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# Learning Box Model using DSO.ai

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# Motivation

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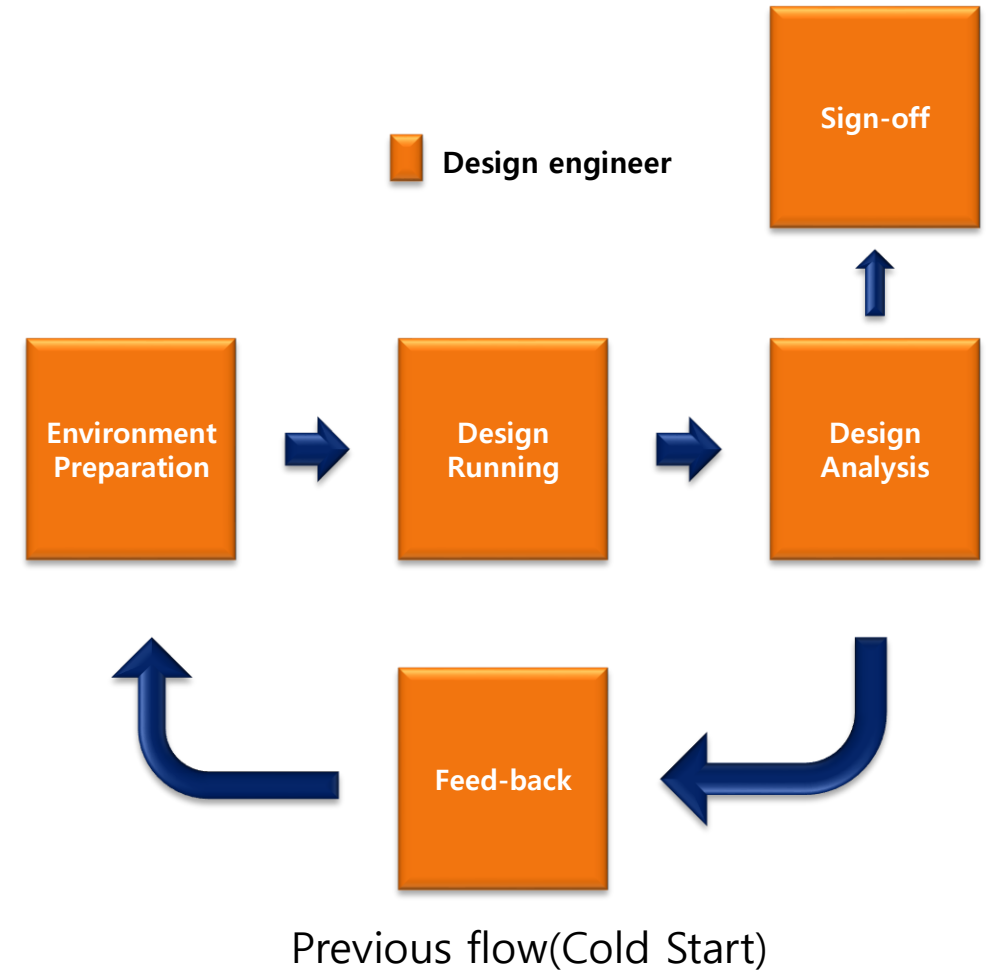
- In order to maximize design PPA, physical Implementation technology has advanced to handle every possible design knob
  - ◆ RTL, floorplan, SDC/UPF, library offering, power budget, etc.
- Overwhelming number of design knobs posed a new challenge for physical designers as reaching an optimal recipe within a given time-to-market is close to impossible for most modern size designs.
- Learning-Box Model is a new ML based model to find optimal combination of application options specifically for P&R tools like FC/ICC2.
  - ◆ Minimize the effort of Cold-start by using pre-trained ML model combined with an optimal app-opt candidates.



# Shortcoming of previous work

Implementation recipe optimization flow

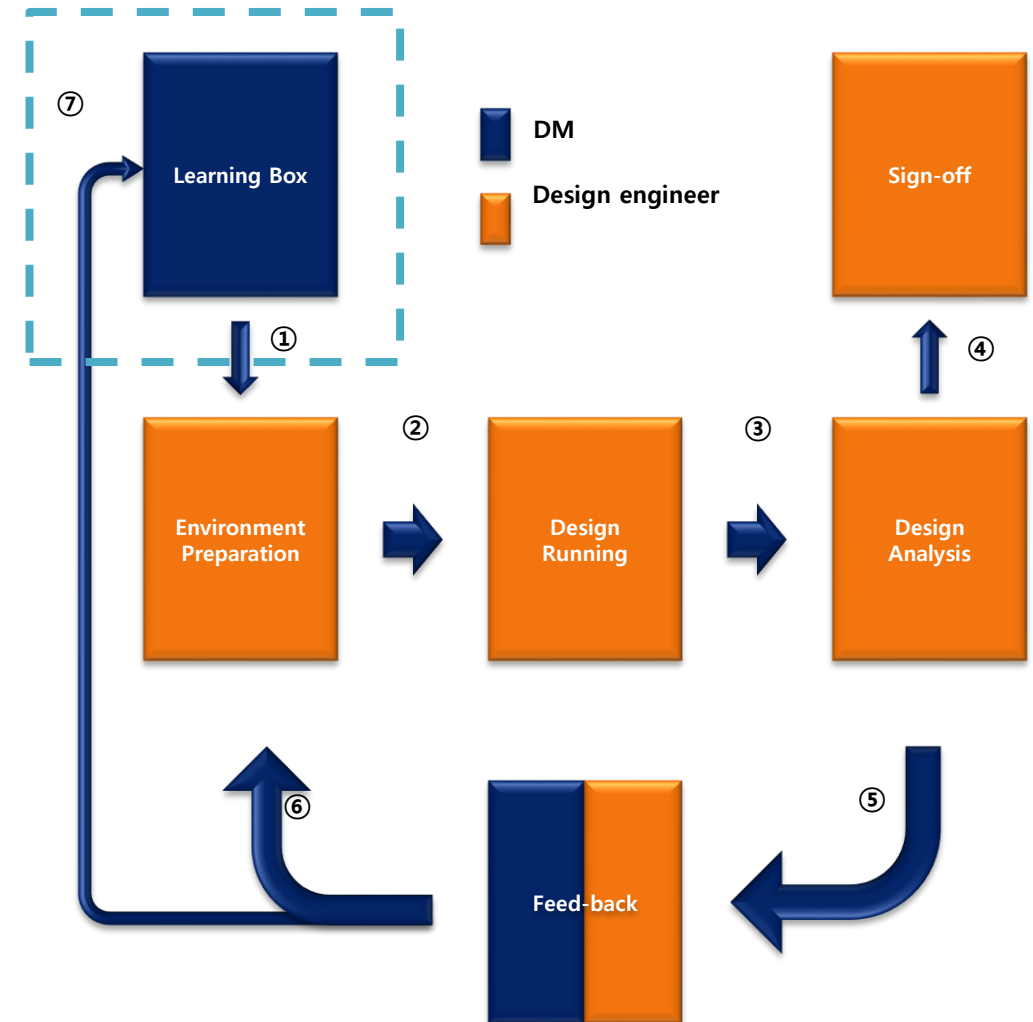
- **Previous work flow need a huge computing resource and much time**
  - ◆ Design engineer perform the implementation without pre-trained ML model and that is called by “Cold Start”
  - ◆ During the development, engineers need to make ML model to reduce the recipe search space for the next iteration(Warm start). It takes much time and huge computing resource.
- **To overcome, pre-trained ML model (Learning Box Model) is needed**
  - ◆ Computing resource will be reduced by learning box model. Engineer could run with less machine resource.
  - ◆ Search space will be reduced by pre-trained learning box model



# Learning Box Model Flow

## Implementation recipe optimization flow

- **Pre training Learning box**
  - ◆ Recipe(permutons) for better PPA
  - ◆ Suggested metrics and ADES to analysis the PPA
  - ◆ Preparing a pre trained ML model before project start
- **Environment Preparation**
  - ◆ Running strategy : worker number / iteration
  - ◆ Redefine metricon and ADES to fit the design spec and goal
  - ◆ Add new recipe(permuton) to get better PPA
- **Design Running**
  - ◆ Actual P&R runs at this step with a selected recipe from prepared environment
  - ◆ Running status check
- **Design Analysis & Feed-back**
  - ◆ DB analysis : PPA
  - ◆ DSO.ai environment analysis
    - The best result should be top rank and its PPA results must be better than reference environments
  - ◆ **Feed-back for preparation**
    - Adjust the metricon and ADES to bring the best result to the top rank
    - Updated ML model by design running
  - ◆ **Feed-back for learning box**
    - Analyze whether the learning box model is suitable for the reference block
    - If not, the learning box model inputs such as recipe and training block should be updated
- **Sign-off**
  - ◆ Follow the design sign-off flow such as physical and timing sign-off



\*ADES(Aggregate DDesign Score) : Target score to optimize that is made by metrics

\*Metricon(Metrics) : WNS, TNS, leakage power, dynamic power ...

# Experimental Results

Samsung 4nm process

Block	Reference / Learning Box	Setup			hold			Cell area	Low vth ratio	DRC(Short)
		WNS	TNS	NVP	WNS	TNS	NVP			
BLOCK1	Reference	-0.271	-231.0	25173	-0.350	-2320.0	52047	534674	6.73	1173(76)
	Learning Box	-0.172	-147.0	18164	-0.350	-1197.0	29037	502001	4.92	146(25)
BLOCK2	Reference	-0.727	-324.0	17857	-0.727	-2386.0	53084	711,809	9.44	555(13)
	Learning Box	-0.762	-129.0	6943	-0.762	-1055.0	37351	712,331	8.56	601(14)

- Pre-trained learning box model is trained by other block using same process. Total number of training is 90(30 max workers, 3 iterations)
- Learning Box Model is applied to 2 test blocks to optimize the performance, power and routability with fewer machine resource than Cold start.
  - ◆ The ADES is made by WNS, TNS, LVTH, DRC and CELL AREA to optimize them
- Total negative slacks(TNS) are reduced by 36~60% and low threshold voltage(lvth) ratios are reduced by 9~26% with similar or better DRC / Short number.



# Summary

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- Using DSO.ai, search space of design knobs will be optimized to optimize the design PPA.
  - ◆ If the pre-trained ML model is ready before the design starts, we can reduce machine resource
- Suggested Learning Box Model flow serve the pre-trained ML model to push PPA and guides for design flow
  - ◆ Pre-trained ML model, running guide, metricon and ADES configuration
- The experimental results using Samsung 4nm process shows
  - ◆ Learning Box Model can reduce the TNS by 36~60%
  - ◆ Learning Box Model can also reduce the low threshold voltage ratios by 9~26%

