SAfeDJ Community: Situation-Aware In-Car Music Delivery for Safe Driving

Xiping Hu[1], Jun-qi Deng[2], Wenyan Hu[3], Georgios Fotopoulos[4], Edith C.-H. Ngai[4], Zhengguo Sheng[1], Min Liang[5], Xitong Li[6], Victor C. M. Leung[1], Sidney Fels[1]
[1] The University of British Columbia, Canada | [2] The University of Hong Kong, Hong Kong | [3] Nankai University, China | [4] Uppsala University, Sweden | [5] IBM, China | [6] Massachusetts Institute of Technology, USA
{xipingh,zhengguo,vleung,ssfels}@ece.ubc.ca, jqdeng@eee.hku.hk, edith.ngai@it.uu.se, gzliangm@cn.ibm.com, xitongli@mit.edu

ABSTRACT
Driving is an integral part of our everyday lives, but it is also a time when people are uniquely vulnerable. Poor road condition, traffic congestion and long driving time may bring negative emotion to drivers and increase the chance of traffic accidents. We propose SAfeDJ, a situation-aware in-car music delivery application, which turns people's trips into pleasant journeys and driving into a safe and enjoyable activity. SAfeDJ aims at helping drivers to diminish fatigue and negative emotion. It is built on a vehicular healthcare platform that enables communications among drivers and integrates with multiple types of sensors to promote safe driving. Prototype implementation and initial results of SAfeDJ have demonstrated its desired functionality in drivers' daily lives and feasibility for real-world deployment.

Categories and Subject Descriptors
C.2.4 [**Computer Systems Organization**]: COMPUTER COMMUNICATION NETWORKS - Distributed Systems - Distributed applications.

General Terms
Design, Human Factors, Algorithms.

Keywords
Vehicular sensor application, situation-aware, cloud.

1. INTRODUCTION
According to the statistics published by the World Health Organization (WHO), 1.2 million people die and 50 million people are injured or disabled on roads every year [1]. Statistics in Europe shows that approximately 10-20% of all traffic accidents are due to diminished vigilance of drivers due to, e.g., fatigue or negative emotion. Previous research has demonstrated that not only does listening to suitable music while driving not impair driving performance, but it could lead to an improved mood and a more relaxed body state, which could improve driving performance and promote safe driving significantly [2]. Thus, we propose SAfeDJ, a novel situation-aware music delivery application for drivers, to help drivers to diminish fatigue and negative emotion during driving.

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SAfeDJ integrates multiple sensors with drivers' social contexts, leverages the advantages of cloud computing and information retrieval, and incorporates a novel cognitive music recommendation mechanism that can intelligently deliver suitable music to drivers according to each driver's specific situations. SAfeDJ provides a seamless and economic solution with a user-friendly (tab-based) mobile application to drivers, enables them to conveniently enjoy favorable music suitable for their situations (traffic conditions, environmental conditions, mood, etc.) through smartphones while driving. For example, this mechanism may deliver lounge music to drivers when they feel tired, and intelligently switch to light music when the traffic congestion is intensive and the driver's blood pressure is high. Furthermore, SAfeDJ enables the drivers to manually or automatically share enjoyable music with friends over social networks while driving. This feature could help to stimulate and improve their driving experience together with friends towards safe driving in a social context.

Currently, a variety of mobile application based solutions have been proposed for safety improvement in vehicular application scenarios, such as V-Cloud [3], CrashHelp [4], and LCCA system [5]. Most of them focus on the long-term health monitoring of vehicular users, or only consider the real-time traffic situations to avoid traffic accidents. However, there is no music-oriented mobile application specifically designed for vehicular users yet. Some music recommendation systems available in the market, like Last.fm and Xiami, recommend music to users only based on their listening behavior and history. Different from them, SAfeDJ orchestrates multiple sources of sensing data and recommends music not only based on drivers' listening behaviors, but also their current situations while driving.

2. SYSTEM ARCHITECTURE DESIGN
Figure 1 shows the system architecture of SAfeDJ with three tiers: network tier, mobile device tier, and cloud tier.

Network tier: It makes use of any available wireless network connectivity within vehicular ad hoc networks (VANETs) and between mobile devices, vehicle onboard systems, and the Internet, employing technologies such as WiFi direct, Bluetooth, Dedicated Short Range Communications (DSRC), and wide area cellular networks. The network tier enables fast communications between the drivers and the cloud servers. This is crucial to support mobile applications for safe driving, which requires real-time collection and dissemination of health and traffic data efficiently and reliably over the heterogeneous vehicular networks.

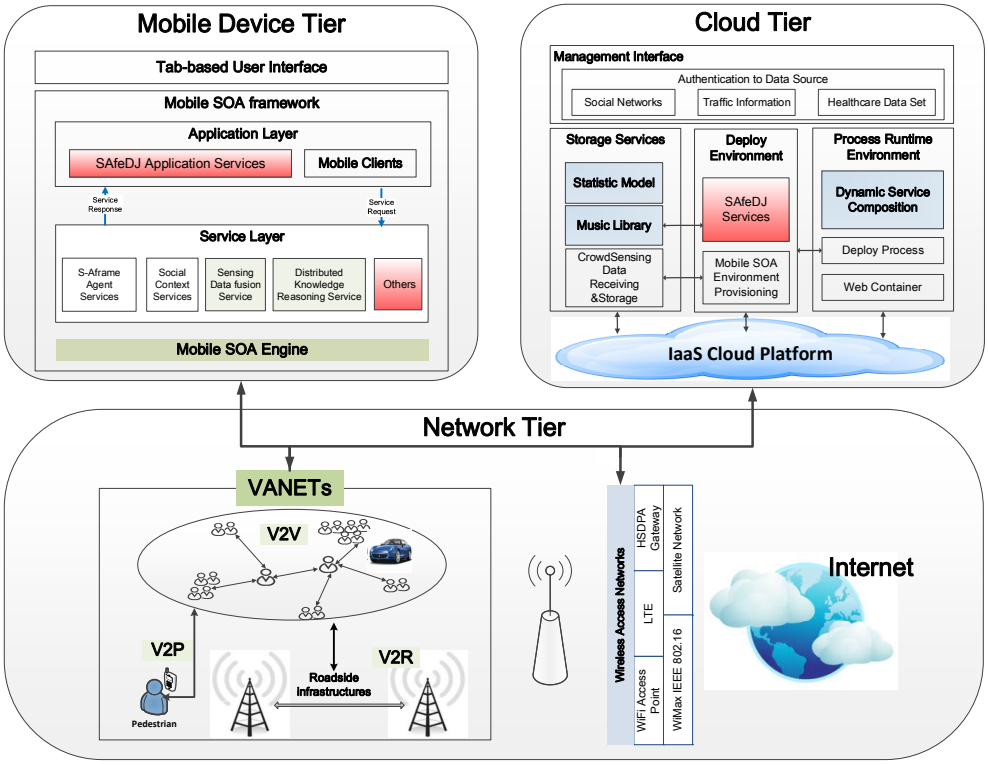

Figure 1. System architecture design

Mobile device tier: Based on the mobile Service Oriented Architecture (SOA) framework [6] developed in our former work, the SAfeDJ in-car music delivery application could be deployed on different mobile devices and work self-adaptively across VANETs and via cloud platforms over the Internet. Moreover, in order to store and interpret the health-related sensing data (e.g., from wearable sensors, mobile devices, and sensors on board vehicles), music preferences, and dynamic traffic data efficiently, we provide two novel services for sensing data storage and distributed knowledge reasoning. They enable real-time state analysis and music matching by aggregating multi-dimensional sensing data.

Cloud tier: The cloud tier works in parallel with the mobile device tier. The cloud tier could be built based on the Vita cloud platform [7] introduced in our earlier work. The cloud tier works as a central coordinating platform to: i) aggregate the health-related sensing data (e.g., the medical history of the driver), traffic data (e.g., road traffic monitoring through crowdsensing [8]), and Internet services (e.g., weather and geographic information, social activities) from multiple sources; ii) interpret the data, perform matching and deliver appropriate music to the drivers according to their situations dynamically. The text should be in two 8.45 cm (3.33") columns with a .83 cm (.33") gutter.

3. SAFEDJ MOBILE APPLICATION

Based on the cloud-based system architecture, we develop and deploy a prototype of SAfeDJ to demonstrate the functionalities of situation-aware in-car music delivery for safe driving. As shown in Figure 2, SAfeDJ consists of three major components: (i) Sensing data fusion service, (ii) Music library and matching service, and (iii) Music sharing and social networks. The sensing data fusion service provides real-time state analysis of the current driving situation by integrating the driver's health data, the car sensors, and the road information. The health data (e.g., heart rate) of drivers can be collected by wearable sensors such as wristbands, while the car data (e.g., speed, temperature, fuel consumption) can be read by advanced onboard diagnostic port scanners. The outside environment can be deduced with the roadside and in-car sensors, news summary, and updates from other drivers. All the input data will be fed into the real-time state analysis module to infer the mood of the driver and the current driving condition.

Then, the state analysis module will perform music matching based on the road situation and mood of driver. For example, if the driver is under stress as he is late for work in a traffic jam, then some relaxing music will be played to relieve his stress. The music library will be updated from time to time, and be connected to the music sharing service via social networks. This enables drivers to share enjoyable music with their friends who have similar music preferences or experience similar traffic conditions.

In addition, to implement the prototype of SAfeDJ, a number of techniques are adopted. For example, to store and interpret the integrated sensing data on mobile devices, we implement a SQLite database and lightweight ontology-based similarity computation methods [8]. To set up the cloud platform to communicate with mobile devices efficiently, *RESTful Web service*, *Apache ODE*, *JBoss jBPM* [7] and a series of open source packages are adopted.

As shown in the bottom of Figure 2, under these experimental settings, the cloud platform of SAfeDJ can finish the information retrieval tasks and return the results to a mobile device efficiently in real driving scenarios (less than 7s even in quite intensive computing situations when the size of data set is 36000). It shows

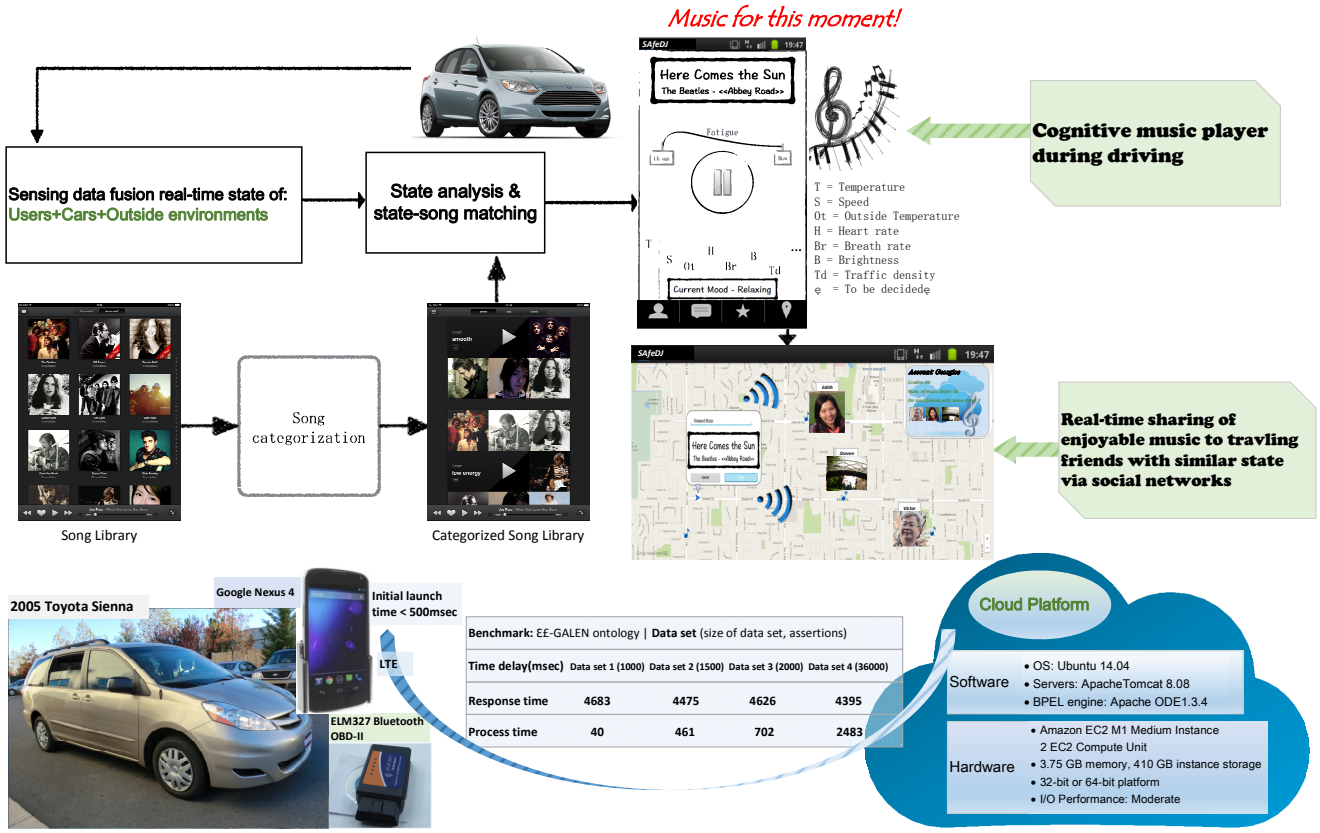

Figure 2. SAfeDJ mobile application for situation-aware in-car music delivery

that our solution can deliver favorable music to drivers' mobile devices on board vehicles efficiently in practice.

4. CONCLUSIONS AND FUTURE WORK

In this paper, we have proposed SAfeDJ, a novel situation-aware in-car music delivery application for promoting safe driving. It is designed based on a cloud-based network architecture, which supports the deployment of multi-dimensional sensing devices, intelligent data aggregation and state analysis, and music matching for drivers according to their mood, music preference, and driving situation. SAfeDJ also connects drivers with their driving friends via social networks for sharing enjoyable music. We have implemented a prototype version of SAfeDJ and performed initial experiments to verify its functionality and practicability in real driving situations. In the future, we shall conduct comprehensive experiments to evaluate the system performance of SAfeDJ under different geographic (e.g., urban vs. rural) and traffic situations (e.g., traffic jams). We shall also explore the relations between traffic conditions, health data and music preferences.

5. ACKNOWLEDGMENTS

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