TELKOMNIKA, Vol.17, No.3, June 2019, pp.1344~1351
ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
DOI: 10.12928/TELKOMNIKA.v17i3.10408

AHP-TOPSIS for analyzing job performance with factor evaluation system and process mining

Gabriel Sophia[1], Riyanarto Sarno*[2]
[1]Department of Management Technology, Faculty of Bussiness and Management Technology
[2]Department of Informatics, Faculty of Information Technology and Communication
Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
*Corresponding author, e-mail: sophia27gabriel@gmail.com[1], riyanarto@if.its.ac.id[2]

Abstract

Job performance is a type of assessments which refers to scalable actions, behaviour and outcomes that employees engage in or bring out linked with and contribute to organizational goals.This research employed the Factor Evaluation System (FES) method to analyze the job performance due to the common usage of the method. In analyzing employees, FES consists of nine factors; however, those nine factors are considered to be insufficient. Hence, the researchers used the process mining method to improve FES. Process mining analyzes job performance in details. The steps taken in process mining consist of time stamp, case, activity, and resources of employee. This means that the method can be continuously used, since the researcher provides weight for each factor. The weight of each factor is obtained from Analytic Hierarchy Process-Technique for Order Preference by Similarity to Ideal Solution. The result shows that FES with process mining are good for job performance but AHP-TOPSIS is considered to be incompatible for usage compared to the real work because the priority of the FES factors from the method is inconsistent with the priority factor made by manager of the warehouse officer.

Keywords*: AHP-TOPSIS, factor evaluation system, job performance, process mining*

1. Introduction

Job performance is one type of assessment which refers to scalable actions, behavior and outcomes that employees engage in or bring out linked with and contribute to organizational goals [1-4]. Contextual performance and task performance constitute types of employee behavior. Contextual performance focuses on individual performance while task performance focuses on core technical skill [5].

Many researchers used the Factor Evaluation System method to analyze job performance, so did this paper [6, 7]. Factor Evaluation System is a commonly used method in determining levels within an organization. Each level shows the degree of difficulty and responsibility of a position which, at the same time, indicates the level of wage and level of qualification required in that position [7]. FES uses nine factors to analyze the position. There are 2 types of FES; standard FES to classify functional position and standard FES alongside the classification to manager to evaluate structural positions. In previous study, FES usually was only used to help the company to obtain the position performance evaluation that influence work achievement which has to be connected with position burden.

FES should be available for review, since the document is public. Nevertheless, FES is unable to deal with changes because FES has been predetermined regarding the nine factor rules. Currently, we need to analyze every activity to obtain the best result for performance evaluation. To improve the analysis result using FES, this research combines aforementioned method with the process mining [8]. Until recently, a study discussing the FES method with business processes remains a rarity.

Process mining is a technique in terms of process management which supports the analysis of business processes based on event logs [9-11]. It is a set of techniques which automatically construct a model of an organization's current activities and its major activities variations [12]. To extract the information from the real executions constitutes one of the objectives of process mining [13, 14]. From the event log of company, the history of time stamp, case, activity, and resources of employee can be identified [15, 16]. Besides containing activity

Received June 22, 2018; Revised January 31, 2019; Accepted February 28, 2019

and case, event log also contains information about trace [17]. Process mining assists the FES method to further analyze the factors [18].

In order that this method not only used to measure the employee performance, weight for each factor must be identified. In the previous study, researcher use AHP to obtain the weight for the job performance. Thus, this paper uses another method namely AHP-TOPSIS (Analytical Hierarchy Process Technique for Order Preference by Similarity to Ideal Solution) to obtain the weight and order [19-21]. TOPSIS is used to obtain more accurate information regarding the weight. In this research report, the researcher proposed a notion to analyze job performance using combination of FES with process mining and AHP-TOPSIS.

2. Research Method

The objectives of this research is to recalculate using this method. The steps are as follows.

2.1. Step 1: Identifying the Standard Operating Procedure (SOP) from the Company

An example of SOP is shown in Figure 1, while Table 1 presents the attributes of the events in the logs. The table consist of Case ID, Activity, Start and Finish Time and Resources showing the activity doer.

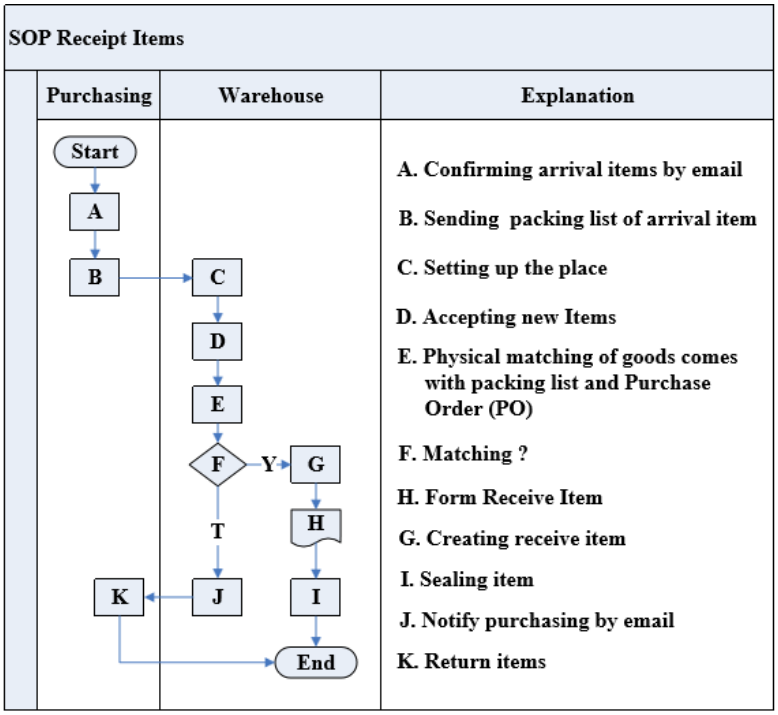

Figure 1. SOP receipt items

Table 1. Example of Event Log

Case ID	Activity	Start Timestamp	Complete Timestamp	Resouces
CPB02	Confirming arrival items by email	10/9/17 10:00 AM	10/9/17 10:05 AM	Purchasing
CPB02	Sending packing list of arrival item	10/9/17 10:05 AM	10/9/17 10:07 AM	Purchasing
CPB02	Setting up the place	10/9/17 10:07 PM	10/9/17 3:00 PM	Warehouse
CPB02	Accepting new items	10/10/17 10:00 AM	10/10/17 5:00 PM	Warehouse
CPB02	Physical matching of arrived items Purchase Order (PO)	10/11/17 8:00 AM	10/11/17 10:00 AM	Warehouse
CPB02	Notify purchasing by email	10/11/17 10:00 AM	10/11/17 10:04 AM	Warehouse

2.2. Step 2: Drawing the SOP with YAWL Format

YAWL (Yet Another Workflow Language) is an application used to create a business process model. Using YAWL, detail activity can be identified because the result of YAWL is based on record logs. The initial SOP in Microsoft Visio format was redrawn using the YAWL format to later be simulated. Drawing the SOP in YAWL format was not only based on the initial SOP, but also on the event log. Figure 2 is the main SOP or SOP level 1 of Receipt Items.

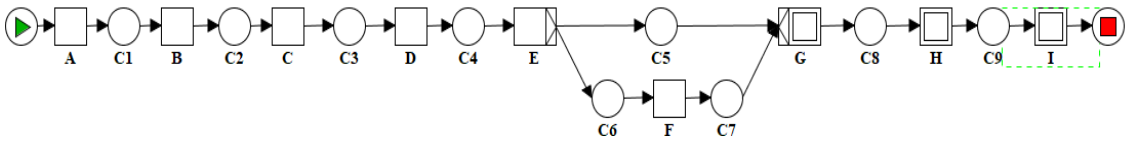

Figure 2. SOP level 1–receipt items

The result of the redrawn SOP is possibly the same as the initial, but most result are usually longer. In Figure 2, three double box buttons are present indicating the fact that certain activity can be more in detailis and is presented in next figure. Figure 3 shows the continuation activity from the SOP of Receipt Items that usually called SOP level 2.

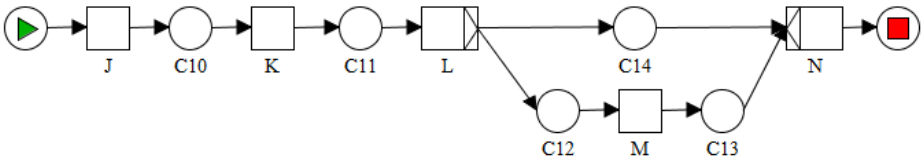

Figure 3. SOP level 2–received items (G)

Figure 4 shows the level 2 of SOP Sealing Item which came from the button H in the SOP level 1. Figure 5 is still part from the continuation activity from the SOP level 1–Receipt Items. That figure shows activities which are contained in button Entry MC.ADD.

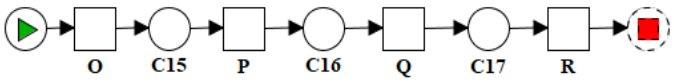

Figure 4. SOP level 2–sealing items (H)

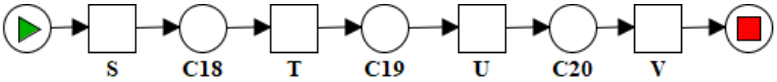

Figure 5. SOP level 2–entry mc. Add (I)

After the business process model was created, the next procedure was to categorize every activity undertaken by the warehouse officer position. Each activity was analyzed using the nine FES factors. Table 2 presents the collection of the activity from SOP Received Items Level 1 and Level 2. Other than that, all activities in SOP level 1 and level 2 have resources and division in charge in that. The result initially consisted of 10 activities. In that table, the activities become 19.

Table 2. Activity in SOP Level 1 & Level 2

Not	Activity	Resources	Division
A	Confirming arrival items by email	dessy	Purchasing
B	Sending packing list of arrival item	dessy	Purchasing
C	Setting up the place	indy, kholid, Hafid, Enggal	Warehouse Officer
D	Accepting new items	indy, kholid, Hafid, Enggal	Warehouse Officer
E	Physical matching of arrived items Purchase Order (PO)	Hafid, Bagas	Warehouse Officer
F	Notify purchasing by email	Hafid, Bagas	Warehouse Officer
G	Received Item (2)		
J	Creating New Form on Database	Hafid, Bagas	Warehouse Officer
K	Select the Vendor	Hafid, Bagas	Warehouse Officer
L	Approving selected PO	Hafid, Bagas	Warehouse Officer
M	Edit the number of item received	Bunga, Hafid, Bagas	Warehouse Officer
N	Save Receive Item Form	Bunga, Hafid, Bagas	Warehouse Officer
H	Sealing Item (2)		
O	Writing the seal number	April, Ninda	Admin Sales
P	Open the item Packing	Hafid, Bagas, Migdad	Warehouse Officer
Q	Glue the seal	Hafid, enggal	Warehouse Officer
R	Entry Item Database	Hafid, Bagas	Warehouse Officer
I	Entry Mc.add (2)		
S	Open the Packing	Enggal	Warehouse Officer
T	Open the item database	Bagas, hafid	Warehouse Officer
U	Scan Barcode Mc.Add	Bagas, hafid	Warehouse Officer
V	Update item Database	Hafid, Bagas	Warehouse Officer

2.3. Step 3: Analyzing the Business Process Model Followed by Calculating Every Activity of A Position Using Standard FES

From Table 2, 19 activities from one SOP are obtained. There are 3 activities (confirming arrival items by email, sending packing list of arrival item and writing the seal number) which as a matter of fact were done by another position, i.e the purchasing and admin sales. Consequently, only 16 activities are included for the warehouse officer position in SOP Received Items. Table 3 shows the value of each FES factor (column 2–9) to the activity (column 1).

Table 3. Activity with Factor FES in SOP Level 1 & Level 2

Activity	Factor									Total
	1	2	3	4	5	6	7	8	9	
C	350	125	125	150	75	25	20	20	5	895
D	50	25	25	25	25	25	20	20	5	220
E	200	125	25	25	25	10	20	20	5	455
F	200	25	25	25	25	25	20	5	5	355
J	50	25	25	25	25	10	20	5	5	190
K	50	25	25	25	25	10	20	5	5	190
L	50	25	25	25	25	10	20	5	5	190
M	50	25	25	25	25	10	20	5	5	190
N	50	25	25	25	25	10	20	5	5	190
P	50	125	25	25	25	10	20	20	5	305
Q	50	125	25	25	75	10	20	20	5	355
R	200	125	25	25	75	10	20	5	5	490
S	50	25	25	25	25	10	20	20	5	205
T	200	25	25	25	25	10	20	5	5	340
U	200	25	25	25	75	10	20	20	5	405
V	50	25	25	25	75	10	20	5	5	240
Total	1850	900	500	525	650	205	320	185	80	5215

2.4. Step 4: Every Position Consists of Different Factor which Has More Influence from the Other

Its is required to determine the hierarchy from the highest to the lowest factor by asking the manager. After obtaining the priority factor, the FES was calculated using AHP. The basic step in the AHP method are [22, 23]:

1) Structure elements in criteria, sub-criteria, alternatives, etc
2) Make a pair-wise comparison of elements in each group
3) Calculating the weighting
4) Calculating the Consistency Index (CI)

5) Identifying the Ratio Consistency Index (CR), CR < 10%

$$CR = \frac{CI}{IR} \quad (1)$$

in which:
CR = Consistency Random
CI = Consistency Index
IR = Index Ratio

To calculate the weight with AHP the list of from Table 4 was used. Table 4 shows the the weight of FES factor from the AHP which will be used in the next step. To test the weight consistency of AHP, so the next step is calculated the value of CI and CR, of which CR value<10%.

$$CI = \frac{9.60 - 9}{9 - 1} = 0.075$$

$$CR = \frac{0.075}{1.45} = 0.05 < 10\%$$

Table 4. Weights of FES Factor from AHP

FES Factor	Weight
Knowledge Required by the Position (KR)	0.31
Scope and Effect (SE)	0.22
Guidelines (G)	0.15
Complexity (C)	0.11
Work Environment (WE)	0.08
Physical Demands (PD)	0.05
Supervisory Control (SP)	0.04
Purpose of Contacts (POS)	0.03
Personal Contacts (PC)	0.02

2.5. Step 5: Proceeding the Calculation Using TOPSIS

TOPSIS is a method introduced by Yoon and Hwang [24, 25], in which alternative being the closest distance to a positive ideal solution and the farthest distance from the negative ideal solution are chosen. The steps are shown below.

1) Normalization of decision matrix. Normalization with TOPSIS starts by squaring all factors followed by dividing the initial value by the total squares. Table 5 shows the normalized each factor with TOPSIS.

2) Weighting on a normalized matrix. Weight is obtained from the AHP result. Table 6 is the result of the matrix multiplication between weight and normalization factor.

Table 5. Normalized TOPSIS

Activity	1	2	3	4	5	6	7	8	9
A	0.596	0.430	0.801	0.849	0.405	0.451	0.556	0.365	0.183
B	0.085	0.086	0.160	0.141	0.135	0.451	0.222	0.365	0.730
C	0.341	0.430	0.160	0.141	0.135	0.180	0.222	0.365	0.183
D	0.341	0.086	0.160	0.141	0.135	0.451	0.222	0.091	0.183
E	0.085	0.086	0.160	0.141	0.135	0.180	0.222	0.091	0.183
F	0.085	0.086	0.160	0.141	0.135	0.180	0.222	0.091	0.183
G	0.085	0.086	0.160	0.141	0.135	0.180	0.222	0.091	0.183
H	0.085	0.086	0.160	0.141	0.135	0.180	0.222	0.091	0.183
I	0.085	0.430	0.160	0.141	0.135	0.180	0.222	0.365	0.183
J	0.085	0.430	0.160	0.141	0.405	0.180	0.222	0.365	0.183
K	0.341	0.430	0.160	0.141	0.405	0.180	0.222	0.091	0.183
L	0.085	0.086	0.160	0.141	0.135	0.180	0.222	0.365	0.183
M	0.341	0.086	0.160	0.141	0.135	0.180	0.222	0.091	0.183
N	0.341	0.086	0.160	0.141	0.405	0.180	0.222	0.365	0.183
O	0.085	0.086	0.160	0.141	0.405	0.180	0.222	0.091	0.183

Table 6. WeightxNormalized Factor

Activity	FES Factor								
	1	2	3	4	5	6	7	8	9
A	0.131	0.065	0.088	0.255	0.016	0.009	0.017	0.029	0.009
B	0.019	0.013	0.018	0.042	0.005	0.009	0.007	0.029	0.037
C	0.075	0.065	0.018	0.042	0.005	0.004	0.007	0.029	0.009
D	0.075	0.013	0.018	0.042	0.005	0.009	0.007	0.007	0.009
E	0.019	0.013	0.018	0.042	0.005	0.004	0.007	0.007	0.009
F	0.019	0.013	0.018	0.042	0.005	0.004	0.007	0.007	0.009
G	0.019	0.013	0.018	0.042	0.005	0.004	0.007	0.007	0.009
H	0.019	0.013	0.018	0.042	0.005	0.004	0.007	0.007	0.009
I	0.019	0.065	0.018	0.042	0.005	0.004	0.007	0.029	0.009
J	0.019	0.065	0.018	0.042	0.016	0.004	0.007	0.029	0.009
K	0.075	0.065	0.018	0.042	0.016	0.004	0.007	0.007	0.009
L	0.019	0.013	0.018	0.042	0.005	0.004	0.007	0.029	0.009
M	0.075	0.013	0.018	0.042	0.005	0.004	0.007	0.007	0.009
N	0.075	0.013	0.018	0.042	0.016	0.004	0.007	0.029	0.009
O	0.019	0.013	0.018	0.042	0.016	0.004	0.007	0.007	0.009

3) Determining the ideal positive solution and the ideal negative solution. The positive ideal solution is denoted by A+ and the negative ideal solution is denoted by A- .

$$A^+ = \left\{\left(\max v_{ij} \mid j \in J\right)\left(\min v_{ij} \mid j \in J'\right), i = 1,2,3, \ldots m\right\} = \{v_1^+, v_2^+, \ldots v_m^+\} \quad (2)$$
$$A^- = \left\{\left(\max v_{ij} \mid j \in J\right)\left(\min v_{ij} \mid j \in J'\right), i = 1,2,3, \ldots m\right\} = \{v_1^-, v_2^-, \ldots v_m^-\}$$

where:
v_{ij} = matrix element v row i and coloum j
J = {j = 1,2,3,…n and j associated with benefit criteria}
J' = {j = 1,2,3,…n and j associated with cost criteria}

From Table 6, the minimum and maximum score for each factor of FES is obtained. The next procedure is determining the ideal positive solution and the ideal negative solution. Table 7 shows the result of calculation score from the matrix which consist of positive ideal solution (A+) and negative ideal solution (A-).

Table 7. Calculation of Positive Ideal Solution and Negative Ideal Solution

A+	0.360	0.163	0.264	0.794	0.034	0.019	0.037	0.062	0.102
A-	0.169	0.115	0.070	0.212	0.024	0.009	0.010	0.058	0.027

4) Sorting options, after calculating the proximity relative to positive ideal. Table 8 shows the results, which are positive ideal values (V) for each FES factor.

Table 8. Proximity Relative to Positive Ideal

V	0.319	0.414	0.211	0.211	0.414	0.333	0.211	0.483	0.211
Factor	1	2	3	4	5	6	7	8	9

The proximity relative to positivef ideal in AHP-TOPSIS denote weight for factor FES. The highest score indicates that one factor is more important than the others. Table 9 shows the sequence of weights to the FES factors.

2.6. Step 6: Comparing Average Value

The last step is comparing the average value of each activity with the weight factor.

3. Results and Analysis

From the analysis, not only is the value from every activity, but also the best score. The best score is used to determine the new standard in the recruitment process of the position. Moveover, using the FES method and process mining in the event log for a period time enables to analyze the average and total time of certain task. It can be used by the company to identify

the capability of employee in order to find out which one needs training or reward. To obtain such data, researchers can use a method called AHP-TOPSIS to obtain the weight and order of the priority. Upon the completion of the AHP analysis, the result was used for the TOPSIS analysis.

Table 10 shows the sequence of the FES factors from the highest to the lowest. From the table, it is obtained that the most influential factor from FES is purpose of the contacts factor based on AHP-TOPSIS. However, this factor is considered to be inconsistent with the factor priority made by manager of the warehouse officer as shown in Table 5. Job performance combined with process mining generates a more detailed analysis about employee assessment because it enables to elaborate every activity that has been done by the worker. The AHP-TOPSIS completes the analysis by producing not only the weight of each factor but also giving an important sequence of FES factors.

Table 9. Result of Sequence AHP-TOPSIS

Factor	Weight
Purpose of Contacts (POS)	0.483
Scope and Effect (SE)	0.414
Work Environment (WE)	0.414
Physical Demands (PD)	0.333
Knowledge Required by the Position (KR)	0.319
Guidelines (G)	0.211
Complexity (C)	0.211
Supervisory Control (SP)	0.211

Table 10. Result of Sequence AHP-TOPSIS

No	Factor	Weight
1	Purpose of Contacts (POS)	0.483
2	Scope and Effect (SE)	0.414
3	Work Environment (WE)	0.414
4	Physical Demands (PD)	0.333
5	Knowledge Required by the Position (KR)	0.319
6	Guidelines (G)	0.211
7	Complexity (C)	0.211
8	Supervisory Control (SP)	0.211
9	Personal Contacts (PC)	0.211

4. Conclusion

Based on the research, this report proposed a hybrid method in analyzing job performance using Factor Evaluation System and process mining. Process mining helps the FES method to obtain in-details information regarding the activities. The result shows that the initial 10 activities from initial SOP become 19 activities in the latter analysis. It means that the FES method is able to analyze all activities in a position in addition to analyzing the position in general.

In order to use the result of analysis in long term and as a reference in recruiting new employee, this paper report uses AHP-TOPSIS to obtain the weight of each factor. The result shows that AHP-TOPSIS can give the weight and sequence of FES factors that can used to standard for each activity but the values still are incompatible for use compared to the real work because the result obtained using AHP-TOPSIS is not equivalent to the sequence predetermined by the manager. For future research, it is considered to be imperative to conduct in-detail analysis using another method in order to obtain the weight combination for the FES method and process mining.

Acknowledgments

Authors give a deep thank to Institut Teknologi Sepuluh Nopember, the Ministry of Research, Technology and Higher Education of Indonesia, Direktorat Riset dan Pengabdian Masyarakat, and Direktorat Jenderal Penguatan Riset dan Pengembangan Kementerian Riset, Teknologi dan Pendidikan Tinggi Republik Indonesia for supporting the research.

References

[1] Tiesinga LJ, Halfens RJ, Algera-Osinga JT, Hasman A. The Application of a Factor Evaluation System for Community Nursing in the Netherlands. *Journal of Nursing Management*.1994; 2(4): 175-179.

[2] Sun X, Luo N. Study on the Effectiveness od Point-Factor Job Evaluation System in Operation Position. *Journal Communications in Information Science and Management Engineering*. 2013; 3(3): 154-160.

[3] Iskandar A, Salbiah E, Purnamasari I. Analysis of Structural Position Performance With Factor Evaluation System (FES) Reference To Determine Work Achievement Indicators With Remuneration As Intervening Variables in Bogor, West Java Province, Indonesia. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*. 2014; 18(2): 223-234.

[4] Jankingthong K, Rurkkhum S. Factors Affecting Job Performance: A Review of Literature. *Silpakorn University Journal of Social Sciences, Humanities, and Arts*. 2012; 12(2): 115-127.

[5] Sîrbu J, Pintea FR. Analysis and Evaluation of Jobs – Important Elements in Work Organization. *Procedia–Social and Behavioral Sciences*. 2014; 124: 59-68.

[6] Minister for the Empowerment of State Apparaturs and Bureaucratic Reform of Indonesia. PermenPAN dan RB 34 Tahun 2011. *Regulation of the Minister of State for the Utilization of the State Apparatus and Bureaucratic Reform of the Republic of Indonesia Number 34 of 2011 concerning Guidelines for Job Evaluation (in Indonesia: Peraturan Menteri Negera Pendayagunaan Aparatur Negara dan Reformasi Birokrasi Republik Indonesia Nomor 34 Tahun 2011 Tentang Pedoman Evaluasi Jabatan)*. 2011.

[7] Office of Personnel Management (OPM) Classification Standards. TS-107 August 1991. *The Classifier's Handbook*. US Office of Personnel Management; 1991.

[8] Sophia G, Sarno R. *Job* Performance Analysis Using Factor Evaluation System and Process Mining. *ISEMANTIC 2018 International Conference on Application for technology of Information and Communication Conference.* Semarang. 2018: 177-183.

[9] Sarno R, Fauzan AC, Nurlaili AN, Rahmawati D, Sungkono KR, Effendi YA. Manajemen Proses Bisnis–Model & Simulasi. Surabaya: ITS Tekno Sains. 2017.

[10] Mukhlash I, Rumana WN, Adzkiya D, Sarno R. Business Process Improvement of Production Systems Using Coloured Petri Nets. *Bulletin of Electrical Engineering and Informatics*. 2018; 7(1): 102-112. DOI: 10.11591/eei.v7i1.845

[11] Budiawati GI, Sarno R. Time and cost optimization of business process Distribution Company using goal programming. *ISEMANTIC 2018 International Conference on Application for technology of Information and Communication Conference*. Semarang. 2018: 29-34.

[12] Sarno R, Wibowo WA, Kartini K, Amelia Y, Rossa K. Determining process model using time-based process mining and control-flow pattern. *TELKOMNIKA Telecommunication Computing Electronics and Control*. 2016; 14(1): 349-60. DOI: http://dx.doi.org/10.12928/telkomnika.v14i1.3257

[13] Caesarita Y, Sarno R, Sungkono KR. Identifying Bottlenecks and Fraud of Business Process usig Alpha ++ and Heuristic Miner Algorithms. *International Conference on Information and Communication Technology and System (ICTS)*, 2017. DOI: 10.1109/ICTS.2017.8265660

[14] Sarno R, Sinaga Fe. Business Process Anomaly Detection using Ontology-based Process Modeling and Multi-level Class Association Rule Learning*. International Conference on Computer, Control, Informatics and its Applications (IC3INA)*. 2015: 12–17. DOI: 10.1109/IC3INA.2015.7377738

[15] van der Aalst WMP. Process Mining: Discovery, Conformance and Enhancement of Business Processes. *Springer Heidelberg Dordrecht*. 2002. ISBN: 978-3-642-19344-6, DOI 10.1007/978-3-642-19345-3

[16] Sarno R, Haryadita F, Kartini, Sarwosri, A AS. Business Process Optimization from Single Timestamp Event Log. *International Conference on Computer, Control, Informatics and its Applications (IC3INA)*. Surabaya. 2015: 50-55. DOI:10.1109/IC3INA.2015.7377745

[17] Sarno R, Effendi YA. Hierarchy Process Mining from Multi-source Logs. *TELKOMNIKA Telecommunication Computing Electronics and Control*. 2017; 15(4): 1954-1969. DOI: 10.12928/TELKOMNIKA.v15i4.6326

[18] Gabriel S, Sarno R. Process Mining and Factor Evaluation System Method for Analysing Job Performance*. International Symposium on Advanced Intelligent Informatics (SAIN)*. 2018.

[19] Shaout A, Yousif MK. Performance Evaluation–Methods and Techniques Survey. *International Journal of Computer and Information Technology*. 2014; 03(05): 966-79. ISSN: 2279–0764.

[20] Yudatama U, Sarno R. Evaluation Maturity Index and Risk Management for IT Governance using Fuzzy AHP and Fuzzy TOPSIS (Case Study Bank XYZ*). International Seminar on Intelligent Technology and Its Applications (ISITIA)*. 2015: 323-328. DOI:10.1109/ISITIA.2015.7220000

[21] Wiguna KA, Sarno R, Ariyani NF. Optimization Solar Farm Site Selection Using Multi Criteria Decision Making Fuzzy Ahp and Promethee: Case Study in Bali. *International Conference on Information & Communication Technology and Systems (ICTS)*. 2016: 237–243. DOI: 10.1109/ICTS.2016.7910305

[22] Subramanian N, Ramanathan R. A review of applications of Analytic Hierarchy Process in Operations Management. *International Journal of Production Economics*. 2012; 138(2): 215-241.

[23] Cahyapratama A, Sarno R. Application of Analytic Hierarchy Process (AHP) and Simple Addictive Weighting (SAW) Method in Singer Selection Process*. International Conference on Information and Communication Technology (ICOIACT).* 2018: 234-239. DOI: 10.1109/ICOIACT.2018.8350707

[24] Yoon KP, Hwang CL. Multiple Attribute Decision Making: An Introduction. *Thousand Oaks: Sae Publications*. 1995.

[25] Yudatama U, Sarno, R. Priority Determination for Higher Education Strategic Planning Using Balanced Scorecard, FAHP and TOPSIS (Case study: XYZ University). *IOP Conference Series: Materials Science and Engineering,* 105(1): 012040. 2016.