Application of Agents for Efficient Energy Consumption: Coalition Formations approach; A Systematic Review

Areej A. Malibari, Amjad H. Gamlo and Azoof E. Metro

Faculty of Computing and Information Technology, King Abdul Aziz University, Jeddah, Saudi Arabia

Abstract

An agent based system has been introduced with the aim to optimize the consumption of cooling energy in the Kingdom of Saudi Arabia. The minimization of cooling consumption cost and maintaining the comfort of the householders has been the main target of the study. It has also provided an overview of the coalition formation and multi agents system and some applications of coalition formation as well. The applications in terms of energy matters and consumption have been presented. This review has aimed to develop an efficient algorithm for distributing the coalition value among multiple agents. The study has applied the algorithm to reduce the energy consumption for more than one building in the same area. Different algorithms and techniques have been taken as consideration to reduce the consumption costs. The algorithm has also been compared with some coalition formation algorithms and showed different levels of energy consumptions. The thermal categories have also been determined in the study, which can be later used in the matter of optimization the cooling system consumptions.

Keywords: Agent, Coalition, Formation, Multi-Agent

Introduction

The open distributed computing applications have become a very large perspective and needs a multifaceted task to accomplish the operations. The applications can perform the multiple tasks to attain the objectives and the multifaceted tasks involve dependencies between the multiple agent and they cannot predicate in advance. A computer system that is acting autonomously in some environment to convene its delegated aims is called an agent. One of the important properties of autonomy is agent and this indicates that the agent is able to perform without the intrusion of human or other systems [1, 2].

The agents are considered as an important agent that respond in a timely manner to bring change in the environment and are able to interact with other agents as well and exhibit goal directed behavior are considered as an important agent. Such properties make the agents to interact with other agents and human. The properties are helpful in maintaining the interaction among agents and human via coordination, negotiation and cooperation. Multi agent systems consist of multiple agents, which interact with each other on behalf of user to enhance the performance and fulfill the objectives.

Application of Agents in Energy Optimization. A study conducted by Sayan et al. [3] of category non-cooperative trading demonstrated that the proposed algorithm creates improved and greater quality coalitions when benchmarked against a heuristic coalition development algorithm and two coalition's preparation algorithms that leverage an ant colony optimization method [3]. As the problem of the study was related to the Ant Colony Optimization algorithm, which suffer from two major disadvantages in inspired search approach. (1) Sup-optimal solution and (2) it takes a higher computational time. The solution suggested for this problem was a novel hybrid CF algorithm also called sA-ANT that allows ants to dynamically deposit pheromones to their respective solution qualities to increase the search exploration.

Unlike the simulated agents, simulated robots must travel to the task location before forming the task. sA-ANT minimizes the robot's distances while computing efficient robot.

Yeung, Wu and Poon [4] conducted a study, which has presented another thought in creating the multilateral [4]. It has also presented another thought in creating multilateral exchanges utilizing GT and multi-agent displaying. It also indicated that the variety in transmission line costs, incorporation of counter-stream inside of a coalition, and arrival of transmission imperatives by having more gatherings included in an exchange adds to the inclination of multilateral exchange. The authors assumed that the coalition is only allowed to contain a particular number of agents up to q (i.e. at least 3 agents and at most 5 agents) agents. The algorithm works by making the agents negotiate about which of them performs which of the algorithms.

Xiang, Li, and Li [5] found that a user can decrease its own specific energy utilization by delegating a fragment of the occupation to adjoin users in a coalition [5]. It additionally proposed in like manner passed on cooperation techniques in light of preoccupation hypothesis and point of interest the issue as a non-transferable utility CF amusement in which users join or split from coalitions depending upon the close-by slant. The simulation results demonstrated that their proposed structure gives equivalent energy investment funds and a lower execution unpredictability when contrasted with a brought together comprehensive inquiry approach.

Khan et al., [6] demonstrated that the proposed coalition development formations yield critical additions as far as the diminished normal false alert likelihood and expanded normal throughput per CR when contrasted with the non-helpful Formations [6]. The proposed coalition development empowers the CRs to build their achievable throughput, under the recognition likelihood requirement, while likewise considering the overhead in detecting reports consolidating. The dynamic model of coalition formation is utilized to express and model the conduct of the coalition framing CRs after some time. In the proposed diversion, CRs structure coalitions either to build their individual increases (narrow-minded coalition development) or to expand the general additions of the gathering (unselfish coalition formation).

Coalition Formation. Coalition has main features that make it unique from other organization. "Coalitions in general are goal-directed and short-lived; they are formed with a purpose in mind and dissolve when that purpose no longer exists, or when they cease to suit their designed purpose, or when the profitability is lost as agents depart" [7]. The coalition formation process can usually be considered to involve three main activities including Coalition Value, Coalition Structure Generation, and Payoff Distribution. The present study has aimed to develop an efficient algorithm for the distribution of coalition value among multiple agents. Applying the developed algorithm in order to reduce energy consumption for more than one building at the same area has also been the main focus. The main aim of the study was to compare the developed algorithm with some common coalition formation algorithms.

Coalition Formation in Multi-agents Systems. The computer systems are required to complete more complex tasks autonomously as the world is facing the technology evolution. Agents and multi-agent systems have to carry the categories that make them a good choice in making numerous software and applications of computer system. Studies conducted on coalition formation characterize two traditional methods [8] that usually frame two of the following sections:

1. The blocking approach has been considered, which needs the safety of coalition game plan in order to "block". The idea of blocking has been negatively sent as something that destabilizes or decimates the suggested course of action. It must be appeared that blocking can be viewed as a feature of the "Formation setup" that prepares an outcome [8].
2. The study suggested a non-corporative collating, in which the people are supposed to make suggestions to form a coalition, which can be acknowledged or dismisses. This might make a new proposition making and the progressive rounds of the dismissal and acknowledgement assume the position of blocking. The speculation of bartering and non-cooperative front has served as the keystone for most of the hypotheses of coalition development [8].

A multi-agent model in conjunction with game theory has been introduced by the cooperative game theory in order o determine the Coalition Formation (CF) for multilateral trade. A model has been actualized by the Java programming dialect and the improvement devices for operators (JATLite/JAT0.3) created by

the Stanford University. The matter of Coalition Formation has been covered by this model for multilateral changes, which refers that it answers the multiple problems in a way free-market generation organizes for many sided agreements that are usually valued lacking a principal forming cost. The task of each agent is to follow the posture of control free market generation, which can be administrator, communication, physical or any gathering might be included in the free-market. This has also determined a gainful and workable coalition association under the reasonable play home. The model is a rule and easy to the extent that consequent trade seems to work, examined in the study. The assortment in the corresponding line costs, which joins the counter-stream within a coalition incorporated into a multilateral trade [4]. The issue of how different coalitions are to be shaped among the portable clients gathering to reduce the average energy cost has been conducted by Xiang, Li, and Li [5]. It has been accepted by the researchers that when a portable client intends to frame a coalition with different clients, it enters a necessary occurrence with the alternative clients inside the coalition and takes into account the advantages and benefits of the coalition. All the clients are freely sensible and with this thought, the main problem of the study is covered by how the adaptable clients are arranged in closeness with one another to outline coalition. This has been done in order to complete the average algorithm genuine occupation with the aim of minimizing the utilization of power.

It has also been suggested by Xiang, Li and Li [5] that the algorithms are concentrated assignments that can be distributed or circulated among the adjacent cell phones and give more attention to the issue that gathering of the clients that are versatile might work together with one basic target of work [5]. A client can specifically reduce or diminish its own consumption of energy by appointing a division of employment to adjacent client in coalition. Additionally, it has also been proposed that conveyed procedures for cooperation in light of the diversion theory and the details of the issue as a non transferable utility, Coalition Formation game in which the client split or join from relying upon the nearby inclination. It has been appeared through simulation process that the proposed algorithm diminishes up to 22% of the average energy cost compared with the non-cooperative situation, and the time of running balances well as the number of users formulate [5].

One of the key advancements to acknowledge the spectrum reuse and build the spectrum competence in Cognitive Radio Systems (CRNs) is the spectrum sensing. It considered Energy efficient helpful and Multichannel range detecting in the Cognitive Radio Systems. A Cooperative Spectrum Sensing and Accessing to (CSSA) plan for all secondary users has been proposed by Hao et al., [9]. This secondary user plan is helpful in sensing the authorized channels of the primary users in the detection of space. The secondary user, which can detect the channel that have a chance to transmit parcels is resolved to sit still and the secondary users will have a chance to transmit parcels in the knowledge of transmission opening. The Multichannel spectrum sensing issue as a coalition formation diversion has also been figured out. Hao et al, (2011) has also proposed appropriating algorithms to locate the model segment that expands the total utility of the substantial number of segments that achieve the ideal total utility. The self association has been observed among secondary users that gains a higher total utility after every cycle. Similarly, the optimality and union of the proposed algorithms are demonstrated by the simulation results [9].

In multi-agent spaces, operators structure coalitions to perform errands. The standard models of the helpful GT accept that the wanted result is either the terrific coalition or a coalition structure that comprises of disjoint coalitions (i.e., a parcel of the formation of operators). Chalkiadakis et al., [10] presented a model for helpful games with covering coalitions [10]. It also concentrated on the ideas of soundness in this setting. Specifically, they characterized and contemplated a thought of the center, which is a speculation of the comparing idea in the conventional models of helpful diversion theory. The efficient energy consumption and coalition formations approach have been studied previously in numerous researches. Table 1 and 2 have listed the previous related works regarding the application of agents for efficient energy consumption.

Table 1: An Overview of the Most Related Previous Studies

Authors	Category	Problem	Solution	Evaluation	Results & Conclusion
Xiang, Li, and Li (2015)	Cooperative Game Theory	How various coalitions are to be framed among a gathering of portable clients to diminish the average energy cost?	Through exchanging the generally low correspondence energy cost for high algorithms control consumption, with the target of minimizing the energy consumption	It appeared through Simulations that the proposed algorithms of this study diminish up to 22% of the average energy costs contrasted with the non-cooperative circumstance, and the running time balances well as the number of users formulates.	It found that a user can decrease its own specific energy utilization by delegating a fragment of the occupation to adjoin users in a coalition...
Ramirez et al., (2015)	Cooperative Game Theory	A low intricacy virtual MIMO coalition's formation algorithms.	Improving the MSs execution by shaping virtual coalitions with the RSs. In this way, control investment funds are acquired through multi-radio wire clusters by actualizing the ideas of spatial differences and spatial multiplexing for uplink transmission.	It has been demonstrated intelligently and by duplications that when generally gobbled up force is considered as a streamlining metric, the energy feasibility of the single forming keeping in mind the end goal to acknowledge wires gadgets is not overall enhanced a virtual MIMO show.	The proposed structure gives equivalent energy investment funds and a lower execution unpredictability when contrasted with a brought together comprehensive inquiry approach that is composed of the BS.

Ramos, Burguillo and Bazzan(2015)	Non-cooperative trading	Benefitting from V2G sessions.	The development of coalitions among PEVs has been proposed to handle this issue. In this paper, they depended on space information with a specific end goal to propose a novel demonstrating for such issue.	They tentatively exhibited that their system is both capable (it beats best in class algorithms to the extent runtime) and feasible (game plans were 96.5% of perfect, all things considered).	It explored how the likeness among the PEVs' vitality profiles can be utilized to enhance the development of coalitions. The vitality profile of a PEV gauges to what extent such PEV will be accessible for the V2G session. In view of this, it became for amplifying the coalitions' length of time.
Lai, Chen, and Liu (2014)	Cooperative Game Theory	In any case, because of the extra handling power in getting and retransmitting other's data, not all nodes and helpful conventions can accomplish energy proficiency.	The consolidations system is associated with a supportive correspondence tradition, to be particular WNC, to show and affirm its ampleness.	The cooperative systems accomplish adjusted power circulation, which helps to enhance the system lifetime.	Reproductions demonstrate that for the same system setting, the cooperative transmission systems can require 3.3 times less aggregate power, representing both transmission and preparing power, than the immediate transmission systems to give an equivalent nature of administration.
Guazzone, Anglano, and Sereno (2014)	Cooperative Game Theory	Abuse the capability of cloud organizations for the decrease of	Coalitions among sets of Cloud Suppliers (CPs) developed, by	Numerical results are shown to demonstrate the suitability of the	An appropriated algorithm has been formulated, in perspective of

| | | the energy bill. | a formation of CPs consent to commonly utilize their own particular assets to run the VMs of different CPs. | proposed count. | cooperative game theory (CGT), that allows an arrangement of CPs to helpful capably set up their associations in a way that their individual advantage is extended with respect to the case in which they work in separation, and they showed that, by using their algorithm and the proposed CPs' utility limit, they can self-organize into Nash-stable associations and, by strategy for iterated executions, to conform to environmental changes. |
| Sayan and others (2013) | Non-cooperative trading | Ant Colony Optimization algorithm suffer from two major disadvantages in inspired search approach. (1) Sup-optimal solution and (2) it takes a higher computational time. | A novel hybrid CF algorithm also called sA-ANT allows ants to dynamically deposit pheromones to their respective solution qualities to increase the search exploration. Unlike the simulated agents, | They evaluated their new technique by comparing it with Vig and Adam's heuristic algorithm by 4 metrics: (1) Number of unique coalition, (2) Coalition quality, (3) Traveling distance and (4) | This experimental study demonstrated that the proposed algorithm creates improved and greater quality coalitions when benchmarked against a heuristic coalition development algorithm and |

			simulated robots must travel to the task location before forming the task. sA-ANT minimize the robot's distances while computing efficient robot coalition.	Computational time.	two coalition's preparation algorithms that leverage an ant colony optimization method.

Table 2: Summarized form of related work

Publication	Buildings No.	Agents No.	Techniques	Results
(Mokhtar, Liu, & Howe, 2014)	1	Multi-Agent	1. Artificial neural networks. 2. Computational intelligence algorithms. 3. Online learning mechanism.	Better energy control and thermal comfort management are demonstrated in comparison to the existing system.
(Yang S.-Y. , 2013)	1	Multi-Agent	4. Case-based reasoning (CBR) with Web service. 5. Ontology techniques.	22.44% total energy saving.
(Yang R. &., 2012)	1	Multi-Agent	Optimization algorithm for building energy management.	High comfort level is maintained when the total energy supply is low.
(Alex Rogers, 2011)	1	1	1. Gaussian process. 2. Greedy heuristics.	1. 15% costs reduction over one month. 2. 9% carbon emissions reduction over one month.
(Sarvapali D. Ramchurn, 2011)	5000	5000	Mathematical programming techniques.	1. 17% costs reduction over one month. 2. 6% carbon emissions reduction over one month.
(A.I. Dounis, 2011)	1	Multi-Agent	1. Fuzzy logic. 2. Genetic Algorithms.	Successful simulation model.

(Zhang Lin, 2010)	1	Multi-Agent	Collecting data sensors and wireless/Ethernet networks.	The problem of unnecessary power consumption in the case of nobody in the building is solved.
(Varick L. Erickson, 2009)	1	1	1. Wireless camera sensors. 2. Gaussian process. 3. Agent-based model simulation.	5% to 14% energy saving compared to the other energy saving strategies.
(Hani Hagras, 2008)	1	1	1. Neural Networks. 2. Fuzzy logic systems. 3. Genetic Algorithms.	7.7% gas and electricity energy saving.
(Jarunee Duangsuwan, 2008)	1	Multi-Agent	1. Wireless sensor network. 2. Some policy management.	Occupant's comfort is achieved while energy consumption is maintained.
(Paul Davidsson, 2005)	1	Multi-Agent	1. Bluetooth and indoor positioning system. 2. April & Aprill++ programming languages.	Considerable energy saving results while added comfort value is provided to the customer.

Applications of Coalition Formation in Energy Matters. Energy saving is one of the important problem that coalition might help to resolve. The Information Communication Technology division is a key part being in charge of around ten percent of the world carbon foot shaped impression and the electrical energy utilization [11]. Energy cannot be put away on a huge scale effectively; the power network must adjust the supply to all clients at any time. The measure of interest required on persistent time is normally conveyed by the base load stations inferable from security and proficiency [2].

There are some situations that are moderate to chill off and start up as they are not ready to coordinate the crest burden periods. The coalition formation would be tested to lessen he productivity energy consumption through a connecting a coalitional hypotheses. A coalition is able to implement understandings among its clients while it interacts non-cooperatively with the other non-member people and outside world as a rule [12]. It has been suggested that the solitary node in a system coordinates with each other exploiting the cooperative correspondences that is able to prompt the transmission power source. It has also been suggested that all nodes and helpful conventions might accomplish the energy proficiency.

A model has been proposed to guarantee the effectiveness of the cooperative system, comprising of the transmission solicitation stage and helpful transmission stage using the coalition development. The main aim is to locate the decent structure of collaboration in which the singular nodes is helpful and is able to accomplish the particular productivity of energy.

The merges system is connected with the helpful communication convention and it is specific to wireless network co-cast (WNC) in order to exhibit and enhance the accuracy. Reproduction demonstrates that for the similar system settings, 3.3 times less aggregate power is required by the cooperative transmission system, representing the preparing power and transmission. Moreover, the cooperative system adjusts the power of circulation and it helps to enhance the lifetime of a system capacity. The simulation revealed that the iterative merge and split methods have to be utilized just

as a part of the little size system while the proposed combining process has a great deal of significance regarding more points of interest in vast size systems [13].

A low intricacy and virtual multiple inputs and the multiple output (MIMO) coalition formation algorithm has been considered. The main aim of the study was to get the changes in the energy proficiency by shaping the multi-radio wires virtual clusters for information transmission. Virtual can be firmed by finding an instant and speedy game among the single radio wire gadgets, for example Mobile Stations (MS) execution by firming the virtual coalitions with the Relay stations. In this manner, the control investment funds are acquired through the multi radio wire clusters by focusing the ideas of spatial multiplexing and spatial differences for uplink transmission [14]. The researchers also intended to enhance the usually extended control as an alternative of the transmitted power of the system's gadgets. It has been established logically and by the reproduction that the system generally determined the power, which has been considered as the streamlining metrics [14].

Coalition Formation in Heating-Cooling Problem. There are different applications of energy saving that are intended to maintain the energy consumption and to minimize the over stated costs and its harmful effects as well. The heating and cooling system is one of the resources that consume the energy in buildings. These applications also invest the agent properties in order interact with the environment and know about its thermal characteristics. Agents can be considered smart enough to deal with the best heating and cooling processes and minimizes the energy consumption.

A better balance between the conflicting objectives and the existing multi-agent system are provided by the use of computational intelligence algorithm. The existing multi-agent system utilizes a well defined approach for its agents. The integration of the gARTMAP to the agents offers an online mechanism for learning. The results from the study conducted by Mokhtar, Liu & Howe [15] demonstrated that the present system which has been incorporated provided a better energy control and thermal control management as well for the building in contrast with the present system [15].

The related work can be characterized into two categories according to the number of agents involved, including the multi-agent system and the individual agent project. Although these number of agents differ in the perception of energy savings. Some of them deals with the thermal categorization of the building and predicts the user consumption behavior and then makes adjustments on the heating and cooling system dependently.

A study conducted by Mokhtar, Liu & Howe [15] has considered a multi-agent technique that included the artificial neural networks, Computational intelligence algorithms and online learning mechanism [15]. This has resulted with the better energy control and the thermal comfort management and demonstrated in contrast with the existing system. A total of 22.4 percent total energy saving has also been resulted in the study conducted by Yang [16] which implemented the Case-based reasoning (CBR) technique with Web service and also the ontology technique using multi-agents [16].

A study conducted by Yang [17] has resulted with the maintained high comfort level when the total supply is low [17]. The techniques used by the researcher were the optimization algorithm for building energy management. The Gaussian process and the greedy heuristics technique were used by Alex Rogers [18], which resulted in 15 percent reduction in cost over one month and 9 percent carbon emission reduction over one month [18]. The mathematical programming technique has been utilized by the Sarvapali & Ramchurn [19]. This study gave results with seventeen percent reduction over one month and six percent carbon emissions reduction over one month. Furthermore, successful simulation model has been resulted in a study conducted by Dounis [20] by using the fuzzy logic technique and the genetic algorithm [20].

Zhang Lin (2010) has collected the data sensors and wireless and Ethernet networks as a technique using multi-agent system [21]. The study resulted with the problem of unnecessary power consumption in the case of nobody in the building is solved. The wireless camera sensors, Gaussian

process and the agent-based model simulation technique have been implemented in a study conducted by Varick [22]. This study provided the results with 5 percent to 14 percent energy saving as compared with other energy saving strategies.

Neural Networks, Fuzzy logic systems, Genetic Algorithms were the techniques used by the Hani Hagras [23]. This has resulted with 7.7 percent gas and electricity energy saving. Occupant's comforts achieved while energy consumption has been observed maintained in the investigation of Duangsuwan [24] by using the wireless sensor network and some other policy management procedures [24]. A study conducted by Davidson (2005) revealed considerable energy saving results while added comfort value is provided to the customer, using a Bluetooth and indoor positioning system and April & Aprill++ programming languages [25].

Conclusion

This review has contributed to understand the multi-agents and intelligent agent systems that can be used in various applications where the human-like responses are needed. Some helpful applications of the coalition formation have been viewed that might provide different approaches proposed by several scientists for the energy saving with the use of intelligent agents techniques. The overview and comparison of different previous studies have shown thermal models that can be utilized according to the thermal parameters comprising a modeling formula. The best cooling behavior for the cooling system have been found using the optimization process, which suggested that different optimization algorithms can be used.

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