

Container handling operation analysis using process mining: a case study of H container terminal

*Riska A. Sutrisnowati, Sunghyun Sim, Nur I. Utama, Natanael Y. Wirawan,
Nur A. Wahid, Hyerim Bae*



한국SCM학회 2018 춘계컨퍼런스

Presenter: Riska A. Sutrisnowati
2018.05.25



부산대학교
PUSAN NATIONAL UNIVERSITY



<http://bsclab.pusan.ac.kr>

Outlines

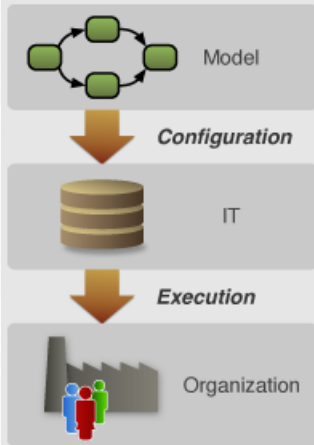
- Introduction
- Related works
- Analysis framework
 - Process analysis
 - Resource analysis
 - Advanced analytics
- Conclusion & future works

Introduction

BPM & Process mining

It's BPM, but upside-down.

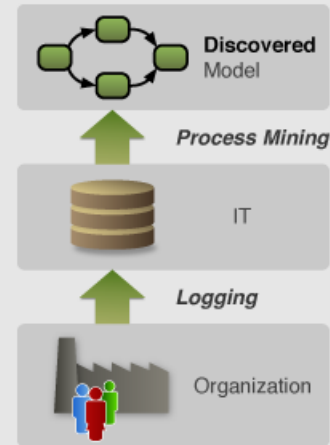
Using process mining, you can turn the traditionally top-down approach of BPM on its head.



Business process management (BPM) is usually a top-down approach. You start by designing your process in a high-level model.

Then, you configure a system for managing and controlling your process.

This system then coordinates work between your employees, and other resources in your organization.

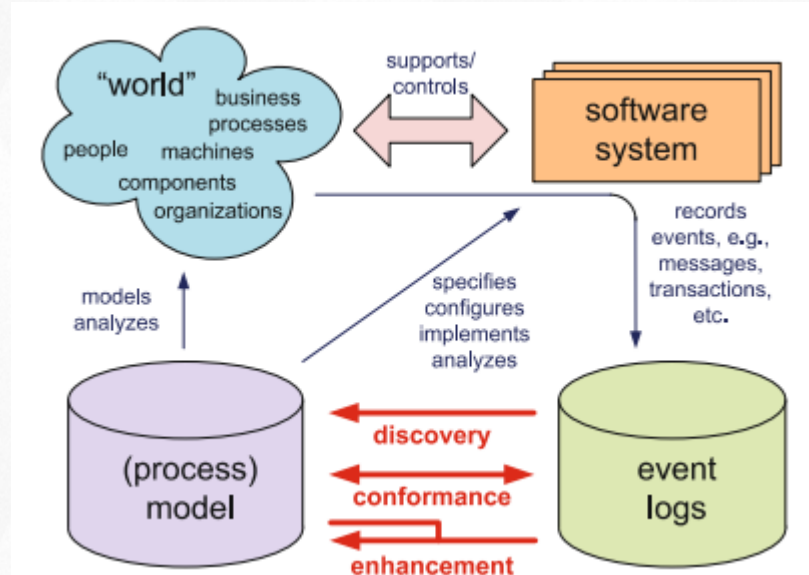


Process mining can analyze your process in a **bottom-up** fashion. You **don't need to have a model** of your process to analyze it — Process mining uses the history data in your IT systems.

Your IT system already records all steps of your process in execution. With process mining, you **get a process model from these data**. This way, your **real process**, and actual business rules, can be **discovered automatically**.

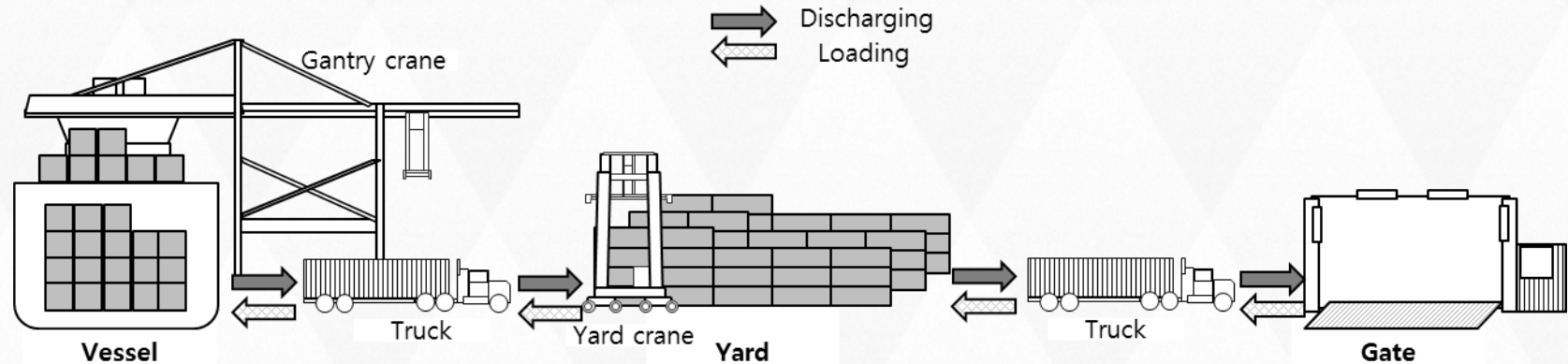
Introduction

Process mining framework



Introduction

Port process

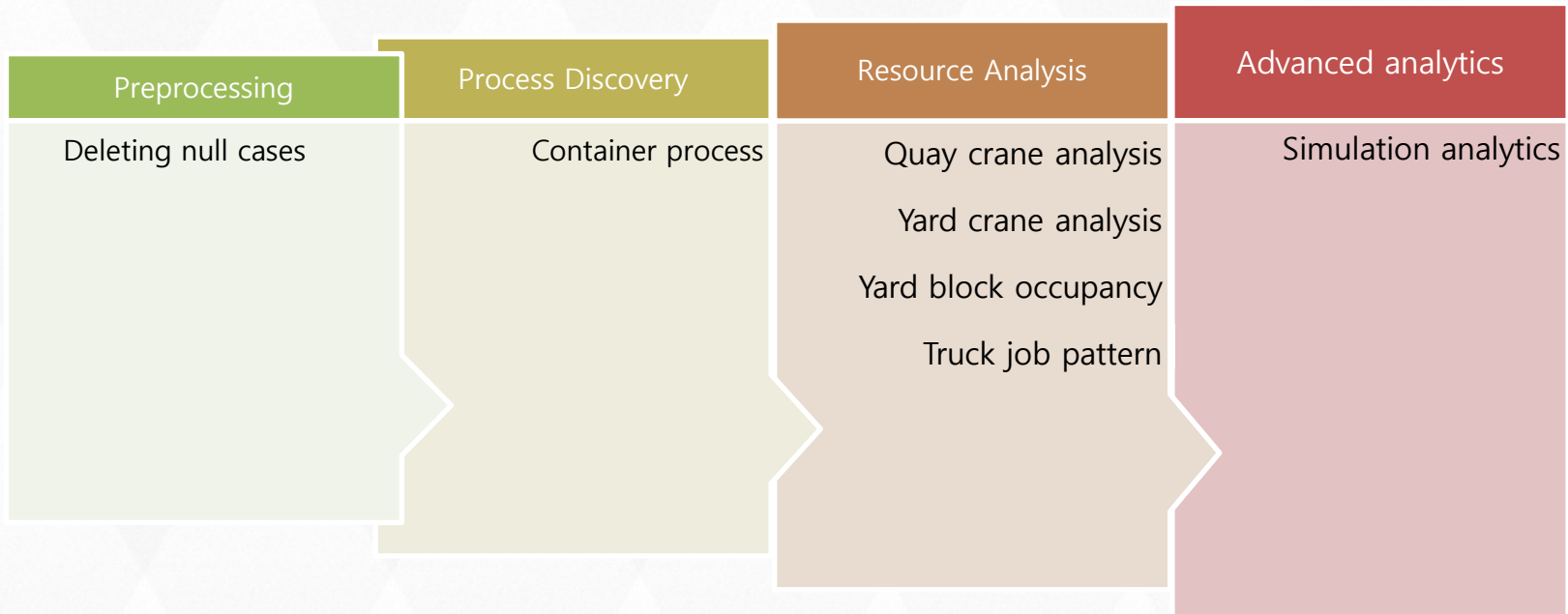


Sutrisnowati, R. A., Pulshashi, I. R., Bae, H., Jeon, D., and Sul, S.-O. Time-gap analysis considering multi-dimensional perspective for process performance evaluation. ICIC Express Letters Part B: Applications (ISSN 2185-2766) 9, 5 (2015), 1435–1440.

Related Works

References	Summary
Yahya, B. N., Song, M., Bae, H., Jeon, D., Sul, S.-O., and Sutrisnowati, R. A. Port logistics data analysis using process mining. In Proceeding of Korean Operations Research and Management Science (2012)	Overall framework on how process mining can be applied to container handling process data.
Sutrisnowati, R. A., Pulshashi, I. R., Bae, H., Jeon, D., and Sul, S.-O. Time-gap analysis considering multi-dimensional perspective for process performance evaluation. ICIC Express Letters Part B: Applications (ISSN 2185-2766) 9, 5 (2015), 1435–1440.	Analyzing a multi-dimensional perspective of container handling process in respect to execution time
Park, S., Sutrisnowati, R.A., Bae, H., Port logistics simulation using CPNTools with yard trucks and gantry crane configuration. In Proceeding of ILS2016.	Colored Petri net simulation for container handling process with a variation size of yard trucks and gantry cranes

Analysis Framework



Preprocessing

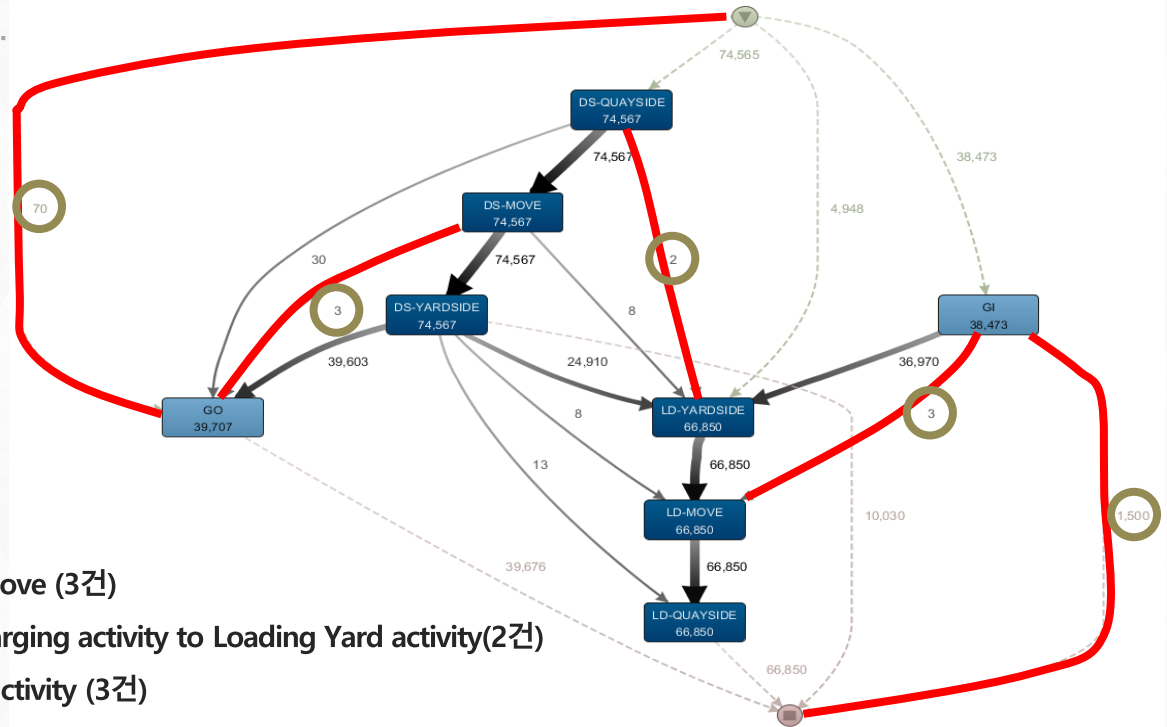
Deleting null cases

VESSEL	CONTAINER_NO	MCHN_ID	MCHN_TP_CD	FULL_EMPTY	JOB_TYPE	POD	BLOCK_BAY	JOB_START_DT	JOB_END_DT	OUTSERVICE
V1	C01	QC01	QC	M	DS-QUAYSIDE	KRPUS	M-08	20180106200118	20180106200250	NULL
V1	C01	YT01	YT	M	DS-MOVE	KRPUS	M-08	20180106200250	20180106200736	NULL
V1	C01	YC01	YC	M	DS-YARDSIDE	KRPUS	M-08	20180106200736	20180106200908	NULL
V1	C01	NULL	NULL	M	GO	JPHKT	NULL		20180202200041	AC1

There are 21 cases of Gate Out activity having empty start timestamp.
So all 21 cases (100 rows of events) are removed from the merged data

Process analysis

Process model discovery

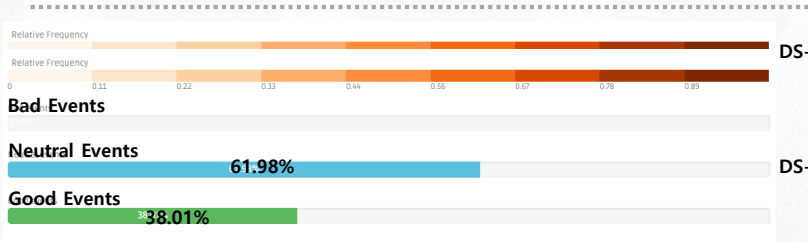


Anomaly flows (indicated in red):

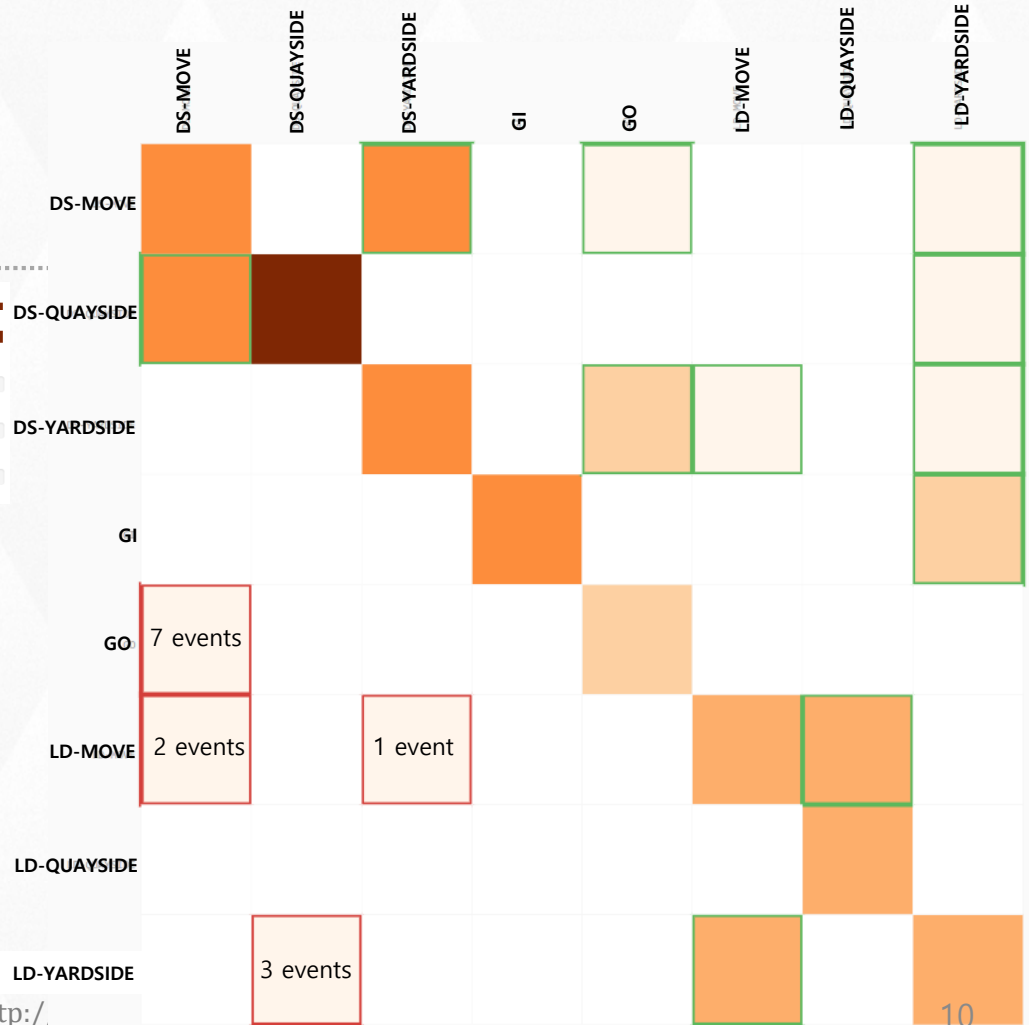
- Cases only contain Gate Out activity (70건)
- Gate out activity directly follows Discharging move (3건)
- Without using a truck to move from QC Discharging activity to Loading Yard activity(2건)
- Loading move activity directly follows Gate In activity (3건)

Process analysis

Heat map flows: Activity vs activity

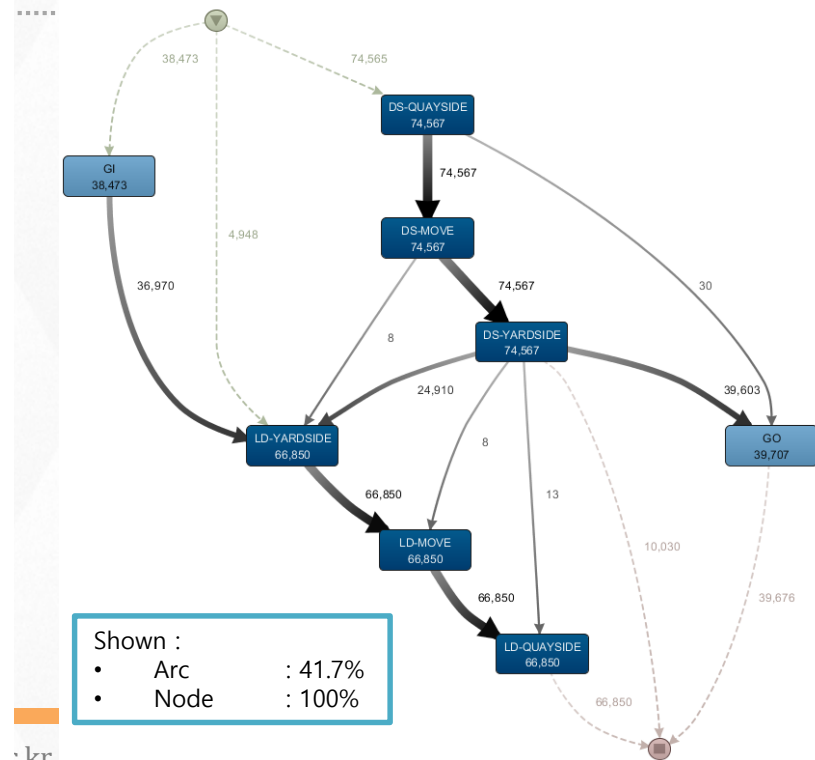
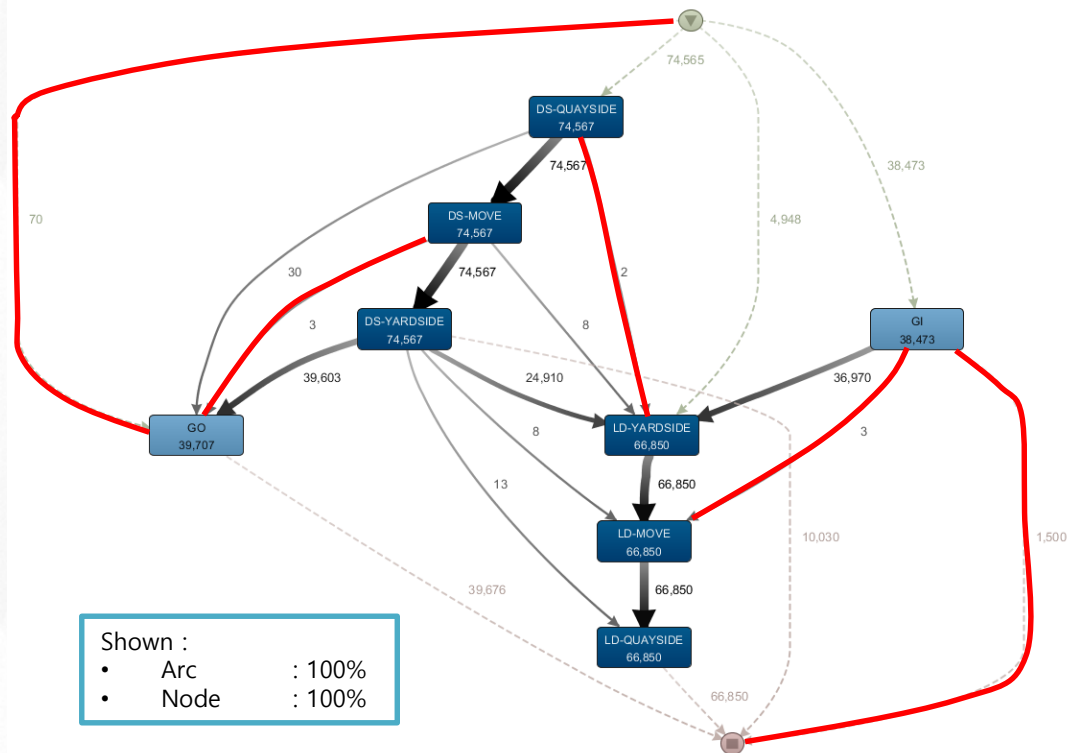


Bad events occur in a very small numbers
13 events (0.01%)



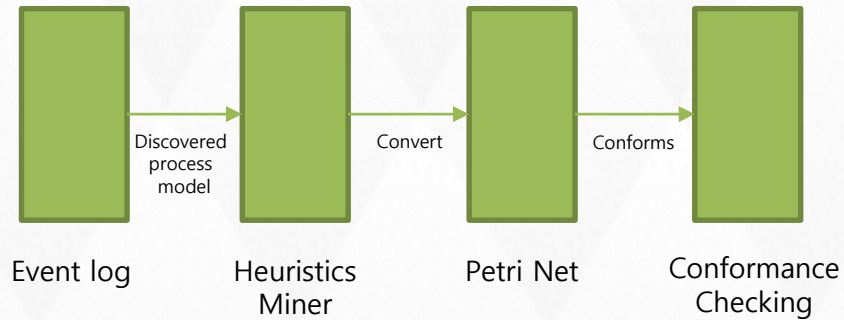
Process analysis

Filtering out anomaly flows

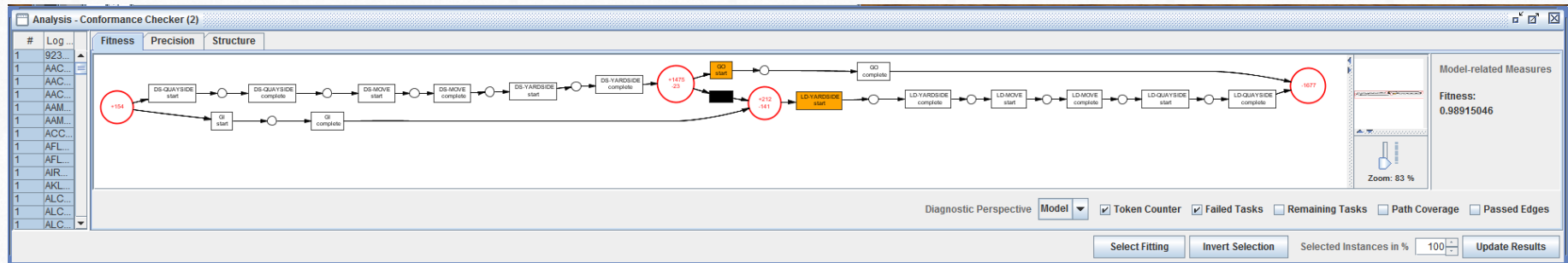


Process analysis

Conformance checking

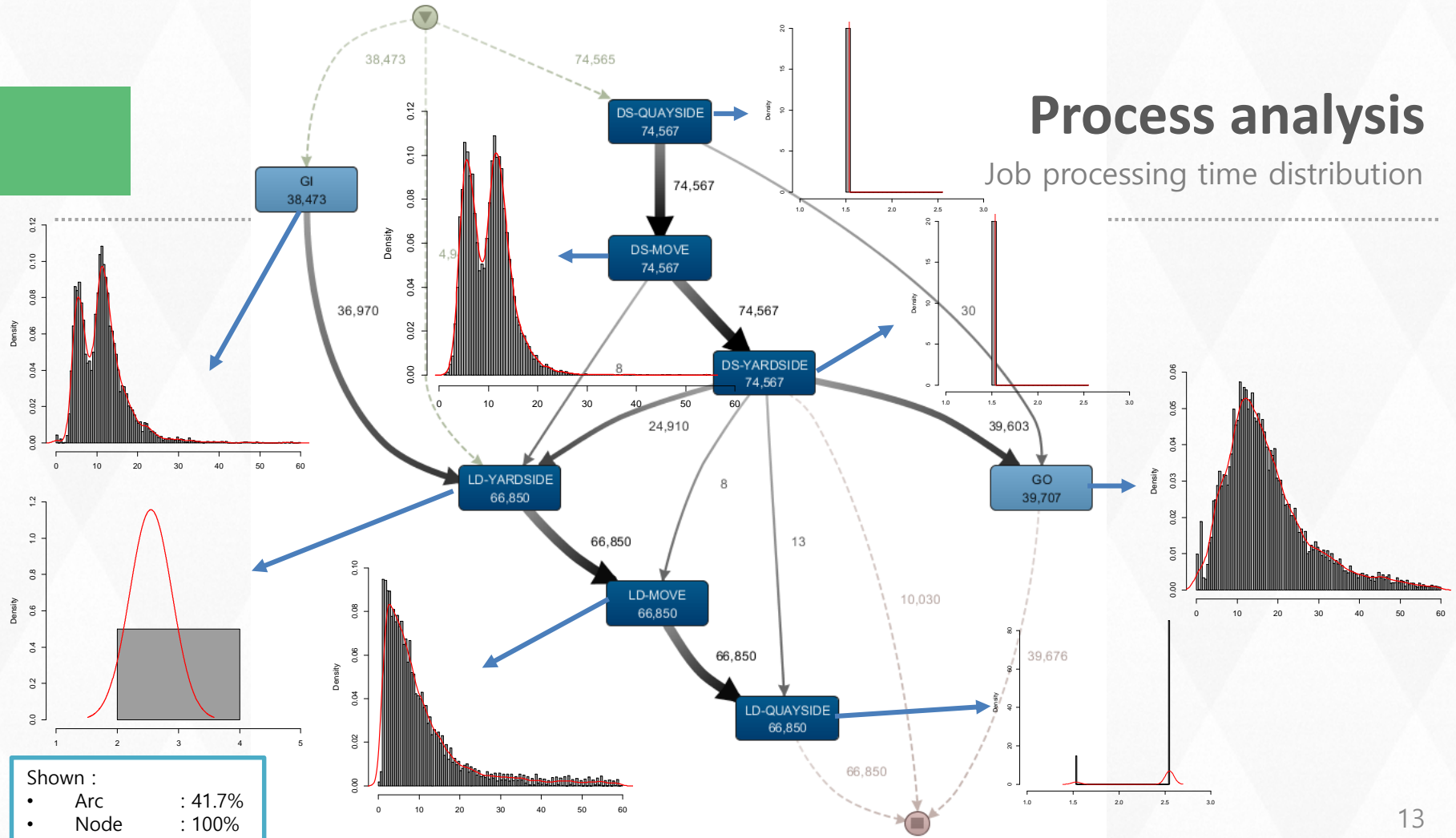


- Fitness: 98.91%
- The model conforms 98.91% of event logs
- Model flexibility: 23.53%



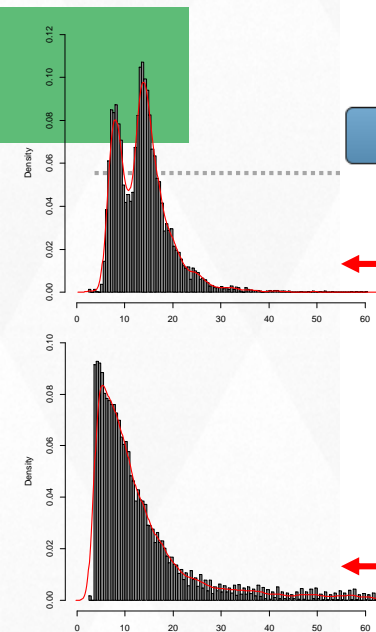
Process analysis

Job processing time distribution



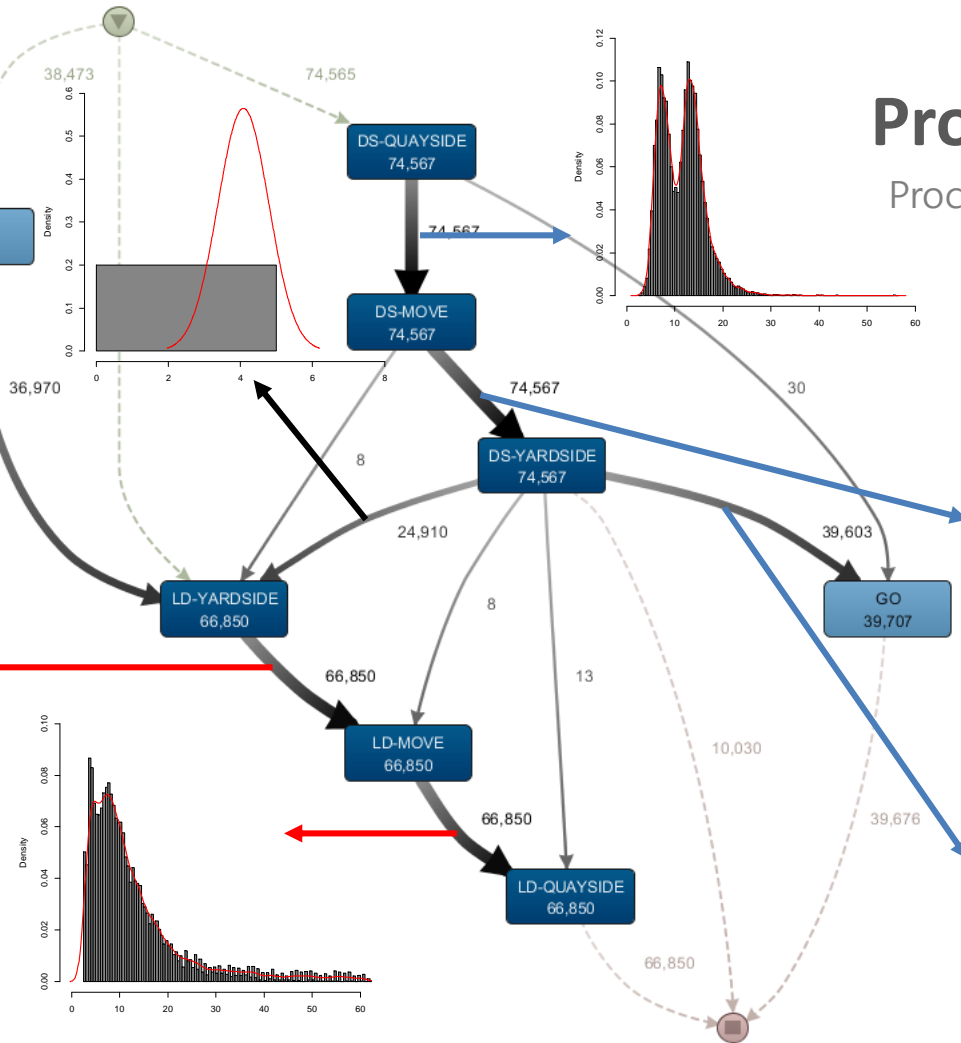
Process analysis

Processing time distribution
between jobs



Shown :

- Arc : 41.7%
- Node : 100%





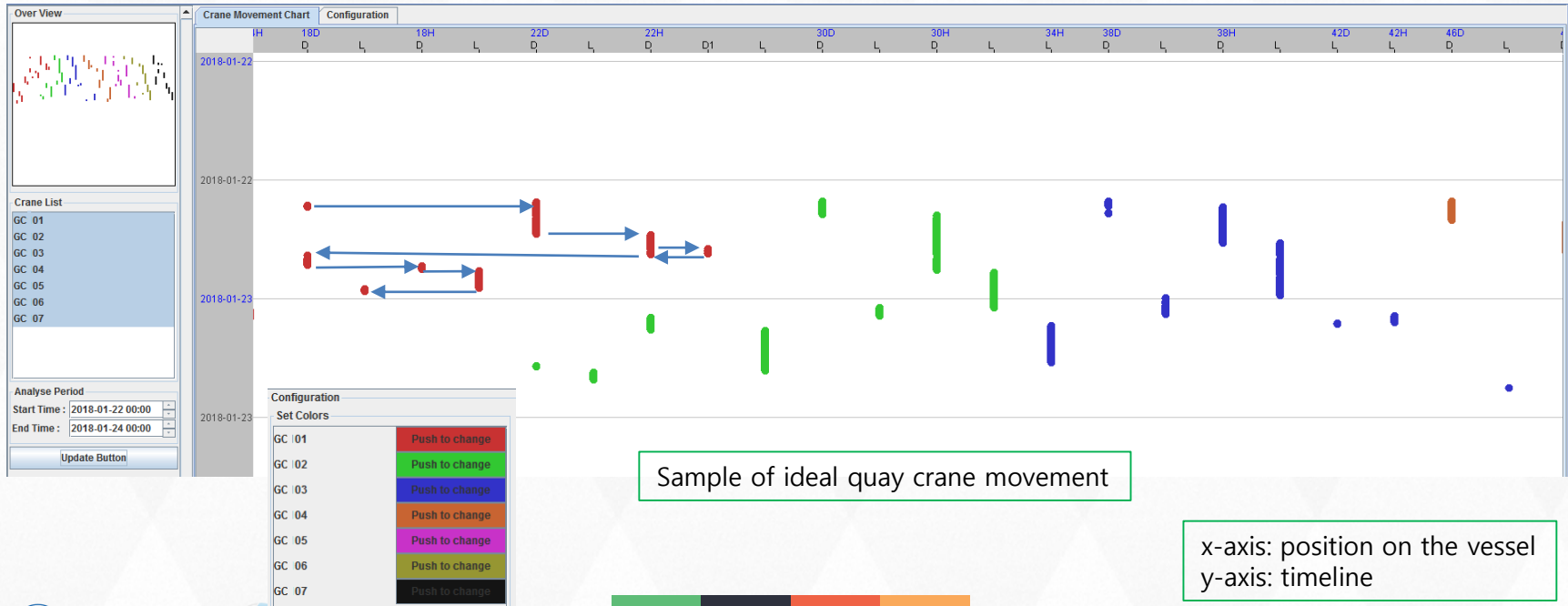
RESOURCE ANALYSIS

Quay crane



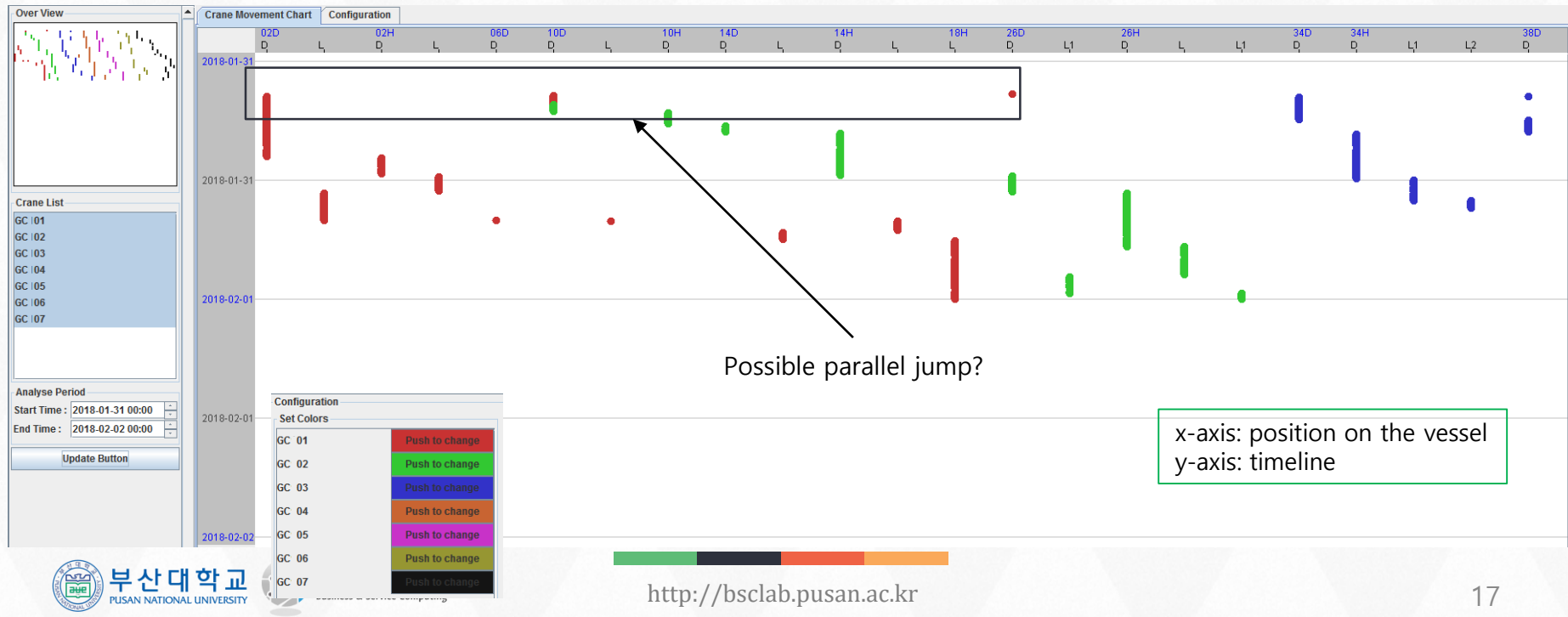
Quay crane movement analysis

Vessel 01



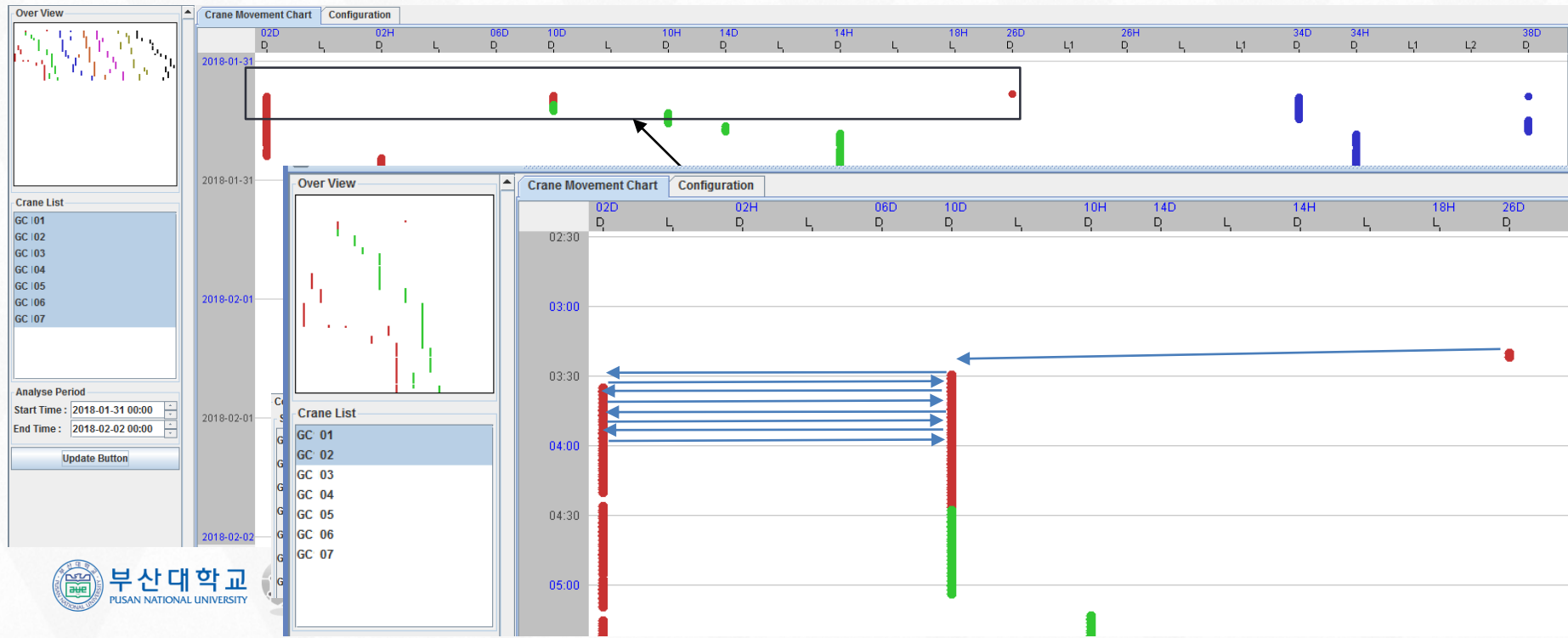
Quay crane movement analysis

Vessel 02



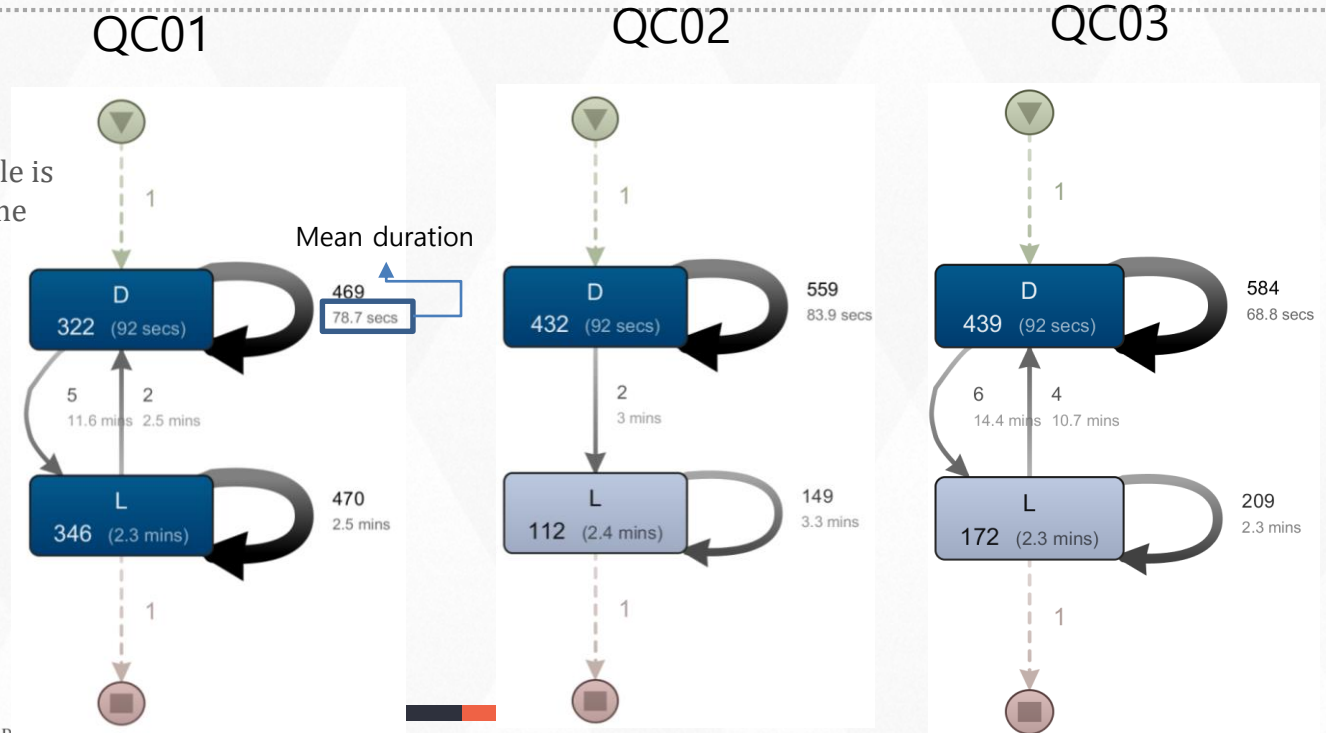
Quay crane movement analysis

Vessel 02

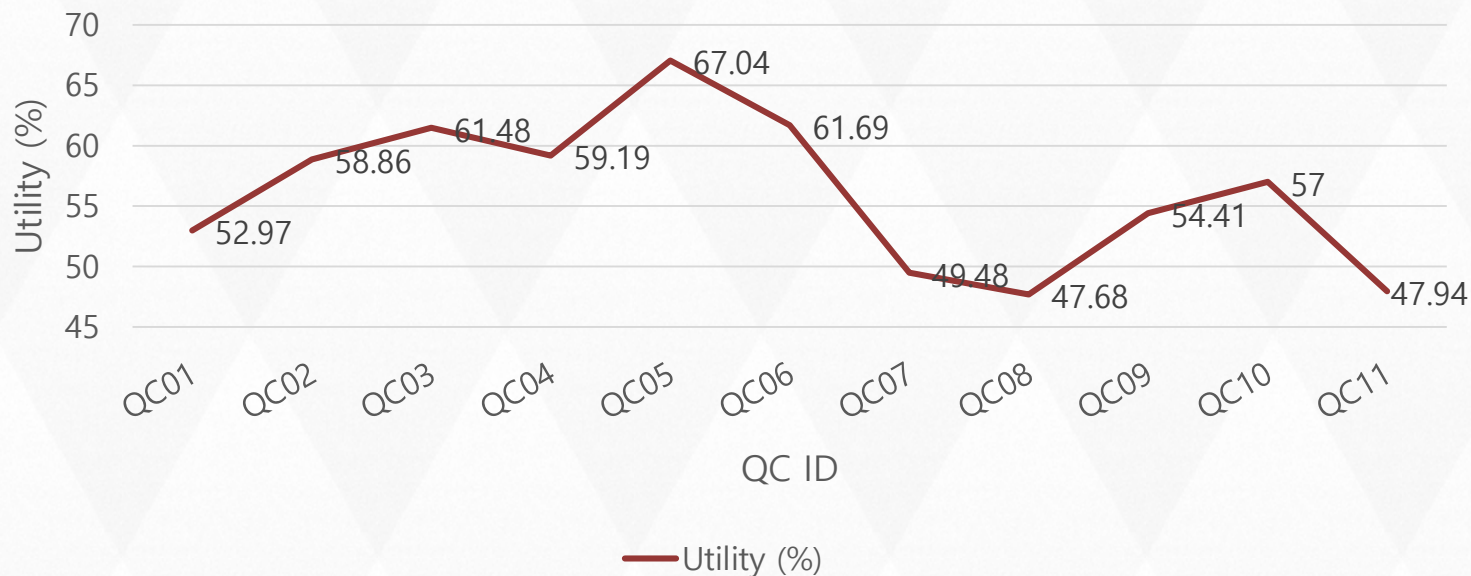


Quay crane dual-cycle analysis

- Vessel V02
- The proportion of dual cycle is quite low in each quay crane



Quay crane utility to duration related KPI





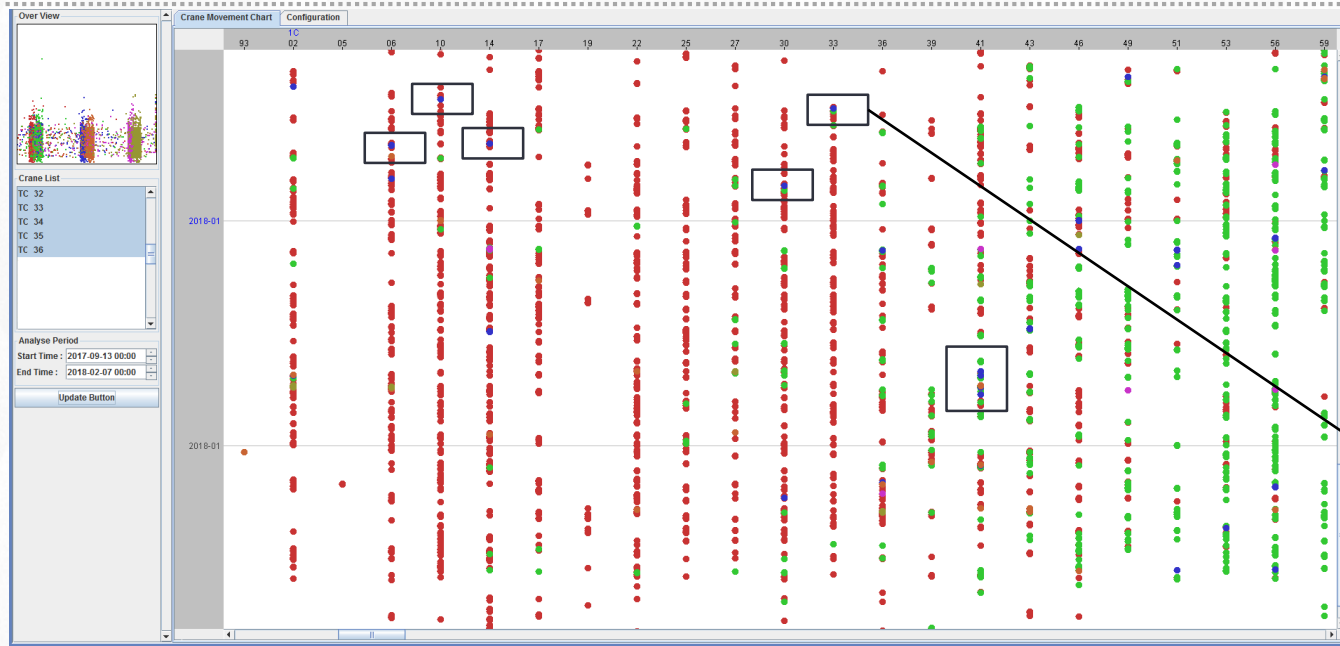
RESOURCE ANALYSIS

Yard crane



YC Movement

YC ID: YC32-YC36



x-axis: block-bay position
y-axis: timeline

Sporadic TC33 job in between TC31 and TC32

YC Workload analysis

Workload of TC11 in one day (Jan 1st 2018)





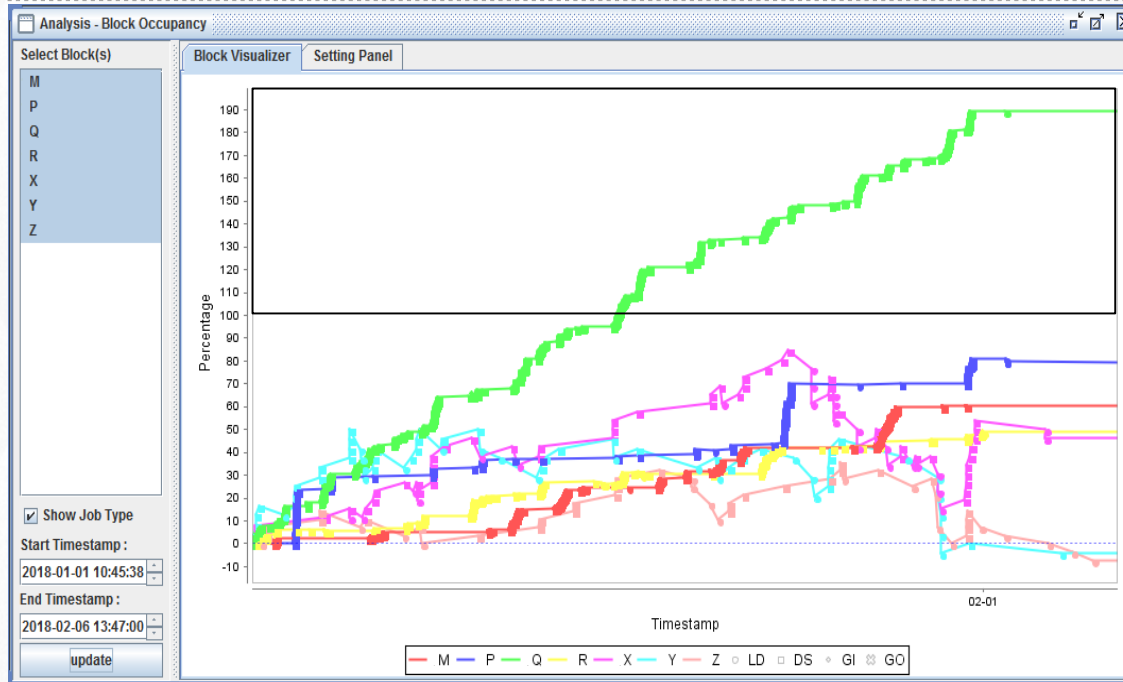
RESOURCE ANALYSIS

Yard block



Block Occupancy

Block M-Z




Block Q has over occupancy (e.g., occupancy more than 100%).

Based on the yard block layout, block Q is used for dry and reefer container.



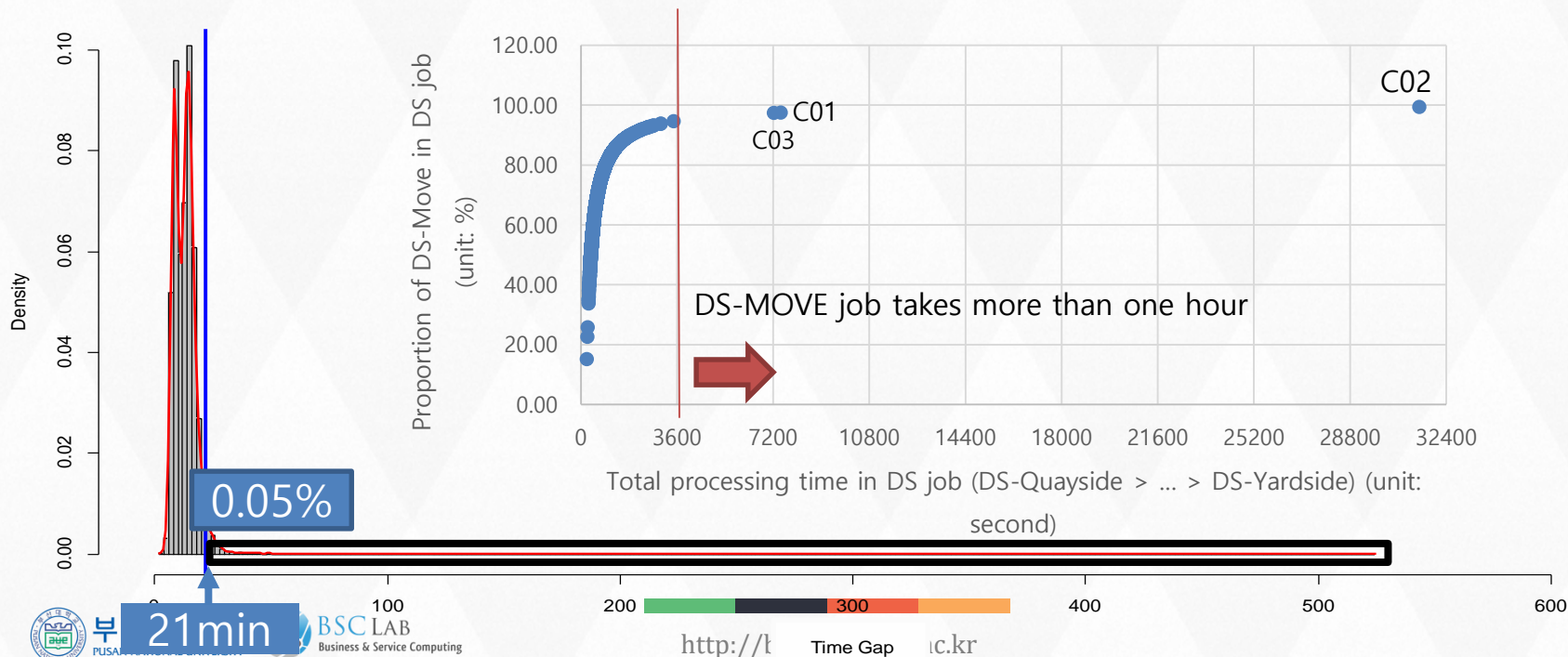
RESOURCE ANALYSIS

Truck job pattern



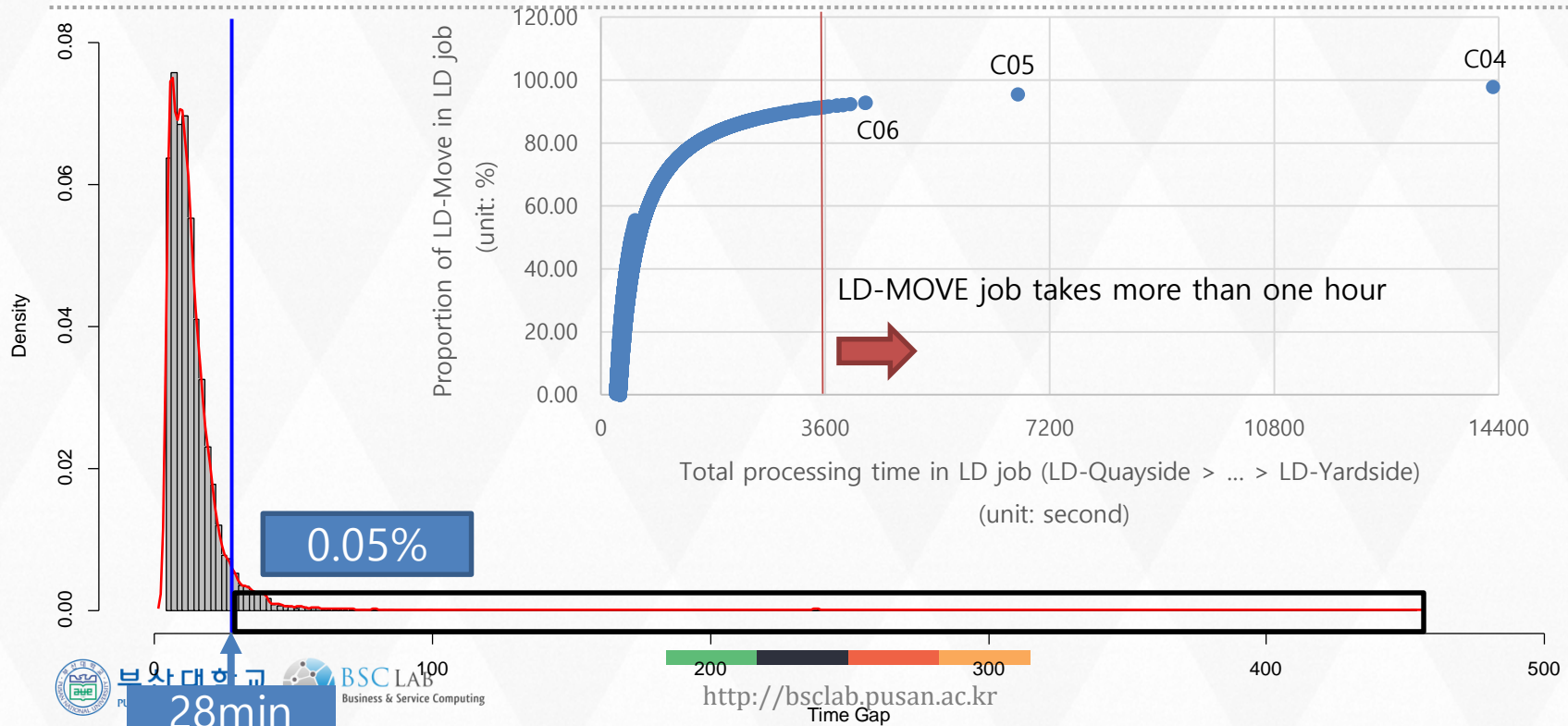
Truck job pattern

Proportion of DS-Move in Discharging jobs



Truck job pattern

Proportion of LD-Move in Loading jobs





ADVANCE ANALYTICS

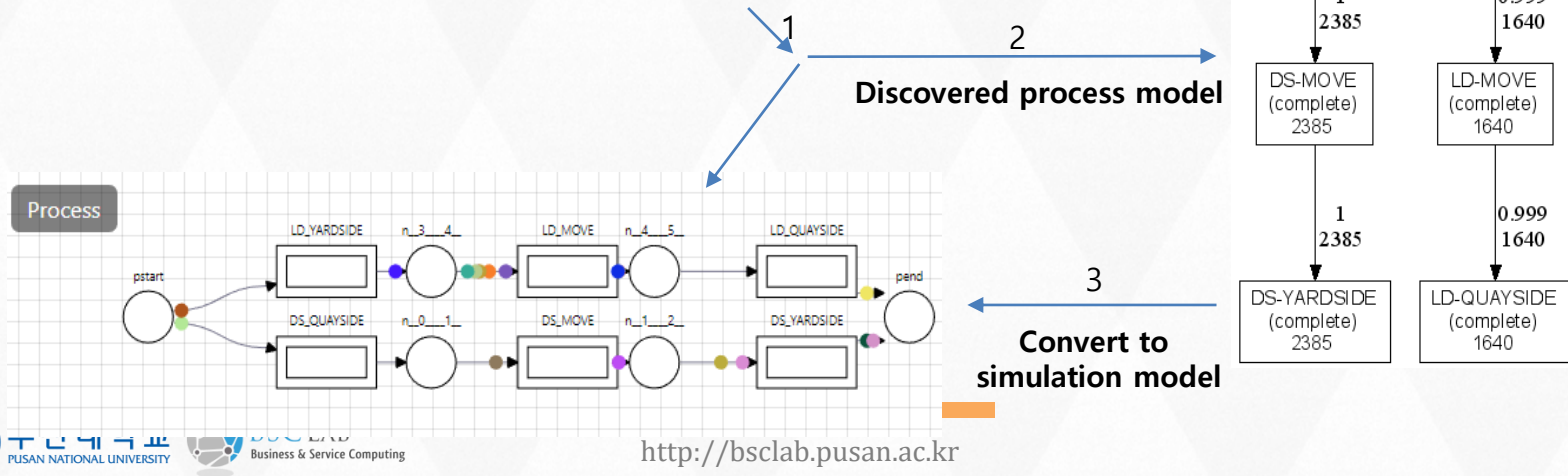
Petri net simulation



Advance analytics

Event log

VESSEL	CONTAINER_NO	MCHN_ID	MCHN_TP_CD	FULL_EMPTY	JOB_TYPE	POD	BLOCK_BAY	JOB_START_DT	JOB_END_DT	OUTSERVICE
V1	C01	QC01	QC	M	DS-QUAYSIDE	KRPUS	M-08	20180106200118	20180106200250	NULL
V1	C01	YT01	YT	M	DS-MOVE	KRPUS	M-08	20180106200250	20180106200736	NULL
V1	C01	YC01	YC	M	DS-YARDSIDE	KRPUS	M-08	20180106200736	20180106200908	NULL
...



Advance analytics

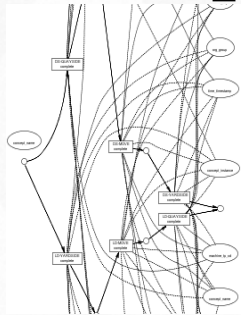
Petri net simulation model generation

VESSEL	CONTAINER_NO	MCHN_ID	MCHN_TP_CD	FULL_EMPTY	JOB_TYPE	POD	BLOCK_BAY	JOB_START_DT	JOB_END_DT	OUTSERVICE
V1	C01	QC01	QC	M	DS-QUAYSIDE	KRPUS	M-08	20180106200118	20180106200250	NULL
V1	C01	YT01	YT	M	DS-MOVE	KRPUS	M-08	20180106200250	20180106200736	NULL
V1	C01	YC01	YC	M	DS-YARDSIDE	KRPUS	M-08	20180106200736	20180106200908	NULL
...

What-if simulation analytics

Decision Point 분석 Organizational 분석

Statistical 분석

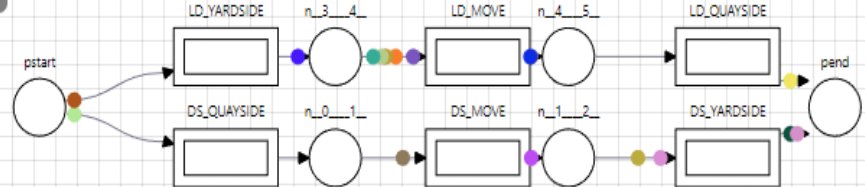


Org Model Manager	Task <=> Org Entity	Org Entity <=> Resource
Add OrgEntity	OrgEntityID	OrgEntityName
Remove OrgEntity	OrgEntityID	OrgEntityName
Change OrgEntity Property	OrgEntityID	OrgEntityName
Add Resource	ResourceID	ResourceName
Remove Resource	ResourceID	ResourceName
Change Resource Property	ResourceID	ResourceName

Activity	Minimum (in Seconds)	Maximum (in Minutes)	Arithmetic Mean (in Minutes)	Standard Deviation	Geometric Mean	Sum (in Minutes)
DS-MOVE	131.0	37.916666666666664	10.931956673654778	304.7802079163517	587.2336847444213	26072.71666666667
DS-QUAYSIDE	92.0	1.5333333333333334	1.5333333333333334	0.0	91.999999999999152	3657.0
DS-YARDSIDE	92.0	1.5333333333333334	1.5333333333333334	0.0	91.999999999999152	3657.0
LD-MOVE	0.0	58.766666666666666	6.915142276422757	463.5304267758185	0.0	11340.833333333334



Process



Advance analytics

Config/Resource	GC	YT	Makespan with 4,028 containers	Throughput	#of containers finished at 74,803 sec
장비구성 1 *	7	94	81,005 sec	0.0497 c/sec	3,717 containers
장비구성 2	7	84	81,168 sec	0.0496 c/sec	3,716 containers
장비구성 3	7	104	80,770 sec	0.0498 c/sec	3,729 containers
장비구성 4	6	94	93,958 sec	0.0428 c/sec	3,212 containers
장비구성 5	6	84	94,124 sec	0.0427 c/sec	3,188 containers
장비구성 6	6	104	93,934 sec	0.0428 c/sec	3,205 containers
장비구성 7	5	94	112,876 sec	0.0356 c/sec	2,664 containers
장비구성 8	5	84	113,037 sec	0.0356 c/sec	2,680 containers
장비구성 9	5	104	112,656 sec	0.0357 c/sec	2,664 containers
장비구성 10	4	94	141,680 sec	0.0284 c/sec	2,130 containers
장비구성 11	4	84	141,712 sec	0.0283 c/sec	2,126 containers
장비구성 12	4	104	141,674 sec	0.0284 c/sec	2,130 containers
장비구성 13	3	94	188,047 sec	0.0214 c/sec	1,595 cases
장비구성 14	3	84	188,032 sec	0.0213 c/sec	1,594 cases
*실제 장비 구성					

Conclusion & future works

- Conclusion:
 - In port logistics, terminal operating systems records every job happens during container handling process.
 - Using these recorded logs we conducted a thorough analysis using process mining technique.
 - Given a port logistics process is a complex process wherein many types of equipment are used, we divided the records into several perspectives that each one, later, are analyzed.
 - Based on the analysis that we do on the data, we found that significant improvement needed to increase the performance of each equipment for container handling process
 - However, the main concern is the abstraction level of jobs is too grain and particular jobs, i.e., rehandling in yard, are not included in this analysis
- Future works:
 - To obtain a more comprehensive analysis, we would like to analyze a more detail job abstraction level
 - Include vessel perspective and road truck perspective that are not included in the present analysis
 - With feedbacks from the domain expert, a recommendation systems can be generated for better operation

Acknowledgements

- This research was partly supported by the MSIT(Ministry of Science and ICT), Korea, under the Grand Information Technology Research Center support program(IITP-2018-2016-0-00318) supervised by the IITP(Institute for Information & communications Technology Promotion) and National Research Foundation of Korea (NRF) grant funded by the Korean government(MEST)(No.NRF-2015R1D1A1A09061331).



THANK YOU

