Information Modeling to Calculate CO_2 Emissions Caused by Distribution and Its Allocations

Tomokazu Yoshifuji, Masayuki Goto, Tetsuo Yamada, Tadayuki Masui
Faculty of Environmental and Information Studies
Musashi Institute of Technology
3-3-1 Ushikubo-nishi Tsuzuki-ku Yokohama-shi, Kanagawa, 224-0015
Japan
masui@yc.musashi-tech.ac.jp

Abstract
The purpose of this research is to consider the structure of information management system for environmental logistics to measure CO_2 emission caused by distribution activities with high accuracy. The conducted research technique develops information model consisting of "The information system to get the data of fuel consumptions" and "Radio Frequency Identification (RFID)-Tag information system". Basically, this paper proposes new concept which makes it possible to grasp the CO_2 emissions by each transported goods unit. This system contributes to show how amount is loaded by owner in their transportation activities. Finally we propose the new paradigm in which the customers can choice the goods based on the information not only its prices but its environmental loads per goods or owners.

Key words: Environmental Logistics, Environmental Activities, RFID, CO_2 Allocation, Fuel Consumption

Introduction
In recent years, it has been one of the most important problems to improve the efficiency of the truck transportation in logistics from the viewpoints of the environment and economics. Especially in Japan, the "Revision Law Concerning Rational Use of Energy" requests transportation and owner companies to make efforts to decrease Carbon-dioxide (CO_2) emissions in their logistics processes. To realize this direction, it is necessary to grasp the volume of CO_2 emissions caused by their delivery or transportation activities (Figure 1).

However, many of the transportation companies cannot increase their workload practically, because most of them are small or medium-sized companies in Japan. In addition, under the current situation of rising oil prices and demand for excessive services, it has been more difficult for them to make enough profit and to also make efforts to reduce the CO_2 emissions. It is necessary to construct a framework of CO_2 monitoring system which doesn't need unacceptable many efforts.

Therefore, this study aims to develop the information model of the system in order to collect the data automatically in daily activities, calculate the CO_2 emissions, and allocate the total emissions to owners of goods. The system proposed in this study consists of the following three sub systems:

1) "The information system" to collect the data of fuel consumptions of truck and driving status.
2) "The RFID-Tag information system" to get the data of loads transported by trucks.
3) "The calculation system and database" to unify all information and to allocate the total CO_2 emissions to owners or shippers of goods.

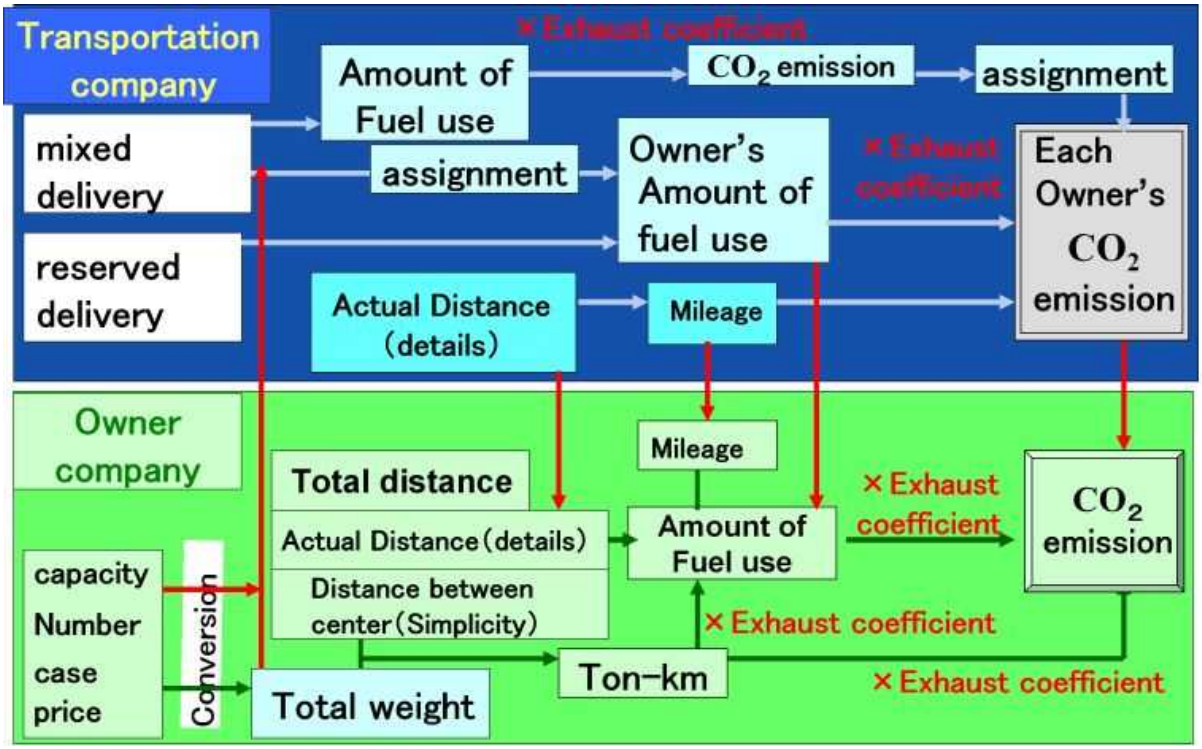

Figure1: Intelligence sharing between transportation company and owner company (ref.1: "Manual for introducing the environmental logistics management system"p.29, JILS)

Three Sub Systems

1) "The information system" to get the data of fuel consumptions of truck and driving status

In this research, the delivery route is divided into the some running sections defined as intervals between stopping and unloading points.

First of all, this system grasps the information such as the delivery route and fuel consumption of the truck for each section (Figure 2) in real-time and calculates the CO_2 emissions by using the advanced fuel gauge. For this system, we introduce the existing advanced fuel gauge named "TRU-SUM" (Figure 3) (*1) in this study. We develop and improve the TRU-SUM system to measure the fuel consumption in more details and in real-time. This system clearly distinguishes running-time and stop-time with a manual operation by a driver or deliverer (Figure 4). In the future, we are going to make the functions to the fuel gauge where the both times can be automatically distinguished and recorded.

*1: The TRU-SUM is one of the systems to calculate the fuel consumption of trucks what provided by Toward Logistics Ltd. This is "Run analysis software" made for administration, cost management and security management of distribution activities.

The travel information obtained in Table 1 is as follows: Truck Number, Time Stamp, and Fuel Consumptions. This system clarifies the data of fuel consumptions of truck and driving status which enables to acquire the necessary information to grasp CO_2 emissions by the owner.

Moreover, in the case of the route delivery, it is expected that the environmental

impacts allocated to the owners change depending on the round route. Therefore, another information processing should be considered for allocating the fuel consumption by each delivery methods and contracts.

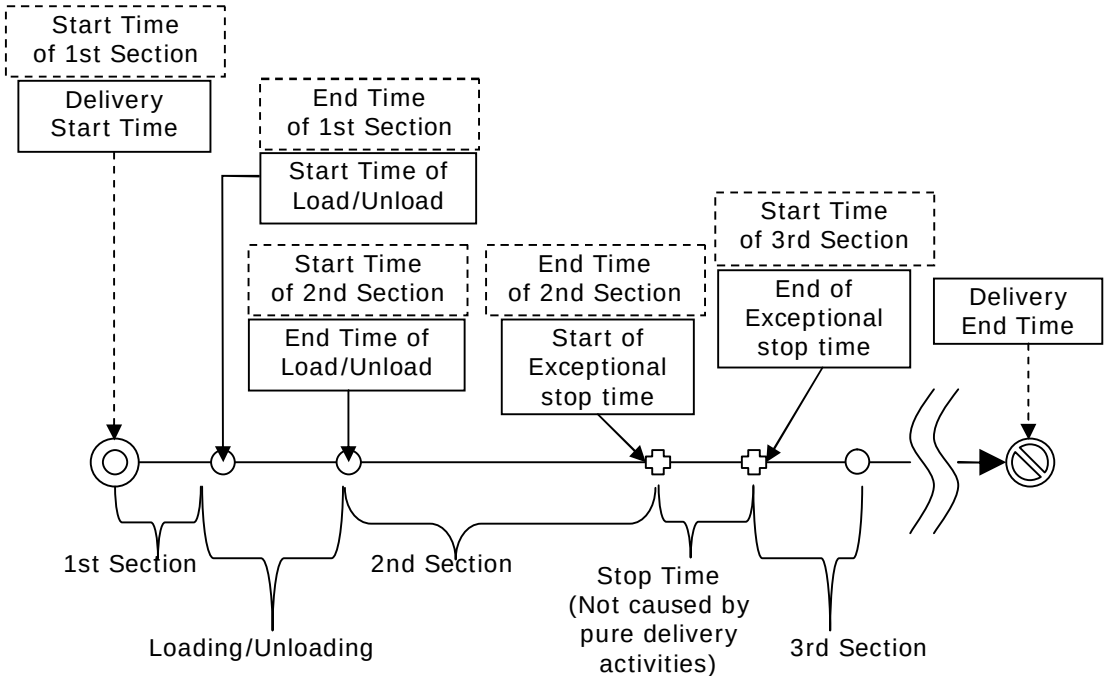

Figure2：Timing to get the data of fuel consumptions of truck and driving status (Case: Direct sending)

Table 1: The list of information that we grasp first

Label	**Explanation**
Truck Number	Identification number of truck
Sequence No.	Sequence No. for calculation
Time Stamp	"yyyy/mm/dd hh:mm:ss"
Event No.	Classification number of each event (start/stop)
Latitude	Latitude (GPS) of loading/unloading point
Longitude	Longitude (GPS) of loading/unloading point
Deliverer ID	Deliverer (Driver)'s ID number
Mileage (km)	Accumulation Mileage delimited by event
Volume of Fuel Consumption	Accumulation fuel consumption delimited by event
Trip ID	ID number allocated each trip on delivery
Section ID	ID number allocated each section on trip

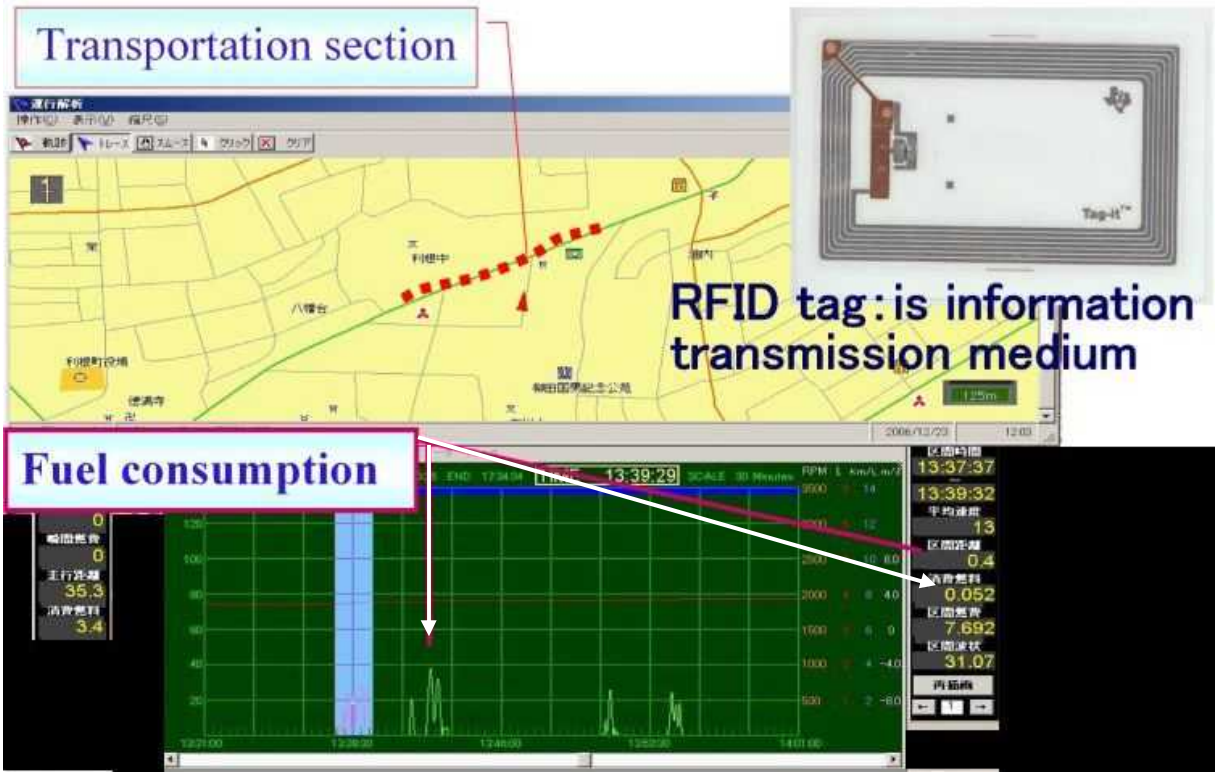

Figure3: Run analysis software (TRU-SAM)

Figure 4: User Interface for Driver

2) "The RFID-Tag information system" to get the data of loads transported by trucks

This system grasps clearly the loading and unloading goods by using RFID-Tag system with IC-Tags and antenna. It works by sticking the RFID-Tag on goods, and setting up an antenna and reader/writer on the vehicle as shown in Figure 5. By reading the owner information and goods ID, each loading/unloading information is grasped in real time according to a timing of loading/unloading. We examine the two types of RFID systems of 950MHz and 2.45GHZ belts. The appropriate frequency belt has to be chosen in consideration of the communication range, its accuracy and other characteristics. By the practical experiments, we'll propose how to choose the optimal frequency belt of the RFID-Tag system in the future.

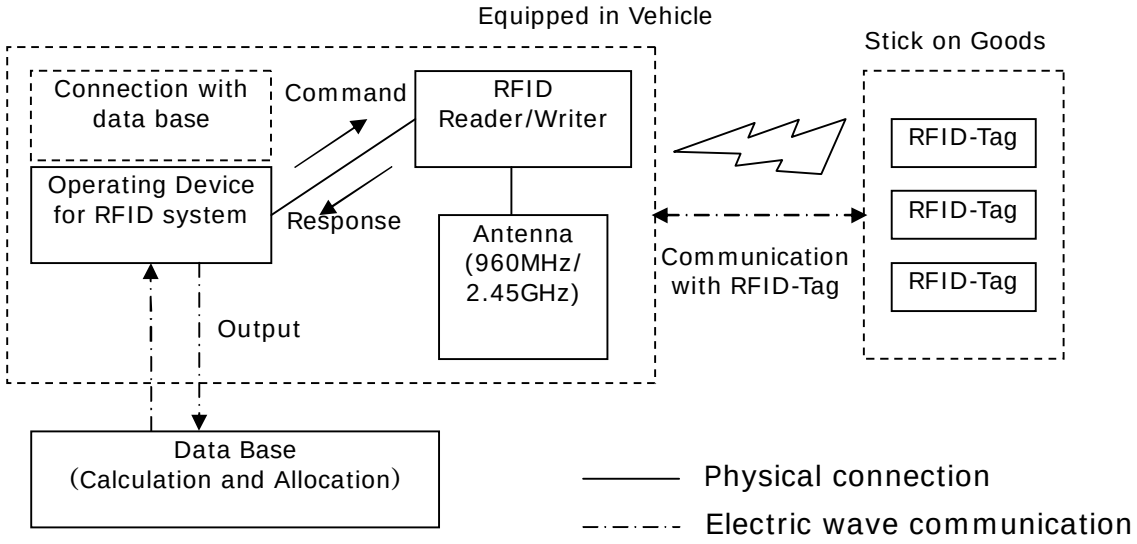

Figure 5: Communication between the data base and RFID-Tag

< Necessary equipment as for one vehicle in this system >

- RFID-Tags (These memory size should be increased or decreased according to the volume of information data)
  The RFID-Tags are stuck on the commodity or each box, and luggage information is recorded (Figure 6). It is necessary to select an appropriate tag based on the use conditions of a surrounding shield, the noise, etc.
- RFID reader and writer: 1 unit
  To send and receive the data with the antenna efficiently, we set the output format and frequency of the measurement.
- RFID antenna (The number of antenna should be increased or decreased by the situation of operation)
  This system is used to communicate with the RFID-Tag. Because there are several frequency bands of Tag-system, it is necessary to select the best one appropriately according to use conditions.
- The equipment for operating this system (for vehicle)
  In the experimentation phase, we use a laptop PC for operating and maintaining this system. However, another information system instead of the PC might be applied in the future condition of the fixed antenna setting and large-scale operation.

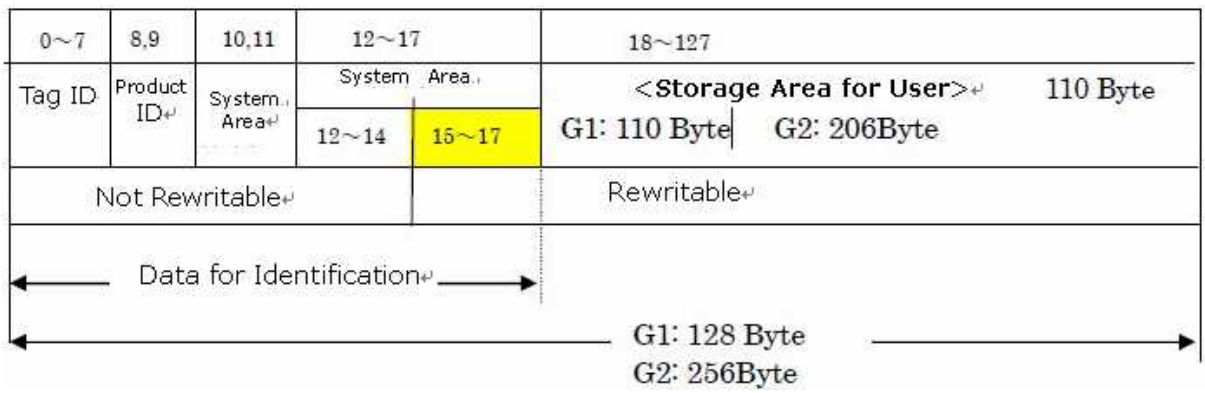

Figure 6: Storage Area in RFID-Tags

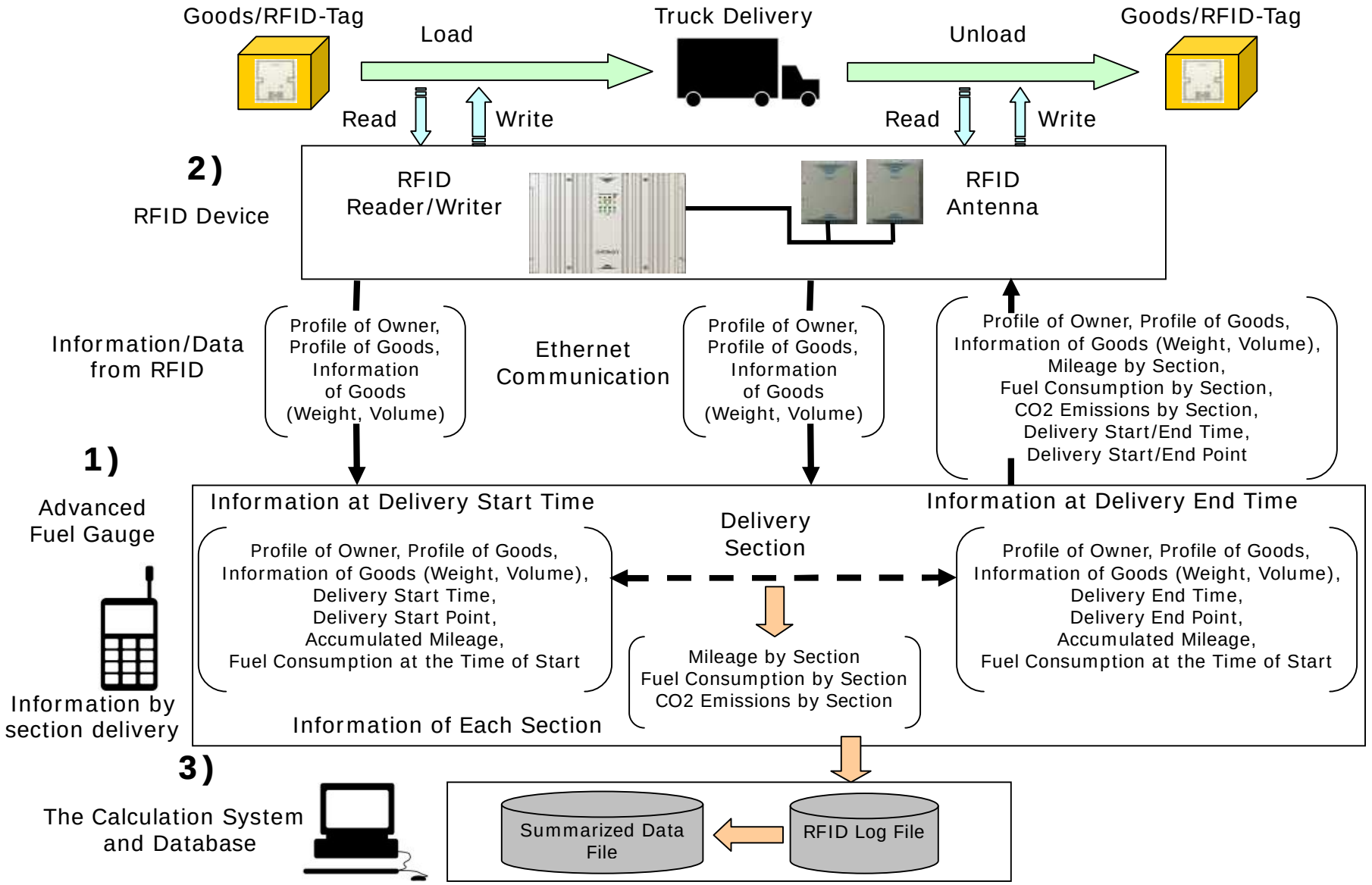

Figure 7: Whole image of this system

3) "The calculation system and database" to unify all information and to allocate CO_2 emissions to owners

Finally, the information from these two systems is integrated. By using the collected information on the database, we allocate the CO_2 emissions to each good by each transportation section in real-time as necessary. Figure 7 shows the whole image of this system. The information system to get the data of fuel consumptions of truck and driving status" and "The RFID-Tag information system to get the data of loads transported by trucks" are connected by the Ethernet communication.

Table 2 shows necessary data at the calculation phase. It means necessity to distinguish the time required for pure running time and other work, and to record in order to share CO_2 emissions to owners.

Table 2: The list of information that we acquire

Label		Explanation
Start Time of delivery		This data is recorded when the delivery starts
Trip ID		ID number allocated each trip of delivery
Start Time of each Section		This data is recorded when deliverer (driver) push the button
End Time of each Section		This data is recorded when deliverer (driver) push the button
Start Time of Loading/ Unloading	Start Time of Loading	This data is recorded when deliverer (driver) push the button
	Start Time of Unloading	
End Time of Loading/ Unloading	End Time of Loading	This data is recorded when deliverer (driver) push the button
	End Time of Unloading	
Start of Exceptional stop time	Start Time of Arrival Time Adjusting	This data is recorded when deliverer (driver) push the button
	Start Time of Rest or Other Action	
End of Exceptional stop time	End Time of Arrival Time Adjusting	This data is recorded when deliverer (driver) push the button
	End Time of Rest or Other Action	
Fuel Consumption Volume In the Section		Fuel consumption data from measuring by using "TRU-SUM"
Section ID		ID number allocated to each section on trip
Mileage in the Section		Mileage data in each section
End Time of Delivery		This data is recorded when the delivery finished

By constructing this system, it enables to grasp information on the amount of the CO_2 emissions and the luggage related to the delivery in real time and understands the amount of CO_2 emissions for each good individually. The ideal system is appropriately switchable to share CO_2 emission according to the difference delivery method such as the route delivery and direct sending.

The volume of CO_2 which is allocated per goods unit is useful information from the viewpoints of both management in transportation activities and marketing strategy by using the information to get the new customers. By using the data of CO_2 emissions for each goods unit, it enables for customers to choose their delivery method from the supplier, i.e., the route delivery and the direct sending by each goods, depending on its environmental loads.

Conclusions

We developed the information modeling that was able to understand the CO_2 emissions caused by distribution activities and its allocations in detail with using the fuel system and the IC tag system. It is shown that the amount of CO_2 emission that each luggage invented was able to be grasped individually by calculating CO_2 emissions in the delivery activities on real time.

This system makes it possible to get the information of CO_2 emissions and loading/unloading automatically, and to allocate its environmental load while the track is running in real time. Since the detailed CO_2 emission data according to delivery of the goods can be grasped, it becomes to be able surely to supply necessary information to shippers or owners.

By this concept proposed in this paper, the information of the CO_2 emissions by each transported good is available to purchasing decision when the customers buy the necessary good based on not only its price but the environmental load. This is the new paradigm in the near future society.

To spread this concept and these fundamental systems in practice, the cost factor of the equipment and operation should also be discussed.

It is a future subject to decrease the cost for equipment, to develop the method to gain the data of companies and goods, and to develop the allocation method of CO_2 emissions automatically according to its delivery method in real time.

Reference

Goto M., Masui T., Kawai N. (2006) “A study on Logistic System with Environmental Efficiency and Economic Effectiveness”, The Proceeding of International Symposium on Logistics 2006, Beijing

Japan Institute of Logistics System-Logistics Environmental Management System (2008.1) “Green Logistics Guide”, in Japan

Ministry of Economy, Trade and Industry (2008.2) “Guidance of data exchange related to amount of CO2 exhaust”, in Japan

Japan Institute of Logistics System General Institute (2007.12) “2007’s Investigation annual report”, in Japan

Energy Conservation Center Japan (2006.1) “Manual for revision Law Concerning Rational Use of Energy”, in Japan