Expression of Interest (EoI)

MSCA Postdoctoral Fellowships 2026

Host Institution: University of the Balearic Islands (UIB) — Department of Mathematics and Informatics. SRV-INTER Group

Project

`Intelligent Redundancy Management of TSN-Based Critical Real-Time Distributed Control Systems`

Hosting Information: University of the Balearic Islands (UIB)

Offer Deadline: July 10th, 2026
EU Research Framework: Horizon Europe - MSCA Postdoctoral Fellowships 2026
Country: Spain
City: Palma, Balearic Islands

Organisation/Institute

Organisation/Company: Universitat de les Illes Balears (UIB)
Department: Departament de Ciències Matemàtiques i Informàtica (DMI)

Contact Information

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Secondment/Collaboration Opportunity:

Up to eight months: Dependable Software Engineering research group. Mälardalen University (Sweden) - Prof. Sasikumar Punnekkat

Description

Project Title: Intelligent Redundancy Management of TSN-Based Critical Real-Time Distributed Control Systems

Research Context & Motivation

The digital transformation of energy sectors, a cornerstone of the **EU Digital Decade** and the **Green Deal**, relies on the deployment of Smart Microgrids (SMGs) to integrate both renewable and non-renewable Distributed Energy Resources (DERs) effectively.

The autonomous operation of an SMG is carried out by what is known as an **Automation System**. In particular, automation systems where failures are not an option are implemented

in the form of **Critical Real-time Distributed Control Systems** (CRDCs). Thus, CRDCs are being increasingly deployed as the automation system of SMGs that support critical infrastructures such as hospitals, airports, and power plants.

A CRDC demands a communication network that guarantees hard-real-time (time determinism) and high fault-tolerance requirements. In this context, **Time-Sensitive Networking (TSN)**, which has emerged as the future global standard for deterministic Ethernet in Industry 4.0, possibly is the best technology for supporting the communications of CRDCs.

However, current TSN mechanisms for fault tolerance mainly rely on static **spatial redundancy** (i.e., IEEE 802.1CB). On the one hand, while space redundancy is adequate to tolerate permanent faults, it is not efficient to tolerate temporary faults, which should be tolerated by means of a type of redundancy not supported by TSN, i.e. **time redundancy** (message retransmissions). Moreover, there is a lack of solutions that exploit TSN to provide **flexible fault-tolerance** so as to **adapt** (dynamically reconfigure) space and time redundancy when link, interconnection devices (switches), and end-nodes fail, specially in complex network topologies. This is essential for sustaining ultra-high levels of system reliability and availability even as the number of faults accumulates or concurrent fault scenarios emerge.

This research is therefore urgent as current TSN-based infrastructures lack the native capability for the autonomous and fault-tolerant re-configuration of space and time redundancy required by CRDCs. By filling the gap, this project will develop an intelligent redundancy management framework capable of dynamically reconfigure these types of redundancy, while guaranteeing the real-time communication requirements. Ultimately, this work contributes to ensure the resilience and operational continuity of the CRDCs that safeguard the EU's future carbon-neutral energy infrastructures.

Goal & Objectives

The primary ambition of this project is to develop an **Intelligent Redundancy Management Framework (IRMF)** that enables TSN-based control systems to guarantee ultra-reliable communication in the presence of multiple, concurrent faults.

- **Objective 1:** To design and implement a dynamic management algorithm that autonomously adjusts both spatial redundancy (path replication) and time redundancy (proactive retransmissions) in response to permanent and temporary faults affecting the network.
- **Objective 2:** To develop a flexible configuration agent integrated into the TSN **Centralized Network Configuration (CNC)** entity, enabling the autonomous re-configuration of network resources without violating the strict hard-real-time constraints of the SMG automation system.
- **Objective 3:** To validate the IRMF using a **UIB's experimental TSN testbed**, demonstrating its effectiveness in keeping operational continuity for critical infrastructures under complex fault scenarios.

Research Method

The project follows a rigorous **experimental and computational approach** based on the three-stage paradigm (specification, design, and evaluation). Initially, the research will focus on the **specification of fault and failure models** for the automation system, identifying the types and patterns of faults that the CRDCs must withstand to ensure dependable operation. During the **design phase**, these models will guide the development of the intelligent redundancy management algorithms and the autonomous configuration agents. This phase will integrate third-party timing analysis tools and scheduling solutions to ensure that both the **reconfiguration process itself** and the **resulting network configuration** fulfill the required **real-time**

requirements. Subsequently, the research will leverage a high-fidelity **hardware-in-the-loop (HiL) infrastructure**, utilizing a complex topology of interconnected TSN switches and peripheral devices for medium or large scale validation. Fault injection techniques, supported by FPGA-based tools and real-time Ethernet analyzers, will be used to measure latency and jitter under stress. In alignment with **Open Science** practices, all developed algorithms and non-proprietary datasets will be published in Open Access repositories (e.g., Zenodo), and the project will adhere to a Data Management Plan ensuring FAIR (Findable, Accessible, Interoperable, Reusable) data standards.

Technology & Infrastructure

The fellow will have full access to:

- **Experimental TSN Testbed:** A high-fidelity Hardware-in-the-Loop (HiL) infrastructure comprising a complex topology of interconnected industrial-grade TSN switches and peripheral devices for medium or large scale validation.
- **Advanced Validation Tools:** Full access to FPGA-based fault injection platforms, real-time Ethernet network analyzers, and timing analysis software to ensure strict real-time compliance.
- **Dedicated Research Resources:** High-performance computing workstations for modeling, training and simulation.
- **Full access to:** the UIB's digital library and specialized IEEE/ACM databases.
- **Workspace:** Dedicated laboratory space within the **Department of Mathematics and Computer Science** at the University of the Balearic Islands (UIB), integrated into the research group's collaborative environment.

Expected Output

The project is expected to yield high-impact results, including at least **one publication in a Q1 journal** (e.g., *IEEE Transactions on Industrial Informatics*) and presentations at flagship conferences such as **RTSS** or **ETFA**. Beyond academic output, the project aims to produce a **proof-of-concept prototype** of a flexible configuration agent within a CNC, which could lead to technology transfer opportunities with industrial partners such as **TTTech** or **SOC-E**.

For the fellow, this project provides a unique pathway to **professional independence** by establishing a distinct research line within the UIB's **Systems, Robotics & Vision (SRV) Group**. This will allow the fellow to gain specialized expertise in the critical intersection of Power Systems and TSN-based automation while fostering long-term collaborations with international industry leaders like **ABB**.

Proposing University

The **Universitat de les Illes Balears (UIB)** is a leading research institution. We hold the **HR Excellence in Research** award (HRS4R), ensuring a supportive, transparent, and high-quality environment for the fellow's career development.

- **Institutional Excellence and Rankings:** The **Universitat de les Illes Balears (UIB)** is a leading research institution with a distinguished track record in productivity and impact. In the global **U-Ranking 2025**, the UIB maintains the **73rd position**, while in the **U-Ranking Volume 2025**, it holds an outstanding **18th position** nationwide. Comprehensive ranking and performance data can be accessed at: `https://www.u-ranking.es/universidad/UIB`.
- **Horizon Europe Engagement:** The UIB is deeply integrated into the European Research Area, currently participating in or leading **18 Horizon Europe projects**. This

active involvement demonstrates the institution's competitiveness and its capacity to foster high-impact international collaborations, providing the fellow with a vibrant ecosystem of ongoing research, networking opportunities, and cross-disciplinary innovation.

- **MSCA Hosting Capacity:** The UIB has a proven track record in managing Marie Skłodowska-Curie Actions, having successfully participated in **9 MSCA projects within the last five years**. This extensive experience ensures that the institution provides not only a high-level scientific environment but also a robust administrative and financial support structure, fully aligned with the requirements of the Horizon Europe framework and the European Charter for Researchers.
- **Infrastructure:** The fellow will be supported by a dual-tier technical environment. For heavy computational workloads, such as training intelligent redundancy management algorithms or performing network simulations, the **UIB's Center for Information Technology (CTI)** provides high-performance computing (HPC) resources. Additionally, the **SRV Laboratory** offers a dedicated workspace for (1) daily research and professional operations, (2) mid-range computing and software development, and (3) specialized **prototyping and testing** on an industrial-grade TSN-based communications infrastructure, including instrumentation tools for validation of dynamic reconfiguration of redundancy.
- **Mentorship and Research Environment:** The fellow will be integrated into the **Systems, Robotics and Vision (SRV)** group, and will be supervised by senior members of the **Intelligent Embedded Systems and Robotics (SRV-INTER)** unit. The supervisors bring a distinguished track record of leadership in national competitive projects, ensuring top-tier technical guidance. Furthermore, the fellow will be embedded in the broader **SRV-INTER** ecosystem, which possesses extensive experience in European-funded projects. This dual-layer support combines specialized national leadership with the group's collective expertise in the European Research Area, providing an ideal environment for the fellow's career development. Project portfolios are available at `https://srv.uib.es` and `https://www.uib.eu/research/structures/structure/SRV-INTER/`.

Our Support for Your Proposal

We don't just host you; we help you win. Candidates selected for this topic will receive:

- **Support in preparing for the MSCA Postdoctoral Fellowship application**, including individual consultation, proposal review, and guidance from experienced mentors at UIB.

Candidate Requirements

- **Degree:** PhD in **Computer Science, Industrial Engineering**, or related disciplines. The degree must be obtained by Sept 9, 2026, and no earlier than Sept 2018.
- **Prior Knowledge:** While not required, experience in **industrial ethernet communications** (particularly TSN standards), **embedded systems programming**, and **network instrumentation and simulation tools** is desirable. Knowledge of **Artificial Intelligence (AI)** and **intelligent agents** for the development of autonomous configuration modules, as well as prior experience with fault-tolerant architectures or power system automation, will be positively valued.
- **Mobility Rule:** Candidates must not have resided in **Spain** for more than 12 months in the 3 years immediately prior to the call deadline.

Interested?

Interested candidates should send the following to `julian.proenza@uib.es` by **July 10th, 2026**, with subject "MSCA Postdoctoral Fellowships 2026":

1. A brief CV (max 2 pages).
2. A motivation letter (1 page) outlining research alignment.
3. A 1-page summary of your proposed research idea.

More information

We look forward to building a winning proposal with you!