Managing the Coevolution of Organizations and Information Systems

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Abstract

In today's ever-changing socio-economic environment, organization and the embedded information system need to evolve as an organic whole on a continuous basis to adapt to new business requirements. In order to guide the coevolution of organization and information system, this paper introduces Tropos Evolution Modeling Process for Organizations (TEMPO). The conceptual framework of this model is grounded on analogies between information system, socio-economic system, and living system; agent-orientation is applied as an overarching paradigm that aligns the three domains. In particular, by interpreting Kauffman's NKC model, which was intended to simulate the coevolution of species in an ecosystem, with Tropos ontology, we introduce the concept of goal interface as the evolution frontier of an organization. Within this interface, evolution is viewed as a process of negotiation between agents on goals both within and beyond the original organizational boundary. The organization is re-stabilized when agreements are reached on the relations between goals. In order to assist the identification and resolution of goal interactions, a goal relation taxonomy and corresponding negotiation strategies are presented. TEMPO is illustrated with a real-life case study, which demonstrates how to evolve an online retail website under the new European e-commerce legislation.

1. Introduction

Organizations in the twenty-first century have to be able to adapt rapidly to changes in the socio-economic milieu. Information systems, which are becoming an organic component of organizations, need to evolve in concert with organizational change. The realization of agile coevolution of organization and information system, however, has been impeded due to lack of appropriate analysis and design methodologies. Information systems are modeled with programming concepts such as data structures, while organizations are understood in terms of customers, stakeholders, competitors and their respective goals. The 'semantic gap [2]' between the two domains represents a major obstacle in modeling the coevolution of organization and information system.

The emergence of agent-orientation as a modeling paradigm [11] provides novel opportunities for aligning the modeling of organization and information system. From an agent-oriented perspective, both of them are viewed as decentralized adaptive systems, consisting of coordinated agents in pursuit of their respective goals. Therefore one uniform ontology can be used to cover both domains. However the existing literature does not address evolutionary aspects of agent-oriented modeling.

Inspired by the 'ontological continuity [22]' underlying socio-economic system, information system, and living system, we explore the coevolution of organization and information system by extending concepts in biological evolution to agent-oriented modeling. Another significant notion of our approach is the use of negotiation as a metaphor for evolution, i.e., organization evolves as its agents negotiate and agree on new goals.

The rest of the paper is structured as follows. Section 2 outlines the conceptual framework that underlies the model. Section 3 elaborates on the model, including the definition of goal interface, a taxonomy of goal relations and corresponding negotiation strategies, and the process model. Section 4 illustrates the model with a real-life case study: the evolution of an online retail solution under the new European legislation is modeled stepwise. Section 5 concludes and identifies future research directions.

2. TEMPO conceptual framework

From the perspective of complex systems [12], an enormous range of phenomena, natural and artificial, from molecular machines within cells to markets, societies and even the entire world socio-economy, can be modeled as evolving systems of interacting agents [10]. In the same vein, three fundamental analogies: information system as socio-economic system, socio-economic system as living system, and information system as living system, are assumed in the TEMPO model.

The agent-orientated Tropos ontology [1] is adopted as a unified framework for modeling both organization and information system. Based on the fundamental analogies, Kauffman's NKC model, which simulates the coevolution of species in an ecosystem [12], is projected into Tropos ontology to model the organization-information system coevolution. The framework is shown in Figure 1.

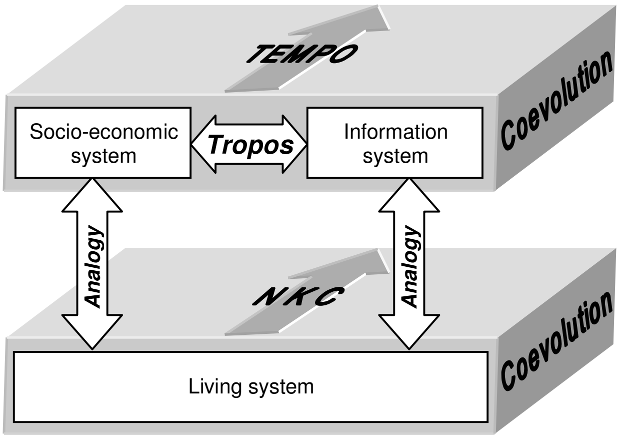

Figure 1. TEMPO conceptual framework

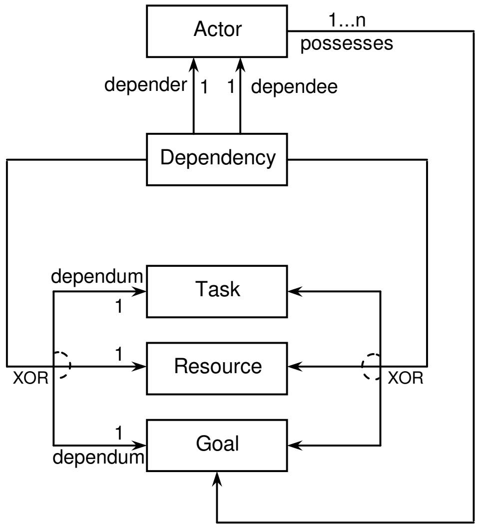

Figure 2. Partial Tropos ontology diagram

2.1. Information system as socio-economic system

Organizational computing requires close alignment of business objectives and information technology, which, in turn, requires a unified framework for modeling both organizations and the embedded information systems.

Agent-orientation is a modeling paradigm applicable to both socio-economic systems and information systems. According to this approach, both organization and information system are viewed as decentralized complex adaptive systems, consisting of large numbers of autonomous agents involved in parallel local interactions, which give rise to macro-level system behaviors [14] [19].

Tropos [1] is one of the state-of-the-art agent-oriented information system development methodologies. The ontology of this methodology, as illustrated in Figure 2, is centered on the concept of agents and other mentalistic notions such as goals, tasks, resources and dependencies. Models in Tropos can be categorized into two types: Strategic Dependency (SD), which addresses the relations between agents, and Strategic Rationale (SR), which specifies the intentions within agents.

The Tropos development process consists of five phases: early requirements analysis, late requirements analysis, architectural design, detailed design, and implementation. In particular, significant attention is paid to the analysis of organizational setting of information systems.

In order to better model the emergent properties of agent-oriented systems, Tropos draws from organizational theory and defines a set of organizational patterns, e.g., *Structure-in-5*, *Hierarchical contracting, Joint venture*, *Embassy*, *Matchmaker*, etc [7] [8]. These patterns can be used as generic architectures for both socio-economic systems and information systems.

2.2. Socio-economic system as living system

Modern economics has a tradition of using biological metaphors to understand economic processes [9], giving rise to a rich collection of novel research fields such as sociobiology and bioeconomics. Biological approaches to economics rest on the ontological continuity, i.e., the construction of metaphors, between natural and socio-economic domains [22]. Based on these metaphors, biology-based theories are extended to economic realm. For example, the concepts of 'self-organization' have been used to account for the self-amplifying features of innovative change in the markets [22].

Similarly, the TEMPO model assumes an analogy between socio-economic organization and living system. The fundamental resemblance between the two domains is that both are undergoing continual evolution that results from the cooperation and conflict from within, i.e., the interactions among the various comprising components, and outside, i.e., the interactions between the system and the environment.

2.3. Information system as living system

The parallel between computing and biology, or more generally, biosciences, has inspired burgeoning research fields, such as evolutionary computation and artificial life. Recently in the face of the so-called complexity crisis, which looms in modern information systems [10], the metaphorical use of biosciences to tackle the issue of system complexity is gaining increasing attention in both academia and industry.

The analogy between information system and living system applied in the TEMPO conceptual framework lies in the fact that both information system and living system can be viewed as vast and entangled hierarchies of various goal-directed, self-governed agents, which constantly interact with and adapt to one another; the emergent systems consisting of these agents, in turn, demonstrates continual evolution, which helps to maintain the fitness of the systems.

2.4. Kauffman's NKC coevolution model

Organisms in nature continuously coevolve both with other organisms and with a changing abiotic environment. In these processes, the fitness of one species depends upon the characteristics of other species that it interacts with. Meanwhile all species simultaneously adapt and change [12].

In an attempt to provide a framework for modeling the genetic interactions in coevolution processes and explore the structure of 'fitness landscape' that underlies adaptive evolution, S. A. Kauffman introduces NKC model, which is named after the three main parameters that determine the behaviors of species' interaction and change with one another.

In particular, N refers to the number of genes in a genotype; each of the genes makes a fitness contribution, which depends upon the gene itself and upon K other genes in this genotype; in addition, each of the N genes depends upon C genes in other genotypes. When the three parameters changes, the model generates a family of fitness landscapes, providing a basis for statistical analysis of adaptive evolution.

More generally, the NKC model can be interpreted as: among the N components of a system, each depends on K other components internally, and on C components of other systems with which this system interacts. K and C represent the degree of the system's *internal coupling* and *external coupling* respectively.

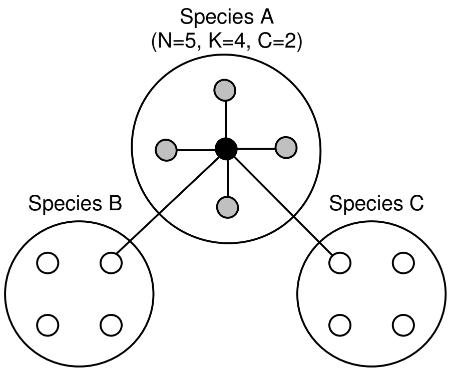

Figure 3. A gene in species A coupled to K=4 genes internally and C=2 genes in other species

3. Tropos Evolution Modeling Process for Organizations (TEMPO)

By interpreting the general NKC model with Tropos ontology, i.e., components as goals and coupling between components as dependency relations between goals, we construct TEMPO to model the organization-information system coevolution. The key elements of TEMPO include the definition of goal interface, a taxonomy of relations between goals in this interface, the use of negotiation as a metaphor for organization evolution, and a process model that aligns all these concepts.

3.1. Goal interface

Interdependency between the goals of the interacting agents both within and beyond the original organizational boundary produces a dynamic area. Specifically, some original goals might be affected by, i.e., have dependency relations with, goals newly elicited from organizational environment. These dependency relations, together with the involved goals, comprise the *goal interface*.

Inspired by the NKC model, we partition the goal interface into three modules: *C module*, i.e., the newly elicited goals that have some dependency or contribution relations with goals in the original SD/SR model; *N module*, i.e., goals in the original SD/SR model that have either direct or indirect dependency or contribution relations with the new goals; and *K module*, i.e., goals in the N module that have only indirect dependency relations with the new goals. Dependency relations between C and N modules represent the *external coupling* between the organization and the environment; dependency relations between K module and the rest part of N module represent the *internal coupling* at the goal interface.

Goal interface is the dynamic evolution frontier of the organization: C module causes immediate changes in N module; changes are then propagated through K module to the entire organization.

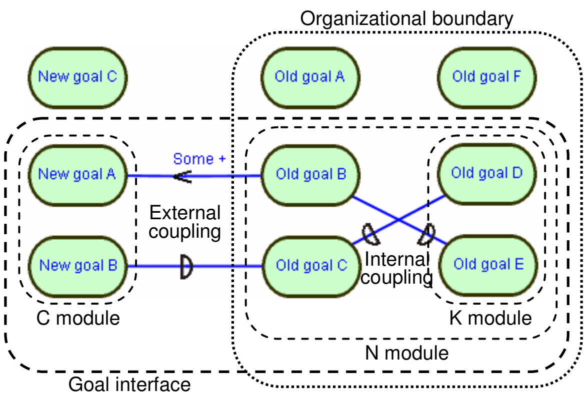

Figure 4. Goal interface

3.2. A taxonomy of goal relations

The coordination of the various cognitive elements in the goal interface requires an understanding of the nature of interactions, or relations, among goals. The following presents a goal relation taxonomy, which categorizes the interactions of goals along two dimensions: organization and utility. In stead of providing an overarching classification, this taxonomy is aimed at assisting the analysis and planning of the goal interface,.

3.2.1. Organization dimension. From an organizational perspective, goals interact at four levels: *intra-agent* level, *inter-agent* level, *intra-organization* level, and *inter-organization* level.

1. *Intra-agent goal relation* refers to a class of interactions that exists among the goals of a single agent. From a functional point of view, intra-agent relations may enhance the internal cohesiveness of agents, and lead to the establishment and maintenance of agent identities and boundaries [14].
2. *Inter-agent goal relation* refers to a class of interactions that exists among the goals of a several different agents. Inter-agent goal relations may strengthen the linkage between agents in complex organizations; it may also stimulate the formation of common organizational structures [14].
3. *Intra-organization goal relation* refers to the collective interactions among the goals of comprising agents of an organization. The significant difference between inter-agent relation and intra-organization relation is that only when the majority of agents of an organization are involved in the interaction, is it classified as intra-organization relation. This type of relation can provide a high-level, systemic view of an organization [17].
4. *Inter-organization goal relation* refers to the collective interactions among the goals of several organizations. Inter-organization goal relation may shed light on the strategic relationship between organizations.

3.2.2. Utility dimension. Depending on whether the interactions among goals entail favorable or adverse situations, goal relations can be categorized into *positive* relations and *negative* relations.

1. *Positive goal relation* refers to a situation in which the fulfillment of certain goal(s) enhances the attainment of other goal(s). Positive goal relations can lead to beneficial combinations of cognitive elements, e.g., cooperation among agents. According to the degree of benevolence of goals towards each other, positive goal relations can be classified into the following types.
   - *Overlap* refers to a situation in which two goals are identical with each other, so that one agent can achieve both of them [21].
   - *Subsumption* refers to a situation in which the fulfillment of one goal implies the fulfillment of the other [13]. The subsumed goal can be viewed as a subgoal of the subsuming goal.
   - *Contribution* refers to a situation in which one goal contributes helpfully to the other goal.
2. *Negative goal relation* refers to a situation in which the fulfillment of certain goal(s) interferes with the attainment of other goal(s). This is similar to the definition of *conflict* in organizational theory that conflict is "a condition that is manifested when the goal-oriented intentional behaviors of members of one unit or coalition of units result in blocked goal-directed behaviors and expectations of other organizational units [14]". Hereafter the term 'negative goal relation' and 'conflict' are used interchangeably. Depending on the antecedents, or source factors, of conflict, negative goal relations can be classified into the following three categories.
   - *Logic incompatibility* refers to a situation in which the specifications of two or more goals involve mutually exclusive logical states. Logic incompatibility can lead to negative contribution among goals, which might eventually cause the other two types of conflict antecedents: resource scarcity and task interdependency.
   - *Resource scarcity* refers to a situation in which goals result in mutual dependency on shared pool of resources. The major factors of the resource pool that affect the degree of conflict potential include: *divisibility* of resource pool, i.e., if the shared pool is indivisible, a win-lose condition might arise, leading to high conflict potential; *depletability/replenishability* of resource pool, i.e., pools that can be replenished are associated with less conflict potential than depletable ones; *contingency* of resource pool, i.e., pools that are accessible only through coordinated action of several agents tend to involve a lower conflict potential than pools that can be accessed though uncoordinated actions of individual agents. [14]
   - *Task interdependency* resulted by agents' intent to fulfill their goals may affect conflict potential. Three types of interdependency can be discerned in the order of increasing intensity: *pooled interdependency*, in which tasks are performed independently, *sequential interdependency*, in which one task cannot be accomplished until another task in the throughput process has been finished, *reciprocal interdependency*, in which certain resources are circulated between two tasks. High task interdependency may lead to, or intensify, negative goal relations. [14]

3.3. Goal-oriented negotiation strategies

Human negotiation procedure is used as a metaphor for organization evolution process. Corresponding to the goal relation taxonomy, a set of strategies, or heuristics, is introduced in order to guide the management of goal relations in a changing organization.

3.3.1. Negotiation as a metaphor for organization evolution. From an organizational perspective, evolution is the process of adaptation of the mental states of the organization's agents to the changing environment. In this process, the relations among agents' cognitive elements, such as goals, need to be identified and reconfigured such that the dysfunctional aspects of the relations can be eliminated while the functional aspects can be enhanced.

This process is similar to human negotiation, which is "a form of decision making in which two or more parties talk with one another in an effort to resolve their opposing interests [16]". In the TEMPO framework, we view organizational evolution as a process of negotiation on the agents' mental states, especially goals. Human negotiation strategies provide heuristics for managing both positive and negative goal relations.

3.3.2. Negotiation on positive goal relations. Positive goal relations can generate benefit for the overall system, and thus need to be properly utilized. Depending on the degree of benevolence among agents, a set of strategies is introduced to fully exploit the positive relations.

1. *Overlap: redundancy elimination.* When two or more goals overlap, one of the identical goals needs to be preserved, while others can be removed. The preserved goal can be either assigned to the original agent, or reallocated to another agent capable of achieving it.
2. *Subsumption: merge.* When one goal is subsumed by another goal, the subsumed goal can be merged into the subsuming goal. The merged goal can be either assigned to the agent of the subsuming goal, or refined into a collection of subgoals, which are then allocated to a group of agents.
3. *Contribution: partial merge.* The contribution of one goal to another is due to the overlapping of some of their subgoals. The overlapped subgoals can be merged into one of the goals and eliminated from the other. The two modified goals can continue to be possessed by their original agents. In an extreme case, the two goals may be merged into a high-level goal and assigned to one agent.

3.3.3. Negotiation on negative goal relations. Negative goal relations might cause difficulties in organizational planning. Depending on the antecedents of negative goal relations, a set of strategies is introduced to analyze and resolve the negative relations.

1. *Logic incompatibility: the negotiation strategy choice model.* Synthesized from human negotiation behavior [16], the negotiation strategy choice model serves as a framework for the selection and evaluation of conflict resolution strategies. Depending on the degree of coordination the two agents may exhibit in negotiation, three basic strategies are postulated. These strategies are partially mutually exclusive, i.e., conditions that discourage/encourage the use of one strategy should encourage/discourage the use of others.
   - *Unilateral concession* refers to a situation in which one of the conflicting goals is relaxed, or partially achieved, i.e., only some of its subgoals are achieved, while the other goal is preserved. An extreme case of unilateral concession is that one of the conflicting goals is totally abandoned.
   - *Coordination* refers to a situation in which both conflicting goals exchange a certain degree of relaxation in search of a mutually acceptable agreement. Coordination covers several specific forms. In particular, *bilateral concession* is a case in which the conflicting goals selectively abandon some of their subgoals, and the conflict is resolved. *Bilateral reconfiguration* is a case in which the conflicting goals are refined into subgoals; some of the subgoals might be dropped from one goal and merged into the other, until an alternative, conflict-free combination of goals is formed. When facing some difficult controversy, *third-party intervention* might be needed to facilitate coordination. This is a case in which a new agent is introduced to mediate, arbitrate, or elicit new knowledge from the conflict situation.
   - *Competition* refers to a situation in which both conflicting goals continue to be pursued by agents, although this might eventually lead to unilateral concession from one of the conflicting goals. Competition can be categorized into two types: *unregulated competition*, in which the conflict is actually tolerated and preserved, and *regulated competition*, in which some agent is introduced to mediate the conflict through certain mechanisms, e.g., English auction.

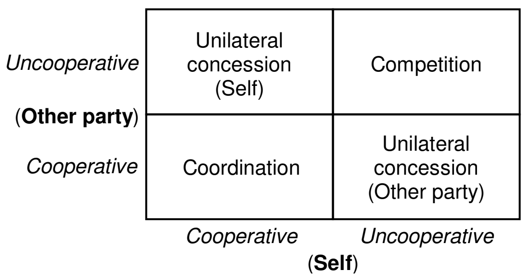

Figure 5. Negotiation strategy choice model

2. *Resource scarcity: reallocation.* Resource induced conflict might be resolved by reallocating resources to goals. Specifically, three basic strategies can be applied depending on the qualitative attributes of the resource pool [14] [18].
   - *Relaxation* refers to the process of reducing the amount of resource that a goal depends upon. In some cases a goal might totally abandon its dependency on certain resource. The relaxation of resource can be *unilateral*, i.e., one of the conflicting goals relaxes resource while the other preserves resource, or *bilateral*, i.e., both goals exchange relaxation based on their respective preferences.
   - *Reconfiguration* refers to a situation in which both conflicting goals make selective changes to their dependency on resource, so that a mutually acceptable allocation can be elicited. Specifically, reconfiguration can be viewed as the process of dividing, regrouping the bundle of resources, and re-matching them to goals.
   - *Joint access* refers to a situation in which the two conflicting goals can only access the resource pool through joint action. If necessary, an access manager agent is introduced to coordinate the goals. The matchmaker organizational pattern [2] can be considered an example of joint access.
3. *Task interdependency: temporal resolution.* The simultaneous execution of two or more inter-dependent tasks might lead to conflict. Temporal overlap of tasks can be resolved through *serialization* of tasks [13]. Specifically, two strategies can be applied to eliminate temporal overlap: *spreading task*, i.e., shifting the time intervals of conflicting tasks, and *reducing intervals*, i.e., shrinking one or both of the task intervals.

3.4. Process model

Given the Strategic Dependency (SD) model and Strategic Rationale (SR) model of an organization, or information system, and the new requirements in the form of business goals, TEMPO process model helps analyze the impact of the new requirements and evolve the original SD and SR models to incorporate the new goals. This process consists of three steps, each of them consisting of three iterative sub-steps.

Step 1: Goal interface identification. The high-level goals identified from business environment might trigger a series of changes in the organization. This step is aimed at outlining the preliminary goal interface in the original SD/SR model. Specifically, the three constituent modules need to be analyzed.

1. *C module elicitation*: the new business goals tend to be global and abstract, and thus need to be incrementally refined into an AND/OR goal tree. Subgoals can be elicited through asking *How* questions to high-level goals [3]. The output of elicitation is one or several preliminary goal hierarchies, which constitute the C module of the goal interface.
2. *N module identification*: through discovering external coupling, i.e., dependency relations between goals in the C module and the original SD/SR model, the N module, which consists of all affected goals and the associated dependency relations, can be identified.
3. *K module propagation*: in the original SD/SR model goals that are indirectly affected by the C module can be captured through discovering internal coupling in the goal interface. That is, by identifying dependency relations between goals in N module, K module is gradually delineated. Meanwhile, the goal interface is propagated in the SD/SR model.

During the three sub-steps, new goals and dependency relations might gradually emerge, and thus the sub-steps might need to be performed iteratively until no more goals or dependency relations can be elicited.

Step 2: Goal relation management. The preliminary goal interface identified in Step 1 needs to be coordinated and transformed based on the goal relations involved in the interface. The management of goal relations contains three steps.

1. *Goal relation diagnosis*: the various goal relations in the interface need to be diagnosed according to the taxonomy, mainly along the utility dimension, so that appropriate strategies can be used to negotiate on goal relations.
2. *Goal-directed negotiation*: once a goal relation in the goal interface is captured, based on the mapping between goal taxonomy and heuristics, negotiation strategies can be selected according to the types of the relation between, and the characteristics of, the involved goals. Goal-directed negotiation also includes the implementation of the strategies, i.e., the resolution of goal relations. This usually leads to changes in the configuration of goals, resources, tasks and agents in the original SD/SR model.
3. *Resolution evaluation*: after the selected strategies are implemented in the SD/SR model, the resolution should be evaluated based on 'local' non-functional requirements (NFR) i.e., NFR on the agents associated with the resolution, If the requirements are not satisficed, either the specific implementation needs to be altered, or the strategies need to be changed.

The three sub-steps are carried out iteratively so that more goal relations are diagnosed and resolved if needed.

Step 3: Interface integration. The goals in the original SD/SR model that are not affected by the new business goals is integrated with the transformed goal interface. Then the architecture-level SD model is constructed from the evolved SD/SR model. Specifically, this involves three sub-steps.

1. *Strategic Rationale (SR) model composition*: The part of the original SD/SR model that is outside the goal interface is integrated with the transformed goal interface. The output of the composition is a complete evolved SD/SR model, the configuration of which has incorporated the new business goals.
2. *Strategic Dependency (SD) model abstraction*: Architecture, as an emergent property of organization, is abstracted from the new SD/SR model, and is defined in terms of actors and the dependency relations between them. Actors are individual agents or aggregations of agents. The abstraction can be based on defined organization patterns: the selected pattern is instantiated into a specific architecture [8].
3. *Architecture evaluation*. The abstracted architecture is evaluated whether organization-level non-functional requirements are satisficed. If not, more iteration(s) of abstraction and evaluation need to be performed until a satisfactory architecture-level SD model is constructed.

4. Case Study: evolving osCommerce under new European e-commerce legislation

This case study demonstrates the use of TEMPO for analyzing new requirements and guiding the evolution of information systems as organizations. Specifically, how an online retail website evolves to meet new legislative requirements is outlined to illustrate the process model.

4.1. osCommerce

Released under the GNU General Public License, osCommerce is an Open Source online retail e-commerce solution that allows online stores to be setup conveniently. osCommerce was started in March 2000, and has since matured to a solution that supports 1,395 registered online shops worldwide.

Supported by its development community, the solution is undergoing continued evolution. The project website (www.oscommerce.com) features open and rich project documentation, including source code, community forums, bug reports, CVS server, progress reports, development work board, and interview transcripts, helping us capture the evolution process of solution.

A screenshot of the osCommerce solution is provided in Appendix B. The SD/SR model of Version 2.2 of the osCommerce solution, as depicted in Appendix C, are derived through analyzing the source code.

4.2. New European E-Commerce Directive

Comprehensive new e-commerce legislation recently became effective in Europe. In June 2000, the European Parliament and the Council adopted the E-Commerce Directive in order to harmonize regulations applicable to information society services in the European Union. EU Member States were given until January 17, 2002 to implement the Directive into their national laws. [6]

The provisions in the European E-Commerce Directive are divided into three main sections: establishment and information requirements, commercial communications contracts concluded by electronic means, and liability of intermediary service providers [6]. All companies offering services to EU residents are required to comply with the Directive.

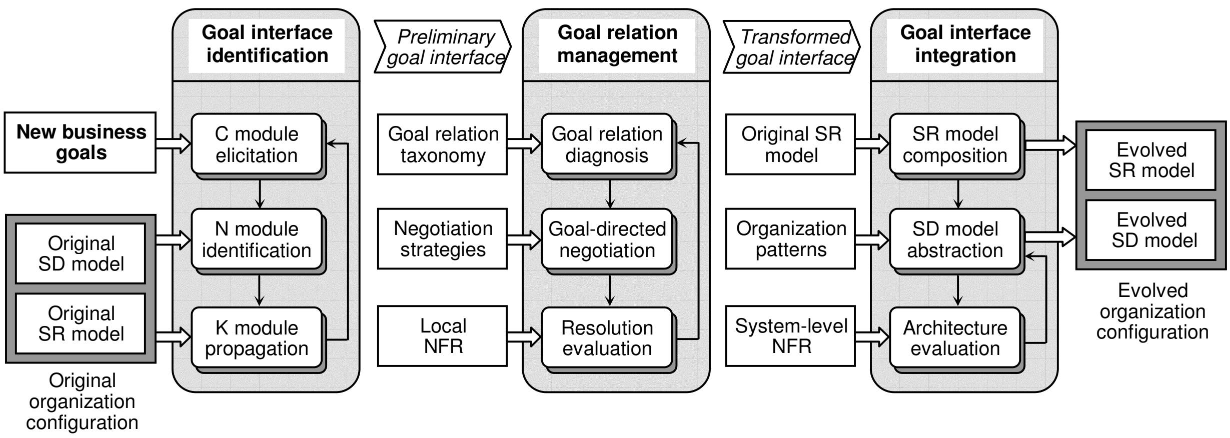

Figure 6. TEMPO process model

4.3. Modeling the evolution of osCommerce

In order to change the original osCommerce solution to meet the new legislative requirements, we use TEMPO to guide the evolution. The detailed modeling process is provided in Appendix C.

Step 1: Goal interface identification. The new goal hierarchy of C module is elicited through identifying provisions in the Directive that are applicable to Business-to-Consumer (B2C) e-commerce [20].

Because there are no preexisting SD and SR models of osCommerce, they are abstracted from the source code. Organization patterns are extensively used in this process. In particular, based on Porter's generic value chain model [15], we define a new organization pattern: *Value chain* to represent a string of collaborating agents working together to satisfy requirements for specific products or services.

Based on the new goal hierarchy and SD/SR model, C, N, K modules of the goal interface are identified.

Step 2: Goal relation management. Three types of relations are detected in the goal interface: goal overlap, goal subsumption and goal contribution. According to the corresponding negotiation strategies, associated goals are removed, merged, or partially merged. Modified goals are then assigned to responsible agents.

Step 3: Goal interface integration. The transformed goal interface is integrated with the rest part of the original models. Then an architecture-level SD model is abstracted based on *Strucuture-in-5* pattern. This model consists of five actors, each of which consists of a group of agents.

5. Conclusions and discussion

In order to guide the coevolution of organization and information system in a changing business environment, this paper introduces TEMPO. This model is centered on the definition of goal interface, the classification of goal relations, and the application of corresponding negotiation strategies as heuristics for organization evolution.

In the case study, Tropos demonstrates its strength in modeling socio-technical systems, e.g., e-business systems. Tropos ontology also has the potential to model economic dependency network, e.g., business value chain. However it proves insufficient for representing temporal relations. Thus the dynamic aspects of organizations, e.g., market mechanisms, cannot be properly modeled with Tropos.

This study leaves much room for further investigation. The negotiation strategies in this model are partly based on research on distributed artificial intelligence, leaving an opportunity to automate the evolution process. In an ideal case, organizations and information systems can coevolve themselves in an autonomic way to meet new requirements from the business environment [10].

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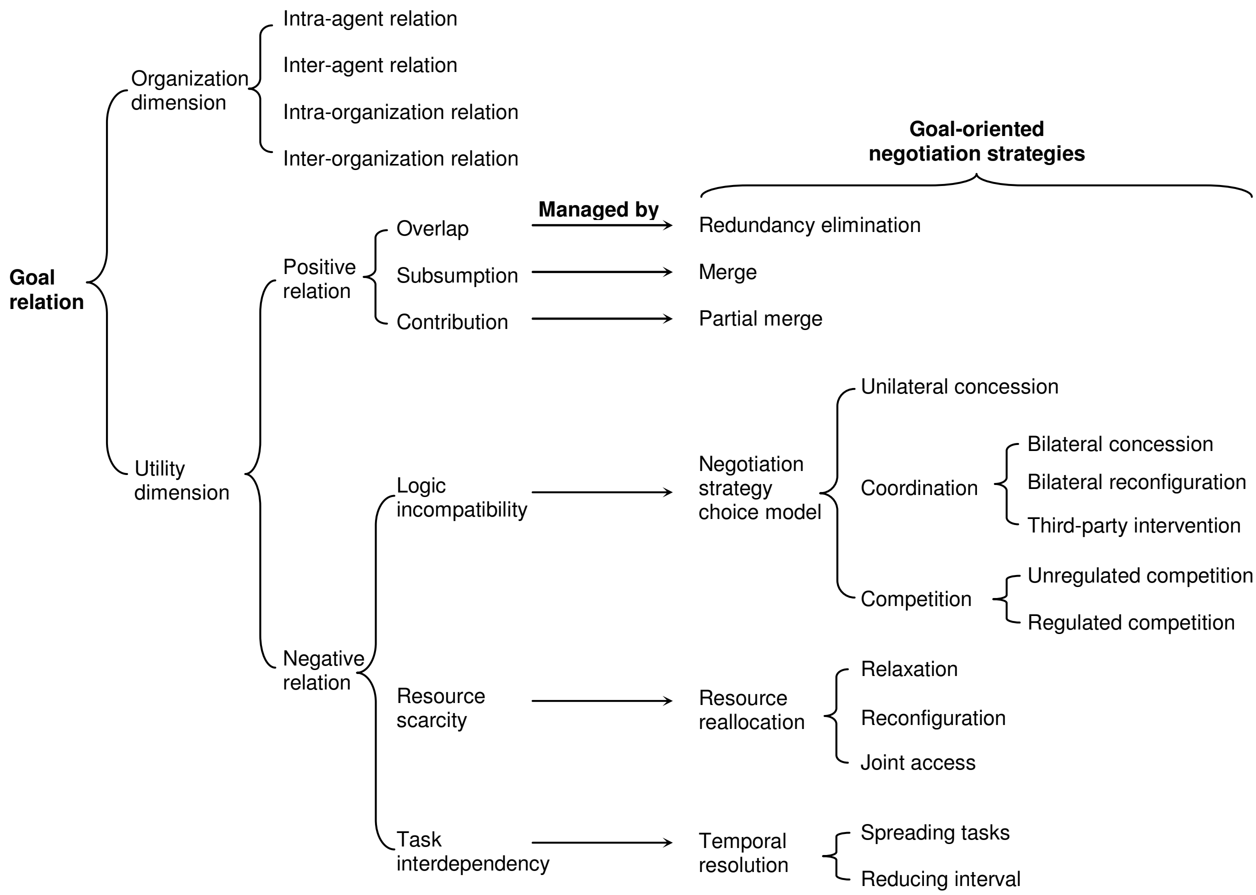
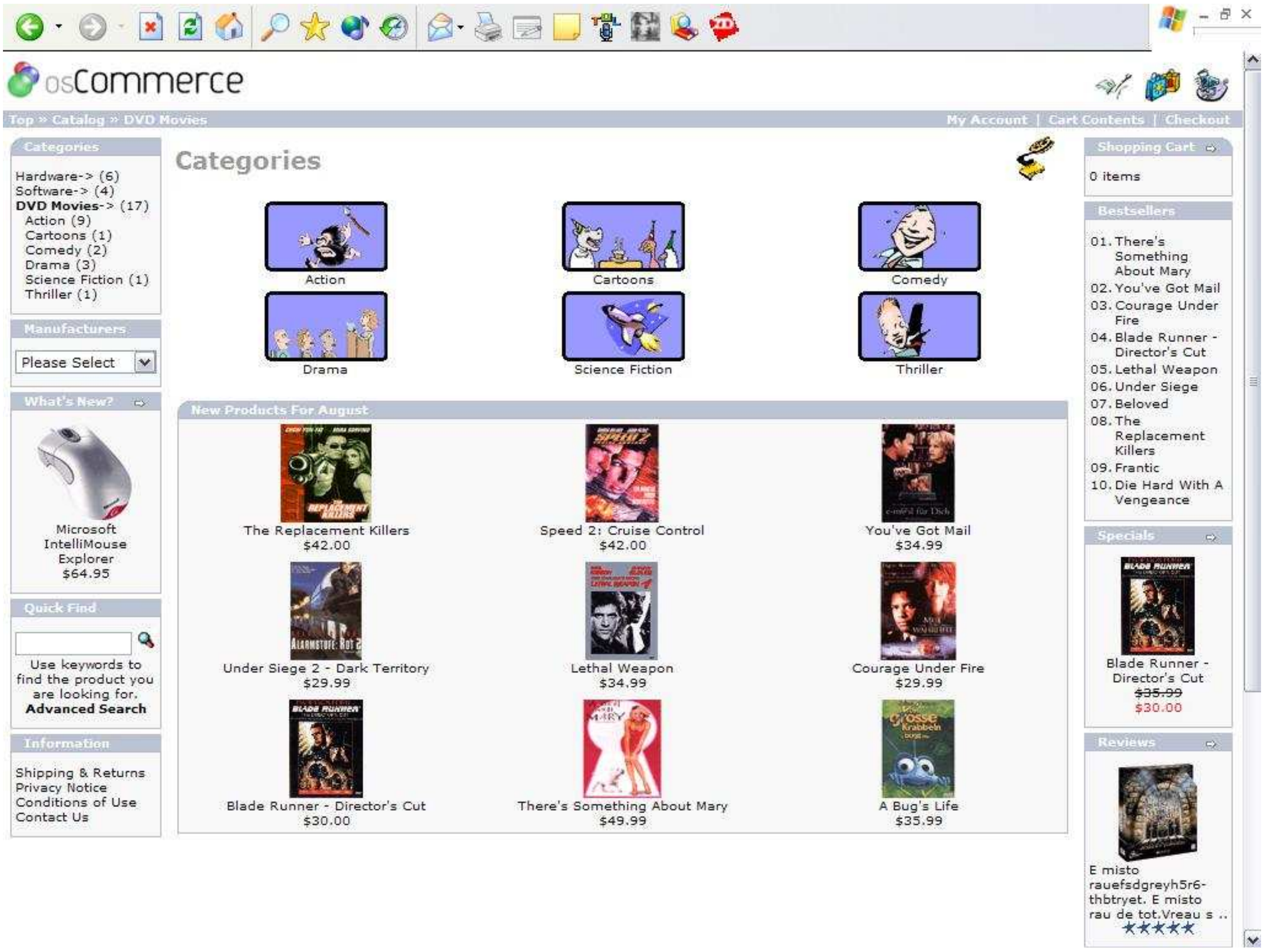
Appendix A. Goal relation taxonomy and corresponding negotiation strategies

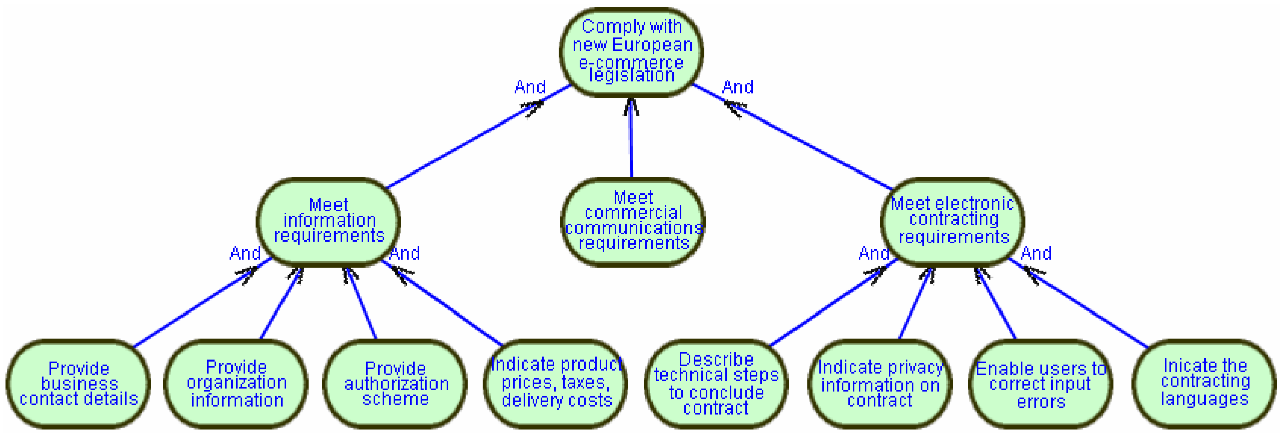


Appendix B. osCommerce online retail solution screenshot (product catalog)



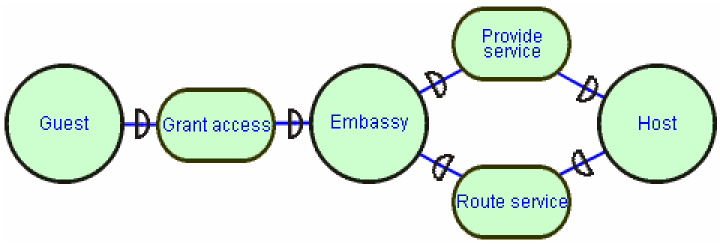
Appendix C. Managing the evolution of osCommerce under new e-commerce legislation

Step 1: Goal interface identification. First, an overall new goal hierarchy is elicited through asking *How* questions to the root goal, *Comply with new European e-commerce legislation*.

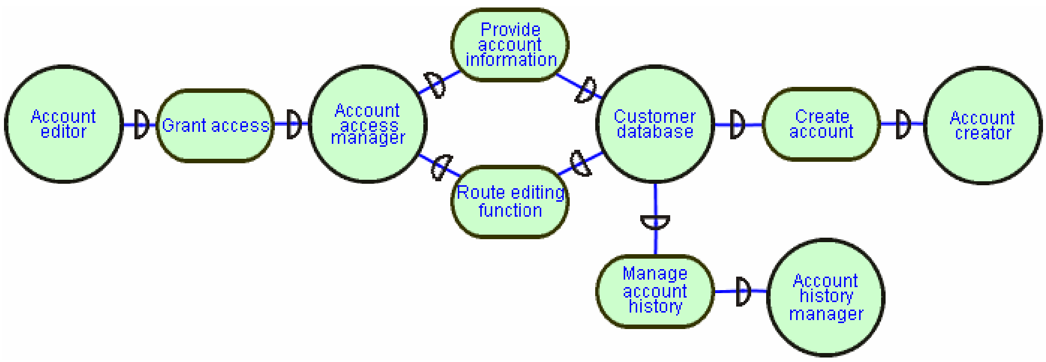


Elicited new goal hierarchy

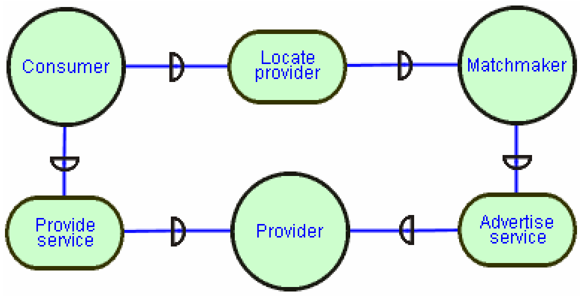
Detailed SD/SR models of osCommerce are abstracted from the source code. Model abstraction is based on certain organization patterns.



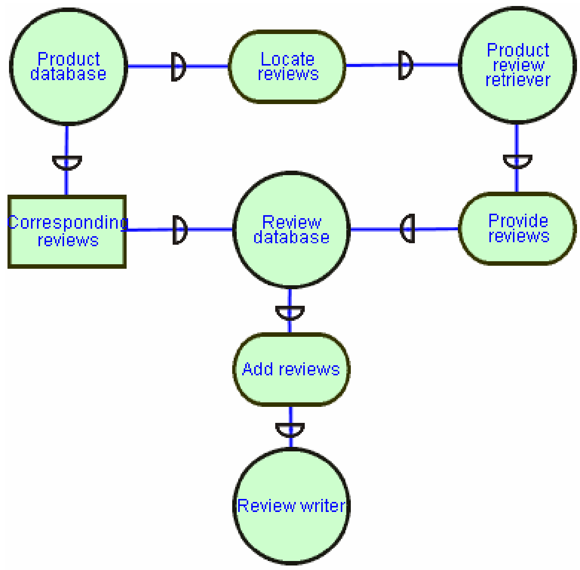
Embassy pattern



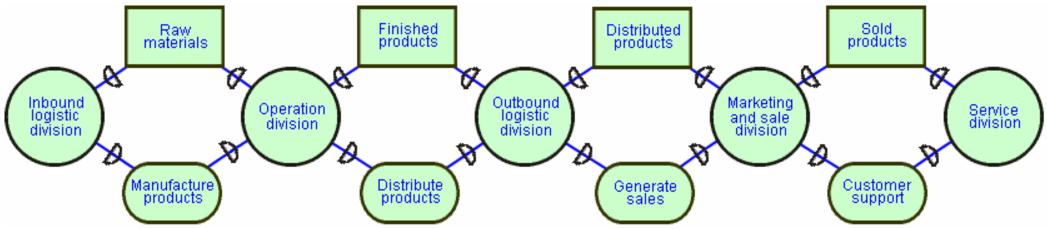
osCommerce customer account management SD model based on embassy pattern



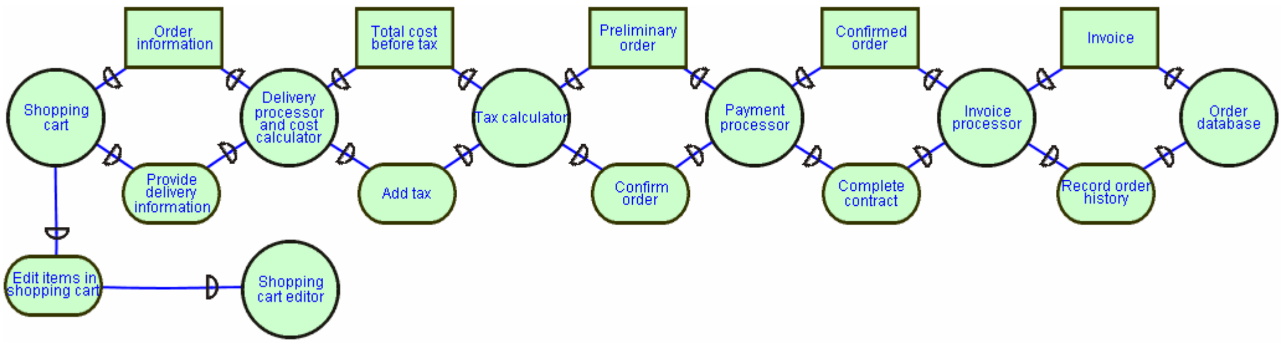
Matchmaker pattern



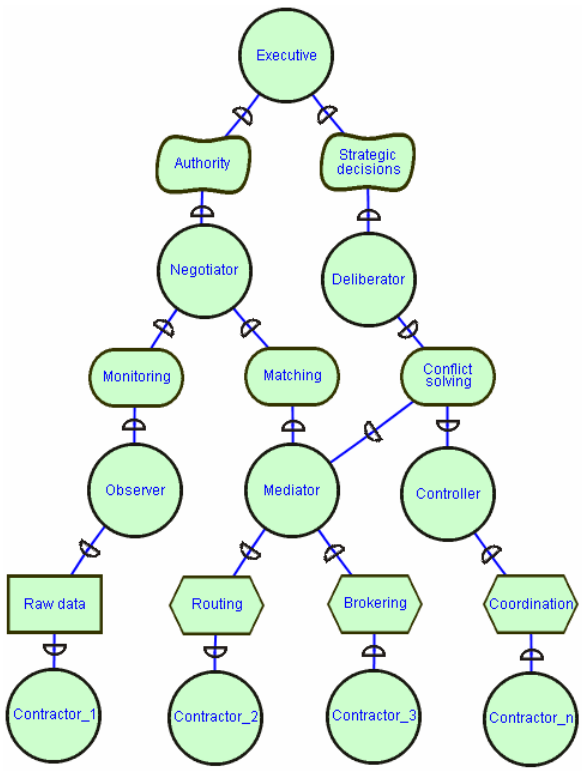
osCommerce product information management SD model based on matchmaker pattern



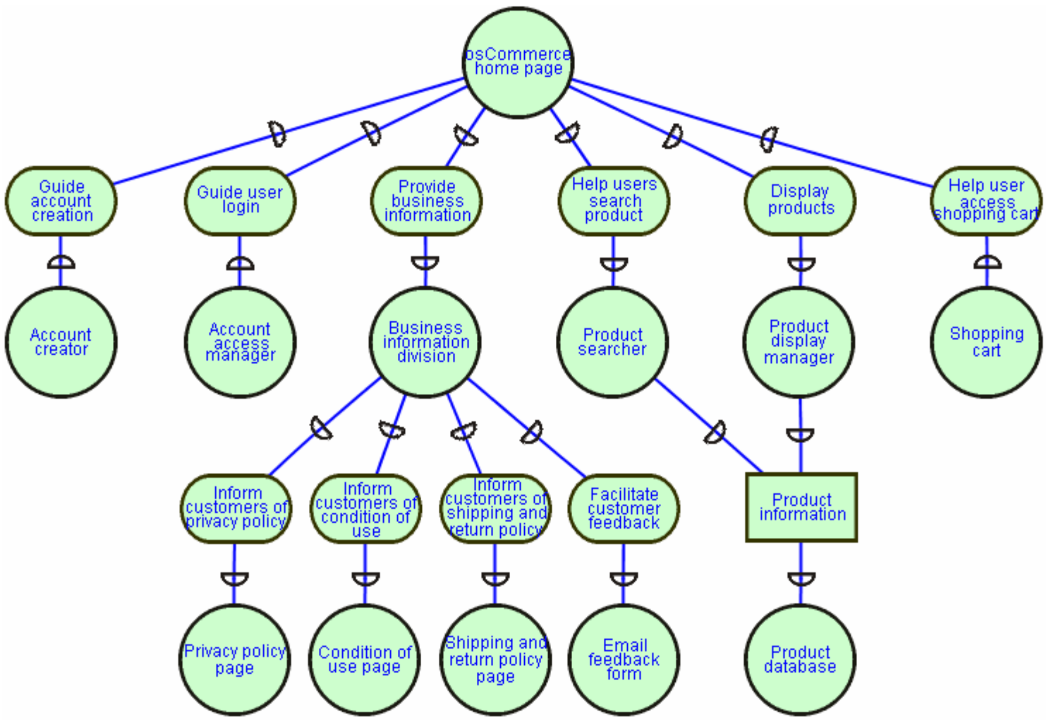
Value chain pattern



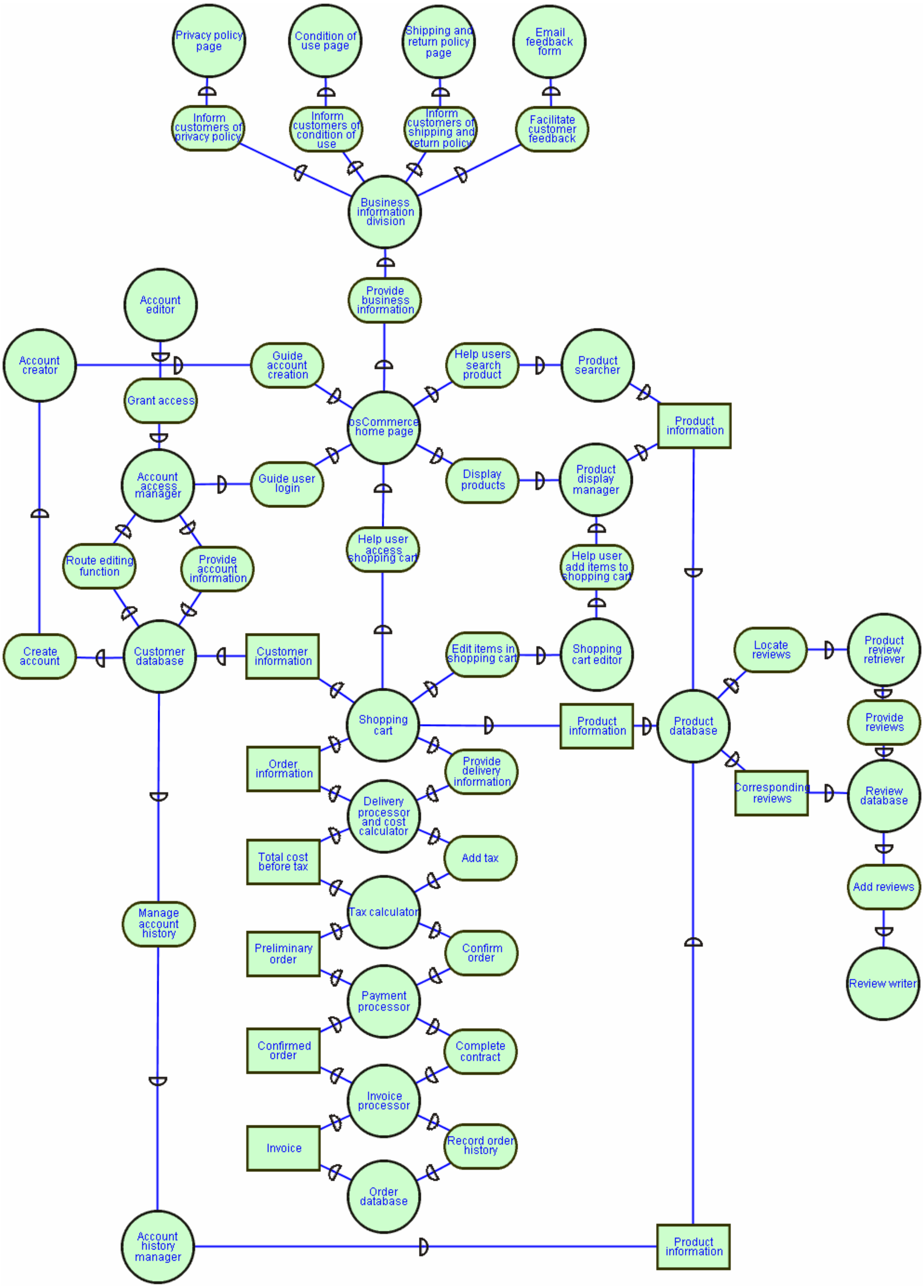
osCommerce order management SD model based on value chain pattern



Hierarchical contracting pattern

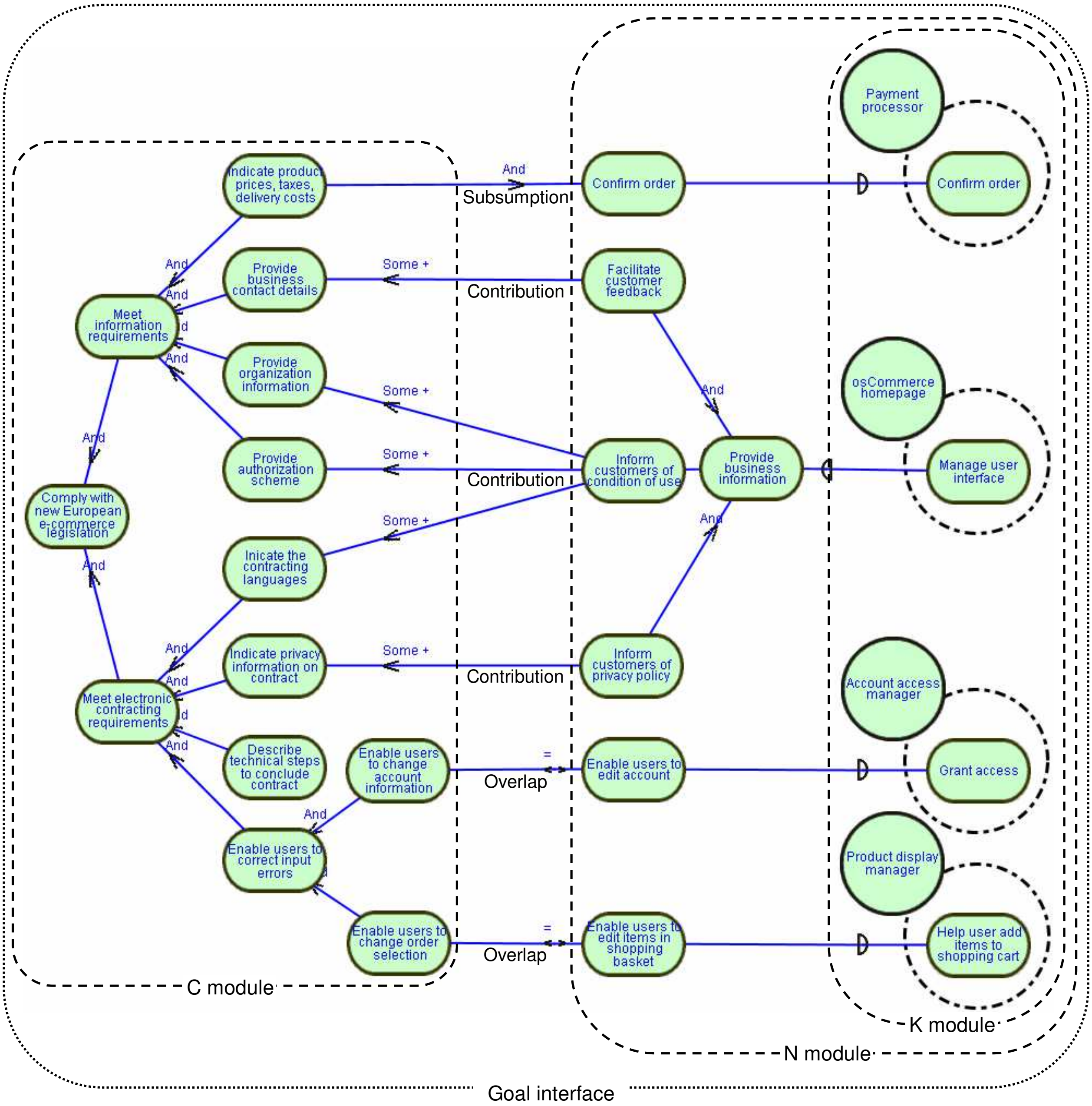


osCommerce store front SD model based on hierarchical contracting pattern



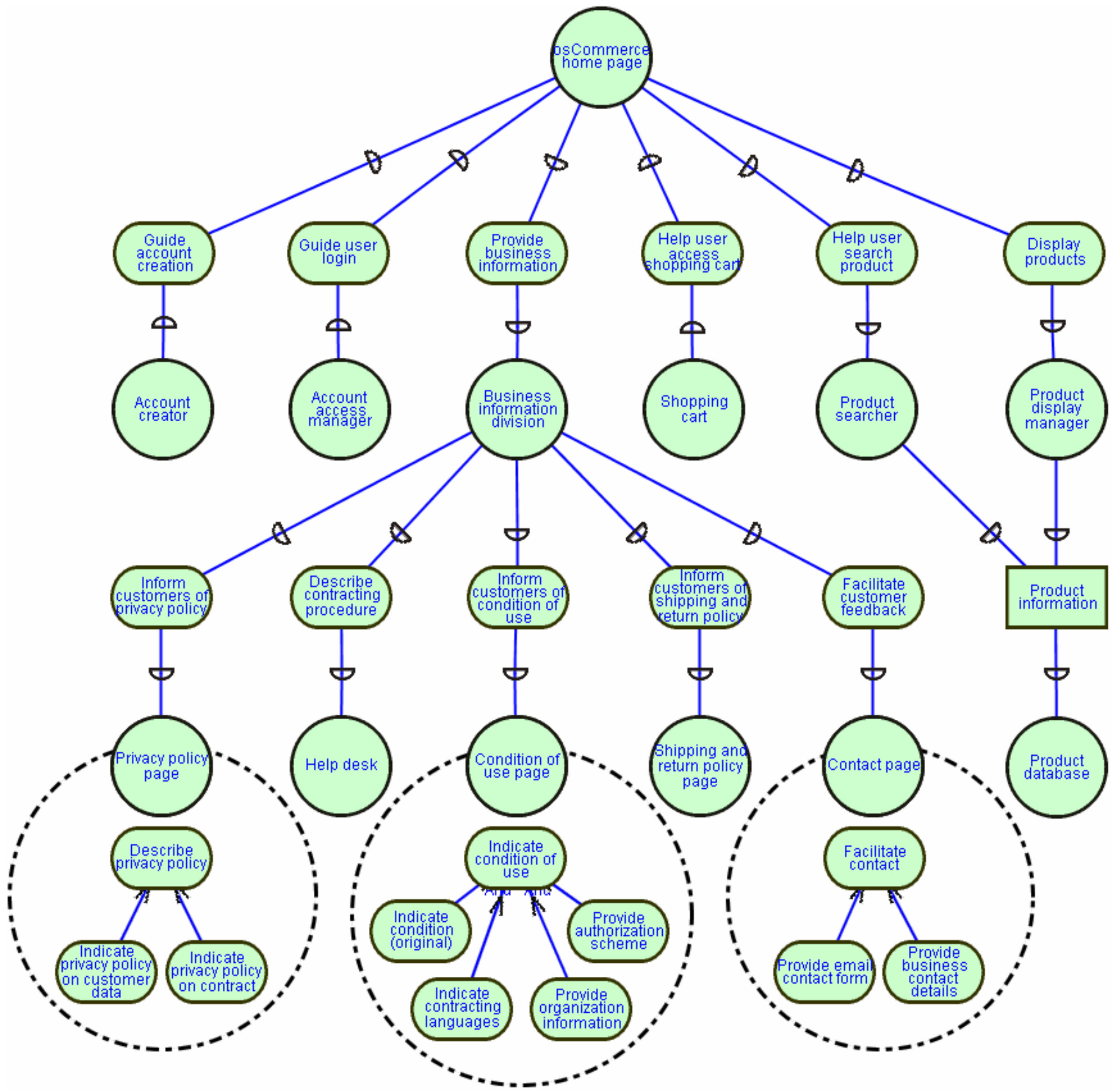
osCommerce overall SD model

N, K, C modules are captured through analyzing the new goal hierarchy and the overall SD model.



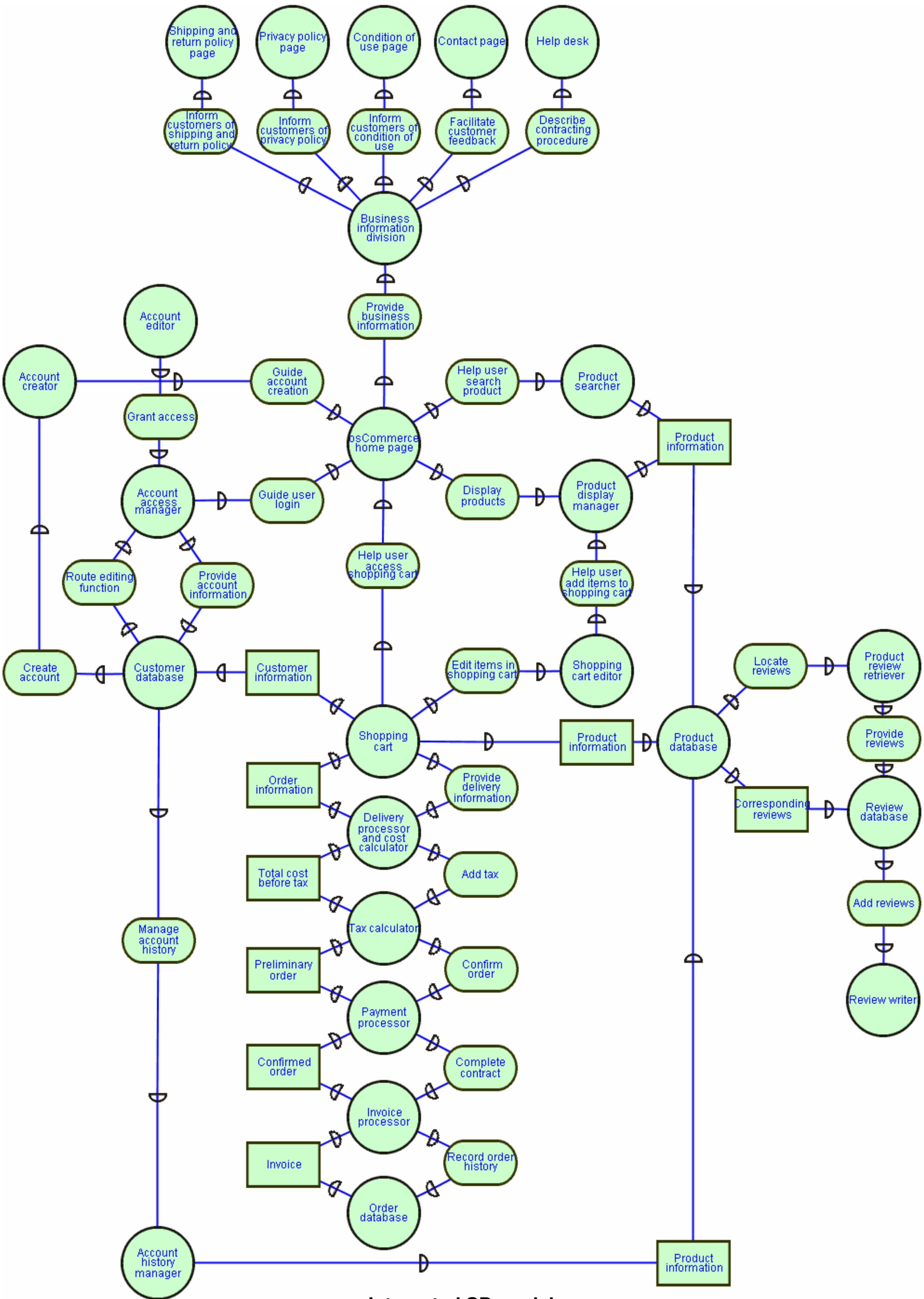
Preliminary goal interface

Step 2: Goal relation management. As shown on the previous page, three types of goal relations: overlap, subsumption, and contribution are detected in the preliminary goal interface. These relations are managed with corresponding strategies. The transformed goal interface is as follows. In particular, the goal *Inform customers of privacy policy*, *Inform customers of condition of use*, and *Facilitate customer feedback* have been modified. A new agent *Help desk* is introduced in order to describe contracting procedure.



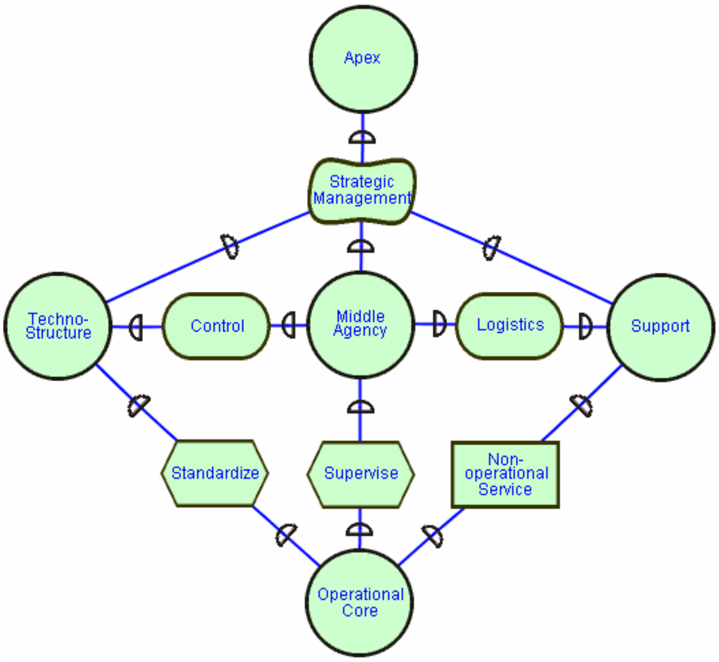
Transformed goal interface

Step 3: Goal interface integration. Transformed goal interface is integrated with the rest part of the overall SD model.

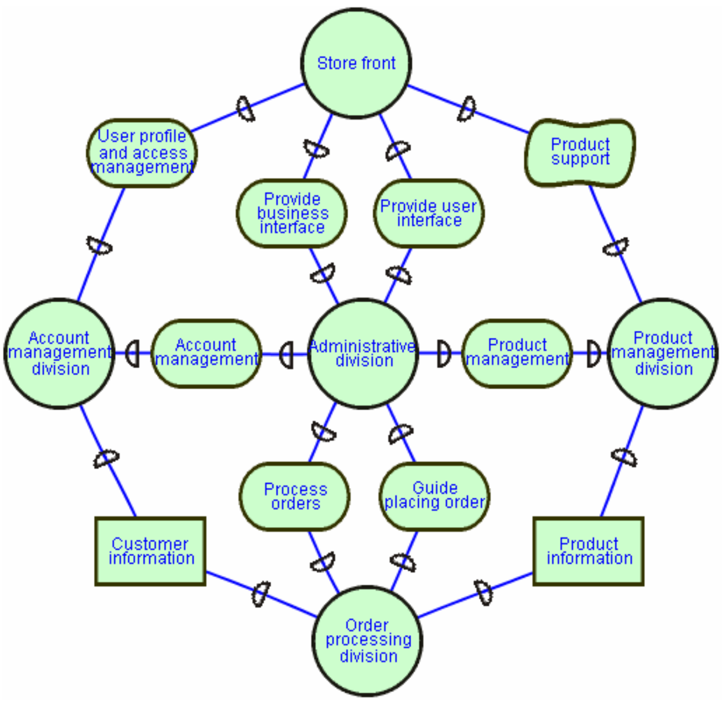


Integrated SD model

Structure-in-5 is selected as the organization pattern, based on which the organization architecture is generated.



Structure-in-5 pattern



osCommerce architecture based on structure-in-5 pattern

The constituent agents of the five actors in the organization architecture are listed in the following table.

Constituent agents of the actors

Store front
osCommerce homepage
Business information division
Shipping and return policy page
Privacy policy page
Condition of use page
Contact page
Help desk

Order processing division
Shopping cart
Delivery processor and cost calculator
Tax calculator
Payment processor
Invoice processor
Order database

Account management division
Account creator
Account editor
Account access manager
Customer database

Administrative division
Product searcher
Product display manager
Account history manager
Shopping cart editor

Product management division
Product database
Review database
Product review retriever
Review writer