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Tunnel Vision

N.J. Nelson B.Sc. C. Eng. M.I.E.T.
Micross Automation Systems
4-5 Great Western Court
Ross-on-Wye, Herefordshire
HR9 7XP UK
Tel. +44 1989 768080
Email njn@micross.co.uk

Abstract

An industrial control system written in Forth is described, using multiple techniques introduced in previous Euroforth presentations.

1. Introduction

Commercial laundering is possibly the largest industry to be almost invisible. Have any of you ever considered how clean sheets miraculously appear on your hotel bed every morning? There are a lot of hotel beds, even in a small place like Reichenau. To wash all those sheets, one needs a serious washing machine. The machine in your back kitchen perhaps takes a 5kg load, every 90 minutes. A *real* washing machine takes a 100kg load, every 90 seconds. If you'd like to buy a new one, you won't get much change from €1m.

2. Economics

Buying a new washing machine is a major investment. To make a return on that investment, you need to keep the machine in continuous operation over a period of many years. The machines are therefore made of high quality materials, and arranged so that parts that wear out, such as bearings, can be easily replaced. The machines use large quantities of energy, water and chemicals, which means that a sophisticated control system is needed to minimise costs and maximise profitability.

The mechanical life of a high quality machine can be 20 years or more. But the rapid improvements in automation technology in the past ten years, means that control systems of older machines have become obsolete, and spare parts are very hard to source. This has created a lively market for automation system upgrades.
Option a) Buy a new machine for up to €1,000,000
Option b) Keep your old machine and buy an automation upgrade for €30,000
This is a compelling economic argument.

3. Machine description

A typical CBW - this is a 50kg 14 compartment model, capable of washing up to 35 tonnes per day

Most modern high-throughput washing machines are Continuous Batch Washers (CBWs) - commonly known as "Tunnel" washers. They essentially consist of a long cylindrical tube containing a mechanism similar in action to an Archimidean screw. The screw oscillates for a period, to give the washing action, then performs a complete rotation to transfer the wash load from one section to another. Various valves enter the cylinder in places, to supply and drain water, introduce chemicals, and inject steam for heating.

An array of pumps move water between various sections, and a high proportion of water is recycled. There may be water level sensors, temperature sensors and possibly pH sensors.

Soiled washing is delivered to the machine from an overhead rail conveyor system. Clean washing is passed to a press or centrifuge, then to an array a large tumble dryers.

The normal operation of the entire installation is completely automated.

4. Traditional automation solution

All the actuators and sensors are connected to a programmable logic controller (PLC). All machine control is carried out by the PLC, which is programmed in one of the IEC 61131-3 family of languages. A Human-Machine Interface (HMI) display is used to show information to the operator, and to enable wash program parameters to be entered. The HMI is typically programmed in a vendor-specific WYSIWYG environment in which display elements are directly linked to PLC registers.

5. Limitations of the traditional solution

All washing machines are different, according to original manufacturer, capacity, water flow diagram, sensor requirements, and inlet / outlet interfaces. Therefore, a certain amount of new software is required for every machine, and software productivity is therefore an essential consideration for an economical automation solution. A PLC is clearly necessary for the physical connection of sensors and actuators - but it has been demonstrated that programming in IEC 61131-3 is extremely inefficient when compared to a highly flexible language such as Forth. The HMI programming method is highly restrictive in both style and content.

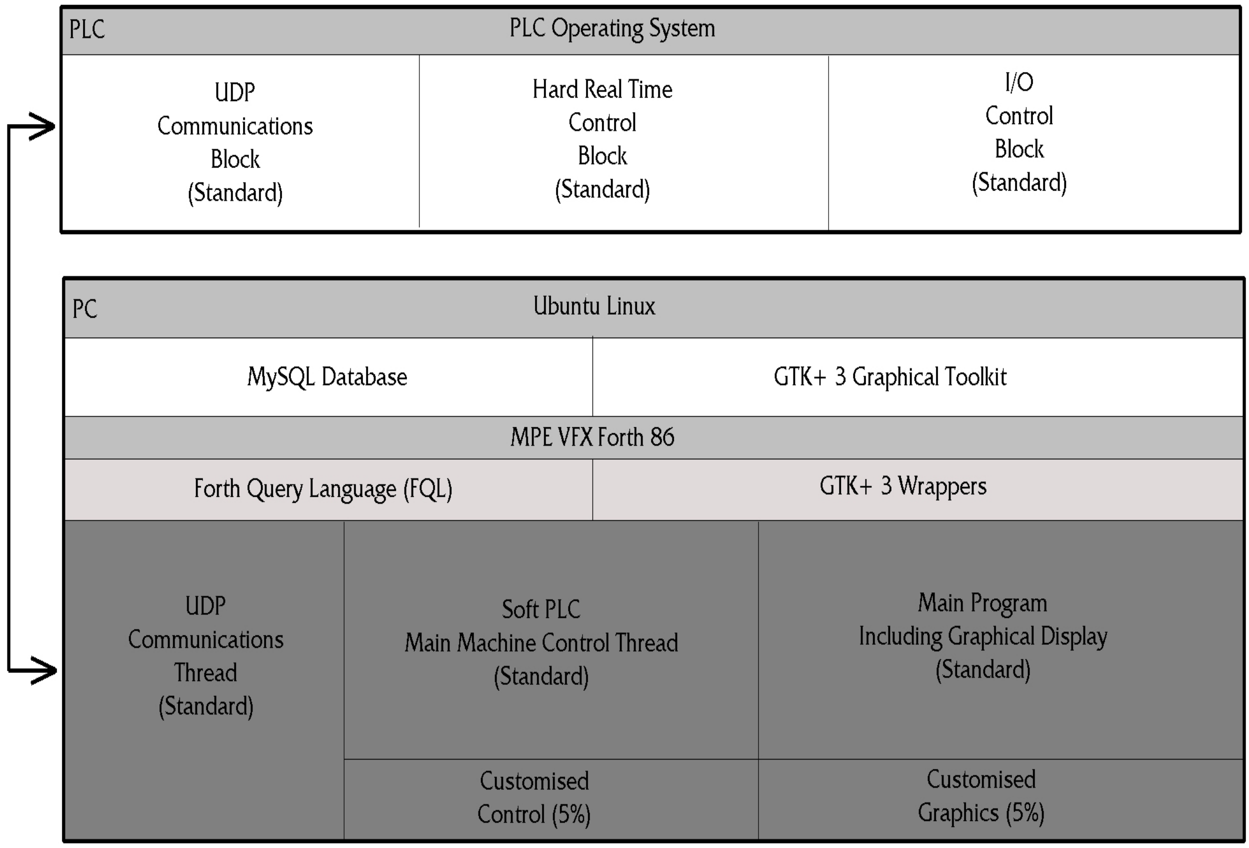
6. A better automation solution

From a software point of view, the only advantage of programming in the PLC, is that it is "hard" real time. But for an application like a tunnel washing machine, only a very small number of functions require hard real time, and these can be standardised. For all other functions, "soft" real time is adequate. This includes all the most complex functions such as selection and calculation of chemical proportions, and all functions that might need different treatment for different machines. All these functions can be handled much more easily in Forth.

Therefore, instead of using a vendor-specific HMI display unit, we opted for a functionally standard PC. Although the PCs we use are fairly standard from a programmer's perspective, they are in fact specialised industrial PCs, which are rugged, fanless, and have multiple connectivity options. A standard touchscreen is also used.

The actual machine control (except for the few critical hard real time functions) all takes place within a high priority thread within the same applications program as the main display. This technique has been proven over many years in a Windows environment. However, in the past few years, it has become increasingly difficult to structure reliable automation programs in Windows. Recent favourable experience with Linux (but for display only programs) prompted us to make a bold decision, to use Linux for the first time in a mission-critical automation environment.

7. Program structure



8. How to program a CBW (it's simple!)

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: (MAIN-LOOP)
  LEVELTIMERS          \ Service water level timers
  MACHINE              \ Overall machine control
  PUMP1                \ Control pump 1 (fresh water in)
  PUMP2                \ Control pump 2 (flush water into compartment 1)
  PUMP3                \ Control pump 3 (tank 2 to compartment 8)
  PUMP4                \ Control pump 4 (tank 2 to tank 1)
  PUMP5                \ Control pump 5 (tank 3 to tank 1)
  PUMP6                \ Control pump 6 (tank 4 to compartment 12)
  LINTMOTOR            \ Control lint motor
  WEIRBOXES            \ Control weir boxes
  REFRESH12            \ Control fresh water to tanks 1 & 2
  RINSE12              \ Control compartment 12 rinse water
  RINSE13              \ Control compartment 13 rinse water
  RINSE11              \ Control compartment 11 rinse water
  DOSING               \ Control dosing
  ROTATION             \ Control rotation
  LOADING              \ Control loading
  PRESS                \ Control press
  STEAM                \ Control steam
  ALARMCANCEL          \ Control alarm cancel
  TRACKING             \ Track loads through shuttle and tumblers
  RAILCOMS             \ Monitor rail comunications
; ASSIGN (MAIN-LOOP) TO-DO MAIN-LOOP
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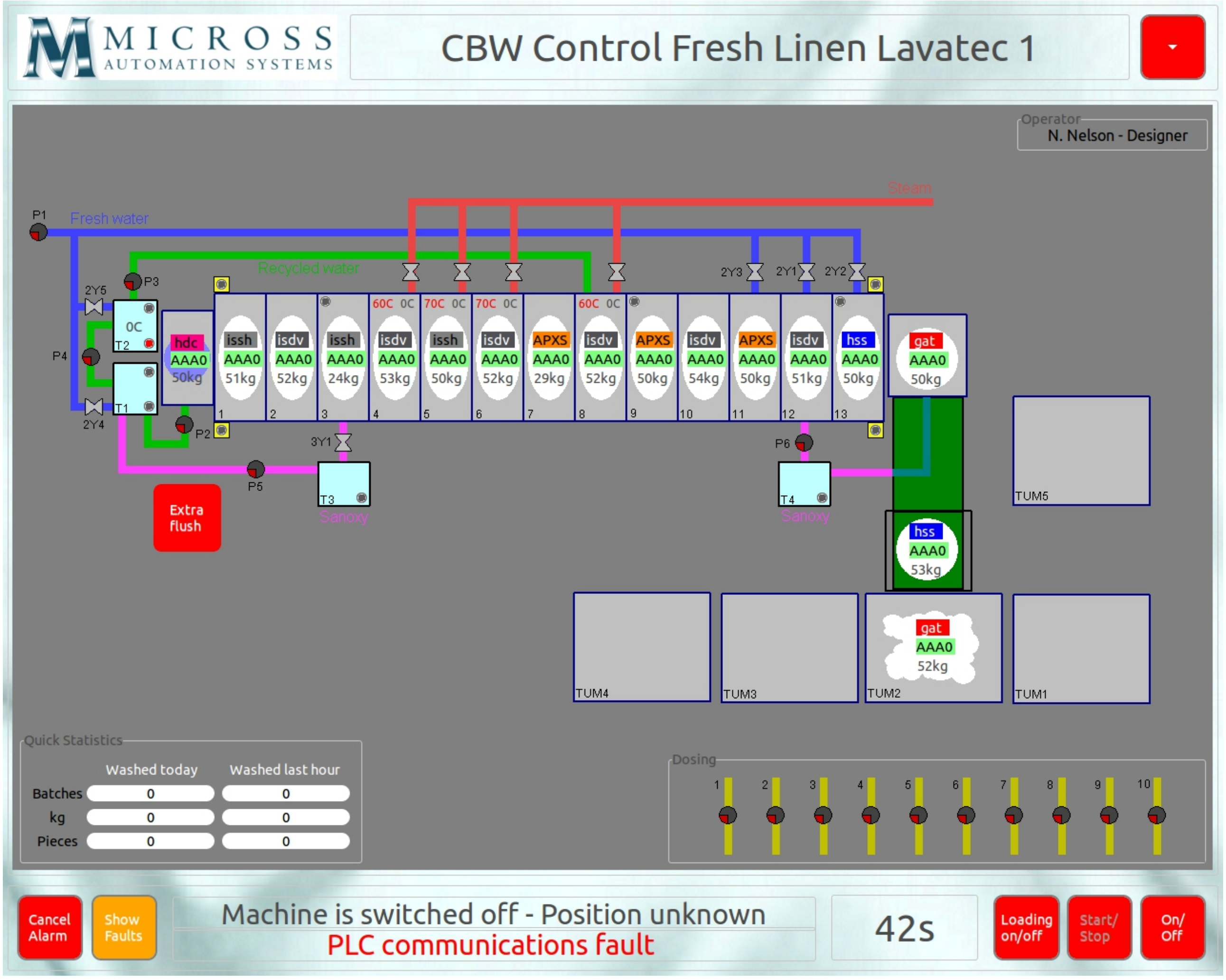
9. Result and conclusion



a) Soft real time control is not only feasible in Linux, it is actually much more stable than it is in Windows.
b) Moving the control elements from the PLC to the PC greatly simplifies the communications, removing the barrier between control and visualisation.
c) It is much quicker and more efficient to program the machine control in Forth than it is in IEC 61131-3.
d) The look and feel of the visualisation received much more favourable comments from the customer and the operators, when compared with standard HMIs.

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NJN
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