dish wireless

DISH WIRELESS Future of the Connected Vehicle

White Paper – January 6, 2022

This white paper discusses how DISH 5G will support the fast-growing connectivity needs of vehicles, delivering optimization and intelligent vehicle connectivity supported by cloud infrastructure.

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EXECUTIVE SUMMARY

This white paper discusses how DISH will support the fast-growing connectivity needs of vehicles by delivering cost-effective optimization and intelligent vehicle cloud connectivity supported by private, public or hybrid-cloud infrastructure. Efficient vehicle data flow and management, for both consumer and commercial vehicles, is critical to creating a superior in-vehicle experience, even before achieving Level 4 autonomy. Properly-timed extraction and analysis of critical data is a primary value focus for connected vehicle OEMs, transportation service providers and other industry players. Use cases continue to expand across transportation services, passenger infotainment, in-vehicle advertising, location and tracking, vehicle diagnostics, hazard alerts, driver behavior and feature measurement.

Multiple gigabytes per hour of data are being generated in aggregate from the various systems within any connected vehicle today, and the volume of this vehicle-generated data continues to grow. The adoption of Level 4 driving autonomy will increase the volume of data to multiple terabytes per day, depending on the number of sensors, cameras and the quality of the video from each camera. Cost-effective and secure connectivity, as well as storage and intelligent analysis of vehicle-generated data, both in transit or at rest, is an industry imperative. Without a thoughtful and deliberate approach to managing the exponential growth in tonnage and conversion to actionable information, there is a risk of drowning in an ocean of data with ever-increasing cost and risk of achieving a return on investment.

Four key components form the backbone of DISH's strategic plan to satisfy the growing connectivity needs of vehicles while driving cost efficiencies to industry players and end-users alike. The first component is dynamic access to the best network at a given time for a given use case. This dynamic network access capability means a vehicle can utilize the best network and associated radio technology to transport data in the most efficient, reliable and cost-effective manner.
To enable this, DISH's 5G network will provide network functionality that supports new device technologies and flexible subscriber management policies. Unlike traditional carrier and network service provider business models that force devices to be locked and committed to a specific network, DISH is taking a customer-centric approach that gives a connected vehicle the ability to leverage the best technology available from multiple networks simultaneously.

The second component is a unique 5G services ecosystem, specifically designed to serve the automotive industry. As connectivity needs grow due to greater workloads created by existing and next-generation connected vehicles, network performance characteristics — such as throughput and latency — must also improve significantly to keep up with demand. Stakeholders in the automotive space, from vehicle OEMs to transportation service providers, will need network functionality and cloud integration capabilities. These functionalities and capabilities will be used in the factory and continue onto the street to provide the ability to manage services and updates for new, smarter vehicle models coming into the market. 5G network slicing is just one new technology that DISH will provide to deliver these services to enterprise customers.

The third component is a private 5G network solution for key players in the automotive industry. A private 5G network is similar to a public 5G network, but it is tailored to a specific set of enterprise customer needs or may be appropriated to a specific local area. In addition, it provides all of the necessary 5G network service characteristics while offering users a range of greater control over the network operations and data security. 5G-enabled manufacturing facilities, fleet management depots, dealerships, repair shops, aftermarket service providers, logistics companies and transportation service providers can utilize various private 5G solutions to offer a robust connectivity experience for their operational and end customer needs.

The fourth component is dynamic pricing, which allows customers to fully manage the cost of their desired connectivity solutions. Cost benefits are achieved through optimization of the storage and movement of vehicular data to and from the cloud, based on the dynamic, temporal, spatial and network state information. The optimum movement of the data to and from the vehicle can reduce costs by more than 50% through coordination and correlation of data consumption with network resource availability and system utilization. This white paper describes how DISH will provide unique 5G solutions to deliver a comprehensive connected vehicle experience for drivers and passengers, and favorably bend the cost curve of connected vehicles using DISH's cloud-native, open, 5G network.

DISH 5G Advantages for the Connected Vehicle

DISH's industry-first network deployment allows customers to take advantage of the capabilities enabled by a state-of-the-art, greenfield, cloud-native, 5G O-RAN, without the burden of legacy 2G, 3G and 4G systems. DISH 5G is an open platform that will empower its customers to manage and control service-specific network slices to optimize the connectivity between any vehicle and their unique cloud platforms.

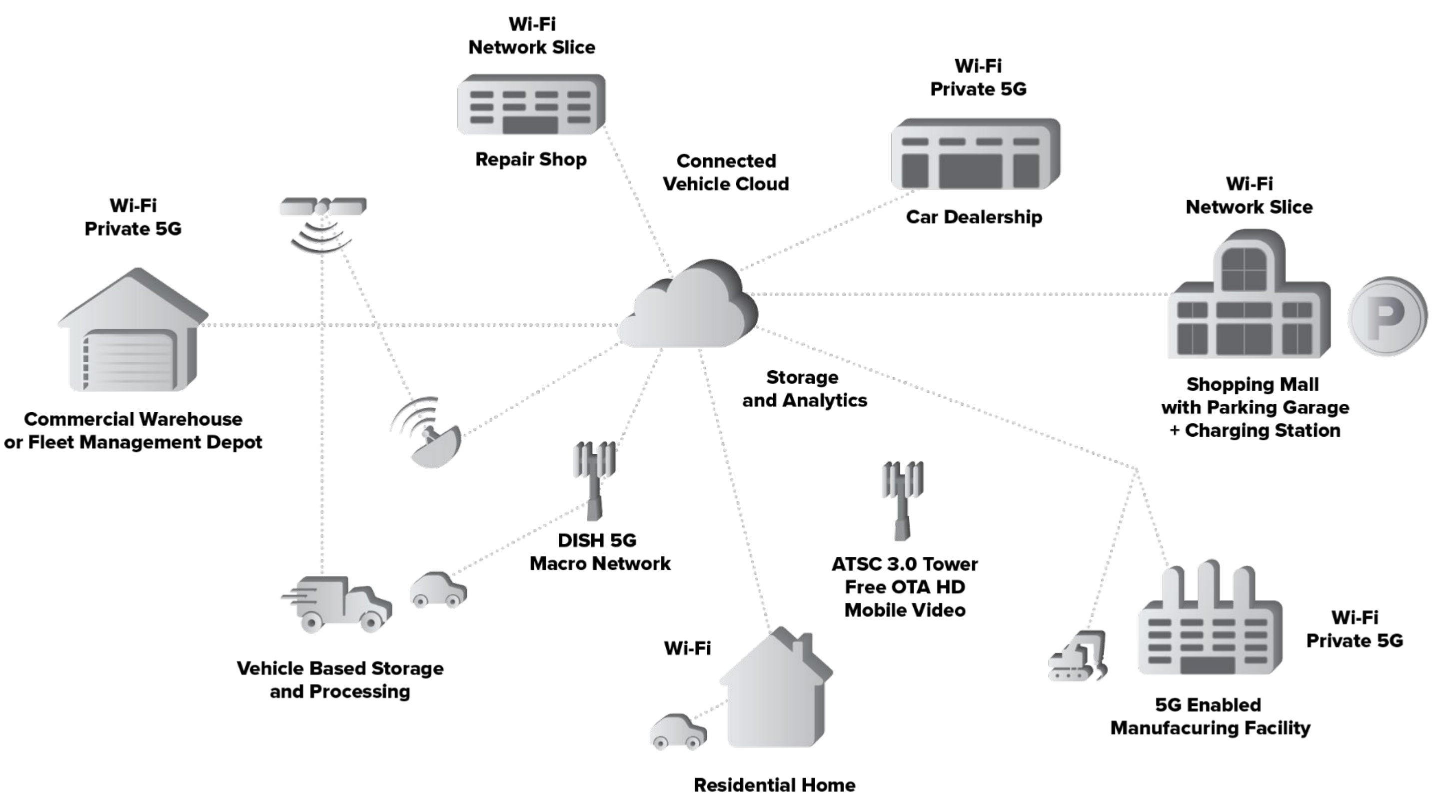
DYNAMIC NETWORK ACCESS SELECTION

Given the diversity of connectivity needs and the ROI requirements of vehicle OEMs, the future connected vehicle needs to intelligently select the right network at the right time. Infotainment features and vehicle apps may require a continuous wireless connection with specific, minimum data speeds, and the downlink connection (from cellular tower to vehicle) is the primary direction of the data traffic. On the other hand, vehicle diagnostics messaging may only require an occasional data link connection with a primary direction in the uplink (from vehicle to cellular tower or Wi-Fi router). In between, many use cases require specific network performance, data security or cost management parameters that different wireless access networks can provide. This means that the connected vehicle must have the freedom and intelligence to utilize more than just a single, dedicated network. The DISH 5G cellular network may be best suited for certain mobility applications, whereas CBRS or Wi-Fi may be the best choice for fixed service applications. In addition, new broadcast technology networks — like ATSC 3.0 — leverage current, high-power towers across every city in the U.S. to deliver a suite of infotainment, telematics and safety services for vehicles. ATSC 3.0 is the newest broadcast video standard that enables free, over-the-air video content to be viewed in moving vehicles. ATSC 3.0 broadcasts are currently live in over 28 U.S. markets and will expand to cover the entire country in the coming years.

The future connected vehicle will aim to provide all of these services by incorporating the use of multiple access networks, as shown in **Figure 1.** An intelligent vehicle platform connecting across this variety of access networks can integrate with any number of customer cloud systems to deliver vast amounts of data to and from the vehicle. This bulk data can then be selectively analyzed by the end customer to derive the most value. If Wi-Fi is a suitable network access, unlicensed Wi-Fi access points, both public or private, can be used when the vehicle is within range, provided the necessary authentication and encryption is in place. Should a more robust solution be required, a private 5G network strategically located at an OEM factory, fleet depot or dealership can be utilized to upload larger amounts of data from the vehicle to the cloud. Continuity and session handover between the different access networks is critical and this can be supported when the sessions are anchored to a common network core. DISH's 5G network provides this solution, giving freedom and network intelligence to the connected vehicle.

Unfortunately, ubiquitous coverage is not available with any terrestrial wireless network. Complementary connectivity using satellites is an option that can be utilized to augment the terrestrial network. DISH and its affiliate company, EchoStar Corporation, have over 25 years of experience owning and managing satellite services, serving every industry vertical with comprehensive coverage across the U.S. Aside from the cost benefit of cooperative and integrated management of the data traffic through each network slice, each slice can support unique customer controlled encryption and Public Key Infrastructure (PKI). The DISH cloud-native 5G network supports robust vehicle connection security and customer controlled policy management.

Figure 1 - Connected Vehicle Connectivity Architecture



Enablers for Dynamic Access Selection

DISH and the wireless industry have adopted eSIM with some support for iSIM, both of which are key enablers for dynamic access and network selection. This functionality removes the need for physical SIM cards, and DISH customers can remotely provision modules within a vehicle, over-the-air, with the appropriate credentials to operate on multiple networks. All of the enablers detailed below support the creation of an intelligent platform that is absolutely necessary for the successful mass deployment and operation of the truly connected vehicle.

Universal Modem Compatibility

Traditionally, carriers manage the modem and SIM cards for a specific device. This provides carriers full control of the wireless connection, rate card-based pricing and volume discounts based on consumption tiers. The rate cards are periodically renegotiated and there is some degree of “lock-in” to a service provider based on the SIM card and the limitations of the modem installed in a device. As a result, enterprise customers are forced to commit to a carrier for their wireless needs.

DISH is adopting a “universal modem” support strategy for enterprise customers and applications. A universal modem is a key enabler of any intelligent vehicle platform and is required for a vehicle to connect to multiple networks, based on the location, time of day and data throughput required. It is important to ensure the universal modem installed within the vehicle supports the appropriate frequency bands for working on multiple carrier networks.

Limiting the bands will reduce the options available to the connected vehicle to work with multiple service providers.

For the U.S. market, it is critical to have the following bands supported by the modem to work on any of the carrier networks:

- LTE/LTE-M support for 3GPP bands B71, B26, B5, B12/17, B25/2, B66, B70, B41 and B48
- 5G support for 3GPP bands n71, n26, n5, n12/17, n25/2, n66, n70, n41, n48 and n77
- ATSC 1.0 and 3.0 support for TV frequencies that cover 54 - 598 MHz

Aside from the bands listed above, support for the different carrier aggregation options should be considered. Support for Wi-Fi is also necessary to optimize the cost of the connectivity to the cloud. By leveraging the continuity of connections between wireless technologies, additional cost optimization can be realized.It is possible to take advantage of the surface area of a vehicle to support more advanced antenna solutions to maximize the RF performance and data throughput. Most service providers can support a minimum of 2T2R and there is support for higher orders of MIMO. Moreover, the design of the RF front end within the vehicle should take into account future capabilities of wireless networks. DISH is actively working with manufacturers to ensure open support for these and future spectrum bands, as well as the necessary technology enablers.

eSIM Functionality

A critical factor in adopting a universal modem is the support for eSIM and future enablement of iSIM. eSIM stands for “embedded SIM,” which is an embedded universal integrated circuit card (eUICC) installed directly into a device that can be programmed dynamically. This avoids the requirement for installing a separate physical SIM card into the device. iSIM or “integrated SIM,” is a future technology that integrates the SIM directly into the device’s cellular module hardware, resulting in savings from the elimination of dedicated SIM components such as SIM cards, chips and trays.

DISH is committed to full support for eSIM and the secure element — the eUICC. Through this approach, enterprises can download different profiles from different carriers without being locked into any single provider for the connectivity. Multiple profiles can be supported simultaneously and these will allow the device to dynamically optimize connectivity to the cloud, selecting the best network for the given task. Enterprise customers can also benefit from the capability of upgrading device profiles remotely and dynamically.

Rather than the traditional model of swapping out SIM cards, devices can be updated over-the-air providing time and cost savings. DISH believes this approach empowers enterprise customers to integrate wireless technology in more impactful ways in their business.

The standards for eSIM support were published in 2014 and adoption for M2M use cases has been underway for several years. Unfortunately, while the technical capability to allow industrial customers to switch carriers by simply changing profiles has been in place for some time, some traditional wireless service providers have introduced business rules to lock a module to their network and thereby increase the switching cost. As a consequence of these business practices, the promise of eSIM has yet to be fully realized.

The opportunity for the connected vehicle is to ensure any module or modem has embedded support for a carrier-agnostic eSIM and eUICC. The SM-SR can be used by enterprise customers to manage the status of the profiles on the eUICC over-the-air. The SM-SR secures the connection between the eUICC and the SM-DP for the delivery of different wireless service provider profiles. Use of this standardized architecture future proofs the ability to effectively change operator profiles on the fly and over-the-air. This will enable the enterprise customer to have service agreements with multiple service providers.

Through the use of this technology, it is possible to have different vehicles connected to different networks, and move the vehicle-generated data through different networks depending on the business objective function.

Dual-SIM Options

The support and interest in dual-SIM solutions has increased recently, as it can be supported within the eSIM architecture. In fact, the architecture will soon allow for multiple active profiles. The following implementations are currently being pursued and discussed within the wireless industry:

- DSS – Dual-SIM Standby allows for a customer to select which of two SIMs can be used to make and receive services. Only one SIM can be active at a given time, but DSS allows the vehicle to have the optionality of choosing between two service providers during its life cycle.
- DSDA – Dual-SIM Dual-Active allows for two connections using two transceivers to be active at the same time. The device is registered, authenticated and connected to both service providers. This design is optimal for enabling dynamic access selection, so the vehicle can utilize both services to deliver an optimal experience, from leveraging both services to provide the highest data throughput to utilizing the service with the better signal quality.
- DSDS – Dual-SIM Dual-Standby shares the same transceiver, but only one connection is active at any time. The advantage is that, rather than paying for two active connections at the same time, the vehicle can switch from one service to the other seamlessly, provided that the service provider's network supports eSIM.

Evolution towards iSIM

With iSIM, the SIM functionality is embedded into the main SoC and removes the need for a separate processor. Market-leading semiconductor IP company, ARM, has promoted the adoption of iSIM, originally launched in 2018. The evolution and development of iSIM builds upon the eSIM remote provisioning functionality, provides hardware level root-of-trust and enables multiple profiles to be remotely downloaded over-the-air. The embedded deployment of the SIM functionality will reduce power consumption and further enhance the security of the connectivity. Architecturally, the solution is consistent with eSIM. The future support for this capability will provide additional options to vehicle OEMs as they design and develop new vehicle models.

UNIQUE 5G SERVICES ECOSYSTEM

DISH is taking a customer and developer-centric approach to its 5G network implementation. Instead of building a one-size-fits-all network and trying to design for enterprise customer needs across every industry vertical, DISH is embracing an open business model where customers and developers can utilize the first and only 5G SA network to deliver enhanced customer and enterprise value. Unencumbered by legacy network infrastructure and antiquated business systems, DISH offers all enterprises the unique opportunity to innovate new products and services pertinent to their own business models. Further, companies can now bring innovative solutions to market at their own pace. Innovation cycles will no longer be dictated by a monopolistic group of telecom industry insiders offering the same old set of proprietary solutions.

Standalone 5G Network Delivers True 5G Services with Incremental Advantages

There are several network architecture options used to deploy 5G service. Most utilize a hybrid network that contains 4G and 5G network infrastructure, resulting in a 4G LTE network that offers some 5G characteristics but is ultimately bogged down with legacy system baggage. During the transition from 3G to 4G LTE technology, it took over a decade for carriers to gradually upgrade network equipment and cellular towers in the United States. The disadvantage to this method was that networks were not able to yield the comprehensive 4G LTE services and benefits. A similar situation is taking place today, as carriers have launched very limited 5G services because the overall infrastructure is still optimized to support 4G LTE.

These hybrid network deployments are defined as non-standalone 5G networks, or 5G NSA. Traditional providers' timeline for upgrading network infrastructure to 5G is hindered by the need to support legacy technologies, as 4G LTE-fielded devices continue to dictate business operations. DISH's advantage is that it is building a 5G network from the ground up, using a network architecture design called "5G standalone," or 5G SA. In DISH's 5G SA network, all of the elements are designed to meet the newest standards and specifications of 5G technology. Therefore, 5G network benefits can be realized the moment the network is operational, without any retrofitted upgrades.

5G provides significant enhancements over existing 4G LTE service characteristics, as well as new capabilities such as Ultra-Reliable Low-Latency Communication (URLLC). URLLC is a set of features that provides low latency and ultra-high reliability for mission critical applications, which can offer significant benefits to the connected vehicle industry. Safety innovations, including vehicle-to-vehicle accident avoidance through communication beyond the line of sight, is just one example of how a 5G network can enable unprecedented Vehicle to Everything (V2X) applications and use cases.

Virtualized, Cloud-Native Network Easily Integrates with Customer Infrastructure

Customer needs should define how the 5G wireless network operates, not the other way around. To achieve this, DISH has elected to virtualize its 5G network architecture. 5G virtualization can be used to replace traditional hardware capabilities with software functions within the RAN. Network Function Virtualization (NFV) provides the ability to react at the speed of machines, allowing for an instantaneous response which is of utmost importance for security, customer control and flexible consumption.

DISH's 5G SA network is cloud-native, which means it can leverage the unique capabilities of the cloud while providing several unique advantages. First, since the cloud can host network resources, such as the network functions, these can be conveniently accessible from anywhere within the network coverage map. The cloud provides additional computing resources and services to be accessible to user equipment. Instead of depending on physical resources for network upgrades, the cloud can provide additional network horsepower whenever it is required.

Second, the cloud-native design easily enables integration with any customer's cloud infrastructure, providing advanced capabilities, cost efficiencies and flexibility.

Third, a cloud-native design provides enhanced network reliability. Redundant network functions can live in the cloud as a backup in case there is a service disruption, such as a power outage.

Fourth, network infrastructure upgrades can occur with little to no network disruption.

Finally, these capabilities empower a customer to participate as a co-developer with DISH. They can leverage the cloud-native aspects of DISH's 5G network as a pipeline for development and customers with advanced technical capabilities can seamlessly integrate their existing architecture with the DISH 5G network without having to invest in infrastructure. The end result: customers can deploy their services in a faster, more cost-effective manner that is fully aligned with their needs.

Open-RAN (O-RAN) Network Framework

One of the key hardware infrastructure components of a cellular network is the radio access network (RAN). In 5G, the technology is called 5G New Radio, or 5G NR. Importantly, 100% of DISH's RAN is NR-compliant. 5G NR was developed to be the global standard for the air interface of 5G networks. It delivers significantly faster and more responsive communication with devices. It also allows radio resources to be dynamically adjusted to support demand fluctuations and spikes, as well as timely updates for new use cases.

There are different frameworks for selecting RAN equipment. DISH has adopted an open radio access technology framework called Open-RAN, or O-RAN. O-RAN involves the interoperability and intercompatibility of open, non-proprietary hardware and software. "Open" refers to an open-source software development, versus the locked or closed-source systems currently used by traditional providers. This open ecosystem overcomes the steel threaded nature put in place by legacy carriers and empowers anyone to innovate and go-to-market at their own pace without reliance on big tech manufacturers to define, develop and launch innovation. DISH is working with industry-leading partners to build a highly secure, open, intelligent, virtualized and interoperable RAN.

In traditional RAN architecture found in 4G LTE, many elements of the network are proprietary, designed to only work with specific components from the same vendor or from a specific list of approved vendors. This forces carriers to be dependent on specific vendors, and limits their ability to quickly upgrade network components and launch new products. It also requires carriers to rely on vendors' specific product roadmaps to deploy newer and more powerful RAN equipment. Finally, it is costly— adding a single hardware element can require significant changes to the system when vendors are unwilling or unable to support a request.

With an O-RAN system, DISH has the freedom and flexibility to customize its network and can install new technologies in a fraction of the time, cost and effort. Instead of being limited to one vendor, DISH can source components from many different O-RAN-compliant vendors, allowing it to choose the best software and hardware components across multiple vendors to deliver the best combination to its customers. It can also duplicate network equipment, sourcing components from multiple vendors, providing flexibility and durability to network operations. For example, it can upgrade specific network components using one vendor while keeping operations running on another vendor's equipment, thus avoiding overall network disruptions in operations or performance.

5G Network Security

DISH is adopting a “secure by design” development strategy, with a zero-trust model, integrating industry and security best practices into its products and embracing security design principles to be able to rapidly respond to the ever-changing security needs of network customers. DISH will continuously iterate, modify and enhance its network at the speed required for tomorrow's customers.

After studying classical, closed network security, DISH determined current security postures do not meet today’s enterprise and consumer security requirements. To address these pitfalls, DISH is integrating 5G security solutions from the ground up, hand picking innovative, next-generation partners that provide security and innovation, ultimately giving much of the control back to the customer. With these key partners, DISH will offer customers the security that is expected from a leading, forward-looking, enterprise-ready provider. One of DISH’s key tenants is a zero-trust security model. As part of the zero-trust model, DISH is taking the “never trust, always verify” approach. This approach is an industry best practice and necessary for any open system. Zero-trust ultimately provides threat prevention and more control for both the provider and the customer. Important components of DISH’s 5G security roadmap include real-time threat correlation, 5G slice security support for a software chain of trust and end-user control. These components improve the network’s threat detectability and the capability to automatically serve, act and adapt. Traditional providers have commingled networks that lack end-to-end security, supply chain security and complete transparency, and are unable to provide elastic consumption based on customer needs. These traditional, flat infrastructure networks have every client transversing the same network, inherently increasing threat exposure. With the new, cloud-native technology available today, open interfaces allow for a more competitive market and provide the network operator the ability to follow a “best of breed” technology approach, leveraging a software chain of trust where technology can be switched out, upgraded and specialized for the network user.

5G Network Slicing

The one-size-fits-all network operations methodology employed in legacy technologies (2G, 3G, 4G LTE) no longer address the diverse needs of the market. Enterprise customers require more from a carrier, including quality of service (QoS) guarantees, network service exposure, enhanced security features and dynamic control capabilities. 5G enables a new approach towards efficiently delivering services to meet these needs through a technology called network slicing.

A network slice is an independent end-to-end logical network that runs on shared physical infrastructure, such as the DISH 5G MNO, or dedicated private infrastructure. For QoS guarantees, network performance attributes can be used to provide a service level to customers. Attribute examples include speed, data throughput, latency, reliability, signal quality and security. Connected vehicles require a distinct level of service for different use cases. Live infotainment could demand a massive amount of data throughput whereas V2X safety systems will require ultra-low latency and high network reliability. A network slice can be provisioned to support each of these, not just for the single connected vehicle customer, but for all customers that require a similar service. For transportation service providers, both the driver and the passenger (customer) can benefit from a network slice tailored to their specific needs. An operations slice covers the driver and transportation logistics, while a passenger slice can provide infotainment and Wi-Fi.

Another example use case for network slices is data isolation. Transportation service providers, vehicle OEMs and dealerships may each have different, specific policy management or security requirements regarding data traffic that originates from the connected vehicle. They may wish to specify, manage or control how their most sensitive data travels across DISH's 5G network infrastructure. Network slicing can provision and isolate the data as required to provide an extra layer of security.

Finally, network slices can also be applied to the physical network infrastructure and capabilities of the DISH 5G network. The capabilities of the network slice aren't limited to the user plane.

Utilizing this revolutionary technology, vehicle OEMs and other enterprise customers could for example:

- Manage a network slice with QoS provisioning that changes from one time period to another, thus offering dynamic control or reconfiguration capabilities.
- Dedicate spectral and RAN resources for a specified time period.
- Utilize a temporary network slice in an isolated, mountainous area to conduct vehicle prototype performance testing.

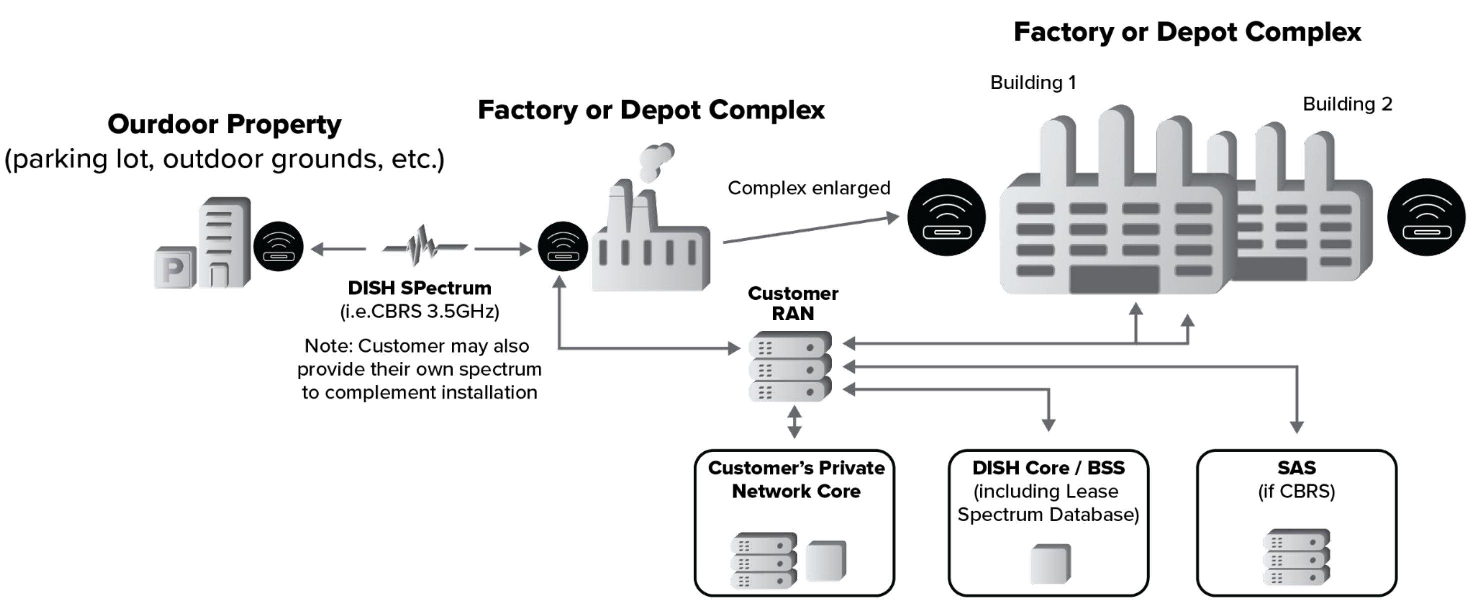
DISH is enabling dynamic end-to-end network slicing on its 5G SA network that will not only support the diverse requirements of an evolving enterprise market, but also offer a degree of network management, reconfiguration and control never seen before.

PRIVATE 5G SOLUTIONS

A wireless private network is a wireless local area network (LAN) that serves users and devices in a specific area, such as a private Wi-Fi network. Private 5G defines the newest generation of private networks, which leverage the virtualized network architecture and robust performance characteristics of 5G technology.

The basic architecture, shown in **Figure 2**, is similar to a public 5G cellular network, including similar RAN and core elements; however, a private 5G network is on a much smaller scale or targeted geographic footprint. These elements may or may not be provided by DISH. In some instances, DISH may only provide the spectrum.

Figure 2 - Basic Private 5G Network Architecture



A private 5G network provides unique advantages over standard Wi-Fi and private LTE networks. First, all four key uses cases of 5G are possible: Enhanced Mobile Broadband (eMBB), Massive Machine-type Communication/IoT (mMTC), Ultra-reliability and Low-latency Communications (URLLC) and Reduced Capabilities (RedCap). These advantages are ideal for deployment at customer facilities such as 5G-enabled manufacturing sites, vehicle dealer networks and fleet management depots.

Private 5G-enabled manufacturing network technology makes automotive factories of the future possible. It allows machines and computing power to collaborate in real time, presents the opportunity to transform the speed of launch, flexibility of present manufacturing facilities and can act as a springboard for organizations, allowing them to rethink the way they do business. The future connected vehicle could start its data transception life cycle right on the floor of a 5G-enabled manufacturing facility and never stop its connectivity journey until it is permanently taken off the road.

Fleet managers operating at scale need to measure and analyze the right data at the right time in order to make business-critical decisions on constantly moving assets. A private 5G network deployed across a customer's depots and connected fleet can efficiently deliver this critical data to a customer's cloud infrastructure. Key insights, such as strategic asset placement, current location, vehicle state, driver safety and performance tracking as well as vehicle health and preventative maintenance scheduling need to be proactively delivered. Achieving this level of detail requires a connected vehicle powered by an intelligent platform that can access the right network, at the right time and right cost.

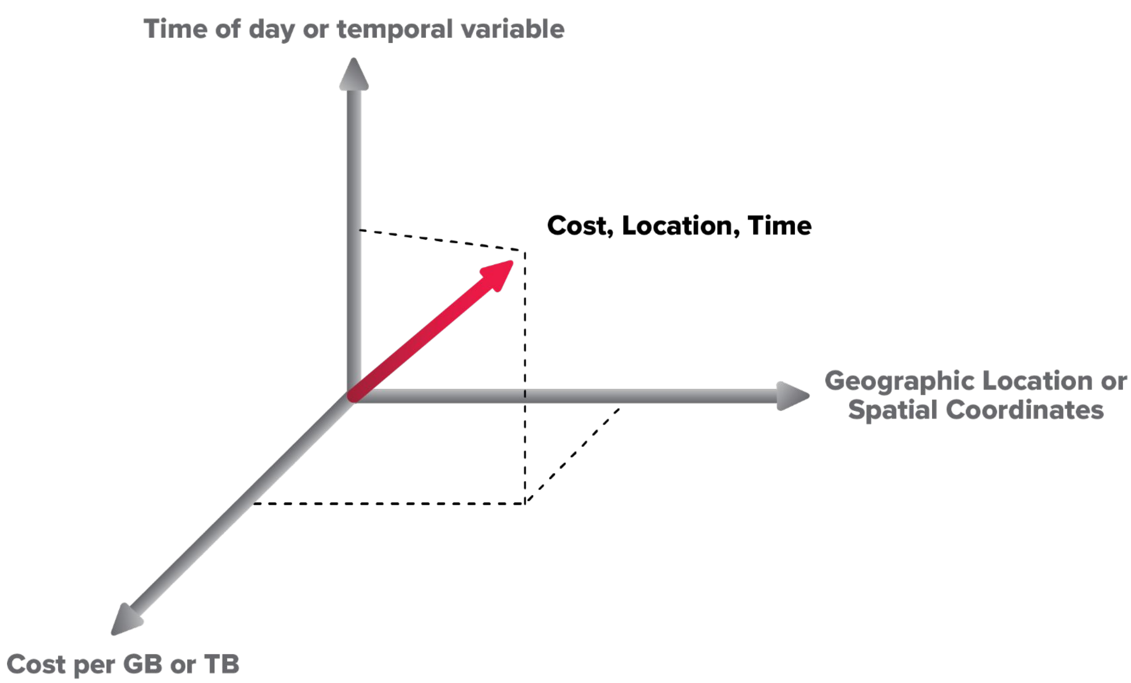
A private 5G network setup in a nationwide chain of vehicle dealerships, repair shops or charging stations could be utilized to upload significant vehicle performance and telematic data to any subscriber OEM's cloud. These sites could also be used to download important software updates to all vehicles within range of the private network. Network slicing ensures that only the required service levels necessary are implemented with a level of secure encryption chosen by the customer to protect critical data as needed.

DISH private 5G offers an ideal connectivity solution to power the enormous data transfer needs of consumer and commercial connected vehicles in a secure, controlled, customizable network environment tailored to their exact needs. Purchasing only the required capabilities delivers significant ROI and long-term cost savings over the traditional, one-size-fits-all approach.

MANAGING CONNECTIVITY COST WITH DYNAMIC PRICING

Traditionally, service providers manage the SIM cards, control the wireless connection and provide pricing based on a rate card with volume discounts based on consumption tiers. The rate cards are periodically renegotiated and there is some degree of “lock-in” to a service provider based on the SIM card and the limitations of the modem installed in a vehicle. The market is shifting and dynamic pricing of the network resources is possible, as a function of time, location and the price per unit of capacity, based on real-time network utilization. An illustration of this function is shown in **Figure 3**. The three-dimensional surface area defined by this function shifts based on the service level requirements. It is possible to optimize the total cost of connectivity by considering the time of day, location of the vehicle and the dynamic network load.

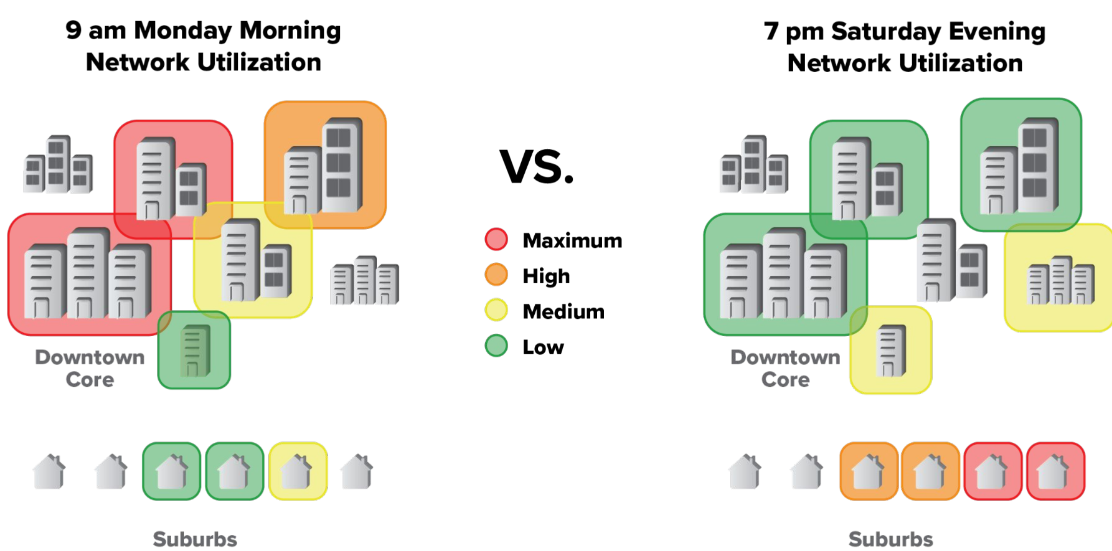
Figure 3 - Dynamic Pricing of Network Function



The network is equivalent to a "gigabyte factory," with a significant fixed cost. The average wireless network utilization is typically less than 25%, and it can be significantly lower depending on the specific geography of coverage and decreasing customer density. The utilization and efficiency of the network can be increased with a dynamic pricing model linked to the specific location of any connected device and time of day. **Figure 4** shows examples of the varying loads on a wireless network through time of day and the variable density of consumption in a network over a defined geography. This can be considered in aggregate or down to a sector-by-sector level within a network.

By optimizing the on-vehicle storage and the movement of the vehicle-generated data, based on the customer-defined service requirements, it is possible to take advantage of the network when the marginal cost is lower, as opposed to moving the data during peak hours and on heavily utilized sectors. The dynamic pricing model for use of the network resources and vehicle connectivity is a function of intertemporal and interspatial price discrimination with dynamic adjustment due to stochastic demand for network resources. This allows DISH customers to discover a statistically lower overall cost structure for a customer-defined service tier on their own terms. These cost savings could potentially be passed on to the end-user, enabling wider adoption and utilization of connected vehicle services across the entire market.

Figure 4 - Network Loading Variation Based on Time of Day and Location



CONCLUSION

DISH is deploying an open, cloud-native, standalone 5G network, with support for secure network slicing, to enable connected vehicle customers to have their own private, virtual wireless networks that can seamlessly integrate with each of their unique cloud environments. The end-to-end network slice and supporting systems allow for complete customer-driven management of the security, encryption and policies for any type of connected vehicle.

The quality of the connection will vary as the vehicle moves in both time and space, through diverse geographic areas and across different types of network coverage. Dynamic access to the best network available can help smooth out this variability, ensuring the required QoS is maintained at all times. The total cost of the connectivity can be reduced by more than 50%, since it is possible to optimize the storage and movement of significant tonnage of data to and from the connected vehicle, based on the service level requirements and the objective function of the customer-defined use case. Depending on the need, some data can and will be moved in real time with minimal latency, while other data will be moved non-real time in different geographies, through different networks, depending on the rules established by the customer.

The four key components of DISH's strategic plan address the full range of connected vehicle requirements and drive significant cost efficiencies:

- Dynamic access to the best network at a given time for a given use case means the intelligent, connected vehicle can utilize the most suitable network and associated radio technology to transport large amounts of data in the most efficient, reliable and cost-effective manner. This optimization allows customers to process and analyze the targeted data needed to make insightful business decisions.

- A unique, open 5G services ecosystem that enables intelligent platforms that can adapt as the connectivity needs of smarter vehicles continue to grow and industry stakeholders demand more network functionality and control mechanisms. 5G network slicing is just one new technology that DISH will provide to enable these services for enterprise customers

- Private 5G network solutions tailored to provide unique network service characteristics while giving the customer complete control over the network operations and data security. 5G-enabled manufacturing sites, fleet operations centers, vehicle dealerships and other aftermarket service providers can utilize these solutions as a robust connectivity experience for their operational and customer needs.

- Dynamic pricing to effectively manage the cost of the connectivity is achieved through optimization of the storage and movement of vehicular data to and from the cloud, paired with coordination and correlation of data consumption with network resource availability and system utilization.

DISH 5G - Future of the Connected Vehicle

DISH's industry-first, standalone, 5G O-RAN network is powered by a unique customer-centric, open business model. This pure, greenfield network, unencumbered by legacy infrastructure and antiquated business systems, empowers customers and developers to innovate and deploy at their own pace. Support for next-generation enablers like eSIM, universal modems and advanced antenna solutions make it possible for companies to take full advantage of the DISH 5G cloud-native network and favorably bend the cost curve of supporting the full spectrum of connected vehicles.

ACRONYMS

2G / 3G / 4G / 5G .... Second / Third / Fourth / Fifth Generation

2T2R .... 2 Transmitters, 2 Receivers

3GPP .... 3rd Generation Partnership Project

ATSC .... Advanced Television Systems Committee

CBRS .... Citizens Broadband Radio Service

DSDA .... Dual-SIM Dual-Active

DSDS .... Dual-SIM Dual-Standby

DSS .... Dual-SIM Standby

eSIM .... embedded SIM

eUICC ....,........ Embedded Universal Integrated Circuit Card

iSIM .... Integrated SIM

iUICC .... Integrated Universal Integrated Circuit Card

LTE .... Long Term Evolution

M2M .... Machine to Machine

MIMO .... Multiple Input and Multiply Output

NSA .... Non Standalone

OEM .... Original Equipment Manufacturer

ACRONYMS

ORAN .... **Open Radio Access Network**

OTA .... **Over the Air**

PKI .... **Public Key Infrastructure**

QoS .... **Quality of Service**

RAN .... **Radio Access Network**

ROI .... **Return on Investment**

SA .... **Standalone**

SIM .... **Subscriber Information Module**

SM-DP .... **Subscription Manager - Data Preparation**

SM-SR .... **Subscription Manager - Secure Routing**

SoC .... **System on a Chip**

URLLC .... **Ultra-Reliable Low-Latency Communication**

V2X .... **Vehicle to Everything**