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Application of Game Theory for Resource Management in Ubiquitous Environment

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ABSTRACT

Resource data I/O rate, consumption and organization lead to a number of innovative challenges in computer engineering. Efficient resource allocation and organization is one such challenge. Maximum benefits can be reaped if resources are renewable resources. These renewable resources will require different strategies from the conventional one. With the variable I/O rate of data generated by resources, it becomes further challenging to maximize the profit gained. An efficient strategy can help to this effect.

With recent advancements in technology, a ubiquitous environment has started facing many challenging tasks in resource allocation and organization. This paper presents an algorithmic solution for allocation and organization of renewable resources in a ubiquitous environment. This algorithmic solution can be used in different industrial and social applications. Smart home system is one such area where renewable resource allocation and organization finds its use.

Keywords:- Resource Allocation and Organization, Ubiquitous Environment, Renewable Resource, Game Theory.

I. INTRODUCTION

With recent advancement in technologies, a Ubiquitous environment presents us with many challenging problems. When the resources being used are renewable, the study of resource allocation and organization strategies becomes an even more interesting and challenging field. Obtaining maximum profit from the allocation and organization of these resources is one of the challenges considered in this paper. In different applications of renewable resources, data production and consumption is varying. It depends on the time factor and demand for the data. In certain cases, production and consumption of data with different quantities are simultaneous processes. This may take 3 steps namely production, storage and consumption of data. There are also external environmental factors which decide the production and consumption of data. Data consumption is based on demand of the data. To satisfy this demand, data production and consumption should be maintained at optimal levels. By proper resource allocation and organization, data production and consumption rate is controlled to gain the maximum profit and satisfy the system constraints. Management of such systems is a challenging task. Issues with these types of systems are overflow, underflow or starvation problems. These problems can be solved by adjusting the rate of input-output (I/O) without breaking the constraints of the system. With the proper allocation and organization strategy for resources, optimal output can be achieved. Game theory also deals with similar cases. Application of game theory to such systems where I/O data rate and demand of data is varying is an interesting area of research.

Game theory is an interactive decision theory. Decisions are taken based on how much payoff it will gain and based on certain rules. Each player behavior is supposed to be rational. By talking in the language of the Game Theory, rationality means irrespective of other players move, each player tries to maximize his profit or payoff with his/her optimal move. Each player have the set of actions or moves which are define according to the game rules and which help to increase his/her payoff.

II. LITERATURE SURVEY

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In recent years, wind, solar energy, hydro-power, biomass renewable energy systems has gain the popularity. Integration of this systems with smart grid, will be able to satisfy the current customer's demands with less impact on environment. Phuangpornpitak et. al. describes integrating renewable energy in smart grid system and what are the benefits and barriers of it. They also talk about the role of renewable energy and distributed generation in smart grid and specify the some existing work done in smart grid renewable energy system [1].

A. R. Al-Ali *et al.* talks about the integration of renewable and storage energy resources with smart grid at the consumer site. They proposed an embedded system for smart home which integrates renewable resource i.e. solar energy and storage unit to it. Two-way communication is maintained between the customer and utility provider for optimize energy flow and consumption efficiency. Power flow scheduling is done according peak and off-peak period [2].

Ji-Yeon Son *et al.* uses the home context information resource aware management system for smart home resource model. By using the resource relation graph, home knowledge is build. With the help of this graph, reason for failure in home network can be found. This model can be also used as basis for the management of the heterogeneous resources in various domains [6].

According Dong-Hoon Yi *et al.*, to guarantee the optimal resource allocation in Internet, resource reservation plays important role. They have taken two types of reservation schema into consideration - advance and immediate reservation. For balanced resource management between above types, they proposed revenue based resource management schema. Pro- posed schema adaptively changes by analyzing the relationship between the service cost and price [4].

Yuan-Shun Dai *et al.* discuss about resource management systems(RMS) in grid computing where resource sharing is on large scale and multi-institutional and wide-area communication happens. First they calculates the RMS availability in grid using hierarchical Markov model. Based on this best RM servers number is determine for minimizing cost. Interaction among the different request queues is permitted by using one common queue for optimize allocation of resources to requests [5].

Nishanth Shankaran *et al.* provides the framework for resource management in distributed real-time embedded systems. Their Integrated Planning, Allocation, and Control (IPAC) framework, which provides ,dynamic resource allocation, decision-theoretic planning and run-time system control to provide coordinated system adaptation and enable the autonomous operation of open distributed real-time and embedded systems [7].

Zhenhuan Gong *et al.* proposes systems for elastic resource allocation in cloud computing. Predictive Elastic reSource Scaling (PRESS) model is present in their work. This model predicts the online resource demand with both cyclic and non- cyclic workloads. For resource prediction, integration of two approaches is done in PRESS model : 1. Signature-driven resource demand prediction 2. State-driven resource demand prediction. Their results shows high accuracy in resource usage prediction and better profit to server provider by its allocating strategy as compare to other approaches in range of workloads [3].

Mihaela-Andreea Vasile et al. proposes resource-aware hybrid scheduling algorithm. Hierarchical clustering algorithm is used to clusters the available resources into groups. Tasks are divided into groups of resources in first phase and then classical scheduling algorithm is performed on each group [8].

Xiaoyong Tang et al. proposed reliability-driven scheduling architecture. They introduce reliability priority rank (RRank) to estimate the tasks priority by considering reliability over- heads. A reliability-aware scheduling algorithm is developed for precedence constrained tasks to achieve high reliability using directed acyclic graph(DAG) [9].

Siamak Baradaran et al. proposes a hybrid meta-heuristic algorithm (HMA) for MultiMode Resource-Constrained Project Scheduling Problem (MRCPSP) in PERT networks [10].

M. Mavronicolas *et al.* discuss the game theory and challenges associates with it. They also talks about different applications of it in computer science field [11].

III. PROPOSED SYSTEM

Game theory helps players to make decisions for maximum payoffs based on rules. Here players make the moves such that their benefit will be maximum from taken decision. In the game, there are three elements are present :

- Game players
- At each stage in game, information and set of actions to be perform
- Benefit of each taken action i.e. payoff

By applying game theory concept on resources in ubiquitous environment, each resource can be consider as players of game, at each point resource environment information is available to players such as sensor data and based on this information set of actions are performed. Rules of the games are defined by the constrains on the system.

Data producer, consumer resources and storage unit of data can be consider as players of the game. Resources produce and consumer data at different quantities. This data is stored in data container. Based on the information available about the container, producer-consumer decides their actions. Container has a threshold value associated with it say θ.

Rules of the game are as follows :

- Container should always have threshold value amount of data in it at any given time. In other words, consumer is allowed to consume data from container by satisfying constraint that after consumption of data , data in the container is greater than or equal to threshold data value.

Available Data ≥ Threshold Data value (θ)

- After adding data into buffer, container overflow should not occur.

Available data + a' ≤ threshold data value (θ)

where, a' is generated data.

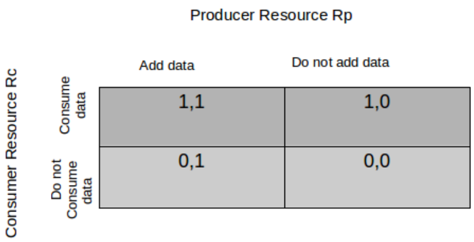

Figure 1. Payoff Matrix for Players R_p and R_c

A. *Mathematical Model :*

Let S be a programmers perspective of system such that

$$S = \{s, e, X, Y, DD, NDD, f_{in}, f_{out}, f_{me} \mid \varphi \}$$

Above terms will be explain in the flow of explanation.

Let, s be the known distinct start state which contributes in the initialization of functions. Let e be the known distinct end state going into which may result into desired outcomes. Let, Y be the set of outcomes of S and X be the input set of S. The function f_{me} is the implementation of the proposed algorithm resulting into outcome Y. Let, DD the deterministic behavior of function and data which helps in identifying the load/store functions or assignment functions which contribute in the space complexity resulting into tables and NDD be the non-deterministic computing functions of the system S which is to be solved by computing functions which contribute in time complexity of the algorithm.

Let $R \in X$ is the set of the resources present in the ubiquitous environment such that,

$$R = \{Rp, Rc, Rs, C\}$$

where, R_p is the producer resources which produces the data, R_c is consumer resource which consumes the data, R_s is set of sensor resources which provides the information about the environment and C is the container for storage of data.

Let $D \in X$ be the consumable data resource that can be stored in container C. $C \in R$ has the maximum capacity C_{max}. Lower threshold value is assigned to the container $\theta \in C$. X becomes,

$$X = \{D, R\} \text{ and } C \in R = \{C_{max}, C_a, \theta\}$$

Let C_a be the current available capacity of container. Rules of the game are :

- Current available capacity should be always between the threshold capacity value $\theta \in C$ and maximum capacity value.
  $C_{max} \in C$
- Producer resource R_p is allowed to add data into container, if C_a is
  $C_{max} \leq C_a \geq \theta$
- Consumer resource R_c is allowed to consume data according to demand if C_a is,
  $C_{max} \leq C_a \geq \theta$.

R_s provides the information I to players R_p and R_c at each point in the game. This information I contains the current available capacity of container C_a, Timestamp, Sensor data etc. Using this information each player decides his next move in the game. Information set I is the deterministic data of the system which helps for finding the solution.

Payoff is assigned to players as 0 and 1, where 1 indicate the successful operation by the player and 0 indicates the failure of the operation by the player. Playoff matrix for players is shown in figure 1. In payoff matrix, 1st number indicate payoff of the player R_c and 2nd number indicate payoff of the player R_p. For example, if cell contain value (1,0), then 1 is the payoff of player R_c and 0 is of player R_p.

Now using the Information set I, Producer player R_p adjust its rate of data generation and decides whether add data in container C or not. Calculated input and output data will be the non deterministic data, as using the information I, this data is calculated which changes as information stats gets changes.

Let the function $f_{in} \in S$ be a computation function which adjust the rate of data generation $d' \in D$ generated as shown in equation 1,

$$d' = a * D \qquad (1)$$

Where, $a \in I$ is the time critical factor which affects the amount of scalable input to D

Let the function $f_{out} \in S$ be the computation function which calculate the required amount of output data $d'' \in D$ as shown in equation 2,

$$d'' = b * D \qquad (2)$$

Where, b' is the demand factor which affects the output data rate of the D.

Demand b' is addition of all the demands for data D present with player R_c as shown in equation 3.

$$b' = \sum_{i=0}^{m} bi \qquad (3)$$

The worst case analysis of availability of resource $D \in X$ in container $C \in R$ is represented by F_{me} where,

$$Fme(C,D) = \begin{cases} Ca = Ca - d'' & : Ca = Cmax \\ Ca = Ca + d' - d'' & : \theta < Ca \leq Cmax \\ Ca = Ca + d' & : Ca = \theta \end{cases}$$

As the rules defined for the players, set of operations are defined according in F_{me} function. Based on the current status of Ca provided by the *I*, players choose one operations out of three.

IV. DATA TABLE AND DICUSSION

Sample data set is taken for example shown in table 1. d' and d'' is the input data and output data which is the demand for data respectively at time t. Threshold limit of container θ is consider as 25. At time 0, Ca i.e. current capacity of the container is assumed as 70. Ca' is the capacity value of container after operations performed by players. The performance graph shown in figure 2, displays the comparison between proposed algorithm and producer consumer problem on the basis of resource utilization variance using data from table 1.

TABLE 1: Input Output Data Table

Input			**Output**			
Time	**d'**	**d''**	**Our Solution**		**Producer-Consumer**	
			Ca	**Ca'**	**Ca**	**Ca'**
1	**0**	**0**	**70**	**70**	**70**	**70**
2	**15**	**25**	**70**	**60**	**70**	**45**
3	**30**	**10**	**60**	**80**	**45**	**75**
4	**30**	**45**	**80**	**55**	**75**	**30**
5	**10**	**45**	**55**	**65**	**30**	**40**
6	**50**	**20**	**65**	**05**	**40**	**60**
7	**40**	**20**	**95**	**75**	**60**	**40**
8	**25**	**10**	**75**	**90**	**40**	**65**
9	**20**	**30**	**90**	**80**	**65**	**85**

10	**25**	**25**	**80**	**80**	**85**	**85**

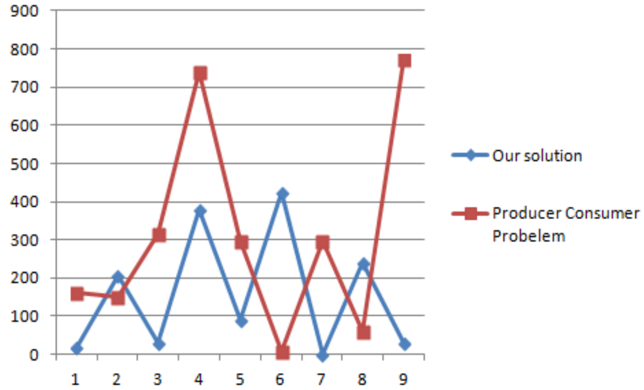

Figure 2: Comparison Graph between Our Solution and Producer Consumer

V. CONCLUSION

In this paper, how resource game theory can be used for resource management is explained. Performance of resource allocation and organization algorithm is tested successfully using the above research methodology to check efficiency of proposed methodology. Results are compare with producer consumer problem. As seen from graph [Figure 2], variance in producer consumer problem is more as compared to our proposed solution.

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