

# Surveillance of Parimutuel Wagering Integrity Using Expert Systems and Machine Learning

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## Abstract

Parimutuel wagering is a significant source of revenue for many state governments. MonitorPlus is a surveillance system for parimutuel operators and regulators. Using industry expertise and best practices, MonitorPlus examines each and every wager and account transaction for evidence of fraud, crime, and money laundering. Alerts are generated in real-time. In forensic discovery mode, MonitorPlus is designed to collaborate with skilled analysts to discover more complex suspicious wagering patterns. MonitorPlus utilizes machine learning, so its risk profiles are current: its knowledge base improves with time. Each alert is accompanied by an automatically generated, rule-based explanation. This is critically important if an event rises to the level where legal action is required. Our development and deployment strategy is based on a new paradigm of a secure surveillance utility, where real-time alerts and data-intensive forensics support multiple regulatory jurisdictions. We believe this surveillance paradigm can be applied to other application domains such as lotteries, casinos, online gaming, and financial services.

## Background: Parimutuel Wagering

Computing winning odds for horse racing was one of the first applications of computing. In 1850, Augusta Ada Lovelace (1815-1852) formulated such an application for the Analytical Engine proposed by Charles Babbage (1791-1871) [2]. Their solution (which was financially unsuccessful) was not helped by the vagaries of the fixed-odd market maker system, where a number of market makers (“bookmakers”) compete for bets by offering payoffs that depend on a particular event. Bookmakers individually adjust and offer new odds to players – based on supply and demand – so that bookmakers almost always make a profit.

In 1867, Joseph Oller (1839-1922) invented a new kind of wagering system that was based on the same principle as a lottery – it returns to winners a proportion of the total amount wagered. In this system, the entire money bet on an event goes into a “pool.” The host removes a known flat percentage (the “takeout percentage”) typically between 15%-25% to cover expenses. The amount of money left is called the net pool. Wagering takes place

any time up to the start of the event. When the event is over, the holders of winning tickets share the net pool among themselves. Such “parimutuel” (i.e., mutual betting) wagers are thus pure bets against all the other players: the host makes a riskless profit. Unlike a casino, the host does not place bets.

Theoretically, the parimutuel system cannot lose money for the host. This was of tremendous interest to wagering establishments that wanted an alternative to the riskier, less transparent fixed odds systems. Moreover, municipalities saw parimutuel wagering as a risk free way of raising funds. Parimutuel wagering was legalized in France in 1887, and in England and the United States in 1927.

The totalisator (abbreviated as “tote”) is the name of the computing system that calculates payoff odds. The first automated totalisator was a mechanical computer built in 1913 which was similar to reconstructed models of the Babbage Analytical Engine. The device is also a metonym for service companies: a totalisator or tote company is an organization that computes odds and payouts.

In the United States today, parimutuel wagering is a significant source of revenue for many state governments. For example, over the past decade New York City’s Off-Track Betting (OTB) Corporation averaged yearly revenues of about \$1 billion, with a takeout percentage in the range of 20%: the takeout goes to New York State and New York City governments [14].

## Example of Parimutuel Pools

Suppose that there are three “betting interests” (horses) – Red, Blue and Green. Individual wagers are placed on the horse that wins and the tote adjusts the odds as wagers accumulate. Betting is halted just before the race. Suppose a total of \$30,000 is wagered on Red, \$70,000 on Blue, and \$12,000 on Green. Blue is the favorite; Green is the long shot. The total amount wagered on this racing event on the three mutually exclusive outcomes (only one horse can win) is \$112,000. A 20% takeout results in a net pool of \$89,600 (the amount that is to be shared among the players with the winning bet) and a riskless profit of \$22,400 for the host. If Blue wins, betters on Blue stand to make a profit of \$89,600 minus the cost of the wager

(\$70,000), or \$19,600. The players who bet on Red or Green lose. If Green wins, bettors on Green stand to make a profit of \$89,600 minus the cost of the wager (\$12,000), or \$77,600. The players who bet on Blue or Red lose.

The host operator frequently reports the decimal odds for each possibility, defined by the net pool (profit) divided by the amount wagered. For example, if Red wins, the profit is \$2.99 per each dollar wagered. The reciprocal of these decimal odds can be used to define an implied probability for each outcome. Note that these implied probabilities are not true probabilities in that they do not add to one; this is one important property of both fixed odd and parimutuel wagering. The host (or bookmaker) makes a riskless profit if the sum of implied probabilities exceeds one. For parimutuel this is always the case; for fixed odd betting this is true only if the market maker creates a "dutch book." The excess is called the over-round. In economics and finance, the assumption of efficient markets requires probabilities that sum to unity. Note that if the \$ takeout is set to 0%, then the wagering is efficient and the probabilities sum to unity. In financial terms, this corresponds to the efficient markets requirement of "no arbitrage."

Other wagers have their own separate pool. For example, most parimutuel operators offer the following wagers on one or more selected horses:

Place Pool: the horse finishes first or second.  
Show Pool: the horse finishes first, or second or third.  
Exacta Pool: two finish first and second, in exact order.  
Quinella Pool: two finish first and second (unordered)  
Trifecta Pool: three finish in exact order.  
Pick Four: Four horses in four different races finish first.  
Pick Six: Six horses in six different races finish first.

### **Parimutuel Infrastructure**

In the United States, rules, payout specifications and tote computations are specified by "model rules" published by the Association of Racing Commissioners International, Inc. (RCI), a parimutuel industry group that was originally formed in 1934 by state racing commissioners. The purpose of the Model Rules [15] is to standardize the regulatory issues between different jurisdictions. In addition, each state has its own rule versions (for example, see [16]). The RCI also developed a standard Inter-Tote System Protocol (ITSP) which facilitates the transfer of wagering information between the various tote systems. Other industry organizations are The Jockey Club (TJC) formed in 1894 and the National Thoroughbred Racing Association (NTRA), formed in 1942. Both TJC and the NTRA have been involved with the development of the Wager Transport Protocol (WTP) [11] that is designed to replace ITSP and support the transmission of detailed wager requests to a host. This support extends from the host data centers to the retail terminals.

The parimutuel network infrastructure includes thousands of wagering sites (including racetracks and off-track wagering facilities), as well as phone, personal

computer, special hand-held wagering devices and digital TV Simulcast [10]. This technology infrastructure supports betting from sites in multiple jurisdictions. In particular, "guest wagers" from one jurisdiction (from other states or even from other countries) are combined electronically at the "host" (the organization that runs the race); the host calculates winning prices and payouts.

Parimutuel organizations also support wagering from special accounts – called Advance Deposit Wagering (ADW) accounts. These are similar to electronic brokerage accounts at financial institutions. ADW currently represents at least 10 percent of all parimutuel wagers. Parimutuel protocols also support computer-assisted wagering ("robotic wagering").

### **Problem Description: Parimutuel Integrity Surveillance**

The basic problem that state governments and parimutuel organizations have is the regulation and maintenance of wagering integrity. A loss of integrity for legalized wagering generates adverse reaction from law-abiding players: this reaction includes a decrease in wagering and thus a loss of revenue for state governments.

Regulatory control of parimutuel wagering largely takes place at the state level. Thus, regulators must constantly watch for possible fraud, crime, and money laundering. Independent monitoring of parimutuel wagering and account activity is a regulatory requirement in New York State. Other jurisdictions, notably Minnesota, Massachusetts, California, Oregon, and Kentucky, are increasingly interested in independent monitoring of wagering and account activity [13]. Regulations vary between jurisdictions, as do levels of regulatory control.

Historically, regulators have focused on overseeing racetrack operations, with little direct control over tote companies. For example, racing commissions are the licensing entities for horseracing and are statutorily authorized to promulgate and enforce the rules of parimutuel racing and wagering. In the last few years, state regulatory associations have expressed an interest in expanding their oversight role to wagering integrity.

### **Application Objectives**

Our application objective can be summarized in one word: monitoring. Indeed, the federal government is increasingly frustrated with the unmonitored nature of wagering and ADW activity. Tom Ridge, a former Secretary of Homeland Security told one of the authors:

"Parimutuel is an unmonitored bank rife with problems and a potential source of money laundering and terrorist financing. The parimutuel franchise is at risk if the industry does not monitor itself."

State and provincial regulators are increasingly concerned with pool manipulation, money laundering and

potential terrorist financing. This demands continuous independent monitoring. Parimutuel operators are increasingly being required to exercise diligence in the detection of inappropriate transaction activity.

In addition to statutes requiring independent monitoring in certain jurisdictions, the parimutuel organization may be subject to considerable financial losses, and can be held legally liable for failing to take appropriate measures to mitigate such risks. The impact of a publicized inappropriate event can have a devastating impact on a parimutuel operator – including potential legal action, and loss of license to operate in a given jurisdiction. Ultimately, unmonitored systems lead to erosion of confidence in the operator by bettors, licensed racing participants, regulators and law enforcement agencies.

### Conventional and Knowledge-Based Approaches

Detection of inappropriate activity involves a holistic, enterprise-wide approach consisting of policy definition and implementation, due diligence, independent monitoring, reporting and training. Our application follows this approach and includes: expert analysis of inappropriate wagering and account activity; creation of risk scenarios; detection and alerting of potentially inappropriate electronic transaction activities in wagers and accounts.

There are “racetrack security” organizations that review a limited portion of historic data files. However, this conventional review is typically not independent, automated, or comprehensive; neither does the review occur in real-time. Further, reviewing post facto data files is a side business for these organizations, and significantly, only parimutuel entities that contract with these organizations for other, non-related services are reviewed. Our application, in contrast to other racetrack security organizations, is independent: its only function is the independent monitoring of parimutuel wagering and accounts.

No racetrack security organization has a set of automated AI based analysis tools that has been developed specifically for the parimutuel industry. None has a real-time automated execution engine either, so a human analyst must manually review historic data. Racetrack security organizations can only manually review a limited number of data elements so the vast majority of wagering and account data elements will not be reviewed at all.

Without an artificial intelligence solution, racetrack security organizations cannot offer consistency. A review of a particular historic data extract can only be as good as the particular human analyst performing the work at a given time. There is no ability to consistently apply the collective body of parimutuel industry knowledge.

### Application Description: MonitorPlus

Our application, MonitorPlus is a significant and innovative advance over other parimutuel surveillance

monitoring solutions in that it is knowledge-based. The major AI components consist of a deductive inference engine for generating real-time alerts that is coupled with an inductive machine learning system. This combination of a rule-based expert system that is tightly coupled with a machine learning component offers unusual flexibility in our domain.

The major standard components include a Tote Transaction Engine that recomputes and validates all tote transactions; a relational database management system supporting on-line analytical processing (OLAP); and a report generator for alerts and detailed analysis. A top-level data flow schematic of our solution is shown in Figure 1.

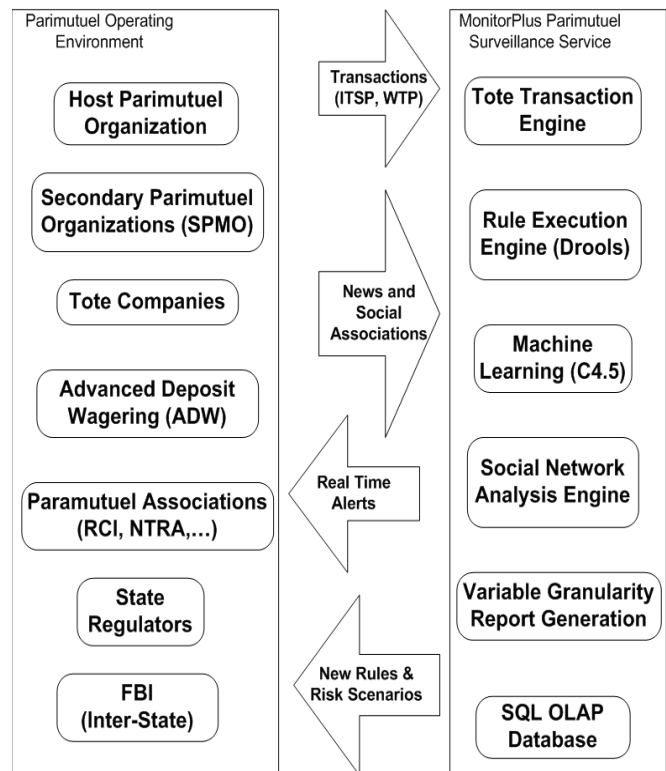


Figure 1. Data Flow of the MonitorPlus Environment

We are not aware of any previous artificial intelligence based systems applied to parimutuel wagering surveillance. There have been a number of artificial intelligence based systems applied to financial market surveillance [4], [5]. One of these is the New York Stock Exchange Integrated Computer Assisted Surveillance System (ICASS) [8], [9]. ICASS technology integrates heterogeneous databases (both public and non-public), artificial intelligence, and various systems on computer networks. Regulatory analysts maintain continuous surveillance of market activities throughout the trading day, monitoring adherence to trading rules, and checking up on any deviations from standard profiles. Effective surveillance requires examining enormous quantities of data in order to

differentiate between normal and unusual trading activity. Both authors of this paper worked on ICASS.

Even though wagering integrity surveillance is a totally different domain than financial market surveillance, there are analogies between gambling systems and financial systems, and lessons learned from one domain can be applied to the other domain. Indeed, many terms used in financial market surveillance (such as “front running”) directly come from the racing domain [3].

In both domains, data-intensive surveillance is very difficult because of the large quantity of transaction data that must be examined. We believe that a knowledge-based methodology that couples expert rules with inductive learning can be used in other types of data-intensive surveillance and computer-based forensics. In any case, the MonitorPlus application is unique for the parimutuel industry.

### Modes of Operation

There are two modes of operation. In alert mode, MonitorPlus uses its rule base and inference engine to generate real-time alerts. Alerts can be displayed on any Internet enabled computer; they can be emailed, sent to a Blackberry or transmitted to any other device, thereby allowing a parimutuel operator to take immediate corrective actions. In forensic discovery mode, MonitorPlus becomes a collaborative system that uses machine learning and clustering algorithms to discover new suspicious patterns and clusters that can be formulated into new rules.

MonitorPlus rules are grouped into about 9 major and 70 minor surveillance categories. They include:

**Account Wagering Fraud.** Fraud includes fixing the winner in a race; taking advantage of hidden data to cash in on parimutuel pools; using insiders (who are prohibited from wagering or making certain types of wagers); using trainers or jockeys, or associates on their behalf, wagering against a horse they ride.

The MonitorPlus fraud surveillance rules identify suspect patterns, such as accounts with very occasional but highly profitable wagers, or other potential fraud activity such as accounts where profits are highly linked with race participants and their associations. MonitorPlus alerts include account identifiers to facilitate their inspections and investigations.

**Past Posting.** Past posting is a situation where wagers are placed after a race has started. Past posting may be due to a technical issue where a stop wagering signal fails to be initiated or fails to be registered; to a failure to activate the prescribed stop wagering procedure in a timely manner; or to a failure to communicate a stop wagering command to a guest wagering location.

The MonitorPlus past posting surveillance rules detect instances of wagers or wager clusters that have been placed just before wagering ends and determines whether the distribution of wagering transactions is normal or abnormal.

**Cancel Delay.** A Cancel Delay is a wager that is allowed to be cancelled more than a reasonable time after purchase and/or after wagering on a contest has ended. Cancel Delay fraud is associated with odds manipulation. It results in gaining an unfair advantage by observing the beginning of a race before deciding whether to hold or cancel bets.

The MonitorPlus cancel delay surveillance rules detects cancellations that exceed a “reasonable” time limit after wagers have been placed. MonitorPlus detects this potentially illegal activity by linking wager transactions and cancel transactions, and by identifying cancellations that occur after betting transactions have ended.

**Odds Manipulation.** One betting strategy is to monitor betting “action” – the increase in the number of wagers which lead to the dynamic changing of odds. One way action increases is with a contestant that has excessive money wagered on it by other bettors (a “bet down” contestant). Other players looking for value or overlays will bet against a “bet down” contestant and will instead bet on an alternative. This bettor will react to the win odds and base a selection from readily available public information about contestants.

In addition, an odds manipulator may even cancel the manipulating wagers – thus recovering the very funds used for the purpose of odds manipulation! The removal of those wagers in turn could contribute to a late drop in odds and payoffs. Obviously, this scenario could generate adverse reaction from law-abiding fans, ranging from a perception of a “fixed race” to a perception of “past posting” -- making a bet after the official time when no more bets are to be taken.

When combined with robotic wagering – which provides an instantaneous view of the odds for all other pools – odds manipulation can be achieved by placing a large wager or set of wagers just before the wagers of traditional slower patrons. This is another type of “front running” – where one player takes unfair advantage of other players using advance knowledge of pending wagers. This is similar to the front-running situations associated with high frequency trading, “naked access,” and flickering quotes associated with today’s financial markets,

The MonitorPlus odds manipulation surveillance rules utilizes a series of automatically generates datasets that track wagering totals, odds progression, and cancel transactions that indicate suspicious time series patterns.

**Pool Arbitrage and Robotic Wagering.** Pool arbitrage occurs when the bettor has computer access to the latest possible betting totals in each pool, thus facilitating a computer program to generate wagers in appropriate amounts for specific bet combinations for each, with a sufficient level of confidence that the winning wager payoffs will not vary significantly from the projected values. This is especially effective where wagering levels are modest as the variability on each contestant is greater when separate pools are compared. Pool arbitrage need not be deployed on an absolutely risk-free basis with respect to each race evaluated: ironically, a risk-free profit strategy

on each race could limit other wagering opportunities by restricting the amount wagered. The arbitrage strategy, in combination with whatever selection strategy is employed, needs only to reliably demonstrate, over time, a sufficient rate of return to justify the time and effort involved.

Pool Arbitrage may also be effective for major events, where a much more significant portion of wagers may be from more casual bettors whose wagers may be mainly in reaction to publicity about the event or the contestants.

The MonitorPlus surveillance rules for pool arbitrage and robotic wagering identify computer facilitated arbitrage wagering sources. It issues alerts and detailed reports concerning the effect of potentially inappropriate wagers on the overall parimutuel pools. MonitorPlus generates robotic wagering datasets to identify and monitor the impact of arbitrage over several levels of granularity: per time, per race, and per pool.

**Performance Fraud.** When a horse wins at long odds -- contrary to expectations based on past performances -- or conversely, is bet down to a level inconsistent with its past performances, there is good reason to open a formal investigation. In the past, investigations were only occasionally pursued, based on anecdotal and fortuitous information sources. This is because of the complexity, cost, and tedium associated with obtaining and evaluating complex wagering and other data relating to a suspect race.

The MonitorPlus surveillance rules for performance fraud provide a timely alert when race results coincide with suspect wagering activity. MonitorPlus utilizes data sources such as past performance, licensee rulings, affiliation data, and investigative intelligence to further classify alerts and assist the investigative process.

**Money Laundering & Terror Financing.** Money laundering is the process by which criminal monetary profits are cycled through financial transactions to disguise their origins and provide a source of apparent legal income to the perpetrators. In the past, no parimutuel organization was able to rule out the possibility of collusion between a money launderer and a parimutuel employee or associate. Such collusion can obscure a winner's identity in order to transfer prize money to a money launderer. Parimutuel operations are vulnerable to sanitizing "dirty money" that may come from criminal activities and organizations. The laundered money can be subsequently used for illegal purposes -- including terror financing.

The MonitorPlus surveillance rules for money laundering specifically identify suspect wagering patterns that are indicative of collusion and possible money laundering.

**Dead Contender Scenario.** The easiest way to illegally fix a race (and cash in on parimutuel pools) is to illegally arrange a favorite or second favorite win. Fixing a race, by having a so-called "Dead Contender" lose, requires only a very small number of people -- maybe only one. Exotic pool bets based on the outcome of one event, with high payoffs when the favorites are off the board, are most vulnerable.

The MonitorPlus surveillance rules for dead contenders identify these types of wagers for pools associated with each contest to detect any suspect or significant over-representation of wagering activity that excludes obvious favorites.

**Social Network Scenarios.** MonitorPlus identifies suspect associations between trainers, jockey agents, jockeys, owners, veterinarians, criminal histories and association with Advance Deposit Wagering accounts.

## Use of AI Technology in MonitorPlus

In our domain of parimutuel wagering surveillance (and fraud surveillance in general), criminals are always creative. The domain is open -- not closed. AI technologies like Bayesian belief propagation networks work best in a closed constrained environment. Similarly, our evaluation of neural networks found that they require massive training sets and generally discover patterns only in a limited domain -- again contrary to our open domain that allows creative criminals. Neural networks weights are often difficult to map into natural language rule-based explanations.

MonitorPlus employs the following different AI technologies; clustering, decision trees (via automatic inductive rule generation), rule-based knowledge, and an expert system inference engine. This multi-paradigm approach uniquely overcomes inherent expert system limitations. Our expert system is coupled to the clustering tools and the machine learning engine so that new rules that can be generated by new information. Our rule-based knowledge representation also facilitates the generation of automatic explanations that regulators find easy to understand.

In addition to AI technologies, MonitorPlus employs software technologies (such as Java, Ajax and Struts), and relational database technologies (SQL). In order to accommodate the older tote protocols and feeds, we have traditional C and C++ programmers on our development team. MonitorPlus also uses a proprietary on-line analytical processing (OLAP) application called T-REX.

## AI Components

The MonitorPlus database collects data from tote sources using the appropriate protocols, and models the data in SQL archives. Conflicts are normalized so that there is a uniform and simple method of accessing data. Secondary data tables, indices, and catalogs are also created, as well as test data tables.

Rule induction is accomplished using the algorithms of the C4.5 tool [6]. The decision trees generated by C4.5 are used by MonitorPlus for automatic rule generation. We use C4.5 instead of the later See5 mainly because C4.5 has an open source Java based implementation (within the WEKA library) that can be integrated into a Java Enterprise environment; See5 does not have such integration capabilities. The training sets can be of any

size, and it depends on the specific domain. In general we obtained best results with training sets of around 100 to 500 records. Figure 2 shows an example of a C4.5 tree for a dead contender.

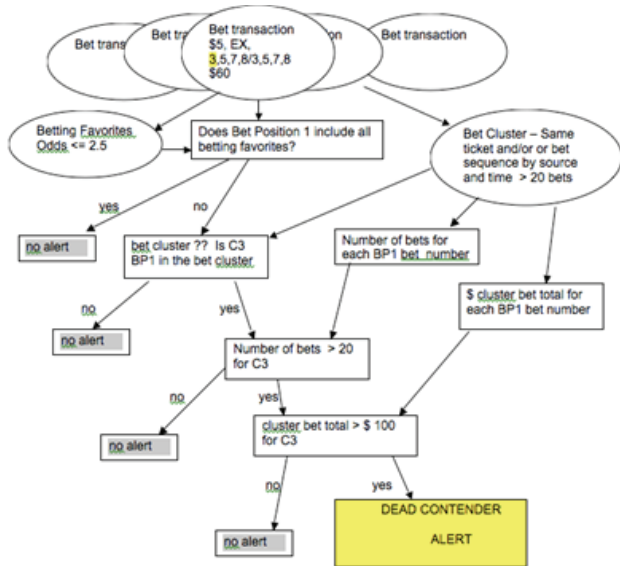


Figure 2. C4.5 Induced Decision Tree for Dead Contender

We selected Drools [1] as our business rule management system. Drools is based on various industry standards for its business rule engine and enterprise framework for the construction, maintenance, and enforcement of business policies in an organization, application, or service. It consists of a logic-based language and a forward chaining inference based rules engine (a production rule interpreter) that uses an enhanced implementation of the Rete algorithm (made famous by OPS5).

We did our initial implementations on Drools 4. We are in the process of evaluating Drools 5 (Drools Expert and Drools Fusion) since Drools 5 is stable. Drools Guvnor is clearly not a fit for our application, because we require that the engine must be integrated within a more complex system containing its own customized user interface. In alert mode, the Drools runtime engine fast implementation of Rete fires rules on live data.

For example: Figure 3 shows a Drools rule that was automatically generated from C4.5. It results from examining known cases of high bets placed on winning horses that had poor odds, automatically discovers and creates rules for possible money laundering.

Our subject matter experts can also manually create rules. One example of such a surveillance rule is the detection of race fixing: the goal is to flag accounts that contain just a few big bets, but with a high return to the wager. One of our subject matter experts (SME) has over 30 years of parimutuel experience -- as a regulator, steward and judge. Our SME uses the MonitorPlus tools to create rules based on what-if and production scenarios. In

forensic analysis mode, Drools is used as a rule editor and SQL interface.

IF PLAYED < 30	THEN	RegularAccount
IF PLAYED > AVERAGE_PLAYED	AND	
RETURN_RATE < 1.2	AND	
RETURN_RATE > 0.7	THEN	MoneyLaundry
IF TOTAL_BET_OVER_AVG > 1	AND	
AVERAGE_PLAYED > 1	THEN	Possible_MoneyLaundry

Figure 3. C4.5 generated Drools rule

The rule-based knowledge representations map conveniently into an easy-to-understand user interface. For example, from the "Lobby," analysts see the amount of new alerts, separated by priority. On the Notifications tab, analysts are presented with detailed information related to the alert, including its priority, a brief description, and the date the alert was raised. From the list, they can query drill down into any specific alert, details, or triggering event.

Finally, on the alert detail tab, analysts can access more detailed information regarding the alert. Analysts can access a detailed description on the triggering event cause that raised the alert (in this example, the details of the wager that generated the alert). Each MonitorPlus alert also presents a recommended course of action to take.

We frequently heard the question: "Are technologies such as OLAP better than the AI technologies?" Simply stated, the answer is "no." OLAP is convenient for clustering and statistical reports (especially in forensic analysis mode). But real-time self-documenting rule-based alerts are required when our goal is to prevent potential criminals from engaging in fraudulent activity in real-time. Figure 4 shows how our proprietary clustering algorithm justifies a potential money laundering alert in a Pick 3 pool.

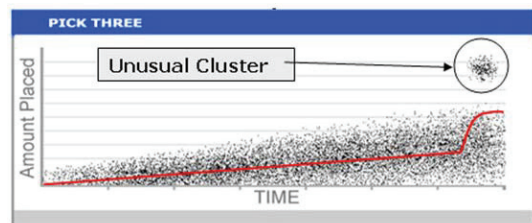


Figure 4. Clustering

## Application Use and Benefits

The benefits of a fraud surveillance system are measured by how many harmful events are avoided or caught early. This is significant in the parimutuel industry, where millions of dollars fund state and other public programs, charities, and other expenditures. Parimutuel wagering scandals induce players to be wary of making parimutuel wagers in much the same way that insider trading and

financial market scandals induce investors to be wary of financial markets. In both cases, volumes drop and the parimutuel operators (or financial market makers) lose business. In the parimutuel case, this additionally jeopardizes the funding of government programs: the state loses income.

One example of a harmful event that spurred the development of MonitorPlus was the Pick Six Scandal that unfolded from October 2002 to March 2003. In this scandal, a tote company employee was able to electronically alter wagering transaction records. In particular, the employee altered an advance deposit wagering Off-Track Betting account set up at the small village of Catskill, New York. The altered transaction data was used in a Pick Four pool hosted at Balmoral Park (Illinois) and a Pick Six hosted at Belmont Park (New York), both made through the New York OTB network. Both resulted in collecting more than \$100,000 from the Catskill OTB account. The wagering pattern was unusual. For example, the transaction records of the first four races of the Pick Six were changed after these races were completed. The employee corrected the selections based on the race results in a way that this ensured a winning wager regardless of the outcome of the final two races. A similar strategy was used at the Breeders' Cup, hosted at Arlington Park (Illinois). Had this Pick Six been successful, it would have netted more than \$3 million. Instead, the employee and accomplices were caught, arrested, convicted and imprisoned. In the investigation, host and secondary parimutuel organizations were involved, as well as NTRA and RCI. The FBI was also called in due to inter-state criminal activity.

### **Some Specific Payoffs**

We believe MonitorPlus would have uncovered the suspicious Pick Six wagering patterns in real-time. As evidence, we have a short list of similar patterns that MonitorPlus uncovered:

**Pool Arbitrage.** MonitorPlus discovered a computer assisted wagering source that utilized pool arbitrage. That wagering source produced a net rate of return of \$1.50 per each \$1 wagered over 30+ consecutive racing days.

**Money Laundering.** Our "flying under the radar" clustering algorithm detected potential money laundering by automatically grouping accounts with multiple small bets on favorites.

**Suspicious Robotic Wagering.** An ADW robotic account had an unusually high rate of return over forty consecutive race dates. MonitorPlus identified all participants (owners, trainers, jockeys).

### **Application Development, Deployment, and Maintenance**

In the aftermath of the Pick Six scandal, RCI announced plans to create RCI Integrity Services (RCI-IS), a national monitoring service and database for parimutuel wagering.

RCI-IS specifically was formed to serve as a service bureau. During this time the first version of MonitorPlus was funded and developed. After about 20 months of testing, the first version of MonitorPlus was validated by RCI-IS and became the only tested and approved parimutuel surveillance system. Moreover, MonitorPlus was implemented as a secure surveillance utility: it was independent of any particular tote company, parimutuel organization, or state regulator and could be used across multiple legal jurisdictions.

In addition to a variety of test files, RCI-IS was able to obtain actual parimutuel transactions data (from two US states), and actual robotic wagering data from an ADW company. Every MonitorPlus component, from the extraction of data for analysis, formatting data for analysis, development of rule profiles, automatic generation of alerts, alert notification (delivery, feedback, subscription, and management) was extensively tested. The results and findings were presented at numerous parimutuel industry events. Each and every function of MonitorPlus (in alert mode and forensic analysis mode) was tested by the execution and analysis of hundreds of what-if queries. The real time alert capabilities of MonitorPlus were tested with real time data streams and test files with millions of records of parimutuel wagering activity. In addition, we were able to stress test the system to loads far in excess of industry load, including extraordinary loads due to special race day events.

Since MonitorPlus is a utility, it does not require hardware installation. It accepts secure data from any tote, in any form (preferably using a secure protocol). This utility model for surveillance dramatically simplifies maintenance, and avoids version configuration issues that plague surveillance applications in industries such as financial services.

Even though the earlier versions of MonitorPlus were a success for the technology, in some sense the business model it was based on was a failure. RCI-IS was disbanded because the parimutuel industry resented a quasi-regulatory body acting as an independent monitor. The industry was really afraid that the regulatory authority controlling RCI-IS would interfere, specifically if an alert was raised that did not rise to the level that would normally require regulatory notification or intervention. The industry was also concerned that the regulators would snoop around the client-base – for business reasons, the identity of large bettors are closely guarded. Even though the parimutuel operators have a common interest to eliminate criminal activity, they are competitors with each other.

The business conflicts associated with the RCI-IS organization impacted the funding to keep the initial owners of MonitorPlus alive long enough to make sales. When Advanced Monitoring Systems, Inc. took control in 2008, it agreed to become a voluntary – not mandatory – centralized service utility. This approach was successful. The original development team of about ten programmers and knowledge engineers continued development and incorporated all features described in this paper. Currently

MonitorPlus is under contract to routinely monitor parimutuel wagering at 11 thoroughbred and harness racetracks and six Off Track Betting associations (including New York State OTB). Our secure surveillance utility paradigm is also being applied to other domains: MonitorPlus monitors the Oregon State Lottery.

### Acknowledgements

We wish to thank all of those who gave so generously in time: Samuel Cohen, Diego Gentile, Marie De Luca, Steve Keech, Bart Lewin, Ed Martin, John Martinson Sr., John Martinson Jr., Guillermo Morzan, Txema Monzon, Denny Oelschlager, Sergio Piano, Bezalel Raz, Benno Reibstein, J.P. Saraceno, Mike Sack, Erica Selis, Clive Spenser, Dr. Frances Tischler, Jeff True, Mariano Videla.

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