Designing a Simple and Flexible Workflow Management System for Collective Decision Making

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ABSTRACT
Workflow management systems have become important tools for business automation and collaboration. In this paper, our review of related academic work and current commercial workflow management systems shows that current workflow management systems are powerful and universal. However, they are often complicated to use and require significant computing resources to host the workflows and the management system itself. This paper presents an approach to designing a simple and yet flexible workflow management system called SimFlow which can support online and dynamic collaboration and coordination. A simple control panel for workflow assignment to handle dynamic changes, which occur frequently in customized workflow management, is proposed. Moreover, SimFlow employs a microkernel approach where external email servers are used instead of having its own message passing system. The proposed workflow management system focuses mainly on sequential and semi-sequential workflows. Therefore, SimFlow can substantially reduce the system complexity and its workload compared with other systems.

CCS Concepts
• Applied computing → Business process modeling, Electronic data interchange, Business process modeling • Computing methodologies → Cooperation and coordination • Human-centered computing → Collaborative interaction, Collaborative content creation

Keywords
Workflows, workflow management systems, e-collaboration, business process modeling and monitoring, business automation.

1. INTRODUCTION
Workflows are generally associated with Business Process Re-engineering [2] which can be monitored and managed by computers nowadays. A workflow is usually shown, in a supporting software, as a diagram of activities to achieve a given result or desirable outcomes. A workflow management system (WfMS) is the kind of system that defines, creates, and manages workflows and is usually implemented by a software. Workflow management has always been important in our life. Initially it is used to plan, test, and optimize business processes as it makes it easy to visualize the lacks, overlapping, or waste of resources and activities. Nowadays workflow management is also used to monitor and conduct business processes. It is especially useful when e-collaboration is involved where online coordination between participants are required. Modern WfMS are used in different kinds of business processes [1,3,4,6] such as in ordering and shipping a product to customers, new hiring, requesting IT services, or requesting and approving a business trip. As many business activities can be automated by software, modern WfMS can also be used as effective business automation tools [9]. They have also become powerful communication and collaboration apparatuses to integrate IT and human resources into hybrid systems to carry out business transactions and help workers to collaborate seamlessly [5]. Since most workflows involve collective decision making where communication is the key, communication plays an important role in any WfMS. In fact, there have been efforts where several WfMS enhance their communication tools in a way that they can be as effective as emails or can even replace them [1]. However, such kinds of universal and powerful WfMS are expensive and require significant IT resources and support to run. On the other hand, as emails are used extensively for initializing, conducting, and supporting many business activities, there have been attempts to turn email systems into workflow management tools such as automatic grouping of emails into threads and categories. However, these have led to confusions and affected the user experience as the automatic grouping of emails is far from perfection and grouping of related emails is simply not enough to substitute a workflow management system. Therefore, there are demands for simple WfMS which are compact, easy to use, cost less to run, and yet can support collaboration and coordination. In addition to that, due to the rapid changes in our modern and dynamic world, the workflow configuration has to be flexible, even after the customization of workflows [4,9].

This paper proposes a design for a simple WfMS called SimFlow which can handle dynamic changes in workflows after their creation and is also compact as it uses external email servers instead of implementing its own communication system. The rest of the paper is organized as follows. Section 2 explains the foundation of workflow management and reviews related academic work as well as commercial WfMS. Section 3 describes the proposed workflow management system SimFlow. Section 4 provides more details on how SimFlow can be used for collaboration and coordination. Finally, conclusions and future work are provided in section 5.

2. REVIEW OF RELATED WORK
According to [6,7], a workflow can be described as a representation of a business process where materials, work, information, and other resources are transformed step by step into products and services. Workflow usually consists of operations which carry out these transformations. Workflows were first used and studied in the early

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days of the last century to organize manufacturing processes efficiently and visually. Gantt chart was used to show steps and schedules of work. Later, its variations called workflow diagrams were used in offices for planning and monitoring business processes. Then, Petri net was used to design complex workflows. Nowadays, workflows are represented by software which can be even more powerful in emulating and executing various kinds of business processes, from simple to complex. However, WfMS software would need powerful servers to run.

2.1 Related Academic Work

According to [2], workflow management includes: (i) process modelling, where techniques for capturing and describing a business process and workflow models are defined to create workflows; (ii) process reengineering, where process optimization and automation are carried out through workflow implementation and modification.

In process modelling, a process is described by its abstraction which then leads to the process model where its tasks and their relationships are described using a language for workflow description (WSL). There can be: (i) rule-based WSL, where the logics and constraints of business processes are represented as sequences of rules; (ii) graphics-based WSL, where tasks and their relationships are described by diagrams. WSL allows us to specify the task structure or control flow as well as its input and output or its data flow. It also needs to specify task attributes such as task owner, participants, duration, deadline, priority, and required resources. Routing between tasks in a workflow can be described via a WSL and can be parallel, conditional, and rule-based. In parallel routing, one process can be split into several tasks which can be executed at the same time. In conditional routing, the next task can start only when certain variables receive given values. In rule-based routing, a set of rules described in WSL will be used to define which task will be the next one. To achieve reliability and tolerance exception handling is needed to deal with the situation when a task fails [6].

There are several modelling techniques for workflows:

(i) communication-based technique, where the ultimate goal is customer satisfaction, each workflow has four phases based on interaction between a customer and a worker: preparation, negotiation, performance, and acceptance.
(ii) activity-based technique, where the goal is to model the work not the human factors. Object-oriented workflows are used to model the tasks and their dependencies.
(iii) hybrid technique, where we use a combination of communication-based and activity-based techniques.

In process reengineering, tasks and their relationships, described in process modelling, are optimized so that the workflow desired outcomes are achieved with minimal resources. The optimization can be done by having users analyze the workflows visually and modify the workflows accordingly. Some systems may assist users with data-mining capacity using soft computing techniques such as neural networks. However, it would generate extra system workload to run those additional components.

From the user's point of view, there are several kinds of workflows: (i) sequential workflows: where tasks follow each other on a timeline; (ii) state machine workflows: where a task can have many states rather than just done or not done and the task dependency can go backward; and (iii) rules-driven workflows: where the work progress depends on rules, this is the most complex kind of workflows.

2.2 Commercial WfMS

There are various kinds of commercial workflow management systems. Evaluations in [8,10] show that most of them are built to be universal and powerful enough to handle all kinds of workflows. For example, Trackvia is designed for big organizations in healthcare, finance, and manufacturing. It can integrate with other business applications. Integrity is a cloud-web-based WfMS where users can create and monitor workflows via dashboards in real-time. However, its charts and forms can be too complicated for users with no IT nor engineering background. Kissflow is a system where users can automate different kinds of business processes. However, the system administration can be too much to handle. Monday.com is another universal and powerful system which is built to handle workflows of any kinds. It is very complex and has its own internal messaging system. Nifty is a WfMS with the focus on creating collaborative workspace. It has many tools for team projects including team chat. With Zapier, users can create workflows representing business processes which can be connected to other applications. Similarly, Slack builds their WfMS so that it can even replace emails [1]. Wrike is a cloud-based platform where users can create workflows while integrating with other cloud-based storage and workflow services. Team leaders can manage team efforts, track progress, and view the performance of team members. However, it is expensive and the system is complex and requires significant time to learn.

There are two main approaches for commercial WfMS: (i) general-purpose and (ii) special-purpose. The general-purpose approach is when they are built for all kinds of users, to take advantage of the fact that they can be available at anytime and anywhere as most of them are cloud-based. Although they can be customized into specific kinds of workflows for specific kinds of projects, it would take a long time just to learn all the features and how to do it. As these systems have to be complex enough to be able to generate all kinds of workflows, the charts in the workflow are often complicated and require engineer's mind set to understand and handle. Sometimes IT expertise is even needed to set up and configure the systems. Another approach is to build customized WfMS specifically for one particular kind of business processes. Unfortunately, the customized WfMS are usually not flexible and users often struggle to get exactly what they need and cannot make changes to existing workflows.

3. A MODEL FOR SIMPLE WORKFLOW MANAGEMENT

As discussed above, most popular WfMS is robust and can support all kinds of workflows. However, that comes at a cost as it makes the systems complex and overloaded. On the other hand, most of the time we only need sequential workflows. Therefore, we propose a model for simple workflow management called SimFlow with a focus on sequential and semi-sequential workflows which has one timeline but can have parallel tasks and multiple states.

In our model, users can create and define a workflow **template** or pattern for each kind of workflows. For example, a template P for workflows representing salesman travel requests and approvals. Each template contains **elements** such as actors and tasks explained in details below. A **workflow**, which represents a business process, is an instance of the given workflow pattern and can be created based on its template. For example, a workflow pX, an instance of template P, represents a specific travel request by a worker X. Users are the ones who use the workflow management system to create workflows. Actors are the ones who participate in those workflows.

3.1 Elements

There are several kinds of elements in our SimFlow model. The following elements can be included in a template:

- **Shelf** /Thread is the timeline or backbone of a workflow template. As we focus on sequential and semi-sequential workflows, each workflow will have only one shelf.
- **Actors** are entities, usually people participating in the given business process such as workers or managers. Actors are connected to the shelf/thread of the workflow via tasks, as shown in Fig.1.
- **Tasks**/Forms are the work needed to be done by actors. They are usually represented by forms being filled-in as the work is being done. Tasks can have different states:
  + New + Archived + Done
  + In Progress + Aborted

  There is a set of operations which can be performed over a form/task, by an actor:
  + Create + Lock
  + View + Unlock
  + Modify + Delete
  + Approve + Add Items (Data, Actor, Channel)
  + Reject + Remove (Data, Actor, Channel)
- **Data** are information in the system storage which is involved in the tasks/forms. There is a set of operations which can be performed over a data, by an actor:
  + Create + Read + Lock
  + Delete + Write + Unlock
- **Channels** define which actors can communicate with each other, as shown in Fig.2. To reduce the system workload we use external email servers instead of building our own message system. For example, a communication channel between several workers will simply be the list of those people emails.
  + Connect to an Actor
  + Disconnect from an Actor
  + Send (a message) to an Actor
  + Receive (a message) from an Actor

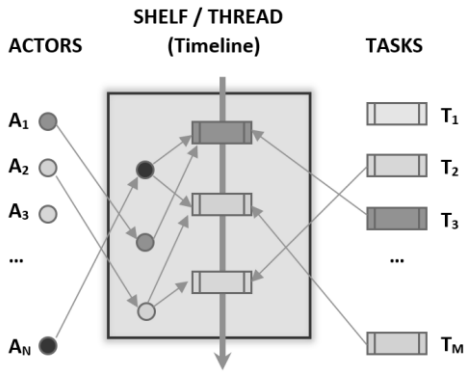

Figure 1. Timeline, Actors, and Tasks in SimFlow

3.2 Templates

A template is built to predefine the features and properties of a group of similar workflows. Workflows of that kind can be created based on its template. The users can take the following actions over a template:

+ Create + Lock + Clone
+ Delete + Unlock + Modify
+ View

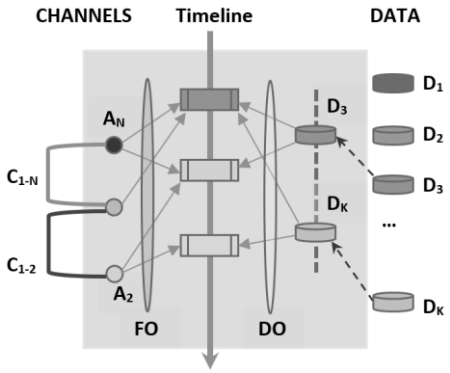

Figure 2. Data and Communication Channels in SimFlow

3.3 Workflows

The users can take the following actions over a workflow:

+ Initiation + Lock + Clone
+ View + Unlock + Delete
+ Modify

Status: a workflow can have the following states:

+ New: 0
+ Active (In-Progress): [1 to 99] (%)
+ Done: 100
+ Deleted: -100
+ Paused: -[1 to 99] (%)

The transitions between these states are shown in Fig. 3. When a workflow is created it has NEW state. It is changed to ACTIVE or in-progress state when its first task is started. It can be put into PAUSED state when users temporally stop the workflow. After any of the tasks of the given workflow is resumed it goes back to the ACTIVE state. When all tasks in the workflow are finished the workflow will get DONE state. A workflow can be deleted only when it is in the PAUSED or DONE state.

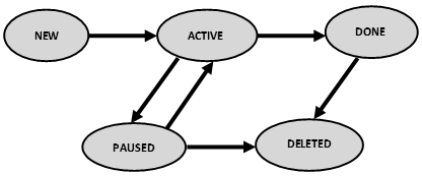

Figure 3. States of Workflows in SimFlow

Workflow Control Block

As we need to keep track of each workflow, in terms of its components, status, etc., a record for each workflow called Workflow Control Block (WCB) is created and stored in the system. The WCB contains the workflow ID, its title, the shelf contents which are tasks represented by forms, participating actors, and data involved in the workflow, as shown in Fig. 4.

WID:	020901
Status:	15(in progress: 15%)
Owner	u7365
Title:	"Travel Request"
Shelf:	t01,t03,t02
Forms:	f01,f03,f02
Actors:	a05,a11,a19
Data:	Pointers to emails, files, ...

Figure 4. Workflow Control Block (WCB)

Directory of Workflows
The system keeps a list of workflows in the Directory of Workflows (DW), as shown in Fig.5. It contains workflow IDs with which the system can allocate the corresponding WCBs and the workflows themselves. It also shows the status of each workflow and let users be able to pause, resume, or delete workflows.

WID	% Status	Pause	Resume	Delete
01624	25	◉	○	○
17293	100	○	○	◉
38251	53	◉	◉	○

Figure 5. Directory of Workflows (DW)

Workflow Assignment Matrix & Control Panel
The two main components of a workflow are actors and tasks. In order to create a template for a given kind of workflows users would need to be able to add and remove actors, who represent people involved in the workflow, and the tasks, which represent what needs to be done. Workflow Assignment Matrix and Control Panel (WAM) is a dashboard for viewing and adjusting the assignments of actors to tasks/forms. A new task or actor can be created when necessary, as shown in Fig.6.

Actors\Objects	T_3	T_M	T_2	+ T
Orders	1	2	3	
A_N	C,M			
A_1	M,A,R	V,M		
A_2		M,A,R	A,R	
+ A				

Figure 6. Assignment Matrix in SimFlow

A WAM template is created for each workflow template. When a workflow is created a WAM for it is also created as an instance of the given WAM template. After that, the users would still be able to modify the order of tasks/forms and participating actors. This makes our system flexible enough to implement dynamic online collaboration and coordination where changes can occur after the workflow is created.

3.4 System Architecture of SimFlow

The SimFlow model consists of three layers: (i) User Interface, which has a graphical WEB interface and an API interface to interact with other programs or apps and other systems; (ii) Processing, which has a number of units to represent and manage the workflows; and (iii) Data, which stores necessary information about the workflows, users, and their activities, as shown in Fig.7.

In order to reduce the complexity of the system, SimFlow employs email adapters so that it can use available external email servers for workflow communication rather than building our own communication system. The communications channels simply connect emails of involved actors. SimFlow also uses the microkernel approach where only a small kernel, which consists of the Manager, Workflow Engine, and Auditor units, is active while other units are loaded only when they are called.

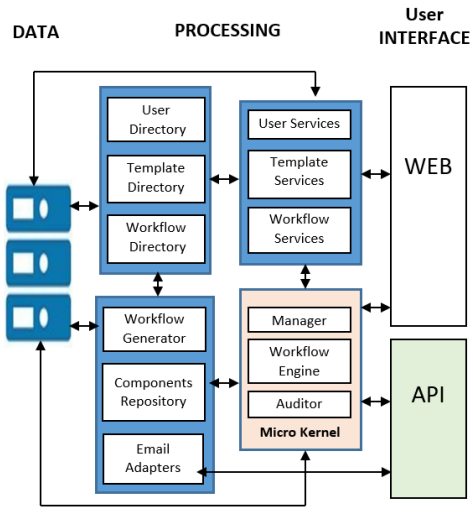

Figure 7. Architecture of SimFlow

4. FLEXIBLE COLLABORATION AND COORDINATION

Our model can support dynamic collaboration and coordination where tasks can be modified and participating actors can leave or join tasks during run time. The users can make adjustments in workflows even after their creations and customization.

Workflows for e-Collaborations
In SimFlow, a workflow can be created to represent a business process that involves e-collaboration when a collective decision or a collaborative content is made by many users. People, who are involved in the collaboration, are represented by actors and are assigned to the workflow. Usually the collaboration can be divided into a sequence of steps or decisions which are represented by tasks. As this sequence defines the order of tasks, it is indeed a timeline. In our model, a task is defined by a web form which is managed by actors. If a decision requires approvals of several workers then the actors representing those workers will have the access to the form and can also manage it. The contents of the web form, which represents a task or decision making, are generated based on prebuilt components or form. After creating and customizing tasks the user can move them around the timeline, as shown in Fig.2, to get the desired outcome based on the process logistics. In a collaborative task, represented by the form, an actor A_x may need to wait before doing his/her part until other part of the task is done, by other actor A_y. To implement this coordination the fields (of the web form) managed by actor A_x will be disable until other fields managed by actor A_y are filled-in. Completing a field in the web form may trigger the release or unlocking of some data, enabling other fields of the web form, or starting another web form representing the next task. Actors can have discussions with each other if there is a communication channel between them, via emails.

For example, when a salesman needs to make a trip to see a client he needs to ask the secretary for a travel request. Then, the salesman and the client and become the two actors who need to work together on defining the schedule of the meetings with all of the details including the objectives of the meetings. Then, it would need to be forwarded to his supervisor who may like to change certain parts of the meeting schedule. After the supervisor approves the request it would go to the finance/accounting department head who will check to see if there is available fund for the whole trip. Once the

finance department head verifies the necessary fund, the CEO can approve it. Then, the travel plan will progress further by the purchase office worker who will use the company bank account to buy the transportation tickets, making hotel reservations, etc.

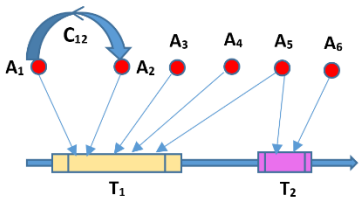

Figure 8. Collaboration in a Travel Request and Approval

In SimFlow, this collaboration logistics can be represented by a workflow in a simple way, as shown in Fig. 8. As this kind of travel requests is popular, the secretary may have already built a template TR for all travel requests. When the salesmen asks, the secretary creates a workflow based on that TR template which should have the following actors: salesman A_1, client A_2, supervisor A_3, finance head A_4, the CEO A_5, and purchase worker A_6. There should also be a communication channel C12 between the salesman and the client so that they can discuss details of their meeting schedule. These two actors must also work together to define and complete the trip objectives in T1. Once the salesman actor A_1 and the client actor A_2 finalize and approve the trip plan in T1 it should be viewed and approved by A_3, A_4, and A_5. After that, the purchase plan is generated via task T2 and should be implemented by A_6.

Flexibility

In our model, users can change the collaboration logistics at any time as necessary. Users can change the order of how the actors participating in the workflow. They can also add or remove the actors dynamically as needed. The workflow change cycle is shown in Fig. 9. First, the change is planned and proposed. Then, it will be validated to make sure that the given change would not affect the integrity of the whole workflow. Next, the rest of the workflow needs to adapt (i.e. modify and adjust) to the initial change. During this time, all workflow activities will be paused and data will be locked. Finally, the change is executed and marked as completed.

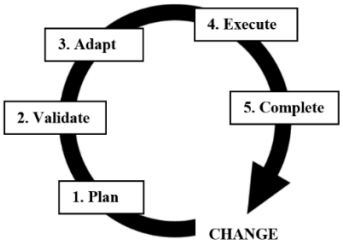

Figure 9. Workflow Change Cycle

In the last example, if there is a change, for instance, the CEO is away and he grants the finance department head the authority to approve the travel request then we can simply disable actor A_5 which represents the CEO and let actor A_4, which represents the finance head, have access to T2 and can approve the purchase form in T2.

5. CONCLUSIONS

We have proposed a simple and yet flexible model for sequential and semi-sequential workflow management. This system can cope with dynamic changes after the workflow is deployed. The main difference between SimFlow and other existing commercial workflow management systems is that it is simpler and easier to use while its workload is substantially less compared with others, because: (i) it is based on the microkernel approach; (ii) it has no message passing system of its own as external email servers are used instead; and (iii) the workflow engine only needs to handle simple kinds of workflows: sequential and semi-sequential ones which are the most popular kinds of business workflows. Therefore, SimFlow can avoid the complexity problem seen in other WfMS and does not require significant IT resources to host. It can become an effective tool for e-collaboration, intelligent business modelling, and business automation in various domains and applications.

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