Research on CBB Mechanism Construction of Technical Service Organization

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Abstract. In the process of knowledge productization, the demand for modularized design of comprehensive knowledge service solutions is increasingly urgent in technical service institutions. Establish CBB definition, classification and hierarchical design for products, services and solutions. Put forward the design concept of "equal responsibility and right", inspire the enthusiasm for the commercialization of scientific and research findings, form a return and a virtuous circle. Clarify the construction path, design a sharing platform, realize the module sharing and reuse of products and projects, improve efficiency, reduce costs and reduce risks.

Keywords: Knowledge services · Modularization · CBB

1 Introduction

With the rising demand for technical services in the whole life cycle of complex products, the rapid technological innovation and the development of the industrial chain, it is no longer possible for technical service institutions to rely on a single professional technical service. The long-term coexistence of products, services and solutions will become a typical service form—that is, comprehensive knowledge service solutions. Among them, products generally refer to commodity-off-the-shelf sold by the piece and with after-sales maintenance service in a narrow sense; services generally refer to timing, metering and pricing services, such as testing, consulting services, and training; solutions generally refer to technical services customized for specific products, specific fields or specific problems [1]. The knowledge service solution has the characteristics of comprehensiveness, totality and integration. Two urgent needs for the research results of technical service institutions should be satisfied: first, the components or modules that make up the knowledge service solution have the characteristics of high reuse and low coupling, which means that the achievements accumulated by the enterprise can be standardized, modularized and shared; second, the achievement modules can exist for a long time in a tradable mechanism, forming stable support and output for knowledge service solutions, and forming benefits feedback and a virtuous circle for scientific research project achievements. Therefore, the modularization design of technical service products has been paid more and more attention by institutions at home and abroad.

Companies with software and hardware as the main product form gradually establish an efficient R&D system based on integrated product development in order to achieve

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large-scale development [2]. They have built a product platform and select shared modules that support different types of products in the platform [3, 4]. Intel Corporation, the world's largest CPU manufacturer, promotes the construction of common foundation, aiming to unify the specifications of laptop accessories [5]. By building a shared information platform, the 16th Research Institute of the 9th Academy of China Aerospace Science and Technology Corporation (CASC) has preliminarily realized the coordinated transformation of IT-based scientific research and production models [6]. The 38th Research Institute of China Electronics Technology Group Corporation has realized the reuse of knowledge in design and development through the management of common basic modules [7]. Southwest China Research Institute of Electronic Equipment has used the concept of shared module management to carry out the PCB parallel design based on Cadence [8]. The No. 289 Factory of the Ninth Academy of Aerospace Science and Technology Group has promoted the research and development of general software modules through the development of software modular construction, which have been applied in many models [9]. Under the background of military-civilian integration, AVIC Qing'an Group has carried out a new model of research and development of aviation electromechanical products, and proposed the idea of modularized research and development of CBB for general-purpose military and civilian products [10].

Most of these management mechanisms are aimed at the design, development and production of software or hardware products with physical properties. From the perspective of physical modularization, through the analysis and decomposition of products, the service or solution products such as test, detection, analysis, consultation and training are rarely involved in each stage [11]. In view of the modularization requirements of comprehensive technical service solutions, this paper proposes the modularization and classification of project knowledge, the establishment of sharable technologies, services, and product shelves, to realize the reuse of design and development knowledge, reduce costs and improve efficiency; the equal design of "responsibilities and rights" promotes the transformation of achievements and benefits feedback, forming a virtuous circle.

2 Knowledge Modularization Connotation

2.1 Definition of Knowledge Modularization

Knowledge modules are common building blocks (CBB), supporting products, services and solutions, software, hardware, data, tools, forms and other finished products or finished components that can be reused, reduced costs or improved efficiency.

It includes the following four aspects:

(1) Product attributes. It is clear that CBB is an integral part of the product in the internal research and development process, and can also be a product with independent sales or use characteristics.
(2) Reusability. CBB is a physical module, knowledge module or technical module that can be reused in multiple products, services and solutions.
(3) Use effect. It can clearly achieve the ultimate goal of improving efficiency and reducing cost.

(4) Expression form. According to the product characteristics of technical service institutions, the expression form of CBB include software and hardware products, various data, forms and practical tools.

2.2 CBB Reuse Rate in Products

Comprehensive knowledge service products can be divided into three types: software and hardware products in a narrow sense, technical services, and single solutions. These three types of products are different in the form of existence, composition, service, etc. The specific classification characteristics are shown in Fig. 1.

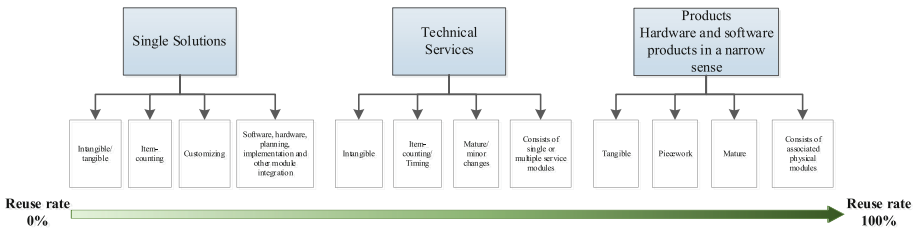

Fig. 1. Classification characteristics of comprehensive knowledge service products

In the narrow sense, software and hardware products are generally tangible value outputs, which are composed of mature modules through physical or logical connection to form a complete whole. They are produced in batch and serve users in the form of piecework. The main demand for its knowledge modularization is the physical module. In the narrow sense of software and hardware products, knowledge modules have the highest reuse rate. The modules that make up a mature product are fully mature with no changes to the modules allowed during mass production, so the reuse rate is 100%.

Technical service is a service output based on a product or a certain technology, consisting of relatively mature single or multiple services. It can provide services in batches or partially customized, or in the form of timing or item-counting. The main demand of its knowledge modularization is technical modularization and substantiality. The technical service relies on a certain technology. The basic service process and procedures remain the same, but certain adjustments will be made according to the differences in the service objects so that the knowledge modules that make up the technical service will be changed accordingly with the decreasing reuse rate.

The focus of the solution is integration, so as to provide integrated value output after integrating multiple products (multiple physical products or multiple technical services) into a whole. Most of them are customized services, providing services to customers in the form of items. The main requirements of its knowledge modularization include physical modules as well as technical modules. The solution focuses more on using existing products or technologies to solve the actual problems of customers, and provides more customized products or services. The proportion of direct use of knowledge modules is not high so that the reuse rate of this way is the lowest.

2.3 Mapping Relationship Between Products and CBB

CBB supports the production of enterprises as a product component, while it supports the production of upstream enterprises as a product in external sales. The specific mapping model is shown in Fig. 2.

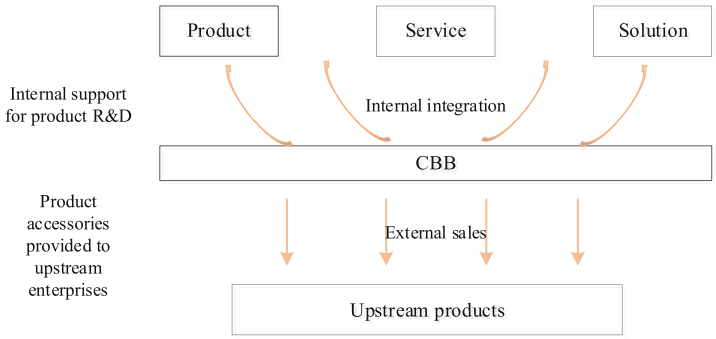

Fig. 2. Classification characteristics of comprehensive knowledge service products

Products, services and solutions are composed of multiple modules. In the research and development of new products, existing modules can be selected as product components. The selected CBB may be a component module of the previous generation product or a component module of other types of products. At this time, CBB is an essential component of a new enterprise product, service or solution, and it is a product component.

In order to maximize the technology and use value, CBB can also be sold as an independent product and used as a supporting component for products produced by other companies. At this time, CBB can be considered as a product of the enterprise.

3 Classification and Hierarchical Design

3.1 Classification of CBB

Considering the comprehensiveness of knowledge service solution products, CBB is divided into five categories: software, hardware, data, tools, and forms.

(1) Software CBB: a software module with independent functions that can be transplanted, updated and used independently, or a software composed of multiple functions that can be packaged and used independently. A Software CBB can be a software product or a module that composes a software product and has independent functions. The most important demand is that it must have source code, independent functions and external interfaces, which can be directly called during the development of other software.

(2) Hardware CBB: Hardware components with independent functions that can be combined, integrated and used, or hardware that can be packaged, used and delivered independently. A Hardware CBB can be a small hardware product, or a module or subsystem that composes a hardware system. The most important feature is the physical property. It can be an integral part of a specific product or a universal tool and accessory used in the test process.
(3) Tool CBB: a method carrier with specific functions, properties and uses. The Tool CBB is an electronic tool, calculation model and other tools that developed to realize a specific work. It can be a calculation tool that embeds cumbersome calculation formulas to simplify a certain work, or it can be a statistical tool to standardize the work process.
(4) Data CBB: a data package with specific purpose, which is not limited by the data carrier, has a certain amount of data, and can be updated, filled and used. The core of the Data CBB is data, so a large amount of data must be equipped and can be updated for a long time.
(5) Form CBB: templates, forms, processes, samples or cases with specific purposes. In addition to the software, hardware, tools, and data that can be made visible, there are a large number of technical methods, test methods, solution cases, work guidelines, work procedures, process plans, test specifications, report templates, checklists, consulting and training courseware, etc. in the research results of technical service institutions, these results are displayed and explained in the form of text, so they are uniformly classified as Form CBB. Form CBB is the main component in the CBB system of technical service institutions.

3.2 Hierarchy of CBB

Given the differentiated and customized design requirements of knowledge service solutions, CBB is divided into four levels: A, B, C, and D according to the use value and use performance of CBB in practical applications.

(1) A-level CBB can be independently packaged and sold. With the highest maturity, it can be sold directly as a finished product and can be used directly without any modification. A-level CBB mainly includes software modules, hardware components and other directly-formed products, and they can be directly called or selected for use among multiple products, such as manufacturing parts or software modules of a manufacturing company.
(2) B-level CBB is difficult to package and sell independently, but can be reused after minor or general modifications. The maturity is high, but it is seldom to sell directly as a finished product.
(3) C-level CBB is difficult to package and sold independently, and can be reused only after major modifications or adjustments. The maturity is not too high, but it has high reusability.
(4) D-level CBB is that which has not reached the A, B, and C maturity levels, but has use value or reference within a certain range. This type of CBB is used in a relatively small range, and needs to be modified during the use process.

4 Construction Path

Enterprises can build CBB through forward-planning and backward-sorting methods. This paper focuses on building CBB with backward-sorting.

The forward-planning method adopts a slim waist type structure. In the product development/project research planning, design, and demonstration stages, the module is divided according to the product planning and structure, and the product function and technology are decomposed according to the core and key technologies determined in the Functional Flow Block Diagram (FFBD). These are to find shared technologies, analyze and form modules with technological leadership and general to similar products/projects. The formation and path of forward-planning CBB are shown in Fig. 3.

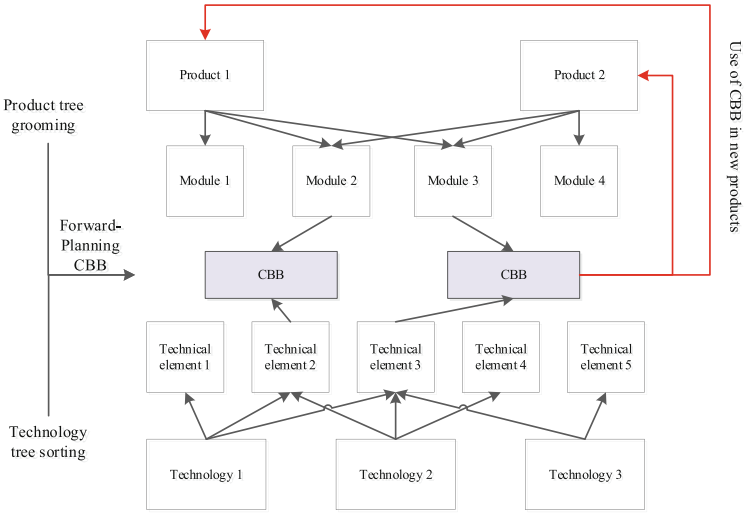

Fig. 3. Forward-planning CBB construction

Forward-planning is the basis for promoting products to continuously occupy the market. However, it is generally difficult to form a CBB based on market demand, product lineage planning, and technical direction planning because it requires companies to have strong market analysis capabilities and a clear product structure. When constructing the CBB mechanism, most enterprises use the backward-sorting method to form the CBB. This paper adopts the backward-sorting method to construct the CBB management mechanism.

The backward-sorting method relies on the research results of previous projects. After the product/project research is completed, the results of multiple products/projects are shared, analyzed and extracted, and the software and hardware modules and technical modules that can be shared and participated are sorted out. Figure 4 shows the formation and use path of CBB in backward-sorting method.

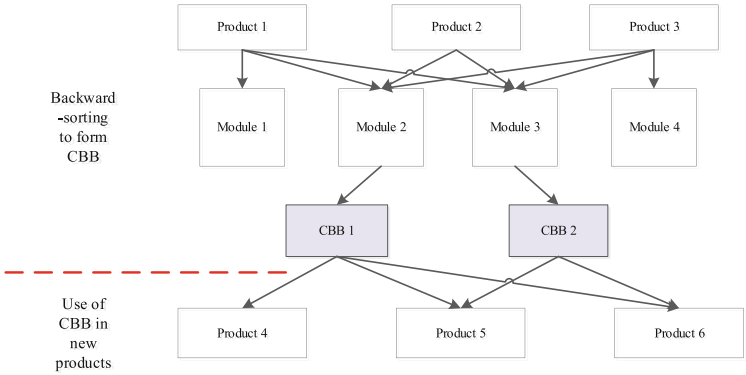

Fig. 4. CBB construction in backward-sorting method

5 Design of "EQUAl Responsibility and Right"

5.1 Stakeholders of CBB

As a management mechanism of an enterprise, CBB involves many stakeholders such as decision-making, management, marketing, design, production, sales, etc. The purposes and demands of each party are quite different. Therefore, how to identify the relevant parties and realize the balance of interests of the parties is the top priority to ensure the effective implementation of the CBB mechanism. The model of each stakeholder is shown in Fig. 5.

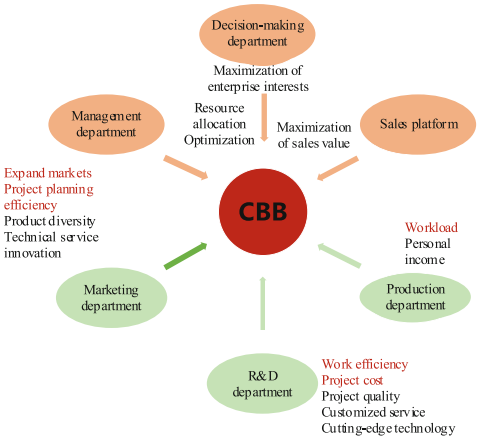

Fig. 5. CBB stakeholder model

The decision-making department, management department and sales department are the supporters of the construction of the CBB mechanism. The marketing department, R&D department and production department have positive and negative perceptions of CBB, which are closely related to their management demands:

(1) The decision-making department is most concerned about maximizing the overall benefits of the enterprise. CBB can achieve efficient reuse of past results, avoid repeated investment, reduce labor costs, and improve production efficiency, which has a significant effect on improving the overall efficiency of the enterprise.
(2) The management department is the executive department of various management mechanisms. The most concern is whether the overall resource allocation of the enterprise is optimal. CBB mechanism can fully revitalize the previous product modules or technical modules to realize the sharing among multiple products, and greatly improve the utilization of resources.
(3) The sales department pursues the maximization of sales output value. The CBB mechanism promotes the upgrading of products to a certain extent, which is more conducive to the realization of output value growth.
(4) The marketing department has the function of developing the business market, and tends to carry out efficient product development, making it the supporter of the CBB mechanism. On the other hand, it has the function of planning and launching new products, which is more inclined to technological innovation and inhibits its use of CBB.
(5) The R&D department tends to use CBB in order to improve R&D efficiency and reduce project costs. But when conducting cutting-edge technology R&D or developing customized solutions, it focuses more on innovation and uniqueness rather than the use of CBB.
(6) When the production department uses the existing CBB, it has the advantages of low cost and high efficiency. Based on the consideration of reducing workload, CBB will be used. However, when product production, technical services or external solutions are provided based on existing basic modules, personal creative work will be reduced with lower income, so CBB will not be used all the time.

Based on the analysis of the CBB stakeholder model, the main stakeholders are identified as decision-making and management, planning and implementation, and CBB holders. The specific responsibilities and rights of each stakeholder are shown in Table 1.

5.2 Ownership and Protection of Intellectual Property Rights

Considering that CBB consists of condensed and shared modules of multiple products, it is generally formed by the joint design and development of multiple persons. In order to avoid intellectual property disputes and benefits feedback disputes, CBB application adopts the method of joint declaration of applicants, who need to negotiate the contribution ratio of CBB and sign to confirm, as the basis for determining the CBB holders and holding ratio.

After accepting the CBB declaration, a certain range of announcements will be made. The main function is to avoid any disagreement among employees on the value, composition and contribution ratio of the CBB during the application process. This can prevent unfair competition and avoid intellectual property risks. When there is an objection, the employee can file an appeal and submit supporting materials. At the same time, it is necessary to review the confidentiality and loss of state-owned assets through technical organizations to ensure legality.

Table 1. Responsibilities and rights of stakeholders

	Responsibility	Right
Decision making and management	Policy guidance and resource guarantee Improve the CBB mechanism, eliminate policy barriers, and strictly control management links Promote the generation and use of CBB	Maximize the benefits of the organization Organizational resource optimization
Planning and implementation	Analyze, select and accurately use CBB Propose CBB requirements and carry out CBB planning CBB use value or effect analysis and evaluation	Use project funds independently Benefits feedback from cost savings
CBB holder	Modify and maintain CBB Promotion of CBB holdings Priority use of CBB held	CBB benefits feedback of use CBB benefits feedback of sale

5.3 CBB Use and Maintenance

In the process of product/project R&D, CBB can be selected at each stage of planning, implementation and delivery according to the development and production requirements. According to CBB's security level, technical value, application scope, etc., it is used in the form of external sales, internal free use, application for paid use, approved use, and restricted use. When loopholes and defects in design, production and use are found during use, CBB holders have the rights and obligations to maintain them. Maintenance should not cause subversive changes to the main functions and performance, but should maintain the common functional interface of CBB as much as possible.

5.4 Benefits Feedback Mechanism

In order to promote the establishment of the CBB mechanism and establish a virtuous cycle of benefits feedback, certain material incentives are given to the teams and individuals that generate CBB to ensure that CBB can be continuously generated. According to the level and use form of the CBB, a certain percentage (such as 5–15% of the gross profit from sales) will be commissioned and given out to the CBB holder. In the initial stage of the establishment of CBB mechanism, in order to promote the use and gradually improve the performance and versatility of CBB, it is advisable to appropriately reward teams that actively use CBB.

6 Shared and Participating Platform Design

In order to promote the operation of the CBB mechanism, realize the explicitness of the CBB shelf, and facilitate CBB sharing and participating, it is necessary to build a sharing and participating CBB platform. The platform includes basic information, functional performance introduction, statistical analysis and other information by access of browsing or downloading.

(1) CBB basic information. In order to ensure the CBBs to be unique and identifiable, the platform includes basic information such as the number, name, type, maturity level, security level, holder and other basic information of each CBB. The sharing and participating platform structure is shown in Fig. 6.
(2) Function and performance introduction. In order to fully demonstrate the characteristics of CBB and facilitate its selection and use, the platform includes a brief introduction of CBB, description of main functions and performance, possible application fields and usage methods.
(3) Browse and download. In order to promote the wide access of CBB, the direct download is permitted for some CBBs that do not involve state secrets, trade secrets, and core competitive technologies.

Numbering	Name	Type	Classified	Maturity	Holder	Main Function Introduction	Listing Status	Browsing/Downloading Person	Browsing/Downloading Time	Download Filename
CBB unique number	CBB Chinese name	Software/Hardware/Data/Tools/Forms	Fill in based on whether it involves state secrets or commercial secrets	Class A/Class B/Class C/Class D	All holders (including the contribution ratio of holders)	The technology that CBB relies on, the functions it realizes, the products it can support, etc.	Officially put on the shelf/stay on the shelf/off the shelf	The browsing/downloading usage of each CBB recorded in the information system.		

Fig. 6. Sharing and participating CBB platform data structure

7 Typical Applications

7.1 The Predicament of Technical Service Institutions in the Military Industry

The demand for modularization of technical service products in military research institutes is becoming more and more prominent. Military industrial research institutes are mainly responsible for technical research work such as national defense, basic scientific research projects of military industry, key technology research, and equipment pre-research. They take the completion of the research and production of weapons and equipment as the core, and focus on technical research, technical services in specific fields and small batch production.

In recent years, with the increase in model development tasks, the amount and complexity of projects undertaken by military research institutes continues to grow, and at the same time, the design and development cycle is shortened but the engineering quality requirements are gradually improved. In order to improve R&D efficiency, reduce

R&D costs, and relatively adapt to the diverse development needs of equipment, military research institutes are gradually exploring the CBB management mechanism during the R&D process of their projects.

7.2 Exploration of an Aviation Research Institute

The CBB mechanism was established and operated in an aviation research institute, the standard of General Requirements for CBB Management was issued, and all staff were trained for publicity and implementation, and a CBB management system was built to form a CBB shelf. Since the CBB mechanism has been in operation for one year, nearly 50% of the CBB in the institute have been submitted by the researchers, and a total of 254 items have been approved and put on the shelves. The CBB on the shelf is used in the browsing/downloading, application in projects, and online sales, and so on.

With the continuous advancement of the CBB mechanism and the increasing number of CBBs on the shelves, the number of browsing/downloading, as a primary form of use, continues to grow steadily, which reflects the use value of CBB to a certain extent. Taking the browsing/downloading situation from August 2019 to December 2021 as an example, the CBB on the shelf has a total of 12,473 browsing/downloading times, of which 5669 are downloaded. The distribution trend of CBB shelf browsing/downloading is shown in Fig. 7.

The number of CBB browsing and downloading are growing at an average rate of nearly 7% per month, with 7.8 browsing/downloading per capita across the institute. During the product/project planning stage from March to June 2020, the number of CBB browsing increased significantly.

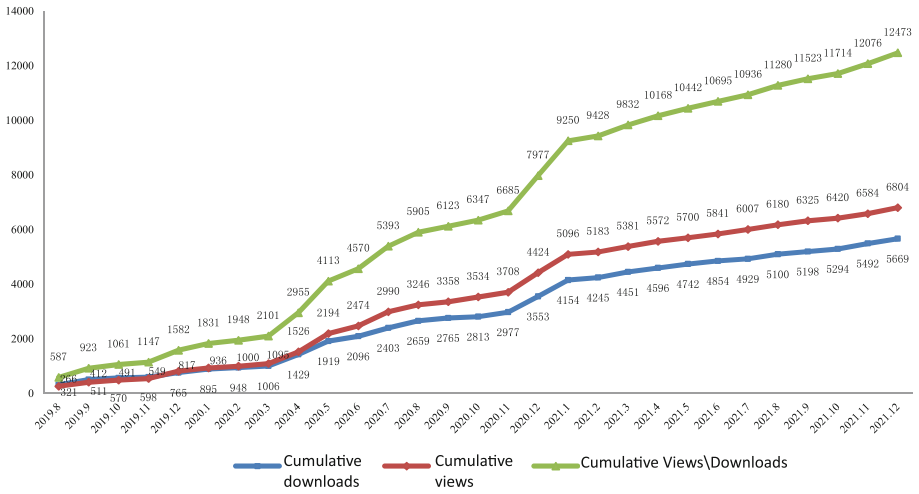

Fig. 7. CBB shelf browsing/downloading trend graph

7.3 Initial Results

In view of the strong relationship between the generation and use of CBB and the project/product R& D process, CBB generation is a necessary condition for project delivery. A positive cycle is formed, from CBB generated by the project to CBB used by the project. At the same time, the generation and use of CBB can be included in the relevant requirements of employee assessment and evaluation, which plays a role of policy-promotion in the early stage of the establishment of CBB mechanism.

CBB has been applied in hundreds of projects/products planning and implementation, and the project R&D utilization rate of CBB on the shelf is nearly 60%. Some projects have reduced the field service time by nearly 30%, some project costs have been reduced by more than 20%, some projects have realized the replacement of senior employees by new recruits, and some projects have realized multi-functional composite development.

Some CBBs have achieved Internet sales revenue, and some templates, workflows, cases have achieved hundreds of repeated sales, exploring a new growth pole for online sales of knowledge service solutions. A virtuous circle has been initially realized, that is the research results continued to generate benefits with just one-time investment in research projects.

7.4 Benefits Feedback

Internet sales of CBB have been fed back to dozens of CBB holders according to the specified proportions based on the online sales profits; CBB used in the project has been fed back according to the specified proportions of project cost saving contribution.

8 Conclusion

The construction of the CBB mechanism is a useful exploration of the management transformation of technical service institutions, a beneficial discovery of the redistribution of project results for knowledge service solutions, and a practice under the principle of ownership by enterprises, income-right enterprises and individuals sharing. It contributes to realize the modularization of products, knowledge and technology and the sharing and participating of research results. It will significantly improve the efficiency of scientific research and production, reduce costs, and shorten the research and development cycle, and realize one-time R&D investment of products/projects, reuse of products and modules, and multiple outputs.

An aviation research institute has proved through practice that the CBB management mechanism can maximize the reuse of knowledge, technology, and product modules, improve work efficiency, reduce R&D costs, and achieve “once input, multiple outputs”.

The research direction and focus of the future CBB management mechanism will focus on: (1) CBB technical value assessment, including CBB pricing, use value evaluation and so on; (2) Exploration of the reform of disposal rights, including CBB holder conversion, CBB inter-enterprise transactions, and price-based shareholding 3) Embedded application of knowledge-based CBB in projects/products, including software-based knowledge-based CBB, interface standardization of knowledge-based CBB, and intelligent notification and invocation of knowledge-based CBB.

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