Evolution of Business Processes and a Process Simulation Tool

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与普通软件不同之处，在于，很多人参与一个流程，会出现异常

Abstract

Business processes, such as workflows, are software, too. However, development, evolution, and deployment of business processes have different difficulties from general software. Control, introduction, evaluation, and testing of business processes are difficult because multiple processes are related to each other and many people are involved in processes. To solve these problems, we propose BPT/BPR/BPS (Business Process Tactics, Reengineering, and Simulation) lifecycle, based on multi-agent groupware model. BPT means activities to control processes dynamically, which we have already proposed. In this paper the simulation phase is mainly focused. We give a simulation model which has some original aspects, and show a prototype of simulation tool.

Keywords: *Business Process, Simulation, Multi-Agent Systems, Human Factor, Agent-Based Groupware, Workflow Systems.*

1. Introduction

部署

This paper discusses the development and deployment (i.e. introduction) of workflow or business process applications, where users take part in the process one by one, using asynchronous communication like e-mail or shared files on servers.

For business process applications on a business process automation platform (i.e., workflow management systems), the development cycle is roughly described as a cycle of analysis, definition, operation, evaluation, and reengineering of business processes. This lifecycle is similar to general software development cycles, but has special difficulties because a lot of people are involved in a process, because two or more organizations may be involved in a process, and because process exceptions are inevitable. Moreover, since many business processes are concurrently operated in offices, the problems are more complicated.

业务流程的分析、定义、操作、评估和重新设计。

业务流程异常不可避免

Problems are itemized as follows:

- **Control**
  Multiple business processes are usually managed by different managers, who sometimes belong to different organizations or departments. If these processes compete a common resource, it is difficult to automatically decide which can precede the other.

- **Decision of introduction/evolution**
  Even if a new business process is defined, it is often difficult to immediately introduce the new process because it is difficult to convince all the involved people or managers that the new process is a better one.

- **Evaluation**
  Since multiple processes are concurrently running in offices, it is difficult to evaluate efficiencies of processes. Operation of a process is often interrupted by other predominant processes, so that process performance is difficult to evaluate. Many kinds of exceptions, like absence of personnel, changes of business environment, etc., make process evaluation more difficult. Also, unpredictable human factors make it further more difficult.

- **Testing**
  A business process involves too many people and re-

*currently, SHARP Corp.

sources. It is difficult to test a newly defined or evolved process in the field.

In our research we adopted a multi-agent approach to solve the control problem[11]. Based on this multi-agent scheme, we propose a business process development/deployment process to solve other problems. This paper will outline the approach and describe the developed tools.

2. BPT/BPR/BPS Approach

The development and deployment process we are proposing here includes BPT, BPR, and BPS activities. In this section we will outline our BPT/BPR/BPS approach.

2.1. BPT

BPT就像是下层管理者的工作，而BPR就像是上层管理者的工作。 策略手段

BPT stands for *Business Process Tactics*. As the tactics means lower level techniques than the strategy, BPT is contrasted to BPR (*Business Process Reengineering*). BPT is like a lower level manager's job, while BPR is like a senior manager's. BPT is an activity that tries to optimize each workflow process instance by acquiring the necessary resources and considering the priority relative to other process instances.

For example, one BPT activity is to shorten a workflow process instance to prepare for a worker's long vacation. Another example is to designate an alternative worker for a sick worker. 例如，一个BPT活动是缩短工作流过程实例以准备员工的长假。另一个例子是为生病的工人指定另一个工人。

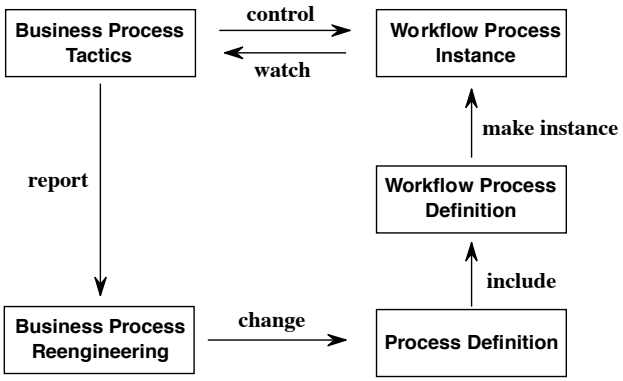

Figure 1. Business Process Tactics and Reengineering

Figure 1 shows the relationship between BPT and BPR, and other relationships involving artifacts (workflow process definition and business process definition), and runtime object (workflow process instance).

A workflow definition is a subpart of a business process definition that is controlled by an automatic engine. A workflow process instance is created from a workflow process definition.

A BPT activity watches a workflow process instance and takes care that the instance runs well without exceptional events, delays, etc. If necessary and possible, a BPT activity controls a workflow instance, i.e., changes the process definition for the instance only.

The difference between BPT and BPR is that BPR changes a process definition artifact, but BPT does not. BPR is basically an independent activity from BPT, but it can be helped from some reports from BPT activities. Repeated exceptional events suggest that some kind of process reengineering is required.

Our approach is to provide automatic agents for BPT activities[11]. This will be described in section 4.

2.2. BPR

As described above, BPR means activities to evolve business process definition. Since many people research BPR techniques, we are currently omit it from our research focus. Here we just suppose that BPR can be performed manually or automatically.

2.3. BPS

BPS代表业务流程仿真。通过BPS，我们希望评估业务流程再造后的流程。这是因为在实际字段中测试业务流程是困难的。我们正在尝试通过BPS解决过程引入、过程评估和过程测试问题的决策。

BPS stands for *Business Process Simulation*. By BPS, we would like to evaluate a process after BPR. This is because it is difficult to test a business process in the real field. We are trying to solve decision of process introduction, process evaluation, and process testing problems, by BPS.

BPS is not our original invention, but have already been researched. However, in most business process simulations, human behavior is modeled only in terms of processing time and human actions are scheduled by a top-down manner, but it lacks reality. We need a richer and more flexible user model for business process simulation including human behavior.

We cannot expect correct or precise simulation of particular process instance, since human behavior and exceptional events cannot be predicted. However, macroscopic and statistical information can be acquired from repeated simulation, which helps evaluation of processes. We are aiming at this point.

We have designed and prototyped a simulation tool with human behavior model. In section 5, it will be described.

由于无法预测人的行为和异常事件，我们不能期望精确或正确地模拟一般过程实例。然而，宏观和统计信息可以从重复的模拟中获得，这有助于评估过程。我们正瞄准这一点。

3. Agent-based Groupware

Before proceeding to the succeeding sections, we should clarify the notion of agent in our research, and should de-

代理是软件模块，是用户的代理，或者实现用于组活动（成本优化、人员调解等）的一个方面的功能。
代理可以通过交换消息与另一个代理通信。基于Agent的群件是一种由多个Agent组成的群件体系结构。

scribe why we adopted the multi-agent architecture.

什么是代理

We use the word "agent" in the following sense. An agent is a software module that is a surrogate for a user, or implements functions for an aspect of group activities (cost optimization, mediation of people, etc.). An agent can communicate with another agent by exchanging messages.

Agent-based Groupware is an architecture of groupware consisting of multiple agents. Multi-agent systems are very suitable to implement groupware thanks to the following features.

多代理系统非常适合于实现群件

开发性

1. Openness:
   This basic feature means that it is widely applicable to large companies that have many divisions, joint ventures, loosely organized groups like those of alumnus/alumna or volunteers, and virtual enterprises. Concretely it means that the groupware satisfies the following conditions:
   - Each user can belong to multiple workgroups concurrently. To realize this, supporting functions are needed to enable users to concurrently take part in multiple business processes[6], and also personal tasks[8].
   - It positively utilize wide area networks like the Internet, intranets, and extranets.
   - Inter-organizational security issues are consciously maintained.
   - Distributed management is possible. It is important to allow each manager of divisions or sub-organizations to manage her or his group in her or his own way.
   - The system accepts the cultural differences among different sub-groups. For example, each sub-group has its own glossaries[9], constraints in schedule, job priorities, and management styles.
2. Scalability: 可扩展性
   It should be possible to append new elements to the system, or remove elements from it. It should also be possible for the system to run efficiently regardless of its size.
3. Evolution: 演化
   It should be dynamically adaptable to exceptional events as well as to accept evolutionary process refinement or reengineering.

它应该动态地适应异常事件，接受

4. Business Process Tactics

The WorkWeb System[11] is a multi-agent based system that enables BPT activities for multiple workflow processes.

在本研究中，我们假设多重工作流由多人管理的开放情况。在这种情况下，工人可以被视为应该分配给多个工作流的资源。因此，可能存在资源冲突问题。

In this research, we supposed open situations where multiple workflows managed by multiple people. In such a case, workers can be regarded as resources that should be assigned to multiple workflows. Hence there may be resource conflict problems.

情况动态变化的时候，会发生资源问题，

Resource problems may also occur when situation is dynamically changing. For instance, if a worker cannot be engaged to a workflow activity because of illness or an emergency new job, that workflow cannot obtain enough resources for in-time operation.

We adopted a multi-agent architecture[8] to solve these problems. We assigned an agent to each individual. This type of agent is called a *personal agent*, and managed the individual's personal schedule and personal list of tasks (i.e., worklist). We introduced another type of agent that is called *BPT agent*. BPT stands for *Business Process Tactics*. BPT means dynamic and on-the-fly change of processes to react dynamically occurring problems, without changing process definition. Of course it is a contrast to BPR, which means changes of process definition and solutions for long-term problems. A BPT agent watches a workflow status and begins negotiation with personal agents when it finds problems. For example, it can delay deadlines for each activity, substitute activity performers, report troubles to mangers, etc. (Figure 2)

BPT的定义！

代替

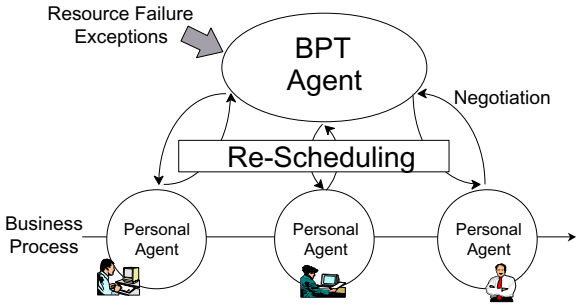

Figure 2. BPT Agent

The name of WorkWeb System is not related to the World Wide Web. The system image is a web because the flows of work are supposed to be horizontal strings and crossing views (or resource constraints) are supposed to be vertical strings (Figure 3).

5. Business Process Simulation

5.1. Approach

In our approach, a simulation is performed on the agent-based groupware model. The simulation model can be interpreted on this model as follow, in terms of business process simulation model given by Tumay[14].

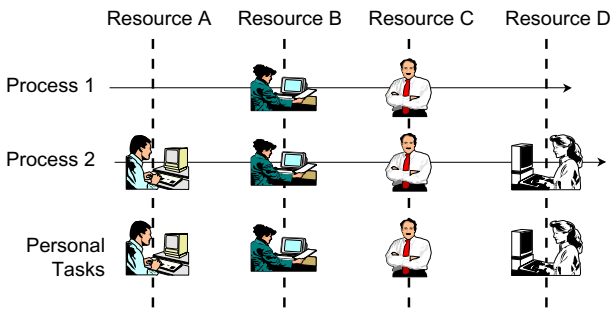

Figure 3. WorkWeb System Image

- A pair of a human and a personal agent is assigned to an activity [1]. It is contrasted to normal business process simulations where only a human is assigned to an activity.
- Connectors between activities are implemented with messages exchanged among agents.
- Multiple processes should be simulated simultaneously because agent-based groupware is open.
- Project-based processes and production-based processes are mainly the targets of simulation. Processes that include physical transportation and simulating queue of people are now out of our focus.

仿真的目标就是先验地估计业务流程重组的结果

One of the objectives of simulating agent-based groupware is to estimate the result of business process reengineering a priori. More detailed objectives are as follows.

- To estimate the impact of introducing agents to the business process system.
- To estimate the impact of changes of rules on some agents.
- To estimate the impact of process changes such as changes of processing order or changes of resources assigned to each activity.
- To estimate the robustness of process against changes of randomly occurring events like interrupting jobs or absence of a person.
- To estimate mutual dependencies among two or more processes.

[1] We use the word *task* from the viewpoint of individual worker. He or she has many tasks of business processes and personal tasks. We use the word *activity* to refer to a step of a business process. A task may correspond to an activity of a business process.

Among them, the most important factor is the behavior of resource, especially in cases of human resources, when multiple tasks are ordered to the resource from multiple processes. To model this factor, we should pay attention to the order of starting tasks and time assignment to tasks by a person.

5.2. Simulation Model

In case of groupware, human factors often prevent system deployment[4]. Hence human behaviors should be considered in simulation.

Original aspects of our simulation model are as follow.

5.2.1 Types of Human Behavior

In the simulator, human behavior is modeled from the viewpoint of personal order of processing tasks. The simulator provides following four (typical but extreme) types of human behavior in processing tasks.

- A person who obeys the order recommended by his or her personal agent. (Obedient)
- A person who never takes a rest whenever he or she has tasks to do and tries to finish tasks as early as possible. In other words, he or she is a diligent worker. (Hasty)
- A person who starts a task as late as possible to keep the deadline. He or she is like a student who does not prepare for an examination until the previous night of the examination day. (Lazy)
- A person who does a task in parallel with other tasks. To model such a person in the simulator, time for every task is divided many parts from its start time to its deadline in scheduling. (Concurrent)

These models are very extreme samples. However, these patterns will give information of the factor of human behavior in an agent-based groupware.

In future, by introducing other parameters, we will be able to enhance the model. For example, one of the workers categorized as Lazy starts a task really just before its deadline, another may take more time margin before its deadline. For another example, one worker categorized as Concurrent switches tasks at every hour, another may switch tasks randomly.

For now, these additional parameters have not yet been implemented, so model expansion remains as future work. There is room for further discussion about modeling human but these four models are currently assumed in the simulator.

5.2.2 Two Schedules

To model a human who does not obey an agent, both an agent and a human must have their own schedule table in the simulator.

Scheduling by an agent A personal agent schedules tasks in a task list by its own priority. This scheduling must be optimized regardless of human factors. The optimization, however, is difficult to realize perfectly and the following simple algorithm is now adopted.

1. All tasks in a task list are sorted in order of priority. If some tasks have equal priority values, they are sorted in order of deadlines.
2. Every task is assigned to a schedule slot in that order.

This schedule is referenced by the agent to check whether the user has enough time to do a new task.

Scheduling by a human We suppose a schedule table for a user that exists in the user's mind. Tasks are supposed to be listed by the order of *processing type* and *personal priority*. Tasks are actually processed according to this schedule. A schedule table of an obedient person is supposed to be identical to that of the agent.

Figure 4 illustrates the model of agent's and user's schedule table.

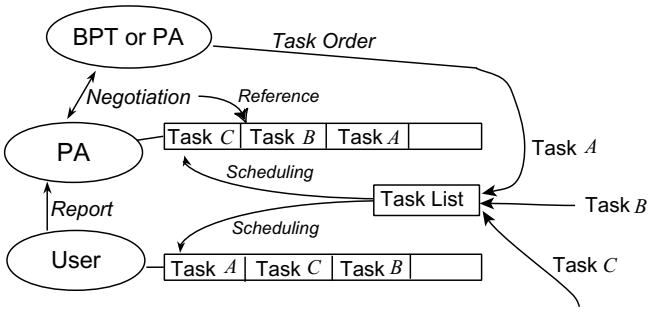

Figure 4. Two Schedules by an Agent and a Human

5.2.3 Personal Priority

Our model has two priority parameters for each task.

A *personal priority* is the priority value given by the worker in charge of it, whereas a *process priority* is given by the task requester. Process priority takes a same value for all tasks involved in a process, but different personal priority values may be given to those tasks because different persons are assigned to them.

For example, if John owes Mary a great deal, John will complete a task requested by Mary earlier than other tasks. For another example, if John simply likes a task, he starts that task earlier than others. In these cases, personal priority for John is high.

5.2.4 Contact Frequency

This parameter defines how frequent a human reports a result of his or her task to the personal agent or how frequent a personal agent checks a result of his or her task by accessing a task data (for example, an electronic document) or inquiring him or her about it.

When a personal agent receives his or her report, data of the task list, especially the rest of time required for the task, is updated in the agent and also the agent's schedule table is updated. Sometimes an agent finds that some tasks do not keep their deadlines. In that case, the agent must report it to another agent that requested the task. Examples of *contact frequency* parameter values are *periodic*, *at completion of every task*, *at switching tasks*, and *never contact*.

5.3. Tool Overview

A prototype of simulator has been implemented. The simulator is implemented on Windows 98, using Visual C++ 6.0. All agents and human are realized as classes of C++. A clock triggers all of those instances to update them. Communication delay between agents are not considered, because it is negligible compared with human activities.

Our prototype currently has only a Japanese version. In this paper, screenshots are unfortunately those of Japanese version, but we will give comments as much as possible.

A main window of the simulator is shown (Figure 5). It is divided into four subwindows, the left one is to define a flow of a process, called workflow window. The upper-middle one is a list of processes/meetings/vacations, and the lower-middle one is a list of workers, which is called human-data window. The right subwindow is called result window, which shows the simulation result by diagrams.

5.3.1 Human-data Window

On this subwindow, users can define human resources. The definition should include each worker's name, an icon, and simulation parameters. One of the simulation parameters is processing type: Obedient, Hasty, Lazy, or Concurrent. Another parameter is contact frequency: *periodically*, *at every switching of tasks*, or *at finishing a task*. These parameters are defined on a pop-up subwindow shown in Figure 6.

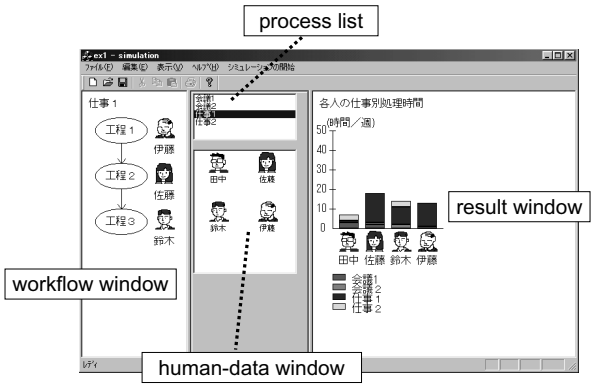

Figure 5. Main Window

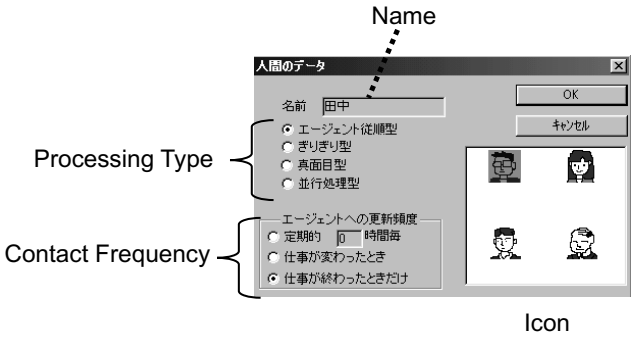

Figure 6. Detailed Definition for a Human Resource

5.3.2 Process List

On this window, the simulator user can define the processes. Besides regular business processes (i.e., workflows), meetings and vacations can be defined as one category of processes.

For a process, name, priority, and generation triggers (periodic or probable) can be defined. For a meeting, name, priority, duration time, generation triggers, and announcement time (when the meeting is announced to the participants) can be defined.

5.3.3 Workflow Window

On this subwindow, a simulator user can define activities of a process, which is selected on the process list window, and their order with a graphical interface. For each activity, name, deadline, primary worker in charge, and alternate worker for substitution (if any) can be defined. For each worker, time taken to accomplish the activity and personal priority value are defined.

For a meeting, participants and their personal priority can be defined as well.

5.3.4 Result Window

This subwindow shows results of a simulation. Generally, there are many views of results of a simulation and two of them are realized in the simulator. Currently we have two views to simulation results.

The first view shows how much time workers spend on each process with a bar chart, which is called a time distribution chart.

The second view shows a throughput (accomplished tasks per week) of each process as a bar chart, which is divided into two colors, green and red. Green refers to processes that kept deadline and red refers to processes that missed deadline. Figure 7 is an example of results with English comment. In case of meetings, the number of processes that kept deadline means the number of meetings that all participants could attend.

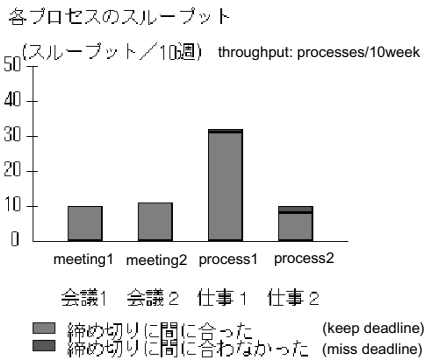

Figure 7. Throughput of Process

5.4. Sample Simulation

Here are simple simulation examples.

The first one illustrates the impact of human behavior. Here we define three workflow processes, each of which has three activities. Three workers are assigned to these activities. From the viewpoint of these workers, three kinds of tasks are periodically or randomly ordered to them.

If all the workers are Obedient, our simulation shows that they can process 90 – 95% of workflow instances in time, when 10 workflow instances randomly appear for one week in average.

However, with the same setting except that all workers are Lazy type, our simulation shows they can process only 65 – 70% of them in time.

The second one demonstrates the impact of personal priority. We suppose three workflows: Workflow#1, Workflow#2, and Workflow#3. Each priority value is 1, 5, and 8, respectively, and all of them have three steps of activities, and all workers are `Lazy`. Workflow#1 is generated once a week, and it takes 12+8+4 hours and the deadline is five days after its generation. Workflow#2 is generated randomly, three times a week in average. It takes 1+1+1 hours and the deadline is two days after its generation. Workflow#3 is generated randomly, once a week in average. It takes 8+4+4 hours and the deadline is three days after its generation. When personal priority values are equal to process priority value, Workflow#3 can always keep its deadline, while about 20–50% of other workflows cannot keep theirs. However, when the personal priority value for the second worker of Workflow#3 is changed to 1, Workflow#3 sometimes (0–20%) misses its deadline.

These examples seems to be trivial ones, but they show our simulator prototype can illustrates the impact of human factors to business processes.

6 Related Work

Research community of business process simulation pointed out that business process simulation with human entities is difficult because of capricious nature of human [3, 13, 14]. In spite of it, business process simulation is at least partly successful, because the capricious nature is compensated by large number of simulation trials. Existing simulation researches only deal with closed systems where processes are managed in top-down manners.

Of course some workflow management system products have simulation features, but they are, in most cases, just visual demonstration of processes. Randomly generated events and human factors are not considered.

In the community of CSCW researchers, the idea of business process simulation has not yet been introduced. To enhance workflow or business process models and their management systems, CSCW research community took some approaches as follow.

- Some researches dealt with exception handling and deviations[1, 2, 7, 5]. The WorkWeb System was also one of such research activities of this approach. Simulation is our new tool to evaluate the dynamic attributes of workflow and human behavior.
- Zhao and Stohr tried to optimize the process turnaround time[15]. Their work is especially focused on claim processing. Their purpose is to estimate and control the turnaround time when a claim appears (i.e., when a workflow instance is generated). Our purpose is to know the dynamic nature of processes and human and to evaluate processes.

7. Conclusion

In this paper, we have proposed BPT/BPR/BPS cycle of business process evolution, and simulation model for agent-based groupware. We have also described a prototype simulator implementing that model as well as simple examples of simulation result.

The purpose of simulation is to evaluate processes and agents before introducing them to the real workplace. Evaluation should be made from the viewpoint of robustness, turnaround time, impact of human capricious behavior, etc. Modeling human behavior including lazy or selfish workers is one of the original points of research.

In order to develop groupware successfully, one of the most fruitful approaches is participatory design. POLITeam is a good example of such a design approach[10, 16]. However, it needs cooperation of many people and costs. Simulation does not reveal all attributes of groupware systems' and human behavior, but at least it can filter out some unsuccessful processes or unsuccessful staffing of people. To try simulation before field testing will be helpful and reduce development cost.

Simulation model should be built based on real data of human behavior histories. A database of human behavior history is to be introduced to the simulation system[12].

Our most important future work is to try simulation with various settings and find some general or common nature of agent-based groupware. We are continuously trying this using our prototype simulator.

Other future work includes refinement of the scheduling algorithm for personal agents, human behavior pattern models, and the contact frequency model.

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