Use Case 29: Data Acquisition from External DMS Network Monitoring Subsystem

Summary:

This use case describes how an Energy Management System (EMS) could get analogue and status measurement data from an external Network Operations – Network Monitoring (NO-NMON) subsystem within a Distribution Management System (DMS). The measurement data could originate from a variety of sources including Remote Terminal Units (RTU), networked Intelligent Electrical Devices (IEDs), manual data entry or calculations within the Network Operations system. The NO-NMON subsystem will present all measurement information in a consistent manner regardless of the source.

Data maintenance and Telemetry network maintenance are considered separate use cases but relevant Actors and Systems are shown for reference.

This use case includes a very simple form of data discovery which returns a numeric key if a named measurement exists and an error return code if a named measurement does not exist. It is assumed that the EMS has some rules to define the set of names that it will attempt to discover.

This use case assumes a single context for all information exchanges.

Actor(s):

Name	Role description
Data maintenance technician	A person who maintains the data describing the electrical and telemetry networks. *{participates in pre-conditions only}*
Telemetry System	(External System) Provides information in the form of analogue measurements, status, or accumulator data from substation, neighboring control center, or field device.
Control engineer	A person who monitors and controls system operations

Participating Business Functions:

Acronym	Business Function Abstract Component	Services or information provided
AM AM-EINV	Records and asset management Substation and network inventory	*{participates in pre-conditions only}* Substation display Telecontrol database For example, the off-line definition database and functions within a SCADA system.
MC MC-TLM	Maintenance & Construction Telemetry Network	*{participates in pre-conditions only}* Telemetry Communications Links The physical telemetry network is considered an Actor within this use case.

Acronym	Business Function Abstract Component	Services or information provided
NO	Network operations	
NO-NMON	Network monitoring	Network switching state Data acquired from SCADA Data acquired from field crews For example, the real-time database and functions within a SCADA system.
EMS	Energy Management System	For example, network security and pricing calculations, load forecast.

Assumptions / Design Considerations:

0 Name/Structure cross-reference table

It is assumed that the EMS only requires a relatively static subset of the electrical network monitored by the DMS Network Monitoring component. For example, substations at the boundary of transmission and distribution networks may by monitored by one system with data supplied to the other.

The EMS and DMS components may have different internal representations of the power system network. If the EMS does not use exactly the same name and structure internally as the DMS, then it needs a set of cross-reference tables and/or rules to map the relevant DMS name/structure to the desired EMS name/structure.

For example, equipment with different nominal voltages at the same physical location ('a substation') may be represented in the DMS as belonging to several substations, one for each voltage level; and may be represented in the EMS as belonging to different voltage levels within a single substation.

This use case assumes an information exchange based on a simple hierarchy of Company, Substation, Equipment, [optional Terminal], Measurement names. An alternative is a multi-level description string using '/' or '\' characters to separate PowerSystemResource names.

"...For example the method used on the NERC ISN is a concatenated string approach (which follows the hierarchical problem well)

I/R/C/F/EO/T/P/VT where:

I=Interconnection
R=Region
C=Company
F=Facility
EO=Electrical Object (could be divided into Volt/Class/ID)
T=Terminal
P=Phase
VT=Value Type (i.e. quantity)

E/I/CE/8 FISK/38TR 72/12/A/MW

Means

Eastern Interconnection, MAIN Region, ComEd, Fisk Generation Plant, 138 KV Transformer 72, 12KV Winding Terminal, A Phase, MegaWatt
[source: Dennis Friend]

0 Interesting measurements

It is assumed that the EMS has rules for which types of measurements are applicable for different equipment types. These rules may depend on the particular EMS application e.g. Generation or Network Analysis. Information on equipment type is not exchanged as part of this use case. In other words the intelligence on which measurements are *useful* resides in the EMS and its data maintenance staff.

In this use case, the DMS is considered the master of the data and has the intelligence on which measurements are *available*. It is assumed that information on available, valid names for Company, Substation, ConductingEquipment and Measurements are made available to the data maintenance staff of the EMS system. Note that in order to decide which measurements to use, it may be necessary to supply additional information on the connectivity and normal topology of the DMS equipment. However, it is beyond the scope of this use case whether any of such information is supplied on paper or electronically.

0 Numeric keys or handles

SCADA systems will usually have some internal numeric key or handle for measurements that are used for fast lookups of values. These keys may have a specific meaning such as an array index or a C++ pointer address. In the latter case, the key is only valid whilst the process is running. However for the purposes of this use case, it is sufficient that these numeric keys can be passed to EMSs to allow faster information exchanges than using name strings.

0 Subscription table

It is assumed that the Network Operations – Network Monitoring component and/or associated middle-ware supports tables recording which measurements have been subscribed to.

It is also assumed that these subscription tables are automatically tidied up after a permanent loss of connection.

0 Analogue measurement limit processing & alarm states

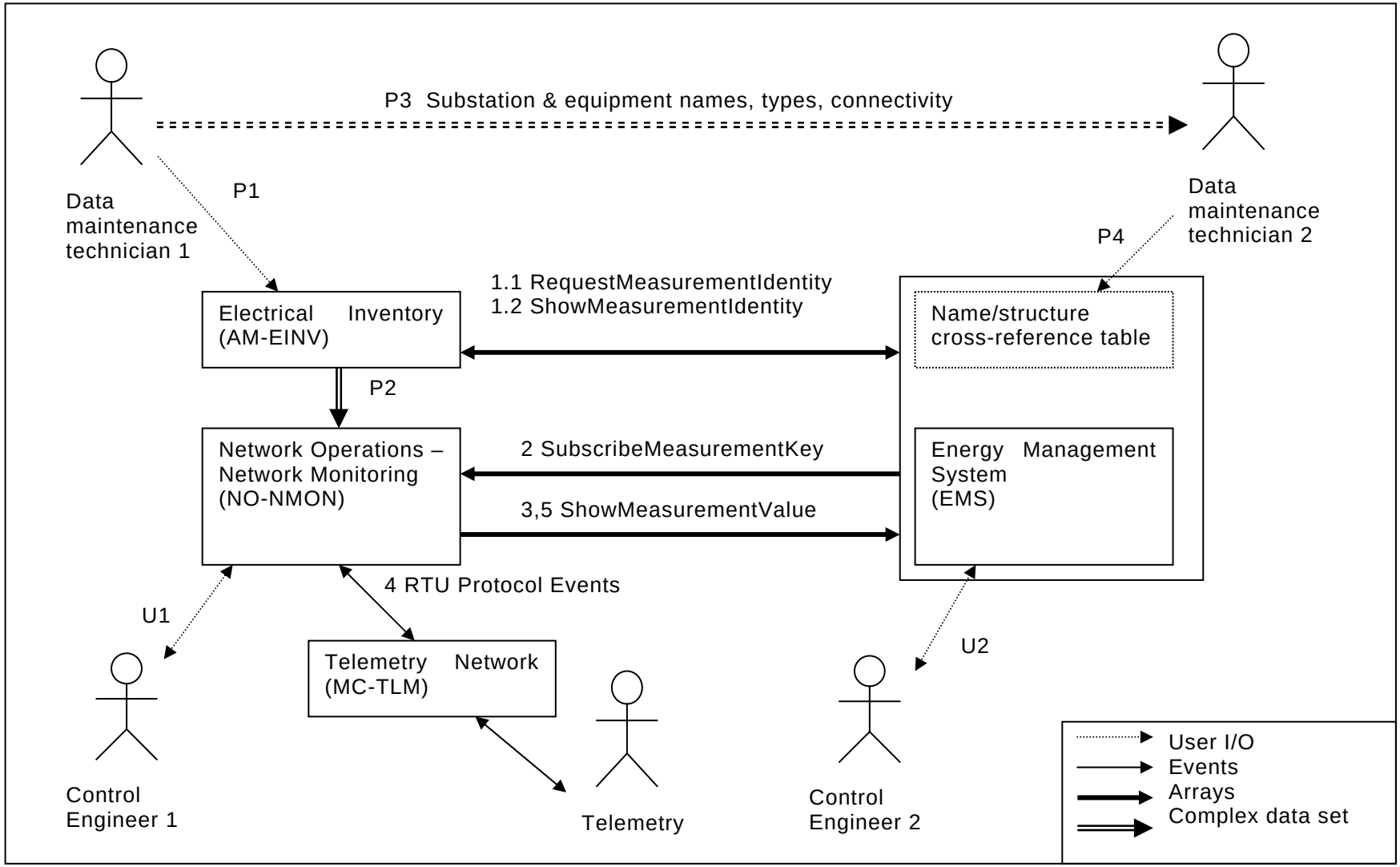
It is assumed that the Network Operations – Network Monitoring component compares analogue measurement values against limits and passes the alarm state to the EMS. The meaning of each alarm state must be passed to the EMS as part of the pre-conditions, not necessarily in an electronic from.

0 Status measurement values & alarm states

It is assumed that the Network Operations – Network Monitoring component produces numeric values for status measurements with pre-defined meanings. It is likely that the numeric status values correspond to a set of alarm states for each type of equipment and/or measurement. The meaning of each status value and/or alarm state must be passed to the EMS as part of the pre-conditions, not necessarily in an electronic from.

Integration Scenario Diagram:

This diagram shows the participating components and major information exchanges. The numbers refer to the sequence steps.



Pre-conditions:

P1. A data maintenance technician has defined the master inventory of the telemetry database.
P2. The telemetry database has been configured in the real time Network Operations – Network Monitoring system
P3 Information on names of Substations, Equipment and Measurements has been passed to the data maintenance staff of the EMS system
P4 If necessary, a set of identifier cross-reference tables has been set up within the EMS system to allow EMS system names to be translated into the names within the NO-NMON system.

Normal Sequence:

(This shows in time order, the sequence of information exchanges between the subsystems)

Use Case Step	Event	Description Of Process	Information To Be Exchanged	ProducerTo Receiver Abstract Component	Message Type (Verb/Noun)
1.1.	EMS requests mapping of names to keys	EMS sends list of names	Company.name Substation.name Equipment.name Measurement.name	EMS to AM-EINV (or NO-NMON)	RequestMeasurementIdentities
1.2.	Return numeric keys	looks up names zero or negative key means name(s) not found	As above plus MeasurementUnit.name Measurement.key	AM-EINV (or NO-NMON) to EMS	ShowMeasurementIndentities
2.	EMS subscribes to required measurements	EXT sends list of keys. NMON sets up subscription table.	Measurement.key	EMS to NO-NMON	SubscribeMeasurementKeys

Use Case Step	Event	Description Of Process	Information To Be Exchanged	ProducerTo Receiver Abstract Component	Message Type (Verb/Noun)
3.	NMON system sends current values. This is an implicit acknowledge-ment to the subscription request	For each entry in each subscription table find most recent value.	Measurement.key MeasurementValue .value MeasurementValue. .quality	NO-NMON to EMS	ShowMeasurementValues
4.	Telemetry system sends measurement event using RTU protocol	NMON Interprets RTU message; stores data in real time database; Calculates alarm states if any; raises alarms as necessary; logs changes as necessary;	Measurement.key MeasurementValue .value .quality .timestamp	In terms of IEC61970, this is all internal to NO-NMON	Not applicable
5.	NMON sends changed data values	Check EXT subscription table references for changed measurements	Measurement.key MeasurementValue .value .quality .timestamp .alarmState .source	NO-NMON to EMS	ShowMeasurementValues

Post Conditions

U1 The NO-NMON use interface is updated with new measurement values
U2 The EMS component contains a copy of the measurement values which are displayed on relevant user interfaces.

Exceptions / Alternate Sequences

A. Orderly exit / change of interest

Use Case Step	Event	Description Of Process	Information To Be Exchanged	ProducerTo Receiver Abstract Component	Message Type (Verb/Noun)
A1.	EMS unsubscribes to specified measurements	EMS sends list of keys.	Measurement.key	EMS to NO-NMON	Unsubscribe-MeasurementKeys
A2.	Confirm change in subscription (optional)	Removes keys from subscription list. A copy of these keys could be returned.	Measurement.key Or none.	NO-NMON to EMS	AckUnsubcribe MeasurementKeys

B. Lost connection

Essential: When connection is lost between NO-NMON and EMS for a significant time (minimum 0, maximum 24 hours), the subscription tables are deleted.

Possible: When connection is lost between NO-NMON and EMS for less than some configured time delay, then after reconnection, the measurement values are sent automatically for measurements in the subscription table. This is probably middle-ware dependent.

C. Telemetry Network status

As well as measurements for power network equipment, this interface could be used for measurements i.e. status of telemetry network equipment such as RTUs or CommunicationsLinks. It is not necessary to have standard types of non-conducting equipment as they can all be represented as generic PowerSystemResources.

D. Change in network model

If equipment is added or removed to either component model, then the models can be kept consistent by repeating the whole use case. If lists of the identity of equipment that has been inserted, deleted or updated are available, then it is feasible to un-subscribe and re-subscribe to data for the affected equipment.

E. Multi-level description

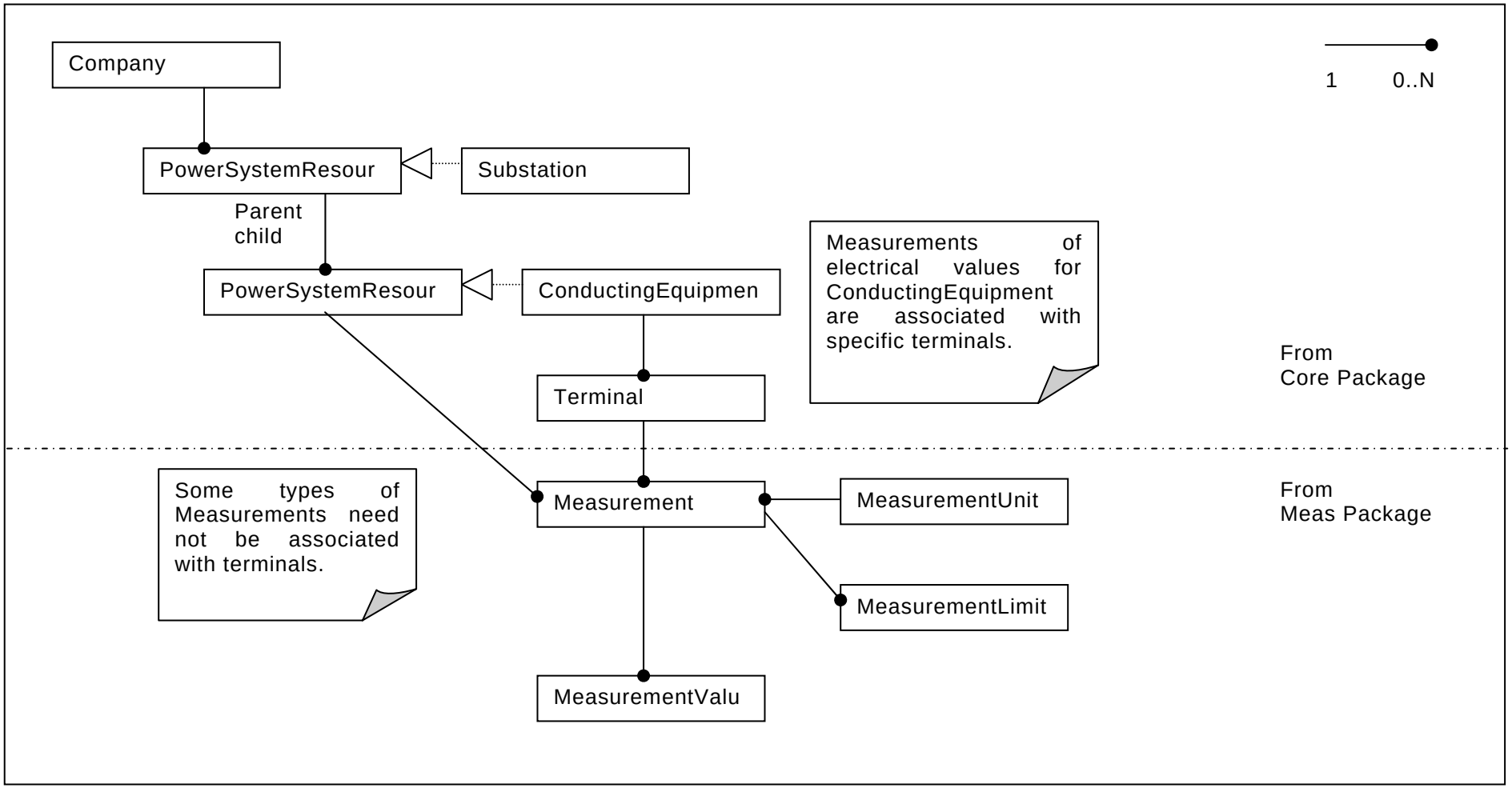
As an alternative to a fixed set of names as in step 1.1 and 1.2, the information exchange could be a single string which is a concatenation of the PowerSystemResource name hierarchy separated by a standard character e.g. ‘/’ or ‘\’.

F. Measurement message superset

As an alternative to the two-stage information exchange of (one) MeasurementIdentity and (many) MeasurementValue, it is feasible to put all the information into a single message structure.

Static Data Reference Model – Relevant classes from Core and Meas packages

This is an extract from the IEC61970 Common Information Model, i.e. a reference model that can support a wide range of standard interfaces. Most of these classes are used only to set up the initial subscription. MeasurementValue attributes represent dynamically changing data.



Information Model for normal sequence.

Class	Class Attributes	Attribute Type	Domain	Relations
Company	Name	String	Globally unique	Company(1).operates. (1..N)Substations
Substation {isA.PowerSystemResource}	Name	String	Unique within Company	Substation(1).parent. .child(1..N)ConductingEquipment {Inherit from PowerSystemResource}
Equipment = ConductingEquipment isA.PowerSystemResource}	Name	String	Unique with Substation	ConductingEquipment(1).has. (1..N)Terminals
Terminal	Name	String	Unique for type of equipment	Terminal(1).has. (1..N)Measurements
PowerSystemResource	Name	String		PowerSystemResource(1).has. (0..N)Measurements
Measurement	Name – Note 1 Key – Note 2	String Long integer		Measurement(1).has. (1)MeasurementUnit Measurement(1).has. (0..N)MeasurementLimit Measurement(1).has. (1..N)MeasurementValue
MeasurementUnit	Name – Note 3	Enumeration or String	kV, MW, MVAR, kA kW, KVAR, V, A etc.	
MeasurementLimit				Internal to NO-NMON system Or could be duplicated in EMS system
MeasurementValue	Value – Note 4	Double		Value of measured quantity
MeasurementValue	Quality	Bits		As IEC61850
MeasurementValue	TimeStamp – Note 2	Date/time		
MeasurementValue	AlarmState – Notes 2,5	Enumeration or String	NORMAL, HIGH, LOW etc.	
MeasurementValue	Source – Note 6	Bit mask, enumeration or String	METERED = RAW, DEFAULT, ESTIMATOR, CALCULATED, REMOTE	Internal to NO-NMON. If “Metered”, then the MeasurementValue is associated with Telemetry.

Note 1. IEC61970 is not clear on what Measurement.name means. Possibilities include:

The name of the quantity e.g. Potential, Current, Real Power, Reactive Power
The symbol of the quantity e.g. V, I, P, Q
The same as the unit name e.g. kV, A, MW, MVAR
As above with a suffix to indicate the measurement source e.g. MW01, MW02
As any of the above but translated into the local language.

Note 2. Additional to IEC 61970 Part 301 Common Information Model - Draft 5

Note 3. IEC 61970 will define a set of valid Units. A given implementation is likely to only support a subset e.g. kV not V, A not kA. Translation between these types of units could take place within either component. The optimal location will depend on the specific project implementation. It may be easier to add code to perform a specific translation than to add large numbers of derived measurements.

Note 4. The value for analogue measurements is of type double. The value for status or counter measurements may be an integer number but this could be coded as a double anyway. The meaning of the status numeric values must be supplied to the EMS as a pre-condition.

Note 5. The permitted values of alarmState are the recorded as MeasurementLimit.name and must be available within the EMS as a pre-condition. The alarmState could also represent the meaning of status numeric values as above. Valid alarm states will depend on the type of equipment and the type of status measurement.

Note 6. IEC61970 is not clear whether there is a standard set of possible values for the source attribute or whether it is an implementation specific string.
Issues include:

a. Some external applications such as a State Estimator need to distinguish between types of measurement source, particularly between raw telemetered measurements and others. This could be done using Quality bits.
b. The intelligence to decide on the ‘best’ measurement value may be application specific.
c. It is feasible that a system will have multiple transducers or telemetry communication paths for the same quantity. This could be dealt with by
    i. Many messages with different message header context information, one measurement name and key;
    ii. One message header context, many measurement names and keys;
    iii. One message header context, one measurement name and key, possibly many MeasurementValue.sources.

The method adopted affects the information exchanges that map measurement names to keys. It is clearly desirable to have the same Measurement name for a quantity regardless of the source of the data. This use case assumes a single context and hence multiple MeasurementValue.sources.

Measurement Quality and Source flags

Attribute name	**Description**	**OPC**

Attribute name	Description	OPC
	Copied from 61850-7-3	
badReference	The sensor calibration is bad.	QUALITY_SENSOR_CAL
commFailure	Value is not valid due to a communication failure.	QUALITY_COMM_FAILURE
blocked	Value is blocked (unavailable) for transmission.	QUALITY_OUT_OF_SERVICE
substituted	Value has been substituted, e.g. by input of an operator, or software.	QUALITY_LOCAL_OVERRIDE
nonTopical	Value is old and possibly invalid, as it has not been successfully updated during a specified time interval.	QUALITY_LAST_USABLE
invalid	Value may be incorrect and should not be used.	QUALITY_BAD
overFlow	Value is beyond the capability of being represented properly. E.g. counter overflow	
overRange	Value is beyond a predefined range of value.	QUALITY_EGU_EXCEEDED
transientState	Value is due to a transient condition.	
defaultValue	Value is a default value	
test	Value is transmitted for test purposes.	
	Proposed to match OPC	
subNormal	Value is derived from multiple sources where the majority has less than required good quality.	QUALITY_SUB_NORMAL
configError	There is a server configuration error concerning this value.	QUALITY_CONFIG_ERROR
sourceError	The source of the value is not connected.	QUALITY_NOT_CONNECTED
	A device failure has been detected.	QUALITY_DEVICE_FAILURE
	A sensor failure has been detected.	QUALITY_SENSOR_FAILURE
	Additional quality from State Estimator	
estimatorReplaced	Value has been replaced by State Estimator.	
suspect	State Estimator has detected a bad measurement.	
	Possible flags to indicate measurement source	
remote	Value has been transferred from another control centre	
metered	Value has been read from a RTU or IED	
calculated	Value has been calculated within data acquisition subsystem	
operatorReplaced	Value has been substituted by the control centre operator	

Message Data Model

Each data structure uses attributes from the static reference model in the previous diagram.
In XML, each message type is a document that contains one to many data structures.
In IDL, each message type is a one-way method with an argument that is a sequence of data structures