

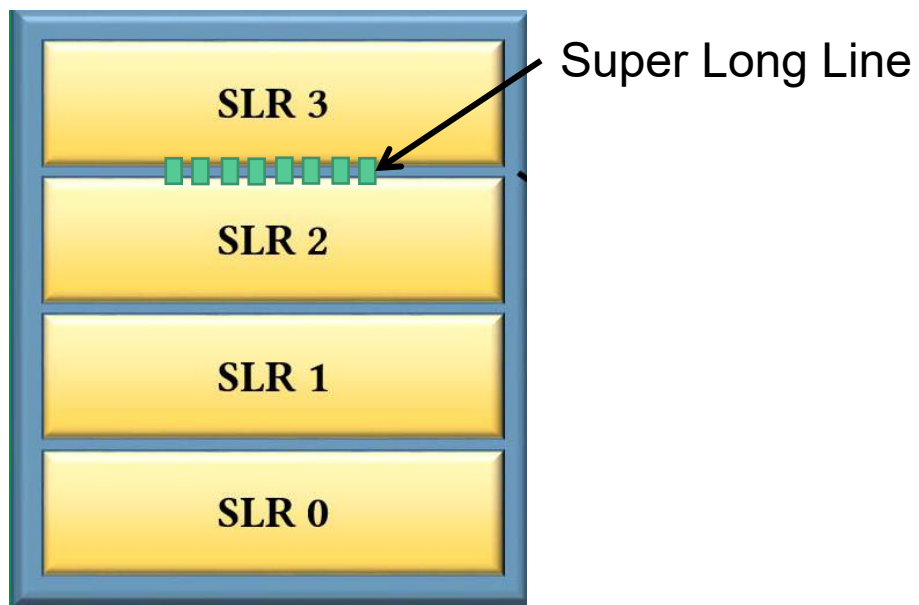
赛题解析

西安电子科技大学 祁仲冬

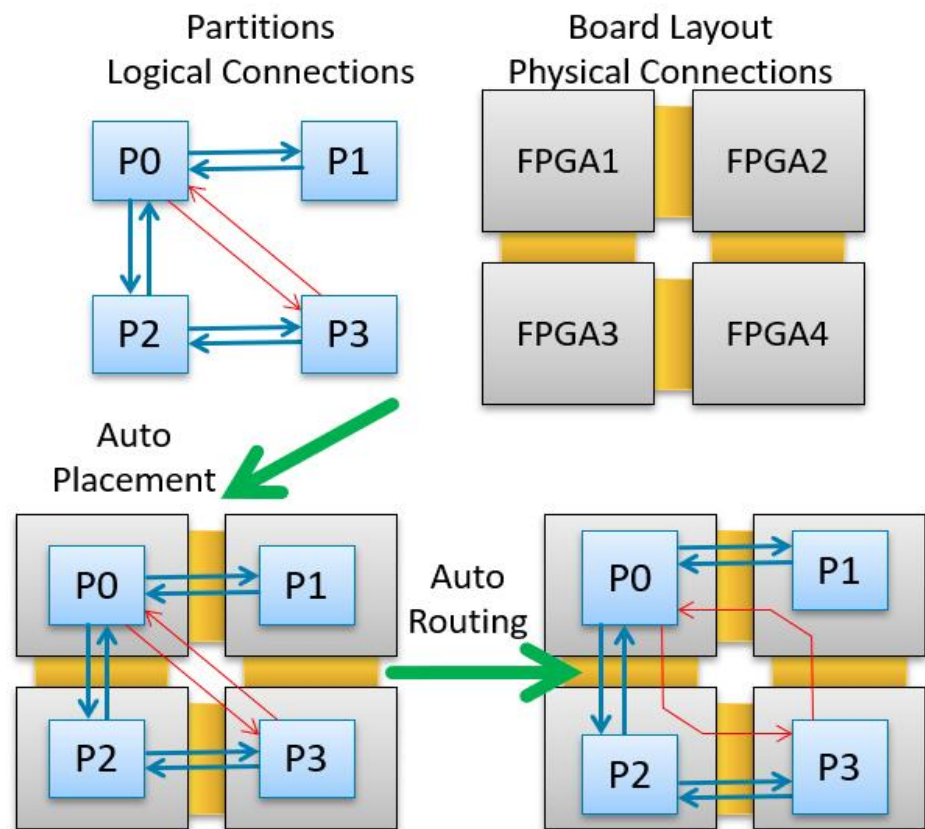
赛题背景

多Die封装的FPGA

- Super Logic Region (SLR)
- Super Long Line (SLL)

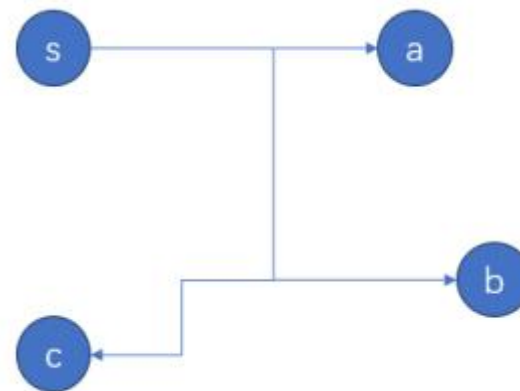
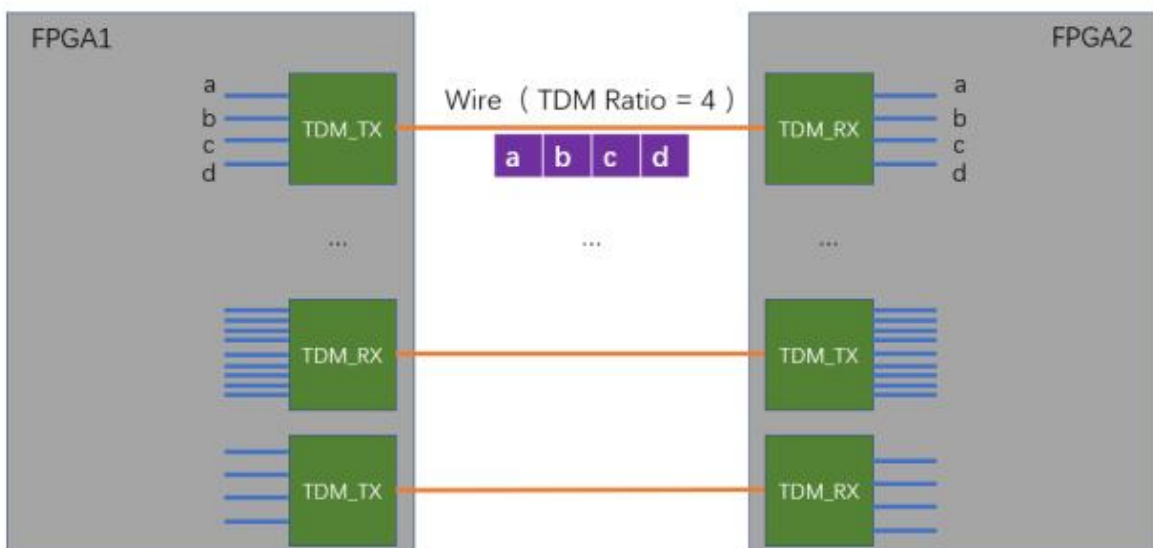


多FPGA系统划分与布线

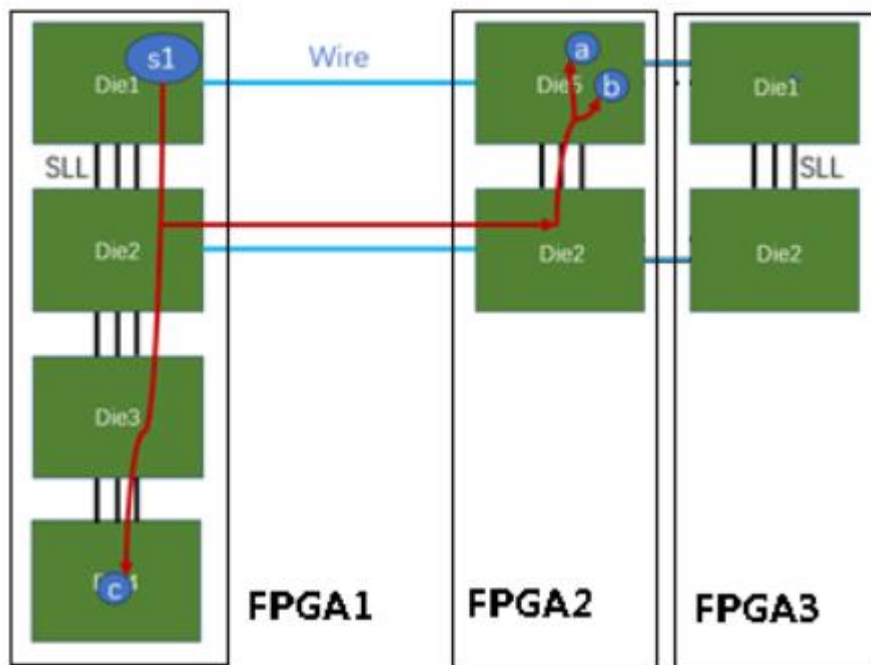
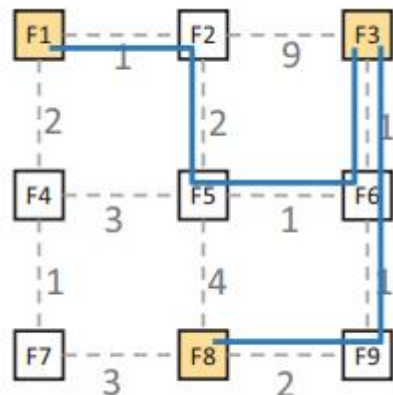


基本概念

- 划分：将一个电路分割为多个部分，每个部分称为一个划分。
- TDM：Time Division Multiplexing，时分复用，通过在一条线路上顺序传输不同信号，达到复用线路的效果。
- 线网：一条线网（net）连接一些端点，信号从其中一个端点（Source）传递到其他端点（Sink）。



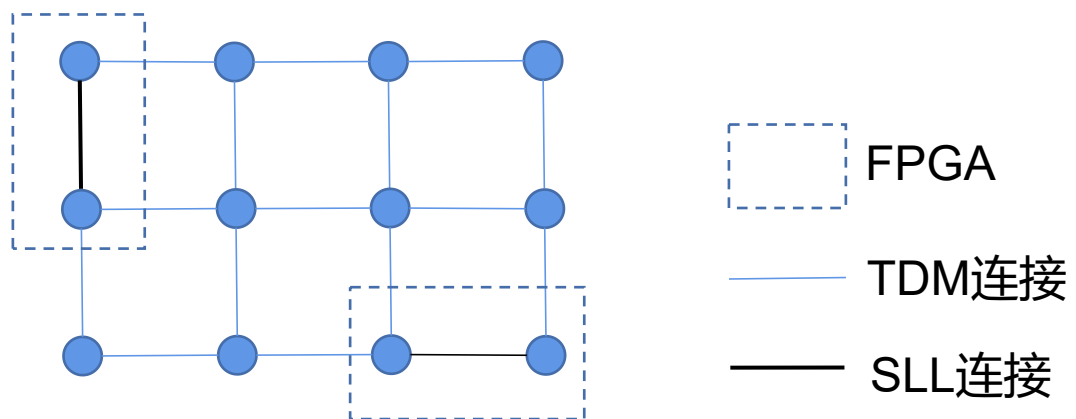
赛题解析



- 布线的目标是 minimized 各线网的最大时延
- 一条线网的最大时延是从Source端点到各Sink的时延中的最大值
 - $\max((\sum(Tc * Delay)))$
 - 同一个FPGA内的Die之间的Tc取值为该线网横跨Die的个数
 - 不同FPGA之间的Tc取值为0.5
- 经过每个Die的信号延Delay取值为1
- $TDM\ Delay = A + B * Ratio$
 - Ratio基数为4, 向上按倍数逐步增加
 - A为常量1, B为常量2

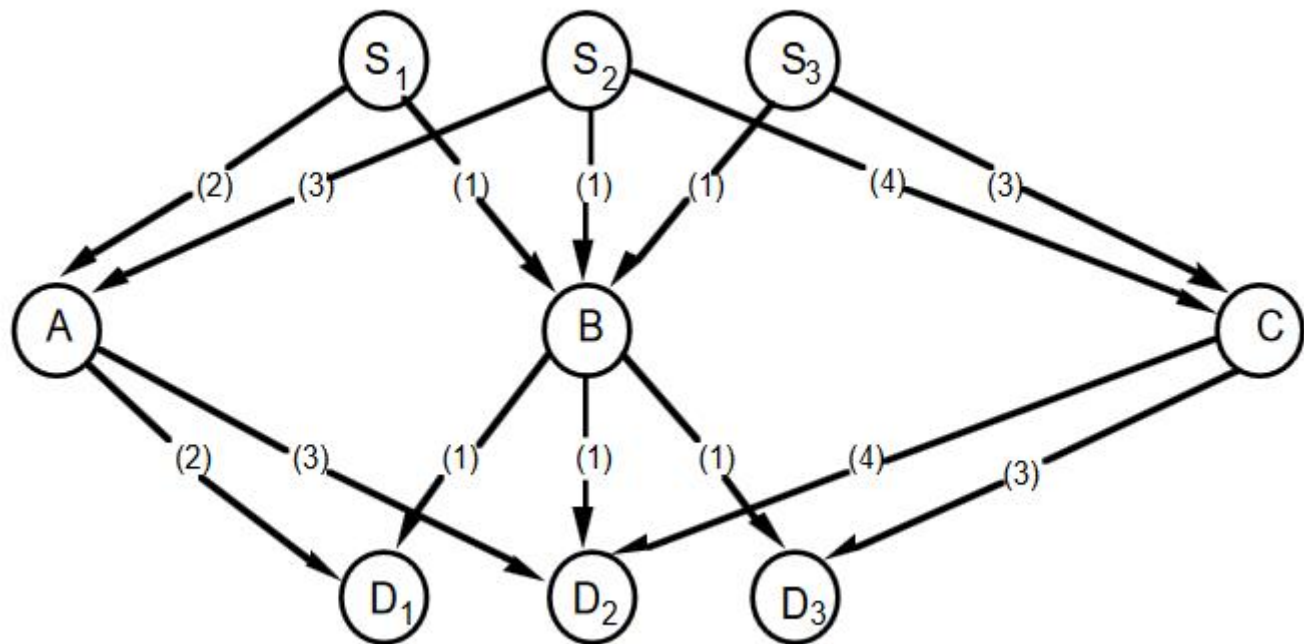
赛题解析

- 布线容量约束为SLL数量
- 时延的计算公式是考虑TDM和SLL的加权线长



解题思路

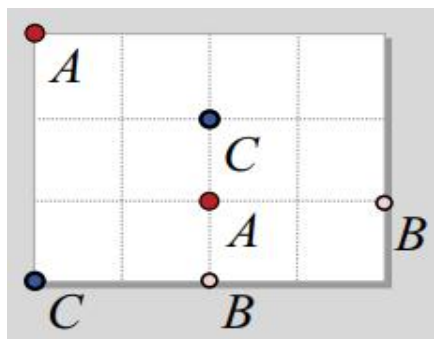
- 基于协商的拆线重布



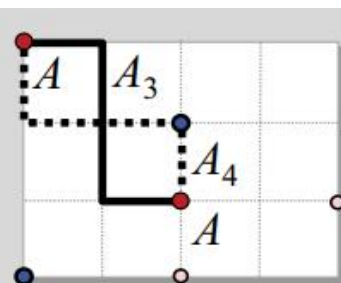
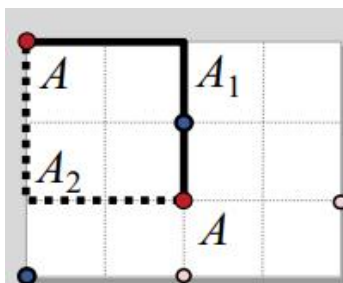
L. McMurchie and C. Ebeling, "Pathfinder: A negotiation-based performance-driven router for FPGAs," in Proc. Int. Symp. FieldProgrammable Gate Arrays, 1995, pp. 111–117.

解题思路

- 基于数学规划的并行布线



min TotalCost



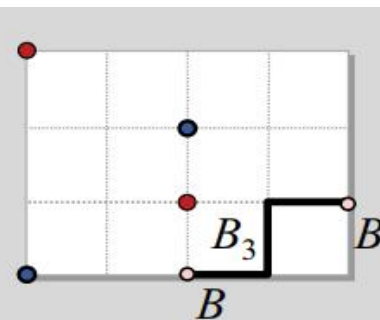
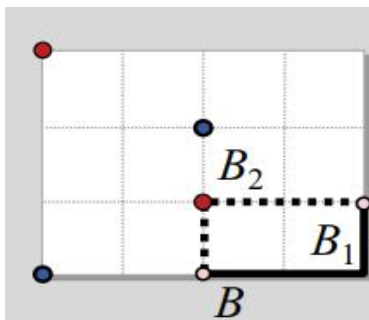
Net Constraints:

$$x_{A1} + x_{A2} + x_{A3} + x_{A4} \leq 1$$

Variable Constraints:

$$0 \leq x_{A1} \leq 1, 0 \leq x_{A2} \leq 1,$$

$$0 \leq x_{A3} \leq 1, 0 \leq x_{A4} \leq 1$$



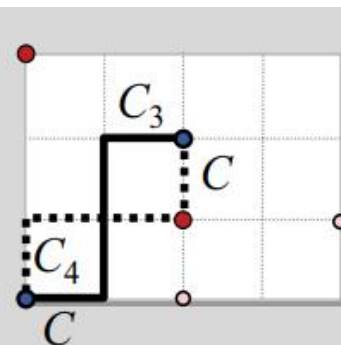
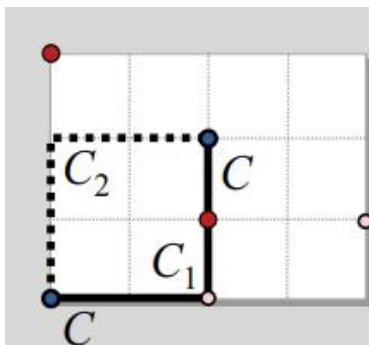
Net Constraints:

$$x_{B1} + x_{B2} + x_{B3} \leq 1$$

Variable Constraints:

$$0 \leq x_{B1} \leq 1, 0 \leq x_{B2} \leq 1,$$

$$0 \leq x_{B3} \leq 1$$



Net Constraints:

$$x_{C1} + x_{C2} + x_{C3} + x_{C4} \leq 1$$

Variable Constraints:

$$0 \leq x_{C1} \leq 1, 0 \leq x_{C2} \leq 1,$$

$$0 \leq x_{C3} \leq 1, 0 \leq x_{C4} \leq 1$$

$$\begin{array}{l} G(0,0) \sim G(1,0) : \quad x_{C1} + x_{C3} \leq \sigma(G(0,0) \sim G(1,0)) = 1 \\ G(1,0) \sim G(2,0) : \quad x_{C1} \leq \sigma(G(1,0) \sim G(2,0)) = 1 \end{array}$$

相关论文

- Peng Zou, Zhifeng Lin, Xiao Shi, Yingjie Wu, Jianli Chen, Jun Yu, Yao-Wen Chang: Time-Division Multiplexing Based System-Level FPGA Routing for Logic Verification. DAC 2020: 1-6
- Dan Zheng, Xiaopeng Zhang, Chak-Wa Pui, Evangeline F. Y. Young: Multi-FPGA Co-optimization: Hybrid Routing and Competitive-based Time Division Multiplexing Assignment. ASP-DAC 2021: 176-182
- Wei-Kai Liu, Ming-Hung Chen, Chia-Ming Chang, Chen-Chia Chang, Yao-Wen Chang: Time-Division Multiplexing Based System-Level FPGA Routing. ICCAD 2021: 1-6

谢谢!

Q&A