Challenges for Automating PCB Layout

Wen-Hao Liu
Principal Research Scientist
Nvidia Research
wenhliu@nvidia.com
Background

Digital Design
Large size, standardization, fully-automation

PCB Design
Human-managable size, customization, manual design
Motivation

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

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

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

Big PCB Designs:
>2K components
>200K nets
>60 metal layers
>200 routing rules
(40 layout engineers, 1 month effort)
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.
- Rule setup is labor intensive
• The functionality of a PCB design is compiled by different combinations of components. Different components have different tradeoffs between performance, cost, area, and power. The designers need to select the components wisely to meet the spec with minimal cost.

• Different components have different usage model and limitation specified in a corresponding datasheet or document.

PCB Layout Flow (cont.)

Component Selection

Schematic Drawing and Simulation

Physical Layout (Place and Route)

Verification and Validation

Layout Planning and Rule Setup

Data Sheet

Components

- Capacitors
- Resistors
- Inductors
- Diodes
- Microchips
- Transistors
• Designers draw the logical connectivity between components and assign proper voltages for components. Then, run SPICE simulation for the schematic to verify its behavior.
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.)

- Routing stage creates wires and vias using semi-auto or manual solutions
- Co-optimize routing and placement for routability
- Post refinement is involved to spread and size wires to improve yield and performance.
Automation Opportunity – Component Selection

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

[1] https://resources.altium.com/p/can-you-use-chatgpt-pcb-design
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 and schematic diagram to verify its correctness.

Automation Opportunity – Auto Layout

- Auto placement and routing solutions are investigated by EDA companies in decades, but it does not meet designers’ expectation for 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](image1)

![Auto-routed design](image2)

![After Manual design](image3)
Automation Opportunity – Auto Layout

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

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

Take Away

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