A grammar of business rules in Information Systems

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Abstract

There are many situations during information system development (ISD) where there is a need to do modelling on a business level before more detailed and robust modelling are done on the technical system level. Most business level modelling uses some form of natural language constructs which are, on the one hand, easy to use by untrained users, but which are too vague and ambiguous to be used in subsequent systems level modelling by systems analysts, on the other hand. The goal of this article is to suggest a subset of morphology, syntax and semantics concepts that may be used to analyse texts containing business rules during Information Systems analysis and design. The contribution of this research is to provide a better understanding of the fundamental entities in business and ISD modelling and their relationships in order to improve informal, mostly textual, business modelling.

Keywords: business rules, modelling, grammar, morphology, syntax, semantics

Disciplines: Information Systems, Information Systems Development, Information Systems Analysis and Design, Linguistics

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1. Introduction

There are many situations during information system development (ISD) where there is a need to do modelling on a business level before more detailed and robust modelling are done on the technical system level. Most business level modelling uses some form of natural language constructs which are, on the one hand, easy to use by untrained users, but which are too vague and ambiguous to be used in subsequent systems level modelling by systems analysts, on the other hand. The goal of this article is to suggest a subset of linguistic concepts that may be used to analyse texts containing business rules during Information

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Systems analysis and design. Although references are to other linguistic modules, the main focus is on *following three levels of modelling entities and their relationships:*

- Base entities (corresponding to the morphological level in linguistics);
- Structure entities (corresponding to the syntactical level in linguistics); and
- Role entities (corresponding to the semantic level in linguistics).

2. Background

One of the problems hampering information systems development (ISD) is the lack of a truly **integrated** modelling technique or set of techniques. Truly integrated modelling techniques will support modelling during all the phases of the ISD life cycle, from business analysis and systems design to development, and ultimately the maintenance of the resultant system. Integration does not pose such a huge problem during the later phases of system design and development. Techniques such as the Unified Modelling Language (UML) provide for modelling integration during the later phases of the ISD life cycle adequately. The problem underlying this research is specifically the integration between modelling for business and modelling for ISD. For example, how can we model business rules for an organisation so that business users can easily understand and use it, while at the same time that model has enough expressive power to create a design enabling programmers to implement those same business rules in an information system?

The integration problem has another side to it. Not only is there an integration problem between the business side and ISD, but also between different aspects of business modelling. Zur, Muehlen and Indulska (2010:39) refer to research that point to representational weaknesses in process modelling languages. They speculate that business rule modelling languages can overcome these weaknesses, but the integration of rule and process modelling is seen as problematic. They refer to a recent study showing that organisations frequently supplement their business process modelling notation (BPMN) models with business rules in textual annotations. Similarly, Recker (2010) found in a study on the use of BPMN that a major problem is support in articulating business rules.

Excellent modelling languages and techniques exist for ISD, but very few of them can be simply applied to business modelling. Wilcox and Gurau (2003) identify a number of problems with integration definition for function modelling (IDEF) for business modelling and then propose UML instead, but then with the provision that it must be extended with an extension like the Eriksson-Penker Business Extensions. The problems are mostly related to complexity, with most business users finding it too difficult to express their business needs in an ISD language or technique, or expressiveness, with users not being able to model everything they require (Recker, 2010). In practice, most business modelling is done in unstructured text format, which leads to unclear, ambiguous descriptions. There is also a big jump from the unstructured text in use case narratives and textual specifications to the detail needed in a technical level class or entity diagram. For instance, in a study on practical experiences with eliciting classes from use case descriptions, Cox and Phalp (2007:1286) concluded the following: "It can be construed that there is a lack of detailed guidance about moving from a use case description to elements of design." Thirdly, there is a need to integrate the techniques between non-technical business use (e.g. to define business rules and to define enterprise architectures) and technical IT use (e.g. specifying systems interfaces and designing information system applications).

According to Sinha et al. (2009:327), natural language remains the main way of specifying requirements. The adoption of more formal requirements modelling has been slow, mainly because of the "high entry barrier for customer participation". This paper makes a contribution to Information Systems by a transdisciplinary approach that integrates the theory process of business rules analysis with insights borrowed from linguistics in order to solve the practical problem referred to above, i.e. to bridge the gap between vague business texts and precise, formal and programmable statements to be used in Information Systems development. The natural language statements of use cases can easily be ambiguous and vague, but it is a little bit easier to be more clear and direct with the proposed grammar.

Information can be transmitted or stored in material media only when a language is available. There are different kinds of languages (Gitt, 1997):

- Natural languages
- Artificial communication languages, such as Esperanto, flag codes and traffic signs
- Formal artificial languages, such as mathematical calculi, chemical symbols, musical notation, algorithmic languages and programming languages
- Special languages found in living organisms, such as genetic languages, bee gyrations, pheromonal languages and hormonal languages

The subset of morphology, syntax and semantics identified below, using a grounded, analytical approach, forms the building blocks for a formal, artificial language that may be used to facilitate the creation of algorithms in business programming. The adopted linguistic concepts enables the processes of communication in the complex systems of ISD (cf. Checkland, 1999). To function as a whole, there must also be some form of communication between the system components. Each subsystem receives inputs, which stimulate further activity to produce outputs, passing this either to other subsystems or to the environment (Patching, 1990).

During the 1970s, mainly as a result of work done by Checkland (2000), the concept of the so-called "soft system" emerged. At the centre of this approach is the concept of a human activity system modelled by using ordinary language rather than mathematical symbols. It can be used in poorly structured situations where the choice of system and the delineation of system boundaries are controversial. The research in this article is an example of the use of human language and linguistics, albeit a subset of natural language, that can be used to model human activity systems in information systems (IS), for example, the use of nouns, verbs and adverbials to indicate physical and conceptual things, business actions, as well as the location, time and reasons of these (cf. Zachman, 1987; Sowa and Zachman, 1992).

The next section gives an overview of business rules in IS in order to understand the need for linguistic analysis to be addressed later.

3. Business rules in IS

Business rules are one of the major means by which a system "organisation" controls itself, and a major part of ISD is to elicit business rules and to embed them into an IS subsystem of the organisation with the purpose of enabling the control of a part of the organisation. For instance, business rules embedded in the financial IS, together with the business rules embedded in the manual procedures in a financial department, assures control of the financial subsystem of the organisation. Business rules have gained prominence over the last few years.

They are seen as important assets of organisations that should be managed carefully (Ram and Khatri, 2005). Business rules can also be seen as an important (maybe the most important) link between business and IS (Bajec and Krisper, 2005).

There is no generally accepted standard definition for business rules (Hamza and Fayad, 2005). Many definitions for business rules have been proposed, but in essence, business rules are statements that govern the structure and behaviour of various business components. Some characteristics of business rules are as follows (Bajec and Krisper, 2005):

- They exist in various forms, from simple to very complex and dynamic.
- They can originate:
  - internally, mostly derived from strategic processes, determining the organisation's vision, goals and policies; or
  - externally, from government, industry or specific professional rules as well as natural timeless facts (Herbst, 1996).
- They can be based on explicit (formalised knowledge in the form of principles, procedures, facts, figures, rules and formulas) or tacit knowledge (knowledge that is difficult to see and express).
- They can be found in documents, procedures, policies, regulations, user manuals and IS.
- Explicit business rules are a manifestation of a richer underlying implicit knowledge.

Steinke and Nickolette (2003) consider a business rule good if it has the following characteristics:

- *Declarative*: It is not stated in a procedural manner.
- *Precise*: The meaning of the rule is clear.
- *Atomic*: The rule contains one concept only.
- *Consistent*: There are no conflicting rules.
- *Non-redundant*: No information is repeated.
- *Business-oriented*: It is stated in business terminology.
- *Owned by the business*: Business people are able to maintain the business rules.

3.1 Business rules and ISD

Information systems normally implement a large number of business rules, for example, the 627 business rules applied in a 12 000-line COBOL application and the 809 in a 30 000-line COBOL application (Fu et al., 2004). A typical information system has three elements: an interface (usually GUI), application code/logic and a database. Business rules can be stored in any of these three elements. This can cause various problems with the maintenance of business rules. Steinke and Nickolette (2003) propose that a further layer be introduced to manage business rules.

Business rules also require explicit treatment during ISD to ensure IS agility; otherwise the rules do not reflect real business. This results in applications that do not meet business needs, a lack of documentation on business rules, business rules that are buried in program code, business logic that is hard to maintain and business rules that are hard to control (Bajec and Krisper, 2005). The majority of IS business rules are not explicitly modelled during analysis and design. These rules are only implicitly specified in system models and implicitly embedded in application program code and database structures (Ram and Khatri, 2005).

Updating an implemented set of constraints is not easy, because the mapping between high-level constraints and their implementation in various software artefacts are not explicitly done and maintained (Fu et al., 2004). Therefore, business rules captured in an information system initially can be adequate, but may get outdated and out of sync later on. There is thus a need for a formal approach towards capturing and managing business rules (Ram and Khatri, 2005).

Various conceptual models have been proposed to capture the meaning and structure of business rules, but most of them only capture a limited range of constraint types. This has given rise to the development of constraint definition languages. These languages are, however, more oriented towards logical than conceptual design and are difficult for users to understand (Ram and Khatri, 2005). According to Bajec and Krisper (2005), business rule management (BRM) is needed to manage information about business rules' evolution and to coordinate their changes centrally.

3.2 Types of business rules

Various types of business rules are identified in the literature and various attempts have been made to classify these rules. The Business Rules Group's classification has become the *de facto* classification of business rules and forms the basis of the classification used in this study (Hay and Healy, 2000). The Business Rules Group classifies business rules as follows (ibid.):

- *Terms*: define a thing or data about it
- *Facts*: indicate connections between terms
- *Constraints (*or *action assertions)*: allow or prohibit actions
- *Derivations* (or *inferences)*: define the transformation of knowledge from one form to another, for instance, formulas

Over and above the types of business rules specified by the Business Rules Group, other types of business rules can also be identified. According to Perkins (2000), a *business statement* is a simple declaration in business language stating strategic business rules such as critical success factors, the enterprise mission, goals, policies, objectives, strategies, performance measures, information needs, functions and events. Steinke and Nickolette (2003) classify business rules on a business statement level as follows:

- *Mandates*: published policies that must be followed, otherwise consequences will be faced, e.g. pay VAT.
- *Policies*: published policies that should be followed to implement the organisational rules, e.g. mission statements. A business policy is a general statement or direction for an organisation (Ram and Khatri, 2005). For example: "We only rent cars in legal, roadworthy condition to our customers." Each policy may be composed of more detailed policies (Hay and Healy, 2000).
- *Guidelines*: rules followed, depending on some judgment, e.g. management style. Steinke and Nicolette (2003) define guidelines as the "shoulds" of the organisation and mandates as the "musts" of the organisation.

Table 1 summarises the different business rule types.

Type	Explanation	Source
Terms	Word or phrases that have specific meanings for businesses in designated contexts.	Hay and Healy (2000)
Facts	The relationships between different entities and between an entity and its attributes.	Von Halle (2000)
Constraints	Statements about some dynamic aspect of the business indicating the results that actions can produce.	Hay and Healy (2000)
Derivations	Business rules derived from other business rules and information.	Hamza and Fayad (2005)
Business statements	A declaration in business language stating strategic business rules.	Perkins (2000)
Mandates	Published policies that must be followed, otherwise consequences will be faced.	Steinke and Nickolette (2003)
Policies	Published policies that must be followed to implement organisational rules.	Steinke and Nickolette (2003)
Guidelines	Rules followed, depending on some judgment.	Steinke and Nickolette (2003)

Table 1: Business rule types

3.3 Business rule relationships

Hamza and Fayad (2005) consider businesses to consist of business objects (like objects and processes) plus business rules. A business change means that either one or more business objects or one or more business rules have changed. Business objects and business rules can be classified according to their stability (probability to change) as stable, partially stable or unstable.

Bajec and Krisper (2005) identify the following business components related to business rules: business goals, processes or activities, ECA structures (meaning, when event happens, and conditions are met, execute activity), business rule descriptions, business terms, business concepts, business actors and resources (e.g. organisation unit, business function or business role). These components are related to business rules in many ways. For instance, business rules support the achievement of business goals, trigger activities, define ECA structures, are described in business rule descriptions, define business concepts, are the responsibilities of business actors and are related to resources. Business rules also relate to other business rules, for instance, one business rule supports another business rule or is in conflict with another. Rosca and D'Attilio (2001) provide an example of sets of business rules applied to a business action. For instance, business action *calculate discount* can be supported by the following business rules: “*orders > 500 get 30% discount*”; “*orders > 100 receive 15% discount for preferred customers*”; and “*orders < 100 receive 10% discount*”.

Business actions are seen as fairly stable, while business rules can change frequently. According to Steinke and Nicolette (2003), a business rule is not a passive, static element. It is triggered by an event, an action, an operation, a condition or a parameter. To really understand a business rule, one should understand the cause and effect on the event. Poo (1999) defines an event as a set of activities that are performed either fully or not at all (depending on preconditions), after it was invoked by a stimulus (actor or point in time reached by system) and it has an effect on the state of a system by creating or deleting objects and/or changing the state of exiting objects. Herbst (1996) states that the environment of business rules consists of processes, data model components, organisational units and IS components.

In summary, businesses consist of the following:

- **Events** invoked by some actor or a point in time
- **Actions** (e.g. processes and activities) caused by these events
- **Business rules** constraining events and actions
- **Business objects** (e.g. actors and resources)

All of these business components are related to each other and to themselves (i.e. business rules are also related to other business rules).

3.4 Business rule representation

Business rules are represented in various formats from natural language statements to formalised rule languages (Ram and Khatri, 2005). Hamza and Fayad (2005) suggest the reuse of business rules, but also contend that it is complex and hard to achieve. They suggest that to accomplish this, business rules should semantically be abstracted and generalised.

Hamza and Fayad (2005) propose a rule dependency diagram showing the relationships between rules and business objects, as well as between rules and other rules. Fu et al. (2004) define constraint business rules in terms of structures and constraints and use structure-constraint (S-C) graphs to represent them. A structure is defined as follows by Fu et al. (2004):

- It is an intension for a set of data.
- It can be primitive or a composite of other structures; in other words, not only flat but nested structures are also allowed.
- It has a depth, which is the number of nested structures it consists of.
- It must be acyclical, i.e. not be a component of itself.
- It has a domain:
  - Primitive structure – the set of values from which the structure draws its instances.
  - Composite structure – the Cartesian product of its components’ domains.
- It has a state at a specific time – the subset of the domain that the structure has at that time.

For example, the structure that a mobile phone service provider can use to record orders received from its customers is as follows (Fu et al., 2004): order(customer(id, name, status); service(network, freeTime); and recommender(id, name, status).

The composite structures are *order, customer, service* and *recommender*; and the primitive structures are *id, name, status* and *freeTime*. The depth of *order* is 2, *customer* is 1 and *id* is 0.

Fu et al. (2004) represent constraints using predicate logic with two restrictions: they only use a small subset of predefined predicates (like *ENUMERATE*, *EQUAL*, *ATMOST* and *SUBSUME*) and they use meta-level elements (like *network* and *freeTime*) in predicates. To represent nested structures, they use path expressions (like *service.freeTime*). Constraints can be related to structures and these relations can be represented using S-C graphs. An S-C graph is created from a set of structures (S) and a set of constraints (C).

3.5 From business rules to IS modelling

Business rules are statements that govern the structure and behaviour of various business components. They are very important in the context of analysing, designing and developing IS, but also in businesses in order to model strategic, tactical and operational business rules. Business rules are mostly classified as terms, facts, constraints (action assertions) or derivations. Some research has gone into the structure of the various types of business rules. Business rules are linked to other business objects such as actors and resources, actions such as processes, activities and events invoked by actor and time. Due to the length of this article, readers are referred to Shelly and Rosenblatt (2012) for more background on the use of business rules in Information Systems analysis and design.

Businesses are defined by business rules and these business rules are incorporated into IS as follows:

- **Business objects** (e.g. actors and resources) are described by *terms*, *facts* and *derivations,* which are mostly embedded in databases and files.
- **Events** and **actions** (e.g. processes and activities) are described by *constraints* and are mostly embedded in programs and manual system procedures.

The goal of this article is to formalise the subset of morphological, syntactic and semantic concepts being used in business-rule texts in order to bridge the gap between unstructured language and ISD. A formal grammar of business rules will help to represent all types of business rules so that these can again be converted into IS models with relative ease. The next section proposes such a subset of linguistic concepts that may provide this bridging facility.

4. A linguistic analysis of IS modelling

Modelling is closely linked to linguistics and language. Most modelling techniques use linguistic constructs to help analysts to identify IS modelling constructs. In the literature, numerous authors link linguistics and IS modelling (Chen, 1976; Capuchino, Juristo and Van de Riet, 2000; Carter, Long and Truex, 2007; Leppanen, 2006; Charaf, Rosenkranz and Holten, 2010). This principle is still valid in contemporary data modelling, e.g.: “As a general rule, a noun in a business rule will translate into an entity in the model and a verb (active or passive) associating nouns will translate into a relationship among the entities” (Coronel et al., 2013:38). This article builds on this principle and extends the limited traditional examples into a comprehensive system. In his seminal work on entity relationships, Chen (1976) has shown that there is a correspondence between ERD constructs and natural language. He shows that a common noun corresponds to an entity type, a proper noun to an entity instance, a transitive verb to a relationship type and an adjective to an entity attribute. Capuchino et al. (2000:26) propose a conceptual modelling method based on the idea "… that there is some relation between the linguistic world, in which the user need is represented, and the OO [object-oriented – authors' insertion] conceptual world, in which developers represent the above need."

The purpose of this section is to expand the statements made by Chen, Capuchino et al. and others, and to do an extended comparison between linguistics concepts and IS modelling. Fundamental linguistic concepts are related to IS modelling. Linguistics is divided into a number of different areas. The areas of morphology, syntax, semantics and pragmatics are directly applicable to IS modelling, while other areas like phonology and phonetics are not. The last two areas have to do with sounds of language and the sounds of human speech, respectively (Stabler, 2010), not contributing to the issue of modelling directly. A number of standard works on linguistics and natural language processing were used to provide the information in this chapter (Stabler, 2010; Shinghal, 1992; Valeika and Buitkiene, 2003; Kornai, 2007; Haspelmath, 2001). Where required, other works were used and specifically referenced.

4.1 Morphology

Morphology is concerned with one of the most fundamental units of linguistic structure, namely the word.

4.1.1 Words and morphemes

Words are constructed out of morphemes, i.e. any part of a word that cannot be broken down further into meaningful parts. Compare for instance the words "class" and "classes". The morpheme "class" cannot be broken down any further, while the word "classes" consists of a base morpheme, "class", and a plural morpheme, "es". In a similar manner, we have the words "schedule", "schedules", "scheduled" and "scheduling" related to the base concept of "to schedule". Table 2 relates the linguistic concept of words and morphemes to IS modelling.

Linguistic concept	IS modelling link
Words and morphemes	Not all words used in a specific area to be modelled will be used for IS modelling. For instance, when verbs are specified in process and object modelling, only the lexeme (represented by the first-person present tense format) is normally specified, e.g. "order" and not "orders" or "ordered".

Table 2: The link between IS modelling and the linguistic concept of words and morphemes

4.1.2 Lexicon

In a natural language, such as English, all words in the language are described in a general dictionary that represents the language's lexicon, i.e. a list of definitions of every word in the language. Table 3 relates the linguistic concept of the lexicon to IS modelling.

Linguistic concept	IS modelling link
Lexicon	In a business or information system, situation words can have very specific meanings not necessarily as defined in the natural-language dictionary. Therefore, most modelling methodologies recommend defining all words (often called terms) that have a context-specific meaning in a data dictionary (cf. Shelly & Rosenblatt, 2012:217). For instance, in normal use "client" and "customer" can be seen as synonyms, but in a specific organisation "client" could mean "a client who has no account with us", while "customer" could mean "a client who has an account with us".

Table 3: The link between IS modelling and the linguistic concept of the lexicon

4.1.3 Lexical categories

Words can firstly be grouped as open-class or closed-class words. Open-class words (also called content words) belong to the four major lexical categories of noun, verb, adjective and adverb. Closed-class words (also called grammatical or function words) belong to the minor lexical categories.

(a) Open-class and closed-class words

The set of open-class words tends to be quite large and "open-ended", i.e. new words can be created and added almost unlimitedly. Just consider all the new words created fairly recently as a result of advances in information technology, e.g. "cell phone", "email", "spam", "hacker". Closed-class words belong to the minor lexical categories of articles ("the", "a"), demonstratives ("this", "that"), quantifiers ("all", "most", "some", "few"), conjunctions ("and", "or"), comparatives ("more", "less"), prepositions ("to", "from", "at", "with") and pronouns ("I", "you", "she", "her", "them"). The set of closed-class words tends to be relatively small and additions or changes to it is unlikely to happen often (e.g. it is highly unlikely that changes or additions to the lexical group of articles will take place in the next few years). Table 4 relates the linguistic concept of open and closed class words to IS modelling.

Linguistic concept	IS modelling link
Open-class words vs. closed-class words	There is an unlimited number of concepts as described by entities, objects and processes, but a more limited number of "reserved" words, like "if", "and", "or", and "for every".

Table 4: The link between IS modelling and the linguistic concept of open and closed class words

(b) Nouns

Nouns denote persons, places or things, e.g. *the* *<u>man</u>* *walked to* *<u>London</u>*. The things can be those we perceive through our senses or those we can conceive in our minds as ideas. Things also include animals. Nouns have certain important properties: (1) number, i.e. singular or plural, (2) case, categories such as subject (nominative case), object (accusative case), and marking ownership, origin or association (genitive case) and (3) gender in languages like German and French.

Various categories of nouns, called **genus**, can be identified:

1. **Proper nouns:** Names of specific persons, places or things, such as "Shakespeare", "Canada", "Mount Everest", "Susan". These nouns are written beginning with an upper-case letter.
2. **Common nouns:** Names of non-specific persons, places or things, such as "city", "horse", "women", "milk", "ambition", "thought". A common noun cannot be a proper noun and vice versa.
3. **Count nouns:** Those that can be counted, such as one "man", two "men", etc. When used in sentences, these nouns are frequently preceded by words like "a", "an", "each", "every" or "many".
4. **Mass nouns** (or non-count nouns): Those that cannot be counted. These nouns do not usually have a plural form. Examples are "dirt", "foam", "water", "honesty", "homework", "steel". When used in sentences, these nouns are frequently preceded by words like "much", "more", "little" or "less". Some nouns can be used both as count and mass nouns, e.g. "she pulled out two hairs" (count noun), "she cut her hair" (mass noun).
5. **Collective nouns:** Name of a group with the members of the group sharing some characteristics: an "army" (of soldiers), a "crowd" (of people), a "flock" (of geese), a "herd (of cows) and a "team" (of players). A collective noun is usually considered to be singular.
6. **Compound nouns:** Those that were originally written as two or more words. Either a sequence of separate words, a sequence of hyphenated words or one word derived from merging the original sequence of words, for example, "funny bone", "mother-in-law", "blackboard".
7. **Concrete nouns:** Names of tangibles like "book", "board", "plane", "crowd", "water" and "Mount Everest".
8. **Abstract nouns:** Names of intangibles like "ambition", "fragrance", "honesty", "integrity", "truth" and "thought". An abstract noun cannot be a concrete noun, and vice versa.
9. **Living nouns:** For example, "plant", "shrub", "man", "woman", "boy", "girl", "colt", "filly".
10. **Animate nouns:** For example, "man", "woman", "boy", "girl", "colt", "filly".
11. **Human nouns:** For example, "man", "woman", "boy", "girl".
12. **Masculine nouns:** For example, "man", "boy", "colt".
13. **Feminine nouns:** For example, "woman", "girl", "filly".
14. **Neuter nouns:** For example, "plant", "shrub".

Note that genera 1–8 are normally found in grammar books (Stabler, 2010:58–60), while genera 10–14 are used to create natural language processors (Shinghal, 1992:145–146). A noun may be of more than one genus, for example, a colt is a common, count, concrete, living, animate, masculine noun. Table 5 relates the linguistic concepts regarding nouns to IS modelling.

Linguistic concept	**IS modelling link**
Noun	Nouns are very important in IS modelling and many modelling techniques recommend using nouns to identify modelling objects, for instance, entities (ERD) and classes (UML).
Number of a noun	An important part of data and object modelling is to identify the one or the many parts in a relationship. For instance, *one* customer can have *many* orders. There is also the concept in object orientation of the design pattern called "singleton", a class with just one instance – for example, the class *Current president of the country* will always just have one instance.
Case of a noun	The nominative and accusative cases of a noun can be used to clearly make a distinction between subjects and objects. The genitive case can be used to identify whole-part relationships like aggregation in class diagrams, and entity-attribute relationships in ERDs – for instance, the product's components and the client's name.
Genus of a noun	The whole concept of categorisation per se is important. It relates to, for instance, class hierarchies. Proper nouns are rarely used in modelling (unless there is in reality only one of a type, e.g. *The Reserve Bank of South Africa*). Proper nouns will mostly indicate the value of an attribute. A more generic noun indicating the relevant role will rather be used. For example, *Finance Department* should be seen as a specific instance of *department*.
Count and mass nouns	The distinction between count and mass nouns has no direct use in IS modelling, but in practice most nouns are count nouns.
Collective nouns	Collective nouns may indicate special relationships like aggregation, e.g. *project team* implies *team members*.
Abstract and concrete nouns	There is no distinction in modelling between the two types. Both types are handled equally.
Human and neuter nouns	Human nouns indicate possible actors and agents, while neuter nouns indicate mostly the objects of actions.

Table 5: The link between IS modelling and the linguistic concepts regarding nouns

(c) Verbs

Action verbs portray actions, e.g. "he <u>walked</u> slowly forward", while **existence verbs** indicate states of existence, e.g. "Absa <u>is</u> a bank". Different types of verbs can be identified concerning their transitivity. **Transitive** verbs take one noun phrase after them, like "the client <u>paid</u> his account"; **intransitive** verbs do not take any noun phrases after them, like "John <u>laughed</u>";

while **ditransitive** verbs take two noun phrases, like "the Pope proclaimed Elizabeth the queen". Another categorisation of verbs concerns auxiliary and main verbs. **Auxiliary verbs** are a closed set and includes forms of the verb "be" ("is", "am", "are", "was"), forms of the verb "have" ("have", "has", "had"), forms of the verb "do" ("do", "does", "did") and modal auxiliaries indicating possibility, necessity and obligation ("can", "could", "will", "would", "shall", "might", "may", "must"). **Main verbs** are verbs like "run", "walk" and "sing".

A verb has six properties. Like a noun and a pronoun, a verb has a **person** (first, second or third) and a number (singular or plural). For example, "walks" is a third person singular verb. In a sentence, the person and number of a verb is the same as the person and number of its subject.

The **tense** of a verb indicates the time of the action or the state of existence portrayed by the verb. There are three tenses: past, present and future. Within each tense there are four aspects:

- Simple – action just happens
- Perfective – action completed in past, present or future
- Progressive (or continuous) – action continues in past, present or future
- Perfective progressive – a combination of perfective and progressive.

The **voice** of a verb denotes the relationship of the verb with its subject. It can be active or passive. In active voice, the subject does the action portrayed by the verb: "Archie showed the book." In passive voice, the action is done to the subject: "The book was shown by Archie."

The **mood** (or mode) of a verb tells us about the attitude and understanding of the speaker or writer about the action or state of existence portrayed by the verb. A verb can have three modes: indicative, imperative and subjunctive. The indicative mood makes a statement or asks a question, for example, "she will be a singer", or "will she be a singer"? The imperative mood issues a command, an exhortation or a request, e.g. "show your book" or "have mercy on me". The subjunctive mode expresses (1) certain stock expressions, like "be that as it may", "come one, come all"; (2) a condition expressed contrary to fact, like "if I were you, I would have greeted her" (in reality, I am not you); (3) a desire, recommendation or a requirement by using words like "ask", "demand", "essential", "important", "insist", "move", "necessary" and "obligatory", for example, "I insist that he show his book". The subjunctive is gradually disappearing in practice, except in stock expressions.

Transitive verbs can sometimes occur without an overt direct object, but there is almost always an implied, unexpressed, covert direct object. For instance, "he ate" implies that he ate food and not something else. There are a few transitive verbs that have little information and depend on the rest of the predicate to provide meaning. For example, "John does my taxes", "she does her nails", and "they are having a meeting". Table 6 relates the linguistic concepts regarding verbs to IS modelling.

Linguistic concept	**IS modelling link**
Verb types	Action verbs (plus a noun phrase) are mostly used to describe action-related modelling constructs like functions, programmes, use cases, processes, etc. For example, the "*OrderProduct* screen" or the "*PrintEmployeeDetail* report". Note that on a higher level, action-related constructs are defined by nouns, for example, "payroll system". Existence verbs are indicative of relationships between entities, e.g. "the cashier is an employee". Main verbs are used mostly, while auxiliary verbs are seldom used, except for modal auxiliaries that are used in business rules, e.g. "all orders must/should be authorised by the department manager."
Person and number of a verb	Because one works with roles, the person and number of a verb is not relevant and most modelling techniques indicate verbs to be first person singular form (or lexeme).
Voice of a verb	Only the active voice is used in modelling. Passive voice sentences are basically never used to model and are transformed to active.
Tense and aspect of a verb	This is related to time and state and can be indicated in different ways. Modelling will mostly be done in simple present tense. If this is an as-is or a to-be picture of the system, it will be indicated by the context.
Mood of a verb	Most modelling will be in indicative mood. Imperative mood will be used to specify business rules and instructions, for instance, "only authorised managers can approve leave application".
Transitivity of the verb	Most verbs will take one object, for example, "update client information" and "order product". Implied direct objects are normally made explicit. If a transitive verb with little information, such as "does", occurs, it normally indicates a function or process on a higher level in the decomposition hierarchy. For instance, "manager does day-end procedure" is most probably on a higher level than "manager prints day-end report".

Table 6: The link between IS modelling and the linguistic concept of verbs

(d) Adjectives

Adjectives specify the attributes of a noun or pronoun, e.g. "the tall girl danced". When an adjective is part of a noun phrase, it is called an attributive adjective, e.g. "the fat lady". When an adjective is not part of the noun phrase and it complements a verb, it is called a predicative adjective, e.g. "the lady is fat". Table 7 relates the linguistic concept of adjectives to IS modelling.

Linguistic concept	IS modelling link
Adjectives	They relate mostly to the values of attributes of a corresponding entity or object, e.g. "red" is the value of attribute "colour" of entity/object "rental car".

Table 7: The link between IS modelling and the linguistic concept of adjectives

(e) Adverbs

Adverbs modify verbs ("he sang loudly"), adjectives ("a very tall building"), other adverbs ("unbelievably quickly") and sentences (sadly, he died). Semantically, adverbs indicate when, where, how or to what degree.

Adverbs can be of the following types:

1) **Adverbs of manner** modify a verb to tell how an action is done, e.g. "he waited eagerly".
2) **Adverbs/adverbial phrases of place modify** a verb to tell where an action is done, e.g. "she lives near the sea".
3) **Adverbs of time** modify a verb to tell when or how long an action is done, e.g. "he cried yesterday" and "he cried unendingly".
4) **Adverbs of frequency** modify a verb to tell how frequently an action is done, e.g. "he cried once".
5) **Adverbs of degree** modify a verb to tell how much an action is done, e.g. "he nearly had an accident".
6) A **sentence adverb** modifies a sentence to tell about the writer's comments, e.g. "frankly, he is a snob".
7) **Adverbs of focus and viewpoint** explain the focus or viewpoint of a sentence, e.g. "he doesn't like pudding, especially Christmas pudding" and "financially, things are going well".
8) **Truth adverbs** express what the speaker knows about the truth of statement, e.g. "maybe she is lost" and "the athlete allegedly took steroids".
9) **Comment adverbs** makes comments about what is being said, e.g. "he wisely didn't say a word".
10) **Linking adverbs** relates to a previous clause or sentence, e.g. "He worked very hard. However, he still had time to relax," and "in conclusion, we must invest internationally to survive".

Table 8 relates the linguistic concept of adverbs to IS modelling.

Linguistic concept	IS modelling link
Adverbs	Adverbs relate, among other things, to the different aspects of the Zachman framework. For instance, "the client orders stock weekly/monthly" relates to the *when* aspect of Zachman's framework and "stock is stored in the stockroom" relates to the *where* aspect.

Table 8: The link between IS modelling and the linguistic concept of adverbs

(f) Compound words

Words can occur in compounds. These compounds can occur with various combinations of lexical categories. For instance: noun + noun ("spaceship", "electronic mail"), adjective + adjective ("red-hot"), adjective + noun ("blackboard"), and noun + adjective ("earthbound", "pitch-black"). Table 9 relates the linguistic concept of compound words to IS modelling.

Linguistic concept	**IS modelling link**
Compound words	In many modelling situations, compound nouns are written as one word, for example "User_Rights" or "UserRights".

Table 9: The link between IS modelling and the linguistic concept of compound words

(g) Word relationships

It is also important to realise that specific words can be linked across lexical categories. For instance the verb "pay" is related to the nouns "payer" and "payee", and the adjective "payable", while the adverb "quickly" is linked to the adjective "quick". Table 10 relates the linguistic concept of word relationships to IS modelling.

Linguistic concept	**IS modelling link**
Word relationships	There are no specific uses of this concept in modelling.

Table 10: The link between IS modelling and the linguistic concept of word relationships

(h) Conjunctions

Conjunctions connect words or groups of words, e.g. "you <u>and</u> I are a couple". A conjunction is employed to connect words, phrases or clauses. For example, "he is fat <u>and</u> ugly", "we went to the movies <u>after</u> we had dinner" and "the kind <u>and</u> generous man gave alms to the poor".

A conjunction can belong to one of the following classes:

1) **Subordinate conjunctions** connect two finite clauses by making one clause subordinate to the other, e.g. "<u>When</u> I walked down the street, I saw him on the road".
2) **Coordinating conjunctions** connect words of the same formation and grammatical class, e.g. "John <u>and</u> Mary are married", "I will work <u>and</u> study next year".
3) **Correlative conjunctions** are pairs of conjunctions that behave together like subordinate conjunctions, e.g. "he <u>neither</u> works <u>nor</u> studies", "<u>the</u> more <u>the</u> merrier" and "<u>both</u> John <u>and</u> Susan are engineers".

Table 11 relates the linguistic concept of conjunctions to IS modelling.

Linguistic concept	**IS modelling link**
Conjunctions	Conjunctions relates to Boolean logic in modelling and programming. It occurs mostly in conditional statements, e.g. *<u>If</u> the salary > x <u>and</u> the number of years in the company > 20 then …*

Table 11: The link between IS modelling and the linguistic concept of conjunctions

(i) Interjections

Interjections express emotion, e.g. "Wow, what a concert!" Table 12 relates the linguistic concept of interjections to IS modelling.

Linguistic concept	IS modelling link
Interjections	Not used in any IS modelling.

Table 12: The link between IS modelling and the linguistic concept of interjections

(j) Determiners

Determiners call attention to nouns by occurring before the nouns, e.g. "a mob damaged his bicycle". The most frequently used determiners are "a", "an", and "the". The determiner "the" makes the noun it determines definite, e.g. "The child fell down" (a specific child). The determiners "a" and "an" make the noun they determine indefinite, e.g. "a child fell down" (any child). Articles occur with noun phrases and can either be definite ("the") or indefinite ("a", "an"). Table 13 relates the linguistic concept of determiners to IS modelling.

Linguistic concept	IS modelling link
Determiners	Determiners are not really used in IS modelling, for instance, the name of a use case would rather be "register new client" than "register the new client".

Table 13: The link between IS modelling and the linguistic concept of determiners

(k) Prepositions

Prepositions indicate a semantic relationship between entities, such as the following:

1) Location of one entity in relation to another, e.g. "the book is on/under/above/below/near the bookshelf".
2) Direction, e.g. "he travelled from his house to work".
3) Accompaniment, e.g. "with/without salt".

A preposition is one or more words that reveal the relationship between the object of the proposition and some other word in the clause. A preposition and its object constitute a prepositional phrase. For example, "the cost of this book is high".

Some prepositions relate to place, such as "in", "inside", "under", "across", "on top of", "below", "in front". Most prepositions of place indicate where something is or where it is going. For example, "there was a barrier across the road" (position) and "the man ran across the road" (movement). Prepositions of place can also have more abstract meanings, e.g. "I'm into classical music", "his behaviour is above reproach and "the people are behind their manager". Some prepositions of place are one-dimensional. "At" is used when we see something as a point in space, e.g. "he was waiting at the house". Some are two-dimensional: "on" can be used for a surface, e.g. "the picture is on the wall", or it can be used for a line, e.g. "the house is on the main road". Some are three-dimensional: "in" is used when we see something as all around, e.g. "the man in the blue shirt".

Prepositions can also indicate time, e.g. "we met in 1999", "on Tuesday", "in spring", "during the week", "since last week". There are many idiomatic phrases beginning with a preposition, e.g. "he drives at top speed", "I saw it on television", "we arrived in time for dinner", "we arrived on time for dinner", "we arrived in good time for dinner" and "we arrived just in time for dinner". Table 14 relates the linguistic concept of prepositions to IS modelling.

Linguistic concept	IS modelling link
Prepositions	In modelling, the presence of prepositions indicates relationships, mostly spatial or time-related.

Table 14: The link between IS modelling and the linguistic concept of prepositions

(l) Pronouns

Pronouns are words that are usually used in place of nouns or noun phrases, e.g. "she looked him in the eye". The noun or noun phrase that is replaced by a pronoun is called the referent (or antecedent) of the pronoun. For example, in the sentence "Anita walked to the door where she saw her younger brother leaning on crutches; he was wearing a cast on his left foot", the referent of the pronoun "she" is Anita, while the referent of the pronoun "he" is Anita's younger brother.

The referent of a pronoun need not always be a particular noun or noun phrase. For example, in "he cheated, but it did not help him to succeed", the referent of "it" is his cheating. The referent of a pronoun can often be found by seeing how the pronoun is declined. Table 15 relates the linguistic concept of pronouns to IS modelling.

Linguistic concept	IS modelling link
Pronouns	Pronouns are never used in modelling. The noun to which the pronoun refers is normally used.

Table 15: The link between IS modelling and the linguistic concept of pronouns

4.2 Syntax

The study of the structure of sentences is called syntax. Sentences are made up of clauses, clauses are built up from phrases and phrases are built up from one or more words.

4.2.1 Phrases

There are five kinds of phrases:

1) **Verb phrases** consist of an ordinary verb ("come", "sing") plus optional auxiliary verbs ("is", "had", "can").
2) **Noun phrases** consist of a noun and usually a determiner in front of it. A noun phrase can also be a pronoun. A **noun phrase** is a group of words that is not a clause but, as a unit, behaves like a noun. For example, "the rowdy boys were punished". The word "boys" is the vital part of the noun phrase. It is called the *headword* of the noun phrase.
3) **Adjective phrases** consist of an adjective, sometimes with an adverb of degree ("very").
4) **Adverb phrases** consist of an adverb, sometimes with an adverb of degree ("almost").
5) **Prepositional phrases** consist of a preposition plus a noun phrase.

Table 16 relates the linguistic concept of phrases to IS modelling.

Linguistic concept	IS modelling link
Noun phrase	Composite noun phrases are normally translated into a single name, such as "EmployeeLeave" or "Employee_Leave".

Table 16: The link between IS modelling and the linguistic concept of phrases

4.2.2 Clauses

Sentences are made up of one or more main clauses. A main clause has a finite verb. "And", "or", "but", and "so" are used to join main clauses, e.g. "it was late and I was tired". A subclause is part of a main clause, e.g. "the wind caught him as he fell", "I was tired because I was working". We use "because", "when", "if", "that", etc. in sub-clauses. Clauses are built up from phrases. The elements of an English clause are as follows:

- **Subject:** The person or thing about which the clause is.
- **Predicate or verb:** It describes what the subject did, what action was done to the subject or what state of existence the subject is in.
- **Object:** This is a person or thing affected by the action of the verb.
- **Complement:** This relates to the subject.
- **Adverbial:** This relates to the verb.

The **subject** of a sentence is those words that tell us what the sentence is about. If the subject of a sentence comprises more than one part (connected by the words "and", "but" or "or") the subject is a **compound subject**. For example, "Jan and Susan helped with the chores". The **predicate** is those words that do not constitute the subject. The predicate of a sentence tells us the following:

- What the subject did: "Susan toured France".
- What action was done to the subject: "Susan was cheated by the guide".
- What state of existence the subject is in: "Susan looked ill".

Normally the subject occurs before (to the left) of the predicate, but they can be transposed. For example, "*Ill looked Susan*".

When the predicate explains more than one action or more than one state of existence (connected by the words "and", "but" or "or"), then the predicate is a **compound predicate.** For example, "she hopped, skipped and jumped". Note that the sentence "he ate curry and rice" is not a compound predicate, because it explains only one action, namely "eating". Sentences can have both a compound subject and compound predicate.

A group of words containing a subject and predicate constitutes a **finite clause.** A sentence has at least one finite clause. A **non-finite clause** is a group of words that express some sense of action or a state of existence, but the clause can never exists by itself, and is connected to some finite clause. For example, "I appreciated his visiting me".

Some basic clause patterns are as follows:

- *A train – stopped* (subject – intransitive verb)
- *Five men – carried – the bag* (subject – transitive verb – object)
- *The student – was – unlucky* (subject – verb – complement)
- *A course – is presented – every semester* (subject – verb – adverbial)

- *The mother – gave – the baby – its dummy* (subject – verb – indirect object – direct object)

Note that all clause patterns contain a subject and a verb in that order. The most common clause pattern is subject – verb – object.

4.2.3 Sentence

A sentence is a grammatically autonomous word group that makes sense by expressing a thought. Sentences are used to make statements, ask questions and issue directions. Sentences can be simple, i.e. they consist of one clause that stands on its own, or complex, i.e. they consist of two or more clauses. A sentence can have positive or negative polarity (e.g. "she is there" vs. "she is not there"). Different kinds of sentences can be identified: Elliptical sentences are sentences from which words have been elided (deleted), for example, "(If) garbage (goes) in, (then) garbage (comes) out". Existential sentences are sentences containing an expletive like "there"; for example, "there are several lamps on the stand" is equivalent to "several lamps are on the stand". Declarative sentences make a statement and ends with a period. Imperative sentences issue a command or a request. The subject, usually "you", is often elided, for example, "please lend me the book". Interrogative sentences ask a question and ends with a question mark. The subject is the same as the corresponding declarative sentence. Exclamatory sentences express emotion and end with an exclamation mark. They can also take on the structure of a declarative, imperative or interrogative sentence, for example, "Isn't she lovely!"

A sentence S constitutes a noun phrase NP followed by a verb phrase VP. This can be indicated as follows:

S →NP VP

A noun phrase can have different formats, such as:

NP →N	(N = Noun)
NP → DET N	(D = Determiner)
NP → DET ADJ N	(ADJ = Adjective)

A verb phrase can have different formats, such as:

VP → V	(V = Verb)
VP → V NP	
VP → V NP PP	(PP = Prepositional phrase)

Table 17 relates the linguistic concept of sentence (and related concepts) to IS modelling.

Linguistic concept	**IS modelling link**
Sentence	Many modelling constructs can be translated into sentences. For instance, a use case diagram can be translated into a sentence by making the actor the subject, and the use case name the predicate and object, such as "client orders product".
Sentence polarity	Sentence polarity is related to Boolean logic. It appears mostly in a conditional statement like "if it is <u>not</u> the end of the month, then…".
Elliptical sentences	Ellipsis is not used in modelling because everything must be explicitly stated.

Linguistic concept	**IS modelling link**
Existential sentences	Existential sentences and expletives are not normally used in modelling.
Declarative sentences	Most statements in modelling can be translated into declarative sentences.
Imperative sentences	Imperative sentences are used when modelling instructions to a user of a system, for example, "place the paper in the printer". They are normally used in business rules and conditions and constraints.
Interrogative sentences	Interrogative sentences are not really used in modelling.
Exclamatory sentences	Exclamatory sentences are not really used in modelling.

Table 17: The link between IS modelling and the linguistic sentence and related concepts

4.3 Semantics

Semantics is concerned with meaning on both word and sentence level. Three types of meaning can be identified: referential, social and affective meaning.

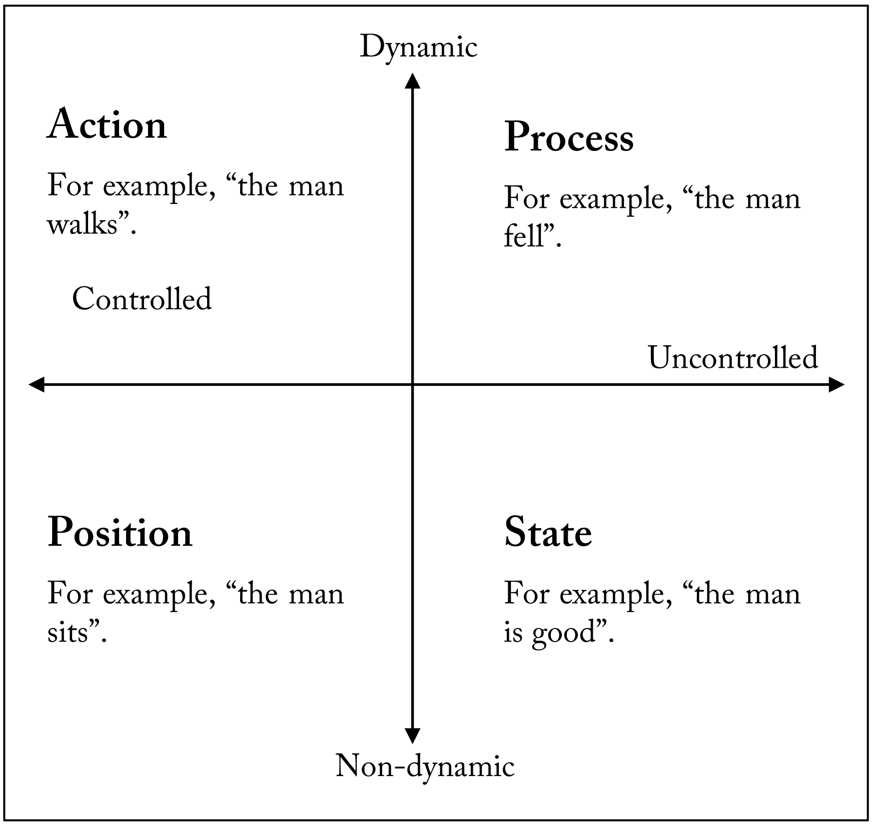

Figure 1: Predication types (adapted from Dik, 1997a; Dik, 1997b)

Referential meaning refers to looking for the meaning of a word or sentence by considering the person, object, abstract notion, state or event to which the word or sentence refers. In a referring expression, like "John's car", the specific car belonging to John is the **referent** of the expression. **Social meaning** refers to the fact that over and above referential meaning, the choice of words can also convey social class, ethnicity, regional origin, gender and context. For instance, people calling their drink "pint", "beer" or "lager" can indicate different social classes. With **affective meaning,** the choice of words conveys the language user's feelings, attitudes, and opinions. For example, by using the word "speed cop" instead of "traffic officer" a different level of respect is indicated.

4.3.1. Semantic functions

The Functional Grammar of S.C. Dik distinguishes between four states of affairs (or predications), based on the parameters controlled/uncontrolled and dynamic/non-dynamic (Dik, 1997a; Dik, 1997b). These four predication types are summarised in Figure 1.

Table 18 relates the linguistic concept of predication types to IS modelling.

Linguistic concept	**IS modelling link**
The four states of predication: action, process, position, state	In IS, no distinction is normally made between the first three states of predication. All of them will be represented by either a use case or function or program or any other action-related construct. State, on the other hand, is specifically specified in especially UML, but also implicitly in ERDs.

Table 18: The link between IS modelling and the linguistic concept of predication types

A predication is the combination of the predicate plus compulsory terms (or arguments) and optional terms (or satellites). Arguments and satellites can have different semantic functions (roles which the referents of the terms fulfil in the predication) (Dik, 1997a; Dik, 1997b; Weigand, 1992).

The following are different semantic functions that can be identified (adapted from Dik, 1997a; Dik, 1997b):

- **Agent:** The controller of an action, e.g. "the dog chases the car".
- **Positioner:** The controller of a position, e.g. "he maintains the peace between the different negotiating parties.
- **Force:** The non-controlling entity that initiates a process, e.g. "the exchange rate fluctuation caused the stock prices to fall".
- **Processed:** The entity passively undergoing a process, e.g. "the average cost price slid to an all-time low".
- **Zero:** The entity primarily involved in a state, e.g. "the price is high" (the price does not control the state – it just happens to be in it).
- **Patient (or goal):** The patient is the entity affected or effected (produced) by the operation of some agent, positioner, force or processor, e.g. "the manager prints the report".
- **Receiver (or recipient):** The entity to which something is transferred as a possession, e.g. "the employer paid the salary to the employee".
- **Location:** The place where something is located or where a predication takes place, e.g. "the cashier works in the front office".

- **Direction:** The entity towards which something moves or is moved, e.g. "They sent the order to the Procurement Department."
- **Source:** The entity from which something moves or is moved, e.g. "The supplier mails the invoice from the factory".
- **Reference:** The second or third term of a relation with reference to which the relation holds, e.g. "The policy reflects the company's mission statement".
- **Interested party (or beneficiary):** The person or institution to the advantage/disadvantage of whom the predication is effected, e.g. "The strategic report is produced for top management."
- **Company:** The entity together with which the predication is effected, e.g. "Finance created the feasibility study together with the IT Department".
- **Instrument:** The tool with which an action is executed or with which a position is maintained, e.g. "The credit clerk determines the client's credit rating by means of the credit rating procedure."
- **Manner:** The way or manner in which an action is executed, a position is maintained or a process takes place, e.g. "The developer creates the program according to the company's development standards".
- **Speed:** Indicates the quantity of action or process which is run through per time unit, e.g. "The project needs to done 25% faster to reach the deadline".
- **Role (or quality):** The role/function/authority/capacity by virtue of which an action is executed or a position is maintained, e.g. "As the head of the department, Alta performs appraisals".
- **Path (or route):** Indicates the orientation or route of a movement, e.g. "The Finance Department sends the invoice via the supplier's standard ordering channel".
- **Time:** The time at/from/until which a predication takes place, e.g. "Financial year ends on 30 September".
    - **Duration:** A subcategory of time. The period of time in which a predication takes place, e.g. "The quote is valid for 5 days".
    - **Frequency:** A subcategory of time. The number of times that a predication is repeated in a certain period, e.g. "The start-of-day procedure must be executed every week day at 07:00".
- **Circumstance:** A second predication taking place at the same time as the main predication, e.g. "While the cake is in the oven, the icing can be made". Some subcategories of circumstance are as follows:
    - **Real condition:** E.g. "If the order is bigger than 20, give 10% discount".
    - **Unreal condition:** E.g. "If the profit is 500%, the company can pay off all its debt".
    - **Concession:** E.g. "Although a client is a pensioner, they get full benefits".
    - **Exception:** E.g. "The fee is R50, but children pay R10".
    - **Restriction:** E.g. "Projects greater than R10 million cannot be authorised without the steering committee's approval".
- **Result:** A second predication which is brought about as the result or consequence of the main predication, e.g. "When an order is placed, the stock levels are updated".
- **Purpose:** A second predication in the future which the controller deliberately wishes to bring about by means of the main predication. The purpose serves as the motivation for the main predication, e.g. "The execution of the audit procedure will ensure compliance with the audit standards at financial year-end".

- **Reason:** A motivation for the occurrence of a controlled predication in terms of a causal ground ascribed to the controller, e.g. "The project team worked overtime, because the project manager required them to".
- **Cause:** A motivation that is not ascribed to any of the participants of the predication, but which is given by the speaker as an explanation for the occurrence of the predication, e.g. "The building project was late because of excessive rainfall".

Semantic functions expressed by non-verbal predicates (nouns, adjectives, adverbs and prepositional phrases, in combination with copulative verbs) are as follows:

- **Existence:** An argument expressing the mere existence of a zero-argument, e.g. "Inflation will always be with us".
- **Identity:** An argument expressing the identity or species of the zero-argument, e.g. "The university alumni are those graduates who have completed their degrees at the university".
- **Class:** An argument that designates the class of which the subject is a member, e.g. "He is a permanent member of staff".
- **Quality (or property assignment):** An argument expressing the quality of characteristics of the zero-assignment, e.g. "His age is 40 years".
- **Possessor:** A term indicating the owner of the zero-argument or other element, e.g. "The receiving branch becomes the owner of the rental car".

Table 19 relates the linguistic concept of semantic functions to IS modelling.

Linguistic concept	**IS modelling link**
Agent	The agent is normally the actor or external agent in various modelling techniques.
Positioner	In IS modelling, a positioner is never explicitly distinguished.
Force	Force is not explicitly indicated, but implicitly; for instance, when a non-human actant (such as algorithm) has an "initiates" stereotype in use case modelling, it is the equivalent of a force.
Processed	In IS modelling a processed is never explicitly distinguished.
Zero	An entity in ERDs and a class in UML is a zero in relation to their respective attributes.
Patient and receiver	A patient refers to the person or thing that is affected or effected by an action or process. A receiver can be indicated in use case modelling as an external receiver actor (ERA).
Location	Location is rarely indicated in IS modelling and then only implicitly as in the deployment diagram in UML.
Direction and source	A direction and source are never explicitly distinguished in IS modelling.

Linguistic concept	IS modelling link
Reference	Reference is not used in IS modelling.
Interested party	An interested party is not separately distinguished, but is included in, for instance, use cases as an actor.
Company	Company is not used in IS modelling.
Instrument	Instrument is not directly used in IS modelling, but relates to the means or mechanism of a process in IDEF0.
Manner	Manner is not used in IS modelling.
Speed	Speed is not used in IS modelling.
Role	This concept is used a lot in IS modelling, but no specific role modelling construct exists.
Path	Path is not used in IS modelling.
Time, duration, frequency	Time concepts are very important in modelling, but it is only really in UML that time is explicitly modelled.
Circumstance	Circumstance relates to concurrent activities, as modelled in a UML activity diagram.
Real condition, unreal condition, concession, exception, restriction	These are all related to business rules, but no specific modelling constructs exist for them, except secondary ones like a decision symbol in a UML activity diagram.
Result	Result relates to the output of an IDEF0 diagram.
Purpose, reason, cause	They all relate to the "why" aspect of Zachman, but no specific modelling construct exists.
Existence	Existence relates to the associations between entities in ERDs and classes in UML.
Identity	Identity relates to the definition of a term.
Class	Class relates to the inheritance or generalisation/ specialisation concept in OO (object orientation).
Quality	Quality relates to the values of the attributes of an entity (ERD) or a class (UML).
Possessor	Possessor is not an explicit construct in IS modelling, but could be related to the owner in a CATWOE table (soft system methodology).

Table 19: The link between IS modelling and the linguistic concept of semantic functions

4.3.2 Lexical semantics

Lexical semantics is concerned with the relationships among word meanings (Stabler, 2010; Shinghal, 1992; Valeika and Buitkiene, 2003; Kornai, 2007; Haspelmath, 2001).

(a) Hyponymy

A hyponym is a term whose referent is totally included in the referent of another term, for instance, “blue”, “red” and “yellow” are all hyponyms of “colour”. The “higher” term, “colour”, is called the hypernym. Hyponymy is not restricted to nouns or adjectives only, but can also occur with verbs and other grammatical classes, for instance, “walk” can be the hypernym for “stroll”, “saunter”, “amble”, “hike”, etc. Hyponymy can exist at more than one level, for instance, “aquamarine” and “royal blue” are hyponyms of “blue”, which is a hyponym of “colour” in turn. Table 20 relates the linguistic concept of hyponymy to IS modelling.

Linguistic concept	IS modelling link
Hyponymy	Hyponymy is an extremely important concept in modelling which relates to “a kind of”, “is-a” relationship or inheritance relationship in OO.

Table 20: The link between IS modelling and the linguistic concept of hyponymy

(b) Part-whole relationships

Part-whole relationships are where the referent of one term is included in the referent of the second term, for instance, “room” and “house”. It differs from hyponymy in that a room is not a type of house, but in (part of) the house. Table 21 relates the linguistic concept of part-whole relationships to IS modelling.

Linguistic concept	IS modelling link
Part-whole relationship	Part-whole relationship relates to the aggregation concept in OO.

Table 21: The link between IS modelling and the linguistic concept of part-whole relationships

(c) Synonymy

Two words are synonymous when they mean the same thing; more formally, when every referent of term A is a referent of term B, and vice versa. For example, “rent” and “hire” can be synonyms. Table 22 relates the linguistic concept of synonymy to IS modelling.

Linguistic concept	IS modelling link
Synonymy	Synonymy is an important concept, especially in analysis. Most methodologies indicate the importance of identifying synonyms when defining terms. Mostly, one term will be seen as the main term and all other as synonyms of that term.

Table 22: The link between IS modelling and the linguistic concept of synonymy

(d) Antonymy

Antonymy denotes opposition in meaning and is a binary relationship, unlike synonymy and hyponymy. The most obvious examples are pairs of adjectives that describe opposite concepts, such as “hot” and “cold”, “open” and “closed”, “dead” and “alive”. However, nouns like “male” and “female”, adverbs like “always” and “never”, and verbs like “love” and “hate” are also antonymous. There are different kinds of antonymy. Words such as “large” and “small” are fairly subjective, e.g. a mouse is smaller than a house, but much larger than a virus. These pairs are called **gradable**. Typically, for gradable antonyms there are words or expressions to describe intermediate words like "medium large", and "fairly small". In contrast, words like "single" and "married" are mutually exclusive and complementary. A person cannot be both at the same time. These pairs are called **non-gradable**. Table 23 relates the linguistic concept of antonymy to IS modelling.

Linguistic concept	IS modelling link
Antonymy	This concept does not feature directly in IS modelling.

Table 23: The link between IS modelling and the linguistic concept of antonymy

(e) Converseness

Converseness refers to a reciprocal concept of oppositeness, different from antonymy. Take, for example, the words "husband" and "wife". The word "husband" is the converse of "wife", because if A is the husband of B, then B is the wife of A. Table 24 relates the linguistic concept of converseness to IS modelling.

Linguistic concept	IS modelling link
Converseness	This concept does not feature directly in IS modelling.

Table 24: The link between IS modelling and the linguistic concept of converseness

(f) Polysemy and homonymy

When a word has more than one meaning, it is polysemic, e.g. "book" can be used as follows: "he reads a book" or "they book their flights". When words sound the same but have different meanings they are homonymic, e.g. "there" and "their". Table 25 relates the linguistic concept of polysemy and homonymy to IS modelling.

Linguistic concept	IS modelling link
Polysemy	This concept does not feature directly in IS modelling. But ambiguous terms are normally clearly identified (in a list of terms) to indicate just one meaning.
Homonymy	This concept does not feature in IS modelling.

Table 25: The link between IS modelling and the linguistic concept of polysemy and homonymy

(g) Metaphorical extension

A metaphor is an extension in the use of a word beyond its primary meaning. It describes referents that are similar to the word's primary referent. For instance, the word "heart" can, over and above its primary meaning of the biological pump, also be used to describe the centre of an issue (the heart of the matter), the seat of emotion (she has broken his heart), etc. Table 26 relates the linguistic concept of metaphorical extension to IS modelling.

Linguistic concept	IS modelling link
Metaphorical extension	This concept does not feature directly in IS modelling.

Table 26: The link between IS modelling and the linguistic concept of metaphorical extension

(h) Tense and modality

The semantic category **tense** indicates the time reference of a word or an entire clause. **Epistemic modality** indicates the attitude speakers have towards the truth of the statements they make. For instance, "they are probably right" indicates probability, "they are right" indicates assertion and "they know what they are talking about, so they should be right" indicates conjecture. **Deontic modality** expresses obligation, permission or suggestion. For instance, "he must wash the car" indicates command, "he may wash the car" indicates permission, while "he washes the car" indicates statement. The modalities are related and the same auxiliary words (like "may", "must" and "should") can indicate both types. Modal verbs (like "order", "allow", "command" and "assume") and modal adverbs (like "possibly", "probably" and "certainly") also indicate modality. Table 27 relates the linguistic concepts of tense and modality to IS modelling.

Linguistic concept	IS modelling link
Tense	Tense indicates mostly the as-is and the to-be situations in modelling.
Epistemic modality	Probability and conjecture are not normally taken into consideration in modelling. Only a few techniques like decision trees do allow for indicating probability, and rich pictures (in SSM) allow for conjecture. Mainstream modelling techniques cater mostly for assertion.
Deontic modality	Command normally indicates the presence of business rules or instructions to users.

Table 27: The link between IS modelling and the linguistic concepts of tense and modality

(i) Reference

Reference provides information about noun phrases and their referents. For example, note the semantic difference between the following two sentences: "he reads <u>the</u> book" and "he reads <u>a</u> book". The first assumes the speaker can identify the book, while the second doesn't. Table 28 relates the linguistic concept of reference to IS modelling.

Linguistic concept	IS modelling link
Reference	When the referents can be identified, for instance, in the phrase “the product”, it indicates a cardinality of one, a singleton (OO) or an instance of an entity or class (in this case “product”). The phrase “a product”, on the other hand, indicates a cardinality of many and the class or entity itself.

Table 28: The link between IS modelling and the linguistic concept of reference

(j) Deixis

Deixis identifies the orientation of objects or events in relation to specific points of reference. All types of deixis share a basic point of the reference: the speaker’s identity and location in space and time.

Personal deixis shows the orientation of our communications with respect to ourselves, our conversational partners and third parties. These are mostly indicated by personal pronouns. First-person pronouns (such as “I”, “we” and “us”) refer to the speaker or group including the speaker. Second-person pronouns (like “you”) refer to the addressee or group including the addressee. Third-person pronouns (like “he”, “she”, “it” and “they”) indicate any other entity besides the speaker and person (or persons) spoken to. Depending on the language, gender, number and even social status can also be indicated.

Spatial deixis indicates, in a language expression, the spatial orientation of the referent of an action or state. Spatial deixis is mostly indicated by demonstratives (like “this” and “that”), adverbs of place (“here” and “there”) and directional verbs (like “go”, “come”, “bring” and “take”). The main reference points are near or far from the speaker.

Temporal deixis indicates, in a language expression, the time orientation of the referent of an action or state. The most basic orientation is the moment at which the expression is uttered. Events before that moment are in the past, during that moment are in the present and after that moment are in the future. Table 29 relates the linguistic concept of deixis to IS modelling.

Linguistic concept	IS modelling link
Personal deixis	Personal deixis can indicate the presence and orientation of a business conversation or transaction. The interaction between a user and an ATM is a classic example: “user inserts card, ATM verifies card”, etc. In IS modelling, the third-person perspective is mostly that of the system being modelled.
Spatial deixis	Spatial deixis indicates the “where” aspect of Zachman, as well as actions involving the movement of either physical or informational entities, for instance, “the clerk emails the invoice to the client”.
Temporal deixis	Relates to the “when” aspect of Zachman.

Table 29: The link between IS modelling and the linguistic concept of deixis

4.4 Pragmatics

For a long time, linguists studied individual sentences in isolation. But language is normally used in larger units, like conversations, monologues, emails or letters. These larger units are studied in pragmatics (also called the information structure).In any sequence of sentences, speakers and writers will mark some elements as more important (highlighting) or less important (backgrounding). This is called the **information structure** and takes into account the discourse context of a sentence.

(a) Discourse

A **discourse** is a series of sentences (or other non-verbal forms of communication) that go together, for example, a conversation in the tea room, an email, a television interview, a comment to you about the neighbour walking by, a speeding fine or telling a joke. These discourses are social instruments used for communication. Discourse can have a major effect on the structure of a given sentence. A conversation is a discourse where more than one person is involved. Some of the properties of a conversation are as follows:

- Any reasonable number of people can take part.
- There are rules governing how people take turns.
- There are principles of socially acceptable conversation behaviour like greeting (opening the conversation) and closing the conversation.

Table 30 relates the linguistic concept of discourse to IS modelling.

Linguistic concept	IS modelling link
Discourse	Any interaction of a user with a system can be seen as a discourse or conversation. You have an opening (like logging in), a closing (like logging out) and all of the steps in-between.

Table 30: The link between IS modelling and the linguistic concept of discourse

(b) Topic

The main discourse function of the subject is to identify the **topic** or theme of the discourse. Topics represent **given information** – information the speaker assumes the hearer already knows. A topic only becomes a topic once it is introduced into the discourse. Once a topic is introduced, it stays the subject of subsequent sentences until a new topic is introduced. The topic is in contrast to the **comment**, the element that says something about the topic. The topic is not necessarily derived from a sentence, but can be derived from the discourse context; for example, “look how cute” when the speaker passes a baby in the street identifies the topic “the baby”.

The context can be on different levels. Firstly, it can be linguistic, the utterances in the discourse preceding the current point. Secondly, it can also be the immediate physical or social environment. Thirdly, it can include general knowledge. Table 31 relates the linguistic concept of topic to IS modelling.

Linguistic concept	IS modelling link
Topic	When doing an analysis, it is important for the analyst to determine the topic when statements are made by users. For instance, the statement "the clerk validates the order", although syntactically and semantically valid, is incomplete pragmatically and must be placed within the topic of the "order process" along with all the other order process steps.

Table 31: The link between IS modelling and the linguistic concept of topic

(c) Speech acts

Certain utterances only declare or state, but there are utterances that in the right circumstances perform an action. For instance, when the bride and bridegroom say "I do", it constitutes entering into a legal contract; or when the supplier states "I will deliver this before 12:00 tomorrow", it constitutes a service contract. These types of utterances are called performative utterances.

There are four categories of speech acts (Searle, 1976):

- **Utterance acts** are simply acts of uttering sound, words, phrases or sentences in a language and can be performed by a non-communicating entity like a parrot or tape recorder.
- **Illocutionary acts** are acts performed <u>in</u> saying something. Examples of illocutionary acts are asserting, reporting, stating, asking, suggesting, ordering and proposing.
- **Perlocutionary acts** are acts performed <u>by</u> saying something. Examples of perlocutionary acts are inspiring, persuading, intimidating, misleading, embarrassing and irritating.
- **Propositional acts** refer to something and characterises it with a predicate. For instance, "the earth is flat" or "nobody is perfect".

Table 32 relates the linguistic concept of speech acts to IS modelling.

Linguistic concept	IS modelling link
Speech acts	The sending of business transaction messages between different agents constitutes illocutionary acts. This forms a major part of IS and organisations.

Table 32: The link between IS modelling and the linguistic concept of speech acts

5. Conclusion

Because language is so fundamental to modelling, linguistics is a very important reference discipline for modelling. Of special interest are linguistic concepts and constructs that are absent or underemphasised in modelling. Based on the comparison of linguistics and IS modelling in this article, some very interesting conclusions can be made.

One of the first insights is that linguistics makes a clear distinction between the different levels of morphology, syntax, semantics and pragmatics. In IS modelling, some of these levels are often neglected. IS modelling, and the teaching thereof, mostly concentrates on the morphological, and to some degree the syntactical level, but not really on the semantic and pragmatic levels. For instance, when learning a new modelling technique like use case diagrams, the basic constructs such as agent, use case and association will be taught and examples given, but very few rules will be given of what a good use case "sentence" or "clause" is.

On a morphological level, the main conclusion is that only a subset of all the words used in a specific universe of discourse will actually be modelled. In a sense, the root meanings of words are used rather than derivations of those root words.

On a lexical level, a number of significant conclusions can be made:

- In language the two main things that are communicated are "things"[4] as represented by nouns and noun phrases and the relationships between them as represented by various other linguistic concepts. One of the most important relationships is that of action represented mostly by verbs. For instance, when somebody says "Humpty-Dumpty sat on the wall", the relationship between the two things ("Humpty-Dumpty" and "the wall") is indicated by the phrase "sat on". It mainly shows the spatial relationship between them, one under and the other on top. It also shows that this spatial relationship is not necessarily true now, but that it was true somewhere in the past, because it says "sat" and not "sits" or "is sitting".
- By contrast, in modelling, the two main things that are modelled are "things" (agents, actors, entities, objects, etc.) and actions (processes, functions, programs, use cases, etc.), with the relationships between things taking at most a third place.
- Various lexical types give rise to a number of relationship types between things:
  a) **Action relationships** indicate dynamic relationships where subject things execute actions on object things in a finite (even if long) amount of time. The linguistic concepts indicating action relationships are action verbs, predicates and prepositions. Action relationships can indicate many subtypes, such as the following:
     a. **Association relationships,** e.g. "Customer orders product".
     b. **Movement** between two locations, e.g. "The flight transports passengers between origin airport and destination airport".
  b) Action and existence verbs also indicate **static relationships** showing permanent relationships between "things", e.g. "Order consists of products" and "The customer order is filled".

On a semantic level, semantic functions can be linked to many concepts in IS modelling, such as agent, role, etc. The interesting part is the big number of semantic functions that are either not explicitly defined or not defined at all in IS modelling. These can provide the basis for developing richer, more nuanced modelling constructs. Further, also on a semantic level,

4 The words "thing" or "things" is used rather than "object" or "entity" because of the current IT connotations of those words.

lexical semantics indicates relationships between words, many of which are present in IS modelling, like "inheritance" (hyponymy) and "aggregation" (part-whole relationships). However, the relationships missing from ISD modelling point to interesting opportunities to enrich modelling. For instance, converseness can help to identify processes or functions such as "buy" and "sell", "input" and "output", or "debit" and "credit". By understanding that these functions go in pairs, finding one of the pair can cause an automatic query concerning the other half of the pair.

On a pragmatic level, it is clear that communication is not made up of loose sentences but of sentences structured together in bigger units forming discourses. Similarly, a series of IS modelling diagrams does not constitute a proper model of a specific universe of discourse. Modelling is only complete when all diagrams are properly placed within an integrated structure and related to a wider context encompassing the total IS under discussion.

The grammar of business rules developed in this article can be used:

1) To understand business rule texts better (by means of a linguistic analysis of the text).
2) To rewrite unstructured business rules into a more formal way that more closely represents ISD constructs; for instance, instead of allowing passive sentences, only active sentences are permitted, sentences must always follow the basic subject-predicate-object/complement form, and only predefined (by the users themselves) words can be used.
3) To suggest ways to transform business rules directly into ISD statements and diagrams (an IS analyst who understands the basic grammatical concepts will be able to more easily identify business concepts and relations in business texts and to relate these more directly to IS design structures).
4) To identify building blocks for an integrative ISD modelling technique (the fundamental entities of business and ISD modelling can be divided into three categories: base entities (corresponding to the morphological level in linguistics), structure entities (corresponding to the syntactical level in linguistics) and role entities (corresponding to the semantic level in linguistics).

The suggested grammar may, therefore, assist information systems analysts to explore existing business rules in a methodical and systematic way. Implementing this type of linguistic approach may also help prospective analysts to do a better job of capturing business rules since it provides a toolkit to understand and model textual narratives. In future work, an empirical study could evaluate the impact of such an alternative approach by reporting on the quality of business rules produced by students who have been taught in using the grammar of business rules vs. those who have not. It would also be interesting to test and evaluate the proposed method with programming practitioners who have developed tacit abilities to capture business rules in order to find out whether the linguistic concepts affirm and concretise their assumed notions in a manner that these can be shared and used for IS design and development.

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