15-413 Software Engineering

Carnegie Mellon University

School of Computer Science

JAMES

Problem Statement

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1. The Problem

Smart card technology has opened up a vast range of applications. Some of the key applications include pay phones, mobile communications, electronic cash, parking, health care and network access. The possibilities of smart cards are endless, because the smart card is a cost effective storage medium that provides high security and portability. It is estimated that by 2001, over 100 billion transactions will be made using a smart card. Smart cards will enable us to manage our daily and professional life, from ordering food and theater tickets to controlling our health insurance or finances via telephone, anywhere in the world. The chip can store all the information necessary to make tomorrow's paperless, cashless society secure and convenient, changing the way we live and do business.

One important application will be the use of the card for the automotive industry as a value added service. Within Mercedes-Benz there are ideas and concepts for a broad spectrum of chip card applications to support physical mobility, financial mobility (financial transactions), mental mobility (telecommunication, media services), and financial security (assurances) of the card owner (Figure 1).

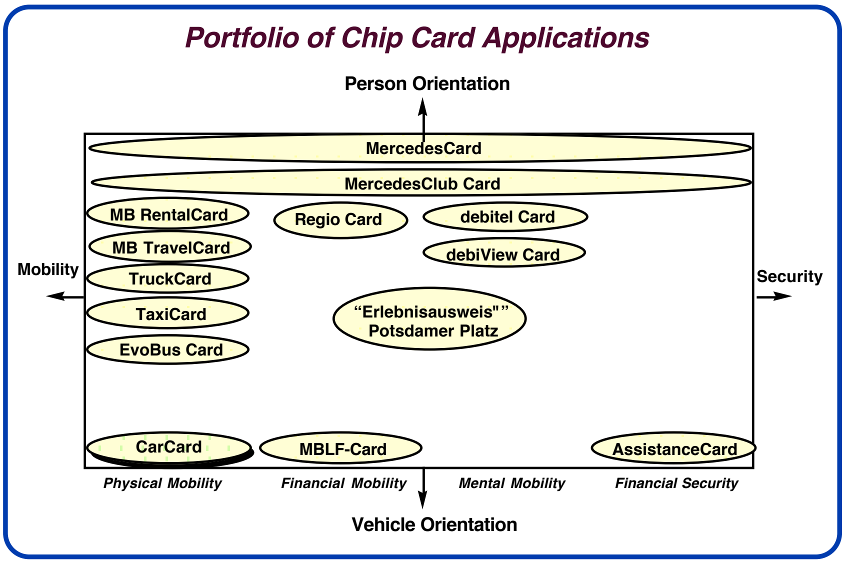

Figure 1: Portfolio of Daimler-Benz chip card applications

Daimler Benz Corporation plans to deliver a CarCard with each Mercedes-Benz passenger car sold. The card can contain car and owner specific data. The goal is to simplify car maintenance and repairs in the beginning at Mercedes-Benz service outlets, however in a second step at any service outlet, even for non-'Mercedes-Benz' repair shops. The CarCard data may include owner and driver data, car identification, car configuration, warranty data, maintenance calendar, maintenance and repair history, mobility guarantee, 24 hour service package, individual service packages, etc.

This Daimler-Benz CarCard will be introduced first in Belgium this year, followed by other European countries. This CarCard as a vehicle specific medium: a dealer performs a maintenance operation, adds a warranty description and makes customer specific notes that allow him to treat the customer in a very personal manner (Figure 2).

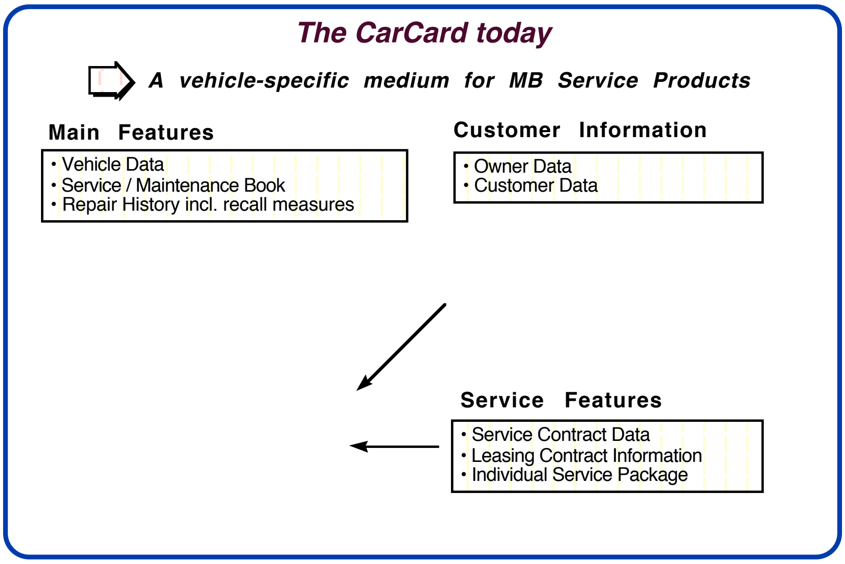

Figure 2: Today's CarCard features

The Problem

Several problems are emerging with the introduction of the CarCard. As of now, Daimler Benz has already issued various kinds of cards in addition to the CarCard. Other car manufacturers are contemplating the introduction of their own smart cards. At the current early state of smart card penetration in the automotive sector this poses a possibility of incompatible card standards and APIs between cards from different car manufacturers.

This would make it very difficult to comply with a law established by the European Union (EGVO), that requires by the end of the century that all automotive companies provide maintenance information for their cars, so standard maintenance jobs can be performed by any garage , whether it is affiliated with a specific car manufacturer or not.

Moreover, there is already an existing array of cards for all kinds of different applications ranging from banking, transportation, phone cards to health care cards. Because of customer expectations and current product characteristics only dedicated card applications are introduced, not a common chip card covering the whole application spectrum in one. If this problem is not handled carefully, the future smart card user will most probably be swamped with a plethora of cards if any service application requires its own card carrier, potentially leading to confusion and additional costs.

Another problem specific to the CarCard introduced this year is that its software solution is not extendible to include other applications. Each application has to be hand-crafted. This makes it very expensive to offer a portfolio of smart card applications.

2. Objectives

Daimler-Benz Corporation wants to reduce the variety of cards and to offer only one or two cards that can be customized for multiple purposes; i.e. that can host different application modules on demand.

This shall be achieved by the development of a standard software architecture for automotive chip card systems. To deal with many applications the architecture must be based on a common extensible infrastructure that allows the selective inclusion of applications from a smart card application portfolio. In addition, it is planned to define a class library specific for the needs of the automotive industry. Especially, the software architecture should allow to load / modify applications on the smart cards via the internet with an adequate security concept.

The main focus of the JAMES project is on an architectural vision with a twofold plan: First, to establish a software architecture for automotive smart card applications and second, to identify an automotive class library providing a set of common functions for these applications. We also plan to explore the issue of the interaction between smart cards and telematic applications because no standards are currently available for these types of applications.

To provide portability, the transmission of data from the smart card via the card reader to another software system must be independent from the smart card specific data format.

To cope with the complexity of these objectives, a software prototype must be developed in the JAMES project starting on August 26, 1997. The software prototype will be evaluated by the customer on Oct 24, 1997 to provide feedback to the developers. This might result in a refinement of the software architecture and the class library. A revised prototype must be delivered on December 9, 1997.

3. Scenarios

3.1. Maintenance Assistant

Mr. Rogers pulls into Mercedes delarship to get his fluids checked in his new Mercedes Benz 300 SEL. He gives Bob the Maintenance Guy his smart card. Bob the Maintenance Guy inserts the card into his card reader and pulls up Mr. Rogers' information. Bob notices that Mr. Rogers bought his car 6 months earlier and that he has driven it 5280 miles. The system informs Bob that Mr. Rogers is due for an oil change. The system also gets in touch with Daimler Benz headquarters and inquires about required services that need to be performed on 1997 Mercedes Benz 300 SELs. The system tells Bob that, according to Daimler Benz, seat belts were inadvertently ommited from this model and they need to be installed. The good news is that according to the smart card, Mr. Rogers has accumulated 250 Bonus Points (and receives another 20 for having his oil changed at the dealership). It turns out that this dealership is offering a reward of brand new windshield wipers for only 270 bonus points. Bob the Maintenance Guy tells Mr. Rogers about the exciting news and also that he will need to leave his car at the garage for 6 weeks while the seat belts are installed and the oil is changed. Mr. Rogers (knowing that he can get new tires for 1000 bonus points) decides to save his bonus points for a later time and only get the required maintenance done. Once the maintenance tasks are performed, Bob adds the information to the maintenance history on Mr. Rogers' smart card, updates the bonus point total, and sends Mr. Rogers on his way.

3.2. Log Book Assistant

Jim is a businessman that spends most of his life driving his car. Before beginning a new trip, Jim plans and prepares everything. On Monday evening he plans the trip for the next day. The plan includes leaving at 8.30 am, visiting some clients during the morning, having lunch with another client at noon, a visit to a branch office, and finally, attending a training session at the Columbus branch office at 4.00 PM. He expects to be back home around 6.30 PM. On Tuesday morning, he inserts the card into the car reader installed in the car, selects business mode, selects the trip prepared the day before and leaves his house to visit his first client. The address information about this client is in the card. He checks the address and other information about this first client while driving. Meanwhile, the card will register mileage and other information about this trip in order to allow future reporting. When he arrives, he indicates it to the card. The card records information about time and current mileage. This process is repeated for all the other clients. The time the car is stopped is also recorded. After having lunch with the client he realizes that it is too late for the visit to the branch office, so he decides to go directly to the training session. This is also recorded in the card. After this hard day of work, Jim goes back home, extracts the card from the card reader and keeps it in a safe place. At the end of the week, he downloads all the information about trips in that week and generates some reports to his company, that will include tax-deductible mileage, visits,?

The company CardTester Inc. has a fleet of cars. Each car can be driven by one or more of its employees, for commercial as well as for private purposes. When any employee needs a car s/he just takes one available car, insert her/his personal smart car in the card reader installed in the car and leaves. Jim, employee of the company, is responsible for the cars. He usually was in charge of recording all the information about car utilization, including who, when and why. However, now the way he does his job has changed. Now the employees use the car during the week with no direct control. Each one has a personal smart card that is inserted in a card reader installed in the car. It records information about utilization of the car. At the end of the week, all the information from the employees' cards is downloaded to a database system. The information downloaded includes purpose of the trip, date and time of departure and arrival, mileage, gas level, average speed and maximum speed amongst others. This allows to keep track of utilization of the cars, and to charge the different departments for transportation.

3.3. Travel Assistant

It is Thursday evening. Mr. Mark Smith will flight tomorrow morning to JFK airport in NY. He has to visit an important client in Manhattan at 11am. At the airport, he will be picking up the Mercedes Benz YYY that his company has designated for this situations. Since it is almost weekend, Mr. Smith decided to spend the weekend in New York.

Getting prepared for his trip, he requests directions to get from the airport to his appointment. He also requests the interesting places in Manhattan. He downloads the needed information into his smart card.

When he arrives the next morning to NY, he gets into his car and inserts his smart card into the onboard smart card reader. In the moment he turns on the engine, the system starts interacting with him to take him to his appointment. The onboard display shows him the zone map, his actual position and the complete route. Mr. Smith can ask the system to repeat an instruction, if he didn't understand.

After his business meeting, he decides to drive to Chinatown to have dinner. On his way to Chinatown, he wants to check if there aren't any interesting places to visit. Depending on his current position, the system will give him the appropriate message and will mark it on the map. He decides to stop at the Museum of Modern Art, and the system guides him to it.

3.4. VIP Assistant

Ms. Simpson gets into her Mercedes 300SL, sits down and inserts her SmartCard into the dashbard card reader. Because Ms. Simpson had specified that she would like her car to start automatically, the car starts when the card is inserted and verified. A voice played through the car's speakers says "Good evening Marge". Since it is the evening, the car's headlights and taillights come on, and the dashboard lights illuminate to the full brightness level as Marge had specified in her preferences. The dome light stays on, and the driver's seat and steering wheel slowly adjust to Marge's preferred positions as she closes the door. The rear view mirrors adjust to their proper alignments, and the climate control system is set to maintain a comfortable 71 degrees F (Note that because Marge lives in Springfield, which is in the US, Fahrenheit is used. However, the system may also be switched to metric, and it would then use Celsius). Marge's radio station preset preferences are loaded into the radio tuner, and the radio volume is adjusted to a comfortable level as the radio is tuned to her favorite station, FM 90.5. After the seats, mirrors, and radio are adjusted, the dome light turns off; Satisfied with her preferences, Ms. Simpson drives away in her Mercedes.

4. Requirements

4.1 Functional Requirements

Derived from the scenarios described above, the JAMES system should provide the following functionality:

Vehicle:

- Access to the functionality of a Mercedes Benz Car simulator provided by the Daimler Benz R&D division (F1)
- Provide platform independent Interface to the simulator
- Provide web-based access to the simulator
- Show that JAMES applications are able to be integrated with the existing electronic systems in the car (mirror position, seat position, speedometer, ...)

Maintenance Assistant

- Authentification of customer through Smart Card
- Synchronize the information on the Smart Card with the information in the dealer system
- Receive a maintenance task from Daimler Benz headquarters to be performed on a fleet of vehicles specified by a sequence of serial numbers
- Recommend a set of service tasks depending on the mileage of the car and the last time the car was serviced.
- Add the newly performed maintenance task to the dealer system and update the Smart Card
- Create bonus system/loyalty scheme for frequent dealer visits

VIP Assistant

- Personal adjustments and environment for the driver :

    drive control adjustments: cockpit control settings, suspension and fuel economy

    convenience adjustments: position of the seats, mirrors, radio station, audio-level and air conditioning

    business adjustments: addresses / telephone book, information from the mailbox, appointments book and logbook settings

    general adjustments: settings of navigation system, information systems (such as road conditions, weather information)

- Support multiple cars

Travel Assistant

- Create the route on the Web and download the route and the informations on the Smart Card
- The route contains start and destination as well as important intermediate steps (motels, companies, historicals, sports, attractions, sights, ...)
- Each step has a set of commands that may or may not be executed by the driver
- Show the route on a digital display in the car
- Visualize the position of the car in real-time on a digital map
- The route can be changed dynamically (insertion of new steps, deletion of existing steps)
- Additional information on intermediate steps can be activated or loaded dynamically via cellphone, GPS, ...

Logbook Assistant

- Distinguish between business and private trips.
- Support disconnected mode while driving the vehicle
- Make sure every trip is stored on the Smart Card, even if the driver forgets to enter any information at the beginning of the trip
- Make it impossible to manipulate the trips in the logbook that have already been taken
- Allow multiple drivers to record the use of the same vehicle
- Allow logbook entries for 50 trips
- Allow multiple use of the vehicle by different drivers (fleet management (identification with the Smart Card))
- Create form to report tax deductible usage of the car

4.2 Nonfunctioal Requirements

The JAMES system will consists of a set of applications and servers distributed over the Smart Card as well as enterprise system platforms.

The software architecture of JAMES must be extensible, scalable and platform independent and supoort multi-functionality on the smart card. In addition, it must provide:

- A platform independent web-based interface to the vehicle simulator
- An access control scheme that prevents unauthorized access and allows access for multiple users
- A speaker independent speech interface for all JAMES assistants
- Multi-modal input to JAMES (speech, gestures, and pen-based input)
- Web-based and card based versions of the assistants and a smooth transition between them
- Dynamic downloading of additional assistants to the existing set of assistants on the Smart card (“applets to cardlets”)

4.3 Project Constraints

- A web site will be established, that allows the client to participate in the project remotely from Stuttgart.
- The Target machine is the JavaCard SmartCard

- All Applications must be written in 100% Java and/or must be able to execute on the JavaCard
- Software Development for the JavaCard is done with Schlumberger's Cyberflex Development Environmen (Daimler Benz is Beta tester for the Cyberflex Development Environment)
- The JAMES class library must be published in Javadoc
- The software architecture and class library must be placed under configuration control
- All project documents must be published in HTML or PDF

5. System Design

Figure 3 shows a preliminary subsystem decomposition of the JAMES architecture. Each box in the figure represents a subsystem consisting of a set of distributed objects. The communication between the objects is symmetric (also called peer-to-peer) via a software bus.

The software bus should be implemented with Sun's remote method invocation (RMI) or CORBA/IIOP. RMI could be used for communication between subsystems written in pure Java. Applications running on the Smart Card will be written in a Java subset implemented by Schlumberger making calls to the JavaCard API.

All subsystem interfaces will be written in pure Java. Interoperation with legacy systems (for example a dealer administrative system) written in other languages shall be based on the CORBA/IIOP standard. The public set of methods provided by the objects of each subsystem is called the *service* of the subsystem and is completely described by its API.

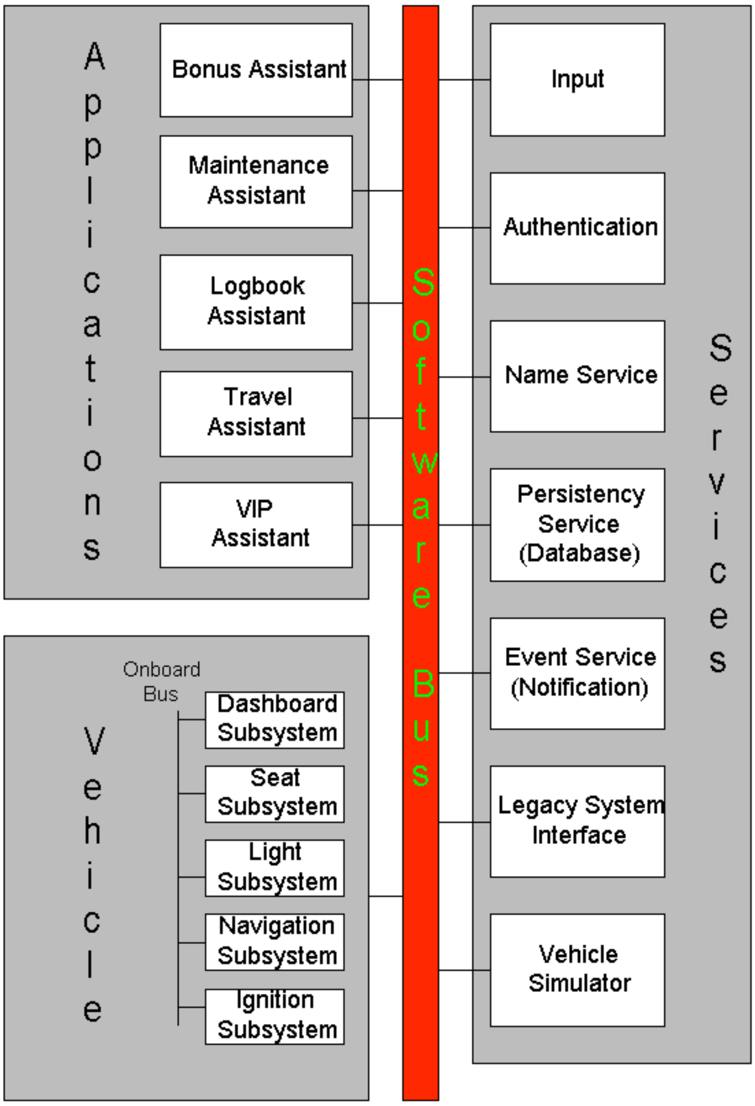

Figure 3: Preliminary Subsystem Decomposition of the JAMES system.

6. Development Environment

The development of the JAMES system makes use of the facilities offered in the clusters on CMU Campus as well as the Vehicle Systems Laboratory located at Building D, Room 154A. While the clusters are shared with other students taking other courses, the resources at the vehicle lab are to be used solely for the development of JAMES.

The following development environments are provided:

CodeWarrior Pro (Interactive Development Environment). A software development environment with a powerful symbolic debugger for Java 1.1. CodeWarrior runs on the platforms Windows 95, Windows NT and MacOS 8. It allows cross compilation.

Rose/Java (CASE Tool). A CASE tool supporting the object-oriented model based development of systems written in Java. It provides modeling based on UML and OMT and supports round-trip reengineering between models and source code.

Cyberflex Development Environment. Schlumberger's programming development environment for the Cyberflex card.

Visibroker for Java (Object Request Broker). Middleware following the OMG CORBA standard. It provides remote method invocation across heterogenous platforms.

Caffeine. A Java Development Environment to program on top of CORBA/IIOP. It allows Java objects to invoke other objects over a CORBA IIOP ORB without requiring the programmer to write IDL. Caffeine is part of Visibroker for Java.

5. Target Environment

Simulator. The JAMES system is to be used by drivers driving a Mercedes Benz vehicle. During this project the vehicle is represented by a simulator provided by the client. Details about the simulator will be made available during the project.

Cyberflex Card. Also called the Butterfly card. The processor on the card is a 8 bit 1 MHz CPU (Motorola 6805), with 4KB EEPROM on chip and a 1.2 Kbyte library. The maximum application size is 2.8 KB bytes (= 4.0 KB - 1.2 KB). The cards that we have available in the lab have a maximum application size of 1896 bytes. The stack size is 16 bytes. Heap size is <<?>>

Smart Card Readers. The Litronic Argus 210 reads Cyberflex smart cards. The reader can be attached to a PC via a serial RS 323 cable.

8. Client Acceptance

The client considers this problem statement to be a broad definition and does not expect that all the functionality mentioned in this document will be demonstrated at the end of this semester. However, the analysis and design should be extensible to include this functionality in a future version of the system.

During the requirements analysis phase of the project the client will negotiate with the software engineers an acceptable prototype for delivery. After the negotiation phase the specific requirements for the client acceptance test will be baselined. The client expects to sign off on the negotiated deliverables within 4-6 weeks of the client presentation.

For a demonstration of the system on client acceptance day, the following scenario will be used.

9. Deliverables

The client expects a successfull demonstratation of the JAMES prototype in a field trial with a simulator on December 9, 1997 from 9:00 - 10:20 AM in the Software Engineering Lab at Carnegie Mellon University, Pittsburgh with participation of remote observers at Daimler Benz Headquarters, Stuttgart and other viewers around the world viewing the demonstration remotely in real time over the Internet. A set of documents on a CD-ROM describing the requirements analysis (RAD), the system design (SDD), object design (ODD), testing procedures (TM) and user manual of the DAIMLER system should accompany the demonstration.