

## Approximate computing for communications

### Basic information:

Applications are invited for 15 full-time PhD student positions (called Early Stage Researchers or ESR) for PhD degrees for 36 months. The positions are offered within the Approximate Computing for Power and Energy Optimisation (APROPOS) International Training Network action of the highly appreciated EU-funded Marie Skłodowska Curie grants. The positions are fully funded for a 36-month period. You can choose your position in one of 14 top-level universities and companies in Europe and complement your experience within periods from 3 to 9 months of cross-sector secondments by working with the highly committed industrial partners of the action. You are encouraged to apply for up to three positions within APROPOS network if you believe your profile is suitable for multiple topics. A separate application is needed for each position in case you apply for multiple positions.

**APROPOS** is an international, multidisciplinary and multi-sectorial training network programme on approximate computing. APROPOS is funded by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska Curie grant agreement No. 956090.

The ESR project is listed below. Please read the description carefully before applying. We recommend you choose the position you apply for based on your technical profile and desired technical expertise, rather than based on the hosting location, as all positions involve high-level research mobility.

### Project information:

APROPOS will train 15 Early Stage Researchers to tackle the challenges of future embedded and high-performance computing by using disruptive methodologies. Following the current trend, by 2040 computers will need more electricity than the world energy resources can generate. On the communications side, energy consumption in mobile broadband networks is comparable to datacentres. To make things worse, Internet-of-Things will soon connect 20 to 50 billion devices through wireless networks to the cloud.

APROPOS aims at decreasing energy consumption in both distributed computing and communications for cloud-based cyber-physical systems. We propose adaptive Approximate Computing to optimize energy-accuracy trade-offs. Luckily, in many parts of the global data acquisition, transfer, computation, and storage systems there exists the possibility to trade off accuracy to either less power or less time consumed – or both. As examples, numerous sensors are measuring noisy or inexact inputs; the algorithms processing the acquired signals can be stochastic; the applications using the data may be satisfied with an “acceptable” accuracy instead of exact and absolutely correct results; the system may be resilient against occasional errors; and a coarse classification or finding the most probable matches may be enough for a data mining system. By introducing a new dimension, accuracy, to the design optimization, the energy efficiency can even be improved by a factor of 10x-50x.

APROPOS will train the spearheads of the future generation to cope with the technologies, methodologies, and tools for successfully applying Approximate Computing to power and energy saving. The training, in this first ever ITN addressing approximate computing, is to a large extent done by researching energy-accuracy trade-offs on circuit, architecture,

software, and system-level solutions, bringing together world leading experts from European organizations. In addition, we will provide network-wide and local trainings on the substance and on the complementary skills needed in both industrial and academic work life.

**ESR Host Unit:** Wirepas Ltd, Finland

**ESR 14 work description:** Low power mesh networks are a key technology in Internet of Things (IoT) domain, especially in systems including large number of devices in high densities. This far mesh technologies have been implemented on relatively simple radio transceivers, such as Zigbee and Bluetooth BT/BLE radios which limit e.g. the device-to-device distance and link reliability, and thus, overall system capabilities. Wi-Fi can be used in mesh configuration (IEEE 802.11s), but is heavily limited in scalability and power consumption due to IEEE 802.11 MAC and PHY design. More capable radios, such as LTE-M type radios, have not really been used in low power, low cost mesh networks scope, but are used solely in star configuration in cellular networks. LTE-M type radios, however, provide superior link performance and reliability compared Zigbee, BT/BLE, and Wi-Fi. The drawback is higher power consumption and cost of the LTE-M radio chipsets.

The work includes design, simulation, and prototyping of mesh protocols and algorithms on LTE-M type radios. The target is to minimize the power consumption and cost of the wireless devices by using approximate computing and other necessary techniques. Inside a device, the work concentrates especially on TDMA and FDMA MAC designed for mesh operation and its co-operation with an LTE-M type PHY (OFDM including HARQ). Although the main scope is not in the PHY, necessary approximation techniques in this layer will also be identified that support the target of overall device power and cost optimization. Also, analysis of partitioning the techniques to optimal processing blocks, such as application processor, modem host processor, and baseband processor, will be carried out. The impacts will be analyzed in mesh network level to assess the feasibility and performance in real large scale systems.

The work will be done in tight co-operation with Wirepas R&D team developing the mesh protocol firmware and Wirepas' semiconductor partners providing the radio chipsets.

**ESR 14 Objectives:**

- Demonstrate the energy-accuracy trade-offs in approximate MAC layer and other mesh protocol layers
- Apply approximate computing to low-energy adjustable radio protocol design
- Support the benchmarking activities

**ESR Expected Results:**

- Proof-of-concept implementation of adjustable radio protocols
- Methods for designing low-cost approximating radio protocols
- Completion of the PhD/D.Sc.(Tech) at the hosting unit withing 36 months

**Planned secondment(s):** TAU, supervisor Prof. Jari Nurmi, M24, 4 months and M40, 5 months for coursework, academic training, thesis writing, and aligning with the research outcome of TAU research on approximating hardware.

**Supervisory team:**

- Prof. Jari Nurmi (TAU), main supervisor
- Assoc.Prof. Elena-Simona Lohan (TAU), academic co-supervisor
- Dr. Aleksandr Ometov (TAU), academic co-supervisor
- Dr. Ville Kaseva (Wirepas), industrial co-supervisor

**Enrolment in Doctoral degree:** Tampere University, Finland

**Target degree:** PhD/D.Sc.(Tech.) in Doctoral Programme of Computing and Electrical Engineering (DPCEE)

**Degree details:** <https://www.tuni.fi/en/study-with-us/doctoral-programme-computing-and-electrical-engineering#switcher-trigger--overview>

**Expected start date:** July 2021 (M9 from the beginning of the project)

**Approximate gross salary:** about 3600 EUR/month for researchers without family (and about 4000 EUR/month for researchers with family); Note: for different positions within the same APROPOS network, the salary is country- and unit-dependent.

**Duration:** 36 months

**Researcher Profile:** First Stage Researcher (R1)

**Research Field:** Engineering; Computer science; Technology

**Type of contract:** Temporary

**Job Status:** Full-time

**Hours per week:** 36,25

**Trial period:** 6 months

**Working and living conditions in the country:** Finland is among the most stable, free, and safest countries in the world, based on prominent ratings by various agencies. It is also ranked as one of the top countries as far as social progress is concerned. Tampere is counted among the major academic hubs in the Nordic countries and offers a dynamic living environment. Tampere region is one of the most rapidly growing urban areas in Finland and home to a vibrant knowledge-intensive entrepreneurial community. The city is an industrial powerhouse that enjoys a rich cultural scene and a reputation as a center of Finland's information society.

Read more about Finland and Tampere:

- <https://www.visitfinland.com/about-finland/>
- <https://finland.fi/>
- <https://visittampere.fi/en/>
- <https://expat-finland.com/>

**Unit details:** At Wirepas, we are changing the way things are connected to the internet. Our mission is to help global efficiency, safety, and sustainability by championing wireless mesh connectivity at a massive scale. We offer fully automatic, reliable, and robust wireless connectivity at industry lowest energy consumption to enable the most demanding IoT use cases. We operate globally and serve several verticals within the IoT market, such as logistics, smart lighting, smart metering, and industrial IoT. We are undisputed technology leader in low power wireless mesh networking and our vision is to become the standard for massive IoT market.

Read more about Wirepas at [www.wirepas.com](http://www.wirepas.com)

**Seconding Unit description:** Tampere University is the second largest university in Finland, established in the beginning of 2019 through the merger of Tampere University of Technology and the University of Tampere. This combination built a unique environment for multidisciplinary, inspirational and high-impact research and education and a hub of expertise in technology, health and society.

Tampere University is the majority shareholder of Tampere University of Applied Sciences and together the two institutions form a higher education community of 30,000 students, 330 professors and 4,400 other staff.

Read more about Tampere University:

- <https://tuni.fi/>
- <https://www.timeshighereducation.com/world-university-rankings/tampere-university/>

**Eligibility criteria:** please check carefully that you are eligible; all conditions below are compulsory

**Transnational mobility:** The researcher must not have resided or carried out their main activity (work, studies, etc.) in the country of the host organization for more than 12 months in the 3 years immediately prior to the start date. Note: the mobility rule applies to the (main) beneficiary where the researcher is recruited, and not to partners to which the researcher is sent or seconded. It is also only determined at one point in time: at the time when the ESR starts working for APROPOS.

**Early-Stage Researchers (ESRs)/fresh MSc graduates:** All researchers recruited in APROPOS must have less than 4 years since the completion of their first MSc degree and have not been awarded any doctoral degree at the date of the employment.

**Background requirements:** The applicant must be in possession of Master of Science (MSc) diploma in a relevant field, such as: electrical engineering, communications engineering, computer engineering, software engineering/computer science, signal processing, radio communications, mathematics, physics, aerospace engineering, mechanical engineering, biomedical engineering, etc.

**English language requirements:** The candidate must be in possession of an English certificate with good level according to the regulations of the university to which the student will be enrolled for the PhD degree – check the degree requirements of the corresponding doctoral program for details.