글로벌 소프트웨어 개발에서의 지식이전에 대한 실증적 연구

An Empirical Study on Managing Knowledge Transfer in Global Software Development

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요 약

본 연구는 글로벌 소프트웨어 개발에 있어서 본사와 해외 개발 사이트 간의 지식이전이 성공적인 소프트웨어 개발에 영향을 미친다고 보고, 지식이전에 영향을 미치는 요인을 분석하였다. 커뮤니케이션 인프라, 파트너쉽, 거버넌스 구조를 독립변수로 보고, 이들 독립변수와 지식이전과의 관계를 실증분석하였다. 실증 분석은 최근 프랑스 기업들의 해외 개발 거점으로서 발전하고 있는 Mauritius의 기업들에 대한 설문 조사를 토대로 이루어졌다. 본 연구의 결과는 최신 트렌드인 글로벌 소프트웨어 개발을 계획하거나 수행 중인 기업들에게 효과적인 지식이전을 위한 해결책을 제시해 주고 있는데, 이러한 점이 본 연구의 의의라고 할 수 있다.

키워드 : 글로벌소프트웨어 개발, 지식이전, 커뮤니케이션 인프라, 파트너쉽, 가버넌스 구조

Ⅰ. Introduction

Generally, software development involves collaboration among developers. The success of the development is determined by knowledge transfer among developers. As global software development is increasing, knowledge transfer between a corporate headquarter and offshore development locations has been a major issue in relation to developing the software that satisfies user requirements (Tiwana, 2004). Knowledge transfer between headquarter and offshore sites starts as the project manager in headquarter provides project specifications to team leaders in offshore locations (Kim, 2007). While the team leader studies the project description, she or he communicates directly with the project leader to clarify any misunderstanding or to improve design or effectiveness. As system requirements change continuously, knowledge transfer regarding new and changed system functionality continues through maintenance and support phases (Ebert and Neve, 2001). Types of knowledge transferred between headquarter

and offshore sites include project status knowledge, project experiential knowledge, quality management knowledge, development standards knowledge and company culture knowledge (Bharadwaj and Saxena, 2006, Kobitzsch *et al.*, 2001).

Earlier studies on knowledge transfer in global software development tend to be anecdotal. While Ebert and Neve (2001) argued that the intranet-based shared work environment was essential for knowledge transfer, Battin *et al.* (2001) asserted that continuous communications and relationship building through liaisons were possible solutions to knowledge transfer problems. Governance choice seems to have a relationship with knowledge transfer as well. Kim (2007) indicated that setting up subsidiaries allows for more control over operations of offshore sites, and thus improved knowledge transfer. This raises the question of whether successful knowledge transfer depends on the relationship factor or governance mechanism, or both. To answer this, we address the following research question: what factors affect knowledge transfer in global software development? This study focuses on the following factors affecting effective knowledge transfer: quality of communication infrastructure, quality of partnership and types of governance mechanism--between headquarter and offshore site.

Ⅱ. Factors Affecting Knowledge Transfer

2.1 Previous Studies on Knowledge Transfer

Knowledge transfer is defined as "a process of systematically organized exchange of information between entities" (May *et al.*, 2005). Most of studies on knowledge transfer was focused on transfer of knowledge among employees within an organizational boundary and the factors affecting knowledge transfer within the organization can be grouped into four dimensions-technology, human resource, trust and structure.

Among others, Information and Communication Technology (ICT) plays a key role to coordinate knowledge transfer between employees by mitigating temporal and special barriers (Hendricks, 1999). The common technologies that firms use for knowledge transfer are internet, intranet and extranet. With search engines, it permits the knowledge to be searched across multiple repositories. Groupware system allows the knowledge to be stored and transfer among group members. The components of groupware system include e-mail, meeting systems and knowledge repository. In the example of BPE (British Petroleum Exploration), desktop videoconference technology allows virtual team to transfer the knowledge of remotely located engineers (Davenport, 2000).

Human resource factor of knowledge transfer deals with incentives to make employees motivated for knowledge transfer. Researchers argue that employees' intellectual capital should not be considered as the firm's asset (Davenport. 2000, Stewart, 1998, Preffer and Sutton, 2000). Rather employees are investors of their intellectual capital and choose to invest their knowledge when the reward meets at their acceptable levels (Kelloway and Barling, 2000). Employees are likely to transfer their knowledge to the extent that they have the motivation to do so (Markus, 2001).

According to Davenport and Prusak (2000), trust is a major factor that affects knowledge transfer among employees. Trust reduces the fear of opportunistic behavior of the other in terms of taking advantage of the knowledge gain. Thus, they view that mutual trust in the relationship be a prerequisite for transfer of the embedded implicit knowledge of the

individuals to others. The structural factor of knowledge transfer deals with intra-organizational structures that facilitate collaboration. Efficient structure for knowledge transfer deals with creating a field in which individual members collaborate to create a new concept (Goffee and Jones, 1996, Grant, 1996, Nonaka and Konno, 1998). The horizontal structure opposed to the vertical structure encourages knowledge transfer and collaboration among employees. The horizontal structure includes various types of teams such as project teams and task-force teams made of members coming from diverse functional departments. Based on common tasks and shared goals, the teams generate a high degree of strategic focus and goal accomplishment (Goffee and Jones, 1996).

Among these four factors, technology, trust and structure could be applicable to knowledge transfer between geographically separated headquarter and offshore location. Since knowledge transfer in global software development is mandatory and must occur during daily activities regardless of incentive, human resource dimension is excluded in this study. The following section deals with the factors affecting knowledge transfer among members of global software development team. Specifically, quality of communication infrastructures, partnerships and governance structure will be discussed as factors affecting knowledge transfer in global software development.

In this study, types of knowledge transferred across boarder are considered to range from noncodifiable to codifiable. When knowledge transferred can not be prescribed in advance, the knowledge is described as noncodifiable knowledge. The opposite is codifiable knowledge. While project status knowledge, quality management knowledge, development standards knowledge are codifiable, project experiential knowledge and company culture knowledge are noncodifiable. The third type of knowledge is sensitive knowledge either in codifiable or noncodifiable format. Confidential knowledge such as encryption techniques is categorized as sensitive knowledge.

2.2 Quality of Communication Infrastructure

Infrastructure is defined as structural elements that provide the framework supporting a larger, complete structure (Broadbent *et al.*, 1997; Byrd and Turner, 2000). Communication infrastructure is a structure that can be shared by individuals for communication and coordination. Communication infrastructure consists of information technology (IT) based communication tools and networks. Quality is considered to be multidimensional. Among them, the most cited dimension is "fitness of use." It refers to products or services having features that users need or desire (Garvin, 1988). When applied to communication infrastructure in global software development, fitness of use can be represented as communication infrastructure possessing the features that developers need or desire. Thus, we investigated the features of communication infrastructure that developers need or desire in global software development.

Due to geographical distances between headquarter and an offshore development location, IT-based communication mechanisms play a critical role in the transfer of system requirement knowledge (Kim, 2007). Various two-way communication mechanisms, such as IP phone, e-mail, and video conference were utilized not only to deepen the understanding the requirements, but also to ensure a high quality of software. Media choice is determined by the media richness required by information (Bharadwaj and Saxena, 2006). When information requires media richness, the probability of video-conference be-

ing used is higher than that of telephone and e-mail.

While requirement knowledge is the highest in information richness, project status is the lowest. In global software development, 80% of communications is performed via IP phone (Kim, 2007). The team leader in offshore sites communicates with the project leader in headquarter 5~10 times per day using an IP phone. The remainder is done via e-mail or video conferencing. Thus, the first feature of communication infrastructure is to provide various communication mechanisms such as phone, video-conferencing, and e-mail.

Workflow management tools play a major role in the communication and coordination of team members. A study on a domestic outsourcing case (Kim and Kim, 2007) documented how workflow management tools monitor a series of activities performed by the provider. First, the workflow management system registers service requests by the outsourcer. Then, the provider forwards feedback on registration, processing status and reasons for any delayed processing. The system also records individuals involved in each activity as well as the time of the activity. Potential use case of workflow management tools for communication in global software development project can be inferred by this domestic case. Thus, the second feature of communication infrastructure is to provide workflow management tools for project management.

According to Ebert and Neve (2001), intranet-based shared work environment is considered to be essential for success of global software development: "often a file with source code is replicated as variants that are concurrently updated and synchronized (p.66, Ebert and Neve, 2001)." CASE (Computer Aided System Engineering) technology provides a shared work environment in which multiple versions of software can be controlled. CASE also provides shared work environments in which much of explicit knowledge including the development process and project contents, standardized methods and diagrams can be documented and shared by developers for communication (Bhaeadwaj and Saxena, 2006, Valacich *et al.*, 2001). Thus, the last feature of communication infrastructure is to provide standardized documents for project management.

The reliability of communication infrastructure can also represent its quality. In general, the reliability of the system refers to the user's attitudes, including certainty and analysis of the system over time (DeLone and McLean, 1992, Nelson *et al.*, 2005). The existence of errors during communication is asked to measure reliability of communication infrastructure. One of the biggest concerns in inter-organizational communication is data security. The potential risk of their confidential data being accessed by other companies is a genuine concern. Providing confidentiality during communication also influences the quality of communication infrastructure. The relationship between the quality of the communication infrastructure and knowledge transfer is summarized formally in the following hypotheses:

Hypothesis 1 : Quality of communication infrastructure is positively associated with the level of knowledge transfer in global software development.

Based on the literature reviewed above, the following items were derived to measure the quality of the communication infrastructure: (1) providing proper communication interface; (2) providing communication systems for project management; (3) providing standardized documentation for project management; (4) no errors during communication; and (5)

providing confidentiality during communication.

2.3 Partnership Quality

Outsourcing is presented as a partnership (Dank-Baar, 2007). In manufacturing outsourcing, relationships between the partners are considered to be heavily dependent on trust. Open communication and mutual learning based on mutual trust have influenced outsourcing success (Chesbrough, 2003). Trust is thought to foster knowledge transfer and learning because trust increases interactions between individuals and aids in acquiring tacit knowledge (Kale *et al.*, 2000, Moorman *et al.*, 1992, Anderson and Narus, 1990). In global outsourcing for manufacturing products, communication technology has made knowledge transfers between partners much more efficient. However, much of manufacturing knowledge is experiential in nature. Thus, communication technology alone is not sufficient for knowledge transfer (Dank-Baar, 2007). Mutual trust between partners is vital in filling this discrepancy.

According to Bradach and Eccles (1989), the level of trust between organizational groups has a major impact on knowledge shared by these groups. Similarly, mutual trust between the IS and line groups was found to have a positive impact on increased levels of shared knowledge between these groups (Nelson and Cooprider, 1996). Trust reduces the fear of opportunistic behavior of the others in terms of taking advantage of the knowledge gain; and reduces transaction costs (Davenport and Prusak, 2007, Sun, 2007). Thus, mutual trust in the relationship is a prerequisite for the transfer of an individual's knowledge. In global software development, much of explicit knowledge can be codified and included in a database or handbook. However, "sticky" knowledge can be transferred by trust-based communications between partners.

Defined as the pledge of relationship continuity between partners, the commitment on prescribed agreements is also considered to facilitate communication and knowledge transfer to achieve mutual goals (Hewett and Bearden, 2001, Das and Teng, 1998, Liefer and Mills, 1996). Expressed by trust and commitment (Lee and Kim, 1999, Chakrabart, 2007), the level of partnership quality is expected to increase the level of knowledge transfer. The relationship between partnership quality and knowledge transfer is summarized formally in the following hypotheses:

Hypotheses 2 : The level of trust and commitment is positively associated with the level of knowledge transfer in global software development.

Modified from the instruments of Lee and Kim (1999) and Lee and Cavusgil (2006), the following items were asked to measure trust and commitment: (1) willingness to provide assistance to our counterpart-without exception; (2) sincere at all time; (3) perform pre-specified agreements; (4) faithfully provide pre-specified support in a contract; and, (5) consistent efforts fulfill obligations and verbal agreements.

2.4 Types of Governance Structure

Major types of governance structures found in global software development are captive, joint ventures (JV), third-party vendor or mixed structure. Among these, captive and JV are considered to be hierarchical governance. Mixed structure is a combination of captive, JV and third-party vendor. Under

mixed structure, the offshore location can perform not only the tasks delegated by parent company but also the tasks contracted with third client companies.

The governance choice is explained by resource dependency and transaction cost views. From the resource dependency views, the subunit's activities performed for the organization are considered to be resources (Nord, 1980, Pfeffer and Salancik, 1978). Since achieving organizational goals depends on the resources (i.e., the activities of the subunits), the governance choice by an organization is associated with ensuring that the resources are obtained economically. Referred to as vertical Foreign Direct Investment (FDI), captive is set through the direct investment of a home company (Goswami, 2007). The primary reason that the home company chooses the captive model is the lack of a third-party vendor who could meet the demanding requirements of the home company (Kurien, 2003). A governance choice for a JV between a global company and a local service provider (Budhwar and Luthar, 2006) is explained in a similar manner with an example being IBM's acquisition of Daksh e-Service in India. It falls into the "vertical acquisition" as it is between firms in buyer and seller relationships (Walter and Barney, 1990). As the outsourcing industry grows, IBM had to broaden and deepen the scope of its outsourcing. Instead of setting up a captive center, IBM decided to leverage local capabilities and acquire a local service provider (Srinivasan and Mishra, 2007, Shi, 2007).

From a transaction cost views, the hierarchical governance structure is chosen due to transaction costs associated with incomplete contract problem (Williamson, 1979). A previous study on offshore outsourcing indicates that setting up hierarchical governance could have more control over the operations and better communication. It also reduces concern for the provider's opportunistic behavior regarding sensitive knowledge (Kim, 2008). Shi (2007) indicated the 'asymmetrical learning' by an outsourcer and its vendor. Asymmetrical learning causes the outsourcer to be more vulnerable from the vendor's opportunistic behavior, which makes a hierarchical governance more favorable (Shi, 2007). The opportunistic behavior of the vendor has been a concern in inter-organizational knowledge transfer. According to Kobitzsch (2001), restricted technologies, such as encryption, are more difficult to transfer to independent partners. The newest technologies are transferred overseas through subsidiaries rather than licensing (Mansfield and Romeo, 1980). As technical intensity increases, organizations adopt a work mode that is organized in a hierarchical manner to effectively utilize the exclusive patent of the new technology (Jones, 1987). In a similar manner, the more hierarchical the governance structure is in global software development, the more effective the communication would be. Thus, knowledge would be transferred more efficiently. The relationship between the governance mechanism and knowledge transfer is summarized formally in the following hypotheses:

Hypotheses 3 : Higher level of hierarchical governance structure is positively associated with the level of knowledge transfer in global software development.

A sample of service providers were asked to indicate their governance structure among the four categories of the governance structure used in this study: vendor, subsidiaries, JV and mixed structure.

2.5 Knowledge Transfer in Global Software Development

The questionnaire item to measure the degree of knowledge transfer was adopted from Ko *et al.* (2005). Ko *et al.* (2005) studied knowledge transfer from consultants to clients in enterprise system implementation. They found that defining user requirements and system architecture require extensive communication and learning between users and the analyst and among team members. The original items to measure the degree of knowledge transfer between clients and consultants were modified to be relevant in global software development.

Ⅲ. Research Design

Data to test the model and hypotheses were drawn from a field study of 15 offshore sites in Mauritius (Kim and Kim, 2008) and an additional field study of more 15 sites in the same country. Study respondents were chosen based on key-informant methodology (Phillips and Bagozzi, 1986). For each site, a respondent was either a director or a manager involved in a global software development project. For the quality of the communication infrastructure and the quality of partnership, they were asked to rate each item on a five-point scale anchored on strongly disagree (1) and strongly agree (5). For types of governance structure, they were asked to indicate a governance structure among the followings: vendor, subsidiaries, JV mechanisms and mixed. As India is a popular destination for companies using English for global software development, Mauritius is one of the favored destinations for French companies.

Increasingly, companies bundle software development and business processes together for global sourcing. Therefore, samples include pure software development projects as well as combined projects of software development and business process sourcing. Convenience sampling was adopted, i.e. companies were selected on the basis of ease of access. <Table 1> shows descriptive statistics of the surveyed firms.

〈Table 1〉 Descriptive Statistics for Sample Companies

		Frequency	Percentage
Company Age	Less than 2 years	4	13%
	2~4 years	10	33%
	4~6 years	5	17%
	Over 6 years	11	37%
Industry	Pure Software Development	21	70%
	Call Center	4	13%
	Accounting	2	7%
	Finance	1	3%
	Not Answered	2	7%
Position	Manager	14	47%
	Director	9	30%
	Consultant	4	13%
	Engineer	3	10%
Department	Management	10	33%
	IT	4	13%
	Consulting	3	10%
	Software Development	7	23%
	Etc.	6	20%

Ⅳ. Data Analysis

The validity and reliability of the instruments were evaluated. Using the principal components method with a quartimax rotation, the factor analysis was performed to identify valid constructs. As shown in

<Table 2>, the factor analysis resulted in two factors, each of which has an Eigen value greater than 1. Factor loading for each item of the two factors was over 0.4. Accordingly, each item is considered to be important in interpreting the factors. The two factors were: Partnership Quality and Communication Infrastructure Quality. Reliability, as represented with Cronbach's alpha, was over 0.7 for each factor. The reliability coefficients above 0.60 are typically considered satisfactory (Hair, 1998). Correlations among independent variables and Knowledge Transfer were checked. While the Person Coefficients among factors were not significant, they between the factors and Knowledge Transfer ($p < 0.01$).

Next, we investigated the relationships among the individual factors and Knowledge Transfer. To address the possibility that some of the constructs combined multiplicatively rather than additively in Knowledge Transfer, we conducted a step-wise regression analysis (p-in = 0.05. p-out = 0.10). Since captive and JV are considered to be hierarchical governance, we coded them as hierarchical. Since the governance structure variable is categorical, we used dummy variables to include them in a regression. Since there are three categories for a given response could be in--hierarchical, vendor or mixed-we created three dummy variables. Among the three dummy variables, only two of them should be in a regression equation (Albright *et al.*, 2000). For the dummy variable, Dummy_Hierarchical, we assigned '1' for the hierarchical governance structure. We coded dummy variable, Dummy_Mixed as '1' for the mixed governance structure. Only 5% of the sample is pure vendor. While 44% of the sample answered that its governance structure is hierarchical, 40% responded as Mixed. Among 44% of hier-

〈Table 2〉 Results of Factor Analysis

(** significant parameter at p = .01)

Questionnaire Items	Factors	
	Partnership Quality	Communication Infrastructure Quality
keep each other's promises.	.894**	
faithfully provide support	.822**	
sincere at all time.	.797**	
perform prespecified agreements.	.737**	
provide assistance without exception	.588**	
Communication systems for project management		.803**
documentation for project management		.798**
no errors when we communicate		.739**
privacy and confidentiality		.713**
properly designed communication interface.		.585**
Cronbach's Alpha	.862	.840
Eigen Value	4.749	47.487
% of Variance	47.487	68.017
Cum %	53.876	70.643

archical, 37% was captive and 7% was joint venture. The mixed represents subsidiaries or JVs that also have separate businesses from the mother company as the vendor.

As shown in the regression model in <Table 3>, Partnership Quality (β = .511) and Communication Infrastructure Quality (β = .478) have significant impacts upon Knowledge Transfer. The R-square value was 0.611 and the Standard Error of Estimation was 0.453.

V. Conclusions

According to Central Limit Theorem, a sample of 30 or more can be considered to follow normal distribution (Aczel, 1989), which allowed this study to use t-distribution for testing hypotheses and made a contribution to the theory of global software development. This study identified the factors that affect knowledge transfer in global software development projects. Similar to previous research done within an organizational boundary, partnership quality was found to be a determinant in knowledge transfer. Although the results are similar, implications of the results are far different due to the geographical distance among offshore locations. In global software development, the chances for relationship building between dispersed project members are limited due to the geographical distance. However, headquarter should provide opportunities for developers at various sites to get acquainted with developers. This could take place through liaisons, meetings, visits to parent company facilities and parent-company interaction, training developers of partner companies by parent companies, and the transfer and rotation of personnel. According to a global project manager in Centrica, UK, whom the prime investigator of this study met in the conference, mutual trust is the most important for the success of the global projects. The following question was then asked to the manager: how can we build mutual trust between project mangers and team members? The answer was socialization. The team even spent the holidays together.

Similar to previous research, the communication infrastructure quality was found to be important for knowledge transfer. However, the company that wishes to move its software development to global locations must know that the environment that it faces is far more challenging than the domestic environment. A global team could be scattered in multiple countries and time zones such as USA, India, China, France and Russia. Global team members' heavy accents and cultural difference made them difficult to understand each other. Yet, it is important for team members to understand meanings of deadline, requirements, relationships between tasks, impact of individual task on others. Various communication technology should be explored and used com-

〈Table 3〉 Hierarchical Regression Results

Independent Variables	Standardized Coefficients(β)	T	Sig.
Partnership Quality	.511**	4.171	.000
Communication Infrastructure Quality	.478**	3.882	.001
Governance Type(Dummy_Hierarchical)	-.367**	-2.974	.006
Governance Type(Dummy_Mixed)	.043	.222	.826

Note) $^{+}p < .10$; $^{*}p \leq .05$; $^{**}p \leq .01$.

plementarily to coordinate activities across sites as well as to overcome the problems associated with language barriers and time zone differences. In addition to the fitness of use, the reliability and security of the infrastructure seem to be prerequisites for knowledge transfer in global software development.

Unlike earlier studies in which the captive was found to have higher levels of communication and knowledge transfer, this study showed that hierarchical governance has negative impacts on knowledge transfer. Similar results were found in marketing literature. The marketing literature asserts that asymmetric power between manufacturers and resellers reduces the frequency of communication (Mohr and Nevin, 1990). Less powerful members tend to be concerned about their message being ignored by more powerful members. Since the parties are unequal in power, information flow tends to formal and unidirectional, from the more powerful member to the less powerful (Blair *et al.*, 1985). The characteristics of the message are described as directive and persuasive (Jablin, 1987). Future Research is called to investigate into the relationships between governance type and knowledge transfer in global software development.

Companies in the United States and Europe are increasingly adopting global software development. In France particular, companies have taken their software development to offshore locations such as Mauritius, Tunisia, Romania, Russia, India and China. Compared to western countries, global software developments by Korean firms are in its infancy stage. The McKinney Institute reports direct and indirect benefits that the U.S. gained from offshore developments to India (www.mckinsey.com). When the U.S. pays $1 to India, the U.S. gains $1.46; even after the U.S. pays to $0.33 to Indian government for tax. The U.S. still gains $1.13. The gain comes from: (1) cost saving from the task that is offshored; (2) export of equipment and supplies that Indian company need; and (3) economic gain by relocating employees whose jobs were offshored. Global software development by Korean firms needs to be considered as a way to restructure the Korean economy indicated by the McKinney Institute reports. The results of this study will assist the company that plans to start the global software development either as a provider or a client by providing guidelines for effective management of the global development.

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An Empirical Study on Managing Knowledge Transfer in Global Software Development

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Abstract

In a global software development project, knowledge transfer between a corporate headquarter and offshore development sites is considered to be important for effective software development. This article presents empirical research that investigates factors influencing knowledge transfer in global software development. The factors evaluated in this study are: 1) quality of communication infrastructure, 2) quality of partnership and 3) types of governance mechanism. Questionnaires were collected from offshore development sites in Mauritius. While the quality of both the partnership and communication infrastructure were found to be determinants to knowledge transfer, hierarchical governance had a negative impact on knowledge transfer. Although the results are similar to the previous studies done within an organizational boundary, implications of the results are far different due to the geographical distance among offshore locations. Future research is called for to investigate the relationships between governance type and knowledge transfer.

Keywords: Global Software Development, Partnership Quality, Communication Infrastructure Quality, Governance Structure, Knowledge Transfer

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이화여자대학교 컴퓨터학과를 졸업하고 Texas Tech University에서 경영정보학 석사와 박사를 취득하였다. 현재 이화여자대학교 경영대학 경영정보시스템 부교수로 재직 중이다.
주요 관심분야는 비즈니스 프로세스 관리 (Business Process Management)로서 현재 프로세스 아웃소싱과 관련된 조정 및 통제 메커니즘에 대한 연구를 수행 중이며 관련 분야에서 다수의 논문을 발표하였다. 한국경영정보학회와 한국시뮬레이션 학회 회원이다.

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