[acronym]*1*

Publicado en enero 2026 por
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Yo, D. Ignacio Gutiérrez Serrera con NIF número 77928386Q,

DECLARO

mi autoría del trabajo que se presenta en la memoria de este trabajo fin de grado que tiene por título:

Upstream - Beyond

Lo cual firmo,

Fdo. D. Ignacio Gutiérrez Serrera
en la Universidad de Sevilla
28/01/2026

Dedico este TFG a mis padres, que siempre me han apoyado en todo y fueron los que me recomendaron hacer un TFG sobre este proyecto cuando era un mar de dudas, al verme mi padre tan motivado trabajando en él y mi madre querer jugar al juego.

No olvides añadir una nota de agradecimiento a quienes hayan contribuido emocionalmente al proyecto fin de Grado.

La idea de este TFG me surgió cuando le pregunté al profesor que impartía la asignatura Diseño y Pruebas 1 si podía hacer para complementar el juego un jugador automático, y fue él mismo el que me sugirió que sería más indicado para un TFG. Al ser un trabajo pensado para 6 que realizamos entre aproximadamente 3,5 miembros, quedó bastante chapucero, así que empecé a mejorarlo por mi cuenta, hasta que mi padre me dijo que me veía muy entusiasmado con el proyecto, que intentase convertirlo en TFG, y recordé las palabras del profesor. Así, los objetivos de este TFG son el de mejorar el juego para que sea lo más eficiente posible, añadir un jugador automático, mejorar la experiencia de uso general y corregir varios de sus fallos. Además, derivado del framework que se trataba en Diseño y Pruebas 2, también quiero hacer un proyecto base para reducir y automatizar la creación de elementos repetitivos que siempre son iguales, como listados o formularios de edición, así como añadirles comprobaciones de seguridad. Estos son los puntos principales, pero el objetivo de verdad es hacer un proyecto de nivel del que me sienta realmente orgulloso y me acerque más al día en que pueda decir que soy ingeniero informático de verdad porque haya adquirido conocimientos en las diversas áreas que abarca esta carrera.

1

3

The good parts of a book may be only something a writer is lucky enough to overhear or it may be the wreck of his whole damn life – and one is as good as the other.

Ernest Hemingway (1899–1961),
Novelist

Resumen de lo que va a ocurrir en el capítulo. ¿Cuál es el objetivo que tenemos con este capítulo?

1.1 El mundo del X (videojuego, e-commerce,...)

Hay que ir poco a poco acotando el contexto donde se desarrolla el proyecto. No se debe sobreentender que el evaluador de la memoria sabe del tema. Escribid el texto para la abuela.

1.2 Subcontexto

1.3 Subsubcontexto

1.4 Estado del arte

Cómo se encuentra la industria hoy en día a nivel económico y tecnológico.

5

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Novelist

Aquí mal un breve resumen del capítulo.

2.1 Motivación

Esta sección se rellenará cuando tengamos un producto de mercado en lugar de un proyecto en el que haya un cliente específico. Deberá justificar brevemente el problema a resolver, escenario en el que se aplica, hipótesis de partida, público objetivo, etc.

2.2 Listado de objetivos

Objetivo 1. Blabla Detalles del objetivo 1.

Objetivo 2. Blabla Detalles del objetivo 2.

9

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3.1 Estructura organizacional del proyecto

¿Se hace en grupo? En caso afirmativo, ¿cuál va a ser la responsabilidad de cada uno?

3.2 Metodología de desarrollo

Indicar en qué metodología nos basamos, explicarla brevemente y luego adaptarla a nuestras necesidades. Cada una de estas cuestiones debe ser una subsección.

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4.1 Resumen temporal del proyecto

Resumen del proyecto	
Fecha de inicio	10/10/2014
Fecha de fin	10/10/2014
Periodicidad de las revisiones	3 semanas
Carga de trabajo semanal	12 horas
Horas totales previstas	225 horas
Horas finales	234 horas

Cuadro 4.1: Tabla resumen de tiempos y planificación

4.2 Planificación inicial

Aquí un desglose de las iteraciones, comienzo y fin de cada una:

Resumen de iteraciones	
Iteración 1	10/10/14 a 21/10/14
Iteración 2	21/10/14 a 15/11/14
...	dd/mm/aa a dd/mm/aa

Cuadro 4.2: Planificación temporal de iteraciones

Explicar cómo se han decidido las fechas, interacción con fechas importantes y situaciones personales.

ESTE CAPÍTULO DEBE ESCRIBIRSE AL COMIENZO DEL PROYECTO

4.3 Informe de tiempos del proyecto

Lo mismo que el anterior pero con datos reales. Ver Tabla **??**.

Justificar los retrasos de forma detallada aquí para cada una de las iteraciones. Explicar las razones.

Resumen de iteraciones	
Iteración 1	10/10/14 a 21/10/14
Iteración 2	21/10/14 a 15/11/14
...	dd/mm/aa a dd/mm/aa

Cuadro 4.3: Planificación temporal de iteraciones

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Novelist

Resumen de lo que va a ocurrir en el capítulo. ¿Cuál es el objetivo que tenemos con este capítulo?

5.1 Resumen de costes del proyecto

Resumen del proyecto	
Costes de personal	5.045 €
Sueldo neto	2.030 €
Impuestos	1.000 €
Costes sociales	2.015 €
Costes materiales	560 €
Costes indirectos	450 €
TOTAL	8.000 €

Cuadro 5.1: Tabla resumen de costes

5.2 Costes de personal

Ya hablaremos de esto

5.3 Costes materiales

Y de esto también. Ver Sección **??**.

5.4 Costes indirectos

Y esto es una fiesta

80

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Resumen de lo que va a ocurrir en el capítulo. ¿Cuál es el objetivo que tenemos con este capítulo?

6.1 Lista de características

Aplicar aquí la primera iteración de Feature Driven Development.

6.2 Diseño arquitectónico

Descripción de los sistemas de producción, preproducción y pruebas.

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7.1 Características a desarrollar

1. Funcionalidad A. Ver Tabla **??**.
2. Funcionalidad B.

Análisis de valor aportado 0001	
Propuesta	Trabajo que pretende analizarse y justificarse
Valor	Qué valor aporta al proyecto o al usuario final.
Coste	Qué costes en términos de esfuerzo, adquisiciones y limitaciones tiene la propuesta
Opciones	Qué otras opciones se tienen que aporten un valor similar? ¿Es realmente un valor relevante para el proyecto/cliente
Riesgos	Qué riesgos pueden surgir a la hora de desarrollar esta propuesta.
Deuda técnica	Posibles deudas técnicas que se asumen con el desarrollo de esta propuesta.

Cuadro 7.1: Análisis de valor aportado 0001

7.2 Diseño

Aquí una discusión de cómo va a afectar todo al diseño

Debe insertarse un diagrama UML de diseño con los cambios y hacer referencia en el texto así Fig. **??**.

Un memorando técnico por cada decisión de diseño.

7.3 Implementación

Un memorando técnico por cada decisión de implementación y refactorización que afecte al diseño.

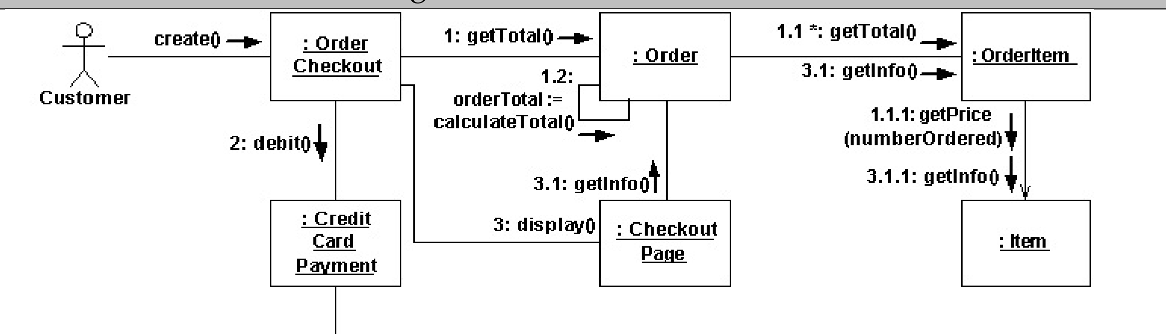
Aquí el modelo de diseño en formato vectorial preferentemente (pdf)

Figura 7.1: Diagrama UML de diseño para la iteración 1

Memorando técnico 0001	
Asunto	¿Cuál es el problema?
Resumen	¿Cuál es la solución propuesta?
Factores causantes	Descripción pormenorizada del problema
Solución	Descripción pormenorizada de la solución propuesta
Motivación	¿Por qué propone esta solución?
Cuestiones abiertas	Factores a tener en cuenta en la solución cuya dimensión se reconoce.
Alternativas	Otras soluciones consideradas y la razón por la que se excluyeron.

Cuadro 7.2: Memorando técnico 0001

<table>
<tr><th colspan="2">Identificador</th><th colspan="3">Descripción de la acción de alto nivel</th></tr>
<tr><td colspan="2">0001</td><td colspan="3">Prueba</td></tr>
<tr><th colspan="5">Métodos de alto nivel</th></tr>
<tr><td colspan="5">[return_type] method_name1 (param1:type1, ...)</td></tr>
<tr><th colspan="5">Pasos (Usar Pseudocódigo o similar)</th></tr>
<tr><td colspan="5">1. Paso 1.</td></tr>
<tr><td colspan="5">2. Paso 2.</td></tr>
<tr><th colspan="5">Métodos de bajo nivel necesarios</th></tr>
<tr><td>Paso</td><td>Clase</td><td>Método</td><td>Mem. Técn.</td><td>IU</td></tr>
<tr><td>1</td><td>ClassName</td><td>[return_type] method_name1 (param1:type1, ...)</td><td>001</td><td>SI</td></tr>
<tr><th colspan="5">Diagrama de Colaboración</th></tr>
</table>



Identificador	Descripción de la acción de alto nivel			
alvotermar02	Grubber			
Métodos de alto nivel				
[return_type] grubber (param1:type1, ...)				
Pasos (Usar Pseudocódigo o similar)				
1. Lanzar 2 dados				
2. Compara resultado de los dados con kicking del open-side				
2.1. Si valor dados es menor o igual a kicking, avanza 10m				
3.1. Si no hay defensa y el golpeo es exitoso, el pateador retiene la posesión del balón				
3.2. Si hay defensa y el golpe es exitoso, el atacante tira un dado y suma su valor al de speed y strength y el defensor lanza 2 dados y lo suma al valor de speed y strength de su jugador, el vencedor será aquel que tenga más puntos, si es igual, la posesión es del defensor				
4.1. Si no es exitoso y hay defensa el balón pasa a posesión del defensor				
4.2. Si no es exitoso y no hay defensa de lanza un line-out				
Métodos de bajo nivel necesarios				
Paso	**Clase**	**Método**	**Mem. Técn.**	**IU**
1	Dice	[Integer] throwDice ()	001	SI
2	ClassName	[Int] compareKickingToDice (kicking:Integer, dice: Integer)	001	SI
2.1	ClassName	[Integer] setLine (line:Integer)	001	SI
4.2	ClassName	[Integer] lineOut ()	001	SI

7.4 Pruebas

Descripción de las pruebas realizadas al software

7.5 Despliegue

Breve resumen de cómo se han desplegado los cambios en el sistema de producción.

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Novelist

Resumen de lo que va a ocurrir en el capítulo. ¿Cuál es el objetivo que tenemos con este capítulo?

8.1 Sección libre

Estructurar en función del proyecto.

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Novelist

Resumen de lo que va a ocurrir en el capítulo. ¿Cuál es el objetivo que tenemos con este capítulo?

9.1 Informe post-mortem

Qué es un informe post-mortem

9.1.1 Lo que ha ido bien

- Argumento a favor 1.
- Argumento a favor 2.
- Argumento a favor 3.

9.1.2 Lo que ha ido mal

- Argumento en contra 1.
- Argumento en contra 2.
- Argumento en contra 3.

9.1.3 Discusión

En función de lo anterior, qué cambiaría si empezara hoy el proyecto de nuevo.

9.2 Trabajos futuros

Enumera los puntos abiertos y que no se han resuelto. Indica si darían lugar a otro proyecto y de qué forma se podría acotar.

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Ernest Hemingway (1899–1961),
Novelist

This is an example of an abstract. Multiple lines are supported. Several paragraphs. It jumps to the next page. Blau blau blau. I am introducing more text to reach the third line

A.1 Software Product Lines

- Objective of a Product Line (PL) (mass production and customisation) [?]
- The focus in software derives in Software Product Lines (SPLs).
- Variability management: variability models
- When and how are used VMs: FMs are described in FODA report as a key element in SPL since they represent the variability and commonality of the different products in a SPL.

A.2 Feature Models

To Abductive Section in 2.1

As the number of products to be built by a SPL may be large and the constraints among features may be complex, representing such an information in a manageable and compact manner is a must. Feature Models (FMs) represent the set of products a SPL may build in terms of product features. Some features are optional while others are mandatory. To indicate the relationships among features, they are hierarchically linked, forming a tree whose root is a feature representing the whole functionality of a product. The root feature is refined in child features, which increase the level of detail and reduce the scope of features. Recursively following this refinement process, a tree-like structure is obtained where three basic kinds of hierarchical relationships are used:

- Mandatory: a mandatory relationship affects a parent and child feature. It forces the child feature to appear in a product whenever its parent feature does.
- Optional: a child feature connected to a parent feature by means of an optional relationship may be optionally selected whenever its parent feature is.
- Set-relationships: three or more features are part of a set-relationship: a parent feature and a set of two or more child features. A set-relationship contains a cardinality that constraints the number of child features to be selected in a product whenever its parent feature is selected. If the cardinality is [1.,1] it is commonly remarked as an *alternative relationship* where only one child feature may be selected at the same time. If the cardinality is $[1..N]$ (where N is the number of

child features), it is also known as an *or-relationship* as any combination of child features is allowed while at least one is selected.

Although FMs can represent most of the most frequent constraints, the hierarchical nature of these models might hinder the representation of some constraints. Under this circumstance, *cross-tree constraints* can be added. The most common kinds of cross-tree constraints are:

- Dependency: a feature depends on another feature if the second one must be part of a product whenever first one is selected.
- Exclusion: two features exclude themselves if both of them cannot be part of a product at the same time.

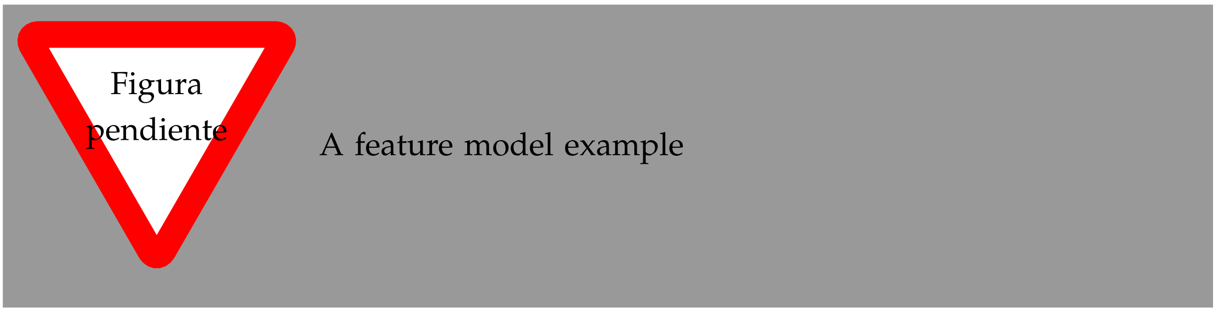


Figura A.1: An example of a Home Integration System

The example in Figure **??** describes a *Home Integration System* (HIS) SPL in terms of its features and the relationships among them. Leaning on this example we define some useful terms:

Partial configuration : a partial configuration is a composed by three sets of selected (S), removed(R) and undecided(U) features. A feature can only be in one of these sets and every feature in the FM (fm) must be in one of them, i.e. $S \cup R \cup U = fm$ and $S \cap R \cap U = \emptyset$. A partial configuration represents an intermediate state during the process of a customer selecting the feature for a custom product. For example, $S_P = \{...\}$, $R_P = \{...\}$ and $U_P = \{...\}$ define a partial configuration for the sample FM where some features are still to be decided if they are to be selecter or removed in a configuration.

(Full) configuration : a full configuration or simply a configuration is a partial configuration such that the set of undecided features in empty. For example, $S_F = \{...\}$ and $R_F = \{...\}$ describe a full configuration for the example FM.

Product : a product is a representation for a full configuration such that only the selected features are remarked. For instance, $P = \{\}$ is a product for the above full configuration. A product such as `A,B` is a valid since all the constraints within the FM are satisfied. However, A,B and C is not a valid product since D is required.

Validation A partial configuration is *valid* if all the relationships and constraints are satisfied given the sets of selected, removed and undecided features. So the definition applies for valid full configurations and valid products. As a conclusion we can affirm that a FM represents all the valid products in a SPL.

Objetivo: Briefly expose attributes as an important asset in feature models.

It is frequent that features are not enough to represent information that is relevant to represent a SPL variability. In this case, FMs are extended with feature attributes such as cost, versions, RAM consumption, etc. in the so-called Extended Feature Models (EFMs) [**?**]. Besides relationships, an EFM contains constraints that affect attributes which reduce even more the set of products a FM describes. Above definitions remain when attributes are introduced into FMs.

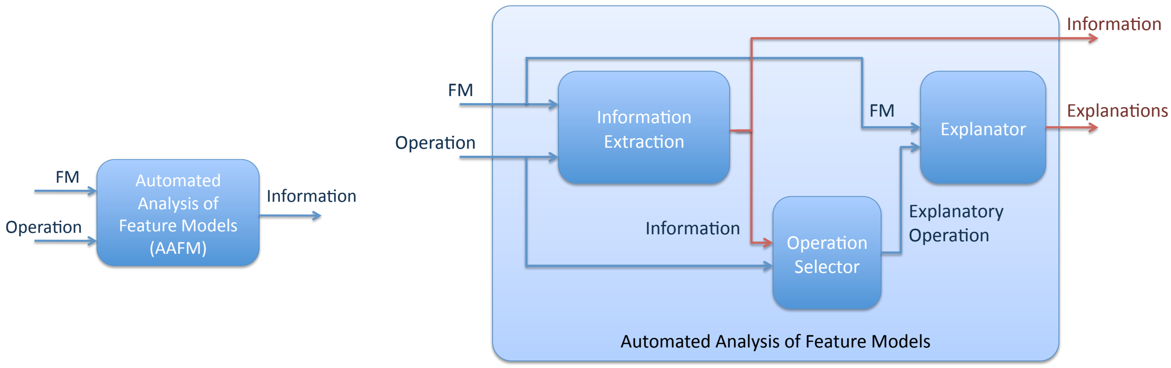
A.3 Automated Analysis of Feature Models

A.3.1 Scope

To Abductive Intro

FMs are used all along the SPL development as key models and many of the development decisions are taken relying on the information contained within them. Most of the times, relationships are complex and hinder the manual extraction of information. Manually obtaining information such as 'which is the product that costs the less?', 'does the feature model contain errors?' or 'why there exist no product containing certain features?' can be an unfeasible task. The complexity and compactness of FMs justify the need of an automated support of these operations. So the *Automated Analysis of Feature Models* (AAFM) arises as a topic of interest to deal with this problem in the SPL community.

The AAFM can be seen as a black-box process that receives a FM and an operation as inputs and obtains information (its kind depends on the analysis operation) as an output (Fig. **??**). There are many operations that extract information from a FM such as 'counting products' operation whose result is a natural number indicating the number of customised products that can be built; or 'list of products' operation that obtains each of those products. This vision of AAFM as a black-box is valid for a subset of analysis operations that we call *information extraction operations* (IEO) that can be seen as processes to extract information from FMs. In other words, an IEO makes explicit an implicit information within a FM.



(a) The AAFM seen as a black-box process

(b) Extending the AAFM process with explanations

Figura A.2: A different view on AAFM distinguishing between information extraction and explanatory operations

Use me to explain in a larger text than 'side-text' anything that is important to a reader not familiar with the dissertation context for example.

However, there is a subset of analysis operations known as *explanatory operations* (EO) whose objective is explaining the result obtained from a IEO. Sometimes, the result is not the expected one and the analyser needs to know which are the relationships that have caused it. For example, let us suppose that the IEO 'which are the products described in a FM that cost less than $1000?' obtains no products as a result. If we were expecting to obtain at least one product, it is important to determine the relationships in the FM that are responsible of that behaviour, so an EO 'why there is no product costing less than $1000?' will shed light on the relationships that avoid obtaining any product. Obtaining no result is not the only case that claims for explanations. If we obtained only one product as a result and we were expecting to obtain at least 10 products, although an answer is obtained the result is unexpected and the discrepancy reasons have to be found. Moreover, explanatory operations are also useful even when an expected result is obtained, to reinforce the certainty that the result is correct. So it can be concluded that EOs complement the information an FM analyser obtains from IEOs.

The complexity of feature modelling relies on correctly setting the relationships that describe the set of products to be built in a SPL. Relationships are the only elements responsible of the results obtained in FM analysis. So an *explanation* is a set of relationships that may have caused that result. While IEO provides for an unique response that is known for certain, an EO provides for a set of probable explanations to a result obtained from a IEO, being only one of them a valid explanation. It would be the analyser the one in charge of discriminating the correct explanation, maybe performing new analysis operations.

THIS IS A SIDE TEXT. USE TO REMARK IMPORTANT INFORMATION

Therefore, two kinds of operations are distinguished in AAFM: information extraction and explanatory operations. Explanatory operations have no sense without a paired information extraction operation and its result. To ensure that explanatory operations are always paired to an information extraction operation, we define a new black-box process of AAFM that incorporates explanations as an additional output (see Figure **??**)

1. Information extraction: the original process, which remains the same.
2. Operation selector: depending on the information extraction operation the analyser asks for and the information obtained as a result, this process provides the explanatory operation to be performed. In other words, it pairs an explanatory operation to an information extraction operation.
3. Explanatory analysis: provides a set of explanations from the FM and the explanatory operation.

The overall process can be encapsulated into a holistic black-box process which receives the FM and the information extraction operation as inputs and provides a result and explanations as outputs. It can be seen as we just add explanations as an output to the analysis process.

To realise this view on the AAFM, we need to give details on the insides of these black-boxes. Since the information extraction process is already rigourously defined in

Benavides' PhD dissertation, the purpose of this paper is defining the remaining two sub-processes. We formalise the explanatory analysis process by means of default logic and provide the criteria to implement the operation selector process.

Most Common Techniques to perform AAFM Operations.

A.4 Dynamic Software Product Lines (DSPL)

What is a Dynamic Software Product Line (DSPL). Different points of view. What is important is the automation of reconfiguration properties relying on SPL techniques.

We focus in the application of explanations in DSPLs as an application of our results. Specifically we have worked in MAS and smart homes providing a solution for automating product reconfiguration.

A.5 Hypothesis and Objectives

Objetivo: Justifying that explanations are a particular set of operations in AAFM that are not solvable by means of the techniques that are used up-to-date

Objetivo: Set an impacting phrase that summarises the hypothesis

Hypothesis

Explanations cannot be solved by AI techniques used to solve AAFM. There should exist other AI techniques to solve explanations.

Objective of the dissertation

Defining a framework to provide solutions for explanatory analysis in FMs.

This dissertation summarises our contribution to solve some of the objectives we set in our PhD project.

- Defining a catalog of analysis operations where explanations are applied.
- Rigorously defining these operations in terms of logics.
- Proposing solutions to these operations.
- Validating our results by means of tools and projects where they are applied.

Next chapter focuses on refining how we have contributed to deal with the above objectives.

A piece of code...

```
public Map<Cardinality,CardinalValue> detectWrongCardinals() {
        // any other implementation of Map can be used instead.
        Map<Cardinality,CardinalValue> result =
                new TreeMap<Cardinality,CardinalValue>();
        for( r : relationships) {
                if (r instanceof Set) {
                        Set set = (Set)r;
                        Cardinality card = set.getCardinality();
                        Domain dom = card.getDomain();
                        for (value: dom.getValues())
                                if (isWrongCardinal(card,value))
                                        result.put(card,value);
                }
        }
        return result;
}
```

A coolTable. Use inside a table.

Use \TableSubtitle{n,title} to add a subtitle as the header. n is the number of columns and title is the text to place. [**?**]

long

A Catalog of FM Explanatory Operations (2009 version)		
Information Extraction Operation	**FM Explanatory Operations**	
	Why? operation	*Why not? operation*
Valid FM	-	invalid FM
Valid Configuration	valid partial conf.	invalid partial conf.
Valid Product	valid product	invalid product
Products Listing	vaild Product/Config	invalid FM/Product/Config
Products Counting	vaild Product/Config	invalid FM/Product/Config
Optimisation	vaild Product/Config	invalid FM/Product/Config
Core feature	core feature	core feature
Variant feature	variant feature	variant feature
Dead feature detection	-	dead feature
False-optional feature detection	-	false-optional feature
Wrong-cardinality detection	-	wrong cardinal
Information Extraction Operation	**Configuration Explanatory Operations**	
	Why? operation	*Why not? operation*
Valid Configuration	valid partial conf.	invalid partial conf.

Cuadro A.1: Most frequently used explanatory operations and their corresponding information extraction operations