Roadmap Technical Expert Group Network Communication

Sino-German Intelligent Manufacturing / Industrie 4.0 Standardisation Sub-Working Group

国家智能制造标准化总体组
National Intelligent Manufacturing Standardisation Administration Group

STANDARDIZATION COUNCIL INDUSTRIE 4.0

GPQI
Dialogues for Innovation and Trade

Published by
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn, Germany

Tayuan Diplomatic Office Building
No. 14, Liangmahe Nanlu, Chaoyang District
100600 Beijing, PR China
E info@gpqi.org I www.gpqi.org

Design
flow.asia

Photo credits
shutterstock/PopTika

On behalf of
German Federal Ministry for Economic Affairs and Climate Action (BMWK)
Berlin, Germany 2023
Beijing, China 2023

Text
Standardization Council Industrie 4.0
German Commission for Electrical, Electronic & Information
Technologies of DIN and VDE
60596 Frankfurt am Main

National Intelligent Manufacturing
Standardisation Administration Group
China Electronics Standardization Institute,
No. 1 Andingmen East Street,
Dongcheng District, Beijing, 100007, China

Authors/Experts
DOMINIK ROHRMUS, LNI4.0 / SHIHUI DUAN, CAICT

The German Federal Ministry for Economic Affairs and Climate Action (BMWK) has commissioned the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH to implement the Global Project Quality Infrastructure (GPQI).

Federal Ministry for Economic Affairs and Climate Action

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

This publication is a result of the Sub-Working Group Intelligent and Connected Vehicles of the Sino-German Standardisation Cooperation Commission in cooperation with

中华人民共和国工业和信息化部

SAC 中国国家标准化管理委员会
Standardization Administration of the P.R.C.

Partners involved

SINO-GERMAN STANDARDISATION COOPERATION COMMISSION

The central body for standardisation cooperation between Germany and the People's Republic of China is the Sino-German Standardisation Cooperation Commission (SGSCC). Under the chairmanship of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and the Standardization Administration of the People's Republic of China (SAC) as part of the State Administration for Market Regulation (SAMR), experts from standardisation organisations, authorities and companies from both countries work on a variety of topics in the Commission. These include electromobility, Industrie 4.0/ intelligent manufacturing as well as intelligent and connected vehicles. Professional exchange within SGSCC is conducted by the German Institute for Standardization (DIN), the German Commission for Electrical, Electronic & Information Technologies of DIN and VDE (DKE) and the Standardization Administration of China (SAC).

SUB-WORKING GROUP INTELLIGENT AND CONNECTED VEHICLES

The Industrie 4.0/Intelligent Manufacturing sub-working group (SWG I4.0) of the SGSCC is the decisive platform for the Sino-German exchange on standardisation for I4.0. Founded in May 2015, it supports the coordination of common positions in international standardisation bodies and the promotion of IEC/ISO standards. Through technical exchange in the SWG, existing standardisation gaps are identified and bilateral cooperation in these areas is promoted. The cooperation of BMWK with SAMR and the Ministry of Industry and Information Technology (MIIT) of the People's Republic of China in the SGSCC is supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH within the Global Project Quality Infrastructure (GPQI). On behalf of BMWK, GPQI advises and supports technical policy dialogues and implements agreed technical measures in collaboration with the actors involved.

At the technical level, the work is led by the German Standardization Council Industrie 4.0 (SCI 4.0) and China's National Intelligent Manufacturing Standardization Administration Group (IMSG). In semi-annual meetings, priority topics are agreed for the SWG, which are implemented during the year under the guidance of experts from the two countries.

- The SWG I4.0 is currently (2023) addressing the following areas of activity
- Digital Twin/Asset Administration Shell (TEG DT/AAS)
- Artificial intelligence in industrial applications (TEG AIAI2M)
- IT security (TEG ITS)
- Functional safety (TEG FS)
- Predictive Maintenance and Condition Monitoring (TEG CMPM)
- Use cases and applications (TEG UCA)
- Network Communications (TEG NetCom)

The results developed within the framework of SWG I4.0 to date have been published by BMWK and SCI4.0 in collaboration with SAMR, MIIT and IMSG and can be accessed under the following link

NATIONAL INTELLIGENT MANUFACTURING STANDARDISATION ADMINISTRATION GROUP

The National Intelligent Manufacturing Standardisation Administration Group (IMSG) was established to promote and accelerate the progress of intelligent manufacturing in China under the leadership of the Standardisation Administration of China (SAC) and Ministry of Industry and Information Technology (MIIT). It is responsible for carrying out practical work on intelligent manufacturing standardisation, including participation in international standard-setting on intelligent manufacturing as well as organising exchange and cooperation on international standards.

STANDARDIZATION COUNCIL INDUSTRIE 4.0

The Standardization Council Industrie 4.0 (SCI 4.0) was founded at the Hannover Messe 2016 as a German standardisation hub by Bitkom, DIN, DKE, VDMA and ZVEI. The initiative aims to initiate standards for digital production and to coordinate these standards nationally and internationally. SCI 4.0 orchestrates implementation of the standardisation strategy of the German Platform Industrie 4.0, which includes coordination with standardisation organisations (SDOs) and international partners as well as interlocking with pilot projects. The aim of this coordinated approach is to ensure that standards exploiting the potential of Industrie 4.0 are developed in a coordinated manner. SCI 4.0 is supported by DKE and the German Federal Ministry for Economic Affairs and Climate Action (BMWK).

Global Project Quality Infrastructure

The German Federal Ministry for Economic Affairs and Climate Action (BMWK) established the Global Project Quality Infrastructure (GPQI) to promote the development of well-functioning and internationally coherent quality infrastructures. GPQI supports political and technical dialogue and implements bilaterally agreed activities in collaboration with all relevant stakeholders. The project aims to reduce technical barriers to trade and to enhance product safety through bilateral political and technical dialogue on quality infrastructure (QI) with some of Germany's key trading partners.

Contents

1 Introduction

1.1 SWGI4.0 / TEG background

Sino-German standardisation cooperation on Industrie 4.0 (I4.0)/Intelligent Manufacturing (IM) initiated the study on communication technologies of interest to this Sino-German collaboration. Potential topics were identified, including wireless communication, co-existence management, Wireless Industrial Application (WIA) and Time-Sensitive Networking (TSN) profiling for industrial automation.

The Technical Expert Group (TEG) Network Communication (NetCom) was created to drive I4.0/IM industrial communication-related subjects as mentioned above. It also reviewed the IEC new work item proposal (NP) for TSN profiling for industrial automation. In addition, it raised for discussion in international standardisation the aspects of spectrum and co-existence management. Although TEG NetCom started out with a focus on WIA and TSN areas, it was agreed to extend its scope to include wireline communications. Hence, the specifications, guidelines and testing activities in addition to IEEE 802 standards and projects are at the core of Sino-German TSN activities. The IEC/IEEE 60802 TSN profile for industrial automation will extend our joint activities in the years ahead.

1.2 Objectives of this roadmap

The aim of formulating a strategic roadmap is to delineate forthcoming research endeavours and collaborative initiatives between the German Labs Network Industrie 4.0 (LNI 4.0) and the Chinese Alliance of Industrial Internet (AII).

2 Cooperation

Proposal for cooperation between LNI 4.0 and AII

LNI 4.0 and AII have a history of collaborative involvement in international committees. Both entities plan to test draft standards from international working groups, with a particular emphasis on IEEE 802.1 TSN TG (Task Group) and IEC SC 65C WG 18.

In the light of this well-established basis, the proposal is to initiate a direct exchange of research and test findings and to formalise and strengthen this collaborative endeavour. The intention is therefore to initiate the process for a Memorandum of Understanding (MoU) between LNI 4.0 and AII.

This collaborative effort will culminate in the creation of a comprehensive Sino-German study report, with a primary emphasis on the exchange of test results relating to draft standards emanating from IEEE 802.1 Working Group and IEC SC 65C Working Group 18. Additionally, the report will endeavour to explore insights derived from relevant study items, namely large-scale TSN networking and LRP RAP (the standardisation reference is IEEE Draft Standard P802.1Qdd), as set out in forthcoming chapters.

3 Study item: large-scale TSN networks

3.1 Current status in China

The promotion and application of TSN technology has gradually begun in China, with many industrial enterprises attempting to deploy TSN networks within their factories. The trend is now to use a TSN network as the primary network to carry all business operations within a factory. It is therefore necessary to conduct relevant research into this matter.

Although the IEEE 802.1 TSN task group has defined a relatively comprehensive set of TSN protocols, many issues have been identified in practical applications. These issues include a gradual increase in cumulative errors with clock synchronisation as the network scale grows, varying degrees of precision between switches from different manufacturers and an overall lack of unified management tools, leading to cumbersome manual configurations. These engineering implementation problems significantly hinder the large-scale deployment and application of TSN.

China has deployed a corresponding large-scale TSN network testbed, which is continually expanding. It is expected that the number of TSN network nodes in this testbed will exceed 30. The testbed includes commercial TSN switches from several manufacturers, NXP TSN evaluation boards, TSN controllers, and more. Conducting research on large-scale TSN network deployment through this testbed serves two purposes: it addresses practical application issues and contributes to further improvements in existing TSN standards.

3.2 Current status in Germany

Established by industrial automation companies in 2017, the aim of the international TSN testbed of LNI 4.0 is to bring industrial communication stakeholders and market participants together to foster the next level of ethernet technologies in industrial applications. Here, the use cases of small and medium-sized enterprises are at the centre of the LNI 4.0 TSN testbed. By organising 'plugfests', international experts are able to test their components alongside other development products on the basis of underlying standards, and provide reviews and pre-competitive feedback on the draft standards of the standardisation organisations. The TSN testbed does this jointly with all international partners.

The study item large-scale TSN networks is not yet in the focus of LNI 4.0 due to its SME focus. This is because SMEs do not usually have the need to operate large networks but rather act as system providers or system integrations for large-scale networks.

3.3 Prospects in China and Germany

The two countries understand that use cases are drivers for the market adaption of TSN technologies. Both economical and technological use cases must be articulated on a global scale to ensure that TSN technologies develop at low cost based on joint global standards. The study item large-scale networks based on TSN standards enables a vast amount of potential use cases, many of which require a different selection of features.

Both China and Germany choose to focus on production line use cases (see Figure 1). The main criterion for these use cases is a TSN

network that connects different machines from various vendors. In the Industrie 4.0 context, this means that both centrally as well as ad-hoc flexible machine configurations in TSN networks are necessary.

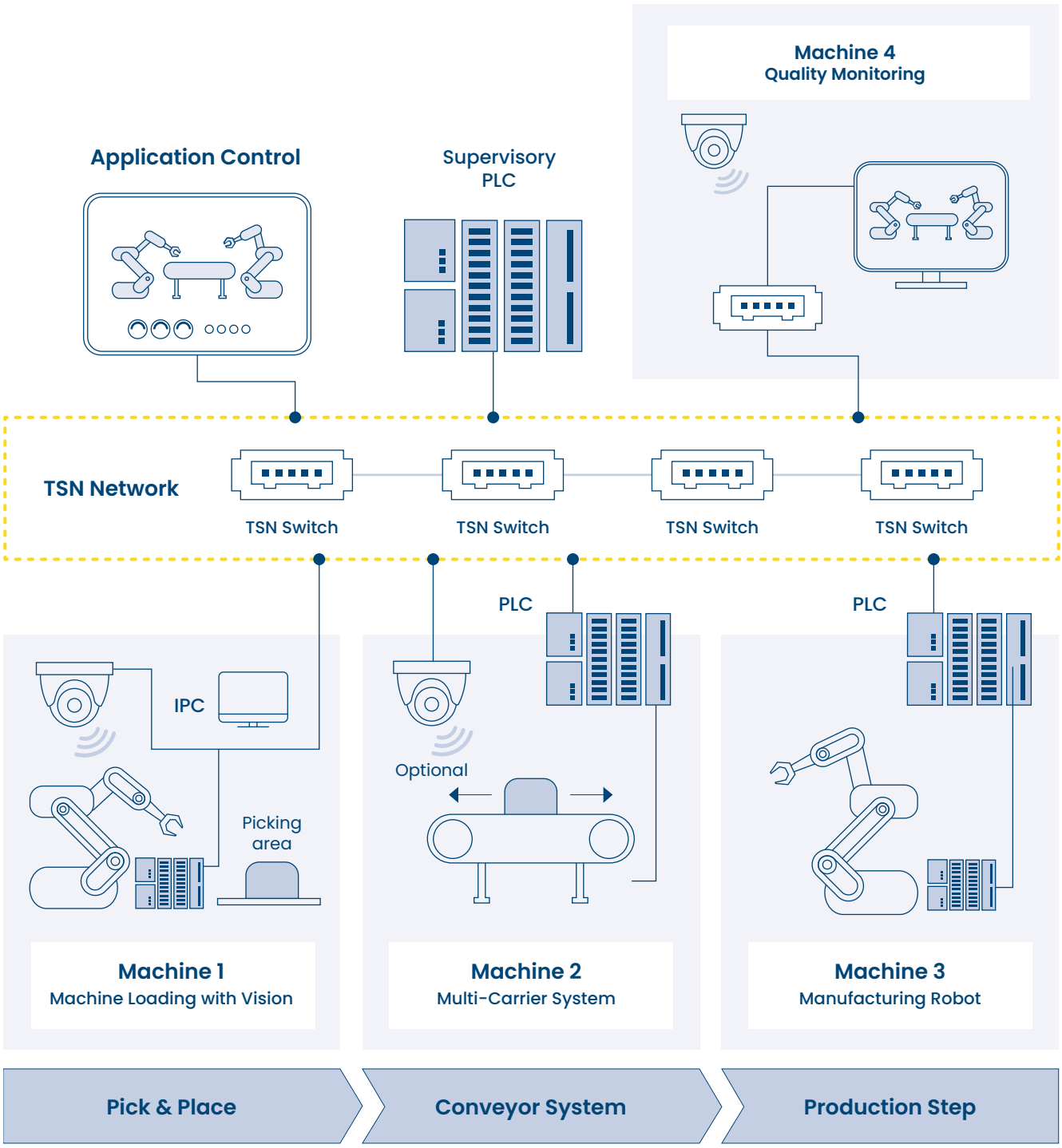

Figure 1: Production line use case with TSN

These use cases typically come with the following requirements:

- OT personnel is in charge of production: this avoids additional cost of specialists, e.g. network operator.
- Production rate must be met: begin design with sequence of actions with time constraints.
- Stepwise commissioning of machines to be supported: start with partial network in operation.
- Downtime must be minimised to increase Overall Equipment Effectiveness: limit the effects of failures, avoid side effects caused by components not needed in production and minimise dependencies between connected machines.

Upcoming requirements which are addressed by TSN large-scale networks:

- Multiple applications must be supported on a single network: integrate formerly dedicated connections; eliminate discrete cabling, additional interfaces, installation and associated error sources.
- Make machine data accessible for Smart Manufacturing: avoid reprogramming machines to get access to useful data.

In order to achieve these requirements, we provide guidance and testing abilities for these time-sensitive applications. The focus for the applications is on the following characteristics:

- dynamic E2E stream allocation for 'plug & produce';
- exposure of stream diagnostics;
- leveraging of existing production line networking technology for real time;
- support for minimum viable solutions.

4 Study item: LRP RAP

Each network uses standards for the stream reservation protocol. In the context of TSN, additional options must be selected, such as the Link-local Registration Protocol/Resource Allocation Protocol (LRP RAP).

4.1 Current status in China

There are currently no specialised institutions in China dedicated to research into LRP RAP at protocol level. Instead, most research efforts are focused on link discovery and resource reservation from the perspective of devices or networks. If there is an interest in collaboration on this topic in future, consideration could be given to combining this with research on the TSN large-scale network testbed.

4.2 Current status in Germany

In Germany, the LNI 4.0 TSN testbed chose the drafted reservation protocol IEEE802.1Qdd, which is based on MSRP, a distributed stream reservation protocol which has been defined in the Q standard for quite some time. The IEEE802.1Qdd draft contains so-called Resources Allocation Classes (RA-Class) for streams. Each RA-Class includes a mathematical model for dimensioning the required bandwidth, max per hop latency and network resources. Based on the use case and the Qdd draft, an RA-Class has been designed which enables Qdd to be used more efficiently. In this context LNI 4.0 contributes towards Qdd to make the RA-Class template mechanism more flexible for I4.0/IM applications.

4.3 Prospects in China and Germany

Both countries understand that successful realisation of the aforementioned use cases requires standardised stream reservations. China and Germany will therefore foster standardisation activities in this field with IEEE and support adoption by the markets.

5 Summary and outlook

China and Germany agree that the results of these collaborations can be considered in international standardisation organisations such as IEEE and IEC, including methods for testing TSN networks and feedback on upcoming standards.

To this end, LNI 4.0 and AII intend to initiate an MoU process to further specify study items and use cases as a focus for the two organisations.