Cloud-based crowd sensing: a framework for location-based crowd analyzer and advisor

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Abstract Cloud computing is an emerging field of computer science to integrate and explore large and powerful computing systems and storages for personal and also for enterprise requirements. Mobile Cloud Computing is the inheritance of this concept towards mobile hand-held devices. Crowdsensing, or to be precise, Mobile Crowdsensing is the process of sharing resources from an available group of mobile handheld devices that support sharing of different resources such as data, memory and bandwidth to perform a single task for collective reasons. In this paper, we propose a framework to use Crowdsensing and perform a crowd analyzer and advisor whether the user can go to the place or not. This is an ongoing research and is a new concept to which the direction of cloud computing has shifted and is viable for more expansion in the near future.

1. Introduction

Cloud computing revolutionized the way computers connected to their superior successors such as supercomputers and intelligent machines. These enabled users to expand their computers efficiency and boundaries of its computing power. By subscribing to a cloud service provider services any layman user gains access to multi-million-dollar computing equipment. Its flexible agreements and the ease of access mechanisms made users to process easier to achieve tasks. This ventured as the world trend looked at mobile devices to perform to the capabilities of a PC. Experts worked on integrating cloud computing with mobile devices.

1.1. Mobile Cloud

Mobile Cloud Computing, on its own is a separate field of study and research for offloading the operations of a mobile onto the cloud. Its main objective is to offer a powerful computing environment to a mobile device by combining the concepts of mobile computing and cloud services but mobile devices are considered less powerful compared to the high end personal computers. How to achieve such big tasks that are carried out in cloud computing to a mobile? Well, this was a challenge few years back and not now. Mobile cloud computing, has become the next iteration to mobile technology and as well as cloud computing's. This was possible through various number of researches and techniques and algorithms that worldwide technicians created when the mobile market grew and the processes that a mobile can do increased.

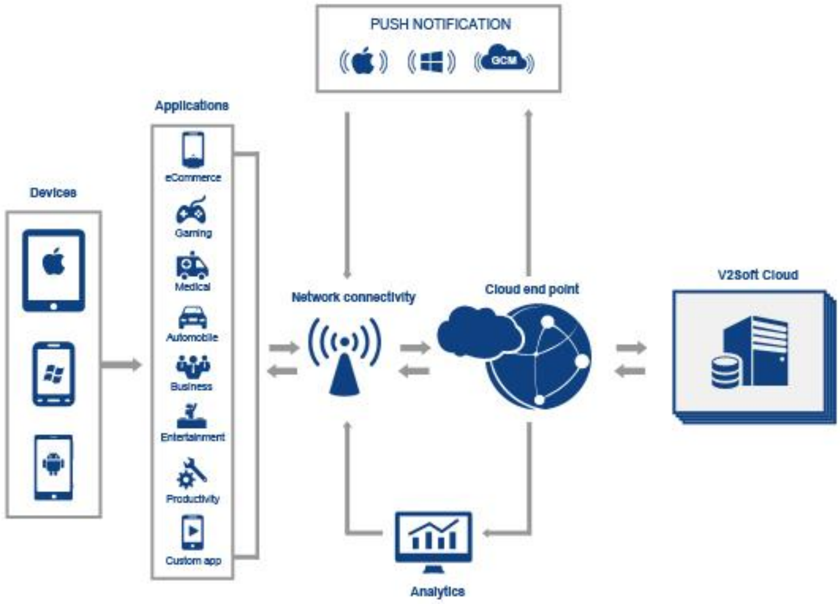

Figure 1. Mobile Cloud Computing

The way this concept was created, was that we had a client. A small entity that can access the information from a number of data available throughout the world in different datacentres which has a collection of grouped, classified data that is enabled with a supercomputer to process it. This processing and data deliverance provided a huge way to bring out the cloud computing processes to hand-held devices. The idea was convincing for the single reason mobile has become a hit for. Mobility. A user can't take a computer to anywhere he wants, he can take a laptop but he cannot use it for the intended purposes. Whereas a mobile is equipped with large number of input systems that not only provide quality data but also provides a great number of application gateway to a very efficient future.

Though, the computing power of mobiles have increased from the time the concept was found, even now, this field is under research as we still don't know how much we can put into a mobile device, as it largely requires the ability to process humungous amounts of data transactions that are necessary for making this technology to function. The answer doesn't lie in the hands of mobile companies to try and push in hard high-end computing resources into a small mobile, nor it means that the computers produced nowadays has to work hard on shrinking either. The key to mobile cloud computing is to minimize the resources used in the hands of the user and maximize the throughput a cloud platform processes.

The world has now changed into a phenomenon of social networking. If it wasn't changing to this direction, the applications that a cloud can run is very limited. Though internet privacy and its regulations are still in effect, the public feedback among the world and its digitization has not only provided data but has also proven to be worth when analyzed. Large amounts of research has been done on generating an emotion against topics, places, environments, ideologies, policies that people pour into these social networking platforms which in turn pour it on the cloud. This information can be well used for the benefit of the concept and its applications, rather than removing crowd sentiments.

Several applications have already surfaced with the help of mobile cloud. A simple translation, face-recognition and many more applications are available in the market. All these applications are just a mere breakthrough to what mobile cloud can do. Imagine a situation, on a digitized world, a user wants to access an open live translation interface. The user may speak and the mobile speaker will translate to the receiver and the vice-versa to the earpiece. This was a work that is being done by many multinational companies. This is a start and many more inventions and applications are yet to be discovered in this field. One of this is Crowd sensing.

1.2. Crowdsensing

The concept of mobile Crowdsensing has been developed for making communications easier between mobile devices to handle the huge amount of data flow. Crowdsensing is the concept where a group of available handheld devices communicate and work with each other to share their resources such as bandwidth, energy and computation to perform a process of similar interest. This works in different ways. There has been a concept conceived as incentivization. Just like an employer to an employee, the volunteer mobile devices, and the devices that are willing to give their resources are given incentives for providing the service. This service, is on its own a marketing strategy to welcome different groups into the participating event.

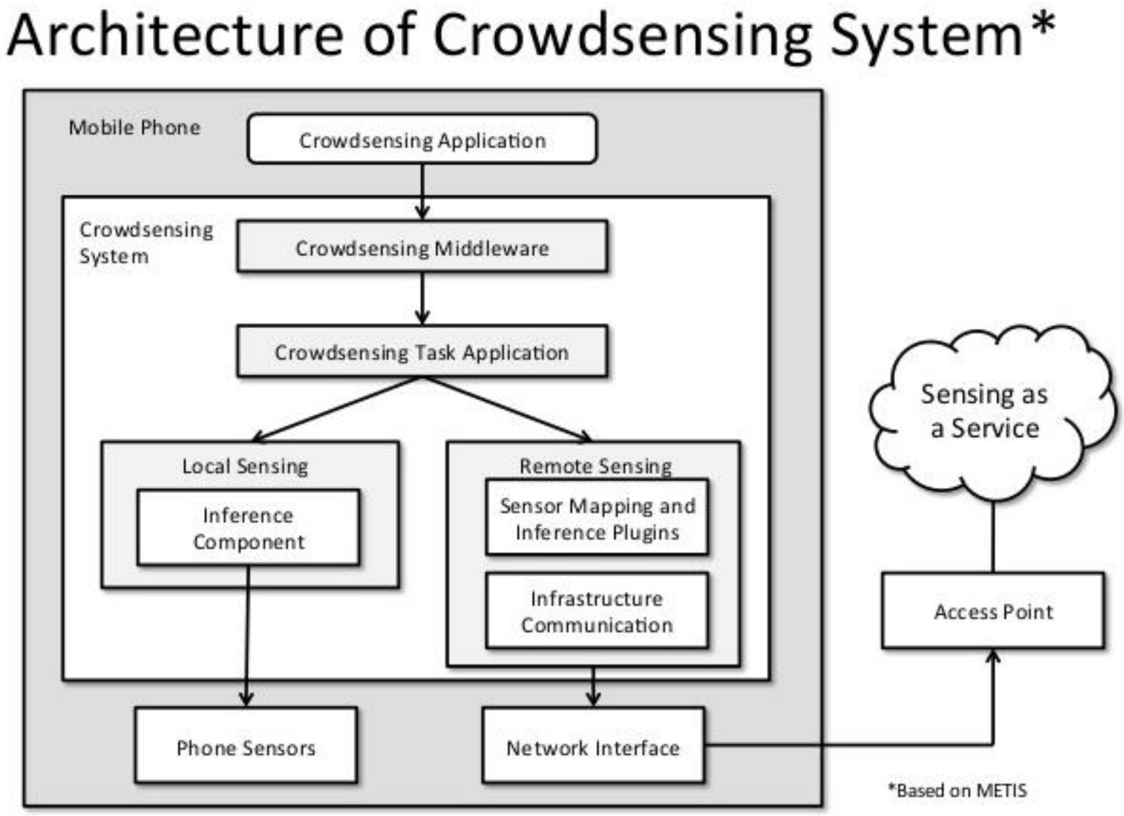

Figure 2. Crowdsensing architecture

Another such application for crowdsensing is based on the input sensors and communication strategies they possess. A user who wants to know the raw data of a remote place who couldn't reach there. That user, can look on to any available clients who's participating on the crowdsensing strategy, can look in to that node and enable its sensors. Also, applications such as crowd management are also possible in crowdsensing. The main drawback crowdsensing and mobile cloud ends up again and again is that both of these domains are still a developing field and the rate of development has not been dealt with much. This current scenario must end up in rapid development to ensure the level of applications these two could give the world combined.

Though this is an in-place substitute for data collection activities, crowdsensing has been challenged with many troubles. One of them is security. People though even when being a voluntary participant, can only give so much data to the cloud. The personal handset's data should not be tampered or shared. Secondly, the data transmitted cannot be authorized by anyone. So, if there are any changes, the data mid-way can't be detected without the help of many other nodes. Also, predictions, obtain from a place needs accurate and trust-worthy inputs. This way, there are many red flags, that crowdsensing needs to tackle in order to solve the issue and progress further.

1.3. Commonly Used Crowdsensing Frameworks

In [1] the paper proposes a technique to avoid congestion in a dense Crowdsensing scenario where it requires human willingness and eNB incentivizing process to move the user to a less dense network and provide a better load balancing technique. Technique proposed in [2] a MoST or Mobile Sensing Technology, is a framework created to find the user's presence and activity in a given area. This can be done by taking inputs from the sensors found in the mobile device. The proposed use of this architecture is to make use of this technique to gather a crowd of common interest into a designation such as cultural gathering or an event etc. and provide active crowd management. A data trading mechanism provided through the software proposed in [3] the developers created two mechanisms to conserve the cost and to provide performance using Crowdsensing for profit driven data acquisition. In all these collective papers, the final outcome is the use of different mobile sensors and algorithms developed integrated based on the Android operating system, to achieve a common objective. This has proved to be useful at concepts like geofencing, activity planning.

In this paper, we propose a framework with mobile Crowdsensing, where a user must have an idea about a place, without even going there. For example, if a user wants to go to a match, the algorithm must ensure whether it is advisable to the user or not. It would get input from the users available from the location, get inputs from sensors such as microphone, images, social media posts, weather reports, data acquisition from number of devices present at the place and compile a data based on the location and present it to a user who checks on whether or not to go to that particular location. It may also be used to provide suggestions to gather a mass crowd to a particular event of personal interests based on the activity sensed from the user's interests. It is also mandatory to provide a good security towards the privacy of information obtained from these inputs. In order to get voluntary inputs, we need to provide service level incentives to the users who participate in sourcing the Crowdsensing operation in the given area.

2. Background Study

In their paper, Sun, Wen, and Jiajia Liu [1] elaborate on the three paradigms in crowdsensing, namely, centralized communication paradigm, opportunistic communication paradigm and D2D-enabled communication paradigm [1] with their scope, advantages and disadvantages. An enhanced D2D-enabled communication crowdsensing paradigm used in crowded areas to accomplish effective load balancing and well-grounded communication in mobile crowdsensing is proposed by them. This paradigm is used because the others are not suitable for real-time scenarios in crowdsensing in crowded areas. The highlight of this model is that it profits of the intelligence of crowds [1] to accomplish effective load balancing and well-grounded communication in mobile crowdsensing.

Cardone, Giuseppe, et al. [2] puts forward a framework called "MoST" (Mobile Sensing Technology) for comparing the existing services with the newly developed services [2]. This framework allows newly developed scenario based application to process with cost efficient infrastructure. It also does performance comparison with Google Library. Finally based on the obtained results, the work of this paper is extended to an "activity detection" module [2].

Rahman, Md Abdur, and M. Shamim Hossain [4] propose a framework that combines multiple mobile devices using cloud. It supports diversity amongst people belonging to different cultures by grouping their devices together to create a community based on their interests [4]. This technique can be used in various situations like finding a location based on a person in your community or finding a lost person in a swarm of people. In order to achieve these tasks, the framework makes use of a requester and a crowdsource. A requester and a crowdsource is similar to a client and server. A requester is the client and the crowdsource is the server. The framework also uses human intelligence as a support to the mobile devices.

Zhang, Xinglin, et al. [5] in their paper elaborate on the different incentives used for efficient crowdsensing. According to this paper, the increase in number of mobile devices has paved a way for crowdsensing. In order to increase the number of participants for the sensing systems to work, incentives play a vital role. [5] The incentives are of three types: entertainment, money and service. The incentives of entertainment include location based mobile games which enhances the players experience by combining different sensing devices. Service as an incentive is based on the mutual benefit model. It has two key players: contributor and consumer [5]. In money as an incentive, the sensed data can be sold for an amount by the contributor. Each of these incentives, including their subtypes, is highlighted and explained in detail in this paper.

The paper of Hong, Hua-Jun, et al. [6] highlights on optimizing the emerging technique of cloud based video crowdsensing [6]. This is solved in three steps. Firstly, the optimal transcoding problem is solved and an algorithm that increases the quality of videos when played on mobile devices is proposed. Secondly, the throughput of different file transfer protocols is calculated and a real-time algorithm based on the best protocol is suggested. Finally, a practical approach to look for sensor-annotated videos understanding the functioning of cloud databases is put forward. The above three algorithms are assessed using comprehensive simulations and experiments.

In their paper, Guo, Bin, et al. [7] describes about the evolution mobile sensing along with the techniques for social networking through mobiles and mobile crowd sensing. These things make use of diverse crowd sourced data. MCSC [7] has two main features, the first one is making use of the diverse crowd sensed data and the other one is the participatory sensing and participatory social media; it also presents the fusion of human and machine intelligence in both the sensing and computing processes. This paper further elaborates the features and characteristics of MCSC. The significant characteristics have been categorized as explicit/implicit and heterogeneous cross-space data mining, but there are still many challenges and opportunities that have to be explored.

Junyi Wang, Jie Peng, Yanheng Wei, Didi Liu, Jielin Fu [8] in their paper came up with a strategy to reduce the amount of time and energy a hand-held device consumes to offload an application to the cloud. The main purpose of coming up with this strategy is because of the limit of the resources on a hand-held device. It is an application for offloading that can adapt based on the transmission decision. This strategy fits well to offload an application to multiple clouds. Their future work it to device a policy for offloading between many hand-held devices and clouds.

Liu, Yanchen, Myung J. Lee, and Yanyan Zheng [9] came with a strategy to break the bottlenecks that occur in a cloudlet during the computation process. To do this, they considered a resource allocation issue that is intensive in resource and sensitive in latency. The strategy proposed solves a major problem: optimization. The simulation result points out that the allocation strategy is easy to adapt. This strategy is much better than the greedy algorithm strategy for large-scale environments. The more the number of users increases the higher the quality of service. Their future work involves further study on the resource allocation problem and taking into consideration the real-time traffic situation in cloud.

Since cloud provides various services and resources to the users, managing these services and resources can be a hectic task. An efficient way for combining the services is using an ad hoc cloud environment. The ad hoc is of two types, static and mobile [10]. The main purpose of ad hoc is to bring down the price and increase the efficiency of the environment. Shila, Devu Manikantan, et al [10] proposed a framework for improving the management of the services and resources in an ad hoc cloud environment when it is static and mobile. An architecture is also produced to come up with techniques for a secured cloud environment.

Jin, A-Long, et al. [11] propose a TI mechanism which is feasible to manage the resources between the buyers and sellers. The buyers are referred as the hand-held devices and the sellers as

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cloudlets. To make TI mechanism more effective they came up with an enhanced form of TI. The enhanced form is much more effective than the first form but in comparison to the first form, the second one is more effective for sellers. For accessing the cloudlets that are available in the nearby vicinity, the authors have taken into consideration MCC. If the cloudlets are close the consumption of energy is reduced as well as the latency time of the hand-held devices is also reduced. The results prove the concept put forward.

Li, Yibin, et al. [12] the technique proposed makes sure that the thin clients are energy efficient and highly reliable when dealing with the cloud. The technique is called as the EDTS algorithm. This algorithm is based on the DVS technique. The EDTS is based on two constraints time and probability. This algorithm uses the results from scheduling algorithm to minimize the consumption of the energy. Tests were conducted on android devices and was proved that the algorithm is efficient and stands by their concept.

Changsheng You, Kaibin Huang and Hyukjin Chae [13] gives a solution for the problem of sustaining the battery power of a hand-held device. The solution is provided by combining MCC and MPT. This is done by making use of the theory of optimization. Further, if a non-causal CSI is given, an adaptive algorithm was proposed to put up with the loss of performance of the system. This can be enhanced to a full-duplex transmission, that is it can handle multiple MPT and it improves the efficiency of power transfer during offloading.

3. Proposed Architecture

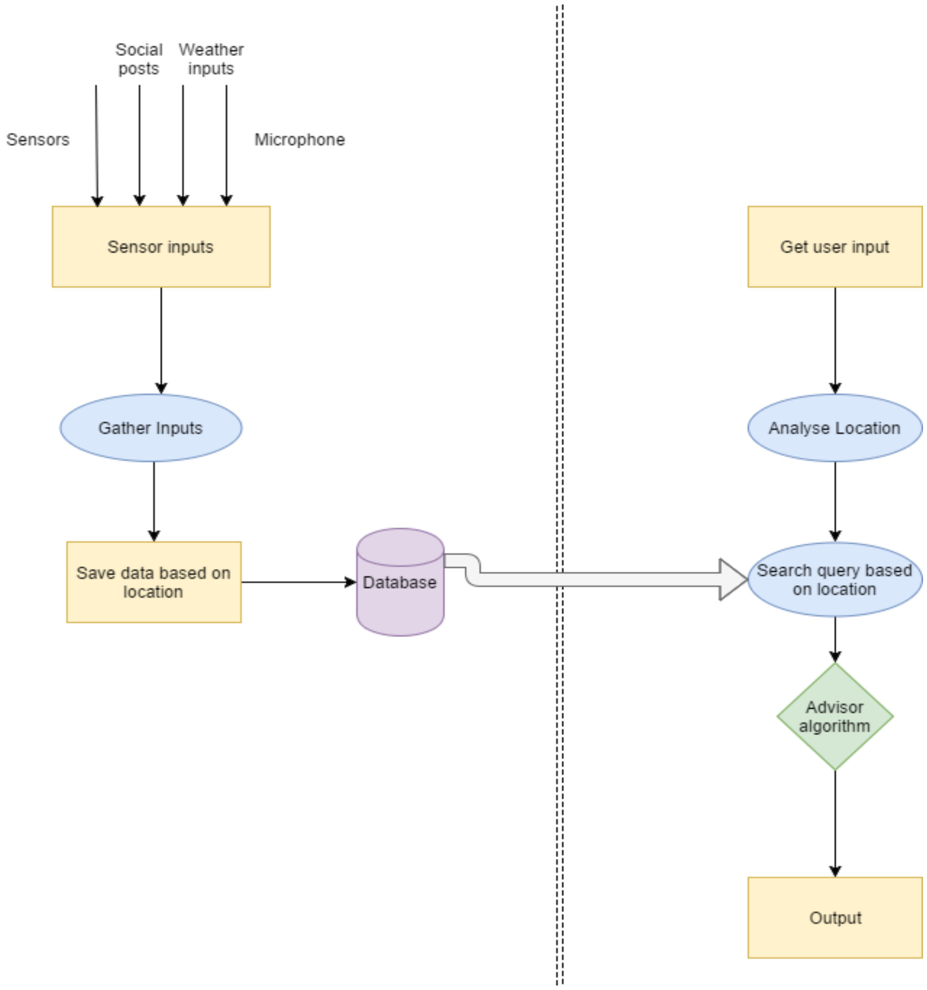

Figure 3. Proposed Architecture

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3.1. Tools that can be used:

- Android or iOS or any mobile operating system.
- Cloud Services from CSPs like Amazon Web Services, etc.
- Standard IDE.

3.2. Description

Since we are working with mobile devices, it is better to call the working model as an application. The application's proposed work flow will be as follows.

- The application will gain access to the device's sensors such as accelerometer, proximity sensor, microphone, weather report, camera, signal coverage, GPS.
- This will be gained through the input sensors as said above.
- Once the sensors' inputs are received the numerical data will be saved into the server where the cloud application classifies these data into region specific data. This way, the work of the participating node is done.
- Secondly, the user who wants to search must enter the search location as his destination.
- Then the destination's location will be retrieved.
- The database will be queried for the search of all the available data metrics obtained on the server for that particular location.
- This will provide the cloud with the metrics to evaluate the decision with the advisor algorithm.
- Then, the advisor algorithm would calculate the sentimentality with these metrics and provide a decision to whether the user can go or not to the place.

This particular algorithm can also be mended to sense user centric events that are located nearby to not only provide decisions but also to suggest them as well.

4. Advisor Algorithm

1. Get input location.
2. Retrieve all data allocated to the location.
3. Calculate the average data metric with the formula:
$$\sum_{i=1}^{n} d\, i \div n \tag{1}$$
Where di is the instance average over the period of time. This di is stored as D_{avg}
4. If (D_{curr} (current data) / D_{avg} >1.5)
Advice = No Go.
5. Else, Advice = Go.

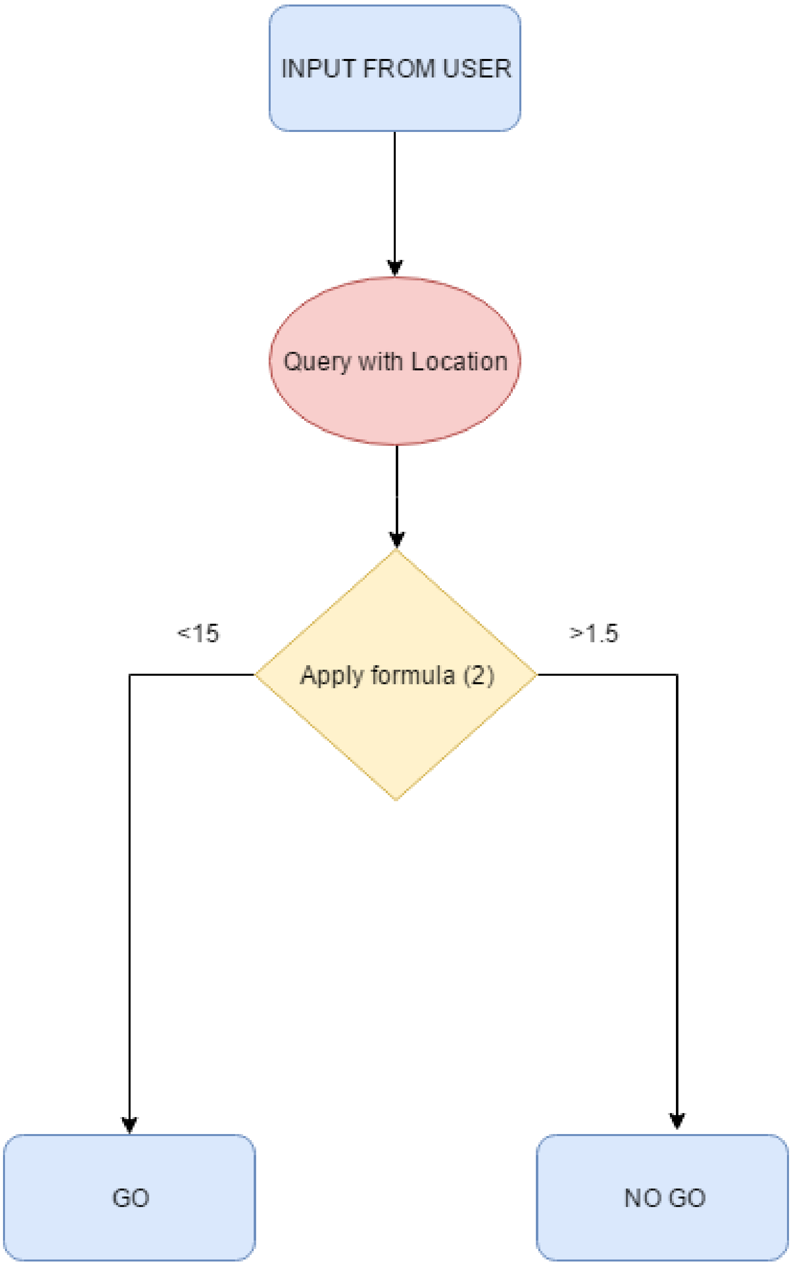

Figure 4. Advisor algorithm

5. Conclusion

The proposed architecture would serve as a viable solution to the given issue. As an emerging work in progress, crowdsensing is on expansion, but hasn't opened many doors yet. More extensive studies over the concept is required and the boundaries have to be checked. The given concept may be changed as per the technological needs and as per the evolution of mobile technology. This framework is merely a step stone for the big works that can be achieved in Mobile Cloud and Mobile Crowdsensing.

5.1. Merits and Demerits

Crowdsensing has its own merits and demerits, as this particular application which we propose is prone to attacks and misdirection. End to end user encryptions is not possible as the program flow does not work on the process of communication between two devices but a collection of interlinked devices. However, identity and search information between the nodes must be kept a secret. Unless and until proper security measures are invoked, the system is useless. For that, we must rely on the security services provided by Cloud Services and there need not be any security on the system. Every user must be registered to the network and the services.

5.2. Future Work

The future work to be done are as follows, the application must be enabled real time and also, we can provide live feeds for the users to work upon and choose. Different activity tracking and suggestions can be involved for people gathering and information systems. Social networking help can be achieved in node approval and incentivizing. These works must be updated with the help of mobile technology as well.

This way, the work must involve less resource sharing and more throughput to avoid user exhaustion. Also profit enabling mechanisms can be included in order to make sure the investment in the field grows and more popularity is gained for the work.

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