AAHLS (Lab 3)

1. 簡介

本報告探討 AAHLS（Lab3），內容分為三個部分。第一部分著重在解釋 host program(host.cpp)中，透過 OpenCL 配置以及調用 u50 對 application program 進行硬體加速的流程。在二部分則著重在 kernel 的優化，分析不同優化方法對於 kernel 以及整體 application program 的 timeline 影響。第三部分則是 LAB3 的相關截圖。

2. 報告內容

#1:

(1) 內容:

整體 host program 分為幾個部分，分別是: Target Device 的識別、OpenCL 的 context、program 以及 CommandQueue 的建立、load Binary file 以及 create Kernel，再來是創建 system/global memory，設定 kernel argument 和 data transfer，然後是配置 CommandQueue，標示不同 kernel 之間的 dependency，已執行 kernel，最後是將結果讀回 system 以確認是否正確。(Option) : 可以透過 profiling 分析不同 kernel 以及 kernel 對 system 的執行狀況優化 host program 或 kernel design。接下來會進行進一步的講解。

首先先確認 main 的 argc 的數量是否是 4，接著依序進行 PCIE 上所有 platform 的搜尋，找到目標 platform 後進行同一 platform 下 devices 的搜尋，最終回傳目標 device(U50)。

接著創建 context，依據 context 創建 CommandQueue，並將 binary file load 進 memory，透過 context 和 xclbin_Memory 創建 program，再將 target device 和 program 綁定。

再來就能透過 program 創建 kernel，並分配 host memory(此 project 有 3 個)，以及 global memory(此 project 有 7 個)，接著分配 arguments 到各 kernel，為 kernel 開始運作做準備。在分配 host memory 部分，要注意 4K alignment，在傳輸 data 到 global memory 才能更迅速。

然後就可以開始 copy data 從 host memory 到 global memory 並且配置 kernel 的 CommandQueue。這邊有兩點要注意:
第一是從 host memory 傳輸 data 要使用 clEnqueueMigrateMemObjects，因為它能更靈活判斷傳輸 data 的時機，在確保資訊在 dependent command 執行前進行傳輸，而不用向 clEnqueueWriteBuffer / clEnqueueWriteBuffer 一樣會 halt 住，等待傳輸完成才能繼續執行。而 buffer size 在這邊是一個重要的點，過大的 buffer size 會導致 waste，而

過小則會使的 PCIE 的 utilization 太低，可以透過簡單實驗找出平衡點，根據具體情況進行 tradeoff。

第二則是 CommandQueue 的配置要描述清楚不同 kernel 間 dependency。尤其是 out-of-order 的模式，這樣才能讓 accelerator 的 utilization 最高。

最後則是執行 kernel 並將結果從 global memory transfer 到 host memory，並比較結果是否正確以及對整體系統進行 profiling。後兩步是 option，通常是在開發階段會採用。當然也不要忘了最終要 release mem object 以及 free host memory，否則執行時間久了會出現 memory leakage 問題。

#2:

(1) 內容:

從 baseline 可以看出，CommandQueue 雖然是 out-of-order 模式，但 host 並沒有真正設定 parallel execution，而是依序執行。

而到 KernelParallel 部分，CommandQueue 總算設定好不同 kernel 之間的 dependency，使得 KB 和 KA，KpB 和 KvConstantAdd 可以同時執行，此時 KB 要在 KpB 後執行，KA 要在 KvConstantAdd 後執行，而 KCalc 則在 KA 和 KB 之後。

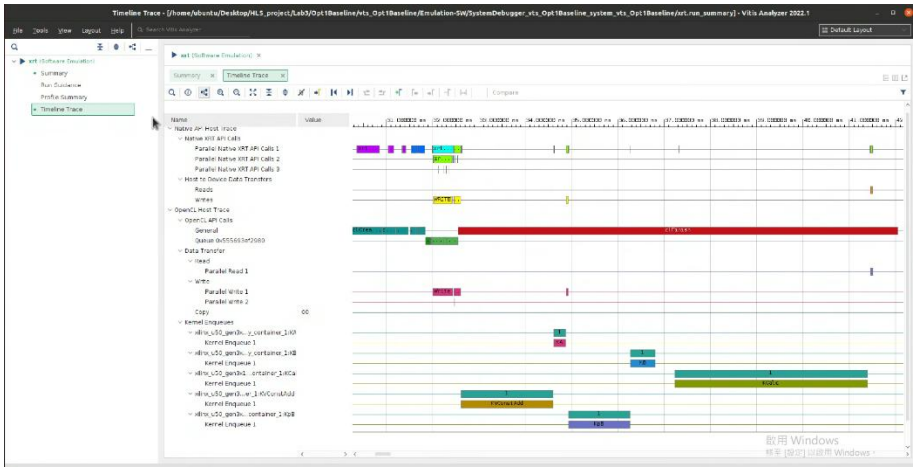
再來到 DataBurst 支援使用 burst 方式進行資料傳輸，這部分優化加快 kernel KpB 的執行速度，讓它跟 KvConstantAdd 一樣快，使 KB 執行更快，降低 KCalc 等待時間。

最後是使用 array partition 方式，進一步 boost kernel 的執行速度。

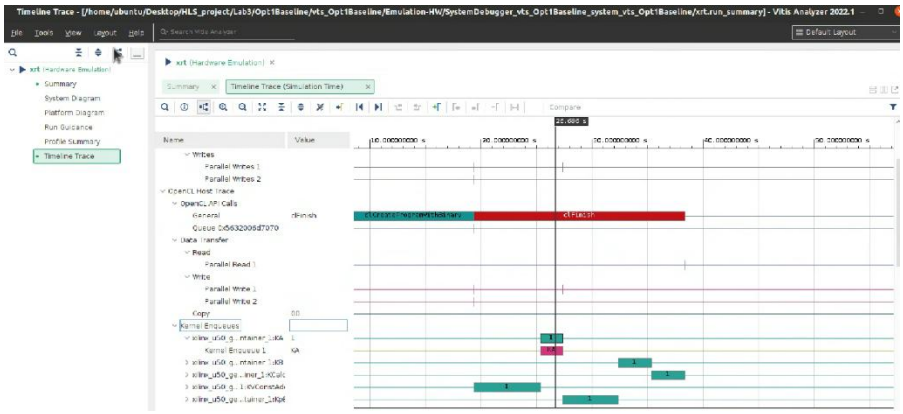
#3:

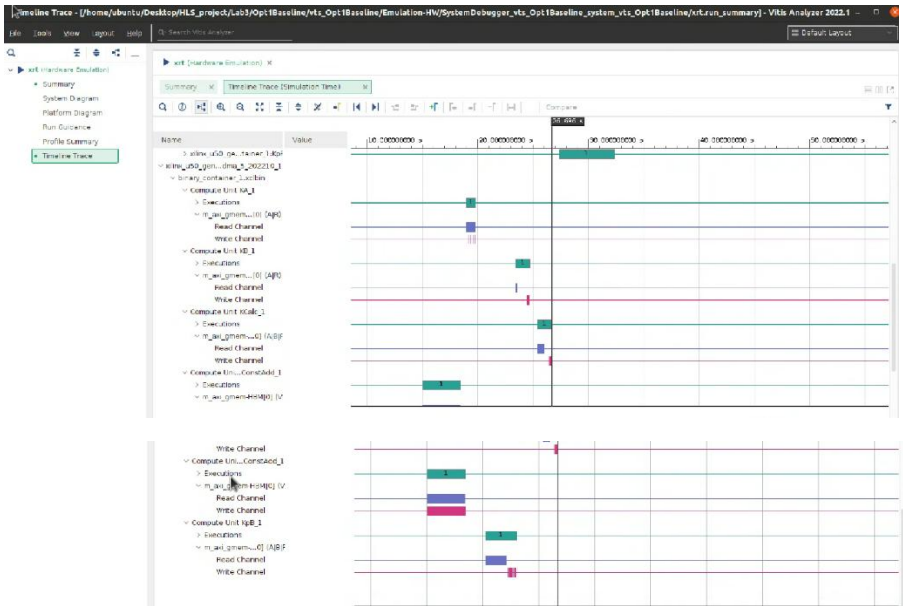
(1) Opt2Baseline

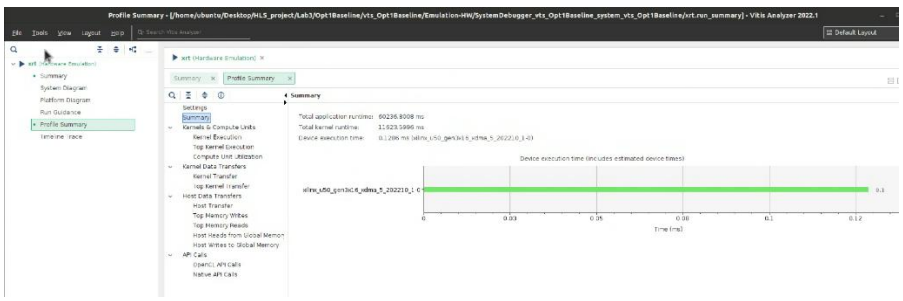
I. Software emulation



II. Hardware emulation







(2) Opt2KernelParallel

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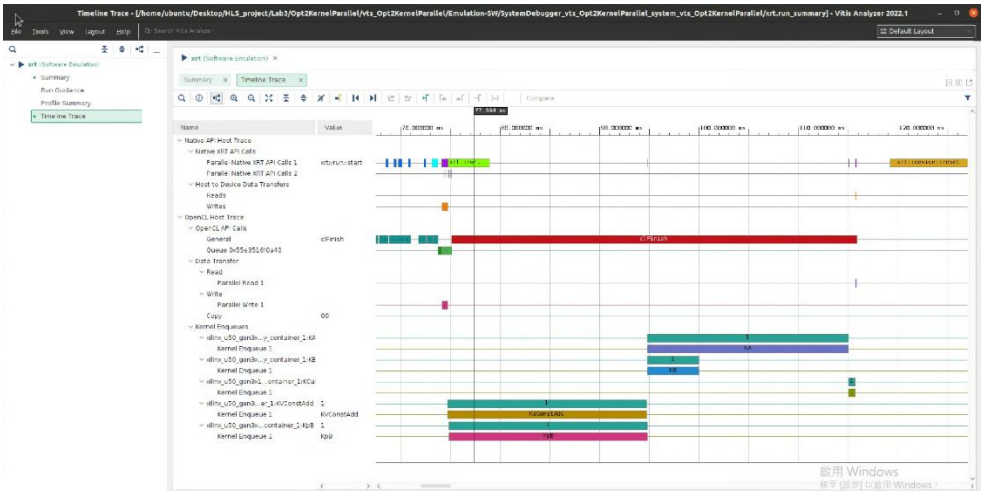

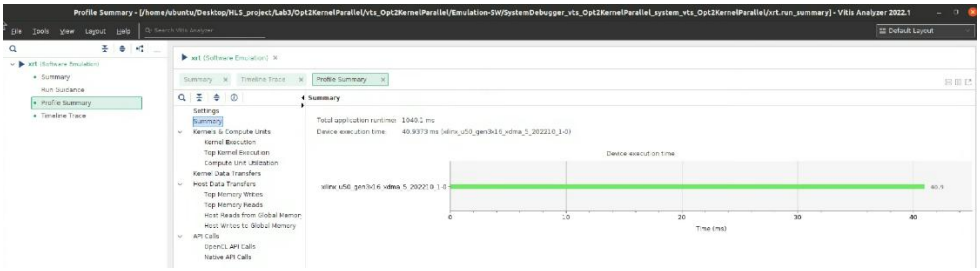

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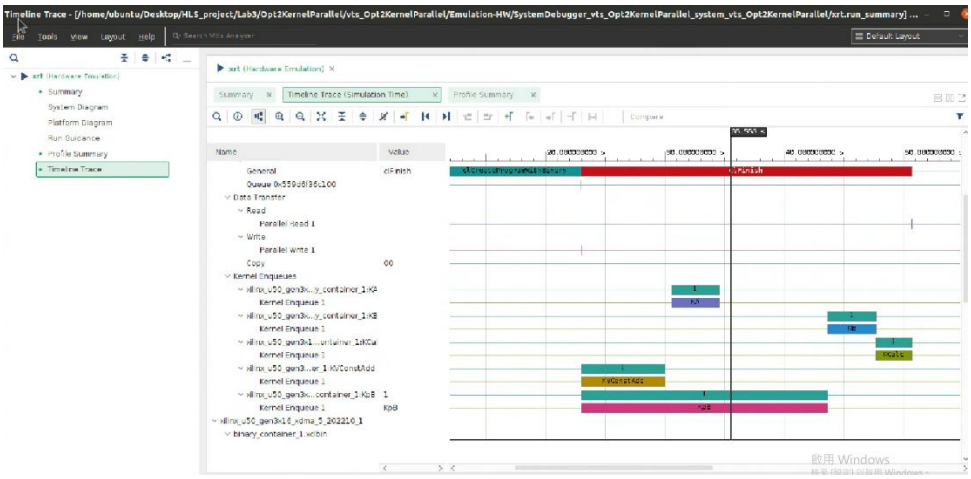
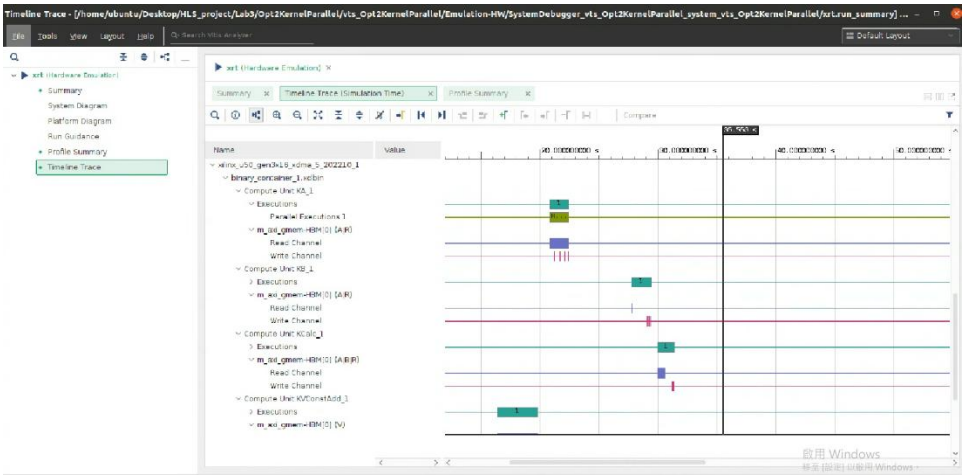
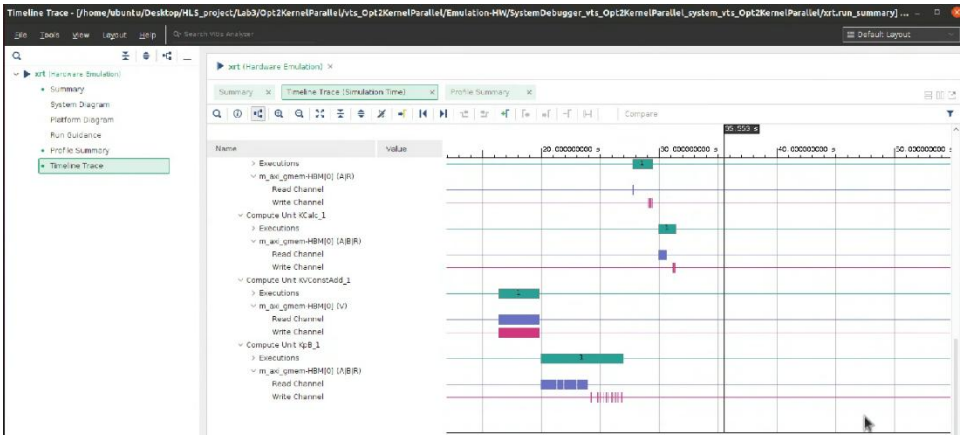
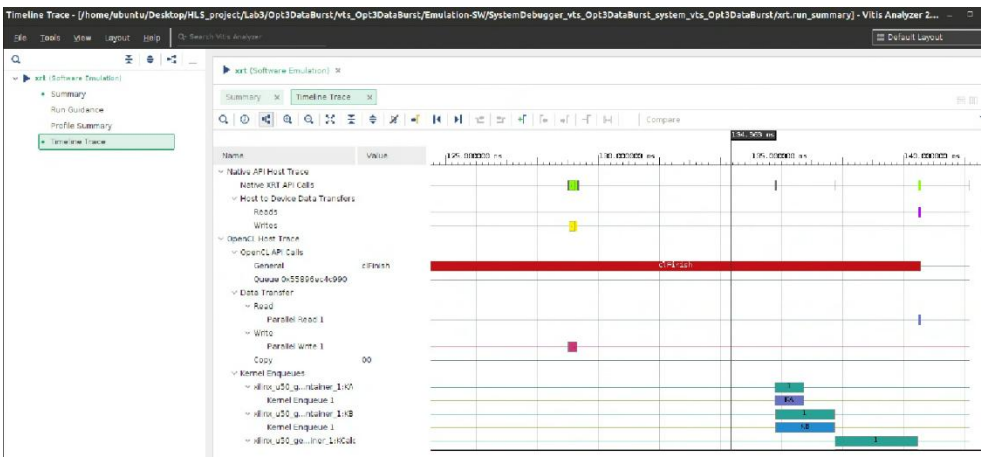


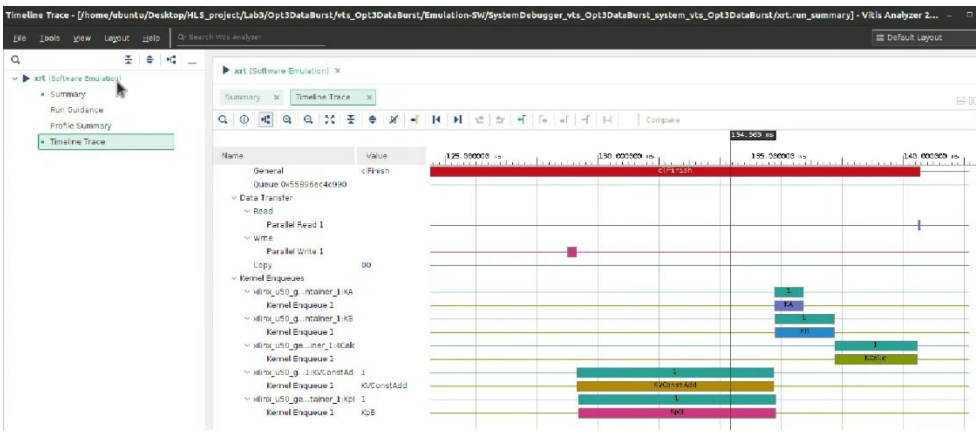


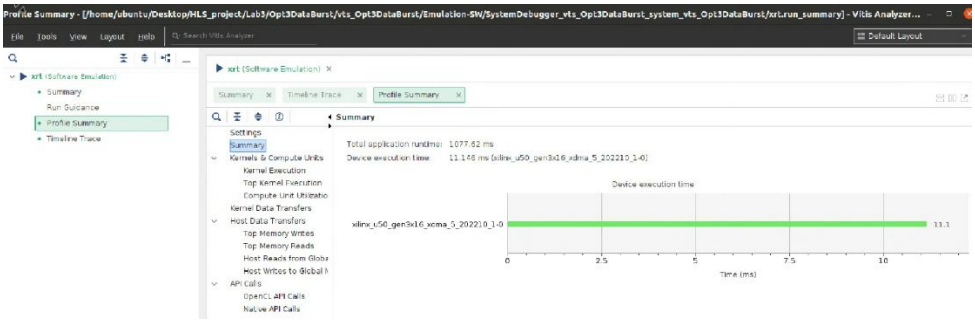


(3) Opt3DataBurst

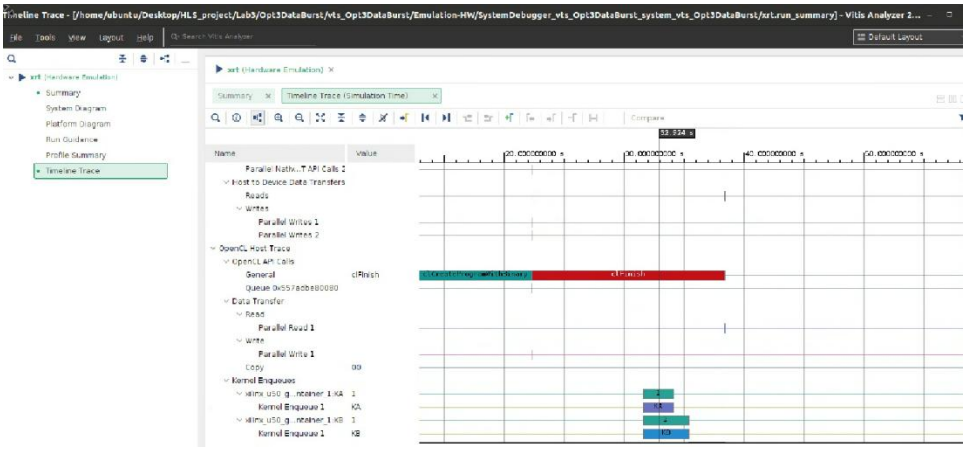
I. Software emulation

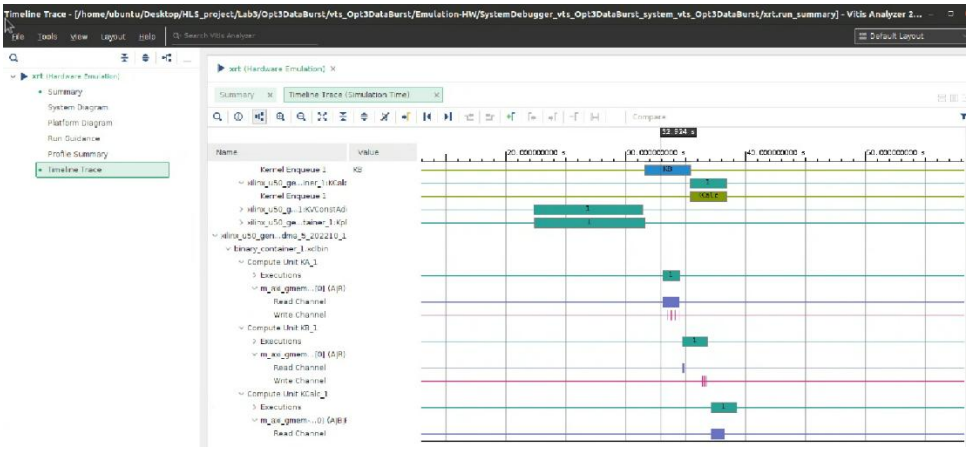


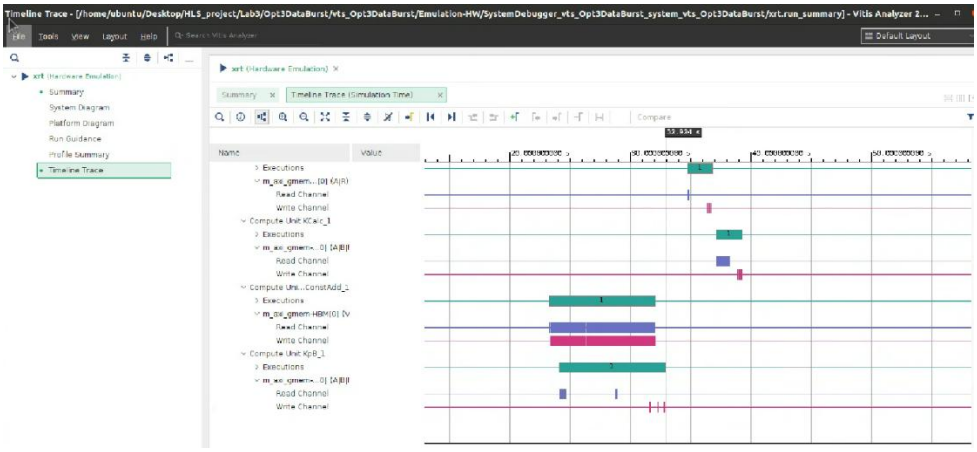


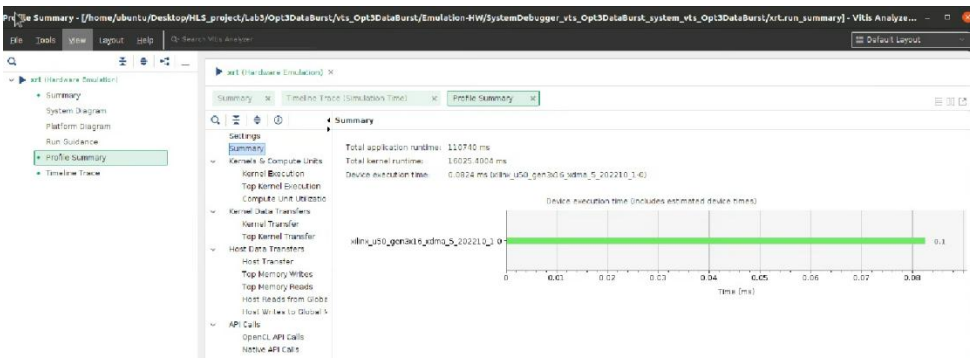


II. Hardware emulation









(4) Opt4ArrayPartition

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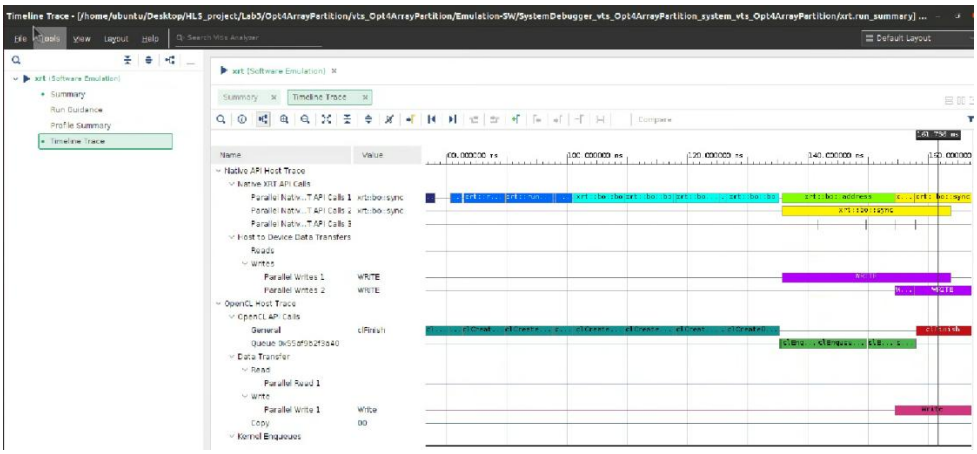
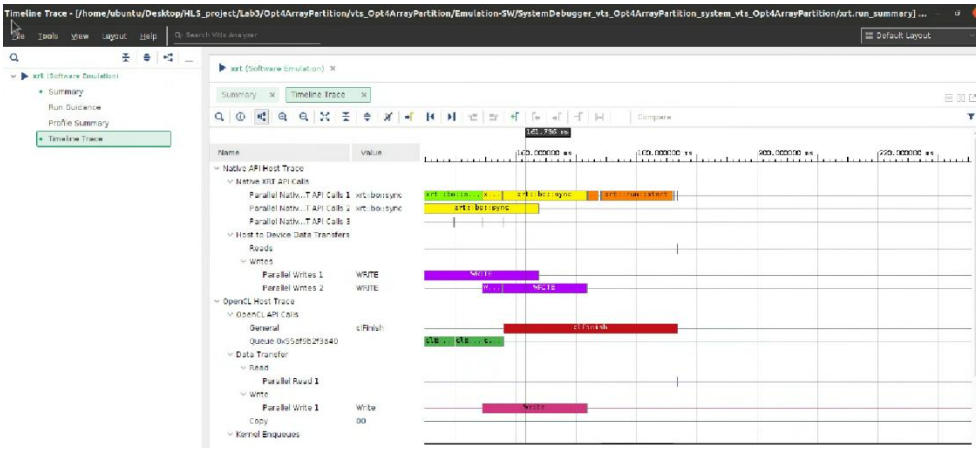
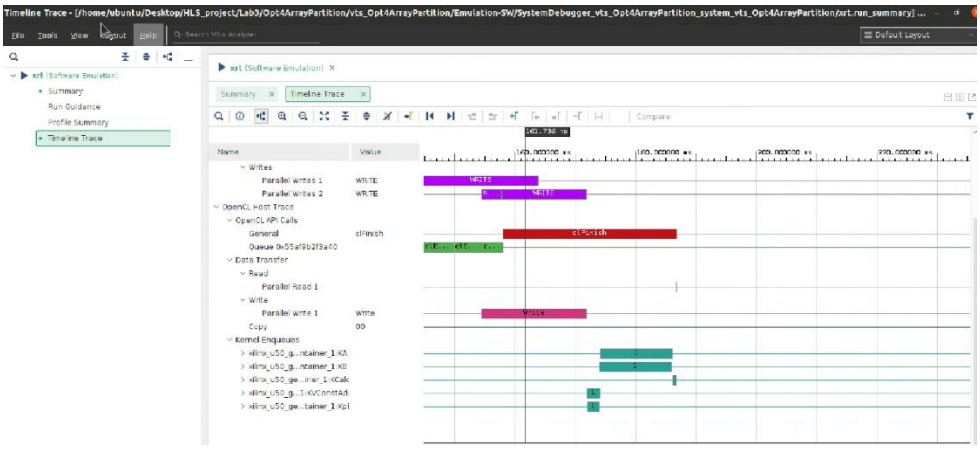
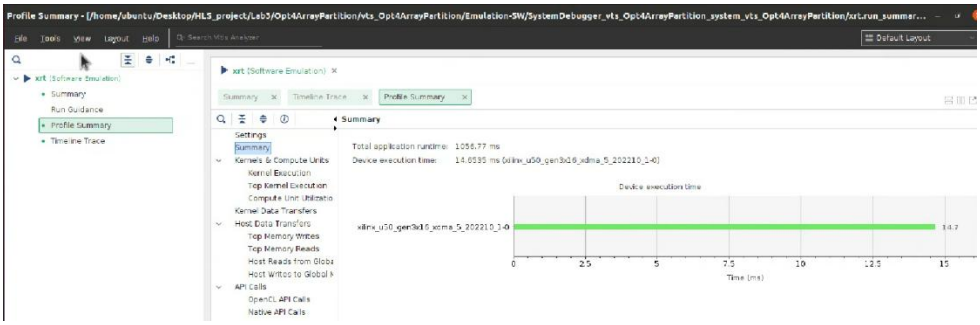
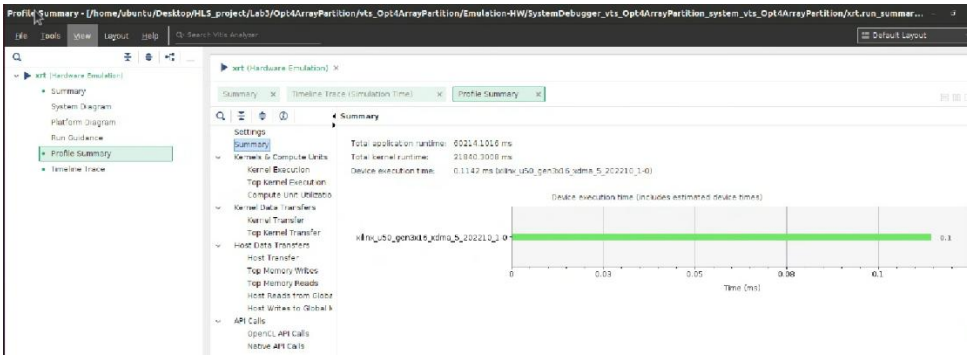


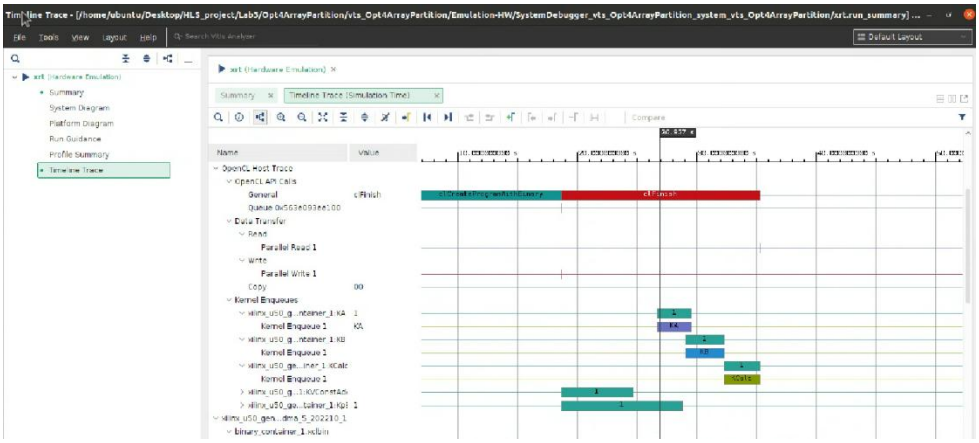


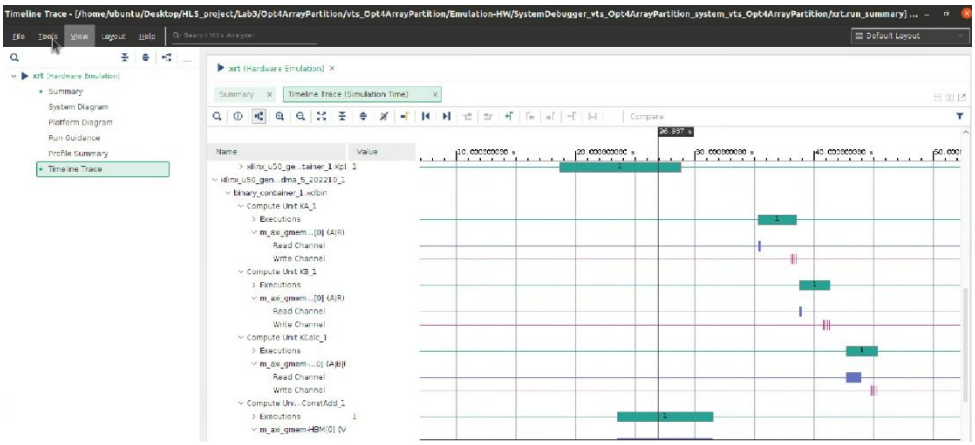


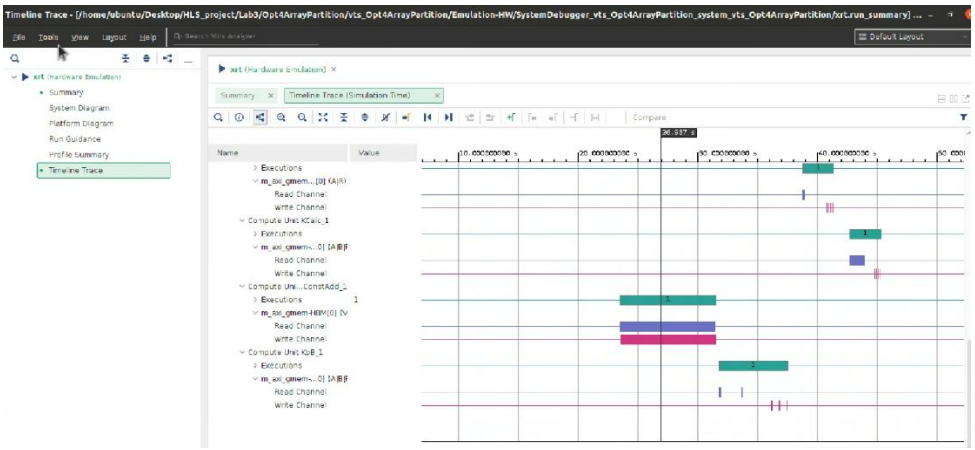


II. Hardware emulation

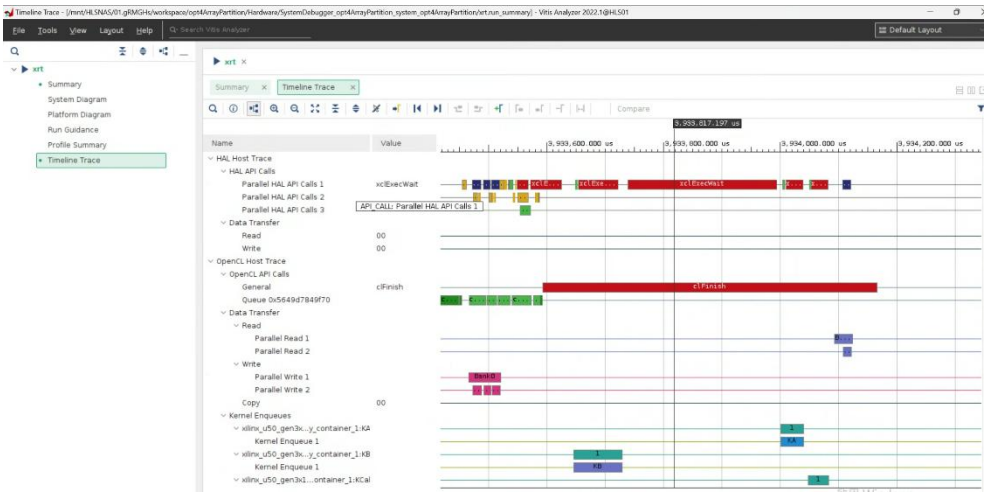


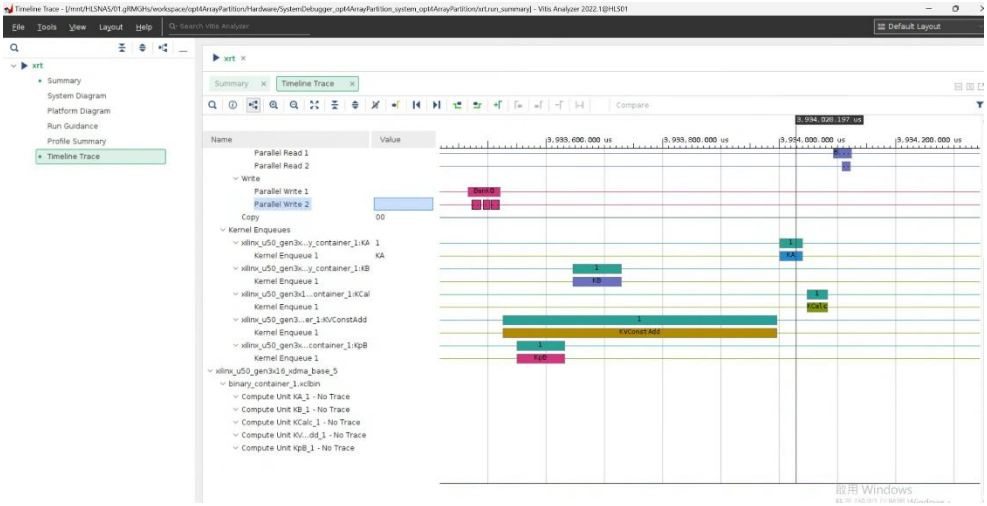






III. Hardware





Console | Problems | Vitis Log | Guidance

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```
Host-Info: ============================================================
Host-Info: Verifying final results (only 5 first failures are printed)
Host-Info: ============================================================
Host-Info: Test Successful
HOST-Info: ============================================================
HOST-Info: (Step 7) Custom Profiling
HOST-Info: ============================================================
HOST-Info: ------------------------------------------------------------------------------
HOST-Info: Name           | type          | start        | end          | Duration(ms)
HOST-Info: ------------------------------------------------------------------------------
HOST-Info: K_KVConstAdd   | kernel        |   3933525468 |   3933995339 |     0.469871
HOST-Info: K_KpB          | kernel        |   3933549777 |   3933631475 |     0.081698
HOST-Info: K_KA           | kernel        |   3934000465 |   3934039694 |     0.039229
HOST-Info: K_KB           | kernel        |   3933645215 |   3933728152 |     0.082937
HOST-Info: K_KCalc        | kernel        |   3934047294 |   3934082775 |     0.035481
HOST-Info: Transfer_1     | mem (H<->G)   |   3933450120 |   3933520697 |     0.070577
HOST-Info: Transfer_2     | mem (H<->G)   |   3933453099 |   3933453099 |            0
HOST-Info: Transfer_3     | mem (H<->G)   |   3934091924 |   3934123853 |     0.031929
HOST-Info: ------------------------------------------------------------------------------
HOST-Info:     Kernels Execution Time (ms) :  0.557307  (K_KCalc'end - K_KVConstAdd'begin)
HOST-Info: Application Execution Time (ms) :  0.673733  (Transfer_3'end - Transfer_1'begin)
HOST-Info: ------------------------------------------------------------------------------


HOST-Info: DONE
```