The Changing Role of Vehicle Networks

Sam Abuelsamid (00:05):

Welcome to the NXP Podcast focusing on the technology and issues behind today's connected world. I'm guest host Sam Abuelsamid of Navigant Research. Today, we're going to take a deep look into the changing structure and role of vehicle networks. Connected vehicles mean more data and lots of it. This data can be beneficial in multiple ways. Whether it's for new applications and services from consumers, fleets, and manufacturers, or the data used for advanced driving assistance systems. The vehicle data revolution means big changes in the way automotive networks operate. To gain some insight into these changes, I'm joined by Ray Cornyn, Vice President of the Vehicle Dynamics Group and Networking at NXP Semiconductors and Brian Carlson, Director of Product Line Management at NXP.

Sam Abuelsamid (00:49):

So Ray, let's set the vehicle data stage for us. What's happening with vehicle data currently and where are we heading with all this data that's being generated by all the sensors and other sources of information in the car?

Ray Cornyn (01:02):

It's a very good question. Today, the data that is inside the vehicle is predominantly remaining inside the vehicle. But as you look to the future, the ability to access and use that data maybe inside a cloud infrastructure has become much more significant. But to handle that data securely and also ensure that the right data is sent to the infrastructure is critical. There's a massive amount of data actually in the vehicle today. You think of all of the sensors and the information that's there, and some of the information that comes from ADAS systems, you've got a massive amount of data that you can use to do intelligent things, understanding the environment the vehicle is in.

Sam Abuelsamid (01:45):

How much data is actually being generated today and how much we can expect in the future? We've heard about some of these automated driving prototypes that have as many as 30 to 40 sensors around the car to try to understand the environment around the car. How much data is there that's being produced?

Ray Cornyn (02:00):

It's amazing today that already seeing that the data available inside the car is generating about four terabytes of data every hour inside a vehicle. Not all of that information is usable. You wouldn't necessarily want to send that all to the cloud, but there's a lot of valuable information in there already. Today, that is moving around inside a lot of kind of legacy architectures and a lot of legacy networks inside the vehicle today. What we're seeing is a move to modernize the vehicle infrastructure to allow that data to be more easily handled and acted upon.

Sam Abuelsamid (02:35):

We have a lot of vehicles already on the road that are connected. We started in the late 90s with GM OnStar. That has accelerated pretty dramatically in the last decade. How many vehicles are being shipped now with connectivity and where we expect that to go in the coming years?

Ray Cornyn (02:54):

The recent figures that we've seen said in that in around about 2018, there was about 40% of the vehicles actually were shipped as connected vehicles. By the time we get to around about 2025, that's starting to look in the 70%, 75% range. So there's a lot of connectivity there in the vehicle pool today. Just the level of data and information and access has been relatively limited. It's been predominantly connection into an infotainment system. What we're now starting to talk about is connectivity through to all of the information that's inside the vehicle.

Ray Cornyn (03:33):

Things that you don't realize today is your car is sitting there recognizing and measuring simple things like the exact temperature and pressure that it's sitting in. They have rain sensors on them. You've actually got the best weather station cloud-sourced in the world basically. There's many more sensors. As you said, there's the ADAS sensors, but there's even nowadays very intelligent tire pressure sensors that can give you very detailed information about the roads you're actually driving on.

Sam Abuelsamid (04:03):

What types of connectivity do we have in these vehicles? One of the challenges for automakers is the relatively long development cycle compared to a lot of consumer electronic products. It takes three to five years to bring a new vehicle to market. These also tend to be much more long live products than typical consumer electronics. We don't scrap cars out every two years like we do with smartphones. So what type of connectivity are we using and how is that changing?

Ray Cornyn (04:32):

Traditionally, inside vehicles today, the standard bus structure is what's known as CAN. That's been around for a few number of years. But as the data inside the vehicle has increased, there's been a move to start moving data around on Ethernet inside the vehicle. Then the connectivity outside the vehicle then tends to be 5G or some form of V2X interconnect. So you're seeing the legacy networks being integrated into more modern Gigabit Ethernet type networks inside the vehicle.

Sam Abuelsamid (05:07):

Before we get into all the deep technical details of how you're going to achieve this, let's talk a little bit more about why are we taking advantage of this data? What's the benefit to consumers, to the manufacturers? How's the role of data going to change the customer experience? Especially now, as cars in general are becoming so good, that from a pure product perspective, it's hard to find a bad car anymore. So manufacturers really want to focus on that customer experience component. So tell us a little bit more about how we're using data to benefit that.

Ray Cornyn (05:38):

There's a number of different benefits that you look at in terms of having access to that data. There's the benefit of upgradability in vehicles. Exactly as you said, people don't want to throw away their car after a couple of years because it has become dated in its functionality. So the ability to significantly upgrade vehicles in terms of software and being able to effectively send large amounts of data to the vehicle to upgrade. Not just the infotainment system, the whole vehicle allows manufacturers to build in future proofing of the vehicles.

Ray Cornyn (06:14):

But then you also get the benefit back to the car makers in terms of the information that's provided back from the vehicle in terms of predictive maintenance, feature availability, ability to actually just source massive amounts of data so that they can actually offline develop and test new functions. So there's a number of different benefits brought to the car maker and the consumer in that. Brian, do you want to talk maybe a little bit about some of the benefits to the consumer?

Brian Carlson (06:44):

A big trend we see especially with OEMs, they want to be able to provide differentiation. So we think this is a key area where they can adapt the vehicle over time to the usage patterns of the driver and the passengers. So being able to adapt that car over time to make it more intelligent and to be able to provide more functionality that is aligned to those preferences will provide a lot of value to the user. Also being able to capture that information of the driver's preferences too. That information can be used when they go from one vehicle to another, potentially, when they go from their personal car to a rental car, or other vehicle. They know where their seat position is. They know their preferences for their XMs, radio, etc. So there's those benefits.

Brian Carlson (07:31):

There's also the knowing that your vehicle is always up to date with safety and security. That I don't have to bring the vehicle to the shop. This is a big hassle for a lot of people. But one thing that's interesting is you can monitor the road conditions. So all this different data can tell if you hit a pothole and all that information could be accumulated across all the vehicles so the Department of Transportation or whoever's repairing the roads would have access to information. So that allows the roads to be kept and prioritize repairs just based on the data that's being streamed up to the cloud.

Ray Cornyn (08:04):

Yeah. I actually think of the benefits of big data in terms of when you have a mass population of vehicles with real sensors for EBS systems, your sensors for dynamic control. There are some really nice intelligent tire sensors that actually listen to the road. If you can continue to dump that data up into the cloud, the analytics that can be done on the road around you are quite phenomenal. As Brian said, if you think of... Especially we're sitting here in Detroit which has notoriously difficult road conditions.

Sam Abuelsamid (08:37):

If you don't like the weather, just staying around for a couple hours.

Ray Cornyn (08:38):

Yeah. The roads pay the price of the changing weather conditions. So if you've got a set of cars driving down [inaudible 00:08:46], and you can detect from them... The few sensors will react when they're going over potholes. That information can continually be up to the cloud, or uploaded to the cloud. But even the degree of pothole can actually be measured by those sensors. So the local government and cities can say, "Well, actually, we have to go and repair that one because we've sourced data from 500 cars this morning and that's a really big porthole." You'll have all of that information just automatically been fed up into the cloud.

Ray Cornyn (09:19):

The new intelligent tire sensors, they can actually detect when you start to drive on ice. So instantly, you've got information going back up to the cloud saying this is black ice that's on the road here. Then you can send a warning to all the vehicle around it. So the amount of data that's there and the amount of things your vehicle knows and it's very valuable information to everyone around in society in general is just as phenomenal in terms of what can be done with that data.

Brian Carlson (09:46):

One other use case I'll talk about where we're seeing a lot of interest too is the usage based insurance. We're already seeing some of this today with the dongles that people are plugging in underneath their steering wheel. I saw a report from one of the largest US insurers that 70% of their drivers are actually getting reduced rates due to the use of those dongles. The rates typically I think were 14%, 15% on average. I mean, there's actually a cost savings. So based on your driving behavior, it could actually allow you to get reduced insurance rates.

Brian Carlson (10:19):

Interesting thing about that is now that that data is all being accumulated, it's not an aftermarket dongle that now the OEM has the capability to actually participate, and you start to see some OEMs that are either getting directly involved in insurance or they're working with an underwriter to provide insurance. So you can almost imagine over time kind of subscription fee where I get all these great services, all these different upgrades to your vehicle over time for a subscription service. You pay a monthly fee. Maybe it's your car payment that includes your insurance, all these services as part of that monthly fee.

Brian Carlson (10:53):

So there's a lot of attraction to the OEMs to be able to have a stream of revenue that comes monthly. Not just a one time sell of the vehicle, but how the monthly revenue stream that goes on for 10 years because the average life... I saw the other day, the average life of a vehicle on the road to the US is 10 years.

Sam Abuelsamid (11:12):

Actually, I think it's closer to 12 now.

Ray Cornyn (11:14):

Yeah. It's gone up.

Brian Carlson (11:14):

It's increased. So going back to what Ray was saying too is over time, we talk a lot about the upgradable vehicle. Over-the-year updates are very critical aspect of that to be able to proliferate new capabilities over the life of that vehicle over a decade. So you don't want to be driving a vehicle that's 10 years old where through software upgrades or software defined vehicle, you could actually improve that user experience over the whole decade of a car.

Sam Abuelsamid (11:40):

Tesla has definitely improved over the last six or seven years since they launched the Model S and subsequent models the consumer benefits. Tesla customers love the fact that they can get added features to their car after they bought it. It just magically appears. So using that technology in that way can be a huge user experience and customer experience benefit that brings customers back again and again to buy your vehicle.

Brian Carlson (12:04):

Exactly. Loyalty is the keyword there. I mean, we talked to OEMs and they want to have customer loyalty. So if you can provide those features... Tesla's a good example of that. When you talk to Tesla owners, they're very enthusiastic. Sometimes they'll come in... I don't if they call them e-strikes, but they get these new features. It's like a present every day. They get some kind of new feature.

Sam Abuelsamid (12:22):

Or you can play asteroids on the center screen of the car.

Brian Carlson (12:24):

Exactly. So that's the interesting thing, is it becomes really an interesting... Your owners become very enthusiastic and they become more loyal to your brand. So we see that for OEM. So there's a real value here to have that stickiness to providing those capabilities within the vehicle. So those that invest in infrastructure to support all these things are the ones that will come out ahead over time.

Sam Abuelsamid (12:45):

So one of the interesting capabilities that's enabled by all this connectivity is manufacturers being able to collect telemetry data from vehicles and understand and correlate how that data relates to things that are potentially going to fail in the vehicle or that are degrading in the vehicle. Talk a little bit about, what are the sorts of things that can be done to benefit consumers in particular or fleet operators when you have that kind of data?

Brian Carlson (13:16):

This actually is one of the most interesting applications I think of vehicle data because it not only benefits the OEM, it benefits the driver, or consumer, or the vehicle also. So when you have all that data, you have access to all the different sensors. You can put a lot of intelligence both at the edge and in the cloud to look for what we call anomalies, if there's some kind of degradation going on. Once you know that something's about to degrade, you can actually look at that data from that individual vehicle, but also correlate that across a whole fleet of vehicles. What that allow you to do is to determine first of all if there's something that's a fleet wide issue, maybe it's going to be a recall issue. You can prevent a recall which is very costly. When you know that something's about to go bad, you can tie that data and information into the business intelligence of the OEM because they maintain huge data lakes of all the information for manufacturing and sales and warranty.

Brian Carlson (14:10):

That data now becomes really critical information to the supply chain part of that. So when they know that a part's about to go out, they can actually make sure that that part's available and it's actually in stock at your dealership. So the user experience is really good because it is something that they can't fix over the air. If you do have to go to the shop to replace a physical part, that part will be there. You won't have to wait days for a part to be shipped from across the country for example.

Sam Abuelsamid (14:36):

There's even potential where if you have tied in some of your personal information to your vehicle account or your vehicle owners account like your calendar, when it detects something that is going to need to be serviced or even just regular maintenance, it can provide an alert to the driver and say, "Hey, would you like to schedule an appointment, a service appointment?" It can find a spot in your calendar that's suitable and do that for you automatically.

Brian Carlson (15:01):

Exactly. So this whole thing is about convenience to the user, right? The vehicle data has so much value, like I said, not only for the OEM but also for the end user and that's a great example. We want to make life as easy and seamless as possible, eliminate the trips to the shop. Like I said before, I think I've had to go spend a half day just getting things updated when that could have been done over the air. So it's all about convenience for the user.

Ray Cornyn (15:27):

There's an example I was aware of where a car maker started to see some weird issues and could detect the data. Historically, they would have had to recall the vehicles to reprogram them because they understood that the wear mechanism could be accommodated for software. In the case where you can do this properly over the air, the user will not actually experience any issue. That can be made in the background and the vehicle can remain roadworthy the whole time of its life without ever having to go back to a dealer. So the benefits to the owner in terms of convenience of that type of predictive maintenance and the ability where a software update can actually fix something without you ever perceiving an issue is a massive benefit both to the user and the car company as well.

Brian Carlson (16:13):

One other example of this is I bought a vehicle that had one of the new nine gear automatic transmissions. When they first came out, there were a lot of issues and they knew it when they first came out. They had to sit 20,000 vehicles on a lot until they worked the software out. Well, even after the vehicles were sold, experiencing issues with the transmission, it was all software. So with vehicle data, you could actually be monitoring all those transmissions around the world real time, look for anomalies, look for issues, and actually be optimizing the performance of the transmission.

Brian Carlson (16:42):

So again, smoother shifts and better performance, better fuel economy. That's all done behind the scenes and it gives a much better user experience because I don't have to go the shop. I don't have issues with feeling my transmission not shifting as smoothly as it should. But there's another great example I thought about how this can all be done dynamically through the cloud by monitoring that data and understanding what's going on before the customer calls you with a complaint or ends up at the shop to tell the guy, "There's something wrong with my transmission."

Sam Abuelsamid (17:09):

A lot of the benefit there as well comes from the fact that manufacturers can see how people are actually using that vehicle in the real world environment. They may find things or find situations, scenarios, that they may not have thought of during their testing or they may not have seen during their testing. So that can feed back into their product development process as well and make future products better as well as the current product.

Brian Carlson (17:32):

That's exactly right. You can actually put features within the vehicle and test those with real data. If you have a million vehicles on the road and you want to test some functions, what's a better way to do it than have a million vehicles in parallel driving around testing it? You can get direct data from those vehicles all instantaneously. It's actually pretty amazing. We come from the embedded side within the vehicles but the whole cloud infrastructure, we work with a lot of cloud providers and how much work can be done in the cloud and how you can take that data, run it through machine learning and do artificial intelligence and then feed that back into the car. It's really amazing where the technology is going and how automotive is actually being positively impacted by all the breakthroughs in artificial intelligence.

Sam Abuelsamid (18:12):

How does the data that we get off of these vehicles play a part in improving the overall functional safety of both current generation vehicles as well as next generation highly automated vehicles?

Brian Carlson (18:25):

You can't have safety without security. If there is a vulnerability that someone could attack the vehicle and impact the safety, there's new technologies that are coming into play in the vehicle called intrusion detection and prevention systems. That's really becoming important even to the point where governments are talking about legislating requirements to have this IDPS within the systems. So that's going to be key to monitoring real time what's going on and all the networks in the vehicle to understand if there's some kind of Day Zero attack on a vehicle, and that that could be looked at across the fleet and to be able to react and to shut that down.

Brian Carlson (19:03):

Overall, safety in general is very critical of course in automotive. These devices require a pretty high level of safety as we go forward. One thing we're seeing is the trend to go from what's called ASIL B to a higher level called ASIL D. This is something that we've actually designed into the S32 devices, including S32G, that goes from what we used to call fail-safe where if there's a fault, the device just puts it in some kind of safe mode to what we call fail operational. Which is becoming even more important as we go to autonomous vehicles because you don't want to be driving down the road, something happens, and all of a sudden, it just stops in the middle of road.

Brian Carlson (19:46):

So a fail operational mode that can be supported through an ASIL D system allows you to gracefully... Maybe a degraded mode of operation, maybe it's to drive over to the side of the road or do something else. But these devices like S32G have built into them the intelligence and capability to localize the fault and understand how to react to the fault and to recover from the fault if possible. So safety is a huge issue and that will continue to increase as we go forward. We've designed in to support ASIL D actually, across our whole family of S32 devices.

Sam Abuelsamid (20:23):

Is that something you would do through having additional cores on the chip and perhaps also having some diversity of cores? Different types of cores on the chip that can give you that fail operational capability?

Brian Carlson (20:37):

Yeah. Functional safety is a really complex topic and Lock-Step cores, of course, redundancy is a key part of it. Some people think that if you have redundant core, that's enough, that's not. That is a key thing you do need to have. There's a lot of monitoring that goes on throughout the system to determine if there's faults also. Plus there's error correction. So if there's an error in memory, all your memories have to be able to detect and correct errors within memories. Even if you have an alpha particle that hits your memory, you need to be able to recover from that. So I would say there's a lot that goes into functional safety even at the system level within the chip and then working with other devices within the system to achieve an ASIL D level. So it is quite complex and redundant cores is part of that strategy.

Sam Abuelsamid (21:23):

Going back to security for a moment, one of the challenges as we go forward, as we add more conductivity to the vehicles and at the same time we're also adding more and more degrees of automation, both in terms of driver assist features and eventually higher level automation systems, that creates a potential for more risk. So those over the air updates, it's going to be crucial to make sure that the vehicle stays secure and vulnerabilities that are found get corrected quickly.

Ray Cornyn (21:54):

When we've been focusing on the latest processors that we're developing for this market space, security has been number one in the development of the architectures. But not only just building a standard level of security, building a level of security that can be itself upgradeable through the whole lifetime of the vehicle. We've recently been developing a new security system for our latest microprocessors, microcontrollers that allow that security to the build in. Some of the first experiences I think people saw in OTA systems that weren't secure really focused the industry and has been certainly a big focus for NXP and actually fits very well in with the history of NXP and what we've worked in security. So you see that very much expanding and all the new products we're building and developing for this market space.

Sam Abuelsamid (22:43):

Are there any limits to the types of things that you can do with the data? What wouldn't you want to do with the data? What would you want to avoid?

Ray Cornyn (22:51):

People have a right to their own personal information. You don't want to be effectively pushing this into everybody's fear of big brother is watching. So you got to be really careful with that, that is data inside the vehicle. That is the owners' data needs to be kept there. So it's important that the information that is getting uploaded into the cloud is specific information that is suitable for the vehicle. I agree that there's probably going to have to be a little bit of work done and some of the legalities of how that information is controlled and really is sourced. But just the possibilities and the benefits for generally safety and security in society is just a great opportunity. But with that opportunity, yes, you're right. There's certain things that you do that are personal and you want to remain inside that vehicle.

Sam Abuelsamid (23:46):

As we start to mature automated driving technologies and we start to deploy Robo taxi services, automated mobility services, what are some of the benefits that you can get from that connectivity to help enable those kinds of services for the fleet operators or the manufacturers that are running those vehicles? How would we use connectivity in those kinds of cases?

Ray Cornyn (24:07):

Mobility as a service definitely is a key application that we're seeing improved service over time based on location, usage patterns, and just basic analytics. From a fleet perspective, because there's also commercial vehicles, this data is really important for maintaining the fleet, understanding what's going on as far as how the drivers are driving, how the equipment is performing, if there needs to be maintenance like prognostics vehicle health. I think there's a lot of areas for taxi services to leverage the data to be much more streamlined operations, reduce costs, and also improve user satisfaction. Based on where their users are located, they can derive a lot of analytics I think of how to provide the best service possible.

Sam Abuelsamid (24:49):

It sounds like there's a lot of opportunity from this for operational improvements for fleets. Whether they're carrying passengers or delivering goods or anything else, especially the vehicle analytics, vehicle health reports. Understanding predictive maintenance and diagnostics, it sounds like, and of course, energy use as well in those vehicles.

Ray Cornyn (25:10):

Yeah. It even goes even further even in passenger vehicles. As you're driving down the road and the prognostics are happening, there's a lot of interesting benefits that come out that also from the OEM perspective, they can monitor what's going on across the fleet to find out if there's any potential issues across the fleet. That could indicate that there potentially could be a recall or some other issue that can be very, very costly when the government comes down and you have to do a recall that's more public exposure. It's more costly. So that can start to prevent these things.

Ray Cornyn (25:42):

Also, from the users point of view, there's a convenience there because as they monitor these things, they know if you have a part potentially that's about to go out, they can actually tie the data. This data goes into what's called a data lake in the server. That data, lake it's combined with all the business intelligence, the supply chain, all that for the OEM. So now, they could actually have that part ready to go at your local dealer before you even know that that part's about to go out. So there's actually efficiencies also from that perspective for the OEM as well as the convenience for the driver because when they go to shop, that part will be available for them.

Sam Abuelsamid (26:17):

Maybe go in for an oil change or a tire rotation. Even if they weren't planning to do some other kind of service, they could have that done proactively before they maybe get stranded somewhere.

Ray Cornyn (26:27):

Exactly. That's the real benefit of the driver, is that these kinds of issues are handled ahead of time. Then also the conveniences I mentioned before, I've been through a couple OTA processes. Not even OTA, my daughter's truck. They sent me a USB stick, I had to plug it in and wait 40 minutes and open and close the doors. The process is just not that good in a lot of cases today. So we want to make that whole process seamless so you don't have to spend your time going through a process or waste of your time taking it to the shop so they can plug it in and do updates to your vehicle that way. So it's all about convenience and keeping your car on the road as much as possible and out of the shop.

Sam Abuelsamid (27:08):

You wake up in the morning, get a message on the screen, "Your car's been updated. We fixed these issues or added these additional features and you are all ready to go."

Ray Cornyn (27:17):

Exactly.

Sam Abuelsamid (27:18):

All right. So let's dive in a little bit into some of the technical details of how you make this happen. What sorts of changes need to happen to the hardware, to the vehicle architecture, electrical and electronic architecture, to facilitate all of this use of data?

Ray Cornyn (27:34):

One of the first things that has to happen and is already happening is the ability... So today's vehicle architectures are relatively simple. I mean, there's a standard canvas interface that basically works in principle of broadcast. So your sensors and your actuators, things like brick systems just effectively broadcast information, but it's not in the form that you think of in terms of internet information. So what you then need is a centralized systems that can actually take those and convert them more into the format that we're used to from the internet age. So basically, you change... You're taken from legacy information, legacy architectures, and then effectively start to paint them through Gigabit Ethernet. Then you start treating it more in a similar way that you do internet data.

Ray Cornyn (28:28):

So that is the principle that you should actually be able to call up the IP address of one of your bricking centers if you have done the architecture in a modern way. So most things in automotive view, you don't tend to go in and see, "I'm starting completely from fresh again," but they're completing your architecture. You tend to try and build from what you have today to integrate into more modern package. Even if you look at some of the, let's call it the new generation vehicle makers, they are doing some really original things but they are still trying to be in some of the more proven automotive technology but bring those into the 21st century.

Sam Abuelsamid (29:09):

As we get into more vehicle electrification and more automation, it does give manufacturers an opportunity since they're leaving behind a lot of other legacy pieces to perhaps make a bigger jump. Is that right?

Ray Cornyn (29:23):

Oh, that's definitely true. We've discussed that before. Electric vehicles make it so much easier to actually... The whole principle of an upgradeable vehicle because you can control things like the way the battery charges. You can control the way the electric motors work in pure software. You don't have this legacy [inaudible 00:29:41]. So generally, the architectures of electric vehicles and the fact that it does allow a more significant architectural step definitely... That's why you see a lot of the features. That's why Tesla were able to make data inroads. If you look at some of the other electric vehicles at the moment, you again see that major step in architectures. There are still some things that are there from the traditional auto industry that everybody wants to use because there's a lot of proven safety there but you want to be able to upgrade, migrate that into the modern world.

Brian Carlson (30:16):

Yeah. I mean, a key thing, we call these the disruptive players in the industry. You have your traditional OEMs and now there's a lot of what we call disruptive potentially that are coming in. A lot of Chinese companies, a lot of Silicon Valley companies. If you think about it along those lines is that they have kind of a clean slate. So they can start from a point that optimizes the vehicle, not something that's evolved over 30 or 50 years. So with a clean slate and an EV, which an EV over a combustion engine is much more straightforward architecturally. From a complexity point of view, they can get rid of a lot of the harnesses. Some of these harnesses, the cables within the vehicles, are two and a half, three inches thick. They're hard to maneuver. Their reliability, they're the third biggest contributor of weight in the vehicle.

Brian Carlson (31:04):

So if you start to remove all of that and go to more of a streamlined architecture. We talked about Ethernet. Ethernet is really coming into play here, moving to gig up to 10 gig and beyond over time. That's going to really shift how these vehicles are made. That's what we like about it because we develop processors that manage this data, that move the data, that secure the data. As the data rates go up, you need more performance and that's really what we're trying to help drive the industry and support those shifts in architectures that are driven by all the new electronics and more data that has to go through the vehicles.

Sam Abuelsamid (31:40):

Yeah. You mentioned the wiring harnesses. A lot of car assembly plants, these wiring harnesses are so thick and heavy that when they unpack them, before they can load them into a vehicle, they actually have to run them through an oven to heat them up, to make them pliable enough to maneuver them into the body of the car.

Brian Carlson (31:58):

Exactly. That's an issue. We actually talk about that a lot. It's not just about the weight of the vehicle, but it's actually the manufacturing of the vehicle because you want to streamline the cost of manufacturing for the OEM. So if you can support these new simplified architectures, that brings a lot of benefit to the OEMs.

Ray Cornyn (32:16):

Yeah, because one of the things that one of my colleagues was talking about this recently in terms of his team were core in a lot of door control modules. One of the biggest issues now in manufacturing for vehicles in terms of the way [inaudible 00:32:30] is the wiring harness is getting so fat that goes into the door that it's starting to be difficult to make it pliable enough for when you're opening and closing the door. So that has basically today already get some networking capability in it. It's not a massive web of wires that's going across there. So the idea that you could simplify this and maybe take it down to one connector because you have to remember there's a lot of information now coming through. A lot of cars have cameras in the doors. There's the replacement for rear view mirror. So the side mirrors becoming cameras.

Ray Cornyn (33:05):

So that idea that you may have a two-inch thick cable going into the door, which could maybe be replaced by a single Gigabit Ethernet or a 10 gig, it starts to make manufacturability of these modem systems very attractive to the car makers.

Brian Carlson (33:21):

I think what we've seen is I'd say 90% plus the innovation of the vehicles in electronics and with electronics comes more wires. If you take the old path, put everything on a CAN bus or LIN bus, more and more wires are starting to occur. So we basically, I think, we hit a tipping point. The industry is realizing that. We talked about security. Security is the first thing that the industry realizes. We got to fix security. You have to design security from the start, but now we're running into this roadblock of, "I have too many wires. It's too much to deal with, these issues with manufacturing, the weight, the cost, reliability." It's really hit a point where something has to break or change. So that's why we're seeing a big shift in, how do I re-architect the vehicle to address all these issues, be secure from the cloud all the way to the fuel pump, and to be able to have minimal wires and weight in the vehicle so I have the most efficiency both in... Especially with EVs, the range of the vehicle.

Brian Carlson (34:16):

I've heard Ford in one of the public forums recently said, "You can take a 40, 50 mile per hour effective EV and put all this ADAS equipment in the back and now it becomes a 20 mile per hour effective." Weight is a big deal. So all the equipment and such and the power that some of these things take becomes a constraint. So these are the things that the industry has to deal with. How do I make vehicles more easy to build, better, higher reliability? Then as we go to EV, how do I make sure I'm providing the range that people want so they'll accept the EVs? That was always the thing in the past. Now we're hitting 300 miles, etc, and it's becoming attractive because it's a good range at least to be acceptable. But all those factors have to go into it. How do I reach that 300 miles plus?

Sam Abuelsamid (35:03):

The cost of the battery is the single biggest cost unit in an electric vehicle. That's coming down, but if you can also find other ways like this to simplify the manufacturing, the electrical architecture to offset some of that cost, then you can make the overall vehicle cost and the EV start to bring that more in line with traditional vehicles.

Brian Carlson (35:25):

Exactly. Then we'll talk maybe later about ECU consolidation. So ECUs are the boxes within the vehicle, the electronic control units. They're just generically called ECUs. But right now, there's some 175 to 200 of these boxes in the car from all different types of manufacturers in tier ones. Those boxes, just the physical boxes themselves, cost money to build and to make. There's more cables and connections. What we see is, "How do I reduce that?" Again, with the harnesses, "How do I also reduce the boxes? That's additional weight and complexity." So what we're seeing is those boxes because more and more software. Now, processes become more higher performance that they can run multiple software loads in parallel. I can start getting rid of boxes and have more almost towards a centralized compute architecture.

Brian Carlson (36:14):

So it's really interesting. There's a lot of things in parallel that are going on in this industry right now. They're all being driven by simplification, lower cost, providing more software capabilities. As we said, a lot of innovations is electronics, but software going from 100 million lines of code to 300 million lines of code in the next few years. There's a lot of things hitting the automotive industry very quickly and people are starting to react to be able to address those.

Sam Abuelsamid (36:41):

Yeah. You mentioned earlier the evolution of the vehicles over the last 30, 50 years. We started putting electronics into vehicles in the 1970s to deal with first emission standards and then adding active safety equipment like anti-lock brakes and other things. Each time we added a feature to a car, and they may come from a different vendor, it comes with its own actuator, its own sensors, and its own little computer, which is how we end up with 100 plus computers in the car that all have to be talking to each other at some point. So let's move into that centralized compute or a next generation computing architecture for the vehicle. How do we overcome that problem of all these distributed computers around the car and the associated wiring?

Ray Cornyn (37:25):

The kind of first step that the industry has been taking is to move to what are known as domain control architectures where you start to group some of those functions about it together. We talked earlier about whether there would be three, four or five different domains. So you start seeing people doing things like putting all of the ADAS functionality together and then managing it with a more powerful central computer. Then the same maybe for power train, the same for body electronics. That's the kind of architectures you're going to start to see appearing over the next couple of years. They're aimed at reducing those number of boxes and simplifying the connectivity between them. Beyond that, there are some newer architectures that are getting worked on for the maybe 2025 time period and beyond. There are people starting to look at physicals, all the controllers. So this is taking it to the next extreme where you basically say, "I'm actually going to locate may be a central controller and four physical domains, one each corner of the vehicle. I'll have a simple Ethernet backbone between all of them."

Ray Cornyn (38:33):

Then those modules will look after everything that's required at that corner of the vehicle, whether it's body electronics, whether it's lighting, whether it is breaking, whether it is steering and you run those functions as virtual functions in say those zones. Big, big change in the way software is done in automotive today, but a radical simplification in the wiring of the vehicle and the width of the wiring. So you're starting to see there's more, as Brian called them, disruptive players where they can actually start from fresh and design a whole architecture themselves.

Ray Cornyn (39:09):

But this means just you're talking about being able to go from hundreds of modules. I mean, you're never going to go from hundreds to one. But you will maybe be able to go from hundreds to 10 or 20, or something like that, or even four or five. But that's what we're starting to see is the next generation. That means that the computing processes for automotive now have to be capable of running multiple applications independently which has not really been the case. Most of today's auto multiprocessors are quite traditional, simple microcontrollers. But you're now talking about running applications in virtual environments. So there's a lot of architectural work on that next generation of processors.

Sam Abuelsamid (39:53):

In terms of performance, what kinds of levels of performance do we need in these domain controllers versus the traditional microcontroller ECU?

Ray Cornyn (40:03):

There's a massive range of microcontrollers used in automotive today. But they tend to be in the 50 to a couple of hundred megahertz with maybe a few cores. What we're talking about in domain controllers is getting into using gigahertz processors, using apps processors in special way. See if the application is... So we're talking about a significant maybe 10X the previous generation, but obviously, using far fewer of them. So it's not 10 times the performance and the same number of modules. It is intended to be 10 times the performance and a significantly reduced number of modules.

Brian Carlson (40:40):

Right. What that drives is really more and more software and technologies that have to come into play like hypervisors and hardware that can actually isolate between those different modules that were effectively very isolated because they were physically different boxes. How do I emulate separate boxes within a processor? A lot of new technologies have to come into play to make that safe and secure and to make sure that that works on a bigger processor. So it's a lot of interesting things going on. We were involved with service-oriented gateways where you can have multiple things and services running in parallel within the box. That brings a lot of new software technologies into play also.

Sam Abuelsamid (41:21):

Over the last 15, 20 years, we've all been accustomed to getting broadband in the home, having a cable or DSL or fiber connection coming into our house. Going through a router and then getting distributed to all the increasing number of devices we have in our homes. From maybe one or two computers to now perhaps having dozens of devices with light bulbs that you can control from across the country and all sorts of other things. What's the analog to that in the modern connected vehicle having that one pipe coming in, and then having this information distributed, then similarly having the collected information going back out again? How is that going to work in the modern connected vehicle?

Brian Carlson (42:03):

I kind of hinted at it the last word, the service oriented gateway. Generally, what we see today are gateways. We've been seeing gateways coming into vehicle for some time now. But what we're going to use are called service oriented gateways, which is that 10X performance increase that we've been talking about. Basically, the gateway is very much like that router or gateway that you have in your home where you have the cable modem or other type of ISP provider propping up big fat pipe to you. Same type of thing. We're now going from 4G to 5G into these gateways. The gateway has connectivity throughout the vehicle. It's central to the vehicle so much like you talked about... In my house, same thing. Probably 30 or 40 devices are connected typically wirelessly.

Brian Carlson (42:44):

But in the car, most of those are wired so you have a wireless connection coming into the gateway. You could have 20 to 25 different connections that go all over the car. Whether it's Ethernet or what we call the legacy automotive interfaces which are CAN, LIN, FlexRay, these types of interfaces that they're not going to go away overnight. But the gateway is the key. It brings all that in. It provides isolation. It provides security. It moves the data efficiently from one part of the vehicle to another and from the cloud also to the different parts of the vehicle. So it's really central to the whole concept of vehicle data.

Sam Abuelsamid (43:21):

So that gateway, having those multiple connections going out, is that what differentiates this really from the telematics control unit that we have today? Which is typically maybe only connected to your in-vehicle infotainment.

Brian Carlson (43:34):

Exactly. This is an interesting thing of how these architectures will change. But look at the telematics unit or the TCU, T-box, there's different names for it. But as we see that, that becomes kind of a centralized place for your smart wireless up on the shark fin or up on your roof. That's where it's going to take all the Bluetooth, WiFi, GPS, all those signals. That basically will feed a fat Ethernet pipe that goes into the gateway. The gateway is central and distributes that data throughout the vehicle. Whether it's the infotainment, or it's the ADAS system. Of course, ADAS, there's a lot of things going on, and a driver assistance and eventually autonomous driving that needs lots of data interactivity with the cloud also. That gateway is a central fundamental... It's required really for safety and security reasons also for these new architectures going forward.

Sam Abuelsamid (44:25):

So this gateway, it's part of this network infrastructure that's rapidly changing. What other types of changes are occurring in this gateway module? Is that where you're also embedding a lot of security? Or are the security components also distributed among those domain controllers?

Brian Carlson (44:42):

Yes. The gateway itself actually does have embedded hardware security in the gateway devices themselves. Actually, you want end-to-end security. So even those devices like I said, your fuel pump or your other areas, you want that security. That's actually one of the benefits that we introduced the S32 family of devices where we have our hardware security edge that goes across from the gateways all the way to the edge nodes throughout the vehicle. That's really critical because if there's any weak link within that connectivity from the cloud to one of the end devices, that's a security vulnerability, right? So security is very important. You have the front end centralized security that's moving data securely from point A to point B within the vehicle, but you have to maintain the security all the way out to the edge.

Ray Cornyn (45:29):

At this point in the industry, it's a time where we're starting to see massive changes in the way vehicle architecture should be done. You pointed back to electronics first came in, I guess, the late 1970s?

Sam Abuelsamid (45:42):

Yeah. Late 70s. Yes. Some of the first electronic initially.

Ray Cornyn (45:46):

Early 80s. Everything up to this point has been a kind of steady evolution. With fast connectivity inside the vehicle, with CAN networks and they've been upgraded. But you've seen this major step forward for your... The vehicle starts the power of the Internet of Things. All of the information that's there inside the vehicle is now getting opened up to cloud and big data analysis. But you're working inside an industry that has some very justifiable legacy because it took a lot of years to prove the safety and reliability of all the systems.

Ray Cornyn (46:24):

What you're seeing at the moment is this transition from that traditional industry into a very modern 21st century Internet of Things kind of vehicle. What we've been trying to do is act as the conduit of that information out through the gateway, but also accommodate the newer and newer systems that are coming from some of those disruptive players as well. So it's trying to combine that upgradability but with a view of where the world is going within the next five to 10 years. The idea of coping with some of the security challenges. One of the things that we built into all of these modern parts is that safe concept. So safety as well as security.

Brian Carlson (47:07):

Look what happened to the smartphone and how that is a tool we use for so many things in our lives. Similar thing is happening here within this gateway of various services that can leverage all that vehicle data. So what I think is going to happen is a whole ecosystem of players are going to come into it. I work with a lot of people that have traditionally been in the IT space, enterprise space. They're now coming into automotive because devices like the S32G that we offer gives them the ability now to participate in the automotive industry where they didn't have the opportunity to do that before. I think we're going to see a lot of innovation not just from the disruptors that are in automotive today, but also from the people coming from the IT space that have software capabilities that they want to put into the automobile. They now have a platform to do it.

Ray Cornyn (47:52):

People are starting to use really some of the first IoT capabilities and some of the first connectivity benefits. People being able to see images from the vehicle. Honestly, today, they all feel a little bit clunky because there's not enough data bandwidth. There's not enough data infrastructure there. The architectures inside the vehicle today just don't lend themselves to that amount of data. But you can see the first benefits, as you said, the idea of being able to... I can do it. My car, on your cell phone, you can sit there and go, "Okay, so let's have a look around the car and show you what's there." But honestly, it's kind of slow and the image isn't very good. But you know that that could become something really, really valuable.

Ray Cornyn (48:37):

So as Brian said in the keynote, we're in the start of this technology. But to really make it work, the vehicle architectures have to have a significant upgrade. That's what we've effectively been working on the next generation vehicles coming out in 2021. Then what's the really big stakes on in '25 and beyond?

Sam Abuelsamid (48:59):

All right. Well, I thank Ray Cornyn and Brian Carlson for joining me here today. I'm Sam Abuelsamid from Navigant Research, and this has been the NXP Podcast.