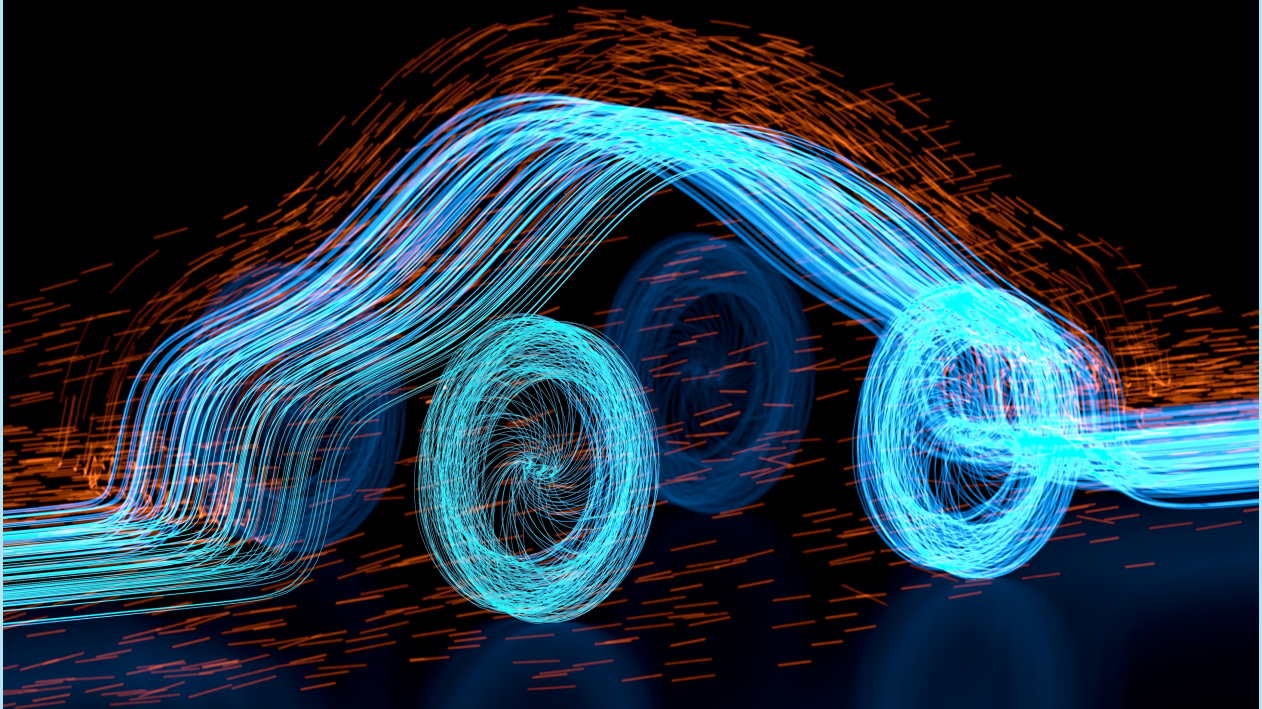


AWS Architecture Monthly



April 2020
Automotive

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Editor's note

Connected, autonomous, shared, and electric vehicle trends are converging to revolutionize the automotive industry. In this unprecedented age of innovation, automotive companies rely on Amazon Web Services (AWS) to fuel their digital transformation efforts, and get their products to market faster, while retaining ownership and control of their data and brand experience.

AWS provides the broadest and deepest set of capabilities, including artificial intelligence (AI), Internet of Things (IoT), HPC, and data analytics, the highest performance and security, the largest customer and partner community, and a relentless pace of innovation.

With AWS as their strategic partner, automotive companies are empowered with the knowledge, capabilities, agility, and speed they require to thrive in the new era of mobility.

We hope you'll find this edition of Architecture Monthly useful, and we'd like your feedback. Please give us a star rating and your comments on the Amazon Kindle page (<https://amzn.to/Kindle-magazine>). You can view past issues at <https://aws.amazon.com/whitepapers/kindle/> and reach out to aws-architecture-monthly@amazon.com anytime with your questions and comments.

In April's issue:

- **Ask an Expert:** Dean Phillips, AWS Tech Leader, Automotive
- **Blog:** 5 Automotive Trends at CES 2020
- **Case Study:** Toyota Research Institute
- **Solution:** AWS Connected Vehicle Solution
- **Whitepaper:** Connected Vehicles and the Cloud

Annik Stahl, Managing Editor

Ask an Expert:

Dean Phillips
Worldwide Technical Leader, AWS Automotive

I had the opportunity to speak with Dean Phillips, Worldwide Technical Leader for Automotive at AWS.

What are the general architecture pattern trends for the automotive industry?

Our customers are investing in:

- Manufacturing connectivity solutions to unlock data from siloed systems in the plant floor
- New and innovative connected vehicle services including personal digital assistants with Alexa Automotive
- Advanced telematics and over the air software updates (OTA)
- Edge deployments of machine learning inference to support autonomy
- Advanced insurance use cases involving traffic scenarios and driver distraction
- Massive data lake projects to make enterprise data assets available to all lines of business.

Throughout all of these investment areas is the common theme of data and machine learning. One popular architectural pattern we find across these workloads is serverless computing in the form of AWS Lambda, containers, and Amazon API Gateway. Additional patterns are realized using AWS solutions, reference architectures, and managed services to accelerate customer deployments, such as the AWS Connected Vehicle Solution (<https://amzn.to/AWS-auto-connected-vehicle>), AWS Smart Factory (<https://aws.amazon.com/manufacturing/smart-factory/>), and AWS Lake Formation (<https://aws.amazon.com/lake-formation/>).

What are some questions customers need to ask themselves before considering AWS for their company?

Customers come to AWS because we accelerate their time to value and ability to innovate. Customers gain agility by quickly assembling new solutions and experimenting with the largest collection of managed services available in the industry. We do this by providing a continuous stream of new offerings and enhancements to our services all while keeping costs low and charging only for what they use. Automotive customers require highly available, global solutions to address their entire customer base 24 hours a day, 365 days per year.

For instance, our autonomous vehicle customers have massive software-in-the-loop simulation requirements that can demand over a million cores of compute. They do this on the AWS Spot market with our spare capacity, and shut down the environment when done. Our infrastructure is designed to scale up and down as needed and our customers like this flexibility.

Several important questions customers should consider before selecting AWS as their cloud partner:

- Do you have a project identified for a proof of technology to begin experiencing the benefits of AWS?
- Have you begun some education and training to understand our services?
- Do you understand the shared responsibility for managing the security of your system and how you plan to authenticate your users?
- Have you identified the regions where your application will reside?

These are just a few of the very important considerations when planning a project on AWS.

When putting together an AWS architecture to solve business problems specifically for an automotive company, do you have to think at all differently?

Automotive customers need to understand the experimental nature of cloud computing. Cloud allows you to spin up infrastructure and services and deploy your application code very quickly. There is no up-front investment required to start developing. Much can be learned by identifying the features you wish to deploy first and learn the CI/CD process that works for your organization. It's important to get something deployed end-to-end as quickly as possible and evaluate the solution architecture in the process.

There are always many architectural decisions that can be made at each step along the way. Considering the vast array of services available on AWS, it's easy to find yourself in an endless matrix of architectural candidates to evaluate. Pick one and simply try it. If it doesn't work out then try another approach. It's very easy to wire up our services, which makes it such a great platform for experimentation and development. Once you have a working architecture you can begin to leverage the benefit of our highly available services and redundant infrastructure.

Do you see different trends within the industry in cloud versus on-premises?

Automotive customers require the global scale, agility, and scalability of the AWS cloud for their connected vehicle and autonomous vehicle projects. Both of these workloads require a global presence to support the customer base. We've seen a number of customers move from on-premises to AWS to take advantage of the global regional presence for these workloads. Autonomous driving test vehicles generate terabytes of data per day that get

uploaded for development and testing of perception models, path planning algorithms, and massive simulation workloads. Once customers begin to scale out their Advanced Driver Assistance Systems (ADAS) and autonomous programs, it becomes very difficult to manage the infrastructure required to support the growth.

What's your outlook AWS in the automotive industry, and what role will cloud play in future development efforts?

One thing is clear: Amazon is hyper-focused on delivering value to our customers. We will continue to invest in technologies and services our customers need to support their business, and we do this working backwards from their perspective. Automotive customers are moving more and more workloads to the cloud gaining the benefits of agility, elasticity, global scale, and the ability to quickly innovate at lower costs.

About our expert



Dean is Worldwide Technical Leader for Automotive at Amazon Web Services. As a technical executive and strategist, Dean leads a community of automotive Solution Architects who apply artificial intelligence, machine learning, and Internet of Things technologies to build connected mobility, autonomous vehicles, and Smart Factory solutions with their customers.

Blog:

5 Automotive Trends at CES 2020

By Mark Dipko

Online at: <https://amzn.to/AWS-auto-CES-2020>

We had an incredible response to the Amazon Automotive exhibit at CES 2020, which combined AWS, Alexa Auto, Amazon Pay, Amazon Fire TV, and other Amazon businesses. Customers, media, and analysts packed the booth to discuss how Amazon enables our automotive customers to accelerate the future of mobility.

For those that didn't make it, or simply didn't get to see it all, here are our top five automotive insights from CES 2020.

#1. Expect the unexpected

CES has always been a test bed for innovation, and 2020 was no exception. Whether it was Toyota announcing their Woven City, Hyundai partnering with Uber Elevate's future aerial ride hailing service, or Sony unveiling a car, it is clear that automotive companies are serious about the transition from automakers to mobility companies.

The interconnectivity of the various vehicles, sensors, and intelligent devices and the ability to ingest, analyze, and act on the vast amount of data they produce remains an ongoing challenge.

In the Amazon Automotive booth at CES:

The Blackberry, Karma, and AWS demo showed how manufacturers can govern data from their vehicle's sensors to create value for their customers through in-vehicle and third-party applications. In addition, the demo showcased how manufacturers can provide internal value by proactively managing vehicle maintenance, using machine learning to predict the health of the EV battery.

Accenture's Data Monetization Platform presented an architecture to allow manufacturers to share data with third parties through AWS Data Exchange while also leveraging blockchain technology to ensure compliance to the customer's privacy choices.

#2. It's all about me

Personalization is a mega-trend that we experience across industries – from our mobile phones, to our vehicles to our online interactions. In automotive, personalization of the user experience has grown from simply remembering your seating, radio, and temperature settings, to understanding and automating your behaviors.

As we move to more shared-usage vehicles, the ability to provide a familiar experience becomes even more important. But personalization is also key in the shopping journey, where the customer increasingly favors content that is customized to their particular interests.

In the Amazon Automotive booth:

The Future of Automotive Retail Demo showcased a personalized customer journey powered by ZeroLight and Clinch and running on AWS. Watch the walkthrough video from CES 2020.

The Future Mobility Experience Demo, built by Elektrobit, demonstrated how Alexa, AWS, and other Amazon products and services can be used to create an intelligent in-vehicle experience.

#3. Autonomous drives ahead

Self-driving vehicles has grown to become a separate topic area of CES. While there were a large group of exhibitors and demonstrations, this year did not have the fanfare of years past.

Rather, the focus leaned toward the application of self-driving technology. Autonomous trucking companies are now consistently shipping products on select routes using AV. Automotive OEMs and suppliers are innovating around the user experience and business models of both shared and personal use vehicles.

Challenges remain in simulating real-world conditions across every possible scenario. This includes managing the vast amounts of data needed to create self-driving algorithms and providing the infrastructure and tools to train and deploy them at scale.

Relevant Amazon Automotive demos at CES:

The Unity demo showed how AWS Cloud computing resources can be used to accelerate autonomous Software in the Loop (SiL) simulation by running a large number of simultaneous simulations in parallel. Read more on Unity's blog (<https://blogs.unity3d.com/2020/01/07/unity-simulation-is-now-on-aws/>).

The Dell EMC and National Instruments demo showcased how AWS partners with industry leaders to provide solutions for complex autonomous vehicle workloads like Hardware in the Loop (HiL) simulation.

WeRide showed how they developed and deployed their China-based autonomous taxi fleet using AWS autonomous and connected vehicle platforms.

#4. It's all talk

Voice assistants were omnipresent at CES again this year, showcasing that integrations in every imaginable device and automotive remains a critical domain. A recent report from Capgemini Research Institute estimates that nearly three-quarters of drivers will use an in-car voice assistant three years from now. Automotive OEMs are still walking the line of developing their own voice assistant versus embedding an existing assistant.

As voice continues to permeate the automotive user experience, the ability to understand the user's intent across multiple languages becomes table stakes. The battleground is shifting to the ability to integrate with vehicle functions and the vast and expanding ecosystem of applications outside the vehicle to provide customer value and convenience.

Highlighted Amazon Automotive booth demos:

Amazon Pay and Exxon announced a partnership that will allow vehicles equipped with Alexa to pay for gas using only their voice.

Lamborghini announced they would be the first production vehicle to enable car control through Alexa, providing voice control of windows, temperature, and vehicle driving mode.

Rivian showcased their R1T Electric Truck, with the ability to control nearly all vehicle functions using Alexa.

#5. The new generation

The automotive discussion around 5G is beginning to take shape, with OEMs, suppliers, and telecommunications providers beginning to lay out their strategy. BMW announced 5G connectivity for their iNEXT electric crossover, and Verizon, HERE, and Harman showcased pedestrian safety initiatives enabled by 5G.

In the Amazon Automotive booth:

At CES, Denso showcased the possibilities of their cloud-to-edge computing platform for a variety of mobility use cases, by training vehicle sensors to detect and react to a variety of incidents related to vehicle security, driver behaviors, mapping, and perception. Learn more in the solution brief.

We expect to hear a lot more on 5G at Mobile World Congress next month. There will be continued development on how 5G will enable new mobile computing innovations, including computing capabilities at the network edge to power future smart city and mobility initiatives.

Online at: <https://amzn.to/AWS-auto-CES-2020>

Real-world example

AWS at CES 2020

Join Arianne Walker, Chief Evangelist of Alexa Auto, and Mark Dipko, Worldwide Marketing Leader of AWS Automotive, as they walk through the Amazon Automotive booth at CES2020, and show how Amazon helps automotive companies accelerate the future of mobility, including demos from Rivian, Cadillac, Denso, Blackberry QNX, and more.

<https://amzn.to/AWS-auto-CES2020>



Case Study:

Toyota Research Institute Advanced Development, Inc.

Online at: <https://amzn.to/AWS-auto-TRI>

To keep pace with the accelerating development of automated driving, an “automatic map generation platform” using AWS serverless architecture was constructed in just two months.

TRI-AD was founded in March 2018 via a joint investment between Toyota Motor Corporation, Denso, and Aisin Seiki. Through the advanced development of software for automated driving, the company has combined research and mass production to pioneer the field of automated driving.

Thanks to the development of control systems and AI technology, the processes that govern “decisions” and “operations” have evolved rapidly. On the other hand, when considering the daily changes to roads, it is no easy task to maintain mapping information and ensure that it remains up to date. According to Mandali Khalesi, VP of the Automated Driving division, “these difficulties have meant that maps are presently limited to specific nations and regions, or to high-speed roadways where the collection of up-to-date information is comparatively easy.”

However, carrying out continual updates to maps of public highways with high precision has proved a major burden when carried out by a single corporate group. In response, TRI-AD announced the construction of an “Automated Mapping Platform (AMP)” in January 2019, one in which any company could participate in the creation and use of high definition maps.

AMP uses information gathered from satellite images and sensor data from automobile makers such as Toyota Motor Corporation, taxi companies, and delivery companies. Such information allows for the efficient creation and update of high-precision maps. AMP enables developers at automobile makers and suppliers to use the maps, which has accelerated development of Toyota Motor Corporation’s automated driving applications.

Khalesi continued by stating “At present, a number of vendors who possess satellite imagery and onboard camera technology, from automotive companies within the Toyota Motor Group to those outside, have expressed their intention to participate in proof of concepts (or “PoCs”) and we expect more partners to join us in the future.”

The quality of AWS's management services was key in the decision to adopt the platform

After the announcement of its new AMP architecture, TRI-AD launched a prototype to carry out PoCs with partner companies. In order to prioritize speedy development, AWS was adopted early with the intention of exploring the use of cloud services. AWS is already being used for a number of projects at TRI-AD, including machine learning and deep learning. It has become one of the standard elements of the company's IT infrastructure. AWS is also used frequently by Toyota Research Institute (TRI), an AI technology research organization in Silicon Valley, and both companies have experienced the merits of its development efficiency. Not only that, but use of the management services offered by AWS was said to be another deciding factor in its adoption. Ryo Igarashi, the engineer in charge of AMP's cloud operations development, stated that "given the limited staffing resources that confront developers, the rich management resources AWS offers have been essential for achieving short-term development. In addition, we expect the number of partner companies participating in PoCs to increase and even if new features are developed, the scalability that enables easy expansion of resources and services has been highly rated."

According to TRI-AD's design, AMP consists of three elements: collection and accumulation of data, highly precise map development, and the broadcasting of these highly precise maps. The core of data collection and accumulation consists of two segments, the real-time upload of data from running automobile probes and the batch upload of compiled data from taxi companies and other fleet partners. In terms of map development, developers from companies participating in AMP can access the Developer Portal and create map information tailored to their application by developing and deploying unique algorithms in the cloud. The resulting data will be registered and stored in a specialized Map Marketplace and broadcasted as an API, as necessary, to their autonomous fleet.

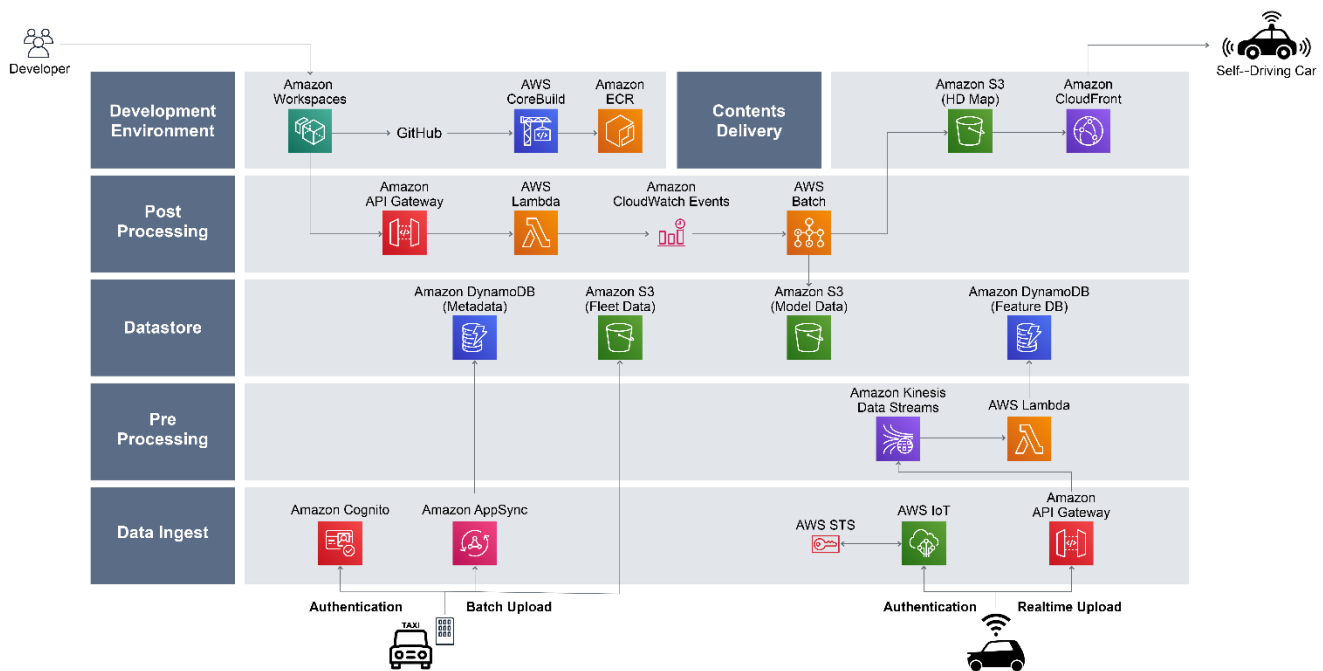
"Our AMP prototype is based on the policy of first making the product and then trying it out, meaning agile development where improvements are made as it is used. By prioritizing an environment where PoCs with partners can proceed easily, we focused on scalability that would be necessary for its future usage," says Igarashi.

Achieving scalable and shortened development cycle via serverless architecture

Development of the prototype began in April 2019, and it was released two months later in June. By coordinating with the architects of AWS solutions and professional service consultants, TRI-AD'S developers were able to achieve a shorter development period.

The prototype was created via active utilization of serverless architecture. Use of client certificates issued by AWS IoT formed the basis for real-time upload of data collection and accumulation tools. Tokens were received from AWS STS and certified by the Amazon API Gateway, ensuring the secure upload of data. Batch uploads were based on user certification by Amazon Cognito, while the running vehicle data and metadata were collected via Amazon S3 and AWS AppSync, respectively, before being accumulated on Amazon DynamoDB.

(See larger image online at: <https://amzn.to/AWS-auto-TRI>)



Accelerating innovation in the field of automated driving and working with partners to address social issues

"As a next step, we will begin work on the architecture of the future usage environment with the goal of implementing services," Khalessi said. "In pursuit of future global expansion within America, Europe, and Asia, we are planning to build in overseas compatibility and strengthen coordination with our international partners. AMP will enable rapid innovation in the field of automated driving and, together with our partners, will contribute to solving social issues."

Real-world example

Toyota Research Institute: On-Demand Self-Service Portal for Data Scientists to Process Data Sets

Arthur Mandel from Flux7 and David Fluck from Toyota Research Institute explain how they leveraged the power of AWS P3 GPU instances and Service Catalog to create an on-demand self-service portal for their data scientists to process data sets quickly and securely. Find out how to use Service Catalog products and trigger them on-demand to create P3 compute clusters to process machine learning data sets.

<https://amzn.to/AWS-auto-Toyota-video>

Solution:

AWS Connected Vehicle Solution

Online at: <https://amzn.to/AWS-auto-connected-vehicle>

What does this AWS Solution do?

Amazon Web Services (AWS) enables automotive manufacturers and suppliers to build serverless IoT applications that gather, process, analyze, and act on connected vehicle data, without having to manage any infrastructure. With AWS IoT, customers can connect vehicles and devices to the AWS Cloud securely, with low latency and with low overhead.

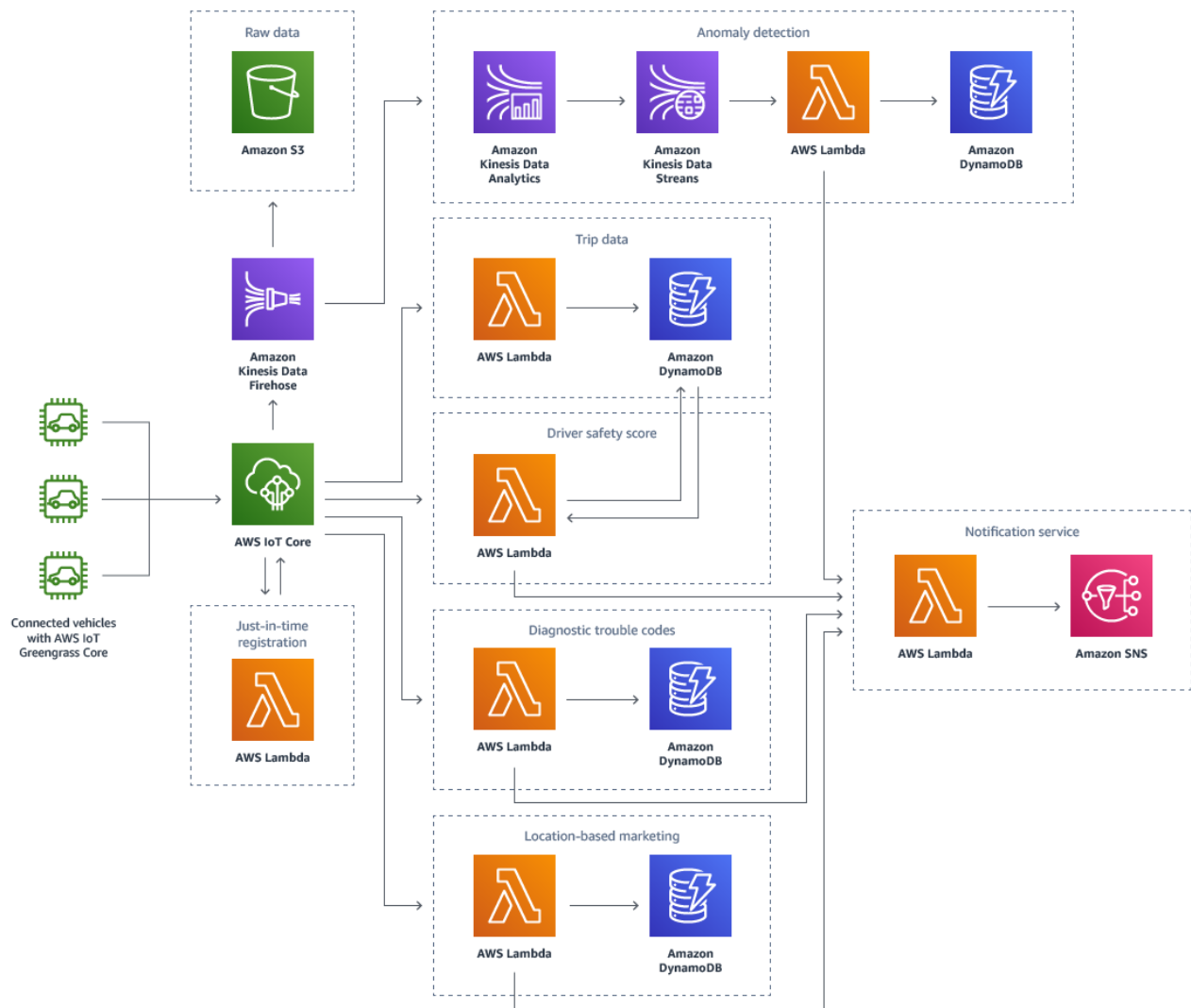
To help customers more easily develop and deploy a wide range of innovative connected vehicle services, AWS offers a connected vehicle solution that provides secure vehicle connectivity to the AWS Cloud, and a framework that helps customers integrate AWS IoT Core and AWS IoT Greengrass into the Automotive Grade Linux (AGL) software stack.

Version 2.1.1 of the solution uses the most up-to-date Node.js runtime. Version 2.0 uses the Node.js 8.10 runtime, which reaches end-of-life on December 31, 2019. To upgrade to version 2.1.1, you can update the stack. For more information, see the deployment guide (<https://amzn.to/2AWS-auto-solution-deployment>).

AWS Solution Overview

The connected vehicle solution includes capabilities for local computing within vehicles, sophisticated event rules, and data processing and storage. The solution is designed to provide a framework for connected vehicle services, allowing you to focus on extending the solution's functionality rather than managing the underlying infrastructure operations. You can build upon this framework to address a variety of use cases such as voice interaction, navigation and other location-based services, remote vehicle diagnostics and health monitoring, predictive analytics and required maintenance alerts, media streaming services, vehicle safety and security services, head unit applications, and mobile applications.

The diagram below presents the components and functionality you can build using the solution implementation guide and accompanying AWS CloudFormation template.



AWS Connected Vehicle Solution Architecture

When AWS IoT receives a message, it authenticates and authorizes the message and the Rules Engine executes the appropriate rule on the message, which routes the message to the appropriate backend application.

An AWS IoT rule sends telematics data to an Amazon Kinesis Data Firehose delivery stream, which encrypts and streams raw vehicle telematics data to an Amazon S3 bucket. If an Amazon Kinesis Data Analytics application detects an anomaly, the record is sent to Amazon Kinesis Data Streams, which invokes an AWS Lambda function that parses the record, stores it in an Amazon DynamoDB table, and triggers an Amazon Simple Notification Service (Amazon SNS) notification to users.

The trip data AWS IoT rule invokes an AWS Lambda function that processes vehicle telematics data during a trip and stores it in a DynamoDB table.

The driver safety score AWS IoT rule detects the end of a trip and invokes an AWS Lambda function that processes aggregate trip data to generate a driver's safety score, trigger an Amazon SNS notification to the driver, and add the score to the trip data table.

The diagnostic trouble code AWS IoT rule detects diagnostic trouble codes in the IoT topic and invokes Lambda functions that store the trouble code in a DynamoDB table, translate the trouble code into layman's terms, and trigger an Amazon SNS notification to the user.

The location-based marketing AWS IoT rule detects the location of the vehicle and invokes a Lambda function that determines whether the vehicle is near a point of interest. When the vehicle is near a point of interest, the function logs the location in a DynamoDB table and triggers an Amazon SNS notification to the user that contains an advertisement.

The full solution online at: <https://amzn.to/AWS-auto-connected-vehicle>

Real-world example

DeepMap Charts the Future of Automated Driving

Perhaps you think the world is already sufficiently mapped. With the advent of satellite images and Google Street View, it seems like every square inch of the globe is represented in data. But for autonomous vehicles, much of the world is uncharted territory. That's because the maps designed for humans "can't be consumed by robots," says Tom Wang, the director of engineering at DeepMap, a Palo Alto startup that provides HD maps for self-driving cars.

<https://amzn.to/AWS-auto-video-DeepMap>



Online at: <https://amzn.to/AWS-auto-vehicle-whitepaper>

Introduction

In just over a century, the automobile has done more to enable personal mobility than almost any other device, allowing people to travel almost anywhere, whenever they like. Over the past 2 decades, the mobile phone revolution and ubiquitous high speed data connectivity has transformed the way people see the world and has provided a glimpse into aspects of life in faraway lands. It has changed how people interact, creating connections between those whom have never met in person, and enabling them to do more in less time. The transformations from in-person conversations and written letters to wired networks and then to a vast trove of data constantly floating through the air would have been hard to conceive in the early 1900s.

However, as life gets busier, the personal mobility machine people know as the car and the ubiquitous yet utterly intangible communications network will fuse. By 2020, virtually every newly built vehicle in North America—and most vehicles globally—will be connected. Harnessing that communications power requires managing where the messages go, making sure the wrong messages do not end up at the wrong destination, and keeping it all running. Not so long ago, that meant every company would have to build its own unique infrastructure, something most are ill-equipped to do, particularly as the number of connections and complexity of the interactions increase. Today, fast, reliable, and robust cloud computing platforms provide the underpinnings to build new businesses and services that cross manufacturer platform boundaries seamlessly.

Anyone with a great idea can now execute it faster and reach a wider addressable market than ever before. New business models can be deployed on cloud platforms at a fraction of the cost of building out dedicated network infrastructure and scaled up easily to meet customer demand. Cloud providers also have the expertise to keep the platform more secure and resilient. Synergy is a vastly overused and abused word, but the connected car and the cloud definitely create the opportunity for products that are more than just a sum of parts.

Supporting the Connected Car from the Cloud

Two decades after General Motors' (GM's) launch of its OnStar services in the US, the concept of the connected car is hardly new. However, a confluence of factors is driving a rapid expansion of deployment. These include accelerating wireless speeds, declining service costs, and the ability to more easily build services using readily available cloud infrastructure resources.

Why is the Car Connected?

Modern life is increasingly connected, with most people around the world now carrying at least a mobile phone most of the time. With more than 2 billion active Android devices and 1.3 billion iOS devices, nearly half of the world's population now has at least one device with them that outperforms the super computers of a generation ago. These mobile connected computers share and collect data from almost every part of the world.

In many cases, these portable devices have faster wireless data connections than people's home internet service—analytics company StatCounter reported that mobile internet use surpassed desktop use in 2016. With all that ubiquitous connectivity, it makes sense that the most mobile device in most people's lives, the car, should be part of the same ecosystem. Through the course of the 20th century, the automobile changed the way humans live, work, and play, adding a degree of mobility never previously imagined.

In the 21st century, changing lifestyles, busier schedules, and increasing urbanization mean that many people spend more time in the car commuting than ever before. The Texas Transportation Institute report, 2015 Urban Mobility Scorecard, estimated that Americans wasted an average of 42 hours annually due to congestion, and that commuters in the worst congested cities lost double that amount. Staying connected gives commuters a means to be productive, entertained, or educated during those hours of playing hurry up and wait.

Connectivity also provides a means to take friction out of life and add convenience by reducing the need to remember mundane things like, "when did my car last get serviced," "where did I park," or "where can I grab a quick lunch on the way to my next meeting." The next generation of assistants will add contextual awareness of where a person is and what they intend to do, combined with their preferences to make the vehicle more personalized and proactive, rather than reactive. As cars become ever more automated, connectivity will be a key enabler with continuously updated maps, communication with other vehicles, people, and devices nearby, and the ability to be fully productive or thoroughly entertained while heading to a destination.

Read the full whitepaper online: <https://amzn.to/AWS-auto-vehicle-whitepaper>

Real-world example

Building TuSimple's Level 4 Autonomous Driving Truck Using AWS

TuSimple's Level 4 autonomous driving truck system achieves an industry-leading 1000 m of perceptual range. Learn how they use a variety of AWS products and services including AWS Snowball Edge, Amazon S3, Amazon EC2 P3 Instances, and deep learning on AWS to accelerate their development and continually refine the system in pursuit of perfection.

<https://amzn.to/AWS-auto-TuSimple-video>