

The Advantages of Distributed Intelligence

Introduction: Machines Are Becoming More ‘Motion-Centric’

Today’s automation machines are becoming more motion-centric than ever before. The number of controlled axes per machine has increased significantly over the past 10 years and will continue to increase. Motion has become the most critical process on the machine. Machines are going from using complex mechanical cams with one or two motors to multi-axis servo motor systems. This new generation of machine designs offers increased speed, precision, and productivity.

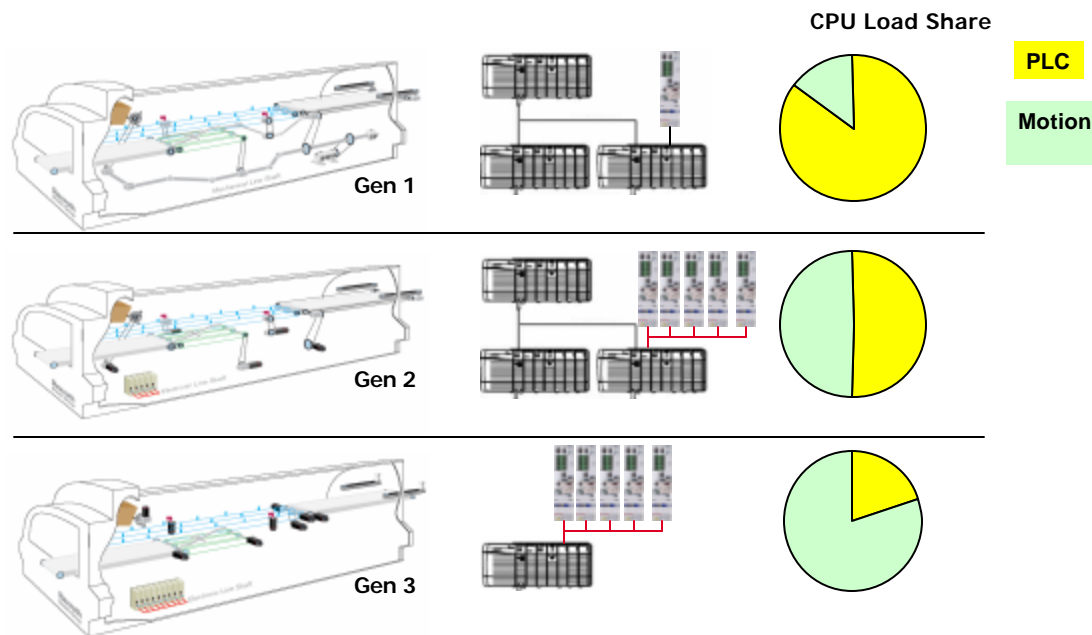


Figure 1: Progression of Motion-Centric Machines. The number of controlled axes per machine has increased significantly over the past 10 years and will continue to increase.

Disadvantages of Centralized Control

Until recently, centralized control systems were the standard in motion control system architectures. Centralized control systems feature ‘centralized intelligence’ where all feedback loops are closed by a main controller – resulting in shared processing power for all axes. Centralized control systems can not deliver the flexibility and performance that the industry demands. In a centralized control system, the main controller is burdened with the motion control tasks for each axis – in addition to other essential control tasks such as PLS or probing. As the number of axes increase, so do update times, as well as the need for faster processors.

In a typical centralized control system, axis count is non-granular. For example, a motion control card might only be available in 2, 4, 8, or 16 axes. For a 5-axis machine, an 8-axis setup is only made available. As a result, more functionality than needed has to be purchased. Additional and/or more powerful processors may need to be added to the system to handle the increased axis count.

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With centralized systems, additional functionality is achieved by adding expansion cards to the centralized controller. This functionality is limited by the number of card slots the control has left available. In addition, these expansion cards consume processing power of the main controller. In addition, the PLC-based central controller typically solves motion as a subset of the main logic process. While this hierarchy is suitable for conveyor systems and other logic-driven, asynchronous processes, it causes needless delays when applied to a high-speed process such as flow wrapping.

The two figures below show how a PLC-based system is outperformed by a motion-centric controller. The first chart shows the baseline, Rexroth controller, compared with a competitive PLC-based controller. The next figure shows practical implications of this lack of processing speed. On a high speed flow wrapper, it is critical to follow the velocity path accurately. If this is not done, the effective sealing and wrapping of the product will be compromised.

Competitive Path Planner Performance Using the Latest Processors

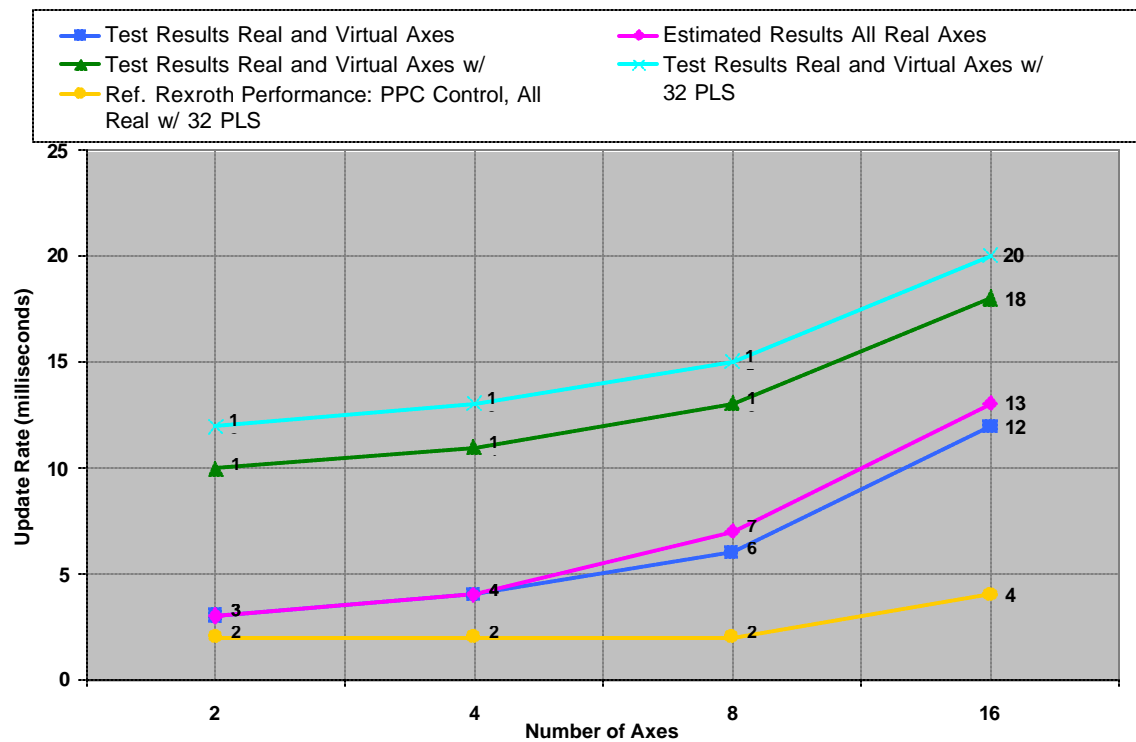


Figure 2: This chart shows the baseline, Rexroth controller, compared with a competitive PLC-based controller. Notice how the Rexroth controller (gold line) stays flat regardless of the number of axes, finally rising after eight axes. In contrast, the competitive controller's processing speed varies greatly depending on the number of axes, whether these axes are real or virtual (real axes normally take more processor cycles), and the number of Programmable Limit Switches (PLS) required.

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Competitive Path Planner Performance Using the Latest Processors

Application: 1500 products/min (25 products per second / 40 ms per product)

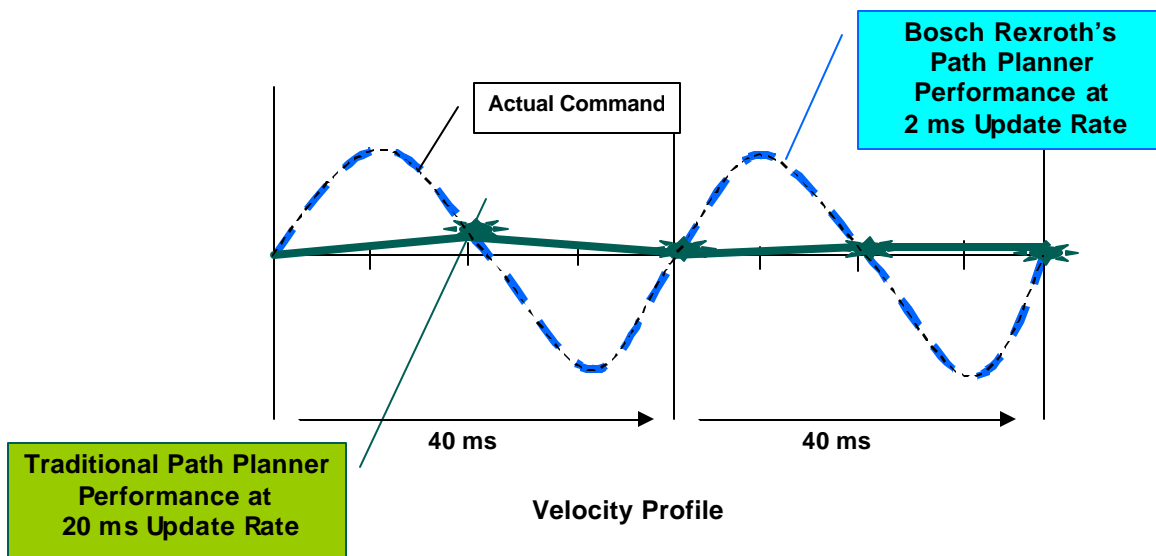


Figure 3: This figure shows practical implications of this lack of processing speed. The dotted line is the velocity command path generated by the control program. The blue line is a velocity path generated at a 2ms update rate, while the green line is a velocity path generated by a competitive, PLC based system running at a 20ms update rate. It is apparent which system will follow the calculated path more accurately.

Distributed Intelligence

To minimize the overwhelming processing power required by a control system, the motion control functionality is distributed to intelligent axes drives which are capable of closing the feedback loop. Distributing the intelligence makes adapting and adding functionality to the main motion controller easier.

The communications between the control and the intelligent drives is made possible by the use of SERCOS, the only internationally approved digital open standard with the performance to synchronize multi-axis motion control. Distributed intelligence removes the burden of motion control from the main controller – allowing more processing power to perform other crucial tasks such as axis sharing, Electronic Line Shafting (ELS), and follower-axis capabilities.

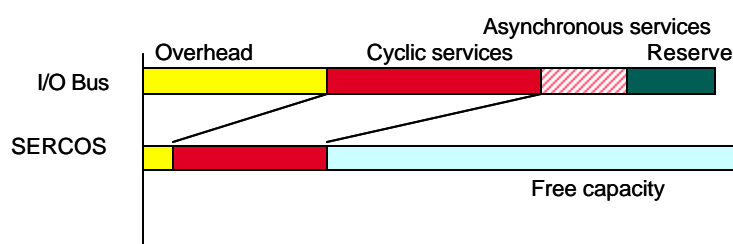
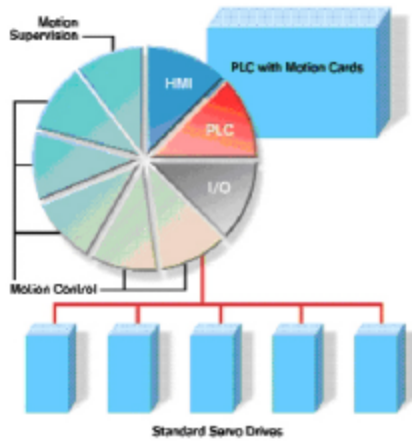


Figure 4: SERCOS interface is deterministic for motion control compared to an IO fieldbus communication.

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The growing demands
of motion...



...are met through
distributed intelligence.

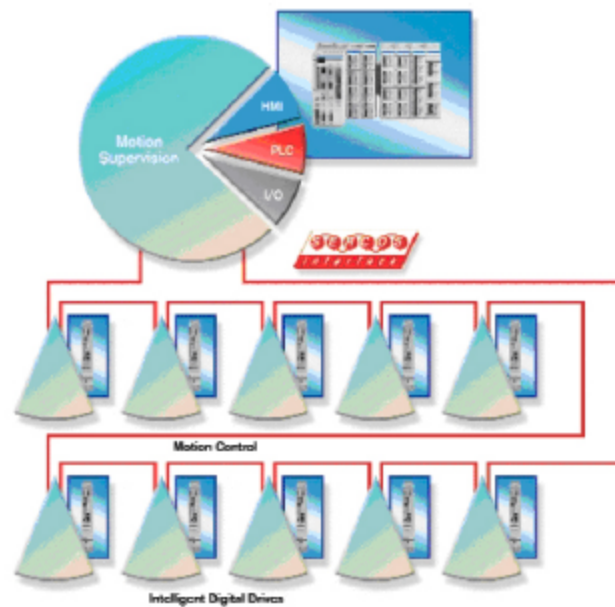


Figure 5: Machines are becoming more motion-centric; as axes increase, machines can become more flexible and productive. Rexroth's distributed intelligence is designed around the motion-centric machine, so you can add more intelligent digital drive axes without having to upgrade or change the control platform.

Advantages of Distributed Intelligence

Distributed intelligent systems perform sensing, monitoring, control, and other applications.

- Lower processing requirements make for higher system performance.
 - The main controller system has a lower processing requirement because the task of position loop closures is divided up by each drive unit. Thus, a higher system performance overall, because the processor in the drive is dedicated to the axis performance only, and the main controller has more of its own processing power for hierarchy control functions.

The Advantages of Distributed Intelligence

- Distributed intelligence allows for modularity and flexibility in machine design.
 - Additional machine axis can be added with minimal set up at the main controller compared with a centralized controller controlling all servo axes.
- Distributed intelligence simplifies system development, installation and testing
 - Modularity with system development
 - Parallel setup
- Distributed intelligence provides better real-time behavior on automated systems.
 - The local processors in drives make critical real-time behavior such as closed-loop control, and sensor inputs possible.
 - Touch probes
 - Cam tables
 - Lead screw error compensation
 - Backlash compensation
 - Absolute feedback positioning (no axis homing required)

Originally, distributed systems were an attractive alternative to centralized systems since they greatly reduced wiring. However, less wiring is just the beginning to the advantages of distributed intelligence architecture. Distributed intelligence allows for advanced functionality including Electronic Line Shafting (ELS), cam tables, high-speed registration, and absolute feedback functionality to be performed by the drive – instead of the main processor. This allows for unmatched performance when compared to centralized intelligence. For example, synchronizing 40 servo axes using centralized architecture would require a tremendous amount of processing power and the performance would be nowhere near that of distributed architecture.

Distributed intelligent drives with local inputs and outputs can react quicker to high-speed inputs than a centralized controller performing multiple tasks. The distributed intelligent drive can react within microseconds of the input activation to stop motion of the axis for example. The distributed intelligent drive only needs to signal the main controller of the high-speed input action acknowledgement. The centralized controller must divide its processing power amongst all drive units connected, and the reaction time of the high speed input is not as fast. Depending on how fast the axis is traveling, the difference of microseconds compared to many milliseconds could be a potential crash, or missing the mark.

In contrast to centralized control systems, distributed control systems allow for complete scalability in axis count. Since the processing power is integrated within the servo drives, no additional burden is put on the main controller. Adding additional axes is as simple as adding in additional servo drives. Distributed intelligence allows for supercharged control systems that are not possible with centralized intelligence.

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More Drive-Based Functionality

By integrating more intelligence into the drive, Rexroth servo drives are capable of functionality such as drive-integrated safety and predictive maintenance. Safety functionality occurs 8 times faster in the drive than in the centralized control.

The Rise of Distributed Intelligence

The use of distributed intelligence in servo drives is increasing in numerous applications. The most recent emergence of distributed intelligence, in the last few years, is the use of distributed intelligent servo drives for packaging applications.



Figure 6: Distributed intelligence in packaging. Flow wrapper lines, vertical wrappers, case packers, food cartoners, smart belt systems, and thermoformers are some of the applications taking advantage of distributed intelligence in the servo drive.

Likewise, in the printing and converting market, machines which were once mechanically linked with gears and timing belts to several print cylinders and a central motor running the line are now using distributed intelligent servo drives at each print cylinder. The distributed intelligent servo drives at each print cylinder allows online job change and helps minimize downtime in maintenance issues. In addition, applications in the automotive industry have been using distributed intelligence for years.

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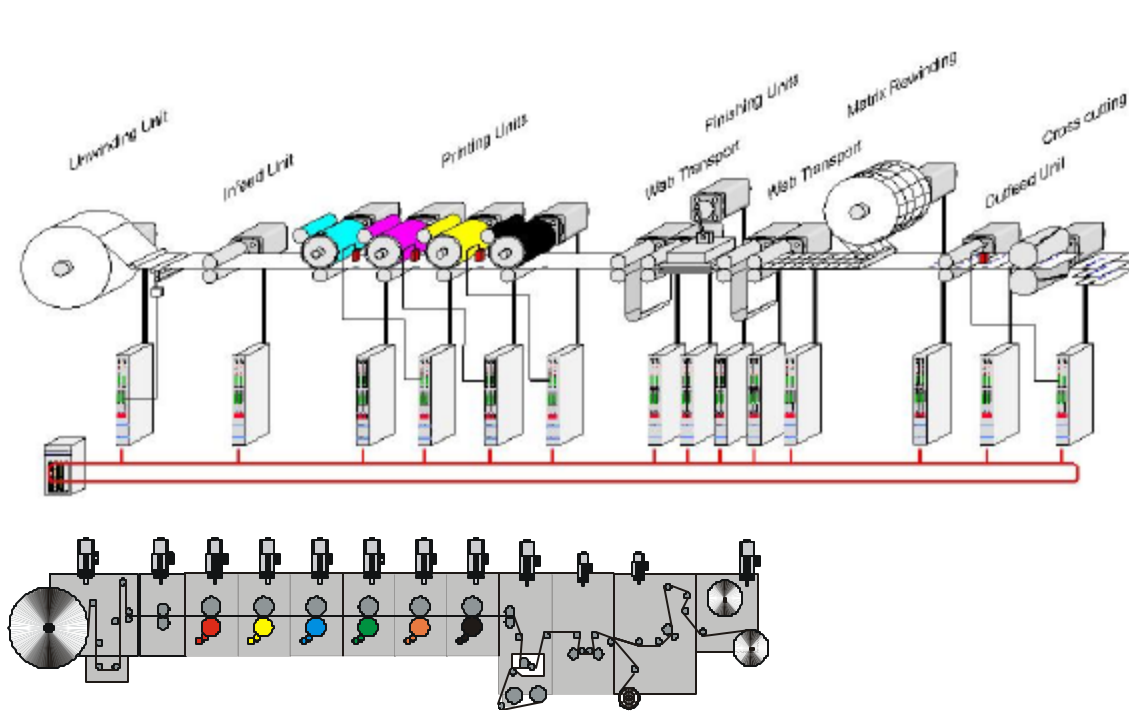


Figure 7: Distributed intelligence in printing and converting. Newspaper printing presses, unwinders/rewinders, coaters and laminators are some of the applications taking advantage of distributed intelligence. Other applications include register control, tension control, winder and dancer control, electronic cams, and electronic gears.

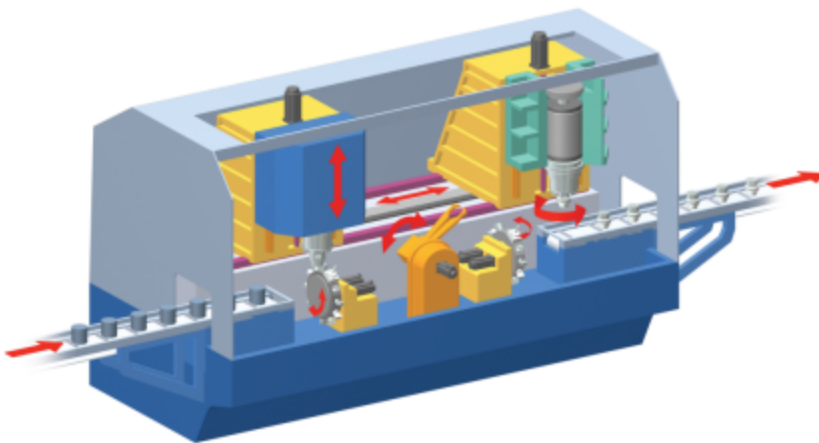


Figure 8: Distributed intelligence in the automotive industry. Distributed intelligence is used on machining transfer lines. Transfer lines are constructed of several machining stations performing different or similar machining tasks such as drilling, tapping, and milling.

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Conclusion

Some may argue of the higher cost for multiple processors, but as machine builders see the advantages of distributed intelligence, the advantages of machine design, and flexibility, it becomes clear how the advantages outweigh the cost.

Adding functionality and intelligence in a drive-by-drive distributed fashion gives designers greater freedom in creating machines that give users more convenience and flexibility. Because processing power is no longer a critical issue, more servo controlled axes are practical along with the advantages of faster setup, greater precision, and higher reliability.