Transportation System Design for Transporting Heavy and Oversize Goods

การออกแบบระบบขนส่งสำหรับการขนส่งสินค้าที่มีน้ำหนักและขนาดใหญ่

Wanpen Pengsomboon[1], Sichai Thanawasien[1] and Aekavute Sujarae[1]

วันเพ็ญ เพ็งสมบูรณ์[1], สุชาย ธนวเสถียร[1] และเอกวุฒิ สุจเร[1]

[1]Information Technology, Faculty of Science and Technology, Shinawatra University

[1]คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยชินวัตร

Received: January 7, 2019

Revised: April 17, 2019

Accepted: April 19, 2019

Abstract

The transportation of heavy and oversized shipment, e.g. 100 tons or more, from the factory to the final destination can be a complicated task which involves a lot of planning, transporting, unloading and installing processes. One example is transporting power transformers. This research developed a new end-to-end logistics management algorithm, supporting the transportation of heavy and oversized shipments in the context of timing, location of personnel, communication and the regulations involved from the process of preparation, real-time management to the installation at the destination. This logistic management system helps to reduce the mistakes in the preparation of all the procedures involved. The process of planning includes the monitoring the main routes, accidents, natural disasters, traffic conditions, theft along the route, and coordination between the point of origin and destination. In the event that the unforeseeable circumstances occurred, secondary routes will be taken. The context will provide useful information for the shipper in decision making whether to use the original or secondary routes; and once the shipment has reached the destination, the business regulations involved during the inspection, the process of unloading shipments, the storage and the supervision of installation process according to the company standards will also be undertaken

Keywords: power transformer, transportation, logistics management system, heavy goods and oversize

บทคัดย่อ

การขนส่งสินค้าขนาดหนักและใหญ่กว่าปกติ เช่น หม้อแปลงไฟฟ้าขนาด 100 ตันจากต้นทางไปยังจุดหมายปลายทาง เป็นกิจกรรมที่มีความซับซ้อนและต้องมีการวางแผนการดำเนินงาน ในบทความนี้ได้เสนอการวิจัยถึงระบบงานการขนสินค้าขนาดหนักและใหญ่กว่าปกติ และข้อมูลบริบทเชิงเวลา สถานที่ บุคคล สารสนเทศ และกฎทางธุรกิจในการดำเนินงานตั้งแต่การเตรียมการขนส่ง การบริหารจัดการอย่าง Real-time ในระหว่างการขนส่งและการติดตั้ง ณ จุดหมายปลายทาง ระบบบริหารจัดการการขนส่งนี้ช่วยลดข้อผิดพลาดในระยะเตรียมงานเพราะมีการนำบริบทอันเกิดจากกฎธุรกิจมาใช้ในการกำกับดูแลว่าทุกกระบวนการขั้นตอนที่ถูกต้องได้ดำเนินการแล้วในระหว่างการเดินทาง ก็มีการมอนิเตอร์ข้อมูลของเส้นทางหลัก ที่เดินทางทางอยู่ ในเรื่องอุบัติเหตุ ภัยธรรมชาติ สภาพจราจร มิจฉาชีพ และการประสานงานกับฝ่ายต้นทางและปลายทาง ในกรณีที่มีสิ่งไม่คาดคิดเกิดขึ้น เส้นทางที่ใช้จะมีเส้นทางสำรองไว้แล้ว ซึ่งข้อมูลบริบทต่าง ๆ จะช่วยให้คณะผู้ขนสินค้า สามารถตัดสินใจว่าจะเดินทางต่อด้วย เส้นทางเดิมหรือใช้เส้นทางสำรอง เมื่อถึงจุดหมายปลายทางส่วนบริบทกฎทางธุรกิจก็จะเข้ามาตรวจสอบ ขั้นตอนขนสินค้าลงจากรถ และจัดเก็บในสถานที่จัดเตรียมไว้ว่า สามารถทำได้อย่างเหมาะสม

คำสำคัญ: หม้อแปลงไฟฟ้ากำลัง, การขนส่ง, การติดตั้ง, สินค้าขนาดหนักและใหญ่

Introduction

Transportation of goods in the supply chain cycle is a topic that is gaining momentum among the fields of industry and education, especially when its cost could reach up to 30%. Major challenges of logistic are time sensitivity, safety, ensuring that goods will timely reach destinations, and containing risks of public exposure to both hazardous materials and oversized shipments in the case of accidents.

Heavy and oversized shipment, whether via roads, rails, or maritime, has been a significant concern of the U.S. and European nations. However, research that addresses the notion is scarce, as most of the studies are focused on the practicality of procedures , which is often ambiguous. The entire process solely accounts the physical execution.

Thus, the conditions include specific contexts and capture of context-related information by event-driven sensors (Jocub as cited in Shaki Kundee et al., 2017) 's research in the Logistical field, data acquisition is performed by a software agent that automated data capture from installed sensors in the system. Finite State Machine was also another data capture method used for data gathering (Dong, 2004).

Nevertheless, significant sensors in logistics include RFID, GPS, and various level sensors such as humidity, gas leak, flood, pressure sensor, etc.

Research Objective

This research examined transportation of heavy and oversized shipment - an over 100-ton transformer-with hydraulic trailers .

Recent major challenges of transporting 100 tons transformers:

1. Communications issues between senders and recipients, specifically coordination and ITSG. Also, the preparation of space that requires continuous adjustments due to the ambiguity of official regulations.

2. End-to-End Visibility issuethroughout the entire route, as drivers lack real-time information on road conditions and other occurrences throughout the transport route. This issue impedes response time resulting in incapability to resolve issues

3. Business legal issues in transport preparation not automated and monitored by the system, potentially causing controversies and error.

Research Framework

Implementation of solutions to transportation of heavy and large shipment requires not only general transport information but also context data (Ian, 2005). According to Dey context is defined as information that indicates a state of an entity or object of interest-which can be persons, places, objects involving in interactions between users and applications that are compliant with relevant business laws.

Therefore, the condition consists of context data and context-based data capture. This research utilized the following context-based data: (1) RFID and GPS data (2) Online Infor-Sensor data (3) Timing (4) Business Regulation.

Incorporating business rules and process into the context enables the creation of an algorithm to dictate the process of excess weight shipment from the origin to destination, while ensuring safety and punctual delivery. Information technology can be used to improve the work process in the supply chain within and between the organizations. By using the available information and network of high-speed information so that the company can share the supply chain management information in all level and positions. The success of the operation is to be able to use the technology effectively and in the information technology, the business regulations applies and other regulations and be a set manual work.

In studying the Logistic management, it will focus on the studies of business regulations within the supply chain. By looking at the usage that affected the efficiency of Logistic operation; choosing to observe the land transport as an example of business operation and operating context from the delivery using information technology to control all related persons e.g.drivers, and related things e.g. containers, vehicles, or location e.g. route, and final destination and time e.g. delivery time. These environmental information can be used to create business advantage in information technology by speed control, accuracy and safety. This is due to the management system that has good business regulations and respond well to the changes in context and events.

Literature Reviews

The literature review contains an overview of previous logistics and supply chain studies. Antonio Bucchiarone and applied and utilized logistics and supply chain technique to approach logistical issues involving in transporting cars from a port to car dealers. The transportation process consists of unloading cars from cargo ships, accessorizing cars according to demands, and transporting cars to dealers.

Antonio et al., (2011)'s results suggested the use of dynamic adaptation to addresses inadvertently arising contexts. This approach relies on adapting, enabling the system to regulate any unplanned situation. For example, damages on the transporting truck while heading to a storage facility would automatically initialize a reparation process before finally going to a storage facility.

The application of fleet management in agricultural practices suggested that actual implementation of context-awareness-using data captured from context-based machinery interacting with remote machinery users-was not executed (sorensen). Thus, contextual data of the running machinery and its locations would be beneficial, enabling farmers to manage their work process. Similarly, contextual data ensures that the maintenance schedule is carried out.

The context-based data on maintenance is crucial to reducing machinery down time, increasing the effectiveness of the process, and ultimately reducing business loss.

Bartiomiej and Anne (2009) stated that improving the effectiveness of supply chain management is dependent on the cooperation of IT department and company flexibility to adapt to system changes. Business rule management fosters company dynamics that enables it to acclimate to unpredictable climates, while a business process management system provides structure for step-by-step process management.

This research leveraged the process overview to model the research by integrating the two factors, using BPM that corresponded to xPDL.

Antionio et al., (2010) found a method that transforms business rules embedded in the process by constantly molding them according to contexts in real-time events, in order to achieve the objective. This method calls for new planning and execution as contexts change. The notion has been proven in a logistical model.

In a transportation system, since content disclosure may be required, information plays a significant role in the development of supply chain. Wesseis and Lang developed an intelligent system that functions together with its context-ensuring compliance to business regulatory, providing an effective structure, and enabling users to pinpoint exactly where the transport is in the supply chain. Data directly collected from various storage devices were fed into the logistic system for it to classify cargo related contexts.

The implementation of RFID technology using UHF frequency permitted data reading from a container from 3 meters away. FRID distantly captured environmental contexts into the supply chain system to integrate business rules in real-life contexts. It ultimately adjusted the supply chain process to fit the context. Logistics in the automotive business regularly undergo serious issues due to supply chain mismanagement. Using a conventional approach while the ever-evolving situation calls for context-aware system results in monumental business loss.

Zachos, Kounkou and Maiden (2013) presented a development of task model-based application for management. This research developed a user-task model, gearing for the variety of its application. Searching for the most suitable approach to be used was the responsibility of EDDIE system-which provided services for user task. . This research considered parameters for creating questions in order to find a service from assigned tasks. Therefore, the adaptation system facilitated continuous work progress as contexts changed under the basis of change mechanism to help users reach the objective.

Associated with transporting heavyweight and oversized cargo is the risk. There are technical risk, economical risk, social risk, an political risk. Palsaitis.R. and Petraska A. has proposed a risk management model for planning phase of sale transportation and then are traffic accidents, natural disasters and animals, security in highway. It is desirable to find routes that minimize the risk, Babu et.al.,(2016) has proposed a heuristic risk management system to obtain multi-optimal routes for transportation.

Materials and Methods

Process of transporting heavy transformers

Transportation of heavy transformers of up to 100 ton and 3M×5xM×3.5M dimension requires preparation: parts need to be disassembled and stored in containers, route survey, and site preparation for assembling heavy machinery. Mainly, there are 14 following steps:

Table 1

Process of transporting heavy transformers

After informed by the production department that the transformer passes inspection		
1. Check documents in the system	-Drawing TFO -Drawing for Transportation -Customer's site map -Customer's Contact person -Date of Delivery at Site	If not contact project manager.
2. Contact assembly team for disassembling transformer parts	3-5 days	Working time depends on the size of the transformer
3. Notify the packaging team for measurement	3-5 days	Working time depends on the size of the transformer
4. Ready transport vehicle and check if transformer oil is shipped together with transformer	-Choose vehicle according to transformer weight and size -If yes, check with oil factory in Samut Sakorn	Check the comparison chart regarding Modular Hydrolic/Trailer/ Flat bed
5. Ask customers for readiness of delivery site	Schedule dates for Site Survey	

Table 1 (continue)

After informed by the production department that the transformer passes inspection		
5. Ask customers for readiness of delivery site	Schedule dates for Site Survey	Prepare vehicle for transport Cameras Measurement tapes Camera for image-based measurement of the height between a road and the overpass or signage
6 Site Survey from origin to destination	Check for bad road condition and signage	
7. Inspection of destination site	-Readiness of platform for transformer -Area surrounding the platform, especially area for jacking and skidding -If pipes are laid in front of the platform and a crane is required for transportation -Road condition within the site and its available space to accommodate turning radius	Go through a checklist: If the ground is unable to withstand heavy weight, prepare a metal plate to place in front; Pay for the crane; Check transformer weight and placement-requires communication with a customer as manhandling has higher cost than jacking and skidding; contingency plan for alternative routes
Detail inquiry	-Direction in which transformer is facing space for wiring -Mark the spot for transformer -Placement area -Storage for parts and oil	
8.Fix marked errors during the survey		
9. Check the readiness of transformer and parts	Recheck the transport vehicle and ask the logistic company to send planned route transport to clients	Calculate the number and type of vehicles needed to carry transformer and parts, as well as cost
10. Schedule meetings with clients, project management, transport company to set a transport date	Recheck at site work	Present contingency route

Table 1 (continue)

After informed by the production department that the transformer passes inspection		
11. Schedule the moving date for the transformer and parts with the factory	-Transformer vehicle goes in first -Parts vehicles goes in after the transformer is placed -Other vehicles transport oild from Samut Sakon	Prepare space for transport vehicle to move the transformer via an industrial crane/forklift
12. Date of transportation	Notify insurance agent/security team/production/highway police to ready the route	Ensure that all transport vehicles latch all the parts, cover them with canvass, and latch again
13. Travel to destination	In case of a situation, evaluate problems and check the contingency route	
14. Reach destination, place the transformer on a platform, and move parts and oil to the prepared storage	Ensure that the transformer is placed in the degree according to client specification	Bring back equipment and obtain signatures as a verification of delivery from clients

Architecture

The transportation process stated in section 3 can be applied to create an information technology system used to manage an entire loop of management from start to finish. The following context data-analyzed and categorized into 5 dimensions-from various sensors and time is implemented in the system:

Data collection on business rules is gathered into 5 dimensions:

1. Space-Inclusive business rules pertaining to specific locations, districts, cities, or country.

2. Time-Business rules pertaining to certain points in time, starting from the initial process, meeting location, destination, checkpoints, and border checkpoints that could be further divided into different activity lengths over short, medium, or long term.

3. People-Business rules relevant to each individual, driver, group, or population of a city.

4. Information-Business rules pertaining each sensor, a group of sensors, a network, integration of logistical information in the value chain of logistics.

5. Business Rule–Evaluation of system process to examine if execution is carried out according to business rules. This context data is presented as rules or checklists embedded in the system to ensure mechanism accuracy.

5.1 Time data

Time is an important context. Different points in time have different effects on an environment according to the following categories of context: (1) Range of time in the day (2) Day of the week

(3) Week of the month (4) Month of the year

Contexts of a range of time within the day:

Morning	(10:00-11:00)
Noon	(11:30-13:00)
Afternoon	(13:00-18:00)
Dusk	(18:00-10:00)
Late night	(10:00-12:00)
After midnight	(12:00-06:00)

Contexts of days of the week

Working days	Monday to Friday
Weekend	Saturday-Sunday

Within one-week Public holiday may be included

Within one week personally special days such as birthdays may be included

Contexts of month of the year are seasons such as rainy season or winter. Typical seasons are:

Octobe-January	Winter
February-May	Summer
June-September	Rainy

Architecture of oversized cargo transportation is referred to as Heavy Goods Logistics Architecture (HGLA), as displayed in overall architecture figure 1, which consists of:

Logistics Process, this process depends on the industry and company practices. In the industry, transporting a 100 tons transformer follows the process defined in section 3

Context Processing, an integration of data from different sensors to co-analyze with real-time travel status for management and decision-making purposes such as resting, finding new routes, stopping, avoiding certain routes, cooperating with government officials.

IoT Sensor, a group of Sensors that integrate data from physical sensors and transform them into input for context processing

Info, Sensor, a Data sensor that processes information from the Internet - such as accidents and natural disasters-to be used in transportation process,

Processing layer, the layer is comprised of server application and server data base, which consolidates the entire system through 3G/4G internet connection

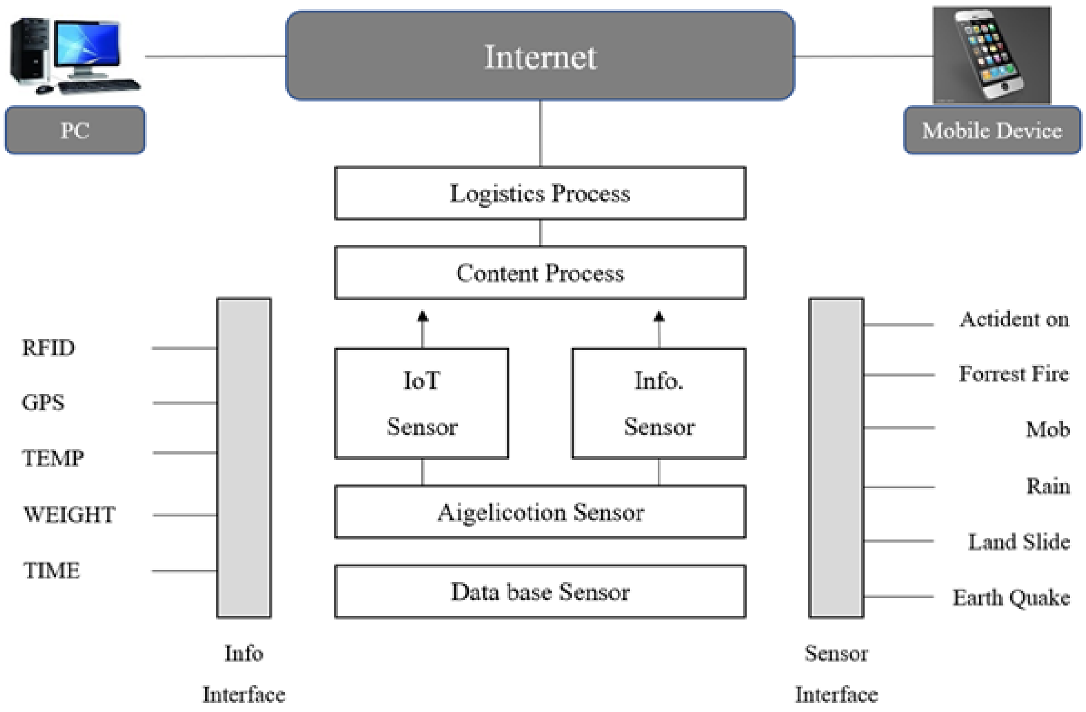

Figure 1 Architecture of transporting oversized goods

Context-based application in logistics

1. Utilization of context

The four context uses defined by Dey will be applied in this research. However, the study further adds contexts regarding business rules particular to heavy shipment transportation and information from the internet. The application of context utilization occurs in 3 phases: (1) Preparation before transportation (2) During transportation (3) Arrival at destination

Context utilization is classified into phases as followed:

Preparation before transportation: (1) Disassemble and pack parts in cartons (2) Prepare Transport vehicle and staff (3) Survey main and contingent routes (4) Coordinate with on-site staff to prepare delivery site (5) Schedule dates and times, and draft agenda

2. During Transportation.

2.1 Transporting via main route.

2.2 Scheduled break such as lunch.

2.3 Unscheduled breaks.

2.4 Short detour.

2.5 Issues with vehicle or transformer.

2.6 Accidents.

2.7 Natural disasters.

2.8 Being forced to stop by criminals.

2.9 Confrontation with traffic police.

3. Contingency routeOver 24-hour delay.

4. On-site Delivery at destination.

4.1 Entrance to unloading area.

4.2 Readiness to handle the delivery.

4.3 Assembling parts.

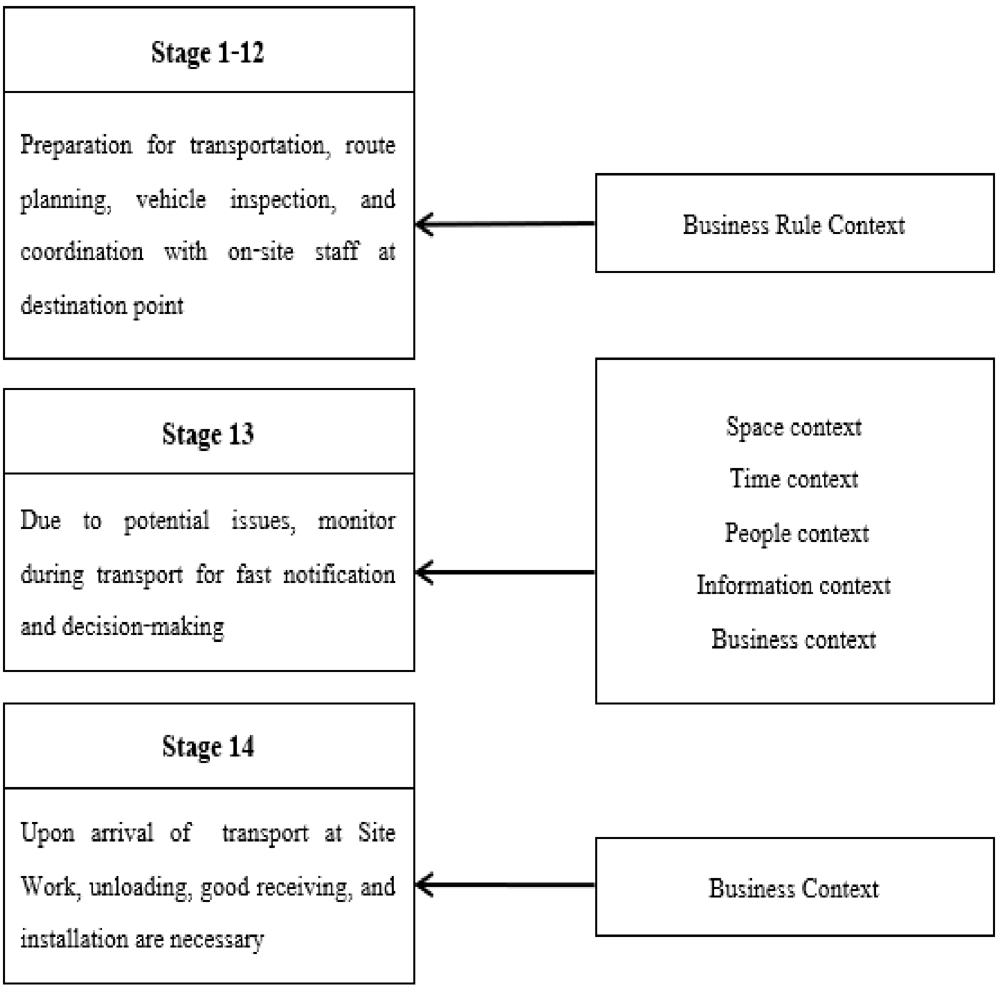

Figure 2 Applications of context use during heavy and oversized transportation

5. Heavy & Oversized Goods Transportation Algoritum.

5.1 Procedure: Preparation; Preparing for heavy and oversized equipment transportation.

5.1.1 Record numbers of box n and parts in each box.

5.1.2 Record numbers of parts not contained in the box in m pieces.

5.1.3 Input Packing List.

5.1.4 Context of loading the transport: Confirmation n+m boxes.

5.1.5 Set Goods Status Ready.

5.1.6 Truck Rating (ready, not ready).

5.1.7 If not ready then get a new Transport.

5.1.8 Set Transport Status; Ready.

5.1.9 Set Team to survey routing to destination if routing OK then Routing

Status=Ready.

5.1.10 Set Team to Survey an altanate Route if altanate route is OK then Altanate Routing status=Ready.

5.1.11 Status Check: Packing is ready and transport condition is ready and main routing is ready and back up routing is ready and associate component is ready and transformer oil depot was informed then set status to go otherwise set status to No Go and go to preparation mode.

5.2 Procedure: Transport; on road travel to destination.

5.2.1 Inform to obtain Transformer Oil from depot in Samutsakorn then let transport 2 to pick up transformer Oil at t+2 days, then if the transport is on-route then Transport go to the destination using main route.

5.2.2 If info, sensor indicates unsafe condition to continue on main Route then prepare to swtch to the backup Route.

5.2.3 If RFID packing tracking not equal m+n then alert the driver.

5.2.4 If No problem reported in the Backup Route is ready then switch to Backup Route otherwise find a place to stop temporally If info sensor indicates, short range problem condition then try avoidance strategy.

5.2.5 If encounter accident then tries avoidance strategy

5.3 Procedure: At Destination: Arrival at destination.

5.3.1 If arrival at destination then inform Logistics manager.

5.3.2 If site preparation is ok then unload the goods and inform Logistics manager.

5.3.3 If Transport 2 already arrived then information Logistics manager.

5.3.4 If install the goods successfully then inform Logistics Manager and Customers else. Inform problem arisen and recommend solution.

5.3.5 If verification of goods is ok then get the signature from customer received all of goods (Main Tank and Accessories)

Result

Experiment of context-based logistic system for heavy and oversized cargo, according to the algorithm in section 3, leads to the development of a client-service prototype-using HTMLS, PHP, and MySQL database. Figure 3 displayed a user status for transport

The acceptance level of using this heavy and oversized goods transportation process was assessed by random selections of 15 logistic staff involved in transportation of 100-ton transformer. Process of assessment includes presentation, explanation, and system display concerning: older methods: (1) Acceptance (2) Effectiveness

The survey resulted in 98% of acceptance level among logistic staff. In fact, 95% of the participants expected higher efficiency of the process. Most participants advocated for visibility while transporting: support system to notify and coordinate between origin and destination to resolve issues. Furthermore, applying business regulation to the context facilitates compliance with business laws, as a transporter fulfilled all legal requirement of the process.

Conclusion

Transporting excess weight load of over 100 tonis a complex process. Specificallly, the transportation of power transformer which is heavyweight and oversized from a manufacturer in Thailnad, from the factory to the installation site in another province, which can take a few days on the road. The current manual management process follows an established policy in which the outcome is not fully controllable.

This study examined the transportation of a 100 tons transformer with the dimension (width×length×height) of 3m×5m×3.5m. Multiple hydraulic trailers were required to install additional axels to properly support the shipment weight on the road. Some parts of the transformer disassembled and stored in separate cartons. Understanding heavy and oversized shipment mechanism led to innovation of the process itself. Development architecture design on information technology based on the awareness of the context (context-aware), control algorithm, and contingency plans designed to increase resiliency when confronted with issues. This research developed a prototype of systematic heavy shipment transportation process, aiming to reduce issues while transporting that ultimately resulted in cost reduction.

The prototype was evaluated by 15 experienced staff in the field of logistics. Outcomes were deemed effective by 98% of staff. However, since the conventional transportation process is executed manually, employing suitable information technology that was significantly improved the process efficiency and reduced ystem that is welcomed by the users. Expectations in higher efficiency will increase because the staff felt assured of the heavy and oversized cargo handling

References

Antonio, C., Raman, K., Marco, P., & Heorth, R. (2011). *Adaptation of Service-Based Business Processes by Context-Aware Replanning* (Research report). Italy: Fondazione Bruno Kessler.

Babu, Md. A, Trabassum J., & Hassan, Md. N. (2016). Risk Management System in Goods Transportation Model Using Multi-Optimality by MODI Method . *Open Journal of Applied Sciences, 6*(8), 540-548.

Bartiomiej, G., & Anna, P. (2009). Usage of Business Rules in Supply Chain Management. *Total Logistics Management, 2009*(2), 5-13.

Claus, G. S. (2012). Fleet Management and coordination. *23 rd Annual Meeting of the Club of Bologna, Bolongna, Italy, 9 November 2012*.(pp. 1-10). Bolongna: The Club of Bologna.

Dong, Q. (2005), *Finite State Macine* (Research report). China: Chongqing University of Posts and Telecommunications P. R. China College of Mathematics and Physics.

Ian, D. (2005). *Qualitative Data analysis,* (1st). London: Taylor & Francis.

Jacob, A., Multer, M., & Kim, S. (2007), *An Event-Driven Approach to Dynamic Situation Detection: Project IT Food Trace-IT supported Food Trace ability* (Research report). Germany: Germany Ministry for Research and Technology (BMBF).

The Trilateral Logistics (TRILOG) Project. (2002). *Transport Logistics: Shared Solutions to Common Challenges*. Paris: Organisation for Economic Co-oeration and Development.

Palsaitis, R., & Petraska , A. (2012), Heavyweight and oversized cargo Transportation Risk Management. *Transport and Telecommunication, 13*(1), 51-58.

Shaki, K , & Garg , M.L. (2017). Web Data Mining through Software Agent. *International Journal of Computer Application(0975–8887), 166*(5), 44-48.

U.S. International Trade Comission (USITC). (2011). *Large Power Transformers from Korea: Preliminary Investigation No.731-TA-1189, September2011* (Research report). Washington, DC: U.S. Inter national Trade Comission (USITC).

WESSEL,A., Jedermann, R., & Lang, W. (2010). Embedded of ontext aware objects for the Transport Supervision of perishable goods. Journal WSEAS *Transactions on Circuits and Systems, 9*(5), 295-304.

Zachos, K., Kounkou, A., & Maiden, N.A.M. (2013). *Exploiting Codified User Task Knowledge to Discover Services, the European Community's seventh Framework Programe FP7/2007-2013 under grant agreement 215483 (SCube and from the FP7 EU-FET project 213339* (Research report). Luxembourg: The Community Research and Development Information Service (CORDIS).