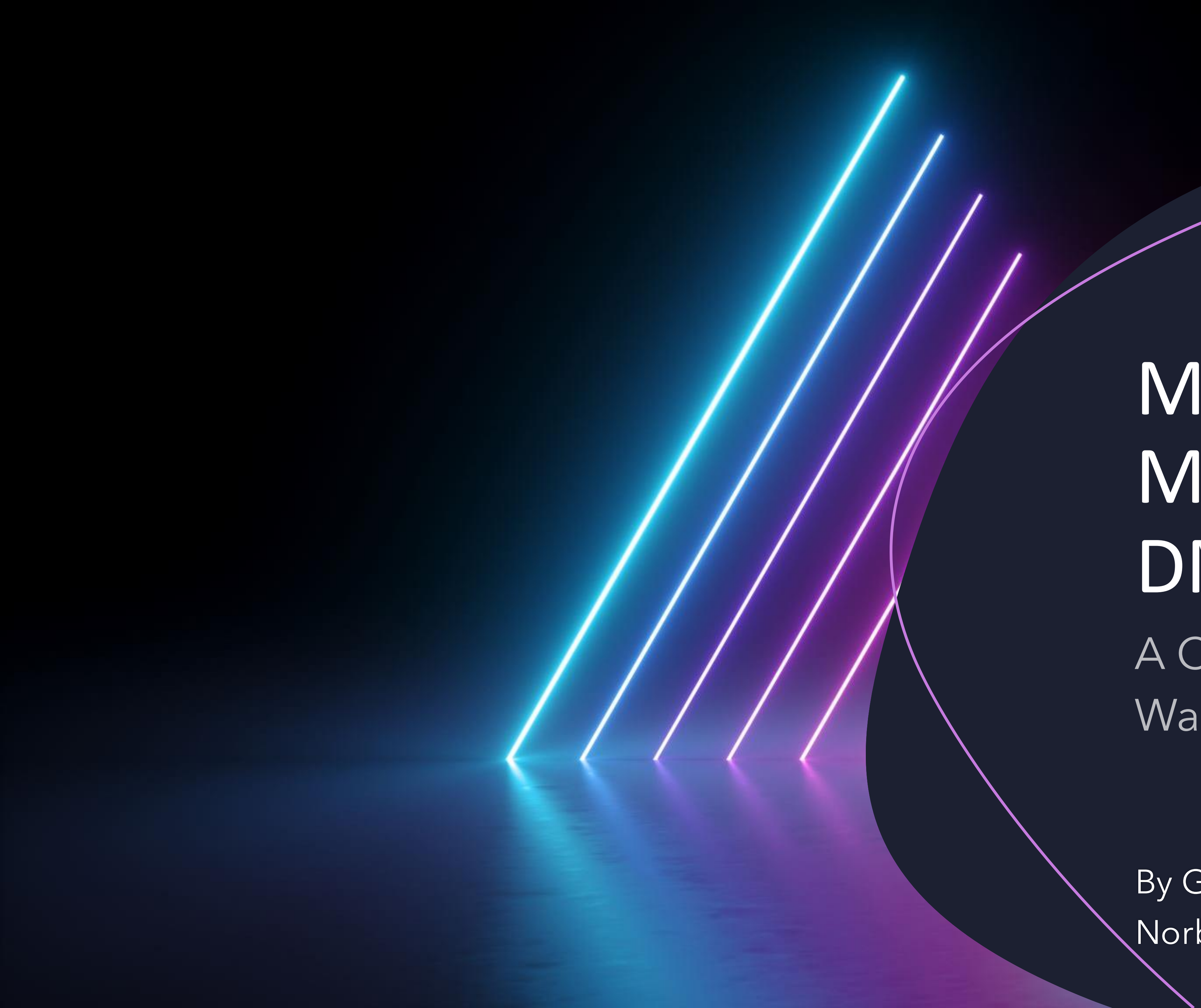


Multi-Level Modeling with DMLA

A Contribution to the MULTI Warehouse Challenge

By Gergely Mezei, Ferenc Somogyi, Norbert Somogyi and Gergely Gembela

The Challenge

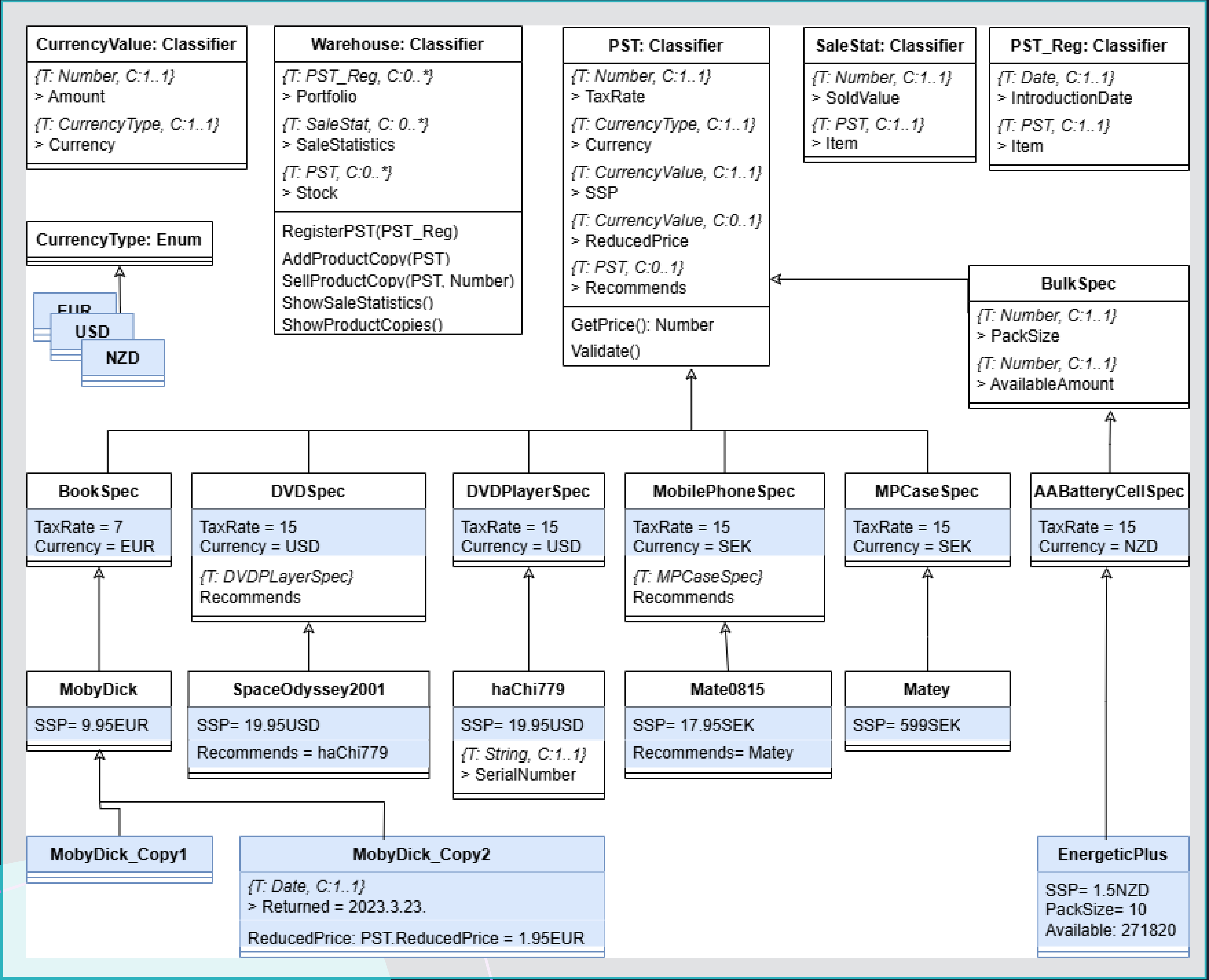
- Modeling a warehouse and its products
- Product Specification Type (PST)
- Product Specification (e.g. Book/DVD specification)
- Individual product copies & Bulk products
- Price (standard, reduced) & Currency handling
- Recommendations between products

DMLA

- Instantiation (refinement):
  - Between entities, not levels (BookSpec – MobyDick)
  - Classifier – Refinement
- Building blocks
  - Entity (class): Book
  - Slot (field): Book has a price
  - Operation (method): Get final price of a book
  - Annotation (annotation/constraint): Type constraint, Final instance

Interpretation

- PST: Common behavior and structure
  - Refined to concrete products
- Explicitly modeled Warehouse entity
  - Encapsulate operations (e.g. add products, sale statistics)
  - More than one warehouse: different PSTs, products, stock, stat
  - PST introduction date/Sale stat: managed by the Warehouse
- Real-life object representation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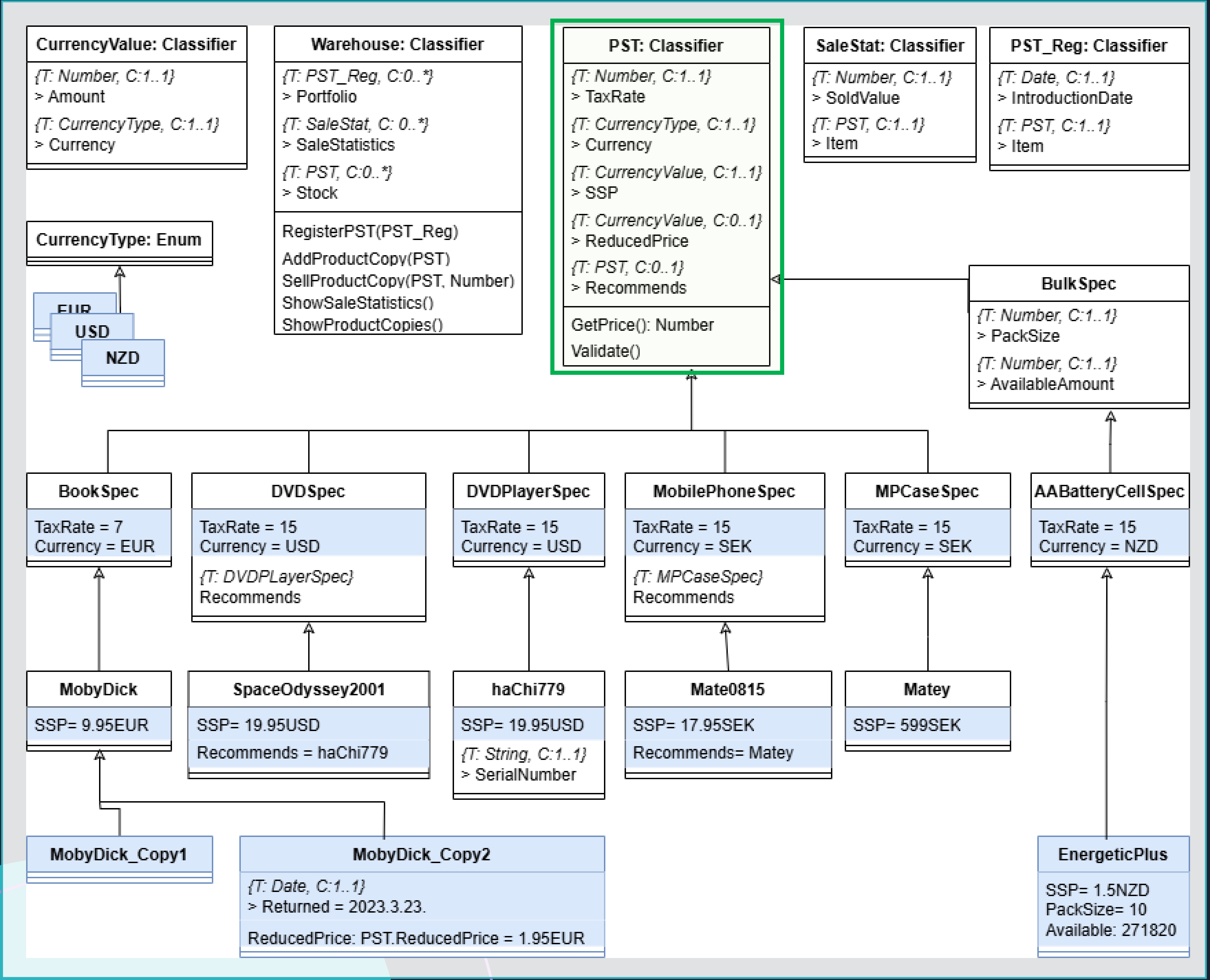
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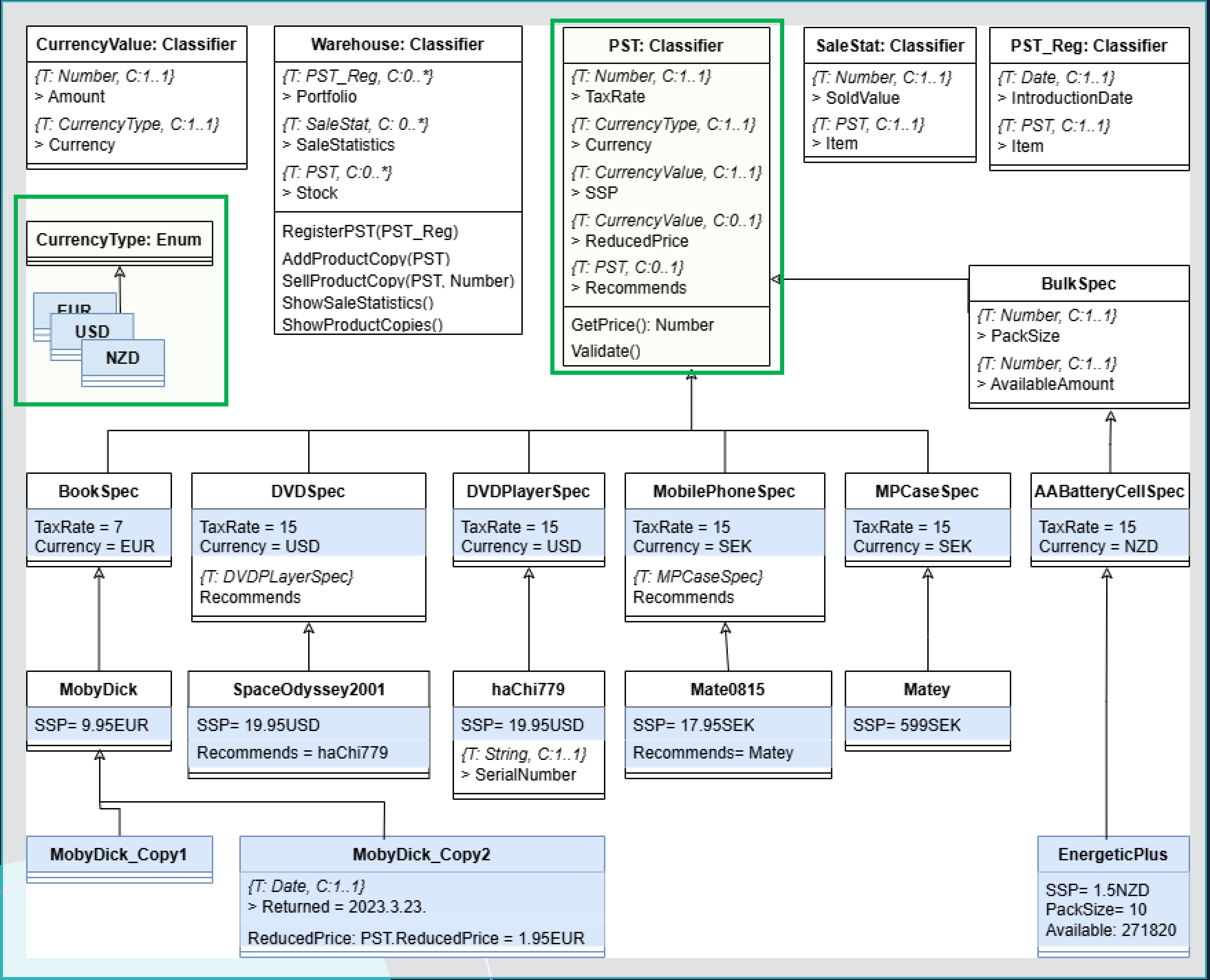
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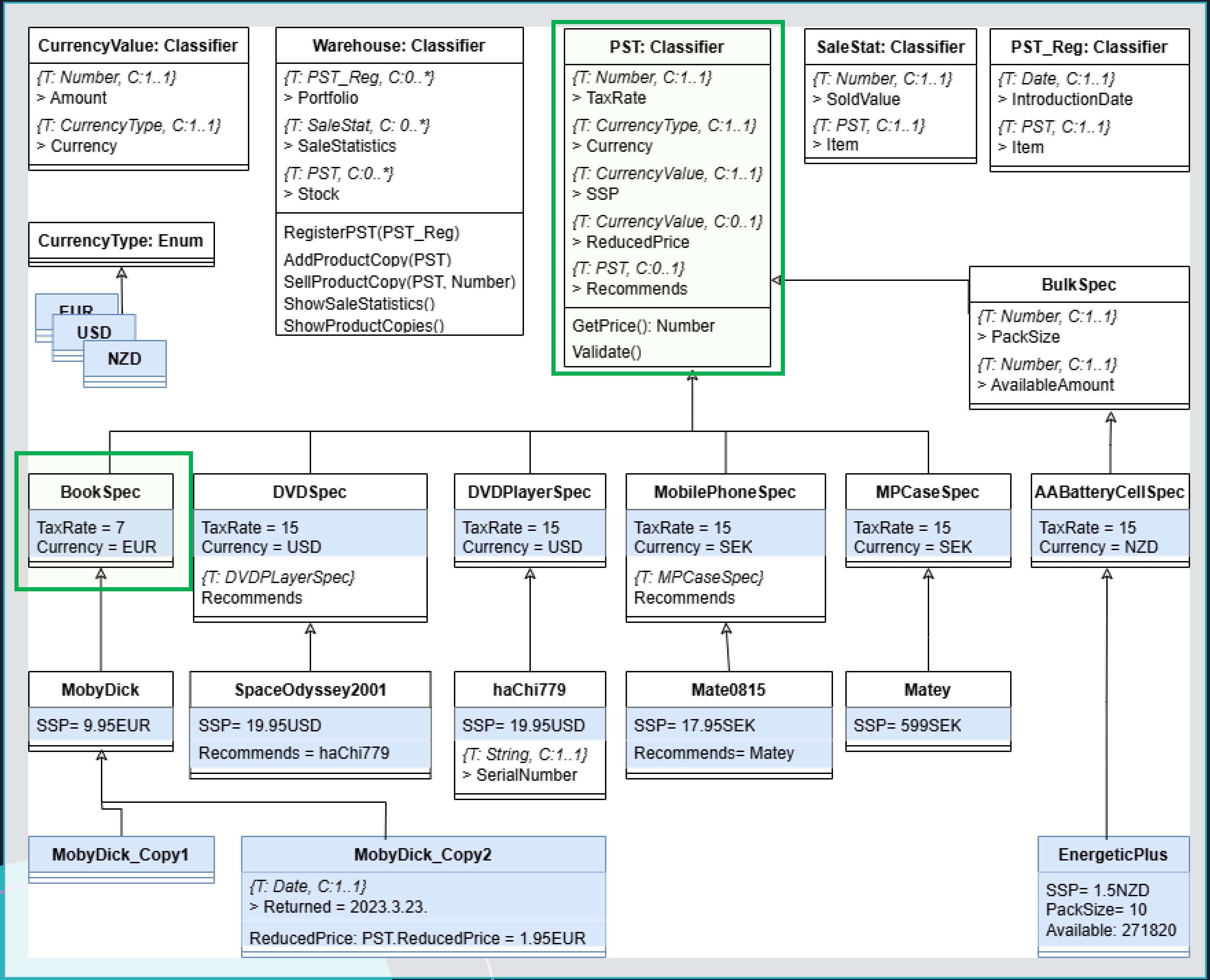
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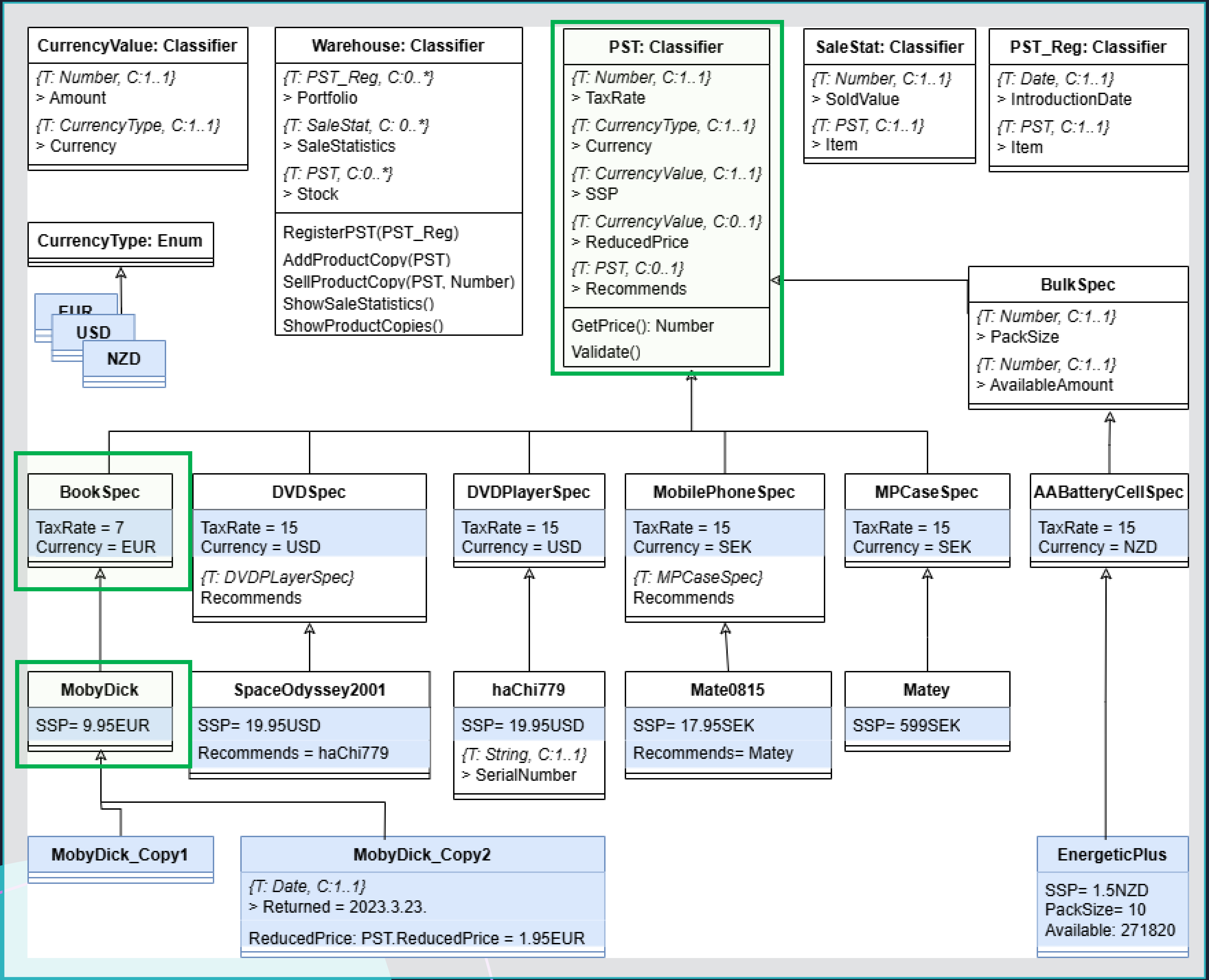
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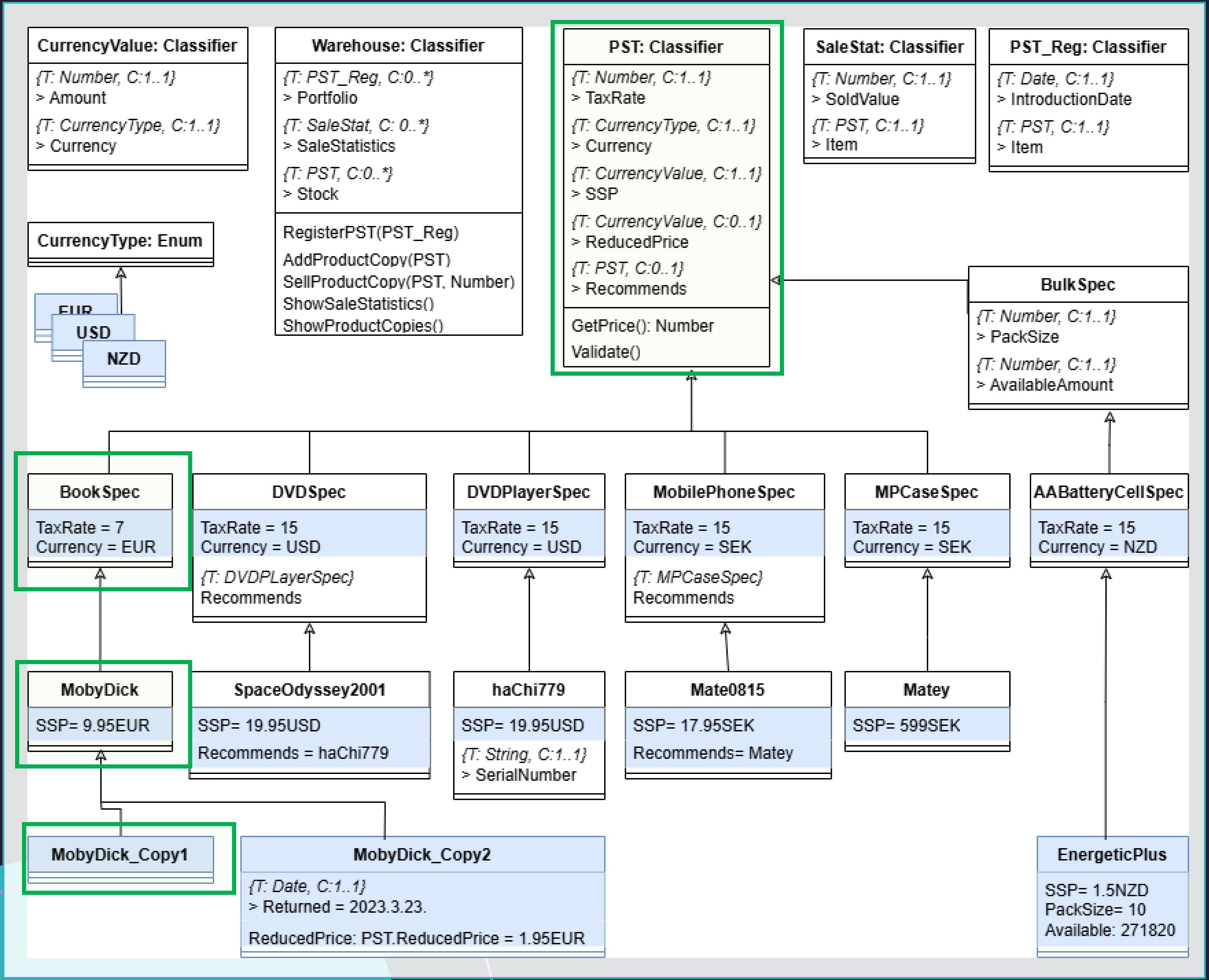
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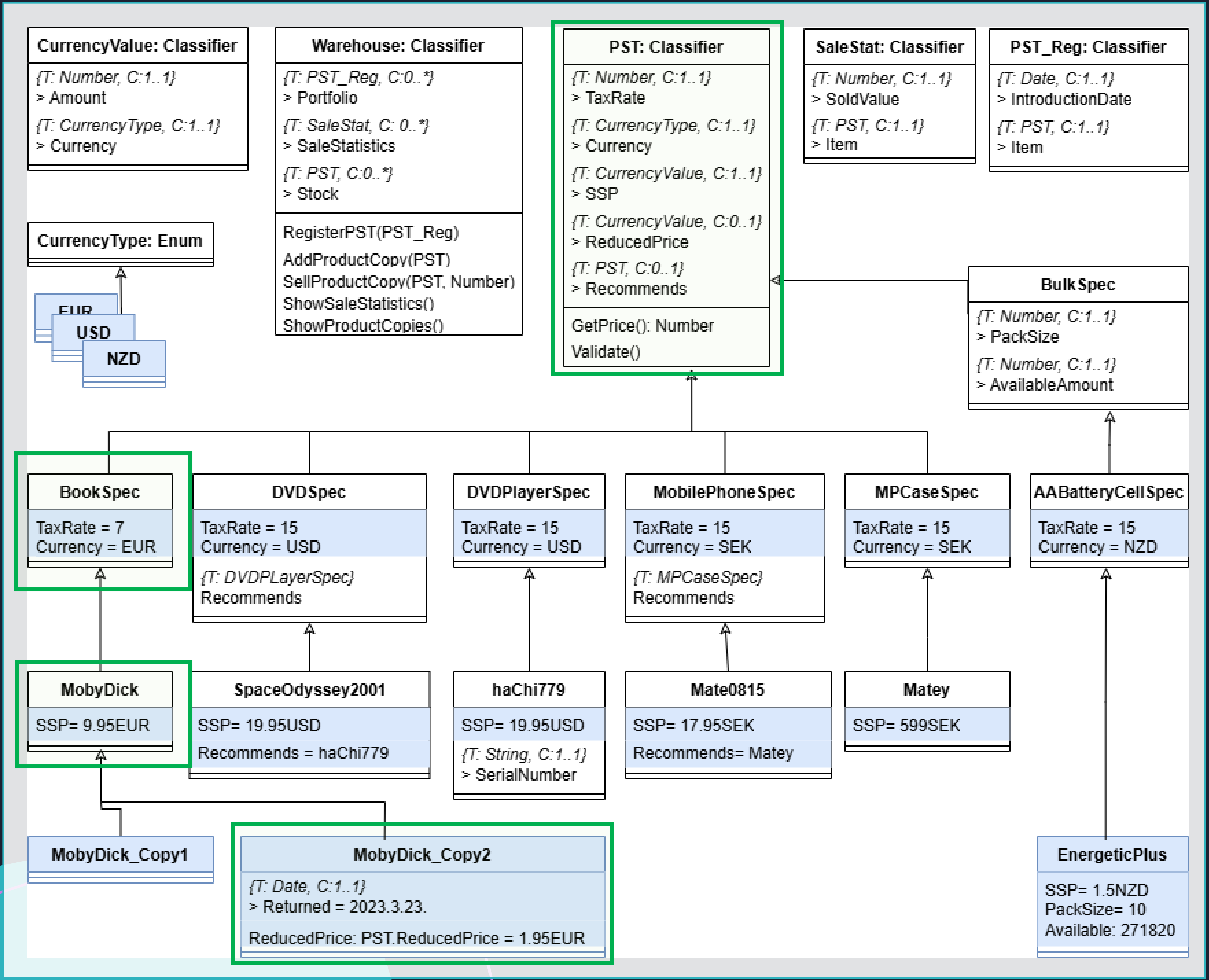
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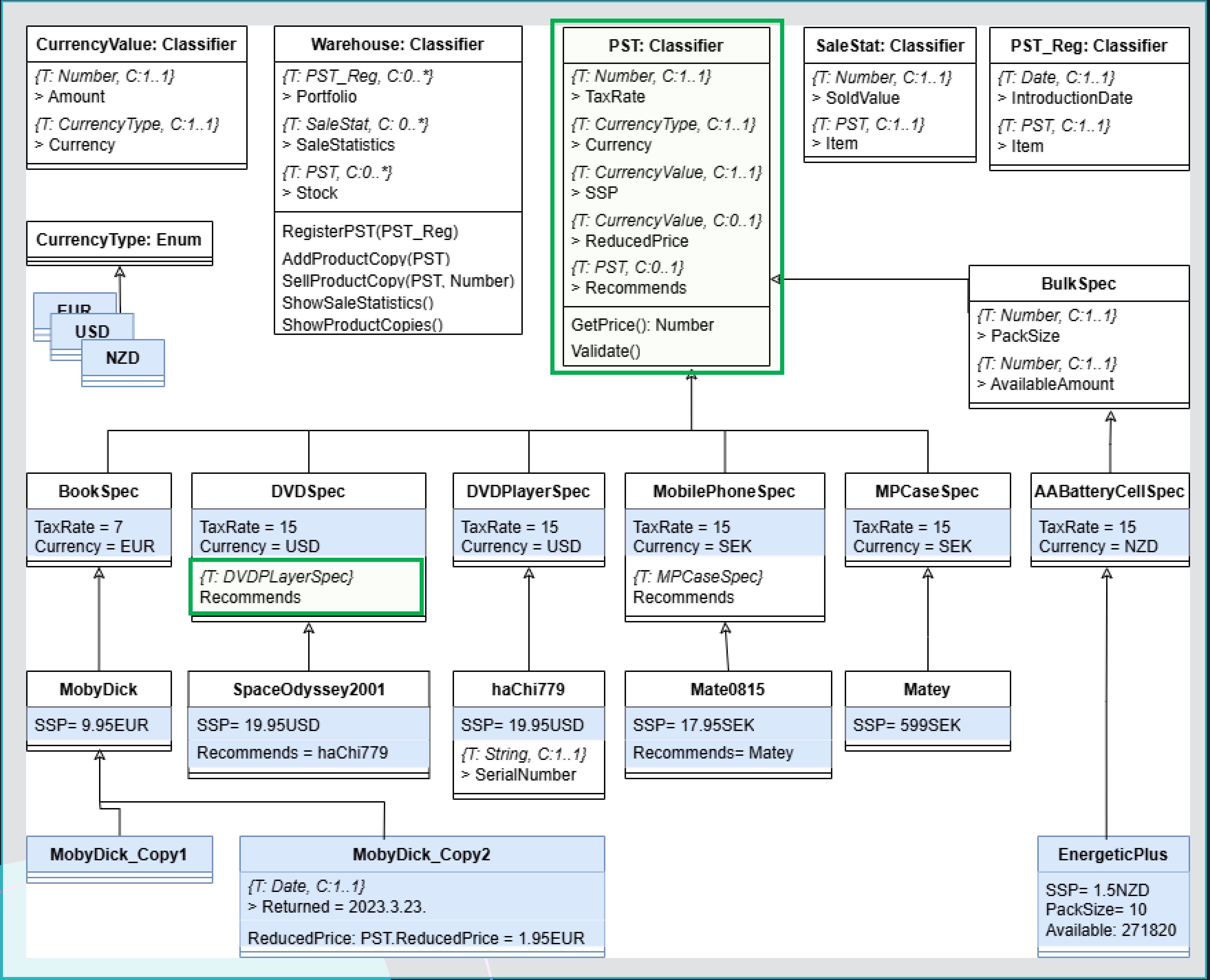
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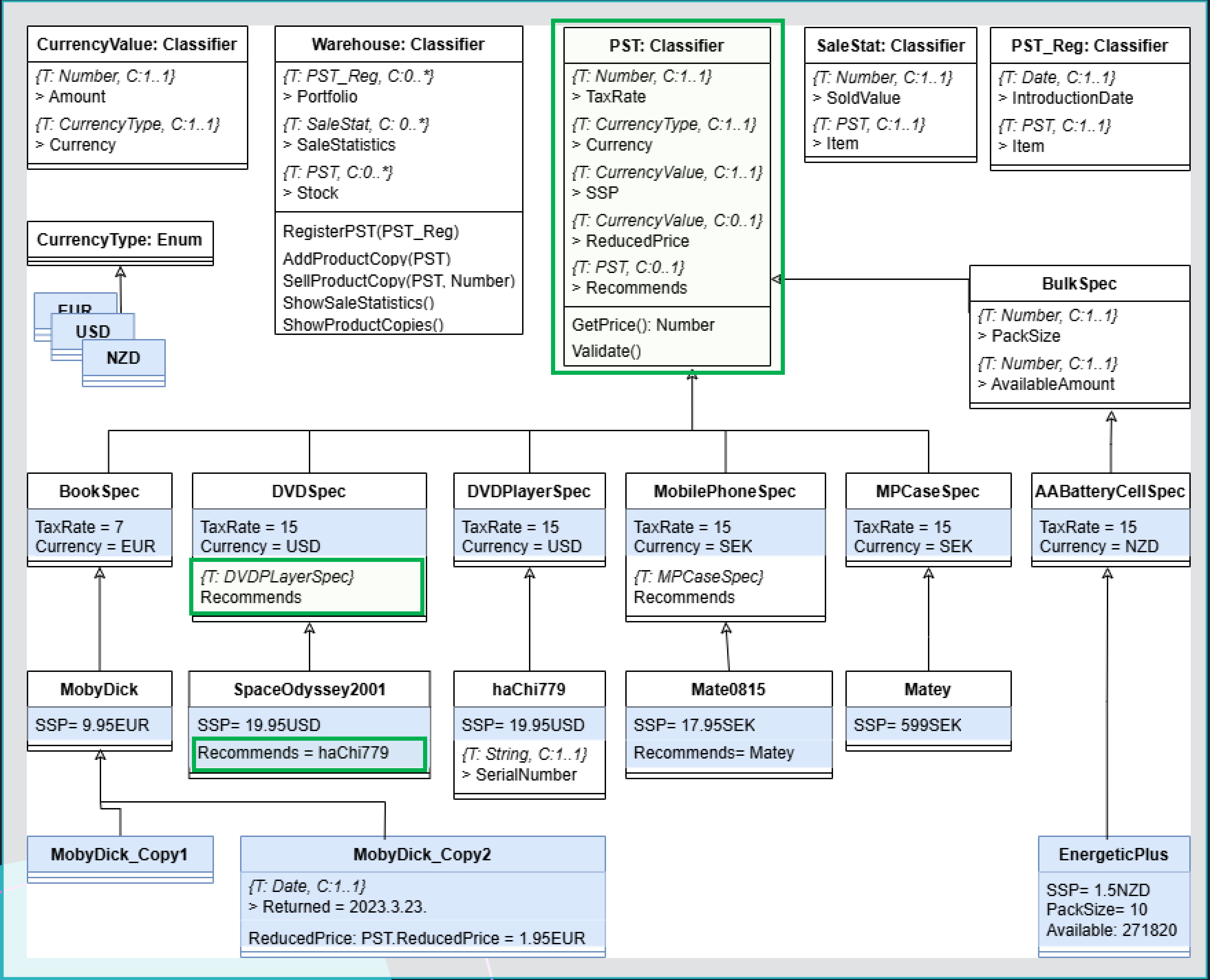
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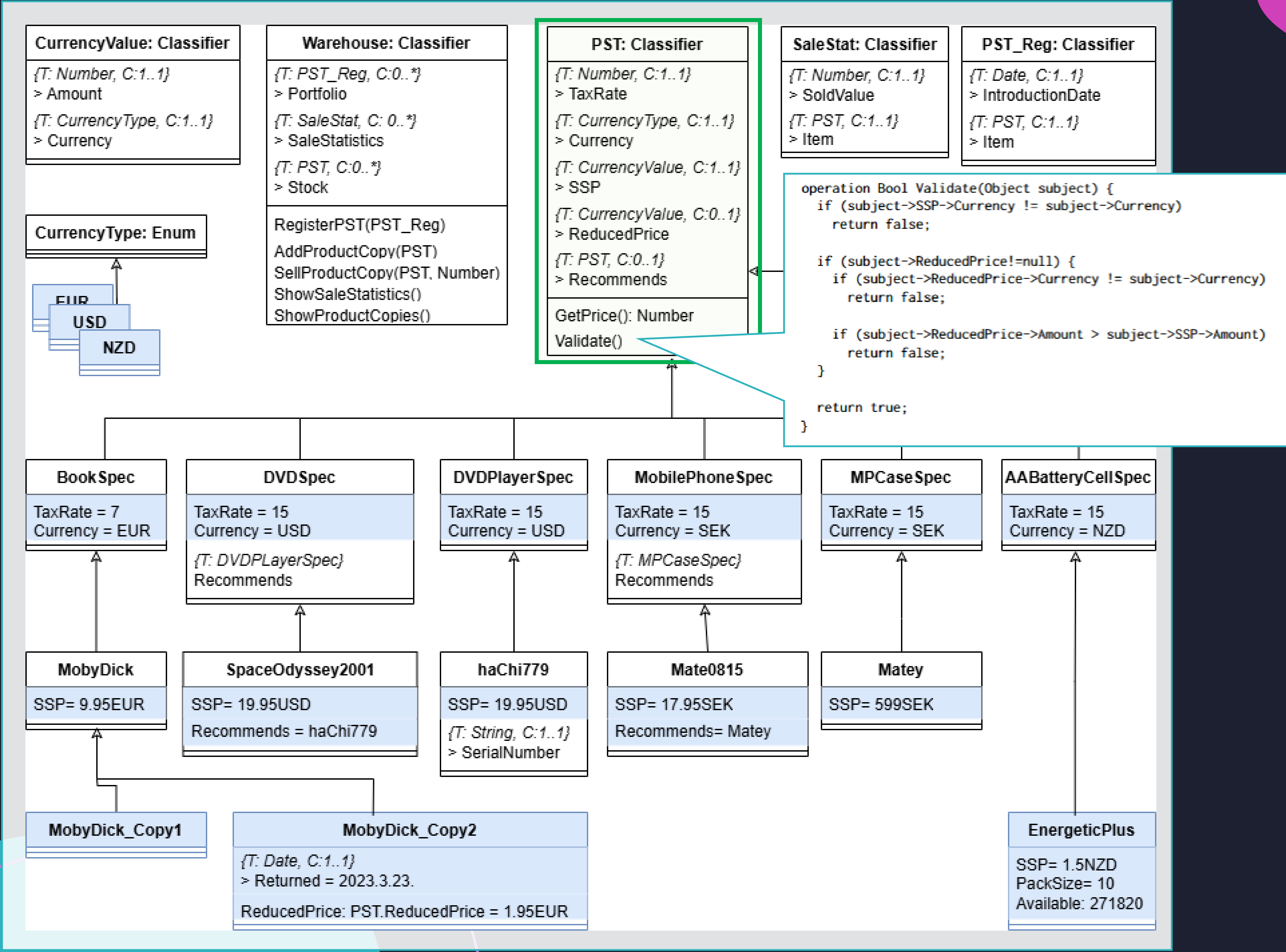
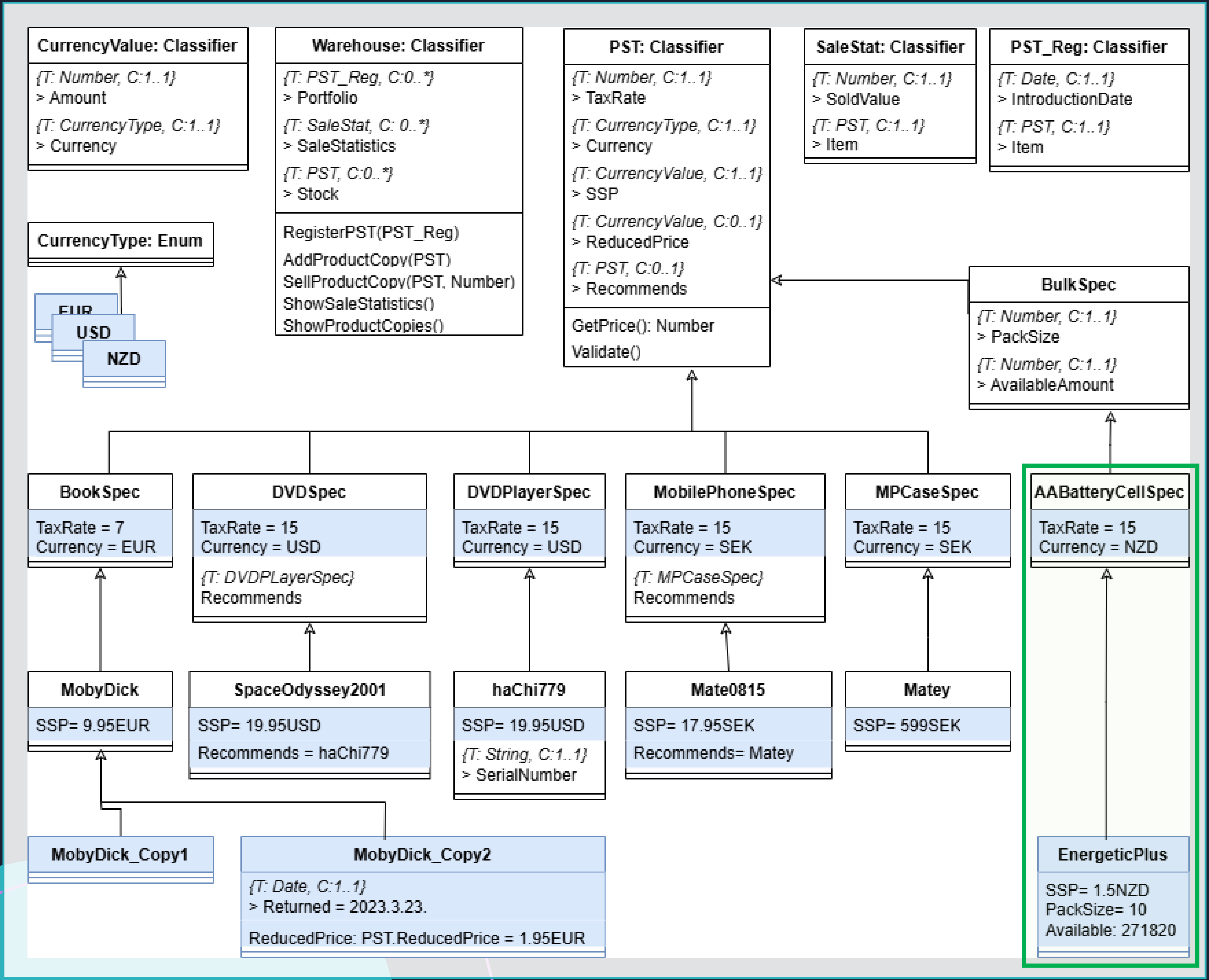
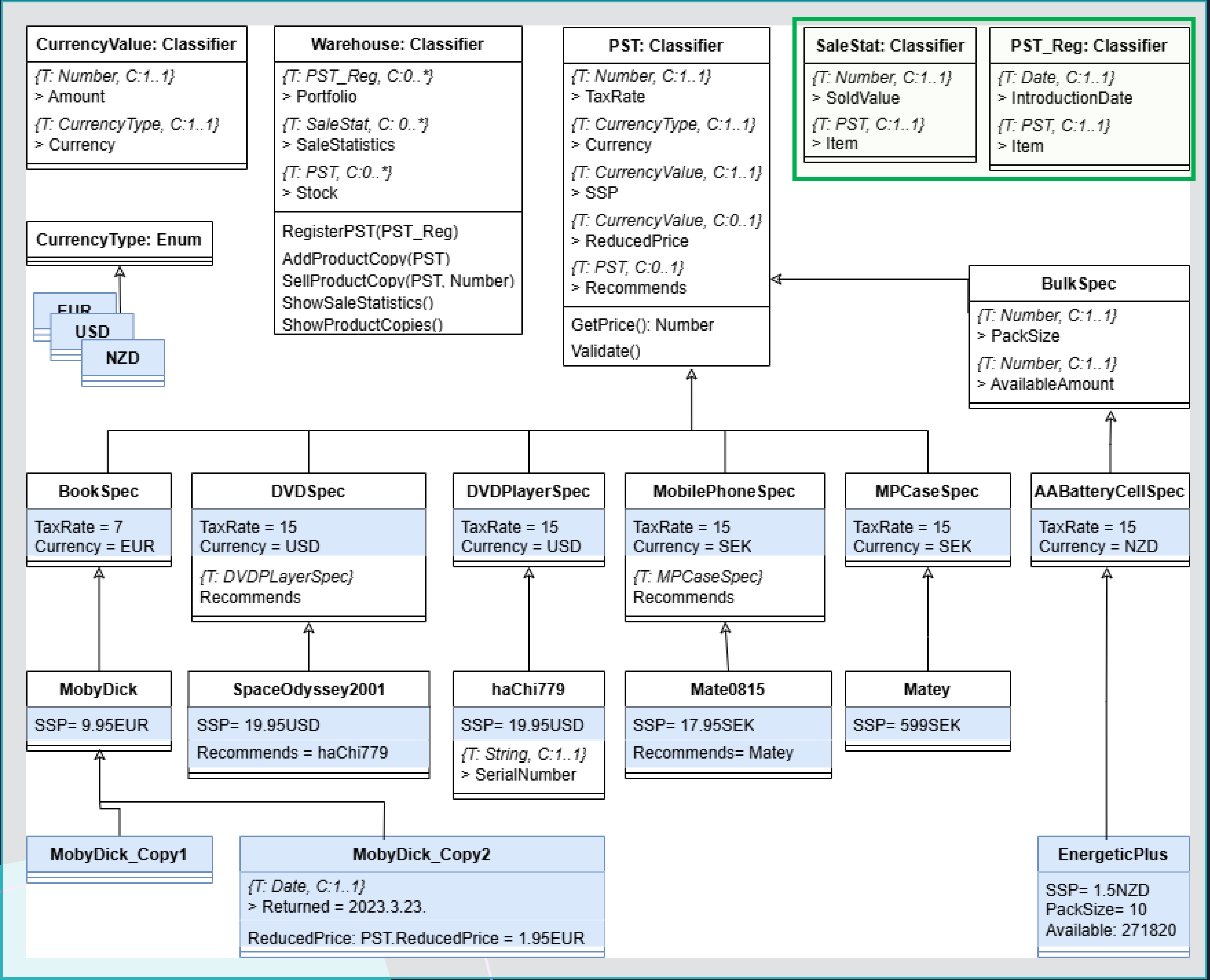
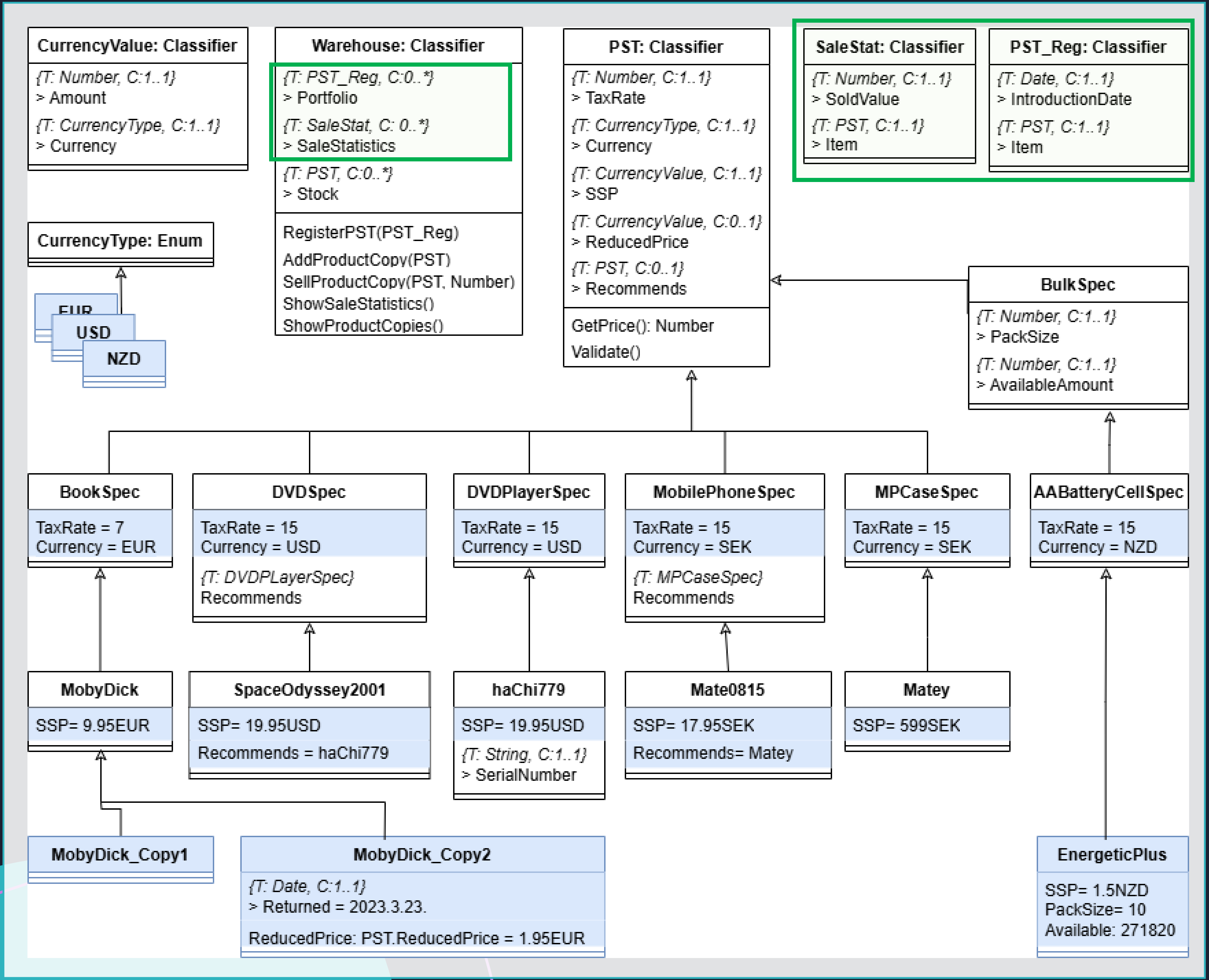
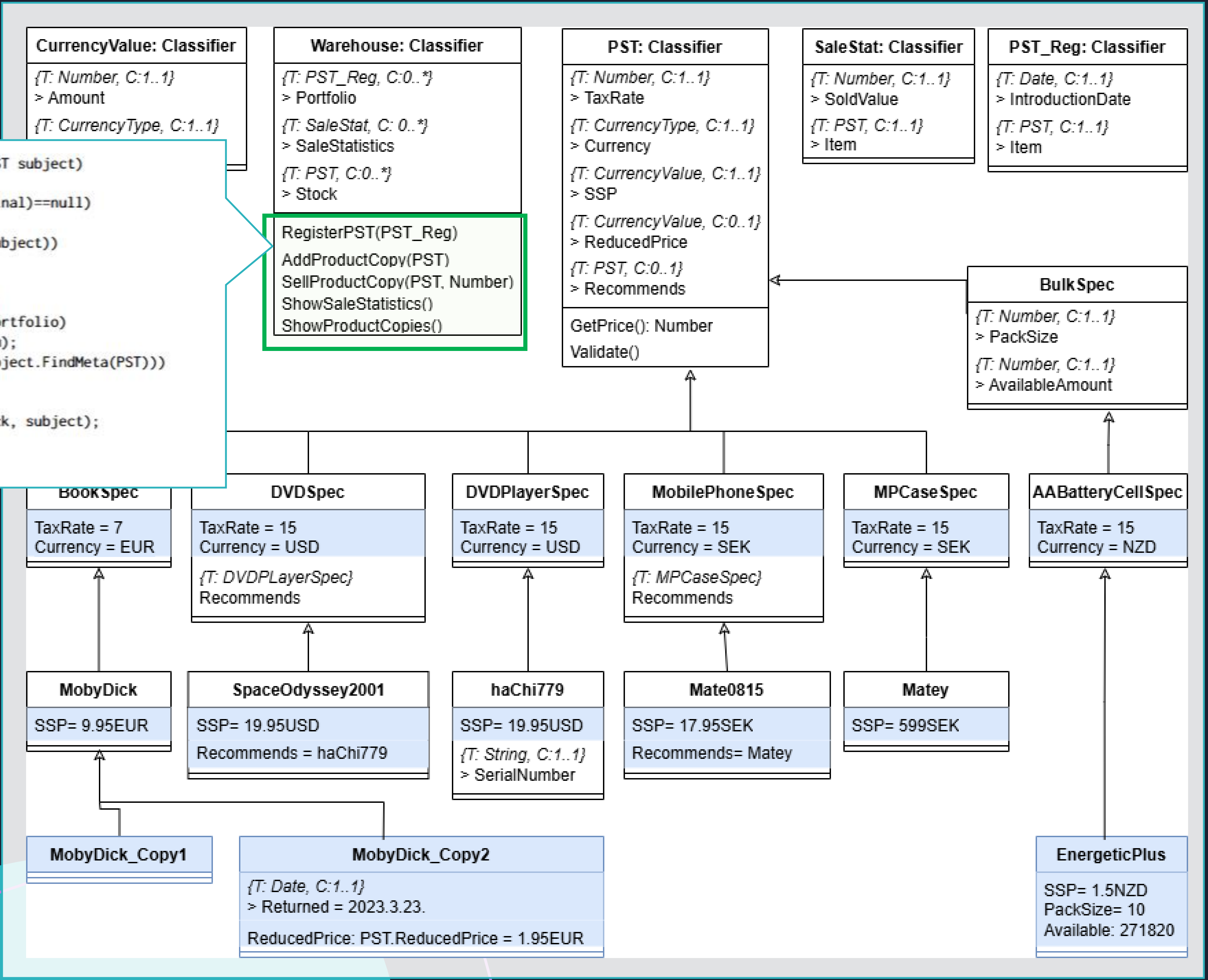


```
operation Bool Validate(Object subject) {
  if (subject->SSP->Currency != subject->Currency)
    return false;

  if (subject->ReducedPrice!=null) {
    if (subject->ReducedPrice->Currency != subject->Currency)
      return false;

    if (subject->ReducedPrice->Amount > subject->SSP->Amount)
      return false;
  }

  return true;
}
```


CurrencyValue: Classifier
{T: Number, C:1..1}
> Amount
{T: CurrencyType, C:1..1}
> Currency
Warehouse: Classifier
{T: PST_Reg, C:0..*}
> Portfolio
{T: SaleStat, C: 0..*}
> SaleStatistics
{T: PST, C:0..*}
> Stock
RegisterPST(PST_Reg)
AddProductCopy(PST)
SellProductCopy(PST, Number)
ShowSaleStatistics()
ShowProductCopies()
PST: Classifier
{T: Number, C:1..1}
> TaxRate
{T: CurrencyType, C:1..1}
> Currency
{T: CurrencyValue, C:1..1}
> SSP
{T: CurrencyValue, C:0..1}
> ReducedPrice
{T: PST, C:0..1}
> Recommends
GetPrice(): Number
Validate()
SaleStat: Classifier
{T: Number, C:1..1}
> SoldValue
{T: PST, C:1..1}
> Item
PST_Reg: Classifier
{T: Date, C:1..1}
> IntroductionDate
{T: PST, C:1..1}
> Item
CurrencyType: Enum
EUR
USD
NZD
BulkSpec
{T: Number, C:1..1}
> PackSize
{T: Number, C:1..1}
> AvailableAmount
BookSpec
TaxRate = 7
Currency = EUR
DVDSpec
TaxRate = 15
Currency = USD
{T: DVDPLayerSpec}
Recommends
DVDPlayerSpec
TaxRate = 15
Currency = USD
MobilePhoneSpec
TaxRate = 15
Currency = SEK
{T: MPCaseSpec}
Recommends
MPCaseSpec
TaxRate = 15
Currency = SEK
AABatteryCellSpec
TaxRate = 15
Currency = NZD
MobyDick
SSP= 9.95EUR
SpaceOdyssey2001
SSP= 19.95USD
Recommends = haChi779
haChi779
SSP= 19.95USD
{T: String, C:1..1}
> SerialNumber
Mate0815
SSP= 17.95SEK
Recommends= Matey
Matey
SSP= 599SEK
MobyDick_Copy1
MobyDick_Copy2
{T: Date, C:1..1}
> Returned = 2023.3.23.
ReducedPrice: PST.ReducedPrice = 1.95EUR
EnergeticPlus
SSP= 1.5NZD
PackSize= 10
Available: 271820


CurrencyValue: Classifier
{T: Number, C:1..1}
> Amount
{T: CurrencyType, C:1..1}
> Currency
Warehouse: Classifier
{T: PST_Reg, C:0..*}
> Portfolio
{T: SaleStat, C: 0..*}
> SaleStatistics
{T: PST, C:0..*}
> Stock
RegisterPST(PST_Reg)
AddProductCopy(PST)
SellProductCopy(PST, Number)
ShowSaleStatistics()
ShowProductCopies()
PST: Classifier
{T: Number, C:1..1}
> TaxRate
{T: CurrencyType, C:1..1}
> Currency
{T: CurrencyValue, C:1..1}
> SSP
{T: CurrencyValue, C:0..1}
> ReducedPrice
{T: PST, C:0..1}
> Recommends
GetPrice(): Number
Validate()
SaleStat: Classifier
{T: Number, C:1..1}
> SoldValue
{T: PST, C:1..1}
> Item
PST_Reg: Classifier
{T: Date, C:1..1}
> IntroductionDate
{T: PST, C:1..1}
> Item
CurrencyType: Enum
EUR
USD
NZD
BulkSpec
{T: Number, C:1..1}
> PackSize
{T: Number, C:1..1}
> AvailableAmount
BookSpec
TaxRate = 7
Currency = EUR
DVDSpec
TaxRate = 15
Currency = USD
{T: DVDPLayerSpec}
Recommends
DVDPlayerSpec
TaxRate = 15
Currency = USD
MobilePhoneSpec
TaxRate = 15
Currency = SEK
{T: MPCaseSpec}
Recommends
MPCaseSpec
TaxRate = 15
Currency = SEK
AABatteryCellSpec
TaxRate = 15
Currency = NZD
MobyDick
SSP= 9.95EUR
SpaceOdyssey2001
SSP= 19.95USD
Recommends = haChi779
haChi779
SSP= 19.95USD
{T: String, C:1..1}
> SerialNumber
Mate0815
SSP= 17.95SEK
Recommends= Matey
Matey
SSP= 599SEK
MobyDick_Copy1
MobyDick_Copy2
{T: Date, C:1..1}
> Returned = 2023.3.23.
ReducedPrice: PST.ReducedPrice = 1.95EUR
EnergeticPlus
SSP= 1.5NZD
PackSize= 10
Available: 271820

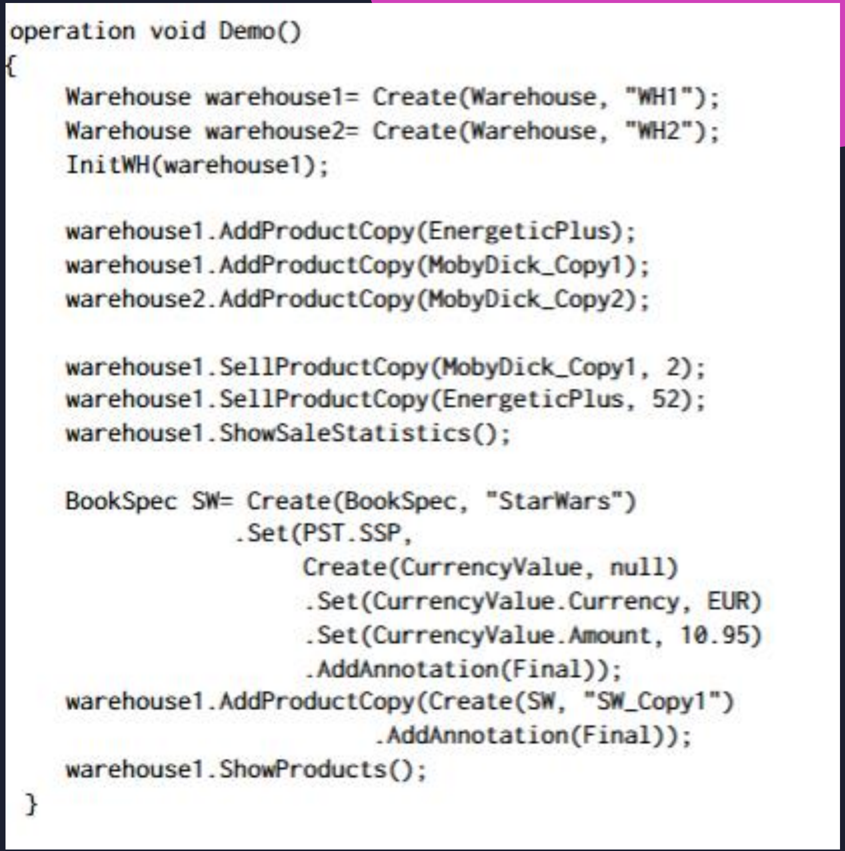

CurrencyValue: Classifier
{T: Number, C:1..1}
> Amount
{T: CurrencyType, C:1..1}
> Currency
CurrencyType: Enum
EUR
USD
NZD
Warehouse: Classifier
{T: PST_Reg, C:0..*}
> Portfolio
{T: SaleStat, C: 0..*}
> SaleStatistics
{T: PST, C:0..*}
> Stock
RegisterPST(PST_Reg)
AddProductCopy(PST)
SellProductCopy(PST, Number)
ShowSaleStatistics()
ShowProductCopies()
PST: Classifier
{T: Number, C:1..1}
> TaxRate
{T: CurrencyType, C:1..1}
> Currency
{T: CurrencyValue, C:1..1}
> SSP
{T: CurrencyValue, C:0..1}
> ReducedPrice
{T: PST, C:0..1}
> Recommends
GetPrice(): Number
Validate()
SaleStat: Classifier
{T: Number, C:1..1}
> SoldValue
{T: PST, C:1..1}
> Item
PST_Reg: Classifier
{T: Date, C:1..1}
> IntroductionDate
{T: PST, C:1..1}
> Item
BulkSpec
{T: Number, C:1..1}
> PackSize
{T: Number, C:1..1}
> AvailableAmount
BookSpec
TaxRate = 7
Currency = EUR
DVDSpec
TaxRate = 15
Currency = USD
{T: DVDPLayerSpec}
Recommends
DVDPlayerSpec
TaxRate = 15
Currency = USD
MobilePhoneSpec
TaxRate = 15
Currency = SEK
{T: MPCaseSpec}
Recommends
MPCaseSpec
TaxRate = 15
Currency = SEK
AABatteryCellSpec
TaxRate = 15
Currency = NZD
MobyDick
SSP= 9.95EUR
SpaceOdyssey2001
SSP= 19.95USD
Recommends = haChi779
haChi779
SSP= 19.95USD
{T: String, C:1..1}
> SerialNumber
Mate0815
SSP= 17.95SEK
Recommends= Matey
Matey
SSP= 599SEK
MobyDick_Copy1
MobyDick_Copy2
{T: Date, C:1..1}
> Returned = 2023.3.23.
ReducedPrice: PST.ReducedPrice = 1.95EUR
EnergeticPlus
SSP= 1.5NZD
PackSize= 10
Available: 271820



```
operation Bool AddProductCopy(PST subject)
{
    if (subject.HasAnnotation(Final)==null)
        return false;
    if (Contains(this->Stock, subject))
        return false;

    Base[] portfolio=new Base[];
    foreach(Base pst in this->Portfolio)
        Add(portfolio, pst->Item);
    if (!Contains(portfolio, subject.FindMeta(PST)))
        return false;

    this.AddValue(Warehouse.Stock, subject);
    return true
}
```

Dynamic usage

- Static set of entities vs. dynamic test bench
- Unit tests for the domain
- Fully dynamic behavior
  - Warehouse creation/management
  - Product add/sell + sale stat calls
  - Refinement hierarchy modifications:
    - PST, product spec, product copy creation/modification



```
operation void Demo()
{
    Warehouse warehouse1= Create(Warehouse, "WH1");
    Warehouse warehouse2= Create(Warehouse, "WH2");
    InitWH(warehouse1);

    warehouse1.AddProductCopy(EnergeticPlus);
    warehouse1.AddProductCopy(MobyDick_Copy1);
    warehouse2.AddProductCopy(MobyDick_Copy2);

    warehouse1.SellProductCopy(MobyDick_Copy1, 2);
    warehouse1.SellProductCopy(EnergeticPlus, 52);
    warehouse1.ShowSaleStatistics();

    BookSpec SW= Create(BookSpec, "StarWars")
                .Set(PST.SSP,
                     Create(CurrencyValue, null)
                      .Set(CurrencyValue.Currency, EUR)
                      .Set(CurrencyValue.Amount, 10.95)
                      .AddAnnotation(Final));
    warehouse1.AddProductCopy(Create(SW, "SW_Copy1")
                           .AddAnnotation(Final));
    warehouse1.ShowProducts();
 }
```

Weaknesses…

- Weaknesses
  - Currency validation is applied not before setting its value
  - Bulk products are handled as objects (?)
  - Operation AddProduct uses PST to cover all PST refinements
  - Slots exist (can be refined) at all levels
  - No graphical interface (DMLA has a textual language only)

… and strengths

- Strengths
  - Flexibility in changing/extending refinement chains
    - Custom refinement steps in any refinement chain
    - Product (copy) management and sale statistics handles this automatically
  - Dynamic management of the domain entities
    - Programming interface – as in real-life scenarios

Conclusions

- Our solution
  - Covers the requirements
  - Has difficulties when levels are explicit and fixed
  - Can easily handle evolving requirements/refinement chains
  - Supports dynamic behavior
- Future…?
  - Move towards real-life industrial case studies

Thank you for your attention