Research Journal of Applied Sciences, Engineering and Technology 11(12): 1410-1416, 2015
DOI: 10.19026/rjaset.11.2248
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: July 24, 2015 Accepted: August 20, 2015 Published: December 25, 2015

Research Article

Construction of Cloud Service Platform for Chemical Production and Management

Quan Xiao and Shenghua Xu
School of Information Technology, Jiangxi University of Finance and Economics, Nanchang, Jiangxi, 330032, China

Abstract: Currently, chemical production companies are facing problems of mass data and high cost in the process of informatization for Chemical Production and Management (CPM). In this study, we introduce cloud computing technology to investigate the construction of cloud service platform for CPM and build a architecture model for the platform, which includes physical resource layer, service construct layer, service provider layer and user layer. We describe the key techniques for the development of the platform and explain the operational process through an application instance.

Keywords: Chemical production and management, cloud computing, cloud service platform, SOA

INTRODUCTION

With the rapid development of science and technology and increasingly fierce international competition in these years, for traditional chemical production companies, how to effectively improve production and change the CPM mode from previous high energy consumption and low additional value are important issues to be faced now. Through informatization, chemical companies are able to acquire newest R and D information of chemical production techniques conveniently. Thus, they can timely determine the development direction and increase the CPM efficiency (Kiselyova *et al*., 2010). Meanwhile, by means of information management methods, strategic decision-maker of chemical companies can acquire all aspects of information in CPM on different levels and granularities. The real and time-sensitive information lays an objective foundation for the scientific decision-making and it has been a hot trend for CPM to implement overall informatization management with the aid of IT (Jiang and Wang, 2010).

As the deeper integration of IT into chemical production process, the CPM data become volume even hyper-volume (Xu, 2012). In this context, the management and application requirements of chemical data cannot be satisfied in traditional centralized or local mode (Cala *et al*., 2013). Meanwhile, many chemical companies especially small and medium-sized companies are facing the problems of capital shortage in IT investment. They are expecting a low input and high return IT architecture to serve as CPM system in the process of informatization. However, if each chemical company sets up the IT infrastructure and installs the CPM system individually, the cost would be hard to afford (Martens *et al*., 2012).

Cloud computing is a popular IT service mode in these years and has been propelled by many famous global IT companies such as Amazon, Microsoft, Google, IBM. The service mode of cloud computing can solve the problems of mass data and information island for CPM (Kunio, 2010). The integration of cloud computing and CPM system makes it possible for chemical companies to acquire better IT service under the limited investment. The distributed and layered solution of cloud computing is able to satisfy the requirements of chemical company for CPM and can effectively reduce the cost and business complexity (Boss *et al*., 2007). The problem to be solved for chemical cloud computing in the next step is how to integrate various CPM businesses together into a uniform platform via cloud computing technology (Wan *et al*., 2012).

In this study, we combine cloud computing technology and CPM system to investigate the construction of CPM service platform based on cloud computer theory and methodology. We expect our work can provide chemical companies with better IT service and lower investment in their informatization process. It is expected on one hand to improve the application effectiveness of existed CPM systems and on the other hand, to save capital for chemical companies and promote their production and management capabilities on the whole.

LITERATURE REVIEW

Cloud computing: Cloud computing technology is evolved from grid computing and it is a fusion of grid

Corresponding Author: Quan Xiao, School of Information Technology, Jiangxi University of Finance and Economics, Nanchang, Jiangxi, 330032, China

computing and virtualization technology (Foster *et al*., 2008). Consequently, cloud computing can implement the gridding distributed computing by integrating various computing resources into a resource pool, meanwhile, it can realize virtual server and virtual storage via virtualization technology. Cloud computing is a new kind of computing mode based on Internet, where a mass of computers and servers connecting together, forming the "cloud". People can connect their PC with the cloud to carry out computing tasks, as the way we utilize resources such as water, electricity and gas.

There are some representative characteristics of cloud computing (Stieninger and Nedbal, 2014):

Large-scale: The establishing of powerful calculating and storing capability needs a huge resource pool, which is consist of vast computers and servers. There are over hundreds of thousands even millions servers in the clouds of Google, Amazon and Microsoft. Private clouds of some companies reach thousands of servers.

Virtualization: The servers, computers, storage and communication devices in traditional mode are virtualized as a basic resource pool in cloud computing mode, where users can acquire resources as needed. The applications created in the virtual resource pool by different users are independent, so they needn't care the physical servers where the applications are running.

Safe and reliable: The data stored in could are maintained by professional cloud service providers and the multi-copy techniques can effectively reduce the risks of data damaged by malfunction and virus invasion. The reliability of cloud computing is ensured by the techniques of fault tolerant and cluster nodes interconvertible. There is a high availability of data and applications stored in the cloud.

Flexible: In cloud computing mode, it is easy for users to visit services as cloud storage and cloud applications. It is unnecessary to install different software for different devices, just a browser and device connecting to Internet. Users can flexibly choose from various applications and services provided by cloud as demand and the scale of computing resources can be extended or reduced dynamically as needed.

Cost saving: In traditional informatization mode, massive funds and time would be invested to build the information systems. In addition, the cost of system management and extension grows rapidly with the growth of data. By the centralized management mode of cloud computing, companies can build an available cloud with hundreds of dollars in several days. Cloud computing can not only save money, but also can free the IT team of the company and acquire more professional technical service.

As defined by NIST (National Institute of Standards and Technology), the application mode of cloud computing include IaaS, PaaS and SaaS (Mell and Grance, 2009).

IaaS (Infrastructure as a Service): IaaS means the hardware resources and computing resources are provided as infrastructures. In IaaS mode, users don't need to purchase physical hardware, but to rent virtual IT resources from cloud service provider to satisfy their application demands. IaaS have some similar aspects as the previous virtual host service. Users can utilize cloud infrastructures without affording the cost of hardware.

PaaS (Platform as a Service): PaaS means that cloud service provider provides users with an integrated platform, where applications can be designed, developed, tested and deployed. In PaaS mode, a suite of SDKs and Web Service resources is available for developers to invoke to build enterprise IT systems.

SaaS (Software as a Service): SaaS means users don't need to install software in their own computers, but to get services from cloud service provider via SLA protocol, which is a new form of acquiring software services. The essence of SaaS is to provide computing capability that satisfies customer's software demands.

Service Oriented Architecture (SOA): As previously mentioned, cloud computing can provide a universal platform for chemical companies to integrate and adjust various business processes quickly and flexibly. Cloud computing can provide complete integration services from infrastructure to platform then to software, but the precondition for integration to play an efficient role is that the company own a favorable service oriented IT architecture.

According to the characteristic of CPM, the cloud computing platform should be designed with SOA. CPM is core competency in chemical company, which is almost associated with all other businesses. CPM has relatively high requirements for the collaboration between business segments, so the architecture of cloud should integrate all business processes. For the businesses that are similar and high related, the platform should realize the reusing of business services, while for those businesses that have great differences, the platform should provide flexible service configurations. SOA can satisfy the dynamic demands of CPM (Badidi and Esmahi, 2011).

SOA is a component model which can associate different function modules and process units in applications by interface between services. In SOA, business logics can be converted to correlative services or repeatable tasks accessible by network. The definition of interface in SOA is neutral and SOA is independent to hardware platform, operator system and programming language, which is a good base architecture for CPM cloud.

The roles in SOA include: service user, service provider and service registration center. Service user may be an application or a service, which queries services from registration center according to requirements and executes service functions in accordance with the contract of interface. Service provider is a network-addressable entity that receives and performs requests from users. It releases services and interface contracts to service registration center to facilitate service users discovering and using them. Service registration center is a supporter of service discovery, which contains a storage base of available services and allows service users to search provided interfaces.

ARCHITECTURE MODEL OF CPM CLOUD SERVICE PLATFORM

On the basis of CPM business requirements and related research achievements, we design the architecture of CPM cloud shown as Fig. 1.

Physical resource layer: This layer contains various physical software and hardware resources of computing, storage, network, software and capability. Through virtualization and servitization, all hardware, network, storage devices, operation systems, databases and applications from IaaS layer to SaaS layer are abstracted as service resources. The originally complicated resources are unified as one kind of resource, therefore the objects to be integrated are simplified and the complexity of service combination is reduced. We define resources in physical resource layer as:

Definition.1: Resource ron physical resource layer is represented as a quintuple (r_{id}, $r_{provider}$, $r_{location}$, $rcall$, $rattribute$), where rid is identifier of r, $r_{provider}$ is provider of r, $r_{location}$ is the location of r, r_{call} is the calling mode of r, $r_{attribute}$ is the attribute description of r. Set R = domain(r) is called resource domain, which is consist of resource r of the same kind. The set constitutes of different resource domain is called resource space, noting $\gamma_{\mathrm{r}} = \{\mathrm{R}_1, R_2, \ldots, R_n\}$.

Service construction layer: On this layer, the original service resources with fine granularity in physical resource layer are encapsulated into logic services with coarse granularity, then they are deployed on appropriate nodes in cloud to create service index. Service construction layer has the capability of self-supervisory, self-recovery and self-deployment and can supply service provide layer with efficient reusable service resources. Service construction layer can be defined as:

Definition.2: Service s is a six-tuple (s_{id}, $s_{provider}$, $s_{location}$, s_{call}, $s_{attribute}$, f), whrer s_{id} is identifier of s, $s_{provider}$ is the provider of s, $s_{location}$ is the location

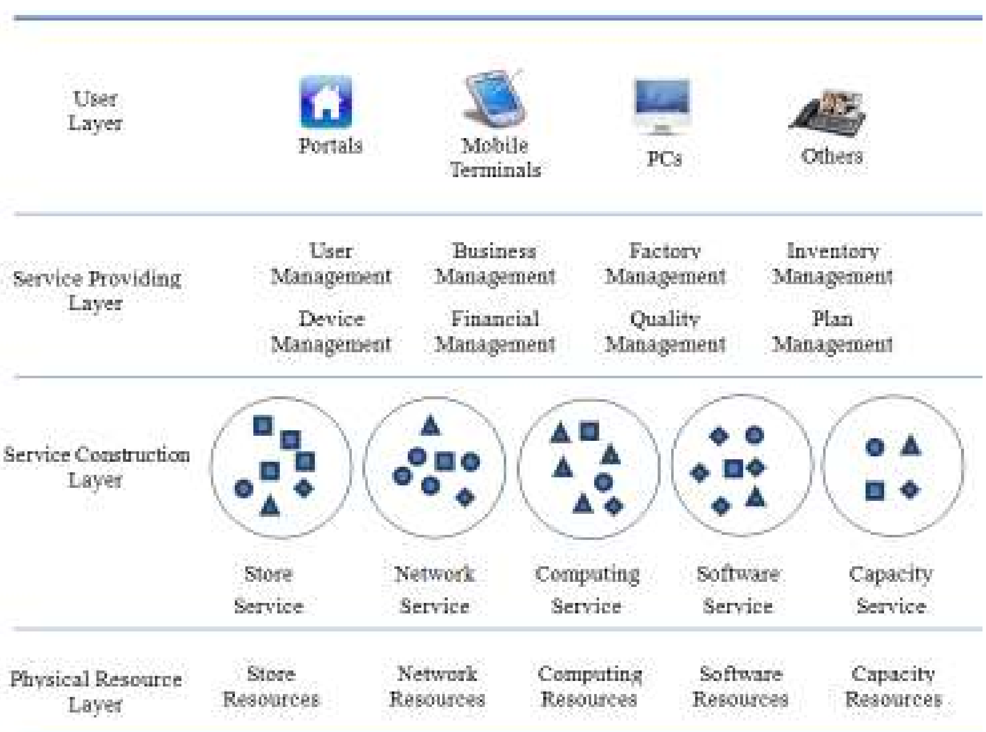

Fig. 1: Architecture of CPM cloud

of s, s_{call} is the calling mode of s, $s_{attribute}$ is the attribute description of s, $f: s \rightarrow r$ is a map from resource to service. Service space $\gamma_s = \{S_1, S_2, \ldots, S_n\}$ is consist of service domain $S = domain(s)$ encapsulated from different resource domains.

After the physical resources encapsulated to resource services, the schedule of physical resources is changed to the discovery, selecting and invoking of resource services.

Service providing layer: In terms of the service combination strategy of SOA, the autonomous, platform independent, loosely coupled and reusable services are utilized to build evolvable distributed applications rapidly with low cost on service providing layer, in order to flexibly coping with the frequent changes of CPM businesses. Service providing layer can provide CPM oriented services such as management of operation, inventory, device, finance management, quality, plan, user, workshop, etc. and implement the unified schedule of required services by users or applications. Service providing layer is defined as:

Definition 3: Service providing is an ordered couple $SP = (SR, S)$, where SR is service requirement domain, S is service domain. Service providing is a process of searching all result set $s_{set} = \{s_1, s_2, \cdots, s_n\}$ from service domain S that satisfy the conditions in service requirement domain SR. The goal of service providing layer is to search result set s_{set} that satisfies SR, then to select and order the results in s_{set} through service optimizing strategy.

User layer: This layer provides kinds of required supporting services by CPM cloud services and interfaces for visiting each layer. It accepts users' requests and returns the processing results of requests, implementing the interactions between users and service platform. User is defined as:

Definition 4: User is represented as a six-tuple $u = \{u_{id}, u_{attribute}, r_{provide}, sr_{set}, u_{type}, u_r\}$, where u_{id} is identifier of user u, $u_{attribute}$ is attribute description of u, $R_{provide}$ represents resource set provided by u, $r_{request}$ is resource set requested by u, sr_{set} is service requirement set of u, u_{type} is type of u(service provider or service consumer), u_r is rating of u.

KEY TECHNOLOGIES FOR PLATFORM IMPLEMENTS

Dynamic allocation of resources: On the basis of the operation law of information system and the ever-expanding trait of business system, we adopt two different running modes in CPM cloud service platform according to load of virtual machine to dynamically allocate resources and ensure availability.

Extension mode: Extension mode can be divided into two modes of configuration extension and quantity extension.

Configuration extension mode: Under this mode, the virtual server is allocated with a default configuration $conf_0 = \{n_0, f_0, m_0, d_0\}$, where n_0, f_0, m_0, d_0 represent number of CPU kernels, CPU frequency, memory capacity and disk size respectively. We set a configuration extension strategy $CES = \{ces_0, ces_1, \cdots, ces_n\}$, where $ces_i = \{cond_i, conf_i\}$ means that when configuration extension condition $cond_i$ is satisfied, the configuration will be extended to $conf_i$. The extension here is generalized, which includes reduction. For example, if the CPU occupancy rate of a virtual server exceeds 60% for more than 3 min because of a service r_k being visited by many users, then the custom workflow will trigger configuration extension condition $cond_k$ automatically and promote the configuration of virtual server to $conf_k$ to satisfy the overload visiting demand.

Quantity extension: We utilize Microsoft NLB technique to build cluster $C = \{server_1, server_2, \cdots, server_m\}$ composed of m virtual servers and set up quantity extension strategy set $QES = \{qes_0, qes_1, \cdots, qes_n\}$, where $qes_i = \{cond_i, n_i\}$, i.e., when the quantity extension condition $cond_i$ is satisfied, the number of running virtual server will be extended to n_i. This mode is able to increase virtual machine dynamically thus support mass flow systems.

Drift mode: In CPM cloud service platform, we provide drift technique between virtual and physical servers. Generally, a virtual server will have ceiling configuration $conf_{\max} = \{n_{\max}, f_{\max}, m_{\max}, d_{\max}$, when the configuration requirement $conf_{\text{req}} = \{n_{\text{req}}, f_{\text{req}}, m_{\text{req}}, d_{\text{req}}\}$ of a computing task meets the logical condition of "$n_{\text{req}} > n_{\max} || f_{\text{req}} > f_{\max} || m_{\text{req}} > m_{\max} || d_{\text{req}} > d_{\max}$", the maximum performance of the virtual server may not satisfy the rapid expansion of applications. Base on resource control and management software AIM, applications running on virtual servers can be drifted to physical servers with more powerful computing capability.

Drift mode is able to implement planned transfer from virtual machines to physical machines when application load exceeds the maximum capacity of virtual servers.

Safety and reliability techniques: With regard to safety of the platform, the virtualization technology can lower the cost of safety system to some extent, but it may bring risks of network security, components security and the mutual attack on account of incomplete isolation. Consequently, we adopt multi-plane optimizing isolation technique to design three planes of management, business and storage, in which management plane consists of business management sub-plane and IT management sub-plane. Virtual or physical firewalls are set up for each plane respectively. According to business and information confidential level, several security groups are divided. Hosts in one group can visit each other, while hosts in different groups can visit referring firewall strategy and hosts in insecurity groups cannot visit other hosts, thus security of the platform is ensured.

For the reliability issue, the cloud platform employs cluster technique and high-speed communication network to form a computing cluster, where the running resources can drift between computers, transfer and extend real-timely, in which way the high reliability, expandability and disaster resistance are guaranteed. High performance server greatly improves the RAS characteristic of CPM cloud and the downtime is shorten to the extreme. Via the NLB technique in cluster, more than one server can provide services simultaneously to support high concurrent visits, thus ensure the high reliability further more.

QoS Management: In CPM cloud service platform, we measure and evaluate the capability of resource services to satisfy users' demands by QoS management. In the strategy of service optimized selecting, QoS management can provide references for users and systems to select best resource services. Different kinds of resource services have different QoS attributes, the CPM cloud service platform can implement dynamic and extensible resource service QoS management architecture by QoS functions of modeling, measuring, information collecting, storing and supervising.

APPLICATION INSTANCE

On the basis of architecture model and key technologies proposed above, we designed a prototype platform for CPM cloud service, as shown in Fig. 2 and 3. The platform can realize gathering and sharing of various resources and provide superior, convenient and efficient services for chemical companies.

The operation process of the system can be described as follows.

Firstly, as service provider, user $u_{provider}$ register the owned resource $r = (r_{id}, r_{provider}, r_{location}, r_{call}, r_{attribute})$ on the physical resource layer, then the service construction layer encapsulate r to service $s = (s_{id}, s_{provider}, s_{location}, s_{call}, s_{attribute}, f)$ by resource pooling technique and deploy to appropriate cloud nodes. Resource service index are created so that

Fig. 2: GUI design of CPM cloud service prototype platform

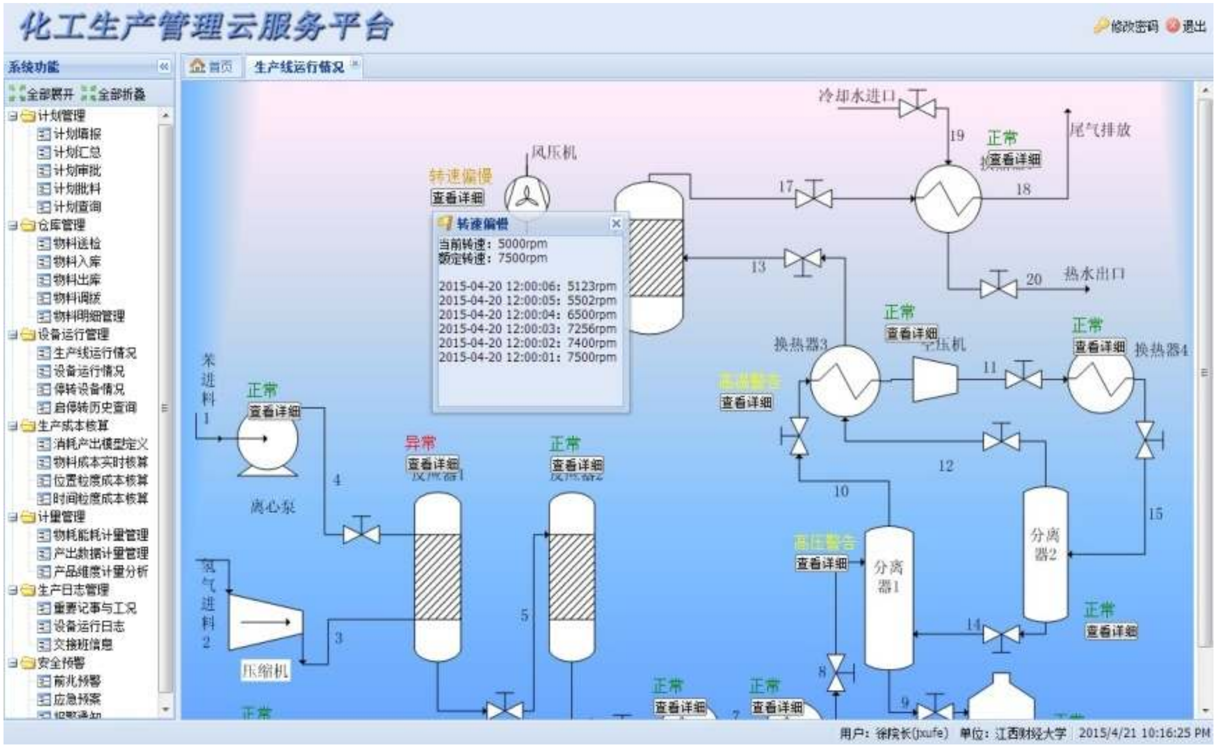

Fig. 3: Production supervision interface

the service providing layer can managing and scheduling services uniformly. After the resources being registered in registration center, the service providing layer will show them in resources list for users to select on the user layer.

On the other hand, as consumer of services, user $u_{request}$ can select services needed on user layer and also can describe service requirement sr_{set} to the platform. The platform accepts sr_{set} and resolves it and then dynamically organize and schedule related resources according to service optimized selecting strategy. The most suitable services are provided to $u_{request}$, or several candidate services $s_{set} = \{s_1, s_2, \cdots, s_n\}$ are provided orderly.

All services are rented by users through the form of virtual machine. The platform can dynamically monitor the running status of virtual machine and extend or drift as needed, to promote the reliability of the system.

CONCLUSION

It is urgently needed for chemical companies especially middle and small-sized to utilize cloud computing technology to promote level of CPM. In this study, we investigate the construction of CPM cloud service platform through cloud computing technology, build architecture model of the platform and analyze the key techniques for platform implement. By techniques of cloud computing and virtualization, it is able to realize centralized management and high extent sharing for computing resources. Chemical companies can effectively balance the relationship of cost, quality and schedule.

The chemical informatization is a long-term issue, we need to further study promoting the capabilities of computing, resource managing, risk resisting and outward serving for cloud service platform. Concretely, the intelligent cloud, service optimized recommending strategy, integration of computing resources and linkage with IoT are topics worth to research in the future.

ACKNOWLEDGMENT

This study has been supported by Science and Technology Project for Jiangxi Province (Grant No. 20133BBE50038) and Research Project for Jiangxi University of Finance and Economics. The author would be like to thank the reviewers for their helpful comments and suggestions for improving the manuscript.

REFERENCES

Badidi, E. and L. Esmahi, 2011. A scalable framework for policy-based QoS management in SOA environments [J]. J. Softw., 6(4): 544-553.

Boss, G., P. Malladi, D, Quan, L. Legregni and H. Hall, 2007. Cloud Computing [R]. IBM White Paper, IBM, New York.

Cala, J., H. Hiden, S. Woodman and P. Watson, 2013. Cloud computing for fast prediction of chemical activity [J]. Future Gener. Comp. Sy., 29(7): 1860-1869.
Foster, I., Y. Zhao, I. Raicu and L. Shiyong, 2008. Cloud computing and grid computing 360-degree compared [C]. Proceeding of the Grid Computing Environments Workshop. Austin, TX, pp: 1-10.
Jiang, L. and J. Wang, 2010. The design and realization of products management information system in aluminum processing enterprises [C]. Proceeding of the International Forum on Information Technology and Applications, pp: 85-87.
Kiselyova, N., V. Dudarev and V. Zemskov, 2010. Computer information resources of inorganic chemistry and materials science [J]. Russ. Chem. Rev., 79(2): 145-166.
Kunio, T., 2010. NEC cloud computing system. NEC Tech. J., 5(2): 5-10.
Martens, B., M. Walterbusch and F. Teuteberg, 2012. Costing of cloud computing services: A total cost of ownership approach [C]. Proceeding of the Hawaii International Conference on System Sciences, pp: 1563-1572.
Mell, P. and T. Grance, 2009. Perspectives on cloud computing and standards. Technical Report, National Institute of Standards and Technology (NIST), Information Technology Laboratory.
Stieninger, M. and D. Nedbal, 2014. Characteristics of cloud computing in the business context: Asystematic literature review [J]. Global J. Flexible Syst. Manage., 15(1): 59-68.
Wan, F., N. Luo, R. Qi, Z. Ye, W. Du *et al*., 2012. Technologies for the construction of cloud computing platform of virtual plant in chemical processes [J]. Comput. Appl. Chem., 29(9): 1075-1078.
Xu, X., 2012. From cloud computing to cloud manufacturing [J]. Robot. Cim-Int. Manuf., 28: 75-86.