Paper

An Architecture for Cyber Business Community Platform in Business-to-Business Electronic Commerce and Collaboration

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This paper presents new architecture for managed cyber business community platform to realize secure, fair and efficient business-to-business electronic commerce. The main features of the architecture are dynamic inter-enterprise business relationship management and service level management from the business viewpoints, which, the authors think, are the most important factors for realizing managed cyber business community platform. For the first feature, this paper presents new method that explicitly describes inter-enterprise business relationship with business level workflow and whereby dynamically controls the sharing and exchange of confidential information depending on the current status of inter-enterprise business relationships. For the second feature, business-driven and directory-based system management scheme is newly proposed, which integrates requirements and objects in a system with directory from the viewpoints of security, reliability and performance, respectively, and makes it easy to translates service level requirements from business viewpoints into information and communication level requirements. The proposed architecture has been applied to electronic business platform services called "TWX-21", Trade Winds on Extranet in 21st century, and proved to be very useful.

Keywords business-to-business electronic commerce, cyber business community, service level management, workflow, relationship management

1. Introduction

Increasingly competitive business environments are demanding more agile and worldwide inter-enterprise cooperation and competition. These business demands coupled with emerging new information and communication technologies like the internet have brought about business-to-business Electronic Commerce (B2B EC). B2B EC has the possibility to promote smooth and agile inter-enterprise cooperation throughout the whole business processes and largely improve the benefits consumers get from services as well as the enterprises' competitiveness [1][3]. As the means for making B2B transactions, Value Added Networks, VANs, have been widely used. However, most of the traditional VANs use proprietary communication protocols, and their applications areas are limited to mainly batch-mode EDI (Electronic Data Interchange) for expensive or large volume deals among large or medium-scale enterprises. New B2B EC, which employs open protocols for communication, software and business processes, is expected to dramatically extend application areas and create new businesses (cf. Figure 1) as follows. B2B EC targets not only routine and static business processes but also strategic and dynamic business processes such as decision-making and collaboration among different enterprises. Moreover, B2B EC targets small-scale enterprises and inexpensive non-production goods as well.

While B2B EC has abundant possibilities as mentioned above, it has to handle much more various types of business transactions than in case of traditional VANs, ranging from routine transactions with fixed trading partners to non-routine, i.e. strategic, transactions with non-fixed or new trading partners. To cope with this problem and realize managed cyber business community platform where enterprises can freely as well as safely find new trading partners and conduct strategic trading and collaboration, the authors think, the following two requirements are crucial. First requirement is dynamic inter-enterprise business relationship management. In case of non-routine, i.e. strategic, transactions with non-fixed or new trading partners, inter-enterprise business relationship may dynamically change. Therefore, it is necessary that enterprises can safely share and exchange information even in the environment where inter-enterprise business relationship dynamically changes. Second requirement is service level management. It is very difficult for a B2B EC system to satisfy users' service level requirements for the following reasons. A B2B EC includes various types of non-routine transactions, whose traffic pattern is hard to predict, and consists of intricately interrelated quite a few components, which makes it difficult to detect a service level degradation and its causes as well as estimate its effects to the service level of the whole system. To cope with these difficulties, new method is necessary that can manage large number of intricately interrelated components from user' business viewpoints. This paper newly presents system architectures to realize the above two requirements. For the first requirement, this paper presents a workflow-based new architecture that explicitly describes inter-enterprise business relationship with business level workflow and whereby dynamically controls the sharing and exchange of confidential information depending on the current status of inter-enterprise business relationships. For the second requirement, this paper newly presents service level management architecture which is business-driven, i.e. from business viewpoints, and directory-based. This architecture integrates requirements and objects with directory not only in a hierarchical manner from a business level to an information and communication level, but also from diverse viewpoints, i.e. security, reliability and performance. This makes it easy to manage a B2B EC system so as to satisfy users' security, reliability and performance requirements.

There has been other research on EC service architecture. TINA [4] and ADSS, autonomous decentralized service system, [9] focus on trading such as brokerage among buyers, sellers and mediators, while Commercenet eCo Framework [8] and OMG

(Object Management Group)-EC-Framework [5] present an object-oriented or XML-based software framework. This paper focuses on the architecture for realizing managed cyber business community, which, as mentioned above, is extremely important for B2B EC, but has not been discussed.

In the following, architecture for dynamic inter-enterprise business relationship management and that for service level management from the business viewpoints are presented in chapter 2 and 3, respectively, and the application results are shown in chapter 4.

2. Dynamic Relationship Management Architecture

2.1 Outline of Architecture Proposed architecture for dynamic business relationship management is workflow-based. Inter-enterprise business processes and business relationship status are expressed with workflow, and the current business relationship status is reflected on access control.

The following outlines the structure and mechanism of proposed architecture (cf. Figure 1).

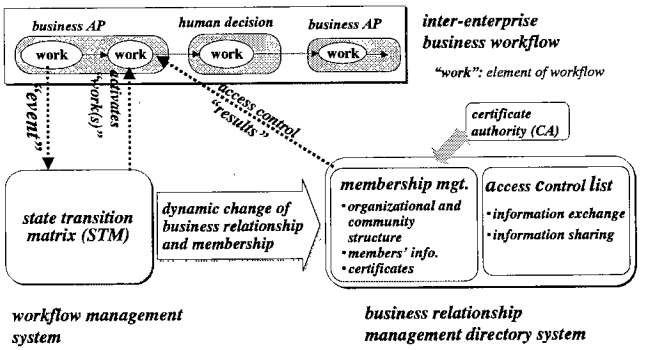


Fig. 1. Dynamic Business Relationship Management Architecture

i. Inter-enterprise business processes are expressed as a business workflow. An element of workflow is "work" which corresponds to either a business application or a human decision. A business workflow is driven by a workflow management system according to its state transition matrix ("STM"). "STM" defines the set of business states and their transition rules. Each time the workflow management system receives an "event" from "work" or outside of the business workflow, it acts according to "STM" such that it changes the state of "STM", activates next "work(s)" and informs the business relationship management directory system of the state change. Based on this notification, the directory system checks if any change in access control is required. For example, enterprise A allows its trading partner B to access some confidential information only after a non-disclosure agreement between them has been reached. The workflow diagram and its "STM" are defined and maintained by users or service providers. Open APIs (Application Program Interfaces) like CORBA-IDL (Common Object Request Broker Architecture-Interface Definition Language) or XML (Extended Markup Language) API are employed between business applications and the workflow management system. The workflow management system is "distributed" in the sense that it may be located at arbitrary distributed servers, which enables dynamic load balancing and automatic switch over in case of failure and therefore improves system's scalability and reliability.

In order to express inter-enterprise business processes which consists of not only routine but also non-routine, i.e. strategic, "work", this paper applied a multiple type workflow model [7]. The model is suitable to modeling business processes where routine and non-routine "work" coexists. In the model, how non-routine "work" acts may vary depending on its conditions. Besides, the model treats the influence of external data on workflow, more precisely conditions of workflow. Furthermore, the model provides facilities such as adapters and wrappers to connect workflow with other systems like legacy systems and ERP (Enterprise Resource Planning) systems.

ii. The information for business relationship management such as membership, business relationship, and access control list is managed in integrated manner with a directory, e.g. LDAP (Light weight Directory Access Protocol) directory. The details of the business relationship management directory system will be described in the following section. The directory may be replicated in distributed servers for load balancing. Each time a member enterprise wants to exchange or share information with other member enterprises through a business application, the business application accesses the business relationship management directory system to check whether the required information sharing or exchange is permitted and what kinds of access are permitted.

2.2 Membership Management Membership management is one of the key elements of the dynamic business relationship management architecture. The architecture assumes membership and allows only member enterprises to access the B2B EC system as the basic requirement for realizing secure and trustworthy cyber business community. Any member enterprise has to satisfy required qualification standards. A member enterprise receives a digital certificate issued by certificate authorities. Digital certificate information for each member enterprise is stored in business relationship management directory system.

Figure 2 shows the outline of membership management directory. Its features are:

i. Each enterprise may have plural membership if it wants to distinguish the roles among them. For example, different division, department or sections in the same enterprise may have different membership and therefore digital certificates.

ii. Any members may form their own business sub-community and limit the extent of information sharing and business workflow within the sub-community. Of course, a member may belong to different business sub-communities.

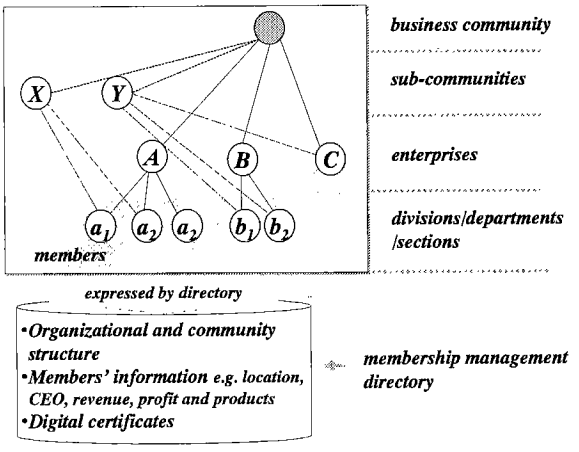
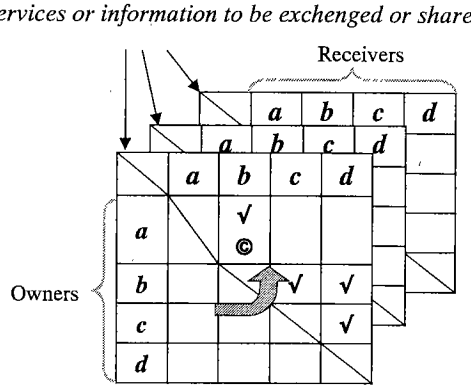


Fig. 2. Outline of Membership Management

2.3 Access control Access control is another key element of the proposed architecture and aims to enable member enterprises to share and exchange confidential information according to specified business rules and current business status. For realizing this purpose, access control list allows the owner of information to

specify which members can access, receive or modify which information under what conditions. As stated in previous section, conditions for access control can be dynamically changed according to "STM". Figure 3 shows the outline of access control. Access control list describes the agreements and dynamic conditions for information sharing and exchange among members in terms of each service or information item.



a,b,c,d : members
√ : agreement exits for exchanging or sharing information for specific service
© : dynamic conditions

Fig. 3. Access Control List

3. Service Level Management Architecture

As mentioned, the proposed architecture for service level management from the business viewpoints aims to simplify service level management by integrating service level requirements in a hierarchical manner as well as from diverse viewpoints, i.e. security, reliability and performance. The features of the proposed architecture are as follows.

i. Layered architecture: The proposed architecture considers a B2B EC system as a layered architecture which ranges from business application level to information and communication level. A B2B EC has so many and various kinds of elements that it is useful to understand a B2B EC system as a layered architecture.
ii. Directory-based architecture; Using directory, the proposed architecture integrates elements in the same as well as different level in the above layers from the viewpoints of security, reliability and performance, respectively.

3.1 Layered Architecture The architecture consists of following four layers (Figure 4):

i. A business platform, which consists of business applications and users' inter-enterprise business processes,
ii. A business management platform, which is the core of the proposed architectures, and responsible for inter-enterprise business relationship management and service level management from business viewpoints,
iii. An application platform, which is for software development and coordination and supports many distributed software technology standards, e.g. CORBA, LDAP, XML and inter-workflow APIs, and
iv. A network platform, which is a communication-level platform that supports standard Internet protocols as well as other legacy protocols.

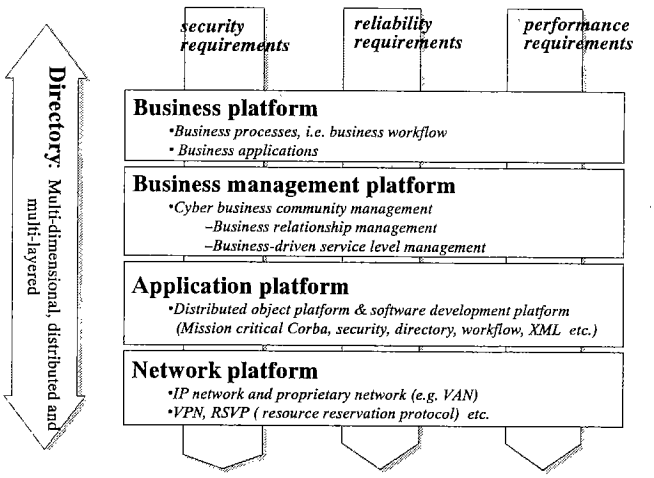


Fig. 4. Architecture for Service Level Management

3.2 Directory-based Architecture Requirements and objects in the same as well as in different layers are integrated with directory from the viewpoints of security, reliability and performance (Figure 4). Directories are used in a new way so that they may express multi-dimensional, distributed and multi-layered relationships among objects and requirements in a B2B EC system. Here, "multi-dimensional" means that the relationships in the directory are integrated from the respective viewpoints of service-level management, i.e., security, reliability and performance. "Multi-layer" means that requirements and objects in not only the same but also in different layers of the system architecture are integrated. Finally, "distributed" means that objects even in distributed computers are related as well. This new scheme simplifies the translation of business-level requirements into information- and communication-level requirements.

4. Applications

4.1 Outline of TWX-21 The proposed system architecture was implemented as the core framework of electronic business platform services called "TWX-21", Trade Winds on Extranet in 21st century. TWX-21 began service in October 1997 and had a membership of about 10,000 enterprises by the end of March in 2001. TWX-21 provides a wide range of inter-enterprise business application services such as Internet-EDI, Web-based EDI, quotation, technical document exchange, supply chain information sharing, online-catalog-based buying and selling, and netting, i.e., offset accounting. Here, Internet-EDI means EDI with IP-based communication protocols, while Web-based EDI is EDI with HTTP or XML and requires a trading partner only Web browser. TWX-21 targets many industries including manufacturing, construction, chemical, distribution, transportation, public, international trade and finance [6].

4.2. Application of Dynamic Relationship Management Architecture to Quotation

i. **Application results** Dynamic business relationship management architecture was applied to the quotation service of TWX-21 (cf. Figure 5). In the quotation service, participating enterprises have to securely share and exchange confidential information such as prices, attached technical documents and the status as well as the history of the quotation process. Here, dynamic business relationship management capability is required because conditions for permitting access to confidential information change dynamically as the quotation process proceeds.

The quotation process was expressed as an inter-enterprise workflow among a buyer side enterprise and supplier side enterprises. First, a buyer side selects candidate enterprises from TWX-21 members, and sends them a request for quote (RFQ). Next, the candidate enterprises receive the RFQ and some of them quote. Then, the buyer enterprise receives the quotes either to make final selection or to limit the candidates and proceed to the next round quotation.

Some examples of the business relationship status defined in STM (status transition matrix) are "a certain supplier is invited to the quotation", "the supplier quoted" and "the supplier was accepted in n-th round quotation". The status dynamically controls the right for each of the participating enterprises to access to confidential information. Examples of confidential information are progress of quotation, contents of quotation, invited enterprises and accepted enterprise. Examples of access control are: "only invited suppliers can access the RFQ information and selection results" and "only suppliers that survive up to a certain round selection can receive the next round RFQ and access the progress information until then".

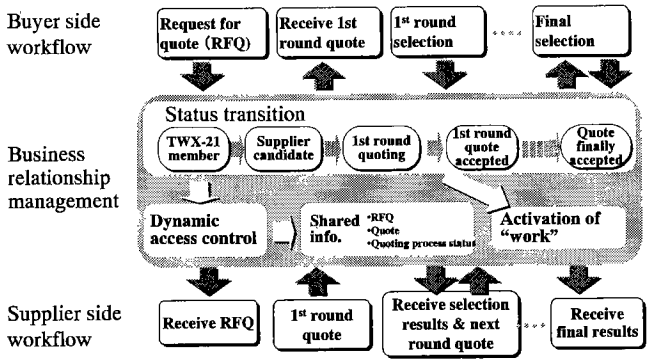


Fig. 5. Application of Dynamic Relationship Management Architecture to Quotation

For describing the quotation process, the multiple type workflow model was applied. The first capability of the model is that the model allows non-routine "work" to act differently depending on its conditions. Application examples of this capability are: "sellers' quotations influence buyer's selection, and alternately the buyer's selection influences sellers' following activities" and "the number of sellers who have survived up to a certain quotation round is not predefined, but the quotation service creates tasks for each one of them to send them selection results". An example of the model's second capability, i.e. ability to treat influences of external data on workflow, is: "a supplier may change specification or price of his quotation depending on the external data about specifications and prices of products or parts relevant to the quotation". An example of the model's third capability, i.e. facilities to connect workflow with other systems, is: "introduction of automated connection between workflow and design document management systems made it easy to attach technical documents and drawings to RFQ and quotations, and contributed to streamlining the quotation process.

ii. **Evaluations** Many enterprises have applied the quotation service of TWX-21, and have succeeded in speeding-up their quotation process, improving rivalry among trading partners as well as developing new trading partners. By realizing dynamic sharing and exchange of confidential information, the proposed architecture contributed to making the quotation process online-interactive and therefore further speeding it up. In some application case, quotation process which had been paper-based and taken 14 days was shortened to 7 days. If the quotation service had not applied the proposed architecture and therefore were not online-interactive but daily-batch-based, it would have taken about 9 days. Therefore, it is estimated that the proposed architecture contributed to speeding-up the quotation process by 2 days, in this case.

Besides, by making use of workflow, the proposed architecture was useful to:

a. Accurately specify business relationships and information access conditions, which increased productivity in developing and testing of the quotation service software,
b. Easily customize the quotation service by modifying the workflow so as to better express user enterprises' specific business processes or requirements, and
c. Easily provide the quotation service with transaction recovery and tracking capabilities that most commercial workflow products have as standard features.

4.3 Application of Service Level Management Architecture

4.3.1 Application results

i. **Outline of application results** Service level management architecture was applied to TWX-21 as its core framework. Figure 6 shows the outline of the application results.

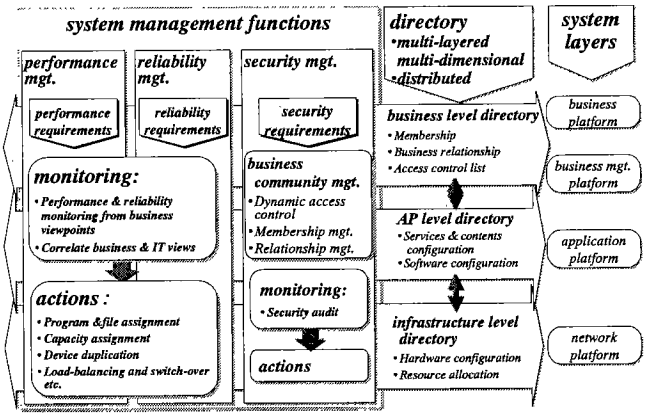


Fig. 6. Application of Service Level Management Architecture

Based on the proposed architecture, the system configuration of TWX-21 was designed as in Figure 7.

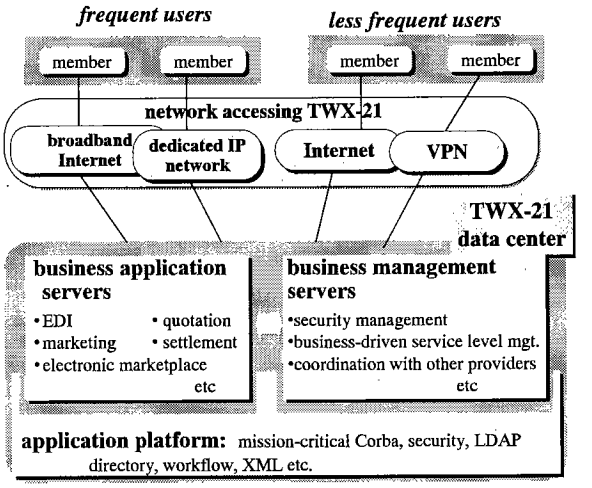


Fig. 7. System Configuration of TWX-21

It consists of TWX-21 data center and communication networks for members to access to TWX-21 data center. TWX-21 data

center consists of two groups of servers, business application servers and business management servers, which correspond to the first and second layers of the architecture (Figure 4). Both of these servers include application platform as their basis, which corresponds to the third layer of the architecture. Members access the TWX-21 data center through an IP-based network such that frequent users use broadband VPN or dedicated IP network while non-frequent users use VPN or just the Internet.

The following describes the application of the proposed architecture from the viewpoints of performance, reliability and security, respectively.

ii. **Performance management** Performance status from the business application viewpoints, e.g. response time and throughput for each business application, as well as information and network viewpoints, e.g. response time and throughput for each software and hardware component, are periodically monitored and correlated with each other. For this correlation, multi-layered directory functionality, i.e., the integration of requirements and objects in not only the same but in different layers of the system architecture, is fully utilized. Based on the monitoring and correlation, if some performance degradation is detected at business application level, it is easy to locate the bottleneck at the information and network level. On the contrary, if any performance degradation is detected at information and network level, it is easy to estimate its effect on the business-application-level performance. These monitoring and correlation capabilities make it easy to detect performance bottlenecks and take proper measures to satisfy the performance requirements. Examples of the measures are modifications of program and file assignment, capacity assignment and load balancing.

iii. **Reliability management** Reliability status indicators at business application level, e.g. failures in each business application service, as well as at information and communication level, e.g. failures in each software and hardware component, are monitored and correlated with each other. These monitoring and correlation capabilities make it easy to take proper measures for avoiding reliability bottlenecks such as program and file assignment, device duplication and recovery time improvement.

iv. **Security management** The proposed architecture provides security management functions at not only the communication network level but also at the business management level. Business-level security management corresponds to the dynamic business relationship management in chapter 4. In terms of communication network level security, IP-based standard technologies are applied, e.g. firewall, virtual private network (VPN), digital certificate, encryption and digital sign.

v. **Components' service level monitoring system** In order to monitor the service level of each object in the system, TWX-21 introduced monitoring system shown in Figure 8 [2]. Users of the system, e.g. service providers, can monitor the performance, reliability and network-level security status for each "service" from Web browser. "Manager" of the monitoring system distributes and installs "agents" to the remote target systems, receives monitor data from "agents" and presents the monitoring results to users. Here, "manager" looks up system configuration information in LDAP directory in order to, for example, figure out the location of the target services, summarizing monitored data from component level to system or business application service level or vice versa. Examples of monitoring items are as follows:

a. Performance
   - Response time and throughput for each business application service
   - Resource utilization of information and communication elements, e.g. CPU, memory, storage and communication devices
   - Number of sessions and processes
b. Reliability; operation status and fault record for each service
c. Network-level security; various reports about security inspection results for each service

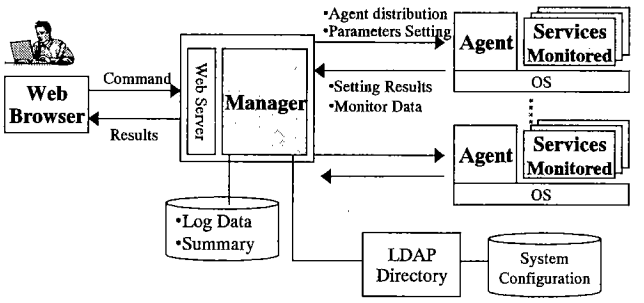


Fig.8. Outline of Components' Service Monitoring System

4.3.2 Evaluations

The application of the proposed architecture simplified the service level management of TWX-21. In normal conditions, the architecture was useful to simplify the capacity planning of TWX-21 and reduce the possibilities of service level degradation. When service level degradation should happen, it took, in most cases, less than several minutes to detect the degradation and its causes. If TWX-21 had no applied the proposed architecture, it would have taken from dozens of minutes to several hours to detect the causes.

5. Conclusions

This paper presented new system architectures for realizing managed cyber business platform that promotes global and dynamic inter-enterprise trade and collaboration. The architecture for dynamic inter-enterprise business relationship management and that for service level management from the business viewpoints are newly presented. The proposed system architectures were applied to an electronic business platform services called TWX-21 as the core framework, and proved to be useful.

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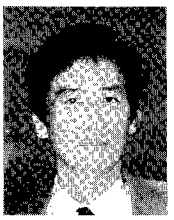

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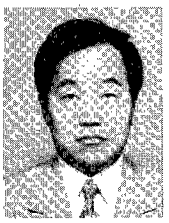

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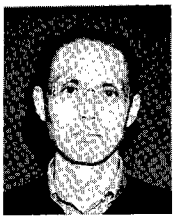

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