International Journal of Navigation and Port Research
Vol.31, No.2 pp. 141~149, 2007 (ISSN-1598-5725)

A Study on the RTLS based Dynamic Planning of Yard Tractors in Container Terminals

† *Seok-Yong Lee* · Chul-Ho Lee***

**, ** Department of Business Administration, Pusan National University, Busan 609 735, Korea*

Abstract : *The competitiveness of container terminals hinges on minimizing the time vessels spend in port and on schedule services. Many previous researches on container terminals have tried to optimize the equipment allocation plan and to improve the activity of resources. Nevertheless, there have been few researches conducted on yard tractors, which move containers between the quay and the yard. The aim of this study is to propose the use of Real Time Location Systems (RTLS) based Dynamic Planning for yard tractors. Only RFID (Radio Frequency Identification) tags, which are attached to yard tractors, are able to support RTLS implementation. The system can provide real time job ordering in terms of load balancing using the information on location, in regards to the movement of yard tractors. This study will present the practical feasibility of RTLS, which can ultimately reduce the congestion of Hot Queues in container terminals. As a result, container terminals can be more productive and competitive. In order to accomplish the purpose of this study, we examined previous studies on the competitiveness of container terminals and summarized the potential of RTLS using RFID. In addition, we identified the role of yard tractors and proposed the two rules of Dynamic Planning for the yard tractors. We then fulfilled computational experiments on how yard tractors carrying containers by RTLS ordering. Finally, the benefits and the implications of this study are discussed.*

Key words : *Dynamic planning, Yard tractors, Real time location system, Container terminals*

1. Introduction

Over 90% of world trade is conducted with containers owned by multinational shipping companies. Annually over 20 million containers are transported by sea [9]. Cost reduction and process efficiency are more critical due to an increase in global sourcing among international ports, as well as an increasingly competitive environment. Moreover, shipping companies are building larger sized vessels in order to achieve economies of scale, and require cost saving from ports of call. In accordance with this significant change, it has forced ports to become more productive. Ports have been constructed to support and facilitate international trade; container terminals perform inter organizational logistics. As nationwide logistics becomes global, the productivity of ports can be considered as important as national competitiveness.

Since ports import containers, container terminals have become key players in the global port and logistics industry. Currently container terminals, which no longer remain as simple transportation nodes, are being renewed to become combined logistics hubs. These hubs fulfill not only transportation, reservation, and cargo handling, but also perform port and logistics supply chain management (Cuadrado et al., 2004). Major international container terminals have been increasing their competitiveness by aggressively importing Information Technology. For instance, Rotterdam port has established competitive strategies with e-Business supporting systems based on efficient port administration. Hamburg port has administrated information networks between the port and the hinterland with 4PL (4^{th} Party Logistics) systems. Also, PSA seek enforcing strategies involving productivity and efficiency by supporting e-Business, which stems from port development and enlargement (Lee, 2006).

As Information Technology further develops, container terminals can provide more productive services such as EDI (Electronic Data Interchange), AEI (Automatic Equipment Identification), and GPS (Global Positioning System). These technologies mitigate international trading activities and relieve congestion that might occur in supply chains. Despite a variety of Information Technology being adopted by container terminals, there is no sufficient guarantee of optimal operation. As a result, many aspects of terminals are unpredictable, such as equipment malfunctions, load congestion, bad weather, information delays etc. For these reasons, the Dynamic Planning in container terminals has been embossed. Dynamic Planning is more concentrated on

† Corresponding Author : Seok-Yong Lee, mislsy@tu.ac.kr 051)620-3761
** irontiger@pusan.ac.kr 051)510-2577

real time job controlling than previous approaches.

In this study, we propose the use of Real Time Location System (RTLS) by utilizing Radio Frequency Identification (RFID) technology to deploy Dynamic Planning in container terminals. In particular, tags are attached to the yard tractors, so it is possible to track the movement of the yard tractor in real time and to allocate loads on time. First, we examined previous studies on competitiveness of container terminals in terms of critical success factors from a resource based view. We also examined the potential of high technologies. Second, we identified the congestion of Hot-Queues in container terminals by analyzing business processes. Third, we proposed the conceptual architecture of RTLS using RFID. Fourth, we discussed the practical feasibility of the proposed system and the result of computational experiments. Finally, we summarized the implications of this study and the direction of future research.

2. Literature Review

2.1 Competitiveness of Container Terminals

Asian port logistics, including Korea, have been developing with North America and Europe to be the 3rd largest world-wide trading zone. Hence, container throughput of domestic ports has risen to 14,523,138TEU in 2004. Its growth rate shows 10% annual increments since 2000. However, port development extensions and aggressive tactics to lure foreign containers to China has become a threat to domestic ports. According to the comparative study on major ports competitiveness (Clark, 2001), productivity of domestic ports is lower than Singapore, Hong-Kong, Taiwan and Japan, which have lesser container throughput. Consequently, improving productivity in container terminals competitiveness has become the most critical success factor for the domestic ports to be logistics hubs in North-Eastern trading zones.

The elements constituting port competitiveness are facilities, location, expenses, services, and the quantity of goods transported. Among these, key performance indicators are focused on operating time and cost such as in and out cost, delay time, loading unloading cost, cargo working delay cost, custom clearance cost, and clearance delay cost etc (Korea Maritime Institute, 1999). Port productivity, which is practically discernment competitiveness, closely related to the critical factors port of call (Kang, 2001). Container terminals have to maintain superiority in competitiveness to attract the large scale shipping companies as customers. Table 1 depicts summarized critical factors for the port of call from major previous literature.

Table 1 Factors for the port of call

Researcher	Subject of Study	Critical Factors
Willingale (1984)	Shipping-Companies	Proximity of hinter land Proximity of sea rout Port facilities Port capability
Slack (1985)	Shippers	Number of call Inland transportation cost Proximity of port Delay of vessel at a port Composite connected transportation
Brudg & Daley (1986)	Shippers Transporter	Transportation fee Cargo working facilities Customer response Cargo loss Efficiency of transportation time Shipment information
Murphy (1989) (1992)	Terminals Shipping-Companies	Port facilities Cargo loss and damage frequency Right time processing Cargo working cost Large vessel availability Flexibility
	Terminals Shipping-Companies Shippers	Non-standard cargo handling Large sized cargo handling Small sized cargo handling Low damage and loss Port equipments
Murphy & Daley (1994)	Shipping-Companies Shippers Forwarder	Equipment use availability Shipment information Cargo loss Efficiency loss Trouble shooting capability Expertise processing capability Ease of pick-up Transportation efficiency
FAMAS (Connekt, 2001)	Shippers	Transportation service time in front of gate Transportation service cost in front of gate Shipping schedule and frequency Quality of information services Proximity of hinter land Additional logistics services
Tongzon (2001)	Shipping-Companies	Port efficiency Vessel frequency Port facilities Port cost Customer response Cargo damage potentialities
P&O Nedlloyed (Mason, 2003)	Shippers	Fixed date services Frequent departure rate Reliable services Compliance due date Sufficient vessel capabilities Minimiz transshipment time Minimize transporation fee

Generally, the most important factors for the port of call are cost factors including fees and schedule and operation factors including facilities and scale. The competitiveness of container terminals hinges on minimizing the time vessels spend in port and on-schedule services.

2.2 Resource Based View on Container Terminals

According to the resource-based view of business, an organization's strategic modification efforts are focused on the acquisition and use of resources, such as management experiences, or workforce skill (Barney, 1991; James and Salisbury, 2001). This is critical in container terminals that acquire cargo handling equipment such as quay cranes, yard cranes, yard tractors, computer systems, and skilled man power. Only through collaborative processes among those resources, can container terminals improve their productivity. Likewise, resources are stocks of available factors of production owned or controlled by a firm (A mit, 1993). Also, resources are regarded as including all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm. This enables the firm to conceive and implement strategies that improve its efficiency and effectiveness (Daft, 1983).

Resources are often developed in functional and sub-functional areas by combining physical, human, and technological resources (A mit, 1993). Container terminals perform their services by utilizing heterogeneous resources such as equipment, labor, Information System (IS), and their own business processes. From a resource based perspective, IS resource, is inimitable, valuable, and can be rent-yielding (Ravichandran, 2005). IT assets such as networks and databases are unlikely to be rent-yielding, since they can be easily procured in factor markets (Mata et al., 1995). In effect, even if they use similar solutions for terminal operation; each terminal has different value chains inside the system. It also involves their business; therefore container terminals tend to keep their operating systems concealed.

According to the literature, four characteristics of a resource must be present for it to be the basis of a sustainable competitive advantage (Barney, 1991; James and Salisbury, 2001). First, the resource must be valuable in the situation it is to be used: a valuable resource enables a firm to do something beneficial. Second, the resource must be rare: resources that are held by one or only a few firms enable those firms to do things their competitors cannot. Third, resources must be inimitable: inimitable is the extent to which given competence cannot be copied (Barney, 1991). Finally, the resource must be non-substitutable: resources that are non-substitutable enable a firm to sustain an advantage by preventing competitors from accomplishing the same objective using a different set of resources (James and Salisbury, 2001).

Constructing container terminals is the only purpose for port development and it is an important matter closely connected with saving costs. Furthermore, it encourages competitive capabilities, to improve the productivity of container terminals by the efficient utilization of container terminal resources (Yi et al., 2000). In regards to this, container terminals have to consider valuable resources to support their optimized business processes and how they can differentiate their business processes using the resource. H is one of the container terminals in Busan port, which has obtained tremendous improvements by using wireless phones. Hence, container terminals need to conduct business processes with technologies.

2.3 Real Time Location System using RFID Technologies

RTLS tracks the movement of objects using real time information. Also, it controls the object using wireless automated identification technology. Especially, RTLS monitors assets or the location of objects using RFID or CLS (Cellular Locating System). The location oriented information system in container terminals takes charge of core operating roles. It is appropriate that RTLS in container terminals is implemented by constructing wireless networks such as RFID technology. Therefore, it has a limited area and unpredictable business environment. Proposing RTLS in this study, gathering real time information from attached tags on yard tractors provides updated job control direction by adopted job rules. In this place, real time means the system can calculate the location within 30 seconds after the tag generates its information (Jeong, 2006).

RFID is an emerging technology intended to complement or replace traditional bar code technology to identify, track, and trace items automatically (Asif and Mandvi Walla, 2005). It is claimed to add intelligence and to minimize human intervention in the item identification process. Using electronic tags, which have a larger available storage, is far superior to bar codes. More importantly, tags can be identified in the absence of line-of-sight and bar codes are frequently contaminated by constant handling. The antenna of the tags and the readers communicate by using radio waves. After the antenna, stored inside the tag, receives radio waves the chip inside the tag converts the information into a signal. The reader receives the signal through the antenna transmitted from the tag and next transmits it to the server (Yu, 2005).

Marks & Spencer Co. in England experimented with attached RFID tags on 3.5 million convey receptacles replacing barcodes, and successfully reduced 1/6 information scanning speed. As a result, they expect that they can reduce 88% of operating costs within the next 10 years compared to the barcode system (Widlingm and Delgado, 2004). Not only companies, but also governments and public research organizations, have been deploying diverse projects. ETRI (Electronic and Telecommunications Research Institute) has launched field experiments on 433MHz active tags and proved its practical possibilities and validity(Pyo, 2005). The ministry of maritime affairs and fisheries is pursuing these projects which have focused on efficient port logistics with RFID. It can also be the basis of sealing technologies for containers to ensure that the containers have not been tampered with or opened without authorization, such as TAV (Total Asset Visibility) in the U.S. The TAV network has been deployed in 36 countries world wide and helps the Department of Defense to track and identify thousands of containers, providing real time data on location. The modern port logistics industry requires not just visibility, efficiency, productivity also security by adopting RFID technology.

3. Dynamic Planning in Container Terminals

3.1 Business Process in container terminals

Container terminals normally consist of three sections gate, yard, and berth. From the gate, container trucks arrive at the gate in advance, operators begin to check the container numbers compared to the COPINO (Container Pre-Notification Notice). After identifying the right container the truck then can enter the terminal, and the driver looks for the section of the yard where the container should be unloaded. If it is necessary the transfer crane begins to move to the area to meet the truck then the crane picks the container up and places it in the planned slot. The quay crane begins to unload containers from the vessel and the yard tractors carry the containers to the planned slot in the yard. The yard crane moves to the place to pick the containers up and unloads it at the right slot simultaneously. The scope and flow of business processes in container terminals is depicted in Fig. 1.

When a vessel arrives at the berth, the import containers have to be taken off the vessel by quay cranes and the containers transferred from the quay cranes to yard tractors that shuttle between the yard and the berth. The yard consists of a number of lanes, where containers are stored for certain periods. The yard is operated by yard cranes which can be rubber tired ground crane or straddle carriers depending on terminals. They served transfer containers between the yard tractors and stacks in lanes or stacks and yard tractors. If the yard tractor arrives at the stack, it puts the load down or the stack crane takes containers off the yard tractors and stores them in the stack. After a certain period the containers are retrieved from the stack by cranes and transported by yard tractors to the transportation mode, such as barges, trucks or trains. The processes can be executed in reverse order to load export containers onto a vessel from the gate in terminals.

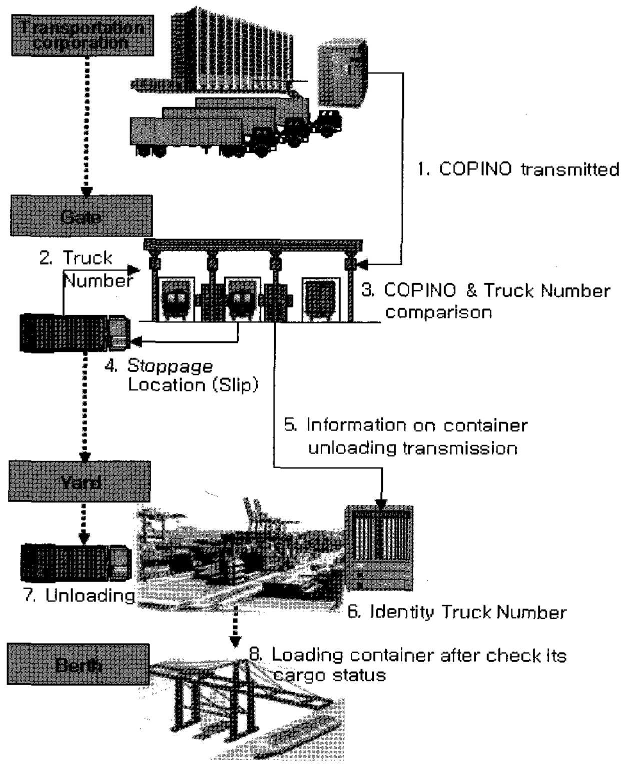

Fig. 1 Business Processes in Container Terminals

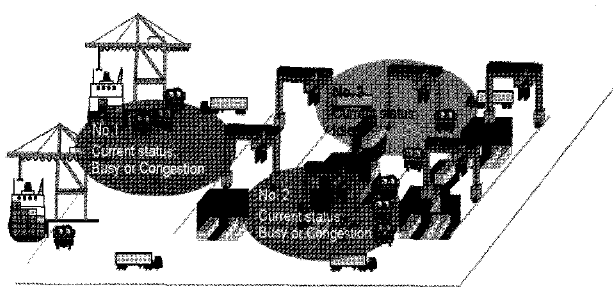

Fig. 2 Congestions Status in Container Terminals

There can be congestion, however, due to the load on the equipment not always being stable in spite of the work load being reserved. For instance, as depicted in Fig. 2, No. 1

and No. 2 areas are busy or congested while No. 3 area is inactive. In most cases there are a number of quay cranes, if the number 1 quay crane is busy, but the number 2 crane is idle, then it could be transferred to the busy section. If operators can recognize this situation in real time, they can balance job ordering in real time towards that equipment and its operators. If possible, operators can control all congestion in terminals, and then it is obvious that the productivity of the container terminals performance will be increased. According to operators in container terminals, such congestion can occur frequently which is called a Hot-Queue.

Container terminals predominantly concentrate on reducing Hot-Queues to be more efficient. Usually Hot-Queues occur while containers are transported in or out, loaded or unloaded, or transferred. Firstly, being transported in, it can occur after passing the gate to before being stored in the yard. Secondly, being transported out; it can crop up after being taken off the transfer crane until being transported out of the gate. Thirdly, being loaded, it can arise after being taken off the transfer crane onto the yard tractors until being loaded. Lastly, being unloaded, it can transpire after being taken off the quay crane to the yard tractors until being stored in the yard. At present, the main operators cannot recognize, in real time, the exact location where congestion occurs during these processes. Recognizing which berths are inactive and which blocks in the yard are congested is not possible.

3.2 proposing the RTLS

To maximize the ability of resources such as equipment, staff, operators etc., container terminals must be able to change job ordering in real time to balance the load. This could be possible by implementing RTLS based Dynamic Planning System (DPS). Attaching RFID tags onto yard tractors which are moving between quay and yard, with the information transmitted among the equipment sensing by tags, DPS constructs ad-hoc networks which can change job orders and give directions towards yard tractors. This means that the system can be controlling all yard tractors and can monitor the whole business process in real time. Therefore, the operators not only can monitor the movement of resources, but also can order jobs simultaneously. Many researches on RFID technologies are vaguely expecting positive benefits from implementing the technologies from unclear and forcible perspectives. Nevertheless, in this study we propose clear and distinct benefits with a certain scope which is focused on the inside of container terminals. Above all, the whole system architecture conceptually has 4 layers such as in Fig. 3.

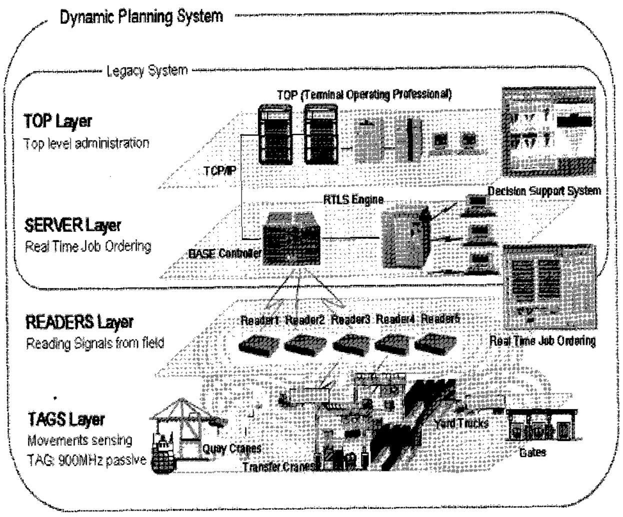

Fig. 3 Proposed Conceptual System Architecture

1) TOP Layer

The TOP layer generally consists of three subsystems such as the planning system, operation system, and management system. The planning system performs berth, yard, vessel, and rail planning if it is necessary. The operation system performs control and monitoring, operating equipment, EDI, and Web services. The management system performs billing, statistics and analysis, and decision support.

2) SERVER Layer

The SERVER layer is the most important and it consists of the base controller, which performs real time job ordering. It also performs load balancing by way of supporting by rule-based engines. Rule-based engines have algorithms for bound of load. All information transferred from each tag sending signals is integrated and processed into the base controller. Once this information is transmitted to rule-based engines, it is then applied with suitable algorithms. Finally, the optimized job ordering directions are transmitted to the base controller again. The base controller then immediately assigns the renewal order among the equipment.

3) READER Layer

The READER layer consists of a number of readers which can be installed at points such as rooftop lighting. These transmit signals to identify the movements of equipment. The readers send radio waves to tags, which energize them and start broadcasting their data. This automatic process reduces read times, so the reader can read all the tags within its reading range in quick succession.

4) TAG Layer

The TAG layer, tags attached into yard tractors, recognizes a range of readers and transmits their signals on the movements in real time. Since metals and liquids absorb radio waves, the presence of such items in the environment adversely affects the performance of RFID devices [2]. Which tags are suitable in the container terminals environment needs to be discussed.

3.3 Rules for the DPS implementation

The DPS can provide real time job ordering in terms of load balancing using the information on location concerning the movement of equipment. For the automated operations by the system, there are two required operation rules regarding yard tractors. These are the shortest operation time and equal load distribution. Firstly, the shortest operation time rule includes movement on yard tractors from one point to another. For instance, the time spent moving from quay crane to import yard block. Secondly, the equal load distribution rule is the balancing of loads among yard blocks. If a block has higher stacking layer that means it needs much more re-marshalling to stabilize following operations. Operators should be able to make decisions on what rule would be appropriate in each decision epoch according to yard conditions.

These two operation rules are based on the three requirements. The first concerns the quay side and the yard working concurrently to maximize the availability of yard tractors supported by DPS (Briskorn, 2006). The second pertains to implementing the dual-cycling of yard tractors which transport imported containers from the quay side to the import yard blocks. It then moves to export yard blocks, and moves export containers to reserved berths in one cycle. The third refers to the performance of computer resources because there would be a tremendous amount of real time information that the system must control.

On the assumption that the time spent of each quay crane and each yard crane are same, the shortest operation time rule can be depicted pseudo codes in Fig. 4.

Once a vessel enters the berth, yard tractors are allocated to each quay crane sequentially. When yard tractors complete transporting the imported containers from the berth to the import blocks, they seek the closest export block. Also, yard tractors move to the closest block, and then transport the export container to the reserved berth. The equal load distribution rules can be depicted using pseudo codes in Fig. 5.

```
{INPUT: t is a given YT's number from 0 to n}
{OUTPUT: List R of YT's number which is t, imported block
         number i, export block number e}
begin
  R[1] = t
  R[2] = i = remainder when t divided by total numbers of
         import blocks + 1
  For e = i TO 4
     IF available (e) THEN
        R[3] = e
        BREAK
     ELSE
        {if there is no export block available, then go to QC}
        R[3] = 0 {0 is one of QCs not export block}
     ENDIF
  ENDFOR
end
```

Fig. 4 Pseudo code on the shortest operation time rule

```
{INPUT: t is given YT's ID from 0, EC is a list of
        containers in export blocks}
{OUTPUT: List R of YT's ID which is t, import block
        number i, export block number e}
begin
  R[1] = t
  R[2] = i = remainder when t divided by total number of
        import blocks +1}
{max is a maximum value of EC's containers}
  max = EC[1]
  FOR j = 2 TO EC's containers
    IF max < EC[j] THEN
      Max = EC[j]
    ENDIF
  ENDFOR
{c is a number of ME, ME is a list of export block number
        which includes maximum value}
 c = 0
 FOR k = 1 TO EC's containers
   IF max = = EC[k] THEN
     c = c + 1
     ME[c] = k
   ENDIF
 ENDFOR
{if export block number less than import block number, then
        go to one of QCs}
 FOR 1 = TO c
   IF i < = ME[1] THEN
     R[3] = e = ME[1]
     EC[e] = EC[e] - 1
     BREAK
   ELSE
     R[3] = 0 {0 is one of QCs not export block}
   ENDIF
 ENDFOR
end
```

Fig. 5 Pseudo code on the equal load distribution rule

In contrast with the shortest operation time rule, yard tractors complete transporting the imported container from the berth to the import block. Then the yard tractor seeks the export block which is handling the lowest amount of containers from the working list. Hence, the yard tractor moves to the export block, then transports the export container to the reserved berth.

4. Experiment Result

We examined how yard block status would be changed by applying each rule on yard tractors using computer language. The pseudo codes proposed above in this study were compiled to C language, and then were executed with given initial amounts of stacked containers in each block.

Table 2 experiment result of rules application

Shortest operation time						Equal load distribution					
YT movement Import→Export		Block No.				YT movement Import→Export		Block No.			
		1	2	3	4			1	2	3	4
YT No.	Initial amount of stacked container	**23**	**22**	**25**	**21**	YT No.	Initial amount of stacked container	**23**	**22**	**25**	**21**
0	1→2	23	21	25	21	0	1→3	23	22	24	21
1	2→2	23	20	25	21	1	2→3	23	22	23	21
2	3→4	23	20	25	20	2	3→3	23	22	22	21
3	4→0	23	20	25	20	3	4→0	23	22	22	21
4	1→0	23	20	25	20	4	1→1	22	22	22	21
5	2→2	23	19	25	20	5	2→2	22	21	22	21
6	3→3	23	19	24	20	6	3→3	22	21	21	21
7	4→4	23	19	24	19	7	4→0	22	21	21	21
8	1→1	22	19	24	19	8	1→1	21	21	21	21
19	2→2	22	18	24	19	9	2→2	21	20	21	21
10	3→4	22	18	24	18	10	3→3	21	20	20	21
11	4→0	22	18	24	18	11	4→4	21	20	20	20
12	1→2	22	17	24	18	12	1→1	20	20	20	20
13	2→3	22	17	23	18	13	2→2	20	19	20	20
14	3→3	22	17	22	18	14	3→3	20	19	19	20
15	4→0	22	17	22	18	15	4→4	20	19	19	19
16	1→3	22	17	21	18	16	1→1	19	19	19	19
17	2→2	22	16	21	18	17	2→2	19	18	19	19
18	3→0	22	16	21	18	18	3→3	19	18	18	19
19	4→4	22	16	21	17	19	4→4	19	18	18	18
20	1→1	21	16	21	17	20	1→1	18	18	18	18
21	2→2	21	15	21	17	21	2→2	18	17	18	18
22	3→0	21	15	21	17	22	3→3	18	17	17	18
23	4→4	**21**	**15**	**21**	**16**	23	4→4	**18**	**17**	**17**	**17**
Total amount of remained container		**73**				Total amount of remained container		**69**			

As depicted in Table 2, the total number of yard tractors is 24 and each number of the import and export blocks is 4. According to the results, the remaining amount of containers is 73 when applying the shortest operation time rule and 69 when applying the equal load distribution rule. The result shows the equal distribution rule records better performance than the shortest operation time rule for the handling on any given amount of containers. Moreover, applying the equal load distribution rule requires less re-marshalling as a result of the difference of the remaining amount of containers. Among these blocks 6 is by applying the shortest operation time rule and only 1 by applying the equal load distribution. Nevertheless, it is very risky to presuppose the equal load distribution rule is better than the shortest operation time rule. Business environments in container terminals are not stable. Unpredictable situations can occur unexpectedly and generalized practical experiments are needed. This can be estimated in proportion to flow of time such as simulation.

5. Implications and Future Work

Generally, domestic container terminals can handle 18 containers per hour in yard. In contrast, H container terminal is currently handling over 23 containers per hour in yard by using wireless phones. For this reason, operators who are in charge of container handling in terminals are expecting an improvement of 40~60% in productivity and a decrease of 20~30% of re-marshaling through the implementation of real time job ordering. Such benefits not only improve efficiency, but also redesign business processes in terminals. In business process, considerable work load can be automated in terms of most manual work load transferred to the system from the planner or vehicle scheduler. Redundancy of some resources can be minimized and speed can be raised. Consequently, drivers of equipment can reduce touch-event. Such as confirm and report by touching the computer screen, human intervention and mistakes can be tremendously minimized. With these positive results, ultimately equipment pooling and ad-hoc networking can be possible through peer to peer communication

This study proposed RTLS based DPS using RFID as an enabler of real time job ordering and a driver of dynamic planning. We can conclude this study by highlighting some of these implications. First, this study can demonstrate the practical potential of implementing RTLS and more realizable benefits of attaching RFID tags. There is clearly a role for these high technologies in container terminals.

Second, it is not necessary to debate about standardization because the scope is restricted to container terminals. Inside container terminals, the proposed system in this study is to be able to adapt 900MHz passive tag which is specified by the Ministry of maritime and fisheries (MOMAF). Also other tags can be considered if the performance is successful. Third, a vast expense can be saved by attaching only into yard tractors inside container terminals. It takes considerable time and budget to implement RFID technology in all port and logistics according to the nationwide policy. However, there is a lack of explanations on the reliable experimental performance between two operation rules. Also, there can be diverse approaches with various algorithms for the dynamic planning. These limitations can be studied in further research.

References

[1] Amit, R. and Schoemker, H. (1993), "Strategic assets and organizational rent", Strategic Management Journal, Vol. 14, No. 1, pp. 33-46

[2] Asif, Z. and Mandviwalla, M. (2005), "Integrating the supply chain with RFID: A technical and business analysis", Communications of the Association for Information Systems, Vol. 15, pp. 383-427.

[3] Barney, B. (1991), "Firm resources and sustained competitive advantage", Journal of Management, Vol. 17, No. 1, pp. 99-120.

[4] Briskorn, D., Drexel, A., and Hartmann, S. (2006), "Inventory-based dispatching of automated guided vehicles on container terminals", OR Spectrum, Vol. 28, pp. 611-630.

[5] Brudg, B. and Daley, J. (1986), "Shallow-draft water transportation" marketing implications of user and carrier attribute perceptions", Transportation Journal, Vol. 24, pp. 238-221.

[6] Clark, X., Dollar, D., and Micco, A. (2001), "Maritime Costs and Port Efficiency", World Bank.

[7] Connekt (2001), International State-of-the-art in container logistics and performance requirements for mega hubs.

[8] Cuadrado, M., Frasquet, M., and Cervera, A. (2004), "Benchmarking the port services: A customer oriented proposal", Benchmarking: An International Journal, Vol. 11, No. 3, pp. 320-330.

[9] Cueno, C. (2003), "Safe at Sea", Information Week.

[10] Daft, R. (1983), Organization theory and design. New York: West.

[11] James, B. and Salisbury D. (2001), "Understanding the influence of organizational change strategies on information technology and knowledge management strategies", Decision Support Systems, Vol. 31, pp. 55-69.

[12] Jeong, D., Ji, D., Jeong, Y., and Back, Y. (2006), "Design and Implementation of RTLS Using Active RFID at 433MHz", Korea Society of Information Processing Conference 26th, Vol. 13, No. 2.

[13] Kang, Y. (2001), "A study on the Rationalization of the Port Logistics in Korea", The Journal of Logistics Study, Vol. 11, No. 2, pp. 25-47.

[14] Korea Maritime Institute (1999), Report on Port Logistics Business Process Re-engineering.

[15] Lee, S., Kim, Y., Seo, C., and Park, N. (2006), "A study on the potential and requirements in shipping companies with RFID technology", International Journal of Navigation and Port Research, Vol. 30, No. 2, pp. 151-159.

[16] Mason, T. (2003), "Network Strategy A Global Carrier Perspective", TOC 2003 Europe Jenoa June 10th.

[17] Mata, J., Fuerst, L., and Barney, B. (1995), "Information technology and sustained competitive advantage: A resource-based analysis", MIS Quarterly, Vol. 19, No. 5, pp. 487-505.

[18] Murphy, R. (1989), "Assessing International Port Operations", International Journal of Physical Distribution and Logistics Management", Vol. 19, No. 9, pp. 3-10.

[19] Murphy, R. (1992), "Port Selection Criteria: An Application of a Transportation Research Framework", Logistics Transportation Review, Vol. 28, No. 3.

[20] Murphy, R. and Daley, J. (1994), "A comparative analysis of port selection factors", Transportation Journal, Vol. 34, pp. 15-21.

[21] Pyo, C. (2005), "433MHz Active RFID technology development status", Electronic and Telecommunications Research Institute.

[22] Ravichandran, T. and Lertwongsatien, C. (2005), "Effect of information systems resources and capabilities on firm performance: A resource-based perspective", Journal of Management Information Systems, Vol. 21, No. 4, pp. 237-276.

[23] Slack, B. (1985), "Containerization, Inter-Port Competition and Port Selection", Maritime Policy and Management, Vol. 12, No. 4, pp. 293-303.

[24] Tongzon, J. (2001), "Efficiency Measurement of Selected Australian and other International Ports using Data Envelopment Analysis", Transportation Research, Part A, Vol. 35, pp. 107-122.

[25] Widlingm, R. and Delgado, T. (2004), "RFID demystified", Logistics & Transport Focus, Vol. 6, No. 5, pp. 32-42.

[26] Willingale, C. (1984), "Ship-Operator Port-Routing Behavior and the Development Process", Seaport systems and spatial change.

[27] Yi, D., Kim, S., Park, N., and Lee, T. (2000), "Developing a conceptual model for sharing container terminal resources: A case study of the Gamman Container Terminal", Maritime Policy & Management, Vol. 27, No. 2, pp. 155-167.

[28] Yu, S. (2005), "Radio Frequency Identification of ubiquitous society", Korea e-Business Association.

Received 5 March 2007
Accepted 31 March 2007