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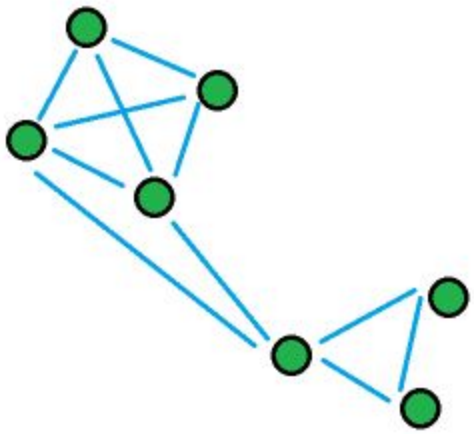
A Feature aimed **mobile and web-based** application for smart tracking of people and vehicles using the conceptual **framework of Swarm Intelligence**.



Problem Statement:

Smart movement tracking solution of people/vehicles from point A to point B

Team: Deluminators

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Our Approach

On brainstorming towards developing solutions for the smart tracking of people/vehicles, for tracking any kind of deviation, finding time-taken in traveling, tracking for overspeeding, we first looked at the points of application, where our idea could be applied and what problems are faced in those situations, so that we can train our application so as to cater tracking solutions along with addressing these issues.

On researching over the problem statement, we find that apart from applying the project in the green corridors of Kaziranga National Park, we can also implement our idea in the cases when floods are creating devastating effects, where it is uncertain about where and when the vehicles carrying the relief materials or rescue people are approaching and, to also track people who are stuck in their homes or unsafe places in those floods or even any kind of calamity. Furthermore, we believe we can even apply our project in ***creating a rapid notification based service for any kind of emergency situation*** such as women safety, where our solution not only helps in becoming a tracking tool but also a quick communication channel.

Our Solution

On digging more into the problem statement, some points came into the highlights, first one being, the current tracking services are facing are firstly lack of proper and stable internet connection and secondly, lack of a proper communication channel so as to transmit and receive information and finally, unstable GPS and GPRS data sources from which location information can be fetched.

In devising the solution for the above-said problems we considered applying the conceptual framework of **Swarm Intelligence** into our product thus making a solution which can track and communicate *without the usage of GPS/GPRS/Internet technologies* thus making a sustainable solution for varied usage and applications, so as to simplify the whole tracking process.

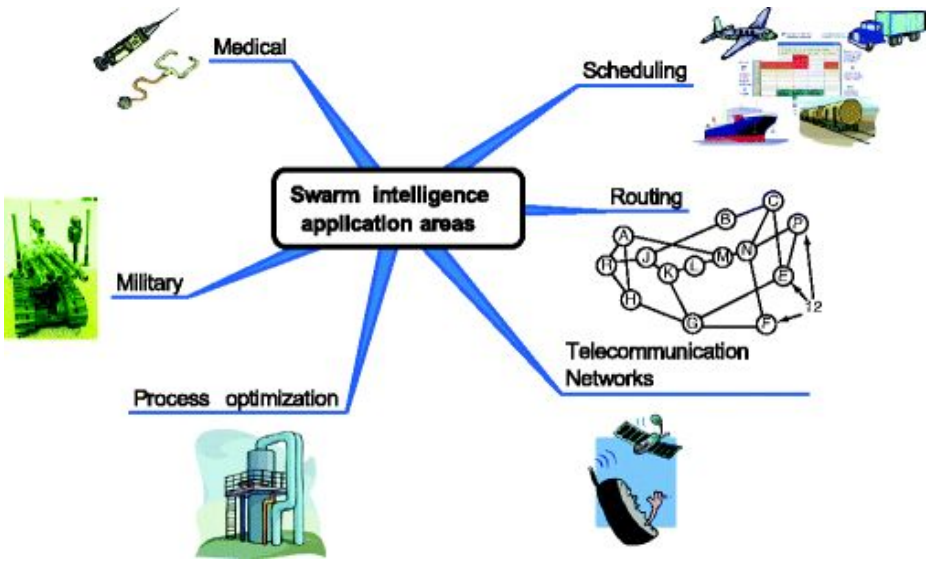


Image Source: https://link.springer.com/chapter/10.1007/978-3-540-69913-2_6

For a note, basically Swarm Intelligence conceptualizes the making of a decentralized system where information of individual nodes is localized to them, and with mutual understanding, they transmit the information or relations as and when required.

Also, P2P and mesh networks (used in our application) are usually used when referring to concepts on different network layers.

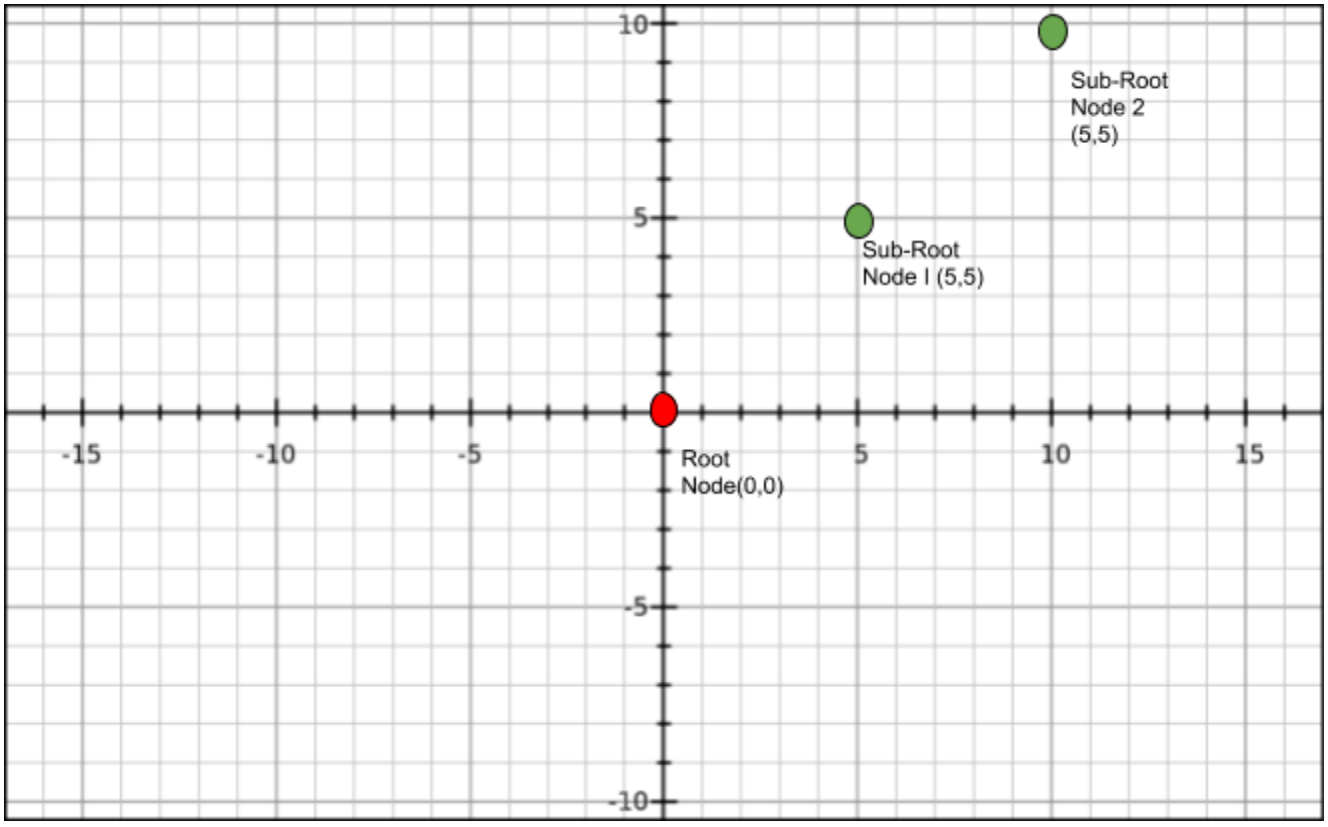
A **mesh network** is a topology used to organize nodes into a network that can transmit data between nodes that are not in direct physical contact with each other. Different models on the same layer would be star (e.g. local ethernet setups) or hub-spoke topologies for example.

P2P on the other hand refers to how endpoints talk to each other on the application layer, i.e. they connect to each other "directly" (abstracted over the underlying network layers of course) to exchange information. It contrasts with the client server model, where a server would act as relay or storage for the data that clients read or write.

How are we going to apply Swarm Intelligence in our product?

Let us explain the procedure that we plan to execute through an example

1. We first devise an imaginary coordinate system across our region, to get information about the coordinates of any particular point, for reference we can use the global positioning system for its coordinates also. Here we either mark the origin with an imaginary point or a permanently situated point, say a Police Station, or a Petrol Pump which are very unlikely to change their position and will be fixed in their place.



2. Now let us say Person A buys a new car and fills petrol from the very first time from a petrol pump situated at Sub Root Node 1 which is in coordinates (5,5) and similarly Person B also buys a new car and fills petrol from the very first time from a petrol pump situated at Sub Root Node 2 which is in coordinates (10,10), now this values gets recorded and stored.
3. On keeping the coordinate system fixed over the region we want, on further movement, the individual people or even vehicles just need to update their coordinates depending on the amount of distance

traveled and in which direction they have traveled. Now, for finding that information we will be using the **Accelerometer/Odometer** for finding accurately the amount of distance they have traveled and we will be using the **Gyroscope/E-Compass** for finding their direction of travel, now the said sensors come already inbuilt in modern smartphones and cars, so we just need to make the necessary mobile application for storing, updating, maintaining and communicating the location data.

4. Using this strategy, we are basically making the **location data** of any car or person **localized** to them depending upon their movement, and this information is to **mutually shared** by its surroundings for finding who is currently at what location with relative to them, thus **eliminating** the usage of any network-based service such as **GPS/GPRS**.

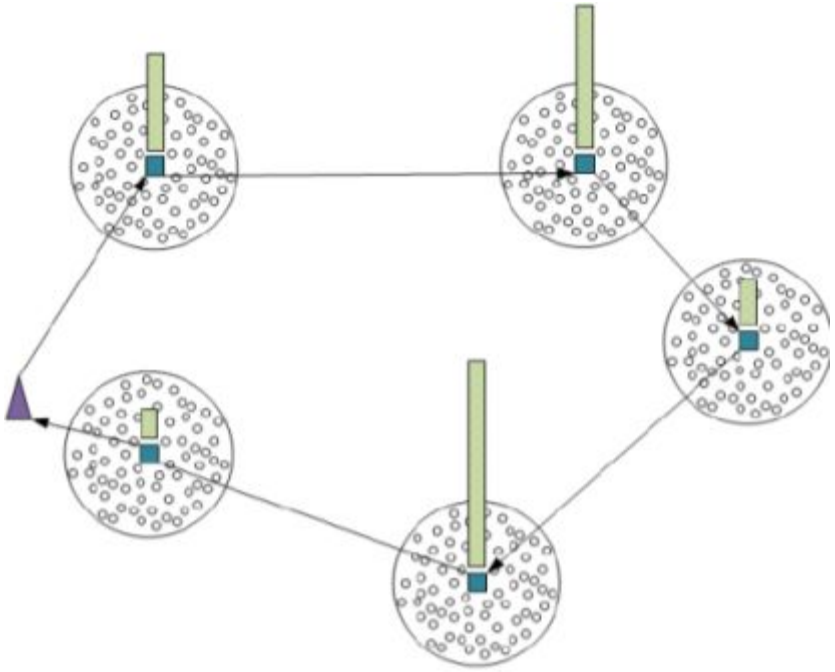


Image Source
https://www.researchgate.net/publication/282938546_UAV-based_data_communication_in_wireless_sensor_networks_Models_and_strategies

5. Now, by this we have the individual vehicles/persons will have the information about their location and the location of persons/vehicles in their vicinity. Now for communicating about their location to persons/vehicles, not in their vicinity, we plan to implement our second part of the project which is based on swarm communications. Basically we are aiming at first to make swarm networks consisting of localized nodes(vehicles & people) and then a large group of those networks being accessible from their root node (say police station in this case), now any sort of disturbance in any of those nodes will immediately notify all the other nodes in their swarms and thus making a chained network, although there exists a root node, is actually devoid of any authority as such thus making the complete network

process decentralized, by which the location and tracking data can be collected locally, transmitted upon use, and tracked collectively as per authorization.

6. We plan to integrate three sub-modules using our mobile application for the communication process, firstly, a Bluetooth as well as a Wi-Fi module having both transmitting and receiving feature, and along with this a Radio Frequency module where we are going to make all the smartphones to act as localized smartphone cell towers for appropriate data transmission as well as receiving features.

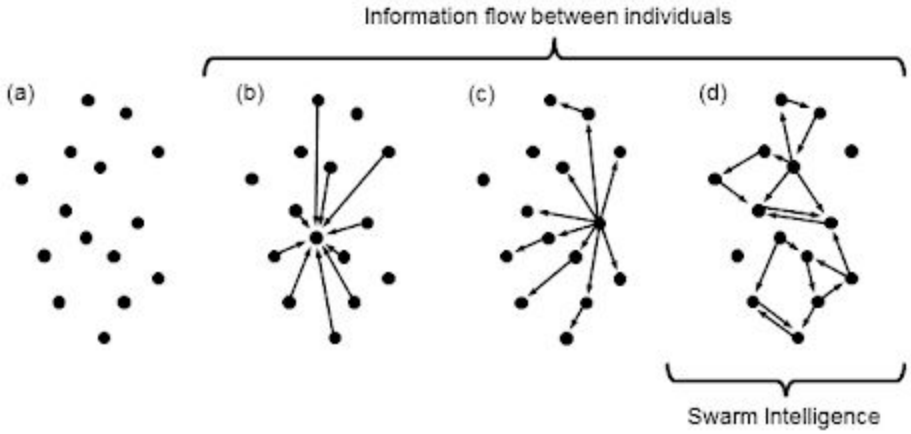


Image Source: http://ioannougroup.com/news_events/new-paper-swarm-intelligence-animal-groups-open-access/

7. Now, if suppose a user wants to track the location of saying a Car A which will be assigned a unique Vehicle Address say 1101083, the user will need to request from our application for the location of the car with the vehicle address and an encrypted hash key which lets them become authorized to fetch the location.
8. This information will be broadcasted to all the users in the neighborhood using the communication channels, and they again will let this message to flow forward and the process continues until either the message reaches the correct destination where the hash key will be verified and the location of the asked Car will be sent in encrypted format in a similar route using our interconnected swarm network of communications, and when it reaches the source which asked for the location, the location data will be decrypted and will be used. We also plan to use the concept of Binary Search Tree using which we will be limiting the flow of both request data and sent data to not go beyond their localized swarms so as to prevent unnecessary data communication channel and unauthorized flow of information.
9. By these above steps, both our tracking the location feature and communication channel will be built which will operate without the use of any globalized authority or service but will work on localized services, nodes, and networks using smart, simplified, and strategized functionalities.

How the features can be applied to the problem statements in both the normal and crisis times?

- **For travel across the green corridors of Kaziranga National Park:** In the vehicles traveling through the green corridors, what they mainly fear is either moving into an unknown or unwanted location or accidents with any animal life or other vehicles, now our solution profoundly solves the problem where the necessary mobile tower networks and internet facilities are not available and thus having a proper track of the location is often very difficult. But using our product, we aim to solve the problem. For example, let's say 5 cars are moving in a road with a certain distance between them, thus maintaining the said swarm of cars, now in case any car moves to an unwanted direction, its neighboring car will automatically get the notification about its change of direction because of the disturbance created in the swarm, and through this, they can simply alert all the cars of their swarm using peer to peer networks in a chained fashion along with localized broadcasting. Furthermore, using object detection techniques of modern machine learning/deep learning algorithms if any car detects any incoming animal or human in their path, they can immediately inform all its neighborhood vehicles using the specifically made communication channel.

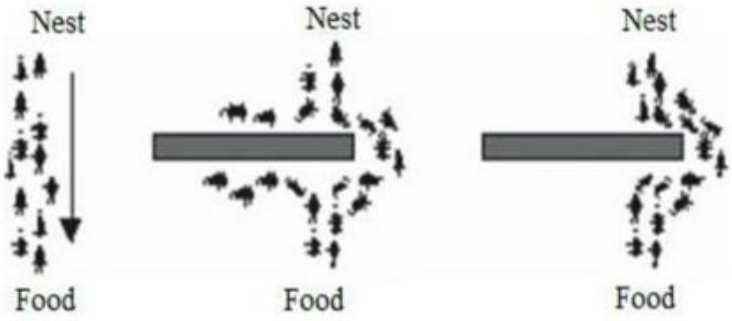


Image Source
https://www.semanticscholar.org/paper/Survey-Paper-on-Swarm-Intelligence-Keerthi-Ashwini/9b58610d12f3c4d9fe1335372509bb1bd1bb3c87

The image provided is analogs to how swarm networks can be used to detect any change in individual nodes in their movement or behavior.

- **For tracking relief support and people stuck in places during floods:** When floods makes a devastating effect in any region, and that results in limited availability of GPS/GPRS, internet, or even cell towers and thus it is very difficult to either track or communicates both the relief support people & vehicles carrying relief materials and people stuck in unsafe places during the calamity. Now for tracking the relief support vehicles such as trucks carrying essential food or medical equipment or people coming for help, our idea can be used, where lets say someone needs to find the current location of a truck carrying the relief material, they just need to make a request in our mobile application, now as our application makes the continuous usage of localised networks of bluetooth, wi-fi and radio frequencies as mentioned in the ideation of our communication channel, thus in this case their request message travels through various peers and adjoining swarms, and finally reaches a common data center such as police station which is in constant communication

with the relief trucks, now until the relief trucks are inside the flood hit region, they can communicate with the said Police Station through normal channels of communication but when they are inside the region, they will be able to use our application to communicate because of our interlinked peer-to-peer localised chained communication network, and that's how the information of location and their tracking can be estimated and detected, and similar to this, analogy for people who are stuck at various places can be used where they can put request for help along with their relative location which will travel through the swarm network and reaches the required help center say Police station.

- **For tracking any person in need of help, especially for women safety:** On researching how safeguards to women can be made in an urgent manner in case of any emergency, we found that it is necessary to initiate localized help by simultaneously informing the Police and Women welfare departments and her family members. For this, we planned to create a safeguarding model where people can volunteer for protecting women in a collective and localized way when their need is seen. In our model, people will be differentiated into various classes called Angels or Alphas, Betas and Gammas, where the Alphas is the group of people who either signed up to voluntarily help women or maybe those who are in the nearest vicinity to them after proper authorization. The Beta Group includes people in the armed forces such as Police, or even the Women's Welfare Departments, and then the Gammas includes people who are known to that particular individual like family members, friends, etc. Upon feeling any sight of emergency or danger, the woman on making a request in our application, the nearby swarm network will be activated and through our communication channel, the people present in the vicinity will be informed about the situation for immediate help, and this request will progress spreading until halted by the woman, or response by the Beta or Gamma people with their appropriate authorization. With this localized and dynamically changing network of nodes and consequently a network of swarms (each swarm containing several individual nodes), we plan to implement an immediate action plan to make a self-sustaining model for better women protection channels.

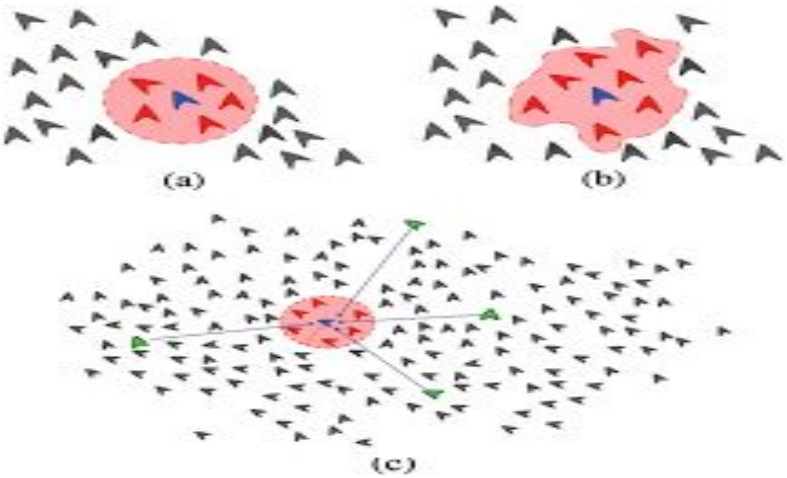


Image Source: https://www.nature.com/articles/s41598-018-34208-x

The figure shows the analogs of distribution of volunteers among the swarms and outer swarm networks for an immediate call for help

Operational Stages

1. **The first stage of operation**
    - Primarily to be used by the people having our application installed in their cellular devices.
    - A dashboard displaying the current status and location of the user, simultaneously running the Swarm Intelligence module in the background and calculating the relative position with respect to the other fixed and movable devices detected.
    - A button to calibrate the skeleton metrics onto the map of that particular area, using cellular data and GPS features, thereby providing a piece of detailed two-dimensional location information.
    - The dashboard also encapsulating tracking features to show live movement details en route a journey, along with displaying the live/ average speed, status, and coordinates of the availing user.
    - A ***Networking*** module providing some exclusive features like smart broadcast and smart location share i.e., the broadcast feature would transmit the location information of the availing user to all the connected devices within the network circumscribed by a particular range, while the smart location share is a feature built solely for the purpose of sharing the location data to specific known users of the concerned user, embedding the concept of hash keys for identification purposes.
    - The networking module implemented therefore would provide emergency aids to concerned users in the event of any mishap occurring.
    - All the data transmission methods hereby being availed are being done through the concept of p2p mesh network transmission, where every individual cellular device works simultaneously as a receiver and a transmitter, thus selecting automatically the best network protocol available for the successful transmission.
    - Lastly, we have a fleet management system provided onboard, wherein, every individual vehicle moving under a particular fleet of vehicles has access to the unique identifier keys of every other vehicle moving under that particular fleet.
    - Live tracking information of all the vehicles moving under a particular fleet, such as the speed details of every individual vehicle and likewise, would be visible to each member of that fleet, and in the event of any fleet disruption, the remaining vehicles under the fleet would automatically adjust themselves based on the current situation.

2. **The second stage of operation**
    - Primarily focused on the vehicles traveling through routes wherein proper monitoring is a dire necessity
    - Users having/ not having our application, both, can be tracked and monitored.
    - The registration number of the vehicles entering this bounded route would be captured at the point where the monitored road starts, using tools such as OpenCV, etc.

- As a second layer of monitoring, the IEMI number of the cellular device detected with the user, from the network source connected to, is collected and stored alongside the registration plate details of the vehicle captured.
- The concerned path is to be divided into sections, with each section having a node manager to track that portion of the path is to be set up.
- Each node is associated with a particular length of the strip and as and when a vehicle enters and leaves a specific segment, the node of the segment turns active, constantly measuring the time the vehicle stays in, while crossing the segment, through emitted radiofrequency waves, and thereby provides an average speed measure of the vehicle from the distance and the time recorded, in that particular segment of the strip.
- A small and light and magnetic hardware device, encompassing accelerometric and gyroscopic sensors, is to be provided and can be availed in case the user does not have a cellular device along with him/her.

3. **The third stage of operation**
    - This stage is for providing the most accurate tracking information and details of the vehicles traveling through the roads it is being used at.
    - The concerned strip to be laid out with smart reflectors, embodying cameras for detecting the approaching vehicles, also containing micro cellular modules for data transfer.
    - Each reflector to have its own range for tracking
    - As a vehicle approaches, the camera present onboard the reflector starts analyzing the vehicle, and the speed thereby gets calculated by the rate at which the size of the captured vehicles increases.
    - At a certain instant, when the vehicle is not too close, neither too far off, the registration plate of the vehicle gets captured and stored and updates onto the system of our application.

Novelty/ Uniqueness-

Many tracking software is available today in the market, which functions using GPS and GPRS data, however not many solutions have been developed in this field, which can function without using these parametric. Our solution claims to work without using GPS and GPRS and this lays the first step towards its uniqueness. Some features being provided onboard are-

- A first in its segment tracking concept, based on the abstract idea of Swarm Intelligence, which would enable localization of data and it's smart transferring, eliminating the usage of GPS and GPRS information.
- Quick and secure communication channel, for smart information transfer even at the places having no network connection.
- Anomaly behavior detection among different vehicles and smart dashboards for tracking them.
- Smart and foolproof emergency channels with authorization for the quick summoning of emergency services.
- A system for tracking people and relief, working at places having no network connectivity, for efficient relief management.
- A system for summoning authorized persons for women's safety and security.

Business/ Social Impact

While developing any application, it is important to make sure that it has a social as well as a business impact. Our solution to is aspired to have command in these two fronts, in the below mentioned following ways-

- It becomes difficult at places with no connectivity aids, for tracking applications, to function, thereby increasing the chances of mishaps occurring at such places.
- Inconsistent network coverage causes misinformation generation and also drives towards tracking data lacking.
- A solution providing consistent tracking and information collection is needed to tackle the issues.
- Our solution works on the conceptual framework of Swarm Intelligence, thus eliminating, insensitivity caused by poor network connectivity issues, and thus provides error-free results.
- Our application would cater to solutions to all the tracking issues arising from connectivity and network issues and would help maintain an organized and well-sorted record.
- The communication channel provided onboard would help in fast and secure information spreading even at times when there is no internet connection.
- Vehicles would be storing independently their individual data and help track mishaps early and error-free, simultaneously tracking the behavioral characteristics of other vehicles traveling in their fleet.

Prerequisites

For backend and web app

node and npm installed

For android app

node, npm and react native cli installed

Installation and Setup

A step by step series of examples that tell you how to get a development env running

To start the server

Go to root of the project, change directory to backend

cd backend

npm install

npm start

Server will be running on localhost

To start the web app

Go to root of the project, run

cd webapp

Open index.html file

To start the android app

On your android device enable usb debugging connect usb to you PC.

Go to root of the project, run

cd mobileapp

npm install

react-native run-android

A metro server will run and then,

An android app will be running on your android device.

Technology being used

As stated in the ideal solution, we will be making an integrated mobile application, for which we plan to use the React Native framework in the frontend, NodeJS, and ExpressJS framework in the backend, MongoDB and Mongoose in building the database system. For initial or normal usages, we can also fetch the required location data for which we plan to use the Here Maps API, but for making special usages, we plan to integrate the sensor information from Accelerometers, Odometers, Gyroscopes, and E-Compass, for gaining the necessary information about distance moved and direction used for finding the relative location in the localized swarms. For building the communication channels, we plan to integrate the Bluetooth technology, Wi-fi, and Radio Frequency technology currently available in almost all smartphones and partially in vehicles for building the localized tower-based peer-to-peer decentralized channel-based communication channel. For building any required ML/DL models, frameworks like Scikit-Learn and Tensorflow are to be used, and if required cloud deployment can also opt for the smooth functioning of the application.

Frontend

[HTML](https://www.w3schools.com/html/)

[CSS](https://www.w3schools.com/css/)

[JavaScript](https://www.javascript.com/learn/strings)

Android

[ReactNative](https://reactnative.dev/)

Backend

[Nodejs](https://nodejs.org/en/)

[mongoDB](https://www.mongodb.com/)

[express](https://expressjs.com/)

Other

[Mapquest](https://www.mapquest.com/)

[Here API](https://developer.here.com/)

[Google-Map-API](https://developers.google.com/maps/documentation)

[PWA](https://web.dev/progressive-web-apps/)

[Helmet](https://helmetjs.github.io/)

Scope of Work

Later we aim to implement specific emergency channels for the easy summoning of specific relief vehicles at times of natural calamities like floods, and also features addressing specific issues like women safety.

Implementation Roles within the team

While the entire team has worked dedicatedly in researching and ideation for the problem statement, but in specific roles, **Sanjiban Sengupta,** being the team lead, was responsible for general concept design, process design, machine learning/artificial intelligence, scripting, and documentation, **Ananya Aprameya,** is responsible for process design, backend development, integrations with hardware, operations development, and project scaling, **Debrup Dutta** is responsible for Concept Design, Documentation,

Scripting, framework development, and lastly, **Sourav Kunda,** is responsible for developing the mobile application, integration, and deployment.

References

Apart from the image sources, the following were taken for reference in our research and ideation.
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http://www.scholarpedia.org/article/Swarm_intelligence
https://www.sciencedirect.com/topics/engineering/swarm-intelligence

What is Swarm Intelligence? By Unanimous AI: https://www.youtube.com/watch?v=UcNm1c8kggE

What is Swarm Intelligence? By California Management Review
https://www.youtube.com/channel/UCKXvPGqxAllFgkttRSTEQAA

The Technology of Swarm AI, By Unanimous AI: https://www.youtube.com/watch?v=xODlyNdxuEY