Extending GRAMPS Shaders

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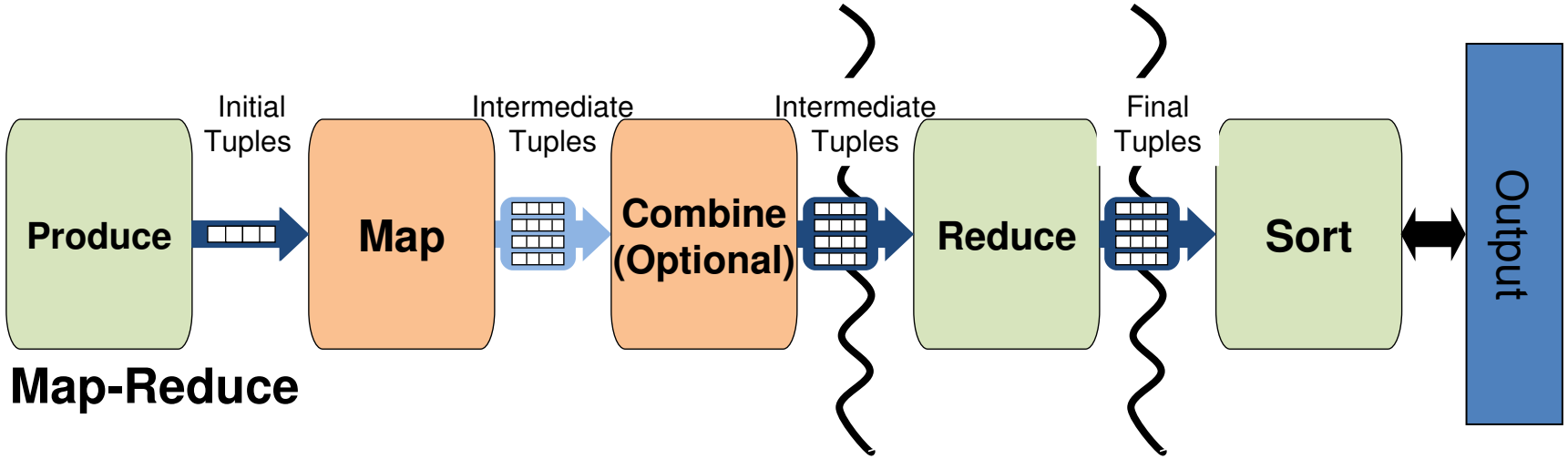
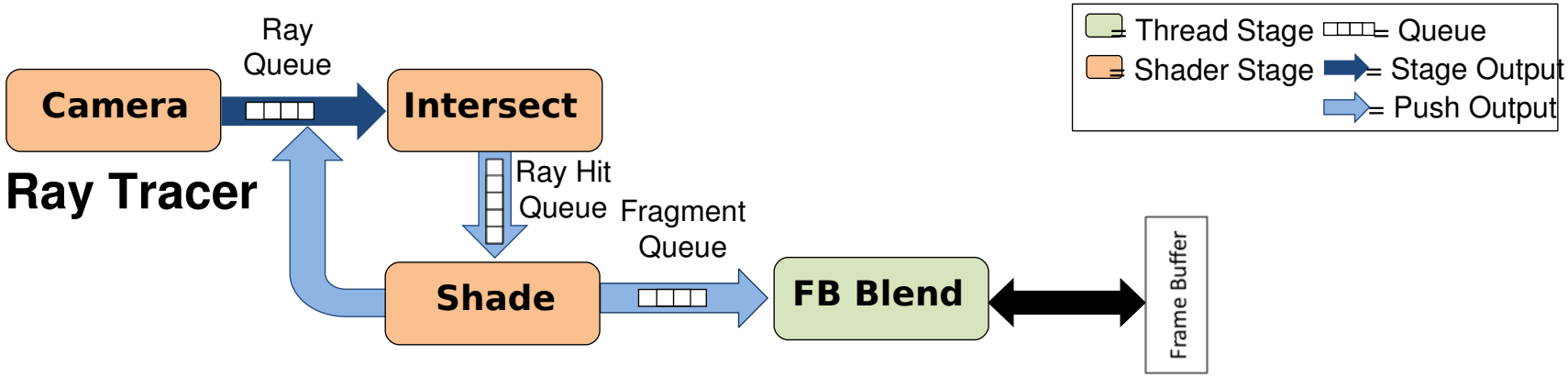
FLASHG

Agenda

- GRAMPS Reminder (quick!)
- Reductions
- Reductions and more with GRAMPS Shaders

GRAMPS Reminder





GRAMPS Shaders

- Facilitate data parallelism
- Benefits:

  auto-instancing, queue management, implicit parallelism, mapping to ‘shader cores’
- Constraints:

  1 input queue, 1 input element and 1 output element per queue (plus push).

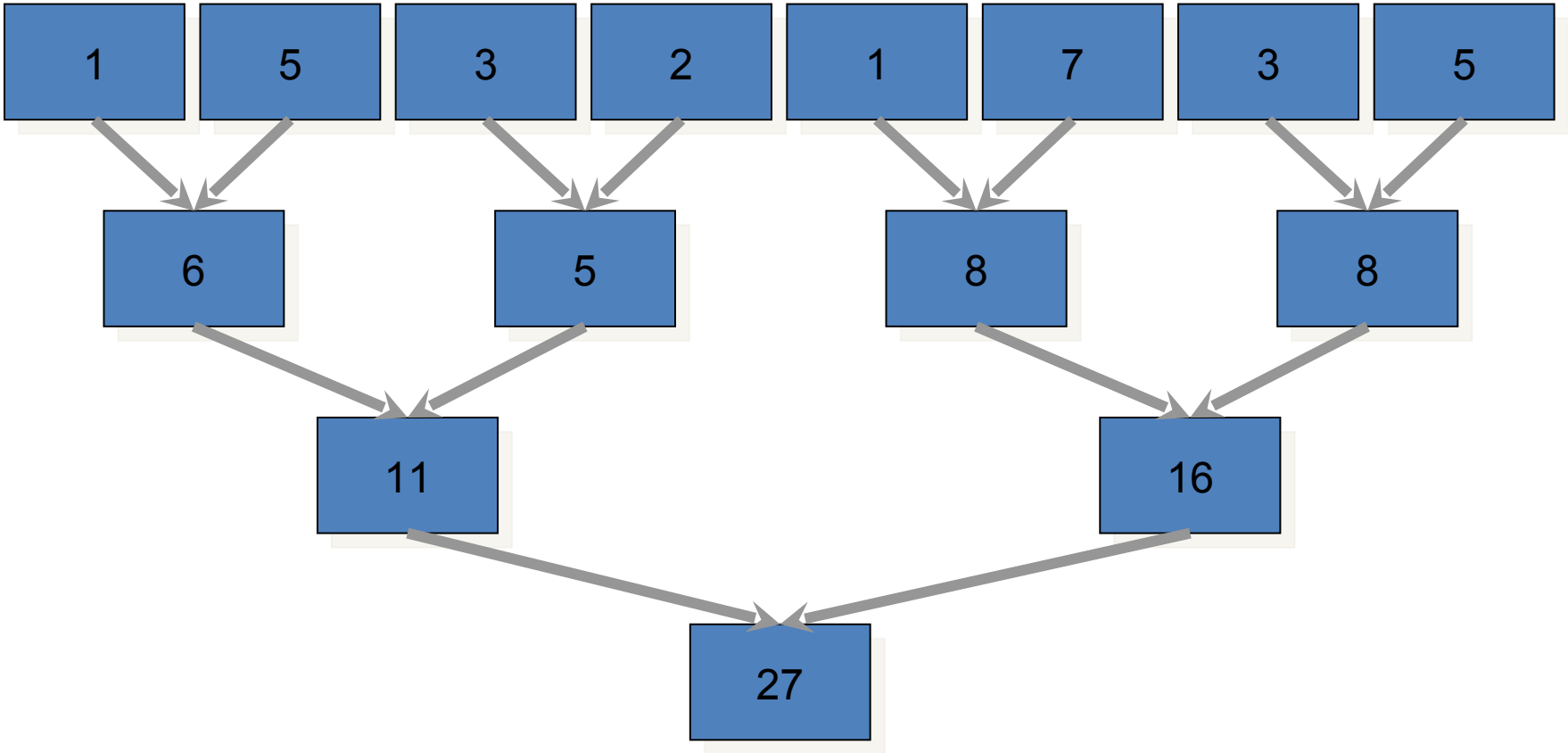
➢ Effectively limits kernels to “map”-like usage.

Reductions

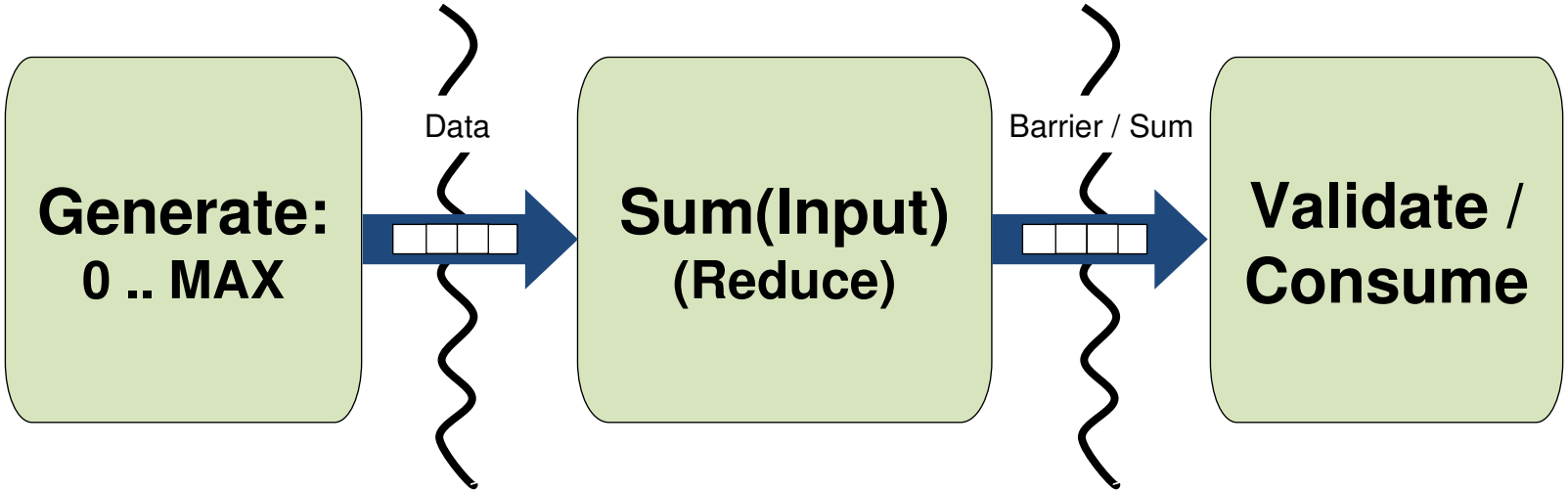
- Central to Map-Reduce (duh), many parallel apps
- Strict form: sequential, requires arbitrary buffering
  - E.g., compute median, depth order transparency

- Associativity, commutativity enable parallel incremental reductions
  - In practice, **many** of the reductions actually used (all Brook / GPGPU, most Map-Reduce)

Logarithmic Parallel Reduction



Simple GRAMPS Reduction



- Strict reduction
- All stages are threads, no shaders

Strict Reduction Program

```
sumThreadMain(GrEnv *env) {
    sum = 0;
    /* Block for entire input */
    GrReserve(inputQ, -1);
    for (i = 0 to numPackets) {
        sum += input[i];
    }
    GrCommit(inputQ, numPackets);

    /* Write sum to buffer or outputQ */
}
```

Incremental/Partial Reduction

```
sumThreadMain(GrEnv *env) {
    sum = 0;
    /* Consume one packet at a time */
    while (GrReserve(inputQ, 1) != NOMORE) {
        sum += input[i];
        GrCommit(inputQ, 1);
    }

    /* Write sum to buffer or outputQ */
}
```

Note: Still single threaded!

Shaders for Partial Reduction?

- Appeal:
  - Stream, GPU languages offer support
  - Take advantage of shader cores
  - Remove programmer boiler plate
  - Automatic parallelism and instancing

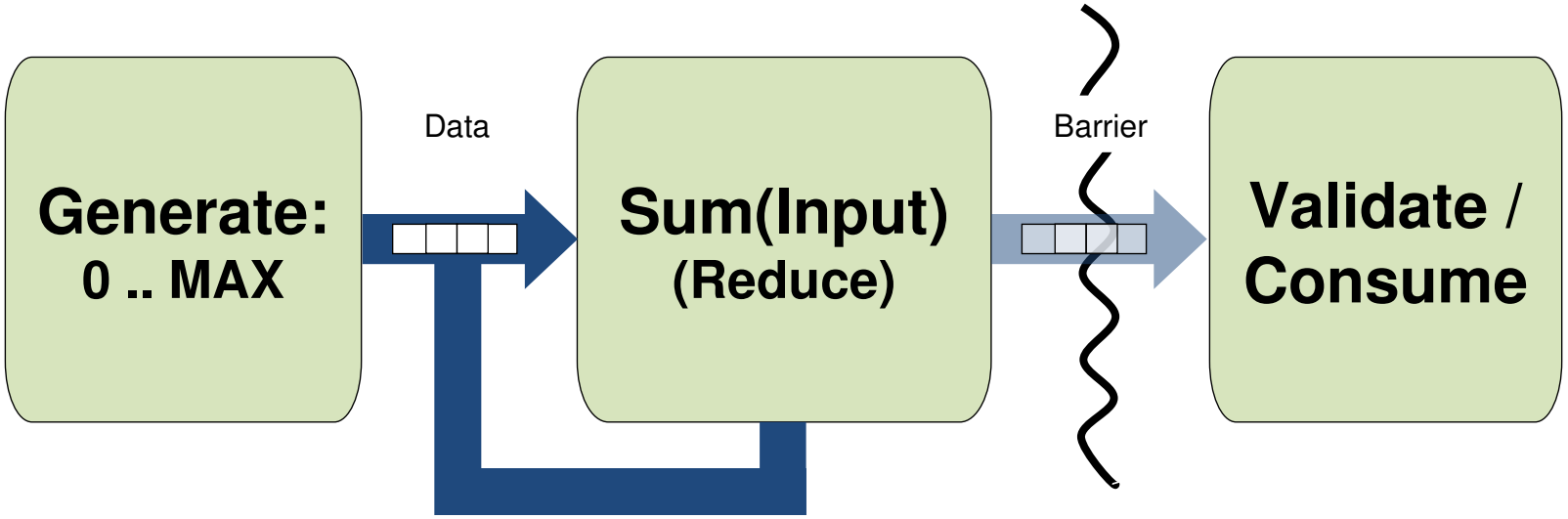
- Obstacles:
  - Location for partial / incremental result
  - Multiple input elements (spanning packets)
  - Detecting termination
  - Proliferation of stage / program types.

Shader Enhancements

- Stage / kernel takes N inputs per invocation
  - → Must handle < N being available (for N > 1)
- Invocation reduces all input to a single output
  - – Stored as an output key?
- GRAMPS can (will) merge input across packets
  - → No guarantees on shared packet headers!

- **Not** a completely new type of shader
- General filtering, not just GPGPU reduce

GRAMPS Shader Reduction



- Combination of N:1 shader and graph cycle (in-place).
- Input “Queue” to validate only gets NOMORE

Scheduling Reduction Shaders

- Highly correlated with graph cycles.
  - Given reduction, preempt upstream under footprint.
- Free space in input gates possible parallelism
  - 1/Nth free is the most that can be used.
  - One free entry is the minimum required for forward progress.
- Logarithmic versus linear reduction is entirely a scheduler / GRAMPS decision.

Other Thoughts

- (As mentioned) Enables filtering. What else?
- How interesting are graphs without loops?

- Are there other alternatives? Would a separate “reduce” / “combine” stage be better?

- Questions?