

# A Quantitative Assessment of the Complexity of Static Conceptual Schemata for Reference Types of Front-Office

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## Abstract

*This paper describes how measurement knowledge and expertise gained in the software engineering field can be transferred to the area of business process modeling and analysis. More specifically, we present results from an evaluation study of alternative front-office system designs. The front-office is the part of a service-oriented organisation where the services required by a customer and offered by the service provider are agreed upon. In this paper an approach is presented to formally evaluate the complexity of alternative front-office system designs. This complexity assessment method integrates two techniques: conceptual modeling and software artifact complexity measurement. The results of the complexity assessment are part of a balanced approach towards determining the optimal level of service customisation for a company.*

## I. Introduction

In today's service industries, service providers are confronted with saturated markets, in which retaining existing customers and building long-lasting customer relationships become increasingly more important. One strategy to deal with the problem of customer retention is service customisation. Apart from the effect on customer satisfaction, customisation introduces switching costs and thus entry barriers for competitors. Indirectly, if the customisation strategy is effective with respect to customer retention, it also eliminates the need for expensive marketing efforts directed at acquiring new customers.

Lampel and Mintzberg (1996) distinguish five degrees of service customisation (Table 1). It is evident that the higher degrees of customisation offer the best perspectives for customer satisfaction and retention. However, they also require other information about the customer, the products that build the customised service, and the service delivery process than the lower degrees of customisation. As a consequence, the front-office must be organised such that the information required by the adopted degree of service customisation is readily available for the service specification process.

De Vries (1997) has presented an information model for front-office customer interaction (Table 2). This model can be used to determine what kind of information is needed for five different types of front-office organisation, each of them supporting a particular degree of service customisation. Companies that plan to introduce a front-office can use the information model of de Vries as a reference framework for organising the front-office and designing a front-office information system. The model is also useful for organisations that wish to move to another level of service customisation, and thus re-organise their front-office and re-engineer their front-office information system.

The introduction of a front-office with supporting information system or the re-engineering of an existing front-office information system is costly. It is no certainty that each and every company must strive for the highest degree of service customisation. There might be an optimal degree of customisation for a company. However, the conceptual frameworks of Lampel and Mintzberg, and de Vries lack quantitative information to support decision making regarding this choice.

**Table 1: Degree of service customisation according to Lampel and Mintzberg (1996)**

DEGREE OF CUSTOMISATION	DESCRIPTION
Pure standardisation	The same service is offered to each customer.
Segmented standardisation	A different standard service is offered to groups of customers (i.e., market segments).
Customised standardisation	A customer specifies a customised service built from standard components.
Tailored customisation	A customer specifies a customised service using standard service design and delivery processes.
Pure customisation	A customer specifies the service design and delivery processes.

The problem of choosing the right type of front-office for a company can (and must) be approached from different perspectives, including the financial perspective (e.g., cost/benefit analysis, ROI calculations), the technological perspective (e.g., feasibility studies regarding the standardisation and componentisation of the offered services) and the market perspective (e.g., opportunities for market segmentation, customer profiling). This paper contributes to a balanced approach towards front-office system evaluation. We approach the problem of choosing the right degree of service customisation (and corresponding type of front-office) as an instance of a more generic problem, i.e. the issue of business process change (BPC). One criterion for a successful BPC project is that it reduces the complexity of the involved business processes (Johansson *et al.* 1993). Hence, the goal of this paper is to present an assessment method for the complexity of a front-office system.

The method presented in this paper uses two techniques. First, the different types of front-office described in the information model of de Vries are modelled using the conceptual modeling technique described in (Snoeck *et al.* 1999). Next, the complexity of the resulting conceptual schemata (one for each type of front-office) is measured with a suite of specification measures that was developed using the distance-based approach to software artifact measure construction (Poels 1999, Poels and Dedene 2000).

The basic rationale of our approach can be described as follows. As conceptual schemata are models of reality, complexity measures for those schemata are approximate measures for the complexity of reality itself. Hence, the complexity of a conceptual schema for a front-office is equated with the notion of front-office complexity itself. There is however an additional aspect to consider. According to the framework for information system architecture of Zachman (1987), the conceptual schema is the basis for the business model, i.e. the actual 'heart' of the information system. To develop, maintain and implement information systems in an effective and efficient manner, the complexity of this most inner layer in an information system architecture must be assessed, evaluated, and if necessary controlled and improved.

This paper is organised as follows. Section II briefly discusses the front-office information model of de Vries. In section III conceptual schemata for the different types of front-office are presented. Next, section IV introduces a measure suite for assessing various complexity aspects of conceptual schemata. The actual complexity measurements are presented and analysed in section V. Section VI discusses the assumptions underlying our approach and motivates the way we handle them. Finally, section VII contains conclusions.

**Table 2: Information model of front-office customer interaction of de Vries (1997)**

FRONT-OFFICE TYPE	DEGREE OF CUSTOMIZATION	RELATION-RELATED	PRODUCT-RELATED	PROCESS-RELATED
1. 'Counter'	Pure standardization	Anonymous transactions	End products	Delivery times for products
2. 'One stop shop'	Segmented standardization	Characteristics of market segments	Assortments	Delivery times for assortments
3. 'Field and inside service'	Customized standardization	Customer profiles	Standard components	Available capacity
4. 'Control room'	Tailored customization	Development of the relationship	Smallest replicating unit	Capacity assignment
5. 'Symbiosis'	Pure customization	Opportunities for partnership	Design knowledge	Implementation and outsourcing opportunities

## II. The front-office information model

The information model of de Vries (1997) can be used as a reference framework for the application of information and communication technology in the front-office. The model relates the provisioning of customised services to the main instrument of the front-office: information. The degree of service customisation adopted determines the information services that are needed to support the service specification process.

Overall, the front-office workers need product-information, process-information and information on the customer-relationship. Table 2 shows for each degree of service customisation and corresponding front-office type the type of information that is needed. According to de Vries the information requirements change with the degree of customisation. For instance, in the case of pure standardisation the front-office is organised as a 'counter' (e.g., a ticket dispenser, an automatic teller machine). The identity of individual customers is unknown and only information on end products (e.g., price) and their delivery process (e.g., delivery times) is needed. In case of segmented standardisation customers are offered specific assortments of services depending on the market segment to which they belong. Here, front-office workers need a different type of information, for instance, information about the characteristics of market segments. In case of customised standardisation a customer specifies a customised service using a set of standard components. Here, the front-office workers need to know, amongst other things, the price, delivery times, capacity constraints, etc. of each standard component. For the highest degrees of customisation (i.e., tailored customisation and pure customisation) the emphasis shifts from process and product related information to customer-relationship information. More specifically, information is needed on the commercial value of a customer. In case of 'symbiosis' front-office workers even need to know the strategy and future plans of a customer.

## III. Conceptual schemata for types of front-office

In (de Vries *et al.* 1998) static conceptual schemata are presented for the different types of front-office in the framework of de Vries. These schemata were written using a variation on the Bachman notation. In (Poels *et al.* 2000) the same schemata were presented, but now in the more standardised and familiar UML notation (Booch *et al.* 1999).

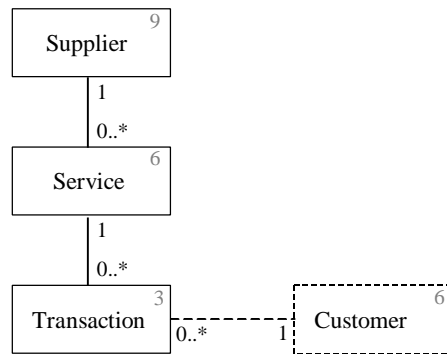
Fig. 1 presents the conceptual schema for the 'counter' type of front-office. For a better understanding of the schemata we must note that they have been developed using a conceptual modeling technique that is described as 'business modeling by contract' (Snoeck *et al.* 1999). The key concept in this technique is existence dependency. An object type *X* is existence dependent on an object type *Y* if each instance of *X* is always associated to exactly one instance of *Y*. Moreover, the association between an instance of *X* and an instance of *Y* is unchangeable, i.e. the instance of *X* is always associated to the same instance of *Y*. For instance, in Fig. 1 SERVICE is existence dependent on SUPPLIER implying that each instance of SERVICE is always associated to one and the same instance of SUPPLIER. The existence dependency association between SERVICE and SUPPLIER thus expresses the business rule that each service is supplied by exactly one supplier, and that the same service cannot be supplied now by supplier A and later by supplier B. Business modeling by contract offers a schema restructuring mechanism that transforms all associations between object types, including special kinds supported by UML like aggregation and composition, to existence dependency associations.<sup>1</sup> Associations that originally did not express existence dependency (e.g. aggregation) are instantiated via a contract pattern into a contract object type that is existence dependent on the (originally) associated object types. For instance, in Fig. 1 TRANSACTION is a contract object type that is existence dependent on both SERVICE and CUSTOMER because a service is not existence dependent on a customer, nor vice versa.

Working with existence dependency as the cornerstone for conceptual modeling offers many advantages. One advantage is that formal semantics can be added to UML schemata. Another advantage, especially relevant for the evaluation study described in this paper, is that the schema restructuring algorithm makes the schemata more comparable because only one type of semantic association between object types is used.<sup>2</sup>

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<sup>1</sup> The only exception are the generalisation/specialisation relationships between object types. These are left unchanged by the schema restructuring algorithm.

<sup>2</sup> It must be noted that the conceptual schemata originally proposed in (de Vries *et al.* 1998) did not contain generalisation/specialisation relationships between object types, which further simplifies our study.



**Figure 1: 'counter' type of front-office**

As the concept of existence dependency is also the basis for guaranteeing the semantic integrity between structural and behavioural aspects of a conceptual schema (Snoeck and Dedene 1998), default behaviour can be added to the object types in the conceptual schemata. In other words, the schemata can be made less static by 'dressing' the object types with operations. The following rules have been followed in this process:<sup>3</sup>

- Each object type has three default operations of its own, i.e. one operation to create an instance of the type, one operation to end the life of an instance of the type, and one operation to modify the state of an instance of the type (without creating it or ending its life);
- All operations are propagated from existence dependent object types to the object types they are existence dependent on.

In Fig. 1 the number of default operations for each object type is shown in the upper right corner of the object type classifier.

Note that in Fig. 1 the CUSTOMER object type is optional, as customers are anonymous in this type of front-office. All information needed for standardised service transactions can be encapsulated in the SUPPLIER, SERVICE and TRANSACTION object types in the diagram. For instance, descriptive attributes of the SERVICE object type include the service functionality description, price and warranty conditions and service procedure descriptions. Transaction amounts and timestamps are descriptive attributes of the TRANSACTION object type.

A 'one-stop-shop' offers a specific assortment of services to customers depending on the market segment to which they belong (Fig. 2). The essential front-office processes are the determination of market segments and assortments. Individual customer information must not be stored. Other information like the segmentation criteria, assortment discount rates, etc. can readily be encapsulated in the front-office object types.

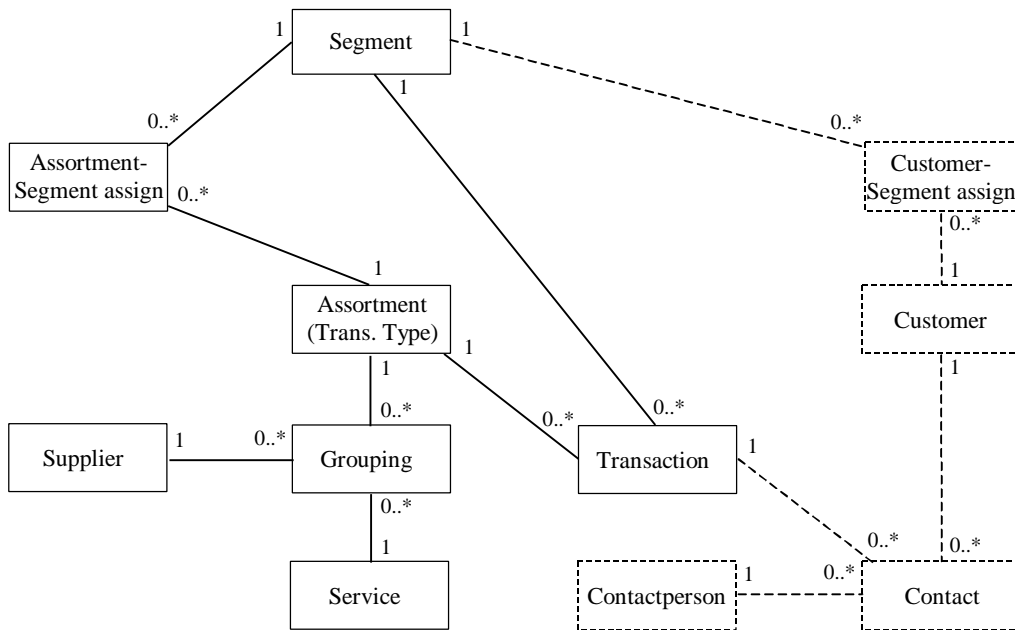
According to de Vries *et al.* (1998) the 'one-stop-shop' model unfolds from the 'counter' model. The primary effects of customisation are the concepts of segmentation and assortments.

The 'field and inside service' type of front-office is a clear extension of the 'one-stop-shop' (Fig. 3). To offer customised standardisation the front-office is organised into a field service (e.g., sales people) that is supported by an inside service. The former is responsible for the customer relationships, whereas the latter is responsible for profiling, matching, and the bundling and offering of services.

The main difference with the previous front-office type is that the collection of customer related processes is now a non-optional part of the schema. Customised standardisation requires for instance that customer profiles are built in order to meet the customer's requirements. De Vries *et al.* note that "the product bundling and transformation into proper transactions to the customer becomes increasingly complex" (de Vries *et al.* 1998, p. 8). So, without providing an explicit definition of 'front-office complexity', it is argued that the front-office type modeled in Fig. 3 is more complex than the front-office types modelled in Figs. 1 and 2.

Figs. 4 and 5 show the conceptual schemata of the 'control room' and 'symbiosis' types of front-office. The schemata clearly show that the emphasis shifts from product and process related information to the customer relation. The 'control room' front-office aims to establish a structural link with commercially attractive customers by means of tailored customisation. Within the bounds of the standard service design and delivery process, the front-office representative and the customer specify the service to be provided. In the 'symbiosis' model the service provider and the customer collaborate completely in the various steps of designing, acquiring, and producing customised services.

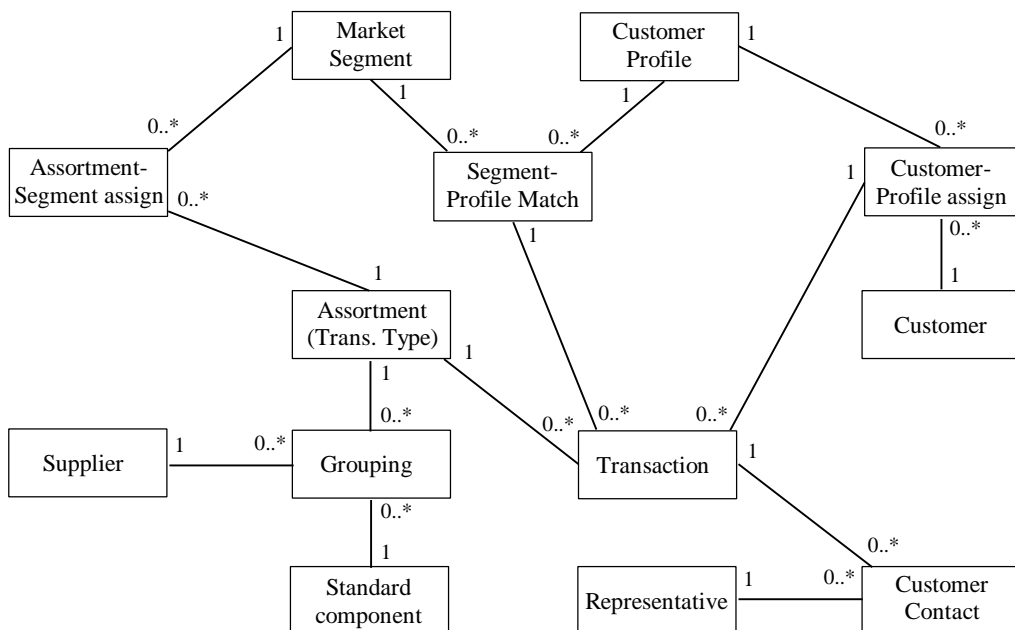
<sup>3</sup> For the detailed rationale of these rules we refer to (Snoeck and Dedene 1998).



**Figure 2: 'one-stop-shop' type of front-office**

De Vries *et al.* note that "the [control-room] model is less complex than the previous front-office type, due to the emphasis of the different steps (actions) in the relation (link)" (p. 9). They further note that "despite its simplicity, the model supports the required information needs for this type of front-office" (p. 9).

Regarding the 'symbiosis' front-office type it is noted that "Although 'symbiosis' is the most far-reaching level of relationship building, customisation and process control, with a lot of detailed information, the domain model to support it is relatively simple, since the information is indeed very closely linked to the customer, involved as a partner in the 'symbiosis'" (p. 11).



**Figure 3: 'field and inside service' type of front-office**

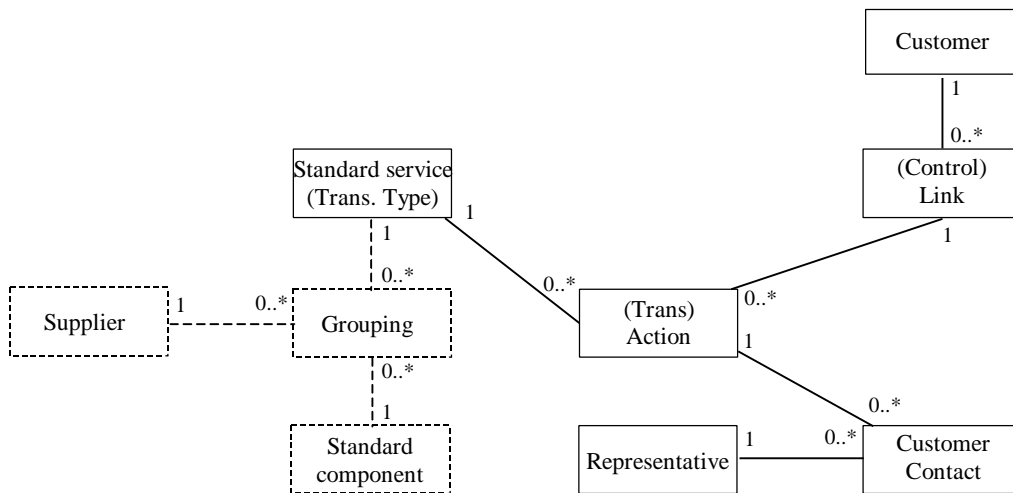


Figure 4: 'control room' type of front-office

#### IV. Complexity measures for conceptual schemata

In modern object-oriented and component-based approaches towards information system development, the conceptual schema, capturing the entities, events and rules relevant for a business process or a collection of business processes, constitutes the inner layer of a system's architecture (Jacobson *et al.* 1992, D'Souza and Wills 1998). The object types in the conceptual schema are implemented as business object classes. They thus form a sizeable subset of the final set of system classes. Therefore, it can be argued that the complexity of the conceptual schema has an impact on the total information system development or re-engineering costs. Although this perspective is relevant for the research questions of this paper, we are primarily concerned here with the measurement of models of reality to evaluate reality itself. The 'reality' refers to the different types of front-office as identified in (de Vries 1997). The 'models of reality' are the front-office type conceptual schemata. A basic assumption of our research is that we equate the notion of front-office type conceptual schema complexity with that of front-office type complexity. Some further thoughts on this assumption are expressed in section VI.

Although in (de Vries *et al.* 1998) observations are made regarding the relative complexity of the different types of front-office, a formal definition of front-office complexity is not presented. In order to quantify the notion of front-office complexity (or front-office type conceptual schema complexity), we need to define this concept more precisely.

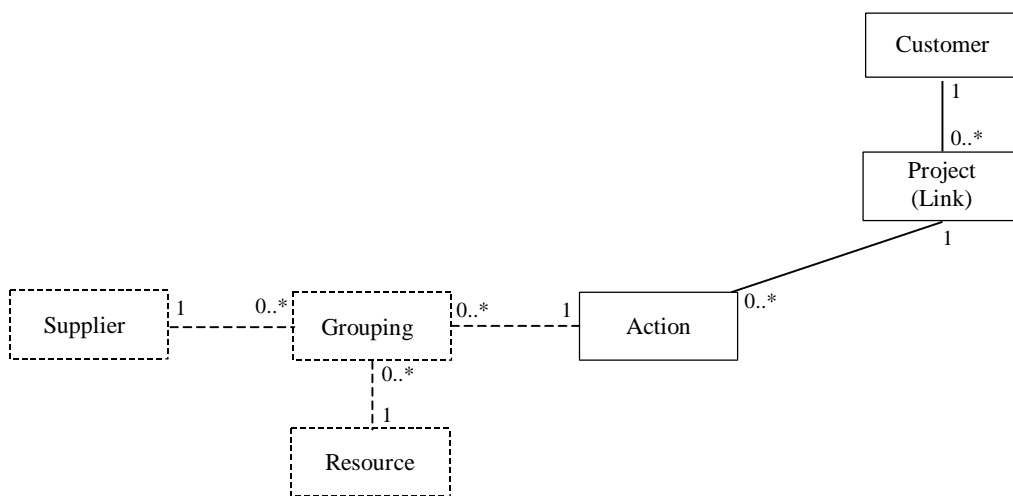


Figure 5: 'symbiosis' type of front-office

Conceptual schema complexity has been measured in the context of quality frameworks for conceptual modeling (Lindland *et al.* 1994, Moody *et al.* 1998). Moody (1998) defines conceptual schema complexity from a Systems Theory perspective, i.e. the complexity of a system is determined by the number of elements that build a system and by the number of relationships between the elements of a system. Conceptual schemata qualify as 'systems'. Object types and default operations are elements of a conceptual schema 'system'. Associations are relationships in a conceptual schema 'system'. Hence, obvious complexity measures for the conceptual schemata of the front-office types are:

- #OT            The count of object types
- #ED            The count of existence dependency associations
- #DO            The count of default operations

According to Assenova and Johannesson (1996) conceptual schema measures that return counts of basic modeling blocks (e.g. object types, associations, attributes) provide only a limited view on conceptual schema complexity. Also Lindland *et al.* (1994) contrast complexity aspects that focus on the size of a conceptual schema, like the number of object types and the number of operations, against structural complexity aspects. Therefore we add the following structural complexity measure to the measure suite:

- CD            The count of existence dependency associations divided by the count of object types

The CD measure is similar to connectivity density measures that have been proposed for static object-oriented analysis 'models' (Genero *et al.* 1999) and concept-oriented knowledge schemata (Lethbridge 1998). The CD measure has a very natural interpretation. In case the conceptual schema only contains binary associations, then the value of CD multiplied by two gives us the average number of existence dependency associations an object type is involved in. This number can be considered as a 'relative' complexity value. It can be used to compare the structural complexity of conceptual schemata of different size.

In the absence of further detailed information on the data, function and behavioural interaction dimensions of the conceptual schemata for front-office types, these crude measures provide a high-level, abstract view of the relative complexity of each of the front-office types, as observed in their respective conceptual schemata.

## V. Evaluating the complexity of the front-office type conceptual schemata

Table 3 shows the complexity measurements for the conceptual schemata of Figs. 1 to 5.<sup>4</sup> Only the non-optional parts of the schemata (i.e., object types and associations in solid lines) are taken into account.<sup>5</sup> The optional parts are considered as being outside the scope of the front-office.

The measurements in Table 3 indicate that there is a complexity increase when moving from a 'counter' front-office (pure standardisation) to a 'one-stop-shop' (segmented standardisation), and when moving further to a 'field and inside service' organisation (customised standardisation). However, complexity decreases when moving to a 'control room' type of front-office offering tailored customisation. It even decreases further in case of 'symbiosis' (i.e., pure customisation).

**Table 3: Complexity measurements**

FRONT-OFFICE TYPE	#ED	#OT	#DO	CD
'counter'	2	3	18	0.67
'one-stop-shop'	7	7	42	1.00
'field and inside service'	14	13	108	1.08
'control room'	5	6	45	0.83
'symbiosis'	2	3	18	0.67

<sup>4</sup> In order not to overload the figures, the number of default operations for object types is not shown in Figs. 2, 3, 4 and 5. These numbers can easily be derived using the rules presented in section III.

<sup>5</sup> For instance, #DO does not include the default operations of optional object types, nor their possible propagation into non-optional object types.

It must be noted that, according to the measures we used, the 'control room' and 'symbiosis' front-office types are less complex than the 'field and inside service' front-office type, despite the fact that the level of service customisation is higher. This result substantiates arguments in favour of the 'control room' and the 'symbiosis' types. Whereas a state of 'symbiosis' between the customer and the service provider might seem far-fetched and not realistic for every type of service industry, the 'field and inside service' front-office organisation is clearly sub-optimal with respect to front-office complexity. Increasing the level of service customisation can reduce this complexity.

It can be argued that the complexity differences between the different front-office type conceptual schemata are largely due to a size effect. The #OT, #ED, and #DO measurements show a same upward and downward evolution (Fig. 6).

The size effect is cancelled out when using the CD measure. Again, complexity increases with the level of service customisation up to the level of customised standardisation (i.e., the 'field and inside service' front-office type), after which it drops again. The CD measure shows the same evolution in complexity values as the #ED, #OT, and #DO measures, but the curve is somewhat smoother (Fig. 7).

These results illustrate that there is more than just a size effect in the relationship between the complexity of a front-office conceptual schema and the level of service customisation that is offered. The number of business entity types involved in the front-office processes cannot fully explain the complexity of a front-office type. The CD measure, which can be considered as a size-independent structural complexity measure, further supports the intuitive observations on the relative complexity of the different types of front-office that were made in (de Vries *et al.* 1998).

## VI. Threats to validity

The results of this study may be looked upon from two perspectives. First, the complexity of a front-office conceptual schema might propagate into the information system that supports the front-office processes. This is a factor worth considering when adopting a particular reference type for the front-office. Second, the complexity measures for the front-office type conceptual schemata can be used as proxy measures for the complexity of the front-office itself.

In order to draw conclusions from our work and to support strategic decision making regarding the right level of service customisation for a company, we need to examine and evaluate in detail the various assumptions underlying our complexity assessment approach. This is done in the next subsections.

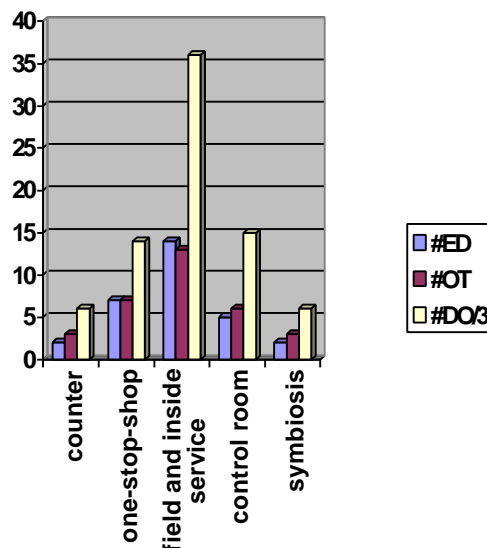


Figure 6: a size effect?



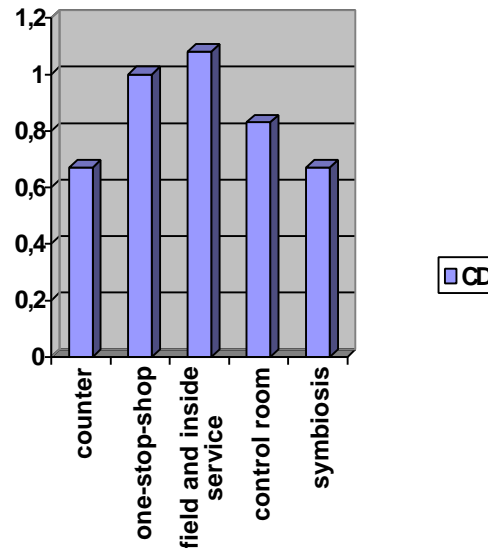


Figure 7: connectivity densities

#### A. Modeling assumptions

- Crucial to our research framework is that the front-office conceptual schemata truly represent front-offices as they exist in reality, or, in case of the reference schemata, truly represent the different types of front-office as they exist in the conceptual framework of de Vries. This is the question of model validity. Checking model validity is a tough problem however. It must be noted though that object orientation has proven to be an excellent language to model business processes (Wang 1994). Besides, the models of the different types of front-office do reflect observable differences in the front-office organisation resulting from information requirements specific for each level of service customisation. Differences between the reference schemata can be traced back to the information model of de Vries, and vice versa. We therefore have confidence in the model validity of the conceptual schemata presented in this paper and published before in (Poels *et al.* 2000).
- Only one sub-schema of the front-office type models is measured, i.e., a static conceptual schema showing the object types that are involved in the service specification processes, the static structure of the front-office organisation, and a default set of operations. Other aspects like dynamic behaviour, flow of work, etc., that are captured in other types of model (e.g., state transition charts, activity diagrams, business process models, etc.) may determine front-office complexity as well. In case these sub-schemata are available, other complexity measures (e.g., business object life cycle complexity (Poels 1999), information flow coupling between business (sub-)processes (Castano *et al.* 1998), value added of business processes (Housel and Kanevsky 1995)) can be applied. In this paper, the focus of the complexity assessment was on the complexity of the structural model of a front-office. The view of a front-office organisation and its service specification processes that is expressed by a structural model corresponds closely to the perspective taken in the information model of de Vries. The specific notions of complexity that were measured are similar to those used for evaluating quality aspects, including complexity, of conceptual schemata, and find their motivation in a Systems Theory perspective on a conceptual schema (Moody 1998). Connectivity density measures have been used to measure structural complexity in a variety of software models and artifacts (Fenton and Pfleeger 1997). Given that the model validity of the front-office types conceptual schemata is satisfactory, we may therefore assert that the notions of conceptual schema complexity considered in this paper reflect complexity aspects of the front-office types themselves, though we acknowledge that other perspectives on front-office complexity can be taken as well.
- The conceptual schemata of section III do not model front-offices, but front-office types. It can be questioned how good or relevant these types are. In other words, what is the validity of the information model for front-office customer interaction of de Vries, especially if it is used as a

reference framework for front-office organisation? Again, this is a difficult question to answer. Outside the scope of the front-office type framework, the validity of our results cannot be guaranteed. The external validity might be threatened by the fact that the conceptual schemata, if used as the basis for the business model in a layered front-office system architecture, result in the definition of a domain models. They model the functional domain 'front-office', regardless of the characteristics and specific working environment of individual businesses. When a company adopts some type of front-office, then the relevant domain model must be customised (e.g., adding additional object types and associations, introducing other types of associations, adding behaviour on top of the default operations, etc.). As a consequence, the complexity values for the customised model might be different than those for the 'generic' domain model. Another aspect to consider is the scope of the models. It is assumed that the conceptual schemata capture all relevant processes within the scope of the front-office. One explanation for the decreasing complexity values in the 'control room' and 'symbiosis' models could be that they are too abstract and general and do not capture adequately the information that is needed in these situations. This is again the question of framework validity. In our opinion, the scope of the models is appropriate, but a balanced approach requires that other factors be taken into account as well. For instance, we must also consider the complexity of the mid-office, where new services are developed, bundled, packaged, etc. Perhaps the mid-office gets increasingly more complex when moving to higher levels of service customisation. This is however a question outside the scope of this paper.

### *B. Measurement assumption*

- The validity of the measures is assumed. Measure validity is an important issue in software measurement (Zuse 1998). The direct measures used in this study (i.e., #ED, #OT, #DO) have been developed using a measure construction approach that is based on the representation and uniqueness theorem of the segmentally additive proximity structure, as found in advanced textbooks on Measurement Theory (Suppes *et al.* 1989). As a consequence, the validity of the measures can be formally proven and the scale type is ratio. For brevity's sake, we refer to (Poels and Dedene 2000) for details on the measure definition and validation approach that was used. The connectivity density measure CD is an indirect measure that relates two of the direct measures (i.e., #ED and #OT). Although it is less straightforward to validate indirect measures, especially if they are density measures (Zuse 1998), the scale type is ratio *in a wide sense* as defined by Roberts (1979).

## **VII. Conclusions**

In this paper a method was proposed to assess the complexity of the front-office, i.e., the part of a service organisation where an agreement is reached between a customer and the service provider. The method is based on two techniques: conceptual modeling and software artifact complexity measurement. It was applied to a reference framework for front-offices in order to quantify the relative complexity of different types of front-office. The results of the complexity assessment can be used as complementary information in a balanced approach towards front-office type evaluation. They help a company to determine the right level of service customisation.

The use of the modeling and measurement method presented in this paper is of course not limited to the evaluation of front-office types. We have investigated generic types of business process transformation with respect to complexity changes (Poels and Dedene 2001). We also used our method to quantify the impact of information system re-engineering (Poels *et al.* 2000) and business model reuse (Snoeck and Poels 2000). Important in all these applications is that the various modeling and measurement assumptions underlying the assessment are made explicit. These assumptions, and the way we handle them, determine the validity of the approach and its results.

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