# Performance Time Evaluation of Domestic Container Terminal using Process Mining and PERT

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***Abstract-Excellent Service is one of the goals of the company which is always leveled and maintained. One of the performance assessments the main service of a terminal is how fast the loading and unloading process. Evaluation of loading and unloading analyzes the number of cranes unload or load in hours, which is usually called Crane Box Hour (CBH). The performance evaluation especially the loading and unloading analyzes each process and the recorded event log in Terminal Operating System (TOS) system. Optimizing the service time is carried out by analyzing the event log using Alpha ++ and PERT Algorithms. It was shown that the problem (bottleneck) occurred clearly, and was visualized to evaluate the Critical Path.***

***Keywords-****Loading and Discharge Performance, Mirah Terminal, Multipurpose Terminal, Domestic, Styling, BCH (Keyword)*

## I. INTRODUCTION

The terminal handles domestic container services at Tanjung Perak Port includes: PT. TPS, PT. BJTI, PT. TTL, Patchouli Terminal, and Mirah Terminal. Mirah Multipurpose Terminal main services is the container service in addition to the non-container service segment. With the spirit of change and domestic terminal services structuritation, Mirah Terminal is required to clean up and evaluate work performance of loading and unloading. With the effectiveness of loading and unloading performance, will be able to reduce logistics costs because it will reduce the cost of ship mooring, container accumulation costs in the terminal and other time-related surcharge. The basic concept of domestic container service is based on performance of ship loading and unloading services measured by Crane Box Hour (CBH)

### 1.1 Mirah Terminal Profile

Mirah terminal is one of the terminal under Tanjung Perak Branch management. Mirah Terminal is a multipurpose terminal serving the loading / unloading activities of Container or Non-Container (General Cargo, Bag Cargo, Dry, Motorcycle or Car). The largest business segment of this Terminal is loading and unloading services of containers [1]. Mirah Terminals have a land with a length of 640 meters, 15 meters wide, and into a 6 meter LWS pool. Performance standards set management is 10 Box or Crane / Hour, and 60 minutes Shipping Delivery Service. Mirah Terminal has a facility of 2 units of 40 Ton Tire Rubber Tyred Gantry, and Warehouse covering 13,440 M.


Fig.1 Mirah Terminal Area

### 1.2 Terminal Service

Mirah Terminal serves loading and unloading of containers. In the loading service process, management requested to do 75% stack first and the rest will be done by truck closing. As for unloading service done losing due to limited field capacity. Service is carried out in a package that consists of:

- **Loading Process**
  a. Loading Package
  b. Receiving Truck Loosing Package
- **Discharge Process**
  Delivery Loosing Package

In the process of handling or container handling in the port, the activities included in it are:

1. Receiving is the activity of Container movement from hinterland / out through in gate to Container yard (CY) / stacking field to stack / stacked.
2. Loading: is the Container movement activity in the Container yard (CY) / piling field to the dock to the ship to load
3. Unloading / discharge - is the activity of Container movement from ship to Container yard (CY) / stacking field to stack / stacked.

4. Stevedoring - is the work of unpacking the container from the hold of the vessel to the top of the chassis / dock or vice versa by using a ship crane or ground crane
5. Trucking / haulage - is the work of transporting a container by using a chassis within the working area of the port of the hull of the vessel to the Container yard (CY) / stacking field or vice versa.
6. Lift on - is the work of lifting the Container from the container to the top of the chassis using a transtainer / top loader or other device.
7. Lift off - is the work of lifting the Container from the top of the chasis to the stacking place by using transtainer / top loader or other tool.
8. Stacking: is the work of constructing a Container in a Container yard (CY) / stacking field or other container.

## II. LITERATUR REVIEW

### 1.1 Standard of Loading and Unloading Performance

The Government, in this case the Ministry of Transportation of the Directorate General of Sea Communications, has issued the Regulation of the Director General of Sea Transportation number: HK.103 / 2/18 / DJPL-16 on Port Operation Performance Standards at Commercial Operated Ports. The regulation has been stipulated that Mirror Conventional Terminal BCH = 10 per Container / Crane / Hour, BSH = 10 Container / Ship / Hour, Receiving Service = 60 Minutes, and Delivery Service = 90 Minutes.

### 1.2 SPINER

SPINER is a Terminal Operating System called Terminal Operation System (TOS), an application used to record container transactions for domestic terminal services. The Terminal Operation System is a system where the system itself serves as a guide in performing its activities to manage all activities that run in the terminal area.

The SPINER application can record ship arrival planning, start work, request process, bill issuance process, payment process, pranota process, billing process, note issuing process integrated with ERP (ie SAP). Not only record the transactions, SPINER has Event Logs that can be derived and analyzed. It can provide data to support multi-criteria analysis decision [3]. This approach allowed for a transparent, safety, auditable and reproducible strategy in the processes of Discharge and Loading [4].

### 1.3 Mining Process with Alpha++ Algorithm

A method which used to mine the process sequence in the event logs is called Mining Process [5] . The algorithm used in this performance evaluation is the Alpha ++ algorithm. The Alpha ++ algorithm is an algorithm that can detect / catch an implicit relationship or dependency between processes [6]. Not only that, Alpha ++ is chosen because of its advantages compared to other Alpha algorithms. Described in the journal Van der Alast that Alpha algorithm expanded into Alpha + and expanded again to Alpha ++ [7].

### 1.4 PERT

Program assessment and assessment technique which is known as PERT is a network model able to mapping the completion of random activities [8]. PERT diagram has two main components of activities (activities) and milestone events / events (milestones) [9]. Both components are characterized by arcs and dots. Activities are depicted on arcs and milestones depicted on dots (circles).

The PERT making plans process consists of the subsequent steps:

- Discover precise sports (sports) and milestones,
- Decide the precise sequence of sports,
- Version a network diagram,
- Estimating the time required for each pastime,
- Determine vital tiers and pathways,
- Reveal and examine and accurate the PERT diagram for the duration of the challenge.

## III. EXPERIMENT AND DISCUSSION

To know the performance of loading and unloading one cycle must be done by using:

a. Describes Business Processes using YAWL

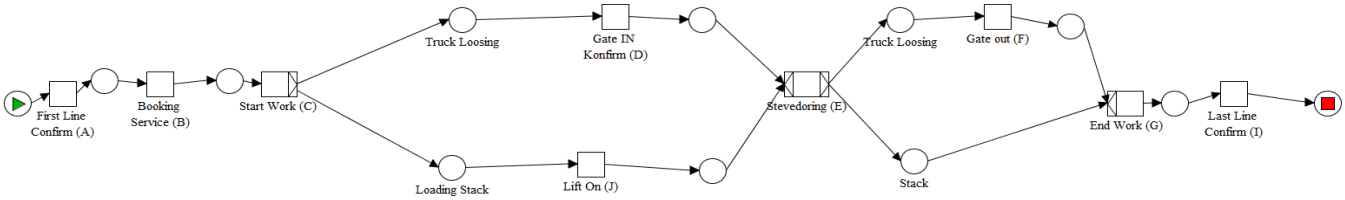



Fig.2 Domestic Terminal Business Process

The loading and unloading process of Container is generally made after confirmation from the Shipping Agent prior to the Start Working Process of Loading and Unloading [2].

Event log can be derived from Terminal Operating System (in SPINER application) [10]. The eventlog format is a text that can be converted into a csv extension file.

As follows

b. Downloading Event Log data on the system

| KD_CABANG | KD_TERMINAL | CASE_ID | VOYAGE_NO | CONTAINER_NO | SERVICE_CODE | ACTIVITY | TRANS_DATE | RESOURCES | COSTS |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6009628 | I000000020170202009 | TAKU6009628 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6013741 | I000000020170202009 | TAKU6013741 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6014408 | I000000020170202009 | TAKU6014408 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6020545 | I000000020170202009 | TAKU6020545 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6022471 | I000000020170202009 | TAKU6022471 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6023713 | I000000020170202009 | TAKU6023713 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020139TAKU6026040 | I000000020170202009 | TAKU6026040 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6026190 | I000000020170202009 | TAKU6026190 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |
| 2 | 2 | I0000000201702020090217 09DCL020136TAKU6042077 | I000000020170202009 | TAKU6042077 | DCL | Firstline Confirm | 30/09/2017 12:00 | Foreman | 3500 |

Fig.3 Csv Extension Files from Eventlogs

From the csv file can be converted into file with. mxml.gz extension by using the help of disco application.

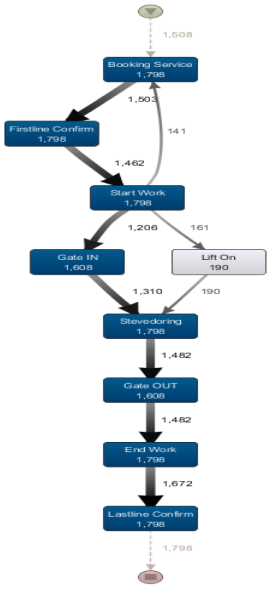



Fig.4 Result Import Data csv eventlogs.

After that, done export data form format mxml.gz. by pressing the Export Data button


Fig.5 Button Export Data

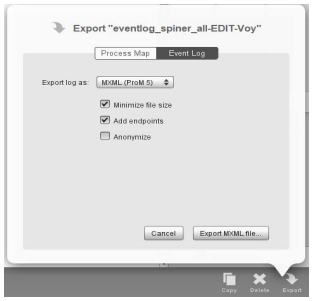



Fig.6 Export data ke format mxml.gz

Then select menu Export data into MXML (Prom 5) that this .mxml.gz file types can then be processed and carried out mining process [12].

c. Time Evaluation, using Performance Analysis with Petri Net using Alpha Algorithm.

The first process for evaluation is, that it must first be simulated business flow with Alpha ++ (Fig.7).

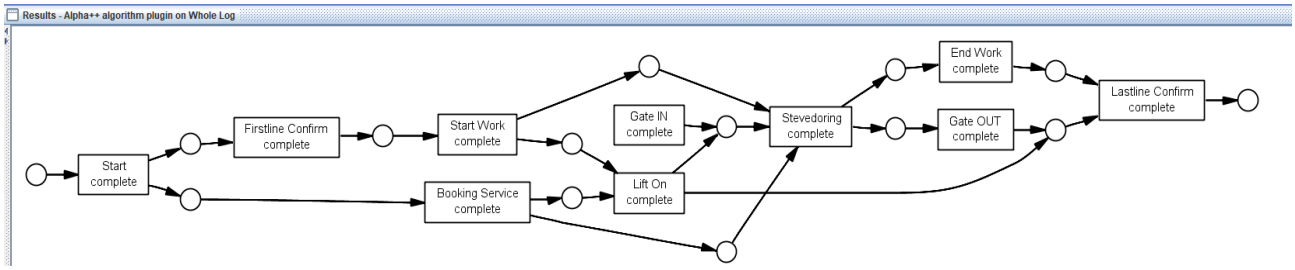



Fig.7 Business Simulation Flow with Alpha++

Thereafter, it is necessary to evaluate whether the Alpha ++ generating process is appropriate or close to the business processes of the company [11]. Furthermore, to evaluate the time in detail can be done Performance Analysis with Petri net [13]. Fig.8 is Simulation Result of Performance Analysis with Petri net [14].

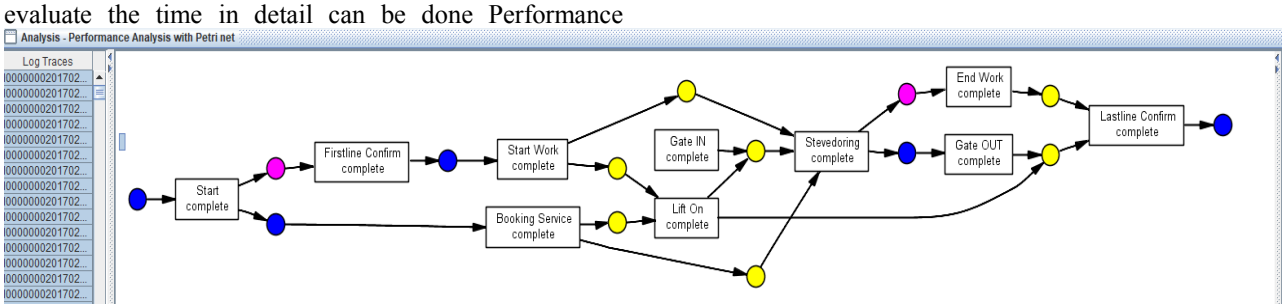



Fig.8 Simulation Performance Analysis with Petri net

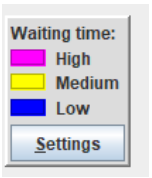



Fig.9 Waiting Time

Fig.9 this is the description of waiting Time for Simulation overall performance analysis with Petri net. With the aid of using performance assessment evaluation with Petri net, can understand the highest waiting time point [15]. There are two points that have a high waiting time that is between start complete and first line confirm complete is in Fig.10

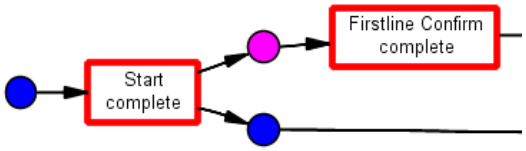



Fig.10 High Waiting Time Start Complete dan Firstline Confirm Complete.

Evaluation of transaction time between start process and first line confirm complete average 12.9 hours and the highest time is 24.75 hours. To see the detail can be seen in Fig.11 Evaluation of Transaction Time between Start process and Firstline Confirm Complete.

| | Time in between (hours) |
|---|---|
| avg | 12.9 |
| min | 0.0 |
| max | 24.75 |
| stdev | 9.59 |
| fast 25.00%... | 0.19 |
| slow 25.00... | 24.3 |
| normal 50.0... | 13.55 |

Fig.11 Evaluation of Transaction Time between Start process and Firstline Confirm Complete

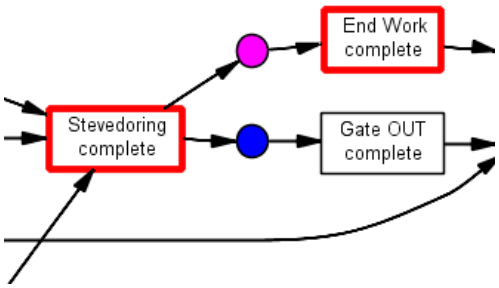



Fig.12 High Waiting Time Tinggi between Proses Stevedoring Complete process and End Work Complete

The second point observed has a high waiting time that is in Fig.12 Waiting Time High between Stevedoring Complete and End Work Complete.

Evaluation of transaction time between Stevedoring process complete and end work confirm complete average 13.93 hours and the highest time is 50.03 hours. To see the detail can be seen in Fig.13 Evaluation of Transaction Time between Stevedoring Complete and End Work Complete process.

| | Time in between (hours) |
|---|---|
| avg | 13.93 |
| min | 0.02 |
| max | 50.03 |
| stdev | 13.14 |
| fast 25.00%... | 2.2 |
| slow 25.00... | 33.43 |
| normal 50.0... | 10.03 |

Fig13 Evaluation of Transaction Time between Stevedoring Complete and End Work Complete process

d. Evaluation of Time by using Performance Sequence Diagram Analysis

Evaluation per service flow can be seen from Fig.14 which is flow of one transaction cycle. There are 15 transaction cycle patterns and have varying averages per transaction.

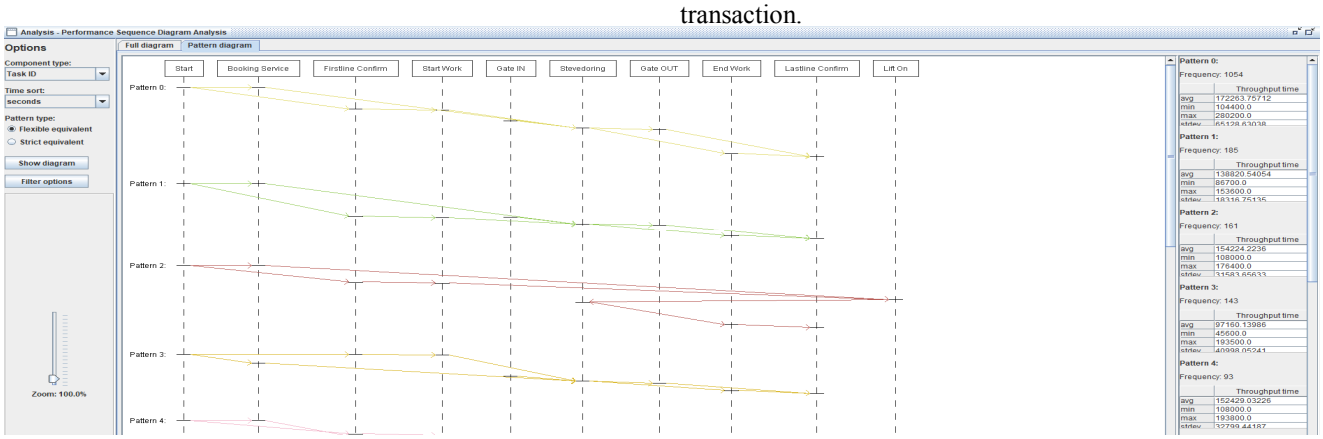



Fig.14 Average evaluation of transaction time

By using PROM it can be used to evaluate the average of service activities that is in Fig.15. Delivery Loosing service has an average of 41.99 hours, Receiving loosing has 43.31 hours on average and Loading has an average of 44.43 hours.

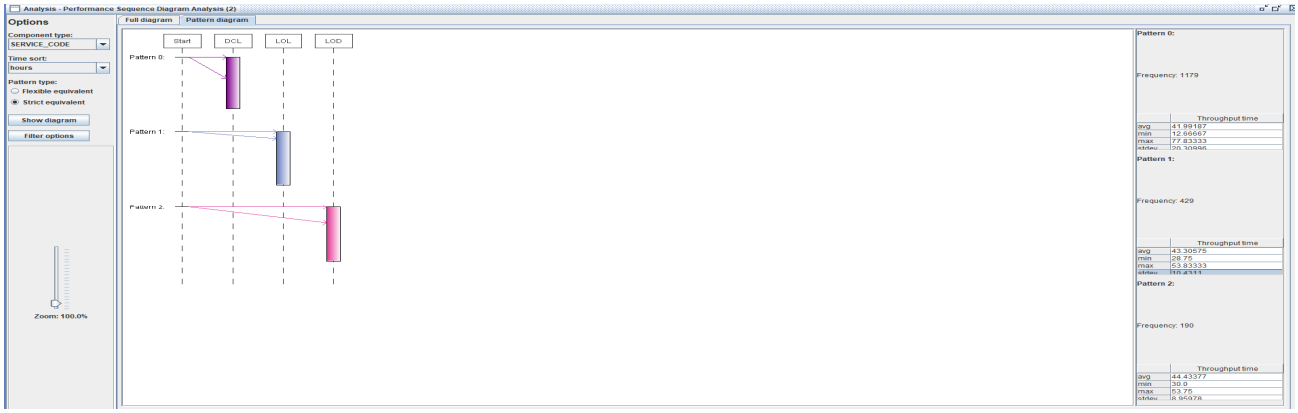


Fig.15 Average evaluation of transaction time per service

e. Evaluation of Pert

Calculate optimistic, general and pessimistic time of domestic container service. Fig.16 is Figure of service process flow and optimistic service time.

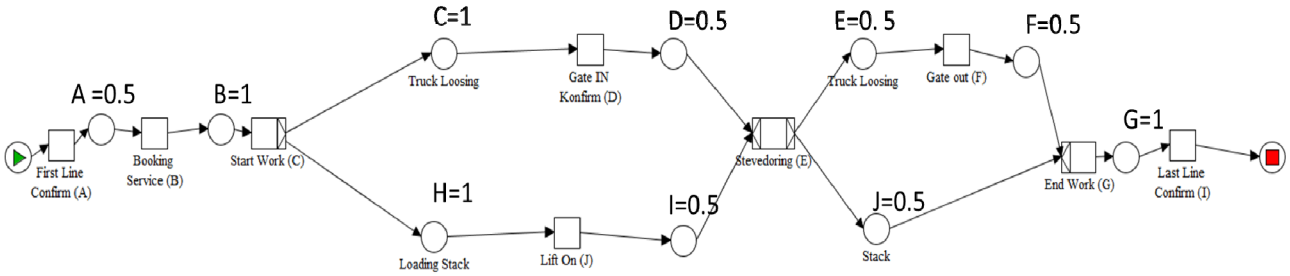



Fig.16 Service Process Flow and optimistic time

After that, the calculation is done by filling the PERT table in Fig.17. The table contains the Activity Name, previous activity, optimistic time, normal time, and pessimistic time.

| Activity Number | Activity Name | Immediate Predecessor (list number/name, separated by ',') | Optimistic time (a) | Most likely time (m) | Pessimistic time (b) |
|---|---|---|---|---|---|
| 1 | A | | 0.25 | 0.5 | 1 |
| 2 | B | A | 0.1 | 1 | 3 |
| 3 | C | B | 0.3 | 1 | 2 |
| 4 | D | C | 0.2 | 0.5 | 1 |
| 5 | E | D | 0.25 | 0.5 | 2 |
| 6 | F | E | 0.25 | 0.5 | 1 |
| 7 | G | F,J | 0.3 | 1 | 2 |
| 8 | H | B | 0.25 | 1 | 2 |
| 9 | I | H | 0.1 | 0.5 | 1 |
| 10 | J | I | 0.3 | 0.5 | 1 |

Fig.17 PERT Table

From the results of the run table will show the results of evaluation as shown in Fig.17

| 05-13-2018 04:28:26 | Activity Name | On Critical Path | Activity Mean Time | Earliest Start | Earliest Finish | Latest Start | Latest Finish | Slack (LS-ES) | Activity Time Distribution | Standard Deviation |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A | Yes | 0.5417 | 0 | 0.5417 | 0 | 0.5417 | 0 | 3-Time estimate | 0.125 |
| 2 | B | Yes | 1.1833 | 0.5417 | 1.725 | 0.5417 | 1.725 | 0 | 3-Time estimate | 0.4833 |
| 3 | C | Yes | 1.05 | 1.725 | 2.775 | 1.725 | 2.775 | 0 | 3-Time estimate | 0.2833 |
| 4 | D | Yes | 0.5333 | 2.775 | 3.3083 | 2.775 | 3.3083 | 0 | 3-Time estimate | 0.1333 |
| 5 | E | Yes | 0.7083 | 3.3083 | 4.0167 | 3.3083 | 4.0167 | 0 | 3-Time estimate | 0.2917 |
| 6 | F | Yes | 0.5417 | 4.0167 | 4.5583 | 4.0167 | 4.5583 | 0 | 3-Time estimate | 0.125 |
| 7 | G | Yes | 1.05 | 4.5583 | 5.6083 | 4.5583 | 5.6083 | 0 | 3-Time estimate | 0.2833 |
| 8 | H | no | 1.0417 | 1.725 | 2.7667 | 2.45 | 3.4917 | 0.725 | 3-Time estimate | 0.2917 |
| 9 | I | no | 0.5167 | 2.7667 | 3.2833 | 3.4917 | 4.0083 | 0.725 | 3-Time estimate | 0.15 |
| 10 | J | no | 0.55 | 3.2833 | 3.8333 | 4.0083 | 4.5583 | 0.725 | 3-Time estimate | 0.1167 |
| | Project | Completion | Time | = | 5.61 | HOURs | | | | |
| | Number of | Critical | Path(s) | = | 1 | | | | | |

Fig.18 Activity Analysis PERT

PERT simulation can also be done the number of observations 1000. Fig.19 PERT simulation results can be evaluated Average service is 5.60 hours.

| 05-13-2018 | Completion Time From | To (included) | Frequency | % | Cumulative % |
|---|---|---|---|---|---|
| 0 | 0 | 1.67 | 0 | 0.0000 | 0.0000 |
| 1 | 1.67 | 2.06 | 0 | 0.0000 | 0.0000 |
| 2 | 2.06 | 2.46 | 0 | 0.0000 | 0.0000 |
| 3 | 2.46 | 2.85 | 0 | 0.0000 | 0.0000 |
| 4 | 2.85 | 3.24 | 0 | 0.0000 | 0.0000 |
| 5 | 3.24 | 3.64 | 1 | 0.1000 | 0.1000 |
| 6 | 3.64 | 4.03 | 4 | 0.4000 | 0.5000 |
| 7 | 4.03 | 4.43 | 30 | 3.0000 | 3.5000 |
| 8 | 4.43 | 4.82 | 89 | 8.9000 | 12.4000 |
| 9 | 4.82 | 5.21 | 171 | 17.1000 | 29.5000 |
| 10 | 5.21 | 5.61 | 225 | 22.5000 | 52.0000 |
| 11 | 5.61 | 6.00 | 201 | 20.1000 | 72.1000 |
| 12 | 6.00 | 6.40 | 148 | 14.8000 | 86.9000 |
| 13 | 6.40 | 6.79 | 79 | 7.9000 | 94.8000 |
| 14 | 6.79 | 7.18 | 38 | 3.8000 | 98.6000 |
| 15 | 7.18 | 7.58 | 13 | 1.3000 | 99.9000 |
| 16 | 7.58 | 7.97 | 1 | 0.1000 | 100.0000 |
| 17 | 7.97 | 8.37 | 0 | 0.0000 | 100.0000 |
| 18 | 8.37 | 8.76 | 0 | 0.0000 | 100.0000 |
| 19 | 8.76 | 9.15 | 0 | 0.0000 | 100.0000 |
| 20 | 9.15 | 9.55 | 0 | 0.0000 | 100.0000 |
| 21 | 9.55 | and over | 0 | 0.0000 | 100.0000 |
| | Total | Observations = | 1000 | Random Seed = | 27437 |
| | Average | Completion | Time = | 5.60 HOURs | |
| | Chance | to finish in | 0 HOURs | = 0.0000% | |

Fig.19 PERT Results of Simulation

For the PERT evaluation method can also map, which Critical Path becomes the main time of service. Fig.20 is a Critical Path diagram PERT.

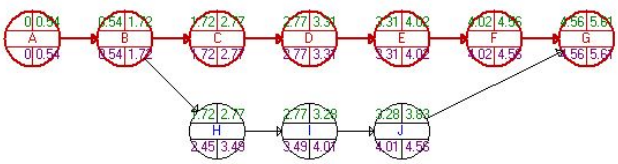



Fig.20 Critical Path PERT diagram

Fig.21 is a Figure Gantt chart with a description of the critical path of the service process.

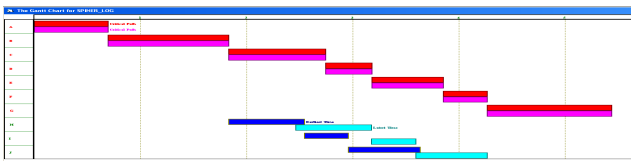
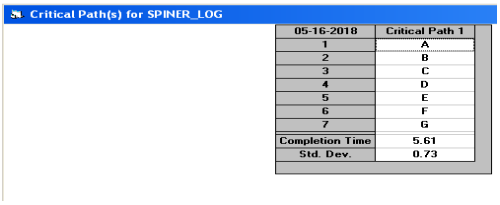


Fig.21 PERT Gantt Chart

Critical Path is a technique of analyzing network activities / activities when running a project in order to predict the total duration. A project's critical path is a sequence of activities that determines the fastest time possible for a project to be completed. With PERT we can know Critical Path that is on Fig.22 [16].



Critical Path(s) for SPINER_LOG

| 05-16-2018 | Critical Path 1 |
|---|---|
| 1 | A |
| 2 | B |
| 3 | C |
| 4 | D |
| 5 | E |
| 6 | F |
| 7 | G |
| Completion Time | 5.61 |
| Std. Dev. | 0.73 |

Fig.22 Critical Path(s)

## IV. CONCLUSIONS

From the above description and analysis, the author can make the following conclusions:

a. Evaluation by using Mining Process can be used to find out high waiting process

b. Mining process can also be evaluated at time per-service or per-activity so that it can be done evaluation or improvement.

c. Using a combination of PERT methods can be used to determine the Critical Path, which further determines which activities can be aligned or serialized (sequential)

d. For this problem, found 2 points that have a long waiting time is to start of first line and Stevedoring to end work. This can occur due to changes in ship arrival schedule, wait for the load, and the damage of loading and unloading tools.

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