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Business Process Improvement of Production Systems Using Coloured Petri Nets

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ABSTRACT

The quality of information systems affects the company's business performance. Therefore, it is necessary to analyze business processes to determine any discrepancies between the planned business processes and the actual ones. Based on the results of this analysis, the business process can be improved. The fundamental factor of manufacturing companies is production process. In reality, there are many discrepancies between the actual business processes with the pre-planned, so that there should be analyzed. The analysis can be performed by modeling the business process using Coloured Petri Nets (CPN). In this study, the objectives are to determine the level of conformance checking of business processes, reachability graph and the bottleneck analysis. The results of the analysis are used to construct a recommended model. Based on the analysis of the case study, e.g. a steel industry in Indonesia, the recommended model has a better value than initial model.

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1. INTRODUCTION

The rapid development of information and communication technologies affects the dependence of business industry on information systems, i.e. the dependence will be increasing. In other words, the quality of information systems affects a company's business. One of the things that affect the quality of information systems is their maintenance. One of system maintenance activities is to evaluate the information systems whether some parts of the system are not in accordance with the conditions of the current company.

One of the information systems used by many companies today is the Enterprise Resource Planning (ERP). ERP is an information system that supports the business processes of an organization [1]. There are a lot of companies that take advantage of ERP, such as a manufacturing company. The production processes have a structured planning. But in reality, the process of production does not always smoothly according to the planned business process. Incompatibility of the production process leads to problems in production and cause delays in production. That is because the actual business process has some differences compared with the plan. On the other hand, at one time, the company was not only producing one product or request from the customer. Production delays that do not fit the plan may affect customer confidence to the company. Thus it is necessary to determine cause of the delay in production process, location of the delay and duration of the delay. The analysis can be done by using the model of the actual business processes. The actual data can be obtained from the event log or database owned by the company's production system.

Event log is history data of a system [2]. Process mining is required to analyze the event log and business process models in order to obtain information about the company's performance. Then the process

mining can analyze the correspondence between the planned business processes with actual conditions that occur in the production process. In addition, the analysis also obtains information about the average time of each activity. Then we can infer the activities experiencing a delay and duration of the delay occurred. The results of the analysis can be considered to evaluate the implemented business processes.

The business process of production is a complex system that requires modeling business processes that can provide a better understanding. Coloured Petri Nets (CPN) is a model that can describe complex systems of manufacturing and logistics processes such as transportation, inventory, order processing, warehousing, distribution and production [3]. Based on the research conducted by Robles, models of Coloured Petri Nets (CPN) could provide a better understanding of the business processes of the textile industry. With a better understanding of the business processes, it can analyze the performance of the business processes that are implemented by the company.

Some studies related to Coloured Petri Net, among others, performed by WMP van der Aalst that discusses modeling and analysis of logistic systems using Coloured Petri Nets [4]. The study aims to investigate the contribution to the performance of the logistic component of corporate organizations to obtain information regarding the production of goods with a shorter time and at a competitive price. It demonstrated the performance of logistics model process using time in CPN. Gharehchopogh and Soufizadeh have analyzed the correctness and authenticity of DHCPs with the use of and to prove the accuracy of a protocol's performance [5].

Based on the description above, we analyze the business process of production systems using Coloured Petri Nets (CPN). The CPN can be used to analyze the performance of business processes. Our proposed approach is as follows. First we collect the data from event log and build a model of Petri nets. Then we analyze the model such as conformance checking, reachability and bottleneck. Next, the Petri Nets are transformed into Coloured Petri Nets. Finally, the conclusion is drawn according to the results of analysis and simulation.

2. PRELIMINARIES

This section introduces some notions, models and properties that are used in the sequel.

2.1. Event Log

In general, any information system keeps their records for every event on log to monitor the course of a process. The records are forms of data or audit trails of transactions [6]. As time goes by, the activities that are using the information system are increasing then the event logs are growing. Event log is a record of history that contain a sequence data of activities. Event log contains data about an event that refers to each case and activity. In most systems, the event log contains a timestamp, the executor and some additional data [4], [6]. Information on the business process can be obtained through the event log of information systems of a company. The analysis is conducted prior to the event log mining process [7].

2.2. Business Processes and Business Concept

Business processes are measurable and structured activity to produce a specific output for a particular customer circles. Davenport explains that a process is a specific sequence of work activities across time and space with a prefix, suffix, and clearly define the input and output [8].

In general, a manufacturing company has a business process that is run by eight departments, namely marketing and sales, engineering design, manufacture operation (MO), PPIC, procurement, logistics, production and shipping. These are following respective of subject:

a. Marketing sales: seeking customers and receive orders.
b. Design engineering: planning for material on a project to work on and make an estimated cost.
c. Manufacture operation: create a work order, the pricing plan the project in detail and then compare it with the price of materials from suppliers, but MO also issued a delivery letter of finished products to the customer.
d. PPIC: make a list on the availability of materials and labor scheduling.
e. Procurement: make a reservation of materials to the supplier.
f. Logistics: as materials warehouse production and accept the arrival of materials from suppliers.
g. Manufacturers: doing the fabrication process to finish goods.
h. Shipping: arrange the delivery of goods which have been finished to the customer.

2.3. Process Mining

A process is a specific sequence of work activities across time and space, with a prefix and suffix, and clearly define the input and output [8]. Process mining is the process of getting information from the

database in the form of a pattern by using a particular method of mining. The purpose of the process is to find out the information that was previously not known manually. There are three types of process mining [1]:

a. Discovery: the process mining without involving the process model. Business process model is only formed from the existing event log.
b. Conformance: involving models of the processes. The purpose of this type of process mining is to examine whether the existing model is in accordance with that occurs in reality, i.e. check whether data recorded in the log is in accordance with the model or vice versa.
c. Extension: involving a process model. The model is expanded with a new aspect. The goal is not to check the conformity but to enrich the existing model. In this work, we analyze a process that involves process mining of the type conformance.

2.4. Business Process Model

A business process model consists of a series of models and boundaries execution of activities [9]. By using a model of business processes, we obtain the definition and design of the structure of each business process graphically.

a. Business process models can be used as [1]:
b. Insight: the modeling process is used to determine the ability of designers and analyzer to create the structure and rules of business processes and visible information systems. Hence, inconsistent or flawed design can be seen.
c. Analysis: the process model as the starting point of all kinds of analysis, ranging from validation and verification and analysis of system performance.
d. Realization: the model can determine information systems.
e. In this work, we utilize business process model to analyze the performance of the system.

2.5. Bottleneck

The term bottleneck is known in various fields. In general, bottleneck is a jam. In the world of computer science, understanding the bottleneck is an accumulation process on one case/place caused because there is an activity that requires a long execution time while the subsequent activity can only be performed when the event has been completed executed. So the bottleneck is causing a long time to complete a process. Petri nets can describe when there is a bottleneck, so that it can be seen as a processes contained in the business process of bottleneck. PROM can illustrate how the occurrence of bottlenecks [7].

2.6. Conformance Checking

Conformance checking is an analysis that is used to compare the recorded behavior, or in this case the event log with some business process models for possible irregularities [10]. ProM has a plugin called analysis of conformance checking (conformance checker). On ProM, this analysis involves three evaluation dimensions that can be used as a reference for assessing the suitability level of business process models with the event log. Dimensions of evaluation used in conformance plugin checker ProM is fitness, precision and structural. Here is an explanation of the three dimensions of the evaluation:

a. Dimensions of Fitness

Dimensions of fitness is an indicator that describes the amount of trace of logs recorded in the business process model. This dimension focuses on the performance of the algorithm. Fitness value will diminish as the number of logs that are not captured by the model decreases. Here is the formula for fitness values [11]:

$$f = \frac{1}{2}\left(1 - \frac{\sum_{i=1}^{k} n_i m_i}{\sum_{i=1}^{k} n_i c_i}\right) + \frac{1}{2}\left(1 - \frac{\sum_{i=1}^{k} n_i r_i}{\sum_{i=1}^{k} n_i p_i}\right) \quad (1)$$

Annotation: k=different trace amount of a log for each log trace; $(1 \leq i \leq k)$
n_i=amount of instant process of i-th process
m_i=the number of missing tokens
r_i=the number of remaining tokens
c_i=the number of visited tokens
p_i=the number of produced tokens

b. Dimension of precisions

Dimension of precisions is an indicator that illustrates the number of traces which may be formed from something that is not derived from the log. Precision value will decrease as the number of cases outside the event log that is formed from the existing model decreases. It can be calculated by the advanced behavioral appropriateness fomula as follows [11]:

$$a'_b = \left(\frac{s_f^l \cap s_f^m}{2|s_f^m|} + \frac{s_p^l \cap s_p^m}{2|s_p^m|}\right) \quad (2)$$

where: s_f^m=relation to sometimes follows for model processing
s_p^m=relation to sometimes precedes for model processing
s_f^l=relation to sometimes follows for event log
s_p^l=relation to sometimes precedes for event log

c. Dimension of structure

Dimensions of structure is an indicator that shows the ability of the complexity of the shape model of good ability in handling the process XOR or AND. This dimension focuses on simplicity, which means the value of the structure will be reduced in line with the modeled task more than once. To calculate the value of the structural formula, we can use advanced structural appropriateness formula [11]:

$$a'_b = \left(\frac{|T| - (|T_{DA}| + |T_{IR}|)}{|T|}\right) \quad (3)$$

Annotation: T=set of transitions from model of Petri nets
T_{DA}=set of allternative duplicate tasks
T_{IR}=set of redundant tasks

These three dimensions have a value from 0 to 1. If the value of these dimensions is close to 1, the degree of conformity of business processes with the event log is higher or business processes are executed in accordance with the planned business processes.

2.7. Coloured Petri Nets

Petri nets is a model that can be used to analyze business processes. One analysis that has been done is the analysis of ERP business process performance. Some applications of the Petri net have been discussed in [12], [13], [14]. Coloured Petri nets (CPN) is a Petri net where each place has a type, and each token has a value (color) corresponding to its place type [1]. Color is used to differentiate each token. CPN is a discrete-event modeling language that combines the capabilities of Petri nets with a high-level programming language.

A CPN consists of nine tuples CPN=(P, T A, ∑, V, C, G, E, I) where [15]:

- P is a set of places
- T is a set of transitions that satisfy $P \cap T = \emptyset$
- $A \subseteq PxT \cup TxP$ is a set of arcs that shows the relationship between places and transitions
- ∑ is a non-empty set of colors.
- V is a set of variable types that satisfy $Type[v] \in \sum$ for every variable $v \in V$
- $C : P \rightarrow \sum$ is a set of color functions that maps color to place
- $G : T \longrightarrow EXPRv$ is a guard function that maps guard for each transition t that satisfy $Type[G(t)] = Bool$.
- $E : A \longrightarrow EXPRv$ is a set of arc expression functions that maps an arc expression for each arrow that satisfies $Type[E(a)] = C(p)_{MS}$, where p is place that connected with arrow a.
- $I : P \longrightarrow EXPR_{\emptyset}$ is a initialization function that maps an initial expression for each place p that satisfy $Type[I(p)] = C(p)_{MS}$.

Relationships that can be formed by Petri nets is the process of running straight, parallel, XOR, one conditional, and more than one conditionals [6].

2.8. Reachability Graph

Reachability graph is a graph that illustrates each state that can be reached. Reachability graph of a net N=(P, T, F, W, M0) is represented by a graph G=(V, E, v0), where [1]:

a. V=reach(N) is a set of points called reachable markings
b. v0=M0 is the starting point in the form of early node layout
c. E=$\{(M, t, M') | M \in V \text{ and } M \xrightarrow{t} M'\}$ is the set of points which is the point of each marking M for each successor markings and point by firing transition.

2.9. ProM and CPN Tools

ProM is a tool for process mining made by Wil van der Aalst at Eindhoven University of Technology, The Netherlands. Technical analysis of run-time on ProM utilizes event log which is converted into a *.mxml format.

CPN Tools is a software tool used for editing, simulation and analysis of coloured Petri nets. These tools were originally developed by CPN group at Aarhus University, Denmark, and is now managed by the IS Group at Eindhoven University of Technology, Netherlands [16].

2.10. Applications of Coloured Petri Nets

Santana Robles has conducted a research on business process modeling supply chain in the textile industry. Santana Robles built CPN models that can be used to gain a better understanding of the behavior of the process on textile company received a request from the customer. In the literature, CPN models can describe complex systems of manufacturing and logistics processes comprising: transportation, inventory, order processing, warehousing, distribution and production. These models can be used to measure the performance of the textile industry, i.e. how to influence the behavior of suppliers to meet the demand and how the influence of the quantity of inventory in the production process of the company. Furthermore, it can show the importance of sharing information between suppliers to reduce the uncertainty of the data. After the simulation of the model, we can observe the average use of production equipment [3].

Andric has conducted a study on business process modeling inventory at Politika publishing company. The case is the existence of any discrepancy between the availability of materials needed. In this case, the CPN model is necessary to analyze the inventory management. After obtaining the model, Andric conducts an analysis of the situation that occurred in inventory, by considering the possibility of improvements. Further modification and simulation of business processes is needed in order to obtain a better business processes than the current business process [17].

WMP van der Aalst discusses modeling and analysis of logistic systems using Coloured Petri Nets [4]. The study aims to investigate the contribution to the performance of the logistic component of corporate organizations to obtain information regarding the production of goods with a shorter time and at a competitive price. From this research, the modeling of logistics processes can be represented by CPN (e.g. goods and the capacity of the resources represented by the token, buffers, storage space and place represented by the media, and the operation is represented by the transition).

3. RESULTS AND ANALYSIS

In this section, first we construct a Petri net model from event log. Then we discuss the existing Petri net model of the event log. After that, we construct a new Petri net model from the same event log by using techniques in process mining. Finally, we export the obtained Petri net model as a coloured Petri net.

3.1. Case Study

The following diagram is the business process of a manufacturing company based on the departments that are in charge of each activity that depicted in Figure 1.

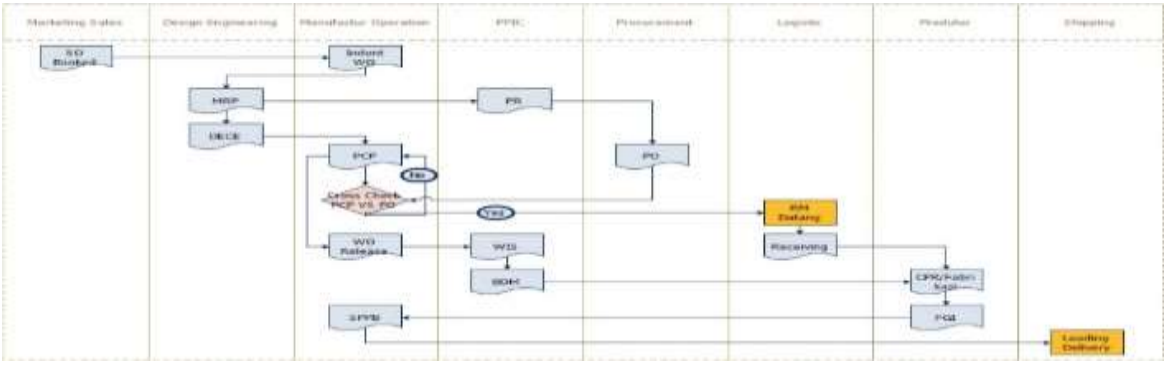


Figure 1. Business process in a manufacturing company

3.2. Data and Model of Petri Nets

The required data in this research is the event logs of several projects that have been completed by a manufacturing company. In this case, the project in question is the power plant A and B. Then we process the data to fit the structure of the event log. Event logs are stored in *.csv files as shown in Figure 3.

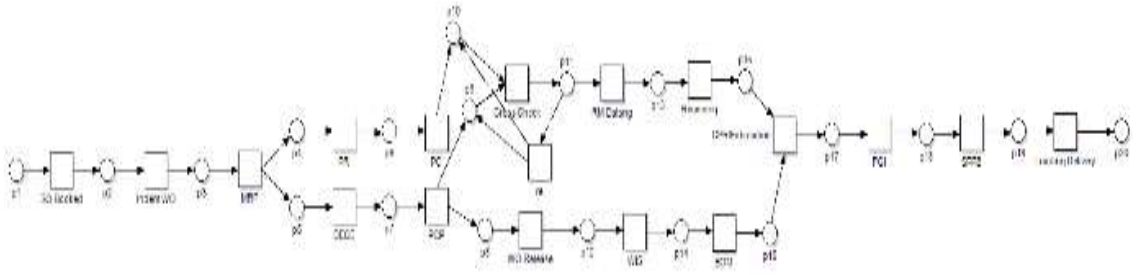


Figure 2. Current Petri net model of event logs

	A	B	C	D
1	SO ID	Activity	Time	CreatedBy
2	8386	SO	4/1/2013 14:31	MAR
3	8386	Indent WO	4/5/2013 0:00	NKP
4	8386	MRP	9/18/2013 16:01	SLO
5	8386	DECE	9/25/2013 14:51	BTR
6	8386	PCP	9/25/2013 14:51	NKP
7	8386	PR	9/26/2013 10:45	LKY
8	8386	PO	9/27/2013 17:26	AHM
9	8386	WO Release	10/2/2013 9:28	NKP
10	8386	Receiving	10/11/2013 16:19	DCO
11	8386	WIS	11/20/2013 0:00	CDF
12	8386	PR	11/29/2013 17:34	LKY
13	8386	PR	12/3/2013 9:34	LKY
14	8386	PR	12/5/2013 16:43	JND
15	8386	PR	12/5/2013 16:47	JND
16	8386	PR	12/5/2013 17:44	JND
17	8386	WIS	12/6/2013 0:00	CDF
18	8386	WIS	12/6/2013 0:00	CDF
19	8386	CPR/Fabricati	12/7/2013 11:36	EKS
20	8386	FGI	12/7/2013 11:42	WRT
21	8386	PR	12/23/2013 16:55	IDP

Figure 3. Pieces of event logs in *.csv

Then we convert the data from the event logs into a .csv file extension *.mxml. The conversion is done by using Nitro.

In addition to data, we require a model in the form of Petri nets, as shown in Figure. 2. The business process that is modeled as Petri nets with existence *.pnml can be analyzed.

On activity crosscheck carried decision-making with PCP parameters of PCPcost and POcost, i.e. if PCPcost < POcost the necessary repetition of the activity of PCP to get results in PCPcost ≥ POcost. In the model of Petri nets given activity Re are useful when conditions PCPcost < POcost met. Thus, in the Re activities, it is necessary to recalculate the value of PCPcost and POcost.

3.3. Process Mining

This step is done by using ProM. First, we open the event log files with extension *.mxml. Information on the obtained event logs are 2 cases containing 65 event logs. Besides that, ProM gives an information that there exist 14 event cases or activities on event log: SO, indent WO, MRP, DECE, PCP, PR, WO release, PO, WIS, receiving, SPPB, CPR/Fabrication, loading delivery and FGI. Besides that, we also know that the process in event log is started with SO activity and ended with loading delivery activity. However, in event log, there is no data on CrossCheck, re, BOM dan RM visitation activities.

Then the next step is to create business processes that has extension file *.pnml with the option: raw. Before importing Petri nets into the ProM, we need to construct a mapping between the event log and Petri nets. Crosscheck, re, BOM and RM visitation activities are rated with invisible because the activities are not contained in event logs. From the mapping, we obtain a graph with invisible transition Petri nets.

3.4. CPN Model

a. General structure

Each CPN model formed by CPN export plug-in has top-level page overview as shown in Figure 4a. The environment is described in more detail on subpage environment shown in Figure 4b. On the subpages, there is a color set CASE_ID used to indicate a particular case. Variable c is a variable with the data type CASE_ID that illustrates a case. The figures show that functions c + 1 is the default function and a simple way to get the unique ID of each case. To set the arrival between each case, exponential distribution is used. For the purpose of the data perspective, there is a token that contains the variable c and some of attributes of

data defined by the color set DATA. The initial value given to attribute POcost and PCPcost data is 0. Besides that, for the purpose of the perspective organization, there are place resources which is set ANYBODY place with a color set that contains all of resource token.

Subpage process shown in Figure 4c is a business process from the start place until the end place. Any activity on subpage process has subpages which contain detailed information on each activity.

b. Structure of subpage activities

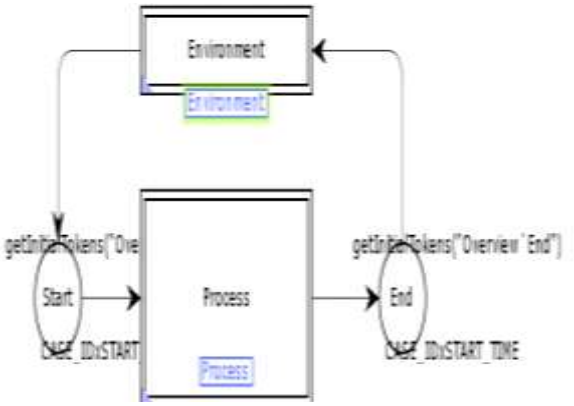
Any activity or transition on subpage process has subpages that consist of two transitions are start transition, and complete transition. Each transition of subpage is between two places that has the type of port in and the place that has the type of port out. Both places are a place with color set CASE_IDxSTART_TIME. Arc joining the place with type of port in is associated with the start transition.

Besides having the two places, every activity has subpage execution place which is denoted by E and resource place. Place E is a place with a color set CASE_IDxSTART_TIMEx(resource_type). The resource place is a place with color set ANYBODY, which is a set that contains the whole resources.

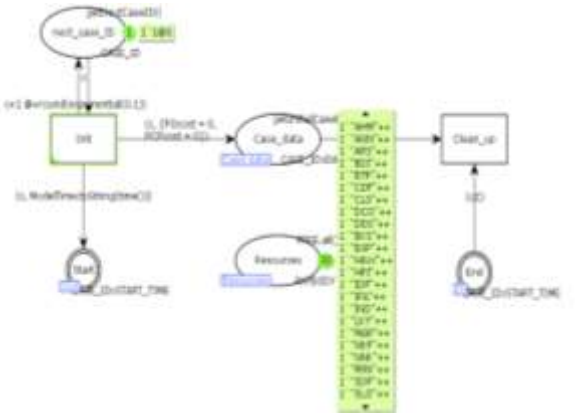
Each place and transition on each subpage has the following place rules:

a. Place type of port in with start transition and end transition with place type of port out connected with arc that has (c,t).
b. Each start transition and place E associated with arc that contains variables (c, t, [resource type]) and execution time.
c. Each place E and complete transition is associated with arc that contains variables (c, t, [resource type]).

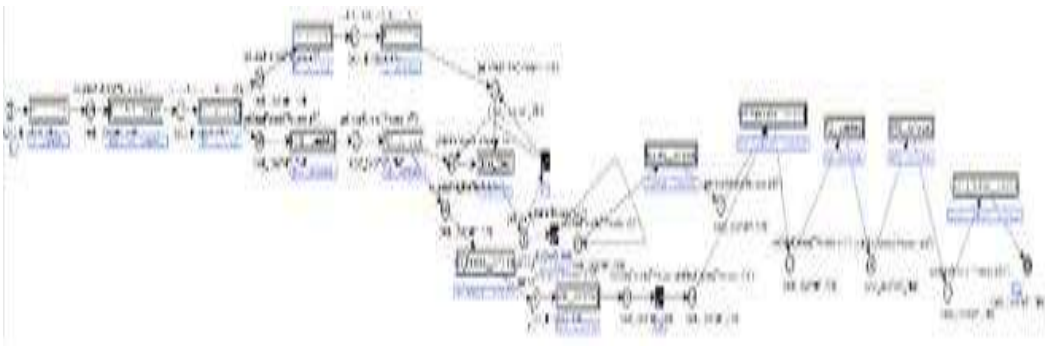
Each complete transition of resource place is associated with arc that contains variable with type-resource and also arc that connects resource place with start transition.



(a) Overview



(b) Environment page



(c) Subpage process

Figure 4. Coloured Petri nets model

4. DISCUSSION

The main objective of this section is to construct a model with better performance compared to the existing one. In order to come up with such model, first we have to do some analysis such as conformance checking, reachability graph and bottleneck analysis.

4.1. Conformance Checking

Conformance checking is an analysis that involves the dimension of evaluations that can be used as a reference for assessing the business process model. Dimension of evaluations used in the conformance checker plug-in ProM is fitness, precision and structural. The values of the three dimensions of the model are as follows:

a. Dimension of fitness of the model is 0.442, which indicates that the model cannot describe actual events well.
b. Dimension of precision of the model is 0.175, which means that the possibility of trace that can be formed outside the event log data with trace formed by the event log has a big difference.
c. Structural dimension of the model is 0.889. The structural value indicates that the business process model can handle the process of XOR and AND fairly well.

4.2. Reachability Graph

Reachability graph is a graph that shows all the reachable states. From the resulted reachability graph, we can see that the model can reach all the activities of SO until loading delivery at every place. Because of all the activities and the place can be reached then occurred flows are known from the reachability graph. The reachability graph shows that the occurred activity crosscheck and re invariants or events are performed repeatedly.

4.3. Bottleneck Analysis

Bottleneck occurs in two processes: indent WO-MRP and MRP processes-DECE. Here is an explanation of each bottleneck:

a. Indent WO–MRP

	Waiting time (days)	Synchronization time (da...	Sojourn time (days)
avg	84.61	0.0	84.61
min	2.55	0.0	2.55
max	166.67	0.0	166.67
stdev	116.05	0.0	116.05
fast 25.0	2.55	0.0	2.55
slow 25	166.67	0.0	166.67
normal	0.0	0.0	0.0

Figure 5. Bottleneck of indent WO–MRP

The results of the bottleneck analysis that depicted in Figure 5 provide information that there was a long waiting time in this process: in average 84.61. Based on the interviews conducted, the cause of the bottleneck in this process may be due to changes in demand for the material by the customer so that the information about the material used to create the document MRP should be reviewed. Material changes allow weight gain product. According to the company's procedures, if the weight exceeds the weight after a material change to the existing products in the SO, the SO experiencing holds. If SO has occurred on an activity, then the others cannot do anything. Then the activity can be undertaken if carried changes to the data that generates the value of weight in SO is greater than the value of the weight on the next activity

b. PCP–WO Release

Figure 6 provides the information that the PCP-WO release has an average waiting time of 6.78 days. So the process of PCP-Release WO is indicated as a bottleneck. Bottleneck in this process can occur because PCP cost is greater than COGS (Cost of Goods Sold) or of SO cost. It violates company procedures, because SO cost > HPP > PCP. Thus it cannot be carried before the release of the WO revision of PCP up according to the cost to the company procedures.

	Waiting time (days)	Synchronization time (da...	Sojourn time (days)
avg	6.78	0.0	6.78
min	6.78	0.0	6.78
max	6.78	0.0	6.78
stdev	0.0	0.0	0.0
fast 25.0...	0.0	0.0	0.0
slow 25....	0.0	0.0	0.0
normal ...	6.78	0.0	6.78

Figure 6. Bottleneck of PCP–WO release

4.4. Recommended Model

From the analysis of conformance checking previously described, we modify the existing business process model. The modified business process model is shown in Table 1 and its graphical representation is shown in Figure 7.

Table 1. Recommended Business Process

Business process model	Event log data	Recommended model
Transition BOM and RM visitation	There is no activity between BOM and RM visitation	Remove the transition between BOM and RM visitation
Relation process PR-PR	There exist a lot of PR–PR relations	Add PR–PR relation

Then we analyze the conformance checking of the business process model that has been recommended to determine the suitability of the event log. The model has a fitness value of 0.64, dimension of precision of 1.0 and structural precision of 1.0. The precision values indicate that the models can record all relations or activity sequence. The structural value shows that there are no redundant invisible tasks or in other words there is a data on all existing activities in the model. Finally, the fitness value cannot reach a value that meets the criteria of good models because there are some tasks that are not captured by the model.

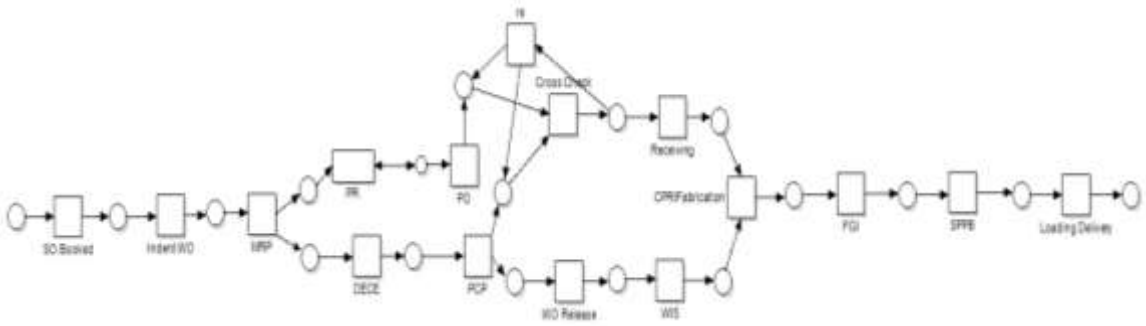


Figure 7. Recommended business process model in Petri net

Analysis of the recommended model shows that the value of each dimension of the evaluation of the model recommended by the event log is higher than the existing business process model. The difference can be seen in Table 2.

Table 2. Comparison between Dimension of Evaluation

Aspect	Existing model	Recommended model
Fitness value	0.442	0.640
Precision value	0.175	1.000
Structural value	0.889	1.000

The business process model associated with the recommended model is shown in Figure 14.

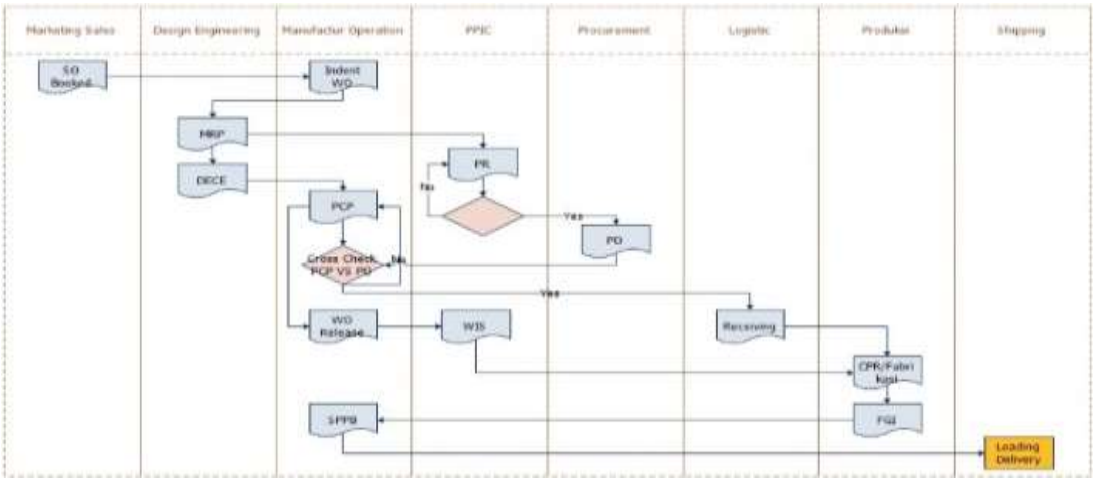


Figure 8. Recommended business process model

The level of fitness model in the business processes with event log affects the validity in evaluating the performance of business processes. The validity of the analysis affects the suitability of information on the whereabouts of the bottleneck. After knowing the location of bottlenecks, the company can find out the cause of the bottlenecks. Thus the company can take some actions so that bottlenecks do not occur again. Cost incurred by the company can be minimized if the bottleneck that occurs can be eliminated due to a long production also affects the cost.

5. CONCLUSION

In this paper, we proposed an approach to analyze business process of production systems using Coloured Petri Nets (CPN). The CPN can be used to analyze the performance of business processes. Firstly, we collect the data from event log and build a model of Petri Nets. Secondly, the Petri Nets are transformed into Coloured Petri Nets. Third, we analyze the model such as conformance checking, reachability and bottleneck. Finally, we modify the existing business process model to improve its performance.

Based on the overall results of the research, it can be concluded as follows:

a. Conformance checking results show that the model has a fitness value of 0.441, precision value of 0.175, and the structural value of 0.889. From these values it can be concluded that the degree of conformity of the model with the actual state of the company is low.
b. The results of the analysis showed that the bottleneck occurs in the following processes:

1) Indent WO-MRP can be due to changes in customer demand for the product by the material so that there should be a review of the product weight. It takes quite a long time. Furthermore, changes in the material can lead to hold on SEO. Hold status that occurs in SO causes other activities that cannot be done before the weight given in accordance with company procedures are heavy on MRP less than the weight at SO.
2) PCP-WO release due to costs generated on PCP activity violated company procedures are SO cost > HPP > PCP cost. So we need to revise the PCP to find the value of the cost that meets the company's procedures.

Bottleneck like the Indent WO-MRP can occur in any activity documentation on business processes that involve material changes. Similarly bottleneck as the PCP-WO release can occur in any activity in the business process that involves a material change to cause a change in cost.

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