Semantic Support for Electronic Business Document Interoperability

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The Motivation of this work...

- The European Commission’s “Enterprise Interoperability Research Roadmap” foresees a “Interoperability Service Utility (ISU)”
  - “Interoperability as a utility-like capability needs to be supported by an enabling system of services for delivering basic interoperability to enterprises, independent of particular IT deployment”

- A very important component of “Interoperability Service Utility” is the interoperability of the business document instances exchanged through the service utility
- This work is being realized within the scope of the ICT 213031 iSURF Project
  - http://www.iSURFProject.eu
Talk Outline

- A Brief Overview of Electronic Business Document Standards
- UN/CEFACT Core Component Technical Specification
- Semantic Tools for Interoperability Support
  - Use of Ontologies for Semantic Annotation and Ontology Alignment
  - Document Translation
  - System Architecture and Operation
- Conclusions
The development of electronic business document standards has been evolutionary based on:

- The traditional EDI technology
- Affected by the technological developments such as the Internet and XML
- Affected by the interoperability needs of the current more dynamic eBusiness applications

No document standard is sufficient for all purposes because the requirements significantly differ:

- Amongst businesses, industries and geo-political regions
Some Example Business Document Standards

- Vertical Standards
  - RosettaNet, CIDX, PIDX, OTA, HL7, …

- Horizontal Standards
  - OAGIS, GS1 eCom, xCBL, cXML, UN/CEFACT CCL, UBL, …

- A survey and analysis of electronic business document standards investigating:
  - The document design principles
  - The use of code lists
  - The use of XML namespaces
  - How the standards handle extensibility and customization

- is available at:
    - http://www.srdc.metu.edu.tr/webpage/publications
UN/CEFACT Core Component Technical Specification (CCTS)

- The ultimate aim of business document interoperability is to
  - Exchange business data among partners without any prior agreements related to the document syntax and semantics
  - Hence support “Interoperability Service Utility (ISU)” at the content level

- Therefore, document standard need to adapt to different contexts, be extensible and customizable

- UN/CEFACT Core Component Technical Specification (CCTS) is an important landmark in this direction
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UN/CEFACT Core Component Technical Specification (CCTS)

- UN/CEFACT CCTS provides a methodology to identify a set of reusable building blocks, called Core Components to create electronic documents.

- Core Components represent the common data elements of everyday business documents such as “Address”, “Amount”, or “Line Item”.

- These reusable building blocks are then assembled into business documents such as “Order” or “Invoice” by using the CCTS methodology.

- UN/CEFACT CCTS Core Components are syntax independent.
UN/CEFACT Core Component Technical Specification (CCTS)

- Core components are defined to be context-independent so that they can later be restricted to different contexts:
  - Business Process Context
  - Product Classification Context
  - Industry Classification Context
  - Geopolitical Context
  - Business Process Role Context
  - Supporting Role Context
  - System Capabilities Context
  - Official Constraints Context
Main Features of CCTS Approach

- Business document schemas are composed of several basic and aggregate components

- Aggregate components themselves are collections of other basic and aggregate components in a recursive manner

- Standard components are modified in response to contextual needs

- When a document schema needs to be customized for a context, users need to discover or provide component versions applicable to that particular context
Why CCTS is important?

- This concept of defining context-free reusable building blocks, which are available from a single common repository, is an important innovation:
  - The incompatibility in electronic documents is incremental rather than wholesale
  - The users are expected to model their business documents by using the existing core components and by restricting them to their context with well defined rules
  - Dynamic creation of interoperable documents becomes possible because if users cannot find proper components to model their documents, they can create and publish new core components
  - The horizontal interoperability among different industries is greatly facilitated by using a single common repository and by customizing the components to different industry contexts
Some of the UN/CEFACT CCTS based Business Document Standards

- **UN/CEFACT Core Components Library (CCL) 07A**
  - 96 ACC, 212 ASCC, 636 BCC
  - 184 ABIE, 337 ASBIE, 1011 BBIE
  - 35 Datatypes

- **Universal Business Language (UBL) 2.0**

- **Open Applications Group Integration Specification (OAGIS) 9.0**

- **Global Standards One (GS1) XML**

- **All standards implement CCTS differently!**
<table>
<thead>
<tr>
<th>Action</th>
<th>Unique ID</th>
<th>Dictionary Entry Name (DEN)</th>
<th>ACC/BC/ASC/CC</th>
<th>Definition</th>
<th>Library Note</th>
<th>Object Class Term Qualifier(s)</th>
<th>Object Class Term</th>
<th>Property Term Qualifier(s)</th>
<th>Property Term</th>
<th>Representation Term</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Accounting Account, Details</td>
<td>ACC</td>
<td>An account for recording debits and credits to general accounting, cost accounting, or budget accounting</td>
<td>Accounting Account</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Accounting Account, Identification, Identifier</td>
<td>BCC</td>
<td>The unique identifier for this accounting account</td>
<td>Accounting Account</td>
<td></td>
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<tr>
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<td></td>
<td>Accounting Account, Set Trigger, Code</td>
<td>BCC</td>
<td>A code specifying a set trigger for the accounting account to be used in response to a specific event or set of events</td>
<td>Accounting Account</td>
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<tr>
<td></td>
<td></td>
<td>Accounting Account, Type, Code</td>
<td>BCC</td>
<td>The code specifying the type of accounting account such as general, main, secondary, cost accounting, budget account</td>
<td>Accounting Account</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Accounting Account, Amount Type, Code</td>
<td>BCC</td>
<td>The code specifying the amount type for a specific accounting account</td>
<td>Accounting Account</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Address, Details</td>
<td>ACC</td>
<td>The location at which a particular organization or person may be found or reached</td>
<td>Address</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Address, Identification, Identifier</td>
<td>BCC</td>
<td>A unique identifier for this address</td>
<td>Address</td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>Address, Postcode, Code</td>
<td>BCC</td>
<td>A code specifying the postcode of the address</td>
<td>Address</td>
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<td></td>
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<tr>
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<td></td>
<td>Address, PostOfficeBox, Test</td>
<td>BCC</td>
<td>The unique identifier, expressed as text, of a container commonly referred to as a box, in a post office or other postal service location assigned to a person or organization, where postal items may be sent for this address</td>
<td>PostOfficeBox</td>
<td></td>
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<td></td>
<td></td>
<td>Address, Block Name, Text</td>
<td>BCC</td>
<td>The block name, expressed as text, for an area surrounded by streets and usually containing several buildings for this address</td>
<td>BlockName</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Address, Building Number, Text</td>
<td>BCC</td>
<td>The number, expressed as text, of a building or house on a street at this address</td>
<td>BuildingNumber</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Address, Building Name, Test</td>
<td>BCC</td>
<td>The name, expressed as text, of a building, a house, or other structure on a street at this address</td>
<td>BuildingName</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Address, Room Identification, Test</td>
<td>BCC</td>
<td>The identification, expressed as text, of a room, suite, office or apartment as part of an address</td>
<td>RoomIdentification</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Address, Department Name, Text</td>
<td>BCC</td>
<td>A name, expressed as text, of a department within the address</td>
<td>DepartmentName</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Address, Floor Identification, Test</td>
<td>BCC</td>
<td>The identification by name or number, expressed as text, of a floor within the address</td>
<td>FloorIdentification</td>
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</tr>
</tbody>
</table>
The first implementation of UN/CEFACT CCTS in XML

31 Horizontal Business Document Schemas
- Invoice, Order, Dispatch Advice,…

Schemas for common reusable entities
- Amount, Payment, Item, …
The Problem continues: All CCTS based standards use CCTS differently.
How to provide interoperability among electronic business document standards?

- **Harmonization:**
  - The International Electrotechnical Commission (IEC),
  - The International Organization for Standardization (ISO),
  - The International Telecommunication Union (ITU) and,
  - The United Nations Economic Commission for Europe (UNECE)
    signed a “Memorandum of Understanding” to specify a framework of cooperation

- Up to now, OAGIS 9.0 and UBL 2.0 have achieved a level of harmonization: they are based on the same UN/CEFACT Unqualified Datatypes and Core Component Types

- However, the harmonization needs to be extended to the upper level artifacts

- An alternative: Providing semantic tool support for the interoperability of electronic business documents
Providing semantic support for the interoperability of CCTS based electronic business documents

- Within the scope of the iSURF Project, we developed tools:
  - To provide machine processable semantic representations of context domains
  - To utilize these semantics for automating tasks for the discovery, reuse and customization of components and document schemas
  - To provide a semantics based translation mechanism for the interoperability of schemas customized by independent parties
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The Motivation: Context Categories

- Eight categories have been defined for the business context.
- Specific code lists and classification schemas are suggested for each category:
  - Code lists and classification taxonomies provide context values.
  - There are other relevant classifications in use today and there may be others in future.
- Quoting from an email in the Ontolog Forum by Duane Nickull:
  "Even when the CCTS group decided to limit their context qualifier set to only 8 context aspects, they still had an almost infinite explosion of context. If you took 8 singular contexts and had only 300 enumerated values for each one, the number is so large no one group could ever possibly list all the combinations in a lifetime without computers"
Context Ontologies

- We developed Web Ontology Language (OWL) ontologies to represent taxonomy of these classifications:
  - They become machine processable
  - It becomes possible to formally specify relationships between different classifications
  - Specified relationships are interpreted by reasoners to compute additional relationships
Context Ontologies

North American Industry Classification System (NAICS)

23   Construction
236  Construction of Buildings
2361  Residential Building Construction
2362  Nonresidential Building Construction
238  Specialty Trade Contractors
2381  Foundation, Structure, and Building Exterior Contractors
2382  Building Equipment Contractors
2383  Building Finishing Contractors

<?xml version="1.0"?>
<rdf:RDF
  <owl:Ontology rdf:about="NAICS Ontology"/>
  <owl:Class rdf:ID="_23_Construction" />
    <owl:Class rdf:ID="_236_Construction_of_Buildings">
      <rdfs:subClassOf rdf:resource="#_23_Construction" />
    </owl:Class>
    <owl:Class rdf:ID="_2361_Residential_Building_Construction">
      <rdfs:subClassOf rdf:resource="#_236_Construction_of_Buildings"/>
    </owl:Class>
    <owl:Class rdf:ID="_2362_Nonresidential_Building_Construction">
      <rdfs:subClassOf rdf:resource="#_236_Construction_of_Buildings"/>
    </owl:Class>
  </owl:Class>
</rdf:RDF>
Context Based Customization

A Core Component

geo="US"

US Core Component

geo="US-CA"

California Core Component

geo="US-CA", product="shoe"

California Shoe Core Component

geo="Japan"

Japan Core Component

geo="Japan", product="shoe"

Japan Shoe Core Component
Custom components are applicable for the context hierarchy they are defined for:

- Defense, Law Enforcement & Security Equipment
- Computer Equipment & Peripherals
- Telecommunication Equipment

Product Classification

- Software
  - Database Software
  - Multimedia Software
  - Networking Software
- Hardware
  - Computers
  - Storage Devices
  - Display Devices
Context Ontologies

- We developed a tool to convert classifications to context ontologies in OWL representation:
  - Geopolitical context
    - M49, ISO-3166
  - Industrial Classification context
    - NAICS, NACE, ISIC
  - Product Classification context
    - CPC, UNSPSC

- These context ontology classes are then used to annotate customized document components.

- Note: This is in addition to defining element values through code lists.
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Annotating Components with Context Ontologies

When a component “item” is defined for the “Manufacturing” context, it becomes applicable to all subclasses in the context ontology.
Influence of Aligned Ontologies on Component Discovery and Reuse

NAICS

33 - Manufacturing

336 - Transportation Equipment Manufacturing

3364 - Aerospace Product and Parts Manufacturing

336411 – Aircraft Manufacturing

ISIC

C - Manufacturing

C-30 - Manufacture of other transport equipment

C-303 - Manufacture of air and spacecraft and related machinery
Generating Context Ontologies

- ISIC Classification
  - owl ontology
- NAICS Classification
  - owl ontology
- NACE Classification
  - owl ontology

Alignment leads to

Industrial Classification Context Ontology

Reasoning leads to

Inferred Industrial Classification Context Ontology
Aligning Context Ontologies

- A joint ontology is generated for each context category
  - Imports all ontologies relevant to that particular category
  - Allows additional ontologies to be added without effecting existing ones
  - Allows specification of correspondences between different ontologies
- Ontology alignment is to be assumed by domain experts and standard issuing bodies
- Our work focuses on how such correspondences can be exploited once they are specified
Aligning Context Ontologies

- Any OWL construct can be utilized including but not limited to:
  - Equivalence \((A \equiv B)\)
    - NACE:45-Construction, NAICS:23-Construction
  - Composition \((A \equiv B \cup C)\)
    - NAICS:11-Agriculture, Forestry, Fishing and Hunting, ISIC:A-Agriculture, Hunting and Forestry, ISIC:B-Fishing
  - Subsumption \((A \subseteq B)\)
    - NACE:CA-Mining and Quarrying of Energy Producing Materials, NAICS:211-Oil and Gas Extraction
Ontology Alignment Operations

\[(B \cup C) \equiv Y\]

\[C \subseteq Y\]
How to Annotate Components with Context Ontology: Component Metadata

- When a component is customized for a context, its metadata is created:
  - To express the standard component it is derived from, and
  - The context it is applicable to by specifying references to classes from ontologies

- When a custom version of a component is required for a specific context:
  - Component metadata is queried to gather applicable versions with the help of inferred context ontologies

- When a document schema needs to be customized for a specific context, component metadata is queried
  - To gather custom versions of components included in that schema and
  - Those versions are used to replace the original components in the customized document schema
Component Metadata

```
<UBLComponentMetadata rdf:ID="cac_Item">
    <componentURI rdf:datatype="string">http://www.srdc.metu.edu.tr/ublschema/common/UBL-CommonAggregateComponents-2.0.xsd</componentURI>
</UBLComponentMetadata>

<CustomComponentMetadata rdf:ID="Item-industry_naics_23_cnstrctn">
    <element rdf:datatype="string">srdc:industry:naics:_23_cnstrctn:ubl:Item</element>
    <typeDef rdf:datatype="string">srdc:industry:naics:_23_cnstrctn:ubl:ItemType</typeDef>
    <componentURI rdf:datatype="string">http://srdc.metu.edu.tr/customSchemaRepository/industry_naics__23_cnstrctn.xsd</componentURI>
    <applicableContext rdf:resource="string">http://srdc.metu.edu.tr/contextOntology/naics.owl#_23_Construction</applicableContext>
    <isExtensionComponent rdf:datatype="boolean">false</isExtensionComponent>
    <originalComponent rdf:resource="http://srdc.metu.edu.tr/componentRepository/ublInstances.owl#cac_Item"/>
</CustomComponentMetadata>
```
Component Discovery Service

Product Classification Context

owl:Thing

unspsc:51 Drugs and Pharmaceutical Products

unspsc:5110 Antiinfective drugs

unspsc:5112 Cardiovascular Drugs

unspsc:511015 Antibiotics

Item_A

Validity Period_D

Industrial Classification Context

owl:Thing

Item_M

naics:32 Manufacturing

naics:322 Paper Manufacturing

naics:325 Chemical Manufacturing

Item_A for Antibiotics context? Item_A

Item for Cardiovascular drugs context? Item_M

Validity Period for Antibiotics context? ValidityPeriod_D

Item for Antibiotics Manufacturing context? Item_A+M
Component Discovery and Merging

1. If there are no customized components in the parent classes, the original standard component is used
2. If there is a customized component applicable to a parent context, for example, for class B, say “C1”, this version is applicable to context class D
3. If there are customized components applicable to multiple parent context classes, for example, “C2” for class “A” and “C3” for class “C”, the context applicable to class “D”, is generated by merging the components “C2” and “C3”
Component Discovery and Merging

- Similarly, for the context class J, the components "C1", "C2", and "C3" must be merged.
Assume we wish to customize a “catalogue” to “Antibiotic Manufacturing”
Assume the customized components “ValidityPeriodD”, “itemA” and “itemM” are annotated using respective context ontology classes
The Customized “catalogue” contains the components “ValidityPeriodD”, and a merged version of “itemA” and “itemM”
Component Merge Service

- Given multiple custom versions of a component, generates a combined version
  - Derivation operations (extensions and restrictions) are extracted from individual versions
  - Extracted derivations are successively added to the base version
- Resulting component is a valid specialization of all versions in terms of UBL validation
Component Merge Service

Original Component
- Item
  - Description [0..1]
  - BrandName [0..∞]
  - OriginCountry [0..1]

Custom Component 1
- Item
  - Description [0..1]
  - BrandName [1..∞]
  - OriginCountry [0..0]

Custom Component 2
- Item
  - Description [0..1]
  - BrandName [0..5]
  - OriginCountry [0..1]
  - ID [0..1]

Merged Component
- Item
  - Description [0..1]
  - BrandName [1..5]
  - OriginCountry [0..0]
  - ID [0..1]

- BrandName ⇒ [1..∞]
- OriginCountry ⇒ [0..0]

- BrandName ⇒ [0..5]
- ID ⇒ [0..1]
Eliminating Redundancy

- Merging extension operations may cause redundancy in merged component
  - Custom versions may contain the same extension
  - Custom versions may contain structurally different yet semantically similar extensions

- UBL Component Ontology is (to be described later in the talk) utilized to discover semantic redundancy
  - In case of equivalent extensions, only one extension is added to the merged component
  - In case of subsuming extensions, only the extension corresponding to the child class is added
Eliminating Redundancy

- Assume (2) and (3) are merged to yield (4): there is redundancy

- This redundancy is automatically eliminated
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Motivation: Need for Semantic Interoperability

- Businesses operate in different contexts mandating different rules and regulations for their operations
- Improved customization mechanisms have the potential to encourage more users for tailoring schemas for their needs
- As more users adopt customized schemas, it becomes harder to maintain interoperability among the UBL Community
- A mechanism is required to support interoperability:
  - Individual communities should be free to adopt schemas that best suit their specific needs
  - Members of different communities should not need to know each others’ schemas in order to make business
UBL Communities

- Manufacturing Context
  - Manufacturer<sub>1</sub>
  - Manufacturer<sub>2</sub>

- Retailers Context
  - Retailer<sub>1</sub>
  - Retailer<sub>2</sub>

- Government Context
  - Gov. Agency<sub>1</sub>
  - Gov. Agency<sub>2</sub>

Translators
Semantic Translation Mechanism

- A semantic translation mechanism is developed
- This mechanism is based on a UBL Component Ontology which represents structure and semantics of components
- Component Ontology is processed by reasoners to compute further relationships between components
- These relationships are interpreted to adapt document content between different schemas
UBL Components

```xml
<xsd:element name="Order" type="OrderType" />
<xsd:complexType name="OrderType">
  <xsd:sequence>
    <xsd:element ref="IssueDate" />
    <xsd:element ref="Buyer" />
    <xsd:element ref="SellerParty" />
    <xsd:element ref="OrderLine" />
  </xsd:sequence>
</xsd:complexType>

<xsd:element name="FamilyName" type="FamilyNameType" />
<xsd:complexType name="FamilyNameType">
  <xsd:simpleContent>
    <xsd:extension base="udt:NameType"/>
  </xsd:simpleContent>
</xsd:complexType>
```
UBL Component Ontology

Business concepts such as PostalAddressConcept, DeliveryAddressConcept, specifying concepts represented by UBL components

Data Type

Aggregate Type

Basic Type

Type Definition

Element Declaration

Concept

extendBasicType

isA

isOfType

referElement

representConcept
UBL Component Ontology

- Classes are defined in terms of relations with other classes
- Existential restriction construct of OWL is used to specify those relations

  - aBasicType ≡ (BasicType ∩ (∃extendBasicType. aDataType))

  - anAggregateType ≡ (AggregateType ∩ (∃referElement. (anElement₁ ∩ .. ∩ anElementₙ)))

  - anElement ≡ (ElementDeclaration ∩ (∃representConcept. aConcept ∩ ∃isOfType. aType))
UBL Component Ontology

OrderType ≡ (AggregateType ∩ (∃referElement. (IssueDate ∩ Buyer ∩ SellerParty ∩ OrderLine)))

Any AggregateType that has referElement relationship with IssueDate and Buyer and SellerParty and OrderLine is an OrderType

Order ≡ (ElementDeclaration ∩ ∃representConcept.OrderConcept ∩ ∃isOfType. OrderType)

Any ElementDeclaration that has a representConcept relationship with OrderConcept and isOfType relationship with OrderType is an Order

FamilyNameType ≡ (BasicType ∩ (∃extendBasicType. udt:NameType))

Any BasicType that has an extendBasicType relationship with udt:NameType is a FamilyNameType
Computing Translations

- For a human being, the similarity between Order and CustomOrder is obvious
- Component Ontology expressions describe components in a machine processable manner so that automated processes can compute the relationship between Order and CustomOrder
Computing Translations

1. Order ≡ (ElementDeclaration ∩ (∃representConcept. OrderConcept) ∩ (∃isOfType. OrderType))
2. OrderType ≡ (AggregateType ∩ (∃referElement. (IssueDate ∩ Buyer ∩ SellerParty ∩ OrderLine))))
3. Buyer ≡ (ElementDeclaration ∩ (∃representConcept. BuyerConcept) ∩ (∃isOfType. PersonType))
4. PersonType ≡ (AggregateType ∩ (∃referElement. (FirstName ∩ FamilyName)))
5. FirstName ≡ (ElementDeclaration ∩ (∃representConcept. FirstNameConcept) ∩ (∃isOfType. FirstNameType))
6. FirstNameType ≡ (BasicType ∩ (∃extend. TextType))
7. FamilyName ≡ (ElementDeclaration ∩ (∃representConcept. FamilyNameConcept) ∩ (∃isOfType. FamilyNameType))
8. FamilyNameType ≡ (BasicType ∩ (∃extend. TextType))
9. CustomOrder ≡ (ElementDeclaration ∩ (∃representConcept. OrderConcept) ∩ (∃isOfType. CustomOrderType))
10. CustomOrderType ≡ (AggregateType ∩ (∃referElement. (IssueDate ∩ Customer ∩ SellerParty ∩ OrderLine))))
11. Customer ≡ (ElementDeclaration ∩ (∃representConcept. BuyerConcept) ∩ (∃isOfType. CustomPersonType))
12. CustomPersonType ≡ (AggregateType ∩ (∃referElement. (Name ∩ Surname)))
13. Name ≡ (ElementDeclaration ∩ (∃representConcept. FirstNameConcept) ∩ (∃isOfType. NameType))
14. NameType ≡ (BasicType ∩ (∃extend. TextType))
15. Surname ≡ (ElementDeclaration ∩ (∃representConcept. FamilyNameConcept) ∩ (∃isOfType. SurnameType))
16. SurnameType ≡ (BasicType ∩ (∃extend. TextType))

17. FirstNameType ≡ NameType (6 and 14)
18. FirstName ≡ Name (5, 13 and 17)
19. FamilyNameType ≡ SurnameType (8 and 16)
20. FamilyName ≡ Surname (7, 15 and 19)
21. PersonType ≡ CustomPersonType (4, 12, 18 and 20)
22. Buyer ≡ Customer (3, 11 and 21)
23. OrderType ≡ CustomOrderType (2, 10 and 22)
24. Order ≡ CustomOrder (1, 9 and 23)
Translatability

- Equivalence relationship between Component Ontology classes is an indication of structural and semantic similarity between corresponding components
  - It is possible to translate content between such components

- Class-subclass relationship between Component Ontology classes is an indication that corresponding components are semantically similar and structurally subsuming
  - It is possible to translate all content from subsuming component to the other, but some of the content cannot be translated back
Talk Outline

- A Brief Overview of Electronic Business Document Standards
- UN/CEFACT Core Component Technical Specification
- Semantic Tools for Interoperability Support
  - Use of Ontologies for Semantic Annotation and Ontology Alignment
  - Document Translation
  - System Architecture and Operation
- Conclusions
System Architecture

User Tools
- Context Ontology Registration Tool
- Extension Component Definition Tool
- Component Customization Tool
- Document Schema Customization Tool
- Document Translation Tool

Service Layer
- Component Registry Service
- Component Discovery Service
- Document Schema Customization Service
- Component Merge Service
- Document Translation Service

Reasoning Layer

Knowledge Base
- Context Ontology Metadata
- Component Metadata
- UBL Component Ontology
- Component Repository
Component Registry Service

- Component Registry Service maintains knowledge base constructs:
  - Component Repository: XSD definitions for standard, custom and extension components
  - Component Metadata: Metadata definitions in OWL to facilitate component discovery
  - Component Ontology: DL definitions in OWL that support translatability computations
Component Merge Service

- Given multiple custom versions of a component, generates a combined version
  - Derivation operations (extensions and restrictions) are extracted from individual versions
  - Extracted derivations are successively applied to the original component version
- Resulting component is a valid specialization of merged versions in terms of UBL validation
Document Translation Service

- Translation is accomplished by traversing the original document in a top-down manner. For every element:
  - First the corresponding UBL Component is gathered
  - Then the Component Ontology class representing that component is located
  - Then the corresponding Component Ontology class applicable for the target context is computed:
    - First equivalent classes are checked
    - Then sub-classes are checked
    - Finally super-classes are checked
  - If an applicable component can be computed, a corresponding element is added to the target document
  - If an applicable component cannot be computed, original element is added to the UBLExtension hierarchy of the target document
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Conclusion

- Specific contributions of our work:
  - Annotation of components using classes from context ontologies
  - Development of context ontologies for the formal representation of business context domains
  - Facilitating the discovery, reuse and customization of components
  - Development of a component ontology to represent structure and semantics of components
  - Utilization of the ontology for the computation of similarities between components
  - Providing a prototype implementation for the realization of our approach
Thank you very much for your attention!

Questions?
Extra Slides: Improving the Performance of the Translation Process
UBL Component Ontology

- UBL aggregate types are composed of numerous elements
- Not all elements are significant for determining translatability
  - All mandatory elements are considered significant and automatically defined in component ontology expressions
  - It is expected from users to specify which optional elements are to be considered as significant for translatability computations
UBL Component Ontology

```xml
<xsd:complexType name="EndorsementType">
  <xsd:sequence>
    <xsd:element ref="DocumentID" minOccurs="1" maxOccurs="1"/>
    <xsd:element ref="ApprovalStatus" minOccurs="1" maxOccurs="1"/>
    <xsd:element ref="Remarks" minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element ref="EndorserParty" minOccurs="1" maxOccurs="1"/>
    <xsd:element ref="Signature" minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>

EndorsementType ≡ (AggregateType \[∃\]referElement.(DocumentID \[∩\] ApprovalStatus \[∩\] EndorserParty))
```

- This allows translatability computations to consider only significant elements
  - Improves outcome and performance of translatability computations