Wi-Fi for IoT: Overcoming Connectivity Standard Fragmentation Using a Software-Defined Modem

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Linley IoT Conference, April 27, 2016
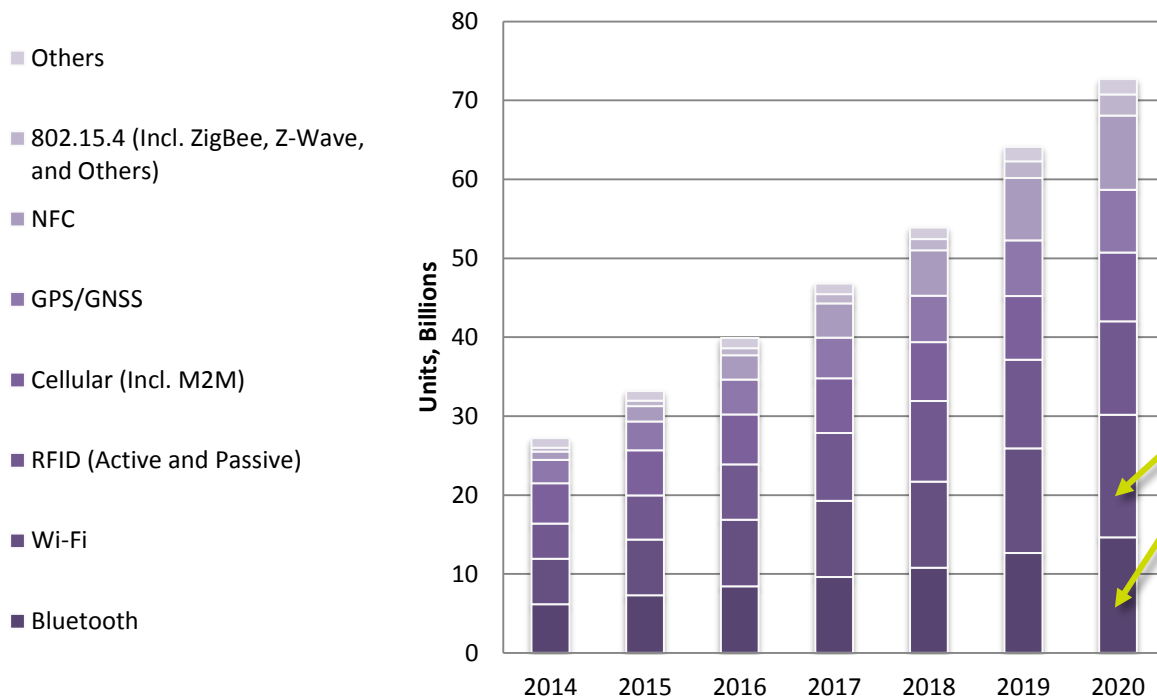
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Agenda

▶Wi-Fi in IoT

▶Wi-Fi Complexity & Fragmentation

▶Using Software based Phy solution to address those issues

▶Conclusion

Wireless Technologies in IoT Devices

CEVA®

Installed Base of Wireless Connected Devices by Technology

Legend:
- Others
- 802.15.4 (Incl. ZigBee, Z-Wave, and Others)
- NFC
- GPS/GNSS
- Cellular (Incl. M2M)
- RFID (Active and Passive)
- Wi-Fi
- Bluetooth

Chart: Units, Billions (y-axis 0–80) for years 2014, 2015, 2016, 2017, 2018, 2019, 2020
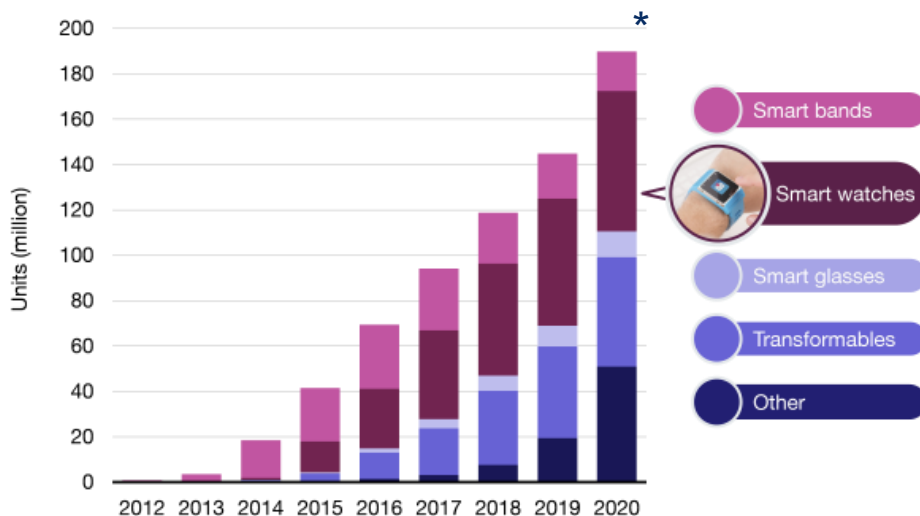
IoT devices are all getting connected wirelessly

Wi-Fi and/or Bluetooth in more than 30 billion devices by 2020

Wi-Fi connections forecast to overtake Bluetooth by 2020!

IoT & Wearable Markets – Key Trends

- The Internet Of Things becomes personal
  - Smart City → Smart Home → Smart People/Body
- Wearable devices to become fastest ramping consumer technology device to date
  - Faster than even smartphones and tablets
  - CAGR of 50% between 2014 and 2020
- Mass adoption depends highly on price
  - Cost-down cycle requires further system integration
  - Many Wi-Fi enabled SoC design opportunities

Smart bands
Smart watches
Smart glasses
Transformables
Other

Wireless Technologies in IoT Devices

▶ IoT devices are all getting wirelessly connected

▶ Wi-Fi and Bluetooth are by far the most popular wireless technologies in IoT Devices

▶ Wi-Fi and/or Bluetooth in more than 30 billion devices by 2020

▶ Wi-Fi connections forecast to overtake Bluetooth by 2020!

▶ Wi-Fi in IoT devices:

  ▶ Smart Home to represent more than 50%
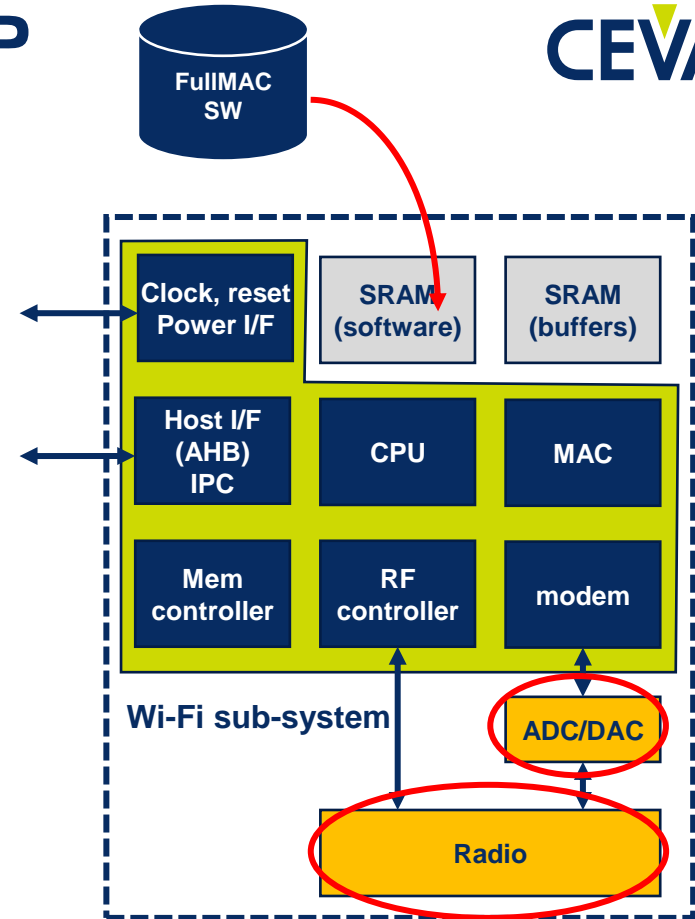 ▶ Attach rate approaching 20% in wearable

A big IoT market: The Smart Home
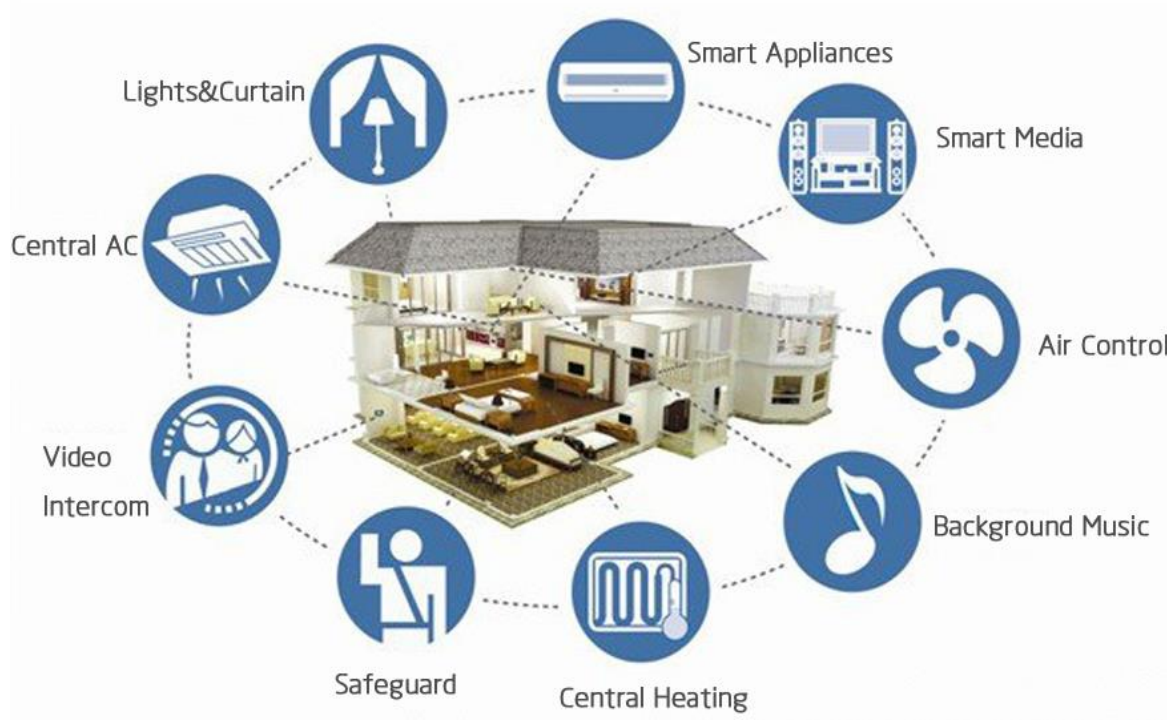
- ▶ Market potential of 15+ nodes in 600+ million households, creating a 10+ billion market!

- ▶ Huge potential for Wi-Fi:
  - ▶ Multi room video and audio streaming
  - ▶ Surveillance camera
  - ▶ Smart appliances
  - ▶ …

- ▶ TV and OEM remote control to become the biggest Wi-Fi markets in Smart Home

Wi-Fi IP: a complex system IP

- A Wi-Fi IP is a complex System IP with
  - Hardware accelerators
  - Software protocol stack
  - DSP
  - CPU platform: CPU, bus system, interfaces
  - Memories
  - Clock and power management
  - Analog & radio (process dependent)

- CEVA shave the complexity by providing a fully integrated sub-system for easy and fast integration into SoC, while enabling evolution and differentiation

FullMAC SW

Clock, reset Power I/F

SRAM (software)

SRAM (buffers)

Host I/F (AHB) IPC

CPU

MAC

Mem controller

RF controller

modem

Wi-Fi sub-system

ADC/DAC

Radio

Wi-Fi IP creating minimal constraints

▶ Constraints on MCU/APU should be minimized

- ▶ No real time constraints
- ▶ No interference with application, and vice versa
- ▶ Maximum task off loading

▶ CEVA simplifies application development by providing a self contained isolated system IP which does not interfere with the MCU/APU

Low Power Wi-Fi IP

▶ Low Power is key, particularly in wearable

▶ Supports all protocol level low power features
  ▶ Ex: WMM-PS

▶ Efficient clock gating during active and sleep modes
  ▶ Functional clock gating: functions are gated when not in use
  ▶ Friendly design with automatic clock gating (done at synthesis level)

▶ Efficient power gating
  ▶ Several power domains
  ▶ Switch off most of the design when in low power mode
 ▶ Small retention memory, short wake up time

Interoperable Wi-Fi IP

▶ Wi-Fi is a complex standard

▶ Need to ensure interoperable Wi-Fi IP for best user experience

  ▶ Interoperability with the standard (Wi-Fi Alliance CERTIFICATION)

  ▶ Interoperability with 3rd party solutions
    ▪ Some may have bugs or limitations

  ▶ Upgradable to performance improvement and differentiation
    ▪ Thanks to use of DSP

▶ Need to enable an easy implementation of patches

  ▶ Highest flexibility to handle a bad behavior with a buggy 3rd party device by a software patch
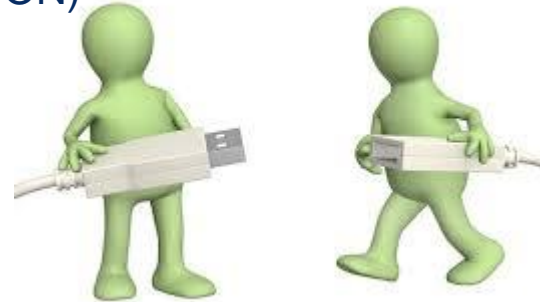
Wi-Fi standard fragmentation
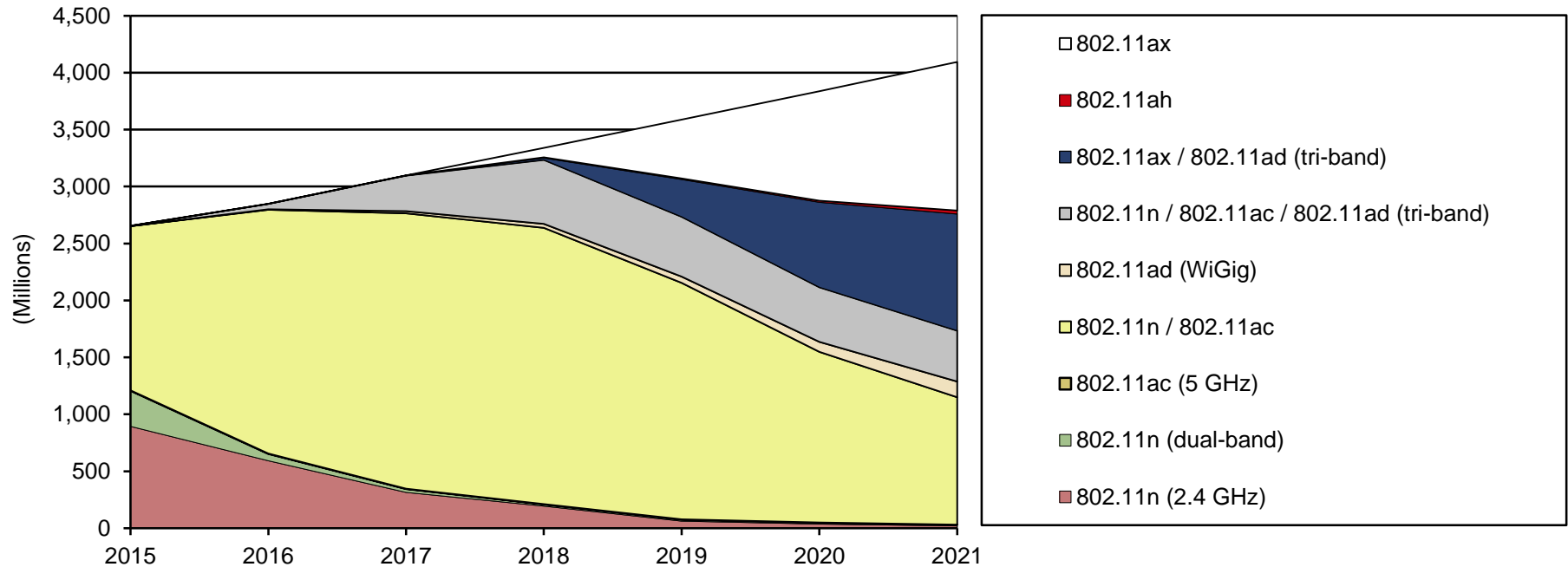
▶ Wi-Fi format fragmentation is expanding, hard to predict which flavor to start with

    ▶ 802.11n / 802.11ah(Hallow) / 802.11ax?

RivieraWaves Wi-Fi Platforms

CEVA®

Industry's Smallest, Most Power-Efficient Wi-Fi IP Platforms
Complete solutions including PHY and MAC, up to 802.11ac 4x4

	Full MAC	HW PHY	SW PHY
RivieraWaves Sense: 802.11b/g/n 1X1	✓	✓	✓
RivieraWaves Surf: 802.11ac 1X1 and 2X2	✓	✓	
RivieraWaves Stream: Up to 802.11ac 4X4	✓		✓

► **RivieraWaves Sense: 802.11b/g/n 1X1**
  ► Lowest power, lowest cost
  ► Available as hardwired or software-based modems
  ► Upgradeable to support 802.11ah and LTE Cat0

► **RivieraWaves Surf: 802.11ac 1X1 and 2X2**
 ► Low power design
  ► Supports Wave 2 MU-MIMO

► **RivieraWaves Stream: Up to 802.11ac 4X4**
  ► Flexible & future-proof SDM design for wireless infrastructure
  ► High throughput up to 1.7Gbps MU-MIMO

CEVA Wi-Fi high level integration scheme

- From integration point of view:
  - MAC SW
  - MAC HW
  - PHY

- Same architecture is used for:
  - 802.11n
  - 802.11ac
  - 802.11ah
  - 802.11ax (roadmap)

- Exact same MAC is used

➔ Only PHY requires upgrade
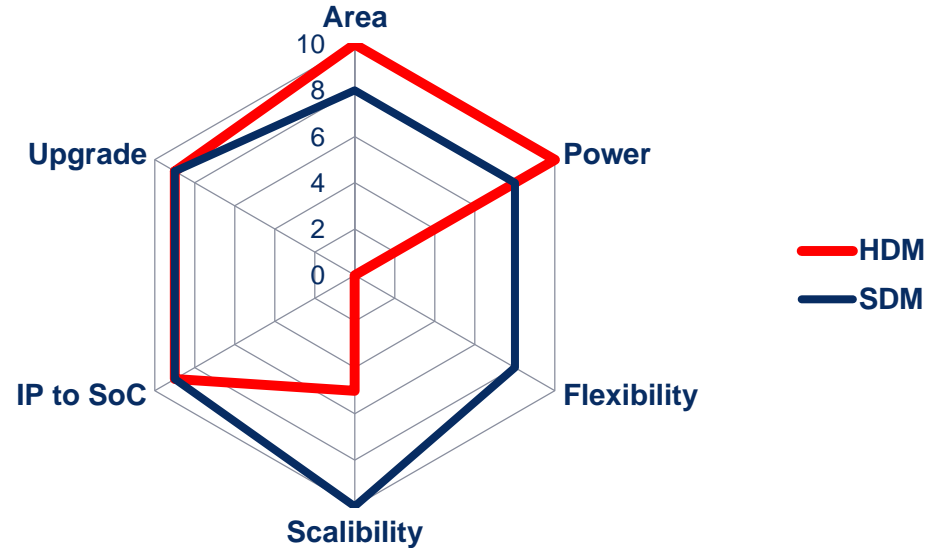
Software Defined Modem

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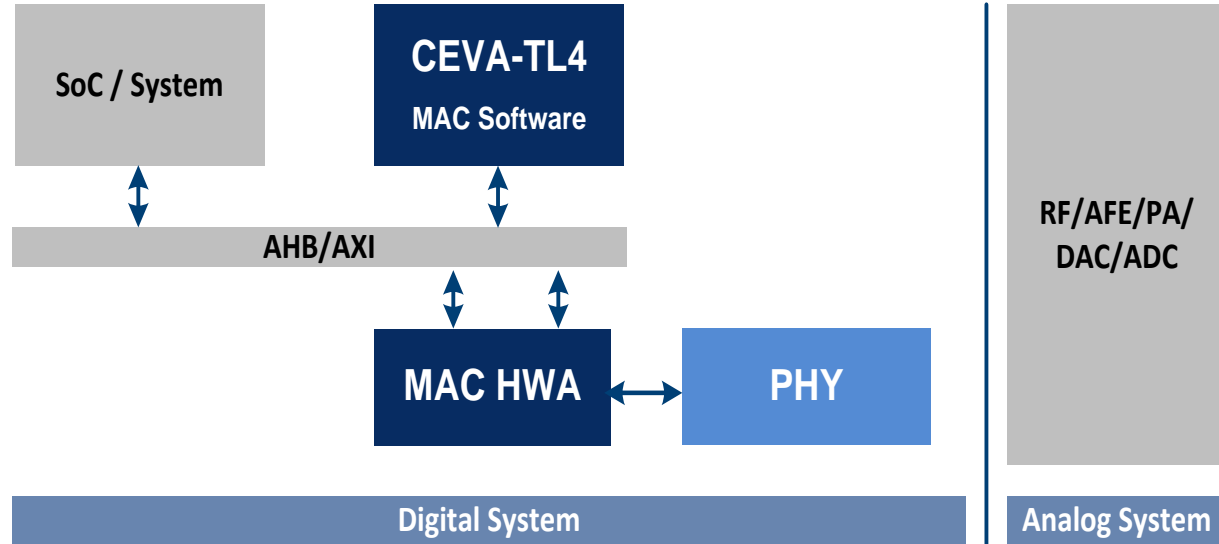
- ▶ SDM HW/SW split:
  - ▶ RF interaction done in HW
    - ▶ Allows maximum power saving
  - ▶ Fixed algorithm in HWA-2
    - ▶ Allows maximum power saving
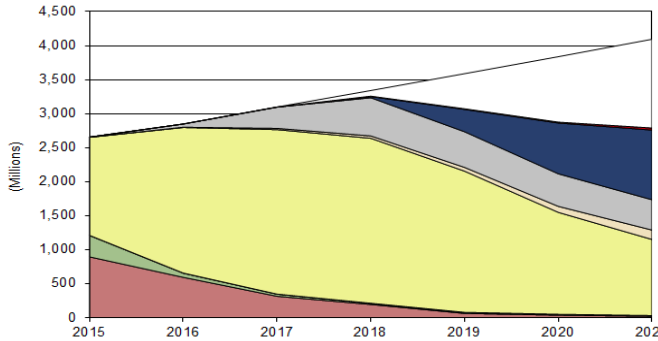 - ▶ DSP SW can be tuned for every scenario

PHY

SW MDM

DSP XC-5

Bus Matrix Interconnect

MAC HWA

HWA-2

HWA-1

RF/ Analog System
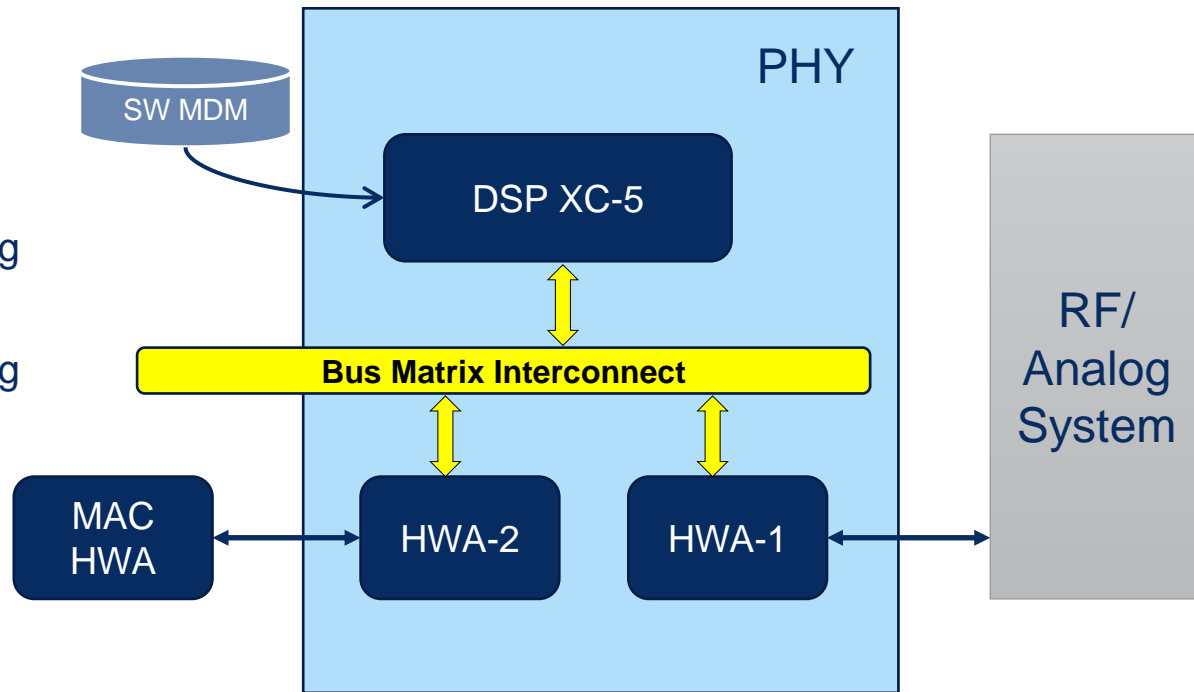
Hardware vs Software defined Modem

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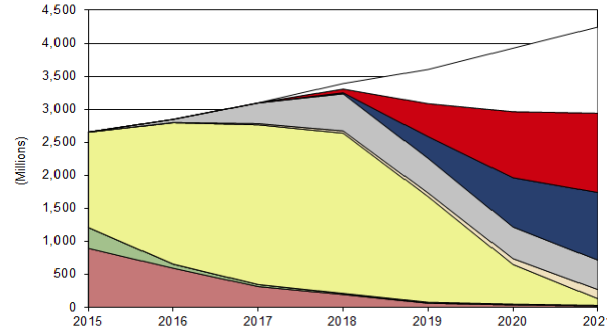
▶ HW/SW defined modem pros/cons

  ▶ Hardware defined modem allows:

    ▶ Best area

    ▶ Maximum power efficiency

  ▶ Hardware drawback:

    ▶ Fixed implementation => no flexibility

  ▶ Software defined modem allows:

    ▶ High level of flexibility

    ▶ High level of scalability

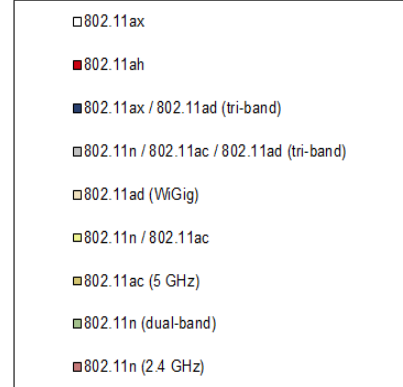 ▶ Software drawback:

    ▶ Small penalty on area and power

Radar chart with axes: Area, Power, Flexibility, Scalibility, IP to SoC, Upgrade. Scale 0 to 10. Legend: HDM (red), SDM (dark blue).

Hypothetical several Wi-Fi standards trends

Current outlook

What if scenario

Legend:
- 802.11ax
- 802.11ah
- 802.11ax / 802.11ad (tri-band)
- 802.11n / 802.11ac / 802.11ad (tri-band)
- 802.11ad (WiGig)
- 802.11n / 802.11ac
- 802.11ac (5 GHz)
- 802.11n (dual-band)
- 802.11n (2.4 GHz)

- SDM allows to:
  - address several standard flavors and several scenario
  - address it in a fast way with existing HW
  - delay the decision to go to full optimization

In the what if scenario SDM allow to wait 2019 to go to 802.11ah full optimization but still addressing this market with low penalty

SDM platform

▶ **SDM platform:**

  ▶ Reduces the cycle time to address several Wi-Fi markets

  ▶ Cost effective (versus buying off-the-shelf chips)

  ▶ Scalable solution (1x1-802.11n => 2x2-802.11ac and beyond)

  ▶ Enables differentiation

    ▶ Customers can add their secret sauce by software

▶ **Wi-Fi SDM is part of CEVA Dragonfly solution:**

  ▶ Dragonfly = DSP + HWA + SW libraries

  ▶ Enables to go beyond just Wi-Fi and addresses different wireless standards like 802.15.4g, Sigfox, LoRa, LTE Cat M, NB-IoT, GPS, …

Conclusion

- SDM Wi-Fi integration is a smart choice for IoT
  - Wi-Fi is ubiquitous and is the best wireless technology to connect to internet
  - SDM platform enables evolution and differentiation
  - Small, cheap, low power
  - Lower power than Bluetooth when higher data transfer required

- CEVA is the smart choice for Wi-Fi IP
  - Widely adopted in APAC, Europe and US
  - Only IP company to provide turnkey solutions for all flavors from 11n1x1 → 11ac 4x4, including SDM platforms
  - Highest experience in licensing and supporting Wi-Fi since 2002!

CEVA
The DSP Powerhouse

Thank You
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