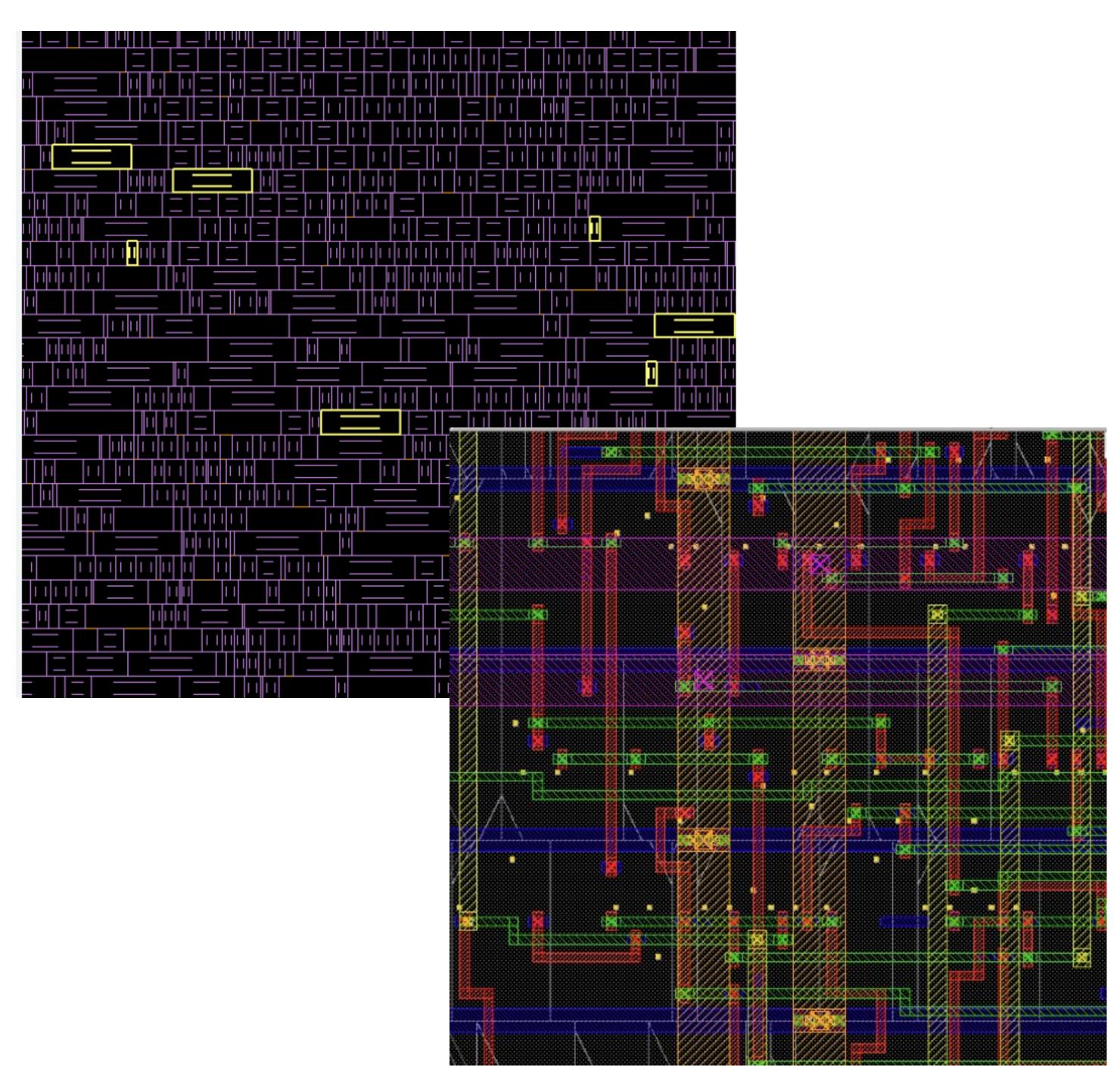
Challenges for Automating PCB Layout

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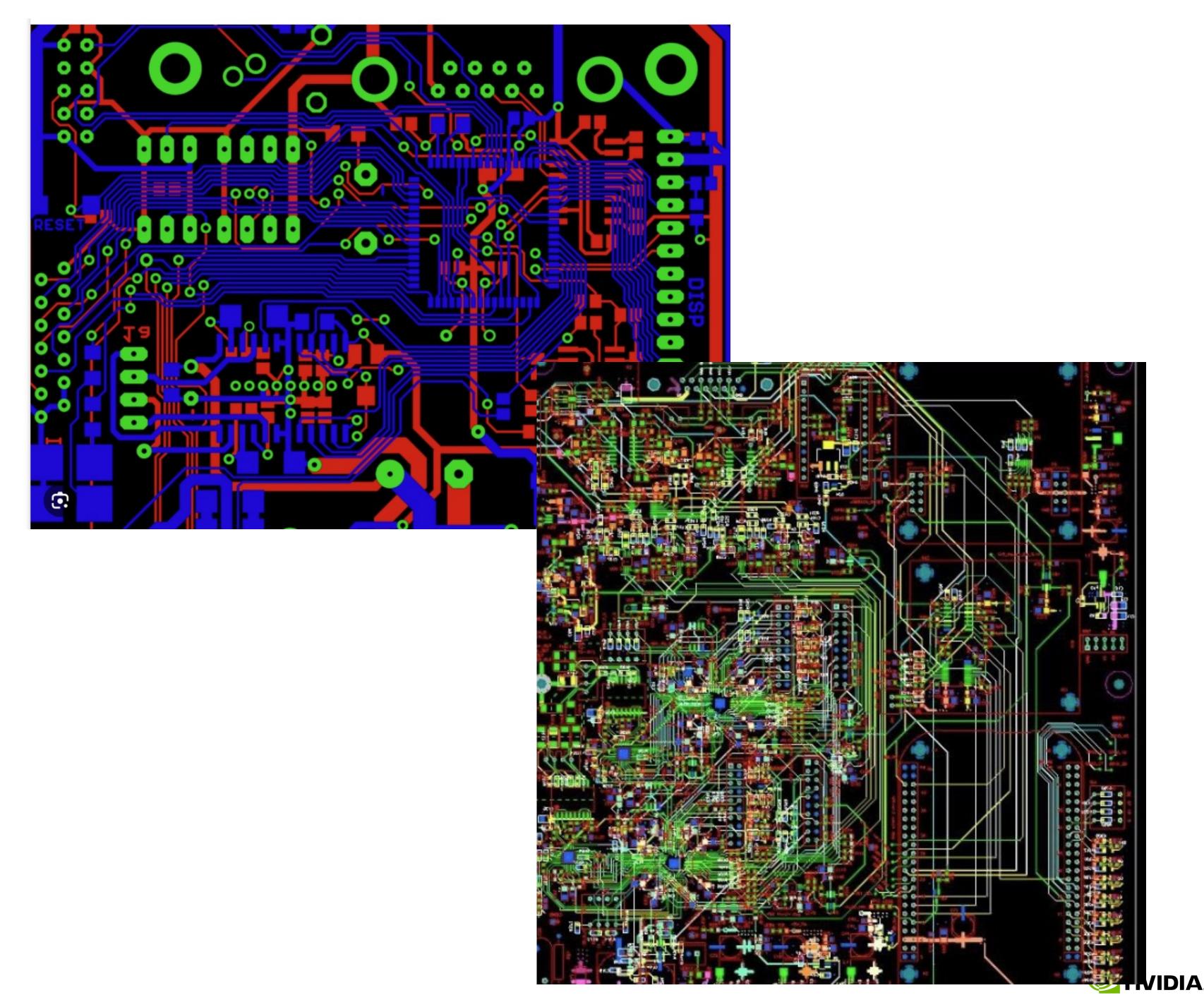


Digital Design Large size, standardization, fully-automation



Background

PCB Design Human-managable size, customization, manual design





• Printed circuit board (PCB) design is typically done by semi-auto or manual manners in the past

- dramatically.

Big PCB Designs: >2K components >200K nets > 60 metal layers > 200 routing rules (40 layout engineers, 1 month effort)

Motivation

• The scale of PCB designs rapidly enlarges, such that the engineering effort of the manual design increases

• PCB houses are looking for the productivity improvement contributed by automation





• Rule setup is labor intensive

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Allegro's constraint manager

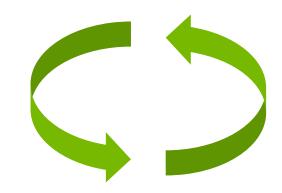
PCB Layout Flow

• At the planning stage, PCB houses rely on experienced engineers to plan the footprint, routing layers, and environment setup for a PCB design.

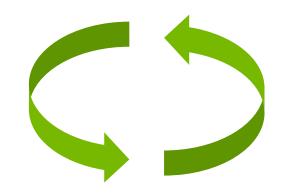
Layout Planning and Rule Setup



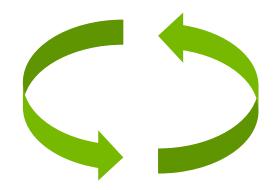
Component Selection



Schematic Drawing and Simulation

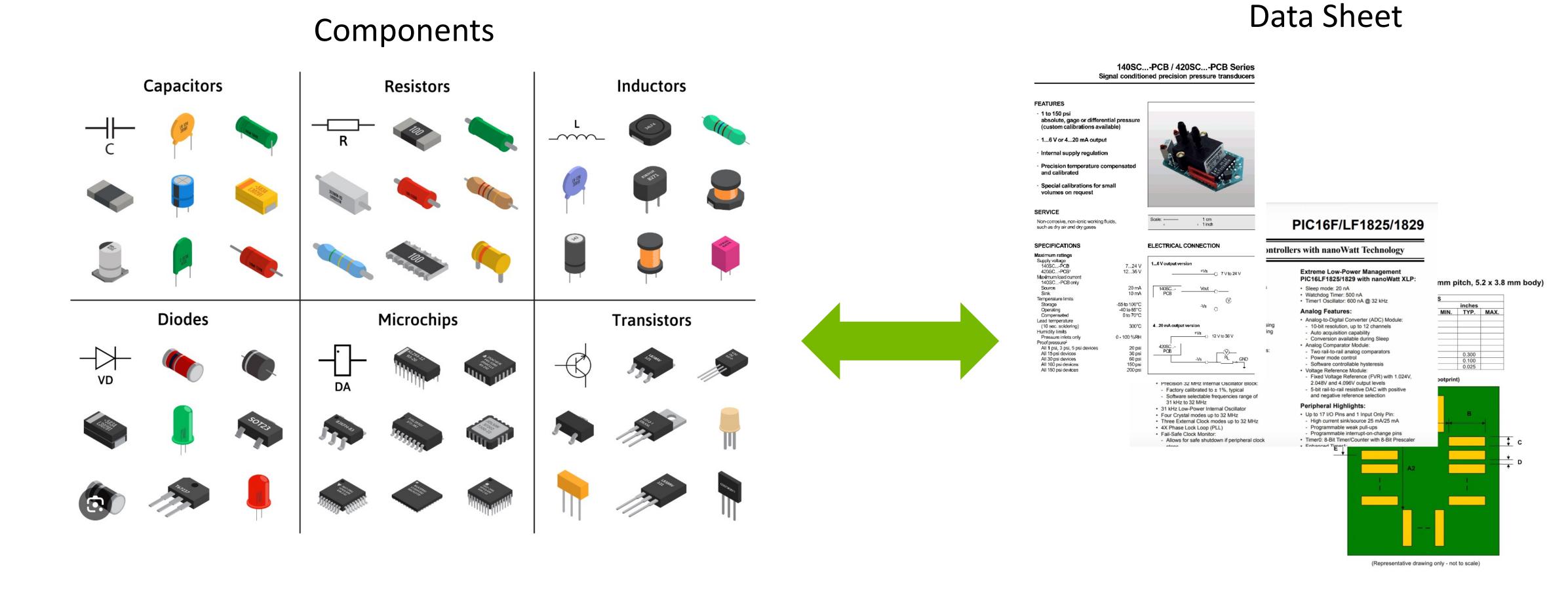


Physical Layout (Place and Route)





- components wisely to meet the spec with minimal cost.
- corresponding datasheet or document.



PCB Layout Flow (cont.)

• The functionality of a PCB design is compiled by different combinations of components. Different components have different tradeoff between performance, cost, area, and power. The designers need to select the

• Different components have different usage model and limitation specified in a

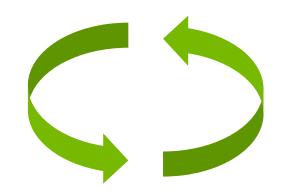
Layout Planning and Rule Setup



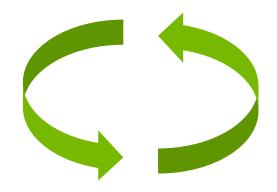
Component Selection



Schematic Drawing and Simulation

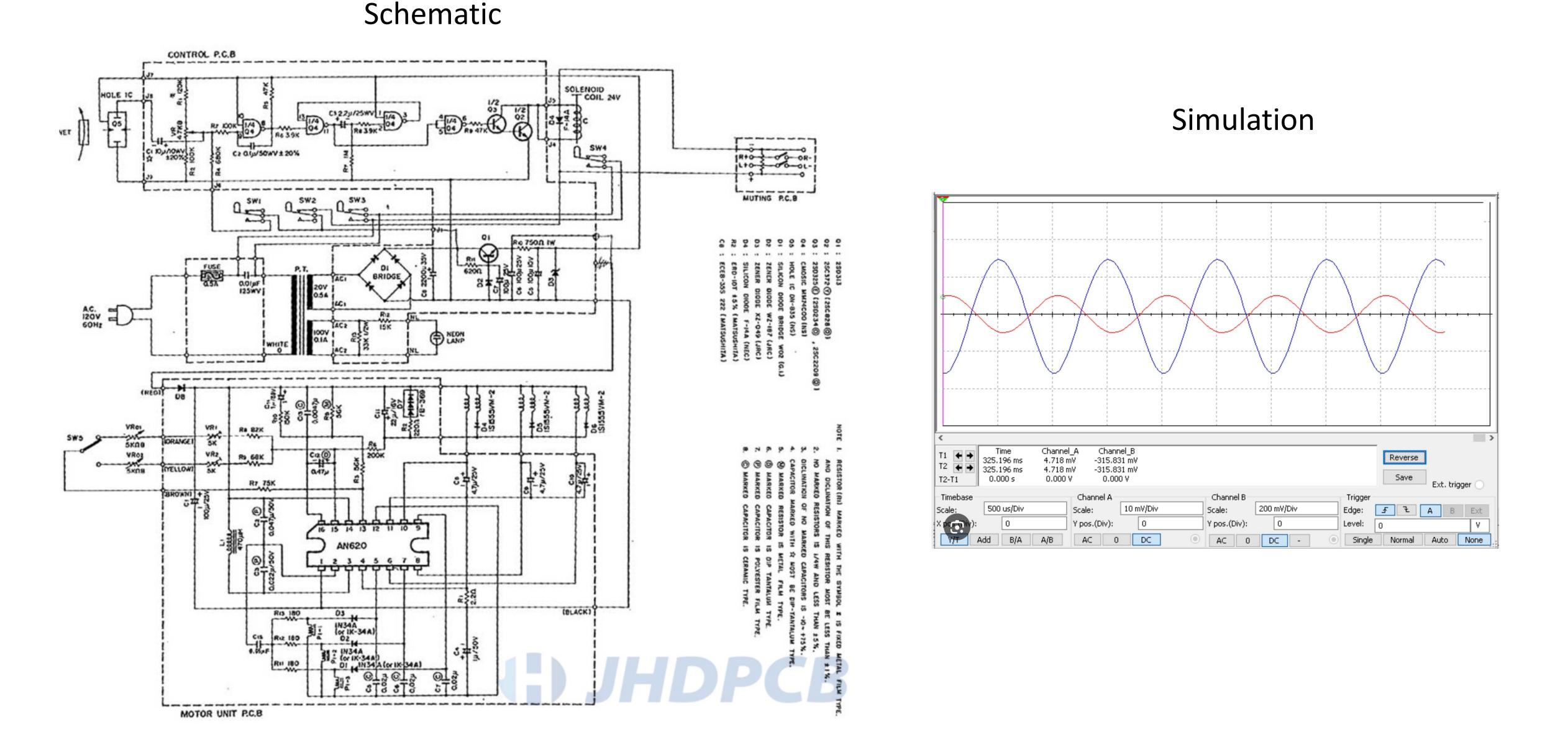


Physical Layout (Place and Route)



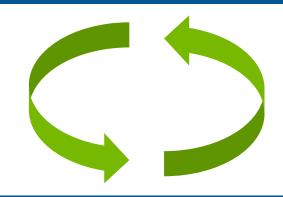


• Designers draw the logical connectivity between components and assign proper voltages for components. Then, run SPICE simulation for the schematic to verify its behavior.

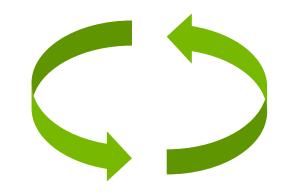


PCB Layout Flow (cont.)

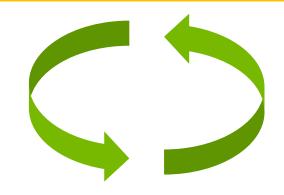
Layout Planning and Rule Setup



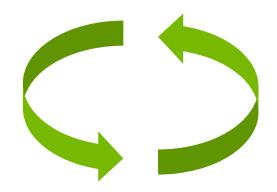
Component Selection



Schematic Drawing and Simulation



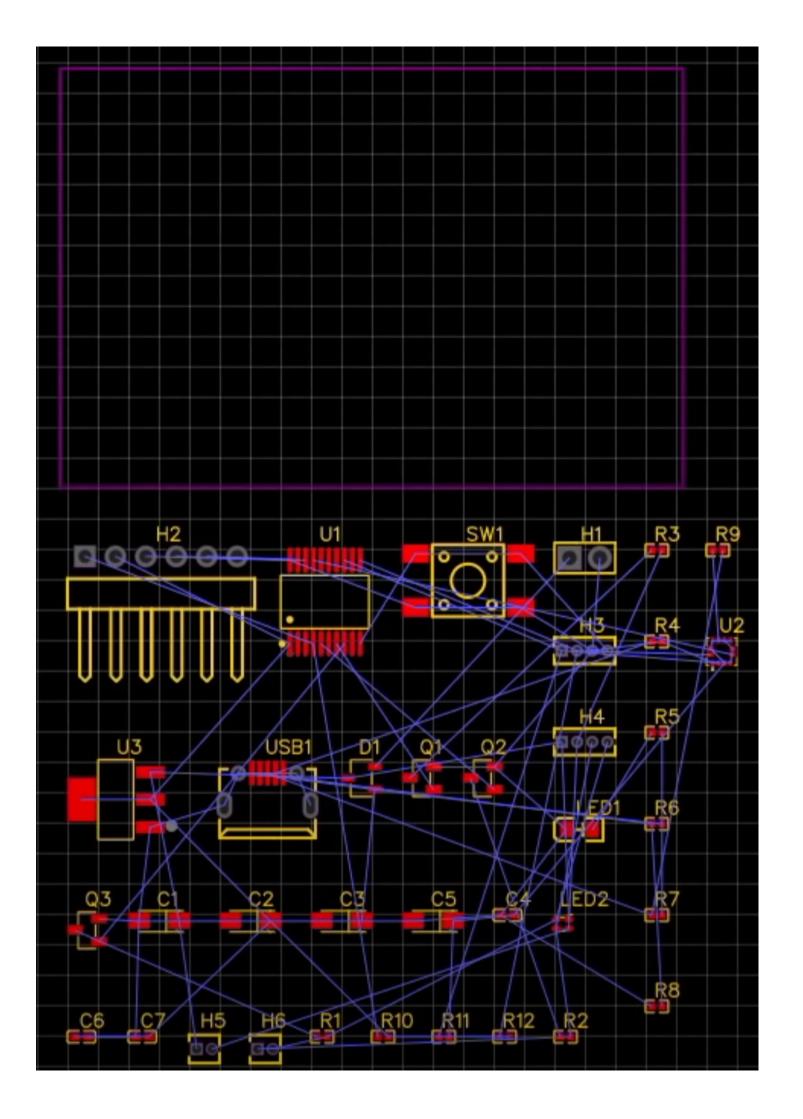
Physical Layout (Place and Route)

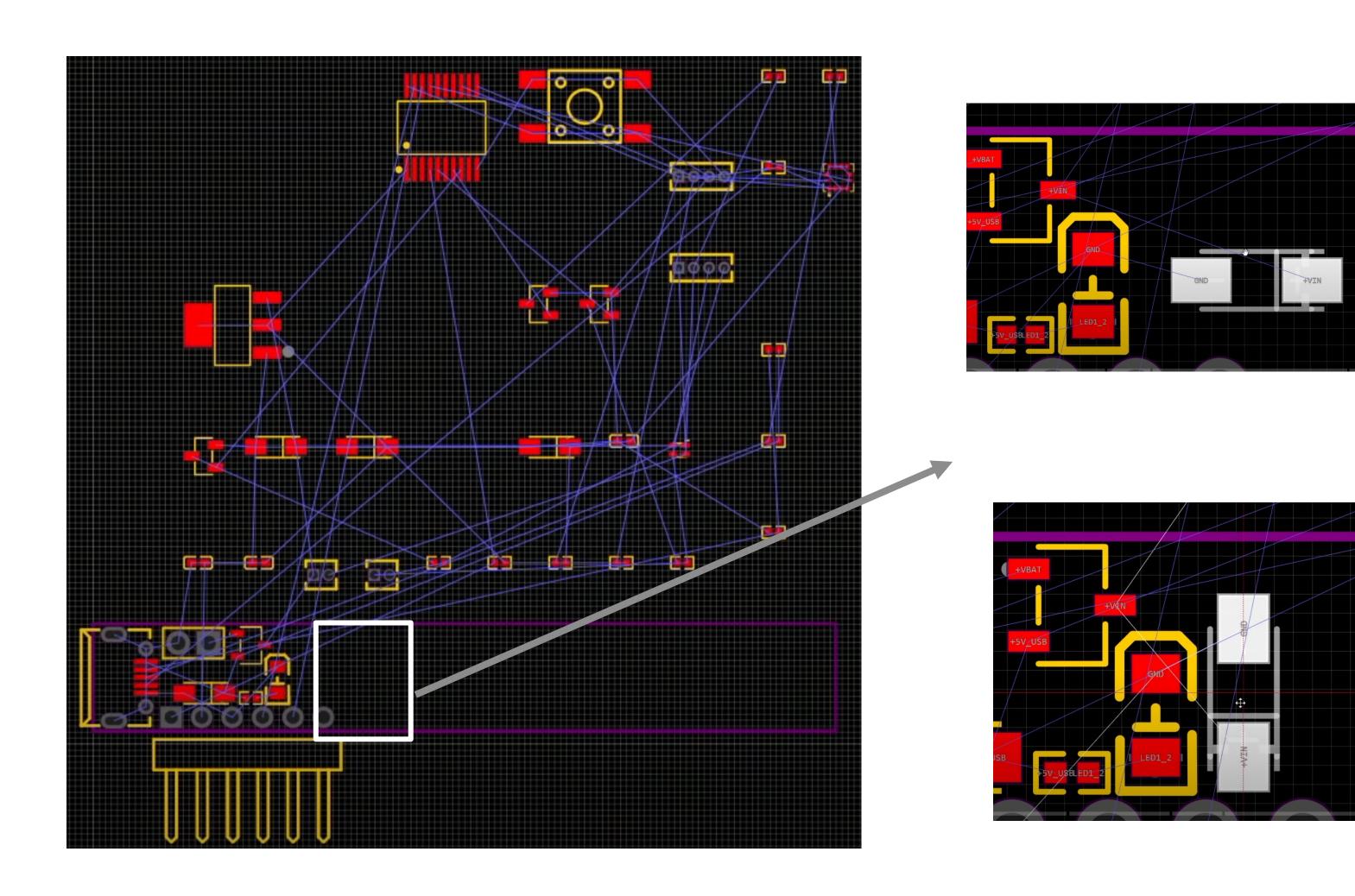




• Placement stage puts components in PCB outlines using the following operations

- Move components
- Rotate components
- Enlarge or shrink outline
- Re-select component



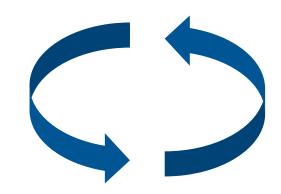


PCB Layout Flow (cont.)

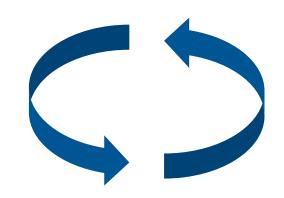
Layout Planning and Rule Setup



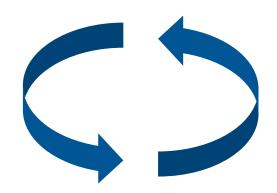
Component Selection



Schematic Drawing and Simulation

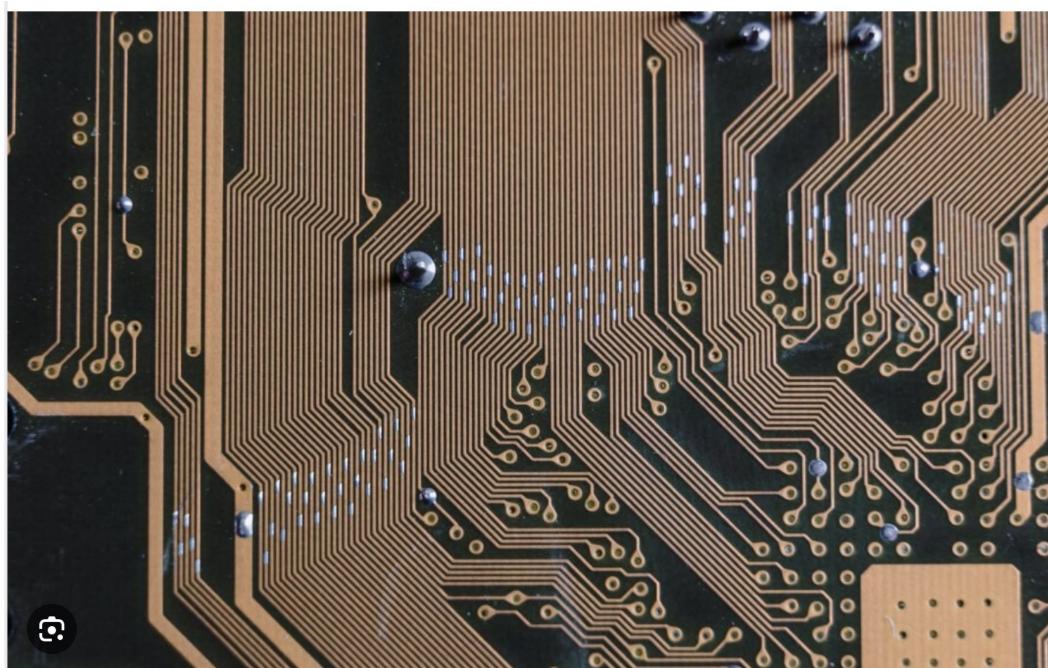


Physical Layout (Place and Route)





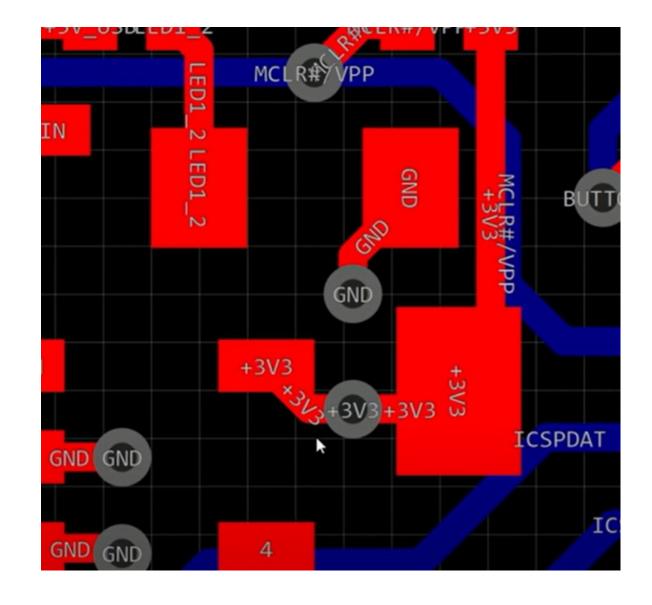
- Co-optimize routing and placement for routability
- performance.



PCB Layout Flow (cont.)

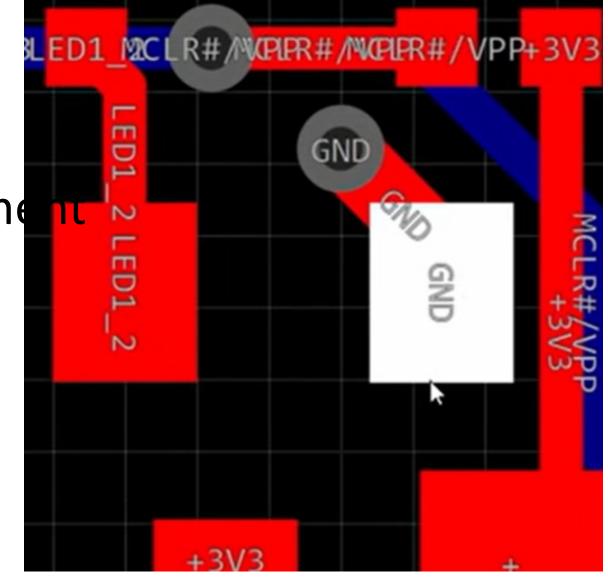
• Routing stage creates wires and vias using semi-auto or manual solutions

• Post refinement is involved to spread and size wires to improve yield and

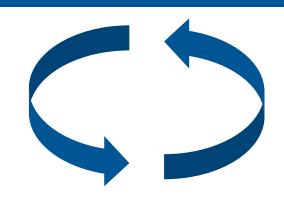


Before post refinement

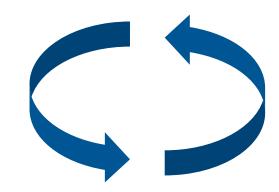
After post refineme



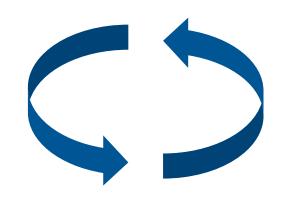
Layout Planning and Rule Setup



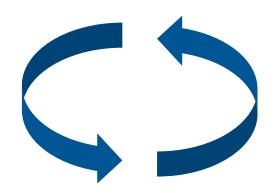
Component Selection



Schematic Drawing and Simulation

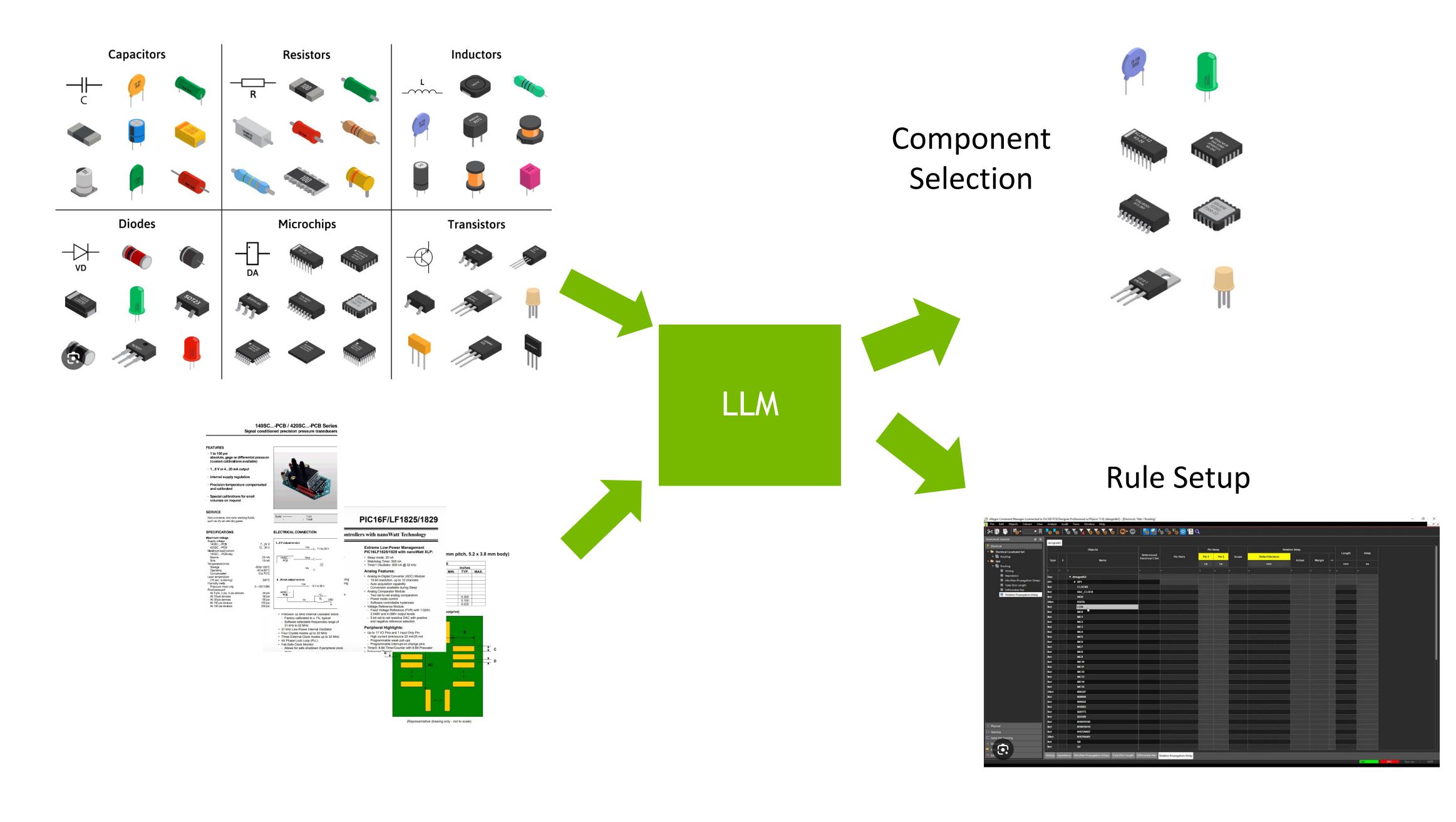


Physical Layout (Place and Route)





Automation Opportunity – Component Selection



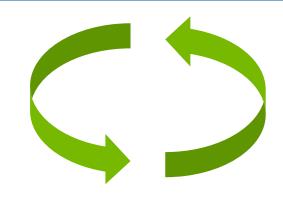
[1] https://resources.altium.com/p/can-you-use-chatgpt-pcb-design

• Use Large Language Model to select components [1] and rule setup

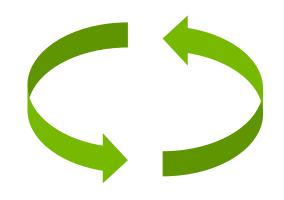
Layout Planning and Rule Setup



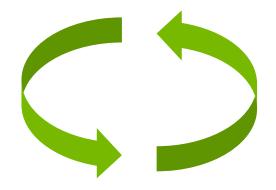
Component Selection



Schematic Drawing and Simulation



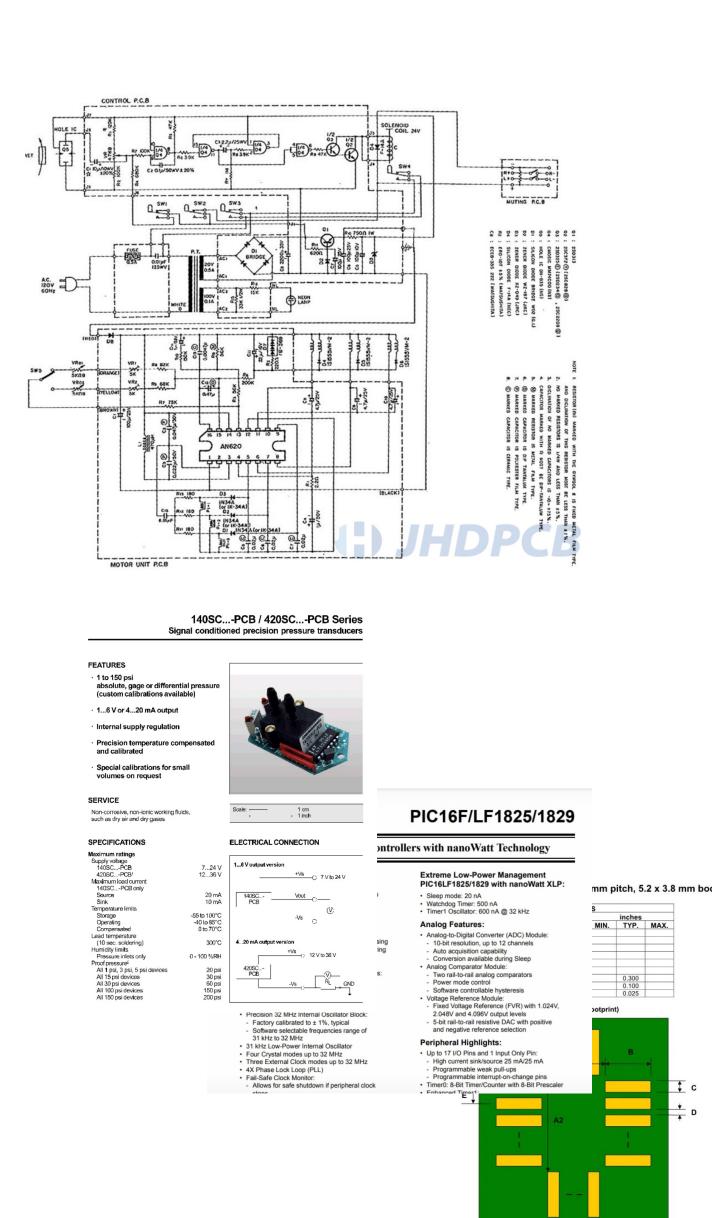
Physical Layout (Place and Route)





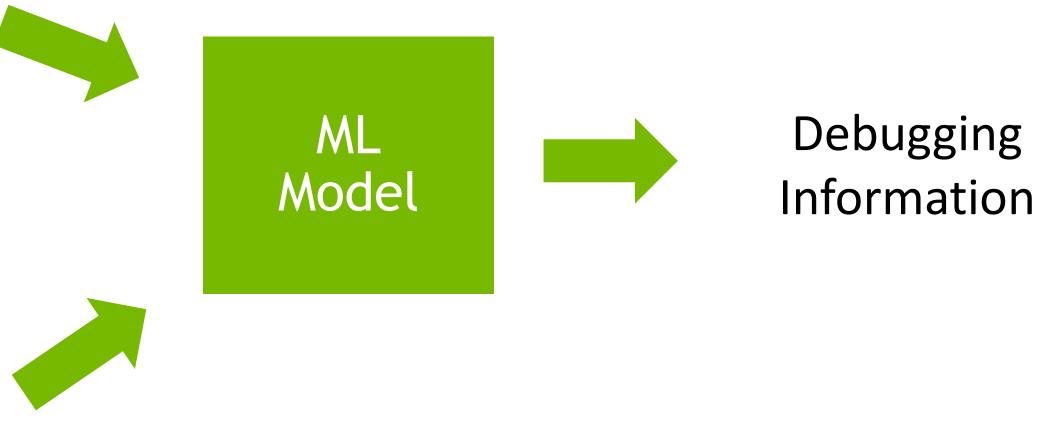
Automation Opportunity – Schematic Verification

- and schematic diagram to verify its correctness.



• Designers usually need to check the datasheet time to time during schematic drawing stage to verify the correctness of the schematic.

• The work [3] uses machine learning (ML) model to parse the datasheet

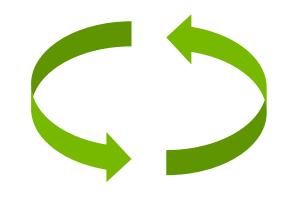


[3] K.-C. Chen et al, "Massive Figure Extraction and Classification in Electronic Component Datasheets for Accelerating PCB Design Preparation," in Proc. of MLCAD, 2021.

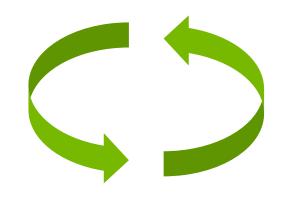
Layout Planning and Rule Setup



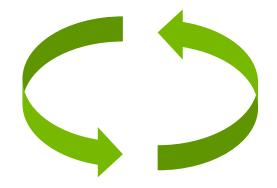
Component Selection



Schematic Drawing and Simulation



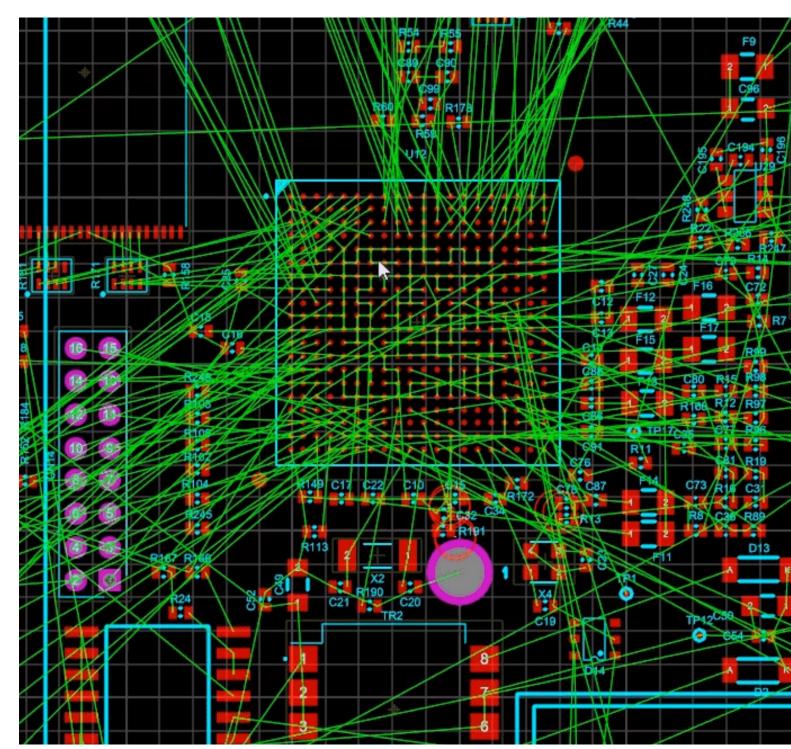
Physical Layout (Place and Route)





- general usage due to the following reasons
 - High placement and wire density
 - Custom rules
 - Intelligently use rule tolerance
 - Low return of investment
- Standardization is required

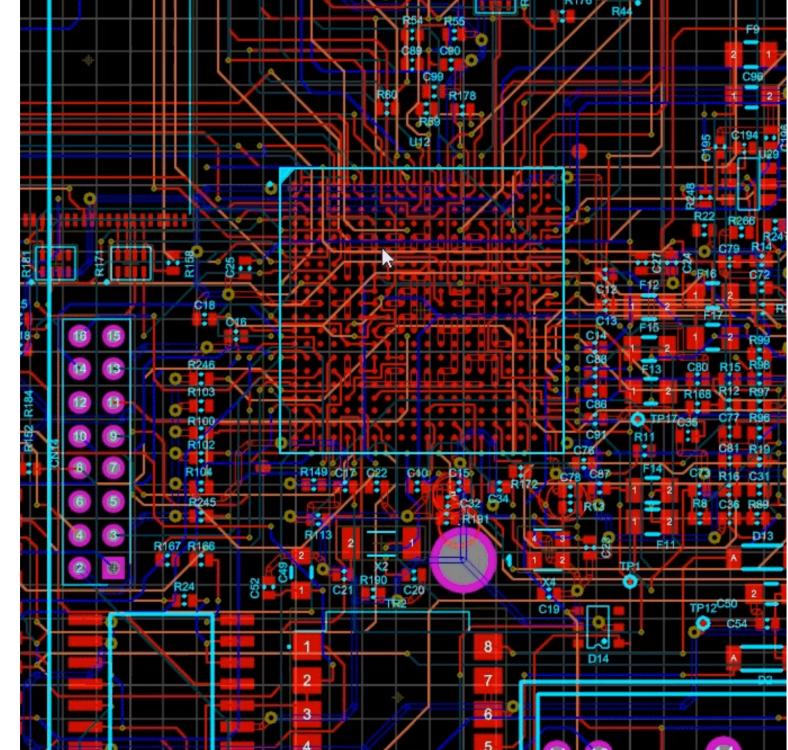
Unrouted design



Automation Opportunity – Auto Layout

• Auto placement and routing solutions are investigated by EDA companies in decades, but it does not meet designers' expectation for





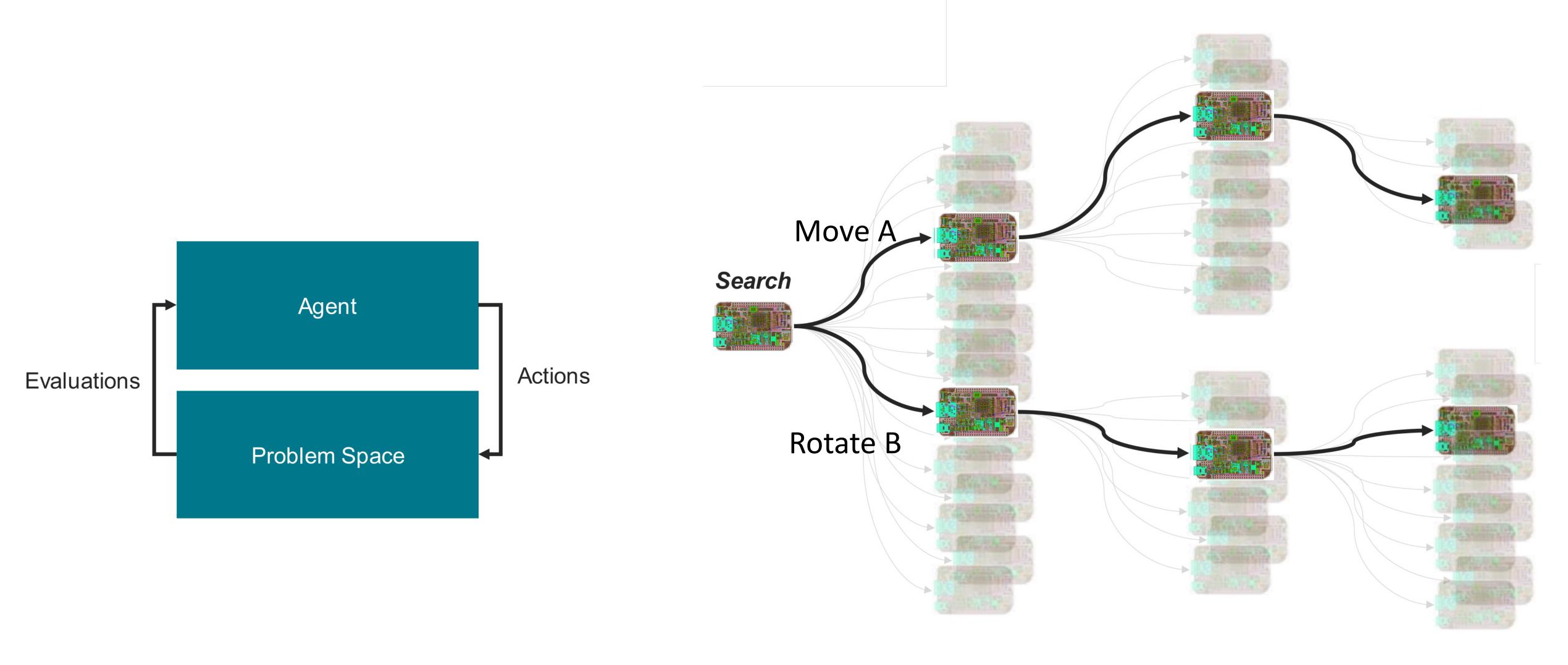
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• PCB layout requires place-and-route co-design. There are several actions which are executed iteratively to approach good a solution.

• The work [6] suggested to use reinforce leaning agent to explore the best action according to the current situation.



[6] Taylor Hogan, "Goal Driven PCB Synthesis Using Machine Learning and Cloud Scale Compute," in Proc. of ISPD, 2023.

Automation Opportunity – Auto Layout



more critical

• Push-button solution may not be realistic at this movement, but we can consider automation engine as an assistant to help productivity

• There are several ML-based solutions which can help productivity for PCB design

• Standardization is necessary for automation

Take Away

• Because the size of PCBs increases dramatically, the need of PCB automation becomes more and

