Study of a Remote Monitoring System for Senior Drivers

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***Abstract*—ITS (Intelligent Transport System), which connects people, vehicles and roads by information and communication technologies, has been drawing much attention these days. Telematic services, in particular, have been deployed by domestic as well as foreign automobile companies in various ways. However, in most cases their services are intended to support drivers themselves. In the meantime, provision of services to the people taking care of elderly people in the family is considered to become increasingly important towards the future, in such countries as Japan where the aging society is becoming a serious problem. In this paper, we present a system by which people having an elderly person in their family can remotely monitor his health conditions when he is driving a car.**

***Index Terms*—Senior Driver, Sensor Data, Telematics.**

I. Introduction

ITS is playing an important role in the present automobile society. As well-known examples of the ITS, we have ETC (Electronic Toll Collection System) used on expressways to collect tolls automatically without stopping vehicles and VICS (Vehicle Information and Communication System) which acquires information on traffic congestion and regulations on a real-time basis. By utilizing these systems, traffic problems including traffic accidents and congestion have been greatly alleviated.

Besides the above-mentioned services, we also have a type of ITS called "Telematic service system" that provides real-time information to the people riding a vehicle, based on a telecommunication system specifically installed in the vehicle. The telematic service system provides not only news and weather forecast but also entertaining elements such as downloading of games and music through linkage with a car navigation system. Telematic services have been deployed within and outside Japan by various different ways.

Telematic services are essentially targeting drivers themselves, especially young to middle-aged drivers, but in Japan where the aging of society is expected to advance rapidly, it is thought that there will be increased opportunities for senior citizens to drive cars. Under the current household environment, there are many cases where elderly persons live separately from young family members, and it is often difficult for family members to cope with the situation swiftly when something happened to the health conditions of their elderly person while he or she is driving a car. Thus, it is thought to become necessary and important in the future that services are provided not only to drivers themselves but also to the people who need to take care of their elderly family members.

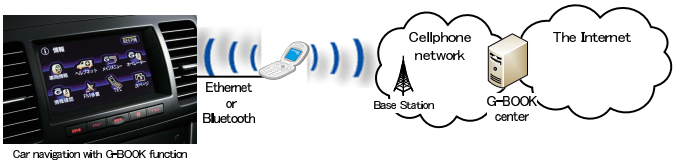

Fig. 1. Configuration of G-BOOK

Recently, systems to support personal healthcare activities of curing and preventing users' lifestyle-related disease in the course of daily life have been well developed [1] and also, studies such as HASC (Human Activity Sensing Consortium) [2] to monitor human behavior in daily life have greatly progressed. Thus, we can apply them to the monitoring of health conditions of elderly people when they stay in the same place. However, since these studies are not giving any consideration to the situation where the people who are being monitored move from one place to another, we cannot use them as they are for the system to monitor the health conditions of driving people.

Under such circumstances, we propose in this paper a system to store health conditions and geographical information of a car-driving person in a management server on the Internet through a cellular network, which family members or relatives of the car-driving person can browse from a remote place at any time, on a real-time basis, through a security-tight communication method.

We will describe several existing services/systems in Section II, the outline of our proposed system in Section III, operation of our proposed system in Section IV, trial implementation of our proposed system in Section V, and finally a summary of this paper in Section VI.

II. Existing Services and Systems

A. Telematic services

Telematic services have already been deployed by G-BOOK [3], CARWINGS [4] and others.

The configuration of G-BOOK is shown in Fig. 1 [3]. G-BOOK is offering Map On-demand Service by which they

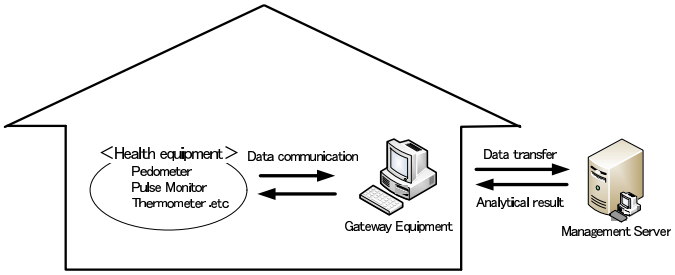

Fig. 2. Configuration of NEDO's Home Health Care Project

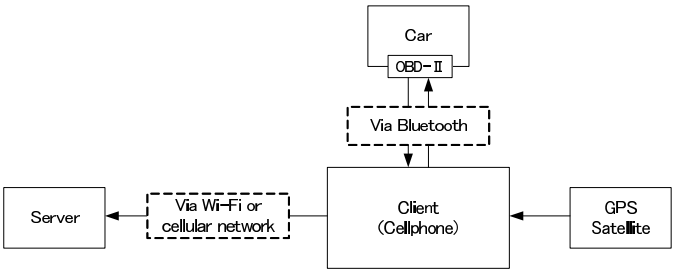

Fig. 3. Configuration of Cell Link

deliver information on newly opened sections on major and toll roads between the present location and the destination to the car-navigation system as well as Probe Communication Service by which they predict traffic conditions based on the latest traffic information from VICS and past statistic data. They also provide Help Net Service by which they assist transmission of messages from a vehicle to Help Net Center in case of emergency.

In the case of CARWINGS, besides similar services to those provided by G-BOOK, they are offering services by which they check the geographical information of the destination and also confirm the schedule registered by Google Calendar in the vehicle, by using Google maps.

These above-mentioned services are, however, all intended to assist drivers themselves. And, since they use their own management centers, their services are exclusive and not open to general users. In the meantime, Japan is a country where the aging of society is getting more and more a serious problem. Then, services by which family members / relatives of an elderly person can monitor his or her health conditions at any time even when he or she is driving a car, will definitely become necessary in the future.

B. NEDO's Home Health Care Project

As an example of personal healthcare support systems, the outline of the high-efficiency health measuring equipment (system) developed by NEDO (New Energy and Industrial Technology Development Organization) is shown in Fig. 2. This is a system to collect health-related information measured at home by measuring equipment such as a manometer and a clinical thermometer in the gateway equipment and to transmit it to the management server for analyses and storage. The information stored in the management server can be browsed through the Internet from individual homes and medical institutions. However, this system assumes that the people monitored always stay at home and thus, it cannot cope with the situation where these people get out of home.

C. Cell Link

In the case of Cell Link [5], studies to transmit data obtained from a vehicle to the management server on the Internet on a real-time basis have been performed. As shown in Fig. 3, various data including engine rotation, vehicle speed and temperature of cooling liquid obtained through OBD (On-Board Diagnostic)-II mounted in the vehicle are transmitted to the cellphone through Bluetooth. Geographical information at the time of data acquisition is also collected using GPS function of the cellphone. These data are transmitted to the management server on the Internet through Wi-Fi or cellular networks.

However, this system is not paying sufficient attention to the security at the time of transmission, and thus, there may be a possibility that personal information such as the name and age of the driver is leaked.

III. Outline of our Proposed System

A. configuration

The configuration of our proposed system is shown in Fig. 4. In our proposed system, two cases are assumed. One case assumes that a person is walking and another case assumes that a person is driving a car. In the case of a walking person, biological information from PMD (Personal Monitoring Device; such as pedometer, manometer and pulse monitor) attached to the person as well as geographical information obtained from GPS is collected as sensor data. The walking person also holds TD (Transmission Device) to transmit the collected sensor data to SMS (Sensor data Management Server) in the Internet. As the TD which the walking person holds while walking, a Smart-Phone is assumed in our study. In the case of a person driving a car, VDM (Vehicle Monitoring Device) which collects vehicle-related information such as steering information from the steering wheel. The sensor data are stored as a file in VMD and transmitted to SMS on the Internet periodically via a cellular network from the TD. At SMS, the sensor data received from the TD are stored in the Database in SMS. Observers who want to see the health conditions of the driver can browse the information of the driver via the Internet at any time.

B. Reporting of sensor data

Sensor data are collected by connecting VDM and TD, and PMD and TD with Bluetooth. Sensor data are periodically transmitted by UDP. In the meantime, since personal information is included in the sensor data transmitted from TD to SMS, how to ensure the security is important. In our proposed method, we utilize DPRP (Dynamic Process Resolution Protocol) [6] for authentication and PCCOM (Practical Cipher COMmunication) [7] for encryption. Because DPRP and PCCOM are mounted in the kernel, the security of applications is automatically secured.

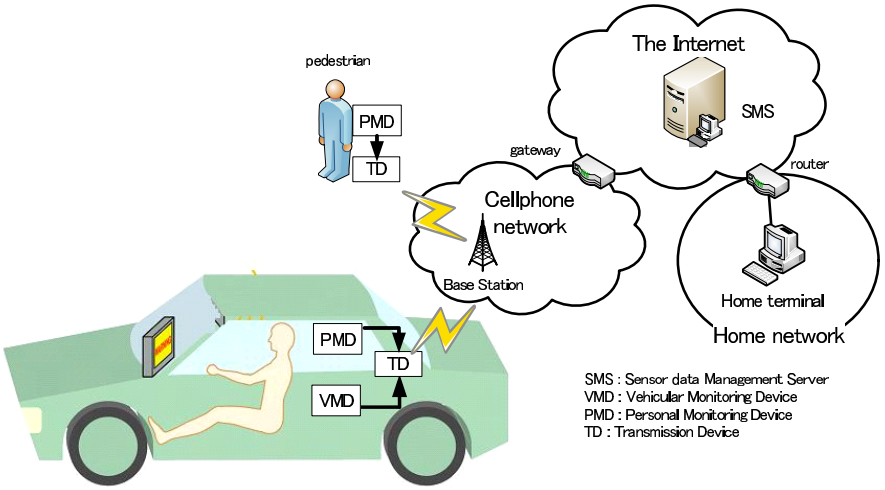

Fig. 4. Configuration of our Proposed System

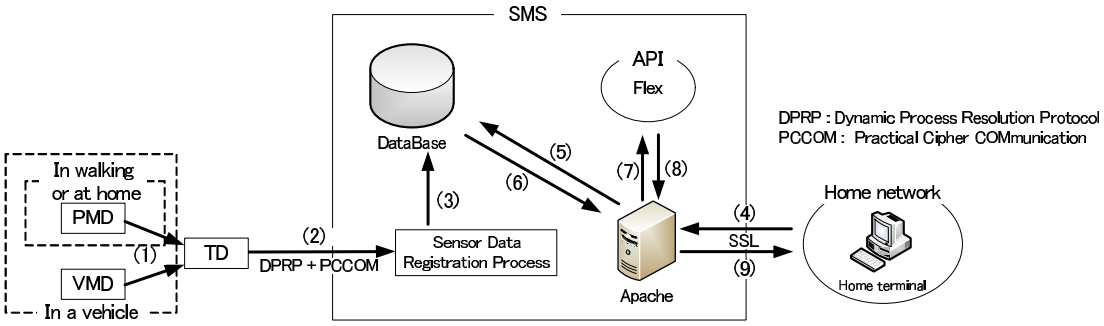

Fig. 5. Flow of our Proposed System

C. Browsing of sensor data

When an observer browses the sensor data in SMS from his/her home terminal, the observer uses an user ID and a password. When the observer specifies specific sensor information, SMS obtains necessary data from the database, transforms it into the form of a graph by a graphic API(Application Program Interface) and sends it to the home terminal. Meanwhile, SSL is used for the above-said communication.

IV. Operation of our Proposed System

Operation of our proposed system is shown in Fig. 5. The data transmitted from TD are registered in the database after being processed by sdrp (Sensor Data Registration Process) of SMS. Requests from a home terminal for the browsing of sensor data are processed by Apache.

A. Connections between VMD and SMS, and PMD and SMS

TD obtains necessary sensor data from PMD and VMD (Fig. 5, (1)). For PMD, a health device commercially obtainable from the marketplace is assumed, and TD collects data in accordance with the interface. Meanwhile, VMD keeps information on the vehicle as a file. TD reads sensor data from VMD as an NFS client (Fig. 5, (1)).

As the next step, TD periodically sends the obtained sensor data to SMS in UDP packets (Fig. 5, (2)).The contents of the report are defined in XML (Extensible Markup Language) format so as to sufficiently deal with an increase of sensor information in the future. In sdrp, sensor data received are registered in the database by SQL after being analyzed, using XML analysis library (Fig. 5, (3)).

B. Sensor data transmission format

We defined the format for the sensor data transmission as shown in Fig. 6. The descriptions in Fig. 6 correspond to the following rules.

- <user>～</user>
  Information on the account of user is described. With this description, the server can identify the user.
- <sensors>～</sensors>
  One or more additional <sensor> tags are inserted as sub-elements. When sending multiple sensor data, multiple <sensor> tags are inserted in the <sensors> tag.
- <sensor>～</sensor>
  As sub-elements, three tags of <sensor-type>, <sensor-device> and <sensor-data> are inserted.
- <device>～</device>
  Device information on the sensor is described. With this

```
<root>
  <user>
    <first_name>taro</first_name>
    <last_name>meijo</last_name>
    <password>d6a9a933c8aafc51e55ac0662b6e4d4a</password>
    <username>meta</username>
  </user>
  <sensors>
    <sensor>
      <device>
        <vendor>067b</vendor>
        <product>2303</product>
      </device>
      <data>
        <type>1</type>
        <date>20100510</date>
        <time>123045</time>
        <la>3445.0121</la>
        <lo>13721.6907</lo>
      </data>
    </sensor>
    <sensor>
      ...
    </sensor>
  </sensors>
</root>
```

Fig. 6. Format for sending sensor data

information, we can identify from which sensor device the data obtained, even if the sensor-type of the sensor devices is the same.

- <data>～</data>
  Data acquired from the sensor are described. The number and names of sub-elements vary depending on the sensor-types.
- <type>～</type>
  ID that can identify the kind of sensor data (GPS and pulse monitor, etc.) is inserted. In the server, a table to register sensor data is determined, based on this information.

C. Communication between home terminal and SMS

When Apache in SMS receives from a home terminal a request for browsing of sensor data (Fig. 5, (4)), the sensor data are retrieved from the database by SQL (Fig. 5, (5) and (6)) and made into the form of a graph through the graphic API (Fig. 5, (7) and (8)). The graphic data are then sent to the home terminal (Fig. 5, (9)).

As the graphic API, Flex [8] is used. In addition, when displaying geographical information, Google Maps API [9] is used.

D. Mail delivery service

In order for an observer to learn the present situation of the driver, it is necessary for the observer to get access to SMS every time. In our proposed method, SMS delivers to the observer e-mails indicating the present state of the driver

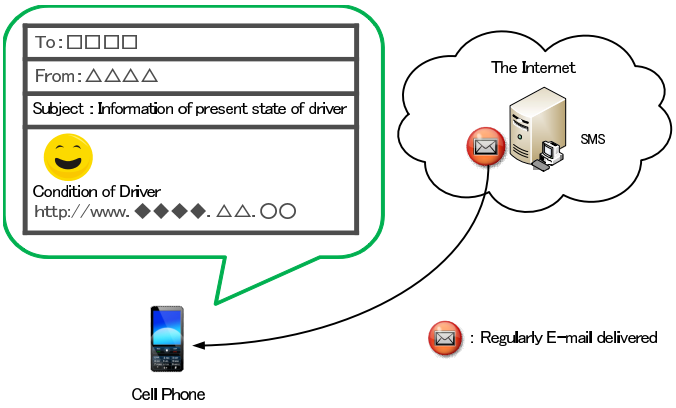

Fig. 7. Mail delivery service

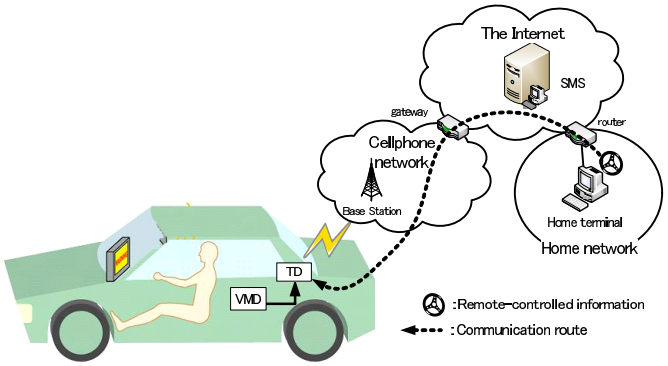

Fig. 8. Operation in case of emergency

in pictograms once a day. The observer can see that there is no problem occurring to the driver unless there are some changes in the pictograms, and in this way, the observer can avoid the trouble of getting access to SMS regularly (Fig. 7). As necessary, the content of SMS can be browsed by a click, as URL is indicated in the mail.

E. Operation in case of emergency

Operation in case of emergency is shown in Fig. 8. When SMS detects any abnormal value in the sensor data received, it dispatches an emergency message to the home terminal so that a hot-line between the home terminal and the vehicle can be obtained. The hot-line indicated here means a direct communication between the home terminal and the vehicle without going through SMS. In the future, it will also become possible for the home terminal to give instructions to the vehicle as needed (e.g. instructions to the driver to stop the vehicle immediately at the edge of the road). In order to secure the highest level of security, DPRP and PCCOM are also applied to the hot-line.

V. IMPLEMENTATION

A. Configuration of our trial system

Towards the realization of our system, we implemented the following trial system. We took geographical information from UBS-type GPS into PC and transmitted it to SMS through a

Fig. 9. Our trial device

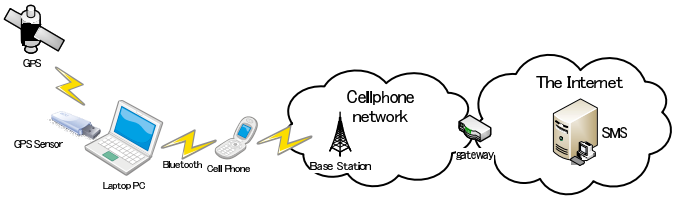

Fig. 10. Configuration of our trial system

TABLE I
DEVICES USED FOR OUR TRIAL OPERATION

	Type
PC	AUSU Eee PC [10], OS:Linux
GPS sensor	CanMore USB-type GPS module, GT-730 [11]
Cell Phone	Docomo P-01A [12]

cellphone. The appearance of the trial device is shown in Fig. 9 and the configuration of the trial system is shown in Fig. 10. Devices used in the trial system are listed in Table I.

As the cellphone, we used a cellphone equipped with the function of DUN (Dial-up Networking Profile) as a modem. By making the pairing of Bluetooth between PC and the cellphone in advance, we can start TCP/IP communication between the PC and SMS. We made no change in the program of the cellphone because it is used just as a modem.

B. Operation of the program

The operation of the program implemented in the PC is as follows. The sensor data from GPS are outputted to a local file at regular intervals. The local file is regularly read and transmitted to SMS after being converted to XML format defined in IV-B. After the data transmission, if a correct response is returned, the transmission is considered to have been successful. If no response is returned for a certain predetermined time period, the registration in the server should be considered to have been failed, and the same data are retransmitted at the next transmission time together with other new data. This method is based on the assumption that there may be cases where the network cannot be used. Transmission is done only when it is feasible. In the meantime, although we plan to incorporate DPRP and PCCM in Linux kernel in the future, we have not done it this time.

Fig. 11. Picture of GPS data displayed on SMS

C. Results of trial implementation and full-scale implementation in future

Fig. 11 shows a picture displayed on the side of SMS, which indicates the contents reported from the PC to SMS. We loaded our trial device in a vehicle shown in V-A and we drove the vehicle in town. We obtained GPS information at an interval of 5 seconds and transmitted it to SMS. From the results of our trial system, we could confirm that we can store sensor data in SMS through the cellular network and display them on the screen of a home terminal. We plan to implement the function into an Android terminal as the next step. Because the Android terminal offers an environment where OS based on the Linux kernel, middle-ware and application are open, we will be able to implement DPRP and PCCM, as we mentioned in our proposal. Android terminal can be used as TD while walking.

VI. CONCLUSION

In this paper, we have shown the outline of a system by which people can remotely monitor the health conditions of a car-driving senior person. We have also shown the operation of our proposed system, and the implementation of our trial system.

As the next step, we will determine detailed specifications of devices and plan to implement and evaluate the system on a full-scale basis.

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[10] EeePC, “http://www.asus.co.jp/index.aspx/”
[11] GT-730, “http://www.canmore.com.tw/index.php/”
[12] P-01A, “http://www.nttdocomo.co.jp/”

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Study of a Remote Monitoring System for Senior Citizens

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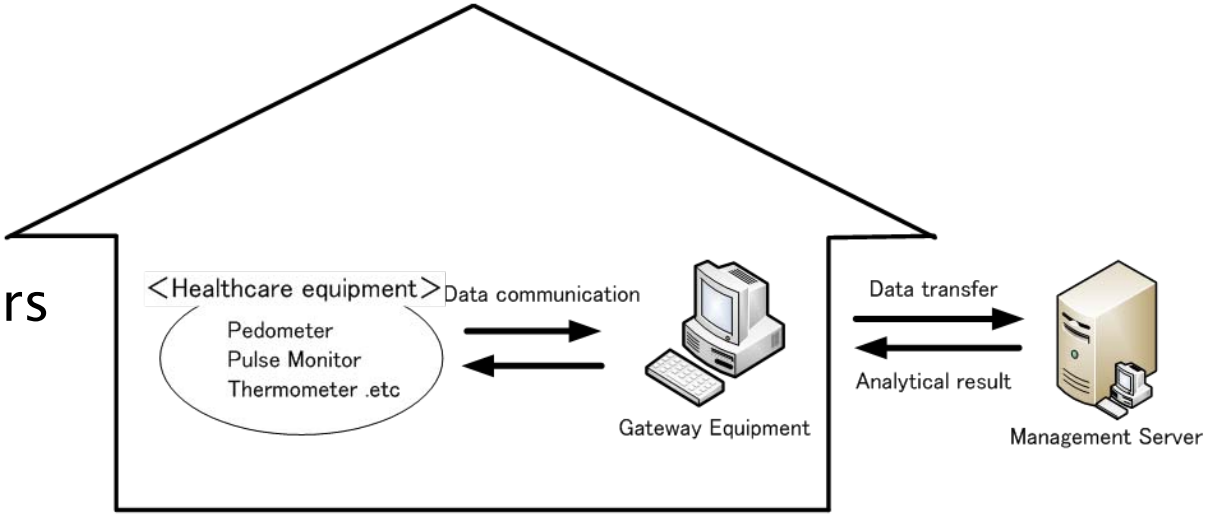
Fewer Children and Aging Society

- An increase in population of seniors
  - The family can not necessarily watch seniors at any time
  - The chance that seniors drive increases
- Development of a remote monitoring system that watches seniors
  - This is a service for families who care seniors
  - Secure communication

1. Home Healthcare Project

- Proposal

  Support health maintenance of seniors



- Contents
  - Health information is collected in the gateway device
  - They are transmitted to the management server
  - The health information is analyzed in the management server
  - Families and medical institutions watch analytical results

Service when targets are staying at home

2. Telematics Service

- G-BOOK[1]：Using cell phone and personal computer

~MAP On Demand~

~PROBE Communication~

~MUSIC On Demand~

~Safety & Security~

Service for drivers

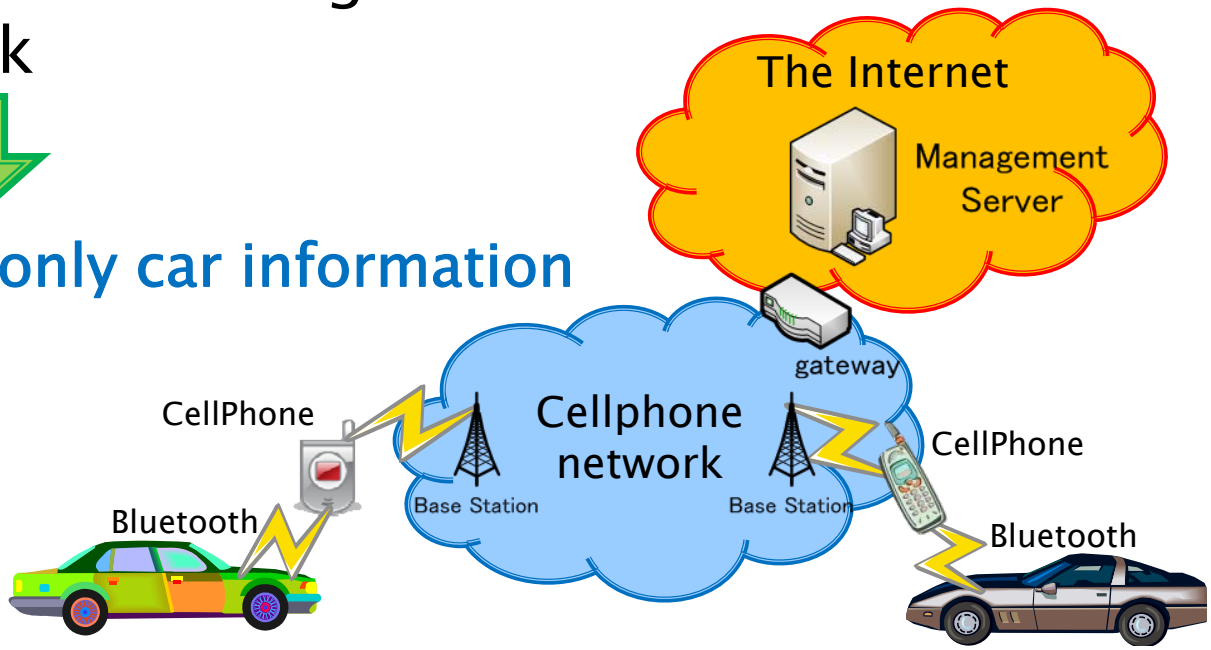
1：“G-BOOK”、http://g-book.com

3. Cell Link[1]

- Collect car information from the car

  Engine revolutions, car speed, and temperature of coolant
- It is transmitted to the Management Server via Wi-Fi or cell phone network

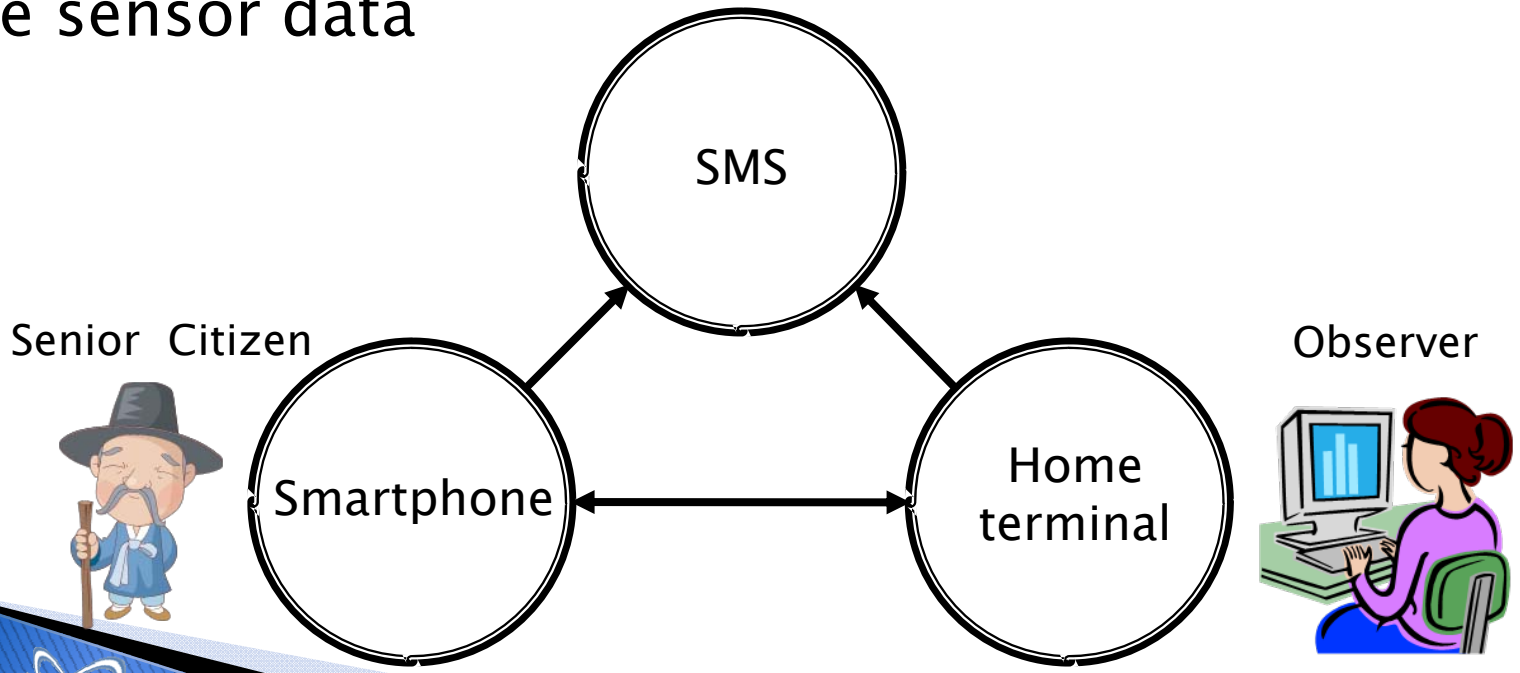
Service intended for only car information



1: Huasong Cao : Real-time Data Tracking of Automo-biles via a Cell Phones, ICCE, Conference, IEEE (2010).

Objective of our proposal system

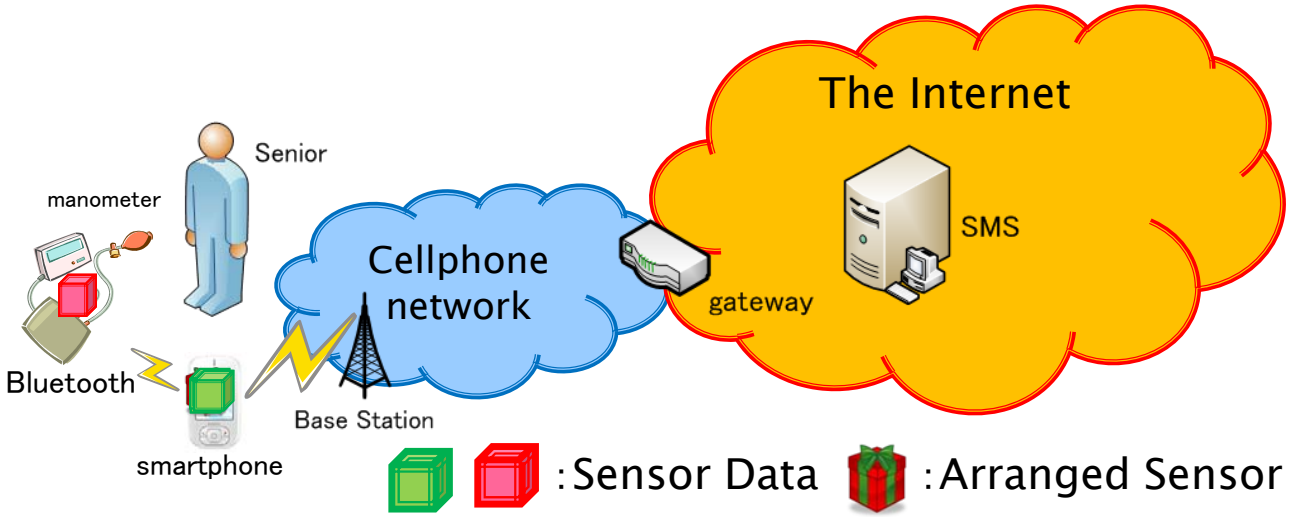
- Senior's sensor data is collected in the smartphone
- The sensor data is periodically transmitted to SMS on the Internet
- Only the observer[1] who watches the senior can browse the sensor data



1 : family and relative, etc. SMS: Sensor data Management Server

Senior is at home or walking

- The sensor data is collected in the smartphone
  - GPS, Walking count, Manometer, Pulse monitor
- It is arranged to the XML[1] format and is transmitted to SMS on the Internet with UDP communication
- Cipher communication with the original technology[2]

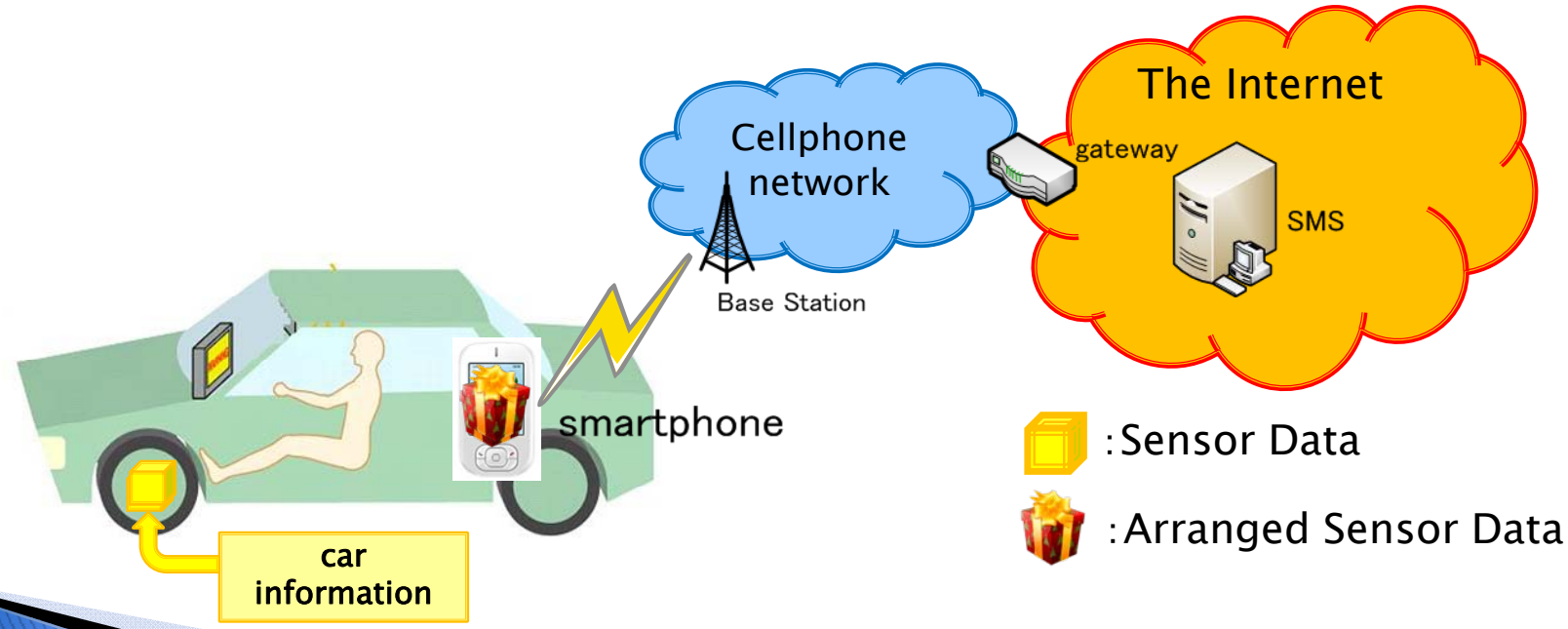


XML:Extensible Markup Language

2 : S.Masuda : Proposal for a Practical Cipher Communication Protocol that Can Coexist with NAT and Firewalls, IPSJ, Vol.47, No.7, pp.2258-2266(2006)

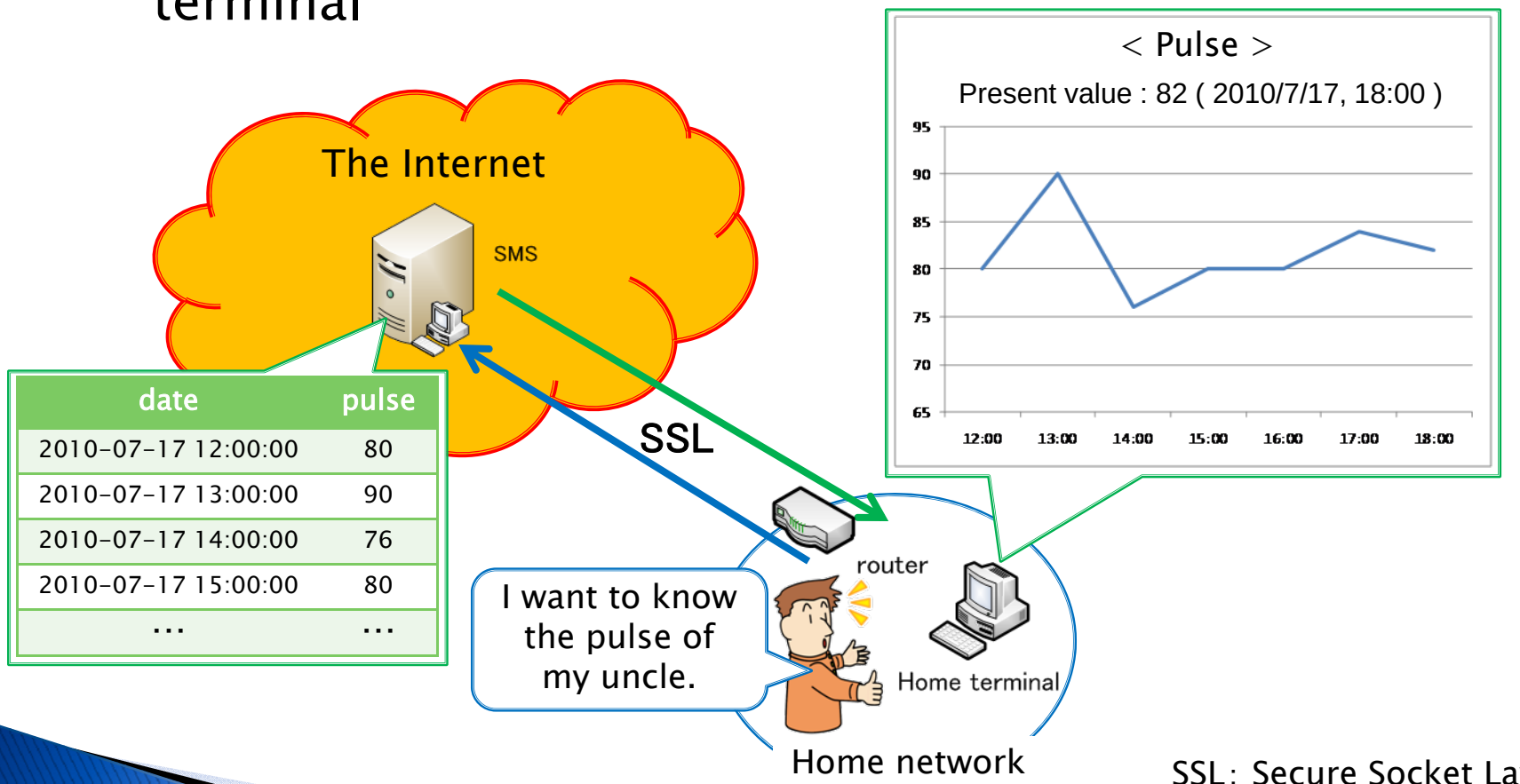
At Driving

- The smartphone collects car information
  - Engine revolutions, Car speed, Variance of the distance from a car to a center line
- It is arranged to the XML format and is transmitted to SMS
- Cipher communication



Watch the sensor data

- An Observer can browse the sensor data from the home terminal



Mail delivery service

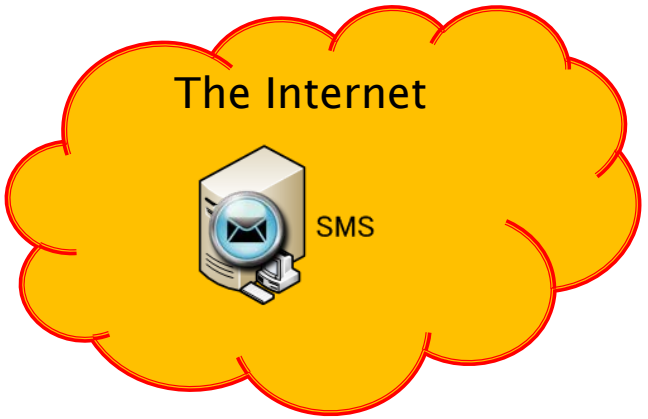
- A Mail is transmitted to the cell phone of observers once a day
- Senior's present condition state is shown with the pictograph

To:□□□□

From:△△△△

Subject : Information of present state of driver

Condition of Driver:
http://www. ◆◆◆◆. △△. ○○

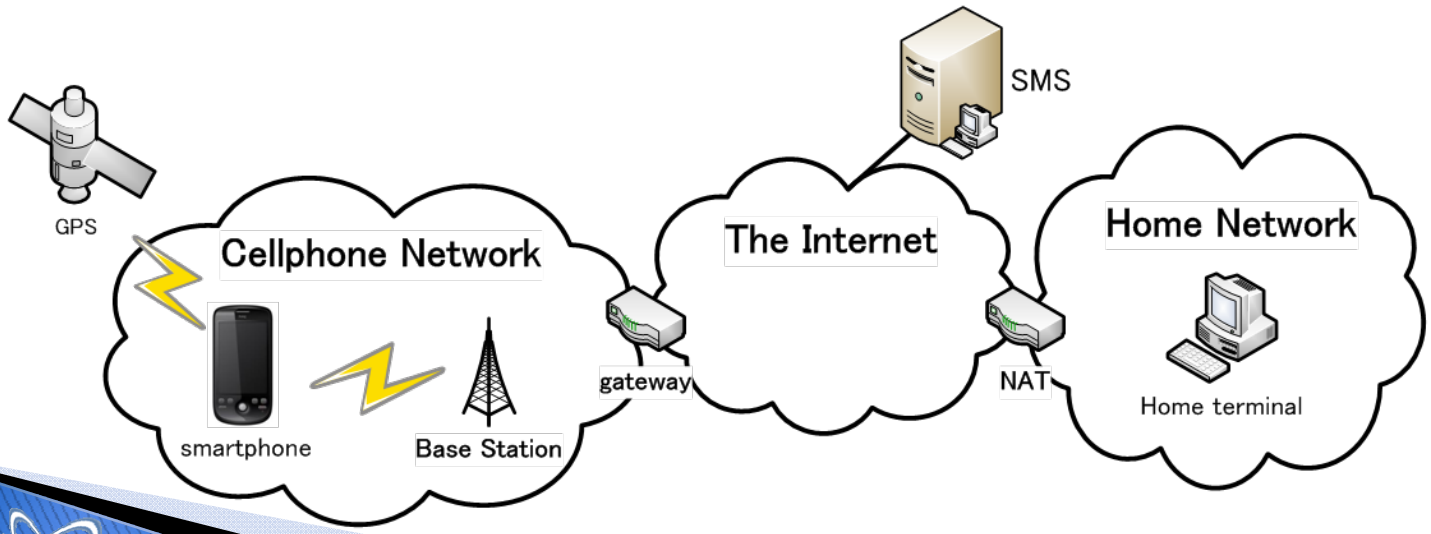


Cell Phone

: E-mail

Implementation

- Smartphone obtains a location from GPS information and a walking count from the calculation
- Smartphone transmits the packets to SMS on the Internet via cell phone network
- An observer accesses SMS to browse the data



Result of views

Conclusion & Future Works

- Conclusion
  - We have proposed the remote monitoring system for senior citizens
  - This is the service for observers who watch seniors
  - We have confirmed the basic operations with the trial system
  - Other information will be displayed soon
  - Sharing of the information with medical institutions that can decrease the load of observers

- Future Works
  - Definition of specifications in detail
  - Implementation and evaluation of the system

- Appendixes

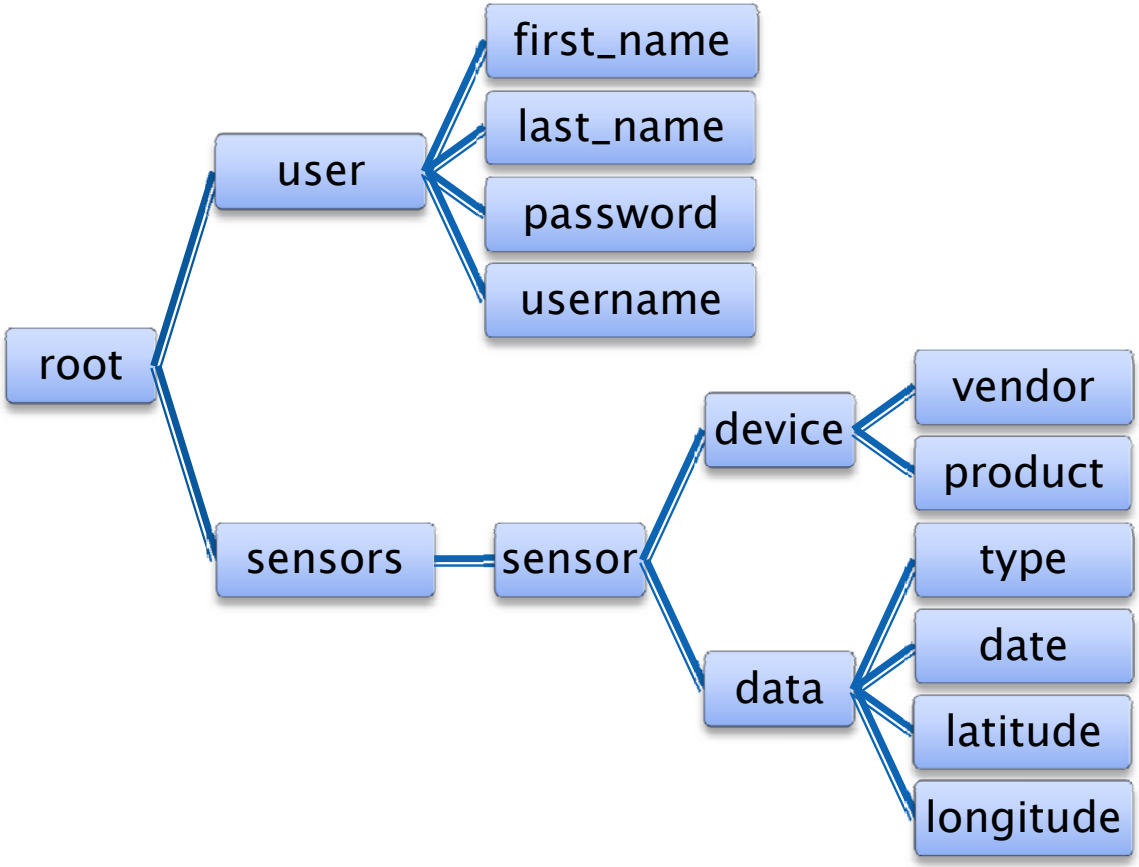
XML format

```
<root>
   <user>
      :
   </user>
   <sensors>
      <sensor>
         <device>
            :
         </device>
         <data>
            :
         </data>
      </sensor>
         :
   </sensors>
</root>
```

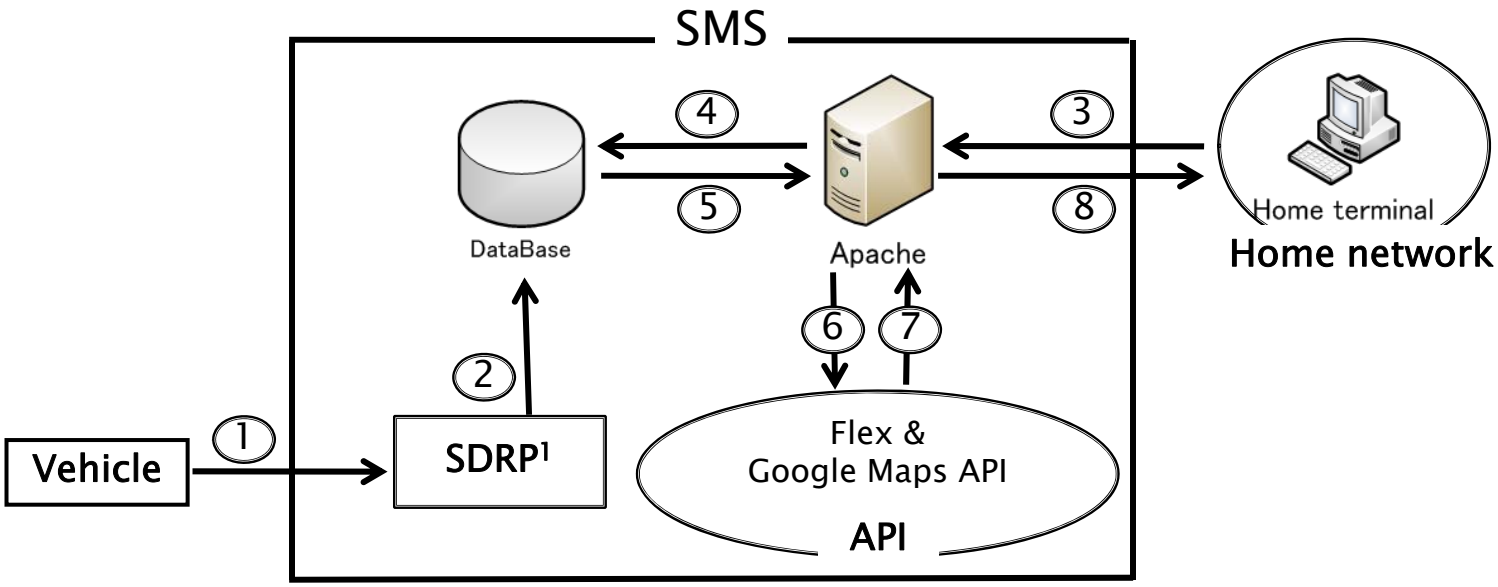
- <user> tag
  - User information
- <sensors>→<sensor>→<device> tag
  - Information of sensor device
- <sensors>→<sensor>→<data> tag
  - Sensor type, Obtain data

- Possible to use it without depending on the sensor device and the manufacturer
- Possible to transmit the data of a different sensor type together.
- Possible to correspond flexibly even if the kind of the sensor data increases in the future

XML format(Case of GPS information)



Process of SMS



Number	Process
①	Transmit the sensor data with UDP in the XML format
②	After XML is analyzed, it registers in the Database by SQL
③、⑧	Request to browse the sensor data ／ Transmit the graphic data
④、⑤	Request to reading the sensor data ／ Transmit the sensor data
⑥、⑦	Request graphic data ／ Transmit the graphic data

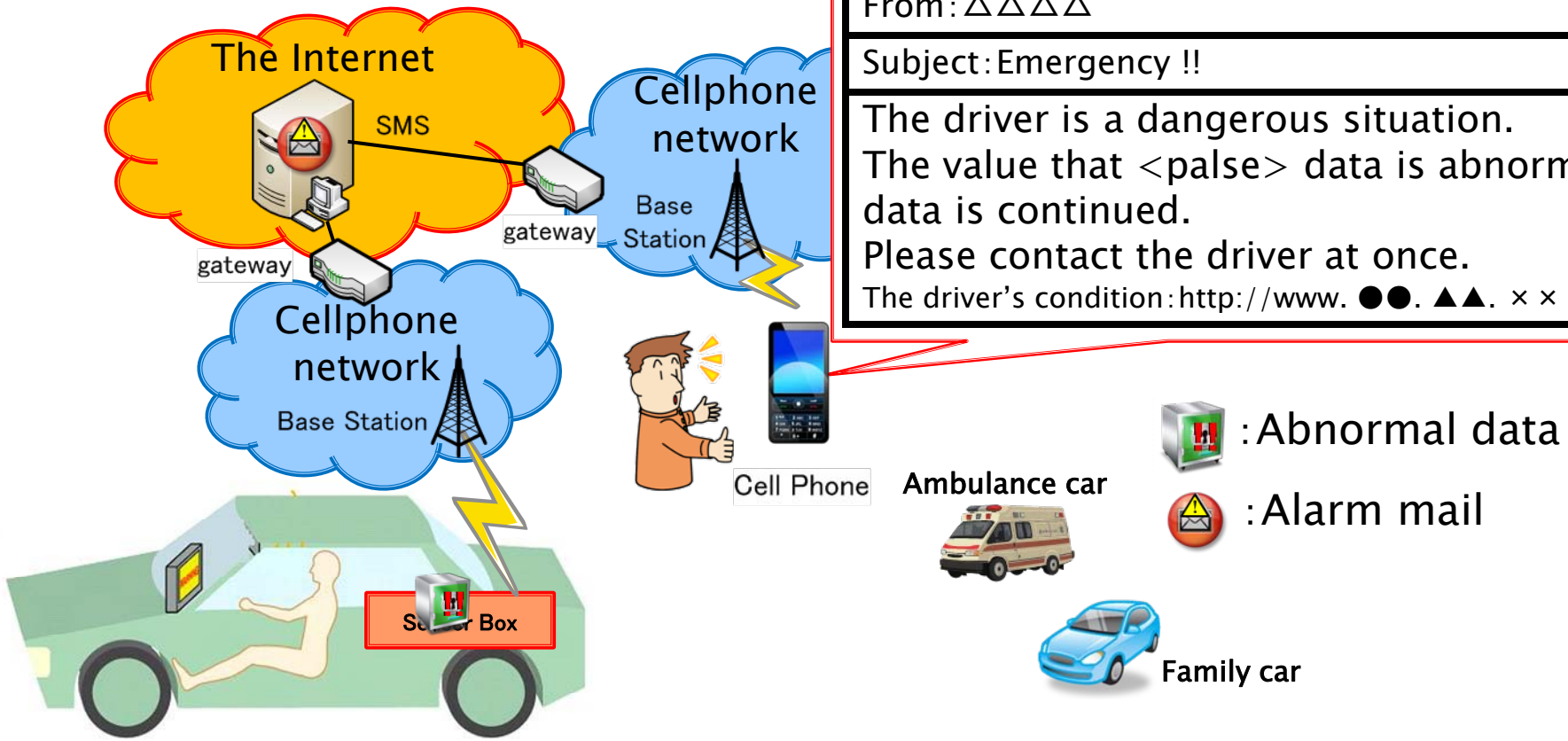
1：Sensor Data Registration Process

Database Registration Information

Table name	Registration information
User table	User name, Password
Sensor device table	Device information of each company
Sensor device manufacturer table	Sensor device manufacturer information
Sensor type table	Sensor type information
Sensor data table	GPS information, Pulse information, Blood pressure, etc

Operation in emergency

- When the value with abnormal sensor data continues, the alarm mail is transmitted to the cell phone.



Operation in emergency ~Remote control~

- The Hot-Line is secured
  - Communicates directly with the vehicle between home and terminal
  - Drawn to the shoulder by remote control
  - Secure security according to the encrypted communication
  - Give priority to the operation of the driver when conscious over the driver