



**BNP PARIBAS**  
CORPORATE & INVESTMENT BANKING

# The Market Risk system

## An Overview

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Head of Market Risk IT

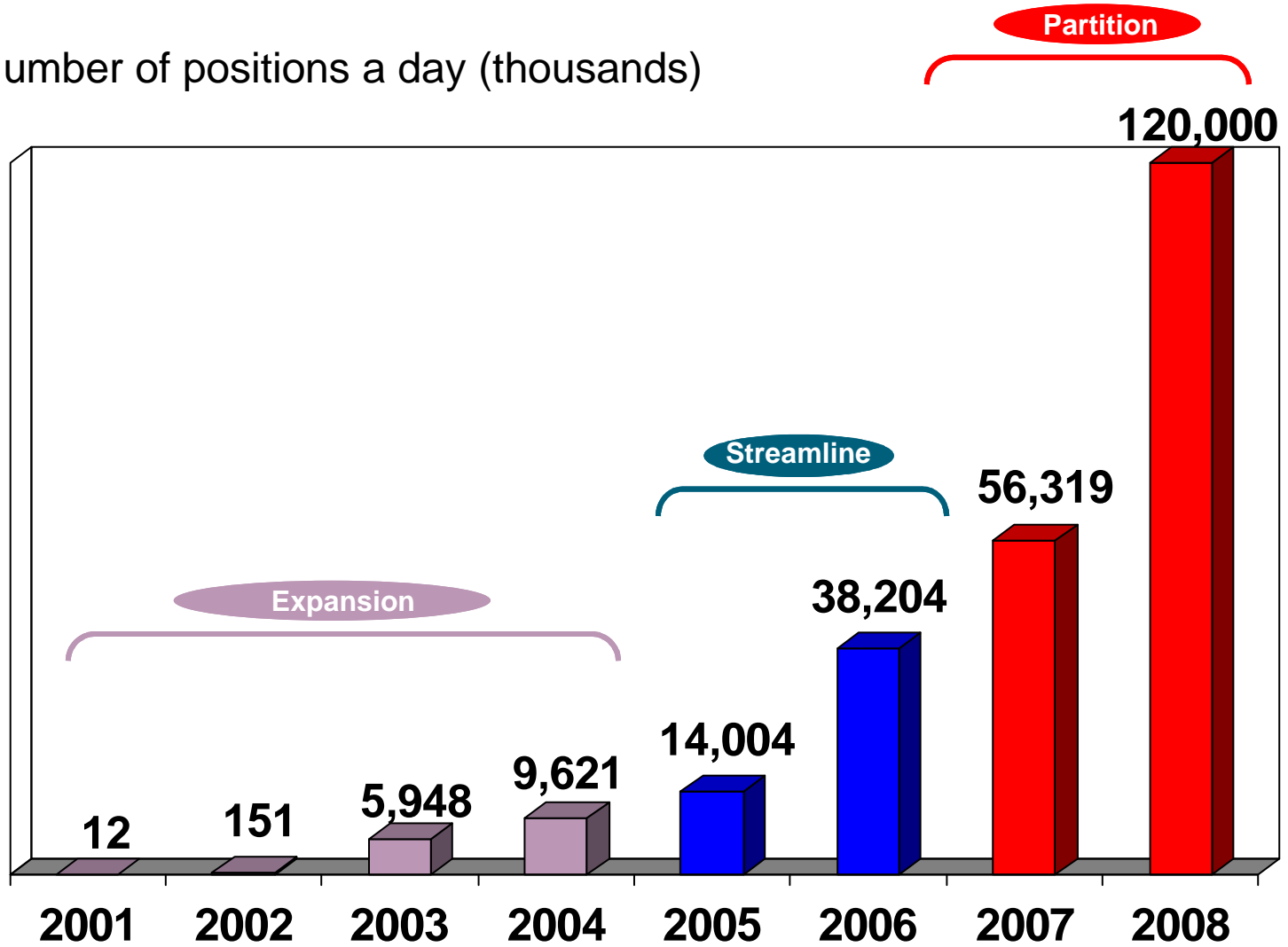
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Market Risk IT Functional Architect

14 March 2008



# What's the story?

Number of positions a day (thousands)





## Agenda

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- **Who are BNP Paribas?**
- What is Market Risk?
- What are the architectural concerns of Market Risk at BNPP?
- In-depth look at the data loading architecture



## BNP Paribas: Who are we?

- One of the largest international banking networks with strong positions in Asia and a significant presence in the United States.
- Three core businesses
  - Corporate and Investment Banking
  - Retail Banking
  - Asset Management and Services
- N°6 in the banking industry and n°1 French company ('Global 2000 Forbes' 2007)
- AA+ credit rating: One of only four banks worldwide with this rating or above ('The Banker' magazine, February 2008)



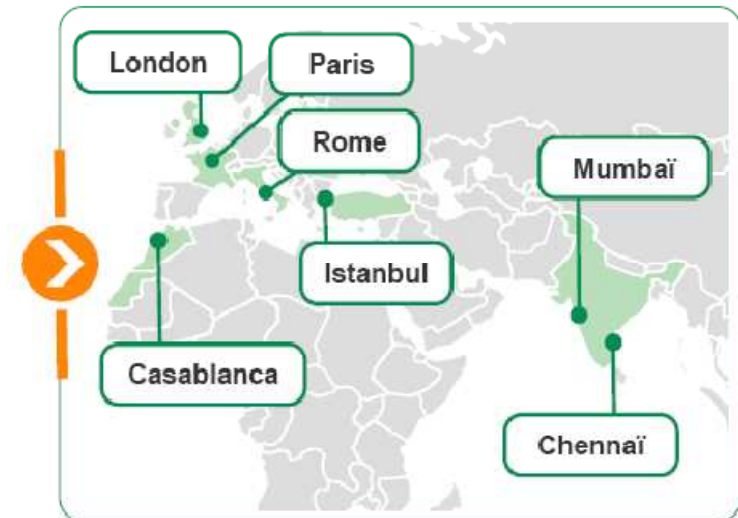


## We're a global company



- BNP Paribas operates in over 85 countries, and has 162,700 employees including 126,600 in Europe - of whom 19,900 are in Italy and 64,100 in France and in the Overseas Departments; 15,000 in North America and 8,800 in Asia.

- Internationalised IT development
  - 3 major centres in Western Europe (Paris, London and Rome)
  - 4 global development centres in emerging markets (800 staff at the end of 2007)
  - Significant development also takes place in New York, Singapore, Tokyo and Hong Kong
- Market Risk IT has over 30 staff in London, Paris, Mumbai and Hong Kong





# Corporate and Investment Banking (CIB)

## ■ Award winning Corporate and Investment Banking

- Fixed Income
- Equities and Derivatives
- Corporate Finance
- Energy Commodities  
Export Project
- Structured Finance
- Cash Management
- Loan and Portfolio  
Management



Corporate &  
Investment  
Banking







## Agenda reminder

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## What is Market Risk?

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- The risk of losing money because of fluctuations in financial markets
  - Interest rates go up, or down
  - Share prices change
  - And so on ...
- Why is it important?
  - It's a regulatory requirement that determines the amount of capital a bank must put aside on its balance sheet to cover potential losses (**Regulatory Capital**)
  - It gives a view of short-term potential losses due to fluctuations in the market and allows us to hedge against those losses
- How do we measure it?
  - Value at Risk (VaR)
    - The worst loss expected for a given portfolio due to 'normal' market movements over a given time horizon within a given confidence interval.





## Value at Risk as measured at BNP Paribas

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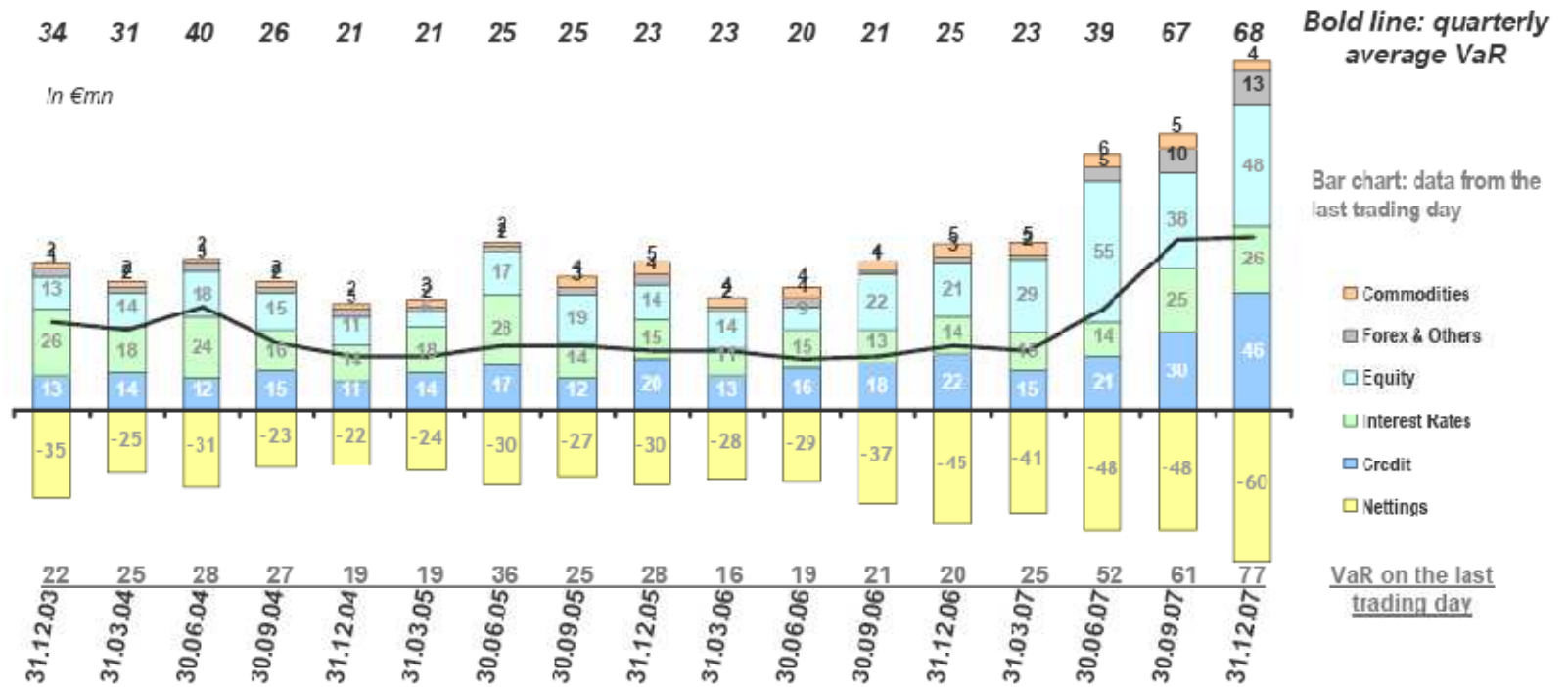
- VaR measurements at BNP Paribas use a confidence level of 99% over 1 day.  
So VaR at BNP Paribas is:
  - The worst loss expected for a given portfolio due to normal market movements over 1 day with a 99% confidence level.
- Or equivalently
  - For normal market conditions, the minimal amount we can expect to lose on the next trading day no more than 1% of the time.
- VaR is calculated and reported by a single global system called MRX (Market Risk eXplorer)
  - We start at the level of calculating VaR for individual deals and positions, and aggregate up to the VaR for the whole of BNP Paribas
  - Both deal-level and aggregated views of VaR are useful
  - We calculate VaR across:
    - all financial products
    - all BNP Paribas trading activities globally



# BNP Paribas aggregated Value at Risk (99%, 1 day)

## ■ BNP Paribas 2007 Published Results

<http://invest.bnpparibas.com/en/results/documents/4Q07-Master-GB-Final.pdf>





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# MRX – The BNP Paribas Market Risk system

- A single global system including:
  - a data warehouse of positions, sensitivities, securities and OTC deals
  - a VaR calculation engine
  - a data analysis and drill-down tool

The screenshot displays the MRX system interface, which is a data analysis and drill-down tool. The main window shows a large table with columns for various financial metrics, including positions, sensitivities, and securities. The table is organized into sections, with some rows highlighted in red. The interface includes a navigation pane on the left and a status bar at the bottom.

Symbol	Quantity	Price	Value	Delta	Gamma	Vega	Rho	Theta	Volatility	Skewness	Kurtosis	Correlation	Market	Index	Position	Status	Sub
EURUSD	1000000	1.2500	1250000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURUSD	EURUSD	1000000	Active	EURUSD
USDJPY	1000000	100.0000	100000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	USDJPY	USDJPY	1000000	Active	USDJPY
GBPUSD	1000000	1.5000	1500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	GBPUSD	GBPUSD	1000000	Active	GBPUSD
JPYUSD	1000000	0.0070	7000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	JPYUSD	JPYUSD	1000000	Active	JPYUSD
EURJPY	1000000	125.0000	125000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURJPY	EURJPY	1000000	Active	EURJPY
EURGBP	1000000	0.7500	7500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURGBP	EURGBP	1000000	Active	EURGBP
EURCHF	1000000	0.7500	7500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURCHF	EURCHF	1000000	Active	EURCHF
EURAUD	1000000	1.5000	1500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURAUD	EURAUD	1000000	Active	EURAUD
EURCAD	1000000	1.2500	1250000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURCAD	EURCAD	1000000	Active	EURCAD
EURHKD	1000000	7.5000	7500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURHKD	EURHKD	1000000	Active	EURHKD
EURSGD	1000000	1.2500	1250000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURSGD	EURSGD	1000000	Active	EURSGD
EURNZD	1000000	1.5000	1500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURNZD	EURNZD	1000000	Active	EURNZD
EURINR	1000000	75.0000	75000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURINR	EURINR	1000000	Active	EURINR
EURBRL	1000000	1.5000	1500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURBRL	EURBRL	1000000	Active	EURBRL
EURMXN	1000000	15.0000	15000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURMXN	EURMXN	1000000	Active	EURMXN
EURKRW	1000000	1500.0000	1500000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURKRW	EURKRW	1000000	Active	EURKRW
EURTRY	1000000	15.0000	15000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURTRY	EURTRY	1000000	Active	EURTRY
EURRUB	1000000	75.0000	75000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURRUB	EURRUB	1000000	Active	EURRUB
EURZAR	1000000	15.0000	15000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURZAR	EURZAR	1000000	Active	EURZAR
EURHUF	1000000	200.0000	200000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURHUF	EURHUF	1000000	Active	EURHUF
EURPLN	1000000	4.0000	40000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURPLN	EURPLN	1000000	Active	EURPLN
EURCZK	1000000	20.0000	20000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURCZK	EURCZK	1000000	Active	EURCZK
EURSEK	1000000	10.0000	10000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURSEK	EURSEK	1000000	Active	EURSEK
EURNOK	1000000	10.0000	10000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURNOK	EURNOK	1000000	Active	EURNOK
EURDKK	1000000	7.5000	75000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURDKK	EURDKK	1000000	Active	EURDKK
EURISK	1000000	100.0000	100000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURISK	EURISK	1000000	Active	EURISK
EURIDR	1000000	15000.0000	15000000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURIDR	EURIDR	1000000	Active	EURIDR
EURPHP	1000000	50.0000	50000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURPHP	EURPHP	1000000	Active	EURPHP
EURTHB	1000000	30.0000	30000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURTHB	EURTHB	1000000	Active	EURTHB
EURMYR	1000000	4.0000	40000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURMYR	EURMYR	1000000	Active	EURMYR
EURSGD	1000000	1.2500	12500000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURSGD	EURSGD	1000000	Active	EURSGD
EURNZD	1000000	1.5000	15000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURNZD	EURNZD	1000000	Active	EURNZD
EURINR	1000000	75.0000	75000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURINR	EURINR	1000000	Active	EURINR
EURBRL	1000000	1.5000	15000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURBRL	EURBRL	1000000	Active	EURBRL
EURMXN	1000000	15.0000	150000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURMXN	EURMXN	1000000	Active	EURMXN
EURKRW	1000000	1500.0000	1500000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURKRW	EURKRW	1000000	Active	EURKRW
EURTRY	1000000	15.0000	150000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURTRY	EURTRY	1000000	Active	EURTRY
EURRUB	1000000	75.0000	750000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURRUB	EURRUB	1000000	Active	EURRUB
EURZAR	1000000	15.0000	150000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURZAR	EURZAR	1000000	Active	EURZAR
EURHUF	1000000	200.0000	200000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURHUF	EURHUF	1000000	Active	EURHUF
EURPLN	1000000	4.0000	40000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURPLN	EURPLN	1000000	Active	EURPLN
EURCZK	1000000	20.0000	200000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURCZK	EURCZK	1000000	Active	EURCZK
EURSEK	1000000	10.0000	100000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURSEK	EURSEK	1000000	Active	EURSEK
EURNOK	1000000	10.0000	100000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURNOK	EURNOK	1000000	Active	EURNOK
EURDKK	1000000	7.5000	75000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURDKK	EURDKK	1000000	Active	EURDKK
EURISK	1000000	100.0000	100000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURISK	EURISK	1000000	Active	EURISK
EURIDR	1000000	15000.0000	15000000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURIDR	EURIDR	1000000	Active	EURIDR
EURPHP	1000000	50.0000	500000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURPHP	EURPHP	1000000	Active	EURPHP
EURTHB	1000000	30.0000	300000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURTHB	EURTHB	1000000	Active	EURTHB
EURMYR	1000000	4.0000	400000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURMYR	EURMYR	1000000	Active	EURMYR
EURSGD	1000000	1.2500	125000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURSGD	EURSGD	1000000	Active	EURSGD
EURNZD	1000000	1.5000	150000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURNZD	EURNZD	1000000	Active	EURNZD
EURINR	1000000	75.0000	750000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURINR	EURINR	1000000	Active	EURINR
EURBRL	1000000	1.5000	150000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURBRL	EURBRL	1000000	Active	EURBRL
EURMXN	1000000	15.0000	1500000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURMXN	EURMXN	1000000	Active	EURMXN
EURKRW	1000000	1500.0000	15000000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURKRW	EURKRW	1000000	Active	EURKRW
EURTRY	1000000	15.0000	150000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURTRY	EURTRY	1000000	Active	EURTRY
EURRUB	1000000	75.0000	750000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURRUB	EURRUB	1000000	Active	EURRUB
EURZAR	1000000	15.0000	150000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURZAR	EURZAR	1000000	Active	EURZAR
EURHUF	1000000	200.0000	200000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURHUF	EURHUF	1000000	Active	EURHUF
EURPLN	1000000	4.0000	40000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURPLN	EURPLN	1000000	Active	EURPLN
EURCZK	1000000	20.0000	200000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURCZK	EURCZK	1000000	Active	EURCZK
EURSEK	1000000	10.0000	100000000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	EURSEK	EURSEK	1000000	Active	EURSE



## MRX Key Facts

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### ■ Data

- 15,000 files received per day
- 80 GB input data processed per day
- 100 million rows loaded into the fact table per day
- Fact table contains about 4 billion rows
- Dimension tables contain up to 10 million rows each

### ■ Calculations

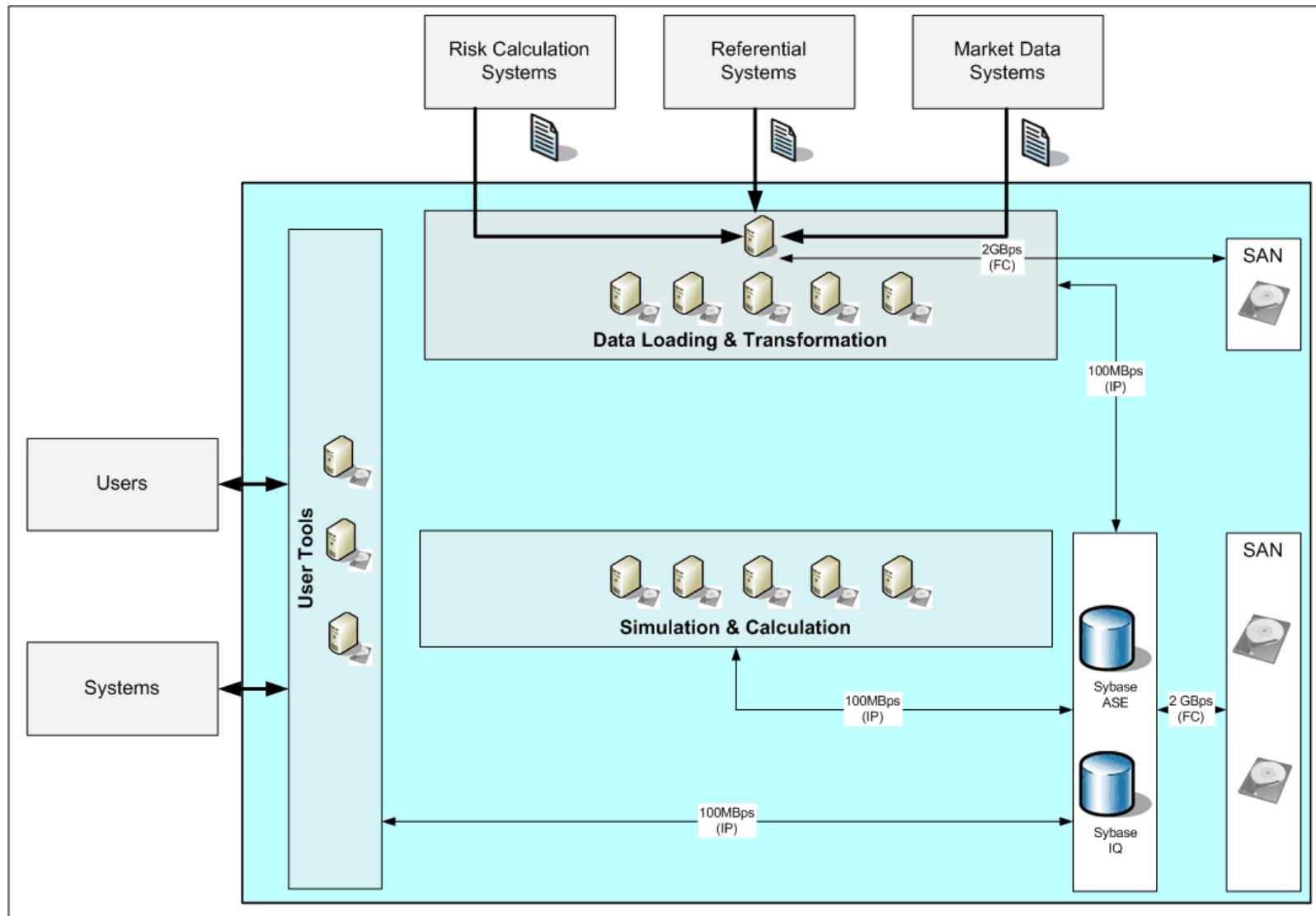
- 75,000 VaR calculations per day
- 10 GB of VaR statistics generated each day

### ■ Views and reports

- 400,000 queries, views or reports per day
- 20,000 ad-hoc queries, views or reports per day



# MRX Infrastructure





## MRX must be extensible by users

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- Calculate the risk for tomorrow based on the markets yesterday
- Rapid changes happen in financial markets
  - New data feeds and reports must be commissioned *quickly*
- The MRX system must be very flexible and extensible, whilst still keeping its industrialised reliability
- Large amounts of in-house configuration features in the ETL (extract, transform, load) pipeline allow turn-around of new feeds and transformations within one day
  - Data volumes increase continually – metrics and capacity planning are very important
- Scripting language for screens (Jython-based) allow super-users to create or change screens within one day
  - The problem of badly written queries must be managed (essentially ad-hoc queries from the DBA's perspective)





## MRX must be reliable

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- The complete VaR for BNP Paribas must be calculated every week day all year long
  - Each week day the whole world is loaded afresh and recalculated
  - Operation and support activities run 5 days a week (including all holidays) all year; maintenance mostly at weekends
- Users around the world
  - Tokyo start at 1am GMT
  - New York finish at 10pm GMT
  - Occasional weekend use
- Data loading and user querying run in parallel for over 12 hours each day
  - As soon as a file is loaded its data is available for querying and it will be queried
- Large-scale industrialisation of system and data feeds – MRX must work reliably and automatically; there's not enough time to re-do a complete day
  - Sophisticated data quality tools and expert business team to handle data issues



## Architectural Categorisation

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In Market Risk we analyse our system using the following categorisation of architectural concerns

- Availability – service/resource is accessible, business continuity
- Performance – latency (response time) and throughput (batch processing)
- Scalability – support the service as the load increases
- Reliability – the integrity and consistency of the application
- Manageability – ensure the continued health of the system
- Maintainability – add or modify code with impacting existing functions
- Usability – easily and safely use the system
- Security – protect functions and data from theft, disclosure, damage, audit
- Extensibility – user modification



## MRX Information Architecture Principles

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- Data distributed across two data stores
  - Availability and consistency must be considered
- BASE is important (Basically Available, Soft-state, Eventually consistent)
  - Availability and scalability are higher priorities;
  - State is *softish* – can rebuild 1-2 lost hours on restart by rerunning data loading jobs
  - There is weak consistency between data in separate data stores; data is eventually consistent (via automatic and explicit synchronisation mechanisms).
- ACID isn't important (Atomicity, Consistency, Isolation and Durability)
  - Very little transaction processing (some reference data updates, task handling, configuration updates)
  - 2-phase commit not used



## MRX and the CAP Theorem

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- Originally posited by Eric Brewer
  - For example, refer to excellent Werner Vogels talk at QCon, London 2007  
<http://www.infoq.com/presentations/availability-consistency>  
<http://www.webperformancematters.com/journal/2007/8/21/asynchronous-architectures-4.html>
- CAP Theorem – pick two of three for distributed data
  - Consistency
  - Availability
  - tolerance to network Partitions
- MRX values Availability and Partition tolerance over Consistency
  - Strong consistency not important; eventual consistency sufficient, where eventual is less than a day
  - It's better to have old data available than no data (as long as we know it's old data)
  - Partition-tolerance is important for business continuity reasons



## How to make Architectural Concerns real

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- How do we get to allocate budget and resources to our architectural concerns?  
Warning: this depends on your budget process

- Present a horror story  
*The system will collapse, the bank won't trade and everyone will lose their bonus' if we don't make this non-functional change right now!*

Never a good idea, shows you haven't been doing your capacity planning

- Hide in a business deliverable  
*We'll deliver the risk on our new Orange Juice futures product (and nobody knows, but we'll spend 50% of the effort on fixing that big operational problem)*

It makes estimating, planning, metric gathering and process improvement initiatives (CMMI, 6-Sigma) difficult in the long term

- Make the benefits explicit  
*These are our architectural concerns; if we make this non-functional change, you'll see these improvements to the architecture*

MRX does this with the help of an *Architecture Heatmap*



# The Architecture Heatmap

- Architectural concerns x-axis
- System components y-axis
- Colour coded severity
  - Red must be addressed soon
  - Yellow is a known issue
  - Green has no known problems
- Reviewed after every release
- A *before* and *after* version help gain buy-in

Area	Component	Concern	Severity	Resolution	Resolution	Resolution	Resolution	Resolution	Resolution
Area 1	Comp 1.1	Concern 1.1	Green	Resolution 1.1	Resolution 1.1	Resolution 1.1	Resolution 1.1	Resolution 1.1	Resolution 1.1
	Comp 1.2	Concern 1.2	Yellow	Resolution 1.2	Resolution 1.2	Resolution 1.2	Resolution 1.2	Resolution 1.2	Resolution 1.2
	Comp 1.3	Concern 1.3	Green	Resolution 1.3	Resolution 1.3	Resolution 1.3	Resolution 1.3	Resolution 1.3	Resolution 1.3
	Comp 1.4	Concern 1.4	Green	Resolution 1.4	Resolution 1.4	Resolution 1.4	Resolution 1.4	Resolution 1.4	Resolution 1.4
	Comp 1.5	Concern 1.5	Green	Resolution 1.5	Resolution 1.5	Resolution 1.5	Resolution 1.5	Resolution 1.5	Resolution 1.5
	Comp 1.6	Concern 1.6	Green	Resolution 1.6	Resolution 1.6	Resolution 1.6	Resolution 1.6	Resolution 1.6	Resolution 1.6
	Comp 1.7	Concern 1.7	Green	Resolution 1.7	Resolution 1.7	Resolution 1.7	Resolution 1.7	Resolution 1.7	Resolution 1.7
	Comp 1.8	Concern 1.8	Green	Resolution 1.8	Resolution 1.8	Resolution 1.8	Resolution 1.8	Resolution 1.8	Resolution 1.8
	Comp 1.9	Concern 1.9	Green	Resolution 1.9	Resolution 1.9	Resolution 1.9	Resolution 1.9	Resolution 1.9	Resolution 1.9
	Comp 1.10	Concern 1.10	Green	Resolution 1.10	Resolution 1.10	Resolution 1.10	Resolution 1.10	Resolution 1.10	Resolution 1.10
Area 2	Comp 2.1	Concern 2.1	Red	Resolution 2.1	Resolution 2.1	Resolution 2.1	Resolution 2.1	Resolution 2.1	Resolution 2.1
	Comp 2.2	Concern 2.2	Red	Resolution 2.2	Resolution 2.2	Resolution 2.2	Resolution 2.2	Resolution 2.2	Resolution 2.2
	Comp 2.3	Concern 2.3	Red	Resolution 2.3	Resolution 2.3	Resolution 2.3	Resolution 2.3	Resolution 2.3	Resolution 2.3
	Comp 2.4	Concern 2.4	Red	Resolution 2.4	Resolution 2.4	Resolution 2.4	Resolution 2.4	Resolution 2.4	Resolution 2.4
	Comp 2.5	Concern 2.5	Red	Resolution 2.5	Resolution 2.5	Resolution 2.5	Resolution 2.5	Resolution 2.5	Resolution 2.5
	Comp 2.6	Concern 2.6	Red	Resolution 2.6	Resolution 2.6	Resolution 2.6	Resolution 2.6	Resolution 2.6	Resolution 2.6
	Comp 2.7	Concern 2.7	Red	Resolution 2.7	Resolution 2.7	Resolution 2.7	Resolution 2.7	Resolution 2.7	Resolution 2.7
	Comp 2.8	Concern 2.8	Red	Resolution 2.8	Resolution 2.8	Resolution 2.8	Resolution 2.8	Resolution 2.8	Resolution 2.8
	Comp 2.9	Concern 2.9	Red	Resolution 2.9	Resolution 2.9	Resolution 2.9	Resolution 2.9	Resolution 2.9	Resolution 2.9
	Comp 2.10	Concern 2.10	Red	Resolution 2.10	Resolution 2.10	Resolution 2.10	Resolution 2.10	Resolution 2.10	Resolution 2.10
Area 3	Comp 3.1	Concern 3.1	Green	Resolution 3.1	Resolution 3.1	Resolution 3.1	Resolution 3.1	Resolution 3.1	Resolution 3.1
	Comp 3.2	Concern 3.2	Green	Resolution 3.2	Resolution 3.2	Resolution 3.2	Resolution 3.2	Resolution 3.2	Resolution 3.2
	Comp 3.3	Concern 3.3	Green	Resolution 3.3	Resolution 3.3	Resolution 3.3	Resolution 3.3	Resolution 3.3	Resolution 3.3
	Comp 3.4	Concern 3.4	Green	Resolution 3.4	Resolution 3.4	Resolution 3.4	Resolution 3.4	Resolution 3.4	Resolution 3.4
	Comp 3.5	Concern 3.5	Green	Resolution 3.5	Resolution 3.5	Resolution 3.5	Resolution 3.5	Resolution 3.5	Resolution 3.5
	Comp 3.6	Concern 3.6	Green	Resolution 3.6	Resolution 3.6	Resolution 3.6	Resolution 3.6	Resolution 3.6	Resolution 3.6
	Comp 3.7	Concern 3.7	Green	Resolution 3.7	Resolution 3.7	Resolution 3.7	Resolution 3.7	Resolution 3.7	Resolution 3.7
	Comp 3.8	Concern 3.8	Green	Resolution 3.8	Resolution 3.8	Resolution 3.8	Resolution 3.8	Resolution 3.8	Resolution 3.8
	Comp 3.9	Concern 3.9	Green	Resolution 3.9	Resolution 3.9	Resolution 3.9	Resolution 3.9	Resolution 3.9	Resolution 3.9
	Comp 3.10	Concern 3.10	Green	Resolution 3.10	Resolution 3.10	Resolution 3.10	Resolution 3.10	Resolution 3.10	Resolution 3.10



## Agenda reminder

---

- Who are BNP Paribas?
  
- What is Market Risk?
  
- What are the architectural concerns of Market Risk at BNPP?
  
- **In-depth look at the data loading architecture**
  - MRX & Data
  - The legacy
  - Re-Architecture
  - Tomorrow...





## Data Loading in MRX

---

MRX is a transversal system.

### ■ Data Complexity

- Consolidate Risks from more than 40 systems
- Many different formats
- Diversity of data

### ■ Data Volume

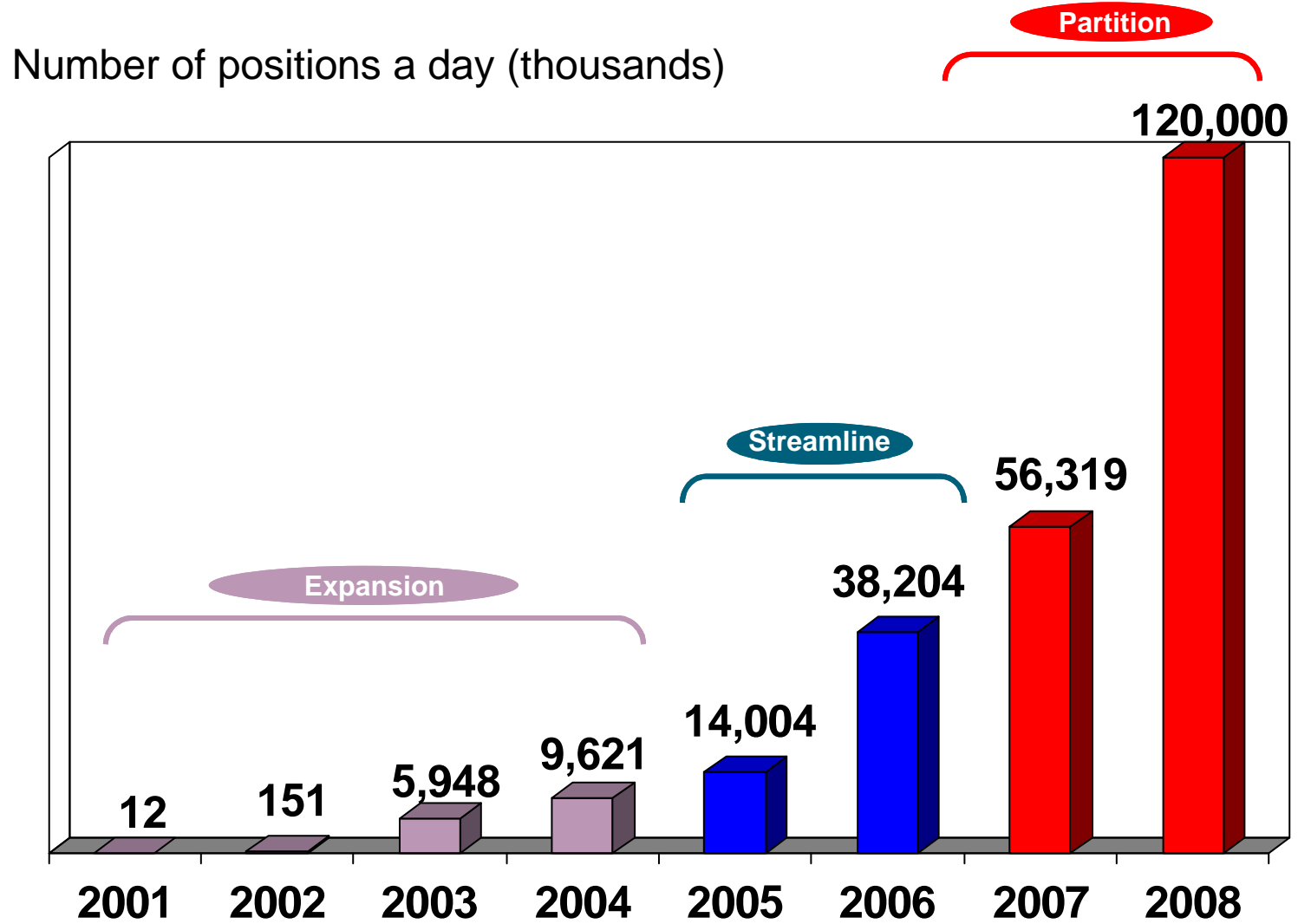
- 15,000 files received per day
- 80 GB input data processed per day

### ■ Derived Data

- Stress, limits, VaR...
- Complex flow of data and events



# Exploding data volumes





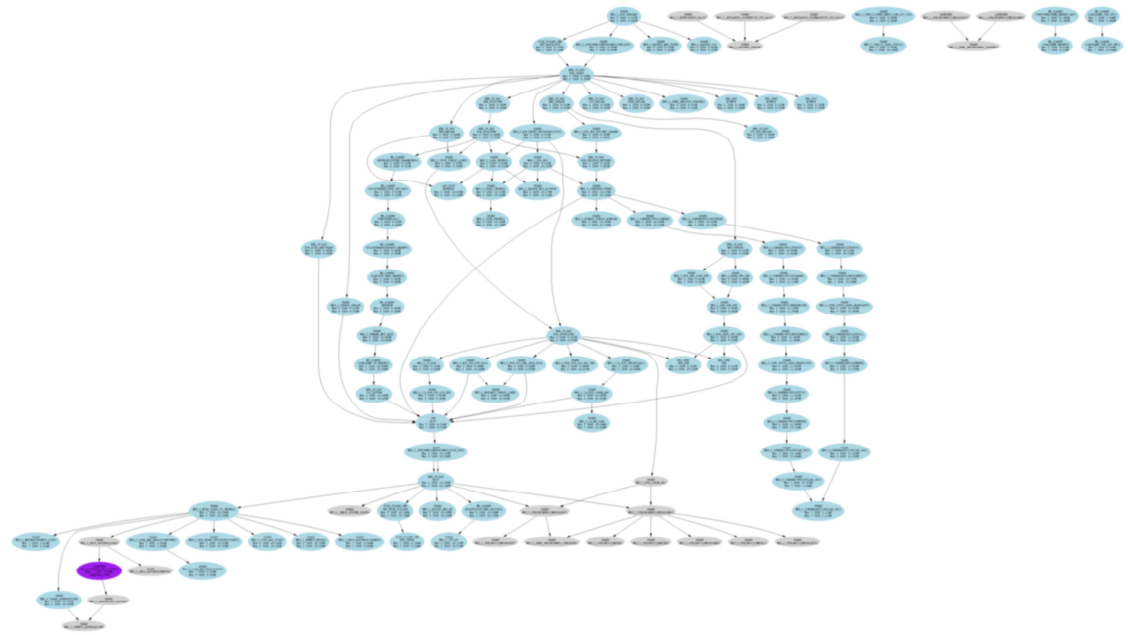
# Batch Processing

## ■ What is a batch

- Job
- Dependency
- Scheduling

## ■ Architectural concerns

- Granularity of the batch
- Resource Availability
- Critical path
- Data is only available at the end of the batch





## Event Driven Processing

---

A *continual* batch is the key to MRX success

- Explosion of feeds in the last 3 years
- Flow of data and events
- Dynamic dependencies (Data driven)
- Why it matters, key factors
  - Continuous feed of data
  - Get data at an early stage
  - Spread the load during the day
  - Finer grained system
  - More resilient to upstream feed issues



# Continual Batch – 11pm GMT

<b>Vanilla</b> Current: 69,106,899.52 Current: 69,106,899.52		<b>Vanilla</b> Current: 55,241,826.11 Current: 55,241,826.11		<b>Vanilla</b> Current: 51,441,576.57 Current: 51,441,576.57		<b>Convex Forward FX Option (CVXOP)</b> Current: -54,437,143.73 Current: -54,437,143.73		<b>Convex Forward FX Option (CVXOP)</b> Current: -4,669,302.48 Current: -4,669,302.48		<b>Swaption (OS)</b> 25,871,624.44 25,871,624.44		<b>Swaption (OS)</b> 23,660,030.32 23,660,030.32	
<b>Vanilla</b> 40,473,896.80 40,473,896.80		<b>Vanilla</b> Current: 37,546,970.31 Current: 37,546,970.31		<b>Vanilla</b> 31,585,515.17 31,585,515.17		<b>Vanilla</b> 31,422,643.96 31,422,643.96		<b>Convex Forward FX Option (CVXOP)</b> 24,611,144.41 23,611,144.41		<b>Convex Forward FX Option (CVXOP)</b> 19,254,016.88 19,254,016.88		<b>Convex Forward FX Option (CVXOP)</b> 16,619,706.50 16,619,706.50	
<b>Vanilla</b> 37,718,148.50 37,718,148.50		<b>Vanilla</b> Current: 37,135,763.52 Current: 37,135,763.52		<b>Vanilla</b> 23,876,588.75 23,876,588.75		<b>Vanilla</b> 23,876,588.75 23,876,588.75		<b>Vanilla</b> -18,351,452.46 -18,351,452.46		<b>Swap (SW)</b> Current: -41,083,838.81 Current: 41,083,838.81		<b>Swap (SW)</b> 17,291,389.63 17,291,389.63	
<b>Vanilla</b> 37,718,148.50 37,718,148.50		<b>Vanilla</b> Current: 35,330,249.40 Current: 35,330,249.40		<b>Vanilla</b> 22,759,268.77 22,759,268.77		<b>Vanilla</b> -8,155,652.28 -8,155,652.28		<b>Swap (SW)</b> 15,271,546.80 15,271,546.80		<b>Swap (SW)</b> -8,653,028.44 -8,653,028.44		<b>Cap-Floor (CF)</b> Current: 29,005,866.29 Current: 29,005,866.29	
<b>Yield Curve Option (SPYCO)</b> Current: 57,182,826.78 Current: 57,182,826.78		<b>Yield Curve Option (SPYCO)</b> Current: 49,043,730.85 Current: 49,043,730.85		<b>Yield Curve Option (SPYCO)</b> -41,186,136.81 -41,186,136.81		<b>Swap (SW)</b> Current: 17,305,071.35 Current: 17,305,071.35		<b>Swap (SW)</b> 11,873,090.09 11,873,090.09		<b>Swap (SW)</b> 6,747,022.82 6,747,022.82		<b>Cap-Floor (CF)</b> 5,018,061.18 5,018,061.18	
<b>Yield Curve Option (SPYCO)</b> Current: 56,469,905.21 Current: 56,469,905.21		<b>Yield Curve Option (SPYCO)</b> 27,053,821.92 27,053,821.92		<b>Yield Curve Option (SPYCO)</b> 22,444,444.44 22,444,444.44		<b>Yield Curve Option (SPYCO)</b> 20,911,297.14 20,911,297.14		<b>Yield Curve Option (SPYCO)</b> 19,378,148.50 19,378,148.50		<b>Yield Curve Option (SPYCO)</b> 17,845,000.00 17,845,000.00		<b>Yield Curve Option (SPYCO)</b> 16,311,851.52 16,311,851.52	
<b>Yield Curve Option (SPYCO)</b> Current: 52,672,112.46 Current: 52,672,112.46		<b>Yield Curve Option (SPYCO)</b> 26,776,394.02 26,776,394.02		<b>Yield Curve Option (SPYCO)</b> 25,243,245.58 25,243,245.58		<b>Yield Curve Option (SPYCO)</b> 23,710,097.14 23,710,097.14		<b>Yield Curve Option (SPYCO)</b> 22,176,948.70 22,176,948.70		<b>Yield Curve Option (SPYCO)</b> 20,643,800.26 20,643,800.26		<b>Yield Curve Option (SPYCO)</b> 19,110,651.82 19,110,651.82	



# Continual Batch – 4am GMT

<b>Vanilla</b> Current: 69,106,899.52 Current: 69,106,899.52		<b>Vanilla</b> Current: 55,241,826.11 Current: 55,241,826.11		<b>Vanilla</b> Current: 51,441,976.57 Current: 51,441,976.57		<b>Convex Forward FX Option (CVXOP)</b> Current: 54,437,143.73 Current: 54,437,143.73		<b>Convex Forward FX Option (CVXOP)</b> Current: 44,809,442.44 Current: 44,809,442.44		<b>Swaption (OS)</b> Current: 25,871,624.44 Current: 25,871,624.44		<b>Swaption (OS)</b> Current: 23,660,030.32 Current: 23,660,030.32					
<b>Vanilla</b> Current: 40,473,896.80 Current: 40,473,896.80		<b>Vanilla</b> Current: 37,546,970.31 Current: 37,546,970.31		<b>Vanilla</b> Current: 31,585,515.17 Current: 31,585,515.17		<b>Vanilla</b> Current: 31,422,643.96 Current: 31,422,643.96		<b>Convex Forward FX Option (CVXOP)</b> Current: 18,200,000.00 Current: 18,200,000.00		<b>Convex Forward FX Option (CVXOP)</b> Current: 18,200,000.00 Current: 18,200,000.00		<b>Swaption (OS)</b> Current: 11,262,882.17 Current: 11,262,882.17		<b>Swaption (OS)</b> Current: 10,368,345.89 Current: 10,368,345.89		<b>Swaption (OS)</b> Current: 8,862,776.17 Current: 8,862,776.17	
<b>Vanilla</b> Current: 37,718,148.50 Current: 37,718,148.50		<b>Vanilla</b> Current: 37,135,763.52 Current: 37,135,763.52		<b>Vanilla</b> Current: 23,876,588.75 Current: 23,876,588.75		<b>Vanilla</b> Current: 23,876,588.75 Current: 23,876,588.75		<b>Swap (SW)</b> Current: 17,291,389.63 Current: 17,291,389.63		<b>Swap (SW)</b> Current: 17,291,389.63 Current: 17,291,389.63		<b>Swap (SW)</b> Current: -16,177,293.15 Current: -16,177,293.15		<b>Cap-Floor (CF)</b> Current: 29,005,866.29 Current: 29,005,866.29		<b>Cap-Floor (CF)</b> Current: 29,005,866.29 Current: 29,005,866.29	
<b>Vanilla</b> Current: 35,330,249.40 Current: 35,330,249.40		<b>Vanilla</b> Current: 22,759,268.77 Current: 22,759,268.77		<b>Vanilla</b> Current: 22,759,268.77 Current: 22,759,268.77		<b>Vanilla</b> Current: -18,301,402.46 Current: -18,301,402.46		<b>Swap (SW)</b> Current: 15,271,546.80 Current: 15,271,546.80		<b>Swap (SW)</b> Current: 15,271,546.80 Current: 15,271,546.80		<b>Cap-Floor (CF)</b> Current: 7,557,622.77 Current: 7,557,622.77		<b>Cap-Floor (CF)</b> Current: 6,747,622.82 Current: 6,747,622.82		<b>Cap-Floor (CF)</b> Current: 6,747,622.82 Current: 6,747,622.82	
<b>Yield Curve Option (SPYCO)</b> Current: 57,182,826.78 Current: 57,182,826.78		<b>Yield Curve Option (SPYCO)</b> Current: 49,043,730.65 Current: 49,043,730.65		<b>Yield Curve Option (SPYCO)</b> Current: 41,186,130.61 Current: 41,186,130.61		<b>Yield Curve Option (SPYCO)</b> Current: 41,186,130.61 Current: 41,186,130.61		<b>Swap (SW)</b> Current: 11,873,090.09 Current: 11,873,090.09		<b>Swap (SW)</b> Current: 11,873,090.09 Current: 11,873,090.09		<b>Swap (SW)</b> Current: 11,873,090.09 Current: 11,873,090.09		<b>Cap-Floor (CF)</b> Current: 6,747,622.82 Current: 6,747,622.82		<b>Cap-Floor (CF)</b> Current: 6,747,622.82 Current: 6,747,622.82	
<b>Yield Curve Option (SPYCO)</b> Current: 56,469,905.21 Current: 56,469,905.21		<b>Yield Curve Option (SPYCO)</b> Current: 27,052,921.59 Current: 27,052,921.59		<b>Yield Curve Option (SPYCO)</b> Current: 20,444,342.36 Current: 20,444,342.36		<b>Yield Curve Option (SPYCO)</b> Current: 20,444,342.36 Current: 20,444,342.36		<b>Yield Curve Option (SPYCO)</b> Current: 20,444,342.36 Current: 20,444,342.36		<b>Yield Curve Option (SPYCO)</b> Current: 20,444,342.36 Current: 20,444,342.36		<b>Yield Curve Option (SPYCO)</b> Current: 20,444,342.36 Current: 20,444,342.36		<b>Yield Curve Option (SPYCO)</b> Current: 20,444,342.36 Current: 20,444,342.36		<b>Yield Curve Option (SPYCO)</b> Current: 20,444,342.36 Current: 20,444,342.36	
<b>Yield Curve Option (SPYCO)</b> Current: 52,672,112.46 Current: 52,672,112.46		<b>Yield Curve Option (SPYCO)</b> Current: 28,776,894.07 Current: 28,776,894.07		<b>Yield Curve Option (SPYCO)</b> Current: 15,848,212.70 Current: 15,848,212.70		<b>Yield Curve Option (SPYCO)</b> Current: 15,848,212.70 Current: 15,848,212.70		<b>Yield Curve Option (SPYCO)</b> Current: 15,848,212.70 Current: 15,848,212.70		<b>Yield Curve Option (SPYCO)</b> Current: 15,848,212.70 Current: 15,848,212.70		<b>Yield Curve Option (SPYCO)</b> Current: 15,848,212.70 Current: 15,848,212.70		<b>Yield Curve Option (SPYCO)</b> Current: 15,848,212.70 Current: 15,848,212.70		<b>Yield Curve Option (SPYCO)</b> Current: 15,848,212.70 Current: 15,848,212.70	





# Continual Batch – 3pm GMT

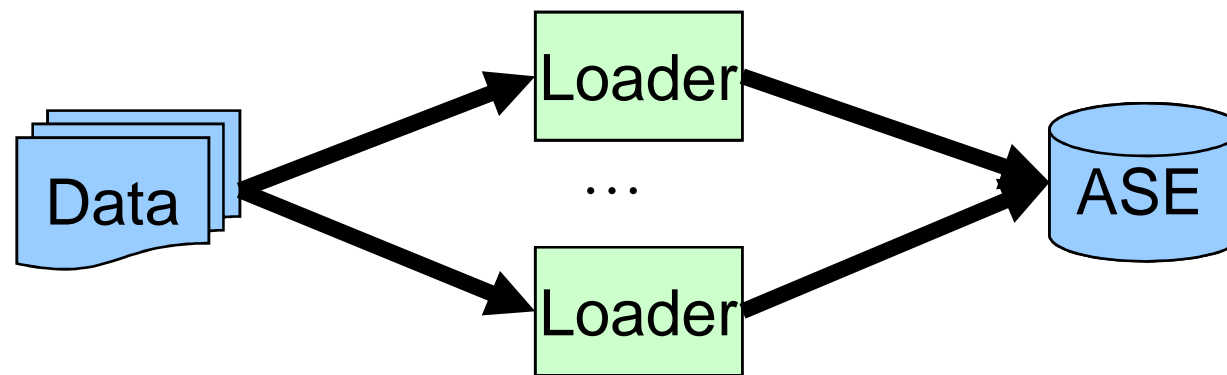
<b>Vanilla</b> Current: 59,106,899.52 Current: 59,106,899.52	<b>Vanilla</b> Current: 55,241,826.11 Current: 55,241,826.11	<b>Vanilla</b> Current: 51,441,976.57 Current: 51,441,976.57	<b>Convex Forward FX Option (CVXOP)</b> Current: 54,437,143.73 Current: 54,437,143.73	<b>Convex Forward FX Option (CVXOP)</b> Current: 55,000,442.49 Current: 55,000,442.49	<b>Swaption (OS)</b> Current: 25,871,624.44 Current: 25,871,624.44	<b>Swaption (OS)</b> Current: 23,660,030.32 Current: 23,660,030.32			
<b>Vanilla</b> Current: 40,473,896.80 Current: 40,473,896.80	<b>Vanilla</b> Current: 37,546,970.31 Current: 37,546,970.31	<b>Vanilla</b> Current: 31,585,515.17 Current: 31,585,515.17	<b>Vanilla</b> Current: 31,422,643.96 Current: 31,422,643.96	<b>Convex Forward FX Option (CVXOP)</b> Current: 16,204,670.99 Current: 16,204,670.99	<b>Convex Forward FX Option (CVXOP)</b> Current: 16,191,176.00 Current: 16,191,176.00	<b>Swaption (OS)</b> Current: 22,562,930.62 Current: 22,562,930.62	<b>Swaption (OS)</b> Current: 13,610,916.08 Current: 13,610,916.08		
<b>Vanilla</b> Current: 37,718,148.50 Current: 37,718,148.50	<b>Vanilla</b> Current: 37,135,763.52 Current: 37,135,763.52	<b>Vanilla</b> Current: 23,876,588.75 Current: 23,876,588.75	<b>Vanilla</b> Current: 23,876,588.75 Current: 23,876,588.75	<b>Vanilla</b> Current: 18,301,462.46 Current: 18,301,462.46	<b>Swap (SW)</b> Current: 17,291,389.63 Current: 17,291,389.63	<b>Swap (SW)</b> Current: 17,291,389.63 Current: 17,291,389.63	<b>Swap (SW)</b> Current: -16,177,293.15 Current: -16,177,293.15	<b>Cap-Floor (CF)</b> Current: 29,005,866.29 Current: 29,005,866.29	<b>Cap-Floor (CF)</b> Current: 10,124,430.70 Current: 10,124,430.70
<b>Yield Curve Option (SPYCO)</b> Current: 57,182,826.78 Current: 57,182,826.78	<b>Yield Curve Option (SPYCO)</b> Current: 49,043,730.85 Current: 49,043,730.85	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Swap (SW)</b> Current: 17,305,071.35 Current: 17,305,071.35	<b>Swap (SW)</b> Current: 11,873,090.09 Current: 11,873,090.09	<b>Swap (SW)</b> Current: 15,271,546.80 Current: 15,271,546.80	<b>Swap (SW)</b> Current: -8,653,698.44 Current: -8,653,698.44	<b>Cap-Floor (CF)</b> Current: 6,747,622.82 Current: 6,747,622.82	<b>Cap-Floor (CF)</b> Current: 6,747,622.82 Current: 6,747,622.82
<b>Yield Curve Option (SPYCO)</b> Current: 56,469,905.21 Current: 56,469,905.21	<b>Yield Curve Option (SPYCO)</b> Current: 49,043,730.85 Current: 49,043,730.85	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91
<b>Yield Curve Option (SPYCO)</b> Current: 52,672,112.46 Current: 52,672,112.46	<b>Yield Curve Option (SPYCO)</b> Current: 49,043,730.85 Current: 49,043,730.85	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91	<b>Yield Curve Option (SPYCO)</b> Current: 41,106,130.91 Current: 41,106,130.91





## Data Loading – The Legacy

- Loader transforms, maps and loads data
  - Configurability, Usability, Availability...what else?



- Architecture concerns
  - Mostly C++ and C (highly skilled developers)
  - Data centric
  - In-house libraries (addressing infrastructure issues)
  - Monolithic approach – (years of) over engineered software
  - Perform poorly (do-it all approach), un-scalable (DB contention)...



## Paradigm Shift

---

### ■ Process

- Streamline processing – break the complexity
- Staged the loading process
- Offload the Database

### ■ Event Flow

- Message event driven processing

### ■ Data

- Move data close to processing
- Hand on data from one processing stage to the next without going via the database
- Data caching



## Data Architecture

---

- Sybase ASE, Transactional Database
  - Feed configuration,
  - Reference data,
  - System status...
  
- Sybase IQ, Database Warehouse
  - Static Data,
  - Market Data,
  - Risk Data,
  - Stress, VaR...



## Data Architecture - Sybase IQ

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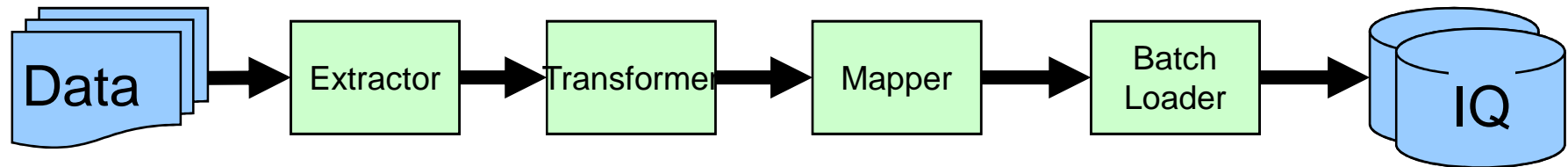
- What is Sybase IQ?
  - Storage Saving/Compression – less I/O, less disk, more CPU, more memory
  - Performance - store data per column – one writer
  - Table Versioning
  - Reduced Maintenance Costs
  - Scalability – Multiplex IQ, workload is shared between multiple servers
  
- How MRX uses it
  - Channel data through files whenever possible
  - Very fast batch load – ideal for large volume of data
  - De-normalised data model
  - Use Indices
  - Event Driven Processing – continuously update the Database



## Data Loading – New Architecture

- Staged Data Loading

- SEDA architecture



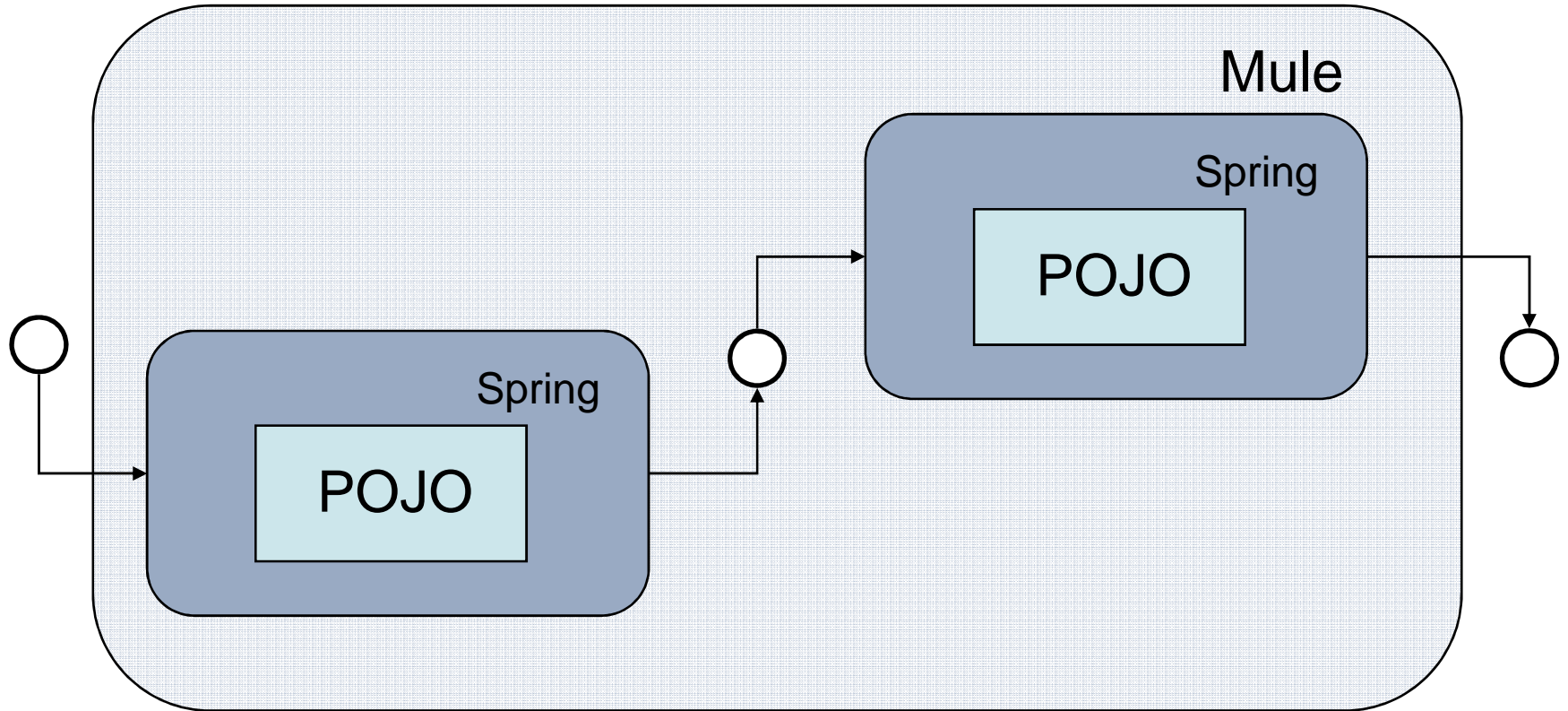
- Technology

- Java + Open Source projects,
- Spring (Components),
- Mule (Integration and assembly),
- ActiveMQ (Messaging)



# Component Assembly

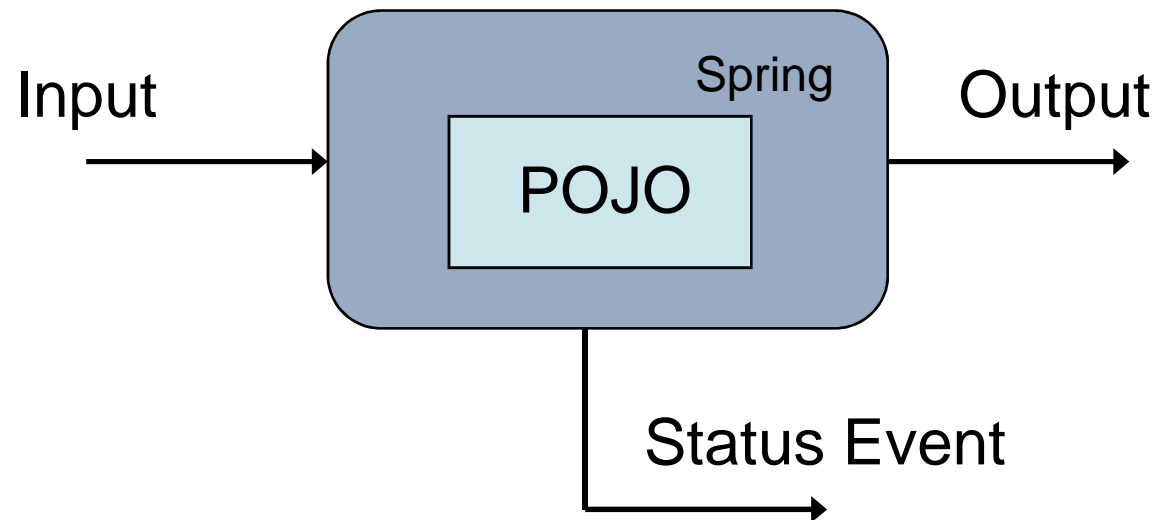
## ■ POJO, Spring and Mule





## Component & Message

- Message Pattern
  - Input, Output, Status
- Status Event
  - FAIL, WARN, REJECT, COMPLETE
  - Event Segregation and Routing



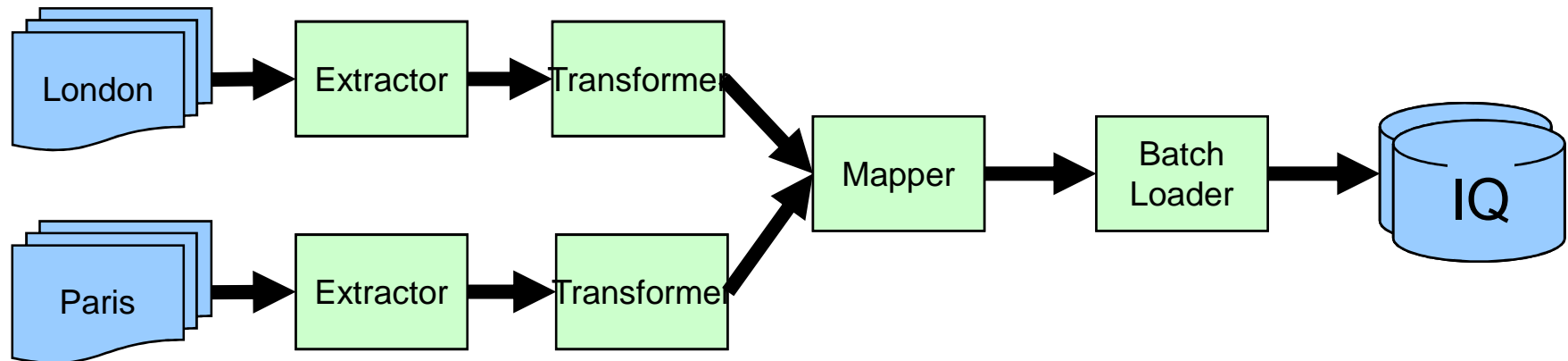




## Data Loading – Partitioning

### ■ Partitioning – Database

- Partitioning per day
- Every day is a new day
- Fast loading, Fast retrieving



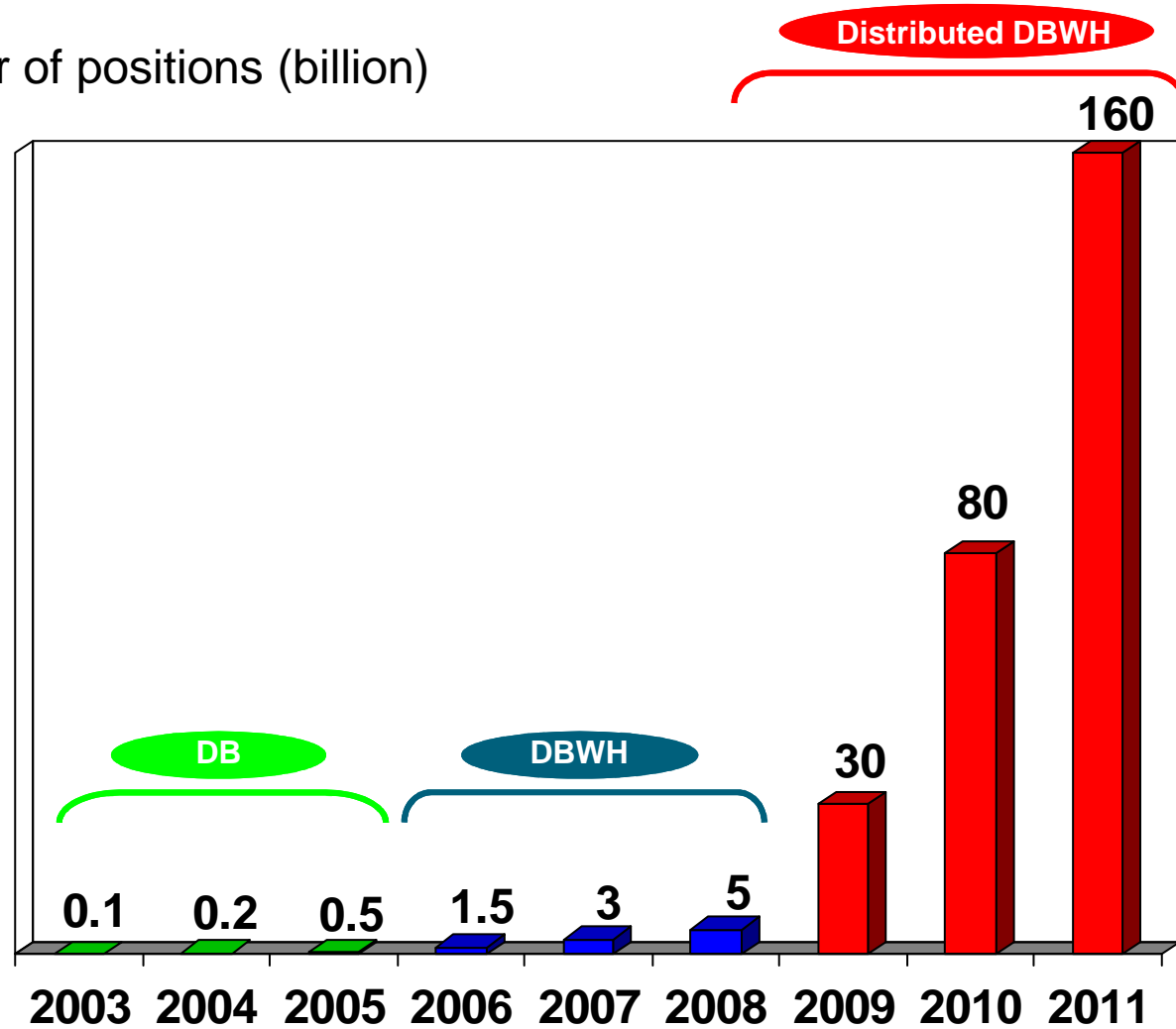
### ■ Partitioning - Process

- Processing data where it is produced,
- Minimize data movement,
- Reduce latency



# Exploding data volumes

Number of positions (billion)





## Very Large Database

---

- A Market Risk Data Warehouse
  - 5 years of positions,
  - Volume increase (consolidation, deal level, organic growth...),
  - Database will grow from 0.6TB to 25TB,
  - Number of positions will grow from 4 billion to 300 billion
  
- Database Architecture
  - Database Storage,
  - File System, Backup system,
  - Network, Fibre Channel,
  - IQ Multiplex



## Summary

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To recap...

### ■ Architecture

- Java & Open Source
- Event driven architecture – Pipelined components
- Re-usable POJO components
- Multiple deployable artefacts

### ■ Message Driven Data Loading

- continuously move data from data sources into Sybase IQ
- Fast, scalable continuous data loads
- Dynamic throttling feature
- Best for large data volumes
- no table locking - Sybase IQ versioning
- users run queries even while Data Warehouse is updating



## Questions

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Thank you!

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