MXDAG: A Hybrid Abstraction for Emerging Applications

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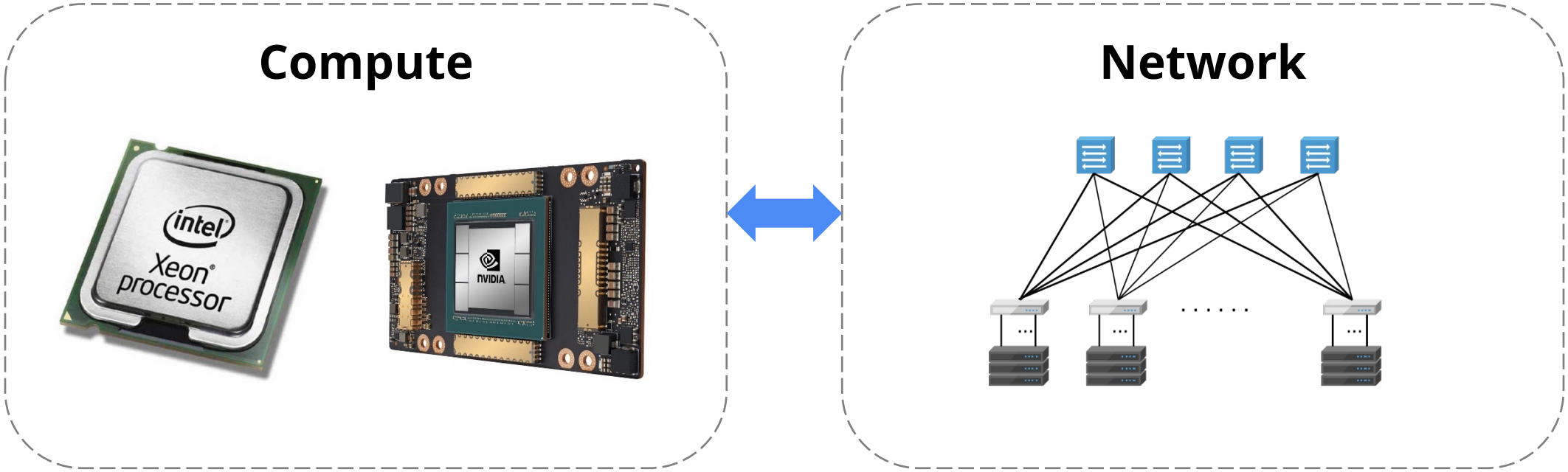
RICE
UNCONVENTIONAL WISDOM

Trending Cloud Applications/Frameworks

Amazon
Lambda

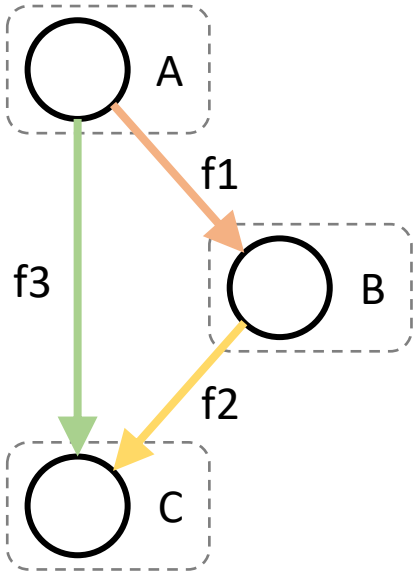
Compute and Network Resources are Both Critical

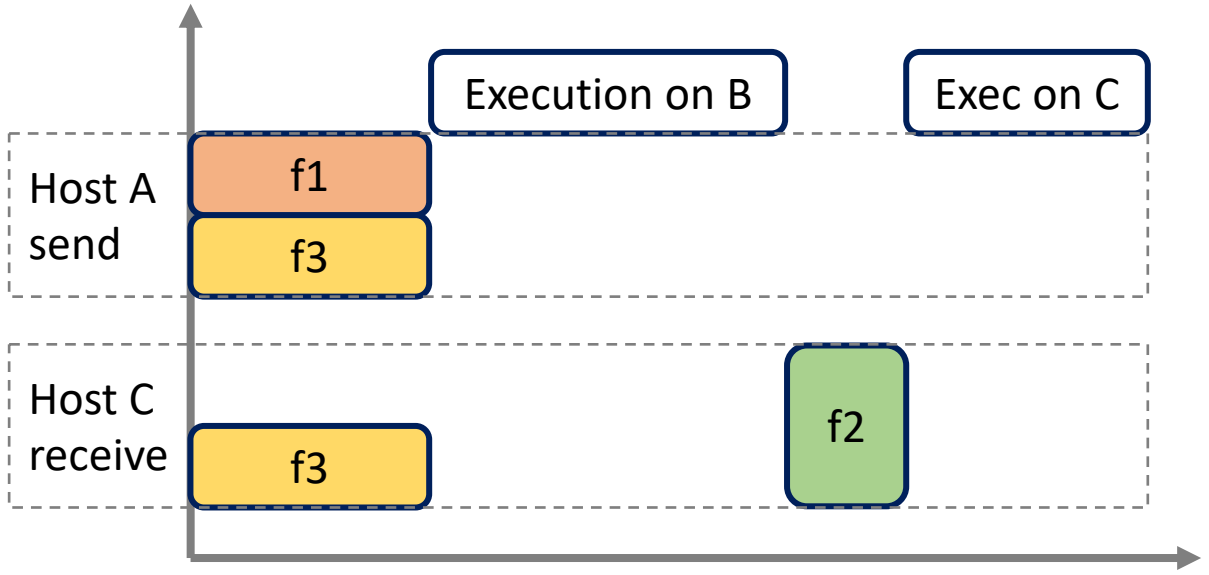


Questions:

- How to schedule the resources to improve application performance?
- How to share the resources among multiple applications?

1. Previous DAGs Lack Explicit Network Co-scheduling





Without co-scheduling, flows 1&3 start at the same time and share the NIC bandwidth equally

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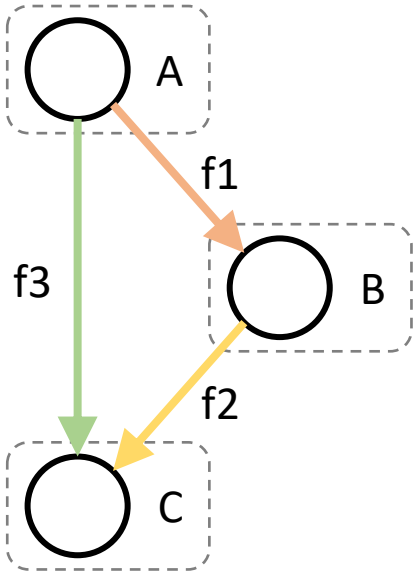

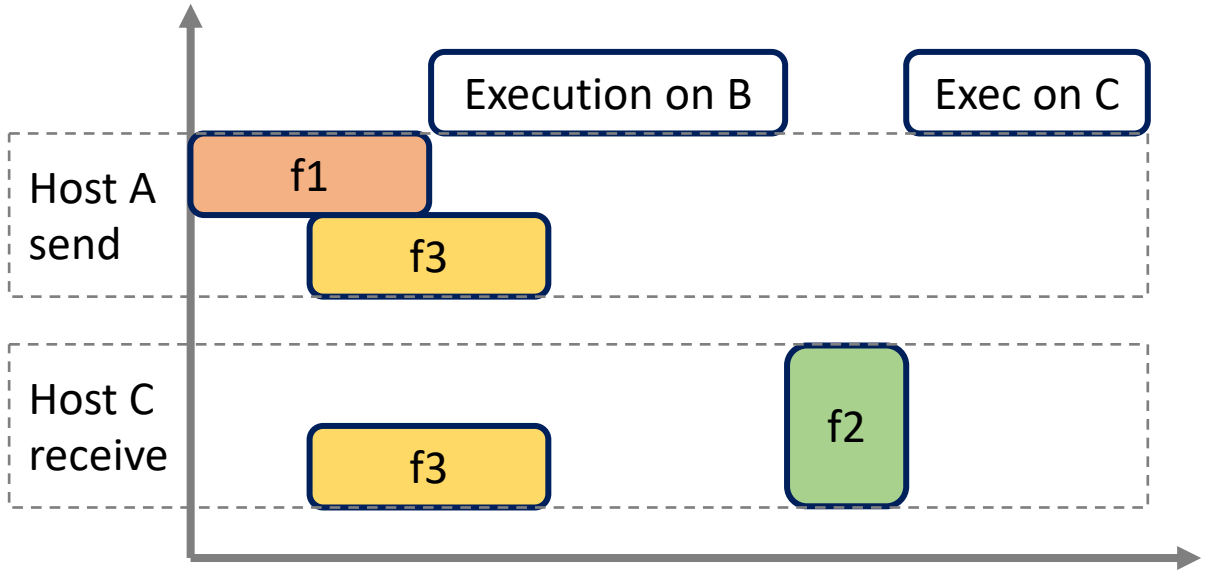

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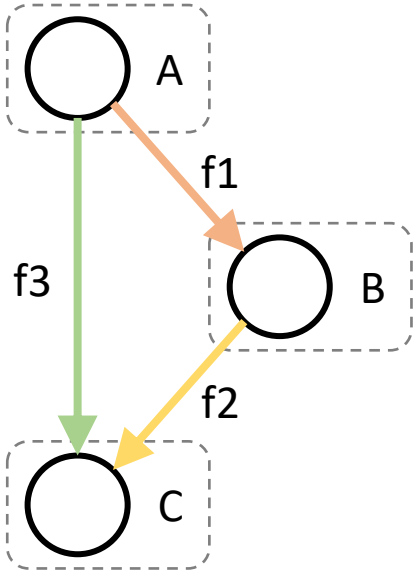

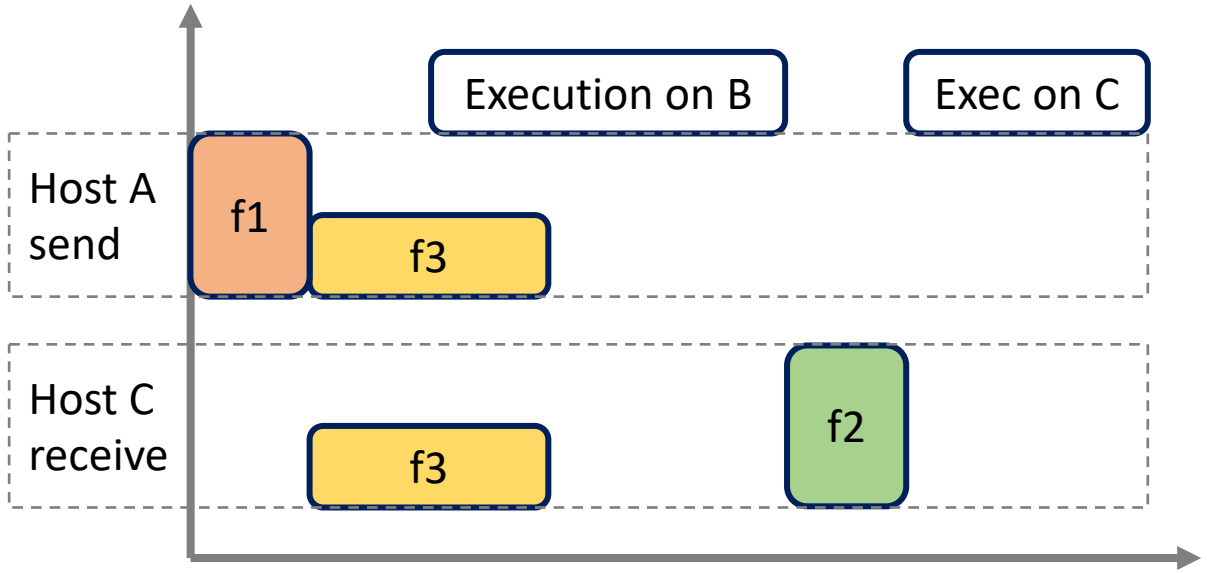

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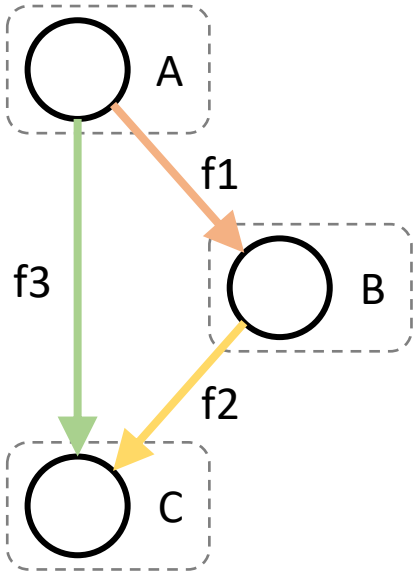
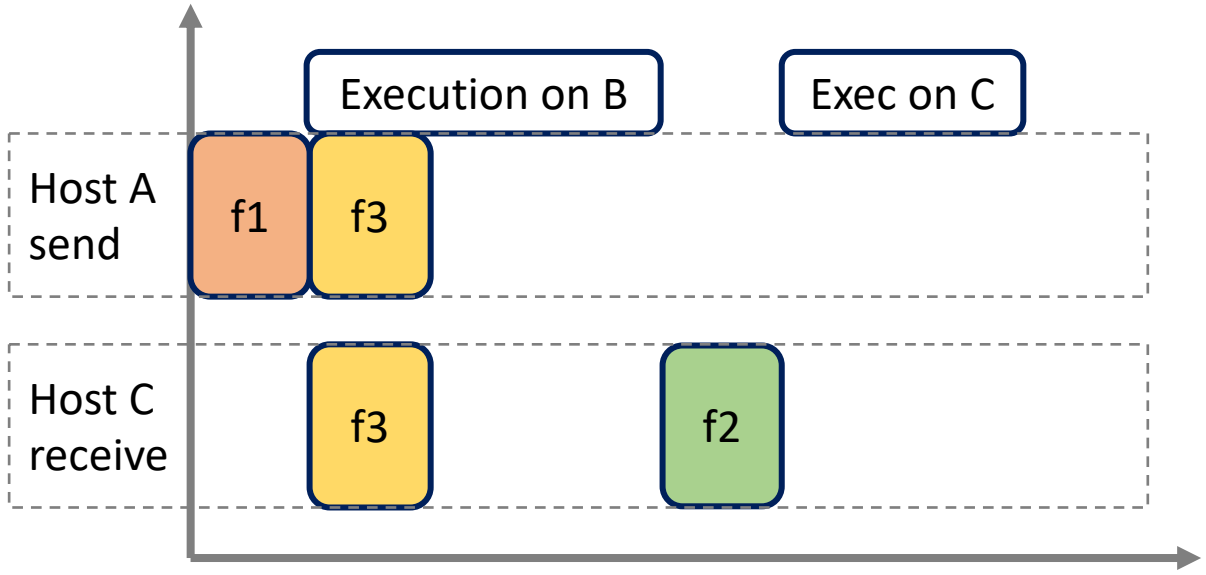
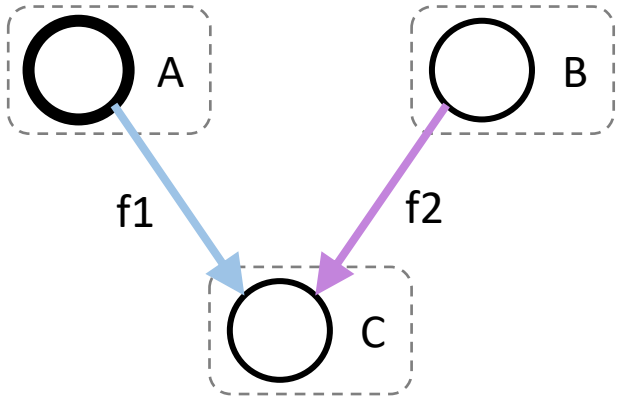
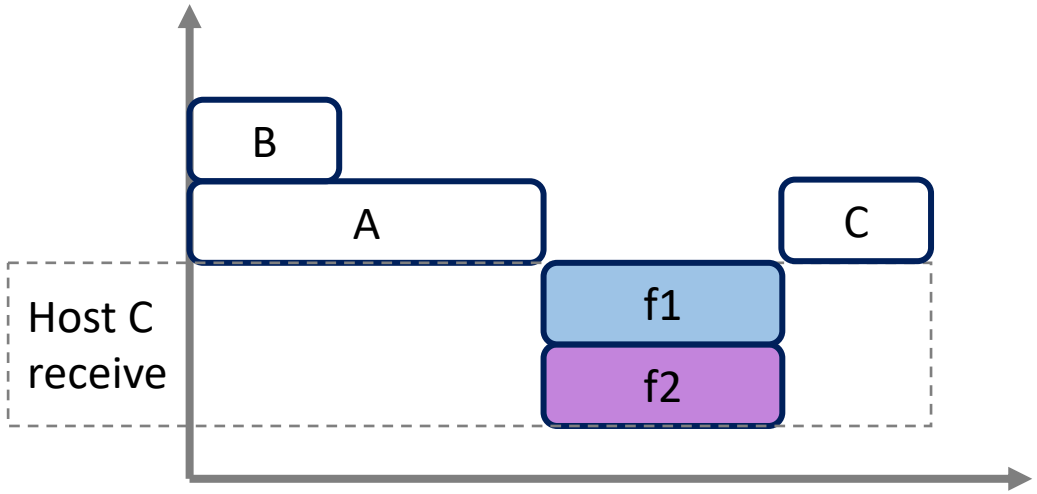




With co-scheduling, flow 1 is prioritized over flow 3 and allows task B to start earlier, reducing overall completion time

2. Coflow Abstraction Lacks Global View





Coflow can obscure the critical path information and lead to sub-optimal performance

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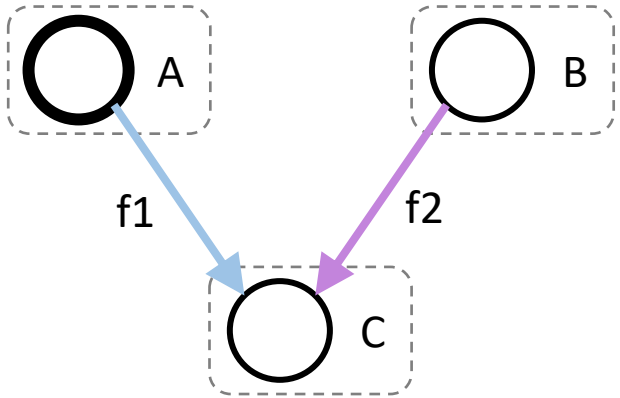

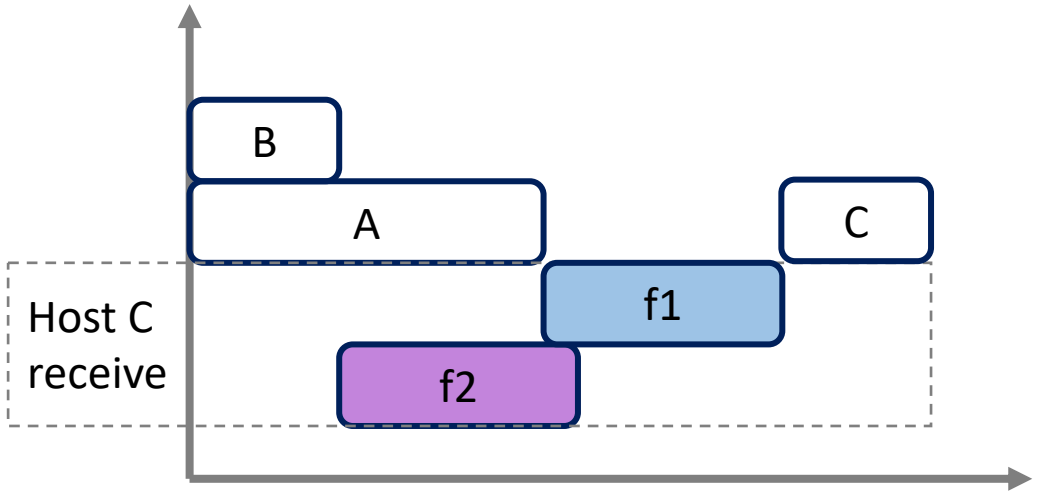

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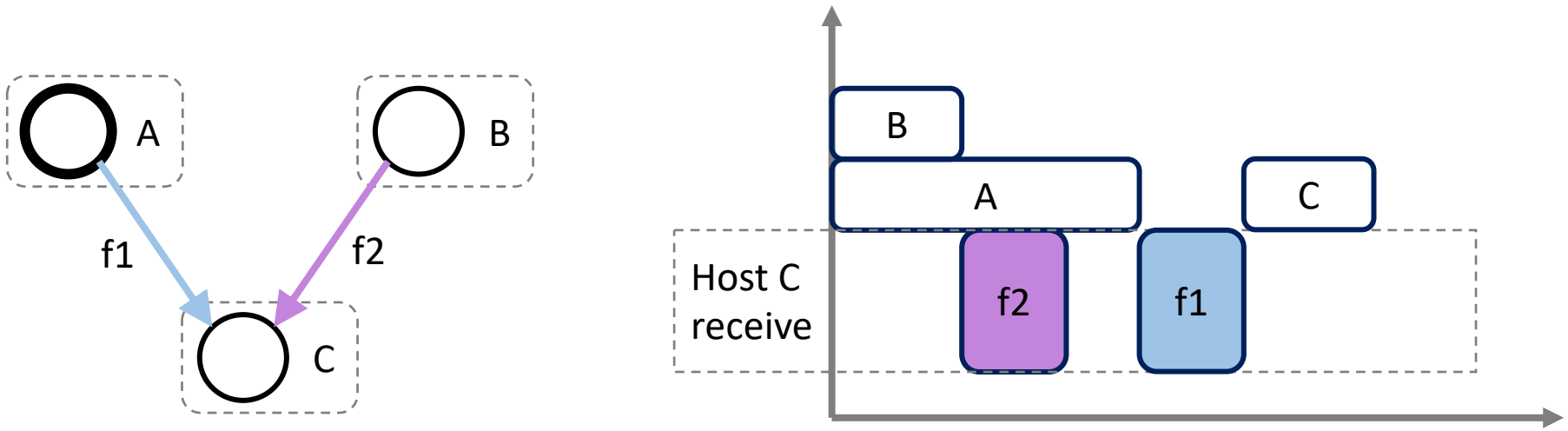
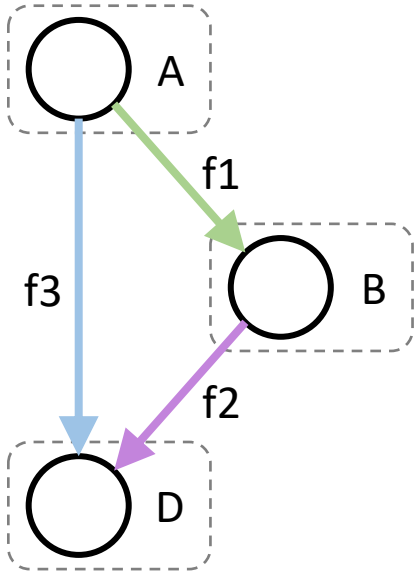
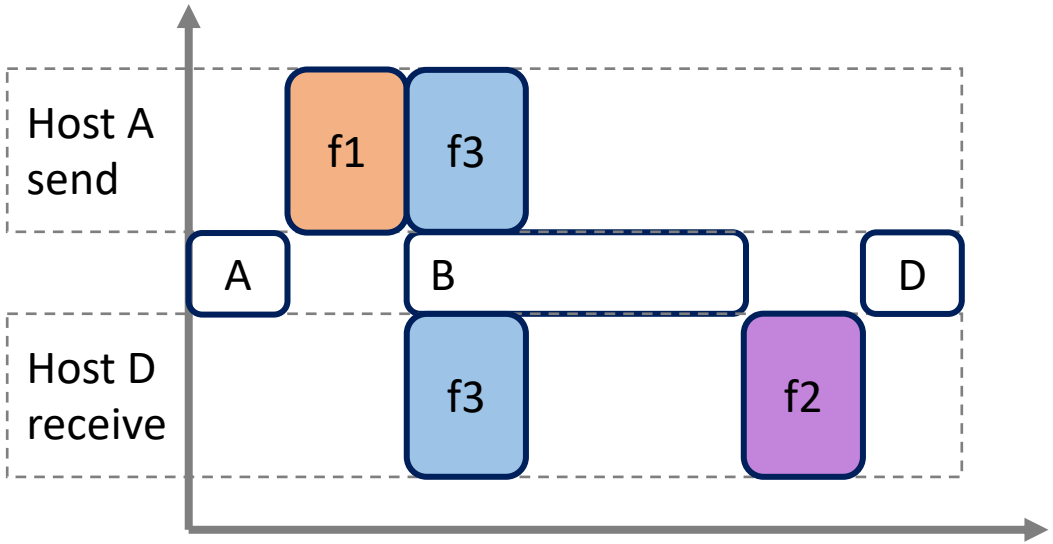


Asymmetric DAG can be better scheduled without Coflow abstraction

3. Both Abstractions Lack Pipelineability Analysis





Optimal scheduling without pipeline

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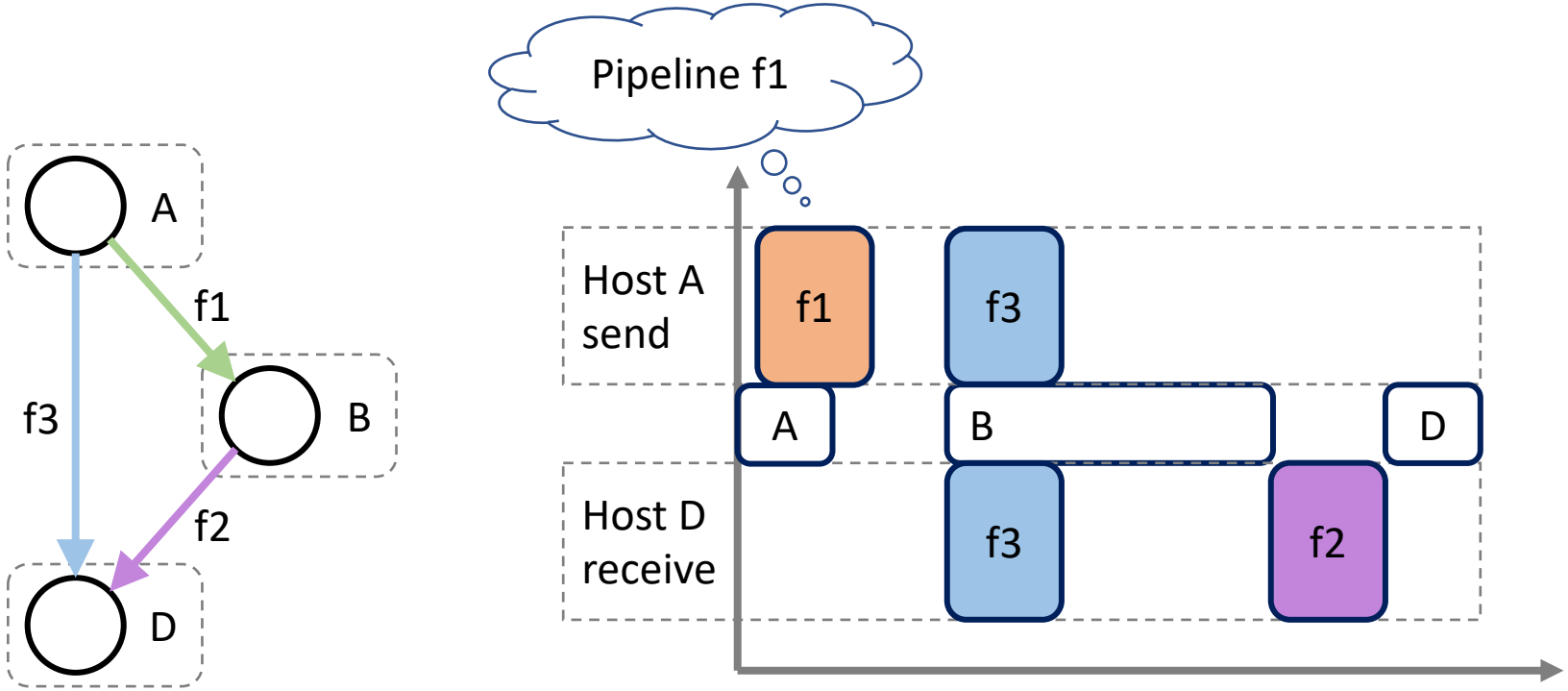

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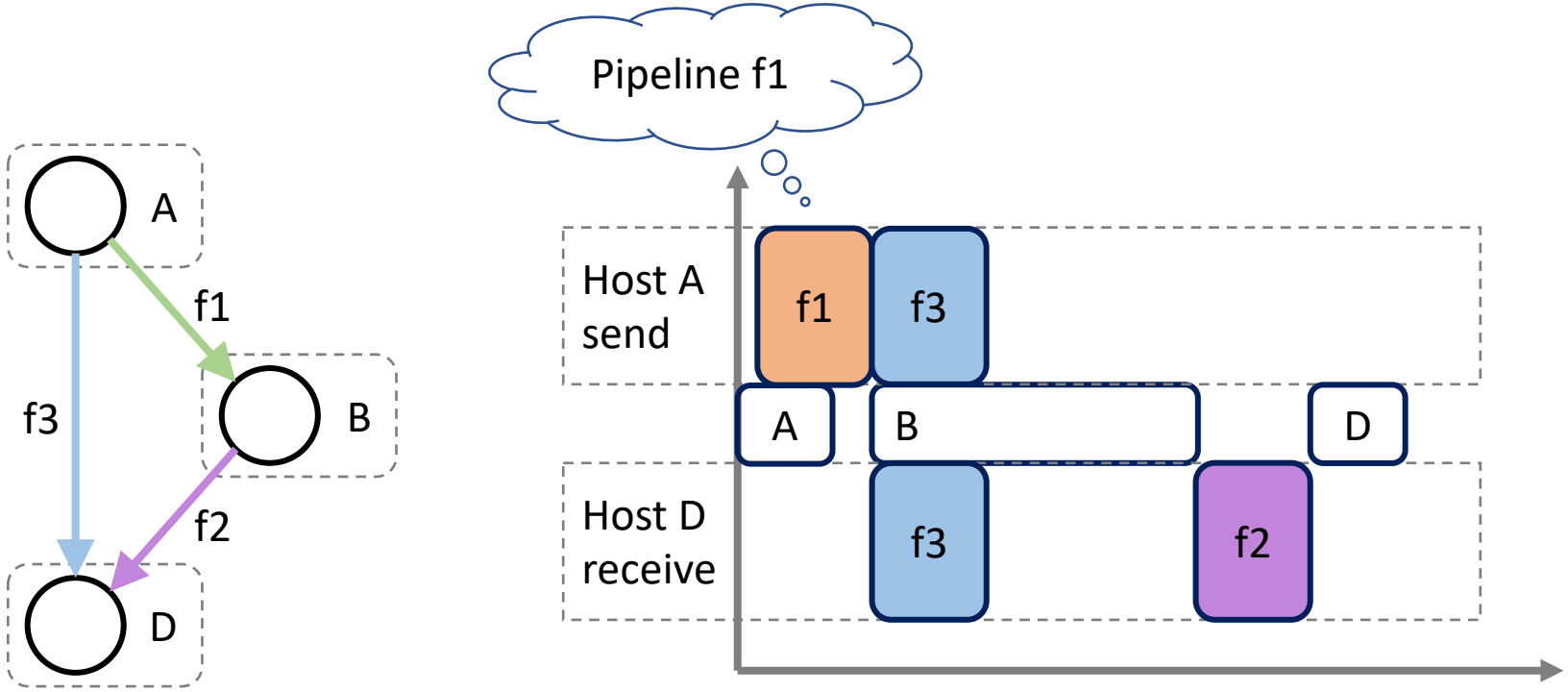

Good pipeline leads to improved performance

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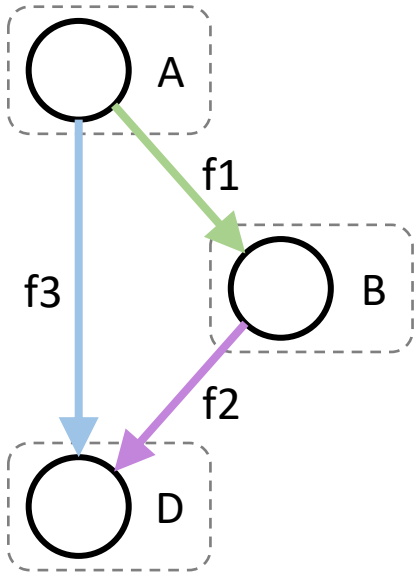

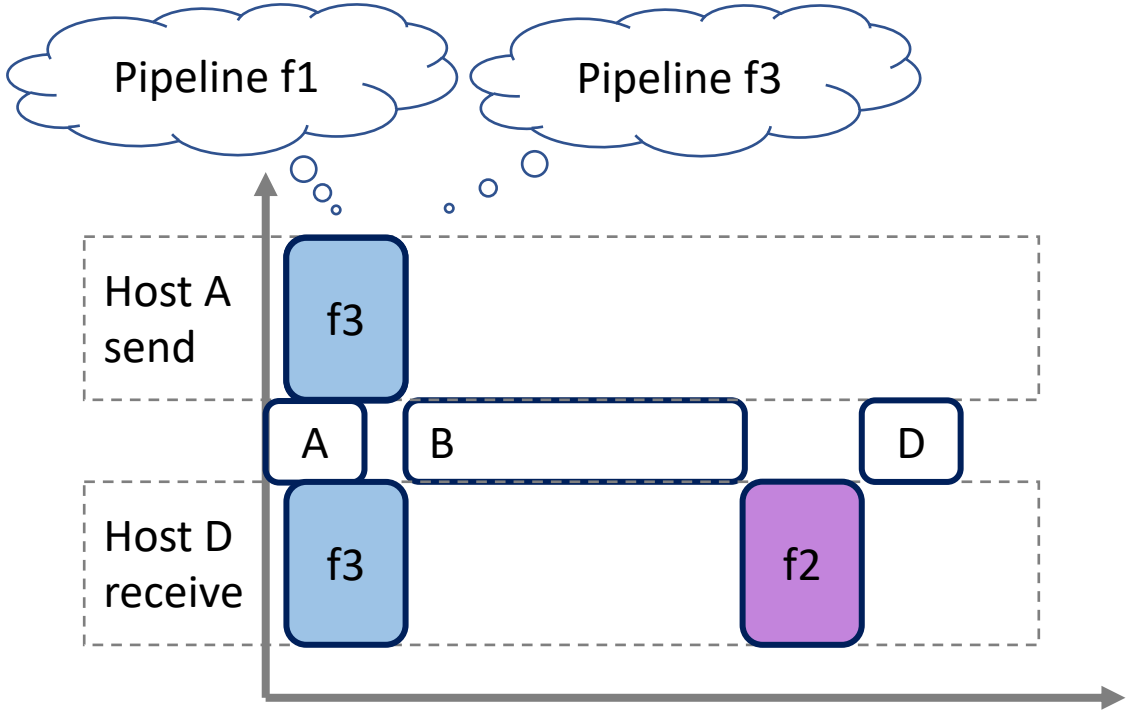

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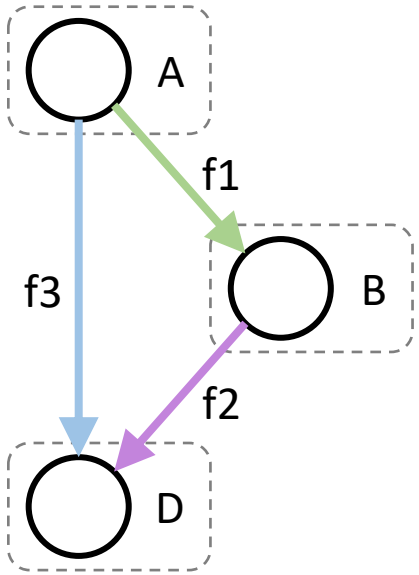

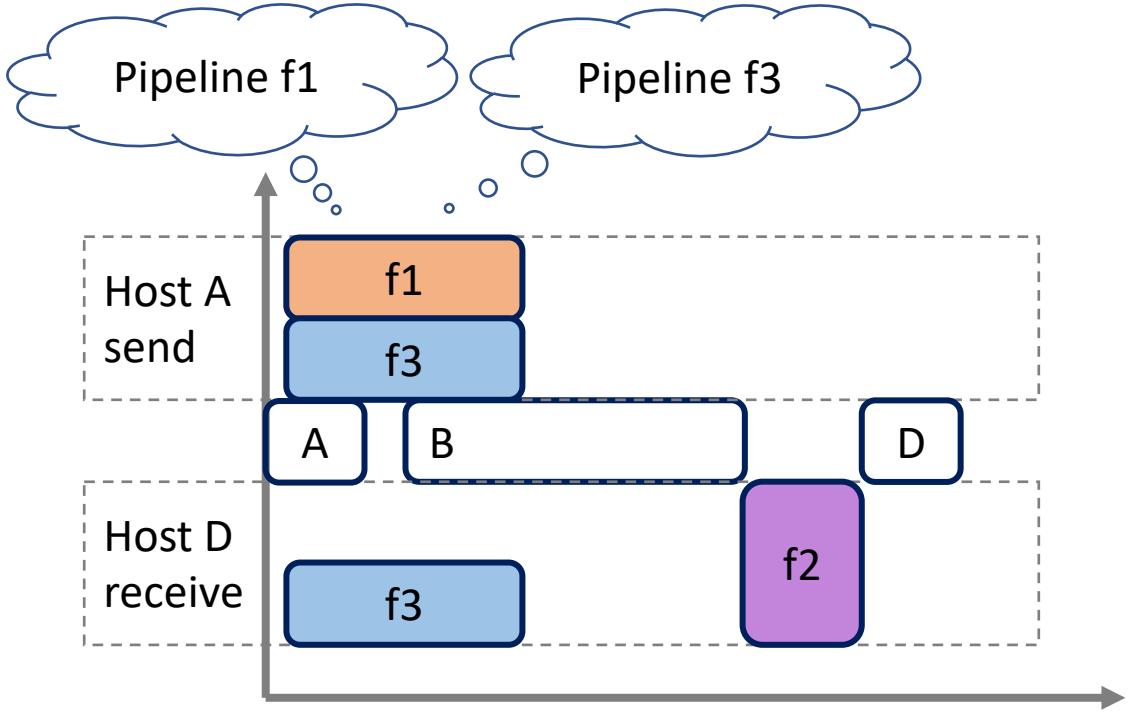

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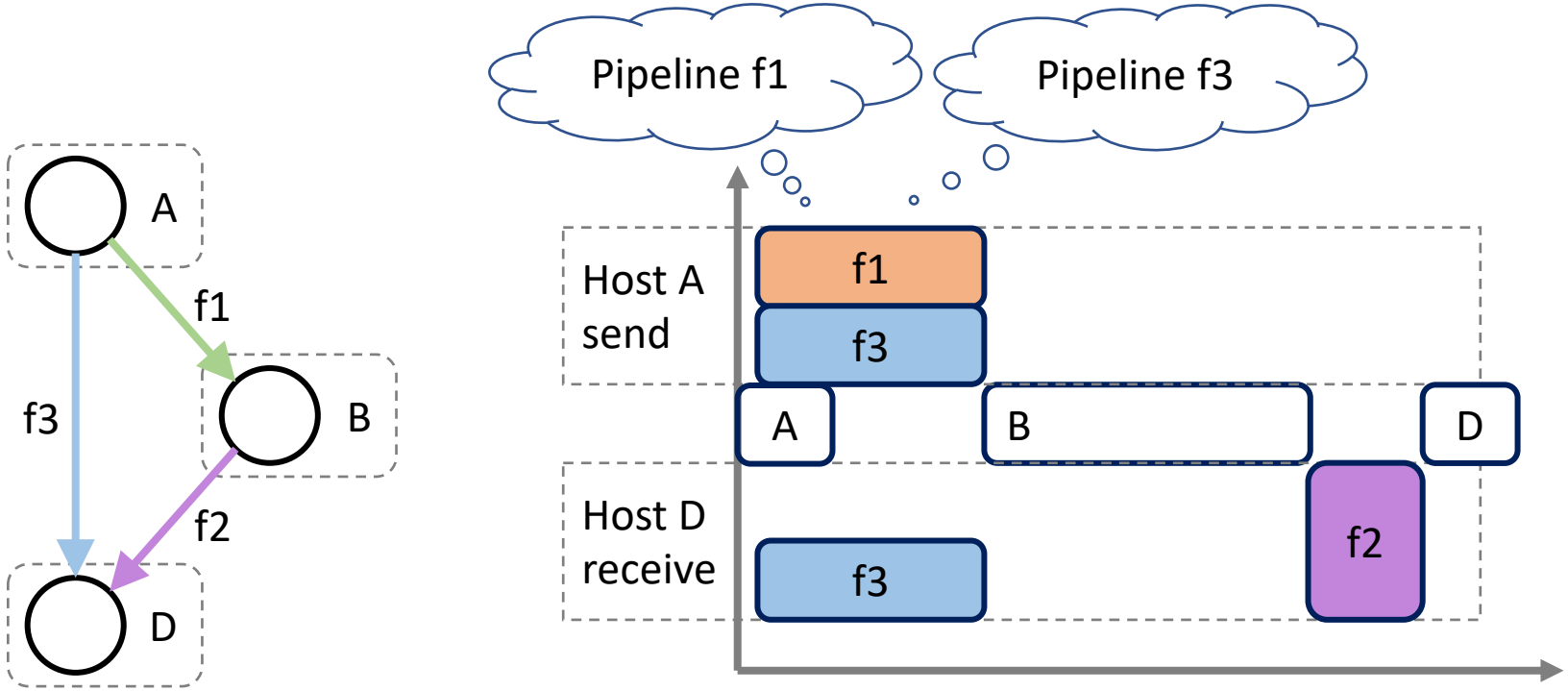


Inappropriate pipeline leads to performance degradation

Better Abstraction is Required for Co-scheduling

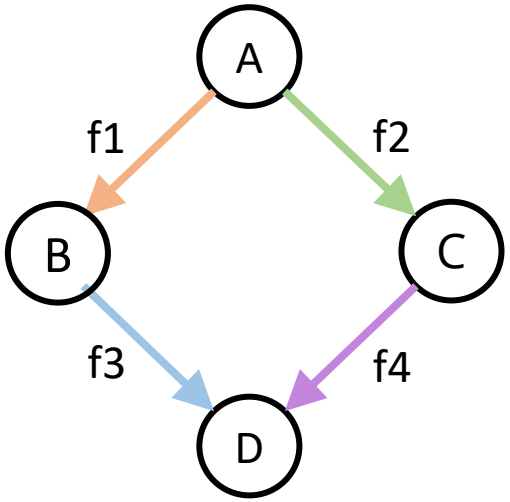
- Explicitly consider both **compute** and **network tasks** to find the **end-to-end critical path**
- Allocate the resources to optimize the performance of the critical path
- Schedule the pipeline while taking resource sharing into consideration

Benefits

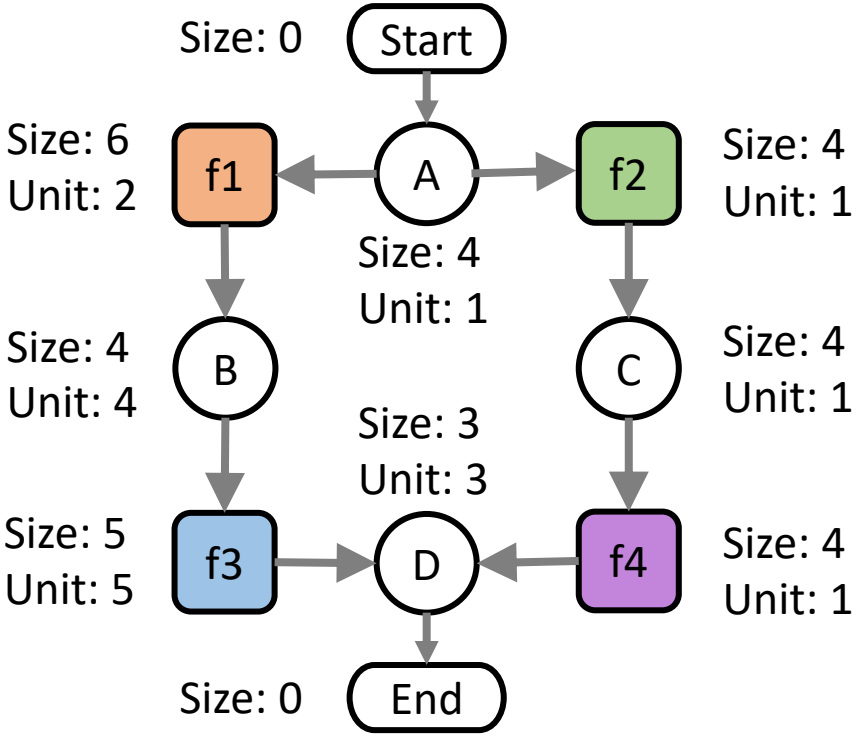
- Finer-grained view of the application
- Better critical path analysis
- Improve application performance and resource utilization

MXDAG: A Compute-Network Hybrid Abstraction

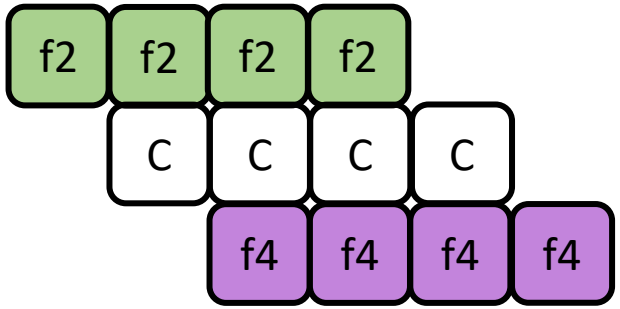
- **Nodes:** Both Compute and Network tasks (MXTasks)
- **Edges:** Dependencies between MXTasks
- **Size:** Ideal completion time of an individual MXTask
- **Unit:** Smallest unit size under pipelining



Traditional DAG



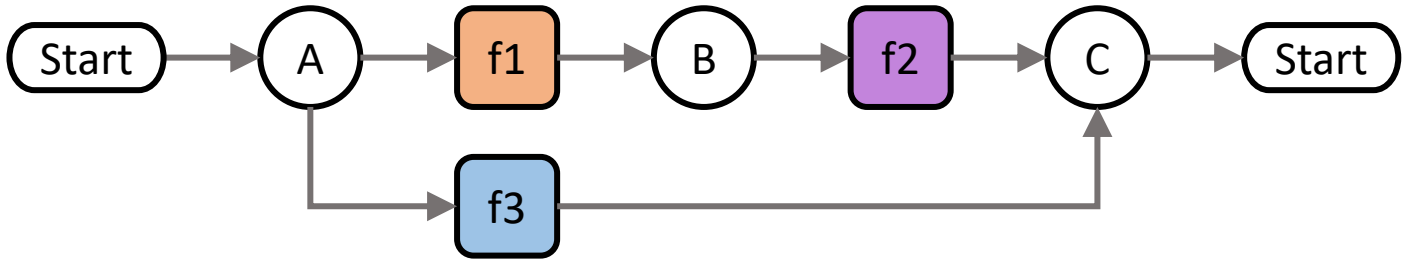
MXDAG

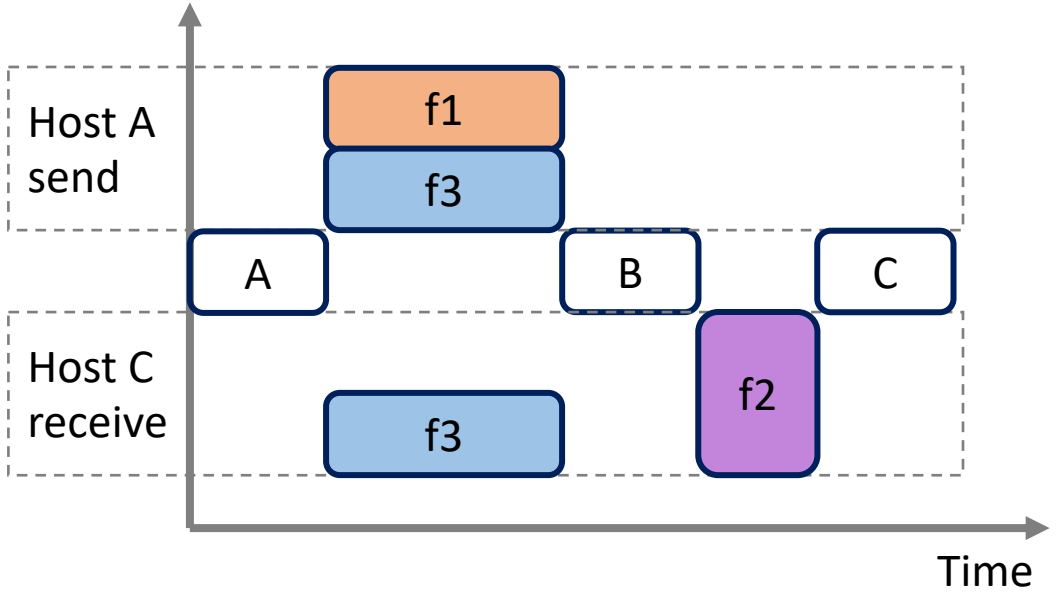


Pipelineability

Schedule A Single MXDAG

Key Principle: **Prioritize** the **end-to-end critical path** since it dominates the completion time.





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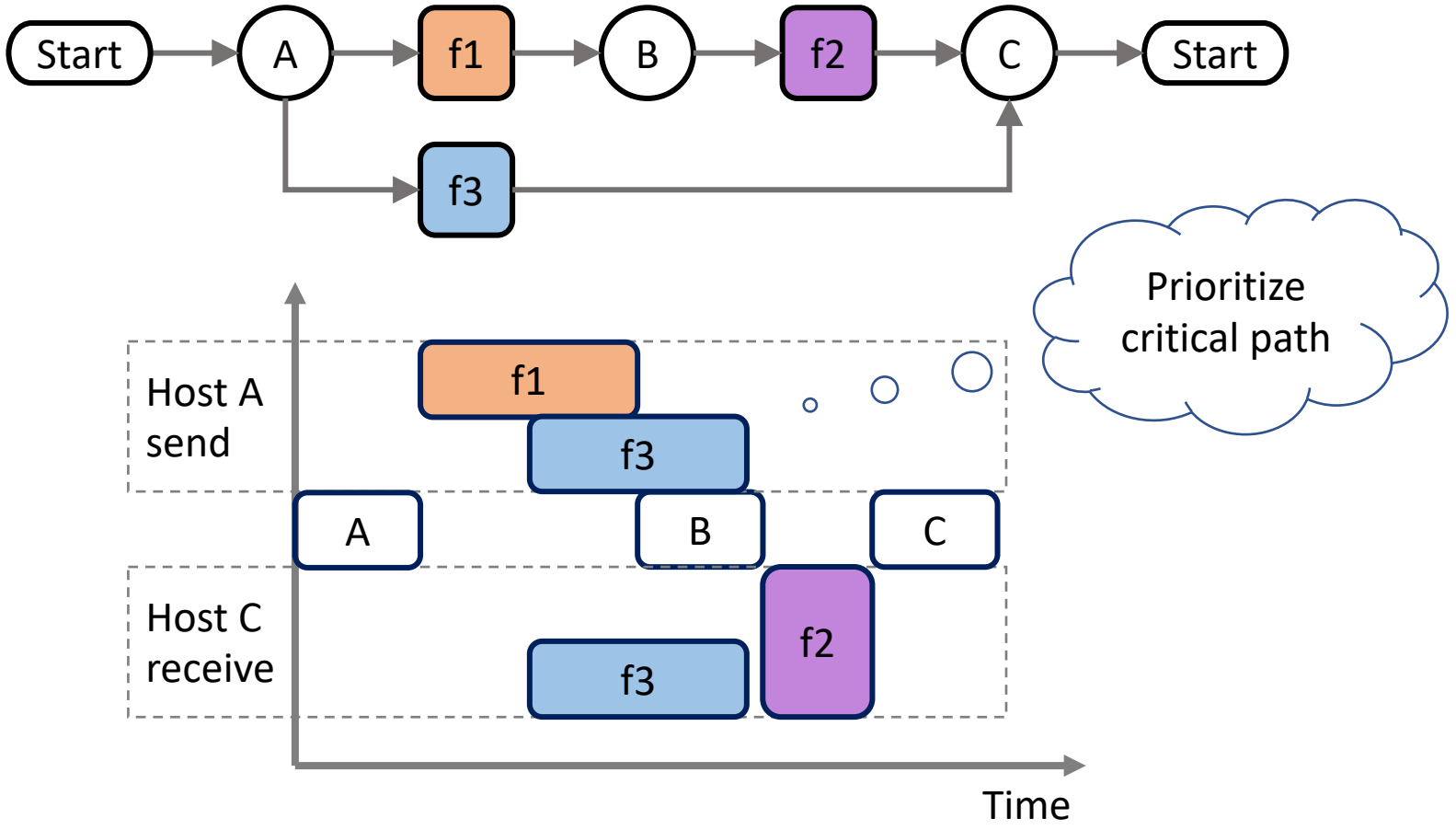

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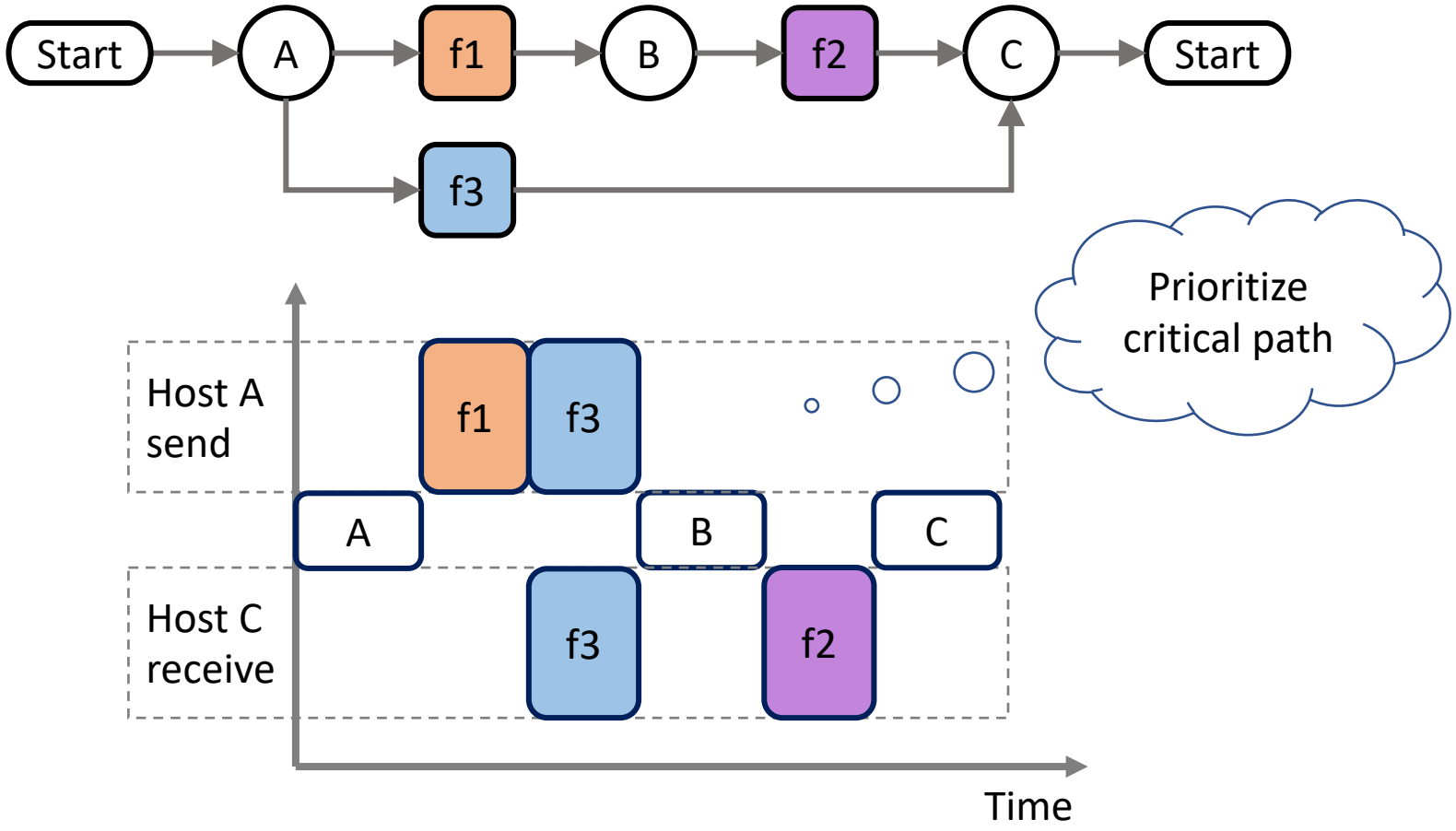

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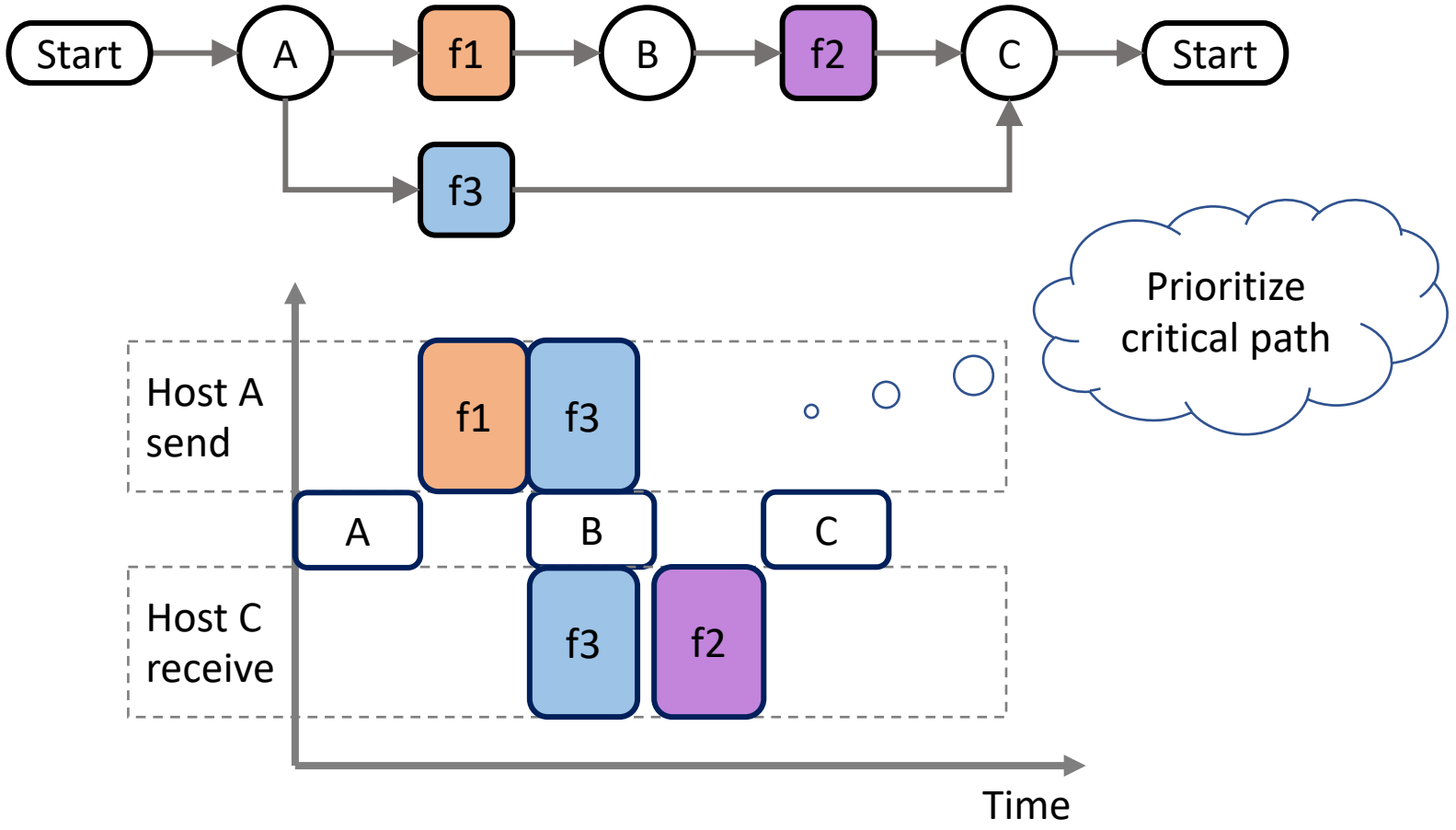
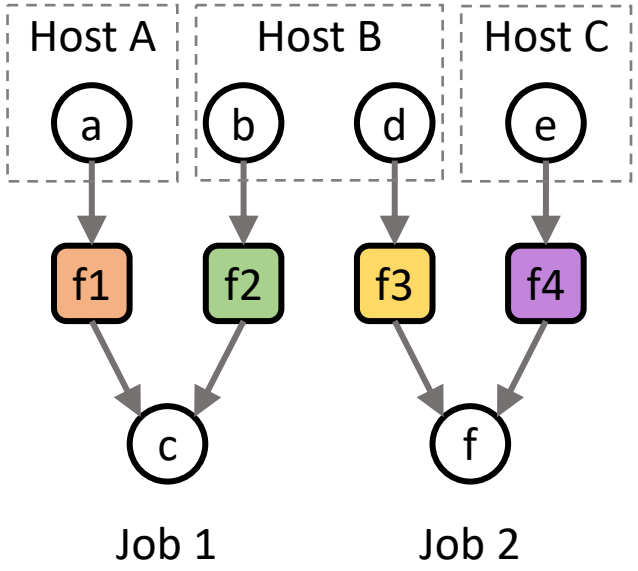
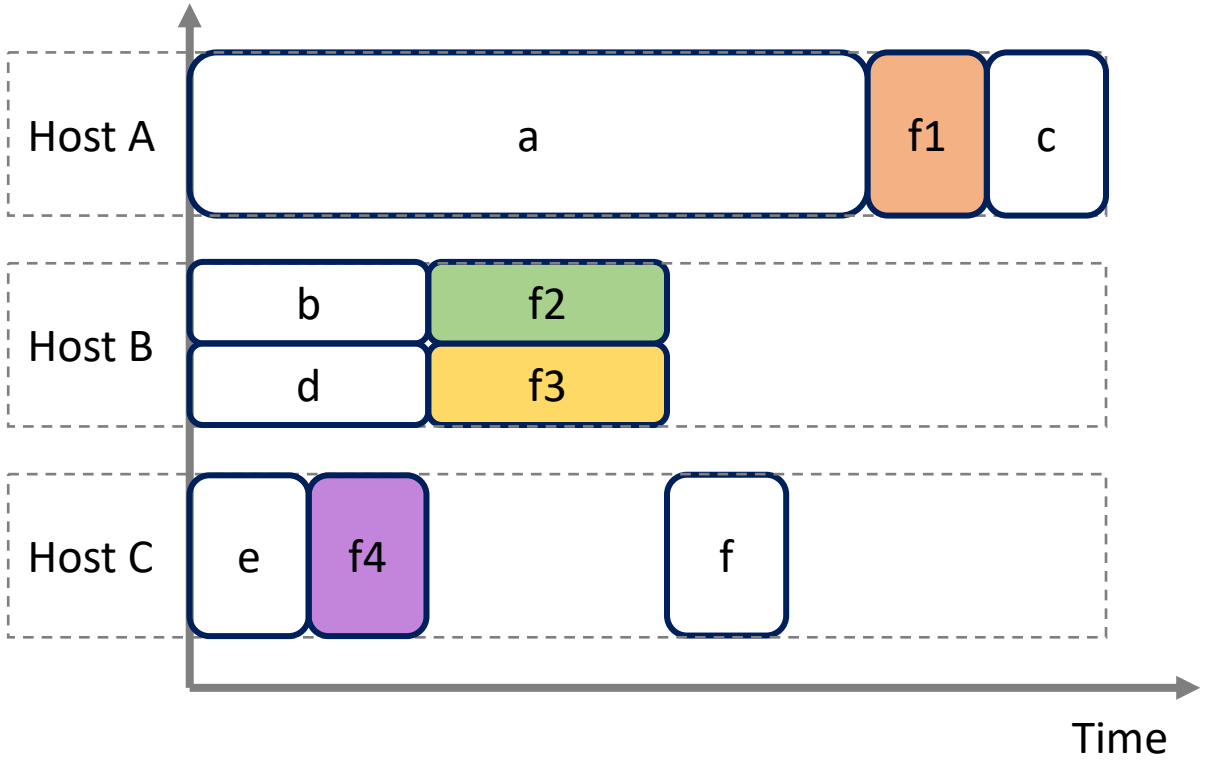


Schedule Multiple MXDAGs

Key Principle: **be altruistic,** namely, try to benefit others without hurting its own performance

Method: **delay the execution of the non-critical path** until necessary





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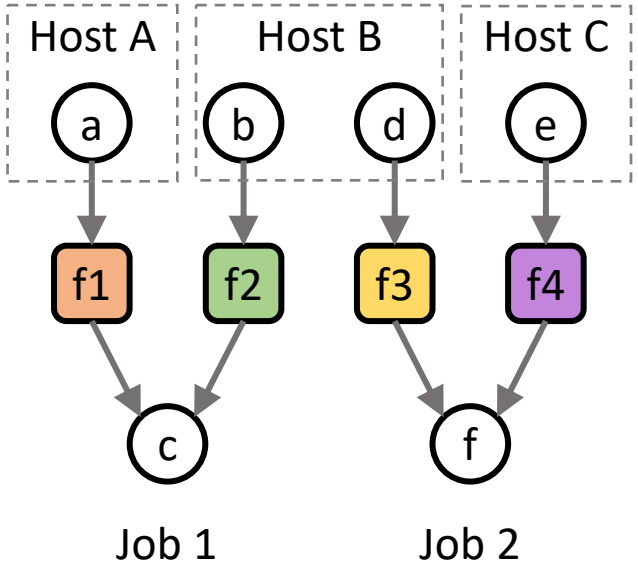

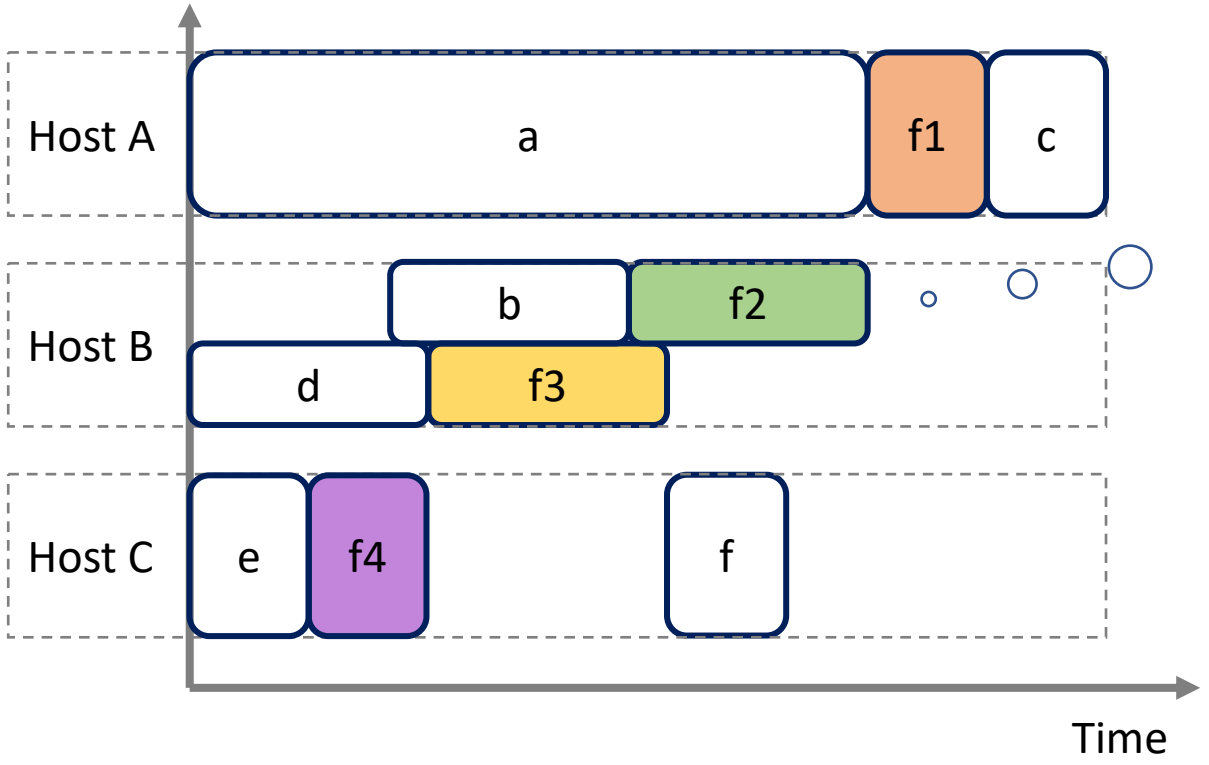

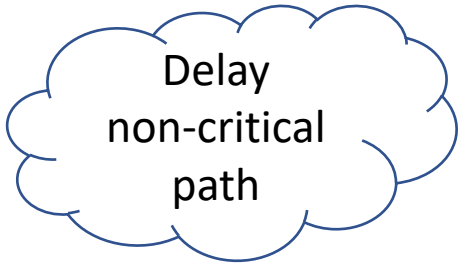

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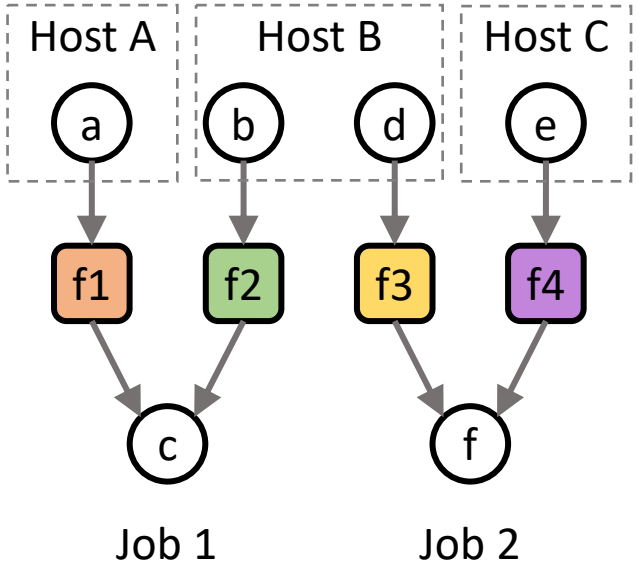
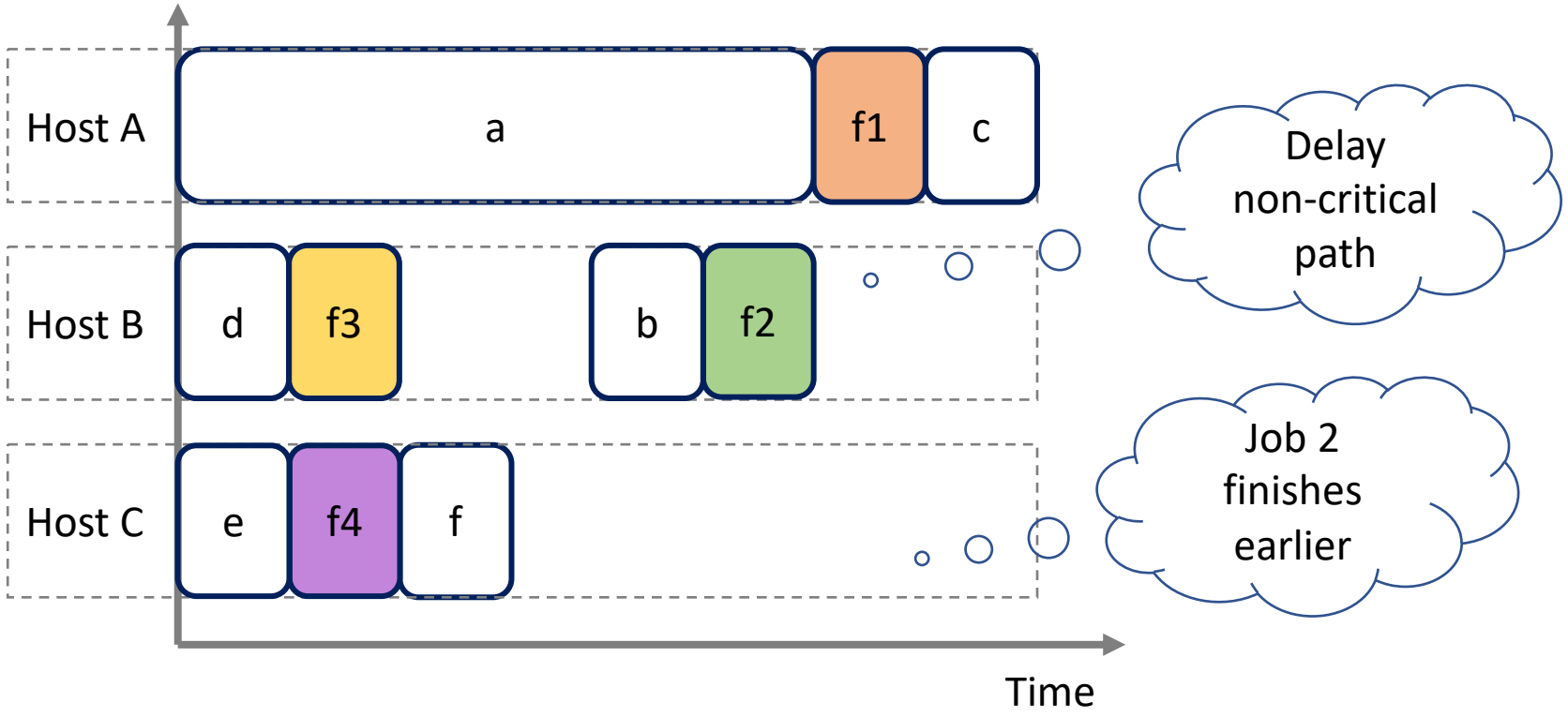
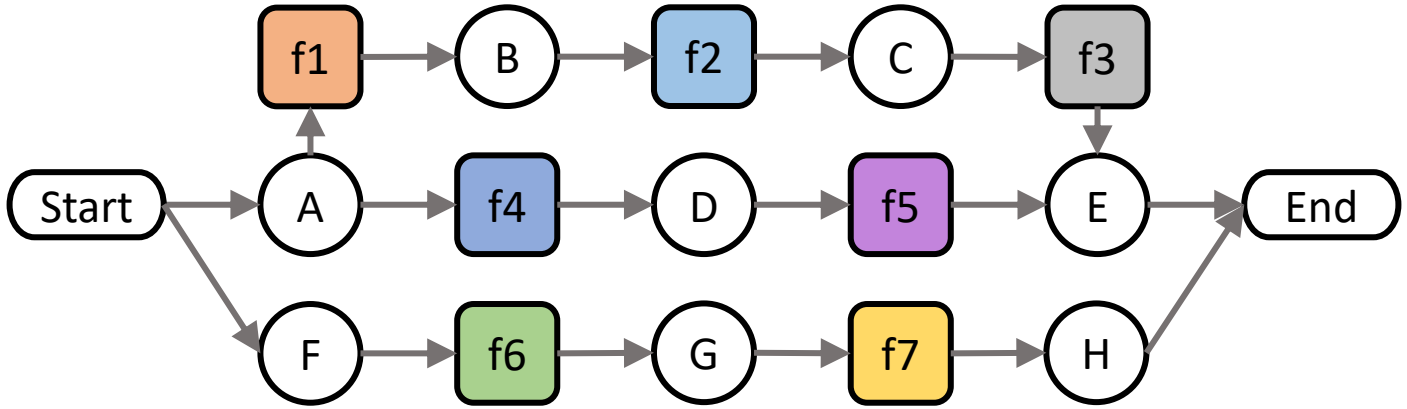




Other Usages of MXDAG

Runtime close-loop control:



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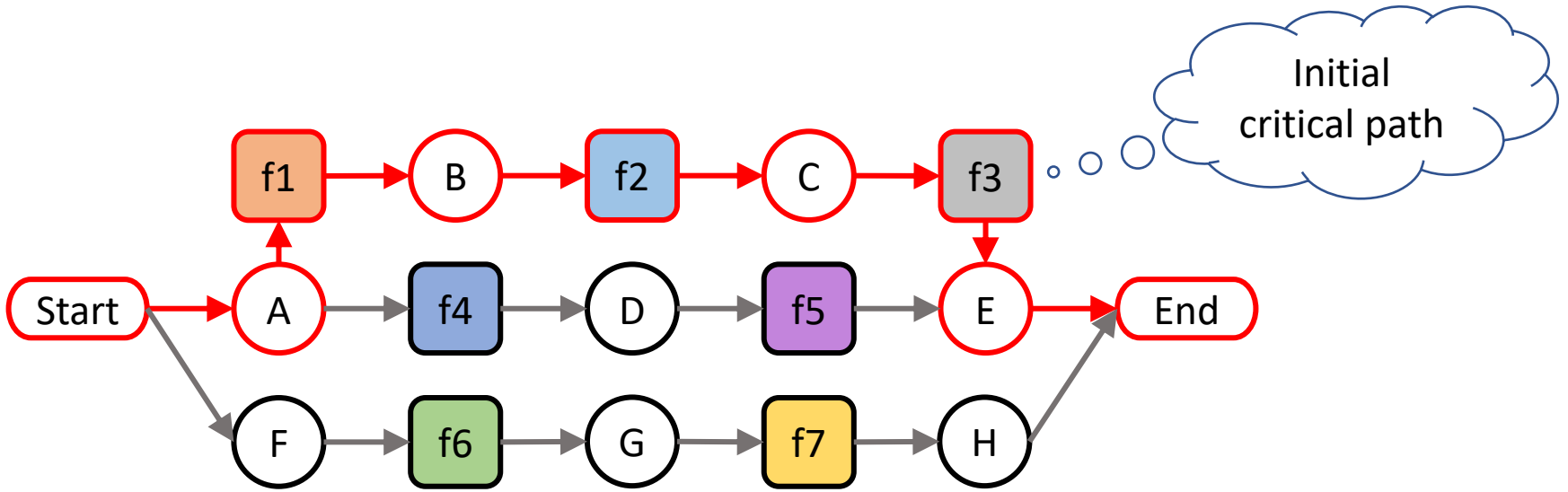

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Runtime close-loop control:

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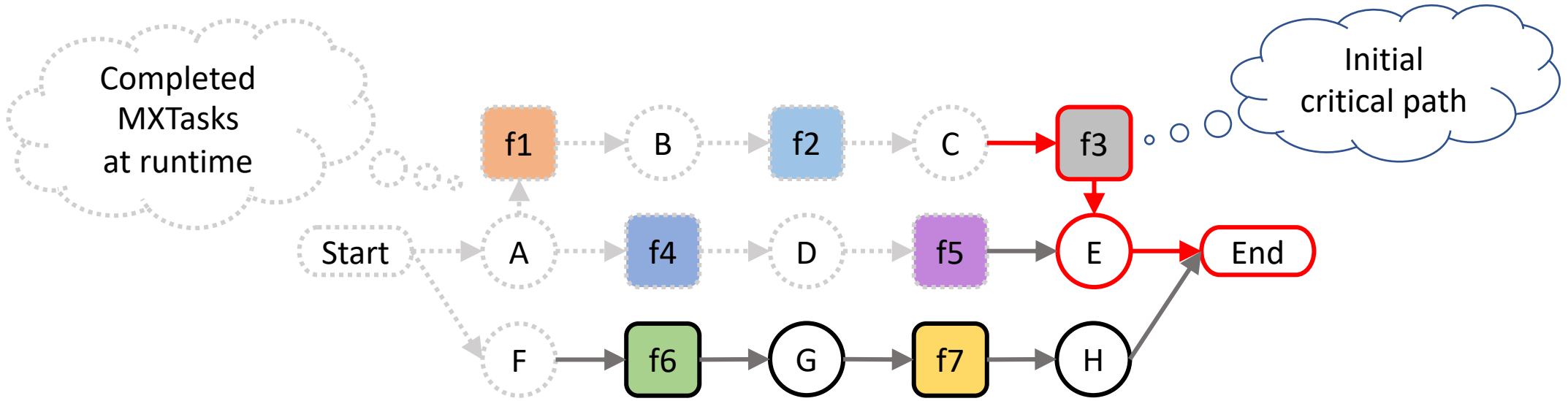
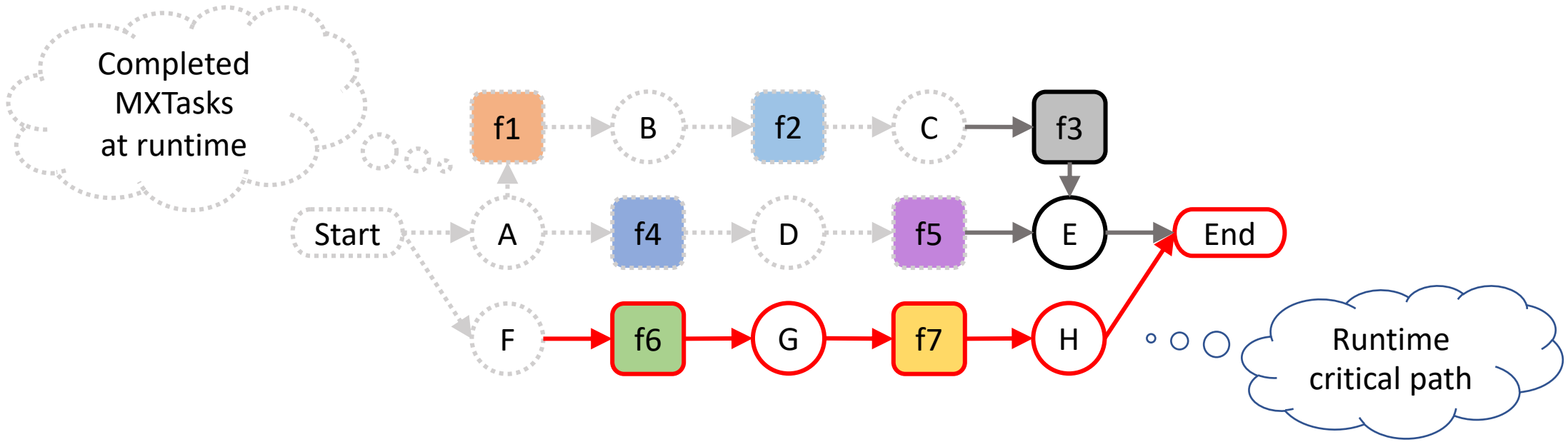


Other Usages of MXDAG

Runtime close-loop control:

1. Identify the network or compute **stragglers at runtime** with monitoring;
2. **Reschedule** the resources depending on the **runtime critical path**.



Conclusion

- MXDAG provides the first comprehensive abstraction for emerging applications
  - Treat compute and network tasks equally as MXTasks
  - Introduce pipelineability in abstraction and make the pipelines runtime reconfigurable
- Provide principles for the compute-network co-scheduler
  - Prioritize the **critical path** within a single MXDAG
  - Be **altruistic** for multiple MXDAGs
- Other usages:
  - Monitor the application's path-wise progress at runtime
  - Mitigate the global stragglers among the application's tasks
  - …

Q & A!

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Method: **delay the execution of the non-critical path** until necessary