**Hybrid Quantum Computing - A gentle introduction to Quantum Computing from a Software Engineering perspective**

**ABSTRACT**

During the last decade there have been significant advances in the construction of quantum computers. It is reaching the point of having the first quantum processors (QPU) capable of addressing problems of a certain magnitude. The first computer with 400 qbits has recently been announced and the launch of a 1000 qbits computer has been announced for 2023. These advances have motivated that the discipline of Quantum Programming, which had remained latent for several decades, is now gaining relevance day by day.

The success of Quantum Computing systems will depend not only on having powerful QPUs but also on the fact that software engineers are able to develop quantum software components and integrate them into classical systems. However, it is common for software engineers who try to approach the field of Quantum Computing to find great difficulty in doing so. Some of the reasons for this are as follows. On the one hand, the programming model based on quantum circuits that integrate quantum gates is of a very low abstraction level. This forces software developers to approach the theory of quantum information and the mathematical bases of quantum mechanics, which requires a great effort. On the other hand, Software Engineers usually try to approach quantum software development from the same perspective they are used to. However, the principles of Quantum Computing are very different from those of classical computing. Realising on that and understanding the differences is an additional gap that is difficult to bridge.

This course aims to help software engineers to address the aforementioned difficulties. The course introduces basic concepts of Quantum Computing and quickly goes on to show the structure of a quantum program and the main techniques and patterns used to develop them. Likewise, the integration of a quantum programs in classical software systems is also addressed. All the above is done from a practical perspective.

**SHORT BIO**

Professor Murillo is currently a Full Professor in the field of Software Engineering at the University of Extremadura (Spain). He develops his research activity within the Quercus Software Engineering Group which he contributed to create in 1995. Currently, he leads the SPILab (Social and Pervasive Innovation Lab) which is focused on the development of service technology for mobile devices.

Professor Murillo and his lab are members of the Spanish network of Science and Engineering Services. Since 2012, the SPILab team has specialized in building distributed, service-oriented architectures for mobile devices. Their main contributions have been the Internet of People (IoP) concept and the People as a Service (PeaaS) architecture. Both promote considering mobile devices as an infrastructure integrated in the cloud in which services can be deployed. These concepts were some of the precursors of the need for what we know today as Fog and Mist Computing. In all this research, the application areas were that of health and aging. Finally, from 2018, the practical problems faced in the field of health have led him to open a new research direction related to the development of software for quantum systems and its integration with classical service-oriented ones. In this field, the SPILab is currently collaborating in the development of the QHealth project, which deals with the modeling of systems in the field of pharmacogenomics for the development of precision medicine. As part of the work in this field, QSERV, a proposal developed jointly with the University of Castilla-La Mancha and Prof. Mario Piattini for the development of service technology that supports the construction of hybrid classical/quantum systems has been granted by the Spanish Ministry of Science and Innovation.

Most recently, Prof Murillo was appointed General Manager of the Foundation of Computing and Advanced Technologies of Extremadura (COMPUTAEX). COMPUTAEX was created in 2009 by the regional government of Extremadura to promote the development of information technology, the use of intensive computation and advanced communications. The foundation manages CenitS, the Center for Research, Technological Innovation and Supercomputing. CenitS manages three supercomputers (LUSITANIA, LUSITANIA II y LUSITANIA III) which are a Singular Scientific and Technological Infrastructure (ICTS) recognized by the Spanish Ministry of Science and Innovation. COMPUTAEX is a member of the Spanish Supercomputing Network. Prof. Murillo will contribute to the specialization of CenitS in the fields of Health and Energy as well as the development of quantum software technologies to enable quantum computing such as future HPC. The Foundation is currently one of the partners of the Quantum Spain project who aims to build the first quantum computing in Spain and provide with quantum simulation capabilities to a network of supercomputers.