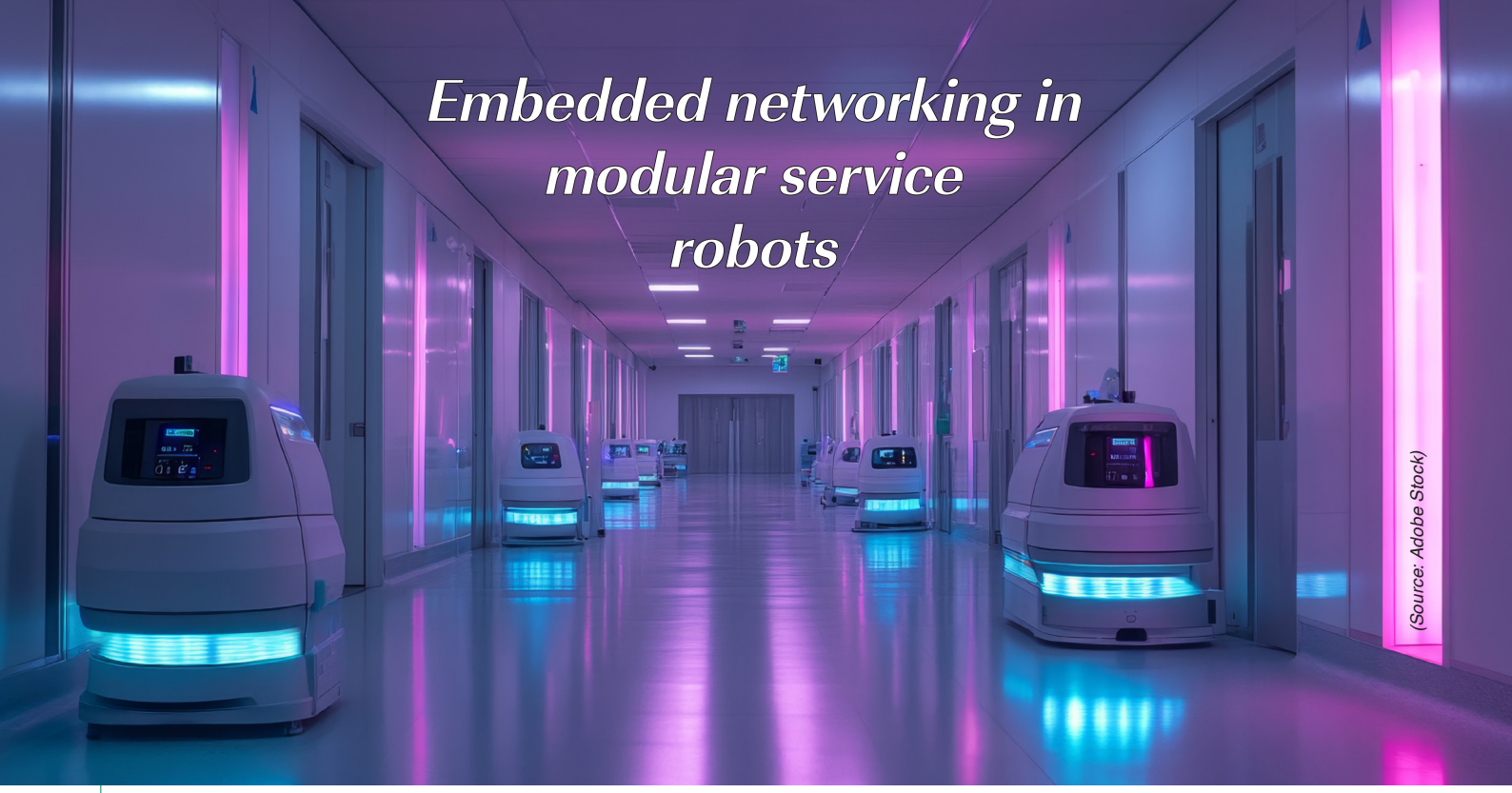
Embedded networking in modular service robots



(Source: Adobe Stock)

CAN is a preferred communication technology in service robots. CAN networks are used to communicate between several modules. Standardized CAN interfaces would be helpful to increase the market for provided modules, e.g., for navigation or for handling purposes.

Unfortunately, it is unclear, what belongs to the modular service robot market. Additionally, the markets of service robots are highly fragmented. This means, the production volumes are very low. Many of them are unique, meaning they are single units. But in total, it is a huge market, which is increasing. The nonprofit International Federation of Robotics (IFR), established in 1987, reported for 2023 a 30-percent increase for service robots, summing up to 205000 units. Nearly 80 percent (162284 units) of the service robots are developed in Far East: China, Japan, and Korea are in the lead. Europe follows with 33918 units.

"The service robotics industry is on the move: more and more robots are serving on factory floors, in shopping centers, or helping with deliveries on the street," said Marina Bill, the IFR president. In 2023, about half of the service robot market was installed for transportation and logistics.

In the U.S.A., medical service robots are booming. There are about 199 companies developing modules for applications in hospitals and other healthcare robots. Many of them are small and start-up companies. In China, there are some 107 service and medical robot manufacturers. The proportion of Chinese companies offering professional service robots is higher than in North America. In Germany, IFR counted 83 companies developing service robots or modules. These IFR figures seemed to be conservative compared with other market research. The Association for Advanced Automation (A3) reported an annual production of about 500000 logistics robots, for example. There is also the question: Are agriculture robots belonging to the service robot markets?

In general, service robots are different from industrial robots, which are used, for example, for welding and assembly purposes. Service robots are used in non-industrial environments for hospitality, healthcare, and home maintenance purposes or for logistics tasks. Agriculture robots have some similarities: Predictability is not always given, because of the changing environments. Professional cleaning robots have also some similarities with some service robots.

Common to all kinds of service robots is the navigation and the movement in not predictable environments. They need to avoid obstacles, to find an efficient path, and to perform tasks without permanent supervision. Therefore, service robots use advanced sensors to understand the surroundings. Increasingly, they are supported by AI (artificial intelligence).

Technical challenges for professional service robots

These challenges include navigation, dexterity of control, and cognition for human interaction. Improving vision software would help to navigate professional service robots. To automate non-factory tasks in a challenging environment is still in an early stage. Dexterity is a key issue, because unlike industrial robots, service robots are often not operated behind cages. Their actuation power should be limited, in order to avoid damage of human beings or handled objects (e.g., plants and animals in case of agriculture robots). This is the same as with robots

XML schema for inter-module communication

CiA is going to submit a proposal for an XML schema describing OSI (open systems interconnections) layers and sublayers. This is a generic approach for wired and wireless communication technologies. Of course, it is suitable for CAN-based networks, too.

Table 1 shows the OSI layers and sublayers, which defines the communication interfaces of service robot modules. Not all of them need to be defined. However, the more are defined the higher is the level of compatibility and interoperability.

The value definitions of the shown communication functions are defined in separate tables. As an example, the defined values for CAN-based PMA (physical medium attachment) sublayers are given in Table 2.

Using these definitions in an XML schema allows the service robot module supplier to describe all implemented communication interfaces. For the system designer, it is possible, to check the compatibility and interoperability of communication interfaces of a module with other modules. The higher the granularity of definitions, the more valuable is the statement of compatibility and interoperability.

In the case of the PCS (physical coding sublayer), the definition should provide information about the selectable bit rates as well as the sample points. To simplify this, existing documents such as CiA 301 (CANopen CC application layer and communication profile) or CiA 1301 (CANopen FD application layer and communication profile) should be referenced. The XML schema for communication interfaces also can reference optionally the related CANopen XML schema (CiA 311 respectively CiA 1311-1), in order to provide more detailed information.

Table 1: Definition of OSI layers/sublayers and communication functionality

Function	Data type	Entities	Reference
PMD	uint16	1	Table with value definitions
PMA	uint16	1	Table with value definitions
PCS	uint16	N	Table with value definitions
DLL	uint16	N	Table with value definitions
NL	uint16	N	Table with value definitions
TL	uint16	N	Table with value definitions
SL	uint16	N	Table with value definitions
PL	uint16	N	Table with value definitions
AL	uint16	N	Table with value definitions
SafetyProtocol	uint16	N	Table with value definitions
SecurityProtocol	uint16	N	Table with value definitions
NetworkRedundancy	uint16	1	Table with value definitions
Profile	uint16	N	Table with value definitions

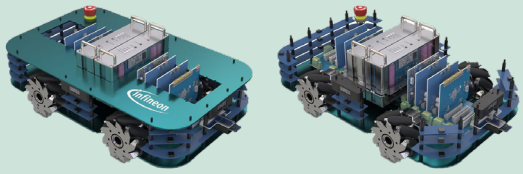
Table 2: Value definitions for the PMA sublayer

Value	Transceiver type	Remarks
0000_h	Reserved by document	
0001_h	CAN-HS transceiver (ISO 11898-2:2024)	No low-power and no selective wake-up capability
0002_h	CAN-FD transceiver (ISO 11898-2:2024)	No low-power and no selective wake-up capability
0003_h	CAN-SIC transceiver (ISO 11898-2:2024)	No low-power and no selective wake-up capability
0004_h	CAN-SIC-XL transceiver (ISO 11898-2:2024)	No low-power and no selective wake-up capability
0005_h to $FFFD_h$	Reserved for other PMA implementations	
$FFFE_h$	Proprietary	
$FFFF_h$	Not provided	

collaborating with humans on the factory floor. A better face-to-face interaction with humans requires an improved cognition. For all these improvements a reuse of modules would help to decrease development effort and to reduce production costs for a dedicated single service robot.

The core modules of service robots are sensors, actuators, and processing units. Advanced features such as collision avoidance or room modeling require built-in radars and other complex sensors. Smart navigation modules require sensor fusion, and smart handling ▷

Robotics development platform



Robot development platform with enclosure (left) and without enclosure (right) (Source: Infineon)

Infineon offers a development platform for mobile (service) robots. The one-stop shop approach consists of several modules equipped with semiconductors provided by the German chipmaker. Some modules feature CAN connectivity. For example, the central control and HMI (human machine interface) module (also known as motherboard) is based on the XMC microcontroller series featuring one on-chip CAN FD protocol controller and one CAN FD transceiver. Up to four motor control units, two battery management system modules, two power distribution modules, and one LED module are part of the platform. They also can communicate via on-module CAN FD ports. *hz*

modules are based on multiple electrical motors. The variety of modules is very high. Scalable modules are the demand.

Standardization of modules

It is hard to standardize service robot module interfaces for all small and niche markets. There are too many variants. Nevertheless, a kind of standardization is needed to find service robot modules originally developed for another kind of robot application. In the ISO/TC 299/WG 6, experts have developed a standardized description of service robot modules by means of an XML (extensible markup language) schema. The ISO 22166 document series standardizes also the electronic description of communication interfaces. This includes all seven OSI (open systems interconnection) layers. The intention is that the robot service developer can select appropriate modules with compatible and interoperable communication interfaces by means of these standardized descriptions.

Unfortunately, the first edition of the ISO 22166 series does not specify sufficient details regarding the communication interface description. The second edition will improve this. It is intended to provide in a standardized way information about the used connector including pin-assignment. The description of the CAN physical medium attachment (i.e., transceiver) and the supported bit rates including sample-point location will be standardized, as well. For CAN-based interfaces, the data link layer variants (CAN CC, CAN FD, or CAN XL in the future) will be provided as well as the supported higher-layer protocols (i.e., CANopen CC or CANopen FD).

Of course, the interface description also may cover the application functionality by means of implemented device or application profiles. A typical example is CiA 402 for a simple robot wheel. A more complex wheel with a steering function would need a profile, which is not yet available. A navigation module profile specification is another example, which could be desired. Grippers and other handling modules are further examples for profile specifications to be developed. ◀

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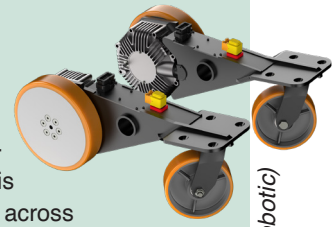
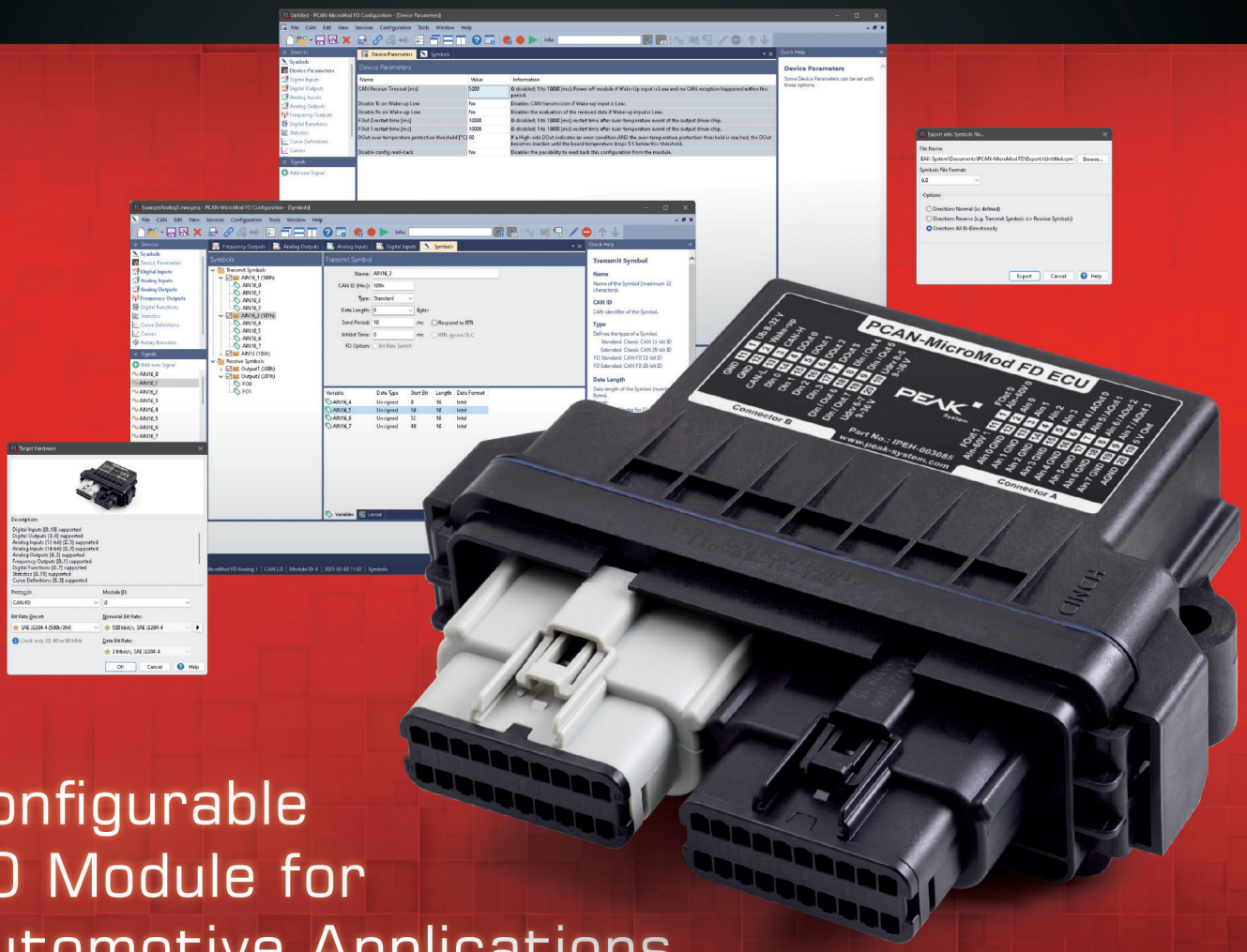
Brief news: Service robot wheel drives



(Source: Mobotic)

- ***Bluebotics:*** The Ant Lite+ CANopen host controller can control the Smartris CiA 402 compliant drives for service robots by Suitomo (Japan). The wheel drive units are available in different sizes. The host controller calculates the motion by means of x, y, and angle coordinates directly or via a PLC. There are more than 6000 Ant Lite+ units in operation. This includes also automated forklifts.
- ***Heidrive:*** The Heimotion servo motor units with reinforced planetary gears can be controlled by the company's CANopen-connectable controllers. They are available with an output power of up to 2300 W. A discrete safe encoder signal can be provided for a higher-level safety controller. The products are intended for AGVs (automated guided vehicles) and AMRs (autonomous mobile robots).
- ***Metronix:*** The Smartservo drives optionally equipped with a CANopen interface come in IP67-rated housings. They are suitable to be integrated into AMRs. The flagship is the BL 4840-M servo drive, which can be mounted on the motor. It measures 66 mm x 80 mm x 125 mm. The output power is 700 W.
- ***Mobotic:*** The Mobodrive DD drive systems are available with a CANopen interface. They are configurable and the motor controller is integrated. The products are used across various industries including intralogistics, agriculture, heavy load transportation, and healthcare.
- ***Nanotec:*** The WD42 wheel drive with a length of 103 mm is designed for AGVs and service robots. They consist of a BLDC motor, a planetary gearbox, a magnetic encoder, and an exchangeable wheel. The products can be connected to the company's motion controllers providing CANopen connectivity. They feature a nominal speed of up to 2,2 m/s and a rated power of 183 W. Wheel diameters from 75 mm to 140 mm and four reduction ratios are available to meet individual requirements.
- ***Zhongling Technology:*** The ZLAC8030L wheel servo drive features a CANopen interface compliant with the CiA 402 profile. The default bit rate is 500 kbit/s. The products are used in AGVs as well as in cleaning and agriculture robots. Overvoltage and overcurrent protection is integrated. *hz*



Configurable I/O Module for Automotive Applications

PCAN-MicroMod FD ECU

With CAN FD, a mix of digital and analog I/Os, and its tough case, the PCAN-MicroMod FD ECU can be your solution for integrating custom accessories in utility and heavy duty vehicles operating under harsh conditions.

The PCAN-MicroMod FD ECU can be configured with a Windows software via CAN. Besides simply mapping its I/Os to CAN messages, several function blocks for processing the data are available as well.

Specifications

- High-speed CAN connection (ISO 11898-2)
  - Complies with CAN specifications 2.0 A/B and FD
  - CAN FD bit rates for the data field (64 bytes max.) from 40 kbit/s up to 10 Mbit/s
  - CAN bit rates from 40 kbit/s up to 1 Mbit/s
- Wake-up by CAN bus or by separate input
- 4 digital inputs
  - Pull-up or pull-down configurable
- 8 digital outputs with High-side switches
  - 2 outputs with 5 A and 6 outputs with 2 A
  - 4 alternatively usable as a digital input or additionally for reading back the output level
- 8 analog inputs
  - Resolution 16 bit
  - Measuring range adjustable: ±2.5 V, ±5 V, ±10 V, ±20 V
- 4 of the analog inputs alternatively usable as analog output
  - Resolution 12 bit
  - Voltage range adjustable: 0 to 5 V or 0 to 10 V
- 2 frequency outputs
  - Low-side switches (3 A)
  - Adjustable frequency range from 0 to 20 kHz
  - Alternatively usable as analog inputs with voltage range from 0 to 60 V
- Connections for CAN, I/O, and power supply via two 20-pole automotive connectors (Molex MX150)
- Plastic casing with increased Ingress Protection IP67 and flange
- Operating voltage 8 to 32 V; suitable for use in 12 and 24 V vehicle electrical systems
- Extended operating temperature range from -40 to +85 °C (-40 to +185 °F)
- E1 type approval

Optionally available: Connection adapter board for simplified wiring using Phoenix screw terminal connectors.

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