



# The Past and Future of Wi-Fi

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# Disclaimer

- I am here as an individual who has participated in the development of 802.11 standards
- Information exchanged here is strictly my opinion and is not that of Intel Corporation where I am an employee, IEEE 802.11 where I am a member or Wi-Fi Alliance where I am a member
- Information exchanged here is not indicative of any product plans at my company or project plans at Standards Definition Organizations of which I am a member of
- I am not an authorized spokesperson for Intel, IEEE 802.11 or WFA
- I am not an expert/authority – I am here to learn as well. So, feel free to point errors in my opinions/improve my observations. I am all ears

# Agenda

- **A Brief History of 802.11/Wi-Fi**
- **Struggles to get Wi-Fi working**
- **What made 802.11 successful?**
- **Future of 802.11/Wi-Fi**
- **Q&A/Discussion**

# A brief history of 802.11/Wi-Fi

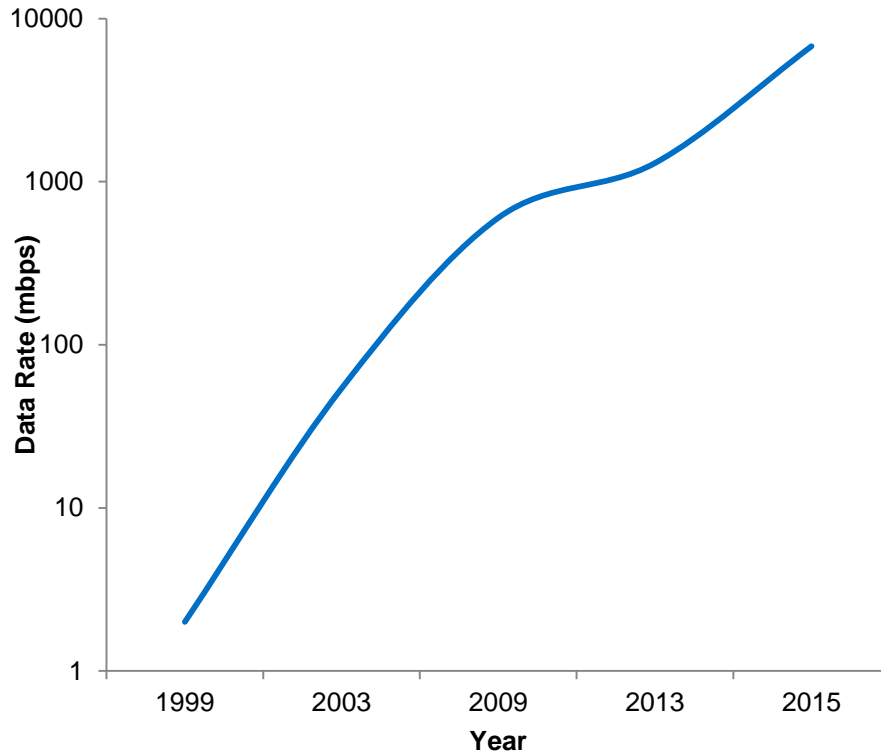
- 1985 – FCC deregulates 2.4-2.5 GHz spectrum for unlicensed use
  - Led to the development of several technologies – mostly proprietary, expensive, slow, unreliable and non-interoperable
  - 1991 – WaveLAN by NCR and ATT; Vic Hayes, father of 802.11
- 1990 – IEEE 802 Executive Committee launched an effort to establish a Wireless LAN standard
  - Fast, Robust, Interoperable, Cheap and Reliable WLAN
  - Vic Hayes, chair of IEEE 802.11 WG
  - 802.11b Ratified in 1997 – Max data rate 2Mbps
  - 802.11a and b Ratified in 1999 – Max data rate 54 Mbps in 5GHz; 11Mbps in 2.4 GHz
  - WFA Established
  - 802.11g Ratified in 2003 – Max data rate 54 Mbps in 2.4 GHz
  - 802.11-2007 Released
  - 802.11n Ratified in 2009 – Max data rate to 600 Mbps; MIMO, Coding improvements, Spatial Streams; additional bands in 5GHz, 40 MHz channels
  - 802.11-2012 Released
  - 802.11ad Ratified – operates in the 60GHz band; data rates up to 7Gbps
  - 802.11ac Ratified – operates in the 5GHz; data rates up to 1.3 Gbps; Multi-User MIMO, 80 and 160 MHz channels
  - We are here ...

1997: Authentication + WEP  
2001: WEP issues documented  
2003: WPA (subset of 802.11i)  
2004 802.11i Ratified  
2004-2005 WFA WPA/WPA2 certifications  
2006 – WPA2 mandatory in all WFA certified implementations  
2007 - WPS (Wireless Protected Setup) Certification – improved authentication

# Struggles to get Wi-Fi Working

- **Interoperability** – resolved primarily by WFA certification and by other Vendor Initiatives
- **Security** – resolved by constant evolution of the 802.11 security architecture and a companion WFA program
  - There are still known vulnerabilities
  - Robust Security Setup is still not user-friendly
- **Network Management**
  - Proprietary mechanisms exist for enterprise deployment
  - ‘who implements support first ?’ syndrome
- **Lack of OS Support**
  - Bad implementations causing the OS to look inferior

# What made 802.11 so successful?



- Affordable
- Robust and Reliable
- Interoperability
- The standard and implementations kept up with the demand
- Secure – evolved as vulnerabilities were exposed
- Relationship between IEEE 802.11 and WFA
- Vendor Initiatives
  - AP-centric
  - STA-centric

# Future of 802.11/Wi-Fi

- Information becomes “always available”
- Secondary/tertiary use of licensed spectrum
- Automatic security configuration without loss of robustness
- Robust and interoperable Network Management
  - The network becomes ‘smarter’
- Heterogenous Networks where
  - Wi-Fi acts as an aggregator – of shorter-range links
  - Wi-Fi is at either/both ends – a longer range link for the long-haul
- Intra-vehicular/vehicle-to-infrastructure Wi-Fi communication

- More pervasive in every ones lifestyle
- You will often catch yourself asking “How did I/we manage without Wi-Fi?”