Recent Trends in Workflow Management
Products, Standards and Research

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Abstract. In the last few years, workflow management (WFM) has been
the focus of intense activity in terms of products, standards and research
work worldwide. Work in many areas of computer science impacts workflow
management. Many workflow companies and research groups are in existence
now. Several conferences and workshops are being held regularly. In this
paper, 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 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. Many conferences and workshops are being held frequently. Some of the
trade magazines and industry conferences regularly give excellence awards in
recognition of leading/innovative products and implemented novel/important
workflow applications. 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).

Historically, workflow had its origins in office automation. Initially, manual
routing of folders with routing slips was replaced by imaging-based,
document-centric systems. Later, general-purpose, graphical workflow management
systems (WFMSs) were developed.

Over the years, various definitions have been proposed for concepts relating
to WFM. For example, Giga Group (http://www.gigaweb.com/) once
gave 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.

Giga also defined the associated management software as follows: “workflow software is designed to improve business processes by providing the technology enabler for automating these aspects of the workflow: routing work in the proper sequence, providing access to the data and documents required by the individual work performers, and tracking all aspects of the process execution”. One of the chief goals of WFM is to separate process logic from task 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, and the integration of heterogeneous and isolated applications. This is similar to the distinctions which have been made in the software engineering community between programming in the large versus programming in the small. Such modular programming concepts were popularized during the 1970s. They have been revived now in the context of object-oriented programming.

The focus in the last few years on business process reengineering by enterprises as a cost saving and service improvement measure has contributed significantly to the recent popularity of WFMSs. 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. Some of the novel applications being considered for WFMSs are: system monitoring and exception handling, and systems administration. A point to note is that WFM is not intended to deal with only business processes. Attempts are being made to embed workflow functionality in the operating system so that the OS can exploit it for allowing specification of administration policies for a variety of routine and exceptional situations. Some organizations have found the high-level process definition capabilities of WFMS products to be a useful functionality by itself. These organizations use the WFMSs as process documentation tools for the purposes of, for example, ISO9000 certification. This is a first step towards the subsequent full-blown operational exploitation of WFMSs.

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. A market research report, dated August 1997, from the workflow industry watcher Delphi Group (http://www.delphigroup.com/) estimated that the overall workflow market for the calendar year 1996, including software and vendor services, rose 14.3% to US$933 million (from US$816 million in 1995). Delphi has projected that the market will grow 12.4% to US$1.05 billion in 1997. The Delphi report did not include revenues from groupware products like Lotus Notes/Domino (http://www.lotus.com/). 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. According to Delphi, Staffware (http://www.staffware.com/) had the greatest revenue growth in 1996 (134% to $18 million). 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/). After the purchase of Lotus by IBM, the price for a Lotus Notes client was also reduced. 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 WFMS applications. Considering the difficulties that users face in customizing a general-purpose WFMS product for specific applications, InConcert (http://www.inconcertsw.com/) has recently decided to concentrate on producing vertical market-specific (e.g., engineering, manufacturing and telecommunications) products.

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). Some of the significant events were: purchase of Lotus (developer of the groupware product Notes/Domino) by IBM (producer of the workflow product FlowMark and imaging/document management product ImagePlus

Some of the planned mergers did not come to fruition - e.g., the one involving Staffware and CSE Systems, and another one relating to ViewStar and Caere. 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/Products/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. Example suites are FileNet’s Discovery Suite (http://www.filenet.com/prods/edm/suite.html), IBM’s EDMSuite (http://www.software.ibm.com/data/edmsuite/) and Open Text’s LiveLink Intranet.

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.

In addition to Delphi and Giga Group, a number of other market research firms also track the workflow area. They are Creative Networks (http://www.cnlive.com/), Dataquest (http://www.dataquest.com/), Gartner (http://www.gartner.com/), International Data Corporation (http://www.idc.com/), Meta Group (http://www.metagroup.com/), Patricia Seybold Group (http://www.psgroup.com/) and Sodan (http://www.sodan.co.uk/). Sodan publishes a newsletter called Workflow World ten times each year.

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/). It was formed in 1993 and it currently has about 200 members (vendors, users, analysts, systems integrators, universities, ...). WFMC defined a reference model for a WFMS’s architecture. Version 1.1 of the document (WFMC-TC-1003) describing the model was published in November 1994. 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 (http://www.aiai.ed.ac.uk/project/wfmc/validation.html). The workflow API (interface 2, WAPI) specification (WFMC-TC-1009) was initially released in November 1995 and the latest version (1.2) 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 (WFMC-TC-1012). 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-TC-1015).


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://www.omg.org/library/schedule/CF_RFP9.htm). The plan is to define the interfaces and semantics required for manipulating and executing interoperable workflow objects and metadata.

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. Vendors' generic application packages can be tailored to take into account the special needs of a particular enterprise. Developers
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of such packages - like SAP (http://www.sap.com/workflow/wrkflow.htm) and PeopleSoft (http://www.peoplesoft.com/) - have incorporated workflow functionality into their products. This allows different functionalitites of those products to be conveniently invoked in a well-defined order to implement some specific application requirements. Baan V, to be released in 1Q 1998, will also include workflow functionality (http://www.baan.com/3Solutions/Concepts/work/default.htm).

**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. Some of the products with basic web support are: Action Technology's ActionWorks Metro 3.0, JetForm's InTempo (http://www.jetform.com/p&s/intempo.html), Mosaix's ViewStar Process@Work (http://www2.mosaix.com/ProcessAutomation/DataSheets/DataSheet6.html), CSE Systems' CSE/WorkFlow NoLimits, Open Text's Livelink Intranet, SAP Business Workflow 3.1, Staffware's Staffware Global (http://www.staffware.com/aboutsta/97view.htm), and Ultimus's Ultimis CyberFlow (http://www.ultimus1.com/). Process@Work requires the web server Microsoft Internet Information Server 2.0. Staffware Global includes a new client written in Java which can be invoked via a web browser by a user to receive, track and process work. Netscape is bundling Open Text's Livelink Intranet with its SuiteSpot server software family, thereby making available Livelink's workflow functionality via Netscape Communicator client software. 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. Eastman Software's OPEN/workflow 3.1 (http://www.eastmansoftware.com/) and IBM's FlowMark 2.3 (http://www.software.ibm.com/ad/flowmark/) provide support for
distributed workflows involving multiple servers. The former product also allows work queues to be replicated for improved availability.

Ad Hoc Workflows. Production WFMSs are being 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. Products in this category include Staffware for Microsoft Exchange, Keyfile’s Keyflow 2.0 (http://www.keyfile.com/), JetForm’s FormFlow (http://www.jetform.com/p&s/formflow.html), Reach Software’s WorkMan 2.1 (http://www.worksoft.com/) and Ultimus. Some systems like InConcert 3.6 (http://www.inconcertsw.com/prodinfo/welcome.htm) and TeamWARE Flow (http://www.teamware.us.com/) allow executing workflow instances to be dynamically modified. This functionality permits a workflow process to be instantiated without the entire process being completely defined at first and the process design to be inferred by tracking the dynamic modifications that are performed. Once the process is completely defined based on the observance of how the former evolved, the template so generated can be used for instantiating future process instances of that kind.

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. HOLOSOFX's Workflow-BPR and FileNet’s Visual WorkFlo (http://www.filenet.com/prods/vwtext.html) have been integrated so that the former’s output (e.g., process definitions) can be fed into the latter. Also, feedback information from the latter can be fed to the former to refine assumptions made during process analysis. IBM’s Business Process Modeler (http://www.software.ibm.com/ad/promodel/) can also produce input for FlowMark in the form of FDL schema definitions. Users have been demanding tools for enterprise modelling, analysis and simulation of workflows. InConcert has been integrated with CACI Product Company’s SIMPROCESS (http://www.cacisl.com/simprocess.html). Adaptive Information Systems’ Work Modeler (http://www.ais-hitachi.com/) supports simulation of workflows. It is part of the company’s AdaptFile/VisiFLOW software suite. ViewStar’s Process Architect visual workflow builder provides an animated simulation feature to perform “what if” analyses of throughput and to help identify bottlenecks. FlowMark provides an animation tool to step through the exe
execution of a process (even partially specified) for the purpose of debugging the process’s definition.

**Metamodel.** The features of the metamodel supported by the different WFMS products are similar to the ones found in parallel programming languages. Some of them are: block structuring, iteration, recursion, conditional and unconditional branching, and parallel branches. Some systems like FlowMark distinguish the types of connections between activities: data and control. Data flow may be modeled with input and output data containers being associated with activities or via the descriptions of documents that flow through activities. Conditions may be associated with the control flow connections to decide under what conditions control will flow through those connections.

**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) and ONEstone 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.

**OO Architecture.** Some of the WFMSs (e.g., FlowMark) are built using an object-oriented language like C++. Not all such systems expose the object-oriented architecture of the system for users to tailor the system’s functionality. InConcert is an exception in this regard. Objects representing workflow processes and tasks are manifested externally via APIs. Such API functions appear to applications as object classes which are tailorable.

**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.

**Worklist Handling.** When an activity becomes ready to execute, the manner in which information about the ready activity is propagated to the worklists of the users capable of executing that activity differs from system to system. In some systems if such a user is currently logged on his/her worklist is updated immediately and asynchronously at the user’s client machine to include the new activity. In other systems, the update happens only when the user explicitly requests a refresh of the worklist. Yet another approach is to give each user the option of specifying whether the refresh should be performed immediately or on demand. Each approach has its tradeoffs with respect to scalability, performance, ease of use, responsiveness, etc. Once a user finishes executing an activity, how the next activity to be performed by the user is chosen also varies from system to system. In push systems, the user is given the specific next activity to perform. That is, the user is not given a choice and the system decides on work scheduling. Typically, this approach is adopted in production (clerical worker) environments. In pull systems, the user looks at the worklist which contains a list of ready activities and chooses which one to process next. That is, the user does self scheduling. Typically, this approach is adopted in knowledge worker environments.
**Telephony Integration.** ViewStar 5.0 integrates workflow management with telephony, thereby allowing companies to manage phone calls and the actions they trigger as part of a coherent business process. The intent is to integrate front-office (customer care, help desk, ...) and back-office (underwriting, inventory control, loan applications, billing, accounts payable and receivable, ...) processing.

**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/vis21.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 (http://www.hursley.ibm.com/mqseries/) which provides persistent messages and transaction support across a wide variety of platforms. As mentioned before, 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, ...

In the following, I describe very briefly some of the systems-oriented workflow projects.

Exotica (http://www.almaden.ibm.com/cs/exotica/) was a research project that was in existence for a few years (until early 1997) at the IBM Almaden Research Center in San Jose, USA. That project explored issues like scalability, availability, distributed workflows via transactional messaging, disconnected workflow client operations, mapping advanced transaction models on top of WFMSs, alternate workflow repositories, OLE support, and ad hoc workflows. This work was done in the context of IBM's workflow product FlowMark, groupware product Lotus Notes and messaging product MQSeries. Prototyping work was done to support disconnected/mobile clients in FlowMark. A number of papers were written which describe possible enhancements to FlowMark to address the previously mentioned issues.

MENTOR (http://www.dbs.cs.uni-sb.de/) was a joint research project of the Union Bank of Switzerland and the University of Saarland at Saarbrucken, Germany. This project concentrated on the specification, verification and distributed execution of workflows based on state and activity charts.

METEOR (http://lsdis.cs.uga.edu/workflow/) is a research project at the University of Georgia at Athens, USA. Their ORBWork prototype exploits CORBA for intercomponent communications. It is a fully distributed implementation of the workflow server functionality. It is realized using Iona Technologies’ Orbix object request broker and associated products. Some of the METEOR work was done in the context of healthcare applications.

METUFlow (http://www.srdc.metu.edu.tr/metuflow/) is a research project at the Middle East Technical University in Ankara, Turkey. The METUFlow prototype also uses CORBA as its communication infrastructure, thereby resulting in a totally distributed implementation of the workflow server functionality.
MOBILE (http://www6.informatik.uni-erlangen.de/) is a research project at the University of Erlangen, Germany. The project advocates the idea of building a WFMS in a modular fashion so that the resulting system is easy to extend.

OpenPM (http://www.hp.com/hpj/oct96/oc96a8.htm) is a research project at Hewlett-Packard Laboratories in Palo Alto, USA. The OpenPM prototype formed the basis for the HP product AdminFlow (http://www.hp.com/csopress/97apr7b.html). OpenPM uses CORBA-based communications infrastructure and supports OpenView-based systems management environment. It also allows specification of compensation scopes and actions.

Panta Rhei (http://wwwifi.uni-klu.ac.at/~herb/workflow.html) is a research project at the University of Klagenfurt, Austria. Their prototype explores support for the internet and advanced transaction concepts. Its architecture is based on web technologies. It is implemented in Java.

WASA is a research project at the University of Muenster, Germany (http://wwwmath.uni-muenster.de/~dbis/Weske/Common/wasa.html). It concentrates on scientific applications such as geoprocessing, molecular biology or laboratory environments where the requirement to dynamically modify running workflows is considered to be higher than in more traditional workflow applications. A prototype has been implemented in Java with Oracle being used as the repository.

WIDE (http://dis.sema.es/projects/WIDE/) is an European Esprit project involving Politechnic of Milan (Italy), Sema Group (Spain), ING Bank, Manresa Hospital and University of Twente (Holland). The goal of the project is to extend distributed and active database technologies to the workflow arena. The results of WIDE will be implemented in Sema’s WFMS product FORO.

6. Conclusions

As I briefly outlined in this short paper, 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 paper is based is available at http://www.almaden.ibm.com/u/mohan/nato97.eps