Standards:
WAVE / DSRC / 802.11p

Spring 2008
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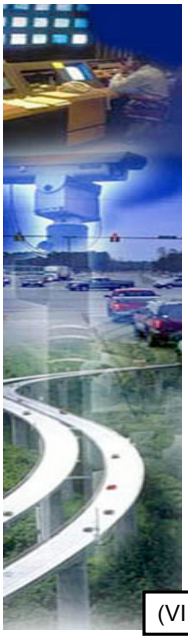
CS 795/895
Vehicular Networks

Outline

- Overview
- WAVE
- DSRC / IEEE 802.11p
- Device Placement
- References


(VII, 2007)

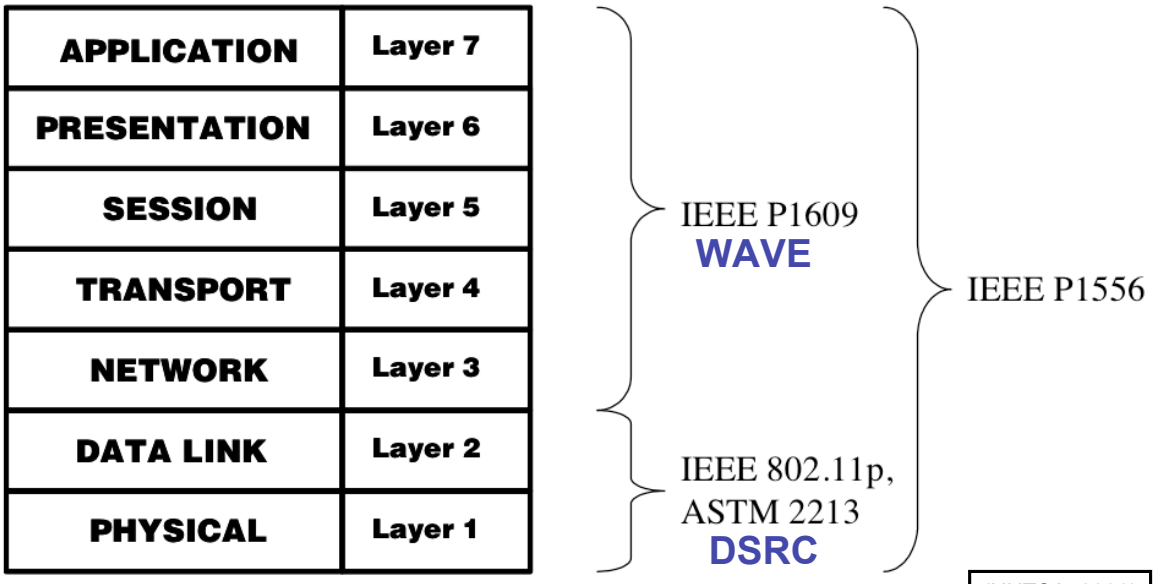
Overview

What is WAVE / DSRC / 802.11p?

- WAVE (Wireless Access in Vehicular Environments)
  - mode of operation used by IEEE 802.11 devices to operate in the DSRC band
- DSRC (Dedicated Short Range Communications)
  - ASTM Standard E2213-03, based on IEEE 802.11a
  - name of the 5.9 GHz Band allocated for the ITS communications
- IEEE 802.11p
  - based on ASTM Standard E2213-03
  - currently draft standard
- DSRC Devices
  - IEEE 802.11 systems using the WAVE mode of operation in the DSRC band

(FC, 2004)

Protocol Stack



(NHTSA, 2006)

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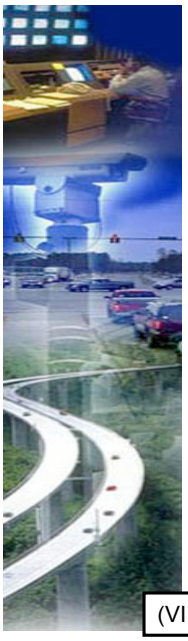

(VII, 2007)

WAVE

Wireless Access in Vehicular Environments

- IEEE 1609
- Defines
  - architecture
  - communications model
  - management structure
  - security and physical access
- Primary architecture components are OBU, RSU, and WAVE interface

(DOT, 2006)

WAVE

Standard Components

- P1609.1 Resource Manager
  - describes key components of WAVE system architecture and defines data flows and resources
  - defines command message formats and data storage formats
  - specifies the types of devices that may by supported by OBU
- P1609.2 Security Services for Applications and Management Messages
  - defines secure message formats and processing
  - circumstances for using secure message exchanges

(DOT, 2006)

WAVE

Standard Components

- P1609.3 Networking Services
  - defines network and transport layer services, including addressing and routing, in support of secure WAVE data exchange
  - defines WAVE Short Messages (WSM), providing an efficient WAVE-specific alternative to IP that can be directly supported by applications
  - defines MIB for WAVE protocol stack
- P1609.4 Multi-Channel Operations
  - enhancements to 802.11 MAC to support WAVE

(DOT, 2006)

WAVE

Security and Privacy

- OBU address randomized
  - prevents tracking vehicles
- Authenticated RSU application announcements
  - prevents bogus message to vehicle
- Link level encryption for all messages
  - prevents eavesdropping
- Authentication
  - PKI
  - US Government is CA

(Jones, 2005)

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(VII, 2007)

Wireless Technologies

		Wireless Technology												
		5.9 GHz DSRC	2.5-3G PCS and Digital Cellular	Bluetooth	Digital Television(DTV)	High Altitude Platforms	IEEE 802.11 Wireless LAN	Nationwide Differential Global Positioning System	Radar	Remote Keyless Entry (RKE)	Satellite Digital Audio Radio Systems (SDARS)	Terrestrial Digital Radio	Two-Way Satellite	Ultrawideband (UWB)
Capabilities	Range	1000 m	~4-6 km	10 m	~40 km	120 km	1000 m	300-400 km	2 km	30 m	US 48 States	30-50 km	N/A	15-30 m
	One-Way To Vehicle	X			X	?		X	X	X	X	X		?
	One-Way From Vehicle	X				?			X					?
	Two-Way	X				?							X	?
	Pont-To-Point	X	X	X		?	X			X			X	?
	Point-To-Multipoint	X	X	X	X	?	x	X	X		X	X		?
	Latency	200 µsec	1.5-3.5 sec	3-4 Sec	10-30 sec	?	3-5 sec	N/A	N/A	N/A	10-20 sec	10-20 sec	60+sec	?

(NHTSA, 2006)

DSRC

Dedicated Short Range Communications

- 5.850-5.925 GHz range
  - divided into 7 channels (each 10 MHz)
- Short range radio
  - 300m (1000m max)
- High data rate
  - 6-27 Mbps
- Half-duplex
  - station can only send or transmit, but not both at the same time

(Jones, 2005)

Old DSRC vs. New DSRC

- 915 MHz
- Range < 30 meters
- Data rate = 0.5 Mbps
- Designed for ETC, but can be used for other applications
- Single unlicensed channel
- Requires special (custom) chip set & software
- Vehicle to roadside
- Command-response

(Armstrong)

- 5.9 GHz
- Range to 1000 meters
- Data rate 6 to 27 Mbps
- Designed for general Internet access, can be used for ETC
- 7 licensed channels
- Uses open off-the-shelf chip set & software
- Vehicle to roadside & vehicle to vehicle
- Command-response & peer to peer

DSRC

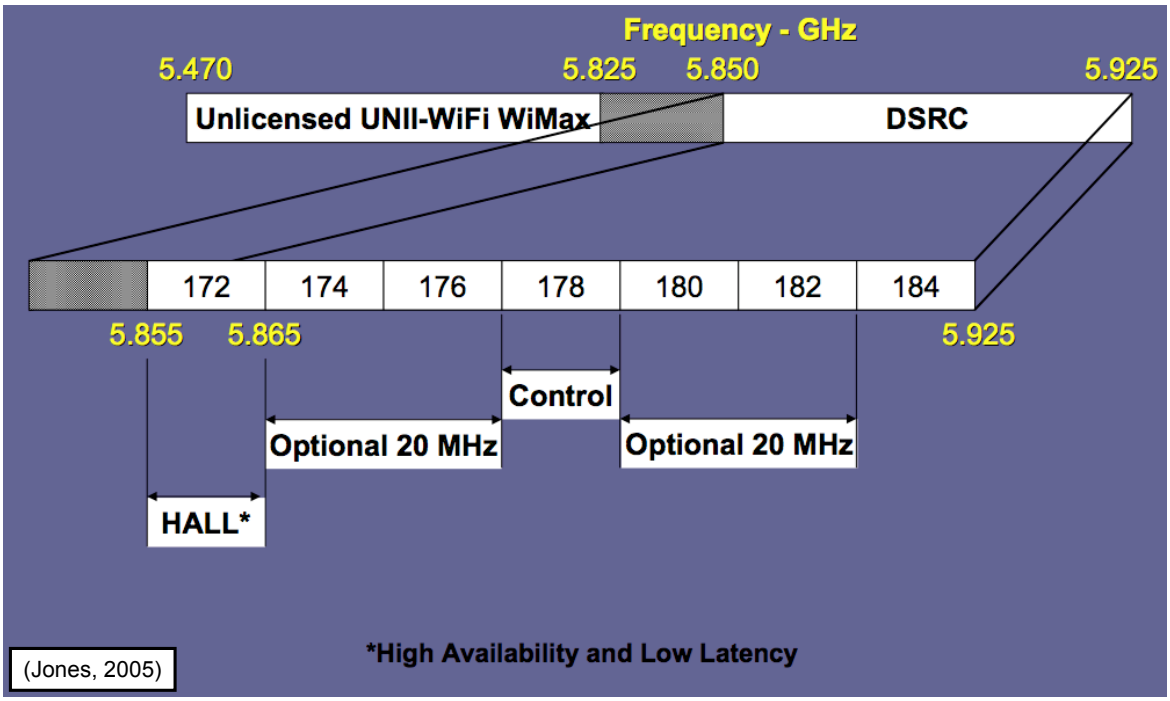
Channel Allocation

- 2 small zone and 2 medium zone service channels are designated for extended data transfer
- 2 service channels are designated for special safety critical applications
- Public safety applications and messages have priority in all channels

(Cash, 2004)

DSRC

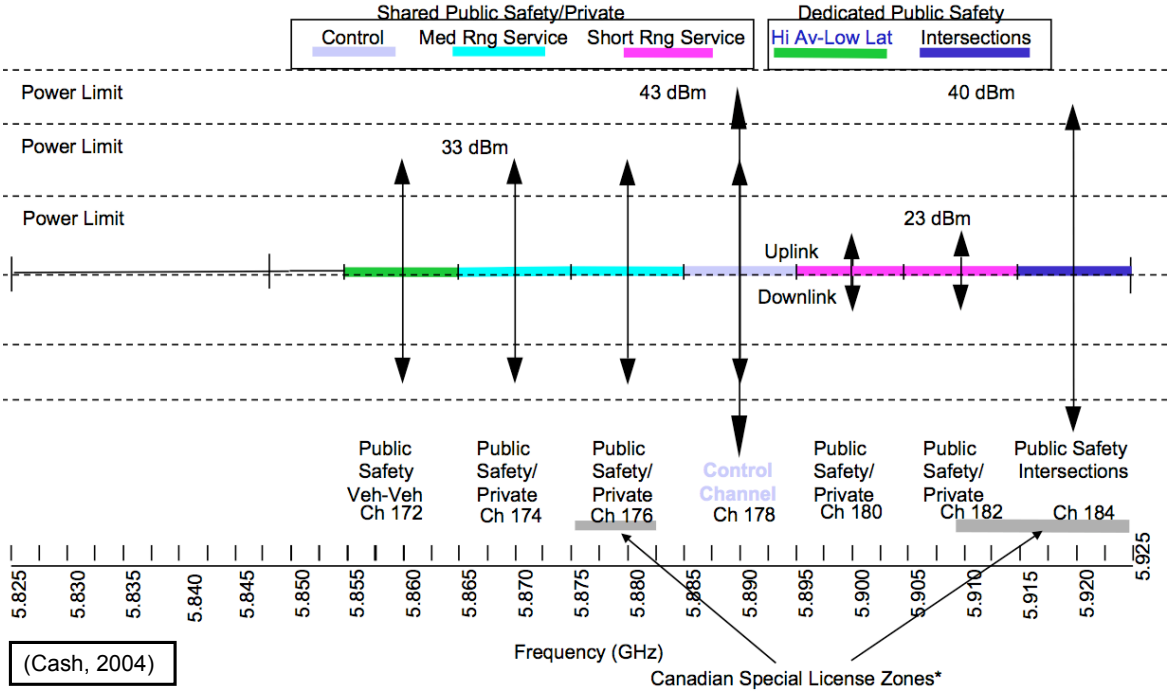
Channel Allocation



(Jones, 2005)

DSRC

Channel Allocation



(Cash, 2004)

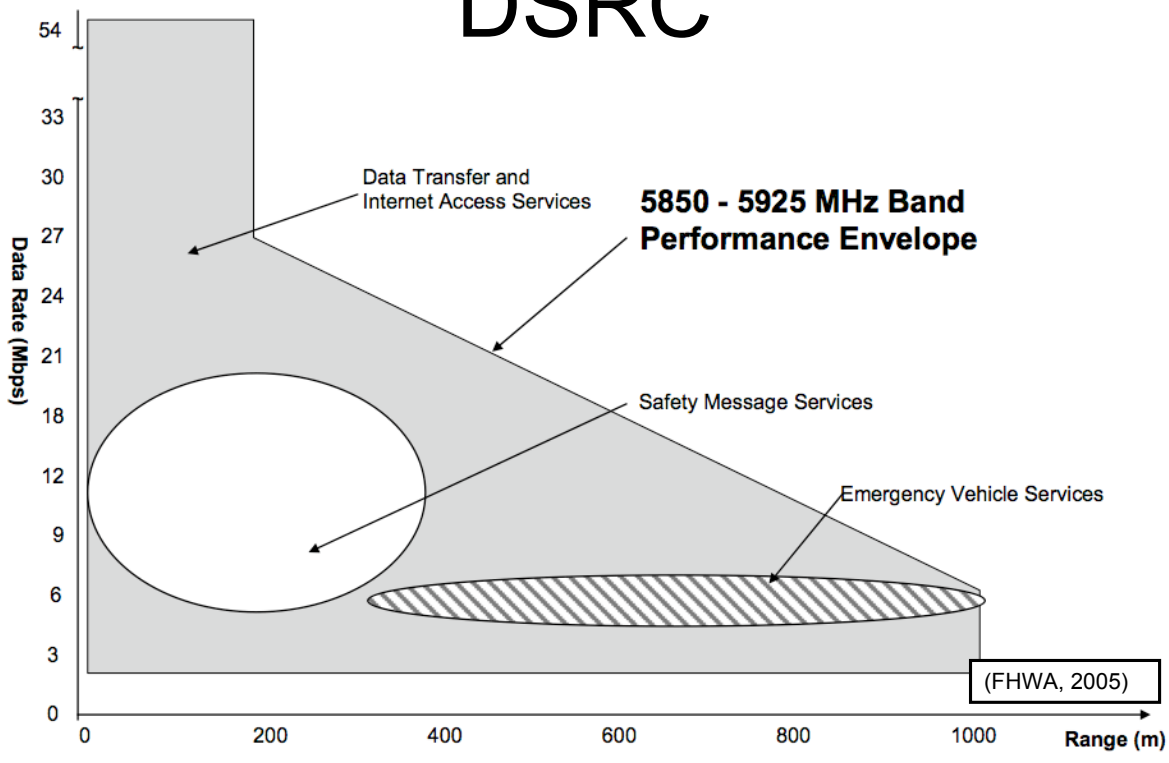
DSRC

How It Works

- RSU
  - announces to OBUs 10 times per second the applications it supports, on which channels
- OBU
  - listens on channel 172
  - authenticates RSU digital signature
  - executes safety apps first
  - then, switches channels
  - executes non-safety apps
  - returns to channel 172 and listens

(Jones, 2005)

DSRC



(FHWA, 2005)

DSRC and 802.11p

- IEEE 802.11p will define link (MAC) layer
- Supports two different stacks:
  - IPv6
    - only on service channels (not control channel)
  - WAVE Short Message Protocol (WSMP)
    - can be sent on any channel
    - allows applications to directly control physical characteristics (channel number and transmitter power)
- Priority
  - applications have a priority level (who gets first access to communications services)
  - MAC transmission priority (based on IEEE 802.11e EDCA)

(Fisher, 2007)

802.11p and Security

- Authenticate messages
- Encrypt confidential data
- Messages must be short and transactions fast
- For broadcast, high-priority messages, there is a new compact certificate format and a public key algorithm with short keys

(Whyte, 2005)

802.11p and Trust

- Vehicle safety
  - operator is untrusted
  - applications should be isolated from operator
- Public safety
  - operator is trusted
- e-Commerce
  - trust model is same as desktop trust model

(Whyte, 2005)

802.11p and Anonymity

- Identifiers:
  - Certificate
  - IP address
  - MAC address

Anonymous Certificates

- Broadcast messages from OBU
  - must be authenticated
  - must not be traceable to a specific OBU
- How?
  - group signatures
  - issue OBU with large number of certificates
  - must be compatible with revocation

(Whyte, 2005)

IP Addresses

- Long-lived IP addresses would only happen when you're stationary
  - no mechanism for hand-off of IP addresses between RSUs
- All devices change IP address when OBU moves from one RSU to another

(Whyte, 2005)

MAC Addresses

- Generate random MAC address out of local space
- When to change?
  - at startup?
    - allows tracking for individual trips
    - not really acceptable
  - when the signing key changes?
    - order every 5-10 minutes
    - close monitoring can follow transitions
      - but this can happen with keys

(Whyte, 2005)

Certificates

Where do they come from?

- OBUs will be provisioned by manufacturer
  - US DOT responsible for root certificate
  - anonymous OBU certificates signed by a pool of certificates held by all manufacturers (don't give away car make)
- RSUs, public safety vehicles given certificates conforming to existing admin hierarchies
  - hierarchical certificates

(Whyte, 2005)

Certificate Revocation

- All certificates for a given vehicle have identifiers derived from a single secret
- To revoke, recover and distribute the secret
- Must be distributed to all vehicles on road, requires infrastructure

(Whyte, 2005)

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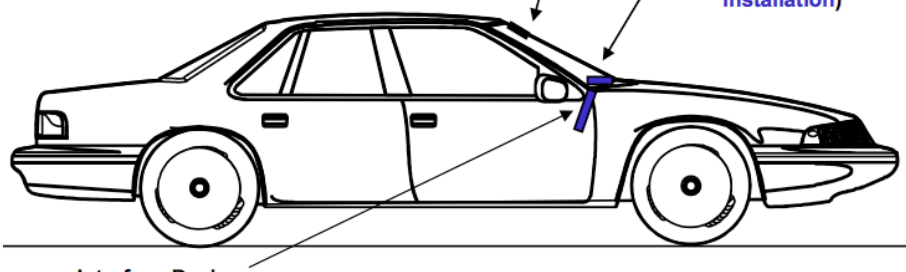
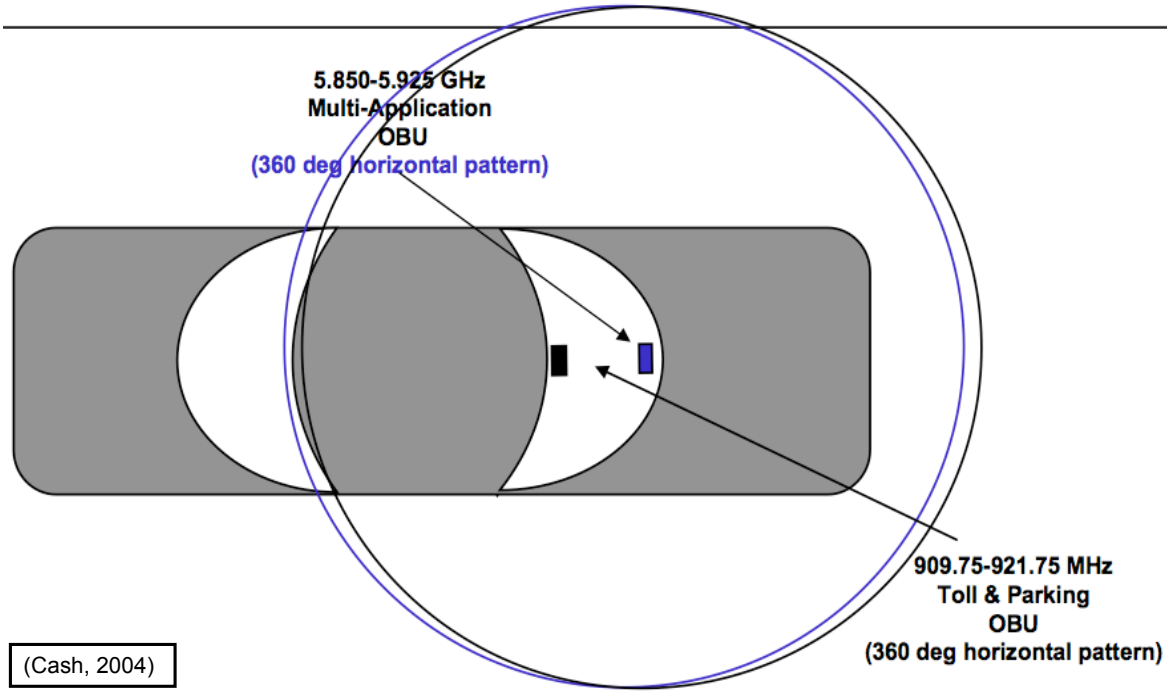
Basic Configuration



(Cash, 2004)

Basic Pattern Example



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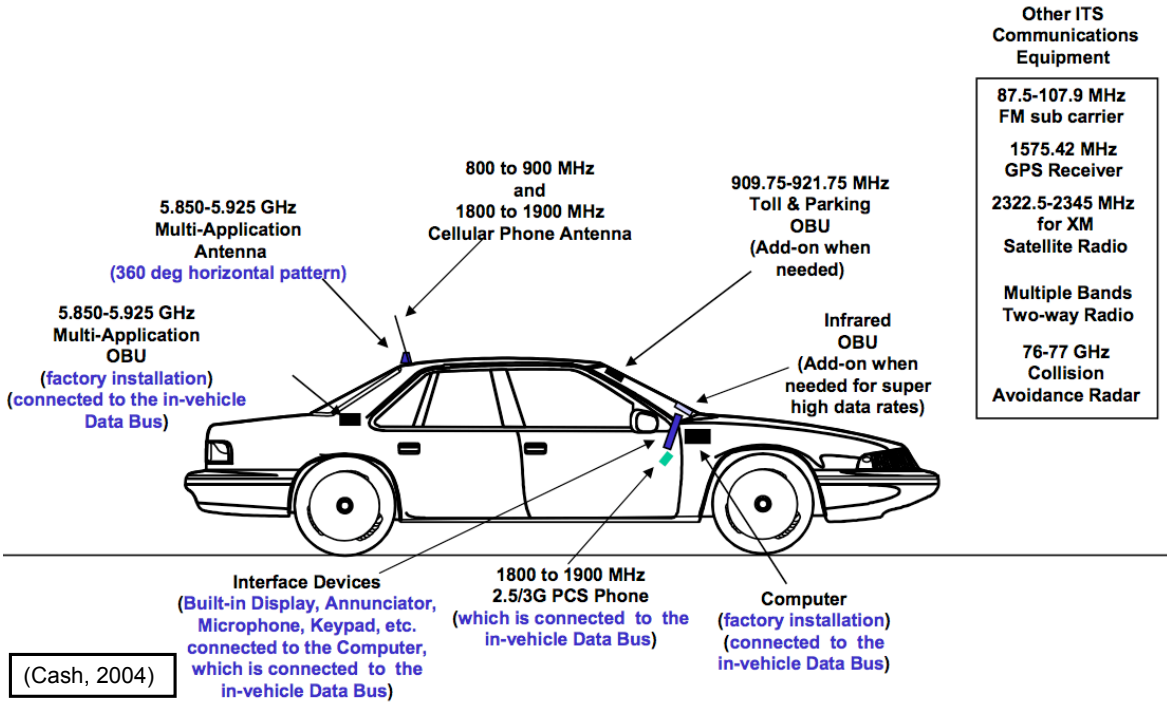
Enhanced Configuration



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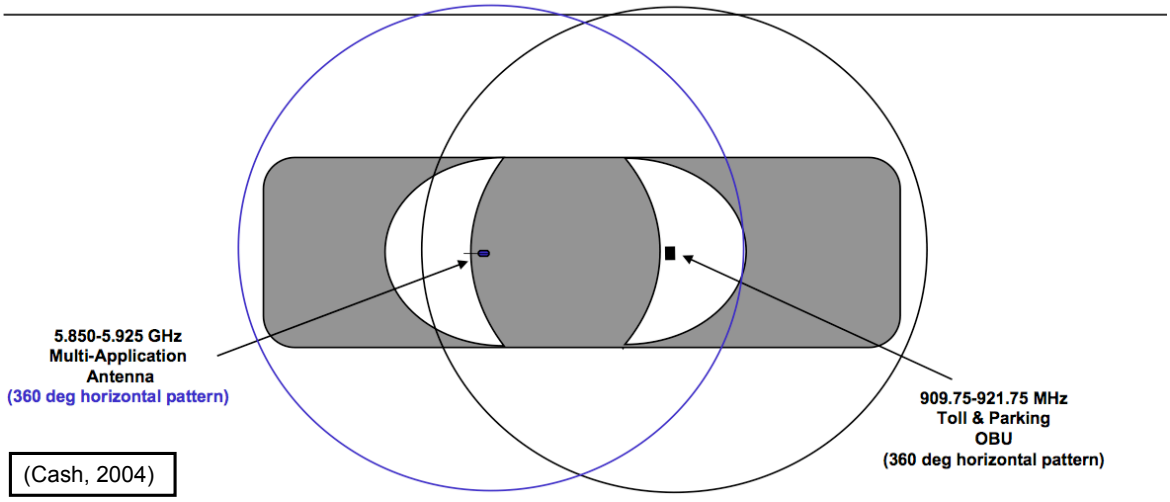
Enhanced Pattern



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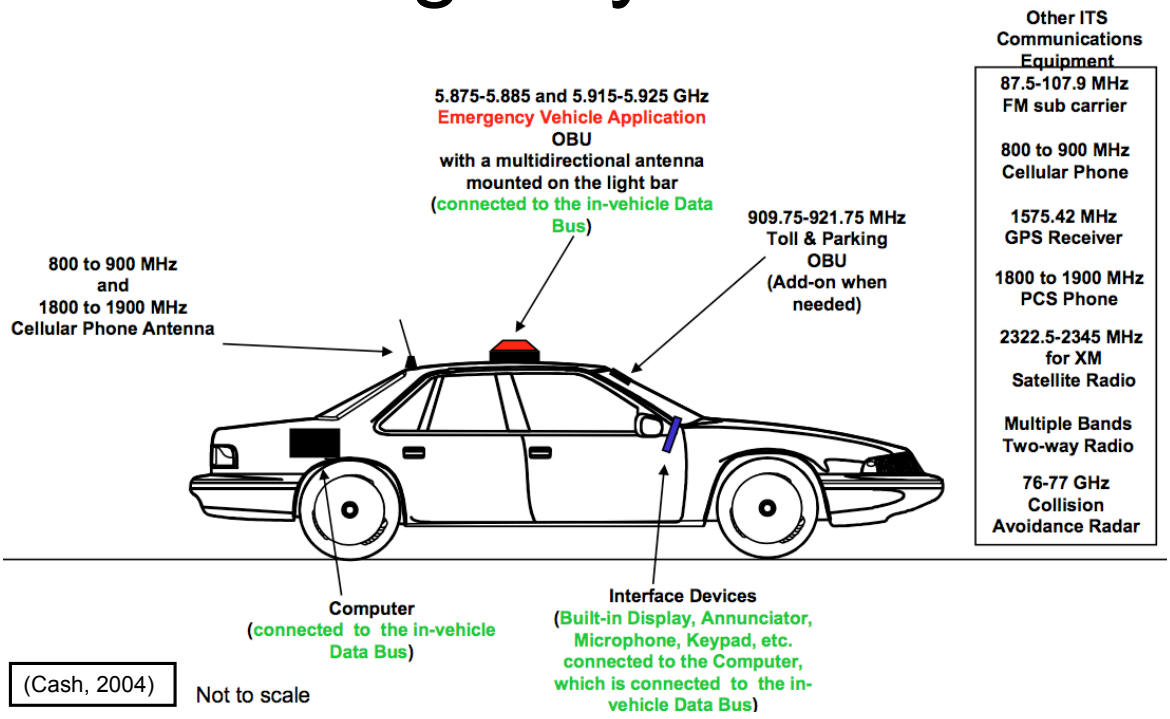
Emergency Vehicle

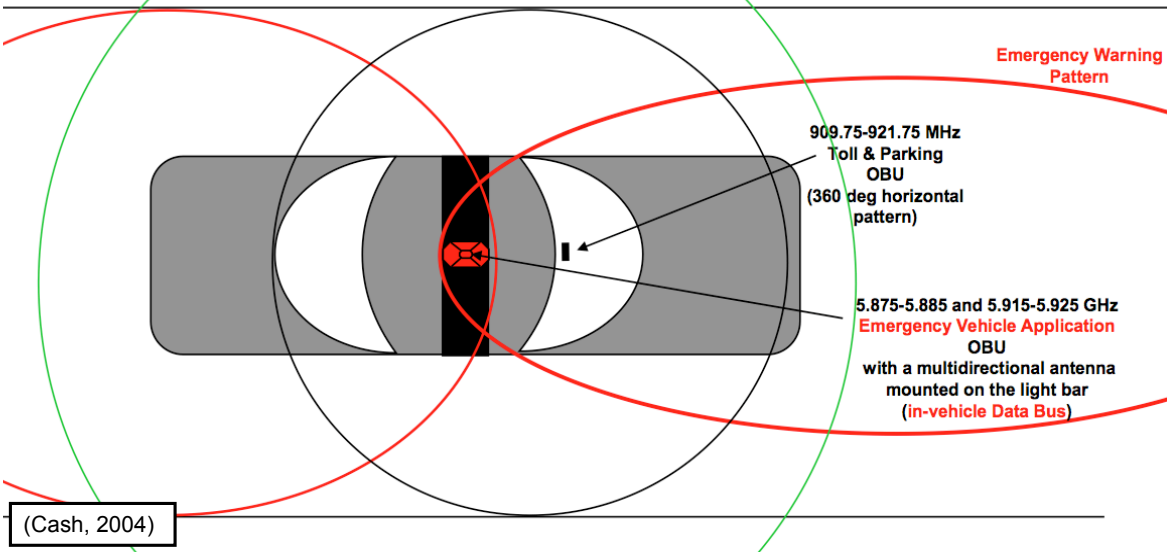


(Cash, 2004)

Not to scale

Emergency Vehicle

The emergency vehicle operator can select the emergency warning forward pattern, the rearward pattern, or the 360 degree multiple antenna pattern depending on the requirements of the application being implemented.



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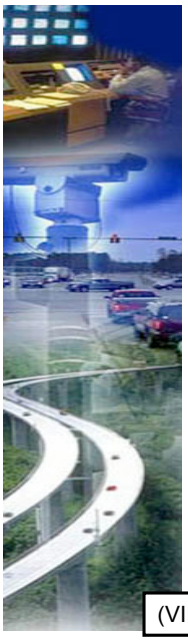

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