EHealth Service Support In IPv6 Vehicular Networks

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***Abstract*—Recent vehicular networking activities include public vehicle to vehicle/infrastructure (V2X) large scale deployment, machine-to-machine (M2M) integration scenarios and more automotive applications. eHealth is about the use of the Internet to disseminate health related information, and is one of the promising Internet of Things (IoT) applications. Combining vehicular networking and eHealth to record and transmit a patient's vital signs is a special telemedicine application that helps hospital resident health professionals to optimally prepare the patient's admittance. From the automotive perspective, this is a typical Vehicle-to-Infrastructure (V2I) communication scenario. This proposal provides an IPv6 vehicular platform which integrates eHealth devices and allows sending captured health-related data to a Personal Health Record (PHR) application server in the IPv6 Internet. The collected data is viewed remotely by a doctor and supports a diagnostic decision. This paper introduces the integration of vehicular and eHealth testbeds, describes related work and presents a lightweight auto-configuration method based on a DHCPv6 extension to provide IPv6 connectivity for resource constrained devices.**

Keywords—Vehicular networks, eHealth, IPv6

I. Introduction

Vehicular networks evolved from their simple dedicated-purpose command and control applications, towards continuously evolving multi-purpose mobile networks to fully integrate the vision of the future Internet [1]. Intelligent Transportation Systems (ITSs) [2] are envisioned to play a significant role in the future, making transportation safer and more efficient. With respect to these expectations, V2I interactions have evolved to include various types of applications, safety-related and user-oriented (infotainment).

A. Towards an Internet of Things

Enabling an Internet of Things is one of the great challenges of the Future Internet. According to some estimates, the size of the Internet doubles every 5.32 years, which will lead to an average of 6.58 connected devices per person by 2020 [3]. These 50 billion things [4] will be probably connected to the Internet in order to gather information for various and unattended applications and to support new markets [5]. On the other hand, these new and exciting possibilities come with the requirement of a larger addressing space. The IPv4 addressing pool exhaustion [6] urges the transition to IPv6 with its huge numbering space (2^{96} times bigger than IPv4's) [7].

In the wide field of health informatics, eHealth is about the use of the Internet to disseminate health related information [8]. This information is captured by small and various devices and stored in large databases to be further processed in order to support diagnostics. The final goal is to improve efficiency and save lives [9]. This paper focuses on the integration scenario between vehicular networking and eHealth technologies. The eHealth devices, Electrocardiograph (ECG), Spirometer, Oximeter and Blood Glucose meter send health-related measurements over Bluetooth to an IPv6-ready phone application attached to an IPv6 Mobile Router (second part of the testbed). The phone sends these measurements after user review, to an application server in the IPv6 Internet. The gathered data are viewed remotely by the user's physician on his/her personal terminal.

B. IPv6 vehicular networks

EHealth is one application example of vehicular networking. V2I and V2V environments include several other examples of safety and service or infotainment applications support. These applications can be roughly classified in two major types: safety-oriented or user-oriented [10]. Safety applications are clearly time-critical tasks, where message delivery with short delay guarantee is the first design goal. In these use cases including eHealth and safety on road, non-IP communication technologies are considered for their reliability [11]. In contrast, user-oriented applications are non-time-critical tasks, in which falls infotainment and other prevention on road applications. The use of IP (best effort) to extend the supported geographic area for these applications is possible [12].

The use of IPv6 in current standardization work for vehicular communications technologies guarantees a better integration in the Future Internet. For example, LTE technology supports IPv6 [13], which opens new V2I services perspective

[14]. In recent ETSI activities, a GeoNetworking protocol combined with IPv6 has been experimented and standardized [12]. GeoBroadcasting safety messages by relaying messages in a vehicle-to-vehicle (V2V) mode in the same geographic zone over IEEE 802.11p, has also been experimented in the GeoNet project.

C. Heterogeneous networks

The small devices (including eHealth devices) forming the IoT are generally limited in terms of computing and networking capabilities. Short range communication technologies, such as Radio Frequency Identification (RFID), Bluetooth, or IEEE 802.15.4 standard are much more common than long range communication technologies (3G, LTE or WiMax). Therefore, an additional functional element, the gateway (GW), translates between both short and long range communication technologies and helps expending the boundaries of the current Internet. From an addressing perspective, these gateways are called Address Translation Gateways [15] due to their dual addressing function (IP and IEEE 802.15.4 in 6LoWPAN, for instance).

This paper describes the integration of a machine type device (M2M) from the IoT world, into an IPv6 vehicular network setting. The remainder of this paper is organized as follows. Section II presents related work in the field of eHealth and vehicular networks. Section III presents auto-configuration in IPv6 networks to meet M2M requirements. Section IV describes the overall system architecture and the functional elements of the adopted solution. Section V shows the protocol messages in the system and section VI gives the details of the prototype implementation along with the functional elements specifications. Current state of integration and future work are given in section VII to conclude the paper.

II. Related work

The eHealth protocol messages carry sensible data and require integrity, confidentiality and availability. Privacy is one of these security issues and has been addressed by proposing pseudonymization of medical data [16].

Embedding eHealth sytems in vehicular network is the focus of WEHealth. WEHealth [17] provides eHealth service for medical needs on roads and enhances security and privacy by the use of the NOTICE framework (a secure and privacy-aware architecture for the notification of traffic incidents). This infrastructure includes short-range communication capable sensorbelts along the road. The infrastructure in NOTICE uses embedded sensor belts in the road at regular intervals (e.g., every mile or so). Each belt is composed of a collection of pressure sensors and a few small transceivers. The pressure sensors in each belt allow every message to be associated with a physical vehicle passing over the belt, eliminating the need to uniquely identify vehicles in order to interact with them. The sensor belts do not communicate with each other directly and rely on passing cars to carry and forward a message between adjacent belts. Check station belts are authentication centers and pseudonyming proxies. They are placed on the roadside and attached to Base Stations to access the PHR (Personal Health Record) server in the Internet. Medical queries or accident alarms can be disseminated through the system to provide health records of the patients. In addition to wireless communications with external sensor nodes on the road, WEHealth platform assumes an underlying IPv4 Internet and the server side (PHR server) is accessible through Base transceivers. The platform presented in this paper does not rely on external interactions with sensors to carry the health-related data to the server.

eCall [18] is a recent European standard that brings the possibility of dialing the EU emergency number (112) in case of a serious road accident automatically without vehicle occupants' intervention. The European Commission adopted measures to ensure eCall will be available in new car models from 2015. Due to typical eSafety applications stringent delay requirements, eCall is to operate only on radio networks (24GHz). The platform described in this paper involves non-time-critical eHealth applications, therefore recorded data can be transported over IP (best-effort).

Monitoring and dealing with a large number of casualties is an important key parameter to disaster response scenarios. The CodeBlue platform [19] provides a protocol and a software framework integrating eHealth devices such as wearable vital sign sensors, handheld computers, and location-tracking tags to handle disaster response and emergency care scenarios. The prototype proposes to integrate device discovery, robust routing, traffic prioritization, security, and RF-based location tracking. In a disaster scenario, handheld computers carried by first responders receive and visualize multiple patients vital signs on the implemented application. Based on these observations, triage operation can help optimizing the chances of survival. Along with these objectives, security and privacy are studied according to legal ramifications specific to the USA regulations. The platform presented in this paper does not focus on a disaster scenario and considers a more general use case. In addition, Internet next-generation communication standards are used (IPv6).

In a recent European project (IIP) [20], one of the priorities was to create a reliable, stable and universal implementation of IPv6 network services, including DHCPv6, DNS and mobility management mechanism as well as applications, including VoIP and IPTV. With respect to these objectives, one target concerns eHealth. By deploying wireless medical sensor technologies over IPv6 to enhance connectivity and security, delivering healthcare services remotely will be possible. One of the objectives is the removal of NAT, to allow easy access for service or/and devices and perform remote configuration and maintenance which is an important issue for the elderly and disabled persons living alone. Our platform also focuses on the future deployment of IPv6 but considers a vehicular setting for the integration.

III. IPv6 Auto-configuration for M2M communications

The perspective of Machine-to-Machine communications in the Internet of Things assumes that small and numerous devices beyond the scale of the number of currently deployed devices, communicate in an unattended manner. The nature of the communication links varies to such extent that only protocols from the Internet Protocol family can glue them all in a meaningful manner. Consequently, auto-configuration mechanisms of network parameters and default route play a role of paramount importance in building these IP networks.

A. Basic IP parameters

Several mechanisms exist for the auto-configuration of basic IP parameters (address, mask, default route) for a device. A rough classification groups them depending on their capacity to maintain a state related to the parameters assigned to a device. For example, DHCPv6 protocol falls within a *stateful* group since it maintains an address assigned to a device, at a specific DHCPv6 Server. On another hand, *stateless* group does not maintain such state: a Router provides a prefix to device and the device forms an address for itself without further assistance from other entities.

The vehicular eHealth scenario considers IP devices deployed in a vehicle equipped with a Gateway offering long-range connectivity. In such a scenario, auto-configuration mechanisms are needed: the Gateway needs not only one address for itself but a set of addresses for the IP eHealth devices. The mechanisms to achieve such auto-configuration are named *Prefix Delegation*. This is an extension to the DHCPv6 [21] protocol. In addition to the typical functionality of DHCP to assign IP address, this extension allows the assignment of a set of prefixes to a Client. The DHCPv6 protocol is specified to work with Relay and Server entities as described in this recent reference [22].

Prefix Delegation for Network Mobility [23] is a specification of behavior for the existing DHCPv6 Prefix Delegation in the context of network mobility. Network Mobility (NEMO) is an extension to the Mobile IP protocol to support groups of devices moving together; such a group can be understood as a capillary network and/or as a vehicular network. This particular prefix delegation mechanism specifies the roles of the Requesting Router (Mobile Router) and of Delegating Router (Home Agent), as well as the placement of the DHCP Relay (Mobile Router).

B. Routing

In addition to assigning addresses to IP eHealth devices in a vehicular network, routing must be set up. Identifying and configuring routes in a system comprising a huge number of devices may quickly become a communication- and compute-intensive task, overcoming the capacity of the existing Internet. The concept of *default* route (the route to be chosen from a routing table when no other route is matching a destination address) provides partial resolution to this problem: it is sufficient for Gateway to hold a single default route (the IP address of the next hop) instead of numerous routes towards too many specific destinations. Default route auto-configuration mechanisms exist basically under two distinct forms. The first is RA-based (the use of stateless address auto-configuration) and the second is a dynamic routing protocol such as OSPF [24]. Currently these two mechanisms are the only IETF mechanisms to assign a default route to an end node.

Devices with limited CPU and memory capacities can benefit from the sole presence of a default route in their routing tables: it is sufficient to store only the default route in order to be able to reach any other node in the Internet. This is especially advantageous for machine-type communications.

Whereas stateless address auto-configuration offers a default route to an end device, it does not offer a set of prefixes. Similarly, the prefix delegation part of the stateful address auto-configuration does offer a set of addresses to the Gateway (in order to further deliver them to the IP eHealth devices) but does not offer a default route.

For a limited capacity device (a constrained vehicular Gateway, or a constrained eHealth device), it is advantageous to use a lightweight auto-configuration protocol offering both parameters:

- An IPv6 route to be used as a default route in the routing table of the Gateway.
- A set of IPv6 addresses (addresses or prefixes), to be used for address auto-configuration on the IP eHealth devices onboard the vehicle.

IV. System architecture

The objective of the system described in this paper is to create a vehicular setting integrating the eHealth technology and to improve current eHealth connectivity by enhancing next-generation communication capabilities. This section describes the overall system architecture during the integration phase of the vehicular and eHealth testbeds. The hardware specifications and the current state of the joint testbed are further detailed in the implementation section.

Figure 1 depicts the overall system architecture of the integrated testbed. The system includes 4 functional elements and 2 types of interactions (short and long-range).

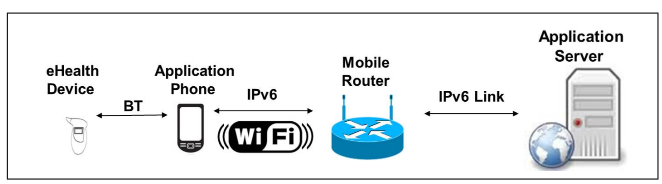

Fig. 1. System General Architecture. First step of the testbeds integration.

From left to right, these elements are:

- **The eHealth Device** provides real time health-related measurements. These measurements can be of different nature such as blood glucose levels or oxygen saturation levels. These M2M devices are provided with Bluetooth technology to send recorded data to another authorized peer.

- **The Application Phone** is in the middle of two different communication technologies. On one hand, short-range Bluetooth technology to communicate with M2M Devices and capture the eHealth data and on the other hand, short-range WiFi technology to send secure IPv6 packets to the server via the Gateway. The phone allows to process the gathered data before sending it to the server along with user comments, which is not possible with a standalone gateway.
- **The Mobile Router (Brick)** provides IPv6 connectivity to in-vehicle devices and a default-route towards the server in the Internet. The gateway uses WiFi to advertise internal IPv6 prefix to the attached nodes. For the long-range communication technology (path towards the server), only LTE provides full IPv6 path from end to end. For testbed purposes, we demonstrate the concept over Ethernet (IEEE 802.3). The Brick has a powerful CPU and provides some resources demanding networking applications, not available to run on a limited battery power device like a smartphone.
- **The Application Server** collects the data from patients and provides a web interface for doctors to support diagnostic. The software running on the server includes a web server accessed over a secure connection (SSL) and a limited-access database server to gather the data by patients. A Java Applet is required to view ECG graphs on the doctor screen.

Vehicular networking and eHealth technologies are combined (Figure 2) in the form of an ambulance equipped with special telemedicine devices that can record as well as transmit the patient's vital signs (body temperature, pulse rate, respiration rate, blood pressure) and critical physiological parameters (ECG, blood glucose levels, oxygen saturation levels) to the nearest hospital in order for the resident health professionals to optimally prepare the patient's admittance. This typical V2I scenario can be greatly enhanced through IPv6 connectivity.

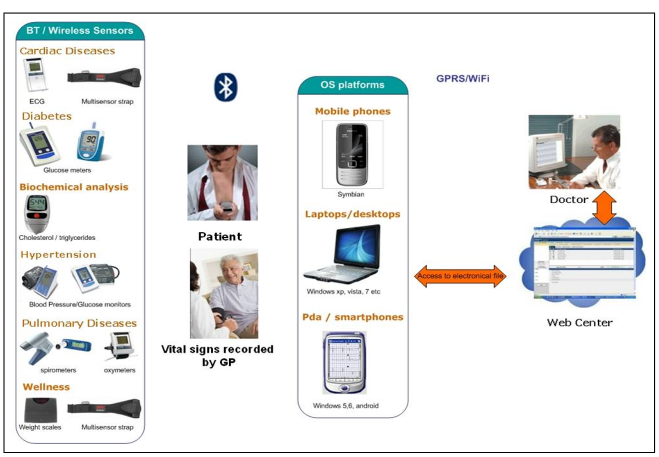

Fig. 2. eHealth Operational Scenario. Vital signs recorded by the patient are sent to the expert for diagnosis.

Assuming a road accident where a serious trauma should be taken into consideration, the ambulance crew has in its disposition a set of handheld lightweight devices that can transfer emergency data to the hospital. The objective in such a situation is to maximize clinical value through a limited set of measurements. All involved devices communicate via Bluetooth to an Android smart phone providing for IPv6 connectivity.

However in an emergency situation (natural disaster, road accidents) where numerous vehicles of different functions (ambulances, fire brigade, police cars) are involved, the scenario could differentiate in order to accommodate for the optimum data transfer to the interested parties (health care provision, law enforcement) via V2V communications. This topic is out of scope of this paper.

V. Auto-configuration Protocol

As exposed earlier, our auto-configuration protocol is lightweight and provides IP addresses to the eHealth devices as well as a default route to the Gateway deployed in the vehicle.

The protocol used for configuring default routes on the gateway with DHCPv6 is illustrated in Figure 3. The protocol has been documented in further details in [25].

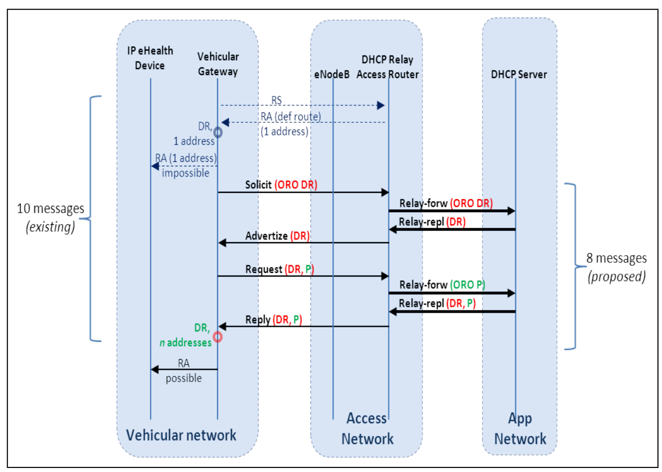

Fig. 3. Auto-configuration Protocol Messages. A comparison of the number of messages between current auto-configuration methods and the proposed one. DR stands for Default Route, P for prefix, and ORO for Option-Request Option.

The above figure describes the extended message exchange performed by the vehicular Gateway and the DHCPv6 entities in the infrastructure.

In the original DHCPv6 protocol, to obtain a set of addresses and a default route, 10 messages are necessary (including Neighbor Discovery messages). The initial RS (Router Solicitation)/RA (Router Advertisement) offer the default route whereas the subsequent DHCP Solicit/Advertize/Request/Reply offer the set of addresses to the Gateway (to advertise for the eHealth devices).

Our proposal is based on DHCPv6 messages only to provide the default route in addition to the set of addresses. As depicted in Figure 3, the total number of messages in the earlier exchange (Gateway-Infrastructure) is reduced from 10 to 8. The use of bandwidth is thus optimized and the number of Round Trip Time (RTT) reduced. The gain depends on the quality of the link between the gateway and the infrastructure.

In a Solicit/Request packet a Client lists the wanted options in the Option Request Option (ORO), composed of a list of option codes. The DHCPv6 Server answers those packets with Advertise/Reply packets containing values for the options asked by the Client.

The relay receives the message from the client and forwards it to the server in a Relay-forward message. The server replies to the relay with an advertise/reply message encapsulated in a Relay-reply message. The content of this message is extracted by the relay and sent to the client.

In its DHCPv6 requests, the client sends a list of required options in the option request option (ORO). This option contains 3 mandatory fields: OPTION_ORO, option-len and requested-option-code, followed by new option fields.

The proposed option is named here OPTION_DEFAULT_ROUTER_LIST. It is possible to concatenate this value with several other existing requested-option-codes. The value of this code in this option is to be assigned. Obviously, this option needs to be understood by the server as well.

In the server side, the default router list option of DHCPv6 (Figure 4) contains: OPTION_DEFAULT_ROUTER_LIST, option-len, router-address, router-lifetime, lla_len (link-layer address length) and optionally router_link_layer_address. As this option contains a list, the pattern containing router_address, router_lifetime, lla_len and optionally router_link_layer_address can be repeated.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   OPTION_DEFAULT_ROUTER_LIST  |          option-len           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
|                         router_address                        |
|                                                               |
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        router_lifetime        |    lla_len    |               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+               |
.              router_link_layer_address(opt)                   .
.                              ...                              .
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Fig. 4. DHCPv6 default router list option fields. This option is used by the server to answer ORO option sent by the client.

VI. Prototype implementation

This section describes the experimentation of testbed integration performed recently[1] to demonstrate the capability to communicate eHealth specific data on the next-generation Internet from a vehicular setting. The underlying network communication protocols used were relying exclusively on IPv6 as the next generation of Internet protocols. The application-layer protocols included, but were not limited to, HTTP and HTTPS.

[1]This work is part of an ongoing effort of the authors in the FP7 EXALTED (EXpAnding LTE for Devices), http://www.ict-exalted.eu/project.

A. Hardware specifications

The Kerlink Wirma Road (Figure 5) is an energy-efficient ARM926EJ-S platform provided with a 2.6.27 Linux kernel. The ARM926EJ-S processor is one of the most popular ARM processors. The Brick platform includes some M2M services and provides several communication capabilities. An integrated chipset provides GSM/GPRS Cellular network service. An integrated WiFi module provides IEEE 802.11b/g connection. An integrated GPS module provides accurate geographic coordinates. GPRS, WiFi and GPS antennas are unified in one vehicle roof antenna. An optional FM Radio is also available. In the front panel, an Ethernet Hub and Serial connections (CAN, RS 232) are present. According to the manufacturer, 10% of the regional buses company in Paris (France) are equipped with this gateway.

For testbed purposes, an additional NETGEAR Access Point (AP) is plugged into the Brick with a USB-Ethernet converter. Its purpose is to ease mobile phones attachment to the network advertised by the AP (essid "EXALTED", WEP Key).

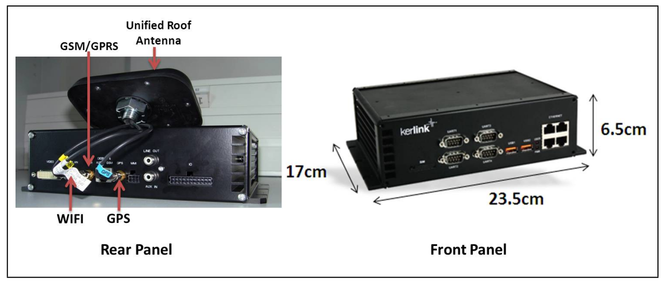

Fig. 5. Kerlink Wirma Road Gateway.

The eHealth devices (Figure 6) used for the testbed are manufactured by CardGuard [26]. The oxygen saturation level is measured by OxyPro, a wireless pulse oximeter. It provides for real time measurements and can be operated in continuous mode. It also provides for pulse monitoring. It displays oxygen saturation and pulse rate averages with the absolute maximum and minimum measurements.

The blood glucose and pressure measurement is performed by Easy2Check device. Blood glucose is measured with the use of an amperometric biosensor where fresh capillary blood is deposited. Its accuracy ranges from ±15mg/dL when glucose <75mg/dL to ±20% when glucose >75mg/dL. Accordingly for the pressure measurements the accuracy is ±3mmHg or ±2% of reading.

Self-check ECG offers 1 to 12 leads ECG events monitoring. It is intended for monitoring symptoms that may suggest abnormal heart function: skipped beats, palpitations, racing heart, irregular pulse, faintness, lightheadedness, or a history of arrhythmia. The recording period is set at 32 seconds while the bandwidth is 0.05 - 35 Hz for the 12 Leads and 0.4 - 35 Hz for the 1 Lead.

Spiro Pro is a spirometer that records Volume (Time and Volume) Flow curves according to international performance standards. It measures lung ventilatory functions during Forced Vital Capacity (FVC) tests. The recording lasts for 17 seconds

Fig. 6. Vidavo eHealth Devices.

and its accuracy for the FVC and FEV 1 is +5% or +0.1L. It is mostly used for asthma or COPD monitoring.

A medical application is installed on an Android smart phone (IPv6-capable) which receives the vital signs from the portable monitoring devices via Bluetooth. The recorded data from the devices are transferred automatically (in the absence of the Mobile Router) through the smart phone via GPRS, Ethernet or WiFi to a designated web center (over IPv4). The application provides a simple Electronic Health Record (EHR) for disease management and treatment and initiates patients' active involvement in healthcare. Analytically, it features browsing on the exams history, viewing of the recorded data, downloading of a diagnosis or advice from a doctor, comments addition and more. The final destination of these data is the EHR of the patient who uses the devices and it is resident in a dedicated server from where it is accessible for reviewing under secure credentials by the treating physicians.

B. Current state of integration

Although the experimentation was performed in a laboratory setting, the hardware equipment is deployable in a vehicle as is: Kerlink's Wirma Road (IPv6 Gateway) is a low-consumption PC platform dedicated to vehicles, whereas eHealth devices are used by professionals of health periodic check-up and continuous monitoring. The kernel support of IPv6 and its associated extensions has been implemented in the gateway during the first phase of the testbed integration. The overall architecture is summarized in Figure 7. In the joint testbed, the Brick runs Router ADVertisement Daemon (radvd), version 1.8.5 compiled for ARM platforms and available for Debian distributions [27]. The radvd is configured to advertise at regular intervals or immediately on solicitations, two different prefixes for two different interfaces. On the Air Interface (AP), which is bridged to the Brick, the 2001:DB8:B:2::/64 prefix is advertised for the devices which connect to the "EXALTED" essid. This is the Ingress Interface of the Brick. On the Ethernet side, the 2001:DB8:A:1::/64 prefix is announced for the connected devices. This is the Egress Interface of the Brick. The server is connected on this side of the Brick, and the traffic is routed through the gateway from one end to the other. These devices form the basis of what will be deployed in a vehicle such as an ambulance.

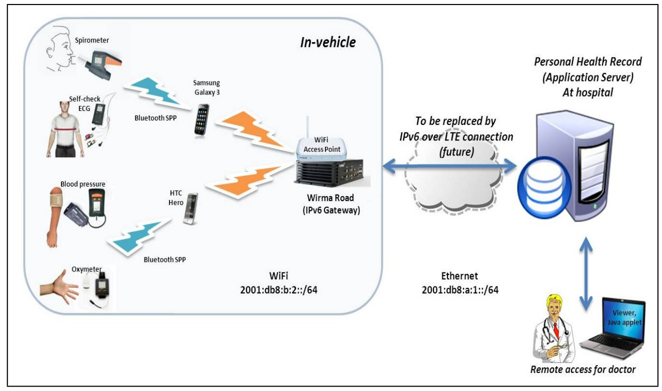

Fig. 7. eHalth and Vehicular testbeds integration. Future work includes replacing server-mobile router Ethernet link by LTE radio link.

As illustrated in Figure 7, on the vehicle side (ingress interface) two phone brands are used. (1) Samsung Galaxy 3 which runs Android 2.2 system. This phone is peered with the ECG and Spirometer devices over Bluetooth. (2) HTC Hero which runs Android 2.3 system. This phone is peered with the Glucometer and the oximeter over Bluetooth as well. Both phones are attached to the AP and configure IPv6 addresses on the 2001:DB8:B:2::/64 prefix. The devices are then used with the Vidavo Android Application that collects the data before sending it to the server over HTTPS along with a user comment (optional).

Fig. 8. Web Interface for remote viewer. The health care specialist will have access to the collected information along with patient comments.

The server, which is located in the Internet side (Egress interface), configures an IPv6 addresse on the 2001:DB8:A:1::/64 prefix. The server is then ready to receive the data. The server application runs over Java (tomcat webserver) and includes a MySQL database, where the collected data is stored and organized per user ID. The physician can then issue a remote access to the server in order to observe the data as depicted in Figure 8. In order to observe these measurements (path from the viewer to the server), IPv4 and IPv6 access to the application server are possible.

VII. Conclusion and Future Work

The infrastructure of the Internet is continuously evolving to support new services. Intelligent Transportation Systems will play a fundamental role in the future, helping to preserve lives and making transportation safer and efficient. EHealth, if supported by vehicular networks could be one of the applications improving vehicle passengers safety.

This paper describes the integration process of vehicular and eHealth testbeds. The vehicular network is designed to work over a fully deployed IPv6 network. EHealth testbed collects, stores and sends health-related measurements to a PHR Server located in the infrastructure where the results can be viewed by a doctor. Performed experimentation demonstrates the capability of eHealth specific data to be sent on the next-generation Internet from a vehicular setting. The underlying network communication protocols used were relying exclusively on IPv6. The application-layer protocols included, but were not limited to, HTTP and HTTPS. The hardware used in this configuration is deployable, as it is, in a vehicle.

Next steps ahead include actual in-vehicle integration and demonstration of cellular capabilities of the Brick. Two scenarios are possible based on the availability of LTE coverage. When LTE coverage will be available (not yet the case in France) live demonstrations can be done thanks to LTE's IPv6 support [13]. In the meanwhile, in-vehicle demonstrations are possible over 3G networks thanks to encapsulating and decapsulating gateways on the edges of the link. Tunneling [28] allows 3G's IPv4 network traversal. In the near future, a method for IPv6 Vehicle-to-Vehicle-to-Infrastructure (V2V2I) communications based on DHCPv6 and Neighbor Discovery, as detailed in the Auto-configuration Protocol section will be described along with a set of experiment results.

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