INTELLIGENCE

SPREADING THROUGH THE HIERARCHY

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Many terminal operators are currently making the necessary investments to meet the challenge of larger ships and the subsequent higher peaks of containers that need to be handled. It is essential to be able to toggle between low activity and high peak periods. Clearly, container terminals will need to keep on top of productivity under these circumstances in order to stay competitive. In adapting to the new operating environment, automation and information technologies play the key role.

Considering the changes in the operating environment and the new opportunities provided by technologies, it is more than relevant to ask whether a different approach to the organisation of the tasks within and between the systems and equipment in container terminals would serve a modern, automated container terminal better. Our analysis suggests that as more or less all equipment in a container terminal is now 'system-enabled' and communicates with other systems and equipment in real-time, it is now time to reevaluate the system architecture.

Reorganising system architecture will help terminals to gain the full benefits of automation, information technologies and connectivity. This article presents an architecture that considers all these aspects. We call it node automation architecture based on distributed intelligence.

AUTONOMOUS TEAMS

Let us start by looking at modern organisations where highly educated and self-motivated specialists work with complex tasks and with special knowledge. In such organisations managers can no longer know everything in detail and they need to rely on their teams. Traditional management methods form an obstacle, hindering the organisation to perform at its full potential. How should such organisations be managed and led? The answer is empowering teams and individuals, and leading, not managing them, through targets and goals. This means that the management level focuses on strategies, keeping the company on the right course and setting targets while empowered teams figure out the best ways to achieve the targets given to them. This typically also makes organisations lean with only few hierarchical levels.

The node automation architecture for container terminals based on distributed intelligence follows the analogy of a modern specialist organisation. In this architecture the teams of automated and intelligent equipment are capable of acting like the specialists above. They have the best knowledge required to decide on the best and most efficient way to perform the tasks based on real-time process data. All they need is the targets from their manager, the Terminal Operating System (TOS).

NODE AUTOMATION ARCHITECTURE BASED ON DISTRIBUTED INTELLIGENCE

STS cranes, horizontal transportation, automatic stacking cranes, intermodal yard cranes and gates form the nodes of the node automation architecture. Each node is capable of making decisions and taking action independent of other nodes or upper level systems. Each node is also capable of exchanging information and

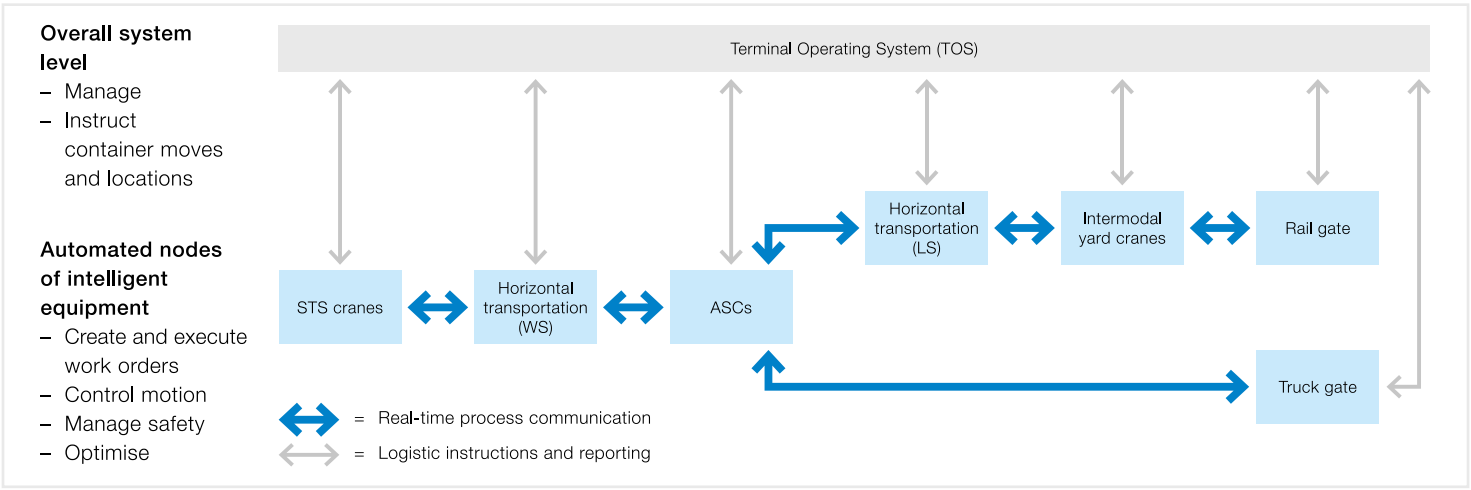

Figure 1: Node automation architecture based on distributed intelligence.

making a "handshake" with other nodes to ensure that correct action will be taken at the right time. Additionally, each node is responsible for safety related functions such as access gates, emergency stops and monitoring of transfer-zone interfaces.

Automation and remote operation is already the standard for stacking cranes and STS cranes are now becoming more and more automated, intelligent, and operate based on work orders from the TOS.

Intermodal yard cranes are also now being equipped with the same automation functionalities as stacking cranes and unmanned units are being introduced. All this equipment is part of a network that is capable of handling, exchanging and acting on real-time information. With the addition of intelligent fleet control for horizontal transport, everyone is getting 'online' and will be able to communicate with each other directly which reduces the need for interactions with the upper level system.

The various types of cranes and horizontal transportation systems are increasingly being equipped with the means to collect information, identify and verify both containers and vehicles. This enables an automated container hand-off at transfer points that is faster, safer and more reliable than a manual hand-off. Information has become an integral part of the process and the driver for more productive container handling in terminals.

Thus, container terminal operations are now very much about the information about the container at all the hand-off points and about the utilisation of that information to create a more efficient and reliable process that allows a large number of containers to be moved as fast as possible. Today it is crucial that information arrives at the hand-off point before the container reaches it, so that the next node in chain can use the information to optimise the next steps in the process.

LEAN ARCHITECTURE WITH NODE AUTOMATION

Real-time information is the backbone of the node automation concept. Based on the information, intelligent equipment can:

- Create work orders based on higher level instructions from a TOS (e.g. a list of containers that need to be moved and on their location in the storage block/on the ship)
- Optimise the execution of work orders within the node based on real-time data
- React to changes in an already distributed instructions list
- Automatically handle the sequence optimisation like dynamic calculations of handover positions to balance the workload of the equipment involved
- Take corrective measures if the reality deviates from the plan (e.g. at discharging the container in the given cell is not the one it should be)
- Communicate with other nodes to achieve seamless flow with minimum interaction with upper level system
- Report the status of the tasks to the TOS.

Just like specialist organisations, the equipment team's ability to operate without continuous interaction with upper level systems, node automation makes the system architecture lean. In fact, as one can conclude from the list above and the examples given later in this paper, deploying node automation leads, for instance, to:

- Simpler system architecture with less vertical interactions and data exchange
- Clearly defined responsibilities between the nodes and decision making based on real-time process data on the "grass root level"
- A reduced need for integration testing at site since each node can be pre-tested individually
- System upgrades can be made per node without impacting the whole system

Node automation architecture is flexible and can be implemented in all nodes or just part of them depending on the terminals needs. However, the full benefits will be realised only if it is implemented throughout the chain from ship to gate.

OPTIMISED YARD OPERATION WITH NODE AUTOMATION ARCHITECTURE

Automatic stacking crane blocks are able to respond to varying seaside and landside volumes and ensure a timely delivery of containers for quay and rail terminal processes. The scheduling function allows optimisation of the use of the cranes within the block based on instructions from the TOS and based on various criteria set, like fastest total execution, minimum energy consumption, importance of the task and vehicle waiting time. This improves productivity and reduces empty travel and, consequently, also energy consumption.

Intelligent stacking cranes interact with gate to prioritise tasks to be performed. The gate can notify stacking crane about a truck with/without container(s) which will arrive at the stacking crane transfer zone. Based on this notification, intelligent stacking cranes can prioritise the work orders to minimise the truck turnaround time, or another work order depending on which task is the most important to complete at that time.

HIGHER THROUGHPUT AT THE QUAY

At the quay STS cranes optimise the discharging and/or loading processes based on the instructions from the TOS. Intelligent STS cranes can exchange

Source: ABB

information about bay/tier/cell locations in real-time for faster loading and discharging, and to optimise moves.

In addition to the TOS, intelligent STS cranes also interface with vehicle control systems. Using the information on their exact position, acceleration and speed of the main motions, as well as the optimum path of the load, they are able to calculate when the container is ready to be picked up by the horizontal transportation or when the next container for loading should be delivered to the crane. The cranes are also able to calculate the completion times for a number of subsequent moves and can thereby request the horizontal transportation system to dispatch vehicles to the right positions at exactly the right time. This enables teams to avoid waiting times and makes it easier to plan for double cycling of the equipment making both the cranes and the horizontal transportation more productive.

At the STS node the identity of each unloaded container is verified using a crane OCR. The information is compared with the stowage and work order information, and the TOS is notified of any discrepancies. The container identity is passed on to the horizontal transportation system.

When loading, the cranes collect accurate stowage information based on the OCR reads and the actual loading positions on the vessel. This information is updated and passed on to the TOS to ensure that correct stowage information is available there.

SUMMARY AND CONCLUSION

The shipping patterns and requirements with regards to the amount of containers to be handled at one time are changing. To keep up with productivity, and thus stay competitive, is the biggest challenge many terminals are currently facing. With the new capabilities of automation and information technologies it is time to challenge the traditional thinking regarding roles and responsibilities of the various systems and equipment used in terminal operations.

Deploying node automation architecture based on distributed intelligence allows a leaner and more efficient system architecture with less hierarchical levels. In this architecture the TOS has the opportunity to take the role of the manager of the operations leading the empowered equipment teams by setting targets, i.e. instructions related to the container moves to be made. The intelligent equipment organised in nodes takes the necessary decisions and collaborates to perform the given tasks in an optimised, safe and accurate way to meet the targets given by TOS and ultimately, terminal's production targets.

ABOUT THE AUTHOR

Björn Henriksson is the Global Technology Manager at ABB Ports. He has long and versatile experience on container terminal automation and electrical systems through the various positions he has held over the years within R&D, engineering and commissioning, including several management positions. Björn Henriksson joined ABB in 2001 via ABB's Executive Trainee program and has a Master of Science degree in Electrical Engineering from Royal Institute of Technology in Stockholm (KTH), Sweden.

ABOUT THE ORGANISATION

ABB Ports develops and delivers intelligent terminal automation solutions and services to make container terminals safer, greener and more productive. The solutions include automation and remote control for all types of container handling cranes, and complete OCR and electrical systems. With the track-record of the largest installed base, ABB's systems help to optimise container handling from ship to gate in greenfield installations and in existing terminals.

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