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WARNING CRITERION ONTOLOGY FOR MEASURING OF COMPLIANCE IN STANDARD OPERATING PROCEDURE IMPLEMENTATION

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ABSTRACT

Management processes without responsive to abnormal activity that might occur can affect the performance of an organization. The Publishing Workflow Ontology (PWO) will be modified for detect abnormal activity, such as wrong pattern, wrong resource, throughput time maximum and wrong duty combine that occurs in the event logs. The new model from modification called "Warning Criterion Ontology (WCO)" can be represent the knowledge base to detect abnormal activity in the business process especially this knowledge can be used distinguishes the activity is allowed to be done by the superior and any activity which should only be done by direct superior. The model used some rule for reasoning, then after reasoning used some SPARQL to detection abnormal activity. Results of detection abnormal activity can be used as attributes for assessment Key Performance Indicator (KPI) activity in determining "The compliance in Standard Operating Procedure (SOP) implementation". This research obtained a value of 96.29% of accuracy resulted comparing into the experts assessment score.

Keywords: *Warning Criterion Ontology, Key Performance Indicator, the Publishing Workflow Ontology*

1. INTRODUCTION

At the end of 2011, Bogor Agricultural University has launched SIMAKER online based on Balanced Scorecard (BSC). SIMAKER is a guideline for each work unit and individual within Bogor Agricultural University to measure the progress and success of each program and activities in order to realize the vision and mission of Bogor Agricultural University. To assess the efforts of work unit in carrying out its business processes, it is necessary Key Performance Indicator (KPI) activities that can measure compliance in Standard Operating Procedure (SOP) implementation. A main problem for assess KPI activities to measure compliance in SOP implementation is how to calculating with objectively.

The business processes that involve human resources and enterprise resources can be played in a coordinated manner then the business goals can be achieved effectively and efficiently [1]. Management processes without responsive to abnormal activity that might occur can affect the performance of an organization. An abnormal activity in the business process if it is not taken seriously, then it can potentially cause disadvantage to the organization. Fraud occurs because there is a mismatch SOP with real events recorded in event logs. Process-based Fraud (PBF) is a fraud that occurs in the business process. Detection of fraud in the process mining has been done with fuzzy miner [2], heuristic mining [3] and association rule learning [4]. In previous research [5] has identified the attributes of PBF, among others: skip sequence, skip decision, throughput time minimum, throughput time maximum, wrong resource, wrong duty decision, wrong duty sequence, wrong duty combine, wrong pattern and wrong decision. In addition, previous research [6] has been added a parallel event into attribute PBF. Then with behavior model of the relation between the originators [7] can be increasing accuracy of PBF.

Balanced Scorecard (BSC) [8] is a tool in the field of management to manage/implement business strategies, measuring the performance of the organization, communicating the vision, mission, strategies and objectives to stakeholders. In measuring performance, the BSC uses four perspectives: financial perspective, customer perspective, business process perspective, and learning and growth perspective. In previous research have proposed an ontology model for balanced scorecard called balanced scorecard ontology (BSCO) [9]. The ontology model is a conceptual representation of the balanced scorecard that can be integrated semantically.

In previous research has been proposed ontology model named The Publishing Workflow Ontology (PWO) [10] which can represent business processes such as workflow and recording process (event logs). However, PWO cannot detect abnormal activity that occurs in the event logs. In previous research [11] has been proposed detecting fraud in business process with ontology-based process modeling. However, that research cannot be integrated semantically with PWO and BSCO. In previous research [12] has been proposed measure warning activity in an organization with linked KPI using ontology-based. However, that research cannot be integrated semantically with PWO. Therefore, this research develops Warning Criterion Ontology (WCO) to represent the knowledge base to detect abnormal activity which can be integrated semantically with PWO and BSCO. Results of detection abnormal activity can be used for assessment attribute to the KPI activity "The compliance in Standard Operating Procedure (SOP) implementation". So with that KPI activity, management gain early warning of the abnormal activity in real time.

2. RELATED LITERATURE

2.1 Petri Net Ontology

A Petri net is a particular type of graph that has some type of object, place, transition, arc and tokens. The symbol arc is a symbol of to connect the place with the transition or a transition to a place. In general, a Petri net can be used to describe a particular business process. Terminology and notation on Classical Petri Nets described in previous research [13], where there is a triple (P, T, F) P is a set of finite number of place described by a circular symbol, T is the set of finite number of transitions are depicted with symbols of the box, whereas ($P \cap T = \emptyset$) and $F \leq (P \times T) \cup (T \times P)$ is the set of arcs (relationships flow) are depicted with symbols directed line. We use Petri Net, because various models in the business processes can be analyzed with Petri Net [14]. Examples of Classical Petri Nets can be seen in Figure 1.

In previous research [15], has been modeled petri net into the ontology model. This shall be achieved by translating some key features of Petri net into classes, properties and axioms ontology of OWL DL.

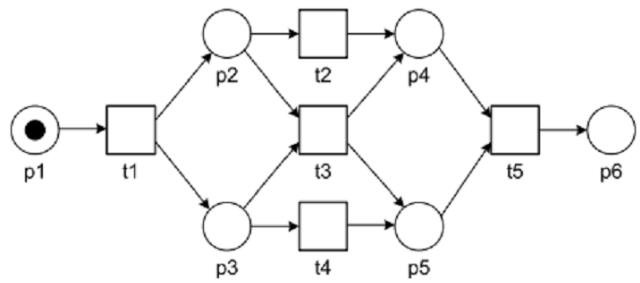

Figure 1: Classical Petri Nets [13]

2.2 Organizational Ontology

In previous research successfully utilize information on event logs to find the relationship between the actors in a business process workflows that have been run. The model generated by the research called organizational ontology (OrO) [16]. This model can provide information about the superior and subordinate of an actor. In addition, a person can be known to the role and organization of the unit. The model of organizational ontology can be seen in Figure 2.

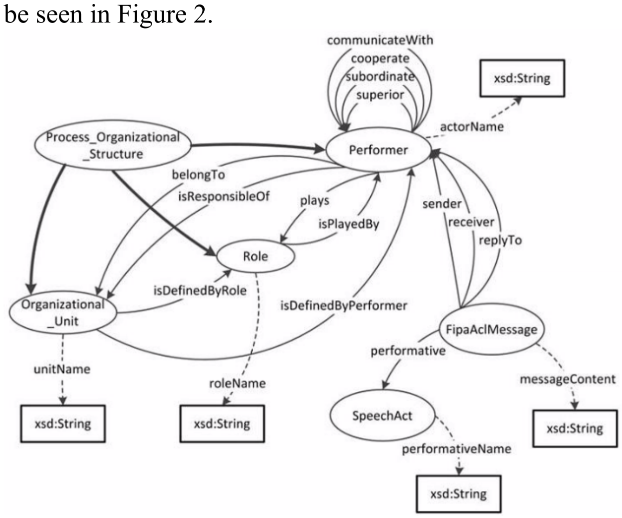

Figure 2: Organizational Ontology [16]

2.3 The Publishing Workflow Ontology

In previous research [17], has developed an ontology model to represent the knowledge base in the domain business processes with represent the workflow, named The Publishing Workflow Ontology (PWO). PWO [10] can describe of the logical steps in a workflow, as, e.g., the process of publication of a document. Each step may involve one or more events (or actions) that take place in a particular phase of the workflow (e.g.,authors are writing the article, the article is under review, a reviewer suggests to revise the article, the article is in printing, the article has been published, etc.). Then in subsequent research for PWO has

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improved the model by adding a class WorkflowExecution and class DurationDescription, but it moved some relation between the classes, namely: class TimeInterval which originally related to the class Step converted to relate to class Action. Excess PWO is able to represent the knowledge base for workflow with class Workflow and recording process (event logs) with class WorkflowExecution. But this model does not detail the role of an actor to their organization (e.g. superior, subordinator and direct superior).

2.4 Balanced Scorecard Ontology

Balanced Scorecard (BSC) [8] is a tool in the field of management to manage/implement business strategies, measuring the performance of the organization, communicating the vision, mission, strategies and objectives to stakeholders. In measuring performance, BSC involves four perspectives: financial perspective, customer perspective, business process perspective and learning and growth perspective. Balanced Scorecard measurement performance based on critical success factors so that the resulting information can be directed and monitored the implementation process is progressing using Key Performance Indicator (KPI). BSC received more attention by the business world, because it can detect the ability of an intangible asset such as the ability of employees. One factor that plays an important role in influencing the performance of an organization, the human resources (employees).

In previous research proposes a model of the Balanced Scorecard in the form of ontology called balanced scorecard ontology [9]. The ontology model is a conceptual representation of the BSC that can be integrated semantically. Model balanced scorecard ontology can be seen in Figure 3.

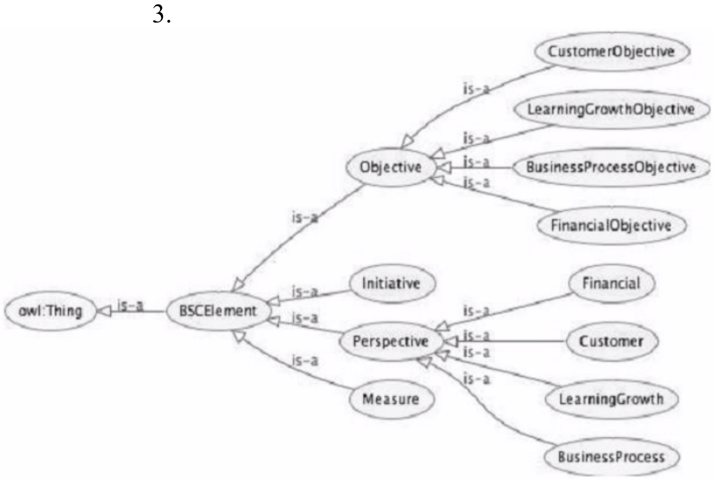

Figure 3: Balanced Scorecard Ontology [9]

3. BUILDING THE WARNING CRITERION ONTOLOGY

Warning Criterion Ontology is the development from The Publishing Workflow Ontology (PWO). The advantages of the model PWO, is able to represent business processes such as workflow and recording process (event logs) using ontology approach. However, the model PWO has a weakness in the definition of the knowledge base of the organizational structure that has rules on an actor, one of them is PWO cannot describe in detail the relationship of superior and the direct superior of the actor with the another actor while executing a individual of class step at the domain workflow. Therefore, it takes ontology model that can represent the domain structure of the organization, one of which is the model organizational ontology (OrO). Where organizational ontology can provide a knowledge base on the organizational structure, so it can be used to sharpen one of detection abnormal activity with resource analysis.

In addition, Warning Criterion Ontology developed by integrating semantically between PWO with Petri net ontology. We make class step (PWO) equivalent with class transition (Petri net ontology) as well as adding some rule. This is done to reduce the nature of the knowledge base on Petri net into the workflow domain (PWO). In the knowledge base workflow (PWO) and business process metamodel (BPM) integration semantically done by adding an object property executedBy the class action (PWO) with class actor (BPM). Then, add the object property performedBy the class action (PWO) with class role (BPM). After that semantically integrates the business process metamodel (BPM) and organizational ontology (OrO) by providing equivalent class in the class role (BPM) and class role (OrO). Add the equivalent class in the class actor (BPM) and class performer (OrO). Then the warning criterion ontology created class employee and class key activity, which the class employee has an object property that distinguishes superior with the direct superior. Object property superior called oro:superior and direct superior called wco:directSuperior. This is done to detect abnormal activity in case of wrong resource, which distinguishes the activity is allowed to be done by the superior and any activity which should only be done by direct superior.

In the class key activity can be connected to class KPI from the balanced scorecard ontology (BSCO) through an object property linkedKPI.

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While class action (PWO) is connected with class KPI through object property has warning action. It is used to connect the KPI to abnormal activity when business processes are executed. In the modeling ontology classes, object property and data property of warning criterion ontology using the prefix of the wco. The model of warning criterion ontology can be seen in Figure 4.

In the model have thirteen classes were added to the prefix of the wco. The advantages of the model WCO, which is contained in class keyActivity and object properties wco:directSuperior. Class key activity is a class that is used to separate normal activities with the key activities that affect the level of compliance in SOP implementation. Where only individual key activity detection will be done. While individuals in the class normal activity is ignored/not conducted detection.

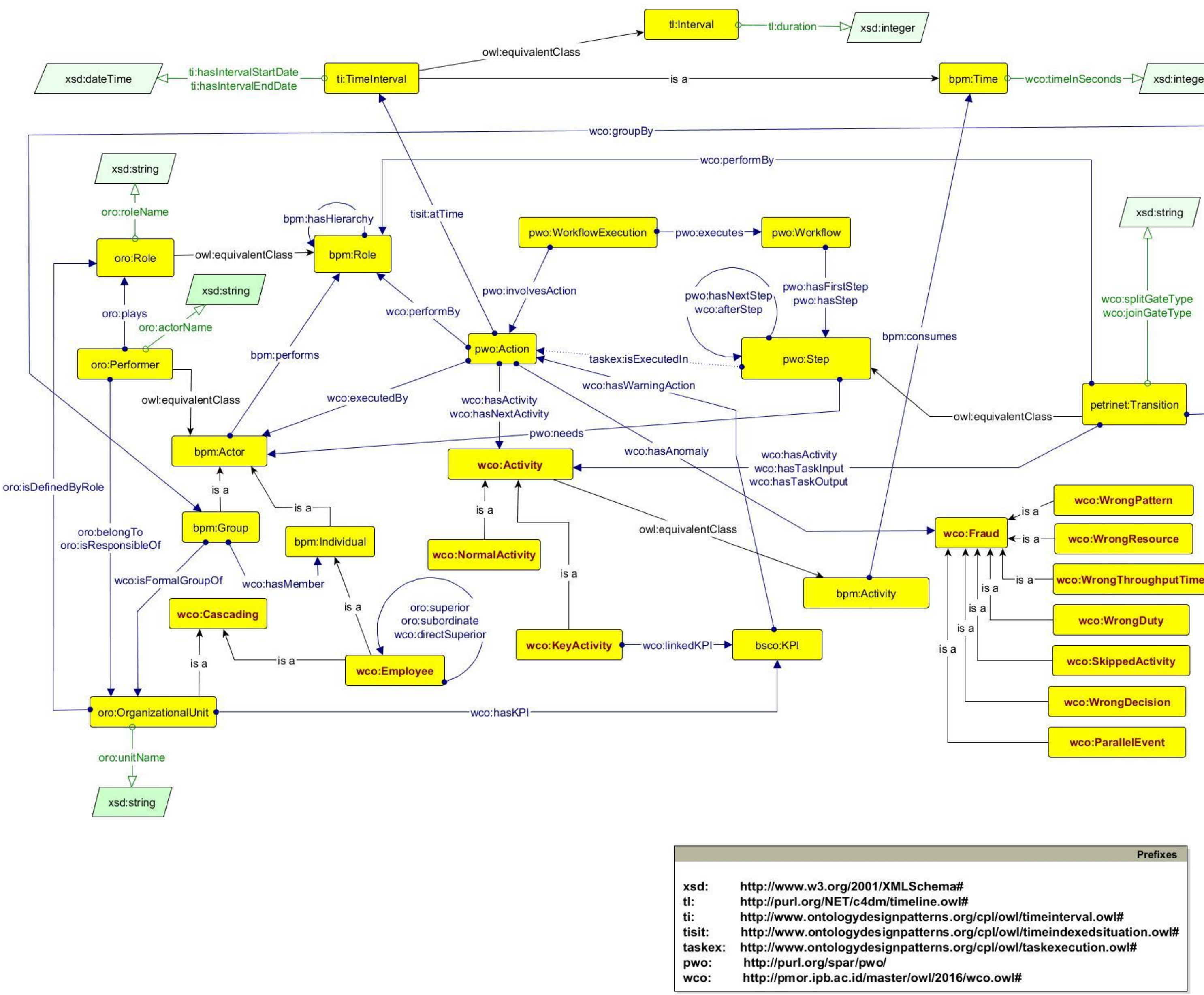

Figure 4: Graffoo [18] representation of the Warning Criterion Ontology

This is done because not all of the activities contained in SOP is a key activity of a unit that is being assessed the level of compliance in SOP implementation. In addition, the WCO models can distinguish between activities that can be done by all superior (object property oro:superior) compared with the activity that should only be done by direct superior (object property wco:directSuperior). The class name and attributes of the WCO models can be seen in Table 1. In addition, the WCO has nine rule used in the model, among others:

1. Place(?c), Transition(?a), Transition(?b), arcPfromT(?a, ?c), arcTfromP(?c, ?b), hasActivity(?b, ?d) → hasTaskInput(?a, ?d)
2. Place(?c), Transition(?a), Transition(?b), arcPtoT(?c, ?b), arcTtoP(?a, ?c), hasActivity(?b, ?d) → hasTaskOutput(?a, ?d)
3. Place(?c), Step(?a), Step(?b), arcPtoT(?c, ?b), arcTtoP(?a, ?c) → hasNextStep(?a, ?b)
4. Step(?a), Step(?b), hasNextStep(?a, ?b) →afterStep(?b, ?a)
5. Step(?a), Step(?b), Step(?c), afterStep(?b, ?a), afterStep(?c, ?b) → afterStep(?c, ?a)
6. OrganizationalUnit(?b), Performer(?c), Group(?a), constitutes(?c, ?a), isFormalGroupOf(?a, ?b) → belongTo(?c, ?b)
7. OrganizationalUnit(?b), Group(?a), Role(?c), performs(?a, ?c), isFormalGroupOf(?a, ?b) → isDefinedByRole(?b, ?c)
8. Role(?b), Employee(?a), performs(?a, ?b) → plays(?a, ?b)
9. Performer(?d), Group(?b), Role(?c), Step(?a), plays(?d, ?c), constitutes(?d, ?b), groupBy(?a, ?b), performBy(?a, ?c) → needs(?a, ?d)

By adding these nine rules, as a source of intelligence that can be used by an inference engine to perform reasoning. So that the existing knowledge base can form the basis of new knowledge based used the rule. Numbers 1 and 2 is a rule that is used to form the basis of the knowledge possessed by the WCO in the form of object properties hasTaskInput and hasTaskOutput. While the numbers 3, 4, and 5 are used to form a knowledge base on workflow domain (PWO) and Petri Net (Petri Net Ontology), in the form of object properties hasNextStep and AfterStep. Set of rules, the numbers 6, 7, 8 and 9 is a rule that is used to supplement information on the individual knowledge of the Employee class based on multiple domain structure of the organization, the information unit attached to actors in the workflow domain. Such information include: object property belongTo, object property isDefinedByRole, object property plays and object property needs.

Table 1: Description and Attributes of WCO.

Class	*Description and Attributes*
Cascading	This class is a representation the preparation of balanced scorecard at each level of the organization. In the model of the WCO, cascading applied consists of organizational units and employee.
Employee	This class is a representation all employees who will be judged performance. In this class in addition to a sub-class of individuals, to domain balanced scorecard. This class is a subclass of class cascading. Attributes: label and actor name.
Activity	This class is a representation associated with activity in the business process, which is be an equivalent class with a class activity on the business process metamodel. Attributes: label.
Key Activity	This class is a representation of the entire activity being a key activity of a unit, or actor will be judged performance. This class is a subclass of class Activity. Attributes: label.
Normal Activity	This class is a representation of all the activity that is not a key activity of a unit or actor. This class is a subclass of class Activity. Attributes: label.
Fraud	This class is a representation of all the criteria Process-Based Fraud (PBF).
Wrong Pattern	This class is a representation the pattern is different between case generated event logs with the SOP.
Wrong Resource	This class is a representation the event is done by actors who do not have authorization.
Wrong Throughput time	This class is a representation the execution time of the event that do not fit compared to the standard time of the event can be executed.
Wrong Duty	This class is a representation the occurrence of different events, but executed by the same performer.
Skipped Activity	This class is a representation the occurrence of a process of skipping activities that should be passed by SOP.
Wrong Decision	This class is a representation in the decision making process, it is not the same as the existing SOP.
Parallel Event	This class is a representation the different events that are executed concurrently, at the same time.

4. PROPOSED METHOD

In this research, a flow of the process of preparing the lecture schedule has been investigated as a case study for detection abnormal activity, such as: wrong pattern, wrong resource, throughput time maximum and wrong duty combine. Figure 5 presents a control flow model depicting the Standard Operating Procedure (SOP) of preparing the lecture schedule. The model also explains the information about actor and role. That SOP is the responsibility of the Directorate for Educational Administration (Dit. AP). The SOP was created with the application WoPed (Petri Net Workflow Designer) [19], there are have 13 place and 11 transitions. The preparing the lecture schedule starts when activity "Coordination form study plan online, academic management system, and the availability of the room" is executed. Then the process is complete if the activity "upload to the form study plan system" is done. The research consisted of two stage: initialization stage and the main stage. In the initialization stage, carried out the integration of ontologies with reasoned, then the weighting of each criterion using the Analytic Hierarchy Process (AHP). On the main stage, do detection with conformance checking the wrong pattern analysis, resource analysis, throughput time analysis and segregation of duty analysis of the ontology SOP and ontology event logs using SPARQL Protocol and RDF Query Language (SPARQL).

This model can to detect wrong pattern, wrong resource, throughput time maximum and wrong duty combine based on key activity of every unit. Once detected, it made linked to the ontology so that they appear as a warning action on a KPI. Then measuring the performance of the unit by using formula KPI measurement. The design of the overall system can be seen in Figure 6.

4.1 Weighting criteria using Analytical Hierarchy Process (AHP)

We use five criteria for assessing the level of compliance in SOP implementation, they are: goal of the SOP, error process flow is executed (wrong pattern), the actor who did not have the right to perform the execution (wrong resource), workmanship too long on an activity (throughput time maximum) and the occurrence of two different activities carried out by the same actors (wrong duty combine). Then each criterion, the comparison between the criteria with the other criteria. To obtain the value of the interest rate criterion obtained by distributing questionnaires.

Respondents are experts who are part of an actor in the SOP of preparing the lecture schedule. Respondents were selected were divided into two groups, namely: lecturers and staff. Moreover, respondents selected were respondents who served as head of the administration or the head of sub directorate.

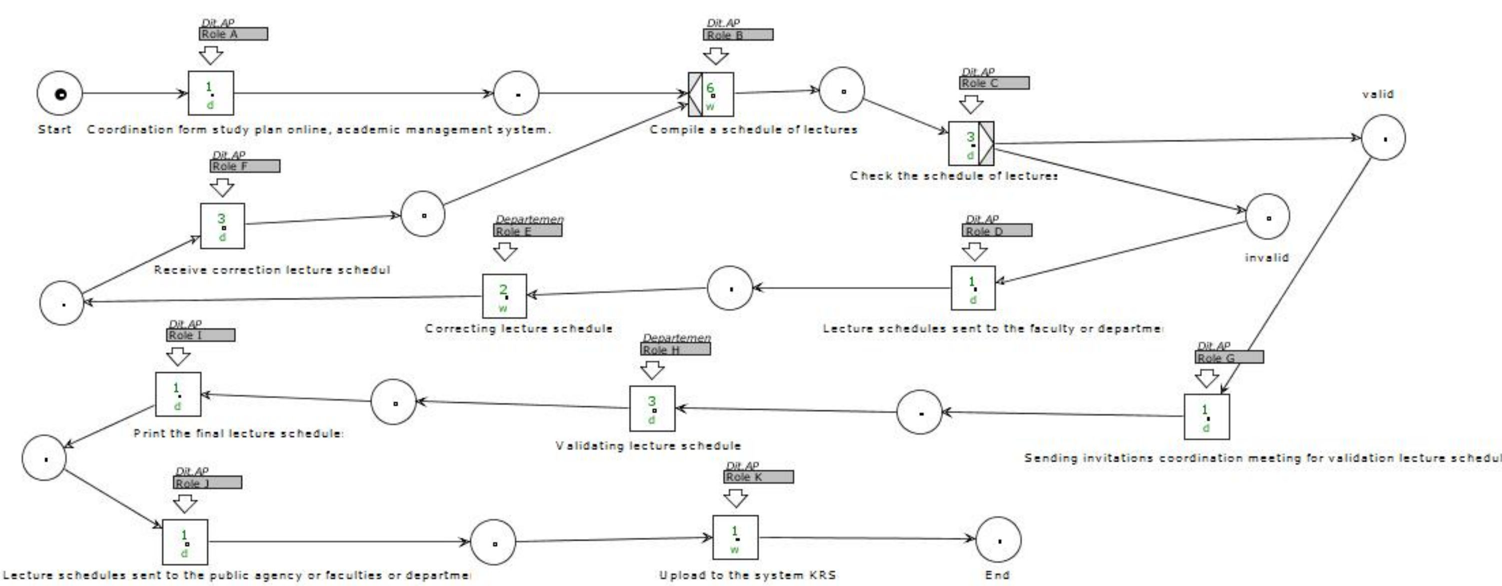

Figure 5: Standard operating procedure preparation process lecture schedules

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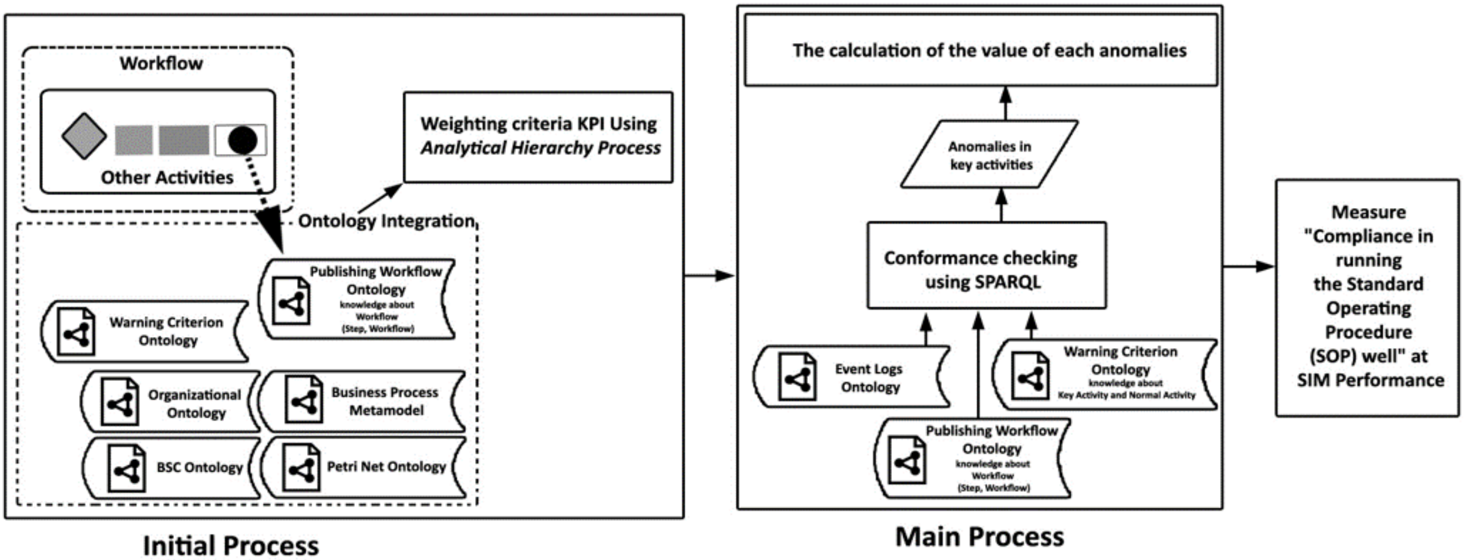

Figure 6: The design of the overall system

4.2 Key Activity

Key activity of every unit used to separate the activity were significantly associated with less activity affect the performance of a unit. In the SOP of preparing the lecture schedule, there are nine activities of the eleven activities held SOP of preparing the lecture schedule is becoming a key activity. Key activities in SOP of preparing the lecture schedule can be seen in Table 2.

Table 2: Key activity in SOP of preparing the lecture.

Key Activity
Coordination form study plan online, academic management system, and the availability of the room
Compile a schedule of lectures
Check the schedule of lectures
Lecture schedules sent to the faculty or department
Receive correction lecture schedules
Sending invitations coordination meeting for validation lecture schedules
Print the final lecture schedules
Lecture schedules sent to the public agency or faculties or departments
Upload to the form study plan system

4.3 Wrong Pattern Analysis

This analysis is used for cases in which where there is a pattern that is different between case generated event logs with the SOP. Examples of wrong pattern to be detected can be seen in Figure 7.

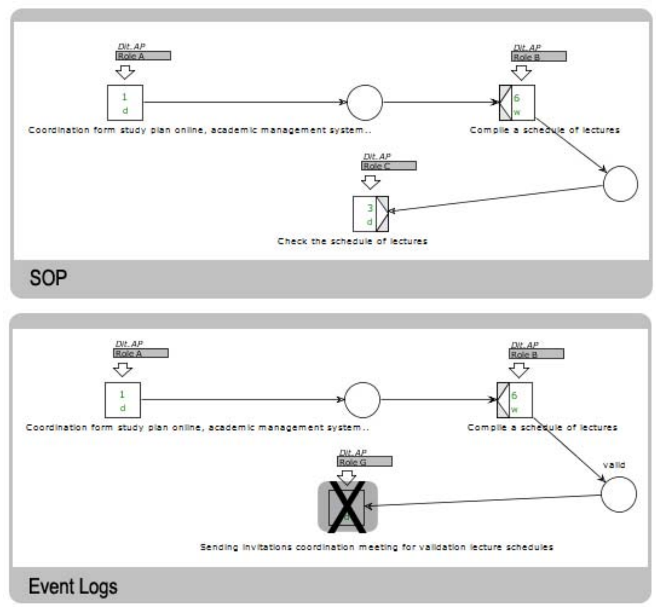

Figure 7: Case of Wrong Pattern

Based on Figure 7 there was activity "Coordination form study plan online, academic management system, and the availability of the room" that is executed after the activity "Check the schedule of lectures", it is not in accordance with the sequence set forth in SOP models used. Therefore, the event has been doing wrong pattern. To detect the wrong pattern can be done by running the syntax SPARQL in Figure 8. If the result parameter result is 0 then going wrong pattern. Detection of wrong pattern analysis is performed based on key activity of every unit. In the SPARQL there are two steps to using key activities, i.e.:

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a. Join with the key activity class
OPTIONAL{
?key a wco:KeyActivity .
FILTER (?key = ?a)
}

b. Filter out what key activities are used in assessing performance

!BOUND(?key)

```
PREFIX pwo: <http://purl.org/spar/pwo/>
PREFIX wco: <http://pmor.ipb.ac.id/master/owl/2016/wco.owl#>
PREFIX sop: < http://www.semanticweb.org/data/owl/2017/sop.owl#>
PREFIX logs: <http://www.semanticweb.org/5f516eba-ea2b-4eea-a527-
79a37659bcc2.owl#>

SELECT distinct (count(?a) as ?hasil)
 WHERE {
        ?step a pwo:Step .
        ?action a pwo:Action .
        ?step wco:hasActivity ?a .
        ?step wco:joinGateType ?gate .
        ?action wco:hasActivity ?a .
        ?action wco:hasActivity ?a .
          OPTIONAL{
            ?key a wco:KeyActivity .
            FILTER (?key = ?a)
          }
        OPTIONAL{
           ?previousStep a pwo:Step .
           ?step pwo:hasPreviousStep ?previousStep .
           ?previousStep wco:hasActivity ?a2 .
           ?previousAction a pwo:Action .
           ?action wco:hasPreviousAction ?previousAction .
           ?previousAction wco:hasActivity ?a2 .
        }
        OPTIONAL{
           ?sop pwo:hasFirstStep ?step .
        OPTIONAL{
           ?previousActionFirst a pwo:Action .
           ?action wco:hasPreviousAction ?previousActionFirst .
           ?previousActionFirst wco:hasActivity ?a3 .
        }
        OPTIONAL{
           ?x a pwo:Step .
           ?x wco:hasActivity ?a .
           ?x wco:hasTaskInput ?c .
        }
        FILTER(
           ?step = sop:transition_2_op_2 &&
           ?action = logs:sid_a55a427b_64c5_4cdc_8909_b6c782e76a00
            &&
           (
             !BOUND(?key) ||
             (!BOUND(?sop) && BOUND(?a2)) ||
             (BOUND(?sop) && !BOUND(?a2) && !BOUND(?a3))||
             (
                !BOUND(?sop) &&
                !BOUND(?a2) &&
                ?c = ?a3 &&
                regex(?gate, "XOR") &&
                BOUND(?previousActionFirst)
             ))}
ORDER BY ?step
```

Figure 8: Syntax SPARQL to detect Wrong Pattern

4.4 Wrong Resource Analysis

In an SOP, the implementation of each event must be in accordance with the actor. Each event has an actor who is executing, and if the event is done by the offender is wrong, then this will affect the value of attribute wrong resource. Examples of wrong resource to be detected can be seen in Figure 9.

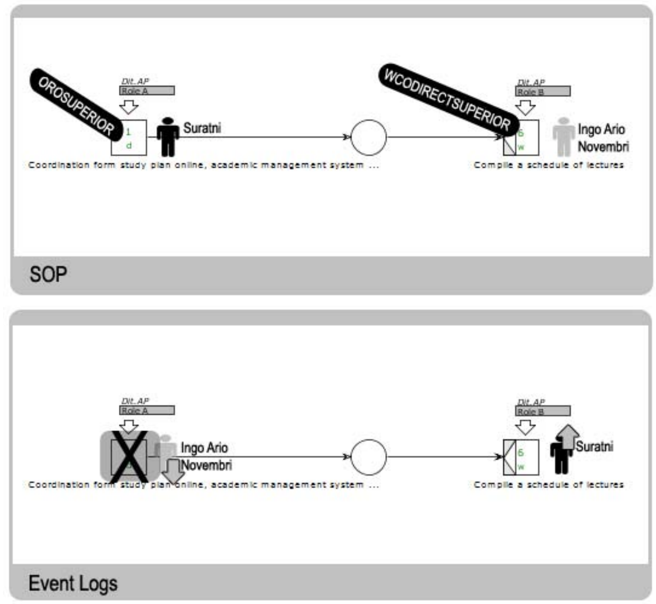

Figure 9: Case of Wrong Resource

Based on Figure 9 there are actors named Ingo has activity "Coordination form study plan online, academic management system, and the availability of the room". That activity should be done by suratni, because that activity does not have the object property oro:superior, then the activity detected as wrong resource. While on "activity scheduling lecture" actor suratni not detected as wrong resource because that activity has a direct superior (object property wco:directSuperior) of. To detect the wrong resource can be done by running the syntax SPARQL in Figure 10. If the result parameter result is 0 then going wrong resource. Detection of resource analysis is performed based on key activity of every unit. In the SPARQL there are two steps to using key activities, i.e.:

a. Join with the key activity class
OPTIONAL{
?key a wco:KeyActivity .
FILTER (?key = ?a)
}

b. Filter out what key activities are used in assessing performance

!BOUND(?key)

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```
PREFIX pwo: <http://purl.org/spar/pwo/>
PREFIX wco: <http://pmor.ipb.ac.id/master/owl/2016/wco.owl#>
PREFIX bpm: <http://www.semanticweb.org/master/owl/2014/bpm.owl#>
PREFIX oro: <http://www.semanticweb.org/master/owl/2012/oro.owl#>
PREFIX sop: < http://www.semanticweb.org/data/owl/2017/sop.owl#>
PREFIX logs: <http://www.semanticweb.org/b48b4bdc-9572-4d90-b5ba-
ec9fffcb1ffe.owl#>

SELECT distinct (count(?a) as ?hasil)
  WHERE {
        ?step a pwo:Step .
        ?action a pwo:Action .
        ?step wco:hasActivity ?a .
        ?step wco:performBy ?role1 .
        ?step wco:groupBy ?group .
         OPTIONAL{
            ?key a wco:KeyActivity .
            FILTER (?key = ?a)
         }
       OPTIONAL{
          ?action wco:executedBy ?actor1 .
          ?step pwo:needs ?actor1 .
       }
       OPTIONAL{
          ?action wco:executedBy ?actor2 .
          ?step pwo:needs ?actor3 .
          ?actor2 wco:directSuperior ?actor3 .
          ?role2 bpm:hasHierarchy ?role1 .
          ?role2 oro:roleName ?roleName1 .
       }
       OPTIONAL{
          ?action wco:executedBy ?actor4 .
          ?step pwo:needs ?actor5 .
          ?actor4 oro:superior ?actor5 .
          ?role3 bpm:hasHierarchy ?role1 .
          ?role3 oro:roleName ?roleName2 .
       }
       FILTER(
          ?step = sop:transition_1 &&
          ?action = logs:sid_652cd323_36a1_4b44_929e_1787b8fb3230
           &&
          (
           (!BOUND(?key)) ||
           (BOUND(?actor1)) ||
(BOUND(?actor2) && regex(?roleName1, "WCODIRECTSUPERIOR")) ||
(BOUND(?actor4) && regex(?roleName2, "OROSUPERIOR"))
          )
       )
}
ORDER BY ?step
```

Figure 10: Syntax SPARQL to detect Wrong Resource

4.5 Throughput Time Analysis

An event that the execution time is faster or longer than the standard execution time is on SOP, will be identified as abnormal activity. In this study, the implementation of which is longer (throughput time maximum) as compared to the duration of the SOP is one of abnormal activity. Example throughput time maximum to be detected can be seen in Figure 11.

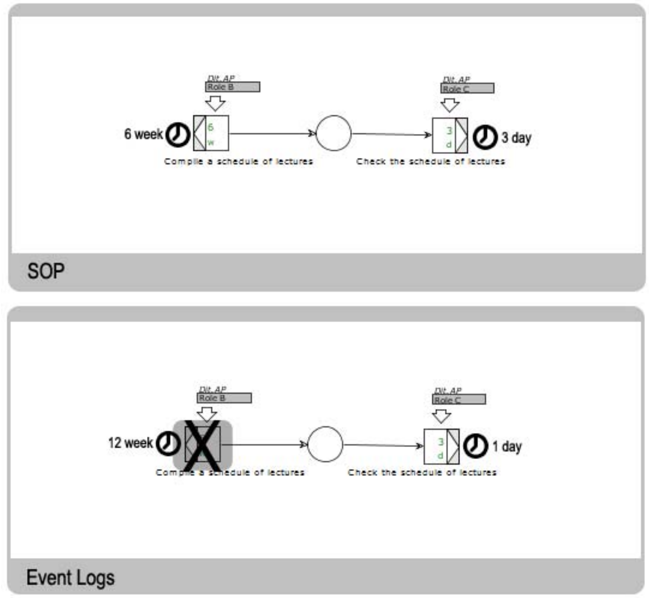

Figure 11: Case of Throughput Time Maximum

Based on Figure 11 workmanship tolerance activity “Develop a schedule of lectures” is six weeks, but in fact worked in twelve weeks. This resulted in the throughput time maximum. To detect the throughput time maximum can be done by running the syntax SPARQL in Figure 12. If the result parameter result is 0 then going wrong resource. Detection of resource analysis is performed based on key activity of every unit. In the SPARQL there are two steps to using key activities, i.e.:

a. Join with the key activity class

   OPTIONAL{
   ?key a wco:KeyActivity .
   FILTER (?key = ?a)
   }

b. Filter out what key activities are used in assessing performance

   !BOUND(?key)

```
PREFIX pwo: <http://purl.org/spar/pwo/>
PREFIX wco: <http://pmor.ipb.ac.id/master/owl/2016/wco.owl#>
PREFIX tisit:
<http://www.ontologydesignpatterns.org/cp/owl/timeindexedsituation.owl#>
PREFIX tl: < http://purl.org/ NET/c4dm/timeline.owl#>
PREFIX sop: < http://www.semanticweb.org/data/owl/2017/sop.owl#>
PREFIX logs: <http://www.semanticweb.org/e96f16b2-2cbc-407d-9595-
5d3419d0b63f.owl#>

SELECT distinct (count(?action) as ?hasil)
WHERE {
        ?step a pwo:Step .
        ?action a pwo:Action .
        ?a a wco:KeyActivity .
```

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```
?step wco:hasActivity ?a .
?step tisit:atTime ?t1 .
?t1 tl:duration ?d1 .
?action wco:hasActivity ?a .
  OPTIONAL{
     ?key a wco:KeyActivity .
     FILTER (?key = ?a)
  }
OPTIONAL{
  ?action tisit:atTime ?t2 .
  ?t2 tl:duration ?d2 .
}
FILTER(
   ?step = sop:transition_13> &&
   ?action = logs:sid_c92e0792_d1a7_4d42_ba36_1110352a7bed
    &&
   (
      !BOUND(?key) ||
      ?d2 > ?d1
   )
 )
}
ORDER BY ?step
```

Figure 12: Syntax SPARQL to detect Throughput Time Maximum

4.6 Segregation of Duty Analysis

Segregation of duty analysis is intended to examine whether there are irregularities in the separation of work tasks. Irregularities occurred if the actor did two events side by side in the same case, where the event is being run have different units with SOP. Examples wrong duty combine to be detected can be seen in Figure 13.

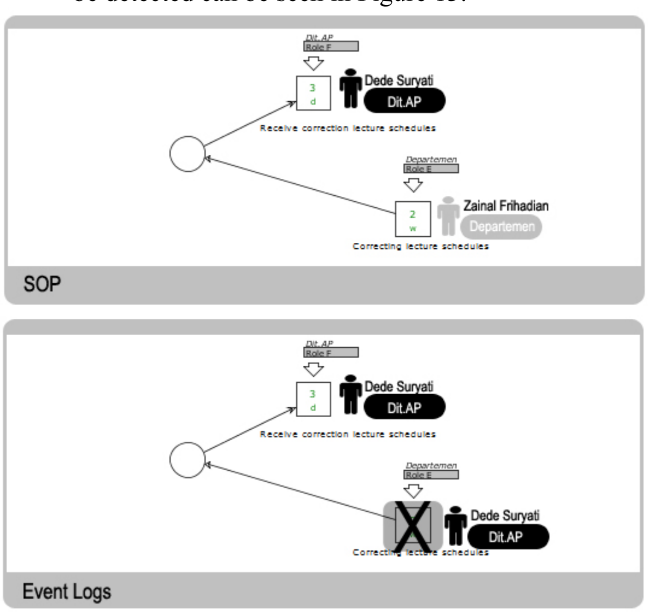

Figure 13: Case of Wrong Duty Combine

Based on Figure 13 there was activity “corrected lecture schedules” should only be performed by actors working in the department. In fact there are actors named Dede. Dede is a staff of Dit.AP. Therefore, the case is declared wrong duty. To detect wrong duty combine can be done by running the syntax SPARQL in Figure 14. If the result parameter result is 0 then going wrong duty combine. Detection of segregation of duty analysis is performed based on key activity of every unit. In the SPARQL there are two steps to using key activities, i.e.:

a. Join with the key activity class

```
OPTIONAL{
        ?key a wco:KeyActivity .
        FILTER (?key = ?a)
    }
```

b. Filter out what key activities are used in assessing performance

```
!BOUND(?key)
```

```
PREFIX pwo: <http://purl.org/spar/pwo/>
PREFIX wco: <http://pmor.ipb.ac.id/master/owl/2016/wco.owl#>
PREFIX oro: <http://www.semanticweb.org/master/owl/2012/oro.owl#>
PREFIX sop: < http://www.semanticweb.org/data/owl/2017/sop.owl#>
PREFIX logs: <http://www.semanticweb.org/8737d97e-fc04-440a-9649-
dd659b35a717.owl#>

SELECT distinct (count(?actor1) as ?hasil)
   WHERE {
        ?step a pwo:Step .
        ?action a pwo:Action .
        ?action wco:executedBy ?actor2 .
        ?action wco:hasActivity ?a .
        ?step wco:hasActivity ?a .
        ?step pwo:needs ?actor1 .
        ?actor1 oro:belongTo ?unit1 .
        ?actor2 oro:belongTo ?unit2 .
        OPTIONAL{
            ?key a wco:KeyActivity .
            FILTER (?key = ?a)
        }
        OPTIONAL{
          ?previousAction a pwo:Action .
          ?action wco:hasPreviousAction ?previousAction .
          ?previousAction wco:executedBy ?actor3 .
        }
       FILTER(
          ?step = sop:transition_4 &&
          ?action = logs:sid_55b695e4_7060_47df_a94e_ee6e06a669e8
          &&
            (
              !BOUND(?key) ||
            !BOUND(?previousAction) ||
            ?unit1 = ?unit2 ||
            (?actor2 != ?actor3 && ?unit1 != ?unit2)
            )
        )
}
ORDER BY ?step
```

Figure 14: Syntax SPARQL to detect Wrong Duty Combine

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4.7 Measuring Key Performance Indicator

To measure the level of compliance in implementing the Standard Operating Procedures (SOP), required the calculation formula to obtain the value of KPI scores are used to determine compliance category. Steps to get a score, namely:

1. Setting a target at the beginning of the year,
2. Obtain value of performance/actual at the end of the year,
3. Calculating the percentage of achievement of KPI, in which a KPI is said to perform well if the higher value of the achievement of the target value. Achievement of KPIs can be obtained using the equation 1.

$$\text{Achievement}_{KPI}\,(\%) = \begin{cases} \frac{actual}{target} \times 100\,\%, & actual < target \\ 0\,\%, & actual = 0 \\ 100\,\%, & actual \geq target \end{cases} \quad (1)$$

4. Calculating Score of KPI using the equation 2.

$$\text{Score}_{KPI} = \text{Achievement}_{KPI} \text{ X } \text{Weight}_{KPI} \quad (2)$$

5. Category compliance in implementing SOP is based on the score obtained. Scale categories were used, namely:

Submissive $= 80\,\% \leq \text{Skor}_{KPI} \leq 100\,\%$
Enough Submissive $= 50\,\% \leq \text{Skor}_{KPI} < 80\,\%$
Less Submissive $= 0\,\% \leq \text{Skor}_{KPI} < 50\,\%$

5. EXPERIMENT AND RESULT

In this section, we obtain comparative priority of each criterion by using AHP through spreading the questionnaire to the experts. Result of filling the questionnaire will be selected on the basis of value Consistency Ratio (CR), which if CR is less than 0.1 (CR <0.1), the result of filling the questionnaire consistently [20]. The result of filling for the SOP of preparing the lecture schedule indicates that there are six respondents from twelve respondents who expressed a consistent. In Table 3, shows the results of value CR for filling out the questionnaire for the SOP of preparing the lecture schedule.

Table 3: The results of value CR for the SOP of preparing the lecture schedule.

Respondent	*Consistency Ratio (CR)*
Respondent 1 (R2)	0.155
Respondent 2 (R2)	**0.053**
Respondent 3 (R3)	**0.086**
Respondent 4 (R4)	0.393
Respondent 5 (R5)	**0.099**
Respondent 6 (R6)	0.39
Respondent 7 (R7)	0.604
Respondent 8 (R8)	**0.097**
Respondent 9 (R9)	**0.099**
Respondent 10 (R10)	0.502
Respondent 11 (R11)	**0.064**
Respondent 12 (R12)	0.479

In Table 3, states that Respondent 2, 3, 5, 8, 9, and 11 had a CR <0.1, so that the weighting is based on the results of the questionnaires of the six respondents can be used. In Table 4 shows the weights used to obtain a score. Table 4. Weighting per criteria for the SOP of preparing the lecture schedule. Based on the average weight of the criteria shown in Table 4, compliance criteria states that the priority in the run the SOP of preparing the lecture schedule sequence is of goal (31.57%), throughput time maximum (21.21%), wrong pattern (18.91%), wrong resource (18.02%), wrong duty combine (10,30 %).

Table 4: Weighting per criteria for the SOP of preparing the lecture schedule.

Respondent	*Goal (%)*	*Wrong Pattern (%)*	*Wrong Resource (%)*	*Through put Time Max (%)*	*Wrong Duty Combine (%)*
R2	25.88	22.54	16.86	25.62	9.10
R3	24.17	24.17	24.17	8.03	19.46
R5	26.99	39.19	5.28	18.60	9.94
R8	23.76	13.99	11.64	44.99	5.63
R9	45.86	7.43	30.26	10.10	6.35
R11	42.74	6.15	19.90	19.90	11.32
Mean	**31.57**	**18.91**	**18.02**	**21.21**	**10.30**

Event logs from SOP of preparing the lecture schedule is the result of the formation of event logs is based on archival documents and interviews. Event logs that were set up, based on real data consists of six semesters of academic periods, namely: Semester Even 2013/2014, Semester Odd 2014/2015, Semester Even 2014/2015, Semester Odd 2015/2016, Semester Even 2015/2016, and Semester Odd 2016/2017.

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Table 5 shows sample event logs from SOP of preparing the lecture schedule Semester Even 2015/2016.

Table 5: Event logs from SOP of preparing the lecture schedule Semester Even 2015/2016.

Event ID	Activity	Originator	Start Time	End Time
E126	Compile a schedule of lectures	Ingo	10/12/15 8:00	12/3/15 16:00
E127	Check the schedule of lectures	Suratni	12/5/15 8:00	12/7/15 16:00
E128	Lecture schedules sent to the faculty or department	Lilis	12/8/15 8:00	12/10/15 16:00
E129	Correcting lecture schedules	Zainal	12/11/15 8:00	12/17/15 16:00
E130	Receive correction lecture schedules	Dede	12/18/15 8:00	12/21/15 16:00
E131	Coordination form study plan online, academic management system, and the availability of the room	Suratni	12/22/15 10:00	12/22/15 12:00
E132	Compile a schedule of lectures	Ingo	12/29/15 8:00	1/5/16 9:00

To test the success or failure of the proposed method and source code SPARQL, then the detection is done with a system that has been developed. The prototype system that has developed a system early warning of the abnormal activity in a business process called Process Mining with Ontology Resource (PMOR). PMOR is an application to help the process mining using .owl resource format (web ontology language). This application is built using the technology MVC .NET Framework, library dotNetRDF (C #) and reasoning using JENA (Java). PMOR equipped models WCO is embedded in Windows Workflow Foundation in the form of source code of derivative CodeActivity class. The result of detection abnormal activity can be seen in Table 6.

To assess the KPI activity, then the calculation is based on the steps to getting a score. The score obtained in this study is divided into two, namely: a score based on data from event logs and a score based on expert opinion. Comparison of the results between expert assessment score can be seen in Table 7.

Table 6: The result of detection abnormal activity.

Semester	Wrong Pattern	Wrong Resource	Through put Time Max	Wrong Duty	Total Event
Event 2013/2014	1	0	3	0	14
Odd 2014/2015	3	0	3	0	14
Event 2014/2015	1	0	3	0	14
Odd 2015/2016	6	0	3	0	14
Event 2015/2016	3	0	6	0	14
Odd 2016/2017	6	0	1	0	17

Table 7: Comparison of the results between expert assessment score.

Semester	Result	Experts assessment score	Error	Accuracy
Event 2013/2014	94.11%	90.00%	4.57%	95.43%
Odd 2014/2015	91.41%	92.00%	0.64%	99.36%
Event 2014/2015	94.11%	94.00%	0.12%	99.88%
Odd 2015/2016	87.36%	93.00%	6.06%	93.94%
Event 2015/2016	86.87%	95.00%	8.56%	91.44%
Odd 2016/2017	92.09%	90.00%	2.32%	97.68%
			Mean	96.29%

Base on Table 7, value of accuracy obtained is 96.29%. The entire semester in column Experts assessment score have above 80% (submissive). According to experts, the score on even 2013/2014 and odd 2016/2017 got a score at least because, in the even 2013/2014 there is a transition the leadership while of the odd 2016/2017 there is a test new academic system. So that many activities Sub-Directorate educational planning should be done which resulted in minimal disruption of the scheduling process. Calculations performance carried out for one year, therefore the data are accumulated based on two periods: the period of even and odd period, example: even 2013/2014 and odd 2014/2015 are the performance

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in 2014. Then, to determine the level of compliance we divide it into three categories, namely: submissive, enough submissive, and less submissive. The measurement results compliance rate per year can be seen in Table 8.

Table 8: The measurement results compliance rate per year.

Year	*Result*	*Category*
2014	92.76%	Submissive
2015	90.74%	Submissive
2016	89.73%	Submissive

Base on Table 8, the level of compliance in 2014 is submissive with a percentage of 92.76%, 2015 is submissive with a percentage of 90.74% and in 2016 is submissive with a percentage of 89.73%. The prototype PMOR can be seen in Figure. 15.

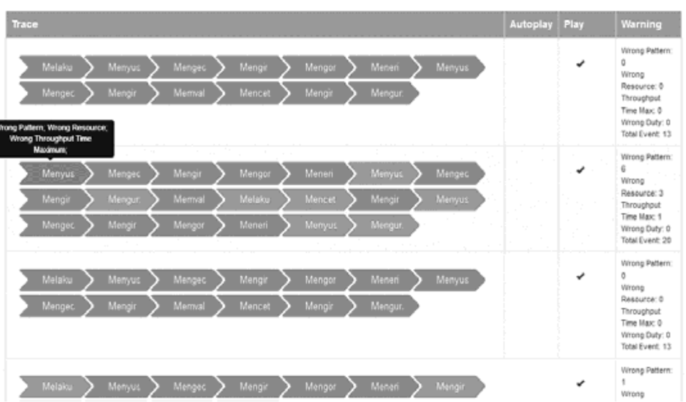

Figure 15: Prototype of PMOR

Initially, using the expert assessment score we can assess the compliance in Standard Operating Procedure (SOP) implementation, but the assessment is still subjective. Therefore, with the approach of process mining technique, where comparing event logs with the flow of business processes or SOP, it will get some abnormal activity if in fact there are activities that are run not in accordance with SOP. This abnormal activity can be detected by ontology approach using our model is Warning Criterion Ontology (WCO).

6. DISCUSSION AND LIMITATIONS

Our model is an expansion of The Publishing Workflow Ontology (PWO), where the PWO model cannot detect abnormal activity when activity on workflow has been performed. In addition PWO cannot distinguish the position of each actor whether on the superior or subordinates. Therefore, by adding an Organizational Ontology (OrO) that can differentiate superiors, subordinates and with adding object property direct superior is expected to add knowledge to the model about the position of each actor used to detect abnormal activity on the wrong resource.

This research only use SOP of administration field, not tested on SOP of academic field. In the academic field there are some rules that are not written on SOP because that cannot be forced or difficult to measure, e.g.: SOP “process of thesis work” there is interaction between lecturers and student and there is a difficulty level every area of research field.

7. CONCLUSION

In this paper we introduced the Warning Criterion Ontology (WCO) for detection abnormal activity, such as: wrong pattern, wrong resource, throughput time maximum and wrong duty combine in the business process which can be integrated semantically with PWO and BSCO. We have shown detection abnormal activity at process of preparing the lecture schedule. Where the value of accuracy obtained is 96.29% based on the comparison between the results of research with expert assessment scores. The level of compliance in implementing process of preparation the lecture schedule in 2014 is submissive with a percentage of 92.76%, 2015 is submissive with a percentage of 90.74% and in 2016 is submissive with a percentage of 89.73%.

In this research, has been add object properties that can differentiate superior with the direct superior on the model WCO. Where the object property named wco:directSuperior. This is done to detect abnormal activity in the case of more complex wrong resource in differentiating activities that may be carried by all superior and activity that should only be done by direct superior. Besides, there is a class key activity connected with the class KPI at balanced scorecard ontology (BSCO) through an object property linked KPI. While class action (PWO) is connected with class KPI (BSCO) through object property has warning action. It is used to connect the KPI with abnormal activity on business processes that have been executed.

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