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COVID-19 CONTEXT-AWARE WSN APPROACH

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ABSTRACT

The apparition of the novel SARS 2 or Covid-19 pandemic and its level of infectiousness as well as its status as a global pandemic have upset the human's life. The difficulty of this disease is its rapid evolution through people contact. All means of development, transportation, communication, industrial, economic and social revolutions and the emergence of advanced urbanization have been affected by covid-19 pandemic. Moreover, in the absence of a vaccine, countries are forced to revolutionize their response and preparedness policies to health emergencies and compel themselves to the new global dynamic. Wireless sensor networks (WSNs), with a context-awareness sensing ability, can greatly improve the way such devices work, both in terms of its accuracy and efficiency. As it is known, WSNs are highly distributed self-organized systems which comprise a large number of resource constrained sensor nodes. This paper proposes a covid-19 context-aware WSN approach to detect affected persons of Covid-19, described by its architecture and different emerging cases.

Keywords: wireless sensor network, covid-19, context-awareness, mobility.

1. INTRODUCTION

The coronavirus defined by many symptoms declared by The World Health Organization (WHO), among the symptoms at the onset of illness were fever 98%, cough 76%, myalgia or fatigue 44%, sputum production 28%, headache 8%. The case is confirmed after analysis test, this first away for confirmed the patient is case positive or negative.

To date, more than 23, 634 indexed papers were published by different research communities around pandemic facets across the world1. In addition, numerous inventions, technologies and policies that are in line with the evolution of the digital transformation have emerged, involving smart cooperation of human, intellectual and technological capital worldwide, with the aim to unveil the multi-dimensional feature of this new virus [1].

Since there are no approved vaccines available today (the time we are writing this paper). So, countries must find ways to live with this pandemic [2]. Before we could reopen public spaces, we need to specify the most effective policies in terms of safety. Also, we need to detect contaminated persons as soon as possible. And as mentioned before fever is one of the most noted illness.
In this sense WSN presents a good solution to detect fever. WSN is composed of multiple tiny, autonomous, low cost and low power sensor nodes. These nodes gather data about their environment and collaborate to forward sensed data to centralized backend units called base stations or sinks for further processing.

In this sense, this paper falls under the research of context-aware systems. Recent research papers discuss health or environmental monitoring using wireless sensor networks (WSN's) because of its importance. In this work we use WSNs context-aware approach to detect covid-19 Virus using a context-aware manager system trying to meet with real time constraints to get better results for WSN applications.

The remaining of the paper is organized as follows: Section 2 presents the start of the covid-19 epidemic. A state of the art of context-awareness is presented in section 3. While section 4 describes the covid-19 WSN model, Section 5 shows our proposed Covid-19 context-aware WSN architecture. Section 6 presents a case study of a Mall to show how WSNs can provide better results.
Finally, Section 7 concludes our work.

2. COVID-19 PANDEMIC

In December 2019, a newly identified infectious disease associated with a novel coronavirus, severe acute respiratory syndrome (SARS) coronavirus 2, originating from Wuhan, Hubei Province, China that received global attention. "On January 30, 2020, the World Health Organization (WHO) declared the outbreak a Public Health Emergency of International Concern. On February 12, 2020, the WHO named the disease caused by the novel coronavirus "coronavirus disease 2019" (COVID-19). A group of international experts, with a range of specializations, have worked with Chinese counterparts to try to contain the outbreak."[3]

To date, hundreds of thousands of COVID-19 cases have been reported worldwide, and the number continues to increase over time as you can see in Figure-1 et Figure-2.

People infected with COVID-19 may have very mild or no symptoms or, on the contrary, a serious illness or death. Most infections are usually mild and their symptoms gradually appear 2 to 14 days after exposure to COVID-19. Among the most common symptoms are: a dry cough, fever and tiredness.

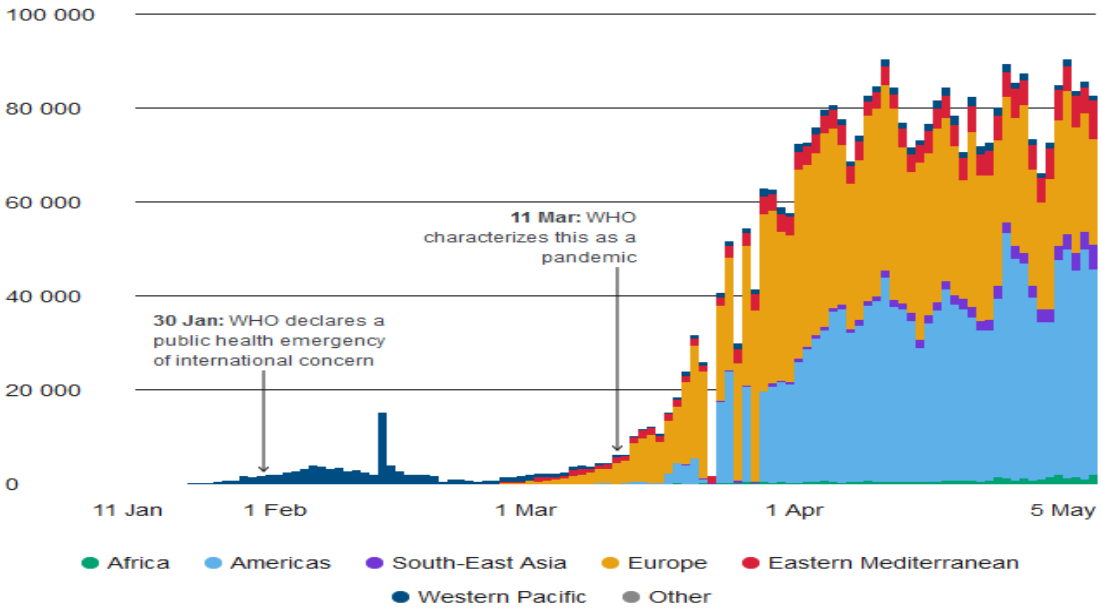

Figure-1. The epidemiological curve for COVID-19 from 11 January to 5 May of daily reported cases and deaths of COVID-19 by WHO[2].

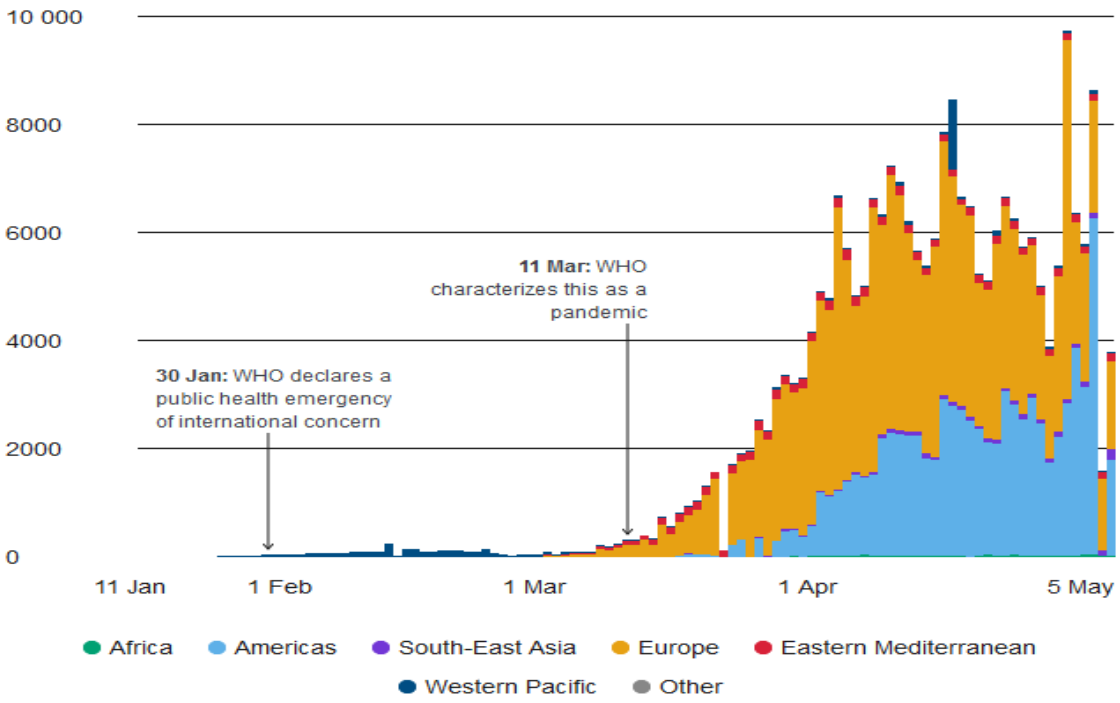

Figure-2. The epidemiological curve for COVID-19 from 11 January to 5 May of daily deaths by WHO[3].

3. CONTEXT-AWARENESS

Ubiquitous sensing was first imagined in 1991 by Mark Weiser [4] as in providing the right information accessible to the user anywhere, anytime and from any device yet making the relevant computing elements and inter-communication invisible to the user.

In one hand, context-awareness is the main property of a ubiquitous system. It characterizes a system's ability to be adapted to the changing contexts. As a result, a context-aware system is a computer system capable of perceiving and using the various information relating to the current context to dynamically adapt its functionality to the needs of the user [5].

In other hand, requirements from mobility represent new challenges that need to be considered and addressed by the IS (Information System). Detecting events occurring in the runtime environment is critical for mobile applications to become context-aware. To be context-responsive, these IS must respond to these events effectively and in real time.

Still, it is challenging to define the word ‘context’ and many researchers tried to find their own definition for

what context actually determinates. For example, in [6] this term is mostly adopted to indicate a set of attributes that characterize the capabilities of the access mechanism, the preferences of the user, and other aspects of the context in which information and services are delivered, these may include the access device (even in the presence of strong heterogeneity of the devices) [7].

Besides, the importance of this concept of "context" has been the inspiration of several studies which gave multiple branching of its dimensions: spatial, spatial mobility, spatiotemporal, environment and personal dimension [8]. Then, so many efforts to categorize contexts have been made: personal context which includes (physical and mental context); physical and conceptual context; physical and logical coordinate; while others consider state-based and event-based context as a categorization [9]. Also, [10] categorised the context into tree main categories: (1) Physical environment context, it concerns the physical world (time, temperature, etc); (2) User context (preferences and needs...); and (3) Virtual environment context where each component of the distributed system is aware of existing services.

[11] also termed the context categorization as the operational vs. conceptual context by: a) Operational categorization: Categorize context based on how they were acquired, modeled, and treated; b) Conceptual categorization: Categorize context based on the meaning and conceptual relationships between the context.
"A context-awareness system refers to a software artefact that delivers information associated with current environment variables such as location and resources." [12]

Generally, most context-awareness works can be classified into three broad fields, which were identified in [13], these categories, where the context is classified at a low level are shown in Figure-3:

a) localization: focuses on determining a user's location without the use of GPS, or as a complement for the GPS, and can be applied to both outdoor and indoor environments;

b) tracking user movement: what is known in the literature by "User activities"; and

c) sensing the surrounding environment; refers to a detection of the user's environment, by identifying objects nearby the user or specific objects of interest (which the authors called object detection) and environmental condition sensing (e.g. as air quality, weather conditions, or environment type).

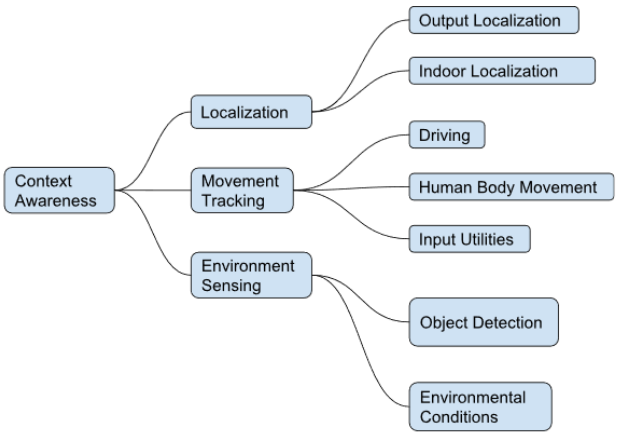

Figure-3. Context-awareness categorisation [13].

In this paper, the use of contextual information is not limited to the interaction between users and applications, but the interaction between the devices within a mobile wireless sensor network. We will take wireless sensor network as an example, the term context refers to the situation and the environment of the sensor nodes, which are objects in the terminology of the given general definition [7]. The concrete context metrics of the sensor node can be, for example:

- Location
- Energy level
- Connectivity
- Sensed data
- Individual preferences
- Mobility
- Traffic rates
- Link quality

The description of a current context consists at least of the description of relevant criteria as defined above, also the current context values for all these criteria. In addition, it may also contain rules for correct interpretation of the combined context. [7] classified the context into three groups: local, link, and global context:

- Local context: local context includes local attributes of network nodes, such as location, mobility and residual energy.
- Global context: global context includes diverse attributes of the network, such as network topology and traffic conditions.
- Link context: link context includes various properties associated with wireless links, such as link quality and bandwidth.

Considering the nature of mobile wireless sensor networks (dynamic), it is high-priced to obtain and maintain global contexts. Hence, local and link context should be exploited efficiently to improve system performance. Context-aware means that, as mentioned above, an entity performs an action while taking into

account its own current context and the context of those it is interacting with.

So, in the scope of our paper, context-awareness refers to the context information that should depend on the specific requirements of the application.

4. THE PROPOSED WSN MODEL

WSN are used in many medicine's application, indeed, see the current situation, using WSN to prevent the covid-19 propagation is very promising. In this section we present a covid-19 WSN model (see Figure-4) that summarize all cases of WSNs. Applications can be constrained by a set of rules, and models can be validated against these rules.

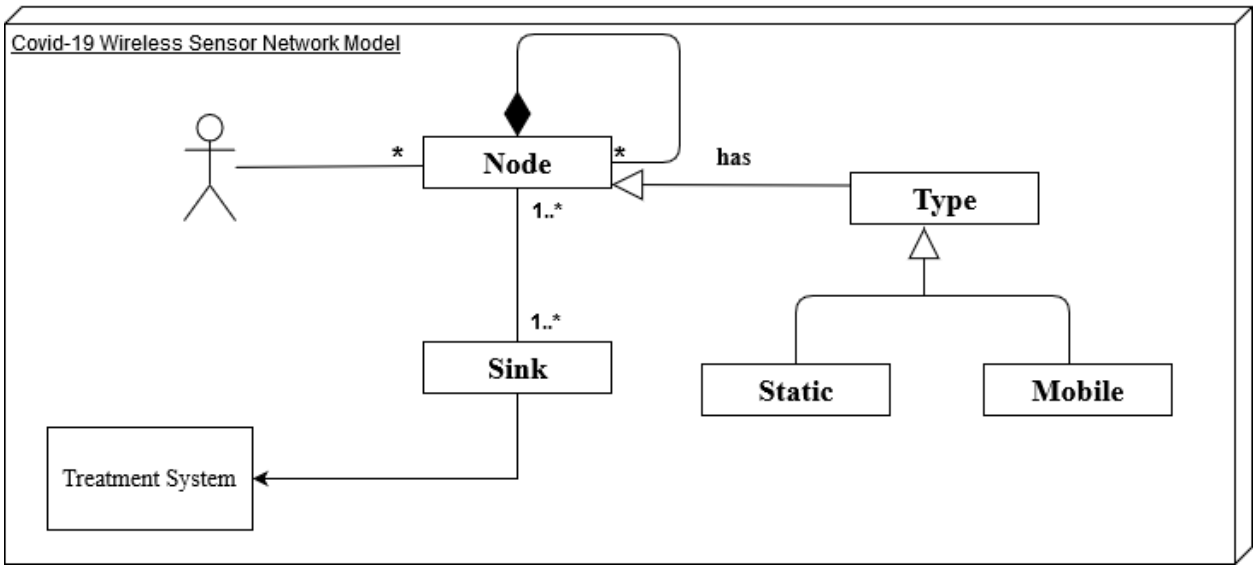

Figure-4. The proposed Covid-19 Wireless Sensor Network model.

- **Node:**

The main component of a WSN is the sensor node. It is a very tiny device that has the ability to sense its immediate environment and store the information. Owing to the progress in semiconductor technology, the cost of these devices is decreasing all the time. In general, these tiny devices consist of a microcontroller, transceiver, power source.

The use of the sensor's node depends on the application, so the choice of the deployment strategy. The node could be deployed randomly or not and could be mobile or static. Depending on our covid-19 context, the WSN used are deployed in deterministic way, that's why we try to clarify this point and explain the WSN contexts:

- Static nodes
- Mobile nodes

- **Sink:**

The Sink is the base station that collet data from sensors nodes, especially it is the link between sensors and the treatment system. In this WSN we can use one sink or multiple sink by considering the covid-19 circumstance with mean the WSN context-awareness:

- One Sink
- Multiple Sink

- **Treatment system:**

The treatment system receive signal from the sink alerted, then inform the medical staff that there is a covid-19 detection. This way without taking more risk that system prevent the virus propagation.

5. COVID-19 CONTEXT-AWARE WSN ARCHITECTURE

There are many typical applications for WSN which means considering different constraints and conditions in the conception of this kind of networks. In the Figure-5 we present the covid-19 context-aware Manager that would help health offices to detect affected people with corona virus quickly and efficiently without taking risks to affect more people. This context-aware WSN architecture (see Figure-5) resumes all possible cases:

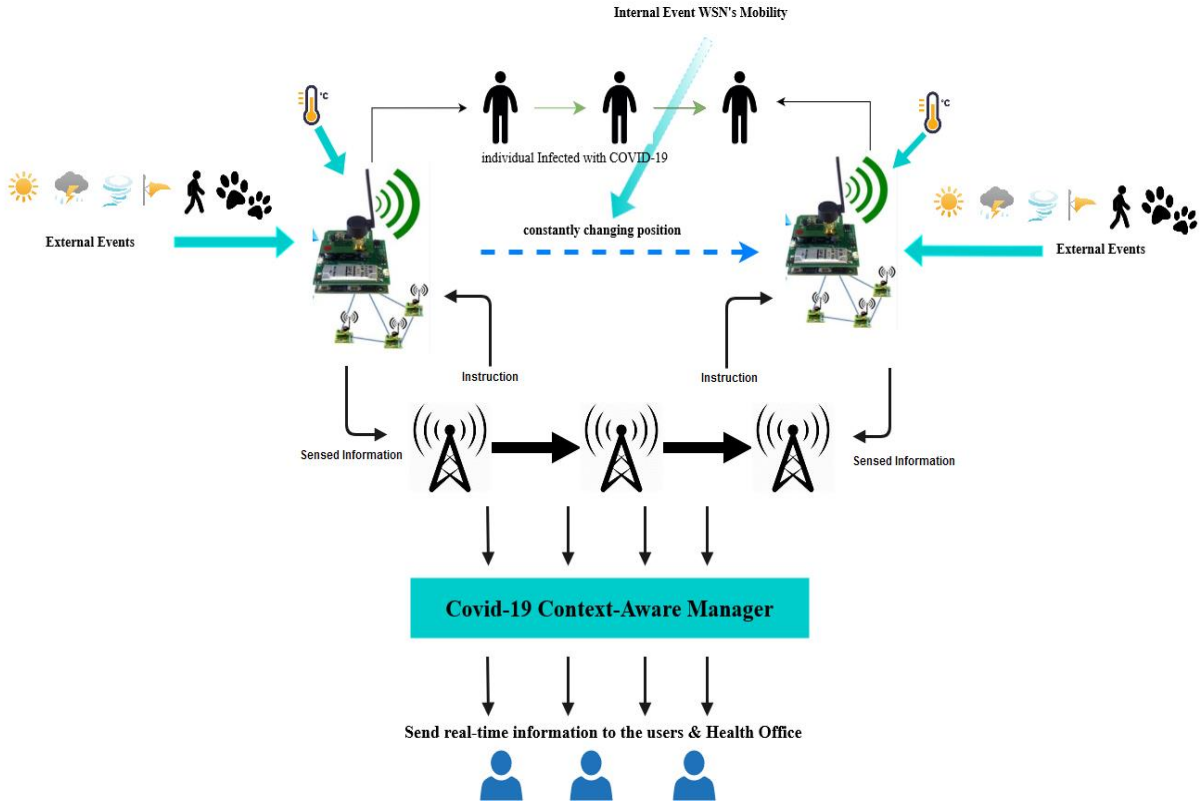

Figure-5. The Covid-19 Context-Aware WSN Architecture.

Case 1: Deterministic deployment with static nodes and one static sink

In order to detect affected people with the corona virus, nodes are deployed to communicate the information detected to the base station, this structure could be good, but still suffer from some problems such as the routing problems, the reliability, and the communication delay.

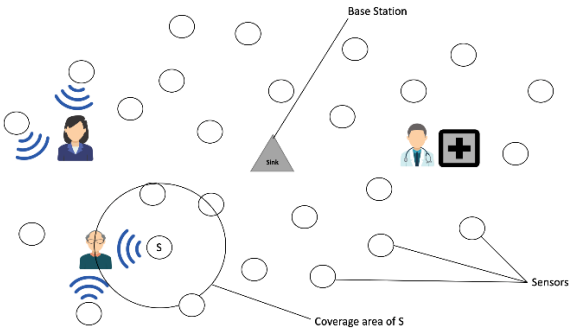

Figure-6. WSN for Covid-19 detection with One sink.

Case 2: Deterministic deployment with static nodes and multiple static sink

Multiple sink is a necessity for covid-19 detection, where the health offices need to keep in touch with the WSN and supervises the situation in real time and from different access point. The nodes in this case communicate the information with the nearest sink in order to assure a fast transmission of the data, then fast diagnostics.

Case 3: Deterministic deployment with mobile nodes and one static sink

The mobile WSN graves many advantages and assures a good coverage of the studied zone. The nodes change the position randomly or not depending on the chosen mode, thus the WSN is self-organised regularly and cover correctly the area to detect almost all covid-19 affected people.

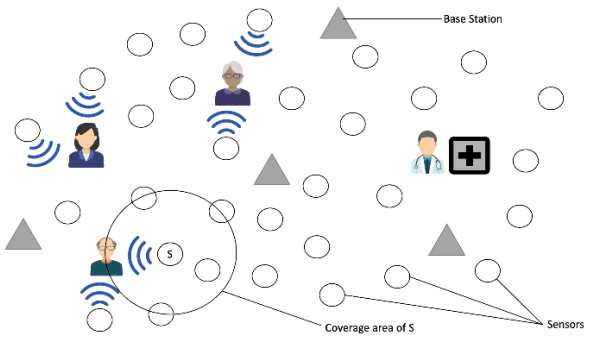

Figure-7. WSN for Covid-19 detection with multiple sink.

Case 4: Deterministic deployment with mobile nodes and multiple static sink

Health information is critical especially when it's to detect people touched by the covid-19, that why this case present the best option that could be selected. Mobile nodes cover zone and detect efficiently the temperature, then inform the health office about the situation promptly

as there is many sinks. Multiple sink is a necessity in this case since it reduces the risk of the virus spread.

Case 5: Other cases

Many events and conditions could affect the WSN's infrastructure and/ or damage its equipment. Our proposed architecture (the covid-19 context-aware manager) presents an adaptive system which takes all those cases and more in consideration, indeed it accommodates with current situation and makes decisions according to the random modifications made.

6. Case study: A shopping center

To show the usefulness of our approach we present the case study of deploying WSNs in Mall. Thanks to the presence of WSNs in a shopping center; at the entrance, in the shops at the exit, in the corridors, in any place where people pass, in an uncontrollable way, and without needing human intervention we will have WSNs that can detect people with high temperature, so it will send directly the information to the base station, and the latter would send the information to the health office to take the necessary precautions.

In a mall there are many shops, so instead of having so many people standing at the doors of each shop to measure the temperature of visitors, we will use WSNs to ensure less contact with people, saving time, and saving money because WSNs are not expensive.

Figure-8. Mall with WSNs.

As you can see in the Figure-8, we have shown how the WSNs will be deployed in several places in a mall in order to cover all the visitors.

Another advantage is the efficiency of WSNs, so that the routing of information will be in real time and the intervention of the parts concerned as well (health office). and also all the visitors are going to be measured so that in the human case it is possible that some people pass without being caught because of the crowd.

7. CONCLUSIONS

The current health crisis is to date one of the most critical crises (coronavirus disease Covid-19) in the history of humanity. Trying to contribute in the research field to detect contaminated persons in early stage, WSN can be one of this solutions. By mixing context-awareness with WSN we can solve some of the existing problems, because its introduction into the systems will help to retrieve system information easier.

In this work, we propose a Covid-19 WSN model and a Covid-19 WSN context-aware architecture that is able to adapt to detect people temperature and transfer suspicious cases to the health officer. We present a discussion of almost all cases possible for a covid-19 WSN and demonstrate the advantage of our contribution.

For a future work, we want to explore more details in the Covid-19 WSNs setting and constraint to offer more services and to propose the implementation of our architecture. Also we intend to use Machine learning (ML) algorithms to eliminate the need for unnecessary redesign. Because, ML provides a collection of techniques to enhance the ability of wireless sensor network to adapt to the dynamic behaviour of its surrounding environment.

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