Workflow Management* Introduction

Workflows and Web Services
Kapitel 6

* Production Workflow – Concepts and Techniques
Frank Leymann & Dieter Roller, Prentice Hall, 2000

Why Care About Workflow Technology?

- Companies use computers to support their business,
  - most frequently
- The way to do business is prescribed via a business process,
  - very often
- Applications support business processes and have to ensure compliance with business processes
  => Application = Business Process + Business Functions
- Changes in how to perform business must be reflected as soon as possible in applications
- A workflow is a business process in execution (an instance of a process model) in a computing environment
  - Not all parts of a process are run in a computing environment - some processes are not run on a computer at all!
  - Often, "workflow" and "process" is identified

"The Business You Are In Determines What Your Business Processes Are"

- Manufacturing
  - Assembly lines of cars, PCs, cloths,...
- Insurance
  - Handling of claims, policies,...
- Finance
  - Stock brokering, settlement, clearing,...
- Banking
  - Loans, savings, current accounts,...
- Database administration
  - Backup & recovery, reorganization, tuning,...
- Software development
  - Waterfall model, spiral model,...
- Telecommunications, administration, government, data warehousing...

There is nothing like a "typical business process"!!!

People Workflow Evolution: 1st Generation

- Electronic document and folder routing (late 80s)
  - Document = image, folder,...
  - Routing through enterprise's organizational structure
  - User associated electronic basket is key
    - Container for documents a certain user has to work on to contribute to a case
  - Potential flow of documents prescribed in advance
    - Routing conditions in terms of document content or document properties
    - Actual routing based on actual content or properties of subject document
- In "paper factories" (administration, insurance, banking,...) work mainly equates to processing documents, thus the term **workflow** has been used for routing documents between people

People Workflow Evolution: 2nd Generation

- Functions performed by users in 1st generation WFMS are mainly retrieval, browsing, editing, archiving,...
- But cases represented by documents were recognized to be only part of larger business processes
  - Not only performance of document management functions required but also usage of other functions provided by application systems supporting the operation of an enterprise
- WFMS extensions needed to invoke any kind of executable
- In-/Out-Basket grew towards worklists
  - Launch-pad for executables
  - Workitem management
    - Prioritization, duration management, life-cycle,...

People Workflow Evolution: 2nd Generation (cont.)

- Launching executables requires parameter passing
- Thus, data flow features complemented available control flows
- In turn, control flows can now be expressed in terms of these new parameters ("business rules")
- Data flow is used for integrating applications with long temporal delays between their initiations
  - Parameters managed by data flow must be persistent
  - Data flow must be allowed to be different from control flow
    - Data produced by application A might be used by application B to be started after a couple of intermediate applications run

People Workflow Evolution: 2nd Generation (cont.)

- Being able to support large spectrum of business processes in computing environments made WFMS of strong interest for Business Process Reengineering (BPR) projects - early 90s
- Goal of BPR is to speedup business processes and reduce their costs. Resulting requirements:
  - Parallelism in workflows (-> speedup)
  - Deadline processing (-> speedup)
  - Monitor actual workflow status (-> speedup)
  - Auditing of significant events, i.e. processing history (-> cost reduction)
  - Maintain execution history for analysis (-> cost reduction)
  - Process activities without human intervention (-> speedup + cost reduction)
    - So-called automatic activities
    - Consequence: (parts of) business processes can be automated ("macro-scripts")

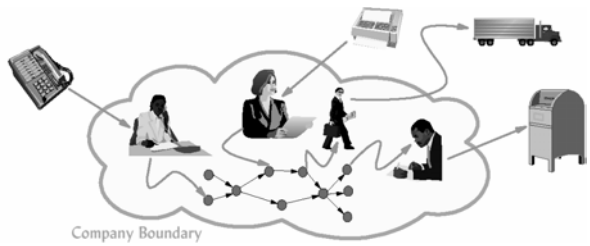
People Workflow Evolution: 3rd Generation

- Workflow-based applications become state-of-the-art (mid 90s)
  - Strict separation of business process logic and business functions
    - Business processes implemented via workflow system
    - Business functions implemented "traditionally" (TP-monitor, ORB,...)
- Enterprises become dependent on WFMS
  - Similar to TP-Monitors and DBMS before
  - The term **production workflow** has been coined to indicate that WFMS is driving operational aspects of an enterprise
- Consequences:
  - WFMS had to provide quality of services known before from "production systems" like DBMS and TPM
    - High/continuous availability
    - Scalability
    - Robustness

People Workflow Evolution: Latest Moves

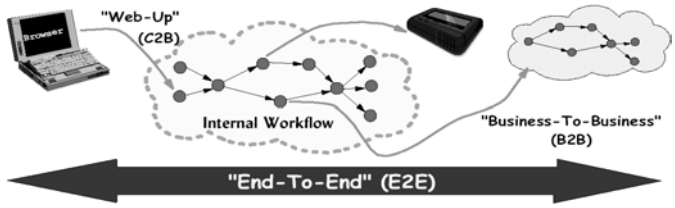
- Application integration becomes important
  - Integrate diversity of application functions
    - legacy applications, newly written applications (e.g. component based),...
    - new invocation paradigms (e.g. message queuing, pubsub)
    - workflows as granules to be integrated
- Organizational integration becomes more and more important
  - Workflows expand across business units of enterprise ("intra-enterprise")
  - Workflows across enterprises become necessary ("inter-enterprise")
    - Creation and enactment of workflows in virtual enterprises
    - Stimulated by mergers and acquisitions, outsourcing, supply chains,...
  - Interoperability of WFMS (building blocks) and web access required
- Workflows understood as business oriented "logical units of work"
  - Advanced transaction management functions required
  - Forward recovery of workflows as well as workflow-based applications
  - Backward recovery (spheres of atomicity and compensation)

Workflows Hidden From The Outside



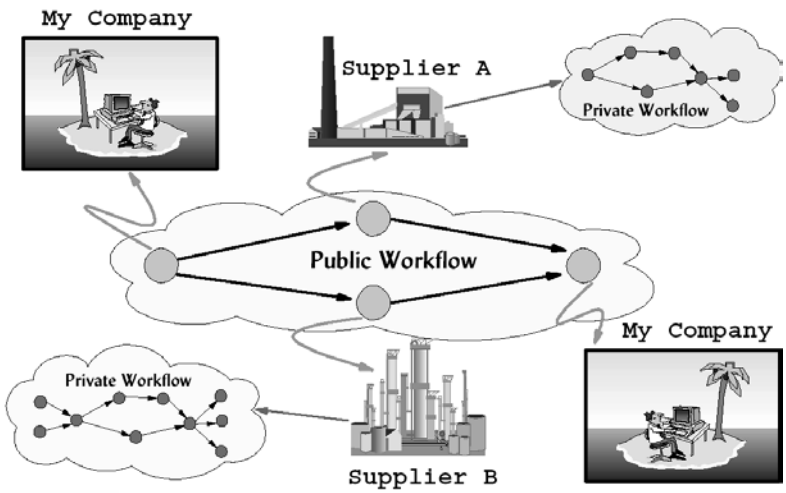
- Company's personnel "translate" requests/responses with the outside into actions performed within workflows
- Inquiries about status usually via phone calls
  - Call center agents receive requested information
  - Limited service to customers & suppliers (e.g. restricted service hours,...)

Workflows And External Communications

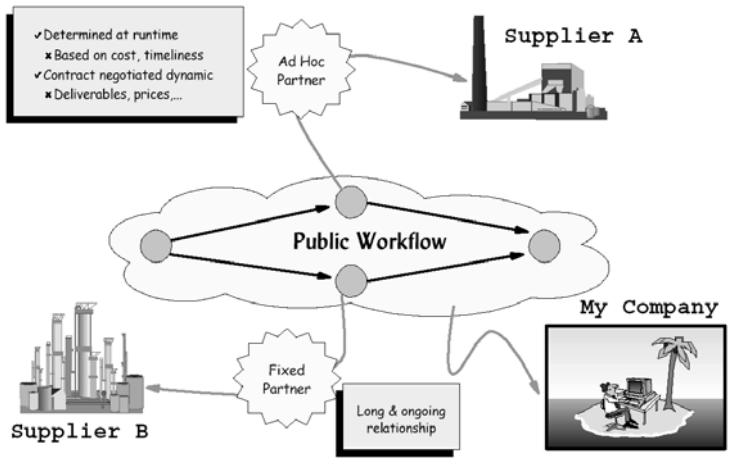


- Customers invoke company's applications to perform certain steps of the business process
  - E.g. place on order, inquire status,...
  - Company's applications must get a browser-based front-end for that purpose ("web-up")
- Workflow activities may directly communicate with the outside
  - Send e-mail, faxes, messages,...
- Workflow activities may trigger actions in another company
  - Simple invokation of program or start of another workflow ("subprocess" from invokers point-of-view)
  - Such "business-to-business" scenarios are the base for realizing sophisticated "supply chains"

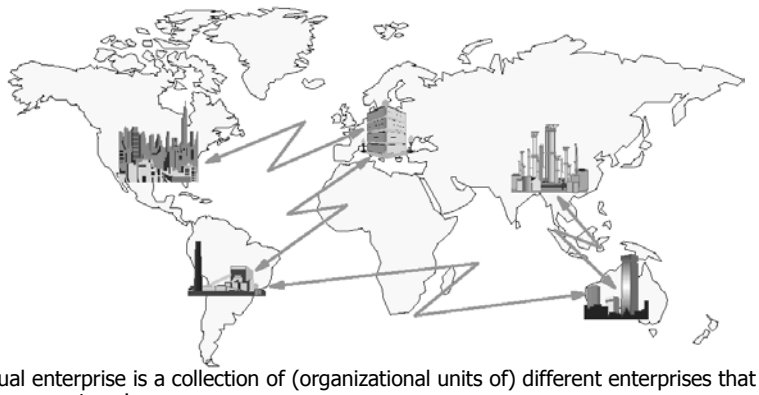
Outsourcing Processes



Finding Trading Partners

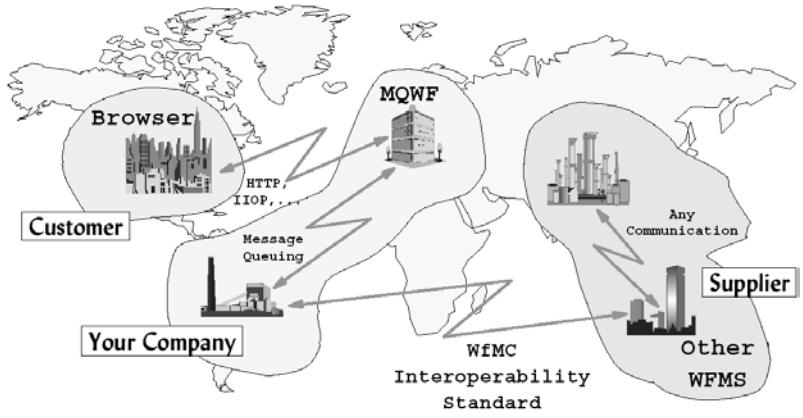


Virtual Enterprise



- Virtual enterprise is a collection of (organizational units of) different enterprises that act as a new enterprise
- Each enterprise contributes to the virtual enterprise
  - E.g. split of order processing & billing, manufacturing, distribution, marketing,...

Virtual Enterprise: Scenario



Transactional Workflow Evolution

- Success of TP Monitors and concept of (classical) transactions have been overwhelming
- Hidden assumption behind classical transactions:
  - Short duration (fractions of a second to a few seconds)
- Technical underpinnings based on this assumption
  - 2-phase-locking, log based recovery,...
- Early 80s started to extend transaction technology towards longer durations
  - Technical underpinnings have to be adapted
- Most famous "transaction models"
  - Nested transactions (closed & open)
  - Sagas
  - Multilevel transactions

Transactional Workflow Evolution: Nested Transactions

- Structure transaction into a tree of subtransactions
- Allow intra-transaction parallelism to speedup processing: siblings may run concurrently
- Overall nested transaction has ACID properties
- Durability of subtransactions is given up (ACI remain)
- Overall nested transaction isolated from other nested transactions ("closed")
- Result
  - Possible speedup of a single closed nested transaction
  - Moderate throughput increase of environment

Closed Nested Transactions

Definition:

A nested transaction is a collection of transactions with the following properties:

1. The collection has a tree structure.
2. Each transaction can commit or abort.
3. The root transaction has the ACID properties.
4. The commit of a transaction will only become effective if its predecessor transaction commits.
   Thus, all transactions can finally commit only if the root commits
5. If a transaction aborts, all transactions of its subtree are aborted too.
   If the root aborts all other transactions abort, too (i.e. subtransactions not durable at time of their commit)
6. Modifications on resources of a transaction become visible to its immediate predecessor transaction ("parent") if and only if the transaction commits.
   Each subtransaction is atomic from its parent point of view
7. Modifications on resources of a transaction are only visible to itself and to its immediate successor transactions ("children").
   Each transaction is isolated from its parent transaction and from its parent's siblings

Open Nested Transactions

- Open nested transactions give up isolation and to a certain degree atomicity
- Subtransactions commit their changes to the outside as soon as they commit
- Consequence:
  Recovery via restoring before-images does not work any more
- Already performed subtransactions of an aborting root must be undone by running application specific logic ("**compensation action**")

Transactional Workflow Evolution: Sagas

- Open nested transactions assumed that compensation actions are scheduled manually
- Sagas require to specify compensation actions in advance and run them automatically on abort

Definition:

A Saga is a sequence [(T1,C1),..., (Tn,Cn)] having the following properties:

1. T1,...,Tn and C1,...,Cn are two sets of transactions, such that Ci is the compensation function for Ti,
2. [(T1,C1),..., (Tn,Cn)] is executed as one of the following sequences:
   i. [T1,...,Tn], if all Ti committed, or
   ii. [T1,...,Ti, Ci-1,..., C1] if Ti aborts and T1,...,Ti-1 committed before.

Transactional Workflow Evolution: Structures

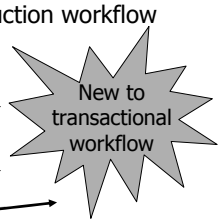
- Structures of transactions have been extended from sequences and trees to directed acyclic graphs
  - Dependencies between transactions are described (e.g. "flexible transactions")
- Backward recovery based on ACID semantics as well as compensation has been folded in
  - E.g. "ConTracts"
- Late 80s, early 90s:
  The term "transactional workflow" has been coined for prescribing control flow dependencies between transactions and their joint backward recovery

Transactional Features of Production Workflows: Merging People Workflow & Transactional Workflow

- Production workflow have the following characteristics:
  - Many executables invoked
    - are classical transactions
    - run automatic (i.e. launched as soon as detected to be performed
    - run unattended (i.e. no interactions with human beings)
- Thus, today's workflow systems impose directed graph structures on set of transactions as discussed for "transactional workflows"
- It is only natural that users now require "transactional workflow features" within production workflow systems

Transactional Features of Production WF (cont.)

- Production workflows invoke a lot of non-transactional programs too (i.e. programs that cannot be simply undone)
- Thus, supporting compensation based recovery in production workflow systems is only natural
- Especially, a "unit of work" must allow to include
  - transactional as well as non-transactional programs
  - long running programs
  - programs that demand human interactions
- Ability to involve people in recovery:
  - In exceptional situations people can be notified as part of recovery processing
  - Human beings might "repair" the exceptional situation allowing to continue processing



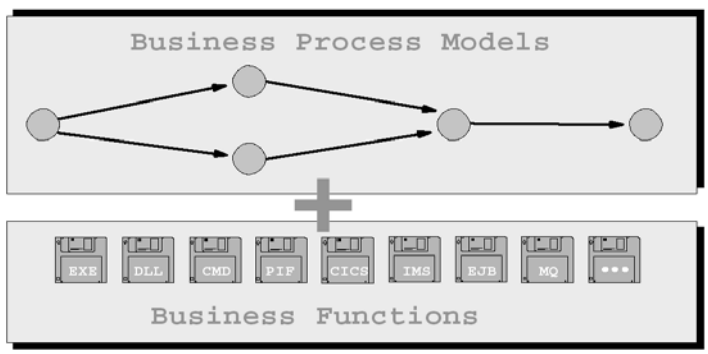
Transactional Features of Production WF (cont.)

- Today's workflow systems maintain complex states for whole workflow as well as for each single step in underlying database
  - Result: Each workflow itself is forward recoverable
- Few workflow systems can include user provided transactions in their own internal transaction processing
  - Result: Complete workflow-based application is forward recoverable
    - More precise: All parts involving transactional steps are forward recoverable
- Today's workflow systems manage long running units of work
  - Spectrum reaches from seconds to hours, days,..., even years!
  - Consequence: Unit of work must be interruptable at "any" point in time
    - Not only between execution steps but execution steps themselves (the latter involves exit conditions and persistent context for activities)

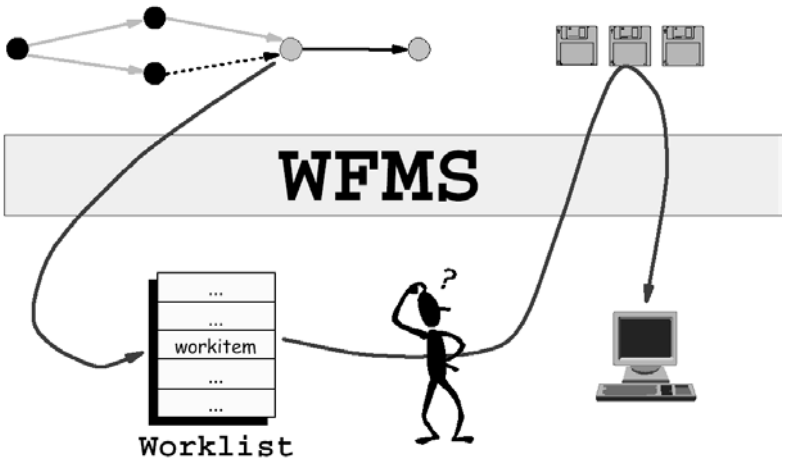
Workflow-Based Applications: Evolution

- Typically, large applications use special "control programs" to ensure the appropriate/correct sequencing of business functions
- Control programs often represent business processes
  - Requires code changes [which part to change?...], recompilation, redistribution of code,... to reflect new business processes
    - What if users of standard applications want to reflect their own processes? Very difficult, cumbersome, expensive (service specialists, consultancy),... thus an obstruction to buy standard software
- Consequence: Implementation of control programs via workflows
  - Application consists of collection of business processes and collection of business functions (= "usual" programs)
  - Business processes are enacted by workflow system that invoke business functions "appropriately", i.e. according to process model
- No coding,... to adapt application to changed business process

Workflow-Based Applications: Structure



Workflow-Based Applications: Execution



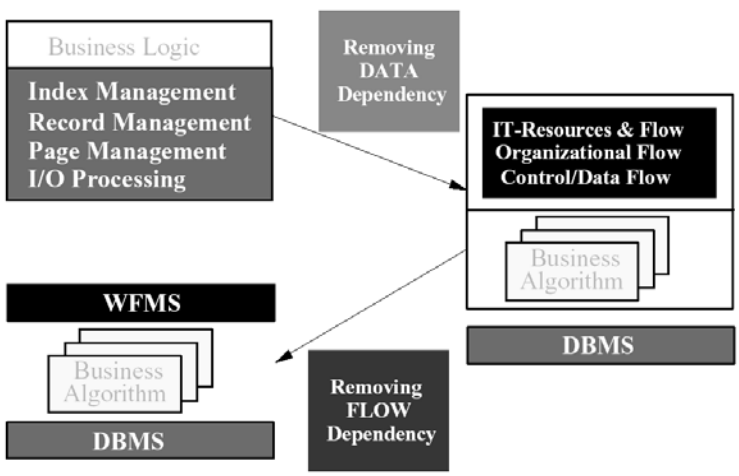
WF-Based Apps: The Role Of Business Processes

- Very important to understand: **Product = Process** from an internal company point of view in many industries
  - E.g. finance (settlement, credit,...), insurance (policy, claim,...),...
- Consequence: Time to create/modify business processes equates time to market for new/modified products
- Thus: Competitiveness of company depends on this time
- Business process represents rules of procedure
  - Often optimized wrt time & costs
- Thus: Process participants must precisely follow specifications
- Workflow-based application
  - flexibility: Creation and modification of business functions independent from specification of business processes
  - enforcement: Workitems scheduled exactly as defined by process model

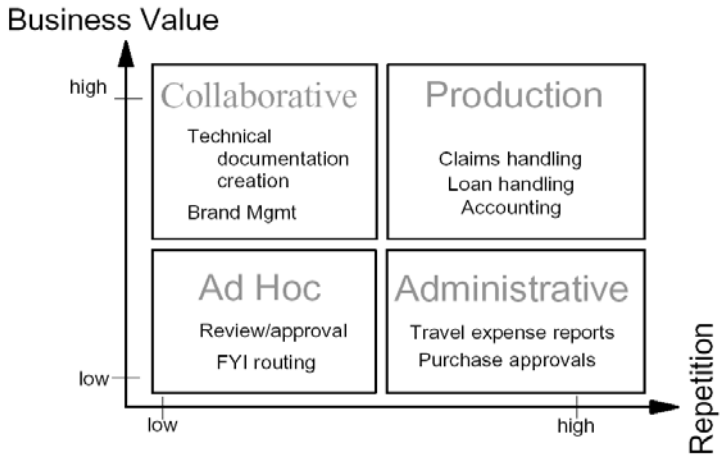
WF-Based Apps: Industry Acceptance

- Large companies adopted this paradigm in the early 90s
  - Built their own workflow systems at that time
    - No real production workflow system was available
  - Benefits: Time to market for new/modified products
- Standard application vendors adopted this paradigm mid 90s
  - Most vendors built their own workflow system because no system dominated the market
  - Benefits: Customization and internationalization
- Standardization started mid 90s
  - Workflow Management Coalition (WfMC) since 95
    - The standard consortium for workflow standards since 99
  - OMG's Workflow Management Facility = Objectification of WfMC
- Vendors roll out production workflow systems 2nd half of 90s
  - IBM MQSeries Workflow, Oracle Workflow, HP ChangEngine, SAP Business Workflow...

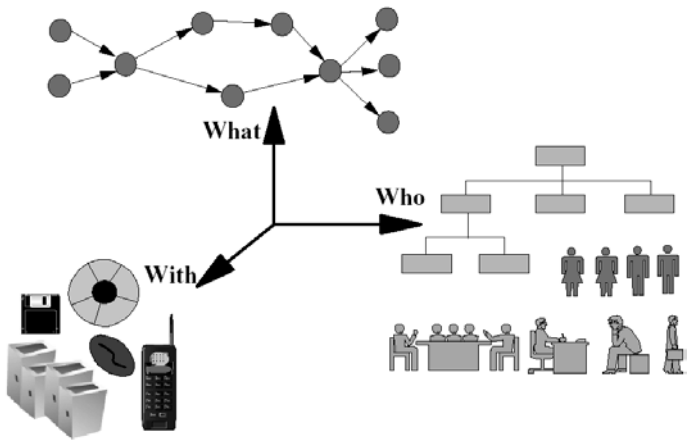
Flow Dependency Removal



Workflow Classification



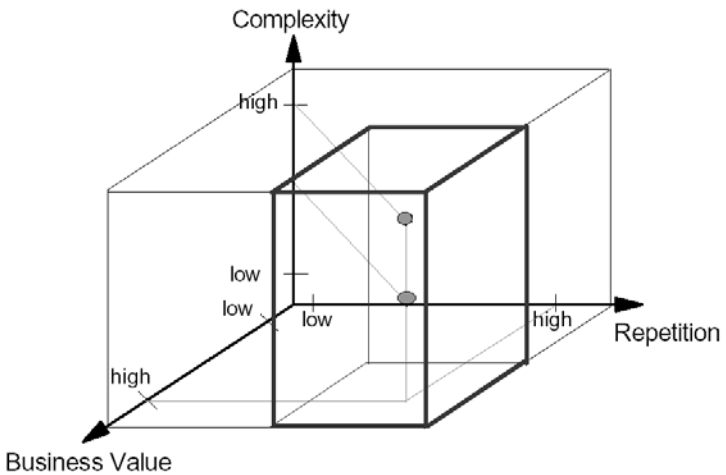
The Three Dimensions Of Workflow



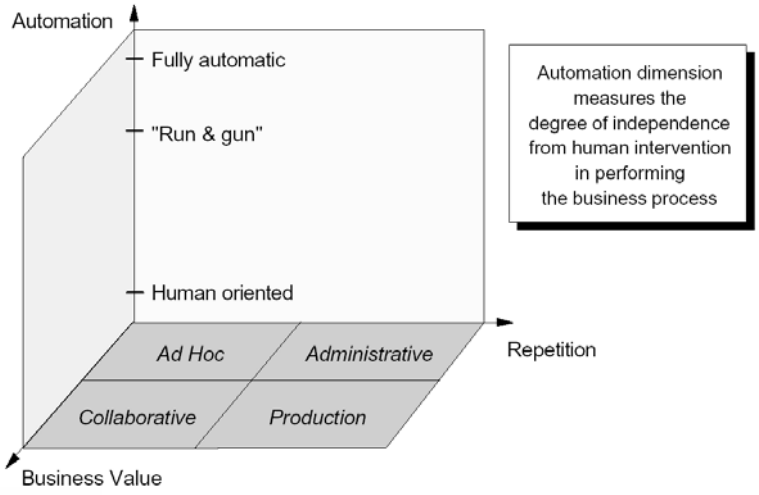
Characteristics Of Production Workflow

- Coordination
  - Process models as enterprise resource
  - Model driven execution of applications
  - Application integration
- Operation
  - Transaction support
  - Reliability
  - Availability
  - High capacity
  - High performance
  - Scalability
- Enterprise
  - Multi platform
  - System management
  - Standard compliance
  - Security
  - Process tracing

Enterprise Workflow

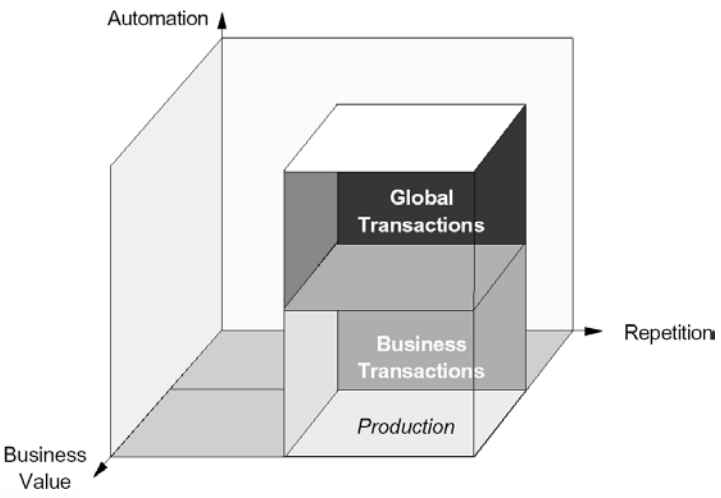


Automation Dimension

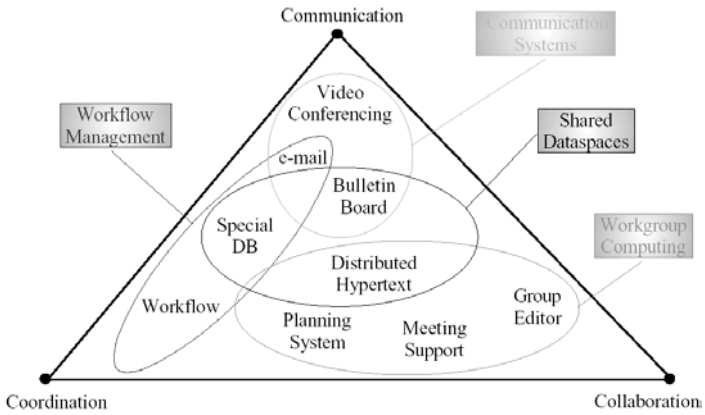


Automation dimension measures the degree of independence from human intervention in performing the business process

Transactional Workflows



Classification Of Groupware



Workflow-Related Technology Areas

- Business Engineering
- Transaction Management
- Object Technology
- Application Development
- Mobile Computing
- Operating Systems
- Systems Management
- Multi Databases
- Internet
- ...