Autonomic Service Configuration for Telecommunication MASs with Extended Role-Based GAIA and JADEx

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***Abstract*— Autonomic Communications have attracted huge attention recently for the management of telecommunication networks in the European Network Research Community. The purpose of this research is to offer the abilities such as autonomy, scalability, adaptation as well as simplicity for management application in complex networks. The accomplished networks inspired by biological mechanisms or market-based concepts could enable agents to be of intelligence, scalablility, and interoperablility in the management functional domains with regards to the large volume requirements from services' fulfillment perspective in decentralized Multi-Agent Systems. In accordance with *TMF and FIPA specifications and requirements,* the autonomy attributes *self-configuring, self-adapting, self-limiting, self-preserving, and self-optimizing* are involved into our simulation. Resource allocation requests are bidded for a long *session* in the multi-unit Vickrey-Clarke-Groves auction. This design adopts the software development methodology-GAIA and the framework-JADEx. We have shown multiple service configuration in dynamic network can be nearly optimized by autonomic behaviors via *bidding* according to business objectives for getting maximum revenues. We conclude this end-to-end approach maintains self-managing capability, easy-to-implement scalability, and more incentively compatible and efficient over other common implementation so that it could achieve the optimal solution to the flexible requirements for the Service Fulfillment for advanced IP networks.**

***Keywords:* Autonomic Communications; Service Management; Self-X Functions**

I. Introduction

The boom of today's internet and its related development of innovative technologies and services has resulted in a dynamic revolution in telecommunication (telco) industries. Telecommunication Networks (TNs) and services fulfillment management are becoming increasingly complex [1]. The operation of these networks consequently requires more complex schemes to cope.

Traditional centralised operations and management approaches are struggling to cope with the scalability, interoperability, stability issues and service configuring tasks are emerged as one of the great challenges in the currently complex service-based Internet. It is worth mentioning that although current policy based network management (PBNM) provides centralised *policy-based* approaches to cover more customer concerns while performance and scalability issues are still covered [2],[3]. There appears to be short of the feasiblly intelligent scheme to manage enormously localized equipment and services dynamically.

Currently, the research on swarm intelligence inspires us to think that wether this swarm biological cognitive pattern can be applied into the various aspects of management such as monitoring, service configuring, service provisioning, accounting, fault management and performance. We hope the future network can be as robust as human body from an biological point of view, which means the network (human body) can resist any attacks, repair itself within local agents (cells).

In this paper we are going to explore one market-based bidding algorithm in allocating multi-service tasks in a dynamical, hostile network environment. In essence, this bidding algorithm shares fundamental featuring properties as biological social insects [4]. We intend to identify the fundamental design patterns and mechanism by applying this quasi-biological algorithm to the Internet systems which also share the same essential characteristics with biological system.

Moreover, multiple agent-based autonomics leads us from the intelligence of the centralised repository to the framework of agents which can then express more independent reasoning [5]. Realizing the dream of *smart* telco system is the great motivation and chanllenge for current researchers and industrial enterprises. The recent introduction of autonomous self-managing behaviour from *agents engineering* sheds some light on this strive. Autonomics has been defined as a system's capability of *self-management,* including the capabilities of self-optimizing, self-healing, self-configuring, and self-protecting (abbreviated above as self-X function) to changes or threatens in the environments [6].

The previous research paper [7] studied the possible *Vickrey-auction* approach to enable packet forwarding service, and a bandwidth allocation system is proposed by using GVA (Generalized Vickrey Auction) in paper [8]. We extend our previous work on one-dimensional single service activation [9] to *multiple-dimensional spaces* in this paper by exploring multiple service configurations for network resources. We adopt an agent based framework *Jadex* with agent design methodology *GAIA* to help in simulating Autonomic Network Management (ANM). This is enhanced with autonomic agent-modelling concepts managing network equipments, services domains, and exploring their suitability to encapsulate the functionality for resources *optimizations* and system *robust* control.

This paper is structured as follows: problem statement is stated in section II. In section III, we briefly review the framework of Autonomic Auction Agents and and clarify confusional concepts of autonomies. The proposed auction structure, functions, protocols and algorithms are presented in section III and IV. The problem domains are well illustrated by demonstrating a Multimedia Message Service (MMS) application functions into the enhanced TMF model. Section IV explores the GVA (VCG) mechanism to optimize the resource allocation in the network management domain cognitively and autonomously[1]. Section IV describes network model and a simulation experiment on the auction agents for distributing multiple resources (e.g. services; bandwidth; mobile SLA agreement; etc.). Finally, section V concludes and provides a description of future challenges.

II. Problem Statement

Current communication networks are struggling to survive due to the fact they are fragile and rigid in nature. They appear to be difficult to operate, configure and repair. In contrast, many biological and social systems (immune system; insect colony; virus cluster; etc.) present desirable behaviors: they are robust, adaptive, and self-organizing even under highly distributed environments. Therefore, our question is whether we can build up network systems inheriting more swarm-like or insect colonial self-organization patterns.

To be specific, we are trying to study service configuration which is essentially dynamic resource allocation issue. Contemporary multi-services/multi-technologies environments provide new challenges of interoperability and flexibility in terms of *Service Fulfillment (SF), Service Configuration (SC) to Service Provider (e.g., ILECs, CLECs, IXC, CAPs, ISPs and ASPs)* in delivering advanced IP networks.

Seeking an *optimal solution* to achieve enormous service tasks with limited network resources is crucial in current network operational system. The latest technologies such as XML, J2EE have made changes in the way of how Operations Support Systems (OSSs) are built possible. The new challenge facing today is that the network outgrows the capability of existing OSSs' propositions. For instance, on one hand, the network has more dynamics and self-configuring mechanism such as routing, bridging, dhcp, and on the other hand, the users requests cannot be fulfilled in real time from the business point of view.

The main goal of Autonomic Agent is to autonomously assign the workload (operation tasks) of searching and sorting vast amount of complex issues, tasks in efficient ways or productive communication methods between components onto the systems themselves in the aspects of agent-based framework. Consequently human operators are released to take on higher value functions.

The brief statements of the problem, methodology, and referred model are:

1. The increased complexity of communication networks and services drives people to seek the solution to the unimaginably complexity of Next Generation Networks (NGNs). NGNs are constructed on the future optical fibre core networks, from the optical-fibre broadband technologies' perspective, the traditional data transportation problem such as congestion problem, modulation/demodulation problems will theoretically dissolve. Instead, more attention will be drawn to offering more robust easy-to-implement services
2. Autonomies provide great chances for the human system administrators and technicians so that they can focus on higher technical issues without intervention into tasks from service configuration, provisioning and assurance processes
3. As the vital specifications from 4-layer-functional EML(Element Management Layer) of TMN models, service fulfillment (service provisioning or service activation) and its quality assurance are key concerns of all operators, otherwise manual configuration of network components causing gaps in the customer care and order management process will result in inaccurate configuration of network elements

[1] Due to the limit of pages, we cannot list the mathmatical model, theorem and proof for our *MMS VCG auction, bidders' benefit function* and *auctioneers' optimal cost function* which can be referred into our full-version paper upon any request.

III. Theory

A. Framework of Autonomic Auction Agents (AAA)

We use the autonomic auction agents framework for distributed, autonomic task assignment involving auction agents [9]. This framework can be applied to a telecommunications service activation problem involving a mobile messaging service application. Autonomic task assignment involving auction agents.

The development of an autonomic capability to the task assignment problem involves the following considerations:

- the description of what functional parts of the application information model are involved in the autonomic behaviour. That is, what state properties can be changed.
- the identification of roles and name-spaces for the various agents that perform in the problem space.
- the identification of an adaptation mechanism (algorithm) in the problem space.
- the description of agent interactions. This involves the specification of a communication protocol and transport architecture.

Information Model: We are concerned to locate the functional part of the application that is to under go autonomic behaviour. This involves identifying the component(s) or properties in the application information model. We then need to provide a mapping between the functional structures in the application and the autonomic mechanisms. In the AAA model, we employ the auction metaphor for the autonomic mechanisms. The commodities that undergo transactions in the auction model are tasks.

Roles and Name-spaces: The assignment of service activation tasks to agents that can perform those tasks immediately identifies two roles: supplier - has tasks that it wishes to assign; consumer - is able to accept tasks and perform them; broker - performs an intermediary role between suppliers and consumers by performing market-making functions.

Adaptation: As indicated in previously, adaptation is a key function in autonomic behaviour. Within the A3 framework, the adoption operation is located in the offer/valuation/bid/settle cycle of the auction agents. AsConsumer agents successfully acquire holdings of tasks, their cash on hand is diminished, reducing their capability to make further acquisitions. Therefore, each Consumer agent requires a plan on how to bid for each task as it is offered. In this case, the plan is largely achieved through the valuation function that the agent uses to determine the amount to bid in each offer.

B. Autonomics Vs Automatic

Despite the range of available exemplar systems, there are few cohesive theories and architectural frameworks that allow a formalised, systematic and engineering-based approach to autonomic system development. One of the most cohesive theories of autonomics has been posed by Holland [10], though the nomenclature is cast in terms of complex adaptive systems. Holland's observes that such systems do have a range of common properties and methods. In general, we describe the fundamental work component as agents, distributed, with relatively small number of rules in a *"name-space"* that unities the collection of agents and there exists an adaptation mechanism whereby an agent can usefully vary its response to the environment itself change.

A key question in the autonomic communications research program is what distinguishes an *autonomic* behavior from a *mere automatic* one. This question probes at the functional heart of what it means to have an autonomic system. One consideration might be for the system to be able to dynamically adjust itself as the environment in which it operates changes. One distinguishing feature in autonomic systems we observe is the ability of the system to cope well in uncertain environments - the ability to adapt its plans as the environment changes in uncertain ways. Holland identifies those plans that use operations involving probabilistic assessment as complex and interesting. Those that do not are automatic, and less interesting. It seems to us that this differentiation is one useful discriminant test for autonomic behavior. That is, the ability to employ a reasonable plan in the face of uncertainty [9].

C. TMF Model

The Telecommunications Services Architecture (see Figure 1.) we have chosen allows us to accomplish three things. It allows us to describe a commercial telecommunications product (or service) in a structured way. Secondly, it allows us to locate the functional component(s) that we wish to enhance with autonomic or *"intelligent"* behavior. Finally, it facilitates the design of simulations based on multi-agent practices allowing us to test and study the complex operations of these service systems [9]. *Adaptation mechanism* can make an agent vary its response to the environment as both the agent's internal state and the environment itself change. In our context of auction (see simulation part), the adaptation process of auction agents and bidder agents goes through the whole auction operation, *publish/bidding/settleResults/Rebidding If required.* Bidders learns to increase bids valuation when *low_bid* token is received.

Within the MMS context, the five layers we describe shows how to implement the whole simulation process of Multimedia Messaging System (MMS) operation. Business system includes instantiating a new product and generating bills and conventional system objects include *product components*, such as e-mail accounts, to physical *resources* such as switches and transmission systems. The layers form logical abstractions for the objects in the system, allowing us to locate the important functions and properties we wish to study. In the multiple service simulation, we envisage many of the objects have the agency functionality that we described in Subsection 2.1 as being necessary to facilitate autonomic behaviours. The layers allow a hierarchical structure indicating the dependency of objects in the upper layers on the objects in lower layers. Ultimately, objects in the lowest layer (resources) are simulated by queues in combination with

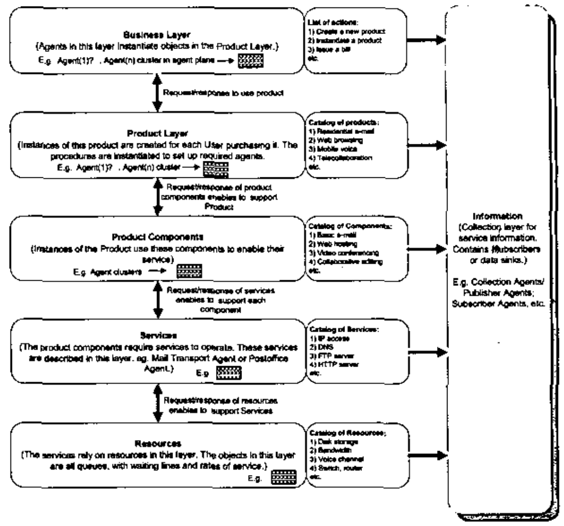

Fig. 1. TMF Telecommunications Service Architecture

state machines and storage mechanisms. We design that the manager agents are residing on each layer of the TMF model, which will monitor, control the information flow, complex tasks, etc.

D. Protocol of Autonomous Multiple Items Auction —

The universal requirements of multi-agent platforms have been predefined in Jade and JadeX (an extended version of Jade). We extend the design structure of autonomous VCG auction agents platform furthermore on the basis of Jade specification and program the type of *specifications* for the instantiated individual *rational* BDI agents into the XML ADF(agent definition file) in JadeX. The java files are used to describe plans implemented in the platform. The agent of Jade can be identified by an unique *naming services* which is each agent alive in the *container* (platform) as being recognized by *<NickName>@<platform-name>* such that the agents can be identified by their unique *NickNames.* The resources assignments on multiple platforms to multiple agents that can perform those tasks directly claim the following roles which is as GAIA methodology described:

(1) Supplier (2) Auctioneer (it plays a role of broker, see Figure 2.) (3) Bidder

Role Schema: Auctioneer Agents (AA)

Description:
Being responsible for decision making of winners and planning for auction process. Manage the efficient way or paths for the transmission of all the information, event flows, and oversees the process to make sure the resources, capacity quotation is satisfied, and new requirement of resources, capacities will be concerned

Protocol and Activities:
CheckNewAuctionComponents, CheckNewRequirements,
InformOtherAuctioneerAgents;

Permissions:
read Supplied *Auctioned_Components_Details* *//current network status*
detected Bidder_Capacity_requirments *// bandwidth, media transporting speed*
Logging *//record whether the tasks are fulfilled or not*
Creat *New_rules* *// modify the current policy system*

Responsibilities:
Liveness:
NetRuleManager=(CheckForNewAuctionComponents, informOtherAuctionAgents)
GenerateLog= (ProuceLogFile, InformManager, InformWinnerOfBids)

Safety:
A succegsful management system is implemented via the connection with knowledge base and policy database

Fig. 2. Gaia Role Model for Auctioneer

In contrast to their roles, in this section we present a high-level description of an auction protocol for multi-objects VCG auction described in the previous section. The interaction protocols is currently implemented on JadeX platform using XML technology to encode the messages with the protocol primitives as described below:

- Subscribe - The subscription message from bidders to auctioneers show the interests of participation into an auction. Besides, this subscriber ID can be used for authentication purpose
- Publishing - The auctioneer checks the availability of auctions and informs the bidders about the current marketing price and time for next auctions.
- SubmitBid - The bidder submits bids values for different auctions which occurs in different sessions for different items. The auction engine will respond by issuing a payment reservation for each bid.
- SettleResult - The auctioneers compare with all the sealed prices bidded by competitors and grant the auction results openly. The bidder will have a chance to claim if they accept the results or reject the results.

The multi-objects auction functional message processing are illustrated as each node in practical network can play the role as both an auctioneer and a bidder during many asynchronous times. Depending on the context and the particular application requirements, the changing of these roles can happen any times whenever needed. For multiple auctions in resource allocation, there are two major domains: auctioneer domain and bidder domain.

E. Evaluation Application

The overall cellular network architecture of MMS implementation is shown in Figure 3. According to 3GPP specification report [11], there are several ways of MMX (MM1, MM3, MM4, MM5, MM6, MM7, MM8) which provide different components of the multimedia messaging system to function as a whole. MMSC supports sending MMS messages between mobile phones, and also supports sending and receiving MMS messages between mobile phones and standard internet e-mail systems.

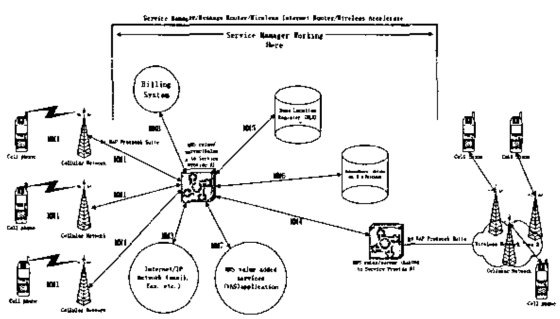

Fig. 3. The MMS Network Architecture

Figure 3 shows the MMS message flows internetworking between two different message centers. In our work, we will focus on the messaging routing service delivery problem. Autonomous mechanism is supposed to assign the routing tasks into servers to reach an optimal resource allocation, as we know, due to geographical reason and server spared space reasons, servers' capabilities cannot always be made full use when facing task assignments, even if central policy control can be changed on time, the optimal distributed results are not scale. Therefore, it is necessary to take advantage of self-managing mechanisms to reduce human's workload, at the same time self-management can get the resource allocation to a dynamically optimal condition.

IV. Description of Experiment

We present this section by summarizing the above ideas in the context of auctioning the storage spaces - 9000 MM_Boxes in 6 MMSC and auctioning 7000 high bandwidth communication link, and auctioning the 9000 SLA contracts. In the australia context, MMSC server is commonly located in key telephone exchanges in most of the 6 capital cities of 6 states. There are about 6 physical location to consider. For the experimental requirements, we assume there are 6 MMSC centers, each enabled alternatively with auctioneer agents or bidder agents in different period of time. This adds more autonomy and robustness into the design. The auctions are to be carried on for a period of time, the interval between two auctions is set to 3 seconds. The storage spaces or bandwidth is to be divided into different parts/units, and these units sold in a multi-unit auction. Taking the MM_Boxes as an illustrative sample, each mobile user could have one mobile number actually, however MMSCs needs to manage the storage server for allocating the message storage resources for mobile users. Conceptually, the MMSCs are the independent buyers/bidders agents. In the context of MM_Boxes, they could not be necessarily identical which means they have difference from each other depending on whether the users require premium or normal services, the differences between these two are capacity and the differences of functional limitation (e.g. real-time stream transmission available or not).

The items in different categories of goods are allowed to be competed by combinatorials (or "package") bidding too, i.e. bidders place bids on any combinational groups of objects as well as on individual object that bidder wishes. Bidder generates a bid vector to be passed on to auctioneers. Successful criteria used by auctioneer is a cost function which maximize the benefit to the supplier. Our combinatorial bidding utilizes a generalization of the Vickrey auction which is Vickrey-Clarke-Groves mechanism. At the end of auctions, all the auctioned objects representing the network resources will be allocated to 6 MMSCs as optimal function assumed. In order to realize autonomous resource allocation, the *auctioneer agent* should reside on each MMSC and each MMSC have the even chance to alternatively play the role of auctioneer or bidder to help assign the MMS service, bandwidth, contracts to MMSC server.

Every MMSC competes independently with its own strategy in the auction according to their own funds capability (initially assigned cash) and its maximum capacity for certain services. The resource can be nearly optimally distributed into MMSC. The initial condition for each MMSC playing the role as bidders agent is:

1) Each MMSC has its maximal capacity in accommodating MM_Box, SLA agreements, and Division_Bandwidth: Max_MM_Box=1800, Max_SLA_agreements=1800, Max_Division_Bandwidth=1300; Simulation uses the initial holdings for each MMSC

are Initial_MM_Box=100, Initial_SLA_agreement=100, Initial_Division_Bandwidth=100

2) The initial allocated funds to each MMSC is evenly distributed as 1800 units of funds, and basic bid is 1 unit is the minimum amount to be participated into each bid

Since we have 3 categories of goods to sell, that is, $A = \{MM\_Boxes\}$, $B = \{Bandwidth\}$, $C = \{SLA\ Agreements\}$, the maximum combination is $2^3 - 1 = 7$ items (A, B, C, AB, BC, AC, ABC), we take the form $Bid(a, b, c, ab, ac, abc)$ to denote the bidder value vector, the sequence of the valuation follows the same sequence number of items. The Jadex container contains auctioneer agents and bidder agents, winners of the auctions will be decided in the container by auctioneer agents. In our simulation, auctioneer agents play the role similar to brokers.

We propose a dynamic business ruling pricing scheme as for the auctioneers who make decision of the winners of a particular sort of goods, the brief state steps of resulted autonomous auction algorithm is listed as below:

1) By taking the supplier's suggestion into consideration, auctioneers choose initial prices for items
2) The maximum expected revenue bundled prices are published to the buyers at the start of auction interval
3) Buyer responds by evaluating his/her own strategies which mainly calculate bidders' benefit function[2]
4) Auctioneers calculate the benefits or the variation between expected maximum revenue and buyers' possible bundled revenue, if variation is located into the region of satisfaction, there is one package sold out, otherwise restart from step 2

There are three main agents in our simulation as below: (1) Auction_Manager_Agents (2) Auctioneer_Agents (3) Bidder_Agents

A. Some Simplified Rules

The goals of Jadex bidder agents are to win the auctioned items. The job of auctioneer agents are to single out the most successful candidates from all the bidders and distribute the specific items to the successful bidder. In addition, all the items should be sold out eventually. Initially units of cash are issued to bidders in order to participate. All the bidder agents are loaded with 100 units of cash. If one bidder win the items, its cash is reduced by the amount of bid value n (n could be 10, 20 or 50, etc). Preferably, if one item couldn't be sold out during one-around, the restarted auction process will rebid and make decision again. The auctioneer publishes an indication of the supplier's preferable prices to the public.

1. **Bid Stratergies:**

The bid values are strongly influenced by each bidder's strategies, while their strategies are determined by the bidder's own benefits function in mind. The bidders take a risk profile associated to its resource availability. This determines how aggressive the bidding strategy is. However it has a sold controlling aspect by not exceeding the ϑ level.

We denote μ as the parameter for the currently maximum available capacity (evaluated by units of cash), which is a key factor for bid strategies; We assume initial capability is 100.

Very Risky Strategy (≥ 5 times larger than published prices)	$\mu \in [0, 100]$
Risky Strategy (≥ 3 times larger than published prices)	$\mu \in [0, 75]$
Conservative Strategy (≥ 1.5 times larger than published prices)	$\mu \in [0, 50]$
Very Conservative Strategy (≤ 1.0 times larger than published prices)	$\mu \in [0, 25]$

Fig. 4. Business Strategy

A bidder's strategy is not static. If his μ falls into some region, for instance, changing from $\mu \in [0, 100]$ to $\mu \in [0, 50]$, his strategy will change from *Very Risky Strategy* to *Conservative Strategy*. The above business rules reflect the *self-configuring* and *self-limiting*[3] behaviors of autonomous bidder agents. In addition to that, *self-adaptation* is also presented in this strategy changing process. As indicated in Section 1, adaptation is a key function in autonomic behavior. These strategies are have been implemented into our autonomous bidder agents, implemented via automatic and manual means via the manager agent GUI.

2. **Extra-rules:**

If the offers from two buyers are identical, auctioneers cannot make decision, he will restart the auction by increasing the price offer

B. Simulation Results

We have generated the simulation under *Jadex* platform on the basis of simplified rules stated as above:

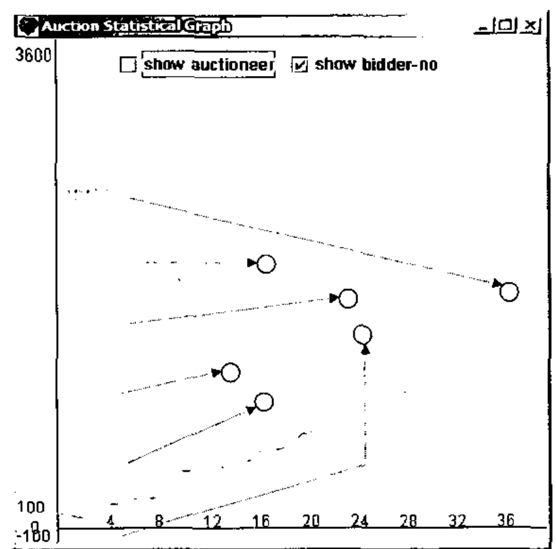

Fig. 5. Agent Holdings Vs Time

[2]Due to limitation on numbers of pages, we cannot list here about MMS *VCG auction, bidders' benefit function* and *auctioneers' optimal cost function.*

[3]Bidder agents will not run out of all its capacity in the early round of auctions, this is a desirable requirement of servers for self-configuring service availability.

The simulation results are presented in Figure 5. which demonstrate the 6 bidders/auctioneers process through the whole multiple auctions and finally get the holdings distributed into each server during limited time period, issued auctioning items are as stated above. The resulting performance shows the desirable holdings based on their dynamically varying bidding strategies. Figure 5 shows graphically the variation of holdings for each of the agents, versus time duration for auction. X-axis is the virtual auction time (in days); Y-axis shows the holdings. Following points are illustrated:

- Each agent experiences some increases or decreases of the holdings due to dynamic strategies in auctions or bidding scheme at different periods of time.
- Each agent corresponds to one of the MMSC server in the simulation. Therefore, all the agents finally process through the *auction space* given to their own *benefit function* and make decision with regards to their own *optimal function*.
- The total number of auction items are clearly sold out in the end which is gurantted by this extended second-chance auction scheme.

Each agent experience some increase or decrease of the holdings due to dynamic auctioning or bidding at different period of time, each agent corresponds to one of the MMSC server in the simulation. Therefore, all the agents finally process through the *auction space* given to their own benefit function and satisfy their own optimal function.

C. Discussion

Each bidder agent has own initiatives, personal interests on any specific auctioning process in the real auction market, however, on the other hand, in the system computing level, the egoism is not mostly the desirable behavior in our simulation paradigm on autonomous network resource allocation, we prefer the less selfish bidder agents in the process the better. We assume most of the bidders share the same *goal*. Most of the auctioneers share the same *optimal function* as well. Hence, network resources are going to be uniformly distributed under this optimal function, such that the *variance value* of the auctioned items in each auctioneer (MMSC servers) will not have too many fluctuations around the *mean value*. Therefore, the worst case won't happen that the smaller amount servers have been located 80%-90% network resources instead. Accordingly, in our simulation we set different strategies for bidders, such as, constantConservative, veryConservative, risky, veryRisky, etc. We setup the same strategy for most of the bidders *instead*. The reason is the different purposes of *real-world auction* and *network resources auction*. In real auction market, the maximum money *revenue* is the only aim for auctioneers' activity of trading goods. But in our network resources auction, getting the resources reasonably distributed in network servers is our final *concern* despite the best bidder is determined by bid price lists and the maximum revenue for sellers as one of the evaluation function. Consequently, this is a trade-off when we setup the simulation parameters and strategies.

V. Conclusion and Future Work

We have presented an efficient *auction* approach to achieve management autonomy in terms of self-configuring, self-optimizing, self-limiting and self-preserving. The results show that dynamic network service configurations can be optimally solved by autonomic behaviors via *bidding* according to high-level business objectives for maximum revenues. This approach has benefits of aligning the network configuration infrastructure with business objectives, and subsequently results in a clear linkage between network policy decision management and business level metrics. By assigning the system functions into lower layers of system abstraction, human operators are freed to focus on other higher level functionality.

Our future work consists of further comparison of various auction adaptive algorithms, and the performance comparison between auction algorithms and generic algorithms, for example, stochastic search method PBIL. The Teleholonic R&D group (TSRG) is aiming at constructing a closed-loop system architecture which will guide the next-stage work among a) *management of complex networks,* b) *autonomous agents system in mobile communication,* c) *the usability of TeleCollobration business system support (mainly from business and human clients point of view)*

VI. Acknowledgement

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