**Proceedings of the 17th World Congress
The International Federation of Automatic Control
Seoul, Korea, July 6-11, 2008**

IFAC

Progressive Adaptive Mechanisms for the International Cooperation

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Abstract: On the modern stage of globalization there are no adequate international institutions to control forthcoming global instability. As a way to establishing their scientific background, progressive adaptive mechanisms for the international cooperation are proposed. They included both international and states mechanisms intended to coordinate multinational corporation activity to prevent expansion of dangerous weapon, capital drain to offshore and so on. Both adaptive mechanisms for international solidarity and adaptive international regimes are considered. The sufficient conditions of their progressiveness are found. Obtained results had been implemented in the international regime of intangible technologies export control.

1. INTRODUCTION

1.1 The problems of the global instability

The beginning of new century falls on a critical stage of a history of mankind. The population of the Earth is sharply growing (under forecasts, approximately up to 10 billion people in 2020, whose big part living in the Asia). Now the several states have achieved high level of technological development. It is accompanied huge consumption of resources which already exceed real opportunities of the biospfere. Already today on a share of 5% of the Earth population living in USA provide approximately 26% of world power expenses and over 35 % of pollutions in an environment. Intensive industrial development of several countries (China, Russia, India, Brazil etc.) also provides growing consumption and pollutions sharply aggravate a problem of natural resources. As a result, environment degrades, and deficit of resource provide quick rising of their costs. At the same time many peoples are practically discharged of elementary education, suffer from famine and deprivations. More the one half of all countries of the world had no access to international financing. Inequity and the environment degradation lead to population migration. This provides obstacles to the realization of a more peaceful and stable international relations. Big inequality in a development and living standards between the countries is the main source of contradictions on the Earth.

Problems of mankind survival provide understanding of necessity of joint efforts on their overcoming. Certainly, growth of interdependence in the economy and ecology inevitably will result in changes in politics. Movement of people on search the ways of mankind harmonious association is observed. The mankind should be united on the basis of the coordination of interests and interpenetrating values of the worlds coexisted.

1.2 The risks and likelihood of the international instability

Global instability provides raising risks in political, economical, ecological and military areas. In fact, fast changes strength interdependence of the sovereign states. So, along with the global competition, states cooperation is needed. But on practice world political system lags behind world economics. International institutions, regimes and coordination mechanisms are weak or absent at all. World financial flows are mainly beyond the control of states and international institutions, which have no possibility to oppose likelihood crisis. Without the control of these flows world economics waits the crash. There are no adequate international institutions to control global financial instability. International Monetary Fund and World Bank try to adapt to quick changes. But their programs were ineffective in the previous world financial crisis in 1998.

One of the serious problems is a capital drain to offshore. The agents arranged that are mainly multinational corporations (briefly - MNK). Often they made it to avoid taxes. Now there are more than 50 offshore in the world. They can to destabilize world financial system. Borodin, Tsyganov and Gurlev (2005) shown that for global sustainable development it is useful international agreement to prevent a capital drain to offshore. The important part of this agreement can be international regime, including mechanism to control MNK.

Another important problem is the expansion of dangerous weapon, especially nuclear, chemical and biological. To solve it there is international agreement to prevent export of so called "intangible technologies", which can be used to product dangerous weapon. States–members of this agreement must to control of MNK export of such technologies. This agreement includes list of restrictions contains more then 100000 indexes of safety export of the intangible technologies. And this list is expanded permanently (sometimes – weekly). Unfortunately such mechanisms of the international cooperation were not

described in the formal way, especially in the condition of quick changes. They have a lack of scientific background, as for example in economics. The contribution of this paper may be considered as the first step to establishing such background, by means of derivation the formal models of international cooperation mechanisms.

1.3 International management and control

Usually international cooperation is managed by the special international mechanisms. They are called international regimes. Young (1982) and Krasner (1983) investigated international regimes dynamics, their rise and fall. Coates and Seamen (1989) indicate that international regimes are closely linked with domestic political and economical mechanisms.

Chestnut and Kopacek (1989) indicate that to reduce the risks and likelihood of the international instability it is possible to apply adaptive control principles. Adequate adaptive procedures provide identification of controlled object structure and parameters of environment and generating the controlling actions making use of current information, in order to achieve the optimal state of the system as a whole.

Systemic investigations of the international cooperation problems include analysis and the account of the human factor effect. It should be understood as an activity manifestation of the people or collectives (elements of control systems) is caused by the availability of their own aims, not necessary coinciding with the goal of the system (Burkov and Tsyganov, 1986). Such elements may utilize available information channels connected with the system control centre in order to improve current or future states. "Active" elements can also predict the results of the adaptive control procedures and to use that knowledge to reach their aims. Active system theory is aimed to design mechanisms which coordinate elements efforts in accordance with the goal of whole system. That theory is based on the principle-agent control.

On practice, international cooperation had no effect in many cases because of the elements "activity" (corruption, distortion of information etc.) The results of the failure of the mechanism used are expansion of dangerous weapon, capital drain to offshore and so on. The concept of progressive adaptive control mechanisms for the international cooperation are intended for eliminate such activity had been derived by Tsyganov (1990a). There the model of the active element described by Burkov and Tsyganov (1986) was used.

1.3 Adaptive mechanisms for international cooperation

Design of the progressive adaptive mechanisms for the international cooperation is based on active system theory and appropriate adjustment norms and incentives such as rates, taxes etc. The example of such mechanism in the multistage international negotiation had been considered by Tsyganov (1990b). The simplest adaptive mechanism of functioning (AMF) of the two-level organization is included the control Centre on the upper level and the farseeing active element (Agent) on lower level. The role of Centre may be played by sovereign state or international institution. The role of Agent is played by MNK. The AMF includes forecasting and decision making procedures: planning, control and stimulation. A method to avoid distortion of information obtained from Agent consists of designing the so-called "progressive" AMF wherein the value of the Agent long-term goal function (corresponding to the solution of the game with the Centre) increases with the growth of the efficiency of the Agent functioning (Tsyganov, 1986). The designing of AMF is based on the obtained solutions of progressive AMF synthesis.

Burkov and Tsyganov (1987) made detail consideration of two AMF main types. The first one is included adaptive procedures of time series forecasting and factor analysis. The second type is included learning procedures for decision making (classification and pattern recognition). They are used mainly for adaptive estimation of the parameters of the decision making procedure, control and stimulation of the Agent. Tsyganov (1991b) derived expert adaptive mechanisms where the learning procedure is based on the expert recommendation.

International regime interacts with domestic mechanisms of the country involved. Example of the detailed description of the interaction between international and domestic regimes dealing with joint ventures had been given by Tsyganov (1991a). Below we consider progressive mechanisms of the international cooperation included both international and domestic mechanisms intended to control MNK.

2. PROGRESSIVE MECHANISMS OF THE INTERNATIONAL SOLIDARITY

2.1 Progressiveness

Let us consider the two-level system, based on non-formal solidarity between sovereign states of the international community (briefly - IC). The states are placed on the upper level and the multinational corporation - on the lower level. Every state is watching on this corporation and forms its own norm for decision making.

Let us consider the system functioning in period t, t=0,1,…. The input of MNK is influenced by the external noise. The output of MNK is the index y_t, that shows the efficiency of the international agreement (for example, y_t is a value of legal profit, or level of safety of the exported intangible technology). That index cannot be greater then potential q_t: $y_t \le q_t$. Maximal MNK output - potential q_t is a stochastic value because of external noise acted on its input. For this reason MNK find out potential q_t only in the beginning of the period t. But the value q_t is remaining unknown to both states. Therefore MNK might diminish y_t, with respect to potential q_t. International mechanism called **progressive**, if MNK choose maximal output: $y_t = q_t$, $t = 0,1,...$

The goal of the IC is to establish progressive mechanism, which corresponds to maximal efficiency of the international agreement. To make that, each state classifies MNK to one of

two categories – "loyal" or "non-loyal" in every period t, $t = 0,1,...$ "Non-loyal" MNK means that it violate international agreement, "loyal" - that violation does not takes place. After classification state encourages "loyal" MNK, or punishes "non-loyal" MNK. These classification and stimulation depends on internal norms for decision making which adopted in each sovereign state. To minimize risk of classification states adjust these norms with the aid of adaptive procedures.

2.2 State-teacher and State-pupil

Let us suppose that there are two states in the IC. One of them called State-teacher and another – State-pupil.

We denote State-teachers norm for decision making in period t, as a_t, $t = 0,1,...$ Its classification f_t depends on norm a_t. To make decision State-teacher uses its classification procedure:

$$f_{t+1} = F(y_t, a_t) = \begin{cases} 0, & \text{if } y_t < a_t, \\ 1, & \text{if } y_t \geq a_t \end{cases} \quad (1)$$

There $f_t = 0$ means that MNK is "non-loyal" (i.e. violate international agreement), $f_t = 1$ - MNK is "loyal" (i.e. carry out international agreement), from the State-teachers point of view. To minimize risk of this classification State-teacher adjusts norm a_t using self-learning procedure:

$$a_{t+1} = A(a_t, y_t) = \begin{cases} a_t + e, & \text{if } y_t < v a_t, \\ a_t - k, & \text{if } y_t \geq v a_t, \end{cases} \quad e > 0, k > 0, v \leq 1 \quad (2)$$

State-teacher informs State-pupil about classification f_t, determined by the rule (1).

Let us denote State-pupils norm for decision making about MNK in period t as b_t, $t = 0,1,...$ Then its classification g_t depends on norm b_t. To make decision State-teacher uses its own classification procedure:

$$g_{t+1} = G(y_t, b_t) = \begin{cases} 0, & \text{if } y_t < b_t, \\ 1, & \text{if } y_t \geq b_t \end{cases} \quad (3)$$

There $g_t = 0$ means that MNK is "non-loyal", $f_t = 1$ - MNK is "loyal", from the State-pupils point of view. To minimize risk of this classification State-pupil adjusts norm b_t using procedure of learning with a teacher:

$$b_{t+1} = B(b_t, f_t) = b_t - l(b_t + f_t), \quad l > 0, \quad (4)$$

where f_t - opinion of the State-teacher, determined by the rule (1).

2.3 Adaptive mechanism of international solidarity

To realize international agreement, sovereign states used procedures A, B, F, G, determined by (1)-(4). Adaptive mechanism for international solidarity S is a combination of procedures used by both states: $S = \{A, B, F, G\}$. This mechanism includes next steps in every period t, $t = 0,1,...$:

State-teacher makes decision about loyalty MNK (f_t) by (1) on the background of the norm a_t determines by (2), and simultaneously sends this opinion to the State-pupil;

State-pupil makes decision about loyalty MNK (g_t) by (3) on the background of the norm b_t determined by (4) and State-teachers opinion;

Both State-teacher and State-pupil encourages "loyal" MNK (or punishes "non-loyal" MNK) because, from the point of view of this state, it carries out (or violates) international agreement.

2.4 Farseeing multinational corporation

Far-seeing active element may predict controlling action and chooses its outputs to maximize its own interest. We consider farseeing MNK which choose output y_t to optimize goal function $W(f_t, g_t, ..., f_{t+T}, g_{t+T})$, where T is number of accounted future periods. This function is raising with f_t, g_t - states decisions about loyalty MNK with respect to international agreement, determined by the rule (1) and (3) in period t, $t = 0,1,...$ In fact, states decisions f_t and g_t can be considered as incentives to stimulate loyalty MNK. We shall say that MNK is **well-disposed to IC** in the case when MNK choose $y_t = q_t$ if the set of optimal outputs includes potential q_t.

Theorem 1. Adaptive mechanism for international solidarity $S = \{A, B, F, G\}$ is progressive, if MNK is well-disposed to the IC.

Proof. Because State–teacher makes decision about loyalty MNK by (1), then f_t is raised with y_t and diminished with a_t. In addition, State–teachers future norms $a_{t+1},...a_{t+T}$ are determined by (2) and diminishes when y_t is raising. Consequently, f_{t+1}, ..., f_{t+T} are growing when y_t is raising. State–pupil makes decision about loyalty MNK by (3), so g_t raising with y_t and diminished with b_t. In addition, State–pupils future norms are determined by (4). Therefore norms $b_{t+1},... b_{t+T}$ diminishes when y_t is raising. Consequently, g_{t+1}, ..., g_{t+T} are growing when y_t is raising. The goal function $W(f_t, g_t, ..., f_{t+T}, g_{t+T})$ is raised with f_t and g_t. Hence this function is growing when y_t is raising, so its maximum takes place when $y_t = q_t$, $t = 0,1,...$. Therefore the set of optimal outputs includes potential q_t. Because of well-disposition to the IC, MNK choose $y_t = q_t$ in every period t, $t = 0,1,...$ Thus considered adaptive mechanism for international solidarity $S = \{A, B, F, G\}$ is progressive.

3. PROGRESSIVE INTERNATIONAL REGIMES

3.1 International regime and institution

International regime usually is realized on the background of international institution, such as International Monetary Fund or World Bank. We consider three-level system, including international institution (briefly - II) on the upper level, two sovereign states on the middle level and MNK on the lower

level. In this system II is watching for MNK, learning and gives recommendation to states. Every state adjusts own norms and makes its decision. The formal description of MNK is quite the same as in item 2.1.

The goal of the II is to establish progressive mechanism, which provides maximal efficiency of the international agreement: $y_t = q_t$, $t = 0,1,...$ To make that, II classifies MNK to one of two categories – "loyal" or "non-loyal" in every period t, $t = 0,1,...$ "Non-loyal" MNK means that it violate international agreement, from the II point of view, "loyal" - that violation does not takes place. This classification depends on II norms. To minimize risk of classification, II adjusts these norms with the aid of learning procedure. II dispatches its classification to states as the recommendation.

When obtaining II recommendation, each state makes its own classification of the MNK to one of two categories – "loyal" or "non-loyal" in every period t, $t = 0,1,...$ After classification state encourages "loyal" MNK, or punishes MNK, if it is "non-loyal", from the its point of view. This classification and stimulation depends on internal norms for decision making which are established in each state. To minimize risk of classification, state adjusts these norms with the aid of adaptive procedures.

3.2 Teacher of the IC

We denote II norm in period t, as c_t, $t = 0,1,...$ Then II recommendation r_t depends on norm c_t. To make it II uses procedure:

$$r_{t+1} = R(\, y_t, a_t \,) = \begin{cases} 0, & if \ y_t < c_t, \\ 1, & if \ y_t \geq c_t \end{cases} \qquad (5)$$

There r_t=0 means that MNK is "non-loyal", r_t=1 - MNK is "loyal", from the II point of view. To minimize risk of recommendation II adjusts norm c_t using self-learning procedure:

$$c_{t+1} = C(\, c_t, y_t \,) = \begin{cases} c_t + m, & if \ y_t < wa_t, \\ c_t - n, & if \ y_t \geq wa_t, \end{cases} \quad m > 0, n > 0, w \leq 1 \quad (6)$$

The recommendation r_t determined by (5), is reported to the IC.

Let us suppose that there are N sovereign states in the IC. Each of them used II recommendation to form its own norm for classification and stimulation of the MNK. We denote the norm of state i in period t as d_{it}, $i = \overline{1,N}$, $t = 0,1,...$ Then decision h_{it} made by this state depends on norm d_{it}:

$$h_{it+1} = H_i(\, y_t, d_{it} \,) = \begin{cases} 0, & if \ y_t < d_{it}, \\ 1, & if \ y_t \geq d_{it} \end{cases} \qquad (7)$$

There h_{it}=0 means that MNK is "non-loyal", h_{it}=1 - MNK is "loyal", from the state i point of view. To minimize risk of classification, state i adjust norm d_{it} using procedure of learning with a teacher:

$$d_{it+1} = D_i(\, d_{it}, r_t \,) = d_{it} - p_i(\, d_{it} + r_t \,), \quad p_i > 0, \qquad (8)$$

where r_t – recommendation of the II, $i = \overline{1,N}$. So II plays role a teacher of the IC.

3.3 Adaptive international regime

To realize international regime, II uses procedures C and R, determined by (4)-(5). Moreover sovereign states uses procedures H_i, D_i determined by (7)-(8), where $i = \overline{1,N}$. Adaptive international regime U is a combination of procedures used both II and states to realize international agreement: $U = \{\, C, R, H_1, D_1,..., H_N, D_N \,\}$. Mechanism U includes such steps in every period t, $t = 0,1,...$

II makes recommendation about loyalty MNK r_t by (5) on the background of the norm c_t determines by (6), and reports it to the states;

State i makes decision about loyalty MNK h_{it} by (7) on the background of the norm d_{it} determined by (8), $i = \overline{1,N}$;

Every state encourages "loyal" MNK or punishes MNK in case when it classified as "non-loyal".

3.4 Progressive international regime

Far-seeing MNK chooses its outputs y_t to optimized goal function $W(\, h_{1t},...,h_{Nt},...,h_{1t+T},...,h_{Nt+T} \,)$, raising with states incentives for MNK loyalty - h_{it} $i = \overline{1,N}$.

Theorem 2. Adaptive international regime $U = \{\, C, R, H_1, D_1,..., H_N, D_N \,\}$ is progressive, if MNK is well-disposed to IC.

Proof. II makes recommendation about loyalty MNK by (5). Then r_t is raised with y_t and diminished with c_t. II future norms $c_{1t+1}...c_{Nt+1}...,c_{1t+T}...c_{Nt+T}$, determined by (6), diminishes when y_t is raising. Consequently, r_{t+1}, …,r_{t+T} are growing when y_t is raising. Every state makes decision about MNK loyalty by (7), where h_{it} is raising with y_t and diminished with d_{it}. Future norms $d_{1t+1}...d_{Nt+1},...,d_{1t+T}$, …,$d_{Nt+T}$ determined by (8) are diminished when r_t is raised. Remember that r_t is raising with y_t. Hence future norms $d_{1t+1},...,d_{Nt+1}...,d_{1t+T},...,d_{Nt+T}$ diminishes when y_t is raised. By (7), $h_{i\tau}$ is diminished with raising d_{it}, $\tau = \overline{t+1,t+T}$. Consequently, $h_{1t+1},...,h_{Nt+1}...,h_{1t+T},...,h_{Nt+T}$ are growing when y_t is raising. Remember that the goal function $W(h_{1t},...h_{Nt},...,h_{1t+T},...,h_{Nt+T})$ is growing with its arguments. Hence it is growing with y_t. If $y_t \leq q_t$ then maximum $W(\, h_{1t},...,h_{Nt},...,h_{1t+T},...,h_{Nt+T} \,)$ takes place if $y_t = q_t$. Therefore the set of optimal outputs of the MNK includes potential q_t. Because of well-disposition to the IC, MNK choose $y_t = q_t$ in every period t, $t = 0,1,...$ Thus considered adaptive international regime $U = \{\, C, R, H_1, D_1,..., H_N, D_N \,\}$ is progressive.

4. INTELLIGENT MECHANISMS OF THE INTERNATIONAL COOPERATION

In previous paragraphs two types of progressive adaptive mechanisms of international cooperation had been investigated. Theorems 1 and 2 give the principles and procedures of these mechanisms. In principle there may be several or many independent norms of international cooperation. Then it is sufficient to arrange progressive adaptive mechanism on every such norm as shown in paragraphs 2 and 3. Then the composition of these mechanisms corresponding to all the norms should take place. The result of such composition will be complex progressive adaptive mechanism of international cooperation.

On practice, international mechanisms and regimes are much more comprehensive and need intelligent control systems. Drawing from experience gained in implementing intelligent control to a varied range of large scale systems, Shubin, Kulba and Tsyganov (2003) highlights the need for a multilevel self-learning and self-organized systems. Particular attention is directed toward adaptations of the widely used self-learning algorithms in an attempt to increase the applicability, range of self-organizing control with the aid of artificial intelligence methodology. On the other hand, the possibility to control of a complex organization in dynamics is based on intelligent information systems (IIS). Burkov and Tsyganov (1987) considered some aspects of IIS include procedures of identification of control objects structure and outside parameters, and predictions. IIS forms the base of control actions on the basis of current information, to attain the systems goal on the whole. To avoid information distortion, passed by the elements to the centre of the system, it is necessary to consider the problem of information system designing in a total problem of procedures synthesis such as planning, regulation and stimulation accepted in this control mechanism.

Tsyganov, Bagamaev and Scherbyna (2004) considered intelligent functioning mechanism (IFM) includes IIS, and procedures of planning, regulating and stimulating. In the IFM information received in the process of system functioning is used by the centre for decision-making and achievement of the systems goal. This IFM ensure possibility to identify the internal structure of elements and their parameters as well as the utilization of internal elements resources in accordance with the centre goal. The main types of IFM are: learning functioning mechanisms, self-organizing mechanisms, expert intelligent mechanisms.

Learning functioning mechanisms (LFM) provide the possibility of estimating the parameters of the organizational potential in its dynamics, supplying more information to plan the organization output indices at the account of learning processes. Self-organizing mechanisms should combine learning and planning for output organization indices (the way it is done in LFM) with the control of organization inputs, i.e. direct influence on the potential of an organization.

Grishutkin and Tsyganov (2001) considered expert intelligent mechanisms (EIM) where the knowledge base is the part of IIS. EIM combines learning with indistinct and qualitative commands from the centre and control on these commands basis. To design EIM it is necessary to create hierarchic man-computer systems with such intelligent possibility as multi-level learning. The EIM includes both knowledge base consists of well-known dependences, any accurate data and the results of individual and collective expertise, and system of knowledge acquisition functioning in an interactive mode with the decision makers who are responsible for a problem solution and answering the question: "what may actually happened, if…?". They implemented EIM to design international regime of intangible technologies.

The concept of the IFM along with the IIS, LFM, and EIM had been used in advanced version of the international regime of intangible technologies export control. The idea consists in flexible information using to solve problems of control and incentives of MNK in such a way that the optimum of the IC will be reached. There also appears the possibility of potential MNK identifying on extra basis of received information and gradual slow output to the sustainable development. This approach is directed to creation of IFM, including procedures of classification and forecasting MNK potential with a high degree of approximation and decision-making procedures.

In this version of the international regime of intangible technologies export control module principle is used. Complex IFM includes IIS, LFM, and EIM. IIS concerning taking order to export some intangible technologies includes two subsystems - of the safety and economical efficiency estimation. They are realized on the background of local computer network. Both safety and economical efficiency estimations are based on results of preliminary expertise of concrete intangible technologies. Safety estimation includes: technological estimation, R&D level, level of quality, weapon manufacturing capacity, period of manufacturing, etc. Economical efficiency estimation is based both on direct costs calculations and the value of price offered by customer. Necessary data are obtained from the customer order, special data base including list of intangible technologies with their parameters, needed to provide the weapon, adaptive norms of the international regime of intangible technologies export, weapon manufacturing costs and expenses (such as work, fuel, raw materials, spare parts). These data are distributed in different areas. Data from each area are introduced into corresponding local LFM to produce local quantitative estimation and adaptive norms will be used for local estimation in a future. These norms are calculated step by step, by appropriate learning procedure of knowledge acquisition. These outputs of local LFM are the same times the inputs of corresponding local EIM. Then outputs of EIM are qualitative estimation (rank), and norms for ranking in a future, calculated by appropriate procedure of learning pattern recognition. This procedure is an important part of knowledge acquisition. Local ranks in different areas are joined by special comprehensive performance estimation procedure. That gives the complex rank of order to export some intangible technologies. Complex rank and local ranks and estimations given by described IIS, create the background for acceptance or rejecting this order. On the

second stage, in case of acceptance this order, IIS, LFM, and EIM are used in the same way to control real process of the intangible technologies export. Necessary data are obtained from the described data base, and special knowledge base including data about process of the export and the correspondent norms of the international regime of intangible technologies.

5. CONCLUSIONS

The IC needs cooperation to prevent the risks and likelihood of the global instability. Provision of ability to control complex hierarchic international systems in its dynamics with incomplete information is based on application of adaptive control. It implies also the consideration of a human factor – system elements activity connected with the availability of own goals.

The aim of this paper is in establishing the formal scientific background of the international institutions to control global instability. The scientific contribution of this paper consists of derivation the formal models of the international cooperation mechanisms. The consideration is based on principle-agent control theory. Its aim is to design progressive mechanisms of functioning system which coordinate elements efforts.

Progressive mechanisms of the international cooperation are considered. They included both international and domestic mechanisms intended to control MNK (for example, to prevent expansion of dangerous weapon, capital drain to offshore and so on). IC obtains information from the MNK in the course of its functioning. This information is used to reach the aim of the IC with the aid of progressive adaptive mechanisms of international cooperation. They included both adaptive mechanism for international solidarity and adaptive international regime. The sufficient conditions of their progressiveness are given by the theorem 1 and 2. Obtained results had been implemented in the international regime of intangible technologies export control.

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