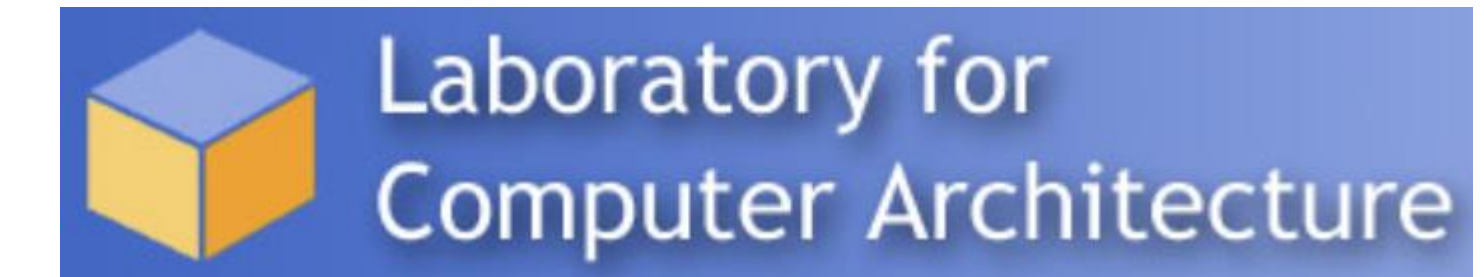


# Cross-FPGA Power Estimation from High Level Synthesis via Transfer-Learning



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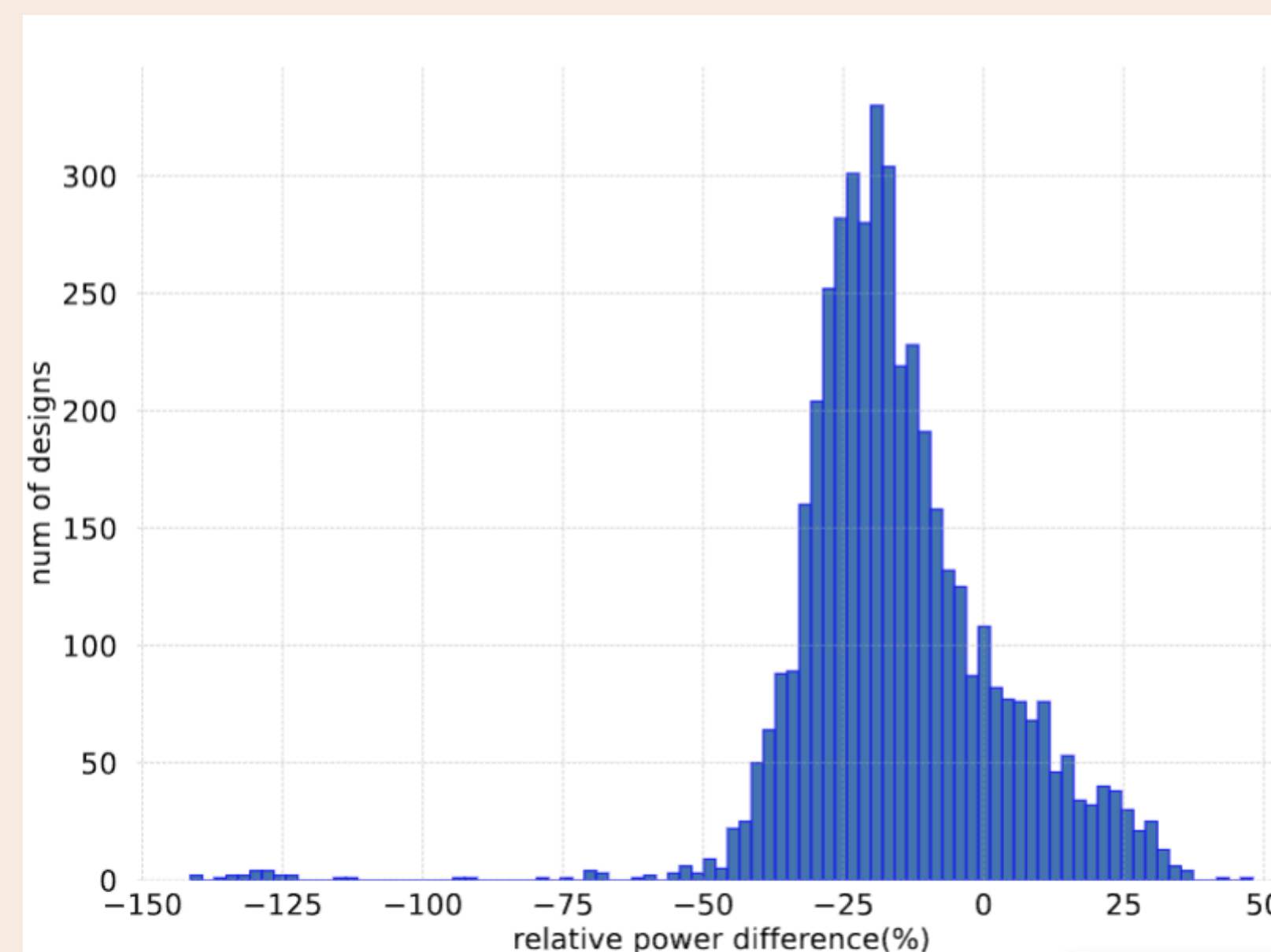
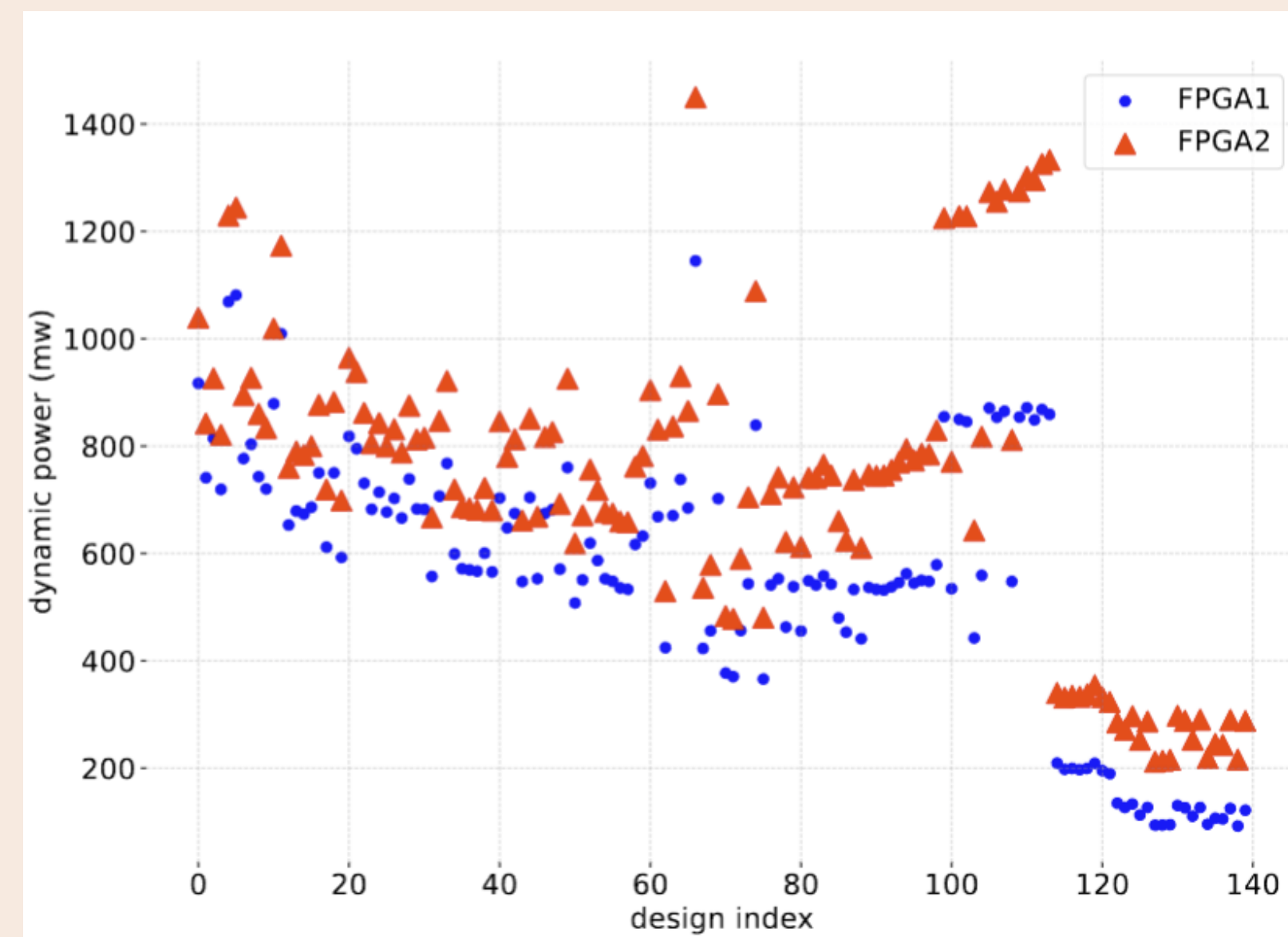


## Abstract

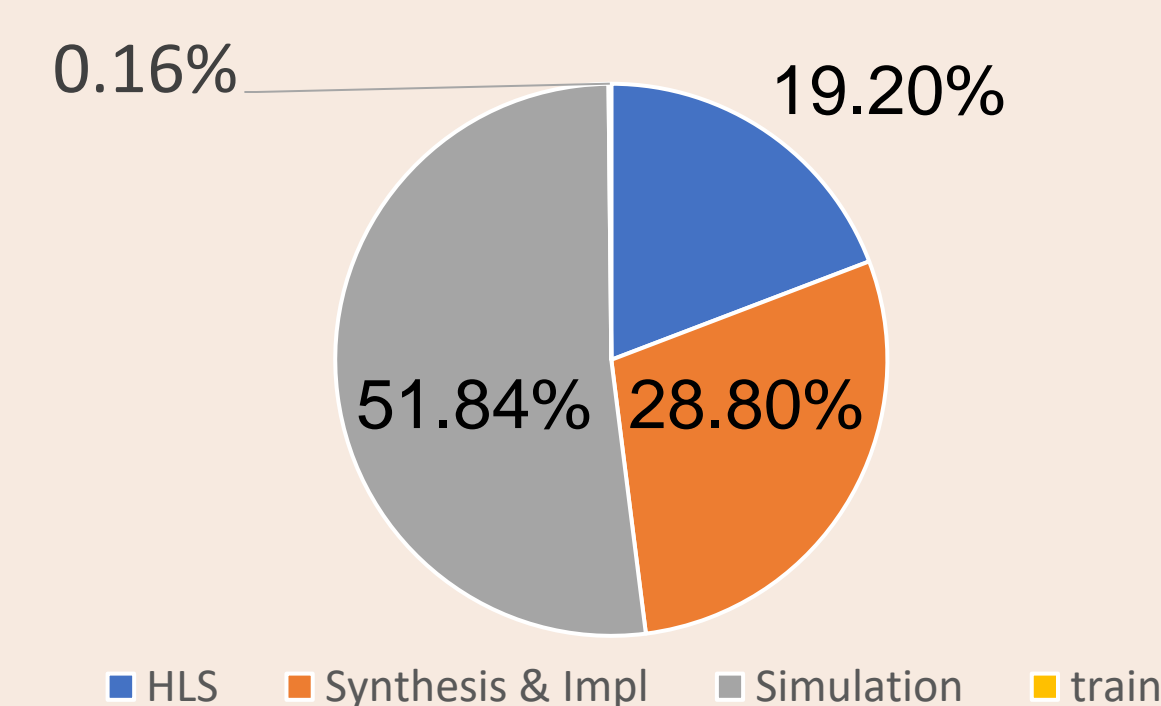
We propose a novel cross-FPGA power modeling methodology called XPNet that combines Transfer-Learning with an innovative data selection technique that enables efficient fine-tuning. XPNet is able to adapt a GNN-based power model to a second FPGA using only 20 data samples, resulting in 6.53% error. We then explore if our approach works for lighter weight ML-based models, such as multi-layer perceptron (MLP), and show less than a 1% degradation in accuracy.

## Motivation

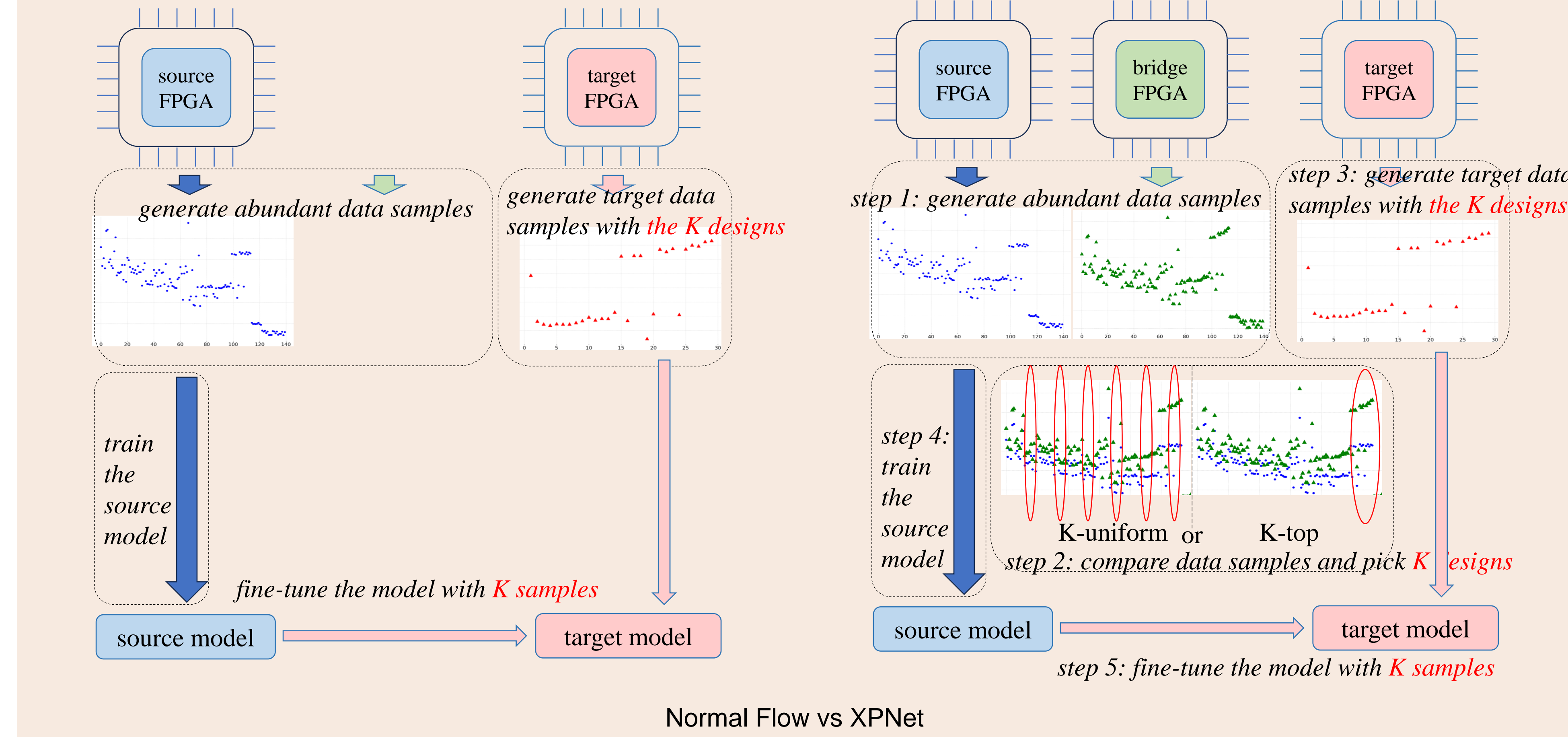
1. the model trained on one FPGA cannot be directly applied to another.



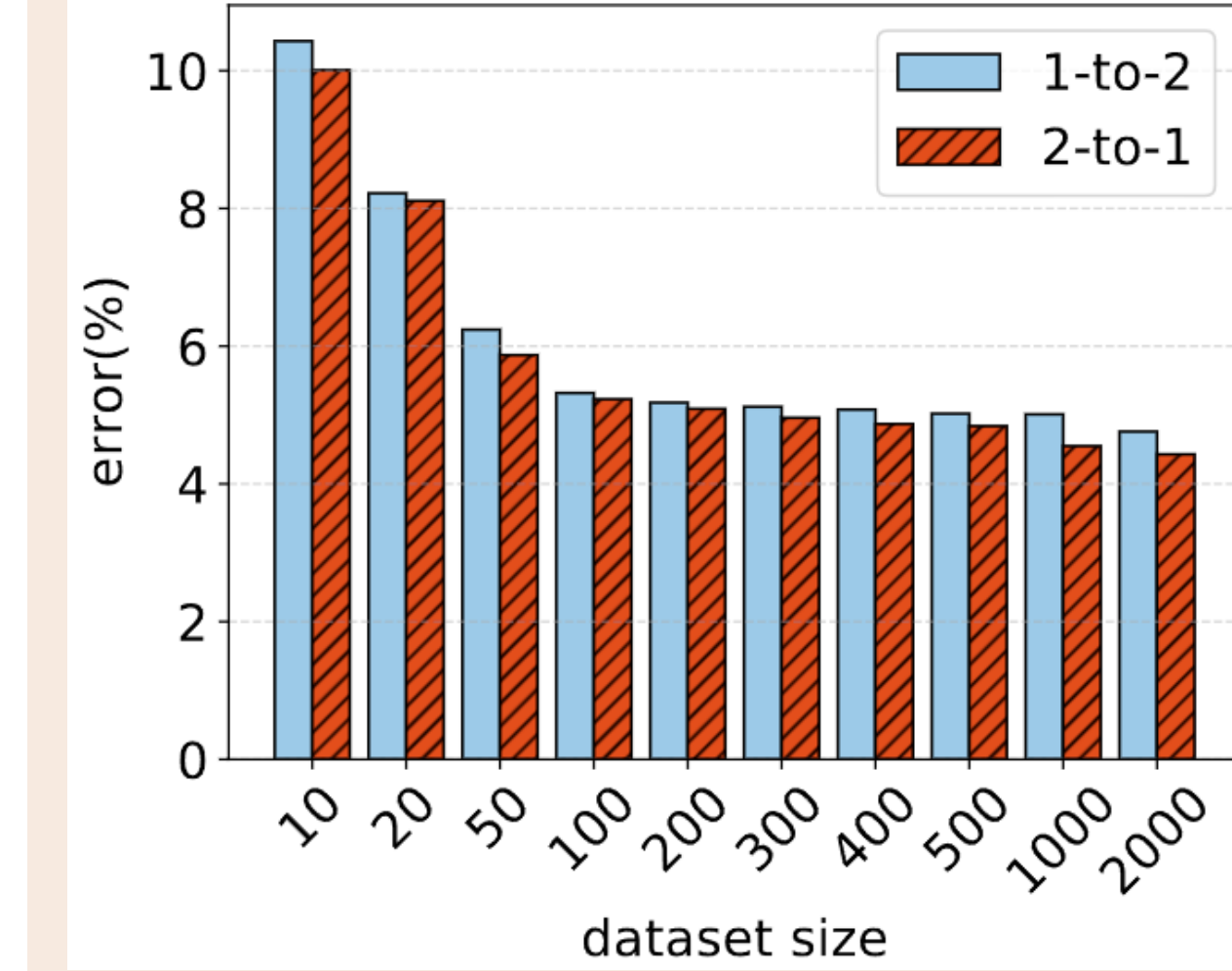
2. the dataset preparation is time-consuming



## Method

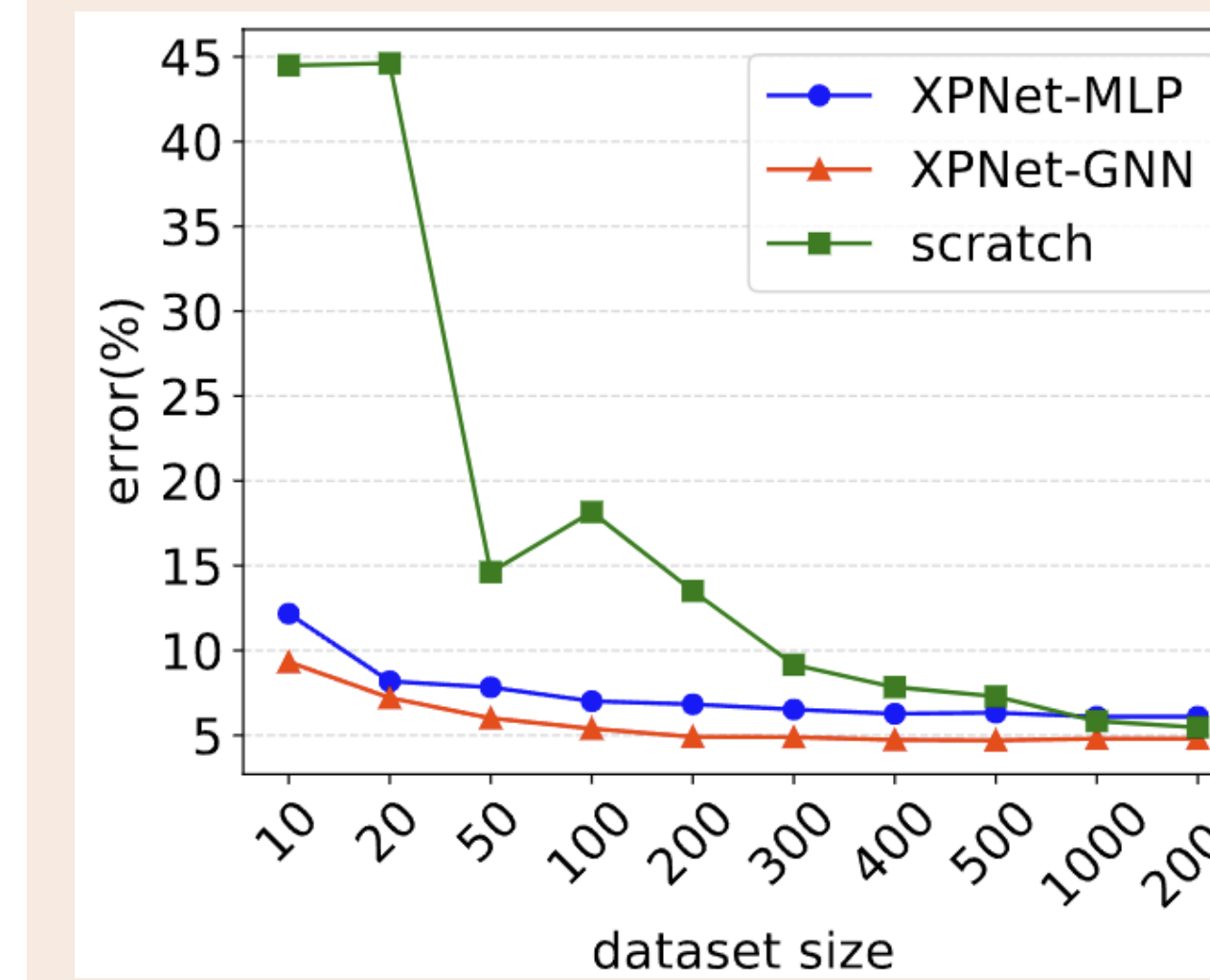


## Results (Continued)



1-to-2: pre-trained model on source FPGA1  
2-to-1: FPGA2 as source and FPGA1 as target

How sensitive to different FPGA architectures?



XPNet with MLP and GNN vs. Training from scratch

Does it work with different power models?

Learning Strategy	speedup
scratch	1
random	4.99x
XPNet	19.8x

How much time saved?

Speedup against train from scratch to achieve comparable accuracy (~6%).

## Experiments and Results

Short name	FPGA1	FPGA2	FPGA3
FPGA type	xczu9eg	xc7v585t	xcvu440
#samples	4779	4779	4779
tech node	16nm	28nm	22nm
#LUTs	274,080	364,200	2,532,960
#DSP	2,520	1,260	2,880
#BRAM(36Kb)	912	795	2,520
LUT-DSP ratio	109	289	880
DSP-BRAM ratio	2.76	1.58	1.14
SLRs	N/A	N/A	3

FPGA used in the experiments

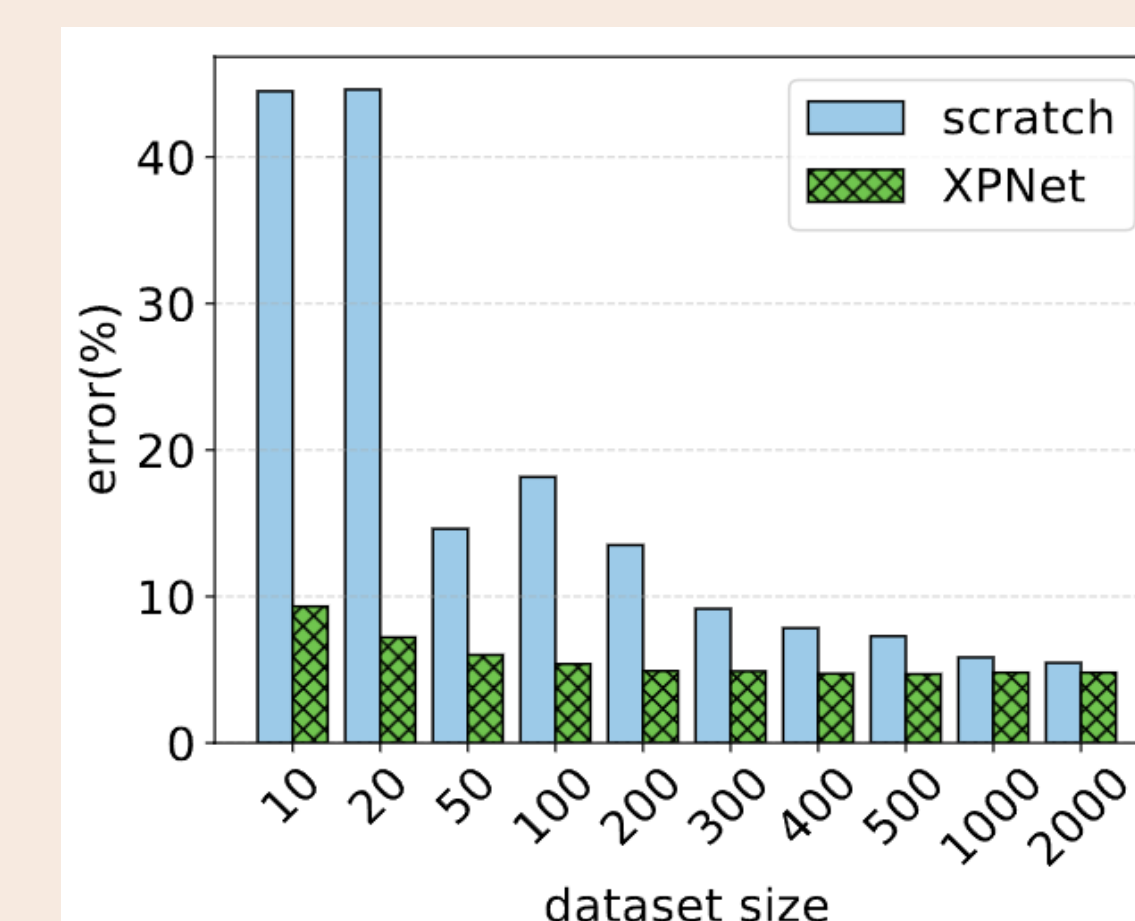
App	Error of Dynamic Power (%)			
	FPGA1		FPGA2	
	GNN	MLP	GNN	MLP
atax	3.89	4.69	5.25	5.85
bicg	3.90	4.43	5.60	5.98
gemm	5.24	5.78	6.50	7.01
gesummv	7.93	8.23	9.43	9.98
k2mm	4.25	5.08	6.00	6.47
k3mm	4.15	5.04	6.47	7.12
mv	4.64	5.34	5.62	6.22
syrk	5.31	5.68	6.22	6.53
syr2k	6.41	6.75	6.46	6.76
average	5.08	5.67	6.40	6.88

Models used in the experiments (GNN is implemented based on PowerGear (DATE'22))

- 4779 samples per FPGA  
- 14337 samples in total  
- Generated from 9 kernels of polybench

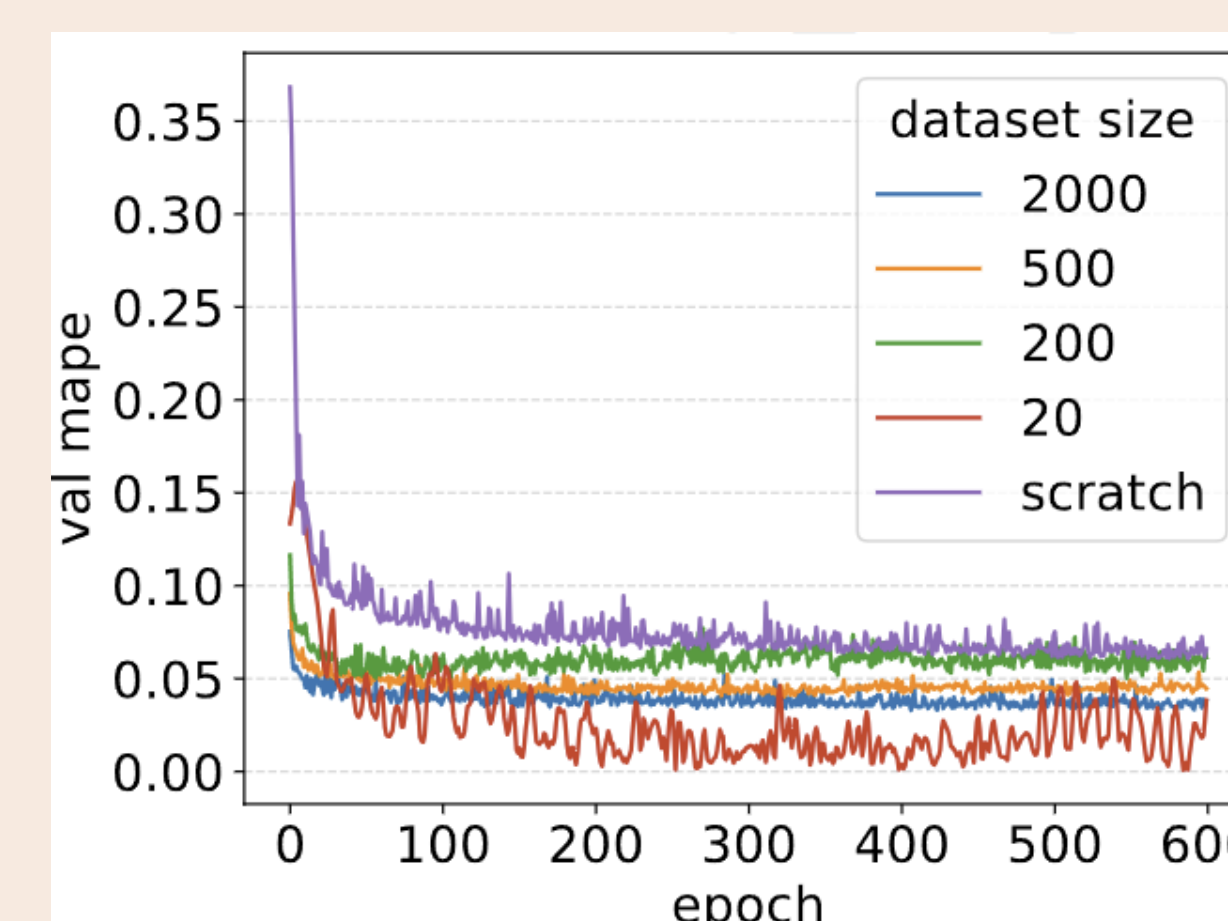


Dataset use polybench subset from HLSDataset

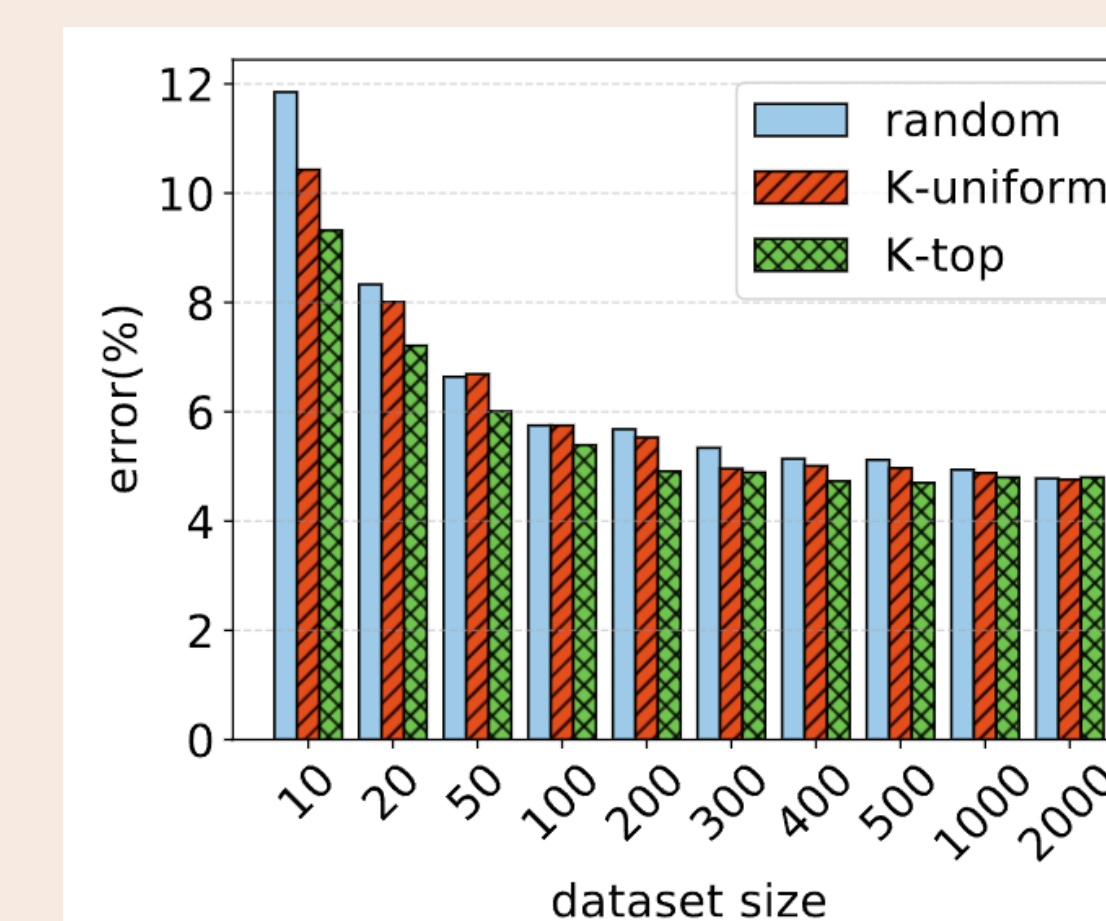


Training from scratch vs XPNet

How effective is XPNet?



Learning curve



random sample selection vs. XPNet with K-uniform, K-top sample selection

How to pick samples for transfer learning?

## Conclusion

- XPNet is able to adapt an existing power model to a new FPGA with very limited data samples (20 samples) to achieve comparable accuracy against training from scratch (6.53% error)
- The robust sampling method on design powers in XPNet helps to improve the transfer learning performance.
- XPNet is not restricted by FPGA architecture
- XPNet can be used in more than one model

## Model Construction

