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(54) SYSTEMS AND METHODS FOR REDUCING THE CARDINALITY OF METRICS QUERIES

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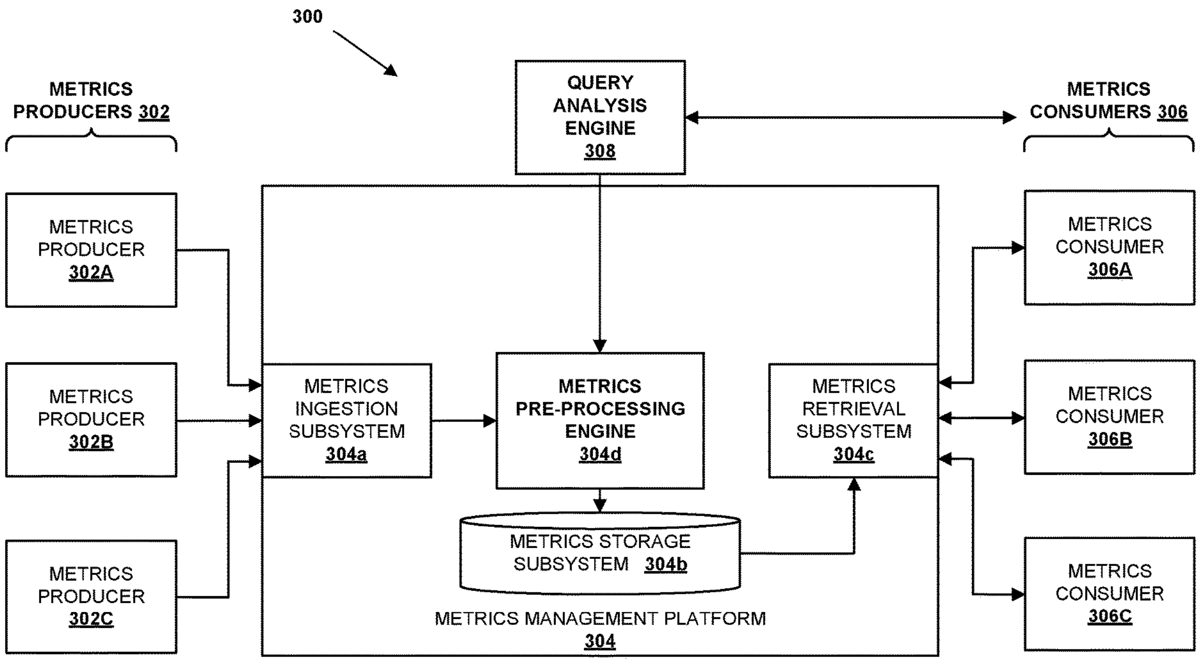
(57) **ABSTRACT**

A computing platform may be configured to (i) perform an analysis of a saved query comprising an expression that specifies a set of one or more unique metrics for which metric data is to be fetched from a metrics management platform when the saved query is run, (ii) determine a strategy for reducing a cardinality level of the saved query based at least in part on the analysis of the saved query, and (iii) cause the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query.


300
METRICS PRODUCERS 302
METRICS PRODUCER 302A
METRICS PRODUCER 302B
METRICS PRODUCER 302C
QUERY ANALYSIS ENGINE 308
METRICS CONSUMERS 306
METRICS CONSUMER 306A
METRICS CONSUMER 306B
METRICS CONSUMER 306C
METRICS INGESTION SUBSYSTEM 304a
METRICS PRE-PROCESSING ENGINE 304d
METRICS RETRIEVAL SUBSYSTEM 304c
METRICS STORAGE SUBSYSTEM 304b
METRICS MANAGEMENT PLATFORM 304

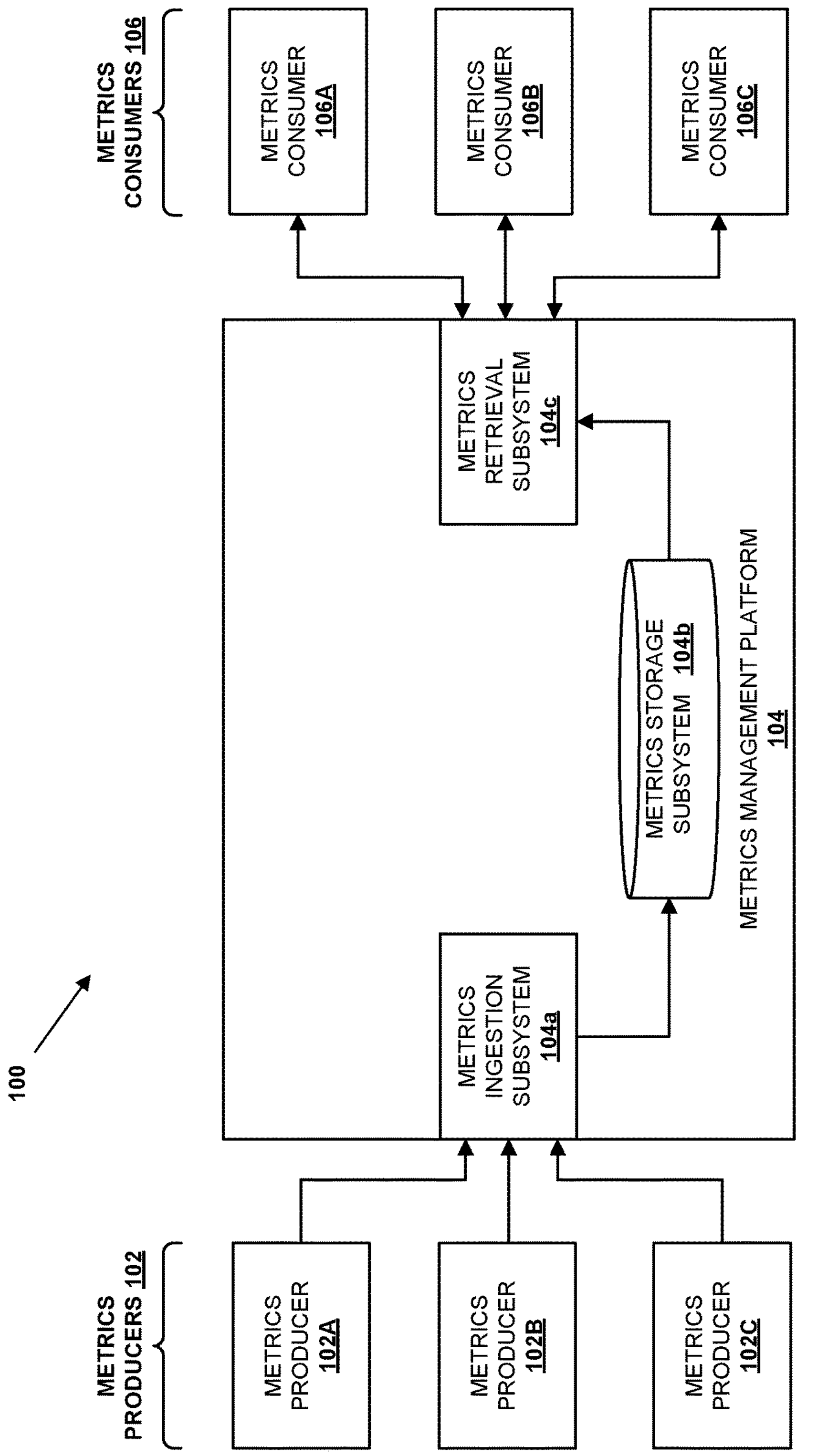

100
METRICS PRODUCERS 102
METRICS PRODUCER 102A
METRICS PRODUCER 102B
METRICS PRODUCER 102C
METRICS INGESTION SUBSYSTEM 104a
METRICS STORAGE SUBSYSTEM 104b
METRICS RETRIEVAL SUBSYSTEM 104c
METRICS MANAGEMENT PLATFORM 104
METRICS CONSUMERS 106
METRICS CONSUMER 106A
METRICS CONSUMER 106B
METRICS CONSUMER 106C

FIG. 1

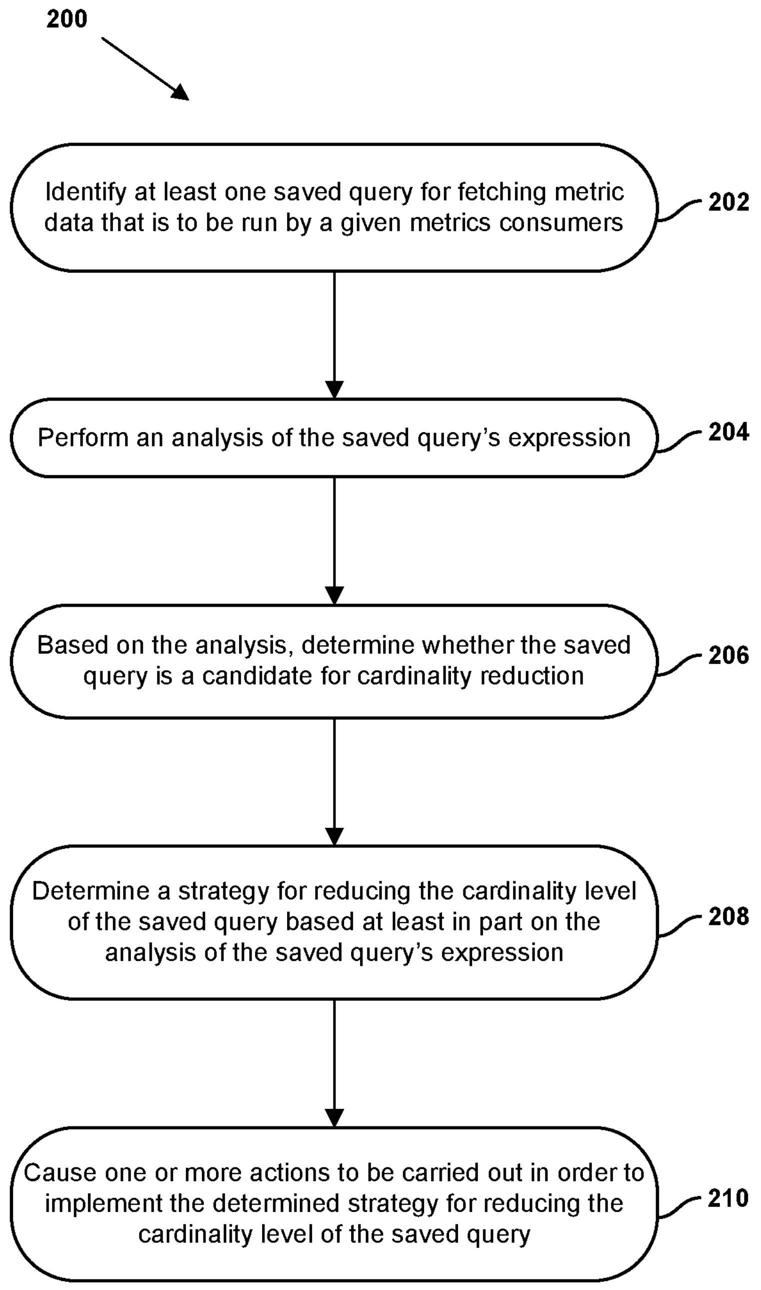

200
Identify at least one saved query for fetching metric data that is to be run by a given metrics consumers
202
Perform an analysis of the saved query's expression
204
Based on the analysis, determine whether the saved query is a candidate for cardinality reduction
206
Determine a strategy for reducing the cardinality level of the saved query based at least in part on the analysis of the saved query's expression
208
Cause one or more actions to be carried out in order to implement the determined strategy for reducing the cardinality level of the saved query
210

FIG. 2

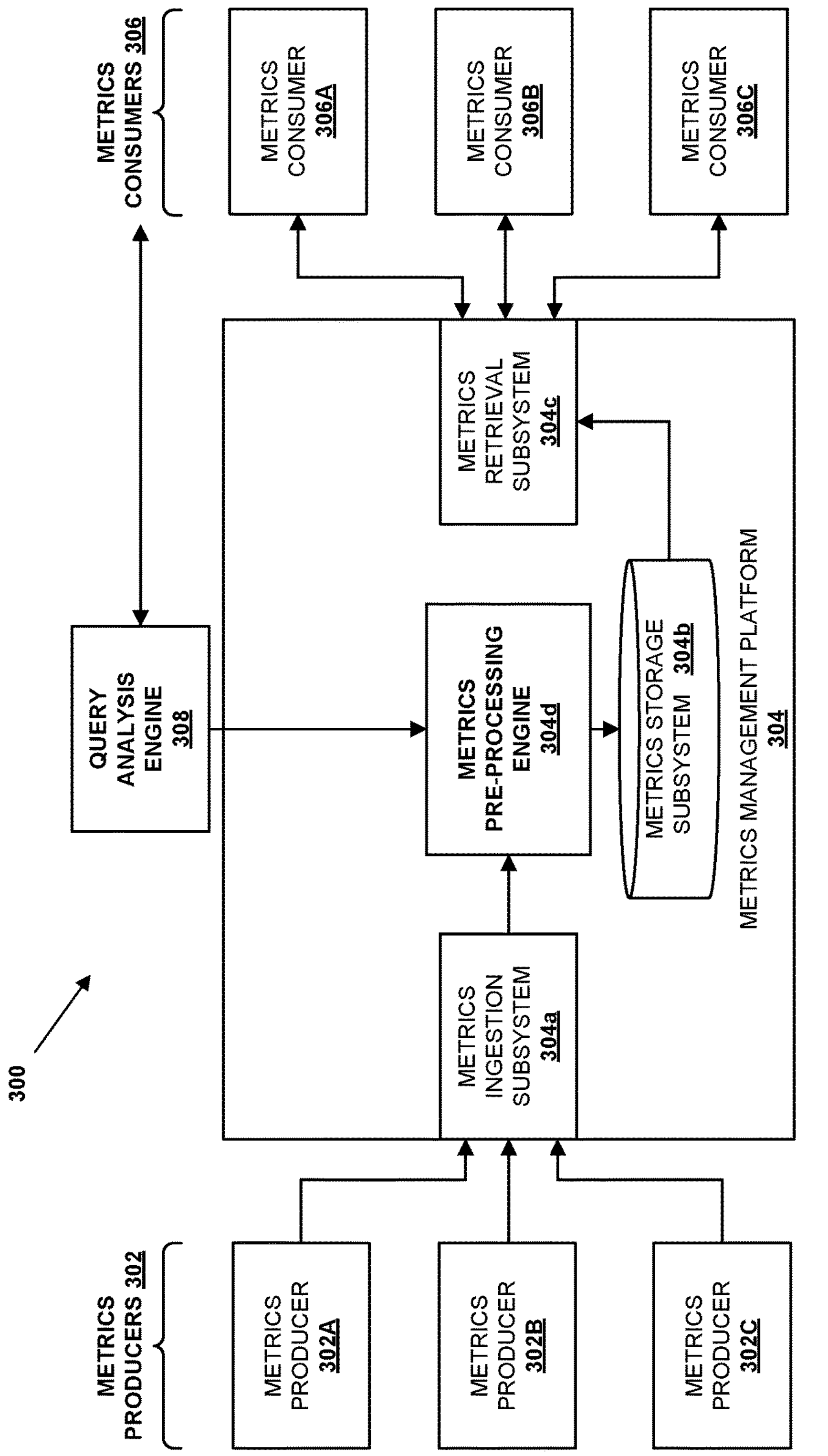

300
METRICS PRODUCERS 302
METRICS PRODUCER 302A
METRICS PRODUCER 302B
METRICS PRODUCER 302C
METRICS INGESTION SUBSYSTEM 304a
METRICS PRE-PROCESSING ENGINE 304d
METRICS STORAGE SUBSYSTEM 304b
METRICS RETRIEVAL SUBSYSTEM 304c
METRICS MANAGEMENT PLATFORM 304
QUERY ANALYSIS ENGINE 308
METRICS CONSUMERS 306
METRICS CONSUMER 306A
METRICS CONSUMER 306B
METRICS CONSUMER 306C

FIG. 3A

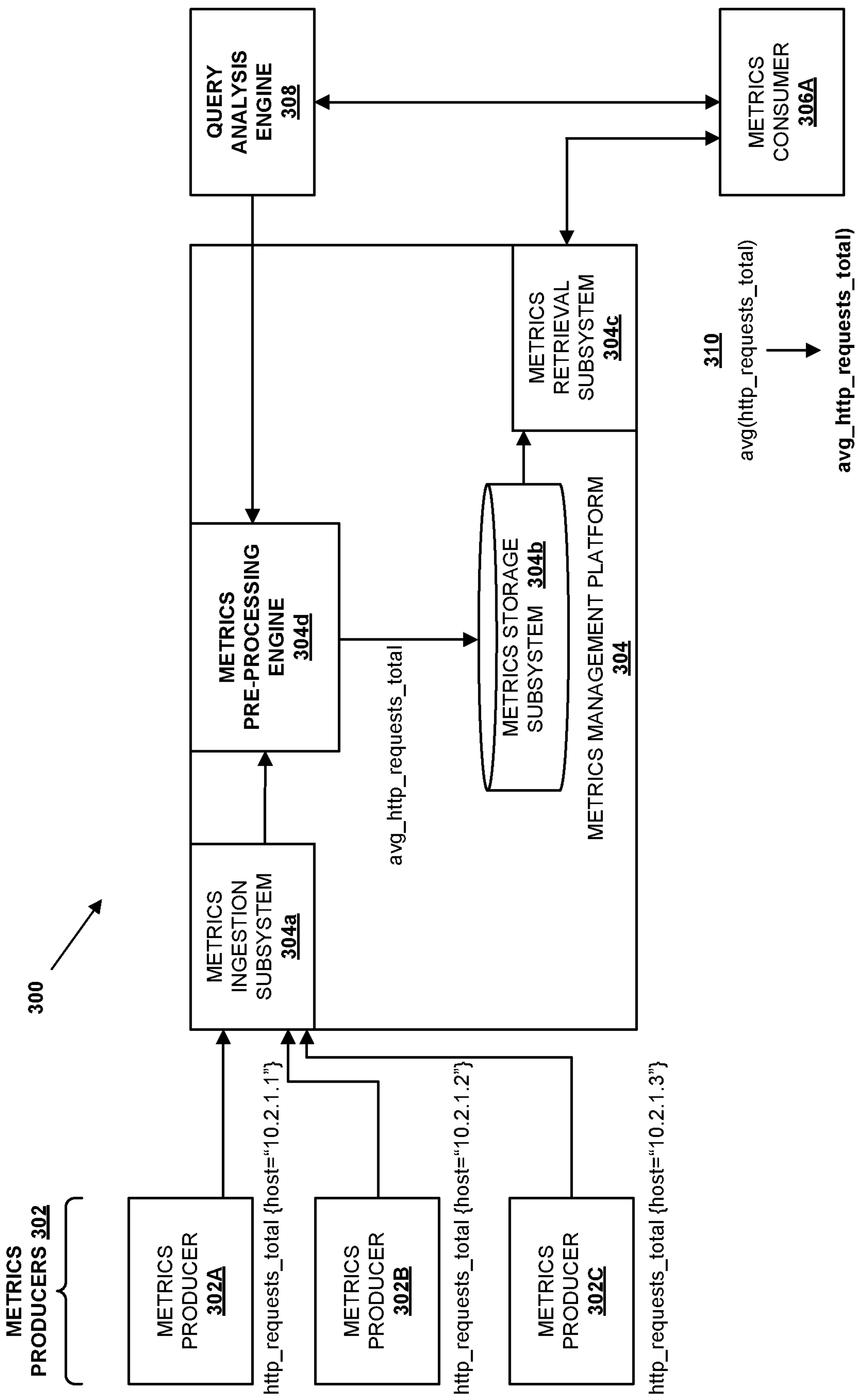

300
METRICS PRODUCERS 302
METRICS PRODUCER 302A
METRICS PRODUCER 302B
METRICS PRODUCER 302C
http_requests_total {host="10.2.1.1"}
http_requests_total {host="10.2.1.2"}
http_requests_total {host="10.2.1.3"}
METRICS INGESTION SUBSYSTEM 304a
METRICS PRE-PROCESSING ENGINE 304d
avg_http_requests_total
METRICS STORAGE SUBSYSTEM 304b
METRICS MANAGEMENT PLATFORM 304
METRICS RETRIEVAL SUBSYSTEM 304c
QUERY ANALYSIS ENGINE 308
METRICS CONSUMER 306A
310
avg(http_requests_total)
avg_http_requests_total

FIG. 3B

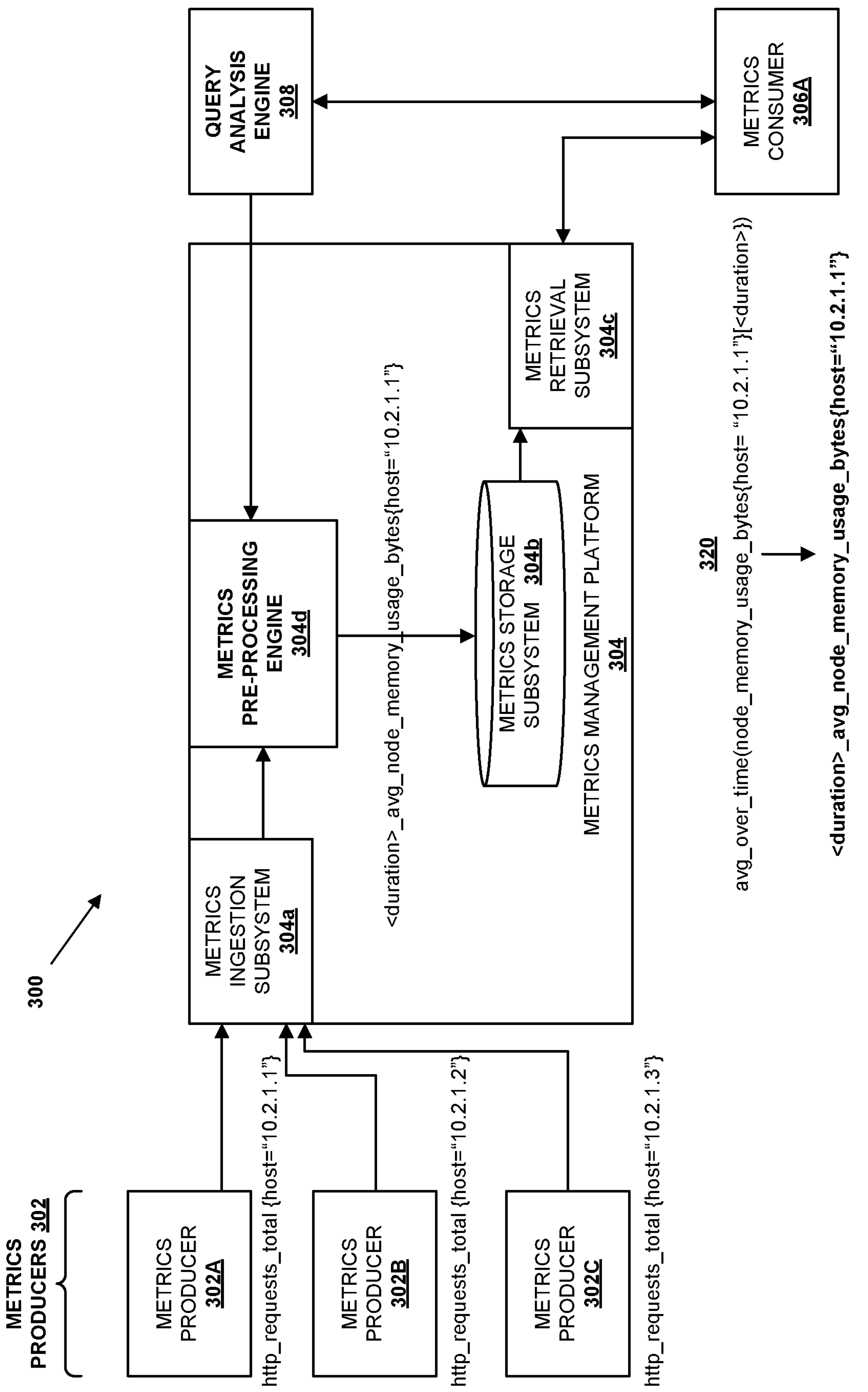

300
METRICS PRODUCERS 302
METRICS PRODUCER 302A
http_requests_total {host="10.2.1.1"}
METRICS PRODUCER 302B
http_requests_total {host="10.2.1.2"}
METRICS PRODUCER 302C
http_requests_total {host="10.2.1.3"}
METRICS INGESTION SUBSYSTEM 304a
METRICS PRE-PROCESSING ENGINE 304d
<duration>_avg_node_memory_usage_bytes{host="10.2.1.1"}
METRICS STORAGE SUBSYSTEM 304b
METRICS MANAGEMENT PLATFORM 304
METRICS RETRIEVAL SUBSYSTEM 304c
QUERY ANALYSIS ENGINE 308
METRICS CONSUMER 306A
320
avg_over_time(node_memory_usage_bytes{host= "10.2.1.1"}[<duration>])
<duration>_avg_node_memory_usage_bytes{host="10.2.1.1"}

FIG. 3C

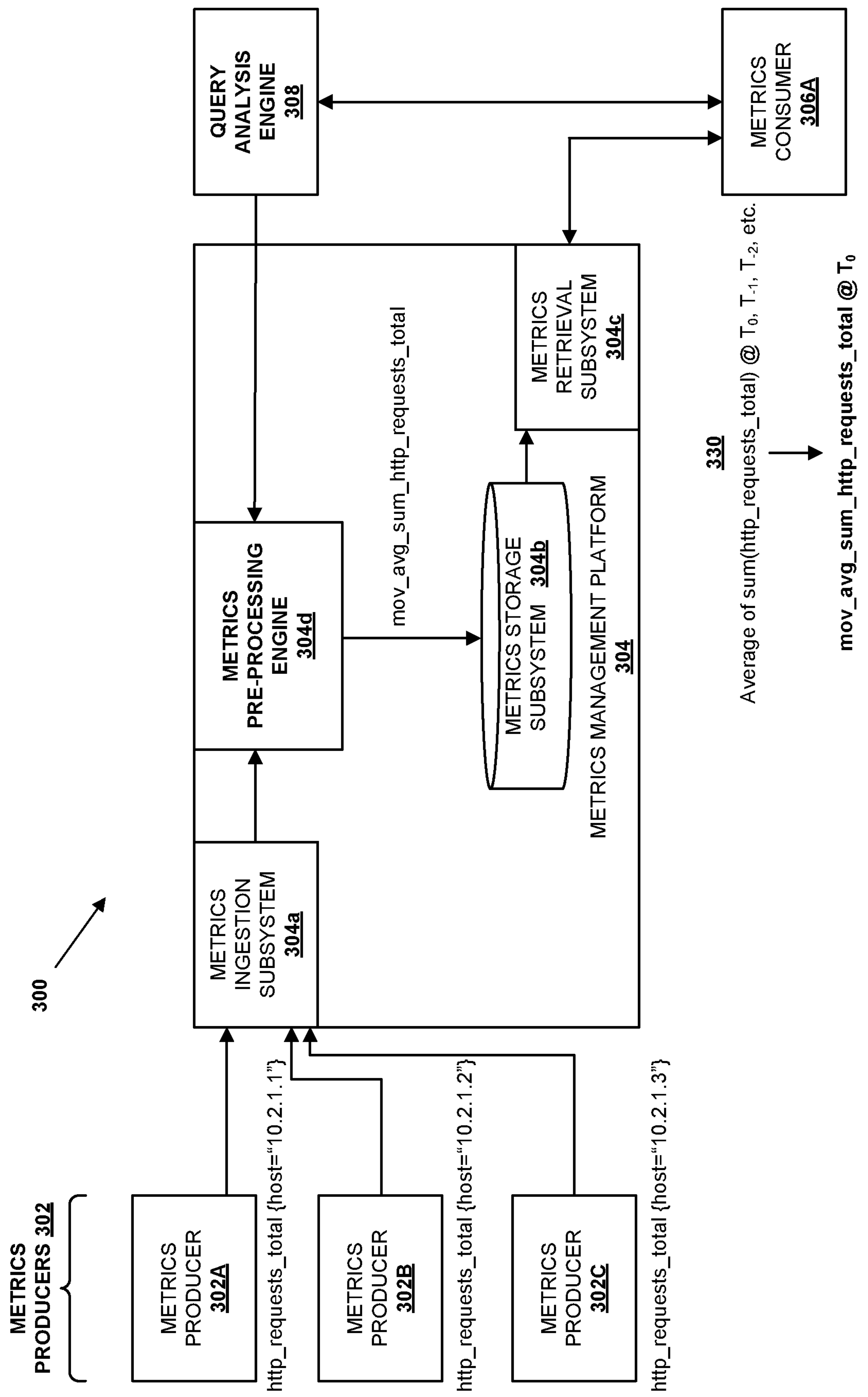

300
METRICS PRODUCERS 302
METRICS PRODUCER 302A
http_requests_total {host="10.2.1.1"}
METRICS PRODUCER 302B
http_requests_total {host="10.2.1.2"}
METRICS PRODUCER 302C
http_requests_total {host="10.2.1.3"}
METRICS INGESTION SUBSYSTEM 304a
METRICS PRE-PROCESSING ENGINE 304d
mov_avg_sum_http_requests_total
METRICS STORAGE SUBSYSTEM 304b
METRICS RETRIEVAL SUBSYSTEM 304c
METRICS MANAGEMENT PLATFORM 304
QUERY ANALYSIS ENGINE 308
METRICS CONSUMER 306A
330
Average of sum(http_requests_total) @ T0, T-1, T-2, etc.
mov_avg_sum_http_requests_total @ T0

FIG. 3D

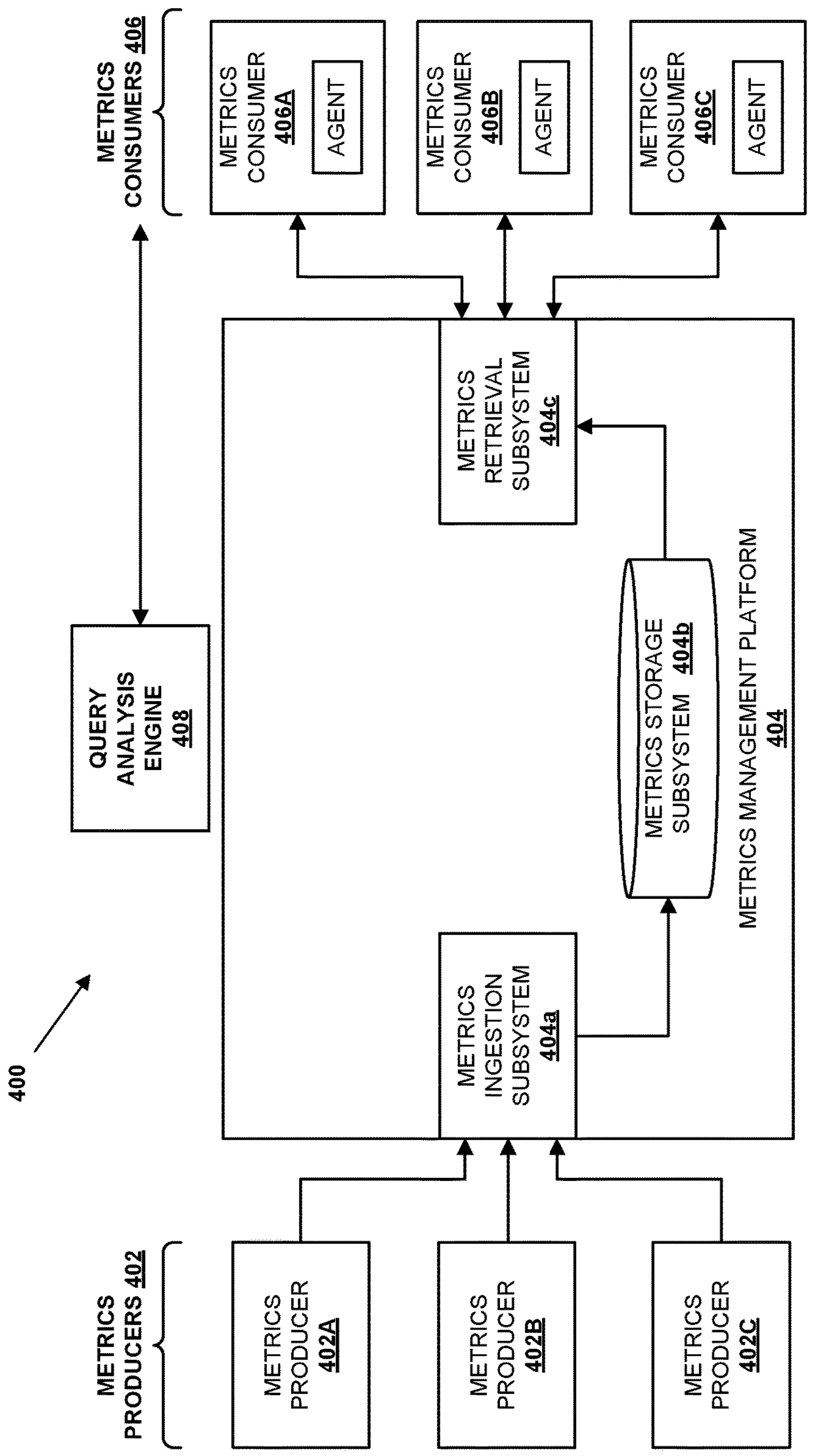

400
METRICS PRODUCERS 402
METRICS PRODUCER 402A
METRICS PRODUCER 402B
METRICS PRODUCER 402C
QUERY ANALYSIS ENGINE 408
METRICS INGESTION SUBSYSTEM 404a
METRICS STORAGE SUBSYSTEM 404b
METRICS RETRIEVAL SUBSYSTEM 404c
METRICS MANAGEMENT PLATFORM 404
METRICS CONSUMERS 406
METRICS CONSUMER 406A
AGENT
METRICS CONSUMER 406B
AGENT
METRICS CONSUMER 406C
AGENT

FIG. 4A

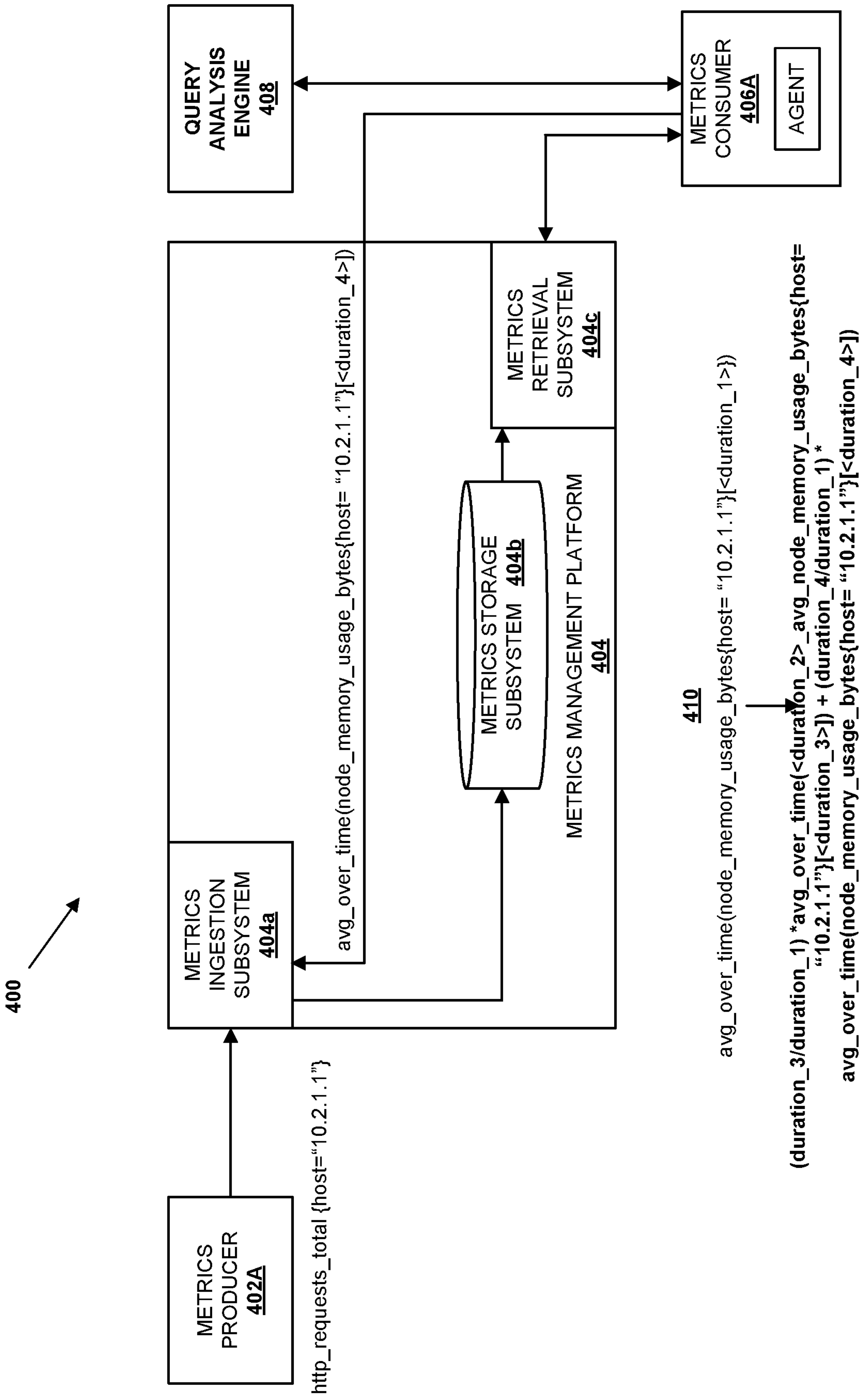

400
METRICS PRODUCER 402A
http_requests_total {host="10.2.1.1"}
METRICS INGESTION SUBSYSTEM 404a
avg_over_time(node_memory_usage_bytes{host= "10.2.1.1"}[<duration_4>])
METRICS STORAGE SUBSYSTEM 404b
METRICS MANAGEMENT PLATFORM 404
METRICS RETRIEVAL SUBSYSTEM 404c
QUERY ANALYSIS ENGINE 408
METRICS CONSUMER 406A
AGENT
410
avg_over_time(node_memory_usage_bytes{host= "10.2.1.1"}[<duration_1>])
(duration_3/duration_1) *avg_over_time(<duration_2>_avg_node_memory_usage_bytes{host= "10.2.1.1"}[<duration_3>]) + (duration_4/duration_1) * avg_over_time(node_memory_usage_bytes{host= "10.2.1.1"}[<duration_4>])

FIG. 4B

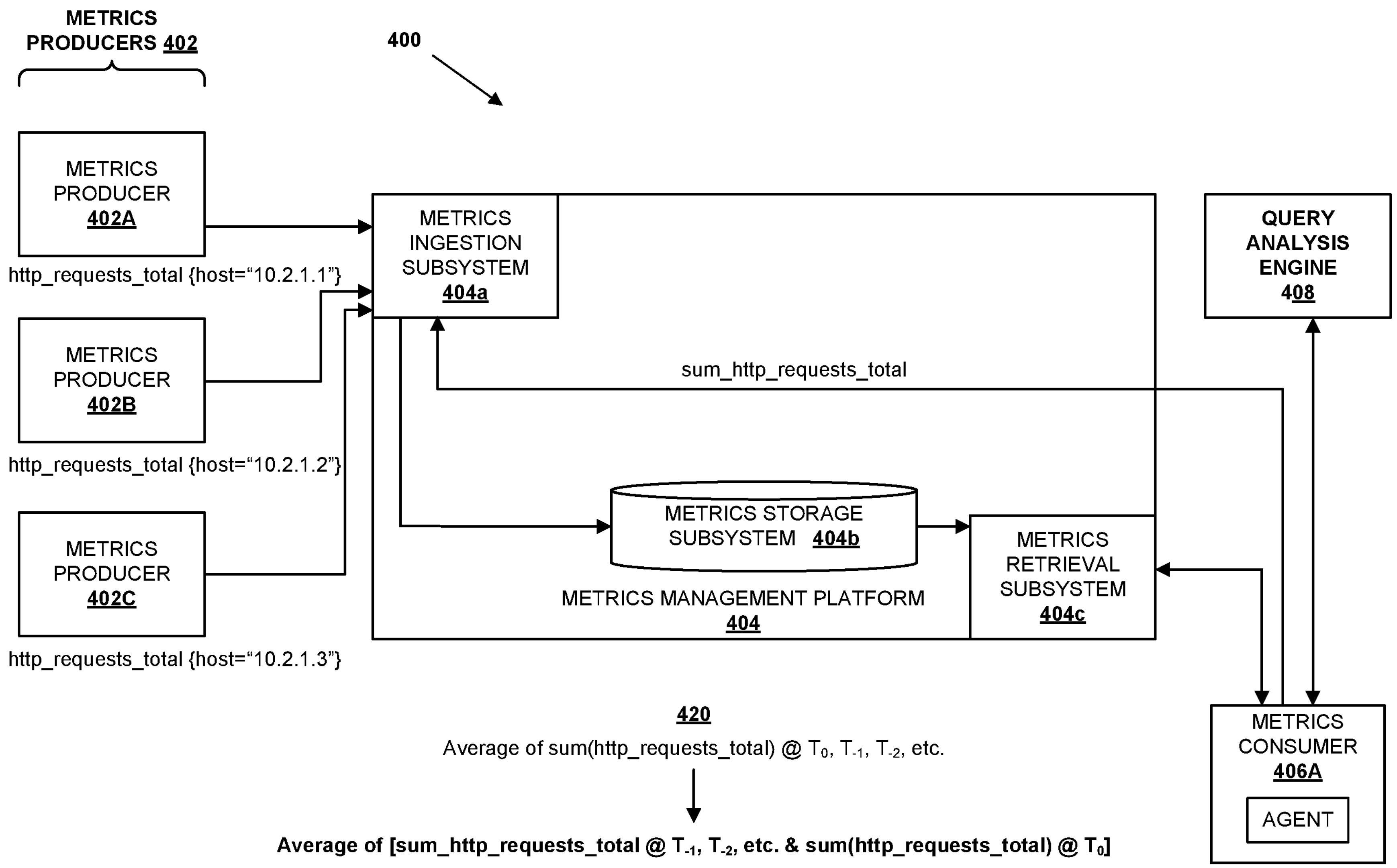

METRICS PRODUCERS 402
400
METRICS PRODUCER 402A
http_requests_total {host="10.2.1.1"}
METRICS PRODUCER 402B
http_requests_total {host="10.2.1.2"}
METRICS PRODUCER 402C
http_requests_total {host="10.2.1.3"}
METRICS INGESTION SUBSYSTEM 404a
sum_http_requests_total
METRICS STORAGE SUBSYSTEM 404b
METRICS MANAGEMENT PLATFORM 404
METRICS RETRIEVAL SUBSYSTEM 404c
QUERY ANALYSIS ENGINE 408
METRICS CONSUMER 406A
AGENT
420
Average of sum(http_requests_total) @ T_0, T_{-1}, T_{-2}, etc.
Average of [sum_http_requests_total @ T_{-1}, T_{-2}, etc. & sum(http_requests_total) @ T_0]

FIG. 4C

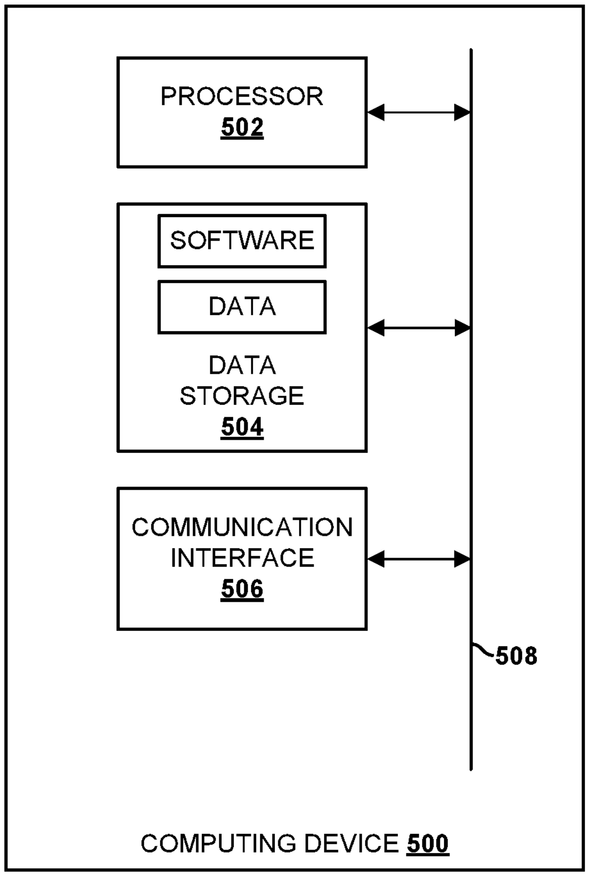

PROCESSOR
502
SOFTWARE
DATA
DATA
STORAGE
504
COMMUNICATION
INTERFACE
506
508
COMPUTING DEVICE 500

FIG. 5

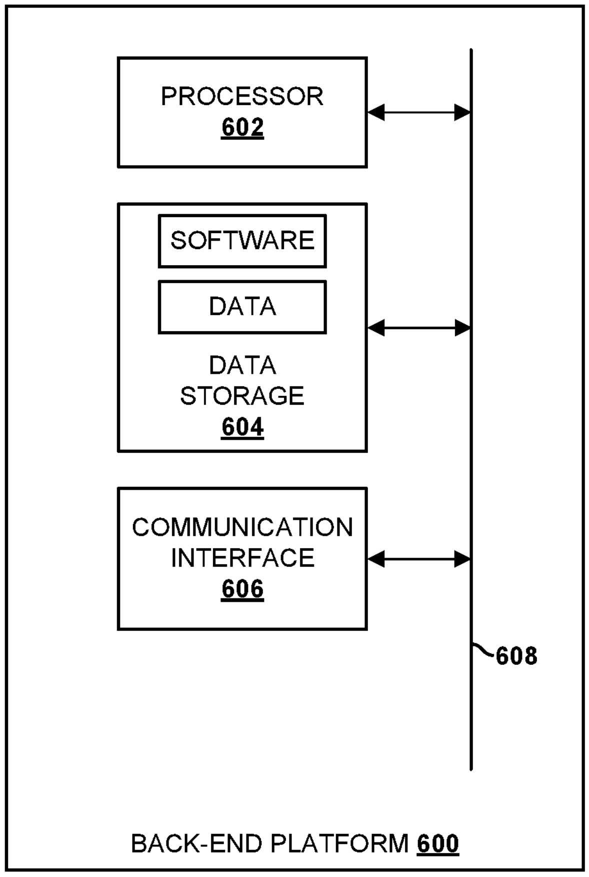

PROCESSOR
602
SOFTWARE
DATA
DATA STORAGE
604
COMMUNICATION INTERFACE
606
608
BACK-END PLATFORM 600

FIG. 6

SYSTEMS AND METHODS FOR REDUCING THE CARDINALITY OF METRICS QUERIES

BACKGROUND

[0001] It is becoming increasingly common for computing devices to generate and output metric data that provides information about the state and/or performance of the computing devices. For example, a server configured to execute one or more server applications (e.g., containerized applications such as microservices) may generate and output metric data that provides information about the state and/or performance of some aspect of the server. As another example, a client device configured to execute one or more client applications (e.g., a mobile application, desktop application, web application, or the like) may generate and output metric data that provides information about the state and/or performance of some aspect of the client device. As yet another example, one computing device may generate and output metric data that provides information about the state and/or performance of some aspect of one or more other computing devices. Other examples of computing devices that generate and output metric data may exist as well.

[0002] In practice, an organization may be interested in monitoring metric data being produced by a wide array of different computing devices (e.g., servers within the organization's back-end platform, client devices running instances of a client application developed by the organization, etc.), and in order to make use of the metric data produced by these disparate software components, the organization may deploy a centralized "metrics management platform" that functions to collect and store metric data from various computing devices that are producing metric data (referred to herein as "metrics producers") so that the metric data can later be accessed and reviewed. For instance, after a metrics management platform collects and stores metric data from different metrics producers, individuals associated with the organization (e.g., developers, engineers, analysts, etc.) can review the stored metric data in order to gain visibility into the state and/or performance of the metrics producers.

SUMMARY

[0003] Disclosed herein is the new technology for reducing the cardinality of saved queries.

[0004] In one aspect, the disclosed technology may take the form of a method that involves (i) performing an analysis of a saved query comprising an expression that specifies a set of one or more unique metrics for which metric data is to be fetched from a metrics management platform when the saved query is run, (ii) determining a strategy for reducing a cardinality level of the saved query based at least in part on the analysis of the saved query, and (iii) causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query.

[0005] In some embodiments, the method may further involve, prior to determining the strategy for reducing the cardinality level of the saved query, determining that the query is a candidate for cardinality reduction based at least in part on the analysis of the saved query. This function of determining that the query is a candidate for cardinality reduction based at least in part on the analysis of the saved query may take various forms, and in some embodiments, may involve determining that the saved query can be modified to achieve some level of reduction in a number of samples that are to be fetched during a respective run of the saved query.

[0006] Further, the function of performing the analysis of the saved query may take various forms, and in some embodiments, may involve one or more of (i) evaluating how many unique metrics are specified by the saved query, (ii) evaluating how many samples are to be fetched for each unique metric specified by the saved query, or (iii) evaluating which types of operations that are applied by the saved query.

[0007] Further yet, the determined strategy for reducing the cardinality level of the saved query may take various forms.

[0008] For instance, in some embodiments, the determined strategy for reducing the cardinality level of the saved query may involve (i) defining at least one new composite metric that is to be used by the saved query, (ii) configuring the metrics management platform to begin producing and storing metric data for the at least one new composite metric based on metric data for a given subset of one or more metrics ingested by the metric management platform, (iii) modifying the saved query so that the expression of the saved query encodes a request for metric data for the at least one new composite metric, and perhaps also (iv) configuring the metrics management platform to either (a) block storage of metric data for the given subset of one or more metrics ingested by the metric management platform or (b) store metric data for the given subset of one or more metrics ingested by the metric management platform in a lower storage tier. And in such embodiments, the function of causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query may involve (i) instructing the metrics management platform to begin producing and storing metric data for the at least one new composite metric and (ii) instructing a given metrics consumer that is to run the saved query to modify the saved query so that the expression of the saved query encodes the request for metric data for the at least one new composite metric. Additionally, in such embodiments, the function of modifying the saved query so that the expression of the saved query encodes a request for metric data for the at least one new composite metric may involve replacing an aggregation operation that is to be applied to fetched metric data for the given subset of one or more metrics with the request for metric data for the at least one new composite metric.

[0009] In other embodiments the determined strategy for reducing the cardinality level of the saved query may involve (i) defining at least one new composite metric that is to be used by the saved query, (ii) configuring the given metrics consumer to begin (a) extracting metric data for the at least one new composite metric during runs of the saved query, and (b) transmitting the extracted metric data for the at least one new composite metric to the metrics management platform for storage, and (iii) modifying the saved query so that the expression of the saved query encodes a request for metric data for the at least one new composite metric. And in such embodiments, the function of causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query may involve (i) instructing an agent installed on the given metrics consumer to begin (i) extracting metric data for the at least one new composite metric during runs of the saved query and (ii) transmitting the extracted metric data for the at least one new composite metric to the metrics management platform for storage; and (ii) instructing the given metrics consumer to modify the saved query so that the expression of the saved query encodes the request for metric data for the at least one new composite metric.

[0010] In another aspect, the disclosed technology may take the form of a computing system comprising at least one processor, at least one non-transitory computer-readable medium, and program instructions stored on the at least one non-transitory computer-readable medium that are executable by the at least one processor such that the computing platform is configured to carry out the functions of the aforementioned method.

[0011] In yet another aspect, the disclosed technology may take the form of a non-transitory computer-readable medium comprising program instructions stored thereon that are executable to cause a computing system to carry out the functions of the aforementioned method.

[0012] It should be appreciated that many other features, applications, embodiments, and variations of the disclosed technology will be apparent from the accompanying drawings and from the following detailed description. Additional and alternative implementations of the structures, systems, non-transitory computer readable media, and methods described herein can be employed without departing from the principles of the disclosed technology.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** illustrates an example network in which a metrics management platform may be utilized to collect and store metric data being produced by metrics producers and then make that stored metric data available to metrics consumers, in accordance with the present disclosure;

[0014] FIG. **2** illustrates a flow diagram showing one possible example of operations that may be carried out by a query analysis engine in accordance with the present disclosure;

[0015] FIG. **3**A illustrates a network environment in which a first embodiment of the disclosed technology has been implemented;

[0016] FIG. **3**B illustrates one example of the functionality that may be carried out by the query analysis engine in accordance with the first embodiment of the disclosed technology;

[0017] FIG. **3**C illustrates another example of the functionality that may be carried out by the query analysis engine in accordance with the first embodiment of the disclosed technology;

[0018] FIG. **3**D illustrates yet another example of the functionality that may be carried out by the query analysis engine in accordance with the first embodiment of the disclosed technology;

[0019] FIG. **4**A illustrates a network environment in which a second embodiment of the disclosed technology has been implemented;

[0020] FIG. **4**B illustrates one example of the functionality that may be carried out by the query analysis engine in accordance with the second embodiment of the disclosed technology;

[0021] FIG. **4**C illustrates another example of the functionality that may be carried out by the query analysis engine in accordance with the second embodiment of the disclosed technology;

[0022] FIG. **5** is a simplified block diagram that illustrates some structural components that may be included in an example computing device; and

[0023] FIG. **6** is a simplified block diagram that illustrates some structural components that may be included in an example back-end platform.

DETAILED DESCRIPTION

[0024] As noted above, it is becoming increasingly common for computing devices to generate and output metric data that provides information about the state and/or performance of the computing devices. For example, a server configured to execute one or more server applications (e.g., containerized applications such as microservices) may generate and output metric data that provides information about the state and/or performance of some aspect of the server. As another example, a client device configured to execute one or more client applications (e.g., a mobile application, desktop application, web application, or the like) may generate and output metric data that provides information about the state and/or performance of some aspect of the client device. As yet another example, one computing device may generate and output metric data that provides information about the state and/or performance of some aspect of one or more other computing devices. Other examples of computing devices that generate and output metric data may exist as well.

[0025] In practice, an organization may be interested in monitoring metric data being produced by a wide array of different computing devices (e.g., servers within the organization's back-end platform, client devices running instances of a client application developed by the organization, etc.), and in order to make use of the metric data produced by these disparate software components, the organization may deploy a centralized "metrics management platform" that functions to collect and store metric data from various computing devices that are producing metric data (referred to herein as "metrics producers") so that the metric data can later be accessed and reviewed. For instance, after a metrics management platform collects and stores metric data from different metrics producers, individuals associated with the organization (e.g., developers, engineers, analysts, etc.) can review the stored metric data in order to gain visibility into the state and/or performance of the metrics producers.

[0026] To illustrate with an example, FIG. **1** shows an example network environment **100** in which a metrics management platform may be utilized to collect and store metric data being produced by metrics producers and then make that stored metric data available to metrics consumers. As shown in FIG. **1**, the network environment **100** may (i) include a number of metrics producers **102**, of which three representative metrics producers **102**A, **102**B, and **102**C are shown as examples, (ii) a metrics management platform **104**, and (iii) a number of metrics consumers **106**, of which three representative metrics consumers **106**A, **106**B, and **106**C are shown as representative examples.

[0027] In general, each of the metrics producers **102** may comprise a computing device installed with software for producing metric data and transmitting such metric data to the metrics management platform **104**. Such a metrics producer **102** may take any of various forms. For instance, as one possibility, a metrics producer **102** could take the form of a server configured to execute one or more server applications (e.g., containerized applications such as micro-services), which may produce metric data that provides information about the state and/or performance of the server and/or the server applications running thereon. As another possibility, a metrics producer **102** could take the form of a client device configured to execute one or more client applications (e.g., a mobile application, desktop application, web application, or the like), which may produce metric data that provides information about the state and/or performance of the client device and/or the one or more client applications running thereon. As yet another example, a metrics producer **102** could take the form of a computing device that produces metric data related to the state and/or performance of one or more other computing devices and/or the software running thereon (e.g., cluster-level metric data for a cluster of nodes running containerized applications). A metrics producer **102** could take some other form as well.

[0028] Further, each of the metrics producers **102** may be configured to produce metric data for a respective set of one or more metrics, where each such metric comprises a time-series variable that provides information about the state and/or performance of some aspect of a computing device (or a collection of computing devices). Such a metric could take any of various forms.

[0029] For instance, as one possibility, a metrics producer **102** may produce metric data for a metric that provides a numerical measure of the extent of a certain type of event that has occurred at a computing device, such as a count or rate of a certain type of network request that has been received by the computing device or a count or rate of a certain type of user request that has been received by the computing device, among other possible examples. As another possibility, a metrics producer **102** may produce metric data for a metric that provides a numerical measure of the time it takes for a certain type of event to be carried out at a computing device, such as a processing or transmission duration for a certain type of network request that is handled by the computing device or a processing duration for a certain type of user request that is handled by the computing device, among other possible examples. As yet another possibility, a metrics producer **102** may produce metric data for a metric that provides a numerical measure of the extent of utilization of a certain type of resource at a computing device, such as an extent of memory utilization, CPU utilization, disk utilization, etc. at the computing device, among other possible examples. As still another possibility, a metrics producer **102** may produce metric data for a metric that provides a numerical measure of the extent of a certain type of error incurred while processing a certain type of event at a computing device, such as a count or rate of errors incurred while processing a certain type of network request or a count or rate of errors incurred while processing a certain type of user request, among other possible examples. In practice, each of the foregoing types of metrics could be produced at an application-level such that the metric reflects the state and/or performance of an individual software application running on a computing device (e.g., a particular server application or a particular client application), a device-level such that the metric reflects the state and/or performance of a computing device independent of any particular software application (e.g., a server or a client device), or a cluster-level such that the metric reflects the state and/or performance of a cluster of multiple computing devices (e.g., a cluster of multiple servers or multiple client devices), among other possibilities.

[0030] A metrics producer **102** may produce metric data for various other types of metrics as well, including but not limited to a metric that provides a numerical measure of how many instances of an item of interest (e.g., number of running containers, number of running application, etc.) exist across the network environment **100**, among various other possible examples.

[0031] Further yet, in practice, a metrics producer **102** may produce metric data for each metric according to a respective sampling interval that defines the rate at which samples of the metric are to be produced by the metrics producer **102**. For instance, if a metrics producer **102** is configured to produce metric data for a given metric according to a 1-minute sampling interval, the metrics producer **102** may function to produce a time series of samples for the given metric that includes a new timestamped sample of the given metric every 1 minute.

[0032] Still further, in practice, a metrics producer **102** may identify each unique metric for which it is producing metrics data in various ways. For instance, according to one possible identification scheme, a metrics producer **102** may identify each unique metric using (i) a metric name, which identifies a general type of information that is represented by the metric, and (ii) a set of one or more labels (or sometimes referred to as “dimensions”) that identifies a specific instantiation of the metric name. To illustrate with a first representative example, a metric name could identify a general type of information such as total number of HTTP requests handled (e.g., http_requests_total), and the set of one or more labels could identify a particular type of HTTP request (e.g., type=“400” and/or method=“POST”), a particular host (e.g., host=“10.2.1.1”), and/or a particular application (e.g., app=“app_1”) for which the total number of HTTP requests is to be captured, which defines a specific instantiation of this metric name. To illustrate with a second representative example, a metric name could identify a general type of information such as memory usage in bytes (e.g., node_memory_usage_bytes), and the set of one or more labels could identify a particular host (e.g., host=“10.2.1.1”) and/or a particular application (e.g., app=“app_1”) for which the memory usage in bytes is to be captured, which defines a specific instantiation of this metric name. Many other examples of metric names and metric labels are possible as well. Further, a metrics producer **102** may identify each unique metric for which it is producing metrics data using various other identification schemes as well, including identification schemes that use a single type of identifier.

[0033] Each of the metrics producers **102** may transmit the metric data to the metrics management platform **104** over a respective communication path. Each of these respective communication paths may generally comprise one or more data networks and/or data links, which may take any of various forms. For instance, each respective communication path between a metrics producer **102** and the metrics management platform **104** may include any one or more of Personal Area Networks (PANs), Local Area Networks (LANs), Wide Area Networks (WANs) such as the Internet or cellular networks, cloud networks, and/or point-to-point data links, among other possibilities. Further, the data networks and/or links that make up each respective communication path may be wireless, wired, or some combination thereof, and may carry data according to any of various different communication protocols. Although not shown, the respective communication paths may also include one or more intermediate systems, one example of which may include a metrics aggregation system, among other possibilities. Many other configurations are also possible.

[0034] Turning to the metrics management platform **104**, as shown in FIG. **1**, the metrics management platform **104** may comprise various functional subsystems, including a metrics ingestion subsystem **104***a*, a metrics storage subsystem **104***b*, and a metrics retrieval subsystem **104***c*, each of which may be configured to carry out certain back-end functionality of the metrics management platform **104** in accordance with the present disclosure.

[0035] For instance, the metrics ingestion subsystem **104***a* of the metrics management platform **104** may generally be configured to (i) receive and ingest metric data from the metrics producers **102**, (ii) optionally perform certain preprocessing operations on the received metric data (e.g., validation, cleansing, deduplication, filtering, aggregation, summarization, enrichment, restructuring, reformatting, translation, mapping, etc.), and then (iii) write the ingested metric data to the metrics storage subsystem **104***b*, among other possible functions carried out by the metrics ingestion subsystem **104***a*.

[0036] Further, the metrics storage subsystem **104***b* of the metrics management platform **104** may generally be configured to store metric data that is received and ingested by the metrics management platform **104**. In practice, the metrics storage subsystem **104***b* may comprise a set of one or more data stores that are configured to store metric data, where each such data store could take any of various forms, examples of which may include a NoSQL database (e.g., a time series database, columnar database, document database, key-value database, graph database, etc.), a relational database (e.g., an Online Transactional Processing (OLTP) database), a file-based data store (e.g., Hadoop Distributed File System), an object-based data store (e.g., Amazon S3, Azure Blob, etc.), a data warehouse (which could be based on one or more of the foregoing types of data stores), a data lake (which could be based on one or more of the foregoing types of data stores), a message queue, and/or a streaming event queue, among other possibilities.

[0037] In at least some implementations, the metrics storage subsystem **104***b* could take the form of a multi-tier storage architecture (or sometimes referred to as a "tiered" storage architecture) comprising multiple different tiers of data stores that are designed to store different classes of metric data. For instance, as one possibility, the metrics storage subsystem **104***b* may take the form of a multi-tier storage architecture comprising two tiers of data stores: (i) a first tier of one or more data stores that are designed to store metric data that is more frequently accessed and/or considered to be of greater importance, which is sometimes referred to as a "hot tier" of data storage, and (ii) a second tier of one or more data stores that are designed to store metric data that is less frequently accessed and/or considered to be of lesser importance, which is sometimes referred to as a "cold tier" of data storage. In this respect, the data stores in the first tier may have characteristics better suited for storage of metric data that is more frequently accessed and/or considered to be of greater importance, such as a data store that has a higher level of performance (e.g., lower latency, higher throughput, and/or greater availability, among other possible aspects of a data store's performance) and/or a lower access cost as compared to the data stores that may be used for the second storage tier but has a higher storage cost than the data stores that may be used for the second storage tier, whereas the data stores in the second tier may have characteristics better suited for storage of metric data that is less frequently accessed and/or considered to be of lesser importance, such as a data store that has a lower storage cost than the data stores that may be used for the first storage tier but perhaps has a lower level of performance (e.g., higher latency, lower throughput, and/or lesser availability, among other possible aspects of a data store's performance) and/or a higher access cost as compared to the data stores that may be used for the first storage tier, among other possible distinctions between the data stores in the first and second storage tiers.

[0038] As another possibility, the metrics storage subsystem **104***b* may take the form of a multi-tier storage architecture comprising three or more tiers of data stores, where each such tier is designed to store metric data having a different level of access frequency and/or a different level of importance. For instance, in line with the discussion above, the data stores in higher tiers may generally have characteristics better suited for storage of metric data that is more frequently accessed and/or considered to be of greater importance, such as data stores having a higher level of performance and/or a lower access cost but a higher storage cost, whereas the data stores in lower tiers may generally have characteristics better suited for storage of metric data that is less frequently accessed and/or considered to be of lesser importance, such as data stores having a lower storage cost but a lower level of performance and/or a higher access cost. Some representative examples of multi-tier storage architectures having three or more storage tiers include those employed by cloud-based storage services such as Amazon Web Services (AWS) (e.g., multiple different S3 tiers), Google Cloud (e.g., standard, nearline, coldline, and archive tiers), and Microsoft Azure (e.g., hot, cool, and archive tiers), but it will be understood that a multi-tier storage architecture having three or more storage tiers may take various other forms as well.

[0039] The metrics storage subsystem **104***b* may take other forms as well.

[0040] Further yet, the metrics retrieval subsystem **104***c* of the metrics management platform **104** may be generally configured to (i) receive requests from the metrics consumers **106** for metric data stored within the metrics storage subsystem **104***b*, (ii) retrieve the requested metric data from the metrics storage subsystem **104***b*, and (iii) return the requested metric data to the metrics consumers **106**, among other possible functions carried out by the metrics retrieval subsystem **104***c*.

[0041] In practice, the metrics management platform **104** may comprise some set of physical computing resources (e.g., processors, data storage, etc.) utilized to implement the foregoing functional subsystems. This set of physical computing resources may take any of various forms. As one possibility, the metrics management platform **104** may comprise cloud computing resources supplied by a third-party provider of "on demand" cloud computing resources, such as Amazon Web Services (AWS), Amazon Lambda, Google Cloud, Microsoft Azure, or the like. As another possibility, the metrics management platform **104** may comprise "on-premises" computing resources of the given software provider (e.g., servers owned by the given software provider).

As yet another possibility, the metrics management platform **104** may comprise a combination of cloud computing resources and on-premises computing resources. Other implementations of the metrics management platform **104** are possible as well.

[0042] Further, in practice, the functional subsystems of the example metrics management platform **104** may be implemented using any of various software architecture styles, examples of which may include a microservices architecture, a service-oriented architecture, and/or a serverless architecture, among other possibilities, as well as any of various deployment patterns, examples of which may include a container-based deployment pattern, a virtual-machine-based deployment pattern, and/or a Lambda-function-based deployment pattern, among other possibilities.

[0043] Turning now to the metrics consumers **106**, each of the metrics consumers **106** may comprise a computing device installed with software that is programmed to consume metric data from the metrics management platform **104**. Such a metrics consumer **106** may take any of various forms. As one possibility, a given metrics consumer **106** may take the form of a server installed with a server application (e.g., a back-end service such as a microservice) that is configured to request and receive metric data from the metrics management platform **104**. Such a server application could take any of various forms, some examples of which may include (i) a server application that drives client-side applications for presenting metric data on a dashboard, which may be referred to herein as a “dashboard engine,” or (ii) a server application that analyzes metric data for purposes of determining whether to issue alerts, which may be referred to herein as an “alert engine.” Further, in practice, such a server application either could be hosted by the same organization that hosts the metrics management platform **104**, in which case the server application may request and receive the metric data via an internal Application Programming Interface (API) (or the like) of the organization, or could be hosted by a different organization than the one that hosts the metrics management platform **104**, in which case the server application may request and receive the metric data via an external API (or the like) of the organization hosting the metrics management platform **104**, among various other possibilities. As another possibility, a given metrics consumer **106** may take the form of a client device installed with a client application that is configured to request and receive metric data from the metrics management platform **104** via an external API (or the like) of the organization hosting the metrics management platform **104**. A given metrics consumer **106** may take other forms as well.

[0044] Further, each of the metrics consumers **106** may be configured to communicate with the metrics management platform **104** over a respective communication path that may generally comprise one or more data networks and/or data links, which may take any of various forms. For instance, each respective communication path between a metrics consumer **106** and the metrics management platform **104** may include any one or more of PANs, LANs, WANs such as the Internet or cellular networks, cloud networks, and/or point-to-point data links, among other possibilities. Further, the data networks and/or links that make up each respective communication path may be wireless, wired, or some combination thereof, and may carry data according to any of various different communication protocols. Although not shown, the respective communication paths may also include one or more intermediate systems, one example of which may include a metrics aggregation system, among other possibilities. Many other configurations are also possible.

[0045] In the network environment **100** of FIG. **1**, certain of the metrics consumers **106** may be configured to run saved queries that cause the metrics consumers **106** to fetch the metric data from the metrics management platform **104**. For example, a dashboard engine may be configured to periodically run a saved query according to some refresh interval that defines that rate at which the dashboard engine is to run saved query (e.g., every 5 minutes, every 30 minutes, etc.), which may then enable the dashboard engine to present the results of the saved query to a user via a client-side dashboard. As another example, an alert engine may be configured to periodically run a saved query according to some refresh interval that defines that rate at which the alert engine is to run saved query (e.g., every 5 minutes, every 30 minutes, etc.), which may then enable the alert engine to evaluate certain alert rules based on the results of the saved query. Other examples of metrics consumers **106** that are configured to run saved queries are possible as well.

[0046] In general, each of these saved queries may comprise an expression that (i) specifies a set of one or more metrics for which metric data is to be fetched from the metrics management platform **104** when the given query is run by the metrics consumer **106** that is configured to run the saved query, and may also (ii) specify one or more operations that are to be applied to the fetched metrics data. The one or more metrics that may be specified by such a saved query may take any of various forms—including any of the example types of metrics described above. Likewise, the one or more operations that are specified by such a saved query may take any of various forms. For instance, as one possibility, a saved query may specify an aggregation operation (e.g., avg, sum, min, max, count, etc.) that is applied to fetched samples of a single metric from multiple timepoints (e.g., samples from a given time window) or fetched samples of multiple different metrics from one or more timepoints. As another possibility, a saved query may specify a binary operation that is to be applied to fetched samples (or aggregations thereof), such as an arithmetic operation (e.g., addition, subtraction, multiplication, division, etc.), a comparison operation, or a logical operation. As yet another possibility, a saved query may specify an operation that computes a non-aggregating, derived value based on one or more fetched samples (or aggregations thereof), such as an operation that computes a rate or a derivative based on multiple fetched samples, among other possible examples. The one or more operations that are specified by such a saved query may take other forms as well.

[0047] Thus, each time a metrics consumer **106** runs such a saved query, the metrics consumer **106** may function to (i) request a given set of metric data from the metrics management platform **104**, (ii) receive the given set of metric data back from the metrics management platform **104**, and (iii) optionally perform one or more operations on the given set of metric data. In turn, the metrics consumer **106** may use the results of the saved query for any of various purposes. For example, if the metrics consumer **106** is a dashboard engine, the metrics consumer **106** may use the results of the saved query to populate a client-side dashboard. As another example, if the metrics consumer **106** is an alert engine, the metrics consumer **106** may use the results of the saved query to evaluate alert rules provisioned at the alert engine and then potentially issue an alert based on the saved query's results. A metrics consumer **106** could use the results of the saved query for other purposes as well.

[0048] This ability to configure metrics consumers **106** to automatically run saved queries is advantageous, because it allows the metrics consumers **106** to fetch metrics data on a periodic basis (and perhaps take some action based on that data) without requiring human intervention. However, this ability to configure metrics consumers **106** to automatically run saved queries can also lead to certain problems.

[0049] One such problem is that organizations typically do not impose any constraints on the "cardinality" of the saved queries that are to be run by metrics consumers **106**, which is generally dictated by the extent of data samples that will need to be fetched during each run of the saved query, including in particular how many discrete timeseries will need to be fetched during each run of the saved query. For instance, a saved query that requires a metrics consumer **106** to fetch a larger number of discrete timeseries during each run will generally be considered to have a higher cardinality level, whereas a saved query that requires a metrics consumer **106** to fetch a smaller number of discrete timeseries during each run will generally be considered to have a lower cardinality level.

[0050] Because organizations typically do not impose any constraints on the "cardinality" of the saved queries that are to be run by metrics consumers **106**, situations can arise where metrics consumers **106** become configured to run saved queries that have a high cardinality level. To illustrate with an example, if a given metrics consumer **106** is configured to run a saved query having an expression that applies an aggregation operation to samples for a set of multiple metrics (e.g., by referencing a metric name without specifying any labels) and that set includes a large number of different metrics, then the given metrics consumer **106** will be required to fetch a large number of data samples (e.g., a large number of discrete timeseries) every time the saved query is run, and the saved query will be considered to have a high cardinality level. Or to illustrate with another example, if a given metrics consumer **106** is configured to run a saved query having an expression that applies an aggregation operation to a time window of multiple samples of a given metric and that time window has a long duration, then the given metrics consumer **106** will be required to fetch a large number of data samples every time the saved query is run, and the saved query will be considered to have a high cardinality level. Other examples of saved queries having high cardinality are possible as well. Unfortunately, allowing metric consumers **106** to be configured with saved queries such as these that have high cardinality can lead to several undesirable consequences.

[0051] First, as the cardinality level of a saved query increases, the time it takes to carry out each run of the saved query typically increases as well. The primary reason for this is that a saved query having a higher cardinality level generally requires a larger number of data samples (e.g., a large number of discrete timeseries) to be fetched during each run of the saved query, which increases the time it takes for the metrics retrieval subsystem **104***c* of the metrics management platform **104** to locate the requested samples within the metrics storage subsystem **104***b* so that they can be returned to the metrics consumer **106**. In this respect, a saved query having a higher cardinality level can introduce an undesirable delay in software applications that utilize the results of the saved query, such as dashboard engines and alert engines, because such applications must wait for each run of the saved query to complete before taking action based on the results of the saved query. Moreover, metrics management platforms and/or metrics consumers often impose a "timeout" period for queries that defines how long a given query operation is permitted to take before timing out (e.g., a 1-minute timeout period), and the increased time that is required to run saved queries having a higher cardinality level puts those saved queries at risk of not completing before the query timeout period expires, which would render those saved queries inoperable and disrupt the functionality the software applications that rely on such saved queries. For example, if a dashboard engine is configured to populate client-side dashboard based on a saved query that cannot complete before the query timeout period expires, that client-side dashboard will never get populated, which degrades user experience. As another example, if an alert engine is configured to evaluate an alert rule for a given type of alert based on a saved query that cannot complete before the query timeout period expires, that alert will never get triggered, which may prevent an organization from recognizing and remedying issues at the metrics producers **102** in a timely manner.

[0052] Second, when an organization's metrics management platform is hosted by a third party, there may be a retrieval cost incurred by each run of a query for fetching stored metrics data that is dependent on the number of unique metrics for which metric data is fetched during the query run, the number of discrete data samples that are fetched during the query run, or both, and in such a scenario, saved queries having higher cardinality levels are likely to increase the retrieval costs paid by the organization. This is because saved queries having higher cardinality levels are likely to cause metric data for a larger number of unique metrics to be fetched during each query run and/or cause a larger number of discrete data samples to be fetched during each query run.

[0053] Third, when there is no constraint on the cardinality level of the saved queries being run by the metrics consumers **106**, the metrics management platform typically has to persistently store all ingested samples of all unique metrics that are received from the metrics producers **102** in a metrics storage subsystem that is suitable for regular querying, which increases the storage cost of the metrics management platform and may also degrade the performance of the metrics management platform (e.g., by increasing the time it takes to locate metric data within the metrics storage subsystem).

[0054] To address these and other problems, disclosed herein is technology for reducing the cardinality of saved queries for fetching metric data from a metrics management platform. One aspect of the disclosed technology takes the form of a new software component referred to herein as a "query analysis engine," which is configured to analyze whether saved queries for fetching metric data are candidates for cardinality reduction and then take action to cause the cardinality level of certain saved queries to be reduced. At a high level, the functionality of the disclosed query analysis engine may involve (i) performing an analysis of a saved query for fetching metric data that is to be run by a metrics consumer, (ii) based at least in part on the analysis, determining a strategy for reducing a cardinality level of the saved query, which may involve defining a new composite metric that is to be used by the saved query to reduce the extent of data samples (e.g., the number of discrete timeseries) fetched during runs of the saved query, and (iii) causing the determined strategy for reducing the cardinality level of the saved query to be implemented. This functionality will be described in further detail below with respect to FIGS. **2**, **3**A-D, and **4**A-C.

[0055] The disclosed technology may achieve various improvements over existing systems for storing and querying metric data. First, by identifying saved queries that are candidates for cardinality reduction and then taking action to cause the cardinality level of the identified saved queries to be reduced, the disclosed technology may decrease the time it takes to complete the identified saved queries and thereby reduce the risk that the identified saved queries will timeout before completing. Second, by identifying saved queries that are candidates for cardinality reduction and then taking action to cause the cardinality level of the identified saved queries to be reduced, the disclosed technology may decrease the retrieval cost incurred during runs of the saved queries. Third, by identifying saved queries that are candidates for cardinality reduction and then taking action to cause the cardinality level of the identified saved queries to be reduced, the disclosed technology may enable the metrics management platform to employ a modified storage strategy whereby metric data for ingested metrics that are not being utilized by any saved queries can either be blocked from storage or stored in a different storage tier, which may reduce the storage cost of the metrics management platform. The disclosed technology may achieve other improvements over existing systems for storing and querying metric data as well.

[0056] FIG. **2** illustrates a flow diagram **200** showing one possible example of operations that may be carried out by the disclosed query analysis engine in accordance with the present disclosure.

[0057] Beginning at block **202**, the query analysis engine may identify at least one saved query for fetching metric data that is to be run by a given metrics consumer. Such a saved query could take various forms, examples of which may include a saved query for fetching metric data that is scheduled to be run on a recurring basis by a dashboard engine or an alert engine installed on the given metrics consumer or a saved query that is stored at the given metrics consumer and is available to be run "on demand" at the request of a user, among other possibilities.

[0058] In line with the discussion above, the saved query that is identified may comprise an expression that (i) specifies a set of one or more metrics for which metric data is to be fetched from a metrics management platform when the saved query is run by the given metrics consumer, and that may also (ii) specify one or more operations that are to be applied to the fetched metrics data. The one or more metrics that may be specified by the saved query may take any of various forms—including any of the example types of metrics described above (e.g., a metric that provides a numerical measure of the extent of a certain type of event that has occurred at a computing device, the time it takes for a certain type of event to be carried out at a computing device, the extent of utilization of a certain type of resource at a computing device, the extent of a certain type of error incurred while processing a certain type of event at a computing device, etc.). Likewise, the one or more operations that may be specified by such a saved query may take any of various forms—including any of the example types of operations described above (e.g., an aggregation operation, a binary operation, an operation that computes a non-aggregating, derived value, etc.).

[0059] Further, in line with the discussion above, the saved query that is identified will have an associated cardinality level, which is primarily dictated by how many data samples (e.g., how many discrete timeseries) will need to be fetched during each run of the saved query. For instance, if the saved query causes the given metrics consumer to fetch a larger number of data samples (e.g., a larger number of discrete timeseries) during each run, the saved query may be considered to have a higher cardinality level, whereas if the saved query causes the metrics consumer to fetch a smaller number of data samples (e.g., a smaller number of discrete timeseries) during each run, the saved query may be considered to have a lower cardinality level.

[0060] The saved query that is identified may take other forms as well.

[0061] At block **204**, the query analysis engine may then perform an analysis of the saved query's expression that facilitates a determination of (i) whether the saved query is a candidate for cardinality reduction and (ii) if so, how the saved query's cardinality level can be reduced. This analysis of the saved query's expression may take various forms.

[0062] As one possible implementation, the query analysis engine may begin its analysis of the saved query's expression by evaluating how many unique metrics are specified by the saved query. In order to perform this evaluation, the query analysis engine may be configured with the capability to interpret notations utilized by certain query languages (e.g., PromQL, SQL, etc.) to reference unique metrics, and the query analysis engine may also have access to a listing of all metrics that have been ingested by the metrics management platform, which may be utilized to facilitate the query analysis engine's determination of how many unique metrics are specified by the saved query.

[0063] For instance, in a scenario where the metrics ingested by the metrics management platform are identified using metric names and corresponding sets of one or more labels, it is possible that the saved query may reference a set of unique metrics by referencing a metric name without specifying any corresponding label, which amounts to a request to fetch samples for all unique metrics having that same metric name. To illustrate with an example, if there is a set of unique metrics that are identified by the metric name http_requests_total and a corresponding set of two labels, type and host, a reference to http_requests_total without any corresponding labels amounts to a request to fetch samples of all of the ingested metrics having the metric name http_requests_total. Or along similar lines, it is possible that the saved query may reference a set of unique metrics by referencing a metric name and specifying a value for only one of multiple possible labels corresponding to the metric name, which amounts to a request to fetch samples for all unique metrics having that same combination of metric name and label value. To illustrate with an example, if there is a set of unique metrics that are identified by the metric name http_requests_total and a corresponding set of two labels, type and host, a reference to http_requests_total{type="400"} amounts to a request to fetch samples of all of the ingested metrics having the metric name http_requests_total and a type value of 400 across all possible host values. Thus, if the query analysis engine identifies this notation within the saved query's expression, the query analysis engine may evaluate the saved query's expression against a listing of all metrics that have been ingested by the metrics management platform in order to determine how many unique metrics are being specified by the saved query.

[0064] The query analysis engine's evaluation of how many unique metrics are specified by the saved query could take various other forms as well.

[0065] In addition to evaluating how many unique metrics are specified by the saved query, the query analysis engine may also evaluate how many discrete samples are to be fetched for each unique metric specified by the saved query. In order to perform this evaluation, the query analysis engine may be configured with the capability to interpret notations utilized by certain query languages (e.g., PromQL, SQL, etc.) to reference multiple samples of a given metric, and the query analysis engine may also have access to data indicating the sampling intervals of all metrics that have been ingested by the metrics management platform, which may be utilized to facilitate the query analysis engine's determination of how many discrete samples are to be fetched for each unique metric specified by the saved query.

[0066] For instance, if the saved query specifies a given metric using the PromQL notation of <metric_identifier>[<duration>], this amounts to a request for all samples of the given metric having timestamps that fall within a lookback window having the specified duration back from the run time of the saved query. To illustrate with an example, if the saved query includes the notation http_requests_total{type="400", host="10.2.1.1"}[5m], this amounts to a request for all samples of the http_requests_total{type="400", host="10.2.1.1"} metric from a lookback window that extends 5 minutes back from the run time of the saved query. Thus, if the query analysis engine identifies this notation within the saved query's expression, the query analysis engine access data indicating the sampling interval of the specified metric and then utilize the specified duration of the lookback window and the specified metric's sampling interval to determine the number of discrete samples that are to be fetched for each unique metric specified by the saved query.

[0067] Along with evaluating how many unique metrics are specified by the saved query and how many unique metrics are specified by the saved query, the query analysis engine may further evaluate the types of operations that are applied to fetched metric data for the metrics specified by the saved query. In order to perform this evaluation, the query analysis engine may be configured with the capability to interpret notations utilized by certain query languages (e.g., PromQL, SQL, etc.) to specify operations that are to be applied to fetched metric data for the metrics specified by the saved query.

[0068] For instance, in line with the discussion above, the query analysis engine may be configured with the capability to identify notations for aggregation operations (e.g., avg, sum, min, max, count, etc.), binary operations (e.g., arithmetic operations, comparison operations, logical operations, etc.), and/or operations that compute non-aggregating, derived values, among various other possible types of operations that may be applied to fetched metric data. To illustrate with an example, if the saved query includes the notation sum(http_requests_total), the query analysis engine may identify this to be an aggregation option that computes a sum of the most-recent sample of every metric having the metric name http_requests_total. Or to illustrate with another example, if the saved query includes the notation avg_over_time(http_requests_total{type="400", host="10.2.1.1"}[5m]), the query analysis engine may identify this to be an aggregation option that computes an average of the samples of the http_requests_total{type="400", host="10.2.1.1"} metric from a lookback window that extends 5 minutes back from the run time of the saved query. Many other examples are possible as well.

[0069] The query analysis engine's analysis of the saved query's expression may take various other forms as well.

[0070] At block **206**, based on the analysis perform at block **204**, the query analysis engine may next determine whether the saved query is a candidate for cardinality reduction. At a high level, this function may involve determining whether any aspect of the saved query's expression can be modified to reduce the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query, which may in turn reduce the cardinality level of the saved query.

[0071] For instance, if the saved query specifies an operation that is to be applied to multiple fetched samples in order to compute a single derived value—such as an aggregation operation that computes an aggregated value from multiple fetched samples or an operation that computes a non-aggregating, derived value from multiple fetched samples—the query analysis engine may determine that the saved query is a candidate for cardinality reduction because the specified operation could be replaced by a notation that relies on a new composite metric and thereby requires a smaller number of samples to be fetched during each run of the saved query.

[0072] The query analysis engine's determination of whether any aspect of the saved query's expression can be modified to reduce the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query may take other forms as well.

[0073] In some implementations, as long as the query analysis engine determines that the saved query can be modified to achieve some level of reduction in the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query, the query analysis engine may determine that the saved query is a candidate for cardinality reduction and then proceed to block **208**. On the other hand, in other implementations, the query analysis engine may additionally evaluate the extent of the cardinality reduction that could be achieved by modifying the saved query before determining whether the saved query is a candidate for cardinality reduction. For example, if the query analysis engine determines that the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query can only be reduced by a smaller amount that falls below a threshold, the query analysis engine may determine that the saved query is not a candidate for cardinality reduction and then leave the saved query unmodified, whereas if the query analysis engine determines that extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query can be reduced by an amount that exceeds the threshold, the query analysis engine may determine that the saved query is a candidate for cardinality reduction and then proceed to block **208**.

[0074] The query analysis engine's functionality for determining whether the saved query is a candidate for cardinality reduction may also take other forms—including but not limited to the possibility that the query analysis engine may optionally be configured to perform an initial assessment of whether the cardinality level of the saved query is within acceptable limits and then decide whether to proceed further based on that initial assessment.

[0075] Turning to block **208**, if the saved query is determined to be a candidate for cardinality reduction, the query analysis engine may next determine a strategy for reducing the cardinality level of the saved query based at least in part on the analysis of the saved query's expression. In this respect, the strategy that is determined for reducing the cardinality level of the saved query may take any of various forms, which may depend on the particular embodiment of the disclosed technology and particular expression of the saved query, among other possible factors.

[0076] For instance, according to a first embodiment of the disclosed technology, a metrics management platform may be provisioned with a configurable engine that is capable of performing certain pre-processing operations on metric data that is ingested by the metric management platform prior to such metric data being stored, which may be referred to herein as a "metrics pre-processing engine." And in this first embodiment, the determined strategy for reducing the cardinality of the saved query may involve (i) defining at least one new composite metric that is to be used by the saved query as a means for reducing the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query, (ii) configuring the metrics pre-processing engine to begin producing samples for the at least one new composite metric, and (iii) modifying the saved query's expression so that it encodes a request for metric data for the at least one new composite metric in place of some portion of the original expression.

[0077] To illustrate with an example, if the saved query's expression encodes an aggregation operation that is to be applied to multiple unique metrics, the determined strategy for reducing the cardinality of the saved query may involve (i) defining a new composite metric that comprises an aggregation of the multiple unique metrics, (ii) configuring the metrics pre-processing engine to begin producing values for the new composite metric, and (iii) modifying the saved query's expression to replace the aggregation operation as applied to the multiple unique metrics with the request for metric data for the composite metric. Or to illustrate with another example, if the saved query's expression encodes an aggregation operation that is to be applied to a time window of multiple samples of a given metric, the determined strategy for reducing the cardinality of the saved query may involve (i) defining a new composite metric that comprises an aggregation of the time window of multiple samples of a given metric, (ii) configuring the metrics pre-processing engine to begin producing samples for the new composite metric, and (iii) modifying the saved query's expression to replace the aggregation operation as applied to the time window of multiple samples of a given metric with the request for metric data for the composite metric. Many other examples are possible as well.

[0078] Further, in the first embodiment of the disclosed technology, the determined strategy may also optionally involve modifying how metric data for certain ingested metrics is handled by the metrics management platform, such as by configuring the metrics pre-processing engine to either block metric data for certain metrics from being persistently stored in the metrics storage subsystem or store metric data for certain metrics in a lower storage tier of the metrics storage subsystem. For instance, if the determined strategy for reducing the cardinality of the saved query involves replacing the saved query's reference to one or more ingested metrics with a reference to a new composite metric, the query analysis engine may further function to (i) evaluate whether the one or more ingested metrics are being utilized by any other saved query for fetching metrics data from the metrics management platform, and (ii) if any of the one or more ingested metrics is not being utilized by any other saved query, configuring the metrics pre-processing engine to either block metric data for the ingested metric from being persistently stored in the metrics storage subsystem or store metric data for the ingested metric in a lower storage tier of the metrics storage subsystem. In this way, the disclosed technology may additionally provide a means for reducing the volume of metric data stored by the metrics management platform (or at least reducing the volume of metric data stored in a higher storage tier of the metrics management platform), which may in turn decrease storage cost and/or improve the retrieval performance of the metrics management platform.

[0079] Turning to a second embodiment of the disclosed technology, metrics consumers that are configured to run saved queries could each be provisioned with a configurable agent that is capable of extracting samples of a new composite metric during runs of a saved query and causing the samples of the composite metric to be transmitted back to the metric management platform for storage, which may be referred to herein as "query processing agent." And in this second embodiment, the determined strategy for reducing the cardinality level of the saved query may involve (i) defining at least one new composite metric that is to be used by the saved query as a means for reducing the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query, (ii) configuring the query processing agent to begin extracting samples of the at least one new composite metric during runs of the saved query and transmitting such samples back to the metrics management platform for storage, and (iii) modifying the saved query's expression so that it encodes a request for metric data for the at least one new composite metric in place of some portion of the original expression.

[0080] To illustrate with another example, if the saved query's expression encodes an aggregation operation that serves to aggregate multiple unique metrics at multiple different timepoints, the determined strategy for reducing the cardinality of the saved query may involve (i) defining a new composite metric that comprises an aggregation of the multiple unique metrics, (ii) configuring the query processing agent to begin extracting values for the new composite metric during runs of the saved query and transmitting such samples back to the metrics management platform for storage, and (iii) modifying the saved query's expression so that instead of aggregating multiple unique metrics at multiple different timepoints, the expression aggregates samples of the new composite metric at the multiple different timepoints. Many other examples are possible as well.

[0081] The determined strategy for reducing the cardinality of the saved query may take various other forms as well, and further examples are described below with reference to FIGS. **3**A-D and FIGS. **4**A-C.

[0082] Lastly, at block **210**, the query analysis engine may cause one or more actions to be carried out in order to implement the determined strategy for reducing the cardinality level of the saved query. The actions that may be carried out in order to implement the determined strategy may take various forms, which may depend on the embodiment of the disclosed technology.

[0083] For instance, in the first embodiment of the disclosed technology, the query analysis engine may cause the determine strategy to be implemented by (i) instructing the metrics pre-processing engine to begin producing and writing samples for the at least one new composite metric and (ii) instructing the given metrics consumer to modify the saved query in accordance with the determined strategy. In turn, the metrics pre-processing engine may thereafter begin to produce and write samples for the at least one new composite metric, and the given metrics consumer may thereafter begin running the modified version of the saved query.

[0084] Further, in the second embodiment, the query analysis engine may cause the determine strategy to be implemented by (i) instructing the query processing agent to begin extracting samples for the at least one new composite metric and transmitting such samples back to the metrics management platform for storage and (ii) instructing the given metrics consumer to modify the saved query in accordance with the determined strategy. In turn, the query processing agent may begin to extract and send samples for the at least one new composite metric, and the given metrics consumer may begin running the modified version of the saved query.

[0085] The one or more actions that the query analysis engine may carry out in order to implement the determined strategy may take other forms as well, and further examples are described below with reference to FIGS. **3**A-D and FIGS. **4**A-C.

[0086] Turning now to FIG. **3**A, a network environment **300** in which the first embodiment of the disclosed technology has been implemented is illustrated. As with the network environment **100** of FIG. **1**, the network environment **300** includes (i) a plurality of metrics producers **302**, of which metrics producers **302**A, **302**B, and **302**C are shown as examples, (ii) a metrics management platform **304** comprising a metrics ingestion subsystem **304***a*, a metrics storage subsystem **304***b*, and a metrics retrieval subsystem **304***c*, and (iii) a plurality of metrics consumers **306**, of which metrics consumers **306**A, **306**B, and **306**C are shown as examples. However, unlike the network environment **100** of FIG. **1**, the network environment **300** of FIG. **3** further includes (i) a metrics pre-processing engine **304***d* within the metrics management platform **304** that sits between the metrics ingestion subsystem **304***a* and the metrics storage subsystem **304***b* and (ii) a query analysis engine **308** that is configured to interact with metrics consumers **306** that are configured to run queries as well as with the metrics pre-processing engine **304***d*. (While the query analysis engine **308** is shown in FIG. **3** as a separate system from the metrics management platform **304**, it should be understood that the query analysis engine **308** could also be implemented as a functional subsystem of the metrics management platform **304**).

[0087] In accordance with the present disclosure, the query analysis engine **308** may be configured to analyze saved queries that are to be run by one or more of the metrics consumers **306** in order to determine whether any of the saved queries are candidates for cardinality reduction. And for each saved query that is determined to be a candidate for cardinality reduction, the query analysis engine **308** may determine a strategy for reducing the saved query's cardinality level based on its analysis and then cause the determined strategy to be implemented by (i) defining at least one new composite metric that is used by the saved query as a means for reducing the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query, (ii) instructing the metrics pre-processing engine **304***d* to begin producing values for the at least one new composite metric, and (iii) instructing the given metric consumer **306** that is configured to run the saved query to modify the saved query's expression so that it encodes a request for metric data for the at least one new composite metric in place of some portion of the original expression. In turn, the metrics pre-processing engine **304***d* may thereafter function to produce and write values for the at least one new composite metric, and the given metric consumer **306** may thereafter function to run the modified version of the saved query, which may involve fetching metric data for the at least one new composite metric instead of metric data for one or more ingested metrics.

[0088] Additionally, in some implementations, the determined strategy for reducing a saved query's cardinality level may further involve modifying how a corresponding set of two or more ingested metrics are handled by the metrics management platform **304**, such as by configuring the metrics pre-processing engine **304***d* to either block metric data for certain ingested metrics from being persistently stored in the metrics storage subsystem **304***b* or to store metric data for certain ingested metrics in a lower storage tier of the metrics storage subsystem **304***b*, in which case the query analysis engine's functionality for causing the determined strategy to be implemented may further involve instructing the metrics pre-processing engine **304***d* to begin performing such a modified handling action with respect to metric data for the corresponding set of two or more ingested metrics. For instance, if the determined strategy for reducing the cardinality of the saved query involves replacing the saved query's reference to one or more ingested metrics with a reference to a new composite metric, the query analysis engine **308** may further function to (i) evaluate whether the one or more ingested metrics are being utilized by any other saved query for fetching metrics data from the metrics management platform, and (ii) if any of the one or more ingested metrics is not being utilized by any other saved query, configuring the metrics pre-processing engine **304***d* to either block metric data for the ingested metric from being persistently stored in the metrics storage subsystem or store metric data for the ingested metric in a lower storage tier of the metrics storage subsystem. In this way, the disclosed technology may additionally provide a means for reducing the volume of metric data stored in the metrics storage subsystem **304***b* (or at least reducing the volume of metric data stored in a higher storage tier of the metrics storage subsystem **304***b*), which may in turn decrease storage cost and/or improve the retrieval performance of the metrics management platform **304**.

[0089] One illustrative example of the functionality that may be carried out by the query analysis engine **308** in accordance with the first embodiment of the disclosed technology will now be described with reference to FIG. **3**B, which shows a scenario where (i) a plurality of the metrics producers **302** are configured to produce metric data for respective metrics having the same metric name but different respective labels and (ii) a given metrics consumer **306**A is configured to run a first representative saved query **310** having an expression that applies an aggregation operation to a set of multiple different metrics (e.g., by referencing a metric name without specifying any labels), which causes the given metrics consumer to **306**A to fetch metric data for every single metric in the set (e.g., every metric having the same metric name) every time the saved query **310** is run.

[0090] In particular, as shown in FIG. **3**B, a plurality of the metrics producers **302** may be configured to produce metric data for metrics having a same metric name of http_requests_total but having different values for a host label. For example, metrics producer **302**A is shown as producing metric data for an http_requests_total{host="10.2.1.1"} metric that indicates a total number of HTTP requests handled by a host having an IP address of "10.2.1.1," metrics producer **302**B is shown as producing metric data for an http_requests_total{host="10.2.1.2"} metric that indicates a total number of HTTP requests handled by a host having an IP address of "10.2.1.2," metrics producer **302**C is shown as producing metric data for an http_requests_total{host="10.2.1.3"} metric that indicates a total number of HTTP requests handled by a host having an IP address of "10.2.1.3," and so on. Further, as shown in FIG. **3**B, the saved query **310** to be run by the given metrics consumer **306**A may have an expression of avg(http_requests_total), which specifies that the given metrics consumer **306**A is to (i) fetch a most-recent sample for every metric having a metric name of http_requests_total, and (ii) average the fetched samples together to produce a single, aggregated value representing an average of the total number of HTTP requests handled by the different hosts as of the run time of the saved query **310**. Thus, in this example, the saved query's cardinality level is dependent on how many different host-level http_requests_total metrics are being produced by the metrics producers **306** in the network environment **300**—when the number of hosts in the network environment **300** is smaller, the saved query's cardinality level will be lower, but as the number of hosts in the network environment **300** increases, the example saved query's cardinality level will likewise increase and may eventually reach a point that could impact negatively query performance.

[0091] In accordance with the first embodiment of the disclosed technology, the query analysis engine **308** may perform an analysis of the saved query **310** in order to determine whether the saved query **310** is a candidate for cardinality reduction, and if so, the query analysis engine **308** may determine a strategy for reducing the cardinality level of the saved query **310**. For instance, in this example, the query analysis engine **308** may determine that the saved query **310** is a candidate for cardinality reduction based on its use of an aggregation operation on an unbounded set of individual metrics, and may then determine a strategy for reducing the cardinality level of the saved query **310** that involves (i) defining a new composite metric identified as avg_http_requests_total that comprises an average of the individual http_requests_total{host=<value>} metrics, which is to be used by the saved query **310** in place of the individual http_requests_total{host=<value>} metrics, (ii) configuring the metrics pre-processing engine **304***d* to begin producing and writing samples for the new avg_http_requests_total metric, and (iii) updating the expression of the saved query **310** so that it specifies the new avg_http_requests_total metric instead of the individual http_requests_total{host=<value>} metrics that form the basis for the avg_http_requests_total metric. In turn, the query analysis engine **308** may cause the determined strategy to be implemented by (i) instructing the metrics pre-processing engine **304***d* to begin producing and writing samples for a new avg_http_requests_total metric that comprises an average of the individual http_requests_total{host=<value>} metrics ingested from the metrics producers **306** and (ii) instructing the given metrics consumer **306**A to modify the saved query's expression from avg(http_requests_total) to avg_http_requests_total.

[0092] In some implementations, the determined strategy for reducing the cardinality level of the saved query **310** may further involve configuring the metrics pre-processing engine **304***d* to either block metric data for the individual http_requests_total{host=<value>} metrics from being persistently stored in the metrics storage subsystem **304***b* or store metric data for the individual http_requests_total{host=<value>} metrics in a lower storage tier of the metrics storage subsystem **304***b*, in which case the query analysis engine's functionality for causing the determined strategy to be implemented may further involve instructing the metrics pre-processing engine **304***d* to begin performing such a modified handling action with respect to metric data for the individual http_requests_total{host=<value>} metrics.

[0093] After the query analysis engine **308** carries out this functionality, the metrics pre-processing engine **304***d* may function to compute a time series of samples for the avg_http_requests_total metric in accordance with a certain sampling interval (e.g., a 1-minute sampling interval), where each respective sample of the avg_http_requests_total metric is computed by averaging samples of the individual http_requests_total{host=<value>} metrics from a corresponding point in time. For example, the metrics pre-processing engine **304***d* may compute (i) a first sample S_1 of the composite avg_http_requests_total metric having a sample time of T_1 by averaging ingested samples of the individual http_requests_total{host=<value>} metrics that were produced at or near T_1, (ii) a second sample S_2 of the composite avg_http_requests_total metric having a sample time of T_2 by averaging ingested samples of the individual http_requests_total{host=<value>} metrics that were produced at or near T_2, and so on for each subsequent sample of the composite avg_http_requests_total metric. As noted above, in some implementations, the metrics pre-processing engine **304***d* may also function to either block the ingested samples of the individual http_requests_total{host=<value>} metrics from being persistently stored in the metrics storage subsystem **304***b* or store such ingested samples in a lower storage tier of the metrics storage subsystem **304***b*, so as to reduce the storage footprint of the metrics data.

[0094] Further, during each subsequent run of the modified version of the saved query **310**, the given metrics consumer **306**A may function to fetch a most-recent sample of the composite avg_http_requests_total metric as opposed to fetching a most-recent sample of every metric having a metric name of http_requests_total. In this respect, the cardinality level of the saved query **310** is reduced, which in turn reduces the time and compute resources required to carry out each subsequent run of the saved query **310**.

[0095] The query analysis engine **308** may carry out similar functionality for other saved queries having expressions that apply an aggregation operation to multiple different metrics (e.g., metrics sharing the same metric name but having different labels), such as an avg, sum, min, max, or count operation, among other possibilities.

[0096] It should also be understood that, based on the query analysis engine's analysis of a saved query having an expression that applies an aggregation operation to multiple different metrics, the query analysis engine **308** could determine not to take an action in order to reduce the cardinality level of the saved query. For example, if the saved query's expression applies an aggregation operation to a relatively-small, bounded set of metrics, the query analysis engine **308** could determine that the cardinality level of the saved query is already within acceptable limits and thereby determine not to take an action in order to reduce the cardinality level of the saved query despite the fact that some extent of cardinality reduction could be achieved by replacing the aggregation operation with a new composite metric.

[0097] Another illustrative example of the functionality that may be carried out by the query analysis engine **308** in accordance with the first embodiment of the disclosed technology will now be described with reference to FIG. **3**C, which shows a scenario where (i) a given metrics producer **302**A is configured to produce metric data for a given metric and (ii) a given metrics consumer **306**A is configured to run a second representative saved query **320** having an expression that applies an aggregation operation to a time window of multiple samples of the given metric.

[0098] In particular, as shown in FIG. **3**C, the given metrics producer **302**A may be configured to produce metric data for a node_memory_usage_bytes{host="10.2.1.1"} metric that indicates the memory usage of a host having an IP address of "10.2.1.1." Further, as shown in FIG. **3**C, the saved query **320** to be run by the given metrics consumer **306**A may have an expression of avg_over_time(node_memory_usage_bytes{host="10.2.1.1"}[<duration>]), which specifies that the given metrics consumer **306**A is to (i) fetch all stored samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from a lookback window having the specified duration back from the execution time of the saved query **320**, and (ii) average the fetched samples together to produce a single, aggregated value representing an average of the memory usage of the 10.2.1.1 host during the lookback window, among other possibilities. Thus, in this example, the saved query's cardinality level is dependent on the duration of the lookback window and the sampling interval of the node_memory_usage_bytes{host="10.2.1.1"} metric—if the ratio between the duration of the lookback window and the sampling interval is smaller (e.g., a duration on the order of minutes and a 1-minute sampling interval), the saved query's cardinality level will be lower, whereas if the ratio between the duration of the lookback window and the sampling interval is larger (e.g., a duration on the order of hours or days and a 1-minute sampling interval), the example saved query's cardinality level will be higher and could impact negatively query performance.

[0099] In accordance with the first embodiment of the disclosed technology, the query analysis engine **308** may perform an analysis of the saved query **320** in order to determine whether the saved query **320** is a candidate for cardinality reduction, and if so, the query analysis engine **308** may determine a strategy for reducing the cardinality level of the saved query **320**. For instance, in this example, the query analysis engine **308** may determine that the saved query **320** is a candidate for cardinality reduction based on its use of an aggregation operation on a range of multiple samples for a given metric, and may then determine a strategy for reducing the cardinality level of the saved query **320** that involves (i) defining a new composite metric identified as <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} that comprises an average of the samples of the node_memory_usage_bytes{host="10.2.1.1"} metric during a lookback window having the specified duration, which is to be used by the saved query **320** in place of the node_memory_usage_bytes{host="10.2.1.1"} metric, (ii) configuring the metrics pre-processing engine **304***d* to begin producing and writing samples for the new <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric, and (iii) updating the expression of the saved query **320** so that it specifies the new <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric instead of the node_memory_usage_bytes{host="10.2.1.1"} metric that forms the basis for the new <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric. In turn, the query analysis engine **308** may cause the determined strategy to be implemented by (i) instructing the metrics pre-processing engine **304***d* to begin producing and writing samples for a new <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric that comprises an average of the samples of the node_memory_usage_bytes{host="10.2.1.1"} metric during a lookback window having the specified duration and (ii) instructing the given metrics consumer **306**A to modify the saved query's expression from avg_over_time(node_memory_usage_bytes{host="10.2.1.1"}[<duration>]) to <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"}.

[0100] In some implementations, the determined strategy for reducing the cardinality level of the saved query **320** may further involve configuring the metrics pre-processing engine **304***d* to either block metric data for the node_memory_usage_bytes{host="10.2.1.1"} metric from being persistently stored in the metrics storage subsystem **304***b* or store metric data for the node_memory_usage_bytes{host="10.2.1.1"} metric in a lower storage tier of the metrics storage subsystem **304***b*, in which case the query analysis engine's functionality for causing the determined strategy to be implemented may further involve instructing the metrics pre-processing engine **304***d* to begin performing such a modified handling action with respect to metric data for the node_memory_usage_bytes{host="10.2.1.1"} metric.

[0101] After the query analysis engine **308** carries out this functionality, the metrics pre-processing engine **304***d* may function to compute a time series of samples for the composite <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric in accordance with a certain sampling interval (e.g., a 1-minute sampling interval), where each respective sample of the <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric is computed by averaging samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from a lookback window extending back from the sample time and having the specified duration. For example, in a scenario where the specified duration is 1 day, the metrics pre-processing engine **304***d* may compute (i) a first sample S_1 of a composite 1d_avg_node_memory_usage_bytes{host="10.2.1.1"} metric having a sample time of T_1 by averaging ingested samples of the node_memory_usage_bytes{host="10.2.1.1"} metric that were produced in the 1-day window prior to T_1, (ii) a second sample S_2 of the composite 1d_avg_node_memory_usage_bytes{host="10.2.1.1"} metric having a sample time of T_2 by averaging ingested samples of the node_memory_usage_bytes{host="10.2.1.1"} metric that were produced in the 1-day window prior to T_2, and so on for each subsequent sample of the composite 1d_avg_node_memory_usage_bytes{host="10.2.1.1"} metric. As noted above, in some implementations, the metrics pre-processing engine **304***d* may also function to either block the ingested samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from being persistently stored in the metrics storage subsystem **304***b* stored or store such ingested samples in a lower storage tier of the metrics storage subsystem **304***b*, so as to reduce the storage footprint of the metrics data.

[0102] Further, during each subsequent run of the modified version of the saved query **320**, the given metrics consumer **306**A may function to fetch a most-recent sample of the composite <duration>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric as opposed to fetching a number of individual samples of the node_memory_usage_bytes{host="10.2.1.1"} metric. In this respect, the cardinality level of the saved query **320** is reduced, which in turn reduces the time and compute resources required to carry out each subsequent run of the saved query **320**.

[0103] The query analysis engine **308** may carry out similar functionality for other saved queries having expressions that apply an aggregation operation to a time window of multiple samples of a given metric, such as an avg, sum, min, max, or count operation applied over a time window of metric samples having a specified duration, among other possibilities.

[0104] It should also be understood that, based on the query analysis engine's analysis of a saved query having an expression that applies an aggregation operation to a time window of multiple samples of a given metric, the query analysis engine **308** could determine not to take an action in order to reduce the cardinality level of the saved query. For example, if the ratio between the duration of the lookback window for the aggregation operation and the sampling interval of the given metric is smaller, such as a ratio that would only require a relatively small number of samples to be fetched during each run of the saved query (e.g., duration on the order of minutes and a 1-minute sampling interval), the query analysis engine **308** could determine that the cardinality level of the saved query is already within acceptable limits and thereby determine not to take an action in order to reduce the cardinality level of the saved query despite the fact that some extent of cardinality reduction could be achieved by replacing the aggregation operation with a new composite metric.

[0105] Yet another illustrative example of the functionality that may be carried out by the query analysis engine **308** in accordance with the first embodiment of the disclosed technology will now be described with reference to FIG. **3**D, which shows a scenario where (i) a plurality of the metrics producers **302** are configured to produce metric data for respective metrics having the same metric name but different respective labels and (ii) a given metrics consumer **306**A is configured to run a third representative saved query **330** having an expression that aggregates multiple different metrics over time (e.g., by referencing a metric name without specifying any labels), which causes the given metrics consumer to **306**A to fetch multiple samples of every single metric in the set (e.g., every metric having the same metric name) every time the saved query **300** is run.

[0106] In particular, as in the example of FIG. **3**B, the example of FIG. **3**D involves a plurality of the metrics producers **302** that are configured to produce metric data for metrics having a same metric name of http_requests_total but having different values for a host label. However, in the example of FIG. **3**D, the saved query **330** to be run by the given metrics consumer **306**A may have an expression that applies a sum operation to the individual http_requests_total metrics at multiple different timepoints (e.g., the current time and one or more time points in the past) and then applies an avg operation to the resulting values, which specifies that the given metrics consumer **306**A is to (i) fetch stored samples of each http_requests_total metric from the specified timepoints, (ii) at each specified timepoint, sum the fetched samples together to produce a respective aggregated value representing a sum of the total number of HTTP requests handled by the different hosts as of the specified timepoint, and (iii) average the respective aggregated values computed for the specified timepoints to produce a single, aggregated value representing a moving average of the sum total number of HTTP requests handled by the different hosts. Thus, in this example, the saved query's cardinality level is dependent on how many different host-level http_requests_total metrics are being produced by the metrics producers **306** in the network environment **300** as well as the number of timepoints specified by the saved query **330**.

[0107] In accordance with the first embodiment of the disclosed technology, the query analysis engine **308** may perform an analysis of the saved query **330** in order to determine whether the saved query **330** is a candidate for cardinality reduction, and if so, the query analysis engine **308** may determine a strategy for reducing the cardinality level of the saved query **330**. For instance, in this example, the query analysis engine **308** may determine that the saved query **330** is a candidate for cardinality reduction based on its use of an aggregation operation on an unbounded set of individual metrics as well as its use of an aggregation operation on multiple samples over time, and may then determine a strategy for reducing the cardinality level of the saved query **330** that involves (i) defining a new composite metric identified as mov_avg_sum_http_requests_total that comprises a moving average of the sum of individual http_requests_total{host=<value>} metrics at multiple timepoints, which is to be used by the saved query **330** in place of the individual http_requests_total{host=<value>} metrics, (ii) configuring the metrics pre-processing engine **304***d* to begin producing and writing samples for the new composite mov_avg_sum_http_requests_total metric, and (iii) updating the expression of the saved query **330** so that it specifies the new composite mov_avg_sum_http_requests_total metric instead of the individual http_requests_total{host=<value>} metrics that form the basis for the mov_avg_sum_http_requests_total metric. In turn, the query analysis engine **308** may cause the determined strategy to be implemented by (i) instructing the metrics pre-processing engine **304***d* to begin producing and writing samples for a new mov_avg_sum_http_requests_total metric that comprises a moving average of the sum of individual http_requests_total{host=<value>} metrics at multiple timepoints and (ii) instructing the given metrics consumer **306**A to modify the saved query's expression to replace the portion referencing the individual http_requests_total{host=<value>} metrics with the new composite mov_avg_sum_http_requests_total metric.

[0108] In some implementations, the determined strategy for reducing the cardinality level of the saved query **330** may further involve configuring the metrics pre-processing engine **304*d*** to either block metric data for the individual http_requests_total{host=<value>} metrics from being persistently stored in the metrics storage subsystem **304*b*** or store metric data for the individual http_requests_total{host=<value>} metrics in a lower storage tier of the metrics storage subsystem **304*b***, in which case the query analysis engine's functionality for causing the determined strategy to be implemented may further involve instructing the metrics pre-processing engine **304*d*** to begin performing such a modified handling action with respect to metric data for the individual http_requests_total{host=<value>} metrics.

[0109] After the query analysis engine **308** carries out this functionality, the metrics pre-processing engine **304*d*** may function to compute a time series of samples for the composite mov_avg_sum_http_requests_total metric in accordance with a certain sampling interval (e.g., a 1-minute sampling interval), where each respective sample of the mov_avg_sum_http_requests_total metric is computed by (i) computing a sum of the individual http_requests_total{host=<value>} metrics at multiple different timepoints and (ii) averaging the resulting sums together. For example, the metrics pre-processing engine **304*d*** may compute (i) a first sample S_1 of the composite mov_avg_sum_http_requests_total metric having a sample time of T_1 by summing ingested samples of the individual http_requests_total{host=<value>} metrics at multiple different timepoints that are defined relative to T_1 (e.g., T_1, T_1−1 m, T_1−2 m, etc.) and then averaging those summed values, (ii) a second sample S_2 of the composite mov_avg_sum_http_requests_total metric having a sample time of T_2 by summing ingested samples of the individual http_requests_total{host=<value>} metrics at multiple different timepoints that are defined relative to T_1 (e.g., T_2, T_2−1 m, T_2−2 m, etc.) and then averaging those summed values, and so on for each subsequent sample of the composite mov_avg_sum_http_requests_total metric. As noted above, in some implementations, the metrics pre-processing engine **304*d*** may also function to either block the ingested samples of the individual http_requests_total{host=<value>} metrics from being persistently stored in the metrics storage subsystem **304*b*** or store such ingested samples in a lower storage tier of the metrics storage subsystem **304*b***, so as to reduce the storage footprint of the metrics data.

[0110] Further, during each subsequent run of the modified version of the saved query **330**, the given metrics consumer **306**A may function to fetch a most-recent sample of the composite mov_avg_sum_http_requests_total metric as opposed to fetching multiple different samples of every metric having a metric name of http_requests_total. In this respect, the cardinality level of the saved query **330** is reduced, which in turn reduces the time and compute resources required to carry out each subsequent run of the saved query **330**.

[0111] The query analysis engine **308** may carry out similar functionality for other saved queries having expressions that aggregate multiple different metrics over time.

[0112] It should also be understood that, based on the query analysis engine's analysis of a saved query having an expression that aggregates multiple different metrics over-time, the query analysis engine **308** could determine not to take an action in order to reduce the cardinality level of the saved query. For example, if the saved query's expression aggregates a relatively-small, bounded set of metrics over a relatively-small window of time, the query analysis engine **308** could determine that the cardinality level of the saved query is already within acceptable limits and thereby determine not to take an action in order to reduce the cardinality level of the saved query despite the fact that some extent of cardinality reduction could be achieved by replacing the aggregation operations with a new composite metric.

[0113] The functionality that may be carried out by the query analysis engine **308** in accordance with the first embodiment of the disclosed technology may take various other forms as well.

[0114] FIG. **4**A illustrates a network environment **400** in which the second embodiment of the disclosed technology has been implemented. As with the network environment **100** of FIG. **1**, the network environment **400** includes (i) a plurality of metrics producers **402**, of which metrics producers **402**A, **402**B, and **402**C are shown as examples, (ii) a metrics management platform **404** comprising a metrics ingestion subsystem **404*a***, a metrics storage subsystem **404*b***, and a metrics retrieval subsystem **404*c***, and (iii) a plurality of metrics consumers **406**, of which metrics consumers **406**A, **406**B, and **406**C are shown as examples. However, unlike the network environment **100** of FIG. **1**, the network environment **400** of FIG. **4** further includes (i) a query processing agent installed on each metrics consumer **406** that is configured to run queries and (ii) a query analysis engine **408** that is configured to interact with metrics consumers **406** that are configured to run queries and the query processing agents installed thereon. (While the query analysis engine **408** is shown in FIG. **4** as a separate system from the metrics management platform **404**, it should be understood that the query analysis engine **408** could also be implemented as a functional subsystem of the metrics management platform **404**).

[0115] In accordance with the present disclosure, the query analysis engine **408** may be configured to analyze saved queries that are to be run by one or more of the metrics consumers **406** in order to determine whether any of the saved queries are candidates for cardinality reduction. And for each saved query that is determined to be a candidate for cardinality reduction, the query analysis engine **408** may determine a strategy for reducing the saved query's cardinality level based on its analysis of the saved query and then cause the determined strategy to be implemented by (i) defining at least one new composite metric that is to be used by the saved query as a means for reducing the extent of samples (e.g., the number of discrete timeseries) that are to be fetched during each run of the saved query, (ii) instructing a query processing agent of the metric consumer **406** configured to run the saved query to begin extracting samples of the at least one new composite metric during runs of the saved query and sending such samples back to the metric management platform **404** for storage, and (iii) instructing the metric consumer **406** to modify the saved query's expression so that it encodes a request for metric data for the at least one new composite metric in place of some portion of the original expression. In turn, the query processing agent of the metric consumer **406** may thereafter function to extract samples of the at least one new composite metric during runs of the saved query and send such samples back to the metric management platform **404** for storage, and the metric consumer **406** may thereafter function to run the modified version of the saved query.

[0116] One illustrative example of the functionality that may be carried out by the query analysis engine **408** in accordance with the second embodiment of the disclosed technology will now be described with reference to FIG. **4**B, which shows a scenario where (i) a given metrics producer **402**A is configured to produce metric data for a given metric and (ii) a given metrics consumer **406**A is configured to run a first representative saved query **410** having an expression that applies an aggregation operation to a time window of multiple samples of the given metric.

[0117] In particular, as shown in FIG. **4**B, the given metrics producer **402**A may be configured to produce metric data for a node_memory_usage_bytes{host="10.2.1.1"} metric that indicates the memory usage of a host having an IP address of "10.2.1.1." Further, as shown in FIG. **4**B, the saved query **410** to be run by the given metrics consumer **406**A may have an expression of avg_over_time(node_memory_usage_bytes{host="10.2.1.1"}[<duration_1>]), which specifies that the given metrics consumer **406**A is to (i) fetch all stored samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from a lookback window having the specified duration_1 back from the execution time of the saved query, (ii) average the fetched samples together to produce a single, aggregated value representing an average of the memory usage of the 10.2.1.1 host during the lookback window. For example, in a scenario where the node_memory_usage_bytes{host="10.2.1.1"} metric has a sampling interval of 1 minute and the specified duration_1 of the saved query **410** is 1 day, then during each run of the saved query **410**, the given metrics consumer **406**A fetches samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from a lookback window that extends 1 day back from the execution time of the saved query **410** (e.g., 1440 samples) and computes an average of the fetched samples over the past 1 day.

[0118] Thus, in this example, the saved query's cardinality level is dependent on the duration of the lookback window and the sampling interval of the node_memory_usage_bytes{host="10.2.1.1"} metric—if the ratio between the duration of the lookback window and the sampling interval is smaller (e.g., a duration on the order of minutes and a 1-minute sampling interval), the saved query's cardinality level will be lower, whereas if the ratio between the duration of the lookback window and the sampling interval is larger (e.g., a duration on the order of hours or days and a 1-minute sampling interval), the example saved query's cardinality level will be higher and could impact negatively query performance.

[0119] In accordance with the second embodiment of the disclosed technology, the query analysis engine **408** may perform an analysis of the saved query **410** in order to determine whether the saved query **410** is a candidate for cardinality reduction, and if so, the query analysis engine **408** may determine a strategy for reducing the cardinality level of the saved query **410**. For instance, in this example, the query analysis engine **408** may determine that the saved query **410** is a candidate for cardinality reduction based on its use of an aggregation operation on a range of multiple samples for a given metric, and may then determine a strategy for reducing the cardinality level of the saved query **410** that involves (i) defining a new composite metric identified as <duration_2>_avg_node_memory_usage_bytes{host="10.2.1.1"} that comprises an average of the samples of the node_memory_usage_bytes{host="10.2.1.1"} metric during a time window having a duration_2 that corresponds to the refresh interval of the saved query, (ii) configuring the query processing agent of the given metrics consumer **406**A to begin extracting samples of the new <duration_2>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric during runs of the saved query **410** and sending such samples back to the metric management platform **404** for storage, and (iii) updating the expression of the saved query **410** so that it uses samples of the composite <duration_2>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric in place of certain samples of the node_memory_usage_bytes{host="10.2.1.1"} metric. In turn, the query analysis engine **408** may cause the determined strategy to be implemented by (i) instructing the query processing agent to begin extracting and transmitting samples for a new <duration_2>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric that each comprises an average of the samples of the node_memory_usage_bytes{host="10.2.1.1"} metric during a time window having a duration_2 that corresponds to the refresh interval of the saved query **410** and (ii) instructing the given metrics consumer **406**A to modify the saved query's expression from avg_over_time(node_memory_usage_bytes{host="10.2.1.1"}[<duration_1>]) to an expression that computes the average of the node_memory_usage_bytes{host="10.2.1.1"} metric during the lookback window having the specified duration_1 by using samples of the <duration_2>_avg_node_memory_usage_bytes{host="10.2.1.1") metric from the portion of the saved query's lookback window for which such samples are available, which is defined as duration_3, and then using samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from the remaining portion of the lookback window for which such samples are not available, which is defined as duration_4 (were duration_3+duration_4=duration_1).

[0120] After the query analysis agent carries out this functionality, the given metrics consumer **406**A may perform one additional run of the original version of the saved query **410**, and during that run, the query processing agent may extract and transmit new samples of the composite <duration_2>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric that each comprises an average of the samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from a respective time window having a duration_2 that corresponds to a refresh interval of the saved query **410**. For example, in a scenario where the node_memory_usage_bytes{host="10.2.1.1"} metric has a sampling interval of 1 minute, the saved query **410** has a refresh interval of 30 minutes, and the specified duration_1 of the saved query's lookback window is 1 day, the query analysis agent may function such that, during the one additional run of the saved query **410** when the given metrics consumer **406**A fetches samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from the past 1 day (e.g., 1440 samples) and computes an average of the fetched samples over the past 1 day, the query processing agent may extract and transmit **48** new samples of a composite 30m_avg_node_memory_usage_bytes{host="10.2.1.1"} metric that each comprises an average of the fetched samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from a respective 30-minute time window during the saved query's 1-day lookback window. In this way, the query processing agent may begin to produce a time series of samples of the 30m_avg_node_memory_usage_bytes{host="10.2.1.1"} metric having a sampling interval of 30 minutes, which matches the refresh interval of the saved query **410**.

[0121] After this one additional run of the original version of the saved query **410**, the given metrics consumer **406**A may begin to run the modified version of the saved query **410**, and during each such run of the saved query **410**, the given metrics consumer **406**A may function to (i) fetch samples of the composite <duration_2>_avg_node_memory_usage_bytes{host="10.2.1.1"} metric from the portion of the lookback window for which such samples are available, (ii) fetch samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from the remaining portion of the lookback window, and (iii) using the fetched samples of these two metrics to compute an average of the node_memory_usage_bytes{host="10.2.1.1"} metric across the lookback window. For example, in a scenario where the node_memory_usage_bytes{host="10.2.1.1"} metric has a sampling interval of 1 minute, the saved query **410** has a refresh interval of 30 minutes, and the specified duration_1 of the saved query's lookback window is 1 day, there will typically be samples of the composite 30m_avg_node_memory_usage_bytes{host="10.2.1.1"} metric available for the first 23.5 hours of the saved query's 1-day lookback window, and the given metrics consumer **406**A may function to (i) fetch samples of the composite 30m_avg_node_memory_usage_bytes{host="10.2.1.1"} metric for the first 23.5 hours of the saved query's 1-day lookback window (e.g., 47 samples), (ii) fetch samples of the node_memory_usage_bytes{host="10.2.1.1"} metric for the last 30 minutes of the saved query's 1-day lookback window (e.g., 30 samples), and (iii) use the fetched samples of these two metrics to compute an average of the node_memory_usage_bytes{host="10.2.1.1"} metric across the saved query's 1-day lookback window, which may involve averaging the samples of the node_memory_usage_bytes{host="10.2.1.1"} metric from the last 30 minutes of the saved query's 1-day lookback window into a time-aggregated value and then computing an average of the 47 samples of the 30m_avg_node_memory_usage_bytes{host="10.2.1.1"} metric along with the time-aggregated value of the node_memory_usage_bytes{host="10.2.1.1"} metric. Correspondingly, the query processing agent may extract the computed time-aggregated value of the node_memory_usage_bytes{host="10.2.1.1"} metric as a new sample of the 30m_avg_node_memory_usage_bytes{host="10.2.1.1"} metric for a new time window extending 30 minutes back from the execution time of the saved query **410** and transmit that new sample back to the metrics management platform **404** for storage, so that the new sample is available during the next run of the saved query **410**. Thus, in this example, the number of samples fetched by the given metrics consumer **406**A during each run by the saved query **410** may be reduced from 1440 samples to 77 samples, which may in turn reduce the cardinality of the saved query **410** by nearly 95%.

[0122] The query analysis engine **408** may carry out similar functionality for other saved queries having expressions that apply an aggregation operation to a time window of multiple samples of a given metric, such as an avg, sum, min, max, or count operation applied over a time window of metric samples having a specified duration, among other possibilities.

[0123] It should also be understood that, based on the query analysis engine's analysis of a saved query having an expression that applies an aggregation operation to a time window of multiple samples of a given metric, the query analysis engine **308** could determine not to take an action in order to reduce the cardinality level of the saved query. For example, if the ratio between the duration of the lookback window for the aggregation operation and the sampling interval of the given metric is smaller, such as a ratio that would only require a relatively small number of samples to be fetched during each run of the saved query (e.g., duration on the order of minutes and a 1-minute sampling interval), the query analysis engine **408** could determine that the cardinality level of the saved query is already within acceptable limits and thereby determine not to take an action in order to reduce the cardinality level of the saved query despite the fact that some extent of cardinality reduction could be achieved by replacing the aggregation operation with a new composite metric.

[0124] Another illustrative example of the functionality that may be carried out by the query analysis engine **408** in accordance with the second embodiment of the disclosed technology will now be described with reference to FIG. **4**C, which shows a scenario where (i) a plurality of the metrics producers **402** are configured to produce metric data for respective metrics having the same metric name but different respective labels and (ii) a given metrics consumer **406**A is configured to run a second representative saved query **420** having an expression that aggregates multiple different metrics over time (e.g., by referencing a metric name without specifying any labels), which causes the given metrics consumer to **406**A to fetch multiple samples of every single metric in the set (e.g., every metric having the same metric name) every time the example saved query is run.

[0125] In particular, as in the examples of FIGS. **3**B and **3**D, the example of FIG. **4**C involves a plurality of the metrics producers **402** that are configured to produce metric data for metrics having a same metric name of http_requests_total but having different values for a host label. Further, as in the example of FIG. **3**D, the saved query **420** to be run by the given metrics consumer **406**A in this example may have an expression that applies a sum operation to the individual http_requests_total metrics at multiple different timepoints within some lookback window (e.g., the current time and one or more time points in the past) and then applies an avg operation to the resulting values, which specifies that the given metrics consumer **406**A is to (i) fetch stored samples of each individual http_requests_total metric from the specified timepoints, (ii) at each specified timepoint, sum the fetched samples together to produce a respective aggregated value representing a sum of the total number of HTTP requests handled by the different hosts as of the specified timepoint, and (iii) average the respective aggregated values computed for the specified timepoints to produce a single, aggregated value representing a moving average of the sum total number of HTTP requests handled by the different hosts. For example, in a scenario where the individual http_requests_total{host=<value>} metrics have a sampling interval of 1 minute, the saved query **420** has a refresh interval of 30 minutes, and the saved query **420** evaluates timepoints across a 5-minute lookback window, then during each run of the saved query **420**, the given metrics consumer **406**A (i) fetches samples of each individual http_requests_total metric from the current timepoint as well as the preceding 5 timepoints, (ii) at each specified timepoint, sums the fetched samples together to produce a respective aggregated value representing a sum of the total number of HTTP requests handled by the different hosts as of the specified timepoint, which produces a set of 6 aggregated values at the 6 timepoints falling within the saved query's 5-minute lookback window, and (iii) average the 6 aggregated values to produce a single, aggregated value representing a moving average of the sum total number of HTTP requests handled by the different hosts over the 5-minute lookback window. Thus, in this example, the saved query's cardinality level is dependent on how many different host-level http_requests_total metrics are being produced by the metrics producers **406** in the network environment **400** as well as the number of timepoints specified by the saved query **420**.

[0126] In accordance with the second embodiment of the disclosed technology, the query analysis engine **408** may perform an analysis of the saved query **420** in order to determine whether the saved query **420** is a candidate for cardinality reduction, and if so, the query analysis engine **408** may determine a strategy for reducing the cardinality level of the saved query **420**. For instance, in this example, the query analysis engine **408** may determine that the saved query **420** is a candidate for cardinality reduction based on its use of an aggregation operation on an unbounded set of individual metrics as well as its use of an aggregation operation on multiple samples over time, and may then determine a strategy for reducing the cardinality level of the saved query **420** that involves (i) defining a new composite metric identified as sum_http_requests_total that comprises the sum of individual http_requests_total{host=<value>} metrics at a respective timepoint, (ii) configuring the query processing agent of the given metrics consumer **406**A to begin extracting samples of the new sum_http_requests_total metric during runs of the saved query **420** and sending such samples back to the metric management platform **404** for storage, and (iii) updating the expression of the saved query **420** so that it uses samples of the composite sum_http_requests_total metric in place of certain samples of the http_requests_total{host=<value>} metrics. In turn, the query analysis engine **408** may cause the determined strategy to be implemented by (i) instructing the query processing agent to begin extracting and transmitting samples for a new sum_http_requests_total metric that each comprises a sum of the individual http_requests_total{host=<value>} metrics at a respective timepoint and (ii) instructing the given metrics consumer **406**A to modify the saved query's expression so that it uses samples of the new sum_http_requests_total metric for a portion of the timepoints and uses samples of the individual http_requests_total{host=<value>} metrics for at least one remaining timepoint.

[0127] After the query analysis agent carries out this functionality, the given metrics consumer **406**A may perform one additional run of the original version of the saved query **420**, and during that run, the query processing agent may extract and transmit new samples of the composite sum_http_requests_total metric that each comprises a sum of the individual http_requests_total{host=<value>} metrics at a respective timepoint within the saved query's lookback window. For example, in a scenario where the individual http_requests_total{host=<value>} metrics have a sampling interval of 1 minute, the saved query **420** has a refresh interval of 30 minutes, and the saved query **420** evaluates timepoints across a 5-minute lookback window, the query analysis agent may function such that, during the one additional run of the saved query **420** when the given metrics consumer **406**A fetches samples of the individual http_requests_total{host=<value>} metrics from 6 timepoints within the 5-minute lookup window, sums the fetched samples across the hosts at each timepoint, and averages the timepoint-specific summed values together across the timepoints, the query processing agent may extract and transmit **6** new samples of a composite sum_http_requests_total metric that each comprises a sum of the fetched samples of the individual http_requests_total{host=<value>} metrics at a respective timepoint during the saved query's 5-minute lookback window. In this way, the query processing agent may begin to produce a time series of samples of the sum_http_requests_total metric.

[0128] After this one additional run of the original version of the saved query **420**, the given metrics consumer **406**A may begin to run the modified version of the saved query **420**, and during each such run of the saved query **420**, the given metrics consumer **406**A may function to (i) fetch samples of the composite sum_http_requests_total metric from the portion of the lookback window for which such samples are available, (ii) fetch samples of the individual http_requests_total{host=<value>} metrics from the remaining portion of the lookback window, and (iii) using the fetched samples of these two metrics to compute a moving average of the individual http_requests_total{host=<value>} metrics across the lookback window. For example, in a scenario where the individual http_requests_total{host=<value>} metrics have a sampling interval of 1 minute, the saved query **420** has a refresh interval of 30 minutes, and the saved query **420** evaluates timepoints across a 5-minute lookback window, there will typically be samples of the composite sum_http_requests_total metric available for the first 5 timepoints within the saved query's 5-day lookback window, and the given metrics consumer **406**A may function to (i) fetch samples of the composite sum_http_requests_total metric for the first 5 timepoints of the saved query's 5-minute lookback window (e.g., 5 samples), (ii) fetch samples of the individual http_requests_total{host=<value>} metrics for the last timepoint of the saved query's 5-minute lookback window (e.g., the most-recent sample of each individual http_requests_total{host=<value>} metric), and (iii) use the fetched samples of these two metrics to compute a moving average of the http_requests_total{host=<value>} metrics across the saved query's 5-day lookback window, which may involve summing the samples of the individual http_requests_total{host=<value>} metrics for the last timepoint into a host-aggregated value and then computing an average of the 5 samples of the sum_http_requests_total metric along with the host-aggregated value of the node_memory_usage_bytes{host="10.2.1.1"} metric for the last timepoint. Correspondingly, the query processing agent may extract the computed host-aggregated value of the individual http_ requests_total{host=<value>} metrics for the last timepoint as a new sample of the sum_http_requests_total metric at that timepoint and transmit that new sample back to the metrics management platform **404** for storage, so that the new sample is available during the next run of the saved query **420**. Thus, instead of having to fetch samples of the individual http_requests_total{host=<value>} metrics for multiple different timepoints during each run of the saved query **420**, the given metrics consumer **406**A may only need to fetch samples of the individual http_requests_total{host=<value>} metrics for a single timepoint, which may in turn reduce the cardinality of the saved query **420**—particularly in a scenario where there is a large number of hosts in the network environment **400**.

[0129] The query analysis engine **408** may carry out similar functionality for other saved queries having expressions that aggregate multiple different metrics over time.

[0130] It should also be understood that, based on the query analysis engine's analysis of a saved query having an expression that aggregates multiple different metrics overtime, the query analysis engine **408** could determine not to take an action in order to reduce the cardinality level of the saved query. For example, if the saved query's expression aggregates a relatively-small, bounded set of metrics over a relatively-small window of time, the query analysis engine **408** could determine that the cardinality level of the saved query is already within acceptable limits and thereby determine not to take an action in order to reduce the cardinality level of the saved query despite the fact that some extent of cardinality reduction could be achieved by replacing the aggregation operations with a new composite metric.

[0131] The functionality that may be carried out by the query analysis engine **408** in accordance with the second embodiment of the disclosed technology may take various other forms as well.

[0132] Turning now to FIG. **5**, a simplified block diagram is provided to illustrate some structural components that may be included in an example computing device **500** that may be configured to carry out any of the various functions disclosed herein, including but not limited to the functions of a metrics producer, a metrics consumer, or a query analysis engine. At a high level, the example computing device **500** may include one or more processors **502**, data storage **504**, and one or more communication interfaces **506**, all of which may be communicatively linked by a communication link **508** that may that various forms, one example of which is a system bus.

[0133] The one or more processors **502** of the example computing device **500** may comprise one or more processor components, each of which may take the form of a general-purpose processor (e.g., a microprocessor), a special-purpose processor (e.g., an application-specific integrated circuit, a digital signal processor, a graphics processing unit, a vision processing unit, etc.), a programmable logic device (e.g., a field-programmable gate array), or a controller (e.g., a microcontroller), among other possibilities.

[0134] In turn, the data storage **504** of the example computing device **500** may comprise one or more non-transitory computer-readable mediums, each of which may take the form of a volatile medium (e.g., random-access memory, a register, a cache, a buffer, etc.) or a non-volatile medium (e.g., read-only memory, a hard-disk drive, a solid-state drive, flash memory, an optical disk, etc.), and these one or more non-transitory computer-readable mediums may be capable of storing both (i) program instructions that are executable by the one or more processors **502** of the example computing device **500** such that the computing device **500** is configured to perform any of the functions disclosed herein (e.g., functions of a metrics producer, metrics consumer, query analysis engine, etc.), and (ii) data related to the disclosed functionality.

[0135] The one or more communication interfaces **506** of the example computing device **500** may take the form of any one or more interfaces that facilitate wireless and/or wired communication with other computing devices or systems, such as a metrics management platform. Each such communication interface **506** may take any of various forms, examples of which may include an Ethernet interface, a serial bus interface (e.g., Firewire, USB 3.0, etc.), a chipset and antenna adapted to facilitate any of various types of wireless communication (e.g., Wi-Fi communication, cellular communication, short-range wireless protocols, etc.), and/or any other interface that provides for wireless or wired communication. Other configurations are possible as well.

[0136] Although not shown, the example computing device **500** may also additionally include an I/O interface, which may generally take the form of (i) one or more input interfaces that are configured to receive and/or capture information at the example computing device **500** and (ii) one or more output interfaces that are configured to output information from the example computing device **500** (e.g., for presentation to a user). In this respect, the one or more input interfaces of I/O interface may include or provide connectivity to input components such as a microphone, a camera, a keyboard, a mouse, a trackpad, a touchscreen, and/or a stylus, among other possibilities, and the one or more output interfaces of I/O interface may include or provide connectivity to output components such as a display screen and/or an audio speaker, among other possibilities.

[0137] It should be understood that the example computing device **500** is one example of a computing device that may be used with the example embodiments described herein. Numerous other arrangements are possible and contemplated herein. For instance, in other embodiments, the example computing device **500** may include additional components not pictured and/or more or fewer of the pictured components.

[0138] Turning now to FIG. **6**, a simplified block diagram is provided to illustrate some structural components that may be included in an example back-end platform **600**, which may be configured to carry out any of the various functions disclosed herein, including but not limited to the functions of a metrics management platform (e.g., metrics management platform **304** or metrics management platform **404**) and/or the query analysis engine. At a high level, the back-end platform **600** may generally comprise any one or more computing systems that collectively include one or more processors **602**, data storage **604**, and one or more communication interfaces **606**, all of which may be communicatively linked by a communication link **608** that may take the form of a system bus, a communication network such as a public, private, or hybrid cloud, or some other connection mechanism. Each of these components may take various forms.

[0139] The one or more processors **602** may comprise one or more processor components, each of which may take the form of a general-purpose processor (e.g., a microprocessor), a special-purpose processor (e.g., an application-specific integrated circuit, a digital signal processor, a graphics processing unit, a vision processing unit, etc.), a programmable logic device (e.g., a field-programmable gate array), or a controller (e.g., a microcontroller), among other possibilities. In line with the discussion above, it should also be understood that the one or more processors **602** could comprise processing components that are distributed across a plurality of physical computing systems connected via a network, such as a computing cluster of a public, private, or hybrid cloud.

[0140] In turn, the data storage **604** may comprise one or more non-transitory computer-readable storage mediums, each of which may take the form of a volatile medium (e.g., random-access memory, a register, a cache, a buffer, etc.) or a non-volatile medium (e.g., read-only memory, a hard-disk drive, a solid-state drive, flash memory, an optical disk, etc.), and these one or more non-transitory computer-readable mediums may be capable of storing both (i) program instructions that are executable by the one or more processors **602** such that the back-end platform **600** is configured to perform any of the various back-end platform functions disclosed herein, and (ii) data related to the disclosed back-end platform functionality. In line with the discussion above, it should also be understood that the data storage **604** may comprise computer-readable storage mediums that are distributed across a plurality of physical computing systems connected via a network, such as a storage cluster of a public, private, or hybrid cloud that operates according to technologies such as AWS for Elastic Compute Cloud, Simple Storage Service, etc.

[0141] The one or more communication interfaces **606** may take the form of any one or more interfaces that facilitate wireless and/or wired communication with other computing devices or systems, including but not limited to metrics producers, metrics consumers, and the query analysis engine (to the extent it is not included as a functional subsystem of the back-end platform **600**), as well as wireless and/or wired communication between functional subsystems of the back-end platform **600**. Each such communication interface **606** may take any of various forms, examples of which may include an Ethernet interface, a serial bus interface (e.g., Firewire, USB 3.0, etc.), a chipset and antenna adapted to facilitate any of various types of wireless communication (e.g., Wi-Fi communication, cellular communication, short-range wireless protocols, etc.), and/or any other interface that provides for wireless or wired communication. Other configurations are possible as well.

[0142] Although not shown, the back-end platform **600** may additionally include an I/O interface that facilitates user interaction with the back-end platform **600**.

[0143] It should be understood that back-end platform **600** is one example of a back-end platform that may be used with the embodiments described herein. Numerous other arrangements are possible and contemplated herein. For instance, other back-end platforms **600** may include additional components not pictured and/or more or less of the pictured components.

CONCLUSION

[0144] This disclosure makes reference to the accompanying figures and several example embodiments. One of ordinary skill in the art should understand that such references are for the purpose of explanation only and are therefore not meant to be limiting. Part or all of the disclosed systems, devices, and methods may be rearranged, combined, added to, and/or removed in a variety of manners without departing from the true scope and sprit of the present invention, which will be defined by the claims.

[0145] Further, to the extent that examples described herein involve operations performed or initiated by actors, such as "humans," "curators," "users" or other entities, this is for purposes of example and explanation only. The claims should not be construed as requiring action by such actors unless explicitly recited in the claim language.

1. A method implemented by a computing platform, the method comprising:

performing an analysis of a saved query comprising an expression that specifies a set of one or mere unique metrics for which metric data is to be fetched from a metrics management platform when the saved query is run;

determining a strategy for reducing a cardinality level of the saved query based at least in part on the analysis of the saved query, wherein the determined strategy for reducing the cardinality level of the saved query comprises:

defining at least one composite metric that is derived from a respective subset of the unique metrics in the set of unique metrics, wherein metric data for the at least one composite metric is to be produced by one or both of the metrics management platform or a given metrics consumer that is configured to run the saved query; and

modifying the expression of the saved query by replacing a request to fetch at least some portion of the metric data for the respective subset of the unique metrics with a request to fetch metric data for the at least one composite metric; and

causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query.

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

prior to determining the strategy for reducing the cardinality level of the saved query, determining that the saved query is a candidate for cardinality reduction based at least in part on the analysis of the saved query.

3. The method of claim **2**, wherein determining that the saved query is a candidate for cardinality reduction based at least in part on the analysis of the saved query comprises:

determining that the saved query can be modified to achieve some level of reduction in an extent of samples that are to be fetched during a respective run of the saved query.

4. The method of claim **1**, wherein performing the analysis of the saved query comprises one or more of (i) evaluating how many unique metrics are specified by the saved query, (ii) evaluating how many samples are to be fetched for each unique metric specified by the saved query, or (iii) evaluating which types of operations that are applied by the saved query.

5. The method of claim **1**, wherein the determined strategy for reducing the cardinality level of the saved query further comprises:

configuring the metrics management platform to begin producing and storing metric data for the at least one composite metric.

6. The method of claim **5**, wherein the determined strategy for reducing the cardinality level of the saved query further comprises:

configuring the metrics management platform to either (i) block storage of metric data for the respective subset of the unique metrics or (ii) store metric data for the respective subset of the unique metrics in a lower storage tier.

7. The method of claim **5**, wherein causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query comprises:

instructing the given metrics consumer to modify the saved query so that the expression of the saved query encodes the request to fetch metric data for the at least one composite metric.

8. The method of claim **5**, wherein the expression of the saved query encodes an aggregation operation that is to be applied to fetched metric data for the respective subset of the unique metrics, wherein the at least one composite metric that is derived from the respective subset of the unique metrics comprises a composite metric that is derived by applying an aggregation operation to metric data for the respective subset of the unique metrics, and wherein replacing the request to fetch at least some portion of the metric data for the respective subset of the unique metrics with the request to fetch metric data for the at least one composite metric comprises:

removing the aggregation operation from the expression of the saved query.

9. The method of claim **1**, wherein the determined strategy for reducing the cardinality level of the saved query further comprises:

configuring the given metrics consumer to begin (i) extracting metric data for the at least one composite metric that is produced during runs of the saved query, and (ii) transmitting the extracted metric data for the at least one composite metric to the metrics management platform for storage.

10. The method of claim **9**, wherein causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query comprises:

instructing an agent installed on the given metrics consumer to begin (i) extracting metric data for the at least one composite metric that is produced during runs of the saved query and (ii) transmitting the extracted metric data for the at least one composite metric to the metrics management platform for storage; and

instructing the given metrics consumer to modify the saved query so that the expression of the saved query encodes the request to fetch metric data for the at least one composite metric.

11. A non-transitory computer-readable medium comprising program instructions stored thereon that are executable to cause a computing platform to perform functions comprising:

performing an analysis of a saved query comprising an expression that specifies a set of unique metrics for which metric data is to be fetched from a metrics management platform when the saved query is run;

determining a strategy for reducing a cardinality level of the saved query based at least in part on the analysis of the saved query, wherein the determined strategy for reducing the cardinality level of the saved query comprises:

defining at least one composite metric that is derived from a respective subset of the unique metrics in the set of unique metrics, wherein metric data for the at least one composite metric is to be produced by one or both of the metrics management platform or a given metrics consumer that is configured to run the saved query; and

modifying the expression of the saved query by replacing a request to fetch at least some portion of the metric data for the respective subset of the unique metrics with a request to fetch metric data for the at least one composite metric; and

causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query.

12. The non-transitory computer-readable medium of claim **11**, further comprising program instructions stored thereon that are executable to cause the computing platform to, prior to determining the strategy for reducing the cardinality level of the saved query, determine that the saved query is a candidate for cardinality reduction based at least in part on the analysis of the saved query.

13. The non-transitory computer-readable medium of claim **12**, wherein determining that the saved query is a candidate for cardinality reduction based at least in part on the analysis of the saved query comprises:

determining that the saved query can be modified to achieve some level of reduction in an extent of samples that are to be fetched during a respective run of the saved query.

14. The non-transitory computer-readable medium of claim **11**, wherein performing the analysis of the saved query comprises one or more of (i) evaluating how many unique metrics are specified by the saved query, (ii) evaluating how many samples are to be fetched for each unique metric specified by the saved query, or (iii) evaluating which types of operations that are applied by the saved query.

15. The non-transitory computer-readable medium of claim **11**, wherein the determined strategy for reducing the cardinality level of the saved query further comprises:

configuring the metrics management platform to begin producing and storing metric data for the at least one composite metric.

16. The non-transitory computer-readable medium of claim **15**, wherein the determined strategy for reducing the cardinality level of the saved query further comprises:

configuring the metrics management platform to either (i) block storage of metric data for the respective subset of the unique metrics or (ii) store metric data for the respective subset of the unique metrics in a lower storage tier.

17. The non-transitory computer-readable medium of claim **15**, wherein causing the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query comprises:

instructing the given metrics consumer to modify the saved query so that the expression of the saved query encodes the request to fetch metric data for the at least one composite metric.

18. The non-transitory computer-readable medium of claim **15**, wherein the expression of the saved query encodes an aggregation operation that is to be applied to fetched metric data for the respective subset of the unique metrics, wherein the at least one composite metric that is derived from the respective subset of the unique metrics comprises a composite metric that is derived by applying an aggregation operation to metric data for the respective subset of the unique metrics, and wherein replacing the request to fetch at least some portion of the metric data for the respective subset of the unique metrics with the request to fetch metric data for the at least one composite metric comprises:

removing the aggregation operation from the expression of the saved query.

19. The non-transitory computer-readable medium of claim **11**, wherein the determined strategy for reducing the cardinality level of the saved query further comprises:

configuring the given metrics consumer to begin (i) extracting metric data for the at least one composite metric that is produced during runs of the saved query, and (ii) transmitting the extracted metric data for the at least one composite metric to the metrics management platform for storage.

20. A computing platform, comprising:

at least one processor;

at least one non-transitory computer-readable medium; and

program instructions stored on the at least one non-transitory computer-readable medium that are executable by the at least one processor such that the computing platform is configured to:

perform an analysis of a saved query comprising an expression that specifies a set of unique metrics for which metric data is to be fetched from a metrics management platform when the saved query is run;

determine a strategy for reducing a cardinality level of the saved query based at least in part on the analysis of the saved query, wherein the determined strategy for reducing the cardinality level of the saved query comprises:

defining at least one composite metric that is derived from a respective subset of the unique metrics in the set of unique metrics, wherein metric data for the at least one composite metric is to be produced by one or both of the metrics management platform or a given metrics consumer that is configured to run the saved query; and

modifying the expression of the saved query by replacing a request to fetch at least some portion of the metric data for the respective subset of the unique metrics with a request to fetch metric data for the at least one composite metric; and

cause the saved query to be modified in accordance with the determined strategy for reducing the cardinality level of the saved query.

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