DLMS/COSEM –
a smart standard for smart metering

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DLMS User Association
Presentation program

- A snapshot on DLMS/COSEM
- Smart metering requirements
- Extensions of the COSEM model for smart metering
- Conclusion
### DLMS/COSEM - Overview

#### COSEM interface classes

**OBIS identification system**

<table>
<thead>
<tr>
<th>Class name</th>
<th>Cardinality</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. logical_name (static)</td>
<td></td>
<td>octet-string</td>
</tr>
<tr>
<td>2. ..... (..)</td>
<td></td>
<td>.....</td>
</tr>
<tr>
<td>3. ..... (..)</td>
<td></td>
<td>.....</td>
</tr>
</tbody>
</table>

**Specific Method(s) (if required)**: m/o

1. .....              
2. .....              

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#### Media dependent lower layers

**COSEM application layer**

- Connection
- DLMS Messaging

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**COSEM**

- IEC 62056
  - 61
  - 62
  - 42
  - 46
  - 47
  - 53

**CEN**

- EN 13757 Part1
DLMS/COSEM scope
The DLMS User Association

- Formed in 1997
- 109 members (May 2008)
- 5 continents
- 48 countries

Utilities
Meter and system providers
System providers
Other
We all talk the same language…

COSEM: Application data modelling

DLMS: Data transport
DLMS compliant meters

- 23 manufacturers
- 89 types certified
Smart residential metering requirements

- Multi-energy
- Messages for the customer
- Load limitation
- Connect / disconnect for load & contract management
- Data security
- Firmware upgrade
- Status / Fraud monitoring
DLMS/COSEM projects – Netherlands

- Smart metering is mandated by the government –
  - 7 M residential Electricity + 6.5 M Gas meters + small C&I
- Driven by European Energy Efficiency Directive 2006/32/EC
- Rollout by Grid operators (GO)
Dutch NTA 8130 documents

- Developed in co-operation by utilities and manufacturers
- P3 IF between the E-meter and the concentrator is based on DLMS/COSEM
- P2 IF between E-meter and other meters is based on M-Bus (E-meter is master)
Smart metering project approach

Use cases and functional descriptions

Logical view of the system / meter provider

Functional view of the user (network operator, retailer, end user)

COSEM interface objects

Companion standard
- object model
- data security
- communication profiles
A possible architecture

Network services

Substation

Unit

Backhaul comms

Central Access Server

P4 IF

PLC OR

Wireless

Business processes of market participants:
• energy producers
• energy retailers
• network service providers
• metering service providers
• energy service providers etc.
• energy end users

End User Energy Services

Smart E-meter / House gateway

Gas meter

Water meter

Heat meter

Local E-generation

P0 IF

P1 IF

P2 IF

P3 IF

Network services

Central Access Server
E-meter shall read the gas meter: registers and load profiles

E-meter acts as M-Bus master, controls up to 4 M-Bus slaves

Install / de-install M-Bus devices

Commands to the gas meter: clock setting, alarm reset, valve control
Multi energy – COSEM solution (1)

- M-Bus master setup objects configure E-meters as M-Bus masters;
- M-Bus master value objects and profile generic objects hold values captured from M-Bus slave devices;
- M-Bus master disconnect control objects control disconnector devices of M-Bus slave devices (e.g. gas valves)
- M-Bus master control log objects log status changes of the disconnect device
### Multi-energy – COSEM solution (2)

**M-Bus master setup**

<table>
<thead>
<tr>
<th>Attribute(s)</th>
<th>Data type</th>
<th>Min.</th>
<th>Max.</th>
<th>Def.</th>
<th>Short name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. logical_name</td>
<td>octet-string</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x10</td>
</tr>
<tr>
<td>2. mbus_port_reference</td>
<td>octet-string</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x18</td>
</tr>
<tr>
<td>3. capture_definition</td>
<td>array</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x20</td>
</tr>
<tr>
<td>4. capture_period</td>
<td>double-long-unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x28</td>
</tr>
<tr>
<td>5. primary_address</td>
<td>unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x30</td>
</tr>
<tr>
<td>6. identification_number</td>
<td>double-long-unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x38</td>
</tr>
<tr>
<td>7. manufacturer_id</td>
<td>long-unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x40</td>
</tr>
<tr>
<td>8. version</td>
<td>unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x48</td>
</tr>
<tr>
<td>9. device_type</td>
<td>unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x50</td>
</tr>
<tr>
<td>10. access_number</td>
<td>unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x58</td>
</tr>
<tr>
<td>11. status</td>
<td>unsigned</td>
<td></td>
<td></td>
<td></td>
<td>x + 0x60</td>
</tr>
<tr>
<td>12. alarm</td>
<td>unsigned</td>
<td></td>
<td></td>
<td></td>
<td>m/o</td>
</tr>
</tbody>
</table>

**Specific methods (if required)**

<table>
<thead>
<tr>
<th>Method</th>
<th>m/o</th>
<th>Def.</th>
<th>Short name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. slave_install</td>
<td>O</td>
<td>x + 0x68</td>
<td></td>
</tr>
<tr>
<td>2. slave_deinstall</td>
<td>O</td>
<td>x + 0x70</td>
<td></td>
</tr>
<tr>
<td>3. capture</td>
<td>O</td>
<td>x + 0x78</td>
<td></td>
</tr>
<tr>
<td>4. reset_alarm</td>
<td>O</td>
<td>x + 0x80</td>
<td></td>
</tr>
<tr>
<td>5. synchronize_clock</td>
<td>O</td>
<td>x + 0x88</td>
<td></td>
</tr>
<tr>
<td>6. data_send</td>
<td>O</td>
<td>x + 0x90</td>
<td></td>
</tr>
<tr>
<td>7. set_encryption_key</td>
<td>O</td>
<td>x + 0x98</td>
<td></td>
</tr>
</tbody>
</table>

- M-Bus protocol parameters mapped to attributes
- Functions executed by invoking methods
Messages for the customer

Requirement: display standard messages on display and customer interface
- reason for disconnect
- threshold limitation
- impending credit shortage etc.
- also messages related to gas, water

COSEM solution:
- use instances of existing Data / Register / Extended register classes
- new OBIS codes:
  - 0.0.96.13.0.255: customer port
  - 0.0.96.13.1.255: display and customer port
Load limitation - key requirements

Triggers: set contract level, anticipate shortage (code red), credit low

Remote setting of thresholds (can be \(I_{\text{max}}\)), with plausibility check

Setting the thresholds shall be logged

If threshold exceeded, disconnect (local)

Manual reconnect by customer
Load limitation – COSEM solution

<table>
<thead>
<tr>
<th>Limit</th>
<th>0...n</th>
<th>class_id = 71, version = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attribute(s)</strong></td>
<td><strong>Data type</strong></td>
<td><strong>Min.</strong></td>
</tr>
<tr>
<td>1. logical_name</td>
<td>(static)</td>
<td>octet-string</td>
</tr>
<tr>
<td>2. monitored_value</td>
<td>(static)</td>
<td>value_definition_type</td>
</tr>
<tr>
<td>3. threshold_active</td>
<td>(dynamic)</td>
<td>threshold</td>
</tr>
<tr>
<td>4. threshold_normal</td>
<td>(static)</td>
<td>threshold</td>
</tr>
<tr>
<td>5. threshold_emergency</td>
<td>(static)</td>
<td>threshold</td>
</tr>
<tr>
<td>6. min_over_threshold_duration</td>
<td>(static)</td>
<td>double-long-unsigned</td>
</tr>
<tr>
<td>7. min_under_threshold_duration</td>
<td>(static)</td>
<td>double-long-unsigned</td>
</tr>
<tr>
<td>8. emergency_profile</td>
<td>(static)</td>
<td>emergency_profile_type</td>
</tr>
<tr>
<td>9. emergency_profile_group_id_list</td>
<td>(static)</td>
<td>array</td>
</tr>
<tr>
<td>10. emergency_profile_active</td>
<td>(dynamic)</td>
<td>boolean</td>
</tr>
<tr>
<td>11. actions</td>
<td>(static)</td>
<td>action_type</td>
</tr>
</tbody>
</table>

**Specific methods (if required)** m/o

- Allows specifying the value to be monitored
- Allows defining normal and emergency threshold, with over / under threshold duration
- Allows allocating the meter to emergency groups
- Allows to specifying the actions (scripts) to be executed
Connect / disconnect – key requirements

Connect: contract open, below threshold, credit ok, emergency over

Disconnect: above threshold, low credit, emergency, contract close

The breaker / valve is not a safety device!

Appropriate security (authentication)

All events must be logged
Connect / disconnect - COSEM solution (1)

Disconnected (0)

Connected (1)

Ready_for_reconnection (2)

remote_reconnect (a)

remote_disconnect (b)

manual_reconnect (e)

manual_disconnect (f)

local_disconnect (g)

remote_reconnect (d)
Connect / Disconnect – COSEM solution (2)

<table>
<thead>
<tr>
<th>Disconnect control</th>
<th>0…n</th>
<th>class_id = 70, version = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attributes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. logical_name</td>
<td>(static)</td>
<td>octet-string</td>
</tr>
<tr>
<td>2. output_state</td>
<td>(dyn.)</td>
<td>boolean</td>
</tr>
<tr>
<td>3. control_state</td>
<td>(dyn.)</td>
<td>enum</td>
</tr>
<tr>
<td>4. control_mode</td>
<td>(static)</td>
<td>enum</td>
</tr>
<tr>
<td><strong>Specific methods</strong></td>
<td></td>
<td>m/o</td>
</tr>
<tr>
<td>1. remote_disconnect()</td>
<td>m</td>
<td>x + 0x20</td>
</tr>
<tr>
<td>2. remote_reconnect()</td>
<td>m</td>
<td>x + 0x28</td>
</tr>
</tbody>
</table>

- Remote disconnect / reconnect
- Manual disconnect / reconnect
- Local disconnect (limiter, prepayment) / manual reconnect
- Control modes control the possible transitions (manual intervention)
- Controls electricity breaker or gas valve
- Works with Limiter class and scripts
Data security – key requirements

Access control

Encryption for confidentiality

Authentication to verify the origin and integrity of messages

Key management

Selective application of these tools
• Several associations are possible between the meter (its logical devices) and data collection systems
• Each association defines security level and scope of access
• No security: to find basic information
• Low level security: password
• High level security: mutual identification
Message security – COSEM solution (2)

- Ciphered APDUs transport secured messages
  - authenticated encryption
  - encryption only
  - authentication only
  - as required by security policy

- Selective authenticated access to attributes and methods: new access rights
## Security setup class

<table>
<thead>
<tr>
<th>Security setup</th>
<th>0...n</th>
<th>class_id = 64, version = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attribute(s)</strong></td>
<td><strong>Data type</strong></td>
<td><strong>Min.</strong></td>
</tr>
<tr>
<td>1. logical_name (static)</td>
<td>octet-string</td>
<td>x</td>
</tr>
<tr>
<td>2. security_policy (static)</td>
<td>enum</td>
<td>x + 0x08</td>
</tr>
<tr>
<td>3. security_suite (static)</td>
<td>unsigned</td>
<td>x + 0x10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Specific methods (if required)</strong></th>
<th><strong>m/o</strong></th>
<th><strong>Min.</strong></th>
<th><strong>Max.</strong></th>
<th><strong>Def.</strong></th>
<th><strong>Short name</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. security_activate</td>
<td>o</td>
<td>x + 0x28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. authentication_key_transfer</td>
<td>o</td>
<td>x + 0x30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. encryption_key_transfer</td>
<td>o</td>
<td>x + 0x38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Security policy determines if authentication, encryption or both apply globally
- Security suite defines algorithm: Galois / Counter mode based on AES 128
- Security activate method turns up security: A – E – AE
- Authentication and encryption keys transferred using AES key wrapping
- GCM implementation: see next slide
Galois / Counter mode authenticated encryption

Legend:
P = Plaintext
A = Additional authenticated data
EK = Encryption key
AK = Authentication key
IV = Initialization vector
C = Cipher text
T = Authentication tag
FC = Frame counter
SC = Security control

Associated data contain:
- Authenticated encryption: SC-AE II FC II Sys-Title II AK ; or
- Encryption only: Null ; or
- Authentication only: SC-A II FC II Sys-Title II AK II APDU
Firmware upgrade – key requirements

- **Triggers:** new functionality, optimization, bug correction
- **Meter data, configuration, metrology must remain unaffected**
- **Download only to selected meters (enable / disable)**
- **Download by broadcast, complete individually**
- **Validation:** success, or discard
- **Activation:** on request or automatically at pre-set time
- **All events must be logged**
## COSEM solution: Image transfer class

<table>
<thead>
<tr>
<th>Attribute</th>
<th>0…n</th>
<th>class_id = 18, version = 0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attribute</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logical_name (static)</td>
<td>octet-string</td>
<td></td>
</tr>
<tr>
<td>image_block_size (static)</td>
<td>double-long-unsigned</td>
<td>x + 0x08</td>
</tr>
<tr>
<td>image_block_transfer (dynamic)</td>
<td>image_block_transfer_type</td>
<td>x + 0x10</td>
</tr>
<tr>
<td>image_transferred_blocks_status (dynamic)</td>
<td>bit-string</td>
<td>x + 0x18</td>
</tr>
<tr>
<td>image_first_not_transferred_block_number (dynamic)</td>
<td>double-long-unsigned</td>
<td>x + 0x20</td>
</tr>
<tr>
<td>image_transfer_enabled (static)</td>
<td>boolean</td>
<td>x + 0x28</td>
</tr>
<tr>
<td>image_transfer_status (dynamic)</td>
<td>enumerated</td>
<td>x + 0x30</td>
</tr>
<tr>
<td>images_info (dynamic)</td>
<td>array</td>
<td>x + 38</td>
</tr>
</tbody>
</table>

### Specific methods (if required)

<table>
<thead>
<tr>
<th>Method</th>
<th>m/o</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>init_transfer</td>
<td>O</td>
<td>x + 0x40</td>
</tr>
<tr>
<td>image_verify</td>
<td>O</td>
<td>x + 0x48</td>
</tr>
<tr>
<td>image_activate</td>
<td>O</td>
<td>x + 0x50</td>
</tr>
</tbody>
</table>

- New interface class “Image transfer” manages image transfer process
- New script allows auto activation
Status / fraud monitoring: key requirements

- Classify events by their kind: HW, SW, power, fraud…
- Capture events in event logs, with snapshot if needed
- Maintain status words
- Maintain error registers
- Allow raising alarms (filtered)
Status / fraud monitoring – COSEM solution

Project specific status table
1 ..... 2...... 3.... 255...

Fixed or flexible mapping

Status objects
01100010

Event code object
53: Magnet tamper

Capture code of last event by kind:
• hardware
• firmware
• power
• tamper
• access....

Capture selected and filtered events in a bit-string, to raise an alarm

Capture selected events in a bit-string
DLMS/COSEM for gas metering

- Project team launched in 2007
- Participants: major industrial associations, utilities and manufacturers
- Result: new OBIS codes to support smart gas meters (going far beyond EN 13757-1)
  - volume conversion
  - mass metering
  - gas composition
  - energy calculation
  - profiles, minima / maxima
  - tariffs (TOU)
  - several measurement and billing periods
Summary

- Very positive experiment with Dutch smart metering project
- DLMS/COSEM is a language not only for meters, but also for partners
  - requirements precisely understood and clarified using COSEM object modelling
  - no interference between object model and protocol
  - new elements of the model can be readily implemented and tested
- “Blue print” for other projects
Many thanks for your kind attention!