The infotainment in vehicles will undergo a big change in the coming years. The FM radio will be replaced by digital high definition radio, digital audio broadcast, and satellite broadcast systems.

The second big change is triggered by the advent of digital media management. Today, 60 million people in the U.S. have downloaded digital music and 59% of those Americans who’ve downloaded music are older than 34. 60% of all U.S. households profess an interest in subscribing to a service that allows them to create their own playlists and have their music in a format suitable to a mobile lifestyle. 46% of U.S. households will have broadband access by 2007 and nearly 30 million households will have data networks by the end of 2007, mostly based on 802.11x wireless (Wi-Fi) technologies. Already there are 2M Wi-Fi networks in use as of Q2/2003 compared with 300K in Q3/2001.

This is clearly a trend that is mainstream today. Music delivery through the Internet allows endless customization and is already economically feasible to distribute personalized, non-mainstream content. Because nobody wants to listen to music solely at the PC, people began compiling playlists and burning CD-ROMs to play back at home stereos and in their cars. But the Rip–Burn–Carry process is very inconvenient and time intensive.

How can it be done more conveniently? Delivering media from the PC to various receivers throughout the home via digital wireless networks is a very compelling proposition. Already, more than 600 forum members support Universal Plug And Play (UPnP) as the standard for media serving, rendering, and control. UPnP is based on W3C standards such as TCP/IP, UDP/IP, HTTP, SOAP, and XML. The UPnP Media Server and AV Protocol describe how a “control point” can access, transfer, and render media files on a networked consumer electronics device. This topology allows a user to maintain a media library on a home PC or entertainment center, and distribute the media to any device in the home and car. Furthermore, it eliminates the need to mix and burn CDs, thereby saving time and improving ease of use.

How can the car be connected to this paradigm? This paper describes the ways of connecting cars to digital content and lists the requirements for building a successful system.

The first question is how to connect cars to media in the home or Internet. Using cellular data channels would not fulfill the performance and cost requirements. In comparison, 802.11x wireless LAN technology provides compelling broadband performance at zero marginal cost per bit delivered. In addition, cars spend a lot of time at home, parked in front of the house. This time can be leveraged to update media in the car.
This leads to the second requirement. Cars are “sometimes” connected devices and cannot stream content from the Internet when on the road. They can only be connected at certain places at certain times. Therefore, media must be cached on a hard drive or on flash memory for playback.

If the memory is removable, it can be carried between the car and a media server (e.g., home PC). Alternatively, a wireless LAN can connect the car to the home network while the car is parked at the house. Finally, the car can update its media whenever it finds a wireless access point hotspot. The biggest availability of WLAN systems today is at the home. However, the worldwide fee-based hotspot market will grow significantly from 28,000 access locations in 2003 to 145,417 access locations worldwide by 2007. Figure 1 highlights the three different methods to deliver media to the car:

The UPnP framework enables all three mechanisms of content delivery. The in-car software embodies a UPnP Control Point and a Media Renderer. Application programming interfaces enable OEMs to develop custom graphical user interfaces (GUI) and features, and provide an abstraction to vehicle controls and buttons to browse and play media in the car. Figure 2 shows the overall architecture of the embedded system.

Figure 1: Content Delivery to Cars

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Leveraging UPnP Discovery Protocol services, a media player finds media servers in the home. The car media player then uses UPnP Content Directory services with synchronization extensions to transfer rich media files from the home server. Multiple media formats are supported, such as audio, video, and pictures.

The PC requires an intuitive UPnP compliant media management application that enables users to add and remove media from a media database. A PC UPnP media server then distributes this media to consumer devices in the car and home.

PC software should seamlessly integrate Internet and media owned by the user, and enable editing of metadata, metadata cleaning, and content recording/ripping, as well as managing UPnP devices.

In addition to the standard features mentioned here, connectivity to cars requires additional properties that will be discussed in this paper. They include:

- Content and device specific filtering synchronization engine
- Periodically and automatic synchronization of updated local and Internet services, media databases, playlists, and media
  - Automatically download and synchronize preferred daily content media and services from providers like Wall Street Journal, CBS, and others
- Support for limited power UPnP LAN connected devices
  o User defined timing for interaction with home
  o Software algorithms to monitor and manage synchronization cycle and process against available battery power
- Sync Interruption Recovery
  o Database corruption protection to prevent media corruption when synchronization interrupts occur
- Content Prioritization System that updates most important, short shelf life content first
- Interactive feedback mechanism
  o Mechanism to tag information and make it available at a different place and time
  o Shortcuts and enhanced content navigation mechanisms that allow safe, convenient access to media and metadata in vehicle environments
- Secure media transfer and digital media rights management
- Secure firmware upgrade through wireless LAN

Wireless LANs are changing the way information is exchanged between vehicles and the connected infrastructure in homes and beyond. Zero margin communication networks allow bringing of content to the car, updating navigation mapping and point-of-interest data, and will enable consumers to configure their cars from their living room, PC, or anywhere in the world on the Internet. The same mechanism also enables car manufacturers to collect vehicle data (e.g., diagnostics) while a car is operating and upload the data while the car is parked in the garage.