# Demystifying USB-C<sup>®</sup> using Linux's USB Type-C<sup>®</sup> Connector Class

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## Presentation Agenda

- USB-C<sup>®</sup> as it is now
- Where Connector Class fits in
  - Power Delivery protocol
  - Linux's USB Type-C connector class
  - Mockup uses
- Remaining SW work
- Where it's headed

## **USB-C<sup>®</sup>** is great and all, but CONFUSING



# Many USB-C<sup>®</sup> Cables, > # of required logos

#### Table 3-1 USB Type-C Standard Cable Assemblies

	Cable Ref	Plug 1	Plug 2	USB Version	Cable Length	Current Rating	USB Power Delivery	USB Type-C Electronically Marked
	<u>CC2-3</u>	C	C	UCP 2.0	< 1 m	3 A	Supported	Optional
	<u>CC2-5</u>	C	J	$C \qquad \underline{OSB \ 2.0} \qquad \leq 4 \text{ m}$	5 A	Supported	Required	
	<u>CC3G1-3</u>	6	G	<u>USB 3.2 Gen1</u>	. 2	3 A		D
	<u>CC3G1-5</u>	L	L	USB4 Gen2	≤ 2 m	5 A	Supported	Required
	<u>CC3G2-3</u>	6	6	<u>USB 3.2 Gen2</u>	-	3 A		D
	<u>CC3G2-5</u>	L	L	usb4 Gen2	$\frac{1}{\text{USB4 Gen2}} \leq 1 \text{ m} \qquad \qquad \text{Supported} \\ 5 \text{ A} \qquad $	Required		
iv	<u>CC4G3-3</u>	С	С	<u>USB4 Gen3</u>	≤ 0.8 m	3 A	Supported	Required
ne	<u>CC4G3-5</u>					5 A		

# **USB-C<sup>®</sup> Port Features "à la carte"**

FRS ask or give

**Unconstrained Power** 

from 2.5W ~ 100W

#### Connector

• Receptacle or Captive Cable

#### Power

- PD2.0 or PD3.0
- Source, Sink, or DRP
- Sources any power output
- Sinks any power input from 0.0W ~ 100W

#### USB Data

- UFP or DFP or DRD
- USB 2.0 Host or Gadget or both
- USB 3.2 Gen 1 or Gen 2 Host or Gadget or both
- USB4<sup>™</sup> PCIe and/or USB 3.x and/or DP

#### **Alt Modes**

- VESA DisplayPort<sup>™</sup> Alt Mode
- Intel Thunderbolt<sup>™</sup> 3
- (Others)



**Source :** "Google Go" Sandwich Order Form

#### No Way to Visually Discern Cable/Port Capabilities



#### What do these do? What are they?

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# **USB Power Delivery Is the Key**

#### Human beings can't tell; computers know instantly.

- I can source 100w via USB PD 3.0, with Unconstrained Power
- I have Intel Thunderbolt™ 3 AltMode
- I have USB 3.2 and USB 2.0 gadget too
- I also have a USB endpoint I'm an external hard drive



- Sorry bud.
- I'm only a USB 2.0 cable
  I don't have enough wires
- ... but can carry 5a (at 20V USB PD 3.0)



- OK. No worries. I got this.
- I only need 10w now, but 65w later
  My battery is full! (USB PD 3.0)
- I can host the USB 2.0 hard drive
- Let me warn the user for you!



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## Linux's USB Type-C<sup>®</sup> Connector Class

/sys/class/typec/

/sys/class/typec/port0

/sys/class/typec/port0/port0-partner/

/sys/class/typec/port0/port0-cable/

/sys/class/typec/port0/port0-cable/port0-plug0

/sys/class/typec/port0/port0-cable/port0-plug1

/sys/class/typec/port0/<alternate mode>/mode1/

Bubbles up TCPC and Embedded Controller function to Userspace.

**Source:** https://www.kernel.org/doc/html/latest/driver-api/usb/typec.html

Me

**My partner** 

SOP'

SOP"

**Our cable** 

C chrome

THUNDERBOLT

### **Mockup: Phone as PD analyser**



**Source:** "Twebkie" web-app by David Schneider (Google) https://twebkie.org/

■	SNIFFER	CONSOLE	FIRMWARE
•	Auto tracing		
VBUS 14	865 mV -2731 i	mA	
	time	type	packet
0	03:17:09.778	VBUS	2546 mV -1 mA
1	03:17:09.780	VBUS	5108 mV 0 mA
2	03:17:09.793	VBUS	311 mV 0 mA
3	03:17:10.063	VBUS	5105 mV 0 mA
4	03:17:10.171	SRC/DFP	SOURCE CAP
5	03:17:10.172	SNK/UFP	GOOD CRC
6	03:17:10.173	SNK/UFP	REQUEST
7	03:17:10.174	SRC/DFP	GOOD CRC
8	03:17:10.175	SRC/DFP	ACCEPT
9	03:17:10.176	SNK/UFP	GOOD CRC
10	03:17:10.188	VBUS	5106 mV -428 mA
11	03:17:10.285	SRC/DFP	PSRDY
12	03:17:10.286	SNK/UFP	GOOD CRC
13	03:17:10.296	VBUS	4503 mV -2942 mA
14	03:17:10.723	SNK/UFP	REQUEST
15	03:17:10:726		timeout
16	03:17:10.727	SNK/UFP	GOOD CRC
17	03:17:10.759	VBUS	5441 mV -2834 mA
18	03:17:10.761	VBUS	6278 mV -2845 mA
19	03:17:10.763	VBUS	7023 mV -2851 mA
20	03:17:10.770	VBUS	7705 mV -2855 mA
21	03:17:10.773	VBUS	9418 mV -2873 mA
22	03:17:10.777	VBUS	10386 mV -2711 m/
23	03:17:10.789	VBUS	11163 mV -2716 m/
2.4	03:17:10.791	VBUS	12590 mV -2715 m/
25	03:17:10.805	VBUS	13178 mV -2720 m/
26	03:17:10.807	VBUS	13742 mV -2720 m/
27	03:17:10.823	VEUS	14258 mV -2722 m/

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### **Mockup: Expose device capability**



**Source: VDM:DiscoverIdentity** + DP USB2.0 Billboard Class Touch Technologies 3p Launcher for Android



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#### **Remaining Work for USB Type-C<sup>®</sup> Connector Class**

- Initially written and upstreamed to mainline Linux in 2017 and out of date.
- Need to sync to latest USB Type-C<sup>®</sup> 2.0 -- USB PD 3.0 R2.0 -- and USB4<sup>™</sup> specs.
- Has no concept of SRCCAP and SNKCAP.
- Need to add Power Data Objects support to properly describe Supplies and Sinks.
- Passive and Active Cable VDO properties not fully exposed.
- UFP/DFP VDOs not exposed (new to USB PD 3.0 R2.0 spec)
- Partner needs indication of DRP, DRD, and UP
- Chrome OS support
  - cros\_ec driver in development

# Help Support This - Use Accurate Properties!

#### Vendors of Cables, Devices, Hosts, and Chargers: Accurately describe product in USB PD 3.0!

- SRCCAP and SNKCAP -- Fill out accurately!
  - UP=1 (if appropriate) Batteries: 1 when full, 0 when empty<sup>1</sup>
  - FRS Supported <u>Static</u> prope
    - Variable PDO

<u>Static</u> property (like DRP/DRD) List wide input Vin range (and test)

#### • VDM DiscoverIdentity -- Please respond, do not use chipset vendor defaults!

- VID:PID + bcdDevice
- $\circ$  AMA VDO
- UFP/DFP VDO
- Cable VDOs

[USB-Data ⇐ ⇒ USB-PD] response Check: MF, Data, Plug/receptacle, Supported Pins<sup>2</sup>

Check: Current, Speed, Length (latency)

- VDM DiscoverSVID -- Please respond accurately!
  - Modes
    List all AltModes

**Source :** <sup>1</sup>USB PD3.0 R2, Section 8.2.6 Use of "Unconstrained Power" bit with Batteries and AC supplies <sup>2</sup> VESA DisplayPort<sup>™</sup> AltMode Specification, Section "5. Discovery and USB PD"

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## **Call for Help - UCSI**

- Intel's UCSI needs major updating too in order to implement
- Ask would be mainly for UCSI specification:
  - Mandate passing up to the OS raw VDOs and PDOs wherever possible
  - Would allow kernel UCSI "USB Type-C Connector driver" to decode them
- Requesting help for ecosystems:
  - Benson's team will add FW + Kernel drivers for Chromebooks (and upstream to Linux open-source kernel)
  - UCSI developer team would need to assist for other PCs

Audience members today are key in helping make that happen.

## **Call for Help - Other Ecosystems**

- Similar reporting should be done in other OSes (not Linux) for users
  - Microsoft Windows, Apple macOS, iPadOS, etc.
- These OSes likely already have a similar framework
  - Keep them up to date with the latest USB Type-C, USB PD, and USB4 specs
  - Expose the information in a readable way in Device Manager/System Profiler

#### Benefit and importance same -- implementation slightly different.

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- BONUS TIME Q&A





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## Доверяй, но проверяй. (Trust, but verify.)









#### **Accurate DiscoverID Responses Matter!**



#### **Accurate DiscoverID Responses Matter!**



### **Accurate DiscoverID Responses <u>Matter!</u>**

#### Source: ChromeOS EC Feature: Enable wake on DP

https://chromium-review.googlesource.com/c/chromiumos/overlays/board-overlays/+/1764523



# Oh no, you broke it!

#### **Useful Tools for USB-C<sup>®</sup> Field Kit**



### **ChromeOS Open-Source Hardware: Fluffy**



### Wasn't enough: so we made a 20 x 20 model

