SMART METER INTEROPERABILITY TESTING – A PERSPECTIVE ON REQUIREMENTS AND IMPLEMENTATION

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Abstract: The data exchange aspects of the second edition of NRS 049 are entirely built on the *DLMS Standardization Framework* (i.e. IEC 62056-1-0), providing a solid first-step towards achieving interoperability between multi-vendor smart metering products in the South African context. A necessary, second and final step, is an interoperability test scheme that will validate conformance to *NRS 049 Ed.* and prove interoperability between multi-vendor implementations. This paper will provide a perspective on the development and implementation of an NRS 049 Ed.2 interoperability test scheme.

Key words: smart meter, interoperability, testing

1. BACKGROUND

Smart metering technology has the potential to improve operational efficiency and revenue collection efforts of South African utilities and thus provide assurance for their financial sustainability. However to this end the deployment rate of the technology has not been as expected and consequently, utilities are forfeiting these benefits. One of the factors limiting this deployment rate has been the lack of interoperable smart metering products in the South African market.

To provide a basis for achieving smart meter interoperability the NRS 049 Working Group has published a second edition of the NRS 049 specification. This edition is specifies open communication standards and adopts the DLMS/Cosem data object model, application layer and data security features. Furthermore the NRS 049 Ed.2 includes smart meter use cases applicable to the South African utility environment and aspects of the *Internet of Things*. This positions NRS 049 Ed.2 as first attempt at a true South African *companion specification*.

2. INTRODUCTION - ACHIEVING INTEROPERABILITY

Achieving interoperability in a multi-vendor environment requires strict adherence to a *companion specification* by product implementers and secondly, there needs to be a robust test scheme to test (prove) the interoperability of product implementations. In fact, testing is at the heart of most world-leading smart metering projects that have achieved multi-vendor interoperability. A relevant example in this regard is Iberdrola, a Spanish utility that has successfully deployed over 4 million interoperable smart meters manufactured and supplied by 9 different meter vendors based on a DLMS/PRIME companion specification. Central to Iberdrola's success in this regard is mainly accredited to its comprehensive T5 companion specification and interoperability testing regime.

Figure 1: Multi-vendor smart meters deployed by Iberdrola

In the South African context NRS 049 Ed.2 addresses the need for a companion specification and all that remains is an adequate interoperability test scheme. Herein a perspective on requirements for the implementation of such a scheme is provided.

3. REQUIREMENTS FOR INTEROPERABILITY TESTING

The purpose of interoperability testing is to prove that end-to-end functionality between, at least, two communicating entities, from different manufacturers, is as required by a companion specification.

Figure 2, below illustrates, at a high level, what an interoperability test entails.

There are several definitions ascribed to interoperability but one that applies to the context of this paper is taken from [1] and means "informally, if we can remove one device, and replace it with another with no degradation in

capability". This is a very great feat but one worth pursuing.

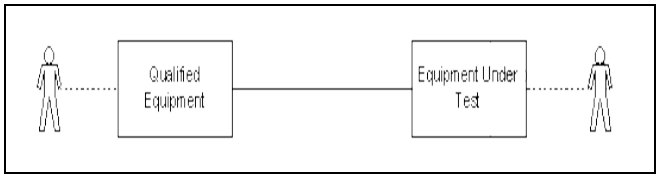

Figure 2: Illustration of interoperability testing

In the context of smart metering systems these entities comprise:

- the Head End System (HES);
- Network Access Points/Network Gateways/Data Concentrators;
- Meters;
- Consumer End Devices (e.g. appliance control devices, customer interface units, etc.)

These are also covered, accordingly, in NRS 049 Ed.2 where their communication interface specifications are covered in detail. Adequate specification (detail) of the communication interfaces is one of the prerequisite for effective interoperability testing. This is because a manufacturer may implement a companion specification in full but if the companion specification itself does not cover full details of the communication interfaces that address the required functionality then, despite testing, interoperability will not be achieved.

Furthermore, the companion specification must provide adequate specification (detail) of the security protocols and algorithms that will be used to encrypt metering data. Preferably, these security features should be based on open standards such as *FIPS PUB 197:2001 – Advanced Encryption Standard*. This is essential as incompatible security implementations will also hinder the achievement of interoperability. Fortunately, NRS 049 Ed.2 adopts security features of the DLMS/Cosem set of standards and what remains is to verify that the specification clear enough to avoid misinterpretation by the envisaged implementers of NRS 049 based products.

Additionally, in developing *Edition 2* the NRS 049 Work Group has adopted the *Internet of Things* principles and specified that IP layer (Layer 3) routing shall be used by all smart meter system communication entities. This is a fairly new approach and most meter manufacturers are accustomed to the "mesh under" approach or more simply routing at Layer 2. Thus NRS 049 Ed.2 needs to very clear on how the Layer 3 routing protocol should be implemented and again, interoperability testing will provide both the implementers and end-users of smart metering systems assurance that there is ambiguity in how the routing requirement should implemented. Inadequate specification of the routing protocol will also hinder the achievement of interoperability and render the testing unfruitful.

4. IMPLEMENTING INTEROPERABILITY TESTING IN A LABORATORY ENVIRONMENT

For the purposes of interoperability testing in a laboratory environment, the following is required:

- A comprehensive test procedure that covers all aspects of the protocol implementation to be tested;
- A set of reference implementations[1]which for the purposes of this paper will entail a *DLMS clients* (e.g. Head End System application) and a *Neighbourhood Network Access Point* (typically a Network Gateway);
- A sniffer for capturing data exchange between the *reference implementations* and the *implementation under test*;
- A protocol analyser;
- The product implementation(s) and/or prototypes to be tested – these should implement the *companion specification* in full – it is recommended that prior to interoperability testing the product implementations should undergo physical layer conformance testing (e.g. G3-PLC certification);

A typically test setup is given in *Figure 3* below.

The test process will typically involve the invocation of data exchange between the *reference implementation* and the *implementation under test* (IUT) under various *use case* scenarios. The "requests" and "responses" resulting from the data exchange will captured and analysed to determine the IUT's interoperability with the *reference implementation*.

This approach to testing will enable the detection of conflicting implementation configurations, gaps in the *companion specification* and/or *the test specification*.

5. TEST TOOLS

Owing to the proliferation of open communication standards in smart metering systems, there are a number of reference implementations (i.e. DLMS Client, NNAP, etc.) available on the market.

This is commendable as it means there are numerous meter vendor-independent test tool options available. Thus "lowering the bar" for new entrants in the South African test house industry who seek to provide interoperability services.

Furthermore well-established research institutions, such as EPRI, have recently begun developing protocol test

[1] A *reference implementation* or *qualified equipment*…

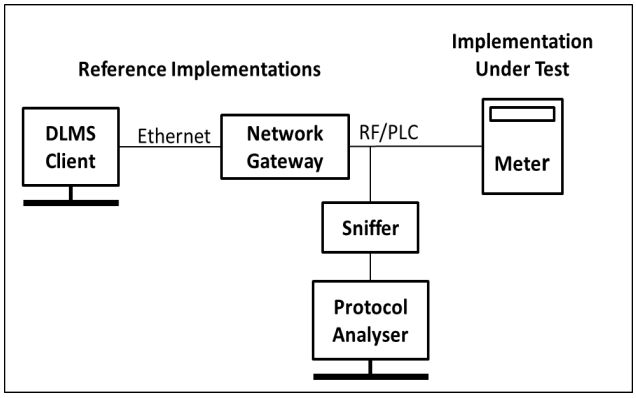

Figure 3: Typical test setup

tools and making them available to utilities and thus enabling utilities to independently test *product implementations* independently based on their particular use cases.

6. ESTABLISHMENT OF A TESTING COMMUNITY/INDUSTRY ALLIANCE

To facilitate the development and maintenance of robust test procedures it is necessary to establish a testing community or a so-called *industry alliance*. The role of such a community would to collaboratively define interoperability requirements for South African smart metering systems and provide a quality assurance process for interoperability testing.

The NRS 049 workgroup is by nature utility-centric and thus not always have access to meter manufacturer experts. Thus a body separate from the workgroup that includes utility experts, testing specialists and meter and software vendor engineers would be most appropriate.

7. CONCLUSION

The NRS 049 Ed.2 specification presents a good foundational *companion specification* for the South African utility industry. However it will only mature through wide meter industry acceptance, product implementations and extensive interoperability testing.

This paper has provided a perspective on the requirements and implementation of an NRS 049 interoperability test regime. This perspective is not at all exhaustive but provides a foundation for industry-wide deliberations.

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