



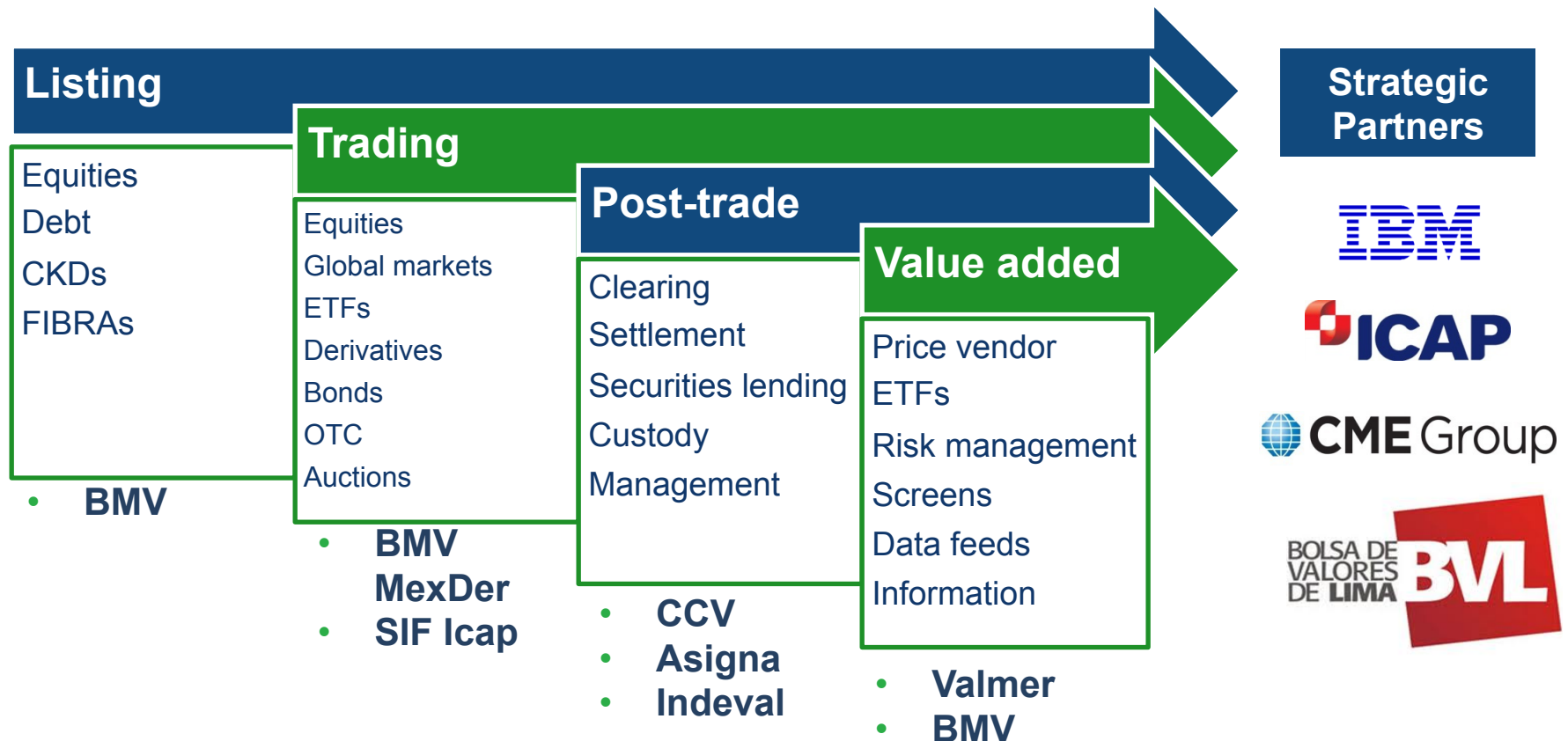
# MoNeT: A Software Initiative to Boost the Mexican Securities Markets

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September 2013

# The BMV Group. A fully integrated Exchange

Bolsa Mexicana de Valores (BMV), operates full service cash and derivatives exchanges, with equities and fixed income securities listings. It offers fully electronic platforms for cash equities, financial derivatives and OTC fixed income and derivatives. Including an order routing agreement with the CME, the largest derivatives exchange in the world. Post trade activities include central counterparts, clearing services and custody.



# Our Strengths

## FULLY INTEGRATED EXCHANGE

### We do:

- Listing
- Trading
- Clearing
- Custody
- Data Sales
- Price Vendor
- Risk Management

## DIVERSIFIED REVENUES

### BMV Group is integrated by 6 different business units:

- Largest business line is only 22% of revenues

## STABLE REVENUE BASE

### 40% of our revenues come from an stable base:

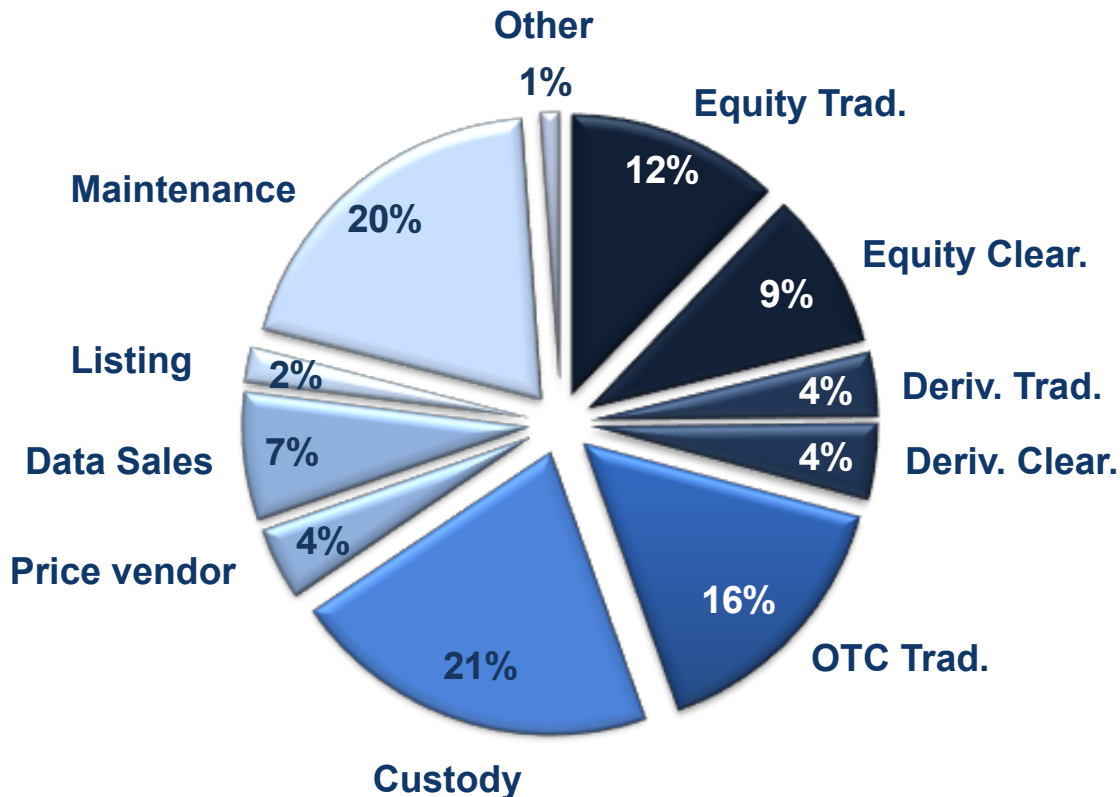
- Maintenance  
✓ 20%
- Custody  
✓ 21%

## ROOM FOR GROWTH

### BMV has growth potential when compared with developed markets:

- Market Cap represents 42% of the GDP
- Share turnover velocity  
✓ 32%

# The BMV Group. A fully integrated Exchange



**1Q13 Revenues**

**528 million**

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**12%**

**CAGR**  
(2008-2012)

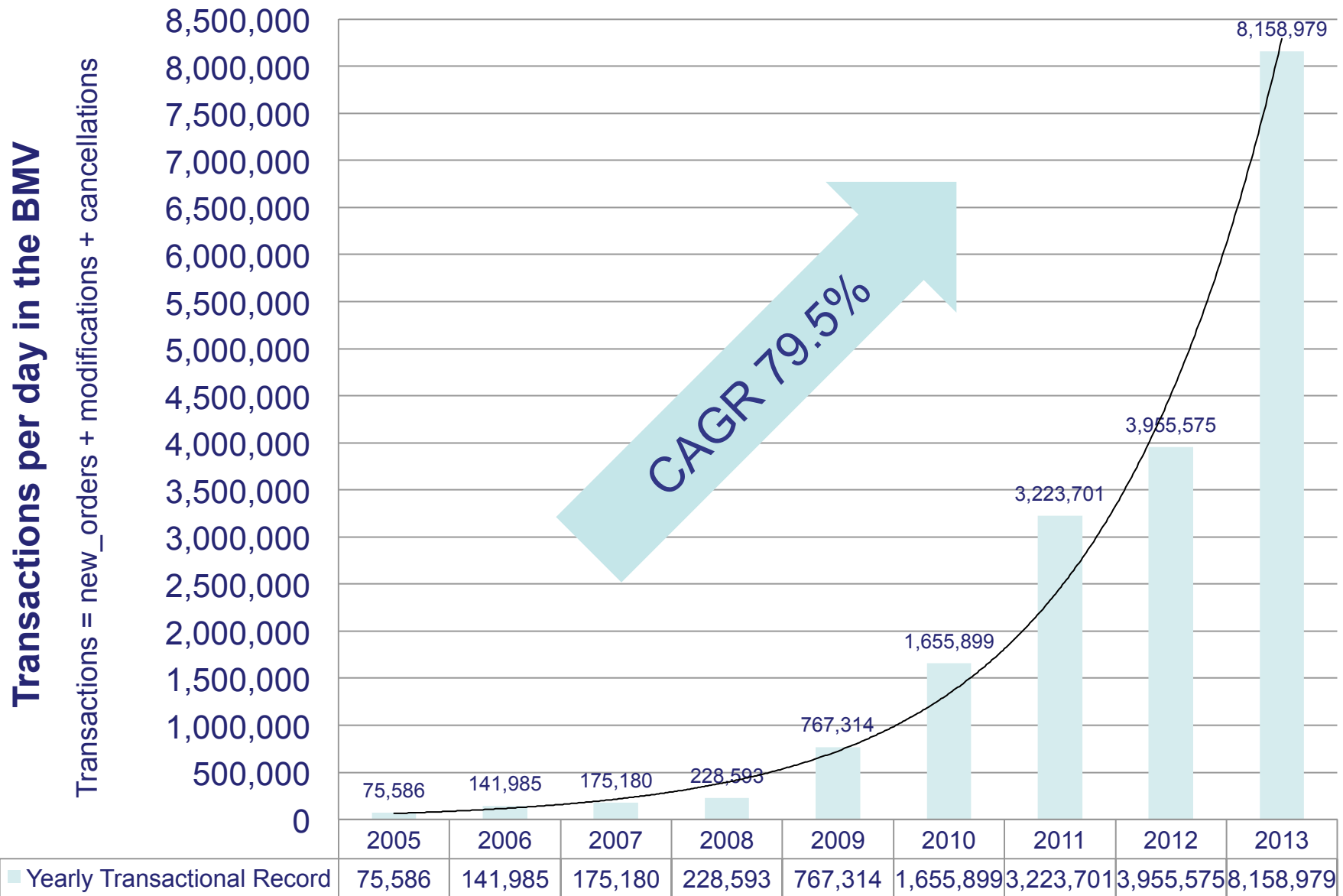
# Background – Cash Market

- The Mexican cash market operated as an open outcry market until 1999, when it became fully electronic using an internally developed system (*Sentra*) based on an HP NonStop platform (Tandem)
- In 2005 Mexican brokers started to adopt the program trading figure and since then the BMV has faced the constant challenge of accommodating an exponential growth of the demand of its transactional services, as well as pressure from the market participants to offer more competitive electronic services, with better performance and functionalities

# Background – Derivatives Market

- The Mexican futures market (MexDer) was created in the year 1998 and started operating as an open outcry market
- In the year 2000 the futures market became fully electronic using an internally developed system (*Sentra Derivados*) based on an HP NonStop platform (Tandem)
- The options market of MexDer was created in the year 2000 and started operating as a fully electronic market, using the trading engine from MEFF (S/Mart), the Spanish derivatives exchange

# Growth of the Demand of Transactional Services – Cash Market



# Background

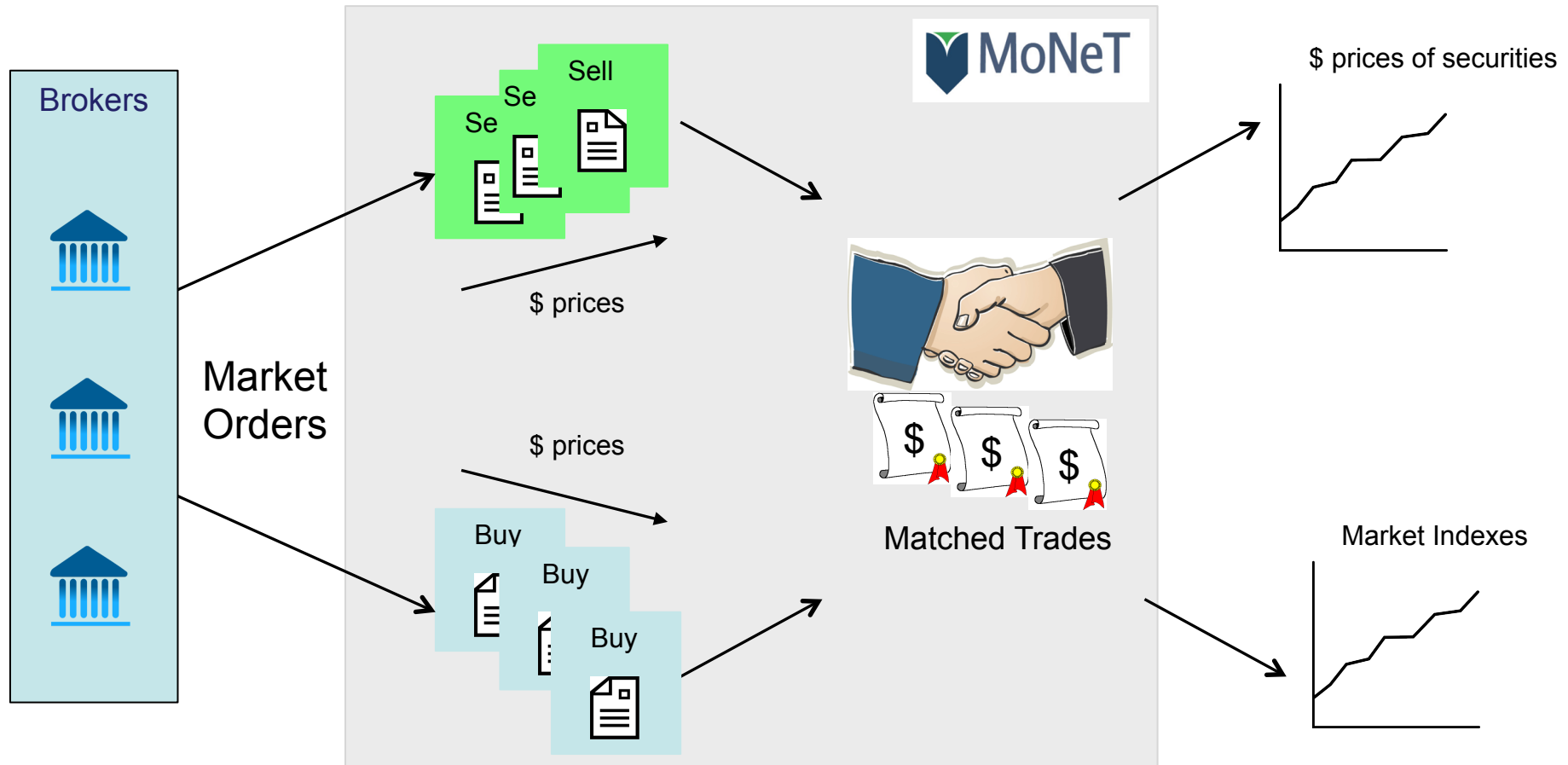
- To respond to the demanding business challenges, the BMV Group executed a broad plan of technological evolution between 2006 and 2013
- The main objectives of this plan were:
  - To provide, as the foundation, a state of the art technological infrastructure that included: a new data center (Tier 4 grade) with a 10G and Infiniband LAN, a new high bandwidth and low latency WAN (up to 100 Mbps), co-location services, latest generation of hardware and software products, etc.
  - To standardize the technological infrastructure across all the companies of the BMV Group in order to reduce maintenance efforts and maximize synergies between companies: common database (Oracle), Web Application Server (JBoss), programming language (Java), software messaging, etc.
  - To replace the major operational systems and components with new software that have much better functionalities and quality attributes: significantly better performance, scalability and continuous availability based on the new standardized technological infrastructure



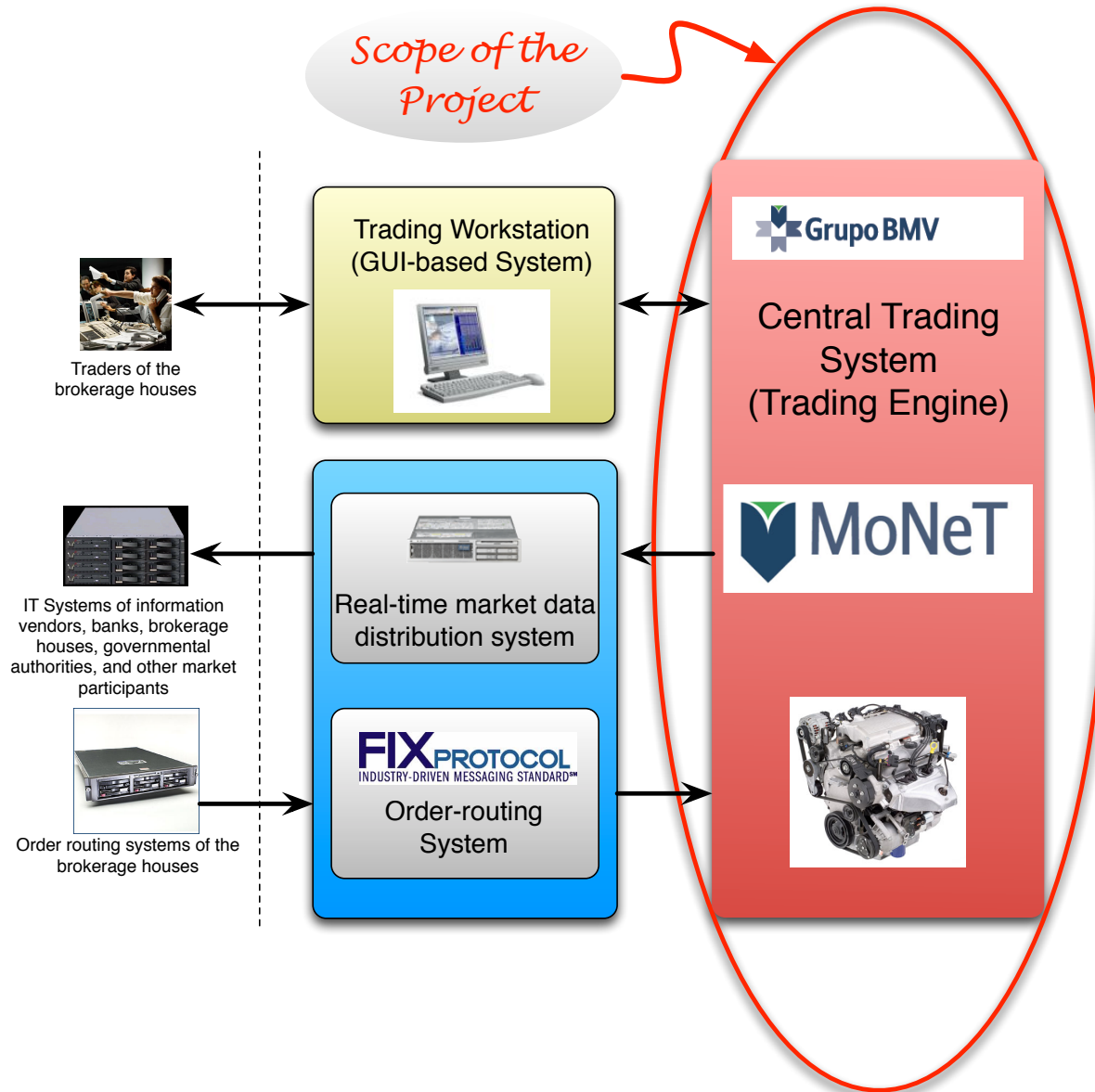
# Background

- One of the most challenging software projects of the technological strategy of the BMV was the replacement of the trading systems for both the cash and derivatives markets (trading engines)
- Trading engines are systems that have very strict and ambitious quality attributes regarding speed (latency), scalability, and continuous availability
- The BMV wanted a single trading engine to replace the three legacy systems that supported the trading function of the cash and derivatives markets
- The BMV had the classic two alternatives: *buy vs build*
- After analyzing the different alternatives considered, it was finally decided in 2009 to build the system internally in the BMV

# The Trading Function



# Trading Infrastructure - Mexican Stock Exchange



# Background

- The development of a multi-market and state-of-the art trading engine represented a very attractive challenge that motivated the technology team of the BMV
- The goals established for the project were:
  - Develop one of the fastest trading engines in the industry
  - Make the system highly scalable and resilient
  - Produce a system with a lower cost of ownership
  - To execute a change management process that would ensure the seamless migration from the legacy system to the new system

# Background

- The adequate design of the system, and an impeccable construction of this design, were key success factors for the project
- The team was committed to the success of the project, and the following partners were selected to help in the execution of the project:
  - Roland Tibell & Associates – consulting for the functional scope and characteristics of the system
  - The Software Engineering Institute of Carnegie Mellon University – Software architecture evaluation and use of the TSP/PSP methodology in the construction of the system
  - IBM – low-latency messaging and continuous availability of the system
  - Sun Java Labs – Consulting on Java language development and runtime behavior

# Design Considerations

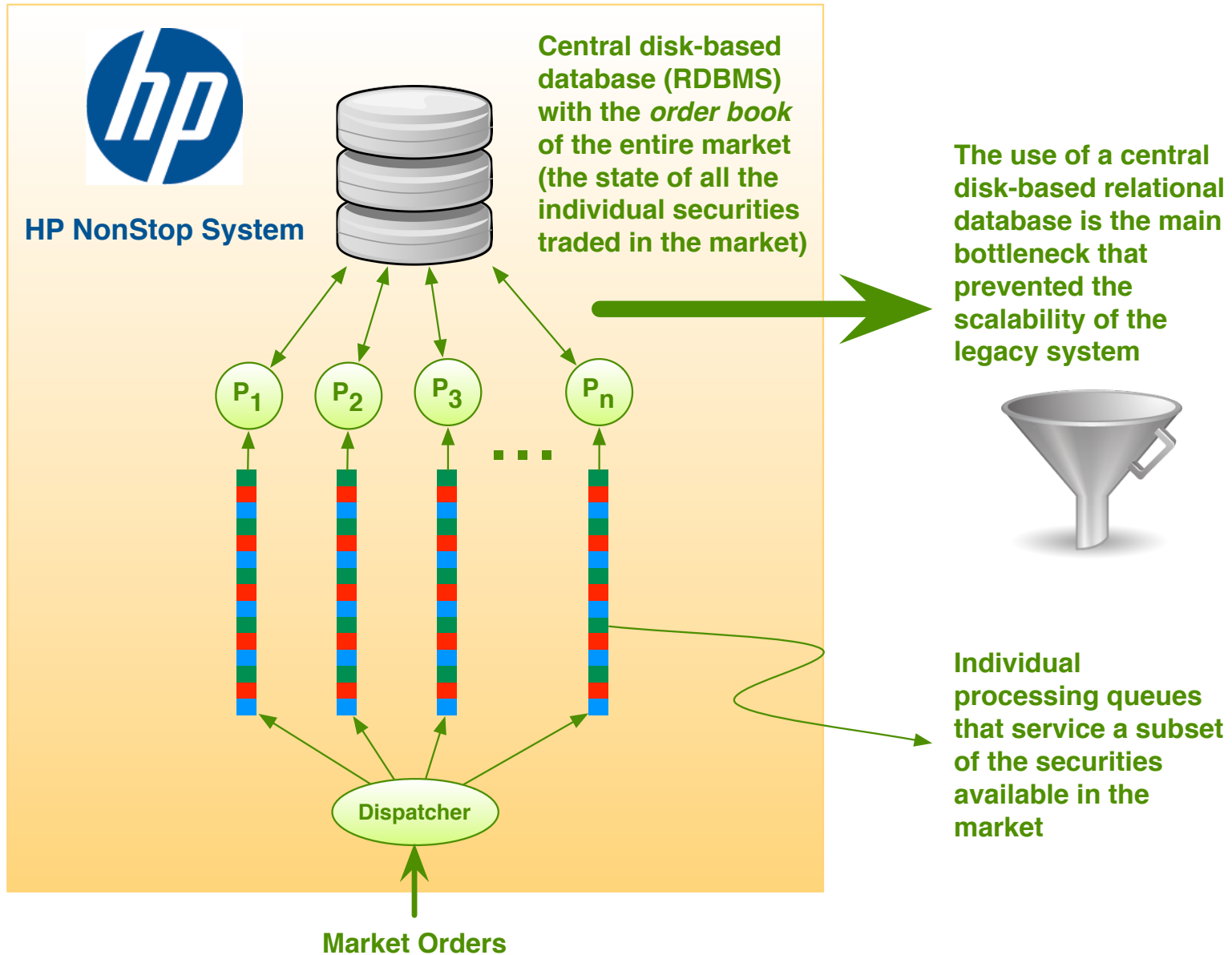
- To achieve the performance intended for the new system it was decided to use an in-memory design approach to maximize the speed of processing
- No mechanical disk drives should intervene in the execution of an online transaction
- The use of in-memory technology marks an inflection point for the design of enterprise applications
- The capacity per dollar and the availability of main memory has increased markedly in the last few years
  - Leading to a rethinking of how mass data should be stored
  - Resulting in an orders-of-magnitude improvement in performance
  - Allowing completely new applications to be developed
- This change in the way data is stored is having a significant impact on enterprise applications

# Design Considerations

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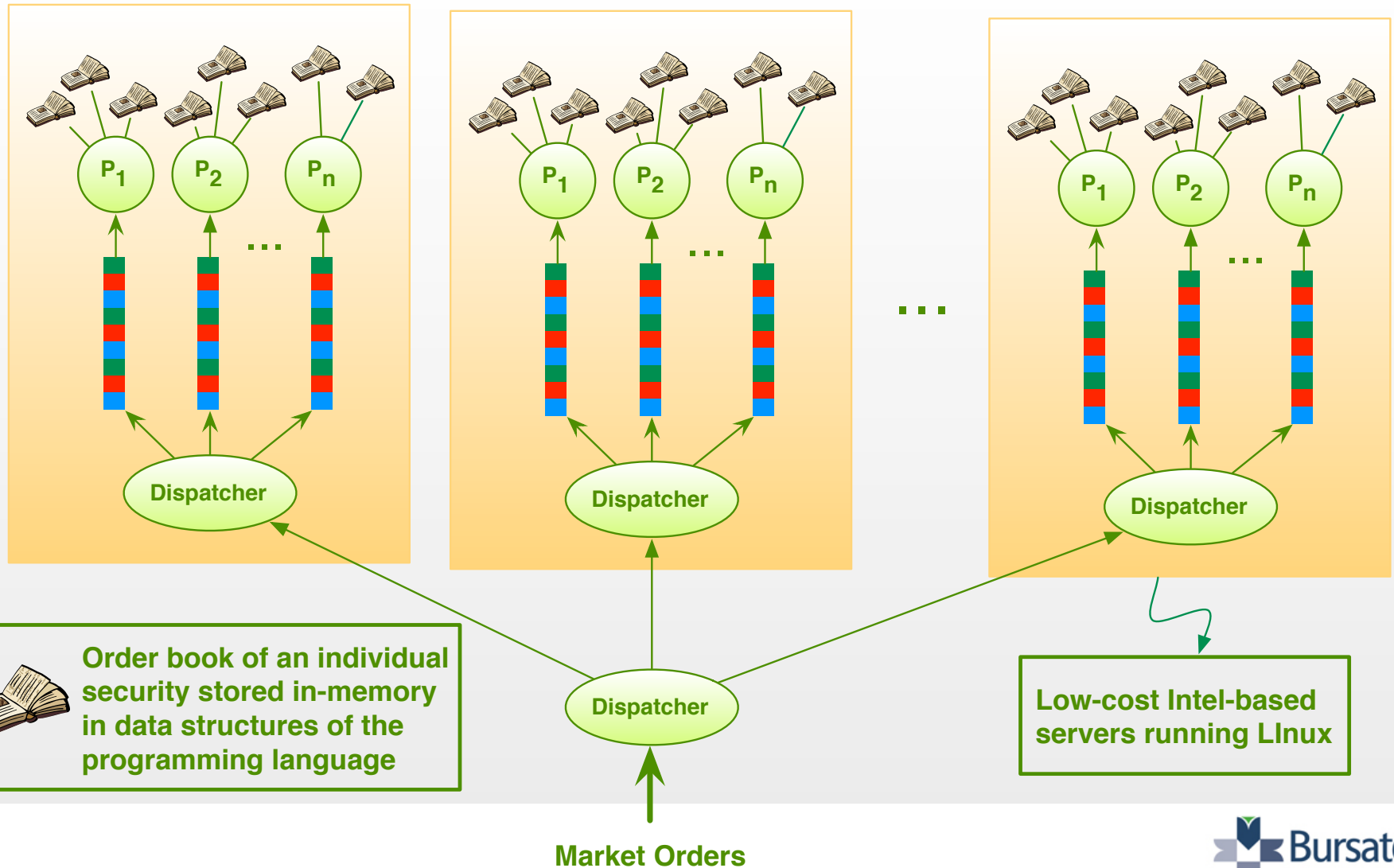
- Speed of execution is maximized with the use of in-memory technology, but that brings challenges for obtaining a design that will guarantee resiliency and continuous availability
- Failure detection and synchronization of backup copies of a running application are complex problems

# Architecture of the Legacy Trading System





# Architecture of MoNeT



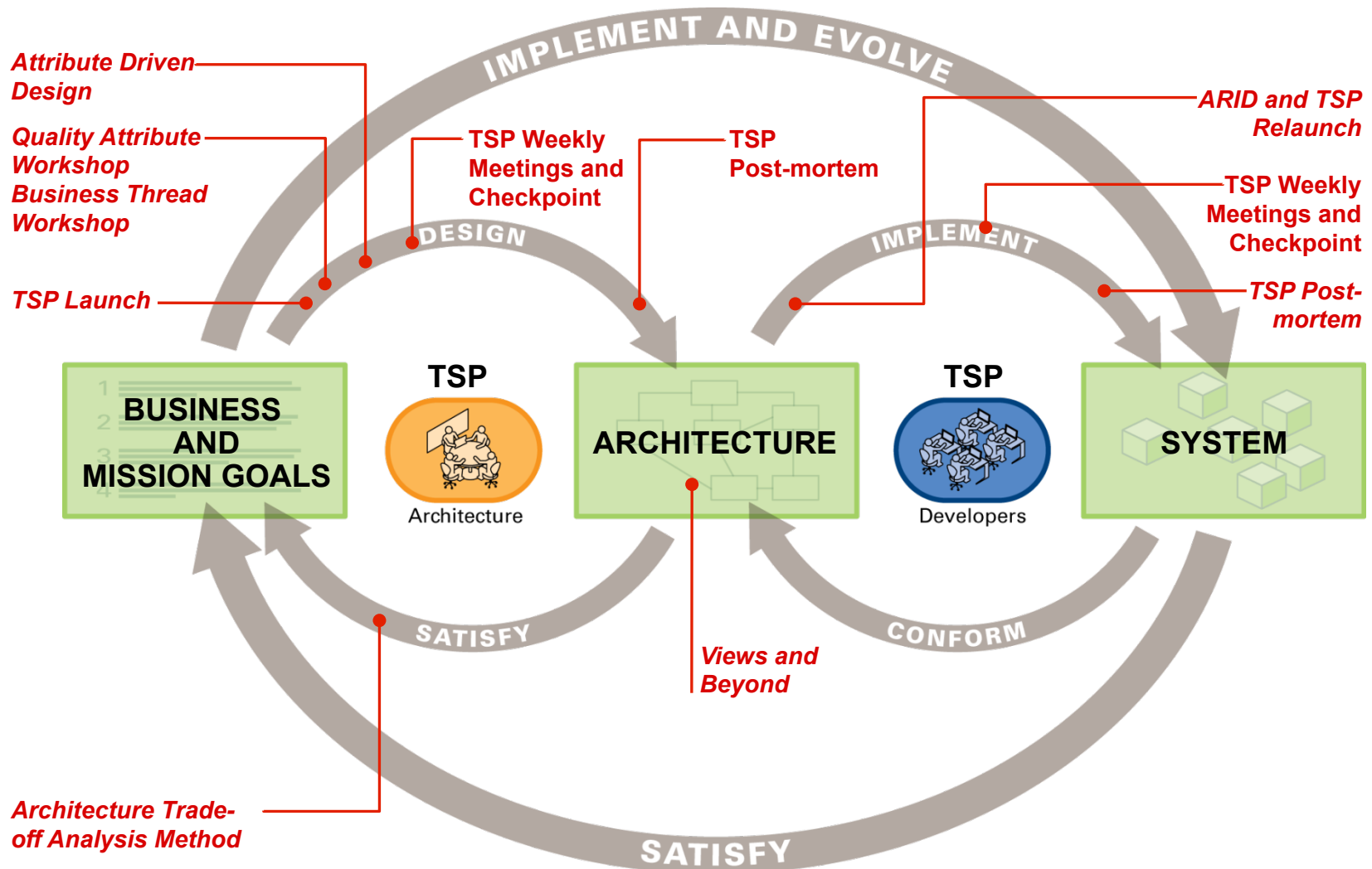
# Emphasis on Quality

- Given the mission-critical nature of the business, quality was a fundamental aspect of the project:
  - Quality of the produced software
  - Quality of the process of migrating from the legacy system to the new system
- An architecture centric engineering (ACE) approach was used, with the help of the SEI of Carnegie Mellon, to ensure that the system was built fulfilling the stakeholder's needs by satisfying its business and quality-attribute goals
- The personal & team software process (PSP/TSP) ensures the development and delivery of the software in increments on time and in high quality
- PSP/TSP promotes quality from the earliest stages of software construction and throughout the software development process

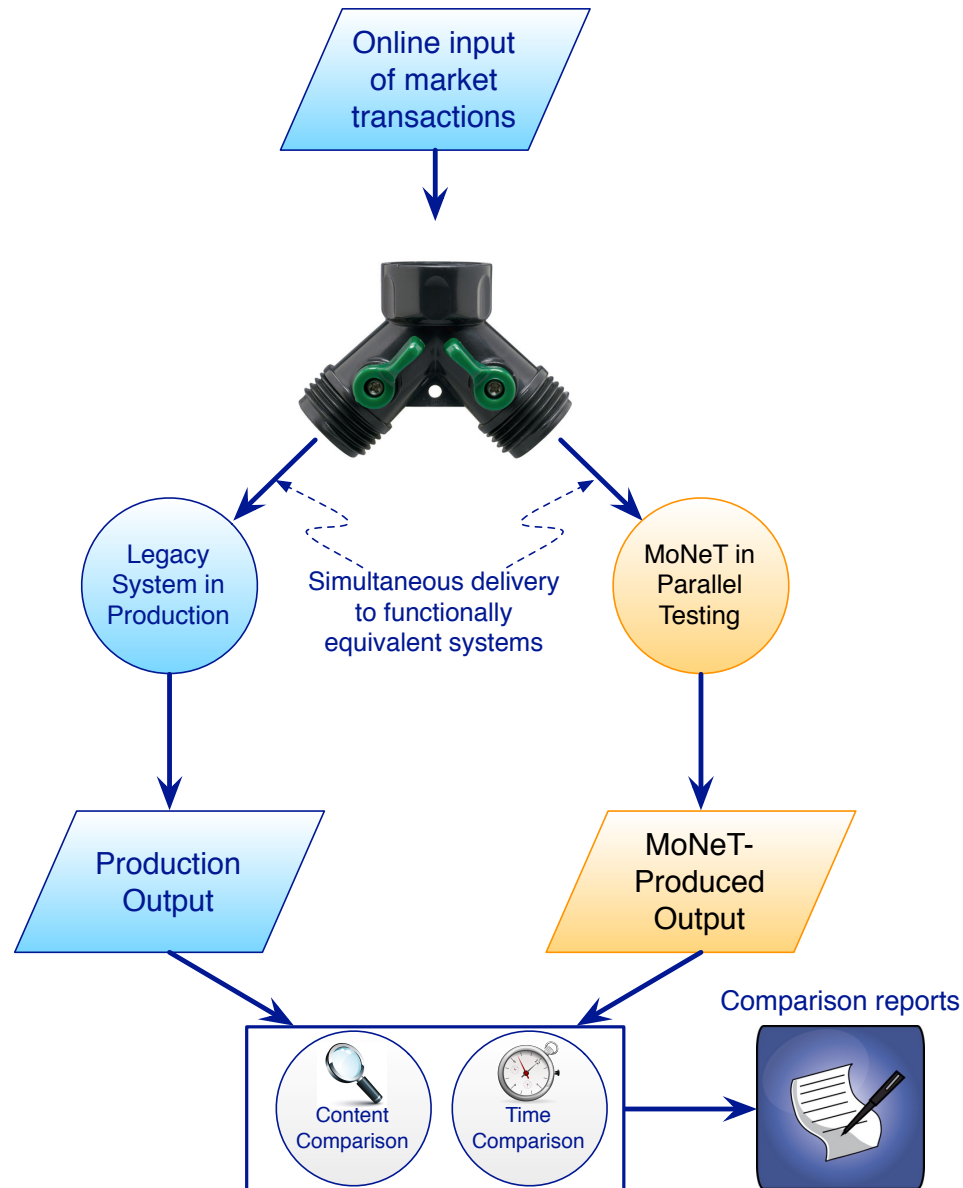
# Emphasis on Quality

- MoNeT was developed combining the approaches of ACE and PSP/TSP to deliver the right product quickly and with high quality
- Multiple strategies of testing were used:
  - Automated tests using a software tool in a continuous integration process
  - A test script executed by internal business users
  - A test script executed by external business users
  - Parallel production execution of MoNeT and comparison of the results produced vs the legacy production system

# ACE / TSP Design, Analysis and Implementation

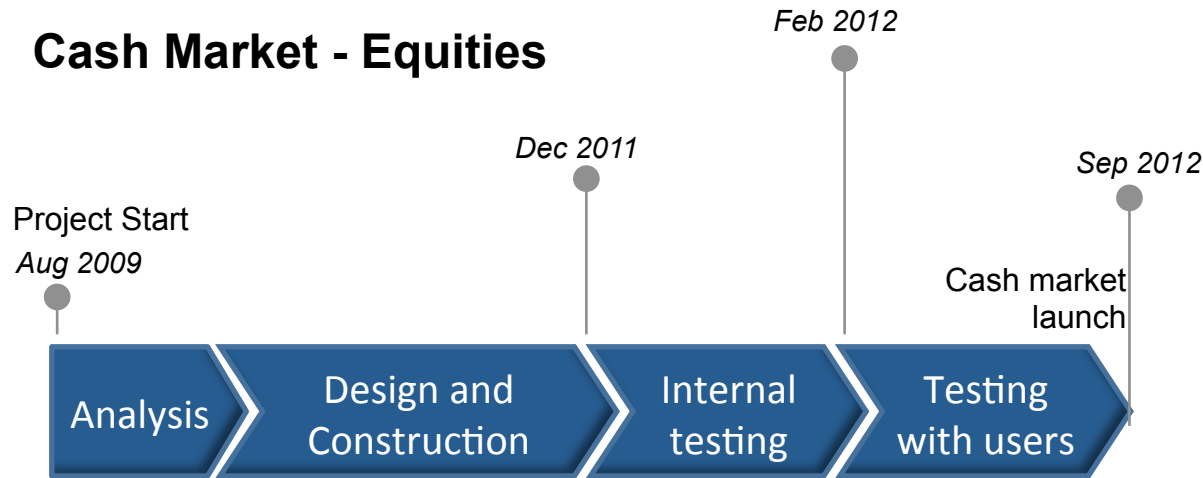


# Parallel Testing of MoNeT vs the Production System

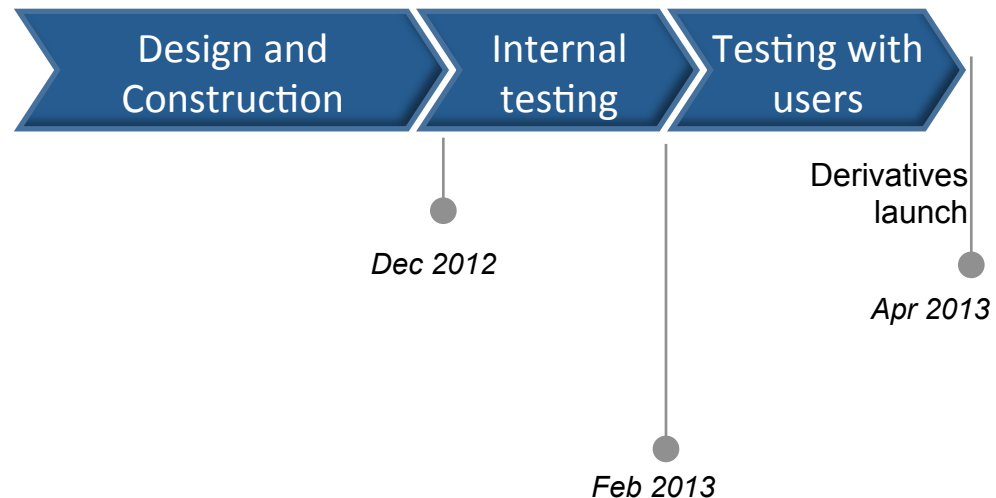


# MoNeT Project Timeline

## Cash Market - Equities



## Derivatives Market

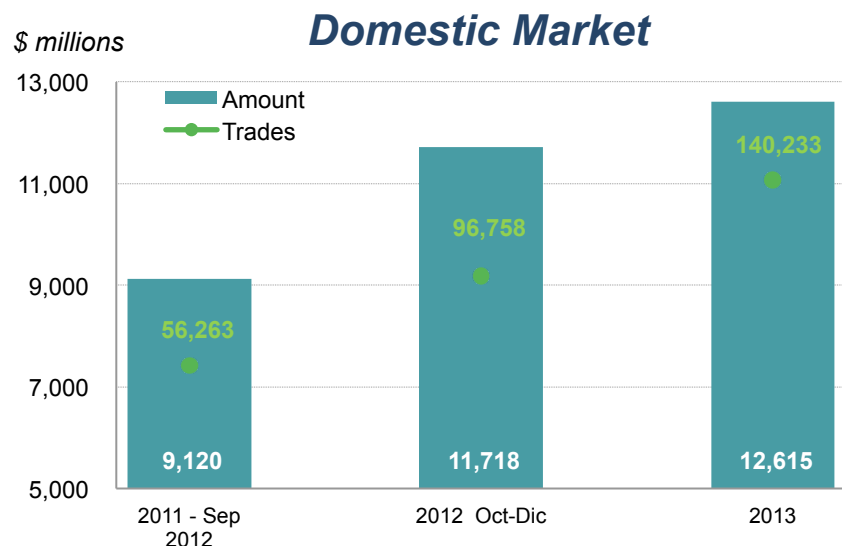


# MoNeT Project Conclusions

- The ACE approach was a success: the architecture designed and reviewed met the quality attributes originally established and has not changed after a year in production
- The quality achieved in the software construction phase was good: in one year of operation the system downtime due to software errors has been of 19 minutes (one failure event), representing an availability of 99.982% in one year
- The software architects were also the software developers
  - This meant that developers had a good understanding of the system architecture and the quality attributes it had to satisfy
  - This helped to ensure that the system construction met the system design and that the business and mission goals were met
- Now that the system is in maintenance mode, we are figuring out the best approach to document and track new requirements

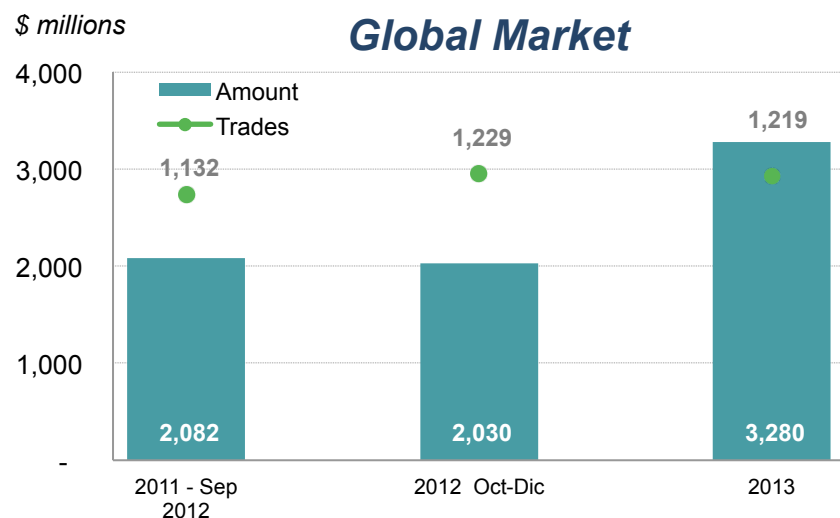
# Trading Behavior change with MoNeT at the BMV

(Daily Average MXP)



Trades

	<i>Domestic</i>	Amount (mdp)	Volume (000)	Trades
A	2011 - 2012 (Jan-Sep)	9,120	315,558	56,263
B	2012 (Oct - Dec)	11,718	364,273	96,758
	Var % B / A	28.49	15.44	71.98
C	2013*	12,615	420,629	140,233
	Var % C / A	38.32	33.30	149.24




Trades

	<i>Global</i>	Amount (mdp)	Volume (000)	Trades
A	2011 - 2012 (Jan-Sep)	2,082	4,337	1,132
B	2012 (Oct - Dec)	2,030	3,722	1,229
	Var % B / A	-2.50	-14.18	71.98
C	2013*	3,280	8,123	1,219
	Var % C / A	57.56	87.30	7.66

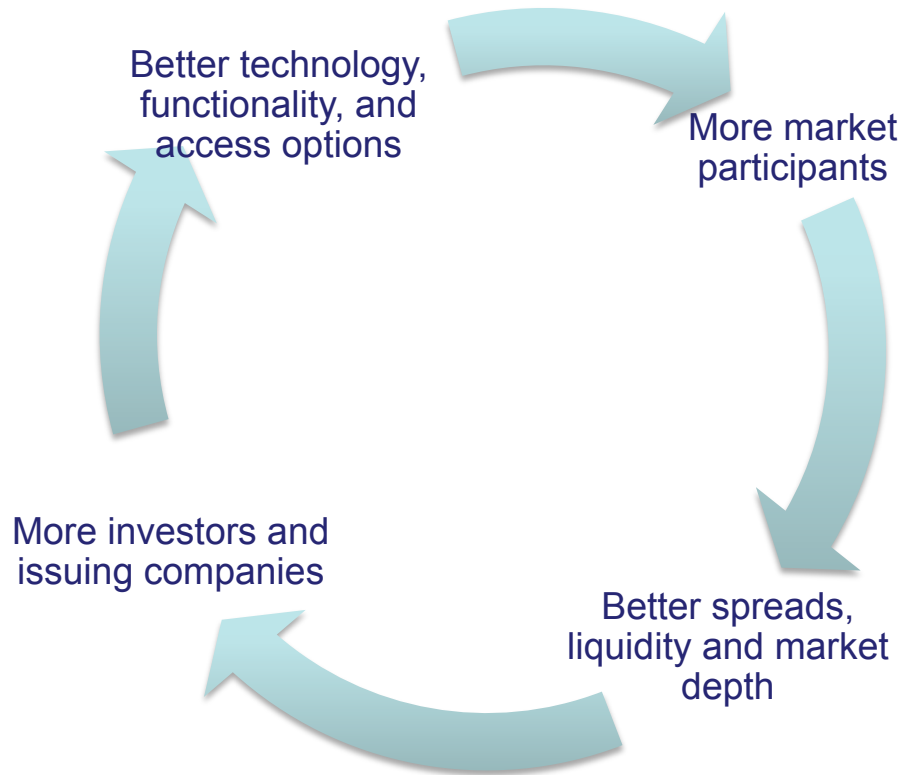
\* Figures as of second quarter 2013



# Comparison of Trading Engines

	Legacy Trading System (Sentra)	
<b>Language</b>	Cobol / C	Java (1.6)
<b>Hardware</b>	HP NonStop (Tandem)	Intel-based servers, or any other hardware platform with a Java-capable operating system
<b>Operating System (O.S.)</b>	Tandem	Linux (can be ported easily to other OS)
<b>Architecture</b>	1 instance / cold backup. Vertical scaling (same box)	1 instance with hot backup, horizontal scaling (many possible instances)
<b>Processing threads</b>	9 automatically balanced depending on trading traffic, allows manual configuration	9 automatically balanced depending on trading traffic, allows manual configuration. Allows up to one thread per CPU-core
<b>Message processing time in Matching Engine</b>	Between 24 and 60 milliseconds	Under 100 microsecond average (between 240 and 600 times faster)
<b>Message capacity (throughput)</b>	230 per second	100,000 per second per current server architecture (with horizontal scaling)
<b>Messages per second, average in production</b>	100	450
<b>Pre-trade Risk filters</b>	N/A	Volume and price

# Business Impact of MoNeT



- The Mexican Securities market has better technology, a better electronic market, more market participants, and a deeper and more liquid market

- This creates a virtuous cycle for investors and issuing companies

END