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Marek Hlavacek, Česká Pojišťovna  
hlavacek@cpintl.cz

Martin Mrázek, SAS Institute ČR  
martin.mrazek@cze.sas.com

## Risk aggregation (Marek Hlaváček)

- business point of view (why)
- mathematical point of view (how)
- automation of risk aggregation in PPF group

## MARS – SAS solution for aggregation process automation (Martin Mrázek)

- Architecture and main features
- Building blocks and integration with other analytical tools
- Efficiency tricks

# Risk Aggregation (not only) within Financial Holding

Marek Hlaváček, Česká pojišťovna

# Economic Capital

- Unified concept for risk management
- Basic idea: as a company is exposed to risk it should hold enough capital to cover potential losses
- Economic Capital is the minimal capital that should cover potential losses in given time period with high probability
- Risk is measured in terms of capital
- Once all risks in company are expressed as volumes of economic capital, it is possible to compare or sum different types of risks

# Economic Capital Usage

## Risk management

- Risk Limits
- Reinsurance Strategy

## Profitability measurement

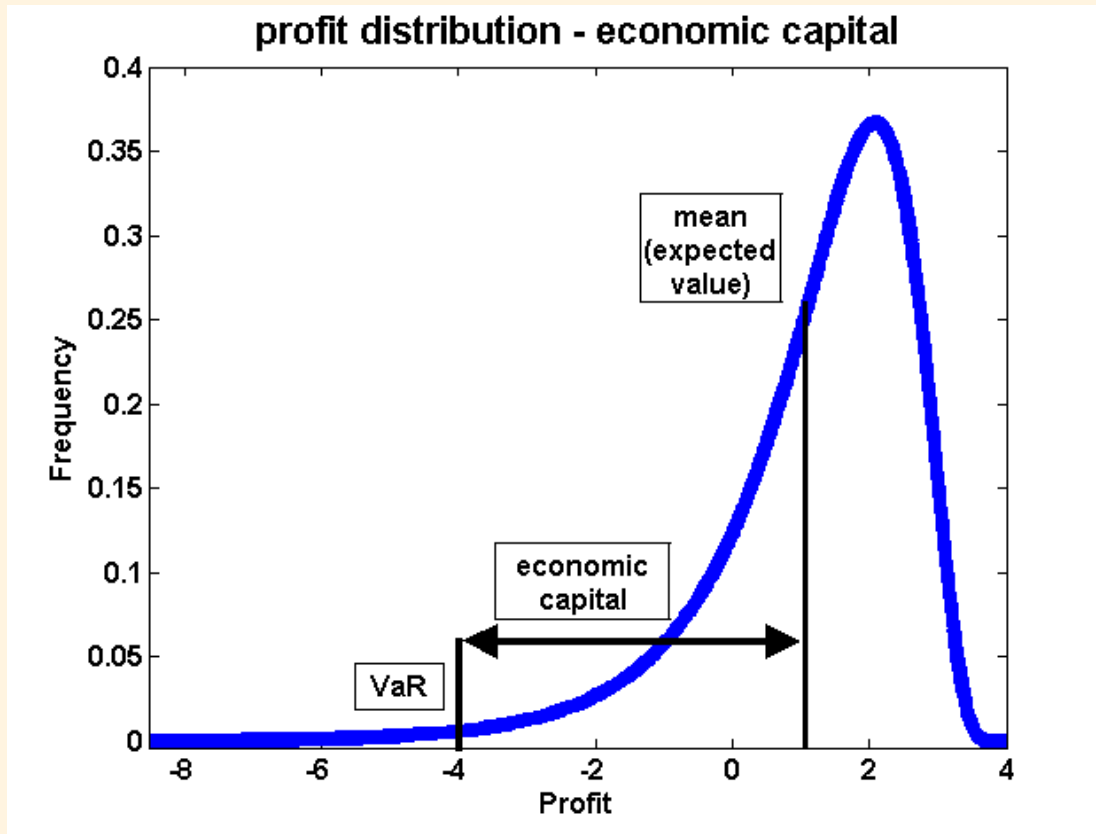
- Comparison of different business lines considering capital costs

## Capital management

## Regulatory requirements

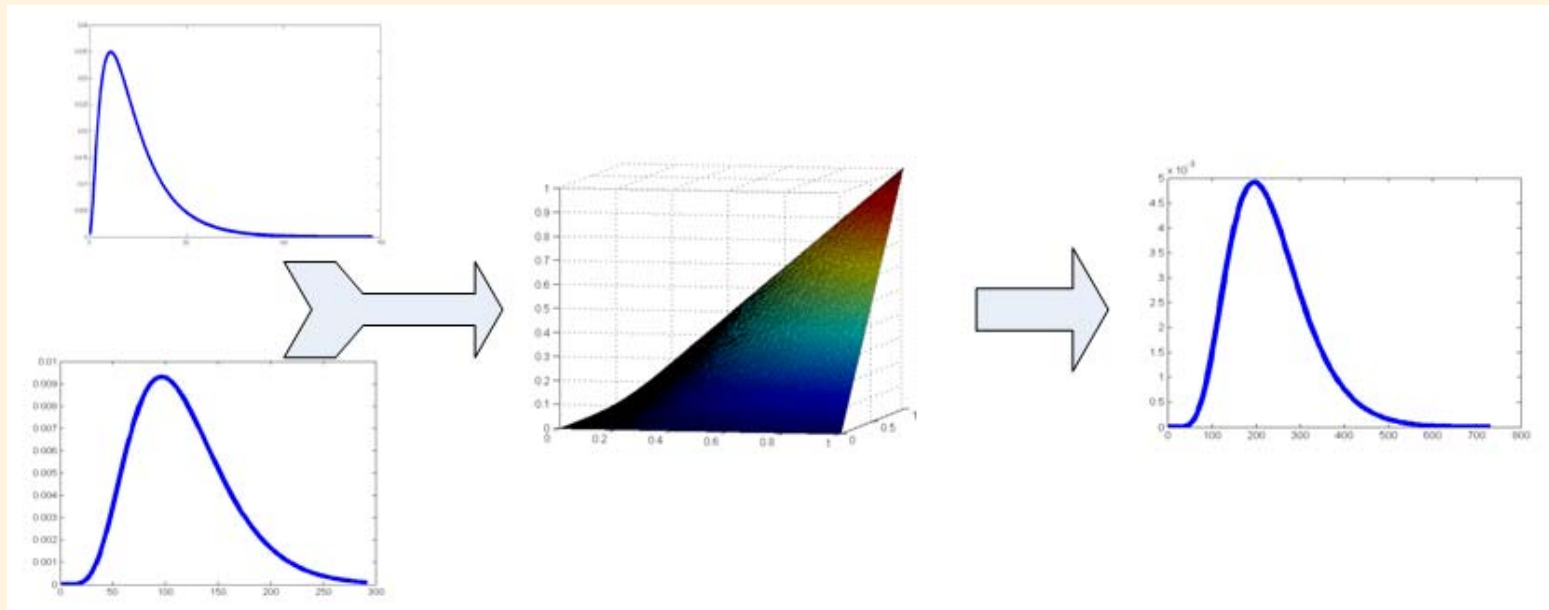
- standard and internal models

# Economic Capital Evaluation



Economic Capital is derived from the probability distribution function of the risk.

# Economic Capital Aggregation

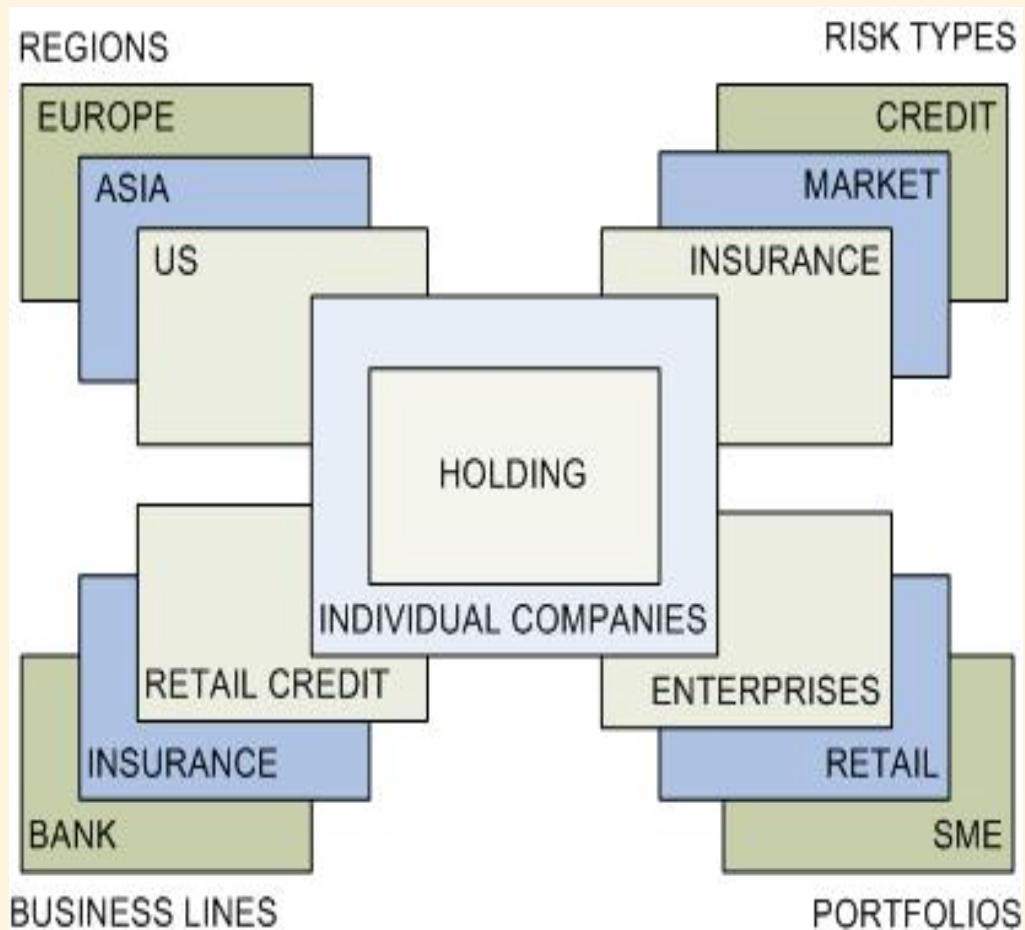


**probability  
distributions of  
marginal risks**

**correlation structure  
described by  
copula function**

**probability  
distribution of  
aggregated risk**

# Economic Capital Reporting



Reporting structure might be really complicated and it might change from report to report.



# Automation of EC aggregation in PPF group

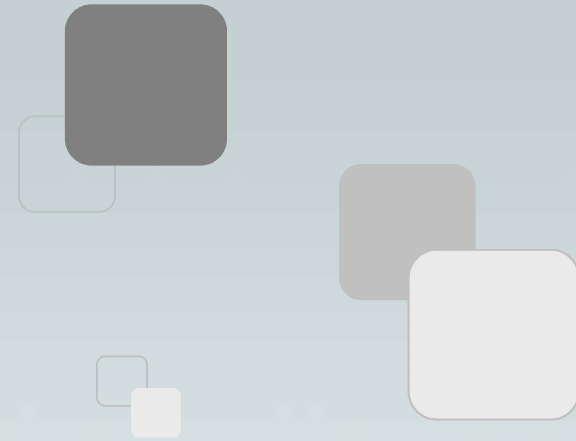
- Set of MATLAB scripts performing data manipulation and computation
  - the reporting structure was described directly in the scripts
  - all data stored in files (xls, csv); no database storage
- Due to the group's dynamics a more robust system become necessary
  - original plan: MATLAB + MySQL
  - finally the solution was implemented as a minor part of more general project using SAS platform
- Duration of implementation: 1 year
- Result:
  - all data stored in database (including company and reporting structure)
  - solution is opened to user defined aggregation methods

# Lessons learned

- EC aggregation might be automated using MATLAB as well as SAS
- Base SAS solution might be easily integrated using standard SAS BI tools into enterprise solution accessed through web portal
- Each specialized SAS procedure uses its own syntax which generates extra learning costs; GUI tools like SAS/Enterprise Guide provide more comfortable way to use the procedures for ad-hoc analysis;
- SAS/Macro language:
  - efficient and flexible text-preprocessor, allows to effectively parameterize SAS procedures
  - lacks features useful in huge projects (declarations, types, ...)
  - SAS/SCL module (object-oriented encapsulation of SAS/Macro and SAS/Base codes) might be more comfortable

# Lessons learned

- Data might be easily reported in (HTML, PDF,...) using Base SAS
- Access to databases:
  - use of SAS direct connectivity is faster than using ODBC
  - in some cases SAS sequential approach allows more efficient manipulation with data than SQL does
- Processed data might become too large to be stored in memory using 32bit architecture; using of 64bit architecture or a file system (like SAS dataset) is then necessary



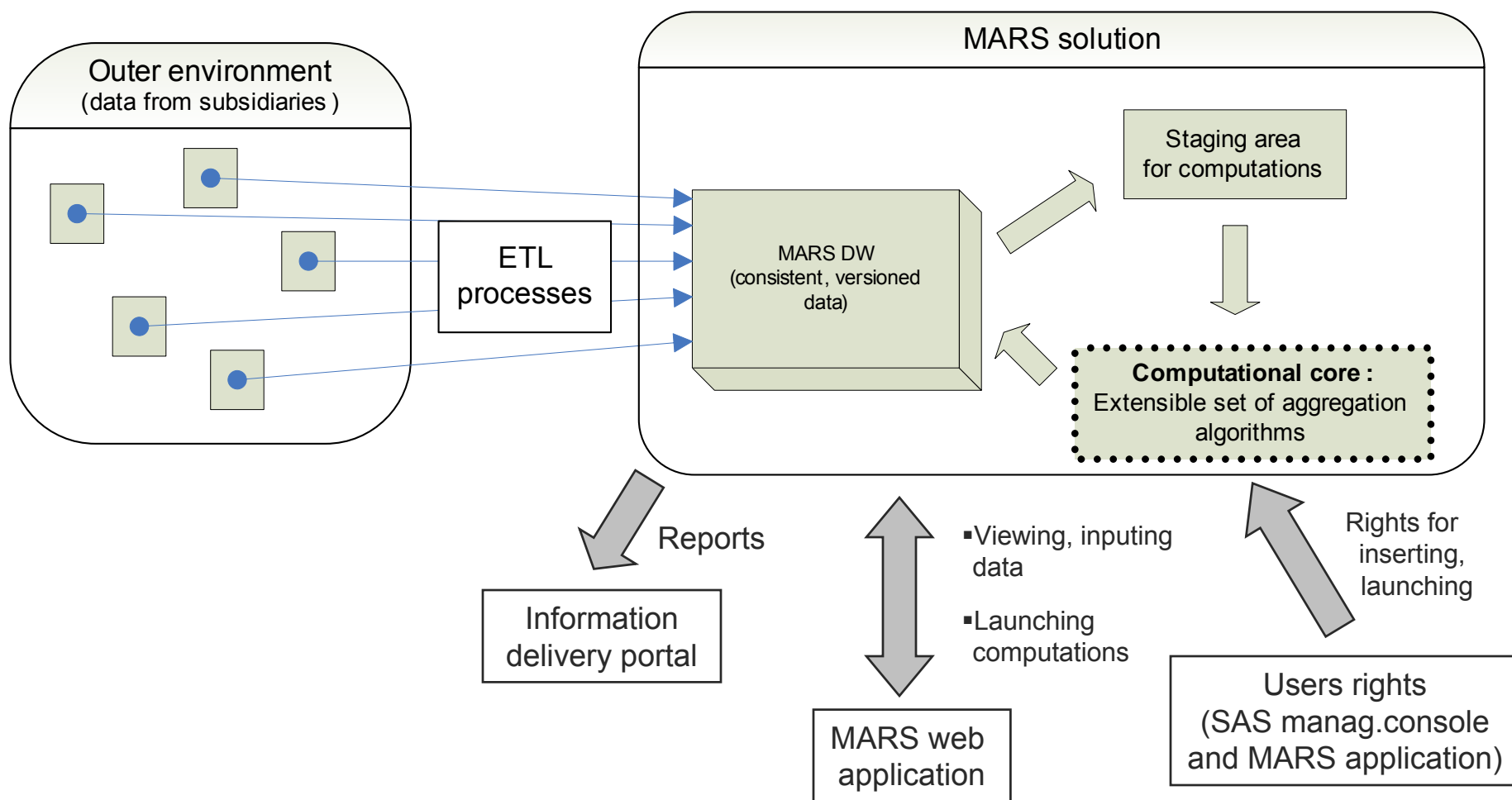
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TO KNOW.®**

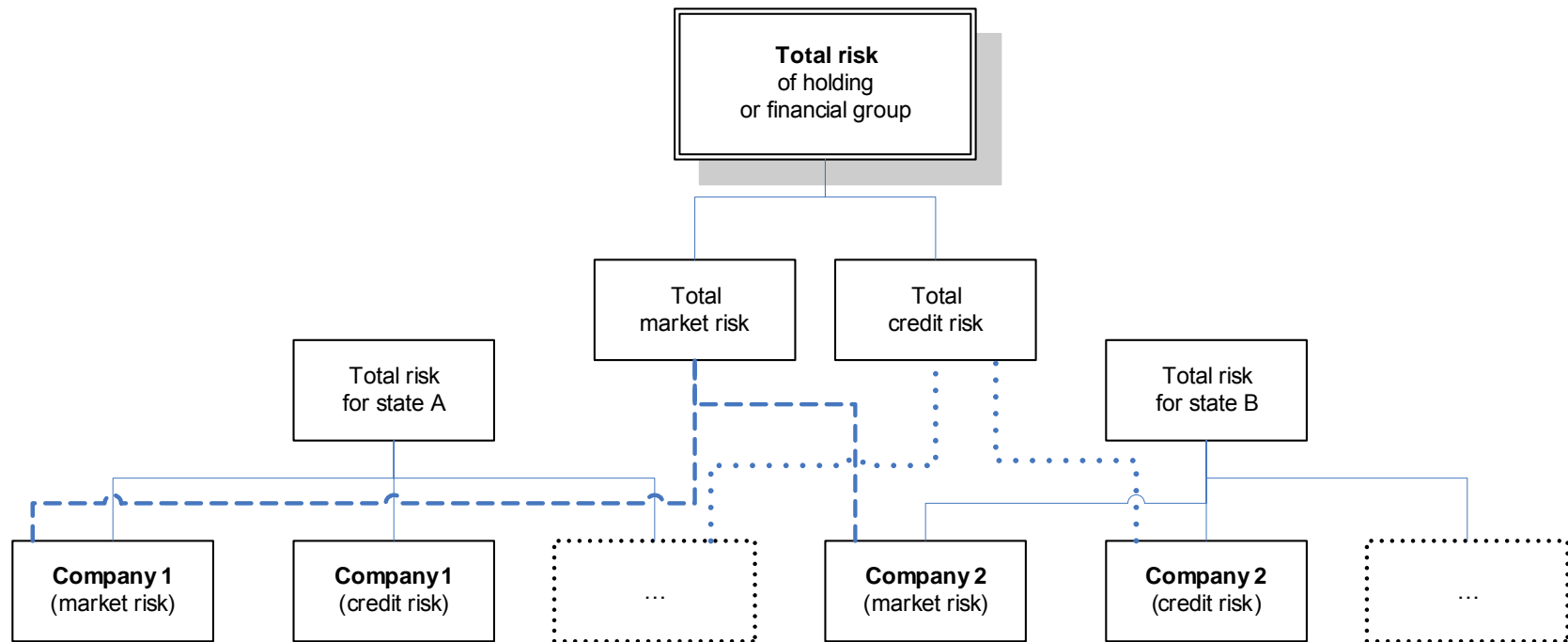
# SAS® MARS

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Solution for  
Economic Capital  
Aggregation

extensible by any external  
aggregation method,  
fully automated and  
parameterized run of  
aggregation scenarios,  
multilevel aggregations,  
parametrized “moods” of  
aggregations,

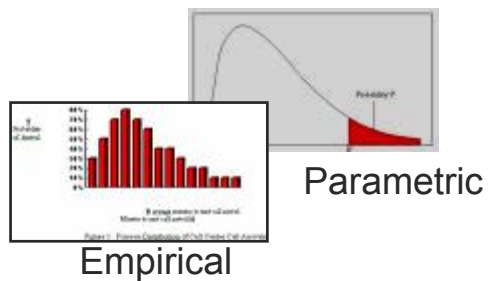




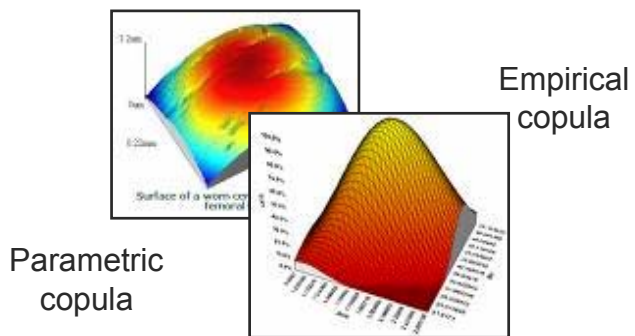
Shown aggregation are related – results of lower aggregations are input of higher ones, all shown aggregations can be computed automatically in one run of the process, each included aggregation can have different set of reported results which are automatically computed during the process.

# Aggregation scenario

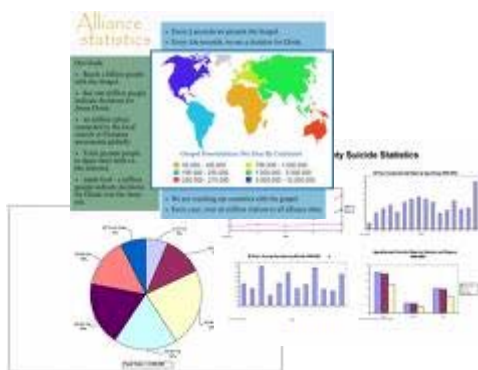
## Marginal distributions of risks



## Copula aggregation method



## Derived statistics for reports



## Parameters of aggregation

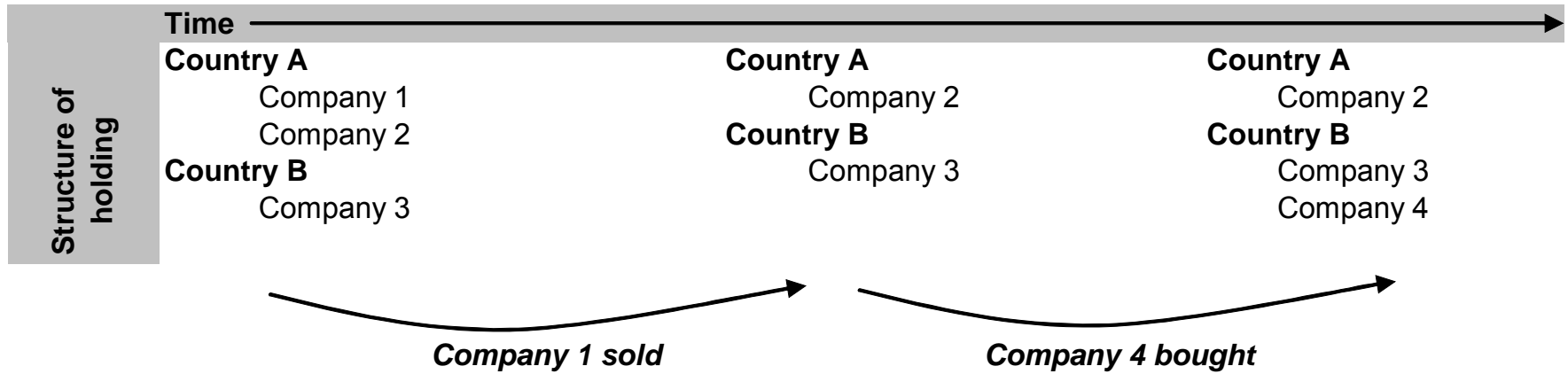


Optimistic



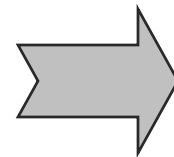
Pesimistic





Store information  
about development  
of the holding  
structure

Just choose a  
historical moment



Computation is automatically  
adjusted to the holding  
structure valid in moment M

## Two time dimensions:

**validity** ... tells when the event occurred

**version** ... shows, how information about the event developed

## Example from accountancy:

31-Jan-05	... end of year
20-Feb-06	... preliminary results of year 2005 (1 <sup>st</sup> version of 05' results)
20-Apr-06	... final results of year 2005 before audit (2 <sup>nd</sup> version 05' results)
20-Jun-06	... final results after audit (3 <sup>rd</sup> version of 05' results)

## MARS solution:

The data can have arbitrary amount of versions...

Data for risk-type R of comp.X on date D		Version time-axis [date-time, seconds precision]	
Validity time-axis [date, days precision]	D'	Version 1	Version 2
	D	Version 1	Version 2 V. 3 Version 4 Version 5
	D''	Version 1	Version 2 Version 3
	D'''		Version 1

## Easy way of making experiments in MARS:

many versions for one validity and testing, which version is the most suitable

Needed functionality	Specific technology used in PPF
General procedural or OO language	SAS/Base, SAS/Macro
Efficient matrix language	SAS/IML
Libraries with statistical and probabilistic functions	SAS/Base, SAS/STAT
Data-storage	MySQL*), SAS tables
Reporting system	SAS/Base, SAS/Graph, SAS/Enterprise Guide
GUI for data inputs, launching computations and scheduling	Java/Spring web application
Security/users metadata administrator	SAS/MC and web application
Aggregation methods	Set of macros / functions / method programs performing ETL, analysis and computations

EC application - SAS Czech Republic - Microsoft Internet Explorer

Address: http://sasrm:8080/ec/index.jsp

Lookups ETL Relational Tables Computation Administration

EC application - SAS Czech Republic - Microsoft Internet Explorer

Address: http://sasrm:8080/ec/index.jsp

Lookups ETL Relational Tables Computation Administration

ETL - Copula function point representations

Search App ETL - param.set Definition]

List of Aggregation definition

Filter: [APP\_LANGUAGE=en]

[Definition] Name	[Definition] Description	Copula function	Copula functions parameters	Copula function point representation
BL[MEM]_ALL[MEM]_LST	--	NORMAL	LIGHT_STRESS	
BL[MEM]_ALL[MEM]_UST	--	NORMAL	ULTRA_STRESS	
RISKS[MEM]_OPT	--	NORMAL	OPTIMISTIC	
RISKS[MEM]_LST	--	NORMAL	LIGHT_STRESS	
RISKS[MEM]_UST	--	NORMAL	ULTRA_STRESS	
CREDIT[BL]_OPT	--	NORMAL	OPTIMISTIC	
CREDIT[BL]_LST	--	NORMAL	LIGHT_STRESS	
CREDIT[BL]_UST	--	NORMAL	ULTRA_STRESS	
MARKET_CREDIT[RISK]_OPT	--	NORMAL	OPTIMISTIC	
MARKET_CREDIT[RISK]_LST	--	NORMAL	LIGHT_STRESS	
MARKET_CREDIT[RISK]_UST	--	NORMAL	ULTRA_STRESS	
ALL_ML[RISKS]_OPT	--	NORMAL	OPTIMISTIC	
ALL_ML[RISKS]_LST	--	NORMAL	LIGHT_STRESS	
ALL_ML[RISKS]_UST	--	NORMAL	ULTRA_STRESS	
ALL_ML[BL]_OPT	--	NORMAL		BL_IL

Aggregation definition - detail

[Definition] Name: RISKS[MEM]\_OPT

[Definition] Description: --

Locked: 0

Copula function: NORMAL

[Method] Description: normalni

Copula functions parameters: OPTIMISTIC

[Prm.set] Description: based on history

Copula function point representation:

[Pnt.set] Description:

Interpolation method:

[Interpolation] Description:

List of Aggregation group

Filter: [APP\_LANGUAGE=en]

Name	Description	Locked
B_S1	Banks in S1	0
B_S2	Banks in S2	0
I_S1	Insur in S1	0
I_S2	Insur in S2	0
O_S1	Other in S1	0
O_S2	Other in S2	0
B_all	Banks in all states	0
I_ALL	Insur in all states	0
O_ALL	Others in all states	0
ALL_S1	All company types in S1	0
ALL_S2	All company types in S2	0
ALL_ALL_i	All comp.types in all states, complast	0
ALL_ALL_ii	All comp.types in all states, states last	0
HC		0
CP		0

EC application - SAS Czech Republic - Microsoft Internet Explorer

Address: http://sasrm:8080/ec/index.jsp

Lookups ETL Relational Tables Computation Administration

Aggregation definition [Edit]

Aggregation definition

Aggregation definition

[Definition] Name:

[Definition] Description:

Text: Copula function: NORMAL

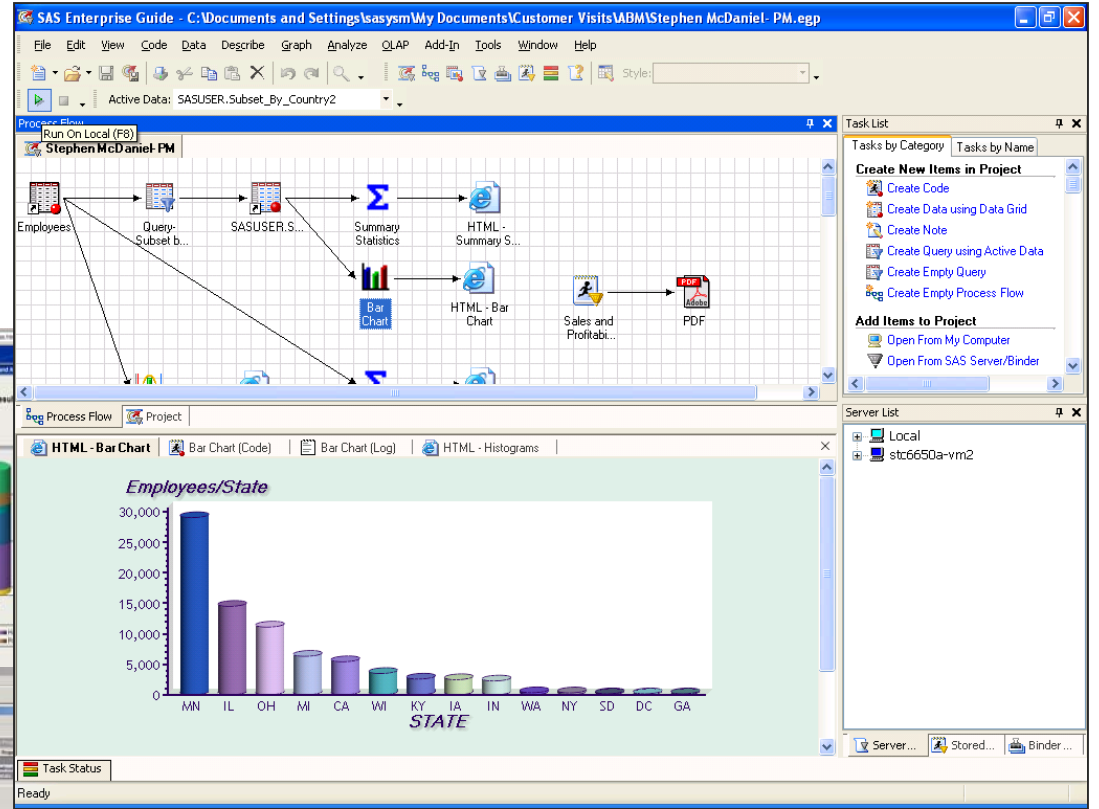
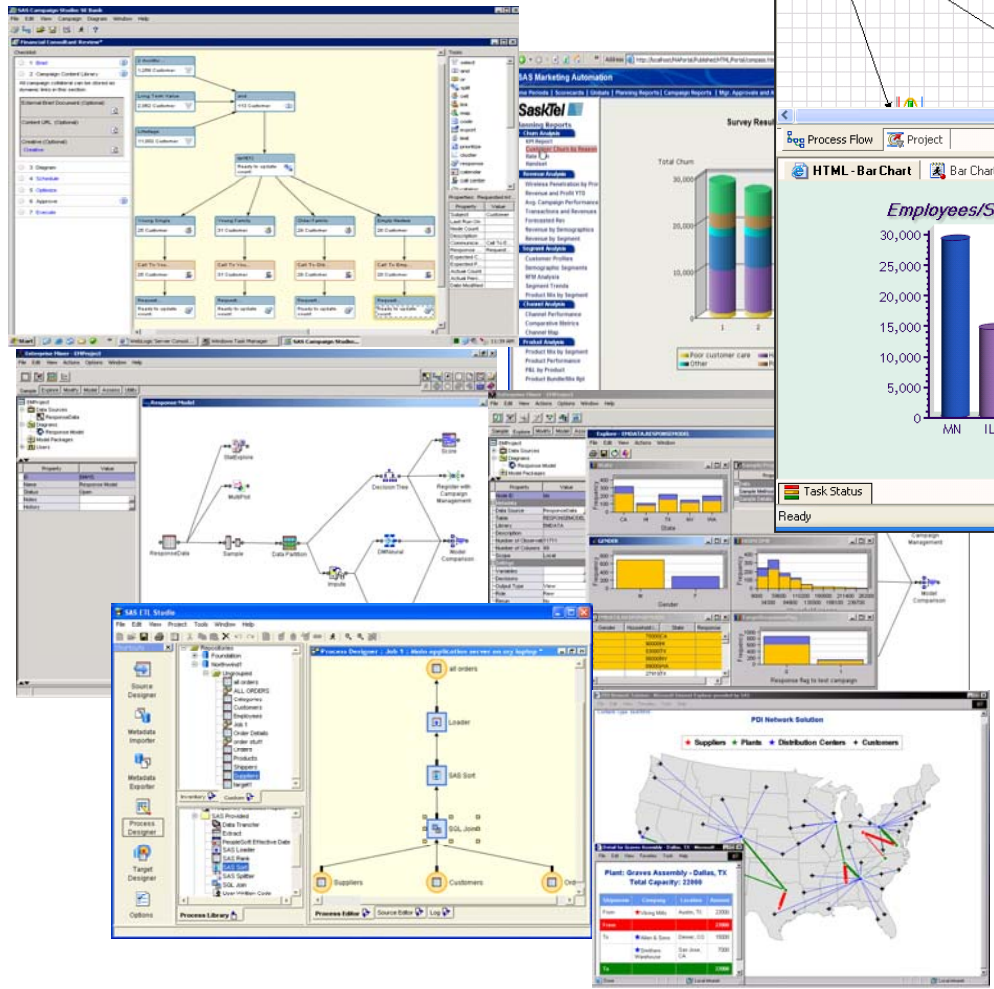
Text: Copula functions parameters: OPTIMISTIC

Text: Copula function point representation:

Stage: Locked: 0

Back Restore Insert

- Intuitive look & feel environment
- Access via Internet Explorer
- Exports to Excel
- Different rights for different users



- SAS Enterprise Guide
- SAS Web-report studio
- SAS data-integration studio

## Information delivery portal

(MARS called from portal, reports visible on portal)

## Several user groups

(junior-analyst, senior-analyst, admin, reader)

## Automatic assignment of appropriate rights

(rights to read/write data, launch processes, view reports)

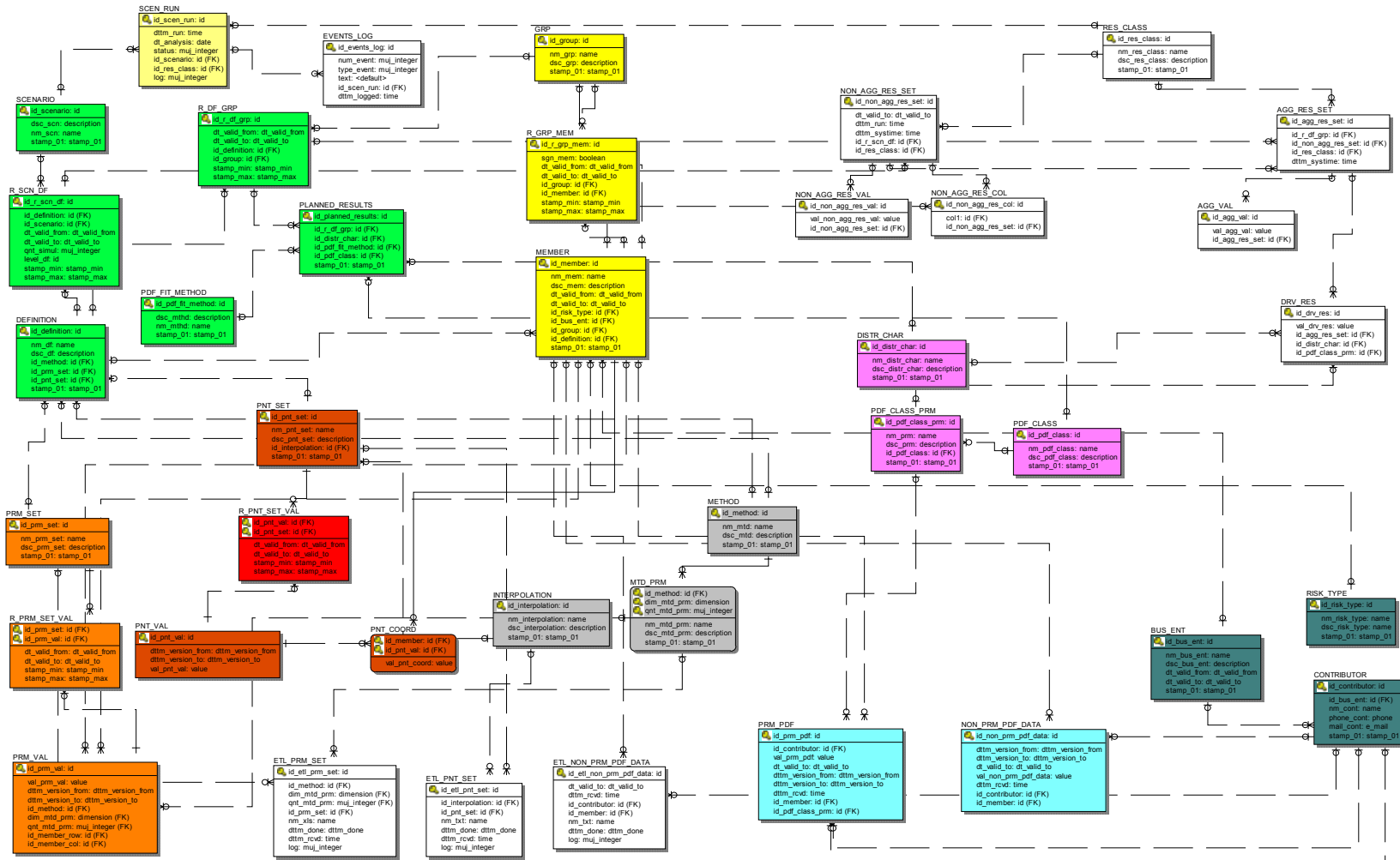
**Unioning methodology:**  
Saves hours of computational  
time,  
intermediate results for one  
report can be used in other  
reports



**Ready for optimization and  
experiments:**

- Arbitrary amount of preliminary results
- Possibility to choose what will be stored in DW and what only left on analyst HDD
- Arbitrary number of simulations





Denormalized storage for  
multidimensional surfaces (easy)

All data-consistency checks on  
DB-level (medium)

Wizards for scenario definitions,  
graphical depiction of scenario  
structure and versioned data  
(hard)