ProNet 4.0 – A Wireless Real-time Communication System for Industry 4.0

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Situation

The use of wireless real-time communication technologies for the flexible networking of sensors, actuators, and controllers in production technology is a crucial building block for the future project Industry 4.0 on the way to the intelligent factory. With WirelessHART and ISA 100.11a, two technologies that have been conceived in particular for industrial use are currently available. However, a closer analysis of these approaches reveals some deficits. In the Networked Systems Group at the University of Kaiserslautern, in close cooperation with the SmartFactory[KL] at the German Research Center for Artificial Intelligence (DFKI) in Kaiserslautern, a new technology overcoming these deficits is being developed.

Technology Offer

In the Networked Systems Group at the University of Kaiserslautern, headed by Prof. Dr. Reinhard Gotzhein, the wireless communication system **ProNet 4.0** (Production Network 4.0) is being developed. Due to its extensive functionality, its real-time support, its service interface, and its high degree of flexibility, it is particularly suitable for use in Industry 4.0.

The service interface to the application is provided by the component **ProMid** (Production Middleware), which is especially devised to satisfy the requirements of factory automation:

- distributed, network-wide service registry for registration and lookup of application services, e.g. sensor and actuator services
- provision of event-based and periodical application services
- multi-hop and real-time capability

For the distributed realization of these service, specialized, mostly novel, highly reliable communication approaches are used:

- **ProSync**: network-wide synchronization with low and bounded inaccuracy
  - ➤ supports, among other things, the synchronous sampling of sensor values

- **ProTop**: automatic discovery of communication and interference topology
  - ➤ makes long manual tuning and configuration activities dispensable

- **ProRoute**: dynamic multicast routing with mobility support
  - ➤ enables, among other things, the provision of services for groups of users, and the use of autonomous mobile robots

- **ProSlot**: network-wide formation of virtual slot regions
  - ➤ substantially improves flexibility of network resource usage
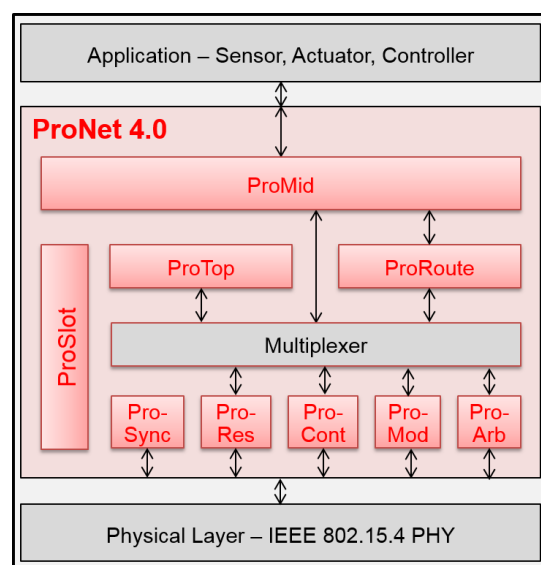
Architecture of ProNet 4.0

- **ProRes**, **ProMod**, **ProCont**: deterministic/contention-based medium access control
  - ➢ support reliable and/or flexible access to the wireless transmission medium: exclusive, priority-based, contention-based
- **ProArb**: network-wide deterministic arbitration
  - ➢ supports, among other things, the dynamic selection of nodes, e.g., a standby-node as replacement for a failing master node

ProNet 4.0 has been prototypically realized on sensor nodes of type Imote2 in the context of the BMBF Excellence Cluster "Software Innovations for the Digital Enterprise". Utilizability has been proven in the demonstrator VI-P in the SmartFactory[KL]. The Networked Systems Group offers to evaluate ProNet 4.0 for use in specialized industrial scenarios, and to adapt and further develop it in cooperation projects with industrial partners.

Comparison with Existing Technologies

In the context of industrial plants, there is demand for reliable, wireless multi-hop communication. This requires hard guarantees regarding maximal transmission latency, freedom of packet loss, and synchronization in mesh networks. In the following table, ProNet 4.0 is compared with WirelessHART and ISA 100.11a, two specialized technologies that are well-established in industry. In addition, WLAN as a representative of general technologies is listed.

Property	ProNet 4.0	WirelessHART	ISA 100.11a	WLAN
Real-time capability	yes	yes	yes	no
Multi-hop capability	yes	yes	yes	no
Mobility support	yes[1]	low	low	yes
Flexibility of medium slotting	high	no	low	no
Multi-channel capability	no[2]	yes	yes	no
Transmission rate (gross)[3]	250 kbps	n · 250 kbps[4]	n · 250 kbps[4]	11-600 Mbps
Topology detection	yes	no	no	no
Deterministic contention	yes	no	low[5]	no

The assessment shows that ProNet 4.0, WirelessHART, and ISA 100.11a possess the required properties for use in production environments regarding real-time and multi-hop capabilities together with sufficient transmission rate, and that general technologies such as WLAN do not. ProNet 4.0 offers advantages concerning flexibility of medium slotting, topology discovery, mobility support, and deterministic contention. The current drawback regarding missing multi-channel capability can be removed, if required.

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[1] under development

[2] Valid for the existing prototypical realization. Can be realized on request.

[3] For networking of production systems, high transmission rates are typically not required.

[4] n = number of usable channels, max. 15 (16)

[5] When using *shared slots*, but restricted to single hop.