



華中科技大學

Huazhong University of Science and Technology

BlockMaestro：在GPU系统中启用对程序员透明的 基于任务的执行模型

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明德厚学 求是创新

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华中科技大学西十二教

2019年9月 日

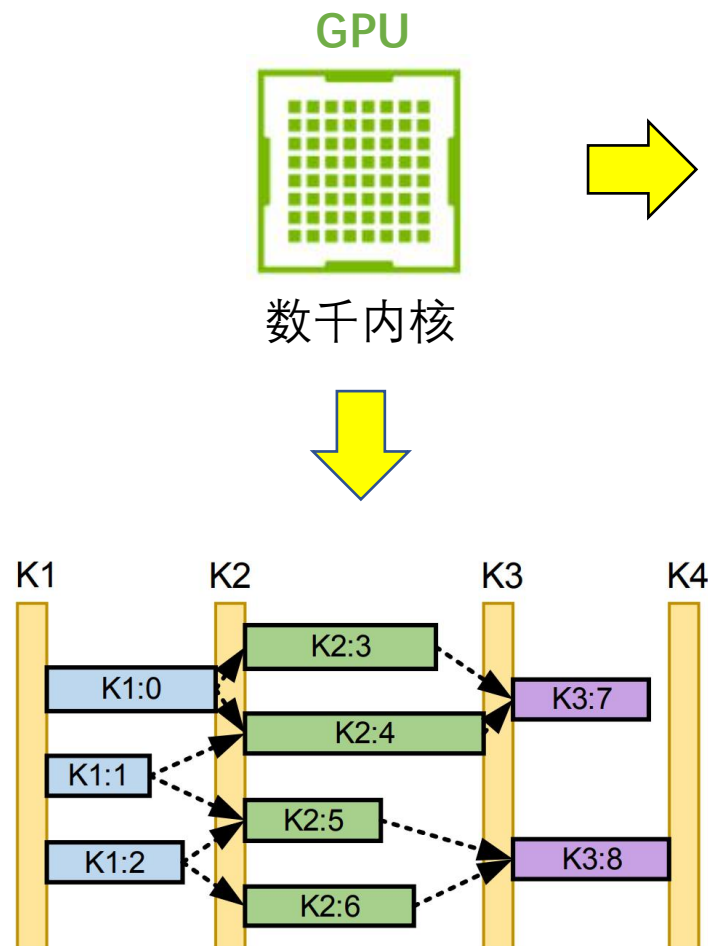
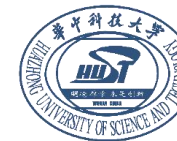
01

背景介绍

Background



GPU



高启动开销 (5-30us/K)

高数据依赖导致等待

低GPU利用率

基于任务的执行模型

- 优点：解决了数据依赖导致的等待问题
- 缺点：需要程序员指定任务依赖关系

02

BlockMaestro设计

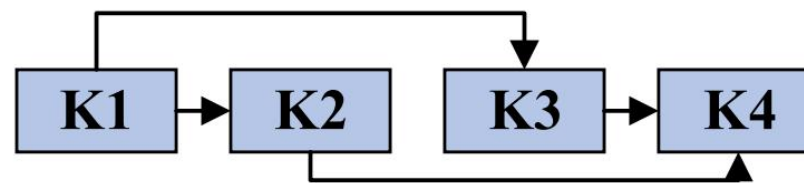
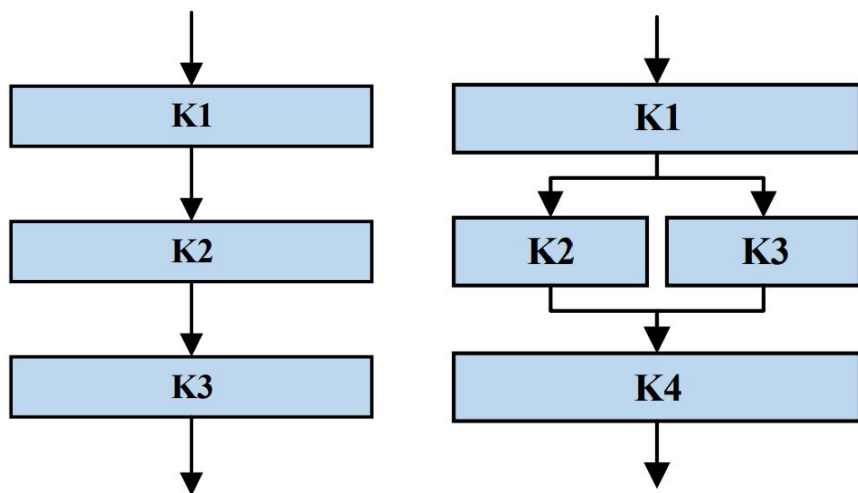
Design of BlockMaestro



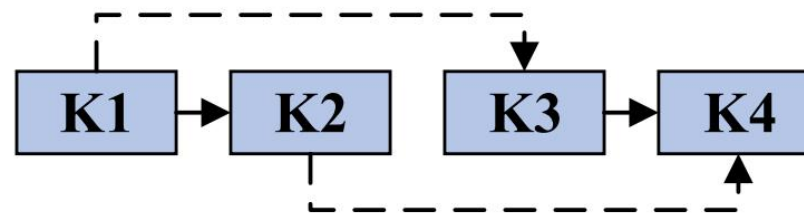
- 如何识别和提取内核线程间的数据依赖关系呢？
- 如何减少内核启动开销呢？
- 如何保证内核预启动的正确性呢？

一、提取内核间的数据依赖关系

1. 内核—内核依赖关系



Without in-order kernel completion



With in-order kernel completion

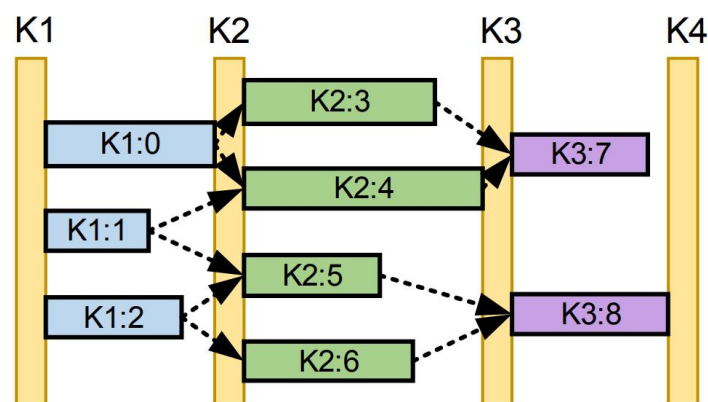
一、提取内核间的数据依赖关系

2. 线程块依赖关系

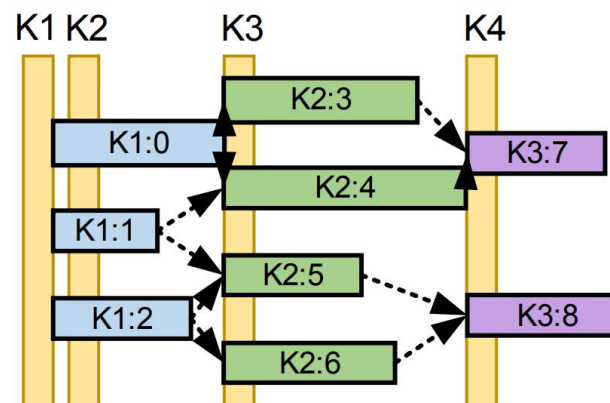
- 在内核启动时，JIT编译程序即时分析线程块间数据依赖。
- 在线程块粒度上识别每个线程块所涉及的数组索引。

二、内核预启动

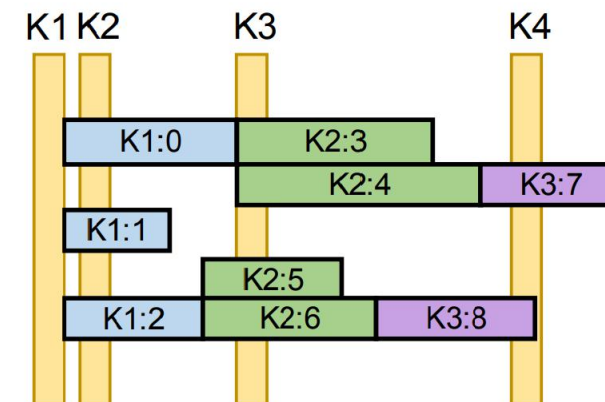
概述:



(a)



(b)

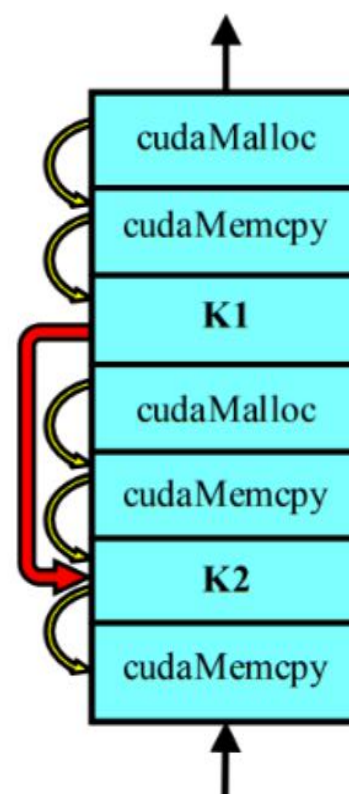
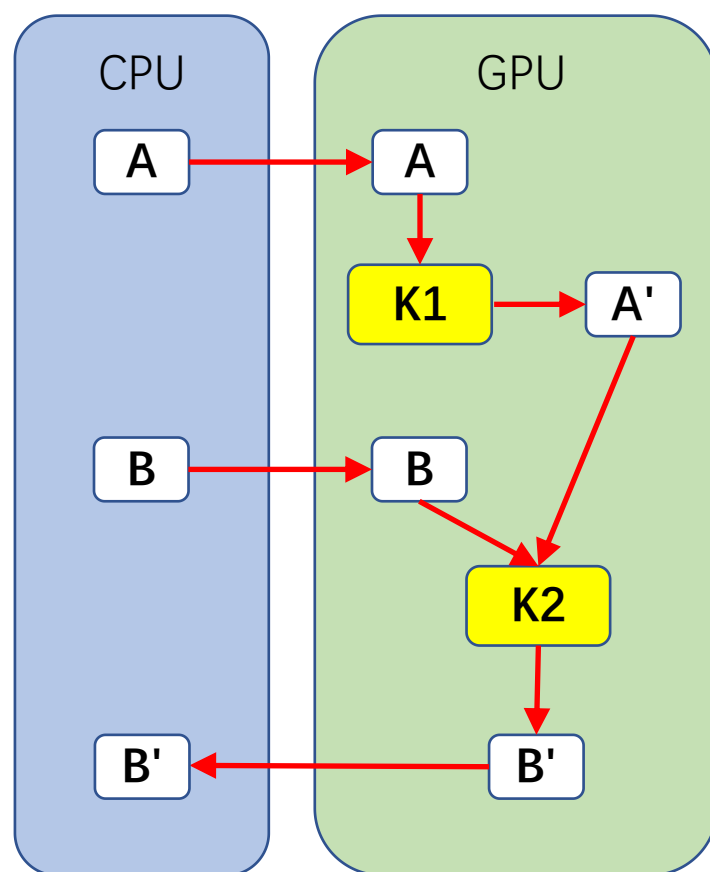


(c)

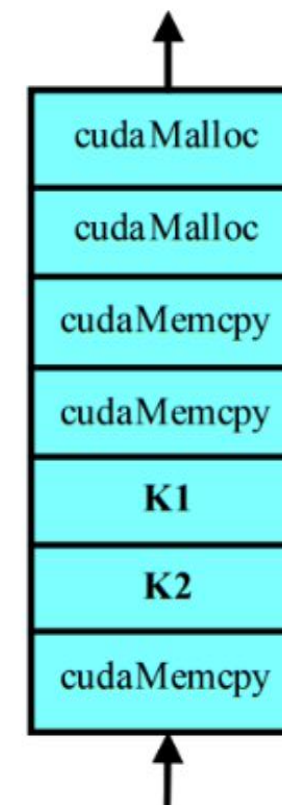
BlockMaestro设计

二、内核预启动

准备工作：程序员透明的API命令重排序



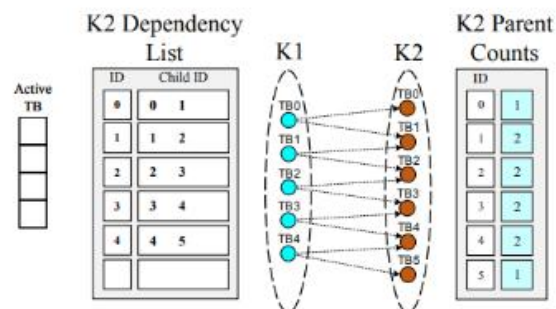
(a)



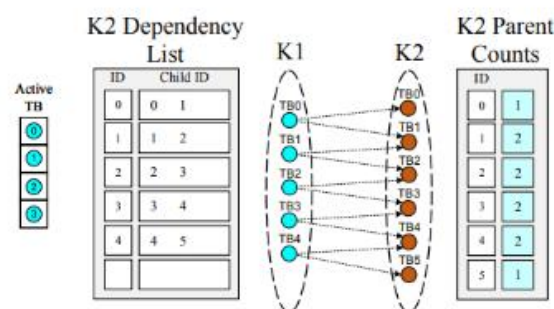
(b)

三、动态解析任务数据依赖关系

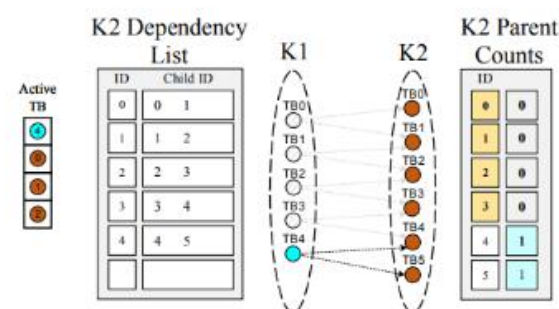
确保预启动内核的正确性



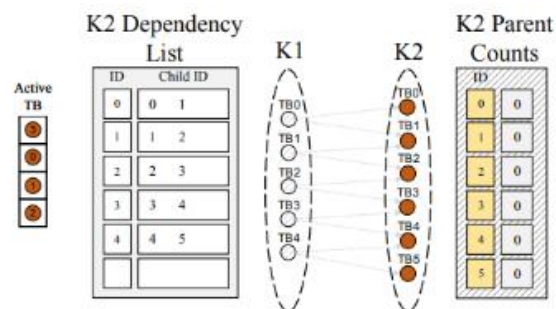
(a) Initial state; K1 is ready to execute on GPU.



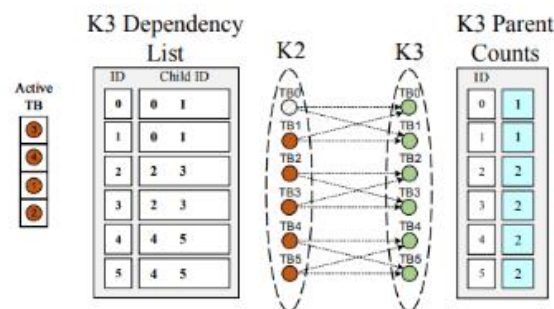
(b) First TBs from K1 are scheduled.



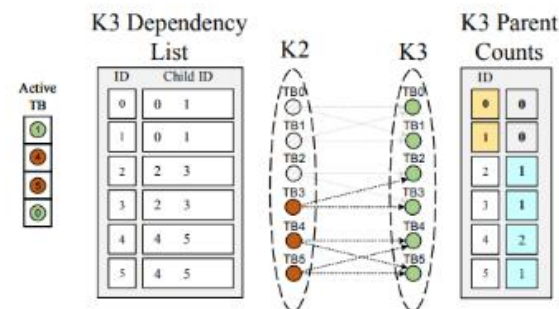
(c) First TBs from K1 finish, resolving the dependencies of their respective TBs from K2, allowing them to run.



(d) K1 is complete. It can now be replaced by the kernel after K2. Other TBs from K2 can now run. Parent count is invalidated.



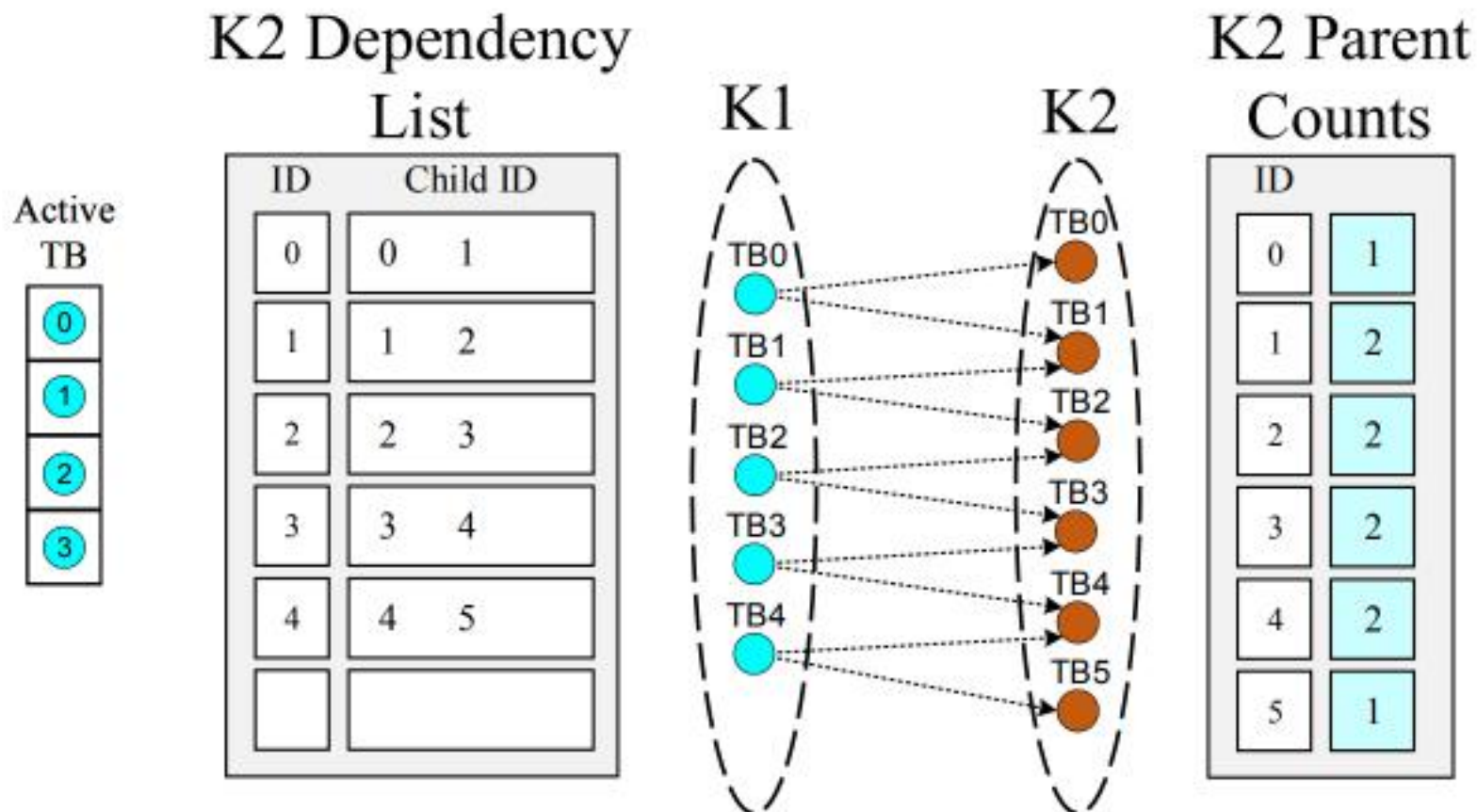
(e) K3 has launched and its dependency list is read from the memory. TB 0 from K2 has finished. Thus its children's parent counts should be decremented in the TB scheduler.



(f) More TBs from K2 finish, resolving the dependencies of their child TBs from K3. First K3 TBs begin execution.

三、动态解析任务数据依赖关系

确保预启动内核的正确性



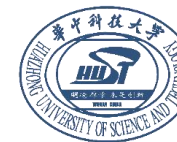
03

实验

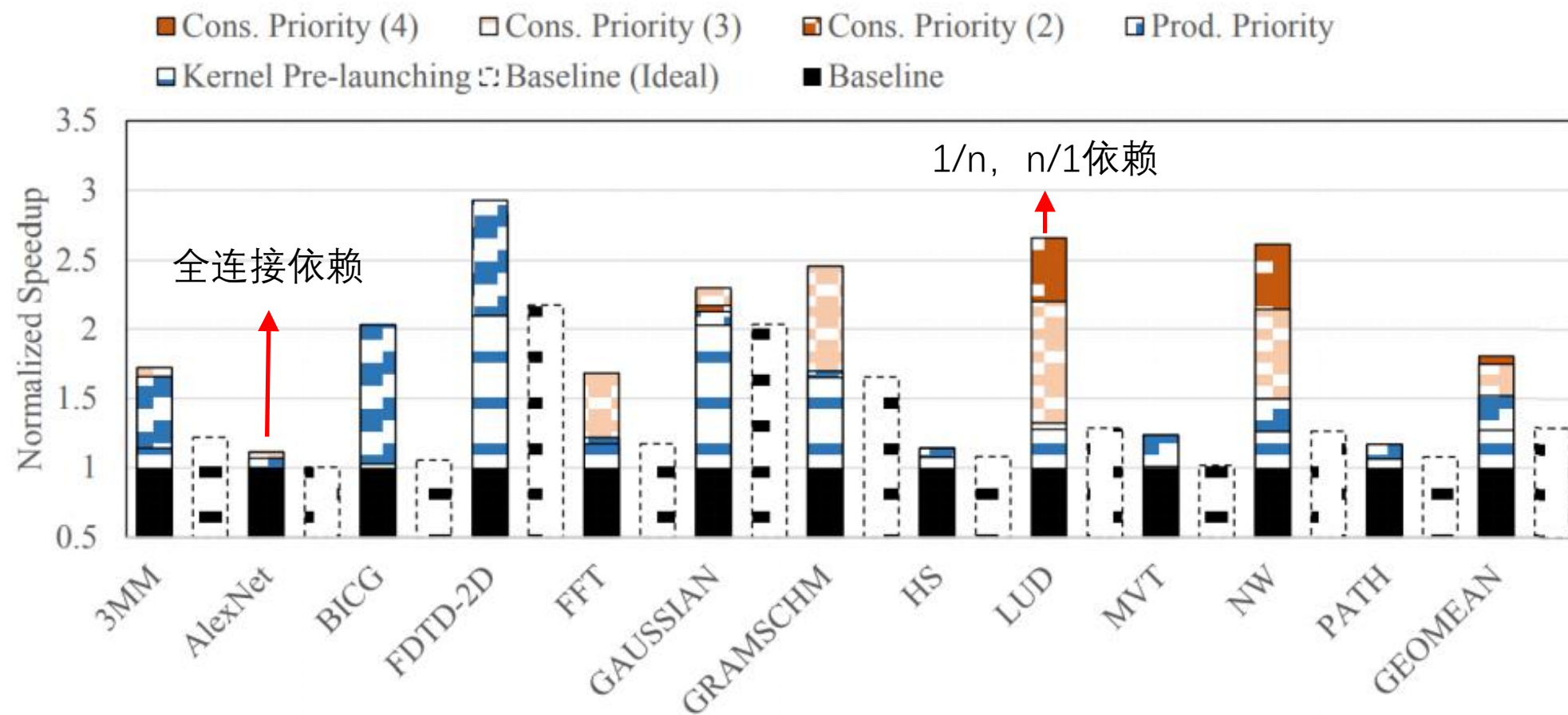
Evaluation



实验结果



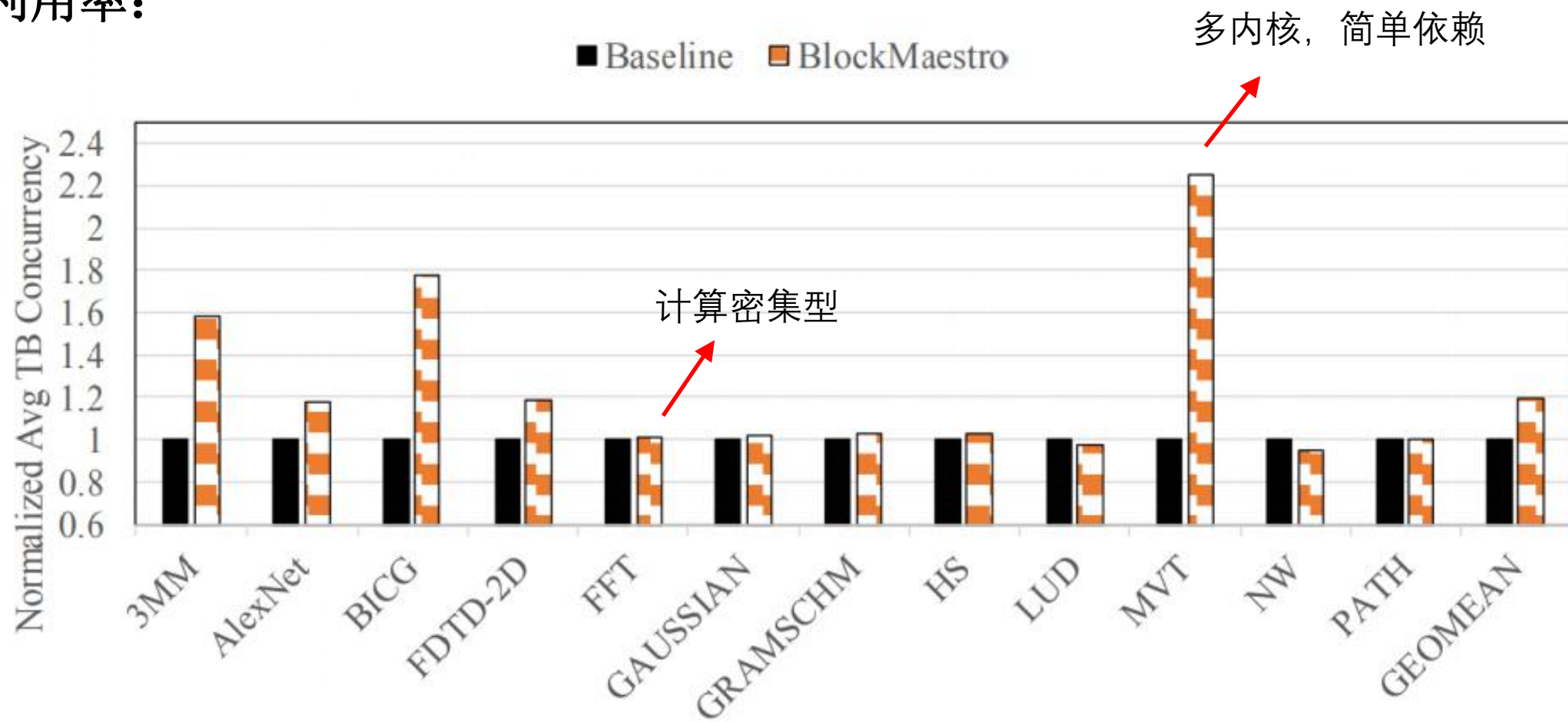
加速:



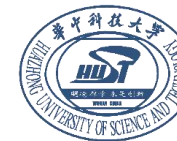
实验结果



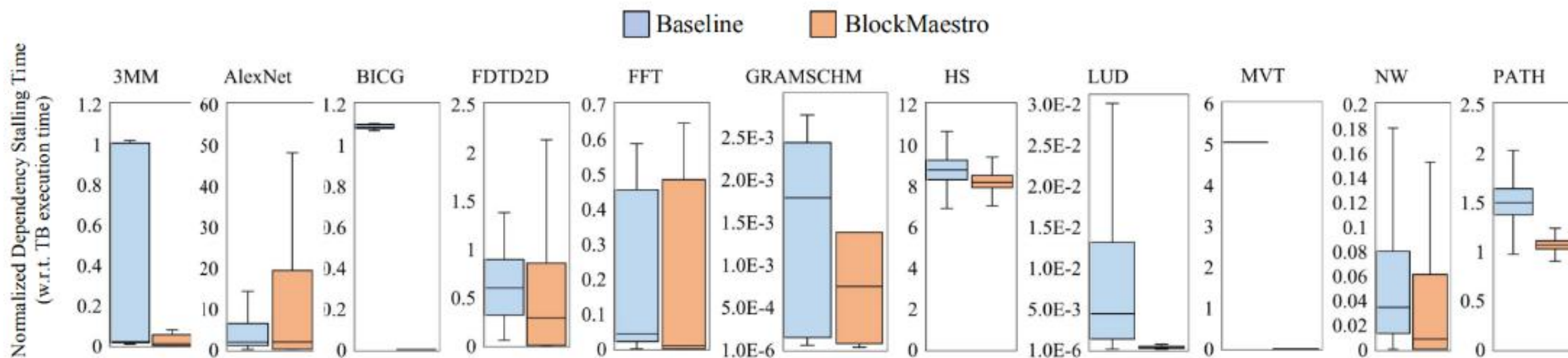
利用率:



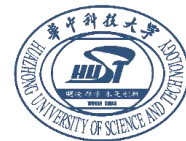
实验结果



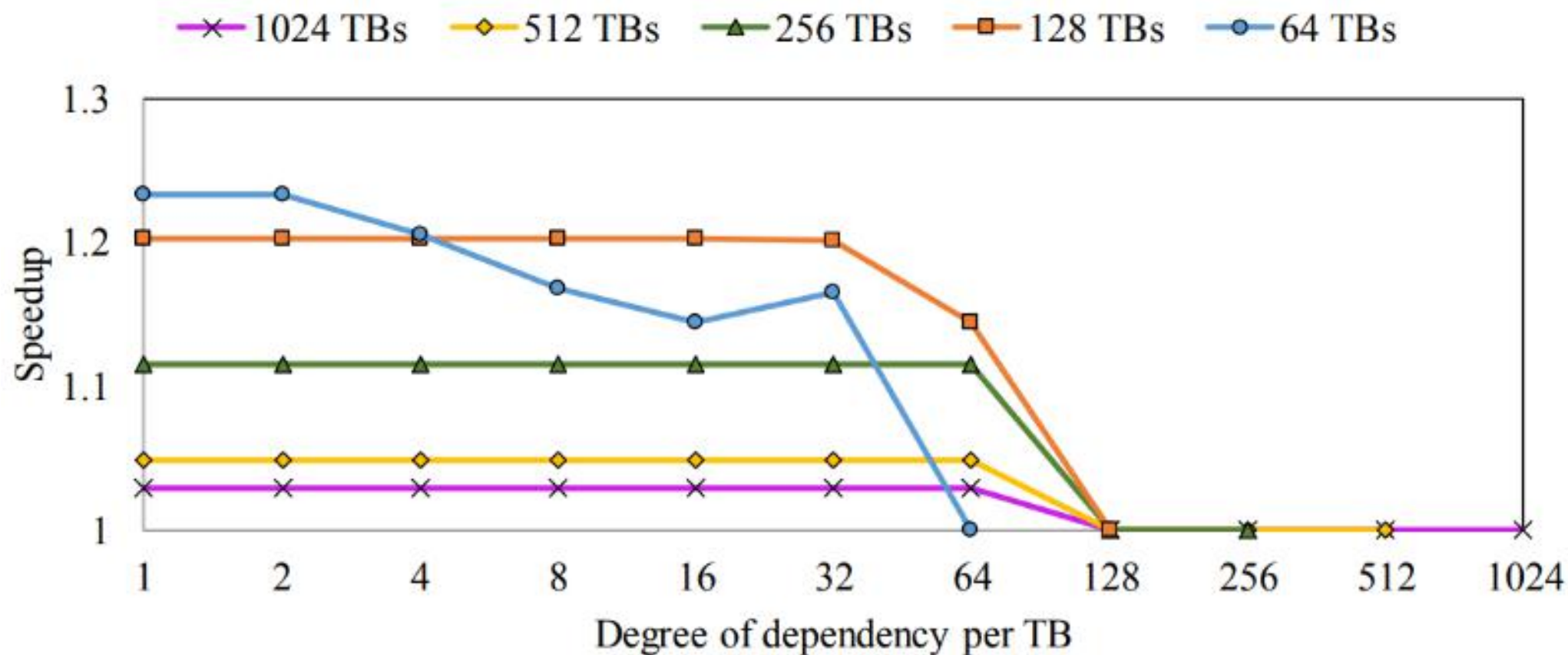
等待时间:



实验结果



依赖关系分析:



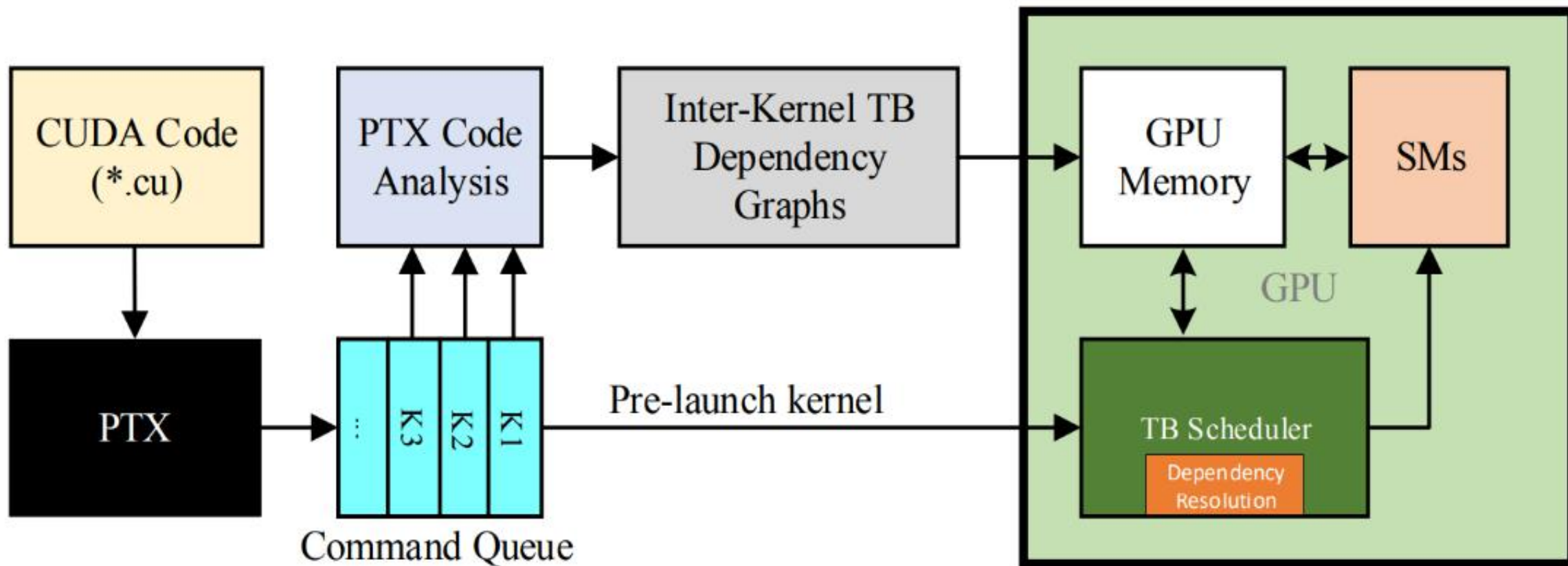
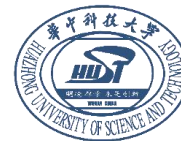
04

总结

Summary



总结





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THANKS

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