

Designing and Verifying Molecular Circuits and Systems Made of DNA

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Inspired by the information processing core of biological organisms and its ability to fabricate intricate machinery from the molecular scale up to the macroscopic scale, research in synthetic biology, molecular programming, and nucleic acid nanotechnology aims to create information-based chemical systems that carry out human-defined molecular programs that input, output, and manipulate molecules and molecular structures. For chemistry to become the next information technology substrate, we will need improved tools for designing, simulating, and analyzing complex molecular circuits and systems. Using DNA nanotechnology as a model system, I will discuss how programming languages can be devised for specifying molecular systems at a high level, how compilers can translate such specifications into concrete molecular implementations, how both high-level and low-level specifications can be simulated and verified according to behavioral logic and the underlying biophysics of molecular interactions, and how Bayesian analysis techniques can be used to understand and predict the behavior of experimental systems that, at this point, still inevitably contain many ill-characterized components and interactions.