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(54) METHODS, APPARATUS AND SYSTEMS TO USE ARTIFICIAL INTELLIGENCE TO DEFINE ENCRYPTION AND SECURITY POLICIES IN A SOFTWARE DEFINED DATA CENTER

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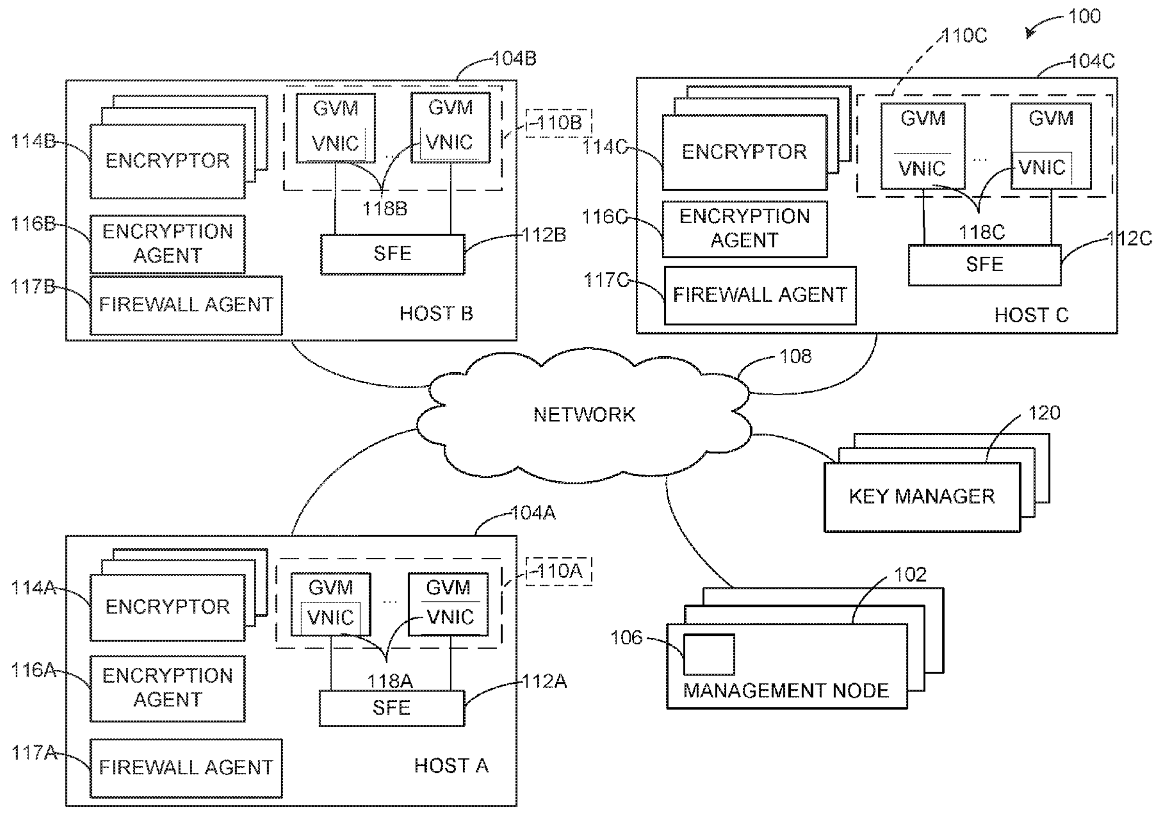
(57) **ABSTRACT**

Methods, apparatus and articles of manufacture to use artificial intelligence to define encryption and security policies in a software defined data center are disclosed. Example apparatus include a language parser to parse a natural language statement into a policy statement that defines a distributed network encryption policy or a distributed network security policy. Example apparatus also include a comparator to compare the policy statement to a set of reference policy templates and a template configurer to select a first policy template from the set of reference policy templates in response to the comparator determining the first policy template corresponds to the policy statement. A policy distributor distributes a policy rule defined by the first policy template for enforcement at network nodes of a software defined data center. The policy rule is a distributed network encryption policy rule or a security policy rule.



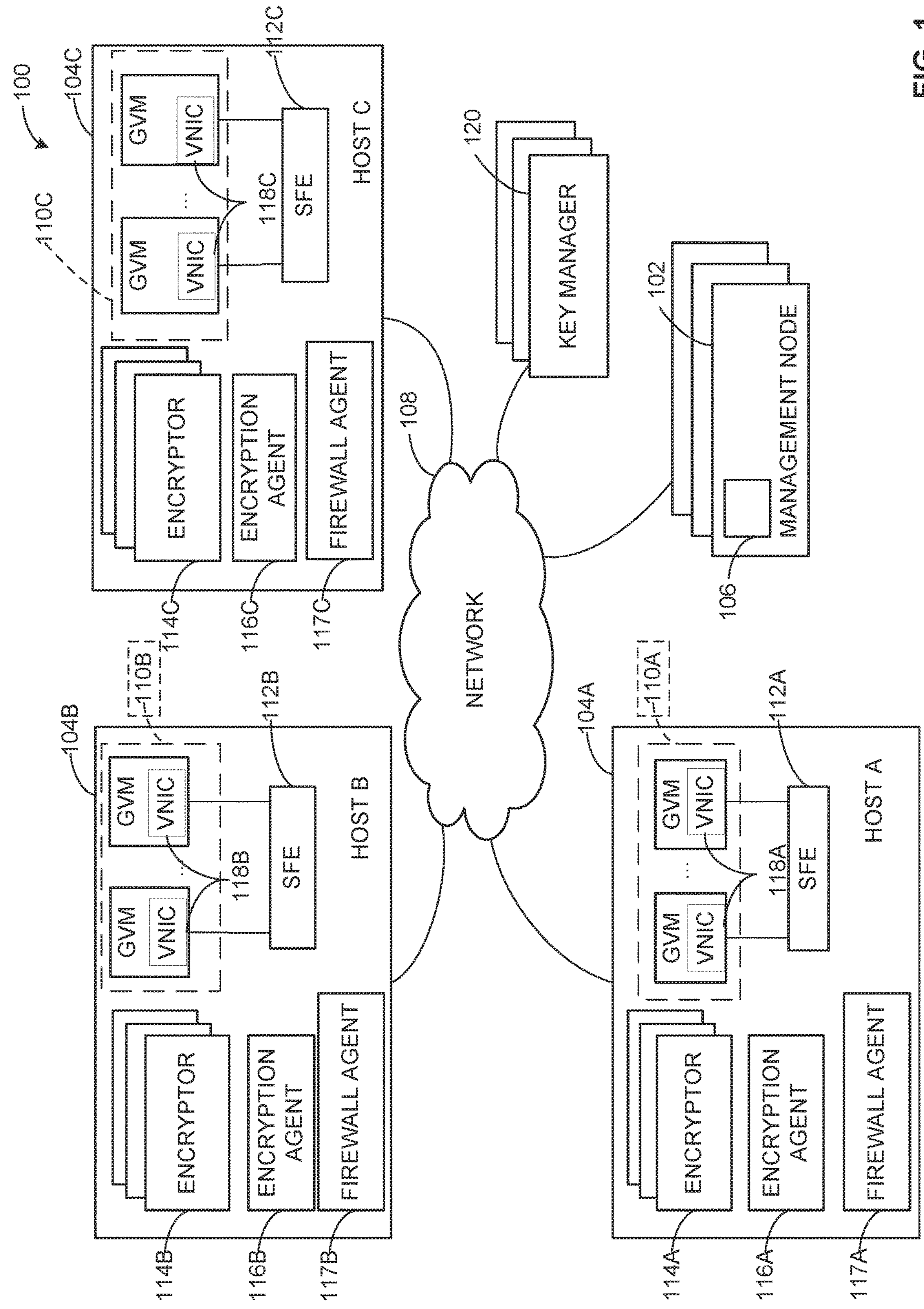

100
104C
110C
GVM
VNIC
GVM
VNIC
118C
112C
SFE
HOST C
ENCRYPTOR
ENCRYPTION AGENT
FIREWALL AGENT
114C
116C
117C
108
NETWORK
120
KEY MANAGER
102
MANAGEMENT NODE
106
104B
110B
GVM
VNIC
GVM
VNIC
118B
112B
SFE
HOST B
ENCRYPTOR
ENCRYPTION AGENT
FIREWALL AGENT
114B
116B
117B
104A
110A
GVM
VNIC
GVM
VNIC
118A
112A
SFE
HOST A
ENCRYPTOR
ENCRYPTION AGENT
FIREWALL AGENT
114A
116A
117A

FIG. 1

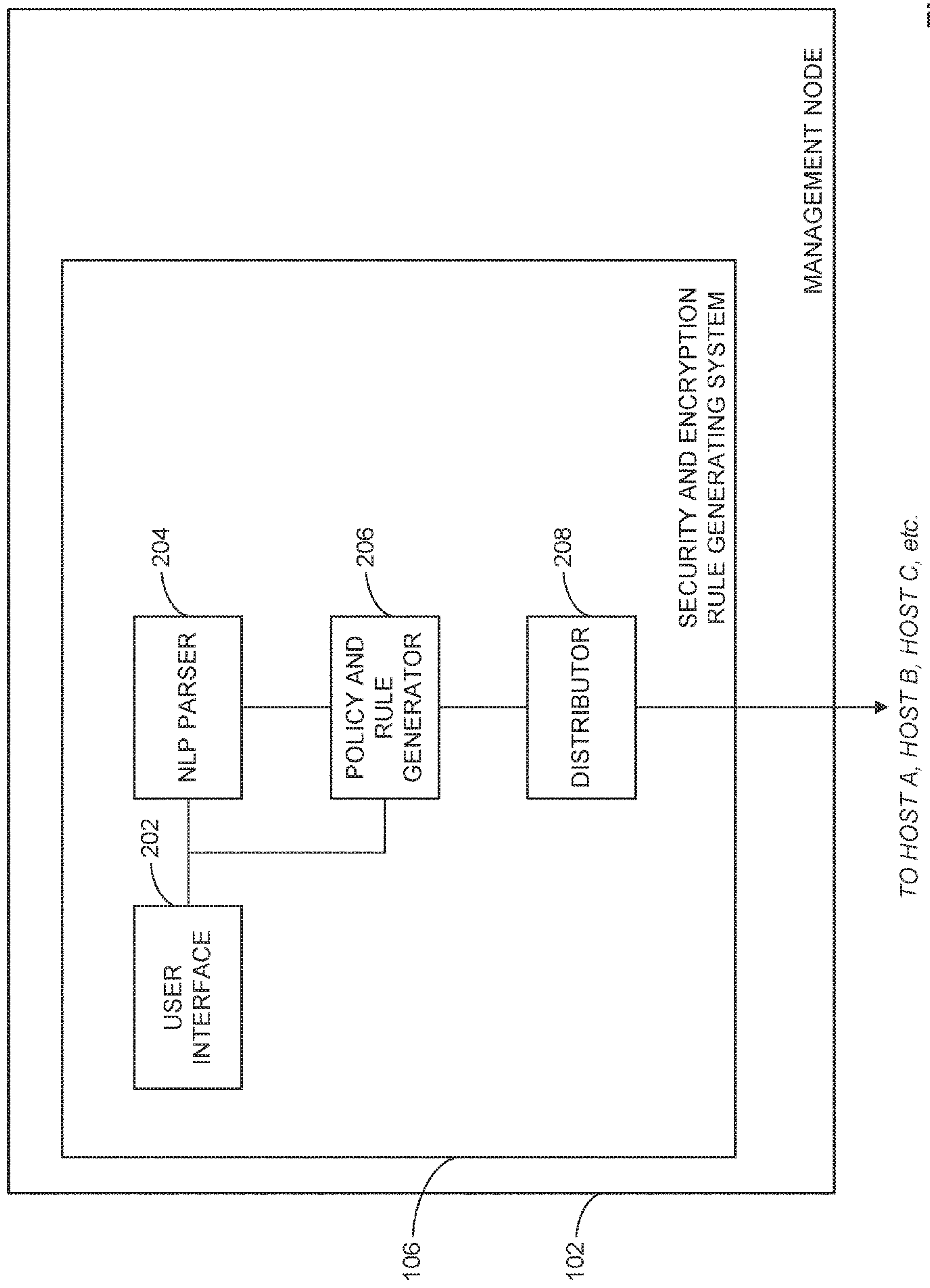

MANAGEMENT NODE
SECURITY AND ENCRYPTION RULE GENERATING SYSTEM
USER INTERFACE
202
NLP PARSER
204
POLICY AND RULE GENERATOR
206
DISTRIBUTOR
208
TO HOST A, HOST B, HOST C, etc.
106
102

FIG. 2

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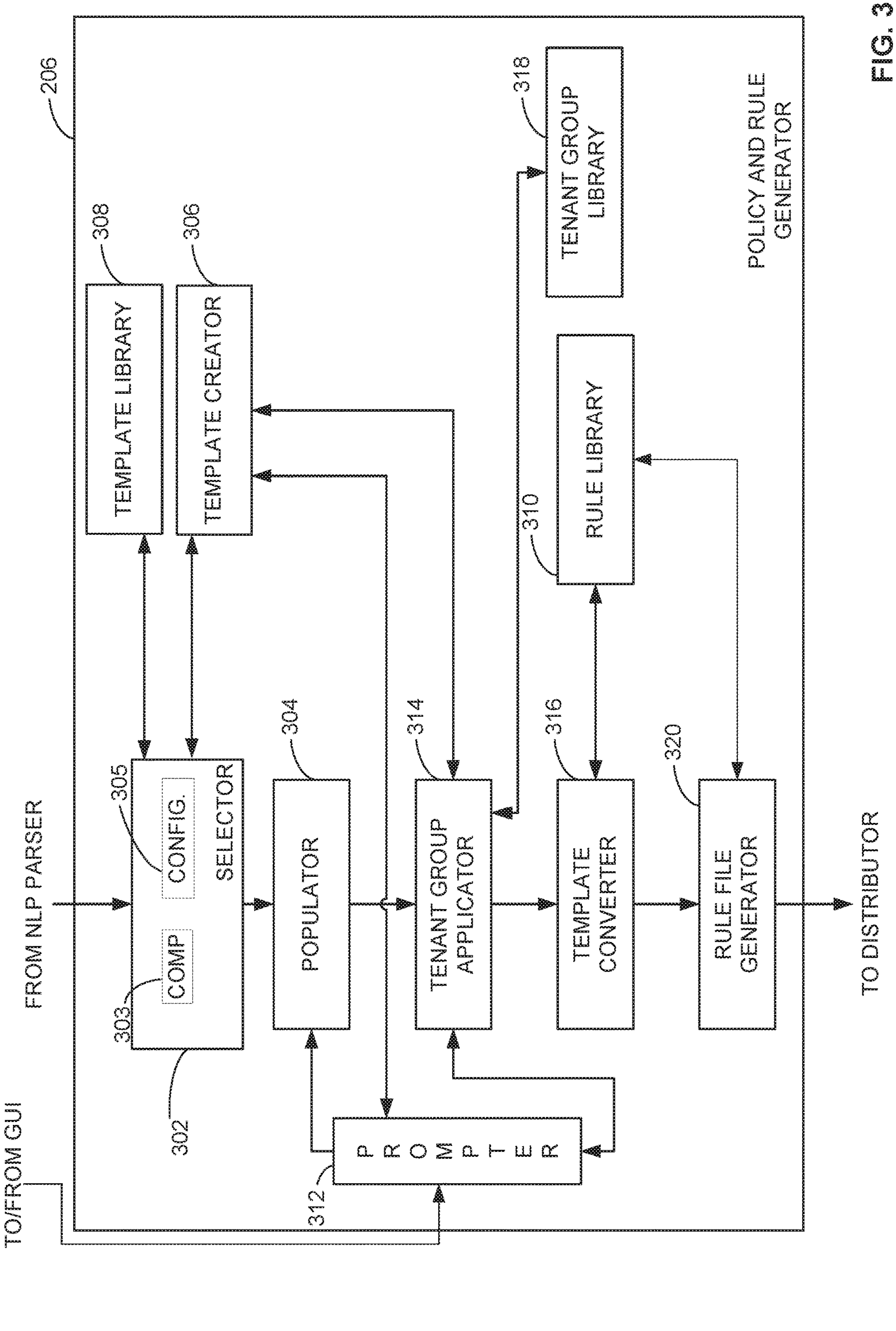

FIG. 3

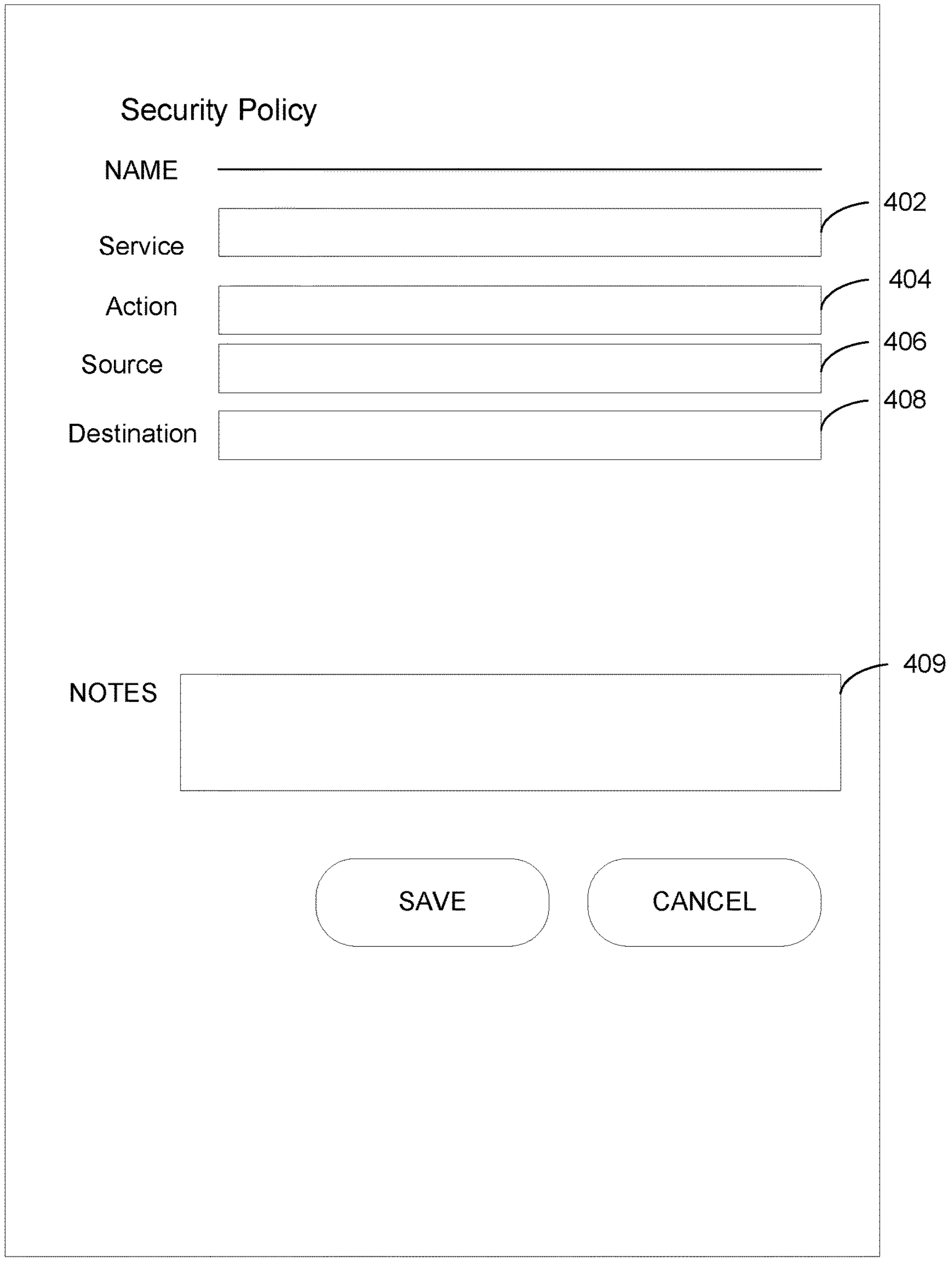
Security Policy
NAME
Service
402
Action
404
Source
406
Destination
408
NOTES
409
SAVE
CANCEL

FIG. 4A

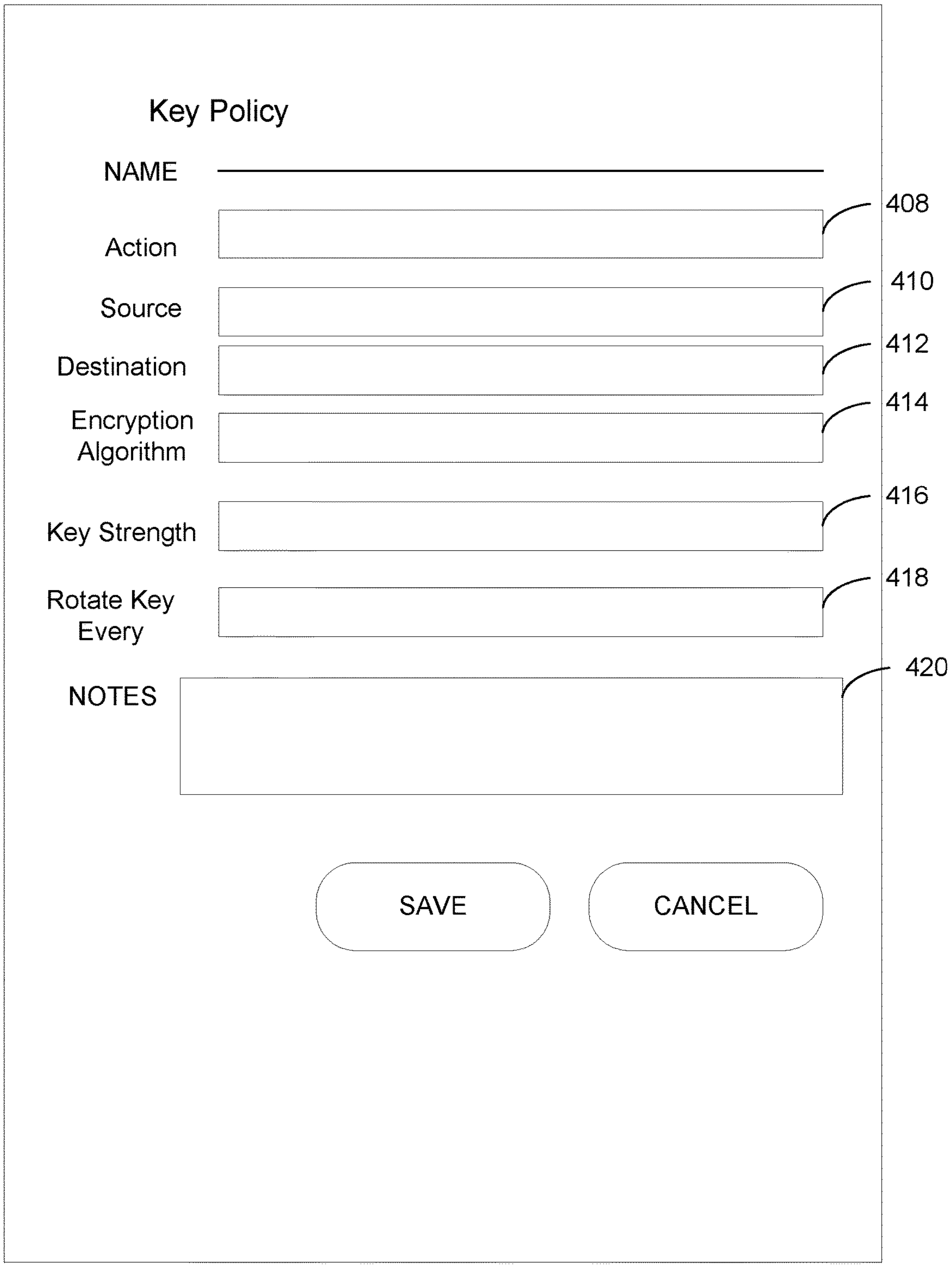
Key Policy
NAME
Action
Source
Destination
Encryption Algorithm
Key Strength
Rotate Key Every
NOTES
SAVE
CANCEL
408
410
412
414
416
418
420

FIG. 4B

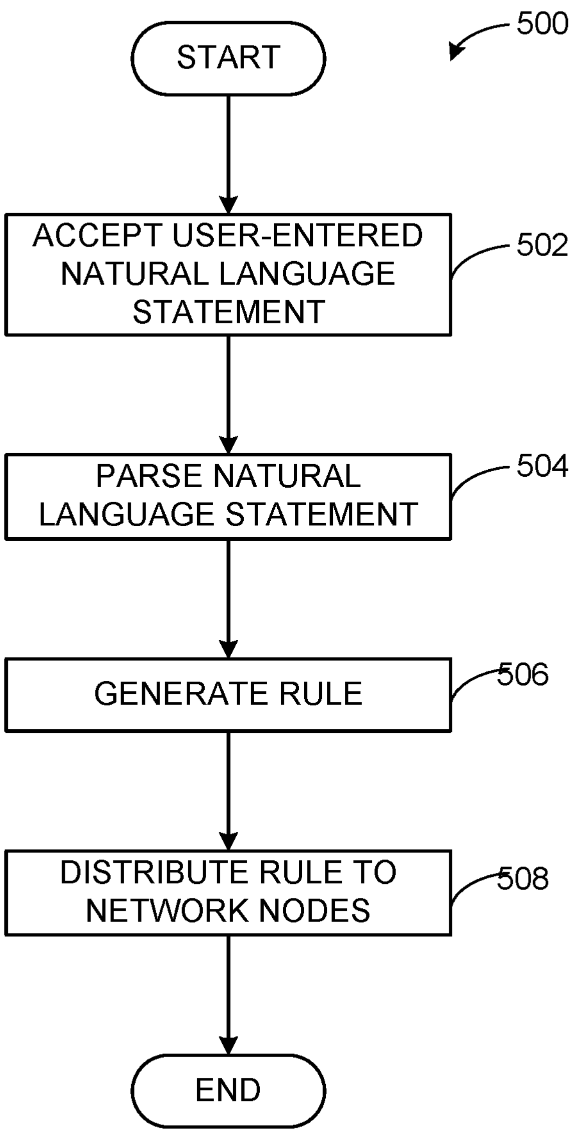
500
START
ACCEPT USER-ENTERED NATURAL LANGUAGE STATEMENT
502
PARSE NATURAL LANGUAGE STATEMENT
504
GENERATE RULE
506
DISTRIBUTE RULE TO NETWORK NODES
508
END

FIG. 5

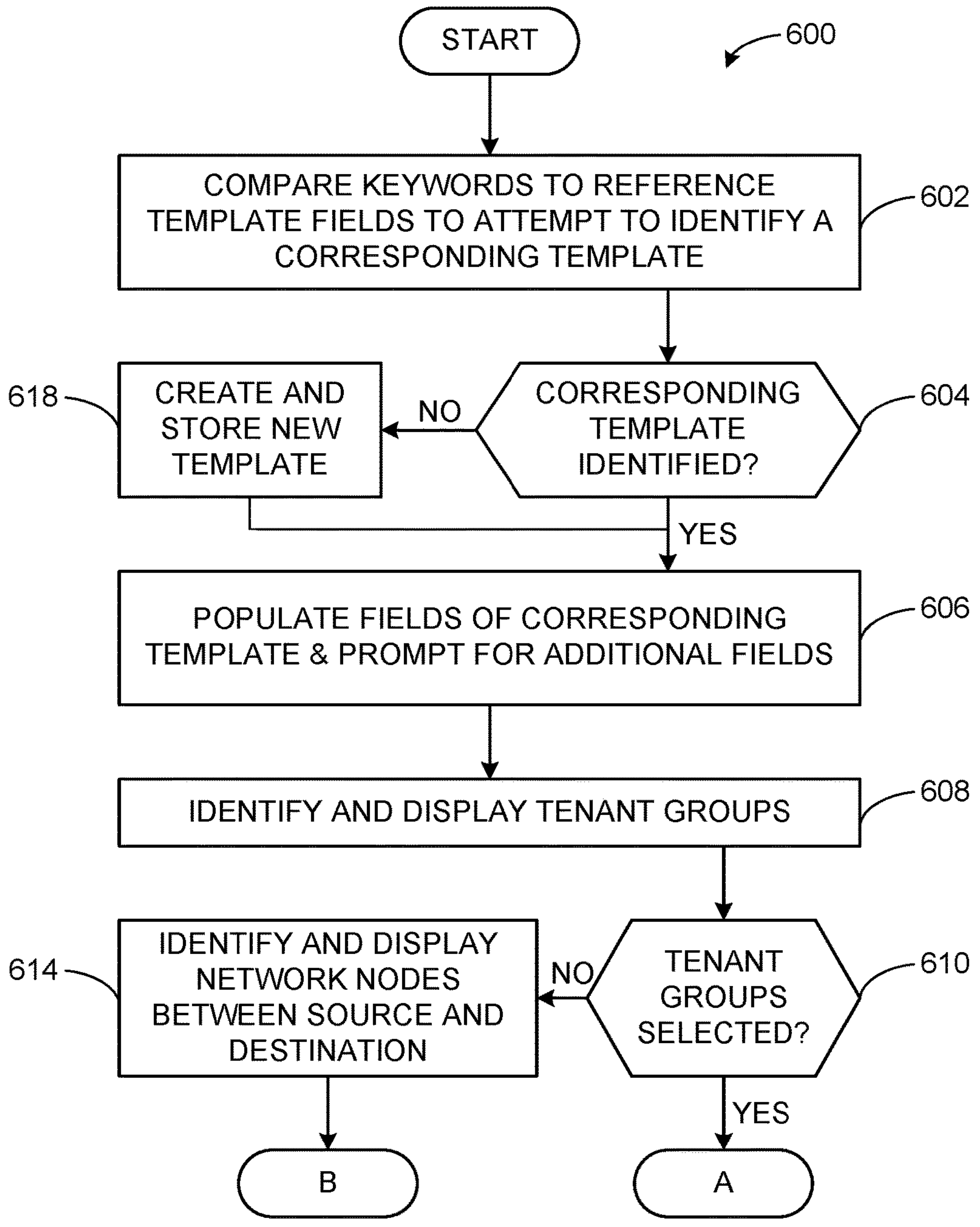
START
600
COMPARE KEYWORDS TO REFERENCE TEMPLATE FIELDS TO ATTEMPT TO IDENTIFY A CORRESPONDING TEMPLATE
602
CORRESPONDING TEMPLATE IDENTIFIED?
604
NO
CREATE AND STORE NEW TEMPLATE
618
YES
POPULATE FIELDS OF CORRESPONDING TEMPLATE & PROMPT FOR ADDITIONAL FIELDS
606
IDENTIFY AND DISPLAY TENANT GROUPS
608
TENANT GROUPS SELECTED?
610
NO
IDENTIFY AND DISPLAY NETWORK NODES BETWEEN SOURCE AND DESTINATION
614
YES
B
A

FIG. 6A

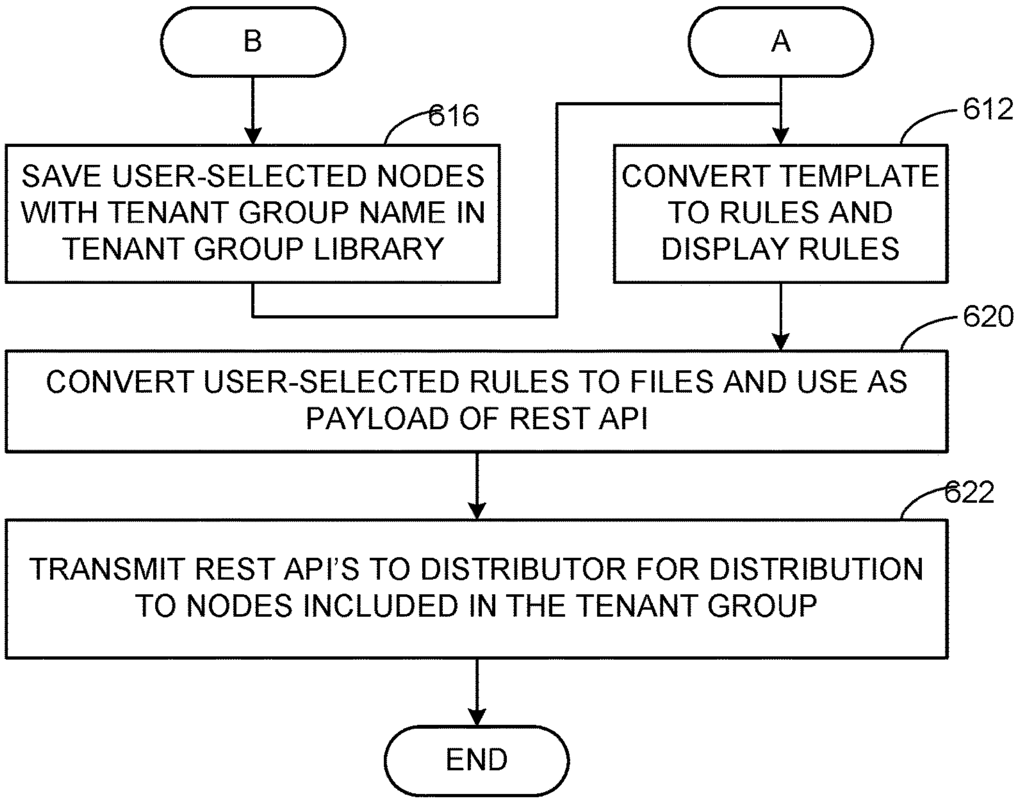
B
A
616
SAVE USER-SELECTED NODES WITH TENANT GROUP NAME IN TENANT GROUP LIBRARY
612
CONVERT TEMPLATE TO RULES AND DISPLAY RULES
620
CONVERT USER-SELECTED RULES TO FILES AND USE AS PAYLOAD OF REST API
622
TRANSMIT REST API'S TO DISTRIBUTOR FOR DISTRIBUTION TO NODES INCLUDED IN THE TENANT GROUP
END

FIG. 6B

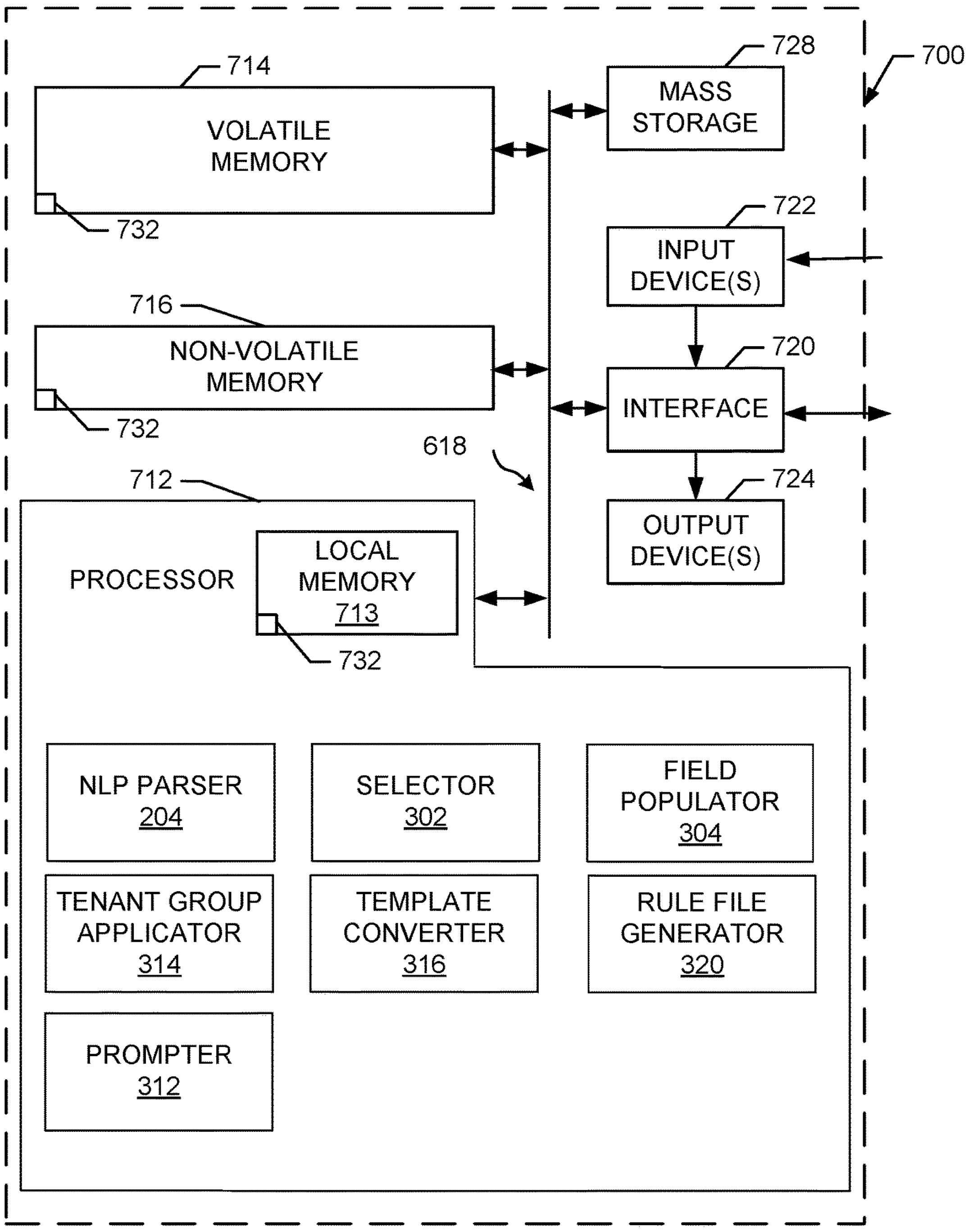
700
714
VOLATILE MEMORY
732
716
NON-VOLATILE MEMORY
732
712
PROCESSOR
LOCAL MEMORY 713
732
618
728
MASS STORAGE
722
INPUT DEVICE(S)
720
INTERFACE
724
OUTPUT DEVICE(S)
NLP PARSER 204
SELECTOR 302
FIELD POPULATOR 304
TENANT GROUP APPLICATOR 314
TEMPLATE CONVERTER 316
RULE FILE GENERATOR 320
PROMPTER 312

FIG. 7

METHODS, APPARATUS AND SYSTEMS TO USE ARTIFICIAL INTELLIGENCE TO DEFINE ENCRYPTION AND SECURITY POLICIES IN A SOFTWARE DEFINED DATA CENTER

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates generally to software defined data centers and, more particularly, to using artificial intelligence to define encryption and security policies in a software defined data center.

BACKGROUND

[0002] Enterprises (e.g., financial service providers, healthcare providers, critical infrastructure providers) store valuable data, and transfer it over networks. Information spreads across datacenters often through dedicated telco-provided networks. Overlay networks can also provide similar service via a public cloud services provider's network, but such communications are susceptible to threats such as snooping, man in the middle attack (MITM), and forging if the provider's network is compromised in some way. As enterprises widely adopt provider cloud-based multi-tenant infrastructure services instead of dedicated datacenters, new challenges are introduced, and protecting the data flowing into, within, and out of the multi-tenant cloud becomes a necessity. In addition, the privacy and security traditionally associated with conventional private enterprise datacenters can no longer be assumed. Thus, cryptography and firewalls may be used, not just at the edge, but also within public as well as private clouds to protect data and communication channels from malicious parties, provide confidentiality to enterprise dataflow in the cloud, and provide the enterprise with better control over its own data. To permit enterprise control over security and encryption rules, an enterprise system administrator, who has knowledge of the specialized format required to define such rules, crafts rules suited to the enterprise at a network management tool for subsequent delivery to and enforcement at a set of compute nodes of the data center.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** depicts an example cloud-based software defined data center having an example management node constructed in accordance with the teachings of this disclosure.

[0004] FIG. **2** illustrates an example security and encryption policy and rule generating system implemented using the example management node of FIG. **1**.

[0005] FIG. **3** illustrates an example policy/rule generator included in the security and encryption policy and rule generating system of FIG. **2**.

[0006] FIGS. **4**A and **4**B illustrate example distributed network encryption and security policy templates created using the example security and encryption policy and rule generating system of FIG. **2** and/or the example policy/rule generating system of FIG. **3**.

[0007] FIG. **5** is a flowchart representative of example computer readable instructions that may be executed to implement the example security and encryption policy and rule generating system of FIG. **2**.

[0008] FIG. **6**A and FIG. **6**B collectively illustrate a flowchart representative of example computer readable instructions that may be executed to implement the example policy/rule generator of FIG. **3**.

[0009] FIG. **7** is a block diagram of an example processing platform structured to execute the example computer readable instructions of FIGS. **5**, **6**A and **6**B to implement the example security and encryption policy and rule generating system of FIG. **3**.

[0010] The figures are not to scale. Wherever possible, the same reference numbers will be used throughout the drawing(s) and accompanying written description to refer to the same or like parts, elements, etc.

DETAILED DESCRIPTION

[0011] As cloud-based Software-Defined Data Centers (SDDCs), instead of dedicated data centers, become more widely used, enterprises are developing greater measures to protect the data flowing into, within, and out of the cloud. Distributed network encryption and distributed network firewalls are two such measures. To permit enterprise control over security (firewall) and encryption rules used to implement distributed network encryption and distributed network firewalls, an enterprise system administrator, who has knowledge of the specialized format required to define such rules, uses that knowledge to craft rules suited to the enterprise. The rules are then provided by a network management tool to a set of compute nodes of the SDDC for enforcement. However, the expertise, training and skill required of the system administrator to define encryption and security rules that adequately protect enterprise data can be significant.

[0012] Example methods, apparatus and systems disclosed herein facilitate the development of encryption and/or security policies and rules through the use of artificial intelligence in the form of a natural language processing (NLP) parser. Example methods, apparatus and systems include a user interface at which a user enters a natural language statement identifying the desired policy/rule to be implemented in an SDDC. An example NLP parser parses the natural language statement to identify key words included in the natural language statement. An example comparator uses the key words to identify a corresponding policy template from among a set of reference policy templates. An example tenant group applicator identifies (e.g., based on user input) a set of compute nodes at which the rule is to be enforced and an example template converter then converts the template into an encryption or security rule in a format that is understandable by encryption and security enforcement tools residing at the compute network nodes of the SDDC. The rule is subsequently transmitted to the compute nodes of the SDDC for enforcement/application thereat.

[0013] FIG. **1** depicts an example cloud-based software defined data center software (SDDC) **100** having an example management node **102** and a set of example host nodes including a Host A **104**A, a Host B **104**B, and a Host C **104**C. The example management node **102** includes an example security and encryption policy and rule generating system **106**, as well as any other tools needed to provision, implement and manage nodes of the SDDC **100**. The management node **102**, Host A **104**A, Host B **104**B, and Host C **104**C communicate via a network **108**, which may comprise one or more networks each of which may comprise one or more local area networks (LANs), wide area networks (WANs), and/or a network of networks (e.g., the Internet), etc.

[0014] In some examples, Host A **104**A, Host B **104**B, and/or Host C **104**C, etc. are implemented using processors on which example guest virtual machines **110**A, **110**B, **110**C have been instantiated. A software forwarding element (SFE) **112**A, **112**B, **112**C installed on each respective Host operates to transmit data received at the respective Host to a virtual machine installed on the Host. In some examples, SFEs **112**A, **112**B, **112**C access corresponding encryptors/decryptors **114**A, **114**B, **114**C when data received from network **108** (or to be delivered to network **108**) is to be encrypted or decrypted. In some examples, SFE **112**A, **112**B, and **112**C are configured to implement one or more logical networks within the SDDC **100** by controlling the manner in which packets/data received at the respective Host are to be forwarded. SFE **112**A, **112**B, **112**C may operate as a security rule enforcement tool that enforces security rules, such as firewalls. In alternate embodiments, security rules may be enforced at other points along the datapath, such as at a virtual NIC **118**A, **118**B, **118**C associated with each virtual machine or container, or virtual (software-implemented) ports, including uplink ports, associated with the software forwarding element.

[0015] In the illustrated example of FIG. **1**, encryption agents **116**A, **116**B, **116**C also installed on respective Hosts receive, via network **108**, encryption rules/policies generated by the security and encryption policy and rule generating system **106** at management node **102**. In certain embodiments, traffic between key managers **120**, management nodes **102**, and encryption agents **116** is communicated over a separate physical network (not separately shown) than the physical network of network **108** that handles production data communication, such as data communicated by virtual machines **110**. In some examples, encryption keys are stored and managed by key manager node **120** coupled to network **108**. The encryption keys are transmitted to encryption agents for usage by encryptors. In some examples, key manager **120** also periodically provides new encryption keys to the encryption agents for one or more of the encryption rules, for example, to make it harder for third parties to break the encryption scheme. Encryption agents **116**A, **116**B, **116**C and encryptors/decryptors **114**A, **114**B, **114**C operate collectively as encryption rule enforcement tools that enforce encryption rules at each respective Host. In some examples, firewall agents **117**A, **117**B, **117**C also installed on respective Hosts, receive, via network **108**, policies and rules generated by security and encryption policy and rule generating system **106** at management node **102**. Virtual NICs **118**A, **118**B and **118**C access a table(s) implemented at the firewall respective firewall agents **117**A, **117**B, **117**C to obtain firewall policies/rules to be applied at corresponding ones of the guest virtual machines **110**A, **110**B. In further examples, one or more software defined firewalls are implemented at a hypervisor at each Host **104**A, **104**B, **104**C having a guest virtual machine or destination endpoint affected by the firewall rules.

[0016] Although FIG. **1** depicts Host A **104**A, Host B **104**B, and Host C **104**C as implementing guest virtual machines **110**A, **110**B, **110**C, respectively, in some examples, a lighter-weight virtualization is employed by using containers in place of guest virtual machines **110**A, **110**B, **110**C. Containers are software constructs such as namespaces for applications that run on top of a host operating system without the need for a hypervisor or a separate guest operating system. Unlike virtual machines, containers do not instantiate their own operating systems. Like virtual machines, the containers are logically isolated from one another and can have their own Layer 2 and Layer 3 (of the OSI model) network addresses. Numerous containers can run on a single computer, processor system and/or in the same development environment. Also like virtual machines, the containers can execute instances of applications or programs (e.g., an example application) logically isolated from application/program instances executed inside other containers.

[0017] FIG. **2** illustrates an example implementation of the security and encryption policy and rule generating system **104** implemented at example management node **102** of FIG. **1**. In some examples, the example security and encryption policy and rule generating system **104** includes a user interface **202**, a natural language processing (NLP) parser **204**, a policy and rule generator **206**, and a distributor **208**. In some examples, user interface **202** is configured to present a display at which a user, such as a system administrator, enters a natural language statement identifying a desired policy to be implemented at the nodes (e.g., Host A **104**A, Host B **104**B, Host **104**C) of the SDDC **100** of FIG. **1**. In some examples, the user enters the natural language statement using a microphone and a software tool converts the spoken language to written text. In some examples, the user enters the natural language statement via a keyboard. A natural language statement, as used herein, refers to a statement that conforms to a natural language spoken by humans during everyday conversations. In contrast, a constructed language is a language that was developed to program computers/machines. Thus, the user can use natural language to formulate a natural language statement to identify a desired policy or rule and need not be specially trained in any particular constructed/computer language to use the security and encryption policy and rule generating system **106** of FIG. **1** and/or FIG. **2**. An example natural language statement such as "block web servers to db servers," may be entered by a user intending to create a policy that will result in a firewall between a set of web servers and a set of database servers. The natural language statement entered via the user interface **202** is provided to the NLP parser **204** which uses artificial intelligence to parse the natural language statement into a set of key words. In some examples, NLP parser **204** is implemented using any available natural language processing parser hardware/software including a parser based on the nltk python language. For example, key words corresponding to the example natural language statement "block web servers to db servers" can include "block," "web" and "db."

[0018] In some examples, NLP parser **204** transmits the identified key words to policy/rule generator **206**, which uses the key words to generate a corresponding policy/rule in a manner described further hereinbelow. Policy/rule generator **206** then causes distributor **208** to distribute the policy/rule to one or more encryption agents **116**A, **116**B, **116**C residing at one or more of Host A **104**A, Host B **104**B and/or Host C **104**C, respectively, for application/enforcement thereat.

[0019] FIG. **3** illustrates an example implementation of policy/rule generator **206** of FIG. **2**. In some examples, policy/rule generator **206** includes a template selector **302**, a field populator **304**, a template creator **306**, a template library **308**, a rule library **310**, a prompter **312**, a tenant group applicator **314**, a template converter **316**, a tenant group library **318** and a rule file generator **320**. In some examples, template selector **302** receives the set of key words identified by the NLP parser **204** (see FIG. **2**) and uses the key words to identify a policy/rule template stored in template library **308** that corresponds to the key words. In some examples, the templates stored in template library **308** include a set of reference templates, each having a set of fields. In some examples, at least some of the fields of the templates are populated. In some such examples, template selector **302** identifies a policy/rule template corresponding to the key words by comparing the key words to information stored in one or more of the populated fields of the templates.

[0020] Referring also to FIG. **4**A and FIG. **4**B, in some examples, at least some of the set of reference templates represent distributed network security policies (see FIG. **4**A) and/or at least some of the reference templates represent distributed network encryption policies (see FIG. **4**B). In some such examples, network security reference templates **400**A (see FIG. **4**A) include a set of fields related to network security including, for example, a service field **402**, an action field **404**, a source field **406**, an destination field **408**, and a notes field **409** into which notes may be entered. Service field **402** identifies a service to which the policy/rule is to be applied. In some examples, the service can be represented as a network protocol and a port number (e.g., telnet 23). In some such examples, data traffic formatted according to the network protocol received at the identified port number will be subjected to the policy/rule. Action field **404** identifies an action (e.g., allow, deny, reject) to be applied to data traffic identified by the service in service field **402**. Source field **406** identifies a source of data traffic and can be formatted as a network address of the source or a logical name of the source. Likewise, destination field **408** identifies a destination of data traffic and can be formatted as a network address of the destination and/or a logical name of the destination. In some examples, source/destination **406**, **408** fields can be configured to accept a tag that identifies a role of a node within SDDC **100**. For example, the tag can identify a node as being a Web application, a Database application, a User application, etc. In some examples, network encryption reference templates **400**B (see FIG. **4**B) can include a set of fields related to network encryption including, for example, an action field **410**, a source field **412**, a destination field **414**, and an encryption cypher field **416**. Action field **410** identifies an action (e.g., encrypt, do not encrypt) to be applied to data traffic transmitted between a source node identified in source field **412** and a destination node identified in destination field **414**. Encryption cypher field **416** identifies an encryption cypher to be used when encrypting the data. In some examples, the template also includes a key strength field **418** that indicates a strength of the encryption key, a key rotation field **420** that indicates a frequency at which the key is to be rotated and a notes field **422** into which notes may be entered.

[0021] Referring still to FIG. **3**, in some examples, when comparing the key words supplied by NLP parser **204**, selector **302** includes a comparator **303** that compares the key words to information entered into one or more of the individual fields of the set of reference templates. For example, comparator **303** can be configured to compare the key words to the contents of the service field **402** and the action field **404** of the reference templates. For example, the comparator **303**, when comparing the keywords "telnet23" and "allow" to the contents of the template fields, will attempt to identify a template having an action field **404** populated with "allow" and having a service field **402** populated with "telnet23." If a reference template meeting this description is identified, based on comparing the keywords to the contents of at least some of the reference template fields **402**, **404**, **406**, **408**, a configurer **305** of selector **302** selects the identified reference template as a match for the key words. In some examples, the key words must match a threshold number of fields of a reference template before the template will be considered a matching template. In some examples, the key words must match the contents of specific fields (e.g., service, action) of a reference template before the template will be considered a match. The selected (e.g., matching) template and keywords are provided to field populator **304** which uses the remaining keywords supplied by NLP parser **204**, if any, to populate corresponding fields of the selected template. For example, the keywords related to source field **406** and destination field **408**, if any, are placed by field populator **304** into the fields of the selected template. In some examples, field populator **304** identifies fields that remain unpopulated, if any, to prompter **312**, which generates a prompt to the user to enter data into the unpopulated fields. Such a prompt can identify the fields that remain unpopulated and include a request to the user to enter information into the unpopulated fields. In some examples, the prompt includes suggested values to be entered into the unpopulated fields of the selected template. The request (or prompt) is displayed to the user via graphical user interface **202** (FIG. **2**).

[0022] After the fields of the selected template have been populated, populator **304** supplies the populated template to tenant group applicator **314**. Tenant group applicator **314** identifies sets of tenant groups by name and supplies the tenant group names to graphical user interface **202** (see FIG. **2**) for display to the user. The tenant group represents a set of network nodes at which the rule will be applied and are typically disposed in the network between the source node and the destination node. Tenant groups are stored in tenant group library **318**. The user replies by selecting one or more of the displayed tenant groups and/or opts to create a new tenant group. If the user selects one or more of the tenant user groups displayed on graphical user interface **202**, tenant group applicator **314** responds to the selection by supplying information identifying nodes in the selected tenant groups and the selected, populated template to the template converter **316**. Template converter **316** then uses the selected, populated template and the set of nodes included in the selected tenant group to generate a set of rules corresponding to the template and causes the rules to be displayed at graphical user interface **202**. For example, the template may indicate that a firewall is to be created between a network entity associated with the tag "Web" and a network entity associated with the tag "db." In some such examples, the tag "Web" refers to a web server and the tag "db" refers to a database server. In some such examples, the tenant group includes nodes that carry data traffic between the web server and the database server and represent nodes at which the policies/rules will be enforced.

[0023] In some examples, the user elects to create a new tenant group at which the policy is to be applied by selecting the appropriate option (e.g., “create new user group”) via the graphical user interface **202**. Referring to the preceding firewall example, in some such examples in which the user elects to create a new tenant group, tenant group applicator **314** identifies (and causes the graphical user interface to display) network nodes that carry traffic between the tagged/identified web server and the tagged/identified database server. The network nodes can include virtual machines, logical ports and logical switches. The user selects the nodes at which the policy is to be enforced and also provides a tenant group name for the nodes. Tenant group applicator **314** causes the newly defined tenant group to be stored in the tenant group library with the user-identified tenant group name. In addition, tenant group application **314** supplies the newly defined tenant group and the selected, populated template to the template converter **316**, which converts the information into a set of rules that will be used to enforce the policy.

[0024] In some examples, template converter **316** converts the supplied template and selected/created tenant group information to a set of rules by accessing rule library **310**. In some examples, rule library **310** contains a set of rules corresponding to each template. The rules include placeholders into which the specific information entered into a template can be substituted/populated and/or specific tenant group node information is substituted/populated. The user is provided an option to select any of the set of rules using, for example, a radial button or check box via graphical user interface **202**. In an example in which the user desires to create a firewall between a web server (implemented with a first virtual machine “VM1” and a logical switch “LS1”) and a database server (implemented with a second virtual machine “VM2”) and the user has selected a first tenant group (“TG1”), the set of rules generated for display can include: 1) Deny ANY from VM1 to VM2 direction IN applied on TG1, 2) Deny ANY from VM1 to VM2 direction OUT applied on TG1, 3) Deny ANY from VM1 to VM2 direction IN/OUT applied on TG1, 4) Deny ANY from VM1 to LS1 direction IN applied on TG1, 5) Deny ANY from VM1 to LS1 direction OUT applied on TG1, and 6) Deny ANY from VM1 to LS1 direction IN/OUT applied on TG1. Further each rule can have a corresponding selection box to be checked or unchecked by the user as desired.

[0025] Referring still to FIG. **3**, the selected rules are supplied to file generator **320** which converts the selected and populated rules to a set of text files in a data exchange format, such as a Java Script Object Notation (JSON) format, or a protobuf format, and inserts the text files into the payload of a rest Application Programming Interface (API). In some examples, the rest APIs are then supplied to distributor **208** for distribution to one or more of the Host nodes (or any other network node) at which the rule will be enforced as described above with reference to FIG. **1**. In some examples, file generator **320** converts rules into text files by accessing rule library **310**. In some such examples, rule library **310** stores a text file in association with each rule and file generator **320** performs the conversion by inserting the information contained in the selected rules into corresponding placeholders contained in the text file. Thus, in advance of using the system, a set of rules and corresponding text files are generated and stored in the rule library. As described, the text files and the rules include placeholders into which the template fields are inserted.

[0026] In some examples, selector **302** determines that none of the reference templates in template library **308** match the key words supplied by NLP parser **204** (FIG. **2**). In some such examples, template creator **306** generates a new template. In some such examples, template creator **306** causes prompter **312** to prompt the user (via graphical user interface **202**) to identify whether the network policy/rule is to be a network security policy/rule or an encryption policy/rule. In response to user input identifying either network security (e.g., a firewall) or encryption, template creator **306** creates a new template having fields related to the type of policy/rule specified by the user. Template creator **306** supplies the newly created template to populator **304**, which responds by populating the empty fields of the newly created template with the keywords supplied by selector **302**. If populator **304** is unable to determine an appropriate field into which a key word is to be inserted, populator **304** supplies the key words to the prompter **312**, which prompts the user, via graphical user interface **202**, to identify a correspondence between the key words and the field of the newly created template. In response to the user input, populator **304** populates the fields of the newly created template. In some examples, template generator **306** causes the completed template to be stored in template library **308** for future usage. In some examples, prompter **312** is configured to prompt the user for any information to be entered into any number of template fields **402**, **404**, **406**, **408**.

[0027] While example manners of implementing the example system of FIG. **1** have been illustrated in FIG. **2** one or more of the elements, processes and/or devices illustrated in FIG. **1** and FIG. **2** can be combined, divided, re-arranged, omitted, eliminated and/or implemented in any other way. Further, any of the security and encryption rule generating system **106**, the user interface **202**, the NLP parser **204**, the policy and rule generator **206**, the distributor **208**, the selector **302**, the comparator **303**, the populator **304**, the configurer **305**, the template creator **306**, the template library **308**, the rule library **310**, the prompter **312**, the tenant group applicator **314**, the template converter **316**, the tenant group library **318**, the file generator **320**, and/or, more generally, the management node **102** may be implemented by hardware, software, firmware and/or any combination of hardware, software and/or firmware. Thus, for example, any of the security and encryption rule generating system **106**, the user interface **202**, the NLP parser **204**, the policy and rule generator **206**, the distributor **208**, the selector **302**, the comparator **303**, the populator **304**, the configurer **305**, the template creator **306**, the template library **308**, the rule library **310**, the prompter **312**, the tenant group applicator **314**, the template converter **316**, the tenant group library **318**, the file generator **320**, and/or, more generally, the management node **102** could be implemented by one or more circuit(s), programmable processor(s), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)) and/or field programmable logic device (s) (FPLD(s)), etc. When any of the appended apparatus or system claims of this patent are read to cover a purely software and/or firmware implementation at least one of the security and encryption rule generating system **106**, the user interface **202**, the NLP parser **204**, the policy and rule generator **206**, the distributor **208**, the selector **302**, the comparator **303**, the populator **304**, the configurer **305**, the template creator **306**, the template library **308**, the rule library **310**, the prompter **312**, the tenant group applicator

314, the template converter **316**, the tenant group library **318**, the file generator **320**, and the management node **102** are hereby expressly defined to include a tangible computer readable medium such as a memory, digital versatile disk (DVD), compact disk (CD), etc., storing such software and/or firmware. Further still, the example SDDC **100** of FIG. **1** may include one or more elements, processes and/or devices in addition to, or instead of, those illustrated in FIG. **1** and FIG. **2**, and/or may include more than one of any or all of the illustrated elements, processes and devices.

[0028] Flowcharts representative of example machine readable instructions for implementing security and encryption rule and generating system **106** of FIGS. **1**, **2**, and/or **3** are shown in FIGS. **5**, **6**A and **6**B. In this example, the machine readable instructions comprise a program for execution by a processor such as the processor **712** shown in the processor platform **700** discussed below in connection with FIG. **7**. The program may be embodied in software stored on a tangible computer readable storage medium such as a CD-ROM, a floppy disk, a hard drive, a digital versatile disk (DVD), a Blu-ray disk, or a memory associated with the processor **712**, but the entire program and/or parts thereof could alternatively be executed by a device other than the processor **712** and/or embodied in firmware or dedicated hardware. Further, although the program is described with reference to the flowcharts illustrated in FIGS. **5**, **6**A and **6**B, many other methods of implementing management node **102**, security and encryption rule generating system **106** and/or policy and rule generator **206** may alternatively be used. For example, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, or combined.

[0029] As mentioned above, the processes of FIGS. **5**, **6**A and **6**B may be implemented using coded instructions (e.g., computer and/or machine readable instructions) stored on a tangible computer readable storage medium such as a hard disk drive, a flash memory, a read-only memory (ROM), a compact disk (CD), a digital versatile disk (DVD), a cache, a random-access memory (RAM) and/or any other storage device or storage disk in which information is stored for any duration (e.g., for extended time periods, permanently, for brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term tangible computer readable storage medium is expressly defined to include any type of computer readable storage device and/or storage disk and to exclude propagating signals and transmission media. As used herein, "tangible computer readable storage medium" and "tangible machine readable storage medium" are used interchangeably. Additionally or alternatively, the processes of FIGS. **5**, **6**A and **6**B may be implemented using coded instructions (e.g., computer and/or machine readable instructions) stored on a non-transitory computer and/or machine readable medium such as a hard disk drive, a flash memory, a read-only memory, a compact disk, a digital versatile disk, a cache, a random-access memory and/or any other storage device or storage disk in which information is stored for any duration (e.g., for extended time periods, permanently, for brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable storage device and/or storage disk and to exclude propagating signals and transmission media. As used herein, when the phrase "at least" is used as the transition term in a preamble of a claim, it is open-ended in the same manner as the term "comprising" is open ended.

[0030] Example machine readable instructions **500** that may be executed to implement security and encryption rule generating system **106** of FIGS. **1**, **2** and/or **3** are illustrated by the flowchart shown in FIG. **5**. Machine readable instructions **500** may be executed periodically and/or aperiodically (e.g., at predetermined intervals, based on an occurrence of a predetermined event, or any combination thereof). Machine readable instructions **500** begin execution at a block **502** of FIG. **4** at which graphical user interface **202** (see FIG. **2**) receives a natural language statement entered by a user (e.g., a system administrator). The natural language statement identifies a desired policy to be implemented at one or more Host nodes of the SDDC **100** (see FIG. **1**). NLP parser **204** (see FIG. **2**) uses artificial intelligence to parse the natural language statement into a set of key words (block **504**). Policy/rule generator **206** (see FIG. **2**) uses the key words to generate a corresponding policy/rule (block **506**). Distributor **208** distributes the corresponding policy/rule to encryption agents **116**A, **116**B, **116**C residing at one or more of the Host nodes for application/enforcement thereat (block **508**). After the rule has been provided to the nodes of the SDDC **100**, the program ends.

[0031] Example machine readable instructions **600** that may be executed to implement policy and rule generator **206** of FIGS. **2** and **3** are illustrated by the flowchart shown in FIGS. **6**A and **6**B. Machine readable instructions **600** may be executed periodically and/or aperiodically (e.g., at predetermined intervals, based on an occurrence of a predetermined event, or any combination thereof). Machine readable instructions **600** begin execution at a block **602** of FIG. **6**A at which template selector **302** (see FIG. **3**) compares the key words identified by NLP parser **204** (see FIG. **2**) to information stored in one or more of the populated fields of the set of reference templates stored in template library **308** (see FIG. **3**) to attempt to identify an existing policy/rule template corresponding to the key words. If an existing policy/rule template corresponding to the key words is identified (block **604**), the corresponding/matching template is selected and supplied (with the keywords that are not yet entered into the template, if any) to field populator **304** (see FIG. **3**), which uses the keywords to populate corresponding fields of the selected template (block **606**). Field populator **304** also identifies fields that remain unpopulated, if any, to prompter **312** which generates a prompt to the user to enter data into the unpopulated fields (also at block **606**). Next, field populator **304** supplies the populated template to tenant group applicator **314** (see FIG. **3**), which identifies a set of tenant groups by name and supplies the tenant group names to graphical user interface **202** (see FIG. **2**) for display to the user (block **608**). If the user selects one or more of the tenant user groups displayed on graphical user interface **202** (block **610**), tenant group applicator **314** responds to the selection by supplying information identifying nodes in the selected tenant groups and the selected, populated template to the template converter **316**, which uses the selected, populated template and the set of nodes included in the selected tenant group to generate a set of rules corresponding to the template (block **612** of FIG. **6**B). Template converter **316** also causes the rules to be displayed at graphical user interface **202** (also block **612**). In some examples, the user elects to create a new tenant group instead of, or in addition to, selecting from a previously created tenant group (block **610** of FIG. **6**A). In some such examples, tenant group applicator **314** identifies network nodes that carry traffic between the source and the destination nodes (e.g., located between the source and destination nodes identified in the populated template) and causes the nodes to be displayed at graphical user interface **202** (block **614**). In some examples, tenant group applicator **314** identifies the nodes to be displayed to the user (e.g., located between the source and destination nodes identified in the populated template) by accessing a network topology database managed by management node **102**. Tenant applicator **314** causes the nodes selected by the user to be saved as a new tenant group in tenant group library **318** with a user-identified tenant group name (block **616**). Thereafter, the program returns to the block **612** and blocks subsequent thereto.

[0032] After displaying the rules via graphical user interface **202**, template converter **316** supplies the selected rules to file generator **320** which converts the selected rules to a set of text files in a data exchange format, such as, a JSON format, and inserts the JSON files into the payload of a rest API (block **620** of FIG. **6**B). In some examples, the rest APIs are then supplied to distributor **208** for distribution to the network nodes at which the rule will be enforced (block **622**).

[0033] Returning to FIG. **6**A, if at the block **604**, selector **302** determines that none of the reference templates in template library **308** match the key words supplied by NLP parser **204** (FIG. **2**), selector **302** notifies template creator **306**, which creates a new template based on input supplied by the user identifying whether the network policy/rule is to be a network security policy/rule or an encryption policy/rule (block **618**). The resulting template created by template creator **306** includes fields related to the type of policy/rule specified by the user. Template creator **306** supplies the newly created template to populator **304**, which responds by populating the empty fields of the newly created template with the keywords supplied by selector **302**, as described above in connection with the block **606** and blocks subsequent thereto. In addition, template creator **306** causes the template to be stored in template library **308** for future usage (also at the block **618**).

[0034] FIG. **7** is a block diagram of a processor platform **700** capable of executing the instructions of FIGS. **5**, **6**A and **6**B to implement security and encryption rule generating system **106** of FIGS. **1**, **2** and/or **3**. Processor platform **700** can be, for example, a server, a personal computer, an Internet appliance, and/or policy and rule generator **206**, and/or any other type of computing device.

[0035] Processor platform **700** of the illustrated example includes a processor **712**. Processor **712** of the illustrated example is hardware. For example, processor **712** can be implemented by one or more integrated circuits, logic circuits, microprocessors or controllers from any desired family or manufacturer. Processor **712** can be used to implement parser **204**, selector **302**, comparator **303**, populator **304**, configurer **305**, prompter **312**, tenant group applicator **314**, template converter **316**, and rule file generator **320** of FIGS. **1** and **2**

[0036] Processor **712** of the illustrated example includes a local memory **713** (e.g., a cache). Processor **712** of the illustrated example is in communication with a main memory including a volatile memory **714** and a non-volatile memory **716** via a bus **718**. Volatile memory **714** may be implemented by Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), RAMBUS Dynamic Random Access Memory (RDRAM) and/or any other type of random access memory device. Non-volatile memory **716** may be implemented by flash memory and/or any other desired type of memory device. Access to main memory **714**, **716** is controlled by a memory controller. Any of random access memory device **714** and mass storage **728** can be used to implement template library **308**, rule library **310**, and tenant group library **318** of FIG. **3**.

[0037] Processor platform **700** of the illustrated example also includes an interface circuit **720**. Interface circuit **720** may be implemented by any type of interface standard, such as an Ethernet interface, a universal serial bus (USB), and/or a PCI express interface.

[0038] In the illustrated example, one or more input devices **722** are connected to interface circuit **720**. Input device(s) **722** permit(s) a user to enter data and commands into processor **712**. Input device(s) can be implemented by, for example, an audio sensor, a microphone, a camera (still or video), a keyboard, a button, a mouse, a touchscreen, a track-pad, a trackball, isopoint and/or a voice recognition system.

[0039] One or more output devices **724** are also connected to interface circuit **720** of the illustrated example. Output devices **724** can be implemented, for example, by display devices (e.g., a light emitting diode (LED), an organic light emitting diode (OLED), a liquid crystal display, a cathode ray tube display (CRT), a touchscreen, a tactile output device, a light emitting diode (LED), a printer and/or speakers). Interface circuit **720**, thus, typically includes a graphics driver card, a graphics driver chip or a graphics driver processor.

[0040] Interface circuit **720** of the illustrated example also includes a communication device such as a transmitter, a receiver, a transceiver, a modem and/or network interface card to facilitate exchange of data with external machines (e.g., computing devices of any kind) via a network **726** (e.g., an Ethernet connection, a digital subscriber line (DSL), a telephone line, coaxial cable, a cellular telephone system). Interface circuit **720** can be used to implement either of graphical user interface **202**, and/or distributor **208**.

[0041] Processor platform **700** of the illustrated example also includes one or more mass storage devices **728** for storing software and/or data. Examples of such mass storage devices **728** include floppy disk drives, hard drive disks, compact disk drives, Blu-ray disk drives, RAID systems, and digital versatile disk (DVD) drives. In some examples, mass storage **728** can be used to implement template library **308**, rule library **310**, and tenant group library **318** of FIG. **3**.

[0042] Coded instructions **732** of FIGS. **5**, **6**A and **6**B may be stored in mass storage device **728**, in volatile memory **714**, in non-volatile memory **716**, and/or on a removable tangible computer readable storage medium such as a CD or DVD.

[0043] From the foregoing, it will be appreciated that the above disclosed example methods, systems, apparatus and articles of manufacture provide advantages in the area of software defined data centers and, more particularly, in the area of private software defined data centers that are implemented within multi-tenant clouds. For example, the security and encryption policy and rule generating system disclosed herein provides network administrators with a simplified, user-friendly tool for use in defining and implementing policies and rules to be applied at the nodes of the distributed network within the software defined data center. In some disclosed examples, the security and encryption policy and rule generating system includes a natural language parser that uses artificial intelligence to parse a natural language statement into a set of keywords. A selector then uses the keywords to identify a matching policy template from among a set of reference templates. A prompter prompts the user to enter information into unpopulated fields of the matching template and further assists the user in identifying a set of network nodes (e.g., a tenant group) to be assigned to enforce the policy. The matching policy template is then converted into a set of rules displayed to the administrator for selection. Selected rules are then converted to a set of rule files and incorporated into the payload of a rest API for transmission to the network nodes to enforce the rules. Due to the user-friendly policy defining interface, example systems disclosed herein permit the definition and application of policies/rules without requiring special expertise in a computer language. Further, the disclosed example systems assist the user in identifying network nodes between a source and destination node at which the rules/policies are to be enforced.

[0044] Although certain example methods, apparatus and articles of manufacture have been disclosed herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of the claims of this patent.

We claim:

1. An apparatus, comprising:

a language parser to parse a natural language statement defining a distributed network encryption policy or a distributed network security policy into a set of key words;

a comparator to compare the key words to a set of reference policy templates;

a template configurer to select a first policy template from the set of reference policy templates in response to the comparator determining the first policy template corresponds to the set of key words; and

a policy distributor to distribute a policy rule defined by the first policy template for enforcement at network nodes of a software defined data center, the policy rule being a distributed network encryption policy rule or a security policy rule.

2. The apparatus of claim **1**, further including a template creator to create a new policy template in response to the comparator determining none of the set of reference policy templates corresponds to the key words.

3. The apparatus of claim **1**, wherein the comparator is to compare the key words to fields in a first one of the reference policy templates to determine whether the key words correspond to a threshold number of the fields in the first one of the reference policy templates.

4. The apparatus of claim **3**, wherein the fields include an action field identifying an action to be taken by a rule enforcement tool, a service field identifying a service to be affected by the policy rule, a source field identifying a source node of the software defined data center and a destination field identifying a destination node of the software defined data center.

5. The apparatus of claim **3**, wherein the key words include a first key word identifying a service to be affected by the policy rule and a second key word identifying an action to be taken by a rule enforcement tool.

6. The apparatus of claim **5**, wherein the first policy template includes a service field corresponding to the first key word and further includes an action field corresponding to the second key word.

7. The apparatus of claim **1**, wherein the template configurer is further to prompt a user to enter information into an unpopulated field of the first policy template.

8. A method to define a policy rule in a software defined data center, the method comprising:

parsing, by executing an instruction with a processor, a natural language statement into a set of key words, the natural language statement to define a distributed network encryption policy or a distributed network security policy;

determining, by executing an instruction with the processor, whether the key words correspond to any of a set of reference policy templates;

selecting a first policy template from the set of reference policy templates in response to determining at least some of the key words correspond to the first policy template; and

distributing the policy rule defined by the first policy template for enforcement at network nodes of a software defined data center, the policy rule being a distributed network encryption policy rule or a distributed network security policy rule.

9. The method of claim **8**, further including generating a new template in response to determining the key words do not correspond to any of the set of reference policy templates.

10. The method of claim **8**, wherein the determining includes comparing the key words to information contained in fields of a first one of the reference policy templates to determine whether the key words correspond to the information contained in a threshold number of the fields in the first one of the reference policy templates.

11. The method of claim **10**, wherein the fields include an action field identifying an action to be taken by a rule enforcement tool, a service field identifying a service to be subject to the policy rule, a source field identifying a source node of the software defined data center and a destination field identifying a destination node of the software defined data center.

12. The method of claim **10**, wherein the key words include a first key word identifying a service to be affected by the policy rule and a second key word identifying an action to be taken by a rule enforcement tool.

13. The method of claim **12**, wherein the first policy template includes first information stored in a service field, the first information corresponding to the first key word, and the first policy template further includes second information stored in an action field, the second information corresponding to the second key word.

14. The method of claim **8**, further including prompting a user to enter information into an unpopulated field of the first policy template.

15. A tangible computer readable storage medium including computer readable instructions that, when executed, cause a processor to at least:

parse a free form language statement into a set of key words, the set of key words to define a distributed network encryption policy or a distributed network security policy;

compare the set of key words to a set of reference policy templates;

select a first policy template from the set of reference policy templates when comparing the set of key words to the set of reference policy templates indicates that the key words correspond to a threshold number of fields in the first policy template; and

distribute a policy rule defined by the first policy template for enforcement at network nodes of a software defined data center, the policy rule being a distributed network encryption policy rule or a distributed network security policy rule.

16. The tangible computer readable storage medium of claim **15**, wherein the computer readable instructions further cause the processor to generate a new template when the comparing of the set of key words to the set of reference policy templates indicates that the key words do not correspond to the threshold number of the fields in any of the reference policy templates.

17. The tangible computer readable storage medium of claim **15**, wherein the fields include an action field identifying an action to be taken by a rule enforcement tool, a service field identifying a service to be subject to the policy rule, a source field identifying a source node of the software defined data center, and a destination field identifying a destination node of the software defined data center.

18. The tangible computer readable storage medium of claim **15**, wherein a first key word identifies a service to be affected by the policy rule and a second key word identifies an action to be taken by a rule enforcement tool.

19. The tangible computer readable storage medium of claim **15**, wherein the first policy template includes a service field populated with the first key word and an action field populated with the second key word.

20. The tangible computer readable storage medium of claim **15**, wherein the computer readable instructions further cause the processor to prompt a user to enter information into an unpopulated field of the first policy template.

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