

ENDPOINT APPLICATION DATA MANAGEMENT

Technical field

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The invention relates to endpoint application data management, such as data management for applications installed on endpoint devices in a distribution network.

Background

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Endpoint devices in a distribution network such as smart meters can have various applications installed on them for providing services to the end consumer and to the utility provider. For example, the applications may provide the end consumers with access to their electricity usage data, or enable time of use billing, or rapid demand response etc. In order to provide these services, the applications may need to both

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access data and share data with other network entities.

Each application can report its data directly to a server. However, this requires ports to be identified and opened on Firewalls and data push times to be randomized across the network. Also, the data location would need to be communicated, since each application and server is a separate ecosystem.

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Improved solutions for managing application data are therefore desirable.

Summary

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Aspects of the invention can provide efficient handling of data at the endpoints and at the central system (e.g. at the head-end system, HES). It can provide a consolidated framework for bandwidth management, security, and centralised data storage and access.

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The described data management modules may be a sub-system of an application management platform for managing applications on endpoint devices. For example, the platform may be configured to monitor application data, to enable and disable applications on specific endpoint devices, to install and uninstall such applications. The

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present disclosure relates to the handling and management of application data to and from applications at endpoint devices. In a particular example, the described system can be used to distribute weather data by zip code to utility meters, which enables enhanced performance and more intelligent software applications.

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According to a first aspect there is provided an endpoint device in a distribution network comprising an application (also referred to as "software application" or "app") installed on the endpoint device for providing a service to an end consumer or to a utility provider, a database for storing data, and an application data management module for supplying data to the application. The application data management module is configured to receive a data request for a type of data from the application, access first data of the type of data from the database, based on the type of data, check metadata associated with the first data to determine a validity of the first data, when the first data is determined to be valid, send the first data to the application, and when the first data is determined to be not valid, send to a central application data management module a data request for the type of data, receive from the application data management module second data of the type of data, store the second data in the database, and send the second data to the application.

The endpoint device may be a utility meter, such as an electricity meter or other connected edge device in a distribution network, such as a power distribution network for supplying power to end consumers. The application may be a native application pre-installed on the endpoint device and used to process data on the device or may be a third party application for processing and/or displaying data. For example, the application may be configured to monitor and/or control a power load, or to supply billing data to a utility provider. The application may require one or more types of data in order to provide the service. For example, the application may require up to date weather data (e.g. local temperature). The endpoint device is configured so that the application requests the data from the data management module, which checks the locally stored data. If the required data is available, the module sends the data to the application. If the data is not available or out of date or otherwise not valid, the module can request the data from a central application data management module, for example comprised by a head end system (HES).

- The endpoint device can further comprise a second application for providing another service to an end consumer or to a utility provider, wherein the application data management module is configured to receive a data request for the type of data from the second application, access the second data from the database, based on the type of data, check metadata associated with the second data to determine a validity of the second data, and when the second data is determined to be valid, send the second data to the second application. The second application may request a different type of data.
- The data module can be configured to receive data requests from a plurality of applications installed at the endpoint device and in response supply data to the plurality of applications. In general, the endpoint device may comprise a plurality of different applications, including both native and third party applications for providing different services depending on the type of endpoint device and the type of distribution network. However, instead of having each application separately establish a connection to and communicate with the central system (e.g. the HES) to obtain required data, the applications request data from the local (on-device) data management module, which processes the requests, and supplies the required data. Hence, only a single secure connection between the data management module and the central system is required for sending and receiving data to and from a plurality of applications installed on the endpoint device. Secure connections can also be established between application data management modules of respective endpoint devices to allow peer-to-peer data sharing. This allows endpoint devices to request valid data from other (neighbouring) endpoint devices, instead of having to communicate with the central system. This can reduce congestion and potential bandwidth problems in the data transport to the central system.
- The metadata may comprise information relating to the acquisition of data and may comprise at least one of a timestamp, a utility meter identifier (meter ID), and a data source identifier. For example, the data may be temperature data and may be tagged with a timestamp indicating the time that the temperature was measured and may be tagged with a data source identifier that indicates the location of the measurement. For example, weather data may be tagged with a location indicator such as a zip code.

- The application data management module can be configured to check the metadata by comparing a parameter of the metadata to a corresponding nominal parameter or parameter range. For example, the parameter of the metadata may comprise a timestamp and the application data management module can then be configured to compare the time stamp to a current time. For example, the module may be configured to receive data at regular intervals, and, when an application requests data, can check the timestamp against the current time to determine if it has received the most recent data. If not, the module can request the data directly from the central system.
- According to a second aspect there is provided a method at an endpoint device for managing data in a distribution network. The method may be carried out by an endpoint device according to the first aspect. The method comprises receiving a data request for a type of data from an application installed on the endpoint device for providing a service to an end consumer or to a utility provider, accessing first data of the type of data from a database at the endpoint device, based on the type of data, checking metadata associated with the first data to determine a validity of the first data. The method further comprises, when the first data is determined to be valid, sending the first data to the application, when the first data is determined to be not valid, sending to a central application data management module a data request for the type of data, receiving from the central application data management module second data of the type of data, storing the second data in the database, sending the second data to the application.
- According to a third aspect there is provided a system in a distribution network. The system comprising a central application data management module configured to obtain first data having a type of data, tag the first data with metadata based on the type of data to create second data, and broadcast or multicast the second data to a plurality of endpoint devices.
- The central application data management module can schedule data pushes and provide synchronization on a randomized schedule, while also segmenting the complete push into multiple smaller pushes. The module can be configured to generate events at the system to notify interested entities (e.g. service providers) that a particular type of data has arrived.

The central application data management module may be comprised by a head end system (HES). The HES may be the HES of a power distribution network comprising an advanced metering infrastructure (AMI). Application data received by the central data management module originating from applications at the endpoint devices can be
5 routed internally within the HES for further processing, analysis or presentation or may be routed to an external entity such as a client server. The routing may be performed by the central application data management module or by a separate entity of the central system, which may be referred to as a data broker. The central data management module may flag to the data broker when data becomes available, and/or
10 may store new data in a database that is accessible by the data broker. The data broker may also be configured to cause the central application data management module to be provided with the first data, and may coordinate with external data sources to provide the first and further data to be broadcast or multicast to endpoint devices. The plurality of endpoint devices may be comprised by a communication
15 network, such as a mesh network.

The central application data management module can be further configured to receive a data request for the type of data from an endpoint device of the plurality of endpoint devices, and, in response to receiving the data request, send the second data directly
20 to the endpoint device. In this way, if an individual endpoint device fails to receive the broadcast/multicast data, then the central system can supply it on demand.

The central application data management module can be configured to, at predetermined intervals (e.g. every 24 h), download further data having the type of data
25 from an external server, tag the further data with metadata based on the type of data to create tagged further data, and broadcast or multicast the tagged further data to the plurality of endpoint devices. For example, weather data may be downloaded at set times and multicast to the appropriate endpoint devices.

The system may further comprise a database for storing data, wherein the central application data management module can be configured to store the second data in the database, and, in response to receiving the data request, retrieve the second data from the database. The database can be optimised for the system and may store the data with the relevant metadata for efficient retrieval by the central application data
30 management module.
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The central application data management module can be further configured to parse the first data to determine one or more parameters, and based on a parameter of the one or more parameters, determine the plurality of endpoint devices. For example, the
5 module can parse the data to determine that the data is associated with a particular location or region, and may then determine the endpoint devices that are located in or otherwise associated with that region to broadcast or multicast the data to. For example, the parameter may indicate the location in which the first data was sourced (e.g. where a measurement was performed to obtain the first data), and wherein the
10 plurality of endpoint devices is associated with the location.

According to a fourth aspect there is provided a method of managing data in a distribution network. The method may be carried out by the system according to the third aspect described above. The method comprises obtaining first data having a type
15 of data, tagging the first data with metadata based on the type of data to create second data, and broadcasting or multicasting the second data to a plurality of endpoint devices.

The method may comprise receiving a data request for the type of data from an
20 endpoint device of the plurality of endpoint devices, and in response to receiving the data request, sending the second data directly to the endpoint device. Hence, if one or more endpoint devices fail to receive the broadcast or multicast data, the system can supply the data on demand (when required/requested by an application on that endpoint device).

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Brief description of drawings

FIG. 1 shows a schematic diagram of a distribution network;

FIG. 2 shows a schematic diagram of a part of a data management system;

30 FIG. 3 shows a schematic diagram of a part of a distribution network;

FIG. 4 shows a flow diagram of a method of managing application data in a distribution network

FIG. 5 shows a schematic diagram of data transport facilitated by an application management module.

Detailed description

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Aspects of the present disclosure may be advantageously implemented in a distribution network for managing data of applications on endpoint devices such as utility meters.

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FIG. 1 shows a portion of an exemplary distribution network. A substation 110 is connected to a distribution network 175, such as a power grid, and is in turn connected to transformers 120, 130, 160, 162, 164. Meters 140, 142, 144, 146, 148, 150 are connected to transformers 120 and 130.

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The meters can communicate with a head-end system 100. In one example, multiple meters are connected via a wireless mesh network. A device in the network, such as a collector or PAN coordinator, may facilitate the communication of data from the wireless mesh network to the head-end system 100 via one or more networks 170. Other types of communication between the meters and the head-end system 100 are also possible including, but not limited to, cellular communications and power line communications.

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A meter may communicate consumption information to the head-end system 100, as well as other information measured or detected by the meter. In some examples, the meter communicates voltage information to the head-end system. The voltage information may be associated with a time interval, such as a 15 minute interval. The meter may provide voltage information for multiple time intervals over multiple days. The head-end system may maintain voltage information provided by the meters in a database 102 or other data storage facility.

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The head-end system may also maintain other types of information about the meters and other devices in the distribution network. For example, GIS information describing the location of a meter or a transformer may be maintained. In some networks, the head-end system also receives data related to the operation of a device other than a meter, such as a substation, a transformer, or other device. The distribution network

may be a power grid, a gas distribution network, or a water distribution network for example.

5 The distribution network may comprise an application management platform. The application management platform can be used to manage applications, which run on the endpoint devices. The platform can support device registration for both residential and commercial devices integration with an application marketplace, and secure new application download and application upgrades.

10 FIG. 2 shows a schematic diagram of a part of a data management system 200. The system comprises a central system 202 (e.g. a HES or a part of a HES), and a plurality of endpoint devices 204 (two shown). Each endpoint device 204 comprises a plurality of applications 206, comprising both native applications 206a of the endpoint device, and non-native applications 206b (e.g. third party applications installed after deploying
15 the endpoint device 204, which may be installed remotely over a wired or wireless network).

The endpoint devices form a communication network, which may be a mesh network, or another network suitable for endpoint devices, such as meters. The endpoint
20 devices can be configured to execute different software applications 206 to provide various functionalities and services to end consumers or to the utility provider. Different endpoint devices may comprise different sets of software applications 206 and therefore provide different services.

25 The endpoint devices 204 may be internet of things (IoT) grid sensors used to provide services to both the utility provider and the end consumer. The endpoint devices 204 can be configured to sample, process, store, and deliver data in real-time. For example, the endpoint devices may be meters configured to sample, process, store and deliver consumption data.

30 Each endpoint device 204 further comprises an application data management module 210 (also referred to as "data module" 210 for short), which can be implemented with one or more processors and instructions stored on the device 204. The data module 210 is configured to manage data of the applications 206 on the device 204. The data
35 module is configured to supply to the applications 206 with the data required by the

applications 206 to provide a service or perform a function associated with the application 206. The data module can also be configured to receive data provided by the applications 206 and to send the received data to other endpoint devices and/or to the central system 202. For example, the data module 210 can be configured to parse data from the applications to determine transmission parameters. For example, the data module 210 can be configured to map a data type to one or more destination addresses and send the data to other data modules at the corresponding addresses. The data module can be configured to determine the transmission parameters from the data source. For example, the data module 210 can be configured to map the identity of the application 206 to a destination address. The data module can be configured to establish a secure connection 212 with one or more data modules 210 of other endpoint devices in the same network. The secure connection can then be used to send and receive application data associated with a plurality of different applications between endpoint devices 204, while only requiring the one connection, instead of each application 206 having to establish a separate connection. Similarly, the data module 210 of an endpoint device 204 is configured to establish a single secure connection 214 to the central system 202 for sending and receiving application data associated with multiple applications 206 on an endpoint device 204, rather than each application 206 having to connect and communicate with the central system 202 directly. The data module 210 can be configured to communicate over the secure connections 212, 214 using a protocol suitable for endpoint devices such as CoAP or protocol buffer ("protobuf").

CoAP is an application layer protocol for edge devices and applications. The CoAP uses a transfer protocol based on Representational State Transfer (REST) on top of HTTP functionalities. REST is a cacheable connection protocol that relies on the stateless client-server architecture. It represents a proper way to exchange data between clients and servers on top of HTTP. It can be used in mobile-based social network applications and can reduce complexity by using HTTP methods (i.e. get, post, put, and delete). The CoAP may be particularly advantageous for battery powered devices with limited CPU and RAM resources.

Protocol buffers provide a method of serializing data that can be transmitted between applications or used in communication between endpoint devices and servers. Protocol buffers are both language-neutral and platform-neutral. Protocol buffers can be

advantageous for using little network bandwidth and by minimizing the size of transmitted data.

5 The applications 206 may enhance energy management for utility providers and end consumers. For example, the applications 206 may provide meter-based flexible billing and demand management used for billing and load management programs, as well as applications 206 that use the endpoint devices 204 as a distribution network sensor.

10 The endpoint device 204 comprises a database 216 for storing application data. The data module 210 can be configured to store data in the database 216 and to retrieve data from the database 216. For example, the data module 210 may receive data that may be required by one or more applications 206, and may store the data in the database 216. The data module 216 can then retrieve the data from the database
15 when the data is requested by an application 216. The database can be configured to store the data with metadata for efficient retrieval and checking by the data module 210. For example, the data may be stored in a format comprising a time stamp, a keyword (e.g. indicating the type of data, and a value (e.g. a temperature in case of weather data).

20 The central system 202 comprises a central application data management module 218 (referred to as "central data module" 218 for short). The central data module 218 is configured to obtain data, tag the data with metadata based on the type of data, and broadcast or multicast the data (with the metadata) to the endpoint devices 204. The central data module 218 can be configured to obtain the data by retrieving it from a
25 database 220, which may be populated by a different entity of the central system 202. Alternatively or in addition, the central data module 218 may download data from an external server or receive data directly from another entity 219 of the central system 202, which may have downloaded the data from an external server. For example, the central data module 218 can be configured to obtain weather data for one or more
30 locations. The central data module 218 can broadcast the data to all endpoint device 204 or can parse the data to determine a set of appropriate endpoint devices 204, and multicast the data to that set of endpoint devices 204. For example, the set of endpoint devices 204 may be associated with a location with which the data is also associated (e.g. weather data may be associated with a location, for example, by a zip code).

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FIG. 3 shows a schematic diagram of a part of a distribution network 300. The network 300 comprises a central system 302, typically a HES or part of a HES, comprising a central application data management module 318 and database 320, which may be the central data module and database described in relation to FIG. 2 above.

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The central system 302 further comprises a data broker 319 being a software module of the application management platform that may be implemented by one or processors and computer readable instructions stored in the central system. The data broker 319 is configured to provide data transport services, both for internal services 10 321 of the central system 302 and external entities such as customers 323 and external third party applications. The data broker 319 can be configured to provide customized routes for transporting the data depending on the type of data, the data source and the destination. For example, the data broker 319 can be configured to use virtual private networks (VPNs), and different data consolidation/packaging for transport, as well as encryption. The data broker 319 can provide new data on 15 demand, for example when receiving a data request from the central data management module 310. The data broker 319 can be configured to provide data directly to central data management module 310, for example via the bus 325, and/or to store the data in the database 320. The data broker 319 may also be configured for direct data transport 20 from one or more applications on the edge devices 304 over the UDP (user datagram protocol) port 322.

The distribution network further comprises an edge network 324 (e.g. a mesh network) connecting a plurality of endpoint devices 304 (two shown). The endpoint devices 304 25 may be the endpoint devices described in relation to FIG. 2 above. Each endpoint device 304 comprises a data module 310 for managing application data of applications installed on the device 304. The edge network 324 is connected to the central system 302 via a gateway (GW) 326. The gateway 326 is connected to central data management module 318 in the central system 302.

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FIG. 4 shows a flow diagram of a method of managing application data in a distribution network. The method comprises receiving a data request for a type of data from an application installed on an endpoint device (Step S400), accessing data and checking metadata (Step S402). Check of the data is valid (Step S404). When the first data is 35 determined to be valid, the method comprises sending the data to the application (Step

S406). When the data is determined to be not valid (e.g. due to being out of date), the method comprises sending to a central application data management module a data request for the type of data requested by the application (Step S408), receiving from the central application data management module new data of the type of data (Step S410), and sending the new data to the application (Step S412). The method may also comprise storing the new data in a database.

In a particular embodiment described below, the type of data is weather data usable by one or more applications installed on endpoint devices (e.g. utility meters). The weather data may need to be delivered to each endpoint device at given intervals (e.g. every 24 hrs). This can be achieved by broadcasting or multicasting the data to the endpoint devices. However, some data modules at the endpoint devices may not receive due to packet losses on the mesh.

When an application on an endpoint device requests, weather data from the data module, the data module can check the timestamp of the weather data. If the timestamp indicates that the weather data was not from the most recent interval (e.g. it is greater than 24 hours), the data module can directly send a data request to the central data module for the weather data (point-to-point), and then delivers the (new) weather data to the application after it receives the data from the central data module.

Figure 5 shows a schematic diagram of data transport facilitated by an application data management module 510. In particular, the diagram shows an internal process communication (IPC) message 501 comprising an application payload 503 and meta data 504 (e.g. comprising an application name, a time stamp and/or a priority level) provided by an application at an endpoint device (not shown) is pushed onto the mesh network 524 (and/or a cellular network 525) by an application data management module 510 of that endpoint device, and transmitted over the mesh network 524 to a central system 502 (e.g. a HES comprising a central application data management module).

The IPC message 501 is put into a queue 506A, 506B before being processed by the application management module 510. For example, a message 501 comprising metadata 504 indicating a high priority level may be put in a first queue 506A, while a message comprising metadata indicating a lower or standard priority level may be put

into a second queue 506B. The queue 506A, 506B may comprise a number of messages 501A to 501N with corresponding payloads 503A to 503N and metadata 504A to 504N. Messages move down the queue as indicated by the arrows as the application data management module 510 processes earlier messages. The application data management module 510 can be configured to process messages from the queues at a pre-defined ratio. For example, the application data management module can be configured to process a plurality of messages in the first queue 506A for every one message processed in the second queue 506B. For example, a good balance between servicing high priority messages while still servicing standard messages in a reasonable time may be had by setting the ratio at 3 to 1. That is, the application management module 510 may be configured to process three messages in the priority queue 506A for every one message processed in the standard queue 506B. High priority messages may be messages associated with system management.

The application data management module 510 processes the queued message 501 and generates therefrom a new message 507 comprising metadata 508 and the payload 503 for pushing onto the mesh 524 and/or cellular network 525. The new message 507 may have a custom format for communication between application data management modules. The application data management module 510 can be configured to set transport parameters for transmitting the message 507. For example, transport parameters may comprise one or more of: ideal interval spacing, minimum interval spacing, maximum interval spacing, and bandwidth (BW) limit. The message 507 is transmitted in packets 515 based on the transport parameters. For example, a time interval 516 between consecutive packets 515 may be randomized within the minimum and maximum interval spacing limits. When multiple endpoint devices are transmitting data, this randomization can provide a beneficial "jitter" in the data flow.

Whilst Figure 5 illustrates data transport from an endpoint device towards a central system 502, the diagram for data transport from a central application management module towards the endpoint devices would look the same, except that the initial message would not be an IPC message, and would instead typically be a REST API message, that is then processed by the central application management module and pushed out onto the mesh network 524 towards the endpoint devices.

The data transport illustrated in Figure 5 may be used by the embodiments illustrated in Figures 2 and 3.

- 5 While specific embodiment have been described above, the skilled person will appreciate that further embodiments falling within the scope of the claims are possible. The features of any one embodiment may be suitably combined with those of one or more other embodiments.

CLAIMS:

1. An endpoint device in a distribution network comprising:
an application installed on the endpoint device for providing a service to an end
5 consumer or to a utility provider; and
a database for storing data; and
an application data management module for supplying data to the application,
wherein the application data management module is configured to:
receive a data request for a type of data from the application;
10 access first data of the type of data from the database;
based on the type of data, check metadata associated with the first data
to determine a validity of the first data;
when the first data is determined to be valid, send the first data to the
application;
15 when the first data is determined to be not valid,
send to a central application data management module a data
request for the type of data;
receive from the application data management module second
data of the type of data;
20 store the second data in the database; and
send the second data to the application.
2. An endpoint device according to claim 1, further comprising a second
application or providing another service to an end consumer or to a utility provider,
25 wherein the application data management module is configured to:
receive a data request for the type of data from the second application;
access the second data from the database;
based on the type of data, check metadata associated with the second
data to determine a validity of the second data; and
30 when the second data is determined to be valid, send the second data
to the second application.
3. An endpoint device according to claim 1 or 2, wherein the metadata comprises
at least one of a timestamp, a utility meter identifier, and a data source identifier.

4. An endpoint device according to any one of the preceding claims, wherein the application data management module is configured to check the metadata by comparing a parameter of the metadata to a corresponding nominal parameter or parameter range.
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5. An endpoint device according to claim 4, wherein the parameter of the metadata comprises a time stamp and the application data management module is configured to compare the time stamp to a current time.
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6. An endpoint device according to any one of the preceding claims, wherein the data module is configured to receive data requests from a plurality of applications installed at the endpoint device and in response supply data to the plurality of applications.
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7. A method at an endpoint device for managing data in a distribution network, the method comprising:
- receiving a data request for a type of data from an application installed on the endpoint device for providing a service to an end consumer or to a utility provider;
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- accessing first data of the type of data from a database at the endpoint device;
- based on the type of data, checking metadata associated with the first data to determine a validity of the first data;
- when the first data is determined to be valid, sending the first data to the
- 25
- application;
- when the first data is determined to be not valid,
- sending to a central application data management module a data request for the type of data;
- receiving from the central application data management module
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- second data of the type of data;
- storing the second data in the database; and
- sending the second data to the application.
8. A system in a distribution network, the system comprising:
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- a central application data management module configured to:

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obtain first data having a type of data;

tag the first data with metadata based on the type of data to create second data; and

broadcast or multicast the second data to a plurality of endpoint devices.

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9. A system according to claim 8, wherein the central application data management module is further configured to:

receive a data request for the type of data from an endpoint device of the plurality of end point devices; and

10 in response to receiving the data request, send the second data directly to the endpoint device.

10. A system according to claim 8 or 9, wherein the central application data management module is further configured to:

15 at predetermined intervals, download further data having the type of data from an external server;

tag the further data with metadata based on the type of data to create tagged further data; and

20 broadcast or multicast the tagged further data to the plurality of endpoint devices.

11. A system according to any one of claims 8 to 10, further comprising a database for storing data, wherein the central application data management module is further configured to:

25 store the second data in the database; and

in response to receiving the data request, retrieve the second data from the database.

12. A system according to any one of claims 8 to 11, wherein the central application data management module is further configured to:

30 parse the first data to determine one or more parameters; and

based on a parameter of the one or more parameters, determine the plurality of endpoint devices.

13. A system according to claim 12, wherein the parameter indicates a location in which the first data was sourced, and wherein the plurality of endpoint devices is associated with the location.

5 14. A method of managing data in a distribution network, the method comprising:
obtaining first data having a type of data;
tagging the first data with metadata based on the type of data to create
second data; and
10 broadcasting or multicasting the second data to a plurality of endpoint
devices.

15. A method according to claim 14, further comprising:
receiving a data request for the type of data from an endpoint device of the
plurality of end point devices; and
15 in response to receiving the data request, sending the second data directly to
the endpoint device