Bridge crane robot with Linux

CRANE DRIVER EMULATOR

ULRICH WOLF

The advantages of Linux's free software model are producing success stories in the most unlikely places. Indeed, Linux is even being used to drive a robotic crane in an Austrian cement works as you'll see in this month's Report.

The 49 tonne colossus swings into action, guided along two railway tracks 198m long. The trolley seeks its goal, and the grab drops, accurate to the centimetre, into the grey mountain of cement clinker. It picks up a few thousand kilos and transports it across the gigantic warehouse. This is a process it repeats over and over again. The colossus in question is obviously a crane, but no ordinary one; this crane is driven entirely by Linux-based computing power. The fact that this Linux crane even exists is down to two things – an enthusiasm for Linux, and the need for economy and efficiency.

Economic change

In the mid-nineties, the cartel-like organisation of the Austrian construction materials industry was feeling the effects of increasing competition, especially from the recently opened-up European market. To safeguard the future of the company,

Everything looks almost identical at first glance, but the Linux crane can distinguish everything.

management at the Perlmooser cement works in the eastern Steiermark, a tranquil area close to the Austrian-Slovenian border, was forced to increase productivity at ever-increasing scale. Hand in hand with this was a reduction in the workforce and modernisation of the plant's technology.

More efficiency in the warehouse

Despite its efforts, by the end of the Nineties, the French Lafarge group – the biggest construction materials producer in the world, had taken over Perlmooser, which now traded under the name of Lafarge-Perlmooser. Although many changes had already been made, the crane machinery used in the plant was still in need of a general overhaul. This is exactly what happened, with Linux entering the equation at the same time. But before we go on to describe this development, it might be useful to briefly look at the cement manufacturing process.

Cement is made from the three components: limestone, marl (an intermediate layer found between the limestone and the topsoil lying on top of it) and sand. These basic materials are ground up and mixed together in a specific way, then heated in a furnace to produce an intermediate product called clinker. This is then combined with other additives such as gypsum, Portland blast-furnace cement or limestone to form various types of cement, depending on the types and amounts of additives used. From this you can clearly see that a cement works is no small place, and requires various bulk goods to be stored, transported and mixed in order to operate. Large warehouses are used to store everything, but while this protects everything from the rain, it does mean that there's a great deal of dust in the air, which reduces the life of any machinery working inside.

Linux solution without precedent

As the result of a favourable combination of chance and sales skill, the small company "Automatix", near Bremen, received the contract to overhaul the plant's electrical system and develop a controller that could completely replace a human crane driver. It just so happened that Jürgen Sauer, the director of Automatix, was a passionate Linux enthusiast who insisted on playing, way back in 1991, with the now-legendary "Task-Switcher", kernel version 0.1, and implemented Linux from Version 0.91 as mail and news-server at FH Hannover. He was therefore more than a little prejudiced when it came to selecting the basic operating system for the crane control system. He could have chosen Solaris as the company also uses Suns in process control, but stability and open source status tipped the scales in favour of Linux.

Open source – less stress

Sauer set himself the goal of not just automating "a bit", but of constructing a full "crane driver emulator" based on Linux. Anyone who now sees the gentle movements with which the heavy grab moves, knows that he has succeeded. Getting his idea of the ground in the first place was difficult, however, as the customer had to be convinced that it was all a good idea. Being a totally new product, all kinds of technical problems also had to be overcome, but thanks to Linux's open source basis and the skills of Sauer's technical team they did eventually achieve their aim. The process did often involve workarounds, and even the odd modifications to the operating system kernel itself.

The approach they took to the task was fairly unusual. The plant was, after all, a prototype. Right at the start it was impossible therefore, to create a complete performance specification. Very often they ended up being amended and adapted to the logistical conditions. As a result, Automatix had to work very closely with the cement works engineers understand their requirements and generate the storage philosophy required in the control software. Even the heuristic knowledge gained by the crane drivers went into the software.

The outcome of Automatix's efforts was that two warehouses in the cement works in Steiermark were fitted with robot cranes built with the company's Linux-based control technology and have been doing their work, mostly without complaint, since February 2000. As no software is completely free from bugs (although the machines sometimes run for months without any problem) from time to time there are still software problems that case the cranes to grind to a halt. Sauer is always on the case immediately, though, hot on the trail of the bug.

Interestingly, the first version of the graphical interface used to program the cranes was Java-based, the theory behind this choice being that it allowed access the programming module from the Microsoft-based computers in the company's offices and not just from the Linux systems. The Java UI was quickly replaced by a KDE-based one for stability reasons, however, and thanks to Qt for Windows, remote access via the office machines is still possible.

Figure 1: The bridge crane at work

[top]
Figure 2: The "eyes" of the crane: The blue boxes are laser scanners, through which a 3D image of the environment can be generated.

[above]
Figure 3: Screenshot of the program interface. The narrow, boldly outlined rectangle represents the position of the crane, the small box inside it is the travelling trolley. The second, black-bordered rectangle on the top edge represents the travelling tripper. The red-bordered area is temporarily prohibited to the crane.

The large number on the bottom line

For the technical director of the works, an engineer named Luger, the operating system of his crane controller is of little importance. Indeed, all that really matters to him is that everything works and productivity has been increased. As he himself sometimes puts it, "the large number at the bottom right hand side of the page is right". In any case, Luger expects the investment made in the plant to have paid for itself in four years.

Quite apart from the savings on labour, the robot plant also brings other advantages. Quality has been improving, for example, as the robot never pours gypsum onto the limestone heap or smashes the conveyor belt with the grab, as would occasionally happen with human crane drivers. Talking of the conveyor belt, this has also been given the Automatix treatment and is now controlled by a Linux system and known as a "travelling tripper".

The smarter crane gives way

The travelling tripper is really just a movable conveyor belt that brings the raw material from the nearby quarry into the warehouses. However, its Linux control system can recognise where there are gaps in the piles of raw material in a warehouse and moves conveyor to fill these areas. As the travelling tripper runs on a rail beneath the crane, certain safeguards have to be programmed to prevent the two from causing each other problems. If an order for material would cause the crane to get in the way of the tripper, for example, the order is postponed until the tripper moves away, the next order being processed in the meantime. It is also possible to switch both devices over from automatic to manual operation should it be necessary at any point.

It was not by chance that Lafarge-Perlmooser took the gamble of going in for such far-reaching automation. The management of the cement works generally takes an open-minded view when it comes to advanced technologies. The Perlmooser works is the only cement production plant in Europe equipped with a flue gas desulphurisation system.

Software with human experience

Luger is very happy with all the new technology, as is the company management, because despite its complexity the plant is actually very reliable. So although the commissioning phase took longer than originally planned, the project, says Luger, is now delivering, and he is very happy with his "bottom right" figures. ■

Figure 4: The travelling tripper.