EasyBand: A Wearable for Safety-Aware Mobility during Pandemic Outbreak

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***Abstract*—COVID-19 (Corona Virus Disease 2019) is a pandemic which has been spreading exponentially around the globe. Many countries have adopted stay-at-home or lockdown policies to control its spreading. However, prolonged stay-at-home can cause worse effects like economical crises, unemployment, food scarcity, and mental health problems of individuals. This article presents a smart consumer electronics solution to facilitate safe and gradual opening after stay-at-home restrictions are lifted. An Internet of Medical Things (IoMT) enabled wearable called `EasyBand` is introduced to limit the growth of new positive cases by auto contact tracing and by encouraging essential social distancing.**

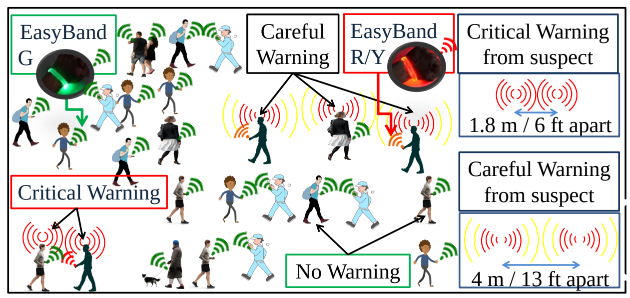

Fig. 1: EasyBand for Social Distance Aware Safe Mobility in Public Domain.

I. Post Pandemic Mobility is a Challenge

COVID-19 (Corona Virus Disease 2019) is a pandemic caused by a newly discovered coronavirus [1]. It is spreading in human populations in an exponential manner. A single positive case of COVID-19 has the potential to spread across a nation in just few days. It spreads through droplets generated by an infected person while coughing, sneezing, spitting, or even breathing air. The probability of the transmission of the disease is directly proportional to the number of infected persons one has met and the time period spent with them. Quarantining COVID-19 carriers is helpful to control the spread of this pandemic. However, it is difficult to identify probable carriers of the virus. This is the reason why various countries are adopting shelter-in-place, stay-at-home, and lockdown as solution.

Prolonged stay-at-home can cause worse effects like economical crises, unemployment, food scarcity, and mental health problems of individuals [2]. Hence, the exploration of better solution is important. One of the solutions can be gradual withdrawal of the lockdown i.e., withdrawing the restrictions in an incremental manner. At first, the restriction may be withdrawn from isolated areas with no positive cases of COVID-19 since the last 20 days which are then gradually merged with neighboring such areas. This article presents `EasyBand` as a solution to the gradual reopening approach. It is an Internet-of-Medical-Things (IoMT) smart wearable device which uses technologies to sense and record the details of another similar device (See Fig. 1).

II. What Has Been Done for Social Distancing during COVID-19?

Various technological approaches has been adapted by different countries to accomplish contact tracing. For example, Israel is using the mobile phone data of COVID-19 patients [3], Taiwan is tracing travel history and mobile phone location to observe quarantined people, and South Korea has created a database of COVID-19 patient's travel route [4]. Singapore has developed a mobile application "TraceTogether" [5] for contact tracing. When two mobile phones having similar mobile applications come together, they communicate and exchange their encrypted ID's through Bluetooth. If a person is detected COVID-19 positive, the Bluetooth data of that person is used for contact tracing. This has become a prototype used by different countries for designing mobile applications for contact tracing of COVID-19 positive persons. CovidWatch [6] is a similar application in which the privacy of each user is kept secure. A Google-Apple venture developed a Bluetooth protocol meant for tracking a user's location and COVID-19 status. India has started its Aarogya Setu mobile application with similar objectives. The status of this application informs the user about the risk of getting COVID-19. [7].

III. Do Mobile Phone Contact Tracing Apps Actually Help to Fight Pandemics?

Mobile application that are used as a solution to contact tracing have some inherited problems. One of the obvious problems is that not everyone have a smart phone. Secondly, one can switch on or off the mobile any time as desired. Thus, even if a COVID-19 suspect met a person during the switch off period, then this will not be recorded by the application. It is quite possible that the application shows no threat of COVID-19 but in reality the user may have already come in contact with a suspect or positive case who is not using this app. Thus, there is a lower confidence on these solutions for contact tracing which may discourage their use. Therefore, there is an urgent need for exploring other suitable ideas that provide solutions to the above problems. Use of a low cost, non-removable wearable device having facilities for indicating the threat possibility is one such idea. A device fulfilling the mentioned objectives will be designed and made available for all people to use as a travel pass for a certain period (say, six months).

IV. A New Approach for Safety-Aware Post Stay-at-Home Mobility

The proposed `EasyBand` has sensors that can sense other such devices present within the radius of 1 to 4 meters (6 to 13 feet). The device also has led lights with three colors such as green, yellow and red: Green is safe, yellow is mildly suspect, and red is highly suspect). Each such device can record information (such as device id, timestamp and the time period) of other devices in close contact with in the detection zone. The device stores these data only for the next 15 days. Before withdrawing the lockdown from an area, all persons may be issued with an `EasyBand` having active green light as the mobility pass. Once a person wears this device, he/she will not be able to remove it. If two persons wearing this device come in close contact, both of these devices record each others details and store them. These data from `EasyBand` become available in city, state, and national data centers, for necessary action. The device will vibrate to provide a warning if it comes within the radius of 4 meters (13 feet) of a yellow or red device. If it comes in closer contact with a yellow or red device, it will beep to provide a critical warning. If a green device spends a long time in close contact with a yellow/red device, its status will automatically change to yellow. This way the device will help the citizens to stay safe by automatically sensing the suspects.

A. Automatic Contact Tracing by `EasyBand`

The contact information of all devices is presented as a graph in which each device is a vertex and an edge between two vertices exists if they come in close contact with each other (See Fig. 2). Each edge is labeled with the frequency of contact and cumulative time they have spent together. For instance, assume a positive case is found at time T. The nodes with path distance 1 from the positive node are converted to red. The redness of the converted lights is directly proportional to the frequency and duration of their contact to the positive node. The nodes which are linked to positive nodes through contact are also probable cases with lower probability and will be marked yellow. The intensity of the yellow color is inversely proportional to the path distance from red nodes. Those positive nodes are removed from the graph assuming they are taken to COVID-19 care.

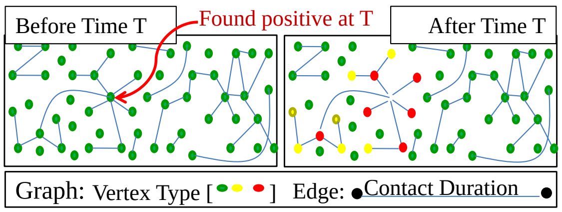

Fig. 2: Contact Graph Before and After Time T of Finding a Positive.

B. Essential Social Distancing Indicator

While traveling, one can sense red and yellow devices with warning signals thus allowing people to maintain the necessary social distancing. It is important for people to practice safe distance from others if nearby red/yellow device exist in order to flatten the curve of infection. This way of dealing with the pandemic will help people to maintain social distance without interrupting their social/professional life. It will ease the problem of contact tracing and will allow local governments to take decisions on their own. `EasyBand` thus has the potential to cope up with the current situation of crisis without any ill effects. `EasyBand` in Healthcare of Cyber-Physical System (H-CPS) is depicted in Fig. 3.

V. Proposed EasyBand: Architecture and Working Mechanism

`EasyBand` is an integrated system consisting of specific building blocks such as a Power Management Unit (PMU), Programmable System-on-Chip (PSoC), wireless stacks, sensors, vibrating motors and I/O unit [8] (See Fig. 4). The PMU is responsible for providing adequate DC voltage to all the internal blocks of the `EasyBand` and to control the LCD. `EasyBand` can have various additional features to be a perfect device for smart healthcare, however battery constraint needs to be considered during its design and operations with additional components and features [9]. `EasyBand`

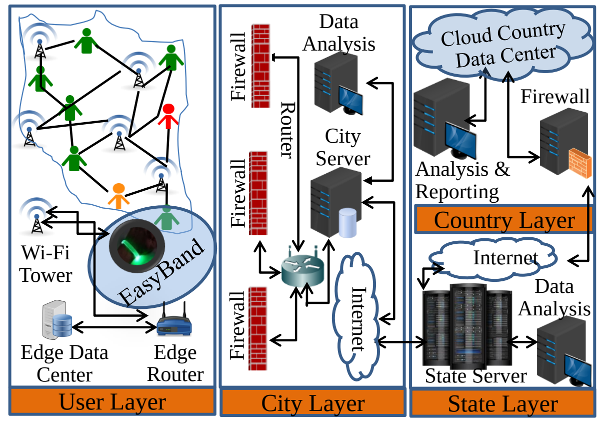

Fig. 3: EasyBand in Healthcare of Cyber-Physical System (H-CPS) of the City, State, and Nation.

can also include infrared (IR) sensors for contactless thermal profile. It is possible to include selected biosensors in this framework for monitoring body vitals as well as environmental quality which can be important during pandemic outbreak and man-made bioterrorism [10]. It has been observed that during the COVID-19 outbreak, people with diabetes are particularly vulnerable, so including our near-infrared (NIR) based sensors from our proposed iGLU for noninvasive (i.e. without needing blood samples) glucose level monitoring can have significant impact on the society [11]. We appreciate that security and privacy issues may arise due to `EasyBand` being part of H-CPS, thus novel solutions like lightweight blockchain and physical unclonable function (PUF) can be integrated in its architecture [12].

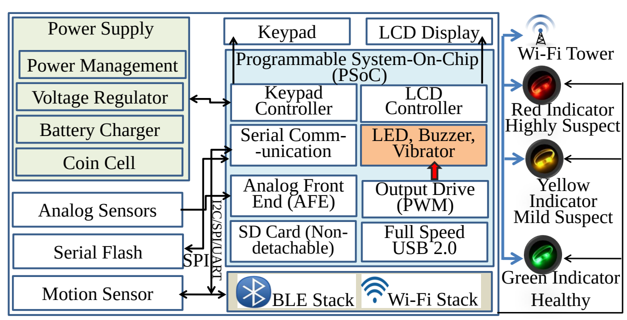

Fig. 4: The Architecture of Proposed EasyBand.

The inter-device communication is performed using the BLE stack present inside the wireless unit of the `EasyBand`. These BLEs work in the

`2.480GHz` frequency band and having a range of 100 meters (328 feet). Every BLE device broadcasts packets at a time interval and other devices listen within the range. The BLEs are used to sense the distance between each other and the Wi-Fi unit performs the data link with a city server through TCP/IP connection. The distance between two `EasyBands` is estimated using the Received Signal Strength Indicator (RSSI). The BLE and Wi-Fi are both interfaced with the PSoC for decision making. All the device logs are stored locally in the SD card and the `EasyBand` communicates with the city server through the Wi-Fi tower by forwarding logs to the city server.

When one red/yellow marked `EasyBand` comes within 4 meters (13 feet) of another band, the PSoC unit gives a PWM signal to the vibrating motor. Similarly, when this range becomes 1.8 meter (6 feet) or less apart (i.e., close contact), the PSoC unit fires a PWM signal to both vibrating motors and the buzzer alarm by updating the log information in the SD card. When two devices come in close contact, the PSoC updates the contact log for both the bands. If the close contact between a red/yellow and green band lasts more then the threshold duration, the green band will update its status to yellow. When a person is detected positive, the city server will remove it from the graph and will take appropriate action.

VI. Conclusions

Safety-aware mobility is needed during the pandemic outbreak due to reasons such as economic sustainability and food supplies. The IoMT-based wearable `EasyBand` is a potential solution for post shutdown safety-aware opening. This solution includes self sensing of probable contaminated individuals, automatic contact listing, current city contamination status visualization and recommendation for self isolation to individuals.

We envision that `EasyBand` will have several advantages over mobile apps. First of all it can be a standalone device and can work without a smart mobile phone and the control over this device is with city administrators. `EasyBand` can be distributed as an on-road pass by state agencies in bulk quantities to individuals as it would be much cheaper than a smart mobile phone. The users will be more confident and can move without fear seeing the green glow of `EasyBand`. We think `EasyBand` will be an integral part of future IoMT driven smart healthcare components of smart cities in the post COVID-19 era [13].

References

[1] C. S. G. of the International Committee on Taxonomy of Viruses, "The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2," *Nature Microbiology*, vol. 5, no. 4, pp. 536–544, March 2020.

[2] S. X. Zhang, Y. Wang, A. Rauch, and F. Wei, "Unprecedented disruption of lives and work: Health, distress and life satisfaction of working adults in China one month into the COVID-19 outbreak," *Psychiatry Research*, vol. 288, p. 112958, June 2020.

[3] J. Tidy, "Coronavirus: Israel enables emergency spy powers," March 2020, https://www.bbc.com/news/technology-51930681, Last Visited on 29 April 2020.

[4] M. J. Kim and S. Denyer, "A 'Travel Log' of the times in South Korea: Mapping the movements of coronavirus carriers," March 2020, https://www.washingtonpost.com/world/asia_pacific/coronavirus-south-korea-tracking-apps/2020/03/13/2bed568e-5fac-11ea-ac50-18701e14e06d_story.html, Last Visited on 29 April 2020.

[5] "Help speed up contact tracing with TraceTogether," March 2020, https://www.gov.sg/article/help-speed-up-contact-tracing-with-tracetogether, Last Visited on 29 April 2020.

[6] "CovidWatch," April 2020, https://www.covid-watch.org/, Last Visited on 29 April 2020.

[7] N. I. Centre, "Aarogya Setu Mobile App," April 2020, https://www.mygov.in/aarogya-setu-app/, Last Visited on 29 April 2020.

[8] A. G. Mohapatra, B. Keswani, S. Nanda, A. Ray, A. Khanna, D. Gupta, and P. Keswani, "Precision Local Positioning Mechanism in Underground Mining using IoT-enabled WiFi

Platform," *International Journal on Computers and Applications*, vol. 42, no. 3, pp. 266–277, 2020.

[9] S. K. Mandal, R. N. Mahapatra, P. S. Bhojwani, and S. P. Mohanty, "IntellBatt: Toward a Smarter Battery," *Computer*, vol. 43, no. 3, pp. 67–71, March 2010.

[10] S. P. Mohanty and E. Kougianos, "Biosensors: A Tutorial Review," *IEEE Potentials*, vol. 25, no. 2, pp. 35–40, March-April 2006.

[11] P. Jain, A. M. Joshi, and S. P. Mohanty, "iGLU: An Intelligent Device for Accurate Noninvasive Blood Glucose-Level Monitoring in Smart Healthcare," *IEEE Consumer Electronics Magazine*, vol. 9, no. 1, pp. 35–42, January 2020.

[12] S. P. Mohanty, V. P. Yanambaka, E. Kougianos, and D. Puthal, "PUFchain: Hardware-Assisted Blockchain for Sustainable Simultaneous Device and Data Security in Internet of Everything (IoE)," *IEEE Consumer Electronics Magazine*, vol. 9, no. 2, pp. 8–16, March 2020.

[13] S. P. Mohanty, U. Choppali, and E. Kougianos, "Everything You wanted to Know about Smart Cities," *IEEE Consumer Electronics Magazine*, vol. 5, no. 3, pp. 60–70, July 2016.

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