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(54) **METHOD FOR PERFORMING REAL-TIME ANALYTICS USING A BUSINESS RULES ENGINE ON REAL-TIME HETEROGENEOUS MATERIALIZED DATA VIEWS**

(75) Inventors: **Diaz H. Nesamoney**, Atherton, CA (US); **Martin Lewis Handwerker**, Palo Alto, CA (US); **Vaikom B. Krishnan**, Fremont, CA (US); **Nasrollah Jazayeri**, San Mateo, CA (US)

(73) Assignee: **International Business Machines Corporation**, Armonk, NY (US)

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(52) **U.S. Cl.** ..... **719/318; 707/8**

(58) **Field of Classification Search** ..... **719/318; 707/8**

See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

6,112,198	A	8/2000	Lohman et al.
6,272,502	B1	8/2001	Lieuwen et al.
6,289,335	B1	9/2001	Downing et al.
6,505,188	B1	1/2003	Ghazal et al.
6,681,230	B1	1/2004	Blott et al.
6,725,287	B1	4/2004	Loeb et al.
6,882,977	B1	4/2005	Miller
7,043,727	B2 *	5/2006	Bennett et al. .... 718/100
7,124,204	B2	10/2006	Givoly et al.

7,139,844	B2 *	11/2006	Smith et al. .... 709/250
2002/0060696	A1 *	5/2002	Seetharaman et al. .... 345/744
2003/0018506	A1	1/2003	McLean et al.
2003/0033179	A1 *	2/2003	Katz et al. .... 705/7
2003/0225769	A1 *	12/2003	Chkodrov et al. .... 707/100
2003/0227479	A1	12/2003	Mizrahi et al.
2004/0030739	A1	2/2004	Yousefzadeh
2004/0034661	A1 *	2/2004	Barron et al. .... 707/104.1
2004/0186860	A1 *	9/2004	Lee et al. .... 707/200
2004/0267828	A1	12/2004	Zwilling et al.

**OTHER PUBLICATIONS**

U.S. Appl. No. 10/446,336, filed on May 27, 2003 entitled "Method for Providing a Real Time View of Heterogeneous Enterprise Data" by Nesamoney et al.

U.S. Appl. No. 10/749,317, filed on Dec. 31, 2003 entitled "A Method and System for Dynamically Joining Views That Share a Common Key in a Streaming Database System" by Yan et al.

(Continued)

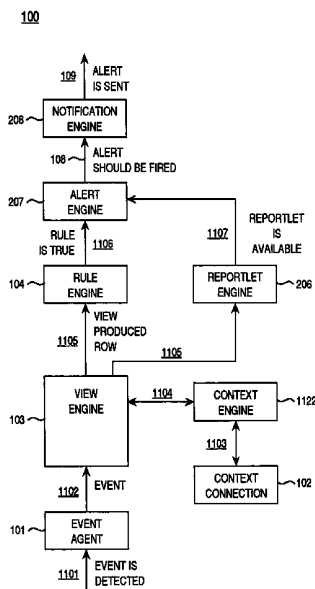
Primary Examiner—Li B Zhen

(74) Attorney, Agent, or Firm—Shumaker & Sieffert, P.A.

(57) **ABSTRACT**

A method for performing real-time analytics using a business rules engine on real time heterogeneous materialized data views is disclosed. The method comprises processing of rows produced by views corresponding to events. The rows are processed according to business rules by a view engine. Views with conditions equivalent to rule conditions are subscribed to by a rule engine, which outputs action messages corresponding to the rule condition. Where the rule condition is satisfied, a statement to that effect is sent, with any available reportlets, to an alert engine. The alert engine handles alert states corresponding to the action statement, saves any corresponding reportlets, and generates a message to fire an alert to a notification engine. The notification engine formats the alert and sends the alert by a selected medium, such as email, a webservice call, or another network protocol.

**25 Claims, 6 Drawing Sheets**



OTHER PUBLICATIONS

U.S. Appl. No. 10/750,507, filed on Dec. 31, 2003 entitled "A Method and System for Dynamically Initializing a View for a Streaming Data Base System" by Yan et al.

U.S. Appl. No. 60/941,166, filed on May 31, 2007 entitled "Streaming Multidimensional Data By Bypassing Multidimensional Query Processor" by Gupta.

\* cited by examiner

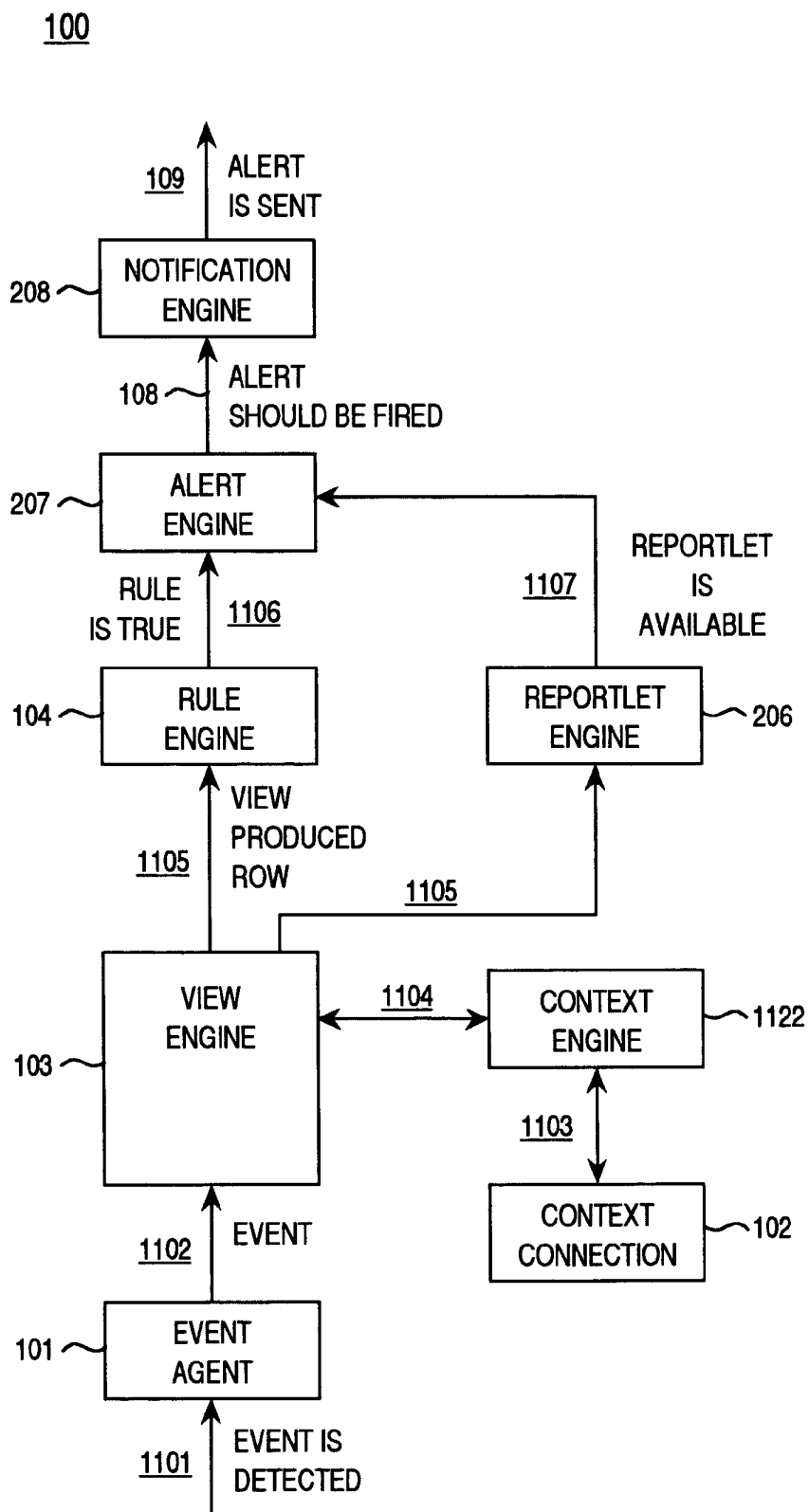


Fig. 1

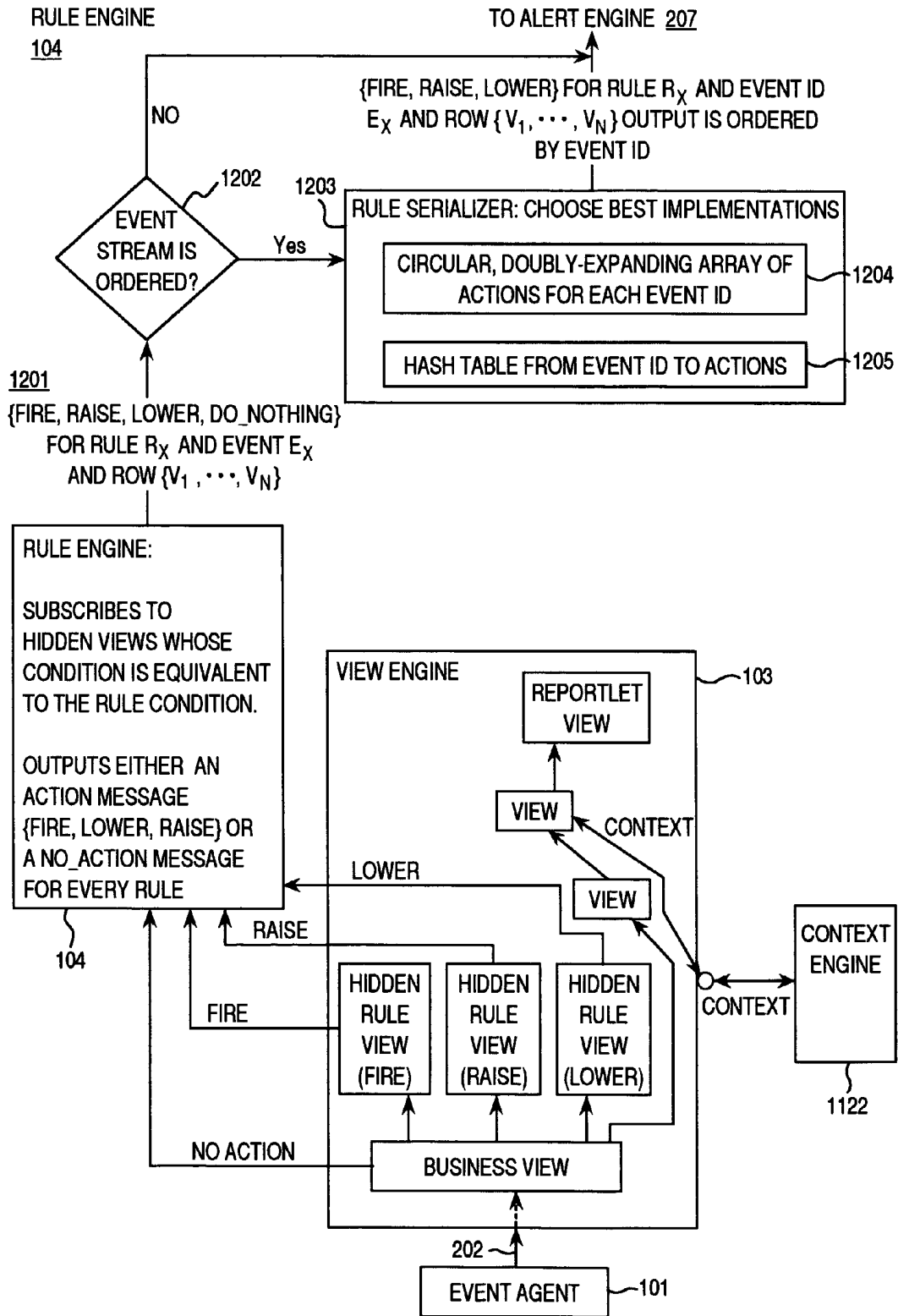


Fig. 2

104  
RULE ENGINE (CONTINUES)

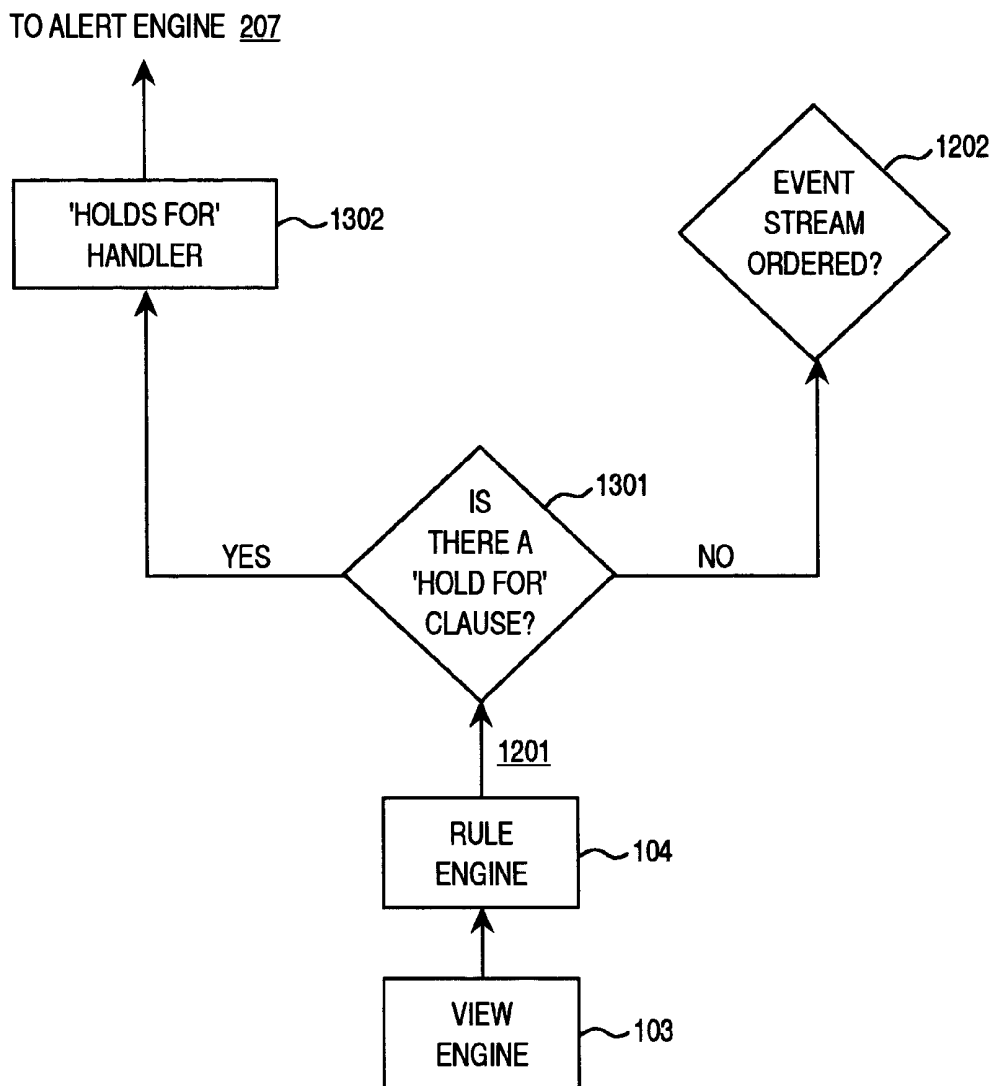


Fig. 3

REPORTLET ENGINE

206

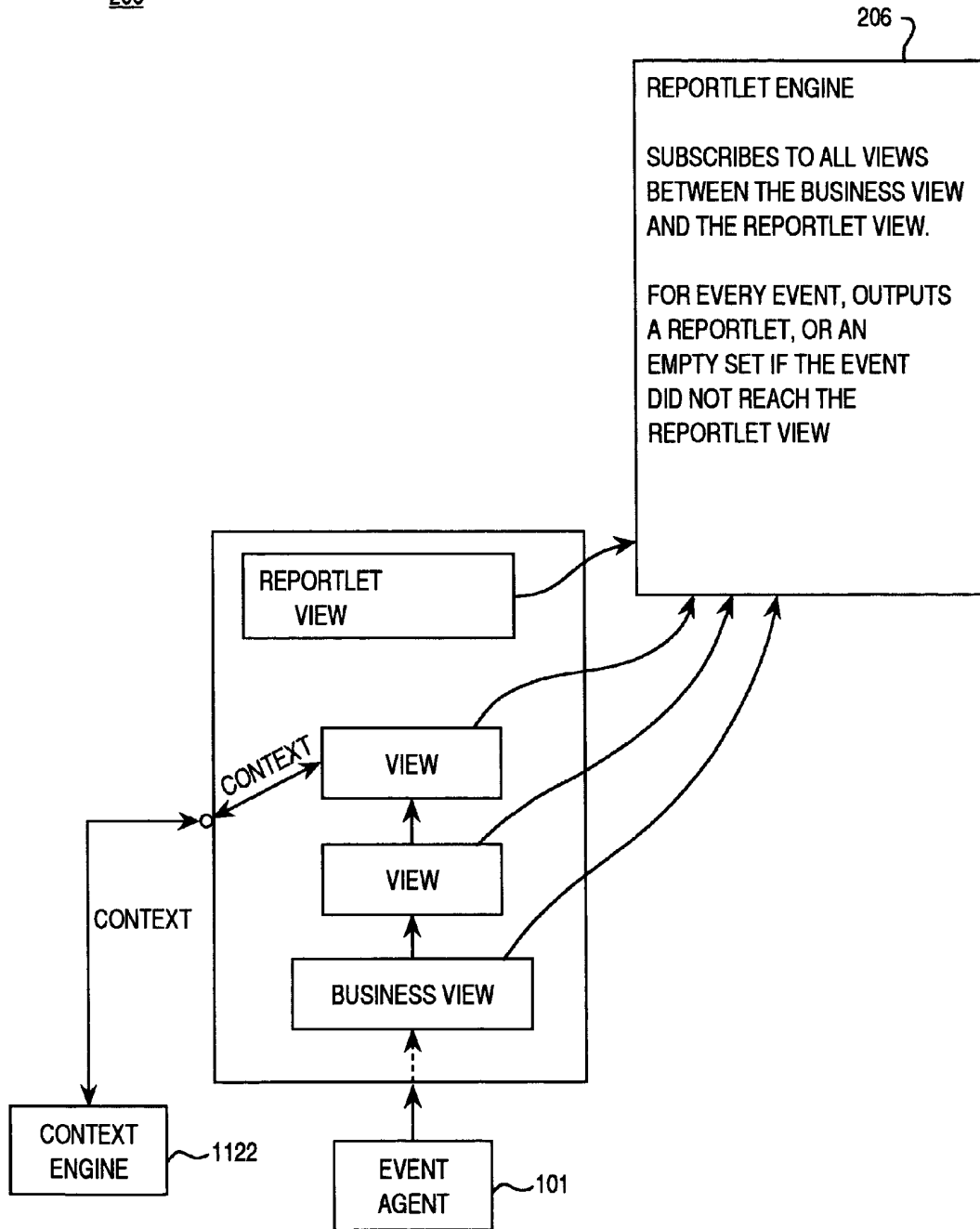
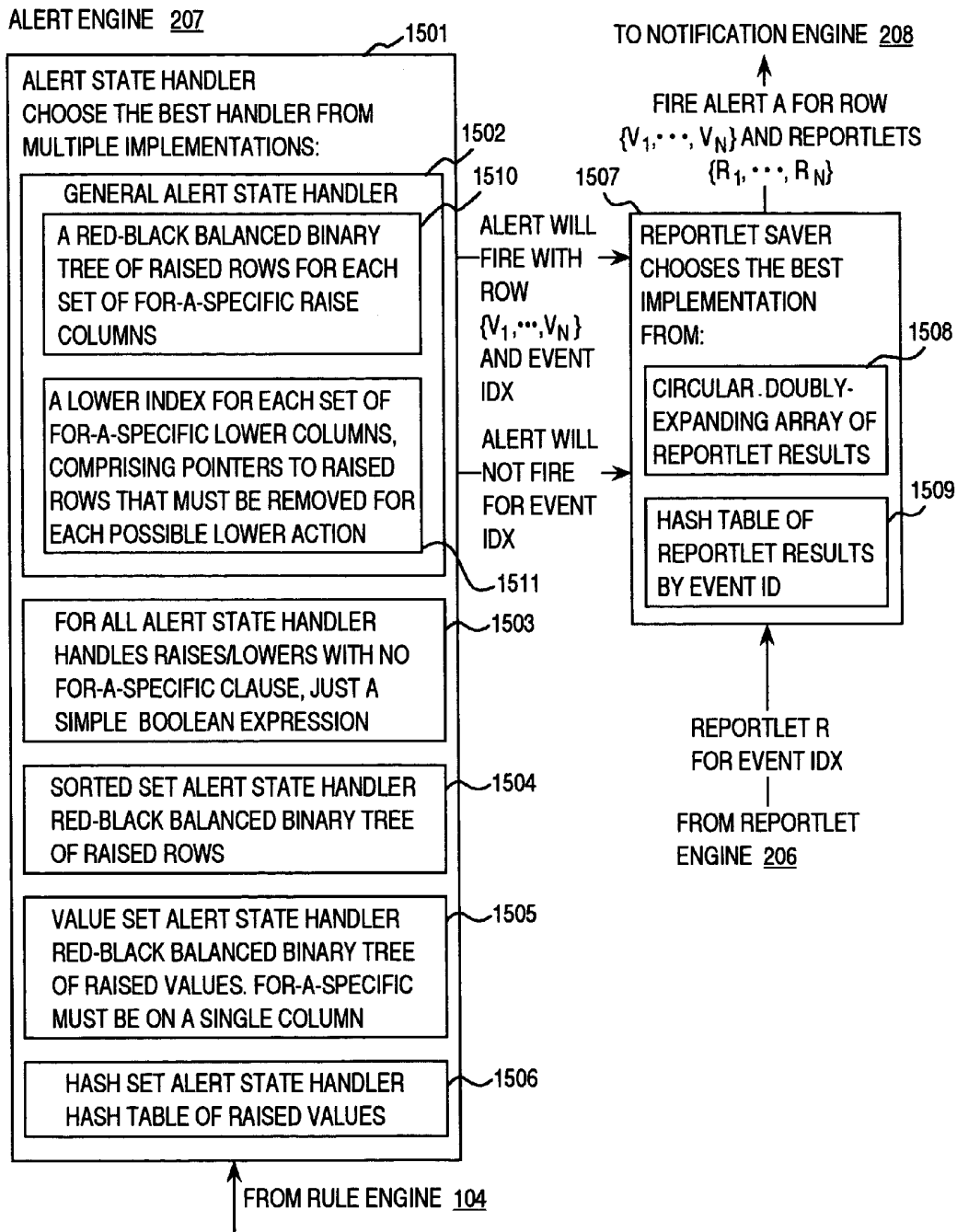


Fig. 4



RULE ENGINE PUBLISHES A MESSAGE  
FOR EVERY EVENT  $E_{x1}$  :  
"RULE  $R_{x2}$  ON VIEW  $V_{x3}$  {FIRED,  
RAISED, LOWERED, WILL\_DO\_NOTHING} FOR  
EVENT  $E_{x1}$  AND ROW  $\{V_1, \dots, V_N\}$  AND  
FOR SPECIFIC COLUMNS  $\{C_1, \dots, C_N\}$ "

Fig. 5

NOTIFICATION ENGINE

PROCESS BY WHICH REQUESTS TO FORMAT AND FIRE AN ALERT ARE HANDLED.

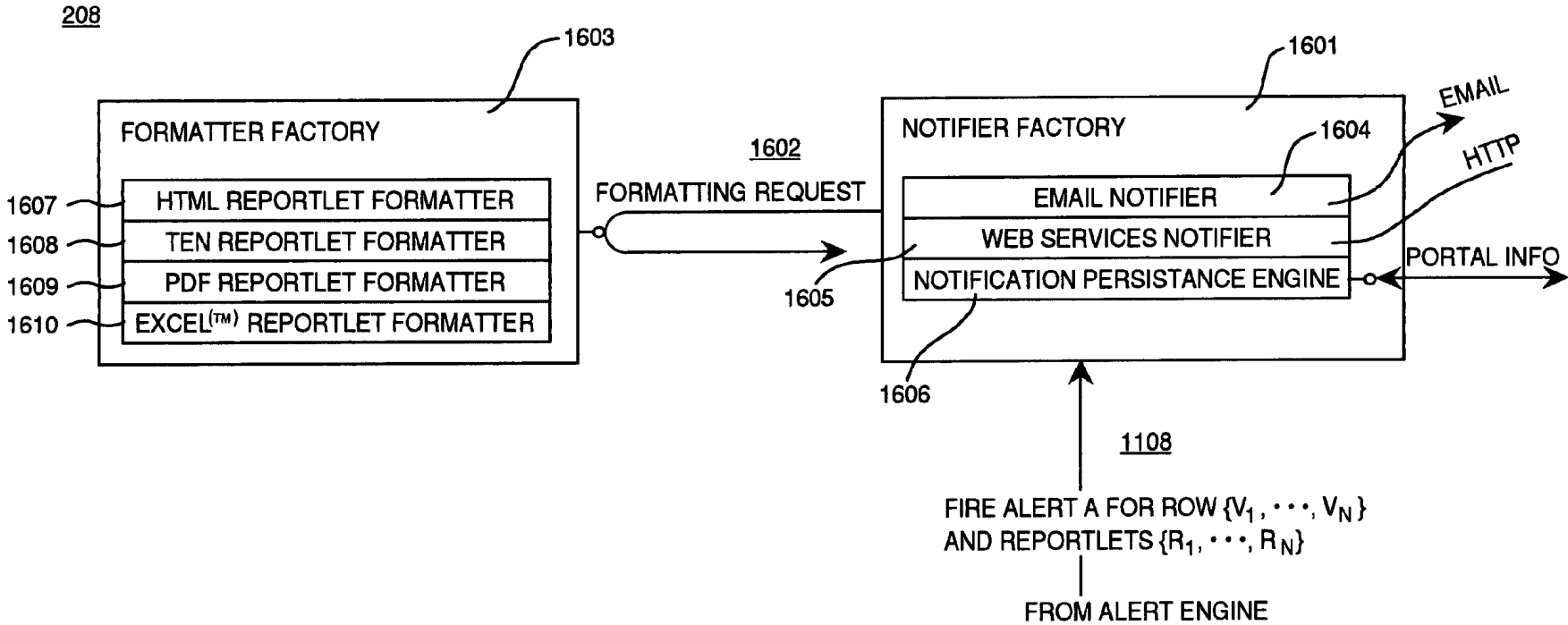


Fig. 6



**METHOD FOR PERFORMING REAL-TIME  
ANALYTICS USING A BUSINESS RULES  
ENGINE ON REAL-TIME HETEROGENEOUS  
MATERIALIZED DATA VIEWS**

FIELD OF THE INVENTION

The present invention relates to the field of business intelligence and analytics. More specifically, embodiments of the present invention relates to a method for performing real-time analytics using a business rules engine on heterogeneous materialized real-time data views.

BACKGROUND ART

Business intelligence and data warehousing software enable information from disparate parts of an enterprise to be obtained with relative ease. Great decision-making benefits are generated by business intelligence (BI). BI software integrates querying, reporting, on-line analytic processing (OLAP), data mining, and data warehousing functionality.

Such decision-making benefits are also provided by BI software because they enable a user to process information from as many databases as comprise a business (or other) organization's data storage resources. Further, BI software allows analysis of needed transactions and summaries, without having to know which databases, servers, and/or other information sources from which the information underpinning such transactions and summaries were derived.

By way of background with respect to the applications to business and other enterprises, an 'event' represents a business event, which is a business activity, transaction, or a change in the state of a business entity, for instance, in a large business. Implicitly, events comprise a time of occurrence and an identity. Examples of events include, but are not limited to, issuing a purchase order, taking a customer service call, replenishing supplies, issuing a forecast, and posting an expense item.

A 'context' represents data associated with an event. Typically, contexts are data that are descriptive of the events. A context can also comprise historic summary data, which can be available in a data warehouse or operational data store (ODS). Context data may also be obtained from other systems of record. Context data provides additional information that may be required for adding meaning to an event. Context data, in so far as it can be conventionally utilized, can be evaluated to ascertain whether or not a given event should trigger a heightened state of scrutiny and observation by analysts of the business environment in which a business or other enterprise is immersed.

Modern businesses face significant and increasing needs to obtain real time access to key business events. This need, for instance, can be expressed as a requirement from a business person that indicates that the certain business metrics need to be monitored in real-time or that when certain changes in these metrics caused by various business events imply adverse conditions or an opportunity, this is cause for an 'alert', e.g., notation of event occurrence, and heightened monitoring of associated data thereafter.

The event, for example could be an increase in call volume into a call center, inventory falling below a certain threshold level, a drop in a demand forecast, increase in the number of returns of a certain product, or that defect rates from a test system exceeded pre-specified limits, etc. At the occurrence of such an event, the business person may want a corresponding alert to attract and guide her/his attention.

Conventional reporting and analysis software (variously called Business Intelligence, Query and reporting tools, Data warehouses etc.) ("BI software") all provide reporting and analysis of business data. They do so by either executing queries directly against operational systems or by extracting and transforming in batches, operational data to an independent data store (sometimes called a data warehouse or data mart).

The above method by conventional reporting software results in the usage of a fixed (or static) data model from which data is analyzed. As a result of that, alert conditions cannot be detected without repeatedly running the reports on the data model, often resulting in poor performance of reports or an impact on the operational system itself, if reports are being run directly on it. In addition since the data is often extracted in batches, the resulting metrics are often hours to days old and therefore unsuitable for real-time analytics.

Some conventional reporting products contain alerting technology, however the alerting is based on repeated processing of batch data and on a fixed data model that is inflexible to the needs of real-time analytics.

Other mechanisms, also called event management software provides for alert conditions to be detected and alerts sent, however, it similarly uses fixed data models and batch updates to the data model and suffers the associated drawbacks described above.

Without event processing capabilities and the ability to combine events with context, and powerful business rules processing capability, the ability of a business organization or a similar organization utilizing BI software to engage in real time data analysis is limited. Lacking ability to engage in real time data analysis, a business organization or a similar organization utilizing BI software has only a limited capability at best to react instantaneously to changes in its business and to the business environment in which it operates.

SUMMARY OF THE INVENTION

A method for performing real-time analytics using a business rules engine on heterogeneous data views is disclosed. The method for monitoring a business activity using materialized real time views of heterogeneous enterprise data comprises specifying an alert level for conditions characterizing a real time event. A data element related to the real time event is processed by a business rule. An occurrence of the event in real time is detected where the occurrence indicates that the alert level specified has been reached. The business rule into which the data element has been translated is executed, and an alert corresponding to the business rule is generated.

In one embodiment, the alert is generated in an end user interaction system. The end user interaction system can be any of a number of media, including, but not limited to, voice, e-mail, facsimile, wireless, a web browser, a query and reporting tool, an annunciator, a personal digital assistant, a portal, and an application. The business rule can be created in a business rule language. The alert level for conditions characterizing a real time event can be specified in various media including, but not limited to, a visual interface and a business rules language interface.

In one embodiment, the event comprises a data element and the business rules language uses a construct to refer to the data element. The occurrence of the event in real time can be detected by a probe into the real-time stream of data materialized in the views. The alert corresponding to the business rule is generated with minimal latency after upon being detected.

FIG. 1 depicts a system for generating a real time view of heterogeneous enterprise data, according to one embodiment of the present invention.

FIG. 2 depicts a rule engine, according to one embodiment of the present invention.

FIG. 3 depicts a rule engine holds for handler, according to one embodiment of the present invention.

FIG. 4 depicts a reportlet engine, according to one embodiment of the present invention.

FIG. 5 depicts an alert engine, according to one embodiment of the present invention.

FIG. 6 depicts a notification engine, according to one embodiment of the present invention.

#### DETAILED DESCRIPTION

A system and method for performing real time analytics using a business rules engine on real-time heterogeneous materialized views is disclosed. In one embodiment, the system and method for performing real time analytics using a business rules engine on real-time heterogeneous materialized views applies a method and/or a system described in co-pending U.S. application Ser. No. 10/446,336, entitled "Method for Providing a Real Time View of Heterogeneous Enterprise Data," by Diaz H. Nesamoney, et al., and assigned to the assignee of the present invention, which is hereby incorporated by reference herein in its entirety.

In the following detailed description of an embodiment of the present invention, a system and method for performing real time analytics using a business rules engine on real-time heterogeneous materialized views, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be recognized by one skilled in the art that the present invention may be practiced without these specific details or with equivalents thereof. In other instances, well-known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the present invention.

Embodiments of the present invention are directed to system and method for performing real time analytics using a business rules engine on real-time heterogeneous materialized views. The system comprises an event-driven alert generator. Upon an agent detecting an event, a real-time view of the event is materialized, for instance as a row or series of rows. Context, such as historical data relevant to the event, can be added to the materialized view. The view can reach a reportlet view. The materialized views are processed according to a business rule, along with any available reportlets. Where the view satisfies the business rule, an alert is requested. Upon formatting (and adding any available reportlets), the alert is sent via email, a web page, persistently, or by another mode, including another network protocol.

A business or another enterprise using the system for performing real time analytics using a business rules engine on heterogeneous materialized views achieves the capability to monitor an event in context. Thus, the business or similar organization can effectively engage in real-time data analysis. Engaging in such analysis greatly increases the organization's effectiveness at reacting nearly instantaneously to changes in its business and to the business environment in which it operates.

As the terms are used herein, the following terms can have meanings comprising the following definitions. An 'event' is any change in the value of a critical data element in a transactional system that must be captured for the purpose of monitoring its value.

A 'context' is additional information added to an event to make it easier and/or more profitable to analyze the event to determine whether action is needed. 'Event context' is the combination of an event view with a context. An event context can be an entity on which an end user alerting business rule is built. Event context appears in one embodiment as a simple view in Structured Query Language (SQL), for purposes of defining rules for alert generation. Context can comprise, for example, historical data.

#### Exemplary Event to Alert Process

FIG. 1 depicts a process by which events enter a system **100**, which can comprise a business activity monitoring (BAM) system, contexts are queried, and formatted alerts with reportlets are sent out of the system, according to one embodiment of the present invention. Process **100** begins with step **1101**, wherein event agent **101** detects an event. Upon detecting an event, event agent **102** provides the event to view engine **103** in step **1102**.

In step **1103**, any available contexts relevant to the event are drawn by context connection **102** by context engine **1122** from a source system (e.g., source system **203**; FIG. 2). In step **1104**, the context engine **1122** provides the contexts to view engine **103**.

View engine **103** outputs rows produced by views that it generates, which correspond to the events. In step **1105**, such a view-produced corresponding to the event detected is sent to rule engine **104** and to reportlet engine **206**.

In step **1106**, rule engine **104** informs alert engine **207** that the rule condition is satisfied. In step **1107**, reportlet engine **206** informs alert engine **207** that a reportlet corresponding to the view-produced rows are available.

In step **1108**, alert engine **207** informs notification engine **208** that an alert should be fired. In step **1109**, notification engine **208** sends an alert.

FIG. 2 depicts the operation of rule engine **104** for generating an action message (such as in step **1106** of process **1**; FIG. 1) to alert engine **207**. As described in FIG. 2, view engine **103** functions as a main memory database system that processes event streams entering the system (e.g., BAM server **100**; FIG. 1), continuously maintains the views, as described above in FIG. 3.

Business users use the materialized views to define business rules. Views can comprise either business views or hidden views. The business views are the views defined by application developers and used by the business users to define business rules.

The hidden views are defined by the rule engine **104** and reportlet engine **206** for the purpose of evaluating rules. The hidden views are therefore generated by the system **100** and are not visible to the users. The hidden views are processed similarly as the business views.

An event stream thread **202** is asynchronously pushed or synchronously pulled from a source system **201**. View engine **103** receives an event from event stream thread **202** of event agent **101**. Context can be received by context engine **1122** to form another business view.

Rule engine **104** subscribes to the hidden rule views of view engine **103** whose condition is equivalent to a rule condition relevant to the business view. Rule engine **104** then outputs an action message **1201** where the rule is met by the

business view. Action message **1201** can call for firing an alert, taking another action (such as raising or lowering the alert), or where the rule condition is not met by the business view, a message to take no action.

Action message **1201** can thus take the form ‘{Fire, Raise, Lower, Do\_nothing} for rule  $R_x$  and event  $Ex$  and row  $\{V_1, \dots, V_n\}$ ’. ‘Fire’ states that the rule condition is satisfied and that an alert should be fired. ‘Raise’ informs the alert engine **207** the point at which an alert should first be triggered. ‘Lower’ allows the system to consider resetting the point at which a subsequent alert is triggered.

Advantageously, this feature rectifies hysteresis, in which subsequent alerts can be distracting and non-informative. For example, a rule can specify that an alert fire when an event occurs, such as an inventory dropping below a certain figure, such as **100**. As soon as the inventory drops to **99**, the alert is triggered, allowing corresponding action to be taken. Prior to taking action, inventory may rise to **100** again and then drop to **99**, triggering another alert. However, since the alert state is already “raised,” another alert will not be sent.

A determination **1202** is made as to whether the event stream is ordered. If not, action message **1201** is sent directly to alert engine **207**. If it is determined that the event stream is ordered, then the action message **1201** is sent to a rule serializer **1203**. Rule serializer **1203** chooses the best implementation for serializing the action message.

Rule serializer **1203** can select a circular doubly-expanding array **1204** of actions for each event identifier. Alternatively, rule serializer can select a hash table from event identifiers to actions. A serialized action message **1206**, ordered by event identifier, is then sent to alert engine **207**.

FIG. **3** depicts the operation of rule engine **104** in one embodiment of the present invention. In the present embodiment, the operation of rule engine **104** corresponds to a temporally significant rule. From the hidden rules **1310** to which rule engine **104** subscribes, message **1201** is generated as described above (FIG. **12**). A determination **1301** is made as to whether the message comprises a ‘holds for’ clause. If not, determination **1202** proceeds as described above.

If it is determined that message **1201** comprises a holds for clause, then the message is handled by a holds for handler **1302**, which can operate in conjunction with a timer. Holds for handler **1302** allows generation of an alert to be forestalled until another (e.g., subsequent) particular event occurs, or cancelled if certain events occur or do not occur during a specified time duration. Upon the occurrence of the subsequent event, message **1201** is sent to alert engine **207**.

Similarly, another determination can be made as to whether message **1201** comprises a ‘For a specific’ clause. If not, determination **1202** proceeds as described above (FIG. **12**). If it is determined that message **1201** comprises a for a specific clause, then holds for handler **1302** (or a dedicated for a specific handler) tracks the Raise/Lower state for each unique tuple in a specific set of columns. Applying this to the inventory example in the Raise/Lower discussion above, the Raise/Lower state can be tracked for each specific item in the inventory.

FIG. **4** depicts the operation of reportlet engine **206**, according to one embodiment of the present invention. Event agent **102** provides the event to view engine **103**. Any available contexts relevant to the event are provided by context engine **1122** to view engine **103**. View engine **103** outputs rows produced by views that it generates, which correspond to the events.

Reportlet engine **206** subscribes to all views generated by view engine **103** that are between the business view and the reportlet view, inclusive. For every event, reportlet engine **206**

outputs a reportlet or, if a particular event does not reach the reportlet view, an empty set. Available reportlets are sent to alert engine **207**.

FIG. **5** depicts the operation of alert engine **207**, according to one embodiment of the present invention. Alert engine **207** comprises an alert state handler **1501** and a reportlet saver **1507**. Alert state handler **1501** receives a message published by rule engine **104** for every event. For an event  $Exam$  such a message can comprise a format such as ‘Rule  $R_{x2}$  on view  $V_{x3}$  {fired, raised, lowered, will\_do\_nothing} for event  $Ex$ , and Row  $\{V_1, \dots, V_n\}$  and for specific columns  $\{C_1, \dots, C_n\}$ ’.

To handle the alert state corresponding to this message, alert state handler **1501** chooses the best handler from amongst multiple handler implementations. The handler implementations comprising alert state handler **1501** can include generic alert state handler **1502**, for all alert state handler **1503**, sorted set alert state handler **1504**, value set alert state handler **1505**, and hash set alert state handler **1506**.

Generic alert state handler **1502** comprises a red-black balanced binary tree **1510** of raised rows for each set of for-a-specific raise columns. Generic alert state handler **1502** further comprises a lower index **1511** for each set of for-a-specific lower columns. Lower index **1511** comprises pointers to raised rows, which must be removed for each possible lower action.

For all alert state handler **1503** handles raises and lowers rules with no for-a-specific clause. In one embodiment, for all alert state handler **1503** is implemented as a Boolean, which is true if the alert is in a raised state. Sorted set state handler **1504** comprises a red-black balanced binary tree of raised rows. Value set alert state handler **1505** comprises a red-black balanced binary tree of raised values wherein for-a-specific must be on a single column. Hash set alert state handler **1506** comprises a hash table of raised values.

Upon choosing the best handler for a particular set of rules and handling the corresponding alert state accordingly, alert state handler **1501** outputs a message to reportlet saver **1507**. The message to reportlet saver **1507** can state, for instance, either ‘Alert will not fire for event  $ID_x$ ’ or ‘Alert will fire with row  $\{V_1, \dots, V_n\}$  and event  $ID_x$ ’. Reportlet saver **1507** receives a reportlet  $R$  for event  $ID_x$  from reportlet engine **206**.

To handle the reportlets corresponding to event  $ID_x$  with the alert state messages from alert state handler **1501**, reportlet saver **1507** selects the best implementation from two choices. The implementations comprising reportlet saver **1507** include a circular doubly-expanding array **1508** of reportlet results or a hash table **1509** of reportlet results by event identifier.

Where the message from alert state handler **1501** states that ‘alert will fire with row  $\{V_1, \dots, V_n\}$  and event  $ID_x$ ’, reportlet saver **1507** sends alert should be fired message **1108** to notification engine **208**. Alert should be fired message **1108** can take the form ‘Fire alert  $A$  for row  $\{V_1, \dots, V_n\}$  and reportlets  $\{R_1, \dots, R_n\}$ ’.

FIG. **6** depicts the operation of notification engine **208** by which requests such as message **1108** to format and fire an alert are handled. Notification engine **208** comprises a notifier factory **1601**, which makes formatting requests **1602** to and receives corresponding formats from a formatter factory **1603**.

Formatter factory **1603** comprises an HTML reportlet formatter **1607**, a text formatter **1608**, a PDF formatter **1609**, and an Excel™ (commercially available by Microsoft, a corporation in Redmond, Wash.) formatter **1610**. In one embodiment, formatter **1610** can format for other spreadsheet programs. Formatter factory **1603** can comprise other formatters, as desired for particular applications.

Notifier factory **1601** comprises an email notifier **1604**, a web services notifier **1605**, and a notification persistence engine **1606**. Email notifier **1604** sends alerts by email. Web services notifier **1605** generates alerts in a format using open standards such as XML to allow the alert-generating web-based application (e.g., system **100**; FIG. **1**) to dynamically provide the alert to another web-based application with which it is “talking” (e.g., server to server). Notification persistence engine **1606** persists alerts, which can later be queried through an interface by a portal. Alerts can be presented by spreadsheet programs, as well as by voice, facsimile, wireless, a query and reporting tool, an annunciator, and a personal digital assistant, or by another network protocol.

In summary, a method for performing real-time analytics using a business rules engine on heterogeneous materialized data views is thus described. The method comprises, processing of rows produced by views corresponding to events. The rows are processed according to business rules by a view engine. Views with conditions equivalent to rule conditions are subscribed to by a rule engine, which outputs action messages corresponding to the rule condition, or a no action message. Where the rule conditions are satisfied, a statement to that effect is sent, with any available reportlets, to an alert engine. The alert engine handles alert states corresponding to the action statement, saves any corresponding reportlets, and generates a message to fire an alert to a notification engine. The notification engine formats the alert and sends the alert by a selected medium, such as email, a webpage, or a spreadsheet.

Embodiments of the present invention are directed to a method for real time analytics using a business rules engine on heterogeneous materialized data views that are both event-definitive and context-definitive. An embodiment of the present invention readily formulates and sustains a maintainable real time view of business events. Further, an embodiment of the present invention has interpretive and predictive usefulness. The method can be performed by a computer system or a network of computer systems acting under the control of computer readable and executable code embodied within a computer readable medium.

An embodiment of the present invention, a method for performing real-time analytics using a business rules engine on heterogeneous materialized data views is thus described. While the present invention has been described in particular embodiments, it should be appreciated that the present invention should not be construed as limited by such embodiments, but rather construed according to the below claims and their equivalents.

What is claimed is:

**1.** A method comprising:

detecting an event within a real-time stream of data while said real-time stream is received from an external system prior to storing said event in a database;

after detecting said event, materializing a real-time view of said event as one or more rows within a stream of rows; probing into said stream of rows, wherein said probing comprises subscribing to a plurality of hidden views automatically generated in response to said stream of rows, wherein a condition of one of said plurality of hidden views is equivalent to a condition of one of a plurality of business rules;

generating an action statement, wherein said generating of said action statement comprises:

determining that said action statement comprises a ‘holds for’ clause; and

upon said determining that said action statement comprises a ‘holds for’ clause, handling said action statement

according to said ‘holds for’ clause, wherein said ‘holds for’ clause selectively forestalls said generating until a particular event occurs, and cancels said generating when said particular event does not occur during a specified time duration;

using a plurality of user-defined dynamic specifications, wherein each individual specification sets forth a change to be detected in said real time materialized view of said event and also a corresponding action to be taken in response to said change; and

upon detecting said change set forth by at least one user-defined dynamic specification, triggering said corresponding action of said at least one specification.

**2.** The method as recited in claim **1** wherein said corresponding action comprises generating an alert.

**3.** The method as recited in claim **2** wherein said alert is generated in an end user interaction system wherein said end user interaction system comprises a medium selected from a group consisting of e-mail, a web browser, a portal, a query and reporting tool, a spreadsheet program, voice, facsimile, wireless, an annunciator, and a personal digital assistant.

**4.** The method as recited in claim **1** wherein said plurality of user-defined dynamic specifications comprises a plurality of business views, wherein said plurality of business views are used to define business rules, and wherein said plurality of business views selectively comprises a business view to which context has been added wherein said context comprises historical data.

**5.** The method as recited in claim **1**, further comprising processing one of said plurality of business views and said plurality of hidden views wherein said rule condition of said one of said plurality of business views is ascertained, wherein said action statement describes the truthfulness of said rule condition, and wherein said action statement is selected from a group consisting of fire, raise, lower, and no action.

**6.** The method as recited in claim **5** wherein said generating comprises:

determining that said stream of rows is ordered; and serializing said statement accordingly.

**7.** The method as recited in claim **5** wherein said processing further comprises:

subscribing to said plurality of business views;

determining that said plurality of business views comprises a reportlet view; and

upon determining that said plurality of business views comprises a reportlet view, outputting a reportlet corresponding to said reportlet view wherein said statement includes said reportlet.

**8.** The method as recited in claim **5** wherein said generating comprises:

publishing a message wherein said message states that a rule on said view took an action selected from the group consisting of fired, raised, lowered, did nothing, for said event and said row and for a specified plurality of columns, wherein said group corresponds to an alert state for said business view; and

handling said alert state, wherein said handling comprises sending a request to trigger said corresponding action and selectively sending a corresponding reportlet.

**9.** A method comprising:

detecting an event within a real-time stream of data while said real-time stream is received from an external system prior to storing said event in a database;

after detecting said event, materializing a real-time view of said event as one or more rows within a stream of rows; probing into said stream of rows, wherein said probing comprises subscribing to a plurality of hidden views

automatically generated in response to said stream of rows, wherein a condition of one of said plurality of hidden views is equivalent to a condition of one of a plurality of business rules;

generating an action statement, wherein said generating of said action statement comprises:

determining that said action statement comprises a 'for a specific' clause; and

upon said determining that said actions statement comprises a 'for a specific' clause, handling said action statement according to said 'for a specific' clause, wherein said 'for a specific' clause tracks a Raise/Lower state for each unique tuple of a plurality of tuples comprising a specific set of columns;

using a plurality of user-defined dynamic specifications, wherein each individual specification sets forth a change to be detected in said real time materialized view of said event and also a corresponding action to be taken in response to said change; and

upon detecting said change set forth by at least one user-defined dynamic specification, triggering said corresponding action of said at least one specification.

**10.** A computer-implemented system for performing real-time analytics on heterogeneous data views materialized as a stream of rows, comprising:

- a processor;
- an agent recorded on a medium readable by the processor, the agent executed by the processor for detecting an event within a real-time stream of data that is received from an external system;
- a view engine recorded on a medium readable by the processor, the view engine executed by the processor for receiving said event from said agent, for materializing one or more real-time views of said event as one or more rows within said stream of rows, wherein said views comprise one or more business views and one or more hidden views, and wherein said business views are used to define one or more business rules;
- a rule engine recorded on a medium readable by the processor, the rule engine executed by the processor for receiving said stream of rows of said real-time materialized views from said view engine, for subscribing to said hidden views, wherein each of said hidden views has a condition equivalent to that of one of said business rules, and for generating a message to take an action corresponding to said condition specified by at least one of said business rules based upon said received stream of rows, wherein said rule engine is further configured for determining that said message comprises a 'holds for' clause and, upon said determining that said message comprises said 'holds for' clause, handling said message according to said 'holds for' clause, wherein said 'holds for' clause selectively forestalls said generating of said message until a particular event occurs and cancels said generating of said message when said particular event does not occur during a specified time duration;
- an alert engine recorded on a medium readable by the processor, the alert engine executed by the processor for receiving said message to take an action from said view engine, for handling an alert state corresponding to said message, and for generating a request to fire an alert; and
- a notification engine recorded on a medium readable by the processor, the notification engine executed by the processor for receiving said request from said alert engine, for formatting said alert as a notice and for sending said notice to a user.

**11.** The system as recited in claim **10** further comprising a reportlet engine receiving said stream of rows from said view engine, for subscribing to said views and, where said views include a reportlet view, generating a reportlet corresponding to said reportlet view, wherein said alert engine is also for saving said reportlet.

**12.** The system as recited in claim **10** further comprising a context engine providing context to said view engine, wherein said context comprises historical data relevant to said views and wherein said context is added to said views, for retrieving said context from a context connection.

**13.** The system as recited in claim **10** wherein said rule engine is further for determining that said event stream is ordered and, upon said determining, serializing said event stream.

**14.** The system as recited in claim **13** wherein said rule engine comprises a rule serializer for performing and serializing.

**15.** The system as recited in claim **14** wherein said rule serializer comprises a functionality selected from a group consisting of a hash table from an identifier corresponding to said event to said action, and a circular, doubly-expanding array of said action corresponding to said event.

**16.** The system as recited in claim **10** wherein said alert engine performs said handling by a functionality comprising a handler selected from a group consisting of:

- a red-black balanced binary tree of raised rows corresponding to a set of 'for a specific' raise columns and a lower index corresponding to a set of 'for a specific' lower columns, wherein said lower index comprises a pointer to one of said raised rows that must be removed to perform a lower action;

- a red-black balanced binary tree of raised rows;

- a red-black balanced binary tree of raised values wherein a 'for a specific' clause corresponds to a single column; and

- a hash table of raised values.

**17.** The system as recited in claim **10** wherein said notification engine comprises:

- a notice factory receiving said request from said alert engine, for performing said sending; and

- a format factory receiving a formatting request from said notice factory, for performing said formatting according to said formatting request.

**18.** The system as recited in claim **17** wherein said notice factory comprises:

- an email notifier for sending said notice wherein said notice comprises an email;

- a web services notifier for dynamically sending said notice to a web-based application; and

- a notification persistence engine for persisting said notice for later querying through an interface by a portal.

**19.** The system as recited in claim **17** wherein said format factory comprises:

- a HTML reportlet formatter;

- a text reportlet formatter;

- a PDF reportlet formatter; and

- a spreadsheet reportlet formatter.

**20.** A system for performing real-time analytics on heterogeneous data views materialized as a stream of rows, comprising:

- a processor;

- an agent recorded on a medium readable by the processor, the agent executed by the processor for detecting an event within a real-time stream of data that is received from an external system;

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a view engine recorded on a medium readable by the processor, the view engine executed by the processor for receiving said event from said agent, for materializing one or more real-time views of said event as one or more rows within said stream of rows, wherein said views 5 comprise one or more business views and one or more hidden views, and wherein said business views are used to define one or more business rules;

a rule engine recorded on a medium readable by the processor, the rule engine executed by the processor for receiving said stream of rows of said real-time materialized views from said view engine, for subscribing to said hidden views, wherein each of said hidden views has a condition equivalent to that of one of said business rules, and for generating a message to take an action 15 corresponding to said condition specified by at least one of said business rules based upon said received stream of rows, wherein said rule engine is further configured for determining that said message comprises a 'for a specific' clause and, upon said determining that said message comprises said 'for a specific' clause, handling said message according to said 'for a specific' clause, wherein said 'for a specific' clause tracks a Raise/Lower state for each unique tuple of a plurality of tuples comprising a specific set of columns;

an alert engine recorded on a medium readable by the processor, the alert engine executed by the processor for receiving said message to take an action from said view engine, for handling an alert state corresponding to said message, and for generating a request to fire an alert; and 30

a notification engine recorded on a medium readable by the processor, the notification engine executed by the processor for receiving said request from said alert engine, for formatting said alert as a notice and for sending said notice to a user. 35

**21.** In a computer system for monitoring business activity, a computer readable medium having a computer readable program code embodied therein for causing said computer system to perform a method for performing real-time analytics on heterogeneous data views materialized as a stream of rows, said method comprising: 40

detecting an event within a real-time stream of data that is received from an external system, wherein said detecting occurs while the real-time stream is received and prior to storing said event in a database; 45

upon detecting said event, materializing one or more real-time views of said event as one or more rows within said stream of rows, wherein said views comprise one or more business views and one or more hidden views, and wherein said business views are used to define one or more business rules; 50

receiving said stream of rows of said real-time materialized views;

subscribing to said hidden views, wherein each of said hidden views has a condition equivalent to that of one of said business rules; 55

generating a message to take an action corresponding to said condition specified by at least one of said business rules based upon said received stream of rows; 60

determining that said message comprises a 'holds for' clause;

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upon said determining that said message comprises said 'holds for' clause, handling said message according to said 'holds for' clause, wherein said 'holds for' clause selectively forestalls said generating of said message until a particular event occurs, and cancels said generating of said message when said particular event does not occur during a specified time duration;

handling an alert state corresponding to said message; requesting that an alert be fired; formatting said alert as a notice; and sending said notice to a user.

**22.** The computer readable medium as recited in claim **21** wherein said method further comprises:

where said views include a reportlet view, generating a reportlet corresponding to said reportlet view; and saving said reportlet; wherein said notice includes said reportlet.

**23.** The computer readable medium as recited in claim **21** wherein said method further comprises adding context to said views, wherein said context comprises historical data relevant to said views.

**24.** The computer readable medium as recited in claim **21** wherein said generating comprises:

determining that said event stream is ordered; and upon said determining, serializing said event stream.

**25.** In a computer system for monitoring business activity, a computer readable medium having a computer readable program code embodied therein for causing said computer system to perform a method for performing real-time analytics on heterogeneous data views materialized as a stream of rows, said method comprising: 35

detecting an event within a real-time stream of data that is received from an external system, wherein said detecting occurs while the real-time stream is received and prior to storing said event in a database;

upon detecting said event, materializing one or more real-time views of said event as one or more rows within said stream of rows, wherein said views comprise one or more business views and one or more hidden views, and wherein said business views are used to define one or more business rules; 40

receiving said stream of rows of said real-time materialized views;

subscribing to said hidden views, wherein each of said hidden views has a condition equivalent to that of one of said business rules;

generating a message to take an action corresponding to said condition specified by at least one of said business rules based upon said received stream of rows;

determining that said message comprises a 'for a specific' clause;

upon said determining that said message comprises said 'for a specific' clause, handling said message according to said 'for a specific' clause, wherein said 'for a specific' clause tracks a Raise/Lower state for each unique tuple of a plurality of tuples comprising a specific set of columns; 50

handling an alert state corresponding to said message; requesting that an alert be fired;

formatting said alert as a notice; and sending said notice to a user. 60

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