

# Workflow Management in the Internet Age

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**Abstract.** For the last many years, workflow management (WFM) has been the focus of intense activity in terms of products, standards and research work worldwide. WFM integrates concepts from many areas of computer science. Numerous workflow companies, and industrial and academic research groups are in existence now. Several conferences and workshops relating to WFM are being held regularly. The popularity of the worldwide web, extranets and electronic commerce is further increasing the desirability of standards in the workflow arena to enable interoperability. The recent emphasis on supply chain reengineering as a means of reducing costs and improving responsiveness is also a factor in this regard. In this extended abstract, which is a condensed version of a paper which appears in the proceedings of the NATO Advanced Study Institute in Workflow Management and Interoperability held in Istanbul in August 1997, I briefly summarize the recent trends in WFM products, standards and research. I address technical as well as business trends.

## 1 Introduction

While workflow management (WFM) as a concept has existed for many years, it is only in the last few years that it has become very popular in the commercial as well as research world. Several workflow companies, and industrial and academic research groups are currently in existence, especially in Europe and North America. Numerous products with varying functionalities have been released in the last few years. Efforts on standardizing workflow concepts and interfaces are in progress under the auspices of the Workflow Management Coalition (WFMC) and the Object Management Group (OMG).

Over the years, various definitions have been proposed for concepts relating to WFM. For example, Giga Group (<http://www.gigaweb.com/>) has given the following definition: “*we call the operational aspects of a business process — the sequence of tasks and who performs them, the information flow to support the tasks, and the tracking and reporting mechanisms that measure and control them — the workflow*”. It should

be noted that the aim of WFM is not to automate necessarily all the tasks of a workflow process. Some tasks (also called activities) might continue to involve humans and even for automated tasks the determination of when to initiate them and/or determining whether such automated tasks have successfully completed might be left to humans. The emphasis is much more on automating the tracking of the states of the tasks of a workflow, and allowing specification of preconditions to decide when tasks are ready to be executed (intertask dependencies) and of information flow between tasks.

One of the chief goals of WFM is to separate process logic from task or activity logic which is embedded in individual user applications. This separation allows the two to be independently modified and the same task logic to be reused in different processes, thereby promoting software reuse as in object-oriented programming, and the integration of heterogeneous applications which were developed in isolation.

The focus in the last few years on business process reengineering, especially with regard to the supply chain, by enterprises as a cost saving and service improvement measure has contributed significantly to the recent popularity of WFMSs. The emergence of the worldwide web as the means for carrying out electronic commerce is also contributing to this trend. EDI (electronic data interchange) on the internet and the emerging XML (extended markup language) standard are also going to be playing significant roles in the emergence of web-based workflows. So far WFMSs have been widely deployed in the following types of businesses/organizations: banking, accounting, manufacturing, brokerage, insurance, healthcare, government departments, telecommunications, university administration and customer service.

Traditionally, WFMSs and workflow applications have been divided into four broad categories: *production*, *administrative*, *collaborative* and *ad hoc*. While this is not a very strict categorization, it helps to distinguish the design points of different products somewhat reasonably. Over the years, vendors have tried to reposition/redesign their products to cover more of this spectrum of applications.

## **2 Market Trends and Business Considerations**

The WFM market has grown steadily in the last few years, although the rate of growth has slowed down a bit in the recent past. Depending on the definition of what constitutes workflow software, different market analysis firms come up with different numbers for the size of the market. But, there is general agreement that commercially workflow is a very significant market with a lot more potential in store.

FileNet (<http://www.filenet.com/>) is widely believed to be the current market leader, although the company has suffered losses in the recent past and has been forced to restructure its operations. In keeping with the trends in the PC arena, some of the workflow vendors have recently reduced their products' per seat prices dramatically. This is the case especially for products which operate with Microsoft's messaging product Exchange (<http://www.microsoft.com/exchange/>). The increase in the popularity of the web has also contributed to the downward trend in prices.

Unlike in the case of some other products, WFMSs involve a longer sales cycle, since their adoption requires executive approval and end user commitment. Adopting a WFMS necessitates a cultural change in the way an organization does its business. It

requires group consensus and retraining. Typically, implementing a workflow solution involves the hiring of consultants for advice. VARs (Value-Added Resellers), tool vendors and consultants stand to benefit economically from the complexities involved in implementing WFM applications.

The WFM market has been undergoing a great deal of consolidation in the last couple of years. There have been many mergers and partnerships involving companies that produce workflow and related products (document management, imaging, text search, e-mail, forms management and groupware). It is anticipated that in the next few years there will be a shakeout in the market and some of the smaller companies will disappear due to inadequate revenues and their inability to keep up with the competition. All the same, new players are still entering the market: application development tools vendor Forte recently introduced its Conductor workflow product (<http://www.forte.com/Product/conductor/index.htm>) and Oracle has included workflow functionality in its InterOffice product (<http://www.oracle.com/products/interoffice/html/features.html>).

One of the major consequences of the above partnerships/acquisitions is that several product suites, where each suite consists of many related products, have been released. This has resulted in improvements in the interoperability amongst the products within a suite. More synergy has been brought about amongst imaging, document/forms management, and workflow products.

Users have demanded better tools to help them in using WFMSs effectively. They have also asked for better synergy between related products produced by different vendors. In response, companies that have specialized in business process and data modelling have begun to work with workflow vendors to better integrate their products.

Several information sources on WFM exist on the internet. Workflow And Reengineering International Association (WARIA) is a non-profit organization whose mission is to make sense of what's happening at the intersection of business process reengineering (BPR), workflow and electronic commerce, and reach clarity through sharing experiences, product evaluations, networking between users and vendors, education and training. The WARIA web site (<http://www.waria.com/>) has a listing of BPR, groupware, and workflow vendors and consultants. The Concordium web site (<http://www.concordium.co.uk/>) also includes a list of WFMS products.

### **3 Workflow Standards**

The Workflow Management Coalition (WFMC) is the main organization that is involved in workflow management standardization efforts (<http://www.aiai.ed.ac.uk/project/wfmc/>). WFMC defined a reference model for a WFMS's architecture. This model has 5 interfaces and application program interfaces (APIs) relating to those interfaces are intended to be standardized. The interfaces/APIs are: (1) Process definition model and interchange APIs, (2) Client APIs, (3) Application invocation interface, (4) Workflow interoperability, and (5) Administration and monitoring.

As WFMC releases its specifications for the various interfaces, vendors have been releasing new versions of their products to support those standards. The latest version

(1.2) of the workflow API (interface 2, WAPI) specification was released in October 1996. In October 1996, an interoperability abstract specification (interface 4) which is designed to ensure that businesses can exchange and process work from two or more workflow engines was published. A specific binding for the requests and responses of the abstract specification was also released at the same time (WFMC-TC-1018). This binding uses internet mail for transport, and MIME (Multipurpose Internet Mail Extension) and CGI (Common Gateway Interface) for content encoding. In November 1996, an audit data specification (interface 5) was unveiled. WFMC published "Workflow Handbook 1997" in January 1997.

While users find it very convenient to define process models using graphical tools, different products provide the graphical support differently. As a result, WFMC decided that it would be too difficult to arrive at a graphical standard for process definitions. Consequently, a language based standard is being worked on for this purpose. Products like FlowMark already support such a language (FlowMark Definition Language, FDL) to allow the convenient export and import of process definitions between different workflow installations.

WFMC and OMG are trying to coordinate their activities to marry workflow and CORBA object technologies. In July 1997, OMG released a call for proposals for a workflow management facility within OMG's object management architecture (<http://wwwwdb.inf.tu-dresden.de/wf-wg/documents.html>). The plan is to define the interfaces and semantics required for manipulating and executing interoperable workflow objects and metadata. Currently, the submitters of different proposals made in response to the RFP are merging their proposals to create an OMG Workflow Facility called jFlow.

In June 1998, WFMC released a white paper which presents arguments for thinking of the internet and workflow as catalysts for radical change (<http://www.aiim.org/wfmc/pr/finalwp.pdf>). It shows how the WFMC specifications can be mapped onto the internet technologies.

As a result of an initiative taken by Netscape, Sun and HP in April 1998, the Internet Engineering Task Force (IETF) is involved in developing a standard called Simple Workflow Access Protocol (SWAP) for producing interoperable workflow products from multiple vendors (<http://search.netscape.com/newsref/pr/newsrelease597.html>).

## **4 Technical Trends**

From a technical perspective, WFM is very interesting since it brings together principles, methodologies and technologies from various areas of computer science and management science: database management, client server computing, programming languages, heterogeneous distributed computing, mobile computing, graphical user interfaces, application (new and legacy) and subsystem (e.g., CICS and MQSeries) integration, messaging, document management, simulation, and business practices and reengineering. Integrating different concepts from these areas poses many challenges. Factors like scalability, high availability, manageability, usability and security also further aggravate the demands on the designs of WFMSs.

**Functionality Evolution.** At the beginning, many of the WFMS products were designed for imaging-based applications. Of late, imaging is being made an optional component of WFMSs, thereby broadening the utility of such systems for a wider set of applications. This is also a consequence of more and more information being digitally captured via online data entry rather than such information having to be extracted from paper documents via imaging technologies like optical character recognition (OCR).

There are a number of similarities between WFMSs and transaction processing monitors (TPMs) since both manage a collection of applications with a significant number of similar requirements in terms of performance, industrial-strength features, interoperability, etc. While, for this reason, WFMSs can be thought of as the next stage in the evolution of TPMs, as a matter of fact none of the existing WFMS products that I know of came about as a result of enhancing any TPM!

**Embedded Workflow.** In the last few years, many general purpose business application packages have been developed for managing human resources, manufacturing, sales, accounting, etc. by companies like Baan, Oracle, PeopleSoft and SAP. The market for such products has grown tremendously as customer organizations try to avoid producing home-grown solutions. Developers of such packages — like SAP (<http://www.sap.com/workflow/wrkflow.htm>), Baan ([http://www.baan.com/3\\_Solutions/Concepts/work/default.htm](http://www.baan.com/3_Solutions/Concepts/work/default.htm)) and PeopleSoft (<http://www.peoplesoft.com/>) — have incorporated workflow functionality into their products.

**Web-based Workflow.** With the widespread and rapid popularity of the worldwide web, very quickly many WFMS products have been adapted to work in the context of the web. The degree of sophistication of web support varies from product to product. Some products permit workflows to be initiated or controlled from a browser. Worklist handling via the web is another form of support that is provided by a few products. In summary, it is the client side WFMS functionality that has been made available through a web browser. The advantage of web support is that no specialized WFMS-specific client software needs to be installed to invoke workflow functionality at a workflow server. In the future, more sophisticated support can be anticipated which would allow the execution of inter-enterprise workflows spanning the internet and involving multiple web/workflow servers. ActionWorks Metro 3.0 comes with over 20 ready-to-run administrative applications that support key human resources, sales/marketing and support processes.

**Distributed Workflows.** WFMS architectures have evolved from supporting mostly single workgroup type environments to providing enterprise-wide (and even inter-enterprise level) functionality. With such enhancements, a single workflow is allowed to span servers and clients across wide area networks. This provides additional scalability, availability and manageability since more servers can be involved in a single workflow and the impact of server failures can be minimized.

**Ad Hoc Workflows.** In the last couple of years, production WFMSs have been enhanced to provide support for ad hoc workflows with different levels

of flexibility. Also, new products which are specifically intended for ad hoc workflows have been introduced recently. Novell released Groupwise Workflow (<http://www.novell.com/groupwise/>) which is based on messaging. It uses as its core workflow engine FileNet's Ensemble (<http://www.filenet.com/prods/ensemble.html>). Several e-mail based WFMS products have been developed recently on top of Microsoft's Exchange messaging product.

**Process Modeling.** Business process and data modelling companies like HOLOSOFX (<http://www.holosofx.com/>) and IDS-Scheer (<http://www.ids-scheer.de/english/index.htm>) are enhancing their respective products Workflow-BPR and ARIS Toolset to generate workflow schema definitions (e.g., FlowMark Description Language versions of workflow definitions for use with FlowMark). This is analogous to, in the relational DBMS world, 4GLs being used to generate SQL programs rather than forcing users to hand code SQL.

**Groupware.** The groupware product Lotus Notes has been around for many years. Recently, the Notes server has been renamed to be Domino and the name Notes is now associated with the client. Domino provides some basic workflow functionality and permits building workflow applications with both database-based and mail-based architectures. Recent releases of Domino provide support for advanced concepts such as agents, field-level replication, integrated web access, web serving, etc. Domino has been ported to run even on the IBM mainframe operating system Posix-compliant OS/390. Other vendors have built products which provide high-level process definition capabilities on top of Domino/Notes. Some of these products are Action Technology's Action Workflow, Pavone's GroupFlow ([http://www.pavone.de/wpub\\_pav/21de.htm](http://www.pavone.de/wpub_pav/21de.htm)) and ON-Estone Information Technologies' ProZessware (<http://www.onestone.de/>). FlowMark 2.3 supports runtime clients based on Lotus Notes, thereby allowing users to take advantage of the replication and disconnected operation features of Notes. With such a client, worklist items and process definitions are made available as Notes documents.

**WFMS State Repository.** Most WFMSs' servers use a relational DBMS as the repository for keeping track of workflow process definitions, organization structure, runtime information on process and activity instances, workflow data, etc. Typically, installations are allowed to choose a DBMS from a variety of different RDBMS products. As described before, some products use Lotus Notes/Domino as the repository. FlowMark currently uses ODI's ObjectStore OODBMS as the repository but work is in progress to make DB2 available as a repository in Release 3.0. The usage characteristic of a DBMS by a WFMS is very different from the usual assumptions made about most database accesses being read-only. As a matter of fact, most accesses made by a workflow server to its repository will be in the form of update transactions. This is because most of the time the server accesses the repository to perform state transitions in the workflow process graph at the time of activity/process instance completions/initiations. Such actions have to be recorded persistently. The update transactions executed by the workflow servers tend to be of short duration. The locking granularity that the DBMS supports can have a significant impact on the number of workflow clients that can be supported. High availability features in the repository DBMS are crucial since any failure of the

DBMS would make the WFMS's operations come to a standstill since the workflow server needs access to it to do its process navigation on an activity completion.

**Transaction Concepts.** While much research has been done in the area of advanced transaction models, none of the current WFMS products supports the transaction concept in any explicit fashion. Typically, the products do not even guarantee that if an activity's execution is an ACID transaction that the execution of that activity and the recording of that activity's completion in the workflow server's repository will be done atomically. The consequence is that the activity may complete successfully but the client node where the activity executed may crash before the activity completion notification is sent to the server and then the server will continue to think that the activity is still in progress. Human intervention will be needed to resolve this situation. This scenario becomes especially difficult to handle where the activity program is a legacy application which was written without its usage in a workflow context in mind.

**Application Development.** A number of vendors have added support for Microsoft's Object Linking and Embedding (OLE) technology. This allows OLE-enabled applications to be very easily invoked by a WFMS as a consequence of starting executions of activities. Activity implementations become much easier to code since passing of data from the workflow engine to the invoked applications is automated. Support for OMG's CORBA has not been forthcoming as much as for OLE in WFMS products.

**Document Handling.** Different WFMSs provide different degrees of support for handling documents. Some WFMSs have built-in document management. Examples of such systems are Eastman Software's OPEN/workflow 3.1 and Keyfile's Keyfile. Certain WFMSs have tight coupling with external document management products. Products built on top of Lotus Notes/Domino, for example, belong to this category. Some products (like FlowMark) have a loose coupling with a document management system (e.g., ImagePlus VisualInfo (<http://www.software.ibm.com/is/image/vi21.html>)).

**Intercomponent Communication.** Some products like FlowMark currently use their own home-grown messaging mechanisms for communication between their components. In the case of FlowMark, work is in progress to replace the special purpose messaging scheme with IBM's MQSeries which provides persistent messages and transaction support across a wide variety of platforms. The next release of FlowMark will be called MQSeries Workflow. It will constitute a part of IBM's Business Integration series of products (<http://www.software.ibm.com/ts/mqseries/workflow/>). Products based on Exchange and Groupwise use the mail system for almost all their communications needs. WFMS products based on Lotus Notes/Domino use that groupware product's native support for messaging. As far as I know, CORBA is not yet supported by WFMS products for this purpose.

## 5 Research Projects

Overall, the workflow research community has not had enough impact on workflow products. There are a few exceptions, of course. Action Technology's Action Workflow originated from research done at Stanford University. InConcert's InConcert grew

out of office automation research performed at the Computer Corporation of America. Pavone's GroupFlow came out of research work carried out at the University of Paderborn in Germany. Some of the ideas from the Intelligent Control Nets project at Xerox PARC were commercialized in the now-defunct FlowPath product of Bull which was sold to Wang.

Much of the research work on workflow management has concentrated on workflow specification (e.g., intertask dependencies) and verification, transactional workflows (e.g., advanced transaction models) and extensions of ideas from active database management to workflow management. There are only a few workflow research groups which are engaged in seriously prototyping their research results using either home-grown WFMSs or commercially available WFMS products. At least some of the prototypes replicate functionality that is already widely available in one or more products.

A number of issues deserve serious attention from researchers: modeling of external events, exception handling (combining production and ad hoc workflows), interoperability, process schema inference, supporting object-oriented views of workflow definitions (e.g., inheritance), fault tolerance, benchmarks, load balancing.

## **6 Conclusions**

As I briefly outlined in this extended abstract, workflow management is a very active field with numerous products and research groups. Technically it is an exciting field since it amalgamates technologies, principles and methodologies from numerous areas of computer science. The product landscape is being transformed significantly due to the absorption of emerging technologies like the worldwide web, and due to mergers and partnerships involving numerous companies which produce complementary products. With the emergence of support for workflow management in process modeling and application development tools, WFMSs are becoming a little easier to use. There is a significant amount of hope riding on the work of the Workflow Management Coalition in order to achieve interoperability across different vendors' products and to make inter-enterprise workflows a reality. Workflow management has a very significant role to play in disparate organizations' drive to improve their efficiency and customer service.

A more comprehensive tutorial presentation on which this extended abstract is based is available at <http://www.almaden.ibm.com/u/mohan/nato97.eps>