The Analysis of Change Region in Business Process Based on the Degree of Similarity in Structural

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Abstract: In the modeling of business process, the similarity of the process model and the change region of it are two important problems. The existing method mainly from the angle of the behavior to consider the degree of similarity, so there has some limitations in studying the similarity of the models. To study the similarity of the source and target models, we put forward the degree of similarity in structural on the basis of the behavioral profiles. Then use the concrete examples and algorithm to obtain the degree of similarity in structural. In the end, we use the existing method to determine the change region of the target model.

Introduction

With the extensive development of the business process models, various companies constructed many different models basing on different purpose. In order to describe the same characteristic of these models, some scholars are studying the consistency and the behavior similarity of the models.

[1] described the effect in trace equivalent and the equivalent of behavioral profiles in judging the consistency of the models, the trace equivalent is much strict than the equivalent of behavioral profiles, but the effect of the consistency degree is the opposite. [2] used the concept of the behavioral profiles to describe the characteristic of the behavior and set up the diagram of the behavioral relation hierarchy and a consistent behavioral profile. [3] analyzed the process model basing on the Petri nets and the thoughts of the behavioral profiles, obtained the change region and the smallest change region. [4, 5] introduced the similarity of the behavior to quantify the similarity of the process.

These are all from the perspective of the consistency and the behavior to analysis the similarity of the models, and then obtain the degree of similarity between the models. In this paper, we base on the structural of the Petri nets, through the transitions of the structural graph in the source model to analysis them in the target model.

Organization of the Text

Motivation for the instance. Fig.1 and Fig.2 give us instances of the purchase process in the companies.

Fig.1. The purchase process graph of the source model

Fig.2. The purchase process graph of the target model

The basic definition. This part mainly introduces some necessary definitions, as to the Petri nets of process models, the weak order relation and the behavioral profiles please refer to reference [1].

Definition 1 (The occupancy of the predecessor transition) Let $N_1 = (P_1, T_1, F_1)$ be a Petri net of a source model, $N_2 = (P_2, T_2, F_2)$ be a Petri net of a target model,

$T_1 = \{t_1, t_2, \dots, t_n\}, T_2 = \{t'_1, t'_2, \dots, t'_m\}, \forall t'_j \in T_2$ there exist $t_i \in T_1, \forall t \in \bullet(t_i) \text{ or } \bullet(t'_j)$, we use $p|\bullet(t_i)|$ to denote the occur probability of $\bullet(t_i)$ under the condition of known, we call it the occupancy of the predecessor transition. It should satisfy the following ones:

(1) If $\bullet(t_i) \cap \bullet(t'_j) = \emptyset$, then $p|\bullet(t_i) \cap \bullet(t'_j)| = 0$ and $p|\bullet(t_i) \cup \bullet(t'_j)| = 1$.

(2) If $\bullet(t_i) \cap \bullet(t'_j) \neq \emptyset$ and $\bullet(t_i) \neq \bullet(t'_j)$, then $p|\bullet(t_i) \cap \bullet(t'_j)| = \frac{1}{n[\bullet(t_i)]} \cdot \frac{1}{n[\bullet(t'_j)]}$, and $p|\bullet(t_i) \cup \bullet(t'_j)| = 1$,

also $p|\bullet(t_i) \cap \bullet(t'_j)|$ respond the probability of the same element in $\bullet(t_i)$ and $\bullet(t'_j)$ can occur at the same time. If the same element in $\bullet(t_i)$ and $\bullet(t'_j)$ can't occur at the same time,

then $p|\cdot(\cdot t_i) \cap \cdot(\cdot t_j)| = 0$.

(3) If $\cdot(\cdot t_i) \neq \cdot(\cdot t_j)$ and $[(\cdot(\cdot t_i))^\bullet]^\bullet \neq [(\cdot(\cdot t_j))^\bullet]^\bullet$, then $p|\cdot(\cdot t_i)| = \frac{1}{n[(\cdot(\cdot t_i))^\bullet]^\bullet}$, $p|\cdot(\cdot t_j)| = \frac{1}{n[(\cdot(\cdot t_j))^\bullet]^\bullet}$,

then $p|\cdot(\cdot t_i) \cap \cdot(\cdot t_j)| = \frac{1}{n[(\cdot(\cdot t_i))^\bullet]^\bullet} \cdot \frac{1}{n[(\cdot(\cdot t_j))^\bullet]^\bullet}$, and $p|\cdot(\cdot t_i) \cup \cdot(\cdot t_j)| = 1$;

If $\cdot(\cdot t_i) = \cdot(\cdot t_j)$ and $[(\cdot(\cdot t_i))^\bullet]^\bullet = [(\cdot(\cdot t_j))^\bullet]^\bullet$, then $p|\cdot(\cdot t_i) \cap \cdot(\cdot t_j)| = 1$ and $p|\cdot(\cdot t_i) \cup \cdot(\cdot t_j)| = 1$.

As to the occupancy of the successor transition can be similarly defined.

Definition 2 (The degree of similarity in structural) Let $N_1 = (P_1, T_1, F_1)$ be a Petri net of a source model, $N_2 = (P_2, T_2, F_2)$ be a Petri net of a target model, and

$T_1 = \{t_1, t_2, \dots, t_n\}, T_2 = \{t'_1, t'_2, \dots, t'_m\}, \forall t'_j \in T_2$ there exists $t_i \in T_1$ corresponding to it and including that $i \in \{1, \dots, n\}, j \in \{1, \dots, m\}$.

(1) The similarity degree of itself: $sim(t_i, t'_j) = \frac{\sum p|t_i \cap t'_j|}{\sum p|t_i \cup t'_j|}$.

(2) The similarity degree of the direct predecessor transition :

$$sim(\cdot(\cdot t_i), \cdot(\cdot t'_j)) = \frac{\sum p|\cdot(\cdot t_i) \cap \cdot(\cdot t'_j)|}{\sum p|\cdot(\cdot t_i) \cup \cdot(\cdot t'_j)|}.$$

(3) The similarity degree of the direct successor transition : $sim((t_i)^\bullet, (t'_j)^\bullet) = \frac{\sum p|(t_i)^\bullet \cap (t'_j)^\bullet|}{\sum p|(t_i)^\bullet \cup (t'_j)^\bullet|}$.

Look for the degree of similarity in structure of the source and target models based on the Petri nets. By introducing the basic definition, we can consider the similarity of the source and target models from the angle of structure. So we give the following algorithm:

Algorithm: The degree of similarity in structural of the source and target models.

Input: a Petri net of a source model $N_1 = (P_1, T_1, F_1)$, a Petri net of a target model $N_2 = (P_2, T_2, F_2)$.

Output: The degree of similarity in structural of them, write down as $sim(N_1, N_2)$.

(1) According to definition 1, we can derive the occupancy of the predecessor transition and the occupancy of the successor transition with the source and target models.

(2) According to definition 2 (1), we can derive the similarity degree of itself with the source and

target models: $sim(t_i, t_j) = \frac{\sum p|t_i \cap t_j|}{\sum p|t_i \cup t_j|}$.

(3) According to definition 2 (2), we can derive the similarity degree of the direct predecessor

transition with them: $sim(\bullet(t_i), \bullet(t_j)) = \frac{\sum p|\bullet(t_i) \cap \bullet(t_j)|}{\sum p|\bullet(t_i) \cup \bullet(t_j)|}$.

(4) According to definition 2 (3), we can derive the similarity degree of the direct successor

transition with them: $sim((t_i)^\bullet, (t_j)^\bullet) = \frac{\sum p|(t_i)^\bullet \cap (t_j)^\bullet|}{\sum p|(t_i)^\bullet \cup (t_j)^\bullet|}$.

(5) According to these steps, give a weight w_1 to $sim(t_i, t_j)$, w_2 to $sim(\bullet(t_i), \bullet(t_j))$, w_3 to $sim((t_i)^\bullet, (t_j)^\bullet)$, and $w_1 + w_2 + w_3 = 1$.

(6) Then calculate the degree of similarity in structural of them:

$$sim(N_1, N_2) = w_1 \cdot sim(t_i, t_j) + w_2 \cdot sim(\bullet(t_i), \bullet(t_j)) + w_3 \cdot sim((t_i)^\bullet, (t_j)^\bullet).$$

Experimental evaluation. According to Fig.1 and Fig.2, we can derive the similarity degree of itself with N_1 and N_2 :

$$sim(t_i, t_j) = \frac{29}{32} \approx 0.906. \quad (1)$$

The similarity degree of the direct predecessor transition with N_1 and N_2 :

$$sim(\bullet(t_i), \bullet(t_j)) = \frac{17 + \frac{1}{2} \times 3 + \frac{1}{12} \times 3 + \frac{1}{3}}{27 \times 1} \approx 0.707. \quad (2)$$

The similarity degree of the direct successor transition with N_1 and N_2 :

$$sim((t_i)^\bullet, (t_j)^\bullet) = \frac{21 + \frac{1}{2} \times 2 + \frac{1}{12} + \frac{1}{3}}{28 \times 1} \approx 0.801. \quad (3)$$

We order $w_1 = 0.5$, $w_2 = 0.25$ and $w_3 = 0.25$, then calculate the degree of similarity in structural of the source and target models is:

$$sim(N_1, N_2) \approx 0.83. \quad (4)$$

Due to the degree of similarity in structural of the source and target models is below 0.85, so there exists change region in the target model. According to Literature [3], we can obtain the change region in the target model is $\{P_{21}'VP_{22}'WXP_{23}'YP_{24}'\}$.

Summary

According to our method, we can know that the degree of similarity in structural of the source and target models is lower than what we have given. So there exists change region in the target model. By the method of predecessors' research, we obtain the change region.

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