

The Innovation Cycle Dilemma

Helmut Lucke, Daniel Schaper, Peter Siepen, Michael Uelschen, Michael Wollborn

Advanced Driver Information Technology GmbH
Robert-Bosch-Straße 200
31139 Hildesheim

{hlucke|dschaper|psiepen|muelchen|mwollborn}@de.adit-jv.com

Abstract: Modern in-car infotainment and navigation systems will incorporate features from the automotive electronics as well as from the consumer electronics. These domains have very different innovation cycles, with effects on the hardware and software development process. The “Innovation Cycle Dilemma” refers to the difficulty in integrating both domains. This paper describes a platform that proved to fulfill the requirements from both domains.

1 Introduction

With the continued trend for more powerful computing platforms in the embedded world it becomes attractive for automotive suppliers to combine more and more driver information functionality onto a single microprocessor. This functionality may include car navigation, communication, media playback and management as well as connectivity. The development to combine such diverse technologies into a single unit is driven by a number of technological and commercial aspects: (1) The trend towards highly integrated specialized ICs, with low power consumption and packaging size, allow a compact form factor; (2) The aim by car makers to achieve higher product differentiation mainly through software [Hä07]; (3) The convergence of software standards, driven by the large popularity of home PCs and portable electronic devices; and (4) The demand of the consumer for cheap and reliable in-car navigation as well as infotainment features such as internet access and playback of different kinds of media.

This ‘convergence’ of a number of different technologies on a single platform is also happening in other areas such as personal computers or mobile phones. However, in the automotive world we are facing an additional problem: Automotive and consumer development cycles are very different [Sc06]. We will give an example:

Starting in 1983 it took 8 years for BOSCH from development to introduction of the CAN bus. It took another 10 years until the CAN bus reached the lower mid segment of automobiles. In contrast, Apple needed less than 1 year to develop and launch the first iPod. In 2005, already the 5th generation was introduced.

In this paper we will describe our approach to overcome the issue of different innovation cycles of the automotive and consumer electronics business. We will focus the discussion on three main areas which we think have most impact on these challenges. These are: International Setup, Development Strategy, Flexible and Scalable Platform.

2 International Setup

Advanced Driver Information Technology (ADIT), an engineering joint-venture between BOSCH/Blaupunkt and DENSO Corp. (the parent companies), started in 2003 at two locations in Germany and Japan to develop a world-wide applicable platform for future driver information and car navigation systems including hardware and software. This setup allows the sharing of development cost and fosters the exploitation of different strengths of the parent companies in the areas of engineering and long-term strategy planning.

The development builds on existing technology as well as on new developments and integration of 3rd party components. Despite the obvious difficulties due to communication overhead and cultural barriers, the international setup has resulted in a number of advantages to the parent companies:

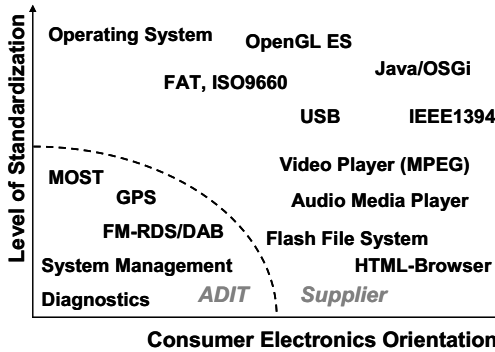
- i. **Reduction of cost.** Natural, for a joint set-up as costs are shared.
- ii. **Reduction of development and test time.** Often one parent company drives a particular technology more and earlier than the other. The following parent company profits from the maturity of such a technology.
- iii. **Worldwide usable platform.** Both parent companies provided ADIT with their respective Intellectual Properties (IP). As a result, the platform is well suited for both the European as well as the Japanese market.

3 Development Strategy

As indicated in the introduction, from a software engineering point of view, we are facing the challenge of integrating a large number of different software modules onto a single platform and to provide our customers with the latest technologies despite the different development cycles. We approach this problem by utilizing 3rd party know how and standardization.

3.1 Use of 3rd party know how

The figure below shows some of the technologies that need to be integrated into a modern car infotainment platform such as the ADIT platform. We differentiate among two axes: the level to which standardization is available and the extent to which the technology is driven by the consumer electronics industry.



If the level of standardization is high, there are usually well positioned technology providers available, who can supply the module with only a minimum of adaptation. Managing such companies is relatively straight forward as the requirements are well understood. On the other hand, if the technology is driven by the consumer electronic industry there are usually 3rd party vendors who actively drive a particular field. Even though

standardization may be low, these companies are in a better position to follow up these trends and respond quickly. By building partnerships with these companies we aim to provide the latest technology trends to our customers. This leaves components with a low degree of standardization and low degree of consumer electronics orientation. Here we see our core know-how and therefore these components are developed by ADIT as our core IP.

As the result, ADIT cooperates with suppliers located all over the world. Some are well-known IP-holders who would be unwilling to change their IP to fit a given architecture; others are small niche players who are experts in a particular field. While ADIT aims at having a flexible architecture that allows the integration of a diverse code-base from different manufacturers, we try to avoid adherence to strict architectural principals which would cause obstacles to our suppliers.

Finally it can be stated that we did not force all current technology trends to be integrated in our platform. An example for this is a mobile phone application. The mobile phone development cycles are about 6 months. This is not compatible with either the OEM or the after-market development cycle of automotive products. Therefore, we decided to provide standardized interfaces for the use with current mobile phones.

3.2 Use of standards

In order to facilitate quick development and software integration by our suppliers the strategy is to utilize standards wherever possible. However, we had to evaluate carefully the appropriateness for automotive (and embedded) use. One example is the graphics API. Since proprietary graphics APIs were used in the past, it was the objective of ADIT to define a new set of standardized graphics APIs. ADIT has chosen the standards OpenGL-ES and OpenVG, defined by Khronos group [Tr06]. OpenGL was also considered but rejected as it is more demanding on computational resources. Two examples are the glBegin/glEnd functions, which are removed and also the use of single-precision and fixed-point data-types.

The OpenGL-ES API covers 3D graphics with the target of 3D map presentation. OpenVG was chosen as a standard API for 2D vector graphics for less demanding applications such as a browser and HMI.

The use of standard APIs enables our customers to develop products in parallel to the platform development. Another benefit is that 3rd party software suppliers can develop on top of the standard APIs and hence reduce development cost. It is also expected that follow-on costs will be lower as standard APIs tend to be more stable than proprietary ones.

4 Flexible and Scalable Platform

The hardware platform developed by ADIT consists of two automotive qualified ICs, which, for the purpose of this paper, are called NAV-IC and MM-IC. The NAV-IC mainly addresses automotive functions like GPS, Digital Radio, Telematics, car networks CAN, MOST etc. The MM-IC integrates consumer electronics technology like 3D graphics, DVD Video, Digital TV and IEEE1394. This chipset faces the challenges of combining automotive and consumer world, in particular flexibility and scalability.

To allow **flexibility**, only established functions like GPS, USB, CAN, etc. are realised in hardware, while both chips provide sufficient computing power to realise many non-established functions in software. Since both chips share the same basic architecture of CPU, internal bus, memory controller and standard interfaces, software development is simplified. Further, by applying different development cycles to these ICs, the different innovation cycles of automotive and consumer electronics world can be addressed.

To allow **scalability**, a broad range of different products is supported. For example, an entry or mid level navigation device with only 2D or 2,5D map is realised by just using the NAV-IC. For building a high level device, which supports features like 3D navigation map, high level speech recognition and multimedia playback, the MM-IC is used in addition to the NAV-IC. In this case, both chips are connected by PCI-Express in order to allow communication between applications and high bandwidth data transfer.

The ADIT software platform supports this flexibility and scalability by providing a number of abstractions at different levels. A key requirement is that the applications should shield from the different hardware configurations that are possible. Thus the middleware has to provide simple logical interfaces which hide the particular hardware configuration.

A communication mechanism is developed which provides optimized communication between software modules independent where they reside physically (which processor) and logically (user vs. kernel space). Thus the platform software can be built in many different configurations using identical source code.

Hardware devices are abstracted using a device specific control module that encapsulate common functions such as device diagnosis, start-up/shut-down/low-voltage behaviour etc in a uniform way. This simplifies software maintenance and upgrade to additional devices.

Since “entertainment” is an important feature of the platform a streaming abstraction capable of stream management via IEEE1394, MOST, I2S, PCIe, including resource allocation and conflict management is also provided.

5 Summary and Discussion

We presented an approach to develop a complex hardware and software platform for the automotive market, targeting products for navigation and infotainment. The increasing difference of innovation-cycle lengths in the consumer and automotive world posed a significant challenge to our work. In response to this challenge we utilized our international setup and effectively employed 3rd party technology experts especially in the consumer electronics domain. In parallel a scalable and flexible hardware/software architecture reflecting the different development speeds, based on industry standards wherever feasible, was pursued from an early stage.

It is evident that Consumer Electronics is driven by ever shorter innovation cycles. This poses a problem to business planning for automotive manufacturers which traditionally plan along longer innovation cycles. In 1998, the AMI-C consortium [Ha04] was formed among the world's major carmakers to develop standard interfaces for multimedia components; however, this initiative was not successful as it failed to find a consensus amid fast changing consumer electronic trends. Eventually major car manufacturers withdrew their support.

The AUTOSAR Initiative [AU06] an open standards organization was formed in 2003 to provide standardization and interchangeability for automotive software components. Though all software components within the vehicle were targeted, good progress was made only on the standardization of electronic control units for various sensors and actuators of the vehicle, but little progress was made defining multimedia protocols. Eventually AUTOSAR decided to postpone multimedia standardization activity. These examples show the difficulty for automotive suppliers, be it OEM or Tier1, to incorporate multimedia developments into their infrastructure.

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