



Automotive Infotainment Software Architecture Report

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Introduction

To best serve the automotive infotainment software market, GENIVI commissioned a study recently to identify the major market factors that will drive the future of IVI architecture. With the assumption that these factors are certainly not comprehensive, there were significant measures taken to identify the most important and relevant market requirement categories and topics through numerous interviews with industry personnel.

Although this report was created with a focus on GENIVI's perception in the market, all major IVI operating system suppliers are examined as well.

The creation of this document was sponsored by the GENIVI Alliance. But in order to capture an empirical industry perspective, there was interview input from GENIVI member companies and non-member companies throughout the global IVI ecosystem as well as contributions from industry consulting organizations iSuppli and Frost & Sullivan.

Purpose

This document's goal is to offer a summary of the commissioned study's compilation, titled "GENIVI Automotive Infotainment Software Architecture Report".

The complete report, available through GENIVI at <http://www.genivi.org/mrd>, captures the IVI software architecture market's customer needs, competitive environment, next-generation systems' projected launch, major OS suppliers' SWOTs (strengths, weaknesses, opportunities and threats), features considered for future versions of IVI products or services, and the market's perception of GENIVI.

In addition to the primary goal of providing IVI software market factors, this document also offers other general perspectives and trends that will shape the future of the global automotive infotainment market.



Companies Interviewed

Conducted were 72 interviews including GENIVI member and non-member companies.

OEM (Vehicle Manufacturers)		
BMW	Chrysler	Fiat
Ford	GM	Nissan
PSA	Renault	Toyota (TIC)

Tier One Suppliers		
Aisin	Alpine	Bosch
Continental	Delphi	Denso
Garmin	Harman (XSe)	Magneti Marelli
Mitsubishi Electric	OnStar	Panasonic
Pioneer	Valeo	Visteon

Silicon Suppliers		
Altera	Arm	Freescade
Frontier Silicon	Intel	Marvell
NEC	NetLogic	NXP
Renesas	Rohm	Samsung
ST Microelectronics	Texas Instruments	Xilinx

OSV (Operating Systems Vendors), Middleware and Services Companies			
Advanced Driver IT	Airbiquity	AllGoSystems	ATX Group
Elektrobit	Google	Hughes Telematics	Inrix
KPIT Cummins	Mentor Graphics	Microsoft	MontaVista
Navteq	Nokia	QNX	TomTom
Vector Informatik	VoiceBox	Wind River	WiPro
Wireless Car			



Competition - Proprietary and Open Platform Architectures (Specifically IVI Stacks and Operating System [OS] Suppliers)

Based upon interview results, major or relevant suppliers include Microsoft, QNX, Microltron, Linux, GENIVI and Android

Microsoft (MS): Has an established customer base and credibility with Ford, Kia and Fiat. Motavi is next-generation MS IVI stack product, which will launch with Japanese OEMs.

Strengths: One-stop shop, support and proven product in the market.

Weaknesses: Boot time is slow; perceived to be caused by OS size. There is a lack of openness to development community and high price (royalty per unit). Perceived lack of automotive focus in the future compared with its overall product roadmap.

Future in IVI: While most interviewees felt MS will be the major IVI stack provider for the near future (3 to 5 years), the majority of respondents thought MS and Linux will share market dominance in the longer term (5 or more years in the future). They also thought MS will have difficulty competing with Linux and/or Linux will dominate market share longer term.

QNX: Currently a major IVI stack provider in the industry. Smaller kernel than MS; viewed as flexible for feature configuration and faster boot time compared to MS.

Strengths: Proven track record in IVI, overall support and lower price than MS.

Weaknesses: Perception of future scalability, especially across next-generation systems requiring higher level of feature integration. Some respondents stated that downloadable apps support in QNX was difficult to configure and the company's response to software issues was not timely.

Future in IVI: Regarding long-term viability in the market, majority of respondents felt QNX will lose market share with niche applications sustaining their viability. They predict QNX will withdraw from the IVI market eventually. Questionable future is also due to lack of a consortium (such as GENIVI) to drive the architecture.

Microltron: While seldom used in the context of being a major player in the IVI stack or OS market, it was mentioned by several interviewees, especially concerning its relevance in the Japanese market. Interview feedback was split between the company's long-term viability and its future exit from the market. It is currently used exclusively or almost exclusively by the Japanese OEMs. Predictions from interviewees are that Microltron will share the Japanese OEM market with MS but will lose market share in Japan eventually and will not be adopted by other non-Japanese OEMs.

Android: There's a great deal of growing interest, particularly for supporting downloadable apps. However, the majority of respondents think Android has the best potential as a supporting OS running in tandem with main OS to support apps. A Chinese manufacturer has launched the first Android-equipped vehicle – Roewe 350 running Android 2.1 - as well as Continental and Parrot, both developing the OS for future applications.

Strengths: Applications development community support, open source and smart phone market position



Weaknesses: Too early to determine if the product will be successful in IVI. Perception that Google will do little, if anything, to configure the product for IVI in their future roadmap.

Future in IVI: Although too early to tell, respondents feel that Android has promise to provide a complimentary OS running in tandem with open source, GENIVI or other OS, in support of applications. 100% respondents indicated that Android would not be a competitor to GENIVI or other IVI main OS suppliers. Additional Android feedback from respondents: Similar to MS, the Japanese OEMs will likely be the slowest adopters of Android due to their risk-averse nature concerning open source. In addition to Roewe, other Chinese and Korean OEMs are very interested in Android and are rapidly evaluating its benefits for adoption.

Linux: Continually growing in IVI applications, interest and development.

Strengths: Open source with huge development community support; perception of reducing development time to market and lowering, if not eliminating, future royalty price models from proprietary OS models and overall IVI software costs.

Weaknesses: Perception of IP, indemnification issues, quality and reliability support.

Future in IVI: Interviewees predict Linux will challenge MS for market share if not be the dominant long-term player in IVI. Several interviewees used the smart phone OS market trend as an example supporting this prediction. Japanese OEMs will be the slowest adopters of Linux.

GENIVI: Industry perceives as the “Automotive IVI Version of Linux”. When asked to compare/contrast GENIVI and Linux, all respondents explained that if GENIVI is successful in its charter and is adopted in the market, most, if not all, companies developing Linux for IVI solutions will switch to GENIVI. Several interviewees had been developing Linux solutions but have changed their strategies to focus specifically on GENIVI as their open source offering.

Strengths: Identical to Linux with the added benefit of being configured specifically for IVI. The strength of the GENIVI consortium will help drive its adoption.

Weaknesses: Not proven. Currently no market penetration, with no significant penetration expected prior to the timeframe between 2013 and 2015. As with Linux, the perception of IP and indemnity issues and overall lack of support are its primary weaknesses.

Future in IVI: Assuming GENIVI meets its chartered goals, it will become the migration path from Linux and will challenge MS, if not become the dominant stack, in the IVI market over the long term. GENIVI’s challenge will be to:

- 1) Launch successfully in production with growing market penetration between 2013 and 2015.
- 2) Alleviate IP, indemnification, quality/reliability and support concerns.
- 3) Validate the development cycle and cost-reduction benefits.

Similar to Linux and Android, Japanese OEMs will be slowest adopters of GENIVI.



Cost/Commercial Considerations for IVI Stacks as they relate to GENIVI or Open Source

- What is the average royalty or unit price for proprietary operating systems?
Respondents' answers to this question ranged from \$2/unit to \$30/unit. The \$2/unit price was explained to be a high-volume low-featured solution. The \$30/unit price was a low-volume very high- end and high-feature content system. The average per-unit price across all OS suppliers ranged from \$5/unit to \$15/ unit.
- What is the total cost of developing an IVI system?
Responses ranged from \$20 million to \$100 million. The average range was \$20 million to \$50 million. The consensus was that the total cost could be broken down into hardware, representing approximately 50 to 60% of the development cost, and software, representing 40 to 50% of the cost. It was also stated that software will continue to grow to more than half of the overall cost in the near future, representing 60% or more of the total cost. Another reference point for the resources required to develop a new IVI product was mentioned in man-years. Across all regions and respondents it was thought 200 man-years is the average human resource directly attributed to the development of a new IVI system.

What potential reductions in development resource might GENIVI or open source offer to the development of IVI systems?

- Most respondents felt 50% of the software costs could be eliminated through utilizing GENIVI or open source development. One respondent said they had completed an in-depth assessment recently of open source development, concluding that the utilization of same would yield a 30% total system development cost reduction or approximately a 50% savings in the software development.
- The assumption regarding interviewees' speculation about the above-cost reductions was that the GENIVI or open source platform was stable and mature – not a first implementation. Several respondents mentioned that the cost of the first GENIVI implementation could cost as much, if not more than, utilizing a standard proprietary stack.

How might the adoption of GENIVI or open source stacks affect the current royalty price model of the future?

- Respondents indicated that while the royalty price model for proprietary OS will remain, it will be driven down. Also, there will be per-unit price models developed for open source offerings established by tier ones or OSVs (operating system vendors) who integrate the open source stacks.
- While nearly all respondents stated future proprietary per-unit prices will be driven down, few made projections of exactly how much these reductions will be. The average reduction was 25 to 50%.

Customer Needs and Corresponding Features – Prioritized by Interviewees

At the time of this report's publication, the priority feature focus was on the mobile device connectivity to the IVI system, as well as defining next-generation support of applications that could be downloaded directly to the head unit or displayed on the IVI system from the mobile device. The next most-mentioned feature was internet radio.

Assuming that all of the features mentioned above will be offered in various configurations across the global automotive IVI ecosystem, it is also assumed these features can be termed "commodities". While differentiation of



IVI systems will certainly be driven by the performance and flexibility of these commodity features, the more relevant and meaningful differentiation of IVI systems, according to the respondents, will be at the HMI level.

Feedback from interviewees regarding HMI differentiation is:

- 1) Voice Recognition: 70% of all respondents stated that voice recognition was either a critical feature for differentiating future IVI systems or was the most important differentiating feature. Assuming this technology can be developed to enable contextual grammar and varying global dialects, it is viewed as the most important HMI differentiating technology. Contextual recognition would enable users to skip numerous steps in navigating through menus in touch/button interfaces, as well as currently cumbersome voice command menus. Enhanced dialect support would alleviate multiple or repeated voice commands. Interviewees mentioned many development activities underway with VoiceBox, SVOX, Nuance and IBM cited as the predominant purveyors of this technology.
- 2) Touch Screen: 27% said that touch screen was either a critical feature for differentiating future IVI systems or was the most important differentiating feature. Although there was little mention of a regional focus, several respondents indicated that Europe would see more future touch screen applications compared with other regions.
- 3) 3D Graphics: 20% stated that 3D graphics was either a critical feature for differentiating future IVI systems or was the most important differentiating feature.
- 4) HUD (Head Up Display): 12% stated that HUD was either a critical feature for differentiating future IVI systems or was the most important differentiating feature. Projected virtual image, with augmented reality (mix of real world surroundings with driver information), was mentioned as a HUD focus because it provides a safer environment compared with windshield projection. 20 Degrees FOV (Field of Vision) was mentioned as a target for driver focus to also optimize the safest driving experience.
- 5) Gesture Recognition: 12% stated that gesture recognition was either a critical feature for differentiating future IVI systems or was the most important differentiating feature. Several tier one suppliers mentioned active development programs they were engaged in for this technology. Omni Swipe for smart phone applications was mentioned as a potential model to be followed.
- 6) Steering Wheel Controls: 8% stated steering wheel controls were either a critical feature for differentiating future IVI systems or are the most important differentiating feature.
- 7) Text to Speech: 8% stated text to speech was either a critical feature for differentiating future IVI systems or was the most important differentiating feature. Several respondents said this would be a higher-end vehicle standard feature.

Market Drivers and Technical Requirements Affecting Future Implementation

The market drivers and technical requirements section focuses primarily on the connectivity technologies that will proliferate future IVI systems and other major market drivers mentioned by interviewees. Interviewed respondents' feedback on IVI connectivity technologies were:

- 1) SD Card Interfaces: All respondents indicated SD card interfaces will remain for the foreseeable future with no identified technology as a potential replacement. Japanese OEMs are the major proponents of SD cards for safety reasons.



2) **USB:** All respondents indicated that USB will remain the standard wired connection for IVI in the foreseeable future. 8% of respondents stated that USB 3.0 will replace 2.0 in 2015, and after 2015 wireless technology will begin replacing USB.

3) **Bluetooth:** All respondents said that Bluetooth will remain the standard wireless connection between consumer devices and the head unit in the foreseeable future. Although 100% of respondents saw Bluetooth as a mainstay for the short term, 47% felt Bluetooth will be replaced with an alternative wireless technology beginning in the 2015 to 2017 timeframe. Most of this group thought Wi-Fi would be the new consumer device connectivity technology in the long term.

4) **Wi-Fi Applications:**

- **Vehicle connection to a hot spot:** 70% of the respondents felt that this application will shrink in the future; while 30% thought it will grow.
- **V2V (Vehicle to Vehicle)/V2R (Vehicle to Roadside):** Driven by safety and mobility efficiency initiatives, 90% of respondents felt this application will grow in the future, and 10% considered its growth is questionable.
- **Vehicle as a hot spot:** 90% of respondents indicated this application will grow in the future. 10% felt it would not, citing non-supportive cellular business models as the detractor.
- **Wi-Fi as the standard connection between consumer device and head unit:** As mentioned under “Bluetooth” and “Consumer Device Connection to Head Unit”, there is a significant industry response indicating this technology can become the standard connectivity protocol for this application. While the current version of Wi-Fi does not support use-cases provided by Bluetooth, Wi-Fi and Wi-Fi direct are being evaluated for development in this application.

5) **Mobile Broadband (LTE and WiMax):** 93% of all respondents indicated that LTE will dominate and potentially completely displace WiMax. 7% felt the two technologies will co-exist. Several of the 93% cited the lack of silicon, handset and wireless carrier roadmaps currently in place or projected to support WiMax as factors in its decline. Predicted timeframes for LTE dominance were as early as 2013, but more probably by 2015.

6) **Consumer Device to Head Unit Connectivity:** USB and Bluetooth are viewed universally by the industry as the near-term standards for wired and wireless connectivity for this application. When asked specifically for perspectives on future technologies that may replace these two standards, response was as follows: --- Of the respondents, 47% felt that Bluetooth would be replaced by a new wireless technology for this application – most felt in the 2017 timeframe. Out of this group, 75% thought Wi-Fi was the most likely candidate.

- When asked about Terminal Mode being a technology holding potential for this application, 83% felt it will be a viable solution in the future. Out of these respondents, one tier one supplier said it is being developed by and will be launched into production by some of their customers.
- Out of the 17% who felt Terminal Mode had limited or no viability, U.S. Department of Transportation mandates concerning driving during display of apps mode and inability to provide certain connectivity solutions (for example, Ford SYNC) were cited as detractors.
- 80% of respondents to the question of CE4A’s potential for developing a viable standard for this application indicated there may be potential. One respondent mentioned that NFC (Near Field Communications) has the potential of providing this connectivity, displacing USB and Bluetooth in 2017.



7). *IVI Serial Communications/Bus Protocols*: Most respondents stated that CAN, LIN, MOST, FlexRay and Ethernet will be required protocols for future IVI systems. Three respondents indicated they are developing Ethernet as a backbone, and it will be deployed as early as 2015. One respondent said that as FlexRay poses a very complex configuration challenge and is optimized for safety applications, they question its viability in IVI domain unless specifically used in support of a safety critical application (ABS/ESC, Chassis, Powertrain, etc.).

Non-connectivity related IVI market drivers:

8). *Future Strategy for Embedded in Head Unit or in Consumer Device*:

- Of the respondents, 20% indicated that safety, security, diagnostics and vehicle usage features should be embedded in the head unit as standard throughout all vehicle segments.
- 14% said that navigation should be embedded as standard in high-end vehicle segment, citing expectations from segment customer profile for this feature.
- 51% indicated that for mid- to low-end vehicle segments, all features should be embedded in smart phone, with connectivity to head unit offered as standard and head unit-embedded features such as navigation and telematics offered as options. Several respondents stated that GENIVI should ensure development of stack supports low/mid-range segment because this will be the high-volume application globally. Several other respondents in this group mentioned that the \$500 end-user price for head unit-embedded navigation was tipping point that would drive application in mass market (low to medium vehicle segments). However, as this end-user price would necessitate an OEM cost of \$250/unit (thought to be extremely challenging in the near term), the embedded navigation in the smart phone would be the widely adopted model for this segment.
- 77% mentioned that high-end segment systems should provide the most amount of feature utilization between those embedded in head unit and those in smart phone. For example, drivers may choose either the head unit or smart phone feature when in the vehicle, and, if the smart phone is not in the vehicle, they may rely on a rich set of embedded features.

Other market drivers addressed in the full version of the GENIVI Automotive Infotainment Software Architecture Report include:

- a) Strategies for protection from potentially harmful software to other IVI features or other vehicle systems.
- b) Telematics trends.
- c) Semi-embedded detachable display.
- d) Server delivery.
- e) IVI and ADAS merge.
- f) IVI application framework.

Inquiries for Full Version of the GENIVI Automotive Infotainment Software Architecture Report

This document's purpose is to offer the reader an abridged or summary version of the report. To obtain a full report, which includes significantly more topics and detailed information, visit <http://www.genivi.org/mrd>. For general information, including GENIVI Alliance membership details, go to www.genivi.org.

