

PhD of National Interest in Blockchain and Distributed Ledger Technology

Research Programme

39th Cycle

Academic Years 2023/2024 – 2025/2026

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Introduction

Blockchain and Distributed Ledger Technology provide building blocks of the so-called “Internet of Value”, since they enable recording of interactions and transfer “value” referring to any record of ownership of asset - for example, money, securities, land titles – and ownership of specific information like identity, health information as well as other personal data.

Almost any national and international strategic research, innovation and development agenda mentions Blockchain and/or Distributed Ledger Technology as key technologies and infrastructures enabling societal progress, with a particular emphasis when they mention at the undoubtedly strategic “digital and green twin transitions” (for example: “PNR 21-27 – the National Research Programme 2021 - 2027”, “PNRR 21-26 the National Recovery and Resilience Plan” and complementary funds).

In the era of the “twin technologies”, the National Doctoral Program in “Blockchain and Distributed Ledger Technology” aims to educate and train a new generation of researchers, professionals and innovators who can provide proper answers to the scientific and innovation emerging challenges from the private sector and public administration.

Aim of the document

This document describes the Research Programme for the Doctoral Research of National Interest in Blockchain and Distributed Ledger Technology (PhD-BC&DLT). The PhD is organized in eight curricula:

- Methodologies, technologies and tools
- Social systems and smart societies,
- Health and well-being,
- Economics and finance,
- Law and Governance,
- Industry 4.0,
- Climate, energy and mobility,
- Agriculture and agrifood.

The PhD is characterized by a strong interdisciplinary and multidisciplinary approach; an overview of the main research themes and scope of the curricula is provided below. Each curriculum offers several scholarships linked to research topics which are described in detail. In order to facilitate their reading by candidates, the information relevant to each scholarship is organized in a data sheet reporting:

- the **title** of the research topic;
- the **research keywords**;
- the **reference European Research Council** sectors which provide information on the research areas, and the list of ERC sectors (for a complete list of the ERC sectors visit the https://erc.europa.eu/sites/default/files/document/file/ERC_Panel_structure_2021_2022.pdf);
- the **reference person** – i.e. the individual, researcher or professor, offering the research topic and available to provide more information via email;
- the **host university** which is the location of the main research activity; in the case of the scholarships, University IUSS of Pavia will be where most of the common activities will be organized;
- the **research topic** describing the scope and objectives of the research in more detail;
- the **research team and environment** indicating where the research activities will be carried out and where most of the collaboration with other researchers and research institutes will be based;
- the **suggested skills** – i.e. the skills that, ideally, the candidate should possess in order to succeed in their doctoral research.

Curriculum 1: Methodologies, technologies and tools

Scholarships of Curriculum 1 are coded **A###**

The curriculum "Methodologies, technologies and tools" focuses on foundational aspects of Blockchain and Distributed Ledger Technology, considering both theoretical and applied research.

Methodologies play an increasingly important role in managing and defining blockchain and, more in general, distributed ledger solutions. A key point is the definition of novel and fault-tolerant distributed consensus mechanisms, cryptographic primitives, and distributed protocols. In particular, consensus mechanisms ensure the integrity of the information stored in blockchains and improve system efficiency and defense against attacks. Data privacy needs to be achieved as well as the opportunities and challenges of blockchain-based self-sovereign identities to guarantee complete control over people's digital identities.

Other research aspects cover but are not limited to blockchain software architectures and novel approaches to blockchain-oriented software engineering. Novel metamodeling approaches represent the groundwork for Blockchain and Distributed Ledger solutions. They can be both domain and domain-independent. Specialized blockchain modeling notations can support the advance in blockchain-oriented software. In this regard, modeling standards, such as UML, BPMN, and other domain-specific languages, can be adopted. It is necessary to improve the state of the art in creating blockchain smart contracts in a high-level and user-friendly modeling language, breaking the technological barriers for non-expert users.

Blockchain software analysis and re-engineering need to be investigated to support the quality of blockchain infrastructure, smart contracts, and related dApp. Optimization aspects are also considered to guarantee the efficiency of smart contracts execution. Formal specification and advanced automatic verification techniques need to be defined, and novel approaches for smart contract testing and auditing of blockchain transactions.

Blockchain technologies are based on adopting different infrastructures such as Ethereum, IOTA, Hyperledger ecosystem, etc. In this regard, recent challenges for the support of security, scalability, reliability, interoperability and performance issues in blockchain and smart contracts on multiple blockchain platforms should be addressed. Certainly of interests are also tools, including open-source software, allowing new specific scenarios such as token sales.

In the curriculum, we also expect to identify and examine the blockchain application in emergent scenarios, including blockchain's role in the metaverse.

Keywords:

- Foundational aspects of Blockchain and Distributed Ledger Technology
- Distributed ledgers
- Distributed Computing
- Metamodeling and Management
- Distributed consensus mechanisms, cryptographic primitives and distributed protocols
- Smart Contracts
- Modelling, analysis and verification
- Model-driven software development
- Dynamic Networks
- Metaverse

Curriculum 2: Social systems and smart societies

Scholarships of Curriculum 2 are coded **B###**

Blockchain technology is increasingly seen as a tool for boosting data transparency and traceability in smart societies and social systems. As a decentralized infrastructure, blockchain can support the management of networks emerging from smart societies, like offering transparent services for the citizens, sharing public data, supporting decentralized identities (Self Sovereign Identities). In the context of social media, we see a clear evolution toward a decentralized model. Web3 proposal claims a vision of the Internet that can cut the intermediation of Big tech companies by completely decentralizing the web. This new model of the Web largely revolves around blockchain technology, which enables the integration of cryptocurrencies and tokens in many social media platforms. This gives the possibility both to reward users for their social actions and to define Non Fungible Tokens (NFTs), digital assets representing real-world objects like art, music, game items, videos so creating a new form of decentralized finance, the Social Finance (SocialFi). These platforms offer a new model which promise to be more private, secure, uncensored and compensatory for their members and to offer quality and trustable contents to the society to overcome the many issues of traditional social systems including data and content rights and monetization, fake news and excessive trolling.

The curriculum is focused on blockchain for smart societies and social systems and will develop both theoretical and applicative competences to develop new solutions for these platforms.

a) Theoretical aspects: several new and challenging theoretical issues arise when considering new models of social interaction. For instance new game theory models are required to describe the dynamics of decentralized markets. To understand the interplay among the social and economic layers at different scale requires not only the support of the technicians, but also of sociologists, lawyers, economists. Furthermore, the huge amount of transactions that a social system may generate demands for new solutions for improving the scalability of current blockchain (off-chain channels, side-chains,...).

b) Applications: several new scenarios are currently arising for the application of blockchain in the context of social and smart communities. Among them, of utmost interest are the integration of rewards and tokens in social platforms, the integration of the blockchain with metaverses, the development of blockchain-based platforms for smart communities.

Keywords:

- Smart Cities e Smart Communities
- Transparency and traceability
- Services to Citizens, Companies and Public Administrations.
- Tokenization
- Cybersecurity
- Inter-ledger technologies
- Self-Sovereign Identity
- Non Fungible Tokens (NFT) and Web3
- Social Interactions
- Vulnerabilities

Curriculum 3: Health and well-being

Scholarships of Curriculum 3 are coded C##

The curriculum on "Health and well-Being" aims to advances in the study of blockchain and DLT in creating innovative and performing solutions to improve the trust between patients and healthcare organizations as well as among healthcare organizations every time data sharing is required. Being very sensitive, the sharing of health-related data requires the compliance with several norms and policies which can be defined at European, national, or even at organization level. In this context, Blockchain and DLT can be beneficial in providing trusted environments to monitor the actual respect of these norms and policies without requiring the building of a complex, and often centralized authority, in charge of checking the compliance and where also the patients can have a role.

In this curriculum, the adoption of blockchain and DLT will be investigated considering the different types and formats of data involved in clinical and research-trials related processes. In fact, the context of the "Health and well-being" domain includes data, data-at-rest, images, genomic data, unstructured data and the approaches to decide between on-chain off-chain data management to balance between the need for trust and the system performance cannot be defined in general but depends on the type of data considered. Moreover, the potential adoption of Blockchain and DLT will consider the connection with well-established protocols (e.g., HL7 in its new FHIR version and DICOM for diagnostic images) and common systems (e.g., PACS for managing images and CRF for setting experiments). Notably, the role of blockchain and DLT in improving the management of genomic data which involve the need to manage important artifacts with a significant size will be investigated. Finally, in conjunction with the usual and fundamental role of the ethic committee which must deliberate on the possibility to manage personal data, smart contracts can be studied to enact the policies in a more agile way.

Keywords:

- Healthcare services
- Hospital's data and automated management
- Healthcare data sharing
- Healthcare data protection
- Trust-based health environments
- Distributed Ledger Technology
- Electronic Health Records
- Privacy preserving data processing
- Etics and Etics Committee

Curriculum 4: Economics and finance

Scholarships of Curriculum 4 are coded **D##**

This curriculum is aimed at Ph.D. candidates who are interested in studying blockchain and distributed ledger technology in economics and finance with a multidisciplinary approach. As one of the most notable blockchain applications, this track will consider the socio-economic, legal, organizational, and technological aspects of cryptocurrencies, central bank digital currencies and non-fungible tokens (NFTs). These include: investigating the user trust and reputation mechanisms behind the shift from institutional, centralized currencies to digital, decentralized ones; assessing how financial and governmental institutions respond to the rise of cryptocurrencies, including the emergence of central bank digital currencies; analyzing cryptocurrency and NFT transactions for the detection of anomalies, frauds, suspicious behavior (cyber-crime), communities, and motifs; business models of token-based economies; developing anonymization and de-anonymization techniques; studying the interplay between cryptocurrency/NFT and social media/virtual worlds; exploring real consequences of virtual money from the metaverse, evaluating the performance and reliability of blockchain algorithms and implementations; analyzing the sustainability of digital ledgers in terms of their energy and environmental footprint, combining game theory, economics and cryptography to understand the incentive models underlying distributed blockchain protocols. The track will also be concerned with research in platform economies and smart contracts as a way to execute actions automatically when agreed-upon conditions are met. Furthermore, it will study communication/interactions protocols to allow blockchain participants to achieve a common goal. Ph.D. candidates will have the opportunity to explore: (programming) languages for the specification of smart contracts; techniques for the analysis and verification of correctness and compliance of smart contracts; legal and regulatory aspects; game theory applied to human-algorithm interaction; psychology of money. Ph.D. candidates in this track may also study blockchain in supply chain management for the digitalization and certification of trade documents and NFTs to protect intellectual property rights.

Keywords:

- Central Bank Digital Currency
- Credit market and financial services
- Illegal markets detection
- Internet of Money
- Valuation services and financial advising
- Business models for DLTs-based financial players
- The economics of DLTs-based financial markets
- Banking & Finance
- Digital asset/Crypto-assets
- Entrepreneurial finance

Curriculum 5: Law and Governance

Scholarships of Curriculum 5 are coded E##

The curriculum on Law and Governance aims to investigate the advanced research questions in three directions:

Theoretical aspects. The blockchain represent a new form of social organization, another type of power, distinct method of decision that indubitable would change the relationships between the institutions, authorities, citizens. That arises relevant questions concerning the legitimacy of the activities conducted in the blockchain, or the validity of the smart legal contracts applied especially in some sectors like the law-making process, justice decisions, and administration services. The autonomy of the decision-maker is fundamental for preserving the normativity of the legal rules and the self-execution of the smart contracts stress some theoretical aspects and pillars of our democracy. The control of the human being in any step of these technologies is another important topic of research investigation in order to avoid manipulation, surveillance, and black-box effect.

Regulation. This track aims to research how to regulate the introduction in the society of the blockchain, distributed ledger technology, smart contract, ICO, NFT and any other connected technologies. It is fundamental to define a stable regulation in its legal foundations (e.g., theory of law) and in the specific domains (e.g., FinTech, Bank, Civil law, Labor Law, Tax Law, etc.) for supporting the emerging market. Furthermore, an international law view is necessary (e.g., UNCITRAL, UNIDROIT, HCCH) for avoiding fragmentation. On the other hand, the European Blockchain Service Infrastructure could be an occasion for regulating at the European supra-national level some principles including the digital identity. The proposal of modifications of regulation eIDAS 910/2014 aims to introduce qualified certifications for the distributed electronic ledger and it is another important example of how the regulation is shaping the emerging sector of the intermediation and disintermediation introduced by the blockchain. Another important topic to investigate is how to protect personal data and how to apply the regulation of GDPR in this context. Finally, the responsibility and liability of the effects of the smart legal contracts is a key issue that needs groundbreaking specific interdisciplinary research. All these topics require an interdisciplinary approach.

Applications. This track aims to research how to apply the constellation of blockchain technologies to the legal domain (e.g., Parliaments, Justice, Administration, Legal Firm, Anti-Money-Laundering, Anti-corruptions, etc.) and to other domains with the goal to guarantee the compliance with the legal framework. All the applications must be law-by-design and it requires legal expertise combined with technological competencies for transforming advanced solutions into market products or services. Some solutions include also legal reasoning and legal argumentation for checking the compliance before the self-execution. Several principles would be included in the applications: transparency, accountability, respect for human rights, privacy, and liability. Human-centered design is fundamental and, in this perspective, also the human-computer interactions devoted to providing usability and explicability are a key goal of this track."

Keywords:

- Smart Legal Contract
- Intelligible Contract
- Self-Sovereign Identity
- Legal reasoning
- Regulation
- Blockchain forensic
- Anti-money laundering, anti-corruption
- Private standards
- Compliance
- Business models

Curriculum 6: Industry 4.0

Scholarships of Curriculum 6 are coded F##

Industry 4.0 includes a new business vision that triggers innovation and adds value into the business by means of the integration of new pervasive ICT technologies (IoT, cloud and edge computing, AI and Machine / Deep learning) into services, products and production plants in order to provide the industrial production system with greater automation and responsiveness, efficiency, automatic optimization of process improvements etc. An important issue for a pervasive usage of Industrial Internet of Things (IIoT) entails accountability requirements for them that can be dealt with using blockchain technologies.

The curriculum on Blockchain and Industry 4.0 focuses on blockchain research for Industry 4.0 applications and covers both application and theoretical aspects. Research issues cover, but are not limited to digital user identity and accountability across business units and consortiums, scalability, interoperability and trust in blockchain systems for IIoT, transparency, information sharing, and privacy control in the next-generation of Blockchain Technology for smart applications.

The curriculum is aimed at training blockchain experts capable of guiding the integration process of Blockchain in innovative scenarios of Industry 4.0. To this end, a direct involvement of organizations playing a major role in this topic is envisioned.

Keywords:

- Technology integration in Industry
- Internet of Things
- Machine learning
- Consensus protocol
- Distributed ledger security
- Blockchain security
- Accountability
- Services, products and supply chain
- Business organization

Curriculum 7: Climate, energy and mobility

Scholarships of Curriculum 7 are coded **G###**

The curriculum on blockchain for climate, energy and mobility focuses on the key strategic orientations of the latest H2020 work programme. The objective is to provide blockchain technology and smart contracts for promoting an open, strategic, and distributed approach in the energy value chains.

Many climate programs have been established over the years. However, the intrinsic multi-lateral and international approach brings many difficulties in linking the political commitment to the technical involvement and contribution, for example, in reducing greenhouse gas emissions. First, the curriculum will study the contribution of blockchain to transparency, traceability, and trust in environment-related programs. Then it will focus on accelerating and steering the digital and green transitions through human-centred approaches and innovations. Creating more resilient, inclusive, and democratic European energy systems will prepare them to respond better to threats and disasters. Distributed energy resources (DERs) call for distributed data collection and management (smart meters, production plans, prosumers). Removing the information asymmetry between DSO, TSO, and citizens will empower them to act in the green and digital transitions.

This curriculum will study distributed methodologies to strengthen the digitally-enabled circular, climate-neutral and sustainable economy through the technical management of energy networks, the aggregation of production in virtual power plants, the management of networks for energy distribution, and the creation and management of energy communities. Attestation and validation of methodologies of energy production will distinguish the cases of green and environmental-friendly production from the traditional ones, especially for blue, green and grey hydrogen. The use of the blockchain will be applied to breakthrough business models and programs in the energy sector and energy mobility (Demand-Response, Vehicle to Grid, energy communities, certification of self-consumption, etc.). Additionally, tracking and tracing batteries for electric mobility, including managing the logic for monitoring their health status, enable such batteries to be used in second-life applications: when they are not good anymore for traction, they still maintain most of their capacity. The application-level challenges described above will be faced with innovative theoretical approaches for guaranteeing privacy (e.g. joining Secure Multiparty Computation to blockchain), security (blockchain and Attribute-based Encryption), and wide adoption (studying the relation between natural language contracts of the energy sector and smart contracts).

Keywords:

- Energy value chains
- Environment
- Disaster monitoring and management
- Resilient and inclusive energy systems
- Environmental data management
- Circular Economy
- Energy communities
- Sustainable mobility
- Battery traceability
- Smart Contracts

Curriculum 8: Agriculture and agrifood

Scholarships of Curriculum 8 are coded **H###**

The Phd candidate will study how current and next generation blockchain can support increased traceability and transparency in food supply chains and support the implementation of green and sustainable schemes. The subject of the study will cover both the application and the theoretical aspects.

From the application side, the study will contribute to the ambition of developing sustainable, productive and climate-neutral, biodiversity-friendly, and resilient farming systems providing consumers with affordable, safe, healthy and sustainable food, minimizing pressure on ecosystems, improving public health and generating fair economic returns for farmers through the exploration and development potential of the use of blockchain in the agri-food sector.

From the theoretical side, all the aspects of tracing, integrity, authentication, identification (covering also Self Sovereign Identity thematics) making use of blockchain will be considered. Characteristics of DLTs to be applied in agrifood with special attention to green and sustainability concerns will be exploited.

Keywords:

- Food supply
- Smart agriculture
- Sustainable cultivation
- Traceability
- Transparency
- Sustainable agricultural systems
- Information asymmetry
- Biodiversity and resilience
- Conscious consumption

Code	Research Topic Host	Host University
Curriculum 1: Methodologies, technologies and tools		
A01	Public Services: challenges and opportunities of blockchain technology	University of Camerino
A02	Smart Contract Testing	University of Camerino
A03	Modular Platform for IoT-Blockchain Integration: Enhancing Security and Transparency	University of Camerino
A04	Traceability and management of waste chains for its digital transformation	University of Camerino
A05	Blockchain technology applied to large territories resource management	University of L'Aquila
A06	Specification and verification of smart contracts and decentralized applications	Gran Sasso Science Institute
A07	Security of Blockchain Systems	IMT School for Advanced Studies Lucca
A08	Blockchain-based Approach for Trusted Sharing of Data and Resources	University of Firenze
A09	Dynamic Networks and Foundations of Layer-Two Blockchain Protocols	University of Rome "Tor Vergata"
A10	Ensuring Correctness of Smart Contracts with Constrained Horn Clauses	University of Chieti-Pescara "G. d'Annunzio"
A11	Noninterference and Security Properties in Private Blockchain Systems	Ca' Foscari University of Venice
A12	Blockchain technology applied to build a Global Integrated Autonomous Networked System	University of L'Aquila
Curriculum 2: Social systems and smart societies		
B01	Tokenization models for social economy and smart communities	University of Torino
B02	DLT solutions for social good: applications and infrastructures	University of Pisa
Curriculum 3: Health and well-being		
C01	Efficient and privacy preserving management of health data based on DLT	University of Milano
C02	Blockchain and Distributed Ledger Technology (DLT) to share and protect hospitals' data	Polytechnic University of Marche
Curriculum 4: Economics and finance		
D01	The entrepreneurship of Distributed Ledger Technology systems in finance and economics	Polytechnic University of Marche
D02	Distributed Ledger Technology for Digital Money	University of Urbino
D03	Blockchain and smart contracts in banking, finance and insurance	Università Cattolica del Sacro Cuore
Curriculum 5: Law and Governance		
E01	Blockchain's role in enabling ethical AI	University of Firenze
E02	Exploring Blockchain and Smart Contracts as a Way to Empower Users in Online Interactions	University of Torino
E03	AI and BCT for internationalization of made in Italy sectors	University of Macerata
E04	DLT for legislative simplification and for policy tracking in the public administration	University of Bologna
E05	The governance of Blockchain and DLT between European policies and national realities	University of Milano Bicocca
Curriculum 6: Industry 4.0		
F01	Methods and techniques for identifying smart contract vulnerability	University of Calabria
F02	Distributed Ledger Technology for Data Backup and Recovery Systems	University of Urbino
F03	Enterprise architecture for blockchain	University of Camerino
Curriculum 7: Climate, energy and mobility		
G01	Blockchain Oriented Software Engineering and Applications to smart energy trading, mobility and decentralized markets	University of Cagliari

Curriculum 8: Agriculture and agrifood		
H01	Implementation of blockchain based smart agriculture systems	University of Bari "Aldo Moro"
H02	Blockchain and smart contracts for data quality and contrasting counterfeits in the agri-food sector	University of Palermo

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A01

Research Title: Public Services: challenges and opportunities of blockchain technology

Research Keywords:

- Blockchain as a service
- Software architecture for blockchain
- Trust in Public Services
- Transparency in Public Services

Reference European Research Council:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_3 Software engineering, programming languages, and systems

Reference Person (a candidate supervisor, also available to provide more information via email):

Barbara Re, University of Camerino, barbara.re@unicam.it

Host University and Department (the University of the main research activities and the main Department(s) involved): University of Camerino, Computer Science Division

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Blockchain technology represents an opportunity to increase transparency in public services. This also guarantees trust in the collaboration between public administrations and third-party organizations. The key idea is to conceive and develop new methodological and technological solutions to enable a trusted ecosystem in public administrations. To achieve this goal, the key idea of the project is to exploit blockchain technology to allow the execution of contracts. Other aspects of the research concern, but are not limited to, the definition of new blockchain-based software architectures and new modeling and meta-modeling approaches for the definition of specific domain-dependent languages.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The Computer Science Division at the University of Camerino comprises senior professors and researchers in the early stages of their careers. The research will be conducted in a collaborative environment in the PROCesses & Services lab, where teamwork is fundamental to the group’s success. Research in computer science carried out within the PROS Lab, deals with developing languages and techniques for modeling, analyzing, and developing process-aware information systems and blockchain-based applications. We strive for personal development with plenty of opportunities for collaboration with students, researchers, and industry partners. The Ph.D. will also be mentored to develop their own research career (e.g., writing a Ph.D. thesis, applying for project funding, preparing auditions for academic positions) and getting on board with ongoing publications, collaborations, and projects in the Computer Science team. Camerino is a lively and beautiful town in the center of Italy, not far from the seaside, it is internationally known for its high concentration of researchers and international students.

Suggested Skills *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research:* Ideally, the successful candidate should have a good background in Computer Science. A good level of skills in mathematical modeling and reasoning, as well as in software engineering and programming, is also required. Experiences with carrying out independent and collaborative research are merits.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A02

Research Title: Smart Contract Testing

Research Keywords:

- Software Testing
- Run-time verification
- Smart contract testing
- Verification, validation, and auditing in blockchain

Reference European Research Council:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_3 Software engineering, programming languages, and systems
- PE6_4 Theoretical computer science, formal methods, automata

Reference Person (a candidate supervisor, also available to provide more information via email):

Andrea Polini, University of Camerino, andrea.polini@unicam.it

Host University and Department (the University of the main research activities and the main Department(s) involved): University of Camerino, Computer Science Division

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Blockchain technologies have had a rather disruptive impact on many sectors of contemporary society. In the last few years, the introduction of Smart Contracts has further increased the potential impact of such technologies. These self-enforcing programs have interesting peculiarities (e.g., code immutability) that require innovative testing strategies. Several reasons ask for high-reliability guarantees, and a thorough testing process of smart contracts. The following is a, probably non-exhaustive, list of relevant aspects:

- Smart contracts can control large amounts of cryptocurrency and other valuable assets
- Smart contracts are deployed and executed in the blockchain environment, which does not allow to revert transactions
- Differently from traditional software, smart contracts cannot be enhanced or fixed after deployment
- The smart contract execution is dependent on possible interactions with other cooperating contracts
- The execution environments and programming languages (e.g. Solidity) are relatively young and continuously evolving
- Lack of best practices
- Lack of mature testing tools

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The Computer Science Division at the University of Camerino is composed of senior professors as well as researchers in the early stages of their careers. The research will be conducted in a collaborative environment in the PROcesses & Services lab, where teamwork is a fundamental aspect of the group's success. Research in computer science, carried out within the PROS Lab, deals with the development of languages and techniques for the modeling, analysis, and development of process-aware information systems and blockchain-based applications. We strive for personal development with plenty of opportunities for collaboration with students, researchers, and industry partners. The Ph.D. will also be mentored to develop their own research career (e.g., writing a Ph.D. thesis, applying for project funding, preparing auditions for academic positions) and getting on board with ongoing publications, collaborations, and projects in the Computer Science team. Camerino is a lively and beautiful town in the center of Italy not far from the seaside, it is internationally known for its high concentration of researchers and international students.

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Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A03

Research Title: Modular Platform for IoT-Blockchain Integration: Enhancing Security and Transparency

Research Keywords:

- Blockchain as a service
- Software architecture for blockchain
- Blockchain integrated IoT platform
- Trustworthy IoT
- Verification, validation, and auditing in blockchain

Reference European Research Council:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_3 Software engineering, programming languages, and systems
- PE6_5 Security, privacy, cryptology, quantum cryptography
- PE6_10 Web and information systems, data management systems, information retrieval and digital libraries, data fusion

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Barbara Re, University of Camerino, barbara.re@unicam.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*): University of Camerino, Computer Science Division

Research Topic: *A brief description of the scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on. The **integration of Internet of Things (IoT) and blockchain** technology has the potential to revolutionize various industries by enhancing security, and transparency. The aim of the PhD. project is to investigate, design and prototype a **modular platform** that leverages blockchain technology to enable the development and deployment of IoT solutions. Such a platform will enable the creation of specialized modules and applications enabling rapid development and deployment of **IoT solutions** without significant infrastructure investments, and leveraging the use of blockchain to enhance security, and transparency. The outcomes of this research will contribute to the **advancement of IoT and blockchain integration** and facilitate the adoption of innovative solutions in various industries. The achieved results should be evaluated in real-world scenarios, to prove the applicability and effectiveness of the solutions proposed.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The Computer Science Division at the University of Camerino is composed of senior professors as well as researchers in the early stages of their careers. The research will be conducted in a collaborative environment in the PROcesses & Services lab, where teamwork is a fundamental aspect of the group’s success. Research in computer science, carried out within the PROS Lab, deals with the development of languages and techniques for the modeling, analysis, and development of process-aware information systems and blockchain-based applications. We strive for personal development with plenty of opportunities for collaboration with students, researchers, and industry partners. The Ph.D. will also be mentored to develop their own research career (e.g., writing a Ph.D. thesis, applying for project funding, preparing auditions for academic positions) and getting on board with ongoing publications, collaborations, and projects in the Computer Science team. Camerino is a lively and beautiful town in the center of Italy not far from the seaside, it is internationally known for its high concentration of researchers and international students.

Suggested Skills *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research:* Ideally, the successful candidate should have a good background in Computer Science. A good level of skills in mathematical modeling and reasoning as well as in software engineering and programming is also required. Experiences with IoT platforms is preferable. Experiences with carrying out independent and collaborative research are merits.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A04

Research Title: Traceability and management of waste chains for its digital transformation

Research Keywords:

- Supply chain
- Software architecture for blockchain
- Blockchain integrated platform
- Blockchain Digital Identity

Reference European Research Council:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_3 Software engineering, programming languages, and systems
- PE6_10 Web and information systems, data management systems, information retrieval and digital libraries, data fusion

Reference Person (a candidate supervisor, also available to provide more information via email):

Andrea Morichetta, University of Camerino, andrea.morichetta@unicam.it

Host University and Department (the University of the main research activities and the main Department(s) involved): University of Camerino, Computer Science Division

Research Topic: *A brief description of the scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The project aims to innovate the management of urban hygiene services and the tracking of waste supply chains according to the technical and quality requirements set by ARERA, relying on blockchain technology for transparency, traceability, trust, and security aspects.

Blockchain enables the creation of digital infrastructures to support the traceability and execution of inter-organizational processes in a distributed manner, without the need for reliance on third-party certifying entities. This allows to have traceable processes in which the data exchanged are verified and immutable. Each actor in the process can communicate directly and without any interoperability problems between different software architectures. Furthermore, blockchain technology can serve as a common communication channel for Enterprise Resource Planning (ERP), allowing the storage of certified immutable information for each phase of the process.

To achieve this goal, it will be necessary to develop smart contracts, which are software programs installed and executed on the blockchain, able to coordinate the execution of the process according to the predefined rules.

To succeed in this objective, the key idea is to combine model-driven approaches with the necessary technologies to support the digitization of processes, their mapping, and the development of innovative traceability solutions.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The Computer Science Division at the University of Camerino is composed of senior professors as well as researchers in the early stages of their careers. The research will be conducted in a collaborative environment in the PROCesses & Services lab, where teamwork is a fundamental aspect of the group's success. Research in computer science, carried out within the PROS Lab, deals with the development of languages and techniques for the modeling, analysis, and development of process-aware information systems and blockchain-based applications. We strive for personal development with plenty of opportunities for collaboration with students, researchers, and industry partners. The Ph.D. will also be mentored to develop their own research career (e.g., writing a Ph.D. thesis, applying for project funding, preparing auditions for academic positions) and getting on board with ongoing publications, collaborations, and projects in the Computer Science team. Camerino is a lively and beautiful town in the center of Italy not far from the seaside, it is internationally known for its high concentration of researchers and international students.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally, the successful candidate should have a good background in Computer Science. A good level of skills in software engineering and programming is also required. Experiences with blockchain platforms are preferable. Experiences with carrying out independent and collaborative research are merits.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A05

Research Title: Blockchain technology applied to large territories resource management

Research Keywords:

- Blockchain and Distributed Ledger technologies
- Data security
- Distributed coordination
- Edge computing
- Multi-agent systems
- Eco-sustainability

Reference European Research Council:

- PE6_4 Security, privacy, cryptology, quantum cryptography
- PE6_6 Algorithms, distributed, parallel and network algorithms, algorithmic game theory
- PE6_8 Intelligent systems
- SH3_1 Environment and sustainability

Reference Person:

Giovanni De Gasperis, University of L'Aquila, giovanni.degasperis@univaq.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of L'Aquila, Department of Information Engineering, Computer Science and Mathematics (Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica – DISIM)

Research Topic: *A brief description of the scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The study of Blockchain and Distributed Ledger technologies to search for innovative applications in the area of large territories resource management. Possible innovative impacts to be analyzed, and possibly developed, in these models are the improvement of data security and eco-sustainability, i.e through the introduction of alternative procedures at lower energy costs. Another area to inspect concerns the simplification of the use of these technologies, reducing the complexity of IT procedures and making them implementable on devices with low energy consumption and reduced computing capability, such as smartphones, tablets or IoT (Internet of Things) devices. Blockchain technology has an impact on various aspects of civil society, for example with the introduction of smart contracts in economic processes, in anti-counterfeiting processes, in the tracing of production processes, in the simplification of administrative procedures.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

DISIM hosts Mathematicians, ICT Engineers and Computer Scientists who extensively cover disciplinary fields related to the proposed research: Cryptography and Cyber Security; Algebra and Algebraic Geometry; Algorithmic and Computational aspects of Distributed Systems; Algorithmic Aspects of Game Theory; Artificial Intelligence and Multi-agent systems; Edge and Distributed Computing.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally the successful candidate should have a background in Distributed Systems (in particular some notions of Blockchain and Distributed Ledger Technology) and basic mathematical aspects of Cryptography and Probability Theory. Moreover, the candidate should have basic data analysis skills and programming languages mostly adopted in the Artificial Intelligence sector.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A06

Research Title: Specification and verification of smart contracts and decentralized applications.

Research Keywords:

- Smart Contracts
- Behavioral Models
- Program Analysis

Reference European Research Council:

- PE6_3 Software engineering, programming languages and systems
- PE6_4 Theoretical computer science, formal methods, automata
- PE6_5 Security, privacy, cryptology, quantum cryptography

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Maurizio Murgia, Gran Sasso Science Institute, maurizio.murgia@gssi.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

Gran Sasso Science Institute, Area of Computer Science

Research Topic: *A brief description of the scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Smart contracts are computer programs running on a blockchain platform. They are usually employed to handle digital assets (cryptocurrencies, tokens, ...), and hence smart contracts bugs can (and have) lead to severe economical losses. The aim of this PhD project is to develop new techniques for the design and implementation of safe smart contracts and decentralised applications. We plan to develop a formal model able to specify smart contracts behaviour at a high level of abstraction. Such specifications can then be analysed for correctness with standard techniques (model checking, static analysis, ...). Compliance of the model with the actual smart contract code can be verified through type-checking or enforced through code-generation.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The research activity will be carried out at the GSSI, Computer Science Area. In particular, the research topics of the scholarship fits well within the activities of the Formal Methods Group composed by three professors, two researchers, two post-docs and several (international) PhD students. Our research spans a broad range of topics from languages, to semantic models, to software verification. The Computer Science Area has recently ranked the first computer science department in the Italian evaluation exercise, and it has been recognised as a “Dipartimento d’Eccellenza”.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

The ideal candidate should have the ability to understand (and reason about) formal models of distributed systems, and possibly skills in program analysis. Previous experience in programming smart contracts, in any platform, is not strictly required but very appreciated.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A07

Research Title: Security of Blockchain Systems

Research Keywords:

- Vulnerability assessment
- Blockchain forensic
- Illegal markets detection

Reference European Research Council:

- PE6_5
- PE6_2
- PE6_11

Reference Person (a candidate supervisor, also available to provide more information via email):

Gabriele Costa, IMT School for Advanced Studies Lucca, gabriele.costa@imtlucca.it

Host University and Department (the University of the main research activities and the main Department(s) involved): IMT School for Advanced Studies Lucca, SySMA Research Unit

Research Topic: A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on

In recent years, the blockchain has emerged as one of the main technologies supporting the creation and management of distributed organizations while granting desirable security properties such as privacy and non-repudiation of transactions. Nevertheless, blockchain-based businesses can involve illegal entities and operations. For instance, many black markets and frauds leverage privacy-preserving properties of the blockchain to prevent their authors from being identified. Similarly, smart contract technology has enabled many threats that directly target the core operations of Decentralized Finance (DeFi). This activity focuses on the security aspects of the blockchain ecosystem. In particular, the relevant research topics include (but are not limited to):

- Vulnerability assessment of smart contracts;
- Illegal markets detection and analysis;
- Criminal schemes and businesses recognition;
- Machine learning-based blockchain forensic analysis.

Research Team and environment: A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program

The IMT School for Advanced Studies Lucca is a Public University School that focuses on analyzing economic, societal, technological, and cultural systems. IMT School fosters an interdisciplinary research approach characterized by the complementarity and discourse between methodologies drawn from economics, engineering, computer science, applied mathematics, and physics. The candidate will work with the SySMA research unit that deals with developing languages and techniques for the analysis, evaluation, and verification of possibly distributed systems. SySMA also studies algorithms and techniques to protect the security and integrity of computer systems, the information they store, and the people who use them.

Suggested Skills: A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research

The ideal candidate should have a Master's degree in Computer Science/Computer Engineering. Moreover, she should have a good knowledge of the fundamental notions of blockchain and basic knowledge of computer security and machine learning.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A08

Research Title: Blockchain-based Approach for Trusted Sharing of Data and Resources

Research Keywords: (<= 6 items)

- Blockchain-based applications
- Formal languages
- Verification
- Model-driven software development

Reference European Research Council:

- PE6_3 Software engineering, programming languages and systems
- PE6_4 Theoretical computer science, formal methods, automata

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Francesco Tiezzi, University of Firenze, francesco.tiezzi@unifi.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of Firenze, Dipartimento di Statistica, Informatica, Applicazioni ‘G. Parenti’ (DiSIA)

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on*

The research focuses on applying blockchain technology to empower trusted sharing of data and resources in collaborative environments. The goal is to safeguard data holders by regulating how data can be shared to ensure privacy and data sovereignty. Similarly, the exchange and use of resources in such a collaborative context should also be regulated and monitored. This poses the following challenges: (i) define the appropriate abstractions for specifying the policy regulating privacy, data sovereignty, and security; and (ii) define effective verification and analysis techniques on top of it. To address these challenges, the candidate should acquire and combine knowledge and expertise concerning blockchain technology, formal languages, and verification techniques.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The main hub of the research activity will be the Dipartimento di Statistica, Informatica, Applicazioni ‘G. Parenti’ (DiSIA, <https://www.disia.unifi.it/>) of the Università degli Studi di Firenze (<https://www.unifi.it/>). DiSIA has been one of the Departments of Excellence 2018-2022 and is one of the Departments of Excellence 2023-2027. The research group involved in the activities related to this scholarship has strong expertise and long experience in developing engineering methodologies based on formal methods, including definition, formalization, verification, and implementation of DSLs. More recently, this approach has been applied to the blockchain domain.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

The ideal candidate should have a good background in programming languages and, possibly, in formal methods and/or smart contracts. Anyone interested in Blockchain topics and enthusiastic about research is welcome to apply. Personal initiative, curiosity, and a positive, collaborative, hands-on attitude are a big plus.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A09

Research Title: Dynamic Networks and Foundations of Layer-Two Blockchain Protocols**Research Keywords:** (<= 6 items)

- Distributed Computing
- Layer 2 Blockchain Protocols
- Dynamic Networks
- Randomized algorithms

Reference European Research Council:

- PE6_6 Algorithms and complexity, distributed, parallel and network algorithms, algorithmic game theory
- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE1_17 Mathematical aspects of computer science

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Francesco Pasquale, Università di Roma “Tor Vergata”, francesco.pasquale@uniroma2.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

Università di Roma “Tor Vergata”, Dipartimento di Ingegneria dell’Impresa “M. Lucertini”

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on*

One of the obstacles to large-scale adoption of Bitcoin is the scalability problem related to the number of transactions that can be included in a block. A natural trade-off between scalability and decentralization actually exists in essentially all blockchains. Several approaches have been proposed and implemented so far to overcome the scalability barrier. The focus of this research topic is on one of such approaches: Layer 2 Blockchain protocols, in which an overlay network of channels between nodes is used and transactions are recorded on the main blockchain only in specific circumstances. The main goal of the research will be to explore the impact of the dynamics of the network of channels on the reliability, decentralization, and security of Layer 2 blockchain protocols.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The successful candidate will join the Distributed Computing research team at the Enterprise Engineering Department of the University of Rome "Tor Vergata", a lively research environment formed by faculty members, postdocs and PhD students. The current main research interests of the team are centered on design and analysis of distributed algorithms, with a newborn research lab focused on cryptocurrencies and blockchains. The team closely collaborate with members of European institutions like INRIA/CNRS in France as well as other Italian universities like Sapienza University of Rome and Bocconi University.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

The ideal candidate has a solid background in computer science and mathematics (algorithms, cryptography, discrete probability), experience with Unix-like operating systems and some tools (Bash, Git), proficiency in at least one programming language, and strong attitude to problem solving.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A10

Research Title: Ensuring Correctness of Smart Contracts with Constrained Horn Clauses

Research Keywords: (≤ 6 items)

- Smart contracts
- Program analysis
- Program verification
- Constrained Horn Clauses
- Satisfiability Modulo Theories

Reference European Research Council:

- PE6_3 Software engineering, operating systems, computer languages
- PE6_4 Theoretical computer science, formal methods, and quantum computing

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Fabio Fioravanti, “G. d’Annunzio” University of Chieti-Pescara, fabio.fioravanti@unich.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*): “G. d’Annunzio” University of Chieti-Pescara, Department of Economic studies

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on*

Smart contracts are computer programs that specify and enforce the execution of contracts and agreements by automatically performing predetermined actions when some events happen or some conditions are met.

The project will focus on (i) developing rigorous methods based on programming language semantics and logic for translating a smart contract verification problem to satisfiability of constrained Horn clauses (CHC), and (ii) enhancing existing methods for checking CHC satisfiability by using CHC transformations, which may propagate constraints by symbolic evaluation, uncover relations among variables, conjecture and confirm the existence of inductive invariants.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The research activities will be carried out at the Computational Logic and Artificial Intelligence Laboratory of the University of Chieti-Pescara. The research team is composed by professors with proven experience in theoretical and applied research in computational logic and, in particular, in formal methods based on CHC transformation, abstract interpretation and SMT solvers for analysis, verification and testing of software, systems and processes with the goal of ensuring their correctness and security. The team has international collaborations with members of academic and research institutions in Europe and America. Department facilities include access to static analysis and verification software and powerful computational resources.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally, the candidate should have a good background in computational logic, programming language semantics and formal methods for analysis, verification and testing.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A11

Research Title: Noninterference and Security Properties in Private Blockchain Systems

Research Keywords: (≤ 6 items)

- theoretical computer science
- formal methods in computer science
- parallel and distributed systems
- stochastic processes
- computer security and privacy
- reversible computing

Reference European Research Council:

PE6_4 Theoretical computer science, formal methods, and quantum computing

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Sabina Rossi, Ca' Foscari University of Venice, sabina.rossi@unive.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

Ca' Foscari University of Venice, Department of Environmental Sciences, Informatics and Statistics

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on*

Distributed computing has become an increasingly pervasive technology as electronic devices connected through the Internet infrastructure are widely adopted for various digital activities by individuals, companies, and institutions. One notable example of this trend is the emergence of blockchain technology over the past decade. Blockchain is a distributed ledger that records transactions among untrusted parties in a decentralized and disintermediated environment, aiming to solve the double spending problem in virtual currency platforms. However, public, permissionless blockchains face several challenges, including conflicts between data immutability and regulatory requirements. In the realm of innovative payment methods, there is a risk of compromising monetary sovereignty and destabilizing financial systems. This concern has led many central banks to explore the concept of central bank digital

currency (CBDC). Consequently, private, permissioned blockchains are gaining momentum as they offer businesses greater control over their operations.

The proposed PhD project focuses on leveraging formal methods to compose models of functional and non-functional aspects of private blockchains' behavior and structure. On the analysis front, the project aims to explore relevant properties such as noninterference and reversibility. Noninterference refers to preventing information leakage, whether qualitative or quantitative, from the private blockchain governance to permissioned users via covert channels. Reversibility, on the other hand, deals with the ability to undo transactions in a manner that ensures regulatory compliance and restores the system to a consistent previous state in a timely manner.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The main hub of the research activities will be the Networking and Distributed Systems Lab of the Department of Environmental Sciences, Informatics and Statistics at the Ca' Foscari University of Venice. The group includes scientists with skills on formal methods for system verification, automated verification tools, performance evaluation and reliability analysis of computer and telecommunication systems, system and network security, cryptography. Currently the team is composed by six professors, three postdocs, three PhD students. The lab has international collaborations in Europe with e.g., School of Informatics at the University of Edinburgh, School of Computing at Newcastle University, and Department of Computing at Imperial College London.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

The candidate should ideally be with a quantitative background, i.e., master's degree in Physics, Computer Science or Applied Mathematics with experience in computational tools, programming languages, data analysis. Candidates should possess English language skills.

Curriculum 1 “Methodologies, technologies and tools”

Scholarship code: A12

Research Title: Blockchain technology applied to build a Global Integrated Autonomous Networked System

Research Keywords:

- Blockchain and Distributed Ledger technologies
- Data security
- Distributed coordination
- Edge computing
- trustless management
- process automation

Reference European Research Council:

- PE6_2 Computer systems, parallel/distributed systems, sensor networks, embedded systems
- PE6_7 Artificial Intelligence, intelligent systems, multi agent systems
- SH1_5 Competitiveness, innovation, research and development
- SH1_7 Organization studies, strategy

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Giovanni De Gasperis, University of L'Aquila, giovanni.degasperis@univaq.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of L'Aquila, Department of Information Engineering, Computer Science and Mathematics (DISIM)

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on*

The study of Blockchain and Distributed Ledger technologies to search for innovative design methodologies to build a Global Integrated Autonomous Networked System.

In the interaction between entities in human organizations there are basic logical elements that are declined in different configurations. In Italy we are at the forefront in the business network sector as the legislator has already codified some of these elements that can also be ported to the international level. The challenge is to broaden the range to include other areas such as services and administrations. Such a system would effectively eliminate human errors and/or opportunism, reserving mere administration to autonomous, transparent, and inspectable software agents.

Research Team and environment: : *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

DISIM hosts Mathematicians, ICT Engineers and Computer Scientists who extensively cover disciplinary fields related to the proposed research: Cryptography and Cyber Security; Algorithmic and Computational aspects of Distributed Systems; Artificial Intelligence and Multi-agent systems; Edge and Distributed Computing, Software Engineering.

Suggested Skills: : *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally the successful candidate should have a background in Distributed Systems (some notions of Blockchain and Distributed Ledger Technology) and basic mathematical aspects of Cryptography and Probability Theory. Moreover, the candidate should have basic data analysis skills and programming languages mostly adopted in the Artificial Intelligence sector. Additional preferred competence is knowledge about human organization systems.

Curriculum 2 “Social systems and smart societies”

Scholarship code: B01

Research Title: Tokenization models for social economy and smart communities

Research Keywords:

- Distributed ledger technologies
- Tokenization
- Financial inclusion
- Diverse economies for local communities
- Smart communities
- Digital twinning

Reference European Research Council:

- SH2_11 Human, economic and social geography
- SH3_3 Social integration, exclusion, prosocial behaviour
- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_5 Security, privacy, cryptology, quantum cryptography

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Paolo Giaccaria, University of Turin, paolo.giaccaria@unito.it

Claudio Schifanella, University of Turin, claudio.schifanella@unito.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):
University of Turin, Department of Economics, Social Studies, Applied Mathematics and Statistics, Department of Computer Science

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Blockchain technology, as decentralized infrastructure, can support the management of networks emerging from small and local communities where citizens collaborate with local stakeholders, like public administrations, associations, etc to develop social well-being. The proposal has as its research topic the analysis of civic applications of blockchain technology in relation to exchange systems and the diverse economies it enables to support. Applying blockchain technology in a local community for civic purposes and social economies involves the design of a tokenized system. In this sense, the field of tokenomics, a discipline that encompasses several mechanisms from different fields, can be called into play. In this regard, at least four thematic cores relevant to the present research can be identified: economic

mechanisms, incentive mechanisms, governance mechanisms, and the scale of the target community. The goal of the research is to systematically define:

- (i) the founding principles that distinguish civic blockchain from mainstream applications, in terms of social innovation and social economy;
- (ii) the fundamental characteristics of the systems in which civic blockchain is applied;
- (iii) the study and the development of diverse economies to be implemented at the local community level;
- (iv) the scalarity of these community development practices, in particular how they interface with different practices in distant places and how non local actors can participate in the local network.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The research activities will be coordinated and carried out within an interdisciplinary team that includes expertise in both social and economic sciences and Computer Science. Both research groups from ESOMAS Department and from the Computer Science Department are made up of researchers with different profiles and backgrounds, and have a long experience on Distributed Ledger Technologies, demonstrated by the participation in different national and international research projects (Co-City, CO3, NLAB4CIT, PININ, Blinc)

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Successful candidates will have earned either a MSc degree (or equivalent) in the Economic fields or a related field. They should have a good background on the fundamentals of blockchain technologies and their use in social goods projects. A degree in Computer Science and/or programming skills in commonly used programming languages for the creation of decentralized applications are an asset.

Curriculum 2 “Social systems and smart societies”

Scholarship code: **B02**

Research Title: DLT solutions for social good: applications and infrastructures

Research Keywords:

- Blockchain applications for social good
- Tokenization and web3
- Decentralized Identity Management
- Transaction Analyses
- Layer-2 solutions for enhancing blockchain scalability
- Cryptographic techniques for privacy enhancing

Reference European Research Council:

- PE6_2
- PE6_5
- PE6_3

Reference Person *(a candidate supervisor, also available to provide more information via email):*

Laura Emilia Maria Ricci, Department of Computer Science, University of Pisa, laura.ricci@unipi.it

Host University and Department *(the University of the main research activities and the main Department(s) involved):*

University of Pisa, Department of Computer Science.

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Distributed Ledger Technology (DLT) has a wide range of applications across different fields, like finance, supply-chain management, identity management, tokenization of different kind of assets, etc. As technology continues to evolve, new and innovative use cases are emerging, offering interesting solutions to various challenges in our society and, in general, for enhancing social good.

The research program is centered on two main pillars: the development of DLT-based solutions for the improvement of social good and the investigation of solutions to overcome pitfalls that are not yet solved for DLT, like the scalability of the blockchain and the privacy issues. In particular, the topics of the blockchain scalability, of inter-ledger technologies, and, in general, of layer-2 technologies, will all have a central role in the research program.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The research activities will be held at the Pisa Distributed Ledger Laboratory (<https://sites.google.com/unipi.it/pisadlrlaboratory>), led by Professor Laura Ricci, who has been member of the group for the definition of the Italian National Strategy for Blockchain Technology. The Laboratory includes 2 Full Professors, 3 Researchers with temporary positions and 5 PhD students, all working on the topic of blockchain. The group has both national collaborations with CNR and international collaborations, among the others, with the University of Cambridge and with the Ethereum foundation. Laura Ricci is the Principal Investigator of the National Project PRIN “AWESOME: Analysis framework for WEB3 Social Media”, a project on blockchain data analytics, which will start in Autumn 2023.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral*

Ideally, the successful candidate should have strong background in computer science. Basic competence in the area of distributed technologies and cryptography are considered an asset, but not strictly required.

Curriculum 3 “Health and well-being”

Scholarship code: C01

Research Title: Efficient and privacy preserving management of health data based on DLT

Research Keywords:

- Distributed Ledger Technology
- Electronic Health Records
- Privacy preserving data processing

Reference European Research Council:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_5 Security, privacy, cryptology, quantum cryptography
- PE6_6 Algorithms and complexity, distributed, parallel and network algorithms, algorithmic game theory

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Stelvio Cimato, University of Milano, stelvio.cimato@unimi.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

Dipartimento di Informatica, University of Milano

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The efficient management of the patient’s Electronic Health Record (EHR) is crucial for taking care of patients’ health in different scenarios, including telecare. The sharing and distribution of health data however poses many problems related to the privacy and security requirements, contrasting with the need of processing and accessing information. Due to their intrinsic security properties (immutability, traceability, etc.), distributed ledger technology has been introduced as viable solution for achieving EHR sharing with privacy and security preservation. Differently from centralized systems, DLT technologies can be deployed to provide platforms for the efficient sharing of e-health data generating irreversible and permanent records of patients, achieving efficient and traceable data-sharing schemes for e-medical records. The candidate will investigate the application of DLT technologies to achieve different security properties related to the implementation of an e-health data sharing platform.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The research activities will be hosted within the SESAR Lab at the Department of Computer Science at the Università degli studi di Milano. SESAR Lab is a major technology transfer centre operating with a number of EU industrial partners in cloud computing, SLAs, and service/software assurance for Big Data, embedded, telecommunication, and health-related systems. The research group is/has been involved in a number of national and International research projects, including several FP7 and H2020 projects (SECURE-SCM, PRACTICE, TOREADOR, THREAT-ARREST, AERAS, etc).

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral*

Ideally the candidate should have a good background on data security and cryptographic protocols with a basic knowledge on distributed ledger technology.

Curriculum 3 “Health and well-being”

Scholarship code: C02

Research Title: Blockchain and Distributed Ledger Technology (DLT) to share and protect hospitals’ data

Research Keywords:

1. healthcare services
2. hospital data
3. healthcare data sharing
4. healthcare data protection
5. trust-based health environments

Reference European Research Council:

- SH1 Individuals, Markets and Organisations
- SH1_10 Management; strategy; organisational behaviour
- SH1_11 Human resource management; operations management, marketing

Reference Person *(a candidate supervisor, also available to provide more information via email):*

Enrico Cori, Polytechnic University of Marche, e.cori@unvpm.it

Host University and Department *(the University of the main research activities and the main Department(s) involved):*

Polytechnic University of Marche, Dipartimento di Management (DIMA)

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The curriculum on "Health and well-being" aims to advances in the study of Blockchain and DLT in creating innovative and performing solutions to improve the trust between patients and healthcare organizations as well as among healthcare organizations every time data sharing is required.

The research will focus on how health services organizations can improve their internal processes, thanks to Blockchain and DLT, in order to protect health-related data, as well as to assure compliance with norms and policies. In turn, the data protection guarantees and compliance with health protocols may have a positive impact on the appropriateness of care and on the economic and financial performance of the healthcare organizations. This, without requiring the building of a complex, and often centralized authority.

In this project, a large attention will be given to the classification of data emerging in Healthcare organizations’ activity: data stream, data-at-rest, images, genomic data and unstructured data.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The candidate will be involved both in the PhD education that is going to be offered in the DIMA's Doctorate, i.e. Management & Law Ph.D. (curriculum of management), and in all the research and education activities that are going to be organized within the Blockchain and DLT National Doctorate.

The Ph.D. student will be able to count on an interdisciplinary research group that holds management, accounting, finance, organization, and information systems skills.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research.*

The candidate should demonstrate a strong interdisciplinary attitude, being required to deal with both methods of Blockchain and DLT, and research tools for management and organization studies.

Curriculum 4 “Economics and Finance”

Scholarship code: D01

Research Title: The entrepreneurship of Distributed Ledger Technology systems in finance and economics

Research Keywords:

- Financial and credit market, financial services
- DLTs – based entrepreneurship
- Business models for DLTs-based financial and business players
- The economics of DLTs-based activities

Reference European Research Council:

- PE6_6 Algorithms and complexity, distributed, parallel and network algorithms, algorithmic game theory
- PE6_7 Artificial intelligence, intelligent systems, natural language processing
- SH1_4 Finance; asset pricing; international finance; market microstructure
- SH1_5 Corporate finance; banking and financial intermediation; accounting; auditing; insurance
- SH1_8 Microeconomic theory; game theory; decision theory

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Marco Cucculelli, Polytechnic University of Marche, m.cucculelli@univpm.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

Polytechnic University of Marche, Department of Economics and Social Sciences

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The economic and financial sector has undergone an unprecedented modernization process. Within this framework, there is growing interest in creating a secure and efficient ecosystem for financial and economic transactions. One possible way is to use blockchain technologies to provide instant and secure access to information while reducing costs. Building on a rapidly evolving – but not yet consolidated – literature on blockchain in economic transactions and the financial industry, the research program aims to explore how DLTs can impact business outcomes by influencing the efficiency of trading processes in business and finance. The program is particularly interested in assessing how entrepreneurship unfolds in DLT-based environments, either for business initiative or for defining appropriate DLT-based business models.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The program is hosted by the Department of Economics and Social Sciences, which has significant and long-standing expertise in applied microeconomics, finance, entrepreneurship, and data science. After examining the role of DLTs in economics and finance, the program will explore the challenges of adopting DLTs in different sectors. Empirical analysis (microeconomic analysis or case studies) must be conducted to support the applied focus of the program. Empirical models aimed at quantifying the impact of DLTs will be developed and applied to financial actors and business initiatives, along with identifying specific business models relevant in a token-based economy. Finally,

connections between DTLs and data science need to be explored to make DTLs useful for the rapidly growing science of data analytics.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research.*

The successful candidate should have a strong background in economics, entrepreneurship and finance. Knowledge of the most common business and financial analysis software applications is a prerequisite. Proficiency in data analytics/data science and DLTs applications will be an asset to the candidate.

Curriculum 4 “Economics and Finance”

Scholarship code: D02

Research Title: Distributed Ledger Technology for Digital Money

Research Keywords:

- Central Bank Digital Currency
- Cryptocurrency
- Internet of Money

Reference European Research Council Sectors:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_4 Theoretical computer science, formal methods, automata
- PE6_5 Security, privacy, cryptology, quantum cryptography
- SH1_1 Macroeconomics; monetary economics; economic growth
- SH1_5 Corporate finance; banking and financial intermediation; accounting; auditing; insurance

Reference Person *(a candidate supervisor, also available to provide more information via email):*

Prof. Marco Bernardo, University of Urbino, marco.bernardo@uniurb.it

Host University and Department *(the University of the main research activities and the main Department(s) involved):*

University of Urbino, Department of Pure and Applied Sciences

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Innovative payment methods based on digital technologies have characterized the last two decades worldwide. After the widespread diffusion of Internet banking tools along with debit and credit cards, the financial crisis of 2008 and the consequent decrease of the trust in financial intermediaries has paved the way to cryptocurrencies (CC), in particular Bitcoin and the underlying blockchain technology. Since a massive adoption of CC may lead to risks of losing monetary sovereignty and undermining financial stability, many central banks are recently exploring the issuance of what is called central bank digital currency (CBDC), which would also reduce the costs associated with managing physical cash, promote financial inclusion, and hopefully discourage tax evasion, money laundering, and other illegal activities.

The research studies of this PhD scholarship will be in the setting of the emerging Internet of money, focusing on a comparison between CC and CBDC both at the conceptual level and in terms of underlying distributed ledger technology. The main goal is the development of a model-based approach to the investigation of the Internet of money.

Research Team and Environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The research activities will take place at the Section of Informatics and Mathematics of the Department of Pure and Applied Sciences of the University of Urbino, possibly in collaboration with other departments. The specific research team within the aforementioned section is composed of researchers and PhD students with expertise in several areas ranging from formal models for concurrent and distributed systems to performance evaluation and security analysis of computer systems and networks, including blockchain technology. The team is currently leading the national research project NiRvAna - Noninterference and Reversibility Analysis in Private Blockchain (<http://www.sti.uniurb.it/nirvana/>), with special emphasis on central bank digital currency.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research.*

The ideal candidate has a strong background in computer science or engineering and a good attitude to interdisciplinary studies, in addition to familiarity with model-based design methodologies as well as teamwork capabilities.

Curriculum 4 “Economics and Finance”

Scholarship code: D03

Research Title: Blockchain and smart contracts in banking, finance and insurance

Research Keywords: (< = 6 items)

- Smart contracts
- Banking
- Finance

Reference European Research Council:

- SH1_5
- SH1_4

Reference Person *(a candidate supervisor, also available to provide more information via email):*

Elena Beccalli, Università Cattolica del Sacro Cuore, elena.beccalli@unicatt.it

Host University and Department *(the University of the main research activities and the main Department(s) involved):*

Università Cattolica del Sacro Cuore, School of Banking, finance and insurance

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The research project will focus on the application of blockchain and smart contracts in finance. Relatedly, the research project will focus on crypto assets. These technologies and crypto assets are still largely deregulated and can generate risks of various kinds, particularly of a systemic nature given the interdependence of the subjects involved in the ecosystem. More specifically, the aim is to investigate the main risks and opportunities of these applications, from a managerial and governance perspectives. The regulatory and legal issues will also deserve attention. The focus is on the agents of the ecosystem, the algorithms, the risks associated with the use of these technologies and crypto assets (issuance, loans, payment services, insurance), and on the ways to mitigate these risks. The field of investigation relates to banks, insurance and financial markets.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The main hub of the research activities will be the School of banking, finance and insurance at Università Cattolica del Sacro Cuore based in Milano. The School is considered as a reference research hub at national and international level for the studies in finance. Moreover, the School has recently been involved in many projects concerning the application of blockchain in finance, and received recognition for this. A strong multidisciplinary view (managerial, legal, technical) on these issues characterises the approach of the School in the study to the subject.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally the successful candidate should have a good background in banking and finance, and should have an exposure to the applications of blockchain in finance. Experience in data analysis and econometrics is considered an asset.

Curriculum 5 “Law and Governance”

Scholarship code: E01

Research Title: Blockchain’s role in enabling ethical AI

Research Keywords: (< = 6 items)

- Blockchain
- AI
- information security
- transparency
- ethics

Reference European Research Council:

- SH2_4 Legal studies, constitutions, human rights, comparative law
- SH1_5 Corporate finance; banking and financial intermediation; accounting; auditing; insurance
- SH1_15 Public economics; political economics; law and economics

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Filippo Zatti, University of Florence, filippo.zatti@unifi.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

The University of Florence, Department of Economics and Management

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The research aims to investigate how blockchain can be applied to implement ethically correct AI systems. It recognises that blockchain can enhance information security and transparency, thereby aiding in identifying false or incorrect data. This contributes to improving compliance with privacy rules and the ethical implementation of AI. The research also emphasises the importance of legal aspects, focusing on regulatory elements, governance, and transparency in AI. Specifically, it intends to explore how blockchain can validate a learning system regarding data and its evolution and the processes and governance of model updates.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The research team consist of professors, lecturers, research fellows and associate members of BABEL- Blockchains and Artificial intelligence for Business, Economics and Law (www.babel.unifi.it), a working group established in March 2019 at the Department of Economics and Management of the University of Florence with diverse backgrounds, including experts in law, economics and blockchain technology and AI ethics.

The presence of experienced researchers with expertise in law, blockchain, and AI ethics will provide valuable guidance and mentorship to the PhD candidate, offering insights, addressing the research, and helping navigate the topic's complexities. The research team will easily let PhD candidate access ample resources, including academic databases, legal literature, technical resources, and relevant case studies. The availability of funding, data sets, and computational resources would also support in-depth exploration and experimentation. The PhD candidate will collaborate with an industry partner working at its headquarters for 12 months to provide real-world insights, practical applications, and access to data or professional expertise. Moreover, the PhD candidate will complete the research at foreign organisations working in the field for 6 months. The PhD candidate will have access to well-equipped research facilities, such as laboratories and legal research centres, which can enhance the quality and productivity of the research. The research team will offer opportunities to attend conferences, workshops, and seminars related to law, blockchain, and AI ethics. These events will facilitate networking, exposure to cutting-edge research, and collaboration with experts in the field. Moreover, a supportive academic environment will encourage collaboration, critical thinking, and innovation with regular research discussions, peer feedback, and constructive critique fostering intellectual growth and providing a platform for sharing ideas and insights.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

An ideal candidate has a strong legal (academic) background and specialises in emerging technologies, data privacy, and AI ethics. The candidate should be interested in exploring the legal aspects of blockchain technology and AI. Strong research skills, analytical thinking, and the ability to analyse complex legal and technological issues are a must-have. Additionally, familiarity with blockchain technology, AI systems, and their legal challenges would be an added advantage. The candidate should be able to conduct interdisciplinary research, collaborate with stakeholders from both legal and technical domains, namely with the company partner, and propose innovative solutions at the intersection of law, blockchain, and AI ethics.

Curriculum 5 “Law and Governance”

Scholarship code: E02

Research Title: Exploring Blockchain and Smart Contracts as a Way to Empower Users in Online Interactions

Research Keywords:

- Blockchain
- Smart contracts
- Personal data sharing
- User empowerment
- Data privacy
- Decentralized Identity Management

Reference European Research Council:

- SH2_9 Legal systems, constitutions, foundations of law
- SH2_10 Private, public and social law
- SH2_11 Global and transnational governance, international law, human rights

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Prof. Cristina Poncibò, University of Turin, Department of Law, cristina.poncibo@unito.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of Turin, Department of Law

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Blockchain technology and smart contracts have shown immense potential to redefine user empowerment in online relationships and transactions. These technologies can provide a secure, decentralized mechanism to manage personal data, as well as authenticate and facilitate digital transactions, potentially revolutionizing privacy, data control, and user agency in the digital space. The research project aims to explore and develop methods for leveraging blockchain and smart contracts for user-centric control of personal data online and enhancing user empowerment in online transactions. The work will primarily focus: (i) on the application and integration of blockchain technology and smart contracts, such as Ethereum contracts written in the Solidity language, to manage user data and online transactions in a secure, privacy-respecting, and user-empowering manner, and (ii) on developing mechanisms for validating, verifying, and testing these blockchain-based data-sharing and transaction systems, incorporating the latest advances in machine learning, neural networks, and signal processing. This research aims to provide users with greater control and trust in their online interactions and transactions..

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The research team of the University of Turin is composed of professors with a track record in theoretical and applied research in blockchain technology, smart contracts, personal data sharing, and consumer law. The team specializes in ensuring data privacy, leveraging decentralized identity management, and applying machine learning techniques for verification and testing of blockchain systems and processes. Their primary goal is to guarantee the reliability and security of these systems. Furthermore, the team has expertise in the formal semantics of smart contract languages and the application of formal verification methods to these systems, enhancing user empowerment in online transactions. International collaborations with members of academic and research institutions in Europe and America broaden the team's perspective and enrich their research approach. Department facilities include access to blockchain nodes, smart

contract platforms, machine learning resources, and other powerful computational tools, enabling rigorous analysis and verification.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally, the candidate should have a strong background in data protection law and legal tech, as well as a good background in computational logic, programming language semantics and formal methods for assessing and validating emerging technologies. English advanced.

Curriculum 5 “Law and Governance”

Scholarship code: E03

Research title:

AI and BCT for internationalization of made in Italy sectors

Research Keywords:

- Internationalization
- Blockchain
- AI
- Made in Italy sectors
- Business model

Reference European Research Council:

- SH1_9 Industrial organisation; strategy; entrepreneurship
- SH1_14 Competition law, contract law, trade law, Intellectual Property Rights
- PE6 Computer Science and Informatics

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Francesca Spigarelli, University of Macerata, francesca.spigarelli@unimc.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of Macerata, Department of Law

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The project is aimed at developing a new business model framework for the use of Artificial Intelligence (AI) and blockchain algorithms to support internationalization of firms and boost human creativity in the Made in Italy sectors. AI is making rapid progress in several industries and has started to influence the field of creativity as well. This raises the need to delve into the application fields of AI in the made in Italy sector (for example the fashion industry), encouraging research and investment in potential innovations and the resulting benefits. The integration of the blockchain in Made in Italy industries assumes a crucial role from an economic as well as a legal point of view. Blockchain technology offers a distributed, secure and immutable ledger that can guarantee the transparency, integrity and traceability of data and transactions in such industries. However, this raises awareness of the management of intellectual property rights and legal responsibilities, as well as of the changes in the relations with the whole value chain, from suppliers to customers, where the high level of quality and innovation must be granted and secured.

As far as copyright is concerned, the use of Artificial Intelligence algorithms in the creative process raises questions about the attribution of paternity of the works. Furthermore, the use of smart contracts based on the blockchain requires an accurate legal assessment as well as the protection of personal data which is another critical aspect when using the blockchain in sectors with high impact of creativity (as the fashion industry).

In terms of relations with customers and suppliers, the use of BCT brings the possibility to establish new relations based on trust and constant feedbacks, with opportunities to develop international market penetration strategies. The research project aims at defining the framework for a new business model for companies in the

Made in Italy industry, where the creativity is not only protected but enacted and valorized. Specific attention is devoted to customer relation and co-creation opportunities offered by BCT and AI in the global markets.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The main hub of the research activities will be the University of Macerata, Department of Law. The Department has strong expertise in establishing and managing inter-sectorial and interdisciplinary research collaborations, thanks to its experiences as coordinator of international projects, integrating legal studies with technology, engineering, and mathematics sciences. Currently, the Department is coordinating the Marie Curie - RISE project "TRUST - digital TuRn in EUrope: Strengthening relational reliance through Technology" (<https://trust-rise.eu/>), which is focused precisely on the legal and economic framework of Blockchain and DLT technologies. The Ph.D. candidate will collaborate with TRUST's research team and be involved in the project research tasks. The Department will provide academic facilities, common services, high-quality and high-technology instrumental resources, and an important library collection.

Also, the China Center at University of Macerata is a wide research infrastructure dealing with internationalization and valorization of Made in Italy sectors, with specific reference to the Asian markets.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Open to interdisciplinary approach. Ideally, the successful candidate should have a good background in economic or legal studies. Expertise in one or more fields such as applied economics, law and technology, digital technologies, business law, intellectual property law, are considered an asset.

Curriculum 5 “Law and Governance”

Scholarship code: E04

Research Title: DLT for legislative simplification and for policy tracking in the public administration

Research Keywords: (< = 6 items)

- Notarization
- eLegislation
- Smart Legal Contract
- Rule as Code
- Checking compliance
- Policy tracking
-

Reference European Research Council:

- SH1_14 Competition law, contract law, trade law, Intellectual Property Rights
- PE6_9 Human computer interaction and interface, visualisation and natural language processing
- PE1_1 Logic and foundations

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Monica Palmirani, University of Bologna, monica.palmirani@unibo.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of Bologna, Department of Legal Studies

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The “Rule As Code” movement intends to create legislative rules in formalized programming codification for evaluating consistency and coherence and so to implement some principles of the “Better Regulation”. The project intend to investigate the legal and technical issue relate to the Smart Contract implementing prescriptive rules (e.g., tax rules) for favoring the checking compliance (e.g., my tax situation), to simplify the document flow management with

legal validity (e.g., evidences of costs) and to track the policies decided by the law-decision maker when are implemented in the public administration (e.g., fight the evasion of the taxation).

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The team is composed by legal scholars, computer scientists and informatics engineers with a dynamic environment where the theoretical aspects are validated on empirical European and International projects. The approach is interdisciplinary with particular attention to combine legal and technical methodologies. The PhD candidate is integrated in an international team with at least two co-supervisors. The PhD programme offers a rich training calendar with courses in different disciplines oriented to provide a holistic approach in blockchain and smart contract domain. Each PhD spends at least one year abroad. The ALMA-AI Center provides infrastructure, workshops, seminars, equipment, networking.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

PhD candidate is graduated in law or in computer science/engineer informatics. In both cases the PhD calendar provides adequate courses for filling the gap and creating the necessary interdisciplinarity competences for facing the topic of research assigned. Fluent English is strongly request.

Curriculum 5 “Law and Governance”

Scholarship code: E05

Research Title: The governance of Blockchain and DLT between European policies and national realities

Research Keywords:

- Regulation
- Private standards
- Compliance
- Smart Legal Contract
- Legal reasoning
- Crypto-assets regulation

Reference European Research Council:

- SH2_4 Legal studies, constitutions, human rights, comparative law

Reference Person *(a candidate supervisor, also available to provide more information via email):*

Costanza Honorati and Andrea Rossetti, University of Milano Bicocca, costanza.honorati@unimib.it; andrea.rossetti@unimib.it

Host University and Department *(the University of the main research activities and the main Department(s) involved):*

University of Milano Bicocca, School of Law, Department of Business and Law, Department of Informatics, Systems and Communication

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Providing for an effective governance of blockchain sets a legal challenge without equals. Difficulties lie in the novelty and complexity of the subject, in the inherent supranational nature of blockchains and hence of the requested governance, which make unrealistic any national and unilateral approach, as well as in the need to have technical knowledge of how a blockchain operates. Against such a framework, the proposed research topic should be construed around the following pattern. A review of current blockchain laws and regulations at national and international level would set the backstage of any further analysis. The current regulatory initiatives mainly concern the basic definitions and the general legal framework - such as for example, but not limited to - the Italian law on crypto-assets and the EU package on the digital market (DMA and DSA). Investigating other jurisdiction would also be welcomed. Strengths and weaknesses of these

regulations should be identified, as well as how they affect blockchain governance. In this regard both centralized and decentralized governance models should be investigated and the effectiveness of these models in managing blockchain assessed. The second part of the research should build on this data and offer some kind of proposals for Blockchain Law and DLT Governance. Such a proposal should be construed so as to ensure that national policies, while respecting the principle of digital sovereignty, promote and facilitate rather than limit international cooperation, through the sharing of knowledge and the harmonization of national standards of governance. The candidate should highlight comparative solutions to solve problems identified in the first part of the research work. The social, ethical, economic and technological implications of these proposals will also be considered.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The main hub of the research activities will be the School of Law, with a research team including scholars with experience in the field of European Union law, comparative law, public law, legal philosophy, and legal informatics. The project, besides involving research groups from the Department of Economics and the Department of Computer Science, will also engage [ReD Open](#), a spin-off from the University of Milano-Bicocca focusing on data governance, and [CELIS](#), a research center in "Law, Innovation and Sustainability" promoting studies and research applied to the fields of technological innovation and artificial intelligence

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally the successful candidate should have strong interest in the research topic, and a reasonable background in EU Law and Public Law. Given the multidisciplinary approach of the research, it would be helpful if the candidate also has some notions of informatics and economic. Possible experience with blockchain and smart contract technologies is considered a relevant asset.

Curriculum 6 “Industry 4.0”

Scholarship code: F01

Research Title: Methods and techniques for identifying smart contract vulnerability

Research Keywords:

- Security
- Blockchain
- Smart Contract

Reference European Research Council:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_6 Security, privacy, cryptology, quantum cryptography

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Antonella Guzzo, University of Calabria, antonella.guzzo@unical.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of Calabria, Dept. Computer Engineering, Modeling, Electronics, and Systems Engineering

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Smart contracts have gained significant attention in recent years due to their potential to revolutionize various industries. However, their increasing complexity and the potential for significant financial losses have highlighted the importance of identifying vulnerabilities in smart contracts. The research focuses on three main categories of vulnerability detection: static analysis, dynamic analysis, and formal verification. The objective is to investigate the applicability of existing detection vulnerability techniques to smart contract, analyze the limitations and challenges associated with each technique, including the balance between precision and scalability, and to address the existing limitations and develop more efficient and accurate techniques to ensure the security and reliability of smart contracts.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The research group includes people belonging to the two main laboratories of the Dept. Computer Engineering, Modeling, Electronics, and Systems Engineering: : (i) SPEME Lab (<https://labs.dimes.unical.it/speme/>), Head of Prof. Giancarlo Fortino, that focuses on the development of innovative methods and systems for engineering distributed intelligent, pervasive, mobile, multimedia and multisensorial systems; and (ii) Cybersecurity Lab, Head of Prof. Andrea Pugliese, that carries out research and advanced training on IT security, focusing on the protection of the end user, protection of digital and electronic payment services and on the development of innovative applications distributed with high requirements. security and privacy, identified as relevant in the analysis of the industrial context and technological innovation. The Laboratories have many collaborations with international and national universities, research centers and companies, both in the frameworks of research projects and in the context of shared research and experimental development activities.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally, the candidate should be interested in the technological and applicative aspects of the DLT research, have the ability to work in a team and be proactive in the research activity.

Curriculum 6 “Industry 4.0”

Scholarship code: F02

Research Title: Distributed Ledger Technology for Data Backup and Recovery Systems

Research Keywords:

- Backup
- Redundancy
- Disaster Recovery

Reference European Research Council Sectors:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_5 Security, privacy, cryptology, quantum cryptography

Reference Person *(a candidate supervisor, also available to provide more information via email):*

Prof. Marco Bernardo, University of Urbino, marco.bernardo@uniurb.it

Host University and Department *(the University of the main research activities and the main Department(s) involved):*

University of Urbino, Department of Pure and Applied Sciences

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

In the IT field, disaster recovery procedures provide for the restoration to the situation prior to the disaster itself by resorting to various data redundancy techniques. Among these, the most effective ones are replication and backup. The term replication means writing the data to another device with very short delays, in some cases even instantaneously (think of RAID systems). In contrast, the term backup means writing the data to another device with wider time delays, typically at least hours, and with the retention of these copies even for long periods: for example, it is possible to trace the version of a file archived tens of days, weeks, months, or years ago.

The disaster can occur for many different reasons, such as natural causes due to climate change, but among the most frequent accidents we must mention those caused by cyberattacks to the digital systems of companies and public administrations. These have seen a rapid increase in the last ten years, in particular those aimed at making digitally archived information inaccessible or modifying it (see <https://www.garanteprivacy.it/temi/cybersecurity/ransomware>) which are the most dangerous and impactful ones.

In cases where the attack is successful, the digitally archived data is encrypted and could become readable again only by knowing the encryption key that the attacking group exchanges with bitcoins sent by the victim. The data then become hostage of the attacking group and from this behavior comes the term of this category of malware: "ransomware".

The damage, in terms of lost productivity and costs of restoring normal functionality, can be calculated, in Europe only, in tens of billions of euros per year and the European Community has recently paid maximum attention to the problem (see <https://www.consilium.europa.eu/it/policies/cybersecurity/>).

Since even internal backup systems could be vulnerable, cloud storage solutions that are intrinsically safe have been assessed for some years, hence the interest in distributed ledger technology tailored to backup and recovery.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The research activities will take place at the Section of Informatics and Mathematics of the Department of Pure and Applied Sciences of the University of Urbino. The specific research team within the aforementioned section is composed of researchers and PhD students with expertise in several areas ranging from formal models for concurrent and distributed systems to performance evaluation and security analysis of computer systems and networks, including blockchain technology. The team is currently leading the national research project NiRvAna - Noninterference and Reversibility Analysis in Private Blockchain (<http://www.sti.uniurb.it/nirvana/>). The research will be carried out in collaboration with Bax s.r.l., a local company working in the IT field with expertise in networking, security, and building & home automation.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

The ideal candidate has a strong background in computer science or engineering and a good attitude to interdisciplinary studies, in addition to familiarity with model-based design methodologies as well as teamwork capabilities.

Curriculum 6 “Industry 4.0”

Scholarship code: F03

Research Title: Enterprise architecture for blockchain

Research Keywords:

- Blockchain as a service
- Software architecture for blockchain
- Interoperability between blockchains
- Verification, validation, and auditing in blockchain

Reference European Research Council:

- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems
- PE6_3 Software engineering, programming languages, and systems
- PE6_4 Theoretical computer science, formal methods, automata

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Marco Piangerelli, Università di Camerino, marco.piangerelli@unicam.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*): University of Camerino, Computer Science Division

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

In the context of micro enterprises, the seamless integration and analysis of data from diverse sources are critical for informed decision-making. The challenge lies in consolidating and extracting meaningful insights from these heterogeneous data sources while ensuring their traceability, immutability, and authenticity. To address those challenges, blockchain technology has been identified as a fundamental tool. By harnessing blockchain's inherent properties, we can create a distributed system that facilitates the integration of data also using different integration technologies, including REST APIs and text file sharing. Once the integration process is complete, data will be used to derive a performance score, in order to evaluate the company's trend and predicts its performance for the next quarter. This prediction will be based on the company's own data as well as information obtained from similar companies. To implement the prediction system, the PyTorch library will be utilized, as it is widely used and well-documented online. Subsequently, a recommendation system will be developed based on the company's performance. Once again, blockchain technology will

play a critical role, allowing the storage of companies actions that will be integrated in a global model to suggest future actions based on the predicted performance score. This personalized approach will enable companies to make informed decisions and drive their businesses based on their own data and tailored suggestions.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program*

The Computer Science Division at the University of Camerino is composed of senior professors as well as researchers in the early stages of their careers. The research will be conducted in a collaborative environment in the PROCesses & Services lab, where teamwork is a fundamental aspect of the group's success. Research in computer science, carried out within the PROS Lab, deals with the development of languages and techniques for the modeling, analysis, and development of process-aware information systems and blockchain-based applications. We strive for personal development with plenty of opportunities for collaboration with students, researchers, and industry partners. The Ph.D. will also be mentored to develop their own research career (e.g., writing a Ph.D. thesis, applying for project funding, preparing auditions for academic positions) and getting on board with ongoing publications, collaborations, and projects in the Computer Science team. Camerino is a lively and beautiful town in the center of Italy not far from the seaside, it is internationally known for its high concentration of researchers and international students.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally, the successful candidate should have a good background in Computer Science. A good level of skills in mathematical modeling and reasoning as well as in software engineering and programming is also required. Experiences with carrying out independent and collaborative research are merits.

Curriculum 7 “Climate, energy and mobility”

Scholarship code: G01

Research Title: Blockchain Oriented Software Engineering and Applications to smart energy trading, mobility and decentralized markets

Research Keywords: (< = 6 items)

- Blockchain
- Distributed Ledgers
- Smart Contracts
- Software Engineering

Reference European Research Council:

- PE6_2
- PE6_3
- PE6_6

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Roberto Tonelli, University of Cagliari, roberto.tonelli@unica.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):
University of Cagliari, Mathematics and Informatics Department (DMI)

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Blockchain Oriented Software Engineering addresses Blockchain software development adopting tools and methodologies already used during the last decades in software development and software system architecture, but taking into account specific Blockchain software peculiarities. Blockchain software suffers from rushed and unorganized development where failures and bugs proliferate. On the other hand traditional software engineering has to deal with a new and different paradigm. One example above all: once code is deployed on Blockchain it cannot be maintained or modified anymore. This Ph.D. program investigates software engineering for Blockchain software and Smart Contracts

development with applications to specific use cases such as supply chain, energy trading, green mobility, diplomas certifications and others.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The research team on Blockchain at University of Cagliari by next October 2023 will count a full professor, an associate professor, five assistant professors (RTDA) and various Post-Doc and Ph.D. students, with more than 10 people involved on Blockchain technology research. There are two groups, one more oriented to practical applications and the other to theoretical background and formal proofs. The teams is among the most cited groups in the field of Blockchain summing up to more than 4000 citations on google scholar in 2022. It has been working on this field of research since 2014/15 and it regularly organizes international workshops and summer schools in the field. It received international awards for its research and the members are PI of various funded projects for more than 3.5M EURO. The group is also a founder member of the IBSI (Italian Blockchain Service Infrastructure) project holding two “validator” nodes.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

The candidate should have specific knowledge on software engineering and methodologies, such as Agile software development, knowledge of standard programming languages such as C, Java or Python, of web development languages, such as javascript and/or nodejs. Further skills on cryptography and formal methods may also be required for better tackling specific topic of research. Mathematical background is also acknowledged.

Curriculum 8 “Agriculture and agrifood”

Scholarship code: H01

Research Title: Implementation of blockchain based smart agriculture systems

Research Keywords:

- Blockchain
- Smart agriculture
- Sustainable cropping systems

Reference European Research Council:

- LS9_8 Applied plant sciences, plant breeding, agroecology and soil biology

Reference Person (*a candidate supervisor, also available to provide more information via email*):
Cataldo Pulvento, University of Bari, cataldo.pulvento@uniba.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of Bari, Dipartimento di Scienze del Suolo della Pianta e degli Alimenti (DISSPA)

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

Traditional intelligent farming systems manage data and program execution centrally and are subject to inaccurate data, data distortion and misuse. Blockchain-based solutions can significantly improve the performance, security and privacy of the agro-tech sector by decentralizing processes. Examples include traceability, authenticity of the food supply chain, crop insurance. This project aims is to design, implement and to evaluate a secure and lightweight blockchain-based system that uses smart farm sensors. We aim to:

- Evaluate, systematize and contextualize existing knowledge and practices on the use of blockchain in smart agriculture,
- Establish a state-of-the-art agrotechnological experimental test bed using existing platforms,
- Design a lightweight blockchain-based framework for smart agriculture by leveraging sensor data,

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The student will take advantage of a research environment consisting of several laboratories for agronomic research, soil, precision agriculture and qualitative analysis; Furthermore, field studies will be carried out at the Department Agricultural Experiment Stations located in Policoro (MT) and Valenzano (BA). The research team is composed of professors of agronomy and herbaceous crops, professors of Mechanical Engineering, expert technical staff for field experimental tests, laboratory analyzes and construction of experimental pilot plants. The student will be able to interact with other students involved in other research programs of the Department.

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Master degree, in Computer Science, Agricultural science, or a related subject. Keen interest in practical problem solving in computer science, and agriculture. It is an interdisciplinary project between IT and agriculture; the student will develop different skills in the field of intelligent agriculture.

Curriculum 8 “Agriculture and agrifood”

Scholarship code: H02

Research Title: Blockchain and smart contracts for data quality and contrasting counterfeits in the agri-food sector

Research Keywords:

- traceability
- transparency
- smart contract
- information asymmetry

Reference European Research Council:

- PE7_8 Networks, e.g. communication networks and nodes, Internet of Things, sensor networks, networks of robots
- PE6_5 Security, privacy, cryptology, quantum cryptography
- PE6_2 Distributed systems, parallel computing, sensor networks, cyber-physical systems

Reference Person (*a candidate supervisor, also available to provide more information via email*):

Pierluigi Gallo, University of Palermo, pierluigi.gallo@unipa.it

Host University and Department (*the University of the main research activities and the main Department(s) involved*):

University of Palermo, Department of Engineering

Research Topic: *A brief description of scope and objectives of the research topic in more detail; in other words, the research topic where the scholarship and the candidate project proposal should rely on.*

The PhD candidate will study how current and next-generation blockchain can support increased traceability and transparency in food supply chains and support the implementation of green and sustainable schemes. The subject of the study will cover both the application and the theoretical aspects. From the application side, the study will contribute to the ambition of developing sustainable, productive, climate-neutral, biodiversity-friendly, and resilient farming systems providing consumers with affordable, safe, healthy, and sustainable food, minimizing pressure on ecosystems, improving public health and generating fair economic returns for farmers through the exploration and development potential of the use of blockchain in the agri-food sector.

The doctoral path will include studying new business and cost models with blockchain-based tracking systems and re-distributing the value of accurate and validated data along the whole supply chain. Also in focus will be implementing a farm-to-fork case study using public and private blockchain networks. The doctoral student will be directed toward solving fundamental challenges, such as identifying what data to record on the blockchain to be meaningful, assigning data consistency levels, mapping the production disciplinary in smart contracts, guaranteeing trusted data through innovative validation methodologies, identifying groups of visibility of information. Finally, the traceability system under study must comply with agri-food and other regulations, such as those on privacy and security. The candidate will also work on NFT in agri-food, to guarantee environmental, social and economic sustainability.

Research Team and environment: *A brief description of the research team and environment where the research activities of the doctorate will be carried out and where most of the collaboration with other researchers and research institutes will be based during her/his doctoral program.*

The candidate will work in the SNAPP lab (Security, Network Applications and Positioning Laboratory), a small and vibrant research environment with many projects on blockchain applications, mainly in the agri-food and energy sectors. Furthermore, the team spans the whole research supply chain; low TRLs (1-5) are tackled by the SNAPP lab, and higher TRLs (6-9) with SEEDS srl, an academic spin-off of the University of Palermo that focuses on blockchain and smart contracts for the agri-food sector. Thanks to the collaboration with several national and international research groups, the candidate will work in cooperation with multi-disciplinary contexts:

cryptographic integrations with the blockchain (with cryptographers), the intelligible smart contracts (with lawyers and linguists), agri-food fingerprinting (with geneticists and agronomists).

Suggested Skills: *A brief description of the background/ideal skills the candidates should already possess at the moment of application in order to succeed in their doctoral research*

Ideally, the successful candidate should have a good background in distributed systems, blockchain, smart contracts and general programming. Experience in system modelling and simulation (Matlab), data analysis (python, bash, UNIX), scripting and virtualization environments (Docker, compose, Kubernetes, Istio, ...) are considered an asset.