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THE INTERACTION OF VEHICULAR NETWORKS ONTO AN AGILE PLATFORM SCHEME FOR SMART CITIES MANAGEMENT

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ABSTRACT

The Opportunistic Vehicular Communications did open new research fields, for the smart cities connectivity development and the vehicular cloud computing in general, that benefits the smart systems, applications and data collectors existing in the City. In this paper, we propose an Agile platform combining the usage of Smart Applications and Vehicular Communications in the Internet of Things (IoT); the Agile platform represents a case study of Internet of Things-related technologies that deploys multiple applications and interfaces to interact with different "Things" by deploying different communication technologies. In this work, we propose the utilization and evaluation of VANETs Networks that represent one of the existent communication tools in a smart city, this network will be deployed by the Agile platform to exchange specific types of informative data, thought there are other communication tools available for the Agile Platform, but, due to its flexibility and availability in a smart city, we are more interested into the VANETs Networks and how the Agile Platform may benefit from this network. In this paper, we describe the architecture and the components of the Agile Platform, how it interacts with other systems, users and servers part of the city, as well as the evaluation of VANET Networks deployment by the Agile Platform for an end-to-end communication.

Keywords: *Agile Platform, Vehicular Networks, Smart City, Smart Applications.*

1. INTRODUCTION

In the recent years, VANETs Networks offered multiple research fields to establish possible and opportunistic connections as well as manage different applications used in vehicular communications, smart grids, smart homes, smart cities. Basically Vanets can play a major role in connecting the diferent “things”, and hence enabling and enhancing the concept of Internet of things. Indeed, vehicular communications provide network connectivity inside and outside cities where wired connectivity is impossible or may cost a fortune and a big amount of resources to be established and maintained, The fact that VANETs afford connectivity inside and outside cities, justifies the importance of vehicular communications as an essential communication tool within the cities, it fills a major gap of the existing networks implemented and applied within the context of smart cities[1].

The opportunistic communication the VANETs Networks offer, are capable of acting as a transmission tool of important data generated within the smart city. This data is either captured by sensors and data collectors or generated by other Smart Applications distributed in different zones within the smart city. The data collected and transmitted varies from data related to traffic, alerts of accidents, floods, road safety, healthcare, transport, energy, homes and buildings and the environment...etc[2-3-4-5-6]. The control servers receive the data transmitted through the vehicular networks, to perform the processing and the analysis required, then reply in case a response is needed or just store the data for further use in future occasions.

In the context of Smart City future vision, the existing Internet infrastructure and the VANETs networks contribute a major role to the transmission and distribution of information and other data within the Smart City. Whereas, the processing and analysis of these data are performed at the control servers, which may produce some unwanted traffic due to the volume of the data transmitted in the networks[7]. In order to avoid such situation, the implementation of multiple access points or processing systems that interact with the control

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servers is required, though this solution is practical, but due to the installation and maintenance costs it is not very handy, especially for larger cities.

In this paper, we present an alternative solution described as the Agile Platform, that is comprised of the embedded smart devices and other normal devices implemented within the city that benfits from the vehicular cloud, utulizes the resources available and under-utilized in the vehicles, requires less access points and data storage systems. The Agile Platform is capable of sensing multiple kind of information, processing, analyzing, interacting with the control server and even storing valuable information. The platform has access to the Internet and in continuous contact with the sensors and data collectors as well as the other smart applications within the city. In this work we describe how The Agile Platform benefis from the Network available in the road, especially from the Vehicular Cloud the vehicular networks offers to the Smart City. This platform combines the usage of both Mobile and Vehicular Cloud Computing to keep the distributed devices connected and data flowing inside the platform. In this paper we are interested in the communication to other systems, vehicles, and network infrastructures by vehicle to vehicle or vehicle to infrastructure networks.

This paper is organized as follow, the next section includes the State of Art that describes the Vehicular Networks utility and usage by the smart applications and smart systems within the Smart cities, then in section 3 we present the Agile Platform full architecture, how it utilizes the Vehicular Networks, and how it can contribute to the improvement of the smart city concept , in section 4 we describe the experimental setup to evaluate and validate our work with the results obtained and some observations, in section 5 we conclude our paper and provide our vision for the future work.

2. THE STATE OF ART

In order to give reality to a well constructed Smart City, we are obliged to elucidate the means capable of connecting the whole city, human to human, machine to machine and human to machine. Where the machine part is represented by different components such as sensors, data collectors, smart applications ...etc, that are part of the global smart city infrastructure. For any existing city that seeks the word "Smart" in its profile, it has to offer multiple and different services to people in different fields. The objectif is to improve the citizen’s lifestyle, while at the same time giving consideration to ways of reducing the system’s impact on the natural environment and resources. Knowing the rapid growth of population within the cities, and its flourishing in the last decades, the Smart City requires the implementation of a smart infrastructure capable of interacting with the people and the rest of different applications and data collectors distributed within the Smart City. towards this goal, one needs to take into consideration the cost and the complexity of the deployed smart city infrastructure. that is capable of utilizing both Continuous and Delay-Tolerant Networks. The Vehicular Network is part of the available networks in the Smart City that is capable of forwarding and trasmitting data between two ore more end users[8-9-10].

The Vehicular Networks does not require a pre-installed infrastructure, rather it uses a free available network comprised of different interfaces implemented in each vehicle circulating on the road, that transmits or transports the data flowing in the Smart City, this network tolerates the data transmission to communications of short and long delays, and gives priority to urgent messages, which may influence and interupt other communications in the same network[11], the Vehicular Networks transmits the data in two different ways:

Data mules: in this case the vehicles are used as data carrier of any type of data accumulated in the city from the data collectors, sensors or smart applications that generates data within the smart city. The vehicles keep the collected data stored until they reach the destination or an access point to transmit the data in the cloud to reach its destination. This solution can be used to carry the data generated/required by a large kind of applications, especially those which are not delay sensitive. The vehicular networks facilitates the transmission to the back-end, with no constraits regarding the delay. Nevertheless, the bigger challenge encountered resides in the different management entities that control the mules or rather the vehicles, and assures that the specific quality of service is met [4-5-12].

Data forwarders: in this case, the vehicles transmit the data in a forwarding way without storing it until they are close to destination but rather, they forward the data between the source and destination or an access point connected to the Internet capable of transmiting the data to the destination. There are two categories; the first one does not send any data until the connection is established using existing routing protocols that helps establishing the route between source and destination, while the second one keeps forwarding the data towards the destination without establishing any route between the source and destination. The second technic may, sometimes, lead to data loss or the dropping of the data [13-14].

Large varities and different types of data are circulating within the Smart City, which imposes the utilisation of different routing protocols for each type of data. Indeed, there are types of data that tolerate long delays whereas there are others that require only short delays and others that need to be transmitted as fast as possible (such as real time applications). In this paper, we are interested in the last category of data that requires the lesser delay possible to be transmitted from the source to destination, with the aknowledgement response. The destination varies from vehicles, mobile vehicles with Internet, or fixed access points installed in the smart city and connected to the Internet. In this context we are using, as routing protoclol, the Ad-hoc On-demand Distance Vector (AODV) routing protocol [14-15]. AODV establishes the route between the source and destination before the start of the transmission of the data. This routing protocol is capable of restoring the route if the route got broken and once the transmission of the data ends this routing protocol deserts the route to avoid congestion in the network.

The source and destination in a Smart City represent two major essential polars. While the source represents different types materials and technologies used to collect data like sensors of different fields that collect data, or smart applications used by vehicles, smart homes, buildings, industrial buildings ...etc, that produce specific data related to there functionalities. This data is usually sent to the destination/back-ends of each specific type of data, to be processed and analyzed.

The data transmission relies on all availabale connexions including the access point, vehicular network, long range wireless network(such as GSM, WImax etc). the goal is to develop a system to support the interactions of the different elements acting within the city(in terms if required and collected data). This system should facilitate the control and the monitoring of these differernt acting elements. We propose in this paper as shown in Fig.1 an Agile Platform that its main functionality is summerized onto sensing multiple kind of information, processing, analyzing, interacting with the control server and even storing valuable information, this platform manages the grand system deployed in the Smart City basing its communication on the Vehicular Cloud; in the next section we are going to present the full architecture of the proposed Agile Platform, with its major functionnalities and its role in the Smart City.

3. SYSTEM ARCHITECTURE

The Agile Platform is designed to take over the basic infrastructure of the Smart City, this platform deploys and interacts with multiple systems, users, data storages(data centers, data warehouses both

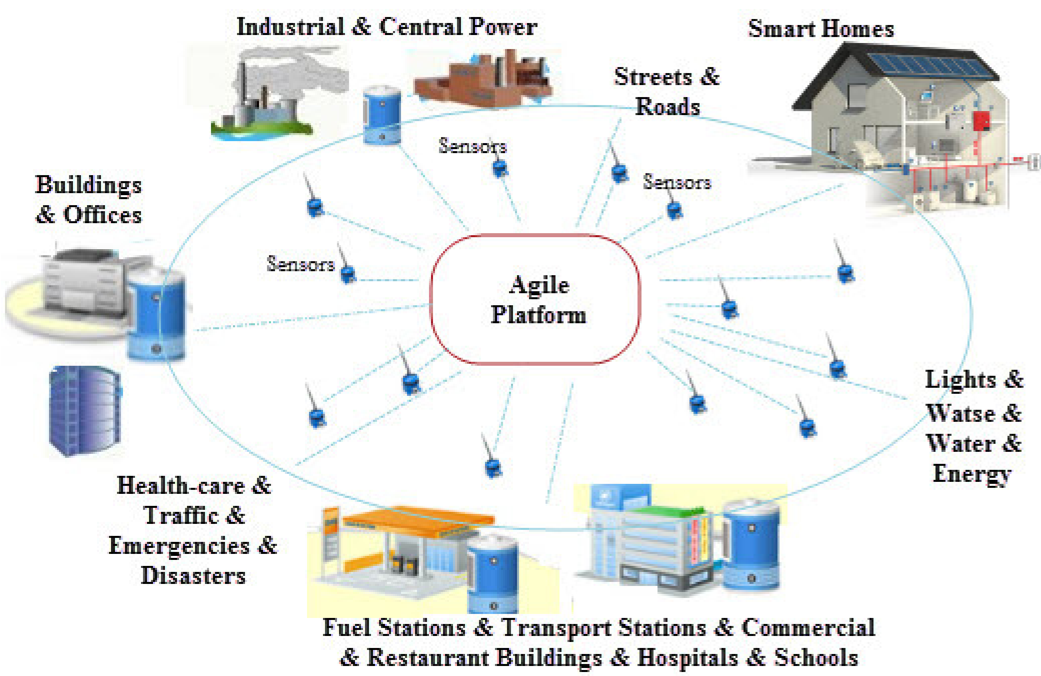

Figure 1: . Interaction of The Agile Platform with the rest of the Smart City Components

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connected to the Internet and capable of processing and storing data), access points, servers ...etc.

3.1 The Agile Platform Design:

The Agile Platform as it is shown in Fig.2 consists of different systems and components:

- *Sensors:* this component represents the data collectors distributed around the city, their main functionalities dwell onto keeping the parties interested in the data collected, with the latest information disponible or generated in real time. The sensors this platform deploys, differ in term of type, sensing technology, the way the data is collected and the communication technologies used to transfer the collected data. The data collected represents different types of possible information existing in the Smart City such as road traffic, accidents, construction work ...etc. That represents information related to vehicles and roads, to information related to calculating the probabilities and percentages of the city or zones of the city's air pollution, or the computing of the energy, water consumption. Sensors deployed by this platform depend on either of the two communication tools avaialable, directly connecting to the Internet(3G, GPS...etc.) or using the Smart City communication Cloud to connect to the Internet, to transmit the information to the interested parties involved. The communication tools used by each sensor depend on the information they provide and its importance and impact on the management of the city.
- *Smart Applications:* this component represents the multiple applications distributed around the city, these applications provide various services in diver fields, and the better the quality of service offered by the smart application, the better its influence onto the smart city. The Smart Applications, deployed by the Agile Platform generate information from the services they provide, this information can be put to use by different systems, users or facilities involved in the service. In order to clarify, we propose an example of the service provided by the Smart Diagnosis System presented in a previous work[18], where the on-board middleware installed in the vhicle monitors the vehicle equipments periodically and continuously, this service require pre-installed sensors on the vehicle, connected to the on-board middleware, while the middleware is connected to the servers/back-ends through Internet directly or using the roadside units for suply informative data. The service sends to the driver/owner in case of possible defection to an equipment, urgent message regarding the vehicle state with possible solutions or direct them to nearby facilities. Smart Applications depend on either one of the two communication tools avaialable, directly connecting to the Internet or using the Smart City Communication Cloud to connect to the Internet. Whereas in comparison to the sensors, most of the smart applications connect directly to the internet, due to the importance of the service's execution time.
- *Data Storage:* its comprised of multiple stations the Agile Platform deploys around the city, these stations receive data from multiple devices, smart applications, nodes and sensors installed in the city. This data is composed of different types of information, depending on the service or data collector providing the information such as air pollution, waste cans levels, roads state, traffic congestion zones, buildings water, electricity and energy consumption...etc; The stations are connected to the Internet directly and compromize two categories; public and private stations, while the private stations accept and store only specific

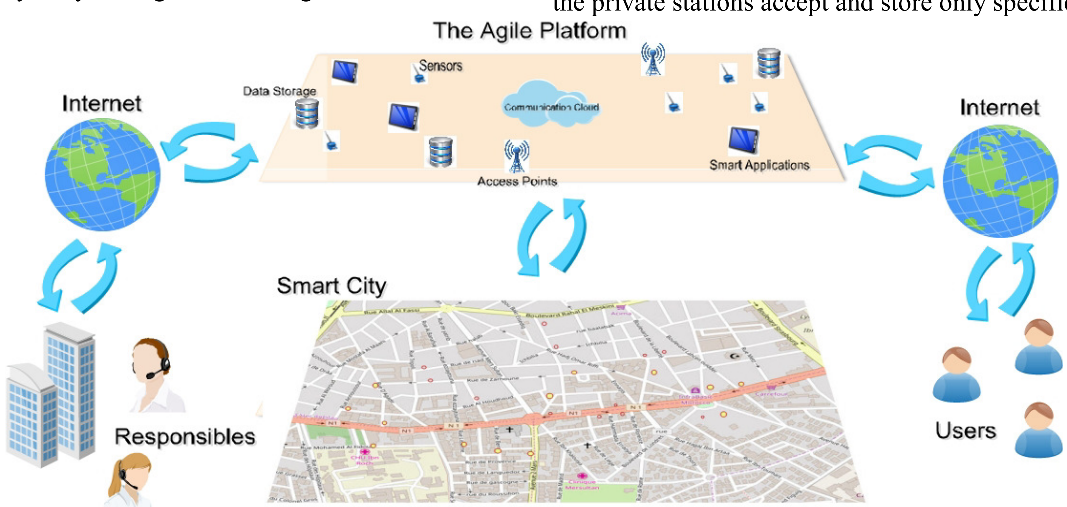

Figure. 2. The Agile Platform Interaction with the different Systems in the Smart city

- data related to the services benefiting from this station, the public accept all the data received. Depending on the technologies used on this station it may process and analyze it before it is stored or transmitted to the servers interested. These stations also are connected to the Smart City Communication Cloud, that offers to the data storage the possibility of communicating with the data collectors distributed in the city. The data storage stations also store data received from facilities and servers, to offer the required information of a specific service when it is needed, as fast as possible, in order to improve the quality of service of some applications.
- _Access Points:_ they represent gateways to the information circulating in the Smart City Communication Cloud to the Internet, especially when the information needs to be transmitted to the back-ends, facilities, servers as fast as possible. They are also used to reduce the overhead the data storage stations may encounter to transmit the information through the Internet. The Agile Platform deploys private and public Access Points, the public allows all the transmission of all information, while the private may specify the type of information that is to be transmitted or allows the utilization of the Internet to only some specific devices.
- _Communication Cloud:_ The Smart City Communication Cloud represents the Communication tools used by the Smart City Cloud, that differs from Wi-Fi, Li-Fi, MANETs, VANETs...etc, these communication technologies that offer a connection between nodes, and allow the transmission of information between two or more end users. These communication technologies are deployed by the Agile Platform in order to connect the sensors, street cameras, devices and other systems that do not have access to the Internet; to either the data storages or the Access Points.

3.2. The Systems Intervening With the Agile Platform:

The Agile Platform interacts with multiple Systems and components of the Smart City as shown in the Fig.2:

- _Servers/ Back-Ends:_ are concerned by the processing and analysis of the data that was not processed and analyzed in advance, then a response is sent in case it is needed. The Servers also act as a safe keeper of historical data for future analysis and comparison, depending on the needs and requests from the services or the data storages. In order to elucidate the importance of this system, we propose the example of historical data regarding the traffic congestions happening for example due to construction works or an accident within the city and how they differ depending on the places or zones this event occurs and how it affects the regular circulation at each period of time within the day. So for more informative data, the data storages deployed by the Agile Platform request for more information from the servers and broadcast the information through the Smart City Communication Cloud, to the vehicles in the concerned zone of the city, to avoid the occurence of an uncontrolled traffic.
- _Intervening Systems:_ they consist of the systems that are influenced and act upon specific events occurence within the smart city, they respond to the

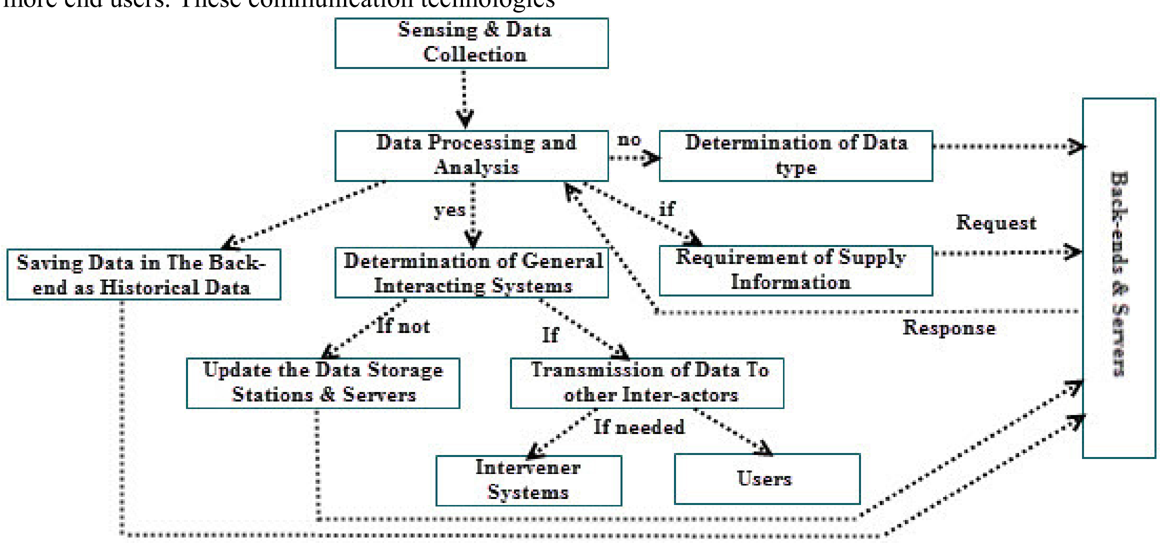

Figure 3: The Agile Platform's Procedure With The Data Collected

call when the event triggered concern them, and to

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- calrify, we give the example of an accident event that happened in the city and how the sensors and street cameras deployed in the city collect this urgent data, then broadcast it through the Smart City Communication Cloud in the city, to alert the nearby vehicles on that zone and also transmit the data to the possible intervining systems like the Ambulance and Police to move as fast as possible to the accident place, and alert the other intervening systems and that is the Hospital to prepare for an incoming patient.
- *Users:* they comprise of either the people living within the city or some of the applications implemented and deployed in the city that interact with the responses received. The systems deployed or in connection with the Agile Platform usually inform the users either by informative, urgent, sensative or entertainment informations in response to an event triggered from a specific service.

3.3. The Agile Platform Main Procedure:

As shown in Fig.3 the major steps the Agile Platform regularly intervenes in are:

- *First:* The Agile Platform identifies the data generated either due to an act of sensing, or the excution of a service, by identifying the source of the data collected; this data will either be transmitted directly through the Internet to the servers interested, or go through the Agile Platform Communication Cloud to reach either an access point or a data storage station.
- *Second:* If the data transmitted directly to the servers provide informative information that is still required by other systems in the city, the servers transmit to the data storage stations the responses needed. As for the data transmitted through the Agile Platform Communication Cloud to the data storage stations or access points, and depending on the information this data contains, it is proccessed before its transmission to the servers, stored in the data storage stations if requested, or wait for a response that contains the information needed, to be stored.
- *Third:* in this step the tools deployed by the Agile Platform, identify the different systems and users influenced and interested by this data in the city, and transmit to this end users the part or the full information they request or need.

In this context and due to part of our research concerns the influence of VANETs Networks onto the management of a Smart City, we are trying to illustrate how the Agile Platform we propose, is capable of utilizing and benefiting more from the under-utilized Vehicular Networks, that is available for us in the Smart City, and so we'll perform our data and information exchange, between the different systems of the Agile Platform and the different intervening systems and Users, using solely the VANETs Networks.

3.4. Vehicular Networks Interaction:

The rapid growth of population in cities, demands an implementation of multiple types of communication tools and technologies, in order to satisfy the global needs of the city inhabitants; due to the huge amount of data circulating within the city, multiple communication technologies are implemented in order to minimize the network traffic, due to the increasing demand of services identified in the Smart City, but the implementation within the Smart City of a full connected infrastructure with all the other infrastructures and services cost a fortune and request continuous and costly maintenance, and it is preferable to use flexible, mobile and opportunistic connections between vehicles and nodes(Servers, Sensors, data collectors ...etc.) whenever the chance is given, this is where VANETs can be considered a powerful tool used for network connectivity within a Smart City, and how the VANETs have evolved from the collection of traffic congestion, road safety and emergency informative data concerning the road, towards a new technology known as the Internet of Autonomous Vehicles, like other instantiations of the Internet of Things (IoT), they are capable of acting as a regular network that is capable of forwarding data between two different entities and connecting them through The Internet of Vehicles, the Internet of Vehicles represent a part of the Smart City communication Cloud that will posses his own storage, intelligence and learning capabilities to anticipate the Smart City needs and intentions. The Art of Vehicular Communications employed within the Smart Cities, are still far from reaching the ideal desired results. Nevertheless, they act as a powerful communication tool when it concerns the handling of traffic congestion, road safety and emergency data, but even so the Vehciular Networks are still under-utilized, that is why we are deploying this communication tool as the basic network available to the Agile Platform to exchange its data between its components, the next step would be to identify the Internet of Vehicles as a powerful communication tool for the Agile Platform, that deploy the mobility of its nodes to a better and flexible communication that tolerate short delays.

The fact that the daily vehicles circulating in the city roads vary from private, public(buses, taxis..etc.) and semi-public(trucks, school buses

...etc) transport systems, limits the benefits of vehicles networks and the full potential VANETs may accentuate in Smart Cities; eventually if all the vehicles in the city were involved, the quality of service would be optimal; but for a realistic alternative, we consider only the public and semi-public moving vehicles that will constitute our Vehicular Networks for a Smart City which may represent between 10-30% of all the vehicles in the city roads, and may go sometimes up to 50%, each interacting vehicle in the Vehicular Networks is required to have an on-board terminal, that integrates different wireless communication technologies(Wi-Fi, ZigBee, Bluetooth...etc.), to communicate with surrounding vehicles, data base stations, nodes, sensors or other infrastructures, some of these vehicles will also be capable to communicate through the Internet.

In this paper, our main interest during the simulation phase consists on the evaluation of the capability of the transmission of messages that require an aknowledgement for the message received between the smart applications, the devices or data storages deployed by the Agile Platform using mainly the vehicular networks as a communication tool.

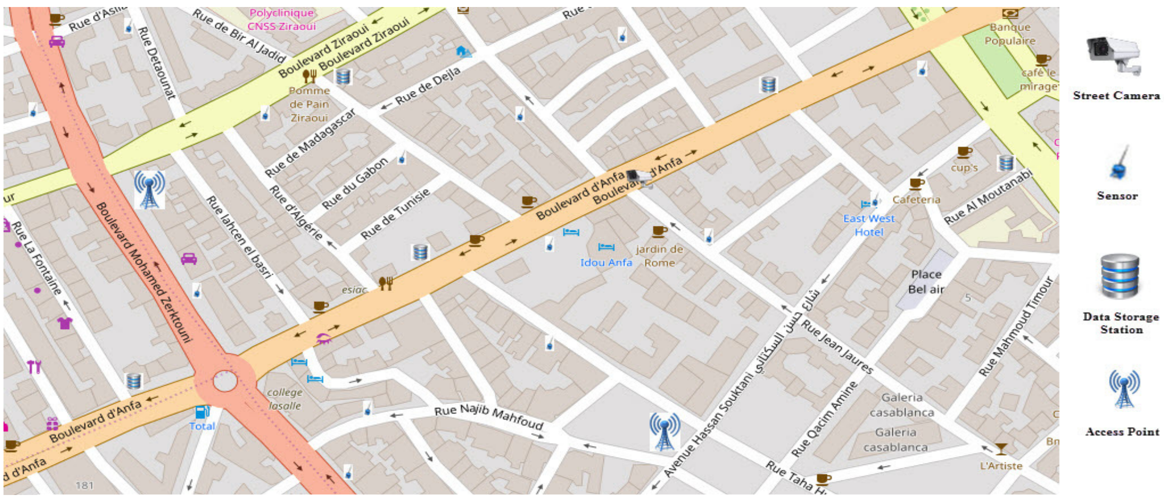

Figure 4: The Map of Casablanca City Taken From OpenStreetMap, And The Systems Deployed By The Agile Platform Positions

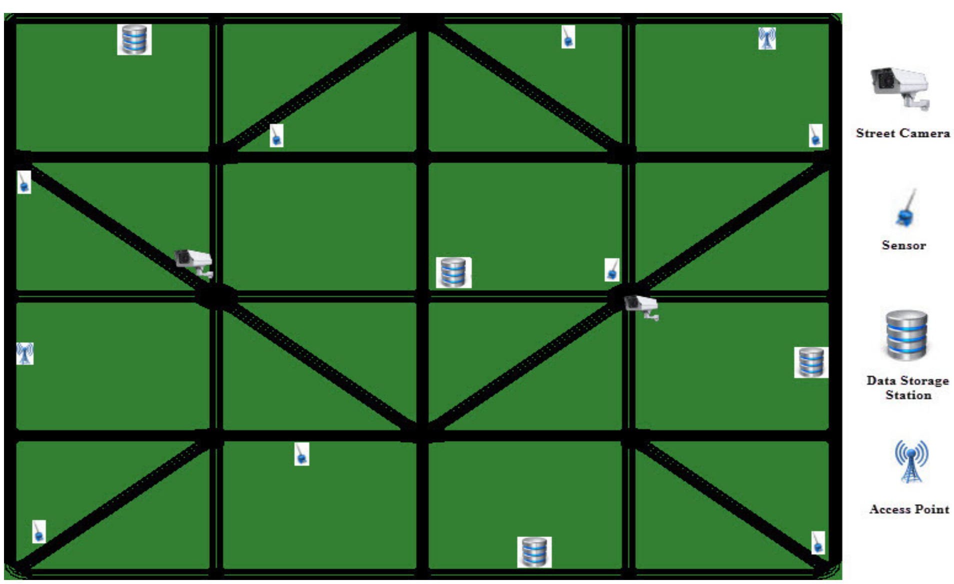

Figure 5: The Configured Map by SUMO, And The Systems Deployed By The Agile Platform Positions

4. SIMULATION

In order to verify if the vehicular communication networks is capable of acting as a trustworthy network for the information exchange, between the Systems deployed by the Agile Platform. We propose the evaluation of the information exchange of some smart applications that we may encounter in a Smart City, we propose the following three services, Smart Energy Consumption Monitoring, Smart Accidents alerts, Smart Waste Management, these applications will act as the source of our requests, to the Data storages, Access Points and the public transportation systems that allow the utilization of their gateway to the Internet. We are interested on the amount of time it takes for requests and responses to be transmitted from the sensors, street cameras, smart applications deployed by the Agile Platform, around the city, towards the gateways available to the Internet in the city.
We set every node(vehicle, station...etc.) in the network involved during the transmission phase, with Ad-hoc On-demand Distance Vector(AODV) [15] Routing Protocol, due to its simplicity and lower delays, the drawback for AODV implementation in VANETs consist on the end-to-end paths do not last much due to high speeds of vehicles, but in some districts where traffic congestions are known which alter the vehicles speeds, the AODV outperforms other Routing Protocols like greedy forwarding and geographical routing, GPSR (Greedy Perimeter Stateless Routing) [16] and GOSR (Geographical Opportunistic Source Routing) [17] (that have shown good performance in VANETs), due to the stability of routes for longer periods of time.

4.1. Configuration of the Maps

To evaluate the utility of Vehicular Networks onto the Communication Cloud designed for the Agile Platform, we will use two different maps. The first map represent a urban scenario from Sidi Balyout district in Casablanca the Largest city in Morocco, we install five data storage stations, two Access Points, four sensors for waste cans monitoring, ten sensors for energy consumption monitoring, and one street camera acting as a data collector for accident alerts as shown in Fig.4, we use the VANETs for the communications, the length of the streets varies from 50m to 300m with multiple junctions that connect 2 to 7 streets, principal streets contain three lanes each direcation, sub streets go from one to two lanes each side, sometimes the street allow traveling in one direction only, the junctions are organized by traffic lights or priority system.
In the second map, each road and street comprise two lanes for each side, only the main streets are composed of three lane each side, we install four data storage stations, two Access Points, four sensors for waste cans monitoring, four sensors for energy consumption, and two street cameras for accident alerts data collection, all these components are installed around the city as shown in the Fig.5, the length of the streets differ from 100m to 200m, with multiple junctions, all organized by traffic lights system.

4.2. Configuration of the Data Generator Systems and The Vehicles

The sensors collecting the energy consumption are installed near the roads to facilitate the communication with passing by vehicles, the street cameras are deployed in major junctions and in areas known for an increase in speed by the drivers, as for the sensors deployed on waste cans, they are placed near roads.
The vehicles, are divided into two groups, public, semi-public group and the private group, the public and semi-public group comprise Taxis, buses, trucks, trams, school buses...etc, we are will use two different scenarios, the first one we deploy only public and semi-public vehicles that will represent 25% of the number of vehicles circulating in the map, then we will deploy all vehicles existing in the road to transmit the information.
The source will be represented by the sensors and street cameras, while the destination will be represented by the data storage stations, Access Points, and public and semi-public transport systems with Internet which will be represented by only 30% of the publiv and semi-public transport systems.
The transmission range of the sensors and street cameras will be fixed on 50m, and for the vehicles, data storage stations and access points on 150m.

4.3. Simulation Configuration

In the map used from Sidi Balyout District of Casablanca City, we generate 400 vehicles, that includes a ratio of taxis, buses, School buses and public trucks, and the rest consist of private vehicles, the Simulation scenario is using this part of casablanca city map taken from OpenStreetMap, as for the second Simulation scenario we generate 580 vehicles distributed between public, semi-public and private transportation systems, all scenarios are configured in the Simulation of Urban

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MObility(SUMO) (version 0.12.3 since it is the version compatible with MOVE), with the help of the Mobility Model Generator for VANETs (MOVE) Simulator, we try to generate a realistic scenario of vehicles mobility, that will be used in the Network Simulator 2(NS2), with the help of MOVE simulator we are capable of setting the movement tragectory of some public and semi-public transportation systems especially the buses, waste trucks and school buses.

We set the Initial Energy used by the vehicles to 0 unless the vehicle represent public or semi-public transport system, or a private transport system that permits data packets transmission. In the first scenario we use only the public and semi-public transportation systems as data forwarders, while in second scenario we deploy all vehicles existing in the City without having access to internet from private vehicles. The Initial Energy is set to 100 Joules, to make the vehicle capable of receiving and transmitting data, the transmission of data and information exchange starts at the second 85 of the simulation.

For all the maps we will transmit a message of 512 bytes size, generated by each sensor, and a message of 2Mbytes, generated by each street camera, the sensors generate data each 10 seconds and require a possible route to transmit the data, the street camera generates data only when an accident occurs, and so we trigger the two accident events one at the 120 second and the other at the 200 second, each event detected by the street camera nearby, We start the transmission of all data at the 85 second.

Table 1. SIMULATION SETTINGS

Parameter	**Value**
Packet Size	512 bytes
Simulation Time	240 seconds
Part of Sidi Balyout Map	1100*700 m^2
Map 2	800*600 m^2
Number of Nodes in Sidi Balyout Map	422
Number of Nodes in Map 2	596
Maximum Average Speed	20-50 (km/h)
Mobility Model	Flow & Directed Trajectories - MOVE Simulator
Vehicles Transmission/ Reception Range	150 m
Data Storages Reception Range	150 m
Sensors/ Cameras Transmission Range	50m
Access Points Reception Range	150m
Routing Protocol	AODV/ DSDV

In all Simulations, we use the AODV routing protocol for data transmission between the the sources and destinations defined above, as for the Interacting vehicles that use the VANETs Netwroks for other purpose, we use the DSDV routing protocol for their information exchange and data distribution, the main objective of all the simulations is to evaluate the average time it would take for the information to reach the Internet, in different situations.

We employ for each data storage station, public and semi-public, and Access point with Internet the same adress, to allow the rapid and fast transmission from source to the nearest destionation with Internet.

4.4. Results and Observation

Table. 2. Results Of The Simulations Performed On Configured City Map

Source	Number of Data Packets Send		Time For Data Packets Transmission (ms)	
	30%	100%	30%	100%
Energy Sensor 1	12	16	421	385
Energy Sensor 2	13	16	295	334
Energy Sensor 3	12	16	152	186
Energy Sensor 4	14	16	57	94
Waste Sensor 1	13	15	638	476
Waste Sensor 2	10	16	934	1082
Waste Sensor 3	12	16	251	238
Waste Sensor 4	15	16	31	48
Camera 1	1	1	519	211
Camera 2	1	1	482	139

Table. 3. Results Of The Simulations Performed On Casablanca City Map

Source	Number of Data Packets Send		Time For Data Packets Transmission (ms)	
	30%	100%	30%	100%
Energy Sensor 1	14	16	249	231
Energy Sensor 2	9	15	1729	1927
Energy Sensor 3	12	16	734	561
Energy Sensor 4	13	16	288	361
Energy Sensor 5	11	16	1074	841
Energy Sensor 6	12	16	251	192
Energy Sensor 7	15	16	61	87
Energy Sensor 8	12	16	628	437
Energy Sensor 9	13	16	433	318
Energy Sensor 10	11	15	512	374

Waste Sensor 1	14	16	107	72
Waste Sensor 2	12	16	529	461
Waste Sensor 3	13	16	391	314
Waste Sensor 4	12	16	413	264
Camera 1	1	1	789	649

The Table.2 and Table.3 illustrate the results obtained through the simulations of both scenarios, the first one that utilizes 30% of vehicles as nodes that allow the forwarding, it shows how systems deployed by the Agile Platform benefit from such Network, though the number of data packets transmitted could have been more, but due to the public and semi-public transportation systems do not cross every road existing in the City, due to privacy, also, only occasionally taxis go through such roads when it is needed; while the second scenario utilizes 100% of the existing vehicles in the roads, and transmits for all the systems all its data to its destination, only when there are no vehicles in the range of sensors transmission, the delay of transmission from source to destination is acceptable, since it does not go beyond two to three seconds.

The number of vehicles decrease more during night time in cities, so the major data exchange occurs during the daylight time, at night time, when lesser vehicles ciculate in roads, we propose to configure the public and semi-public transport systems as Data mules towards the Internet gateways, to make the Agile Platform benefit more from the networks it deploys, and in order to make the Agile Platform benefit more from the Vehicular Networks, we propose during the construction and installation of systems in private vehicles, to add an Interface and very mini data stockage system, that should be exploited by public data circulating in the City, and should by no means affect the private systems functionalities in the vehicle.

5. CONCLUSIONS

In this work, we presented the architecture of the Agile Platform we propose, the platform is comprised of multiple systems and tools for data generation, collection, storage and transmission, such platform, is capable of managing the basic infrastructure of the city, and satisfying the needs of its inhabitants, due to the possibility of collecting data from any part of it, which benefits the quality of service of the services the city provides to its residents.

We also illustrated the importance of the Vehicular Networks deployed as a tool of communication by the Agile Platform, by offering a very satisfactory and alternative network, that is capable of acting as a transmitter and forwarder Network between two different points that are either mobile or fixed and require a short continuous or discontinuous connectivity, where we focused in this paper more on the continuous and the data that require an aknowledgement between the end users.

For future work, we are gonna focus onto implementing our Agile Platform in reality, and try to satisfy the waste cans management, basing the city local communication on Vehicular Networks until we reach a gateway to the Internet to transmit the data to the interested servers, and propose to the systems that may intervene, the actions they should be performing, also we will need to implement some devices on a number of public and semi-public vehicles for data forwarding, which calls for some investements from the industries and facilities interested.

REFERENCES

[1] Jarupan Boangoat, Ekici Eylem; "A survey of cross-layer design for VANETs", Ad Hoc Networks; Volume 9, Issue 5, July 2011, Pages 966–983.

[2] S. Schnaufer, S. Kopf, H. Lemelson, W. Effelsber g, Beacon-based short message exchange in an inner city environment, in: Proceedings of 2010 9th IFIP Annual Mediterranean Ad Hoc Networking Work-shop (Med-Hoc-Net), 2010, pp. 1–8.

[3] H. Qin, Z. Li, Y. Wang, X. Lu, W. Zhang, G. Wang, An integrated net- work of roadside sensors and vehicles for driving safety: concept, design and experiments, in: Proceedings of 2010 IEEE International Conference on Pervasive Computing and Communications (PerCom), 2010, pp. 79–87.

[4] R.A. Gorcitz , Y. Jarma , P. Spathis , M. Dias De Amorim , R. Wakikawa , J. Whitbeck , V. Conan , S. Fdida , Vehicular carriers for big data transfers (Poster), in: Proceedings of the 2012 IEEE Vehicular Networking Conference (VNC), Seoul, Corée, République De, 2012, pp. 1–8 .

[5] R. Sugihara, R.K. Gupta, Path planning of data mules in sensor net- works, ACM Trans. Sen. Netw. 8 (1) (2011) 1:1–1:27, doi: 10.1145/ 1993042.1993043 .

[6] T. Spyropoulos, K. Psounis, C.S. Raghavendra, Spray and wait: an efficient routing scheme for intermittently connected mobile networks, in: Proceedings of the 2005 ACM SIGCOMM Workshop on Delay-

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

tolerant Networking, WDTN'05, ACM, New York, NY, USA, 2005, pp. 252–259, doi: 10.1145/1080139.1080143 .

[7] G. Anastasi, M. Conti, M. Di Francesco, Data collection in sensor networks with data mules: an integrated simulation analysis, in: Proceedings of IEEE Symposium on Computers and Communications, 2008. ISCC, 2008, pp. 1096–1102, doi: 10.1109/ISCC.2008.4625629 .

[8] C. Harrison, I. Donnelly, A theory of smart cities, in: Proceedings of the 55th Annual Meeting of the ISSS, 2011.

[9] F. Gil-Castineira, E. Costa-Montenegro, F. Gonzalez-Castano, C. Lopez-Bravo, T. Ojala, R. Bose, Experiences inside the ubiquitous Oulu smart city, Computer 44 (6) (2011) 48–55. doi: 10.1109/MC.2011.132.

[10] Marsal-Llacuna, M.-L., & Segal, M.E., The Intelligenter Method (I) for making "smarter" city projects and plans, Cities (2016), doi: http://dx.doi.org/10.1016/j.cities.2016.02.006.

[11] F. Viani, F. Robol, A. Polo, P. Rocca, G. Oliveri, A. Massa, Wireless architectures for heterogeneous sensing in smart home applications: concepts and real implementation, Proc. IEEE 101 (11) (2013) 2381–2396. doi: 10.1109/JPROC.2013.2266858

[12] R. Shah, S. Roy, S. Jain, W. Brunette, Data mules: modeling a three-tier architecture for sparse sensor networks, in: Proceedings of the 2003 First IEEE International Workshop on Sensor Network Protocols and Applications, 2003, pp. 30–41, doi: 10.1109/SNPA.2003.1203354 .

[13] Benslimane A, Taleb T, Sivaraj R. Dynamic clustering-based adaptive mobile gateway management in integrated VANET-3G heterogeneous wireless networks. IEEE J Sel Areas Commun 2011;29(3):559–70. doi: 10.1109/JSAC.2011.110306

[14] Chen W, Guha RK, Kwon TJ, Lee J, Hsu IY. A survey and challenges in routing and data dissemination in vehicular ad-hoc networks. In: Proceedings on IEEE international conference on vehicular electronics and safety, Columbus, OH, USA; 2008. p. 328–333.

[15] Perkins, C.E., Belding-Royer, E. M., Das, S.R., "Ad hoc on-demand distance vector (AODV) routing", IEEE Personal Communications, pp.16-28, 2001.

[16] Karp, B., Kung, H. T., "GPSR: Greedy Perimeter Stateless Routing for wireless Networks", MobiCom 2000.

[17] Zhongyi l., Tong, Z., Wei, Y., Xiaoming, L., "GOSR: geographical opportunistic source routing for VANETs", ACM SIGMOBILE Mobile Computing and Communications, Vol. 13, Issue 1, 2009.

[18] Bouroumine Ayoub, Mustapha Zekraoui, Abdelilah Maach *Smart Diagnosis Using An On-Board Middleware,* International Conference On Automation Control 2015, Ankara, Turkey.