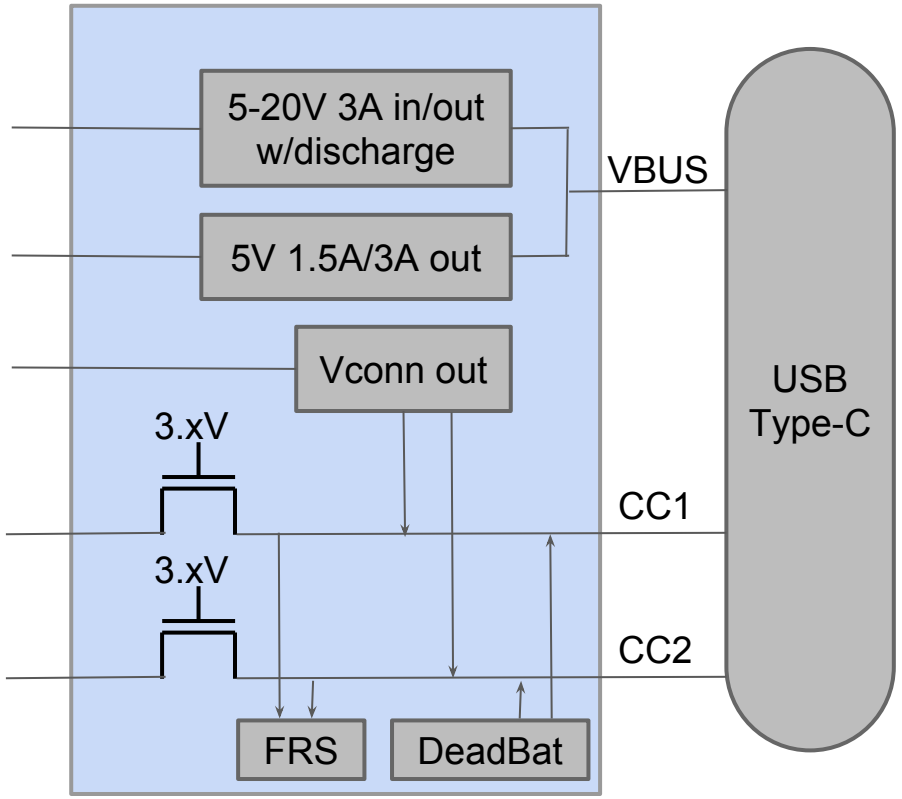
Consequence: move more code to OS kernel

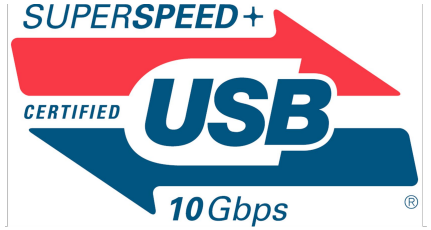
- Today on Chrome OS EC runs TCPM, Power policy and uses TCPC
  - Integrated mux is already controlled by kernel: system up when mux useful
  - Good division for laptop where EC controls power states and battery charge
  - Different from Android phones, which have USB-PD in the kernel
  - Heavily limited code space
  - ECs are disappearing as device form factors converge and prices drop
- Many factors point to TCPM ending up in the OS kernel
  - Needed as the number of “Quirks” increases
  - Needed for PDFU and Auth where internet searches may be involved
  - Allows integrated TCPC and Muxes to be used easily
  - Allows for much more involved power management between ports
  - Downside: complexities handling low-power chargers and low battery

Consequence: Type-C Power Integration Part (TCPIP?)

Frontend chip that sits next to the port

- Power path to/from charger
- Power path for 5V out
- FRS detect, charge in -> 5V out
- Vconn load switch
  - Need 5V low Rds(on) process
- Present dead battery pulldown
- Protect host CC from > 3V
  - Allows TCPC in process without 5V
  - Also protects from CC-Vbus short
- Several vendors sample now/soon





Programmable Power Source is for laptops too!

PPS: Laptops have the same issue as phones

- PPS added to USB-C / PD to allow sink to control source voltage
- Many think this is for phones -- but it is for laptops too!

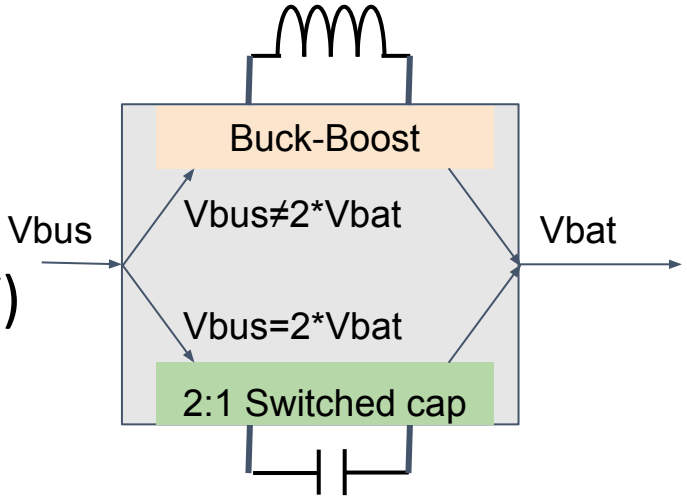
- Problem: laptops are getting thin (thus USB-C) and thermally limited
  - The CPU can max out the thermal dissipation of the enclosure
  - In practice 15V -> 8V buck-boost is 90-92% efficient, at 40W get ~4W heat
    - The CPU must reduce power by 4W → Connecting charger causes slower machine
- Pixel-C tablet had this problem too
  - Solution was to switch to 5V PDO (15W max) when screen is turned on

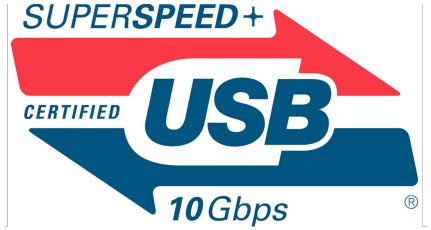
PPS can work for 2S Laptops

Solution for 2S devices:

- Buck-boost for existing 5/9/15/20V adapters
- Super-efficient switched capacitor 2:1 conversion
  - ~98% efficiency measured
  - PPS to get 2x voltage needed to charge battery (~12-18V)
  - Allows use of 3A cables for ~40W charging (1C)
- Charger chip has buck-boost and switched capacitor
  - Control loops match, switch-over seamless
  - Parts for 1S (phones) are becoming available, no 2S yet

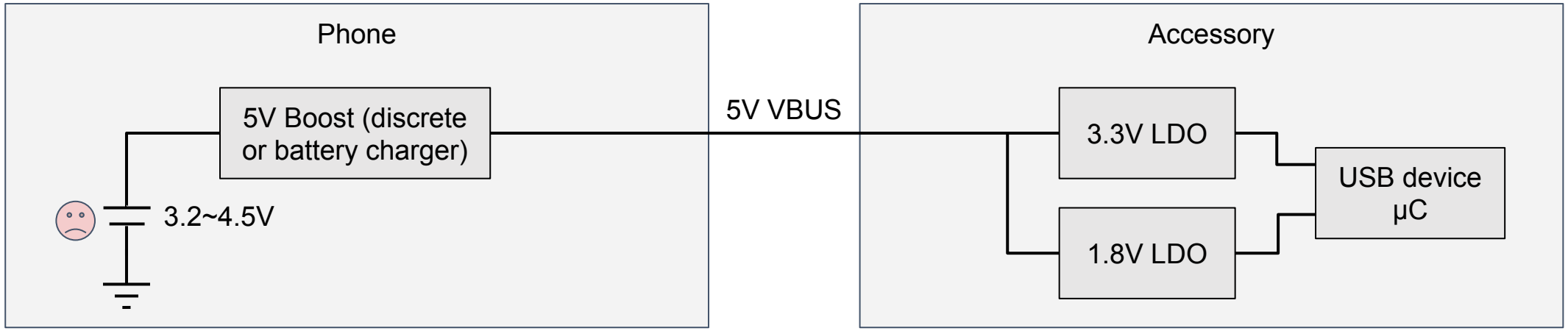
Hopefully by next year we can show data!





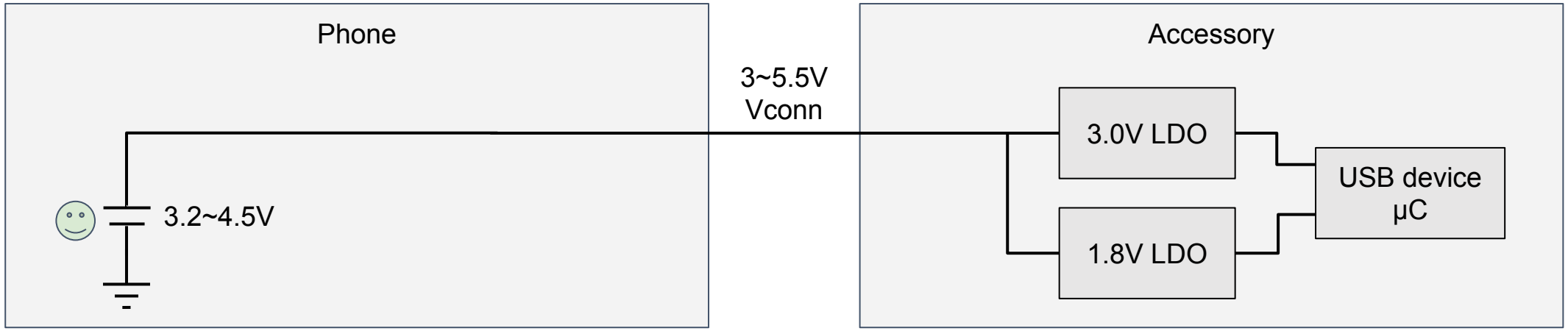
Vconn-Powered USB Devices

Does this look familiar?



- This is how many USB accessories (especially compact audio devices) work with phones today
- Generously assuming boost is ~90% efficient, USB device's core power is coming in at 33% efficiency. Yikes!
- A USB2 device at 0.5A could consume 2.7W at battery

Ideal



- Now we're at 40~56% efficiency, without really changing the accessory
- Limiting maximum current in this mode to 100mA brings the worst-case battery load to 450mW (320mW at low battery)
- Your headphones can no longer ruin your phone's battery life!

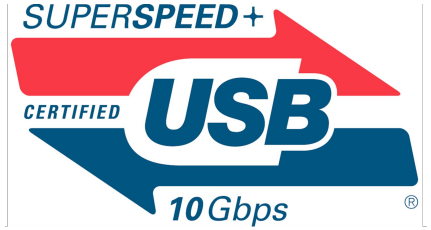
VPDs enable the ideal, but keep compatibility

- VPD must be able to run from both VBUS (4.75-5.5V) and Vconn (3-5.5V), so it works with any kind of host
- VPD adds an eMarker (simplest PD silicon possible) to advertise its capability. Host can probe SOP' to find out it can remove VBUS
- Vconn is only available on cable plugs, so accessory must be direct-attach or have a captive cable

- Optimizing power for VPDs in a phone (or any other PD-capable source or DRP) does not require additional hardware!
- VPD DiscoverIdentity VDO is only defined in PD3, but PD2 devices can safely use PD3 **just** to query eMarkers (minor header change)

VPDs enable something else…(Soon™)

- The VPD architecture leaves room for adding charge-through to a future Type-C / PD spec
- This charge-through approach would be dramatically simpler and cheaper than what's required of multi-port adapters today
- Most DRP implementations out now would be able to support it with a software update
- ...but it's not fully specified yet, so I'll have something to talk about next year



Q&A