# *Export Mobile Device Display Content*

## *Applications and User Interfaces for Inter-Vehicle Communication*

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***Abstract*—Within the Master Project *"Wireless Mobility"* this project was offered to IT Master Students during the second and third term and ran approximately over ten months. The project team developed a demonstrator platform to export the display content from a consumer mobile phone to a larger remote display, e.g. installed in a car. The key requirement was the utilization of non-proprietary technical solutions. This constrain did not limit the scope to standardized solutions only, but proprietary solutions ought to be open source or somehow accessible for the interested community. One important goal of this project was the awareness of latest design constraints and challenges in the Embedded Systems and System on Chip (SoC) area through a Project Based Learning (PBL) strategy. In this context, the students developed personal design competence, including specification, design trade-offs, design for testability, analysis and verification, and realization.**

***Keywords-Embedded System; wireless; mobility; Car PC; Project Based Learing;***

## I. INTRODUCTION

The Master Project *Wireless Mobility* was offered in cooperation with the company *Task9* to IT Master Students during the second and third term and ran approximately over ten months. Today mobile devices such as smart phones usually provide sufficient processing power for complex applications like street maps, internet browsers or multimedia players. In a typical scenario the consumer carries his device, e.g. a personal digital assistant (PDA), with him and has a multitude of personal data stored on the device memory like music files or podcasts. On top of these applications, one can imagine, that mobile phones can connect nearby cars to each other enabling so called consumer car communication based services.

A potential use case for communication between cars is media sharing, i.e. one car streams music that other cars in front or behind can receive. This way, the cars nearby are able to listen to music which is stored only on one car's PC. This scenario offers even more potential: Thinking of the car PC's music collection, one could imagine a kind of need-list broadcasting. The driver could provide a list of songs he would like to get from other cars in case they possess them. Thus, the car's music collection can be updated whilst stuck in traffic. As a further possibility, radio signals can be transferred between near by cars, which could obviate the need of antennas.

Figure 1. Car PC receives navigation data from a mobile device.

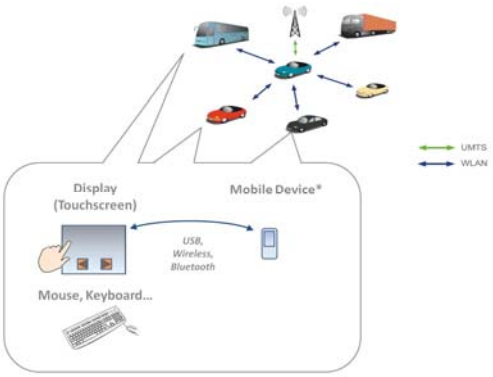


Figure 2. Internal and external car link connections [1, 2].

The mobile device provides various applications that can be controlled by the Car PC. For instance, a music collection can be stored on the mobile device and accessed by the Car PC. Another example is the use of navigation software on the device as shown in Fig. 1.

The car does not need a special navigation system any more but can rather use the mobile device in interaction with the Car PC for this very purpose. These examples demonstrate the advantages of having just one PC in a car that can be used by a variety of applications and devices such as mobile devices.

Anyhow, typical car communication has been expected to start with safety critical applications to improve traffic situation. However, from a technical point of view it is already feasible to interconnect cars via WiFi and cellular technologies by implementing their infrastructure, see Fig. 2.

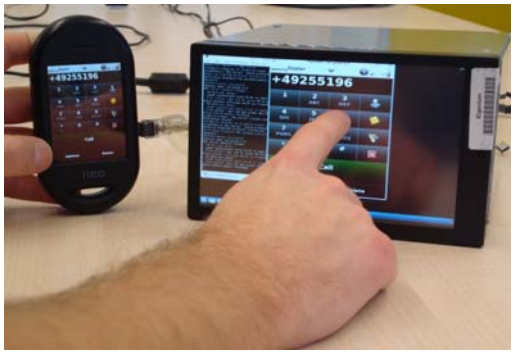


Figure 3. Dialing application forwarded to and used by Car PC.

Figure 4. The Car PC comprises off-the-shelf components only.

Additionally, this paper gives a brief introduction into a possible infrastructure scenario inside a car. Given the idea of an established connection between a mobile device inside each car and the car's infrastructure several applications become feasible. For example, it becomes possible to run a street map application on a mobile device and forward it to an in-car device. In this scenario there is no need for complex and expensive hardware inside the car. A single display with associated input devices is sufficient as all the processing is done on the mobile device. To establish the recurred link several opportunities have been examined within this project.

## II. Design

To handle the mobile device appropriately while driving without violating any existing traffic law there is the need for an embedded device in the car which is easy to handle. Therefore, it is conceivable to install a display or touch screen with a minimum of processing power and software which is embedded in the dashboard of the car and connected to one or more mobile devices (see Fig. 2 and Fig. 3). Depending on the complexity of the car-display it is possible to use different standard connection types like USB, Bluetooth or even WiFi to connect these devices and transport different kinds of information like display data. With this approach it is possible to export the user interface of a single application from the mobile device to the car-display and control it remotely with the help of any input device directly connected to the car-display

As depicted in Fig. 4, we developed the so called Car PC as a test vehicle out of off-the-shelf components. To provide an easy to use interface, the PC is equipped with a touch screen display. The integrated Intel Atom Platform, a Solid State Disk and various communication components (Bluetooth-, GPS-, UMTS- and Wireless adapters, and USB 2.1) ensure high performance and widespread communication possibilities.

## III. Challenges

The Car PC fits the standardized radio slot so no additional space is necessary. Common communication standards are Bluetooth, GPS, UTMS, Wireless and USB. A wireless communication is considered as the most appropriate one. The Car PC is embedded in an enclosed environment. That is why potential heat problems could occur. A possible solution for that could be heat pipes that lead the heat away from the PC's case. Feasible operating systems are Microsoft Windows and Linux. Windows provides driver support for most devices, so this would be a good choice for a smooth running PC. Using a Linux operating system like Ubuntu or Debian, on the other hand, offers more flexibility to customize the system. The demonstrator PC currently uses Ubuntu 9.10 in cooperation with the 9.04 version's kernel 2.6.28, because the 9.10 kernel tends to be problematic regarding wireless adapters. Furthermore, the calibration of the touch screen display was not supported. A Debian operating system should be given a try in a further development phase, because there might be less problems regarding the tools, specially because the current kernel 2.6.32 comes with out of the box USB touch screen support.

## IV. Results

The main achievements of this project are a prototypical endpoint to receive mobile device display data and a huge technical expertise how to set up the communications and the configuration of the selected protocols. The following knowledge was gathered:

VNC transfer is straight forward to use. The advantage is platform independency. A major drawback is the poor performance caused by its frame buffer protocol implementation. Tunneling single X11 applications including window managers (e.g. KDE, gnome, wmaker) via SSH was successful with good performance. Forwarding the X11 window system was not possible with the current configuration because of the operating system used, but worked on different configurations and therefore could be a desirable goal.

## V. Conclusion

The developed Car PC provides a perfect platform for further development of non-proprietary technical solutions. Connecting a mobile device to the PC and establishing a stable transfer with good performance between them still needs further development, as the available standards like X-forwarding need to be improved substantially. One could imagine a System-on-Chip solution that comprises all essential components of the Car PC and integrates them into a single chip. In addition, the costs of such a SoC solution could be reduced.

## References

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