

Building a Digital Twin of the Vehicle Powertrain with MATLAB and Simulink

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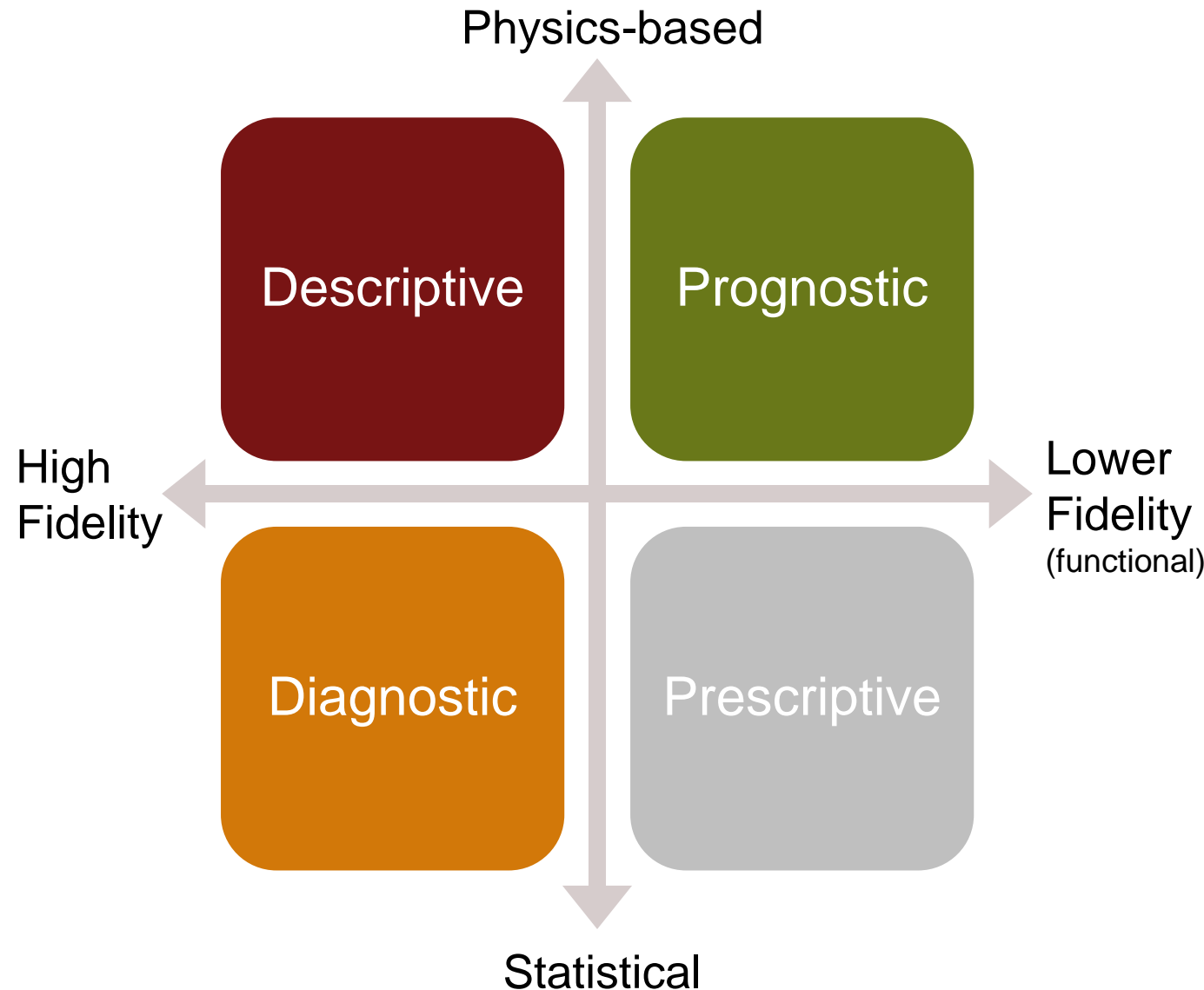
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What is a Digital Twin?

Digital twins refer to computerized companions of physical assets that can be used for **various purposes**.^[1]

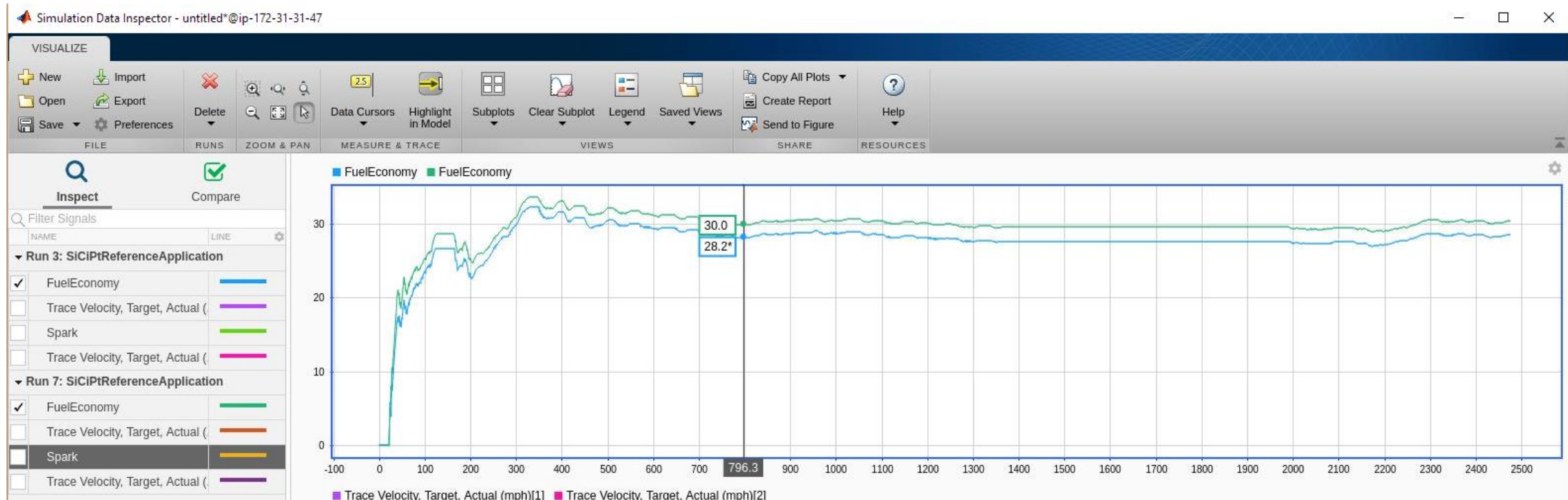
- **Digital twins** use data from sensors installed on physical objects to represent their near real-time status, working condition or position.
- **Digital twins** can be also used for monitoring, diagnostics and prognostics.



[1] https://en.wikipedia.org/wiki/Digital_Twins

Problem Statement:

One of my test vehicles is showing a statistically significant loss in Fuel Economy on the FTP75 lab performance test in the Vehicle Emissions Lab (VEL) using a near production calibration.



- Reduction of technician diagnostic time through Simulation
- Simulation at scale in the Cloud

Agenda

The Solution:

- Demonstration of a Simulink Digital Twin of a vehicle to tackle the problem

Zooming out a bit:

- Big Picture - the MathWorks Fleet and Data pipelines
- Engineering model based design meets IT-powered scalability on the cloud
- Demonstration of a Cloud based parallelized simulation

Tying it all together:

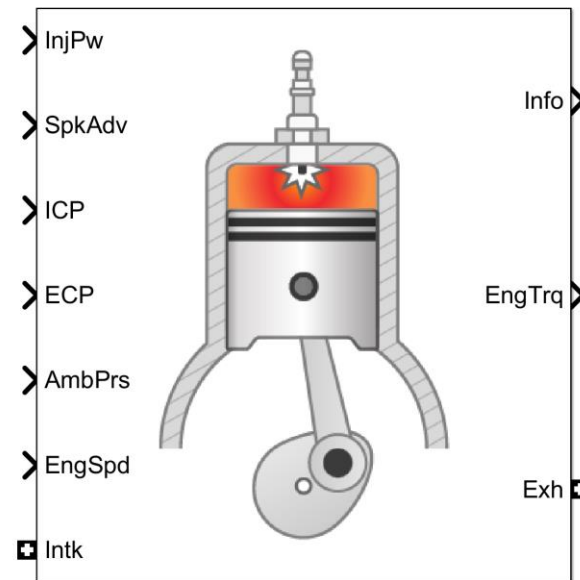
- Challenges
- Takeaways: Data Driven modeling meets Physics based Simulation
- Conclusions and Questions

Key Challenges

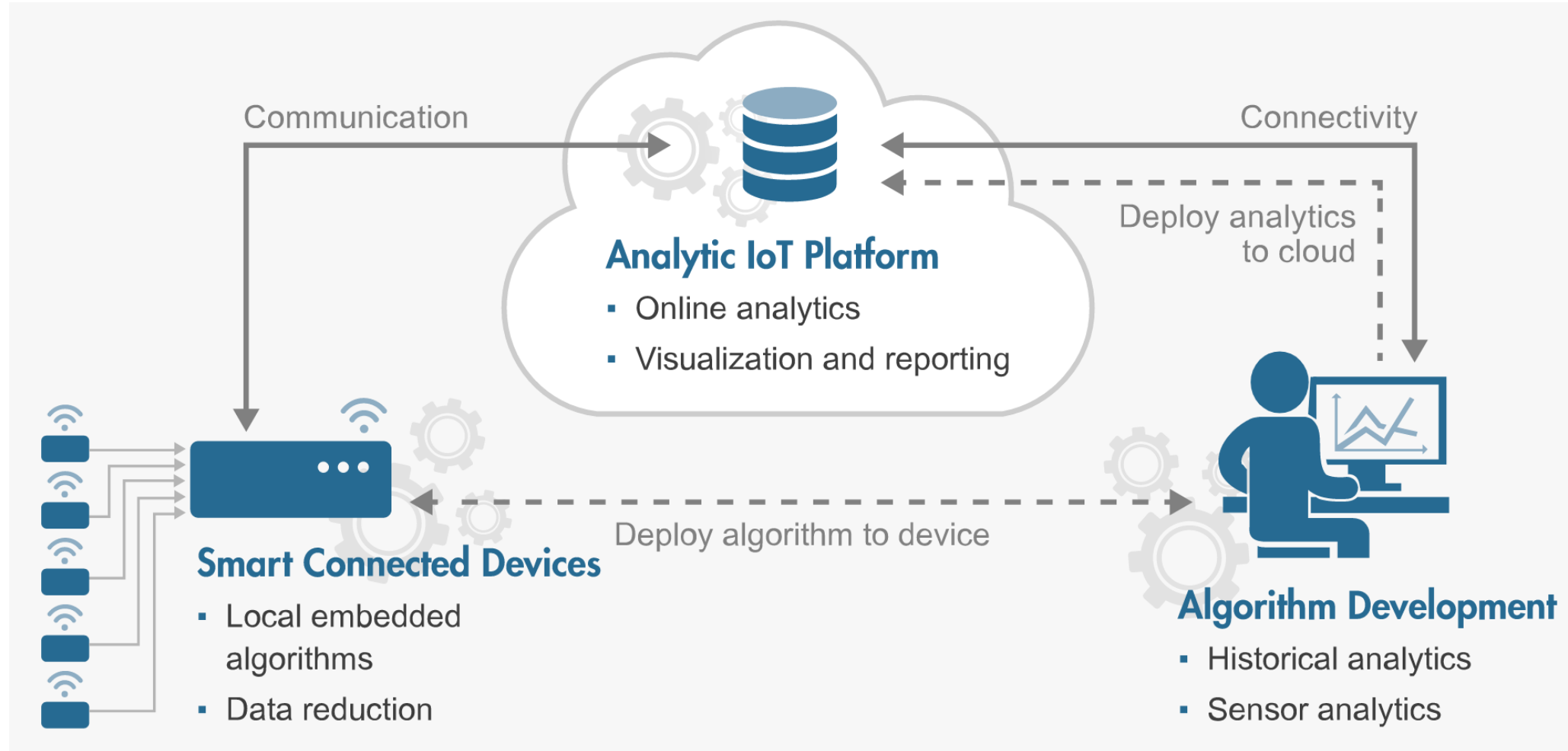
- Expression of digital twin models that dovetail with IT infrastructure
 - Scalability of Simulation
 - Storage, Security and Analytics
 - Platform Fragmentation (and lack of Technical Standards)
-
- Wieland, Ken (25 February 2016). "IoT experts fret over fragmentation". Mobile World.
 - Wallace, Michael (19 February 2016). "Fragmentation is the enemy of the Internet of Things". Qualcomm.com.
 - Ardiri, Aaron (8 July 2014). "Will fragmentation of standards only hinder the true potential of the IoT industry?". evothings.com.
 - "IOT Brings Fragmentation in Platform" (PDF).
 - Raggett, Dave (27 April 2016). "Countering Fragmentation with the Web of Things: Interoperability across IoT platforms" (PDF). W3C.

Demo of a Digital Twin (built with the Powertrain Blockset)

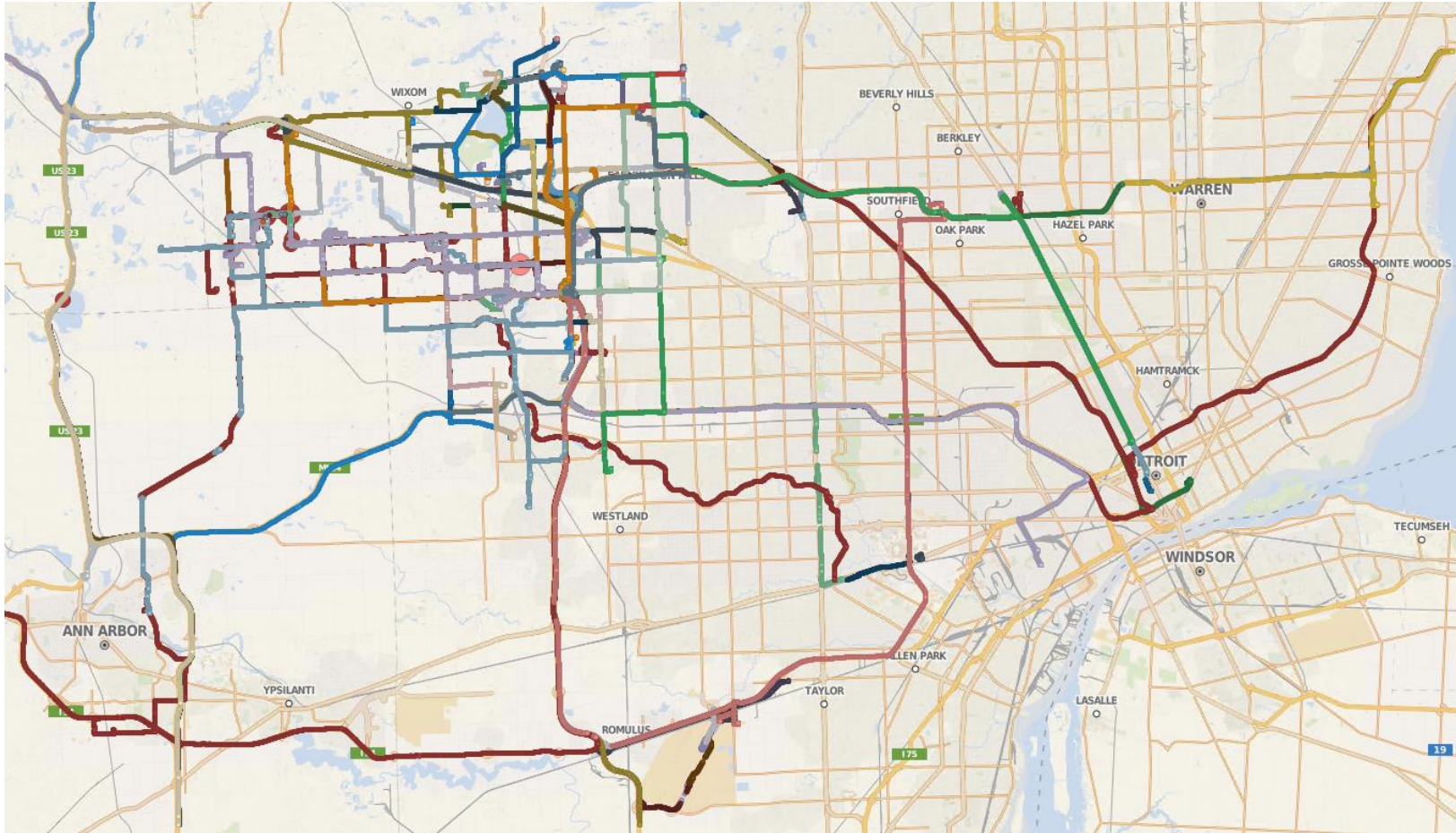
New!



The Big Picture - Internet of Things (IoT) demonstrator



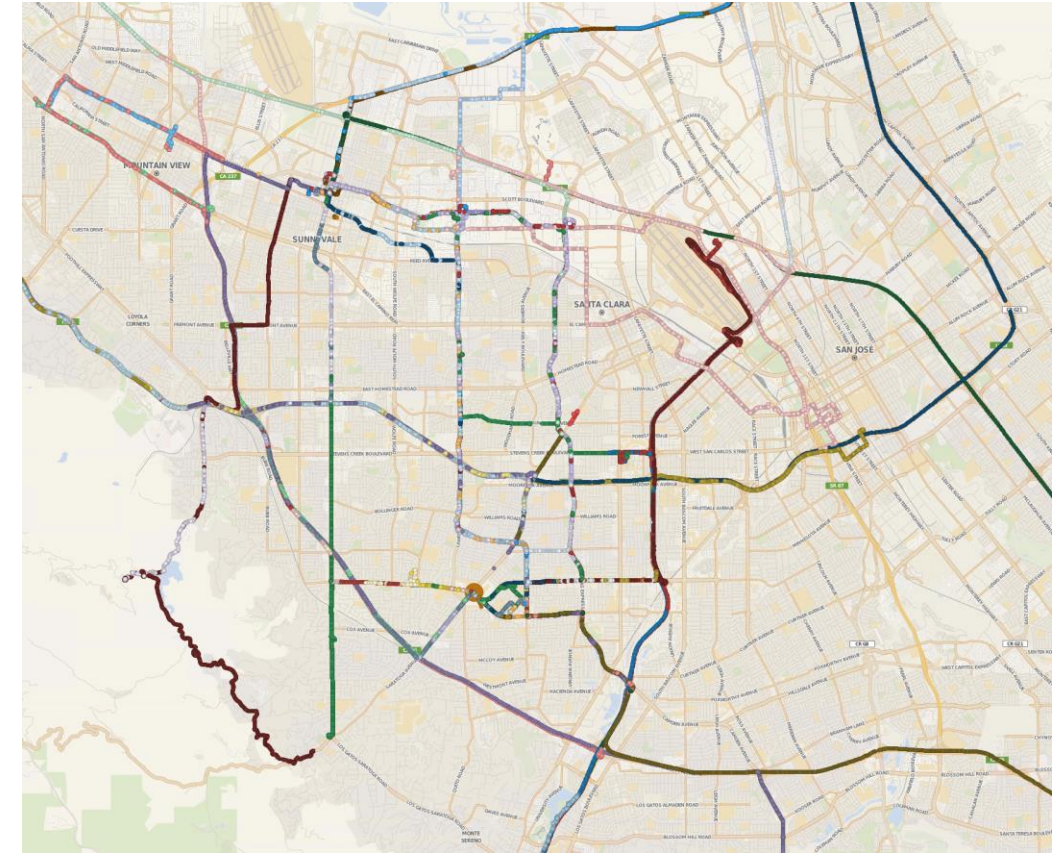
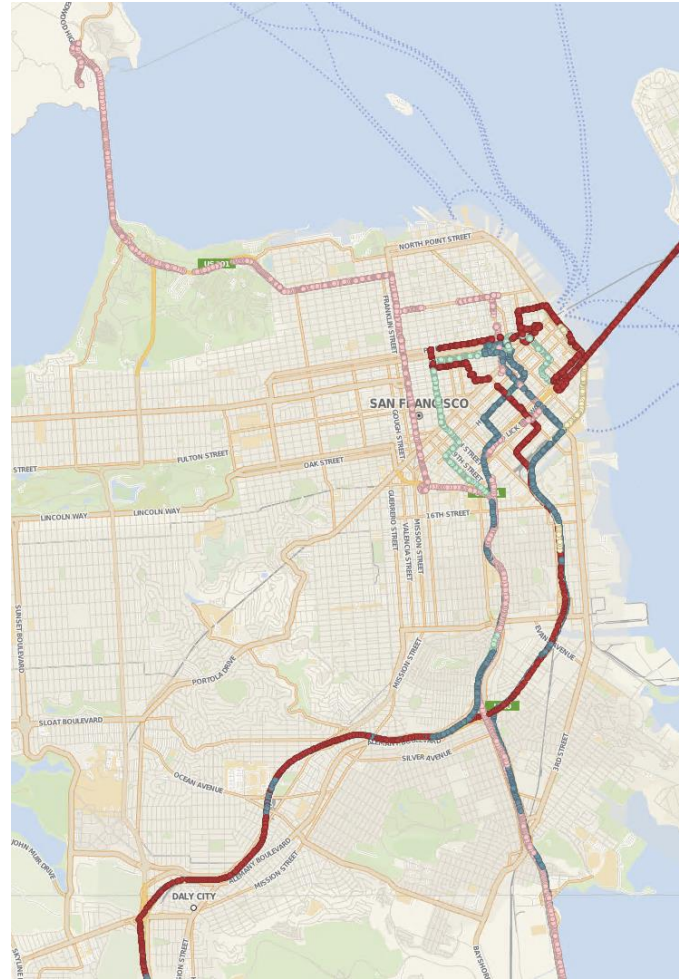
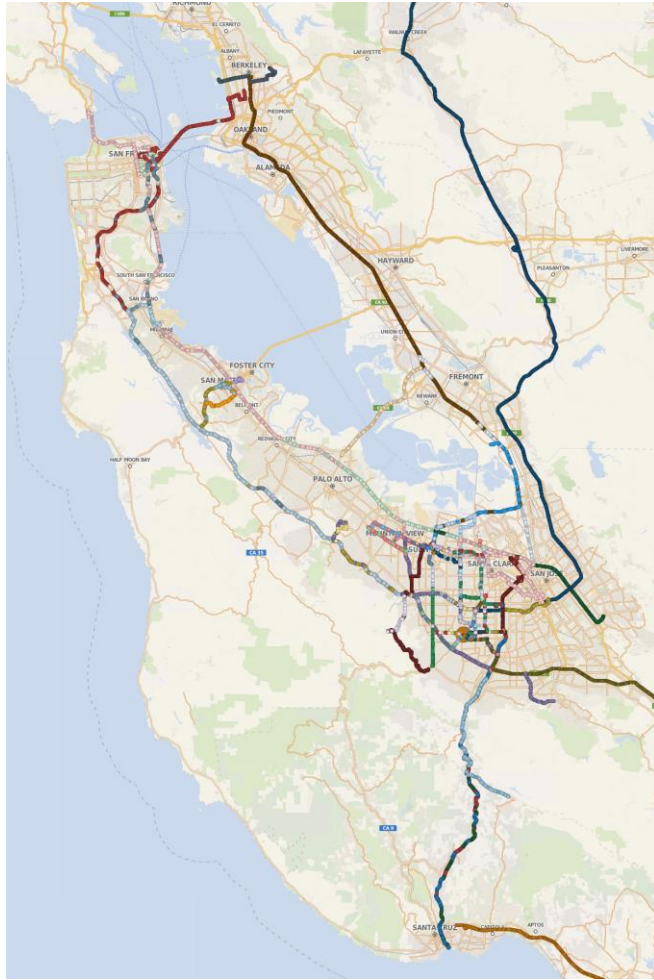
The MathWorks Fleet of connected vehicles (Novi, MI)



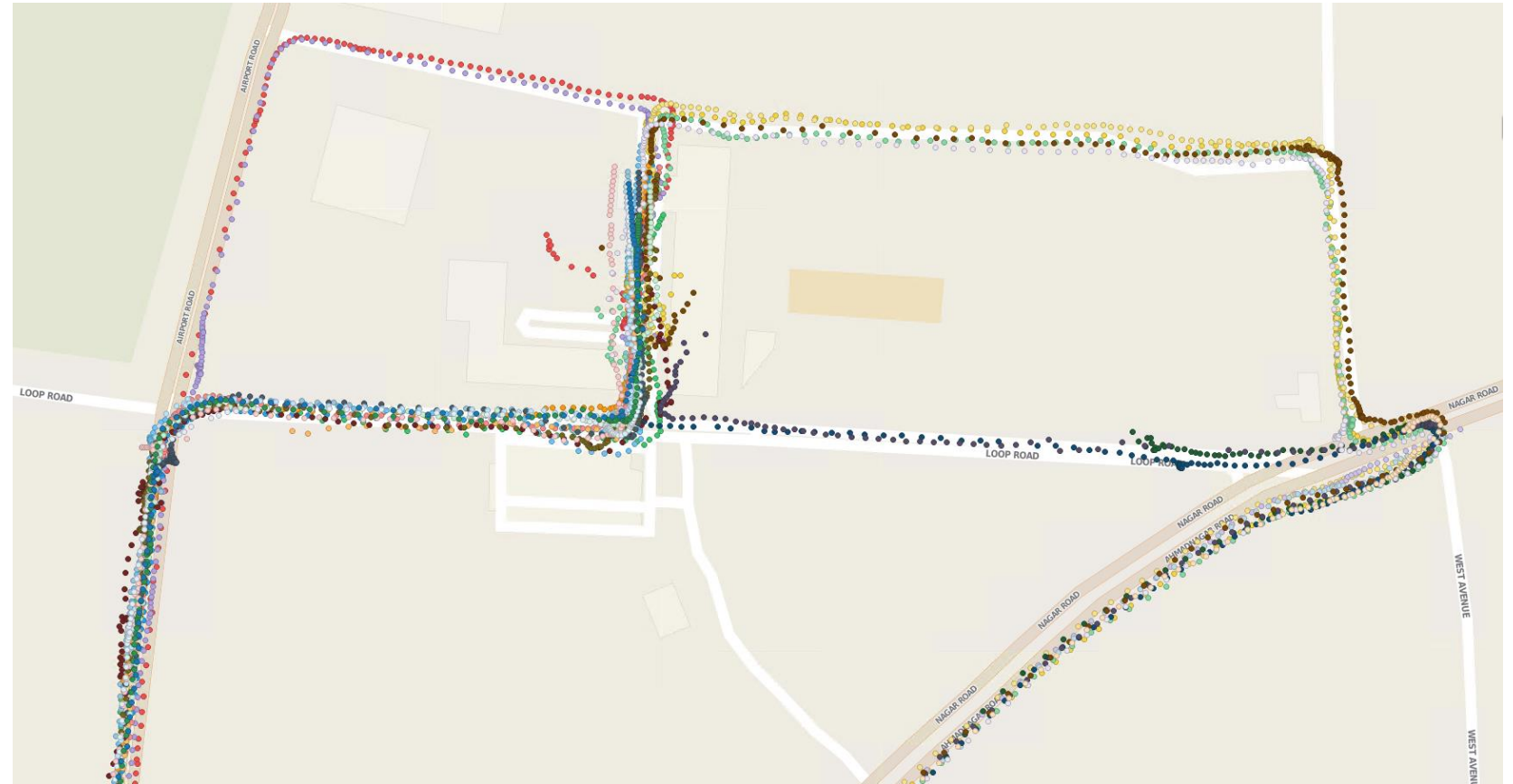
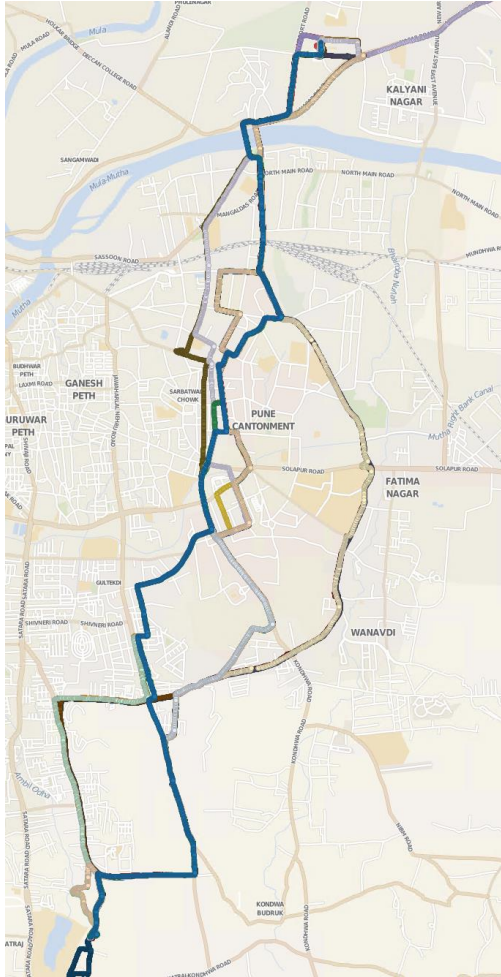
The MathWorks Fleet of connected vehicles (Boston, MA)



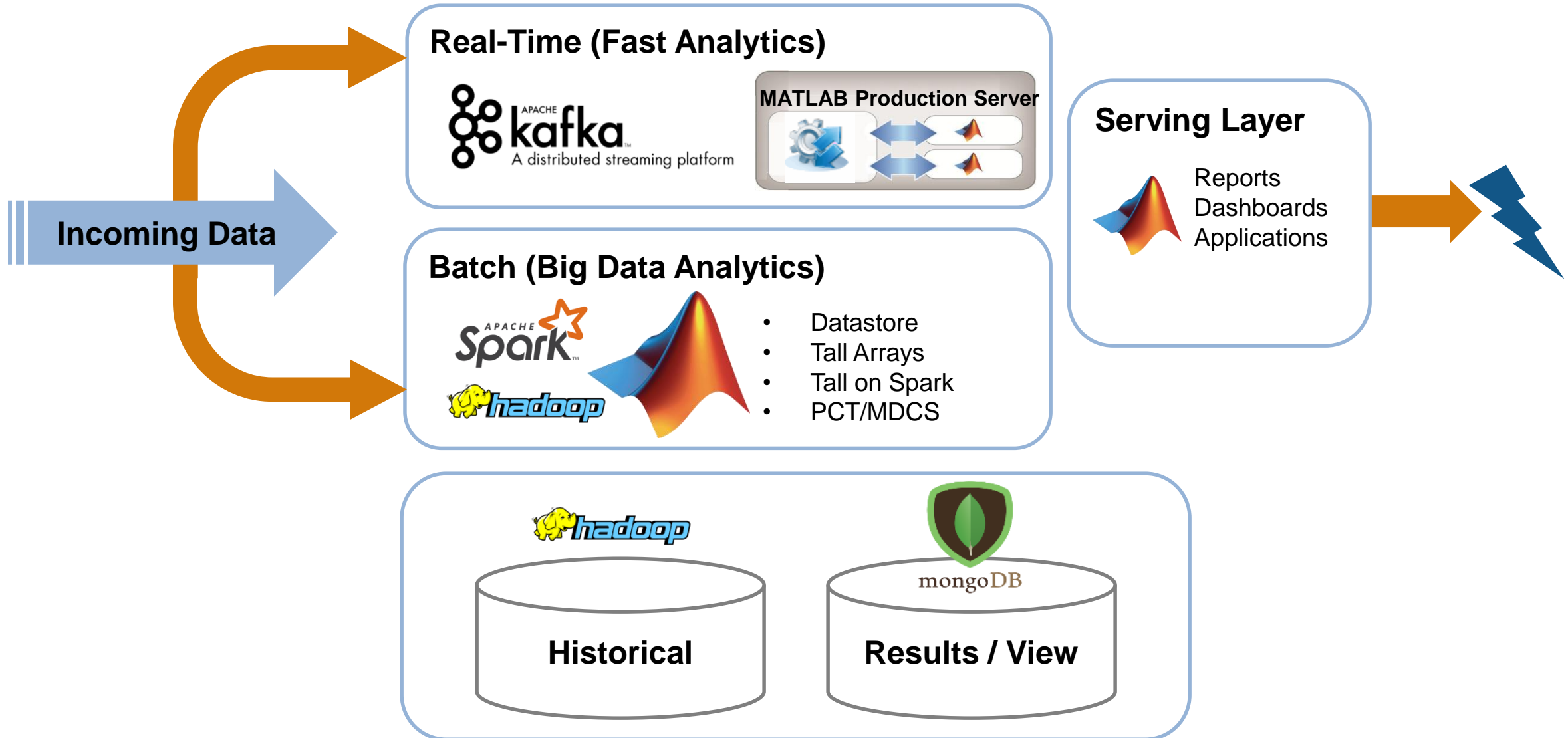
The MathWorks Fleet of connected vehicles (Bay Area, CA)



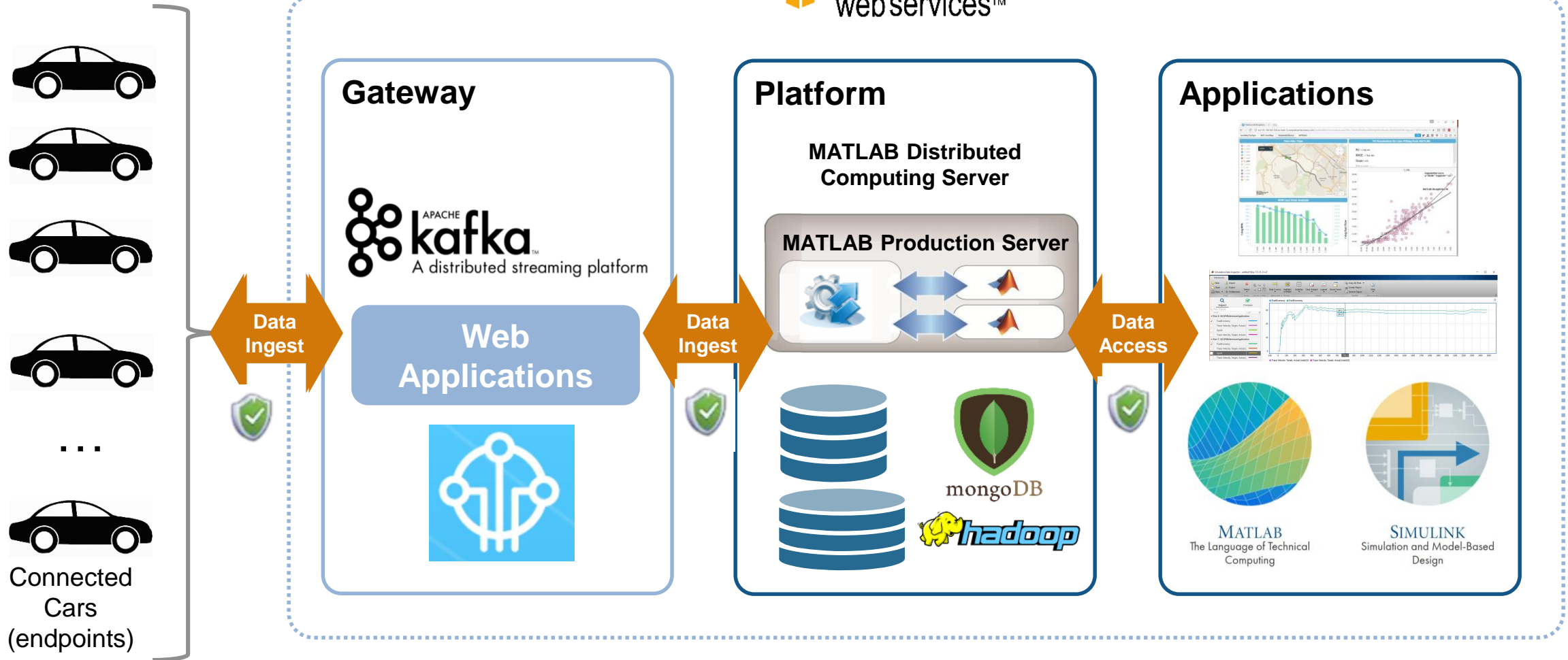
The MathWorks Fleet of connected vehicles (Pune, India)



Conceptual Implementation of the Fleet Demonstrator



Integrating MATLAB / Simulink with the IT stack



New!

Demo of a Parallelized Simulation in the Cloud (parsim)

```
out = parsim(in, 'ShowProgress', 'on');
```

Starting parallel pool (parpool) using the 'local' profile connected to 12 workers.

Running simulations...

Completed 1 of 10 simulation runs

Completed 2 of 10 simulation runs

Completed 3 of 10 simulation runs

Completed 4 of 10 simulation runs

Completed 5 of 10 simulation runs

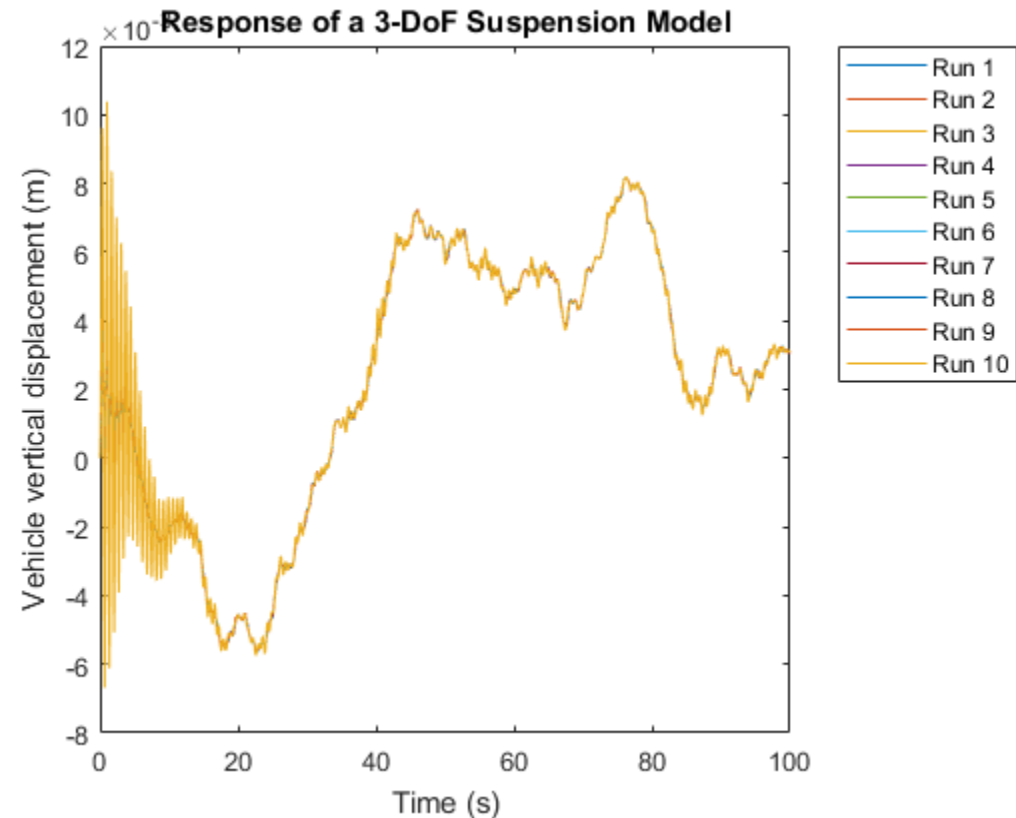
Completed 6 of 10 simulation runs

Completed 7 of 10 simulation runs

Completed 8 of 10 simulation runs

Completed 9 of 10 simulation runs

Completed 10 of 10 simulation runs



Digital Twins in perspective

Digital Twins are characterized by:

- **Uniqueness:** A unique instantiation per physical device.
- **Composability:** Structure, metadata, functionality in composable elements from simpler atomic elements.
- **Monitorability:** Ability to monitor and receive notifications of events.
- **Data Connectivity:** Ability to connect to timeseries data, events, etc.

Key Takeaways and Conclusions

- Engineering design meets Cloud-powered scalability
 - To enable prognostics, diagnostics and other use cases
- Data Driven Models and Physics based Simulation
 - Leveraging data with Physics models allows for creation of digital twin artifacts
- MathWorks tools provide a coherent platform for expression of models from prototype to production that is aligned with your Analytics Strategy and your IT infrastructure.

Questions