Experiences and Lessons Learned in Transitioning Beamline Front-ends from VMEbus to Modular Distributed I/O

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Abstract

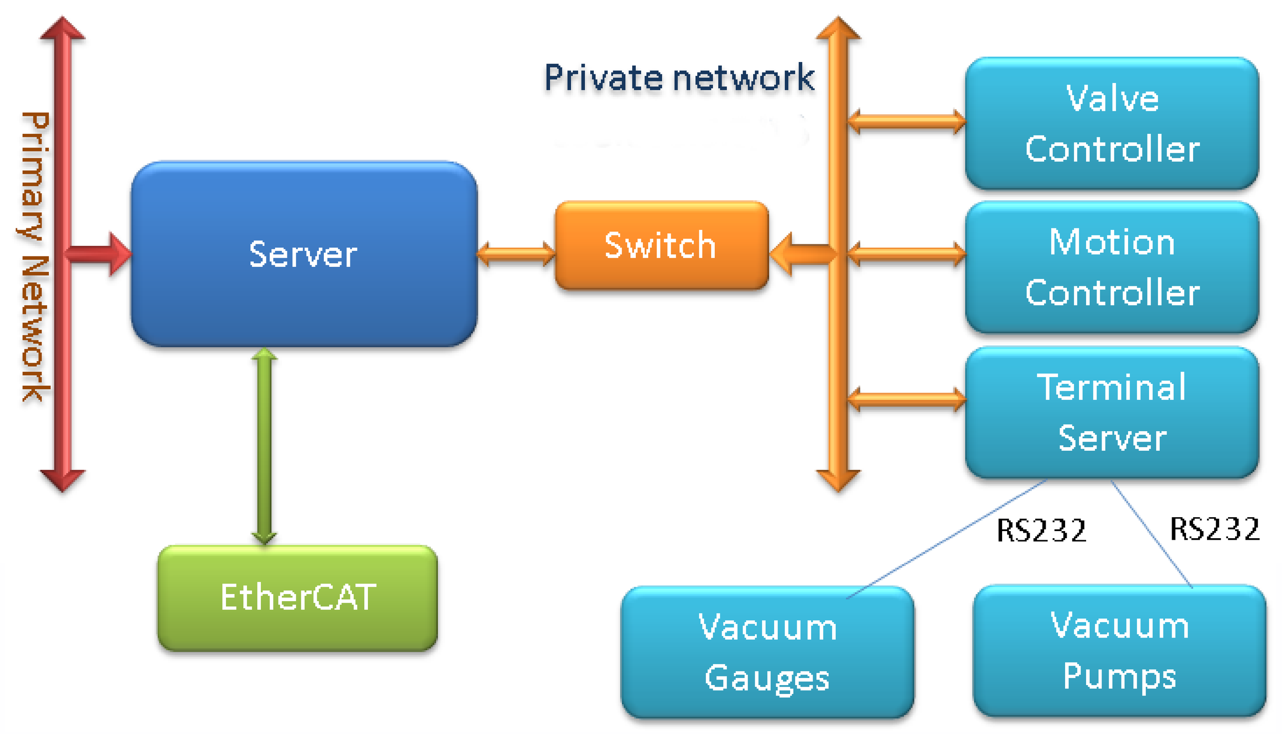
Historically Diamond's photon front-ends have adopted control systems based on the VMEbus platform. With increasing pressure towards improved system versatility, space constraints and the issues of long term support for the VME platform, a programme of migration to distributed remote I/O control systems was undertaken.
This paper reports on the design strategies, benefits and issues addressed since the new design has been operational.

1. Introduction

In 2010, Diamond adopted a new control system design for future beamlines, employing fieldbus distributed control as a viable alternative to the long standing VMEbus architecture.

It is clear that not all the hardware capability of VME was required for beamline control; neither was the use of a hard real-time operating system such as VxWorks. It was also apparent that most I/O functionality required for control of beamline and accelerator equipment can now be realised through Ethernet-attached I/O. There is also now good infrastructure for developing and managing Linux based EPICS IOCs on a PC architecture.

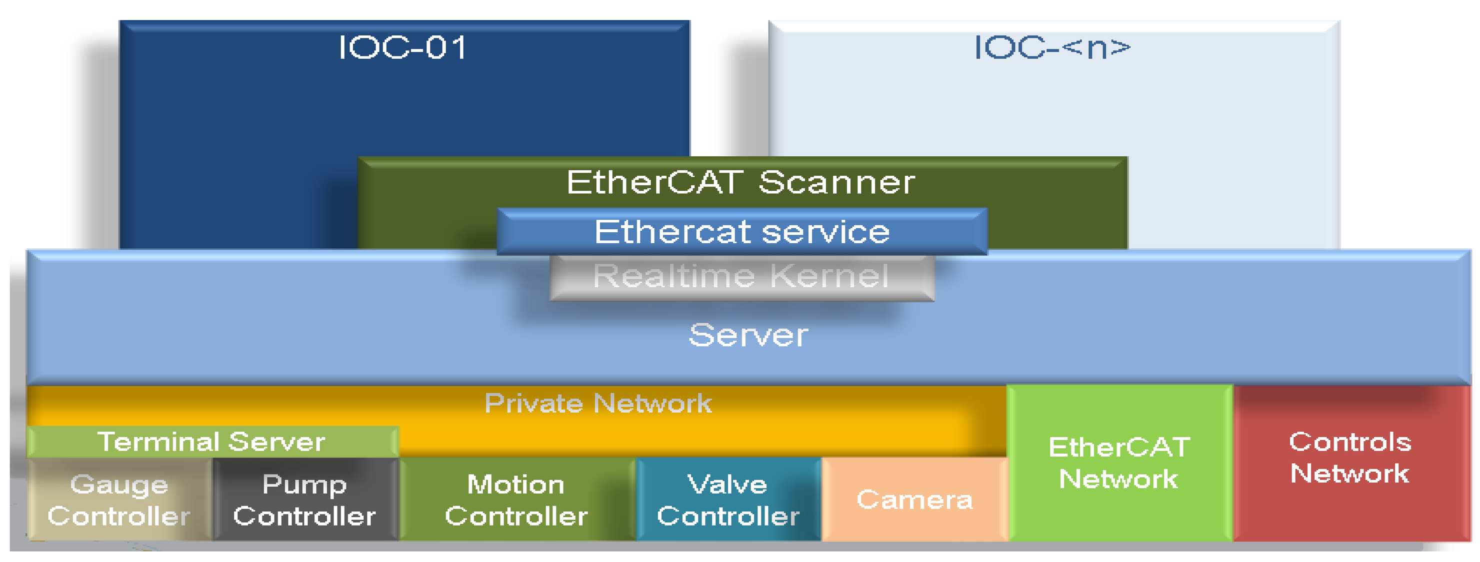
2. Network Topology



The servers are supplied with four network interfaces. This is to facilitate multiple dedicated and isolated networks, typically three are used as:

- Primary EPICS network
- Private Instrumentation network
- EtherCAT network

3. Logical Model



This diagram provides a logical representation of the Linux server in context with the I/O subsystems, traversing upwards to one or more EPICS IOC instances.
The Linux PCs are standard Dell 1U discless servers (currently R320), that boot from an image over the network into a RAM based disk.

4. Selecting Appropriate Remote I/O

Interface	Signal Processing	Interface with IOC	Comments
PLC RIO	Ladder logic in PLC generates machine protection interlock permits, in rapid and predictable response to input signals	Ethernet or serial communications with slow bandwidth in the order of 1Hz. Sharing of field signals between the PLC and IOC is facilitated by mapping in PLC memory and reading it periodically from a client (e.g. IOC) using the FINS protocol.	A new generation of Omron PLCs has been selected to enable the adoption of Remote I/O (RIO) and an Ethernet interface between the server and the PLC. PLC RIO facilitates the reduction of cabling complexity and improving flexibility on deploying I/O into the field.
EtherCAT	Various signal categories are supported for devices not necessarily associated with machine protection, i.e. for monitoring only. Analogue signals may be sampled at rates exceeding 10kHz.	The EtherCAT network is scanned by a dedicated service on the IOC's host Linux server and readings made available to one or more IOCs via network sockets.. This can take advantage of pre-emptive real-time kernel extensions when high bandwidth, determinate signal processing is required	Where remote I/O (RIO) is required and not available on a RIO PLC, EtherCAT modules have been employed.

5. Realised Benefits of Remote I/O

The biggest benefit of RIO has been flexibility of design and the reduction in cabling. This has significantly reduced the number of connections to just those in interface boxes directly mounted out in the field. This has also significantly sanitised the wiring on beamlines. Often the beamline equipment is delivered with different sensors to those expected and we are able to adapt the system for this. The ability to add extra modules into the system as equipment arrives is very useful and suits the piece-meal commissioning of beamline equipment as more complex equipment is delivered.

The Diamond Control Systems now implement some 470 Linux based IOCs; a proportion of which utilise distributed I/O, such as EtherCAT. This design pattern has realised an integrated, versatile and maintainable control system, upon which enhancements and upgrades can be confidently planned on platforms which provide inherent long term stability and support.

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