Multi-Vendor AMR Control System

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Production activities in factories inevitably involve the movement of objects. As labor shortage worsens due to the declining working population, it is desirable to automate relatively low-value-added tasks such as transporting objects. Numerous transport tasks exist in OKI Group factories, and in order to improve the production efficiency of these tasks, it was deemed necessary to quickly implement and operate a smart automated transport system. Furthermore, if deployment at multiple factories is taken into consideration, each factory individually implementing a different system is not efficient from an operational or cost perspective. Therefore, development of a common system is desirable. However, OKI's factories vary in industry, size, and product characteristics, making it important to select a model that appropriately suits the requirements.

This article introduces the RAT (Robot Arm Transporter) system that was developed and implemented to solve these issues. The system is a host system that can centrally control AMRs (Autonomous Mobile Robots) from multiple vendors to meet a wide variety of on-site requirements.

Concept

The following three points were behind the initial concept for the RAT system's development:

1. Centralized control of multi-vendor AMRs
2. Simple on-site setup and operation
3. External system integration and operation without operator intervention (data-driven operation)

Centralized Control of Multi-Vendor AMRs

The system's biggest feature is its ability to centrally control multi-vendor AMRs. The manager layer at the program's core performs centralized control such as dispatch and traffic control of the robots, while the controller layer instantiated for each robot absorbs the differences that exist between the robots. The controller layer is a common class and is designed to operate appropriately for each robot when instantiated (**Figure 1**).

When using multi-vendor AMRs, it is typically necessary to create, edit, and configure an individual map for each. This process is extremely cumbersome and inefficient. Even after the initial setup, the minor layout and positioning changes that often occur during daily operation necessitate partial map revisions. In these cases, maps must be created and edited according to the number of vendors being used. To streamline the process, a standardized map was developed. Specifically, a map is created on one AMR and that map is then distributed to all AMRs for control, regardless of vendor or model, resulting in a more efficient setup and maintenance.

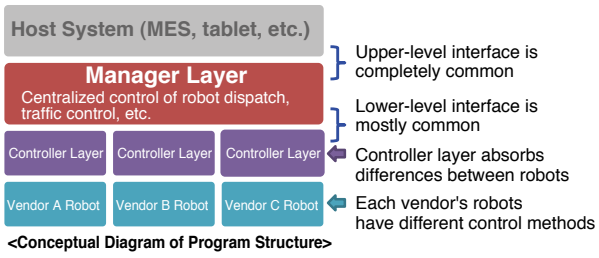

Figure 1. Program Structure

External System Integration / Data-Driven

Integration with external systems is facilitated by using a database rather than having each application communicate directly with the AMR. Furthermore, various statuses can be checked from anywhere by referencing the same database.

One example is the integration with a production progress management system. If the operation calls for a transport request to be issued when a specific monitored object reaches a certain quantity, an application is set up to write a transport request to the database when the condition is met, enabling data-driven control of the AMR's operation.

The system configuration is shown in **Figure 2**.

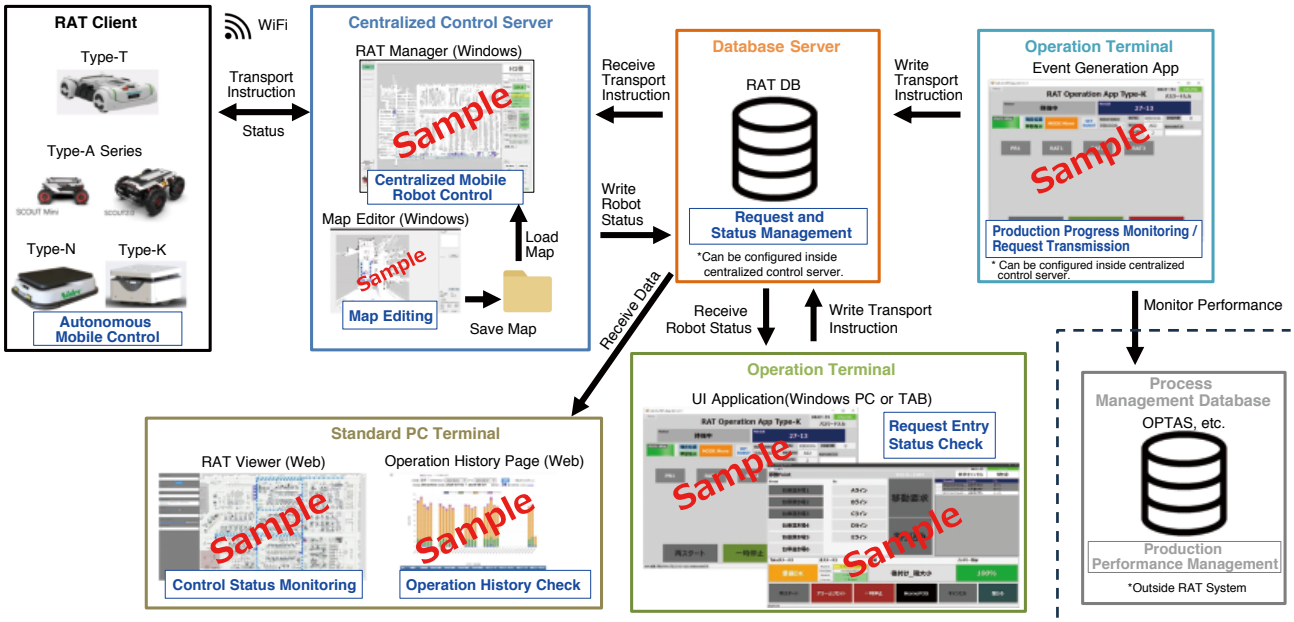

Figure 2. System Configuration

Attachment Modules (Linkage, Lifter, Arm)

Straight out of the box, AMRs are designed to be operated by workers placing the objects to be transported on top of the AMR. However, various attachment modules are required for efficient transport of parts and finished products. While the attachments may be available as options from the vendor and adopted as is, attachment modules are often manufactured in-house to standardize specifications. Typical attachment modules include a cart linkage module (**Photo 1**) for transporting entire carts, a lifter module (**Photo 2**) for lifting and transporting racks and parts boxes, and an arm module for supplying parts to each workbench and collecting empty containers.

Photo 1. Cart Linkage Module

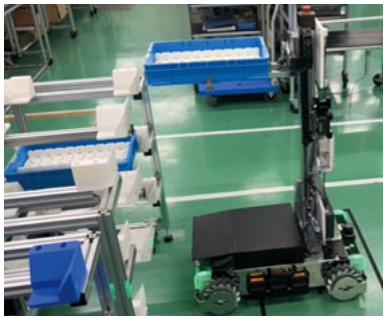

Photo 2. Lifter Module

Facility Integration

Transport within a factory often requires integration with the factory's facilities. Typical examples include automatic doors, elevators, and existing AGVs (Automated Guided Vehicles). OKI consulted with the respective vendors, presented vendors with OKI's standardized specifications, and modifications have been performed. This allows for smooth transport while integrating with various factory facilities.

Field Sensing

As previously mentioned, transport operations can be initiated manually by the worker (button press) or automatically through external system integration.

Additionally, field sensing has been implemented to trigger transport when a cart is placed in a specific location. This allows a worker to simply place a cart loaded with finished products at a designated location, which will automatically issue a request and initiate transport. However, when a worker issues a request, it may not be possible to remotely determine whether an opening is available at the destination, making it difficult to determine whether the transport should proceed. Field sensing can also be used in such a case, making it possible to initiate transport when the destination becomes available. Furthermore, a function has been implemented to automatically search for available locations by grouping multiple destination locations and sensing each location. A worker simply selects a group and requests transport, and objects will be automatically transported to an available location.

Photo 3. Automatic Empty Cart Collection using Cart Sensing

Useful Applications to Assist Operations

In addition to direct AMR control, OKI is also developing and operating convenient applications to assist operations.

The operation visualization application is a web application accessible from the company's intranet. It provides information such as the number of AMR trips, distance traveled, and malfunction status for each factory. The information is utilized to confirm the effectiveness of the implementation, identify defects, and implement countermeasures to improve operations (**Figure 3**).

The operation status application is also a web application. It displays the current location of the robots on a map as well as the status of each, trajectory, heat map for checking congestion status, and network strength information (**Figure 4**). The application also has a tracing function for past information. By specifying a starting and ending date/time, a robot's operating condition and status for that period can be reproduced. This allows the events leading up to a malfunction to be confirmed and enables rapid troubleshooting. Past information can also be displayed in the same way as current information, displaying congestion status and trajectories, and the information can be used for layout considerations.

Figure 3. Web Page Displaying Movement Counts, etc.

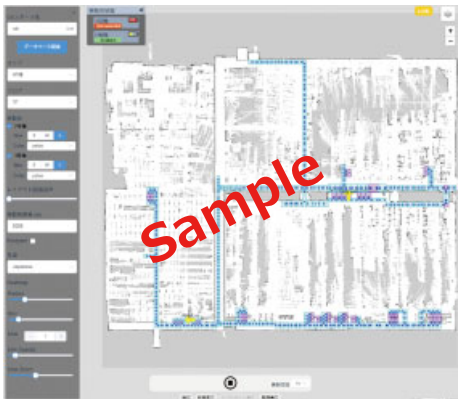

Figure 4. RAT-Viewer for Remote Monitoring of Operation

Implementation Status

OKI is currently implementing AMRs at numerous manufacturing sites, including those of its group companies (**Table 1**).

The AMRs are being rolled out by identifying each factory's transport requirements, making careful adjustments, and adding necessary functions as needed.

A representative implementation example is the flagship OKI Honjo Plant, where two AMRs are currently in operation. The robots prevent mis-transportation by sensing the presence or absence of carts, and objects are transported to available storage areas within a group-specified destination. If an empty cart is present in cart storage area, the system automatically retrieves the cart and returns during the transport of components, further increasing efficiency (**Photo 3**). In FY2025, integration with

factory elevators is planned for inter-floor transport. At OKI Electric Cable, one AGV and one AMR are in operation to transport electrical wire components. Here, a function was implemented in the AMR to enable linkage with the AGV and perform traffic control. Furthermore, the factory layout undergoes drastic changes due to the large size of the workpieces, and during initial setup, the AMR experienced difficulty in estimating its position. Since the AMR was self-customized, the height of the installed LiDAR (Light Detection and Ranging) was raised to avoid the effects of obstacles, thereby achieving stable operation.

Table 1. OKI Group's Implementation Status

Factory Location	Start of Operation
OKI Honjo Plant (Saitama Pref.)	FY2022, July (Normal)
	FY2024, September (High-Speed)
OKI Data MES (Fukushima Pref.)	FY2022, August
OKI Data Manufacturing (Thailand) Co., Ltd. (Thailand)	FY2023, August
OKI Tomioka Manufacturing (Gunma Pref.)	FY2023, March
OKI Nextech Komoro (Nagano Pref.)	FY2022, November
OKI Numazu Plant (Shizuoka Pref.)	FY2023, March
OKI Electric Cable (Gunma Pref.)	FY2024, March
OKI VIET NAM COMPANY LIMITED (Vietnam)	FY2025, October (Planned)
OKI Circuit Technology Joetsu (Niigata Pref.)	FY2025, October (Planned)

Future Outlook and External Sales

Working in conjunction with the Enterprise Solutions Division and Global Marketing Center (GMC) within OKI, the company is preparing for commercialization of the RAT system by exchanging ideas and conducting demonstrations with various clients both in Japan and overseas (**Photo 4**).

Regarding overseas expansion in particular, OKI has received interest from an Asian company and is already in the demonstration phase after submitting a proposal and exchanging ideas with the potential client.

OKI has 19 sales, production, and technology development centers known as Global Innovation Hubs (GIHs) around the world. Working with the staff at these locations, OKI will cultivate local partners and accelerate the global expansion (external sales) of the RAT system.

Overseas support services differ significantly from those in Japan, making it extremely difficult for OKI to build a service support system on its own. Including this aspect, OKI views co-creation with local partners, as a key to external sales of the RAT system, and will continue to work on this matter on a daily basis.

Photo 4. Example of Multi-Vendor AMRs

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TIPS【Glossary】

AMR (Autonomous Mobile Robot)
A transport robot that automatically determines the optimal route while avoiding people and obstacles in factories and warehouses.

Instantiate
The act of generating a concrete entity (instance) from a blueprint (class).

Field Sensing
The collection and monitoring of equipment and environmental data using various IoT sensors in a factory (field).

AGV (Automated Guided Vehicle)
A robot that automatically transports goods along a predetermined route, such as a magnetic tape or rail, in a factory or warehouse.

LiDAR (Light Detection and Ranging)
A remote sensing technology that uses light. It measures scattered light from a pulsed laser beam and analyzes the distance and characteristics of distant objects.

OPTAS
OKI data Production control and Total Analysis System