Detecting and Resolving Conflicts in Adaptation Rules for the Context Aware System

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Abstract*: *Context aware systems are embedded in the environment and provide services anytime and everywhere. Context aware system is built upon context information gathered from the environment and the adaptation rule which describes what need to be performed for the context information gathered. Consistent behavior of the context aware system will be ensured by the complete and correct context information and adaptation rules. There may have a situation where conflicts may occur at context level and adaptation rule level. Many researchers presented different methods to detect and resolve conflict in context information level. In this work we proposed a procedure to detect and resolve conflicts in the adaptation. Two different types of conflicts are addressed in this work. We have discussed about the procedure to resolve these two types of conflicts in the adaptation rule.

Index Terms*: *Context Aware System, Adaptation Rule, Rule Conflict

I. INTRODUCTION

Ubiquitous computing is a field that has great understanding with the use of contextual data. The use of contexts allows the development of different applications that are more adapted to the different situations of many users. Different type of context is handled by the application. The use of contexts as inputs helps on improving the personalization and adaptation of tasks. Context aware computing is the key aspect of ubiquitous computing. Context awareness is the task of automatic execution of standard services based on preprogrammed rules. These preprogrammed rules are also termed as adaptation rules. There are many issues in defining the adaptation rules. The correctness of these rules leads to the flawless performance of the context aware system. There are many issues in defining the adaptation rules. Incompleteness and inconsistencies in the adaptation rules becomes the challenging issues that need to be verified and resolved.Many researchers addressed different issues in context aware computing. Among these one of the major issues is the context conflicts. These Context conflicts is the conflict in the context data. These conflicts may occur while collecting data from redundant context sources or while aggregating those data to compose the whole context. These conflicts could affect the produced decisions and consequently lead to undesirable actions. These context conflicts are resolved by different scheme discussed by many researchers. Some researchers address dynamic conflicts which occur during the run time. They argued that these dynamic conflicts cannot be solved at the design and it can be solved at the run time only. Apart from these types of conflicts, we have discussed about the conflicts in the adaptation rules. In this paper we have discussed about the rule conflicts in the context aware computing. Rule conflict is the conflict which occurs in adaptation rule which activates or deactivates the device at the same time or performs contradiction action for the same context information. These rule conflicts can be detected and resolved in the design time itself. We have proposed an algorithm for identifying the identifying the conflicts in the adaptation rules. In this work we proposed a process for resolving the conflicts in the adaptation rules. This Paper is organized in the following way: Some of the works related to the conflict management are discussed in Section II. In Section III we discussed about the different type of conflicts that occur in adaptation rules. In Section IV we discussed the process of detecting conflicts using decision tree. The process of resolving conflicts in the adaptation rule is addressed in section V. In section VI we explained the conflict detection and resolving with the help of a scenario. Section VII concludes the proposed work and addresses the future work.

II. RELATED WORK

Thais [1] proposed a methodology to resolve conflicts occur due to the incompatibility among the users' profiles and/or the shared environment. Amirreza [2] uses comprehensive graph-based approach to resolve conflicts in context. They have used the policy model for context detection which is based on contextual constraints. Insuk et al. [3] propose a conflict resolution scheme which dynamically resolves conflicts by incorporating the intentions of the involved users as well as their preferences. In [4] they proposed algorithm which will select execution policies through comparing offsets of policies to resolve conflict . Atif et al. [5] present the conflict resolving policies that are defined on the basis of

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the Quality of Context parameters. RCCAR [6] approach is to resolve context conflicts by exploiting the previous context using Association Rules (AR) to predict the valid values among different conflicted ones.

III. CONFLICTS IN ADAPTATION RULES

Conflicts can occur at different layers of context management system. These conflicts can affect the performance of the context aware system. In context acquisition layer, conflicts occur at sensor data. As data is gathered form different sensors, context update at the different frequency may lead to the conflicts in the context information. This leads to inaccuracy in the context data. In context processing modules, high level context information is retrieved from low level sensor data. Conflict may occur when the lower context information are gathered from multiple sensors is processed into a high level context information in a understandable format.In context distribution phase, due to high mobility of sensors, un reliable communication may cause redundant and conflicting context. The context aware application provides required services to the user according to their needs in specific context. An applications behavior is executed through the set of adaptation rules. These adaptation rules will define the application or system behavior in specific environment context. The adaptation rules are defined as an event triggered action type. Event describes the current environment condition and action describes the services that are provided for the current context. While designing the adaptation rule there may be a possible for the occurrence of conflicts. Conflicts in adaptive rules can be categorized into two categories: conflicts in single decision variable and conflicts in multiple decision variables.

A. Conflicts in Single Decision Variable

Decision variable are the action part in adaptation rules. Decision variable is the process of activate or deactivate any devices or any services. In a context aware system one or more environmental factor helps in decision. These factors may be a dependent or independent. These environmental conditions are defined in more than rule. These rules may activate or deactivate any devices or any services. Every rule is independent of other rule and comprised different environmental factors. These rules may contradict each other for some of the environmental conditions. For example for the specific environmental condition one rule may activate a device. At the same time other rule may deactivate the same device. The decision is taken in the order of rule execution. For a same device two different instructions will be issued by the context aware middleware which leads to the erroneous behavior of the context ware system which ends in customer dissatisfaction. For example ,the adaptation rules for curtain in smart home is defined as :

if ($\text{brightness}_{\text{out}}$ = high) then curtains = open
if ($\text{temperature}_{\text{out}}$ > 30) then curtains = close

The first rule is defined of the lighting . and the second rule is defined for the air conditioning. Suppose if the current context have high brightness outside and the temperature inside the room is 32 . For this context the first rule instructs the curtains to be opened. In the same case the second rule instructs the curtains to be closed. This leads to the contradictory behavior of the context aware system.

B. Conflicts in Multiple Decision Variable

In context ware system some sensor values or context values can be used to make decision for different devices or different services. For example room temperature value can be used to activate or deactivate air conditioner and also room heater. Conflict may occur when some context changes triggers two contradictory actions like switch on air conditioner and heater at the same time. Initiating the two contradictory actions for the same context information leads to conflict.For example consider the following rules:

if (motion = true) then airconditioning = on
if ($\text{temperature}_{\text{in}}$ < 19) then heater = on

In the above rule set first rule is meant for the air conditioning ,when a human movement is detected in the room ,air conditioning is set to on. The second rule is for the heater, when a room temperature is below 19 the heater is set to on. Here the conflicting behavior arises when a person is available inside the room and room temperature is measured as 19. At this context both the heater and air conditioning will set to on.

IV. CONFLICT DETECTION

Conflicts in the behavior of the rule can be detected using the formal modelling and verification method [7] . In this work we have used the decision table to identify the conflict in the rule set. Rule set which is comprised of set of rules is converted into decision table for a random context values. The last column of the table will be the decision variable which initiates the action for the current context. Conflicts are identified from the decision table.

A. *Detecting the conflicts in single decision variable:*

Decision tables will be created for the different combinations of values for a context variable. Each table contains the rules as a rows and context variables and decision variable as columns.

Steps:

1. Create decision tables for rule set for each context value set

2. Analyze the decision variable column in each table

3. If any table contains the contradictory values in the decision variable column then conflict occurs else proceed to next table.

B. *Detecting the conflicts in multiple decision variables:*

Decision tables will be created for the different combinations of values for a context variable. Here the rules are represented in rows and columns are decision variables.

Steps :

1. Create decision tables for the rule set with rules as rows and decision variables as columns

2. Analyze the table for true values

3. If any decision variable is true in the same table then

a. Check whether they are contradictory to each other in the behavior by checking the decision table for the inverse value.

b. If they are contradictory to each other the conflict occurs s in that context situation.

c. Else ignore it

4. Proceed with all tables.

V. RESOLVING THE CONFLICT

Many researchers proposed different methods for resolving the conflicts in the context data. In this work we have proposed an algorithm to resolve conflicts in the adaptation rules. In earlier work conflicts resolution is done by dropping the conflicting context based on their time stamp. Some researcher prioritizes the order of execution of the rules based on their significance. In this work we proposed an algorithm which will reconstruct the rules to resolve conflicts

A. *Resolving conflict for a single decision variable*

Conflict for a single decision variable occurs when two different action are defined for different context information. If two different context variables produce different decision classes, then the conflicts can be resolved by constructing the new rule from the existing rules in the following pattern. Identify the rule which deactivates the device or services. Form the inverse condition for that context variable and combine with the rule which activates the device or services. Steps :

1. Analyze the decision table for the decision column with false value.
2. Negate the condition in that rule.
3. Combine the condition with the rule where the decision column has True value..

B. *Resolving conflict for a multiple decision variables:*

Conflicts for multiple decision variables occur when same context data activate two contradictory services or devices. For resolving such conflict we need to verify these two services or devices or contradictory to each other. If they are contradictory then for each decision variable identify the rule which is of same class. Then combine the condition and modify the rule.

Steps:

1. Identify the rulesR1 and R2 that are conflict.
2. Check whether the decision variable of two rules R1 and R2 are contradictory to each other.
3. Identify the rules which have same decision class as R1 and R2.
4. Combine the rules with the corresponding classes.
5. Check whether any conflicts occur.

VI. RESULT AND DISCUSSION

For the experimental analysis , consider the following rule set for a smart home scenario.

Heater:

R1=if ($temperature_{in} < 19\circ C$) then $heating = on$

R2=if ($temperature_{in} > 21\circ C$) then $heating = o f f$

Lighting

R3=if ($brightness_{in} = low$) and ($motion = true$) then $lights = on$

R4=if ($motion = f alse$) then $lights = o f f$

Air Conditioning

R5=if ($temperature_{in} > 27\circ C$) then $airconditioning = on$

R6=if ($temperature_{in} < 24\circ C$) then $airconditioning = o f f$

R7=if ($motion = true$) then $airconditioning = o n$

R8= if ($temperature_{out} > 30\circ C$) then $curtains = close$

For the above set of rules context variables are { temperature$_{in}$, brightness$_{in}$, motion, temperature$_{out}$.} . Context values for these set of context variable are

temperature$_{in}$ ={ 18,19,20,21,22,26,27,28,23,24,25}

brightnessin ={ low, high}

motion = { true , false}

temperatureout ={ 29,30,31}

Current context is defined with these set of context variables { temperature$_{in}$, brightness$_{in}$, motion, temperature$_{out}$. } as {18,low,true, 32}

For all combination decision table need to be created.

- **Conflict resolution for Single Decision Variable :**

For a sample decision table for the context {18,low,true, 32} is described below:

Table 1 : Decision table for air conditioning for {18,low,true, 32}

Rule No	*temperature$_{in}$* >27	*temperature$_{in}$* <24	motion	temperature$_{out}$ > 30	Air conditioning
R5	False	-	-	-	Not satisfied
R6	-	True	-	-	False
R7	-	-	True	-	True

Table 2 : Decision table for Heater for {18,low,true, 32}

Rule No	temperature$_{in}$ >21	temperature$_{in}$ < 19	Heater
R2	False	-	Not satisfied
R1	-	True	True

In table1 R6 and R7 are conflicted each other. To avoid conflicts for the same context variable.According to the procedure for conflict resolution the condition in R6 is negated as temperature$_{in}$ >24 and it is combined with R7 and the new rule is

R7' = if ($temperature_{in} > 24 \circ C$) and motion = true then *airconditioning = on.*

Conflict resolution for Multiple Decision Variables:

Decision table for all rules with all decision variable is created for all context values. For a sample , decision table for the context {18,low,true, 32} is given below in Table 3.Form these table Rule R1 and R7 are contradicted both heater and air conditioning are on. Similarly In R3 and R7 both air condition and light is set to on. But they are not contradictory to each other . But heater and air conditioning are contradictory to each other. When for R1 there is no other rules with the same decision classes. Rules R7 and R5 has the same decision class for different context variable. This can be combined the new rule will be

Rule No	Heater	Air condi	Lights	Curtains
R1	True	-	-	-
R2	-	-	-	-
R3	-	-	True	-
R4	-	-	-	-
R5	-	-	-	-
R6	-	false	-	-
R7	-	True	-	-
R8	-	-	-	false

Table 3: Decision table for Curtains for {18, low,true, 32}

The new rule is

R5'= if ($temperature_{in} > 27 \circ C$) and (motion = true) then *airconditioning = on*

VII. CONCLUSION

Many researchers addressed different issues in context aware computing. Among these one of the major issues is the context conflicts. In this paper we discussed about the conflicts in the adaptation rules. These rule conflict leads to undesired behavior of the context aware system. We have discussed about the two different type of rule conflict like conflict in the single decision variable and conflicts among multiple decision variable. We have discussed about the procedure to identify conflicts. These conflicts are resolved by restructuring the rules. We have explained the procedure with the sample rules for a smart home. While generating rule, there may be possibility to have redundant rules. The rule set need to be optimized and minimized in the future work.

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