

# From Contract Drafting to Software Specification: Linguistic Sources of Ambiguity

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## Introduction

Software requirements specifications (SRSs) & legal contracts for business transactions and other human interaction share many properties.

They need

- to be precise and accurate,
- to be self-consistent, and
- to anticipate all possible contingencies.

SRSs are written usually in natural language, often accompanied by information in other notations, such as formulae, and diagrams.

Contracts are written always almost entirely in natural language.

Ambiguity is anathema to both.

Ambiguity makes it possible for one SRS or legal contract to be interpreted in more than one way.

We are not talking about intentional ambiguity, perpetrated to cause an SRS or contract to be misunderstood by someone or to be understood differently by several.

An SRS is often included as part of a software development contract. Thus, ambiguity in an SRS is a double whammy.

What are the sources of ambiguity in written documents?

common mistakes, failure to recognize technical terms or terms of art—either by the writer or the reader, and common misconceptions about the meanings of words and phrases contribute

We believe that a major, if not the fundamental, source of ambiguity in a written document is poor use of the natural language used to write the document.

The writer making a language error has conveyed a meaning other than that intended.

The reader, in not recognizing an error, has understood a meaning not intended by the writer.

Also, the writer in using the language unusually correctly ends up conveying a meaning other than that intended to a reader who is not aware of the correct usage of or of the correct meaning of the language.

This talk describes a number of ambiguities that were found by the authors in the course of their work and in some case studies examining the requirements elicitation process.

The examples used are simple sentences, whose meanings change according to different interpretations.

Correct use of the natural language eliminates most of these ambiguities.

However, both writers and readers are often so unaware of the correct use of the language, that even when the writer is being correct and precise, the readers do not pick up the intended meaning and misconstrue a sentence.

A sentence can be unambiguous from a linguistic point of view, but be ambiguous from a pragmatic point of view.

The sentence has only one meaning according to language rules, but people, not fully aware of the rules, misinterpret the sentence or think that there are more than one meaning.

Some of the problems are language specific.

Therefore, the examples are given not only in English, but also in Brazilian Portuguese, Portuguese Portuguese, French, German, and Hebrew, respectively, as representatives of the Latin, German, and Semitic languages.

We are not concerned here with ambiguities coming about as a result of translation from one language to another, but of potential ambiguities faced by native speakers of the languages as they work in their own languages.

When mathematical notation makes the meaning of the sentence perfectly clear, an additional sentence in predicate calculus is provided.

Examples and words used as themselves are typeset in a sans-serif font.

## **Definitions of Ambiguity**

- Dictionary Definition
- Software Engineering Definition
- Linguistic Definitions
- Legal Definition

## **Tamagotchi Case Studies**

The most effective but expensive way to analyze the level of ambiguity in a requirements document is to give it to several engineers, to ask each for an interpretation, and to compare the resulting interpretations afterwards (used by Kamsties in his Ph.D. work)

An analogy of the technique should work with a legal contract.

## **All, Each and Every**

All is plural, while **each** and **every** are singular.

However, at least in English, many people use **every** as plural.

Moreover, many people are sloppy about maintaining number and gender across the verb from the subject to the object or predicate.

The noun modified by **all** must be plural.

In any document, **all**, **each**, and **every** vary over an understood population of individual objects, namely the subjects of the document.

Therefore to accurately reflect reality in isolated examples, there must be an understood population for the examples.

The example sentences talk about dog owners; these sentences are assumed to be from a context that delimits the population to all human dog owners in a an organization, the Ambiguityville Dog Owners Club (ADOC).

A requirement for membership is ownership of at least one dog, that is

$$x \in \text{ADOC} \supset x \text{ is human} \wedge (\exists d (d \text{ is a dog} \wedge x \text{ owns } d))$$

These sentences have the members of the population bringing dogs. We assume that the dogs are being brought to a meeting of the ADOC.

All quantification involving  $x$  is understood as quantification over this population of dog owners.

All quantification involving  $d$  is understood as quantification over the dogs owned by these dog owners.

$$d \in \{d' \mid d' \text{ is a dog} \wedge \exists x (x \text{ owns } d')\}$$

If one wants to talk about people bringing their dogs, and he or she wants to use **all**, the correct sentence is

All bring their dogs.

Todos trazem os cachorros deles.

Todos trazem os seus cães.

Tous apportent leurs chiens.

Alle bringen ihre Hunde mit.

Culam maviim et haklavim shelahem.

$\forall x (\forall d (x \text{ owns } d \supset x \text{ brings } d)) .$

The meaning of this sentence is not very precise because it really gives no idea how many dogs are brought by each person.

All that can be said is that every person in the population brings all dogs that he (he  $\equiv$  he or she and his  $\equiv$  his or her throughout the examples.) owns.

This meaning is fine, but usually more information can be given.

To mean that there is precisely one dog per bringer, say

Each brings his dog.

Cada um traz o cachorro dele.

Cada um traz o seu cão.

Chacun apporte son chien.

Jeder bringt seinen Hund mit.

Col echad mavi et hakelev shelo.

$\forall x (\exists! d (x \text{ owns } d \wedge x \text{ brings } d)) .$

To mean that there are one or more dogs per bringer, say

Each brings his dogs.

Cada um traz os cachorros dele.

Cada um traz os seus cães.

Chacun apporte ses chiens.

Jeder bringt seine Hunde mit.

Col echad mavi et haklavim shelo.

$\forall x (\exists d (x \text{ owns } d) \supset (\forall d' (x \text{ owns } d' \supset x \text{ brings } d')))$  .

To mean that all bringers share one dog, say

All bring their dog.

Todos trazem o cachorro deles.

Todos trazem o seu cão.

Tous apportent leur chien.

Alle bringen ihren Hund mit.

Culam maviim et hakelev shelahem.

$\exists!d (\forall x (x \text{ owns } d \wedge x \text{ brings } d)) .$

This situation is so rare that the sentence is rarely ever said with the correct meaning. Most of the time, that sentence is said with the intended meaning of

Each brings his dog.

Cada um traz o cachorro dele.

Cada um traz o seu cão.

Chacun apporte son chien.

Jeder bringt seinen Hund mit.

Col echad mavi et hakelev shelo.

$\forall x (\exists !d (x \text{ owns } d \wedge x \text{ brings } d))$  .

That is, the singular dog is applied mentally and incorrectly to each bringer among the **all** bringers.

When people say

All bring their dogs. ,

Todos trazem os cachorros deles. ,

Todos trazem os seus cães. ,

Tous apportent leurs chiens. ,

Alle bringen ihre Hunde mit. ,

Culam maviim et haklavim shelahem. ,

$\forall x (\forall d (x \text{ owns } d \supset x \text{ brings } d))$  ,

we believe that they are really intending to say

Each brings at least one dog. ,  
Cada um traz pelo menos um cachorro. ,  
Cada um traz pelo menos um cão. ,  
Chacun apporte au moins un chien. ,  
Jeder bringt zumindest einen Hund mit. ,  
Col echad mavi lfachot kelev echad. ,  
 $\forall x (\exists d (x \text{ owns } d \wedge x \text{ brings } d))$  ,

but it is not certain.

In an attempt to get around the imprecision of the sentences

All bring their dogs.

Todos trazem os cachorros deles.

Todos trazem os seus cães.

Tous apportent leurs chiens.

Alle bringen ihre Hunde mit.

Culam maviim et haklavim shelahem.

$\forall x (\forall d (x \text{ owns } d \supset x \text{ brings } d))$

and

All bring their dog. ,  
Todos trazem o cachorro deles. ,  
Todos trazem o seu cão. ,  
Tous apportent leur chien. ,  
Alle bringen ihren Hund mit. ,  
Culam maviim hakelev shelahem. ,  
 $\exists!d (\forall x (x \text{ owns } d \wedge x \text{ brings } d))$  ,

people sometimes feel compelled to add the word individual after their to get

All bring their individual dogs.

Todos trazem os cachorros individuais deles.

Todos trazem os seus cães individuais.

Tous apportent leurs propres chiens.

Alle bringen ihre einzelne Hunde mit.

Culam maviim et haklavim hapratiim shelahem.

$\forall x (\exists d (x \text{ owns } d \wedge x \text{ brings } d))$

and

All bring their individual dog.

Todos trazem o cachorro individual deles.

Todos trazem o seu cão individual.

Tous apportent leur propre chien.

Alle bringen ihren einzelnen Hund mit.

Culam maviim et hakelev haprati shelahem.

$\forall x (\exists! d (x \text{ owns } d \wedge x \text{ brings } d))$

Perhaps the most common *incorrect* sentence in this family is (In some of the languages, the sentence is *so* incorrect that it is *never* said!)

Everybody brings their dog.

Todo mundo traz o cachorro deles.

Toda a gente traz o seu cão.

Chacun apporte son chien.

Jeder bringt ihren Hund mit.

Col echad mavi hakelev shelo.

with the meaning of

Each brings his dog.

Cada um traz o cachorro dele.

Cada um traz o seu cão.

Chacun apporte son chien.

Jeder bringt seinen Hund mit.

Col echad mavi et hakelev shelo.

$\forall x (\exists ! d (x \text{ owns } d \wedge x \text{ brings } d))$  .

The utterer of the sentence has mixed number for Everybody.

He or she uses a singular verb, a singular object, but a plural possessive.

When asked about the **their**, many say that **everybody** is plural, but when challenged about the clearly singular verb **brings**, many see the error and say something to the effect that **their** is a gender-free politically correct possessive that does not sound as sexist as the grammatically correct but politically incorrect **his** or as clumsy as the grammatically and politically correct **his or her**.

The problem does not arise in some of the other languages, specifically in Portuguese Portuguese and French. In these languages, the possessive must agree with the possessed.

In English, Brazilian Portuguese, German and Hebrew, the possessive must agree with the possessor.

Actually, in German, the situation is a bit more complicated. The base word of the possessive agrees with the possessor, but the endings agree with the possessed, as illustrated by the following variations of Each brings his dog.

Each brings his dog.  
Jeder bringt seinen Hund mit.

She brings her dog.  
Sie bringt ihren Hund mit.

He brings his dog.  
Er bringt seinen Hund mit.

Each brings his dogs.  
Jeder bringt seine Hunde mit.

She brings her dogs.  
Sie bringt ihre Hunde mit.

He brings his dogs.  
Er bringt seine Hunde mit.

Proper choice of words in an **all**, **each**, or **every** sentence is used to convey the cardinality of the relation between the subject and the object, that is whether the relation is  $1-1$ ,  $1-n$ ,  $n-1$ , or  $n-m$ .

Each brings his dog. is  $1-1$ ,

Each brings his dogs. is  $1-n$ ,

All bring their dog. is  $n-1$ , and

All bring their dogs. is  $n-n$ .

Being precise about meaning of the relations and cardinality of the relations is easy when mathematical notation with its quantifiers and logical variables are used.

The mathematical expression of the four last sentences above are

$$\forall x (\exists! d (x \text{ owns } d \wedge x \text{ brings } d))$$

$$\forall x (\exists! d (x \text{ owns } d) \supset \forall d' (x \text{ owns } d' \supset x \text{ brings } d'))$$

$$\exists! d (\forall x (x \text{ owns } d \wedge x \text{ brings } d))$$

$$\forall x (\forall d (x \text{ owns } d \supset x \text{ brings } d))$$

Sadly, these grammatical and semantic mistakes are found in mathematical text that accompanies formal statements of definitions, theorems, and proofs.

Fortunately, the formal mathematical statements are usually correct and serve to disambiguate the incorrect or imprecise natural language text.

## **Only, Also, and Others**

Only, almost, also, even, hardly, just, merely, nearly, really, etc. have placement problems. The meaning of the containing sentence depends strongly on the placement of the problematic word.

To be correct, an **only** should be immediately preceding the word or phrase that it limits.

For example, if it is desired to say that the only thing that the boy brings is his dog, one properly says

The boy brings only his dog.

O garotto traz solamente o cachorro dele.

O garotto traz solamente o seu cachorro.

Le garçon n'apporte que son chien. or Le garçon apporte seulement son chien.

Der Junge bringt nur seinen Hund mit.

Hayeled mavi rak et hakelev shelo.

Most will put the **only** before the verb no matter what it modifies, saying, instead,

The boy **only** brings his dog

O garotto solamente traz o cachorro dele.

O garotto solamente traz o seu cachorro.

Le garçon seulement apporte son chien.

Der Junge nur bringt seinen Hund mit.

Hayeled rak mavi et hakelev shelo.

The meaning of this alternative sentence is that the **only** thing the boy does to his dog is bring it. This quite sad, because then the boy does not also feed, love, bathe, etc. his dog; he **only** brings his dog.

The famous Winston cigarette jingle is also incorrect, saying

I only smoke Winstons. ,

Eu solamente fume Winstons. ,

Je seulment fume des Winstons. ,

Ich nur rauche Winstons. ,

Ani rak m'ashen Winstonim. ,

which means that the only thing I do with Winstons is smoke them. I don't eat them or ...

The correct formulation of the jingle is

I smoke only Winstons. ,

Eu solamente fume Winstons. ,

Je ne fume que des Winstons. or Je fume seulement des  
Winstons. ,

Ich rauche nur Winstons. ,

Ani m'ashen rak Winstonim. ,

which says that the only thing I smoke is Winstons.

In most cases, people know what is meant by a sentence with a misplaced only, mainly because the actual meaning of the incorrect sentence is nonsense.

However, there are cases in which an incorrectly placed only yields a perfectly reasonable interpretation and the reader is left wondering what word is really limited by the only.

In “Only His Only Grammarian Can Only Say Only What Only he Only Means” Peter Neumann gives 15 variations of

I said he thought secret users may write secret data.

Each variation is created by putting only in a different place in the sentence. Each sentence potentially has a different meaning.

1. Only(,) I said he thought secret users may write secret data.
2. Only I said he thought secret users may write secret data.
3. I only said he thought secret users may write secret data.
4. I said only (that) he thought secret users may write secret data.
5. I said only he thought secret users may write secret data.
6. I said he only thought secret users may write secret data.
7. I said he thought only (that) secret users may write secret data.

8. I said he thought only secret users may write secret data.
9. I said he thought only secret users may write secret data.
10. I said he thought secret users only may write secret data.
11. I said he thought secret users only may write secret data.
12. I said he thought secret users may only write secret data.
13. I said he thought secret users may write only secret data.
14. I said he thought secret users may write secret data only.
15. I said he thought secret users may write secret data only.

Here is a case of a sentence about secret data for which a misplaced **only** can mislead the reader.

If this sentence were in a specification, there is no telling what the reader might deduce.

Here is a case in which the writer and the reader must be equally precise about meanings, and most people are not.

Most people understand the incorrect Winstons example in the incorrect, but intended way.

## Also

The boy brings also his dog.

O garotto traz tamben o cachorro dele.

O garotto traz tamben o seu cachorro.

Le garçon apporte aussi son chien.

Der Junge bringt auch seinen Hund mit.

Hayeled mavi gam et hakelev shelo.

conveys the meaning that in addition to the other things the boy brings, he brings his dog.

Most people write either

Also, the boy brings his dog.

Tambem, o garotto traz o cachorro dele.

Tambem, o garotto traz o seu cachorro.

Aussi, le garçon apporte son chien.

Auch, der Junge bringt seinen Hund mit.

Gam, hayeled mavi et hakelev shelo.

or

The boy also brings his dog.

O garotto tambem traz o cachorro dele.

O garotto tambem traz o seu cachorro.

Le garçon aussi apporte son chien.

Der Junge bringt auch seinen Hund mit.

Hayeled gam mavi et hakelev shelo.

intending the meaning of the sentence above.

The real meaning of the first alternative is that in addition all the other people who bring their dogs, the boy brings his.

The real meaning of the second alternative is that in addition to all the other things the boy does to his dog, he brings it.

## Even

Even I did not see him on Monday. No one, including I, saw him on Monday, and one would certainly expect that I would see him.

I did not even see him on Monday. I had no contact with him at all on Monday.

I did not see even him on Monday. I saw no one on Monday.

I did not see him even on Monday. I saw him on no day this week, even on Monday of all days.

## **Not**

Not has a placement problem different from that of only.

Except for a major exception, not negates the word that follows it.

However, negating the verb of a sentence normally negates the whole sentence.

Thus

He does not bring his dog.

means

It is not the case that he brings his dog. ,

which should be parsed as

It is not the case that (he brings his dog).

## Negating

He brings his dog.

means that something is happening that causes him not to be bringing his dog, for example,

He does not bring his dog; he brings his *cat*.

He does not bring his dog; he *feeds* his dog.

He does not bring his dog; *she* brings his dog.

From a simple negation, all one knows is that the negated sentence is not true.

Additional information needs to be given to explain in how that sentence is not true.

If there are multiple verbs in a sentence, care must be taken as to the placement of the nots, up to one for each verb.

There are three negations of the sentence

It is clear that he brings his dog.

They are

It is clear that he does not bring his dog.

It is not clear that he brings his dog.

It is not clear that he does not bring his dog.

These three sentences with additional clarifying information are

It is clear that he does not bring his dog. It is clear that something is happening that causes him not to be bringing his dog.

It is not clear that he brings his dog. It is only possible that he brings his dog.

It is not clear that he does not bring his dog. It is only possible that he does not bring his dog.

The two latter sentences say almost the same thing since it is uncertain as to what is actually happening.

The difference is in the stated belief or hope of the utterer.

There are at least five ways to negate the command

Try to bring your dog

They together with clarifying additional information are

Try not to bring your dog. Try to bring your cat or try to leave your dog at home.

Try to not bring your dog. Try to feed your dog.

Do not try to bring your dog. Don't even attempt to bring your dog or force yourself to bring your dog.

Do not try not to bring your dog. Don't even attempt to bring your cat or to leave your dog home.

Do not try to not bring your dog. Don't even attempt to feed your dog.

## **And and Or in the Same Sentence**

In mathematics, there are precedence rules that govern the meaning in a sentence with more than one logical operator, **and** and **or**.

Natural language has no such precedence and associativity rules, and it is not considered good form to use parentheses in natural language text to indicate precedence and associativity.

In many restaurants, the menu says something similar to

With each entree, you get a vegetable and salad or soup.

The customer wonders which of the following is meant.

With each entree, you get (a vegetable and (salad or soup)).

With each entree, you get ((a vegetable and salad) or soup).

The customer guessed that the intended meaning is the former, because where the restaurant is, in North America, salad and soup are both eaten before the main course and the vegetable is eaten with the main course.

It makes sense to have a choice for the before dish and to have that choice *and* the side dish.

However, in China, soup comes after the main course, and there is no salad at all.

In Europe, salad comes after the main course, while soup comes before the main course.

Nevertheless, the guessed meaning was confirmed by the waitress when the customer simply asked for a vegetable and a soup and a salad and the waitress said that he has to choose between the soup and the salad.

In an SRS or a contract, one should not depend on such reasoning to disambiguate a sentence.

The usual approach to make the writer's intent clear is to use physical structure or enumeration to indicate precedence.

The intended meaning of the menu example would be written as

With each entree, you get  
a vegetable  
and  
salad or soup.

or

With each entree, you get  
salad or soup  
and  
a vegetable.

or as one of

With each entree, you get 1) a vegetable and 2) soup or salad.

With each entree, you get 1) a vegetable and 2) a) soup or b) salad.

With each entree, you get 1) salad or soup and 2) a vegetable.

With each entree, you get 1) a) salad or b) soup and 2) a vegetable.

## **A, All, Any, Each One, Some, and The as Quantifiers**

In English, **a** serves as an existential quantifier or a mathematical **let there be** for introducing an arbitrary element of some class.

**Any** or **some** can serve as an existential quantifier.

**Each** or **all** serves as a universal quantifier.

The can serve to designate a previously introduced arbitrary element from a class to which an existential quantifier has been applied.

The can also serve to designate a specific element of a class or a specific component of an element.

Sometimes **a** is incorrectly used repeatedly to refer to the same arbitrarily introduced element, when **the** should be used for all but the first.

Occasionally, **one** is subjected to the same error.

Sometimes, **all** is used incorrectly instead of **any**.

In

A boy brings his dog. The boy feeds the dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge b \text{ feeds } d))$

the A boy introduces a new arbitrary boy, and the The boy talks about the same boy.

The following express the same thought Some in place of A, He in place of The boy, and it in place of the dog.

Some boy brings his dog. The boy feeds the dog.

A boy brings his dog. He feeds the dog.

A boy brings his dog. He feeds it.

Pronouns always refer to previously existentially introduced nouns or specific nouns.

Strictly speaking, a pronoun should refer to the most recent sentential subject.

This rule prevents ambiguity when there are more than one noun to which the pronoun might refer.

However, when the gender and number of the pronoun are sufficient to uniquely identify a previously introduced noun, it seems to be acceptable to have a pronoun refer to a noun that is not the most recent sentential subject.

In

A boy brings his dog. He feeds it. ,

it is clear that the **He** refers to the **A boy** subject of the previous sentence while the **it** refers to the **his dog** object of the previous sentence.

The pair of sentences

The boy brings his dog. The boy feeds the dog.

is not meaningful if they do not follow an earlier introduction of a boy, either by name or by **a** or **some**.

Replacing the his by a in

A boy brings his dog. The boy feeds the dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge b \text{ feeds } d))$

gives

A boy brings a dog. The boy feeds the dog. ,

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge b \text{ feeds } d)) ,$

which eliminates the logical connection between the boy and the dog to make the dog completely arbitrary.

Replacing the The boy by A boy in

A boy brings his dog. The boy feeds the dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge b \text{ feeds } d))$

gives

A boy brings his dog. A boy feeds the dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge \exists b' (b' \text{ is a boy} \wedge b' \text{ feeds } d)))$

The second A boy introduces yet another arbitrary boy. This second boy could be the same as the first or entirely different.

To make it clear that the second boy is not the first, one could say

A boy brings his dog. Another boy feeds the dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge \exists b' (b' \text{ is a boy} \wedge b \neq b' \wedge b' \text{ feeds } d)))$

Combining the introduction of the second dog and the introduction of the second boy yields

A boy brings his dog. A boy feeds a dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge \exists b' (b' \text{ is a boy} \wedge \exists d' (d' \text{ is a dog} \wedge b' \text{ feeds } d'))))$

It is possible to make it clear that the newly introduced boy and dog are not the same as the first.

A boy brings his dog. Another boy feeds another dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge \exists b' (b' \text{ is a boy} \wedge b \neq b' \wedge \exists d' (d' \text{ is a dog} \wedge d \neq d' \wedge b' \text{ feeds } d'))))$

One introduces an arbitrary person and as such serves as an existential quantifier. A subsequent reference to the same person should use a pronoun or some other reference to the **one** such as **The person**.

One brings his dog. He feeds his dog.

One brings his dog. The person feeds his dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge d \text{ belongs to } b \wedge b \text{ feeds } d))$

Unless the intent is to introduce a additional arbitrary persons, it is incorrect to refer to the first **one** with additional **ones**.

One brings one's dog. One feeds one's dog.

$\exists b (b \text{ is a boy} \wedge \exists d (d \text{ is a dog} \wedge \exists b' (b' \text{ is a boy} \wedge \exists d' (d' \text{ is a dog} \wedge b' \text{ feeds } d'))))$

In this case, it is impossible to say that the dogs are owned by the bringers because the owners are yet newly introduced arbitrary persons.

A, any, and some are essentially equivalent as means to existentially introduce an arbitrary object. All three of

Joe brings a dog.

Joe brings any dog.

Joe brings some dog.

mean

$\exists d (d \text{ is a dog} \wedge \text{Joe brings } d)$

Sometimes an existential quantifier is not apparent in the wording.

The sentence

Joe brings his dog.

does introduce an arbitrary dog only to use predicates to narrow down the field to the dog that Joe owns.

$$\exists d (d \text{ is a dog} \wedge \text{Joe owns } d \wedge \text{Joe brings } d)$$

At a hotel in North America, the sign above the door to the swimming pool says,

Any electrical appliance is not allowed in the pool area.

It is clear that the intention is to say,

No electrical appliance is allowed in the pool area.

$\forall a$  ( $a$  is an appliance  $\supset$   $a$  is NOT allowed in the pool area)

## Parallelism

Michael Jackson reports a sign above an escalator.

Shoes must be worn. Dogs must be carried.

The structural parallelism implies a semantic parallelism; the two sentences are structurally identical,

$X$  must be  $Y$ .

Therefore, the reader might be compelled to believe that they are semantically identical with respect to the **must be**.

However, they are quite different.

Expressing the two sentences in conditional form yields

If you want to use the escalator, you must be wearing shoes.

If you want to use the escalator, and you have a dog with you, then you must carry the dog.

The semantic parallelism implied by the structural parallelism would suggest that to use the escalator either,

1. you must wear shoes only if you happen to have them with you, or
2. you must have a dog with you and you must carry it, and if you have no dog with you, you cannot use the escalator.

Our culture helps to recognize the correct meanings.

The same culture helps us realize that shoes are not absolutely necessary, that any reasonably protective footwear such as sandals are sufficient.

The same culture makes us realize also that if one has a cat with him, he must carry it too.

## **From a Case Study**

We look at ambiguous sentences from the light control system requirements specification prepared as a case study for a Dagstuhl Seminar held in June, 1999 on the subject, “Requirements Capture / Documentation / Validation”.

In each case, a problematic sentence is shown from the document, and it is followed by a better formulation based on the rules discussed above.

## 1. Implicit **All** with *n–n* meaning

Sections are divided into offices(O), computer labs(CL), hardware labs(HL), peripheral rooms(P), meeting rooms(M), and hallways(H).

Each section is divided into some hallways (H) and rooms, each of which may be an office (O), a computer lab (CL), a hardware lab (HL), a peripheral room (P), or a meeting room (M).

## 2. All used as Any

Ceiling light groups in all rooms can only be turned on or off in groups.

The luminaires in a ceiling light group in any room are turned on or off only as a group.

### **3. All used as Each**

In all rooms, each ceiling light group is controlled by one or more push-buttons, that toggle the light if switched to the other position.

In each room, each ceiling light group is controlled by one or more push buttons, each of which toggles the light group if switched to the other position.

#### **4. Implicit All used as Each**

In the hallways, several push-buttons can toggle the ceiling light group on and off. All push-buttons are connected in parallel.

In each hallway, several push buttons can toggle the hallway's ceiling light group on and off. All and only the push buttons for one ceiling light group are connected in parallel.

## 5. A used as Each

An office (shown in Figure 2) has one door (d1) to the hallway and can have doors to the adjacent rooms (d2, d3).

Each office (shown in Figure 2) has one door (d1) leading to the hallway and can have up to two doors (d2, d3) leading to its adjacent rooms.

## **6. Singular relative clause for All-induced plural noun**

Each office is equipped with two ceiling light groups (window and wall), that can be dimmed individually with dimmer-actuators Ile1 (window) and Ile2 (wall)

Each office is equipped with two ceiling light groups (window and wall), each of which can be dimmed with its own dimmer-actuator (Ile1 and Ile2, respectively).

## **7. Singular relative clause for All-induced plural noun**

Each office is equipped with three status lines (sll1..3) that show the status of the three light sources.

Each office is equipped with three status lines (sll1, sl2, and sl3), each of which shows the status of one light source in the office.

## 8. Implicit **All** with $n-n$ meaning

Staircases connect several floors.

Each staircase connects several floors.

## 9. Missing Each

At the floor level, a staircase is equipped with XXX.

At the landing of each staircase at each floor, the staircase is equipped with XXX.

## 10. Missing Each

A computer lab has one door (d1) to the hallway and can have doors to the adjacent rooms (d2, d3).

Each computer lab has one door (d1) leading to the hallway and can have other doors leading to adjacent rooms (d2, d3).

## **11. Singular relative clause for All-induced plural noun**

Each computer lab is equipped with two ceiling light groups (window and wall) that can be dimmed individually with dimmer-actuators lle1 (window) and lle2 (wall)

Each computer lab is equipped with two ceiling light groups (window and wall), each of which can be dimmed with its own dimmer-actuator, lle1 and lle2, respectively.

## **12. Singular relative clause for All-induced plural noun**

Each computer lab is equipped with two status lines (sll1, sll2) that show the status of the light sources.

Each computer lab is equipped with two status lines (sll1 and sl2) each of which shows the status of one light source in the computer lab.

## **From Directions for Submitting a Proposal**

The following examples were found in the directions for submitting a proposal to NSERC, the Canadian scientific research funding agent.

### **1. Singular object in a plural sentence**

All NSERC applicants have been or will be given a personal identification number (PIN).

All NSERC applicants have been or will be given personal identification numbers (PINs).

Each NSERC applicant has been or will be given a personal identification number (PIN).

## **2. Singular object in a plural sentence**

For group applications, list co-applicants, their personal identification number, their organization, and the time (in hours per month) they will devote to the proposed research or to the use of the equipment or facility.

For group applications, list co-applicants, their personal identification numbers, their organizations, and the time (in hours per month) they will devote to the proposed research or to the use of the equipment or facility.

For group applications, list co-applicants, and for each, his or her personal identification number, his or her organization, and the time (in hours per month) he or she will devote to the proposed research or to the use of the equipment or facility.

In each of these cases, the second correction is better since it makes clear that for each person there is a unique PIN, organization, and amount of time that will be devoted to the work.

## Or and And/Or

Avoid

A or B

in favor of explicit

Either A or B

A or B and not both

A or B or both

according to intended meaning

Avoid

A and/or B

in favor of explicit

A or B or both

By the way, **nor** must be used with **neither** in the construction

**Neither A nor B**

and that construction is singular if **A** and **B** are both singular.

## **That versus which**

Note the difference

He saw his notebook, which he had lost yesterday, under the bushes.

He saw the notebook that he lost yesterday under the bushes.

## **Pronoun Referring to an Idea**

Avoid

The software we write today is unreliable. This is why we must use formal methods.

in favor of

The software we write today is unreliable. This failing is why we must use formal methods.

The software we write today is unreliable. Therefore, we must use formal methods.

## Multiple Adjectives with a Noun

What is a

used toner container ?

a used (toner container)

OR

a (used toner) container

Since we do not use parentheses in normal writing, use other means to indicate which:

used container of toner

container of used toner

# Until

It is not clear if until is open or closed, that is until but not including or until and including.

Use different wording

through

up to

or

expires by

expires at

## **Guidebooks**

We spoke with a dozen lawyers, all of whom had taken a legal writing course in law school. Not one covered any of these issues in the course.

The courses were focused on research and organization of writing and not on mechanics.

We checked various writing style books, for lawyers, for mathematicians and computer scientists, and for ordinary folk, and found very few of the issues covered.

## Legal

Martha Faulk, Irving Mehler, *The Elements of Legal Writing*,  
Macmillan, 1996: none of the issues

Terri LeClerq, Thomas R. Phillips, *Expert Legal Writing*,  
University of Texas, 1995: only; and/or.

Tom Goldstein, Jethro Lieberman, *The Lawyer's Guide to Writing  
Well*, University of California, 1991: only.

## Mathematics and Computer Science

Donald E. Knuth, Tracy Larrabee, Paul M. Roberts, *Mathematical Writing*, Mathematical Association of America, 1989: only; that vs. which.

Justin Zobel, *Writing for Computer Science*, Springer, 1997: “be careful with ‘all’ and ‘some’”.

Lyn Dupré, *BUGS in Writing: A Guide to Debugging Your Prose*: only; and/or; that vs. which; number and gender agreement; every and each singular; shall vs. will; parallelism in either-or, both-and, prepositions, and adverbs.

## General

William Strunk, Jr. *The Elements of Style*, Macmillan, 1979: that vs. which; number and gender agreement; every and each singular; one and his (wrong).

John C. Hodges, Mary E. Whitten, Judy Brown, Jane Flick, *Harbrace College Handbook for Canadian Writers*, Harcourt Brace & Company, 1994: only; and/or; that vs. which; number and gender agreement; every and each singular.