
Open Architectural Car Multimedia Platform

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Clarion Co., Ltd.

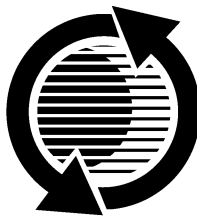
Reprinted From: Vehicle INFOTRONICS:
Enabling the Integrated Mobility Experience
(P-328)

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ISSN 0148-7191

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Printed in USA

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ABSTRACT

In the near future, car multimedia systems will be essential to enable emerging digital media and cater to expanding business opportunities utilizing various information contents. Since a strong demand for the standardization to be ready and beneficial for both the customers and the manufacturers exists today, an open platform is the most desirable. Clarion has co-developed an open architecture in-car multimedia system in a 1DIN form factor for installation in the dash of a vehicle. This open architecture, known as Auto PC, is powered by the Microsoft® Windows® CE 2.0 operating system. This in-car multimedia system will provide solutions for the major tasks required of next generation in-car information systems.

INTRODUCTION

Car audio devices, as in-car entertainment equipment, are going through metamorphoses in their configurations from the conventional combination of an AM/FM radio and a cassette tape player to digitized music sources such as CDs. Moreover, navigational systems are enjoying booming popularity, especially in Japan. Navigational systems, along with LCD display devices, are further refining themselves and are now considered to be the vehicle's information center.

Data storage and delivery is also evolving. With improvements in both storage technology, most recently witnessed in memory and DVD technologies, and wireless technologies, digital data will become more prevalent. The biggest benefits of digitized information are: 1) ease of creating content, 2) easy handling, 3) data integrity (lack of data degradation) during transmission, 4) easy automatic control, and 5) lower product cost to the end user. It is obvious that media utilized in the car environment will become even more versatile and digitized. Also, recent trends suggest vehicles to become a tool to provide not only transportation but also enable productivity in a mobile information environment.

In the near future, a car will be expected to process new digital media information on a real-time bases. The infrastructure of such digital media information is currently taking shape by social demands. In order for in-car multi-

media systems to process this multimedia information, it will be necessary to integrate all the potential technologies into a platform, similar to how its counterpart, the personal computer, has been combined. In this paper, the importance of an open architecture concept and the benefits experienced by both consumers and manufacturers are explained.

DIGITIZATION OF MEDIA

DIGITIZATION OF PACKAGED MEDIA – Large capacity packaged media, such as high-density optical discs like DVD, will become increasingly popular in the automotive environment to provide visual information or to store high quality audio information. With the introduction of DVD-RAM, new applications such as re-writable map databases for navigational systems are expected to become available. Also, IC memory, with its increased capacity, will be used as a major information medium.

DIGITIZATION OF BROADCASTING MEDIA – Digital broadcasting is currently being investigated to replace existing worldwide analog audio broadcasting (e.g., AM, FM). Some hybrid services (e.g., RDS in Europe, RBDS in the United States, VICS in Japan) have already been implemented with digital information being broadcast on FM subcarrier channels. DAB is the first true digital audio broadcasting system and is being rolled out in Europe and Canada. Digital TV broadcasting which can be received in a moving vehicle is currently being examined in Japan. Mobile communications reception via broadcasting satellites is being studied. As a result, broad bandwidth downloading of digital information into a vehicle via a digital broadcasting will soon become a reality.

DIGITIZATION OF COMMUNICATION MEDIA – In the wireless communication realm, digitization is also the trend for increased radio spectrum efficiency. Digital telephone systems are already widespread at a global scale. New systems have already been proposed in an effort to increase the data transmission speed. The establishment of ITS (Intelligent Transportation System) has been examined worldwide. Wireless communication is considered as a key technological function of ITS to exchange information between roadside infrastructure and the vehicle.

VARIOUS DIGITAL MEDIA – As stated above, the advancement of technologies is driving versatile new media to enable the transmission and reception of multiple types of digital information. At the same time, consolidation of functions among each medium will take place. With these advancements, information systems will no longer be dependent on only one medium, and will in fact rely on multiple media forms for the delivery of information. For example, Japan's VICS system utilizes simultaneous reception of data via several media types. In VICS, FM subcarrier broadcasting and infrared/microwave beacon are used to receive real-time traffic information, and the map database in the CD-ROM is used to display the best route based on traffic conditions. Cases such as illustrate how the borderlines between the communication realm and the broadcasting realm are disappearing. In fact, competition between packaged media and wireless media will soon occur. For example, map data for navigational systems are contained on a CD-ROM in today's implementation. In the future, downloading the same data from a satellite will be possible.

DIGITAL CONTENTS BUSINESS

The principal function of automotive electronics is to provide the user a comfortable space that is fun to drive, convenient and safe. In order to achieve this goal, real-time digital information that utilizes communication infrastructures (e.g., emergency service, traffic information, route guidance, general information service) are aggressively being introduced into the auto environment. Content delivery services are drawing strong attention as potential profitable business opportunities. Route guidance or traffic information will be crucial for the driver to reach to his/her destination in a timely manner. In some countries, emergency communication systems are already in operation to better handle life-threatening emergency situations.

This indicates that the driver no longer collects information passively. Rather, he/she can now aggressively collect information via external network resources. The car interior can be transformed from a cabin where the driver sits to get from one place to another to a place where the driver can collect vital information such as route guidance or POIs (Point of Interest) from an information service provider or via the internet. Such environments are becoming a reality in many places all over the world.

The result is the possibility for the automobile to shift its existing role from a mere commuter tool to an "information space" with global-scale connections.

IN-CAR MULTIMEDIA SYSTEM

New functions are required for the in-vehicle equipment to cater to the evolution of the digital media environment. Since the infrastructure is making major progress daily, corresponding devices should follow to keep up with these changes. Technically, simply applying existing products' technologies will easily enable the functionality

for each new medium. However, numerous difficulties such cost, installation or operation issues remain.

HARDWARE COST – In the past, new devices were added for each medium. This practice is believed to raise the cost of the whole system due to the duplication of fundamental functions such as operation, display or calculation.

INSTALLATION SPACE IN A VEHICLE – Limited space in the vehicle will cause inevitable problems as long as a device must be added each time a new medium is introduced. In order to avoid space problems, possibilities of combining black box type equipment and infrared remote controls exist. If several remote controllers are required, each remote controller will only operate a single function resulting in safety hazards of verifying the proper remote controller while driving. Verifying the switches on a moving vehicle will also cause a serious safety hazard.

COMPUTER-BASED MULTIMEDIA SYSTEM – The ultimate solution for all the problems described above is the establishment of a computer-base multimedia system. In reality, almost all media are digitized in today's world. As experienced with the PC, achieving personal, function goals by using software that is application specific on a common platform enables efficient input, processing and output. By implementing a common HMI (Human-Machine Interface), space savings, cost reduction and cohesive tactile feedback are easily achievable. If key components such as ICs can be carried over from a PC, the cost of hardware can be drastically reduced.

Segmentation of hardware and software – The common practice of separating hardware and application software in the computer industry could happen to the AutoPC. This factor could cause revolutionary changes in the existing business structure.

Expandability – Multimedia systems allow customers to build configurations to best suit their desired functionality. Customers are not forced to make a major investment during the initial purchase. They can easily start with a basic system and gradually expand the system with both hardware and software upgrades in the future.

HISTORY OF OPEN PLATFORM

CURRENT ISSUES –

Lack of compatibility among manufacturers – In the past, target functionality was achieved primarily by hardware. Recently, embedded microprocessors have been developed, with the hardware controlled by proprietary software. More major-scale hardware products such as navigation systems with computerized hardware configuration are available now. However, the compatibility and the connectability are not guaranteed between manufacturers because of the lack of an established standard. Customers are forced to select one manufacturer to com-

pose an entire system that may consist of several pieces of equipment.

Barrier among proprietary systems – In the retail market, each manufacturer builds a barrier when a customer purchases its product as the main unit. This situation restricts a customer from selecting potentially better products from competitors.

Car manufacturer's own standard – Similar to the situation in the retail market, there is virtually no existing standard in terms of system compatibility among car manufacturers except the physical layer on some external buses.

Difficulties in introducing after-market products – In the case of analog audio systems, a user can easily modify his/her system by replacing the radio/cassette player or adding amplifiers. Enthusiastic users who are not content with the original manufacturer's original parts are at least given opportunities to upgrade the system.

In the case of multimedia systems, adding or connecting new functions to the standard equipment system is difficult unless room is provided during the vehicle manufacturer's development phase, or the vehicle manufacturer prepares a solution themselves. Due to the lengthy development period necessary for a new vehicle, timely introduction of a new function is rather difficult.

Model year compatibility – Guaranteeing compatibility, even among products from the same manufacturer, is difficult due to the different development period these products went through.

MERIT OF THE STANDARDIZED MULTIMEDIA SYSTEM – As discussed above, standardization for in-car multimedia has not yet been implemented. The following merits are expected to become reality once a new industry standard for both hardware and software that guarantees connectability and compatibility of the entire system is established:

USER MERITS –

System expandability –

- Users are not forced to replace main units when a new function is introduced.
- Users can gradually build up the entire system by upgrading hardware and software.
- Users can tailor their systems to their desired level of functionality.
- Upgrading the entire system will improve performance.
- Improved functionality can be achieved via software upgrades.
- Functions can be expanded by adding peripheral devices.

Manufacturer choices –

- Users can choose optional equipment from among numerous manufacturers.
- Users can select among abundant application software provided by third parties.
- Users can enjoy a wide range of software and hardware solutions made possible because they are developed on the same reference standard.

Uniform Operation – Once the user interface is standardized, users can easily learn the operation of each newly added function based on past experiences.

MERITS FOR RETAIL MANUFACTURERS – Today, even major manufacturers find it difficult to create large-scale systems using only internal resources. For proprietary system development, a manufacturer must develop all the hardware and software on its own. It is easy to image how hard a timely development can be depending on the available resources. It is also possible that a manufacturer has no choice but to develop devices with different specifications for each system. Development expenses could skyrocket, resulting in a higher price to the end users or a delayed product delivery. By adopting an open platform, the manufacturers building systems can achieve the following merits:

Timely market introduction – Once a common platform, especially one with an OS that operates application software, becomes widely adopted, development times can be dramatically shortened. This is because existing software providers can be used to implement new functionality, and the hardware manufacturer can concentrate solely on designing and developing hardware.

Creation of a new market & market share expansion – Once a common platform is publically accepted, manufacturers will be able to reach potential customers who have traditionally been reluctant to invest in proprietary systems. Easy-to-use and user-friendly systems with proper price settings are achievable. Some small markets were previously ignored for many reasons such as an uncommon language spoken in a particular market. With the permeation of the common platform, it is now possible to yield lucrative business opportunities from these small markets.

Development cost allocation – A manufacturer no longer needs to develop the entire system on its own. It can focus its developmental efforts on its most capable area. The entire system development cost can be reduced.

MERITS FOR THE ASSEMBLY LINE ADOPTION BY CAR MANUFACTURERS – Today, the multimedia infrastructure is on such an aggressive growth path that the most recent system cannot be incorporated into a new vehicle model. The open platform provide bridges the gap by enabling the addition of new functions constantly by simply updating the software and hardware. With an

open platform, it is possible to compose a system by using existing modules to reduce the developmental costs. Parts can easily be carried over to reduce hardware costs. If a standard module of a different manufacturer is adopted, there is no need to rely on a single supplier.

NEW BUSINESS CREATION – The separation of hardware and software allows third parties called IHVs (Independent Hardware Vendors) or ISVs (Independent Software Vendors) to enter the business together with existing system manufacturers. Moreover, new services utilizing this common platform are expected to emerge as application software becomes more refined to allow information access, emergency services and efficient vehicle maintenance.

DEFACTO STANDARDIZATION – Public organizations such as ISO take a long time to complete standardization processes. In rapidly growing industries such as PC or multimedia, the actual industry standard supported by many manufacturers functions as the official standard. This standard is called a "Defacto" standard. A defacto standard among in-car multimedia platforms has never existed. The standardization of this system requires the following conditions:

- Guaranteed compatibility among application software manufacturers
- Guaranteed compatibility among devices to exchange content
- Guaranteed compatibility among peripheral devices
- Highly common operations
- In many cases, OS manufacturers take the initiative in setting the standards for computer-based systems. This is because the OS itself plays a major role to connect hardware and application software while managing the interface of each of the modules.

AUTO PC

Clarion has co-developed, together with Microsoft, the Clarion AutoPC which utilizes a vehicle optimized OS based on an open architecture. Microsoft Windows CE 2.0 is the base OS for this system.

The Auto PC includes vehicle navigation, digital entertainment, wireless communication and other application software. It provides a safe and efficient user interface including voice recognition and text to speech for hands-free, eyes-free operation. With the optional cellular interface, the user can instruct the in-car multimedia system to dial a contact contained in the Address Book, a contact that could have just been transferred from the user's Handheld PC via infrared data transmission. The user can receive wireless content, such as real time traffic updates, can be pushed to the vehicle via various wireless carriers. A high-end digital audio system with full digital audio processing results in high-quality sound.



Figure 1. AUTO PC

HARDWARE ARCHITECTURE – The in-car multimedia system consists of three modules, a faceplate module, CPU module and support module. The CPU and support modules are connected via the PCI bus.

The CPU module primarily consists of the microprocessor, PCI controller, DRAM and ROM memory, and ASIC.

The support module consists of the following:

- PCI devices including an IDE controller, USB controller and one ASIC. The CD-ROM device is connected to the IDE controller.
- Input ports for audio source and processing components. The audio path for the tuner is as follows:
 - The AM/FM tuner is connected to the Codec's A/D converter.
 - The digitized signal goes to the DSP for sound processing.
 - The digital signal returns to the Codec for D/A conversion.

The audio path for the CD is as follows:

 - CD music data goes to the DSP for sound processing via the PCI bus by DMA transmission. The DSP equalizes the sound and enhances the sound by adjusting the bass, and treble, volume and adding surround sound effects.
 - The processed digital signal is transferred to Codec.
- Synchronous SRAM data buffering of sound data enables real time sound output without skipping.
- UART for connection of a GPS receiver.

The third module is the faceplate module that controls the user interface. It includes a color LCD with 256 x 64, 3 bit resolution. It incorporates an IrDA input that enables the "squirting" of data between other Handheld PC or Palm Sized PC devices. It is connected to the support module via an high speed serial bus.

This system incorporates industry standard bus architectures for digital data transmission including a PCI bus, I2C and SPI busses for controlling audio source components such as the tuner, DSP, and Codec, and I2S for digital audio data transmission.

SOUND DATA PROCESSING – The AM/FM tuner is controlled via the I2C bus. The signal from the tuner goes to the A/D converter. Each audio channel is digitized with 20-bit resolution at a 44.1kHz sampling rate. The digitized data goes to the Support ASIC through a 32 bit for-

mat serial bus and is truncated into 16 bits for each channel. This data goes into the SRAM for buffering and to the DSP for sound processing through the serial bus.

CD music data comes to the Support ASIC through the PCI-IDE bridge controller and is sent over the PCI bus by DMA transfer. After buffering in SRAM, this data goes to the D/A converter via the DSP.

A monaural signal is used for microphone input for speech recognition. The analog input is digitized with 20-bit resolution in 44.1 kHz. This data is truncated into 16-bit and decimated down to 11 kHz in the DSP.

VEHICLE USB PERIPHERALS –

USB in the car environment – Various kinds of peripherals are available for the Auto PC. The primary system expansion for these peripherals will be through Universal Serial Bus (USB). Cellular phone interfaces for wireless communication, security systems, and CD changers will be connected by USB to the Auto PC.

Vehicle USB system – Clarion's Auto PC is using a different type of USB connector from the one defined in the USB specification. This is because the vehicular environment poses unique challenges such as a 12V supply, environmental reliability against shock and temperature, and installation ease. The Vehicle USB connector consists of eight pins, four pins of which are identical to the existing USB connector including Signal +, Signal -, 5V and ground. The other four pins are defined for 12V, ground, and wake up, with one pin not used. To preserve battery life, the USB host controller is powered off in stand by mode in the present architecture. The main unit host side will be woken up by the device side through the host up line in the event of an emergency. The term host up line is used instead of wake up line to differentiate the implementation used in the Auto PC from the wake up function defined in USB specification.

Development of the USB CD changer – The first device which will be shipped to the market is an USB CD Changer developed by Clarion. This CD Changer incorporates an ATAPI interface, with data and commands translated into USB format in an ATAPI-USB interface (AUI) ASIC. Isochronous data transfers are used to stream music data from the CD changer to the Auto PC host.

Wake up system of Vehicle USB – Currently, the USB controller is powered off to preserve battery life when the user turns off the vehicle. Critical USB peripherals such as security systems should wake up the host system in cases of emergency. The USB specification defines the wake up procedure through the data lines to wake up the USB host controller from a sleep mode; however the specification does not define the procedure to wake up the host controller from a powered-off situation. For this reason, Clarion implemented the host up line that is connected to a non maskable interrupt of the CPU.

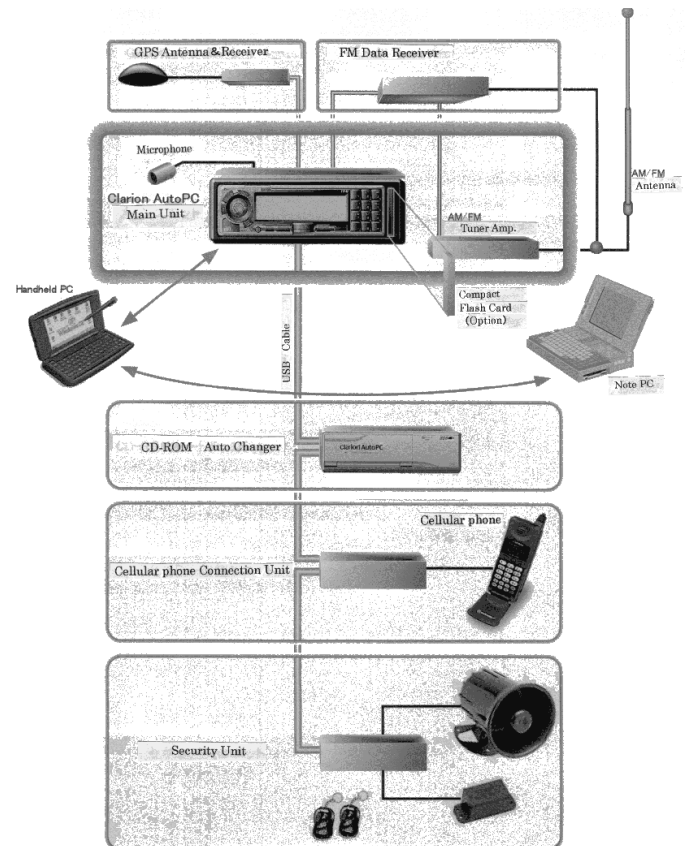


Figure 2. System Diagram

SOFTWARE –

Fundamental in-car application software – The OS will bundle several application software such as radio, CD player, simplified navigation (directions), and Address Book applications.

Interoperability – PIM information (i.e. address book) is useful anywhere, especially in the vehicle. With the Auto PC, PIM information can easily be input in the user's desktop computer. This information can then be transmitted wirelessly to the vehicle so that the user can always have the most recent information. Furthermore, the Auto PC allows all application software to use this centralized database. Therefore, the cellular telephone application can use the phone numbers to dial a contact, the navigation application can retrieve an address from the database, and the e-mail application can address an e-mail from this address book.

ISSUES OF CONCERN

WARRANTY FOR THIRD PARTY PRODUCTS – Numerous application software can run in the open architecture system as long as they comply with the OS requirements. It is possible to guarantee the quality of software that are originally bundled to this product by conducting pre-shipment tests. For after-market software and hardware, users must install them, cognizant of the fact that compatibility issues may exist. If software or hardware cause problems, it is often difficult to pinpoint the source of

problems. Therefore, certification programs or similar efforts must be considered. Also, in order to avoid confusion at the time the unit is sold, easy accesses to information concerning the connection of peripherals for users and dealers must be available.

INSTALLATION – The major difference between the Auto PC and the desktop PC is the installation into a vehicle that the Auto PC requires. Specially trained installation technicians are required to ensure safe and effective installations.

COMPUTER VIRUS – Computer viruses must be considered. For this area, the existing computer industry must be leveraged to ensure that effective countermeasures are in place before this becomes a problem.

CONNECTION TO IN-CAR LAN – Expanding the system by connecting the Auto PC to an information-base type or a simplified control type in-car LAN in the future is highly probable. When this is implemented, the connection method of the Auto PC to a BUS which might be only unique to a certain auto manufacturer must be considered. In addition, firewalls must be in place to ensure that “mission critical” functions cannot be accessed by the Auto PC.

MULTIMEDIA PLATFORM FORECAST

INFORMATION EXCHANGE WITH EXTERNAL SOURCES: A KEY TO THE DIRECTION OF FUTURE AUTOMOBILES – To increase productivity, real-time information (e.g., traffic information, road condition information) must be received and processed in an easy-to-understand and use format. To further enhance efficiency, the vehicle must also communicate with the existing road infrastructure for ETC (Electronic Toll Collection), which will be implemented in the near future.

Although each communication system has its own radio frequency allocation and wireless interface, the ultimate goal is to have data exchanged via the same digital format. The Auto PC platform, which processes this data by software can be the foundation of a system. Internet access is also desirable in the future. The open platform concept also has an inherent advantage for this functionality.

APPLICATION TO COMMERCIAL VEHICLES – Multimedia open platform is applicable for commercial vehicles and has a high potential for success. Cargo vehicles that must be constantly exchange data while on the move, commercial vehicles that need to access the database of an in-house computer network, and emergency vehicles are all equipped with computers today. All these vehicles are ideal candidates for the open architecture platform because of the cost (price and maintenance) benefits.

THE PERMEATION OF THE MULTIMEDIA OPEN PLATFORM – Would an open platform replace every single system? For information communication systems, it is possible for a few systems to satisfy a large portion of the market by combining their influence.

Open architecture → Growing numbers of corresponding systems by multiple manufacturers → Growing numbers of platforms → Growing numbers of participating third party software vendors → Enhance strength of a system in the market → Defacto standard

CONVENTIONAL PRODUCTS – An open architecture computer will not replace all existing systems, but it will certainly create new markets. Conventional systems that are specifically developed with certain focal points and less-cost effectiveness will still exist in a business arena where the abilities to expand, or compatibility are not required.

DRIVING CONTROL – Mission critical driving controls (e.g., engine, brake, steering) require extremely high reliability, and auto manufacturers should be completely responsible for these elements. Open architecture will not be implemented even in the near future for these areas.

CONCLUSION

Almost all media, packaged media, broadcasting media and communication media will be digitized. Computer based in-car multimedia system will play a major role to process the digital data in the dashboard. AutoPC is introduced as the first open-architectural car multimedia platform. Open architecture has many merits for users, retail manufacturers and car manufacturers and creates new businesses. Although some issues of concern regarding the open platform exist, it is expected to be key in the development of future automotive electronics, entertainment, and information systems.