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An Optimization Algorithm for Negotiation Process Using Bayesian Network

[1]Bennett, E.O., [2]Otobo, D.W. & [3]Taylor, O.E.
Department of Computer Science
Rivers State University
Port Harcourt, Nigeria
E-mails: [1]bennett.okoni@ust.edu.ng, [2]otobodina@yahoo.com, [3]onate.taylor@ust.edu.ng

ABSTRACT

This paper presents the design and implementation of an optimization algorithm for complex negotiation process using Bayesian Network. Human beings are always encompassed with negotiation problems. Most negotiators and mediators are faced with the challenges of resignation of positions, threat to lives and criticism. Negotiation mechanism has been developed to validate the agents including the operative rules so that all agents could get typical satisfaction. The protocol we propose guides the agents in efficiently coordinating their interrelated negotiations and to coming to an agreement especially when convergence is difficult to obtain in multiagent settings. Parameter learning component of Bayesian network has been incorporated into the negotiation process and facilitates the result of the negotiation. There were several lose-lose negotiations by three agents and three win-win negotiation by three agents.

Keywords: Optimization, Algorithm, Negotiation, Bayesian Network

1. NTRODUCTION

Negotiation can be said to be an ancient craft, with a composition of art and science, style and substance. Negotiation is aimed to resolve points of difference or to gain advantage for an individual or collectively or to results outcome to satisfy various interest of people. It is aimed at putting forward a position and making concessions to achieve an agreement. The determining factor to which negotiation can be successful, is contingent on the degree at which the negotiating parties trust each other to implement the negotiated solution or goals. Negotiation occurs in organizations such as businesses, non-profits organizations and within or between governments, as well as in sales and legal proceedings, personal issues, like marriage, divorce and parenting. etc. It is a back and forth communication designed to reach an agreement between two parties or the inter-personal decision-making process that is necessary wherever we cannot achieve our objectives single-handedly [1]. Again, [2] defines negotiation as, where two or more parties need to reach a joint decision but having different preferences. People negotiate in everyday situations including outside of the workplace.

It can occur when there is more than one possible outcome from a situation in which two or more parties have an interest, but they have not yet determined what the outcome will be. For example, between a buyer and seller in the purchase of a property, or even between groups of friends. Business negotiations can include suppliers, partnership in businesses or customers, inter-departmental or team discussions to determine aims, processes and resources, management and staff discussions to discuss job priorities and workload, discussions between management and trade unions on rates of pay, recruitment of new people to the business etc... It is the constructive, positive alternative to haggling or arguing, and its aimed at building an agreement rather than winning a battle [3]. In any disagreement, individuals understandably aim to achieve the best possible outcome for their position (or perhaps an organization they represent). However, the principles of fairness, seeking mutual benefit and maintaining a relationship are the keys to successful outcome [4].

Optimization is the process of modifying a system in order to adapt some features that can work efficiently or use lesser resources. In other words, an Optimization algorithm can be said to be the procedure in which a system can be executed iteratively by comparing several solutions until an optimum or a satisfactory solution is ascertained. Besides, process optimization is the methods of adjusting a process so as to optimize certain specified set of parameters without violating some constraints.

The main aim, is to minimize the cost and to maximize throughput and efficiency. This is a major quantitative tool in industrial decision making [5]. Bayesian Networks are able to maintain clarity by making causal assumption explicit. Besides it is sometimes used for modeling in a situation where the relationships to be described are not easily expressed using mathematical notation [6]. Therefore, bringing the theory of optimization and Bayesian Network into practice in area of complex negotiation process, requires that certain issues need to be considered. The type of optimization algorithm that would be in this context, using Bayesian Networks is the probability method rather than deterministic.

It has been observed that, human beings often times are faced with various kinds of crisis in life. Peoples are faced with different kinds of disputes or conflict emanating from various sectors in life such like:

i. Threat to lives
ii. Problems of criticism
iii. Resignation of positions and
iv. consequences of a broken deal, can lead to damage to reputation.

Therefore, human beings at every point in time are encompass with negotiation problems. Again, many people are psychologically reluctant to take the responsibility for their own decision where negotiation or mediation are needed, especially in a complex technological society. Therefore, to eradicate this menace and awareness of the natural history of negotiation processes, there are multiplicity of approaches, styles, strategies and techniques that are now practiced. These styles are traceable to the advent of the modern rationalist approach to negotiation which includes optimization algorithm for complex negotiation processes, using Bayesian Network.

The primary focus of the paper is to develop a system that will carry out negotiation process on complex issues and apply the system to negotiation over civil servant retirement's age, a practical problem, using Bayesian Network.

2. LITERATURE REVIEW

Preparing and planning for e-negotiation mainly involves the generation of a well-conceived plan. Researchers have paid great attention to automated negotiation lately and several models have been proposed. These models can be classified into three main categories [7]:

(a) ***Game-theoretic models:*** provide rich analysis of various negotiations situations and detailed results concerning the optimal strategies agents should choose. i.e. strategies that maximize the outcome of negotiation [8, 9].

(b) ***Heuristic models***: provide generic guidelines for agents and relevant strategies for reaching beneficial agreements. i.e. good enough (not optimal) outcome; the negotiation process also involves an iterative exchange of offers and counter-offers [10].

(c) ***Argumentation-based models***: allow agents to argue about their beliefs during the course of negotiation; agents can submit arguments to justify their negotiation stance or to influence other agents, i.e. to persuade them to change their negotiation stance; the negotiation process may involve an iterative exchange of offers, counter-offers, threats, promises, persuasive arguments, etc [11, 12].

Clearly, there is no universal best approach or technique for automated negotiation that suits every problem domain. However, heuristic models are gaining increasing popularity and therefore, will receive the predominance of our attention.

3. SYSTEM DESIGN

The behavioral and structural details of the system including the negotiation system and the component diagrams are provided. Figure 3.1 shows the negotiation system, whose components are data source, negotiation mechanism, Bayesian Network and negotiation outcome.

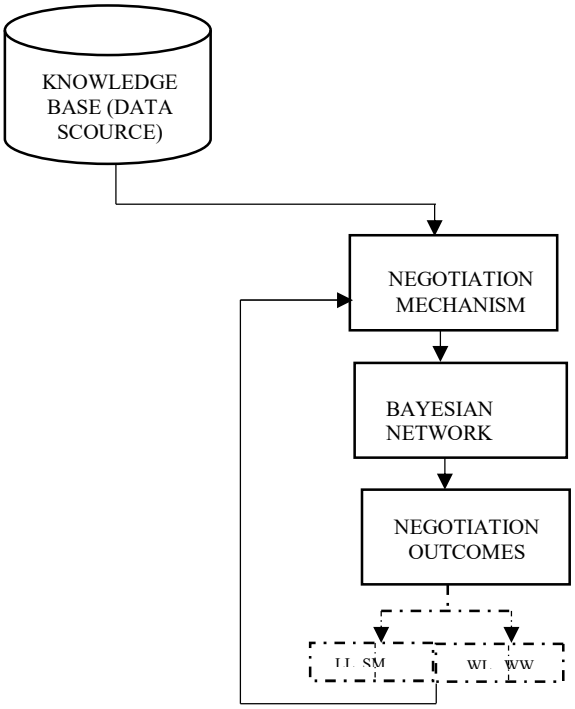

Figure 3.1: System Architecture

The retirement age negotiation data from Bayelsa State, Nigeria Pension Board (data source) serves as input to the system. The negotiation process is modelled via the negotiation mechanism. Thus, negotiation mechanism reveals the issues involved in the negotiation. Bayesian learner applies the negotiation rules and facilitates the result of the negotiation. One of four output is expected from the system: Win-Win (WW), Win-Lose (WL), Lose-Lose (LL) and Stalemate (SM).

3.1 Input Parameters

Inputs are resources needed for executing the process as shown in Table 3.1. The statutory retirement age for workers in the Nigeria civil service is sixty (60) years or thirty-five (35) years of service. Table 3.2 shows the input criteria; users (stakeholders) are allowed to rank measures related to their criteria.

Table 3.1: Input Parameters

S|N	OPERATIVE RULES	VARIABLES NAME
1	Service start time and an end time	R1
2	Service start time in each service must be not earlier than the service request time.	R2
3	Health challenge	R3
4	Retirement age for workers in the Nigeria civil service is sixty (60) years	R4
5	Service duration for workers in the Nigeria civil service is thirty-five (35) years of service	R5

Operative Rules defined the actions triggered by an event.

Table 3.2: Input Criteria

S|N	CRITERIA	RANGE
1	24≤Age ≤30	0
2	31≤Age≤40	1
3	41≤Age≤50	2
4	51≤Age≤60	3
5	10≤Years of Service≤20	4
6	20≤Years of Service≤30	5
7	30≤Years of Service≤35	6
8	Age≤64&& Years of Service≤34	7
9	Age≥65&& Years of Service≥35	8
10	Age≥65	9
11	Years of Service≥35	10
12	Health issue	11

The criteria for the negotiation, ranges from 0 to 10. The lower the range, the weaker the negotiation of a stakeholder and the higher the range the stronger the negotiation of a stakeholder.

3.2 Negotiation Mechanism

Negotiation usually takes place between two agents willing to come to an agreement on conflicting interests. Most approaches in service composition, that use negotiation mechanisms to select services according to their quantity of service values, usually apply negotiation for each required service independently from the others relying on bilateral one-to-one negotiation mechanisms. There could be one-one, one-many and many-many negotiations.
A set of exactly *n* offers $(x_i^t = x_n^t)$ is an agreement (A) at round t $= \sum_{i=1}^{n} x_{ij}^t \leq c_j \in m$

If an agreement is reached with the offers sent at round *t*, the negotiation ends successfully at that round, otherwise all the offers are rejected.

Generally, offers are evaluated in terms of agent utility. The utility of an offer x_i at round *t* is evaluated as follows:

$$(x_i, t) = \begin{cases} 0 \; if \; t = t_{MAX} \; and \; not \; (A) \\ v_i \; (x_i) \; if \; t < t_{MAX} \; and \; (A) \end{cases} \qquad (3.1)$$

Where,
X_i is the offer
(x_i…. x_n) is offer *i* to offer *n*
i = 1,2……, n
V_i = evaluation an offer
V_i *(xi)* is the evaluation function
C_j is the constraint, limitation in negotiation
M is the negotiation issues
A is an agreement
t_{max} is the deadline

In this study, the negotiation mechanism consists of two agents (y, z) negotiating with Proposer (P) agent over civil servant retirement age in order to find the appropriate age and years of service.

Agent ***i*** member of (y, z, p) has a set of criteria ***k*** member (0, 1,…,n) for evaluating the retirement age.

The proposer agent is seeking the appropriate age or service year while the other agents need to meet a certain satisfaction level. The set of x = ($x_{1,}$ x_2..,x_n) comes from the proposer agent which is the set of possible age or years of service for the retirement age, which is obtained as follows:

$$x_{new}^{a} = \frac{x - x_{min}^{a}}{x_{max}^{a} - x_{min}^{a}} \qquad (3.2)$$

$$X_{new}^{b} = \frac{x - x_{min}^{b}}{x_{max}^{b} - x_{min}^{b}} \qquad (3.3)$$

Where,
X = the retirement age
x_{min}^{a} = the minimum age
x_{min}^{b} = minimum years of service
x_{max}^{a} = the maximum age
x_{max}^{b} = the maximum years of service

The appropriate age or years of service can be obtained as follows:

$$P(x) = W_j^p * x_j \quad (3.4)$$

$j = \{0, 1, \ldots, n\}$

Where:
P = is the propose agent
W= represents the weight assigned to the criteria
j = represents the criteria
W_j^p = the weight assigned by proposer agent given by the criteria
x_j = the retirement age based on the criteria
y(x) > j1
z(x) > j2

where,
y(x) = the third-party agent recommendation of retirement age
z(x) = the civil servant agent agreement on retirement age

Applying exclusive disjunction in negotiation; a civil servant can retire by age or years of service, which means 'either one, but not both nor none'. In other words, the statement is true if and only if one is true and the other is false as shown in Table 3.3.

Table 3.3: Exclusive Disjunction

A	B	A⊕B	A∨B	A∧B
0	0	0	0	0
0	1	1	1	0
1	0	1	1	0
1	1	0	1	1

This table indicates that civil servant retires in 0XOR1 and 1XOR0 but continues service in 0A∧B0 and 1A∧B1. It can be expressed as:
A⊕B =(A∨B)∧ (¬ (A∧B) **)**

3.3 Bayesian Network
Bayesian Network is Artificial Intelligence (AI) technique. The essence of this technique is to equip the agents with the required functionalities to mimic human negotiation; to incorporate a learning component into the negotiation process to better mimic human behavior and facilitate the result of the negotiation. The negotiation process is presented in a form of directed acyclic graph. The outcome of the Bayesian Network is represented in Table 3.4 on the next page.

Table 3.4: Bayesian Outcome

Parameter	Network Outcome	Label
Years of Service	Years of service ≥35	Retire
Age	age ≥65	Retire
Health Issue	Ailments	Retire

The Bayesian approach provides a mechanism to determine the probability of a hypothesis conditioned to a set of data (Ellison, 1996). It yields the posterior probability based on a prior probability and a likelihood function derived from a probability model for the data to be observed. Such probability is computed using the Bayes theorem:

$$P(H|E) = \frac{P(H) * P(E|H)}{P(E)} \qquad (3.5)$$

Where,
E represents the rules that corresponds to the criteria for retirement
H represents the hypothesis that needs to be examined based on the rules
P(H) known as the prior probability represents the probability of the hypothesis before considering the rules.
P(E) represents the probability of occurrence of E
P(E|H) known as likelihood represents the probability of observing E given H
P(H|E) known as posterior probability represents the probability of H given E.
The notations applied in negotiation Bayesian model is depicted in Table 3.5.

Table 3.5: Notations

S|N	Notation	Meaning
1	P	is the propose agent
2	W	represents the weight assign to the criteria
3	J	represents the criteria
4	X	represents the age or years of service
5	X_{min}	represents the minimum age or years of service
6	Xmax	represents the maximum age or years of service
7	Y	denotes Third party agent
8	Z	denotes Civil Servants
9	R_t	represents civil servant retirement age at time t
10	$H^P_{y,z}$	represents hypothetical evaluation that the agent (p, y or z) wants to test
11	$P(H^P_{y,z})$	represents the probability of hypothesis
12	$P(R_t\|H^P_{y,z})$	represents the probability that scenario is proposed given hypothesis

The algorithm for the negotiation process as follows:

Algorithm: Negotiation process

1. proposer. offer(age==60 OR year of service==35);
2. //Iteration on proposer's offer
3. while offer is true do
4. **x = proposer. select();**
5. if x is not null
6. proposer.propose(x) is accepted;
7. p.receive(x);
8. z.receive(x);
9. y.receive(x);
10. else if p. response is rejected OR z. response is rejected or y. response is rejected
11. agent Y recommend (age==65)
12. else if agent Y is accepted
13. z accept offer
14. else
15. z reject
16. end if
17. end if
18. end if
19. end while

3.4 Experimental Specification

We have developed a multi-agent system that meets the constraints of the context described in the previous sections. Agents are developed to perform sets of actions organized in their plans. These are represented by interfaces that implement a set of classes and a set of methods such as computing the degree of belief of each action. Proposer agent represents the Bayelsa State Government (P). Bayelsa State Government (P) offer retirement age. the alternative age comes from agent Y. The negotiation stops as soon as agreement is obtained.

3.5 Negotiation Output

The outcome is aimed at agent satisfaction; the result of a process is something valuable for the agent. Table 3.6 shows the outcome of the negotiation system.

Table 3.6: Specification (Output)

S|N	CRITERIA	RANGE	LABEL
1	24≤Age ≤30	0	lose-lose
2	30≤Age≤40	1	lose-lose
3	50≤Age≤60	2	win-lose
4	10≤Years of Service≤20	3	lose-lose
5	20≤Years of Service≤30	4	lose-lose
6	30≤Years of Service≤35	5	win-lose
7	Age≤64 OR Years of Service≤34	6	stalemate
8	Age≥65 OR Years of Service≥35	7	win-win
9	Age≥65	8	Win
10	Years of Service≥35	9	Win
11	Health issue	10	Win

There are three criteria for a possible win, they are: Age≥65 OR Years of Service≥35, Age≥65, Years of Service≥35. 30≤Years of Service≤35 criteria produce a win-lose outcome; 30 years of service was not satisfied while 35 years of service was satisfied. Age≤64 OR Years of Service≤34 criteria produces near miss outcome. The higher the range the better the negotiation.

4. RESULTS AND DISCUSSION

The Bayesian Negotiation Network found in Figure 4.1 accepted integer values and has been fed with civil servants retirement age and years of service. The negotiation system has three agents (p-agent, y-agent and z-agent) linked to each other. However, the system learned the negotiation of retirement age of civil servant via parameter learning, converged and stopped at 86 iterations. Figure 4.2 shows the negotiation outcome made by three agents.

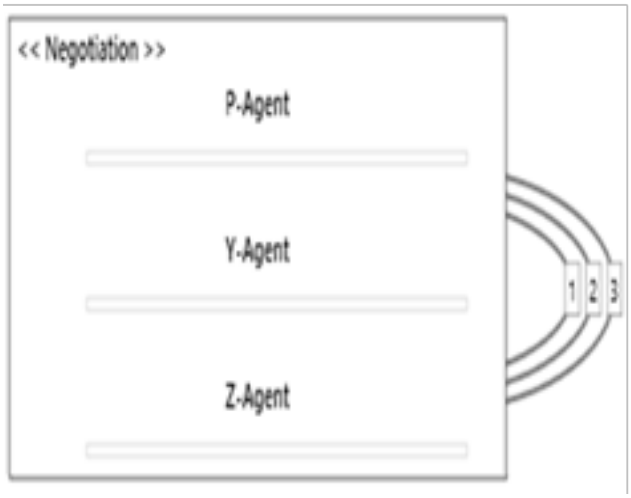

Figure 4.1: Negotiation Network

Eighteen negotiations were conducted by three agents. Three agents agreed retirement by age of service at 65years and year of service at 35years as depicted in Table 4.1 on the next page.

Table 4.1: Negotiation outcome

No. of Negotiation	p-agent (years)	y- agent (years)	z-agent (years)
1	20	15	16
2	22	10	9
3	37	25	23
4	26	22	19
5	35	35	35
6	40	38	36
7	38	25	22
8	60	60	65
9	34	33	28
10	54	42	38
11	62	38	33
12	65	65	65
13	31	14	12
14	35	35	35
15	25	16	15
16	26	14	9
17	45	33	22
18	51	44	37

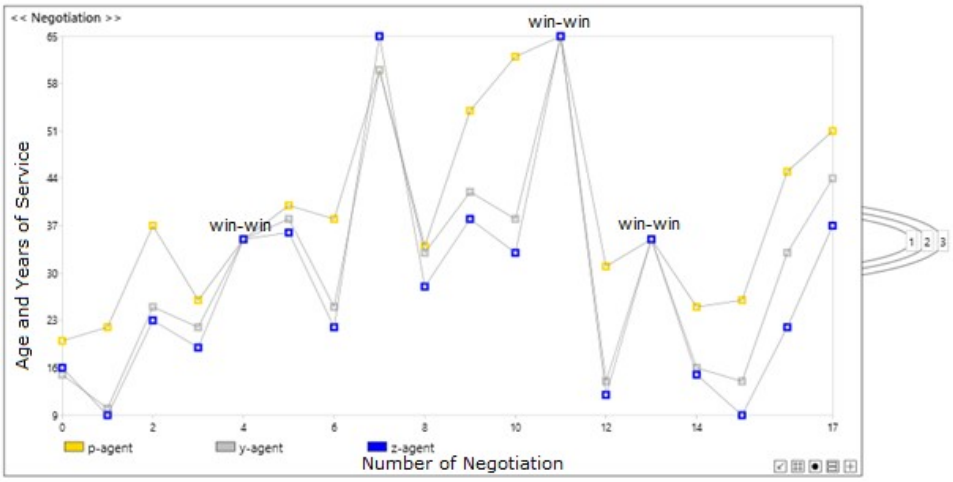

Figure 4.2: Negotiation Outcome

The system output can show a lose-lose negotiation where p-agent, y-agent and z-agent, disagreed on retirement age. It can also show a win-win negotiation. The three agents accepted retirement by years of service; that is service year equal to 35years. The system output also shows the win-win negotiation where p-agent, y-agent and z-agent accepted retirement by age; age equal to 65years. Thus, z-agent can retire either by age or years of service. z-agent is guided by these operative rules: each service must specify a start time and end time, the service start time specified in each service must not be earlier than the service request time, health challenge, retirement age for workers in Nigeria civil service is 60years of age, service duration for workers in the Nigeria civil service is 35years of service. But the y-agent (third party agent) recommended 65years of age for z-agent (civil servant agent).

The system has been tested with 300 records of Bayelsa State civil service. The negotiation age and years of service generated were supplied into Bayesian Network to analyze the performance of the agents. In the Bayesian Network, the negotiation node is made up of three variables of continuous type (p-agent, y-agent and z-agent). The negotiation data learns its distributions in parameter learning. the maximum iteration is set to 100, thus, the learning converges and iteration stopped at 86.

Figure 4.1 shows the negotiation network of p, y and z agents. This network consists of three nodes; p-agent, y-agent, z-agent, they are continuous variables and linked to each other as indicated by 1, 2 and 3 lines.Figure 4.2 shows the negotiation outcome. Each agent is represented in a color. Yellow color represents p-agent, ash color represents y-agent and blue color represents z-agent. y-axis of the line graph represents the negotiation made by three agents in terms of age and year of service, x-axis represents number of negotiations. In y-axis, 20 to 35 represents retirement by age and 36 to 65 represents retirement by years of service. There were several lose-lose negotiations by three agents such as all age below 35years. However, there were three win-win negotiation accepted by p-agent, y-agent and z-agent in 35years for retirement were by age and two negotiations accepted by p-agent, y-agent and z-agent for retirement by years of service.

5. CONCLUSION

We have developed negotiation system using Bayesian Network. The negotiation mechanism consists of two agents (y, z) negotiating with Proposer (P) agent over civil servant retirement age in order to find the appropriate age and years of service. The proposer agent is seeking the appropriate age or service year while the other agents need to meet a certain satisfaction level. Exclusive disjunction has been applied to demonstrate the negotiation. Bayesian Network has been used to mimic human negotiation by incorporating a parameter learning component of Bayesian network into the negotiation process and facilitate the result of the negotiation. However, the negotiation process has been demonstrated in form of directed acyclic graph, detailing the proposer offer, third party recommendation on retirement and parameters for acceptance.

Agent P can create certain situations that can encourage another agent Z to act in a way that reveals its beliefs. Bayesian Network based negotiation system provides both an action selection mechanism that increases likelihood of success (win) in negotiation as well as allowing for updating beliefs about relationships between three factors (retirement age ≥65, years of service ≥35 and health issue) and agent Z decisions based on the decisions taken by agent Y in retirement negotiation context. This study analyzed the Bayesian technique of the negotiation process using parameter learning algorithm. According to the parameters given, the system produced more lose-lose negotiations and three win-win negotiations.

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