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Monitoring System Using GPS for Logistic's Key Performance Indicator

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ABSTRACT

Transportation vendors are important for distribution companies to deliver goods or products. Operational problems of logistic process in transportation vendors' activities are difficult to track and monitor directly in the field, such as driver's position, the delivery, and so forth. These problems result in the difficulty to measure the performance of vendors' activities. The aim of this research is to develop a system which covers monitoring and tracking of their logistic process operation problems. The system is built based on Android integrated with GPS and GSM. This system is also equipped with the ability to recapitulate the performance of transportation vendors in running activities of logistic operation. The performance is measured from some important components in logistic process. They are task asssment, on-time delivery, completed administration and availabilty. The result of this system is capable to show the vendor transportation's key performance indicator (KPI) and minimalize bureaucratic problems.

1. Introduction

The rapid growth of information technology has brought many changes to various business aspects, including logistics. Modern technologies such as GPS (Global Positioning System) and RFID (Radio Frequency Identification) can be used to change semi-manual process to systematic process [1]-[3]. Implementation of these technologies in logistic business sector enhances the performance of logistic process operation [4]. A survey shows that logistic company needs transparency in logistic process operation and more security [5]. GPS (Global Positioning System) is currently the most promising technology for acquiring position information in a field [6]-[9].

Manufacturers that process raw materials into ready-to-use product need logistic to transport their goods to other factories or their suppliers. Then, logistic operations provide transportation service of goods to desired locations (customer included) or warehousing. There are companies which keep their logistic function is part of the companies operation/business process and others keep their logistic function by using vendor transporters (outsourcing logistic) [10]-[12]. Both of them have advantages and disadvantages. Outsourcing logistic function has a high risk of loss competencies which may lead to high cost [13], 14] and hard to monitor their operation and management. Many researches look into logistic function outsource issues but few addressed so far about in-house logistic provider issues [10], [15], [16].

KPI (key performance indicator) in logistic business sector is mainly used to measure and show gaps between fundamental logistic process while delivering goods and the expected performance proposed by the company [17], [18]. Real-time data play a crucial part in this case, because obtaining information and giving feedback to correspondents can be done more quickly (between operators and courier). Implementation of websocket may help achieve that, because its behavior provides full-duplex, communication channel that operates through a single connection which builds scalable and real-time application [19] .

We found empirical findings based on some cases in company. However, in this paper, a cement company, PT. XYZ, is used as a reference. This company uses outsourcing logistic function (vendor transporter). It is facing some issues, such as the incapability of the to complete given assignments, goods not delivered on time, incomplete documents, and availability of fleet difficult to maintain and ready to use. This study proposes a new approach to implementing fleet-management and vendor performance evaluation (KPI). Monitoring application based on node.js platform and android as its client is implemented in this case. It is expected to minimize the risk of outsourcing its logistic provider such as monitoring transporter movement and recording the whole trip data, which is later used to evaluate the transporter's

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performance in doing logistic functions, and capable to evaluate vendor transporter KPI.

The study provides a system of performance for companies which use logistic transporters based on tour records of their drivers. This system is built based on four indicators obtained from the activities of the drivers.

2. Proposed Method

The proposed method is mainly aimed to identify the criteria which should be considered in vendor transporter work performance (KPI) evaluation aspect. We include relevant KPI aspects such as task assignment, manageable delivery time, completed administration and fleet availability management and its system design to achieve related aspects.

2.1. System design

Many technique designs are proposed to develop the system. Figure 1 indicates the scheme of our framework to implement monitoring logistic operation system, which is integrated with GPS (global positioning system) to monitor fleet movement in an on-going delivery process. By using device (smartphone) on each transporter, a real-time communication between transporter and head officer (HO) can be done. It look like using emitting data transaction through websocket [20]. It is to achieve full-duplex communication between client and server.

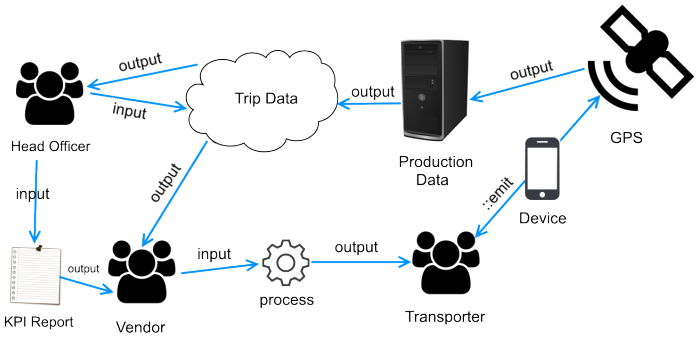

Figure 1: Proposed framework scheme

Three main actors in logistic function operation, which are HO (head officer), vendor transporter, and transporter (driver), are involved in the evaluation of vendor transporter KPI. Internal staff as head officer handles all data transactions between headquarter (HQ) and client (in this case vendor transporter and driver). The design steps can be described as follows. First, head officer input the required trip data (task assignment) which will be assigned to selected vendor. Then, it is processed by vendor and given to transporter (driver). All activities recorded in application device is bundled into one production data including the history of transporter position using GPS emitted from the device. It becomes an output to trip data history. Then, the trip data will be processed by head officer to assess or evaluate KPI of vendor transporter within each evaluation period time.

There are some steps to develop real-time monitoring and tracking system.

Business Requirement Analysis. This phase gathers information regarding business process from process business by interview with related job description required to obtain the requirements.

User Requirement Analysis. This phase is to obtain information from process owner regarding the new proposed model.

Evaluation analysis. Based on requirements analysis, the best method is chosen and transformed into suitable aspects evaluation.

Prototyping. This step is conducted in the architectural design and development of products or services. In this case, the requirements are transformed into an application to understand the system method or concepts.

Implementation. In this phase, the new proposed method is implemented which is customized based on existing business model and solving the current problem.

Reporting (Documentation). Reporting or documentation is taken to track which parts of model is proven to be successful or failed as the solution of the problems.

2.2. The Interview

One of the techniques to obtain information and data in this research is using interview [21]. The discussion of process logistic and performance is done with all stakeholders related to the KPI. Some questions used are listed below.

1. What is the SOP (standard operational procedure) of logistic function in your company?
2. What issues are faced by your company with the current SOP?
3. How can the master data be obtained?
4. What is going to happen if customers reject the delivery?
5. What is going to happen if fleets or vehicles get trouble on delivery?
6. Can vendor reject delivery orders?
7. Can transporter vendor track their driver on their own or only based on your company's monitoring function?
8. What is the expectation of this proposed system?
9. What is the KPI aspect you want to evaluate?

Table 1: KPI aspect evaluation

Aspects	Description	Grade
Task assignment (TA)	Vendor capable to complete given DO	25%
On-Time Delivery (OTD)	Vendor capable to deliver goods on-time	25%
Completed Administration (CA)	Vendor capable to submit` required document	25%
Availability (A)	Vendor capable to make fleet ready in use (delivery order given)	25%
Total		100%

2.3. KPI Evaluation

The proposed system is developed based on vendor transporter's KPI assessment. This KPI evaluation is important for PT. XYZ to make decisions whether to continue outsourcing the

logistic with selected vendor or terminate the vendor and replace with a new one. The discussions and interviews were conducted by the authors with relevant parties to formulate KPI. As the results, there are four aspects as shown in Table 1. These aspects are formulated to evaluate KPI based on user requirements and the issues of outsourcing logistic functions. The four aspects have the same percentage because they are considered as having the same importance.

The four aspects on Table 1 are built based on the variables as shown in Eq (1), Eq. (2), Eq. (3) and Eq.(4).

Task Assignment (TA). Variable TA is derived from assignment (delivery order) completed by vendor divided by total assignment given per evaluation period as shown Eq. (1).

$$TA = \frac{\begin{matrix}Completed\ assignment \\ (per\ evaluation\ period)\end{matrix}}{Total\ assignment\ (per\ evaluation\ period)} x100 \quad (1)$$

On-Time Delivery Target (OTD). Variable OTD is derived from completed delivery expectation (by customer) divided by total assignment given per evaluation period as shown Eq. (2).

$$OTD = \frac{\begin{matrix}Completed\ delivery\ expectation \\ (per\ evaluation\ period)\end{matrix}}{\begin{matrix}Total\ assignment \\ (per\ evaluation\ period)\end{matrix}} x100 \quad (2)$$

Completed Administration (CA). Variable CA is derived from vendor capability to submit required document or return document to PT. XYZ as shown Eq. (3).

$$CA = \frac{\begin{matrix}Returned\ administration \\ (per\ evaluation\ period)\end{matrix}}{Total\ assignment\ (per\ evaluation\ period)} x100 \quad (3)$$

Availability (A). Variable A is derived from total accepted assignment or delivery order given by internal staff of PT. XYZ, and vendor must provide fleet based on contract while outsourcing permission as shown Eq. (4).

$$A = \frac{\begin{matrix}Total\ accepted\ assignment \\ (per\ evaluation\ period)\end{matrix}}{\begin{matrix}Total\ contracted\ unit \\ (per\ evaluation\ period)\end{matrix}} x100 \quad (4)$$

3. Results and Discussion

In the requirement analysis phase, user is able to set up fleet profile, fleet type, license number, and owner of the fleet. He / she can set up feature of transporter data registered under the vendor. Some features can be developed such as the capability to monitor and track location which allows user to use navigation to the destination place noted in delivery note document with Google Maps, delivery order allocation which allows user to set up delivery order dynamically and specifically, the function of Auto-Grab which allows user to grab delivery order along the way in specific radius near loading plant point, the function of Auto-Rejected when the transporter gets limit to order capacity per day, and emergency feature which allows transporter and operator (head officer) to communicate through application message system real-time (using websocket).

Figure 2 shows the proposed business process in logistic operation. The process starts with creating delivery order, then HO determines maps of transporter routes. After mapping transporter routes, driver will confirm the given task to accept or reject delivery order (DO). If transporter accepts the DO, he / she gets delivery number (usually called delivery note). After the transporter has the route, then it will be sent to customer. Once customer accepts the order, then customer will sign receipt document. However, if the customer rejects, the document will be returned back to HO.

Figure 3 shows the flow of the proposed system that can be adjusted dynamically to the defined KPI aspects. It is based on empirical findings in manufacture or company which outsources their logistic provider. There are four main data characteristics flow as: User request report, in which users will request through HTTP to get the report; in this case, the calculation is done in four aspects of KPI previously mentioned. Next is collect data, which is the data source from the delivery process or operational logistics processes that have been running. Data is stored on a local database that is directly integrated with the system and the database residing on the ERP system. The next is data processing, in which data obtained either through the ERP or local database provisioned in the development of this application is processed through back-end. This request will end to the user in the form of report. After getting the result, reports that have been processed will be displayed on the application interface to be viewed by the user who performs data request to be used as consideration or decision making from the user. Figure 4, Figure 5, Figure 6, Figure 7, and figure 8 show the KPI result report based on selected aspect and period. The proposed KPI calculates the overall KPI grade or score based on recorded activity data done in evaluation period time which include task assignment, on-time delivery target, completed administration and availability. The formula of the overall KPI is shown in Eq. (5).

$$\text{KPI} = \frac{TA+OTD+CA+A}{4} \quad (5)$$

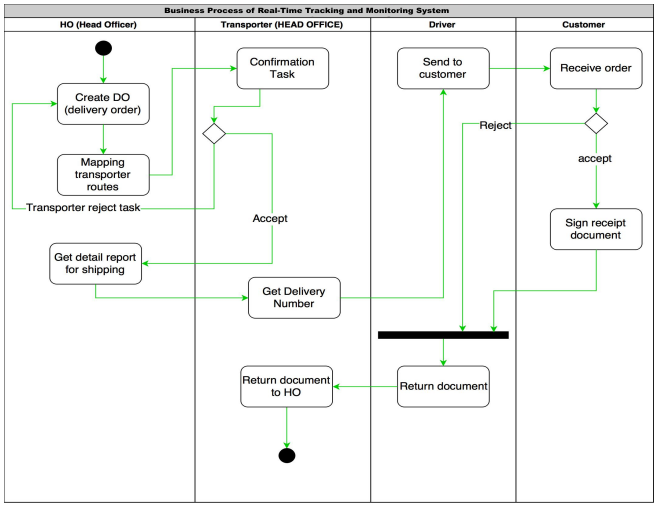

Figure 2: Proposed business process in manufacturer

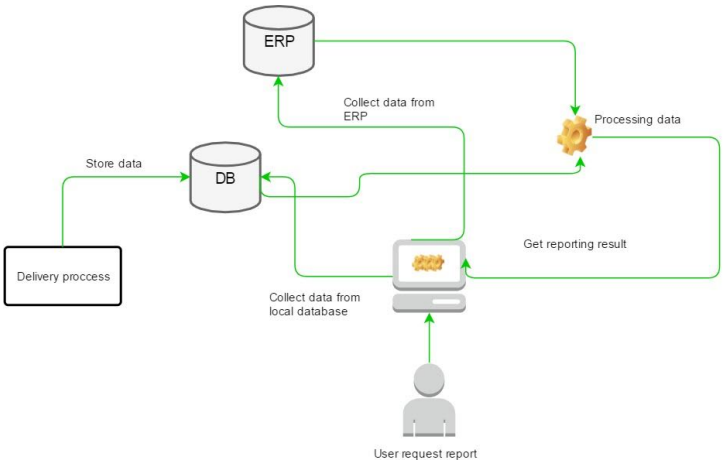

Figure 3: Flow system to evaluate KPI based on defined aspects

The Eq. (5) is calculated is based on Eq. (1), Eq.(2), Eq.(3) and Eq.(4). The result of Eq. (1) is be shown in Figure.4

nama_vendor	total_assignment	completed_assignment	TA
ANDALAN NUSA PR	43	38	88.37
BHANDA CILEGON	33	27	81.82
LINTAS JAWAMAS	19	12	63.16
MAGA NIAGA	22	15	68.18
SINAR PUTRA	15	9	60.00
LIVINA MULYA ABADI	7	6	85.71
TRI KUSUMA JAYA PERKASA, PT	27	25	92.59
TRANSINDO TRANSPORTASI BAHARI, PT	3	3	100.00

Figure 4 the sample data of task assignment

nama_vendor	total_assignment	on_time_delivery	OTD
ANDALAN NUSA PR	43	10	23.26
BHANDA CILEGON	33	5	15.15
LINTAS JAWAMAS	19	8	42.11
MAGA NIAGA	22	4	18.18
SINAR PUTRA	15	7	46.67
LIVINA MULYA ABADI	7	0	0.00
TRI KUSUMA JAYA PERKASA, PT	27	17	62.96
TRANSINDO TRANSPORTASI BAHARI, PT	3	0	0.00

Figure 5 the sample data of On-Time Delivery Target.

The result of Eq. (3) can be shown on Figure 6

nama_vendor	total_assignment	return_dn	CA
ANDALAN NUSA PR	43	26	60
BHANDA CILEGON	33	18	55
LINTAS JAWAMAS	19	6	32
MAGA NIAGA	22	7	32
SINAR PUTRA	15	3	20
LIVINA MULYA ABADI	7	0	0
TRI KUSUMA JAYA PERKASA, PT	27	16	59
TRANSINDO TRANSPORTASI BAHARI, PT	3	1	33

Figure 6 the sample data of completed administration

The result of Eq. (4) can be shown on Figure 7

nama_vendor	total_assignment	avail_unit	AVG_unit_per_day	A
ANDALAN NUSA PR	43	50	1	98.00
BHANDA CILEGON	33	20	1	95.00
LINTAS JAWAMAS	19	10	1	90.00
MAGA NIAGA	22	10	1	90.00
SINAR PUTRA	15	10	1	90.00
LIVINA MULYA ABADI	7	5	0	100.00
TRI KUSUMA JAYA PERKASA, PT	27	20	1	95.00
TRANSINDO TRANSPORTASI BAHARI, PT	3	5	0	100.00

Figure 7 the sample data of availability.

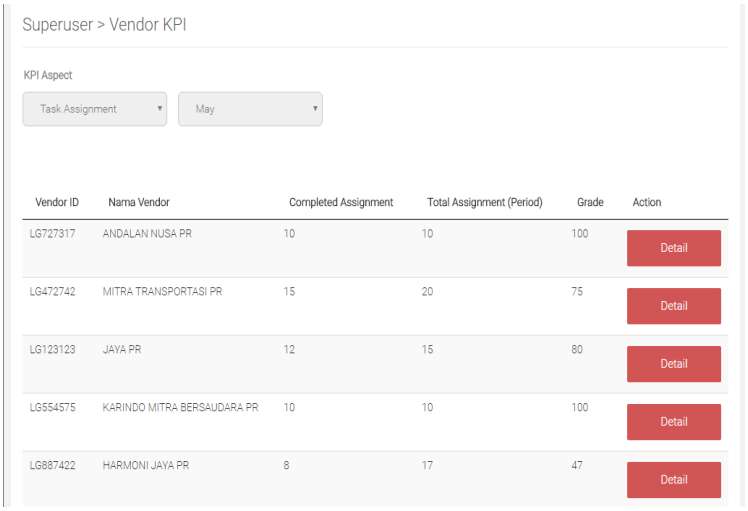

Figure.8: KPI result report

Device ID	UUID	Timestamp	Created at	Lat	Lng	Accuracy	Activity	Battery
125c663531f37f55	67bd3ad48e70	09/14, 14:20:35:1	09/14, 14:20:42:0	45.519408	-73.6168163	13	still (100%)	-
125c663531f37f55	d7801330e1e6	09/14, 14:18:37:3	09/14, 14:20:41:8	45.5192516	-73.6168692	15	on_foot (62%)	96%
125c663531f37f55	07ad5111b499	09/14, 14:18:06:4	09/14, 14:20:41:8	45.5195434	-73.6163816	10	on_foot (100%)	96%
125c663531f37f55	e725aa24facc	09/14, 14:17:36:4	09/14, 14:20:41:8	45.5199382	-73.6159686	8	on_foot (100%)	96%
125c663531f37f55	c93c526ebd10	09/14, 14:17:01:4	09/14, 14:20:41:8	45.5203738	-73.6156441	6	on_foot (85%)	96%
125c663531f37f55	8c9dfc3943e5	09/14, 14:15:26:1	09/14, 14:20:41:8	45.5203253	-73.6149459	4	on_foot (85%)	96%
125c663531f37f55	c2845c8a8c4d	09/14, 14:14:56:1	09/14, 14:20:41:8	45.5201631	-73.6143485	4	on_foot (92%)	96%
125c663531f37f55	433cf408c55c	09/14, 14:14:26:1	09/14, 14:20:41:8	45.5198925	-73.6137712	5	on_foot (100%)	96%
125c663531f37f55	8ba00060edf3	09/14, 14:13:56:1	09/14, 14:20:41:8	45.5195956	-73.6131462	5	on_foot (92%)	96%
125c663531f37f55	000b7ea0eb48	09/14, 14:13:21:4	09/14, 14:20:41:8	45.5193214	-73.6125308	4	on_foot (100%)	96%
125c663531f37f55	bf32cec0875f	09/14, 14:12:51:4	09/14, 14:20:41:8	45.5190425	-73.6119658	4	on_foot (85%)	96%
125c663531f37f55	8925a0ae53f0	09/14, 14:12:26:1	09/14, 14:20:41:8	45.5188121	-73.6113978	4	on_foot (100%)	96%
125c663531f37f55	4c4822d1a3ba	09/14, 14:11:41:0	09/14, 14:20:41:8	45.5184887	-73.6105816	6	on_foot (69%)	96%
125c663531f37f55	b2035adf5139	09/14, 14:11:16:0	09/14, 14:20:41:7	45.5182135	-73.6100563	8	on_foot (100%)	96%
125c663531f37f55	a08cba638951	09/14, 14:10:46:0	09/14, 14:20:41:8	45.5179428	-73.6095	4	on_foot (85%)	97%
125c663531f37f55	6f0d4e04e47e	09/14, 14:10:16:0	09/14, 14:20:41:7	45.517664	-73.6088969	4	on_foot (100%)	97%
125c663531f37f55	29e654415bd7	09/14, 14:09:41:0	09/14, 14:20:44:4	45.5173972	-73.6082512	5	on_foot (100%)	97%
125c663531f37f55	8a775a52c79e	09/14, 14:09:11:0	09/14, 14:20:44:4	45.517105	-73.6077112	6	on_foot (69%)	97%
125c663531f37f55	9ca51cfce82f	09/14, 14:08:31:0	09/14, 14:20:44:4	45.516966	-73.6070105	10	on_foot (100%)	97%
125c663531f37f55	d52e50b493e0	09/14, 14:08:01:0	09/14, 14:20:44:3	45.5173395	-73.6066499	4	on_foot (100%)	97%
125c663531f37f55	e2392ccbd3fe	09/14, 14:07:24:5	09/14, 14:20:44:4	45.5177335	-73.6061499	20	on_foot (92%)	97%
125c663531f37f55	92e704c3cdb0	09/14, 14:06:44:4	09/14, 14:20:44:3	45.518188	-73.6057685	16	on_foot (100%)	97%

Figure 9: Monitoring data sample

This system uses the plugin cordova background geolocation to monitor and track module for implementing the system as shown in Figure 9 [22]. It logs all the required data to monitor transporter movements, such as device id, uuid, timestamp, latitude, longitude, accuracy, and activity (on_foot or stay still). Figure 10 shows the GPS (global positioning system) or GNSS (Global navigation satellite system) which allows users to

determine location (geo positioning) from satellite signal reception [23]. As table 2 indicates, the authors performed the trial using the proposed system in transporter while doing delivery. Trial done on Oct 2019 shows fleet movement with registered trip ID and recorded date of trial This system has a unique system which makes the process efficient and transparent. This system is also very useful for company PT XYZ for monitoring the drivers' activities. It can alsorate the transportation vendor. This system is able to evaluate the KPI of transportation vendor at PT. XYZ, which is influential in decision-making for contract extension between transportation vendors and PT. XYZ.

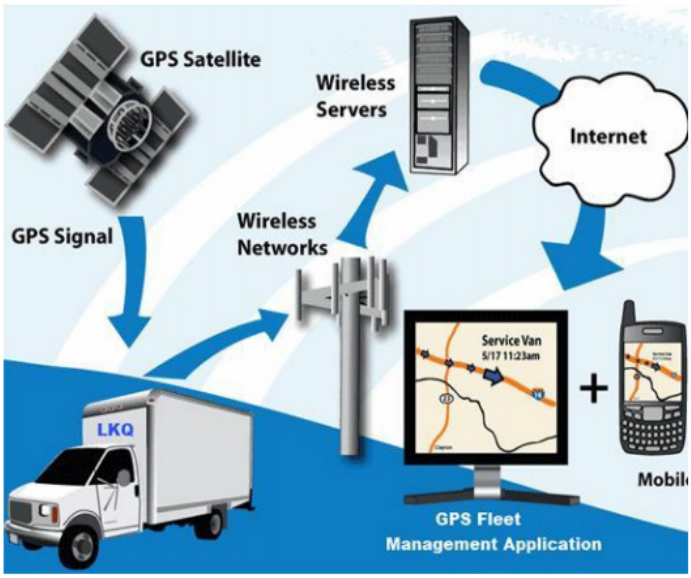

Figure 10: Monitoring process of logistic function

Table 2: Data sample result using monitoring system on transporter fleet

ID	ID Trip	LatLong	Date
SS998710-1570547100000	J21023	51.219243, 4.416459	10/9/2019 19:44
SS998710-1570547555000	J21023	51.218571, 4.422290	10/9/2019 19:49
SS998710-1570547865000	J21023	51.218100, 4.425086	10/9/2019 19:55
SS998710-1570548235000	J21023	51.215775, 4.431201	10/9/2019 20:01
SS998710-1570548502000	J21023	51.213819, 4.441723	10/9/2019 20:07
SS998710-1570548851000	J21023	51.213522, 4.445634	10/9/2019 19:44
SS998710-1570633500000	J21023	51.218243, 4.414238	10/10/2019 17:05
SS998710-1570633955000	J21023	51.219722, 4.415869	10/10/2019 17:12
SS998710-1570634265000	J21023	51.220797, 4.418186	10/10/2019 17:17
SS998710-1570634635000	J21023	51.224990, 4.417028	10/10/2019 17:23
SS998710-1570634902000	J21023	51.226182, 4.417764	10/10/2019 17:28
SS998710-1570635251000	J21023	51.229251, 4.420281	10/10/2019 17:34
SS998710-1570636124000	J21023	51.230112, 4.422311	10/10/2019 17:48
SS998710-1570636415000	J21023	51.230079, 4.426176	10/10/2019 17:53
SS998710-1570636696000	J21023	51.230818, 4.430296	10/10/2019 17:58
SS998710-1570826559118	J243354	51.230991, 4.429542	10/11/2019 08:24
SS998710-1570826561121	J243354	51.229908, 4.429128	10/11/2019 08:32
SS998710-1570826562122	J243354	51.229641, 4.426468	10/11/2019 08:37
SS998710-1570826563120	J243354	51.230152, 4.424990	10/11/2019 08:45
SS998710-1570826564121	J243354	51.229244, 4.424197	10/11/2019 08:50
SS998710-1570826565121	J243354	51.228151, 4.423330	10/11/2019 09:02
SS998710-1570826566118	J243354	51.228791, 4.421419	10/11/2019 09:07
SS998710-1570826567121	J243354	51.229881, 4.420538	10/11/2019 09:12

4. Conclusion

This paper has presented a new approach based on empirical findings and trial in a cement manufacturer outsourcing logistic service. KPI evaluation based on real-time data monitoring is important to determine transporter performance and solution to the issues by outsourcing logistic process function.

This approach will be applied to studies of t logistic business process resulting in KPI evaluation.

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