An E-Market Framework to Determine the Strength of Business Relationships between Intelligent Agents

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Abstract

When an agent enters in an e-Market for the first time, it has no historical information that can be used to determine the strength of business relationship with participant agent, and must therefore rely on the reporting of other agents to prepare for negotiation with that agents. Beliefs of individual agents change through interaction with participant agents and are reflected in their on-going relationships. An understanding of business relationships is fundamental to understanding trade between both human agents in traditional markets and software agents in electronic markets. Two parties in the market establish agreement for mutual beneficial deals or contracts and therefore execute that deal or contract. Contextual information e.g., constraints, preferences, deadlines etc., during execution of the contract are unknown to each of the parties while they established the contract. Deviations between signed contract and executed contract are observed and used to measure the strength of relationship between two parties. We have presented an E-Market framework to describe how Institution Agent can assist for mining Outcome of Contract Execution by observing Argumentation Dialogues to determine how business relationship develops and evolves. In this work, development of an argumentation system is going on where Institution Agent observes the argumentation dialogue between buyer and seller agents. The results of observation are used to determine the strength of business relationship for future interactions between buyer agent and seller agent.

Keywords: Business Relationship, Commitment, e-Market, Institution Agent, Argumentation

1 Introduction

For hundreds, if not thousands, of years trade has principally taken place between agents (merchants) who trust each other. A weak form of trust may be derived from an agent's reputation. The strongest form of trust evolves from business relationships in which two or more agents have a history of reliable trade and, perhaps, the sharing of confidential information. A basic assumption of this work is that trust between software agents will evolve similarly from the relationships between agents in electronic market places. These relationships will involve the exchange of both goods and services, and information.

A Business Relationship is evidenced by an expectation of reliable and trusted trade in the future. If Intelligent Agents are to trade effectively in an e-Market they must therefore be able to model business relationships, and must understand how those relationships strengthen and grow, and how they weaken and die.The world of E-business and Multi Agent Systems differs from traditional markets in the speed at which trade can occur, and so too in the speed at which relationships can develop.

A negotiating agent are capable of exchange proposals, evaluate proposal, and also accept or reject proposals to reach mutual deals. The agent can exchange some additional meta-level information within the messages in the form of argument to explain her current position and future plans with an intention of successful negotiation (Jennings et al. 1998). A systematic comparison of argument based and bargaining based negotiation framework (Rahwan et al. 2004*b*) shows that new information in arguments may help agents to change preferences, increase the probability to establish deals and increase the quality of deal. The authors (Rahwan et al. 2004*b*) also agreed that argumentation may lead agents to worse outcome. Different levels of Reputation (Sabater & Sierra 2002), Commitments (Norman et al. 1998, Jennings 1993), Trust (Sierra & Debenham 2005, 2006, Mui et al. 2002), and Relationships (Sierra & Debenham 2007, Ashri et al. 2003, 2005) etc. between two agents are important factors in agents internal decision making process which leads successful or failure termination of argumentation. The authors (Sierra & Debenham 2007) presented a LOGIC framework and uses *Confidence* as a generalized concept of trust, reliability and reputation measures. An agent capable of performing argument based negotiation needs to evaluate arguments and updating the mental states, generate arguments, and finally select argument (Jennings et al. 1998, Rahwan et al. 2004*a*).

Repeated contract establishment and the outcomes of contract execution should have a major effects directly or indirectly on existing relationships. In our work, contract is composed of a pair of *commitments* between two agents. Intelligent agent involves in e-Market exchange information with other agents through argumentation to establish, modify or sustain contract and relationship develops or evolves between agents due to the result of contract execution especially the deviation between signed contract and executed contract. Hence, we could measure the expectation to establish future contract between two parties in similar dimension by analyzing the outcome of contract execution. The motivation of this work is to measure the strength of business relationships in the e-Market populated by Intelligent Agent.

The following section provide an overview of business relationship with definitions of some important terms used in our work. Section 3 describe the overall e-Market framework for agents to build business relationships and also discusses the issues related to argumentations between agents in an e-market. Section 4 discusses about determining the strength of business relationship showing the need of Outcome database. Next section introduces the evolution of Business Relationship in e-Market. An overall discussion containing concluding remarks are given in Section 6.

2 Background

In the market, a potential number of buyers and sellers are involved in negotiation to buy and sell goods and services. Negotiation is as much of information acquisition and exchange process as it is an offer exchange process- one feeds off the other Debenham (2004*a*).There are some frequent parties in a market who are trying to make deals repeatedly with a minimum amount of effort/time spent by them for negotiation. The history of interactions between different parties plays an important role to develop relationships between them which will simplify negotiation dialogues. Such interaction history involving mutual dealings between two people or parties or institutions are the foundation of any relationship.

Business relationship sometime becomes a never ending relationship, where as sometime relationship might be break down due to some special circumstances. Different types of relationships through interaction in multi-agent systems e.g., dependency, competition, collaboration etc. are identified in Ashri et al. (2003). Customer provider relationship is the expectation of an infinite number of future interactions (or at least the inability to know when the last interaction will occur) that induces customers and providers to cooperate for their mutual gain Schultze (2003). An understanding developed between two parties to provide regular business services for their mutual gain is the basis to build Business Relationship. In the e-Market of Intelligent agents, relationships between agents are developed mainly based on their interaction history especially on the outcome of contract executions.

Contract,C is a pair of commitments $\{(C_\alpha, C_\beta)\}$ between two agents, α and β such that both parties agreed to fulfill their part of commitment in some specific or open time after contract establishment.

Contract Execution, C_E is the enactment of pair of commitments by two parties, where commitments pair are the elements of Contract,C and was enacted with or without any deviations by the parties after Contract Establishment.

Outcome of Contract Execution is an object defined as the evaluation made by Institution Agent on a certain pair of Commitments contained in a contract at the execution time.

Business Relationship between two agents in e-Market is defined as a set of all the historical outcomes of contract executions between two agents from which expectation of future *Contract Execution* can be derived to establish deals or contracts between them.

Strength of Business Relationship in a dimension between two agents is the probability or expectation of the outcomes of contract execution in that dimension and this expectation is derived from historical outcomes of contract execution contained in Business Relationships between two agents.

At any moment of time, t_i relationship between two parties is a set of outcomes represented by $r^{t_i}(\alpha,\beta)$. The strength of relationship in a given dimension, d_j between two parties at time, t_i is the probability or expectation of future contract(φ') execution from a given signed contract(φ) in the dimension, d_j, i.e., $P^{t_i}(\alpha,\beta,\varphi[d_j]) \in [0,1]$ which means α's estimation of the strength of relationship between the pair of parties (α,β) in the dimension, d_j at time, t_i derived from $r^{t_i}_{d_j}(\alpha,\beta)$.

3 An E-Market Framework to Build Business Relationships

In the e-market, agents negotiate to fulfill their need and try to *establish* long term relationship to simplify the process of fulfilling the need. The result of a successful negotiation is the contract signed by two parties which will be executed by the both parties for a specified period in future. There may exist significant deviations meaningful to both parties due to some unknown variables during the contract establishment time. In order to model business relationship, agents use the outcome of executed contract in order to *modify* signed contract if any issue arises or *sustain* on-going or future contracts.

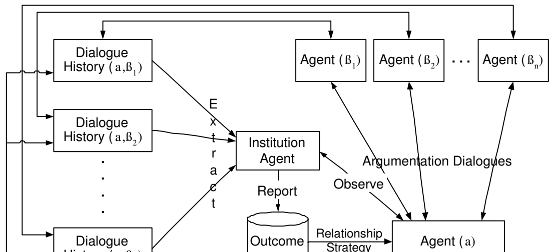

Figure 1: An e-Market Framework to Build Business Relationships

Institution agent observes the execution of contract. Buyer agent or seller agent who counts business relationships will use the result of observation reported in Outcome Database as shown in Figure

1 and use a systematic the steps in our methodology. In our prototype system, we have introduced an institutional agents, who facilitate buyer or seller agent to observe what is happening in the electronic market. We are further developing our system to cover all steps of our methodology. The outcome of our completed work will give us an experimental tool to extend buyer and seller agent to accommodate different algorithm or procedures to study business relationships. Conducting some experiment using our developed prototype system are included in our future research plan. We have introduced Institution Agent to observe the activities between two parties during the execution of the contract and the outcome of observation can be used to measure the strength of business relationship. We are dealing the observation into three phases: Establish Contract, Modify Contract, and Sustain Contract.

- **Establish Contract**
  This phase deals with observing the argumentation between buyer and seller agent and after the agents reach agreement, the Institution Agent will extract the agreed deal from current argumentation dialogue and report *Signed Contract* to both agents. In our work, we describe a *deal* as an aggregate object of an Item and a Free Item i.e., $Item[quantity, price] + FreeItem[quantity, value]$. For example, $Banana[10K, \$20]+Discount[1, 10\%]$ is a deal represents 10% discount on the price $20 for 10K Banana.

- **Modify Contract**
  Institution Agent receives information during execution time from both agents, and fetch information regarding signed contract and assess the changed condition, and report *Modified Contract* back to the concerned participants. As a result, future interaction between pair of agents will be successful. Free item serves a negotiation stance to modify deals. If buyer agent prefers delivery or some free item, both parties can find some alternate deals by modifying previously signed deal, e.g., $Banana[10K, \$20, quality = Top] + Nothing[1, 0]$ with deals either $Banana[10K, \$20, quality = Medium] + Delivery[1, \$5]$ or $Banana[10K, \$20, quality = Top] + Delivery[1, \$5, DeliveryTime = 2\ days]$ during execution time.

- **Sustain Contract**
  Argumentative illocutions e.g., reward, threat or appeal gives wider options to agents for contract execution to maintain minimum deviation with signed contract. Agent use argumentative illocutions to exchange execution time information so that agents can sustain an on-going contract. Sacrifice in one deal and get reward in future deals will reduce argumentation break down. If buyer demands delivery of a Top quality Item, but seller offers delivery with medium quality. Here buyer can declare reward for providing top quality, by passing some private information as a result seller agree to provide free delivery. $reward(deal, info)$, where $deal = Banana[10K, \$20, quality = Top] + Delivery[1, \$5]$ and $info = Need(Apple[10K, next\ week])$. Seller agent can appeal to give Free Pineapple instead of discount. $appeal(deal, info)$, where $deal = Banana[10K, \$20, quality = Top] + Pineapple[1, \$5]$ and $info = Delivery[1, \$5, DeliveryTime = 2\ days\ [delivery\ van = full]$. Sharing private information during contract execution time allows agent to sustain contract.

In this work, we have given concentration mainly on contract establishment. The evolution of relationship will be occurred in two steps: global evolution of the environment i.e., sharing public information and local evolution inside individual agents i.e., sharing private information. Our methodology consists of the following steps and the whole conceptual framework is presented in Figure 2.

- Select a Strategic Moves for argumentation between buyer and seller agents. e.g., Seller will give 10% discount on some items.
- Observing Argumentation Dialogue between two Agents over a period of time
  - Observe the argumentation for contract establishment between agents
  - Institution Agent observes the contract execution between agents
- Calculate the deviation between signed contract and executed contract
- Institution Agent reports deviation to concerned parties
- Search historical dialogues about the contract execution between two parties for the selected and/or similar Strategic Moves
- Based on the deviation on historical data and current contract execution, estimate important parameters that affect the relationships
- Analyze the evolution of Relationship

3.1 Illocution and Language

The illocutionary particles used in Sierra & Debenham (2006) are Offer, Accept, Reject, Withdraw, Inform, Reward, Threat, Appeal. To implement argumentation context mining system, we have added few more illocutionary particles *query, sold, paid, bye, others* etc. having simple semantic meanings and syntax. We have used two illocutionary particles *sold, paid,* which are different from other illocutions because these illocutions are used by Institution Agent for analyzing deviation between utterance and subsequence execution. We are also using a simple content language (info $\in L$) using ProLog like syntax for internal representation of propositional content contained within illocution that both agents have agreed to use. For simplicity of the system, we assumed that both parties have sufficient capacity to communicate with each other using this language. Message contains the vocabularies from defined ontology and deal object. Deal object is a aggregate object derived from objects in item and free item ontology.

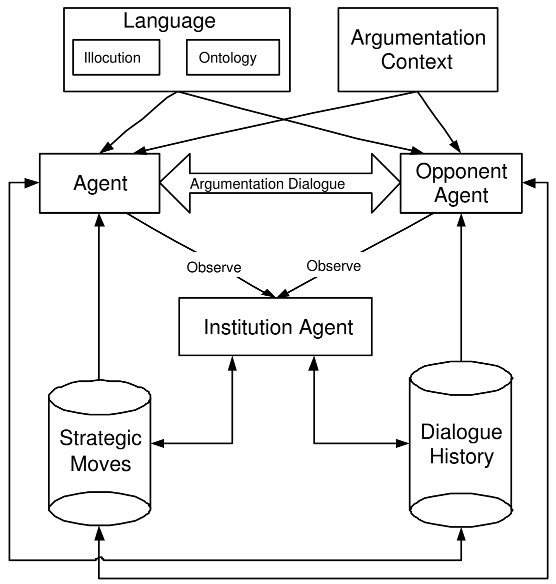

Figure 2: Conceptual Framework of an Argumentation System between Intelligent Agents

In this work, we are using the illocution particles with the following syntax and meaning adopted from Sierra & Debenham (2006).

- *inform(Need(deal))*. Buyer agent informs seller agent about buyer's interest to make a deal or sign a contract in line with some Strategic Moves.
- *offer(deal)*. Seller agent offers a deal to buyer agent which may differ from buyer agent's expected deals in line with some Strategic Moves.
- *accept(deal,[info])*. Buyer agent accept seller agent's previously offered deal. Buyer agents may include additional feedback information to seller agent. The feedback contains positive or negative impression on seller agent's offer.
- *query(deal,[info])*. Any agents ask question to the opponent agent to explain a previous deal. Agents may include additional feedback information to another agent. The feedback contains positive or negative impression on previous deal.
- *reject(deal,[info])*. Buyer agent reject seller agent's previously offered deal. Similar to accept, buyer agents may also include additional feedback information to seller agent. The feedback generally contains negative impression on seller agent's offer.
- *withdraw(deal,[info])*. Agent break down negotiation. Agent may also include additional feedback information, which generally contain negative impression on previous offer.
- *reward(deal,[info])*. Intended to make the opponent accept a proposal with the promise of additional free item as complements. Optionally, additional information in support of the deal can be given.
- *threat(deal,[info])*. Intended to make the opponent accept a proposal by committing some activities which the opponent does not desire. Optionally, additional information in support of the deal can be given.
- *appeal(deal,[info])*. Intended to make the opponent accept a proposal as a consequence of change in belief that the accompanying information might bring about. Agent passes additional information in support of a deal. Appeal can be understood as a combination of an offer and an inform.
- *sold(Item)*. If the previous illocution is accept, the seller agent physically send items and inform buyer by sold illocution.
- *paid(Item)*. After receiving the item, buyer agent inform seller agent what buyer agent have paid. It is also an acknowledgement message.
- *bye()*. The last message by both participants in the e-market is bye(), whether or not the deal is successfully executed.

3.2 Ontology

To interact agents in an electronic market, we need an ontology (Kalfoglou & Schorlemmer 2003) representing the set of concepts, classes, relations, and functions. Two basic ontologies: Item Ontology and FreeItem Ontology are used for defining deal object $deal = Item[issues] + FreeItem[issues]$ and argumentation dialogue using illocution and ontology allows agents to establish, modify and sustain deals.

Item Ontology is defined by its vocabulary, concepts and relationships Vocabulary of ItemOntology={Item, Fruit, Vegetable, Apple, Banana, Tomato, Potato}
Item(Name,Type)
Fruit(Name)
Vegetable(Name)
isa(Banana,Fruit)
isa(Apple,Fruit)
isa(Tomato,Vegetable)
isa(Potato,Vegetable)

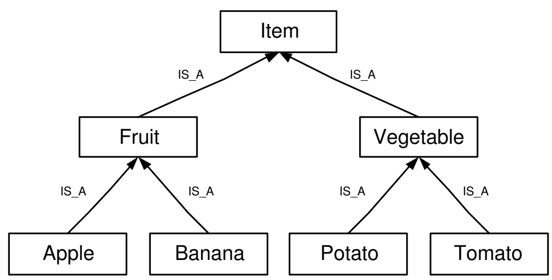

Figure 3: Item Ontology

FreeItem Ontology is defined by its vocabulary, concepts and relationships
Vocabulary of FreeItemOntology={Discount, Delivery, Coupon, Pineapple, Movie, Nothing}

Discount(ItemName, Value)
Delivery(ItemName, Value)
Coupon(ItemName, Value)
Movie(ItemName,Value)
Pineapple(_,Value)
Nothing(_,Value)

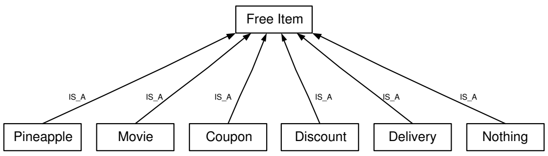

Figure 4: Free Item Ontology

We also measure semantic distance which refers to the notion of relative or useful distance between concepts across the ontology. There observed some deviations between agreed deal and executed deal in some dimensions. So, we need to measure deviation for argument evaluation and decision making process. We use semantic distance between two concepts in Item Ontology on the path length over the ontology tree and the depth of the subsumed concepts on the shortest path between the two concepts (Roddick et al. 2003).

- According to Roddick et al. (2003), if l is the shortest path between the concepts, h is the depth of the deepest concept subsuming both concepts, and k_1, and k_2 are parameters scaling the contribution of shortest path length and depth length respectively, similarity between two concepts c_1 and c_2 are defined as,

  $$Sim(c_1, c_2) = e^{-k_1 l}.\frac{(e^{k_2 h} - e^{-k_2 h})}{(e^{k_2 h} + e^{-k_2 h})}.$$

  Function for Semantic Distance between two items in Item Ontology is approximately represents the following information:
  $Sim(c_1, c_2)) =$
  $$\begin{cases} 0, & c_1.name = c_2.name \\ 1, & c_1.type = c_2.type \wedge c_1.name \neq c_2.name \\ 2, & c_1.type \neq c_2.type \wedge c_1.name \neq c_2.name \end{cases}$$
  For example,
  Sim(Apple,Banana)=1 and
  Sim(Potato,Banana)=2

- We have also used another simple function to estimate semantic distance between two free items. Function for Semantic Distance between two items in FreeItem Ontology is defined as the difference of values of two free items. For Example,
  Sim(Discount(Item,20),Delivery(Item,15))=5 and,
  Sim(Discount(Item,20),Movie(_,10))=10
  The value of an FreeItem will be determined by seller agent and honest reporting of the value of FreeItem is assumed in this work.

3.3 Argumentation Context

Context (Sierra & Debenham 2007) represents previous agreements, previous illocutions, ontological working context, institution norms, and some external parameters that have direct or indirect affect on agents current argumentation. Argumentation Context should contains a subset of historical dialogues which influence the target of current dialogue in such a way that agent can resolve some conflict or achieve some critical goals or reduce the risks of uncertainty or produce some conflict. Agent can extract some candidate arguments or issues in current negotiation threads through contextual analysis. Contextual analysis helps agent in generating and sequencing alternative goals in order to reach mutual decision in bargaining. Context may be a simple form of representation of bindings of issue-value pairs in line with current dialogue. Extraction of relevant issues with their value in real-time in electronic market is a complex research problem. The values in each issues will be revised using initial value, decay limit distribution function when no further information is received for a given time period. Once, some information arrives the values in each issues will be revised using posterior distribution function provided that the arrived information has a significant impact on future dialogues. We can construct a context tree or graph from the historical data from each agent. While the execution proceeds, due to some new contextual information, the context tree or graph will evolve to reflect the contextual information. Each agent will maintain contextual reflection of its own. For simplicity, we refers context as a set of beliefs that modifies agent's default actions during the offer generation or offer evaluation time. Context might have negative, positive or no effect, and detail investigation on Context Monitor, Context Network and Context Miner to obtain Processed Context from Raw Context is going on.

- In an argumentation dialogue, seller agent identifies contextual information *Buyer agent likes pineapple very much*, i.e., $(\alpha, Likes(Pineapple, Maximum))$. If seller agent offer free pineapple rather than discount in a rejected deal, the buyer agent may positively evaluate the offer and accept the deal containing free *Pineapple*.

- In an another argumentation dialogue, extracted context *Buyer agent prefers discount over delivery*, i.e.,$(\alpha, Prefers(Discount[\omega_1], Delivery[\omega_2]))$. If seller agent offers delivery of higher value than discount, but the buyer agent may not accept that offer.

- Agents private information, e.g., *Seller agent has limited stock of Tomato*, i.e., $(\alpha, HasStock(Tomato, Quantity))$ may be the reason for rejecting offer. Seller agent may wish to sell his stock of Tomato to other buyer agents instead of giving discount to current buyer agent.

- Uncertain contextual information *Seller agent believes that buyer agent like pineapple very much*, i.e., $(\beta, Believes(\alpha, Likes(Pineapple, Maximum)))$ can be used during argumentation. Seller agent may offer free pineapple having value lower than discount value and wait for buyer agent's response.

3.4 Interaction Protocol

An interaction protocol is defined by an environment and an interaction diagram. A protocol (Jennings et al. 2001) is a formal set of conventions governing the interaction among participants. The argumentation protocol specify at each stage of argumentation process, agent is allowed to say which argumentation illocutions. The interaction proposal might be based on last utterance or depend on a more complex history of messages between agents (Rahwan et al. 2004*a*). We have defined an argumentation protocol discussed below and the flowchart is shown in Figure 5.

- Initial Setup: Buyer start with *Inform*, and Seller responses with *Offer*
- Argumentation: Buyer or seller use AIR(Accept, Inform, Reject) and ART(Appeal, Reward, Threat) in argumentation.
- Acceptable Deal:Buyer use Accept
- Termination: Anyone use Withdraw to terminate

Elements of an abstract model for argumentation agent is explained inRahwan et al. (2004*a*). In our work, the argumentation phases: Incoming Argument Interpretation, Argument Generation, Argument Selection, and Outgoing Locution Generation have been implemented. We categorized AIR(Accept, Inform, Reject) as Soft Argumentative Illocutions and ART(Appeal, Reward, Threat) as Strong Argumentive Illocution. The simple strategy is used to select an illocution from ART such that opponent will accept, if not inform, and else reject the deal.

- reward: Receiving agent will evaluate reward as some additional profit for accepting the current deal.
- threat: Receiving agent will evaluate threat as some additional loss for rejecting the current deal.
- appeal: Receiving agent will evaluate appeal as some additional information to accept the current deal.
- inform: Receiving agent will evaluate inform as an alternative proposal to the current deal.

During the entire process of argument interpretation, generation, and selection, we are proposing to use the following three categories of contextual information extracted from the history of messages.

- Illocution history provides reward, threat, offers etc that occurred in previous deals.
- Ontological search from history helps us to find out deals on Fruit, Vegetables or any other ontological categories
- Semantic Distance search on dialogue history provides use similar deals e.g., apple or similar items. Potato or similar items in the history

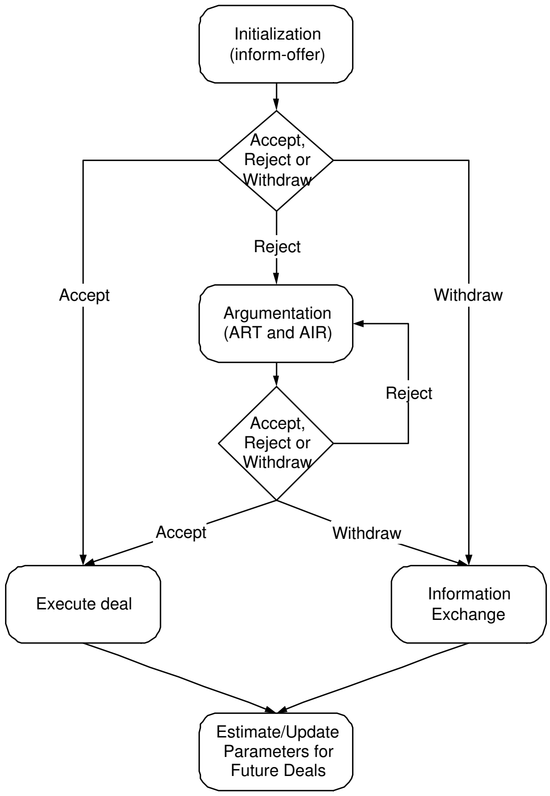

Figure 5: Interaction Protocol

4 Agent Build Business Relationship

Argumentation assist agents to establish deals and build Business Relationships. When agent, α has Need(X), instead of sending message, $\mu(inform, Need(X))$ to a specific partner β_i, agent, α can choose a partner from a set of partners $\{\beta_i | i = 1..n\}$. The problem is how agent, α choose partner agent, β_i from set $\{\beta_i | i = 1..n\}$. The *Confidence(.)* and *Strength(.)* regarding agent's *Need(X)* extracted from entire interaction histories between $\{(\alpha, \beta_1), (\alpha, \beta_2), (\alpha, \beta_3), ...(\alpha, \beta_n)\}$ are used to decide which partner is best to meet current need.
Two parties is an agreement are entered into obligations to supply and to pay for supply. The observer(IA) can determine which dimensions are achieved from the post argumentive illocutions. e.g., sold(quantity=9 Kilo, price \$10/Kilo, delivery day=monday, quality=best). and pay(amount=\$90, payment date=1 day late, quality=average). Institution agent can see argumentation dialogues from interaction history and extract obligation of each parties and see which obligation is not fulfilled by them in post argumentative dialogues and maintain Outcome object and finally, prepare summary measure e.g., reliability of an agent, successful argumentation rate, withdraw rate, commitment fulfillment rate, deviation from agreed value etc. and report it to interacting parties. We assume that IA has such capability.

4.1 Outcome Database

We presented an *outcome* as a tuple of the form $(\alpha, \beta, C_{ID}, deal_{expected}, deal_{actual}, D_{amount}, t, \Delta)$ where a,b are agents, C_{ID} refers to the contract Identifier of the contract with which the current deal relates, expected items ($deal_{expected}$) is a's expected list of items for the deal based on signed contract, actual items ($deal_{actual}$) is the items that actually received by a from b for the executed deal, deal amount(D_{amount}) represents the *formal value* of the deal that occur between two agents, and deviation(Δ) represents the a's estimation of the difference between the formal values of expected items and actual items. In this experiment, *deal* contains any item from Item Ontology and FreeItem Ontology. Similar to Impression database used in REGRET Sabater & Sierra (2002), we have introduced Outcome Database, ODB containing the set of all historical outcomes evaluated by Institution Agents. ODB is used for estimating the strength of relationships between agents. An agent's outcome database $ODB^a \subseteq ODB$ is a set of outcomes containing deals signed by agent, a with some other partner agent.

We define $ODB^a_{item} \subseteq ODB^a$ as the set of outcomes in ODB^a such that $item \in deal_{expected}$ where general form of an outcome in ODB^a_{item} is $(a, \_, \_, \{.., item, ..\}, \_, \_, \_, \_)$. We define $ODB^{a,b} \subseteq ODB^a$ as the set of outcomes in ODB^a where the outcomes is the results of contract executions between agents a, and b. We further define $ODB^{a,b}_{item} \subseteq ODB^{a,b}$ as the set of outcomes in $ODB^{a,b}$ where the outcomes is the results of contract executions between agents a, and b and also $item \in deal_{expected}$ where general from of an outcome in $ODB^{a,b}_{item}$ is $(a, b, \_, \{.., item, ..\}, \_, \_, \_, \_)$. The set $ODB^{a,b}_{item}$ is also a subset or equals to ODB^a_{item} i.e., $ODB^{a,b}_{item} \subseteq ODB^a_{item}$.

Let us consider an example, agent a wants to buy Tomato from agent b. Agent a will consult the $ODB^{a,b}_{Tomato}$ for estimating the strength of Relationship. Any outcomes having $\Delta > \epsilon$ are treated as negative effect on the strength of relationships, whereas $\Delta \leq 0$ are counted as positive effect on the strength of relationships. $ODB^{a,b}_{Tomato}$ will *directly* give us the strength of relationship to make future deals for Tomato. In the absence of sufficient historical outcome in a dimension, *indirect* strength of relationships to make future deals for Tomato using items in Item Ontology other than Tomato using the database $ODB^{a,b}$ can also be measured. The *indirect* strength of relationship between a and b to make future deal for Tomato are measured by using the outcome database, $ODB^{a,b}_{item \neq Tomato}$. Varying the ontological categories and threshold size for semantic distance, agents can show variable flexibility to measure the expectation in future deals.

4.2 Strength of Business Relationship

We have two separate histories: Dialogue History and Outcome Database. Dialogue History contains historical dialogues. Outcome Database is proposed to contains outcome of executed contract especially the deviation between signed contract and executed contract. Institution Agent provide timely information to Outcome Database. In fact, Outcome Database contains summary information extracted by Institution Agent from Dialogue Histories. Structure of Outcome Database is important for measuring trust, honour, reputation and then Confidence on partner agent.

Candidate Partners=Agent has *Confidence(.)* on participant agents to fulfill *Need(X)*.

Negotiation Partner=Select One *Candidate* agent having maximum value of the strength of Business Relationship to fulfill *Need(X)*

Outcome database (ODB) are used for summary measure for choosing possible set of candidate negotiation partners using,

$$Candidate(\alpha, Need(X)) =$$

$$\{\beta_i | \forall_{\varphi \leq Need(X)} Confidence(\alpha, \beta_i, \varphi) > T_c\}$$

$$Negotiator(\alpha, \rho) = arg\ max_i \{Strength(\alpha, \beta_i,$$

$$\{ODB^{\alpha,\beta_i}_{item \leq \rho}\}) | \beta_i \in Candidate(\alpha, Need(\rho))\}$$

and Interaction Histories(more than one agents history) will assist us to select one partner to negotiation based on agents internal world model. Deviation between signed deal and executed deal is represented as,

$$\Delta = V(deal_{signed}) - V^t(deal_{observed})$$

We need a function to transform the deviation between signed deal and observed deal into number between [0,1] such that less deviation means transformed value is close to 1 and more deviation means transformed value is close to 0. One simple approximation is given by where, $f(ODB^{\alpha,\beta_i}_{\varphi}.\Delta) = e^{-\Delta/\lambda}$. Institution agent will keep track on $deal_{observed}$ and any observation is updated to ODB. Agent uses ODB to estimate the Strength(.) of relationship with other agents in some dimension.

$$Strength(\alpha, \beta_i, \varphi) =$$

$$\frac{\sum_{\Delta \leq 0 : ODB^{\alpha,\beta_i}_{\varphi}} P^t_{\beta_i}(\varphi \in deal_{signed})}{\sum_{deal_{signed} : ODB^{\alpha,\beta_i}_{\varphi}} P^t_{\beta_i}(\varphi \in deal_{signed})} +$$

$$\frac{\sum_{0 < \Delta \leq \epsilon : ODB^{\alpha,\beta_i}_{\varphi}} P^t_{\beta_i}(\varphi \in deal_{signed}).f(ODB^{\alpha,\beta_i}_{\varphi}.\Delta)}{\sum_{deal_{signed} : ODB^{\alpha,\beta_i}_{\varphi}} P^t_{\beta_i}(\varphi \in deal_{signed})}$$

This equation measures the Strength to fulfill the need of a single item. Aggregating the values over a class of items e.g., those φ that belongs to ontology, ρ.

$$Strength(\alpha, \beta_i, \rho) =$$

$$\frac{\sum_{\varphi : \varphi \leq \rho} P^t_{\beta_i}(\varphi).Strength(\alpha, \beta_i, \varphi)}{\sum_{\varphi : \varphi \leq \rho} P^t_{\beta_i}(\varphi)}$$

Similarly, α's overall estimate of β_i's Strength is

$$Strength(\alpha, \beta_i) = \sum_{\rho} P^t_{\beta_i}(\rho).Strength(\alpha, \beta_i, \rho)$$

For example, if α want to buy 10K of Banana, α will compute $Strength(\alpha, \beta_i, Banana[10K])$ for agent β_i selecting from those agent having $Confidence(\alpha, \beta_i, Banana[10K])$ greater than a threshold value, T_c. In Sierra & Debenham (2006), $Build(\alpha, \beta, \rho)$ means "agent α considers agent β to be a potential trading partner for deals in a relationship ρ" and agent estimates probabilities that are attached to $P(Build(\alpha, \beta, \rho))$ representing the certainty that it has in this proposition. $Strength(\alpha, \beta_i, \rho)$ examines the Outcome Database, i.e., dialogue history of accepted or offered deals: exact item-ontology-semantic distance-overall, and measure agents capability to execute a deal in a dimension. According to Sierra & Debenham (2007), we can estimate $Confidence(\alpha, \beta_i, \rho)$ by examining the dialogue history of $reward$; $accept$, $threat$; $\sim accept$, $inform$ etc. from accepted, rejected, or withdrawn dialogues as well as ongoing dialogues starting from exact item-ontology-semantic distance-overall, etc. Agent α can estimate what happened and then estimate probability to build relationship as a measure of the strength of Business Relationship.

$$P(Build(\alpha, \beta_i, \rho)) = Strength(\alpha, \beta_i, \rho)$$

E.g., $P(Build(\alpha, \beta_i, Banana[10K])) =$

$$Strength(\alpha, \beta_i, \{ODB^{\alpha,\beta_i}_{item=Banana}.deal_{signed}|$$

$$deal_{signed}.item.Quantity \in [9K - 11K]\})$$

If the above deviation is too small to return a suitable partner, α may be flexible to select partner shown below

$$P(Build(\alpha, \beta_i, Banana[10K])) =$$

$$Strength(\alpha, \beta_i, \{ODB^{\alpha,\beta_i}_{item \leq Fruit}.deal_{signed}|$$

$$deal_{signed}.item.Quantity \in [5K - 15K]\})$$

In other words, if agent, α can select a suitable partner from historical trades of any types of Fruit, α may use the following equation

$$P(Build(\alpha, \beta_i, Fruit)) =$$

$$Strength(\alpha, \beta_i, \{ODB^{\alpha,\beta_i}_{item \leq Fruit}.deal_{signed}\})$$

Therefore, agent, α can select a suitable partner from historical trades of any ontological category, ρ, using the following equation

$$P(Build(\alpha, \beta_i, \rho)) =$$

$$Strength(\alpha, \beta_i, \{ODB^{\alpha,\beta_i}_{item \leq \rho}.deal_{signed}\})$$

In general, agent, α can select a suitable partner from historical trades of any items using the following equation

$$P(Build(\alpha, \beta_i)) =$$

$$Strength(\alpha, \beta_i, \{ODB^{\alpha,\beta_i}_{all\ item}.deal_{signed}\})$$

Using our developed system, we have plan to experiment by measuring the outcome of contracts. We observed that agents can categorize the outcome into three groups: positive, neutral and negative. We stored the outcome into our outcome database for further experiments. We are measuring the differences between signed contract and execution contract for the following three different Strategic Moves.

- If you spend $200 this month, I will give you 10% discount next month

- If you spend $200 this month, I will give you 10% discount next month and Context=Buyer prefer pineapple over 10% Discount, i.e., $(\alpha, Prefers(Pineapple, Discount[10\%]))$

- If you spend $200 this month, I will give you 10% discount next month and Context=Buyer prefer Delivery over 10% Discount, i.e., $(\alpha, Prefers(Delivery, Discount[10\%]))$

We have developed a prototype system to implement an e-market where agents give values to relationship. Initially a buyer agent and a seller agent is joined in the market and we measure strength of relationship for different items across an ontology. We are developing the system using Java. The entire agent architecture developed so far is shown in Figure 6

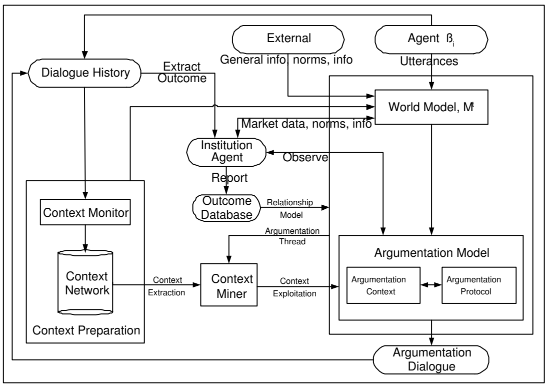

Figure 6: Agent Architecture to Build Business Relationships

5 Introduction Evolution of Business Relationships

Relationship between two parties will evolve depending on the outcome of execution of contracts, some special events in e-Market or group/social influence etc. Any change in relationship between two parties may introduce subsequent change in relationships among other parties in e-Market. Similar to business network in Debenham (2004*b*), relationship network will develop in e-Market which will be basically evolving nature. The evolution of business relationship depending on three broad categories are explained below. This work has mainly focused on the first category.

Evolution based on Outcome of Contract Execution

Relationship between agents are dynamic over time which may evolve after the outcome of any contract execution. Agent may find some commitments not achievable Jennings (1993), which may be also observed in the e-market. If the outcome is successful then relationship will increase. The positive deviation and negative deviation during the enactment of commitment does not always neutralize the effect of them in relationship. Furthermore, two same deviations may have different value on enactment of commitment depending on the contextual information. After several rounds of failure in outcome, if buyer agent estimates the strength of relationship with a seller agent which is less than minimum relationship strength (threshold), the buyer agent can choose another buyer available in the e-Market in order to get better deals.
Therefore, we have to investigate nature of deviation during the execution of contract. We see that only mean value of the outcome of contract are not sufficient to overcome all problems. We can introduce few more statistical parameters, e.g., standard deviation, frequency distribution, maximum deviation, etc. to minimize such problems. Introduction of such parameters will reduce the effect, but does not give us complete structure to evaluate an execution of contract. We are developing the system where we can include functions to estimate different parameters. On the other hand we can further develop the system for using as an efficient tools for simulation.

Evolution based on Events in e-Market

Any events in e-Market give valuable or additional information to agents for deciding future plans. Agents want to observe events in the e-Market especially what other agents actually do. To simplify the observation, we have introduced Institution Agent to observe the events in the market. Some events in e-Market will affect agent's knowledge and trust on it's beliefs. As a result, indirect strength of relationships will evolve after an event occurred which directly or indirectly affect the relationship between two parties. How agents will perform their belief revision process is their internal mechanism. We are dealing with providing an environment for agents to evolve their relationships based on events. In our study of Business Relationships, we only consider those types of events relating the deviation between signed contract and executed contract.

Evolution based on Group or Social Influence

Agents sharing common goals or environments can make groups which will lead them to obtain better benefit from e-Market rather working individually. Any change of relationship between two parties may influence other parties in the same group to update their relationship values using reflexive, transitive rules and as a result network of relationship develops. In our future works, we will investigate for such evolution in details.

Reflexive update: If $r^{a,b}(t_i)$ changes at t_{i+1}, then there is a possibility that $r^{b,a}(t_i)$ may change at t_{i+1} or later.

Transitive Update: If $r^{a,b}(t_i)$ and $r^{b,c}(t_i)$ changes at t_{i+1}, then there is a possibility that $r^{a,c}(t_i)$ may change at t_{i+1} or later.

Network of Relationship: It will be a directed graph and the edge value represents the strength of relationship. No edge means no relationship.

6 Discussion

Managing Relationships in a traditional business is difficult due for the time and cost requirements to communicate updated information, searching new buyers and sellers and evolving existing relationships. E-business using Multi Agent System could make it easier to attract new parties and increase benefits to all involved parties and study relationships among parties. If the customer receives desired commodity from a seller in some previous transactions then the customer would become satisfied on that particular seller and the reputation will increase as a result their relationship will be strengthen. However, after several round of desired outcome received by a buyer, if he receives a commodity which is not as desired level then reputation may decrease but their relationship will not break down immediately. In these situations, if seller tries to replace, refund or any other action on which the customer become happy, then their relationship will be stronger instead of break down. In the marketplace, there should be a set of agents engaged for buying with common interest. There will be a large number of buyer agents, but for the purpose of observing contract execution, we selected one buyer agent and one seller. These two agents negotiate for a specified period of time to execute a number of deals for a set of commodity available in the marketplace within the guideline of signed contract. Deviation between executed deals and signed deals in the contract is measured and this deviation is used to evolve relationship between buyer and seller agents. In some deals, there may arise situations were one party fails to meet standard requirements of the contract terms at least one dimension, e.g., delay delivery, poor quality product, delay in payment, etc. We will further investigate the multi-issue outcome. A set of Strategic Moves has been selected for experiments. We are continuously improving our system to increase functionality and agents capability and we found that the conceptual framework is proving itself as a useful research issue in this field.

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