CONNECTED WORK ZONES

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Foundational Efforts...

◦ SAE/USDOT Connected Work Zone Standard and USDOT Work Zone Data Exchange specification

◦ SAE J2735 V2X Communications Message Set Dictionary

◦ Connected Vehicle Pooled Fund Study (CV PFS) Connected Work Zones effort

Ongoing challenges in connected vehicle deployment...

◦ What comes first: infrastructure vs. vehicle technologies

◦ FCC reallocation of the 5.9 GHz Spectrum

◦ "Who is going to pay?"

◦ Interoperability concerns

Direct vs. Network Communications

Vehicle-to-Everything (V2X) Direct Communications

- 5.9 GHz spectrum, formerly exclusively for dedicated short-range communications (DSRC)

- Reallocated for Cellular-V2X (C-V2X) by the Federal Communications Commission (FCC)

- Roadside units broadcast data for any receiver in range to receive

- No 'handshake' for broadcaster to know who receives the data
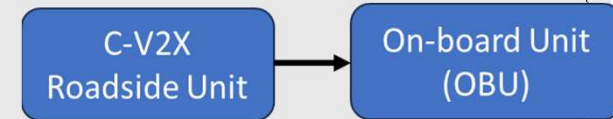
Cellular Network Communications

- The client (e.g., a web browser or mobile application) needs to initiate each interaction

- Request-response model often uses the hypertext transfer protocol (HTTP)
  - Agencies publish and update XML feeds of road events
  - Applications receive updated information when they pulls the data
  - Alternatively, a publish-subscribe model is being demonstrated
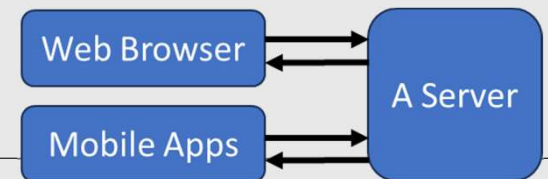
MAP Message:
- Details of all lanes
- Nodes (lat/long) of all approaches
- Crosswalks
- Connections from Ingress to Egress

1

● Ingress lane nodes

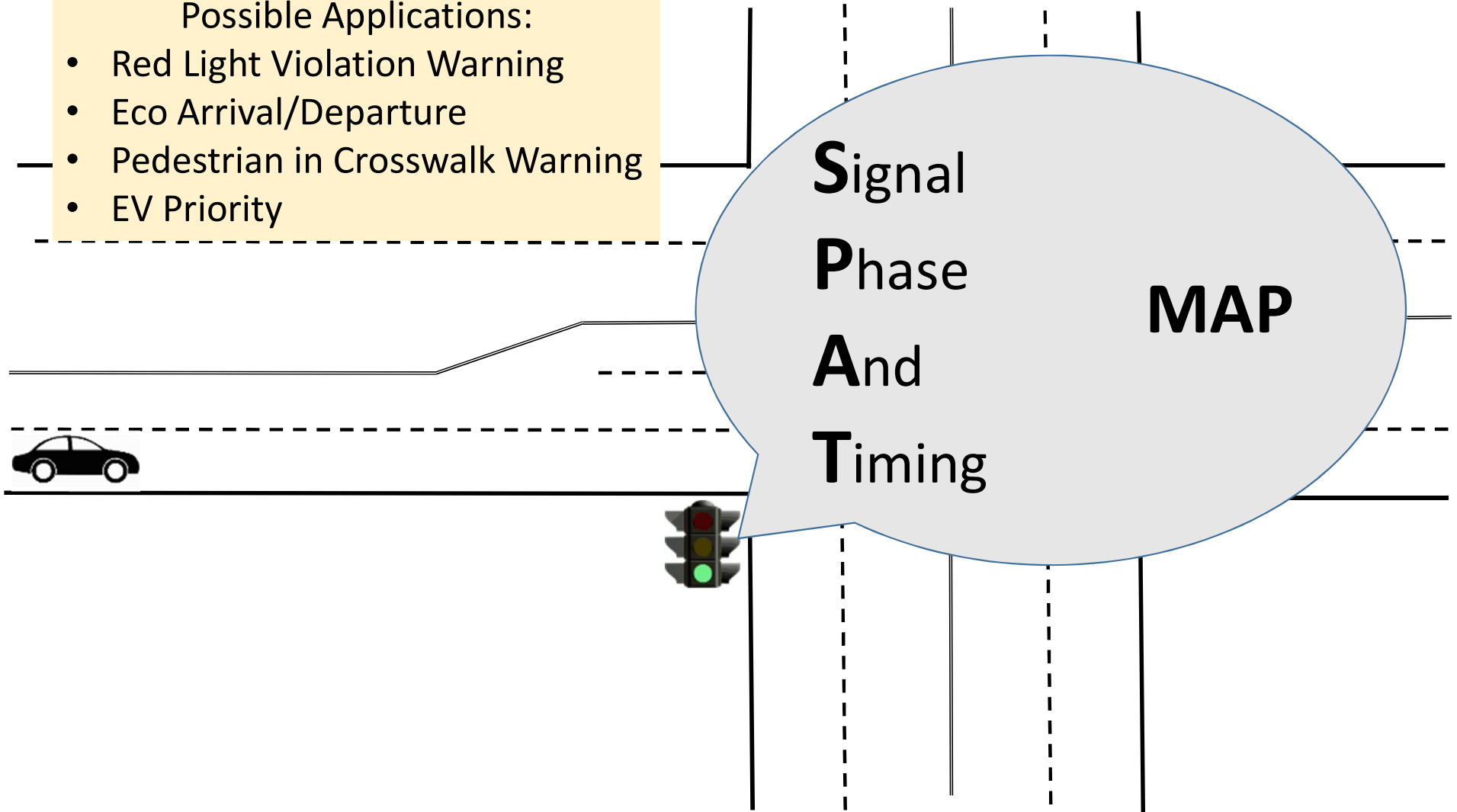● Egress lane nodes

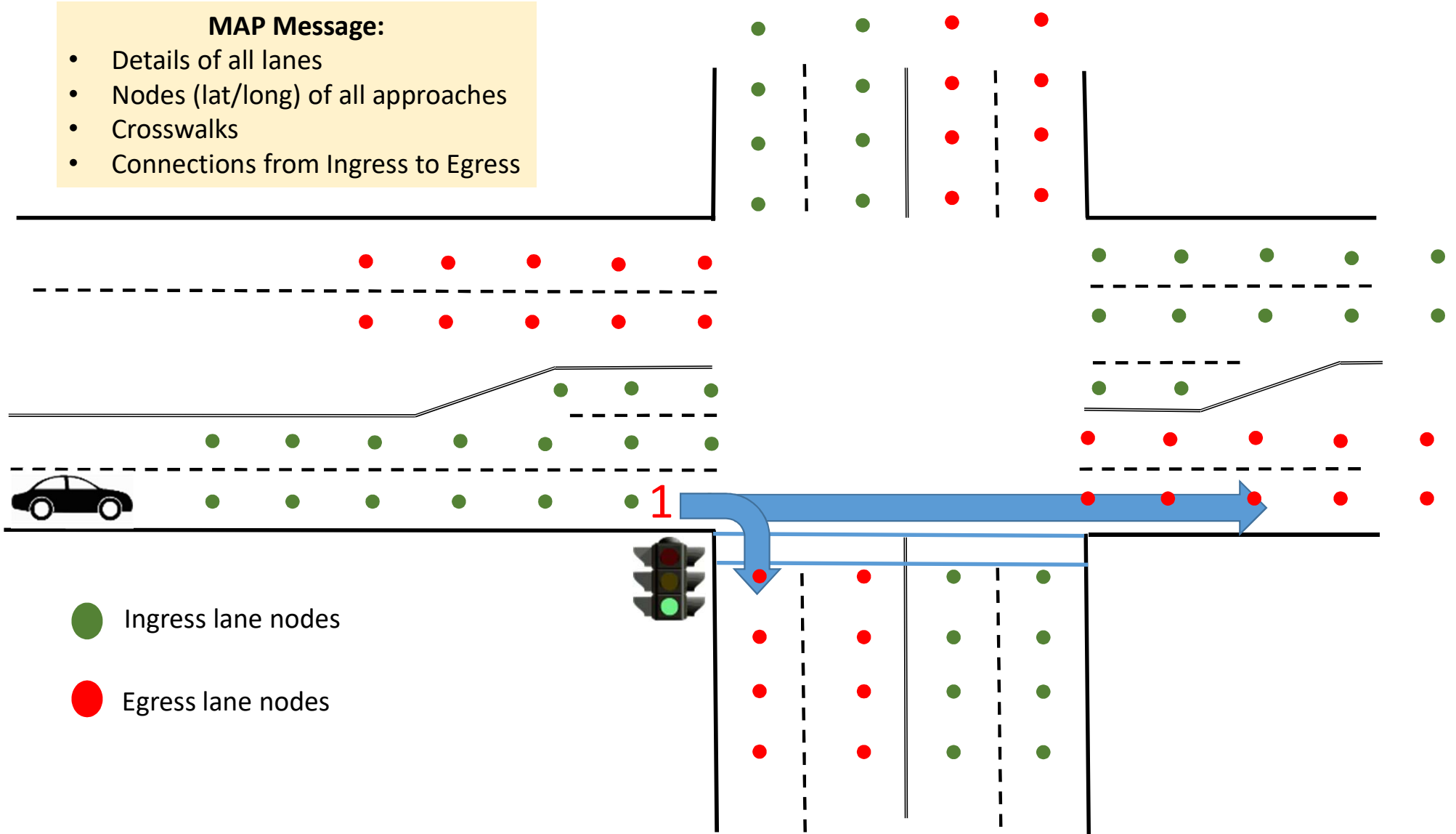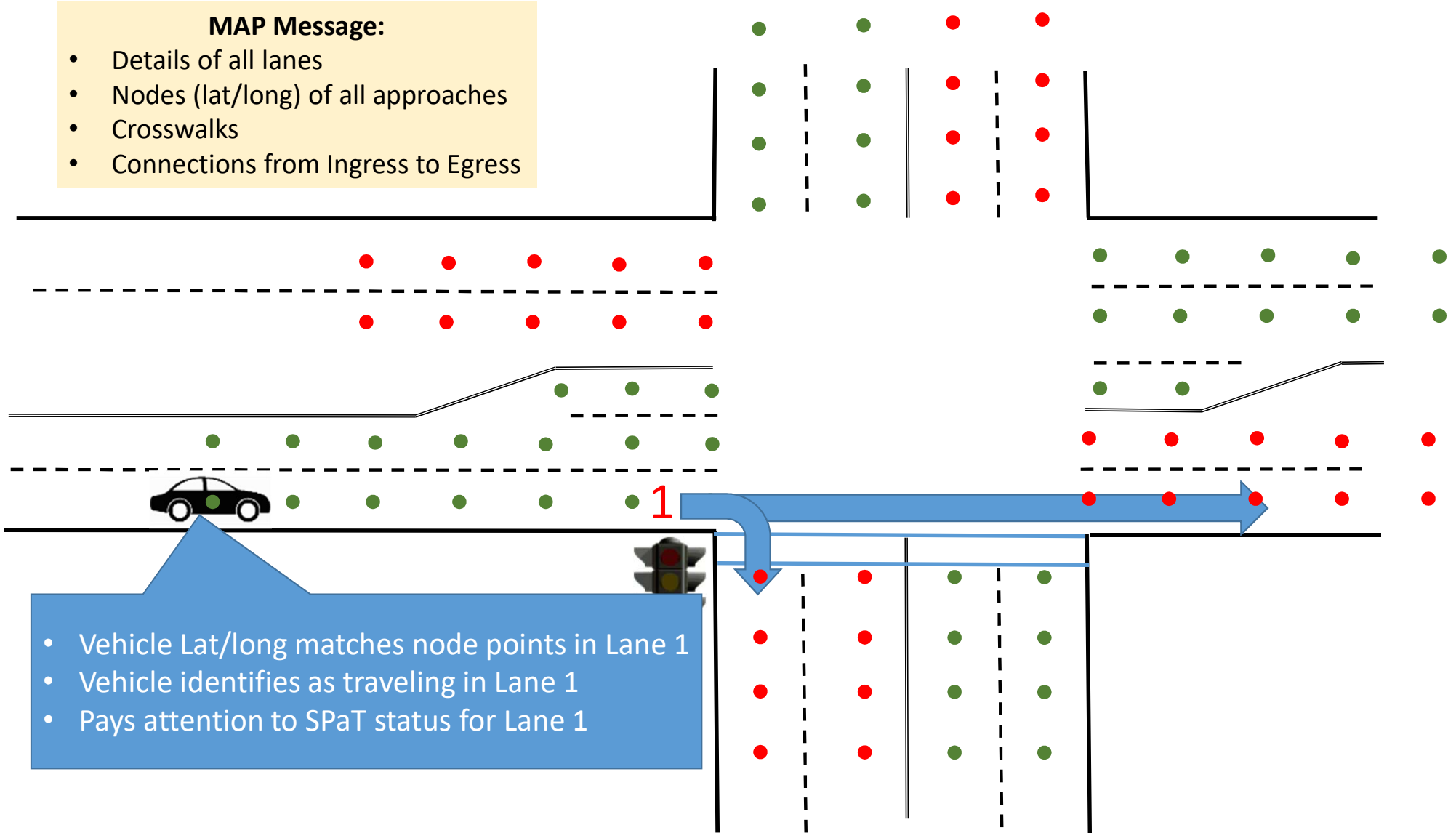**MAP Message:**
- Details of all lanes
- Nodes (lat/long) of all approaches
- Crosswalks
- Connections from Ingress to Egress

1

- Vehicle Lat/long matches node points in Lane 1
- Vehicle identifies as traveling in Lane 1
- Pays attention to SPaT status for Lane 1

Connected Work Zone Concept

◦ Build on Manual of Uniform Traffic Control Devices (MUTCD)

◦ Broadcast audio or visual in-vehicle messages based on content and location of static signs

◦ Consider sight distance

◦ May send different messages for lane closure versus speed

Location of Work Zone

Location of Physical RSU

Where the OBU should display / announce the warning
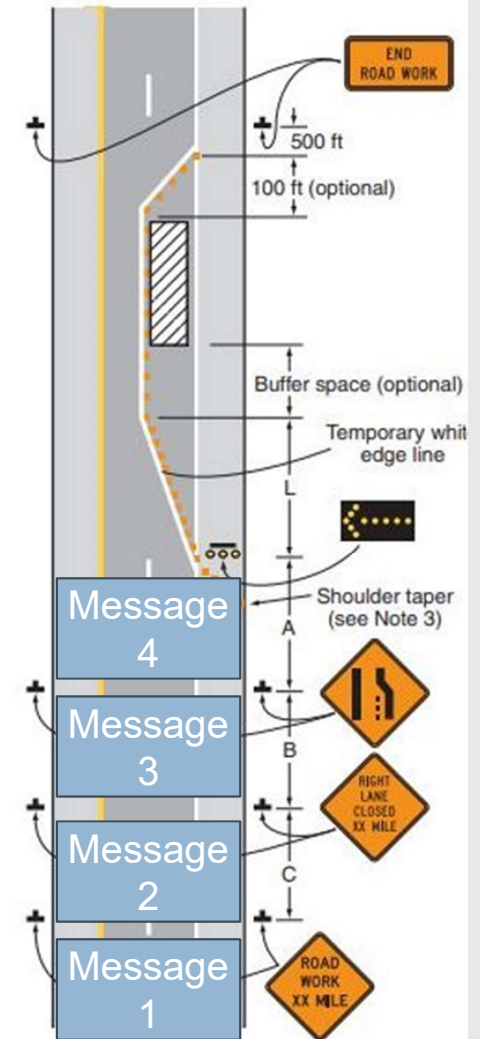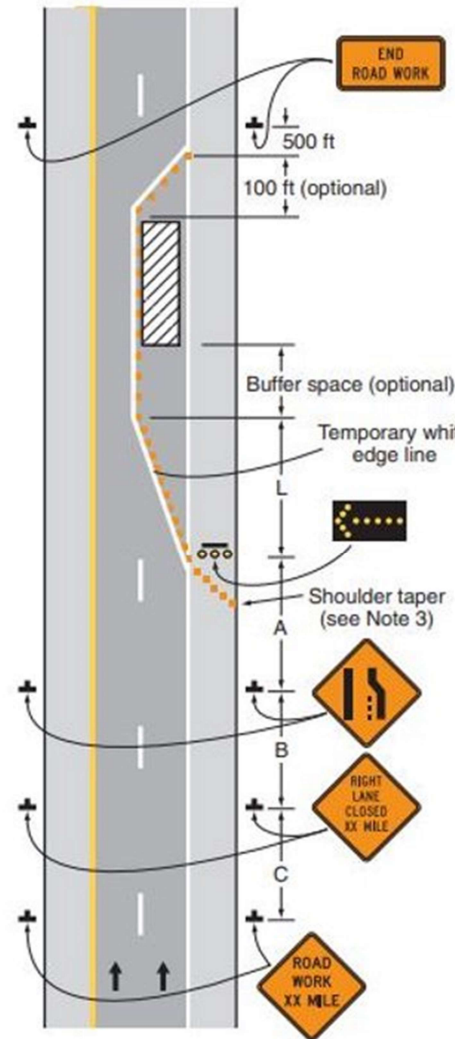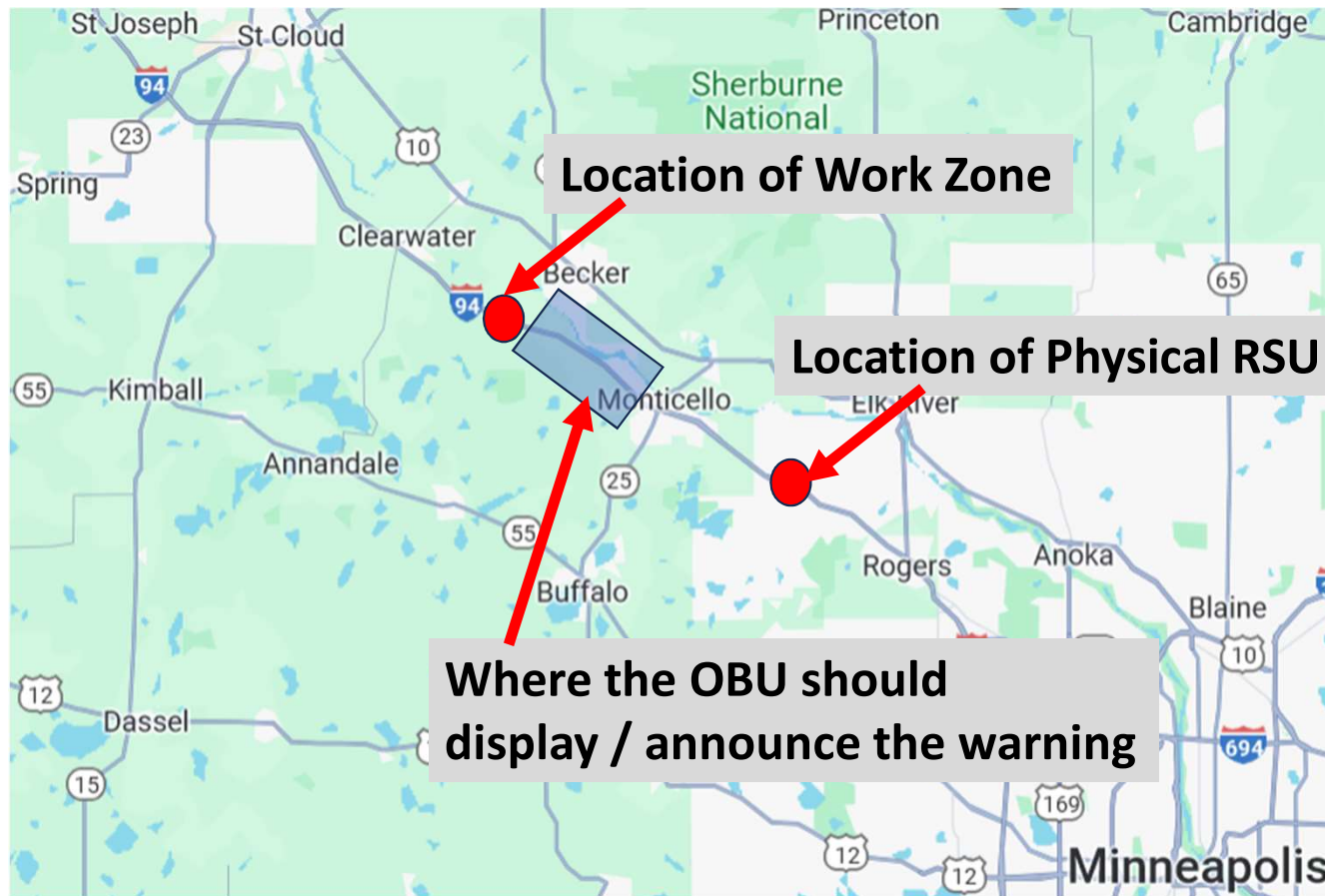
"Valid" Area Polygon

- Allows for upstream RSUs (or cellular networks) to broadcast messages
- OBUs can hold the message until vehicle is in the "valid" area

Sample Traveler Information Message (TIM)

```
----------CSW_1_decoded----------
value MessageFrame ::= {
  messageId 31,
  value TravelerInformation : {
    msgCnt 1,
    packetID 'D2BBCA10A7167605C2'H,
    dataFrames {
      {
        sspTimRights 0,
        frameType advisory,
        msgId roadSignID : {
          position {
            lat 406229758,
            long -1117563307
          },
          viewAngle {from000-0to022-5degrees, from022-5to045-0degrees, from045-0to067-5degrees, from067-5to090-0degrees,
from090-0to112-5degrees, from112-5to135-0degrees, from135-0to157-5degrees, from157-5to180-0degrees, from180-0to202-5degrees,
from202-5to225-0degrees, from225-0to247-5degrees, from247-5to270-0degrees, from270-0to292-5degrees, from292-5to315-0degrees,
from315-0to337-5degrees, from337-5to360-0degrees},
          mutcdCode warning
```

Reference Point Lat/Lon

View Angle
(direction of travel when the message applies)

Sample TIM

Valid Area of TIM
    Polygon – Node Points & Width
    Circle – Center Point and
    Radius

```
},
startYear 2023,
startTime 427370,
duratonTime 32000,
priority 0,
sspLocationRights 0,
regions {
  {
    laneWidth 6000,
    directionality forward,
    description path : {
      offset xy : nodes : {
        {
          delta node-LatLon : {
            lon -1117563307,
            lat 406229758
          }
        },
        {
          delta node-LatLon : {
            lon -1117549145,
            lat 406229921
          }
        },
        {
          delta node-LatLon : {
            lon -1117543888,
            lat 406231224
          }
        },
        {
          delta node-LatLon : {
            lon -1117540420,
            lat 406234385
```

TIM Structure

◦ International Traveler Information
System (ITIS) Codes define the message

```
          }
        }
      },
      sspMsgRights1 0,
      sspMsgRights2 0,
      content advisory : {
        {
          item itis : 13599
        },
        {
          item itis : 7196
        },
        {
          item itis : 12569
        },
        {
          item itis : 8720
        },
        {
          item text : "CURVE AHEAD"
        },
        {
          item text : "!25 MPH ADVISED"
        }
      }
    }
  }
```

Network Cellular-based Solution

◦ Verizon is working to provide in-vehicle messages via cellular communications
  ◦ Similar manner as direct communications via a roadside unit infrastructure
  ◦ Leverages edge computing and Message Query Telemetry Transport (MQTT)
  ◦ Being explored by several agencies, and documented by the Connected Vehicle Pooled Fund Study
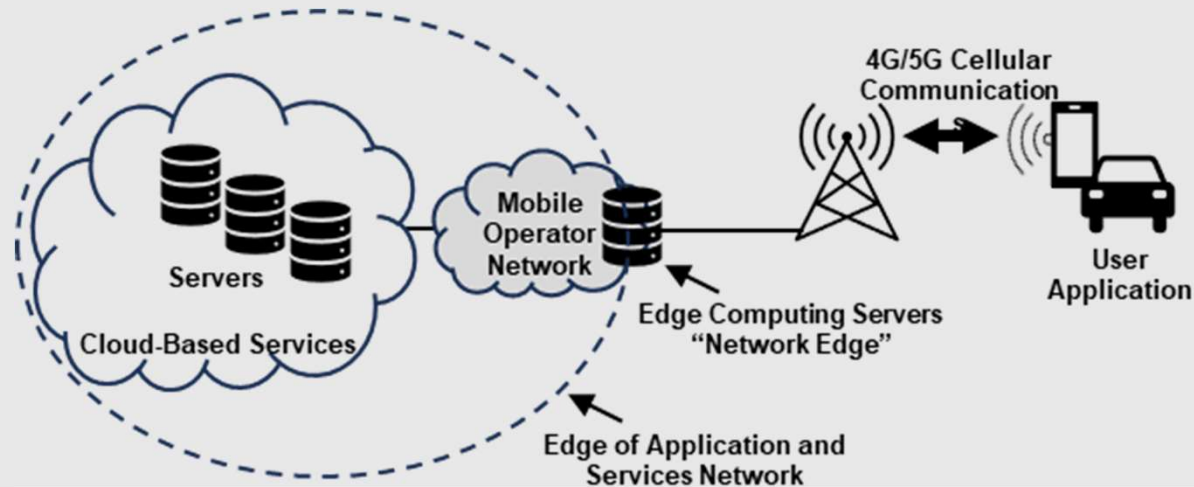
MQTT (Message Queuing Telemetry Transport)

- Uses a Publish / Subscribe model
  - ...but subscribing systems don't want to receive all J2735 messages.
  - They only want those that relate to them
- Routes messages to subscribers based on "Topics" that they subscribe to when they are relevant
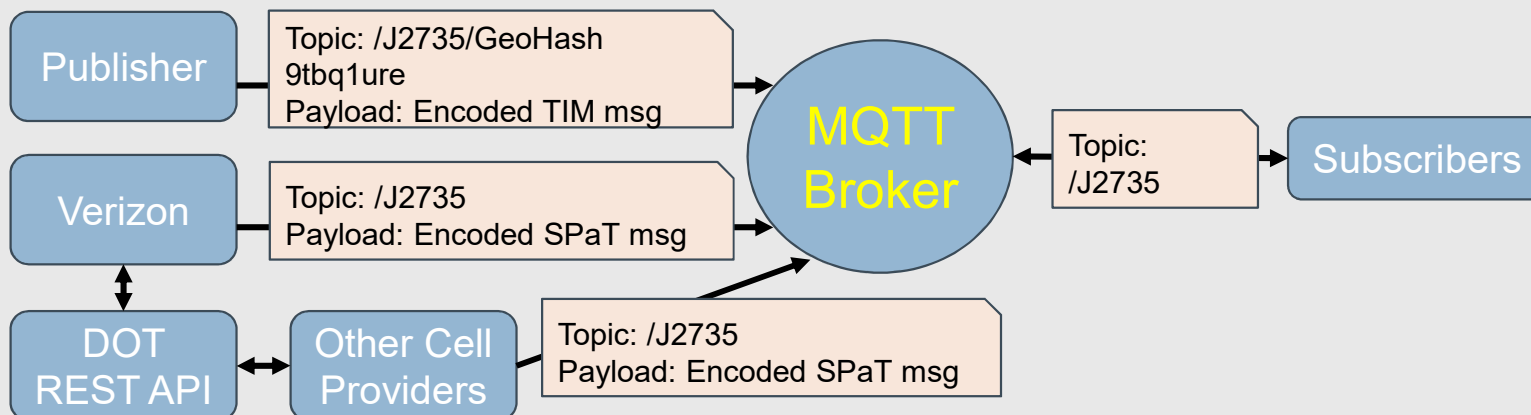
Example Process for Using Cellular Communications for Connected Work Zones
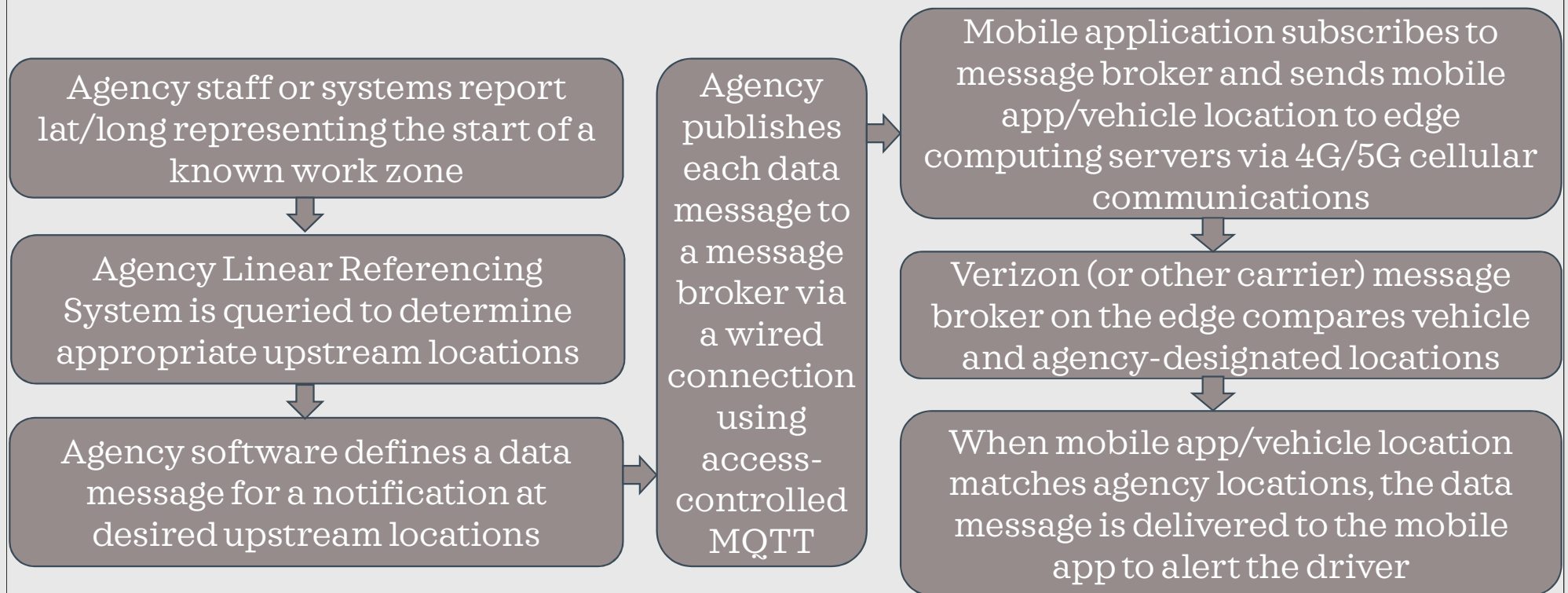
Agency staff or systems report lat/long representing the start of a known work zone

↓

Agency Linear Referencing System is queried to determine appropriate upstream locations

↓

Agency software defines a data message for a notification at desired upstream locations

→

Agency publishes each data message to a message broker via a wired connection using access-controlled MQTT

→

Mobile application subscribes to message broker and sends mobile app/vehicle location to edge computing servers via 4G/5G cellular communications

↓

Verizon (or other carrier) message broker on the edge compares vehicle and agency-designated locations

↓

When mobile app/vehicle location matches agency locations, the data message is delivered to the mobile app to alert the driver

Looking to the future....

- National efforts supported by Athey Creek are working toward an interoperable, network cellular solution for providing connected work zone information
  - Connected Vehicle Pooled Fund Study Connected Work Zones: Caltrans, Arizona DOT, and Maricopa County DOT
  - Utah DOT's Connect the West V2X Accelerator Grant: Utah DOT, Wyoming DOT, and Colorado DOT

- Goal is a seamless solution that is interoperable and consistent:
  - For IOOs to provide information
  - For drivers to receive it
- And:
  - Across jurisdictional boundaries
  - For all network cellular carriers

Conclusion

- Every agency will deploy and respond to new technologies at a different pace

- Agencies are exploring and demonstrating new approaches today that:
  - Leverage developed standards for direct communications
  - Leverage technologies available via network cellular communications
  - Leverage in-vehicle technologies that are already present (i.e., mobile devices)
  - Can be leveraged when cellular-V2X technologies are deployed

For More Information

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