

2023 Wireless Connectivity Market Analysis Report Summary

Takeshi Niwa

丹羽 健

Techno Systems Research

niwa@t-s-r.co.jp



About the report

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Research Items

<Wireless LAN>

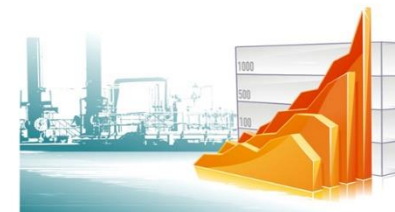
Market Forecast and Break down by Application, Standard/Radio Band (2.4/5/6GHz), WiFi Chip and Module Market Share, Vendor Trend

<Bluetooth/BLE>

Market Forecast and Break down by Application, BLE, Bluetooth/LE Audio, BLE location, automotive... Bluetooth/BLE Chip Market Share, IC Vendor Trend

* Sample report is available.

Please inquiry sample report to Takeshi Niwa (niwa@t-s-r.co.jp)



1. 2023 Wireless Connectivity Market Summary

IC Supply Disruption

2021: IC supply shortage/ strong IC demand across all major end market. Severe shortage for IoT and Auto.

2-3Q/2022: IC supply turn from shortage to over-supply, followed by the demand weakness/ economic down trend (COVID-lockdown, Russian invasion, raw material cost increase..)

2021-2022: User companies and distributors gained IC inventory for BCP. In 2023, many companies reduce the inventory.

- Many chip suppliers expected to suffer by Inventory correction in 2023.
- IC material cost hiked in 2021-2022, remains high in 2023. IC wafer price expected to drop in 2023/ chip price will drop in 2024.

Market Trend- WiFi

- 2022 WiFi device market dropped by 13.9% YoY. Massive decline in Mobile, PC, Smart Home, Home IoT. Industrial and Auto market grew. 2023 market remains weak due to inventory and macro economy. Recovery expected in 2024-2025.
- WiFi 4/5 to WiFi 6 migration ongoing. WiFi 6 accounts 31% in 2023. WiFi 6 adoption expands to auto, CE and IoT devices in 2022 onwards. WiFi 7 arrived the market in 2023. WiFi 8 expected to appear in 2026-2027.
- WiFi emerging application: Smart Home/ Home automation, Industrial/commercial devices, and Automotive.
- Matter support for smart home devices: adding 802.15.4/Thread/Matter on smart speaker, smartphone and MCU WiFi

Market Trend- Bluetooth

- 2022 Bluetooth device market dropped by 6.3% YoY. Mobile, PC, CE, audio, wearable dropped. Home/industrial automation, automotive, healthcare...grew. Like WiFi market, weak market trend continues in 2023.
- Bluetooth emerging application: Home/Industrial automation, smart home, asset tracking/proximity tag, healthcare, retail automation (ESL), automotive digital key, voice smart watch, gaming headset, broadcast speaker, and more. Bluetooth expands application by adding new features like AoA, channel sounding, LE audio, PAwR, as well as new profiles.

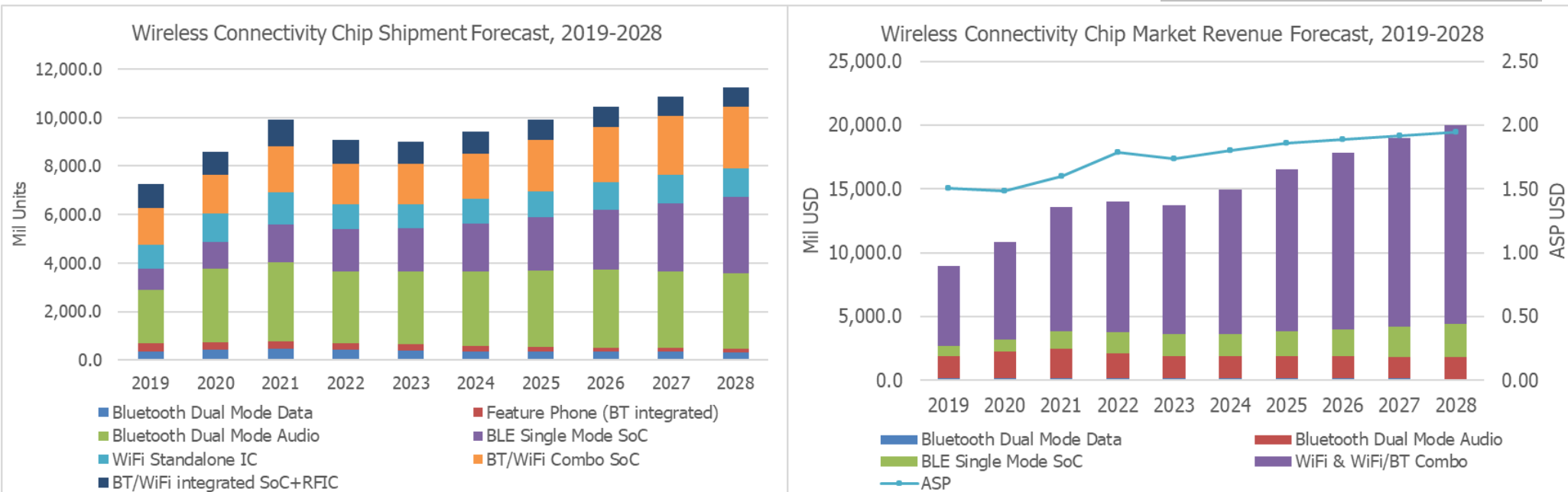
Wireless Chip Industry

- Geographic decoupling – growing local suppliers in China market/ less dependence of China suppliers in western market (depends on end market). More Chinese start-up joins the competition.
- WiFi 7, high end Bluetooth Audio start using 6/7nm advanced node. 12/14nm becomes popular in WiFi 6 and High end BT Audio. MCU WiFi, BLE SoC gradually migrating to 22/28nm from 40/55nm. 22nm and 12nm will be the mainstream process node in the future.

2. Wireless Connectivity Chip and Application

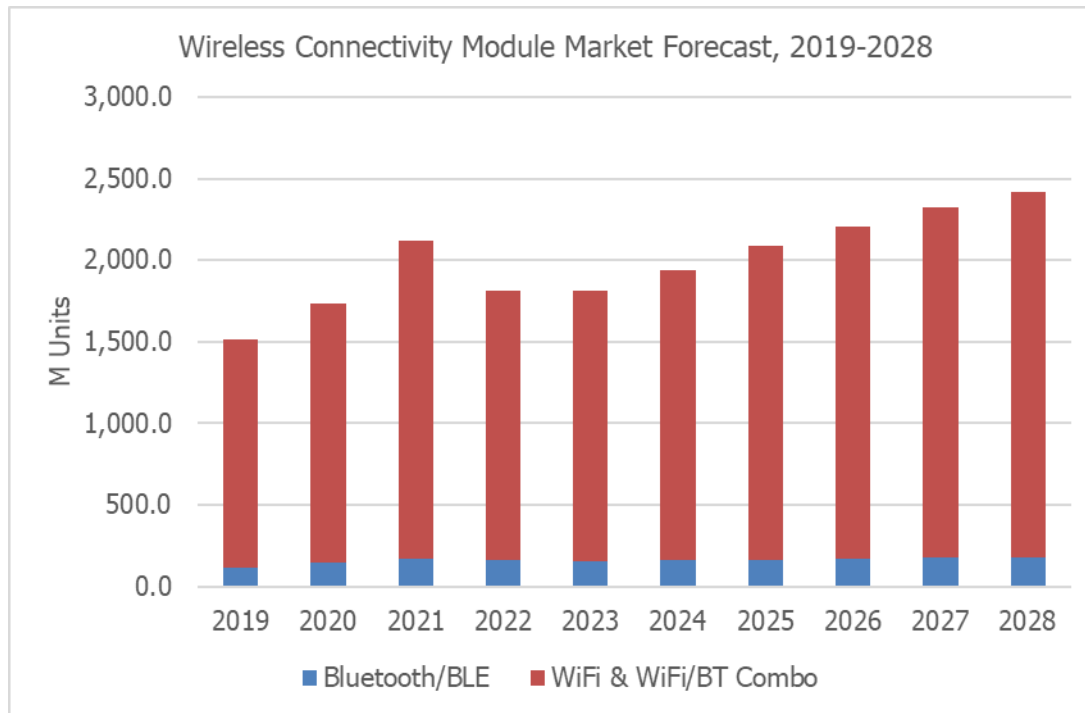
| Wireless Chip | Application | Main Suppliers |
|--|---|---|
| Bluetooth Dual Mode Chip | <p>Bluetooth Data: Bluetooth Serial Module, Handheld Device, POS terminal, HID, Remote Controller</p> <p>Bluetooth integrated Feature Phone SoC: Feature Phone, Wearable</p> <p>Bluetooth Audio SoC: Headset, Earbud, Audio Speaker, Smart Watch, audio transmitter, toy...</p> | <p>Data Bluetooth: YuChip, Qualcomm, Infineon, MediaTek, Realtek, TI, Beken</p> <p>Audio Bluetooth: Qualcomm, Apple, Airoha, Bestech, Realtek, Broadcom, HiSilicon, Actions, Zgmicro, AppoTech, Bluetrum, Beken, Jieli, Freqchip, YiChip, WuQi...</p> |
| BLE Single Mode Chip | Wearable, Healthcare, Tag/Beacon, HID, RCU, Home/Building Automation, mobile accessory, automotive digital Key, TPMS, ESL... | Nordic, Renesas, Telink, Realtek, PhyPlus, Qorvo, ST, Infineon, TI, NXP, SiLabs, Beken, Ambiq, Atmosic, OnSemi, EMMicro, OnMicro, Goodix... |
| WiFi Combo Chip/ Standalone WiFi | <p>Smartphone, Tablet, PC, TV, OTT box, Smart Speaker, Infotainment, Telematics, Smart Watch, Printer, Digital Camera, Home Appliance, IP Camera, Industrial Terminal...</p> <p>WiFi only: Printer, USB adaptor,</p> | Broadcom, Qualcomm, MediaTek, Realtek, Intel, Infineon, NXP, HiSilicon, Espressif, Beken, Apple, TI... |
| WiFi Networking Chipset | WiFi Router/AP, WiFi Broadband Gateway | Broadcom, Qualcomm, MediaTek, Realtek, MaxLinear, SiFlower, Renesas, ZunPai |
| MCU embedded WiFi (WiFi only or WiFi +Bluetooth/802.5.4) | Home appliance, Air Conditioner, Small Appliance, Home Automation, IP Camera, Industrial terminal, industrial automation, Lighting | Espressif, Realtek, Beken, Infineon, NXP, MediaTek, TI, SiLabs, Renesas, ASR, BouffaloLab, iComm, UNISOC, I&C... |
| Bluetooth/WiFi integrated SoC/AP | Smartphone, Tablet, Smart Watch | Qualcomm, MediaTek, Samsung, UNISOC |

3. Wireless Connectivity Chip Market Trend



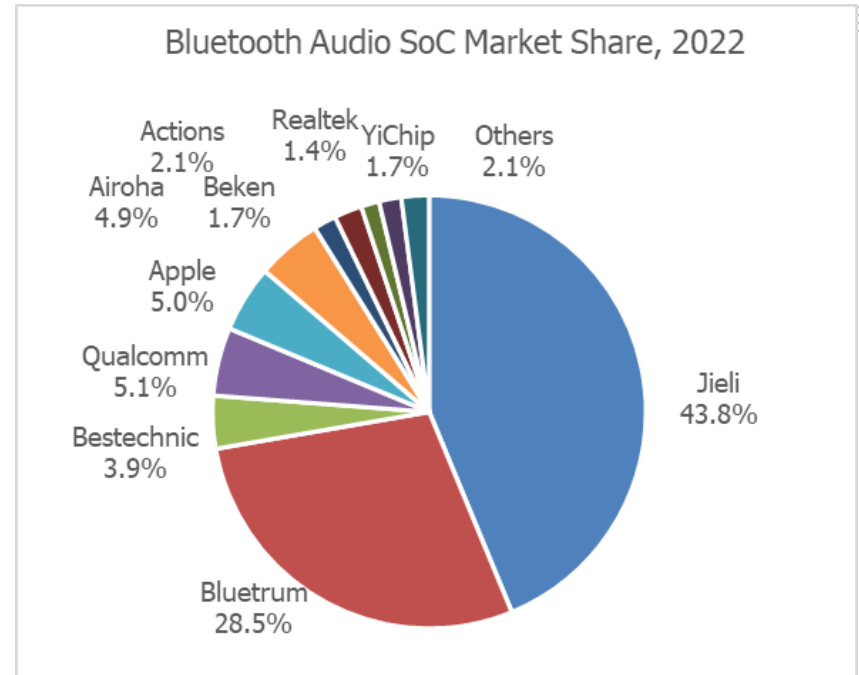
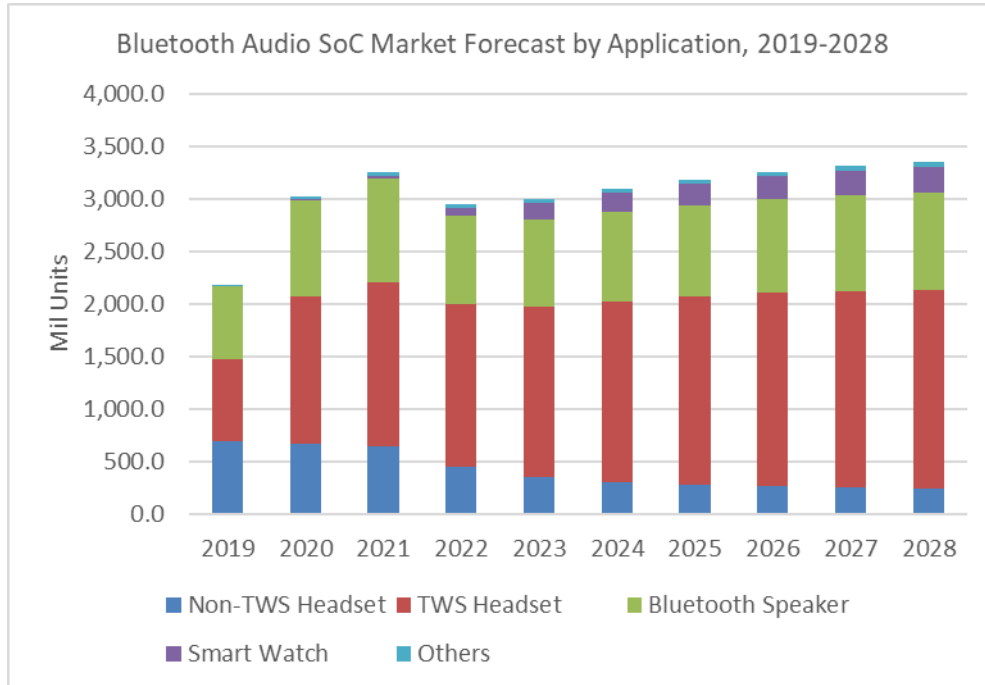
- WiFi/BT total chip volume dropped by 8.4% to 9.1 Billion units in 2022. Continuous decline expected in 2023 for inventory and weak economy. Shipment start to rebound in 2024.
- BLE and BT/WiFi combo chip supports the long term market growth.
- WiFi and combo IC (excluding WiFi integrated SoC) total volume decreased by 14.6% to 2.7 Billion units in 2022. 2023 volume will drop by 1.7%.
- Bluetooth chip (dual mode data/audio, BLE) volume decreased by 4.2% in 2022, better than WiFi market trend. 2023 volume is expected to recover slightly in 2023.
- Wireless chip revenue grew by 2.8% to 14 Billion USD in 2022, due to the IC cost/price increase. 2023 revenue will drop by 2.1% due to the product mix (WiFi shrink). Chip cost increased from 2021 to 2022 but Silicon wafer cost will drop slightly in 2024.
- In 2024 onwards, wireless chip ASP will continue to rise gradually thank to the WiFi standard migration (WiFi 4/5 to WiFi 6/7), MCU/AI... integration in IoT chips.

4. Wireless Connectivity Module Market Trend



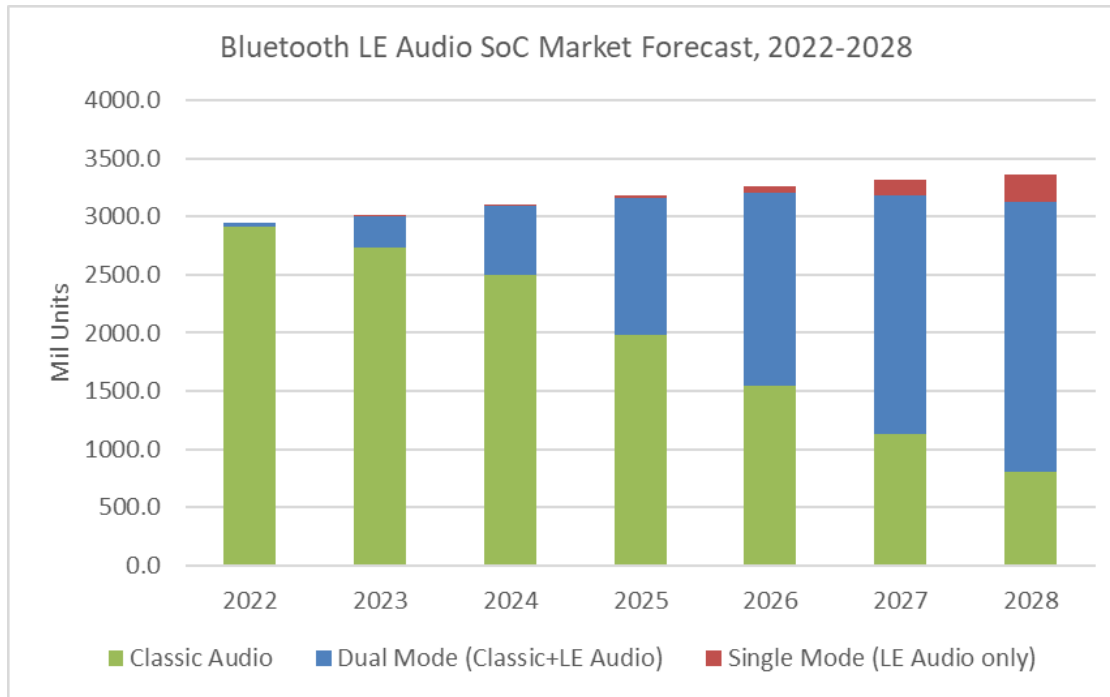
- Definition: WiFi & Bluetooth Module, PCB or SiP module. Excluding WiFi FEM, System on Module (AP+OS + Connectivity), PCBA.
- WiFi Module attach rate is around 60% total WiFi IC shipments. Module adoption rate differs by application, project volume, or RF design expertise in customer side. WiFi AP/Router basically does not use WiFi full module. Many of smartphone and tablet, low end smart speaker and OTT streaming box does not use module.
- In Bluetooth, module adoption rate estimated at 5-8% of Bluetooth IC device shipments. Bluetooth is easier to make chip on board than WiFi. Bluetooth module adaption rate is in shrink trend.

5. Bluetooth Audio SoC Market



- Bluetooth Audio SoC market shrunk by 10% to 2.95 billion units in 2022 followed by the weak consumer demand.
- China low cost BT audio suppliers (Jieli, Bluetrum, YiChip, Beken..) accounts about 75% in volume, but only 30% share in revenue in 2022.
- Low end Bluetooth audio suppliers shows recovery in 2H2022/ 1H2023. Mid/high end suppliers suffers by weak demand during 2022 and 2023. In low end segment, Beken dropped while Bluetrum gained shipment volume . In mid/high segment, all major chip suppliers decreased shipment volume in 2022.
- Smart watch market grows rapidly in Bluetooth audio SoC market. Expected to reach 150+ Mil units in 2023, double from 2022. Bestechnic, HiSilicon, Realtek, Actions, YiChip, Jieli, Bluetrum as main Bluetooth voice smart watch SoC suppliers. Beken, OnMicro, Telink, Goodix, SiFli develops Bluetooth watch SoC.

6. Bluetooth LE Audio SoC Market



New Feature of LE Audio

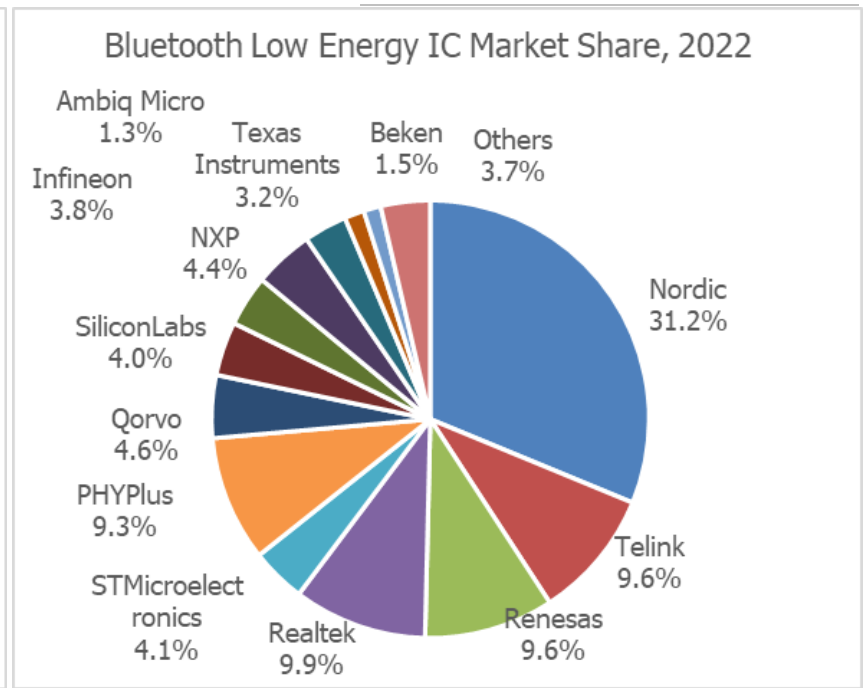
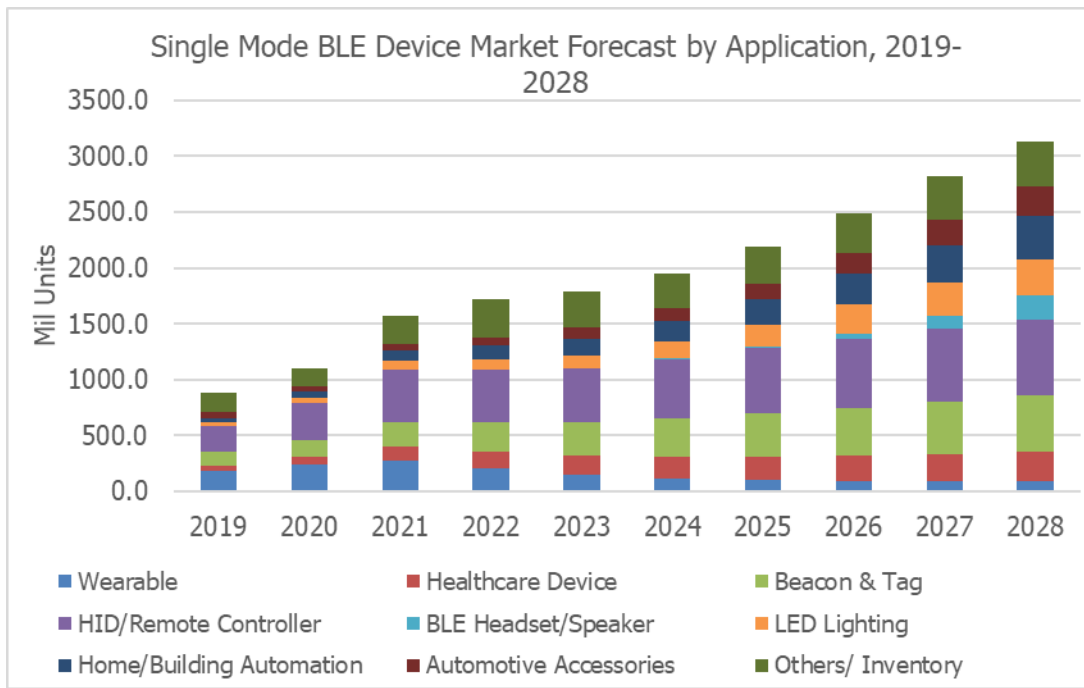
- Improved Bluetooth standard codec (LC3)
- Multi-streaming: standard based TWS
- Broadcast/Multicast (Auracast)

Enhanced Data throughput, up to 8Mbps (2024?)
>> for HD audio, multi-lingual translation,
>> Possible competition with UWB in high bandwidth audio. Or UWB+BT audio dual mode.

New application with Auracast:
Public broadcast speaker, Audio guide, Multi-lingual translation device

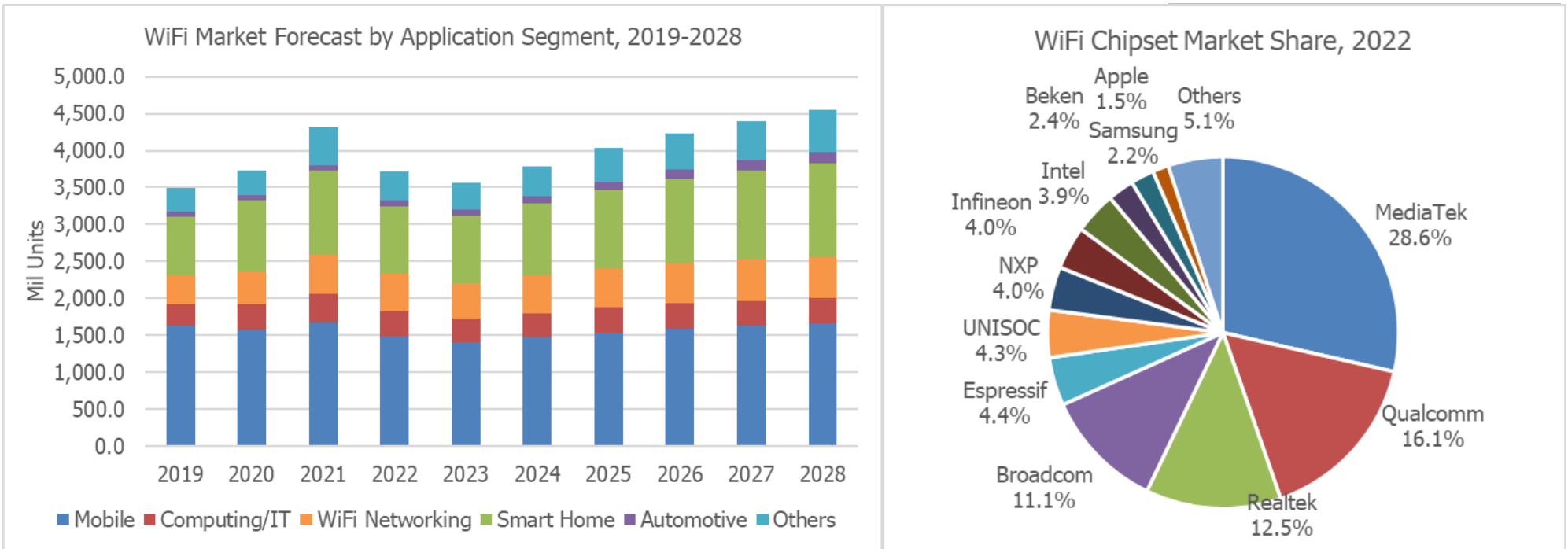
- Bluetooth LE Audio device commercialized in late 2022, market start picking up in 2023-2024. LE audio will account 19% of total Bluetooth audio shipments in 2024, 53% in 2026, and 76% in 2028.
- On host device, Android platform start to support LE audio in 2022. Apple iOS likely to support LE audio in 2023 or 2024.
- Most of LE audio chipset is dual mode: classic audio + LE audio. Single mode LE audio (based on BLE single mode chipset) initially be adopted in hearing aid, public speaker system, translation devices... gradually adopted in consumer audio devices in 2025 onwards.
- Single mode LE audio will account 9% in total LE audio device market in 2028. Dual mode audio chipset remains mainstream.

7. BLE Single Mode Chip Market



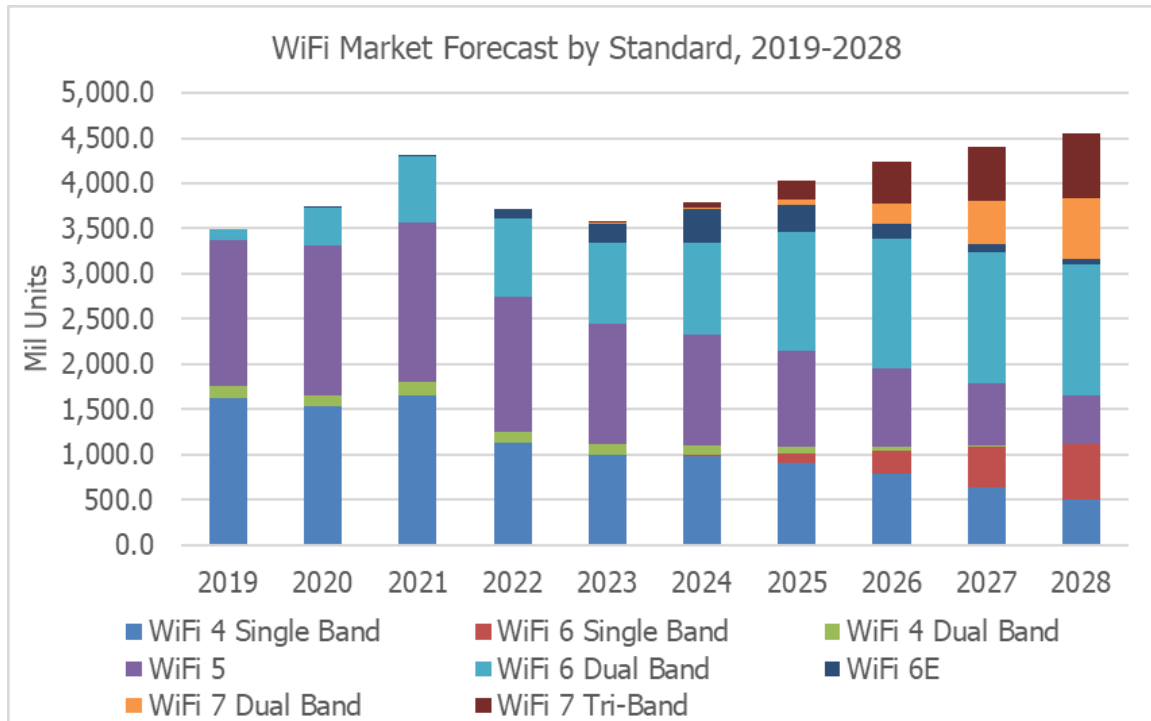
- Despite supply disruption and economic downtrend, BLE single mode device market grow continuously. 1.72 billion units of shipment estimated in 2022, YoY +9.4%. 2023 growth will be decelerated by inventory correction in industrial and commercial market segment.
- Beacon/tag, RCU, home/building automation and lighting, HID, Consumer wearable and Healthcare are the main volume application in 2022. Automotive application emerges. BLE consumer wearable market start to decrease in 2022 due to the competition with dual mode Bluetooth wearable (voice smart watch).
- Followed by the weak consumer demand, Telink ,Renesas, Realtek and Beken shrank in market share in 2022. Nordic and NXP gained share. PhyPlus grew significantly by gaining share from competitors but suffered by price decrease.
- In 2022, 10-15% of BLE single mode device is +802.15.4 Multi-protocol device. After 2023, more 802.15.4 based home automation devices will support BLE (multi-protocol) for supporting Matter.

8. WiFi Market Forecast by Application Segment



- Mobile devices accounts about 40% in WiFi device market in 2022, followed by Smart Home (24%), WiFi networking, PC/IT.
- WiFi device market dropped by 14% in 2022, to 3.72 billion units. Mobile, Smart Home, Computing segment decreased significantly. Demand weakness continues in 2023 due to the inventory correction and weak economy. However, signs of rebound seen in consumer IoT segment. Industrial and automotive WiFi demand remains strong. For industrial & commercial segment, concern of inventory correction emerges in 2H2023.
- The WiFi chip market share includes WiFi integrated mobile processor for phone and tablet. MediaTek, Qualcomm, Realtek and Broadcom are the main WiFi chip suppliers. Top 4 suppliers account about 2/3. The other WiFi suppliers are Espressif, NXP, Infineon, Intel, Beken, Apple, and so on. The main WiFi chip suppliers are different by end market.

9. WiFi Market Forecast by Standard



WiFi 4 (11n) to dual band WiFi 5/6, or Single Band WiFi 6 in IoT applications or low-end broadband devices.

WiFi 5 (11ac) to dual band/ tri-band WiFi 6 /7 in broadband applications

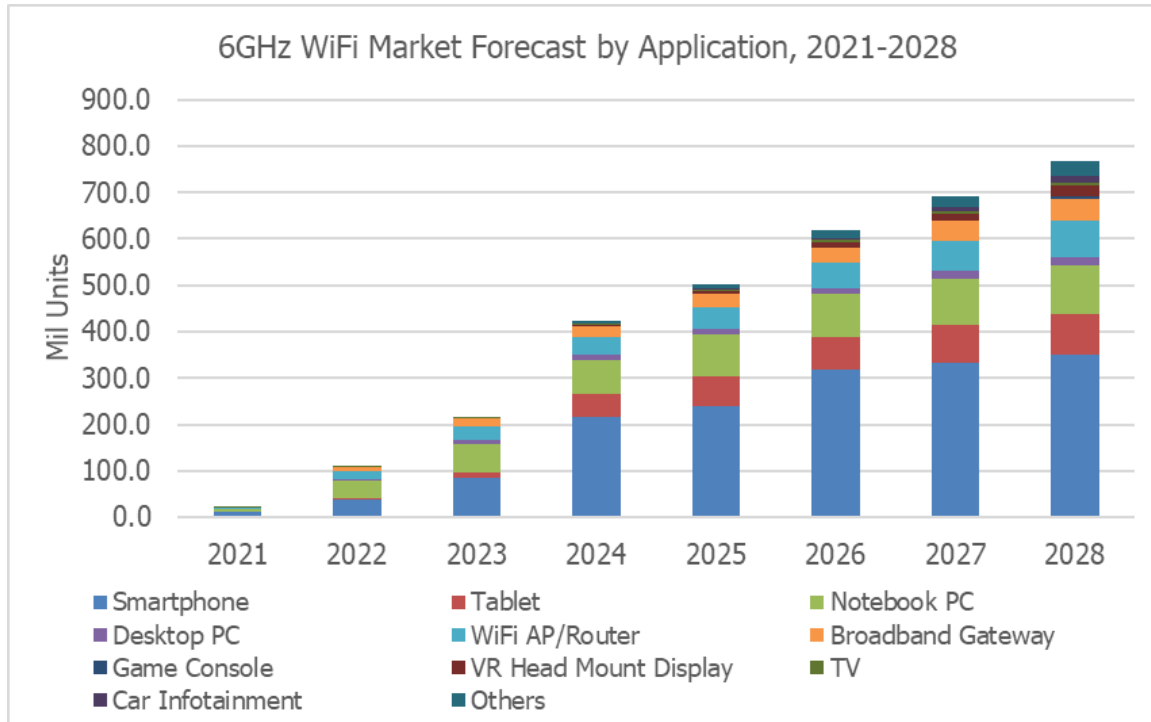
WiFi 7 will have dual band and tri-band configuration but no single band/ 20MHz scheme for embedded devices.

Early discussion for WiFi 8 standard started in 2023. WiFi 8 will implement Multi-AP operation, Low latency, and 640MHz bandwidth.

WiFi 8 chipset and end device could be introduced to the market around 2027.

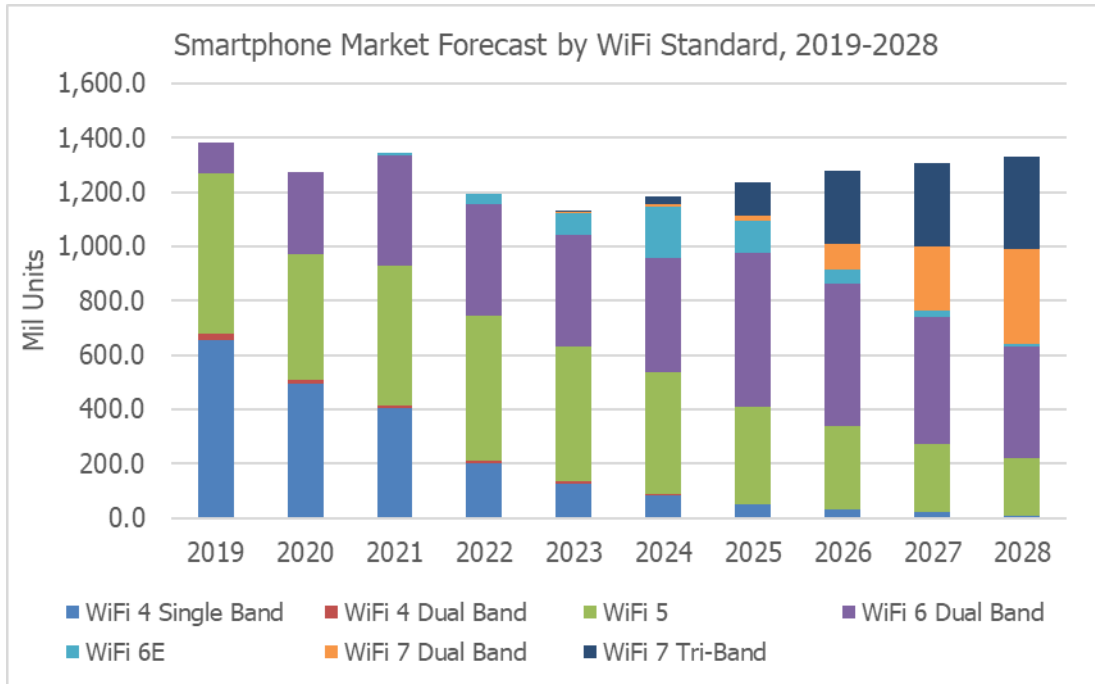
- WiFi 4 shrink from 31% (2023) to 11% (2028). WiFi 5 drop from 38% (2023) to 12% (2028)
- WiFi 6 share increase from 31% (2023) to 47% (2028). Single band WiFi 6 start to grow in 2024-2025.
- WiFi 7 market start picking up in 2024-2025, will holds 31% share in 2028. mainly for Broadband applications.
- 6GHz WiFi market share grow from 6% (2023) to 17% (2028), positioned for high end broadband.

10. 6GHz WiFi Market Forecast by Application



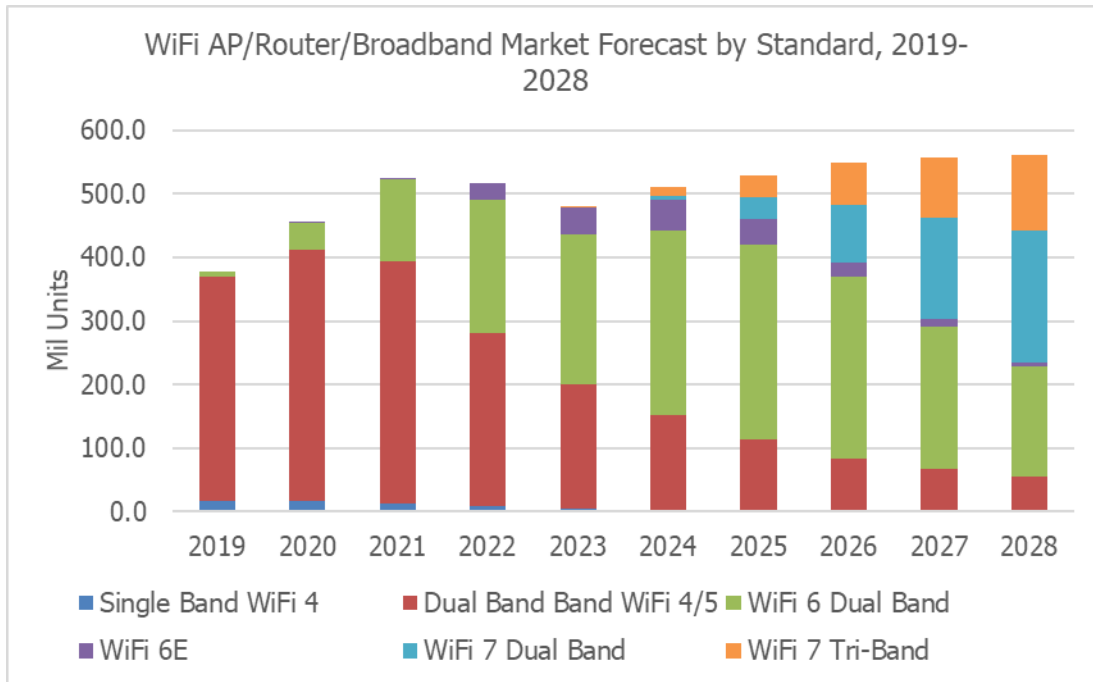
- 6GHz benefits in broadband & streaming applications (PC, smartphone, AP/router/gateway, gaming, TV..), also mission critical applications (factory industrial automation, AGV, line monitoring...).
- 6GHz WiFi spectrum availability differs by region. North America is the lead 6GHz WiFi market. UK, EU, Korea, Japan... follows in 2023. No 6GHz WiFi opportunity in China. Few in emerging countries. 6GHz WiFi main market is developed countries but no China.
- 6GHz WiFi market shows double growth in CY2023 and 2024. 2023 growth is due to geographic expansion and broader industry adoption. Apple is expected to support 6GHz WiFi 6E in 2023 phones.
- Automotive and Industrial automation application to commercialize 6GHz WiFi in 2025.

11. Smartphone WiFi Trend



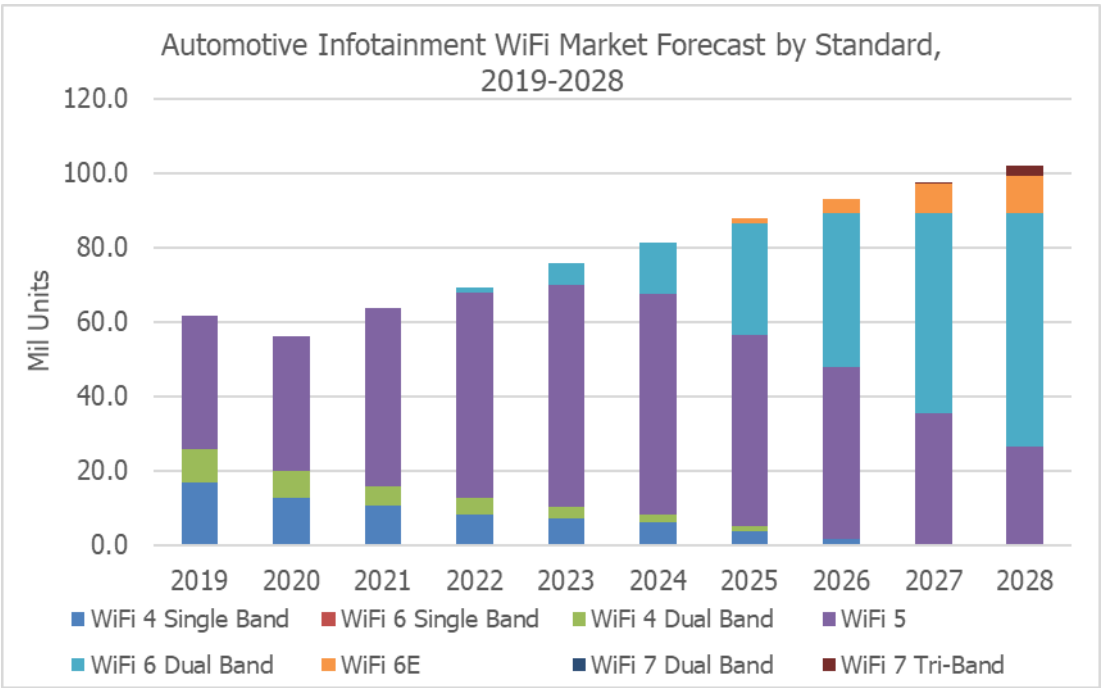
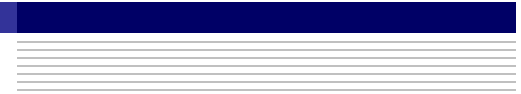
- Smartphone WiFi quickly migrate to WiFi 5 and Wifi 6 during 2022 to 2023. WiFi 5/6/7 will account 88% of total smartphone in 2023.
- WiFi 6/6E will be mainstream with 52% share in 2025. WiFi 6/6E share start to shrink in 2026 as WiFi 7 emerges.
- Smartphone WiFi 7 adoption starts in 2023, cvolume pick up in 2025, and surpass WiFi 6 share in 2027.
- 6GHz tri-band remains mainly in premium phones. 6GHz Wifi volume start picking up in 2023 (8%), rise to 26% in 2028.
- Only premium phones used external WiFi combo chip but Qualcomm start using WiFi combo chip on non-premium phones since 2021/2022.
- Smartphone WiFi/Bluetooth combo supports BT 5.2+ for LE audio, Auracast since 2022/2023.
- 802.15.4 start to be activated in 2023 for Matter.

12. WiFi Networking Market Trend



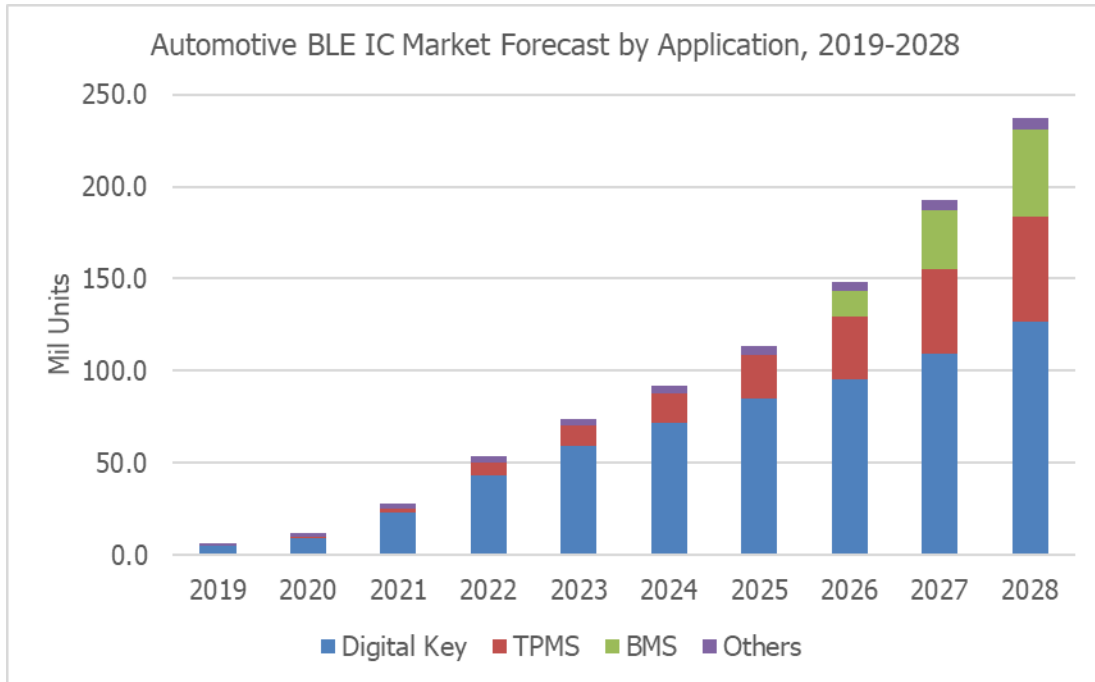
- WiFi AP/Router/Broadband Gateway market decreased by 1.7% in 2022 after the remote work/school demand. Retail WiFi router market dropped significantly in 2022. Enterprise WiFi AP market showed stable growth, Broadband WiFi was almost flattish growth in 2022. WiFi router shipment from broadband ISPs grow in 2022.
- 2023 market volume expect to shrink by 6.8% YoY, all segment suffers by inventory. In 2023 China ISPs start to exclude WiFi from Broadband. This results the massive decrease in broadband WiFi, while growth of ISP WiFi router market in 2023.
- In Broadband sector, WiFi 6/6E accounted 46% share in 2022. WiFi 6 becomes mainstream in developed countries and China. WiFi 6/6E will expand to 66% in 2024/ 2025, then start to shrink in 2026 by the migration to WiFi 7.
- WiFi 7 AP/router has been introduced since 2023 though volume will ramp up in 2025. WiFi 7 will account 13% share in 2025, grow to 58% in 2028. 2.4/5GHz dual band WiFi 7 will be mainstream after 2026.
- MediaTek, Qualcomm and Realtek accounts major share in retail segment. Qualcomm and Broadcom in Enterprise AP. MediaTerk, Broadcom and Qualcomm a major suppliers in ISP broadband WiFi. China local IC suppliers try to expand share in domestic market.

13. Automotive Connectivity Market Trend



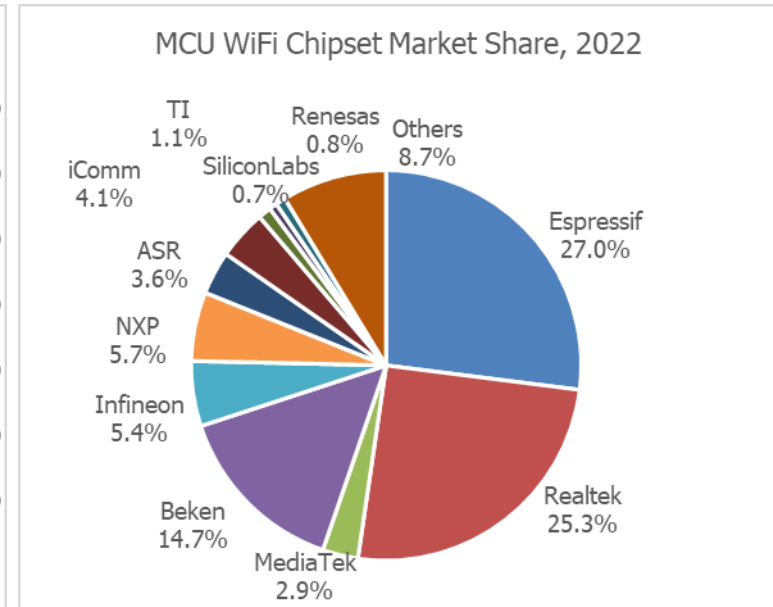
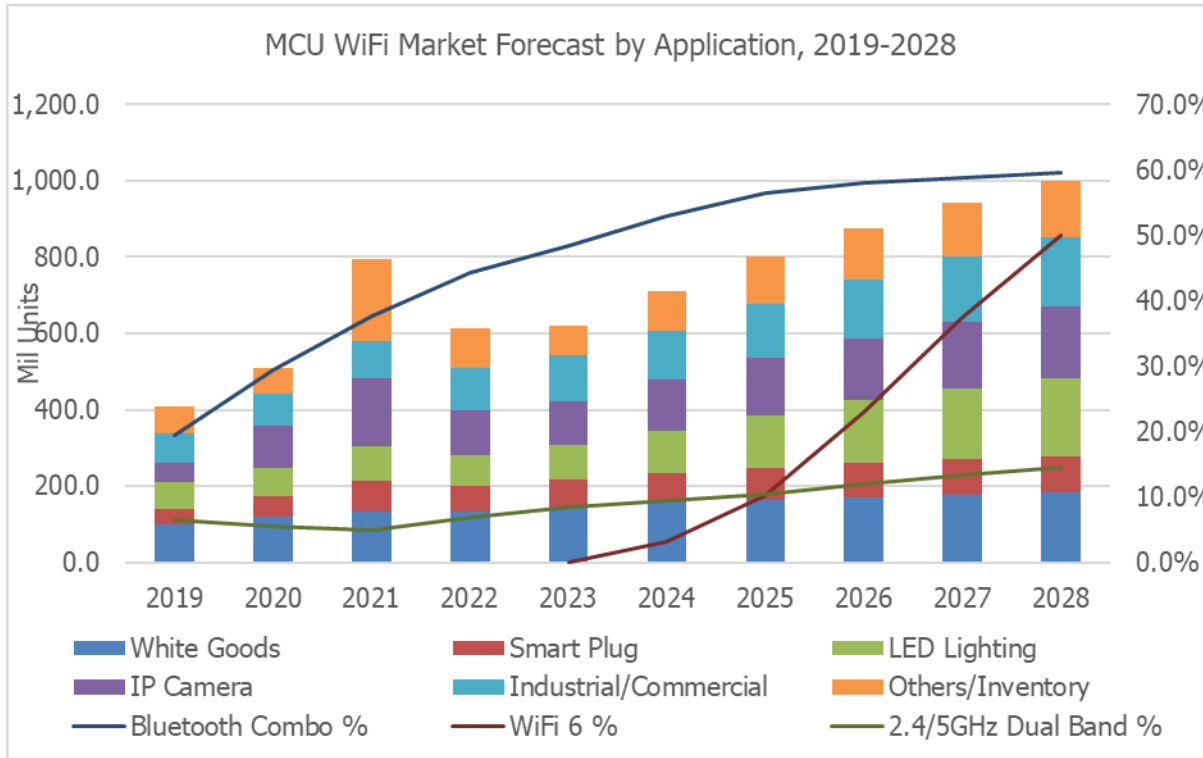
- Infotainment WiFi trend:
 - High end: 11ac > WiFi 6 (2022~), 2*2 MIMO, Dual MAC/Dual Simultaneous. WiFi 6E in 2025, WiFi 7 2027-2028
 - Mid end: 11ac > WiFi 6 (2024~), 2*2 MIMO/ SISO, Dual MAC/Dual Simultaneous
 - Low end: WiFi 4 > WiFi 5 (11ac)
- WiFi 5 is mainstream (79%) in 2022. WiFi 6 market start growing in 2022-2023, will accounts 35% in 2025, 72% in 2028. 6GHz WiFi 6E will appear in 2025 models. Automotive WiFi 7 chipset will be introduced in 2024-2025, will arrive to the market in 2027.
- 6GHz WiFi will accounts around 10% in 2027-2028. Cost and spectrum availability are the challenge in 6GHz wide adoption.
- in Automotive WiFi, Qualcomm, Infineon and NXP accounts major share. MediaTek gains market share. Realtek, UNISOC is expected to enter in China auto WiFi market in the future.

14. Automotive Bluetooth Low Energy Application Market Forecast



- Automotive BLE application: Digital key, Tire Pressure Monitoring System (TPMS) and Battery Management System (BMS). Others: indoor/outdoor sensor data collection, steering switch, button...
- Digital key: Bluetooth for positioning (AoA, channel sounding) or data comm. (digital key access)
- Bluetooth adoption increase since 2021 in China for Smartphone access. From 2022 UWB based secure key access gradually increase. BLE has been used by paired with UWB (ranging + key access).
- BLE based TPMS currently in aftermarket and Tesla. BLE TPMS in before market start growing after 2025.
- Wireless ini Battery management system benefits in reducing wire harness but challenges in robustness of connectivity. Wireless BMS is not popular now. Currently only ADI (2.4Ghz 802.15.4) commercialize wireless BMS. A few of BLE IC vendors offer BLE PHY + proprietary protocol based BMS solution. We assumed the adoption start in 2026 but could be pushed out.

15. MCU WiFi Market Forecast by Application



- White Goods: Big home appliances: A/C, Thermostat, Refrigerator, Washing Machine, Cleaner.
- Others: small appliance, kitchen appliance, home/Building automation (sensor, door lock, remote controller/switch..), Drone, Consumer Toy, Medical device...
- Industrial: handheld device, POS terminal, industrial computer, sensor, meter, robot...
- 2021 strong demand to big drop in 2022. Huge decrease in home IoT, consumer IoT and IPCam. Channel inventory also estimated to be cut off in 2022. industrial/commercial segment grows continuously.
- Demand for dual band/tri-band WiFi in developed countries (to avoid congestion) or factory, hospital... use case (quality of service required). Dual band WiFi accounts 7-9% of total unit in 2022-2023, though grow to 15% by 2028.
- MCU WiFi 6 market will start picking up in 2024-2025, reaching 50% of total unit by 2028.
- MCU WiFi + Bluetooth (+802.15.4) combo chip is getting common. 48% of total MCU WiFi is estimated to support Bluetooth in 2023, to 60% in 2028.
- Espressif keeps top share in this sector, expanding geography and end market. Beken grew significantly in 2021 then deep drop in 2022.

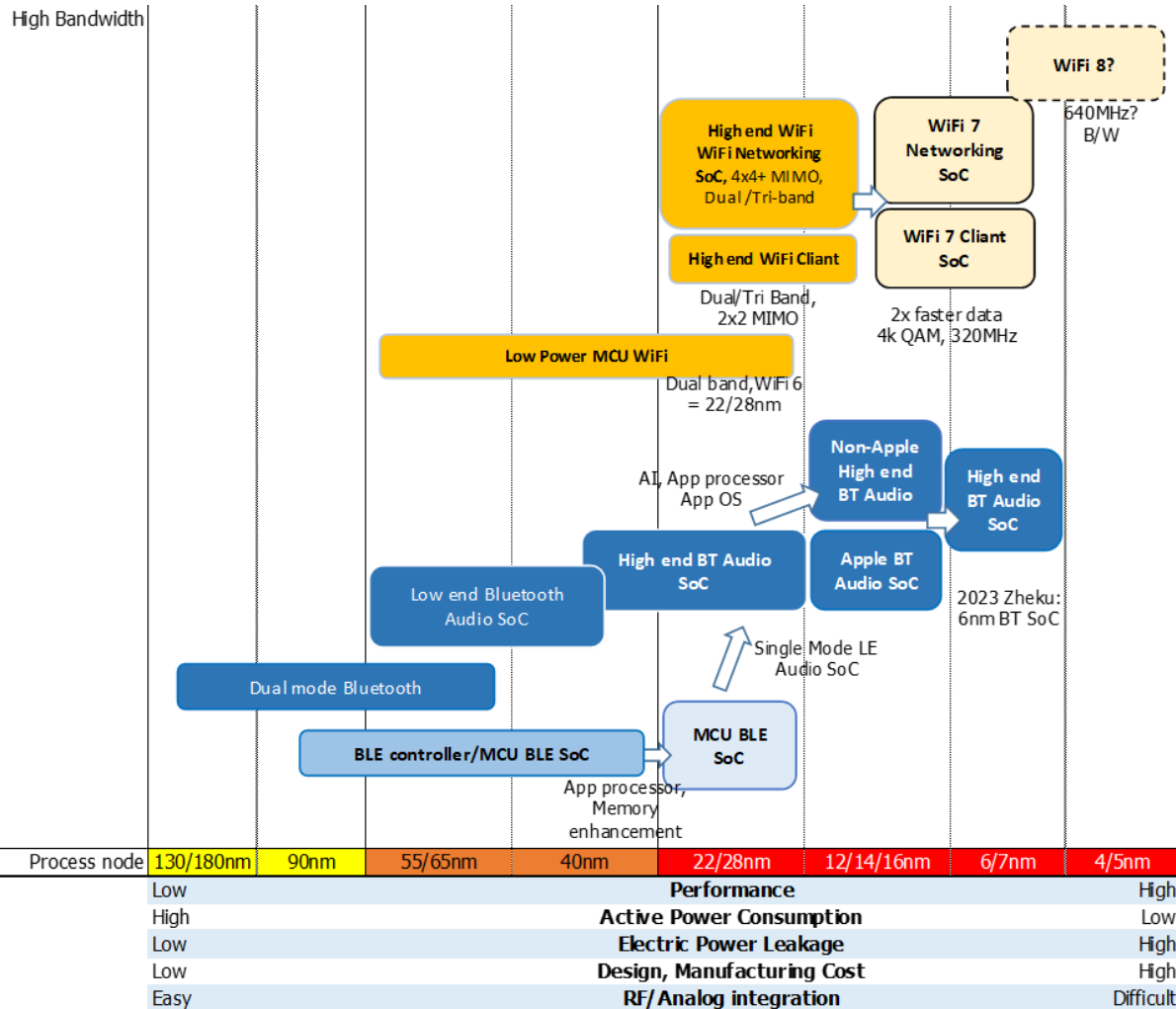
16. Wireless Chip Supplier Market Share Position

| Segment | Mobile (Smartphone/ Tablet) | Networking (AP/Router/Gateway) | CE (TV, OTT, Smart Speaker, Game Console) | IoT (MCU WiFi) | Automotive WiFi | Bluetooth Audio | Bluetooth Data (BLE + Dual Mode) |
|--------------------|-------------------------------|--------------------------------------|---|----------------------|---------------------------|-----------------------|----------------------------------|
| 2022 TAM | 1370Mil units | 517Mil units | 429Mil units | 612Mil units | 82Mil units | 2947Mil Units | 2140Mil Units |
| IC solution | AP SoC+RF, WiFi/BT Combo Chip | Standalone WiFi, WiFi Networking SoC | WiFi/BT Combo Chip | MCU WiFi | Bluetooth/WiFi Combo Chip | Bluetooth Audio SoC | Bluetooth Data SoC |
| Market Share 30+ % | MediaTek | MediaTek | MediaTek | | Qualcomm | Jieli | |
| 20-30% | Qualcomm Broadcom | Qualcomm | | Espressif Realtek | Infineon NXP | Bluetrum | Nordic |
| 15-20% | | Broadcom | Realtek | | | | |
| 10-15% | | Realtek | | Beken | | | YiChip Realtek |
| 5-10% | UNISOC | | NXP | | | | Telink Renesas |
| ~5% | Samsung | | | NXP Infineon | | Qualcomm Apple | PhyPlus Infineon |
| | | | Infineon UNISOC | iComm ASR | | Airoha Bestechnic | Qorvo NXP |
| | | MaxLinear | Synaptics Bestechnic | MediaTek Bouffalo | | | SILabs Qualcomm |
| | | SiFlower | AMLogic Apple | TI | MediaTek | Actions Beken | ST TI |
| | | Renesas | Broadcom | | | Realtek YiChip | Beken MediaTek |
| | Intel Realtek | | | Renesas UNISOC | TI | | Ambiq OnMicro |
| | | | | SiLabs I&C | | ZgMicro WuQi | Atmosic Goodix |
| Small New Entry | | ZunPai Casemic | | Microchip Nordic | Realtek | Telink Appotech | OnSemi Pixart |
| | | | | WinnerMic T-Head | | Frequen SmartLink | EMMicro Abov |
| | | | | Montage AIC | | HiSilicon Broadcom | MacroGiga Frequen |
| | | | | Eswin HiSilicon | | Microchip UNISOC | WillIoT InPlay |
| | | | | | | Zheku | SenaSIC |



- In Mobile, PC and CE area, Platform SoC vendors (MediaTek, Qualcomm, Intel...) has major market share. SoC and connectivity are bundled or integrated.
- High performance WiFi for WiFi networking (AP/router/gateway) segment: MediaTek, Qualcomm and Broadcom accounts major market share. Realtek for low end, MaxLinear for high end market. OnSemi and NXP exit. Chinese start-up (SiFlower, ZunPai) try to expand in the local market.
- Automotive: Qualcomm, Infineon, NXP as main WiFi suppliers. MediaTek try to expand in auto WiFi. TI and NXP for auto BLE. China local suppliers target auto BLE.
- In MCU WiFi, Espressif and Realtek keep major share. Espressif and Beken lost share in 2022 by weak consumer demand. NXP and Infineon accounts major share in industrial/commercial segment.
- Bluetooth audio: Jieli and Bluetrum gains in low end, volume share. QCOM, Apple, Airoha and Bestechnic as main mid/high end suppliers. BT voice smart watch SoC main suppliers: HiSilicon, Bestechnic, Actions, Realtek, YiChip, Jieli, Bluetrum.
- BLE SoC: Fragmented, Nordic keeps top position. NXP, SiLabs, PhyPlus gains share. Renesas, Telink, Realtek lost share by weak consumer demand.

17. Chipset process node, integration trend



Process Node

- High end WiFi start to use 6/7nm process. It will migrate to 4/5nm in next gen WiFi 8.
- High end WiFi 7 chipset uses 6/7nm while mainstream WiFi 7, WiFi 6 uses 12/14nm.
- Low end WiFi migrate from 40nm to 22/28nm.
- High end Bluetooth audio migrate to 6/7nm and 12nm. Low end BT audio suppliers move to 22nm.
- High end BLE (with app MCU) migrate to 22nm in 2022-2023.

Integration

- MCU BLE, WiFi for embedded/IoT: Apps MCU, AI, Sensor MCU, Security. WiFi/BLE/802.15.4 Multi-Protocol.
- Bluetooth Audio SoC for wearable adds GPU/display I/F, Sensor IF.
- BLE Channel Sounding: PLL and Algorithm
- WiFi Networking: Network processor + WiFi Modem + FEM. iPA in 2.4GHz and 5GHz (MTK, QCOM)
- Smartphone WiFi combo: adding 802.15.4 for Matter.