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A Review on Various Social Distancing Technologies to combat COVID-19 contagious disease

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Abstract: The term Social Distancing (SD), which is also referred as "Physical Distancing" means keeping a safe space between yourself and other people, who are not from your household. It is a temporary and most effective way (as of now) to stop or slow down the spreading of contagious diseases. Also, it involves maintaining less physical communication or no communication if not necessary between two or more persons. The minimum distance of separation between two living beings (normally human) should be at least 6 feet or approximately two meters. The human beings are not practiced to SD norms and they will be frequently violating the SD requirements at public places leading to an exponential increase of infections within a short period of time. So, in order to implement SD effectively one can make use of the available technologies such as Bluetooth, Wi-Fi, Internet, Proximity sensors, SD applications (android and iOS), Ultrasound, IR, Image processing techniques and so on.

Keywords: Social Distancing, Physical Distancing, COVID-19,contagious disease, corona virus, pandemic.

I. INTRODUCTION

COVID-19 (Corona Virus Disease-2019) is a viral disease caused by a virus which belongs to the family of coronaviruses. The disease was originated or initially reported in the city of china, 'Wuhan' during the month of December 2019. Most of the people infected with the COVID-19 virus will have symptoms like Fever, Cold and Cough. If the disease is not recognized and treated at its earlier stage, then gradually the patients might experience mild to moderate respiratory illness. For few of the patients who possess very good immunity power, there are ample chances that they may recover without requiring special treatment. Also, there is a possibility of infection without any of these symptoms. The aged people and those with already existing medical problems like High Blood pressure, uncontrolled diabetes, chronic respiratory disease, cardiovascular disease and cancer have more probability to develop serious illness in case of infection. This may pose danger for the life of individuals if not treated with right medicine underintensive care.

The COVID-19 virus primarily spreads through the droplets of saliva or discharge from the nose when a COVID-19 infected person coughs or sneezes without respiratory etiquette (for example, by coughing into a flexed elbow). One of the best courses of action to prevent and slow down the virus transmission is to be well informed about the COVID-19 virus, the disease it causes and how it spreads. The infection spread can be prevented by applying an alcohol based rub recurrently to the arms and / or cleaning the hands with soap and water whenever possible and as frequently as possible and also one should avoid touching their face with hands habitually. The uncontrolled spread of coronavirus disease 2019 (COVID-19) has brought global economic crisis with millions of job losses increasing the unemployment. Globally, with its mortiferous spread to more than 219 countries, there have been 7,21,96,732confirmed cases of COVID-19, including 16,30,521deaths, reported to WHO as on16 December 2020.

Adopting Social distancing measures is the only available solution at present to reduce the spread of virus thereby, lowering the total number of deaths. As can be observed in Fig. 1(a), the peak number of infected cases has come down due to social distancing techniques and also it ensures that the number of patients does not exceed the capacity of public healthcare system[1][2].

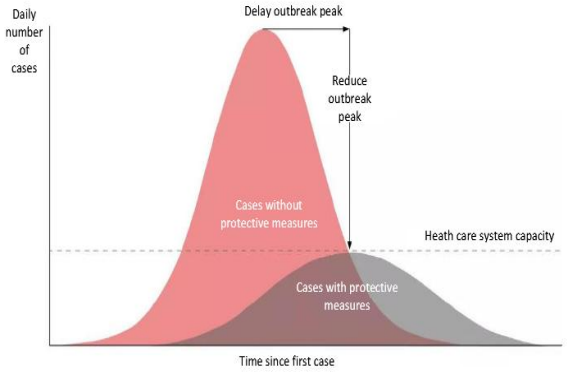

Fig. 1 (a): Effect of social distancing: the peak of the epidemic is postponed and the current infection number matching with available healthcare capacity.

In addition, social distancing not only delays the peak of the outbreak but also provides more time to implement counter steps like upgrading the available healthcare capacity.As a result, this delay provides a buffer time for the invention of an effective Vaccine or a medicine to cure the disease. Finally, social distancing can reduce the final total number of infected cases. More ever, earlier the

socialdistancing is implemented, the stronger the outcome as illustrated in fig. 1(b).

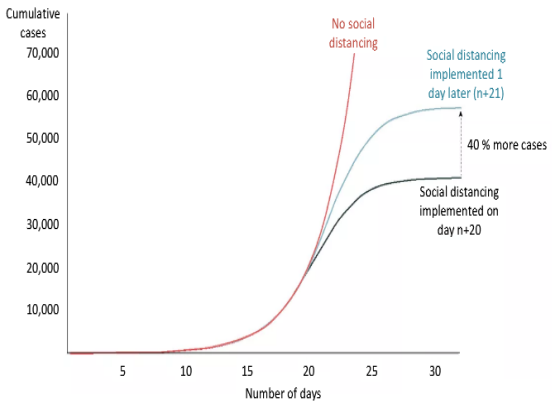

Fig. 1(b): Effect of social distancing: The total number of infections is reduced, Stronger the effect earlier the SD implementation

In most of the countries, the total number of infected cases started declining after two to three weeks of Social Distancing enforcement.

In many countries the Doctors are using the Robots to treat the infected patients at the hospitals. The reason is that the doctors who repeatedly treat the COVID patients have more chances of getting infection, if proper precautionary measures are not followed.The robots and other automated technologies can be used wherever possible. The fig. 2 (a) below shows an Unmanned Aerial Vehicles connected to internet and GPS employed for delivering the medicines and other essential commodities. This ensures minimized or no contact delivery of goods reducing the probability of new infections.

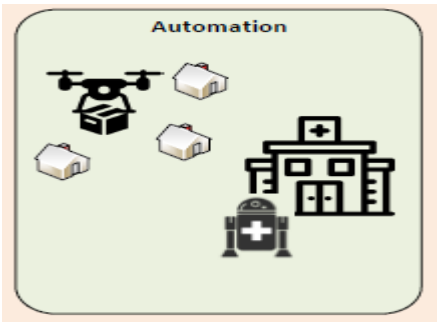

Fig. 2 : Automation, Illustration of how UAVs can be used for contactless delivery.

Several Social Distancing scenarios can be summarised as below:

i. **Distance between two people and from the Crowd:** As shown in fig. 3 (a) below, a minimum distance of 2m or 6ft is considered to be safe. Also the same has to be maintained from the crowd. But, it is recommended to avoid the places that are crowded since they are more vulnerable to infection spread.

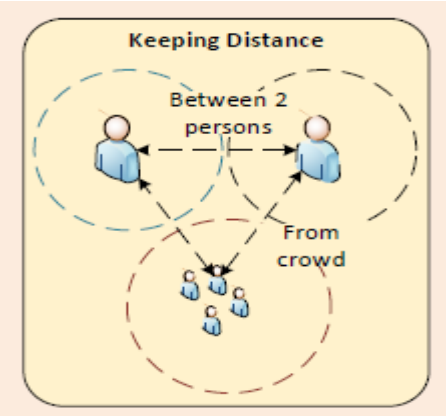

Fig. 3 (a): Keeping distance between people and crowd.

ii. **The Real time monitoring:** The crowd or infected persons under self-isolation or forced quarantine can be monitored through their location tracking with the help of their cell phones. Also they can be watched on big screen using the surveillance cameras. Periodically the SD violators can be sent warning messages and imposed with heavy fines if necessary.

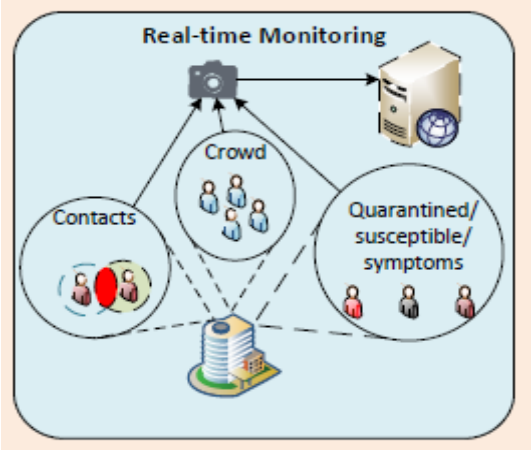

Fig. 3 (b): Real time monitoring of SD

iii. **Infected movement and contact tracing:** With the present technologies using certain dedicated apps designed for COVID tracking can be utilized to see the path that infected has travelled knowingly or unknowingly before his positive result. Now the job

is to warn the people to avoid or skip visiting the places that infected person has travelled. The data can be stored and shared among all other users of the app.

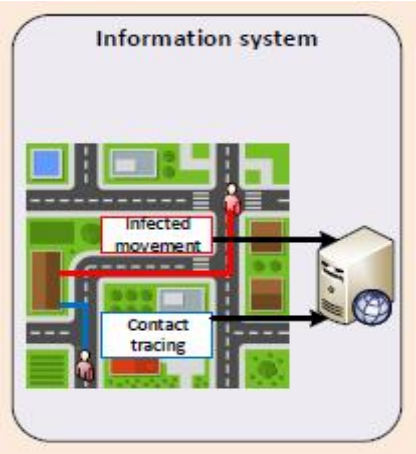

Fig. 3 (c): Information system for contact tracing and infected movement data

iv. **Incentive mechanism:** The implementation of Social distancing measures violates the personal freedom of an individual as the user needs to share his location with the third parties. Certain Incentive measures need to be taken by the government so that people share their personal data, travel history and self-isolation details if any.

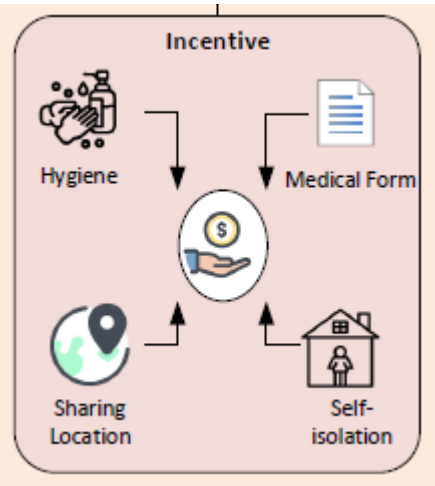

Fig.3 (d): Incentive mechanism to follow SD

v. **Scheduling techniques:** The people visiting public places such as Hospitals are scheduled and a particular time slot is allotted so as to avoid queues in waiting lounge. It prevents creation of crowd and the waiting time of the patients and doctors is also avoided. Home appointment methodology can also be followed for avoiding physically visiting hospitals and other places. The people can use online platforms for their meeting and save time, effort, money and also following SD norms at the same time. The congestion of vehicles can also be avoided with scheduling technique. The scheme is represented in the fig. 3(e) below.

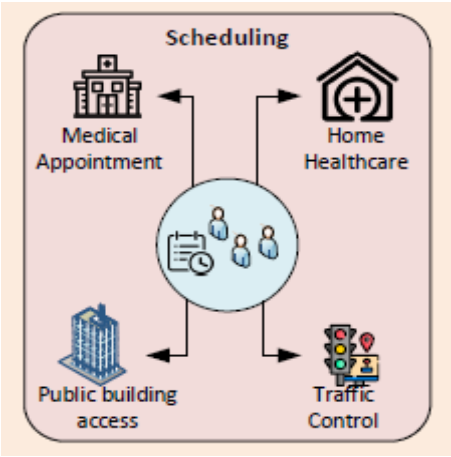

Fig. 3(e): Scheduling to implement SD

This paper is organised as follows. At first, in the literature review section, the procedure for mitigating any general pandemic is discussed. Then follows how the existing technologies like Wi-Fi, Cellular, Bluetooth, Ultrasound, Zigbee, RFID and Proximity sensors are used for implementing SD. Then we have seen the methodology that is followed in Arogya setu app for detection and tracing the infection is seen.

II. LITERATURE REVIEW

A. PROCEDURES FOR MITIGATING ANY GENERAL PANDEMIC

Neil M. Ferguson et al. [1] have proposed general methodologies on how one country can develop the strategies to decrease the severity of a new influenza pandemic. The various strategies that needs to be implemented to control the virus spread are isolating the infected (confirmed cases) individuals, Quarantining the suspects (People returned from highly infected regions, people with symptoms like fever, cough or cold, primary contacts of the infected persons), Closing public places such as Schools, Temples, Parks, Workplaces, imposing strict restrictions on travel allowing only necessary and emergency transport services (Transportation of Food, medicine and Health services). It also insists to impose restrictions on the borders (The International flights have to be cancelled). The closure of

borders may delay the spread by two to three weeks if the restriction imposition is 99% effective. Closing of schools during the peak of the pandemic is capable of reducing the peak attack rate by up to 40%. Isolation and / or household quarantine of suspects will have a significant impact.

In order to reduce the transmission, the confirmed cases should be treated with antiviral drugs on the day when the symptoms start or when it is confirmed that person is detected positive for the virus. The authors [1] also recommend that, the vulnerable countries should have sufficient reserved stock of the medicines in advance and other necessary medical equipment in order to reduce the mortality rate. It presents a model considering transmissions in workplaces, schools and households in US. It states that the transmission outside the household is 70% and within household is 30%. Out of 70% which occurs outside the household, the general community accounts for 33%and the remaining 37% in workplaces and schools. Higher attack rates are observed in Schools which almost doubles the infections every day. A higher transmission rate of 50-60% is assumed to occur at workplaces and schools; hence closure of schools and public places is effective. The estimated Reproduction Number 'R_0' for the 1918 influenza pandemic has a value of 1.7 – 2.0 during its first wave. Whereas the reproduction number R_0 was 1.5 to 1.7 in UK during 1957 pandemic. Therefore, the value of R_0=1.4 is considered to be 'Low', R_0=1.7, is 'Moderate' and R_0=2.0 is 'High'.

The normal people are not used to follow the SD, hence we may take the help of technologies to implement and monitor SD. A positioning system generally keeps track of an object continuously in real time. This is achieved by transmitting the signal from transmitter to Receiver. The received signal is analysed for signal direction, time and signal strength are extracted and analysed. Target position can be estimated based on these features.

B. UTILIZATION OF EXISTING TECHNOLOGIES TO PREVENT SPREAD OF COVID-19

Cong T. Nguyen et al. [3] have proposed several methods that minimize the spread of Corona Virus by reducing the frequency and Closeness of physical contacts between individuals. Different techniques to measure and regulate the distance between people play an important part in implementing Social distancing measures. In this part of the paper we will go through how social distancing can be effectively implemented and monitored using the existing and omnipresent technologies like Wi-Fi, Cellular, Ultra wideband, GNSS, Zigbee and RFID. We will also discuss their advantages, potential applications, limitations and feasibility issues.

(a). Wi-Fi: Wen Liu et al.[4]proposed that Wi-Fi is the most commonly and widely used wireless technology as it is the inbuilt technology in almost all the smartphones. The mobile network may not provide the exact location and position of individuals under poor network conditions in Indoor buildings like Shopping Malls, Airports and Underground locations. Even the GPS and other facilities are unavailable or at low accuracy. A typical Wi-Fi system consists of a Transmitter and Receiver. Transmitter transmits Radio signals for communicating with users in its Region of Interest. The crowd can be detected; they can be warned and force the users to maintain SD.

The crowd or public gathering can be guessed by estimating the network traffic pertaining to that area. With this the authorities can circulate a message to avoid travel or gathering at crowded people and can direct them to choose alternate paths and destinations. This is achieved by estimating the current network traffic and comparing this with that of usual network loads.Consider an example of a Shopping Mall where the mall is occupied with sufficient number of people at a particular time. Then the authorities can prevent or slow down the number of people that are allowed to enter or inform them to choose different time to visit the Mall.

As complete or partial lockdown is implemented in most parts of the world, the people have to stay at Home. So people have to perform their work from home and students have to attend online classes using various connecting /Meeting apps such as Zoom, Google Meet, Google Classroom etc., which have seen a surge in their downloads at that time.Cellular phones are omnipresent and thus they can be utilized to track the position of individuals using cellular network. Human positions in the outdoor environments can be estimated using base stations and indoor environments which are called access points.

(b). Cellular: In today's world, the cellular phones are almost ubiquitous and have covered the whole world all the time. The cellular networks are not only designed to provide communication between the mobile users but also for GPS navigation systems, thus providing the location of the user anywhere anytime**.** The cellular based location services are considered to be more accurate than that of satellite based location services.

In Cellular networks, the position of a certain object is calculated on fundamental localization principles. The signal is transmitted from a single or multiple transmitters (usually a stationary object or moving objects like a mobile) which is then received by a receiver. The receiver then computes the position of the object with help of certain algorithms. The transmitters can be GPS satellites or BSs (Base stations). The cellular technology is better than the GPS

since GPS service will be running in the background always and sometimes the service will be unavailable in indoor environments. The position of the object can be calculated using different techniques. Few of the techniques are given below, namely

1. **Trilateration:** The position of a mobile or stationary object is determined by the measured distances from single or multiple spatially located objects (usually satellites). Different measurement techniques employed are ToA(Time of Arrival), TDoA(Time Difference of Arrival) and RSS (Received Signal Strength).

2. **Triangulation:** The angle of arrival or direction of the signal received is extracted to determine the position. At least two angles are needed for the computation.

With these computation methods, the location and position of a COVID-19 infected person or suspect or quarantined people can be tracked. Also the travel history can also be determined for tracking purposes. Those people who violate quarantine rules will be issued with warning messages, if they still do not comply with the SD measure then they may be forced and penalised if necessary.

(c). BLUETOOTH

Bluetooth hand held devices are very common everywhere. Most of the smartphones will have built in Bluetooth device. In addition to these, they consume very less power compared to Wi-Fi. Hence Bluetooth can be used to detect the users who have come in close proximity with the infected individuals. The Bluetooth devices exchange anonymous codes when they come in close proximity with each other. If one of the users is tested positive for the virus, he/she updates his/her status on the particular app.Later the same is being updated on the server. When rest of the users receives the updates from the app, they will come to know that the user with which they were in close proximity has been tested positive and they all of them will be suggested / forced to stay at home and asked them to check for any symptoms for the Virus. Today, Bluetooth indoor positioning systems (IPS) have become the standard for overcoming the indoor coverage challenges of GPS, helping users to know their location [6][7].

The crowds in the indoor environment can be detected using BT technology. The signals from various devices are transmitted; these are received at a central controller. This calculates the position of individuals. If SD is violated messages are set to users requesting / demanding SD. The admin may also take action to control the inflow and outflow from the ROI. BT serves as an effective and promising technology to implement SD. At the same time it suffers from drawbacks such as low accuracy and privacy breach as the location of individuals is being shared with third party authorities.

(d). ULTRA WIDEBAND

The GPS (Global Positioning System) [15] communicates with four satellites providing accuracy in terms of several meters. The accuracy of GPS still reduces in indoor environments. WLAN (Wireless Local Area Network) offers better accuracy for indoor applications but it requires very high power making it impractical to use in mobile applications. Ultra Wideband (UWB) technology provides better accuracy and requires relatively less power making them suitable for indoor location based applications. UWB receivers with their large bandwidths are capable of resolving multipath components and thus they can accurately estimate the Time of Arrival of the first path signal. Thus in indoor environments, the distance between transmitter and receiver can be calculated accurately yielding an improved accuracy over GPS and WLAN.

The main characteristic of UWB is its high precision indoor localization which makes it suitable for tracking of person/assets (objects), robots in Healthcare, Routing guidance for blind, etc.. A location tracking wireless device can utilize the location data in several ways. In cellular networks, location data can be used for emergency application services, locating patients / doctors in healthcare buildings, fire fighters or victims in fire accidents are good instances, where these UWB wireless location tracking devices found its applications. These types of services are collectively referred as LBS (Location Based Services). LBS's involves 2 important actions, namely:
a. Location of the user is tracked / obtained
b. Suitable services are provided based on location [15]

(e). GNSS (Global Navigation Satellite Systems)

A particular location or the route to reach a particular destination is usually found with the assistance of Navigational satellites. This technology makes use of 3 satellites at a time to find the location at a time using trilateration or triangulation. The accuracy can be much more improved by using one more satellite, so totally 4 satellites. This system can be used for implementing SD and Crowd detection [8].

(f). ZIGBEE

Zigbee technology can be used to detect and track the user's location in Indoor environments. Zigbee control hub can determine the location of the user by analysing the received signal strength investigation from zigbee enabled device. It is low cost, low power with high accuracy but not widely adopted in our daily life [9].

(g). RFID

The RFID technology can be used for localization and tracking of objects. An RFID unit consists of 3 main components, namely: RFID Readers, RFID tags and a data processing system. The users can be located inside an indoor building and Social Distancing can be practiced using RFID technology. Here in this technique, each of the user who stays within an indoor environment are provided with unique RFID tags (similar to ID cards). An RFID reader placed in that building receives the signals from RFID tags. Location of the tag can be estimated based on the received signal. Also, the total number of people present within the building at that time can be determined. Suppose, the total number of people count is exceeding the threshold limit (The maximum number of people with which maintaining SD is possible) then, the admin is notified to control or block the inflow. Otherwise few of the people who are inside must be made to leave the place to maintain SD. To improve the accuracy of Localization, two RFID tags can be used instead of one RFID tag to a target [14] [15].

Another way of implementing the above solution is to employ a RFID reader along with a counter at the entrance of the building which increases its count whenever a person enters the building. Thus the number of people entering the building can be controlled easily. Those people who arrive after a specific threshold count is reached are made to wait in the queue. When certain people leave the building, the people in the queue are allowed to enter.

(h). Proximity Sensors

Hitesh Mohapatra and Amiya Kumar Rath [11] proposed a method with a proximity-based alarming device alerts the user when he or she crosses the threshold SD limit. This equipment will help people to maintain safe distance among them that ultimately help avoidance of spreading coronavirus. This model is the integration of the proximity sensor and an alarming mechanism. This prototype has been tested on a toy for validation purposes. The main objective here is to warn the individuals when they violate the norms of SD knowingly or unknowingly. The device is the combination of Proximity Sensors and an alarming device whose concept is borrowed from the Car's Proximity sensor. The proximity sensor (PS) or perimeter sensor triggers the alarm when an object is close to the sensor perimeter. The PS can remotely sense the presence of a non-metallic object without having a touch. PS uses semiconductor outputs, to have a long lasting battery and service life. Also they can be used at temperatures in the range from -40^0C to 200^0C. A PS emits electromagnetic radiation and detects for a change in echo signal. Whenever an individual with proximity sensor comes in the vicinity of another having PS, An alarm will be issued as warning.

Fig. 4(a): Example of PS with their perimeter

If two persons with an S2D device come in close contact that is within two meters range then both the person will get a warning for social distancing. The alarm can be in any forms like a sound (may be a beep signal) or a digital message alert. Fig. 4(a) illustrates the distancing concept.

The fig. 4(b) Shows men who are equipped with Proximity Sensors. Whenever the human beings cross their safe distance from other men i.e. the sensors come in close proximity of their perimeter of each other. Then a warning is issued with an alarm.

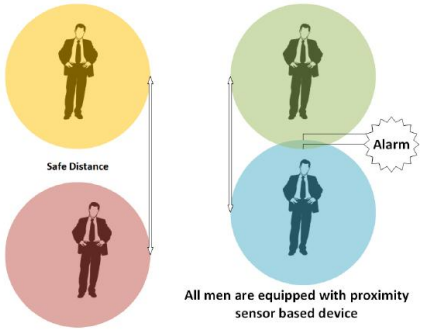

Fig. 4(b). Interaction between the Proximity Sensors of human beings

III. AROGYA SETU APP

Just like other countries of the world, India also worst hit by the COVID-19 pandemic. The first case of COVID-19 positive was marked on Jan 30, 2020 at Kerala. Later it spread like wildfire in almost all states of the India. A strict lockdown for almost three months was imposed to curb its spread. But the authorities found it too lengthy and tedious procedure to track the infected individuals and their primary contacts. So the the Govt. Of India developed "Arogya Setu" which is an android and iOS app for smartphone users across India. The app needs Internet connection, Bluetooth and GPS settings of the user's smartphone to turn ON for functioning [12]. The app is designed for keeping track of the COVID-19 individuals and their immediate contacts.

The app has a set of questions for the user to check his health and records the answers. Based on the answers and symptoms recorded, it detects the possibility of COVID-19 infection. It gives the user information about the containment zones or hotspots. Alerts the user when he is near to a quarantine centre where the COVID-19 suspects are isolated from the public.

The app also keeps record of all other Arogya setu app users who were in close proximity of a recently detected COVID-19 infected individual. This update is sent to all Arogya setu app users and an alert is issued to those who were in the close proximity of infected one. They are encouraged to stay at home and only allowed to come out only in case of an emergency.

The app can also be utilized to issue occasional notifications from the government like "Wash your hands frequently with soap and water", "Avoid touching your face with hands", "Follow respiratory etiquettes while coughing and sneezing" etc.

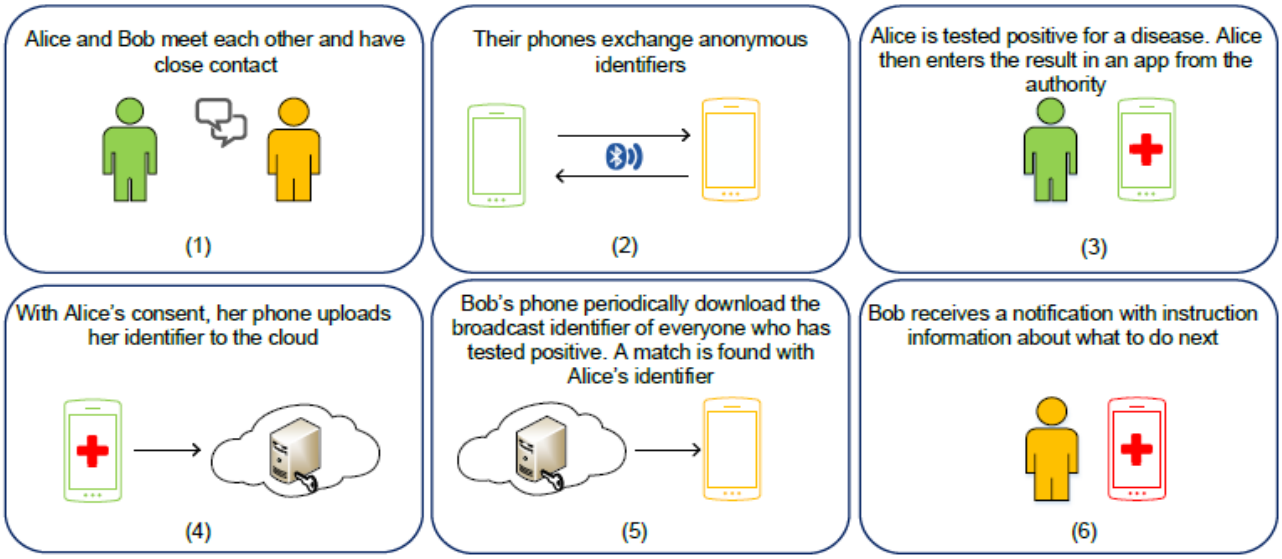

Fig.5 An illustration of a contact tracing app functioning [14]

The various steps that follow Arogya setu app are:

1. Download the "Arogya setu" android or iOS application on smartphone
2. Select to RUN the app. Switch on Bluetooth and GPS settings (Location sharing).
3. An OTP is received by the user on his phone number. Enter the OTP to proceed.
4. Select appropriate Gender
5. The Personal Details: Name, Age,Address, contact number, Occupation and other details are recorded
6. The previous month journey details including abroad journey if any are to be entered
7. A short duration self-assessment test to access to check any symptoms for COVID-19.
8. If the self-assessment result is negative, then suggestions are issued to follow SD norms and step outside home only during emergency.
9. If self-assessment is positive, then strict quarantine rules are issued and self-isolation is recommended and coming out of the home is prohibited. A COVID-19 test at a hospital or from a medical staff is recommended.

IV. THE PRACTICAL DIFFICULTY IN IMPLEMENTING SD FOR A LONG DURATION AND ITS CONSEQUENCE

Once the SD is implemented for a particular duration of time, the total number of daily cases usually will be static or declining. With SD, most of the public places and especially the revenue generating areas of the government like Aviation, Public transport system, Shopping malls, theatres, Hotels, Tourist places will remain closed or non-operational. With this if the authorities prematurely lift the restrictions on SD without any proved pharmaceutical medicine; the countries may suffer from the second wave of the pandemic which can be worse and devastating than the earlier one. So with all the practical difficulties, the government should continue

minimum SD measures and all non-essential services should remain closed to prevent second attack.

V. CONCLUSION

Social Distancing is the temporary and currently known best non pharmaceutical solution to prevent or slowdown of contagious disease like Corona Virus. Wearing Face masks, avoiding frequently touching the face with unwashed hands and frequently washing the hands with soap and enormous amount of water for 20 seconds are the best methods to combat the spread of Corona Virus disease. The disease spread can be slowed down by using contact tracing apps and following SD measures. It is the responsibility of both government and people of the country to follow Physical distancing to curb the COVID-19 contagious disease spread.

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