Web Community of Agents for the Integrated Logistics of Industrial Districts

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Abstract

The industrial districts are characterized by the agglomeration of medium and small-sized industries, localized within a certain geographic area with precise social and cultural connotations. A crucial element of industrial districts is the existence of a wide immaterial flow of knowledge and information. In this sense, the industrial districts seem to have a network shape, rather than a hierarchical one.

The paper aims to rationalize the transportation flow within industrial districts. In particular, it focuses on districts in the first stage of the evolution process; that is, when a lot of companies exist, with low specialized level and absent inter-firm cooperation. Therefore, the considered industrial districts are characterized by non-linear mechanisms of interaction among a variety of entrepreneurs, each of them trying to get his target by conflicting with others, increasing the complexity of the system under examination and making more difficult the strategies for material flows rationalization.

In this situation, a system able to facilitate both the contacts among the agents and the negotiation processes, that creates a community of agents in a district with rare or absent relationships among different companies represents the most adequate solution.

The paper deals with the definition of the community of agents in a real situation, using the communityware tools: web electronic mediums that facilitate the contact with collaborators who have similar interests and preferences, but do not know each other. To define the similarity concept, a fuzzy algorithm is proposed.

1. Introduction

Industrial districts, whose main character is the agglomeration of medium/small industries, represented in the past and still represent a successful model of industrial production organization, a sort of Italian way to overcome the difficulties found by the big industry [5].

Since globalization makes industries compete within wider and wider markets, costs reduction through an appropriate and effective freight transportation system is really relevant for the economical development of the district. In this sense, an effective freight transportation system is a basic factor of benefit in competition for a certain area.

However, the rapid increase of transportation demand did not cause the same reaction in different transportation modes: while the road transportation increased dramatically, the railway transportation even came down. Motivation of such a behavior are found in the lack of flexibility, co-ordination among different agents and appropriate information, as well as in too high costs and inconsistent fares policy.

The growth of road transportation demand is rapidly obscuring the possible economical benefits coming from an increased territorial accessibility, and causes several negative impacts related to current transportation systems, like road congestion, accidents increase, acoustic and environmental pollution.

Actually, in last years several attempts have been made in order to eliminate, or at least to reduce, the environmental impact of transportation systems. Those efforts were basically directed in improving technological characters (for example, using less polluting fuels) and in any case run the risk of being compromised by a fast growth of mobility demand.

This growth cannot be faced by "modal" strategies; that is, replacing a transportation mode by another one [4], because any transportation mode seems ineffective in comparison with a production system more and more transport intensive. Then, the strategies for a more sustainable transport must be directed both in reducing the transportation demand and in building a transportation system integrating economical effectiveness and environmental purposes. To this aim, a higher and higher interest is growing in the field of rationalization of goods flows, which can be obtained through the integrated logistics, coordinating different operations of the logistic chain.

Coordination requires an appropriate information level for all agents about the strategies used by each logistic chain component: information is then a relevant factor in determining the quality of logistic service. The high number of subjects, operations and services involved in a logistic chain suggests the creation of a "community" system, able to communicate and exchange data and information: it is then possible to

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reach a satisfying organization level, anticipating the need of each agent, and not only reacting to agents' action or request.

According to such outlook, innovations in the field of Information and Communication Technology (ICT) can play a key role in the optimization of goods flows within the logistic chain, since they can improve immaterial flows, making more effective the information transfer both through reduction of transmission times and through completeness and clearness of transmission. The most relevant potential of ICT is its capacity to widen dramatically the framework of actions and relationships of economic subjects, supporting reticular systems of existing relationships and making easier their approach to new economic interlocutors [5]. The success of very fast and inexpensive communication tools, like Internet, increased the connection among enterprises, causing that they were linked and able to communicate among themselves. The new communication and cooperation tools allow users exchanging non-structured messages, and produce the bases for the creation of new cooperation frameworks, without complex procedures for coding and decoding of messages. Moreover, the network allows depressing enormously the cooperation costs, since increases the access possibility through a widened sharing of languages [5].

Starting from these considerations, this paper focuses on the attainment of a methodology that allows defining the architecture of an electronic tool able to improve the cooperation and coordination among distributed agents in the logistic field of industrial districts. From this perspective, researches dealing with the e-business and e-commerce could be considered very interesting. In particular, the definition of an *e-market place*, a virtual on-line market where different agents interested in the same problem can cooperate and exchange information quickly, has to be emphasized.

The paper is articulated as follows: in the next section, some problems related to the industrial districts and to logistics are introduced in order to formalize the problem to deal with; last sections are devoted to the architecture definition of a system matching demand and supply of logistics services.

2. The integrated logistics in industrial districts

The industrial districts are characterized by the agglomeration of medium and small-sized industries, localized within a certain geographic area with precise social and cultural connotations [6]. The industries are generally specialized in one or more production steps and are connected each other through a complex relationships network.

Some authors [3];[5] identify the reason of the success of industrial districts in their special forms of knowledge management. With respect to the use of scientific knowledge, typical in the big industry, the district cognitive processes are based on a heritage of languages and social relationships shared by several agents, allowing a fast circulation of information. The territorial context is the element able to connect the different subjects acting in an industrial district. Therefore, a crucial element of industrial districts is the existence of a wide immaterial flow of knowledge and information both upstream and downstream the chain [5]. Then, the industrial district seems to take a network shape, rather than a hierarchical one. This shape, on one hand helps in making the system more flexible; on the other hand, from the perspective of this research, it makes difficult to manage both the material and immaterial flows within the district.

Since the integrated logistics problem is firstly an information-sharing problem, it is fundamental studying the *information channels* within the district; that is, information flow and existing relationships among different companies, to facilitate the rationalization of material flows.

In the specific technical literature, several model for the analysis of inter-firm relationships are reported, like *the constellations of companies*, *the flexible specialization model*, *the forms networks*, etc [6]. Each of them emphasizes a complementary aspect of industrial districts, but they have a common starting point: inter-firm relationships and the continuous process of organization learning and knowledge spread always plays a key role for industrial districts [12].

The inter-firm relationships change following the evolution process of the industrial district [6]. That is, in the first stage (named Formation) the industrial district results from an agglomeration of craftsman-like companies with rare or absent relationships among themselves. In the next phases of the evolution process (Development and Maturity), a leader company emerges and the level of coordination among the different companies improves through stronger relationships.

Also the information flow changes during the evolution process. In fact, the speed of inter-firm information transfer grows with the codification level of such an information [1];[2], which is strongly influenced by the maturity level of the industrial district: in the Formation stage, the inter-firm relationships are rare, the knowledge transfer is made in an informal way (face-to-face discussion, etc.), the level of codification and, therefore, the speed of information transfer are low. In a more developed district with a leader company, it becomes important codifying the information in order to increase the information speed and improve the productivity efficiency.

Therefore, the methodology to be applied in order to rationalize the flows within the district is strongly related with the maturity level of the inter-company relationships.

As an example of industrial district, we propose the "shoes district" located in Barletta municipality, a medium town in Southern Italy. This industrial district is actually in the first stage of the evolution process: there exist a lot of companies, with low specialized level and absent inter-firm cooperation. Therefore, it is characterized by non-linear mechanisms of interaction among a variety of entrepreneurs, each of them trying to get his target by conflicting with others, increasing the complexity of the system under examination and making more difficult the strategies for material flows rationalization. In fact, with regard to freight transportation, each district company behaves like an individual agent: it contacts the transportation service provider just when it needs to send its products. The providers use almost always the road transportation mode, but the lorries are often not full, because the product quantity supplied by a single company is not enough to fill a lorry. This means a number of lorries larger than that one needed if the transportation requests coming from companies belonging to the same district were rationalized; in other words, if the companies agreed upon the shipment dates, so that they could use less means, but completely full, to ship the same quantity of products.

In this situation, a systems devoted only to coordinate different distributed agents seems not enough because the coordination process supposes a pre-agreement regarding the final goal. Therefore, a system able to facilitate both the contacts among the agents and negotiation processes, that creates a *community of agents* in a district with rare or absent relationships among different companies represents the most adequate solution.

3. Community of agents for the district logistics

As for management of material flows in the industrial districts, two kind of community can be identified: goods producers and services suppliers. The interaction between these two categories in a complex system like an industrial district seems to be difficult to implement. To improve those interactions an e-marketplace can be used. It could be defined as an electronic *agorá* where a set of persons or agents can be involved in exchanging services and information. The e-marketplaces are today primarily focused on the matchmaking of buyers and sellers [8]. For the industrial district logistic, the e-market place could be drawn according to the metaphor of the "butterfly market" (fig.1).

To define the e-marketplace, primarily the two interest communities have to be built up. To this aim, what is in specific technical literature about the creation of a coalition among intelligent agents is used. A coalition is a set of agents, each one with his own interests, who draw up a cooperation agreement to carry out a piece of work or achieve a goal [11]. A group has to be entrusted with a task when single agents cannot carry out sufficiently or at all the same task [10].

The cooperation process can be divided in the following stages [9]:

a) finding someone to collaborate with;
b) making contact with the selected people;
c) building a common understanding: that is, the identification of a goal and the way to reach this goal;
d) coordinating activities and work plans through communication among co-workers.

First two stages are emphasized in this research work, since it focuses on the creation of a customers' community. In fact, as already told, in the industrial districts taken into consideration, the inter-firm relationships are absent; that is, the companies do not know each other. Therefore, in order to allow collaboration among industrial companies and rationalization of material flows, the creation of a *community of customers* is needed.

In this sense, the communityware research field seems very interesting. In fact, the communityware can be defined as an electronic medium that facilitates the

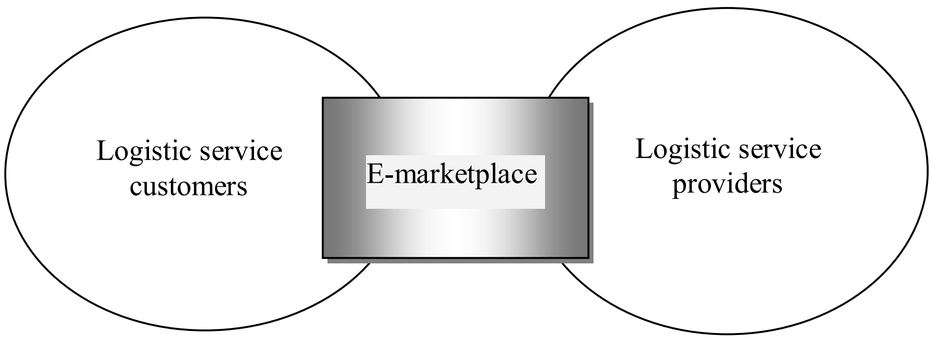


Fig. 1: Logistic e-marketplace

contact with collaborators who have similar interests and preferences, but do not know each other [8].

The communityware has to include essentially three different functions to encourage interactions:

a. knowing each other;
b. sharing preferences and knowledge;
c. generating consensus.

The basic idea is that multiple Internet Agents can form groups of people who share the same interests by analyzing the individual's interests. Resulting clusters can be used for cooperative solution of problems.

Concerning the system for the rationalization of material flow in an industrial district, the solving algorithm can be divided in two different stages:

a. creation of a customers community: identification of companies sharing the same interests with regards to the logistic and creation of contacts among them;
b. creation of coalition (workgroups) among the customers.

With regards to the latter, a peculiarity has to be underlined. According to the specific literature, the coalition among agents grows up as a function of the so-called expected pay-off of different agents. Assuming that the agents are *group-rational* [9], we can suppose that they decide to carry out the coalition only if coalition benefits are at least equal to the sum of benefits they could obtain carrying out the work by themselves.

In this view, the coalition among customers is quite anomalous, since it has neither the aim of increasing the single agents' effectiveness in carrying out a certain work, nor that one of increasing benefits for each agent. Its aim is to increase utility for the whole industrial district, thought as a system. In this case, the expected pay-off is made up by rationalization of material flows within the industrial district and a kind of ***coalition leader*** should be imagined [10], made up by a software agent, undertaking the initiative of forming the coalition among the interested customers agents.

To describe a framework as likely as possible in defining the coalition, the agents' rationality should be considered. In other words, although the basic reason for carrying out coalitions is the rationalization of goods transportation in the industrial district, the attractiveness of a coalition is related to the increase of utility perceived by the agents. In the real case, the agents involved in the coalition making are the companies existing in the industrial district. Therefore, it is essential to attract them showing that an integrated district logistics and, consequently, a reduction of transportation costs start up through a rationalization of goods transportation.

In the next section, the algorithms for making both community and coalitions among customers will be explained in detail; then, we will deal with the algorithm for coalitions among suppliers.

4. The rationalization algorithm for material flows

4.1. The customers' community formation

As we stated in the previous section, the first step to allow cooperation among unknown agents concerns the contact facilitation, that is the individuation of agents sharing same interests, and making easier the contacts among them. In order to support this process, attributes describing the individuals are required [8]. In this paper, the individuals' attributes concern the attributes of transportation demands: shipment time, destination, type of product, quantity of product, etc.

The algorithm for the community creation can be summarized as follows:

a. the customer gains access to the e-based system through the web and formulates his request regarding the shipment of a certain quantity of product toward a destination, using the user interface;
b. during this phase, the customer provides the system with some information about the transportation request, needed to start the negotiation with other agents;
c. when the user gains access to the system, his request is stored in a kind of customer database, where also other transportation requests are stored. This information is used by the customers' coalition leader, but other agents cannot enter this database;
d. the customers' coalition leader starts to browse the customers' database in order to identify similar requests. In particular, this agent looks for requests having destination points close to each other and similar shipment dates;
e. afterwards, the customers' coalition leader finds out the possible members of the customers' coalition. Since these members do not know each other, the leader agent sends them an advice regarding the coalition creation.

At the end of the last step, a *customers community* is created, including all the customers with similar transportation requests. The next steps concern the creation of the coalition, a sub-group of the community formed by the customers who reach an agreement, as described in the following sub-section.

4.2. The algorithm for the formation of customers' coalition

According to the scientific literature about the *coalition game theory*, the process of coalition formation among rational agents is composed by two main steps [9]:

1 first one, all possible coalitions are taken into account and their preliminary values are calculated;

2 second one, consisting of an iterative procedure made up of two sub-stages:
   a) the coalition value is recalculated;
   b) the agents choose the better coalition and create it.

At the end of the previous steps, the system knows all the possible coalition members, that is the customers included in the customers community. The next steps concern the creation of the coalition through different negotiation phases. The algorithm can be summarized in the following way:

a. the shipment dates for the members of the customers community are different for the customers in the e-marketplace. So, a negotiation between the customers and the coalition leader begins, in order to define for each agent the range of shipment date that he can accept. The transportation cost reduces proportionally to the width of this range, because the larger the range is, the greater is the customers' number that can be satisfied, rationalizing the material flow;
b. at the end of the negotiation phase, different clusters of customer agents will be obtained, according to the considered attributes (for example, shipment date and destinations). There will be customers ready to accept large, medium or small variation of the shipment data. This information is important for the creation of coalition; in fact, it is fundamental that the coalitions have some admission constraints [10]. In the case of coalition created to carry out some task, these constraints are represented by the agent's ability to carry out his piece of work. A coalition C is characterized by a capacity vector, equal to the sum of all coalition members capacity [9]. Of course, the coalition C is able to carry out its work if and only if the capacity vector is enough for that task. We can define different coalition among customer agents, each of them characterized by a different capacity vector. In this case, the agent capacity is linked to the attributes of the request that make more or less simple the creation of the coalition;
c. after the definition of the coalitions, the algorithm proceeds evaluating the capacity degree of each coalitions and choosing the best, that is the coalition in which the agents demonstrate the greatest agreement;

The information regarding the selected shipment period and the destinations is stored in the *customer coalition leader's* database. At this point, it is important identifying the suppliers able to carry out the work. For this reason, the customers' leader sends the information to another software agent, the *suppliers coalition leader*, which starts building the suppliers' coalition.

4.3. The algorithm for the formation of suppliers' coalition

For sake of simplicity, we assume that a community of logistic provider already exists. This assumption allows us considering the suppliers as a cooperative agents, ready to create a work team. In the real world, and in particular in a fragmented logistic market, such as that one characterizing the industrial districts, the logistic suppliers compete each other. Therefore it is difficult to reach an agreement. In this work we neglect this problem and assume that, after a pre-negotiation phase, a logistic suppliers pool already exists.

The algorithm can be schematized in the following way:

a. the information about the task to be performed is acquired by the *suppliers' coalition leader* and stored in his task list;
b. to perform some tasks, in most algorithms for creation of coalitions the leader finds out a possible task decomposition using his own *tasks reduction library* [9], that includes possible predefined task decompositions. With regard to the freight transportation problem, the task decomposition can consist in the individuation of different transportation modes, to be organized in intermodal way to reach the destination points. The number of sub-tasks and, therefore, the number of the agents belonging to the coalitions cannot be unlimited; in fact, to make the agents' environment as similar as possible to the real environment, it is assumed that they can communicate, negotiate and reach an agreement. For this reason, a too high number of agents can lead to a costs growth, since the communication, coordination and organization costs strictly depend on the coalition dimension. Moreover, in the case of freight transportation tasks, a high number of agents implies an increase of the costs linked to the numerous loading and unloading operations. Therefore, during this phase the coalition leader decides the maximum number of sub-task, considering the features of the tasks, that is the destination points and the shipment dates;
c. according to the fixed sub-task decomposition, the *suppliers' coalition leader* selects the ability needed to carry out any sub-task and browses the suppliers community of interest in order to select the agents with the required ability;
d. the leader sends to all the possible members of the coalition a message about the necessity of creating a coalition to carry out a task with well defined features;
e. any possible members of the coalition assesses the offer and chooses whether to adhere or not to the coalition;
f. each coalition is characterized by a capacity vector, obtained considering all members' capacity. Therefore, after the creation of different coalitions,

the *suppliers' coalition leader* evaluates the capacity vectors for each coalition, in order to identify the most effective coalition to carry out that task;

g. once the freight transportation is organized, all the information regarding this operation is stored by the *suppliers' coalition leader*. The leader sends this information to the *customers' coalition leader*, who shares them with the customers in the coalition.

5. The system architecture

Following the different steps of the algorithms, the architecture of the proposed system can be schematized as in fig. 2, where the system architecture is reproduced.

In the figure, the module of customers' coalition leader and the module of suppliers' coalition leader are reproduced in detail. Both have a communication module, allowing the agents communicating each other and to other agents in the e-marketplace. Additionally, there is an evaluation module, where information allowing the evaluation as to the possibility of including a certain agent in the ongoing coalition is stored. In particular, the evaluation module of the customers' coalition leader allows taking into consideration the transportation demands stored in the customers' database; then, the customers' coalition leader evaluates the similarity of different requests using the database rules, and identifies the agents submitting similar requests (in terms of shipment dates, destinations, kind of goods) that could take part in the coalition. The evaluation module allows the suppliers' coalition leader getting information about different available suppliers, and evaluating their ability in carrying out a piece of the work.

The customers' database is in the module of customers' coalition leader: information about shipment requests is stored in this database, and form the basis of evaluation process of similarity among transportation requests. Information is introduced in the database when the customer expresses the request and they are eliminated when the request is fulfilled by the suppliers. This module allows the leader getting information required to start the process of coalition creation, without spreading them among other agents that cannot enter the database. In this way, thinking information as important competitive advantages is avoided, since it becomes a common knowledge.

On the contrary, the database of the supplier coalition leader, once the transportation request is satisfied, does not change. In fact, it contains information concerning the supplier able to perform the transportation task. The transportation companies themselves insert this

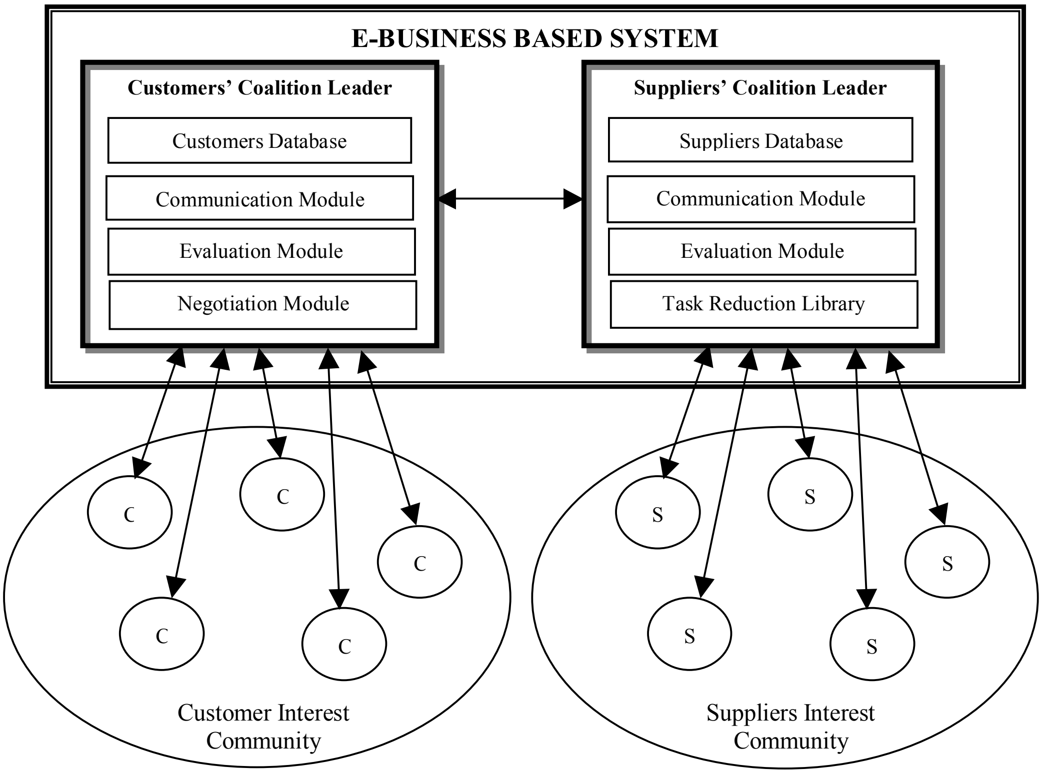


Fig. 2: E-business based system architecture

information, when enter the e-marketplace.

From the fig. 3 we can see that a software agent is associated to each human agent, both customer and supplier. This is because exchanging information as fast as possible during the process of coalition formation is very important. Moreover, using the *User Database Module* and the *Negotiation Module*, the customer agent makes easier the negotiation between the human customer and the coalition leader during the coalition formation process. In the first module, information regarding the service request is stored. The second module (Negotiation) acquires the information from the rather linguistic statements such as: "I will arrive soon" [13]. As for goods transportation, the distance between two different destinations can be defined using linguistic statements such as: "the destinations are far from each other". With this kind of information the human experts seem able to make decisions also in situation characterized by imprecise or lack of information.

Therefore, it seems appropriate to use the fuzzy logic to define the attributes for the coalition formation process. In fact, the fuzzy logic allows performing operation on variables defined in an approximate way and handling variables defined in linguistic terms.

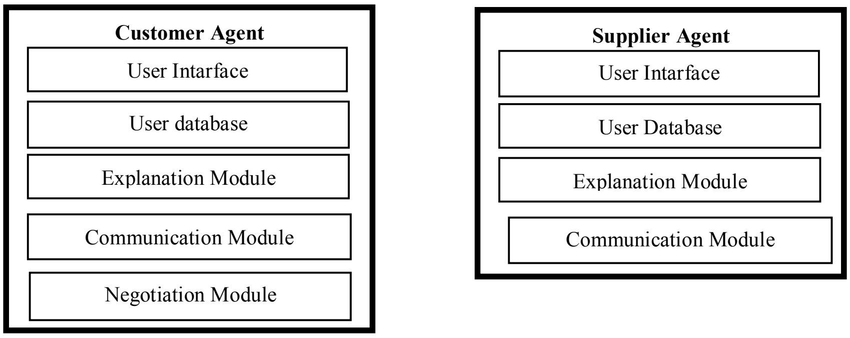


Fig. 3: Customer and Supplier Agent modules

database, and determines the criteria that can be used by the user during the negotiation; for example, whether he prefers to reduce the cost or to change the shipment date. Then, it manages the negotiation with the *customers' coalition leader*.

The explanation module, both in the customers' agent and in the suppliers' agent architecture, allows clarifying the coalition formation process for the end user. The user must be able to interact with the system, and to reach this goal; the system has to be "transparent": that is, the system has to be clear and easy to understand. The explanation mechanism has to provide information to make clear all the aspect of the system, and it also has to provide with the reasons that lead to particular outcomes during the evaluation process.

6. Use of fuzzy logic in forming coalitions

The algorithm for the coalition formation has some attributes difficult to define in a rigorous way. In fact, to identify the agents able to form the customers' coalition, the leader considers the customers with similar requests, with regard to the shipment date and destinations. The similarity concept seems to be difficult to define using *crisp* values. In the real world, the human reasoning is based on approximate values or linguistic statements instead of numeric or precise values. Usually, when we think about the travel time, we do not use statements like: "I will arrive in 17 minutes and 26 seconds", we use

To understand better the use of fuzzy logic in implementation of the proposed system, we focused our attention on the formation process of customers' coalition. The system identifies the possible coalition members comparing different requests and finding possible similarity. In particular, in our research we refer to the *Fuzzy Clustering*.

Let n be the number of customers, included in the *Customers Interest Community*, who expressed a request. Split now, on the basis of significant indicators that should characterize each request, these customers into c homogenous subsets (clusters), with $2 \leq c < n$. The customers belonging to anyone of the clusters should be similar to each other, and as dissimilar as possible from the objects of different clusters [15]. The concept of *similarity relation* is well known in the Fuzzy Sets Theory; it is a reflexive, symmetric, and transitive fuzzy binary relation. A similarity class can be defined as a fuzzy set in which the membership grade of each element represents the similarity of that element to a reference element [7]. For example, the numbers included in the table below represent the degree of similarity between the headers of corresponding row and column [14].

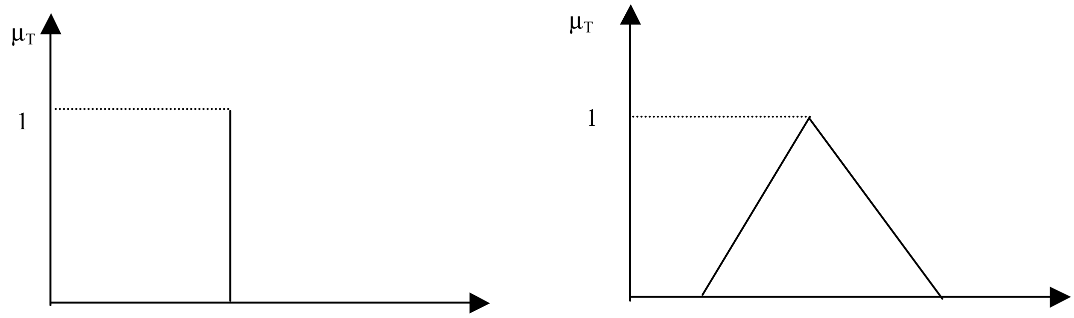
A similarity relation of a finite number of elements can also be represented by a *similarity tree* [14], in which each level represents an α – cut of the relation. That is, for each level we can individuate a threshold that defines the elements that belong to the fuzzy sets "similar".

Table 1. Example of degree of similarity

	X_1	X_2	X_3	X_4	X_5
X_1	1	0.8	0.4	0.35	0.1
X_2	0.8	1	0.3	0.5	0.5
X_3	0.4	0.3	1	0.8	0.9
X_4	0.35	0.5	0.8	1	0.7
X_5	0.1	0.5	0.9	0.7	1

During the creation process of customers coalition, the system considers two different relations: "X_i is close to X_j", as for location of destinations, and "T_i is similar to T_j", as for the shipment date of different customers requests. In particular, with regard to the destinations, the system uses the following algorithm:

a) the distances among all destinations are calculated, and a membership value representing the degree of truth of the statement "X_i is close to X_j" is assigned to each destinations pair $\{X_i, X_j\}$;



a) Fixed shipment date

b) Range of dates for shipment

Fig. 4: Examples of membership function of shipment date

b) considering all elements having a high membership value, a partition of the destination is made up. For example, from the Table 1 the following clusters are obtained:

$$(X_1, X_2), (X_3, X_4, X_5).$$

Since a cluster can be made up of more than two elements, the membership degree with which a destination belongs to that cluster is given by the formula:

$$\mu_{Xi} = \min \{S_{ik}\} \quad (k = 1,\ldots n)$$

where μ_{Xi} is the membership degree of the destination X_i, and S_{ik} are the degrees of closeness of destination X_i to each one of the n destinations currently included in the cluster under consideration. In other words, since the linguistic sentence affirming that X_i belongs to the cluster is "X_i is close to X_1 **and** to X_2 …. **and** to X_n", the logical operator *and* is used to obtain the degree of truth of the statement.

In the case of shipment date, the algorithm slightly changes, since a fuzzy number instead of a crisp one can be used to define the shipment date. The customers then can choose between two alternatives:

a) the shipment date is fixed. In this case the statement is: "I need to send the goods exactly in this date";

b) the shipment date belongs to a range. The statement is: "I need to send the goods approximately on this date".

The membership functions of these two statements are depicted in fig. 4a) and 4b) respectively; they represent also the satisfaction degree of individual customers for certain dates. It is clear that, the greater is the customer's availability to change the shipment date (the support of the fuzzy number), the greater is the possibility to find an agreement among the customers, and then less costs for the shipment.

Using the concepts of the Fuzzy Sets Theory, the degree of "shared satisfaction" μ_{Tij} for two customers having membership functions μ_{Ti} and μ_{Tj} as fuzzy shipment dates, is given by:

$$\mu_{Tij} = \max \min \{\mu_{Ti}(x), \mu_{Tj}(x)\}$$

To create a coalition among the customers, a set of shipment dates, that allow satisfying customers with a degree of shared satisfaction as high as possible, should be found.

For example, let:

- U_i (i = 1,…5) be five customers;
- X_i be the destination for shipment required by the i-th customer;
- T_i be the date of shipment required by the i-th customer.

Assume that the degrees of closeness among destinations are reproduced in Table 1, and the degrees of shared satisfaction μ_{Tij} are reproduced in Table 2.

Considering in this table the elements having a high degree of shared satisfaction, it is possible to create another partition of requests. In this case, the clusters are:

(T1, T2, T4) , (T3, T5)

Like in the previous clusters, obtained considering thegeographical distance, the membership degree of elements belonging to a cluster is calculated through the and operator.

Table 2. Degree of shared satisfaction

	T_1	T_2	T_3	T_4	T_5
T_1	1	0.8	0.4	0.9	0.1
T_2	0.8	1	0.3	0.7	0.2
T_3	0.4	0.3	1	0.1	0.9
T_4	0.9	0.7	0.1	1	0.3
T_5	0.1	0.2	0.9	0.3	1

At the end, different partitions according to different attributes are obtained; in this example, the attributes are geographical distances among destinations and shipment dates. In order to decide the possible coalitions among the customers, these different partitions should be combined using again the *and* operator: the i-th customer should be included in the cluster which X_i **and** T_i belong to. Therefore, the final partition with the possible coalitions is the following:

(U_1, U_2) ,(U_3, U_5), (U_4)

where U_i is, as before, the i-th customer.

This way the system finds the possible agents, members of different coalitions. Afterwards, it has to send to the chosen agents a message in order to give them an advice regarding the coalition creation and to make the coalition actual.

7. Conclusions

The e-business based system obtained using the proposed methodology is able to give a contribution toward the rationalization of the material flows inside an industrial district. In fact, it makes easier the creation of a virtual market place, a kind of electronic *agorà*, where customers and providers of logistic services can meet each other, can exchange information and knowledge, negotiate, reach an agreement, etc.

Actually, several systems similar to proposed one are available on the web, such as *Port Community System*, *Transport e-marketplace*, etc. They focus primarily on matching the demand and offer of logistic services. More in detail, they try to optimize the freight transportation optimizing the coordination among the different supplier agents, geographically distributed. Such a system considers the customer like a single agent who formulates a transportation request, whilst the proposed system considers the customers in an industrial district like an *agents community*, whose organization has to be optimized.

The proposed system is able to improve the immaterial flow of information and knowledge among companies belonging to the same industrial district. This ability of making easier the creation of customers' community is really interesting when the rationalization of material flow in a complex environment, like an industrial district, is involved. An industrial district is made up of a high number of companies, linked each other with a complex inter-firm relationships, that are rare or totally absent when the industrial district is in its first stage of the evolution process. In this case, the rationalization of the material flow of the whole industrial district is possible only if the companies increase the information flow, if they are ready to negotiate among each other; in other words, if they are ready to enroll themselves in a community.

Some more remarks can be made about information dissemination. The industrial districts are often made up of several companies strongly competing among each other; this means that companies are reluctant to share information, often thought as an important factor of competitive advantage. The coalition leader is then crucial to overcome this problem: information about the different companies are only in his database and are not accessible by other agents. The coalition leader runs the process of community and coalition, allowing the customer agents knowing only the information needed for the negotiation and basically concerning shipment dates and destinations. Actually, the coalition leader has the twofold role of diffuser and censor of information.

In the implementation stage, the system is built up along with customers in a collaborative environment, to make easier the creation of a confidence atmosphere, especially regarding the problem of information sharing.

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