Workflow Reengineering: A Methodology for Business Process Reengineering Using Workflow Management Technology

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Abstract

The Workflow Reengineering Methodology (WRM) is a proposed methodology that uses workflow management automation to enable Business Process Reengineering (BPR). Unlike published BPR methodologies that use historical and estimated process data gathered from workflow participants, WRM uses the more accurate, real-time process measurements, gathered by the workflow tool, to improve the efficiency, effectiveness and flexibility of the workflow. The methodology consists of five phases and 32 component steps, together with associated data collection forms to facilitate its implementation. Using the proposed methodology, a case study was conducted to improve the processing of on-line equipment manuals and electronic discrepancy reports for a Naval organization. Preliminary results indicate significant reduction in cycle time, costs as well as personnel required to manage the process.

1. Introduction

Although the development of information technology has had a major impact on the business world, information technology has generally been applied to business processes and procedures that have remained unchanged since the 1950s. As a result, the greater benefit of using the technology to reengineer business processes and procedures remains untapped. To fully benefit from information technology, we need to address the fundamental ways that information technology could be used to reengineer traditional processes to achieve cost savings, improve customer service, and bring about needed flexibility to all aspects of business operations in today's highly competitive global market place.

In this paper we advocate the use of workflow management technology as an enabler to business process improvement and reengineering. Workflow management technology is an approach that automates, integrates, and manages work. It incorporates flexible process modeling, support for "what if" simulation, real-time status monitoring, and performance measurement capabilities that can greatly assist an organization in reengineering its business processes. As such, workflow automation can both automate business practices and provide real-time information and modeling facilities critical to the improvement of business processes. However, a robust workflow management tool, alone, cannot ensure the success of a process improvement initiative. "A successful organizational change and business process redesign initiative requires the use of a formalized methodology as a road map" [1].

In this effort we develop a methodology, called the Workflow Reengineering Methodology (WRM), to facilitate business process reengineering using workflow management automation as an enabling technology. WRM is synthesized from the BPR and process improvement methodologies of Davenport [2], Harrington [3], and Klein [4]; the BPR principles of Linden [5], and Hammer and Champy [6]; as well as original ideas. This methodology enables BPR through workflow automation. The main advantage of this approach is that unlike proposed BPR methodologies that use historical and estimated process data gathered from process participants, WRM uses the accurate, real-time process measurements gathered by the workflow tool to improve workflow efficiency, effectiveness, and flexibility.

As shown in Figure 1, WRM consists of five phases and 32 component steps, together with associated data collection forms and detailed instructions for their use by a change team. These forms can be used to collect and record process data if the workflow tool cannot be used, or is not available, for direct entry. Each phase and step of WRM are briefly described in the following subsections. For an extensive description of the methodology the reader is referred to Bitzer [7].

The remainder of the paper is organized as follows. Sections 2–6 detail each phase of the methodology and its associated steps. Section 7 briefly discuss the application of the methodology to reengineer the processing of

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equipment manual discrepancy reports for a Naval organization that sponsored this research. Finally Section 8 concludes the paper with a summary and provides directions for future research.

2. Phase I: Preparing for Workflow Innovation

During the first phase of WRM a need for improvement in the way business operations is conducted is recognized. An organizational management tool is then researched, obtained, and installed. The business cycles of the organization are identified, and a vision for the organization's future is established. The project environment is defined and a business cycle is selected for improvement. A proactive change management program is employed throughout the organization to prepare all employees for modifications to business operations and to train them on how to operate the workflow management tool.

2.1. Step 1: Identify a Need for Process Improvement

Before innovation can begin within an organization, there must be an identifiable need for improvement expressed by an employee, manager, business owner, regulatory agency, or customer. There are many possible drivers for the dissatisfaction: "Improved financial performance, customer satisfaction, operational efficiency, reliability, and agility are often key internal motivators for a change program" [1]. Once a need for process improvement has been identified, the change requirement is documented and its justification brought to the attention of senior management.

PHASE I: PREPARING FOR WORKFLOW INNOVATION

Step 1: Identify a Need for Process Improvement
Step 2: Gain Management Sponsorship
Step 3: Establish Change Leadership Roles
Step 4: Introduce Automated Workflow Management Technology
Step 5: Build, Educate, and Train a Change Team
Step 6: Identify Business Cycles
Step 7: Create an Organizational Vision
Step 8: Analyze the Project Environment
Step 9: Implement a Change Management Program

PHASE II: AUTOMATING EXISTING WORKFLOW

Step 1: Catalog Business Products
Step 2: Identify Business Processes
Step 3: Select a Process for Implementation and Improvement
Step 4: Construct a Work Breakdown Structure
Step 5: Define Task Components
Step 6: Specify Performance Measures
Step 7: Complete and Verify the Workflow Model
Step 8: Install and Test Required Infrastructure
Step 9: Implement and Monitor Automated Workflow

PHASE III: IDENTIFYING PROCESS IMPROVEMENTS

Step 1: Consider the Customers' Requirements
Step 2: Benchmark Against Industry Leaders
Step 3: Specify Performance Goals
Step 4: Reengineer the Workflow
Step 5: Construct New Workflow Models
Step 6: Simulate Each Workflow Alternative
Step 7: Select the Most Efficient and Effective Workflow

PHASE IV: ESTABLISHING SUPPORTING STRUCTURES

Step 1: Identify Organizational Changes
Step 2: Specify the Required Infrastructure
Step 3: Gain Approval
Step 4: Institute Organizational and Infrastructure Changes

PHASE V: IMPLEMENTING AND MAINTAINING IMPROVED WORKFLOW

Step 1: Implement the New Workflow
Step 2: Manage the Workflow Configuration
Step 3: Perform Continuous Improvement

Figure 1. Summary of Workflow Reengineering Methodology

2.2. Step 2: Gain Management Sponsorship

To be successful, a change effort requires strong executive level management support. Senior managers have a broad and complete picture of the operations of the business and can better understand and predict the effect of a process change on the overall business practices of the company. They possess the authority necessary to approve changes that affect multiple departments, the control required to overcome any controversies or obstacles, and the fiscal oversight to determine if a change effort will receive adequate funding [6].

2.3. Step 3: Establish Change Leadership Roles

The organization must establish key leadership roles to support and assist the change team. These roles include a reengineering leader, an executive-level reengineering steering committee, and a reengineering czar. The leader is an executive-level manager who creates a corporate vision, motivates, oversees the reengineering effort, and

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ensures that the program has continuing financial and managerial support. The steering committee is a group of senior managers who define the organization's reengineering strategy. The reengineering leader is often the chairperson of this committee. The committee determines project priority, controls resource allocations, and provides problem resolution assistance to reengineering teams. The reengineering czar is the organizational expert on reengineering procedures and tools. The czar is a full-time process improvement coordinator who oversees all reengineering projects and acts as a BPR technical advisor to team members and leadership officials, alike [6].

2.4. Step 4: Introduce Automated Workflow Management Technology

During this step, a workflow management tool is procured and installed to automate and improve business practices within the organization. The organization's Information Technology (IT) department consults with employees and surveys workflow software vendors to determine the type of workflow package that best meets the needs of the organization. The IT department also identifies, obtains, and installs the supporting infrastructure required to provide organization-wide connectivity.

2.5. Step 5: Build, Educate, and Train a Change Team

A change team of five to ten employees is assembled to conduct workflow modeling and improvement. The composition of the team is critical to the success of the project. It should include employees from all functional specialties, including the IT department.

At a minimum, the team should include both people who are familiar with the target process(es) and people who are unfamiliar. The role of the former is to bring knowledge of the way things are done today. The role of the latter is to bring the creative naiveté to ask, "Why do we do things this way?." [4]

Because process analysis and redesign are time consuming and must be completed within a limited amount of time, a minimum of 75% commitment level is required for project success [6]. This level of commitment by management will not only allow the project to be completed promptly, it will also signal to employees that the project is of great importance to the company.

Once the team has been assembled, its members are educated on the principles of change management, workflow modeling, business process reengineering, and the steps of WRM. They should also receive extensive training on the use of the chosen workflow management tool.

2.6. Step 6: Identify Business Cycles

Once the change team has been trained, the business cycles of the organization need to be identified and recorded. To determine the organization's business cycles, the change team identifies the mission and goals of the organization by gathering and reviewing any regulations or directives that govern the company's operations. They also need to consult with the executive-level steering committee for clarification and validation of the business objectives.

2.7. Step 7: Create an Organizational Vision

To improve, an organization must possess a vision for what it desires to become in the future. The Executive Steering Committee should define an organizational vision and delineate the business strategy to be undertaken to achieve their stated objectives. According to Davenport, the improvement strategy should be partially non-financial; possess measurable components; be distinctive to the industry and company; be inspirational; be long-term, at least five to ten years, in focus; and address tools for change [2].

The reengineering czar then publishes a business process improvement directive [3]. This directive communicates the purpose and principles of reengineering, the need for process improvement, the corporate vision and strategic plan, the reengineering approach to be undertaken, and the responsibilities of all employees in the improvement effort.

2.8. Step 8: Analyze the Project Environment

Prior to beginning the change effort, the project team must analyze and understand the conditions under which they will operate, identifying change leverages and obstacles that must be clearly identified in order to be utilized or overcome during the reengineering project [2]. To this end, the change team:

- Inventories organizational resources such as personnel, information systems infrastructure, facilities (including utilities), materials, and supplies;
- Delineates project funding to determine the scope of the reengineering effort; and
- Determines project scope and time frame, limiting the reengineering effort to the implementation and analysis of a single business cycle.

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2.9. Step 9: Implement a Change Management Program

To control any employee resistance throughout the course of the workflow reengineering project, an organization must implement a proactive change management approach. Terez [8] provides nine change management guidelines:

- Understand precisely what and with whom you are dealing;
- Take the mystery out of the change by telling and showing employees just what it entails;
- Motivate employees to commit themselves to the change;
- Present the change in the form of a challenge, complete with tangible rewards linked to successful implementation;
- Take steps to ensure that all managers are committed to the same change management game plan;
- Demonstrate how the change preserves or enhances the state of fairness for employees;
- Avoid letting the change become bogged down in excessive employee involvement. Determine and secure the optimal level;
- Draw up an implementation schedule with specific milestones, and review this timetable frequently; and
- Realize that change is a process of movement and that things will keep moving even after implementation is deemed completed.

3. Phase II: Automating Existing Workflow

During the second phase of WRM, the business products of the business cycle under review are identified. The component processes of the cycle are distinguished, and a single process is selected for improvement. The present workflow of this process is modeled and implemented on the automated workflow management tool. The specified performance measures of the workflow are then monitored and recorded in real-time for use in the process improvement phase of the methodology.

3.1. Step 1: Catalog Business Products

- The change team identifies the products that result from the completion of the chosen business cycle. Using the Business Process Identification Form, shown in Figure 2, each product's form (physical or electronic), cost, and value are recorded.

BUSINESS PROCESS IDENTIFICATION FORM for Business Cycle _____

Product	Form	Cost	Value	Business Process	Freq.	Priority	Condition

Figure 2. Business Process Identification Form

3.2. Step 2: Identify Business Processes

During this step, the business cycle is decomposed into its component processes by identifying how each business cycle product is created. Using the Business Process Identification Form, the change team records the process' name, how often it is conducted during an average work week, and the priority assigned to the process: low, routine, high, urgent. The priority of the process will be used by the workflow tool to determine work assignment and precedence.

3.3. Step 3: Select a Process for Implementation and Improvement

Once all the processes of a business cycle are identified and recorded, the team selects a single business process for implementation based on a set of factors. Harrington proposed a Weighted Selection Approach to rate each process on a scale of one to five on the factors of changeability, performance, and business and customer impact [3]. This process is facilitated by using the Process Condition Worksheet shown in Figure 3.

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Process Name	Chageability	Performance	Business Impact	Customer Impact	Total

Figure 3. Process Condition Worksheet, After Harrington, 1991

To determine the value for each element, the change team must answer the following questions:

- Changeability: How easily can the process be fixed? (1 = Can not be changed; 5 = Easily changed)
- Performance: How does the process presently function? (1 = Well; 5 = Badly)
- Business Impact: How important is the process and its product to the success of the company? (1 = Unimportant; 5 = Critical)
- Customer Impact: To what extent is the customer concerned with or affected by the present state of the process or its product? (1 = Unconcerned; 5 = Highly concerned)

The process with the highest total score is the process that is in the greatest need of improvement. Therefore, the change team selects this process for automation and improvement. The ranking of each process is recorded, in order of their reengineering priority, on the Business Process Identification Form. These rankings are used to schedule the remaining processes for future improvement projects.

The Executive Steering committee must identify the owner of the selected process. The process owner is the senior manager responsible for the effective and efficient functioning of that particular process. He/She should understand the tasks involved in the entire process and be able to predict how any proposed changes might affect both the process and the overall business cycle [6].

3.4. Step 4: Construct a Work Breakdown Structure

The change team, with the help of the process owner, constructs a work breakdown structure which is a graphical depiction of the hierarchical structure of a business cycle decomposed into its component parts. The goal of this decomposition is to represent the work of an organization in pieces that can more easily be understood and modeled by the change team. The process is broken into its component sub-processes, and the sub-processes are broken into their fundamental tasks which are the actual work steps of the process.

3.5. Step 5: Define Task Components

A task contains six components: work objects, roles, rules, resources, time, and routing. A work object is the input to, or product of, a task. It is any item that is routed between tasks and/or workflow participants. Work objects take various forms. The object may be a physical resource used to create a product or service, or the product or service itself. It may also be a paper or electronic document that contains information structured in such a way as to have meaning to an organization [9].

The roles of a task are the participants in the activity. They include the people in a corporation who perform the work steps, as well as the suppliers of resources and business customers. Personnel are not designated by name in the workflow model. Roles are assigned by position titles so that a change to a personnel assignment does not require an associated update to the model's data repository.

The rules of an organization describe the behavior of task participants. They define what work is completed within a task and why, where, when and how the work is accomplished. Business rules include information concerning authorization, notification, priorities, product form, resource consumption, role definition, scheduling, security, task, automation, task dependency, task initiation, task iteration, and work completion [9].

Resources are the items consumed in the course of conducting business. They are the input used by an employee to complete an assigned task. Material, money, personnel assets, equipment, and facilities are all examples of resources [10].

Time is also a resource consumed during the completion of a task. Since it is an extremely important aspect of a workflow, it has its own category in the workflow model. A process of a business cycle takes a

certain amount of time to complete. This cycle time is a combination of the time it takes to actually complete a task (task time) and the time required to transfer the work objects to the next task in the workflow (transfer time). Transfer time can be broken down into physical transfer time and queue time. Queues are holding areas for work objects or assignments that are waiting to be processed [9].

Routing is a depiction of the logical arrangement of tasks and the flow of work objects between them. Routing can be serial (one after another), parallel (done simultaneously), or conditional (with the flow dependent upon the initiation or completion of other tasks, or upon the results of a decision) [9].

Detailed data on the participants, work objects, rules, types of resources used, and work object routing are required to establish the automated workflow model. Therefore, they must be collected in advance of model design. The time component and the amount of resources consumed during the task will later be measured and recorded by the workflow tool once the workflow has been automated. These components are the direct determinants of process cost and, hence, more precise values will greatly improve the quality of the improvement analysis.

Using a Task Definition Form, given in Bitzer [7], the change team collects the required workflow data for each task in the process. First, the change team identifies which employee performs each task by asking the process owner to identify the organizational unit wherein each task is completed, the worker who performs the work, and that worker's work site location. The team then interviews each of these personnel at their work site. To aid in the determination of correct process flow, the team conducts these interviews in the order of task completion shown on the work breakdown structure.

At each interview, the change team asks the employee to define and demonstrate, whenever feasible, the work that is completed within the task. They change team can then determine if this work is standardized by governing procedures and ascertain if and how the work conducted might be automated. With the help of the employee, the change team also ascertains better ways of conducting the work of the task.

The team then identifies the work objects involved in the task by recording the task's inputs and outputs. The team records the number of copies of the object, its form (physical or electronic), its format (i.e., document, business form, record of accounts, etc.), the transmission medium used, and the origin/destination task and participant of the work object.

The team next identifies any business rules associated with the task. This involves identifying what triggers the initiation of the task and determining if there are any task completion notifications is required. The team also delineates the task's performance frequency during a single completion of the business process to identify any cyclic routing within the workflow. Further, the team specifies the task's priority (low, routine, high, urgent) in relation to other work that the employee regularly performs; determines if the work of the task is a support function or a core activity that is strategic to the completion of the final product; identifies any decisions made or questions answered by the employee in the course of the work listing the possible and their resulting actions; explains how work completion or success is determined; and ascertains if there are any authorizations required in the course of the work.

Next, the resources (materials, facilities, tools or computer assets) used or consumed during the completion of the task are enumerated. Finally, the team estimates the value added to the final product by the completion of each task by taking the value of the process' final product from the Business Process Identification Form and allocating a portion of it to each task on each of the Task Definition Forms. These are subjective decisions that may require the assistance of the steering committee and process owner.

3.6. Step 6: Specify Performance Measures

Prior to establishing an automated workflow, the team specifies performance indicators that will be recorded by the workflow tool. Harrington specifies three categories of process measurements: effectiveness, efficiency and adaptability [3]. Process effectiveness is a measure of how well the business process meets the needs and expectation of its external and internal customers. It is a measure of the quality of the product. Examples of effectiveness measures include product reliability, performance or usability, durability, appearance and serviceability. Efficiency is a measurement of productivity and level of resource usage. An increase in business productivity or a decrease in the amount of resources used would result in a decrease in the cost to the customer for a good or service. Examples of efficiency measures include the cycle completion time, amount of time spent on rework, resources expended per unit, and amount of value-added to each product unit. Adaptability is a measure of how easily a product or service can be tailored to the needs of a particular customer. Flexibility is the hardest characteristic to measure. However, some possible process adaptability gauges include the number of available customer service representatives, response time to custom orders, average time to process special orders as compared to standard orders, and refusal rate for special orders.

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The change team identifies the performance measures to be used for the process under review, selecting the performance indicators that correspond to the business objectives published in the organizational vision statement. The selected performance measures are recorded, in order of priority, on the Process Performance Form and on each of the Task Performance Forms. These forms are presented in [7]. The team then verifies these measures and their rankings with the process owner and the reengineering steering committee.

3.7. Step 7: Complete and Verify the Workflow Model

Using the selected workflow management tool's workflow builder, the team constructs the workflow model of the process being modeled. First, organizational data, such as personnel, available resources, and office hours, are specified into the tool's data dictionary. Tasks and flows between tasks are then modeled and represented. Finally, any scripts required to monitor the required performance measures are written.

Once the model has been implemented using the workflow tool, the team verifies its completeness by running the tool's model verification feature. A walk-through of the workflow model is then conducted to ensure that the workflow model is accurate and complete. Starting with the initial task of the model, the flow and performance of work through every path of the process is traced to ensure that the model is validated [3].

3.8. Step 8: Install and Test Required Infrastructure

With the help of the IT department, the change team examines the network infrastructure and determines if any additional hardware or software is required to connect all the workflow participants. The team also verifies that all the components required to automate the tasks of the process are installed and operational. Once the required architecture to support the workflow system is in place, the system's performance is tested by having the process participants simulate a cycle of the automated workflow.

3.9. Step 9: Implement and Monitor Automated Workflow

When the workflow system is in place and prior to beginning the collection of performance data, employees are given an opportunity to learn and get comfortable with the new workflow system. Once they are adequately trained, the automated workflow system is implemented and allowed to operate for a couple of weeks. During this period, the team refines the workflow model as required to accurately support the existing workflow.

Once the workflow model is operating satisfactorily and the participants comfortable with the system, the company lets the workflow tool run the process for approximately a month. During this period, the workflow management tool collects process performance data for use in the reengineering phase of the methodology.

4. Phase III: Identifying Process Improvements

Once the existing workflow is automated and while its performance is being measured and recorded, new performance goals for the process are determined. The existing workflow is then analyzed for possible improvements, new workflow models are constructed, and each is simulated to determine its performance characteristics. Finally, the most efficient and effective model is selected for implementation.

4.1. Step 1: Consider the Customers' Requirements

Because the company's customers are quite knowledgeable on what they require from the business' processes and products, their requirements and ideas must be considered in defining the goals of the new process. The change team schedules meetings with a representative sample of the customer base to discuss and record their requirements, improvement ideas, and performance objectives. Surveys can be created and mailed to gather the needs of a broad customer base. Face-to-face contact, however, should be used whenever possible to demonstrate a high level of commitment to the customer's requirements and to foster improved relationships [2].

4.2. Step 2: Benchmark Against Industry Leaders

To maintain and increase their market share, a business must be more innovative than its competitors. To accomplish this, the change team must become aware of any new methods and technologies that are employed within its industry. Possible sources of this information include industry publications, academic studies, consultant firms, as well as on site visits to other companies both within and outside of their competitive circle [2]. For a detailed description of the benchmarking process, the reader is referred to Harrington [3].

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4.3. Step 3: Specify Performance Measures

Using the data gathered from customers and benchmarking process, and the performance objectives specified in the organization's vision statement, the team specifies overall process performance goals (in quantifiable terms) for each of the performance indicators implemented on the workflow tool. Each of these goals is recorded in order of priority on the Process Performance Form. These amounts are then apportioned to each of the process' component tasks and recorded on each of the Task Performance Forms.

4.4. Step 4: Reengineer the Workflow

Using the recorded workflow performance statistics and the new performance goals, the change team identifies ways to improve the performance of the implemented workflow. The reengineering improvement approaches the team considers include the following:

- *Delete or Modify Non-Value Added Tasks*: There are three types of tasks in a workflow, those that add real value to the customer, those that have some business value but do not directly affect the customer, and those that add no value [3]. Tasks that add no value to the final product should be modified or eliminated to save time and resources, thereby, decreasing product cost.
- *Arrange Tasks in a Natural Order*: In traditional processes, tasks are sequenced in strict succession. One person has to complete a task before the next person could begin the following step. This serial routing unnecessarily slows the cycle time of the process. The use of parallel routing decreases the cycle time of the process and get the product or service to the market sooner.
- *Place Work Where It Makes Sense*: A process that includes the transfer of work objects across departmental boundaries "...is expensive, since it involves a variety of departments plus the overhead that's associated with tracking all the paper and fitting all the pieces of the process together" [6]. Each task is analyzed to determine if the work really requires the functional expertise already assigned or if it can be completed by another workflow participant within the same functional area.
- *Combine Tasks to Reduce Hand-Offs*: Work was broken into its basic steps during the Industrial Age and each step was apportioned to different employees. This required the unnecessary transfer of work objects and lengthened the cycle time of the process. "By eliminating the hand-offs, delays, and errors inherent in a traditional sequential process, a case worker-based process can achieve order-of-magnitude improvements in cycle time, accuracy, and cost" [6].
- *Push Decision Making to the Appropriate Task*: In a traditional hierarchical organization, decision making occurred at a management level above the workers. "Referring everything up the ladder means decisions get made too slowly for a fast-paced market" [6]. To speed up these processes, decisions must be pushed down to the personnel performing them.
- *Reduce Checks and Controls*: "Conventional processes are replete with checking and control steps, which add no value but are included to ensure that people aren't abusing the process" [6]. With the implementation of the process on an automated workflow management system, the need for these controls is considerably reduced. The processes enacted are managed by the system and managers need not stop the process to check the status of work. They can simply query the workflow engine for status information and can electronically communicate with the assigned employee.
- *Lessen Cycle Time*: The cycle time directly affects the cost of the product and its time to market. Therefore, these times should be reduced to improve efficiency, but only to a level that still guarantees high quality production. The team determines if each task could be split between two or more employees, or if an automated tool or change in work procedures could be implemented to speed up the work of the task. If the task completion time is short, a determination is made whether the task should remain separate or if it could be combined with the preceding or succeeding tasks.
- *Eliminate Bottlenecks and Resource Shortages*: Bottlenecks are points in the workflow model where the transfer of work objects is slowed. A bottleneck results from the high level of demand for a particular employee or other scarce resource. As a result, work objects must wait in a queue until the resource becomes free. This results in a longer cycle time than necessary. The team identifies any bottlenecks in the workflow and finds ways to eliminate them. For example, if an employee is overworked, his/her work need to be assigned to another employee who has the required skills and available time. If a resource is the cause of the bottleneck, additional units of that resource should be obtained and used or other resources should be considered to complete the task.
- *Make Multiple Versions of the Process*: Many existing organizational processes consist of a single workflow that was constructed to handle all possible work requirements. "To meet the demands of today's environment, we need multiple versions of the same process, each one tuned to the requirements of different

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markets, situations, or inputs" [6]. The streamlining of complex processes decreases the cycle time as the number of required decisions and their related queue times are reduced. It also improves the value of the company's products by incorporating flexibility into their production operations.

- *Capture Information Once, Upstream in the Process*: The repetitive entering of identical information at different points along a process is a non-value adding activity. All of the data required during any task within the workflow should be gathered once at an upstream point in the process and stored for use in later tasks [5].
- *Provide a Single Point of Contact*: A process should have a single employee who will "... answer the customer's questions and solve customer problems ...." [6]. This person will act as a buffer between the process and its customers. This will not only reduce the number of personnel involved in the workflow, it will also improve customer service and response times.

4.5. Step 5: Construct New Workflow Models

The change team incorporates each of the identified improvements into a new workflow model using the workflow management tool and the procedures in Phase II, Step 7. It is recommended to formulate two or three alternative scenarios that negate past process inefficiencies. Each alternative is then recorded the Process Performance and Task Performance Forms.

4.6. Step 6: Simulate Each Workflow Alternative

In this step, the team performs a statistical simulation on each of the workflow improvement alternatives. As the workflow tool simulates each scenario, it gathers performance data that can be used to compare design alternatives. This simulation allows the testing of design alternatives to ensure the validity of the proposed innovations before committing scarce business resources. It can help the change team to brainstorm process improvement ideas and demonstrate how the new process might function, its costs, and problems or benefits. It can identify bottlenecks, periods of peak capacity, or resource shortages, and can measure employee workloads and work completion times. The simulation of the workflow can be used to communicate and sell a new workflow plan to management and employees [11].

4.7. Step 7: Select the Most Efficient and Effective Workflow

The change team records the performance measurements for each workflow alternative on the Process Performance Form and the performance statistics of each task on its Task Performance Form. The data gathered for each model is checked to ensure that each of the workflow options meets the overall performance goals for the process and task. The workflow that is the most efficient, effective, and adaptable, as well as feasible, is selected for implementation.

5. Phase IV: Establish Supporting Structures

Once an improved workflow model has been selected for implementation, any required supporting organizational changes are identified. Necessary modifications or additions to the workflow system infrastructure are also specified. Approval is gained for the new process, and the organizational and infrastructure changes are instituted.

5.1. Step 1: Identify Organizational Changes

The change team determines if any organizational changes (such as personnel changes/reductions, management strategy modifications, training practices and advancement criteria, etc.) are required to support the new workflow design. Change must occur "... not only in process flows and the culture surrounding them, but also in organizational power and controls, skill requirements, reporting relationships, and management practices" [2].

5.2. Step 2: Specify the Required Infrastructure

With the help of the IT department, the change team analyzes the present connectivity of the workflow system infrastructure and determines if there are any additions or modifications required to support the new workflow model. Any necessary infrastructure procurements are identified, and a migration plan for transitioning to the new workflow system is developed.

5.3. Step 3: Gain Approval

The change team makes a request for approval of its workflow innovations during a presentation to the Steering Committee. The presentation should highlight the cost savings that have already been realized due to the automation of the present workflow; demonstrate the simulation of the improved workflow; show the improved

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performance measure statistics that result from the implementation of the changes; and explain the required organizational and infrastructure modifications and their justification.

5.4. Step 4: Institute Organizational and Infrastructure Changes

After gaining approval, the change team informs and educates the affected personnel on the impending procedural, organizational and infrastructure changes. Relevant publications and directives are updated, and organizational adjustments are made. The IT department implements the new workflow support infrastructure and provides on-hands training for workflow participants.

6. Phase V: Implement and Maintain Improved Workflow

During the final phase of the methodology, the new workflow is implemented and any changes to the workflow configuration are documented as the workflow is maintained. A continuous process improvement program is established to ensure that the present process receives periodic reengineering and that all other corporate processes are automated and improved.

6.1. Step 1: Implement the New Workflow

Once the supporting structures are in place and the participants have been trained on the new system and procedures, the new workflow model is implemented. The process owner must actively monitor the performance of the workflow to ensure it is functioning as intended, making any required adjustments.

6.2. Step 2: Manage the Workflow Configuration

The process owner must actively manage the workflow system's configuration so that the workflow model continues to remain standardized and unaltered by unauthorized personnel. Authorized changes made to the workflow template, should be documented, including the justification for the change, and version control procedures instituted. Copies of the old versions of the models should be retained in case there is a need to return to the previous method of doing business. Additionally, all the documentation produced during each workflow reengineering project should be maintained for use as a starting point for the next reengineering project [12].

6.3. Step 3: Perform Continuous Improvement

As depicted in Figure 4, the Workflow Reengineering Methodology is cyclic in nature. The performance of the improved workflow is continuously monitored and periodically reengineered, as required. Additionally, new processes are considered for innovation by the same, or a new, change team. As additional processes are defined and automated, their interrelationships should be identified and analyzed in the reengineering project. Eventually, all processes of the organization will be implemented on the workflow management system and can be concurrently analyzed for improvement.

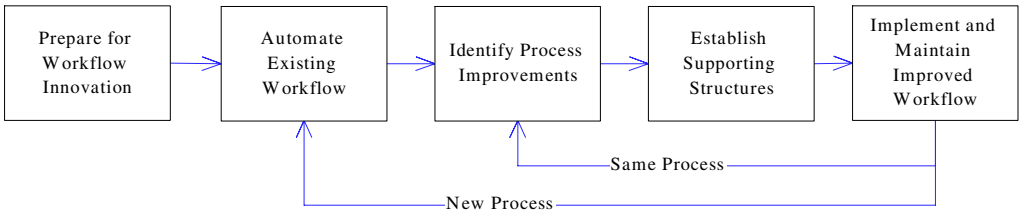

Figure 4. Workflow Reengineering Methodology Cycle

7. Application of WRM: A case study

A case study that included the application of a portion of the methodology was conducted using workflow data gathered from a Naval organization that sponsored this research. The sponsor was interested in exploring the use of workflow technologies and their use in improving their business practices. The organization, however, did not have an organization-wide workflow tool in place during the enactment of this study. Therefore, the application of WRM focused only on the definition, modeling, and improvement of a single workflow within the organization.

Using the data collection forms developed by the authors, the tasks of the workflow were identified and their components were defined during interviews with workflow participants and process owner. The cycle time statistics were estimated by employees and the cost figures were based upon employee pay and resource consumption. The process was modeled on a stand-alone workflow tool and analyzed for improvement using the estimated time and cost statistics captured in the workflow tool. Finally, new workflow models were developed and the most efficient model was identified.

The workflow manipulated in the case study involved the processing of equipment manual discrepancy reports. There were three types of reported discrepancies: invalid or already corrected; non-technical or administrative; and technical. These reports were manually routed between employees, analyzed for validity and responded to by letter. The original workflow involved eight personnel in four different divisions, located in three separate buildings.

The improved workflow incorporated on-line equipment manuals and electronic discrepancy reports. A workflow tool was used to perform electronic routing and control work assignment, resulting in the removal of nine non-value added tasks and five people from the process. Cycle time was reduced by over 95% for the processing of invalid or non-technical discrepancy reports, and by over 55% for technical discrepancy reports. Costs were reduced by over 50% for invalid or non-technical discrepancy reports and by over 30% for technical discrepancy reports.

8. Conclusions, lessons learned, and future research

The relative novelty of process innovation techniques and workflow technology made the development of the workflow reengineering methodology a difficult one. Most existing literature on workflow and business process engineering is fragmented and incomplete. It was, therefore, necessary to synthesize relevant ideas from various sources and incorporate them into a coherent and comprehensive methodology.

The case study showed that WRM promises to be a methodology that can be used successfully to improve an organization's business processes. The data collection and process identification forms significantly streamlined the process definition effort, ensuring that all relevant information was gathered from workflow participants.

WRM is comprehensive, covering the process improvement effort from the identification of a need for change to the final implementation and maintenance of the improved workflow. The method can be applied to any type of process and is designed to be easy for all personnel to learn and understand. Simple forms and detailed guidance are provided for all phases and steps. The methodology suggests employee training topics and is well documented. The workflow tool and the forms used in the methodology document the workflow design and reengineering process as each step is accomplished. The method is enabled by a single workflow management tool that significantly improves and eases the reengineering effort through its graphical modeling tool, simulation features, real-time performance data collection and reporting features.

The application of the methodology to the case study highlighted the importance of having personnel trained in the principles of process thinking. Capturing required process data was greatly simplified because the organization's personnel were well trained in the principles of process thinking. The case study also revealed that it is critical for an organization to have unit-based costing in place prior to undertaking a reengineering project. Particularly in a public organization, employees may not be aware of the value of a good or service or of the quantity or cost of the resources they consume in the completion of their tasks. Determining this information is quite time consuming and requires the assistance of an experienced financial expert. This cost data collection process could easily slow down the progress of the reengineering effort and lessen team motivation.

Future research should include the following two areas that were not sufficiently addressed in the current research: 1) Testing and refining the methodology and 2) Developing a supporting workflow tool.

Due to the time limitation and the lack of an installed workflow tool at the organization involved in the case study, the proposed methodology was not fully tested. To be validated and refined, the methodology in its entirety should be used throughout a complete reengineering project. The reengineering roles should be established and an automated workflow system should be put into place. Each step of the methodology should then be completed and the overall methodology analyzed and improved.

An automated workflow management tool should be developed that supports the proposed methodology in its entirety. The tool should incorporate an easy to use graphical user interface that prompts the user for the required task information. This information should then be automatically incorporated into the workflow model. To streamline the reengineering process, the tool should also enable the side-by-side display, simulation and comparison of design alternatives and their performance statistics.

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