



WORKFLOW SYSTEMS

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Issue V1.R0.M0
April 2005



1 What is workflow?

Workflow can be defined as the automation of a business or laboratory process, in which documents, information or tasks are passed from one participant (machine or human) to another for action, according to a set of procedural rules.

2 What problems does workflow solve?

For many years transaction-led organizations have appreciated the benefits of business process automation. They have understood that if technology is used to automate these processes, then time-consuming and error-prone manual intervention can be eliminated. This helps them to achieve more, in less time, with fewer mistakes. However, the real benefit is greater competitive advantage, as costs are reduced and productivity is improved.

Workflow systems are now being used more and more in the scientific and engineering sectors. Previously many scientific organizations felt that their business processes were too innovative and research-based for automation. However, the commercial pressure to bring products like new drugs, pesticides and household cleaning products to market more rapidly has forced a re-assessment.

The key drivers for process automation are improved business efficiency and compliance. As businesses evolve, processes that have been fundamental to the operation of an organization can become error-prone, inefficient, or expensive. Tessella's customers have needed to continually assess and refine the processes that define their work. This is not always a problem that can be solved by software alone, and Tessella has considerable experience in process specification, design and implementation. This technical supplement describes business process automation and some of the new technologies that are allowing scientific and engineering organizations to reap the benefits of workflow.

Advances in workflow technology, both in commercial-off-the-shelf (COTS) products and in facilitating technologies such as internet-based web services, have opened up the possibilities for highly flexible workflow systems that can be integrated into even the most innovative research laboratory environment. Tessella has expertise in developing workflow systems in a number of specialist areas.

Innovative Systems

For organizations that rely on rapid innovation, such as in the formulation of new chemicals for use in household products such as shampoos or washing powders, any processes that include slow, handcrafted and error-prone calculations are a liability. When coupled with collaborative working that depends on informal email the business processes can become unmanageable. This is especially true in growing multinational organizations where there is a need for global processes. The development of web-based workflow systems, within which entire development processes can be managed from inception to production, can lead to powerful and efficient systems that add real value to the organization.

Workflow for the research data pipeline

Workflow systems are helping biotechnology, pharmaceutical and chemical industries to manage the vast quantities of data that pass through many stages of processing and analysis.

Data that may be captured in the field with handheld devices needs to be fed into the pipeline so that calculations can be performed and reports generated. To keep data flowing in the pipeline, information associated with a particular agrochemical, active pharmaceutical ingredient, or biological organism must pass between scientists and support staff with different roles, such as quality control, curation and analysis. A workflow system can co-ordinate the whole process, ensuring that data is processed in a timely manner. Automatic notification and web-based reporting can give all parties access to the status of samples within the system.

Orchestrating the high-throughput laboratory

High-throughput screening and experimentation require not only the integrated data pipeline, but also the automation of laboratory instruments and robots. Developing a system to coordinate every aspect of a laboratory process, from instrument set-up and run-configuration to fine-grained sample tracking and reporting, is incredibly complex. However, the competitive need for high-throughput demands sophisticated automation. Embracing workflow technology has made high-throughput a reality in many organizations for whom global, fully automated, laboratory systems are essential to the future success of their businesses.

Regulatory compliance

The ever growing need for regulatory compliance is yet another concern that workflow systems can help address. Each industry must comply with external agencies such as the FDA, who need to examine adherence to operational rules. Corporate governance regulations such as the Sarbanes-Oxley Act, introduced in the US to deter accounting fraud and corruption, will force organizations to invest heavily in proving their processes are sound. The need for compliance makes workflow systems essential.

3 An explanation of business process automation

A business process is a flow of actions carried out by people or machines within an organization to complete a task. At an on-line bookstore a business process might be to process a customer order. A number of people and computers will be involved from the moment the order is placed to the time it is delivered. In a laboratory that provides chemical analysis services to the food industry, a process might be to receive a set of samples, define tests, perform assays and send a report to the customer.

A process may involve multiple people and machines all of which need to perform specific tasks at different stages. If the process is manual and even moderately complex, then although computers may be used to hold data and simplify some tasks, the lack of automation will result in time-consuming and error-prone human interventions. Business rules may be broken and the process may fail due to steps being missed or performed incorrectly.

The first step in business process automation is to carry out a thorough review of the systems already in place, and how they are actually used. This may not be a trivial exercise, and many organizations find that by using an external consultancy, such as Tessella, they are prompted to answer the difficult questions that need to be raised at this stage. Let's look at a couple of examples of human-driven processes to see how they can benefit from automation.

3.1 Example: Processing an employee's request for time off work

A bioanalytical laboratory has a business process for handling an employee's request for time off work. The process involves a number of people and some computer systems.

Figure 1 below shows that a number of actions need to be performed in sequence. There is no automation, which can lead to problems.

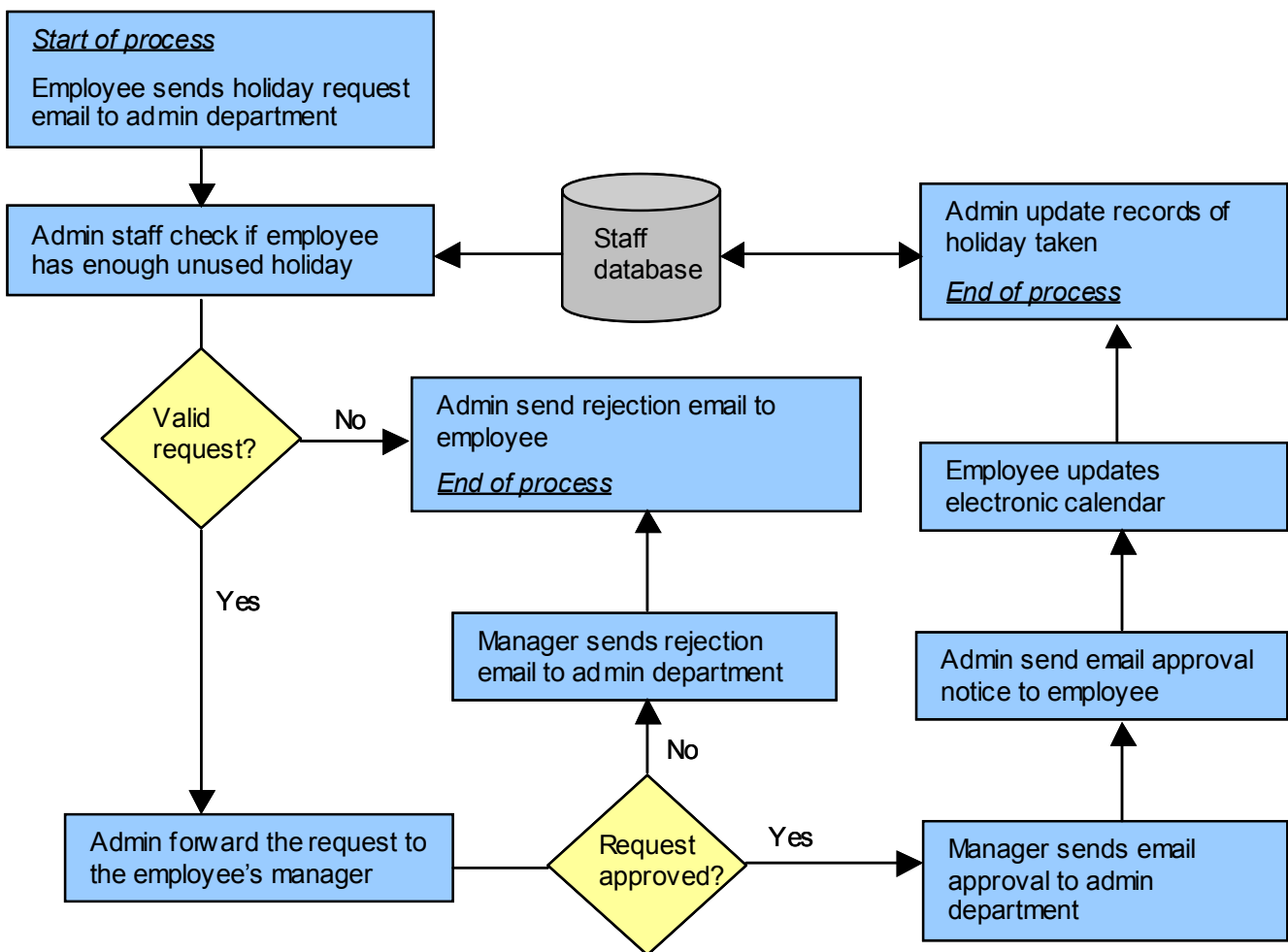


Fig 1: The holiday request process

What could go wrong with this manual process?

- A member of the admin department might lose the absence request sent by the employee. Without an acknowledgement nobody realizes the process has failed
- An administrator might forget to check that the employee has enough unused holiday remaining before forwarding the request to the manager. An approval email would be sent to the employee, and the error would only be spotted later, when an administrator tries to update the staff database
- The manager might forget to respond to the request. The process would come to a halt and the employee would not be able to tell where the request is being held up in the system
- After the request has been approved the employee might update the electronic calendar incorrectly. A colleague may then arrange a meeting for a time when the employee is not available
- At the end of the approval process the staff database might not be updated correctly. The request would appear to have been processed, and the employee would go on leave, but the database would contain no record of the absence

It's clear that although the company makes use of email and a staff database to store absence records, the lack of automation and the reliance on manual intervention means that the process can be time-consuming, and can fail in a number of ways.

Having identified that this manual process is costing time and money, the company decide to automate as much of the process as possible. The workflow outlined in Figure 2 is introduced.

The key difference is that not only are the employee's holiday records stored in the staff database, but also the holiday request and its status are also stored electronically, in a workflow database. A software system manages the process by validating the request, sending automatic emails, modifying staff records and updating the employee's calendar. The system does all of this in response to events, which trigger a response and cause the status of the request to be updated. The employee is able to track the status of the request at any time via a web-interface.

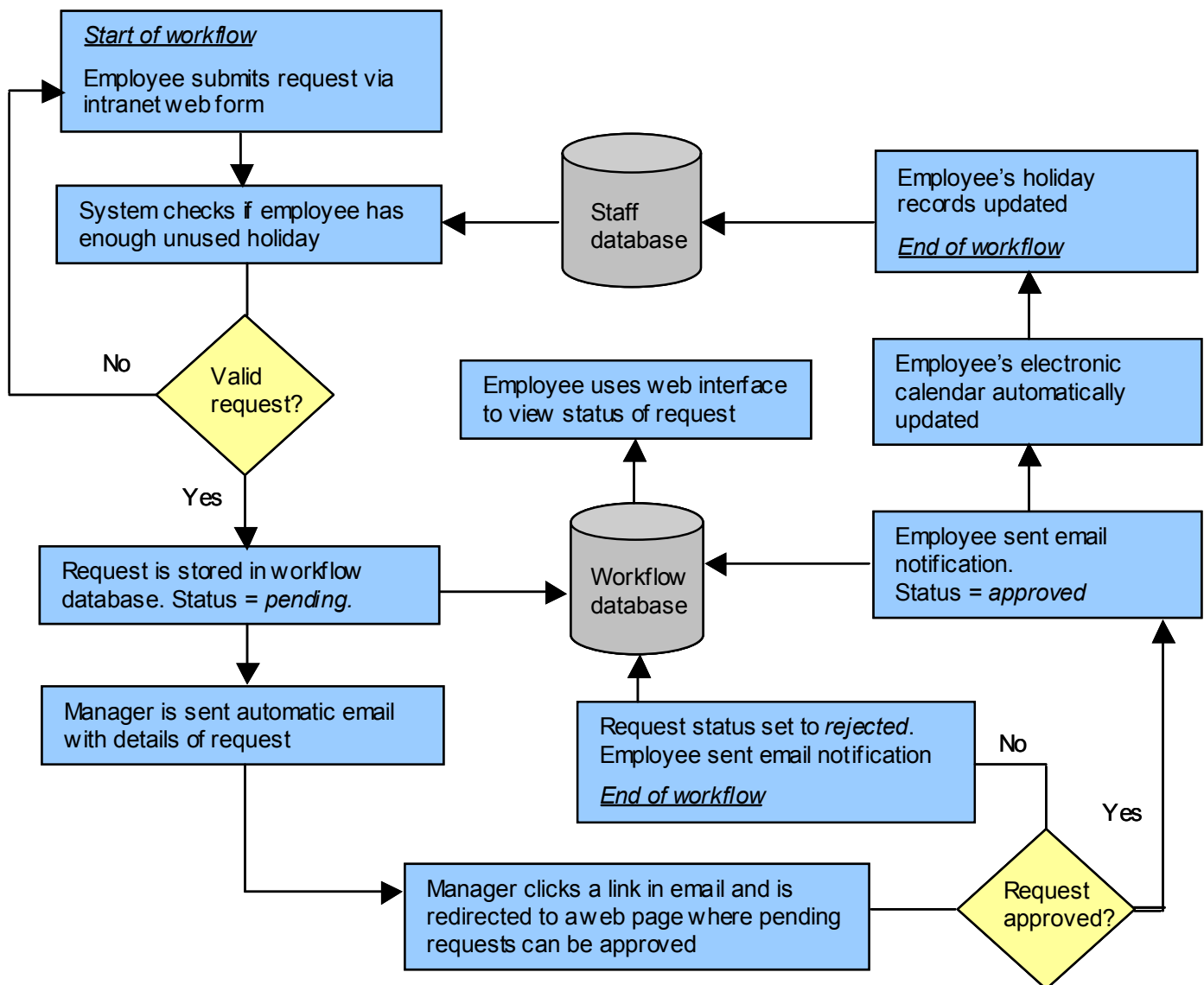


Fig 2: Automated holiday request workflow system

Automation of the process improves efficiency and greatly reduces the potential for things to go wrong. There is much less chance for human error to break the process. If the manager forgets to respond to a request, and its status does not change from 'pending' after a set period of time, then the system can detect this and send an automatic reminder.

3.2 Example: Automating a laboratory process (a LIMS)

Many analysis laboratories operate a similar process. Samples are received, and tests are defined for them. The samples are prepared and tested by an analyst. Results are recorded, and if any are out of specification the tests are repeated. Once all tests are completed successfully, a laboratory manager approves the sample and a report is sent to the customer. Figure 3 illustrates a typical process.

This is another example of a business process that can be automated, and there is an established market for Laboratory Information Management Systems (LIMS) to do exactly that. As with the previous example, a LIMS is an overarching software system that allows a process to be automated. A simple LIMS might be a set of Excel templates and macros; a more sophisticated system might include a workflow database that stores all data relating to samples, the laboratory resources and the staff working in the laboratory. The status of a sample can be tracked through *received, prepared, tested, approved, reported, stored*. A LIMS may automate data import, integrate instruments and automate email notification and reporting. A LIMS is an example of a workflow system that improves efficiency and throughput by reducing the need for potentially error-prone, manual human intervention in the business process.

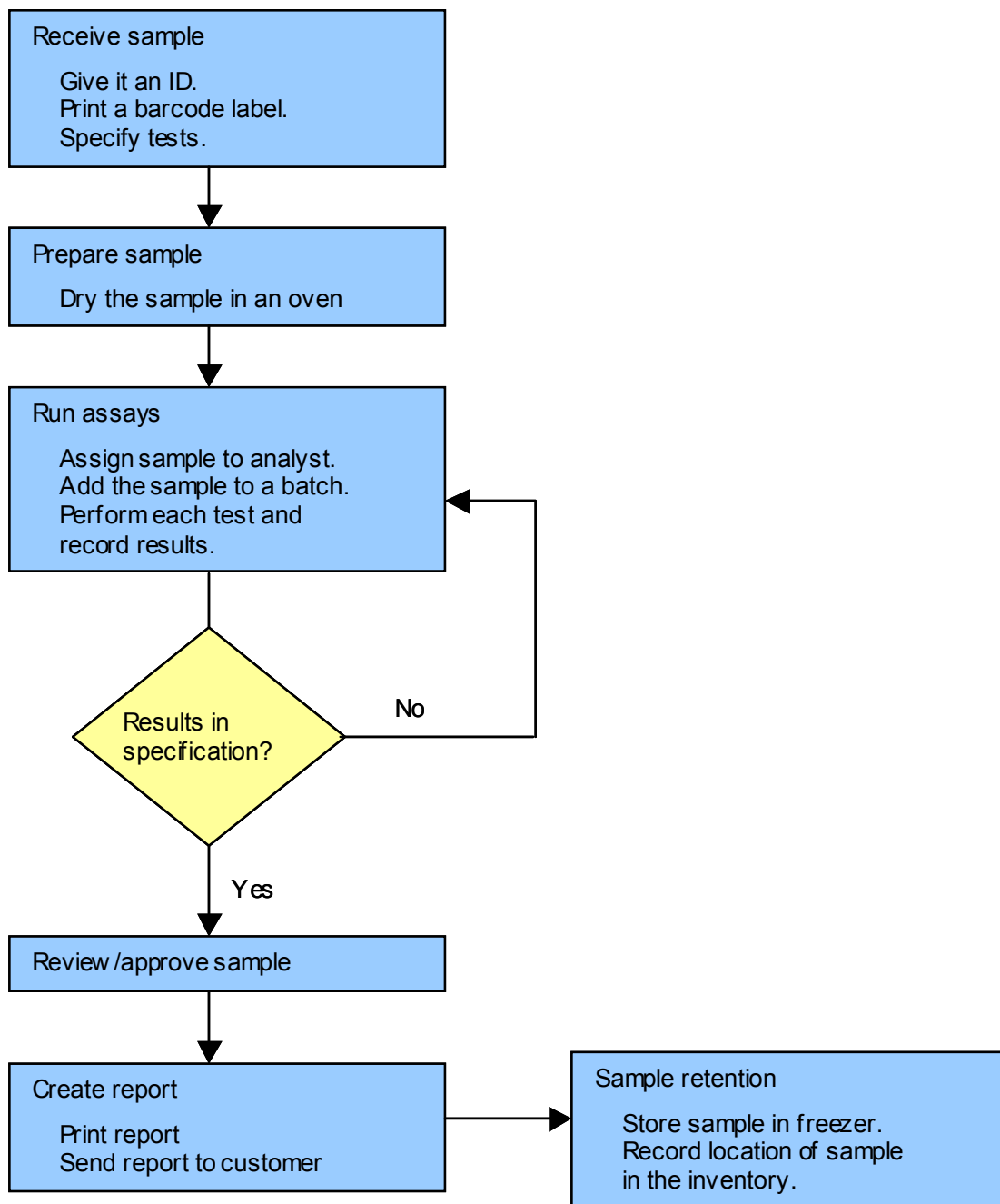


Fig 3: A typical laboratory process

4 Document-driven workflow

Document-driven workflows apply to business processes in which documents pass through various stages of review, modification, approval and publication.

At Tessella, for example, we create a set of standard documents at the start of each new software project. These include a Risk Assessment, Project Description, Project Plan, Quality Plan, etc. Some of these documents are required for every project, while others are optional. Some documents may need to be reviewed and/or approved before others can be created. The lifecycle of each document and the relationships between documents can be complex; without an automated process to manage things it would be very easy for project staff to forget to take action on key documents, according to the procedural rules defined in our quality system. Figure 4 shows part of the procedure for reviewing a Risk Assessment and Quality Plan.

Tessella has solved this problem by using Lotus Notes to manage all its project documentation, which is all stored centrally in our 'Notes Project Database'. Lotus Notes is designed to aid collaboration, and its workflow capability allows Tessella to associate a status with each new document. As a document passes from one person to another its status changes and actions are triggered automatically. The business process is defined in Tessella's Quality System, and the corresponding workflows are implemented as scripts associated with documents.

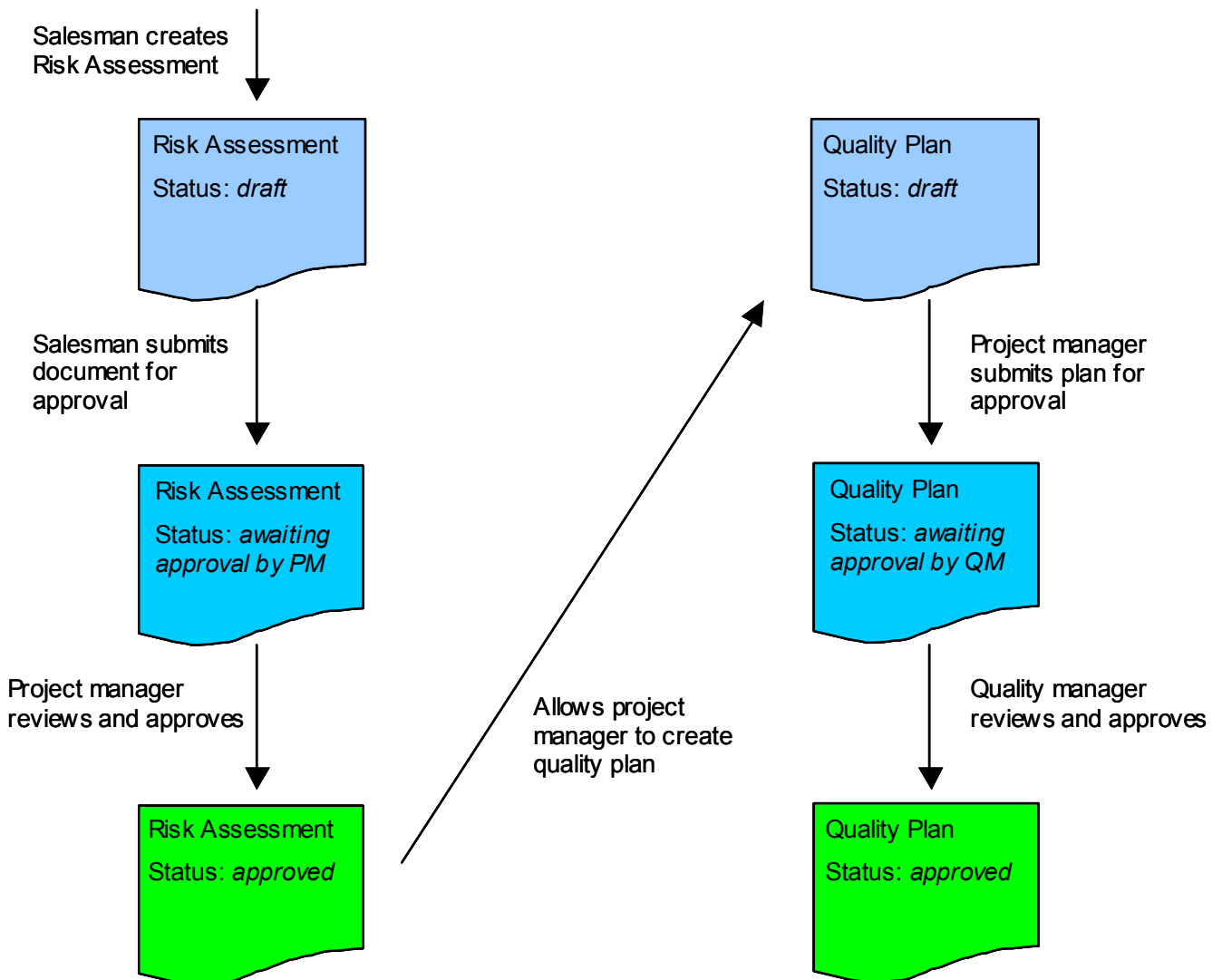


Fig 4: Project documents in a document driven workflow

Figure 4 shows a small part of Tessella’s document-driven project management process. In the early stages of the project a salesman creates a draft Risk Assessment. This is visible to the project manager, and its status is clearly indicated in the user interface as ‘awaiting approval by the project manager’. The project manager receives an automated email notification that a document needs to be reviewed. Other staff may or may not be able to access the document depending upon the security settings within the database. Once approved by the project manager, a Quality Plan document can be created. This is submitted for approval to the Quality Manager, who also receives an email notification that action is required.

In common with many of our customers, Tessella's internal workflow systems need to be tightly integrated with other IT resources, including the finance systems, payroll, timesheet systems and so on. A key question to ask when considering particular workflow technologies is 'how easily will this work with our existing systems?'

5 Workflow Technologies

The definition of workflow as the automation of a process is very general and there are very many ways to design and implement a workflow system. At the simpler end of the scale, a business process can be built into documents, such as spreadsheets, with macros. At the other end of the scale, highly complex workflows can be implemented using dedicated workflow technology such as that built into Oracle or BEA WebLogic.

Let's take a brief look at some of the technological options available.

5.1 Workflow systems based on Macros

Both Microsoft Excel and Word allow documents to have functionality embedded within them in the form of macros. Using Visual Basic for Applications (VBA) a static document can be extended to perform actions based on button clicks or values that are modified. This technique is often used in laboratories where spreadsheet templates are created to define assays and record results. Workflow systems can evolve from simple beginnings rather than being designed up front in a large analysis phase.

This is typical of how an automated system can evolve when staff who are primarily scientists, but who have developed skills in writing macros, are continually looking for ways to automate manual and error-prone tasks and reduce human intervention. What starts out as a static document for recording test results becomes an increasingly functional tool for automating the laboratory process. Some sophisticated tools can be developed in this way, but it's a hit and miss approach, and there are a number of potential problems with such an ad hoc path to automation.

- If the system grows in an informal way with no upfront analysis of the process, it can become difficult to maintain
- Version control of spreadsheet templates can become a problem
- Some macros will be better thought out than others, and changes to the central database system, or file locations will have an impact on the working of the macros
- The quality and robustness of the system will depend on the level of programming skill of the people writing the macros, and often these people are scientists with a hobbyist interest in programming

Although the ideas for automation may be sound, often the implementation can be clumsy and the system is at best fragile and at worst prone to data loss and breakdown in the automated process.

A better approach is to think through the process upfront and build a more professional system in which the full picture is considered and the coding is done in a more coordinated way. Tessella has helped a major pharmaceutical company develop a laboratory workflow system in this way. A suite of Excel templates was developed as workflow tools to automate various stages of data import, analysis and presentation. The tools are designed to be as flexible as possible, which is another benefit of a well thought out system with an upfront design.

Excel and Word macros can help automate a process, and this is a valid approach in many cases. However, for larger, more complex processes, where data integrity and security are very important and many participants are involved, there are more sophisticated, dedicated workflow packages available.

5.2 Building systems with workflow packages

5.2.1 Oracle Workflow and Oracle Workflow for Java (OW4J)

Oracle comes with a Business Process Management (BPM) tool called Oracle Workflow, and at the time of writing this is being evolved in Oracle 10g with the next generation of Java based tools in the form of Oracle Workflow for Java, or OW4J.

Oracle Workflow supports business process modelling, execution and monitoring. A graphical user interface allows an analyst to model a business process as a flowchart. When the workflow is executed tasks can be assigned, email notifications sent and application code executed. The workflow definition itself is saved to a database and can be version controlled. Defining a workflow in this way gives greater flexibility than hard-coded solutions.

Oracle Workflow for Java (OW4J) is the next generation of J2EE-based business process management solution. The user interface for defining workflows is found in JDeveloper, which is Oracle's development environment for Java developers. OW4J complements rather than replaces the Oracle workflow engine.

5.2.2 BEA WebLogic and Business Process Management

BEA WebLogic Platform is a service-oriented architecture (SOA) consisting of an application server, JVM (Java Virtual Machine), enterprise portal and application development framework. BEA's tools offer a standards-based application infrastructure that provides customers with business flexibility.

The Business Process Management functionality within the BEA WebLogic suite of applications provides a sophisticated workflow engine to help automate business processes. The term Business Process Management is used in the industry to mean something more than simply workflow; it represents a higher-level concept in which workflow is just one, important aspect. BPM is all about managing enterprise level business processes and incorporates the integration of heterogeneous systems, also known as EAI (Enterprise Application Integration).

BEA WebLogic's Integration Studio allows specialists to design, execute and monitor complex processes spanning multiple systems and people. As with Oracle Workflow, a graphical user interface is provided in which a business process can be modelled as a flowchart. Once the designer is happy with the model, a workflow template is saved to a database such as Oracle or SQL

Server. Nodes in the workflow can contain actions, which are units of work that are triggered when the node is activated. An action might be to invoke an EJB (Enterprise Java Bean) method or send an XML message to another application. The process engine manages execution of the workflow. XML is used to represent data and JMS (Java Message Service) is used for communication with other workflows and applications.

5.2.3 JBoss jBPM – open source extensible workflow management system

JBoss is an established open source company with a focus on Java based middleware. The JBoss application server is a very popular J2EE platform. JBoss jBPM is a workflow management system in which a process is defined formally in a specialist language called JBoss jBPM Process Definition Language (jPDL). jBPM is a workflow engine that sits in the middle of a system of enterprise applications allowing integration and coordination of the separate applications. Enterprise Application Integration (EAI) is a big topic in the industry at the moment, which is why JBoss, Oracle, BEA etc are all offer competing workflow based products to meet this need.

5.2.4 Web-based workflow systems and BPEL

Web Services (using SOAP, WSDL and XML) are now the standard for doing business over the web. The idea behind a web service is that organizations provide services that are available to be called programmatically over the web. Extending the concept to the next level it has been realized that often a business process may involve multiple business partners offering web services that can be hooked up to define an end-to-end business process. Web services alone do not provide the technology to do this and so BEA, IBM and Microsoft got together in 2002 to come up with a new language called BPEL (Business Process Execution Language for Web Services). BPEL is an abstract, XML based process definition language for defining an end-to-end business process flow. It supports asynchronous transactions, flow control and compensating business logic.

In order to execute a process a BPEL script is parsed by a BPEL engine. The script is a definition of the workflow and can be executed by any BPEL compliant engine. It is not platform or vendor specific.

5.2.5 Other high-level workflow engines

As well as the offerings from Oracle, BEA, JBoss etc, there are organizations that have developed their own workflow engines, which are designed as components that can be integrated into new and existing systems. Tessella has had some experience of this type of engine. Below are just four examples, but there are literally dozens of products on the market, each offering a unique set of features and with varying levels of compliance with emerging standards.

Verity Liquid BPM

The Verity Liquid BPM (formerly the Drala workflow engine from Drala Software Inc) is an embeddable Java component, which can handle hundreds of workflows simultaneously. The engine supports persistence of workflows to a relational database. Complementing the workflow engine is the Workflow Studio, a visual environment for modelling workflows. The Workflow Manager provides monitoring and management services. The BPEL Orchestrator provides tools to build and automate processes using web services based on the BPEL4WS (Business Process Execution Language for Web Services) standard.

Enhydra Shark

Enhydra Shark is an open source extendable workflow engine based on Workflow Management Coalition (WfMC) specifications using XPDL (XML Process Definition Language). It is built using Java/XML technology. XPDL is a workflow definition language similar in concept to BPEL.

OpenSymphony OSWorkflow

OpenSymphony is another open source project dedicated to J2EE enterprise components. OSWorkflow is a workflow engine, which the designers claim stands out from the crowd due to its very high flexibility. This might be of interest to someone who feels that many of the high-level workflow engines lack flexibility, but who doesn't want to go completely down the road of writing everything from scratch. The recommended approach here is to write XML process descriptors "by hand" rather than in a graphical tool (though a graphical tool has now been included).

OpenWF

OpenWF is a workflow management solution from OpenWF.com. It is developed using Microsoft technology including .NET, APS.NET, SQL Server. On offer are a workflow graphic designer, and a workflow engine. A web application interface is provided so no special client software is needed.

5.3 Workflow languages

BPEL has been mentioned above in the context of web-based business processes carried out by web services. Workflows are often defined in a high level language - a kind of script. The workflow engines themselves are usually implemented in a standard object-oriented programming language such as C# or Java.

Common workflow languages include:

- XPD L – XML Process Definition Language, a standard of the WfMC
- BPEL – Business Process Execution Language, developed by BEA, Microsoft and IBM
- BPML – Business Process Modelling Language, created by the Business Process Management Initiative (BPMI) as an XML based meta-language
- YAWL – Yet Another Workflow Language is an open source workflow language developed at Queensland University of Technology, and based on an analysis of other languages. The engine and workflow editor are freely available for download

XPD L, BPEL, BPML, YAWL etc. are not programming languages. Rather, they are XML schemas for the specification of processes that are then interpreted by a system that coordinates workflow instances based on the resulting XML document. BPMN (Business Process Modelling Notation) provides a graphical notation for such XML process descriptions, as does UML (Unified Modelling Language) in the form of activity diagrams. Workflow modelling languages provide “macro” constructs that simplify the assembly of control flow patterns such as splits and joins.

5.4 Custom-built systems for ultimate control and flexibility

Sometimes the most appropriate way to develop a workflow-based system is to create something custom-built using generic programming languages and database techniques. Tessella has worked with a number of customers to develop systems from the ground up that are tailor-made to deliver exactly what is needed. A custom-built system has no limitations imposed by someone else’s software, and the resulting system can be built to the customer’s unique requirements for performance or flexibility.

One such system that Tessella has designed and built is for T&F Informa, a major publisher of academic journals. The CATS (Central Article Tracking System) allows manuscripts to be managed and tracked in a web-based

environment. The customer has special requirements for flexibility, and the chosen solution was a custom-built system using J2EE technology with an Oracle metadata database and separate file stores. The finished system supports multiple workflows and is highly flexible in terms of schedule setup and control. T&F Informa staff are now able to access tracking information globally, across the whole company.

Another example of a custom-built system Tessella has helped develop is the National Flow Forecasting System for the UK Environment Agency. In this case the customer needed a resilient system that could operate under stress during a flood. Tessella teamed up with WL | Delft Hydraulics to build a system based around a centralized scheduling/task dispatcher component feeding multiple execution servers. The servers perform tasks, which are defined in XML. Tasks and information are distributed throughout the system using asynchronous messaging.

There are literally hundreds of products on the market for implementing workflow systems. These vary hugely in performance, ease of use, robustness, flexibility and reliability. Choosing the right workflow system can make all the difference to whether the project is a success and the final system really meets the needs for which it was built. Sometimes the best option is a custom-built system using established technology such as Microsoft .NET or J2EE.

5.5 Summary – the benefits of workflow

The Workflow Management Coalition (WfMC), a non-profit, international organization of workflow vendors, users, analysts and university/research groups, promotes the benefits of workflow as being:

- Improved efficiency by the elimination of many unnecessary steps
- Better process control through the standardizing of working methods and the availability of an audit trail
- Improved customer service through greater predictability in the levels of response to customers
- Greater flexibility of software control over processes enabling redesign when business needs change
- Improved processes, because focusing on processes leads to their streamlining and simplification.

With so many driving forces at work, it is clear that workflow systems are here to stay and will have a major role to play in the future IT strategies of scientific and engineering organizations, both large and small.

For many years Tessella has been helping clients realize the benefits of increased automation of business and laboratory processes. We have developed numerous workflow solutions, including customizations of COTS packages and the development of custom-built systems. Recently there has been a trend towards more formalized 'workflow systems'. We expect this trend to continue. The current focus of research and development is on the introduction of web services and a move towards a new paradigm of Service Oriented Architectures (SOA), in which many loosely-coupled web services are choreographed to carry out a business process, perhaps coordinated using an execution language such as BPEL.

Workflow is a huge field, and there are many old and new technologies that can be used to deliver a system and improve business process management. Tessella has a wealth of experience in many of these technologies. Please contact Tessella if you would like any advice or further information regarding what a workflow based system might do for your organization.

Useful links and References

Workflow Management Coalition (WfMC). This is a non-profit organization with over 300 member organizations. They are the main source of standards.

<http://www.wfmc.org/index.html>

Workflow Patterns. An academic web site dedicated to the study of workflow modelling patterns.

<http://tmitwww.tm.tue.nl/research/patterns/index.htm>

e-workflow – the workflow portal. A dedicated workflow website sponsored by the WfMC. This site has links to many other workflow related sites.

<http://www.e-workflow.org>

Oracle Workflow. Visit the Oracle web site and look for information on Oracle Workflow.

<http://www.oracle.com>

BEA WebLogic Integration. Visit the BEA website and look for information on WebLogic Integration.

<http://www.bea.com>

JBoss jBPM. A recent addition to the JBoss family of middleware products to add business process management.

<http://www.jbpm.org/>

Enhydra Shark. An open source workflow engine. A Java/XML based workflow engine based on WfMC standards and XPDL.

<http://shark.objectweb.org/>

OpenSymphony OSWorkflow. A low-level, open source, workflow system.

<http://www.opensymphony.com/osworkflow/>

OpenWF. A third party workflow engine and graphical design package base on Microsoft .Net technology

[.http://www.openWF.com](http://www.openWF.com)

Queensland University YAWL website. The home of YAWL (Yet Another Workflow Language).

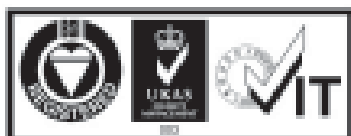
http://www.citi.qut.edu.au/members/research_areas/bpm/projects/yawl/

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