Paper 8

by Paper Aradea

Self-Adaptive Cyber City System

Iping Supriana
School of Electrical Engineering and Informatics
Bandung Institute of Technology
Bandung, Indonesia
iping@informatika.org

Kridanto Surendro
School of Electrical Engineering and Informatics
Bandung Institute of Technology
Bandung, Indonesia
surendro@gmail.com

Aradea
Department of Informatics Engineering
Faculty of Engineering, Siliwangi University
Tasikmalaya, Indonesia
aradea@unsil.ac.id

Edvin Ramadhan
Department of Informatics Engineering
Faculty of Computer Science, Sriwijaya University
Palembang, Indonesia
edvin.ramadhan@gmail.com

***Abstract*—The trend in using information and communication technology as an engine of the current city management system has hypnotized various cities in the world, including Indonesia. Many terms appeared such as cyber city, smart city, intelligent city, or whatever it's called with the various developments of concepts that offer a wide range of sophistication and ease in managing any city needs. But behind the greatness of the proposed system, whether they are aware of how the characteristics of a city should be. In a city, there are so many diversities of the dynamic elements that make us must have an adaptive system to control it. This paper proposes an approach that has concern for the importance of adaptability to help the city management system. Two type of problems that become the main focus that make why the self-adaptive capability is important are deterministic and non-deterministic problems. The developed key strategy consists of two approaches. First, through series of modification for representing new problem space for solving a deterministic problem. Second, a non-deterministic problem is handled by a system that prepared automatically to search solution. The main objective of this paper is to depict a model to handle both types, through cyber city case illustration.**

Keywords—self-adaptive systems; intelligent systems, knowledge representation; rule-based systems, adaptive cyber city

I. Introduction

The growth of urban population in the world today, encourages the growth of needs level, which is increasingly out of control. This is based on the fact that the level of knowledge of the population continues to increase, so [1] causes the issues of social, economic, and environmental become connected with each other. This fact shows that the characteristics of a city have a multitude of interrelated elements, and ultimately led to various challenges and problems, related to the provision of public services. Therefore, cities are required to have an intelligent solution to creating sustainable environments, e.g., [1], the management of infrastructure resources, environmental management, city activities monitoring, and various other activities. All these activities will be connected to the city management system, such as transportation management systems, energy management, water management, waste management, management of municipal administration, health care management, and various other public service management.

Nowadays, many cities in the world, including cities in Indonesia, have made efforts to tackle the problems. The initiative is by utilizing information and communication technology functions, in a concept called the cyber city, smart city, intelligent city and various other terms. Basically, these concepts aim to meet the needs of the city management, through the formulation of the system, which is packed with various facilities, such as the efficiency and effectiveness of implementation, the speed of access, accuracy of services, and others. Various advantages of the features developed will not make a significant contribution, if it is temporary. This is related to the ability of the concept that can be offered to meet the dynamic characteristics of growth in a city.

The key strategies in this paper is the main contribution. We propose a self-adaptive framework for the city management system. The approach is divided into two models, the first is called (a) domain models, a representation of the variability in the context of the needs to be captured, and the environmental behavior of the system, and the second (b) control model, a formulation of the management and adaptation mechanisms which dealing with the growth of the system. The second section of this paper discusses about the concept of self-adaptive systems and cyber city, then on the third section we describe the proposed model, followed by a discussion of related work in section four, and we conclude this paper in section five.

II. Self-Adaptive Systems and Cyber City

Self-adaptive systems (SAS) was present as an alternative solution to solve the problems related to the changes of features and complexity of the system. Including the demands of regional autonomy, automation, adaptability, flexibility, scalability, reliability, speed, and others [2]. Nowadays, there are various definitions of SAS, including SAS as a system that can automatically take appropriate action based on the knowledge of what is happening in the system, guided by the goals, and some users who are given access to the system [3]. SAS can modify the behavior of the system in order to respond to changes in the system itself, or in the system environment [4]. This definition shows that the system has its own knowledge, which makes it able to achieve its own objectives in several ways, and able to make changes in behavior based on events that occur in its environment.

978-1-5090-1636-5/16/$31.00 © 2016 IEEE

The complexity in the environment of the city has forced the developers to manage all their resources. Some initiatives such as the concept of the cyber city, smart city, intelligent city, and others appeared. In this paper, we use the term "cyber city" with the assumption, the term of "self-adaptive" that we use, has been able to represent the meaning of smart or intelligent in a system. Some dimensions associated with the concept, consisting of the needed criteria [5] on competitive levels, mobility access and connectivity, sustainability of natural resources, development of human capital, the level of life quality, and government participation. Thereby, the used dimensions will be able to reflect the diversity of the elements contained in the urban environment. Besides the diversity of the elements, each of these dimensions has a life cycle that will continue to grow and evolve in order to fulfill its objectives, both for the purposes of any criteria or a common goal as a cyber city.

The characteristics and behavior of each of these elements need a converter and synchronizer with a system that will be the main engine in achieving the goals in a city. So [6], all activities that happen in the system environment, need a mechanism that can represent the characteristics and behavior in the real world. The concept of self-adaptive systems were developed as a solution for this problem. This concept aims to establish a cyber city system that able to describe the requirements of each element in a city and able to adapt the environment changes.

III. Proposed Method

A. *Self-Adaptive Framework*

The solution for the issue of the diversity and the growth of various elements in an urban environment will be related to the handling of deterministic and non-deterministic factors. Therefore, we developed a framework as shown in Figure 1, consists of two models: (a) The domain model is represented as a goal model, the domain model is the component that provides basic function and logic of the application, known as the target or managed system, this model was developed based on the goal approach oriented, to exploit human-oriented abstractions, such as the concept of agents and other concepts, it is necessary to represent the real conditions of the city environment, (b) The control model is represented as an inference engine, which is the component that controls or manages the target system using the logic of adaptation, called the controller or autonomic manager. This model uses real-time monitoring to detect the change in the environment and the target system. This model is also able to adapt themselves if necessary, e.g. reconfigure when there is a goal change, optimize themselves when the operation changes, handle certain types of errors, and others.

Domain models are the requirements for the goal of the system that is mapped to the BDI (Belief-Desire-Intention) model, the mapping is intended to define the criteria of the goal to be achieved, determine the solution plan, and determine the needed elements that represented by the ADF (Agent-Definition-File), and plan specification. The views of this agent represent a context of the system, which also represents the trusted fact, and as the environment class for the needs of the monitoring function [7]. This approach provides the ability of variability at run-time. But, in this approach, we extend it through assumptions domains from any knowledge. This approach is able to provide a better way to analyze the variability, which can help in detailing the behavior of the system to fulfill the goal and action adaptation.

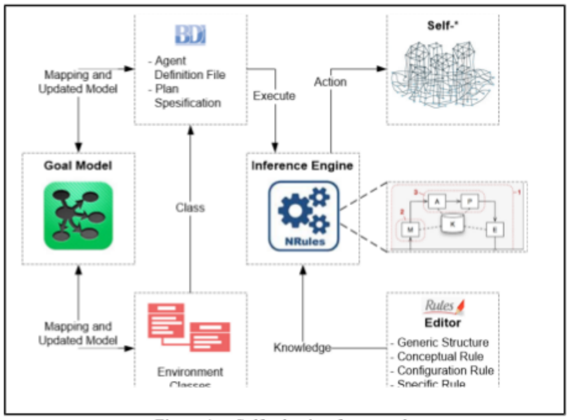

Figure 1. Self-adaptive framework.

Model control is a regulator of the system behavior, by using the pattern of monitoring, analysis, planning, execution results, and knowledge (MAPE-K) [8], explicitly and formalized as an action of the agent or transition rules. By considering the context-aware scenarios, MAPE-K implements an architectural pattern on the ECA (Event-Condition-Action) [9], ECA is one or more "event" refers to the state of the current system, where there are model changes in the application or the system environment. While one or several “conditions” refer to when a specific event occurs, the action of the rule is activated. So one or more “action” that might perform in these conditions will be created to adapt the changes, through some rule operation in determining of behavior the system adaptation.

B. *Structure of Knowledge Base*

Any changes in the system can be stated as the change in a series of node [10], which is any state is modeled into vertices and changes in circumstances described into an arc that connects two vertices. Therefore, the structure which is used to handle dependencies between the elements of knowledge is a directed graph. The motivation for the development of knowledge base structure is based on the fact that the rule-based approach systems in most of its application, only focused on the settings of software behavior through a specially designed knowledge structure model. The problem that might arise from the specificity of these structures is the scope of the variance that can be served, so by formulating some model of a more general and more flexible structure, makes its application on a wide scope of variability can be expanded flexibly.

The developed model can represent a need to capture the various variability in the context and behavior of the system, and can establish guarantees criteria for the management of the system and its adaptation mechanisms. In the design of the developed structures, each node in the graph has some slot of categories, and each category has a number of attributes that can be increased, as shown in Figure 2.

The developed knowledge management mechanism, are prepared to meet the scope of a life cycle system, such as birth (create), used (use), improved (update) and forgotten (delete).

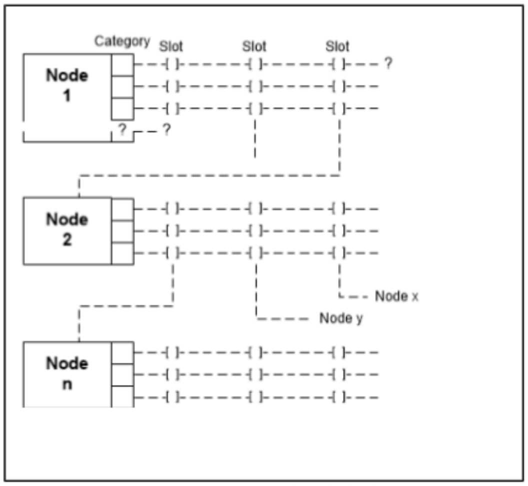

Figure 2. Structure of knowledge base.

So the developed management module consists of, the slots formation, slots expansion, slots adjustment, and slots inspection. Then, the tracking mechanism of a knowledge space, performed by using the slot-accessing modules, trajectory control, and the delayed search. At the same time, the mechanism for handling input of context information and updates, and the output in the form of behavioral adaptation actions are also formed into a module of sensors and actuators.

C. Inference Engine Models

In a formed knowledge structure, knowledge management modules perform a search at the elements that have a cause-effect relationship correspond to the events occurring in the sensor module by using the searching modules of knowledge space. The sensor module will be associated with the context-aware module. Context is information that can be used to characterize the situation of an entity [11]. Context-aware activity performed in two modeling categories called domain modeling context and inference modeling context. As shown in Figure 1, the modeling domain context will be formed by using a model of goal, with the logic-based modeling. This modeling using facts, expressions, and rules to represent the context. At the same time, the inference context modeling performed by using the rule-based approach in managing the knowledge.

This mechanism begins with the agent performance in monitoring the situation or events that occur in system entities through the sensor modules. Event detection performed by the rule of ECA pattern, with the following basic structure:

WHEN	<event> ; one or more transition state
IF	<condition> ; the minimum conditions that must be met to trigger the action
THEN	<action> ; one or more actions when the event takes place
VALID-TIME	<time period> ; specify the period of time during the applicable control action, such as how long the adaptation actions need to be applied

The context information is used as the set of inputs to be monitored as the event and captured by context processor. Connection information contains facts of any context information. The component controller evaluates the condition in accordance with the specific events that occur in the set of the state. In the end, the evaluation results will trigger the action component performer to perform the adaptation action using the transition function in accordance with current conditions. In fact, the context information related to the event of a system entity can be categorized into two problems, the problems categories are the deterministic and non-deterministic problem [12], so the adaptation strategies must be developed to meet both these issues.

Deterministic problems are fixed, so if entering one of the conditions will produce the same output whenever solving problems performed, in other words, the developer has to know what should the system do to adapt the changes and what steps of solutions that can be set before it is implemented. Whereas in the problem non-deterministic, the process of determining step is very difficult to perform, it is caused by too many options steps to be taken, and each selection step does not necessarily lead to the desired solution, in other words, developers do not have a specific solution to address the issue, but they want the system itself that determines its own alternative solutions. Therefore, the criteria for the decision must be able to determine the appropriate adaptation strategies with the category of problems that occur. The problem will be anticipated by using deterministic evolution strategies, where the solution can be designed and are encoded directly by series of developed modifications to represent the new issues space. And for the non-deterministic problems are anticipated by reconfiguration strategy, so the system is prepared to perform a search in the solution space as an alternative solution.

In order to formulate the context inference based on the structure of ECA rule, it can be defined 3 tuple systems: (a) $\sum$: context information (f1...fn), a fact that was captured from environmental events or initial state, (b) Q : system behavior (a1...an), the state system behavior under the conditions of the event or expected end state, both of them are state collections, (c) δ : transition function (t1...tn) as time action adaptation based on the evaluation of the condition for the expected behavior (state modifier function or operator), a collection of state and the operator is known as knowledge. The mechanism of management of knowledge through context inference, is basically related to the search space and search mechanism, so the description of this mechanism is shown in Figure 3. and Table I.

Every time the system can detect the state based on the events that occur in the environment, a set of δ can be expressed as, $\delta = \{tn = (fn, an) \mid n \neq 0\}$, Where fn is the context and an are the expected action behavior for specific contextual n. The quality of the inference engine is very dependent on the selection of one state. The selected state as the adaptive action on the right-hand side (RHS) class, is determined by the expression on the left-hand side (LHS) class, which is declared a match between the rules and facts. For example, by comparing two or more collections of properties with a certain structure based on the required criteria. LHS is an expression that can be a fact, LHS is a single expression (pattern) which is characterized by a name and a collection of slots, or it can be a composite expression of conditional elements (and, or, not), which are used together to connect a single expression (facts) or a composite expression. Class of facts has a containment reference, to the class slot, with attributes slotName and slotValue. The property of this slot is detected to determine the similarity of any elements contained in the facts.

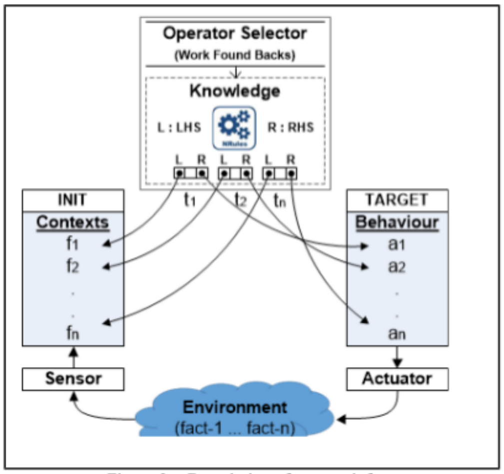

Figure 3. Description of context inference.

Nowadays, there are various algorithms that can be used to build a model selection, known as control strategies. These control strategies can be classified into a blind search, heuristic search, and soft computing. But, this various existing control strategies have their advantages, disadvantages, and consequences for each, so for the suitability control strategy for the issues will be solved is a very important thing to achieving efficiency. As a solution to this problem, we recommend the development of a search tree, this search tree can produce branches that lead us to find a quick solution (expander). Branch in this tree obtained from the operator that match the current conditions. At this point, the multi-control strategy has an opportunity to make improvements in operator voting patterns, so the system can get best search tree. A more detailed description of the multi-control strategy can be seen in our previous paper [12].

D. Case Study

The proposed model has the objective to respond to any changes that occur within the system (domain model), so the system can continue to run normally through the mechanism of the process control (control model). The development of the cyber city system can be initiated through the domain modeling, and continued by identifying every entity in the system along with the achieved goal, in order to define the process and resources, and their relation to one another. Then each of these processes is connected to each interface that will be the executor of the system. And furthermore, every element of the system is mapped into the changing dimensions. This changing dimension consists of [13], the source or origin of the place, where the change occurred, the type of change or the functional and non-functional type, and frequency of occurrence time and how often change occurs.

Figure 4 shows us the mapping of the element of the system to changes dimension (D). Entities are the constituent elements of a city, and for each entity has the process to associate with the other entities and interfaces. Identification of changes can be initiated by defining their origins, can be from an internal source (I) and / or external source (E). Internal sources include the associated changes to the application, middleware or infrastructure, and external sources is an environmental change, such as an external service provider.

TABLE I. PSEUDO CODE OF CONTEXT INFERENCE

Algorithm : Context Inference

```
begin
   INIT ← set WORK ( ∑ , Q )
   while δ : {tn = (fn , an) | n ≠ 0} do
      δ ← find that the LHS of the operator match with
WORK
         say it FOUND
        if FOUND is only one then
           RHS ← set WORK
           else if WORK is equivqlent with TARGET then
           STOP SUCCED
        end
        if FOUND is more then one then
           FOUND ← set WORK one of the FOUND
           BACKS ← put rest of FOUND
        end
        if FOUND is empty then
           else if BACKS is empty then
           STOP FAILD
           else
           BACKS ← set WORK one of BACKS
        end
   end
end
```

Both of the source of these changes will create a causal relationship to each other, and will be associated with the type of change based on the nature of the changes, which consist of functional (F) and / or non-functional (NF). Each type of change would have a frequency of time (T) and number of occurrences. The source of changes will determine the adaptation strategies and associated to the information context, about the internal and external resources. The type of changes will affect the adaptation strategies to determine the behavior of the system in deciding the anticipation of changes towards the goals, and the quality of the system. The frequency of change will affect the response of the necessary adaptations. These processes will capture the requirements for adaptation strategies, both for the deterministic change (evolution), or non-the deterministic changes (reconfiguration).

Based on the mapping, can be defined public service needs that are grouped into the service catalogue as shown in Table II. The service catalogue describes the details of the use of services by each user, and the descriptions of each service specification. The service time explains the length of time used during the service. Options in the catalogue is a category or service class which can be selected based on the level of interest or the effect on the goal (1 = primary, 2 = secondary, 3 = support). The response is part of activities carried against the emergence of changes or incidents, the response is classified by level of seriousness of the incident or problem. The changes lead to incidents or problems in the service catalogue, which can be categorized as facts (fn) of the change, for example (a) policy of the city (f1), the infrastructure changes and structural departments of the city, (b) the growth of activity (f2), the change in business processes of public services, and (c) the service provider (f3), the change of legalization. The emergence of the changes caused by the demand for new forms, new features, and new algorithms in the application of external services.

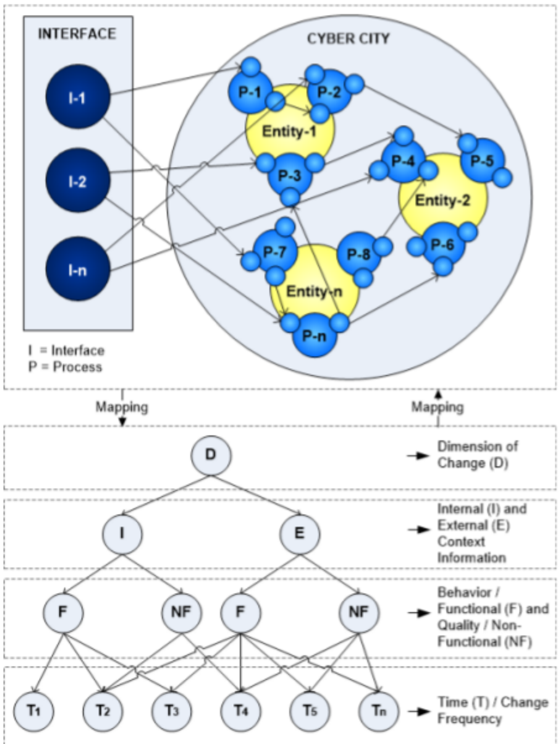

Figure 4. The mapping of the elements in cyber city system to the dimension of changes.

The category of service changes can be considered to define the management strategies of the service catalogue and its recovery specification. The demand for a quick response to the changes performed by matching the changing dimensions with elements of the system. The service catalogue consists of public services in the business process service catalogue (PSn) and the technical specifications of the technology in the technical service catalogue (TSn). Figure 5 shows the mechanism of adaptation refers to information context, starting with the performance of agents in capturing the event of environmental facts (f1, f2, fn) , and also capturing the information context of the service catalogue (PSn, TSn).

The event is the information of each context with the specifications of new environmental facts and the service catalogue ($\sum$ = f1, f2 ... fn ; PSn, TSn). The conditions which discovered are used to evaluate the situation in certain events, including capturing characteristics of each service and change of context (Q = fn $\leftrightarrow$ PSn , fn $\leftrightarrow$ TSn). So the to evaluate the service level agreement (SLA), to choose the most appropriate behavior. Based on the condition that occurs, we take action adaptation (δ = E-tn ; R-tn), which is a process of evolution (E-t1, E-t2, ... E-tn) at a certain time (t) with the consideration of the evaluation of the target of SLA achievement, and the action of reconfiguration (R-t1, R-t2, ... R-tn) or the change handling which not included in the SLA. Basically, this public service adaptation action dealing with the authorization of the portfolio service, such as when the service should be updated, replaced, maintained, refactored, dismissed, or rationalized, it must be based on indicators of system performance.

TABLE II. SERVICE CATALOGUE

Public Service	Description			User		
	Time	*Option*	*Responds*	*UI*	*U I*	*Un*
Service-1.1	24x7	2	2	√	-	√
Service-1.2	24x7	2	1	√	-	√
Service-1.n	24x7	1	1	-	√	-
Service-2.1	24x7	1	2	√	√	√
Service-2.2	08-16	3	4	-	√	√
Service-2.n	08-16	1	1	√	√	-
Service-N.n	24x7	3	3	-	-	√

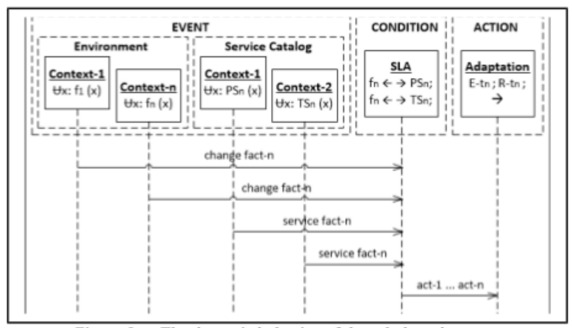

Figure 5. The dynamic behavior of the rule-based system.

IV. RELATED AND FUTURE WORK

Nowadays, there are various method of self-adaptive systems, such as the Tropos4AS model [14], this model provides the high ability of variability for the information needs at run-time by using the transition rule approach, but the behavior of this developed system, covers only the behavior of single agents, meanwhile our proposed model is constructed for the needs of multi-agent behavior. Other models such as Adaptive STSs [15], proposed a model of architecture with the ability of self-reconfiguration for the behavior of multi-agent, but when it comes to user preferences and the need for evolution, this model has not been covering it, and in the model we have provided this capability through the concept of context -aware and special rules models. CARE [16], exploiting the domain of ontology to anticipate changes in context and resources, but the mechanism of reasoning in this model actually can be improved. So, we propose a run-time dynamic rules model that makes the reasoning can be done automatically. ZANSHIN [17] and ASMs [18], emphasis on the generic function of a feedback loop for reasoning at run-time, but the representation of entities of the problem domain as domain models in both models are not reflected, while in our proposed model, it became one of our concerns.

The proposed model in this paper is our early work that needs further research. So, our future work is to break down every specification formed, such as computation model development that stimulate cyber city system, So, the complexity of graph that proposed, depict through series of an experiment. Besides that, previous research that explained at first paragraph will be compared in more detail, So that obtained a result of comparison that shows up the facts in more concrete, through scalability measurement of proposed model. The measurement planned target, related to execution time for amount of goal element and rule.

V. CONCLUSION

The main highlights of this paper include the provision of self-adaptive systems to meet the scope of a life cycle system, where the emerging problems associated with the deterministic and non-the deterministic problem types. There are two proposed adaptation strategies for these issues. First, the evolution strategy by a series of modifications which developed to represent a new problem space is packed to handle the deterministic problems. The second strategy is reconfiguration, where the system automatically is prepared to perform a search in the solution space as an alternative solution, so the non-deterministic problems can be solved by the application of the suitability with the control strategy. We believe the proposed concept in this paper will contribute to the provision of software systems in the context of a dynamic environment, and in particular, a manifestation of the cyber city system construction is expected to be able to accommodate the issue of diversity and dynamic nature of the elements.

REFERENCES

[1] ITU-T, "Overview and role of ICT in smart sustainable cities" Telecommunication Standardization Sector, 2014.

[2] I. Supriana, Aradea, "Automatically relation modeling on spatial relationship as self-adaptation ability", Internationl Conference on Advanced Informatics: Concept, Theory and Application (ICAICTA), Vol. 2, IEEE, Bangkok, Thailand, 2015.

[3] A. G. Ganek, T. A. Corbi, "The dawning of the autonomic computing era", IBM Systems Journal, 42(1):5–18, 2003.

[4] B. H. C. Cheng, K. I. Eder, M. Gogolla, L. Grunske, M. Litoiu, H. A. Muller, P. Pelliccione, A. Perini, N. Qureshi, B. Rumpe, D. Schneider, F. Trollmann, N. Villegas, "Using models at runtime to address assurance for self-adaptive", LNCS, pp.101–136, Springer, 2014.

[5] P. Lombardi, "New challenges in the evaluation of smart cities", Network Industries Quarterly 13 (3): 8-10, 2011.

[6] Aradea, I. Supriana, K. Surendro, "An overview of multi agent system approach in knowledge management model", International Conference on Information Technology Systems and Innovation (ICITSI), IEEE, School of Electrical Engineering and Informatics, ITB, 2014.

[7] I. Supriana, Aradea, "Model self-adaptive sebagai landasan sistem untuk menunjang penumbuhan komunitas", Keynote Paper Seminar Nasional Teknologi Informasi dan Komunikasi (SENTIKA), Vol. 6, 2016.

[8] J. O. Kephart, D.M. Chess, "The vision of autonomic computing", IEEE Computer, 36(1):41–50, 2003.

[9] L. M. Daniele, "Towards a Rule-based approach for context-aware applications", Master Thesis, University of Cagliari, Italy, 2006.

[10] I. Supriana, S. Wahyudin, A. Mulyanto, "Pengembangan motor inferensi untuk aplikasi sistem pakar dalam model diagnosa", Technical Report, School of Electrical Engineering and Informatics, ITB, 1989.

[11] G. D. Abowd, A. K. Dey, P. J. Brown, N. Davies, M. Smith, P. Steggles, "Towards a better understanding of context and context-awareness", Handheld and Ubiquitous Computing, Vol. 1707, Lecture Notes in Computer Science, pp. 304-307, Springer Berlin Heidelberg, 2001.

[12] I. Supriana, R. Agustin, "The multi control strategy for intelligent system", International Conference on Intelligence System and Informatics (ISI), IEEE, 2012.

[13] J. Andersson, R. de Lemos, S. Malek, D. Weyns, "Modeling dimensions of self-adaptive software systems", In Software Engineering for Self-Adaptive Systems, pp. 27-47, Springer-Verlag Berlin, 2009.

[14] M. Morandini, L. Penserini, A. Perini, A. Marchetto, "Engineering Requirements for Adaptive Systems", Journal of Requirements Engineering, pp. 1-27, Springer, 2015.

[15] F. Dalpiaz, P. Giorgini, J. Mylopoulos, "Adaptive Socio-Technical Systems: A Requirements-Based Approach", Journal of Requirements Engineering, 18(1):1–24, 2013.

[16] N. A. Qureshi, I. J. Jureta, A. Perini, "Towards A Requirements Modeling Language for Self-Adaptive Systems", Lecture Notes in Computer Science, in Springer, REFSQ, vol. 7195, pp. 263-279, 2012.

[17] V. E. S. Souza, A. Lapouchnian, K. Angelopoulos, J. Mylopoulos, "Requirements-driven Software Evolution", Computer Science - Research and Development 28(4), pp. 311-329, Springer, 2013.

[18] P. Arcaini, E. Riccobene, P. Scandurra, "Modeling & Analyzing MAPE-K Feedback Loops for Self-adaptation", International Symposium on SE for Adaptive and Self-Managing Systems, IEEE, 2015.

Paper 8

ORIGINALITY REPORT

6%	3%	0%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universiti Teknologi Malaysia Student Paper	3%
2	jict.uum.edu.my Internet Source	3%

Exclude quotes	Off	Exclude matches	< 2%
Exclude bibliography	On		