Context Aware Smart Bus

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A project report submitted to

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SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

in partial fulfilment of the requirements for the course of

CSE2049 – Context Aware Computing

in

B. Tech. COMPUTER SCIENCE ENGINEERING

Vandalur – Kelambakkam Road

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DECEMBER 2021

Abstract:

Usage of public transport is one of the best ways to make the planet green again, not just this there are numerous personal benefits as well. As the time goes on the convenience that private modes of transport provide are so convincing that we tend to prefer them most of the time. Private transport is becoming smarter every day, that it has come to a stage where it can drive by itself, public transport on the other hand had fallen behind due to lack of attention. For the present generation, where growth is of prime importance, in most of the cases there is not much guarantee about the place we live in after 2 or 3 years, it really becomes hard to understand the public transport timings, and exploring a place with public transport needs a lot of planning, knowledge and time as well, where private transport makes it way easier. Technological development in public transport is really a necessity to make itself a choice for future transportation needs.

The paper proposes a solution for this need, a technology that can be integrated into the present bus transportation system, to make it even more reliable and convenient for Usage. It makes the bus aware of its environment and react to it accordingly so there won't be breakdowns and other kinds of failure. Such a huge vehicle becomes smart enough to stop itself in case if it gets closer to other obstacles like humans, other vehicles, etc. It can recognize you and can wait for you in case you are a daily passenger and let you know about its presence and a lot more. This kind of improvements in public transport it way more convenient and safer to use, and thus makes its way to the future of transportation.

Introduction:

The development of technology in transport is a great way to make it more convenient and safer. While the development does happen, most of it is done towards improving the private transport. In the present day, we can order a taxi within seconds, by the click of few buttons on a cellular device, we can know the location of our car or bike, how fast it is moving, in fact any piece of information we want by addition of few more devices to the vehicle. It has reached a stage where we now have cars which are self-driving as well, which means they are aware of the environment they are in, they know the path which leads to their destination, they know about the obstacles near them, and the list never ends.

Coming to the Public transport, there is significant a significant improvement here as well, like Trip Planning and Passenger Communications, which tries to resolve the major hurdle of any potential public transportation riders, to

access easy-to-understand bus schedules and routes, Demand Responsive Transit, Due of the requirement to plan excursions ahead of time, this might be tough to use. Several public transportation agencies, notably the Jacksonville (Florida) Transit Authority, are contemplating programmes to integrate (General Transit Feed Specification) GTFS-flex DRT services in their OpenTripPlanner. Network Planning, A variety of technologies are available to help enhance public transportation network design by enabling for the easy integration of extra data and visualisation. Electronic Ticketing and Fare Collection Systems, The difficulty of acquiring tickets or a lack of comprehension of pricing might be a deterrent to using public transit. Many public transit companies now accept online ticket purchasing. Operations and Fleet Management, Automated vehicle location (AVL) and computer assisted dispatch (CAD) systems can help enhance public transportation system dependability, coordinate transfers, and shorten passenger wait times. Data from AVL/CAD systems, automatic passenger counter systems, and other technologies can help design new and updated public transit services.

The project is another approach to develop technology in public transport, which enables multiple features to the already existing system. To execute this, we deployed various sensors to detect the presence of people both inside and outside the bus, the bus will know you are a regular passenger so it cares your presence, sends you notifications and waits for you if it knows you are near. It is really safe to travel in it as there are cameras deployed and connected to the internet all the time, it knows the weight it can carry so no mid-road breakdown again. It is always being watched so in case of any failure support will immediately know it. Those are some of the abilities which the program adds to the existing bus system, the detailed description is given in the later section of the paper.

Challenges to be addressed:

The major ones are to improve the security, fault tolerance and reliability of the system. Specifically, the system has to be capable of detecting an accident and react to it accordingly, which is addressed in the program where the system intelligently recognises an accident. In order to avoid damage to the bus, to increase the reliability, we need keep a check on the weight inside the bus, and shouldn’t let excess weight to enter as it can damage both structure and engine of the vehicle. A constant monitoring of the structure of the bus is required to ensure the structural strength of the vehicle especially the tourist ones, as structure failure can be catastrophic at times and it can happen due to numerous reasons. Engine Diagnosis and Maintenance remainder this is self-explanatory as the bus is all about its engine and its condition has to be good at all times. Obstacle detection, this is one the important challenges to ensure

that the bus can't harm other people and properties as the vehicle being huge, the driver can sometimes miss the areas which needs the attention.

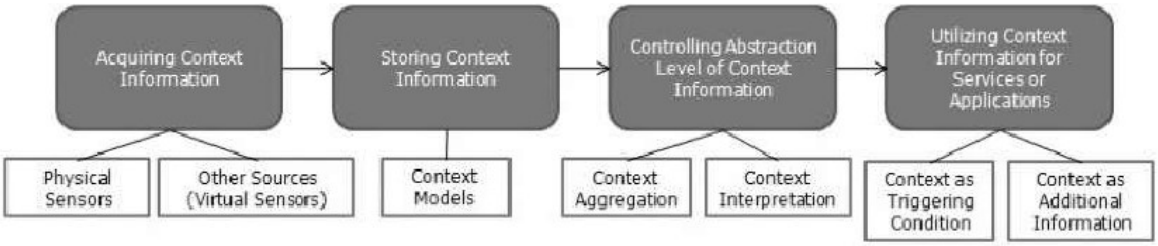
Coming to the reliable working of the software it shouldn't crash in any uncertain situations, so all the required fault tolerances are coded like situations where it can't find the required file, or the file format mismatches which can happen due to connectivity issues.

The software has to be intelligent enough to detect faulty sensors, reporting wrong values so that we don't run into unwanted hustles, especially in situation like some Debre getting stuck on the proximity sensors, weight sensor damage due to wear and tear of the components, and other technical failures.

Context acquisition

Every context aware system are concerned with the acquisition of context, abstraction and understanding of context and application behaviour based on the recognized context. This is the first step of any context aware system by using physical or virtual sensors, the system can acquire various types of context aware information. After acquiring context information, the system stores acquired data into its repository as in JSON file. System controls the abstraction level of context data by interpreting or aggregating context data. Finally, the system utilizes the abstracted context data for context aware application in different ways. The list of sensor data are acquired:

RFID
Vibration sensors
PIR sensors
Weight sensor
Temperature sensor
GPS
Fuel level sensor
Battery level sensor



Context modelling

A context model provides a simplified representation of real world interaction between user and devices. It provides a systematic way of identifying and representing knowledge about relevant entities and relationship among them required to represent a context. Thus, a context model forms a basis for representing and reasoning knowledge about contexts in a context aware architecture. Thus, a context model plays a key role on developing a context-aware architecture and subsequently context-aware systems. For the current context aware using key-value context model via JSON file format to create the model.

Context Adaption

The Program takes the input from the sensors in the form of JSON files, these JSON files are parsed sequentially in a particular order, which is firstly ID is parsed and according to the ID, the next information is determined, like if the ID belongs to a temperature sensor, then in the next step temperature date is read, else if it belongs to a vibration sensor then frequency data is read, in this manner every device is identified first and corresponding data is read. This is the procedure followed by the program in order to adapt to the environment.

Accident Detection and Help call

The detection happens if both vibration sensor and the proximity sensor detect abnormal conditions i.e. an occurrence of huge vibration and an obstacle close to the bus body

Weight detection, and warning sys

The weight is constantly monitored and if the external weight is heavier than a threshold, the system intimates by raising alarms and once the weight becomes safe, it sets alarms down.

Structure health detection, and maintenance call

This is structural health is monitored using vibration sensors, if the frequency becomes more than a threshold at a location then it means there is a structural fault at the area and the driver is intimated accordingly, along with sending an alert to the maintenance department.

Engine Diagnosis and Maintenance remainder

During the operation the load on the engine changes due to many reasons, If the temperature sensor at the engine reports overheating (high temperature), then the driver is intimated, and a notification is sent to the maintenance team.

Obstacle detection and Avoidance
This is executed using proximity sensors, if the proximity sensors report low values i.e. an obstacle nearby, the driver is intimated, as monitoring such a huge vehicle in all areas can sometimes become tedious, in such case the system reports with all the areas where obstacle are detected.

Bus Station detection and Passenger determination
The bus station is detected using RFID sensing, if its near a bus station, the RFID corresponding to that station is detected, and it checks the passenger records to determine the daily passengers list in that location

Passenger ping, and wait determination
If the daily passengers of a location aren't arrived at the station, the system sends a notification to the passenger about the arrival of the bus and if the passenger is near to the bus then it instructs the driver to wait for the passenger.

Person detection and Profile updation
If system identifies the arrival of a new person, it will ask for his/her details so that, if the person wants to come there daily he/she can register themselves to the database and the bus will ensure their presence later on

Fire Safety Mechanism
This is pretty much self-explanatory, if the temperature sensors inside and outside the bus detect extreme temperatures, the extinguishers are turned on.

Context Reasoning

The program is designed in such a way that it can detect and handle multiple types of faults, like if the weight sensor fails, its behaviour is observed overtime and quality is determined, if it fails then it uses the vibration sensor data to determine the load taken by the engine, and hence suspects heavy weight if the engine vibrates more.

Proposed work

Considering the challenges to be addresses, the abstracted data is generated via Arduino Microprocessor installed near all virtual and primary sensors, and

grouping them together as a single context at each particular time. These data is sent over through cloud for all computational processes to react and alert the context system accordingly in real time primarily for security purpose, fault tolerance, reliability, maintenance, Diagnosis, etc.
To address the challenge and react to the accident case scenario, the context aware bus recognizes through the collective information from vibration and PIR sensors which are installed all sides of the bus system to cover completely protection. The pseudo code to react to the accident challenge:

```
if(distance <5){
    System.out.println("Detected Obstacle at sensor "+ ind);
}
if(proxyDetected()){
    alarm.raise(1);
    System.out.println("Calling Maintenance Team");
    net.send("Accident detected <at time "+d+">, Calling Helpline...");
    M.call("Accident vibrations in floor <at time "+d+">");
}
```

To maintain the reliability of context bus it must avoid over weight issue so to avoid the imbalance of bus in high terrain and uneven pathways. The pseudo code is as given below using the weight sensor installed in context bus system:

```
if (extWt < wtThresh) {
    extWeight = (int) extWt;

    if (alarm.status == 1) {
        alarm.down();
    }
}
if (extWt < 0) {
    System.out.println("Uncertainty Detected!!! May be Faulty Weight Sensor");
    net.send("Abnormal Behavior by Weight Sensor, Weight : " + extWt + " <at time "+d+">");
    M.call("Abnormal Behavior by Weight Sensor, Weight :  " + extWt + " <at time "+d+">");
} else if(extWeight > wtThresh){
    System.out.println("Too Heavy, Raising alarms");
    alarm.raise(0);
}
```

An additional parameter of threshold is fixed which involves the weight of the complete bus and the external weight it can carry the payload to travel with passengers. This will maintain the stability of bus throughout.

A regular monitoring of engine also makes the system more reliable to avoid any sudden catastrophic events, so to ensure the structural strength for a longer period. This is maintained using an external installed temperature sensor near the engine to regular monitor the engine temperature to avoid excessive usage. The following code handles the context as follows:

```
if (temp > 75) {
    if (ind == 0 && temp > 200){
        System.out.println("High temperature Detected at Engine, warning Driver");
    }
    else if(ind!=0){
        System.out.println("High temperature Detected inside the cabin");
        System.out.println("Activating extinguishers");
        alarm.raise(2);
        extinguisherState = 1;
    }
}
```

And even other sensors are installed inside the bus for safety of passengers in case any fire accident where automotive fire extinguisher get opened for safer side.

To avoid any accident, the system must be capable in informing about the closest vehicles using obstacle avoidance PIR sensors with a minimal threshold distance unless it is harm. The most important thing is to locate the system in real time to ensure the safety of passenger and to keep live track of bus route to avoid misleading situation, thus GPS installed which sends continuous coordinates to locate the precise location of bus. The code as follows:

```
x_coodinate = (long) context.get("x");
y_coodinate = (long) context.get("y");
if(x_coodinate > 0 && x_coodinate <500 && y_coodinate>0 && y_coodinate <900)
    System.out.println("hyderabad");
else if(x_coodinate > 500 && x_coodinate <700 && y_coodinate >0 && y_coodinate <700)
    System.out.println("karimnagar");
else if(x_coodinate > 500 && x_coodinate <700 && y_coodinate >900 && y_coodinate <1200)
    System.out.println("Trimulgary");
else if(x_coodinate > 350 && x_coodinate <500 && y_coodinate >900 && y_coodinate <1200)
    System.out.println("Begumpet");
else if(x_coodinate > 0 && x_coodinate <500 && y_coodinate >900 && y_coodinate <1200)
    System.out.println("kukutpally");
else
    System.out.println("Unknown Location");
```

To make mush more user-friendly system, the bus captures the photo of each person and stores the profile info in data base to register the default destination and charge him accordingly, and even for safety purpose it alarms if a non-regular of mischievous person enter to take precaution steps.

```
if (info.equals("person")) {
    // if the person is unknown, it will ask the details and save them
    System.out.println("Detected person " + context.get("person") + " at location " + presentLocation + " <at time "+d +">");
}
else if (info.equals("alert")) {
    System.out.println("Unfavourable Situation detected, Raising alarms" + " <at time "+d+">");
    c.resItems = (String) context.get("ResItem");
    net.send(c.resItems + " Detected by camera " + ind + " <at time "+d+">");
    alarm.raise(1);
}
```

To address each challenge and its uncertainity, the system should be capable enough to alert if faulty sensors are recognised, it must be fault tolerant enough so to handle the external factors.the below some of psudo codes to handle the uncertinities fro various sensors:

```
catch (Exception e) {
  wtFaulty = true;
  System.out.println("Unexpected Behavior from Weight system... Reporting to Maintenance");
  net.send("Abnormal Behavior by Weight System" + " <at time "+d+">");
  M.call("Abnormal Behavior by Weight System" + " <at time "+d+">");
```

```
catch (Exception e) {
  System.out.println("Abnormal Behavior from Temperature System");
  net.send("Abnormal Behavior by Temperature System" + " <at time "+d+">");
  M.call("Abnormal Behavior by Temperature System" + " <at time "+d+">");
```

```
catch (Exception e) {
  System.out.println("Unexpected Behavior From Camera... Reporting to Maintenance");
  net.send("Abnormal Behavior by Camera System" + " <at time "+d+">");
  M.call("Abnormal Behavior by Camera System" + " <at time "+d+">");
```

Result and discussion

The result of context system is deeply analysed with the synthetic dataset created through Arduino microcontroller in JSON format and running through Java platform to test the system stability, fault tolerance, uncertainty etc.

Abnormal proximity

```
!!! Alarms Raised !!!
Suspecting Faulty Proximity SensorTransmitting info :Abnormal Behavior by Proximity System <at time Sat Dec 04 00:01:
Received Maintenance call for Abnormal Behavior by Proximity System <at time Sat Dec 04 00:01:06 IST 2021>
```

It’s is the scenario when the proximity (PIR) sensor shows abnormality with repeated values each time and leads to fault detection.

Accident detection

```
This is from Vibration Sensor
Ind : 2
Abnormal Vibrations detected
Calling Maintenance Team
Transmitting info :Accident detected <at time Sat Dec 04 00:01:13 IST 2021>, Calling Helpline...
Received Maintenance call for Accident <at time Sat Dec 04 00:01:13 IST 2021>
```

It’s is case scenario when either bus or other vehicle met with accident cause the vibration and proximity values to reach threshold values and signifies the sign of accident rather than any conflicting rules.

Camera

```
This is from Internal Camera
Detected person Rohini at location 5 <at time Sat Dec 04 00:03:31 IST 2021>


This is from Internal Camera
Detected person Pramod at location 5 <at time Sat Dec 04 00:03:32 IST 2021>
```

Basically cameras are installed for the person detection and context system database updation of the person profile to maintain the frequency and their respective location are updated so to Bus can add stoppage to respective locations.

Engine diagnosis

```
This is from Temp Sensor
High temperature Detected at Engine, warning Driver
```

This plays an important role in reliability and stability of context system, It keeps on monitoring the status of engine and its temperature to avoid any hazardous situation.

Faulty temperature sensor

```
This is from Temp Sensor
Suspecting Temperature sensor of index : 0 <at time Sat Dec 04 00:01:25 IST 2021>
Transmitting info :Suspicious Behavior by Temperature sensor <at time Sat Dec 04 00:01:25 IST 2021>
Received Maintenance call for Suspicious Behavior by Temperature sensor <at time Sat Dec 04 00:01:25 IST 2021>
```

Sensors are electronic devices which even delicate and over usage fails the system hence uncertainty is handled.

Fire detection

```
This is from Temp Sensor
High temperature Detected inside the cabin
Activating extinguishers
```

Temperature sensors even installed inside the bus system for passenger safety in case of fire, smoke.

Heavy weight detection

```
This is from weight Sensor
External Weight : 4087
Too Heavy, Raising alarms
```

External over weight can cause the system to fail in uneven and terrain areas which can lead to accidents.

Passenger wait determination

```
Arrived at location 1
Waiting for Rahul ...
Trimulgary
```

```
Arrived at location 9
Waiting for Kirti ...
Begumpet
```

It’s a user friendly system where it maintains the records of each regular passenger in each station and waits for a bit by informing them to avoid delays and missing of buses.

Profile Updation

```
This is a Pramod's profile update
```

Each time passenger get into bus it updates the profile into context system database and removes temporarily after departure.

Uncertain weight

```
This is from weight Sensor
External Weight : -2500
Uncertainty Detected!!! May be Faulty Weight Sensor
Transmitting info :Abnormal Behavior by Weight Sensor, Weight : -2500 <at time Sat Dec 04 00:00:37 IST 2021>
Received Maintenance call for Abnormal Behavior by Weight Sensor, Weight :  -2500 <at time Sat Dec 04 00:00:37 IST 20
```

Context system is capable enough to catch uncertain events in sensors if negatives values for the weight sensor or unknown value.

Faulty Vibration sensor

```
This is from Vibration Sensor
Suspecting Heavy wt (faulty wt sensor), better Decrease the wt in bus
```

To maintain the stability and durability of bus, it should premise to threshold values to avoid unconditional accidents.

Conclusion

The technical solution proposed in the paper to develop the existing public transport does improve the working of the system, by adding features like ‘passenger ping and wait determination’, which makes it easier for daily passengers, features like ‘accident detection and help call’, does handle the situation especially for bus which travel long distances on roads where there is low population density. In order to increase the reliability, the feature “Structure Health Detection and Maintenance Call” does play a significant role for the longevity of the bus. All the other features are implemented and the results are presented in the results section proposes an approach to execute the features. The Implementation of this solution in real life is completely possible as not many assumptions were done to implement.

We conclude that our solution is a good contributor to the development of technology in public transportation, it can understand the environment around it and take responsible decisions to make itself better, it can protect, care and maintain the wellbeing of itself and its users, which is primary purpose of the project.

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