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Real Time Car Parking System: A Novel Taxonomy for Integrated Vehicular Computing

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Abstract— Automation of real time car parking system (RTCP) using mobile cloud computing (MCC) and vehicular networking (VN) has given rise to a novel concept of integrated communication-computing platforms (ICCP). The aim of ICCP is to evolve an effective means of addressing challenges such as improper parking management scheme, traffic congestion in parking lots, insecurity of vehicles (safety applications), and other Infrastructure-to-Vehicular (I2V) services for providing data dissemination and content delivery services to connected Vehicular Clients (VCs). Edge (parking lot based) Fog computing (EFC) through road side sensor based monitoring is proposed to achieve ICCP. A real-time cloud to vehicular clients (VCs) in the context of smart car parking system (SCPS) which satisfies deterministic and non-deterministic constraints is introduced. Vehicular cloud computing (VCC) and intra-Edge-Fog node architecture is presented for ICCP. This is targeted at distributed mini-sized self-energized Fog nodes/data centers, placed between distributed remote cloud and VCs. The architecture processes data-disseminated real-time services to the connected VCs. The work built a prototype testbed comprising a black box PSU, Arduino IoT Duo, GH-311RT ultrasonic distance sensor and SHARP 2Y0A21 passive infrared sensor for vehicle detection; LinkSprite 2MP UART JPEG camera module, SD card module, RFID card reader, RDS3115 metal gear servo motors, FPM384 fingerprint scanner, GSM Module and a VCC web portal. The testbed functions at the edge of the vehicular network and is connected to the served VCs through Infrastructure-to-Vehicular (I2V) TCP/IP-based single-hop mobile links. This research seeks to facilitate urban renewal strategies and highlight the significance of ICCP prototype testbed. Open challenges and future research directions are discussed for an efficient VCC model which runs on networked fog centers (NetFCs).

Keywords—automated vehicular cloud computing; distributed computing; fog-edge computing; smart car parking management; cloud virtual machine scalability; Cloud Convolution.

I. INTRODUCTION

A. Background Study

The idea of smart car parking systems is recently gaining attention in many countries of the world owing to need for urban renewal programs and smart city initiatives (urbanization). For instance, in last 50 years, urban population of Nigeria has exponentially grown from 17% to 48.6% with an annual rate of 1.72% in 2016 [1]. This population trend has increased significantly from 45.2 million in 1960 to 182.2 million in 2015. By estimation, it is expected to grow to around 203.13 million by the year 2020 [1]. Similarly, the number and size of cities have also increased at the same pace thereby creating concerns to researchers and governments across the globe.

With this population trend, virtually all the large metropolitan cities face the same problem of obsolete commercial public road transport system (PRTS). Obviously, the PRTS is grossly insufficient to cater for the commuter demands and needs. Slow paced city expansion, and absence of parking spaces leads to time delays in searching for parking spaces and increased emissions by commercial road vehicle owners. In most locations, most people travel by their own cars [2], leading to overcrowding in major cities/roads and environmental gas emissions.

A report from the Nigerian Federal Road Safety Commission revealed that in 2010, about 6.6 million vehicles plied Nigerian roads and in 2015 about 9.8 million vehicles also plied Nigerian road resulting in about 69.4% increase in vehicles between 2010 to 2015 [3]. The issue is not in the number of increased vehicles, but the much dependence in the urban areas, knowing that the urban areas lack adequate parking facilities to accommodate this influx of vehicles.

Clearly, people have developed a notion that been comfortable entails owning a car to enable families and friends conveniently visit shopping malls, banks, restaurants, schools, stadiums, etc., for their daily activities without considering the challenges of the existing parking lots. With the influx of vehicles on Nigerian roads as well as the related parking issues in the existing parking lots, there is need for an efficient parking system that would be able to address these problems as the society is moving towards smart city design.

The SCPS is a system that is based on vehicular road sensing and intelligent display that direct vehicles/motorists along the best path for parking in the city. It leverages vehicular cloud computing (VCC) paradigm that aims at merging mobile cloud computing (MCC) and vehicular networking (VN) into...
convoluted communication and computing platforms [4]. This uses Internet of things [5] and Fog computing [6]. Safety considerations in VN now engender VCC to shrink the spectrum of the supported services in order to include the scalable and secured Internet driven applications [7]. Some applications such as Netflix and VTube exploit Infrastructure-to-Vehicle (I2V) links are used for providing data dissemination and content delivery services to connected Vehicular Clients (VCs) [8]. These could be adapted in SCPS. But because of their streaming nature, the applications are delay and delay-jitter sensitive [9] which greatly affect the SCPS.

However, considering all the issues faced in most metropolitan cities owing to population growth density, the SCPS (based on IoT-concentrates) could be used to solve the problems of parking management schemes, and traffic congestion by utilizing advanced technologies accordingly. The system ensures that vehicles can only come into the parking lot if there is free vacant slot, thereby reducing parking problems encountered in parking lot. Also, the introduction of finger print scanner, SD cards and camera in parking lot will increase the security profile against car theft. Since an efficient parking management system will depend on the cloud service provisioning, using the Fog layer [10], [11] will facilitate the QoS requirements of VCC in SCPS. Consider Figure 1 as a vehicular scenario, the Fog nodes represents the virtualized networked data centers hosted at the edge layer of the vehicular network by Road Side Units (RSUs). The Cloud-Fog-VC hierarchical architecture comprises of the edge, Fog and the cloud backbones.

![Figure 1. Cloud-Fog-Vehicular system architecture for SCPS [16].](image)

The main objective of the SCPS-IoT research is to present a novel RTCPS with support for intra-Edge-Fog VCC which will reduce traffic congestion by displaying free vacant slot, ensuring proper parking management scheme in parking lots, and also providing security of vehicles in such environments. The work focused on the vehicular scenario of Figure 1. In context, the Fog-equipped RSUs (cars) broadcast locally processed data to smart phone-equipped IoT VCs through point-to-point TCP/IP based I2V connections. This depends on the one-hop Arduino Duo or IEEE802.11-like wireless links [12]. As for the technical contribution of the work and the novelty of the approach, it must be established that resource management problem in SCPS must address adaptive control of the input and output traffic flows. The pursued objective is to apply related ICCP concepts to evolve SCPS that is supported by the Fog platform. As a result of the scaled number of involved VCs, RSUs and hosted VMs, the proposed SCPS leverages adaptive scheduler which supports distributed and scalable implementation. This will ensure self-sensing and self-configuring capabilities as a variant of cognitive computing [8]. RTCPS security is also introduced.

The reminder of this work is structured as follows. Section II presents VCC Infrastructure while discussing related works on Smart car parking models. In this regard, various comparisons were made also. Section III presents the SCPS-IoT as a research prototype while discussing its architectural components and functionalities. The challenges and open discussions on the VCC are presented in Section IV. The interested reader may refer to [13], [14], [15] and [16] for more explanations on IoT, Fog, Smart City automation and VCC in a simplified context. Section V concludes the work.
II. RELATED RESEARCH EFFORTS

A. VCC Infrastructure Contributions
The work in [16] explored an energy-efficient adaptive resource management for real-time vehicular cloud services. Their work provides real-time cloud services to Vehicular Clients (VCs) within the confines of delay and delay-jitter issues QoS. The authors in [17] provided several recent research efforts targeted at I2V networked infrastructures for achieving data dissemination and content delivery services. The work in [18] explored inter-Fog data exchange in I2V for a number of static RSUs deployed along the road and are spaced apart by a distance $d$. The authors in [19] discussed the dedicated short-range communication (DSRC) standard for an intelligent transportation system (ITS) where an RSU provides I2V point-to-point connections to the served VCs. The works in [20], [21] looked at channel in vehicular networks for the purpose of transmission. The authors in [22], [23] established that the Fog node in VCC comprises an admission control router (ACR); an input buffer of size, a reconfigurable computing platform and the related switched Virtual LAN (VLAN); an output queue of size $N$; and, an adaptive scheduler that reconfigures and consolidates the available computing-communication resources while performing the control of the input/output traffic flows in V2I wireless connections. Similarly, the work in [22] focused on the optimized task and processing rate mapping of an assigned Task Interaction Graph (TIG) which is a computational graph model. The authors in [23] developed a distributed scheduler for performing mobile-to-access point traffic offloading by exploiting Lyapunov-based optimization approach in order to attain a good tradeoff between the average energy wasted by the mobile devices for local/remote traffic offloading and the volume of the Internet traffic generated towards the remote cloud.

Most works in VCC and V2I centered on characterization of the relationship between task sizes, average number of needed CPU cycles and burst factors of the processed task streams [24]. Others focused on the analytical modeling for average energy consumptions of 3G/Wi-Fi and 4G connections [25], [26]. In the latter, the analytical models for average energy consumptions of 3G/Wi-Fi and 4G network connections are reported and tested through field trials. By design, the works in [16-26] in respect of SCPS lacks effective resource management and scheduling optimization. Cyber physical integrations are absent in most studies. These are the gaps this research sought to address.

B. SCPS Technologies
Practical efforts on the already existing smart car parking system are presented based on their associated technologies. The work in [27] proposed a smart car parking system using GSM technology. The work used GSM modem to enable users make parking slot reservation via short message service (SMS). The saved numbers are then used to send entry and exit password which must be correctly entered before access can be granted to users. The system ensures security of vehicles and addresses the issue of traffic congestion. The flexibilities of IoT technology is absent in their work. The authors in [28] carried out a similar work but used short message service (SMS) to enable users send parking application and pay parking fees when getting in and out of the parking lot. The system provided an efficient parking scheme but did not ensure security of vehicles in the parking lot.

The work in [29] proposed a SCPS using Zigbee technology with GMS modem. The GSM modem was used to enable reservation of parking slot via SMS just like [27] while enabling Zigbee technology communication between devices. The system lacks IoT integration and does not give parking guidance to the parking slot. The work in [30] developed a SCPS leveraging image processing in real time. The system was implemented using a camera at the entry of the parking slot which captures the number of vehicles parked in the parking slot. Information about parking slot and guidance is derived through image processing in real time by counting the number of vehicles captured by the camera. The scope of the system was limited to the use of sensors for car detection and it did not put into consideration the security of vehicles in the parking slot.

The work in [2] provided an automated SCPS aimed at eliminating the use of human to human interaction while deploying a machine to machine interaction system with the use of ultrasonic sensors into the parking slots. This aids in the detection of vehicles in and out of the slots. The authors in [31] proposed an intelligent SCPS aimed at reducing traffic congestion at optimum level by using image processing techniques. In the work, information about parking slots and guidance was obtained in real time through image processing by counting the number of vehicular captures by the camera in the vehicle counting modules while being displayed on an LCD at the entrance of the parking area. It supports payments system using an automatic payment module. The system provided an efficient parking management scheme but did not leverage IoT. The paper in [32] on the other hand proposed an automated CPS that leveraged the IoT for its operation. The system incorporated the use of a pi-camera to capture the status of parking area in order to validate the parking slots that are available/unavailable. Information about the parking areas is then sent to the micro controller which in turn updates the centralized servers; hence drivers can access the server via internet. The system was restricted to the use of sensors for detection of vehicles and no mathematical model was also provided for the system. The authors in [33] developed a SCPS using cloud computing and IoT. To reduce waiting time of users and address traffic issues, the work used shortest path algorithm to find minimum distance between users and car park in the system.

The authors in [34] described a similar cloud based IoT car park that allows parking managers to register car parks in the portal (cloud server). The system effectively addressed the issue of improper parking management scheme but did not address security of cars in the various car parks.
Table 1 presents summarized highlights of the existing vehicular technologies.

<table>
<thead>
<tr>
<th>Vehicular Technology for Parking lot</th>
<th>Major Components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBCVPS-GSM Security [27]</td>
<td>GSM Module</td>
<td>GSM Module was used to send entry &amp; exit password to users via SMS.</td>
</tr>
<tr>
<td>IPS-GSM Module [28]</td>
<td>GSM Module</td>
<td>GSM module was used to send SMS to users about status of parking lot and payment fees.</td>
</tr>
<tr>
<td>Zigbee and GSM Secure VPMRS [29]</td>
<td>GSM Module and Zigbee Technology</td>
<td>GSM module was used to enable reservation of parking slot via SMS, while Zigbee was used to enable communication between devices.</td>
</tr>
<tr>
<td>IPRTCS [30]</td>
<td>Camera</td>
<td>Camera was used to capture the state of the parking lot.</td>
</tr>
<tr>
<td>Auto park [2]</td>
<td>Ultrasonic Sensor, Voice enabled System and Camera</td>
<td>Ultrasonic Sensor was used for vehicle detection; Voice enabled System Guidance to Guidance users to designated parking slot and Camera to enhance Security in Parking lot.</td>
</tr>
<tr>
<td>IPMSIP [31]</td>
<td>Camera and LCD</td>
<td>Camera was to capture the State of the parking Lot and the LCD displayed status of parking lot.</td>
</tr>
<tr>
<td>ASPSIoT [32]</td>
<td>Pi-camera and IoT</td>
<td>Pi-camera was used to capture States of parking lot and Information was then sent to the Internet. Thus, The System leveraged on the use of IoT.</td>
</tr>
<tr>
<td>V2I [22], [23]</td>
<td>Smartphone + IEEE802.11-type wireless links. Energy efficient traffic offloading</td>
<td>Smartphone-equipped VCs through point-to-point TCP/IP-based I2V connections.</td>
</tr>
</tbody>
</table>

C. Research Gaps

From the reviewed literatures, the following were the findings as well as the established research gaps.

1. Existing systems have not explored predictive analytics in enforcing location based sensing of available spaces.
2. The use of Arduino which is a low cost embedded chip to achieve the functionalities of smart car parking system (SCPS) is yet to be explored in Fog.
3. Security measures are yet to be fully integrated in Fog based architectures. In a parking lot, this remains an important parameter in achieving a functional and efficient Smart Car Parking System (SCPS).
4. The use of non-intrusive edge layer sensors (low cost device) for vehicular detection and for providing real time parking information in the parking lot has not been explored.
5. Most works in VCC lacks effective resource management and scheduling optimization for SCPS.

III. PROPOSED SYSTEM MODEL

The system has the network side configuration and the edge node hardware integration. Now, following the analysis survey in [13], the proposed system design (network) took care of the following during the embedded design coding for the edge VCs in Figure 1, viz: data stream admission control of the vehicular input traffic to be processed by the Networked Fog Centers for SCPS; minimum-energy dispatch of the data stream (admitted-traffic); adaptive reconfiguration and consolidation of the Virtual Machines (VMs) hosted by the Networked Fog Centers at the Fog layer; and as well as the adaptive control of the traffic injected into the TCP/IP mobile connections. The characteristic features of the proposed VCC scheduler are that: (i) it is dynamic and admits distributed and scalable VCs; and, (ii) it is capable of providing composite QoS satisfaction considering maximum instantaneous rates of the data stream traffic delivered to the vehicular clients. Also, the real performance of the proposed VCC SCPS will consider [15]: (i) client mobility (VCs); (ii) wireless attenuation (fading); and, (iii) Fog layer reconfiguration and consolidation overheads. These are still on-going in this research.

Now, the SCPS based on IoT has infrastructure based sensor network architecture consisting of different modules that interact with each other to ensure a secure and efficient car parking system given the Nigerian context. The system can be implemented in real-time at supermarkets, shopping malls, schools, restaurants anywhere, anytime, etc. as indicated in [13]. The idea is to explore a novel cognitive computing-inspired VCC that has effective resource management and scheduling optimization as highlighted in [15].

A. SCPS Design Components

For the hardware integration, the work selected specialized hardware components to achieve its functionality viz: a black box power supply unit to power the various components; Arduino Duo microprocessor which is the processing unit that coordinates activities of other devices; an ultrasonic distance sensor with a passive infrared sensor for vehicle detection; a camera module used for taking snapshots of users faces when in/out of the parking lot; An SD card module used to access a micro SD card which can write and store the information sent to it by the processing unit; a display screen that gives a visual output to the car owner in other to gain access for an available parking space; an RFID card reader used to read the key tag (unique ID) on the card and sends it to the processing unit; Two servo motors (RDS3115 metal gear) used as the hardware for controlling the opening and closing of the door of individual parking lots; LEDs units used to notify users when
properly parked in the parking lot. A fingerprint scanner used for biometric verification in order to prevent car theft. Also, a GSM module is introduced which interacts with the user via SMS after receiving a signal from the VCC website. Besides, all the received information from the Arduino Microcontroller is used to update the VCC portal via the GSM module. The portal enables users to view status of parking lot in real-time.

B. System Architecture
The proposed system used Figure 1 as the cloud-Fog-Vehicular system architecture for SCPS-VCC. Figure 2 presents the SCPS hardware system architecture. Figure 2 is an interactive based sensor network system where each of the parking slots in the parking lot acts as a different node [2]. The sensors in the parking lot viz: Ultrasonic Distance Sensor (GH-311RT) or Passive Infrared Sensors (SHARP 2Y0A21) are all connected to the Arduino Duo through wired connections. All sensor nodes are connected to the single Arduino Duo. A camera (LinkSprite 2MP UART JPEG) is also incorporated in the system to capture image of the driver’s face at both entry and exit of parking lot and send their images for processing. Finger print scanner (FPM384) and SD card are also connected to the processor through wired connection as extra security measures employed in the parking lot. LEDs are also deployed at each parking slot to ensure proper parking management scheme in the parking lot, while the LCD is used to display vacant parking slot. The system also consist of a GSM Module which interacts with the user via SMS after receiving a signal from the website and also received information from the Arduino Duo is used to update the website via the GSM Module. The website/portal enable users to view status of parking lot at real-time. In this case, Figure 1 shows the backend interface.

![System Architecture Diagram](image)

Figure 2 has a view of sensors arrays in the parking lot developed as a prototype to test the functionality of the SCPS based IoT VCC technology. The various hardware and software requirement needed to actualize the workability of the system alongside their communication requirement has been presented in Section III.

Essentially, the complete system prototype comprises of Arduino Duo controller which has an Atmega AT168 microcontroller that has a pre-installed boot loader for downloading the code script into the board using only a USB-serial connection.

The code is written in Arduino software which is uploaded to the microcontroller using the A-B USB cable. The deployed servo motors in the parking lot controls the opening and closing of the door of individual parking slot. Each slot is equipped with either Ultrasonic Distance Sensor (GH-311RT) or passive infrared sensors (SHARP 2Y0A21). This is used to detect the occupancy of slots i.e. whether a particular slot is vacant or occupied. The connection between the sensor and the microcontroller at the entrance is wired. The initial system design system follows infrastructure based architecture for reliable and cost-effectiveness. Distance measurement is done in each parking slot by GH-311RT (ultrasonic sensor) and at the entrance using the SHARP 2Y0A21 (analog infrared distance sensor). The GH-311RT is a three ping terminal ultrasonic distance sensor with pins labeled: + (positive input voltage), - (negative input voltage), and SIG (used to get the distance). To get the distance, a digital HIGH signal is momentarily sent to the SIG pin and then a digital LOW after which the received is gotten and then sent to the Arduino board. The distance for a properly parked car is 0.5 meters away from the edge of the parking space. Appendix 5 uses algorithm Appendix 1, 2 and 3 for the car parking, online booking and retrieving of car respectively as depicted in Figure 2. Appendix 4 shows a simulated vehicular trajectory.

The SHARP 2Y0A21 is also a three terminal device, with pins labeled similar to that of the GH-311RT, but the mode of operation differs. While the GH-311RT’s reading is obtained by controlling a digital pin of the arduino board, the SHARP 2Y0A21’s reading is gotten by connecting its signal pin (SIG) to any of the analog pins of the arduino board and read the signal using the “analog Read” function of the arduino. Both sensors deployed at the parking slots and entrance provides precise distance measurements of up to 3 meters.

Figure 3 illustrates the demonstration of the two sensors connected to the IoT board for the SCPS-VCC. These sensors
are configured based on predictive analytic intelligence to monitor and detect incoming and outgoing vehicles at all times.

IV. CHALLENGES AND LIMITATIONS

Though this research is at its completion stage, (see Appendix 5), there are lots of challenges relating to zero sensing in smart car parking system. Some of these challenges are discussed below.

i. Determination of SCP information with Sensors
Without a reliable sensor deployment for gathering car occupancy information, detection of empty or occupied slots could be affected. Vehicular sensor selection could affect detection considering the use of either intrusive or non-intrusive sensors. However, design cost, environmental constraints, and design scope may determine the type of sensors to be adopted. Already, this work is leveraged the non-intrusive sensors owing to its ease of integration, and maintainance unlike the intrusive sensors that requires hole excavations or cuts on pavements for its deployment.

ii. Understanding the Workability of the System
There are various classifications of SCPS requiring different architectural model. For instance, the design for parking guidance information model and transit dependent information models are different. SCPS based on smart payment model and E-parking model differs even though both constituutes automated parking systems. Certainly, a good understanding of the system is needed. The system must provide sufficient information/guidelines that would help drivers to find an available parking lot easily. This is an important aspect that is currently being considered in the complete design to enable both educated and uneducated users effectively engage the system in real time.

iii. Absence of Smart Parking Services
There are useful parking services that are currently unavailable. For examples, parking facilities, Analytics for information system availability, advanced navigation services such as an in-house navigation design for ingress and exit traffic controls. To have a flexible, efficient and effective parking system, it is important that the parking lot be large enough to accommodate more parking slots which is cost dependent. It is generally accepted that the number of parking lots should be many and a parking lot should have a large space enough to park the vehicles. A synthetically generated and measured real-world workload trace analysis remains a future research for demonstration.

V. CONCLUSION

This paper has presented disruptive ideas on SCPS within the Nigerian context. Various low cost, low error and high accuracy non-intrusive sensors have been integrated into the system for vehicle detection in parking lot. Hence, providing a more robust and reliable system for end users. The work used Cloud-Fog-Vehicular system architecture for SCPS to derive the VCC hardware architecture. Also, the VCC-SCPS IoT testbed and SCPS prototype based on Non-Intrusive Sensing (NIS) was achieved. The aim is to demonstrate a smart parking system that will guarantee the security of vehicles and also take care of the QoS computing involving intensive delay-sensitive I2V services. Remarkable features of the proposed system have been outlined with respect to RTCPS. The system components and its architectural perspectives are discussed. An LCD was introduced for displaying vacant slot while an LED was used to ensure proper parking management scheme at all times. The work employed a combination of various security measures (multimodal) to ensure safety of vehicles in parking lot, making the system more efficient and reliable. Consequently, the application of the IoT as an integral part of the edge layer and the Fog nodes offers numerous advantages and flexibilities in Nigerian parking context since drivers (users) can conveniently access the
interactive website to view information regarding to parking. Future work will present the actual performance of the control algorithms numerically tested under both synthetic and real-world input traffic using various mobility conditions and settings of the networked Fog platform. Effective SCPS with resource management and scheduling optimization is currently been tested and will be fully demonstrated in a future work. This research will be extended to account for intra-slot traffic arrivals in the application scenario as seen in [15], and[16]. The issue of live migration of the VMs will be analyzed for optimizing energy consumptions at the Fog nodes in the future studies dealing with Vehicular cloud datacenters which takes care of traffic Big datasets.

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REFERENCES


Appendix 1: Car parking Algorithm

```xml
<Begin>
<Output> Screen displays number of available space </Output>
If (UserPresentSmartCard ( )){
    <Input> Read Smart Card </Input>
    TakeSnapshotAndUserfingerprint ( )
    OpenParkingSpaceDoor ( )
    WaitForCarToParked ( )
    If (CarIsProperlyPositionedInSlot ( )){
        <Output> LED Lights Up </Output>
        WaitFor30Secs ( )
        CloseTheDoor ( )
        UpdateSpaceAvailable ( )
    } Else{
        <Output> Car not parked Properly </Output>
    }
} Else{
    <Output> Please swipe Smart Card </Output>
} <End>
```

Appendix 2: Car Retrieval Algorithm

```xml
<Begin>
<Output> Swipe Smart Card </Output>
If (UserPresentSmartCard ( )){
    If (SmartCardIsValid ( )){
        TakeSnapshot ( );
        VerifyFingerPrint ( );
        If (FingerPrintIsValid ( )){
            OpenParkingSpaceDoor ( );
            DeleteFingerPrintFromDatabase ( );
            If (CarIsRemoved ( )){
                UpdateAvailable ( );
            }
        } Else{
            End ( );
        }
    } Else{
        <Output> Invalid Smart Card, Please present a valid smart card </Output>
    }
} Else{
    <Output> Please swipe Smart Card </Output>
} <End>
```

Appendix 3: Online Booking Algorithm

```xml
<Begin>
<Output> Enter Phone number and click on go </Output>
If (PhoneNumberIsEntered ( )){
    <Input> Read Phone Number </Input>
    If (IsSpaceAvailable ( )){
        SendBookingSMSMessage ( );
        <Output> Dear Username, Congratulations!!! You have been booked </Output>
        UpdateSpaceAvailable ( );
    } Else{
        SendWelcomeSMSMessage ( );
        <Output> Sorry, there is no available space now, check back later </Output>
    } Else{
        <Output> Please Enter a Valid Phone number </Output>
    }
} <End>
```

Appendix 4: Vehicular computing clusters
Appendix 5: SCPS prototype based on Non-Intrusive Sensing.