OSADL

OSADL eG · Im Neuenheimer Feld 583 · D-69120 Heidelberg

Building an Open Source OPC UA over TSN Ecosystem
Project phase #3: "Scalability & Tool chain"
Letter of Intent (V11, January 25, 2021)

This Letter of Intent is signed between

_____

hereafter Open Source OPC UA over TSN Ecosystem participant or simply participant

and the

Open Source Automation Development Lab (OSADL) eG, Heidelberg, Germany

hereafter OSADL.

Introduction and overview about previous project phases

A rapidly growing number of companies and organizations is fostering the development of a standardized method for real-time network communication based on OPC UA as platform protocol and Time Sensitive Networking (TSN) as link layer. This broad interest has led to the open62541 project (https://open62541.org/). It was founded to provide an OPC UA implementation that can be freely copied and distributed under the Mozilla 2.0 Open Source license.

The next important evolution of OPC UA after having implemented the base technology were the Publish/Subscribe (PubSub) components to allow for a connection-less and, thus, resource saving communication suitable for the low-power devices that are expected to be used throughout the future Internet of Things. For this purpose, Fraunhofer IOSB in Karlsruhe, Germany, the India based system integrator Kalycito Infotech and the Open Source Automation Development Lab (OSADL) founded a joint interest working group. This group launched a community project and distributed a call for contributions in form of a Letter of Intent of project phase #1. This Letter of Intent was signed by the working group participants

 a) Heidelberger Druckmaschinen AG
 b) Kontron AG
 c) Linutronix GmbH
 d) Pilz GmbH & Co. KG
 e) SICK AG
 f) TQ-Systems GmbH

which resulted in sufficient funding to execute the project in addition to the contributions made by Fraunhofer IOSB, Kalycito Infotech and OSADL.

The software that was created during the project phase #1 from January to March 2018 was merged gradually into the existing open62541 repository in April 2018. The implemented features are

    a) brokerless OPC UA PubSub via IP multicast and the binary message encoding format according to the draft of part 14 of the OPC UA specification,

    b) integration of the publisher in a regular OPC UA server with additional real-time interrupting,

    c) implementation of the subscribers as standalone software, and

    d) a first step towards secure client/server communication.

In a subsequent phase #2 of the project in 2019, throughput of the OPC UA stack was improved among other by adding a fast message path in order to further pave the way towards low-latency real-time communication. In addition, a number of lacking features have been added and adapted to the standard – a work that was crowned by the successful OPC Foundation certification of an OPC UA server built with the open62541 SDK. Last not least, a four-node network demonstrator was built around Intel Apollo Lake processors equipped with I210 network adapters that are connected via Altera SOCFPGA TSN-capable switches made by Kontron and loaded with TTTech switch software. This demonstrator was used to establish and benchmark newly added network interface features of OPC UA PubSub over TSN. The Letter of Intent of phase #2 of the project was signed, among other, by the following participants

    a) Intel Corp.

    b) iss innovative software services GmbH/Balluff GmbH

    c) Kontron Europe GmbH

    d) Nestfield Co. Ltd

    e) Pepperl+Fuchs GmbH

    f) Siemens AG

    g) WIKA Mobile Control GmbH

The support of all participants is gratefully acknowledged. The Open Source licensed OPC UA software open62541 including all above mentioned features and example applications can be accessed via Github at the URL https://github.com/open62541/open62541/. A quick-start guide and a performance measurements whitepaper is available at https://www.kalycito.com/how-to-run-opc-ua-open62541-with-realtime-pubsub-on-realtime-linux-and-tsn-from-source/. In addition, a technology demonstrator that continuously runs a peer-to-peer OPC UA PubSub over TSN network link and monitors its round-trip time is hosted at OSADL and can be inspected at https://www.osadl.org/?id=3394.

Letter of Intent of project phase #3 of the community project

After the successful completion of the above described project phases #1 and #2, there is now an Open Source licensed OPC UA SDK available to be used by industry to create a state-of-the-art OPC UA server that can be certified by OPC Foundation to adhere to the "micro embedded device server" profile. In addition, a PubSub implementation is available that allows using Virtual Local Area Network (IEEE 802.1Q) along with components of Time-Sensitive Networking (TSN) such as high-precision time synchronization (802.1AS) and time-aware traffic shaping (IEEE 802.1Qbv) to establish real-time communication via Ethernet.

To further enhance the existing Open Source ecosystem software pool with the goal to make open62541 the single fully fledged state-of-the-art hard real-time successor of the

wide variety of former real-time Ethernet communications systems, more features of the software itself and additional software components around the SDK are needed. It, therefore, was decided to launch phase #3 of the community project. Since it continues to primarily take care of base technologies, it addresses the various target groups (e.g. controller vendors, field device vendors, machine builders, end users) in the same way.

Operative partner companies

1. Fraunhofer IOSB
   Fraunhofer IOSB (Institute of Optronics, System Technologies and Image Exploitation) is based in Karlsruhe, Germany, and its department of Information Management and Production Control has a long history of successfully developing and researching solutions for the design, operation and maintenance of information, control and test systems. As one of these activities they provide the maintainership of the open62541 project and have largely been contributing to the project.

2. Kalycito Infotech
   Kalycito Infotech helps leading machine builders and automation OEMs globally with consulting and integration services. The company very early identified the potential behind the open62541 stack, PubSub and TSN as candidates to become a universal communication standard from field level to the cloud. Kalycito triggered the initial move and funded Fraunhofer IOSB to develop the PubSub parts under an Open Source license suitable for industry and to build an ecosystem around it.

3. Open Source Automation Development Lab (OSADL)
   The Open Source Automation Development Lab (OSADL) is a registered cooperative and based in Heidelberg, Germany. It was founded in 2005 to provide support for industry when using Open Source software in products. OSADL provides services that are requested by its members but makes many of them available not only to its members, but also to the entire community. These services comprise software development, hardware and software quality assessment as well as legal support, project management and consulting.

All three operative partners are members of the OPC Foundation. In addition, Kalycito is member of the newly constituted Field Level Communication (FLC) Steering Committee of the OPC Foundation. This is important to closely align the software development of this project with international standardization and to make the open62541 software a reference implementation of real-time Ethernet using OPC UA PubSub over TSN.

Open Source policy

Fraunhofer IOSB, Kalycito Infotech and OSADL wholeheartedly agree and adhere to the principles of a community funded Open Source software development:
- Release early, release often
- Manage everything as transparently as possible
- Do not retain any community funded material for proprietary purposes

Licensing

Every software component that is uploaded to the open62541.org project and is intended to finally be copied and distributed to end customers will be licensed under the Mozilla 2.0 (MPL-2.0) license. This license is an internationally accepted Open Source li-

cense with a so-called restricted ("weak") copyleft. In consequence, the mandatory unrestricted rights of an Open Source license to use, analyze, modify and convey the software are granted. In turn, copyright notices and the license text must be made available to recipients when conveying the code. In addition, recipients of a binary delivery must be informed "how they can obtain a copy of" the source code "by reasonable means in a timely manner, at a charge no more than the cost of distribution to the recipient". Software that merely links to such MPL-2.0 licensed software can be distributed under a license of choice of the owner.

Example code and similar material not intended to be copied and distributed is and will be licensed under the Creative Commons Zero v1.0 Universal (CC0-1.0) that does not impose any license obligations. Code that is intended to be combined with the Linux kernel such as drivers or other kernel modules will be licensed under a GPL-2.0 license.

Confidentiality and IP Issues

Any contribution or communication will be kept confidential on request of the Open Source OPC UA over TSN Ecosystem participants with the only exception that the developed software will be made publicly available under Open Source licenses as outlined above.

Project funding and management

The project will be managed in form of a so-called OSADL mixed-funded project, i.e. a subgroup of OSADL members and non-members is formed who contribute to the project. Project management, software development and testing provided by OSADL is partly funded by the project and partly provided from the regular annual OSADL budget while employing existing office and laboratory infrastructure. Deciding which components to develop with which priority is done according to a poll among the participants while taking into consideration the number of votes of their contribution level (see below).

Contribution levels

There are the following four contribution levels that participants may select from:

	Contribution amount (euros)	
Contribution level	OSADL member	Not OSADL member
Silver	5,000.00	7,500.00
Gold	10,000.00	15,000.00
Platinum	20,000.00	30,000.00
Diamond*	30,000.00	45,000.00

*The Diamond contribution provides the privilege on adding the company's hardware or software components as part of the technology demonstrator that is built.

Benefits of the various contribution levels

Participants enjoy a number of benefits that are graded according to the contribution level as given in the following table:

Contribution level	Logo display and listed as contributor	Certification assistance	Number of votes when deciding on the development priority of components
Silver	yes	no	1
Gold	yes	no	2
Platinum	yes	yes	4
Diamond	yes	yes	6

Overall budget and schedule

The overall budget to provide the below given software components is estimated to amount to about 120,000 euros. However, the project will already be launched when and if a minimum funding threshold of 30,000 euros will have been reached. If this also is the final budget, the low-priority and some of the other below given software components will only have a partial or even rudimentary or no implementation at all. The more budget will be available, the more software components will be developed and reach production quality. It, therefore, is expected that project participants will also join in after the start of the project which will be possible during its entire duration. The project is intended to start latest on January 31, 2021 and will last as long as project funds are available.

Deliverables

In contrast to conventional software development projects where the software normally is directly delivered to the project managers and/or collaborating parties, the entire software developed throughout this project will either be uploaded to the repository of the open62541project or, if applicable, submitted to the Linux Kernel Mailing List (LKML). Whenever a significant portion of the developed software is upgraded or added, or a relevant milestone is reached the project participants will be notified immediately.

Subprojects and priorities

The project activities are divided into two different subprojects
- Project #1: OPC UA specific developments and
- Project #2: Realtime Linux + TSN + OPC UA + PubSub + Support for new hardware + Technology demonstrator + Tools ecosystem

and each of them are prioritized into high and low priority. High-priority components will be developed first, while low-priority may only be developed if the budget allows. The assignment of components to high or low priority may be adapted during the project, if participants use their votes as part of the participative project management.

Software Components and Support Planned to be Developed and Delivered under the Community Project

A Project #1: OPC UA specific developments

High priority:

- Parse server/client configuration from a text file
- Common event loop for multiple clients/servers
- Client multi-threading
- Implement the entire feature set of the "Full Embedded Profile" certification category as defined by OPC Foundation
- Undergo the regular OPC Foundation procedure to obtain certification for the "Full Embedded Profile"
- Event filtering (for Standard Profile)
- On-demand Publish of DataSetField (DSF) variables according to PubSub 'PublishedEvents'.

Low priority:

- RAM/ROM optimizations for constrained devices (e.g. binary file node store) and tooling
- Custom memory manager (static memory allocation)

B Project #2: Realtime Linux + TSN + OPC UA + PubSub + Support for new hardware + Technology demonstrator + Tools ecosystem

- *High priority:*
- Security support for the PubSub UADP protocol
  - o Encryption and decryption of the PubSub UADP packets
  - o Implementation of a local API in the OPC UA server of each of the publishers and subscribers to load a key for encryption and signing the PubSub communication
  - o Generate the keys using Python scripts available as part of open62541
  - o Distribution of the key to the peers is done using an out-of-band transport channel such as
    - ▪ individual storage media, e.g. USB memory stick, or
    - ▪ secure copy from a user-controlled secure network peer, or
    - ▪ protected access to a Web server with https network encryption
  - o The user is responsible to maintain a secure trust chain of the key distribution
- Creating a new technology demonstrator using 11th Gen Intel Core processors with TSN capability based on the most recent Linux 5.x-rt release that will be available as next Linux long-term kernel at the time when this project is launched
  - o Optimizing the real-time capabilities of this processor and the related chip set
  - o Support for the Intel integrated TSN controller
- Creating a new Quick Start Guide for OPC UA PubSub over TSN-capable realtime Linux that works out of the box
- Incorporating all software components that are needed to successfully follow the new Quick Start Guide boards using 11th Gen Intel Core processors with

TSN capability in an image for virtualization and automatically executing a script with the Quick Start Guide commands when the image is booted
- Testing and optimizing multicast real-time PubSub in a larger network with up to 16 nodes
- Architecture concepts/application design for PubSub time offsets and RT interrupting based on publishing offset, thread synchronization and wakeup latency of threads.
- Generic interface to TSN (see explanation below*)
- Open Source tool concept and ecosystem of an OPC UA modeler
- Open Source tool concept and ecosystem of a Pub/Sub TSN configurator
- Represent PubSub over TSN configuration in the OPC UA information model as per the latest FLC specification

*Generic interface to TSN

The tests that were conducted so far as part of the phase #1 and phase #2 of the OS-ADL OPC UA/TSN project as well as evaluations at the OSADL QA Farm were primarily based on the Intel I210 network adapter and on the Linux network driver that was provided by the manufacturer. In order to facilitate the use of future TSN network adapters and on-chip network hardware by other manufacturers, a suitable framework is needed. This framework also should provide a uniform configuration interface. To provide such a framework is the goal of the "AccessTSN" project the results of which are planned to be continuously integrated into the proposed project.

Agreed intent

By signing this Letter of Intent, the Open Source OPC UA over TSN Ecosystem participant agrees to accept the above-mentioned conditions. When the funding threshold is reached, this Letter of Intent will be converted automatically into a final consortium agreement that will be concluded without requiring further contractual agreement. Withdrawal from the final consortium agreement without any penalty shall be limited to the condition that

at least 30,000 euros estimated minimum budget is not committed by January 31, 2021.

In any other case, a penalty for breach of contract in the amount of 20 % of the accepted contribution to the budget shall be applicable.

Place of jurisdiction

This Letter of Intent will be governed by the laws of Germany, except for its conflicts of laws principles. The place of jurisdiction for all disputes arising from or in connection with this Letter of Intent shall be Mannheim, Germany.

References

The performance of the existing Open Source OPC UA PubSub over TSN software developed so far is demonstrated in two whitepapers entitled "Open Source OPC UA PubSub over TSN for Realtime Industrial Communication" and "Real-time Open Source Solution for Industrial Communication Using OPC UA PubSub over TSN". They are available on request free of charge.

Contribution level

Selection (please tick)	Contribution level	Contribution amount (euros)	
		OSADL member	Not OSADL member
☐	Silver	5,000.00	7,500.00
☐	Gold	10,000.00	15,000.00
☐	Platinum	20,000.00	30,000.00
☐	Diamond	30,000.00	45,000.00

Project assignment and participative project management

Selection (please tick)	Project #1: OPC UA specific developments	Project #2: Realtime Linux + TSN + OPC UA + PubSub + Support for new hardware + Technology demonstrator + Tools ecosystem
☐	100 %	0 %
☐	75 %	25 %
☐	50 %	50 %
☐	25 %	75 %
☐	0 %	100 %

Signatures

Open Source OPC UA over TSN Ecosystem participant:

Name of the company:

Location:

Date:

Name(s) of the signatory or signatories:

Signature(s):

Open Source Automation Development Lab (OSADL) eG:

Location:

Date:

General Manager or OSADL Director:

Signature: