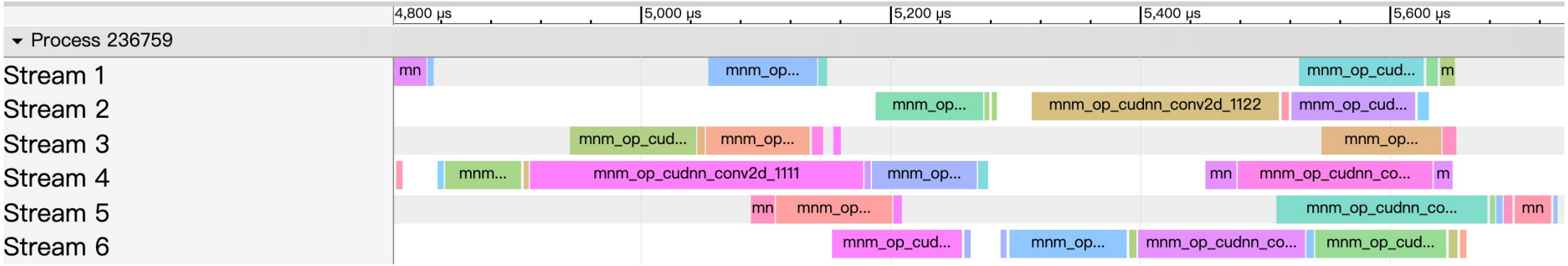
Multi-stream Execution in Meta VM

Yaoyao Ding

Collaborated with Haichen Shen

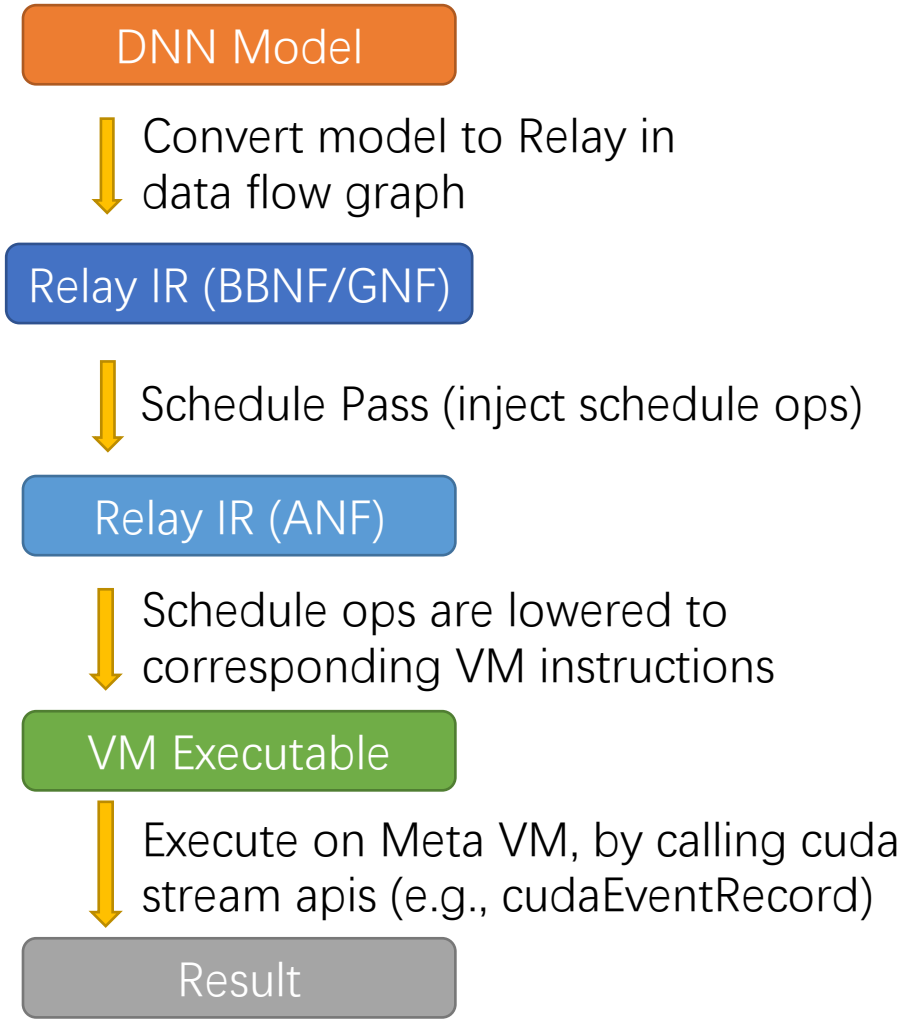
What & Why Multi-Stream Execution

- CUDA stream: support multiple CUDA operations simultaneously
- Operations that can overlap includes:
  - Multiple computation kernels
  - Memory transfer between host and device
  - Data transfer between different CUDA devices and nodes



Multi-Stream Execution allows us to achieves better device utilization.

Multi-Stream Support in Meta VM



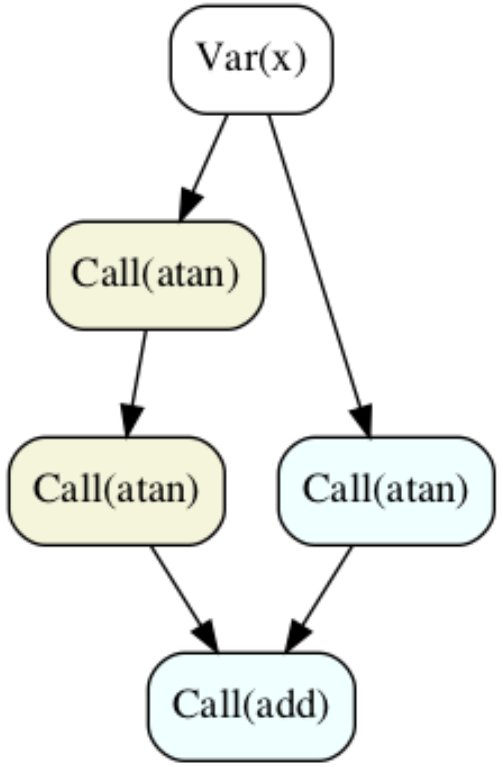
Stream-Schedule Operators

- `set_stream(stream_id)`
  Change the current cuda stream index
- `add_event(event_id)`
  Add an event to current stream
- `wait_event(event_id)`
  Let current stream wait given event

Schedule Policies

- Wavefront Schedule
  Runs available ops wave by wave.
- As Soon As Possible (ASAP) Schedule
  Partition the dataflow graph into chains and run each chain in a stream. Launch ops on critical path first.
- Inter-Operator Scheduler (IOS) Schedule
  Use dynamic-programming algorithm to search partition.

Example – Schedule Pass



(Color indicates stream)

```
def @main(%x) {
  %0 = atan(%x);
  %1 = atan(%x);
  %2 = atan(%0);
  add(%1, %2)
}
```

Before schedule pass

(GNF or BBNF)

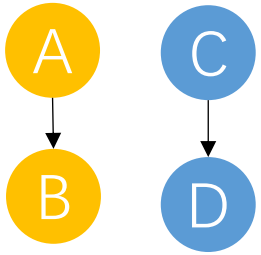
Schedule Pass

```
def @main(%x) {
  let %x_0 = set_stream(0);
  let %x_1 = atan(%x);
  let %x_2 = atan(%x_1);
  let %x_3 = add_event(0);
  let %x_4 = set_stream(1);
  let %x_5 = atan(%x);
  let %x_6 = wait_event(0);
  let %x_7 = add(%x_5, %x_2);
  %x_7
}
```

After schedule pass

(ANF)

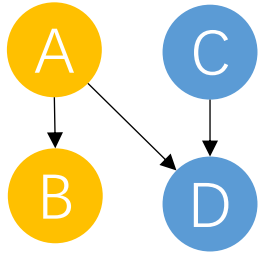
Example – Multi-Stream Execution



Dataflow Graph

```
...
CudaSetStream 0
Invoke A
Invoke B
CudaSetStream 1
Invoke C
Invoke D
...
```

VM Bytecode



Dataflow Graph

```
...
CudaSetStream 0
Invoke A
CudaAddEvent 0
Invoke B
CudaSetStream 1
Invoke C
CudaWaitEvent 0
Invoke D
...
```

VM Bytecode

(Color indicates stream)

Preliminary Result

Inference

Model: Inception V3

Device: NVIDIA Tesla V100

cuDNN: 7.6.5

Result: up to 1.45x speedup