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What Testing Reveals

By Duffy O'Craven

BACnet Testing Laboratories (BTL) provide industry members with verification testing services to ensure interoperability between BACnet devices. As manager of BTL, I see the benefits of verification through testing. I also see the hurdles of verification through testing. I am constantly learning from the experience, and I strive continuously to incorporate what the testing reveals into improving the process for both testers and testing applicants.

Testing starts when BTL receives a testing application form that helps us gauge and estimate the amount of time, and which tests, will be performed on the device.

I would like in this article to convey some of what testing reveals. You can then incorporate this knowledge and improve the parts of the process that occur in your own departments. There are opportunities for improvement before (and after) the part of the process that I oversee, which is just the part where our testers actually have their hands upon Implementations Under Test.

Despite that we do no design; we do no fabrication; we do no monitoring of production, assembly, or commissioning, we see things which reveal much that could benefit those who do design, fabricate, produce, assemble, and commission BACnet devices.

BACnet is one standard. There is only one correct interpretation, and everyone should meet the same standard. We have to ask a series of questions though, because BACnet is one *broad* standard. Every device implements only parts of it, and before we test, we want to know what parts of BACnet this particular device implements. Correction: thinks it implements. Initial overconfidence creeps in, even when a vendor is merely trying to state what their device does.

To capture “what it does,” we have prepared a standard battery of questions that we ask, which we call the BTL Checklist. It ranges from items everyone must implement (ReadProperty, a Device object) through those that few implement (Read Only Schedules, Generates event notifications with timestamps of the Time form), to some

things that we may never see submitted for testing again (Supports object creation and deletion of the Averaging object, ARCNET data-link layer).

What does this checklist reveal? Far more than merely taking it at face value. The check marks tell us much. The absence of check marks tells us more. Some vendors submit for testing, but leave whole required sections blank. That tells us where the obscurity and arcana in parts of BACnet meets the limits of the knowledge of the person completing the checklist. Often I don't know an applicant when I first receive his checklist. Why and where there are errors or omissions in the checklist gives me a good idea of how much education needs to be intertwined with ongoing communication.

Areas such as the line items within Device Communication Control, the proliferation of data types in Data Sharing services, the distinction between initiation and execution, i.e., “Can read INTEGER property values” versus “Contains INTEGER property values,” are some of the common areas where silence in the remitted checklist speaks volumes.

There is no part of the checklist that defies comprehension. Most of the difficulty is novelty. It is hard to understand

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if this is the place where you first encounter it. The checklist is terse, because, well, it is a checklist. If while reading an item on the checklist, you cannot understand the question it asks, that is a time when you should crack open the BTL Test Plan, search for the section whose name is exactly the same as the checklist question, and try to increase your knowledge of BACnet a little bit at a time. The BTL Test Plan is online. It is one of the files within the test package at <http://tinyurl.com/BTLTestPackage>.

When the checklist (along with the BTL Application, which contains a few other essential pieces of information) are complete, then the test case can be prepared. The test case is a codified set of tests which the BTL working group has slated for successful execution by any device that wants to claim it has a correct implementation of a particular BACnet Interoperability Building Block (BIBB). The BIBBs form a tree-like structure of increasing capability for increasingly sophisticated devices, each of which subsumes but still also requires, the lesser BIBBs. The BIBBs are grouped into Device Profiles, which form a coherent level of capability.

The BIBBs also recognize that, since BACnet is a network protocol, the capabilities of BACnet are used in interoperable

pairs of A-side and B-side, which need to implement the two sides of the communication. The A-side BIBBs ask another device to do something. B-side BIBBs represent actions that a device can be asked to do.

A BIBB is actually a miniature standard, so the BIBBs themselves don't reveal much. Which BIBBs a manufacturer chooses to implement, however, reveals a lot. In each Device Profile there are specific minimum capabilities in terms of BIBBs, but there are no maximums. A device which implements more than the minimum BIBBs for its chosen Device Profile, is a more aggressive device. The aggressive devices reveal either extra-competency, or naive over-confidence. After the first device from a development shop is brought successfully through BTL testing and awarded a BTL Listing, future devices from the same development team are generally just as successful whether they are an aggressive device or not. But if a first-time applicant is an aggressive device, hold-on-to-your-hat.

As mentioned earlier, every applicant is initially overconfident, failing between 5% and 20% of the tests when they are first performed. After remedying all defects identified in the implementation, and after a subsequent revision of the firmware fails



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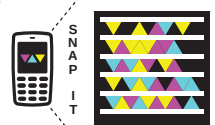
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none of the required tests, the device is granted permission to display the BTL Mark. This can, as you might imagine, occupy a considerable span of time.

For a first-time applicant aggressive device, this can take an inordinate length of time. The chief lesson to be drawn from what this reveals is: implementation of BACnet is complicated.

It is a capable standard, and there is such thing as correct implementation. Until you have truly been subjected to adversarial scrutiny regarding how you implement it, however, you probably haven't implemented it correctly. Take a breath. Take it slow. Cruise into BACnet, before opening up the throttle to see what this baby can do.

When you get your test case and your device into the BTL lab, you are going to initially make great progress. Most tests have less than a half-dozen steps. Several have just two, a command-response. The easy pickings are the early pickings. Then typically, for some test, the process comes to an abrupt halt. Everything which a device claims to do, it must demonstrate that it can do.

For some capabilities, especially the responsive ones, it is easy to figure out how to make it do something: simply ask across the wire for it to do so. But in all but the simplest devices, there are capabilities for which it is not immediately clear, nor universally agreed, how to make it do something. For instance: decoupling Feedback_Value from the input signal that is normally used to verify the output, so that a COMMAND_FAILURE event can be generated in Binary Output and Multi-state Output objects' intrinsic algorithm. For these, the vendor must supply an additional IUT Special Test Instruction telling how to demonstrate that the device can do what it claims that it can do.

What testing reveals here is two-fold: anticipate these situations early, before sending the device or commencing testing. Prepare and provide IUT Special Test Instructions (every applicant is reminded, and referred to an example form for doing so) for every test which will need them. That means the process won't come to a halt in the middle of testing.

Second revelation: a good design will include designing for testability.

The demonstration of certain behaviors, such as entering a TO_FAULT condition, is so elusive in field-deployed devices, that getting it to do so on-demand effectively means supplying an artificial means to use in testing. This is not optional. The likelihood that something works as intended is inversely proportional to the difficulty of ever seeing it occur. If our lab



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cannot test it, because the requisite situation is so elusive that the development team themselves cannot cause it to occur on demand, it probably doesn't work right. Think "testing will have to see this happen," from the beginning when you are doing your design.

Ultimately, the act of testing a successful device just confirms what you hope you already know: it works! So if testing is just going to tell you what you already know, you can skip the effort and expense of testing, right? Not right. Testing does not improve the product. Yet, submitting a product for testing absolutely does. It is the need to do a good job in the engineering of the product, because in order to pass the tests you need to do so, that improves the product. And ultimately that is what the customers want.

Fixing the problems that testing reveals, and revising the claims about the product to match reality, also improves the product. But really the earlier mentioned consequence is the greater gain. Submitting to independent verification by testing raises the quality level of the device from "probably works, most of the time, in the areas that are heavily exercised," to "works correctly." The engineering precision to raise the device

to "works correctly" permeates all aspects of the device, even aspects which are not tested.

In some sense this could occur whether the device then undergoes testing or not. In practice, it does not occur unless the device actually undergoes testing. I can envision a day in the future, when so many devices have undergone testing, and the correct implementation has been achieved by so many different development teams, that the quality level of tested and untested devices is indistinguishable. We are not nearly at that happy place yet. I can also assure you that even in that Eden, if we were to no longer require devices to actually be sent for testing, the quality level would fall. There is an effect achieved by verification through testing which cannot be achieved by any other means.

I end here by sharing with you the slogan of the BTL:

"I have lived in this world just long enough to look carefully the second time into things that I am most certain of the first time," Josh Billings, columnist and humorist (1818-1885).

You don't have to be us to do testing. And you don't have to wait and wonder what testing would reveal. Go ahead, test. Testing will reveal what testing reveals, whether you expect it to or not.●

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