International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 4 Issue 10, October -2015

WORKFLOW AUTOMATION SYSTEM

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ABSTRACT

The Workflow Automation System (WAS), our patent application, is a web based system that has the capability to output ready to use automation of any well-defined workflow. The system has special forms to allow the user to input the workflow in the form of tasks, roles, actions associated with each task and the forms available in each task. The tasks can be of any nature like sequential, parallel or cyclic. In return, the WAS produces a secure online website with a predefined database that completely automates the workflow earlier input. This automation has proper user, role and task management that elaborates what to be done when by whom as defined in the workflow. The significant features of the resultant automation include automatic reminders to the task holders through emails at certain admin defined time intervals, tracking feature for all users of the system with admin defined privileges.

Keywords: Workflow Automation; Web-based solutions.

INTRODUCTION

With the decrease in the price of computer hardware, businesses all round the world are tending to adopt automation of business workflow and avoiding primitive paper based systems. This is due to the apparent advantages like security, alacrity and enhanced management. over the paper based system. Since business workflows are of different types, complexity and nature, a need for a customizable engine is observed that can come up with automation of any workflow. Although, the proposed Workflow Automation System is not a complete solution but rather to some extent, it can produce automation of any office or business workflow quite easily with reasonable amount of time as compared to the traditional systems.

A workflow is simply an ordered series of tasks that accomplish some defined purpose according to a set of rules. There are different types of workflows with respect to the task order. In some workflows, the tasks are assigned to roles one after the other i.e. in a sequential manner. Other workflows have tasks in parallel along with sequential. Some workflows have the series of tasks in a forward-only manner while others have back and forth. Hence, different workflows have different complexities and rules. The presented Workflow Automation System tends to address all these complexities with the help of complex database queries and database table design.

There have been a number of efforts being accomplished to automate workflows for the last two decades. The automation systems kept on changing with the change in the requirements and environment in the offices. Some of the recent approaches of automation of businesses are briefly discussed in the section below along with their pros and cons.

LITERATURE SURVEY

One of the early approaches for developing automation of workflow is Document Management System (DMS). DMS is a computer system (or set of computer programs) used to track and store electronic documents and/or images of paper (Wikipedia contributors, 2009). Initially, it was used only for storing and managing paper documents and was typically knows as storage of scanned documents and images in electronic form on a server. However, nowadays DMS is matured from a basic archival and retrieval system to a complete information management solution. It is now used for making workflow, with its traceability and archiving features. There have been several developments in DMS from time to time. (Al-Ma'adeed, Amire, Hamza, & Al-lebda, 2008) came up with a DMS for managing, verifying and analyzing forensic documents in area of crime investigation. An improved DMS with client/server system is shown in (Banh & Tran, 1996). Also, Hummingbird DMS is a well know DMS that is still used in many organization. It has a Document Management Workflow abbreviated as DM Workflow. DM Workflow works in conjunction with DM to support electronic routing of documents for Windows Desktop and allow users to route multiple documents across their organization (© 2004 Hummingbird Ltd., 2004). Similarly, Documentum which was founded in 1990 is another DMS now known as Enterprise Content Management (ECM)(© 2009 EMC Corporation, 2009). It provides management of

document content and attributes such as check-in, check-out, workflow, and version management. All these DMS kept on improving continuously on the time frame; however, flexibility in making complex workflows remains to a limit. This is the reason many businesses could not adhere with the ready-to-use DMS available in the market due to their frequent changing need in the definition of workflows (Jennex M. E., 2008). Moreover, the DMS are incapable in making complex forms and hiding chunks of information from specified role (like hiding names of members a certain committee in a document), (Audit and Assurance Services Branch Project #08-19, 2009)

As an alternative of using the DMS, there have been a number of attempts to make workflows automation. A web-based approach for automating workflow for an international company is presented in (Yao & Li, 2006) which includes online recording of forms and texts, automatic email notifications and reminders, electronic authorization, a secure mechanism for web access of documents for approval and future references. (Lee, Mark, & Chiu, 2007) improved the workflow of an insurance company by providing alert and exception handling features. (Xiao, Thompson, & Ning, 2006) introduced a workflow automation strategy using a business language for grid architecture. With the help of different programming languages these approaches provide better solutions for company specific constraints than the ready to use DMS. These approaches are efficient enough for their own domain; however, they do not come up with a complete general solution.

For a complete general solution for entire business processes automation, it is found that the companies are moving towards Enterprise Resource Planning (ERP). Using ERP any business can manage and coordinate all the resources, information, and functions from shared data stores. Typically, it has modular software and hardware units that communicate on a local area network. And due to the modular nature, it allows adding and reconfiguring modules while preserving data integration in the shared data source (Wikipedia contributors , 2009). However, among the other shortcomings of the ERP is its high cost which is especially not suitable for small businesses (Exforsys Inc., 2006). Moreover, the cost to train the workers on the process of using ERP is also one of the major limitations of ERP (Exforsys Inc., 2006).

Another latest workflow automation framework is Windows Workflow Foundation (WWF) which was released in 2006 as a part of Microsoft .NET Framework 3.0(© 2009 Microsoft Corporation., 2009). Here the structure of the workflow is declared in XAML (a declarative XML-based language) or any .net Programming language. Workflows comprise 'activities'. Developers can write their own domain-specific activities and then use them in workflows. The developed workflow can be hosted in a web application. WWF provide extremely robust and complete control over solution. However, it is reported that the configuration steps especially in deployment are fairly complicated. Moreover, the learning curve is quite steep and even simple workflow takes a significant time to complete for end user. (Andrew, 2007).

WORKFLOW AUTOMATION SYSTEM

The Workflow Automation System is a framework for building automation of workflows. It provides user-friendly forms for providing information like name of the system, Tasks, Roles, and Action. This information is further used for defining the workflow. Once the workflow is constructed, Forms can be made using the available templates for defining specifically the task for every role. These Forms are made in ASP.net 2.0. In the section below, we discuss the features of this engine that make it distinguishable among the other above mentioned approaches of making workflows.

FEATURES

Following are some of the key advanced features in the Workflow Automation System:

1. **User Management**
   The system facilitates each user with secure login and with dynamic pages having only relevant information. The users can be managed by Administrator without any need of technical support. Users can be within or outside domain. Also more than one role can be assigned to a single user.
2. **Role Management**
   The system facilitates the administrator to define roles and their hierarchy without any need of technical support.
3. **Task Management**
   The system facilitates the administrator to define tasks, their duration, their order, their types like sequential, parallel, initial, final or tailless.
4. **Task Messages Management**
   The messages which are delivered in the form of email to the administrator defined task holder on the initiation of task can be edited by the administrator.

5. **Email Reminders**
   The system facilitates the roles performing tasks by automatically sending email reminders to complete tasks after certain administrator-defined interval. The reminders emails contain the task message that is sent to the user on the initiation of task.
6. **User Action Management**
   Each task defined can have some action associated with. These actions are defined by the administrator. The pre-action and post action task are defined which routes the user on a specific task to another specific task after performing a specific action. The action name and the message representing the action is also administrator defined.
7. **Action tracking**
   The system facilitates users to see the tracking information of all the tasks present in the workflow, with the task names, person name, and role name and the time of action along with the duration each role is taking.
8. **Processing of Parallel and Sequential Tasks**
   With some easy adjustment in defining Task and Action while building the automation, tasks can be made which can be ordered sequential as well as parallel. This feature allows complex workflow requirements to be automated with ease.
9. **Concealment of certain role names from others**
   The roles present in the system are shown information only relevant to them. The administrator can show and hide any chunk of information in the dynamic reports from one role to the other with the help of available forms while defining the system. Apart from this, the names of person performing actions in the Action History can also be made to hide for unwanted roles.
10. **Method to provide Instructions on each webpage.**
    The system provide a user friendly GUI for the administrator to add/ edit instruction present on each webpage dynamically at any stage after deployment.

PROCEDURE

The Workflow Automation System helps user to make workflow of any business or office system. The procedure follows some known steps. Before we start building the system there are some minor preliminary requirements that need to be fulfilled as well. We describe these requirements followed by the steps for building the automation and at the end we discuss the running of the automation:

Preliminaries:
The Workflow Automation System is meant to automate businesses with an established email system and a central repository of employee details and department organization. The employee detail must comprise of ID, Name, Department, employee's email ID (organization email). Whereas, the Department organization must contain the list of all departments with their Head of Department's employee ID. In case if such repository is not present, then the system provides forms for making such repository. However, the email system is a necessary pre-requisite of the Workflow Automation System.

Building the Automation:
Now, we proceed to define the steps for making an automation system. Forms are provided to complete each step in the Workflow Automation System with the administration login.

1. Define System Properties
   The system is defined by three fields, namely: System Full Name, System Short Name, and Complete URL. The full name appears on each webpage as title and in the Footnote whereas the short name is used for the system email ID. For e.g. ABCSystem@organization.com, here "ABCSystem" is the short name of the system.
2. Define all roles involved in the system
   Every role is assigned a Role ID, a Role Name and a Level in organization hierarchy. A higher level denotes a higher level in the organization hierarchy. For e.g. the level of a staff is less than the level of his immediate boss and so on. The levels can be same as well.
3. Define all phases for parallel execution of task
   A Phase is defined by a Phase ID and Phase Title. If two tasks are defined to be run in parallel then each has the same phase ID.
4. Define all tasks involved in the workflow
   Each task is assigned a Task ID, a Phase ID, a Task Title, the Role ID of the role the task is assigned to, first reminder duration (in days) and Second and later reminders duration (in days).
5. Define Actions related to each task

Every action is defined by an Action ID, Action Title, Action Type, Task ID of the task holding the action and either a next Task ID or a next Phase ID. A phase ID is used when the action is to fork into more than one parallel task.

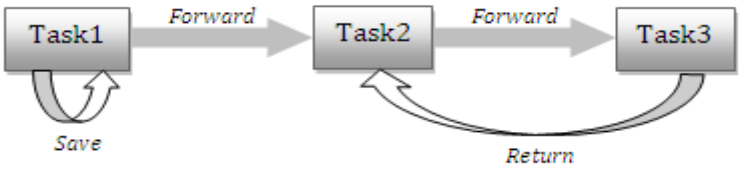

Figure 1: A Typical Forward And Backward Order Of Tasks

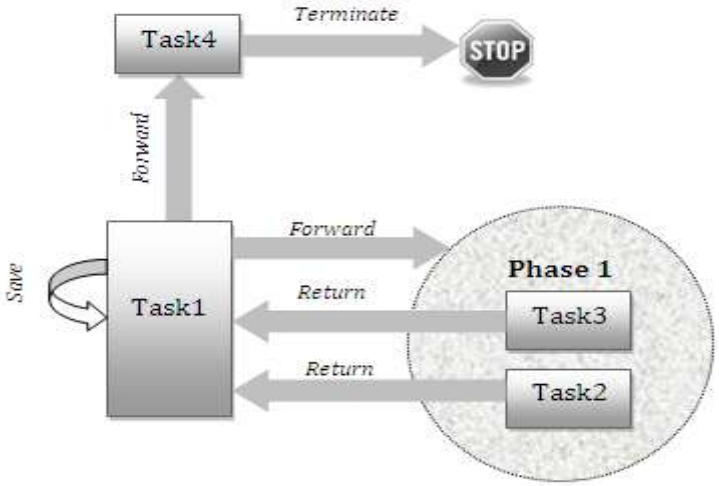

Figure 2: Diverging and Converging Tasks

Action Type is a set of some pre-defined actions that a role can take when assigned a task. These include: Forward, Return, Save, Terminate. The Action may lead the role to complete the task (like save), initiate a new task (like forward), return to the previous task (like Return) or finish the workflow (like terminate).

6. Define Forms used in the system
   Each form is defined by a Form ID, the title of the page and the name of ASP.net form (along with extension ".aspx").
7. Define Forms related to each task
   A task is a set of forms assigned to a role present in the system. The names of each form appear as menu items in the left pane when the task is opened by the user. Some forms are necessary to be filled and saved by the user and others are optional. We define here each task with the Task ID, Form ID, the rank/position of the form name in the menu, a level (which represents some privileges when a single form is to be shown to two different roles), Instructions that appears on the top of each form and a Boolean field representing that the form is necessary or optional for the completion of the task.
8. Define Email templates for each action after task completion
   When a task is completed with a start of another task, an email is sent to the role associated with the next tasks. The email template for this email is to be defined here. It is defined by an Action ID, the next Task ID, and the message. In the table below, the variables that can be used in the template are described. Their values are fetched at run time.

Table 1: Email Templates

S. No.	Variable in Email Templates	Description
1	@@Applicant@@	The initiator of the request/application in the workflow
2	@@ApplicantDepartment@@	Applicant's Department Name
3	@@Receiver@@	The Name of the Person responsible for the Next Task
4	@@ReceiverDepartment@@	Receiver 's Department Name
5	@@Sender@@	The Name of the Person responsible for the Current Task
6	@@SenderDepartment@@	Sender 's Department Name

With these 8 steps, we are done with making the skeleton of the workflow. The workflow can now be accessed on the URL mentioned. Now, the forms need to be made using the available ASP.net Forms and Controls templates.

Running the Automation:
The engine is designed to provide a secure web-based automation of workflow on the URL Specified in the system properties in step 1. A workflow is typically an application that is initiated by a specified role and later it moves through specific tasks assigned to different roles in different offices. Order of tasks related to an application can be forward, backward, diverging or converging as discussed above. At first, the system authenticates each user with LDAP authentication or any other authentication system later customized. After authentication, the system displays the

1. User detail,
2. Application(s) the user is responsible for along with his role in the application and
3. Option to start a new workflow.

By default, the system provides every user the option to start a new workflow; however, this can be customized to limit only specific or desired users. The signed–in user can now open the application he is responsible for, to see the currently active task(s) related to the application. If any of the active task(s) belongs to him, he will be able to see an Open link otherwise he will be able to see Waiting text along with the name of the user, the task is active for. Also, at this stage, he can view the action history of the application as well. This history comprises of all Task Names, Names of the Person assigned with their role and the time of the Actions along with the duration in days and hours each person took to complete the tasks in this application.

In case the active task belongs to the signed-in user, he/she can click on the Open link to open the electronic Application. The electronic Application comprises of menu items on left. Each menu item corresponds to a form. Clicking on the menu item opens the form. If the form is necessary to be filled for the completion of task then a Save button will appear at the bottom of the form otherwise it will not appear.

The last menu item is Action. Clicking on the Action menu item opens a checkout form that shows the checklist of Forms necessary to complete the task and their status (Complete / incomplete). The checkout form also has the list of actions that a user can take on this specific task. Some actions like Return and Save does not require the checklist of Forms to be completed. Actions like Forward require all necessary forms to be completed. Performing a Forward or Return action opens a compose email control with a Confirm Selected Action button. The email has the editable text for requesting action after the application is returned or forwarded. As the task is forwarded or returned, the email is sent to the user responsible for the next task. This concludes the current user's active task. After forwarding or returning the application, he can no more access the forms in the application. However, he will be able to see the changing history of tasks on the application.

STRUCTURE OF THE WEB APPLICATION

In this section, we describe the Structure of the Workflow Automation System application. The system is designed with a Layered Architecture. It is well defined into 3 different layers as shown in

Figure **1**. The bottom-most layer is the DBMS layer, followed by Data Access Layer and finally the Webpage Layer. The first layer is the DBMS layer that consists of Tables and Views. Above this layer is the Data Access Layer (DAL) that has objects and queries. All the SQL queries lie on the DAL. There are 7 DAL files in the Automation Engine. Over the DAL lies the Web pages layer. This layer consists of Forms, Master pages and Controls.

Figure 1, Distribution of Layers in the Fps

DBMS

In this layer, the raw data is stored in the form of the tables. Apart from this, in order to increase the ease of accessing and avoiding complex queries on the later Data Access layer, Views over some of the tables are also stored in this layer. The constraints like primary key and foreign key are also stored along with the tables.

DATA ACCESS LAYER

This layer consists of Data Access Layer files with extension ".xsd". These files contain objects for accessing one or more tables or views in the Database layer. Each Object is linked with the Data in the DBMS through a connection string which is stored in a configuration file on the web server in an encrypted format. The connection string contains the name of the Data source (server name), the initial catalog (Database name), user ID and password. In the usual practice, one object is linked with one table or view. The object contains the attributes of the table or view and the queries which will be used to access the data.

WEBPAGE

The web pages layer is the layer where the data manipulation requests from the user or the system are received and the results of the actions are shown. The web pages use Adapters to access the query methods of the Objects in the DAL. The operations like view, insert, update and delete are performed in this layer. The webpage layer consist of Master Pages that are .master files, Forms which are .aspx file and are usually in a master page file, reusable controls that resides in the form files and CS files that have static routines that can be called from master pages, form files or from controls.

DESIGN

In this section, we discuss the design of the system. The system is designed for the use of Administrators and End Users. The Administrator can develop workflow that includes making routes of task, managing roles, defining actions, assigning time duration for each task, setting up the reminders for each task and other procedures as shown in the Procedure section above. The End-Users are the task holders that performed the action(s) earlier defined by the administrator. The system is designed in such a way that the workflow definition is stored in certain types of tables in the same database while the end user data is stored in another type of tables. The end user cannot alter or update any tables having the workflow definition and are accessed through the workflow Engine by the Administrator only. The end user data is stored in the Dynamic workflow tables and Form Tables with the help of service routines. The service routines use the information related to the workflow from workflow engine. The end user and the administrator are both client and need to be authenticated firstly by the organization email database with the help of the Authentication routines. The client, server and database structure is shown in the figure below.

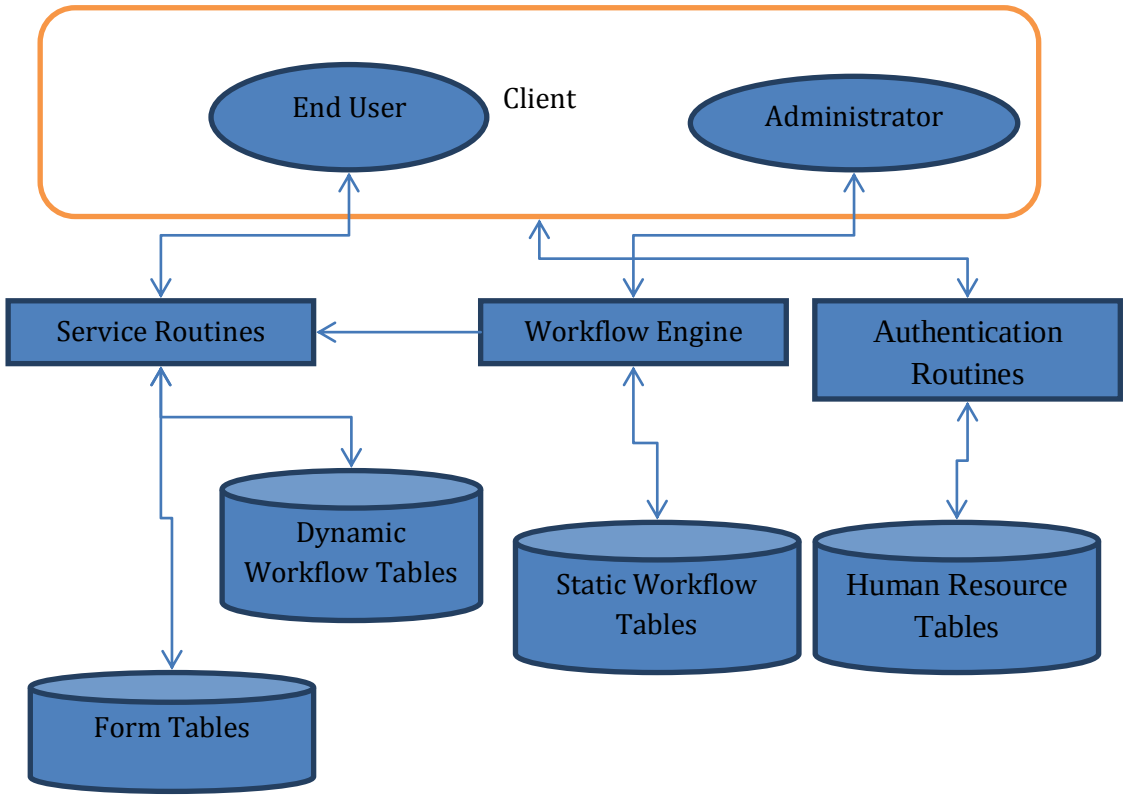

Figure 2: Architecture of the Workflow Automation System

The workflow engine:
The workflow is built with the help of records in the static workflow tables. The workflow engine provides form for the administrator to set up Tasks and Actions. A task is linked with another task with an action as shown in the figure 5.

Service Routines:
The service routines are procedures to run the workflow by the end user. Whenever a task holder performs an action on a task the service routines manage and update the status of task with the help of dynamic workflow tables. With an initiation of a workflow a single record is made in the application table representing the workflow with an Application ID. All the roles participating in the workflow are also stored separately for each Application ID. As the actions are performed in each task the service routines logs the information and automatically send reminders based on the task duration.

Authentication Routine:
The Client either Administrator or the end user are authenticated by the established email system which is a pre-requisite of the workflow automation system.

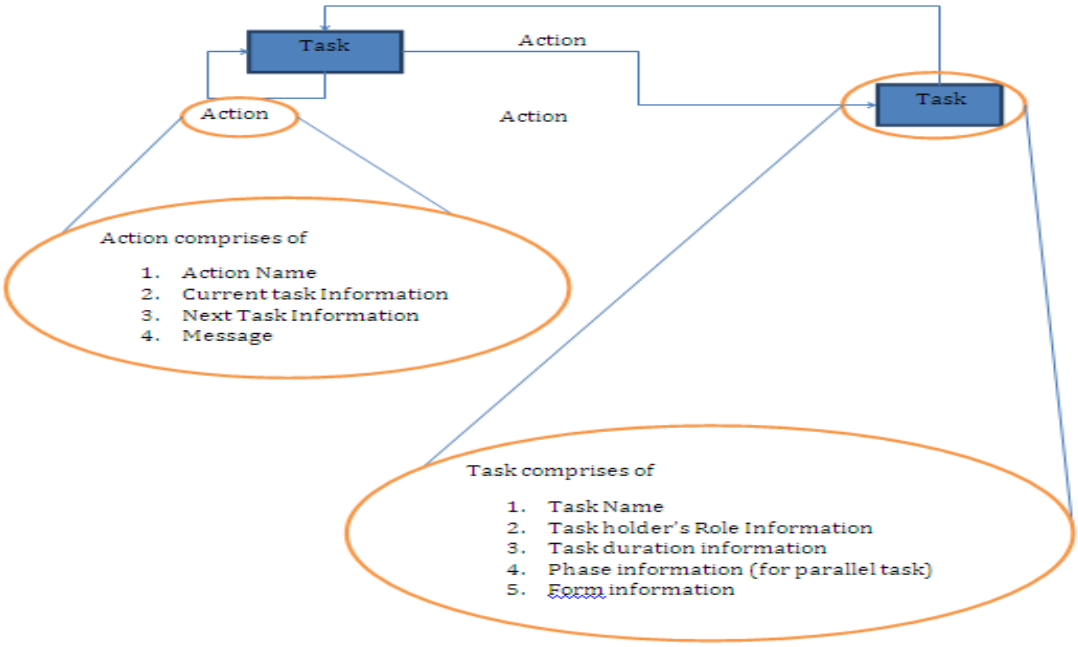

Figure 3: Task Action Relationship in the Workflow Engine

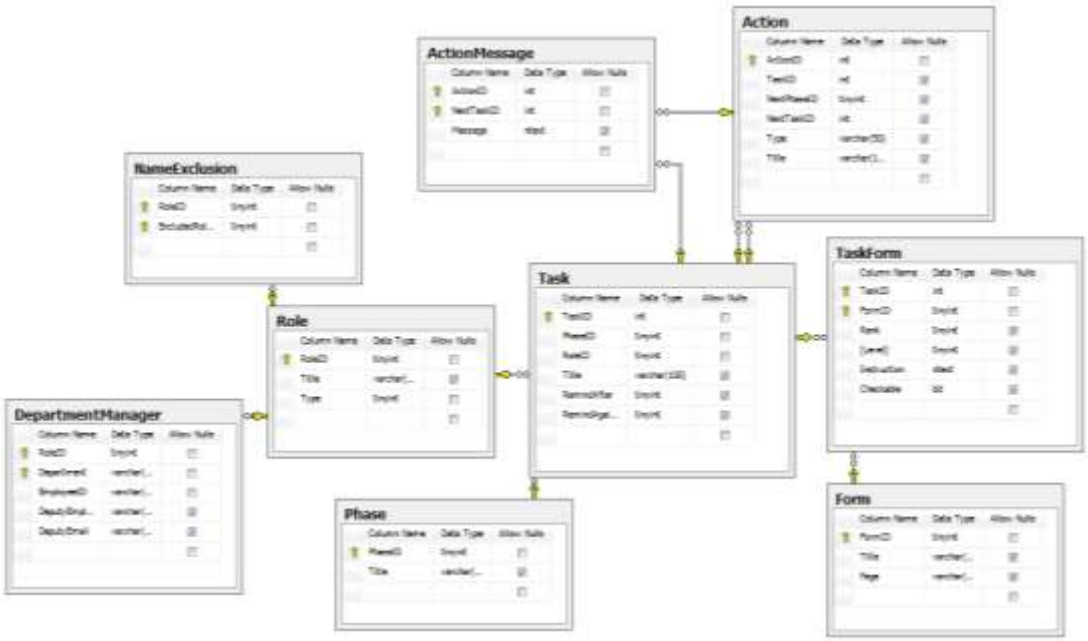

Figure 4: A Low-Level Database Designs Of the Static Workflow Tables That Are Used In the Workflow Engine

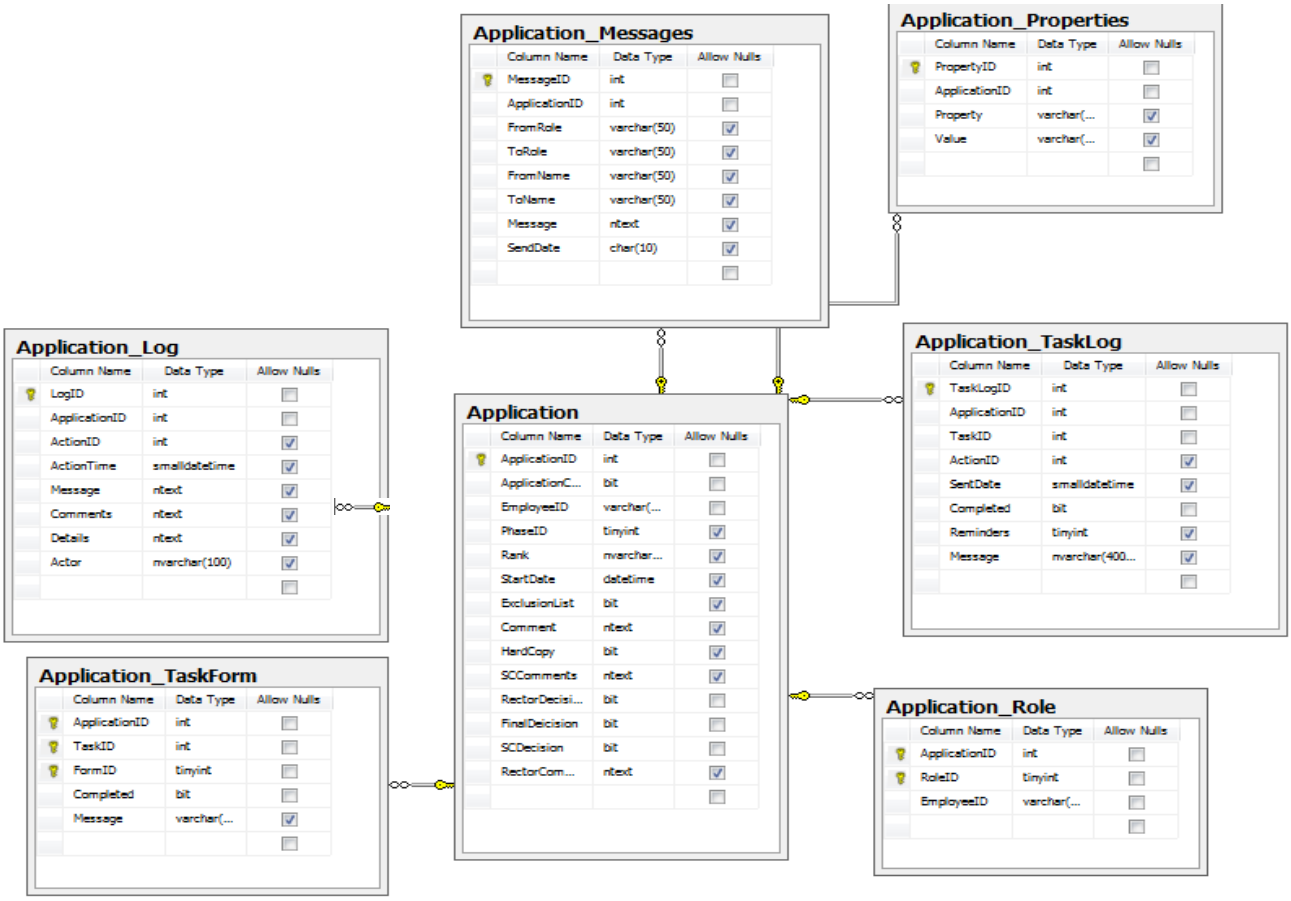

Figure 5: A Low-Level Designs of Dynamic Workflow Tables That Are Used In Service Routines for Running Workflow

Database Design The Database consists of 43 Tables. The tables are grouped into 7 classes depending upon the data and its usage in the system. These groups are described below in brief:

Workflow Tables These tables are mainly responsible for maintaining workflow from one task to the other. There are two types of tables in this category:
Static: These tables are very important and critical as they define the main workflow of the application. The course of action, privileges, and instructions are defined here.

Table 2: Description of the Static Workflow Tables

	Static Workflow Tables	Description
1	Action	All the actions that a role can be performed with respect to the task assigned are stored here
2	ActionMessage	The template of the message that become the contents of the email when a new task is started. The email is sent to the role responsible for the task and will also appear as the role opens the application.
3	Form	All the ASP.NET Forms and their title are stored here. These Titles are used for Menu generation.
4	Phase	In case of Parallel Process, the task is overlooked by the Phase. The Phase ID and Title are stored here.
5	Role	The Role represents the different category of faculty like Applicant, Chairman and Dean.
6	Task	All the tasks with corresponding role and phase (in case of parallel process) are stored here. Also the number of days the system will wait for sending the first and later Reminders if the task is not completed, are also stored corresponding to each task.
7	TaskForm	Information of which Forms are shown for each Task

		and which forms are necessary to complete in order to complete task is stored here.
8	NameExclusion	This table is used for concealment of a role from another role in all the system. It has two fields RoleID and ExcludedRoleID

Dynamic: The dynamic tables are prefixed with "Application_". The data in these tables are changed as the application is moved from one role to the other or a task is being completed.

Table 3, Description of Static Workflow Tables

	Dynamic Workflow Tables	Description
1	Application	This table correspond to one application or project that comprises of different task
2	Application_Role	This table stores the role corresponding to an application. The role is determined by the employee ID
3	Application_TaskForm	The information regarding each task in an application. Which form is to be shown in which task and what instruction should be displayed on the page/form
4	Application_Log	This table is used for building history. It stores all the events.
5	Application_TaskLog	This table specifies whether the task is completed or not.

First Level Form Tables

All the forms has direct link with these tables through the Data Access Layer. All these tables are prefixed with "Form_".
Second Level Form Tables
These tables are directly linked with the First Level Form Tables. No Form Access these tables directly.

Human Resource Tables
These are static tables that are synchronized with the Human Resource Database of the company. These tables include Employee Detail and department organization as discussed in the preliminaries With the help of the above mentioned tables and SQL queries that run over them, the system is designed in such a way that only the desired user(s) at a time can access and open the application. All the other Application roles are shown the application in a waiting state with the name of the person the task is assigned to. All roles can witness the action tracking of the application by opening the application's active task. Also with the help of some complex queries the rules are made for forwarding, returning the application to one or more recipients quite easily by changing the Action and Task table with the help of Forms available. This prevents the developers to write complex queries.

DISCUSSION

The Workflow Automation System provides a framework for building automation of businesses and primitive paper based systems. It helps in managing information as well as providing reports for the high-level authorities for critical business decision. There have been a number of other approaches for building automation systems as discussed in the literature survey. We can merge approaches to outline 3 basic types of solution for making workflows. Table below provides a summary view of the pros and cons of the work flow automation engine with respect to these approaches.

Table 4, Comparison Of Automation Frameworks

	Document Management System (DMS)	Workflow Automation System (WAS)	Enterprise resource planning (ERP)	Windows Workflow Foundation (WWF)	Microsoft Sharepoint 2010 using Sharepoint Designer
Cost	Medium	Not for sale	High	Comes with Visual Studio 2005 and later	High
Flexibility	Limited	Very flexible	Limited	Very Flexible	Very Limited
End-user Expertise	Not needed	Not needed	Needed to some	Needed to some	Not needed

			Extent	Extent	
Developer Expertise	Usually not needed	Not Needed for simple forms	Usually Java and oracle Forms	Very Hard to learn.	Not needed
Ready-to-use	Yes	Yes	No	No	No
Making Complex forms	Difficult	Simple	Difficult	Difficult	Not Possible
Hiding chunks of Information	Very Difficult	Easy	Difficult	Difficult	Not needed
Complex Workflow routes	Very Difficult	Easy	Easy	Easy	Not Possible
Global Access	Usually not	Present	Present	Present	Across Sharepoint site
Reporting Services	Usually not	Present	Present	Present	Present
Email Reminders	Not present	Present	Present	Present	Present
User Friendliness	Medium	High	Medium	High	High
Co-ordination of all company resources and info	No	No	Yes	No	Yes
Central Database	Yes	Yes	Yes	Yes	Yes
Handling More than 1 workflow	Incapable	Incapable	Capabale	Capable	Incapable
Deployment	Simple	Simple	Quite Difficult	Quite Difficult	Simple

Referring to the Table 4, we have compared the Workflow Automation System with 3 up-to-date approaches for building automation of workflows. The Workflow Automation System tends to be a better option for organization in some aspects and not a good option for others. Considering the simplicity and easiness in making complex forms, making complex routes like parallel, cyclic, sequential, and show/hide chunks of info in the dynamic reports, the workflow automation system outshine nearly all other approaches quite significantly. However, some features like handling of more than one workflow is an inherent characteristic of ERP and the automation is not meant to handle this. Considering the Automation Engine and WWF, the end-user-friendliness can be increased to any desired extent by using strong features of C# and ASP.net. However, unlike Automation Engine, the WWF is reported to have a quite steep curve of learning for developers (Andrew, 2007).

Moreover, the automation engine provides the high priority roles or administration a form to view read-only reports showing all the activities and correspondences being performed on the application at any stage. For e.g. the chairman of a department returns the request to the applicant with some valid reasons. The director can view the return and this correspondence as a report on his login after going to the Admin link. This feature is inherently not present in any of the above approaches.

CONCLUSION

A system or framework for automating the workflows in businesses or offices is presented. The Workflow Automation System provides developers an easy and user-friendly environment for developing complex workflows without any need of writing complex queries in minimal amount of time. With some definite steps of customizations, the workflow skeleton is ready to run providing each role a secure login on a web-based system. The Forms for each role can be made using the available APS.net and C# forms and control templates for defining specific task of each user i.e. what to do when by whom.

In the advance features of the system, the most significant are automatic sending of email reminders to complete tasks, Application tracking, Processing of Parallel and Sequential Tasks, Easy concealment of certain role names from others and Easy method to provide Instructions on each webpage. The simplicity and unfussiness for the workflow developers is the main feature of the Workflow Automation System that makes it exclusive among the to-date workflow automation practices. Although, some other approaches present more simpler and straightforward approach, they are incompetent in making complex workflow requirements.

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