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THREE PHASE TECHNIQUES FOR RESOURCE ALLOCATION IN MOBILE CLOUD COMPUTING

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Abstract: **Cloud computing is fast growing technology in communication field, which provides the fast computation and large storage capacity in virtual machine. Nowadays, using the cloud in wireless network is to improve the quality of experience (QoE) of mobile environmental. From cloud, service provider (SP) is a responsible for provide the services to wireless network user. In Mobile cloud computing, cloud mobile media (CMM) services offered by SP and also price for this service. Major challenges in mobile cloud computing are calculation of pricing, power allocation and interference management to user. In our existing, power allocation to end-user is based on three stage stackelberg game theory. To overcome the issues in Mobile cloud computing, propose the telecom operator to mange power using Non-cooperative topology control game theory. Our proposed system improves the end-to- end user performance such as offer CMM service to user without interference.**

***Index Terms*—Mobile cloud computing, telecom operator cloud, small cells.**

I INTRODUCTION

Mobile cloud computing is rapidly distributed technology. First, the number of users the technology has the power to reach: far more than the number of smartphone users alone. The second reason has to do with how applications are distributed today. Currently, mobile applications are tied to a carrier. If you want an iPhone app, for example, you have to first have a relationship with the mobile operator who carries the iPhone. Cloud computing, along with mobility and ubiquitous broadband, is underpinning the creation of the Networked Society. As we move towards a connected world, telecom operators have a unique opportunity to position themselves to capitalize on the growth of cloud services – both as providers and adopters of the technology.Many of the cloud services targeted at consumers are offered by OTT players, which exploit ubiquitous connectivity to provide easy-to-adopt, on-demand services. More often than not, these companies are not providers of communications or connectivity services; hence a market for bundling basic connectivity (fixed or mobile) and communications (voice, messaging, data and video) with cloud-based applications is opened – and largely untapped – for telecom operators. Moreover, telecom operators often have an advantage over OTT web service companies when it comes to offering connectivity with hosted infrastructure.

In the consumer market, this can be as simple as online storage services that enable users to store and share their digital assets in the cloud. By combining cloud services with connectivity and communications-as-a-service (CaaS), telecom operators are creating compelling offerings that enable the monetization of OTT applications to complement their core business.Cloud services, as distributed resources, depend on network performance and would suffer without good connectivity within and between them. Managing cloud connectivity appears to be the most natural value-adding activity for telecom operators given their expertise in connecting and managing networks.

Operators are in a unique position to provide managed connectivity between cloud users and third-party providers, offering flexibility in network resources both in real-time and on-demand. In this role, they are essentially intermediating brokers, enabling users to switch cloud vendors without worrying about network-related details. In addition, operators can

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offer connectivity services according to pre-determined agreements and choose to employ network-based techniques, including caching, optimization and data acceleration, to enhance the user experience of cloud applications. There are also possibilities for operators to offer device management, on top of end-to-end network management.

With telecom operators' move to embrace two-sided business models, they are embarking on a transformation of their internal support systems. This, in turn, is providing them with the capability to expose network assets and interfaces that can be exploited by such features as location and presence, and by OSS/BSS assets such as subscriber profiles. Telecom service providers can embed these attributes (for example, user preferences and activities and analytics thereof) with third-party cloud offerings, enhancing their value by making them more relevant and meaningful to users. Of course, they can also embed these attributes with their own cloud offerings. Either way, it provides the linkage between the upstream and downstream components critical in two-sided business models. Furthermore, telecom operators are able to strengthen their relationships with end-users and third-party providers by acting as a service and billing aggregator.

Small Cells are the most recent evolution of wireless radio technology and are becoming main-stream for Wireless Service Providers (WSPs) as part of their Heterogeneous network (HetNet) strategy. Small Cells are compact and low-powered base stations. The term, Small Cells, is an umbrella term used for a wide range of these compact base stations that include Femto cells, Pico cells, Micro cells and Metro cells.

These low-powered radio access nodes typically have a coverage range from 30 feet to several hundred feet and have become a highly viable solution to alleviate the network congestion by providing for the densification needs of the WSPs. With mobile data traffic expected to double annually, small cell base stations are set to play an important role in expanding the capacity of wireless networks. Mobile operators are realizing that to meet the demands for data, video and application access caused by smart phones and other devices, there is a real beauty to going small. Small cells provide flexibility and increased QoS capabilities at an attractive cost. Implementing a small cell infrastructure is also more environmentally friendly as it will reduce the number of cell towers (maybe even eventually eliminate them) and it provides a cleaner signal with less power.

Network densification requirements for WSPs have led to the need for distributed networks, as coverage and capacity needs have become critical problems. Due to the required density and critical placement of Small Cells, ExteNet's extensive distributed network expertise and experience has become an asset for WSPs in their efforts to ensure a well-designed distributed network providing flexibility, reliability and scalability.

In our proposed system, deploy "telecom operator" as broker between HWN and cloud service provider. Telecom operator is to allocate the power which is to be used the CMM service using non-cooperative topology control game theory. Every user decides own transmission power level based on exchanging information without central authority. Nodes are listed in neighboring order. In this system, power allocation is applied to which node preferred basis on connectivity, balance energy and consumed energy cost.

II SYSTEM DESCRIPTION AND FORMULATION

In this section, we consider a mobile cloud computing system with several third party CMM SPs. The system has a telecom operator cloud that can "mix and interchange" resources offered by different third party CMM SPs, and HWNs contains both macro and small cell base stations. In addition, the problem of joint cloud and wireless networks operations in this system is formulated as a three-stage Stackelberg game.

1. Telecom Operator Cloud and Third Party CMM SPs

In this scenario, telecom operators will pool variety.

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Telecom operators are Future media service will definitely be provided by clouds. The multimedia service may come from different cloud service providers, different network types, different technologies, etc. In this paper, we mainly consider the CMM service model provided by different third party CMM SPs.

Different CMM SPs offer rich multi-media services to the end-users, including the streaming media, interactive service, and mobile gaming, etc. In the previous paper, we have discussed that most of the CMM SPs will choose to partner with the telecom operators rather than to pay. In making a stronger push to monetize data traffic through OTT-style services and applications. They also attempt to restrict these traffic-heavy, low-revenue OTT services such as streaming media, but this may have negative impacts on user experiences, even violates the regulations sometimes.

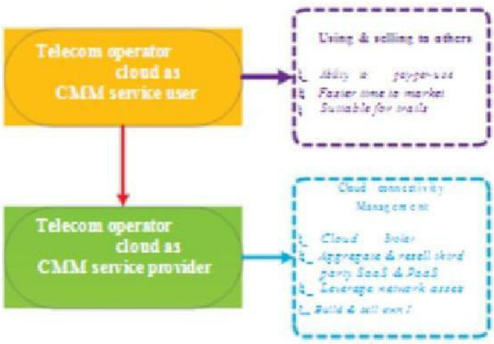

Fig 1.Telecom operator cloud.

Operators can play a natural role in the cloud computing, providing the reliable and low-cost connectivity service for any other third party clouds, but this is just an initial step. Some of the pioneers in this area have already explored a new TOC model [3]. On one hand, telecom operators can use the powerful storage and computing capabilities offered by the cloud for network management, such as billing.

In this case, telecom operators are cloud users. On the other hand, telecom operators can also be cloud providers as well. For example, the telecom operators can leverage the network assets to aggregate and resell the services of third party clouds. Similar to the cloud computing model, for achieving low-cost media services by using the "pay-per-use" approach, mobile cloud computing can also adopt the utility billing model to require resources and provide *Mobile Network as a Service* (MNaaS). As shown in Fig. 1, TOC is in an unique position of being as a cloud "broker" between the wireless networks and the third party SPs, and can manage connectivity and offer flexibility in acquiring network resources on-demand and in real-time.

There are three major roles, namely, cloud connectivity, delivery of cloud-based capabilities, and leveraging network assets to enhance cloud offerings. This TOC model can align itself in the cloud value chain. Furthermore, MNaaS can use network virtualization tech-nique to make the connectivity much easier, since it allows the operator to set up multiple channels over the same infrastructure and use whichever network layer is the most appropriate to deliver the required QoS to suit a particular CMM service with the need of end-users. Most scenarios using MNaaS as a delivery model are that virtual networks are on the top of the existing infrastructure to enable the telecom operator integrate its new services without affecting the existing business.

Therefore, telecom operators can provide all their network resources, and the other third-party players can focus on the operation of virtual networks leased from the telecom operator cloud to set up their own dynamic pricing schemes. Pricing is an important issue in cloud computing.

2. Heterogeneous Wireless Networks with Small Cells

A promising approach to improve the network performance in terms of capacity and energy efficiency is to use a multi-tier or hierarchical structure with small cells . This architecture represents a novel wireless networking paradigm based on the idea of deploying short-range, low-power, and low-cost base stations, which

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operate in conjunction with macrocells

Telecom operators have to deploy multiple wireless access networks with different technologies nowadays to meet the growing demands of users in regards to bandwidth and mobility. HWNs is one of the solutions to make the handover between these technologies more transparent for the end-users, and to facilitate a more seamless experience for roaming. One of the key features in HWNs is to always provide the best data service and network connectivity to the end-users via different available wireless access networks when subjected to different interwork-ing scenarios appearing throughout the time of handover and roaming procedures.

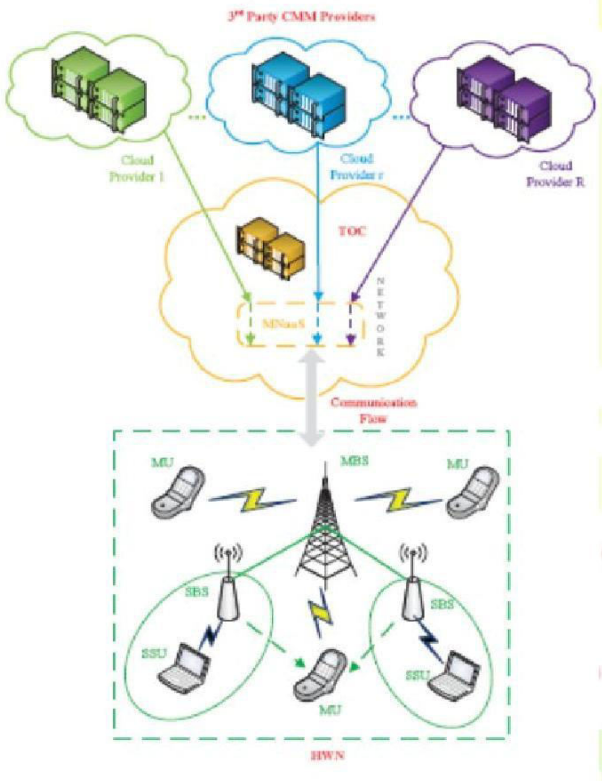

Fig. 2. A mobile cloud computing system with telecom operator cloud.

3. A Game-Theoretic Approach

In this paper, the problem of joint operations of telecom oper-ator cloud and heterogeneous wireless network is formulated as a three-stage Stackelberg game, which is shown in Fig. 3. The main notations used in this paper are listed in Table II. Each third party CMM SP is a leader that provides a cloud media

In practical networks, there are up to 4 users per small cell. However, they use different channels. So the proposed scheme can be easily extended to the practical case. service price x_r to the macrocell and small cells. All the MUs and the SSUs, which are playing the part of followers, decide the amount of media service from the CMM SPs to purchase according to the service price x_r in Stage I of the game. We measure the media service in *bits per second* (bps) to meet the end-user's media demand by guaranteeing performance. In Stage II, firstly, the MBS decides as a follower from which CMM SP to buy the media service, then it acts as a leader to offer an interference price y to the small cells to reduce the interference effect. In Stage III, each SBS decides which CMM SP to buy the service from, based upon the service price x_r and the interference price y charged by MBS.

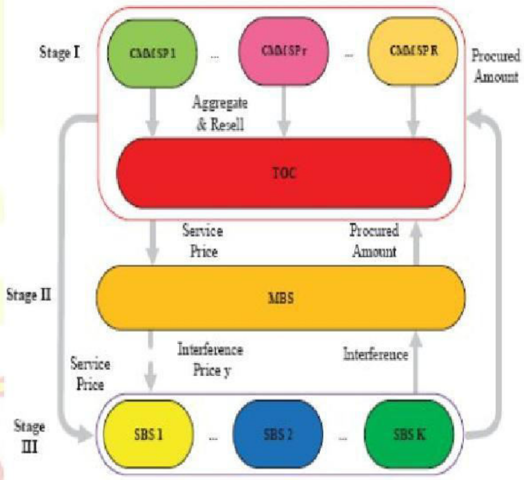

Fig. 3. Three-stage Stackelberg game model.

III. THREE-STAGE GAME ANALYSIS

In this section, we analyze the proposed three-stage Stackelberg game. Then we obtain the equilibrium to this game. Based on the description of the system, we know that each strategy will affect the others. Hence, we will use a backward induction method to solve this game.

1. SBS level Game Analysis

For maximizing the utility function of SBSs, each SBS will choose a proper CMM SP to purchase the CMM service according to the service

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price xr, and the interference price y charged by MBS. For an arbitrary SBS k, its utility function.

2. MBS Level Game Analysis

The MBS, in order to maximize its utility function, will firstly as a follower choose a proper CMM SP to purchase the CMM service based on the CMM service price. Then it acts as a leader to offer an interference price to the SBSs. We will obtain Um, a function of transmission rate sm and interference price y. Here, we consider the most common situation and also use the decomposition method to solve this problem. Firstly we keep the interference price y unchanged to get the optimal $s*m$ to maximize Um, and then. we obtain the desirable value of y. We assume that.

3. CMM SP Level Game Analysis

The Bertrand game is a popular tool to model competition among firms (sellers) that set prices and their customers (buyers) that choose quantities at the price set. The Bertrand game has been successfully applied in cognitive radio networks, and other areas [26]. In our scheme, we use the Bertrand game to model the competition among CMM SPs. We assume that each CMM SP is independent, acts selfishly, and the target is to gain as much revenue as possible. If the CMM SPs act noncooperatively, it will lead a monopoly situation.

All the CMM SPs are eager to set their service prices as the same, and try to maximize their own profits. The profit of an arbitrary CMM SP r depends not only on the service price xr and the cost cr, but also on the service prices $x-r$ offered by the other cloud SPs. Each CMM SP decides its action independently and simultaneously. And the CMM SP with the lowest price will occupy the entire service market. Hence, every CMM SP tries to reduce its service price until hitting the bottom with zero profit. As discussed in Section II, the set of the game players is $\mathbf{R} = \{1, \ldots, r, \ldots, R\}$, the strategy set is xr, and the payoff function of the CMM SP is Ur. The NE of this problem gives the set of prices such that neither CMM SP can increase its net profit Ur by unilaterally changing the price.Without loss of generality, let the cost set in an ascending order $c1 < c2 < \ldots < cR$.

D. Service Allocation Iteration Algorithm

It is important to investigate the uniqueness and the existence of the Stackelberg equilibrium. In the duopoly case, the convexity of the follower's reaction function is essential for uniqueness of the Stackelberg equilibrium . Hence, we will prove that for our model of Stackelberg game exists an unique equilibrium.

Theorem 1. *The unique Nash equilibrium exists in the proposedStackelberg game.*

Proof: In our Stackelberg game model, each stage has its flawless equilibrium in a Nash equilibrium respectively:

The service price strategies $x*$ in offered by the CMM SPs, the service allocation strategy $s*m$, the interference price, and the service allocation strategy $s*k$ in (10). Because we have proven that each stage exists a perfect equilibrium in a Nash equilibrium, the Nash equilibrium of the proposedStackelberg game model exists. We also know that the subgame perfect equilibrium in each stage is unique. Therefore, the totalStackelberg Nash equilibrium is unique.

Algorithm 1 Service Allocation Iteration Algorithm

Initialization:

Initialize the cloud computing service prices, i.e., for each CMM SP r, randomly offers the service price x_r, where $x_r \geq 0$.

Repeat Iterations:

a) The MBS offers the interference price y to the SBSs and decides which CMM SP to purchase the service from based upon x_r and the amount of computing service.

b) Each SBS performs its service allocation.

c) CMM SPs update their prices:

$$x_r[t] = \mathcal{B}_r(x_{-r}[t-1])$$

d) *Until:* $\|x[t] - x[t-1]\| / \|x[t-1]\| \leq \varepsilon$ or reach the preset maximum number of iterations.

End Iteration

To get the Nash equilibrium of the three-stage Stackelberg game, we use a backward induction to solve the problem and present the service iteration algorithm.

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In the above method, we defined the other CMM SPs' strategies as $x-r = (x1, x2, . . . , xr-1, xr+1, ... , xR)$. When $x-r$ is given at iteration $t-1$, we present the best response function $Br(x-r[t-1])$ of CMM SP xr at the iteration t to maximize its total revenue. The condition $x[t]-x[t-1]/ x[t-1] \le \varepsilon$ is the stop criteria. In the proposed algorithm, the MBS decides the interference price y offering to SBSs and the amount of service purchased from the CMM SPs based on the service price xr. The SBS then allocates the power. The algorithm will stop until the service price xr converges. In practice, the proposed iterative algorithm to obatin the threee-stage Stackelberg game equilibrium can be implemented as follows,

1) The CMM SPs randomly offer the CMM service price to the MBS and SBSs.
2) The MBS receives the channel state information from the
SBSs and the MUs.
3) The MBS decides which provider to purchase the service from and the interference price offering to the SBSs.
4) The SBSs perform their power allocation.
5) The CMM SPs update their prices and repeat steps 2, 3
and 4 until the prices converge.

IV. SIMULATION RESULTS AND DISCUSSIONS

In this section, we use computer simulations to evaluate the performance of the proposed scheme. The main system parameters in HWNs are adopted from 3GPP , as listed . In the simulations, we assume that there are 2 CMM SPs. The MUs and small cells are located in the macrocell randomly, and small cells deploy sparsely with each other at 50*m* to 150*m* far from the MBS. Following [32], we set the path loss between SSU and MBS as 15.3+37.6 log10(*Dms* +*Low*), and the path loss between SSU and SBS as 46.86 + 20 log10(*Dss* + *Liw*). *Dms* is the distance between the MBS and the SSU. *Dss* is the distance between the SBS and the SSU. *Low* means the penetration loss of exterior wall, and *Liw* means the penetration loss of the interior wall. They are set as 20*dB* and 10*dB*, respectively. We can also find the parameters of the small scale and shadow fading . The others are shown as below. The transmission bandwidth *W* is 5*MHz* in the MBS and the transmission power is fixed as 46*dBm* from . The general parameters are set as, μk = 0.05, λk = 1, α = 0.03, β = 10, *Brk* and *Brm* = 1. Firstly, we evaluate the performance of the CMM service purchased by BSs with the various lowest prices. Fig. 4 shows that, with the increase of the lowest service price *xr*, *SBS*1 and *SBS*2 have to decrease their transmission rate by performing.

The energy-efficiency power allocation. Due to the fixed transmission power of* the MBS, it performs an increasing*trend with *x r* . The reason is that, by increasing *x r* , the transmission power of SBS decreases as well, which in turn leads to the decrease of interference between the MBS and the SBS.

Hence, the transmission rate of the MBS*has the same variation trend with the service price *x r* . When the service price is too high to afford for the SSUs, the SBSs will lower their transmission rate step by step until stop transmitting anything. Because the SBSs stop their transmission, the SSUs choose another method to receive the CMM service due to the high service prices. The MBS will reach its highest level of the transmission rate shown in Fig. 4. The shape of the curve can change with the parameters. However, the insight remains the same in the figure.

Then we compare the CMM service purchased* by one SBS with three different values of *x r*. Fig. 5 shows that the SBS tries to reduce its interference cost *y* by decreasing its transmission rate *sk* when given the value of service price offered by the CMM SP. Fig. 5 also shows that, in the condition of the same interference price, the lower service price offered by the CMM SPs, the higher transmission rate we can obtain. We also study the service allocation in the MBS with various service prices offered by the CMM SPs in The interference between the MBS and SBSs will be reduced by the increasing trend of the service price *xr*. That is because the transmission power *pm* is fixed in the MBS, the transmission rate of MBS will increase

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with the service price until it reaches the highest level, then the interference turns to zero. We can find how the value of α effects the shape of the transmission rate sk in MBS, the smaller the value of α, the higher level of transmission rate we can obtain. As α increases, there is tradeoff among the transmission rate, service cost and interference revenue in the MBS.

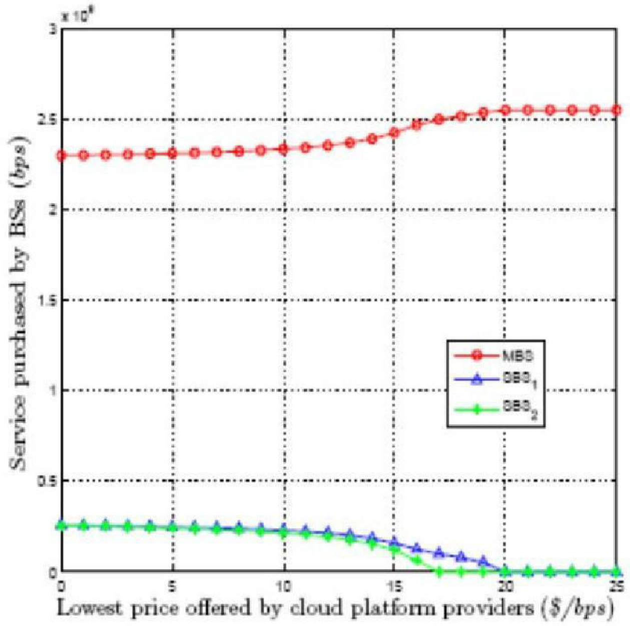

Fig. 4. Service allocation with various lowest prices offered by the CMM service providers.

The utility of SBS, firstly, increases as the power. After it reaches the optimal level, the utility of SBS begins decreasing, because the gain of the transmission rate cannot offset the increase trend of the service cost and interference price. This figure also tells us that the higher the interference price is, the lower utility of SBS will be. In addition,we find that the transmission rate of the MBS. correspondingly increases with the interference price in That is because the higher interference price forces the SBSs to reduce their transmission power.We∗ also observe that the higher the service price x r is, the lower the interference from the SBSs

Hence, the transmission rate will reach a higher level in the MBS with a more expensive service price offered by the CMM SPs. Figure shows the convergence of the proposed Stackelberg equilibrium iteration algorithm. From the figure, we can observe the service of the MBS and SBSs can converge after a few iteration steps because of the convergence of the service price $x{*}r$. Hence, we will obtain the NE by the algorithm.

Then, we study the frame rate (frames per second) and latency of the CMM service in mobile cloud computing environments under two different configurations: the local servers and the remote cloud computing servers over a $100Mb/s$ network with the output viewed through the *virtual network computing* (VNC) protocol, which have the different latency due to the different distances among the remote servers. demonstrates that a high frame rate provides the illusion of smoothness to an enduser. Even a modest latency of $33ms$ can cause the frame rate to drop dramatically from that experienced with a local server. Although the VNC protocol strives to keep the frame rate at an acceptable level, it offers sluggish interaction. Hence, the user experience is considerably poorer than that for the local media service interaction.

V CONCLUSION:

In our system, power level of every user allocates without cooperation in network. In mobile cloud computing, additionally deployment of Telecom operator has brought to accumulate services and billing section. For receiving CMM service, user evaluated energy based on neighboring information. From this system, interference must be reduced. In case of dynamic service allocation, necessary to share with neighbors. In non-cooperative control, should manage dynamic allocation using services sharing. In our allocation techniques, main contribution is two hop neighbor nodes. This method ensures to keep topology of network. It improves the QoE performance of services delivery to user. Our experimental results show services delivered with lower delay and improved throughput with existing.

VI FUTURE WORK:

In future, cost estimation of CMM service in non-cooperative between users in network. When power is shared among neighbors, it will be difficult to determine cost of usage services.

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Allocation and cost estimation is held by telecom operator for enhancing services in future

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