BUYINPORTUGAL.PT

Projeto #12

Mestrado Integrado em Engenharia Informática e Computação

Métodos Formais em Engenharia de Software

4MIEIC03
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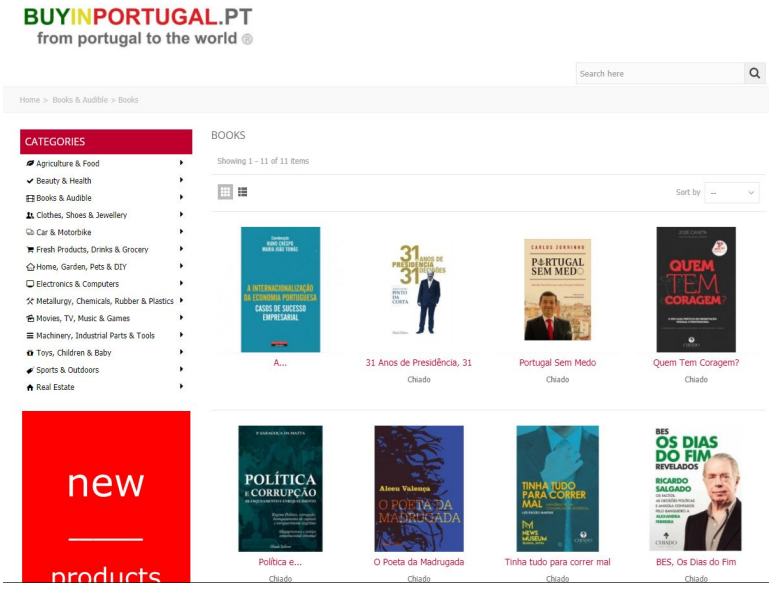
1. Descrição informal e lista de requisitos

1.1 Descrição informal do sistema

A Buyinportugal.pt é um website de comércio online vendedor-vendedor que procurar facilitar a venda de comerciantes portugueses, de pequenas e médias empresas a compradores de todo o mundo. A sua principal missão é simplificar o processo de negócio com Portugal ao ajudar os compradores a encontrar produtos, através de uma boa pesquisa, e serviços de fornecedores portugueses, de forma rápida e eficaz, para isso o site disponibiliza toda a oferta de produtos devidamente categorizada e ainda a informação específica de um produto. Alguns produtos contam ainda com descontos de quantidade associados, sendo possível criar lista de desejos e efetuar compras.

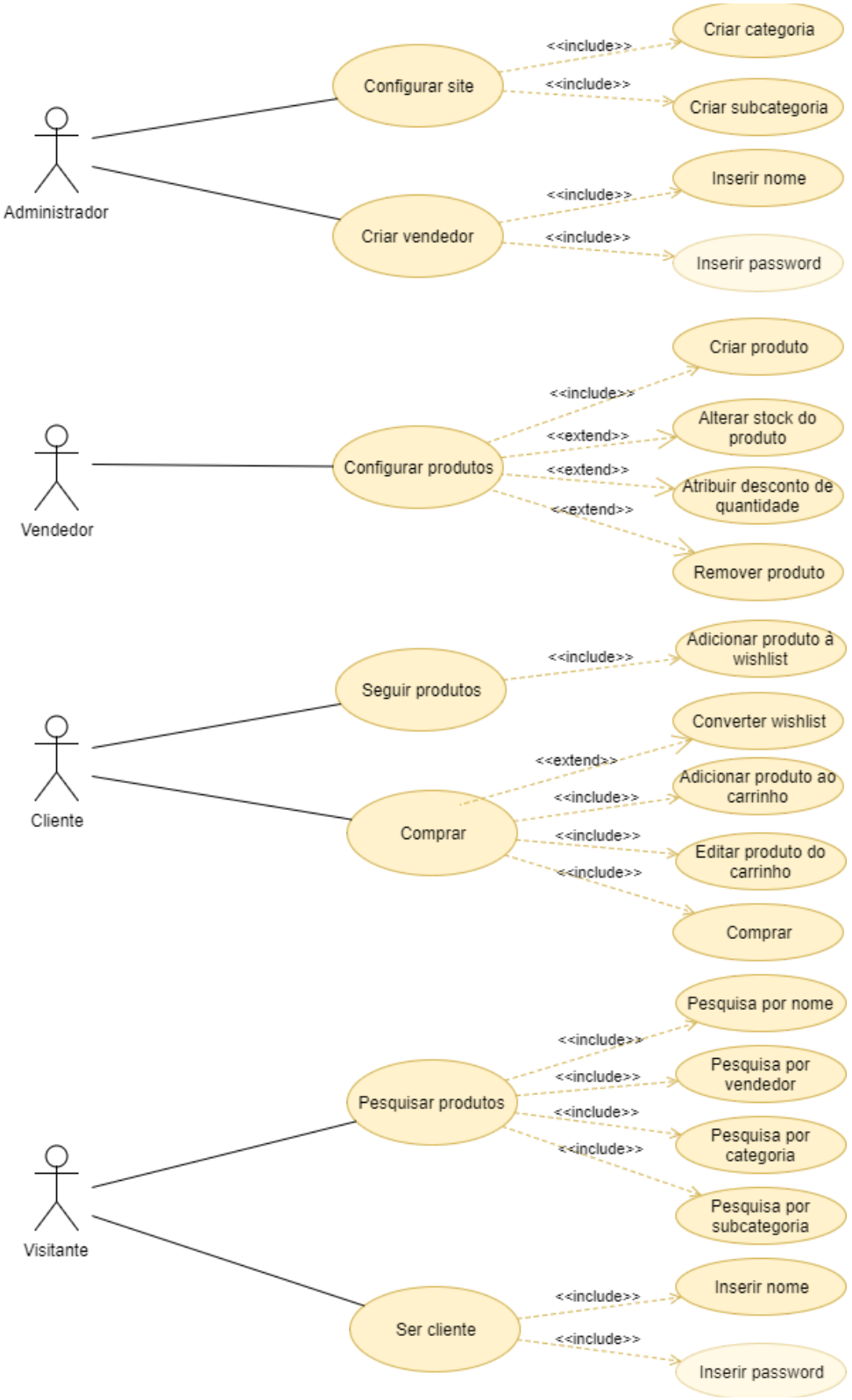


1.2 Lista de requisitos

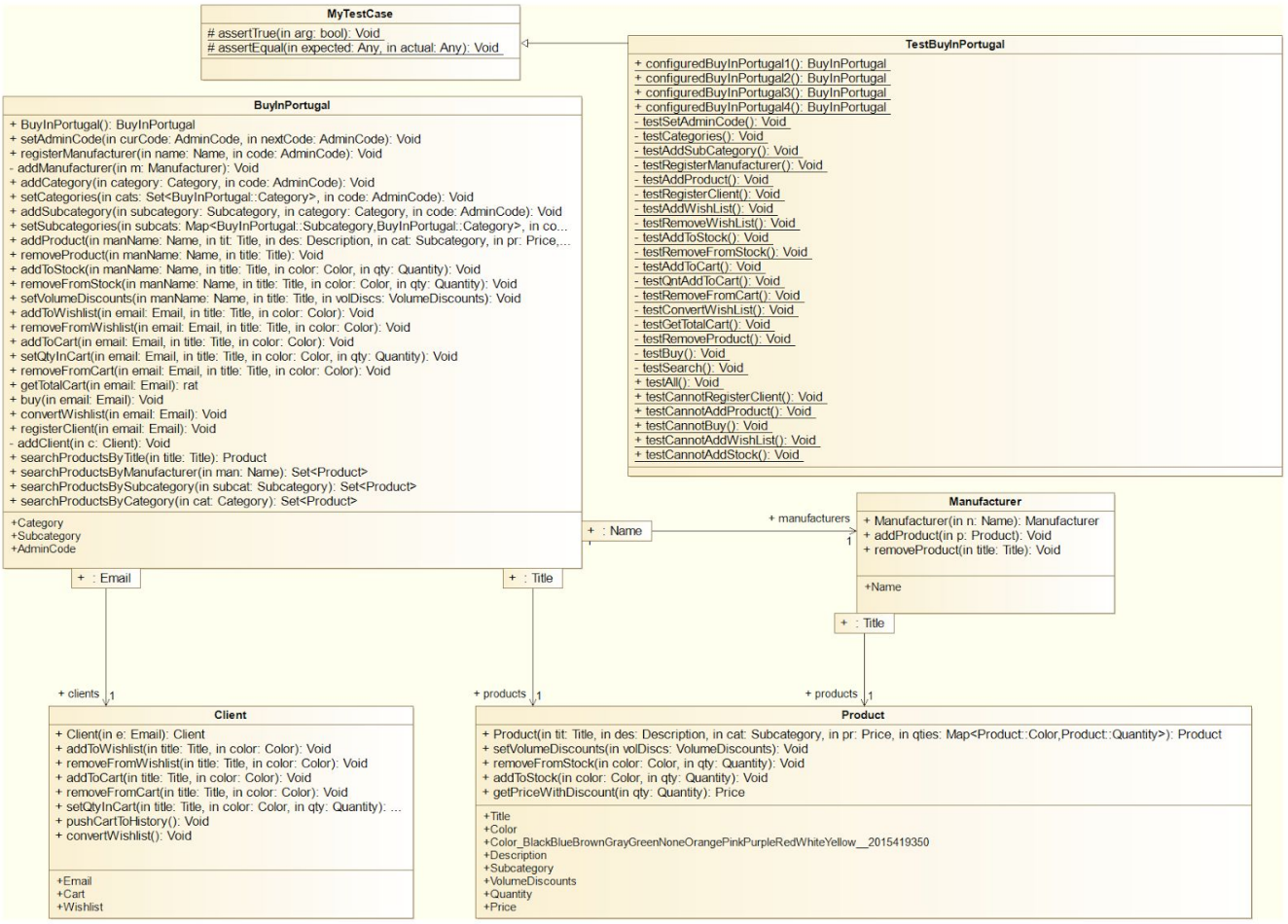
Id	Prioridade	Descrição
R10	Obrigatório	O administrador pode configurar as categorias e subcategorias do site.
R11	Obrigatório	O administrador pode criar vendedores com nome e password.
R20	Obrigatório	O vendedor pode criar produtos para venda.
R21	Obrigatório	O vendedor pode remover produtos para venda.
R22	Obrigatório	O vendedor pode alterar o stock de produtos disponíveis para venda.
R30	Obrigatório	O cliente pode adicionar e remover produtos da sua wishlist.
R31	Obrigatório	O cliente pode adicionar, produtos ao seu carrinho de compras.
R32	Obrigatório	O cliente pode comprar os produtos do seu carrinho de compras.
R41	Obrigatório	O visitante pode tornar-se cliente.
R42	Obrigatório	O visitante pode pesquisar produtos pelo nome, vendedor ou categoria.
R210	Opcional	O vendedor pode atribuir descontos de quantidade a um produto.
R310	Opcional	O cliente pode converter a sua wishlist em carrinho de compras atribuindo quantidades aos produtos respetivos.

2. Diagramas UML

2.1 Diagrama de casos de uso



2.2 Diagrama de classes



Classe	**Descrição**
Client	Define os clientes que pertencem à rede BuyInPortugal.
Manufacturer	Define os fabricantes que podem colocar produtos à venda na rede BuyInPortugal.
Product	Define os produtos à venda na rede BuyInPortugal.
BuyInPortugal	Core model; define a rede BuyInPortugal e as operações que se podem realizar na mesma.
MyTestCase	Super classe das classes de teste, contém assertEqual e assertTrue.
TestBuyInPortugal	Define os testes e cenários de uso para a rede BuyInPortugal.

3. Modelo formal VDM++

3.1 *Class* BuyInPortugal

```
class BuyInPortugal
types
	public Category = seq of char;
	public Subcategory = seq of char;
	public AdminCode = seq of char;

instance variables
	public categories : set of Category := {};
	public subcategories : map Subcategory to Category := { |-> };
	public manufacturers : map Manufacturer`Name to Manufacturer := { |-> };
	public products : map Product`Title to Product := { |-> };
	public clients : map Client`Email to Client := { |-> };

	public adminCode : AdminCode := [];

	-- subcategories should be associated with category
  inv rng subcategories subset categories;
  -- products should be the union of products from all manufacturers
  inv forall product in set rng products
	& exists1 manufacturer in set rng manufacturers
		& product in set rng manufacturer.products

operations
	/** ADMIN OPERATIONS **/

	public BuyInPortugal: () ==> BuyInPortugal
	BuyInPortugal() ==
		return self;

	-- Change admin password
	public setAdminCode: AdminCode * AdminCode ==> ()
	setAdminCode(curCode, nextCode) ==
		adminCode := nextCode
	pre curCode <> nextCode
		and curCode = adminCode;

	-- Register manufacturer
	public registerManufacturer: Manufacturer`Name * AdminCode ==> ()
	registerManufacturer(name, code) == (
		dcl m:Manufacturer := new Manufacturer(name);
		addManufacturer(m);
	)
	pre name not in set dom manufacturers
		and code = adminCode
	post dom manufacturers = dom manufacturers~ union {name};

	private addManufacturer: Manufacturer ==> ()
	addManufacturer(m) == (
		manufacturers := manufacturers munion { m.name |-> m };
```

```
	);

	-- Add category
	public addCategory: Category * AdminCode ==> ()
	addCategory(category, code) == (
		categories := categories union {category};
	)
	pre category not in set categories
		and code = adminCode
	post categories = categories~ union {category};

	-- Set categories
	public setCategories: set of Category * AdminCode ==> ()
	setCategories(cats, code) == (
		categories := cats;
	)
	pre code = adminCode;

	-- Add subCategories
	public addSubcategory: Subcategory * Category * AdminCode ==> ()
	addSubcategory(subcategory, category, code) == (
		subcategories := subcategories munion {subcategory |-> category};
	)
	pre subcategory not in set dom subcategories
		and category in set categories
		and code = adminCode
	post dom subcategories = dom subcategories~ union {subcategory};

	-- Set subCategories
	public setSubcategories: map Subcategory to Category * AdminCode ==> ()
	setSubcategories(subcats, code) == (
		subcategories := subcats;
	)
	pre code = adminCode;

	/** ADMIN OPERATIONS END **/


	/** MANUFACTURER OPERATIONS **/

	-- Add product
	public addProduct: Manufacturer`Name * Product`Title * Product`Description
* Product`Subcategory * Product`Price * map Product`Color to Product`Quantity ==>
()
	addProduct(manName, tit, des, cat, pr, qties) == (
		dcl product : Product := new Product(tit, des, cat, pr, qties);
		let manufacturer = manufacturers(manName)
			in (
				manufacturer.addProduct(product);
				products := products munion {tit |-> product};
			);
			return;
	)
	pre manName in set dom manufacturers
		and tit not in set dom products
		and cat in set dom subcategories
	post dom products = dom products~ union {tit};
```

```
	-- Remove product
	public removeProduct: Manufacturer`Name * Product`Title ==> ()
	removeProduct(manName, title) == (
		let manufacturer = manufacturers(manName)
			in (
				products := {title} <-: products;
				manufacturer.removeProduct(title);
				for all client in set rng clients
				do (
					for all mk_(t, color) in set client.wishlist
					do (
						if t = title then
client.removeFromWishlist(t, color);
					);
					for all mk_(t, color) in set dom client.cart
					do (
						if t = title then client.removeFromCart(t,
color);
					);
				);
		);
	)
	pre manName in set dom manufacturers
		and title in set dom products
	post dom products = dom products~ \ {title}
		and forall client in set rng clients &
			not exists mk_(t1, -) in set client.wishlist
				& t1 = title
			and not exists mk_(t2, -) in set dom client.cart
				& t2 = title;

	-- Add to stock of a product
	public addToStock: Manufacturer`Name * Product`Title * Product`Color *
Product`Quantity ==> ()
	addToStock(manName, title, color, qty) == (
		let product = products(title)
		in (
			product.addToStock(color, qty);
		);
	)
	pre title in set dom manufacturers(manName).products;

	-- Remove from stock of a product
	public removeFromStock: Manufacturer`Name * Product`Title * Product`Color *
Product`Quantity ==> ()
	removeFromStock(manName, title, color, qty) == (
		let product = products(title)
		in (
			product.removeFromStock(color, qty);
		);
	)
	pre title in set dom manufacturers(manName).products;

		-- Set volume discounts
	public setVolumeDiscounts : Manufacturer`Name * Product`Title *
Product`VolumeDiscounts ==> ()
	setVolumeDiscounts(manName, title, volDiscs) == (
	let product = products(title)
```

```
		in (
			product.setVolumeDiscounts(volDiscs);
		);
	)
	pre title in set dom manufacturers(manName).products;

	/** MANUFACTURER OPERATIONS END **/


	/** CLIENT OPERATIONS **/

	-- Add to wishlist of a client
	public addToWishlist: Client`Email * Product`Title * Product`Color ==> ()
	addToWishlist(email, title, color) == (
		let client = clients(email)
		in (
			client.addToWishlist(title, color);
		);
	);

	-- Remove from wishlist of a client
	public removeFromWishlist: Client`Email * Product`Title * Product`Color ==>
()
	removeFromWishlist(email, title, color) == (
		let client = clients(email)
		in (
			client.removeFromWishlist(title, color);
		);
	);

	-- Add to cart of a client
	public addToCart: Client`Email * Product`Title * Product`Color ==> ()
	addToCart(email, title, color) == (
		let client = clients(email)
		in (
			client.addToCart(title, color);
		);
	);

	-- Set quantity from cart product of a client
	public setQtyInCart: Client`Email * Product`Title * Product`Color *
Product`Quantity ==> ()
	setQtyInCart(email, title, color, qty) == (
		let client = clients(email)
		in (
			client.setQtyInCart(title, color, qty);
		);
	);

	-- Remove from cart of a client
	public removeFromCart: Client`Email * Product`Title * Product`Color ==> ()
	removeFromCart(email, title, color) == (
		let client = clients(email)
		in (
			client.removeFromCart(title, color);
		);
	);
```

```
	-- Get total cart value
	public getTotalCart: Client`Email ==> rat
	getTotalCart(email) == (
		dcl sum: rat := 0;
		let client = clients(email), cart = client.cart
		in (
			for all mk_(title, color) in set dom cart
				do (let qty = cart(mk_(title, color))
					in sum := sum +
products(title).getPriceWithDiscount(qty) * qty;
				);
			return sum;
		);
	)
	pre email in set dom clients;

	-- Buy cart from client
	public buy: Client`Email ==> ()
	buy(email) == (
		let client = clients(email), cart = client.cart
		in (
			for all mk_(title, color) in set dom cart
				do (
					products(title).removeFromStock(color,
cart(mk_(title, color)))
				);
			client.pushCartToHistory();
		);
	)
	pre let client = clients(email), cart = client.cart
		in (
			forall mk_(title, color) in set dom cart
			& cart(mk_(title, color)) <=
products(title).quantities(color)
		);

	-- Convert wishlist of a client
	public convertWishlist: Client`Email ==> ()
	convertWishlist(email) == (
		let client = clients(email)
		in (
			client.convertWishlist();
		);
	);

	/** CLIENT OPERATIONS END **/


	/** VISITOR OPERATIONS **/

	-- Register client
	public registerClient: Client`Email ==> ()
	registerClient(email) == (
	dcl c:Client := new Client(email);
		addClient(c);
	)
	pre email not in set dom clients
	post dom clients = dom clients~ union {email};
```

```
	private addClient: Client ==> ()
	addClient(c) == (
		clients := clients munion { c.email |-> c };
	);

	-- Get product by title
	public searchProductsByTitle: Product`Title ==> Product
	searchProductsByTitle(title) == (
		dcl product: Product;
		product := products(title);
		return product;
	);

		-- Get products by manufacturer
	public searchProductsByManufacturer: Manufacturer`Name ==> set of Product
	searchProductsByManufacturer(man) == (
		dcl resultPoducts: set of Product := {};
		resultPoducts := rng manufacturers(man).products;
		return resultPoducts;
	)
	pre man in set dom manufacturers;

	-- Get products by subcategory
	public searchProductsBySubcategory: Subcategory ==> set of Product
	searchProductsBySubcategory(subcat) == (
		dcl resultProducts: set of Product := {};
		for all product in set rng products
			do (
				if product.subcategory = subcat
				then resultProducts := resultProducts union {product};
			);
		return resultProducts;
	)
	pre subcat in set dom subcategories;


	-- Get products by category
	public searchProductsByCategory: Category ==> set of Product
	searchProductsByCategory(cat) == (
		dcl resultProducts: set of Product := {};
		for all product in set rng products
			do (
				if subcategories(product.subcategory) = cat
				then resultProducts := resultProducts union {product};
			);
		return resultProducts;
	)
	pre cat in set categories;
	/** VISITOR OPERATIONS END **/

end BuyInPortugal
```

3.2 *Class* Client

```
class Client
```

```
types
	public Email = seq of char;
	public Cart = map (Product`Title * Product`Color) to nat1;
	public Wishlist = set of (Product`Title * Product`Color);

instance variables
  public cart: Cart  := { |-> };
  public wishlist: Wishlist := {};
  public email: Email;
  public buyHistory : seq of Cart := [];

operations
	public Client : Email ==> Client
	Client(e) == (
		email := e;
	  return self
	);

	-- Add product to wishlist
	public addToWishlist: Product`Title * Product`Color ==> ()
	addToWishlist(title, color) == (
		wishlist := wishlist union { mk_(title, color) };
	)
	pre mk_(title, color) not in set wishlist;

	-- Remove product from wishlist
	public removeFromWishlist: Product`Title * Product`Color ==> ()
	removeFromWishlist(title, color) == (
		wishlist := wishlist \ {mk_(title, color)};
	)
	pre mk_(title, color) in set wishlist;

	-- Add product to cart
	public addToCart: Product`Title * Product`Color ==> ()
	addToCart(title, color) == (
		cart := cart munion { mk_(title, color) |-> 1 };
	)
	pre mk_(title, color) not in set dom cart;

	-- Remove product from cart specific color
	public removeFromCart: Product`Title * Product`Color ==> ()
	removeFromCart(title, color) == (
		cart := {mk_(title, color)} <-: cart;
	)
	pre mk_(title, color) in set dom cart;

	-- Set product quantity in cart
	public setQtyInCart: Product`Title * Product`Color * Product`Quantity ==>
()
	setQtyInCart(title, color, qty) == (
		cart := cart ++ { mk_(title, color) |-> qty };
```

```
	)
	pre mk_(title, color) in set dom cart
		and qty > 0;

	-- Push cart to buy history
	public pushCartToHistory: () ==> ()
	pushCartToHistory() == (
		buyHistory := [cart] ^ buyHistory;
		cart := { |-> };
	)
	pre card dom cart > 0
	post cart = { |-> }
		and len buyHistory = len buyHistory~ + 1;

	-- Convert wishlist to cart
	public convertWishlist: () ==> ()
	convertWishlist() == (
		for all mk_(title, color) in set wishlist
			do (
				if mk_(title, color) not in set dom cart
				then addToCart(title, color);
			);
		wishlist := { };
	)
	pre card wishlist > 0
	post wishlist = { }
		and card dom cart = card (dom cart~ union wishlist~);


end Client
```

3.3 *Class* Manufacturer

```
class Manufacturer
types
	public Name = seq of char;

instance variables
	public name : Name;
	public products : map Product`Title to Product := { |-> };

operations
	public Manufacturer : Name ==> Manufacturer
	Manufacturer(n) == (
		name := n;
	  return self
	);

	-- Add product
	public addProduct: Product ==> ()
	addProduct(p) == (
		products := products munion { p.title |-> p };
	)
```

```
	pre p.title not in set dom products;

	-- Remove product
	public removeProduct: Product`Title ==> ()
	removeProduct(title) == (
		products := {title} <-: products;
	)
	pre title in set dom products;

end Manufacturer
```

3.4 *Class* Product

```
class Product

types
	public Title = seq of char;
	public Description = seq of char;
	public Subcategory = seq of char;
	public VolumeDiscounts =  map Quantity to Price;
	public Quantity = nat;
	public Price = rat;
	public Color = <White> | <Blue> | <Pink> | <Yellow> | <Orange> | <Black> |
<Purple> | <Brown> | <Green> | <Gray> | <Red> | <None> ;

instance variables
  public title: Title;
  public description: Description;
  public price: Price;
  public subcategory: Subcategory;
  public quantities: map Color to Quantity := { <None> |-> 0};
  public volumeDiscounts: VolumeDiscounts := { |-> };
  public colors: set of Color := {<None>};

  inv card colors > 0;
  inv <None> in set colors => card colors = 1;
  inv dom quantities = colors;

operations

	-- Create product with color
	public Product : Title * Description * Subcategory * Price * map Color to
Quantity ==> Product
	Product(tit, des, cat, pr, qties) == (
		subcategory := cat;
	  title := tit;
	  description := des;
	  price := pr;
	  quantities := qties;
	  colors := dom qties;
	  return self;
	)
	pre
		if <None> in set (dom qties)
		then (dom qties) = {<None>}
		else qties <> { |-> };
```

```
	-- Set volume discounts
	public setVolumeDiscounts : VolumeDiscounts ==> ()
	setVolumeDiscounts(volDiscs) == (
		volumeDiscounts := volDiscs;
	);

	-- Remove from stock in products with color
	public removeFromStock: Color * Quantity ==> ()
	removeFromStock(color, qty) == (
		quantities := quantities ++ {color |-> (quantities(color) - qty)};
	)
	pre color in set colors
		and qty <= quantities(color);

	-- Add to stock in products with color
	public addToStock: Color * Quantity ==> ()
	addToStock(color, qty) == (
		quantities := quantities ++ {color |-> (quantities(color) + qty)};
	)
	pre color in set colors;

	-- Get price with discount applied
	public getPriceWithDiscount: Quantity ==> Price
	getPriceWithDiscount(qty) == (
		dcl discountedPrice : Price := price;
		if volumeDiscounts <> { |-> }
		then (
			for all quantity in set dom volumeDiscounts
				do (
					if (qty >= quantity and discountedPrice >
volumeDiscounts(quantity))
					then discountedPrice :=
volumeDiscounts(quantity);
				);
		);
		return discountedPrice;
	)
	post RESULT <= price;

end Product
```

4. Validação do modelo

A cobertura do modelo pode ser confirmada pelas tabelas geradas no Overture:

Function or operation	Line	Coverage	Calls
BuyInPortugal	22	100.0%	336
addCategory	49	100.0%	274
addClient	228	100.0%	128
addManufacturer	43	100.0%	234
addProduct	87	100.0%	200
addSubcategory	65	100.0%	216
addToCart	146	100.0%	84
addToStock	103	100.0%	179
addToWishlist	128	100.0%	54
buy	188	100.0%	18
convertWishlist	206	100.0%	22
getTotalCart	173	100.0%	55
registerClient	220	100.0%	128
registerManufacturer	34	100.0%	234
removeFromCart	164	100.0%	11
removeFromStock	113	100.0%	11
removeFromWishlist	137	100.0%	11
removeProduct	103	100.0%	10
searchProductByCategory	265	100.0%	3
searchProductBySubcategory	251	100.0%	1
searchProductsByCategory	299	100.0%	3
searchProductsByManufacturer	242	100.0%	1
searchProductsBySubcategory	285	100.0%	1
searchProductsByTitle	234	100.0%	1
setAdminCode	27	100.0%	9
setCategories	58	100.0%	212
setQtyInCart	155	100.0%	84
setSubcategories	75	100.0%	190
setVolumeDiscounts	123	100.0%	33
BuyInPortugal.vdmpp		100.0%	2743

Function or operation	Line	Coverage	Calls
Client	15	100.0%	256
addToCart	36	100.0%	153
addToWishlist	22	100.0%	111
convertWishlist	68	100.0%	41
pushCartToHistory	58	100.0%	25
removeFromCart	43	100.0%	88
removeFromWishlist	29	100.0%	38
setQtyInCart	50	100.0%	111
Client.vdmpp		100.0%	823

Function or operation	Line	Coverage	Calls
Manufacturer	10	100.0%	288
addProduct	17	100.0%	384
removeProduct	24	100.0%	9
Manufacturer.vdmpp		100.0%	681

Function or operation	Line	Coverage	Calls
Product	27	100.0%	214
addToStock	67	100.0%	134
getPriceWithDiscount	74	100.0%	32
removeFromStock	59	100.0%	52
setVolumeDiscounts	53	100.0%	8
Product.vdmpp		100.0%	440

4.1 *Class* MyTestCase

Nota: Esta *class* é da inteira autoria dos professores da unidade curricular e foi usada por suprir as nossas necessidade e ser mais simples que a VDMUnit`TestCase.

```
class MyTestCase
/*
  Superclass for test classes, simpler but more practical than
VDMUnit`TestCase.
  For proper use, you have to do: New -> Add VDM Library -> IO.
  JPF, FEUP, MFES, 2014/15.
*/

operations

        -- Simulates assertion checking by reducing it to pre-condition
checking.
        -- If 'arg' does not hold, a pre-condition violation will be
signaled.
```

```
		protected static assertTrue: bool ==> ()
		assertTrue(arg) ==
			return
		pre arg;

		-- Simulates assertion checking by reducing it to post-condition
checking.
		-- If values are not equal, prints a message in the console and
generates
		-- a post-conditions violation.
		protected static assertEqual: ? * ? ==> ()
		assertEqual(expected, actual) ==
			if expected <> actual then (
				IO`print("Actual value (");
				IO`print(actual);
				IO`print(") different from expected (");
				IO`print(expected);
				IO`println(")\n")
			)
		post expected = actual

	end MyTestCase
```

4.2 *Class* TestBuyInPortugal

```
	class TestBuyInPortugal is subclass of MyTestCase
	/* Test cases for BuyInPortugal model*/

	instance variables
		public static testManufacturer : Manufacturer := new
Manufacturer("RENOVA");
		public static testProduct: Product := new Product("Pocket Tissues",
			"- 3-ply base sheet\n- 36x9 tissues per pack\n- Tissue size:
21x21cm",
			"Health & Personal Care",
			1.23,
			{<White> |-> 0,
				<Blue> |-> 0,
				<Pink> |-> 0,
				<Yellow> |-> 0,
				<Orange> |-> 0,
				<Purple> |-> 0,
				<Green> |-> 0,
				<Red> |-> 0
			});
			public static testClient : Client := new
Client("logistica@fe.up.pt");



	operations

		-- Pre configuration 1 that returns a BuyInPortugal model with
categories, subcategories and a manufacturer
		public static configuredBuyInPortugal1: () ==> BuyInPortugal
		configuredBuyInPortugal1() == (
			dcl bip : BuyInPortugal := new BuyInPortugal();
```

```
                bip.setCategories({
                        "Agriculture & Food",
                        "Beauty & Health",
                        "Books & Audible",
                        "Clothes, Shoes & Jewellery",
                        "Car & Motorbike",
                        "Fresh Products, Drinks & Grocery",
                        "Home, Garden, Pets & DIY",
                        "Electronics & Computers",
                        "Metallurgy, Chemicals, Rubber & Plastics",
                        "Movies, TV, Music & Games",
                        "Machinery, Industrial Parts & Tools",
                        "Toys, Children & Baby",
                        "Sports & Outdoors"
                        },"");
                bip.addCategory("Real Estate","");

                bip.setSubcategories({
                "Vanilla Beans" |-> "Agriculture & Food",
                "Plant Seeds & Bulbs" |-> "Agriculture & Food",
                "Nuts & Kernels" |-> "Agriculture & Food",
                "Health & Personal Care" |-> "Beauty & Health",
                "Breads & Bakery" |-> "Fresh Products, Drinks & Grocery",
                "Dairy & Eggs" |-> "Fresh Products, Drinks & Grocery"
                },"");
                bip.addSubcategory("Investment", "Real Estate","");

                bip.registerManufacturer(testManufacturen.name,"");

                return bip;
        );

        -- Pre configuration 2 that returns a BuyInPortugal model containing
all pre config 1 contained plus a product and a client
        public static configuredBuyInPortugal2: () ==> BuyInPortugal
        configuredBuyInPortugal2() == (
                dcl bip : BuyInPortugal := configuredBuyInPortugal1();

                bip.addProduct(testManufacturer.name, testProduct.title,
testProduct.description, testProduct.subcategory, testProduct.price,
testProduct.quantities);

                bip.registerClient(testClient.email);

                return bip;
        );

        -- Pre configuration 2 that returns a BuyInPortugal model containing
all pre config 2 contained plus stock of the product
        public static configuredBuyInPortugal3: () ==> BuyInPortugal
        configuredBuyInPortugal3() == (
                dcl bip : BuyInPortugal := configuredBuyInPortugal2();

                bip.addToStock(testManufacturer.name, testProduct.title,
<Blue>, 36);
                bip.addToStock(testManufacturer.name, testProduct.title,
<White>, 2);
```

```
		return bip;
	);

	-- Pre configuration 2 that returns a BuyInPortugal model containing
all pre config 2 contained plus more products and manufacturers examples
	public static configuredBuyInPortugal4: () ==> BuyInPortugal
	configuredBuyInPortugal4() == (
		dcl bip : BuyInPortugal := configuredBuyInPortugal2();

		bip.registerManufacturer("DANONE","");

		bip.addProduct("DANONE","YOGURT PURE AROMA TUTTI - FRUTTI
4X120G", "", "Dairy & Eggs", 2.45, {<None> |-> 0});
		bip.addProduct("DANONE","YOGURT CHILD ONE BONGO 8 FRUITS
4X155G", "", "Dairy & Eggs", 2, {<None> |-> 0});

		bip.addToStock(testManufacturer.name, testProduct.title,
<Blue>, 36);
		bip.addToStock(testManufacturer.name, testProduct.title,
<White>, 2);

		return bip;
	);


	/** TEST CASES WITH VALID INPUTS **/


	-- Test Set Admin Code
	private static testSetAdminCode: () ==> ()
	testSetAdminCode() ==	(
		dcl bip : BuyInPortugal := new BuyInPortugal();
		bip.setAdminCode("","1234");
		assertEqual("1234", bip.adminCode);
	);

	-- Test Category
	private static testCategories: () ==> ()
	testCategories() == (
		dcl bip : BuyInPortugal := new BuyInPortugal();
		assertEqual({}, bip.categories);
		bip.addCategory("Agriculture & Food","");
		assertTrue("Agriculture & Food" in set bip.categories);
		bip.setCategories({"Beauty & Health", "Books & Audible"},"");
		bip.addCategory("Real Estate","");
		assertEqual({"Beauty & Health", "Books & Audible", "Real
Estate"}, bip.categories);
	);

	-- Test Add SubCategory
	private static testAddSubCategory: () ==> ()
	testAddSubCategory() ==	(
		dcl bip : BuyInPortugal := new BuyInPortugal();
		bip.addCategory("Real Estate","");
		assertTrue("Investment" not in set dom bip.subcategories);
		bip.addSubcategory("Investment", "Real Estate","");
		assertEqual("Real Estate", bip.subcategories("Investment"));
```

```
		);

		-- Test Register Manufacturer
		private static testRegisterManufacturer: () ==> ()
		testRegisterManufacturer() ==	(
			dcl bip : BuyInPortugal := new BuyInPortugal();
			assertTrue(testManufacturer.name not in set dom
bip.manufacturers);
			bip.registerManufacturer(testManufacturer.name,"");
			assertTrue(testManufacturer.name in set dom
bip.manufacturers);
		);

		-- Test Add Product
		private static testAddProduct: () ==> ()
		testAddProduct() == (
			dcl bip : BuyInPortugal := configuredBuyInPortugal1();
			assertTrue(testProduct.title not in set dom bip.products);
			bip.addProduct(testManufacturer.name, testProduct.title,
testProduct.description, testProduct.subcategory, testProduct.price, {<None> |->
0});
			assertTrue(testProduct.title in set dom bip.products);
			assertEqual(testProduct.title,
bip.products(testProduct.title).title);
			assertEqual(testProduct.description,
bip.products(testProduct.title).description);
			assertEqual(testProduct.subcategory,
bip.products(testProduct.title).subcategory);
			assertEqual(testProduct.price,
bip.products(testProduct.title).price);
			assertEqual({<None> |-> 0},
bip.products(testProduct.title).quantities);
			assertEqual({<None>}, bip.products(testProduct.title).colors);
		);

		-- Test Register Client
		private static testRegisterClient: () ==> ()
		testRegisterClient() ==	(
			dcl bip : BuyInPortugal := new BuyInPortugal();

			assertTrue(testClient.email not in set dom bip.clients);
			bip.registerClient(testClient.email);
			assertTrue(testClient.email in set dom bip.clients);

		);

		-- Test Add WishList
		private static testAddWishList: () ==> ()
		testAddWishList() ==	(
			dcl bip : BuyInPortugal := configuredBuyInPortugal2();
			let client = bip.clients(testClient.email)
			in(
				assertTrue(mk_(testProduct.title, <Red>) not in set
client.wishlist);
				bip.addToWishlist(testClient.email, testProduct.title,
<Red>);
				assertTrue(mk_(testProduct.title, <Red>) in set
client.wishlist);
```

```
		);
	);

	-- Test Remove WishList
	private static testRemoveWishList: () ==> ()
	testRemoveWishList() ==  (
		dcl bip : BuyInPortugal := configuredBuyInPortugal2();
		let client = bip.clients(testClient.email)
		in(
			bip.addToWishlist(testClient.email, testProduct.title,
<Red>);
			assertEqual({mk_(testProduct.title, <Red>)},
client.wishlist);
			bip.removeFromWishlist(testClient.email,
testProduct.title, <Red>);
			assertTrue(mk_(testProduct.title, <Red>) not in set
client.wishlist);
		);
	);

	-- Test Add Stock
	private static testAddToStock: () ==> ()
	testAddToStock() == (
		dcl bip : BuyInPortugal := configuredBuyInPortugal2();
		let product = bip.products(testProduct.title)
		in(
			assertTrue(product.quantities(<Blue>) = 0);
			bip.addToStock(testManufacturer.name,
testProduct.title, <Blue>, 36);
			assertTrue(product.quantities(<Blue>) = 36);
		);
	);

	-- Test Remove from Stock
	private static testRemoveFromStock: () ==> ()
	testRemoveFromStock() ==  (
		dcl bip : BuyInPortugal := configuredBuyInPortugal2();
		let product = bip.products(testProduct.title)
		in(
			assertTrue(product.quantities(<Blue>) = 0);
			bip.addToStock(testManufacturer.name,
testProduct.title, <Blue>, 36);
			bip.removeFromStock(testManufacturer.name,
testProduct.title, <Blue>, 30);
			assertTrue(product.quantities(<Blue>) = 6);
		);
	);

	-- Test Add to Cart
	private static testAddToCart: () ==> ()
	testAddToCart() == (
		dcl bip : BuyInPortugal := configuredBuyInPortugal3();
		let client = bip.clients(testClient.email)
		in(
			assertTrue(mk_(testProduct.title, <Red>)  not in set
dom client.cart);
			bip.addToCart(testClient.email, testProduct.title,
<Red>);
```

```
                        assertTrue(mk_(testProduct.title, <Red>) in set dom
client.cart);
                );
        );

        -- Test Add Quantity to Cart
        private static testQntAddToCart: () ==> ()
        testQntAddToCart() ==      (
                dcl bip : BuyInPortugal := configuredBuyInPortugal3();
                let client = bip.clients(testClient.email)
                in(
                        bip.addToCart(testClient.email, testProduct.title,
<Blue>);
                        assertTrue(client.cart(mk_(testProduct.title,<Blue>)) =
1);
                        bip.setQtyInCart(testClient.email, testProduct.title,
<Blue>, 35);
                        assertTrue(client.cart(mk_(testProduct.title,<Blue>)) =
35);
                );
        );

        -- Test Remove from Cart
        private static testRemoveFromCart: () ==> ()
        testRemoveFromCart() ==    (
                dcl bip : BuyInPortugal := configuredBuyInPortugal3();
                let client = bip.clients(testClient.email)
                in(
                        bip.addToCart(testClient.email, testProduct.title,
<Red>);
                        bip.removeFromCart(testClient.email, testProduct.title,
<Red>);
                        assertTrue(mk_(testProduct.title, <Red>) not in set dom
client.cart);
                );
        );

        -- Test Convert WishList
        private static testConvertWishList: () ==> ()
        testConvertWishList() ==  (
                dcl bip : BuyInPortugal := configuredBuyInPortugal3();
                let client = bip.clients(testClient.email)
                in(
                        bip.addToWishlist(testClient.email, testProduct.title,
<Red>);
                bip.convertWishlist(testClient.email);
                assertTrue(mk_(testProduct.title, <Red>) in set dom
client.cart);
                assertTrue(client.cart(mk_(testProduct.title,<Red>)) = 1);
                assertTrue(mk_(testProduct.title, <Red>) not in set
client.wishlist);

                        bip.setQtyInCart(testClient.email, testProduct.title,
<Red>, 35);
                        bip.addToWishlist(testClient.email, testProduct.title,
<Red>);
                bip.convertWishlist(testClient.email);
```

```
                assertTrue(mk_(testProduct.title, <Red>) in set dom
client.cart);
                assertTrue(client.cart(mk_(testProduct.title,<Red>)) = 35);
                assertTrue(mk_(testProduct.title, <Red>) not in set
client.wishlist);
                );
        );

        -- Test Get Total Cart
        private static testGetTotalCart: () ==> ()
        testGetTotalCart() ==     (
                dcl bip : BuyInPortugal := configuredBuyInPortugal3();
                bip.addToCart(testClient.email, testProduct.title, <Blue>);
                bip.setQtyInCart(testClient.email, testProduct.title, <Blue>,
2);
                assertTrue(bip.getTotalCart(testClient.email) = 2.46);
                bip.addToStock(testManufacturer.name, testProduct.title,
<Blue>, 1000);
                bip.setVolumeDiscounts(testManufacturer.name,
testProduct.title, { 500 |-> 1, 750 |-> 0.5, 1000 |-> 0.25});
                bip.setQtyInCart(testClient.email, testProduct.title, <Blue>,
500);
                assertEqual(500, bip.getTotalCart(testClient.email));
                bip.setQtyInCart(testClient.email, testProduct.title, <Blue>,
600);
                assertEqual(600, bip.getTotalCart(testClient.email));
                bip.setQtyInCart(testClient.email, testProduct.title, <Blue>,
800);
                assertEqual(400, bip.getTotalCart(testClient.email));
                bip.setQtyInCart(testClient.email, testProduct.title, <Blue>,
1000);
                assertEqual(250, bip.getTotalCart(testClient.email));
        );

        -- Test Remove Product
        private static testRemoveProduct: () ==> ()
        testRemoveProduct() ==     (
                dcl bip : BuyInPortugal := configuredBuyInPortugal3();
                bip.addToCart(testClient.email, testProduct.title, <Blue>);
                bip.addToCart(testClient.email, testProduct.title, <Red>);
                bip.addToWishlist(testClient.email, testProduct.title, <Red>);
                bip.removeProduct(testManufacturer.name, testProduct.title);
                assertEqual({ |-> }, bip.products);
                assertEqual({ |-> },
bip.manufacturers(testManufacturer.name).products);
                assertEqual({ }, bip.clients(testClient.email).wishlist);
                assertEqual({ |-> }, bip.clients(testClient.email).cart);
        );

        -- Test Buy
        private static testBuy: () ==> ()
        testBuy() == (
                dcl bip : BuyInPortugal := configuredBuyInPortugal3();
                bip.addToCart(testClient.email, testProduct.title, <Blue>);
                bip.setQtyInCart(testClient.email, testProduct.title, <Blue>,
35);
                bip.addToCart(testClient.email, testProduct.title, <White>);
                bip.buy(testClient.email);
```

```
                    assertEqual([{mk_(testProduct.title, <Blue>) |-> 35,
mk_(testProduct.title, <White>) |-> 1}],
bip.clients(testClient.email).buyHistory);
                    assertEqual({ |-> }, bip.clients(testClient.email).cart);
                    bip.addToCart(testClient.email, testProduct.title, <Blue>);
                    bip.buy(testClient.email);
                    assertEqual([{mk_(testProduct.title, <Blue>) |->
1},{mk_(testProduct.title, <Blue>) |-> 35, mk_(testProduct.title, <White>) |->
1}], bip.clients(testClient.email).buyHistory);
              );


              -- Test Search
              private static testSearch: () ==> ()
              testSearch() ==     (
                    dcl bip : BuyInPortugal := configuredBuyInPortugal4();
                    let product = bip.searchProductsByTitle(testProduct.title)
                    in (
                          assertEqual(testProduct.description,
product.description);
                    );
                    let products = bip.searchProductsByCategory("Beauty & Health")
                    in (
                          assertTrue(card products = 1);
                    );
                    let products = bip.searchProductsBySubcategory("Dairy & Eggs")
                    in (
                          assertTrue(card products = 2);
                    );
                    let products = bip.searchProductsByManufacturer("DANONE")
                    in (
                          assertTrue(card products = 2);
                    );
              );
              -- Entry point that runs all tests with valid inputs
              public static testAll: () ==> ()
              testAll() ==
              (

                    IO`print("Set admin code: " );
                    testSetAdminCode();
                    IO`println("Finish");

                    IO`print("Add Category: " );
                    testCategories();
                    IO`println("Finish");

                    IO`print("Add SubCategory: " );
                    testAddSubCategory();
                    IO`println("Finish");

                    IO`print("Register Manufacturer: " );
                    testRegisterManufacturer();
                    IO`println("Finish");

                          IO`print("Add Product: " );
                    testAddProduct();
                    IO`println("Finish");
```

```
                IO`print("Register Client: " );
                testRegisterClient();
                IO`println("Finish");

                IO`print("Add to Stock: " );
                testAddToStock();
                IO`println("Finish");

                IO`print("Remove from Stock: " );
                testRemoveFromStock();
                IO`println("Finish");

                IO`print("Add Wish List: " );
                testAddWishList();
                IO`println("Finish");

                    IO`print("Add Remove Wish List: " );
                testRemoveWishList();
                IO`println("Finish");

                IO`print("Add To Cart: " );
                testAddToCart();
                IO`println("Finish");

                IO`print("Add Qty To Cart: " );
                testQntAddToCart();
                IO`println("Finish");

                    IO`print("Remove from Cart: " );
                testRemoveFromCart();
                IO`println("Finish");

                IO`print("Convert Wish List: " );
                testConvertWishList();
                IO`println("Finish");

                    IO`print("Get Total Cart: " );
                testGetTotalCart();
                IO`println("Finish");

                    IO`print("Buy: " );
                testBuy();
                IO`println("Finish");

                    IO`print("Remove Product: " );
                testRemoveProduct();
                IO`println("Finish");

                    IO`print("Search: " );
                testSearch();
                IO`println("Finish");
);

    /** TEST CASES WITH VALID INPUTS END **/

    /***** TEST CASES WITH INVALID INPUTS (EXECUTE ONE AT A TIME) ******/
```

```
		public static testCannotRegisterClient: () ==> ()
		testCannotRegisterClient() ==	(
			dcl bip : BuyInPortugal := new BuyInPortugal();
			bip.registerClient(testClient.email);
			bip.registerClient(testClient.email); -- breaks pre-condition
		);

		public static testCannotAddProduct: () ==> ()
		testCannotAddProduct() == (
			dcl bip : BuyInPortugal := configuredBuyInPortugal1();
			bip.addProduct(testManufacturer.name, testProduct.title,
testProduct.description, testProduct.subcategory, testProduct.price, {<None> |->
0});
			bip.addProduct(testManufacturer.name, testProduct.title,
testProduct.description, testProduct.subcategory, testProduct.price, {<None> |->
0}); -- breaks pre-condition
		);

		public static testCannotBuy: () ==> ()
		testCannotBuy() == (
			dcl bip : BuyInPortugal := configuredBuyInPortugal3();
			bip.addToCart(testClient.email, testProduct.title, <Blue>);
			bip.setQtyInCart(testClient.email, testProduct.title, <Blue>,
40);
			bip.buy(testClient.email); -- breaks pre-condition
		);

		public static testCannotAddWishList: () ==> ()
		testCannotAddWishList() ==	(
			dcl bip : BuyInPortugal := configuredBuyInPortugal2();
			bip.addToWishlist(testClient.email, testProduct.title, <Red>);
			bip.addToWishlist(testClient.email, testProduct.title, <Red>);
-- breaks pre-condition
		);

		public static testCannotAddStock: () ==> ()
		testCannotAddStock() ==	(
				dcl bip : BuyInPortugal := configuredBuyInPortugal2();
				bip.addToStock(testManufacturer.name,
testProduct.title, <Blue>, -36); -- breaks pre-condition quantity = nat
		);


	end TestBuyInPortugal
```

5. Verificação do modelo

5.1 Exemplo da verificação de domínio

No.	PO Name	Type
26	BuyInPortugal`getTotalCart(ClientÈmail), client	legal map application

O código a analisar é o seguinte(acesso ao mapa sublinhado) :

```
-- Get total cart value
public getTotalCart: Client`Email ==> rat
getTotalCart(email) == (
dcl sum: rat := 0;
let client = clients(email), cart = client.cart
in (
	for all mk_(title, color) in set dom cart
	do (let qty = cart(mk_(title, color))
		in sum := sum + products(title).getPriceWithDiscount(qty) * qty;
	);
	return sum;
);
) pre email in set dom clients;
```

A prova é trivial e o *map* é sempre bem aplicado pois a pré condição `pre email in set dom clients` assegura que o *map clients* só é acedido dentro do seu domínio

5.2 Exemplo da verificação de invariante

No.	PO Name	Type
56	Product`Product(Product`Title, Product`Description, Product`Subcategory, Product`Price, map (Product`Color) to (Product`Quantity))	state invariant holds

O código a analisar é o seguinte(alteração de estado sublinhado) :

```
-- Create product with color
public Product : Title * Description * Subcategory * Price * map Color to Quantity
==> Product
Product(tit, des, cat, pr, qties) == (
	subcategory := cat;
	title := tit;
	description := des;
	price := pr;
	quantities := qties;
	colors := dom qties;
	return self;
)pre
	if <None> in set (dom qties)
	then (dom qties) = {<None>}
	else qties <> { |-> };
```

Os invariantes relevantes são:

```
inv card colors > 0;
inv <None> in set colors => card colors = 1;
inv dom quantities = colors;
```

Quanto ao `inv dom quantities = colors` a prova é trivial pois temos `colors := dom qties` na inicialização da variável o que implica o invariante.

Quanto ao `inv card colors > 1 <=> <None> not in set colors` é preciso mostrar que a pré condição assegura esse invariante, ou seja:

```
if <None> in set (dom qties) then (dom qties) = {<None>} else qties <> { |-> } =>
card colors > 0 and <None> in set colors => card colors = 1;

if <None> in set (dom qties) then (dom qties) = {<None>} else qties <> { |-> } =>
card (dom qties) > 0 and <None> in set (dom qties) => card (dom qties) = 1;

if <None> in set (dom qties) then (dom qties) = {<None>} else qties <> { |-> } =>
if <None> in set (dom qties) then card (dom qties) = 1 else card (dom qties) > 0;
```

Esta implicação é verdadeira.

7. Geração de código Java

Gerar código Java a partir do modelo VDM++ é muito intuitivo com a ferramenta Overture. Todas as classes e *libraries* necessárias para a execução do programa ficam alocada na pasta /generated/java. A partir daí para executarmos e testarmos o teste foi necessário implementar alguns métodos *main()*. No caso dos testes consistiu em alterar a nome da nossa função testAll() que executa todos os testes bem sucedidos. Para experimentarmos cada método na *class* BuyInPortugal também implementamos outro método *main()* e após instanciarmos um objeto dessa classe, com a ajuda de alguns *prints* conseguimos explorar o trabalho realizado e verificar que os métodos cumpriam a sua funcionalidade.

8. Conclusões

Este projeto realizado no âmbito da unidade curricular de Métodos Formais em Engenharia de Software foi desafiante em vários aspetos. Foi um primeiro contacto com esta “metodologia” de produção de software que nos obriga a formalizar o modelo que queremos representar numa forma que nunca tínhamos concebido. A idealização de cada função pensando sempre em primeiro lugar nas restrições de entrada e nos resultados que procuramos obter com a sua execução antes mesmo de pensarmos em como a desenvolver foi algo que nos surpreendeu positivamente.

O trabalho e os resultados obtidos foram positivos na nossa opinião, visto que conseguimos implementar uma solução que representa o modelo sugerido, conseguimos completar tudo o que havíamos definido e o facto de termos seguido a sequência de modelação sugerida desde a listagem de requerimentos, passando pelo desenho do diagrama de classes, definição das invariantes e condições à conceção das funções, propriamente dito, foi também muito importante.

De uma forma geral como foi aqui descrito tudo decorreu de forma positiva no entanto acho que um aspeto que poderia ter sido melhorado foi a priorização da realização de testes que nem sempre acompanhou a velocidade com que íamos implementando os casos de uso.

A contribuição dos membros do grupo foi igualitária e procuramos sempre distribuir o trabalho de forma a termos contacto com todas as camadas do programa.

9. Referências

1. Overture (http://overturetool.org)
2. Mdelio (https://www.modelio.org)
3. Buyinportugal.pt (https://buyinportugal.pt)
4. Slides fornecidos pelos docentes relativos a VDM++