Workflow Management

Workflow basics and evolution towards coordination

Distributed Systems

Sistemi Distribuiti

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Academic Year 2014/2015

Outline

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Introduction

More complexity:

- Market pressure of cost and lead-time production
- Internationalization and globalization
- New customer satisfaction view – Customer care
- Product customizability – more fragmentated market

Brief Process management history

The Workflow History

- Improvements: 1982 production branches + 1987 transportation and communication means
  - Switch from Fordism-model to Taylor Scientific Management
  - Economic/social obstacols: centralized control functions, health diseases, no customer demand meeting
- 1990s change: from product quality to customer satisfaction, from production to market model
  - Focus on processes organizations structure and behavior. Main organization breakthroughs:
    - Process take command over formal structure and work organization.
    - Organizational structures and work rules reshaping
  - Process Management View: basic tasks reunification into coherent business processes

Outline

Process definition

A process is a set of rationally linked tasks through which an organization generates value to reach its targets.

Two types of processes:

- Primary/operational processes (material, informational and relational processes)
- Change processes (continuous processes' development and redesign)

Which impact on using process work approach?

- response times, service and quality improvement, cutting across departmental demarcations.

Initial process management method → the procedure:

- multiple functions involvement
- step by step progress

Problems: Cost and time consuming. It didn't fit in the concept of process organizations.

New way for looking at processes: the workflow.

Workflow definition

A workflow is a unit of work within a process generating products/services related to customer satisfaction.

Two types of workflows:

- Case-based workflow (standardize workflow, permanent process-team and microstructures)
- Ad hoc workflow (specific, temporary needs of unique project teams)

Which impact on using process work approach?

- Customer satisfaction, cost reduction, flexibility, working life improvement.

Initially, it was developed as an evolution of the office automation systems (1970s).

A workflow can be examined from a number of perspectives:

- control-flow perspective, the temporal order of the various tasks in a workflow
- data perspective, how data is defined and passed between workflow elements and/or how the external environment is captured
- resource perspective, how resources are involved in task execution

Workflow Management Definition

- Workflow is composed by a main customer served by a supplier or cooperative network that works towards satisfaction of the main or secondary customers of the process.

  Workflow work units are assigned to participants, which may link into an organizational model, that must look up at a specific timing given by explicit and accurate representation of the temporal order of the various activities of the business process.

- Workflow Management helps organizations to specify, analyze, execute and monitor workflows.

  Different workflow management systems may be implemented supporting the use of different languages.

Outline

Workflow Conceptual models

Overview of Main Concepts of Workflow

What do we want to define? what are the entities involved in a workflow?

3 workflow conceptual models

The organizational model

- It structures resources in classes of objects with the same characteristics
- It attributes to each resource authorization to perform tasks

The informational model

- It describes the structure of the workflow forms, documents and data
- It can be used to determine whether a task is likely to be executed or not

The process model

- It defines the component tasks, their coordination, task's info and performers
- Tasks have an identity, a pre-condition situation, an action to perform and a post-condition configuration

The first 2 models affect the last one. The organizational defines and manages set of potential performers, the informational allows access to the objects to be processed.

Workflow Description Language I

Overview of Main Concepts of Workflow

How must workflows be expressed?
What is the expressive power required for their definition?

Workflow Description Language Definition

- Used to design workflow models in order to capture processes at a level of detail that is sufficient to enable their execution.
- Evaluation in terms of useful representing and reasoning about the various aspects of processes.
- There are almost the same number of languages and existing systems
- The ideal one: expressive power to describe the 3 previous models in a uniform way, or at least languages allowing interactions between these models.

Workflow Description Language II

Overview of Main Concepts of Workflow

The Main Business Workflow Description Languages: BPMN and BPEL

BPMN

- Business processing modeling notation: supports analyst decision making.
- It's based on scenario analysis, simulation and other techniques.
- BPMN process models aren't meant to be directly executable. On the other hand, BPEL helps organizations defining class of business processes for Web service interactions.
- Control-flow dependencies and communication actions interact through constructs corresponding to parallel, sequential, and conditional execution, event, and exception handling.

BPEL

- BPEL allows for the specification of executable business processes, and therefore can be used to support the execution of BPMN models.
- BPMN and BPEL are used together.
- Drawbacks to modeling and execution separation. Sometimes, the languages are based on different paradigms or the modeling language contains potentially complex concepts and little consideration was given to their precise meaning.

Workflow Description Language III

Overview of Main Concepts of Workflow

The Main Academic Workflow Description Language: YAWL

Petri nets

- A directed graph with two types of nodes (places and transitions) and arcs (no same-nodes connection)
- Places may contain zero or more tokens, which model the flow through the system.
- A transition can have preceding places (input places) and succeeding places (output places).
- State change: one of its transitions fires (at least one token in each of its input places), removing one token from each of its input places and adds one token to each of its output places.

YAWL (Yet Another Workflow Language)

- Petri-Nets limitations: capturing (1) patterns involving multiple instances, (2) advanced synchronization patterns, and (3) cancelation patterns. The limitations in Petri nets triggered the development of YAWL
- YAWL consists of tasks (i.e., transition-like objects) and conditions (i.e., place-like objects)
- YAWL took Petri nets as a starting point and introduced mechanisms that provide direct support for the control-flow patterns, i.e. allowing tasks to be directly connected, compressing visual model representation
- YAWL improvements were also possible because this language implemented and used workflow patterns as initial requirements.

Workflow Description Language IV

Overview of Main Concepts of Workflow

Workflow Patterns

- The Workflow pattern initiative establishment in 1990s.
- Aim: delineating the fundamental requirements that arise during business process modeling on a recurring basis and describing them in an imperative way.
- Patterns identification: 43 control-flow, 40 data, 43 resource perspective, several exception.
- Specialized form of design patterns in the area of software engineering.
- Workflow patterns indicate requirements for workflow languages.
- Referring to recurrent issues and solutions related to process-oriented app development.
- Each workflow language can be formally described by a set of primitive modeling constructs, syntactical rules for composition, and the semantics of these constructs.
- Focus on workflow patterns that originate from business requirements. The semantics of these patterns are much less formal because we cannot assume a (formal) language.
- Patterns are context-oriented, i.e., a workflow pattern typically describes certain business scenarios in a very specific context.

Outline

Workflow Management Technology I

Workflow management technology supports business processes, integrating data flows, information, communication and knowledge management in a working process at any time.

As a result it increases productivity and flexibility needed for business competitiveness.

Workflow Management Technology Development

- At the beginning the technology emphasis was on document storing, tracking and retrieval in working processes.
- Then, workflow software was introduced through integrated office systems as electronic mail and in office information systems.
- Lastly, thanks to personal computer diffusion, it spread in networked environments.
- Nowadays, workflow management systems are applications prototyped by users to determine the flow and define forms and applications to be used

Workflow Management Technology II

It's important to analyze history, definitions and different ways of workflow management approach, it allows us to understand why it's changed and how to improve tool usage.

Workflow Management Technology Definitions

- General definition: workflow management is the first method facing the problem of offering integrated support to routine and non-routine work providing their users with some exception handling mechanisms.
- Hales & Lavery (1991): a proactive computer system which manages the flow of work among participants, according to a defined procedure consisting of a number of tasks
- De Michelis and Grasso (1993): a technique for process modeling and automation.
- Hsu & Howard (1994): an integrator of disparate mainframe applications.
- Then Ellis & Wainer (1994): a system that helps organizations to specify, execute, monitor and coordinate the flow of work items within a work group of organization. It coordinates user and system participants, together with the appropriate data resources, directly by the system or off-line, to achieve defined objectives by set deadlines.

Workflow management technology fundamentals I

The workflow management technology is measured through standard message based on templates or forms.

The crucial point of workflow management technology is the analysis before implementation.

Functional requirements

- Application development must be customizable in a graphical end-user environment
- Steps (actions), sequencing (order of actions), routing (who does the action) and conditions (rules for doing and routing actions) definition must be effective using a flowchart generator
- There must be simulation facilities, workflow analyzers that automatically check the workflow
- The workflow can be re-used, dynamic and flexible as well as action assignment.
- The workflow maps (abstraction vs. decomposition) should allow zooming processes.
- Flows must be monitored. A mgmt reports that represent the current state of the process
- Due date for the task accomplishment. Workflow applications should notify user that there's a step or action to do.
- Alternative workflow path for a period of the time-recovery.

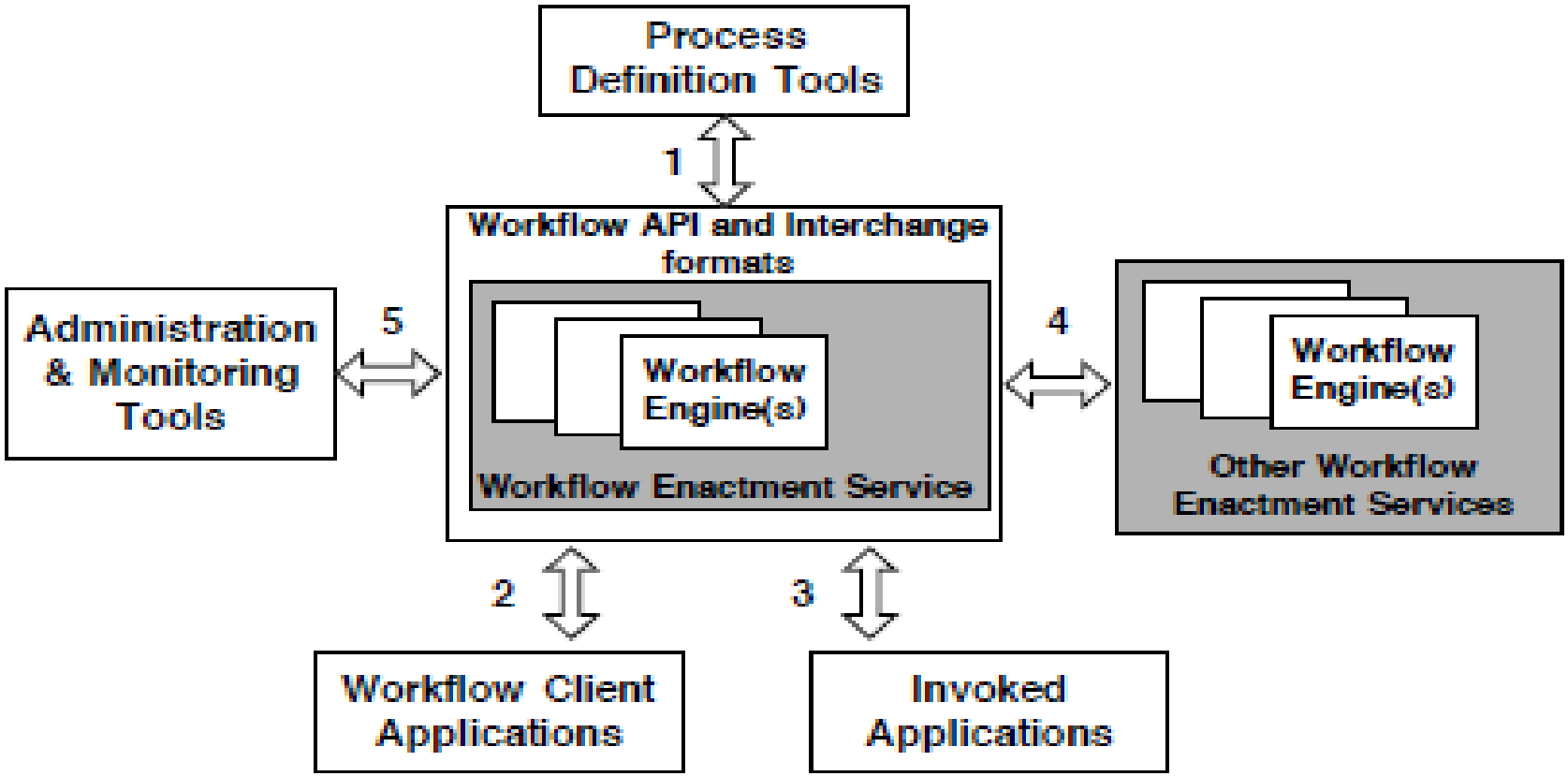
Workflow management technology fundamentals II

System Integration requirements

- Process management tools should be customizable and easy-to-use by users as well as form generation and modification. There should also be an online help system
- Data must have the possibility to be connected from different source as well as workflow messages. Offline paper documentation, external and also non-electronic resources
- Link recurrent organization processes with the workflow

Workflow management system architecture and implementation I

How to design and implement software supporting the main issues?



Workflow management system architecture and implementation II

Architecture 6 components

- The *Workflow Enactment Service that* supports the execution of workflow processes
- The *Workflow Definition Tools that* helps the workflow designer in specifying and analyzing workflow models
- The *Workflow-Client Applications that* invoke the Workflow Enactment Service and enable the end user to interact with the WfMS
- *Invoked Applications* called by the Workflow Engine
- *Administration and Monitoring tools* that enable the workflow admin to set parameters, follow workflow executions though time and react to possible problems
- *Other WfMS* may be connected to the current one via interface 4.

Comparing workflow management systems

WFMS choice should be taken after organization business processes analysis.

WFMS choice

- It should support the most suitable workflow patterns, i.e. they can be used to compare WFMS.
- The patterns should focus not only on the process perspective (i.e.control flow or routing) but also on the other perspectives (e.g. organizational modeling)

If a pattern is not directly supported or even not supported at all by the WFMS, this does not imply that it is impossible to realize the functionality.

No tool support all the patterns.

Outline

The social organization of work

- The individuals need to cooperate in order to work together achieving organization or own targets.
- Schmidt concept (1990): cooperative work pertains to the sphere of production and is related to *content* and *production* separating it from social interaction concept that is a bit more general.
- *Organizations exist because they produce something for customers* (whether as products or services does not make a difference for the cooperative nature of work).
- Cooperation doesn't involve direct communication between participants. They cooperate also without knowing each other.

Computer Supported Cooperative Work (CSCW) I

CSCW brief history

- 1980s: The groups and organizations interactions analysis field study came from network analysis field
- 1984: CSCW was firstly used to describe the topic of the interdisciplinary workshop, intended to discuss how to support people in their work arrangements with computers
- 1985: Rice & Richards gave a network analysis definition
- 1990s: awareness that networked infrastructure could support group activities in a more effective way.
- 1991: Bannon argued that CSCW has emerged as a new interdisciplinary forum for research into the issues central to the design, implementation and use of technical systems which support people working cooperatively

Computer Supported Cooperative Work (CSCW) II

Groupware definition

- *Group* concept as the main unit to focus on is directly related to the term *groupware*
- Groupware: “a generic term for specialized computer aids that are designed for the use of collaborative work groups. Typically, these groups are small project-oriented teams that have important tasks and tight deadlines. Groupware can involve software, hardware, services and/or group process support.” (Johansen, 1988)

CSCW definition

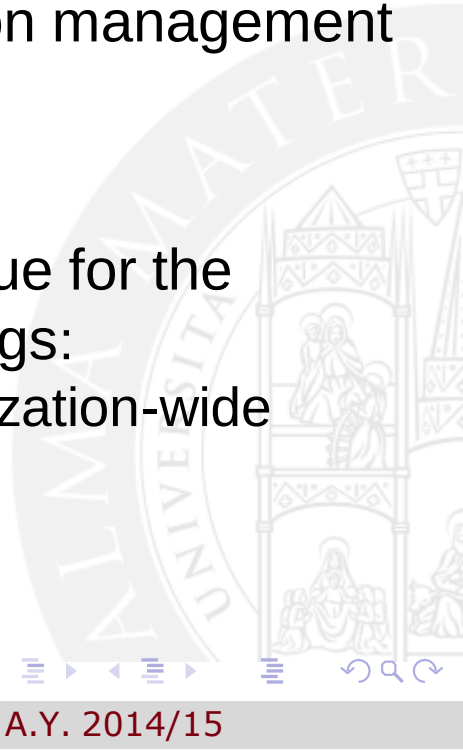
Computer Supported Cooperative Work (CSCW) is an identifiable research field focused on the understanding of nature and characteristics of cooperative work with the objective of designing adequate computer based technologies to support such cooperative work.

The role of computing in CSCW I

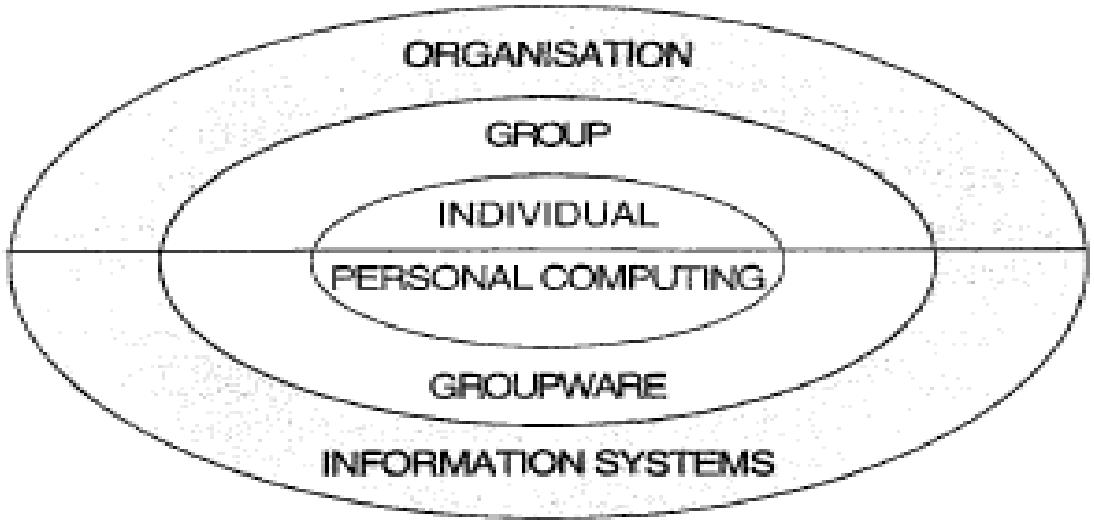
- Organizations do not run on information, they run on relationships.
  - Organization should invest in communication and knowledge management in order to serve customers by satisfying their needs trough cooperative work.

- CSCW support men managing the complexity and providing new ways of using traditional tools or new tools to improve organization management

- Developments in the field of CSCW might become the glue for the traditionally separate aspects of computing in work settings:
  - Single-user applications (personal computer) and organization-wide systems (transaction processing)



The role of computing in CSCW II



CSCW in the context of organizations, groups and individuals (from Grudin 1994:94)

Rings explanation

- 3 different rings: each one represents one focus on computer development and principle customer or user of the resulting product.
- Middle ring: CSCW focus because it represents groupware, designed with groups in mind.
- Inner ring: represents applications designed for individual users
- Outer ring represents the entire systems designed to serve organizational goals.

Cooperative network analysis

- Network analysis goal: obtain from low-level or raw relational data higher level descriptions of a system.
- Network analysis elements: nodes that can be any point capable of participating in a relationship, and connections, used for relations in cooperation, bounds and behavior (social network hinges)
- Network behavior is characterized by the articulation of work, work structures and composition necessary to produce the commitment, and synchronization or sharing among its members.

Cooperative network description

- Cooperative network is a set of network's members and products commitments.
- The scope: identify types of cooperation (coordination, collaboration and co-decision)
- Other four similar dimensions need: commitment, nodes, relation, and articulation.
- Commitment: unit of work that must satisfy customer needs. It defines network member's roles and responsibilities, the bounds of a cooperative network

Basic distinction for cooperative work

during the course of a process, different types of cooperation may be needed.

Coordination

- Individuals coordinate actions each other, concurring to its completion
- Main issue: *synchronization*. Break down the process into appropriate component actions!

Collaboration

- Individuals work together to produce a results of all individual contributions of the ensemble
- Share knowledge. Success depends on having a common goal and process understanding

Co-decision

- Individuals collect all information needed to take a joint decision evaluating pros and cons.

Collaboration and co-decision can be mixed with coordination over space or time when there are complex situations or networks *(collaboration/coordination, co-decision/coordination)*.

Coordination network support design procedure

- Identify the balance between activity synchronization and information sharing; its variance depends on the type and dynamics of cooperative networks and the capabilities of the individuals being part of it.
- Assess the current levels of synchronization and sharing.
- Identify the support tools which will provide the optimum balance between activity synchronization and information sharing that are paramount in describing the support requirements of cooperative work.

Cooperative network performance

Cooperative networks performance

- Cooperative networks performance is defined by *communication disciplines.*
- They offer a theoretical framework for pragmatics in human communication, moving the observer (user) from outside to inside the system.
- Performance is defined by speed, robustness and efficiency measured by channel capacity and information transmission rate.

New evaluation criteria

- Flexible communication systems which are able to manage themselves in the social system where they are implemented
- The communication disciplines are grouped together concerning:
  - execution (synchronization, identification, addressing, naming),
  - organization (delegation, authorization, re-organization),
  - administration (valuation, copying, cancellation, composition).

Dynamics of cooperative work

Dynamics together with articulation describes what is called *behavior* in network analysis.

In the small

- Characterized by: well defined roles, rules and a common history shared among members.
- The boundary between “in the small” and the rest of the world: generally well defined.
- Past experience influences its future, continuity in the ensemble.

In the large

- Characterizes by: occasional persons interactions. No specific roles.
- Interactions: related to the subject and to the goals.
- Impossible to analyze past events to understand how the future could be.

Outline

Inter-Organization Workflow (IOW) I

Distributed Systems common point

- Just as coordination is nearly invisible when conducted successfully, also distributed system is seen by users as a collection of independent computers that appears to its users as a single coherent system (Transparency).

- Workflow coordination issues (like Distributed Systems): collaboration, through which many entities should work altogether as a single coherent system, and amalgamation that let many heterogeneous entities look altogether as a single uniform system.

- A solution? The middleware for DS and IOW for Workflows. They enable interaction between autonomous distributed components.
  These layers hide differences in technology, structure, behavior, providing a common interface for both applications and components (as O.S)

Inter-Organization Workflow (IOW) II

IOW Flexibility

- Inter-Organizational Workflow (IOW) technology is fundamental to help organizations with flexible and cooperative activities that must be coordinated to meet customer needs. Organization have developed mechanisms for cooperating actors in order to describe their expected behavior.

- WFMS have a significant relevance in an organization because they support coordination complexity that rises proportionally with activities distribution. Although computer-based technology improved the way coordination complexity was handled, there are a lot of problems. For example, WfMS are too rigid and semantic interoperability at the workflow and business level is still a challenge.

- Flexibility is one of the most important features a workflow must have due to business process evolution adaptation. Indeed, workflow execution must be correct and reliable independently by changes in the process.

IOW cooperation forms and openness

IOW systems depend on the type of process they must support.

There are 2 main cases of cooperation forms regarding business process workflow definition

No definition of a process

- It realizes coordination through awareness and explicit communication.
- It has only a common goal with self-organized agents and information sharing is a key to these types of IOWs.

Detailed definition of a process

- It has different degree of tailorability of the tasks by the actors.

The computing context must be o*pened*, IOW could evolve.

3 open-related issues

- Interoperability, components/systems difficulty to work with different ones
- Portability, how much an app can be moved to a different DS and keep working;
- Extensibility, difficulty to add new components and functionality to an existing DS.

IOW coordination through Multi-Agent Systems (MAS)

Agents' field technology improvement are significant. Real-world app, dealing with info complexity, unpredictability and heterogeneity, resources and services.

MAS coordination supports IOW

- Artificial participants, responsible of the automated execution of some tasks, intelligent interfaces with respect to the workflow system, encapsulating the execution of tasks and individual activities
- Coordination artifacts like target of the agents activities, as computational objects, or tools that agents use to support their work toward goal achievement

Coordination artifacts

- They capture the structure and function of workflow engines that coordinate the workflow activities, encapsulating the execution of workflow specifications (rules in terms of coordination laws), encoded in some workflow language.
- They support awareness, coordination and mutual knowledge, managing dependencies and interactions occurring among agents involved.

Workflow Management Architecture Construction

To build flexible, dynamic and scalable workflow management architectures properties defined for the coordination artifact abstraction can be exploited.

Coordination artifact abstraction properties

- Malleability, workflow engines coordinating behavior forged and tuned dynamically
- Inspectability, workflow engines coordinating state and behavior fully observable
- Linkability, workflow engines linked together, parts of the same workflow within different execution contexts

WFMS and Virtual Enterprises (VE)

WfMS and virtual enterprises (VE) support the integration of heterogeneous resources, services, and processes.

Virtual Enterprises (VE)

- VE is a temporary aggregation of autonomous, independent and possibly heterogeneous enterprises connected through a network.
- Main target: deliver a product or a service in response to customer needs, providing the flexibility and adaptability to frequent changes that characterize the openness of business scenarios.[3]
- Complexity: huge amount of dependencies among activities with heterogeneous information and resources.
- VE activities modeled as agents, featuring tasks to be pursued autonomously and pro-actively, typically involving the interaction with other agents and services, with the related coordination problems. Workflow management coordination problem.

VE Infrastructure Requirements and Tuple Centre Model

Virtual Enterprises (VE) Requirements

- Promote the conceptual homogenization of VE resources, information, and activities.
- Support consistent interactions with shared services among processes, while minimizing VE impact on participant infrastructure.
- Provide abstractions and mechanisms for security, safety and privacy
- Help to govern the dependencies characterizing the execution of business processes, such as task assignments, prerequisite and temporal constraints, which require the development of a WfMS.
- A suitably expressive model and a coherent runtime environment embodying and supporting the model.

Tuple centre model

- Used for designing and implementing flexible agent-based WfMS.
- It allows to program the behavior of a tuple centre (programmable tuple spaces), defining reactions to interaction, by determining how a tuple centre should react to incoming/outgoing communication events.

Distributing Workflows

How to distribute workflows among different engines.

3 points to deal with

- Composability. Understanding the best way to share information among several independent activities, and to coordinate them over a distributed scenario
- Ownership: stakeholders of independent activities within an IOW may not be willing to share everything, and to open up completely to the other participants.
- Alterity: External infrastructure that has to support the main workflow engine, a third-part that not directly controlled by any of the workflow participants. IOW does not belong in principle to any of the participant organizations.

Architecture for Distributed Workflow

Build an abstract architecture for distributed workflow based on a coordination infrastructure to support the main workflow. It shouldn't be pervasive, each participant own and govern portions of the supporting infrastructure.

Fundamental features

- Composability of workflow engines. Nodes interoperability is an obvious feature for any distributed infrastructure, not for distributed coordination artifacts.
- Linkability. The ability to link different stages of separate but related workflows to synchrony and coordinate activities.
- Alterity. A distributed workflow may in principle be hosted by a workflow node (call it the main workflow node, implicitly defining the main scope of the workflow). This node is not required to belong to one of the workflow participants.

It should consist of a:

- main workflow node that contains the distributed workflow general specification
  - a number of workflow nodes distributed across workflow participants
- a network of workflow events exchanged among the workflow engines, to maintain global consistency of the distributed workflow activities.

Agent Coordination

One of the most complex issue that a VE and a WfMS must deal with is agents' coordination.
TuCSoN is an infrastructure that manage agents' coordination (Omicini and Zambonelli, 1999)

TuCSoN

- Both a model and an infrastructure for the Internet agents coordination. An agents and tuple centers collection working together in a possibly-distributed set of nodes.
- It supports multiplicity of independent environments, internet nodes or administrative domain of nodes by providing tuple centers: multiple, independent interaction spaces.
- Agents access tuple centers by name, either locally in a transparent way, or globally on the Internet in a network-aware fashion.
- Tuple centers can be seen as workflow engines, encapsulating the set of rules that constitute the workflow. Tuple centers represent workflow rules in terms of coordination rules programmed.

How does TuCSoN expressed coordination rules?
Using ReSpecT specification language, a general-purpose interpreter for workflow specifications expressed in terms of logic-based workflow language, which are embodied within tuple centers.

TuCSoN as an Infrastructure for VE and WFMS

TuCSoN Infrastructure features

- It guarantees portability among platforms because it's developed in Java.
- It is designed to support different kind of middleware because its architecture is based on a lightweight core.
- Agents can interact with other agents without knowing their identity or their position, supporting the integration between heterogeneous information sources.
- TuCSon tuple centers are more powerful than tuple spaces because they can be programmed to suitably react to incoming/outgoing communication events, by defining the coordination laws ruling agent interactions
- The ability of defining the dynamic behavior of tuple centers is also the key feature that allows TuCSoN to fully support heterogeneity at the process level and, more generally, to face the coordination of dynamic aspects inside the VE

Outline

Summing Up

Workflow evolution

- Office information system
- Workflow-based languages
- Workflow Management tools
- Computer Supported Cooperative Work
- Social Behavior implementation

Sociology integration

- Social network analysis and agent-based approach, new scientific fields
- Autonomy, MAS support VE and WFMS
- Agent is the way!

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Academic Year 2014/2015