On the Viability of Adaptive Paris Metro Pricing in Agent Based Model for Federated Clouds

V. Pradeep Kumar, M. Gopichand, N. Srinivasu

Abstract*: Federated Clouds provides efficient resource pricing using static and dynamic methods. Most of these pricing models are analyzed based on cloud service provider perspective to maximize their revenue. Need of pricing model to prioritize the users request for allocating resources according to their demands and provide maximum utility within optimal price. This paper analyzes the viability of Adaptive Paris metro pricing (APMP) in agent based model for federated clouds to achieve equilibrium between provider and users of cloud in gaining maximum revenue with optimal price. Further APMP achieving strategy proof is analyzed with simulation support for federated clouds.

***Index Terms*: Federated Clouds, Cloud resource pricing, Adaptive Paris Metro Pricing, Agent based model.**

I. INTRODUCTION

Federated clouds play a prominent role in providing flexible cloud services to customers without any loss on effective utilization of resources in cloud computing. It avoids vendor lock-in problems for cloud customers. It provides reliable resource pricing management along with criteria for evaluating the customer satisfaction in utilization of resources with a nominal price. It doesn't ensure customers to face the losses with overhead investment in cloud resource pricing with prior knowledge of resource requirements. Many pricing models were proposed to handle the issue of resource pricing in federated clouds. Every model has it owns problems and concerns in providing effective utilization of resources at appropriate price. Cloud pricing models can be of both static and dynamic. Static pricing models haven't much importance in federated clouds and they are not favorable to cloud customers in performing effective resource management. Dynamic pricing schemes have been given much importance in federated clouds for providing resources at any time without any delay for cloud customers at nominal price but all these schemes were developed in cloud service provider perspective to achieve maximum revenue for him they haven't worked for cloud customer perspective. Dynamic pricing scheme has given a mechanism to satisfy rational user's requests for multiple resource types [9].This scheme was developed to achieve strategy proof dynamic scheme with fixed pricing and able to provide solution of incentive management for individual rational users.

Market based resource allocation mechanism was provided with one of the dynamic pricing scheme where they resolved thorough economic perspective issues for allocating resources [10] and highlighted computational challenges which are undertaken in terms of providers perspective. Revenue maximization [7] was achieved using one of the dynamic pricing schemes where auction theory was taken in to consideration for bidding resources by different service providers to provide resources to customers. Different bidding strategies were highlighted in this scheme in order to achieve maximum revenue for cloud service providers. Heterogeneous user demands with truthful online auctions were designed for cloud computing to support variety applications and valuation types of job oriented and resource aggressive [2].Specific bidding language was used in this model to generate multiple users resource type requests and evaluated for designing payment function and maximize bidder's utility with allocation rule.

Agent based dynamic pricing model was highlighted in [1] [5] for price determination. The fair pricing function and non negative price function were used by provider agents [1] to estimate the profit gained by them and water filling algorithm was used for evaluating fairness, risk freeness, non-negativity and stability for above pricing functions. The price determination for multi-tenant environment [5] was done through agent based approach some specified algorithms like limited discount period, Protection level were analyzed for calculating revenue for providers. Thus it is clear from above discussion that dynamic pricing schemes were designed mostly in perspective of providers to generate maximum revenue but none of the model has highlighted the customer perspective of gaining optimal price for maximum resources utility. Further in this paper we discuss the Paris Metro Pricing Scheme in related works and highlight the extended features of PMP in Adaptive Paris Metro Pricing (APMP) scheme in agent based model for federated clouds in motivating example and system model and try to analyze the achievement of equilibrium price between multi-users and providers using game theory approaches.

II. RELATED WORKS

Paris Metro Pricing (PMP) [14] is simplest approach of static pricing used during network congestion to provide differential services dividing complete channel into set of classes for different users in order satisfy their requests for efficient usage of network for optimal price.

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A mathematical model of PMP scheme was analyzed for pricing packet networks [11], in this network is split into autonomous sub-networks and each sub-network has its own capacity

link for allocation of user requests and categorization of classes is done based on the users request to achieve high utilization of network by generating maximum revenue for network providers. In this paper they highlighted on multi-application extension of PMP for different classes by considering losses and delays as per Quality of Service (QoS) requirements of user's requests.

PMP viability for digital services was analyzed by considering it as flat rate pricing scheme for achieving social welfare and provider profit by categorizing classes in terms of utility sensitive service and latency sensitive service [6].PMP model was tested for different internet service classes under competition like social optimum, monopoly and duopoly. Optimization of internet pricing was highlighted in [8] [15][12] in order to enhance usage of internet under different circumstances. Formulation of new pricing schemes was done under multiple QoS networks [8] and was analyzed to offer better pricing to enhance customer usage of internet. Prioritization of pricing classes for differentiated service networks was analyzed for customers with elastic traffic [15] in order to maximize the profits with formulation as a non-cooperative game. The Tirupathi pricing model was formulated in [12] to achieve for social optimality in internet pricing and the model was analyzed for differentiated join services for parallel queues.

PMP pricing model was analyzed for QoS with a single service provider in [13] and formulated it as a subscription pricing with taking congestion of channel into consideration. Different aspects of system at equilibrium for QoS, user choice, provider profit and undifferentiated service with user choice were evaluated. Applicability of PMP for 5G heterogeneous networks [3] for different user equipments in providing multi radio access technologies services using differentiated service classes. The extended version of PMP i.e. Adaptive Paris Metro Pricing (APMP) for mobile data networks was analyzed for providing dynamic accessible prices of differentiated classes for specific time period [4].In this APMP model the goal was to achieve maximum revenue for operators and achieve optimal revenue for mobile users with in a mean time.

III. APMP USAGE IN AGENT BASED MODEL

A. Motivation and System Model

The motivation of considering the Adaptive Pricing Model (APMP) in agent based model for federated clouds is most of requests made by cloud customer agents lead to resource congestion at provider agents. This resource congestion can be resolved by migration of some set of resources to the required provider agents from others by forming a collation. APMP is used for pricing those resources by avoiding congestion and given pricing choice to get service the request for specified resources. APMP enhances dynamic pricing scheme approach in agent based model of federated clouds to generate maximum revenue for provider agents and provide optimum pricing function for customer agents to have a better choice of optimal price for high utility of resources. Let us consider the resource requirements given by cloud customer agent as a three tuple specifying computing, primary memory and secondary memory requirements i.e. $Req_j(Comp_j, Pm_j, Sm_j), 1 \leq j \leq J$.This resource request is collected by broker agent and provide information to different provider agents then all provider agents try to form collations in order to satisfy the customer agent requirements. The aggregated provider agents will specify the price information along with service time specifications to broker agents for categorizing them into different classes. Each class i formed at broker agents will announce the acceptable price information $ACP_i \leq ACP_{i+1}$ and specify the service time $ST_i \leq ST_{i+1}$ in advance.

The cloud customer agent j will be using pricing function to pay the total price for usage of resources of particular class i and total available capacity of resources is given by

$$TP_j = ACP_i + ST_i * C\alpha_i \qquad (1)$$

$$C\alpha_i = \sum_{l=1}^{L} (Prcmp_l * Wcmp_l + Prpm_l * Wpm_l + Prsm_l * Wsm_l) * \hat{\lambda}_l \qquad (2)$$

$$1 \leq i \leq I, 1 \leq j \leq J, 1 \leq l \leq L$$

Price vector for each resource of class i ($Prcmp_l, Prpm_l$, $Prsm_l$) , resources provided weighted vector of class i($Wcmp_l, Wpm_l, Wsm_l$), $\hat{\lambda}_l$ is total delay taken to form the class i and make available for service.

The total pricing function in (1) varies for different time instances and cloud customer agents who have utilized

the resources will have an optimal choice to choose among different classes and their utility of resources is maintained in a separate log file for future prediction of cloud customer requirements. Delay parameter considered in (2) is normally used during outage and loss of resources measurement so as to avoid congestion of resources allocation during service time.

The utilization of resources for optimal price is estimated for particular user θ is given by

$$Uty_\theta(j) \cong V_{max} - TP_j - \theta \, Func(N_j, C\alpha_j) \qquad (3)$$

V_{max} -Maximum utility of available resources for accessible price

TP_j - Total pricing function used for calculating actual price of utilization.

$$V \geq TP_1 \geq TP_2 \geq \ldots\ldots \geq TP_m \geq 0$$

$Func_j(N_j, C\alpha_j)$ -Congestion function for total no of customer agents N_j while utilizing $C\alpha_j$ capacity of resources available for utilization.

The cloud customer agent finally will have a choice (1) Select the class i service so as to get high utility

$$i = \arg max_{j \in \{1,\ldots,m\}} Uty_\theta(j) \qquad (4)$$

(2) .Move out of service classes in order to not to get service $Uty_\theta(j) < 0$.

Let the total resource usage for class i be δ_i

$$\delta_i = \sum_{i=0}^{I} Z_{ij} \quad (5)$$

Where Z_{ij} is the set of resources utilized by customer agent j for particular instance.

Total revenue can be calculated for provider agent is given by

$$TR= \sum_{i=0,j=0}^{I,J} (ACP_i * Uty_\theta (j) + ST_i * \delta_i) \quad (6)$$

The complete utilization of all classes by customer agent j is measured by

$$Func_{cap}(N_j, C\alpha_j) \cong \sum_{j=0}^{J} \frac{N_j}{C\alpha_j}. \quad (7)$$

The total delay caused by all classes to get serviced for customer agent j is specified by

$$Func_{lat}(N_j, C\alpha_j) \cong \sum_{j=0}^{J} \frac{1}{N_j - C\alpha_j} \quad (8)$$

B. Strategy Proof using APMP

The strategy proof can be used to check viability of APMP in agent based model for federated clouds. It checks causes of social welfare S(p) and attaining provider profit π(p) where p is set of differentiated prices p= $(p)_{i=1}^{m}$ for m service classes and there exists a set of cut-off users at equilibrium θ= $(\theta)_{i=1}^{m}$.

The equilibrium between customer agent total pricing function and provider agent revenue is analyzed by following constraints.

C1: $\theta_1 \geq \theta_2 \geq \theta_3 \geq \ldots\ldots \geq \theta_m$.

C2: $Func(N_j, C\alpha_j) \leq Func(N_{j+1}, C\alpha_{j+1})$ for $j \neq m$

$N_j \cong F(\theta_m)$ $if\ i = m$ or $F(\theta_i) - F(\theta_{i+1})$ if $1 \leq i \leq m$

C3: $P_{i-1} - P_i = \theta_i(Func(N_i, C\alpha_i) - Func(N_{i-1}, C\alpha_{i-1})$ if $1 \leq i \leq m$

$P_1 = V - \theta\, Func_j(N_1, C\alpha_1)$

The above equilibrium constraints are considered while calculating social welfare and provider profit.

Social welfare is given by

$$S(p) \cong \sum_{i=1}^{m} \int_{\theta_{i+1}}^{\theta_i} (V_{max} - \theta\, Func(N_j, C\alpha_j))\, .f(\theta)\, d\theta \quad (9)$$

Where f(θ) cumulative distributed function.

Provider Profit is given by

$$\Pi(p) \cong \sum_{i=1}^{m} P_i . N_j \quad (10)$$

The social welfare takes care of individual rational where each user will get chance of choosing their optimal price without any loss in utilizing the class i resources and generating revenue for provider is calculated using total profit. Incentive compatibility is attained by calculating loss of probability and outage probability while utilizing resources after allocation by broker agent.

Loss of probability is given by

$$Func_{loss}(N_j, C\alpha_j) \cong \sum_{j=0}^{J} \left(\frac{N_j}{C\alpha_j}\right)^k \frac{1 - \frac{N_j}{C\alpha_j}}{1 - \left(\frac{N_j}{C\alpha_j}\right)^{k+1}} \quad (11)$$

Outage Probability is given by

$$Func_{out}(N_j, C\alpha_j) \cong \sum_{j=0}^{J} \left(\frac{\varepsilon N_j}{C\alpha_j}\right)^{C\alpha_j} \quad (12)$$

IV. RESULTS

Analysis of Social welfare and Total profit for capacity and latency service Let us consider 4 service classes with price vectors PV1 (11.95, 23.25, 6.35), PV2 (9.34,12.45,4.23) PV3(4.56,17.89,13.35) PV4 (5.67,41.34,2.34) Resource vectors RV1(5,8,90) ,RV(6,16,50), RV3(4,4,60), RV4(10,32,100), delay vector(0.65,0.23,0.38,0.04) acceptable price vector (58.95,87.97,67.45,45.86) Service time vector (0.96,0.45,0.34,0.89) ,2 customer agents request vectors Reqv1(2,16,50) Reqv2 (3,8,80) .To check the social welfare and total profit for capacity shared service and latency shared service.

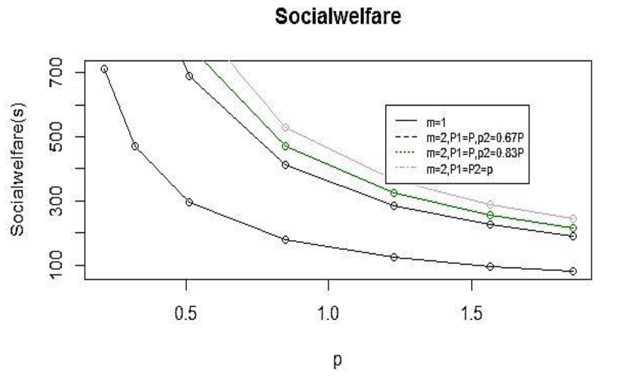

Figure 1: Social Welfare for capacity service $Func_{Cap}(N_j, C\alpha_j)$

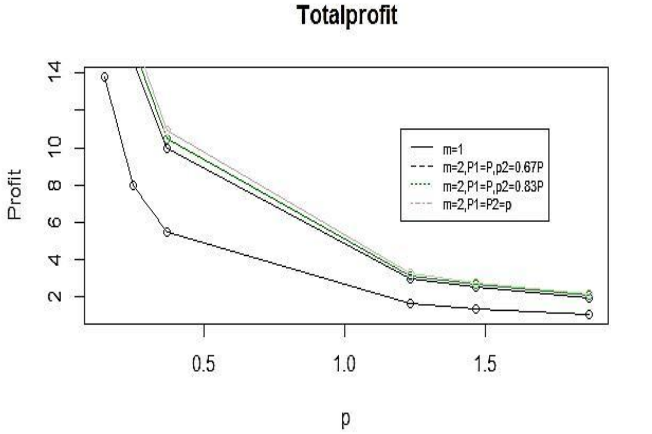

Figure 2: Total Profit for capacity service $Func_{Cap}(N_j, C\alpha_j)$

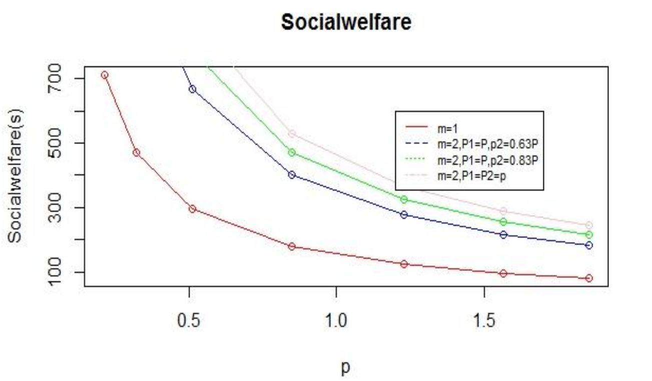

Figure 3: Social Welfare for latency service $Func_{lat}(N_j, C\alpha_j)$

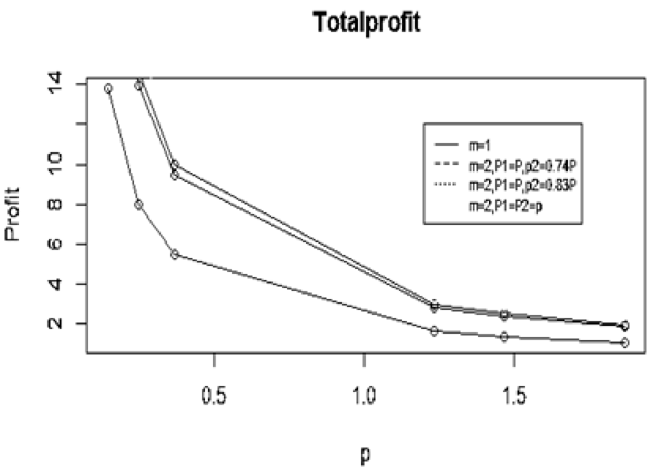

Figure 4: Total for Latency Service 【$Func_{lat}(N_j, C\alpha_j)$

The Figure 1and Figure 2 are used for observation of social welfare at congestion of capacity service where every customer agent will have equal choice of getting benefited by utilizing resources from differential priced classes for different values m, p1, and p2.similarly Figure 3 and Figure 4 are used of observation of total profit at latency service where every customer agent will gain equal chance getting profit earned for different values of m, p1, p2.

B. Viability of differentiated pricing for APMP

The capacity service considered for $Func_{cap}(N_j, C\alpha_j)$ is differentiated for N_j then

$$\frac{\partial Func_{cap}(N_j, C\alpha_j)}{\partial N_j} = \frac{1}{C\alpha_j} \quad (13)$$

The latency service considered for $Func_{lat}(N_j, C\alpha_j)$ is differentiated for N_j then

$$\frac{\partial Func_{lat}(N_j, C\alpha_j)}{\partial N_j} = \frac{1}{(N_j - C\alpha_j)^2} \quad (14)$$

The above equations will be used for realization of APMP applicability for checking social welfare and total profit.

V.CONCLUSION AND FUTURE WORK

The APMP approach in agent based model for federated clouds applicability is analyzed for achieving strategy proof in order to make customer agents attain an optimal price by having a choice for getting serviced with differential pricing. The congestion of capacity and latency service influence on total profit and social welfare is measured and simulated for different p values. The service class formation mostly depends on collation formation by provider agents so, further work need to be done in that direction to form service classes at broker agent in order to provide optimal choice of price to service customer request at different instances.

REERENCES

1. Jain, Kamal, Tung Mai, and Vijay V. Vazirani. "A Performance-Based Scheme for Pricing Resources in the Cloud." In International Conference on Web and Internet Economics, Springer, Cham, pp. 281-293,2017.
2. Zhang, Hong, Hongbo Jiang, Bo Li, Fangming Liu, Athanasios V. Vasilakos, and Jiangchuan Liu. "A framework for truthful online auctions in cloud computing with heterogeneous user demands." IEEE Transactions on Computers ,Issue 65,vol. 3, pp: 805-818, 2016.
3. Passas, Virgilios, Vasileios Miliotis, Nikos Makris, Thanasis Korakis, and Leandros Tassiulas. "Paris metro pricing for 5g hetnets." In Global Communications Conference (GLOBECOM), 2016 IEEE, pp. 1-6. IEEE, 2016.
4. Huang, Huai-Sheng, Shu-Chiung Hu, Po-Han Lee, and Yu-Chee Tseng. "An adaptive Paris Metro Pricing scheme for mobile data networks." International Journal of Network Management Issue 26, vol.no. 6 ,pp: 422-434,2016.
5. M. Hussin, A. Abdullah, R. Latip, "Agent-Based Pricing Determination for Cloud Services in Multi-Tenant Environment", International Journal of Computer and Communication Engineering, vol. 3, pp. 454-459, 2014
6. Chau, Chi-Kin, Qian Wang, and Dah-Ming Chiu. "Economic viability of paris metro pricing for digital services." ACM Transactions on Internet Technology (TOIT) Issue14, vol. 2-3, pp: 12-33, 2014
7. Xu, Hong, and Baochun Li. "Dynamic cloud pricing for revenue maximization." IEEE Transactions on Cloud Computing ,Issue 1,vol. 2, pp: 158-171 , 2013.
8. Puspita, Fitri Maya, Kamaruzzaman Seman, and Bachok M. Taib. "Optimization of Internet Pricing Under Multiple QoS Networks." 2012.
9. M. Mihailescu and Y. M. Teo, "Dynamic resource pricing on federated clouds," in Proc. 10th IEEE/ACM Int. Conf. Cluster, Cloud Grid Comput., 2010, pp. 513–517,2010.
10. Mihailescu, Marian, and Yong Meng Teo. "Strategy-proof dynamic resource pricing of multiple resource types on federated clouds." In International Conference on Algorithms and Architectures for Parallel Processing, Springer, Berlin, Heidelberg, pp. 337-350, 2010,
11. Ros, David, and Bruno Tuffin. "A mathematical model of the Paris metro pricing scheme for charging packet networks." Computer Networks ,Issue 46, vol no. 1 ,pp: 73-85,2004
12. Dube, Parijat, Vivek S. Borkar, and D. Manjunath. "Differential join prices for parallel queues: Social optimality, dynamic pricing algorithms and application to internet pricing." In INFOCOM 2002. Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE, vol. 1, pp. 276-283. 2002.
13. Jain, Ravi, Tracy Mullen, and Robert Hausman. "Analysis of Paris Metro pricing strategy for QoS with a single service provider." In International Workshop on Quality of Service, pp. 44-58. Springer, Berlin, Heidelberg, 2001.
14. Odlyzko, Andrew. "Paris metro pricing for the internet." In Proceedings of the 1st ACM conference on Electronic commerce, pp. 140-147. ACM, 1999.
15. Marbach, Peter. "Pricing priority classes in a differentiated services network." In Proccedings of the Annual Allerton Conference on Communication Control and Computing, vol. 37, pp. 1075-1084. 1998.