INTERNET MULTIMEDIA ON WHEELS: CONNECTING CARS TO CYBERSPACE

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ABSTRACT

An integrated solution to seamless connectivity and innovative in-trip services is being researched at the Daimler-Benz Research and Technology Center in Palo Alto. The Internet Multimedia on Wheels Concept Car has an on-board, integrated wireless communication system and the computing infrastructure to provide Internet connectivity from the car to any specific server on the Internet while stationary or in motion. Essentially, the car is like any other node on the Internet with a unique Internet Protocol (IP) address such as the Vehicle Identification Number (VIN). Thus, an entirely new type of services can be delivered to cars in an efficient and secure way through increasingly less expensive wireless data connectivity over the Internet.

INTRODUCTION

With the advancement of the computing and communications revolution, the Internet is becoming more and more part of our daily life. We send e-mail, check our bank account, read newspapers, and "surf" the net just for fun. New multimedia applications even allow us to listen to "Internet-Radio," watch "Internet TV," make phone calls, and do video-conferencing over the Internet. By contrast, this communications revolution has yet to reach the automobile. Drivers and passengers in cars typically enjoy access only to radio broadcasts and occasionally television. To reduce the unproductive driving time, people use their cellphone for voice communication. Moreover, today information cannot be personalized or adapted to the driver's and passenger's needs. The challenge is to provide the Internet's multimedia capability in the automobile environment with varying and limited bandwidth, thereby, enable a whole new class of services to and from the car.

At the same time, there is a strong effort in the Intelligent Transportation Systems (ITS) community to stimulate research and industry to build an infrastructure which will lead to better traffic and transit resources management and enhanced safety. From cost and reusability perspectives, it is necessary that a single infrastructure provides most of the functionality instead of building a separate system infrastructure for each service. Internet has the potential to be such an infrastructure. The car is essentially a probe in this model collecting and sending data to service centers, which in case of future navigation systems will be used for building dynamic real-time traffic models that would be used for on-demand route guidance by individual vehicles.

VISION

First we define the term "Internet Car":

An Internet Car is one which is like any other node on the Internet. Although it is highly mobile, it uses standard TCP/IP protocols to communicate with the other nodes on the Internet. An Internet car can be an Internet client as well as an Internet server. The car in essence becomes an open platform for services to be delivered over the Internet .

Some scenarios where the Internet car would be useful for drivers and passengers are:

- Services from Internet service providers e.g. safety, security, news, stock, city guide, navigation, email, and movies.
- Seamless access to office or home computer from the car.
- Personal devices (smart cards, HPCs) can be used to personalize car seats, climate, phone numbers, Internet services bookmarks, and computing man machine interface.
- Interactive audio/video games over the Internet for passengers.
- Personalized Internet based services e.g. "my" commute traffic information.

- Geo-specific information access on demand e.g. "nearest" Chinese restaurant.
- Internet based roadside assistance and remote diagnostics.

It is an open question what impact Internet content will have on the car, but it is our belief that ultimately it will be used to optimize the safety and security of the car along with comfort and convenience. Figure 1 illustrates a systems view of the Internet Multimedia on Wheels concept including a number of components that may be included in a full implementation.

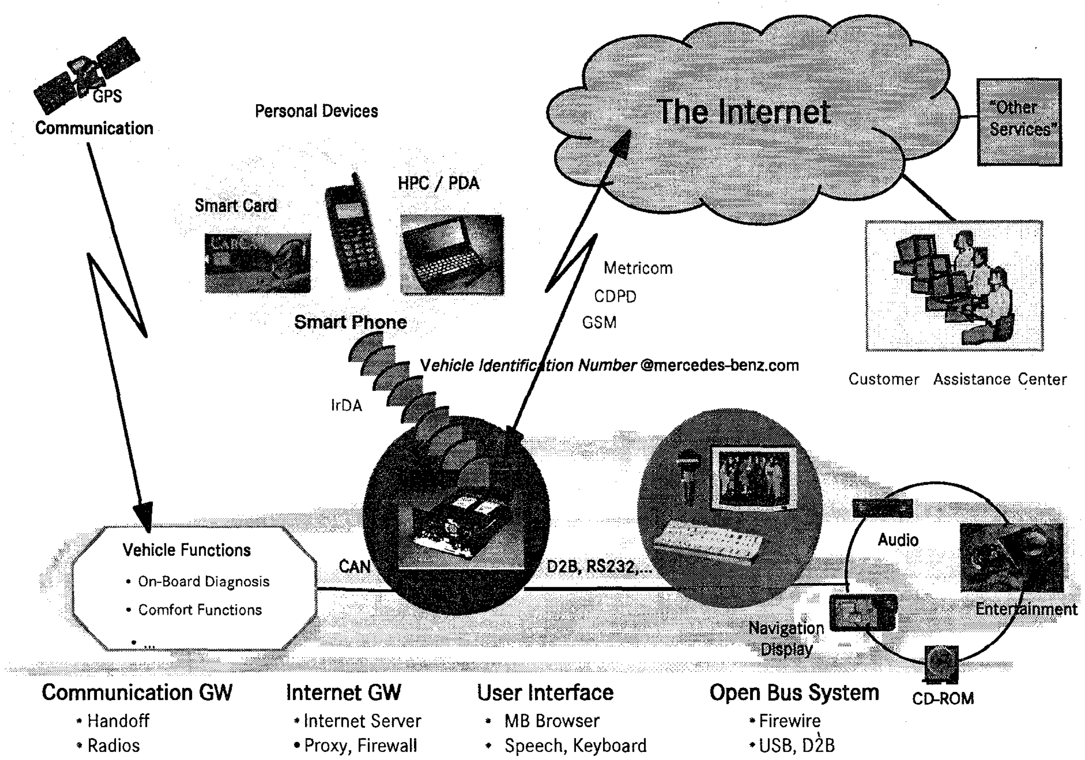

Figure 1: A systems view of the Internet Multimedia on Wheels concept.

There are a number of ways to bring the Internet connectivity and content into a car. These methods differ widely in terms of functionality, connectivity, in-car infrastructure and system requirements. The strength of connectivity to the Internet may range from a fully connected model where data and services are available all the time down to a disconnected model which requires the drivers/passengers to bring Internet data on a storage media with them.

MAJOR CHALLENGES

An overarching challenge for connecting cars to the Internet is to define a system architecture with flexible distribution of computing power and communication between the automobiles and the infrastructure. The answer may be as simple as the cost of wireless communication. At one end, the car may only have the input/output devices and a modem to request and receive information. On the other hand, the car may have state-of-the-art computing power with on-board storage media to receive raw data, and to process it. Clearly, the form of the final architecture will depend on costs and business models. In all cases it will always be necessary to maintain the integrity, security, reliability and speed of communication.

Wireless communication is expensive and the bandwidth is quite restrictive for applications requiring transfer of other than a few hundred bytes of text data. There are a number of wireless service providers using different flavors of communication protocols and bandwidth to support the Internet protocol e.g., the frequency hopping spread spectrum Ricochet network, Cellular Digital Packet Data (CDPD), and Personal Communication Services (PCS). The challenge is to provide the basic infrastructure that can provide national or global coverage without employing a whole array of modems.

The presence of multimedia information in a moving vehicle can be a potential hazard to safety of the car. It is essential that the software architecture is open for development of new services and benefits from being easily adaptable to new and evolving Internet technologies. At the same time a metric that will define what services are deliverable to drivers under what mobility conditions, and which services can be used by passengers should be established to optimize the safety in the car.

BENEFITS

Automobile access to the Internet opens up a wide range of new opportunities for drivers, passengers, and customer assistance centers. It also increases the security and safety of the car. The quality of travel can be improved by personalized route plans delivered to the car with up to the minute road and traffic information.

Drivers will be able to access their voice-mail, e-mail, and travel-related information such as restaurant guides and movie theater locations. The driver will have access to these services in a hands-free, eyes-free manner through voice commands and speech technology.

Passengers can additionally access richer interactive applications such as on-board or Internet games, audio-on-demand, and web surfing. They can access information about cities and historical places during a drive as they pass them.

Drivers and passengers can also use their personal devices like Smart Phones, Personal Digital Assistants (PDAs), Hand-held PCs (HPCs), etc., in an integrated fashion. Also, by integrating GPS and mapping technologies, the Internet car becomes "location aware" which will be used for a new class of services that will go well beyond classical navigation.

For the customer assistance centers that currently rely on a "telephony-based" service, the Internet car will provide a richer "datacentric" multimedia environment to deliver new services including operator's help manuals and intelligent roadside travel assistance. For these new services, user interfaces will be designed that allow easy and safe handling of the interactive media.

By grounding the concept and architecture of information technology for a car around the Internet and open standards, the Internet car can take full advantage of the tidal wave of Internet based services, technologies, and devices for many years to come, thereby transforming driving and riding into a completely new experience.

MOBILE SYSTEMS DESIGN

Inherently, the design of a system to provide access to Internet from cars must take into account the mobility aspect. Mobility in the system needs to be handled at two places. First, at the point of attachment (for example, at home or office), and secondly, during the time of travel. There are standardization efforts in this area already in the Internet community such as the Mobile IP proposal [1,2] along with the IPv6 proposal to Internet Engineering Task Force (IETF). In summary, Mobile IP assigns temporary care-off addresses to visiting hosts and directs Internet packets addressed to them at the home location to be forwarded to the point of attachment when a mobile (in this case the car) moves from one subnet to another.

Networking may be carried out using a variety of wireless technologies. Metricom, CDPD and Satellite based systems are the most attractive technologies in the US for connectivity to the Internet from the road. The 19.2 kbit/s bandwidth, CDPD wireless data service is already available in nearly 80 cities and may be used in conjunction with Circuit Switched CDPD to provide national coverage. Code Division Multiple Access (CDMA) is still being tested as a viable alternative for wireless Internet access. For short range data transaction, high bandwidth is typically the primary requirement. WaveLAN, IR or RF based solutions are most appropriate here. Finally, the new Java based smart card technologies will link personal information to cars. They will, in essence, provide a new way to communicate the identity of drivers/occupants to the car in an unobtrusive manner over the Internet. This information may then be used by the car to provide personalization of the seat position, climate, user interface in the car. The ramifications of such personalization features would include improved safety while driving, because mundane information for access to information services can be individually filtered out.

Internet communication is based on standard TCP/IP stack. However, TCP [3] does not have any special provisions to work over wireless connections. It's congestion control algorithm assumes that a time-out in transmission is due to congestion but not to the loss of a packet. So, when a timer goes off, TCP slows down and sends less packets to avoid the congestion. In wireless networks it is very likely that the timer went off because of the loss of the packet, so the proper way to deal with this problem would be to send the packet again as soon as possible. Currently there are two major ways to improve the performance of TCP over wireless [7]:

- Indirect TCP [4] splits the TCP connection into two separate connections. The first connection goes from the sender to the base station and the second from base to mobile station over the wireless link. The drawback of this scheme is that the semantics of TCP as an end-to-end protocol are hurt. The base station acknowledges (Ack) each received packet in the usual way but this is no guarantee for the sender that the packet has reached the receiver.

- Snooping Agents [5,6]. The basic idea behind this agent is that it observes and caches TCP segments going out to the mobile host and Acks coming back from it. Therefore, it sits in the link layer of the base station. When it sees a packet going out to the mobile host but sees no Ack coming back in a relatively short time, it just retransmits the packet without telling the source sender that it is doing so. When it sees a duplicate Ack from the mobile host going by, it also generates a retransmission meaning that the mobile host has missed something. The duplicate Acks are discarded to avoid a source of misinterpretation by the sender as being a sign of congestion. One drawback of this solution is that the system is implicitly aware that TCP is used as the transport protocol. Also, when the link is very lossy, it will run into the same problems as without the system. This can be fixed by a selective repeat mechanism which is applied when the base station notices a gap in the inbound sequence numbers. It requests a selective repeat of the missing bytes using a TCP option. The findings in [6] strongly suggest that such a TCP aware link layer algorithm improves the throughput and the goodput over wireless links substantially without compromising the end-to-end semantics of TCP.

Our research would focus on the questions, whether the snoop agent can be placed anywhere in the network and how this would change the performance of snooping.

IMPLEMENTATION

In the first implementation of the Internet Multimedia on Wheels concept, we have designed multimedia units for two different zones with the user interfaces as shown in the following figures. In these units, there is a color screen, channel select buttons, IrDA (Infrared) transceiver to support hand-held devices, and an audio outlet.

The access to applications is different in these two zones. The driver and the navigator have access to a single multimedia unit in the front (Figure 2), and the passengers in the back seat have access to individual multimedia units (Figure 3). The applications in the front zone are more traffic and navigation driven. In the rear zone, there is access to navigation, office applications, interactive games, and infotainment.

The driver has access to the navigation system and local or Internet based services. He will be able to use voice commands to access these services from the Internet.

The passengers in the rear can enjoy a richer multimedia environment on their multimedia sets for navigation, games, stereo, or Internet access. The built-in IrDA transceivers will allow HPCs/PDAs to interact with the systems in the car.

In addition, the hand-rest in the driver's zone has a slot for a personal device to enable the driver to bring in personal preferences to the car.

TODAY'S RESEARCH SCENARIOS

Drivers and passengers will use the Internet car for both fun and productivity. The Internet based navigation unit will plan a route which takes into account real-time traffic information and traffic history. Drivers will access news, voice mail, email, stock quotes, weather information all through a hands-free, eyes-free audio interface. Co-passengers will access rich multimedia information from various domains such as infotainment, office work, and entertainment. The car will empower the driver and passengers to choose the way they would like to spend their time from a large selection of options and services.

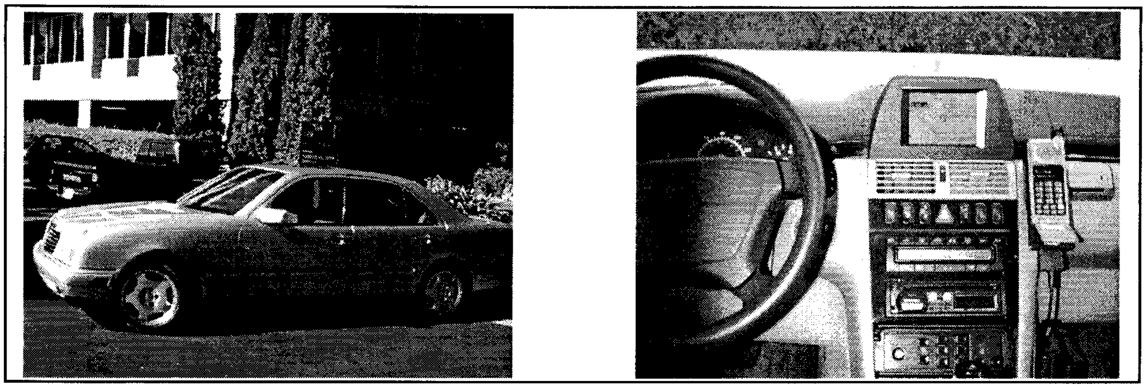

Figure 2: The E 420 Internet Multimedia on Wheels Concept Car and the front multimedia zone.

Figure 3: The rear passengers multimedia units with screens, channel selectors for games, computer, navigation, IrDA and Audio outlets

Furthermore, safety and security will be enhanced because Customer Assistance Centers will be always connected to the car. Services such as remote door unlocking, warning for bad road conditions, weather, accidents, and remote diagnostics, will add to the safety and security of cars.

THE FUTURE

Having an Internet address, the car becomes an integral part of cyberspace. Not only can passengers request information but also fleet owners and customer assistance centers can request information from the car or even modify the car's behavior. This ultimately leads to a network-centric solution where the car can be continuously monitored, and where in essence every Electronic Control Unit (ECU) will be addressable through the Internet protocols. In fact, the very concept turns every car into a probe with vast implications for traffic guidance and control.

It will be possible to analyze driving habits and optimize engine performance. Customer assistance technicians can download code to the vehicle to perform diagnostic tasks or upgrade the software version.

ECU's can use external data from the infrastructure to adapt in an optimal way to weather conditions, road conditions, and traffic to provide new safety services.

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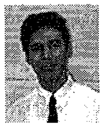
AUTHORS



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