Automated Mass Conversion of Monitoring and Control Logic Between Platforms

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Executive summary

This article suggests that the use of automated tools to execute upgrades, from aging Programmable Logic Controller (PLC) and Remote Terminal Unit (RTU) platforms, to modern replacements, will help to reduce the investment and risk required to commission operations on the replacement platform.

Introduction

Nothing Lasts Forever

There are many challenges in maintaining an aging Distributed Control System (DCS), PLC or RTU install base. Older sites, in many cases, include solutions dating back to the 1980s or 1990s and were developed using software tools that may no longer be available or able to run on modern computers. Documentation, describing the design and/or implementation of a specific application, can often be lost in the intervening decades. In addition, the skills and experience necessary to employ these legacy development tools may not have been maintained. With our customers, we often encounter situations in which the developer, who originally wrote, tested and installed the solution, has left the organization, and because the site kept performing as expected for many years, no further effort was made to build the capacity to maintain it. A final set of problems can occur due to these applications residing on hardware that has become obsolete. As the stock of spares is diminished over time, the ability to maintain operations at that site is ultimately lost.

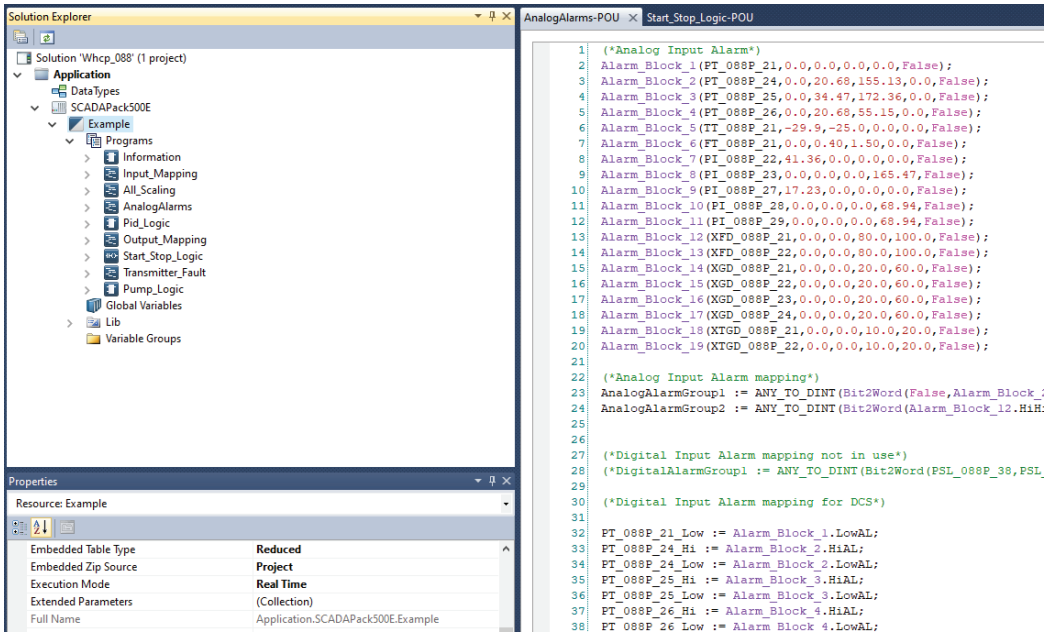

Figure 1

Example of SCADAPack Workbench Structure Text Application

Aside from aging equipment and loss of skills, and even where the systems are operating as designed, increasing demands and regulations may mandate a new methodology to evolve away from an older platform. Consider, for example, the focus of the 2019 WEFTEC 2019 conference on cybersecurity at a hardware and software level[1] or a recent example of an NSA report which highlights the vulnerabilities of commonly used PLCs[2]. These problems are not unique to the water/wastewater field. Old PLCs and RTUs will need to be replaced someday.

Why Automated Conversion?

Despite the evolution of industrial automation in recent years, the development of PLC and RTU applications is often performed in isolation, by users employing manual procedures and a range of tools. This inefficient approach has, in large part, been a product of the platform-specific implementations of IEC 61131-3, produced by PLC and RTU manufacturers. While many newer PLC and RTU platforms have taken efforts to ease development and to facilitate more sophisticated development practices, this does not address the aging install base used to control and monitor water wastewater sites. Ultimately, this article will suggest that automatic conversion of PLC and RTU applications should be considered by users with an install base that includes:

1. Obsolete RTUs and PLCs
2. Large numbers of RTUs and PLCs
3. A mix of different RTUs and/or PLCs
4. A variety of unique applications

FIgure 2
Mix of PLCs and RTUs

Challenges of Manual Conversion

To address these site maintenance barriers, systems operators should take an approach to proactively migrate applications from aging platforms to newer platforms that can be sustainably maintained. A major challenge to this approach is the diversity of platforms that can require replacement. This creates a practical barrier in that programmers, looking to migrate a system from an older RTU or PLC to a newer RTU or PLC, must learn each individual platform. Consider the steps required now for a user to convert an application from one platform to another are as follows:

1. Study the platform from which the solution is being ported (the source platform) including its tools.
2. Create a development environment for the source platform.
3. Manually convert the code from the source platform to the target platform.
4. Verify that the target platform application performs as expected when compared to the source platform application.
5. Document the updated application.

An example of the extensive requirements can be viewed online[3]. One consideration specific to the conversion of IEC 61131-3 code from the source to the target platform is that the time involved with the code conversion can vary significantly based on the language being used. For instance, the conversion of structured text (ST) code can easily be performed manually using a cut-and-paste method. It has been observed, however, that the copy-paste-modify approach can often prove to be error prone as the process is dull and repetitive and thus leaves developers less focused.

Consider the example below showing two code fragments from SCADAPack™ Workbench and its direct equivalent in RemoteConnect™ Logic Editor:

SCADAPack Workbench:

```
TON_NoTorque(Well[0].Control.iMode = eMODE_TORQUE AND Well[0].Status.Drive.
iMotorTorque <= 0 AND (Well[0].Status.iMode = eSTATE_AUTO OR Well[0].Status.iMode =
eSTATE_STARTUP), T#30s);

iTemp := F_DEL(i_sFileName + '.bak');
```

RemoteConnect Logic Editor:

```
TON_NoTorque(Well.Control.iMode = 3 AND Well.Status.Drive.iMotorTorque <= 0 AND
(Well.Status.iMode = 300 OR Well.Status.iMode = 30), T#30s);

F_DEL_0(CONCAT_STR(i_sFileName, '.bak'), iTemp);
```

Observe that although each platform uses very similar code, even in these simple cases, differences can occur, including: defined words being supported in one environment and not the other, the need to replace a function with a function block (FB) and the syntax of an FB call being different.

Challenges of Manual Conversion - continued

These challenges are only increased when working with the graphical IEC 61131-3 languages: ladder diagrams (LD) and function block diagrams (FBD), where the challenges of differing syntax, custom functions, and platform-based timing are coupled with the need to graphically recreate the implementation. Also, the interpretation of the IEC 61131-3 graphical languages may vary between development environments.

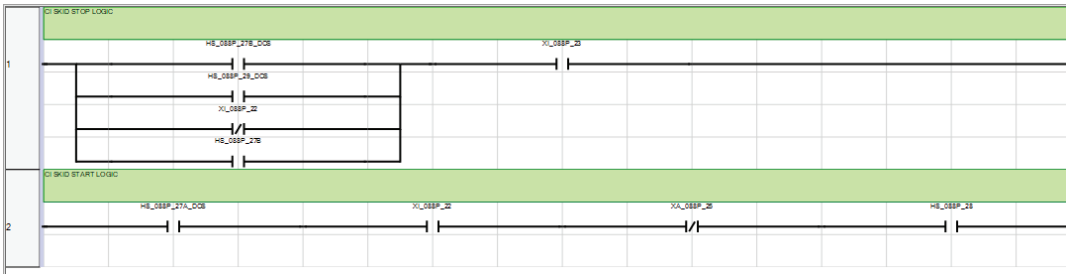

FIgure 3
LD Example

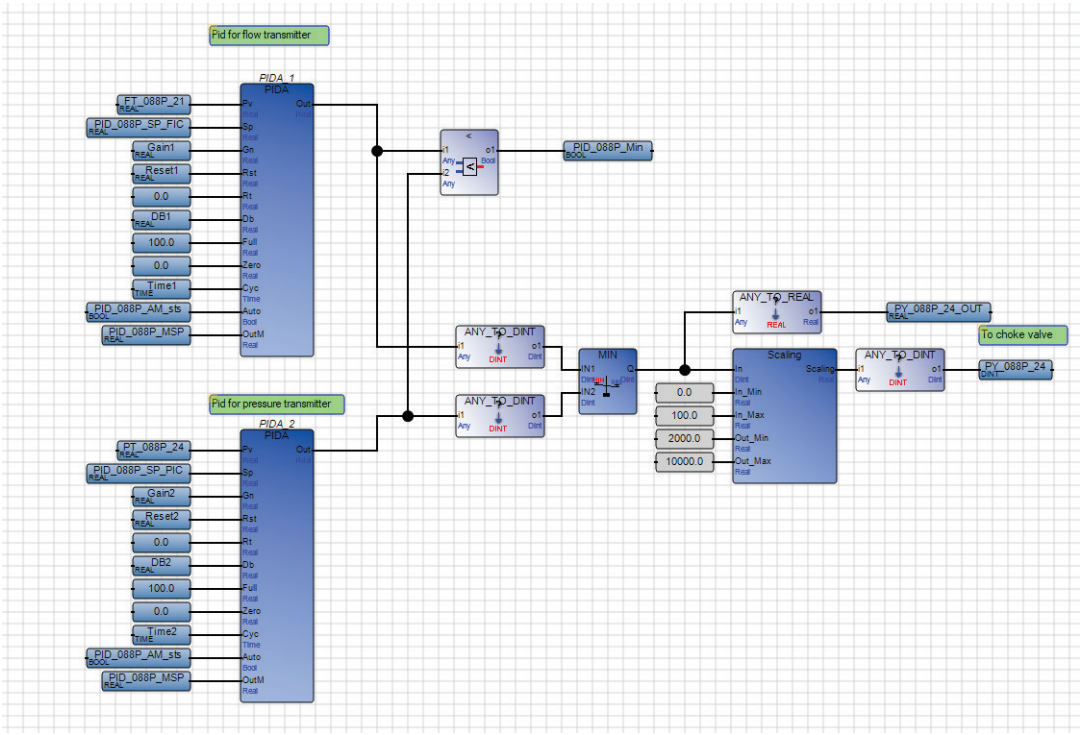

FIgure 4
FB Diagram Example

Considering the need to repeat this process for each application, the time and effort required to migrate to a new platform can increase significantly.

A Solution: Automated Conversion

A powerful approach that can help to mitigate the significant costs involved in PLC and RTU modernization projects for system operators, consultants and developers, with this manual, platform-by-platform, and labor-intensive approach, - while avoiding the trap of attempting to indefinitely support aging platforms - is the use of automated conversion tools. The primary benefits of an automated conversion approach are reduced costs, time and risk; industry analysis suggests migration costs can be reduced by up to 40% using an automated approach[4]. Using the EcoStruxure™ Control Engineering – Converter tool as an example, the process is, in outline:

1. Conduct source code analysis to transform the source code into a generic platform independent set of source files.
2. Replace references to source PLC or RTU to references to target PLC or RTU.
3. Generate the code for the target platform.
4. Manually adjust code on target platform (the automatic conversion tool will indicate where this is required).

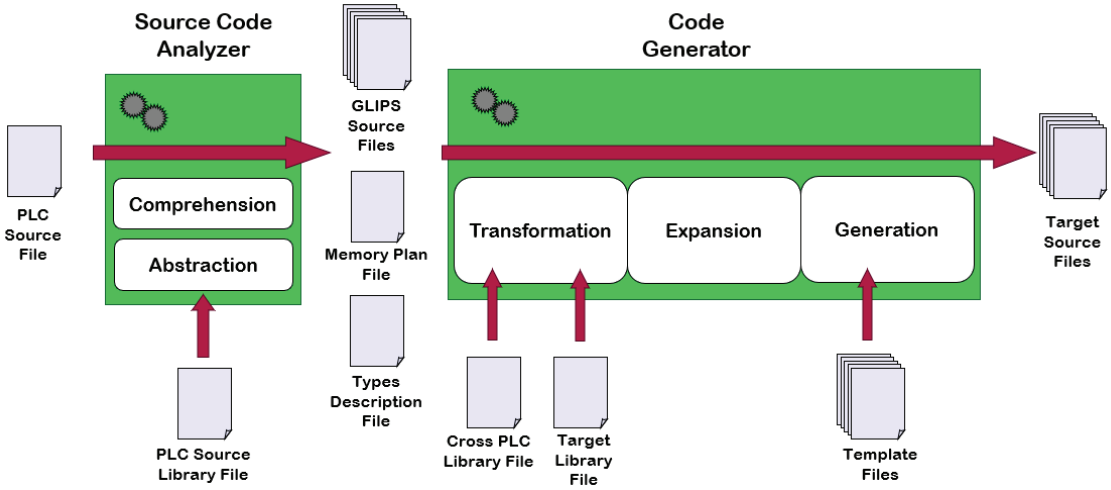

Figure 5
Conversion Process Example

A Solution: Automated Conversion - continued

Using the EcoStruxure Control Engineering – Converter, source code is imported to the platform-independent GLIPS language. GLIPS is sufficiently abstract such that it can be transformed so as to produce target code for a variety of PLCs, RTUs, and other systems used for embedded applications (C code can be generated as well). The flexibility of this platform-independent code is essential to an effective code translation system. Specifically, the following components of the IEC 61131-3 application should be translated by an automated tool:

- Memory Organization: variables, points, registers, sizes, locations
- Data Types: simple types, structures, enumerations, functions, FB
- System Libraries
- System Information: status variables, timers
- Application Structure: tasks, Program Organization Unit (POU)

In addition, the conversion process should support the translation and conversion between all five IEC 61131-3 languages (ST, LD, FBD, SFC, and IL), and advanced transformation mechanisms can even help customize the target code to specific needs, such as going from one language to another for a given section (ST <-> LD for example).

Some tasks, due to the wide range of platforms and their unique implementations, typically require a user to manually update. These tasks commonly include the assignment of I/O to PLCs, RTUs, and expansion modules, and the configuration of communication port settings, security and credentials. This challenge can be expected for protocols more complex than Modbus™, such as DNP3 or IEC 60870-5-104.

Once the application has been converted by the tool, the development team, freed from the tedious task of code translation, is now positioned to focus on completing the migration to the new install base by allowing the developers to concentrate on finalizing, validating, and commissioning the new platform. This can help to fully leverage the new platform's capabilities, which is a hidden benefit of migrating beyond duplication of the obsolete system's functions.

Summary

There are many challenges associated with maintaining aging systems currently in use by many water utilities. Personnel retirements, equipment end-of life, changing regulations, and the need for more sophisticated or efficient operations can force the need to move away from older platforms. The cost of a manual program-by-program change can be prohibitive due to the time required, by the developer performing the conversion, to learn the old system, and to then manually duplicate it on the new platform. The manual change approach also creates risk.

When planning a large migration project, water system operators should consider an approach that uses the automated conversion of PLC and/or RTU code from the old platform to the new. The benefits of using an automated approach increase as the mix of source platforms, source applications, and size of the install base increases. The automated conversion of PLC and RTU code has been used successfully in other industries and this experience can benefit the water and wastewater field[5]. The key benefits of this automated approach are reduced costs, time and risk.

[1] ISA WWID Fall Winter 2019

[2] NSA and CISA Recommend Immediate Actions to Reduce Exposure Across Operational Technologies and Control Systems

[3] Waste Water Treatment Plants PLC Platform Migration & Upgrades

[4] EcoStruxure Control Engineering – Itris PLC Converter

[5] Itris Customer Testimonials

About the author

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