DENSO
Crafting the Core

Connected Cars

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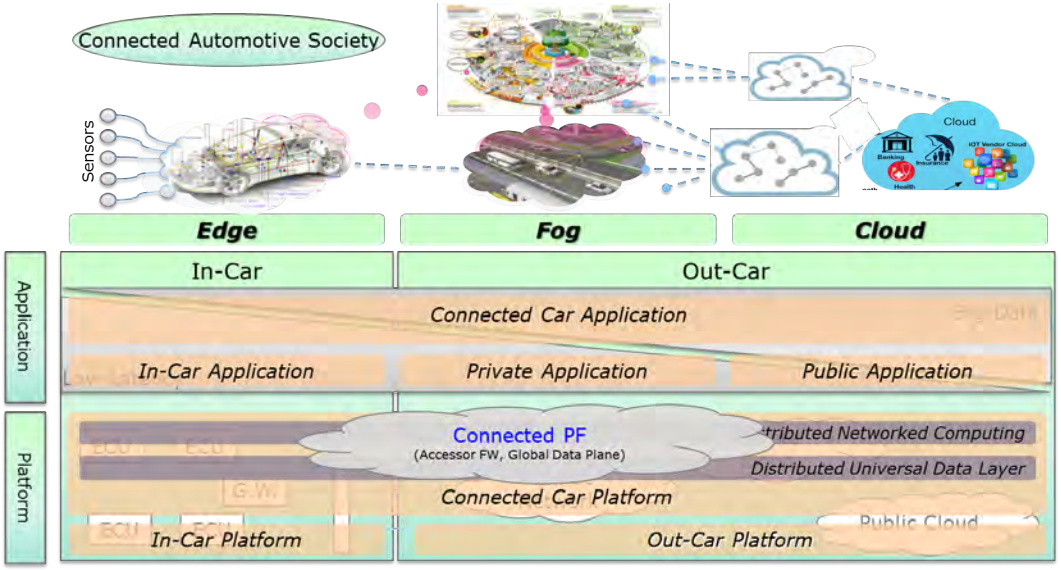
Overview of Connected Car

- Connected car business value lies in the range of services offered (B2C, P2P, etc.)
- Car as an integral part of system of systems (Eg. Smart cities)
- Rapidly emerging requirements: shared ownership, zero-casualty safety, reliable service development and deployment methodology, seamless interconnectivity, etc.



Safety

Mobility

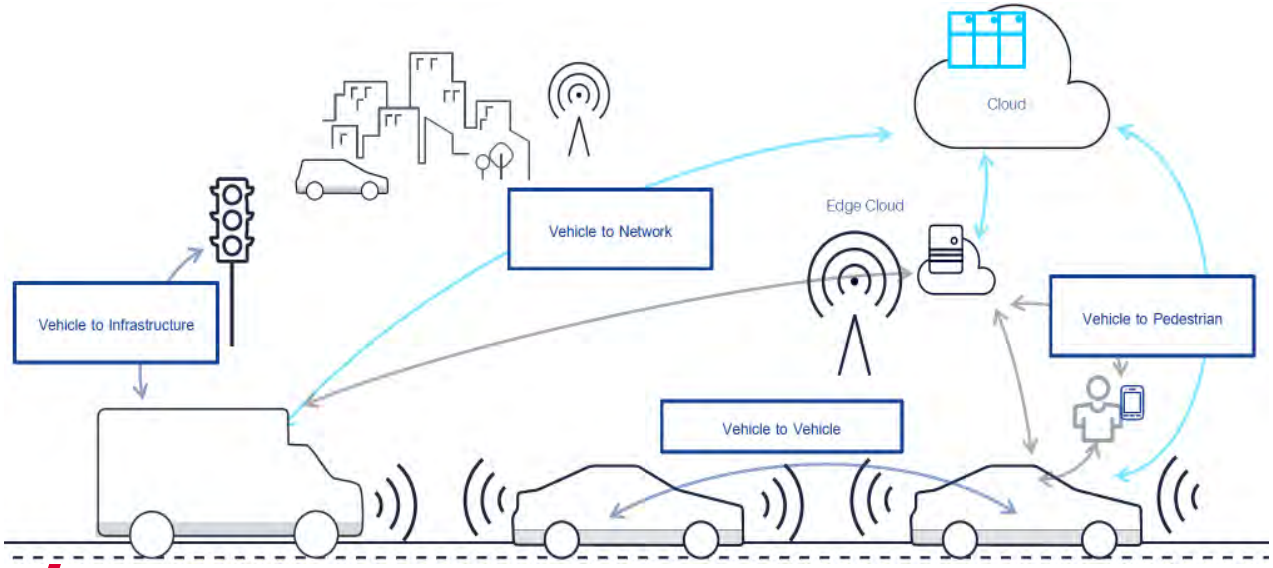
Environment

Convenience

Challenges for future mobility systems

Source: US DOT

- Integration of automotive with heterogeneous subsystems and complex societal dynamics
- Highly networked, time coordinated interactions with highest degrees of assurance and safety
- Increasing complexity of V2X systems demand distributed computing with massive data

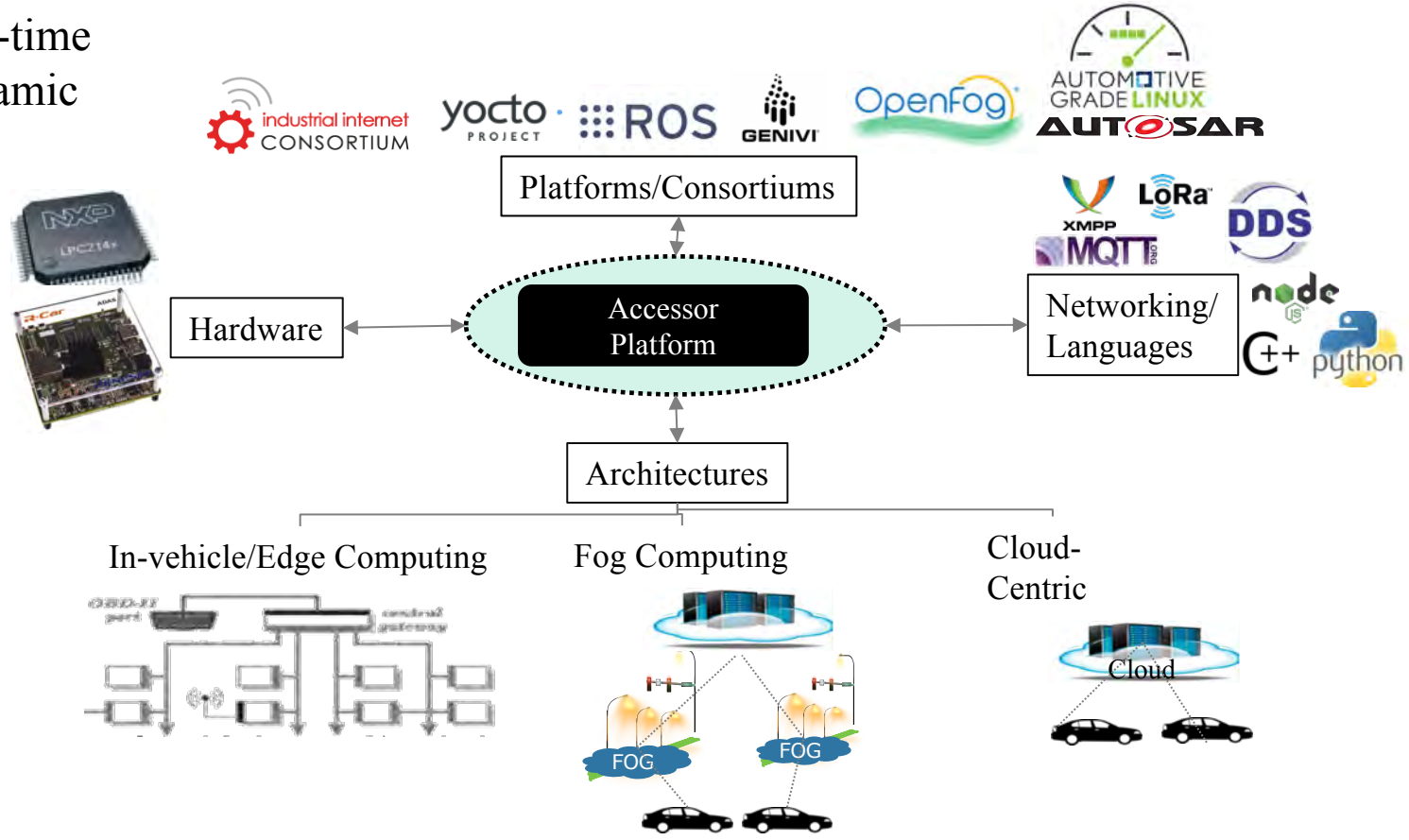


Source: 5GAA/NOKIA

Integrating Accessors with Automotive

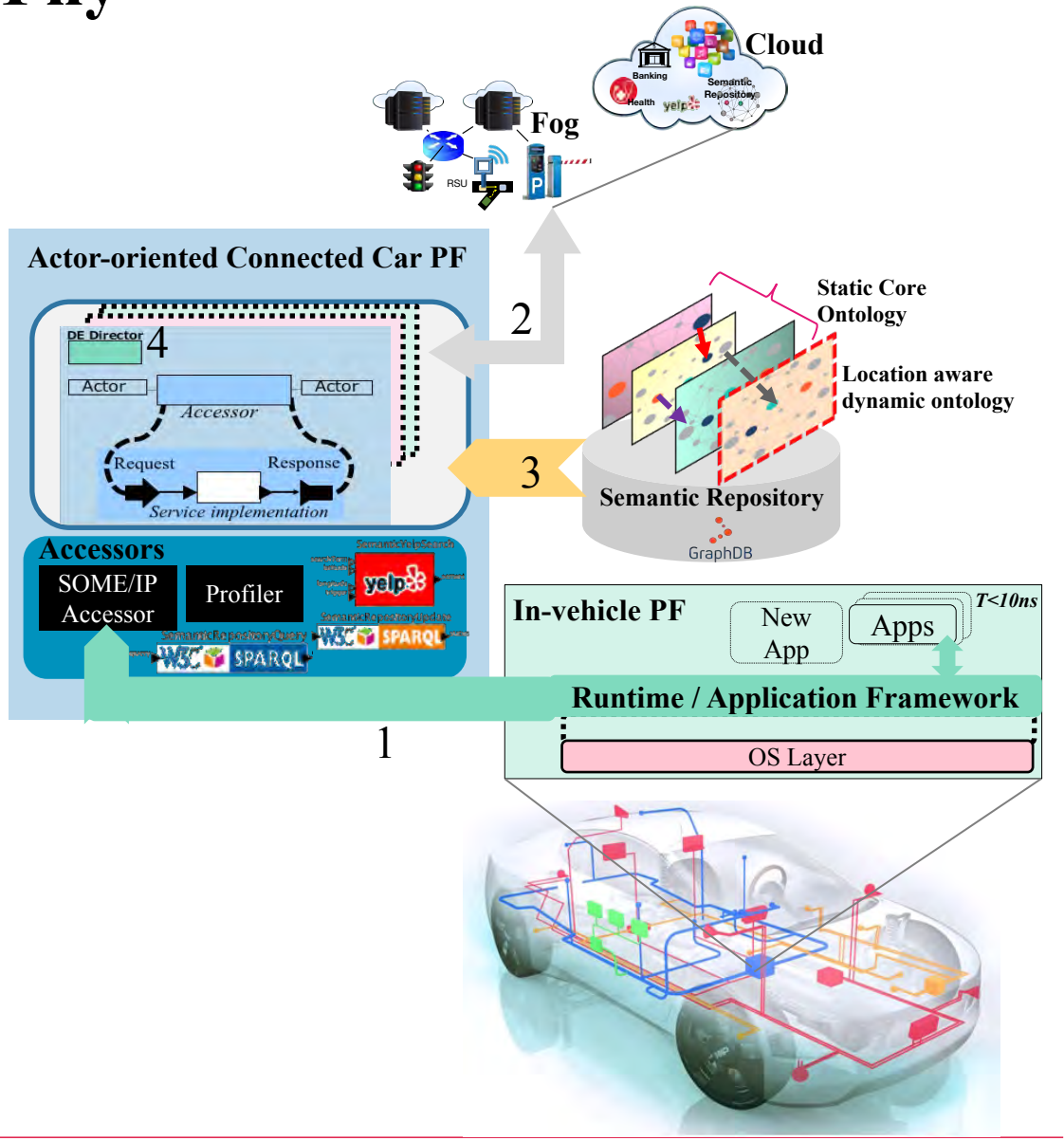
Architectures that allow development, deployment and maintainability of evolving services are necessary.

- Open Interfaces
- Adaptive
- Real-time
- Dynamic



Collaboration with iCyPhy

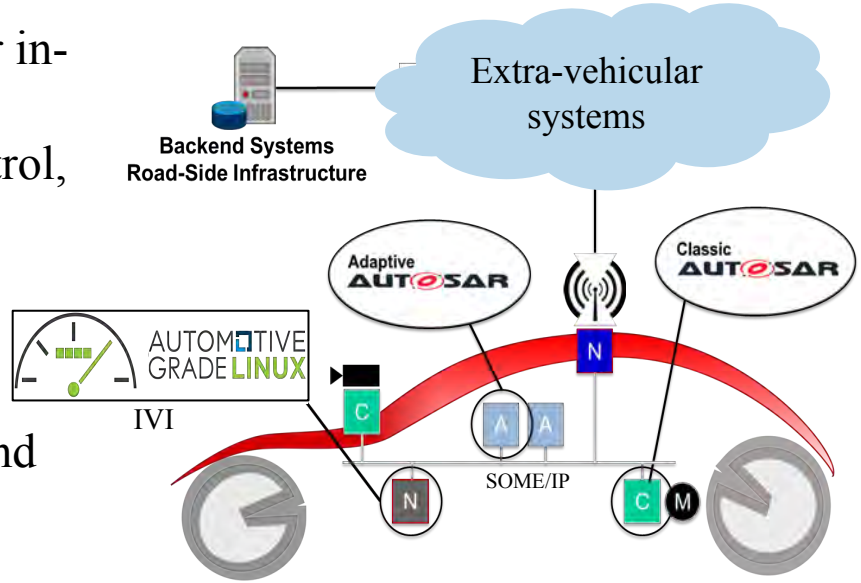
1. Integrating Accessors with evolving in-vehicle platforms
2. Adaptive services leveraging Fog/Cloud
   - Load balancing of vehicular compute tasks using a road side unit
   - Coordinated traffic control using RSU
3. Semantic service discovery
4. Deterministic behavior of distributed connected car applications



Integrating with in-vehicle PFs

- Legacy automotive platforms are designed for in-vehicle applications running over network of dedicated ECUs such as seat temperature control, diagnostics, etc.
  Eg. Classic AUTOSAR

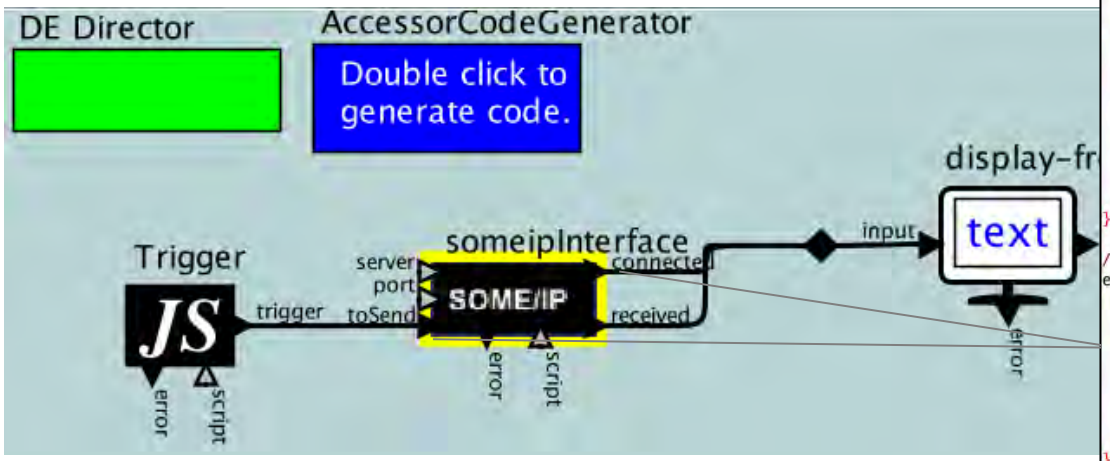
- Emerging platforms are on track to serve evolving Infotainment, ADAS, autonomous and connected (V2X, telemetry) functions
  Eg. AGL, Adaptive AUTOSAR



- Scalable service-Oriented MiddlewarE over IP (SOME/IP) is the communication backbone for Adaptive AUTOSAR
  - also has implementations for interoperability with AGL
  - allows applications to communicate over Ethernet in pub/sub pattern
  - provides additional features such as serialization, service discovery

- SOME/IP is primarily meant for inter and intra-ECU application interaction.

SOME/IP Accessor in Capecode



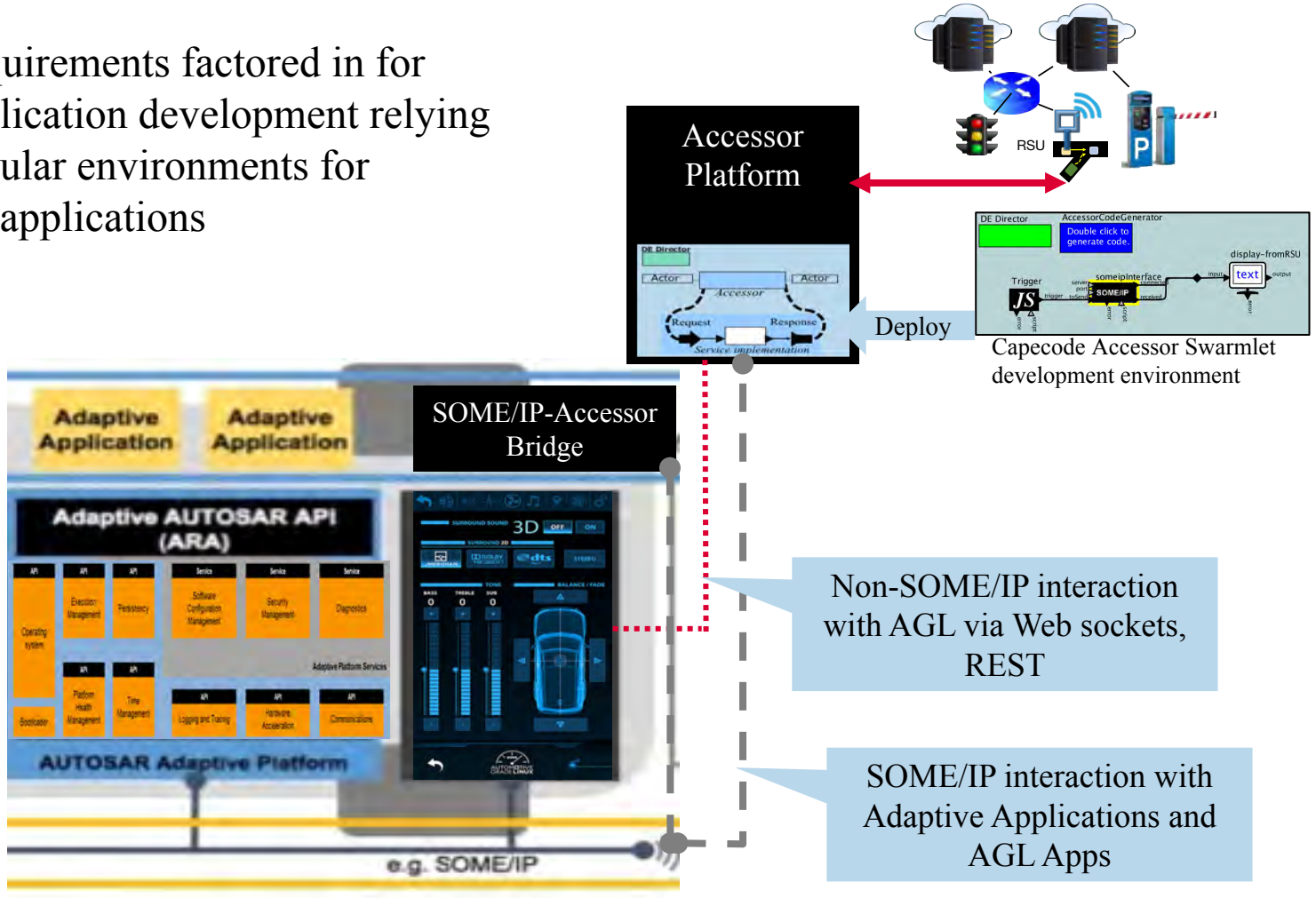

```
exports.setup = function () {
    this.extend('net/WebSocketClient');
    this.parameter('func', {
        type: "string",
        value: "notify",
        options: ["notify","publish","request","response"]
    });

    this.parameter('configFilePath', {
        type: "string",
        value: "./config/vsomeip-udp-service.json"
    });
};

/** Override inputHandler on 'toSend' from WebSocketClient. */
exports.toSendInputHandler = function () {
    var msg = this.get('toSend');

    var data = {
        "type": this.getParameter('func'),
        "msg": msg
    };

    this.exports.sendToWebSocket.call(this, data);
};

/**  Inherits initialize from WebSocketClient.
 *   Advertise the topic we are publishing to.
 */
exports.initialize = function () {
    this.exports.ssuper.initialize.call(this);

    var configFileContents = getResource(this.getParameter('configFilePath'), nu
    var data = {
```

- SOME/IP accessor allows interaction with Adaptive AUTOSAR Applications

- The SOME/IP accessor provides interface to specify
  - Communication pattern (notify/subscribe/request/response)
  - Configuration (.json) to set local environment variables for SOME/IP

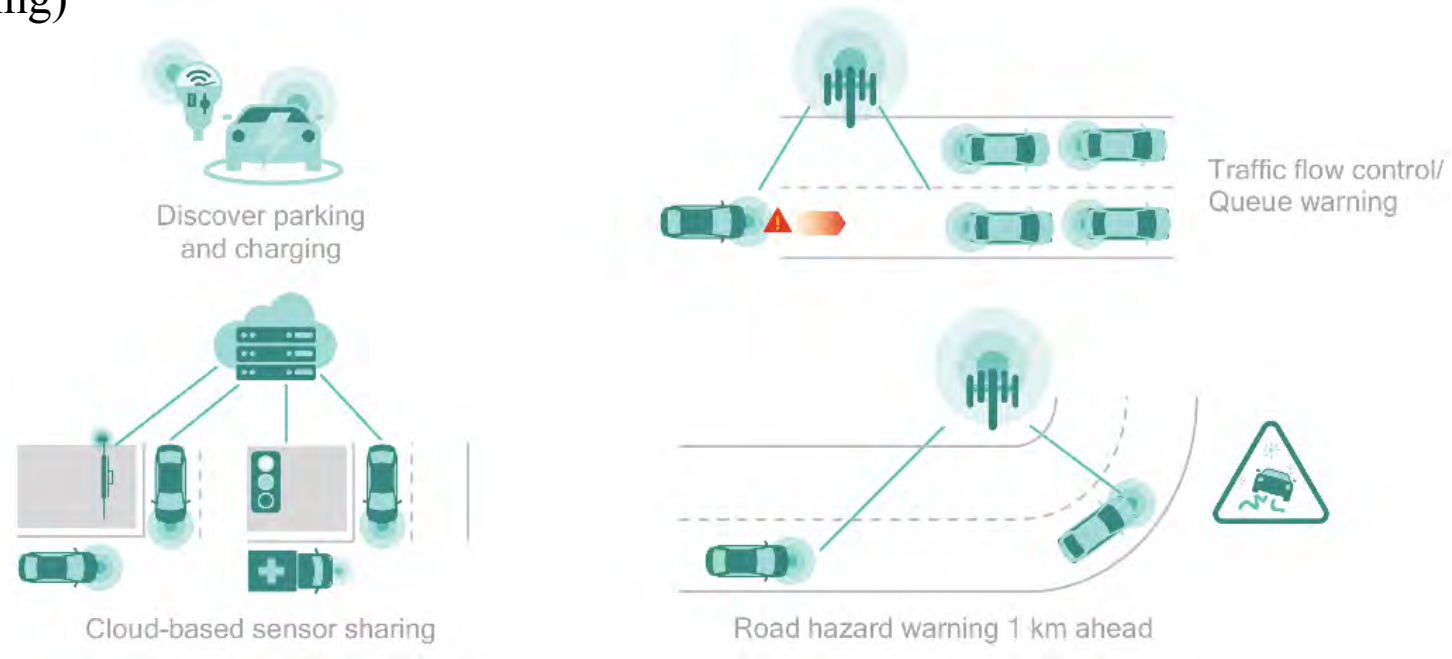
Integrating with in-vehicle PFs

- New accessors to be developed to interact with Adaptive Runtime and AGL's Application framework
- ECU-level requirements factored in for connected application development relying on extra-vehicular environments for safety-critical applications



Adaptive services leveraging Fog/Cloud

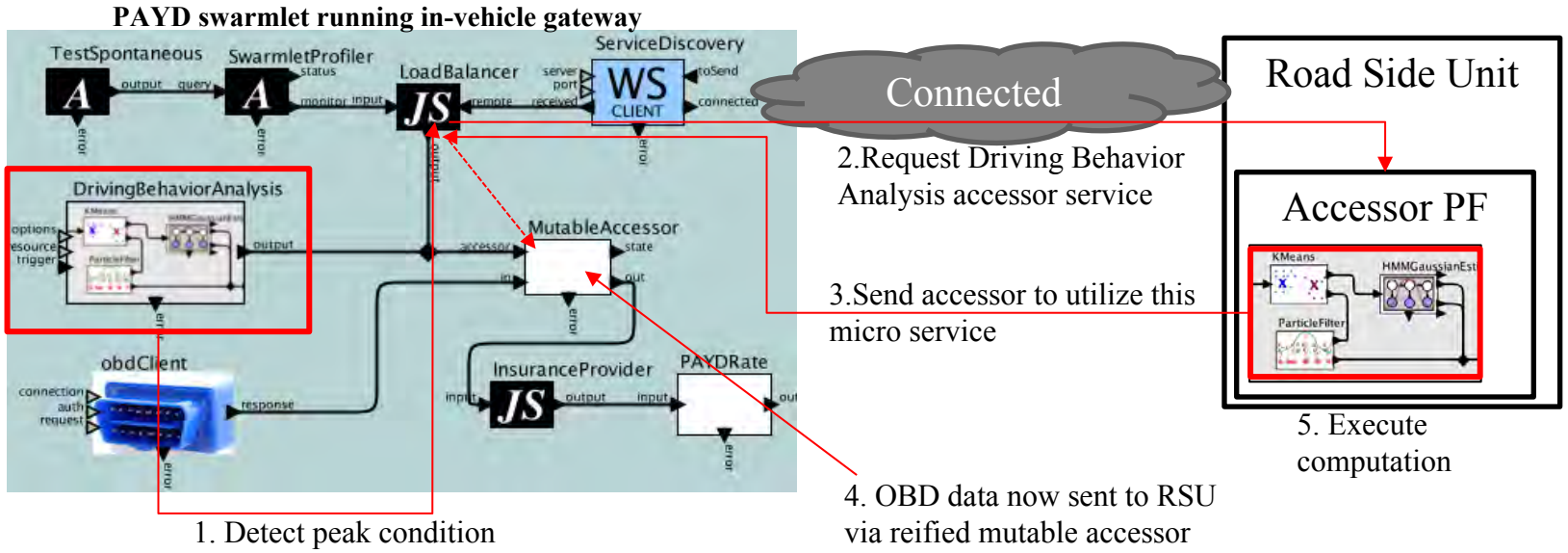
- For complex connected and self-driving functions:
  - Endow **Computation Bandwidth** in-vehicle by offloading critical tasks to other compute nodes in the fog/cloud (eg. Trajectory planning)
  - Utilize latest, better **Service Implementations** at fog/cloud (eg. Maps)
  - Maximize the **Data Availability** for some services that rely on a wider set of sources not available from within the vehicle (eg. road conditions)
  - Perform **Configuration Management** of time-critical distributed applications (eg. Platooning)



https://www.qualcomm.com/media/documents/files/accelerating-c-v2x-commercialization.pdf

Load Balancing

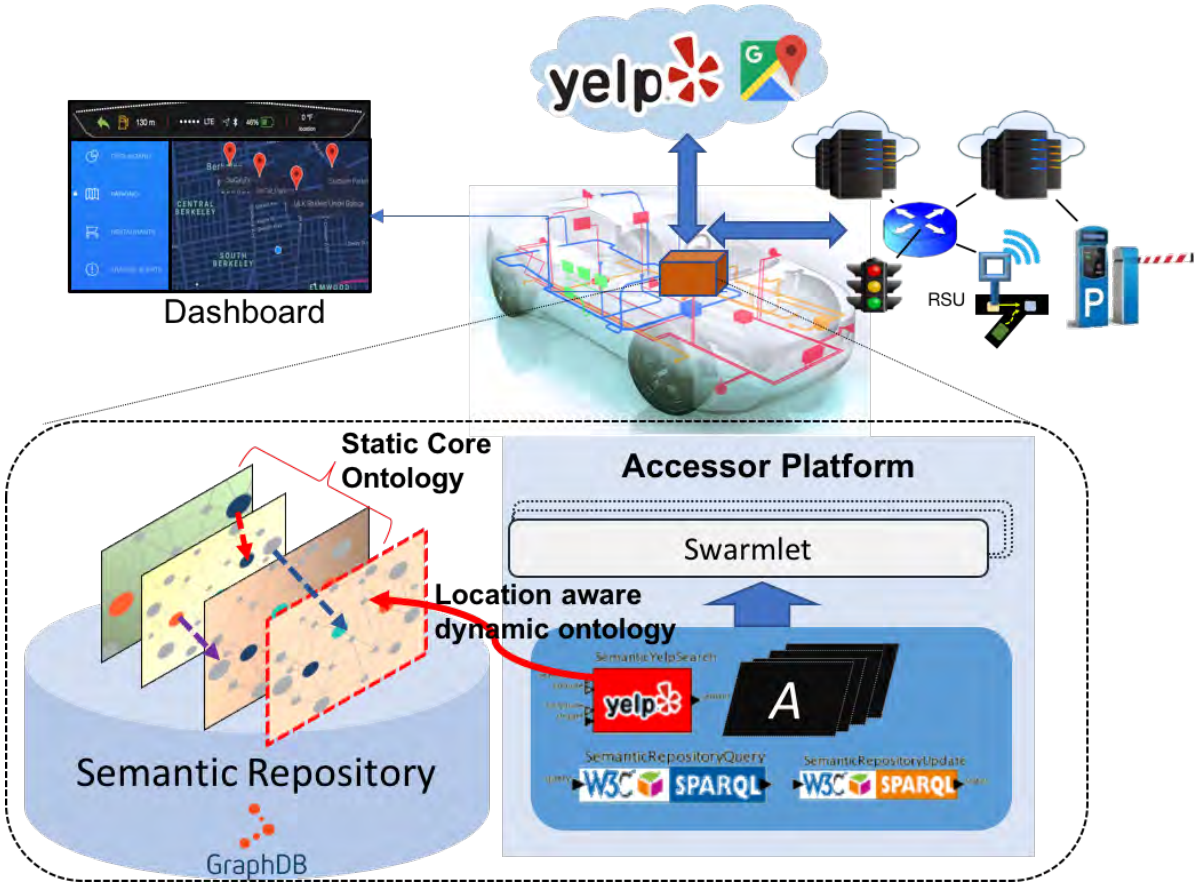
- Driving behavior analysis offloaded to an RSU offering compute as service
- RSU maintains microservices composed of accessors that can be discovered
- Vehicle swarmlet downloads an accessor to this microservice
- Network latency and data bandwidth should be factored in to decide on “offloading”



Semantic Repository for service discovery

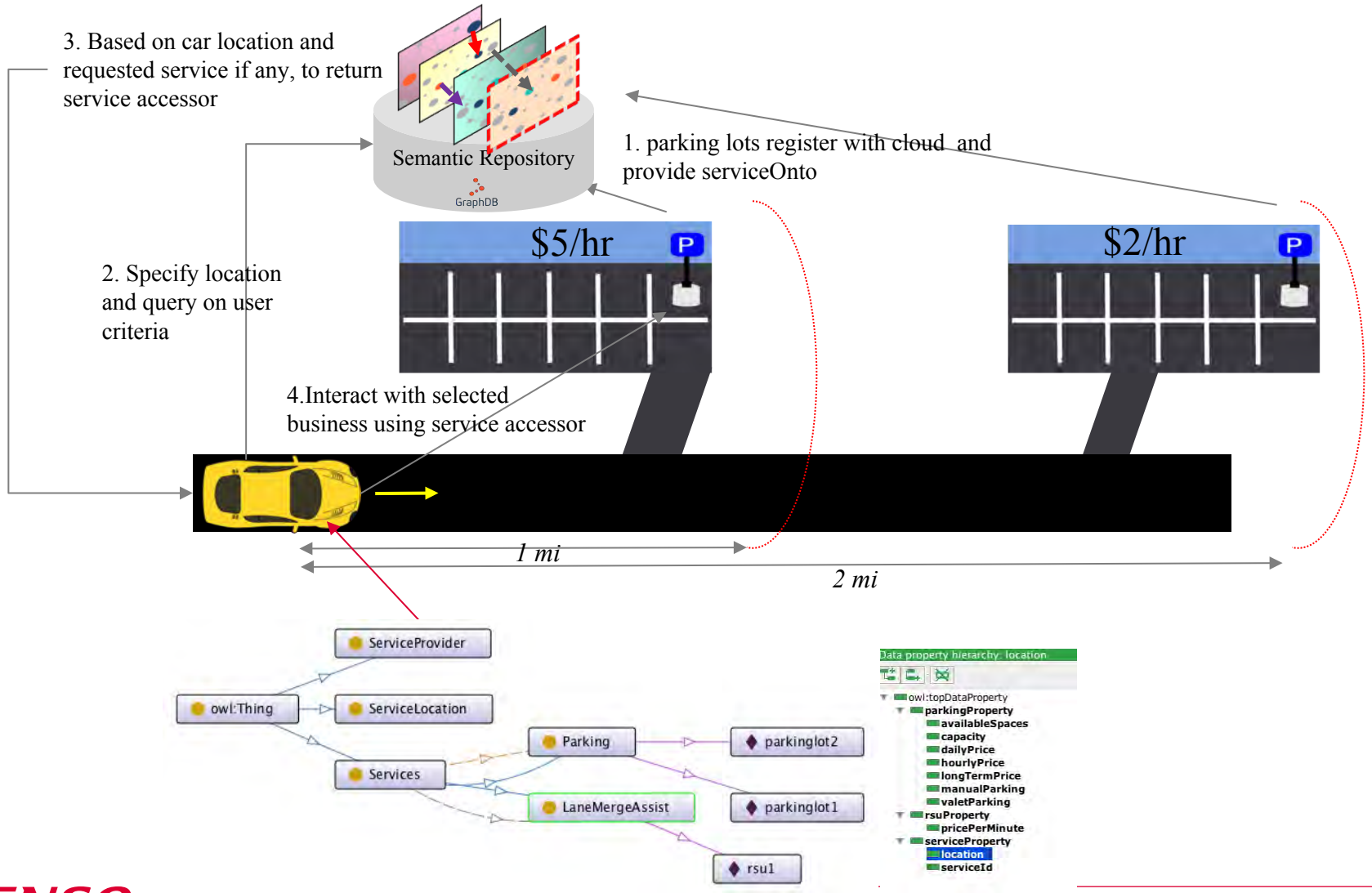
- Maintain core vehicle ontology and dynamic temporal ontologies (from web services) in semantic repository
- Vehicle swarmlets query the semantic repository for location based service discovery

Details in Matt's presentation



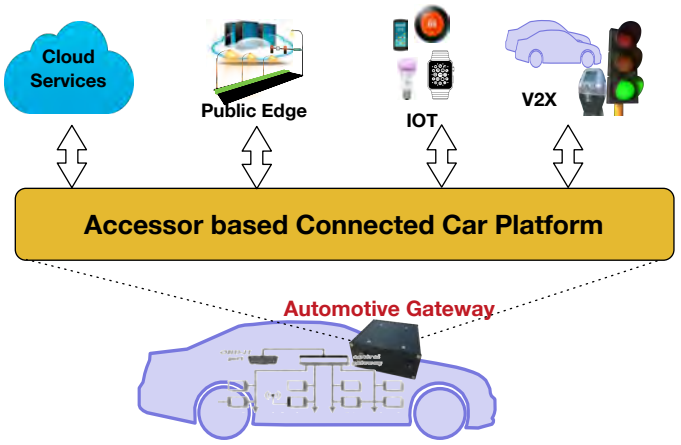
Semantic Repository for service discovery

- Parking lots that satisfy user criteria “nearest first”



Conclusion & Future Work

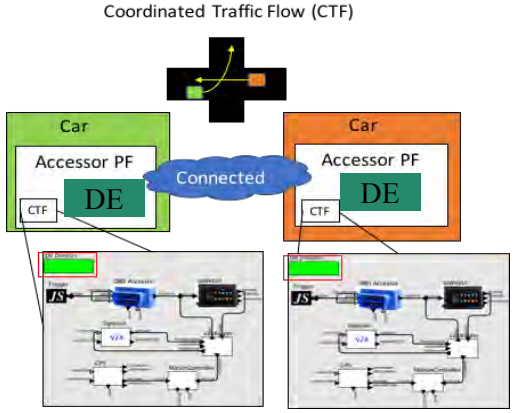
- Accessors based connected car PF
  - Facilitates rapid prototyping and deployment of connected services
  - Has potential to interface and interoperate with in-vehicle and extra-vehicular things
  - Enables development of adaptive, dynamic and distributed services for connected automotive



- Evaluation of current work with test deployment of connected applications

- Continue development of connected car specific accessors and core libraries for Accessor PF
  - Interfaces to embedded ECUs and sensors to synergize with Self-driving applications
  - Networking (V2X interface accessors such as DSRC, C-V2X)

- Deterministic timing across network for connected swarmlets (Eg. Coordinated Traffic Flow)



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