TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Direzione II – Ricerca, Terza Missione, Procedure Elettorali
Divisione I – Ricerca Nazionale
Ripartizione III – Scuola di Dottorato

Richiesta per borsa di studio da attivare ai sensi di quanto disposto dal D.M. n. 1061 del 10/08/2021

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CHIEDE

l'attivazione di una borsa di studio di dottorato ai sensi di quanto disposto dal D.M. n. 1061 del 10/08/2021. A tal fine comunica quanto segue:

La borsa sarà attivata sul seguente corso di dottorato accreditato per il XXXVII ciclo: Scienze Chimiche

Area per la quale si presenta la richiesta (selezionare solo una delle due):

☐ Innovazione

X Green

Tipologia di cofinanziamento (pari ad euro 8000 una tantum):

X Nome dell'Ente finanziatore pubblico o privato: Comunità Europea – Progetto Horizon2020 - European Research Council

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☐ Fondi di ricerca dipartimentali

Progetto di Ricerca (massimo 10.000 battute complessive spazi inclusi):

Il presente progetto prevede il coinvolgimento di una studentessa straniera e per questo è stato redatto in lingua inglese:

The main goal of this PhD project will be to provide a radical breakthrough in data storage technology and achieve the basic functions of persistent storage on a DNA-based platform. Namely, "create", "read", "update", and "delete" (CRUD) . The motivation is rooted in both the need to increase the physical density of information storage as well as to reduce the **energy consumption foot-print of data centres**. Energy consumption is rapidly becoming a central source of worry to major economies. The global annual energy consumption footprint of data-centres is already larger by >40% than the total energy consumed by the UK alone in 2016 and is expected to continue to grow rapidly over the next few years. This problem is further compounded by the emergence of applications that are expected to require petabyte (1015 byte), exabyte (1018 byte), and

even as much as zettabyte (1021 byte) level data sets (e.g. personalized medicine applications). This growth is not sustainable, which means that novel data storage solutions will be needed in the very near future.

Storage of data on synthetic DNA was originally proposed by Richard Feynman in 1959. DNA can potentially be the highest-density large-scale data storage strategy ever created (e.g. current demonstrated bench-mark is 215 petabytes -215 million gigabytes- in a single gram of DNA). Several works have already demonstrated the capacity of DNA to store enormous amounts of information per gram , but present DNA synthesis and subsequent sequencing does not facilitate all four persistent storage CRUD functions in a scalable and automatable manner. While it is possible to both create and read, synthesis and sequencing are currently slow and cost prohibitive causing an enormous latency (i.e. the time interval between stimulation and response) barrier. The goal of this PhD project is to allow DNA storage to achieve the four CRUD features on much faster time-scales, thus overcoming the latency barrier and making it a viable and attractive alternative for current data storage state-of-the-art.

Project Objectives

In order to providing a real-world solution to data-storage problem, we have set the following breakthrough technological target objectives for the PhD project so we could ultimately achieve a prototype for a DNA-based CRUD storage device:

Objective 1: The PhD student will first develop multiple versions of what would constitute a rewritable and stable “bit” (short for "binary digit" which is the smallest unit of measurement used to quantify information). The criterion would be to enable rapid write, delete, and read a bit of information without using repeated cycles of DNA synthesis. Second, the PhD student will develop novel encoding methods and associated synthesis approaches that will be dedicated towards applications of data storage. Such synthetic biomolecules will contain characteristics that will make them specifically suited for the complementary non-sequencing rapid-read capability that is an essential part of CRUD.

Objective 2: the PhD student will complement the effort of Objective 1 by developing non-sequencing rapid read out of the CRUD bits. To do so, the student will adapt single molecule spectroscopy techniques to produce signals with sufficient signal-to-noise ratio to enable definitive identification of a CRUD-bit state using previously trained machine-learning algorithms.

Objective 3: the student will integrate the CRUD-bits and rapid read modalities with several microfluidics platforms to make multiple candidate CRUD-storage units. The storage units will be the irreducible memory unit of CRUD-storage device, which will allow both repeated writing and reading operations on the CRUD-bits.

The units will be housed within either a droplet array or an integrated microfluidics platform to provide easy access to input and output operations.

The adoption of revolutionary effective DNA storage solutions by the mass market will become game-changers in terms of removing existing limitations from further growth of "big data" applications thus creating new market opportunities, growth and employment is a fast-growing market. As such we foresee a significant impact in the following aspects:

- Contribute directly to minimising impact on the environment by reducing the energy foot-print of large data and cloud-computation centres, thus bringing important benefits for society.

- Scientific and technological contributions to the foundation of exabyte level and above big data applications.

- Creating a new "green" biomanufacturing sector using various CRUD-based applications.

- Potential for future social or economic impact or market creation related to peta and exalevel data innovation.

For these reasons, several benefits will be gained from undertaking the project at National level and the project will have a strong benefit for the Italian and EU scientific excellence because of the high impact of this research in many aspects of the real life (environment, technology, health). Because of the importance of this research field and of the results that will be achieved, this PhD project will represent an important step for the career of the young researcher involved as it will broaden her expertise giving a multidisciplinary aspect to her curriculum. This experience will be crucial to give the young researcher the necessary experience to develop a position of professional maturity and independence. The project will be carried out in the laboratory of Biosensors and Nanomachines headed by Prof. Francesco Ricci.

The PhD student will also have the possibility to visit and do a research period at the premises of the Ulisse Biomed company, a company based in Trieste and expert in the field of diagnostic and DNA nanotechnology and with which a fruitful collaboration with the laboratory of Biosensors and Nanomachines is established.

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