Today's headphone ecosystem is broken because it is analog based, allows limited connectivity and does not provide power. It is a closed system that does not allow innovation to occur.

Solution Statement

The group’s recommendation is to use USB-C as the physical connector, i.e. move from analog to digital. Improved connectivity will occur with the implementation of Soundwire as two-way digital communication will be enabled.

Draft Specification Features:

- Low pin count
- Digital bidirectional data
- Standardized command and control
- Discoverability
- Power management
- Interrupt handling
- Buffering
- Low latency
- Low gate count
- Should not need an MCU/MPU/DSP but enables one
- Should be backwardly compatible
- USB-C compatibility
- Active hearing protection
- Security options
- Support of headphones, microphones and sensors
- Variable clocking options
- Cable length requirements (3m) and can support longer cables
Support of studio standards (e.g. DXD)
Less than 10us latency mode (one way)
Support of Soundwire

**Minimum requirements are:**
1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 15, 17, 19

**Possible Additional Features:**
- Improved fidelity
- ANC inside the headset
- Sensor feedback
- No battery required
- Environmental and contextual awareness
- Dynamic adjustment of EQ/settings/etc.

**Work to be done:**
- Class definition
- New Physical Layer for Soundwire
- Reference design
- Hardware/Peripheral vendor support
- Ecosystem evangelization

**Actions List:**

<table>
<thead>
<tr>
<th>Responsible</th>
<th>Due Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Ricci / Terry Shultz</td>
<td>12/2/2014</td>
<td>Complete report for publication</td>
</tr>
<tr>
<td>Devon Worrell / Leng Ooi</td>
<td>12/31/2014</td>
<td>Work with USB-C ad-hoc to bring group’s recommendations to their attention</td>
</tr>
<tr>
<td>Jim Rippie</td>
<td>12/31/2014</td>
<td>Work with MIPI to bring group’s recommendations to their attention</td>
</tr>
<tr>
<td>Whit Hutson / Brad Lambert / Tony Doy</td>
<td>3/31/2015</td>
<td>Build reference designs to prove the recommendations can work in a real system</td>
</tr>
<tr>
<td>Everyone in group</td>
<td>6/30/2015</td>
<td>Promote to the wider community and advocate adoption</td>
</tr>
</tbody>
</table>

**Expanded Problem Statement**

**Technical Limitations – Headphones and Speakers**

1. Safety issues, ear damage
2. Prevents innovation – 3.5mm is hard barrier in place
3. Headphone sensitivity – standardization range; ear buds, headphones, wired vs. wireless
4. Common return leading to crosstalk & noise, HP to mic, L-R
5. Amplifier <> load mismatch
6. Testability – standard methodology?
7. 3.5mm socket limits slim devices
8. USB-C is a new physical connector which enables new protocols (including Soundwire and Slim bus if they don’t kill each other in the standards meetings)
**Constraints:**

Power consumption, cost, size, transducer excursion limits, and geographical laws

**Connectivity:**

1. Integration of more stuff – mics, sensors
   - Battery life – saving where possible
2. Wireless connectivity – is this out of scope?
3. Will certain companies force the issue – away from 3.5mm?
4. Charging – if only a single connector is available? Two USB-C or wireless + USB-C?

**The vision 5 years out: I plug in my USB-C (or other) connector and….**

- I get better audio (high-res, spatialization or HRTF, multichannel feed, custom mix)
- I get medical applications (that are encrypted for security)
- My Augmented Reality audio for gaming (XYZ dimensions) sounds great (motion sensors)
- I go hunting and have killer audio cues
- My listening device is recognized, then personalized for my listening experience and hearing ability
- The room is scanned and the HRTF is adjusted to suit
- Sensor (mics, motion, heart rate, etc) integration aids my listening experience (active feedback)
- Active hearing protection
- Active sealing compensation

**Experience:**

- Augmented reality – head tracking, motional
- HRTF – need to identify the device
- Tone shaping – where does it live, headset or device? Automatic?
- Solving the headset button issue – I push buttons – nothing happened. Should there be one standard to rule them all? Active circuitry on the headset – or passive and sensed on the device?
- How many channels is enough?
- In-the-box ear buds are cheap? What features makes an aftermarket headset compelling?
- What drives adoption? In-box will always be low quality – what do users want in an aftermarket headset?
- Mechanical noise – cables rubbing on shoulders, etc microphonics
- Hearing impaired – prescription ear buds? Extract prescription > download profile
- Why wired? Charging issues, too expensive for in-box

**Applications:**

- Music Listening
- Audio Books
- HRTF
- Multichannel
- ANC
- Active Hearing Protection
- Fidelity Enhancement = headphone, speaker Identification for association with User Defined DSP algorithms

**Ideas for the Story:**

- How do we transition to Nirvana?
- What’s wrong now?
I have to buy another freaking accessory?
What is compelling to make me buy an aftermarket headset?
Appropriate transition path?

Introduction:

Ear pod is Nirvana (see Project Bar-B-Q 2007 report, iHear the Future)

Output: (why analog 3.5 and today’s USB 2.0 is not good enough)

What challenges still unresolved, why re-invent, alternatives...

- HP Devices, Sensors, Transducers, Card Reader, MI accessories etc.
  - No Power (analog) (today’s feature headphones require a battery)
  - No Digital (analog)
  - High processing Overhead (USB 2.0 and today’s audio stack)
  - Power budget (USB 2.0)
  - Analog Crosstalk
  - Limited number of analog channels (2 earpiece, 1 mic)
  - No feedback channel to support adaptive environmental awareness / adjustment
  - No intelligent device identification (headset vs. headphone; in-ear vs. circum-aural or supra-aural)
  - Long term peak acoustic standards dependent on headphone device and driver product BOTH meeting regulatory requirements
  - Cannot store user-specific parameters (prescription / preferences)
  - No digital mic input
  - No sensor support
  - No power budget control or dynamic resource allocation available
- Connectors, cables
  - Size is an issue (today’s connectors are too big in z-axis)
  - Pin definition still in progress – two digital pins still available
  - Analog 4-pin audio is supported with an i.d. resistor in the connector
  - Soundwire could be a good choice, but MIPI did not address long cable problem.
  - Mechanical reliability
  - The button conundrum
  - Enough pins for command and control and data protocol
  - No sensor data on Soundwire (MIPI)
- Motherboards
  - Layout issues – analog requires final interface to be physically close to the connector
  - Grounding / crosstalk, low-quality flex film
- Audio hardware vendors
  - USB is not evolving fast enough for audio on it’s on – it’s broken (DW)
  - Latency (usb)
  - Clicks / pops
  - Fidelity (noise floor, crosstalk)
  - Power states
- DSP processing Core
  - No idea or standardization of interface parameters or requirements
  - No flexible DSP applications for these devices (agree on whose processing gets priorities – let the best technology win, and there’s no arbitration structure in place)
  - Handshaking (see monkey bus)
- SoC vendors
  - Everyone has their own COMPETING strategy (business and technology)
  - Difference in applications (mobile vs. PC)
• Cannot guarantee good experiences -- don’t have enough information for discovery, arbitration
  • Cannot support environmental awareness (continually sensing) or keyword voice wake in low power
• Algorithms and Brand
  • Everyone says that theirs is the best
  • Brand differentiation is hard to do without self-identifying products and feature arbitration
• Applications and operating systems
  • Device discoverability and identification
  • Cannot parse and pass the metadata
  • Application vendor: Legacy, base
  • Need more classes (whitelist is a kludge solution)
  • Where to put volume control
  • No common format (digital audio)
  • App has to support all the advanced features (HRTF, head tracking, blah blah)
  • Sensor processing has to reside in the app

1. Possible solutions (pros & cons)

  • Use today’s USB and analog 3.5mm (do nothing)
    a. Does not give new digital solutions – solves nothing
    b. Today’s connector is not reversible
  • Fix USB connector but leave protocol at 3.1
    a. Doesn’t solve power, cost, latency, stack overhead
  • Wireless ubiquity
    a. Does not provide power
    b. More hostile RF environment
    c. No backwards compatibility
    d. Latency
    e. Security
    f. Airplane mode
  • Use new USB-C (and / or others who must not be named) capability to define new interfaces
    AND a better reversible connector
    a. Provides the framework to solve all of the issues as called out
    b. Analog backwards compatibility
    c. Handshaking & protocol
    d. Multi-channel digital audio
  • Thunderbolt
    a. Too big, proprietary
  • Convert existing 3.5mm 4-pin connector to digital
    a. Mechanical reliability
    b. Stupid user syndrome (autodetect analog vs. digital device)
    c. Data integrity
  • 5-pin 3.5mm or 2.5mm
    a. Mechanical nightmare
    b. Poor reliability

2. Challenges to solution

  a. Regulatory requirements
  b. EMI / EMC / RFI conducted and radiated
  c. Component specifications (device vs. system)
  d. New system application performance requirements
  e. Higher cost (perceived)
  f. More complex solution – potential for implementation errors
g. There is no class implementation (discoverability, C&C, Power) and they must all be created
h. Support forever?
  i. Don’t alienate existing install base
  j. Daisy chaining / bridging strategies are needed

3. Planners and marketers business path to management

   a. HP Devices, Sensors, Transducers, Card Reader, MI accessories etc.
   b. Connectors, cables
   c. Motherboards
   d. Audio hardware vendors
   e. DSP processing Core
   f. SOC vendors
   g. Algorithms and Brand
   h. Applications and operating systems

4. Domains

   a. HP Devices, Sensors, Transducers, Card Reader, MI accessories etc.
   b. Connectors, cables
   c. Motherboards
   d. Audio hardware vendors
   e. DSP processing Core
   f. SOC vendors
   g. Algorithms and Brand
   h. Applications and operating systems

5. Recommendations and strategies

   a. Reference designs
   b. Application documentation and support
   c. Standards bodies
   d. Test strategy
   e. Celebrity endorsement

Other Reference Material
What does USB-C look like:

- Analog Audio is standard as part of the specification is support for all the same capabilities as currently supported by the 3.5mm “Universal Jack”
  - Analog Headphones
  - Analog mono microphone
  - In-line buttons
  - Headphone, Microphone or both detection

USB-C provides Universal support going forward
- CTIA (more typical) and OMTP headsets
- Stereo Line input and output
- Stereo stand alone Microphone
- Simple dongle with no active components
- Simple Decode of CC1 & CC2
- Option for alternate Modes with Secondary Digital Audio for docking

**USB-C provides Universal support going forward**

- Analog Appliance mode, if implemented, would best be implemented on all USB-Type C connectors
  - Should have all the features of 3.5mm Universal Jack and not sub-set
  - Enables multiple Analog device support and new usage opportunities
- Audio hardware needs to be close to the USB Type C connector
  - Audio hardware should provide any swapping logic needed
  - Optimize for 2 connector/jacks for one audio hardware component
- Docking “standardization” uses Digital interface not analog and currently on path to use Soundwire* on USB Type C alternate mode
  - Using USB not best or well aligned with offloading capabilities and consistent user experience
- Digital Audio as a 2nd interface for walk up ports is not being pursued at this time

**Next Generation suggested audio hardware view**

- New Codecs being developed to support USB-C & Soundwire
- Full and “Jack” versions reduce number of packages required
- Bridging to Soundwire enables new “Smart” microphones and speakers
An example Screen/Lid audio solution

- 3.5mm headphone jack and USB-C Connector
- External USB 2.0 switch is required
- Codec built in Class D amplifier drives speaker has Basic SPL
A Design for a Dock/Base

- 3.5mm headphone jack and USB-C headphone (USB2 switch is required)
- External amplifier is used to drive speaker with larger SPL and better sound

Using Soundwire as a 2-pin interface in one or more of the USB-C Guest modes, such as for docking

- Selecting A6/B6 is recommendation
- In this case will not short A6/B6 and A7/B7 on both Lid and Base side
- A6 and A7 are USB 2.0 D+/D- bus, B6 and B7 can be used as serial link to convey digital audio content and controls when in docking alternate mode