

Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: MAC Proposal to IEEE 802.15.7

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Re: Some technical system design details for 15.7 VLC.

Abstract: Some technical details for MAC are being proposed.

Purpose: To trigger discussion and initiate merger with other group members of TG 7.

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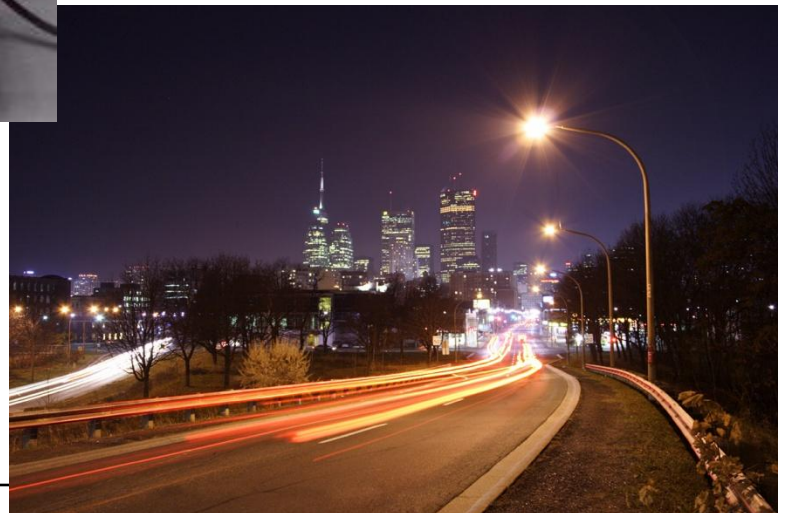
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MAC Proposal to IEEE 802.15.7

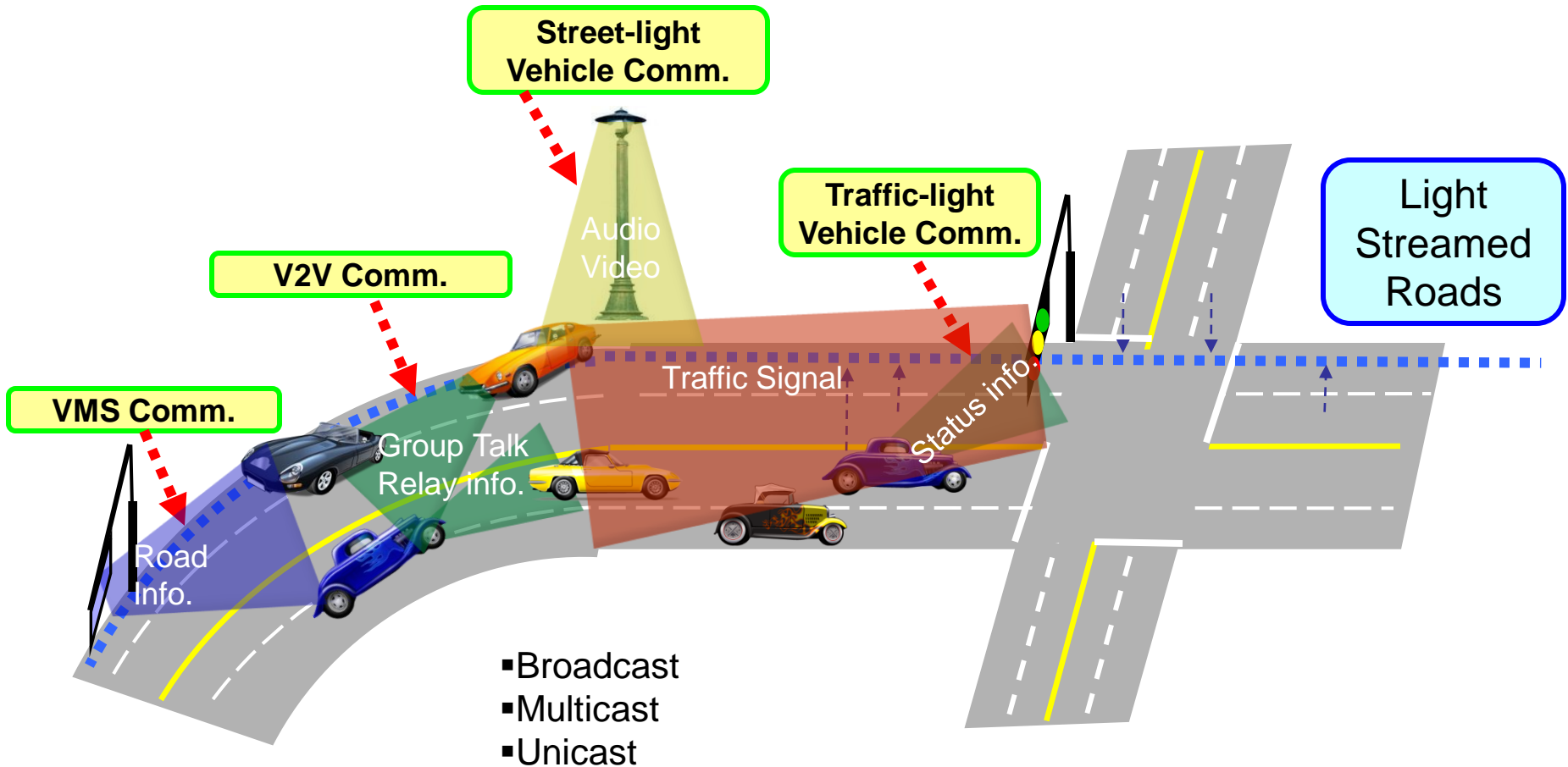
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Automotive LED



Light Streamed Roads (Light makes Roads)



Automotive Application Using VLC

- Between traffic-light(or infra) and vehicle
 - Traffic signal information broadcast
 - Idle-stop and go
 - Eco-driving
 - Vehicle reports road environment
 - Collecting and providing road information
 - Traffic status
 - Emergency situation
 - Road surface information
- Between vehicle and vehicle
 - Relaying traffic signal and road information
 - Guiding the direction
 - Maneuvering information

Broadcast/Multicast/Unicast

- Broadcast/Multicast
 - From traffic-light to vehicle (downlink)
 - From vehicle to vehicle
- Multicast Service
 - Accident announcement lane by lane
 - Group driving
 - Common interest sharing
- Unicast
 - From vehicle to traffic-light (uplink)
 - From vehicle to vehicle
- No Acknowledgements for Broadcast or Multicast frames

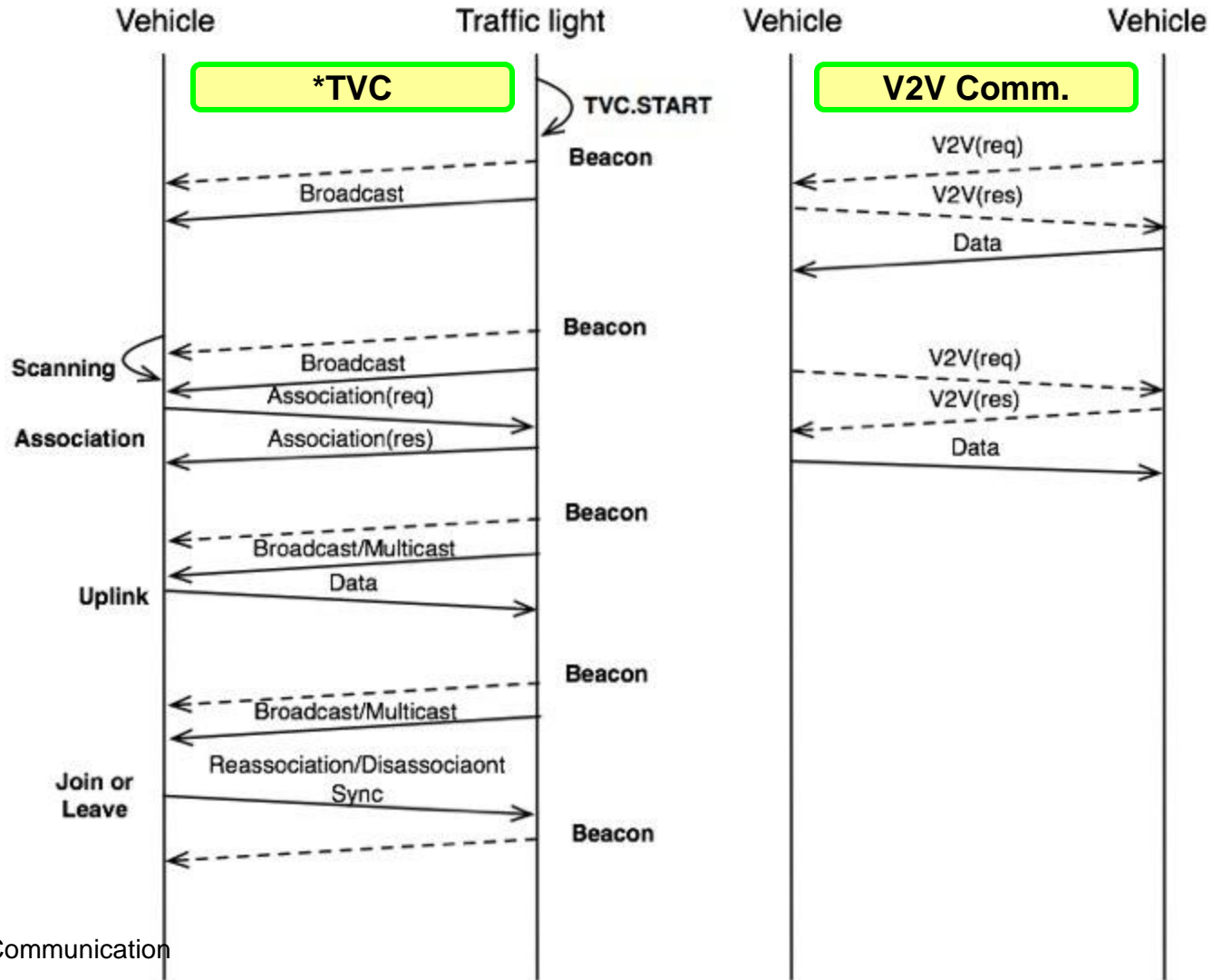
MAC Consideration

- Device
 - LEDs(Tx) & PDs(Rx) around cars
- Requirement
 - Support for the Light Streamed Road
 - Infra to Vehicle or Vehicle to Infra
 - Vehicle to Vehicle
 - Automotive adaptation
 - Upload request by many cars which approach to intersections
 - Relay data from vehicle to vehicle
 - High mobility

MAC Function

- Scanning
 - Search for a network (infra such as traffic-light, VMS, and street light or vehicle)
- Synchronization
 - Recognizing Beacon
 - Time Synchronization
 - Adopt PHY parameter
- Association/Reassociation
 - Integration into a network
 - **Multicast join**
 - Traffic-accident propagation
 - Road traffic information sharing
 - Road surface information announcement
 - Join/Leave, i.e. change networks
- Scheduling
 - Control data timing (ex. TDM)

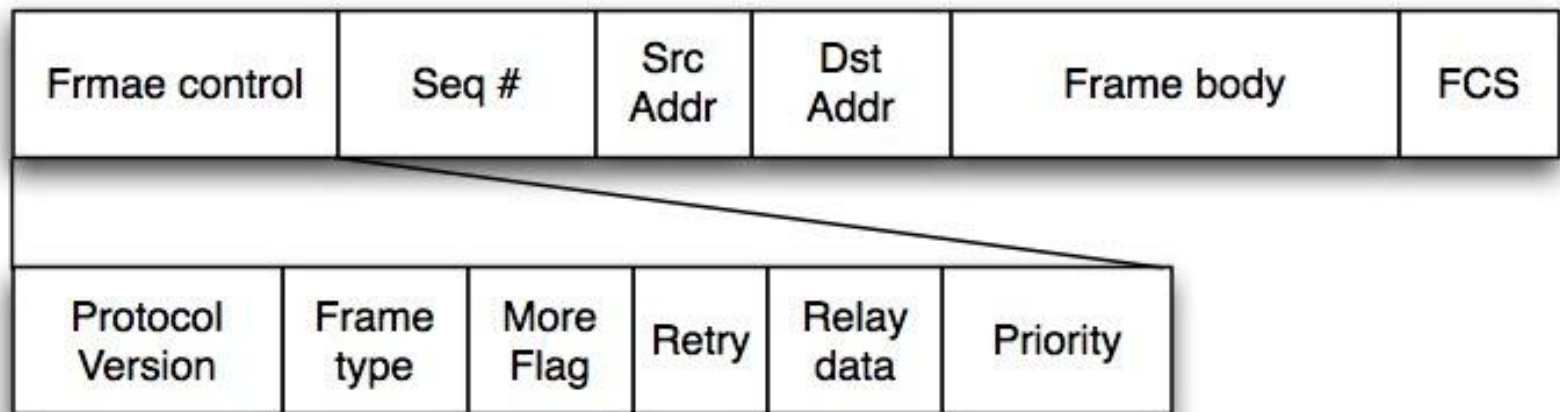
Communication Procedure



*TVC :
Traffic light Vehicle Communication

Framing Details : Format

- Generic 802.15.7 MAC



- Addressing

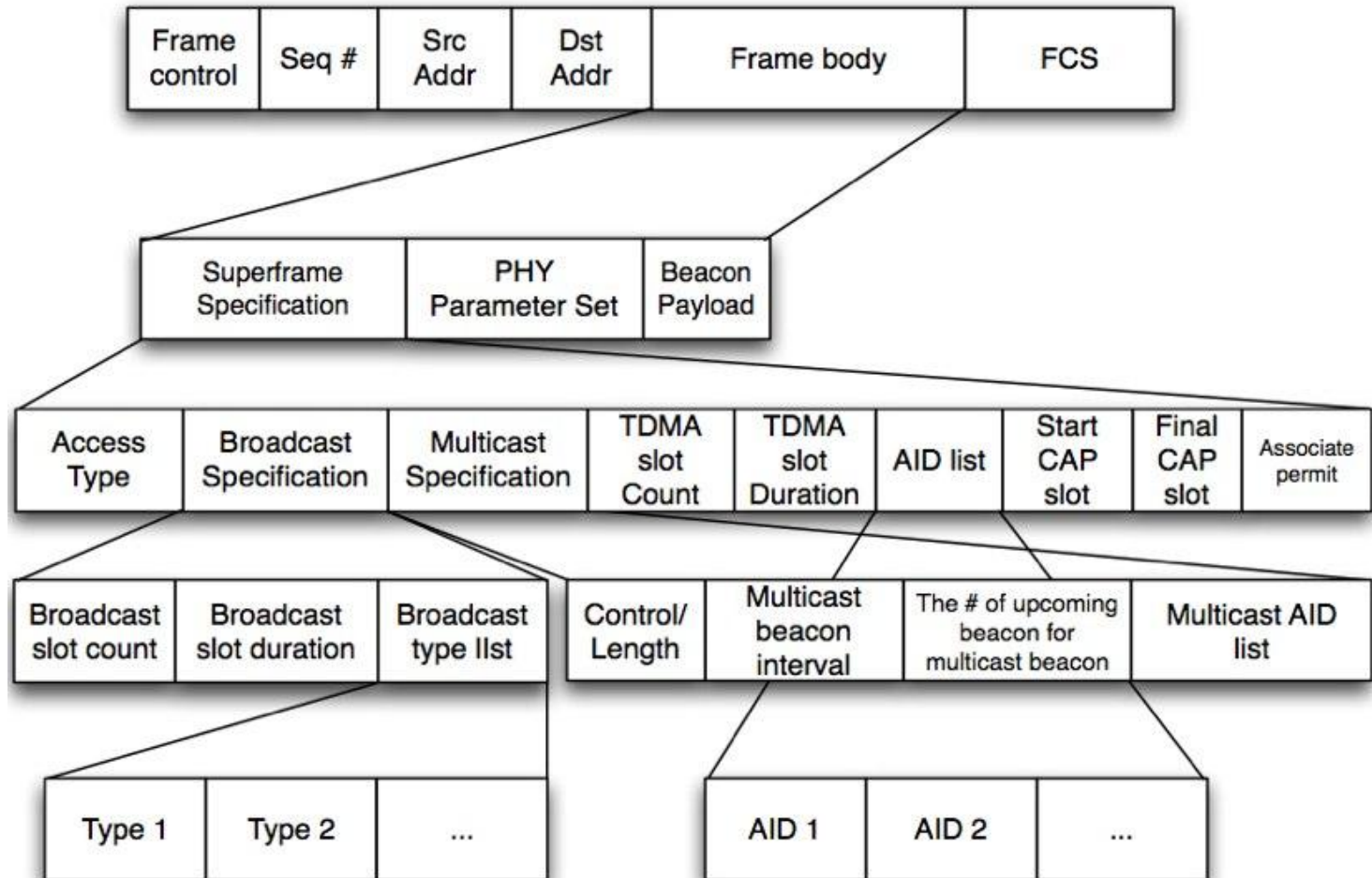
- Broadcast : 11111111 11111111
- Multicast : 10XXXXXX XXXXXXXX
- Unicast : 00XXXXXX XXXXXXXX

Framing Details : Frame Types

- Frame Types
 - Beacon
 - Data
 - TVC
 - From Traffic-light to Vehicle
 - **From Vehicle to Traffic-light**
 - V2V
 - **From Vehicle to Vehicle (like ad-hoc)**
 - ACK
 - Command
 - Scanning
 - **Association(TVC) / V2V(V2V)**
 - Reassociation/Disassociation
 - Sync

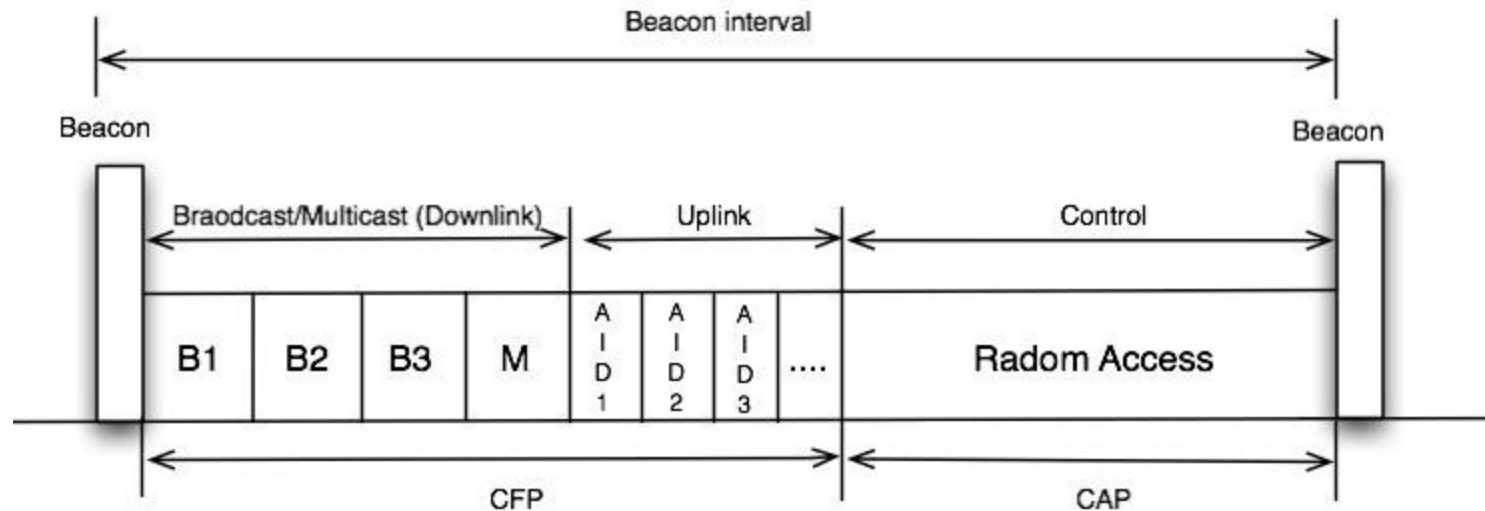
Beacon (1/3)

- Beacon Frame



Beacon (2/3)

- Superframe



B1 : Broadcast slot 1
 B2 : Broadcast slot 2
 B3 : Reserved
 M : Multicast slot
 AID1 : Association ID 1
 AID2 : Association ID 2

Beacon (3/3)

- Message type : Beacon
- Message subtype : Beacon notify
- Information
 - Beacon Sequence Number (BSN)
 - Traffic-light descriptor
 - Traffic-light ID
 - Logical channel
 - Among Red, Yellow, Green Left, and Green
 - Channel page
 - Timestamp
- Direction message
 - From Vehicle MAC to Vehicle upper layer

Data payload (1/2)

- Infra(Traffic light, VMS, Street light) to vehicle
 - Downlink
 - Broadcast/Multicast data

TYPE 1 (Traffic Signal Information) Downlink

Current Signal	Next Signal	Next Signal Remaining Time	Green Signal Remaining Time	Right Arrow Waiting/Passing	RightArrow Remaining Time
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TYPE 2 (Road Status Information) Downlink

The total # of passing cars	The AVG # of passing cars/min	Emergency Description	Road Surface Status
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- Uplink
 - Unicast data

Road Status Information UPlink

Stop & Go Count	Avg Speed	Emergency Description	Road Surface Status
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Data payload (2/2)

- V2V

- Broadcast/Multicast/Unicast

TYPE 1 (Traffic Signal Information) - Relay data

Current Signal	Next Signal	Next Signal Remaining Time	Green Signal Remaining Time	Right Arrow Waiting/Passing	RightArrow Remaining Time
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TYPE 2 (Road Status Information) - Relay data

The total # of passing cars	The AVG # of passing cars/min	Emergency Description	Road Surface Status
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Type 3 (Road Status Information)

Stop & Go Count	Avg Speed	Emergency Description	Road Surface Status
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Type 4 (Group Driving)

Common Interest	Guiding Information
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Type 5 (Multimedia Information)

Audio	Video	Advisetisement
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Scanning

- Message type : Command
- Message subtype : Scanning
- Information
 - Logical channel
 - Among Red, Yellow, Green Left, and Green
 - Channel page
 - Scan duration
- Direction message : From Vehicle to Traffic-light

Association (1)

- Message type : Command
- Message subtype : Association request
- Information
 - Logical channel
 - Among Red, Yellow, Green Arrow, and Green
 - Channel page
 - Listen interval
 - **Capability info**
 - Device type
 - Position (window shield, head light, tail light)
 - Property
 - Supported rate
 - **Direction**
 - **Access type**
 - TDM, Random Access
- Direction message : From Vehicle to Traffic-light

Association (2)

- Message type : Command
- Message subtype : Association Response
- Information
 - **Association ID**
 - Contact # : Sequential increase
 - Lane # : Green Left – 00, Green – 01, Right - 10
 - Step # : The volume number of cars which can pass the intersection
 - Traffic-light ID
 - **Mobility type**
 - Red – ISG (static), Approaching (low mobility)
 - Yellow – Adaptation (high mobility)
 - Green – Pass (High mobility)
 - Green Left or Right – Look around (mid mobility)
 - **Access type**
 - Status
- Direction message : From Traffic-light to Vehicle

Reassociation (1)

- Message type : Command
- Message subtype : Reassociation Request
- Information
 - **Current traffic-light ID**
 - Logical channel
 - Channel page
 - Listen interval
 - Capability info
 - Device type
 - Position (window shield, head light, tail light)
 - Property
 - Supported rate
 - Direction
 - Access type
 - TDM, Random Access
- Direction message
 - From Vehicle to Traffic-light

Reassociation (2)

- Message type : Command
- Message subtype : Reassociation Response
- Information
 - **Association ID**
 - Contact #
 - Lane #
 - Step #
 - Traffic-light ID
 - **Mobility type**
 - Red – PIS (static), Approaching (low mobility)
 - Yellow – Adaptation (high mobility)
 - Green – Pass (high mobility)
 - Green Left or Right– Look around (mid mobility)
 - Access type
 - Status
- Direction message
 - From Traffic-light to Vehicle

Disssociation

- Message type : Command
- Message subtype : Disassociation
- Information
 - Disassociation reason
 - **Current Traffic-light ID**
 - **Association ID**
- Direction message
 - From Traffic-light to Vehicle
 - From Vehicle to Traffic-light

Start

- Message type : Command
- Message subtype : Start
- Information
 - **Traffic-light descriptor**
 - Traffic-light ID
 - Logical channel
 - Channel page
 - Timestamap
 - Beacon
 - Superframe Specification
- Direction message
 - From Traffic-light to Vehicle

Sync (1/2)

- Message type : Command
- Message subtype : Sync request
- Information
 - **Traffic-light descriptor**
 - Traffic-light ID
 - Logical channel
 - Channel page
 - Timestamap
- Direction message
 - From Vehicle to Traffic-light

Sync (2/2)

- Message type : Command
- Message subtype : Sync loss indication
- Information
 - Loss reason
 - Traffic-light descriptor
 - Traffic-light ID
 - Logical channel
 - Channel page
 - Timestamap
- Direction message
 - From Vehicle MAC to Vehicle upper layer

V2V (1/2)

- Message type : Command
- Message subtype : V2V request
- Information
 - **Capacity info**
 - Device type
 - Supported rate
 - **Characteristic**
 - Duplex
 - Tx only / Rx only / Both
 - Type
 - Allocation / Deallocation
 - Access type
- Direction message
 - From Vehicle to Vehicle

V2V (2/2)

- Message type : Command
- Message subtype : V2V response
- Information
 - **V2V ID**
 - **Capacity info**
 - Device type
 - Supported rate
 - **Characteristic**
 - Duplex
 - Tx only / Rx only / Both
 - Type
 - Allocation / Deallocation
 - Access type
 - **Mobility type**
 - **Status**
- Direction message
 - From Vehicle to Vehicle

Conclusion

- Propose automotive MAC for VLC
 - Support for the Light Streamed Road
 - Infra to Vehicle or Vehicle to Infra
 - Vehicle to Vehicle
 - Hybrid media access scheme
 - TDM, Random Access
 - New frame format for the automotive adaptation