Conceptual Fit: A Criterion for COTS Selection

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Abstract. COTS systems selection consists in evaluating the user requirements with respect to characteristics of candidate systems, using a set of criteria. One criterion that has received little attention is what we call conceptual fit. The criterion assesses the fit between the conceptual structure of the user requirements and that of a system. We evaluate the fit in terms of the existing misfits. We formally define the notion of conceptual misfit and we present a method that determines the conceptual misfits between the user requirements and a set of candidate systems. The method consists in defining a superschema, the mapping of the conceptual schemas of the candidate systems and of the user requirements to that superschema, and the automatic computation of the existing conceptual misfits. The method has been formalized in UML/OCL. We have conducted an exploratory experiment with the aim of evaluating the feasibility, difficulty and usefulness of the method, with positive results. We believe that the conceptual fit criterion could be taken into account by almost all existing COTS selection methods.

Keywords. COTS selection, Conceptual Fit, Conceptual Modeling

1. Introduction

Nowadays, many organizations build many of their information systems by customizing and/or integrating Commercial-off-the-shelf (COTS) systems [4]. In most cases, there are several alternative COTS systems that could be used to build an information system. Selecting the most convenient COTS system for a particular situation has become a critical activity in information systems engineering.

In general, COTS systems selection is a difficult decision for an organization due to the diversity of those systems, the possibly large number of candidates, the large number of technical and non-technical characteristics that must be taken into account, and the possibly high impact of the decision on the future activities of the organization [6].

The difficulty, frequency and practical significance of COTS systems selection justify the large volume of research work devoted to it and the large number of selection methods that have been proposed so far. Early published works date back at least to 1995 [7], and it is still an active research area. See [8], [15] for recent surveys on this topic.
COTS system selection essentially consists in evaluating user requirements with respect to characteristics of candidate systems. The evaluation is performed by defining a set of criteria, assessing the importance of each criterion for the users and the degree to which the criterion is satisfied by a system. Evaluation criteria must be customized for each selection situation [7]. The criteria taken into account usually include functionality, quality attributes, architecture, costs and risks.

One kind of criterion that has received little attention is what we call conceptual fit. It is similar to what is called domain compatibility in OTSO, which refers to how well a system and its features map into the terminology and concepts of the domain [7]. It is also similar to what is called suitability of data in the GOTHIC method, which evaluates how a particular system represents the data of a UML class or association of a common domain model [2].

This paper analyzes the conceptual fit between user requirements and COTS systems. We formally define the notion of conceptual misfit and we present a formal method that determines the existing conceptual misfits between a set of user requirements and a system. The absence of conceptual misfits indicates a perfect conceptual fit.

Our notion of conceptual misfit has been inspired in the ontological expressiveness analysis [17], in the fitness relationship between a business and the system which supports it [5], and in CASSM, an analytical usability evaluation method of interactive systems that focuses on conceptual fit [3].

We propose conceptual fit as a criterion to be used for COTS selection. It can be taken into account in almost all existing selection methods. As an exploratory experiment, we have evaluated the conceptual fit of a potential new online shop with a set ecommerce platforms consisting of three content-management systems for ecommerce websites (osCommerce, Magento, CS-Cart) and Amazon webstore. Based on this experiment, we conjecture that conceptual fit analysis enables an early discrimination of candidate systems, which reduces the effort of the selection [10].

The structure of the paper is as follows. Next section formally identifies the different kind of conceptual misfits that may exist between a set of user requirements and a COTS system. Section 3 formalizes the general problem of evaluating the conceptual fit of a set of user requirements and a set of COTS systems. In section 4 we describe the method we propose for solving that problem. Section 5 describes an exploratory experiment in which we apply the proposed method in the above mentioned context of ecommerce platforms. Finally, section 6 summarizes the conclusions and points out future work.

2. Conceptual Fit

By conceptual fit we mean the fit between two structural conceptual schemas. In our context, one conceptual schema is that of the user requirements and the other one is that of a particular COTS system. For the purposes of this paper, we will assume simple structural conceptual schemas consisting only of entity types, ISA hierarchies, attributes and binary associations. This can be easily extended, if desired [12].

Figure 1 shows the UML metamodel $M$ of the schemas that we consider in this paper. Entity types have a name, may be abstract or concrete, may be a singleton or be
unconstrained, and may have sub/supertype associations between them. Entity types may have attributes, which are properties. Properties have a minimum and a maximum cardinality, and a type. Cardinalities may be zero, one or unconstrained. Associations have two ordered participants, each of which is a property, as before.

Assume now that we have two instances of $M$ that we call $U_i$ (for user requirements) and $S_j$ (for COTS system). We are interested in knowing how well $U_i$ and $S_j$ fit each other. To this end, we try to see whether there are misfits between them. Based on the simple metamodel $M$ we identify three kinds of misfits in the schema elements, called deficits, incompatibilities and excesses, which we define in the following. Of course, in a more complex metamodel, additional misfits could be identified. The idea is that the degree of fit of $U_i$ and $S_j$ is inversely proportional to the number of misfits, the maximum being the absence of them.

2.1 Entity Type Misfits

We say that there is an entity type deficit between $U_i$ and $S_j$ with respect to (wrt) $E$ if $E$ is a concrete entity type of $U_i$ but $E$ is not an entity type of $S_j$. Note that we consider only the concrete entity types of $U_i$ because these are the ones of interest to the users. Abstract entity types in $U_i$ are unions of concrete ones.

For example, if $U_i$ includes the concrete entity type Bundle then there is an entity type deficit between $U_i$ and osCommerce wrt to Bundle because that system does not include Bundle. It is not possible to define instances of bundles in that system.

There is an entity type cardinality incompatibility between $U_i$ and $S_j$ wrt $E$ if $E$ is a concrete entity type of $U_i$ and an entity type of $S_j$, but $E$ is unconstrained (not a singleton) in $U_i$ and a singleton in $S_j$. Both $U_i$ and $S_j$ have the entity type $E$ but, in $U_i$, $E$ may have several instances while only one instance is allowed in $S_j$.

For example, if $U_i$ includes the unconstrained concrete entity type Store, then there is an entity type cardinality incompatibility between $U_i$ and osCommerce wrt to Store because Store is a singleton in osCommerce.

We say that there is an entity type excess between $U_i$ and $S_j$ wrt $E$ if $E$ is a concrete entity type of $S_j$ but $E$ is not an entity type of $U_i$. In this case, $S_j$ includes an entity type
that is not of interest to \( U_i \). For example, Magento includes the concrete entity type \textit{GroupedProduct}. If this type is not required by \( U_i \) then there is an entity type excess.

### 2.2 Attribute Misfits

There is an \textit{induced attribute deficit} between \( U_i \) and \( S_j \) wrt \( A \) if \( A \) is an attribute of the concrete entity type \( E \) in \( U_i \) and there is an entity type deficit between \( U_i \) and \( S_j \) wrt \( E \). In this case, the deficit is induced by the entity type deficit. For example, if \( U_i \) includes the attribute \textit{price} of \textit{Bundle}, then there will be an induced attribute deficit with all systems whose schema does not include \textit{Bundle}.

There is an \textit{attribute deficit} between \( U_i \) and \( S_j \) wrt \( A \) if \( A \) is an attribute of the concrete entity type \( E \) in \( U_i \), \( S_j \) includes \( E \), but \( S_j \) does not include \( A \).

There is an \textit{attribute cardinality incompatibility} between \( U_i \) and \( S_j \) wrt \( A \) if \( A \) is an attribute of the concrete entity type \( E \) in \( U_i \), \( S_j \) includes \( A \), but the cardinalities are incompatible. An incompatibility arises when the minimum cardinality in \( U_i \) is zero and one in \( S_j \), or when the maximum cardinality is unconstrained in \( U_i \) and one in \( S_j \).

An example of this misfit occurs when users require that \textit{SaleableItem} may have several images (unconstrained attribute) and a system (such as osCommerce) allows at most one.

There is an \textit{induced attribute excess} between \( U_i \) and \( S_j \) wrt \( A \) if \( A \) is an attribute of the concrete entity type \( E \) in \( S_j \) and there is an entity type excess between \( U_i \) and \( S_j \) wrt \( E \). In this case, the excess is induced by the entity type excess.

There is an \textit{attribute excess} between \( U_i \) and \( S_j \) wrt \( A \) if \( A \) is an attribute of the concrete entity type \( E \) in \( S_j \), \( U_i \) includes \( E \), but \( U_i \) does not include \( A \). In this case, \( S_j \) includes an attribute that is not of interest to \( U_i \).

### 2.3 Association Misfits

There is an \textit{induced association deficit} between \( U_i \) and \( S_j \) wrt \( R \) if \( R \) is an association between the concrete entity types \( E_1 \) and \( E_2 \) in \( U_i \), and there is an entity type deficit between \( U_i \) and \( S_j \) wrt \( E_1 \) or \( E_2 \). In this case, the deficit is induced by the entity type deficits.

There is an \textit{association deficit} between \( U_i \) and \( S_j \) wrt \( R \) if \( R \) is an association between the concrete entity types \( E_1 \) and \( E_2 \) in \( U_i \), \( S_j \) includes \( E_1 \) and \( E_2 \), but \( S_j \) does not include \( R \).

There is an \textit{association cardinality incompatibility} between \( U_i \) and \( S_j \) wrt \( R \) if \( R \) is an association between the concrete entity types \( E_1 \) and \( E_2 \) in \( U_i \), \( S_j \) includes \( E_1 \) and \( E_2 \), but the cardinalities of one of its participants are incompatible. An incompatibility arises when the minimum cardinality in \( U_i \) is zero and one in \( S_j \), or when the maximum cardinality is unconstrained in \( U_i \) and one in \( S_j \). For example, consider the association \textit{SaleableItem} – \textit{Category}. If \( U_i \) requires that an item may have several categories, then there will be an \textit{association cardinality incompatibility} with Amazon webstore, because it only allows one.

There is an \textit{induced association excess} between \( U_i \) and \( S_j \) wrt \( R \) if \( R \) is an association between the concrete entity types \( E_1 \) and \( E_2 \) in \( S_j \), and there is an entity
type excess between $U_i$ and $S_j$ wrt $E_1$ or $E_2$. In this case, the excess is induced by the entity type excess.

There is an association excess between $U_i$ and $S_j$ wrt $R$ if $R$ is an association of the concrete entity types $E_1$ and $E_2$ in $S_j$, $U_i$ includes $E_1$ and $E_2$, but $U_i$ does not require $R$.

3. Evaluating the Conceptual Fit Criterion for COTS Selection

The general problem of evaluating the conceptual fit criterion can be defined as follows:

**Given:**
- The user requirements $U_i$ of a system in some domain and
- A set $S_1, ..., S_n$ of $n$ candidate COTS systems in that domain,

**Determine:**
- The conceptual misfits (deficits, misfits and excesses as defined in the previous section) between $U_i$ and each of the $S_1, ..., S_n$.

Conceptual fit analysis can be performed considering the complete set of user requirements $U_i$ and of the candidate systems $S_1, ..., S_n$ or considering only a fragment of them. The latter possibility is likely to be of much more practical interest in most cases.

The set of conceptual misfits found can be used as a basis for selection. If there are no misfits between $U_i$ and $S_j$, then there is a perfect fit between them.

If there are one or more deficits or incompatibilities between $U_i$ and $S_j$, then the selection of $S_j$ would require either the change of the user requirements $U_i$ (changing their intended way-of-working) or a customization of $S_j$ for the user (customizing existing systems to accommodate users’ requirements) [14].

If there are one or more excesses between $U_i$ and $S_j$, then the selection of $S_j$ would imply dealing with the unneeded features related to those excesses, and the need of the corresponding resources.

If all misfits had the same cost, measured by the cost of changing requirements, the cost of customization or the cost of the unneeded features, then the preferred system according to the conceptual fit criterion would be the one with a minimum number of such conceptual misfits. In practice, however, it is likely that users find some misfits costlier than others and therefore some weighting and judgment must be required.

4. A Method for Determining the Conceptual Fit

A straightforward approach to the solution of the general problem of determining the conceptual fit would be to consider each $S_j (j = 1, ..., n)$ separately, and determine the conceptual misfits between $U_i$ and $S_j$ as indicated in Sect. 2. This may be the only available solution in some contexts, but it is very costly. It requires knowing the $n$ conceptual schemas and evaluating $U_i$ wrt each of those schemas. When the number $n$
is large and/or the conceptual schemas are large, the evaluation effort may be large too.

However, in a context where the selection process must be performed several times with the same set of candidate systems $S_1, \ldots, S_n$ with different user requirements $U_i$, then a better solution would be to build an intermediate superschema $S$. That superschema $S$ should integrate $S_1, \ldots, S_n$ in a way such that $U_i$ and each of the $S_1, \ldots, S_n$ could be mapped to $S$, and such that the conceptual misfits of $U_i$ and each of the $S_1, \ldots, S_n$ could then be computed automatically.

Note that the superschema we propose is similar to the “reference models” used in professional organizations as “an abstract framework for understanding significant relationships among the entities of some environment, and for the development of consistent standards or specifications supporting that environment.”

One of the most prominent examples of reference model is the HL7 RIM\(^2\).

A similar idea was proposed in the “Domain-based COTS product selection method” (DBCS) [9] where a “domain model” is the common reference for the system to be developed and the existing COTS systems. In the context of schema translation, a similar idea was proposed in MIDST [1] where there is a supermodel, such that each model is a specialization of the supermodel and a schema in any model is also a schema in the supermodel.

Based on the above idea, the method we propose consists of four parts:

1. A superschema $S$ that is a union of all schemas $S_1, \ldots, S_n$ and all possible user requirements $U_1, \ldots, U_m$ in a given domain.
2. The definition of the schemas $S_1, \ldots, S_n$ in terms of $S$.
3. The definition of user requirements $U_i$ in terms of $S$.
4. The (automatic) computation of the misfits between $U_i$ and $S_1, \ldots, S_n$.

We describe these parts in the following.

4.1 The superschema

In our method, the superschema $S$ is an instance of the metamodel shown in Fig. 1 for a domain $D$ such that:

- $S$ includes the schemas of all possible COTS systems $S_1, \ldots, S_n$ in $D$.
- $S$ includes all possible conceptual user requirements $U_1, \ldots, U_m$ in $D$.

By inclusion of schemas here we mean that:

- $S$ comprises all concrete entity types, attributes and associations that may be required by $U_1, \ldots, U_m$. On the other hand, the cardinalities of the attributes and associations in $S$ must not be incompatible with those that may be required by $U_1, \ldots, U_m$.
- $S$ comprises all concrete entity types, attributes and associations that are implemented in $S_1, \ldots, S_n$. On the other hand, the cardinalities of the attributes and associations in $S$ must not be incompatible with those that are implemented in $S_1, \ldots, S_n$.

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\(^1\) OASIS SOA Reference Model (SOA-RM) TC (https://www.oasis-open.org/committees/soa-rm/faq.php)

\(^2\) HL7 Reference information model. (http://www.hl7.org/implement/standards/rim.cfm)
4.2 Mapping Conceptual Schemas of COTS Systems to the Superschema

For the purposes of conceptual fit analysis we need to know for each $S_j (j = 1, \ldots, n)$ in $D$:

- The entity types of $S$ implemented in $S_j$ and their corresponding cardinalities. We are interested only in the entity types that are concrete in $S_j$. If $S_j$ implements all subtypes of an abstract entity type $E$ in $S$, then $S_j$ also implements $E$.
- The attributes and associations of $S$ implemented in $S_j$ and their corresponding cardinalities.

Figure 2 shows the extension of the metamodel defined in Fig. 1 needed to represent the part of $S$ that is implemented by $S_j$. A COTS system is assumed to implement a set of concrete entity types (with a cardinality that may be Singleton or Unconstrained), a set of attributes and a set of associations.

Note that if $S$ includes an abstract entity type $E$ with subtypes $E_1, \ldots, E_m$ and $E$ has an attribute $A$, then a system $S_j$ that implements two or more of those subtypes could implement $A$ differently in each case. Our metamodel of Fig. 2 takes this possibility into consideration by indicating in AttributeImplementation the implemented entity type. A similar reasoning applies to the association participants.

The mapping process can be superschema-driven or system-driven. In the former, the elements of $S$ are taken in some convenient order, and for each of them it is checked whether or not it is implemented by the system. If the element is a concrete entity type that is not implemented by $S_j$ then there is no need to check the implementation of its attributes and associations. To use this process, the conceptual schema of $S_j$ needs not to be explicit; what is needed to know is what entity types, attributes and associations of $S$ are implemented in $S_j$.

In the system-driven process, the elements of the conceptual schema of $S_j$ are taken in some convenient order, and each of them is mapped to $S$. To use this process the conceptual schema of $S_j$ must be explicit.
4.3 Defining Conceptual User Requirements

For the purposes of conceptual fit analysis of $U_i$, we need to know:

- The entity types of $S$ required by $U_i$ and their corresponding cardinalities. We need to know only the entity types that are concrete in $U_i$. If $U_i$ requires all subtypes of an abstract entity type $E$ in $S$, then $U_i$ also requires $E$.
- The attributes and associations of $S$ required by $U_i$ and their corresponding cardinalities.

Figure 3 shows the extension of the metamodel defined in Fig. 1 needed to represent the user requirements in terms of $S$. It is nice to see that the extension has the same structure as that of Fig. 2. User requirements are assumed to consist of concrete entity types (with a cardinality that may be Singleton or Unconstrained), a set of attributes and a set of associations.

Note that similarly to the previous case, if $S$ includes an abstract entity type $E$ with subtypes $E_1, \ldots, E_m$ and $E$ has an attribute $A$, then if $U_i$ requires two or more of those subtypes, it could require $A$ differently in each case. The same applies to association participants.

As in the mapping of systems, the definition of user requirements can be superschema-driven or requirements-driven.

4.4 Computing Misfits

In our method, once we have defined the instance of $M$ (Fig. 1) corresponding to the superschema $S$ for a domain $D$, the instances of the candidate COTS systems $S_1, \ldots, S_n$ in $D$ and their mapping to $S$ (Fig. 2), and the instance of the user requirements $U_i$ and its mapping to $S$ (Fig. 3) we can then automatically compute the misfits between $U_i$ and $S_1, \ldots, S_n$. In what follows we explain the details of the computation in terms of the UML schemas shown in Figs. 2 and 3 and we give the formal definition of each misfit in OCL.
Entity type deficit. Let \( E \) be an entity type required by \( U_i \). There is a deficit of \( E \) in \( S_j \) if \( E \) is not implemented in \( S_j \) directly or by exclusion. There is a direct implementation when \( E \) is also an entity type of \( S_j \). There is an implementation by exclusion when there is an entity type \( E' \) implemented by \( S_j \) such that \( E' \) is a supertype of \( E_1, E_2, \ldots, E_p \) \((p > 0)\) and \( E_1, \ldots, E_p \) are not required by \( U_i \). The exclusion of \( E_1, \ldots, E_p \) by \( U_i \) implies that the population of \( E \) and \( E' \) will always be the same, and therefore \( E' \) can implement \( E \) in \( S_j \). In OCL:

```ocl
class EntityTypeDeficit:
  def isDeficit(c:COTS): Boolean
  body isImplementedBy(c) isUndefined

  where
    isImplementedBy(c) is defined:
    body
      if directImplementation(c) isNotEmpty
        directImplementation(c) isNotEmpty boolean true
      else
        if implementationByExclusion(c) isNotEmpty
          implementationByExclusion(c) isNotEmpty boolean true
        else
          oclUndefined(EntityTypeImplementation)
        endif
      endif

  and such that
    directImplementation and implementationByExclusion are:
    body
      directImplementation(c) set(EntityTypeImplementation)
      body
        c.entityTypeImplementation ->
        select(ei|ei.implementedEntityType = self.requiredEntityType)

      implementationByExclusion(c) set(EntityTypeImplementation)
      body
        self.requiredEntityType.parent.entityTypeImplementation ->
        select(ei|ei.cOTS = c and ei.implementedEntityType.child
        forAll(e|e.entityTypeRequirement ->
        select(er|er.userRequirements = self.userRequirements) -> isempty) ->
        asSet())

Entity type incompatibility. Let \( E \) be an unconstrained entity type required by \( U_i \). There is an incompatibility when \( E \) is implemented by a singleton entity type in \( S_j \). The OCL formalization is:

```ocl
class EntityTypeIncompatibility:
  def isIncompatible(c:COTS): Boolean
  body cardinality = EntityTypeCardinality::Unconstrained and
  isImplementedBy(c).cardinality = EntityTypeCardinality::Singleton

Entity type excess. Let \( E \) be an entity type in \( S_j \). There is a misfit of this kind when \( E \) does not implement any entity type in \( U_i \). In OCL:

```ocl
class EntityTypeExcess:
  def isExcess(u:UserRequirements): Boolean
  body not u.entityTypeRequirement ->
    exists(er|er.isImplementedBy(self.cOTS) = self)
Induced attribute deficit. This happens when $U_i$ requires an attribute of entity type $E$ and there is an entity type deficit between $U_i$ and $S_j$ wrt $E$. In OCL:

```ocla
context AttributeRequirement::isInducedDeficit(c:COTS):Boolean
body requiredEntityType.entityTypeRequirement->exists(er|er.userRequirements = self.userRequirements and er.isDeficit(c))
```

Attribute deficit. This happens when $U_i$ requires an attribute $A$ of an entity type $E$ that is implemented in $S_j$ but that implementation does not include $A$. In OCL:

```ocla
context AttributeRequirement::isDeficit(c:COTS):Boolean
body requiredEntityType.entityTypeRequirement->exists(er|er.userRequirements = self.userRequirements and er.isImplementedBy(c).isDefined) and self.isImplementedBy(c).isUndefined
```

where `isImplementedBy(c)` is defined in the same context by:

```ocla
isImplementedBy(c:COTS):AttributeImplementation
body let ai:Set(AttributeImplementation) = c.attributeImplementation->select(ai|ai.implementedEntityType = self.requiredEntityType)
in if ai -> notEmpty then ai->any(true) else oclUndefined(AttributeImplementation) endif
```

Attribute cardinality incompatibility. This happens when the cardinalities of an attribute required by $U_i$ are incompatible with those of its implementation in $S_j$.

```ocla
context AttributeRequirement::isIncompatible(c:COTS):Boolean
body (minCardinality = Cardinality::isZero and isImplementedBy(c).minCardinality = Cardinality::isOne) or (maxCardinality = Cardinality::Unconstrained and isImplementedBy(c).maxCardinality = Cardinality::isOne)
```

Induced attribute excess. Let $A$ be an attribute of a concrete entity type $E$ in $S_j$. There is a misfit of this kind when $E$ is an entity type excess for $U_i$. In OCL:

```ocla
context AttributeImplementation::isInducedExcess(u:UserRequirements):Boolean
body implementedEntityType.entityTypeImplementation->exists(ei|ei.COTS = self.COTS and ei.isExcess(u))
```

Attribute excess. Let $A$ be an attribute of a concrete entity type $E$ in $S_j$. There is a misfit of this kind when $E$ is an implementation of an entity type required by $U_i$ but $A$ is not implemented.

```ocla
context AttributeImplementation::isExcess(u:UserRequirements):Boolean
body implementedEntityType.entityTypeImplementation->exists(er|er.userRequirements = u and er.isImplementedBy(self.COTS).isDefined) and not u.attributeRequirement->exists(ar|ar.isImplementedBy(self.COTS) = self)
```
**Induced association deficit**\(^3\). There is misfit of this kind when \(U_i\) requires an association \(R\) between the concrete entity types \(E_1\) and \(E_2\) and there is an entity type deficit between \(U_i\) and \(S_j\) wrt \(E_1\) or \(E_2\).

**Association deficit.** There is misfit of this kind when \(U_i\) requires an association \(R\) between the concrete entity types \(E_1\) and \(E_2\) that are implemented in \(S_j\), but \(S_j\) does not include \(R\).

**Association cardinality incompatibility.** This happens when the cardinalities of an association required by \(U_i\) are incompatible with those of the implemented association in \(S_j\).

**Induced association excess.** Let \(R\) be an association between the concrete entity types \(E_1\) and \(E_2\) in \(S_j\). There is a misfit of this kind when \(E_1\) and \(E_2\) are an entity type excess for \(U_i\).

**Association excess.** Let \(R\) be an association between the concrete entity types \(E_1\) and \(E_2\) in \(S_j\). There is a misfit of this kind when \(E_1\) and \(E_2\) are implementations of entity types in \(U_i\) but \(R\) is not.

### 5. Application to the Selection of an eCommerce Platform

In what follows, we describe an exploratory experiment we performed to evaluate the feasibility, difficulty and usefulness of the application of the conceptual fit criterion in COTS selection. We assumed the requirements of a potential online shop and considered four existing ecommerce platforms: osCommerce\(^4\), Magento\(^5\), CS-Cart\(^6\), and Amazon webstore\(^7\).

#### 5.1 The Superschema

Online shop platforms have large conceptual schemas, and their complete integration into one (even larger) superschema would not be easy. However, for the purpose of COTS selection, in our method such complete integration is not necessary. It suffices to only consider those concepts (entity types, attributes and associations) that enable an effective discrimination between systems \([10]\). This means that the superschema should include the concepts that are important or critical for the users and that are not implemented by all candidate systems. In the experiment, we had available the complete schemas of osCommerce \([16]\) and

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\(^3\) Due to space constraints the OCL formalization of the association misfits is not shown, although it is similar to the one of the attribute misfits.
\(^4\) [oscommerce.com](https://www.oscommerce.com)
\(^5\) [magento.com](https://www.magento.com)
\(^6\) [cs-cart.com](https://www.cs-cart.com)
\(^7\) [services.amazon.com](https://services.amazon.com)
Magento [13] and we studied in depth the relevant parts of the other two. Based on this, we developed a super-schema consisting of 35 entity types, 82 attributes and 40 binary associations. Figure 4 shows a fragment of that super-schema. The fragment shows the kinds of products that are sold in on-line shops. Those kinds are SimpleSaleableItem (with subtypes VirtualProduct and DownloadableItem), VariantProduct (a materialization of a Model), GroupedProduct (a set of products) and Bundle (a product with options).

5.2 Mapping Conceptual Schemas of COTS Systems to the Superschema

The mapping of a candidate system to the superschema is easy for those who know (or, better, have developed) that system and are familiar with its domain. In the experiment, due to our knowledge of the superschema and the candidate systems, we used a combination of the superschema and system-driven processes.

5.3 Defining Conceptual User Requirements

In the experiment, we assumed that the user requirements were those of an arbitrary existing commercial online shop. We studied and experimented (read-only) the relevant parts of that shop. We then used a superschema-driven process to define its conceptual requirements, as indicated in Section 4.3. In total, the requirements of that shop consist of a subset of the superschema consisting of 22 entity types, 29 attributes and 18 associations.

5.4 Computing Misfits

Table 1 summarizes the number of misfits per each type found in each system, computed as indicated in Sect. 4.4. In this experiment, no entity type deficits have
Table 1. Misfits found per type in each system

<table>
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<th></th>
<th>osCommerce</th>
<th>Cs-cart</th>
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been found, and therefore there are not induced deficits. The analysis has detected a number of deficits and incompatibilities whose importance should be assessed in the selection process. Some of them may be critical. The high number of excesses of Cs-cart and Magento may indicate that they are “excessive” for the user’s needs.

6. Conclusions

We have proposed a new criterion for COTS systems selection, which we call conceptual fit. The criterion assesses the fit between the conceptual structure of a given system and of the user requirements. We have identified three kinds of misfits in the schema elements, called deficits, incompatibilities and excesses. The idea is that the degree of conceptual fit is inversely proportional to the number of misfits, the maximum being the absence of them.

In principle, the conceptual fit criterion could be taken into account by almost all existing selection methods. In particular, it is likely to be useful in methods such as PORE [11] that propose an iterative selection approach. Conceptual fit could be taken into account in the early stages of product selection, because it enables an early discrimination between candidate products.

We have formally defined the general problem of evaluating the conceptual fit between the user requirements and a set of COTS systems in some domain, and we have proposed a new method for its solution. The method consists in defining a superschema, the mapping of the conceptual schemas of the candidate systems and of the user requirements to that superschema, and the automatic computation of the conceptual misfits. We have formalized the method in UML and OCL. We have applied the method in an exploratory experiment of COTS selection in the domain of online shops to evaluate its feasibility, difficulty and usefulness, with positive results.

The main effort required by our method is the development of the superschema and the mapping of the candidate systems to it. However, this must be done only once per domain (such as online shops) and the result could be reused in all COTS selections of a domain. This fact opens the possibility for professional organizations, consulting
companies, and so on to make that effort and make the results available to all interested information systems developers.

The work reported here can be extended in several directions. We mention three of them here. The first is to take into account more conceptual constructs than those considered in the metamodel of Fig.1, such as association classes, data types or enumerations, or behavioural constructs [14]. Second, the method should be tested in a real-world project of COTS selection in order to experimentally confirm its cost effectiveness in practice. Ideally, the project could be developed in one of the domains for which there is already a superschema, such as the reference model HL7 RIM in the health care domain. Third, it could be useful to develop recommendations for the integration of the conceptual fit criterion into existing selection methods.

References