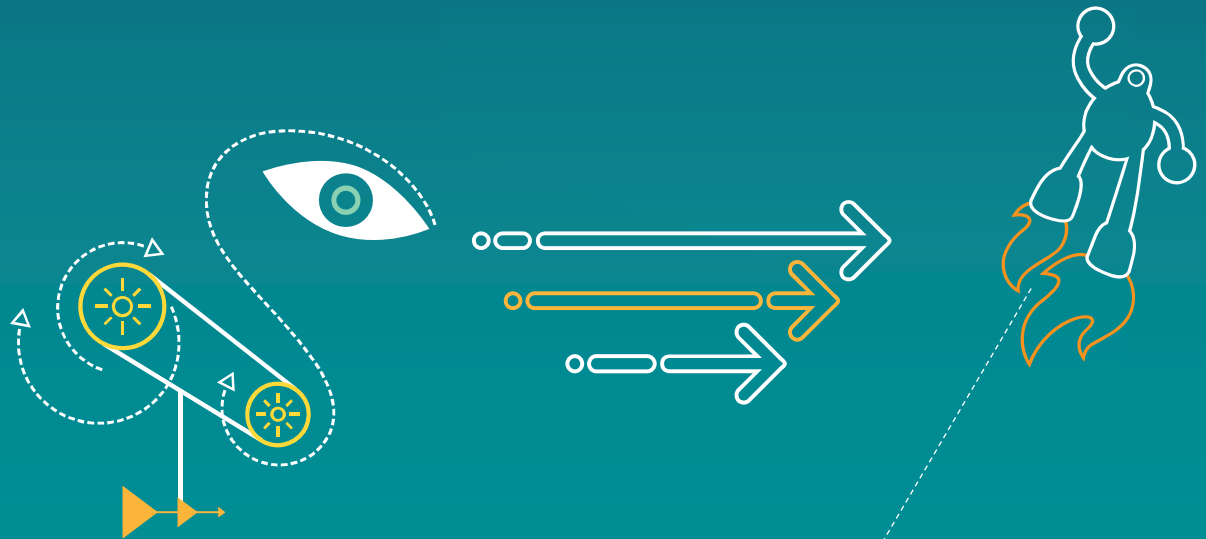


Michal J Koenig
Senior Director, Product Management
Qualcomm Technologies, Inc.

Wireless Connectivity for Advanced Outdoor Lighting Systems



Agenda

Michal Koenig

- Wireless Technologies Overview – Outdoor Lighting

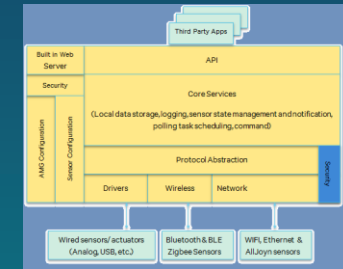
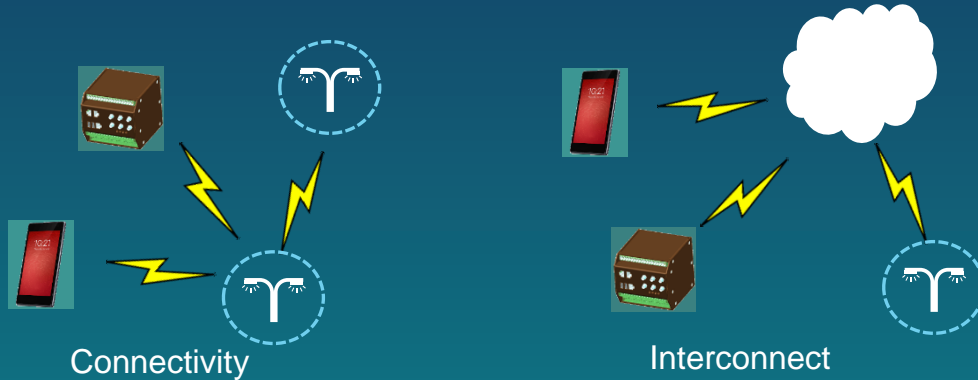
Himanshu Mehra

- Indoor Lighting
 - PoE
 - Reference Architectures and Interoperability
 - Introduction to Protocols

Shane Dewing

- Introduction to Open Connectivity Forum (OCF) and IoTivity

Intelligent Connectivity Defined



At the Edge Processing

Localized/P2P connections between assets, sensors and humans

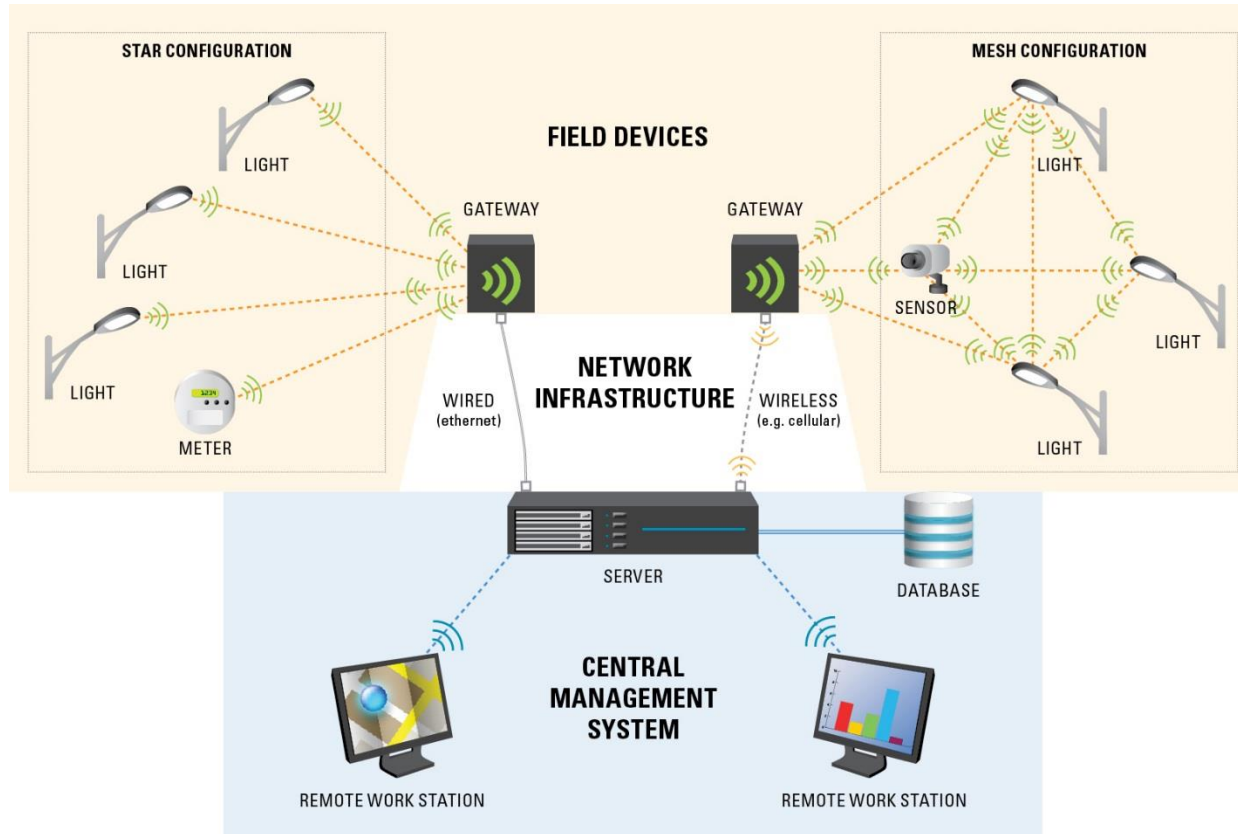
- Plug and play secure wireless connectivity
- Asset to asset communications
- Asset to human communications
- Asset to gateway communications

Connection between an asset and/or gateway and the cloud for processing and analysis of large amounts of information and to facilitate operations and maintenance

Localized and real time analysis of the health and state of an asset to facilitate command and control and to enable new service

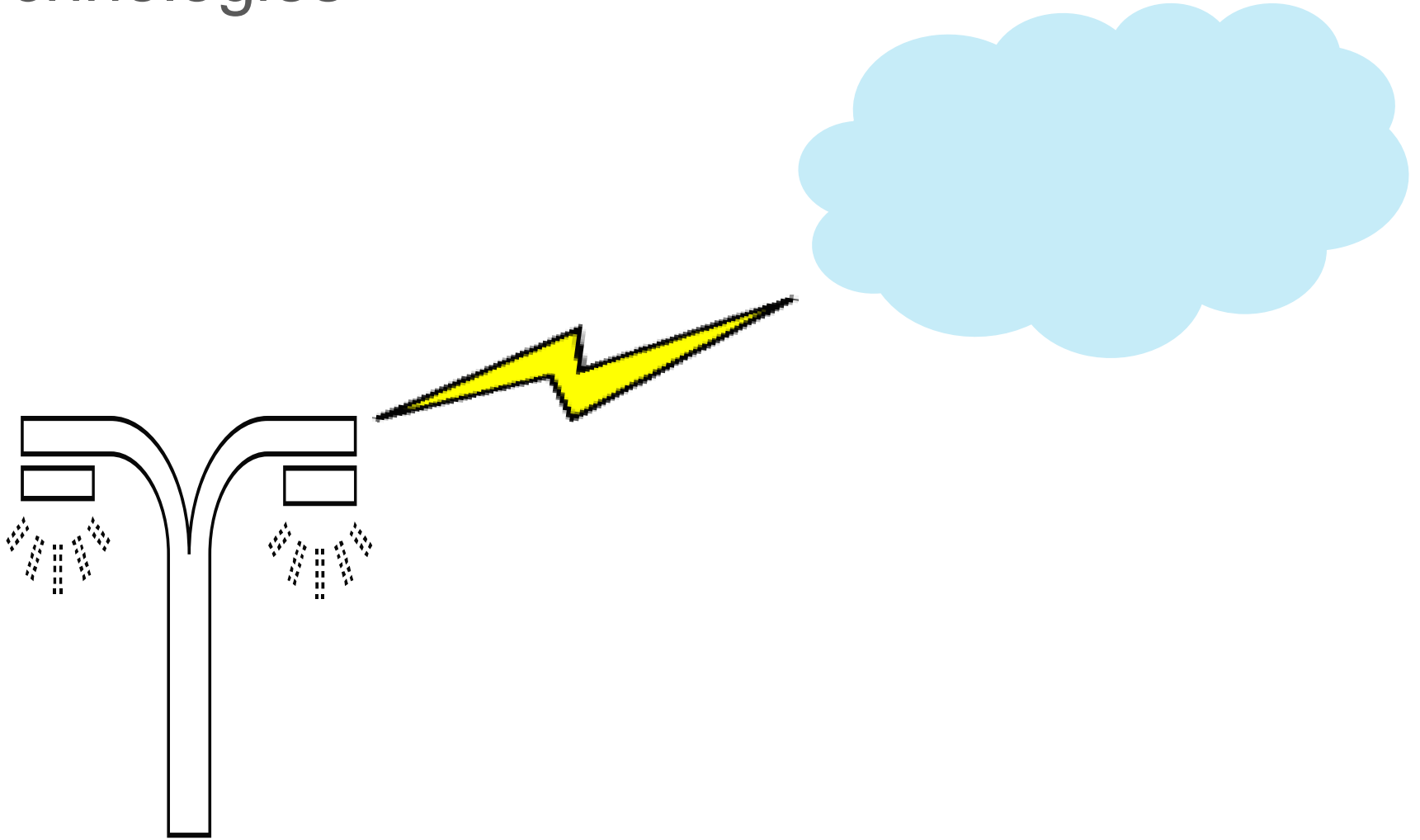
- Open and secure architecture that supports developer communities for application development

Lighting Systems



Architecture diagram of Outdoor Lighting Control System using WWAN
(Image Credit: California Lighting Technology Center, UC Davis)

Outdoor Lighting System Interconnect Technologies



Interconnect Wireless Technologies

Device to Cloud

2G/3G/4G Cellular

5G Cellular (Future)

802.11.xx (WiFi)

802.15.4 (ZigBee, Thread)

Low Power WAN (LP WAN)

- LoraWAN (Proprietary)
- SigFox (Proprietary)
- Narrowband IoT (NB IoT, 3GPP)

2G/3G/4G

Cellular Technologies including GPRS-EDGE, cdma1X, CDMA-DO, WCDMA, LTE

5G (Future)

Mission critical enhancements addressing the needs of the Industrial IoT Industry

- Very low latency
- Very high reliability (coverage, availability, accessibility, etc.)
- Very high position accuracy
- Very high connection density
- Very high security and data integrity

802.11.xx (WiFi)

Wireless local area network (WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands

- Open Source
- Managed by IEEE 802 Standards Committee
- Half duplex technology (communications in one direction at a time)
- Best effort access technology
- Extremely wide spread global deployments
- High power consumption

802.15.4 (Zigbee, Thread)

Low-rate wireless personal area networks (LR-WPANs)

- < 250 kb/s

Managed by IEEE 802.15 working group

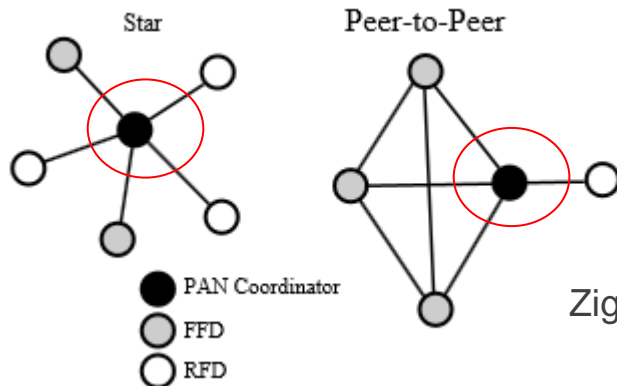
Operates at 800MHz, 900MHz and 2.4GHz

First of low power mesh network technologies (Zigbee)

Good for distance between 10-100 M (depending on power/data rate relationship)

Zigbee requires the establishment of a FFD (Full function device) and then a reduced function device (RFD)

Thread each node maintaining an IP address



Zigbee Implementations

Low Power Wan (LP WAN)

LoraWAN (Proprietary)

- Low Power Wide Area Network with features specifically needed to support low-cost, mobile, secure bi-directional communication for Internet of Things (IoT), machine-to-machine (M2M), and smart city, and industrial applications.
- Proprietary technology licensed by Semtech (Camarillo, CA)
- Large scale deployment happening in Korea (joint venture between SK Telecomm and Samsung)
- Half duplex technology (communications in one direction at a time)

SigFox and others (Proprietary)

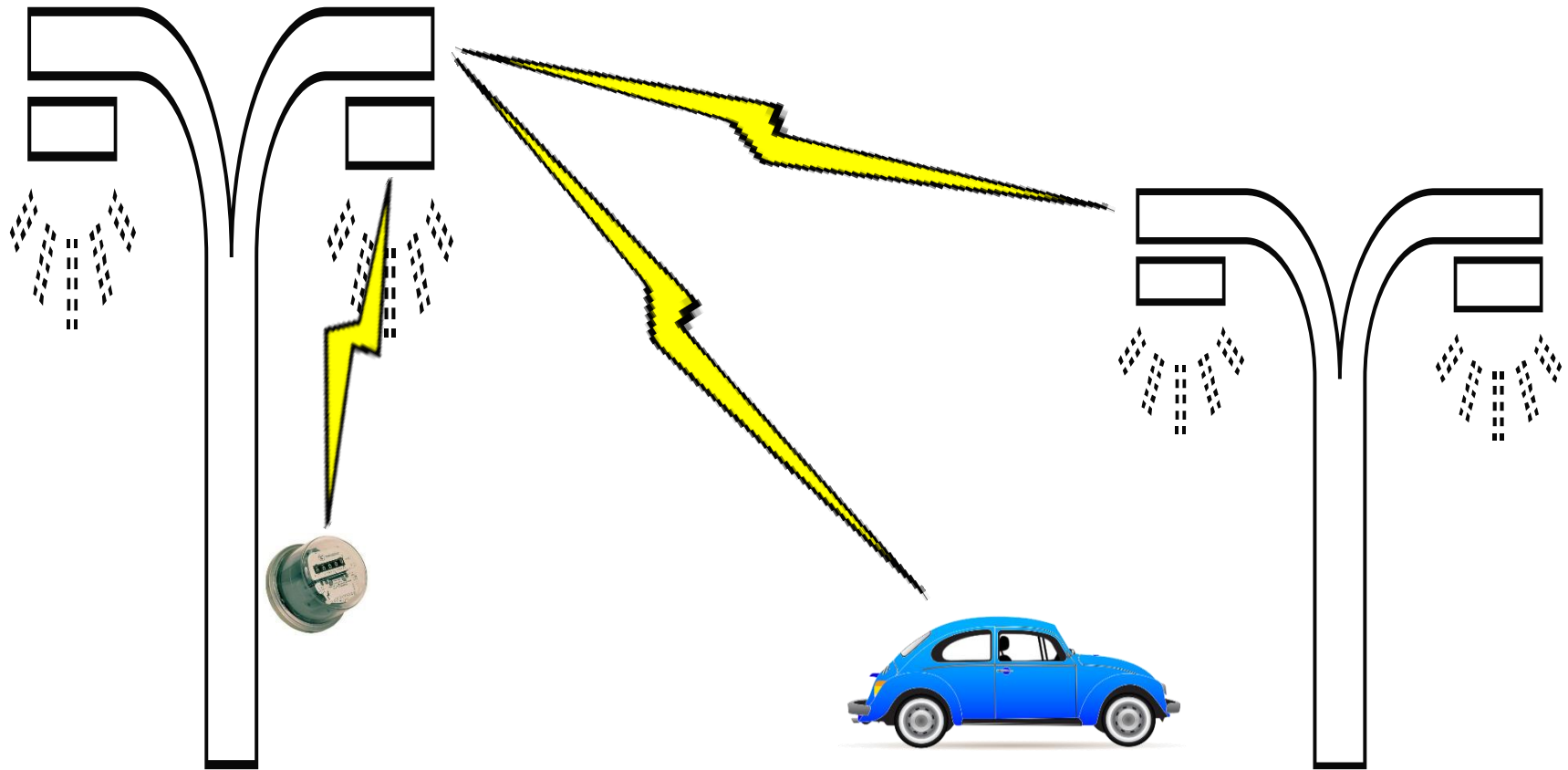
- A “cellular” like IoT network
- Uses UNB (Ultra Narrow Band) wireless technologies (various)
- Full duplex network (bi-directional, simultaneous)

Narrowband IoT (NB IoT, 3GPP)

- An enhancement to 3GPP (cellular) standards addressing the needs of Wireless IoT
- Offered by incumbent cellular providers, typically in their LTE bands

Lighting System Connectivity Technologies

Device to Device



Connectivity Technologies

802.11.xx (WiFi, 802.11.ah)

802.15.4 (Zigbee, Thread)

LTE-U (Future)

Bluetooth Low Energy (BLE)

Dedicated Short Range Communications (DSRC)

802.11.xx (WiFi)

Wireless local area network (WLAN) computer communication in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands

- Open Source
- Managed by IEEE 802 Standards Committee
- Half duplex (communications in one direction at a time)
- Best effort access technology
- Extremely wide spread global deployments
- 802.11.ah
 - To operate in the sub 1GHz frequency range. Due to the favorable propagation characteristics of the low frequency spectra, 802.11ah can provide improved transmission range compared with the conventional 802.11 WLANs operating in the 2.4 GHz and 5 GHz bands. 802.11ah can be used for various purposes including large scale sensor networks, extended range hotspot, and outdoor Wi-Fi for cellular traffic

802.15.4 (Zigbee, Thread)

Low-rate wireless personal area networks (LR-WPANs)

- < 250 kb/s

Managed by IEEE 802.15 working group

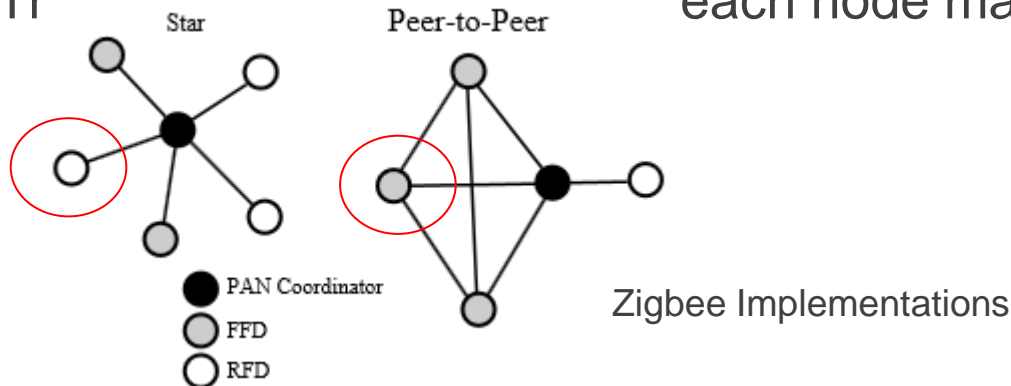
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LTE-Unlicensed (LTE-U)

LTE in unlicensed spectrum (LTE-U) is a proposal for the use of the 4G LTE radio communications technology in unlicensed spectrum, such as the 5 GHz band used by dual-band Wi-Fi equipment. It would serve as an alternative to carrier-owned Wi-Fi hotspots.

- To operate in the WiFi 5GHz spectrum
- Same waveform (technology) as LTE (cellular 4G)

Bluetooth Low Energy (BLE)

A wireless personal area network technology designed and marketed by the Bluetooth Special Interest Group aimed at novel applications in the healthcare, fitness, beacons, security, and home entertainment industries. Compared to Classic Bluetooth, BLE is intended to provide considerably reduced power consumption and cost while maintaining a similar communication range. BLE is not a dominant player in the outdoor industrial space, yet.

- Uses 2.4 GHz radio frequencies, as does Bluetooth, but they are not compatible with each other (BLE is not backwards compatible with BT. Use different channel configuration)
- Uses 40 2MHz channels
- Less than 10 mW power
- Max range ~ 100 M
- 1Mb/s data rate, .25 Mb/s application/information rate
- FSK modulation with frequency hopping overlaid to reduce localized/narrow band interference

Dedicated Short Range Communications (DSRC)

One-way or two-way short-range to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards. It is a WiFi based technology that supports low latency, mission critical Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2X) communication and transactions in a licensed/protected frequency band.

From the DOT's web site:

- Designated licensed bandwidth:** For secure, reliable communications to take place. It is primarily allocated for vehicle safety applications by FCC Report and Order FCC 03-324.
- Fast Network Acquisition:** Active safety applications require the immediate establishment of communication and frequent updates.
- Low Latency:** Active safety applications must recognize each other and transmit messages to each other in milliseconds without delay.
- High Reliability when Required:** Active safety applications require a high level of link reliability. DSRC works in high vehicle speed mobility conditions and delivers performance immune to extreme weather conditions (e.g. rain, fog, snow, etc.).
- Priority for Safety Applications:** Safety applications on DSRC are given priority over non-safety applications.
- Interoperability:** DSRC ensures interoperability, which is the key to successful deployment of active safety applications, using widely accepted standards. It supports both V2V and V2I communications.
- Security and Privacy:** DSRC provides safety message authentication and privacy.