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Jaroch et al.

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(54) **METHOD AND APPARATUS FOR PROVIDING FORENSIC VISIBILITY INTO SYSTEMS AND NETWORKS**

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H04L 29/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 63/1416*** (2013.01)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

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* cited by examiner

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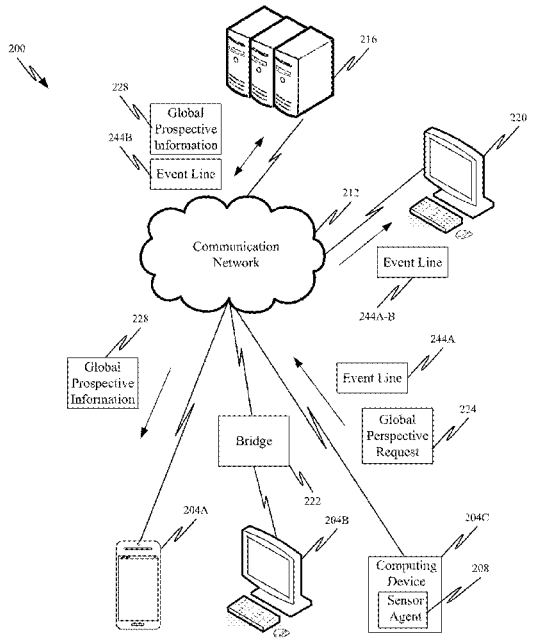
(74) *Attorney, Agent, or Firm* — Merchant & Gould P.C.

(57) **ABSTRACT**

Methods and systems for providing forensic visibility into systems and networks are provided. More particularly, a sensor agent may receive events defining an action of a first object acting on a target. The object, the event, and the target are then correlated to at least one originating object such that an audit trail for each individual event is created. A global perspective indicating an age, popularity, a determination as to whether the object may be malware, and IP/URL information associated with the event may then be applied to at least one of the object, the event, the target, and the originating object. A priority may then be determined and assigned to the event based on at least the global perspective. An event line containing event information is then transmitted to an end recipient where the information may be heuristically displayed.

19 Claims, 15 Drawing Sheets



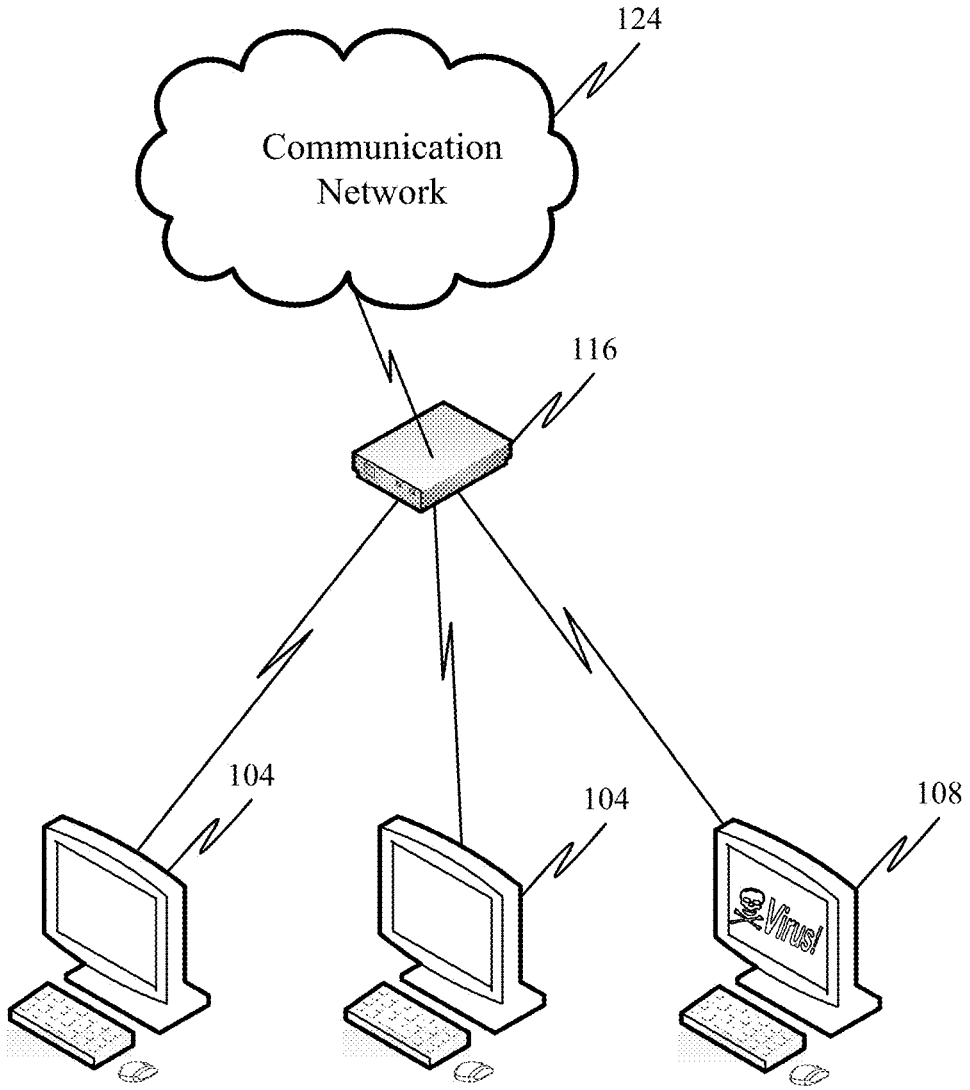


Figure 1

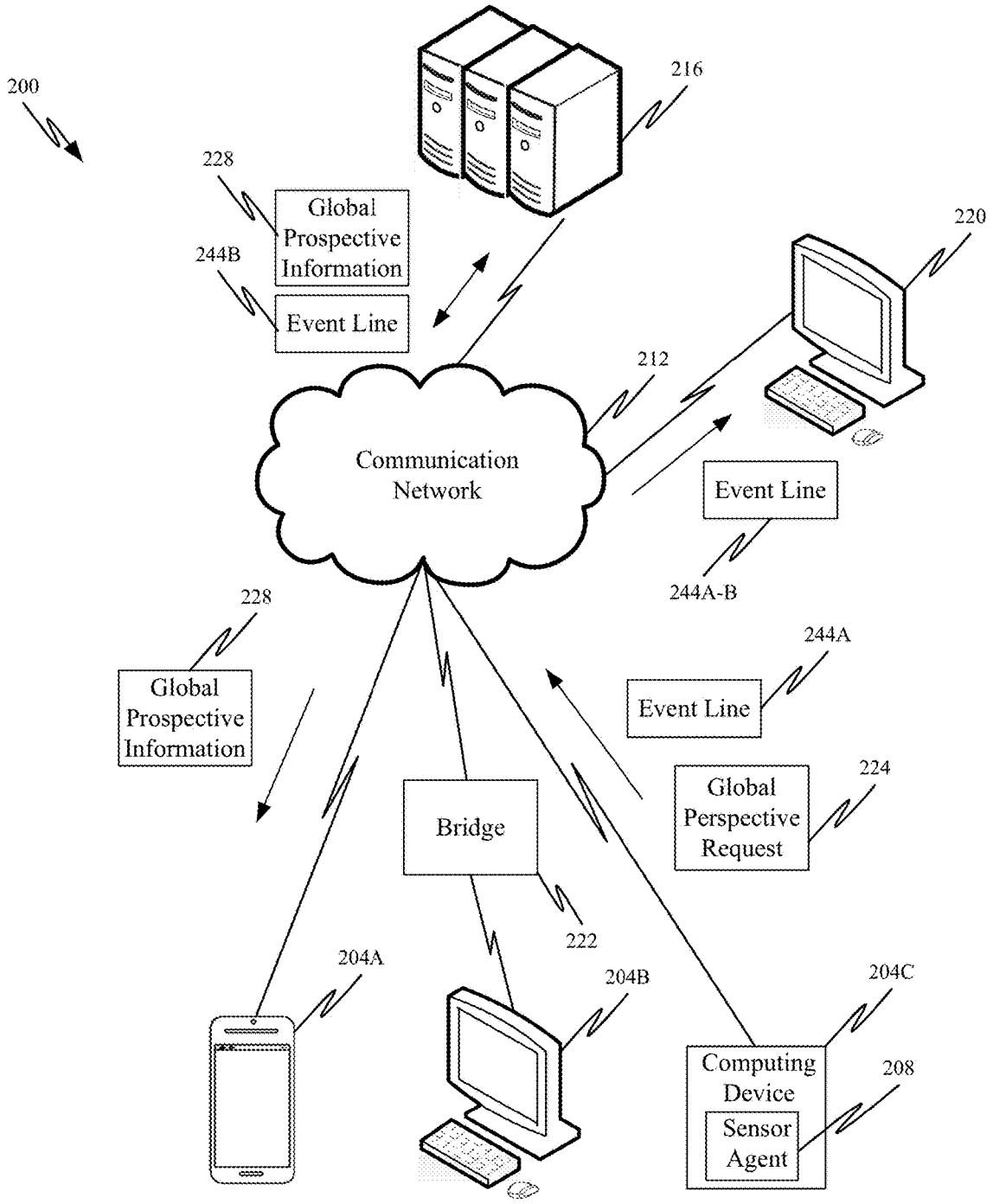

200
216
228
Global Prospective Information
244B
Event Line
220
212
Communication Network
Event Line
244A-B
228
Global Prospective Information
244A
Event Line
224
Global Perspective Request
Bridge
222
204A
204B
204C
Computing Device
208
Sensor Agent

Figure 2

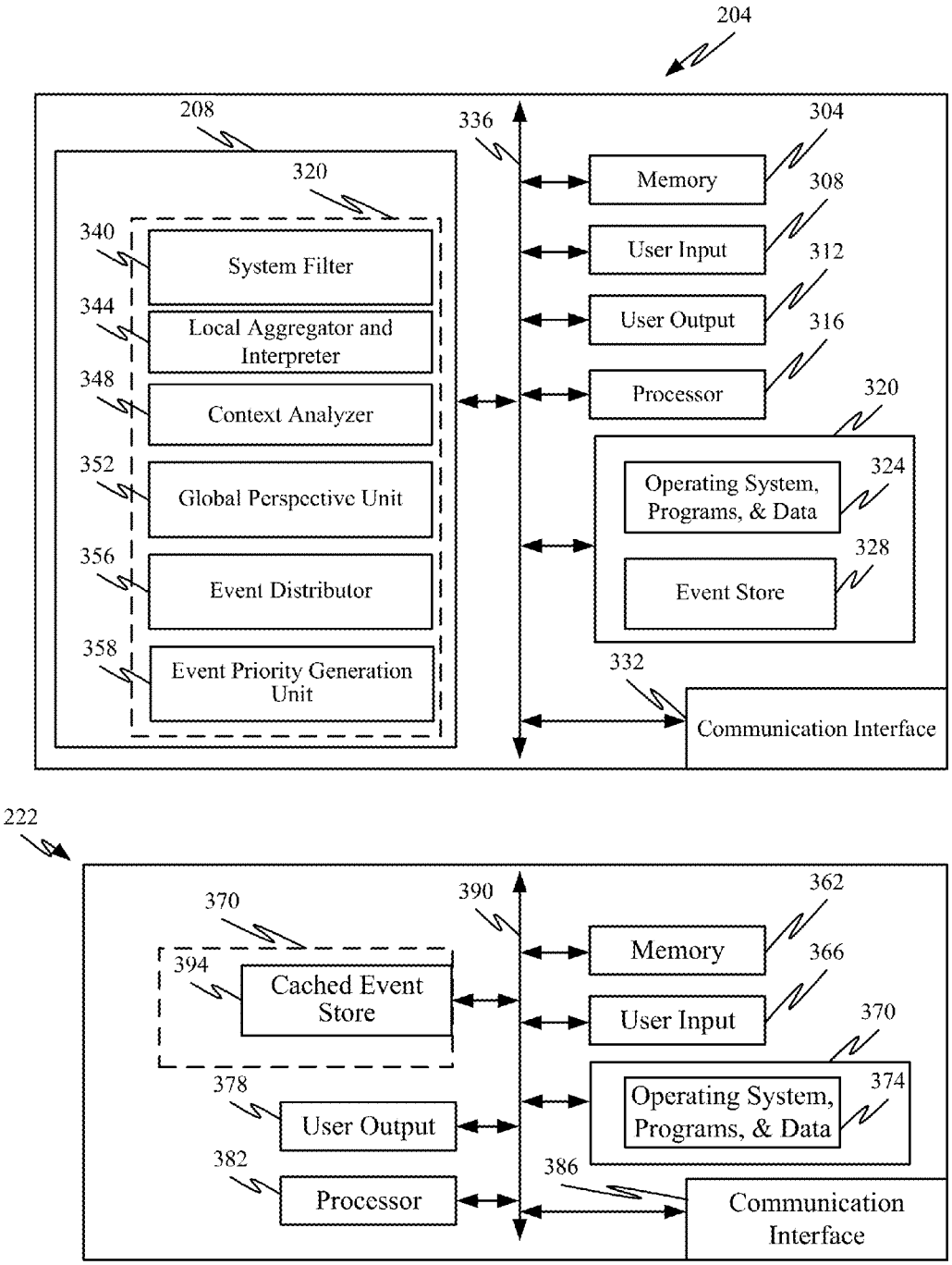

204
208
336
304
320
Memory
308
340
System Filter
User Input
312
344
Local Aggregator and Interpreter
User Output
316
348
Context Analyzer
Processor
320
352
Global Perspective Unit
324
Operating System, Programs, & Data
356
328
Event Distributor
Event Store
358
Event Priority Generation Unit
332
Communication Interface
222
370
390
362
394
Cached Event Store
Memory
366
User Input
370
378
Operating System, Programs, & Data
374
User Output
382
386
Processor
Communication Interface

Figure 3

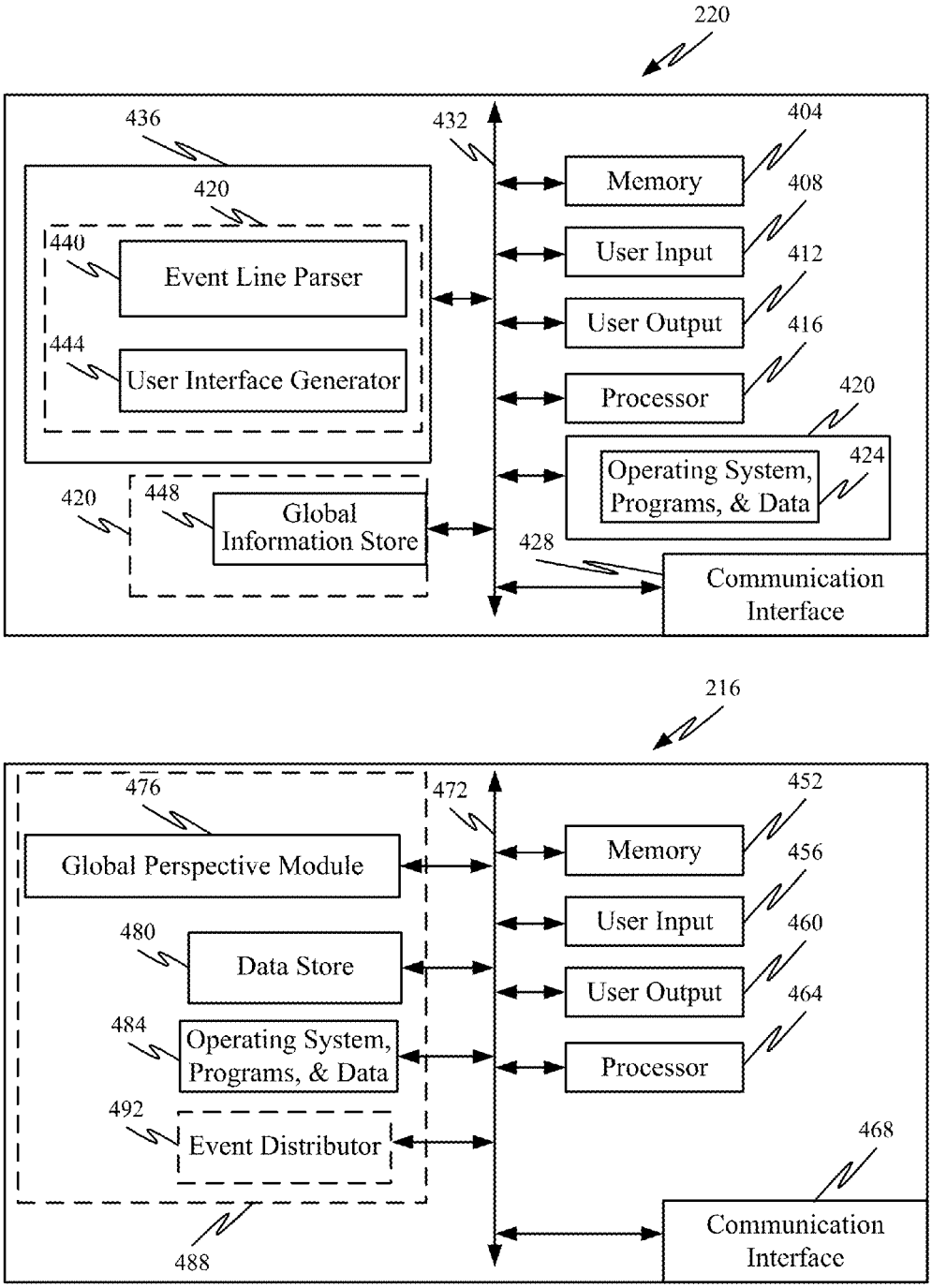

220
436
432
404
420
Memory
408
440
Event Line Parser
User Input
412
User Output
416
444
User Interface Generator
Processor
420
Operating System, Programs, & Data
424
420
448
Global Information Store
428
Communication Interface
216
476
472
452
Global Perspective Module
Memory
456
User Input
460
480
Data Store
User Output
464
484
Operating System, Programs, & Data
Processor
492
Event Distributor
468
488
Communication Interface

Figure 4

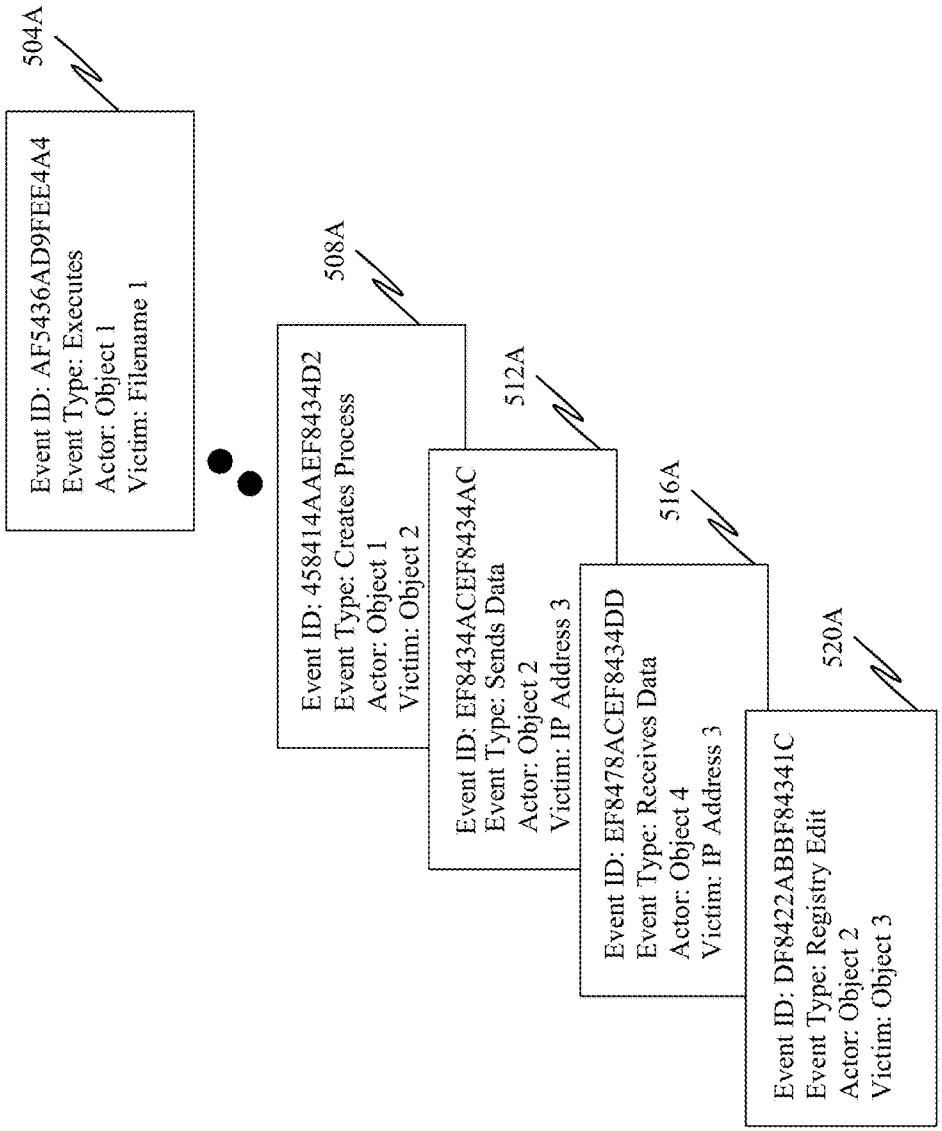

504A
Event ID: AF5436AD9FEE4A4
Event Type: Executes
Actor: Object 1
Victim: Filename 1
508A
Event ID: 458414AAEF8434D2
Event Type: Creates Process
Actor: Object 1
Victim: Object 2
512A
Event ID: EF8434ACEF8434AC
Event Type: Sends Data
Actor: Object 2
Victim: IP Address 3
516A
Event ID: EF8478ACEF8434DD
Event Type: Receives Data
Actor: Object 4
Victim: IP Address 3
520A
Event ID: DF8422ABBF84341C
Event Type: Registry Edit
Actor: Object 2
Victim: Object 3

Figure 5A

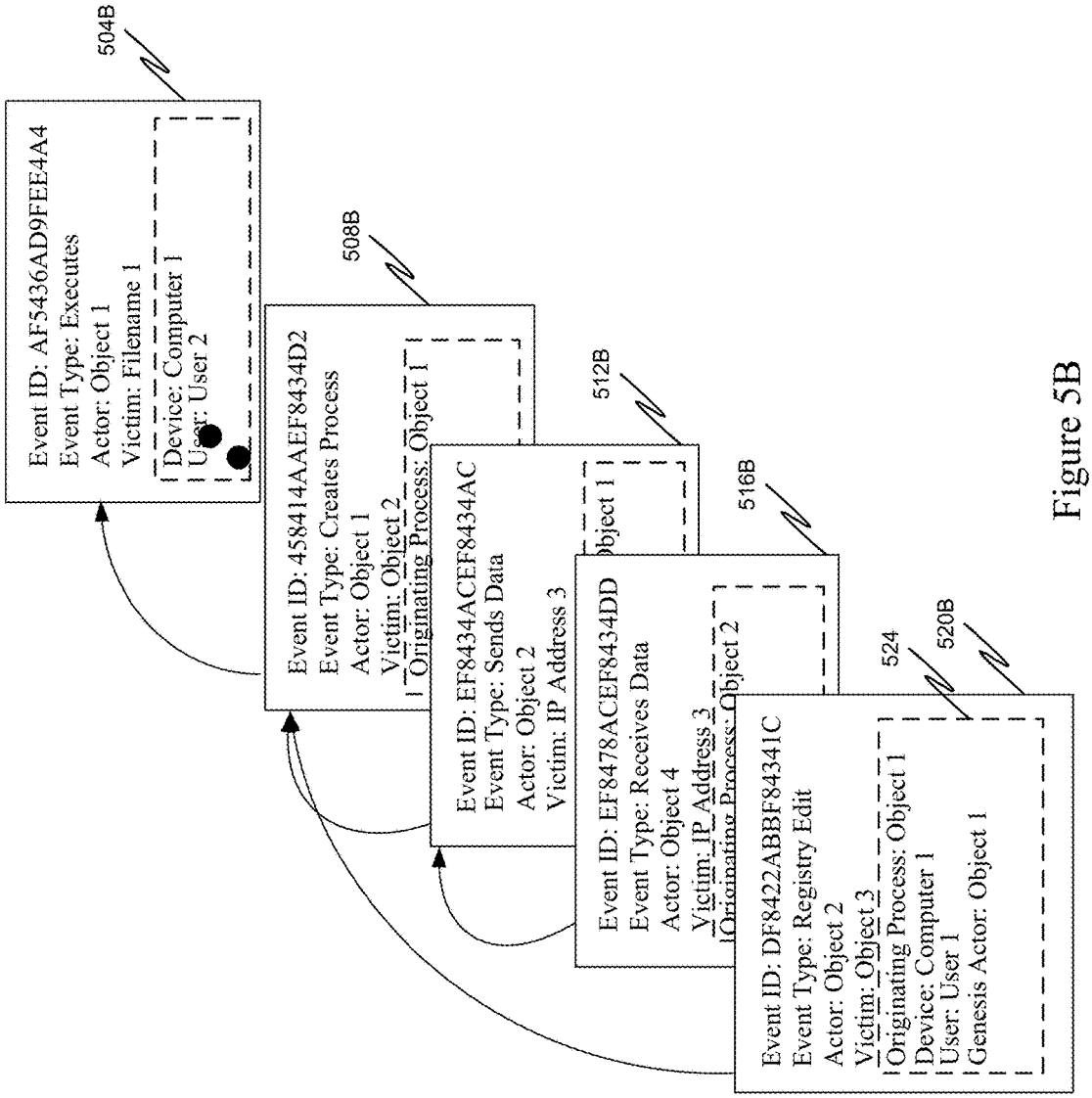

504B
Event ID: AF5436AD9FEE4A4
Event Type: Executes
Actor: Object 1
Victim: Filename 1
Device: Computer 1
User: User 2
508B
Event ID: 458414AAEF8434D2
Event Type: Creates Process
Actor: Object 1
Victim: Object 2
Originating Process: Object 1
512B
Event ID: EF8434ACEF8434AC
Event Type: Sends Data
Actor: Object 2
Victim: IP Address 3
516B
Event ID: EF8478ACEF8434DD
Event Type: Receives Data
Actor: Object 4
Victim: IP Address 3
Originating Process: Object 2
524
520B
Event ID: DF8422ABBF84341C
Event Type: Registry Edit
Actor: Object 2
Victim: Object 3
Originating Process: Object 1
Device: Computer 1
User: User 1
Genesis Actor: Object 1

Figure 5B

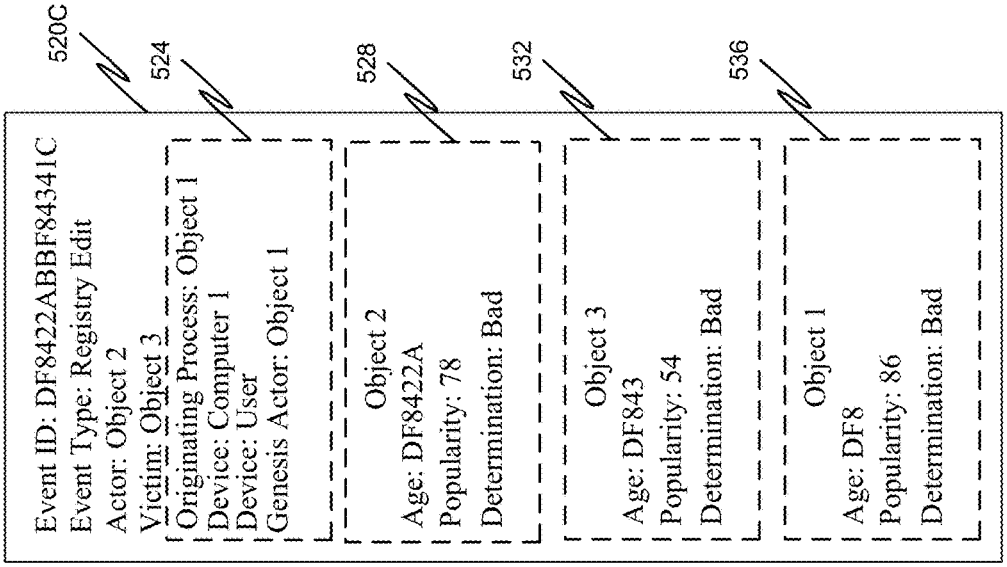

520C
Event ID: DF8422ABBF84341C
Event Type: Registry Edit
Actor: Object 2
Victim: Object 3
524
Originating Process: Object 1
Device: Computer 1
Device: User
Genesis Actor: Object 1
528
Object 2
Age: DF8422A
Popularity: 78
Determination: Bad
532
Object 3
Age: DF843
Popularity: 54
Determination: Bad
536
Object 1
Age: DF8
Popularity: 86
Determination: Bad

Figure 5C

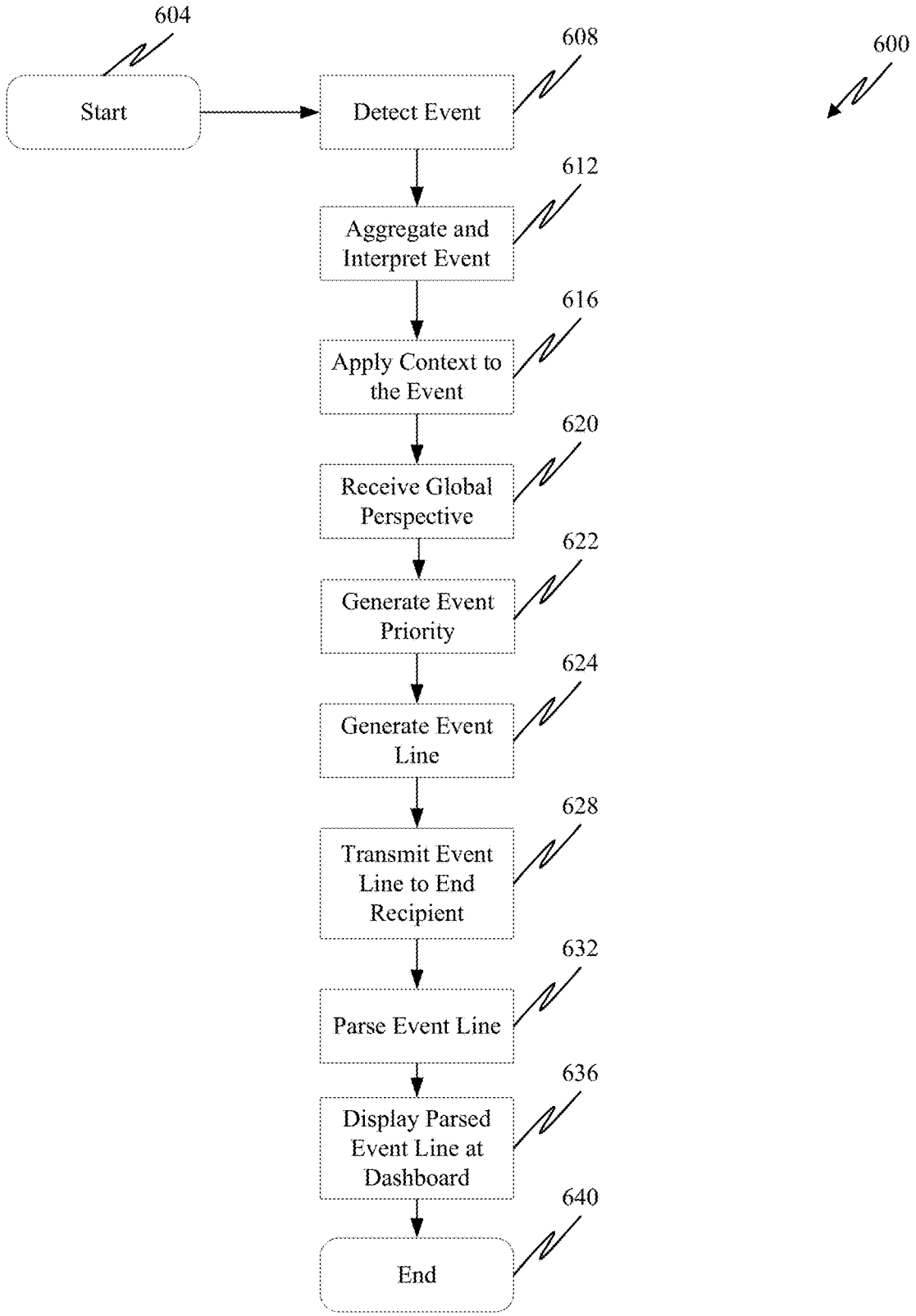

604
Start
608
Detect Event
600
612
Aggregate and Interpret Event
616
Apply Context to the Event
620
Receive Global Perspective
622
Generate Event Priority
624
Generate Event Line
628
Transmit Event Line to End Recipient
632
Parse Event Line
636
Display Parsed Event Line at Dashboard
640
End

Figure 6

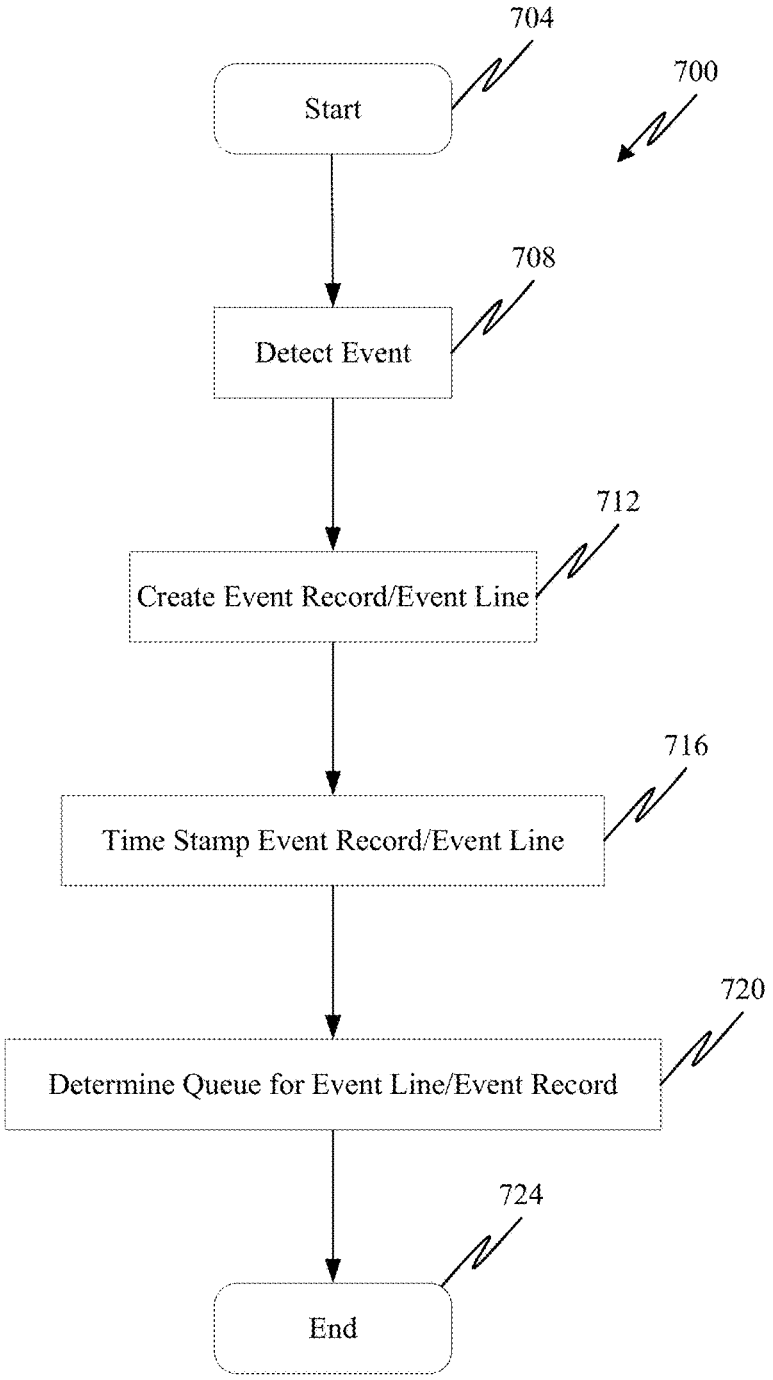

704
700
Start
708
Detect Event
712
Create Event Record/Event Line
716
Time Stamp Event Record/Event Line
720
Determine Queue for Event Line/Event Record
724
End

Figure 7

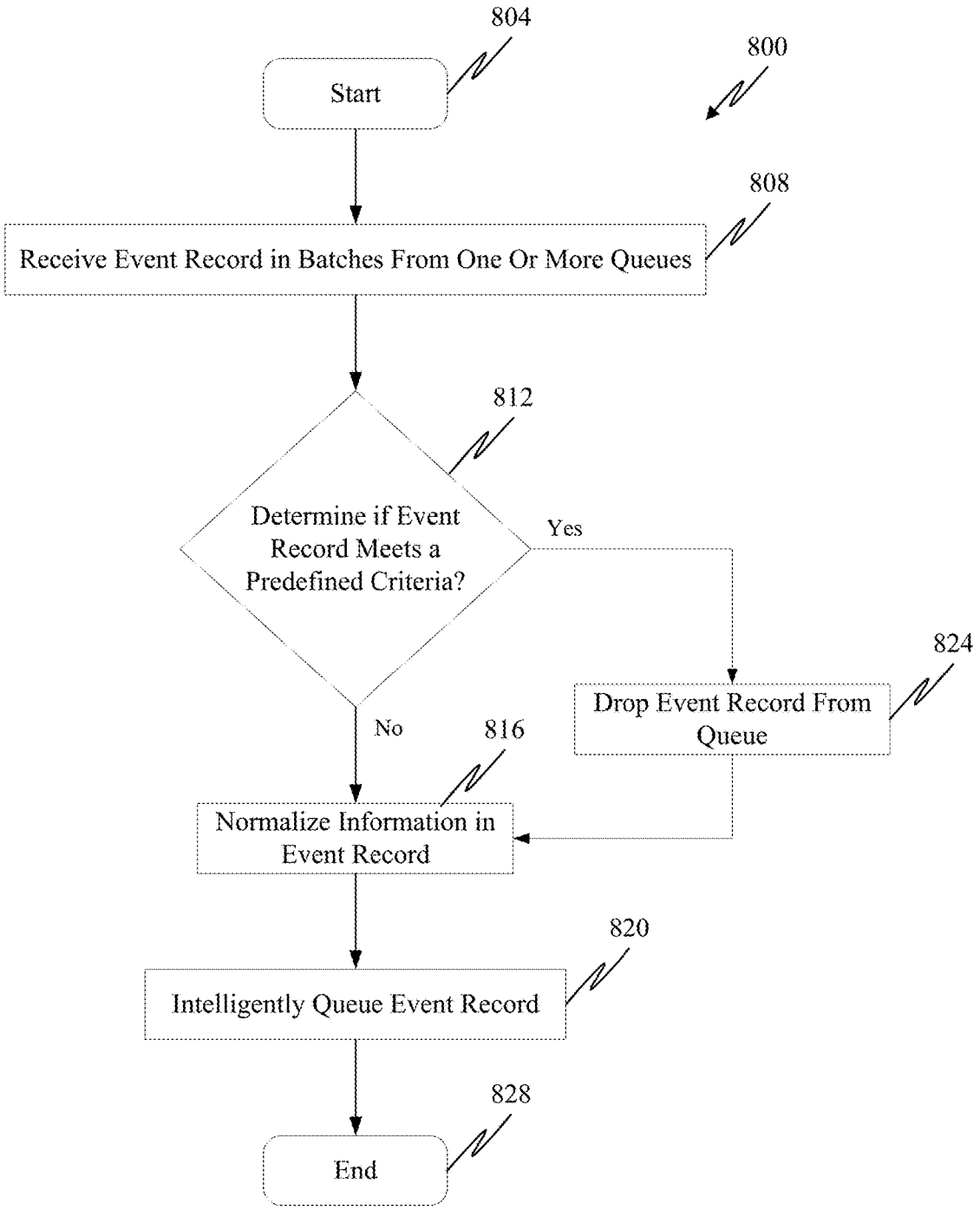

804
800
Start
808
Receive Event Record in Batches From One Or More Queues
812
Determine if Event Record Meets a Predefined Criteria?
Yes
824
Drop Event Record From Queue
No
816
Normalize Information in Event Record
820
Intelligently Queue Event Record
828
End

Figure 8

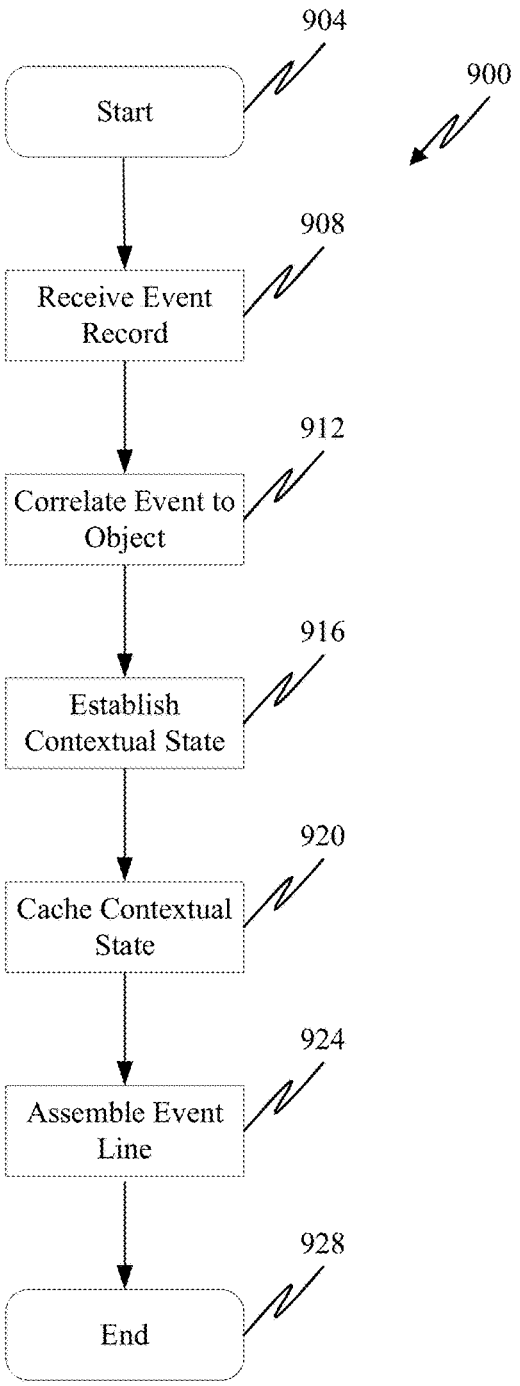

904
900
Start
908
Receive Event Record
912
Correlate Event to Object
916
Establish Contextual State
920
Cache Contextual State
924
Assemble Event Line
928
End

Figure 9

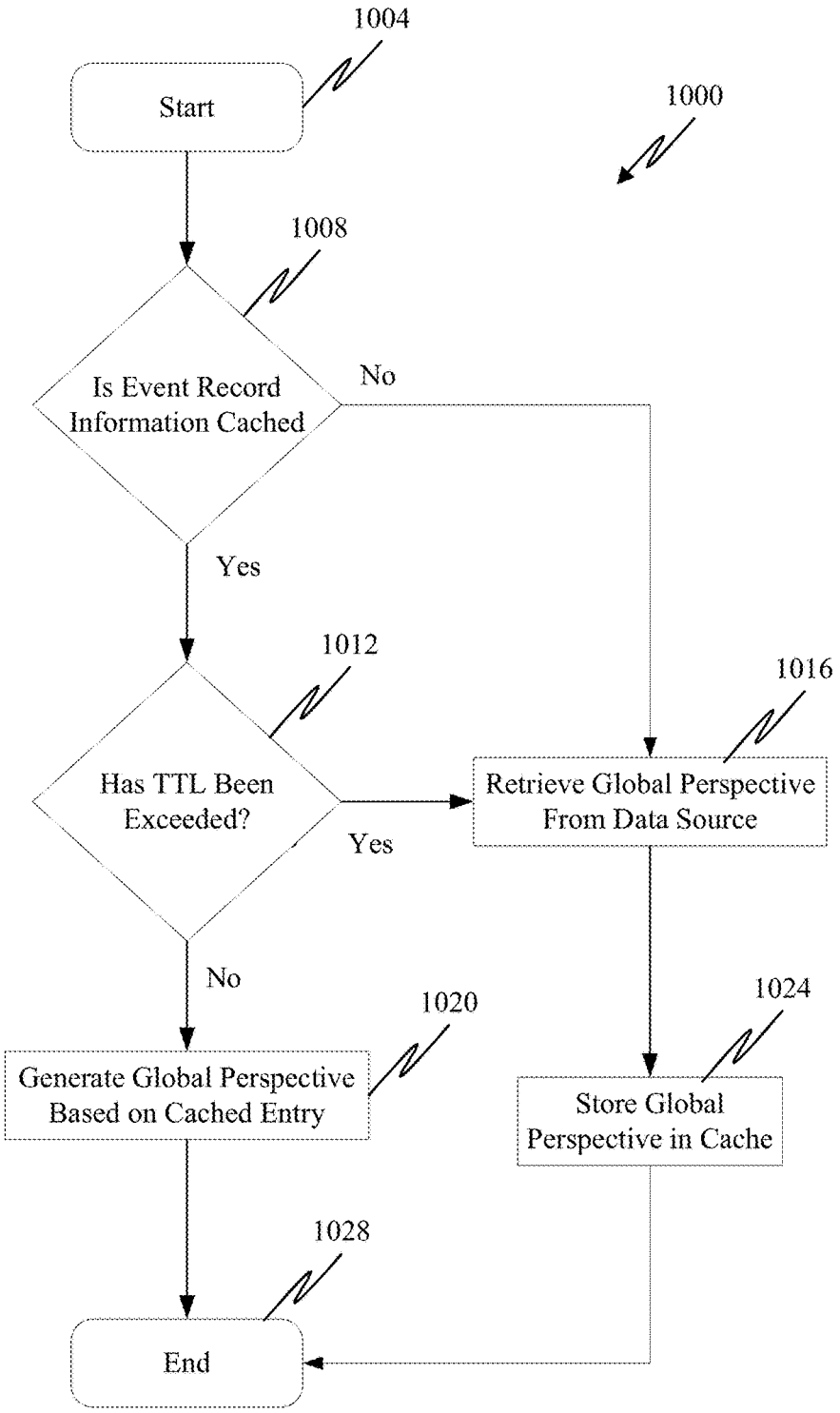

1004
Start
1000
1008
Is Event Record Information Cached
No
Yes
1012
1016
Has TTL Been Exceeded?
Retrieve Global Perspective From Data Source
Yes
No
1020
1024
Generate Global Perspective Based on Cached Entry
Store Global Perspective in Cache
1028
End

Figure 10

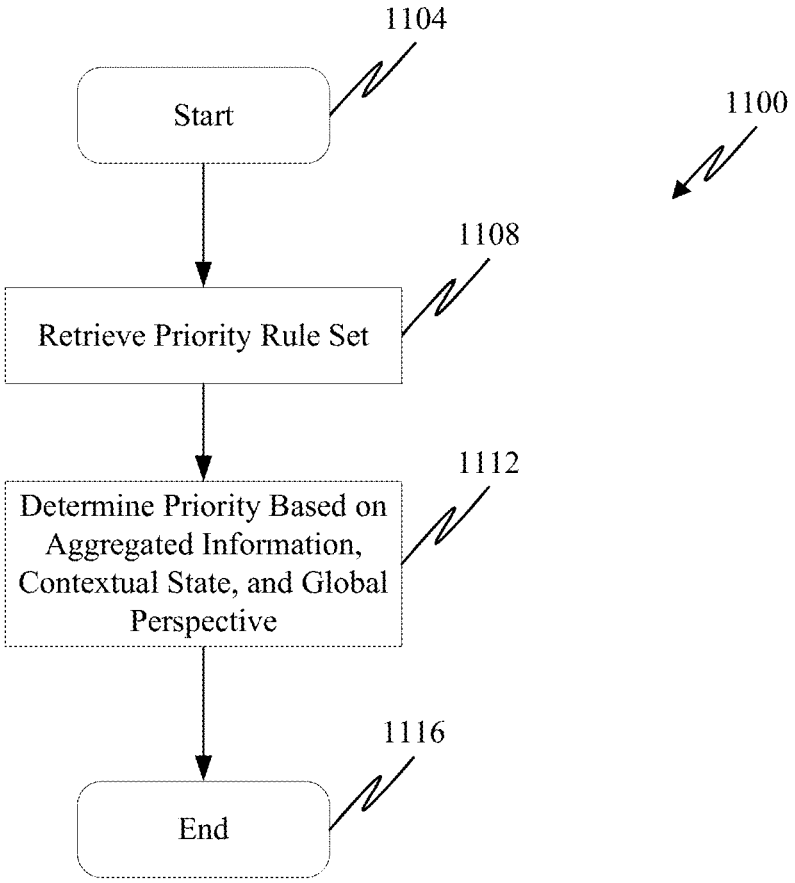

1104
Start
1100
1108
Retrieve Priority Rule Set
1112
Determine Priority Based on Aggregated Information, Contextual State, and Global Perspective
1116
End

Figure 11

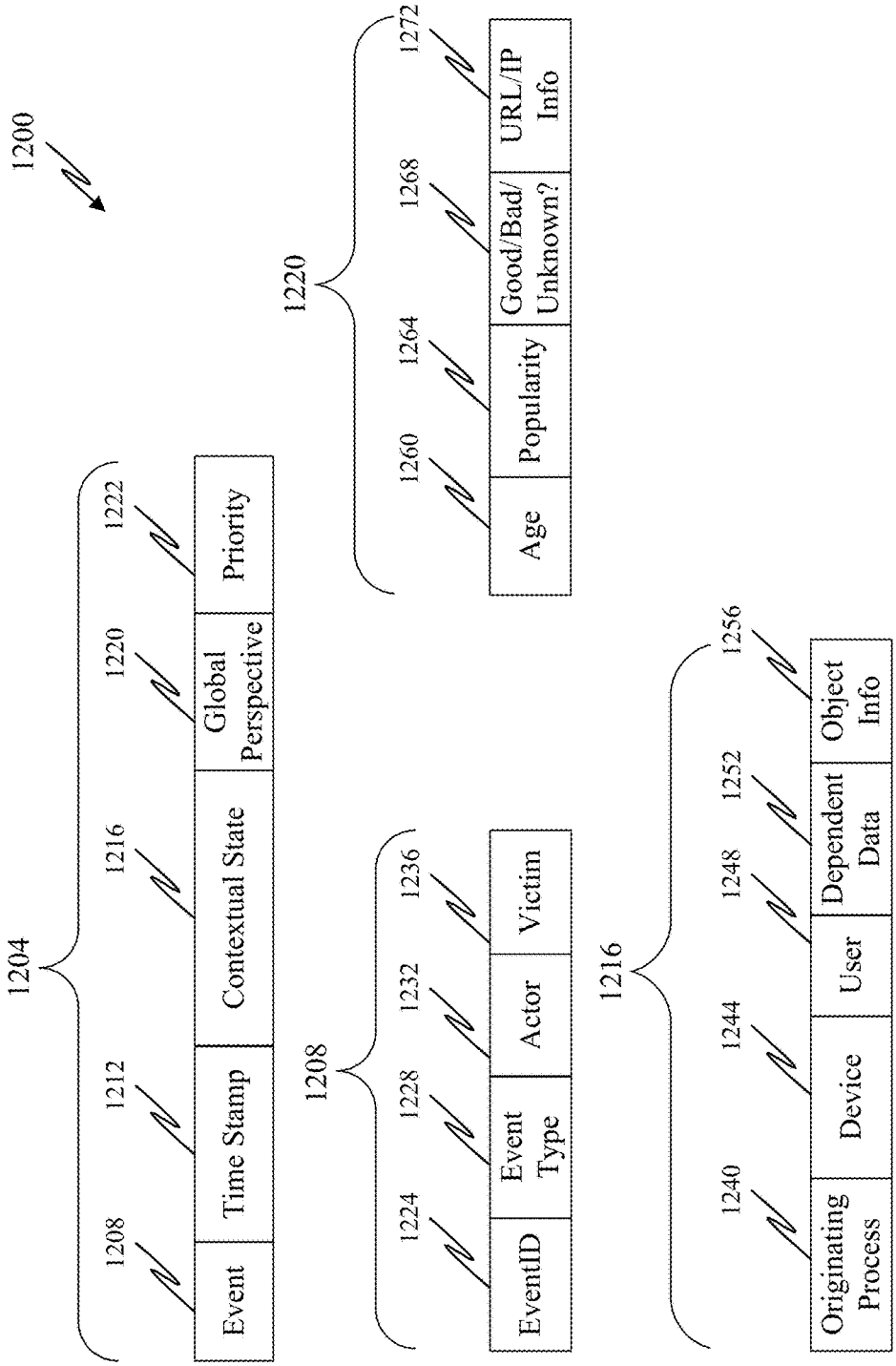

1200
1204
1208
Event
1212
Time Stamp
1216
Contextual State
1220
Global Perspective
1222
Priority
1220
1260
Age
1264
Popularity
1268
Good/Bad/ Unknown?
1272
URL/IP Info
1208
1224
EventID
1228
Event Type
1232
Actor
1236
Victim
1216
1240
Originating Process
1244
Device
1248
User
1252
Dependent Data
1256
Object Info

Figure 12

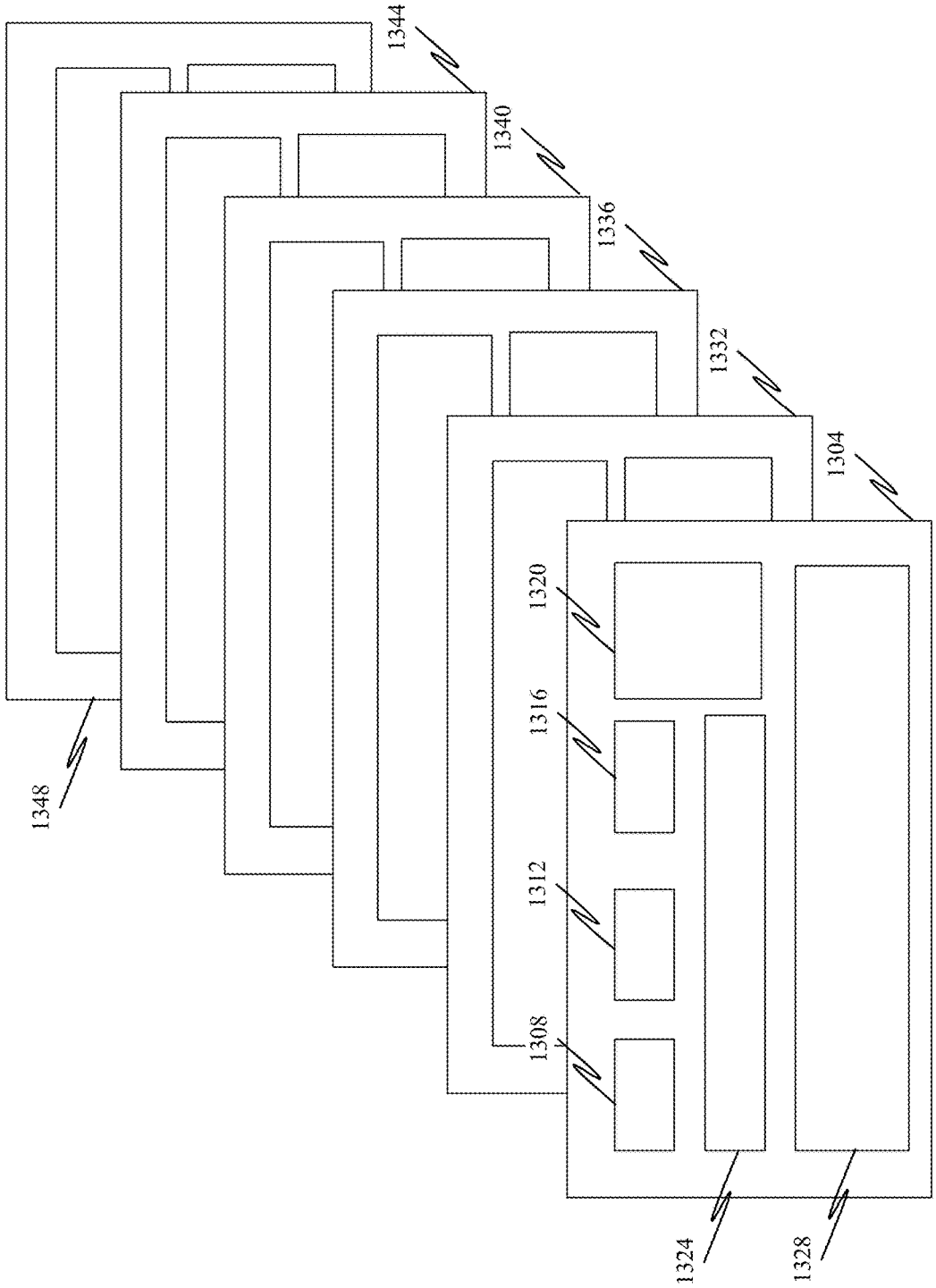


Figure 13

METHOD AND APPARATUS FOR PROVIDING FORENSIC VISIBILITY INTO SYSTEMS AND NETWORKS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/819,470, filed May 3, 2013, the entire disclosure of which is hereby incorporated herein by reference.

FIELD

Methods and apparatuses for providing forensic visibility are described. More particularly, methods and systems for providing forensic visibility into client systems having full audit trails are described.

BACKGROUND

Network forensics generally relates to the capture, recording, and analysis of network events in order to discover the source of security attacks or other problem incidents. Network forensic systems generally utilize one of two approaches: the "catch it as you can approach" and the" stop, look, and listen approach." "Catch it as you can" systems immediately write the packets to a disk file, buffering in memory as necessary, and perform analysis in batches. "Stop, look and listen" systems analyze the packets in memory, perform rudimentary data analysis and reduction, and write selected results to disk or to a database over the network.

However, existing network forensic tools, such as network sniffers and packet capturing tools, passively collect information about network traffic. Such tools may be able to detect and capture information associated with communication sessions, such as hostnames, ports, protocols, IP addresses, etc.; however, such tools tend to receive network events outside of a host or system. That is, a network forensic tool, such as a network sniffer, may reside at a network edge and may receive network events concerning the network from one or more hosts or systems. Accordingly, network edge devices have no ability to establish any sort of context from within the host or system that is generating the event. Therefore, devices residing at a network edge may monitor, record, and or analyze network traffic between the host and the device, but information that may be useful within the host is not obtained.

For example, FIG. **1** generally illustrates a comparative example including computing devices **104** and **108** in communication with a network edge device **116**. The network edge device **116** may be commonly referred to as a "sniffer" which may monitor, capture, and analyze network traffic between the network edge device **116** and the computing devices **104** and **108**. The network edge device **116** may further be in communication with a communication network **124**, such as the internet. Accordingly, the network edge device **116** may monitor, capture, and analyze network traffic between the computing devices **104** and **108** and between the computing devices **104**/**108** and the communication network **124**.

However, as previously mentioned, the network edge device **116** has no ability to monitor, capture, and/or analyze what is occurring within each of the computing device **104** and **108**. In at least one comparative example, computing device **108** may contain or otherwise be infected with one or more pieces of malware. The term "malware" is used herein to refer generally to any executable computer file or, more generally "object", that is or contains malicious code, and thus includes viruses, Trojans, worms, spyware, adware, etc. and the like. Indeed, the network edge device **116** may be able to monitor, capture, and analyze communication traffic including the information, both encrypted and unencrypted, source and destination ports, source and destination IP address, and protocols utilized by the computing device **108**, but the network edge device cannot provide details regarding files modified, registry entries changed, and/or new processes that are created. Accordingly, the network edge device **116** has no way of knowing to what extent the virus may have impacted the computing device **108**, what additional files may have become infected, or what processes and/or objects operating are linked to the virus. What is needed therefore, is a solution that eliminates the guesswork and allows for end-to-end visibility of every event within a system and/or within a network.

SUMMARY

It is, therefore, one aspect of the present disclosure to provide a system and method whereby events occurring within a computing device are captured and additional context and a global perspective is provided for each capture event. For example, a sensor agent may provide visibility into occurrences across an environment, such as a networked environment, to ensure that an administrator is aware of any system changes and data communication in and out of computing devices residing on the network. In this implementation, six components, or modules, may be utilized in the event gathering and processing: low level system filters, a local aggregator and interpreter, a context analyzer, a global perspective module, an event priority module, and an event distributor may be utilized to provide forensic visibility into one or more computing devices of a communication network.

The system filters may be built upon the same or similar technology related to behavior monitoring and collection, as discussed in U.S. application Ser. No. 13/372,375 filed Feb. 13, 2012, "Methods and Apparatus for Dealing with Malware" (US-2012-0260340-A1), which is incorporated herein by reference in its entirety for all that it teaches and for all purposes. These filters intercept system events in a manner such that the operation of the system filter does not impact system performance, a key aspect of this solution. Events at this level tend to be very raw and generally not individually useful—on an average system, tens of millions of events take place every minute and the noise ratio can prevent forensic solutions from being able to provide sufficient value to the end consumer of their data due to the inability to quickly find important events. A product which impacts system performance will have considerably diminished value to an administrator and can negatively affect the results of an analysis undertaken. For example, a system filter that requires a majority of the available computing and system resources may render one or more communication devices unable to perform its primary function and may steer a real-time forensics analysis to an irrelevant analysis of events; irrelevant because such event analysis of information may be based on old and outdated event information. In some embodiments, events are gathered and timestamped accurately and sequentially, establishing a chronological order of system events for consumption at a higher level.

In at least one embodiment, the second component, the local aggregator and interpreter, receives events from the

low level system filters, collecting them in batches from the queues in which they are inserted in real-time, and transmits these events to a local service process where the events are held for further analysis. At this stage, intelligent caching may be invoked to drop events which are duplicates of recent events, and some data normalization may be performed to ensure consistency. Caching may be implemented sparingly but in critical areas to ensure redundant events are not continually reported—many applications perform thousands of the same events (network access to the same destination IP address, for example) and transmitting these events into an external log source would create a significant amount of unnecessary noise and potential performance degradation. The cache may integrate a "time to live" concept to prevent applications from hiding their traffic within their noise. The caches may automatically roll over to ensure sufficient space is always available without requiring exorbitant amounts of memory.

In addition, data normalization takes items such as kernel filenames, usermode filenames, process objects, registry objects, and other system structures and normalizes them into a standard format which is easy more easily consumed by automated parsers. Consolidating and normalizing data at this stage allows the data to be handled much more quickly at the higher levels to avoid reprocessing data and potentially missing events just because they were referred to slightly differently (\Device\HarddiskVolume1\Windows\file.exe instead of C:\Windows\file.exe for example). In some embodiments, an aspect of this subsystem provides the ability to process events asynchronously. The subsequent modules which will execute over the data can potentially take a considerable amount of time to complete but delaying the response for each event at this phase would result in a significant system slowdown. Instead, events are intelligently queued in multiple layers to minimize the number of individual threads but still ensure each event is given sufficient time to be independently processed. Because of this structure, there is no performance difference if an event takes one millisecond to be processed or one hour for the full series of routines to complete.

In at least some embodiments, the context analyzer is utilized to ensure that a user, such as a network administrator, is provided the deepest view of the most important data but still has access to the full range of data if they wish to see it. The analysis starts by correlating events to objects (their originating processes, devices, and users), and creating an audit trail for each individual event. This allows an administrator to forensically track back any event which occurs to what triggered it. As previously discussed, conventional products in this space receive events outside of the system (for example, as a network edge device) and therefore have no ability to establish context within the system. The present solution eliminates the guesswork and allows for end-to-end visibility of every event from the bottom of the stack to the top. As contextual state is established, it is cached and aggregated to be quickly queried in subsequent lookups further reducing latency and improving the responsiveness of the system.

After the contextual analysis completes, the sensor agent attempts to establish a global perspective for each event by calling the cloud database using an infrastructure similar to the infrastructure discussed in U.S. application Ser. No. 13/372,375 filed Feb. 13, 2012, "Methods and Apparatus for Dealing with Malware" (US-2012-0260340-A1), but with an additional layer capable of responding in a highly scalable manner which avoids the overhead generally associated with the complex rule processing within the overall database. This response includes information related to the age, popularity, and determination of an object—whether it is known good, bad, or unknown. This data may then be normalized and appended to each relevant portion of the event line. Further lookups are performed for network activity, assessing the reputation and category of each website and IP address as they are contacted.

The event priority module may contain priority logic, or one or more rule sets, to associate a priority to one or more events. The event priority module may utilize information from the local aggregator and interpreter, the context analysis module, and the global perspective module, to determine, or otherwise assign, a priority to an event; such a priority may be based on a rule set. The rule set may be provided by an administration system, backend system, end recipient **220**, or other component of a forensic system.

The event distributor may then batch and transmit the events to the end recipient after the global perspective has been applied. In some embodiments, the event distributor may batch and transmit the events to the end recipient after the even priority has been determined. In one implementation, a syslog protocol may be used to send each event as a line of log data to be processed by an end consumer—usually a display/query engine. The transmission of events requires an additional layer of asynchronous processing as the response time from the recipient cannot be allowed to slow down the higher level global perspective and contextual analysis work which is ongoing in other threads. Therefore, a transmission engine of the event distributor may build the final event line, packages it together with information about the host itself, and then send it directly into a separate queue where it will then be sent shortly after (usually a few seconds) while maintaining the pre-set timestamp of precisely when the event took place even if it is sent several seconds later.

The recipient of the event, whether hosted on a third party platform or using other proprietary software, may then display single events and/or perform wider analysis on groups of events, producing dashboard views and graphs to aid the administrator in identifying events that are most pertinent to their current investigation.

In accordance with at least one embodiment of the present disclosure, a method is provided, the method comprising gathering one or more events defining an action of a first object acting on a target; generating a contextual state for at least one of the one or more events by correlating the at least one event to an originating object, the contextual state including an indication of the originating object of the first object and an indication of at least one of a device on which the first object is executed and a user associated with the first object; obtaining a global perspective for the at least one event by obtaining information associated with one or more of the first object and the originating object, the information including at least one of age, popularity, a determination as to whether the first object is malware, a determination as to whether the originating object is malware; and Internet Protocol (IP) Address or Uniform Resource Locator (URL) information; assembling an event line including details associated with the at least one event, the details including information uniquely identifying each of the first object, the action of the first object, the target, and the originating object; and transmitting the assembled event line.

In accordance with further embodiments of the present disclosure, a system is provided, the system comprising a device including a communication interface; a processor; data storage; and a sensor agent stored on the data storage that is executable by the processor, wherein the sensor agent

is operable to: gather one or more events defining an action of a first object acting on a target; generate a contextual state for at least one of the one or more events by correlating the at least one event to an originating object, the contextual state including an indication of the originating object of the first object and an indication of at least one of a device on which the first object is executed and a user associated with the first object; obtain a global perspective for the at least one event by obtaining information associated with one or more of the first object and the originating object, the information including at least one of age, popularity, a determination as to whether the first object is malware, a determination as to whether the originating object is malware; and Internet Protocol (IP) Address or Uniform Resource Locator (URL) information; assemble an event line including details associated with the at least one event, the details including information uniquely identifying each of the first object, the action of the first object, the target, and the originating object; and transmit the assembled event line utilizing the communication interface.

In accordance with further embodiments of the present disclosure, a system is provided, the system comprising a device including a communication interface; a processor; data storage; and a sensor agent stored on the data storage that is executable by the processor, wherein the sensor agent is operable to: gather one or more events defining an action of a first object acting on a target; generate a contextual state for at least one of the one or more events by correlating the at least one event to an originating object, the contextual state including an indication of the originating object of the first object and an indication of at least one of a device on which the first object is executed and a user associated with the first object; assemble an event line including details associated with the at least one event, the details including information uniquely identifying each of the first object, the action of the first object, the target, and the originating object; and transmit the assembled event line utilizing the communication interface.

In accordance with at least one embodiment of the present disclosure, a method is provided, the method comprising obtaining an event line from one or more computing systems; parsing the event line to retrieve event information for at least one event, wherein the event information includes an event type, a contextual state for the event, a global perspective for the event, and a priority for the event; and displaying the event information for the at least one event to a display device.

In accordance with further embodiments of the present disclosure, a system is provided, the system comprising a device including a communication interface; a processor; data storage; a display device; and a parser stored on the data storage that is executable by the processor, wherein the parser is operable to: obtain an event line from one or more computing systems utilizing the communication interface; parse the event line to retrieve event information for at least one event, wherein the event information includes an event type, a contextual state for the event, a global perspective for the event, and a priority for the event; wherein the processor is operable to cause the event information for the at least one event to be displayed at a display device.

Additional features and advantages of embodiments of the present invention will become more readily apparent from the following description, particularly when taken together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a comparative example of a communication network, edge device, and one or more computing devices;

FIG. **2** depicts a communication network including one or more computing systems, global perspective information server, and one or more end recipients in accordance with an exemplary embodiment of the present disclosure;

FIG. **3** illustrates a block diagram depicting details of a computing system and a bridge in accordance with an exemplary embodiment of the present disclosure;

FIG. **4** illustrates a block diagram depicting details of a global perspective information server and an end recipient in accordance with an exemplary embodiment of the present disclosure;

FIGS. **5**A-C illustrates exemplary events, events having an applied contextual state, and events having an applied global perspective in accordance with an exemplary embodiment of the present disclosure;

FIG. **6** illustrates a flow chart depicting details of at least one embodiment in accordance with an exemplary embodiment of the present disclosure;

FIG. **7** illustrates a flow chart depicting operational details of a system filter in accordance with an exemplary embodiment of the present disclosure;

FIG. **8** illustrates a flow chart depicting operational details of a local aggregator and interpreter in accordance with an exemplary embodiment of the present disclosure;

FIG. **9** illustrates a flow chart depicting operational details of a context analyzer in accordance with an exemplary embodiment of the present disclosure;

FIG. **10** illustrates a flow chart depicting operational details of a global perspective unit and/or global perspective module in accordance with an exemplary embodiment of the present disclosure;

FIG. **11** illustrates a flow chart depicting operational details of an event priority generation unit in accordance with an exemplary embodiment of the present disclosure;

FIG. **12** depicts a first data structure employed in accordance with at least some embodiments of the present disclosure; and

FIG. **13** depicts one or more dashboards in accordance with at least some embodiments of the present disclosure.

DETAILED DESCRIPTION

FIG. **1** depicts aspects of a system **200** for providing forensic visibility into one or more computing devices **204**, **208**, and **212** in accordance with at least one embodiment of the present disclosure. In general, the system **200** includes one or more computing device **204**, each of which are interconnected to a global perspective information server **216** and end recipient **220** by one or more communication networks **212**. The computing device **204** may comprise a general purpose computer, such as but not limited to a laptop or desktop personal computer **204**B, a tablet computer, a smart phone **204**A, or other device capable of communications over a communication network **212** and capable of presenting content to an associated user. The computing device **204** may also comprise a processing unit that is interconnected to an affiliated input/output device.

The communication network **212** may include one or more networks capable of supporting communications between nodes of the system **200**, including but not limited to a computing devices **204**A-C, the global perspective information server **216** and the end recipient **220**. Examples of communication networks **212** include the Internet or any wide area network (WAN), local area network (LAN), or networks in various combinations. Other examples of communication networks **212** in accordance with embodiments of the present disclosure include wireless networks, cable

networks, satellite networks, and digital subscriber line (DSL) networks. In addition, different communication networks **212** may share a common physical infrastructure, for at least some portion of the physical network. For instance, a computing device **204** may be interconnected to a communication network **212** comprising the Internet and to a separate communication network between the computing device **204** and an end recipient **220**.

The computing device **204** includes and/or executes a sensor agent **208** in connection with the presentation of content to the user. In accordance with at least one embodiment of the present disclosure, six components, or modules, may be utilized by the sensor agent **208** to gather and process events. The sensor agent **208** may include, but is not limited to, low level system filters, a local aggregator and interpreter, a context analyzer, a global perspective module, an event priority module, and an event distributor. Of course, and as can be appreciated by those skilled in the art, all six modules may not be required by the sensor agent **208**. In at least one embodiment, the sensor agent may comprise fewer than six modules. That is, at least some functionality of the one or more modules may be provided by another device, such as a global perspective information server **216** for example. Moreover, it should be understood that the sensor agent **208** may include varying combination of modules. For example, the sensor agent **208** may include two of the six modules, three of the six modules, four of the six modules, or five of the six modules.

The system filters may intercept system events in a manner such that they do not impact system performance. Events may define those actions or behaviors of an object acting upon another object or some other entity. An object in this sense may be a computer file, part of a file or a sub-program, macro, web page or any other piece of code to be operated by or on the computer, or any other event whether executed, emulated, simulated or interpreted. Events may include, but are not limited to file activity, registry events, code events, network/internet events, process/thread events, window/GDI events, input events to name a few. An event may have three principal components: information and/or details describing the object performing the act (the "Actor"), information and/or details describing the act being performed (the "Event Type"), and information and/or details describing the object or identity of another entity upon which the act is being performed (the "Victim" or "Target"). For example, the event data might capture the identity, e.g. the IP address or URL, of a network entity with which an object is communicating, another program acting on the object or being acted on by the object, a database or IP registry entry being written to by the object, etc. While simple, this structure allows a limitless series of behaviors and relationships to be defined. Examples of the three components of an event might include, but are not limited to, those illustrated in Table 1.

TABLE 1

Actor	Event Type	Victim
Object 1	Creates Program	Object 2
Object 1	Sends data	IP Address 3
Object 1	Deletes Program	Object 4
Object 1	Executes	Object 2
Object 2	Creates registry key	Object 4

Moreover, in some embodiments, the Actor, Event Type, and/or Victim may be represented in the form of a so-called signature or key relating to the object key. Key generation is mainly to keep the data storage and transmission requirements as minimal as possible. The keys for each object may be formed by a hashing function operating on the object at the computing system **204**. Accordingly, an event may include the three principal components as a key of the object performing the act (the "Actor"), a key of the act being performed (the "Event Type"), and the key of the object or identity of another entity upon which the act is being performed (the "Victim" or "Target"). Additionally, events at this level tend to be very raw and generally not individually useful—on an average system, tens of millions of events take place every minute and the noise ratio can prevent forensic solutions from being able to provide sufficient value to the end consumer of their data due to the inability to quickly find important events. Accordingly, in some embodiments, events are gathered and time stamped accurately and sequentially, establishing a chronological order of system events for consumption at a higher level.

The second component, the local aggregator and interpreter, receives events from the low level system filters in batches from the queues in which they are inserted in real-time, and transmits them to the local service process where they are held for further analysis. In accordance with at least some embodiments of the present disclosure, the events may be cached and normalized such that kernel filenames, user mode filenames, process objects, registry objects, and other system structures are converted into a standard format for ease of consumption by one or more automated parsers. Following the aggregation and interpretation of the events, the context analyzer creates, or obtains, a contextual state by correlating events to objects and creating an audit trail for each individual event. In some instances, the sensor agent **208** of the computing device **204** may determine if contextual state information is available locally within a cache. If the contextual state information is not available locally, the sensor agent **208** of the computing device may obtain such contextual state information from a source of contextual state information accessible to the sensor agent **208**.

Contextual state information may include, but is not limited to, originating processes, devices, and users. Additionally, contextual state information may include GenesisActor information and ancillary data. GenesisActor information may contain the object that is not the direct Actor of an event but which is the ultimate parent of the event being performed. For example in the case of a software installation, the GenesisActor would be the object that the user or system first executed and that initiated the software installation process, e.g. Setup.exe. Ancillary data may include data associated with the event type, actor and victim. For example, an event such as that used to record the creation of a registry run key may identify the Actor object as creating a registry run key, the event type itself (e.g. "regrunkey"), and the Victim or subject of the registry run key. The ancillary data in this case would define the run key entry itself; the Hive, Key name and Value. As a contextual state is established for each event, the contextual state may be cached and aggregated to be quickly queried in subsequent lookups further reducing latency and improving the responsiveness of the computing device **204**. Contextual state information may be provided by the sensor agent **208** and/or a source of contextual state information accessible to the sensor agent **208**. For example, the global perspective information server **216**, in some embodiments, may be able to provide contextual state information to the sensor agent **208**

for one or more events. Moreover, such contextual state information may be provided from one or more other computing devices **204**.

After the contextual analysis completes, the sensor agent **208** establishes a global perspective for each event by calling on the global perspective information server **224**. For example, the sensor agent **208** of the computing device **204** may determine if global perspective information is available locally within a cache. If the global perspective information is not available locally, the sensor agent **208** of the computing device **204** may issue a global perspective request **224** utilizing the communication network **212** and destined for the global perspective information server **216**. The global perspective information server **216** may respond with global prospective information **228** and such information may be provided to the sensor agent **208** associated with the computing device **204**.

The global perspective information **228** may include information related to the age, popularity, and determination of an object of the event—whether it is known good, bad, or unknown. The global perspective information may be retrieved or otherwise obtained for each object of an event and any objects provided as a part of a contextual information state. In some instances, the reputation and category of each website and IP address are obtained as they are contacted. Such information may then be normalized.

The event priority module may contain priority logic, or one or more rule sets, to associate a priority to one or more events. The event priority module may utilize information from the local aggregator and interpreter, the context analysis module, and the global perspective module, to determine, or otherwise assign, a priority to an event; such a priority may be based on a rule set. The rule set may be provided by an administration system, backend system, end recipient **220**, or other component of a forensic system. For example, a rule set may determine that an event meeting certain conditions be assigned a priority according to a scale of severity. For instance, a rule set may specify that an event having a specific actor, victim, and/or origination process together with a global perspective indicating a specified age, popularity, malware determination, and/or IP/URL reputation be assigned an event priority representative of a potential risk assigned to the computing device **204** and/or network. Accordingly, when the event line containing event priority information is received at an end recipient **220**, the end recipient **220** may be able to more easily identify events, and/or instances of malware, that require more immediate attention.

An event distributor of the sensor agent **208** may then create an event line comprising information from the event, information from the contextual state, information from the global perspective, and information from regarding the priority of the event. Alternatively, or in addition, an event distributor of the global perspective information server **216** may create an event line comprising information from the event, information from the contextual state, and information from the global perspective.

Accordingly, once the event distributor of the sensor agent **208** and/or the event distributor of the global perspective information server **216** create the event line for at least one event, the event line **244**A-B may be sent to an end recipient **220** from the computing device **204** and/or the global perspective information server **216**. The event distributor may batch and transmit the events to the end recipient **220** after the global perspective has been applied. In at least one implementation, the syslog protocol is utilized to send each event as a line of log data to be processed by an end consume such as a display/query engine like the product "splunk".

Alternatively, or in addition, some embodiments of the present disclosure may feature an optional bridge **222** which may be a dedicated device residing locally on a network. The bridge **222** may aggregate communications to and from one or more computing system **204** such that information to and from sensor agent **208** is cached at the bridge **222**, optimizing global perspective requests and other communications. That is, the bridge may be shared across some or all devices in a network. In some embodiments, the bridge **222** may act as a local cache or data store for caching requests to the global perspective information server **216** and event lines directed to the end recipient **220**. Additionally, the bridge **222** may perform selective or intelligent caching of global perspective information such that subsequent lookups or requests of global perspectives may be served from the local cache of the bridge **222**.

FIG. **3** illustrates additional aspects of a system **200** in accordance with embodiments of the present invention, and in particular illustrates additional features and components of a computing device **204** and a bridge **222**. The computing device **204** may comprise a general purpose computer, tablet computer, smart phone, or other device or federated group of devices capable of supporting communications over a communication network **212**. The computing device **204** may include a processor **316**, memory **304**, one or more user input devices **308**, such as a keyboard and a pointing device, and one or more user output devices **312**, such as a display, speaker, and/or printer. Alternatively, or in addition, the user input **308** and the user output **312** may be combined into one device, such as a touch screen display. Computing device **204** may further include a communication interface **328** for communicating with another computing device **204**, a global perspective information server **216**, an end recipient **220**, and/or the communication network **212**.

Processor **316** is provided to execute instructions contained within memory **304** and/or storage **320**. As such, the functionality of the computing device is typically stored in memory **304** and/or storage **320** in the form of instructions and carried out by the processor **304** executing such instructions. Accordingly, the processor **316** may be implemented as any suitable type of microprocessor or similar type of processing chip. One example of the processor **304** may include any general-purpose programmable processor, digital signal processor (DSP) or controller for executing application programming contained within memory **304** and/or storage **320**. Alternatively, or in addition, the processor **316**, memory **304**, and/or storage **320**, may be replaced or augmented with an application specific integrated circuit (ASIC), a programmable logic device (PLD), or a field programmable gate array (FPGA).

The memory **304** generally comprises software routines facilitating, in operation, pre-determined functionality of the computing device **204**. The memory **304** may be implemented using various types of electronic memory generally including at least one array of non-volatile memory cells (e.g., Erasable Programmable Read Only Memory (EPROM) cells or FLASH memory cells, etc.). The memory **304** may also include at least one array of dynamic random access memory (DRAM) cells. The content of the DRAM cells may be pre-programmed and write-protected thereafter, whereas other portions of the memory may selectively be modified or erased. The memory **304** may be used for either permanent data storage and/or temporary data storage.

The data storage **320** may generally include storage for programs and data. For example, data storage **320** may

provide storage for a sensor agent **208** including the system filters **340**, the local aggregator and interpreter **344**, the context analyzer **348**, the global perspective module **352**, the event distributor **356**, and/or the general operating system and other programs and data **324**. Additionally, the data storage **320** may also include an event store **328**, such as a database, for storing and/or caching event information, context information, global perspective information, and/or event lines. One or more components of the computing device **204** may communicate with one another utilizing a bus **336**. Alternatively, or in addition, the sensor agent **208** may be provided separate and apart from data storage **320**. That is, the sensor agent **208**, including the system filters **340**, the local aggregator and interpreter **344**, the context analyzer **348**, the global perspective module **352**, the event priority generation unit **358**, and the event distributor **356** may be implemented using a processor, such as a microprocessor **304**. Accordingly, the microprocessor **304** may be specifically programmed to carry out one or more functions of the sensor agent **208**. For example, the processor **304** may execute instructions associated with the sensor agent **208**, including the system filters **340**, the local aggregator and interpreter **344**, the context analyzer **348**, the global perspective module **352**, the event priority generation unit **358**, and the event distributor contained within memory **304** and/or storage **320**. Alternatively, or in addition, the sensor agent **208**, including the system filters **340**, the local aggregator and interpreter **344**, the context analyzer **348**, the global perspective module **352**, the event priority generation unit **358**, and the event distributor **356** may share the processor **304**.

The system filters **340** intercept system events in a manner such that they do not impact system performance. In some embodiments, events are gathered and time stamped accurately and sequentially such that a chronological order of system events is maintained and may be provided for consumption at a higher level. As one example, the time stamp may correspond to the time at which the event took place. Such a timestamp may be added to the event and/or maintained at an event line. Moreover, the system events may then be sorted according to event type and/or processing resources such that the system events are inserted, or stored, in a queue in real-time.

The local aggregator and interpreter receives events from the system filters **340**, and collects the received events into batches from the queues in which they are inserted in real-time. The batches of events are then transmitted to a local service process where the events are held for further analysis. Such events may be held, or otherwise stored, within an event store **328**. At this stage, intelligent caching may be invoked to drop events which are duplicates of recent events, and some data normalization may be performed to ensure consistency. Caching may be implemented sparingly but in critical areas to ensure redundant events are not continually reported—many applications perform thousands of the same events (network access to the same destination IP address, for example) and transmitting these events into an external log source would create a significant amount of unnecessary noise and potential performance degradation. The cache may integrate a "time to live" concept to prevent applications from hiding their traffic within their noise. For example, events meeting predefined criteria may be dropped from the real-time system event queues. In some embodiments, if the predefined criteria include determining if a system event is the same or otherwise matches a previous system event, then the event may be dropped. Additionally, if a duplicate event occurs within a specified time, the event may be dropped from the queue. Alternatively, or in addition, if the duplicate system event occurs within a specified period of time, the duplicate system event may be modified to reflect that the duplicate system event is the same as a previously occurring system event. Accordingly, the later occurring duplicate system event may receive all contextual state information and global perspective information without requiring all of the determinations and/or lookups of such information. However, a time-to-live (TTL) functionality may be implemented on a cache basis to ensure that cached events, or previous events having context and/or a global perspective, are current. Accordingly, not all previous events having contextual information may be available to provide contextual information to a current event. As another option, the later occurring duplicate system event may be modified in a manner such that when the later occurring duplicate system event is interpreted by the end recipient **220**, the end recipient **220** may determine that the system event information may be the same as a previously parsed system event line. Accordingly, a full event line for the duplicate system event is not generated and/or transmitted saving bandwidth and information processing resources. Further, the caches may automatically roll over to ensure sufficient space is always available without requiring exorbitant amounts of memory.

The local aggregator and interpreter **344** may additionally perform data normalization on items such as kernel filenames, user mode filenames, process objects, registry objects, and other system structures and normalizes them into a standard format which is easy more easily consumed by automated parsers. Consolidating and normalizing data at this stage allows the data to be handled much more quickly at the higher levels to avoid reprocessing data and potentially missing events just because they were referred to slightly differently (\Device\HarddiskVolume1\Windows\file.exe instead of C:\Windows\file.exe for example). In some embodiments, an aspect of this subsystem provides the ability to process events asynchronously. The subsequent modules which will execute over the data may potentially take a considerable amount of time to complete but delaying the response for each event at this phase would result in a significant system slowdown. Instead, events are intelligently queued in multiple layers to minimize the number of individual threads but still ensure each event is given sufficient time to be independently processed. Because of this structure, there is little to no performance difference if an event takes one millisecond to be processed or one hour for the full series of routines to complete.

The context analyzer **348** ensures that a user at the end recipient **220** is provided with the deepest view of the most important data but still has access to the full range of data if they wish to see it. Accordingly, the context analyzer **348** correlates objects within system events to additional objects known to exist. For example, the context analyzer **348** may correlate an actor, victim, and/or event type to one or more originating processes, devices, and users. Such a correlation creates an audit trail for each individual event. As will be described later, this audit trail allows an administrator, at an end recipient **220** for example, to forensically track back any event which occurs to what triggered it. Accordingly, this additional information, including the originating processes, devices, and user, allows a contextual state to be established for each event. As each contextual state is established, the contextual state may be cached and aggregated to be quickly

queried in subsequent lookups further reducing latency and improving the performance of the system.

After the context analyzer completes, the sensor agent **208** may attempt to establish a global perspective for each event by calling the cloud database utilizing an infrastructure similar to the infrastructure discussed in U.S. application Ser. No. 13/372,375 filed Feb. 13, 2012, "Methods and Apparatus for Dealing with Malware" (US-2012-0260340-A1, but with an additional layer capable of responding in a highly scalable manner which avoids the overhead generally associated with the complex rule processing within the overall database. Such an additional layer may be named SkyMD5. The response from the SkyMD5 layer may include information related to the age, popularity, and determination of an object—whether it is known good, bad, or unknown. This data may then be normalized and appended to each relevant portion of the event line. Further lookups are performed for network activity, assessing the reputation and category of each website and IP address as they are contacted.

In addition, similar to the contextual analyzer, the global perspective unit may first determine whether or not global perspective information for the particular system event is available locally. For example, global perspective information may be cached or otherwise stored in the storage data **320**. In addition, a TTL approach may be additionally utilized to reduce the amount of traffic, or calls, to the global perspective information server **216**, by the global perspective unit **352** of the sensor agent **208**. Accordingly, contextual state information may only be available locally for a specified period of time and/or specified number of system events.

The event priority module **358** may contain priority logic, or one or more rule sets, to associate a priority to one or more events. The event priority module may utilize information from the local aggregator and interpreter **344**, the context analysis module **348**, and the global perspective module **352**, to determine, or otherwise assign, a priority to an event; such a priority may be based on a rule set. The rule set may be provided by an administration system, backend system, end recipient **220**, or other component of a forensic system. For example, a rule set may determine that an event meeting certain conditions be assigned a priority according to a scale of severity. Such an event priority may then be added to an existing event line or data structure.

The event distributor **356** may batch and transmit the events to the end recipient **220** after the global perspective has been applied. Alternatively, or in addition, the event distributor **356** may batch and transmit the events to the end recipient **220** after an event priority has been determined for the event. In one implementation, the syslog protocol is used to send each event as a line of log data to be processed by an end recipient **220**. The transmission of events requires an additional layer of asynchronous processing as the response time from the recipient cannot be allowed to slow down the higher level global perspective and contextual analysis work which is ongoing in other threads. Therefore, a transmission engine of the event distribute **356** builds the final event line, packages the event line together with information about the host itself, and then sends it directly into a separate queue where it will then be sent shortly after (usually a few seconds) while maintaining the pre-set timestamp of precisely when the event took place even if it is sent several seconds later. The separate queue may be a queue located in the storage data **320** and more specifically in the event store **328**.

The bridge **222** may comprise a general purpose computer and/or server or other device or federated group of devices capable of supporting communications over a communication network **212**. The bridge **222** may include a processor **382**, memory **362**, one or more user input devices **366**, such as a keyboard and a pointing device, and one or more user output devices **378**, such as a display, speaker, and/or printer. The bridge **222** may further include a communication interface **386** for communicating with another computing device **204**, an end recipient **220**, a global perspective information server **216**, and/or the communication network **212**. Processor **382** and memory **362** may be the same or similar as that which was described with respect to processor **316** and memory **304** respectively.

The data storage **370** may generally include storage for programs and data. For example, data storage **370** may provide storage for a cached event store **394** and/or the general operating system and other programs and data **374**. Optionally, as indicated by the dashed line, the cached event store **394** may be separate and apart from the data storage **370**. That is, the cached event store **394** functions independently and/or in cooperation with memory **362** and processor **382**.

The bridge **222** may be a dedicated device residing locally on a network. The bridge **222** may aggregate communications to and from one or more computing system **204** such that information to and from sensor agent **208** is cached and stored at the cached event store **394**, optimizing global perspective requests and other communications. Additionally, the bridge **222** may perform selective or intelligent caching of global perspective information such that subsequent lookups or requests of global perspectives may be served from the cached event data store **394**. One or more components of the bridge **222** may communicate with one another utilizing a bus **390**.

FIG. **4** illustrates additional aspects of a system **200** in accordance with embodiments of the present invention, and in particular illustrates additional features and components of a global perspective information server **216** and an end recipient **220**. The global perspective information server **216** may comprise a general purpose computer and/or server or other device or federated group of devices capable of supporting communications over a communication network **212**. The global perspective information server **216** may include a processor **464**, memory **452**, one or more user input devices **456**, such as a keyboard and a pointing device, and one or more user output devices **460**, such as a display, speaker, and/or printer. The global perspective information server **216** may further include a communication interface **468** for communicating with another computing device **204**, an end recipient **220**, and/or the communication network **212**. Processor **464** and memory **452** may be the same or similar as that which was described with respect to processor **316** and memory **304** respectively.

The data storage **488** may generally include storage for programs and data. For example, data storage **488** may provide storage for a global perspective module **476**, data store **486**, and/or the general operating system and other programs and data **484**. Optionally, each of the global perspective module **476**, the data store **486**, and/or the event distributor **492** may be separate and apart from the data storage **488**. That is, as indicated by the dashed line, each of the global perspective module **476**, the data store **486**, and/or the event distributor **492** functions independently and/or in cooperation with memory **452** and processor **464**.

The global perspective module **476** provides global perspective information at the request of a sensor agent **208**. For

example, and as previously described, the sensor agent **208** may transmit a global perspective request **224** to the global perspective information server **216** requesting global perspective information for one or more system events having a contextual state. Accordingly, the global perspective module **476** may provide the global prospective information **228** to the global perspective unit **352** of the computing system **204**. In addition, in some embodiments the event distributor functionality may reside at the global perspective information server **216**. Accordingly, in such an embodiment, the global perspective module **476** may receive event information having contextual state information. In such an instance, the global perspective module **476** may provide the global perspective information and store the system event, contextual information, and global perspective information in data store **486**. The event distributor **492** may then assemble the event line information, queue the event line for transmission, and transmit the event line to the end recipient **220**. The event distributor **492** may function and/or operate in a manner similar to or the same as the event distributor **356** of the sensor agent **208**. One or more components of the global perspective information server **216** may communicate with one another utilizing a bus **472**.

The end recipient **220** may comprise a general purpose computer and/or server or other device or federated group of devices capable of supporting communications over a communication network **212**. The end recipient **220** may include a processor **416**, memory **404**, one or more user input devices **408**, such as a keyboard and a pointing device, and one or more user output devices **412**, such as a display, speaker, and/or printer. The end recipient **220** may further include a communication interface **428** for communicating with another computing device **204**, a global perspective information server **216**, and/or the communication network **212**. Processor **416** and memory **404** may be the same or similar as that which was described with respect to processor **316** and memory **304** respectively.

The end recipient **220** may further include data storage **420** which may include storage for programs and data. For example, data storage **420** may provide storage for an event line parser **440**, a user interface generator **444**, a global information store **448**, and/or the general operating system and other programs and data **420**. Optionally, as indicated by the dashed line, each of the event line parser **440**, the user interface generator **444**, and the global information store **448** may be provided separate and apart from the data storage **436** where each of the event line parser **440**, a user interface generator **444**, and the global information store **448** functions independently and/or in cooperation with memory **404** and processor **416**. One or more components of the end recipient **220** may communicate with one another utilizing a bus **432**.

The event line parser **440** may parse an incoming event line **244**A-B and store the event lines, either parsed or whole, at the global information store **448**. Accordingly, the end recipient **220** may utilize the parsed event line to generate an user interface utilizing the user interface generator **444**. The generated user interface may then be displayed to a user at an user output device **412**. The user interface generator **444** may create one or more dashboards that provide information to a user of the end recipient **220**. Accordingly, dashboards may display correlated events collected by a sensor agent **204**. Such correlated events may comprise File System/Disk activity, network activity, and registry activity on the endpoint along with the global community data and IP and domain reputation data to provide a complete point of view of the computing system **204** activity and further provide a full meaning to every single reported event. Accordingly, spotting and highlighting behaviours in the event data from computing systems **204** may potentially assist in finding and determining whether such activity is malicious or not.

Moreover, there may exist multiple dashboards each of which provide a specific heuristic that targets a specific potential malicious behaviour. For example, a first dashboard generally looks for executables that have been found and executed from specific critical paths in the computing system **204**; those paths that are known to host malware executables (browser's cache, temporary files folder, system32 folder, auto start folder and so on). The dashboard may filter those files determined as good, unknown and bad from global community information. For unknown files, the dashboard may show their popularity at the global community, i.e. on how many computing systems **204** they have been seen—and if they establish outbound internet connections. If such files connect to the Internet, the dashboard may trace down and identify the specific connection and geolocate the destination address on a world map.

In another embodiment, a separate dashboard may analyze outbound connections from the analyzed endpoints. Accordingly, this dashboard may filter out and highlight connections to high-risk countries, i.e. those countries known to host malicious servers, and retrieve software that actually established the suspicious connections. The dashboard may also provide another point of view; that is, the dashboard may highlight all connections to specific IPs and domains that have been set up recently (e.g. in the last 60 days). All connections may be shown on a map view and the contacted IPs and domains are crosschecked with a database to determine their reputation and website category (if known).

As another example, a dashboard may highlight potential exploits detected on the endpoint by monitoring the most common software usually installed on an average computing system **204** and targeted by exploit attacks. The dashboard may generally identify software like Java, Adobe Acrobat, Microsoft Office, Flash Player and monitor if such software is dropping executable files on the system. Accordingly, if the software behaves in this manner, such a behaviour should be considered a suspicious behaviour, as software should not be dropping any executable files on the system. If such an occurrence is detected, the dashboard may analyze the dropped executable for its popularity in the global community and then identify potential outbound connections established by the just-dropped executable. If an outbound connection is found, the dashboard retrieves the destination IP and renders, or draws, the location of the IP address on a map view, such as a world map.

As another example, a separate dashboard may highlight those new processes created on the monitored computing systems **204** that are undetermined and have only been recently seen in the global community. For every process, a lifetime scheme is assembled which allows the administrator to understand when the undetermined file firstly landed on the endpoint and for how long time it has been active on the system. This dashboard may further provide specific events triggered by the suspicious process while active on the system.

As another example, a dashboard may highlight system processes that have been found to establish concurrent connections to different IPs in less than a specific timeframe and/or threshold, such as one second. If found, the system processes may be suspect and deemed to host malicious code; such malicious code having been injected into the

website. For every established connection, the dashboard may trace and identify the contacted country and the specific IP/domain. As another example, a dashboard may be generated by the user interface generator **448** such the dashboard monitors activities on remote storage services like Dropbox, showing the filename and size of the files being saved on a remote server. The dashboard may further monitor and identify sensitive or classified company data that may be in the process of being stolen or placed (i.e. saved, stored, etc.) on a non-approved storage location.

FIGS. **5**A-**5**C illustrate additional aspects of a system **200** in accordance with embodiments of the present invention, and in particular illustrates event capturing, the application of contextual state, and the application of a global perspective to such captured events. For example, events **508**A-**520**A are representative events that may have been captured by one or more system filters **340** of a sensor agent **204**. The system events **504**A-**520**A may include an Event ID, an Event Type, an Actor and a Victim. Although not illustrated, a timestamp may also be included in the event. As previously described, the actor and the victim may comprise objects. For example, in the system event **520**A, an event type of Registry Edit is captured where Object **2** is modifying Object **3**; accordingly, Object **3** may be the registry hive, a specific registry entry, and/or a specified registry value. Moreover each of the Event ID, Event Type, Actor, and Victim may be hashed resulting in a key that uniquely identifies the data.

As illustrated in FIG. **5**B, a contextual analysis may be applied to the captured events **504**B-**520**B. Accordingly, a context **520**B comprising an origination proceess, Device, User, and in some instances, a GenesisActor may further supplement or enhance the Event ID, Event Type, Actor, and Victim. Although illustrated as including an originating process, GenesisActor, device, and user, the contextual information forming the contextual state **520**B may include more or less information and in varying combinations. Moreover, as illustrated in FIG. **5**B, the originating process or object may determined based on a previous event that initiated or otherwise created the current process and/or object. Additionally, as illustrated in FIG. **5**B, the GenesisActor is determined based on a chain of previous events. For example, the Actor of Object **1** for system event **504**B of Event Type "executes" operates on Filename **1**. Object **1** subsequently creates a process Object **2** in **508**B which is further utilized in both **516**B and **520**B. Accordingly, as the Object **1** initiated subsequent events, Object **1** may be determined to be the GenesisActor for **520**B, **516**B, **512**B, and **508**B.

As illustrated in FIG. **5**C, a global perspective is applied to event **520**C. The global perspective may comprise information for each object in the event and/or the contextual state **524**. For example, a global perspective may be obtained for Object **2**, Object **3**, and Object **1** as illustrated. Accordingly, a global perspective **528** indicating the age of Object **2**, the popularity of Object **2**, the determination of Object **2**, and/or additional IP/URL information of Object **2** may be provided. Similar global perspective information **532**, **536** may be obtained for Object **3** and Object **1** respectfully. Accordingly, an event line may be assembled utilizing the event information, contextual state, and global perspective information. In addition, the global perspective may provide additional information pertaining to an IP/URL address. For example, such information may include a categoryID of the IP/URL, a confidence of such a categoryID, a reputation, geolocation information such as which country the IP/URL is associated with, and/or a threat history associated with the IP/URL.

Referring now to FIG. **6**, a method **600** for providing forensic visibility into a system is provided in accordance with embodiments of the present disclosure. Method **600** is in embodiments, performed by a device, such as the sensor agent **204** and/or the end recipient **220**. More specifically, one or more hardware and software components may be involved in performing method **600**. In one embodiment, one or more of the previously described units perform one or more of the steps of method **600**. The method **600** may be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer-readable medium. Hereinafter, the method **600** shall be explained with reference to systems, components, units, software, etc. described with FIGS. **1**-**5**C.

Method **600** may continuously flow in a loop, flow according to a timed event, or flow according to a change in an operating or status parameter. Method **600** is initiated at step **604** where events of a computing system **204** may be initiated. At step **608**, such an event may be detected. As previously discussed, the events, which may comprise system events, may be detected by one or more system filters **340** of a sensor agent **208**. The sensor agent **208** may be comparatively small compared with other commercially available forensic tools and anti-malware software. This may be achieved by the sensor agent **204** being developed in a low-level language, having direct access to system resources such as the video display, disk, memory, the network(s), and without the incorporation of many standard code or dynamic linked libraries to perform these functions. Memory usage may be optimized by storing data in a local database structure that provides the ability to refer to objects by a unique identifier rather than requiring full filenames or signatures. All unnecessary dynamic link libraries are unloaded from the process immediately as they are identified as no longer being used, and background threads are merged to reduce CPU usage. A small, efficient sensor agent **204** may be deployed more quickly and may be used alongside other programs, including other security programs, with less load on or impact on the computer's performance. This approach also has the advantage of having less surface area for attack by malware making it inherently more secure.

Method **600** then proceeds to step **612** where the local aggregator and interpreter **344** receives events from the low level system filters **340**, collecting them in batches from the queues in which they are inserted in real-time. As previously discussed, intelligent caching may be invoked to drop events which are duplicates of recent events. Further, some data normalization may be performed at step **612** to ensure consistency. Further still, caching may be implemented sparingly but in critical areas to ensure redundant events are not continually reported. Method **600** then proceeds to step **616** where a contextual state may be applied by a context analyzer **348** to the event information. Accordingly, the context analyzer correlates events to objects such that an audit trail for each individual event is created. As a contextual state is established, it is cached and aggregated to be quickly queried in subsequent lookups further reducing latency and improving the responsiveness of the system. Once a contextual state is applied, method **600** then proceeds to step **620** where a global perspective is applied for each event and/or each object of the event and contextual state. Accordingly, information related to the age, popularity, and determination of an object—whether it is known good, bad, or unknown is obtained. In addition, as previously mentioned, the global perspective may contain information

pertaining specifically to an IP/URL address. For example, the global perspective may include information relating network activity and an assessment of the reputation and category of each website and IP address as they are contacted. This data may then be normalized. Method **600** then proceeds to step **622** where an event priority may be applied to the event. As previously discussed, the event priority may be obtained utilizing a rule set and applying such a rule set to aggregated event information, contextual state information, and global perspective information. Accordingly, method **600** then proceeds to step **624** where such data is appended to each relevant portion of an event line.

Method **600** may then proceed to step **628** where the event distributor **356** may transmit the event line **244** to the end recipient **220**. The event distributor may first assemble the information and transmit the batched information after the global perspective has been applied. Once at the end recipient, the method **600** may then parse the event line at step **632** to filter out one or more events. Accordingly, the events may be stored in the data store **480**. Method **600** may then display the parsed event line at one or more dashboards in accordance with step **636**. Method **600** then ends at step **640**.

Referring now to FIG. **7**, additional details regarding step **608** of method **600** is provided in method **700**. Method **700** is in embodiments, performed by a device, such as the sensor agent **204** and/or the system filter **340**. More specifically, one or more hardware and software components may be involved in performing method **700**. In one embodiment, one or more of the previously described units perform one or more of the steps of method **700**. The method **700** may be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer-readable medium. Hereinafter, the method **700** shall be explained with reference to systems, components, units, software, etc. described with FIGS. **1-6**.

Method **700** may continuously flow in a loop, flow according to a timed event, or flow according to a change in an operating or status parameter. Method **700** is initiated at step **704** where events of a computing system **204** may be initiated. At step **708**, such an event may be detected. As previously discussed, the events, which may comprise system events, may be detected by one or more system filters **340** of a sensor agent **208**. Accordingly, at step **712**, an event record may be created. The event record may be the same or similar to that which was described with respect to FIG. **5**A. Accordingly, the event record may include an Event ID, and Event Type, an Actor, and a Victim. Moreover, in some embodiments, instead of creating a separate event record and a separate event line, a single event line for each event may be utilized. That is, the event record may be the event line. Accordingly, at step **716** the event line and/or the event record may be time stamped and stored. At step **720**, method **700** may then determine which queue the event record or event line, should be assigned. In some embodiments, the event record/event line may be assigned to a specified queue based on the event type. Alternatively, or in addition, the event record/event line may be assigned to a specified queue based on the needed resources and the available resources. Method **700** then ends at step **724**.

Referring now to FIG. **8**, additional details regarding step **612** of method **600** is provided in method **800**. Method **800** is in embodiments, performed by a device, such as the sensor agent **204** and/or the local aggregator and interpreter **344**. More specifically, one or more hardware and software components may be involved in performing method **800**. In one embodiment, one or more of the previously described units perform one or more of the steps of method **800**. The method **800** may be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer-readable medium. Hereinafter, the method **800** shall be explained with reference to systems, components, units, software, etc. described with FIGS. **1-7**.

Method **800** may continuously flow in a loop, flow according to a timed event, or flow according to a change in an operating or status parameter. Method **800** is initiated at step **804**. Method **800** then proceeds to step **808** where batches of event records/event lines are received form one or more previously described queues. For each event, method **800** proceeds to determine if the event record/event line meets a predefined criteria. For example, if the current event record/event line matches or is otherwise the same as a previous event record/event line, method **800** may proceed to step **824** where the current event record/event line may be dropped. Alternatively, or in addition, the dropped event record/event line may be modified such that either the contextual analyzer **348** and/or the global perspective unit **352** may be able to determine a contextual state and global perspective based on a previously captured event record/event line. Alternatively, or in addition, the dropped event record/event line may be modified to refer to a previously captured event record/event line such that upon parsing by the end recipient **220**, the current event line/event record is provided meaning from a previously parsed event record/event line

Accordingly, method **800** may then proceed to step **816** where the information may be normalized. The normalization may be implemented with a database which takes complete path names and translates them to representatives paths. So, for example, the Windows\file.exe would end up normalized to % windir %\file.exe, allowing rules to be created for any full path. Similar logic is utilized for paths like % appdata % which would have unique elements per-user and would be difficult to manage if not normalized. Accordingly, once the information in the event record/event line is normalized, method **800** may proceed to step **820** where the events may be intelligently queued. For instance, each event record/event line may be placed in a queue according to an event type. Method **800** may then end at step **828**.

Referring now to FIG. **9**, additional details regarding step **616** of method **600** is provided in method **900**. Method **900** is in embodiments, performed by a device, such as the sensor agent **204** and/or the context analyzer **348**. More specifically, one or more hardware and software components may be involved in performing method **900**. In one embodiment, one or more of the previously described units perform one or more of the steps of method **900**. The method **900** may be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer-readable medium. Hereinafter, the method **900** shall be explained with reference to systems, components, units, software, etc. described with FIGS. **1-8**.

Method **900** may continuously flow in a loop, flow according to a timed event, or flow according to a change in an operating or status parameter. Method **900** is initiated at step **904**. Method **900** then proceeds to step **908** where event records/event lines are received. Method **900** then proceeds to step **912** where objects of the event record/event line are correlated to objects in a contextual state. For example, and as illustrated in at least FIG. **5**B, a contextual state may include originating processes, devices, and users. Accordingly, once objects of the event record/event line have been correlated, method **900** proceeds to step **916** where the event

record/event line includes an established contextual state. In some embodiments consistent with the present disclosure, the contextual state may already be cached and may be obtained based on the event record/event line information. As one example, based on the event type, actor, and victim, it may be possible to recover a contextual state that includes an originating process, the device, and the user. However, not all cached instances of cached contextual state will suffice as different users may utilize a computing device **204**.

Method **900** then proceeds to step **920** where the contextual state may be cached and made accessible for later access. In accordance with at least one embodiment, the event line may be partially assembled where the partially assembled event line may include various combinations of the event type, the actor object, the victim object, and the origination process. Accordingly, the partially assembled event line may later be passed to a global perspective information server. As such, method **900** ends at step **928**.

Referring now to FIG. **10**, additional details regarding step **620** of method **600** is provided in method **1000**. Method **1000** is in embodiments, performed by a device, such as the sensor agent **204** and/or the global perspective unit **352**, the global perspective module **476**, and/or the global perspective information server **216**. More specifically, one or more hardware and software components may be involved in performing method **1000**. In one embodiment, one or more of the previously described units perform one or more of the steps of method **1000**. The method **1000** may be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer-readable medium. Hereinafter, the method **1000** shall be explained with reference to systems, components, units, software, etc. described with FIGS. **1-9**.

Method **1000** may continuously flow in a loop, flow according to a timed event, or flow according to a change in an operating or status parameter. Method **1000** is initiated at step **1004**. Method **1000** then proceeds to step **1008** where method **1000** determines whether event record/event line information is cached. Such a determination may be based upon whether the event information, such as the event type, the actor, and/or the victim, match a predetermined criteria. For instance, not all event types may be cached. In one embodiment, global perspective information caching will cache a specific number of event types occurring within a specified time period. In other instances, all global perspective information for all events may be cached. Accordingly, if it is determined that global perspective information is not cached, method **1000** proceeds to step **1016** where the global perspective information server may be contacted. Accordingly, such a request may provide the global perspective information server **216** with information in an event record and/or a partially assembled event line. Accordingly, the global perspective information or a particular event may be retrieved. The retrieved global perspective information may then be stored at step **1024**. For example, such information may be stored in event store **328**.

Otherwise, if global perspective information is cached for an event record/event line, the method **1000** may proceed to step **1012** were method **1000** may determine whether a time-to-live (TTL) has been exceeded. In some instances, the cached information may expire based on the frequency of occurrence for a particular event. For example, if an event occurs with a high frequency, the global perspective unit **352** may determine that for efficiency reasons, either resources and/or bandwidth, caching for a particular event would be beneficial to improving the overall efficiency of the sensor agent **208** and/or computing device **204**. Accordingly, the method **1000** then proceeds to step **1020** where the global perspective for the event is retrieved based on the cached entry. Otherwise, if the occurrence of the same event happens at a reduced frequency such that it would not be beneficial to cache global perspective information, it might be more beneficial to directly lookup and retrieve such information directly from the global perspective information server **216**. Accordingly, the method **1000** proceeds to step **1016** where global perspective information is received from the global perspective information server. In some instances, the cache of global perspective events may expire according to a predetermined time. At step **1024**, method **1000** may proceeds to step **1028** where method **1000** ends.

Referring now to FIG. **11**, additional details regarding step **624** of method **600** is provided in method **1100**. Method **1100** is in embodiments, performed by a device, such as the sensor agent **204**. More specifically, one or more hardware and software components may be involved in performing method **1100**. In one embodiment, one or more of the previously described units perform one or more of the steps of method **1100**. The method **1100** may be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer-readable medium. Hereinafter, the method **1100** shall be explained with reference to systems, components, units, software, etc. described with FIGS. **1-10**.

Method **1100** may continuously flow in a loop, flow according to a timed event, or flow according to a change in an operating or status parameter. Method **1100** is initiated at step **1104**. Method **1100** then proceeds to step **1108** where a priority rule set is retrieved. The priority rule set may be retrieved directly from an administration system and/or may be received locally from a storage location associated with the sensor agent **208** and/or the data storage **320**. The priority rule set may have one or more predefined criteria for assigning a priority level to an event. The priority level may represent a perceived severity or risk in which such an event poses. Method **1100** then proceeds to step **1112** where an event priority, or level, is assigned to the event.

In at least one embodiment, the priority level may be derived from aggregated and interpreted event information from the local aggregator and interpreter **344**, context analyzer **348**, and global perspective unit **352**. Accordingly, an event having a specified Actor, Victim, Target, originating process, or the like together with a global perspective indicating that at least one of the Actor, Victim, Target, origination process has been determined to be malware may result in a rule set that assigns a priority level to the event indicating that such the event should be immediately brought to the attention of an administrator. Accordingly, the event may be said to have a "high" priority or be a "high" priority event. Method **1100** may then end at step **1116**. With reference to FIG. **12**, details of a data structure **1200** will be described in accordance with embodiments of the present disclosure. In some embodiments, the data structure **1200** may be used as an event line and may contain details specific to an event, context, and global perspective. For example, an event line **1204** may generally include, without limitation, event information **1208**, a time stamp **1212**, context state information **126**, global perspective information **1220**, and a priority level **1222**, where the priority may be a value that ranges between a low and a high number. In some embodiments, the event field **1208** may further include Event ID information **1224**, Event Type information **1228**, Actor **1232**, and Victim information **1236**. In some embodiments, the context state **1216** may include, without limitation, Originating Process **1240** information, Device information

1244, User information 1248, dependent data such as, but not limited to additional meta data and/or ancillary data describing or containing detailed information about one or more objects 1252, and object info 1256. In addition, the global perspective field may include, but is not limited to an age 1260, popularity 1264, malware determination 1268, and/or IP/URL information 1272, where IP/URL information may include, but is not limited to a categoryID of the IP/URL, a confidence of such a categoryID, a reputation, geolocation information such as which country the IP/URL is associated with, and/or a threat history associated with the IP/URL. Of course, additional relevant information may be included in the event line 1204 depending on the event.

FIG. 13 generally illustrates exemplary user interfaces, or dashboards 1304, 1332, and 1336, which may be displayed at an end recipient 220 to a user at an user output device 412. The user interface generator 444 may create the one or more dashboards 1304, 1332, and 1336 to provide information from an event to a user of the end recipient 220. Accordingly, the dashboards 1304, 1332, and 1336 may display correlated events collected by a sensor agent 204. Such correlated events may comprise File System/Disk activity 1308, network activity 1312, and registry activity 1316 on the endpoint along with the global community data and IP and domain reputation data 1324 to provide a complete point of view of the computing system 204 activity and further provide a full meaning to every single reported event, including at least one of an originating process, an Event Type, a Target, a Victim, and a Actor. Accordingly, spotting and highlighting behaviours in the event data from computing systems 204 may potentially assist in finding and determining whether such activity is malicious or not.

Moreover, there may exist multiple dashboards 1304, 1332, and 1336 each of which provide a specific heuristic that targets a specific potential malicious behaviour. For example, a first dashboard 1326 generally looks for executables that have been found and executed from specific critical paths in the computing system 204; those paths that are known to host malware executables (browser's cache, temporary files folder, system32 folder, auto start folder and so on). The dashboard 1326 may filter those files determined as good, unknown and bad from global community information. For unknown files, the dashboard may show their popularity at the global community, i.e. on how many computing systems 204 they have been seen—and if they establish outbound internet connections. If such files connect to the Internet, the dashboard 1332 may trace down and identify the specific connection and geo-locate the destination address on a world map.

In another embodiment, a separate dashboard 1336 may analyze outbound connections from the analyzed endpoints. Accordingly, this dashboard may filter out and highlight connections to high-risk countries, i.e. those countries known to host malicious servers, and retrieve software that actually established the suspicious connections. The dashboard 1336 may also provide another point of view; that is, the dashboard 1336 may highlight all connections to specific IPs and domains that have been set up recently (e.g. in the last 60 days). All connections may be shown on a map view and the contacted IPs and domains are crosschecked with a database to determine their reputation and website category (if known).

As another example, a dashboard 1340 may highlight potential exploits detected on the endpoint by monitoring the most common software usually installed on an average computing system 204 and targeted by exploit attacks. The dashboard 1340 may generally identify software like Java, Adobe Acrobat, Microsoft Office, Flash Player and monitor if such software is dropping executable files on the system. Accordingly, if the software behaves in this manner, such a behaviour should be considered a suspicious behaviour, as software should not be dropping any executable files on the system. If such an occurrence is detected, the dashboard 1340 may analyze the dropped executable for its popularity in the global community and then identify potential outbound connections established by the just-dropped executable. If an outbound connection is found, the dashboard 1340 retrieves the destination IP and renders, or draws, the location of the IP address on a map view, such as a world map.

As another example, a separate dashboard 1344 may highlight those new processes created on the monitored computing systems 204 that are undetermined and have only been recently seen in the global community. For every process, a lifetime scheme is assembled which allows the administrator to understand when the undetermined file firstly landed on the endpoint and for how long time it has been active on the system. This dashboard 1344 may further provide specific events triggered by the suspicious process while active on the system.

As another example, a dashboard 1348 may highlight system processes that have been found to establish concurrent connections to different IPs in less than a specific timeframe and/or threshold, such as one second. If found, the system processes may be suspect and deemed to host malicious code; such malicious code having been injected into the website. For every established connection, the dashboard may trace and identify the contacted country and the specific IP/domain. As another example, a dashboard 1348 may be generated by the user interface generator 448 such the dashboard monitors activities on remote storage services like Dropbox, showing the filename and size of the files being saved on a remote server. The dashboard 1348 may further monitor and identify sensitive or classified company data that may be in the process of being stolen or placed (i.e. saved, stored, etc.) on a non-approved storage location.

In the foregoing description, for the purposes of illustration, methods were described in a particular order. It should be appreciated that in alternate embodiments, the methods may be performed in a different order than that described. It should also be appreciated that the methods described above may be performed by hardware components or may be embodied in sequences of machine-executable instructions, which may be used to cause a machine, such as a general-purpose or special-purpose processor or logic circuits programmed with the instructions to perform the methods. These machine-executable instructions may be stored on one or more machine readable mediums, such as CD-ROMs or other type of optical disks, floppy diskettes, ROMs, RAMs, EPROMs, EEPROMs, magnetic or optical cards, flash memory, or other types of machine-readable mediums suitable for storing electronic instructions. Alternatively, the methods may be performed by a combination of hardware and software.

Furthermore, embodiments may be implemented by hardware, software, firmware, middleware, microcode, hardware description languages, or any combination thereof. When implemented in software, firmware, middleware or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine readable medium such as storage medium. A processor(s) may perform the necessary tasks. A code segment may represent a procedure, a function, a subprogram, a program, a routine,

a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

The foregoing discussion of the invention has been presented for purposes of illustration and description. Further, the description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, within the skill or knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are further intended to explain the best mode presently known of practicing the invention and to enable others skilled in the art to utilize the invention in such or in other embodiments and with various modifications required by the particular application or use of the invention. It is intended that the appended claims be construed to include alternative embodiments to the extent permitted by the prior art.

What is claimed is:

1. A method comprising:

gathering one or more events defining an action of a first object acting on a target;

generating a contextual state for at least one of the one or more events by correlating the at least one event to an originating object, the contextual state including an indication of the originating object of the first object and an indication of at least one of a device on which the first object is executed and a user associated with the first object;

obtaining a global perspective for the at least one event by obtaining information associated with one or more of the first object and the originating object, the information including at least one of age, popularity, a determination as to whether the first object is malware, a determination as to whether the originating object is malware, Internet Protocol (IP) Address, and Uniform Resource Locator (URL) information, wherein the global perspective for one or more related events to the at least one event across a network;

assembling an event line including details associated with the at least one event, the details including information uniquely identifying the first object, the action of the first object, the target, and the originating object; and

transmitting the assembled event line.

2. The method of claim **1**, wherein the information associated with the one or more of the first object and the originating object is obtained from a community database; and

wherein the event line is transmitted to an end recipient.

3. The method of claim **1**, further comprising:

obtaining an event priority based on one or more of the generated context and the global perspective for the at least one event, wherein the event line further includes the event priority for the at least one event.

4. The method of claim **1**, wherein the at least one event includes information uniquely identifying the object performing the action, information uniquely identifying the action being performed, and information uniquely identifying the target upon which the act is being performed.

5. The method of claim **4**, further comprising:

determining whether a global perspective for the at least one event has been cached;

when the global perspective for the at least one event has been cached, determining whether a time-to-live (TTL) value has been exceeded; and

when the global perspective for the at least one event has not been cached, obtaining a global perspective for the at least one event from a community database.

6. The method of claim **5**, further comprising:

determining whether the cached global perspective for the at least one event has expired; and

when the global perspective for the at least one event has expired, obtaining a global perspective for the at least one event from a community database.

7. The method of claim **4**, further comprising:

heuristically displaying information identifying the first object performing the action, information identifying the action being performed, information identifying the target upon which the act is being performed, and the global perspective according to one or more of a location associated with the first object; at least one characteristic of an outbound connection associated with the first object; a dropped executable file; an age of the first object; and a number of concurrent connections associated with the first object.

8. A system for providing forensic visibility into a system, comprising:

a device including:

a communication interface;

a processor;

data storage; and

a sensor agent stored on the data storage that is executable by the processor, wherein the sensor agent is operable to:

gather one or more events defining an action of a first object acting on a target;

generate a contextual state for at least one of the one or more events by correlating the at least one event to an originating object, the contextual state including an indication of the originating object of the first object and an indication of at least one of a device on which the first object is executed and a user associated with the first object;

obtain a global perspective for the at least one event by obtaining information associated with one or more of the first object and the originating object, the information including at least one of age, popularity, a determination as to whether the first object is malware, a determination as to whether the originating object is malware, Internet Protocol (IP) Address, and Uniform Resource Locator (URL) information, wherein the global perspective for one or more related events to the at least one event across a network;

assemble an event line including details associated with the at least one event, the details including information uniquely identifying each of the first object, the action of the first object, the target, and the originating object; and

transmit the assembled event line utilizing the communication interface.

9. The system of claim **8**, wherein the at least one of the one or more events is executed by the processor.

10. The system of claim **8**, further comprising:

a global perspective information server; and

an end recipient device, wherein the information associated with the one or more of the first object and the

originating object is obtained from the global perspective information server and the sensor agent transmits the event line to the end recipient device.

11. The system of claim **8**, wherein the sensor agent is further operable to: cache the one or more events; and asynchronously consolidate and normalize the one or more events.

12. The system of claim **8**, wherein the at least one event includes information uniquely identifying the object performing the action, information uniquely identifying the action being performed, and information uniquely identifying the target upon which the act is being performed.

13. The system of claim **12**, wherein the sensor agent is further operable to:

determine whether the global perspective for the at least one event has been cached;

when the global perspective for the at least one event has been cached, determining whether a time-to-live (TTL) value has been exceeded; and

when the global perspective for the at least one event has not been cached, obtain a global perspective for the at least one event from a community database.

14. The system of claim **13**, wherein the sensor agent is further operable to:

determine whether the cached global perspective for the at least one event has expired; and

when the global perspective for the at least one event has expired, obtain a global perspective for the at least one event from a community database.

15. The system of claim **12**, wherein the end recipient heuristically displays information identifying the first object performing the action, information identifying the action being performed, information identifying the target upon which the act is being performed, and the global perspective according to one or more of a location associated with the first object; at least one characteristic of an outbound connection associated with the first object; a dropped executable file; an age of the first object; and a number of concurrent connections associated with the first object.

16. A system for providing forensic visibility into a system, comprising:

a device including:

a communication interface;

a processor;

data storage; and

a sensor agent stored on the data storage that is executable by the processor, wherein the sensor agent is operable to:

gather one or more events defining an action of a first object acting on a target;

generate a contextual state for at least one of the one or more events by correlating the at least one event to an originating object, the contextual state including an indication of the originating object of the first object and an indication of at least one of a device on which the first object is executed and a user associated with the first object;

assemble an event line including details associated with the at least one event, the details including information uniquely identifying each of the first object, the action of the first object, the target, the originating object, and global perspective information comprising information about one or more related events to the one or more events across a network; and

transmit the assembled event line utilizing the communication interface.

17. The system of claim **16**, further comprising a global perspective information server including:

a processor;

a communication interface;

data storage; and

a global perspective module, wherein the global perspective module is operable to:

receive the event line from the device;

obtain a global perspective for the at least one event by obtaining information associated with one or more of the first object and the originating object, the information including at least one of age, popularity, a determination as to whether the first object is malware, a determination as to whether the originating object is malware, Internet Protocol (IP) Address, and Uniform Resource Locator (URL) information;

assemble a second event line including details associated with the at least one event, the details including information uniquely identifying each of the first object, the action of the first object, the target, and the originating object; and

transmit the assembled second event line utilizing the communication interface to an end recipient.

18. The system of claim **17**, wherein the end recipient heuristically displays information identifying the first object performing the action, information identifying the action being performed, information identifying the target upon which the act is being performed, and the global perspective according to one or more of a location associated with the first object; at least one characteristic of an outbound connection associated with the first object; a dropped executable file; an age of the first object; and a number of concurrent connections associated with the first object.

19. The system of claim **16**, further comprising a bridge including:

a processor;

a communication interface; and

a cached event store, wherein the cached event store is operable to:

receive a first request for a global perspective for the at least one event;

receive a second request for a global perspective for another event, the second request originating from another device;

obtain a first global perspective for the at least one event by obtaining information associated with one or more of the first object and the originating object, the information including at least one of age, popularity, a determination as to whether the first object is malware, a determination as to whether the originating object is malware, Internet Protocol (IP) Address, and Uniform Resource Locator (URL) information;

obtain a second global perspective for the another event;

provide the first global perspective to the device; and

provide the second global perspective to the another device.

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