Design of Client/Server System for Meteorological Map Service Using Mobile Phone Sensor

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***Abstract*—**On the limited urban area meteorological data are hard to be collected because of the cost problem. The facilities collecting the data require high installment cost. Recently, the sensor network technique comes to the fore as a solution. Furthermore a mobile phone also becomes to be recognized as a sensor. This paper studies an application to service the meteorological map using mobile phone sensor. A design results for system implementation are introduced in this paper.

***Index Terms*—** Sensor Network, Mobile Phone Sensor, Meteorological Map Service, USN Application

I. INTRODUCTION

Ubiquitous technique makes it possible that users get useful information by potable mobile devices on real-time. The meteorological information of nearby area is one of the examples. The information includes temperature, humidity, wind velocity, atmosphere values, and air pollution degree. However, to collect the information, related facilities with the sensors have to be constructed or sensor network system must be installed. These systems require high construction cost and maintenance cost. Therefore a new approach to apply an existing mobile phone as a sensor is being tried. One example of the attempts is the project Mobile Millennium [1] performed by U.C. Berkeley, CCITT(California Center for Innovative Transportation), Navteq, and Nokia cooperatively. This project researches the technique that uses the mobile phone as a mobile traffic sensor.

The client/server system for meteorological map service which is proposed in this paper, applies the mobile phone to collect the meteorological data especially on urban area. The mobile phone works as client and sends sensing data and receive meteorological map from server. A server collects the data from clients, analysis the data, generates useful meteorological map, and sends the map to clients. Figure 1 show this idea. The generated map can be used at online clients.

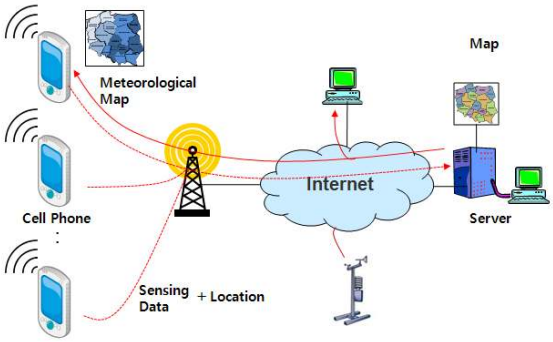

Fig. 1 Meteorological Map Service Using Mobile Phone Sensor

To make this service possible, the privacy and the mobile sensor problem are main obstacles. This paper assumes that the privacy problem of a phone owner who supplies the sensing data and location information could be solved by a contraction. The one who want to get the meteorological map service could supplies the data. One more assumption of this paper is that the meteorological sensors can be equipped on a car. The devices are connected to mobile phone of a driver and the sensing data and location are sent to server periodically.

This paper investigates some issues related to the implementation of the client/server system. First, data structures of sensed signal between a client and server are presented. Secondly, data processing mechanism to collect and store the collected data from clients to database is proposed. Lastly, to generate useful information, several query types are considered.

The volume of collected database on server will be huge and grow rapidly. If the efficient algorithms are developed to treat the data properly, useful application fields of the proposed system are various[2]. This

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paper proposes a useful mechanism to collect and aggregate huge client messages efficiently.

The organization of the remaining parts of the paper is follows. Section 2 reviews the related works on the topic and Section 3 introduces the proposing data model. Section 4 shows processing mechanism, and query types from the collected database. Finally, the conclusions of this paper are in Section 5.

II. RELATED WORK

Recently, Nokia is proceeding with a project to construct a sensor network system for traffic information service based on smart mobile phone with other research centers. This project, called 'Mobile millennium' becomes to show the meaningful results. Figure 2[1] is the service example which shows a client service map. The traffic information map is generated by server, based on collected information from mobile phone clients.

Fig. 2 Service Map Example of Mobile Millennium Project

In Figure 2, the green, yellow, and red colored roads indicate each traffic conditions. The information are collected the mobile phones on the road. Following the research[1], mobile phone is possessed by over 3 billion peoples, connected to the internet always, and equipped by many micro sensors. Upon this idea, they introduce an application field to use mobile phone as a sensor node to build a sensor network.

These kinds of sensor network can use the sensors built in the phone, such as GPS, WiFi, Bluetooth, Camera, Microphone, etc. The collected sensing data can be shared with others. If the individual privacy problem is treated regally, the information can be shared world widely. As examples, the club or restaurant recommendation service, the meteorology and environment monitoring services, and the traffic status reporting services could be implemented.

Fig. 3 Citysense Application Example

Figure 3 shows 'Citysense' example serviced by iPhone[3]. The service recommends some clubs which is more active and clouded. The information are collected from the client mobile phones.

KT has performed a research[5] which uses an environment measurement vehicle equipped with several echo-sensors. The sensing data can transmitted to a station at real time by mobile USN. Figure 4 shows the vehicle and related equipments.

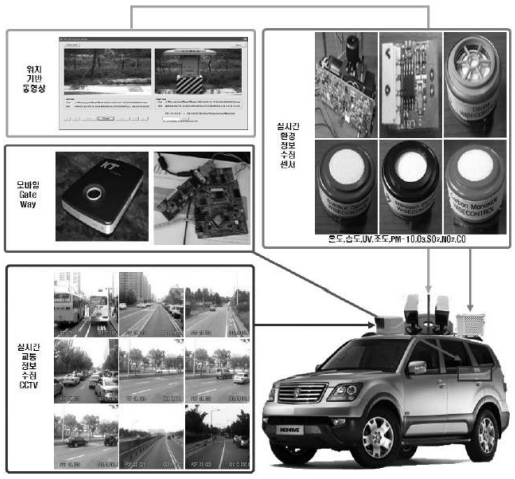

Fig. 4 Mobile USN Atmosphere Measurement Vehicle Equipped with Echo-Sensor(KT)

The collected data are analyzed to generate a echo-map. The map is used to investigate atmosphere pollution. This research shows the possibility of the meteorology service using a mobile phone as mobile sensors.

This paper shows the client/server system design to implement the meteorology service using a mobile

phone as mobile sensors. Especially this paper focused on a useful mechanism to collect and aggregate huge client messages efficiently.

III. DATA MODEL DESIGN

The proposing meteorology map service system is designed under the assumption that the meteorological sensors can be equipped on a car. The devices are connected to mobile phone of a driver and the sensing data and location are sent to server periodically. The server collects and aggregates the client data, and stores them at database. Stored data are continuously retrieved to generate useful service map, meteorology service map.

To implement the system, data frame format of sensed signal between a client and server needs to be defined. And the server which collects the client's sensing data must have a processing mechanism to aggregate continuously arriving client data frames. The aggregated and optimized data are stored on database, and on the same time are queried to generate service map.

A client has many sensors, continuously generates sensing signal, and sends sensed data frame to server periodically. Figure 5 shows data frame format of CVS(Client Sensing Values) which is transmitted to server. A CVS is dived to 3 part largely, that is, head and ID, time and location, and third sensing values.

Head	ID	Date/Time	Location	Num of Data	CSV
Sensor ID 1	Value1	Sensor ID 2	Value2	···	

Fig. 5 CSV Data Frame Format

A serve has to receive mass client data frames, and some of them are duplicated. Because the arrived data must be processed on real time, processing efficiency of the data is very important factor. In the design of a server data schema, this factor has to be considered.

DistrictID (Class1)	GeoID	District Name			District1
DistrictID (Class2)	GeoID	District Name	DistrictID (Class1)		District2
DistrictID (Class3)	GeoID	District Name	DistrictID (Class2)		District3
SensorID	Sensor Name	Value Range			Sensor
TDID	StartTime	EndTime			TD
DistrictID (Class3)	TDID	SensorID	Value		SSV

Fig. 6 SSV and Server Data Schema

Figure 6 shows data frame format of SSV(Server Sensing Values) and server data schema including map data. In figure 6, TD(Time District) means certain time interval and is introduced to aggregate many CSV in a TD to one SSV. This idea can reduce the complexity at server dramatically.

For meteorology map service within city area, this paper proposes 3 class map structures, that is, District1(Class1), District2(Class2), and District3(Class3). Figure 7 shows these 3 district class map structures.

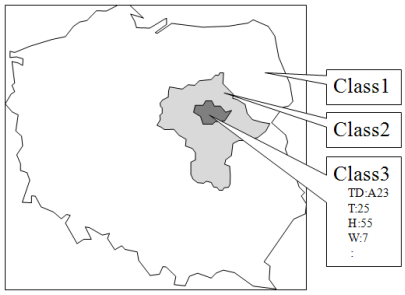

Fig. 7 District Class Map Structures

IV. PROCESSING MODEL DESIGN

The location information in CSV of a client must be mapped to District3. The sensing values of District1 or District2 can be computed through the aggregation of the including District3 values. Thus SSV has only District3 ID.

The mechanism to merge CSVs to SSVs is shown in figure 8. When a TD threshold time is arrived, CSVs buffered at server, start to map to corresponding sensing values of the District3. The overlapped sensing values at the same TD and in the same District3 are aggregated. Here, the aggregation is performed by computing mean value.

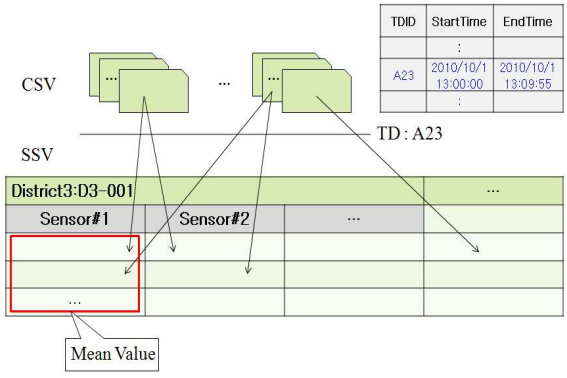

Fig. 8 Mapping CSV to SSV

Figure 9 shows a algorithm of these processing mechanism.

```
CSVtoSSV(list_CSV, TD) { //called at a TD threshold time
   for(CSV:list_CSV) {
      //get corresponding District3 ID
      D3=get_District3(CSV.Location);
      //if no SSV, make it, else get the SSV
      if(!is_SSV(D3, TD)) LSSV=make_list_SSV(D3,TD);
      else   LSSV=get_list_SSV(D3,TD);
      map_SV(CSV, LSSV);    //mapping sensing values
   }
   for(LSSV:list_SSV) {
      aggregate_LSSV(LSSV);    //computing mean values
   }
}
```

Fig. 9 Mapping Algorithms

The SSV is composed with a location (District3 ID : X axis), a time (TDID : Y axis), and sensing values (SensorID/Value : Z axis). The query types on SSV would be dependent on two of X,Y,Z axis. That is, all queries will be one of the X-Y-Z pairs. Because of 3D GUI is very hard to implement, this paper ignores 3 dimensional query.

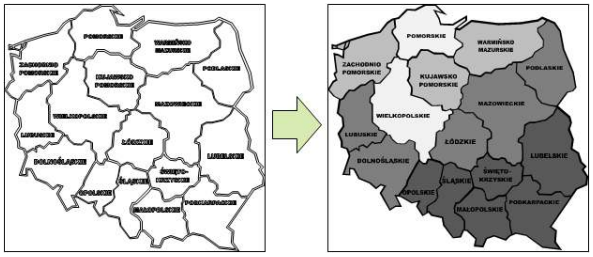

Fig. 10 X-Z Query Example

Among the 3 cases, the following 2 query types are useful. One is X-Z query, which gets all locations and its' sensing values, at certain time. Figure 10 shows this example. In this figure, the query will be like this: at most recent TD, in all District2 (X axis), display all sensing values(or some, Z axis). The Z values will be displayed with various GUI(color, text, symbol, etc.).

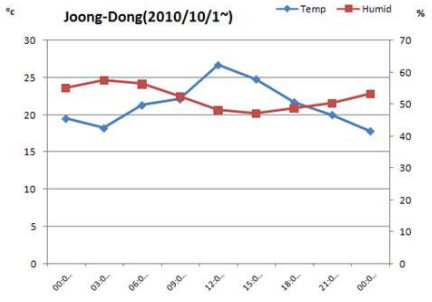

Fig. 11 Y-Z Query Example

Another is Y-Z query, which gets all time and its' sensing values, at certain location. Figure 11 shows this example. In this figure, the query will be like this: at one District, during all time(or some, Y axis), display all sensing values(or some, Z axis). The Z values also will be displayed with various GUI.

V. CONCLUSIONS

Because the meteorological observation towers are scattered over large area, the collected data are very sparse. Therefore, the need for data collection on the limited urban areas like a specific building or subway area brings about vest cost which is required to install the corresponding sensors on the areas. To overcome this problem, this paper proposed the client/server system for meteorological map service applying the mobile phone to collect the meteorological data. The mobile phone works as client and sends sensing data and receive meteorological map from server. To support a client/server system to service meteorology map with mobile phone sensor, this thesis proposes an efficient client/server data model and processing mechanism to map and query.

The environment to use mobile phone as sensor requires many prerequisite conditions, like privacy, mobile sensor problem. However, it is clear that, the mobile phone sensor will be generalized in various application fields, because of its obvious advantages.

Further researches are needed to implement the proposed model and algorithms. The implemented results will be estimated by experiments. The major estimation factors will be the benefit of mobile phone sensor.

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