

Addressing Challenges in Automotive Connectivity: Mobile Devices, Technologies, and the Connected Car

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ABSTRACT

With the dramatic mismatch between handheld consumer devices and automobiles, both in terms of product lifespan and the speed at which new features (or versions) are released, vehicle OEMs are faced with a perplexing dilemma. If the connected car is to succeed there has to be a secure and accessible method to update the software in a vehicle's infotainment system - as well as a real or perceived way to graft in new software content. The challenge has become even more evident as the industry transitions from simple analog audio systems which have traditionally served up broadcast content to a new world in which configurable and interactive Internet-based content rules the day.

This paper explores the options available for updating and extending the software capability of a vehicle's infotainment system while addressing the lifecycle mismatch between automobiles and consumer mobile devices. Implications to the design and cost of factory installed equipment will be discussed, as will expectations around the appeal of these various strategies to specific target demographics.

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INTRODUCTION

Contemporary vehicle infotainment systems face an interesting challenge. The basic functionality of a vehicle infotainment system is expected to remain current for the life of the vehicle, perhaps 10 to 15 years when one considers the secondary market for such a vehicle. But conventional attitudes toward cost optimization generally prohibit oversizing or “future-proofing” system resources. The challenge of keeping systems current can be addressed through a combination of enabling periodic software updates, and by extending the system functionality by taking advantage of the capabilities available in connected devices like mobile phones and tablets.

For software updates the path is clear: we are seeing a transition from entire module replacements at the dealership to secure probe USB or Wi-Fi based updates. Ultimately, it's expected the automotive industry will follow the wireless industry's lead with a firmware over-the-air (FOTA) secure update and provisioning strategy.

However, there are many competing technical solutions available for adding new content to an in-vehicle infotainment (IVI) system. At the most basic level, the addition of new content could simply be addressed through the software update mechanism. However, this approach may not offer the level of flexibility necessary to accommodate user-directed customizations. Establishing an app store approach is another option [Figure 1], although this comes with serious security considerations and available system resources must

be carefully taken into account. The use of app stores is expected to grow significantly in the coming years as automotive OEMs begin to explore apps not only on IVI systems, but on other components of the automotive platform as well.

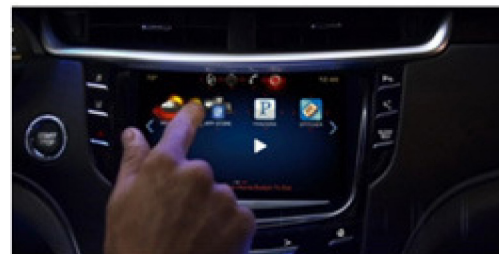


Figure 1. The popular app store approach as it appears on a vehicle's head unit display.

Still, other approaches take advantage of content executing from connected smartphones or other nomadic devices using Bluetooth or other connectivity infrastructures. The use of Bluetooth, according to ABI Research, will rise sharply in the coming years as more car owners grow comfortable using it to listen to music or make phone calls. It's just a matter of time before Bluetooth becomes the preferred method to check emails, exchange text messages, or a post the latest news on a social network account. Bluetooth is expected to enable this in a safe and seamless manner.

THE CHALLENGES

There are many challenges associated with the implementation of connectivity as it pertains to today's connected car. Foremost among these challenges is connectivity *within* the vehicle and connectivity *outside* the vehicle such as Internet via Wi-Fi, LTE, or some other means. Many of the challenges relate to providing connectivity to the myriad of nomadic devices that are brought into the vehicle. Some deal with providing on-going support for the ever-changing formats for audio/visual content, which is often deeply tied to the semiconductor device selected for the system. Both connectivity to consumer devices and support for multimedia formats presuppose the existence of some mechanism for system upgradability over the life of the vehicle. Some challenges result from enabling the use of apps in the vehicle, and providing an application framework that will support these apps in various formats (originating from a variety of sources).

A few of the more pressing challenges for IVI connectivity include:

Codecs and Connectivity

One of the first challenges encountered when designing a new IVI system is dealing with **codecs and connectivity**. Codecs are components; either implemented in the hardware, or software-based with strong ties to the underlying system-on-chip (SoC) or peripheral silicon devices. Some codecs are open but not all. Further, some codecs require the proper licensing which will have to be figured into the design costs. Codecs are used to encode and decode multimedia content into various formats. In modern silicon architectures, a software-based codec is implemented on any of several processor cores or digital signal processors (DSPs) - as asymmetric multiprocessing (AMP) architectures are becoming increasingly popular. Codecs can also be optimized based on a certain processor or system architecture. The point here is that codecs obviously have implications for the portability of resulting software, as there will be variability in both the interfaces to the codec and the compilation tools used.

The consumer device connectivity aspect centers largely on the type of media used for establishing the connection. In contemporary implementations, this is commonly USB or Bluetooth. In exploring solutions related to device connectivity, the selection of the platform operating system, and optionally, a third-party connectivity solution, will be central to the effectiveness of device connectivity, as will the ability to update and extend the related connectivity software (and quite possibly the related hardware, at least with respect to the physical connection to the device).

Increased support for an interactive connection to an application executing on a connected mobile device has implications far beyond the basic USB/Bluetooth protocol. Extensions are required to support iPod Accessory Protocol, Android Accessory Protocol, and Microsoft Media Transfer Protocol. Some uses of these protocols will be discussed in the next section. Also worth mentioning are the various approaches to Digital Rights Management and the required use of an iPod authentication integrated circuit in the IVI system when connecting to some Apple products. Finally, most IVI systems

provide access to unsupported or legacy devices through the availability of an auxiliary analog input. As a result, system software developers must not only map out the types of challenges before the actual design, but work with the silicon/hardware providers to ensure a tight and flawless IVI connectivity solution.

Multi-Zone Audio Connectivity and Multimedia Zones

An extension to the connectivity aspect of the IVI system is **multi-zone audio connectivity**, which is now expanding to **content sharing between multimedia zones**. Multi-zone audio makes it possible for the driver and passenger to define individual entertainment experiences. While the driver listens to music and/or navigation instructions over the vehicle sound system, passengers have access to alternative multimedia content, enabled primarily through support for wireless headsets. This multi-zone audio paradigm can easily be extended to support independent audio and visual displays resulting in the sharing of multimedia content (via USB/Bluetooth connections from a passenger's device) creating "multimedia zones" within the vehicle. A multimedia zone gives each passenger the ability to share and receive digital content through the vehicle's head unit. Beyond the base IVI system built by the automaker, these concepts are often available from a dealer/factory install or by aftermarket Rear Seat Entertainment (RSE) systems [Figure 2].

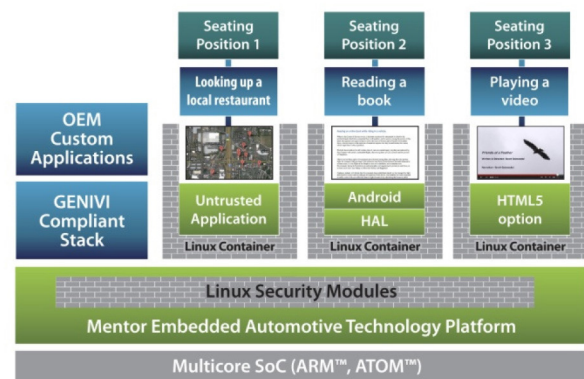


Figure 2. Multimedia zones are created by establishing both “trusted” and “untrusted” partitions that can be separated through the use of hypervisors, Linux containers, and Linux security modules.

While it is expected that vehicle architectures will evolve toward a more consolidated and comprehensive IVI, telematics, RSE, and Instrument Cluster (IC) systems will likely remain as separate and distributed architectures to facilitate vehicle platform scalability. These distributed architectures are more than likely to contain dealer-installed or aftermarket components.

Android Apps

In recent years a great deal of interest has been generated around the use of Android, or more specifically, **Android apps** within the automobile. While enabling support for Android apps is technically feasible and may be a great selling point for certain models, there are still serious concerns. Central among these are system security and driver distraction issues. Several approaches exist to deal with the security aspect of Android integration and some of these are

covered later in this paper. Driver distraction is a very real threat and there are non-profit and government bodies ready to step in and address driver distraction issues.

While in-vehicle Android apps are fueled by the many variations of the Android smartphone, there is one distinct *disadvantage* among automakers that choose to use an app store environment as the sole means of a vehicle's IVI system. There is increasing evidence that vehicle differentiation created by a specific IVI implementation (especially among the mid-range and premium autos) is now a key factor in the success of that vehicle. Android apps, and other apps for that matter, have a very limited scope when it comes to making a vehicle IVI user experience stand out over another user experience. (Although it can be argued, this familiarity between smartphone and dash is exactly what some end users and automakers prefer.) Further, as mentioned before, automakers are reluctant to employ an “all-app” approach due to limited monetization possibilities.

Nevertheless, the market for apps in automotive is expected to grow exponentially. ABI Research expects the number of apps downloaded in cars will jump from 12 million downloads today to 4.3 billion downloads by the end of 2018.

Driver distraction is a prevailing theme when designing any new IVI system. Most of the existing connectivity mechanisms have direct implications of distracting drivers due to the inability to control precisely what appears on the IVI system display. It appears automakers need to do more to mitigate driver distraction. Last year, the National Highway Traffic Safety Administration (NHTSA) reported motor vehicle crashes spiked - to more than 3,300 deaths on U.S. roadways - which can be attributed to driver distraction issues. This uptick has prompted regulators to draft a set of proposed guidelines for automakers and their suppliers. But there is some hesitancy to adopt guidelines because they would take years for widespread adoption and others fear innovation would be stifled. One way to decrease driver distraction is to automate more secondary tasks. Others believe mandatory driver training and better collaboration between technology stakeholders will lessen future potential for driver distraction.

The Internet

Another challenge when adding connectivity to the vehicle is the very nature of the connection. The **Internet connection** can be provided using an on-board wireless chipset, or through a USB-connected or Bluetooth-paired cellular device. While systems marketed with an emphasis on safety typically include on-board wireless connectivity, this nonetheless, exposes vehicle OEMs to the necessity of addressing communication technology changes over time - and across geographies. Many of these changes cannot be addressed through a simple software update or FOTA. This is further complicated in the U.S. market as there is a major transition from the established CDMA to the more advanced LTE technology. And for the end user of the vehicle, leveraging an on-board wireless solution as a basic telecommunications device tends to be prohibitively expensive.

In either case, the availability of an Internet connection raises the possibility to provide Wi-Fi hotspot access for passengers, or even using an engineered Wi-Fi network (i.e., a statically configured network with fixed IP addresses) to supply basic connectivity between the modules in the vehicle. An unrestricted Wi-Fi hotspot can certainly be provided through a nomadic device such as a cellular phone or wireless modem (much like what BMW has started to do). An on-board wireless chipset along with in-vehicle Wi-Fi networking opens the door to additional services to passengers, and offers vehicle OEMs the possibility to simplify wire harness design and perhaps better accommodate the adoption of new connectivity technologies.

Streaming Multimedia Content

Internet connectivity brings the possibility of **streaming multimedia content**. Traditional multimedia players, including those packages available with many legacy RTOS products, are well-suited for playing multimedia from a file. Often, the architecture of these systems requires redesign to better support streaming media. Use of a more sophisticated operating system, especially one with instantiations supporting a desktop environment (Linux, for example) would definitely be beneficial.

Upgradeability

A central issue related to many of the challenges noted in this section is **upgradeability**. Most new IVI systems are requiring at least some level of support for software updates, even if using a simple USB-connected mechanism. Extensions to this idea include FOTA software update strategies when an Internet connection is available. This introduces further concerns around provisioning, including dealing with the compatibility of component versions and having knowledge of the current software component version configuration in a given system. The later concern is particularly important when dispersing condensed update packages (or “binary diffs”) in the interest of speeding update transmittal and thereby reducing the duration of the overall software update. Any update strategy will also have considerable implications for the memory requirements of the system as it is often necessary to maintain redundant memory regions to facilitate the update and protect against update failure.

The update of individual apps in the system will be much less complex as the interdependencies between apps and dependencies on the underlying system services are somewhat easier to address. One option is to simply rely on an app store for handling updates, where a more complete FOTA update strategy is required to update the system software (which may contain some foundation apps). And further simplification of the software update mechanism can be achieved by leveraging apps that actually run on a connected mobile device. Several of the existing connectivity solutions that will be covered in the next section exploit the execution of apps directly on the mobile device, thereby dramatically simplifying software updates (and connectivity hardware updates) for the overall system. Reliance on mobile apps in this way also helps isolate the vehicle OEM to some extent from update concerns.