

CRACS: CENTER FOR RESEARCH IN ADVANCED COMPUTING SYSTEMS

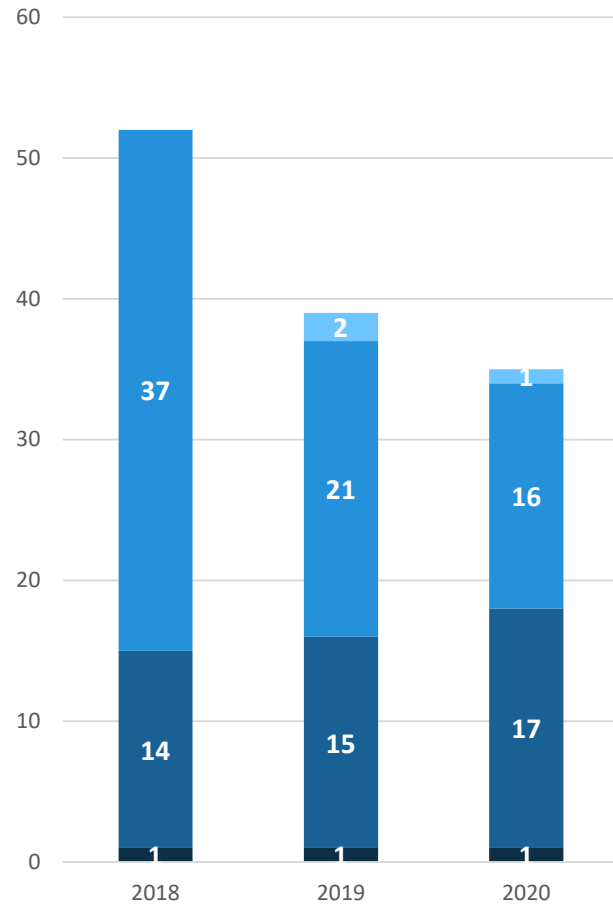
SCOPE AND ACTIVITY FOR 2022

CCI/2022-01-25

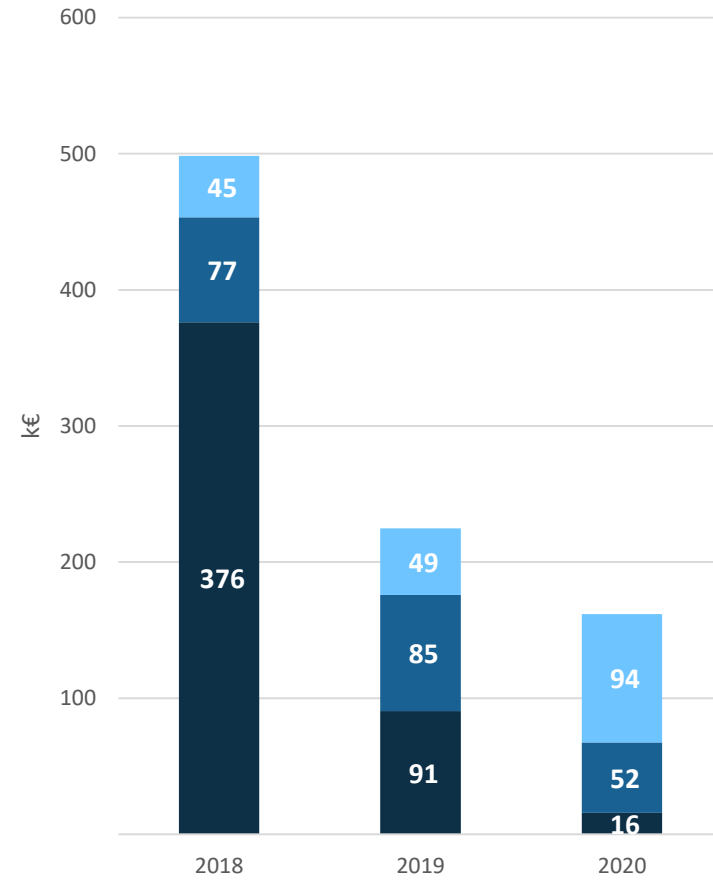
from knowledge
generation to
science-based
innovation



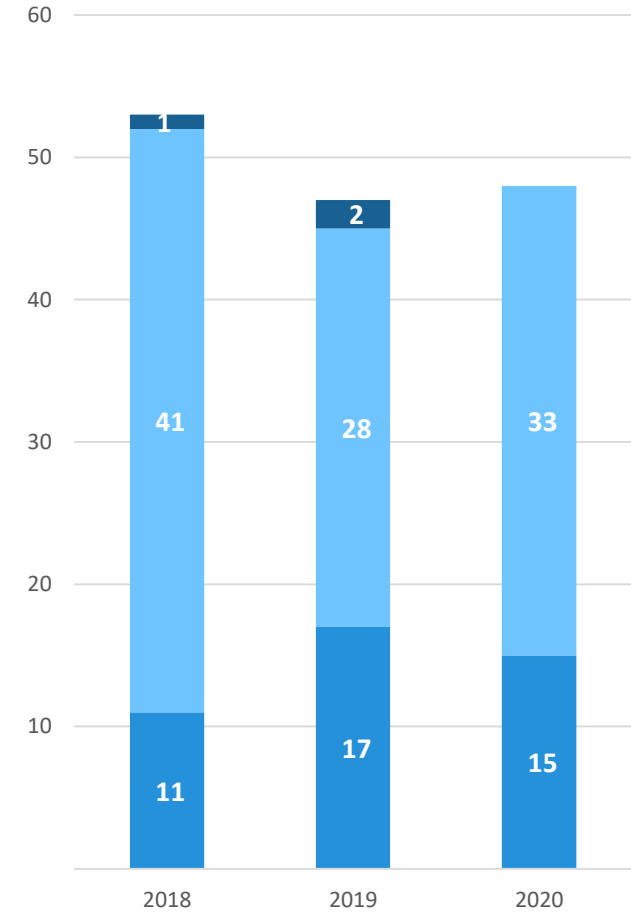
TEAM & ACTIVITY



■ R&D Employees ■ Academic Staff
■ Grant Holders and Trainees ■ Affiliated Researchers



■ R&D Services and Consulting
■ EU Programmes
■ National Cooperation Programmes with Industry
■ National R&D Programmes



■ Indexed Journals ■ Indexed Conferences
■ Books ■ Book Chapters

MISSION & RESEARCH LINES

CRACS mission is to pursue scientific excellence in the areas of programming languages, parallel and distributed computing, information mining, security and privacy, with a focus on scalable software systems for challenging multidisciplinary applications in Engineering, Life Sciences, Social Networks and the Internet of Things. CRACS research is grouped in 3 main research lines:

RL1. Languages and Distributed Computing

RL2. Security and Privacy

RL3. Knowledge in a World of Data

RL1. LANGUAGES AND DISTRIBUTED COMPUTING

This research line focuses on the **design and implementation of software for sequential, parallel and distributed computing**. Examples include: (i) high-level programming languages for logical and probabilistic reasoning, supporting negation, tabling, concurrent data-structures and parallelism; (ii) programming languages and middleware frameworks for mobile wireless networks and the Internet of Things (IoT); (iii) cloud-computing, edge-computing and innovative crowd-sensing and crowd-sourcing applications.

The main intervention areas are:

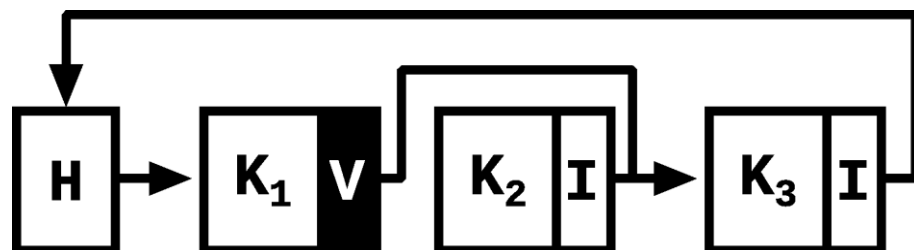
- **Programming Languages**
- **Concurrent Data-Structures**
- **Parallel and Distributed Computing**
- **Edge-Computing and IoT**
- **Middleware and Applications**

The YAP Prolog System, v 7.2

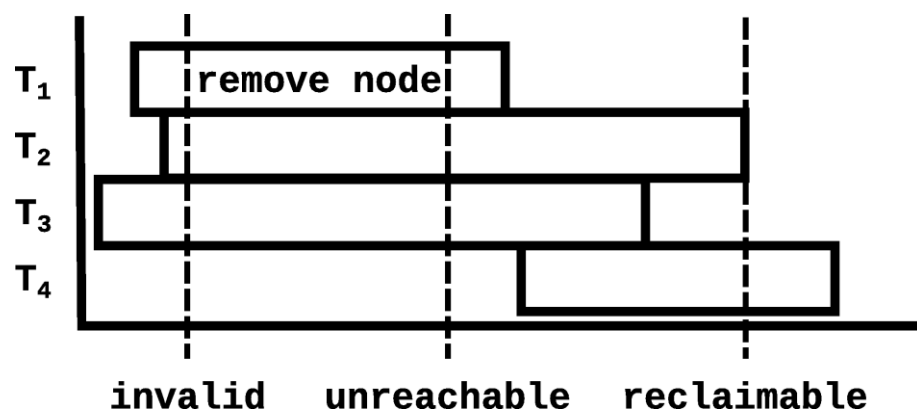


- Yap Prolog is a highly regarded Prolog system in the research community, especially for machine learning, being distributed with the Fedora Linux distribution.
- It supports just-in-time compilation, multiple forms of parallelism, multithreading, tabling, constraints handling, probabilistic inductive logic programming, among many other features and independent packages.
- Recently it has been extended with interfaces to Python, Android and R, and with a Jupyter kernel. It is widely used as a teaching, research and development tool.

Memory Reclamation in Lock-Free Data Structures

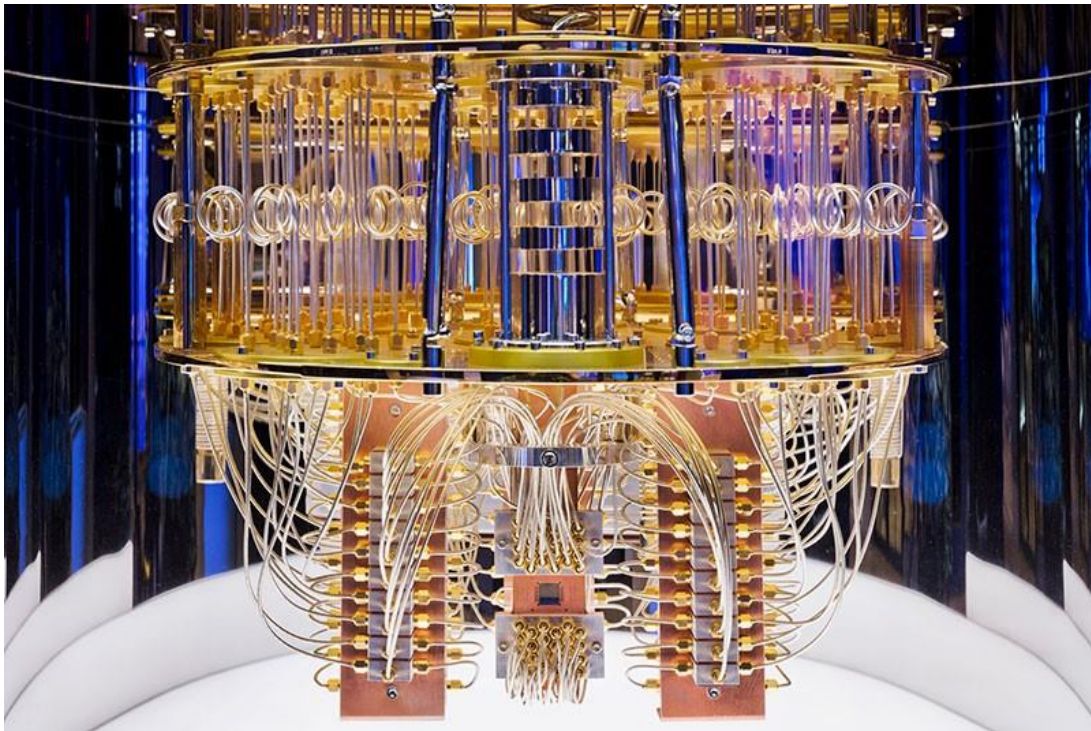


- Lock-freedom allows individual threads to starve but guarantees system-wide progress, i.e., there is no per-thread progress guarantee (individual threads can starve) but it is guaranteed that at least one thread progresses in some well-defined number of steps, regardless of the scheduling policy.



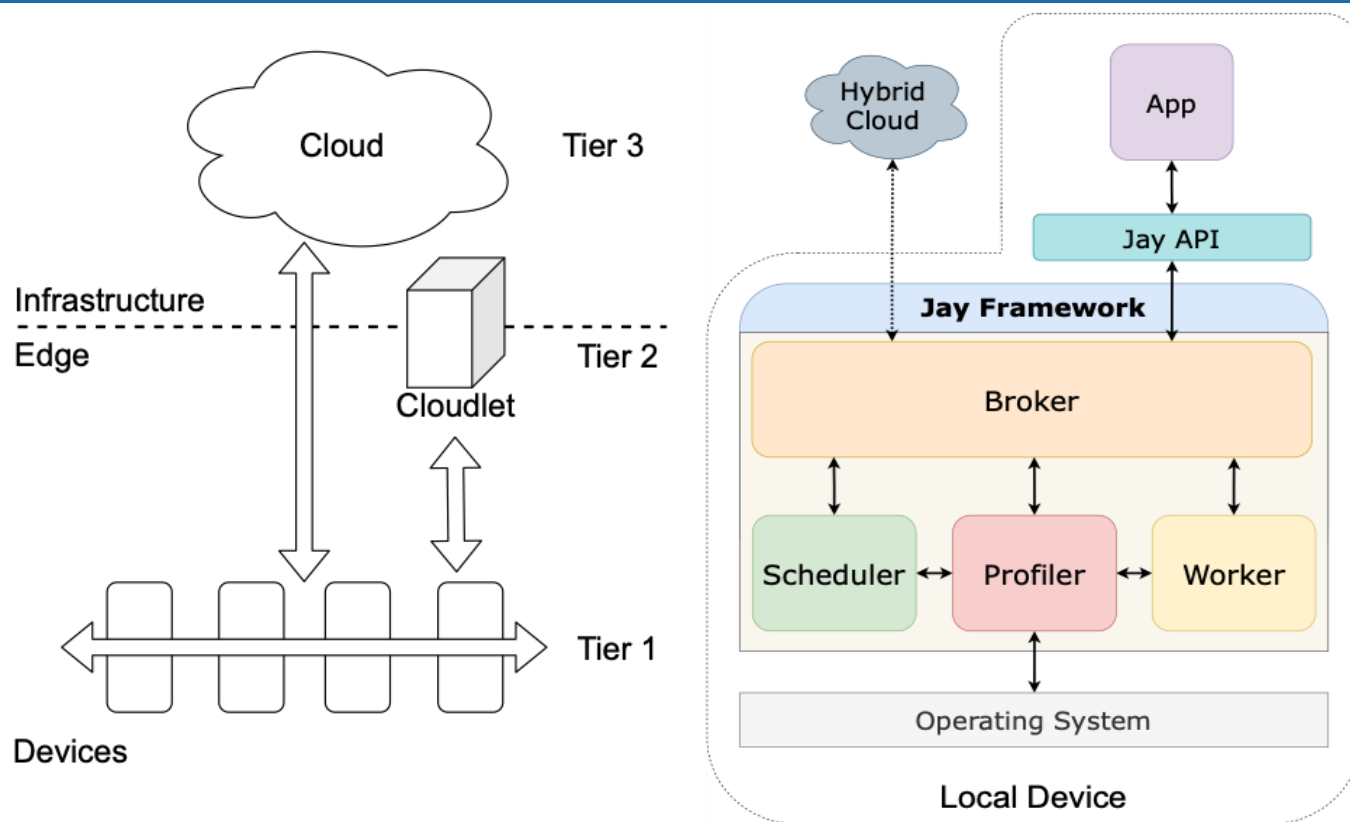
- Implementation, proof and evaluation of novel methods for the efficient removal and memory reclamation of nodes in branching lock-free data structures.
- The ultimate goal is to develop a generic high-level interface that efficiently implements the required synchronization procedures for memory reclamation in lock-free data structures.

Fine-Grained Quantum Complexity



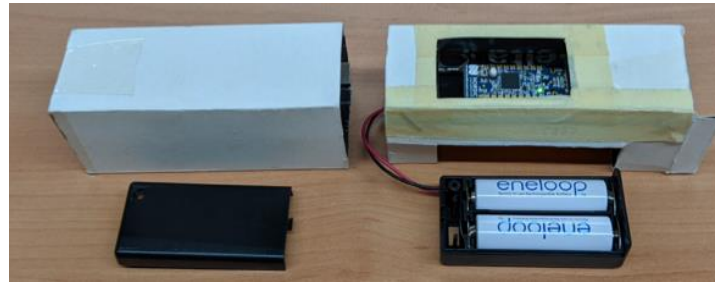
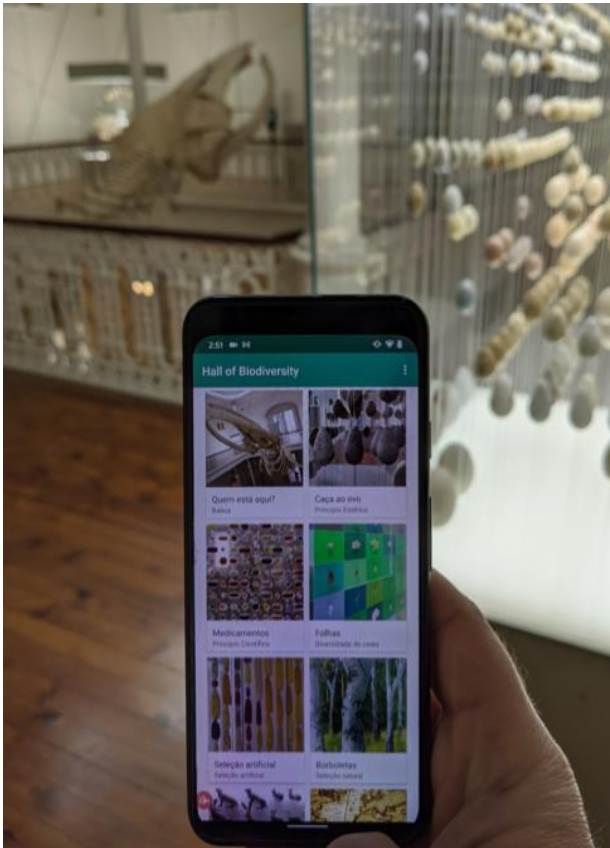
- We have developed new tools that allow us to show that quantum computers are sometimes limited, when compared to classical computers. For example, we have shown that for many problems in computational geometry, the best possible quantum speedup is quadratic.
- As it turns out, early quantum computing technology will require machines that are too big to make use of such mild speedups. Practically speaking, this means that people interested in solving problems in computational geometry (e.g., movie studios) need not be concerned with early investment in quantum computing.

Jay – Adaptive Task Offloading in Mobile Edge Clouds



- Jay is a parametric system for adaptive task offloading in multi-tier mobile edge-clouds.
- Energy-aware and time-aware offloading of computational tasks generated by mobile devices. Offloading decisions rely solely on information and may employ resources available at different tiers in a hybrid cloud.
- Case-study evaluations demonstrated the feasibility of the approach and provided insights on the trade-offs associated to choices of offloading choice, cloud architectures, task characteristics, etc.
- The research takes place in the scope of the Safe Cities project, following up on previous work in the Hyrax project.

Infrastructure for Seamless Indoor Location of Mobile Devices



- We use multiple techniques to tackle the problem of indoor location, namely dead reckoning, trilateration and computer vision. We aim to create non-intrusive, energy efficient, algorithms to locate mobile devices inside a building. These are included in the wider context of an infrastructure to create and manage a potentially large area, providing cheap alternatives to current proprietary indoor location systems, namely for industrial settings and public institutions like museums.

- We have a complete prototype of such an infrastructure based on two technologies: bluetooth beacons and computer vision (using the camera of the devices).

- The research takes place in the scope of the Augmanity and Safe Cities project in collaboration with IT, FEUP, Bosch Ovar, Bosch Aveiro and the Museum of Natural History and Science at UPorto.

RL2. SECURITY AND PRIVACY

This research line focuses on **algorithms and methodologies to improve the usability of privacy and security in software and systems**. Applications include: (i) user-controlled identity management systems protecting personally identifiable information; (ii) secure identity cards and authentication mechanisms with a view to ensure access control to physical locations, networks and online transactions; and (iii) specialized algorithms and tools for sharing sensitive data while preserving privacy.

The main intervention areas are:

- **Identity Management Systems**
- **Secure Tokens for Electronic Identity (eID)**
- **Privacy Enhancing Technologies**
- **Secure Edge Computing and Streaming**
- **Distributed Intrusion Detection Systems**

Project COP-MODE – Automated Privacy Protection for Mobile Devices



Dozens of apps

X



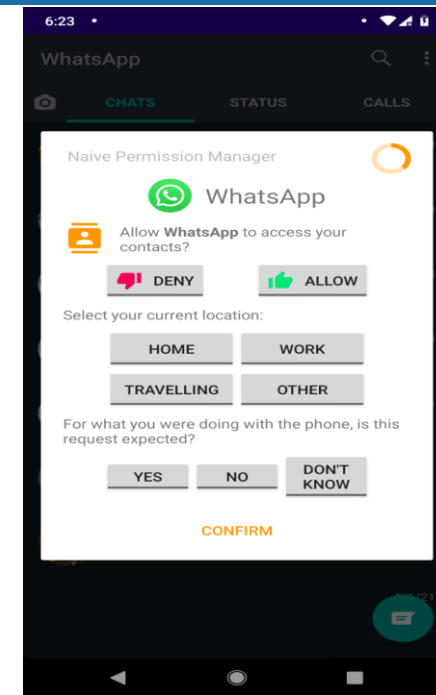
Multiple Configurations

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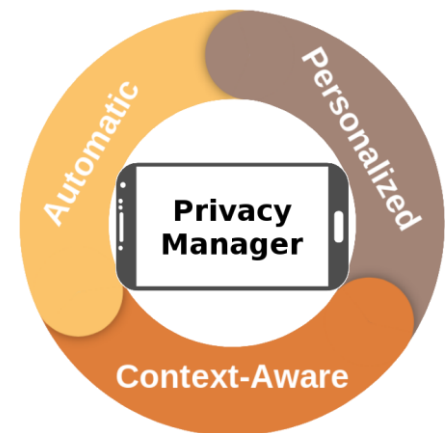
Privacy Loss

1. Data gathering campaigns:
 - 93 users
 - ~65K answers
2. Creation of user profiles through data
3. Prediction of permission requests

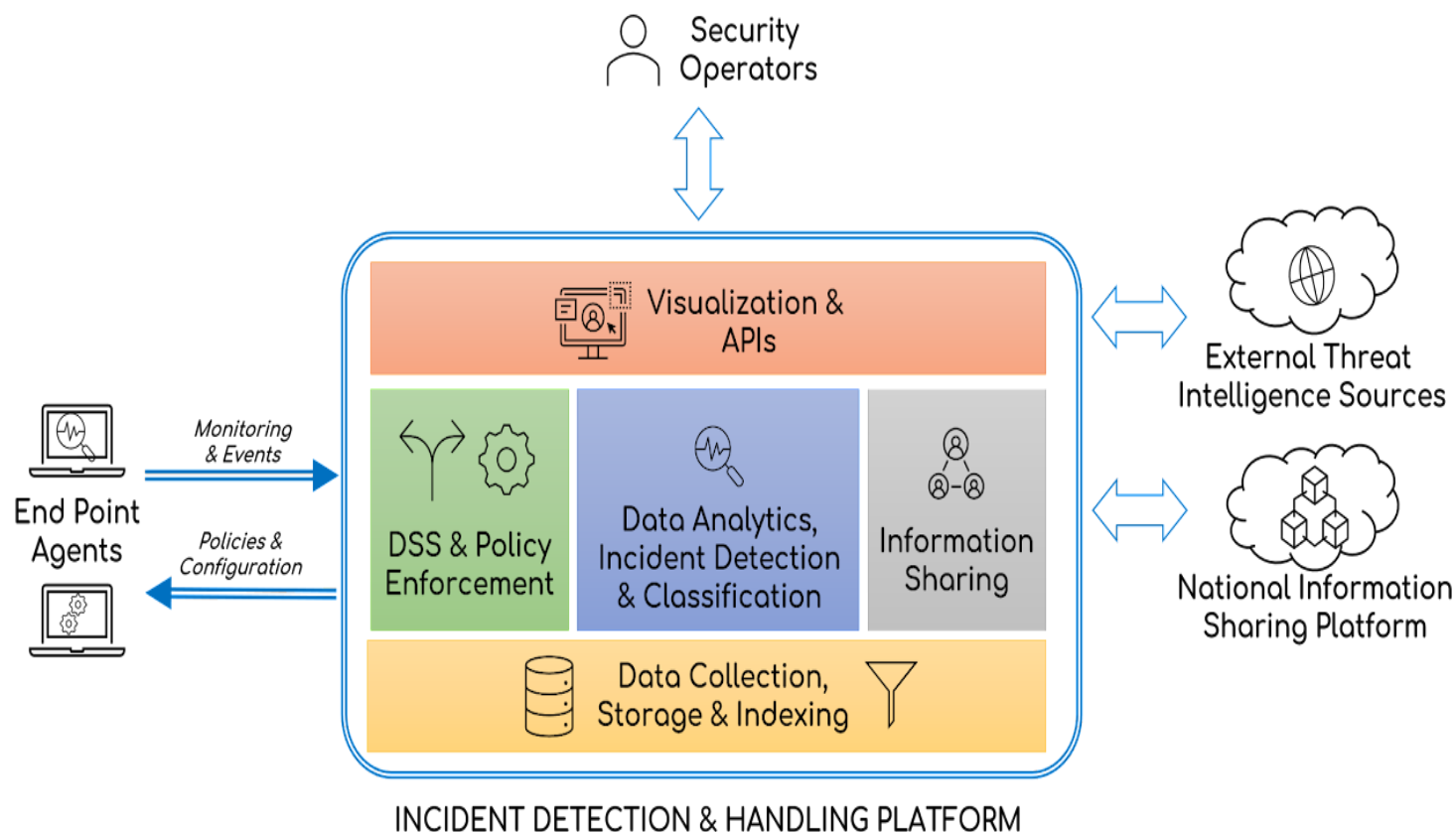


- Automated privacy preferences
- According to **personal** privacy preferences
- Adaptable to user **context**

<http://cop-mode.dei.uc.pt/>



Project PANDORA – European Defence Industrial Development Programme



- The PANDORA project aims at contributing to EU cyber defense capacity building, by designing and implementing an open technical solution for real-time threat hunting and incident response, focusing on endpoint protection, as well as information sharing.

- Our contribution is on a REST API for the secure searching and sharing of cyberattack related information between the member states.

RL3. KNOWLEDGE IN A WORLD OF DATA

This research line focuses on the **bridge between logic, probabilities, data structures and learning**. The focus is on applications that tie our work together with domains, such as, author identification, semantic relatedness, sentiment and emotion discovery, complex networks, motifs discovery, sensor data streams, medical records data, and high-throughput genomics data.

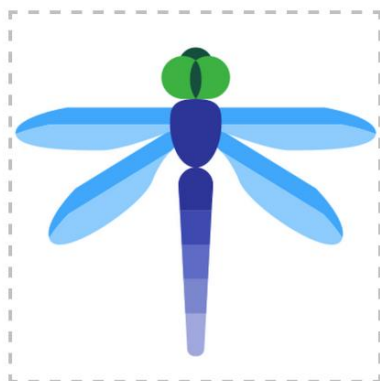
The main intervention areas are:

- **Machine Learning and Discovery**
- **Big Data Applications**
- **e-Learning Environments and Tools**
- **Complex Networks**
- **Bioinformatics**

Biolens: Citizen Science Tools for Evaluating Ecosystem Health

Biolens

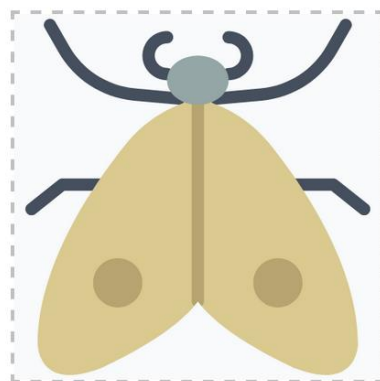
Models



Dragonlens



Lepilens



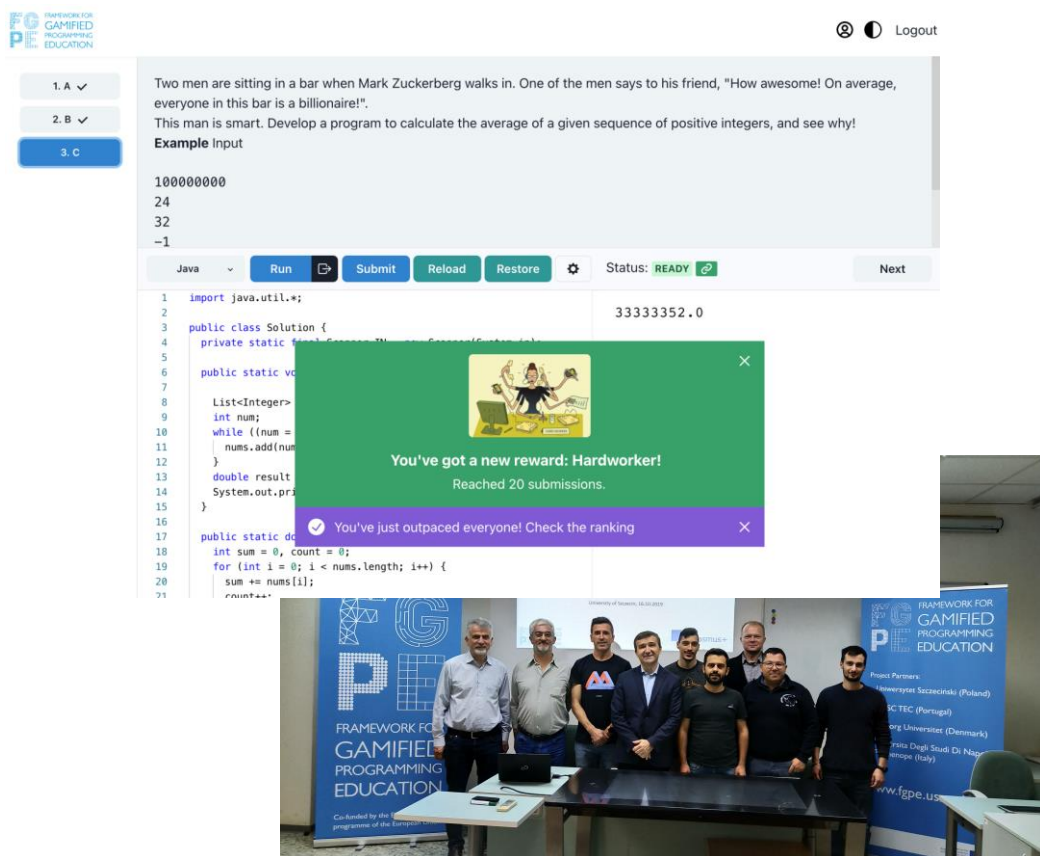
Mothlens

- We use artificial intelligence techniques to develop models that allow the automatic identification of biological species that are sensitive proxies for ecosystem health. The models are available online and via mobile apps so that users can photograph a species, submit the information to a server and get an automatic suggestion for the identification of the living being in the photo.

- Currently we have models for odonata (dragonflies), lepidoptera (butterflies and moths) and for the portuguese flora.

- The project is a collaboration with the Parque Biológico de Gaia, the Portuguese Botanical Society and the Museum of Natural History and Science at UPorto.

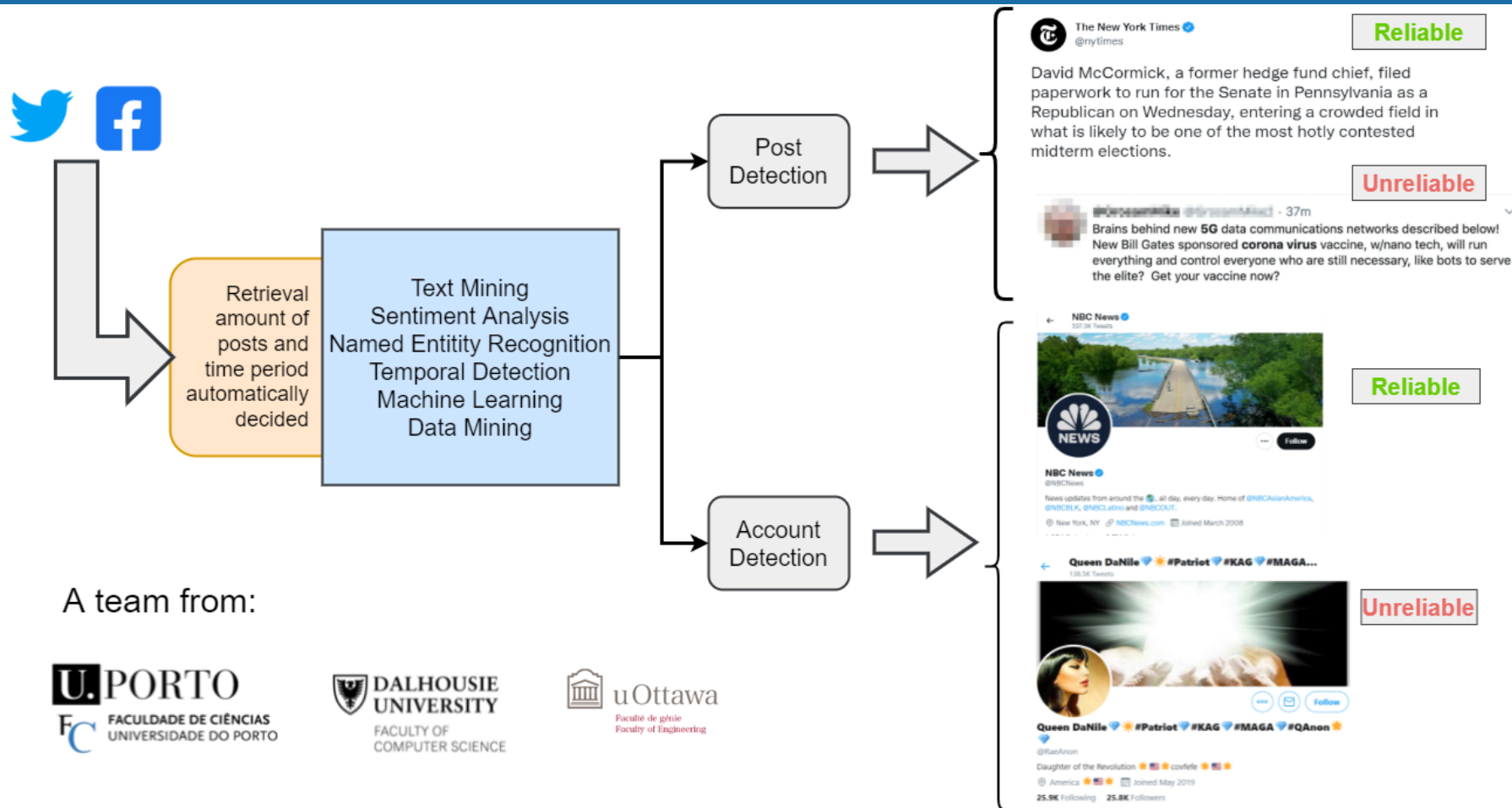
Project FGPE+: Framework for Gamified Programming Education



The screenshot displays the FGPE+ web application interface. At the top left is the FGPE+ logo. The main content area shows a programming problem: "Two men are sitting in a bar when Mark Zuckerberg walks in. One of the men says to his friend, 'How awesome! On average, everyone in this bar is a billionaire!'. This man is smart. Develop a program to calculate the average of a given sequence of positive integers, and see why!". Below the problem is an "Example Input" with the numbers 100000000, 24, 32, and -1. The output is 3333352.0. A code editor shows a Java solution. Two reward pop-ups are overlaid on the code editor: a green one for reaching 20 submissions and a purple one for outperforming others.

- The FGPE+ project aims at providing the necessary software and educational content for an effective application of gamification in programming education, primarily in higher education institutions, by taking advantage of the LTI standard to communicate with the most well-known online Learning Management Systems, such as, Moodle, Sakai, and others.
- Examples includes tools for the gamification and automatic assessment of computing exercises, namely for programming languages, markup languages, and database querying exercises.
- The project is a collaboration with Uniwersytet Szczeciński (Poland), Università Degli Studi Di Napoli Parthenope (Italy) and Kauno Technologijos Universitetas (Lithuania).

Automatic Fake News Detection



A team from:



AUTHENTICUS

<https://www.authenticus.pt>

National repository of metadata of publications authored by researchers affiliated with Portuguese Institutions.

Import & update of indexed publications

Citations & Statistics

Interfaces for researchers

Interfaces for institutions

CiteScore + JCR journal metrics

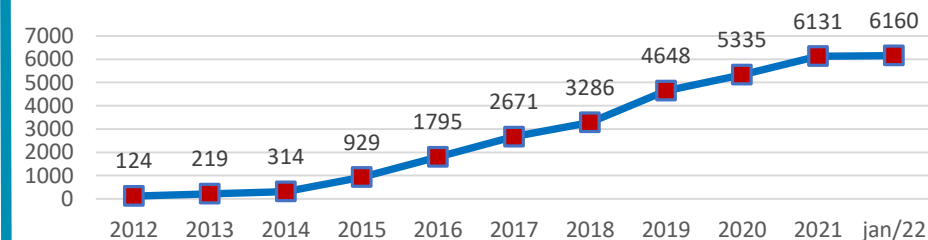
Bidirectional synchronization with ORCID

API

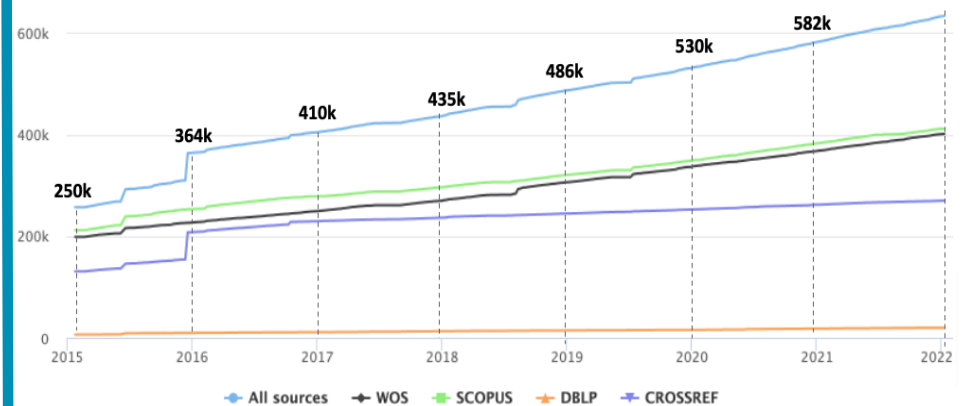
U. PORTO



Users



Publications



RESEARCH & INNOVATION COLLABORATIONS

- CWI, Amsterdam, Netherlands – quantum computing
- IRIF, Paris, France – type theory
- King's College, London, UK – theoretical computer science
- KETH, Stockholm, Sweden – computational complexity
- University of Bristol, UK – computational complexity
- University of Cambridge, UK – project COP-MODE
- Uniwersytet Szczeciński, Poland – projects FGPE & FGPE+
- Università Degli Studi Di Napoli Parthenope, Italy – projects FGPE & FGPE+
- Aalborg Universitet, Denmark – project FGPE
- Kauno Technologijos Universitetas, Lithuania – project FGPE+
- CIFP Carlos III, Spain – project JuezLTI
- Karlstad University, Sweden – project JuezLTI
- Bursa Il MEM, Turkey – project JuezLTI

RESEARCH & INNOVATION COLLABORATIONS

- NII, Tokyo, Japan – computational complexity
- TIFR, Mumbai, India – computational complexity
- University Federal de Goiás, Brazil – type theory
- MIT, USA – project SNOB-5G
- Ottawa University, Canada – automatic fake news detection

RESEARCH & INNOVATION COLLABORATIONS

- Bosch Braga – project Theia
- Bosch Aveiro – project Augmanity
- Bosch Ovar – project Safe Cities
- Instituto de Telecomunicações – projects SafeCities & Augmanity
- HEALTHYSystems – project DM4Health
- Parque Biológico de Gaia, Museu de História Natural e Ciência – project Biolens
- A3ES – authenticus
- CIPES – authenticus
- NIPE, UMinho – authenticus
- CIBIO–InBIO – authenticus
- CCMAR – authenticus

COLLABORATIONS WITH OTHER INESCTEC CENTRES

- CTM – project PANDORA
- LIAAD – automatic fake news detection
- LIAAD & HASLAB – project Theia

OBJECTIVES & MAIN ACTIONS 2022

A key objective for 2022 is to maintain/improve CRACS's international visibility, notoriety and publication output. In particular, we aim to:

➡ maintain the number of publications by CRACS's members around a total of 50 publications in indexed journals and conferences.

➡ maintain/improve the number of international events organized by CRACS members, the number of participation as editor in international journals and the number of participations in program committees (we estimate the organization of 5 events and the participation in 5 journals as editor and in more than 30 program committees).

➡ be successful in new scientific projects, national and preferentially European, in order to increase our funding level, which was decreased significantly in the last years.

OBJECTIVES & MAIN ACTIONS 2022

Development of new projects and increase funding level:

- ➡ Submit project proposals to national and European calls
- ➡ Participation in project Theia with Bosch Braga

Reinforce expertise and promote networking:

- ➡ Organization of international scientific events
- ➡ Organization of International School and Conference on Network Science (netscix.dcc.fc.up.pt)

Growth of current projects/collaborations:

- ➡ BioLens initiative: reinforce collaboration with institutions related to Nature conservation
- ➡ BOSCH-Ovar, BOSH-Aveiro and MHNC: new developments for indoor positioning systems

Grow expertise with new collaborations:

- ➡ CAUP: use deep learning techniques to tackle astrophysics problems in the search for exoplanets

THANK YOU!

**CRACS
SCOPE AND ACTIVITY FOR 2022**

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from knowledge
generation to
science-based
innovation



INNOVATION ACTIVITIES & APPLICATION AREAS

	TEC4AGRO	TEC4ENERGY	TEC4HEALTH	TEC4 INDUSTRY	TEC4SEA	Other
Framework for privacy protection of heterogeneous data types		X	X			X
Encrypted searching of external/cloud encrypted data storages		X		X		