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Multiphysics-Informed ML-Assisted Ch Floorplanning for Heterogeneous Integra

Vinicius C. Do Nascimento, *Student Member, IEEE*, Seunghyun Hwang, Michael Josep Tejas Kulkarni, Qiang Qiu, *Member, IEEE*, Cheng-Kok Koh, Ganesh Subbarayan, *F* and Dan Jiao, *Fellow, IEEE*

***Abstract*—The floorplan of chiplets in heterogeneously integrated systems-in-package (SiPs) must consider multiphysics (electrical, thermal, and mechanical) performance and meet positional constraints during optimization. This article sets forth an efficient framework for chiplet floorplanning subject to positional and multiphysics-performance-based constraints. Traditional multiphysics simulations, often impractical in optimization due to high computational cost, are replaced by a high-fidelity and efficient conditional image generative model via image-based machine learning (ML). This model is accurate and capable of performing real-time prediction of multiphysics performance throughout 3-D SiPs. Utilizing the image-based ML model for fast performance assessment, we further accelerate the physical design by developing a novel and highly parallelizable dynamic rank-revealing (RR) algorithm for solving the underlying constrained optimization problem. We leverage this algorithm to optimize the position of the chiplets subject to multiphysics performance directly without floorplan representation or convexification techniques while meeting a multitude of constraints. The same ML model and constraints are also integrated into a state-of-the-art corner block list (CBL) floorplan representation under a simulated annealing (SA) optimization framework. The accuracy and efficiency of the proposed optimization method are demonstrated in the floorplanning of chiplets on an interposer subject to thermal constraints, and by comparisons against ML-assisted SA-CBL for performing the same task.**

***Index Terms*—Electrical performance, floorplanning, machine learning (ML), multiphysics, optimization, physical design, placement, system-in-package (SiP), thermal integrity.**

I. Introduction

HETEROGENEOUS integration (HI) [1], [2] via advanced packaging is the assembly and packaging of individual components or chiplets, such as CPUs, GPUs, can be separately manufactured using nodes and even different semiconduc Si-Ge, InP, and SiC) onto a single subs tremendous potential to overcome the li monolithic integration technology and ef slow-down of Moore's law.

The physical design of a heterogeneous in-package (SiP) involves optimizing th shape of chiplets in the package, as Each chiplet can be fabricated by differ distinct technology nodes and is subjec tional requirements. Physical design is the final system performance. In additi the physical layout does not have design connections must be of appropriate leng violations. Moreover, an effective phys must consider multiphysics performance thermal, and mechanical performance. Cr package structure is 3-D, which increase verifying physical constraints. In early wo floorplanning [3], [4], [5], [6], such a cap well developed in prevailing physical des

One must rely on fast predictive mo multiphysics performance to facilitate physical design iterations. However, a physics performance of a 3-D SiP rema even with today's most efficient simulatio the underlying optimization problem is di it is not only nonconvex and nonlinear high-dimensional design space with a la straints [7]. The nonconvexity arises from