US008087087B1

(12) **United States Patent**
van Oorschot et al.

(10) **Patent No.: US 8,087,087 B1**
(45) **Date of Patent: Dec. 27, 2011**

(54) **MANAGEMENT OF COMPUTER SECURITY EVENTS ACROSS DISTRIBUTED SYSTEMS**

(75) Inventors: **Johannes P. M. van Oorschot**, Delft (NL); **Emil S. A. Vogel**, Delft (NL); **Ide W. H. Nentjes**, Den Hoorn (NL); **Arthur W. Hillenaar**, Schiedam (NL); **Eddy Snoeck**, BergschenHoek (NL); **Gilles E. Houtekamer**, Bergschenhoek (NL)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1883 days.

(21) Appl. No.: **10/455,940**

(22) Filed: **Jun. 6, 2003**

Related U.S. Application Data

(60) Provisional application No. 60/386,780, filed on Jun. 6, 2002.

(51) **Int. Cl.**
G06F 11/00 (2006.01)

(52) **U.S. Cl.** **726/25**; 726/1

(58) **Field of Classification Search** 726/25, 726/1, 3, 6

See application file for complete search history.

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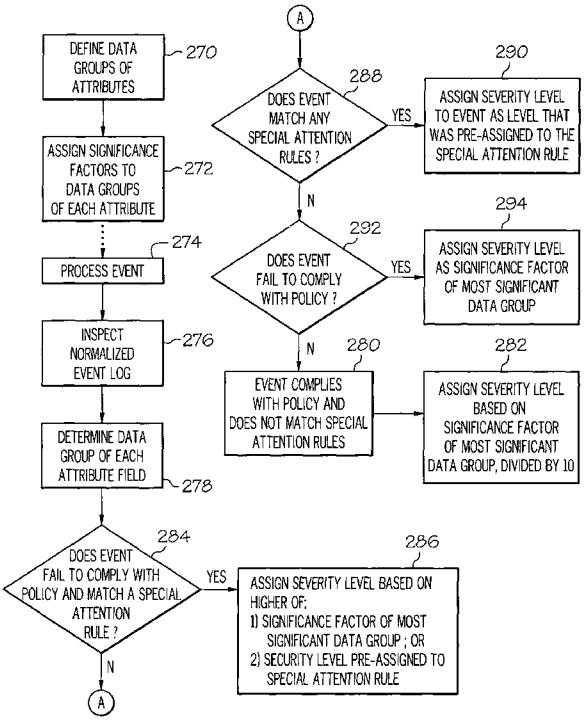
Primary Examiner — Samson Lemma
(74) *Attorney, Agent, or Firm* — DeLizio Gilliam, PLLC

(57) **ABSTRACT**

A computer receives a system event initiated by an initiating client associated with a user. The system event comprises a plurality of data elements associated with respective ones of a plurality of system event attributes. It is determined that the system event fails to conform to the security policy. A greatest of a plurality of significance factors assigned to a plurality of data groups that are associated with the plurality of data elements of the system event is determined. If the system event does not match a special attention rule, the greatest of the plurality of significance factors is assigned to the system event as a severity level. If the system event matches the special attentions rule, then a greater of the greatest of the plurality of significance factors and the pre-assigned severity level is assigned to the system event as a severity level.

24 Claims, 11 Drawing Sheets



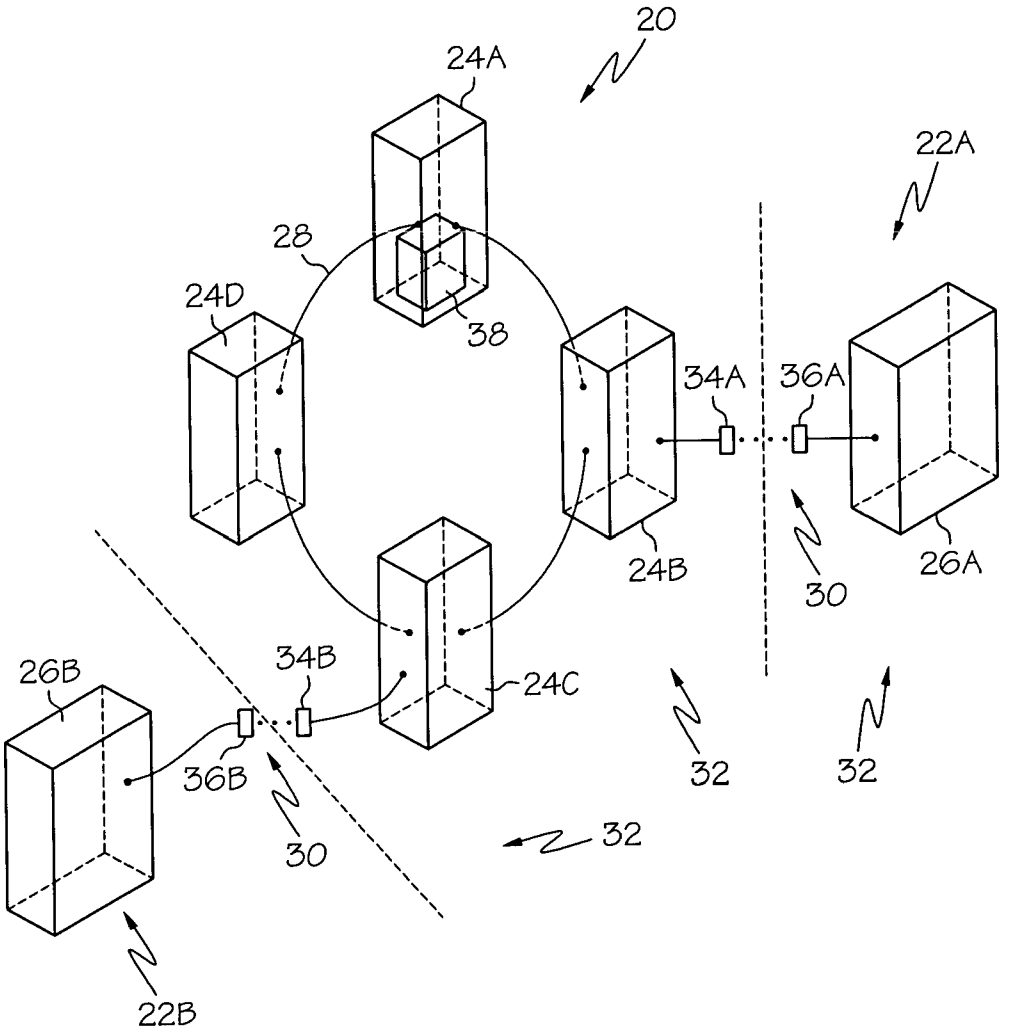

20
24A
22A
28
24D
38
34A
36A
24B
26A
30
26B
34B
24C
36B
32
32
30
32
22B

FIG. 1

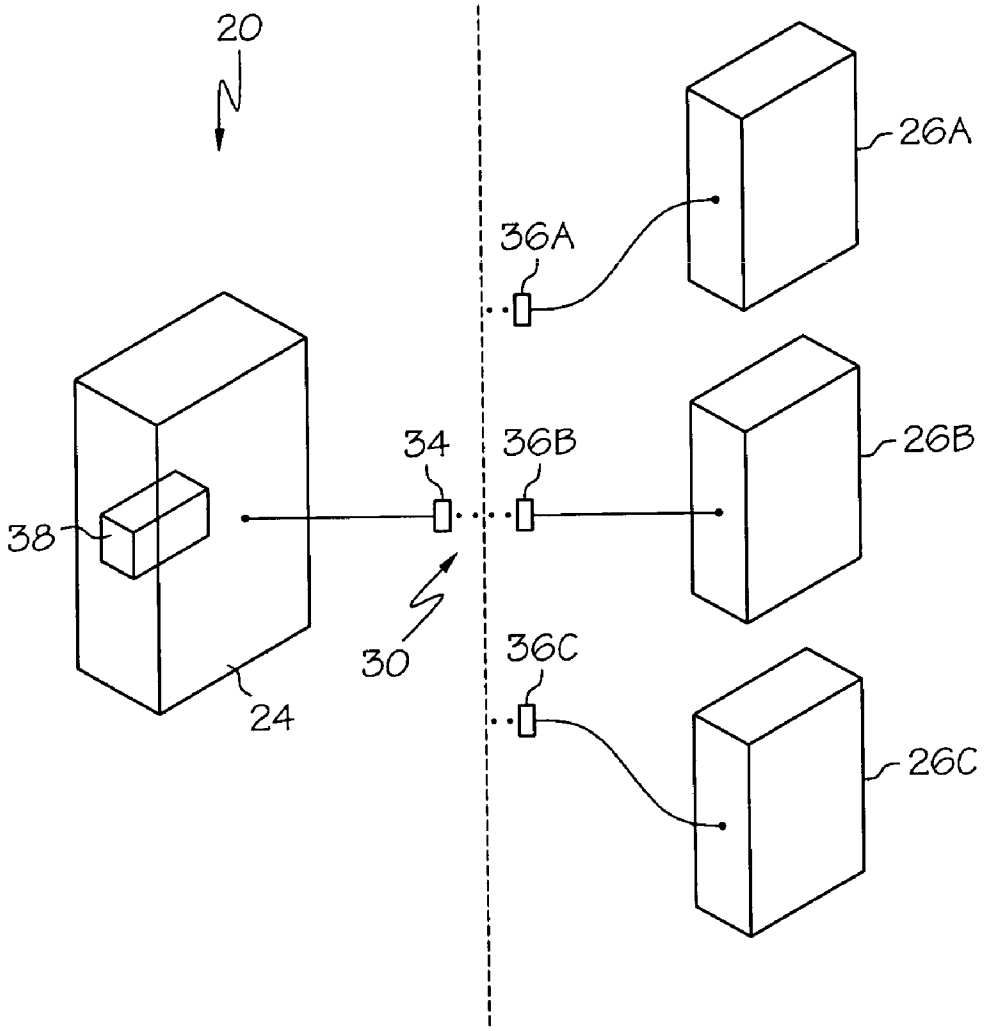


FIG. 2

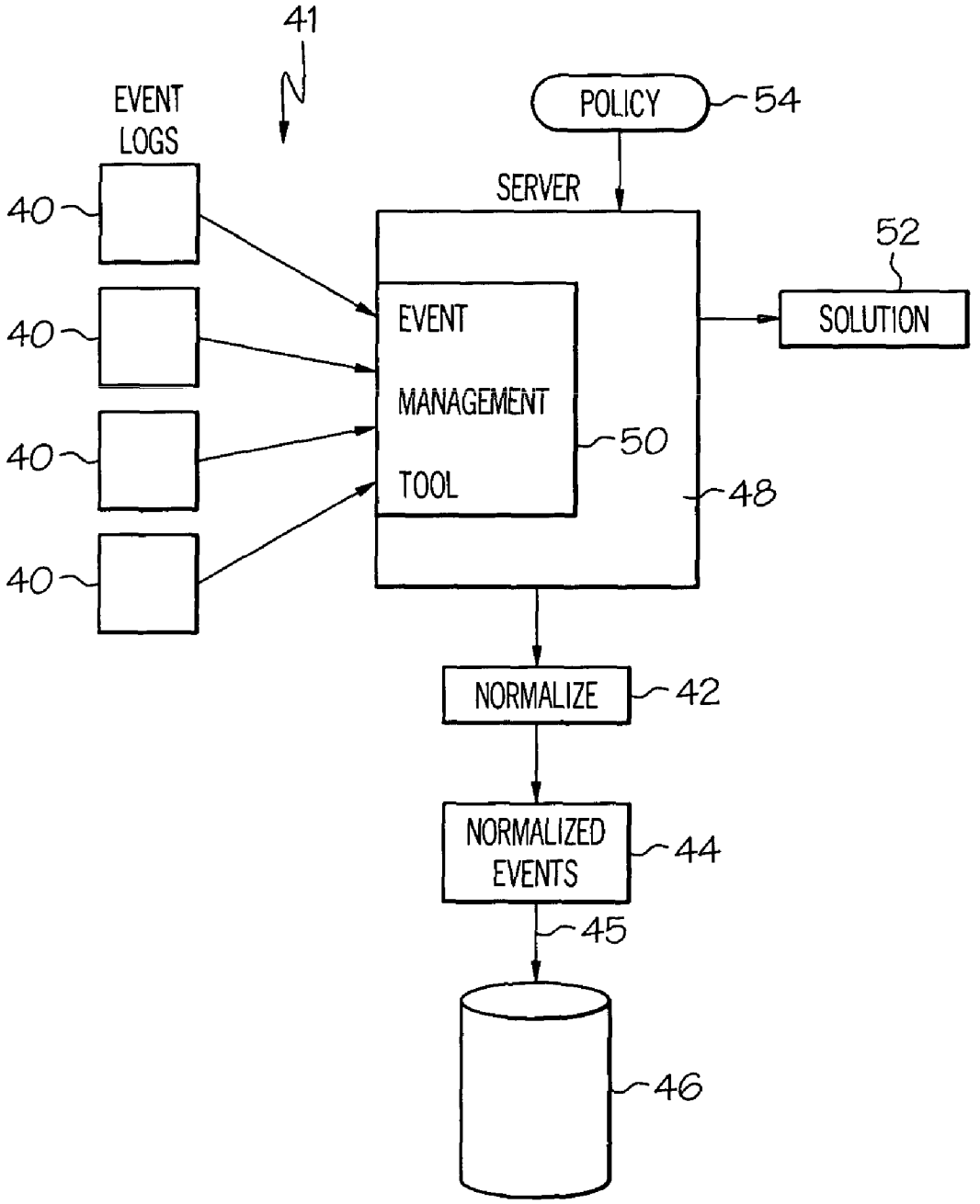

41
EVENT LOGS
POLICY
54
SERVER
40
40
40
40
52
SOLUTION
EVENT MANAGEMENT TOOL
50
48
NORMALIZE
42
NORMALIZED EVENTS
44
45
46

FIG. 3

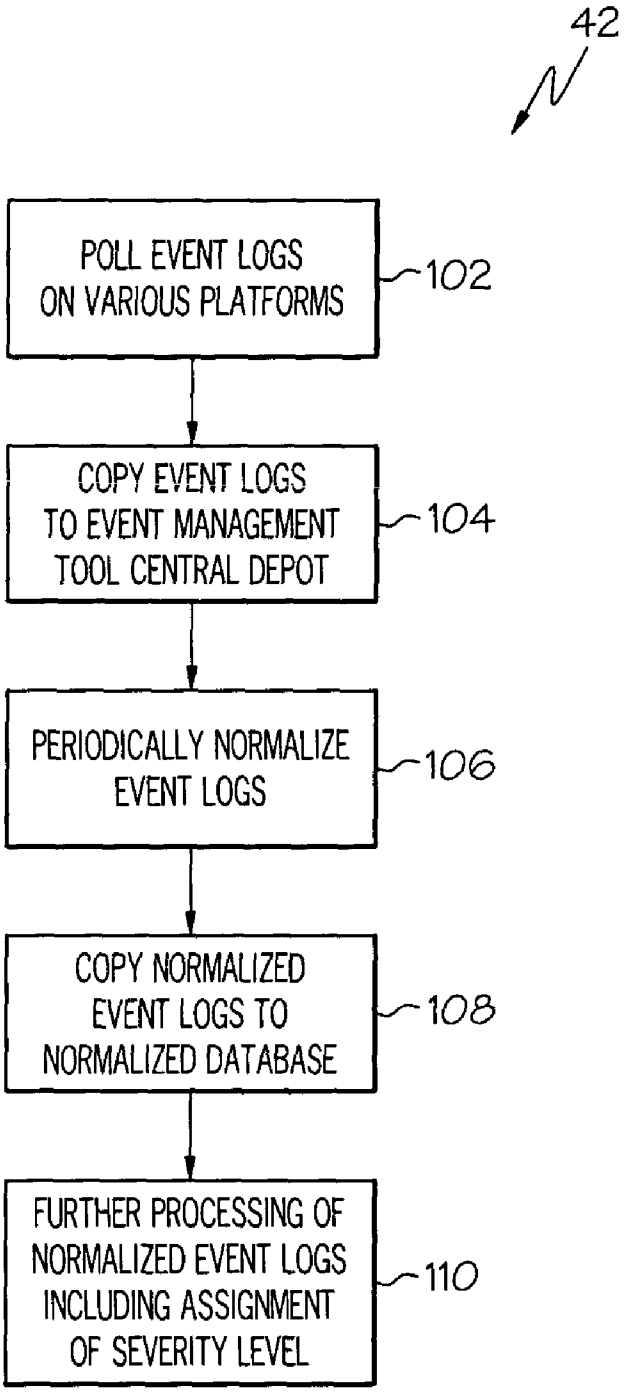

42
POLL EVENT LOGS ON VARIOUS PLATFORMS
102
COPY EVENT LOGS TO EVENT MANAGEMENT TOOL CENTRAL DEPOT
104
PERIODICALLY NORMALIZE EVENT LOGS
106
COPY NORMALIZED EVENT LOGS TO NORMALIZED DATABASE
108
FURTHER PROCESSING OF NORMALIZED EVENT LOGS INCLUDING ASSIGNMENT OF SEVERITY LEVEL
110

FIG. 4

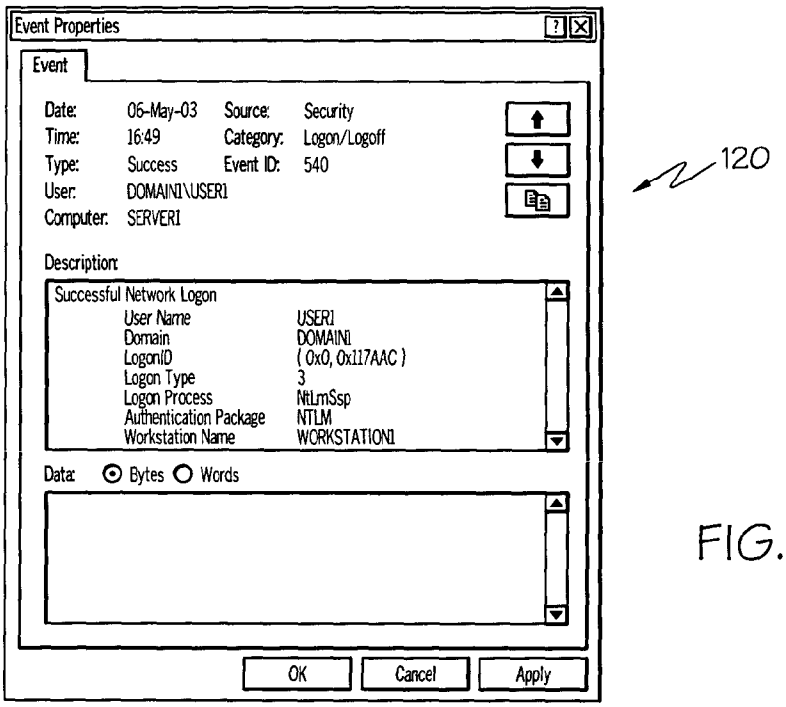

Event Properties
Event
Date: 06-May-03
Source: Security
Time: 16:49
Category: Logon/Logoff
Type: Success
Event ID: 540
User: DOMAIN1\USER1
Computer: SERVER1
Description:
Successful Network Logon
User Name USER1
Domain DOMAIN1
LogonID (0x0, 0x117AAC)
Logon Type 3
Logon Process NtLmSsp
Authentication Package NTLM
Workstation Name WORKSTATION1
Data: Bytes Words
OK
Cancel
Apply
120

FIG. 5A

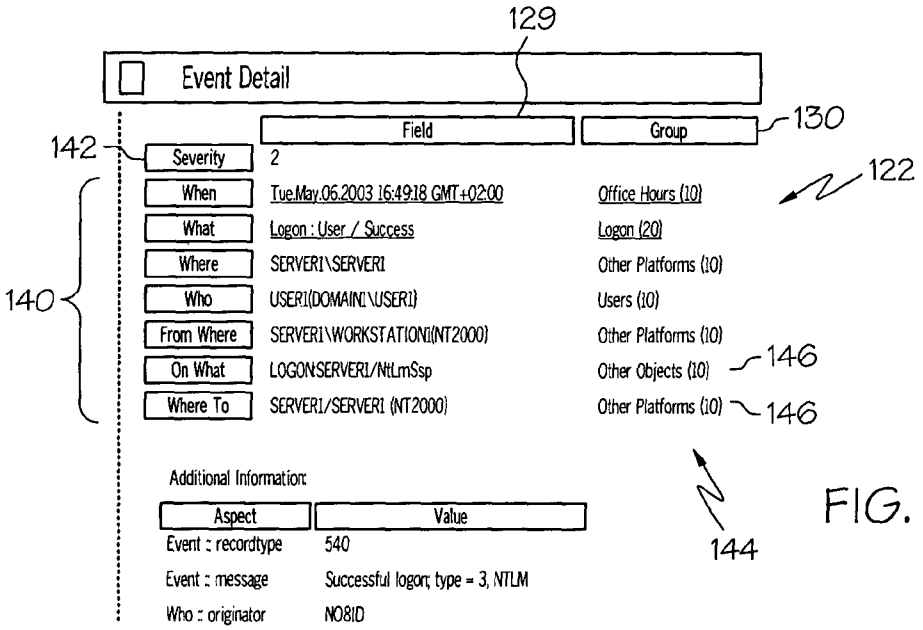

129
Event Detail
Field
Group
130
142
Severity 2
When Tue,May,06,2003 16:49:18 GMT+02:00 Office Hours (10)
122
What Logon : User / Success Logon (20)
Where SERVER1\SERVER1 Other Platforms (10)
140
Who USER1(DOMAIN1\USER1) Users (10)
From Where SERVER1\WORKSTATION1(NT2000) Other Platforms (10)
On What LOGON:SERVER1/NtLmSsp Other Objects (10)
146
Where To SERVER1/SERVER1 (NT2000) Other Platforms (10)
146
Additional Information:
Aspect
Value
Event :: recordtype 540
Event :: message Successful logon; type = 3, NTLM
Who :: originator NO8ID
144

FIG. 5B

2002-12-12 13 : 25 : 20
UTC , 127 . 0 . 0.1 , public , 1 . 3 . 6 . 1 . 4 . 1 . 2620 . 1 . 1 , 127 . 0 . 0 . 1 , 6 , 0 , 1039700120 , 1 . 3 .
6 . 1 . 4 . 1 . 2620 . 1 . 1 . 11 . 0 , D , 12Dec2002 14 : 38 : 09 accept MACHINE03 <ELnk32
snmptrap pronto tcp src 111.111.111.111 dst 222.222.222.222.222 service 25
s_port 65160 len 60 rule 6

124

FIG. 6A

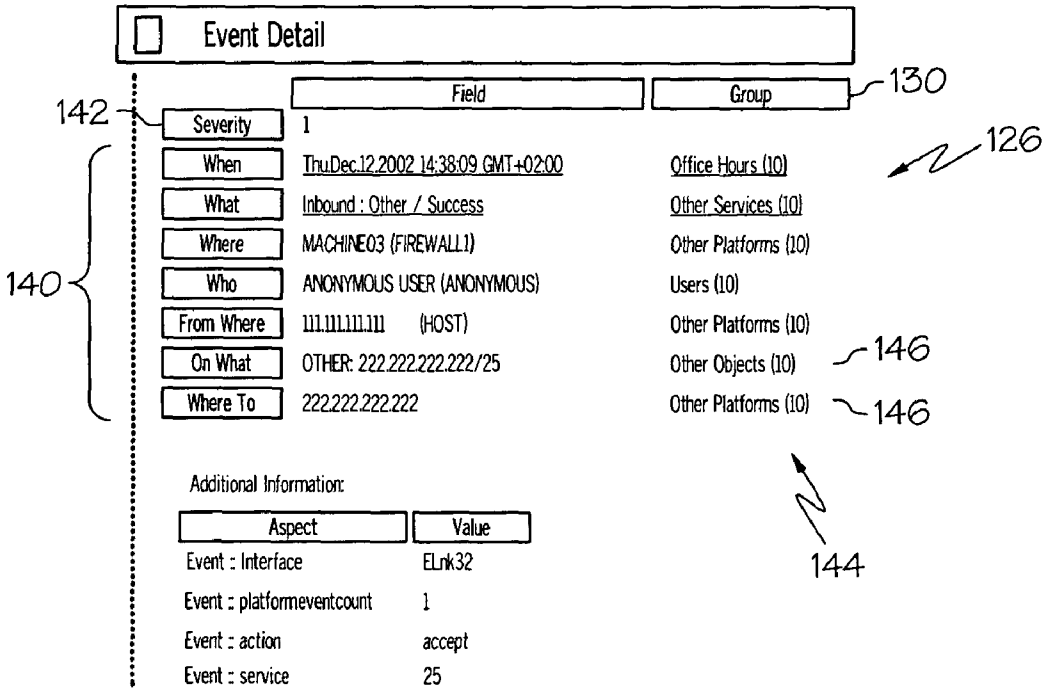


FIG. 6B

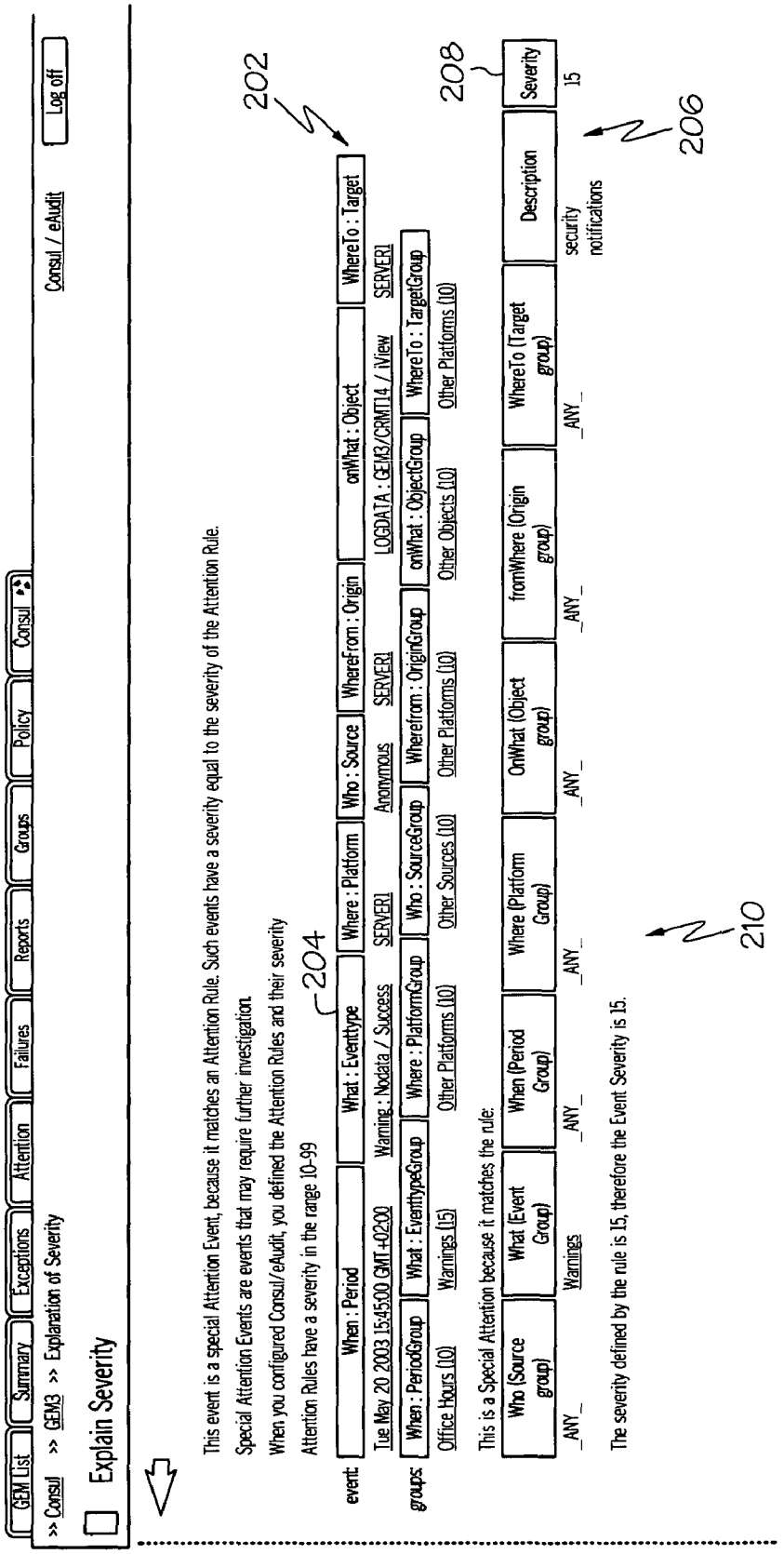

GEM List
Summary
Exceptions
Attention
Failures
Reports
Groups
Policy
Consul
Consul / eAudit
Log off
>> Consul >> GEM3 >> Explanation of Severity
Explain Severity
This event is a special Attention Event, because it matches an Attention Rule. Such events have a severity equal to the severity of the Attention Rule.
Special Attention Events are events that may require further investigation.
When you configured Consul/eAudit, you defined the Attention Rules and their severity
Attention Rules have a severity in the range 10-99
event:
When : Period
What : Eventtype
Where : Platform
Who : Source
Wherefrom : Origin
onWhat : Object
WhereTo : Target
Tue May 20 2003 15:45:00 GMT+02:00
Warning : Nodata / Success
SERVER1
Anonymous
SERVER1
LOGDATA : GEM3/CRMT14 / iView
SERVER1
groups:
When : PeriodGroup
What : EventtypeGroup
Where : PlatformGroup
Who : SourceGroup
Wherefrom : OriginGroup
onWhat : ObjectGroup
WhereTo : TargetGroup
Office Hours (10)
Warnings (15)
Other Platforms (10)
Other Sources (10)
Other Platforms (10)
Other Objects (10)
Other Platforms (10)
This is a Special Attention because it matches the rule:
Who (Source group)
What (Event Group)
When (Period Group)
Where (Platform Group)
OnWhat (Object group)
fromWhere (Origin group)
WhereTo (Target group)
Description
Severity
ANY
Warnings
ANY
ANY
ANY
ANY
ANY
security notifications
15
The severity defined by the rule is 15, therefore the Event Severity is 15.
202
204
206
208
210

FIG. 7

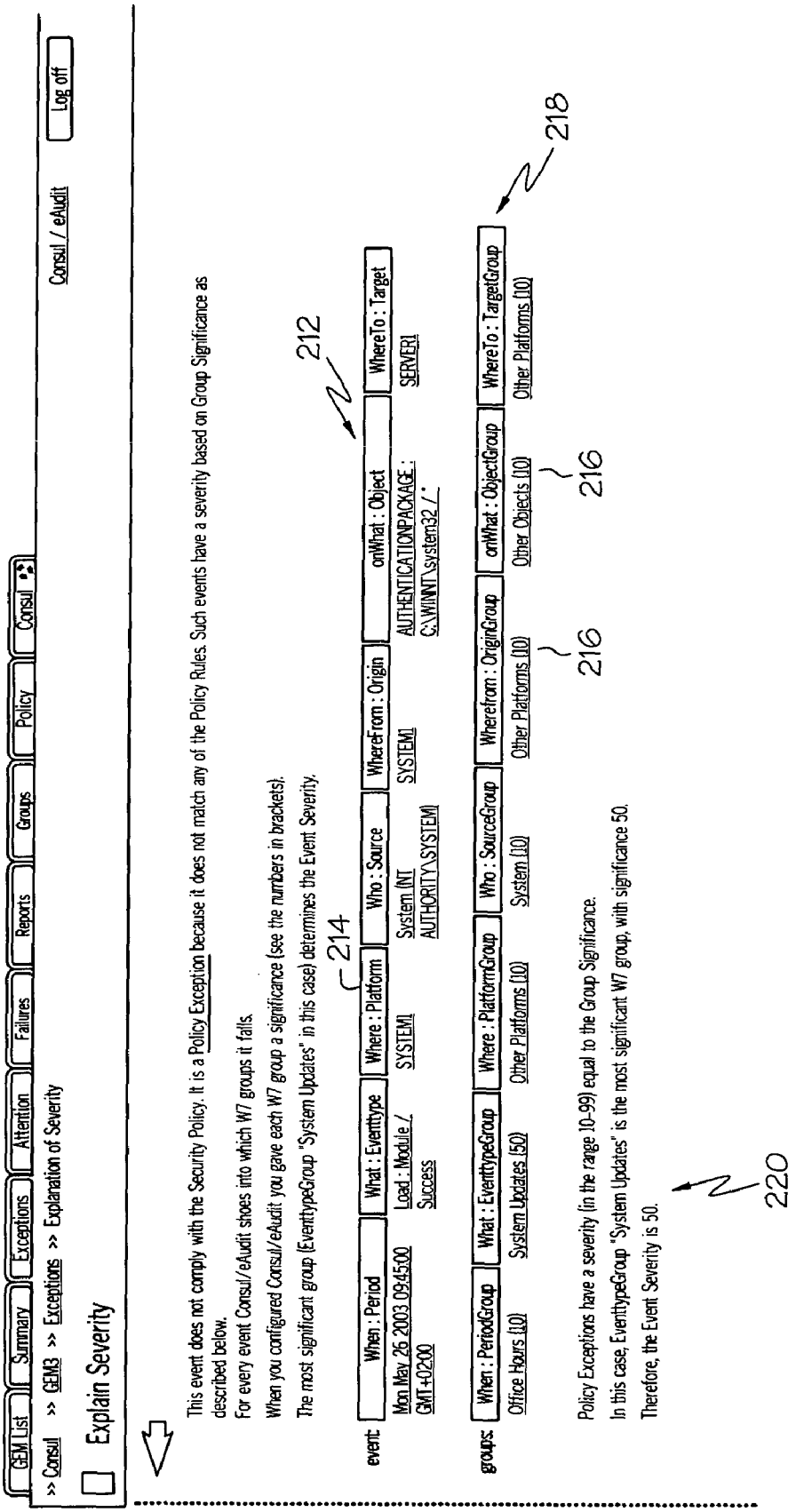

GEM List
Summary
Exceptions
Attention
Failures
Reports
Groups
Policy
Consul
Log off
» Consul » GEM3 » Exceptions » Explanation of Severity
Consul / eAudit
Explain Severity
This event does not comply with the Security Policy. It is a Policy Exception because it does not match any of the Policy Rules. Such events have a severity based on Group Significance as described below.
For every event Consul/eAudit shoes into which W7 groups it falls.
When you configured Consul/eAudit you gave each W7 group a significance (see the numbers in brackets).
The most significant group (EventtypeGroup "System Updates" in this case) determines the Event Severity.
event:
When : Period
Mon May 26 2003 094500 GMT+0200
What : Eventtype
Load : Module / Success
Where : Platform
SYSTEM1
Who : Source
System (NT AUTHORITY\SYSTEM)
WhereFrom : Origin
SYSTEM1
onWhat : Object
AUTHENTICATIONPACKAGE : C:\WINNT\system32 / *
WhereTo : Target
SERVER1
groups:
When : PeriodGroup
Office Hours (10)
What : EventtypeGroup
System Updates (50)
Where : PlatformGroup
Other Platforms (10)
Who : SourceGroup
System (10)
WhereFrom : OriginGroup
Other Platforms (10)
onWhat : ObjectGroup
Other Objects (10)
WhereTo : TargetGroup
Other Platforms (10)
Policy Exceptions have a severity (in the range 10-99) equal to the Group Significance.
In this case, EventtypeGroup "System Updates" is the most significant W7 group, with significance 50.
Therefore, the Event Severity is 50.
212
214
216
216
218
220

FIG. 8

GEM List | Summary | Exceptions | Attention | Failures | Reports | Groups | Policy | Consul

>> Consul >> GEM3 >> Attention >> Explanation of Severity Consul / eAudit Log off

Explain Severity

This event is a special Attention Event and a Policy Exception. It matches an Attention Rule and does not comply with the Security Policy, because it does not match any of the Policy Rules.
The event is given the higher of the Policy Exception Severity and the Special Attention Severity:

Policy Exception Severity is determined from Group Significance.
For every event, Consul/eAudit shows into which W7 groups it falls.
When you configured Consul/eAudit you gave each W7 group a significance (see the numbers in brackets).
The most significant group (EventtypeGroup "Alerts - Medium in this case) determines the Policy Exception Severity.

222

224

event:	When : Period	What : Eventtype	Where : Platform	Who : Source	WhereFrom : Origin	onWhat : Object	WhereTo : Target
	Mon May 26 2003 16:15:00 GMT+02:00	Load : Database / Failure	SYSTEM1	Anonymous	SYSTEM1	DATABASE : - /DB4	SYSTEM1
groups:	When : PeriodGroup	What : EventtypeGroup	Where : PlatformGroup	Who : SourceGroup	Wherefrom : OriginGroup	onWhat : ObjectGroup	WhereTo : TargetGroup
	Office Hours (10)	Alerts - Medium (60)	Other Platforms (10)	Other Sources (10)	Other Platforms (10)	Other Objects (10)	Other Platforms (10)

228

226 226

Policy Exceptions have a severity (in the range 10-99), equal to the Group Significance.
In this case, EventtypeGroup "Alerts - Medium" is the most significant W7 group, with significance 60
Therefore, the Policy Exception Severity is 60

Special Attention Severity is determined from Attention Rule Severity.
When you configured Consul/eAudit, you defined the Attention Rules and their severity.
Attention Rules have a severity in the range 10-99.

227 229

This is a Special Attention because it matches the rule:

Who (Source group)	What (Event Group)	When (Period Group)	Where (Platform Group)	OnWhat (Object group)	fromWhere (Origin group)	WhereTo (Target group)	Description	Severity
ANY	Alerts - Medium	_ANY_	_ANY_	_ANY_	_ANY_	_ANY_	attention required	15

The severity defined by the Attention Rule is 50, therefore the Special Attention Severity is 50.
Event Severity is the higher of the Policy Exception severity (60) and the Special Attention Severity (50), so the Event Severity is 60.

230

FIG. 9

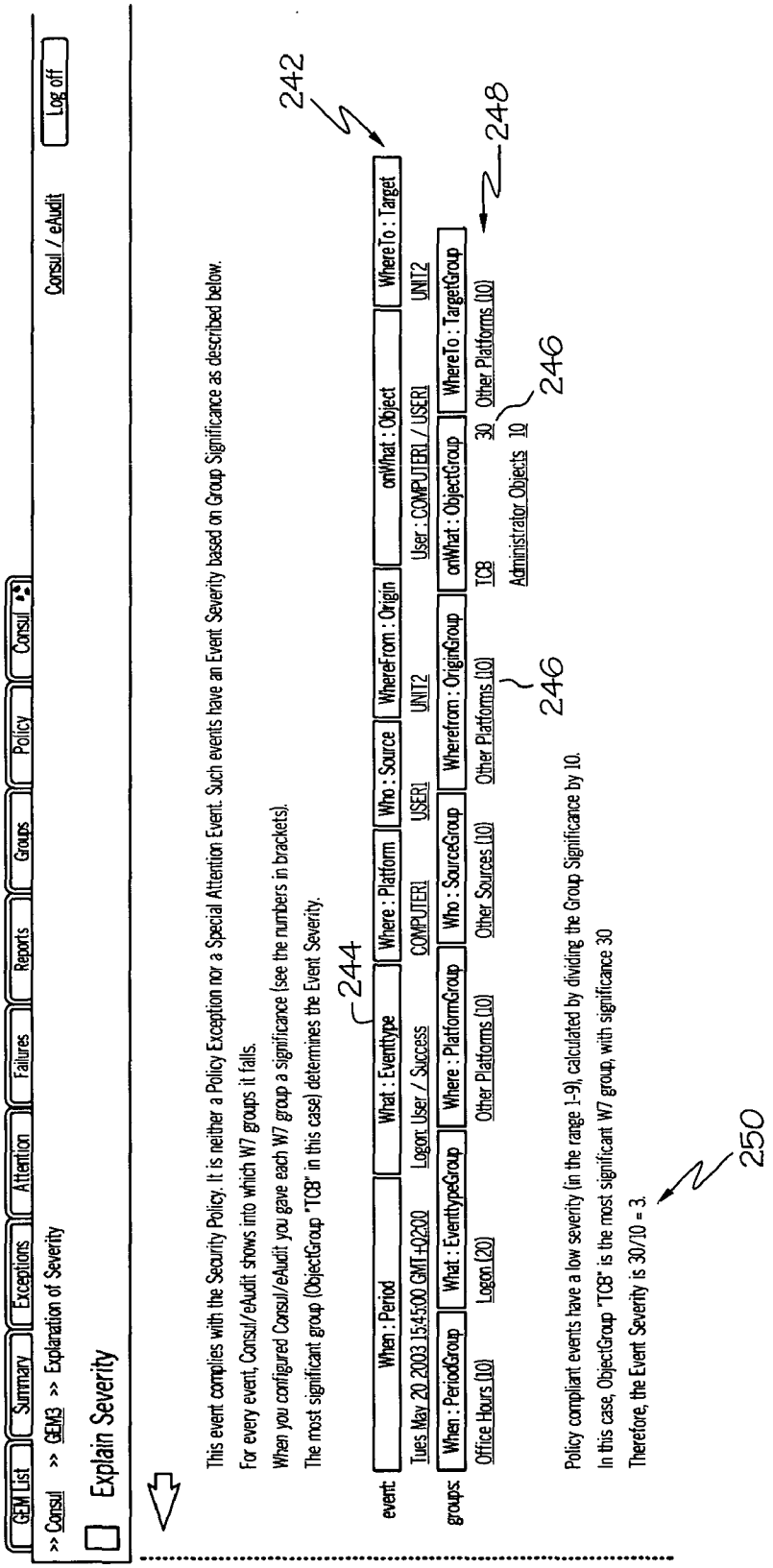

GEM List
Summary
Exceptions
Attention
Failures
Reports
Groups
Policy
Consul
>> Consul >> GEM3 >> Explanation of Severity
Consul / eAudit
Log off
Explain Severity
This event complies with the Security Policy. It is neither a Policy Exception nor a Special Attention Event. Such events have an Event Severity based on Group Significance as described below.
For every event, Consul/eAudit shows into which W7 groups it falls.
When you configured Consul/eAudit you gave each W7 group a significance (see the numbers in brackets).
The most significant group (ObjectGroup "TGB" in this case) determines the Event Severity.
242
event:
When : Period
What : Eventtype
Where : Platform
Who : Source
WhereFrom : Origin
onWhat : Object
WhereTo : Target
Tues May 20 2003 15:45:00 GMT+02:00
Logon: User / Success
COMPUTER1
USER1
UNIT2
User : COMPUTER1 / USER1
UNIT2
244
248
groups:
When : PeriodGroup
What : EventtypeGroup
Where : PlatformGroup
Who : SourceGroup
WhereFrom : OriginGroup
onWhat : ObjectGroup
WhereTo : TargetGroup
Office Hours [10]
Logon [20]
Other Platforms [10]
Other Sources [10]
Other Platforms [10]
TGB
30
Other Platforms [10]
Administrator Objects
10
246
246
Policy compliant events have a low severity (in the range 1-9), calculated by dividing the Group Significance by 10.
In this case, ObjectGroup "TGB" is the most significant W7 group, with significance 30
Therefore, the Event Severity is 30/10 = 3.
250

FIG. 10

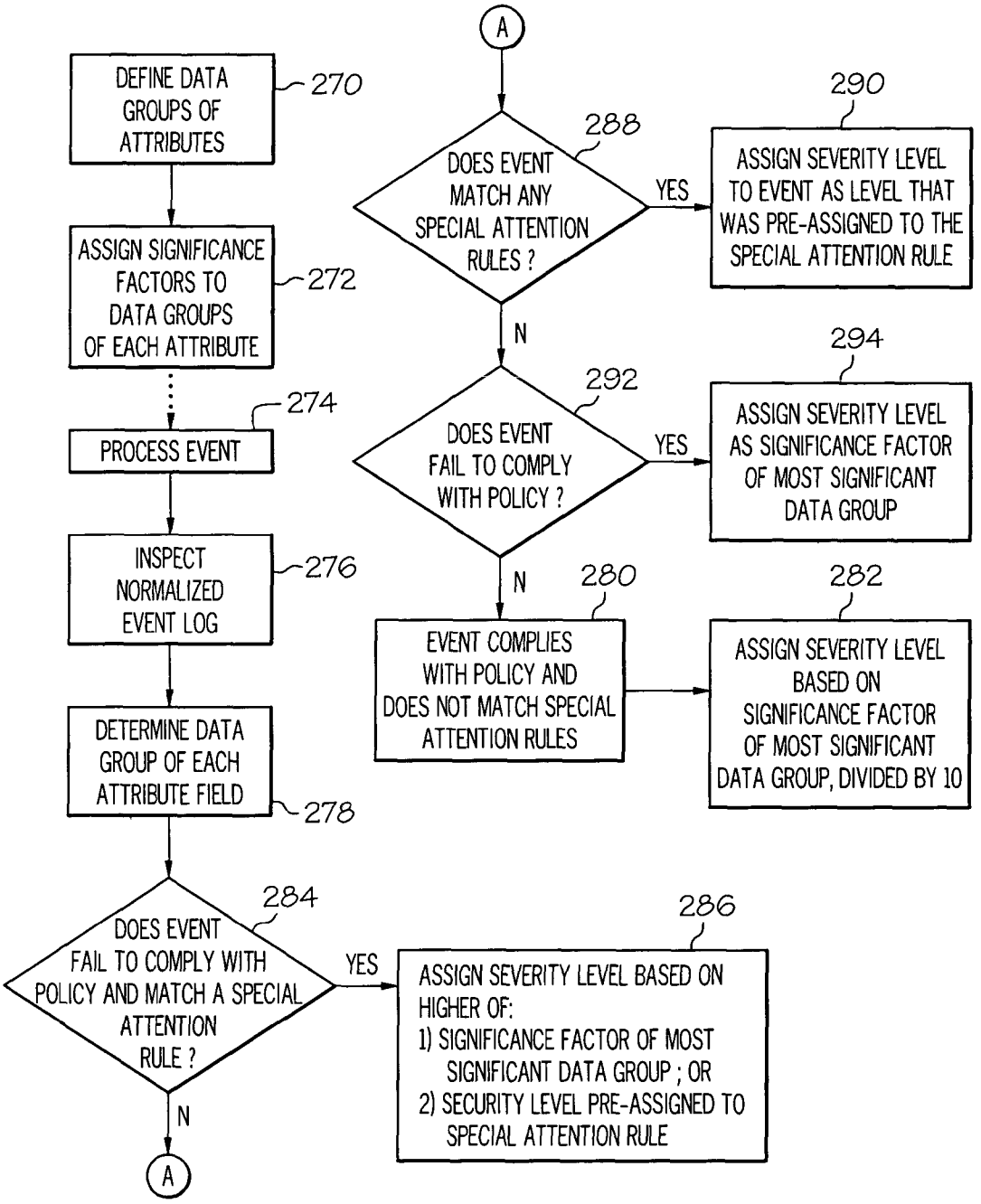

DEFINE DATA GROUPS OF ATTRIBUTES
270
ASSIGN SIGNIFICANCE FACTORS TO DATA GROUPS OF EACH ATTRIBUTE
272
PROCESS EVENT
274
INSPECT NORMALIZED EVENT LOG
276
DETERMINE DATA GROUP OF EACH ATTRIBUTE FIELD
278
DOES EVENT FAIL TO COMPLY WITH POLICY AND MATCH A SPECIAL ATTENTION RULE ?
284
YES
N
A
ASSIGN SEVERITY LEVEL BASED ON HIGHER OF:
1) SIGNIFICANCE FACTOR OF MOST SIGNIFICANT DATA GROUP ; OR
2) SECURITY LEVEL PRE-ASSIGNED TO SPECIAL ATTENTION RULE
286
A
DOES EVENT MATCH ANY SPECIAL ATTENTION RULES ?
288
YES
ASSIGN SEVERITY LEVEL TO EVENT AS LEVEL THAT WAS PRE-ASSIGNED TO THE SPECIAL ATTENTION RULE
290
N
DOES EVENT FAIL TO COMPLY WITH POLICY ?
292
YES
ASSIGN SEVERITY LEVEL AS SIGNIFICANCE FACTOR OF MOST SIGNIFICANT DATA GROUP
294
N
EVENT COMPLIES WITH POLICY AND DOES NOT MATCH SPECIAL ATTENTION RULES
280
ASSIGN SEVERITY LEVEL BASED ON SIGNIFICANCE FACTOR OF MOST SIGNIFICANT DATA GROUP, DIVIDED BY 10
282

FIG. 11

MANAGEMENT OF COMPUTER SECURITY EVENTS ACROSS DISTRIBUTED SYSTEMS

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 60/386,780, filed Jun. 6, 2002.

BACKGROUND OF THE INVENTION

In computer systems, for example local area network and mainframe computer systems, event management systems are employed to record a variety of system events initiated by a user. Computer operating systems include basic capabilities for recording the various events in any of a number of log files. An operating system can be programmed to generate security alerts upon the occurrence of certain event. Although the logs and security alerts generated by the operating system represent a picture of the activity occurring within a system, that picture is somewhat limited in scope and functionality.

Event management tools provide additional capabilities beyond those made available by an operating system, or application running in the operating system environment. Such tools allow for higher-level management of the event logs and security alerts recorded and generated by the underlying operating system. In one example, namely the Consul/eAudit management tool suite available from Consul Risk Management B.V., Delft, The Netherlands, security logs and real-time security data recorded by the underlying operating systems, applications, or security point solutions, are translated into generalized security events, each event being characterized by five attributes, namely: "who" (the user initiating the event); "what" (the type of event that was initiated); "when" (the time at which the event occurred); "where" (the system or device on which the event occurred); and "on what" (the file, device, or setting that was accessed by the event). The generalized security events are managed by the event management tool to provide for a comprehensive security overview of activity within a given computer system. A forensic statement of the activity is generated, and the management tool can respond in a variety of ways including: immediate alerts to security personnel, offline generation of security reports, and the like.

With the growing popularity of the Internet, computer networks continue to become increasingly distributed, in the sense that users initiate events not only within a single computer system, but also across multiple interconnecting systems that utilize different operating systems. Hence, the event management tools currently available are unable to resolve attributes of events that are initiated remotely or acted upon remotely, i.e. external to a given system.

SUMMARY OF THE INVENTION

Embodiments of the inventive subject matter include a method for managing system events in a network. A computer receives a system event initiated by an initiating client associated with a user. The system event comprises a plurality of data elements associated with respective ones of a plurality of system event attributes. The plurality of data elements of the system event is evaluated against a security policy. It is determined that the system event fails to conform to the security policy for the user. The security policy defines permitted actions for different users in accordance with the plurality of system event attributes. A greatest of a plurality of significance factors assigned to a plurality of data groups that are associated with the plurality of data elements of the system event is determined. It is determined whether the system event matches a special attention rule in accordance with the plurality of data elements. The special attention rule defines a prohibited action. If the system event does not match the special attention rule and the system event fails the security policy, the greatest of the plurality of significance factors is assigned to the system event as a severity level. If the system event matches the special attentions rule and the system event fails the security policy, then the greatest of the plurality of significance factors is compared against a pre-assigned severity level that was pre-assigned to the special attention rule, and a greater of the greatest of the plurality of significance factors and the pre-assigned severity level is assigned to the system event as a severity level.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. **1** is a block diagram of a first example of a distributed computer network illustrating a system event initiated from a remote system, and a system event initiating activity on a remote system, in accordance with the present invention.

FIG. **2** is a block diagram of a second example of a distributed computer network illustrating a system event initiated from a remote system, and a system event initiating activity on a remote system, in accordance with the present invention.

FIG. **3** is a block diagram of the normalization and storage of events by a server on which the event management tool of the present invention is operating, in accordance with the present invention.

FIG. **4** is a flow diagram of a normalization procedure in accordance with the present invention.

FIGS. **5**A and **5**B provide an example of an original event log and a normalized event log for a system event of a Windows/NT 2000™ fileserver, in accordance with the present invention.

FIGS. **6**A and **6**B provide an example of an original event log and a normalized event log for a system event of a Checkpoint Firewall-1 Firewall™ server, in accordance with the present invention.

FIG. **7** is a screen shot image of a summary report that is generated in relation to a normalized system event that conforms to a special attention rule, in accordance with the present invention.

FIG. **8** is a screen shot image of a summary report that is generated in relation to a normalized system event that constitutes an exception to the system policies, in accordance with the present invention.

FIG. **9** is a screen shot image of a summary report that is generated in relation to a normalized system event that constitutes both an exception to the system policies and one that conforms to a special attention rule, in accordance with the present invention.

FIG. **10** is a screen shot image of a summary report that is generated in relation to a normalized system event that complies with the system policies, in accordance with the present invention.

FIG. **11** is a flow diagram of a procedure for assigning a severity level to an event, in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** is a block diagram of a first example of a distributed computer network illustrating a system event initiated from a remote system, and a system event initiating activity on a remote system, in accordance with the present invention. With reference to FIG. **1**, a distributed network **32** includes, for example, a local network **20** comprising a plurality, for example four, local servers **24**A, **24**B, **24**C, **24**D. The local servers **24**A, **24**B, **24**C, **24**D each communicate with each other via communication link **28**, for example local area network **28**, or similar communication protocol. The focal network **20** further includes at least one distributed interface **34**A, **34**B to allow for communication between the local network **20** and remote clients **26**A, **26**B, for example via the Internet **30**.

Remote users **22**A, **22**B access the local network **20** via remote clients **26**A, **26**B, which may, for example, optionally be part of a remote network that is external to the local network **20**. Remote clients gain access to the local network via interfaces **36**A, **36**B, which, for example, provide remote client access to the Internet.

In one embodiment, an event management tool **38** in accordance with the present invention is operable on the local network **20**, for example at local server **24**A to record, manage, and respond to, system events that occur on the local network. In one example, a system event is monitored by the operating system of one of the local servers **24**A-D, for example server **24**D, and is logged in a suitable event log, along with multiple other system events, according to operating system convention of the host of the event.

The event management tool software or process **38**, active on server **24**A, periodically polls, or otherwise monitors, the system event logs of other servers **24**B-D in the network, as well as the system event logs of its own host server **24**A, and collects information stored in the system event logs. In one embodiment, the system events, as recorded in the log files, are converted to a convention that can be interpreted and readily managed, by the event management tool **38**. Such conversion, also referred to herein as "normalization", allows for system events generated by different operating systems or different versions of operating systems, located on the local network **20**, to be interpreted by a common event management tool **38**. As an alternative to polling log files, the event management tool may optionally process system events in real time, as they are generated, or may optionally obtain information related to system events from applications running on the operating system, for example Lotus Notes™, Oracle™ database applications, etc., for example in the form of application logs or network appliance (firewalls, routers, etc.) logs

In one example, the normalized system events are characterized according to five attributes, namely: "who" (the client initiating the event); "what" (the type of event that was initiated); "when" (the time at which the event occurred); "where" (the system or device on which the event occurred); and "on what" (the file, device, or setting that was accessed by the event). As described above, these normalized system events can be cataloged and managed by the event management tool **38** to provide for a comprehensive security overview of activity in the local network **20**. A forensic statement of the activity is generated, and the management tool **38** can review the events, identify breaches, and respond in any of a number of ways including, for example, immediate alerts to security personnel, offline generation of security reports, and the like.

While such an event management tool is capable of resolving, and acting on, system events generated within the local network, such a system is unable to resolve attributes of system events that are initiated by clients, or act upon clients, that are remote to the local network, for example remote users **22**A, **22**B. While the source or destination of a system event may be identified according to the remote interface port **34**A, **34**B, no information about the system event external to the port, **34**A, **34**B is available to the event management tool **38**.

The system and method of the present invention overcome this limitation by resolving additional attributes related to the system event during normalization; namely "where from" (the identity of the client initiating the event) and "where to" (the identity of the client acted upon by the event). In this manner, the event management tool **38** has an additional layer of information with which to interpret a system event. This includes the capability of resolving the source ("where from") and client destination ("where to") of system events across distributed networks.

The identity of the client can be derived from information that is unique to a given client. In a preferred embodiment, the identity is derived from the client IP address. In the example of the Internet, each client is assigned a unique IP address that is either fixed, or dynamic, depending on the type and level of Internet access. A fixed IP address identifier may be designated to a client that permanently resides on the Internet. A dynamic IP address may be designated to a client that periodically resides on the Internet, for example through an Internet provider. In the dynamic case, the Internet provider is required to retain a log of the temporarily assigned IP addresses appointed to subscribers.

When an event is logged by a modern operating system, the IP addresses of the source and destination clients are recorded in the event log. The normalization process of the present invention therefore generates a normalized event that includes the "where from" and "where to" attributes, and therefore can base management decisions on these additional parameters.

In the example provided in FIG. **1**, assuming remote client **26**A initiates an event on server **24**B, the security log, as recorded by the server **24**B operating system will include information related to the identity of source client of the event, for example the IP address of the remote client **26**A. Through normalization of the "where from" attribute, the identity of the remote client **26**A is transferred to the event management tool **38**, and can be utilized by the tool in arriving at a system security decision.

In addition, the "where to" attribute can be utilized to track the identity of a remote or local client that is acted upon. For example, if a client accessing server **24**C initiates an event that accesses, or otherwise acts upon, remote client **26**B, the identity, for example the IP address, of client **26**B is recorded in the event log by the operating system of server **24**C. Through normalization of the "where to" attribute, the identity of the remote client **26**B is transferred to the event management tool **38**, and can be utilized by the tool in arriving at a system security decision.

FIG. **2** is a block diagram of a second example of a distributed computer network illustrating system events initiated from remote systems, and system events initiating activity on a remote system, in accordance with the present invention. In this example, a local server **24**, is connected to the Internet **30** via local interface **34**. Remote clients **26**A, **26**B, **26**C, each having a unique IP address, whether fixed or dynamic, access

the Internet via remote interfaces **36**A, **36**B, **36**C. An event management tool **38**, configured in accordance with the systems and methods of the present invention operates on the local server **24** to interpret and respond to system events that involve the server **24**. In this example, assuming the event management tool is configured to normalize logged events according to the attributes "where from" and "where to", resolution of system events initiated by, or acting upon, remote clients **26**A, **26**B, and **26**C, as well as server **24**, is possible.

FIG. **3** is a block diagram of the normalization and retrieval of events by a server on which the event management tool of the present invention is operating, in accordance with the present invention. Event logs **40** are generated by an operating system on a given server, or by multiple similar operating systems on multiple servers, or by multiple different operating systems on multiple servers: The event logs are retrieved **41** by the event management tool **50** operating on server **48**, which normalizes **42** the event logs **40** in the manner described above to generate normalized events **44**. In an alternative embodiment, an event transport process such as SYSLOG or SNMP may be used to immediately transfer the event log to the event management tool on an event-by-event basis. Further, in an alternative embodiment, normalization can occur at each individual server generating the event log **40**.

The event logs **40** are centrally archived on the server **48**, and periodically normalized. The normalized event logs are loaded **45** into a database **46**, and accessed as needed by the event management tool **50**. The event management tool **50** accesses the normalized event logs **46** during its operation, and from time to time, reaches a management decision, for example in the form of solution **52**.

Solution **52**, in one example, is based upon a comparison of one, or multiple, normalized system events with a security policy **54**. The normalized events are compared to a predefined security policy for the system. The security policy defines the bounds of which system events are acceptable, and which system events are unacceptable.

In one embodiment, the system events are each assigned a severity level, based on exceptions or breaches identified during the comparison. The event management tool then reacts to the event or events based on the severity level of the breach. The tool can react in any of number of ways, depending on the application. For example, in the event of a severe breach, the event management tool may react by immediately generating and transmitting an alert alarm or instant message to an appropriate security officer. Alternatively, the event management tool may record the event in a report and periodically transmit the report to an officer.

FIG. **4** is a flow diagram of a normalization procedure **42** in accordance with the present invention. With additional reference to FIG. **3**, the various platforms on the system under the control of the event management tool are periodically polled **41** at step **102** for event logs **40**. As described above, these event logs are generated by the operating system of the host platform, and may be formatted in any of a number of ways, depending on the operating system. The event logs **40** are copied **41** to a central depot of the event management tool **50** at step **104**, where they are stored for processing. The event management tool **50** periodically normalizes **42** the stored event logs, including the normalization of the "where from" (identity of the client initiating the event) and "where to" (identity of the client acted upon by the event) attributes at step **106**. Examples of such normalized event logs **44** are provided below with reference to FIGS. **5**A, **5**B and **6**A, **6**B. The normalized event logs **44** are copied **45** to a database **46** at step **108**, where they are made available to the event management tool **50** for further processing at step **110**, including the assignment of a severity level to the normalized event log, as described in further detail below.

FIGS. **5**A and **5**B provide an example of an original event log and a normalized event log for a system event of a Windows/NT 2000™ fileserver, in accordance with the present invention. The event log **120** of FIG. **5**A is the result of a user USER1 logging onto a Windows/NT 2000™ fileserver from his own workstation WORKSTATION1. The event occurs on a machine SERVER1, i.e. the "computer field" in the original event **120**. The event was initiated from a machine WORKSTATION1, i.e. the "workstation name" in the original event **120**.

With reference to FIG. **5**B, as a result of normalization, the normalized event log **122** is generated. The normalized event log includes the seven attributes described above; namely, "who" (the user initiating the event); "what" (the type of event that was initiated); "when" (the time at which the event occurred); "where" (the system or device on which the event occurred); and "on what" (the file, device, or setting that was accessed by the event); "where from" (identity of the client initiating the event) and "where to" (identity of the client acted upon by the event). In this example, it can be seen that the "computer" field SERVER1 of the original event log **120** is normalized in the resulting normalized event log **122** such that it is applied to both "where" and "where to" attributes, because, in this example, the device on which the event occurred and the identity of the client acted on by the event were both the same, namely "SERVER1". Since the event was initiated from the user's machine, the workstation name, namely WORKSTATION1 of the original event log **120** is normalized to the "from where" attribute in the normalized event log **122**.

The name of the workstation WORKSTATION1 normalized to the "from where" field may alternatively comprise any of a number of client identifiers, such as the IP address of the workstation, the workstation name, an originating email address, a fully-qualified host name, and the like. Similarly, the name of the computer SERVER1 hosting the event may comprise any of a number of similar client identifiers, such as the IP address of the workstation being acted upon, the workstation name, a recipient email address, a fully-qualified host name, and the like.

FIGS. **6**A and **6**B provide an example of an original event log and a normalized event log for a system event of a Checkpoint Firewall-1 Firewall™ server, in accordance with the present invention. The original event log **124** of FIG. **6**A is the result of a connection being made by an anonymous user from outside a firewall to a network protected by the firewall. The normalized event log **126** of FIG. **6**B includes the same seven attributes **140** as those of the example of FIG. **5**B.

With reference to FIG. **6**A, in this example, it can be seen that the event occurs on a machine "MACHINE03", the name of the firewall machine, and this field is normalized in the normalized event log **126** to the "where" field. The connection was initiated from a machine having IP number 111.111.111.111, as shown in the "src" field of the original event log **124**. As shown in FIG. **6**B, this information is normalized in the resulting normalized event log **126** to the "from where" field. The connection was made through the firewall, to a machine with IP number 222.222.222.222, as shown in the "dst" field of the original event log **126**. This information is normalized to the "where to" attribute in the resulting normalized event log **126**.

With reference to FIGS. **5**B and **6**B, the normalized event logs **122** include two columns of information, namely the data that is assigned to the various attributes, i.e. the "field" col-

umn **129**, and a group to which each data element of each attribute belongs, i.e. the "group" column **130**. In addition, the normalized event log further includes a "severity level" **142** that is assigned to the event by the event management tool. The definition of groups and the assignment of the severity level to the event will now be described in further detail.

As a first step in configuring a security policy for the system, groups are defined in the security database. For each dimension, or attribute, in the security database, a number of groups are defined, which categorize the types of data that are to be associated with a given attribute. For example, the "when" attribute may include groups that define time elements, such as "office hours", "weekends", or "weekdays". The "who" attribute may include groups related to the various forms of users, such as "network administrators" or "general users". The "what" attribute may include groups related to the types of actions that can occur, such as "file write actions", "file read actions", "administrative actions", or "email transfer". The "on what" attribute may include, for example, groups related to the types of files being operated on. The "where", "where from", and "where to" attributes may include groups related to the types of clients at which the event can occur, the types of clients initiating the event, or the types of clients being acted upon by the event, for example "web servers", "test servers", "mail servers", "file servers", "workstations", or "database servers". In addition, each group within an attribute is assigned a significance factor, for example in the form of a number 10, 20, 30 . . . , that is used as a weighting by the event management tool in later assigning a severity level to an event, as will be described in detail below.

Upon the definition of groups of the various attributes, a set of policy rules can be generated, which define permitted actions, or normal operations, within a security system. For example, a policy rule can be defined to mandate that only "system administrators" are permitted to modify files after "office hours". A set of policy rules can be cataloged using the event management tool **50** to define normal system operations. Any event that does not meet the criteria of any of the set of policy rules is considered to be an "exception" to the policy. Certain policies may focus on permitted activity related to a certain attribute or attributes. In particular, policies relating to the "where from" and "where to" attributes can mandate, for example, that certain, very sensitive actions are permitted only from certain terminals that are physically well-protected. Such actions may include, for example, modifications to the security environment, or to permit access to client files remotely from only certain users within a defined user group from only certain IP addresses within a defined group of IP addresses, or to permit access to only certain interne sites by certain users. When an event is compared to the set of policy rules, if no match is determined, this means that the event does not comply with policy, and as such constitutes a policy exception. For this reason, this comparison is referred to as "negative" matching.

In addition, a set of policies may be compiled to define abnormal actions, i.e. those actions that are not permitted by a security system. Such policies are referred to herein as "special attention rules", since an event that qualifies as a violation of such a policy may require special attention by security personnel. In various embodiments, such special attention rules may include rules that monitor events that conform to one or more policies, but need to be specially monitored by an independent rule. When an event is compared to the set of special attention rules, if a match is determined, this means that the event has triggered a special attention situation. For this reason, this comparison is referred to as "positive" matching.

As shown above in FIGS. **5**B and **6**B, each normalized system event **122**, **126** is assigned a severity level **142**. The severity level **142** is indicative of the general significance of a given event, and indicative of the extent to which the event conforms to security policies and rules. The severity level provides an additional gauge by which a decision can be made as to the manner in which an event is to be processed or as to the relative importance of the event.

FIG. **11** is a flow diagram of a process for assigning a severity level to an event, in accordance with the present invention. As described above, data groups of the various attributes are pre-defined **270**, and significance factors are pre-assigned to the defined data groups **272**. Upon the processing of an event **274**, the normalized event log data is inspected **276**, and the data groups of each attribute field are determined **278**. Next, a severity level is assigned to the event according to whether the event complies with systems policies, and according to whether the criteria of any special attention rules are met. The steps that correspond to this inquiry **284**, **288**, **292**, and **280**, and the resulting assignment of a severity level **286**, **290**, **294**, and **282** are described in further detail below, with reference to the following set of examples.

In the present example, each special attention rule may be assigned a specific severity level, depending on the significance of the rule. For example, in the case where a normalized system event meets the criteria of a special attention rule (see step **288** of FIG. **11**), the normalized event is directly assigned the severity level of the rule (see step **290** of FIG. **11**).

An example of this is shown in FIG. **7**, which is screen shot image of a summary report that is generated in relation to a normalized system event that conforms to a special attention rule. In this example, the event management tool has determined that the normalized event **202** includes a "what" attribute in the form of a warning. In this case, a special attention rule **206** is matched by the normalized event, the rule being related to "security notifications" and is triggered in the case of a "warnings" group being assigned to the "what" attribute. In this rule **206**, the assigned severity level **208** is 15. Since the normalized event log matches the rule, the event is assigned a severity level **210** of 15.

In another example, the severity level of an event is assigned based on whether the event constitutes an exception to the system policies (see step **292** of FIG. **11**). For example, in the case where an event has at least one attribute that does not fall within system policies, that event is categorized as an exception to the polices. As a result, the event is issued a severity level based on a significance factor that is assigned to each of the applicable groups of each attribute (see step **294** of FIG. **11**).

An example of this is shown in FIG. **8**, which is a screen shot image of a summary report that is generated in relation to a normalized system event that constitutes an exception to the system policies. In this example, the event management tool has determined that the normalized event **212** includes a "what" attribute in the form of a module update **214**. In this case, none of the special attention rules are matched by the normalized event **212**. In addition, it is also determined by the event management tool that the event **212** does not fall within the system policies, so it is deemed an "exception" to the policy. As a result, the significance factors **216** of the various groups **218** of the attributes are inspected to determine which is the most significant. In this case, it is determined that group "System Updates" of the "what" attribute has a significance

factor of 50, which is higher than all other group significance factors, and thus is most significant. Therefore, the event is assigned a severity level **220** of **50**.

In another example, the severity level of an event is assigned based on a combination of whether the event meets the criteria of a special attention rule and whether the event constitutes an exception to the system policies (see step **284** of FIG. **11**). For example, in the case where an event has at least one attribute that does not fall within system policies, that event is categorized as an exception to the polices, yet, the event may still fall within the criteria of a special attention rule. As a result, the event is issued a severity level that is equal to the greater of a first severity level that is based on a significance factor that is assigned to each of the applicable groups of each attribute and a second severity level that is assigned directly to the subject special attention rule (see step **286** of FIG. **11**).

An example of this is shown in FIG. **9**, which is a screen shot image of a summary report that is generated in relation to a normalized system event that constitutes both an exception to the system policies and one that conforms to a special attention rule. In this example, the event management tool has determined that the normalized event **222** includes a "what" attribute in the form of a database load failure **224**. In addition, it is also determined by the event management tool that the event **224** does not fall within the system policies, so it is deemed an "exception" to the policy. As a result, the significance factors **226** of the various groups **228** of the attributes are inspected to determine which is the most significant. In this case, it is determined that group "Alerts—Medium" of the "what" attribute has a significance factor of 60, which is higher than all other group significance factors. At the same time, in this case, a rule **227** is matched by the normalized event **222**, the rule being related to the description "attention required" and is triggered in the case of the "Alerts—Medium" group being assigned to the "what" attribute. In this rule **227**, the assigned severity level **229** is 50. In this case, the assigned severity level of the event is determined as the higher of the policy exception severity, namely 60, and the special attention rule severity, namely 50. Therefore, the event is assigned a severity level **230** of 60.

In another example, the severity level of an event is assigned in the case where the event conforms to the system policies. For example, in the case where the attributes of an event include groups that all conform to system policies, that event is thus determined to comply with the polices (see step **280** of FIG. **11**). As a result, the event is issued a severity level based on a significance factor that is assigned to each of the applicable groups of each attribute, and in one example, the significance factor is divided by 10 under these circumstances (see step **282** of FIG. **11**).

An example of this is shown in FIG. **10**, which is screen shot image of a summary report that is generated in relation to a normalized event log that complies with the system policies. In this example, the event management tool has determined that the normalized event **242** includes a "on what" attribute in the form of an object that falls within the "TCB" group. Since the event management tool has determined that the event **242** complies with the system policies, the significance factors **246** of the various groups **248** of the attributes are inspected to determine which is the most significant. In this case, it is determined that group "TCB" of the "on what" attribute has a significance factor of 30. Therefore, the event is assigned a severity level **250** that is equal to the highest significance factor, namely 30, divided by 10, which equals 3.

Upon the assignment of a severity level to an event, the severity level can be used as a sorting parameter for the solution **52** (see FIG. **3**), which, as described above, may take the form of reports, alerts, warnings, and the like.

In this manner, the present invention provides a system and method by which system events that are generated across distributed systems can be tracked by the event management tool such that the initiating client of an event and/or the recipient client of an event can be resolved in both local and distributed networks. In addition, such information is normalized into a normalized event log such that events generated at a variety of different client operating systems, applications, or network appliances, can be interpreted by the same event management tool. In addition, the normalized events are assigned a severity level that can be used as a gauge of the relative severity of each event with regard to system security.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made herein without departing from the spirit and scope of the invention as defined by the appended claims.

We claim:

1. A method for managing system events in a network, comprising:

receiving, by a computer, a system event initiated by an initiating client associated with a user, wherein the system event comprises a plurality of data elements associated with respective ones of a plurality of system event attributes;

evaluating the plurality of data elements of the system event against a security policy and determining that the system event fails to conform to the security policy for the user, wherein the security policy defines permitted actions for different users in accordance with the plurality of system event attributes;

determining a greatest of a plurality of significance factors assigned to a plurality of data groups that are associated with the plurality of data elements of the system event;

determining whether the system event matches a special attention rule in accordance with the plurality of data elements, wherein the special attention rule defines a prohibited action;

if the system event does not match the special attention rule and the system event fails the security policy, assigning to the system event the greatest of the plurality of significance factors as a severity level; and

if the system event matches the special attentions rule and the system event fails the security policy,

comparing the greatest of the plurality of significance factors against a pre-assigned severity level that was pre-assigned to the special attention rule; and

assigning to the system event a greater of the greatest of the plurality of significance factors and the pre-assigned severity level as a severity level.

2. The method of claim **1** further comprising normalizing the system event according to the plurality of system event attributes to generate a normalized system event.

3. The method of claim **2**, wherein said normalizing the system event according to the plurality of system event attributes comprises associating a first of the plurality of data elements to a data field corresponding to a first of the plurality of system event attributes of the normalized system event.

4. The method of claim **3**, wherein plurality of data elements comprises at least one of the identity of the initiating client and an identity of a recipient client that is acted upon by the system event.

5. The method of claim **3** wherein the identity comprises one of:

an Internet Protocol address, a workstation name, an email address, and a fully-qualified host name.

6. The method of claim **1** further comprising:

receiving a second system event initiated by a second initiating client associated with a second user, wherein the system event comprises a second plurality of data elements associated with respective ones of the plurality of system event attributes;

comparing the second plurality of data elements of the system event to the security policy and determining that the second system event conforms to the security policy for the second user;

determining a greatest of a second plurality of significance factors assigned to a second plurality of data groups that are associated with the second plurality of data elements of the second system event;

computing a conforming severity level as the greatest of the second plurality of significance factors divided by a coefficient common to the second plurality of significance factors; and

assigning to the second system event the conforming severity level as a severity level.

7. The method of claim **1** further comprising generating a solution to the event based on the severity level.

8. The method of claim **7** wherein the solution comprises generation of an immediate alert, an email message, an instant message, or a report.

9. The method of claim **1** wherein the network is a distributed network.

10. A system for managing system events in a network, comprising:

a processor;

a storage media having a security policy stored therein, the security policy defining permitted actions for different users in accordance with a plurality of system event attributes; and

a storage media encoded with program instructions executable by the processor, the program instructions to:

receive a system event initiated by an initiating client associated with a user, the system event configured to act on a recipient client, wherein the system event comprises a plurality of data elements associated with respective ones of a plurality of system event attributes;

evaluate the plurality of data elements of the system event against the security policy to determine whether the system event conforms to the security policy for the user;

determine a greatest of a plurality of significance factors assigned to a plurality of data groups that are associated with the plurality of data elements of the system event;

determine whether the system event matches a special attention rule in accordance with the plurality of data elements, wherein the special attention rule defines a prohibited action;

if the system event does not match the special attention rule and the system event fails the security policy, assign to the system event the greatest of the plurality of significance factors as a severity level; and

if the system event matches the special attentions rule and fails the security policy,

compare the greatest of the plurality of significance factors against a pre-assigned severity level that was pre-assigned to the special attention rule; and

assign to the system event a greater of the greatest of the plurality of significance factors and the pre-assigned severity level as a severity level for the system event.

11. The system of claim **10**, wherein the storage media also has program instructions to normalize the system event according to the plurality of system event attributes to generate a normalized system event.

12. The system of claim **10**, wherein the program instructions to normalize the system event according to the plurality of system event attributes comprises program instructions to associate a first of the plurality of data elements to a data field corresponding to a first of the plurality of system event attributes of the normalized system event.

13. The system of claim **12** wherein the plurality of data elements comprises at least one of identity of the initiating client and an identity of a recipient client that is acted upon by the system event.

14. The system of claim **12** wherein the identity comprises one of:

a workstation name, an Internet Protocol address, an email address, and a fully-qualified host name.

15. The system of claim **10**, wherein the plurality of data elements comprise at least one of:

the identity of a user initiating the system event; the type of system event that was initiated; the time at which the system event occurred; the system or device on which the system event occurred; and the file, device, or setting that was accessed by the system event.

16. The system of claim **10**, wherein the storage media further has program instruction to:

compute a conforming severity level as the greatest of the plurality of significance factors divided by a coefficient common to the plurality of significance factors if the system event conforms to the security policy; and

assign the conforming severity level as a severity level to the system event that conforms to the security policy.

17. The system of claim **10** wherein a solution to the system event is generated based on the severity level.

18. The system of claim **17** wherein the solution comprises generation of an immediate alert, an email message, an instant message, or a report.

19. The system of claim **10** wherein the network is a distributed network.

20. A non-transitory computer-readable storage medium comprising program instructions executable to:

receive a system event initiated by an initiating client associated with a user, wherein the system event comprises a plurality of data elements associated with respective ones of a plurality of system event attributes;

evaluate the plurality of data elements of the system event against the security policy to determine whether the system event conforms to the security policy for the user; wherein the security policy defines permitted actions for different users in accordance with the plurality of system event attributes;

determine a greatest of a plurality of significance factors assigned to a plurality of data groups that are associated with the plurality of data elements of the system event;

determine whether the system event matches a special attention rule in accordance with the plurality of data elements, wherein the special attention rule defines a prohibited action;

if the system event does not match the special attention rule and the system event fails the security policy, assign to the system event the greatest of the plurality of significance factors as a severity level; and

if the system event matches the special attentions rule and fails the security policy,

compare the greatest of the plurality of significance factors against a pre-assigned severity level that was pre-assigned to the special attention rule; and

assign to the system event a greater of the greatest of the plurality of significance factors and the pre-assigned severity level as a severity level.

21. The non-transitory computer-readable storage medium of claim **20** further comprising program instructions to normalize the system event in accordance with the plurality of system event attributes for evaluation.

22. The non-transitory computer-readable storage medium of claim **21**, wherein the program instructions to normalize the system event in accordance with the plurality of system event attributes comprises program instructions to assign the plurality of data elements from the system event to respective ones of attribute fields that corresponds to the plurality of system event attributes.

23. The non-transitory computer-readable storage medium of claim **22**, wherein the plurality of system event attributes comprise at least two of a time attribute, an event type attribute, a platform attribute, a user source attribute, a machine origin attribute, a user recipient attribute, and a machine target attribute.

24. The non-transitory computer-readable storage medium of claim **21**, wherein the program instructions to normalize the system event further comprising program instructions to:

for each of the plurality of data elements,

determine a set of data groups assigned to the one of the plurality system event attributes associated with the data element; and

determine which data group of the set of data groups corresponds to the data element; and

associate the corresponding one of the set of data groups to the data element.

* * * * *