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Peter Fettke

*Johannes Gutenberg-University Mainz*

Peter Loos

*Johannes Gutenberg-University Mainz*

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# SPECIFYING BUSINESS COMPONENTS IN VIRTUAL ENGINEERING COMMUNITIES

**Peter Fettke**

Lehrstuhl für Wirtschaftsinformatik und BWL  
Johannes Gutenberg-University Mainz  
[fettke@isym.bwl.uni-mainz.de](mailto:fettke@isym.bwl.uni-mainz.de)

**Peter Loos**

Lehrstuhl für Wirtschaftsinformatik und BWL  
Johannes Gutenberg-University Mainz  
[loos@isym.bwl.uni-mainz.de](mailto:loos@isym.bwl.uni-mainz.de)

## Abstract

*Component-based software development is a potential reuse paradigm for the future. In this paper, we elaborate the idea of developing business components in virtual engineering communities (component community). A component community is an inter-organizational form for developing business components. The actors of a component community, e. g. business analyst, component developer, component vendor, reuse manager, work collaboratively in development projects. We postulate that in a component community it is necessary to describe business components in a standardized way. Such a description has to address several aspects: What services are offered and requested by a business component? How can these services be used? Are there any interdependencies between the services of a set of business components? What quality characteristics do the offered services fulfill? What are the meanings of used concepts? And so on. In this paper, we present a holistic approach to specify a business component. This approach consists of seven specification levels addressing both technical and business aspects. Furthermore, we show the application of this method by specifying a simple business component that deals with German bank codes.*

**Keywords:** Specification, collaborative engineering, electronic markets, IS development

## Introduction

Enterprise systems are either large standardized off-the-shelf applications like SAP R/3, Oracle Applications, or BAAN IV, or consist of individual software developments. In contrast, the idea of component-based development (CBD) is to assemble an individual enterprise system from a set of components which are traded on software markets (Sametinger 1997; Szyperki 2002). This approach promises to combine the advantages of standardized off-the-shelf applications and proprietary developments.

CBD can be characterized as a mixture of buying standardized software applications and developing individual software. In a CBD scenario, an enterprise that needs a specific business functionality, e. g. an inventory system, can buy required components from different component vendors and integrate them with little effort. The CBD offers an opportunity for small and medium sized enterprises (SME) which normally cannot afford to purchase and maintain large packaged application systems (Turowski 2000, p. 131).

According to (Fellner and Turowski 2000, p. 3), the terms component and business components can be defined as follows: A component is made up of several (software) artifacts. It is reusable, self-contained, marketable, provides services through a well-defined interface, hides its implementation, and can be deployed in configurations with other components that are unknown at development time. A business component is a component that provides a certain set of services from a business application domain. Typical business application domains are banking, insurance, retail or manufacturing industry. The term '(software) artifacts' embraces executable code and its documentation (e. g. comments, diagrams, etc.), an initial description of the component's state (e. g. parameters, initial database setup), specification documents, user documents and test cases. A component is 'reusable' if it can be integrated easily and without modification of its (software) artifacts. A customization of a component that is intended by the developer of the component is not considered as a modification. In other words, the customization of components is consistent with the CBD approach. A component is 'self-contained' if its (software) artifacts belong explicitly to

the component, so that it can be unambiguous differentiated from other components of a software system. This property is a prerequisite for the component's marketability. The characteristic 'marketability' means that components can be traded on component market places.

Today, a market place is either an enterprise-wide component repository or an open market place for software components. In this paper, we introduce the idea of developing business components in a virtual engineering community (component community). A component community is an inter-organizational structure supporting the development of business components throughout their full life-cycle. We argue that the actors in a component community need means to describe business components in a standardized way. Such a description is referred to as a specification. A specification of a business component should be a complete, consistent, and precise description of its outer view. In this paper, we present a method for specifying business components in component communities. The main contribution of the presented approach is to tie together different well-known and preferably standardized specification notations which are needed to specify a business component. So, this work provides means to implement the theory in practice.

There are many approaches to software reuse and software repositories in general (for an overview see (Mili et al. 1998; Mili et al. 2001)). However, we are just aware of three approaches which address the specification of (business) components in particular (Beugnard et al. 1999; Fischer 2000; Han 1999). Compared to these existing approaches, the proposed method is more comprehensive because it comprises both business and technical aspects.

The remainder of the paper proceeds as follows. Section 2 provides a broader discussion of a component community. The proposed specification method is introduced in section 3. Here, an example specification of a business component that deals with German bank codes will be discussed. A bank code is simply a unique identifier, e. g. the string or integer "87070000" is the bank code for "Deutsche Bank Chemnitz, Germany". This component can provide responses to queries such as "To which bank does this bank code correspond?" or "Is a given bank code valid?". Finally, section 4 summarizes the paper and presents directions for further research.

The presented specification method for business components is the result of the work of the research group "Component-based Development of Business Applications". This research group is a subgroup of the "Gesellschaft für Informatik" (German Informatics Society). A comprehensive description of the specification method is given in (Ackermann et al. 2002). Further information about the research group can be found at the web site "www.fachkomponenten.de" ("Fachkomponenten" is the German term for "business components"). In addition to the work of the research group, this paper addresses the specification of business components in virtual engineering communities.

## **Virtual Engineering Communities for Business Component Development**

This section elaborates the idea of developing business components in a virtual engineering community. Such a community can be called component community. A component community can be seen as an electronic marketplace (Malone et al. 1987) where instruments to analyze the supply and demand of business components, to identify and to standardize business components, to discuss the usage of business components etc. are provided. Thus, a component community is a new inter-organizational form for developing component based systems. It is a mixture of an enterprise-wide component repository and an open market place for software components. The development of business component systems using component communities can be seen as a special form of a virtual organization (Wigand et al. 1999). A component community supports the development of business components throughout the full life-cycle of business components. In a component community the actors are not only coordinated by a product specification and a price but also by further information such as business needs, specific components characteristics, development problems etc. The component community offers a collaborative engineering platform.

Such a community includes several functions:

- Virtual project management: A component community offers functionality to initiate a virtual project for a specific application domain.
- Component analysis and identification: It should be possible to make a proposal for a specific component analysis and an exemplified specification. This suggestion can be discussed by the members of the component community.
- Supply and demand of components: Every actor in the community must be able to define his demand and supply for components.

- Invitation of tender: The community offers functions for formulating invitations of tender based on a given component specification.
- Forum functionality: The community offers a platform for problem discussion occurring by component usage.
- Personalization functionality: The user interface of the component community should be very adaptive. Every actor should be able to see in which projects he/she participates, which components he/she has used so far, which components has been updated and so on.

The mentioned functionality gives just a rough overview of the necessary functions of a component community. These requirements need to be more analyzed and elaborated in order to implement a community. However, it makes clear that the actors of a component community need means to describe a business component. Such a description has to address several aspects: Which business tasks of a specific business application domain are supported by a component? What services are offered and requested by a business component? How can these services be used? Are there any interdependencies between the services of a set of business components? What quality characteristics do the offered services fulfill? What are the meanings of used concepts? And so on. To address these questions, we propose a method for specifying business components in the next section. This method can be used to describe business components in component communities.

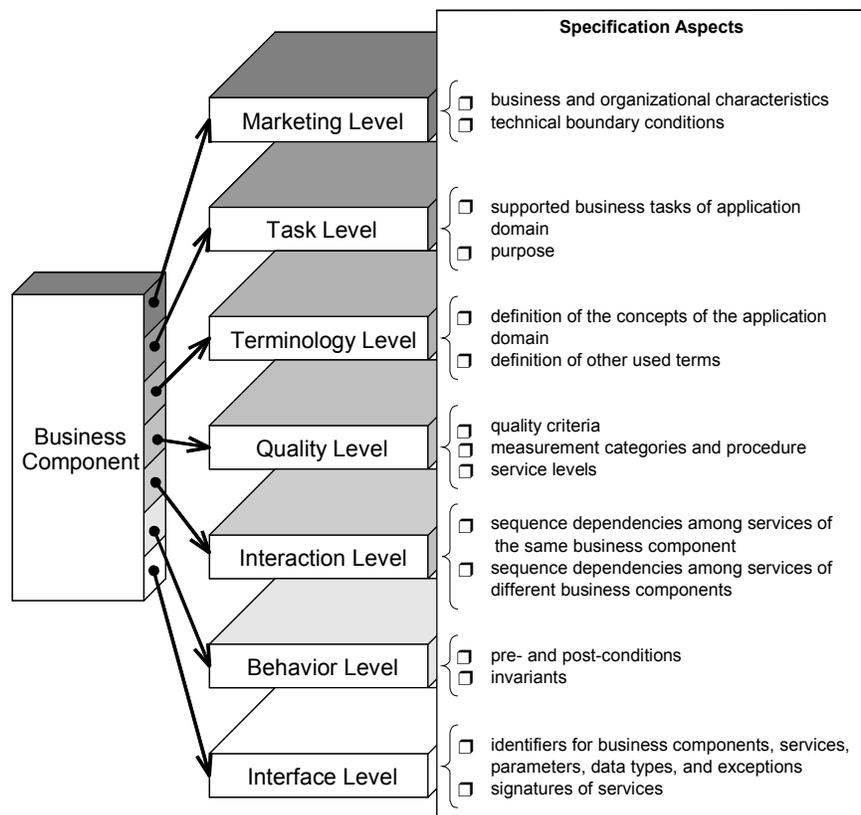


Figure 1. Specification Levels and Specification Aspects (Ackermann et al. 2002, p. 4)

## Specifying Business Components

### Overview

We postulate, that a method for specifying business components is necessary (but not sufficient) to establish a component community. According to (Beugnard et al. 1999), it is useful to specify a business component on different levels. Our approach uses seven specification levels (cf. figure 1). Each level focuses on a specific aspect of a business component specification and addresses different development roles such as reuse librarian, reuse manager, component developer, component vendor etc. (Allen and Frost 1998, pp. 337-340).

Various notations are used on all specification layers. We prefer a formal notation as a primary notation because of its precision and consistency. Furthermore, we also introduce on some specification levels a secondary notation which may be semi-formal or informal. The secondary specification improves the specification comprehensibility and can be considered as a supplementary specification for people not used to formal specifications. The subsequent paragraphs of this sections describes each specification level in more detail.

### Interface Level

The interface level describes the services that are offered by a business component on a technical level. For that purpose the services, public attributes, public variables or constants, and public data types are named, the signature of every service is defined, and possible error states and exceptions are declared. Not only the offered services, but also the services required by the business component to fulfill a smooth operating of the business component are specified. In other words, a business component can be logically considered both as a server that offers services and as a client that requests services.

The OMG Interface Definition Language (IDL) (OMG 2001a) is proposed as a notation for the interface level. This notation is suitable for describing the mentioned specification aspects. Moreover, it is a widely used and well-known notation in industry and research.

```
interface BankCodes
{
    typedef integer BankCode;

    struct Bank
    {
        BankCode bankCode;
        string bankName;
        string city;
    }

    sequence <Bank> ListOfBanks;

    exception UndefinedBank();

    boolean isValidBankCode(in BankCode bankCode);
    boolean isValidBankName(in string bankName);
    boolean isValidBank (in BankCode bankCode,
                        in string bankName);
    string searchBankCode (in string bankName) raises
                        (UndefinedBank);
    string searchBankName (in BankCode bankCode) raises
                        (UndefinedBank);
    ListOfBanks searchBanksWithWildcard(
                        in string bankName);
    ListOfBanks searchBanksWithWildcardAndCityWildcard(
                        in string bankNameWildcard,
                        in string cityWildcard);
};

interface extern
{
};
```

Figure 2. Example Specification of the Interface Level

The interface specification of the business component “BankCodes” is given in figure 2. This business component offers seven services. Furthermore, some public data types (BankCode, Bank, and ListOfBanks), and an exception (UndefinedBank) are declared. This business component does not require services of other business components. Therefore, its extern interface is empty.

The actors of a component community can use this specification level to specify signatures of services which are necessary to implement a virtual project. This specification is precise and addresses only technical aspects. In an early development stage, it may be supposed that the services specified are not assigned to one specific business component.

### ***Behavior Level***

This level describes the behavior of the services which are offered by a business component. This improves the level of confidence of using the business component. Whereas the interface level primarily addresses syntactic issues of using a business component, the behavior level specifies the behavior of services of business components in general and especially in worst case scenarios. For that purpose pre- and post-conditions of using a service and possibly invariants are defined.

The Object Constraint Language (OCL) is proposed as a notation for the behavior level. Formerly, this notation was not part of the Unified Modeling Language (UML), but in the meantime the OMG added the OCL to the UML standard (OMG 2001b). As a secondary notation on the behavior level, each OCL expression may be annotated with comments.

Figure 3 shows the specification of a business component on the behavior level. First, the context of the specification must be defined. The context is declared by an underline. For instance, the context of the first expression is the whole business component “BankCodes”. The second expression refers to the service “searchBankCode” of the business component “BankCodes”.

The first expression specifies that each bank which is managed by the business component must have a bank code greater than zero. Furthermore, the name of each bank must not be empty. The second expression specifies that the service “searchBankCode” may only be called if a bank with the given name exists. Similar expressions may be defined for the other services of the business component.

In a component community, actors are able to define the necessary and desirable behavior of a business component on this specification level. Like the specification on the interface level, the specification on this level is precise and technical oriented. Hence, it is normally used by component developers.

```
(1)
BankCodes
  self.ListOfBanks->forAll(b:Bank | b.bankCode > 0)
  self.ListOfBanks->forAll(b:Bank | b.bankName <> '')

(2)
BankCodes::searchBankCode(name : bankname) : bankCode
  pre : self.ListOfBanks->exists(b:Bank | b.bankName =
                                     bankname)
```

**Figure 3. Example Specification of the Behavior Level**

### ***Interaction Level***

Sometimes it is necessary to define sequences in which services of a business component are allowed to be used. For instance, the service “send reminder of payment” may only be called after the service “charge to the customer’s account”. The interaction level aims to specify these dependencies among the services of business components. A specific dependency can exist among the services which belong to the same business component (intra-component dependency) or between different business components (inter-component dependency).

A temporal logic may be used to express such dependencies. The authors of (Conrad and Turowski 2000) propose an extension of the OCL with temporal operators. This proposal is used as a notation for the interaction level. Because the proposed notation is just an extension of the OCL, its advantage is a smooth integration of the behavior and interaction levels.

The following temporal operators can be used (A, B are Boolean terms):

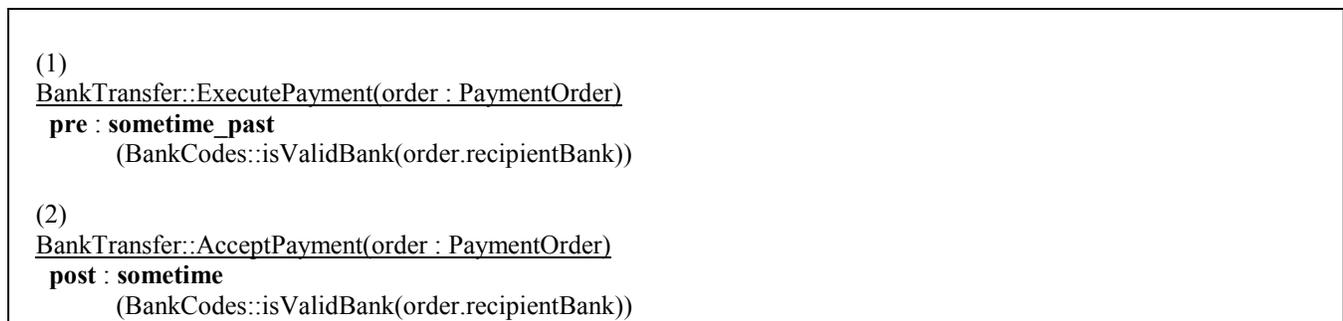
- *sometime\_past* A: A was true at one point in the past.
- *always\_past* A: A was always true in the past.
- *A sometime\_since\_last B*: A was true sometime in the past since the last time B was true.
- *A always\_since\_last B*: A was always true since the last time B was true.
- *sometime* A: A will be true sometime in the future.
- *always* A: A will be true always in the future.
- *A until B*: A is true until B will be true in the future.
- *A before B*: A will be true sometime in the future before B will be true in the future.
- *initially* A: At the initial state A is true.

As a secondary notation on the interaction level, every OCL expression may be annotated with comments.

The business component “BankCodes” is rather simple, its services have no dependencies on other services (cf. paragraph 3.2). But its services may be used by other business components, for instance a business component “BankTransfer” offers a service to execute a payment order. This service may only be called after it is verified that the recipient’s bank details are valid. The first constraint in figure 4 specifies this dependency. Alternatively, this verification may be assured after the payment order is accepted. This dependency is specified by the second constraint in figure 4.

This specification level addresses aspects of the communication between components (component-to-component specification). But note, the definition of such communication dependency need not rely on one specific business component as shown in the example. Instead the specification dependency can refer to an indefinite business component. In this case, the key word “extern” is used as a component identifier.

The specification on this level shows dependencies between the business components of a virtual project. The actors of a component community must take into account these dependencies during the development of the component system. Otherwise, a smooth integration of the business components developed is not possible.



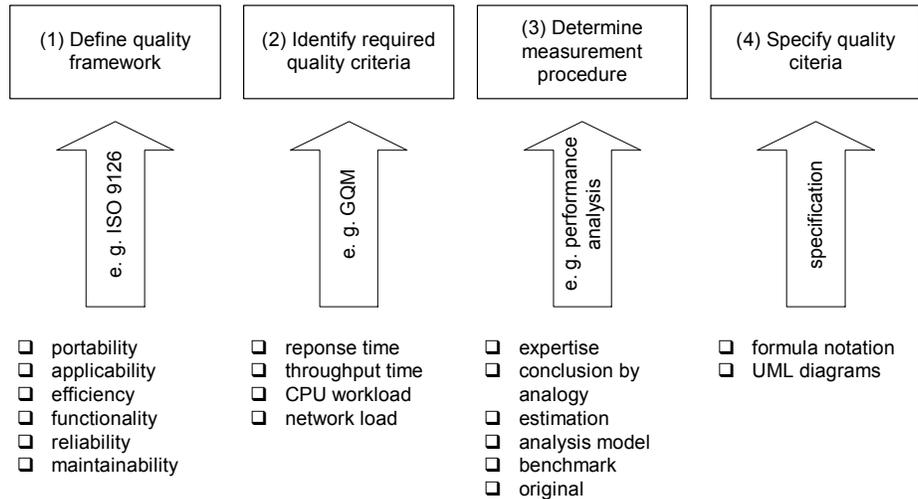
**Figure 4. Example Specification of the Interaction Level**

### **Quality Level**

The specification levels mentioned above focus on the functional characteristics of business components. In addition, it is necessary to define non-functional qualities of a business component. This is the purpose of the specification of the quality level. Such characteristics include availability, error recovery time, throughput time, response time etc. and can be classified as static or dynamic characteristics. Static characteristics, e. g. size of a component, can be measured at the build-time of a business component; dynamic characteristics, e. g. the response time of a called service, can only be measured during the run-time.

Various quality parameters depend on the boundary conditions of the runtime environment (e. g. main memory size, processor type, database management system (DBMS) etc.). Therefore, it is essential to define these boundary conditions accurately. If the boundary conditions are only fuzzy, then it is impossible to measure objective quality criteria. It must be pointed out, that there is a wide range of possible boundary conditions. Some business components may rely on network capacity, others on the DBMS or the processor type etc. Consequently, no universally valid boundary conditions can be defined.

Instead, a general procedure to define and specify quality criteria is introduced. The procedure consists of four steps (figure 5).



**Figure 5. General Procedure to Define and Specify Quality Criteria (Ackermann et al. 2002, p. 13)**

- (1) Define quality framework: The term quality of a business component can be defined in various ways. To that effect, a quality framework has to be introduced to define the concept quality. For this so-called “Factor Criteria Metrics” models such as the ISO 9126 may be used.
- (2) Identify required quality criteria: At the next step, the specific quality criteria will be stated. For instance, the Goal/Question/Metric Method may be used for this (Solingen and Berghout 1999).
- (3) Determine measurement methods: The identified quality criteria have to be quantified by a specific measurement method. Typical methods are expertise, conclusion by analogy, benchmark, estimation, analysis model, and original.
- (4) Specify quality criteria: As the last step, the specific quality criteria of a business component can be defined. For this, no specific notation is proposed. Possible notations are formula notation, or UML diagrams.

Because of the mentioned problems, it is rather difficult to depict a simple example of a quality specification. Nevertheless, a specification of the quality level is sketched out. Starting point of the measurement is the following reference environment:

- processor type: Intel Pentium III 866 MHz
- main memory: 1 GB RAM
- operation system: Windows NT 4.0
- database management system: Oracle 8i
- component system framework: Brokat Twister 2.3.5

The quality of the service “isValidBankCode” is specified in figure 6. The service is called with randomly numbers with uniform distribution which lie in the interval “10000000” to “99999999”.

In a component community, the application of this specification level is twofold. First, a component developer can specify the quality characteristics of a specific business component. Second, it is suitable to define expected quality characteristics which a business component must fulfill in advance.

Quality criteria	Specification
throughput	1.8 s (workload: 1000 requests)
response time	18 ms
response time distribution	0.0324 ms
availability	not available
error recovery time	not available

**Figure 6. Example Specification of Quality the Level**

**Terminology Level**

Every specification level uses various concepts that have a specific, usually not standardized denotation, e. g. identifiers on the interface, behavior, and interaction level, or tasks on the task level. Therefore, it is necessary to define each concept explicitly. This is the purpose of the terminology level. The terminology level can be viewed as a glossary of every concept that is needed to understand the business component specification.

The requirements of the terminology level can be fulfilled by so-called standardized business languages (SBLs) (Ortner 1997). SBLs use explicitly defined patterns to build sentences, and their vocabulary is based on a reconstructed colloquial language. Thus, it is possible to clarify the use of synonyms, homonyms, and other language defects. A SBL allows an explicit specification of the conceptualizations of all terms used on every specification level. Therefore, it is comparable to an ontological approach {Gruber, 1994 #1462}.

SBLs use various definition methods:

- explicit definition of a term based on already defined terms,
- definition of relationships between concepts such as is-broader, is-narrower, is-related etc., and
- introduction of new concepts by examples and counter-examples (to overcome the problem of the beginning of the definition process).

In the following, some sample patterns for building sentences are described (A, B are objects in a general meaning):

- abstract relationship: A is B
- component relationship: A compounds / is part of B
- sequence relationship: A happens before / after / concurrent B

A specification of the terminology level is shown in figure 7. This simple example uses just the abstract relationship pattern.

Normally, users of a component community have a different knowledge background and use different terms. The specification on this level supports the harmonization of the vocabulary used. Hence, it helps to avoid language deficiencies such as homonyms, synonyms etc. in a virtual project.

Concept	Definition
bank code	A bank code is an eight-digit number that identifies a German financial institution. It is also used for transactions between a financial institution and the “Deutsche Bundesbank” (Central Bank of the Federal Republic of Germany). Examples: “87070000”, “12345678”, counter-examples “1234567”, “Deutsche Bank” Synonyms: BC, bank number
bank name	A bank name is an identifier of a financial institution according to the field “brief description of a financial institution office” in the file “SATZ188.doc” (source: Deutsche Bundesbank, www.bundesbank.de). Example “Deutsche Bank Chemnitz, Germany”, counter-example: “87070000”
Response time	The response time is the time period between the call of a business component’s service and its termination.

**Figure 7. Example Specification of the Terminology Level**

### Task Level

By definition, a business component supports the execution of a set of various business tasks. The purpose of the task level is to specify which business tasks are supported by the business component. This information in combination with the marketing layer describes the application domain of a business component.

In contrast to the technical-oriented interface level, the task level provides a conceptual description of a business component. Therefore, as on the terminology level, a SBL is proposed as a specification notation (cf. paragraph 3.6).

The specification of the task level of the business component “BankCodes” is shown in figure 8.

In a component community, actors can specify the services which they expect from a component system in general and a specific business component in particular. Unlike the specification on the interface level, this level focuses on business aspects.

Task	Description
verify bank code	This task verifies if a given bank code is valid or if a given bank code corresponds to a given bank name.
Look up bank code	This task looks up the bank code for a given bank name.
Look up bank	This task looks up the bank name for a given bank code.

**Figure 8. Example Specification of the Task Level**

<b>Name</b>	The name of the business component.
<b>Identifier</b>	A unique identifier to identify the business component.
<b>Version</b>	This attribute defines version and release of the business component.
<b>Branch of Economic Activity</b>	This attribute describes the application domain of the business component from an economical perspective. The International Standard Industrial Classification of All Economic Activities (United Nations 1989) is used, e. g.: manufacturing, retail trade, or financial intermediation.
<b>{Domain}</b>	This attribute describes the application domain of the business component from a functional perspective. It is based on a reference model constructed by (Mertens 2001; Mertens and Griese 2000). Possible values are: research and development, sales, procurement, inventory, production, delivery, after sales services, finance, accounting, human resource, facility management.
<b>Scope of Supply</b>	This attribute specifies all (software) artifacts which belong to the business component.
<b>{Component Technology}</b>	This attribute specifies the component technology.
<b>{System Requirements}</b>	This attribute specifies the system environment that is needed by the business component, e. g. processor type, memory size, secondary memory size, operating system and its version, component system and application framework and their versions, etc.
<b>[Manufacturer]</b>	This attribute describes the manufacturer of the business component.
<b>[Contact Person]</b>	This attribute names a contact person.
<b>[Contractual Basis]</b>	This attributes describes modalities to buy the component, e. g. costs per license, terms of license, terms of payment etc.
<b>[Miscellaneous]</b>	This attribute allows definition of further characteristics of a business component that may be relevant to a potential user.

**Figure 9. Specification Notation for the Marketing Level**

### Marketing Level

The purpose of the marketing level is to ensure the efficient handling of business components from a business or organizational perspective. The specification of the marketing level is especially needed to trade a component on a component market place or component community. It covers three groups of characteristics:

- business and organization characteristics,
- technical boundary conditions, and
- miscellaneous characteristics.

As a notation a tabular form is proposed (figure 9). These conventions are used:

- Each table entry names one attribute which is typed in **bold** letters.
- If the attribute is optional, it is enclosed in square brackets. Example: [optional attribute]
- If the attribute may be specified more than once, it is enclosed in curly brackets. Example: {repeatable attribute}

An alternative approach to specify this level may be based on the Extensible Markup Language (XML). Figure 10 shows the specification of the marketing level of the business component “BankCodes”.

<b>Name</b> BankCodes
<b>Version</b> V 1.0
<b>Branch of Economic Activity</b> Independent
<b>Domain</b> Accounting
<b>Scope of Supply</b> bankcodes.jar: implemented Java-Classes bankcodes.tws: IDL specification of the component create_db.sql: SQL script to setup the database blz0010pc.txt: original source of bank codes data offered by the “Deutsche Bundesbank” (source: <a href="http://www.bundesbank.de/">http://www.bundesbank.de/</a> ) script_sampledata.pl: Perl script to convert the original source of bank codes to a file containing SQL statements bankcodestests.jar: implemented test cases for the business component
<b>Component Technology</b> Brokat Twister 2.3.5
<b>System Requirements</b> processor type: x86 main memory size: 512 MB operating system: Windows NT 4.0, SP 3 database management system: Oracle 8i component system framework: Brokat Twister 2.3.5
<b>Manufacturer</b> Chemnitz University of Technology, Information Systems & Management, D-09107 Chemnitz

Figure 10. Example Specification of the Marketing Level

### Summary and Further Work

This paper introduces the idea of developing business components in component communities. This way of coordinating actors has some advantages for the development of component systems, for instance short communication ways, flexibility, knowledge sharing. However, the actors in a component community need means to describe the characteristics of a specific business

component. To address this necessity, we propose a method for specifying business components. According to our approach a business component is described on seven levels covering both technical and business aspects. Thus, this approach can be characterized as a holistic specification of business components.

There are several areas of further research. First, more experience is needed to apply the proposed specification method to various application domains. To gain more experience with this method empirical research methods (case studies, action research etc.) can be applied. This work validates the proposed method. Second, we have to point out that this approach is primarily a notation standard. To establish this standard it is necessary – among other tasks – to develop a procedural model for component specification that is based on this notation standard. Third, we are preparing an ontological evaluation (Wand and Weber 1993; Opdahl and Henderson-Sellers 2002) of this method to introduce an ontological and hopefully more precise definition of its constructs. Fourth, it is possible to build a prototypical implementation of a component community. In the long term, we think, the mentioned areas of further work may lead to standards for different application domains based on a sound specification method, e. g. standard business components for manufacturing, retail, banking, insurance etc.

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