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Fleet Management Solution

Fuel consumption and collision prevention system modules

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***Abstract*— With the help of satellite communication technology today is easy to identify the exact location. Existing solutions support tracking of place (real-time or historical visibility), status of vehicle which mostly are using centralized web server. The purpose of the paper is to describe how solutions in the field of M2M (Machine to Machine) by combining fleet management solution and cloud computing could deliver new technological innovation. The proposed solution uses GPS based technology, GPRS and cloud computing infrastructure. The vehicle used for testing purposes was equipped with the following devices: GPS device with a GPRS module (TELTONIKA FM4200), sensors for identifying fuel level/status, driver identification and collision prevention system. All the data that the device sends are transferred to a server running in a cloud system through GPRS traffic. All the data is stored and saved in the cloud and the customer could receive it from any device that can have access to a web page. The solution is reliable, scalable and comprehensive that fits the needs and demands of the existing companies on the market. It scales to all possible fleets of all sizes, and the paper also identifies how the solution can improve operations, asset utilization. Although the number of connected devices, machines that require connectivity is increasing, so far they have not been widely adopted in the South East European region, and the research examines the reason for not fully acceptance of the fleet management solution. The concept was developed taking into consideration some of the most common use cases for companies in different fields that they operate.**

Keywords- Cloud Computing; Corporate Entrepreneurship; Fleet Management System; GPS/GPRS technology

I. INTRODUCTION

With the development of the telecommunication industries in recent years most of the markets have reached high level of penetration and other developments are needed for further growth of the industry. The number of embedded devices has continuously been increasing in recent years, different kinds of wireless and wired access systems such as GPRS, EDGE, HSDPA, WLAN, WiMax, Zigbee, and Bluetooth enable various kinds of devices such as sensors, actuators and machines to connect into the Internet, which enables novel types of services called as M2M (machine to machine) services. M2M consists of ICT technologies enabling remote measurements and remote control of devices. It includes sending receiving, storing and processing of measured information, and all kinds of actions needed for controlling devices remotely. Thus M2M creates novel value added by connecting large set of machines, vehicles and embedded devices into the M2M networks and service infrastructures and enable remote actions with devices and their services. This enables more real-time control over the company processes, and creates opportunities to increase the service quality [1].

The main contribution of this research is focused to solve the interoperability challenge by providing M2M architecture to enable smooth creation of the M2M service space in automotive transport and logistics space, also referred as Fleet Management. Fleet Management system has brought GPS technology into every type of vehicle used for both tracking and navigation. The tracking part of the device helps the system detect and notify where the vehicle is moving, whereas the navigation part helps the driver to reach the destination. All existing technologies are able to identify and provide this, whereas the customer demand is increasing in order to provide them with additional benefits.

Devices used in this research paper include TELTONIKA FM1100 and FM4200 [2]. The proposed solution is targeting specific use cases where additional modules are developed and integrated in order to provide more security and cost control benefits for companies using it and those include:

- Fuel Management
- Driver Identification
- Collision Management System

All these systems are integrated and transfer the data which is maintained in cloud infrastructures. The sensors are used to monitor parameters of the fuel level of the vehicle. This is where, when and how much fuel was filled into the tanks of the vehicles, customized alerts can be set when certain level of fuel level is reached. What the fuel sensor does is that it sends information to the device about the fuel level changes in the tank. The TELTONIKA device continuously updates the cloud server with the new parameters using GPRS traffic of the network operator, which has control over the subscription management system for allowing access to companies to use the Fleet Management System. In cases when the fuel level reaches critical level it then notifies the driver and the administrator of the system. Driver identification module enables the driver to start the vehicle engine. This prevents unauthorized usage of the fleet that is owned by the individual/company. In cases when an unauthorized usage is detected the system notifies the owner which vehicle and the location of the vehicle is being used.

The paper is organized as follows. Part 2 of the paper gives an overview of Fleet Management Solutions based on published work. The following part gives more details on the Architecture of the solution including cloud and collision prevention system. Part 4 of the paper shares the result of the experiment and the last part the derived conclusions.

II. STATE OF ART

Various research papers in the field of M2M are made as a proof of concept. Persson in [3] describes how multi-agents are illustrated within a smart parking management application. Other research papers in the field are explained in [4], [5], [6] where the research paper [6] successfully tested and implemented the Alcohol detection in the vehicles that when alcohol will be detected the led from the experiment will glow. Research paper presented in [7] explains how SMS technology can help to locate the vehicle. The proposed work collects positions of the vehicle via GPS receiver and then sends the data of positions to specialized server by the SMS service. After that the position of the mobile vehicle will be displayed on Google Map. The main disadvantage with this solution is that the system offers only live tracking and historical reconstruction.

Paper [8] mainly consists of three steps including vehicle region extraction, Fleet Management and classification. After vehicle detection, a graph-based Fleet Management method is used for building the correspondence between the vehicles detected. And lastly another work which was considered as existing implemented solutions in this paper is described in [9] which is a low cost solution in contrast to expensive solutions. The architecture presented in the paper for Fleet Management system is using wireless sensor technology, which defines the packet structure for communication between the nodes.

Similarly as a substitute technology could be used the communication through satellites but this has many disadvantages and those include the cost of implementing such solutions is ex-pensive for a one time investment but it does not require additional costs for GPRS traffic, neither roaming DATA charges which at the moment are high and are not regulated in the South East European market by regulatory agencies. Another disadvantage is that the device sends parameters to the server after a long period which means that you can’t have real-time tracking experience at all.

The system for fleet management offers powerful features, and enabling such a system involves the following components: GPS device for tracking the vehicle, GPRS module on the device to transfer data through cellular networks public infrastructure, cloud infrastructure [10] to host the server and database, and access to GUI (web interface) that the customer has as a point for managing his fleet.

III. ARCHITECTURE

A. Solution overview

Cellular networks offer a standardized uniform public infrastructure for communication with devices via radio. The upper data speed limit for GPRS of 20-50 kbps is sufficient for transferring data and even higher data rates are attainable with third and fourth generation HSPA/LTE networks.

All vehicles currently are equipped with GPS device that is able to transfer the locations through the signals of the GPS satellites. The user of the system can identify location detail as well as driving history that is related to the route that the vehicle has followed. The GPS device module sends all the parameters using TCP/IP protocol when high reliability is needed sending records more often and modified UDP protocol when the vehicle is mainly out of the home network sending minimum 25 records at once due to saving high DATA roaming charges.

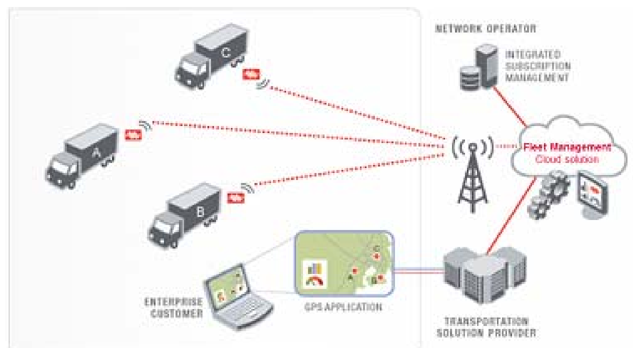

Figure 1. Overview of fleet management system.

Service framework provides generic functionalities for application development; the purpose is to manage components on the device. For example in the experimental phase we have constructed service components for 1-wire devices, fuel tank sensors, impulse counters, alarm buttons, door sensors, ignition etc. Interfaces in the figure are illustrated showing both service discovery and specific protocols.

According to this solution important findings addressed in this paper include:

- Fuel consumption detection
- Driver identification

Fuel consumption can be delivered in some of the following ways. Fuel flow meters [11] are suitable for measuring low viscous liquids like gasoline, diesel, water, beverages, or juices. In principal for safety and accuracy issues this option is not appropriate for the solution because for small amount of fuel consumption flow meters are not accurate. Another way is to use fuel tank level sensors that exist in most of the cars which shows the approximate fuel level in the driver’s indicator panel. This solution is suitable only for big trucks but even there are limitations for trucks that have cylindrical form of tank because additional software adjustments have to be made that in the end reduces accuracy. Third way is to connect to vehicles CAN-bus (controller area network) where SAE J1939 is the vehicle bus standard used for communication and diagnostics among vehicle components. Standardizes parameters are available and among them is the fuel consumption as well. Limitations of this method are that it that limited brands are supported and it's difficult to connect. Apart from that all three methods share common drawbacks of the information accuracy or damage that may be done to the vehicle or the GPS module while integrating it.

Driver identification module takes into consideration delivering communication over the serial protocol providing combinations of memory, mixed signal, and secure authentication functions via single contact serial interface. Module communicates via 1-Wire protocol that is explained in [12].

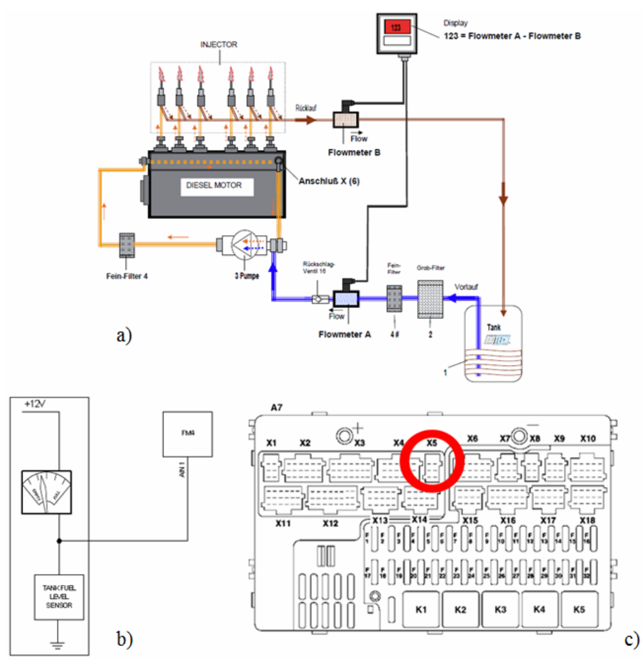

Figure 2. a) Bio-Tech flow meter [11], b) Taltonika fuel tank level sensor [2], c) X5 connector located in the fuse box for CAN wires.

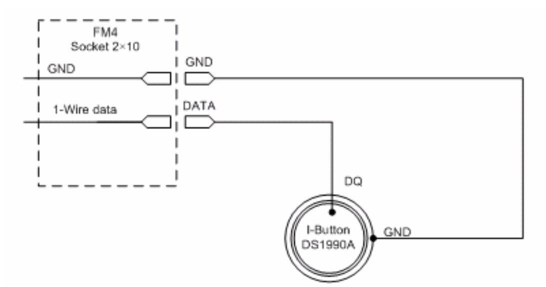

Figure 3. Dallas key iButton DS1990A connection scheme.

Value added service concept requires communication between the device and other devices like alarm, fuel, door sensors. There are no set of communication standards for this type of applications, both fixed and wireless could be used for this purpose. External communication interfaces can support industry standards like ZigBee IEEE 802.15.4 and enable the creation of an open system infrastructure where additional devices such as sensors, actuators and machines could be connected over the time to the Fleet Management service framework. It's a low power consumption, low cost, wireless networking protocol targeted for automation and remote control [13].

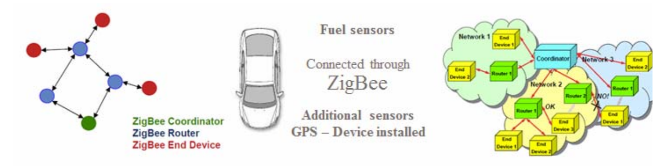

Figure 4. ZigBee network [14], a ZigBee Device Types, ZB Coordinator – 15.4 PAN Coordinator, ZB Router 15.4 FDD/Coordinator, ZB End device 15.4 RFD.

Experimental part of the research proposes different solution which is more feasible for implementation than the abovementioned fuel and driver identification techniques for delivering the solutions.

B. *Cloud infrastructure*

Utilization of the server spaces is high as there are not many using cloud computing infrastructure and web portal for retrieving data. The proposed solution gathers information and transmits data to the server stored in cloud infrastructure. By making data available in the cloud, it can be more easily and ubiquitously accessed, often at much lower cost, and even gain more flexibility by deploying a full service set without having to set up base infrastructure to support. In terms of scalability cloud computing allows the service to scale over a wide demand range [15].

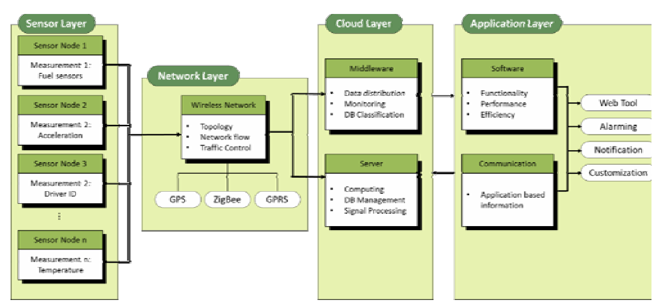

Figure 5. Diagram with information flow and how all layers that are related to one another and displayed on a single graphical interface to the customer.

Sensors range from different parameters such as acceleration, measurement of direction, driver identification, fuel level, temperature, alcohol detection, all of which through wireless network technologies transfer the parameters to middleware and server hosted as components of the cloud layer.

The emergence of distributed cloud-based applications and services brings plenty of opportunities to improve cost, scale, reliability and performance. This represents a fundamental yet massive shift in "computing". In other words, it is the next natural step in the evolution of computing in general, and IT services delivery in particular. The key idea of this paradigm is to provide service, into which a customer could plug-in instantly and modify the service to access centrally located services.

The application layer enables customers have access to web tool, set up alarming and notification messages to different devices ranging from Smartphones, to any other device that has access to a web browser.

Application of Fleet Management to Clouds comprises of:

- Easy purchase of additional licenses for every vehicle through the web tool
- Branding/Customization of the GUI according to every customer need
- Alarming and notification to device by your choice
- Enhancing the model to support bring your own device model and not relying fully to one model as is the case with existing solutions, subject of a development in some other stage of research

The term "Cloud Computing" [10] refers to an online delivery and consumption model for business and customer services, ranging from IT services like Software-as-a-Service (SaaS), and share the fundamental approach of running server components elsewhere, over the Internet.

Extensible cloud architecture is displayed in the following graph.

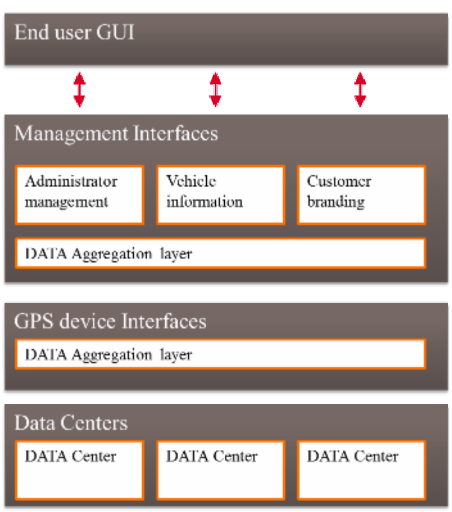

Figure 6. Extensible graph.

- GPS device interfaces: these interfaces do metering based on how much is consumed and alerts predefined by the customers in order to alert them about their fuel consumption, driver identification, geo-fencing.
- Communication layer: because of diverse metering interface systems in the open market, there is a need for a common layer to interface with different metering and reporting systems.
- Management Interfaces: these interfaces control the business management functions such as customer branding of the portal, vehicle information such as registration, servicing, administration of users/privileges through the DATA aggregation layer.
- DATA aggregation layer: This is a common data collection repository designed for frequent updates. This is the collection point for all data across data centers with other connected agencies.

C. *Collision preventing system*

The collision preventing system is a system that is provided by MobileEye [16] a development center for Advance Driver Assistance Systems (ADAS) that cooperates with OEM (Original Equipment Manufacturer) in automotive industry and FMS providers worldwide. Their Collision Prevention System is consisted of the following components (Figure 3):

- Camera/Buzzer Unit
- Display and Control Unit

Figure 7. Components of Collision Prevention System.

The camera/buzzer unit identifies lane markings, vehicles and pedestrians that are ahead of the driver. It also instructs the system display unit as to which alert to display.

The display and control unit provides with visual alerts like visual indication of the driving distance from the vehicle ahead, system status indications like low visibility indication.

The system alerts in several cases for example when the driver is in danger to collision with the vehicle, pedestrian ahead, or also when the driver is about to unintentionally swerve outside of the lane he is driving in.

IV. RESULTS

The implementation was successfully implemented on one of the leading companies in the country for transporting beverages. The whole components of the system were installed on 83 vehicles. The main challenges for the project are that there is no blueprint for development and standards are still being set. Developing an in-house solution from scratch would have taken longer time and increased cost for R&D. The connection scheme is displayed in Figure 4.

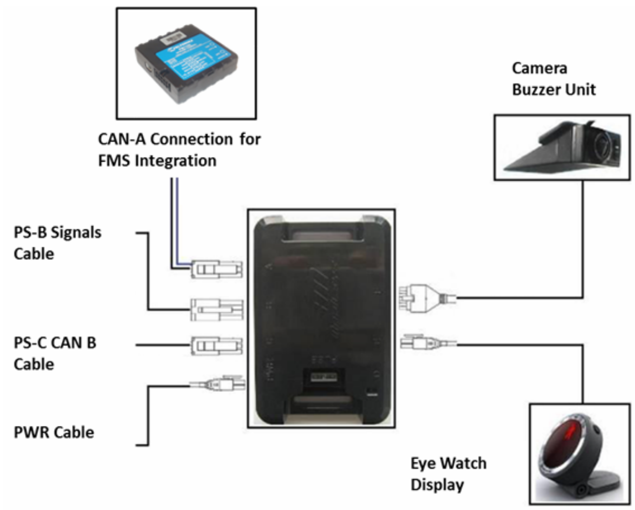

Figure 8. Collision Prevention System connection scheme.

The camera/buzzer unit identifies lane markings, vehicles and pedestrians that are ahead of the driver.

Display and Control Unit gives indications what is the distance from the vehicle ahead.

However, for performing analysis an algorithm for communicating with FMS is used which is the following:

```
    private void HeadwayWarningLevelPerMonthReport_BeforePrint(object sender, System.Drawing.Printing.PrintEventArgs e)
    {
      var generateParameter = GenerateReport.Value.ToString();
      if (generateParameter == "yes")
      {
       _generate = true;
      }
      if (_generate)
      {
       using (var _db = new FleetManagementEntities())
         {
           var start = Convert.ToDateTime(FromDate.Value);
           var end = Convert.ToDateTime(ToDate.Value);
           var period = string.Format("{0} - {1}", start.ToString("dd/MM/yyyy"), end.ToString("dd/MM/yyyy"));
           var model = (from candata in _db.CANDatas
              where
                candata.HeadwayWarningLevel > 0 && candata.DateTimeIns > start && candata.DateTimeIns < end
                 group candata by new
                  {
                    candata.HeadwayWarningLevel,
                      month = (System.Int32?) SqlFunctions.DatePart("month", candata.DateTimeIns)
                  }
                 into grouped
                 orderby grouped.Key.month
                 select new
                  {
                   HeadwayWarningLevelTotal = (Int32?) grouped.Key.HeadwayWarningLevel,
                   HeadwayWarningLevelNumber = (Int64?) grouped.Count(p => p.HeadwayWarningLevel != null),
                   Month = grouped.Key.month,
                   fromToDate = period
                   }).ToList();
                   this.DataSource = model.OrderBy(x => x.Month).ThenBy(x => x.HeadwayWarningLevelTotal);
          }
        }
        else
        {
          this.DataSource = null;
        }
}
```

Driver identification and fuel module were tested and implemented for the purpose of the research paper. Compared to the abovementioned options the following experiment was conducted. For driver identification proximity reader MF7 featuring medium range and small dimensions was used. Interface uses 9.6K Baud Serial ASCII (RS232) [17]. The output format is customized and programmed that it allows apart from driver identification to distribute club cards for passenger identification as well. Fuel module is completely different from the above available options as it uses calculated consumption method which is software developed and provides as good or better accuracy with cheaper implementation. It is based on 3 main parameters for calculating fuel consumption and those include engine hours in stop, driving in a city consumption per mileage and open road consumption. And the source code:

```
    public                                          ActionResult
FuelConsumptionFuelProbePartial(GeneralDataViewModel
generalDataViewModel)

    {

       var    logs    =    _db.Logs.Where(x    =>    x.DateTimeIns    >=
generalDataViewModel.DateFrom       &&       x.DateTimeIns       <=
generalDataViewModel.DateTo        &&        x.IdVehicle        ==
generalDataViewModel.IdVehicle).OrderBy(x => x.DateTimeIns.Value);


       var    fuelCalibrations    =    _db.FuelCalibrations.Where(x    =>
x.IdVehicle == generalDataViewModel.IdVehicle && x.Active);


       var                          culture                          =
System.Threading.Thread.CurrentThread.CurrentCulture.TwoLetterISOLangua
geName;


       var listTemperatureProbe = new List<FuelProbeViewModel>();

       foreach (var log in logs)

       {

         var fuelProbe = new FuelProbeViewModel()

         {

           IdVehicle = log.IdVehicle,

           LitreFuel = GetCurrentFuelLitre(log.AI1, fuelCalibrations),

           DateTimeIns                                              =
log.DateTimeIns.Value.ToString(GlobalHelper.GetStringFormatForDateTime(
culture))

         };

         listTemperatureProbe.Add(fuelProbe);

       }


    listTemperatureProbe[0].DateFrom = generalDataViewModel.DateFrom;

    listTemperatureProbe[0].DateTo = generalDataViewModel.DateTo;

    var vehicle = _db.Vehicles.Find(generalDataViewModel.IdVehicle);

    listTemperatureProbe[0].VehicleCompanyNoPlateNo                  =
string.Format("{0} - {1}", vehicle.VehicleCompanyNo, vehicle.PlateNo);

    listTemperatureProbe[0].FuelTankMax = vehicle.MaxGasLevel.Value;


    return
PartialView("FuelConsumptionFuelProbePartitials/FuelConsumptionFuelProb
ePartial", listTemperatureProbe);

}
```

The results show information relevant for the customer and receive real-time alerts in order to maintain control over the vehicle fleet.

Separate main modules as shown are shown as a result of work of this paper:

- Tracking (live and historical),
- Fuel (cost control feature),
- Fleet (maintain all relevant information for the vehicles like insurance expiry, oil/filter change), and
- Users (administration of privileges and different levels for using the solution)

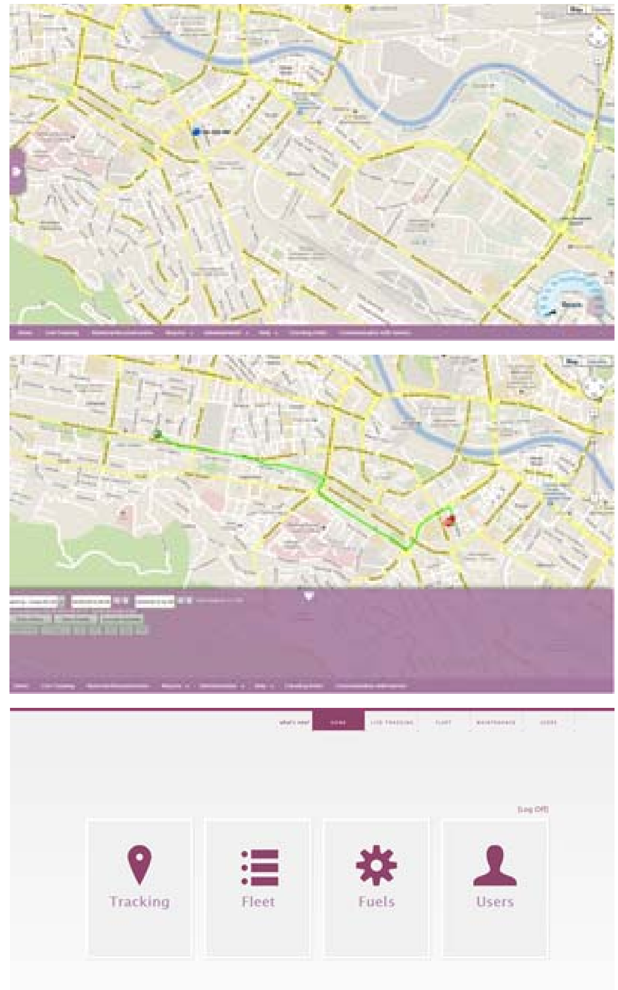

Figure 9. Results from the implemented solution: live tracking, historical reconstruction, administration panel.

V. Conclusions

The paper is a basis for future improvement of the solution providing an integrated support for the development of the application.

M2M is a rapidly growing technology that provides improved customer service, business improvements through optimized asset utilization, improved processes and productivity through communication between remote machines and Fleet Management System.

As future work it is planned to improve the existing system, and the first step is to gather more insights from businesses by conducting interviews with different companies and executives with main focus on transport and logistics.

Additionally improvement on the Service Framework Architecture to support additional M2M verticals apart from Fleet Management is planned for future research.

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