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USER GUIDE
AUG-10022-24

FlexNet Enhanced Supervisory Message (ESM)

SENSUS
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Revision history

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Contents

Introduction 1

Terminology 1

Enhanced Supervisory Message 1

ESM data types 2

Load profile (C12.19) intervals 2

Load profile (C12.19) end readings 2

Snapshots 3

Prerequisites for processing 3

Process incoming messages 4

MCB not set 4

MCB set 4

Meter metadata 4

Identifying metadata changes 5

Updating metadata 5

Disabling metadata ping 6

Metadata management tables 6

READ_META_MASTER 6

READ_META_DETAIL 6

Backfill missing data 7

Backfill configuration settings 7

esm.maxBackfillDays 7

esm.backfillPeriod 8

Identifying missing sample points 8

ESM backfill process 8

Backfill requests 9

Backfill responses 10

Controlling ESM backfill 10

Disabling ESM backfill 10

Backup gap discovery 11

Read_Detail_Type_Id definitions 11

Special considerations 11
Backspool replay 11
Handle meters not in customer time zone 12
Troubleshooting 12

Introduction

The Enhanced Supervisory Message (ESM) enables the Sensus Advanced Metering Infrastructure (AMI) system to support the ESM from the endpoint.

Terminology

Term	Definition	Description
DB	Database	A Regional Network Interface (RNI) server that stores system information, particularly meter data and metadata.
ESB	Enterprise Service Bus	A framework for distributing services amongst network nodes where services are decoupled both spatially and logically.
FlexNet® Network	—	A wireless network consisting of Base Stations, FlexNet Remote Portals (FRPs), meters, and other wireless transceivers that collect, relay, or gather data intended for the RNI.
MCB	Metadata Configuration Change Bit	A bit value indicating that configuration/Metadata has changed. This bit will remain set until the meter sends a metadata ping response. Any configuration changes that cause the metadata message to change will set this bit. This could be a metrology change or a change to ESM configuration, such as a change to the Snapshot List or the Channel Configuration List.
Read Tables	FlexNetDB tables to store legacy and ESM meter reads	The read tables include `read_master`, `read_detail`, `read_detail_value`, and `read_detail_value_sub_value`.
RNI	Regional Network Interface	A set of servers that connects the RF Meter network to external systems. Legacy system is comprised of five servers: NC, DB, Web, Stats, and Map Server. Also includes an LDAP service hosted on one of the servers.
TGB	Tower Gateway Base Station	Main communication hub of the FlexNet network. Receives messages from meters and FNPs and transmits them to an RNI. Receives messages from an RNI and transmits them to meters and FNPs.

Enhanced Supervisory Message

The Enhanced Supervisory Message (ESM) transmits C12.19 load profile datasets, replacing the Legacy Supervisory Message (LSM) with a rich dataset that includes multiple channels. The interval data will be of variable length, unlike C12.19 data that contains non-ESM reads and is a fixed data length. To minimize the bandwidth requirements for delivery, the ESM data can be compressed by data type on a per-channel basis.

The advantages of ESM structure are as follows:

- Provides true C12.19 load profile data delivery from the meter.
- Allows for short interval durations (1 minute or less).
- Channels (1-255) can be configured, but channels greater than 7 are rare.
- Delivers load profile metadata, which is required for data processing, upon a request that is triggered by an indication of metadata configuration change.

ESM data types

The main types of data provided within the ESM are as follows:

- Load profile (C12.19) intervals
- Load profile (C12.19) end readings
- Snapshots

Load profile (C12.19) intervals

The most common data provided within the ESM are C12.19 load profile intervals. These are interval values (delta readings) that are taken by the meter metrology (native hardware) at time-aligned intervals and stored according to ANSI C12.19 standards in meter tables. When sending these values, the FlexNet® radio reads the values from the metrology tables to send them to the RNI. Each channel configured for load profile will have a value at every load profile interval. The FlexNet radio can be configured to suppress certain channels from delivery.

Load profile (C12.19) end readings

End readings provide a cumulative value, associated with the load profile readings, that is time-aligned with the intervals provided. For example, a load profile channel that measures kWh forward energy at specified intervals could also provide one cumulative kWh value for the channel at a configured time.

End readings are defined in the ANSI C12.19 specification for load profile. However, not all meter manufacturers implement the specification. There are alternatives for delivering end readings based on the meter device type:

- On the Sensus iConA Gen 3 Phase 3 meter, end readings are available at every interval, and the meter can provide this to the RNI.
- Because Honeywell meters do not natively support end readings, the meters must be configured as follows to receive end readings:
    - with registers to match the load profile data collection
    - to perform a midnight self-read

This allows the self-read to act as an end reading for the load profile channels. The end reading for Honeywell meters will be available only at midnight.

Regardless of meter type and the method used to get end readings, all end readings are taken by the meter metrology and are unmodified by the FlexNet radio or the RNI.

End readings can be configured to be provided automatically at multiple times, when available, depending on the transmit schedule of the meter.

Some meters can be configured to transmit only end reads and no interval reads. RNI supports this feature and backfills only the missing end reads.

For RNI versions 4.2 and 4.3, end readings are stored in the same row as the interval reads in read_value_sum column in the read_detail_value table.

From RNI version 4.4 to the latest version, end readings are stored in their own rows in the read_detail_value table. The end reading values are stored in the read_value column. The read_value_sum column is no longer used.

Snapshots

The third type of data provided within the ESM is a snapshot reading. A snapshot is a **non-time-aligned** reading that occurs at the time of ESM transmission. This enables a customer to configure a meter as follows:

- to take a reading once per transmit (rather than every interval)
- to measure certain values unavailable for load profile collection by the meter (such as click count)

The snapshot measurements are configured with the meter when the load profile channels are configured. There is no history of snapshots stored within the meter, so snapshot values can never be backfilled.

For RNI version 3.2 and later, ESM snapshots are no longer stored in the `read_detail_value` table. They are stored in the `snapshot_value` and `snapshot_value_sub_value` database tables.

Snapshots can also be processed when received in 32-bit floating point and 48-bit signed formats. When supported by the meter, individual snapshots can be transmitted using only 1 byte if the snapshot value can be fit within the byte. RNI supports this feature as well.

When supported by the meter, voltages can be transmitted in 2-volt resolution in addition to the native and 1-volt resolutions. RNI has been enhanced to support the low-resolution voltages.

Prerequisites for processing

To process an ESM, the RNI requires time zone, transmit rate, customer ID, and meter type along with the metadata that explains the ESM configuration on the meter. Each meter contains unique metadata, although it is likely many meters will be configured the same. Without knowing the metadata for the configuration of a meter, it is not possible to interpret the data received in the ESM from the meter. Metadata explains how the meter is collecting C12.19 data, and how the ESM is organized. It indicates to the RNI how the values found in the ESM should be interpreted, stored, and eventually reported.

If a meter sends an ESM but the RNI does not have current metadata for the meter, the RNI holds onto the ESM temporarily. The RNI does not process the ESM until the metadata that will allow interpretation of the ESM has been collected.

Process incoming messages

Processing an ESM involves a check for a flag from the meter that indicates that a metadata change has occurred on the meter. This indicator is the Metadata Configuration Change Bit (MCB).

MCB not set

If the MCB is not set, the RNI double-checks the database to make sure it has current metadata information for the meter in order to interpret the ESM. If it does not, it processes the message the same as described in the following section, “MCB set.”

If the metadata does exist in the database, the ESM payload is transformed and stored in the database. The same set of tables used for the legacy read process is used for the new ESM and C12.19 data and a mixed meter population.

MCB set

If the MCB is set, then the meter metadata information needs to be updated, and the ESM payload cannot be transformed immediately. In this situation, the following steps occur:

1. Any existing metadata known for the meter is marked as no longer valid. It is kept in the database for reference and for reporting on historical data.
2. The ESM payload is placed in a temporary holding table until the new metadata is collected.
3. A request for the new metadata is sent to the meter. The metadata response is then processed; any pending ESM payloads are retrieved from the holding table, and then read model transformation and storage proceeds.

Meter metadata

Metadata is the description of the ESM data. Enhanced Supervisory Messages consist of data from a given Load Profile data set. Therefore, metadata messages provide information about the given data set. Note that some meters support multiple Load Profile data sets, and each Data Set has its own read data and metadata definition. Please refer to the transceiver specification for the meter to determine how many Load Profile data sets are supported. It is not possible to interpret ESM read data without ESM metadata for the given data set.

Some attributes provided in the meter metadata include the following:

- number of data blocks
- number of intervals per ESM
- interval durations
- number of channels included in the ESM

- channel source and unit of measure (UOM) information
- ESM data compression type
- scalars and divisors to apply to pulse values for individual channels

The metadata also contains a report mask, which indicates the channels that are omitted in the ESM. The report mask enables the customer to configure one or more channels to be collected in the load profile data set in the meter, but not sent back to the RNI on a regular basis. Because the non-reported channel can be requested through a backfill ping, the data will be available when there is a reason to request it.

Many, but not all, of the metadata attributes are C12.19 values from decade 1 tables on the meter. Reading each of these tables individually is inefficient and causes high traffic on the FlexNet network. As a result, the FlexNet protocol includes a message that enables the meter to gather many values, store them in one message, and transmit them once.

Identifying metadata changes

When the metadata for a meter is reconfigured, it sets the Metadata Configuration Change Bit (MCB), indicating a configuration change. The MCB will be present in subsequent transmissions to signal the RNI to request a new set of metadata.

The meter will continue to send ESMs with the MCB set until the RNI acknowledges receipt of the messages by requesting the new metadata. After the new metadata is requested, the meter clears the MCB.

As the ESM configuration for a meter is changed multiple times, the RNI stores each copy of the metadata with timestamps indicating the start and end times. This approach enables the RNI to determine which metadata to use to process an incoming ESM. These times are explained in more detail in the following section.

Updating metadata

When the MCB detects a configuration change, the ESM engine begins to collect new metadata for the meter:

- The existing active metadata in the database is invalidated by setting an end time for the previous metadata for this meter. Because all metadata is timestamped, meter configuration can be correlated to a set of C12.19 meter reads for all samples collected over time.
- A metadata request is sent to the meter. The metadata message response will contain the timestamp of the meter configuration, which will then serve as the metadata start time. This metadata request will also clear the MCB flag for future ESMs.
- When the new metadata is received, it is stored in the FlexNet DB. The holding table is queried for ESMs that have been queued previously due to missing meter metadata. These ESMs are processed, and new data is translated and stored into the database.

- Metadata can be created or updated outside the ESM process by manually pinging for it. The ESM engine will process the metadata response message and store it in the database even if it did not send the request.

Disabling metadata ping

Metadata pings from the RNI can be disabled by setting RNI configuration `esm.suppressMetaPing` to true.

In addition, metadata pings can be selectively suppressed for just the meters that are not installed on the RNI by adding or setting the following property in the file `/opt/flexnet/flexnetapp/profiles/esm/conf/meter_read_stack.properties` on the Flexapp server and restarting ESM.

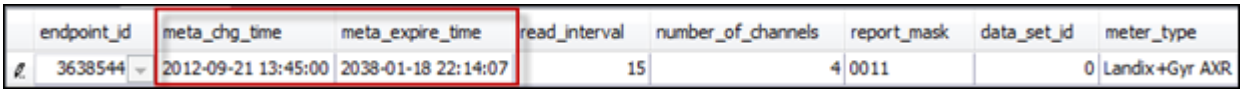
```
esm.read.esmdaservice.pingForMetadataOnlyIfMeterInInstalledState=true
```

Metadata management tables

Although table level knowledge is not required to manage a network of endpoints that use ESM, this section provides metadata traceability for technical personnel.

READ_META_MASTER

The Transmission Level view of metadata is provided by the `read_meta_master` table. The table includes the last metadata change time and the expiration time. This is the first table of interest when seeking registered metadata information.



endpoint_id	meta_chg_time	meta_expire_time	read_interval	number_of_channels	report_mask	data_set_id	meter_type
3638544	2012-09-21 13:45:00	2038-01-18 22:14:07	15	4	0011	0	Landix+Gyr AXR

```
select
  endpoint_id,
  dbo.fn_dt(dbo.fn_lt(metadata_change_time,101)) as meta_chg_time,
  dbo.fn_dt(dbo.fn_lt(end_time,101)) as meta_expire_time,
  read_interval,
  number_of_channels,
  report_mask,
  data_set_id,
  mt.meter_type as meter_type
from
  read_meta_master rmm
  left outer join meter_type mt ON (rmm.meter_type_id = mt.meter_type_id)
where
  rmm.endpoint_id = 3638544;
```

READ_META_DETAIL

The Channel Level view of metadata is provided by the `read_meta_detail` table. The table includes the `source_id` and `channel_data_key` that correspond to the measurements collected. The channels highlighted in the following image have corresponding `read_detail_value` rows. Channels 3 and 4 are purposely suppressed and are not included in the ESM payloads based on the `rpt_mask`.

endpoint_id	channel_id	src_id	rpt_mask	channel_data_key	channel_meta_chg_time	channel_meta_expire_time
3638544	1	0	☐	89	2012-09-21 13:45:00	2038-01-18 22:14:07
3638544	1	0	☐	41	2012-09-21 13:45:00	2038-01-18 22:14:07
3638544	2	20	☐	87	2012-09-21 13:45:00	2038-01-18 22:14:07
3638544	3	1	☑	88	2012-09-21 13:45:00	2038-01-18 22:14:07
3638544	4	5	☑	90	2012-09-21 13:45:00	2038-01-18 22:14:07

```
select
  rmm.endpoint_id,
  rmd.channel_id as channel_id,
  rmd.source_id as src_id,
  rmd.channel_report_mask as rpt_mask,
  rmd.read_detail_value_meta_id as channel_data_key,
  dbo.fn_dt(dbo.fn_lt(rmd.metadata_change_time,101)) as channel_meta_chg_time,
  dbo.fn_dt(dbo.fn_lt(rmd.end_time,101)) as channel_meta_expire_time
from
  read_meta_master rmm
  left outer join meter_type mt ON (rmm.meter_type_id = mt.meter_type_id),
  read_meta_detail rmd
where
  rmm.endpoint_id = 3638544
  and rmm.read_meta_master_id = rmd.read_meta_master_id
order by channel_id
```

Backfill missing data

When the RNI does not receive ESM from a meter for a certain amount of time, the RNI can ask the meter to send the missing data. This process is called backfill. This section explains the backfill process in detail, along with the configuration settings that can be used to control its behavior.

Backfill configuration settings

esm.maxBackfillDays

- Access the `esm.maxBackfillDays` setting from the following location:

  `Launch Pad > RNI Management > System Administration > Configuration > Configuration > Reads > ESM`

- The setting has a default value of 30. This value is used to identify the backfill period when the RNI first receives ESM data from a meter.

  Therefore, setting the `esm.maxBackfillDays` value to a large number will cause numerous backfill operations. If there are many meters in this stage, it could lead to network congestion. The following factors need to be considered for specifying the `esm.maxBackfillDays` value:

  - The value to the utility of the older data
  - The number of meters that are newly installed at any given time
  - The available network and RNI bandwidths

esm.backfillPeriod

Use the `esm.backfillPeriod` setting to dynamically control the backfill period. Only missing sample points that fit in the specified period will be backfilled. Specifying a backfill period is especially useful when there are large sets of missing data due to network issues and when there is no business need to retrieve all the missing data.

Identifying missing sample points

When the RNI receives the first ESM from a meter, it identifies the time period that needs to be backfilled. This period is determined by the `esm.maxBackfillDays` configuration setting and the metadata change time on the meter. The RNI attempts to backfill up until the latest of these two values.

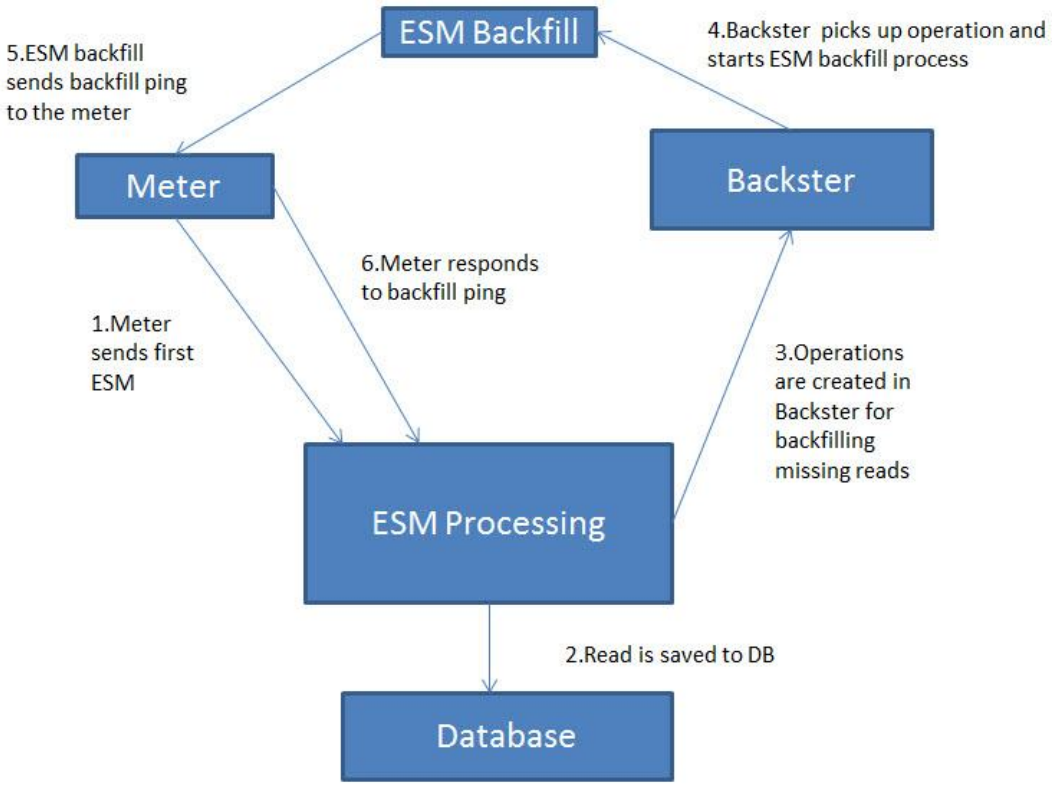
For example, if `esm.maxBackfillDays` is set to 3 and the latest metadata on the meter was changed a month ago, the backfill period is determined to be three days. However, if the metadata was changed just a day ago, the backfill period is determined to be one day. When the first ESM is processed, `NextGenBackfillEngine` (known as Backster) operations are created for the missing sample points in the backfill period, as explained in the next section.

When the RNI has ESM data for a meter and a new message is received, the RNI retrieves the latest existing sample point for that meter from the database. It also determines if there are any missing sample points in the database between the current message and the latest existing sample point. In case of dropped messages and power failures, this process will return a list of sample points to backfill, and records are created in `read_detail` table with `read_detail_type_id` of -1 as described above. The latest existing sample point will be null when the RNI processes an ESM from a meter for the first time.

ESM backfill process

When an ESM is processed and missing sample points need to be backfilled, Backster will be notified about the missing sample points. Backster operations are created in the `backfill_control_1` table; each operation corresponds to a contiguous series of missing sample points for a meter.

For example, when the first ESM is processed and the backfill period is determined for a meter, one Backster operation will be created that covers the entire identified backfill period for that meter. Note that no records are created in `read_detail` table with `read_detail_type_id` of -1 or -5 for the sample points in this case. Any new missing sample points identified for that meter, which are usually due to missed transmissions, will result in the creation of separate Backster operations, and will also create entries in `read_detail` table with `read_detail_type_id` of -1.



Backster schedules the operations to run in batches. Each operation corresponds to a backfill period for one meter, and the backfill period can range from one sample point to the entire backfill period. As a result, Backster runs the same operation multiple times until the entire period identified in the operation is backfilled. The operation is deleted after all the sample points covered by that operation are backfilled. Each operation has a limit on the number of retries and a total expiration period. If the operation is stuck on backfilling a set of sample points, due to bad transmission or any other issues, the operation is deleted after reaching the maximum number of retries. Each Backster operation also has an expiration period of three months, after which Backster permanently drops the operation.

Backfill requests

Backfill requests attempt to fill the most recent gaps first. Multiple intervals can be requested from the meter at one time, but multiple gaps cannot. That is, requests correspond only with contiguous boundaries for which data is missing. The number of sample points requested in each backfill request is the same as the number of sample points that the meter typically transmits in one ESM.

The request will attempt to backfill only sample points that fit in the timeframe specified by `esm.backfillPeriod`. If the parameter is set to 7, the request only backfills for the last seven days from the time Backster picks up that operation. Any Backster operation that attempts to backfill older sample points will be deleted. This sliding window constantly adjusts the sample points that can be backfilled with the passing of time.

Backfill responses

A response to a request for an ESM backfill is identical to an incoming ESM, but with a timestamp occurring in the past. Because of this, backfill responses are processed in the same manner as regular ESM. In addition, the previously missing intervals are now marked as backfilled in the database.

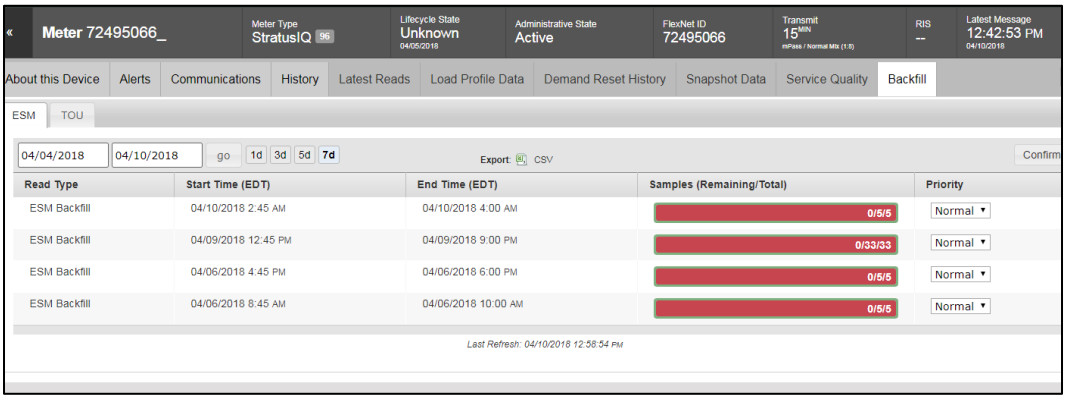
The backfill message responses will always contain the same channels configured to be sent in the supervisory message. If a channel mask is set up, and the meter is collecting a channel not being reported, the automated backfill process is unable to collect it. The unreported channel is available for collection, but not using the automated backfill process.

Snapshots are never included in backfill messages.

Controlling ESM backfill

Backster schedules backfill operations according to the priority of the operation. Operations backfilling midnight sample points get higher priority than the other sample points. This priority can be dynamically adjusted using the Backfill tab in Device Manager.

Each entry in this tab corresponds to a Backster operation for a contiguous set of missing data. The priority of each operation can be increased or decreased. Note that any priority changes do not take effect immediately. Backster will pick up the changes in its next scheduled run.



Disabling ESM backfill

The ESM backfill process can be disabled by modifying the following property in the `/opt/nextgenbackfill/conf/nextgenbackfill.properties` file on the NC server and restarting Nextgenbackfill.

```
ngb.esmBackfill.checkNewWorkSleepTime=0
```

Backfill can also be disabled selectively for meters that are not installed on the RNI. This can be achieved by adding or setting the following property in the file on the Flexapp server and restarting ESM.

`/opt/flexnet/flexnetapp/profiles/esm/conf/meter_read_stack.properties`

```
esm.read.esmdaservice.backfillOnlyIfMeterInInstalledState=true
```

This value defaults to false when not included in this file.

Backup gap discovery

Due to processing errors or manual deletions, there could be cases where there is no record for an interval in the `read_detail` database table. To ensure the contiguity of sample points, another process runs at scheduled intervals that will identify any such missing records. The process creates the records with `read_detail_type_id` of -5. The ESM backfill process creates Backster operations for these sample points so they can be scheduled to be backfilled. The backfill process also changes the `read_detail_type_id` from -5 to -1 after the Backster operations are created.

Read_Detail_Type_Id definitions

Type	Definition
0	ESM
1	Previously missing, now backfilled
-1	Missing, identified for backfill
-2	Permanently missing, does not backfill
-5	Identified as a gap by the backup gap discovery process, will be backfilled

Special considerations

This section explains how to handle cases that are outside the scope of normal ESM processing.

Backspool replay

When replaying one or more backspool files to re-process previously heard messages, special care must be taken to process ESMs properly. To account for possible metadata issues as messages are replayed, the RNI does not need to ping for metadata while processing replayed messages. See Updating metadata on page 5 for additional information.

Because the RNI does not need to ping for metadata while processing replayed messages, a configuration value exists in the RNI database that enables the customer to turn off ESM metadata requests. To turn off metadata requests, set the `esm.suppressMetaPing` RNI configuration parameter to true.

- Access the `esm.suppressMetaPing` setting from the following location:

  `Launch Pad > RNI Management > System Administration > Configuration > Configuration > Reads > ESM`

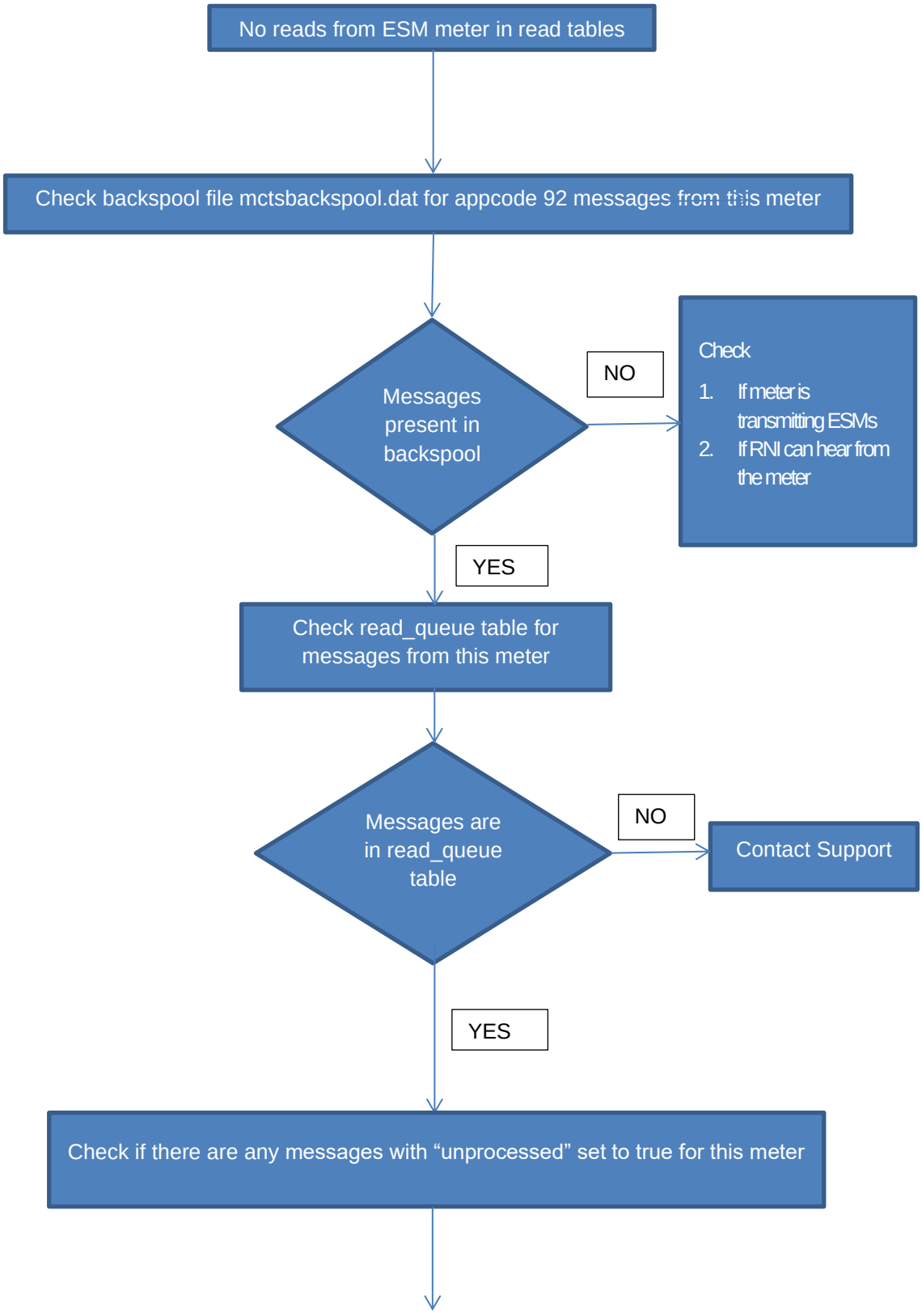
- It has a default value of false and should not need to be changed unless a backspool replay is occurring.

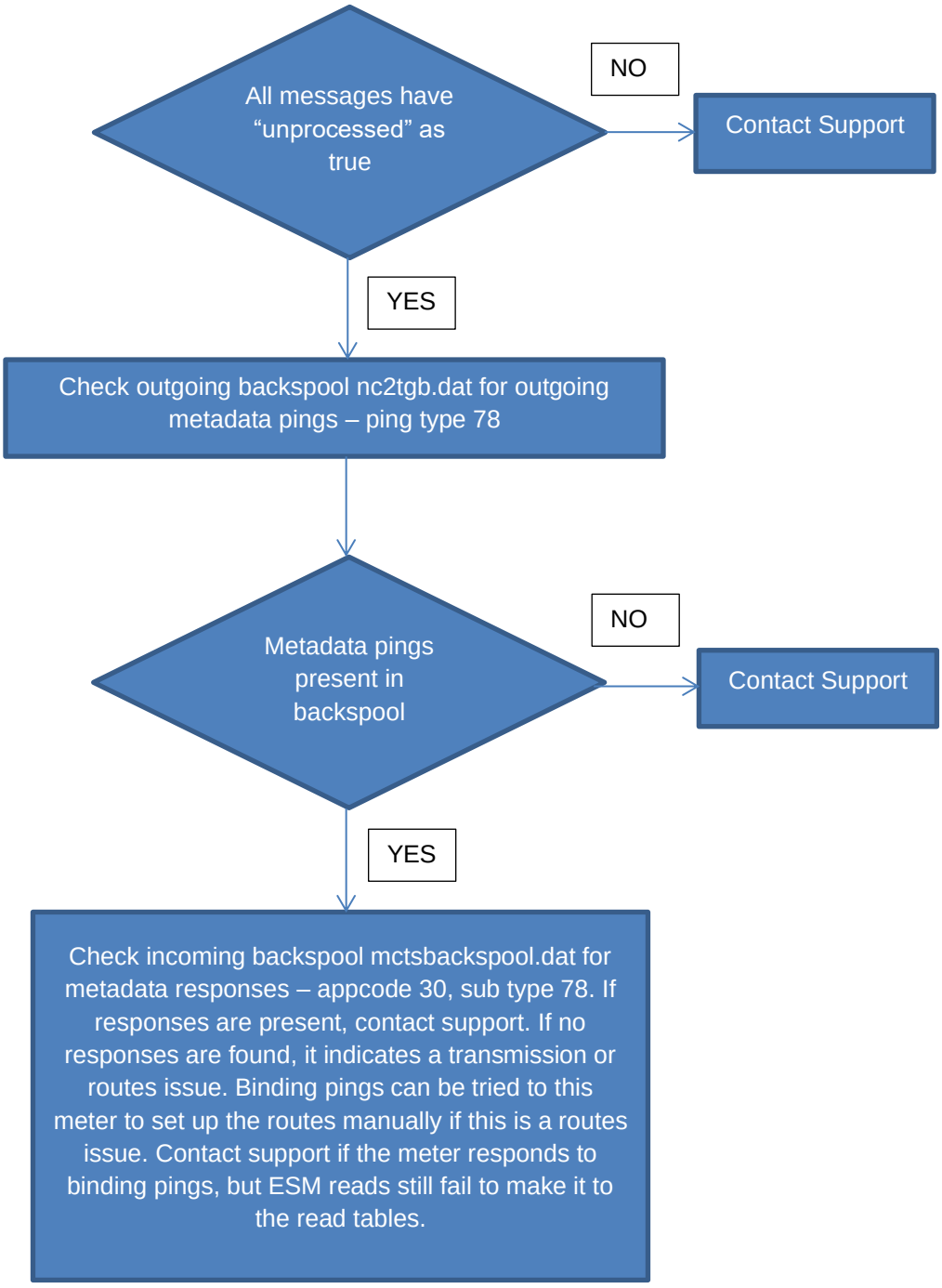
Handle meters not in customer time zone

The ESM flow starts processing an incoming ESM and request for metadata if the basic meter information (FlexNetID, customerID, transmit rate, meter time zone) is available in FlexNetDB. The basic meter information is populated in FlexNetDB when a setup message is received and when the time zone is set to the customer default time zone. If the customer has a meter that is not configured for the default time zone, the meter needs to be inventoried with the correct time zone through Meter Data Management Interface (MDMIF) before the meter is physically installed and any message can be heard from the meter.

Troubleshooting

If the reads from an ESM meter are not observed in the read tables such as `read_master`, `read_detail`, and `read_detail_value`, use the following flowchart for troubleshooting.


No reads from ESM meter in read tables
Check backspool file mctsbackspool.dat for appcode 92 messages from this meter
Messages present in backspool
NO
Check
1. If meter is transmiting ESMs
2. If RNI can hear from the meter
YES
Check read_queue table for messages from this meter
Messages are in read_queue table
NO
Contact Support
YES
Check if there are any messages with “unprocessed” set to true for this meter


All messages have “unprocessed” as true
NO
Contact Support
YES
Check outgoing backspool nc2tgb.dat for outgoing metadata pings – ping type 78
Metadata pings present in backspool
NO
Contact Support
YES
Check incoming backspool mctsbackspool.dat for metadata responses – appcode 30, sub type 78. If responses are present, contact support. If no responses are found, it indicates a transmission or routes issue. Binding pings can be tried to this meter to set up the routes manually if this is a routes issue. Contact support if the meter responds to binding pings, but ESM reads still fail to make it to the read tables.

Xylem |'zīləm|

1) The tissue in plants that brings water upward from the roots;

2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

For more information on how Xylem can help you, go to www.xylem.com

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