Experiencing CAMAF for safer smart mobility

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***Abstract*—In this paper we demonstrate a framework to support research on Cooperative Awareness Messages (CAMs) through a monitoring dashboard, deploying a portable environment named CAM Application Framework (CAMAF); it manages the received CAMs and updates a corresponding specific monitor for each active Cooperative Intelligent Transportation System (C-ITS) entity. Each monitor is configurable by choosing CAM fields and making or changing algorithms to display the desired information. We have tested our proposal in a C-ITS testbed with real live traffic in the SmartHighway localted in Antwerp, Belgium.**

***Index Terms*—C-ITS, CAM, ITS, testbed, V2X, vehicular communications.**

I. Introduction and Motivation

There is a significant increase in the number of vehicles on the road. This trend is believed to maintain for the next decades globally. The fact that road accidents increase as the number of vehicles on the road increase seems to imply a link between the two. Cooperative Intelligent Transportation Systems (C-ITS) can be a solution to decrease or eliminate road accidents since it supports connectivity between road and user applications, which aims to increase road safety, efficiency and driving comfort [1].

Cellular Vehicle to Everything (C-V2X) is the access technology for C-ITS to increase safety, increase traffic-management efficiency, and eventually to improve autonomous driving [2]. C-V2X uses Cooperative Awareness Messages (CAMs), periodically sending status data to neighboring nodes [3]. C-V2X technology is essential for the growth of autonomous driving systems in the years ahead [4]. Furthermore, autonomous driving systems should not only rely on sensors embedded in the vehicle. Therefore, autonomous driving systems need to be aware of the surroundings via communication (CAM) [4].

In this paper we present and demonstrate a monitoring dashboard to support research on CAMs and a framework to develop CAM applications called CAM Application Framework (CAMAF).

II. CAMAF Development and Setup

We developed a CAM application framework called CAMAF. It is designed to be dynamic, aiming to be the core framework for managing CAMs received by vehicles. The framework generates or updates every received CAM into the corresponding specific monitor; based on the station ID and the station type of each vehicle. During our experiments an Road side Unit (RSU) transmits custom CAMs, CAMAF updates these monitors every time a new CAM is received. CAMAF can monitor the following CAMs via the station type: unknown CAMs, pedestrians, cyclists, mopeds, motorcycles, passenger cars, busses, light trucks, heavy trucks, trailers, special vehicles, trams, and roadside units. We illustrate the flexibility of CAMAF with an example: suppose yourself driving a vehicle on the Smart Highway, surrounded by four vehicles that send one CAM every second. Then the service controller inside CAMAF generates a specific monitor that follows a specific algorithm according to the station type.

It also updates the individual monitors when a new CAM arrives from those specific vehicles. The service controller manages all monitors of every group of station types according to a specific algorithm. This algorithm can be different for every vehicle type. Furthermore, CAMAF makes it possible to implement multiple custom algorithms for every station type and to switch between them in real-time. For example, if it needs to monitor a special vehicle differently, we write a new custom algorithm and plug it in the special vehicle monitor of CAMAF. Additionally, every monitor can become aware that a vehicle has stopped sending CAMs. When it happens, the monitor terminates via a configurable interval; by default, a monitor terminates when it has not received a new CAM for more than one second. It happens when the two vehicles are too far from each other to receive CAMs or when the sending vehicle stopped sending CAMs. If one of these four vehicles leaves the Smart Highway, then the specific monitor for that vehicle terminates automatically. Now, only three monitors run in the vehicle, one for each surrounding car.

CAMAF also deploys a Global Navigation Satellite System (GNSS), retrieving positioning data with a configurable interval from an external GNSS device. The latitude, longitude, and altitude are used to track the distance between vehicles that receive the CAMs (where CAMAF is running on) and the sender vehicle. Every received CAM also contains the latitude, longitude, and altitude of the sending vehicle. If the distance between the sender and receiver increases over a configurable limit, then CAMAF ignores those messages.

Within CAMAF we propose a priority variable to filter the received CAMs such, that the driver becomes aware only of the most priority CAM. Suppose, a vehicle and three special vehicles, three police cars named A, B, and C, driving on the highway. Three monitors are running in the vehicle, one for each police car. Suppose that the police cars are blocking the right lane due to an accident. Police car A is sending CAMs informing that light bars and siren are active, it is a "heavy accident", and has the road speed limit changed to 50 km/h. Also, police cars B and C are sending the same type of CAMs, except they do not specify the speed limit. If the driver is using our CAM application which uses CAMAF, the driver only becomes aware of the CAMs sent from police car A. Since CAMs sent by police car A contains more safety-critical information comparing to police cars B and C, namely a new current speed limit. So, the driver becomes aware in advance that the traffic slows down ahead. Consequently, the driver can prepare himself and take the needed safety actions.

III. CAMAF Deployment

This section presents our CAM application experiments on the Smart Highway testbed [5].

A. CAM dashboard

The dashboard, in order to display the received CAMs, adapts itself to a PC, smartphone, or tablet screen via an Internet browser.

B. Screen colors application

A study performed by Chen-hao Dong et al. [6], concluded that when drivers use smartphone navigation, their attention is distracted. By focusing too much on the inside of the car, their attention on the road is reduced. Therefore, our CAM application displays different colors on the screen. We choose it for multiple reasons. First, in less than a second, the driver can look at the colored screen. Second, the colored screen informs the driver much faster than when he needs to read text messages. Third, the colors start from green and loop over every color between green and red. Fourth, it provokes a familiar feeling because we always see red as an important event, e.g., a red stoplight, and green as a safe event, e.g., a green stoplight. Finally, we see yellowish colors as the transition from a safe to a possible dangerous event, e.g., a yellow stoplight. The application also displays panels with additional information. The station ID, station type, speed value, speed limit, siren activated, light bars activated, priority, and distance are among them.

Figure 1 shows the that the driver sees in normal conditions. It means there are no CAMs received from special vehicles, and everything is normal on the road, indicated by the green background. From the moment CAMs are received from special vehicles, our CAM application becomes aware and makes the driver aware of the special vehicle, turning the screen background to a yellowish color. This way, the driver becomes aware that a dangerous situation is happening within a certain distance ahead. Additional information is displayed to the driver when the confrontation is imminent. It also displays an icon of the current speed limit. Figure 2 shows an icon with the type of the special vehicle that sends the CAMs. The driver is also aware that the siren and light bars of the police car is activated by an icon displayed on the screen. The CAM application loops over these icons such that every icon is displayed for a period of one second. When the vehicle that uses our CAM service passes the accident, the application will display the content as shown in Figure 1. CAMAF automatically stops monitoring this special vehicle when it has passed the accident.

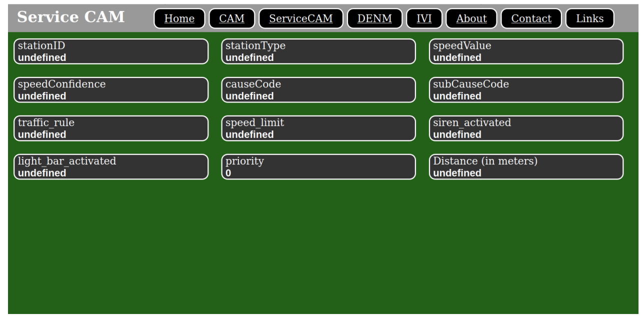

Fig. 1. Default screen

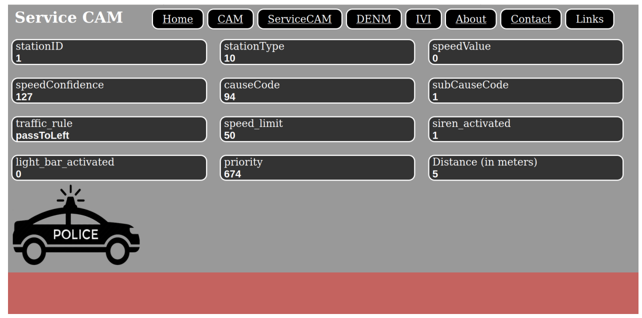

Fig. 2. Displaying the type of special vehicle that is sending CAMs

IV. DEMONSTRATION SETUP

In this demo paper we demonstrate CAMAF at work, showcasing its ease of use and flexibility on a smart highway testbed located in Belgium with real life traffic [5]. And our visual interfaces are shown that we use to make drivers aware of dangerous traffic situations. We will also demonstrate a roadmap with features we are improving inside CAMAF and planning to introduce in CAMAF and in the visual interfaces.

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