What's Driving the Connected Car?

Introduction

Although science fiction has long predicted sentient, communicative and self-driving vehicles, the "connected car" as a concept—and a phrase—is relatively new. Indeed, it first started appearing among Google search queries in 2007. Now the business, technology and automotive trade media are using the phrase literally every day.

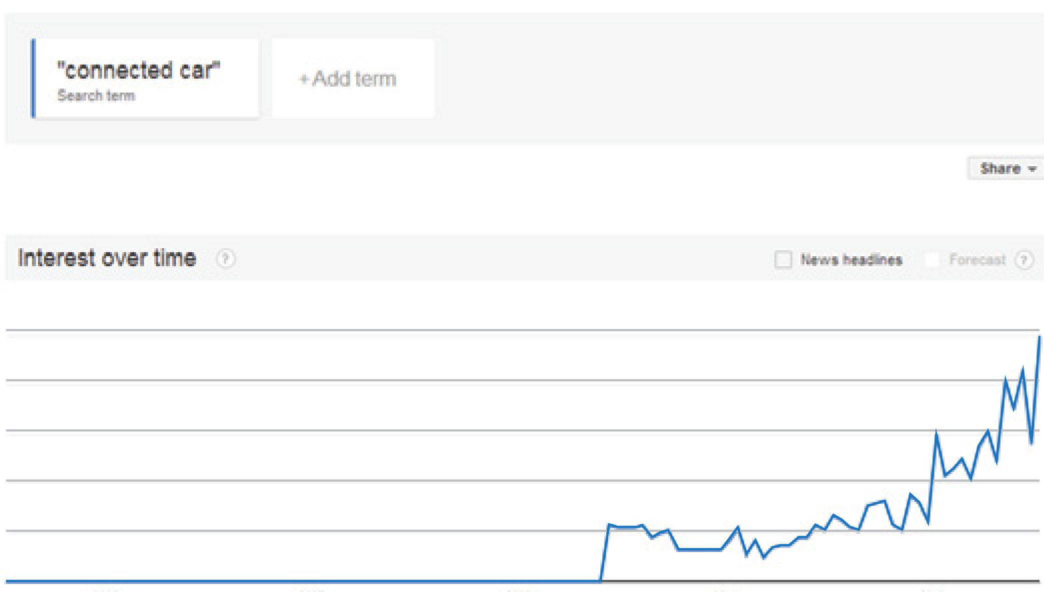

Figure 1: Google search volumes for the term 'connected car' since 2005 (source: Google Trends).

The growth looks set to continue. In 2012, a paper from mobile industry analysts Juniper Research predicted more than 92 million cars would have internet access by 2016.

But where is the connected car going? And is it any more than a technological fad?

In this white paper, Spirent outlines the industry's progress to date, likely next steps, and potential challenges, opportunities and pitfalls automotive research engineers will need to address as development continues.

The Evolution of Automotive Connectivity

Already, vehicles are extremely well connected, with extensive internal networks using an array of protocols to deliver key electronic, monitoring and diagnostic functions.

CAN (Controller Area Network) bus use remains particularly widespread, despite its speed and load limitations, while LIN (Local Interconnect Network) provides a low-cost solution for vehicle body applications, MOST (Media Oriented Systems Transport) fibers deliver in-vehicle media, and high-speed FlexRay enables "x-by-wire" capabilities, such as brake-by-wire, along with other functions where speed and reliability are paramount.

The growing use of automotive Ethernet adds to a complicated hybrid network in most new cars. Naturally, network bandwidth and connectivity go hand-in hand: when people talk about the "connected car", the implication is more about communication outside the vehicle. And here the pace of change is, if anything, faster still.

Until recently, most communication was exclusively one-way: from the infrastructure to the vehicle, otherwise known as X2Car. Global navigation satellite systems (GNSS) and other positioning signals would provide navigation and telematics; Bluetooth would enable hands-free telephone use and media; traffic information would arrive over radio frequencies, via RDS.

Now, however, such channels are increasingly being complemented by Car2X, where the car communicates with its environment, and indeed by two-way exchanges of information with other vehicles (Car2Car).

In Europe, the eCall system—enabling a car to respond to a crash by contacting the emergency services and wirelessly send airbag and impact sensor information, along with satellite positioning co-ordinates—is now being rolled out. Similar capabilities exist in North America, with GM's Onstar Service, while Russia's ERA-GLONASS system is said to be fully interoperable with eCall.

Meanwhile, a 1,100-kilometer Co-operative Intelligent Transport Systems (C-ITS) corridor is in development, connecting Rotterdam, Frankfurt and Vienna. This zone, facilitating two-way communication between vehicles and the surrounding road infrastructure, will roll out slowly over many years, to avoid overwhelming drivers: from simple warnings—such as advanced notice of road works—with anonymized data gathering for road operators from launch, through sensor fusion to more advanced assisted driving services in future.[1]

The Next Five Years

Since OABR (OPEN Alliance 100Mbps BroadR-Reach®) established an open, de facto standard for automotive Ethernet, it looks set to underpin significant further growth in vehicle connectivity, as new functionality pushes in-car bandwidth requirements to unprecedented levels.

In 2012, BMW revealed that new vehicles offering all-round camera coverage achieved dramatic cabling cost reductions over previous models by switching to OABR Ethernet.[2] The same company predicts further development, with Ethernet taking a greater share of the load for infotainment and the increasing number of Driver Assistance Systems (DAS).

Clearly, after significant investment, legacy in-vehicle bus systems will remain in situ for some time to come. Nonetheless, BMW's expectation is that Ethernet will continue to grow—becoming mainstream in 2015, and the mainstay of in-vehicle communication by 2018: effectively acting as a backbone for localized CAN, LIN FlexRay and other systems.

New York-based market intelligence firm ABI Research agrees, predicting Ethernet penetration in new cars worldwide to grow from 1% in 2014 to 40% by 2020.[3]

Arrangements for providing vehicular internet connectivity are likely to see an even greater change.

Currently, major manufacturers offering vehicle connectivity tend to route any internet connection via a secure Virtual Private Network (VPN) tunnel to a static base. As the technology becomes more mainstream, however, spiraling demands upon limited bandwidth mean such arrangements will cease to be practical. Within a matter of years, we believe it will become the norm for vehicles to have their own, direct connection to the internet—with all the opportunities and security challenges this implies.

One potential solution might involve the mobile cloud-based platform being developed by Continental and IBM, following an announcement[4] at last year's Frankfurt IAA International Motor Show. The two corporations are working together to develop new automotive connectivity technologies, including routes for OEMs to perform software updates remotely.

Future Functionality

Manufacturers, technology providers and observers predict the coming years will see vehicles making increasing use of connectivity to become more closely integrated with their surroundings, and make life safer and more convenient for motorists. Future capabilities are likely to include:

Integration with Home Networks. It is widely predicted that vehicles will increasingly be able to notify buildings of their approach, perhaps switching on lights, heating or air conditioning systems. However, Volkswagen[5] also believes it will be important for homes to exchange information with the vehicle while it is parked outside; transferring downloaded music, media and journey plans, while checking vehicle's status—for example, temperature or oil level—mileage information and journey statistics.

Data Exchange with Insurers, Manufacturers and Third-Parties. Currently, telematics systems—such as those used by insurers—tend to store information within the vehicle itself: the so-called "black box".[6] Two-way communication will enable insurers to review usage remotely in real time, manufacturers to monitor and refine performance, and third-party subscription services to record and analyze telemetry and travel patterns.

Diagnostics and Vehicle Health Reports. Connected cars will be able to contact mechanics and garages directly with diagnostics issues, keeping performance parameters under review, and informing the driver earlier at any sign of trouble.

Improved Navigation and Positioning. Where satellite reception is poor—whether in urban canyons, under heavy tree cover or in tunnels and car parks—availability of Wi-Fi positioning will enable the vehicle to understand its exact position with dramatically greater certainty and precision. (For more detail on hybrid and Wi-Fi positioning, read Spirent's Hybrid Positioning ebook.)

In-Vehicle Wi-Fi Hotspot. Whether supplied by the manufacturer or retrofitted, systems are already available to provide local Wi-Fi for passengers' own handheld and wireless devices—some using the vehicle's own internet connection.[7] As brands compete as seek to differentiate themselves, it seems likely that such features could become increasingly standardized.

Social Media Tie-ins. The automotive industry has already found considerable success in using social media marketing to drive brand engagement and sell cars.[8] However, the development of the car into a location-aware, internet-connected device opens new possibilities, from simple automated check-ins and status updates to positioning-based engagement with nearby service providers.

Payment Integration. With the right account setup, cars with wireless connectivity will be able to pay automatically for incidental, driving-related costs such as road tolls, parking and, potentially, fuel.

Streaming of Music and Video on Demand. Subject to bandwidth, in-car entertainment will no longer be governed by physical discs and even mp3 players. As at home, libraries of streaming, on-demand media will give drivers and passengers virtually instant access to countless songs, movies, TV shows and games.

Localized Information and Advertising. There is the potential for motorists to benefit from relevant, highly localized information, warnings and offers; from improved weather and traffic reports to short term discounts at nearby outlets, fuel price information and parking availability.

Police Warnings and Location. To improve safety, vehicle connectivity could enable Police and other authorities to issue targeted warnings—whether based upon a defined location or direct to individual vehicles—while also empowering them to locate a connected car for security or recovery reasons.

Car-to-Car Gaming. With cars able to communicate wirelessly with each other, the lure of passengers challenging each other to live gaming on their mobile devices could become reality.

Real-Time Traffic and Incident Alerts. Cars will be increasingly warned of traffic and incidents ahead, prompting them to slow down or change lanes or route, and adjusting journey time predictions as appropriate. As this becomes more sophisticated, signals from other cars already in traffic will begin inform in-vehicle navigation systems in real time, from average speeds and journey times to, potentially, activation signals from windscreen wipers and headlights.

Assisted and Automated Driving. Naturally, the vehicle's evolving ability to aggregate, interpret and share information will continue to provide new ways of making the process driving safer, easier and more comfortable. Communication between vehicles will enable traffic to flow more easily through junctions, and for cars to maintain safer braking distances when traffic ahead slows down. Ultimately, with 95% of road accidents still attributable to human error, the self-driving, autonomous car could be reach the mainstream in the relatively near future: autonomous vehicles are already legal in four American states.

The Argument Against

It would be inaccurate to suggest that the rise of the connected car is universally welcomed. A number of counter-arguments exist, including:

Preference for Simplicity. Some motorists claim that vehicles are becoming too complicated, and that this—or information overload from infotainment systems—reduces the inherent pleasure of driving. In his article "Down With the Connected Car!", Anton Wahlman argues for the preservation of choice, retaining the ability to choose disconnected cars, or to disconnect vehicles at will.

Potential for Distraction. Concerns over the possibility that new infotainment features will distract drivers have proven sufficient for US Transportation Secretary Ray LaHood to issue guidelines encouraging manufacturers to limit distraction risk from electronic devices. Meanwhile, award-winning movie director Werner Herzog has worked with AT&T to produce a graphic, 34-minute film warning drivers of the dangers involved.[9]

Software and Hardware Upgrades. The rapid pace of development in consumer mobile technology, and the high rate of turnover in operating systems and hardware, are fierce. The iPhone took less than seven years to reach its versions 5S and 5C. As a result, it is understandable if users were concerned that connected vehicles would require frequent software patches which might, in turn, need on-board computer upgrades to keep them safe, reliable and up-to-date.

Opposition to Driver Assistance. As the level of automation in driving grows, so does public distrust. As a 2011 TV advert for the Dodge Charger put it: "Hands-free driving, cars that park themselves, an unmanned car driven by a search-engine company? We've seen that movie. It ends with robots harvesting our bodies for energy." Others simply enjoy driving, or trust their own abilities above those of a computer, regardless of statistical evidence.

Infringement upon Civil Liberties. Some campaigners are concerned that the ability to track the location of a vehicle at any time—and potentially even to remotely disable or impair certain functions—is an infringement upon the civil liberties of the motorist. Even Connected Car specialist IMS admits: "We have mixed feelings about our car giving information about our driving practices to third parties. Especially when our car is Internet connected and boiling over with recorded data on our driving habits, we want to know exactly where this information is going and exactly what it's being used for."[10]

Duplication of Smartphone Functions. Handheld mobile devices continue to evolve rapidly, and it could be argued that direct connectivity in vehicles will always lag behind smartphones and tablets in terms of technical capabilities, intuitive usability and integration into daily life. Again, in his article, Anton Walman compares the multi-year development lead time for new automotive features with the rapid version iteration in mobile telephones.

Security Concerns. Finally, the industry will need to work especially hard to prove that security is watertight—both from the point of view of the systems' technologies, and in protecting sensitive data against hacking and unwarranted surveillance. In January 2014, US Senator Al Franken asked Ford to explain how it collects data from vehicle owners and what it does with the information, having proposed a bill to regulate the collection of location data.

Clearly, it would be prudent of the automotive industry as a whole to acknowledge the concerns of legislators, media and the public at large—clarifying the facts where appropriate, and visibly demonstrating robustness and reliability—in order to clearly win the moral argument, and prevent unnecessary barriers to adoption.

Concrete Benefits: Automotive Ethernet

Certain benefits of advancing in-car communications technology are indisputable and available now: most notably the potential for single, unshielded twisted pair automotive Ethernet cable to replace conventional wiring.

High copper prices in recent years have made the wiring loom a significant cost component in the manufacture of any car. With Reuters estimating further, gains over the next ten years, this situation looks unlikely to reverse in the foreseeable future,[11] meaning manufacturers who shift to 2-wire automotive Ethernet will gain a natural competitive advantage.

Perhaps more importantly, 2-wire automotive Ethernet will reduce the weight of the wiring loom by as much as 30%.[12] A vehicle's combined wiring is among its heaviest components, so extending automotive Ethernet use offers immediate and significant weight savings, in turn improving performance and fuel economy, and minimizing environmental impacts. Broadcom, for example, has estimated that replacing copper wiring with automotive Ethernet can shave 100 pounds from a car's weight.[13]

Smartphone Integration

For some time, there has been disagreement over whether automotive manufacturers would be better served in duplicating and attempting to supersede smartphone technology, or in simply making use of the advanced and increasing technical capabilities of personal mobile devices by integrating them more closely into in-vehicle systems. A recent report[14] predicted half of all car infotainment systems would run Apple's iOS in the Car by 2018.

In 2013, GM chief technical officer Tim Nixon admitted[15] to seeing his two sons taking the "suction-cup approach" to in-vehicle navigation: attaching smartphones to the windscreen and using a free app, in preference to a costly embedded system. As a result, GM has moved to offer a $50 smartphone application of its own, to link the vehicle to a handheld device.

The discussion has been extended by the sudden and decisive switch in consumer focus from after-market satellite navigation systems to smartphone-based applications. In 2012 alone, a 15% global decline in sales of personal navigation devices coincided with a 42% growth in the number of subscribers to turn-by-turn mobile navigation apps.

However, vehicle positioning is quickly becoming increasingly sophisticated. Multiple satellite signals are blended with cellular-based network positioning and an array of high-quality sensory data. In addition, supplementary signals like Wi-Fi will soon be included to give high-accuracy, high-availability results even where satellite coverage is unavailable. As increasing sources of information are added to the mix, a significant review of testing standards for in-vehicle systems will be required to ensure they are blended accurately, and that any spurious positions are recognized and discounted from the overall result.

When such advanced hybrid positioning becomes more widespread, and used for a growing number of assisted driving and for other safety-critical systems, smartphones' heavy reliance upon GNSS will make them unsuitable. While high-end OEMs will continue to offer fully integrated in-vehicle systems, those manufacturers who do choose to integrate handheld mobile device navigation may consider it more effective to enable smartphones to use the car's positioning readings, rather than the other way around.

In either case, the connected car will quickly have positioning and navigation abilities far in excess of even the most highly specified handheld consumer device.

Potential Vulnerabilities

Among other concerns, the automotive industry would be particularly well advised to consider the potential impact of accidental and deliberate interference upon any future connected car networks.

Currently, all existing models for C2C and C2X communication rely heavily upon accurate GNSS clock readings to establish an accepted common framework for time. A prolonged denial of this signal—whether through accidental interference or a deliberate jamming attack—would effectively render such networks inoperable.

Satellite signal jammers are widely available for as little as £150, and although they are most commonly used by drivers attempting to disguise the location of a single car, their disruptive influence can also affect the wider surrounding area.

Worse, the reliance upon satellite time also opens future networks to the possibility of deliberate spoofing. In June 2013, students from the University of Texas successfully used equipment costing under £2,000, and the size of a briefcase, to significantly alter the course of a super yacht worth £50 million.

Were safety-critical automotive systems to be fed an incorrect clock reading, even altering the time by a minute or less, the results could potentially be catastrophic. It is therefore essential that as development continues, the industry builds in a degree of resistance to interference, along with failsafe systems to enable a vehicle to check and recognize when jamming or spoofing has occurred.

Meanwhile, more widespread use of automotive Ethernet could, in theory, increase the potential for hacking through a maintenance interface or in-car Wi-Fi hotspot. Although current systems, notably CAN, can theoretically be hacked, in reality the expertise and equipment required are so specialized as to render this a very remote possibility. Ethernet, however, is a far more common technology, and hacking tools downloaded from the Internet run on standard laptops and PCs. The new systems therefore require thorough security, and rigorous testing.

The Necessity of Testing

The use of Ethernet for the in-car network is new to the automotive industry, so testing and validating the technology to ensure that it works properly is a new process for that vertical even though Ethernet has been an established IT technology for decades. Synchronization is particularly important for the in-vehicle network so that it works essentially in real-time, as well as making sure data is not lost as electrical control units communicate with each other. Lost or delayed radar information from the advanced driver assistance system, for instance, could have major safety effects.

Interoperability among components is another major issue for automotive Ethernet, as vehicles are assembled from components made by a wide range of suppliers. They have so many different vendors and suppliers within the car that vehicle manufacturers have to make sure that every component, or every software stack, is really complying to the standard. As a result, testing and validation is very important.[15]

Security and resilience in the face of accidental and deliberate attack is just one area where the connected car will need to demonstrate, very clearly, that it is utterly trustworthy.

In many cases, winning the initial argument—whether with legislators or the buying public—will depend upon clear, repeatable and standardized tests for every aspect of vehicle connectivity and data use; from Ethernet stability and performance to the 802.11p protocol for automotive Wi-Fi.

Where C2X services are wholly or partly reliant upon data exchanged over cellular networks (whether 4G, 3G, GPRS, GSM or others), vehicles will need to prove their ability to remain safe and operational in areas of poor cellular signal availability—and, of course, to re-acquire their full functionality quickly and smoothly when coverage resumes.

Spirent is testing high-end Ethernet and IP integrity for banks and other major institutions, and is the leader in confirming GPS positioning and navigation security for the world's military, aerospace and space applications. Spirent is currently working with the auto industry to help implement automotive Ethernet successfully.

Spirent was recently selected by Hyundai as its vendor for automotive Ethernet conformance testing.[16] Automotive Ethernet is replacing the traditional, often proprietary in-vehicle communications standards such as the controller area network bus and FlexRay, due to limitations on those technology's bandwidth. So automotive Ethernet is becoming the new communications backbone within the vehicle. It is not just for cameras or infotainment, but for handling the bandwidth requirements for all the connected car information.

About Spirent Communications

Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks.

We help bring clarity to increasingly complex technological and business challenges.

Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled.

For more information, visit: www.spirent.com

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For more information on solutions related to testing connected car technology and applications, visit: https://www.spirent.com/Automotive

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