Press release

Atos announces Q-score, the only universal metrics to assess quantum performance and superiority

Paris, December 4, 2020 – Atos introduces "**Q-score**", the first universal quantum metrics, applicable to all programmable quantum processors. Atos' Q-score measures a quantum system's effectiveness at handling real-life problems, those which cannot be solved by traditional computers, rather than simply measuring its theoretical performance. Q-score reaffirms Atos' commitment to deliver early and concrete benefits of quantum computing. Over the past five years, Atos has become a pioneer in quantum applications through its participation in industrial and academic partnerships and funded projects, working hand-in-hand with industrials to develop use-cases which will be able to be accelerated by quantum computing.

> *"Faced with the emergence of a myriad of processor technologies and programming approaches, organizations looking to invest in quantum computing need a reliable metrics to help them choose the most efficient path for them. Being hardware-agnostic, Q-score is an objective, simple and fair metrics which they can rely on,"* said **Elie Girard, Atos CEO**. *"Since the launch of 'Atos Quantum' in 2016, the first quantum computing industry program in Europe, our aim has remained the same: advance the development of industry and research applications, and pave the way to quantum superiority."*

What does Q-score measure?

Today the number of qubits (quantum units) is the most common figure of merit for assessing the performance of a quantum system. However, qubits are volatile and vastly vary in quality (speed, stability, connectivity, etc.) from one quantum technology to another (such as supraconducting, trapped ions, silicon and photonics), making it an imperfect benchmark tool. By focusing on the ability to solve well-known combinatorial optimization problems, Atos Q-score will provide research centers, universities, businesses and technological leaders with explicit, reliable, objective and comparable results when solving real-world optimization problems.

Q-score measures the actual performance of quantum processors when solving an optimization problem, representative of the near-term quantum computing era (NISQ - Noisy Intermediate Scale Quantum). To provide a frame of reference for comparing performance scores and maintain uniformity, Q-score relies on a standard combinatorial optimization problem, the same for all assessments (the Max-Cut Problem, similar to the well-known TSP - Travelling Salesman Problem, see below). The score is calculated based on the maximum number of variables within such a problem that a quantum technology can optimize (ex: 23 variables = 23 Q-score or Qs).

Atos will organize the publication of a yearly list of the most powerful quantum processors in the world based on Q-score. Due in 2021, the first report will include actual self-assessments provided by manufacturers.

Based on an open access software package, Q-score is built on 3 pillars:

- **Application driven:** Q-score is the only metrics system based on near-term available quantum algorithms and measures a quantum system's capacity to solve practical operational problems;
- **Openness and ease of use:** Universal and free, Q-score benefits from Atos' technology-neutral approach. Its software package, including tools and methodology, does not require heavy computation power to calculate the metrics;
- **Objectiveness and reliability:** Atos combines a hardware-agnostic, technology-agnostic approach with a strong expertise in algorithm design and optimization acquired working with major industry clients and technology leaders in the quantum field. The methodology used to build Q-score will be made public and open to assessment.

A free software kit, which enables Q-score to be run on any processor will be available in Q1 2021. Atos invites all manufacturers to run Q-score on their technology and publish their results.

Thanks to the advanced qubit simulation capabilities of the Atos Quantum Learning Machine (Atos QLM), its powerful quantum simulator, Atos is able to calculate Q-score estimates for various platforms. These estimates take into account the characteristics publicly provided by the manufacturers. Results range around a Q-score of 15 Qs, but progress is rapid, with an estimated average Q-score dating from one year ago in the area of 10 Qs, and an estimated projected average Q-score dating one year from now to be above 20 Qs.

Q-score has been reviewed by the Atos Quantum Advisory Board, a group of international experts, mathematicians and physicists authorities in their fields, which met on December 4, 2020.

Understanding Q-score using the Travelling Salesman Problem (TSP)

Today's most promising application of quantum computing is solving large combinatorial optimization problems. Examples of such problems are the famous TSP problem and the less notorious but as important Max-Cut problem.

Problem statement: a traveler needs to visit *N* number of cities in a round-tour, where distances between all the cities are known and each city should be visited just once. What is the absolute shortest possible route so that he visits each city exactly once and returns to the origin city?

Simple in appearance, this problem becomes quite complex when it comes to giving a definitive, perfect answer taking into account an increasing number of *N* variables (cities). Max-Cut is a more generic problem, with a broad range of applications, for instance in the optimization of electronic boards or in the positioning of 5G antennas.

Q-score evaluates the capacity of a quantum processor to solve these combinatorial problems.

Q-score, Quantum Performance, and Quantum Superiority

While the most powerful High Performance Computers (HPC) worldwide to come in the near term (so called "exascale") would reach an equivalent Q-score close to 60, today we estimate, according to public data, that the best Quantum Processing Unit (QPU) yields a Q-score around 15 Qs. With recent progress, we expect quantum performance to reach Q-scores above 20 Qs in the coming year.

Q-score can be measured for QPUs with more than 200 qubits. Therefore, it will remain the perfect metrics reference to identify and measure quantum *superiority*, defined as the ability of quantum technologies to solve an optimization problem that classical technologies cannot solve at the same point in time.

As per the above, **Atos estimates quantum superiority in the context of optimization problems to be reached above 60 Qs.**

Atos' commitment to advance industry applications of quantum computing

The year 2020 represents an inflexion point in the quantum race, with the identification of the first real-life problems or applications which are unable to be solved in the classical world but may be able to be solved in the quantum world. As for any disruptive technology, envisaging the related applications (as well as necessary ethical limitations) is a major step towards conviction, adoption and success. This is exactly where Atos sees its main role.

Leveraging the Atos QLM and Atos' unique expertise in algorithm development, the Group coordinates the European project NEASQC - NExt ApplicationS of Quantum Computing, one of the most ambitious projects which aims to boost near-term quantum applications and demonstrates quantum superiority. NEASQC brings together academics and manufacturers, motivated by the quantum acceleration of their business applications. These applications will be further supported by the release in 2023 of the first Atos NISQ accelerator, integrating qubits in an HPC - High Performance Computing architecture.

Below are some examples of applications from NEASQC industrial partners that could be accelerated by quantum computing:

- **Carbon dioxide capture with Total**: studying the capture of CO2 to give researchers information about interactions between molecules to understand, simulate, and optimize adsorption (carbon capture);
- **Smart charging with EDF**: optimizing the load of electrical cars on fast charging stations, to prevent queuing and to save time and money, for large floats;
- **Quantum Monte-Carlo with HSBC**: developing efficient algorithms that could either substitute or redefine Monte-Carlo techniques for near-term quantum computers, thus significantly increasing the efficiency of derivative pricing or risk management models;
- **Quantum Rule-Based System with CESGA:** building a quantum rule-based system that solves a specific problem which has a vast amount of data and rules, in order to diagnose and treat a specific type of breast cancer known as invasive ductal carcinoma.

To learn more about NEASQC and the use-cases above (as well as others), please visit https://neasqc.eu/

> **Bob Sorensen, Senior Vice President of Research, Chief Analyst for Quantum Computing at Hyperion Research, LLC,** comments**:** "*Leveraging its widely acknowledged expertise in supercomputing, Atos is working to provide quantum computing users with early and tangible computational advantage on various applications by building on its 'Atos Quantum' R&D program, with the aim of delivering near-term results through a hybrid quantum supercomputing approach.The launch of Q-score is a key innovative step that offers a way for the quantum computing community to better characterize gains by focusing on real-life use-cases.*"

On Friday, December 4, 2020, the Group will hold a media conference call in English at 12 pm CET, chaired by Elie Girard, CEO, and Cyril Allouche, Fellow, Head of the Atos Quantum R&D Program, in order to present Q-score and answer questions from the press. Members of the Atos Quantum Advisory Board will be present. After the conference, a replay of the webcast will be available. Journalists can register to the press conference at: https://quantum-press-conference-atos.aio-events.com/105/participation_form

Atos Quantum Advisory Board members are:

- Alain Aspect, Professor at the Institut d'Optique Graduate School and Ecole Polytechnique, Université Paris-Saclay;
- David DiVincenzo, Alexander von Humboldt Professor, Director of the Institute for Quantum Information at RWTH Aachen University, Director of the Institute for Theoretical Nanoelectronics at the Juelich Research Center;
- Artur Ekert, Professor of Quantum Physics at the Mathematical Institute, University of Oxford and Head of Centre for Quantum Technologies of Singapore;
- Daniel Esteve, Research Director, CEA Saclay, Head of Quantronics;
- Serge Haroche, Professor emeritus at the Collège de France, Nobel laureate in Physics.

To learn more about Q-score, please visit: https://atos.net/en/solutions/q-score

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About Atos
Atos is a global leader in digital transformation with 110,000 employees in 73 countries and annual revenue of € 12 billion. European number one in Cloud, Cybersecurity and High-Performance Computing, the Group provides end-to-end Orchestrated Hybrid Cloud, Big Data, Business Applications and Digital Workplace solutions. The Group is the Worldwide Information Technology Partner for the Olympic & Paralympic Games and operates under the brands Atos, Atos|Syntel, and Unify. Atos is a SE (Societas Europaea), listed on the CAC40 Paris stock index.

The purpose of Atos is to help design the future of the information space. Its expertise and services support the development of knowledge, education and research in a multicultural approach and contribute to the development of scientific and technological excellence. Across the world, the Group enables its customers and employees, and members of societies at large to live, work and develop sustainably, in a safe and secure information space.

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