Market Surveillance at Stock Exchanges: Lessons for the Electricity Industry

by
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Presentation Overview

- **Are people interested in market surveillance in the Electricity Industry?**
- What is market surveillance in the context of a Stock Exchange?
- How does one go about architecting a robust surveillance system?
- Conclusion

Federal Oversight

- Senators Feinstein, Fitzgerald, Harkin, Lugar, Cantwell, Wyden, Leahy Introduce Legislation to Establish Strong Federal Oversight Over Energy Markets (March 4, 2003, Washington, D.C.)
  - Energy Market Oversight Act restores
    - Commodities Futures Trading Commission's (CFTC) authority over online and bilateral energy trades
    - Federal Energy Regulatory Commission's (FERC) powers to investigate and punish possible instances of fraud and manipulation
  - "It has been more than two years since the energy crisis began in California. It is well-past time to bring appropriate oversight to the energy market," Senator Feinstein said. "The legislation would **close a loophole that allows energy trades to take place online with no transparency, no record keeping, and no audit trail - with no federal oversight to guard against fraud and manipulation**. It would also give the Federal Energy Regulatory Commission - FERC - greater authority to investigate and prevent fraud and price manipulation."

Federal Oversight

- Fraud and Manipulation in the Energy Market - In the past two years, evidence has surfaced, proving that energy companies deliberately manipulated the supply and price of energy during the Western Energy Crisis.
  - In September 2002, a FERC Administrative Law Judge ruled that El Paso Corporation withheld natural gas from California - dramatically increasing natural gas and electricity prices in the Western region.
  - On May 6, 2002, FERC revealed Enron memos that showed how the company engaged in a number of manipulative trading strategies - called "Death Star," "Get Shorty," "Fat Boy," and "Ricochet" - to fleece families and businesses in the West.
  - On December 5, 2002, a former El Paso natural gas trader was indicted for reporting fictitious natural gas transactions to an industry publication - in an effort to boost prices and company profits.
  - Dynegy, Duke, El Paso, Reliant, CMS, and Williams have all admitted to engaging in "round-trip" or "wash trades." These are paper trades -- designed to increase volume and revenues -- but where no energy ever actually changes hands.
  - Transcripts and audio tapes of conversations have revealed that plant operators at Williams and AES deliberately worked to keep power offline and drive energy prices higher and higher.
  - In February 2003, FERC released transcripts from Reliant Energy, which reveal how their traders intentionally withheld power from the California market in an attempt to increase prices.
  - In March 2003, Jeffrey Richter, the former head of Enron's Short-Term California energy trading desk, pled guilty to conspiracy to commit fraud as part of Enron's well known schemes to manipulate Western energy markets.

IntercontinentalExchange

More electric power is traded on the IntercontinentalExchange™ than any other fully electronic exchange in the world. The exchange offers a broad selection of tradable products for both peak and off-peak periods.

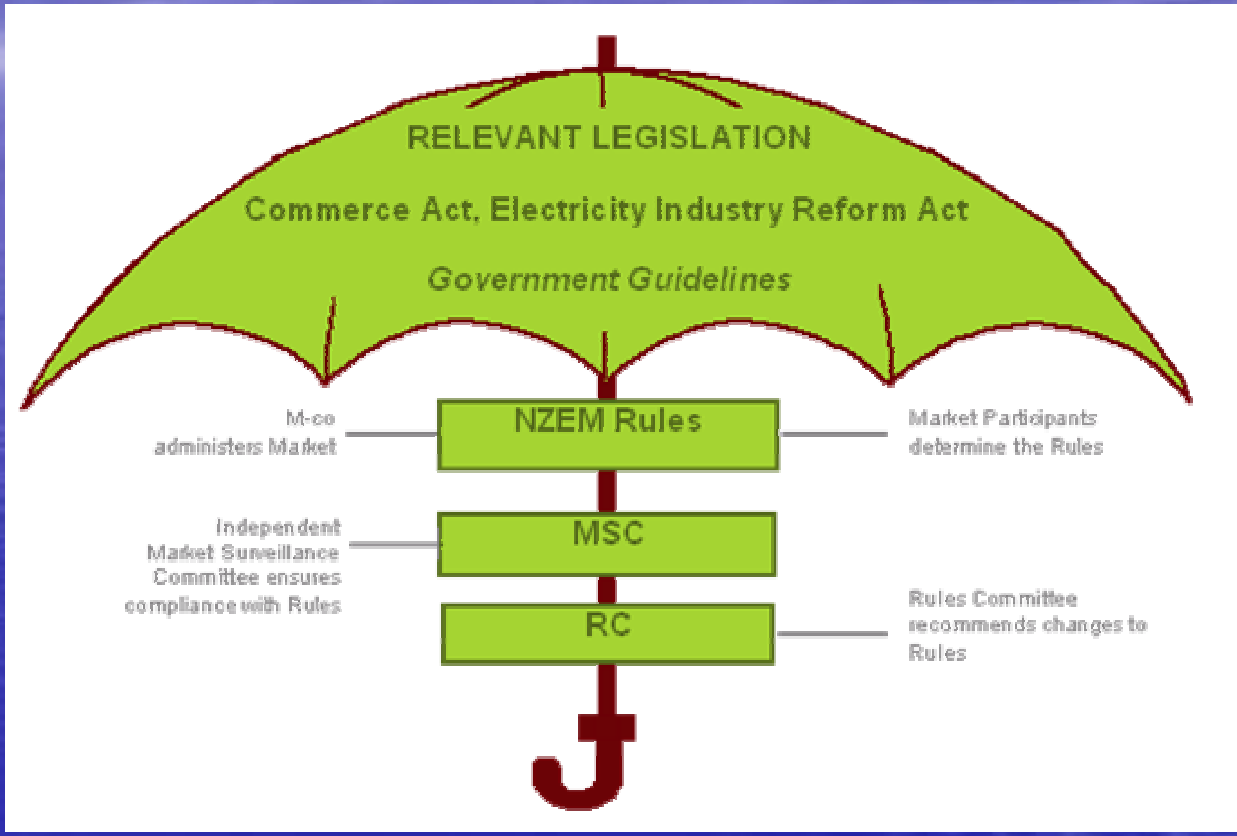
- Listed power products settle either financially in cash or with physical delivery at designated points and times
- Both physical and financial power products can be traded at a fixed price or, for some products, at a differential to Intercontinental's published daily power price indices
- Power Hubs
  - There are currently 18 hubs or delivery points that can be traded throughout the major FERC power regions in North America as well as hubs in the UK, Germany and France.
- Power contracts
  - Power contract forms include swaps, location spreads, time spreads, and options. Over 375 different standard time strips are available, from same-day hourly power to full calendar years. Custom user defined time strips are also available for some products.
- Trading Regions and North America and Europe

New Zealand Electricity Market

- The New Zealand Electricity Market (NZEM) is the world's only voluntary, self-regulated electricity market
- It is the only market with a disciplinary and monitoring committee created by contract, rather than by government regulation
- The Market Surveillance Committee (MSC), an elected body of independent members, is charged with the surveillance and compliance of NZEM

New Zealand Electricity Market

- The MSC is a vital part of NZEM and is modeled after traditional commodity market enforcement bodies (that is, it has similar powers and duties to the New Zealand Stock Exchange's Market Surveillance Panel and the Business Conduct Committee of the New Zealand Futures and Options Exchange)



Ontario Electricity Market

- The Role of the Market Surveillance Panel
  - Mandate and Structure
  - Monitoring
  - Investigating
  - Reporting

- Monitoring: focus on real-time energy price movements and market outcomes, gaming, and the exercise of local market power as reflected in congestion management payments

Ontario Electricity Market

- Are changes in prices a reasonable reflection of the scarcity values of energy and not the result of gaming or the abuse of market power?
- Are the signals sent by price changes that reflect the scarcity values of energy leading to appropriate supply and demand responses? Will any aspects of marketplace rules or structure likely constrain such responses?

Ontario Electricity Market

- To answer these questions, the Market Surveillance Panel has developed a set of tools, including market indicators and models

- These tools will allow the MSP to identify price outcomes that appear to be anomalous, and to understand what factors in the marketplace gave rise to those price outcomes

Ontario Electricity Market

- Market indicator categories employed by Ontario
  - Available Generation (e.g., Total Capacity of Resources)
  - Ontario Electricity Market Volumes (e.g., Total MW Bid on an Hourly Basis)
  - Ontario Market Demand (e.g., Hourly Load Market Clearing Quantity)
  - Ontario Prices (e.g., Correlation between Price and Load)
  - Ontario Nodal Prices (e.g., Price Ranking across Nodes)
  - Price Cost Margins (e.g., Resource Specific Price-Cost Margins)
  - Comparative Prices and Loads for Surrounding Power Markets (e.g., Hourly Prices for each System Day Ahead Mkt, Hour Ahead Mkt and Real Time)
  - Offers (e.g., Market Participant Aggregate Offer / Supply Curve)
  - Dispatch (e.g., Frequency of Individual Resources Setting Price)
  - System Operations (e.g., Frequency of Emergency Purchases)
  - Constrained on/off (e.g., Total Constrained Off MW for Period)
  - Transmission (e.g., Intertie Capability Comparison Year over Year)

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- Are people interested in market surveillance in the Electricity Industry?
  - Anecdotally, yes!
- **What is market surveillance in the context of a Stock Exchange?**
- How does one go about architecting a robust surveillance system?
- Conclusion

Market Surveillance at a Stock Exchange

- The forces of globalization, technology, changing investor demographics, and new forms of competition have dramatically transformed capital markets worldwide

- Open-ness, fairness and sound regulation are cornerstone requirements to ensure efficiency and the fairest of practices in the integration of the global securities marketplace

Market Surveillance at a Stock Exchange

- Evidence of a truly global marketplace and of strong competition
  - Globalization & Increased Cross-Border Activity
  - Growth of emerging markets
  - Market fragmentation
- Evidence of the need for entities to develop strong differentiators
  - Consolidation & Privatization
  - Demutualization
  - Brand development: EuroNext versus Deutsche Bourse, NYSE vs NASDAQ
- Evidence of global standardization
  - Governmental and legislative mandates
  - Global Harmonization – **Federation of Stock Exchanges (FIBV) and Organization of Securities Commissions (IOSCO)** are dramatically stepping up their efforts to promote the immediate needs for real-time market surveillance, risk management and regulation of cross-border trading

Market Surveillance at a Stock Exchange

- Success of the stock exchanges in tackling the above issues hinges on maintaining a clear and strong focus on increasing liquidity, transparency & profitability by developing a sound, consistent regulatory process

- Research from the Georgetown Capital Markets Research Center has shows that investors are willing to pay a premium on a well surveilled stock!

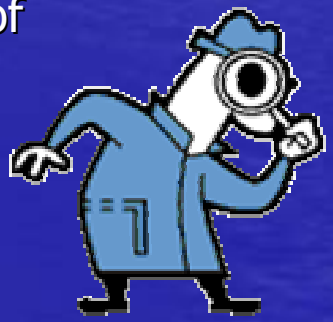
- Of the 150-odd stock exchanges worldwide, only about 60 are admitted into the FIBV due to its exacting standards!

Market Surveillance at a Stock Exchange

- So, what is a market surveillance system and how does it work?

- At the micro level (cop on the beat)
  - Intra-day and 1-2 day monitoring window
  - Involves real-time monitoring
  - Highest data frequency is tick-by-tick

- At the macro level (detective)
  - Inter-day monitoring, typically in the range of weeks, months, and quarters
  - Mostly off-line monitoring
  - Highest data frequency is typically daily summary data



"Cop on The Beat" Surveillance

- The overall problem to be solved is to help the stock market regulators identify "unusual market activity" reliably, in real-time, as a part of intra-day to 1-2 day timeframe monitoring
- As market transactions (buying, selling of specific stocks) occur on the exchange in real-time,
  - the goal of the "cop on the beat" market surveillance system is to identify any market activity that could be deemed unusual,
  - and report it in the form of an alert (to the market regulator) within a few seconds from the time of the occurrence of the specific transaction for the specific stock
- A definition of unusual is - deviating from past learned expectations
- Market activity is characterized in terms of key stock factors, such as price, volume, volatility, news and other events, etc, and variants and combinations thereof

"Cop on The Beat" Surveillance

- An ideal system will
  - keep this real-time surveillance activity going for the entire trading day,
  - individually monitor the few thousands of stocks listed on the exchange, and,
  - scale up to reliably handle a transaction performance of up to a few billion shares of trading per day

- The regulator, upon receipt of an alert for a specific stock, would,
  - score the alert as desired/undesired (based on human information, to determine the sensitivity & specificity of the system), and,
  - take appropriate actions such as
    - halting the trading of the stock,
    - reporting it for further investigation (to the "detective"), or,
    - calling the company for an explanation, etc, as demanded by the gravity of the situation

"Cop on The Beat" Surveillance

- System to monitor stocks on the exchange in real-time
  - Segment and group the market
    - Across space and time
    - Spatial clusters and temporal clusters
  - Use several alert schemes to improve coverage
  - Consider all primary factors such as
    - Price
    - Volume
    - Volatility
    - News and other "events"
  - Handle new stocks separately
  - Allow handling of stocks on an individual basis
  - Create a flexible, modular structure

"Cop on The Beat" Surveillance

- Spatial Groups
  - Vastly different trading behavior calls for segmenting
  - How do we "slice-and-dice" the market?
    - Decrease differences within group
    - Increase differences between groups
    - By industry sector? By company size? By stock behavior?
- Temporal groups
  - How do we account for inter-day differences?
    - Earnings Periods versus Non-Earnings Periods
    - Holidays
  - How do we account for intra-day differences?
    - Account for differences in trading intensity and volatility during the day

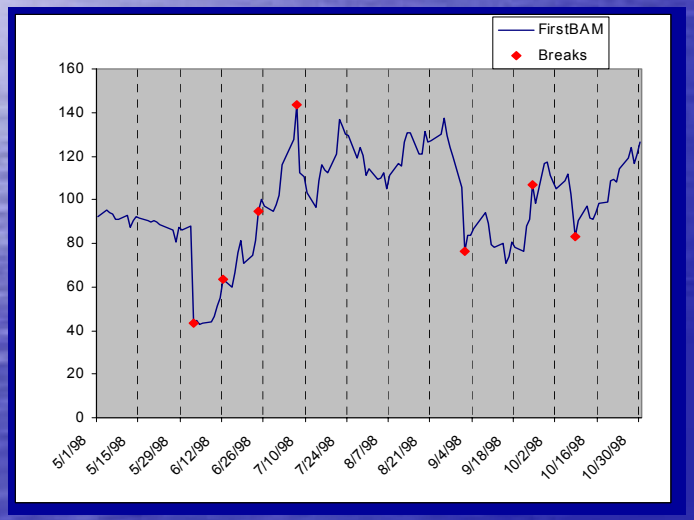
"Cop on The Beat" Surveillance

- Alerts
  - Single Factor Alerts
    - Fundamental alerts based on primary factors
  - Multi-Factor Alerts
    - To cover areas that single factor alerts cannot, individually
  - Time-sequence sensitive Alerts
    - To detect sequences of anomalous events
  - Alerts for issues without an a priori trading history
    - To deal with transfers, IPOs and other new issues
  - Alerts based on comparison of the behavior of the stock
    - With respect to itself
    - With respect to its "peers"
    - With respect to the "entire market"
  - Custom alert coefficients for every stock, but tuning typically done on a group basis? How do you make the system modular?

"Cop on The Beat" Surveillance

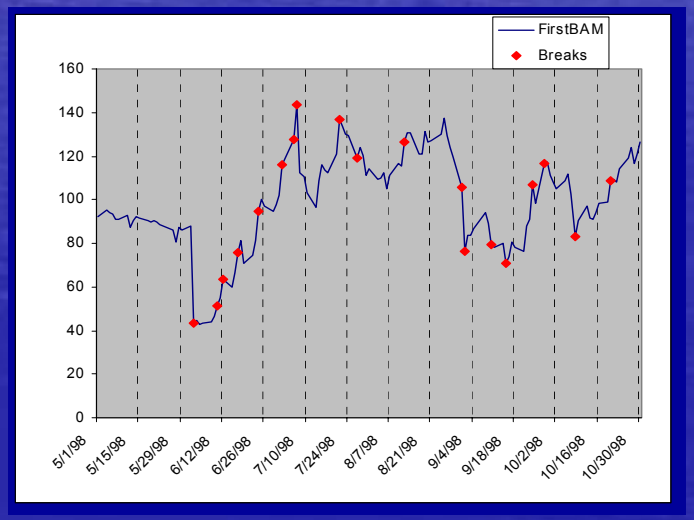
- Individual issue tuning
  - Loosen and tighten parameters on an issue-by-issue basis
  - For every alert, flag if an issue belongs to the Sensitive or Watched Issue List

Loosen



1DThreshold: 1.25
2DThreshold: 1.50
3DThreshold: 1.50

Tighten



1DThreshold: 1.00
2DThreshold: 0.50
3DThreshold: 0.50

"Detective" Surveillance

- Uses "daily summary" input from the system performing "cop on the beat" surveillance
  - Daily summary report from the "cop on the beat" helps the "detective" build a case over time!
- Inter-day monitoring, typically in the range of weeks, months, and quarters
- Detect heuristic fraud & manipulation schemes
- Mostly off-line monitoring of the trading of stocks in relation to people for
  - Trader Compliance
  - Risk management

"Detective" Surveillance

- Front Running
  - An individual has knowledge of a large, potentially market moving order. He trades for his own personal advantage before that knowledge becomes public
  - Typical solution might involve time-series sequence detection and learning. Merge heterogeneous events (alerts from the "cop on the beat" surveillance system, analyst reports, etc) into a single time-series event stream with longitudinal timestamps and mine the event stream to detect repeatable patterns/sequences
    - Institutional customer orders a large block of stock ABCD
    - Brokerage employee X buys call options of stock ABCD
    - Large order is filled
    - Quoted prices for stock ABCD rise on anticipated demand
    - Employee X exercises options to make a nice little profit
  - Luckily these employees tend to commit little, repeat offences to stay "under the radar" and fall into a "set routine" that works - this makes it a repeatable pattern and hence detectable
  - As the micro level market dynamics change, the macro level heuristics defining the fraud schemes change as well – front running in a bull versus bear market!

"Detective" Surveillance

- Other Common Schemes
- Marking The Close
  - Trading a stock near the close of the day in order to affect the published closing price
- Pegging and Capping
  - Trading a stock in order to keep the price above (called pegging) and below (called capping) a pre-specified price in order to make stock option exercise unprofitable
- Pump and Dump
  - Buying a stock to cause the price to rise. The price rise creates a demand and attracts other traders further lifting the price. The original individual then sells the stock
- Wash Trades
  - Two or more traders trading shares among themselves to create the impression of very active trading in a stock without changing respective percent ownership totals
- Insider Trading

"Detective" Surveillance

- To effectively meet the responsibility for providing reliable and secure clearing and settlement services, the system can **review and monitor market members** through its prescribed rules and regulations, and through the laws laid down by the regulatory authorities
  - Historical behavior of members is benchmarked and process models are built using historical information
  - These process models aid in identifying deviations from the normal behavior, which result in alerts
  - These alerts are thoroughly investigated till they result in the indictment of a broker or till the alert is discarded
  - A complete audit trail of the investigation is maintained

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- Are people interested in market surveillance in the Electricity Industry?
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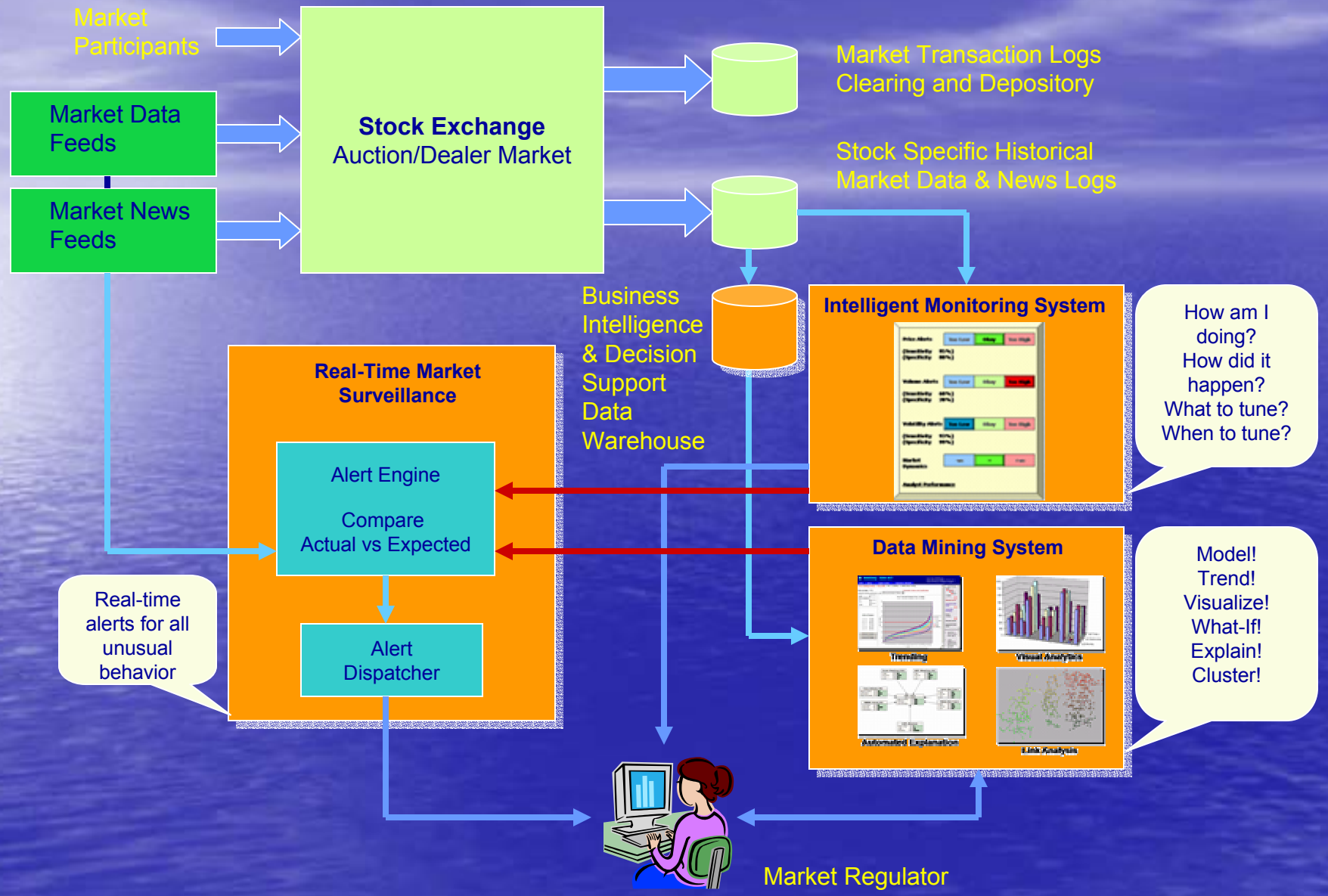
- What is market surveillance in the context of a Stock Exchange?
  - We need two levels of systems
    - "Cop of the beat" and "detective" surveillance
- **How does one go about architecting a robust surveillance system?**
- Conclusion

Stock Exchange Surveillance System

- How does one implement a system that can provide both levels of surveillance services on a modular, scalable, reliable, and continued basis?
- The generic "exception detection" & surveillance system framework is comprised of four key blocks
- They are
  - Decision Support Data Warehouse (your data source)
  - Data Mining System (your modeling system)
  - Intelligent Monitoring System (how good are your models?)
  - Real-Time Market Surveillance System (compare actual versus expected to fire alerts!)

Stock Exchange Context Diagram



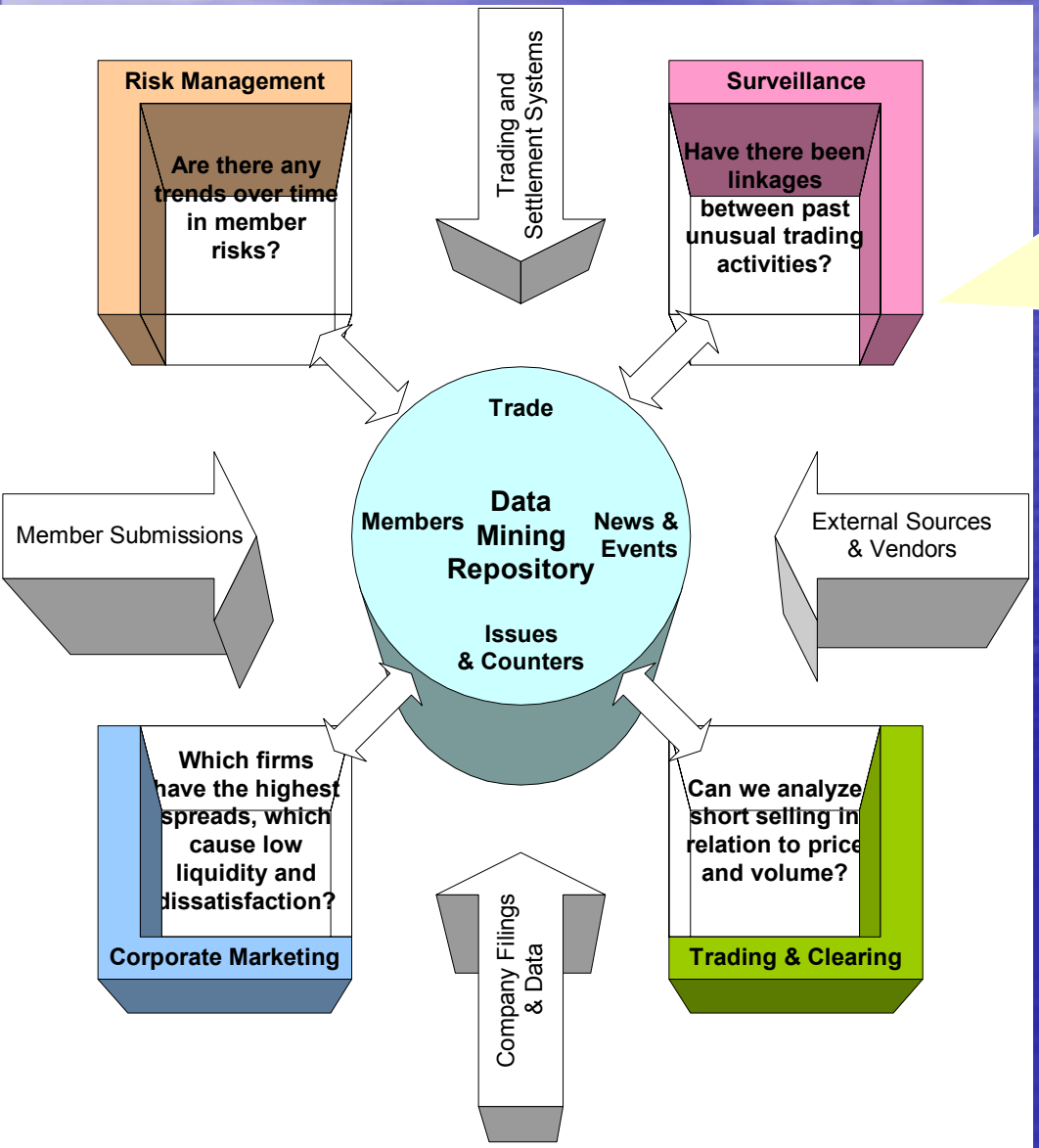
Decision Support Data Warehouse

- It is a critical sub-system that captures the historical logs of market activity
- Typically three types of databases are employed
  - Transactional Databases, which are optimized for speed, are used to log high-traffic data such as tick-by-tick quote and trade data
  - Operational Databases, which are usually implemented as conventional relational databases, incorporate many stored procedures that process raw data into more useful features and provide updated system operation data to other system components
  - Analytical Databases aggregate transactional data into longer time scales to support on-line analytical processing (OLAP) as well as all kinds of statistical analyses and data-mining

Decision Support Data Warehouse

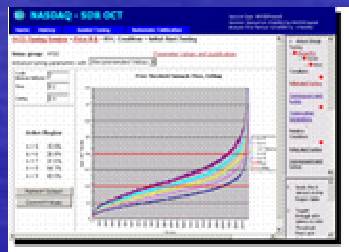
- Support generic data pre-processing
  - Normalization, z-standardization, principal components transformations, creation of rate-of-change (derivative) and area-under-the-curve (integral) variables from raw variables, filtering, re-sampling, frequency domain transformations (such as Fast Fourier Transforms, and wavelets) etc, as required
- Data items are grouped according to multiple time-scales
  - Accommodate data ranging from real-time tick-by-tick data to data that updates/changes at the daily, weekly, monthly, and quarterly frequency
- Data items are also grouped according to the primitive entities that the data items describe

Data Mining System

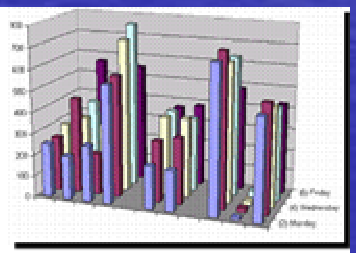


The system would guide the analyst through the following, iterative chain of events for applications such as **trending**, **visual analytics**, **automated explanation**, and **link analysis**

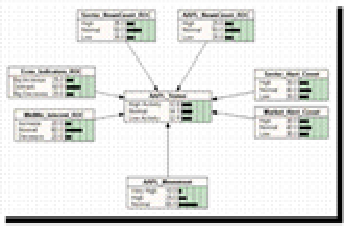
* Organization and input of relevant historical raw data that is descriptive of the underlying process
* Pre-processing the data and extracting features
* Creating training and testing data sets
* Developing models using a variety of techniques
* Scoring the models by performance testing
* Finalizing the winning model by determining suitability for implementation



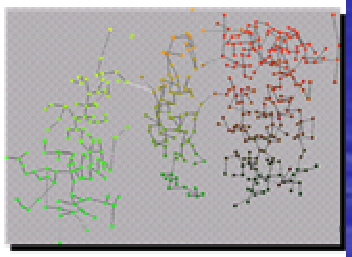
Trending



Visual Analytics



Automated Explanation



Link Analysis

Data Mining System

- The system allows users to rapidly prototype custom models as demanded by the specific application
- The system guides the analyst through the following, iterative chain of events:
  - Organization and input of relevant historical raw data that is descriptive of the underlying process
  - Processing the data and extracting features
  - Creating training and testing data sets
  - Developing models using a variety of techniques
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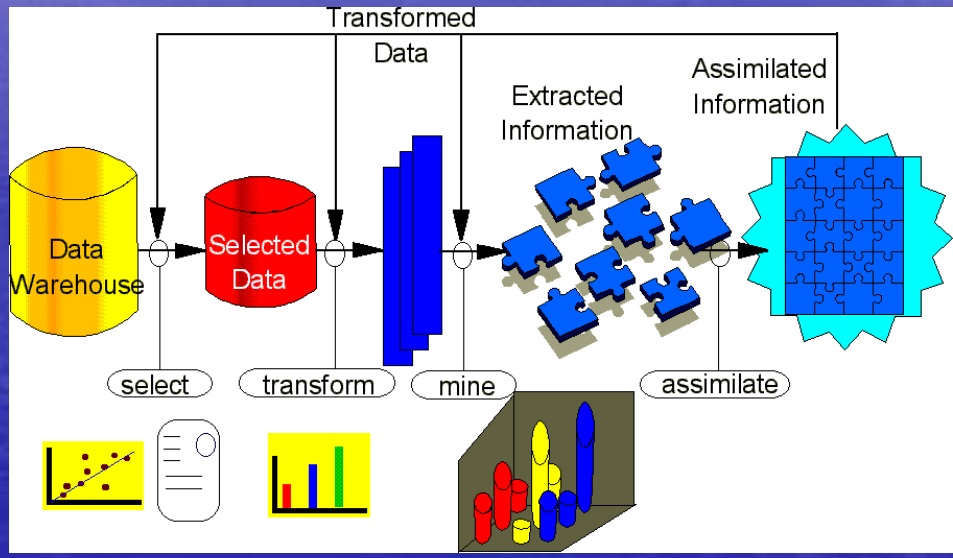


Data Mining System

- Critical need to populate the system with a diverse variety of inter-disciplinary modeling techniques
- For example, to solve a time series analysis problem, pre-processing and feature extraction might involve the following techniques
- Pre-processing
  - Achieve stationarity by using the applicable combination of the following sub-methods
    - Box-Cox transformation for standardization and normalization
    - Lead/lag and autocorrelation/partial autocorrelation analysis
    - Differencing
    - Missing value analysis
    - Filtering (basic IIR and FIR filters) and smoothing
    - Resampling

Data Mining System

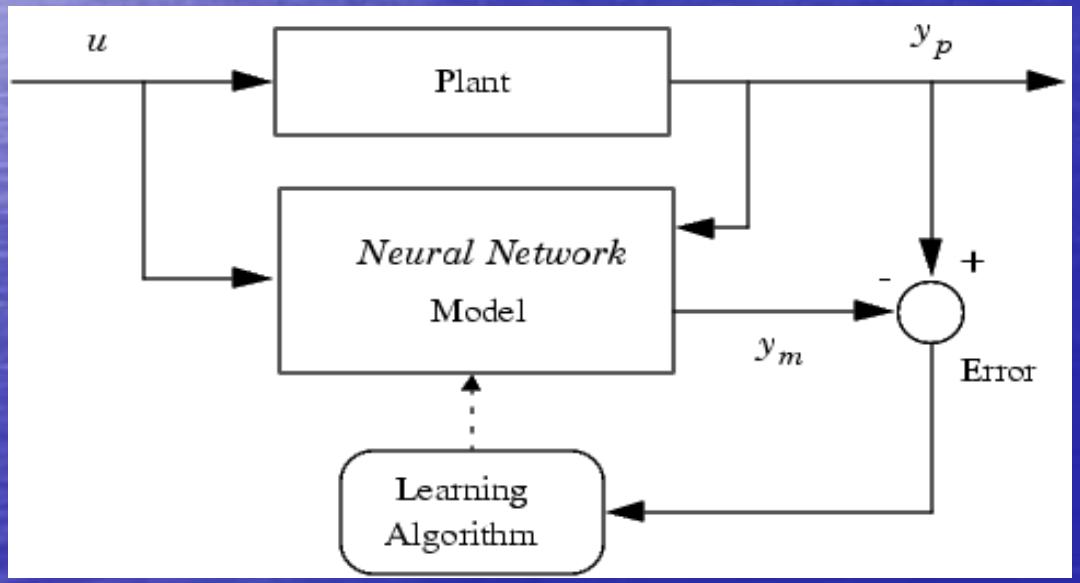
- Feature extraction
  - Decomposition Analysis and Trend Analysis are used to identify several patterns that appear simultaneously in a time series, namely the Seasonality, Trend, Cycling, and Irregularity Components
  - Typically the following methods are employed
    - Spatial methods (similar to pattern templates in technical analysis, also principal components, clustering, etc)
    - Frequency domain methods (unbiased and much more robust, e.g. FFT, wavelets)
    - Combinations thereof
- A test of linearity is also performed at this stage to assess the degree of nonlinearity, if any, to help in the choice of the modeling methods

Data Mining System

- Modeling methods
  - Methods need to support continuous learning of a dynamical process model
  - Model based on theoretical first principles
    - e.g., $E = mc^2$
  - Model based on underlying empirical process data
    - e.g., $y(t) = a_0 + a_1 * y(t-1) + a_2 * y(t-2)$
  - Model based on process heuristics
    - e.g., RULE_1: expect volume increase of 30% on witching days (when options contracts expire)
  - Optimal real-world models are typically a combination of all three

Data Mining System

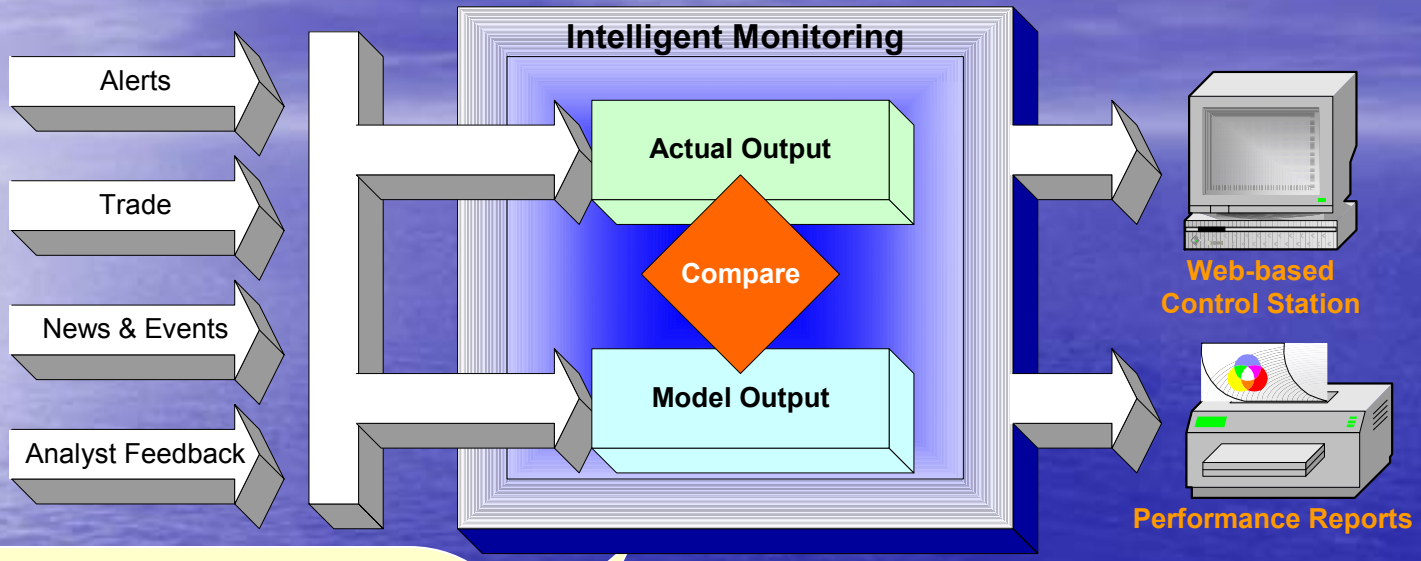
- Continuous learning of a dynamical process model
  - Linear models (e.g., ARIMA, Kalman filtering)
  - Piecewise linear models (e.g., multivariate adaptive regression splines, classification and regression trees)
  - Nonlinear models (e.g., family of neural networks)



Data Mining System

- Model evaluation and scoring
  - Testing and training sets
  - Time periods for back-testing
  - Establish a scoring procedure to rank-order multiple models/methods, for example:
    - Sensitivity = (True positive / (True positive + False negative)) * 100%
    - Specificity = (True negative / (True negative + False positive)) * 100%
- Model execution constraints
  - Many specific models (one for each stock) versus one general model (one for the entire market or one for each sector) to assess the computation requirements versus desired modeling accuracy tradeoff
  - Ease of implementation and maintenance of models in response to changing market dynamics

Intelligent Monitoring System



- Minimizes catastrophic failures
- Reduces unplanned and planned downtime
- Cuts maintenance spending
- Diagnoses problems and avoids false alarms by incorporating your company process expertise into the incident logic
- Provides data feed validation
- A prioritized watch list can show you what's working well, what's not
- Uses existing data feeds, databases and infrastructure computer systems and data historians
- Self-diagnosing, can alert process experts to changing process dynamics

PulseMetrics LLC
DATA TO DECISIONS

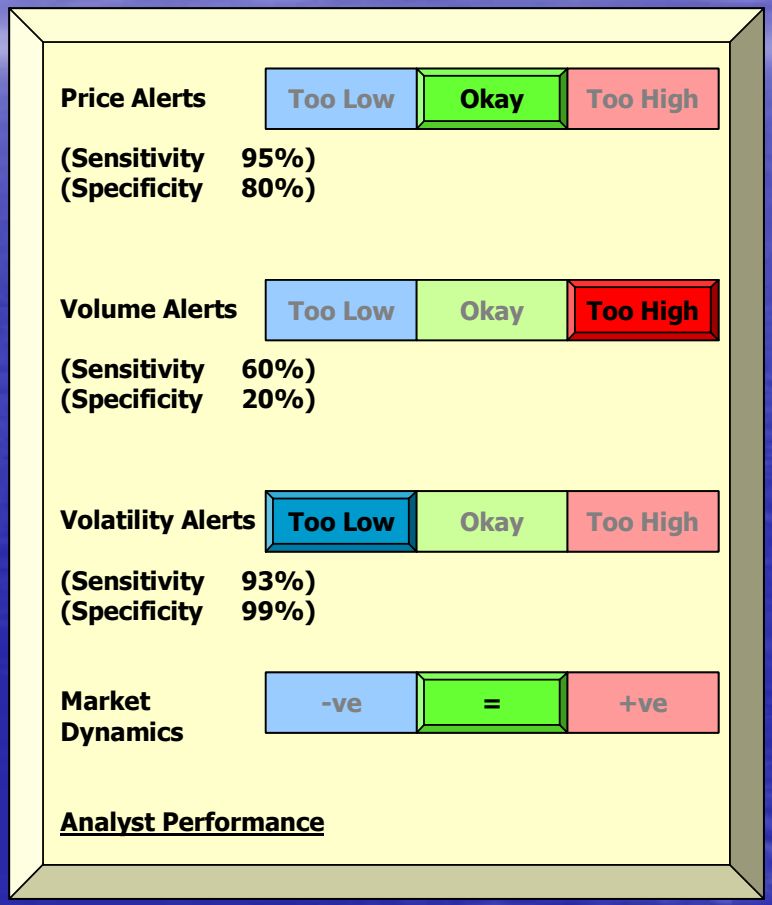
Intelligent Monitoring System

- Meta-level operation – "How is the surveillance system doing?"

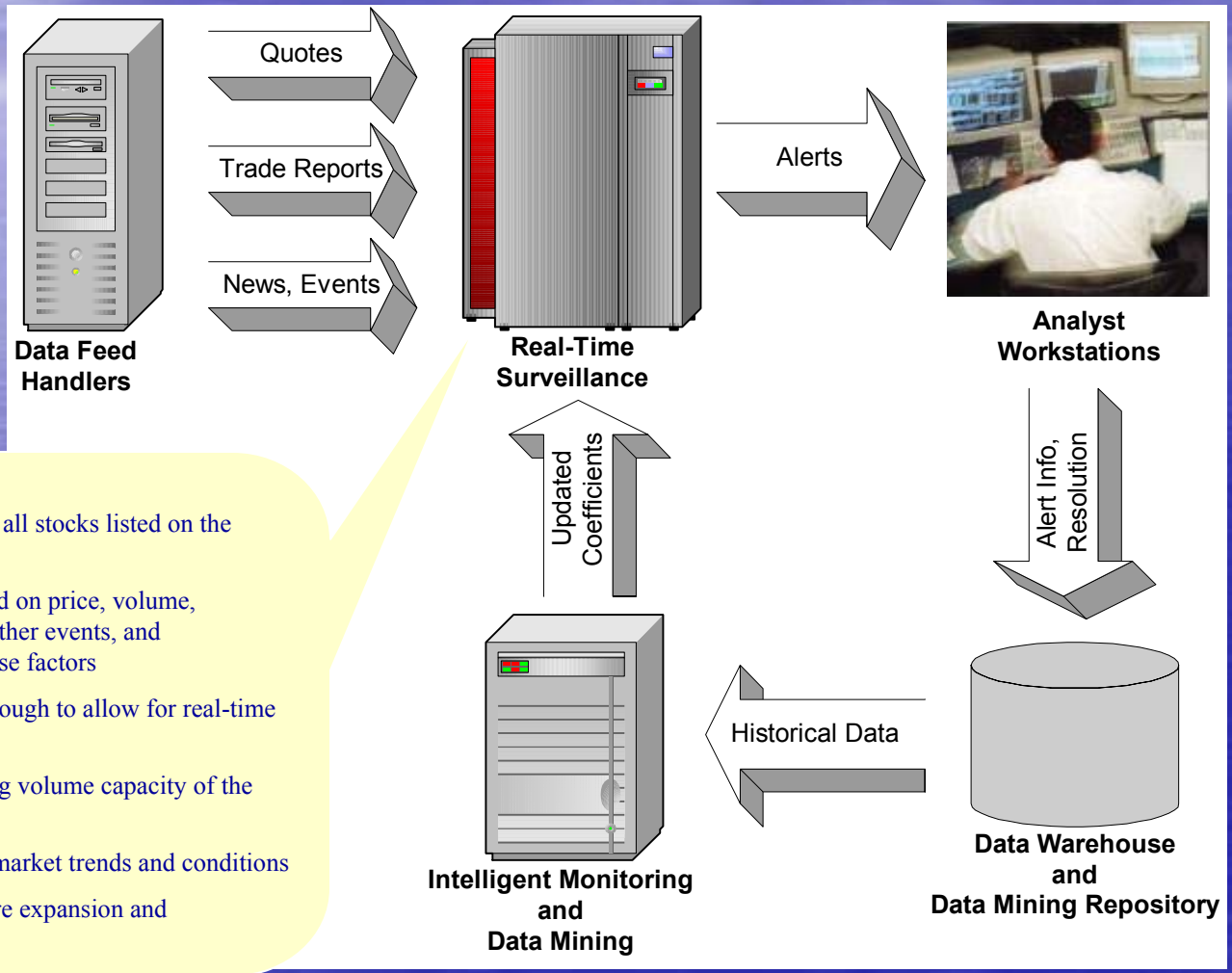
- Watch for variation and degradation in model performance
  - Indications that underlying patterns may have changed
- Generate alerts when significant deviations are confirmed
- Produce regular performance reports
- Provide data-driven explanations, tuning recommendations
- Ensure models always keep in step with ever-changing dynamics

Intelligent Monitoring System

- Example, Market Surveillance Alert Analysis and Update System
  - Analyze alert performance
  - Score alerts for sensitivity (detecting true alerts) and specificity (rejecting false alerts)
    - Sensitivity = True Positive / (True Positive + False Negative)
    - Specificity = True Negative / (True Negative + False Positive)
  - Check model degradation, perform periodic validity tests
  - Guide user through alert tuning
    - System-generated tuning recommendations
    - Justifications based on historic alert performance
    - Context-sensitive help



Real-Time Surveillance System



- Effectively monitor all stocks listed on the exchange
- Develop alerts based on price, volume, volatility, news & other events, and combinations of these factors
- Respond quickly enough to allow for real-time intervention
- Plan for peak trading volume capacity of the exchange
- Adapt to changing market trends and conditions
- Be flexible for future expansion and enhancement

Real-Time Surveillance System

- This system encodes the most current version of the alert algorithms and executes the alert triggering tests for every incoming market event
- The Intelligent Monitoring System ensures that the most current set of alerts are available at any given time to the Real-Time Surveillance System
- A data pre-processing module interfaces the Real-Time Surveillance System with the incoming market data feeds and ensures that the incoming data is in a form that is directly usable by the alert algorithms

- Depending on type of alert, whether it is real-time versus non-real-time, automatically generating versus on-demand generating, etc., once the appropriate data is available to the alert algorithm, it tests for the triggering/generation condition (every time there is a demand by the analyst, or at every quote or trade update, etc.) and sends out an appropriate response that is passed on to the Human Operator via a suitable user interface

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  - Anecdotally, yes!
- What is market surveillance in the context of a Stock Exchange?
  - We need two levels of systems
    - "Cop of the beat" and "detective" surveillance
- How does one go about architecting a robust surveillance system?
  - Have 4 key blocks- data source, modeling systems, model performance watchdog, and alert engine!
- **Conclusion**

Conclusion

- Regulation is seemingly becoming a hot topic in the electricity industry
- However, local enforcement and global standardization are key thrust factors to boost this cause
- One can get inspiration from a (mature) sister industry such as the capital markets
- The generic 4-block system framework provides a sound platform into which domain/process specific regulatory rules can be encapsulated