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## **A Portfolio Model for Natural Catastrophe Reinsurance**

Experience using Ada and the GNAT programming environment

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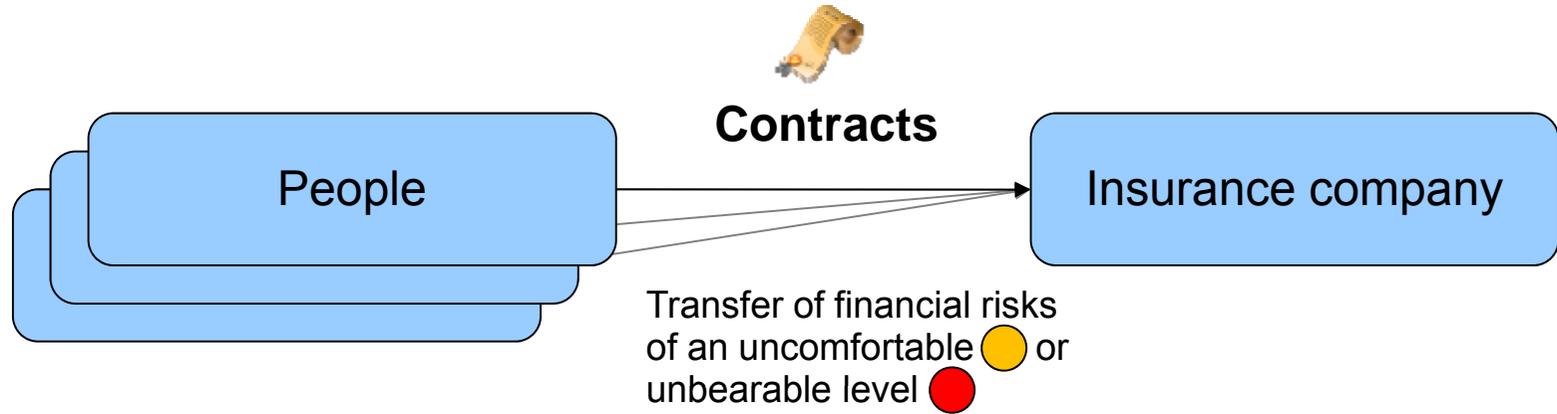
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# What is reinsurance ?



Loss: 1000 € ● → ●

« miracle »: mutualism - law of large numbers

Loss: 1 million € ● → ●

Loss: 100 million € ● → ●

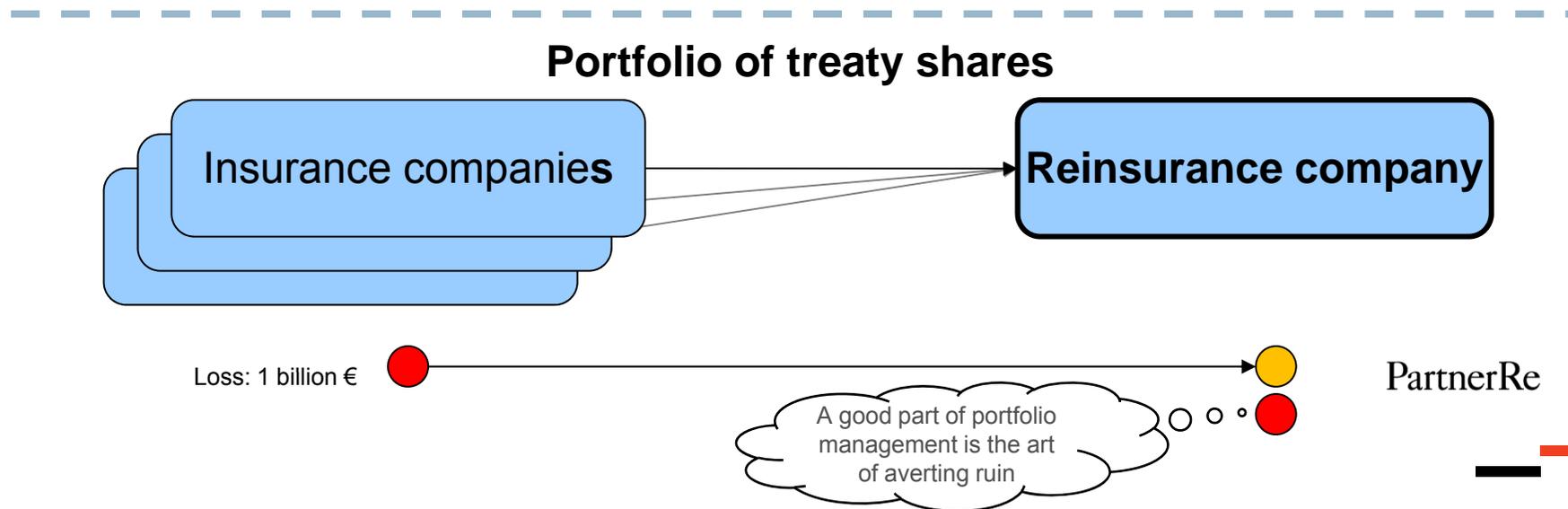
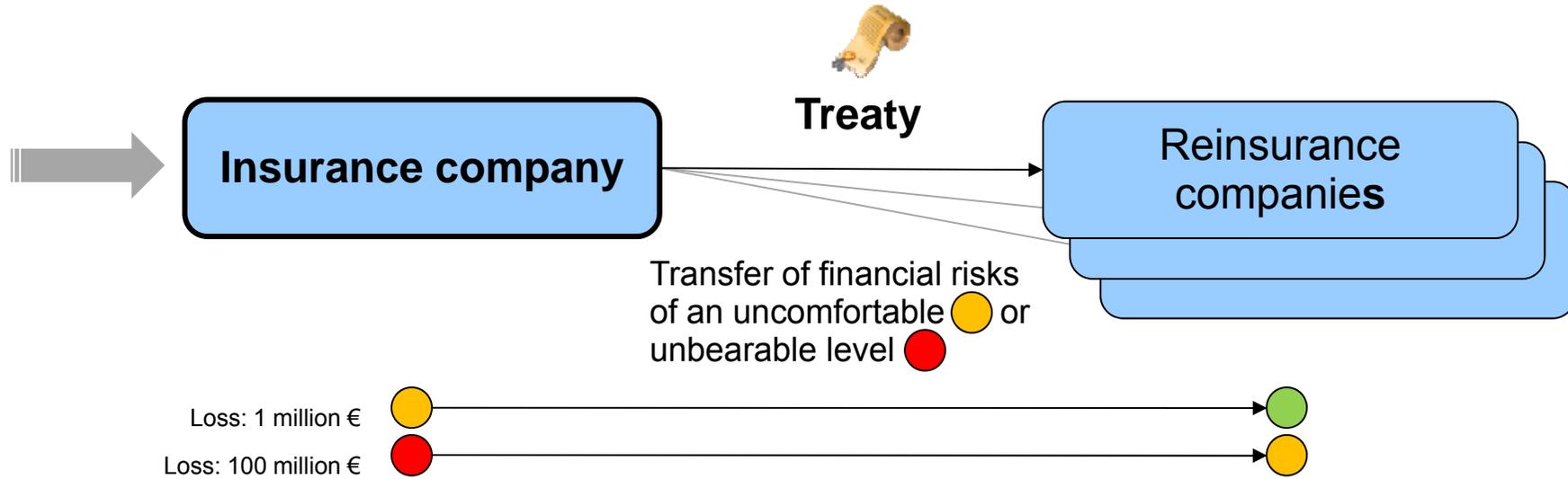


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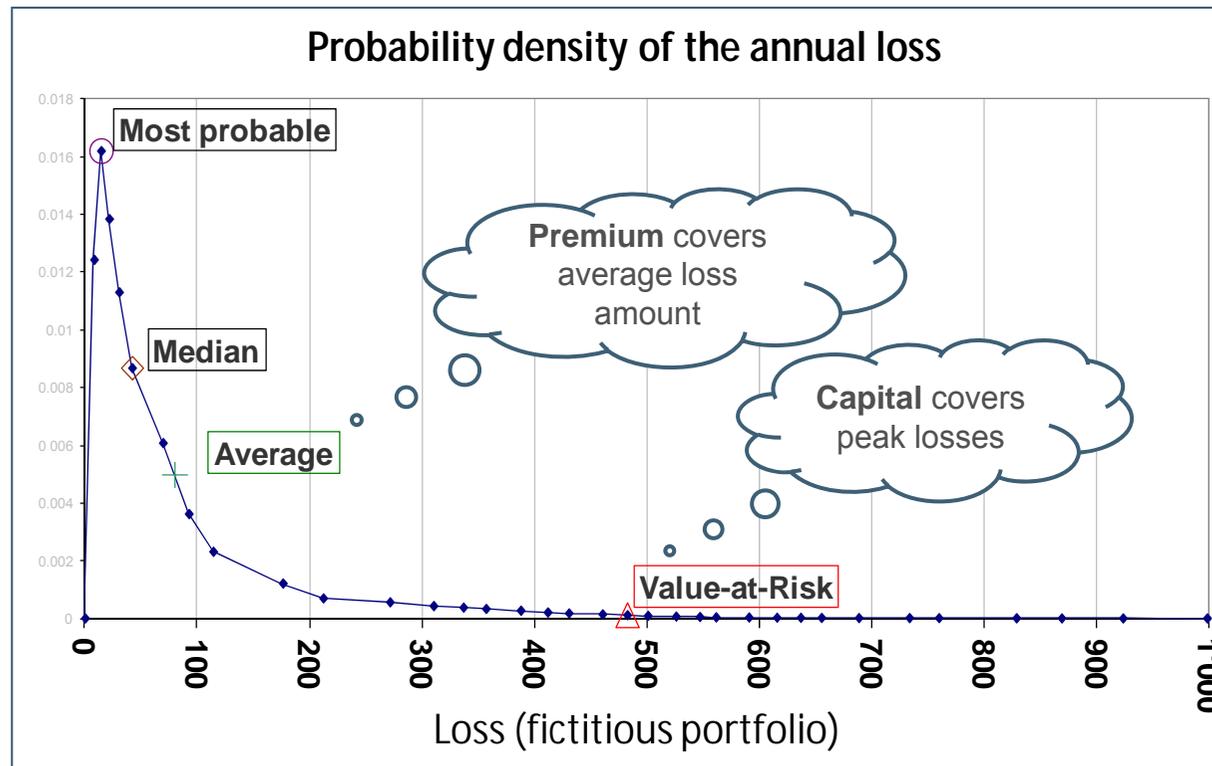
## What is reinsurance ? (continued)





## Use of Portfolio Modelling

1. Compute how much **risk-based capital** is needed.



Worldwide Catastrophe loss distribution

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## Use of Portfolio Modelling (continued)

2. Quantify **diversification** and **profitability** over regions and types of perils (~400 peril zones)
  3. Consider dependencies
- **Large probabilistic model**

Active use, beyond reporting: **portfolio planning and optimization**. Goal: reduce the capital at risk while keeping a certain volume of business and profitability





## How did portfolio optimization cross Lady Ada's way ?

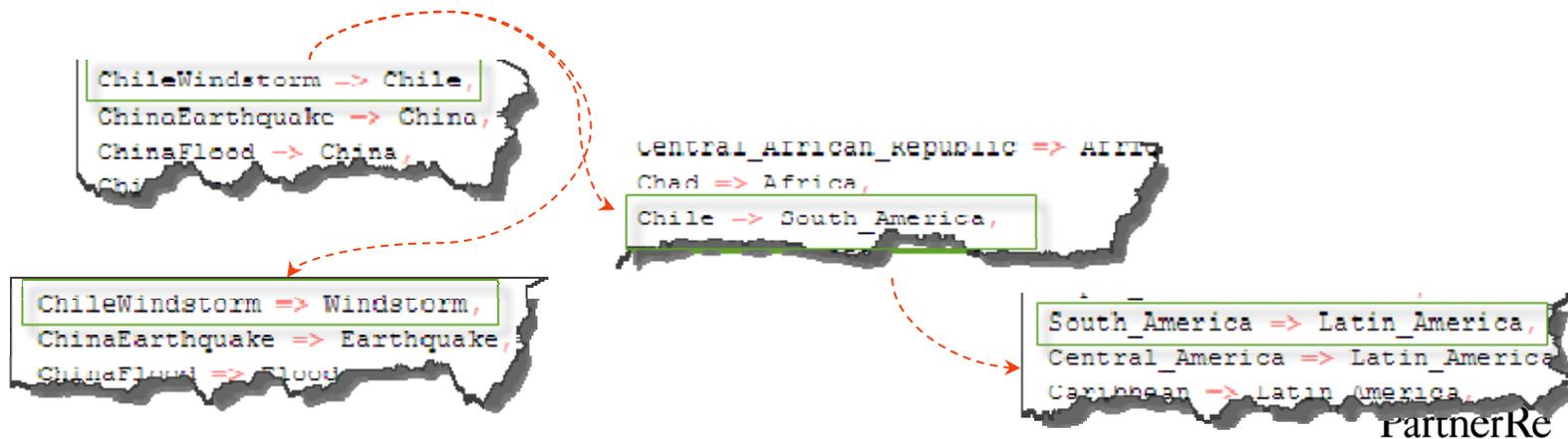
- Portfolio optimization initiative started 2007
- **Idea: genetic algorithm** with random mutations (recent addition: selection) of a portfolio
- **Problem:** the software available in 2007 could not be used for that: 1/2 hour to load a portfolio, > 1/2 hour to compute a single portfolio
- Fall-back, at that time, was to consider over-simplified portfolios, or script an external software (slow *and* over-simplified) 
- **Solution...**





## Portfolio optimization & Lady Ada (continued)

- **Solution:** write a new model from scratch with run-time performance *and* easy maintenance in mind
- **Precomputation.** Furthermore: move **run-time** effort to **compile-time** effort. Embed **constant data** (esp. geography).
- From database to source code: enumerated types (type PerilZone: more than 4000 items!) and arrays with initialized data in an arbitrary, human-readable order:





## Data embedded in source code

- Maintenance of data as source **without** Ada: would be more difficult than in a database, or would need to be at least backed by a database (SQL scripts to regenerate sources)
- Maintenance **with** Ada: easier than in a database. Source code generation had to be done only once, in 2007.

Real example of maintenance change:

```
60
61 country_to_groupcountries: constant array (Country) of Groupcountries:=
62 | ( no_country -> no_group,
```

PM\_Data.Geo.Links

PM\_Data-Geo.ads PM\_Data-Geo-Images.ads PM\_Data-Geo-Images.adb PM\_Data-Geo-Links.ads

Locations

Builder results (2 items)

PM\_Data-Geo-Links.ads (2 items)

62:3 missing index value(s) in array aggregate

62:3 "Sint Maarten"

New country, from the ex-NL Antilles





## Data embedded in source code (continued)

### Gain:

- performance: thousands-fold <sup>\*)</sup>, portfolio is loaded within a second
- code safety (language rules on arrays and case statements)
- data safety: any error in data is caught – would pass through, in SQL

## The number-crunching side...

- Monte-Carlo simulation to compute each portfolio
- Matrix computations for getting correlations into random vectors
- Choice of platform: native; and compiler: GNAT, with optimized machine code generation

**Gain in performance: 20x<sup>\*)</sup>**: a whole portfolio is computed in < 2 minutes

- Possibility of not using access types (pointers, reference types) !

→ faster **and** safer – unusual with IT!

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<sup>\*)</sup> Compared to the previous generation of the Portfolio Model



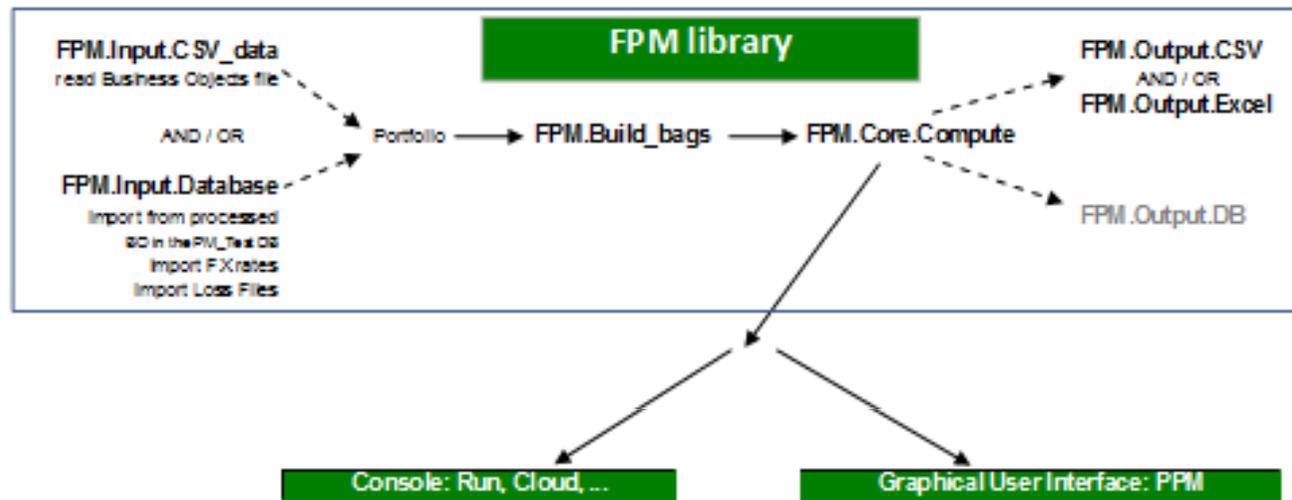


# Fast Portfolio Model architecture



## Fast Portfolio Model

Main scheme

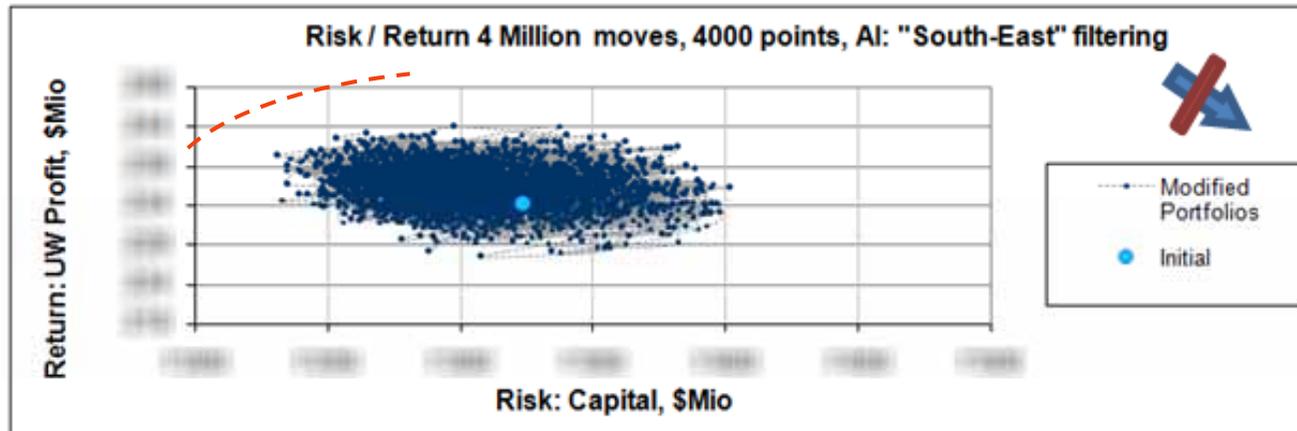


type Portfolio\_data → type Portfolio





## Out of the factory: Portfolio Optimizer



- **Mutation** of a portfolio by moving exposure from a peril zone to another one, all by rescaling treaty shares (must stay realistic)
- **Selection** rule: reject variants with more risk and less profit





## Out of the factory: the Portable Portfolio Model

Prob.	Ret. per.	ALD VaR base	ALD VaR modified
50.00%	2	1064335	
80.00%	5	7425419	
90.00%	10	28220558	
95.00%	20	62219746	
96.00%	25	74087810	
98.00%	50	114371215	
99.00%	100	186763021	
99.50%	200	242871988	
99.60%	250	261682995	
99.80%	500	302248065	
99.90%	1000	331894657	
99.95%	2000	359814118	
99.98%	5000	404749582	
99.99%	10000	441755258	

100% made with free, open-source components: GNAT GPL, GWindows, Excel Writer, database lib, math libs...

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## Portable Portfolio Model (continued)

```
package PPM_Main.Daemons is

    task Status_display is
        entry Start;
        entry Display(pw: in out PPM_Main.Main_window_type);
        entry Stop;
    end;

    task type Simulation_type is
        entry Start;
        entry Run(pw: in out PPM_Main.Main_window_type; vers: PF_Version);
        entry Stop;
    end;

    Simulation: array(PPM_Main.PF_version) of Simulation_type;

end PPM_Main.Daemons;
```





# Portable Portfolio Model (continued)

Portable Portfolio Model - BO Demo 2012.csv <-- fictitious portfolio

File Actions Options Help

- Portfolio
  - Drought
  - Earthquake
  - Fire Explosion
  - Flood
  - Frost
  - Hail
  - Other
  - Strike Riots Civil Commotions
  - Windstorm
    - Europe
      - Central and Eastern Europe
      - France Benelux
      - Northern Europe
      - Scenario Europe
      - Southern Europe
    - Latin America
      - Caribbean
        - Bahamas
          - {pz: Bahamas Windstorm (Scenario)}
        - Barbados
          - {pz: Barbados Windstorm}
        - Cayman Islands
          - {pz: Cayman Islands Windstorm}
        - Dominican Republic

Node Caribbean

Base portfolio

Exposure 138'936'125

Base Premium 8'779'546

---

Simulation status Up to date

Expected loss 5'582'696

Average RRoL 4.02%

Underwriting profit 1'664'936

Capital standalone 86'011'125

Capital allocated 10'177'826

PV RoE (allocated) 17.27%

Prob.	Ret. per.	ALD VaR base
50.00%	2	131'168
80.00%	5	3'876'268
90.00%	10	19'388'846
95.00%	20	35'144'461
96.00%	25	41'421'113
98.00%	50	56'459'711

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