Title
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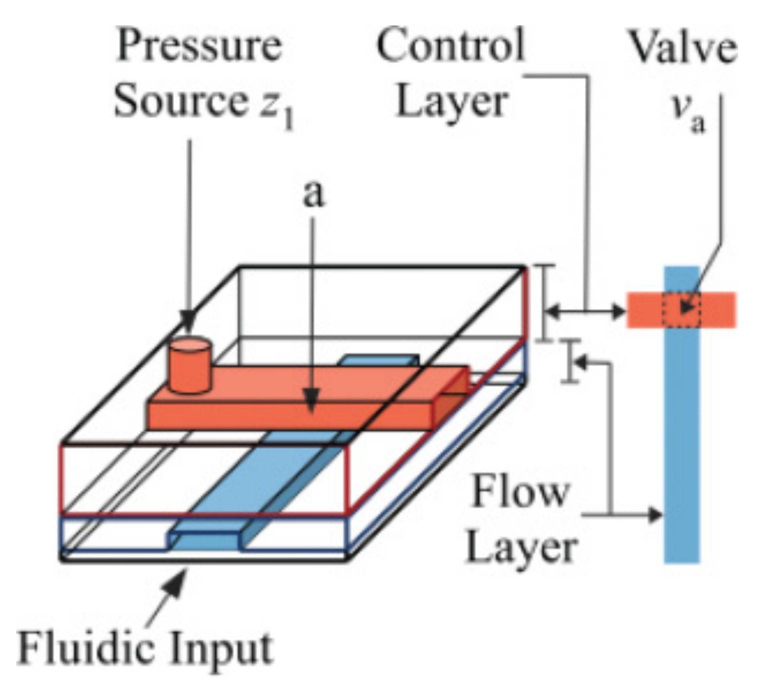
Microfluidics and Lab-on-a-Chip



- The movement of micro or picoliter amounts of fluid through a system in order to perform a biological or chemical operation or assay is known as microfluidics.
- When enough microfluidic operations or assays are combined to create a self contained test or experiment, that device is known as a Lab-on-a-chip (LoC).

Computer Aided Design for Microfluidic LoCs

The development of microfluidic LoCs currently requires a number of design-fabricate-test cycles:

(1) A biologist or chemist comes up with an LoC concept

(2) A device is designed in-house or (2*) using a design consultant

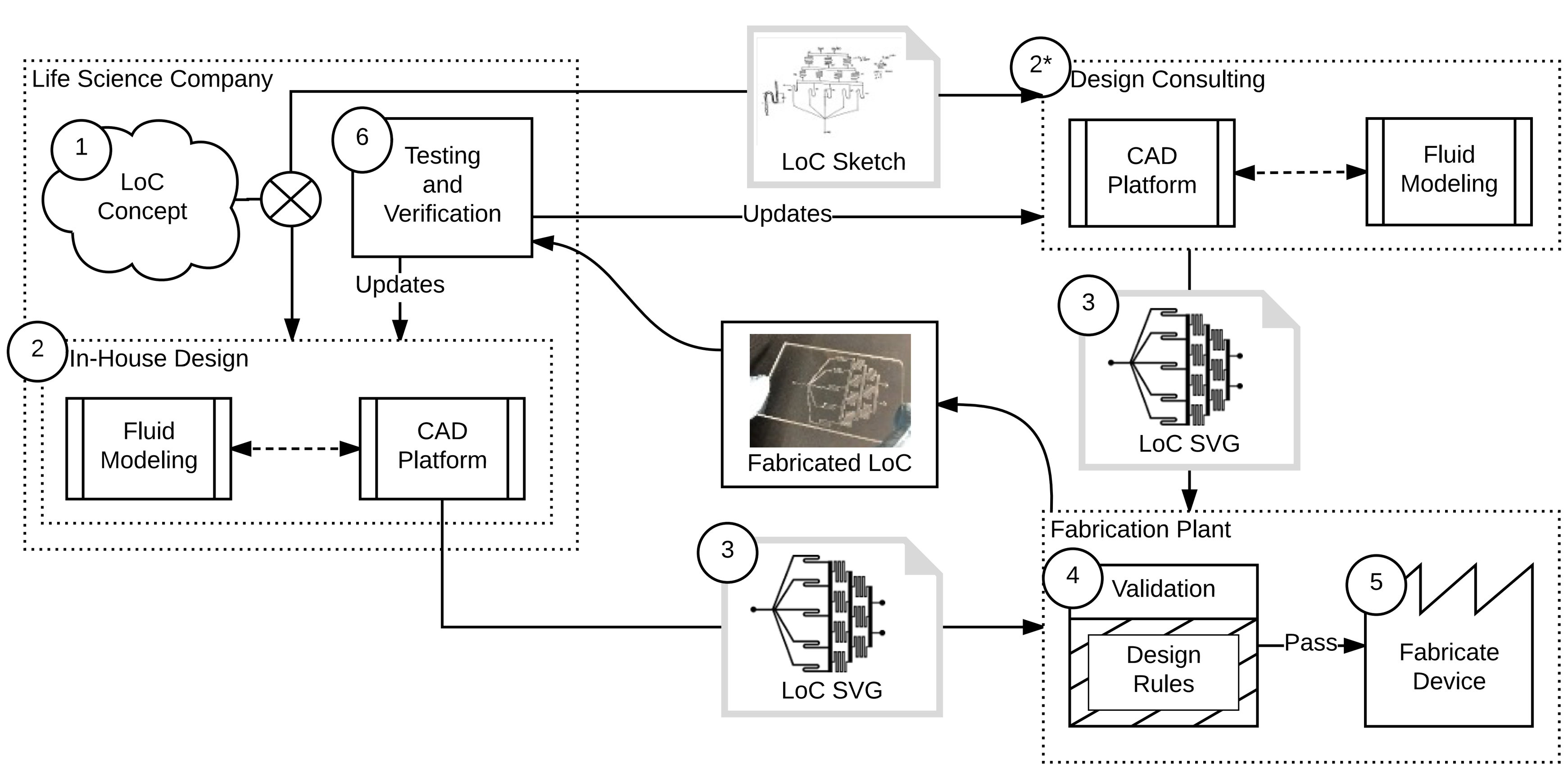
(3) A device design is sent to a fabricator

(4) The fabricator uses their domain rule checker (DRC) to validate that the device meets fabrication requirements

(5) Test device(s) are fabricated and sent back to the designer

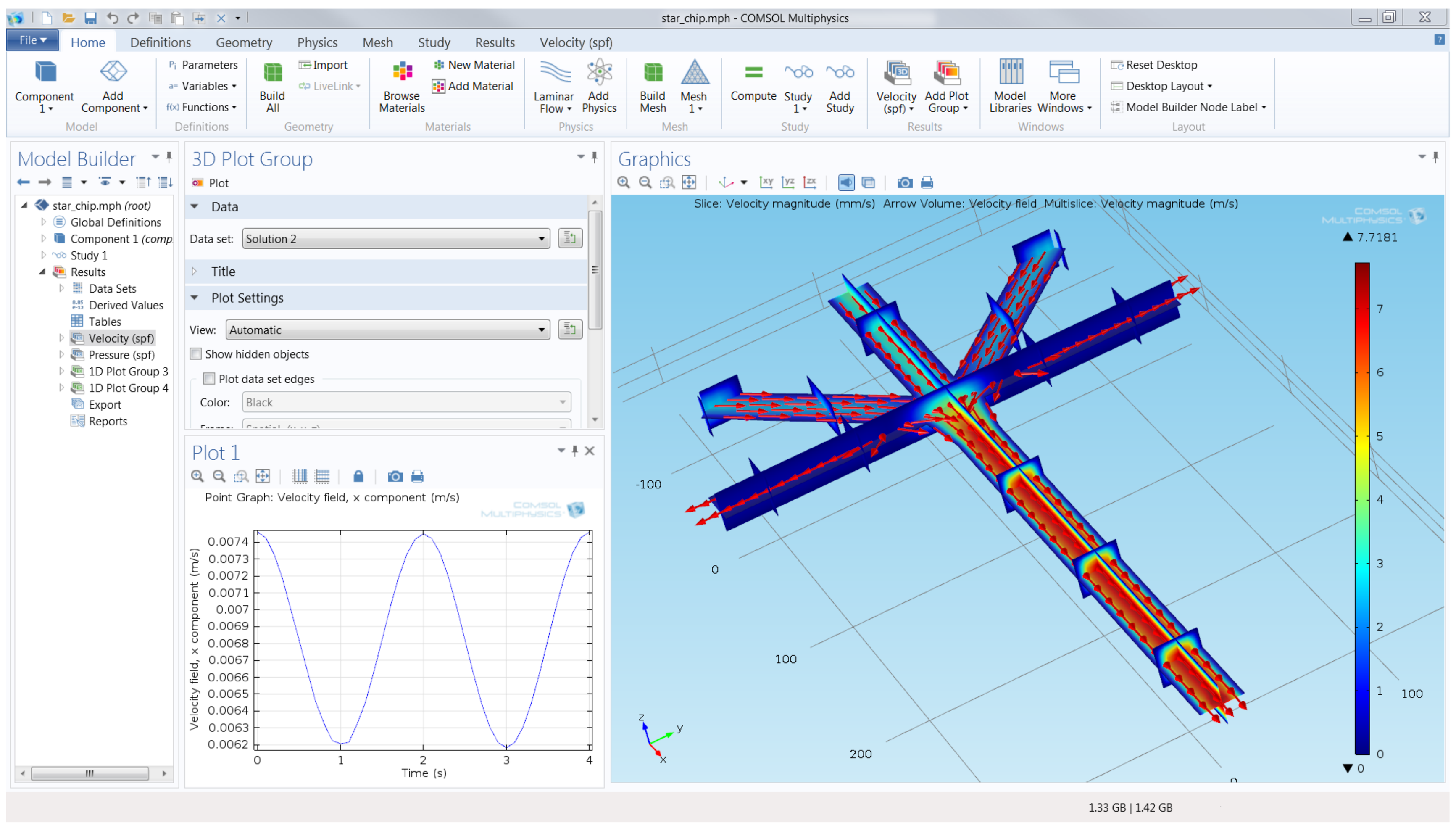
(6) The device(s) are tested for proper functionality

If an issue is detected within the device, the design is re-tooled to try and correct the issue and the cycle continues.



Modeling and Simulation for Microfluidic LoCs

COMSOL and ANSYS are the current standard for modeling and simulating LoC designs. These systems are very labor intensive for modeling even a single LoC component, and the results may not be correct for all microfluidic properties. For example, COMSOL models particles in a fluid as a single point such that particle interactions within the fluid cannot be modeled. This makes some cell sorting methods impossible to simulate and has created an opportunity for new simulation algorithms like MOPSA [1] and platforms like ElectricAnt [2].



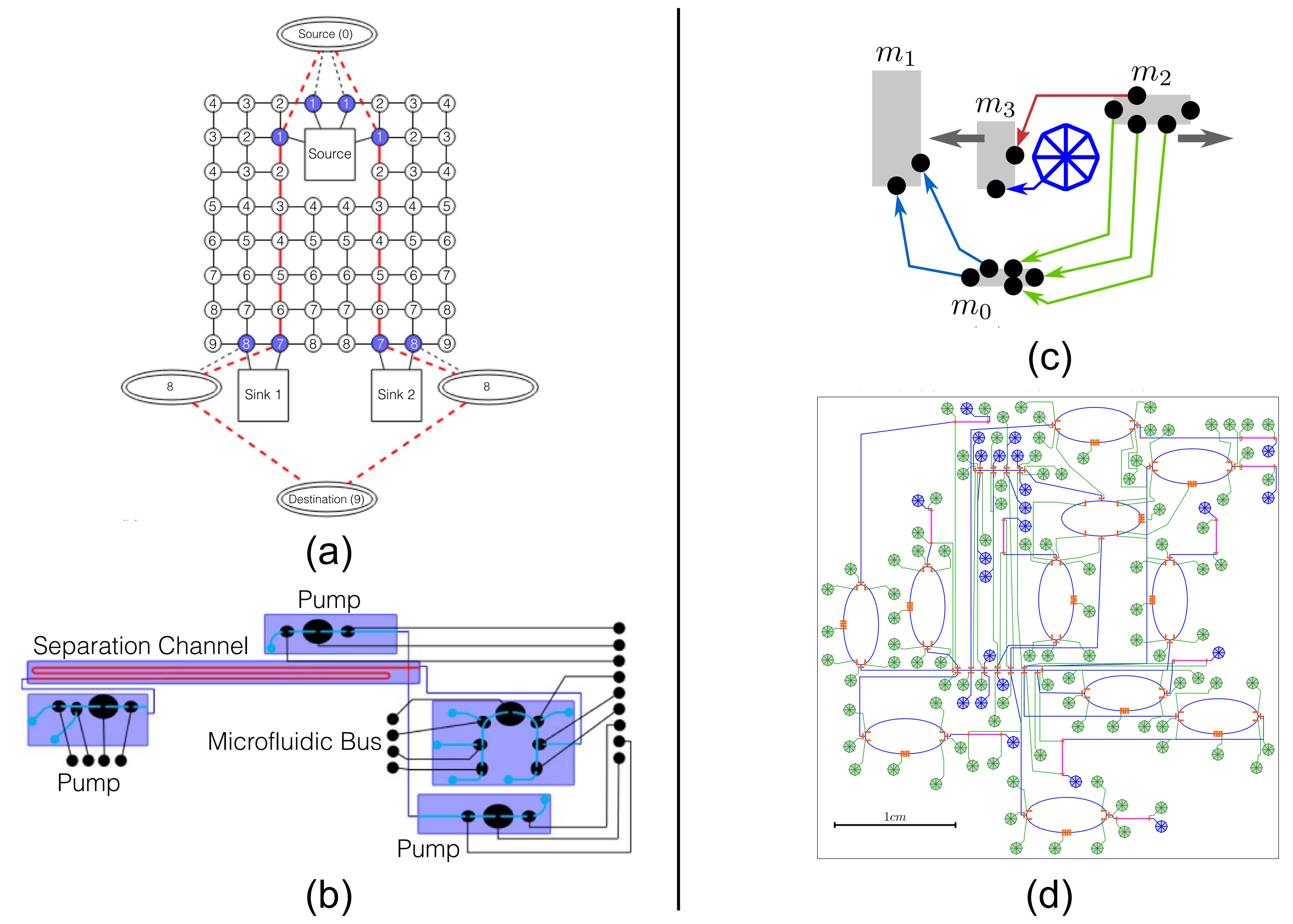
The COMSOL simulation for a single component [3]

Automated Design for Microfluidic LoCs

There have been a number of algorithms created to solve some or all the steps in the microfluidic design process

- Planar Placement and Network-flow Routing [4] performs flow layer placement and routing (a-b)
- PACOR [5] performs equal length routing for the control layer
- Columba [6] performs flow and control layer co-design (c-d)

These algorithms are unlikely to generate designs that can perform the biological or chemical operation because they do not utilize the underlying microfluidic mechanics, especially in passive devices.



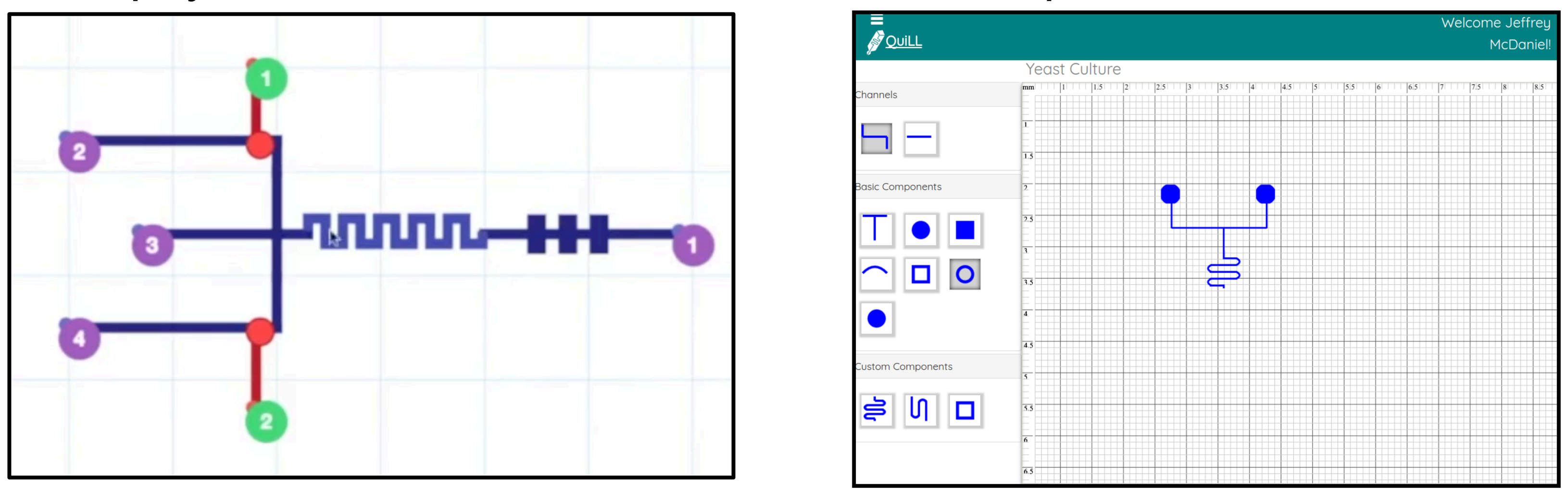
The Case for Semi-Automated Design

These issues necessitates the need for two parallel systems to be created

(1) Algorithms that utilize microfluidic scale fluid mechanics to drive the design of devices

(2) Systems that allow the designer to utilize algorithmic suggestions subverting them through full automation

Creating a platform that is centered around the device designer and surfaces to them a flow model of the device, with algorithmically derived suggestions for component placement and channel routing would enable them to automate well understood aspects of the device design allowing them to pay more careful attention to the novel aspects.



The open source Fluigi Cloud [7] (left) and commercial Quick Liquid Layout [8] (right) are examples of this type of platform

Acknowledgements & References

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