DNAmaker: Automation of the construction of long DNA molecules

Innovation Action following the dnarXiv project

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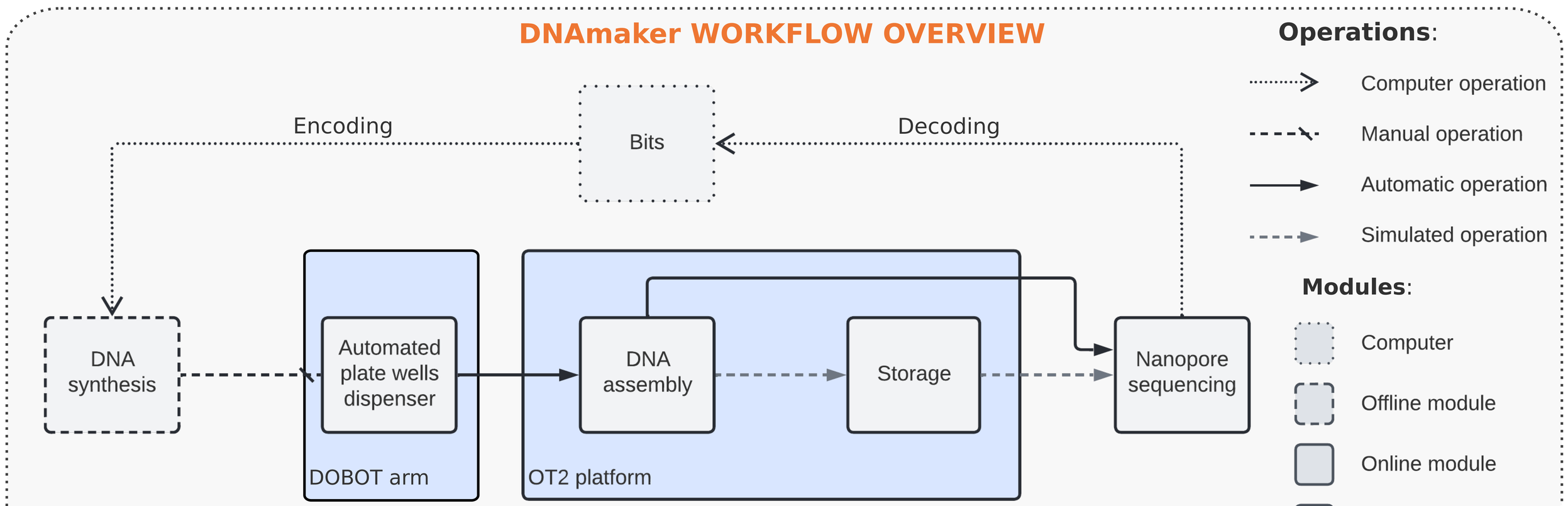
ABSTRACT

Today, the **community consensus** to **store digital information on DNA** is to use **short-single strand DNA (ssDNA) molecules**. This approach has some limitations: encoding constraints, DNA stability, recovering DNA, sequencing technology, *etc*. To overcome them, we chose to store information on **long double-strand DNA (dsDNA) molecules**. It was the **dnarXiv project**. As a **proof of concept** of this design methodology, we encoded the first articles of the **Universal Declaration of Human Rights** (4.2 ko text document) on a **single 24 Kbp DNA molecule**. We sequenced this molecule using Nanopore technology and were able to retrieve the original text.

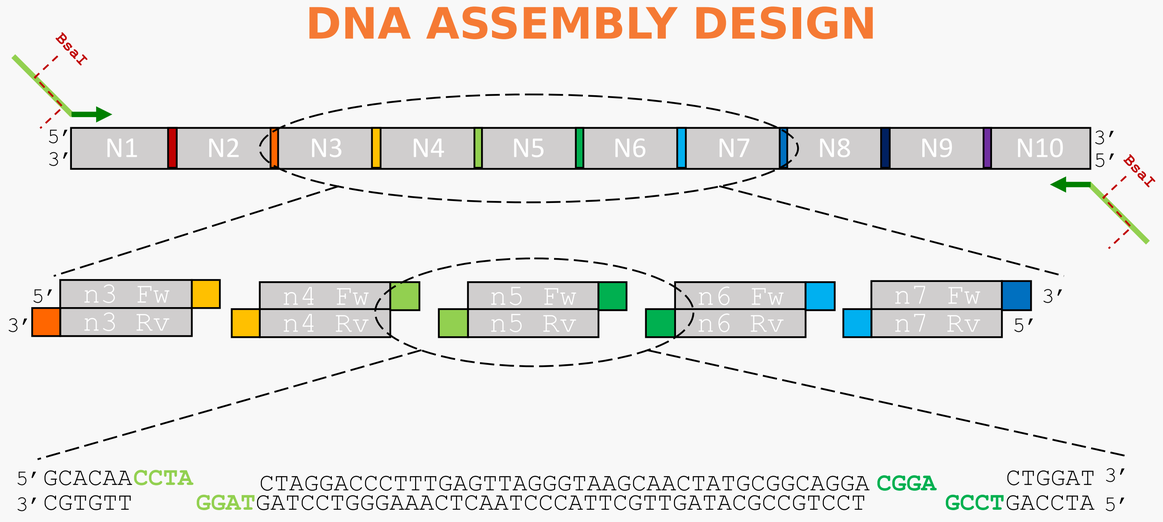
But, **is it scalable?**

Currently, the **construction** of long dsDNA molecule is done **by "hand"**. It's time-consuming, not parallelizable and tedious: **4 days to build 1 long DNA molecule**. To be convincing, **our DNA information storage solution must provide a experimental DNA storage platform with scale-up capacity**. In this end, **DNAmaker project aim to fully automated the DNA construction part of the dnarXiv pipeline with high flexibility in procotols**.

DNAmaker WORKFLOW OVERVIEW

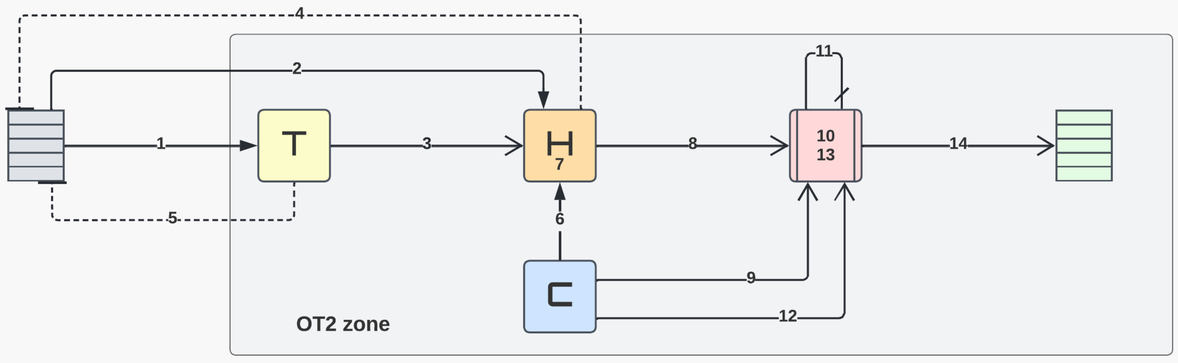


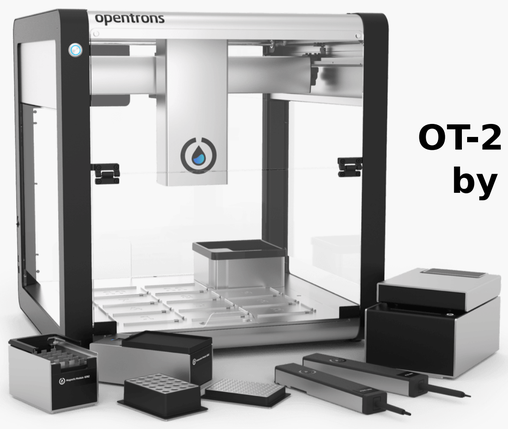
DNA ASSEMBLY DESIGN



Build dsDNA blocks with ssDNA oligonucleotides:
- **Payload**: digital information encoded in DNA.
- **Overhangs**: allow oriented assembly.
- **PCR primers**: allow amplification of dsDNA block.

DNA ASSEMBLY PROCESS





OT-2 automaton by Opentron

MG400 Robotic Arm by DOBOT

EXPERIMENTATIONS

- **Automate the construction of DNA molecules without external feeding**:
  - **Programming** dnarXiv DNA molecules construction protocols to the **OT-2 automaton**.
  - **Optimizing** protocols: reducing reaction times and simultaneous assembly of different DNA molecules in a single microtube.
  - **Validation**: Store automatically a **subset** of the Tim Berners Lee web browser files on DNA molecules and sequence the molecules to retrieve the original files.

- **Automate the construction of DNA molecules with external feeding**:
  - **Programming** the **MG400 arm robot** to automatically feed the OT-2 automaton.
  - **Optimizing** protocol: randomly accessed and recovered using an error-free approach.
  - **Validation**: Store automatically **all** the Tim Berners Lee web browser files on DNA molecules and sequence the molecules to retrieve the original files