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# CROW<sup>2</sup> : Internet of Humans-based Platform for Disaster Relief and Emergency Communication

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**Abstract**—During a disaster incident, existing network infrastructures might either be damaged or overloaded. However, disaster operations require real-time and low latency data communication, especially live video and audio streaming, as well as in integration with social networks. Thus, deployed tactical networks face several challenges to connect intervening teams. To date, there is still a lack of routing standards for such networks. Indeed, in such harsh environment, medical rescue teams, firefighters, military, police and even victims need to be steadily connected to a distant command center (CC) which conducts the rescue operations. In our recent works, a new routing protocol called ORACE-Net was proposed, evaluated and compared to the existing approaches. ORACE-Net aims to create a tactical Internet of Humans (IoH) emergency network. ORACE-Net is implemented on mobile devices and evaluated within realistic conditions. The complete proposed solution consists of the CROW<sup>2</sup>, an Internet of Humans -based platform for disaster relief and emergency communication. In this paper we describe the setup and the demonstration of the CROW<sup>2</sup> platform based on our conducted experimentation.

**Keywords**—CROW<sup>2</sup>, disaster relief, ORACE-Net, Internet of Humans;

## I. OVERVIEW

The important growing number of natural or human-made disasters, make the wireless communication technologies facing several challenges. Indeed, during the disaster incident, existing network infrastructures might be either damaged or over saturated. Thus, tactical wireless networks are deployed along the incident areas in order to connect rescue teams to a distant Command Center (CC) which is conducting the operations. Rescue teams must be able to send their real-time feedback and receive missions to execute such as: i) medical teams may have live medical assistance from the CC, ii) firefighters, police and army may record their missions or use live broadcast within the CC, iii) civilians and injured persons may use the tactical network to tag, share their locations, or search and find their contacts on social networks. With regards to these required services, limitations are expected on the state of the art of the wireless technology. Indeed, in addition to radio technologies inter-operability, coexistence, and energy consumption issues, routing is an important and critical challenge for the tactical emergency networks [1], [2]. In this context, some researches have evaluated existing routing standards in the disaster and emergency relief. Based on our recent works [3], we have concluded that our proposed approach, which is called Optimized Routing Approach for Critical and

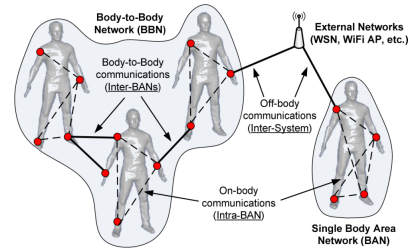


Fig. 1: CROW<sup>2</sup> system wireless communication levels.

Emergency Networks (ORACE-Net), outperformed the existing protocols under realistic assumptions in terms of packet delivery rate and energy efficiency. ORACE-Net provides also higher connectivity than the studied approaches. Finally, we have implemented a complete solution under the CROW<sup>2</sup> project built as an Internet of Humans Disaster Relief and Emergency Communication System. The Critical Rescue Operation using Wearable Wireless sensor networks (CROW<sup>2</sup>) project aims at designing next generation wearable wireless networks system for disaster and emergency relief.

### A. CROW<sup>2</sup> Platform Architecture

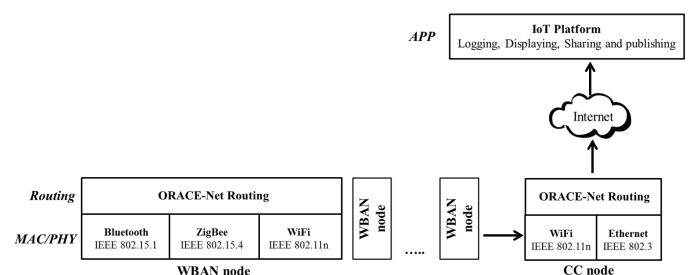


Fig. 2: CROW<sup>2</sup> system design (Layers Overview).

CROW<sup>2</sup> platform has three main levels of wireless communication as depicted in Figure 1: i) On-Body network: vital sensors connected to the rescuer body which sense and send the data towards the Wireless Body Area Network (WBAN) coordinator, ii) Body-to-Body network: on-body collected data is then routed from one WBAN coordinator to another until it reaches the CC, iii) Off-Body network: collected data from the entire network at the CC is then shared and published on Internet of Things (IoT) platform. Figure 2 depicts the CROW<sup>2</sup> layers architecture overview.

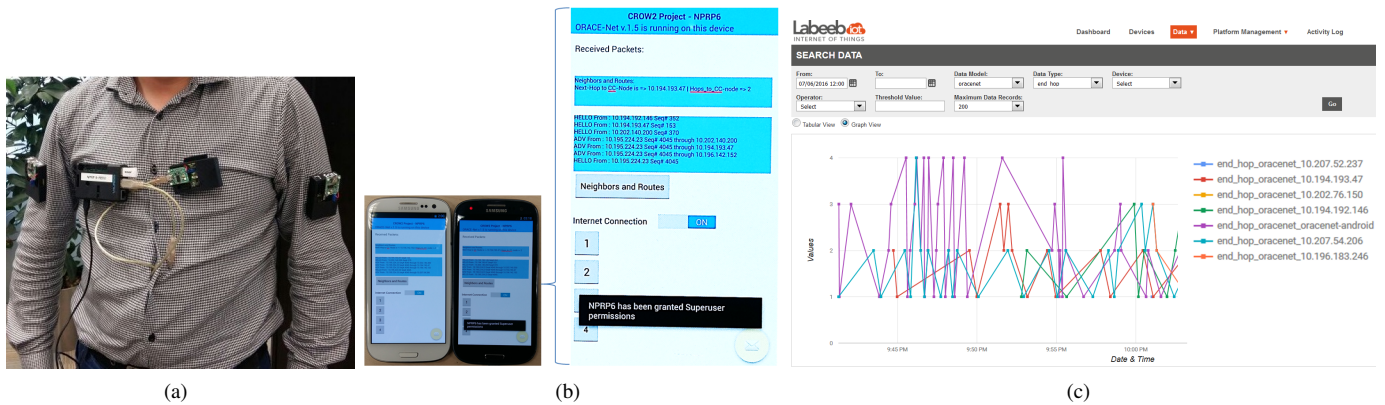


Fig. 3: (a) CROW<sup>2</sup> On-Body System: One Coordinator and three sensors (b) A photo of the ORACE-Net mobile devices displaying the real-time events (received *Hello* and *ADV* packets) and the current default route. (c) Labeeb-IoT interface (on the right) shows the variation of the  $Hop_{count}$  for the connected nodes (mobiles and statics) over the time.

## II. DEMONSTRATION

We will demonstrate the CROW<sup>2</sup> platform including the following components:

- 1) **CC node.** Special node of the network with enhanced capacities. CC node is in charge of gathering data from tactical base station and on-body mobile devices. The CC node publishes collected data on an IoT platform through Internet. CC node is a Raspberry-Pi device on which ORACE-Net routing protocol is running. It is connected to Internet via Ethernet and with the deployed nodes via ad hoc WiFi 802.11n.
- 2) **Tactical nodes (or base station).** Raspberry-pi devices on which ORACE-Net routing protocol is implemented. They are used as tactical base stations only to extend the network coverage, and are intended to be dropped by the rescue teams when they get inside the incident area as detailed in [3]. Tactical base stations may be used as on-body devices, in this they are called tactical nodes. In the latter case the on-body sensors are connected to it, and the base station is a WBAN coordinator. Figure 3 (a) depicts a on-body tactical base station connected over Zigbee IEEE 802.15.4 standard with the sensors and on ad hoc Wifi 802.11n with the rest of the coordinators in the network. It is important to note here that the CC is a tactical base station with enhanced features and accessibility.
- 3) **On-body mobile devices.** Android mobile devices on which ORACE-Net protocol is deployed and ad hoc mode is configured to join the tactical network. Mobile devices are connected to sensors via Bluetooth IEEE 802.15.1. More details on the used sensors in the next paragraph. Once started, the mobile application connects the device to the ad hoc network and starts receiving ORACE-Net messages as detailed in [3].
- 4) **On-body sensors.** Different types of sensors were tested and connected to the CROW<sup>2</sup> platform. During the demonstration we use Shimmer [5] Consensus GSR Development Kit.
- 5) **IoT Labeeb Platform.** Live data are published on

our IoT platform and will be presented and explained along with the demonstration. Labeeb IoT platform assures the monitoring and supervision of the deployed nodes of the network. An example of output is depicted in Figure 3 (c).

The demonstration scenario will include at least one mobile node and one tactical node (or base station) in addition to the CC node. Ideally, for 150 m<sup>2</sup>, 8 nodes might be used (as we tested in our experimentation). Network starts up by powering on the tactical and mobile nodes. Sensed data (e.g., photoplethysmography, heart rate variability, stress, relaxation, electrodermal activity, Galvanic skin response, 3-axis accelerometer, 3-axis gyroscope, 3-axis magnetometer and integrated altimeter), being published on Labeeb IoT platform, could be investigated immediately. The platform shows also statistics of disconnections and delays, hop<sub>counts</sub>, routing tables and real time updates.

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