A MIDDLEWARE FOR INTER-VENDOR MOBILE ROBOT COMMUNICATION

INITIAL MASTER THESIS PRESENTATION

Introduction | Problem Statement | Task Description | Research Questions | Related Work | Significance | References

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1. INTRODUCTION
BACKGROUND

Fig. 1 Mobile robot MIR 100

Industry 4.0

- Brought to public in 2011 [1]
- Digitize the industry [1]
- Goals: [2]
    - Automating processes
    - Increase effectiveness & efficiency
    - Lower material & human resources
    - Increase flexibility
- Challenges: [2]
    - Real-time data exchange
    - Flexibility
    - Security
- Connecting devices & exchange information [2]

Mobile Robots

- Machines that use sensors and software to move [3]
- To adapt to changing requirements [4, 5]
- Vendor-dependent applications & interfaces [6]
- Multi-vendor strategies require communication standard [2]

1. INTRODUCTION
PILOT PROJECT

Fig. 2 Pilot project at BASF in Kaisten [11]

Use of a Driverless Transport

- Tested at BASF site in Kaisten [7]
- Started in 2021 [7, 8]
- A driverless, fully autonomous vehicle [7, 8]
- Transport products between production & logistics warehouse [7, 9]
- Manually loaded [8]
- Automatically unloaded by a mobile robot from a different vendor [10]

2. PROBLEM STATEMENT
RESEARCH PROBLEM

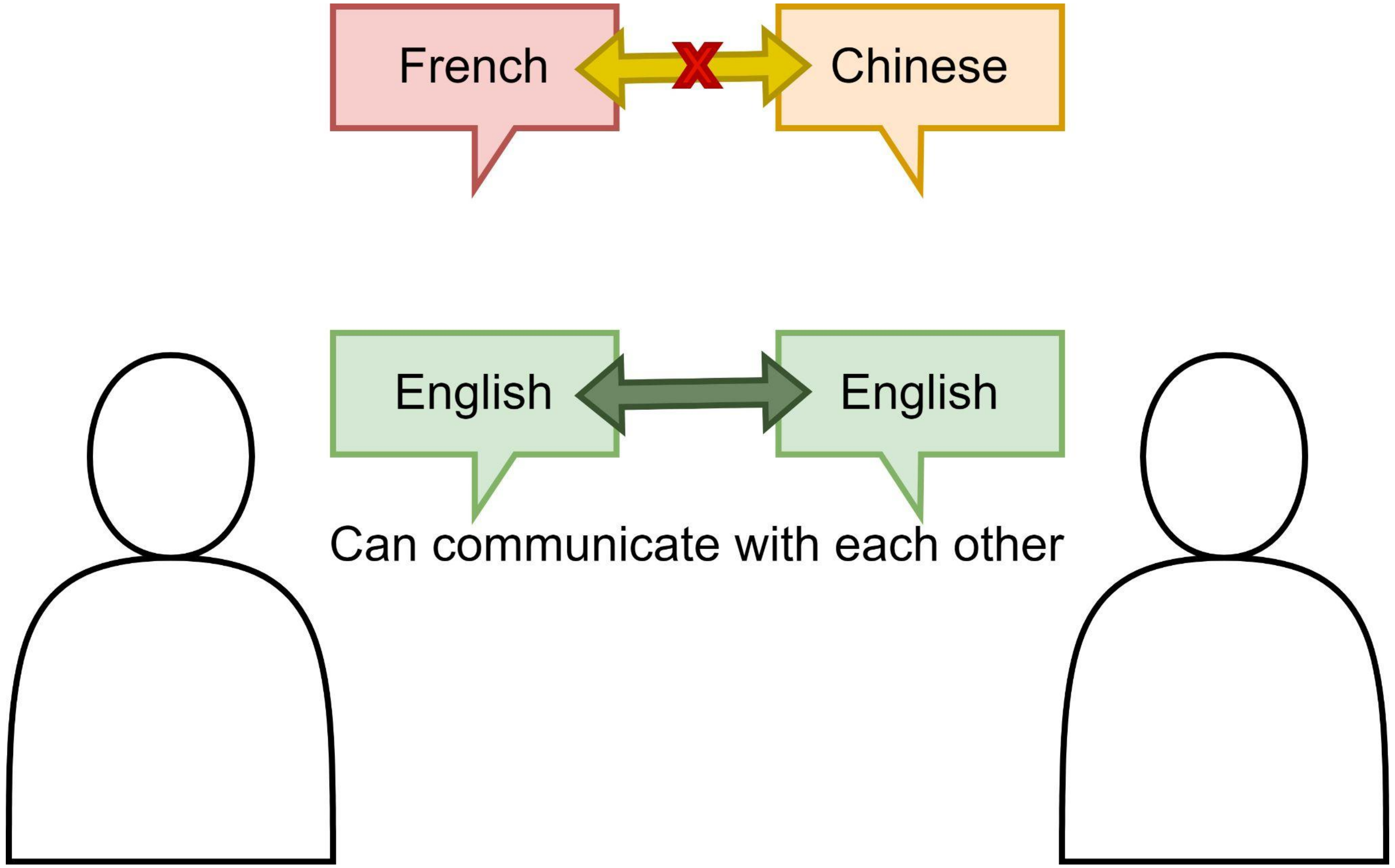

Fig. 3 Human analogue of a communication standard

Motivation for multi-vendor strategy

- Different technical requirements and features [12]
- Increase flexibility
- Vendor independency
- Decrease costs

Problem Statement

- Vendor-specific systems [6]

→ Need for communication standard

- Communication standards under development [6]
- Address external interfaces of mobile robots

→ Need for middleware

- Lack of middleware

3. TASK DESCRIPTION
MIDDLEWARE FOR MULTI-VENDOR COMMUNICATION

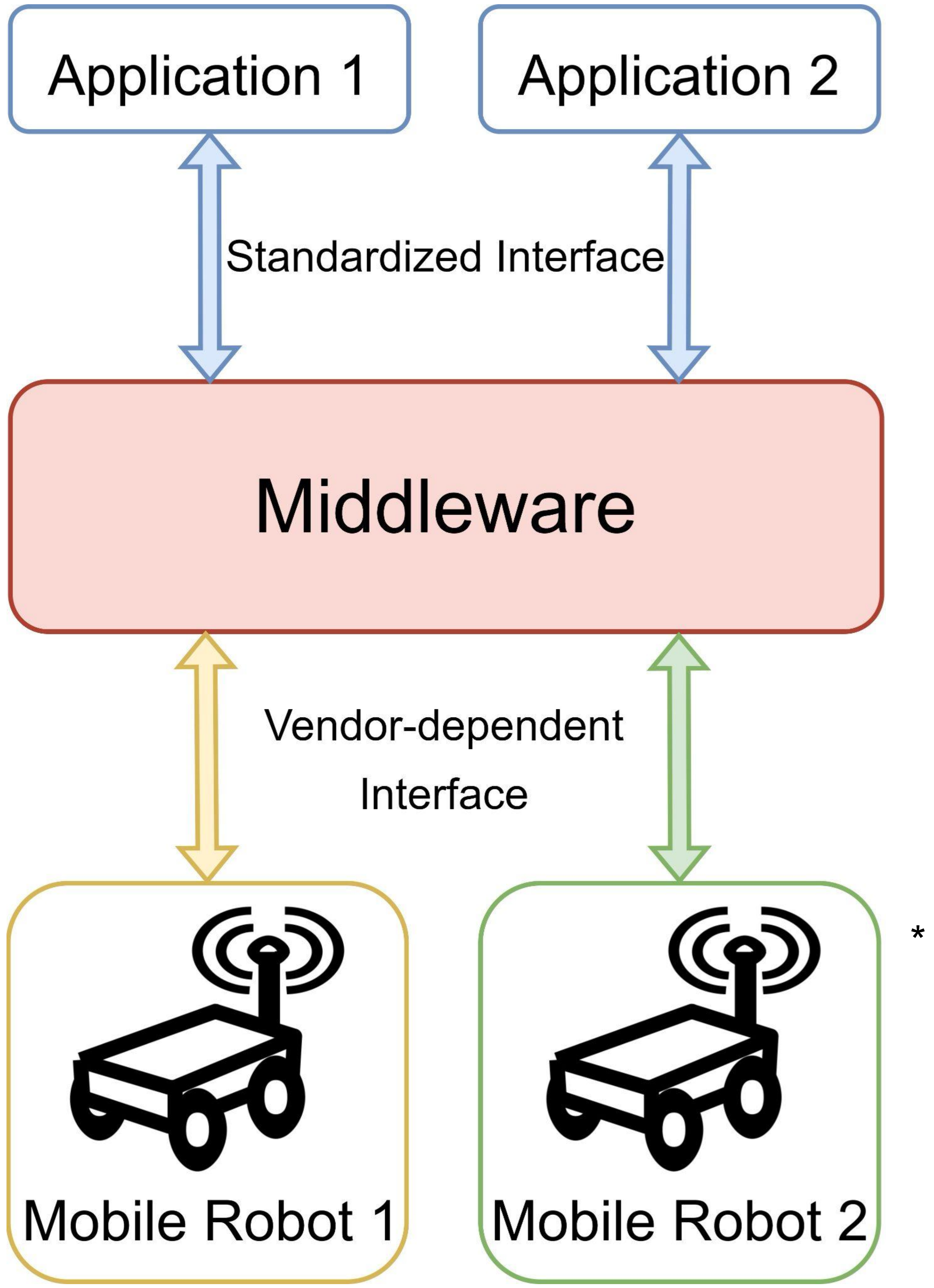

Fig. 4 Middleware for multi-vendor mobile robot communication
* Mobile robot icon from [13]

Must be done

- Two mobile robots from different vendors must be controllable via a middleware
- Mobile robots must drive from point A to point B
- Middleware must have a connection to a manufacturing execution system application

Should be done

- Middleware should have a connection to a business process management system
- Existing communication standards should be used
- Mobile robots should be assigned depending on their functional requirements or data
- Middleware designed for simple integration with new robots

May be done

- Mobile robots may pick up and drop off a load
- Mobile robots may charge

4. RESEARCH QUESTIONS

Main research question

- How to improve communication of process automation systems with mobile robots from different vendors?

  (With focus on simplifying the integration of multiple mobile robots)
  - Identify state-of-the-art for multi-vendor mobile robots approaches
  - Identify existing protocols & communication standards
  - Compare protocols & standards
  - Evaluate suitable communication protocols & standards
  - Identify which data needs to be communicated
  - Identify approach to integrate business process management system and manufacturing execution system application

Optional research question

- How do mobile robots from different vendors communicate with each other in a production plant?
  - Compare direct & indirect communication
  - Identify challenges

5. RELATED WORK

MassRobotics AMR Interoperability Standard

Fig. 5 MassRobotics AMR interoperability standard logo [14]

- Released in May 2021 [15]
- Goal: develop standards to enable use of AMR from different vendors [15, 16]
- Standardized way to share information [16]
  - Manufacturer name, robot model
  - Position
  - Operational state
  - Battery Level

5. RELATED WORK
VDA 5050

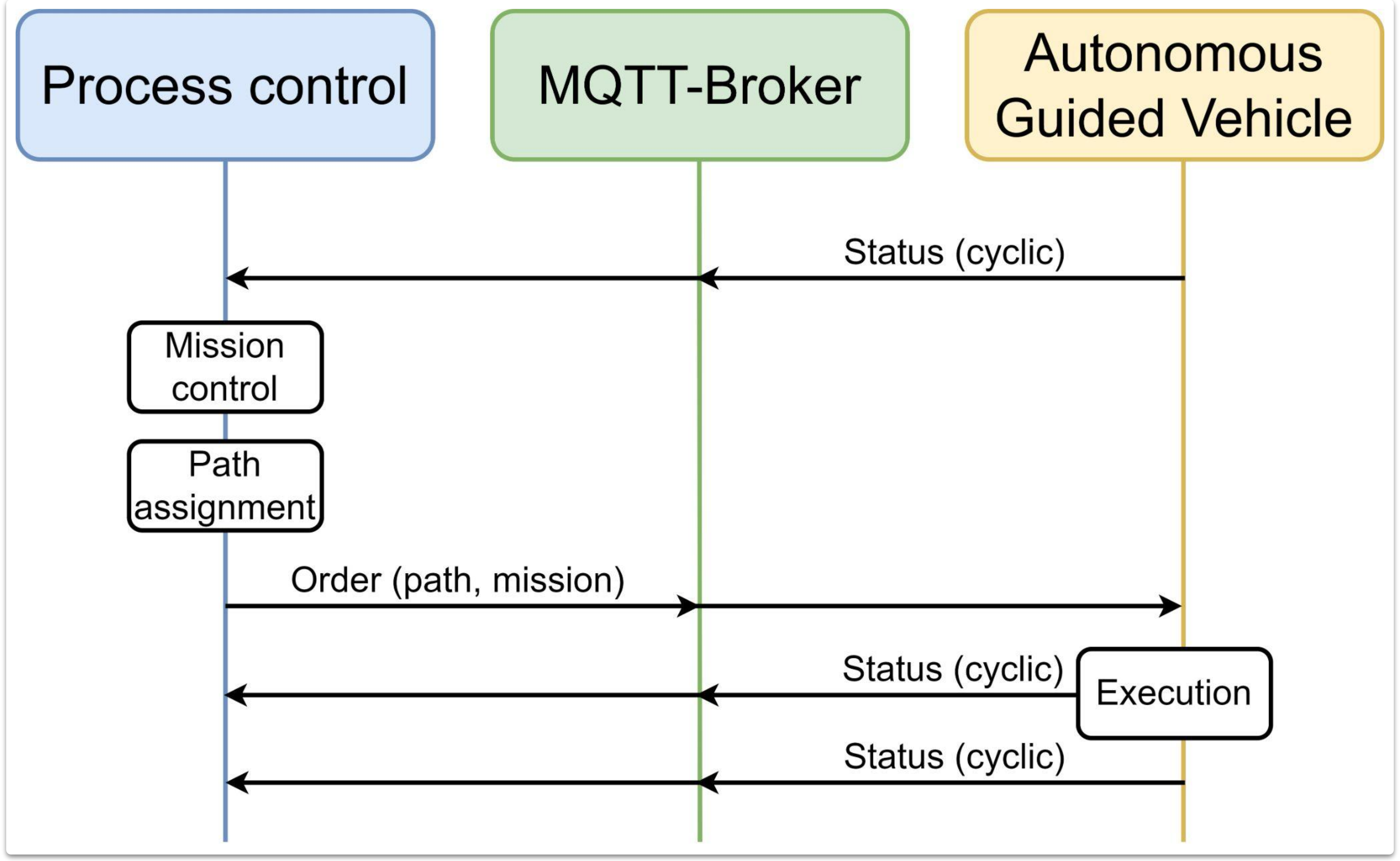

Fig. 7 Process and communication of VDA 5050, derived from [19]

VDA Verband der Automobilindustrie

Fig. 6 VDA logo [17]

- Released in August 2019 [17]
- Standardized interface for AGV communication [18]
- Communication of status and mission data between AGV and master control [18]
- Goal: use of multi-vendor AGVs and simple integration of new AGVs [18]
- Requirements: Pull principle [18, 19]
- Defines actions: [19]
  - Driving
  - Pick up & drop load
  - Charging, pause mode, detect object, wait for trigger

OPC UA

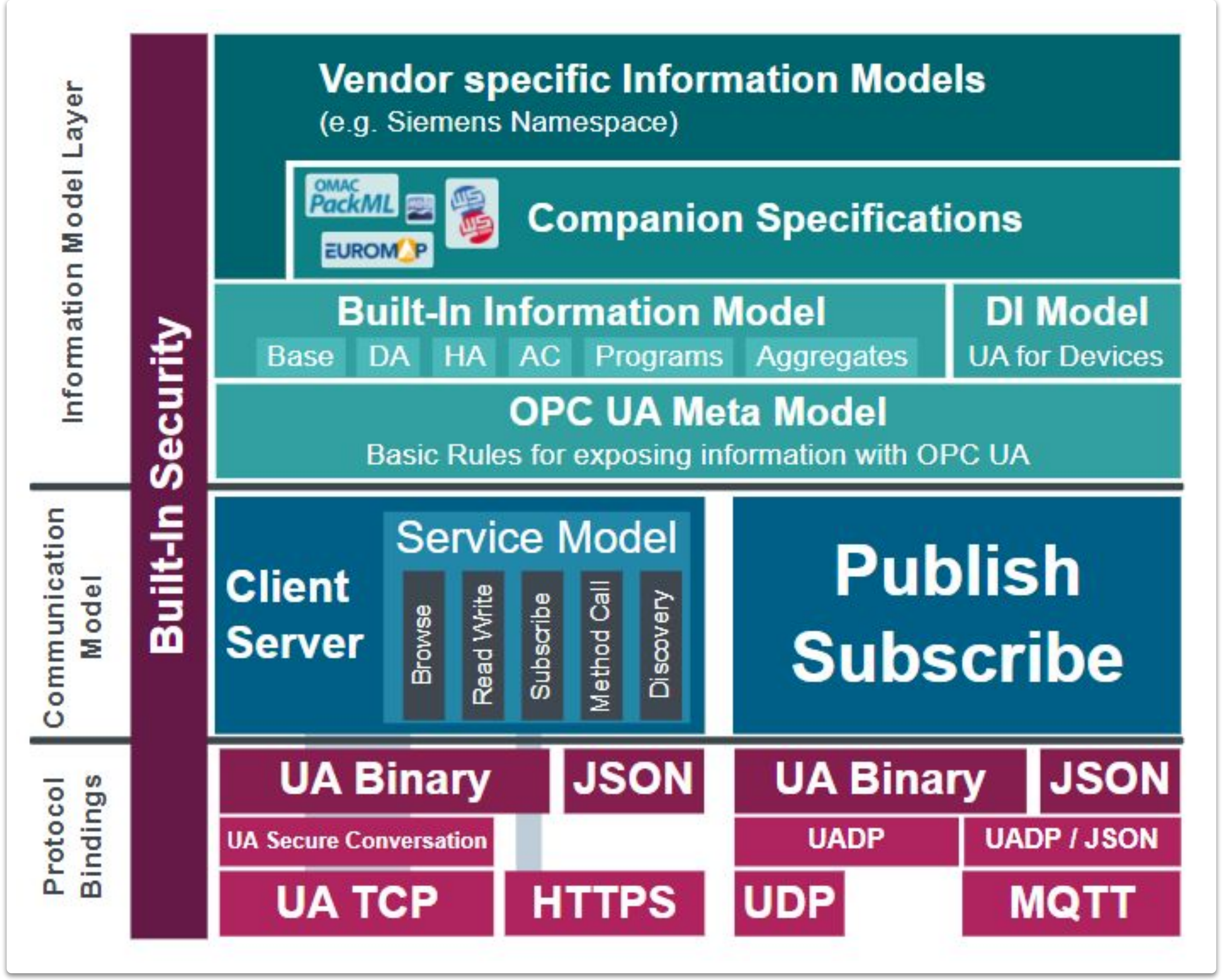

Fig. 9 OPC UA architecture [23]

Fig. 8 OPC UA logo [20]

- Platform independent service-oriented architecture [21]
- Standard for data exchange from sensors to cloud applications [21]
- Goal: create common language for machines [21]

OPC UA Robotics companion specification

- Released in May 2019 [22]
- Information for asset management and condition monitoring [22]
  - Motors, manipulators, controllers, software

6. TASK DESCRIPTION
MIDDLEWARE FOR MULTI-VENDOR COMMUNICATION

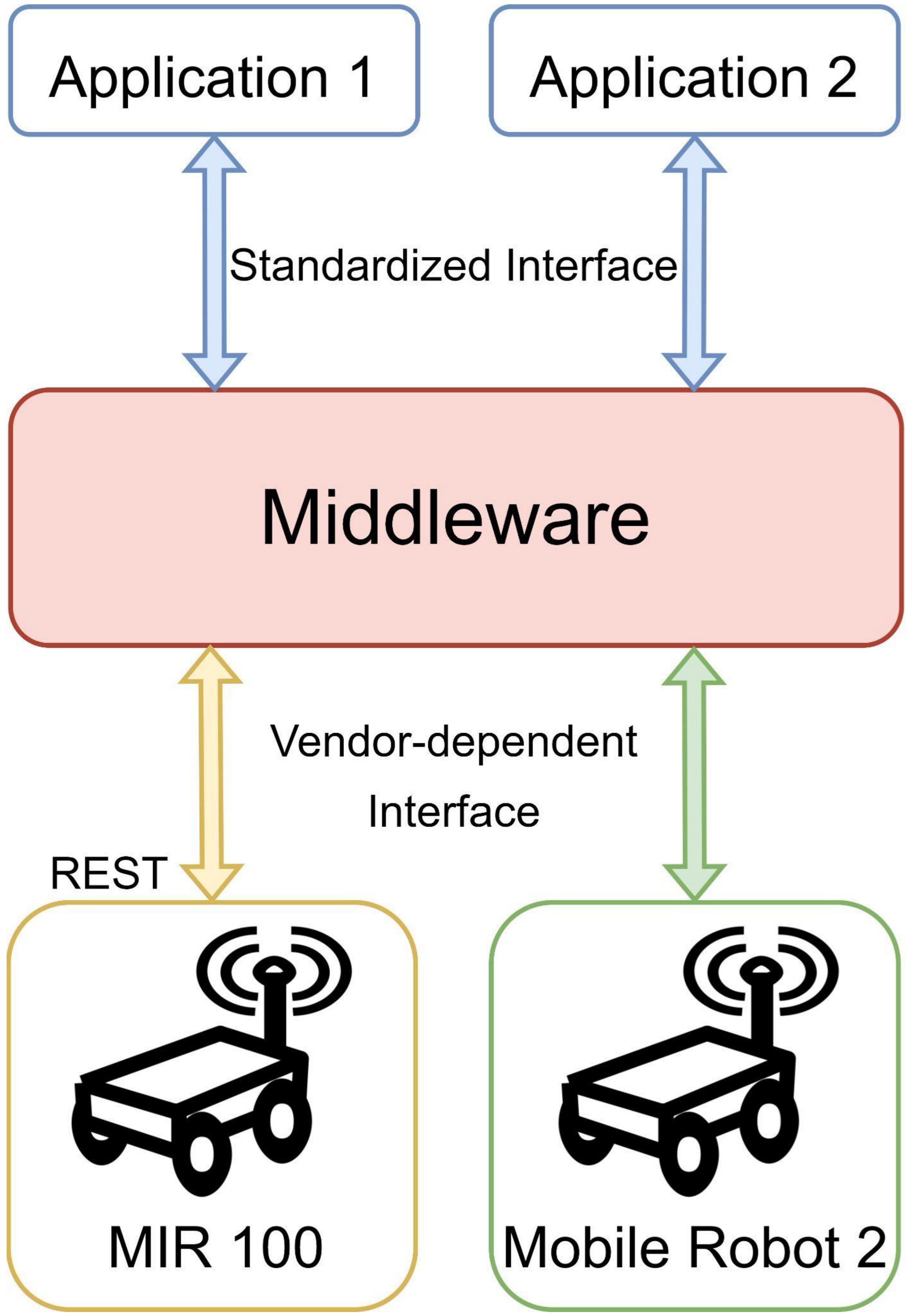

Fig. 4 Middleware for multi-vendor mobile robot communication

* Mobile robot icon from [13]

7. SIGNIFICANCE

- Multi-vendor mobile robot strategies
- Proof-of-concept for existing protocols & standards
- Advantages:
    - Simple integration for multiple mobile robots (“plug and play”)
    - Increased flexibility
    - Reduce costs
    - Minimize errors

Pilot project

- Mobile robot is unloaded after manual user input [8]

→ Fully automating the process

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