

## DEFINING THE CONNECTED CAR REVOLUTION

Software already plays a key role in the operation of modern vehicles. But in the future, it will become the defining characteristic of the personal transport revolution.

Over the last few decades, software has assumed an increasingly important role within vehicle design and construction, controlling everything from infotainment systems to engine performance and driving dynamics. Nevertheless, most manufacturers still differentiate on hardware – engine type, power and performance, trim levels, carrying capacity, design, and so on. This reflects a market in which the combustion engine is still king, vehicle ownership is the norm, and a large segment of buyers care about brand image. However, all of these accepted realities are about to be challenged by:

- The rise of electric drivetrains that are easier to build, easier to control and automate using software;
- A new generation of consumers who demand ‘always on’ connectivity to information via the Internet, and for whom vehicles are a source of convenient, short-term mobility;
- The increasing importance of a software-defined user experience that will become the key driver of differentiation for automotive vendors.

These trends will have a truly revolutionary impact on the automotive industry. Differentiation between competing fuel sources, engine types and power outputs will become irrelevant. Future generations will care less about brand heritage and more about the experience they receive in the vehicle – regardless of whether a person or a computer is driving.

Today’s automotive manufacturers – perhaps facing the additional threat of aggressive competition from completely new players from outside the industry, such as Google and Apple,

but also new players like Lucid Motors, Faraday Future and the German startup SONO Motors – will need to define themselves more as lifestyle enablers and service providers, and less as engineers and OEMs. Perhaps they will even collaborate to create innovative hybrid brands that combine the best of the automotive and high-technology worlds to deliver novel user (not necessarily owner or driver) experiences.

No matter how the market rearranges itself, one thing is certain: Software solutions will drive the required transformation. Importantly, success won’t simply be a case of having the best software, or securing the most productive partnerships. It will require the ability to continuously adapt services and experiences to vehicle users according to their changing preferences and needs – especially because vehicles will increasingly be used by multiple drivers, each of whom will expect a tailored personal transport experience. That could mean anything from slower or faster acceleration, to a specific selection of infotainment applications. Enabling these options will require constant connection between users, vehicles, manufacturers, workshops, dealerships and technology vendors, among others.

The most efficient, scalable and cost-effective way of enabling this brave new automotive world is to share software-generated data and intelligence between the vehicle, the user and vendors via the cloud. VMware and Dell Technologies have the necessary platforms, tools and expertise to help automotive manufacturers achieve this, and reinvent themselves for the coming connected car era.

## PERSONAL MOBILITY, REINVENTED

Today, vehicle personalization is about online configurators and exclusive options programs – the focus is on physical features, from unique paint finishes to different grades of leather upholstery, extra horsepower or bespoke alloy wheels. However, future generations will consume a vehicle less as a personality extension or status symbol, and more as a personal mobility service. In this new era, software will differentiate the customer experience much more meaningfully than the physical attributes of the vehicle, as electric power democratizes performance and automation removes the need for a human driver. At the same time, the rising cost of accommodation in growing urban hubs will mean purchasing a vehicle makes less sense for many people. As a result, ever-larger numbers of consumers will tend to be vehicle users, rather than owners or drivers. So, how will this affect vehicle personalization?

Software will provide consumers with a broader range of experiences, either preconfigured or self-defined – regardless of whether or not they own or drive the vehicle themselves. Everything from driving modes and power



delivery, to entertainment and information services, will be configurable on demand with a few touches, gestures or spoken words.

Manufacturers will leverage this software to deliver new services proactively, with data generated by the vehicle used to drive everything from maintenance and update scheduling, to application delivery or pre-sales and marketing communications – all with minimum effort for the customer.

VMware and Dell Technologies can provide the intelligent data hub and secure network for integrating and managing all of these new services. The result: a new kind of flexible, personalized mobility experience, brought to life by the right combination of cloud- and vehicle-based technologies.

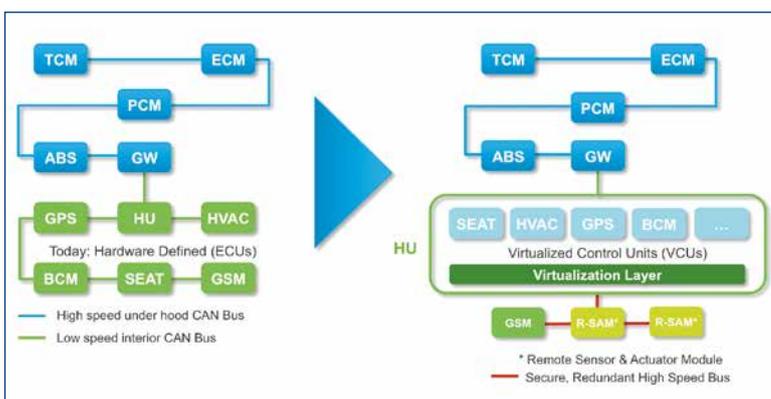
## REDUCING THE RISK OF COMPLEXITY

Complexity in modern vehicles is a major source of cost, inefficiency and risk for manufacturers. For example, producing different busses and installing hundreds of ECUs in every vehicle is extremely time consuming and expensive. Long, complex configuration-specific testing processes delay time-to-market. And software faults that must be repaired manually because there is no space or capacity for fault tolerance to be built in to the vehicle, create additional cost and risk.

Fortunately, a solution is in sight: Replacing multiple ECUs with virtual ones (VCUs) hosted a powerful Master Control Unit (MCU), which then becomes a master control unit or MCU. This greatly reduces the cost of development, testing and manufacturing.

In addition, this virtualized environment can be used to test software updates and vehicle behavior anonymously during real-world journeys, and relay information back to a cloud-based data collection and analysis platform. As a result, software updates will only be deployed operationally when they have been perfected through real-world testing. This minimizes the potential risk and cost of a faulty update for manufacturers, and ensures the customer experience is not disrupted.

VMware and Dell Technologies offer scalable ways of collecting, transmitting, storing, analyzing and utilizing the data required to support this vision, as well as coordinating over-the-air delivery of the required updates. Also together with partners like Harman.



## BEYOND SELLING UNITS

During the 21st century, the business models relied upon by vehicle manufacturers for decades – selling units and maintenance services through dealerships, differentiating on brand heritage, generating profits through financing, etc. – will be challenged and then replaced. There are a number of key drivers behind this trend.

For example, the rise of electric vehicles will mean greater reliability, fewer moving parts and almost zero physical maintenance. Future generations of drivers will care less about heritage and ownership, and more about having access to convenient, connected and personalized



mobility services. And driverless cars will reduce the significance of the vehicle's external image, and increase the importance of the internal experience. New services and applications, and the ability to transfer personalized settings between vehicles, will be key to enabling an optimal and variable experience, fuelled by the enormous and constantly growing volume of data generated by vehicles and drivers.

Automotive OEMs need to be able to capture and make sense of this data in order to create the services, applications and offers demanded by the next generation of consumers, and communicate them in a personalized and consistent way across multiple channels.

VMware and Dell Technologies provide the scalable, intelligent big data collection and analysis platforms to support manufacturers in devising new business models from the wide range of opportunities generated by the connected car.

## THE FAST ROUTE TO CONNECTED CAR COMPETITIVENESS

For many years, the complexity of the vehicle E/E architecture has kept vehicle and service development in the slow lane, because of the testing effort involved: every single possible configuration of hardware has to be tested separately for every model, which takes months or even years.

If your competitors have the same issue, the risk of being at a competitive disadvantage is small. However, as software increasingly defines vehicle characteristics, manufacturers have an opportunity to accelerate time-to-market by eliminating complexity, and streamlining testing and service development processes. The question is: How?

The answer is to radically simplify and virtualize the control systems in the vehicle so that testing and new service development become permanent, efficient



processes, continuously informed by vehicle and user-generated data. The same software-driven architecture can be used in every vehicle. And that means a permanent end to the separate development of different electronic systems and applications for each vehicle range and model.

The manufacturers that are able to do this first will be one step ahead of their peers. VMware and Dell Technologies have the expertise and technology to help OEMs realize this advantage.

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**05 New business models:** Driving new revenue streams through data recycling, shaping the in-vehicle user experience on demand, driverless transport services, and more.



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### Matthias Schorer

Lead Business Development Manager – IoT, EMEA

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[mschorer@vmware.com](mailto:mschorer@vmware.com)

Tel. +49 89 / 3706 17108

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VMware Global, Inc.  
Zweigniederlassung Deutschland

Freisinger Str. 3  
85716 Unterschleißheim

[www.vmware.com/de](http://www.vmware.com/de)



## PROTECTING PEOPLE AND PRIVACY IN THE ERA OF CONNECTED CARS

The connected car era will create a wealth of new opportunities – and just as many new risks. To succeed, automotive OEMs must prioritize security.

In July 2015, security experts Charlie Miller and Chris Valasek made headlines around the world by successfully hacking into a moving vehicle, and taking control of everything from the windshield wipers to the accelerator pedal. The potential consequences are as obvious as they can be deadly. Moreover, as cars become more connected and software-centric, the risk of such attacks increases significantly. That's because as the proportion of vehicle functions that rely on software to control them rises, so does the number of potential entry points for hackers. However, while these kind of 'in motion' attacks will grab most of the media attention when it comes to the security of connected and driverless cars, there are also many other potential risks to consider.

For example, criminals may attempt to hack into vehicles, not to control them, but to steal proprietary or sensitive data from manufacturers, application providers or corporate vehicle operators such as haulage and delivery vehicle drivers. This should provide serious food for thought for automotive OEMs, especially within the context of the 53% rise in annual industrial espionage cases reported by the FBI in July 2015.<sup>1</sup>

Another potentially damaging scenario involves the theft of personally identifiable data from individual vehicle owners or users. For instance, many drivers have their smart phones connected to in-car infotainment systems via Wi-Fi or Bluetooth connections. Increasingly, these devices are being used to make purchases and can therefore be a rich source of financial data such as credit card details. They also continuously transmit

location data, which could be used to prove or disprove a driver's movements and driving behavior by employers, insurance companies or private investigators. All of which creates significant data privacy issues that automotive OEMs need to be aware of, in order to protect themselves against litigation and damage to brand reputation. Moreover, regulations and attitudes to data privacy vary significantly between countries, adding another layer of complexity.

In the worst case scenario, the failure to deal effectively with these issues could reduce or even eliminate consumer demand for vehicles, applications or services that are viewed as insecure. The potential consequences range from missed sales targets, to the market failure of new services or models.

In an ideal world, all of these risks should be preempted through a comprehensive strategy for connected car security covering the entire vehicle lifecycle, from design and manufacturing, through sales, usage and eventual retirement. And so the question arises, what is the optimal approach to connected car security?

VMware's experience in and innovative approach to security in the data center, vehicle head unit and across wireless networks, positions it perfectly to answer that question for organizations across the connected car value chain.

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<sup>1</sup> FBI press briefing, July 2015

## KEEPING THE HACKERS OUT - FROM THREAT TO OPPORTUNITY

It's every driver's (and manufacturer's) worst nightmare – losing control of a vehicle and suffering damage or injury due to a mechanical failure. Fortunately, modern vehicles are so well built and reliable that these instances are rare. But what if an apparent failure was instigated and controlled deliberately from outside the car?

The recent 'in-motion' hack attack staged by two security experts in the US (see previous page) proved that such an attack is possible, although they had actually already achieved a similar feat two years previously. The difference between the two events? In 2013, they were sitting in the vehicle with a computer physically connected to the head unit. In 2015, they hacked into the head unit remotely by exploiting an open port available for connecting to a cellular network via an embedded SIM card. The potential consequences of such an attack in a real world scenario are clear – serious injury or worse for vehicle occupants, and a catastrophic effect on the vehicle vendor's reputation. This provides proof, if any were needed, of the potential dangers associated with increasingly software-driven vehicles. What's more, these kind of 'traditional' hack attacks are not the only threat.

For example, a research fellow at the University of Cork has demonstrated how, by combining a laser device (similar to that used in mass market laser pens) and a pulse generator that can be created on any computer, the lidar sensors guiding a driverless car can be fooled into seeing objects on the road that are not actually there. In the researcher's test, the car slowed down automatically to avoid hitting these phantom objects and, had enough of them been projected onto the road, the vehicle would have stopped completely.<sup>2</sup> Just like the first example, this kind of incident is a great headline maker. But hackers can also inflict damage in many other ways. Potential threats include:

- Vehicle theft or electronic damage/disablement
- Falsifying vehicle information such as mileage data
- Accessing personal information such as phone numbers, address books, credit card details, location information etc., all of which could potentially be misused either directly, or for blackmail purposes
- Intercepting voice or data communications
- Accessing proprietary manufacturer, service provider or app vendor data from vehicle head units

Automotive OEMs must give this issue a very high priority, because failing to address it effectively could have a significant impact on interest in and demand for connected cars, driverless cars and the benefits they bring. However, there is also a more positive angle for manufacturers to focus on.

Vendors that can solve the challenges of securing connected cars in a thorough and scalable way, have a potential speed-to-market advantage over their competitors. In addition, if they can prove the superiority of their security solutions, they will have a powerful differentiator that can help them gain customer trust and build market share.

VMware is a pioneer in the fields of containerization and micro-segmentation, both of which improve security by separating computing resources, networks and data, minimizing the potential impact of hack attacks. Not only that, VMware understands how to leverage this technology in the data center and in the vehicle, in order to give automotive OEMs a competitive advantage in the connected car era.

<sup>2</sup> Reported in IEEE Spectrum, September 2015





## BUILDING TRUST IN THE CONNECTED CAR

One of the biggest threats to the future success of connected and driverless cars is customer inertia and mistrust. Even 'digital natives' that generally care less about online privacy will think twice about taking advantage of connected car functionality, if they think it could put their personal information, or that of family and friends, at risk.

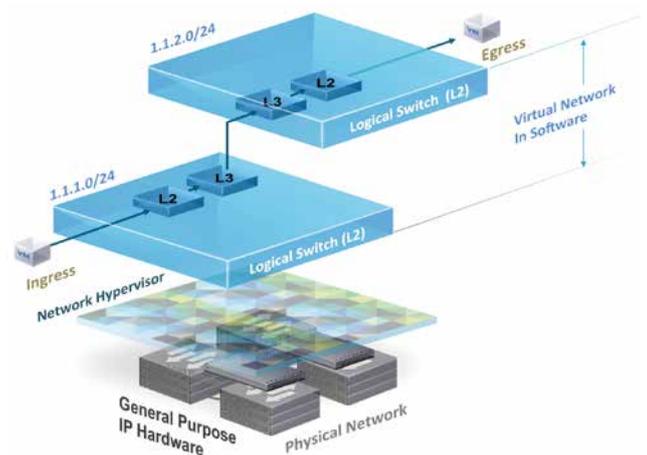
In this context, an important element in delivering a more personalized and connected automotive experience through new apps or services is ensuring that the personal data involved stays private. At the same time, manufacturers must also protect their own infrastructure and data from actions taken by customers or vehicle users. This could involve preventing drivers from using potentially insecure third-party applications within a secure vehicle software or network environment. But it could also be about preventing them from deliberately modifying a vehicle in ways that would invalidate warranties or insurance policies, or at least discovering they have done so, even if they have attempted to cover their tracks.

Finally, as car sharing increases, connected car manufacturers and fleet owners may want to be able to track driving behavior and journeys, and attribute them to specific individuals in the event of extreme driving behavior causing damage to a vehicle or otherwise invalidating a legal agreement.

It is clear that in the connected car era, every vendor in the value chain must perform a continuous and difficult balancing act between protecting customer privacy on the one hand, and ensuring the integrity and traceability of their own data and processes on the other. Finding that balance will be essential in ensuring disputes can be resolved and compliance obligations upheld, and a customizable approach to managing the type and frequency of data collected will be required. For example, some of the data needed for predictive analysis cannot be displayed or made available to third parties, in case it enables the unauthorized/illegal profiling of a driver's behavior.

AirWatch by VMware uses industry-standard algorithms and a strong privacy engine to enable the required customization of collected and stored data types in this scenario. Not only that, the head unit's IoT agent can store data in an encrypted container and transmit it to the data center over secure channels. Containerization, a technology well-established in the enterprise mobility management industry for the separation of corporate and private data, can also be used to address security and privacy challenges across the entire value chain.

VMware's NSX solution enables the three key functions of micro-segmentation: the isolation of networks, segmentation of communications, and support for multiple third-party security products. The same principles could potentially also be leveraged in the vehicle to provide even greater protection.



And, as a pioneer in micro-segmentation (see diagram), VMware can also ensure that if one vehicle application or system is compromised, other systems and services remain unaffected. All of which makes VMware the vendor best positioned to help manufacturers minimize the security risks and privacy/compliance issues that the connected car era will inevitably generate.

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## MANAGING THE 'DEVICE ON WHEELS'

Collecting and analyzing vehicle data as well as updating vehicle software have always been sporadic, slow, garage-based processes. In a world full of connected cars, they will be continuous and conducted in real time over-the-air.

Can you remember the last time you installed software using a CD? Do you still carry memory sticks or extra hard drives around with you to keep your data synced and up to date? If not, it's a sign of the times – because to all intents and purposes, the days of updating computers using physical media are over.

Today, applications, configuration changes and updates are now simply downloaded from central servers, and data is synchronized via the cloud. When it comes to mobile devices, updates and applications are delivered directly 'over-the-air' on demand, or sometimes automatically without the user even being aware of the process. And, in the coming years, exactly the same principles will apply to connected cars.

This new reality will have a transformative effect on how vehicle data is collected, analyzed and used. For example, instead of vehicle information only being available during service inspections, a constant stream of data will pass between drivers, vehicles, and manufacturers via wireless connections. In other words, the car will essentially become a 'device on wheels'. As a result,

car diagnostics will be transformed from a stop/start process that takes place over months and years, to a continuous one that happens in real time.

In addition, new process mechanisms and business opportunities will be created, enabled by over-the-air data and content provisioning. These will include:

- Remote firmware upgrades
- Remote command and control
- Apps, content and user profile deployment
- Post-sales car customization and self-service

By deploying market leading technologies in VMware's Pulse™ IoT Center it is perfectly positioned to manage the secure collection, analysis, management and delivery of the data being transmitted between drivers, vehicle head units and vendors in the 'device on wheels' era. In other words, VMware is a key enabler of the automotive future, in which vehicles will become continuously updateable and personalized conduits for increasingly mobile lifestyles.

## DIAGNOSTICS ON-THE-MOVE

Getting faster access to more detailed car diagnostic data is a key challenge for automotive manufacturers. This data is usually only accessible when the car is being physically serviced at the garage. This means that data collection points are often separated by a year or more. In addition, the process of manually collecting, analyzing and using the data is anything but efficient.

First, an engineer must physically connect a computer to the vehicle's OBD II port to download the relevant information from various sensors and ECUs. The information must then be interpreted and decisions made about how best to use it to optimize the customer experience, and maximize revenue for the garage or dealership. Not only is this inefficient, preventable hardware and software problems cannot be proactively identified and fixed. As a result, the risks of recalls, warranty cases, and lower customer satisfaction and loyalty increase. In the connected car era, these issues will disappear. But the road to this bright future is littered with challenges. For example, there are no common industry end-to-end solutions for remotely collecting



data from vehicles, and there is little or no cooperation between vendors within the value chain to create standards and integrate systems. That's why AirWatch by VMware is such a potentially crucial solution for automotive manufacturers. It uses an agent to collect customizable sets of data from vehicle head units running, and transmits them securely over-the-air in real time. Vehicle data can then be processed in the back end, ideally in a cloud environment, so the data storage and processing is scalable as the volume and variety of data collected increases.

Not only can this approach help manufacturers proactively identify existing or potential future problems with a vehicle, it also opens the door to resolving them remotely over-the-air. This is a truly revolutionary prospect, which will lower costs and risk for manufacturers, and improve service quality for drivers, with a positive knock-on impact on customer satisfaction and loyalty.

## THE END OF MANUAL UPDATES?

Just like a wide range of modern electronic devices, vehicle head units require regular firmware updates. The delivery of these updates over-the-air gives customers instant access to the benefits without the inconvenience of a workshop visit.

VMware's Pulse™ IoT Center in combination with partner solutions has the technology to enable this by deploying 'products' (sets of files, actions, conditions, assignments, deployment options and dependencies) that allow the remote provisioning of software updates. These packages can be standardized centrally according to vehicle model, year of construction, equipment levels, etc., making the update process much more scalable and efficient. Products are provisioned in a distributed way through a network of relay servers to avoid undesirable congestion and latency. And, in addition to larger updates for head units, micro-updates can also be pushed to individual ECUs to fix specific local issues. This helps avoid the need for expensive vehicle recalls that can also have a potentially damaging effect on brand image, customer satisfaction and loyalty.



### Giving customers control

Over-the-air vehicle management is not just about maintenance; it is also about putting more control in the hands of customers. From remote locking to car location tools, over-the-air features allow drivers to improve the user experience in many different ways.

Enabling this requires ever-deeper integration of multiple in-car and back-end systems. VMware's Pulse™ IoT Center uses remote software provisioning, supported by a software-defined data center, to accelerate this integration by streamlining and automating the relevant processes.



## PROFILE ROAMING FOR THE VEHICLE SHARING FUTURE

Adapting cars to individual drivers used to be about moving the seat or the steering wheel. Today, high-performance cars have settings that can change engine behavior and vehicle dynamics to suit individual driving styles. But the next revolution is on the way.

Over-the-air updates provide many new opportunities for adapting aspects of the driving experience remotely. For example, customers could limit the amount of engine



power available when an inexperienced driver is at the wheel, or automatically activate a specific set of apps or entertainment options when a particular driver 'signs in' to the car. Moreover, the shift away from traditional models of vehicle ownership towards car sharing will make this capability increasingly important.

Increasingly, drivers will demand roaming profiles that can be activated in multiple vehicles, regardless of who owns them. As well as improving the user experience and satisfaction levels, this may have additional benefits such as reducing accidents, because drivers will immediately feel comfortable in unfamiliar vehicles. Roaming profiles will also allow separate collection and distribution of data according to the individual driver, or between 'business' and 'personal' driving modes. This will have significant implications in terms of vehicle insurance and may also influence driver behavior in specific circumstances.

The software provisioning capabilities within VMware's Pulse™ IoT Center solution are key enablers of this new functionality, and the new business models that can be derived from it.

## POWERING THE NEW ERA OF CONNECTED CUSTOMIZATION

Despite the availability of hundreds of configuration options when buying a new car, many of them are hard-wired into the vehicle's structure. This is expensive for manufacturers, because it increases complexity and cost on the production line. But it's also limiting for customers, because many of these features are impossible or difficult, time-consuming and expensive to change.

As vehicles become increasingly defined by software, everything from engine performance to in-car entertainment will become easy to modify frequently and almost in real-time. This kind of post-production optimization opens up new business models and revenue streams for manufacturers and third-parties. And for consumers, it creates a new world of possibilities for matching the vehicle experience to their personality, driving style, or even their mood on any given journey. Examples include the delivery of entirely new features or applications, such as pay-as you go access to reports on driving behavior



and real-time tips on how to improve efficiency, or access to more horsepower on demand. The over-the-air provisioning capabilities of VMware's Pulse™ IoT Center will play a key role in enabling people to shape their driving experiences dynamically.

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Freisinger Str. 3  
85716 Unterschleißheim

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## WINNING THE RACE TO THE DATA-DRIVEN FUTURE

From proactive remote maintenance, to the mass-market adoption of driverless vehicles, data is at the heart of the coming connected car revolution.

Connected Cars are on the rise, and Gartner predicts that the number of connected vehicles worldwide will reach 250 million by 2020. The more connected and software-centric these vehicles become, the greater the volume and complexity of data that must be collected, analyzed and leveraged by automotive OEMs to generate revenue, loyalty and brand capital.

Today, manufacturers do not have the infrastructure in place to cope with the volume and variety of data that will be generated by the mass-market adoption of connected cars. And so in the short term, they may require assistance from third-party suppliers that do have the scalable computing resources and know-how to collect and analyze the rising tide of vehicle data. However, in the longer term, it makes sense for manufacturers to control as much of this data collection and analysis as possible, in order to extract and own the value that it produces.

For example, access to a continuous stream of connected car data will help manufacturers improve overall customer satisfaction by enabling a more proactive approach to resolving technical vehicle problems. There will also be an opportunity for manufacturers to: sell certain types of data (such as weather or traffic information) to third party organizations; cross- and up-sell services to vehicle owners and drivers; and evolve the vehicle-as-a-service business model, from people collecting and dropping off vehicles, to vehicles collecting and dropping off people. All of which will help manufacturers offset declines in revenue from traditional

car sales, as people begin to see vehicles more as a utility than as a status symbol.

Ultimately, data will become the lifeblood of the automated automotive future, in which the data-centric services that define the user experience in the vehicle, from automatic route optimization to immersive entertainment, will become more important than the vehicles themselves.

VMware's Pulse™ IoT Center consists of 3 core components that give automotive OEMs the IT platform they need to maximize these opportunities, by making vehicles an integral part of the Internet of Things:

1. A scalable, highly resilient and available infrastructure based on a VMware software-defined data center and public cloud platforms like IBM Softlayer or AWS.
2. A cloud-based data management suite that enables the client collection and analysis of telemetric data in near time, and the communication of commands and alerts based on the results
3. Intelligent device agents that aggregates data from sensors and executes actions within the vehicle, based on commands from the management suite

These capabilities put VMware in a unique position to support the success of automotive OEMs in the data-driven vehicle era.

## SCALING UP FOR A CONNECTED FUTURE



If we assume Gartner's prediction of 250 million connected cars by 2020 to be fairly accurate, automotive OEMs face a huge challenge in dealing with the surge in data volumes created by this growth. With a relatively small number of connected cars on the road collecting and transmitting data from a small number of vehicle systems, types and volumes of data are fairly predictable. But as the number of connected vehicles and the pervasiveness of software inside them increases, data volume and complexity increases dramatically. As a result, the scalability of the

infrastructure supporting the collection, storage and analysis of this data will become a key success factor for manufacturers.

Today, few manufacturers have the required infrastructure to cope with connected cars generating data at scale. But in the long-term, maximum growth and profitability will depend on controlling as much value as possible, in order to make the most of the business opportunities that huge volumes of rich vehicle data create.

Building the infrastructure to support these opportunities efficiently will depend on the smart interplay of scalable cloud computing resources, and striking a balance between analyzing data in the cloud and in the vehicle. It will also require intelligent management of data transmission in order to use network resources efficiently. This could mean, for example, storing data in the vehicle when no data connection is available, and transferring it when back in range, when the car is stationary for a long period, or at defined intervals.

VMware is a pioneer in cloud computing and over-the-air management, and has the expertise and vision to leverage this technology in the data center and in the connected vehicle, in order to give automotive OEMs a competitive advantage.

## PARTNERING FOR QUICK WINS

Realistically, it will take time for vehicle manufacturers to build the infrastructure and capabilities they need to make the most of connected car data. In the short term, there is an opportunity to work with 3rd-party businesses such as telecoms or automotive component firms that have established cloud-based big data infrastructures, and may have greater expertise in managing, analyzing and extracting insights from large volumes of customer data.

Partnering with these companies will give vehicle manufacturers fast access to the capacity and capabilities they need to get to market quickly with new services. But it will also provide a great learning opportunity that will help them shape their own data infrastructure, should they wish to own and operate it themselves in the future.

VMware has the cloud platform, data management solutions and automotive expertise to provide a technology bridge between automotive OEMs and their suppliers, enabling them to create maximum value for themselves and vehicle users.



# THE PROACTIVE PATH TO HAPPIER CUSTOMERS

Today, relationships between vehicle manufacturers and customers are still primarily reactive. Servicing and sales appointments are usually initiated by the vehicle user, and require a physical vehicle inspection or sales meeting at a dealership. The connected car era will turn this situation on its head.

Let's take maintenance and repair as an example. Connected cars will feed a continuous stream of data to manufacturers, enabling ongoing assessment of the condition of every in-vehicle system. At the same time, intelligence built into the vehicle head unit or the cloud will enable one system to react to data produced by another. So, if a potentially hazardous issue, such as excessive brake wear, is detected, the vehicle systems could work together to inform the driver and automatically book a repair appointment at a convenient location, whether the user is at home, on holiday, or on a business trip. With the right analytics tools, manufacturers will also be able to spot patterns in

the data streams they receive. So, if a large proportion of vehicles of a particular model report the same issue in a short space of time, it will become clear that a recall may be needed. This will enable the manufacturer to start and complete the recall more quickly, and make changes to production processes so that the issue does not recur in vehicles currently on the production line. The same concept can also be applied to new vehicle development, by giving test cars to selected customers pre-launch, in order to uncover any issues that weren't identified through internal testing processes.

Faster resolution of issues, and the prevention of them for future customers, will contribute to higher overall customer satisfaction and loyalty. VMware is the ideal vendor to support vehicle manufacturers with an intelligent, scalable infrastructure that will empower them to make the service experience more proactive.

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## DATA AND THE DRIVERLESS FUTURE

Today, many households own or have access to multiple vehicles that spend most of their time either standing idle or operating below their capacity. Large areas of land in towns and cities are given over to parking. And governments often respond to more cars and growing congestion either by building more roads and more parking, which takes up even more land, or by pushing people towards public transport, which is often expensive, overcrowded, and unreliable. One exciting potential alternative is the multi-user driverless car.

Sometime in the next few decades, fully autonomous vehicles will be programmed by users to continuously pick up and drop off passengers from within a family, company or other user group from anywhere. MIT has estimated that this scenario could meet everyone's personal transport needs with 80% fewer vehicles. Not only that, each user will be able to adapt their experience according to personal preferences, in everything from the route taken, to in-vehicle entertainment. The societal implications are significant and include: the virtual elimination of congestion and improved safety through fewer cars, more efficient routing, and fewer accidents; the reuse of land used for parking for more creative commercial or recreational purposes; and a significant reduction in the environmental impact of personal



transport, from improved air quality to lower consumption of natural resources.

If this vision becomes reality, automotive manufacturers will need to transform their business models from vehicle engineering, manufacturing and sales, to the provision of personal transport services on a pay-per-use basis. In this scenario, the ability to collect, manage, analyze and utilize data effectively to provide the most efficient, effective and personalized services will be the difference between success and failure.

VMware has the big data infrastructure, secure over-the-air data and software solutions, and in-vehicle technologies to help vendors reinvent their businesses.

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### Matthias Schorer

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[mschorer@vmware.com](mailto:mschorer@vmware.com)

Tel. +49 89 / 3706 17108

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**vmware®**

VMware Global, Inc.  
Zweigniederlassung Deutschland

Freisinger Str. 3  
85716 Unterschleißheim

[www.vmware.com/de](http://www.vmware.com/de)



## CONNECTED CAR BUSINESS MODELS - DISRUPT OR BE DISRUPTED

Successful connected car business models will put the focus on the user, not the vehicle. Automotive OEMs urgently need good answers to the challenges involved.

As the connected car market evolves, all the businesses in the value chain will increasingly put the user, not the vehicle, at the center of their efforts. This user-oriented approach is what has made B2C technology companies like Apple so successful. And, as vehicles essentially become 'devices on wheels', automotive manufacturers need to start thinking like them.

After Apple launched the iPod in 2001, it quickly became clear that the value for the user actually lay in the service delivered by iTunes, rather than the device itself. Over time, the same principle will apply to the connected car: Users will start to value what they can do in and with the car, more than the car itself. However, reinventing automotive OEMs to become service providers, rather than manufacturers, presents challenges in three dimensions.

**1. Agility:** The life cycle of a modern car from its first conception to its recycling is around 15 years. Pre-launch development takes about five years, which also means that any new car bought today actually contains five-year old technology. Services have lifecycles that are measured in months and weeks.

**2. Complexity:** Vehicle production, especially in terms of electronic systems, has become increasingly complex, with every car containing hundreds of sensors and multiple systems for data collection, management and distribution. Delivering a broader range of digital services to customers implies the need for an even greater level of complexity.

**3. Diversity:** Although it's changing rapidly, automotive OEMs are still engineering and manufacturing firms at heart. They simply don't have the breadth and depth of competence, talent and infrastructure in-house to make a success of everything from infotainment systems to autonomous vehicle services, without external assistance.

In this context, it's clear that building a successful connected car business model will be dependent on establishing the right partnerships across the value chain – and especially in IT.

VMware, together with Dell Technologies is in a unique position to assist automotive OEMs in bringing their strategies to life through, for example, flexible, agile and customer-oriented application development, and the scalable infrastructure platform needed to build and support a broad range of new services. In addition, VMware delivers an IoT platform to broadly manage, monitor and secure all edge systems related to connected vehicle, as well as providing third party tools integration that enables vendors to adjust services and vehicle processes based on predictive analytics. Finally, VMware offers the uniquely dynamic computing infrastructure in the cloud, in the data center and in the vehicle to connect all the relevant systems together securely and reliably. This means VMware is well positioned to help automotive manufacturers succeed in the rapidly evolving connected car and autonomous vehicle era.



## USERS COME FIRST

At the 2015 Frankfurt Motor Show, many commentators noted that automotive OEMs attending the event were positioning themselves as technology companies that happen to make cars, rather than as manufacturers adding technology to vehicles. While the reality may not yet live up to the hype, it is a watershed moment for the industry. It marks the acceleration of the journey towards a future in which vehicles will become mobile and automated extensions of users' living and working environments.

This vision may still take many years to penetrate the mass market, but the first steps have already been taken. Several manufacturers already have vehicles on sale that have park pilots, keep lanes and brake automatically to avoid an accident. And extensive self-driving vehicle tests covering hundreds of millions of kilometers have already been completed by most automotive OEMs and a wide range of tier 1 suppliers. Moreover, potential profitability of in-car online systems is beginning to rise as their popularity increases. This is backed up by a recent PWC survey which revealed that more than 85 percent of Chinese customers in the volume segment would be willing to switch to a different brand of car if it offered more connected features at a reasonable price.\* All of which increases the pressure on brand owners to take their visions of connected and automated vehicles out of the motor show spotlight and testing programs, and into the showrooms.

To succeed, automotive OEMs will have to sharpen their focus on what the user wants to do, rather than what the device (i.e. the vehicle) traditionally allows. And personalization will be key. Today, vehicle customization is mostly about users adapting vehicles through options lists and after-market components. In the future, it will be about multi-user vehicles adapting to individuals by varying the software-based services that are delivered to them

in the car, from entertainment to information, mobility, security and beyond.

As far as today's new vehicle sales are concerned, connectivity options are just more boxes to be ticked on an order form. In the future, vendors will generate revenues through a continuous cross-selling and upselling process across multiple shared vehicles over the user's lifetime, regardless of who owns the car. It's the only way they will be able to retain ownership of the customer, and protect and grow their market share.

VMware together with Dell Technologies and partners delivers the IoT Management platform, back-end infrastructure, app development platforms, in-vehicle intelligence, and secure networking to enable the continuous collection, delivery and analysis of data required to support this new user- and service-oriented future.



\* <http://www.strategyand.pwc.com/reports/connected-car-2016-study>

# B2B SERVICES - THE HIDDEN CONNECTED CAR OPPORTUNITY

Vehicle manufacturers have focused on B2C applications and services in their initial connected car and autonomous driving investments. It's where the volume and the headlines are. However, while it doesn't attract as much attention, selling connected car data to other businesses undoubtedly presents automotive OEMs with new opportunities. And, despite the inevitable data usage and consumer privacy issues, there is no shortage of companies eager to utilize vehicle and user data to generate new revenue streams.

Establishing trusted partnerships with different types of businesses will be essential. In some cases, this will be straightforward because the relationships already exist - rental companies, franchised vehicle dealerships and vehicle fleet owners are prime examples. Others will take longer to build and are likely to involve a significant amount of trial and error before a mutually beneficial formula for generating revenue is identified. The key opportunities include:

**Franchised dealerships:** Connected car data offers dealerships the opportunity to monitor vehicle components in order to detect potential or actual mechanical problems. Different levels of service could be offered to customers who prefer to address problems earlier, and those who want maximum return on their investment e.g. waiting until tread depth is almost illegal before replacing a tire. Offering regular over-the-air software updates for navigation and other in-car systems will also become increasingly attractive.

**Independent repair & maintenance workshops:** By broadening access to maintenance-relevant data to non-franchised workshops, OEMs could also start selling branded parts directly to smaller businesses that wouldn't usually deal directly with manufacturers.



**Insurance companies:** Insurance providers have already begun to offer dynamic, usage-based premiums. Increasingly, they will want direct access to vehicle data for risk- and premium-assessment purposes.

**Advertising firms:** Advertising companies could utilize app and service usage data and combine it with route information, to deliver location-based ads either to the car, or to roadside billboards, based on the profiles of individual drivers.

**Retailers:** For retailers, the ability to connect purchasing behavior with specific driving routes or destinations would enable them to deliver e-coupons to vehicles whenever they are in the vicinity of a specific store.

**Vehicle fleet owners:** Owners of vehicle fleets such as large enterprises or haulage firms will value the opportunity to monitor vehicle condition and driving patterns. It could also help them track performance against, for example, delivery time, fuel efficiency or emissions targets.

**Car park companies:** Car park facility owners could use vehicle data to let drivers know in real time about vacant spaces that match their current journey profile.

VMware has the secure networking and cloud computing technologies to enable the collection, transmission and analysis of the data that will power all of these business opportunities. Moreover, VMware uses its pioneering containerization and segmentation technologies to enable automotive OEMs to treat different types of data in different ways, so as to maximize its value while still protecting user privacy and ensuring regulatory compliance.



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VMware Global, Inc.  
Zweigniederlassung Deutschland

Freisinger Str. 3  
85716 Unterschleißheim

[www.vmware.com/de](http://www.vmware.com/de)