

UML vs. IDEF: AN ONTOLOGY-ORIENTED COMPARATIVE STUDY IN VIEW OF BUSINESS MODELLING

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Abstract: The UML and IDEF sets of languages characterize typical modelling approaches of software engineering and computer integrated manufacturing, respectively. This paper presents a comparative analysis of these languages based on their ontologies and in view of their use in business modelling. A brief introduction to UML and IDEF is followed by a high-level comparison taking into account underlying paradigms and language structure. This is followed by a comparative assessment of the expressive power of the two groups of languages, based on the ontologies of their relevant components. The analysis is structured using a set of views deemed appropriate for the modelling domain (i.e. business). The key findings of this paper aim to provide an insight into the suitability of UML 'versus' that of IDEF in business modelling.

1 INTRODUCTION¹

The survival of businesses in today's demanding global market greatly depends on their *agility*, i.e. their capability to respond adequately and timely to changes in the environment. Agile businesses typically *thrive* on such changes by implementing their own, continuous internal transformation processes.

Business models help promote a deep understanding of the business and can support its operation². A business model is based on an *ontology of change* and as such it is an enabler of business agility. Business modelling aims to produce models that accurately reflect aspects of the business required for the intended use of the models, and which are understood by the target audience. Thus, the models must strike a balance between complexity and expressiveness, reflected in the choice of modelling frameworks, languages and methodologies involved in the modelling effort.

The complexity of the modelled targets often brings about the necessity to use a *set* of candidate

languages for developing business models. Also, the often-perceived failure of the software system to accurately reflect the business that it supports has resulted in calls for the same set of languages to be used in modelling both the business and its information system.

This paper makes a contribution towards an ontology-oriented comparison of the suitability and expressive powers of two candidate sets of languages for the purpose of business modelling, namely the Unified Modelling Language (UML) and the Integrated Definition (IDEF) family of languages. Both sets of languages may be used to model aspects of a business, although they provide different degrees of support for the various views involved in the business modelling effort. This comparative analysis intends to help the enterprise architect understand the available options, and thus make an informed choice of modelling languages for a specific business engineering task.

¹the full version of this paper with additional comparison aspects and a proposed assessment framework may be obtained from the author (<http://www.cit.gu.edu.au/~noran>)

²e.g. by means of model-based control

2 INTRODUCTION TO IDEF AND UML

2.1 IDEF

The IDEF (originally an acronym for ICAM DEFinition) family of languages has its origins in the 1970's US Air Force Integrated Computer Aided Manufacturing (ICAM) program, which aimed to create computer-implementable modelling methods for analysis and design (Menzel and Mayer, 1998). As shown in Table 1, after the initial project which yielded IDEF0 (NIST, 1993a; IEEE, 1998), IDEF1 and IDEF2, there have been another two initiatives that have produced IDEF1X (IDEF1 eXtended) (NIST, 1993b), and IDEF3 (Mayer et al., 1993), IDEF4 and IDEF5, respectively.

The current efforts within IDEF are focused on the refinement and integration³ of the existing languages, and the development of few others (see Table 1).

The currently most used IDEF languages are IDEF0, IDEF1X and IDEF3. A complete introduction to the IDEF family of languages is beyond the scope of this paper, but comprehensive IDEF information is available⁴.

Table 1: The IDEF languages (based on (Cho, 2000))

Project	Language	Purpose
1 st Generation (Original ICAM Project)	IDEF0	Function (activity) Modelling
	IDEF1	Information modelling
	IDEF2	Simulation Modelling
2 nd Generation. (USAF Integrated Info Support System Project)	IDEF1x	Data modelling
3 rd Generation (USAF Integrated Information for Concurrent Engineering Project)	IDEF3	Behaviour modelling (Process description capture)
	IDEF4	Object-oriented design
	IDEF4++	C++ Object-oriented design
	IDEF5	Ontology description capture
In Development	IDEF6	Design Rationale Capture
	IDEF8	Human-System Interaction Design
	IDEF9	Business Constraint Discovery
	IDEF14	Network Design
Envisaged	IDEF7	Information System Auditing
	IDEF10	Implem. Architecture Modelling
	IDEF11	Information Artifact Modelling
	IDEF12	Organizational Design Method
	IDEF13	3-schema Archit Design Method

³hence the IDEF acronym shift from ICAM DEFinition to Integration DEFinition

⁴white papers on IDEF languages and methods are currently available on www.ideal.com and www.kbsi.com.

2.2 UML

The Unified Modelling Language (UML) originates in three modelling method streams, represented by Booch (Booch, 1991), Jacobson (Jacobson, 1994) and Rumbaugh (Rumbaugh et al., 1991). UML has been subsequently complemented by the Unified Process (Jacobson et al., 1999) - a software development methodology based on an iterative development paradigm.

The UML is a set of essentially graphical languages expressed as diagrams. The component languages (refer Table 2) reflect the history of UML: created by unification, rather than competition⁵. Despite their syntax and semantics being defined in a set of meta-models (Rumbaugh et al., 1999) and associated semantics (OMG, 1999b), the languages composing the UML are not completely formalised, and hence subject to interpretation⁶. A comprehensive description of UML is beyond the purpose of this paper⁷.

Table 2: UML language components

UML Diagram	Purpose	Comments
Class	Structure modelling	
Object	Structure (particular) modelling	Derived from Class
Use Case	Function modelling	High-level
Sequence	Behaviour modelling	Equiv to Collaboration
Collaboration	Behaviour modelling	Equiv. to Sequence
State(chart)	Behaviour modelling	
Activity	Behaviour / Function modelling	Use subset for function modelling
Component	Implementation modelling	Software-specific
Deployment	Environment (config.) modelling	Software-specific

3 A HIGH-LEVEL COMPARISON

3.1 Evolution

Both sets of languages have appeared at a suitable time⁸ and have had industry endorsement, either via

⁵e.g. it has been argued that some of the UML languages are somewhat redundant or overlapping in their scope.

⁶precise UML (pUML, <http://www.puml.org>) is one initiative that aims to address such issues.

⁷for more information refer (Rumbaugh et al., 1999)

⁸IDEF has answered a need for computer implementable Analysis and Design modelling methods/languages in man-

government specification (IDEF) or merging of modelling methods through developer, and end user participation in a consortium (in the case of UML). IDEF has preceded UML by nearly a decade, and while as such it has had more time to mature, it has also needed to adapt to historic changes in modelling requirements. The ICAM project developing IDEF has initially produced three languages aiming to model the static, informational and dynamic aspects. However, various changes in the usage of analysis and design paradigms (such as a shift from Data- and Function Driven to Object-Oriented) has prompted a refinement of existing languages and the addition of several new members to the IDEF family.

Currently, the IDEF suite numbers 16 languages, of which 6 are actively used. It appears that some languages have subsumed the scope of others (e.g. IDEF3 has obsoleted IDEF2⁹ and contains IDEF5 elements; IDEF4 contains IDEF6 elements, and IDEF9 appears to have included most of IDEF6's scope).

UML has started with a total of 9 diagram types (languages), which have received minor revisions. A formal constraint language has been developed for and included with UML. This has opened the way towards removing some of its original ambiguities, which also plagued its metamodel description. A modelling process has been developed for the UML users, and several extensions have been developed by third parties for specific domains such as business modelling, user interface design, etc, in effect creating extended modelling languages of which UML is a common subset. Notably, several such customizations are based on ontologies of the IDEF family of languages (such as e.g. the IDEF0-based extension to the UML activity diagram for function modelling (Eriksson and Penker, 1999)).

3.2 Modelling Approach

UML is based on the Object-Oriented Analysis and Design (OOAD) (Shlaer and Mellor, 1988) method; this strongly suggests the UML user to follow an OO design method.

In IDEF, the business architect may choose to use IDEF0, IDEF1/IDEF1X, IDEF3 and IDEF5 for Data- and/or Function-driven analysis and design, or to use such languages in order to *enhance* an OOAD performed in IDEF4¹⁰ (Mayer et al., 1995), which is similar to Rumbaugh's Object Modelling Technique

ufacturing, while UML has addressed calls for an integrated OOAD set of languages in software engineering.

⁹IDEF3 covers features of IDEF2, such as simulation

¹⁰IDEF4 allows the migration of existing IDEF analysis / design models to an object-oriented form.

(Rumbaugh et al., 1991). Thus, the IDEF family gives the user flexibility in the choice of the analysis and design languages and modelling methods (although currently, IDEF's OO extensions are not widely used or supported by modelling tools).

The IDEF family of languages offers components (languages with associated methods) which allow taking a holistic approach to business modelling (such as representing business artifacts in the context of life cycle phases). On the UML side, the Unified Process may also provide a life cycle modelling methodology.

3.3 Language Structure

A set of *integrated* languages must be based on a common metamodel that guarantees the consistency of its components. The syntax and semantics of the IDEF languages are separately described in their associated documentation; however, IDEF developers have not published a common metamodel underlying the component languages. This is a significant drawback, as typically the modelled business views are mutually dependent. For example, the inputs / outputs of an activity modelled in IDEF0 may be further detailed in an IDEF1X data model. Activities modelled in IDEF0 may also appear as Units of Behaviour (UoBs), or as triggers for changes of states in IDEF3 process flow and state transition models respectively. As there appears to be no formal metamodel to enforce consistency between the IDEF languages, a tool or set of tools implementing several IDEF components (e.g. IDEF0, IDEF1X and IDEF3) would have to provide its own internal constraints to ensure coherence between the views modelled in these languages¹¹.

In contrast, UML does have a common framework underlying its languages and binding together the diagrams describing the various views constructed using these languages. The component languages are described in metamodels organised into a collection of packages, which together form a unified UML metamodel. Thus, a modelling tool claiming UML compliance should be based on the UML metamodels and semantics, as detailed in (OMG, 1999b).

The UML specification allows for its extension and customization, which, when performed according to a structured process recommended by the Object Management Group¹², leads to UML *profiles* tailored for a particular domain. This feature provides flexibility but must be used with caution. Any extension to the UML is in fact modifying its metamodel and hence,

¹¹a few modelling tools (e.g. Computer Associates' ER-Win/BPWin) do allow some integration of IDEF0, IDEF1X and IDEF3 models.

¹²OMG is the UML custodian, at www.omg.org

its *meaning* to the intended audience. Thus, any such modification must be properly documented and supported by a glossary, metamodel and preferably have its semantics defined by a First Order Logic (FOL) language; this will ensure that the models created with the customised language are still comprehensible to the target audience.

4 A VIEW-BASED COMPARISON

4.1 Choice of Views

Typical modelling views proposed by the software engineering discipline (Si-Alhir, 1998) include Structural, Behavioural, User, Implementation and Environment.

Table 3: Possible mapping of the views proposed by Software Engineering and Manufacturing

Manufacturing	Software Engineering
Function (Activity, Decision, Behaviour)	Behavioural / User
Information	Structural
Resource	Structural
Organisation	Structural
-	Environment
-	Implementation

Manufacturing and industrial automation propose their own specific views, such as Function, Information, Resources, Organisation, Manufacturing vs. Control, Human vs. Non-human and Software vs. Hardware (ISO/TC184/SC5/WG1, 2000).

The main requirement in the final selection of business modelling views (shown in the left-hand side of Table 3) has been that together, the chosen views should be able to produce models usable by an analysis and design process.

4.2 Ontology Capture

Capturing the ontology of a domain (e.g. business) is a crucial step towards its effective modelling. Note that generally, an *ontology* can be defined either to be just a terminology (described e.g. by a meta-schema), or to contain a theory (composed of terminology, axioms, constraints and inference rules) and operational semantics. Thus, an information / data modelling language may be employed to capture terminology (and

simple constraints such as cardinality / participation) for an ontology, although it may reach its expressive power limits¹³. Axioms, complex constraints and inference rules must then be defined using an FOL language.

UML does not provide a dedicated language for ontology capture. However, UML class diagrams (with or without extensions) can be used to partially represent ontologies¹⁴ (Cranefield and Purvis, 1999), while the Object Constraint Language (OCL) (OMG, 1999a; Warmer and Kleppe, 1998) may be employed to represent the axioms and more complex constraints. Similarly, IDEF1 / IDEF1X may be used for the purpose of partial ontology capture (with limitations similar to UML class diagrams), complemented by an FOL language such as Conceptual Graphs (Sowa, 1998) or UML's OCL.

IDEF5 is a specialised set of languages for the capture and construction of ontologies (Gruber, 1993). This IDEF component uses a schematic language (resembling an information modelling language) for a first-cut ontology capture, and a more precise FOL elaboration language (based on the Knowledge Interchange Format (Genesereth and Fikes, 1992)) for describing axioms, constraints and inference rules. The IDEF5 specification also includes a methodology for capturing ontologies (Mayer et al., 1994).

In conclusion, IDEF5 raises the expressive power of the IDEF family for the purpose of ontology modelling, while on the UML side formal extensions such as ontology capture profiles may enhance UML's capacity to capture ontologies.

4.3 Information / Data

Information is an essential and well-understood aspect of business modelling. Information/data¹⁵ modelling is typically performed at several levels (such as conceptual, logical, physical¹⁶) before the resulting models are implemented in the information system supporting the business. The comparative analysis of IDEF and UML for information modelling purposes must take into account such modelling levels, the implementation and final purpose of the data models, and other environmental constraints (such as the supporting infrastructure).

¹³ conversely, an ontology capture language may be used to model information / data, albeit in a less efficient manner.

¹⁴UML is already used in database schema and knowledge models design (Schreiber, 1999)

¹⁵in this context, data is seen as objective facts composing the Universe of Discourse, while information is the subjective meaning associated to the data by users.

¹⁶presently there is no unanimously accepted terminology describing data modelling levels.

Data modelling may be performed in UML using its OO-based class diagrams, which contain entities that may also encapsulate *operations*. Within IDEF, the IDEF1 (information capture and modelling) and especially IDEF1X (data modelling) languages, both based on the Entity Relationship (ER) model (Chen, 1999) and early relational work by Codd (1970), have traditionally been used to model information and data.

Specific concepts of IDEF1X and UML class diagrams (such as primary/foreign keys, weak entities and relationships vs. object surrogate keys (OIDs), qualified and basic associations) reflect their different underlying paradigms, but provide equivalent expressive power to the two languages. A specific feature of the UML class diagrams (owing to the OO paradigm) is their ability to express *functional* aspects of the entities (classes) represented. This capability allows class diagrams to be more expressive than IDEF1X if needed, e.g. to represent constraints and triggers.

For a relational database application, IDEF1X may be used to model data at conceptual and logical levels; any special constraints can then be represented by text or an FOL language. The resulting model may then be represented at physical level in a relational data definition language (such as the Structured Query Language - SQL) and implemented in the relational database. If UML class diagrams have to be involved in modelling the conceptual and logical levels, an OO to relational mapping should take place at logical level, so that the result can still be implemented in the relational database.

For an OO database application, the use of UML class diagrams at the conceptual and logical levels would facilitate the implementation of the resulting model(s) in an OO data definition language. In this OO-constrained scenario, IDEF1X may also be used for modelling at conceptual and logical levels; however, the result must be subjected to a relational to OO mapping¹⁷, resulting in an UML class diagram (or another OO modelling language) model at logical level.

In the relational implementation scenario, UML's additional expressiveness is not fully utilised; thus, IDEF1X may be a better choice, since it would not require any additional mappings. Constraints (such as referential integrity) will be represented in an IDEF1X implementation by stored procedures and triggers. In the OO implementation alternative, UML class diagrams are an obvious choice since no additional mappings are needed and classes (and functionality) implemented in the OO database may be easily

¹⁷attempts to define object-oriented extensions for IDEF1X, ((Bruce, 1992), IDEF1X97) towards the purpose of facilitating a transition from ER to OO have had little impact, in view of the development of UML and IDEF4.

traced back to the conceptual level.

Both UML class diagrams and IDEF1X have expressiveness and consistency drawbacks. For example, the IDEF1X notation meaning is dependent on the context (with potential ambiguity and complexity consequences¹⁸). The UML class diagrams on the other hand allow distinct Object IDs for duplicate objects, which may create data redundancy problems¹⁹. Both UML class diagrams and IDEF1X are restricted to expressing binary relations / associations, but since a ternary and higher order relation can always be turned into an 'objectified' entity or class, this does not limit the expressive power of either UML or IDEF1X.

Table 4: Information / Data view comparison

Language	Advantages	Shortcomings
IDEF1 / IDEF1X	Data Driven, wide use for RDBMS	Notation may be confusing to users
IDEF4 Link / relationship	Expressive, bridge for ER to OO or hybrid	Relation to IDEF1X not straightforward
UML Class	Expressive, wide use for OO DB	Surrogate keys, bundles data and function

The IDEF4 Static models contain relationships and links diagrams which are similar in meaning to IDEF1X, However, IDEF4 static models also contain inheritance and sub-typing diagrams which are similar to the UML class diagrams concepts (and thus provide an object-oriented modelling mechanism with a comparable expressive power). Thus, the structure of IDEF4 static models (based on both the OO and relational models) and the connection to IDEF1 / IDEF1X allows it to also be employed in hybrid (object-relational) database development. In addition, IDEF4 facilitates the mapping of ER data models developed in the analysis/design phases to OO designs (while all necessary models are contained and expressed in IDEF4).

Scope and space limitations do not allow a discussion in depth of all aspects involved in modelling business information and data.

¹⁸e.g. in IDEF1X different symbols for a relationship's optionality are used depending on its cardinality; thus, a symbol cannot represent independently the optionality and cardinality of the entity next to it, but rather their *combination* (Hay, 1995)

¹⁹for further details refer to (Ettlenger, 1999)

4.4 Function

In the context of this paper, Function modelling is understood to subsume Activity and Behaviour (or Process) modelling, whereby the behavioural aspect further details and enriches the activity perspective (e.g. with temporality, sequencing, states, etc).

4.4.1 Activity

This view of the business aims to describe the activities involved in the business (the 'what'), seeking to abstract from the temporal aspect (i.e. succession, duration, concurrency, etc). It is a well-understood and researched aspect which appears in the large majority of analysis and design methods.

Table 5: Activity view comparison

Language	Advantages	Shortcomings
IDEF0	Decomposable, ICOMs	Notation may be confusing
UML Use Case	Decomposable, Low complexity, comprehensible	Low expressive power. Needs detail and/or extensions
UML Activity	Decision points, roles	Only subset usable (disable timing features)

Note that the *decisional* aspect of a business may be considered a specialisation of the activity sub-view. Thus, an activity modelling language may be used to model decisions. Specialised languages, more expressive for the purpose of decisional modelling do exist²⁰, however they are beyond the scope of this paper.

The UML component which is typically used to detail the activity view of a business is the *use case*. Use cases may be further decomposed and detailed (or extended) to increase their expressive power (which may, however, also result in high complexity). A subset of the UML activity diagram may also be used for activity modelling, provided that it contains no timing-related features (such as synchronization or explicit sequencing). Activity diagrams may be arranged into 'swimlanes' so that they can be attributed to 'roles' (performers). Moreover, hybrid diagrams are possible in UML (e.g. showing outputs for activities). Such features enhance the UML diagrams expressivity, although they should be properly explained to the users and used in a consistent manner.

The IDEF component used for activity modelling is IDEF0. Its ontology originates in the Structured

²⁰notably, GRAI Grids / Nets (Doumeingts et al., 1998)

Analysis Design Technique (Ross, 1987). IDEF0 diagrams contain Activities, which take ICOMs (Inputs, Outputs, Controls and Mechanisms) and can be decomposed in further IDEF0 diagrams. However, IDEF0 lacks decision points and the possibility of expressing roles (Arnesen and Krogstie, 2002); in addition, some elements of its graphical notation may be confusing²¹.

Such specific features of IDEF0 and UML activity diagrams *may* enhance the expressiveness of a business model produced within a specific modelling scenario, depending on the particular expressive power needs.

4.4.2 Behaviour

Behaviour is expressed in business modelling via *processes* - ordered sequences of events aiming to achieve a business outcome, usually within a *scenario*.

UML provides use case diagrams for the high-level definition of scenarios, and activity diagrams to detail them. Sequence, Collaboration and State(chart) diagrams may then be used to further specify behavioural models. In UML, dynamic behaviour may also be modelled in other diagrams; e.g. a class diagram may contain invariants for active classes (or for the whole model), pre-post conditions on operations of active classes, concurrency properties of operations, or signal reception specifications. Significant semantic variation points in the UML are related to dynamic behaviour (such as statechart event queue handling). Sequence and collaboration diagrams are semantically equivalent (depict object cooperation in a behaviour (Fowler and Scott, 2000)).

Behaviour is modelled in IDEF via IDEF3, which captures precedence and causality relations between situations and events; a process is a structured collection of activities related to one another by the temporal constraints. IDEF3 contains decomposable Process Flow Descriptions (PFDs, process-centric) and Object State Transitions Descriptions (OSTDs, an object-centric model of behaviour). An IDEF3 PFD diagram usually covers a single use case scenario, which is consistent with the typical coverage of an UML sequence or collaboration diagram. This coverage equivalence facilitates a meaning-based (Larson, 1998) translation of an IDEF3 diagram to an UML sequence or collaboration diagram and viceversa. The IDEF4 Dynamic model provides state diagrams and client-server diagrams, which are similar to the UML state diagrams and collaboration diagrams, respec-

²¹such as the difference between Inputs and Controls, or the meaning of tunnelled and bundled ICOMs

tively. The IDEF4 and UML state diagrams use common concepts, such as events (to trigger state transitions) and messages (to depict object collaboration). IDEF4 also provides a specialised behaviour diagram, describing implementation of messages in methods of objects. Its notation is similar to the IDEF4 inheritance diagrams and can thus be confusing.

UML activity diagrams are closest in their meaning to the IDEF3 Process Flow Diagrams. Both languages allow for decision points and synchronization. IDEF3 PFD's Units of Behaviour are decomposable, allowing the modeller to achieve a balance between expressiveness and model complexity suited to the specific modelling purpose.

UML collaboration / sequence diagrams and IDEF4 client-server diagrams express essentially the same concept, i.e. how objects work together within a given scenario. IDEF4 client-server diagrams can represent object roles and attributes, while UML sequence / collaboration diagrams are able to represent conditions, loops and nesting of the messages sent between objects.

Table 6: Behaviour view comparison

Language	Advantages	Shortcomings
IDEF3 PFD	Decomposable	Hybrid
UML Activity	Decision points, roles	Hybrid notation potentially confusing
IDEF4 Client - Server	Object roles, attributes	Complex for large use cases
IDEF4 Behaviour	Expressive for methods	Potentially confusing notation
UML Collab / Sequence	Conditions, loops, nesting	Complex for large use cases
IDEF3 OSTD	Junctions, UOB references	Complex for large use cases
IDEF4 State	Synch, object communication	Potentially confusing notation
UML State	Decomposable, history, variables, triggers, activities	Complex for large use cases

UML state diagrams, IDEF3's OSTDs and IDEF4 state diagrams are all based on the Harel State Charts (Harel, 1987). UML state diagrams can represent triggered or triggerless transitions and atomic, composite- and history states²². In addition, UML states can contain embedded variables and activities (usable to connect to corresponding UML timed ac-

²²i.e. composite states that remember their active sub-states when the object them (Rumbaugh et al., 1999).

tivity diagrams). IDEF3 OSTDs allow the representation of the triggering activities as IDEF3 UoBs, enabling a direct connection to the IDEF3's Process Flow Diagrams. Thus, IDEF3 PFDs and OSTDs can represent activity-centric and object-centric views of the modelled business behaviour within the same use case. IDEF4 state diagrams can describe synchronous / asynchronous messages but also object communication, similar to UML sequence and collaboration diagrams. Table 6 synthesises these findings.

4.5 Resources

Business resources may be either information or other artefacts - abstract (e.g. organisational unit), or physical (human or non-human, e.g. items).

The expressive power of UML class diagrams may be enhanced for resources modelling by standard extensions like stereotypes (e.g. <<Physical >>, <<People >>, etc), tagged values and constraints, or by specialised (resource-type) UML profiles (as shown in Section 3.3). The use of UML at conceptual and logical levels would facilitate an OO implementation of the resources database.

IDEF1/IDEF1X or IDEF4 static diagrams may be used for resource modelling in a similar way to the Information / Data view. The expressive power of these languages may be enhanced by First Order Logic (FOL) expressions or text at the conceptual / logical level (which will be translated into stored procedures / triggers at the physical level in a relational resources database implementation).

Table 7: Domain / view-based coverage of languages

Domain / View							
Modelling Language		Ontology capture	Functional				
			Activity	Behaviour			
				Process	State		
UML	Class, Extensions	Use Case, Activity	Activity, Sequence / Collaboration	State			
IDEF	IDEF3, IDEF5	IDEF0	IDEF3 PFD, IDEF4 Behaviour, Client-Server	IDEF3 OSTD, IDEF4 State			
Domain / View							
Modelling Language		Information	Resource	Organisation	Life Cycle	Modelling Method	
		UML	Class	Class	Use Case, Class, Extns	-	Unified Process
		IDEF	IDEF1, IDEF1X, IDEF4 Link / Relational	IDEF1, IDEF1X, IDEF4 Link / Relational	IDEF8	IDEF6, IDEF9	Included in Language Specs

4.6 Organization

The organisational aspect of businesses is typically not as well-understood as e.g. its functional, or in-

formational facets. This makes organizational design of a business a non-trivial exercise, which requires expertise and substantial effort. To assist in this endeavour, various organisational patterns, essentially representing reusable organisational reference models, (Eriksson and Penker, 1999; Keidel, 1999) have been developed.

Typically, the business organisation view may be obtained by mapping the resources (the *who*) on the activities of the business (the *what*). This view may even be considered a specialisation of the resources view (where only resources that can *do* things are represented). The organization model aims to show resource allocation, reporting methods and task assignments.

Thus, business organisation may be modelled by using UML class / object diagrams, or IDEF1X and IDEF4 static diagrams, where for example classes (or entities) are stereotyped to (or named as) organizational units. IDEF12 (as shown in Table 1) is a member of IDEF family specialised for organisational design²³; as for the UML, generic or specialised extensions may be used to enhance organisational models. A relational patterns repository may be modelled using e.g. IDEF1X, while a knowledge base containing facts and rules (representing patterns) may be modelled using UML class diagrams.

Other business organization aspects such as organizational behaviour, or the structure of decision centres²⁴ may be modelled by representing organizational units in the Behaviour view, or the Activity view respectively.

5 CONCLUSIONS

This paper has performed an ontology-oriented analysis of the IDEF and UML sets of languages for the purpose of business modelling²⁵.

The expressive power of languages greatly depends on the theoretical models underlying their components. Some such models are limited²⁶ in their expressive power by their focus on a particular aspect of the Universe of Discourse.

Extending a language with constructs and rules suitable for specific modelling areas is likely to augment its expressive power. However, such extensions must be properly documented, to ensure an unambiguous meaning to the end user. A metamodel of

²³the future of IDEF12 is not clearly defined as yet

²⁴organizational units seen from a decisional perspective

²⁵(Noran, 1999) holds a case study based on this analysis

²⁶such 'limitation' may in fact help avoid unnecessary model complexity.

the extended language should also be constructed and used in order to ensure the consistency of the models created, while FOL languages may need to be used to define their semantics. Other factors also need to be taken into account when creating language extensions, such as user acceptance and training in the extended language.

In the case of IDEF, consistency between the models produced using its various languages has to be provided by the modelling tool or the user. UML may be used for business modelling as-is, with the standard extensions, or involving proprietary constructs (such as described in (Eriksson and Penker, 1999)). UML-provided extensions may reach their limits when modelling a complex business, while dedicated extensions bring about the necessity of glossaries, rigorous metamodel control and FOL languages for semantics definition.

Using the same set of languages to model the software system *and* the business it supports is attractive for two reasons. Firstly, if an accurate business model can be used to derive the requirements for its information system (Marshall, 1999), then these requirements are likely to closely reflect the actual needs of the business. Secondly, if the same set of tools is used in modelling the information system and the business, then consistency may be easier to enforce across the models, and users' training can be effectively focused on the set of tools which is actually used.

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