Not an ideological issue

Control in a world of distributed automation

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There is an increasingly clear trend towards distributed intelligence in today's process automation: Away from centralized systems towards smaller, stand-alone, networked function units that are able to communicate with each other.
By means of key questions, this article examines the most suitable ways to install "control functions" – remotely or integrated – in a PLC-dominated environment.

The range of opinions on this subject is considerable, as it involves optimum efficiency of plant and equipment, and therefore competitiveness.
Initial decisions made during the conception phase will also have significant effects at later stages. While defining the purchasing and operating costs, numerous aspects must be considered, such as nature and purpose of a plant, its size and spatial extension, its complexity, its location and accessibility, plant management and maintenance, service and repair, personnel training level, to name just a few. Moreover, customer requirements can play a role, which in turn are influenced by experience, company standards, or national and application-specific regulations – any of which can lead to modifications of an otherwise standard plant or system. Consequently, the correct solution for such a wide range of differing requirements cannot be found simply by means of a concept. The best solution for a given project can be completely irrelevant for the next one. Therefore, it is impossible to offer a universally applicable solution.

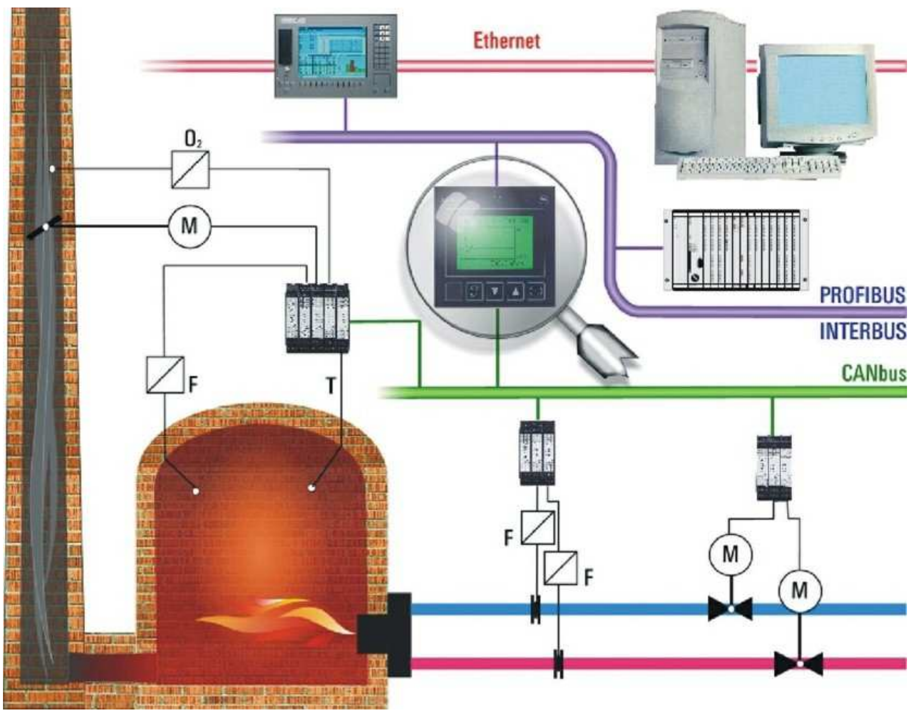


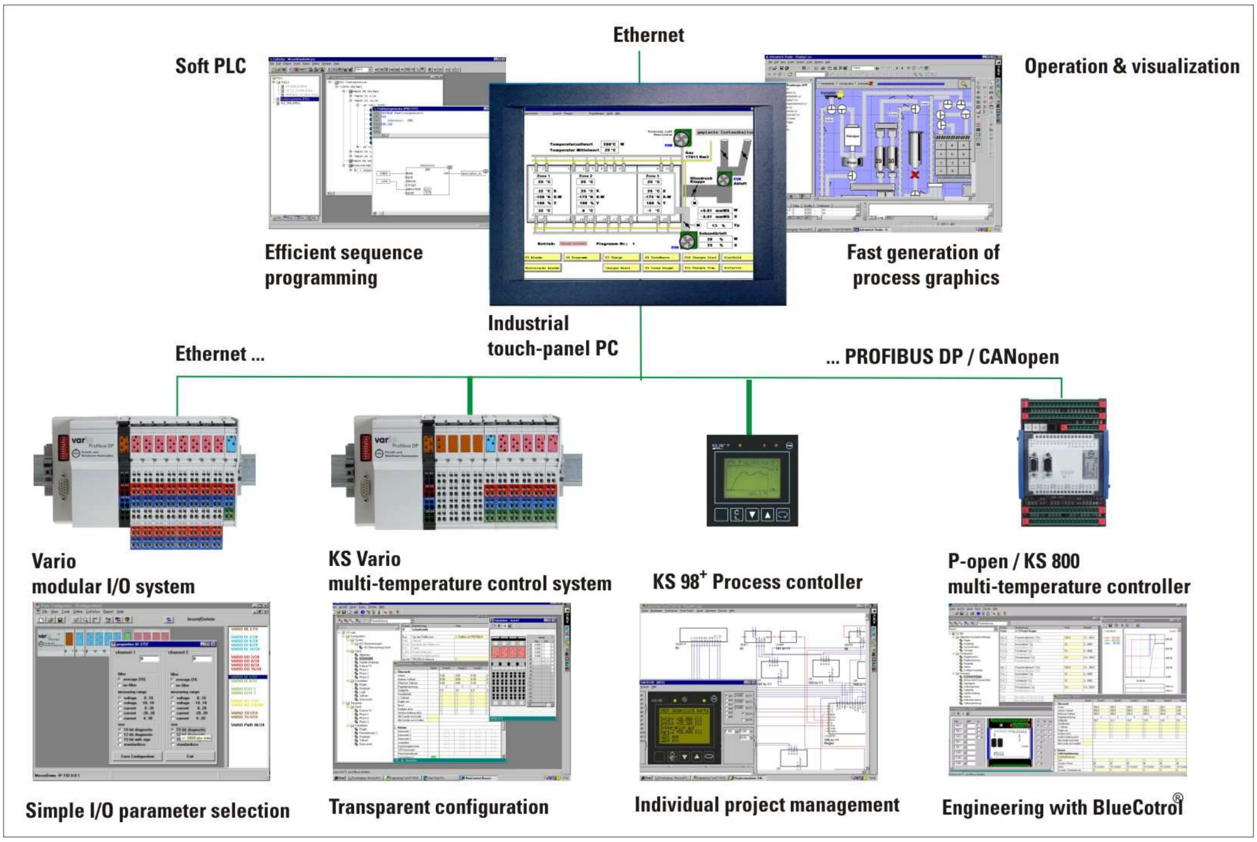
Fig. 1: Spatially distributed intelligent automation units

Centralized or distributed structure?

During the planning stage, the basic plant structure must be defined: A centralized approach, with a powerful PLC, cables leading to central control cabinets, software at a single point – i.e. everything of a piece, or plant modularization into sub-sections, which can also be installed remotely in case of plants spread out over wide areas. The answer can also be 'fuzzy', with central process control in a PLC, and decentralized processing of I/O signals, or even the distribution of intelligent functions over the plant. The issue of "where to locate the control equipment" is addressed equally – centrally, in the PLC, or decentralized in separate controller modules. Modern stand-alone controllers with field bus interfaces provide all that is necessary for distributed concepts. They are close to the process, easy to handle, with/without built-in display and operating facilities (depending on design), and provide simple logic functions.

Even though the general trend towards distributed solutions is obvious, and internationally standardized field bus systems permit simple linking of stand-alone, intelligent automation units, regardless of format, individual cases can easily be subjected to constraints that prevent consistent implementation. As a result, a central, PLC-based solution could be preferable for cost reasons, if one only considers the material costs.

Fig. 2: Task-related Engineering Tools support configuration and process management



In this case, the special tasks of PID control will also be handled by the PLC program. A frequent general line of argument reads as follows:

- A PLC is required anyway, and has lots of reserve capacity.
- Decentralization is not necessary, because no long cables are involved.
- Multi-channel analog I/O cards for direct connection of field signals are cost-effective, and replace expensive transmitters.
- In our experience, galvanic isolation to the field is not necessary; ground loops or stray voltages have never caused any problems.
- Standard PID algorithms are available as modules at no extra charge.
- Today's high-performance CPUs permit several PID controllers to be programmed without difficulty. An interrupt controller ensures adequate equidistance for the calculations.
- Higher demands placed on memory and cycle time due to extra calculations for PID controllers are not critical.
- Subsequent program changes, expansions or adaptations in the field are not expected.
- Local operation and monitoring of the control loops is not required, or is planned by means of on-site terminals.
- No special demands are placed on plant availability.

Perfectly plausible arguments, especially if everyone involved is happy with the results, and no negative experiences have been made so far.

“The cheaper the better”?

The answer: “Sure, but only if the decision isn't too shortsighted, and it is certain that the subsequent costs for operation, maintenance, and service don't exceed the apparent initial savings many times over.” But let's now turn to the decisive questions that will help to reveal hidden cost potentials – from the planning stage through to normal operation. However, answers cannot be given here, and detailed explanations will only be provided if they are necessary for comprehension.
All of the following questions and considerations are associated with possible hidden costs. We will try to make this clear using the simple example of “integrated I/O modules or distributed functions”.
Indisputably, the cost per channel of such I/O modules is lower than that of individual transmitters. What's more, it is quite possible that existing free channels can be used efficiently ... but:

- What is the true outlay for installing a measurement point?
- How much time is required for programming?
- How is calibration carried out, and by whom?
- Is there still a clear distinction of plant sections and measurement & control tasks?
- What consequences does this have for commissioning, maintenance, and service?
- Who is able to make changes or install an additional measurement point?
- How high is the risk of faults through changes in the PLC program?
- Is galvanic signal separation necessary?
- How high is the risk of stray voltages or earth loops when installing an additional measurement point?
- How time-consuming will the resulting trouble shooting be?

Many of these questions don't even arise, if suitable distributed I/Os are selected. With the support of useful Engineering Tools, device configuration is possible without programming experience. A program change involves no more than assigning an address and reserving the associated memory area.

Revealing hidden costs

An even more comprehensive range of questions arises as soon as integrated or distributed PID control is involved:

- What is the scope of the PID algorithm?
  - P, PI, PD, or PID behaviour?
  - Compensation of variable cycle times?
  - Local and variable setpoints?
  - Positioning behaviour?
  - Neutral zone, hysteresis, etc.?
  - Prevention of integral (reset) windup?
  - Behaviour at upper/lower output limits?
  - PID self-tuning aids, controlled adaptation?
- Have important functions been preconfigured and tested in the standard function block, or must they be programmed?
  - Setpoint calculations, gradients, and adjustment range?
  - Limit values
  - Bumpless switchovers
  - Output limiting
  - Pulse width modulation for switching outputs
  - Specific start-up functions
- Type-tested functions: How much time is required to generate and test the program code? Can the functions be used in other programs?
- Who optimizes the control loop, and with which tools?
- Are Engineering Tools provided for self-tuning, and who is able to use them? Is programming experience required?
- Deficiencies in program implementation? PLC program cycle times are variable, but to a great extent the control performance depends on “equidistant” PID calculations!
  - Do programmed interrupts ensure equal calculation intervals?
  - Must pulse width modulation be programmed for the control of switching outputs?
  - Is the process variable measured in the same cycle that generates the output signal?

In simple words: To what extent does control performance depend on the programmer's experience and control engineering know-how? Can problems arise due to program changes? And will someone else still understand the program after a few years? These and many other aspects are pointers to potential outlays and costs, which are not immediately apparent in the initial cost price.

Decentralized or not?

Here, the following key questions arise:

- Are distributed I/O's in use already?
- Can suitable “automation islands” be created?
- Are separate control modules / satellite PLCs available?
- How important is system availability?
- Is availability an issue? May the failure of a component lead to plant standstill? How quickly can faults be detected, localized, and remedied?
- Must a possible PLC overload be expected?
- Programming or parameter adjustment?
- Who is capable of doing the work in-house? Who has the necessary detailed knowledge of the process?
- To what extent will modularity and flexible expandability/scalability represent an economic degree of freedom for future projects?
- How important are on-site (local) display and operation?

♦ How important are direct assignments between controllers/measurement points and the process?
♦ Does temporally decoupled partial/parallel commissioning offer any advantages?
♦ Do the advantages of distributed units justify the individual installation costs?

Sober evaluation

Central or distributed automation is not a question of ideology; it involves the level-headed consideration of demands, necessities, and costs. And especially for enthusiastic proponents of either approach, it is highly advisable to examine critically the individual advantages and disadvantages of both options, and not fall prey to interest-dependent and purposive argumentation from the start. Hereby, not only the fixed purchasing costs up to and including commissioning of a plant or machine are of interest, but in particular the consequential operating costs accumulated over many years, i.e. for maintenance, trouble shooting, and service.
Due to the abundance of different questions and aspects, this article was only able to provide a brief and incomplete survey. A more detailed examination would be enough to fill a book.

Fig. 3: Selection criteria for "centralized/distributed" automation solutions

Check list of decision-making criteria	**important**	**unimportant**
Local operation improves plant management, and simplifies commissioning.		
Clearness and transparency of a plant are important for operating personnel (operation, maintenance, service, etc.).		
High demands are placed on control performance.		
The plant required complex, interactive control concepts (cascade control, override control, setpoint control, etc.).		
Control loops must be adapted manually or automatically to changing process conditions.		
Programming experience is not required for the implementation of measurement points and control loops.		
Process control must be maintained in case of PLC failure.		
Changes to the PLC program may not have any direct effects on control.		
Problems due to different electric potentials must be expected.		
Subsequent plant extensions/ modifications must be possible.		
Replacement of equipment must be possible during operation.		
High demands are placed on plant availability.		
Parts of the Engineering or plant design are to be used repeatedly for other applications.		
Wiring and installation costs are to be reduced.		

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