Naiad: A Timely Dataflow System

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Michael Isard, Paul Barham, Martin Abadi

“Historic” Context

- The world in 2013
  - Hadoop, Spark, etc.: General purpose batch data processing (high latency)
  - Pregel, GraphLab, etc.: Graph processing (iterative)
  - Impala, F1, etc.: Fastish SQL queries
  - MillWheel, Storm, etc.: Stream processing systems (low latency)

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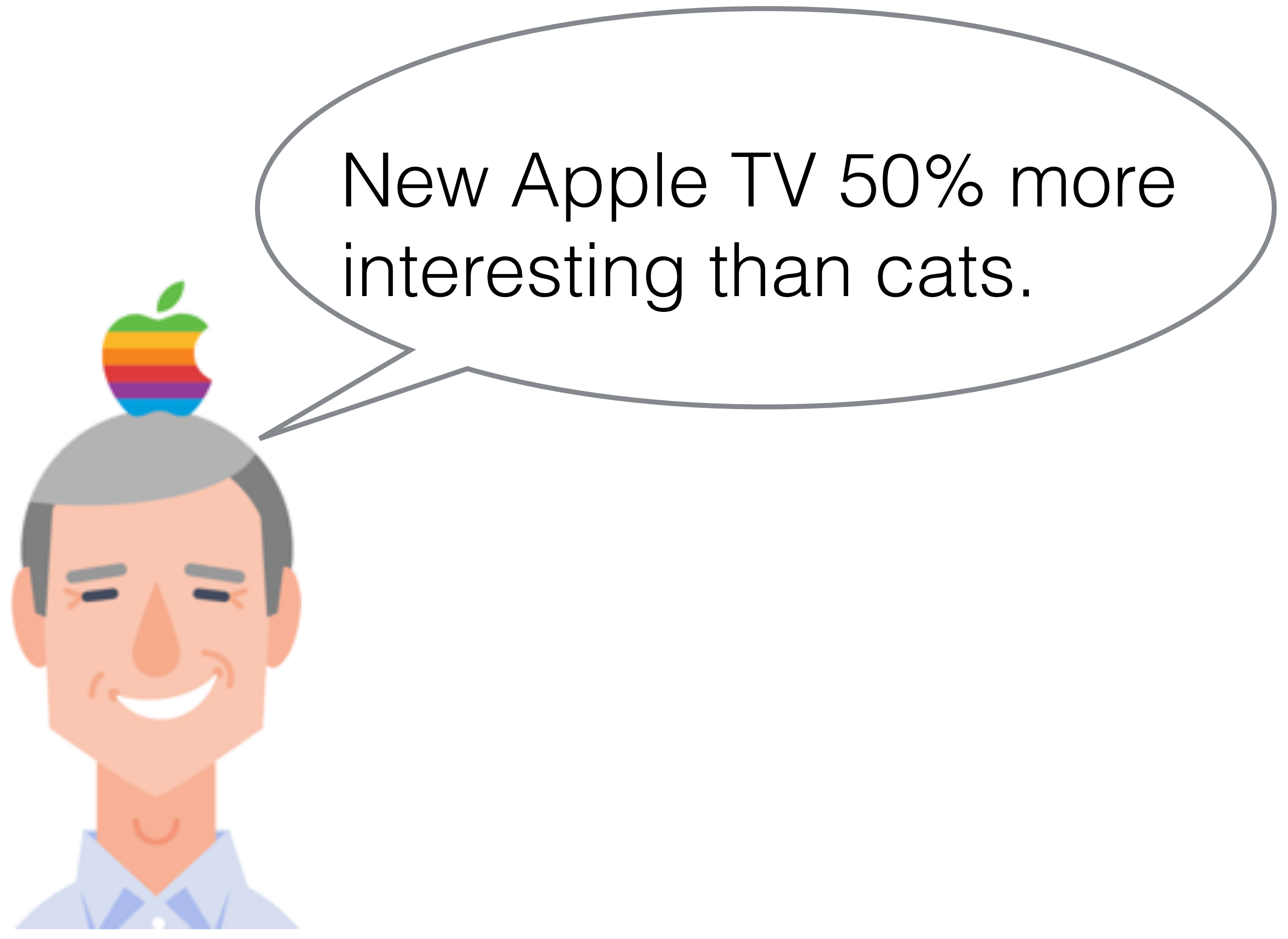
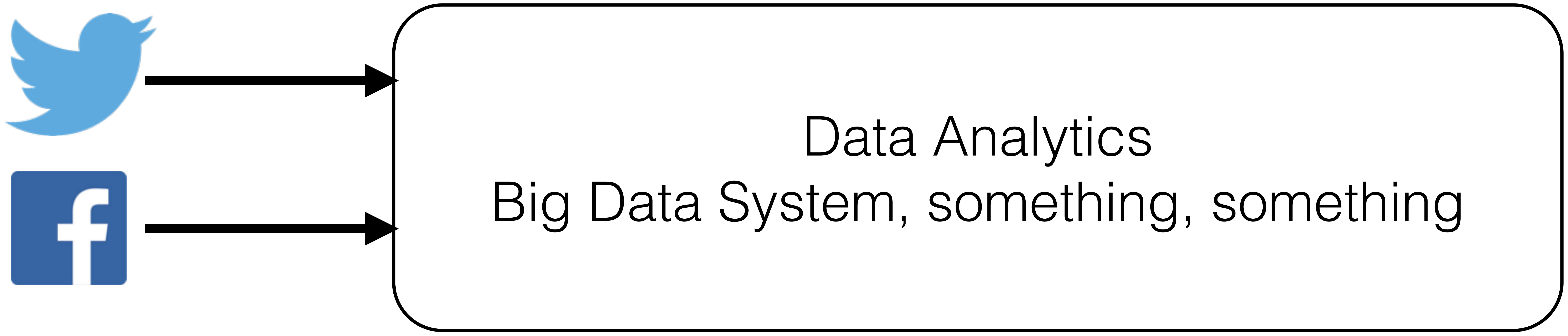
  - MillWheel, Storm, etc.: Stream processing systems (low latency)
- Lots of special purpose frameworks.
- A desire to allow these many paradigms to coexist in one system.
  - See also: Spark Streaming (next week), GraphX (later in the semester).

Why Multi-Paradigm?





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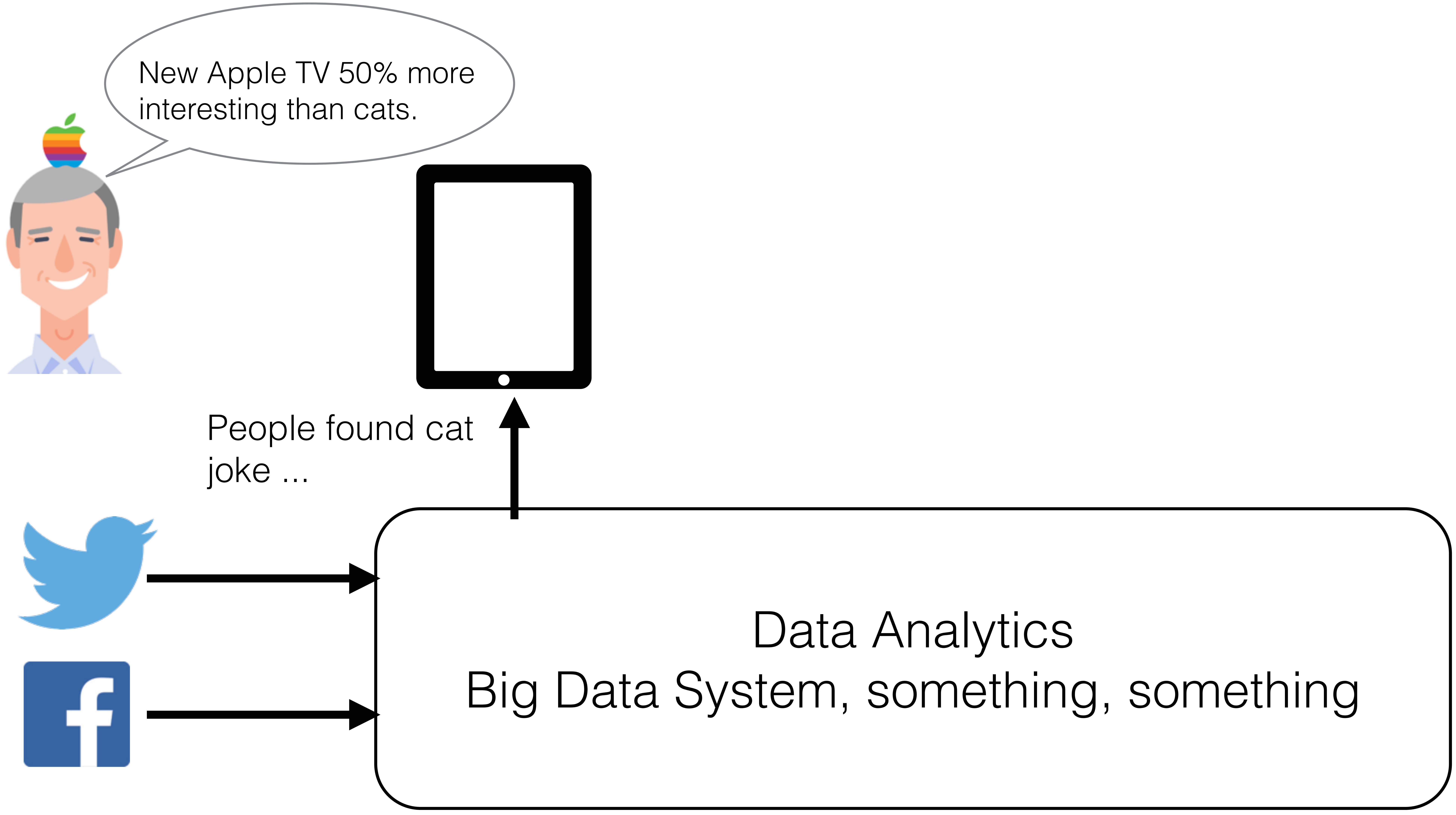
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Data Analytics
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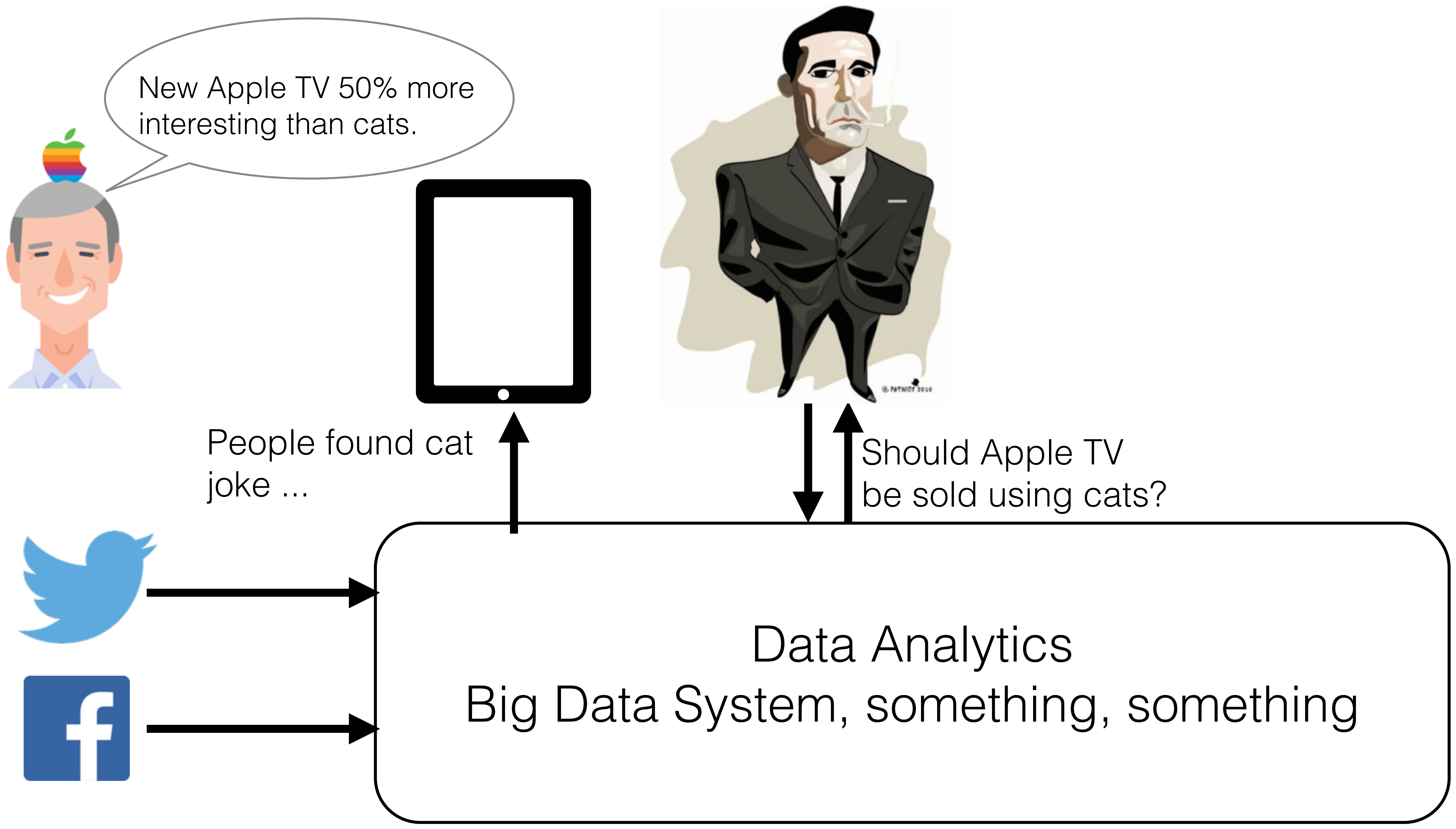
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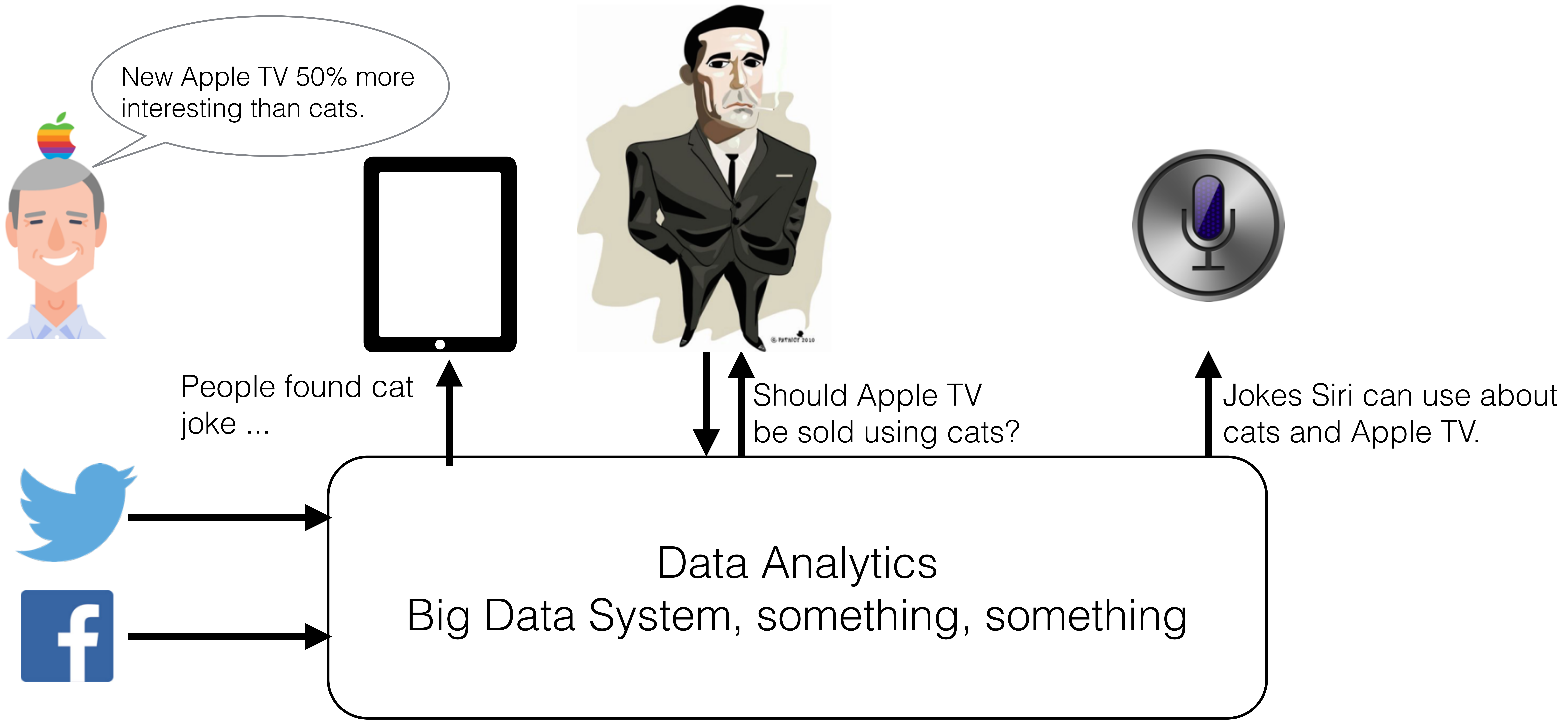
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Jokes Siri can use about cats and Apple TV.
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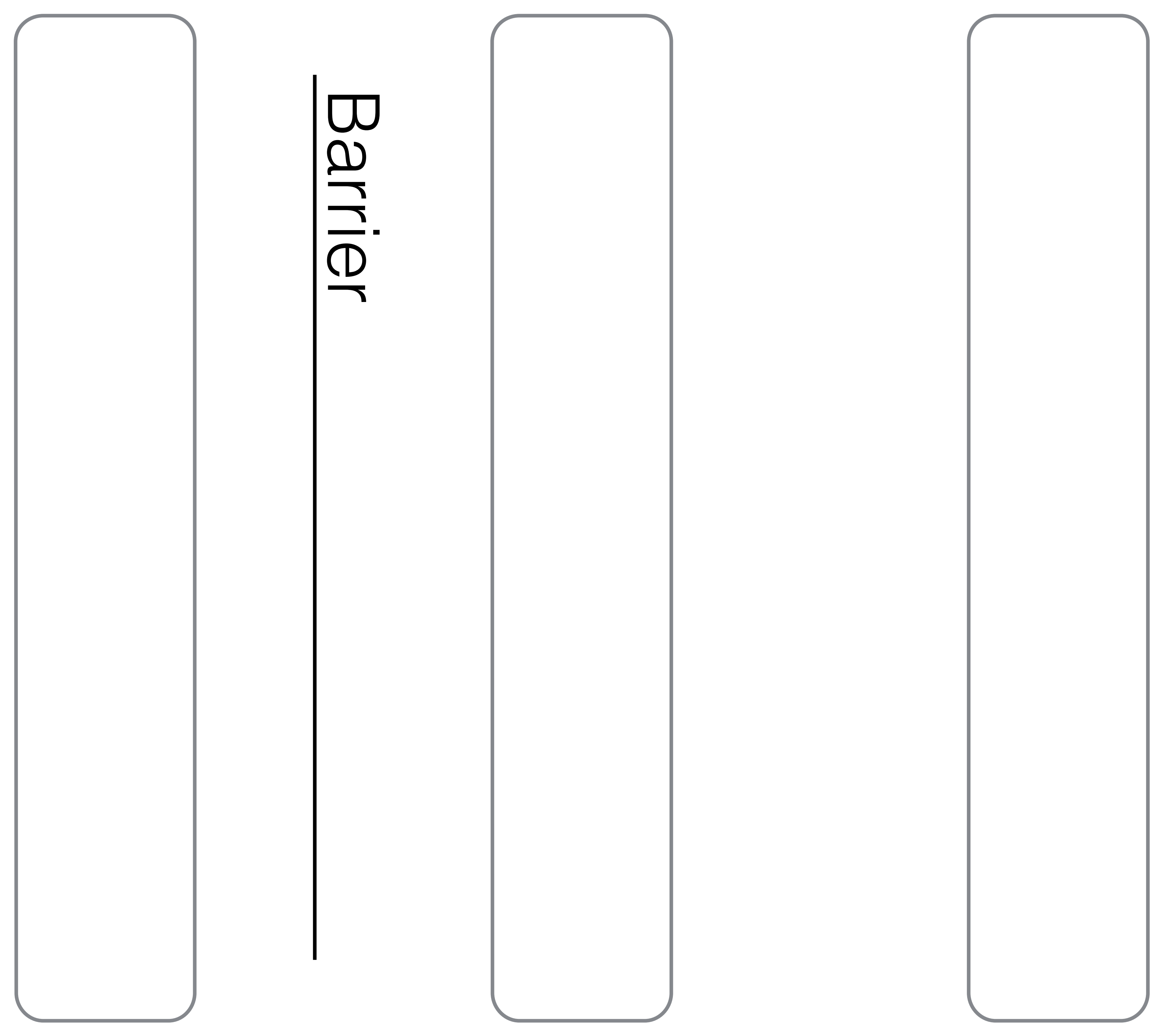

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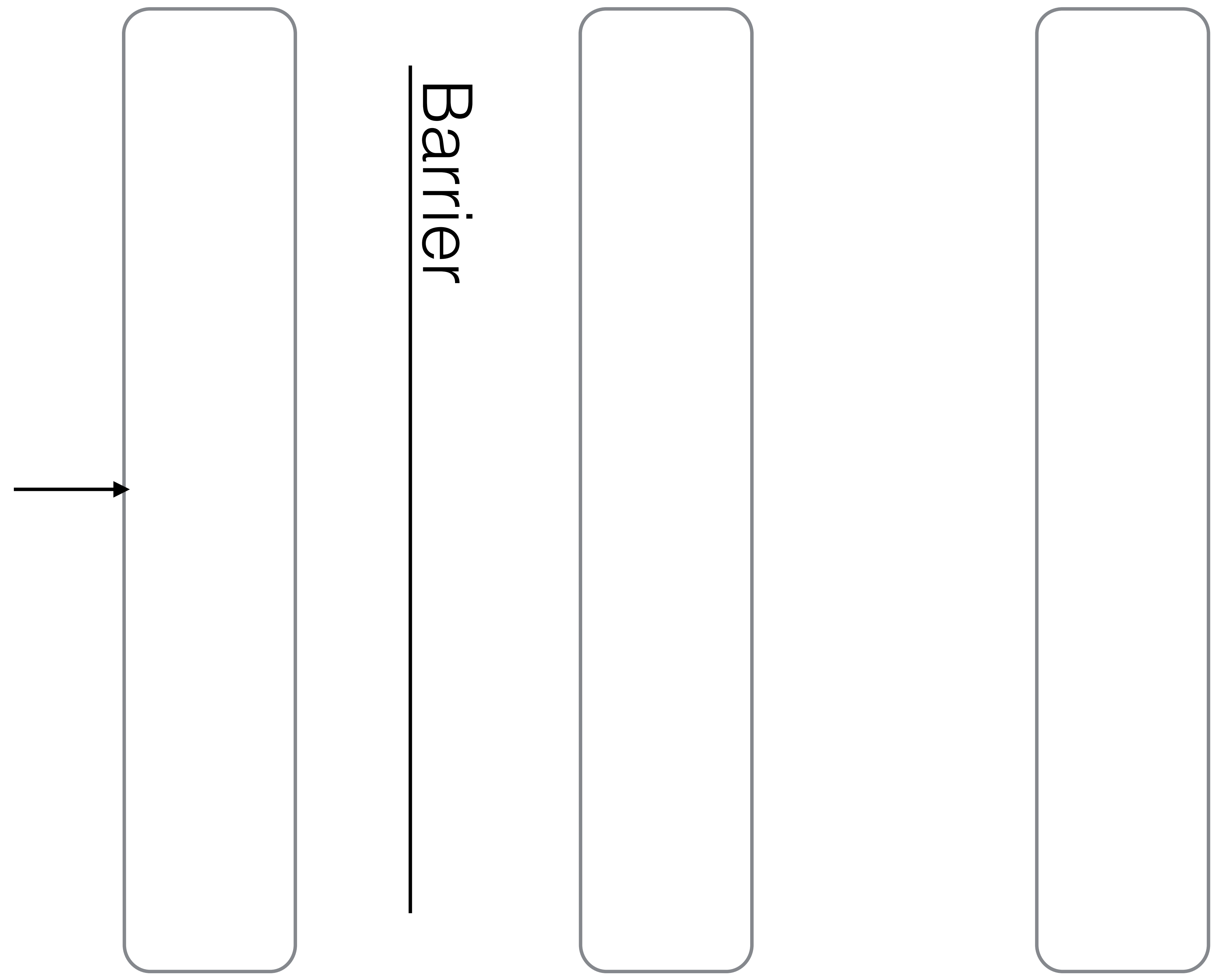

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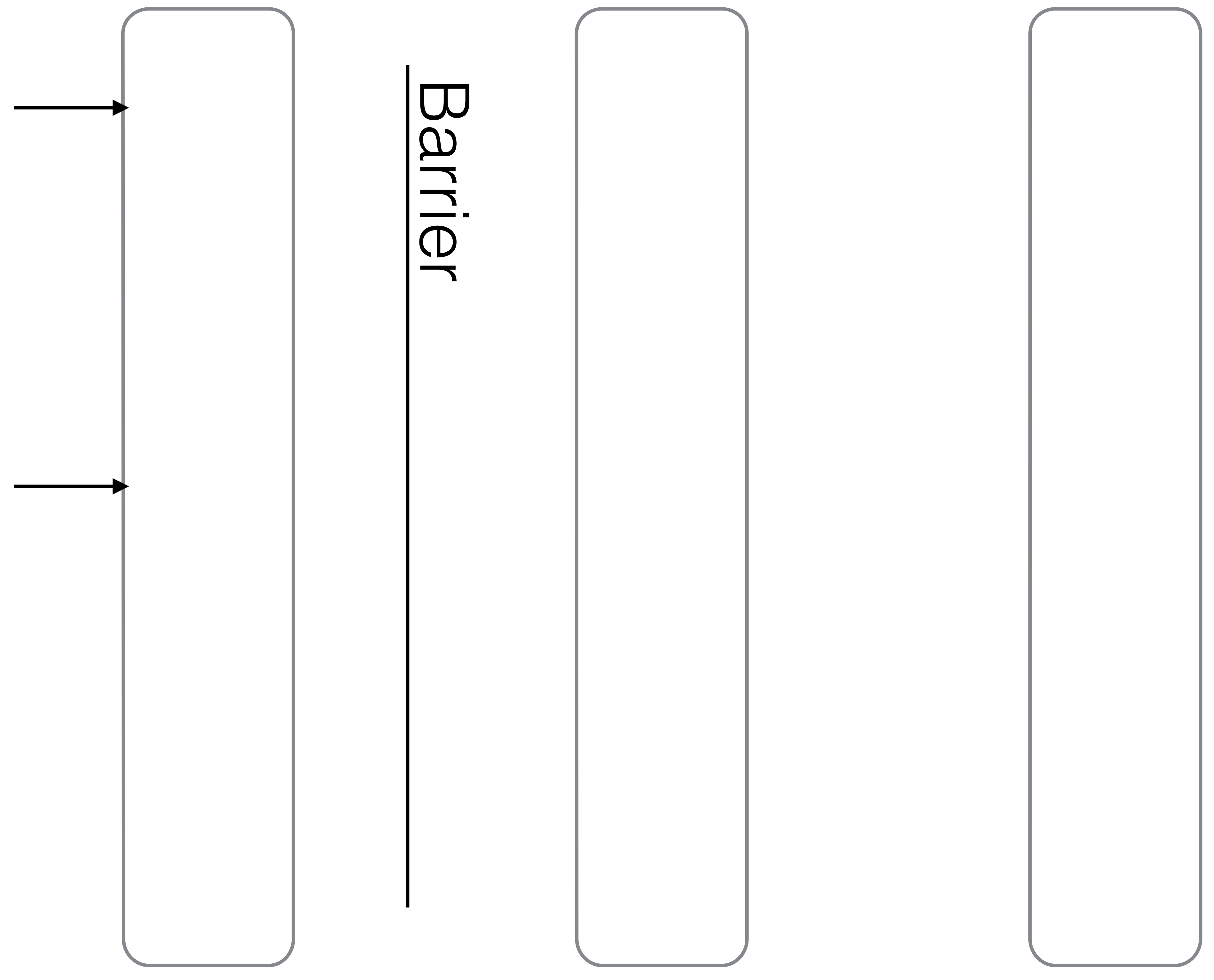

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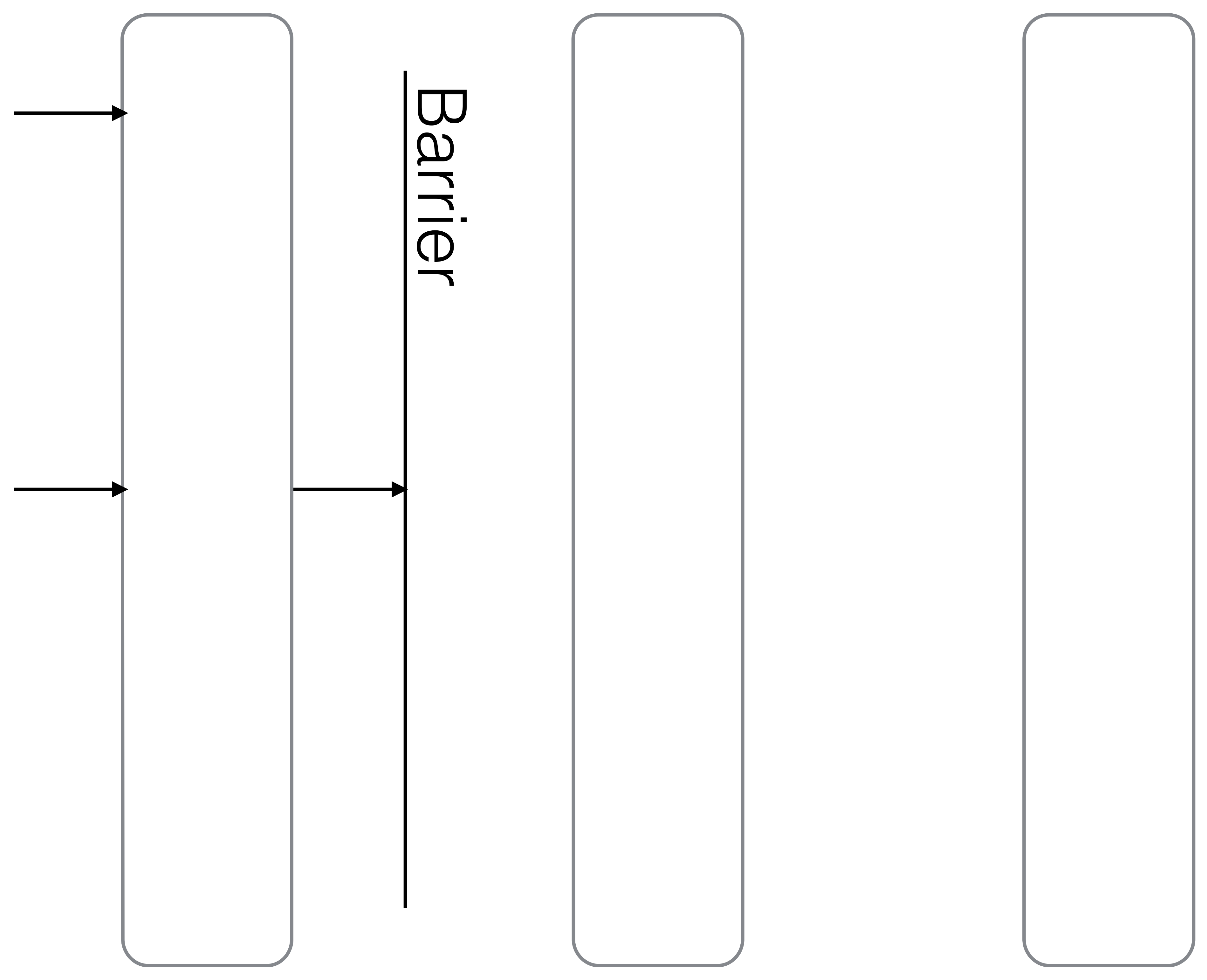

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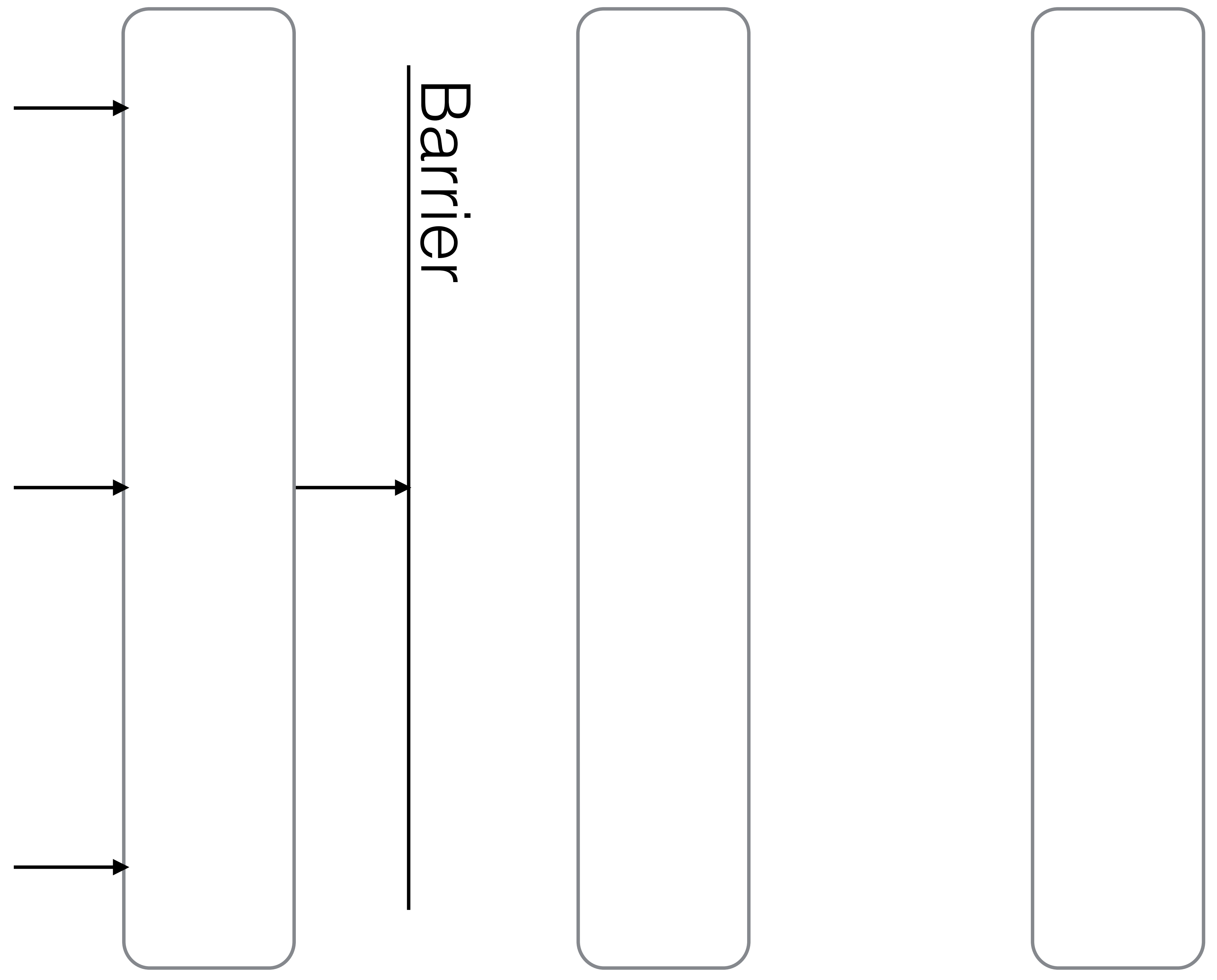

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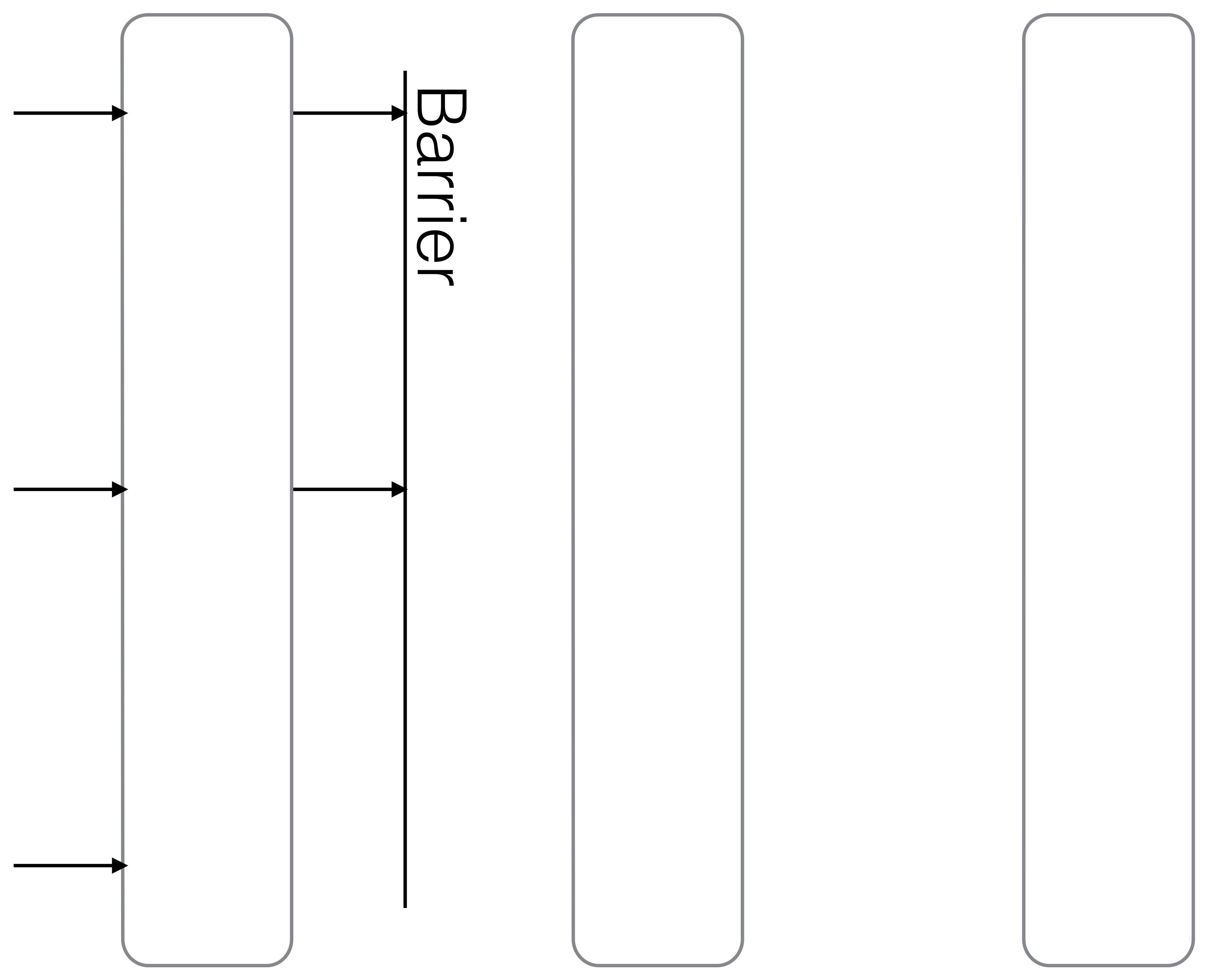

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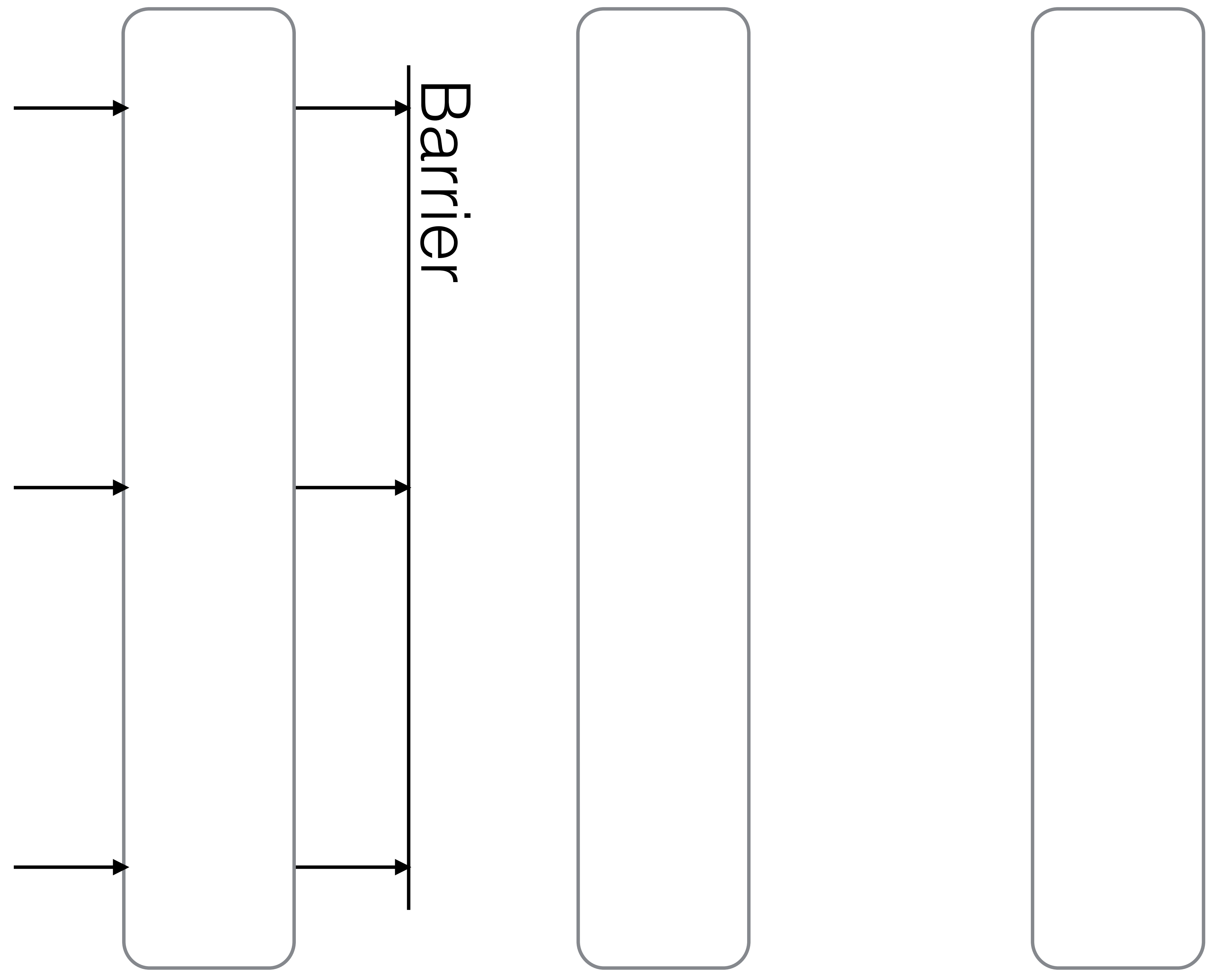

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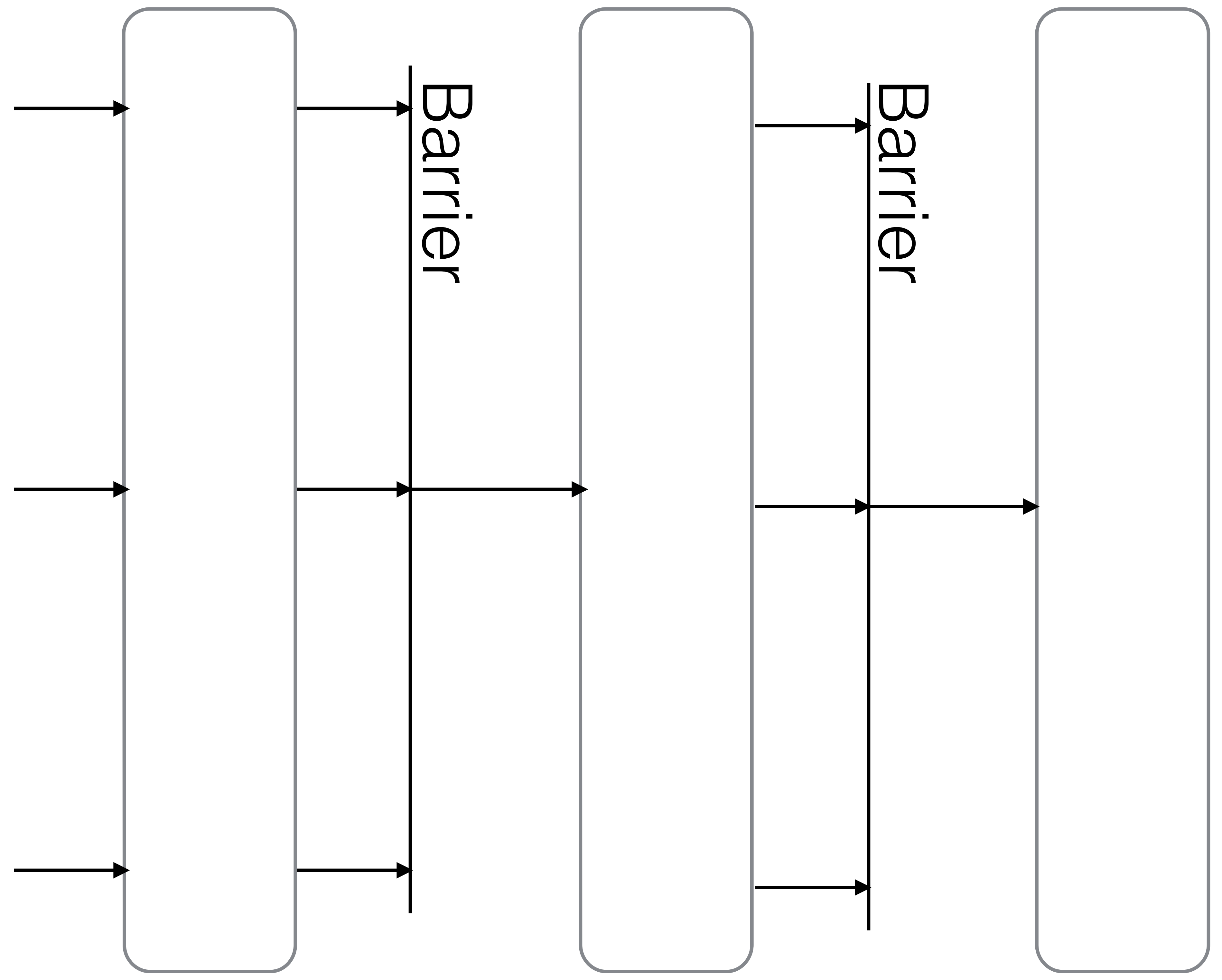

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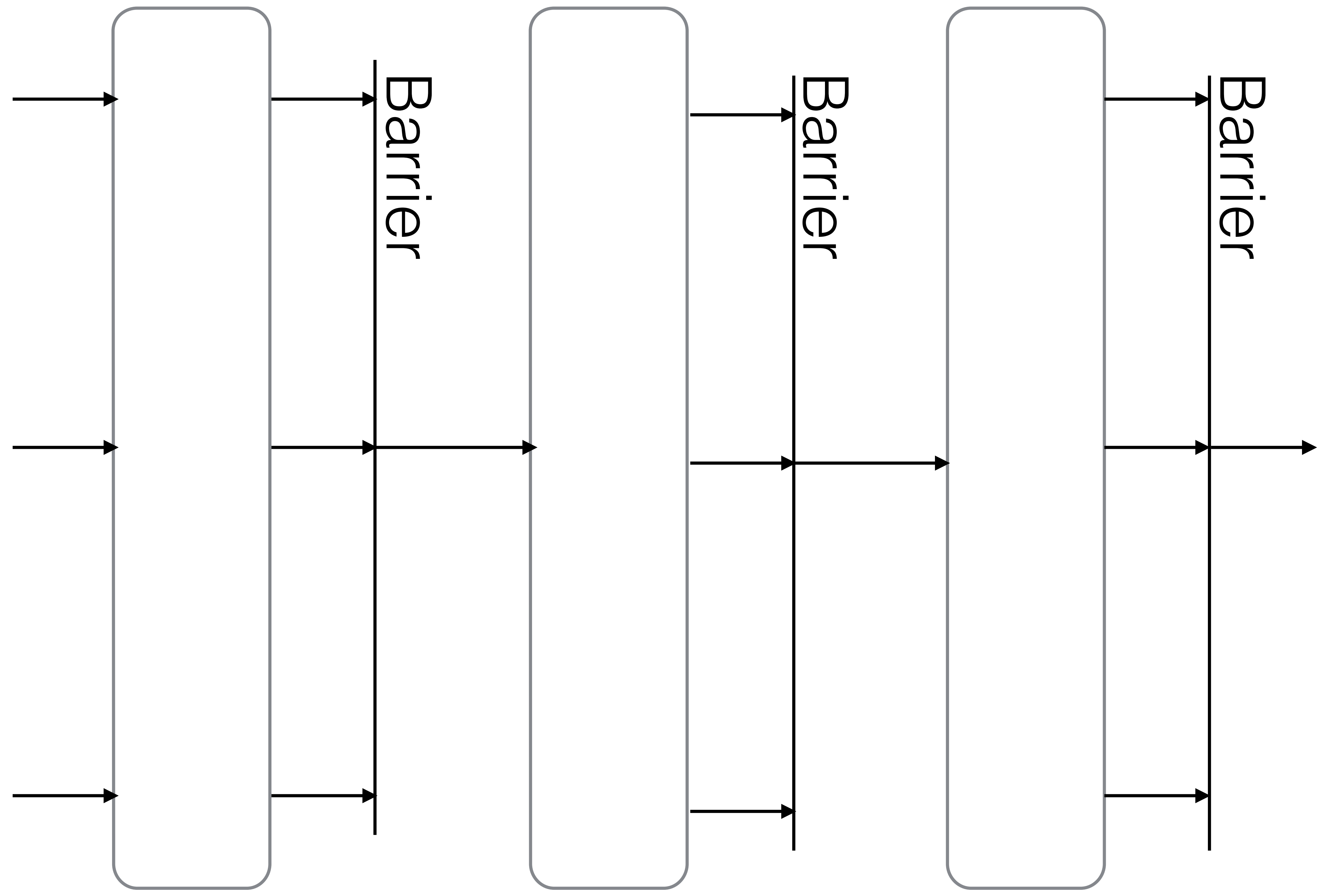

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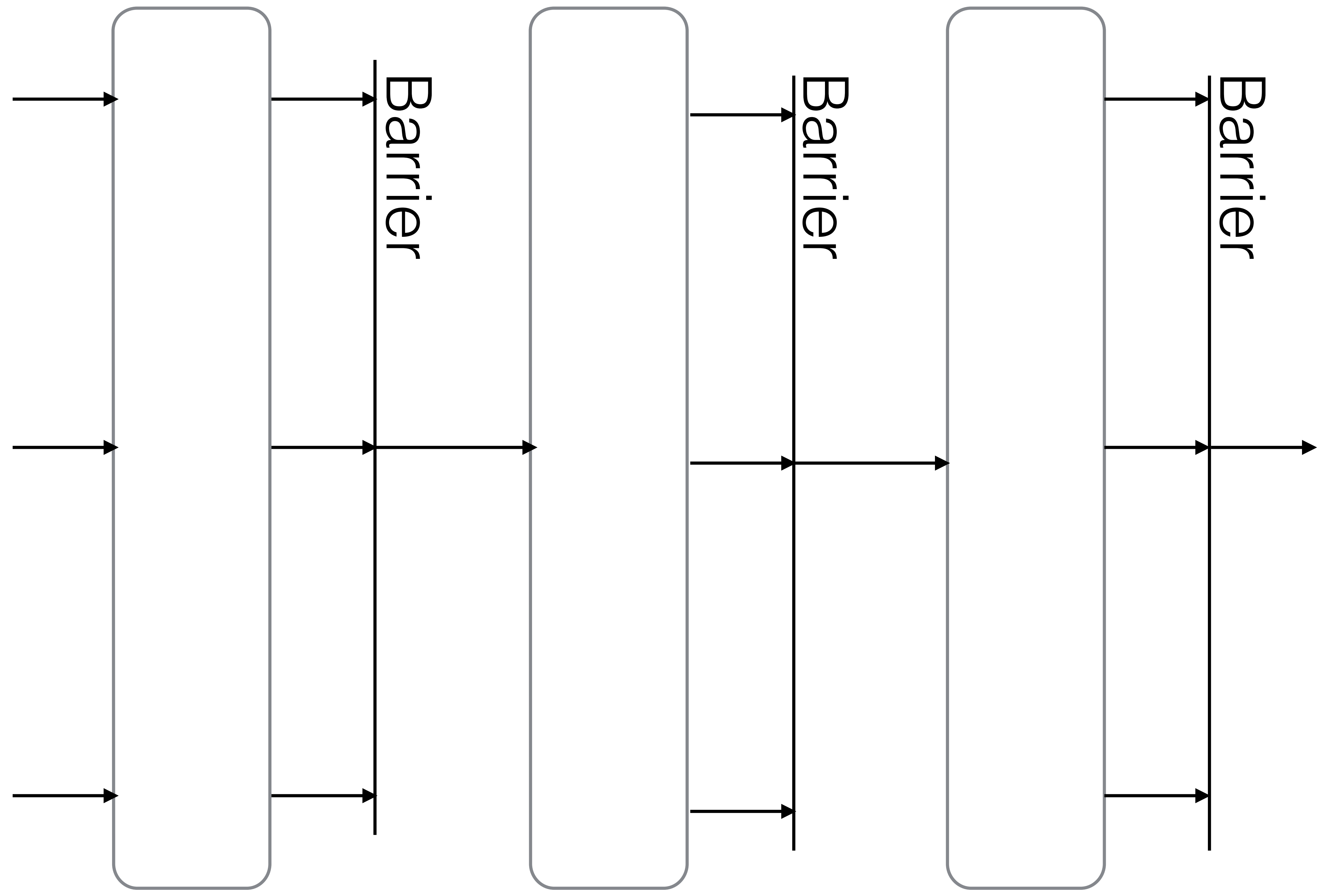

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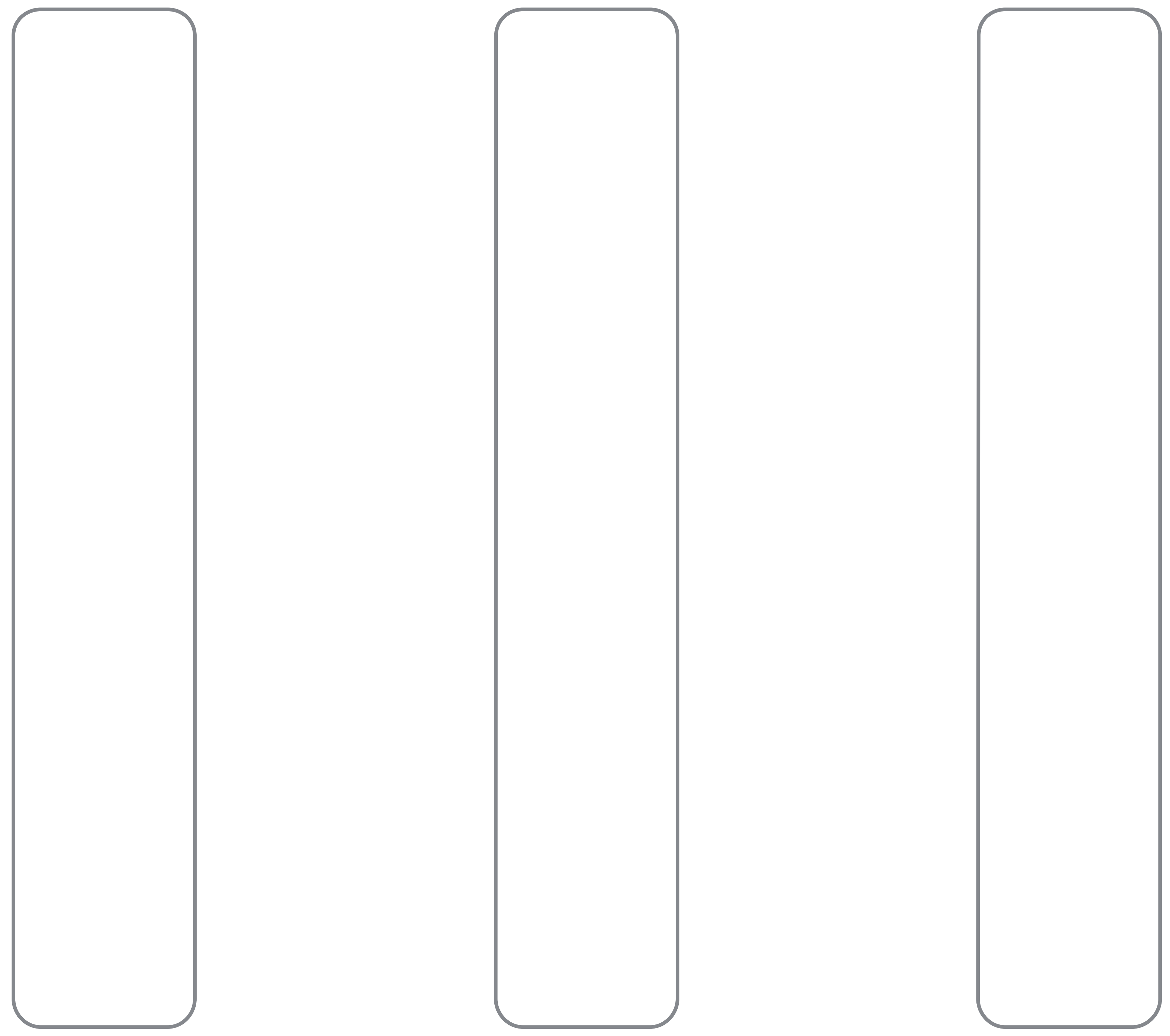

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Out-of-Order Processing

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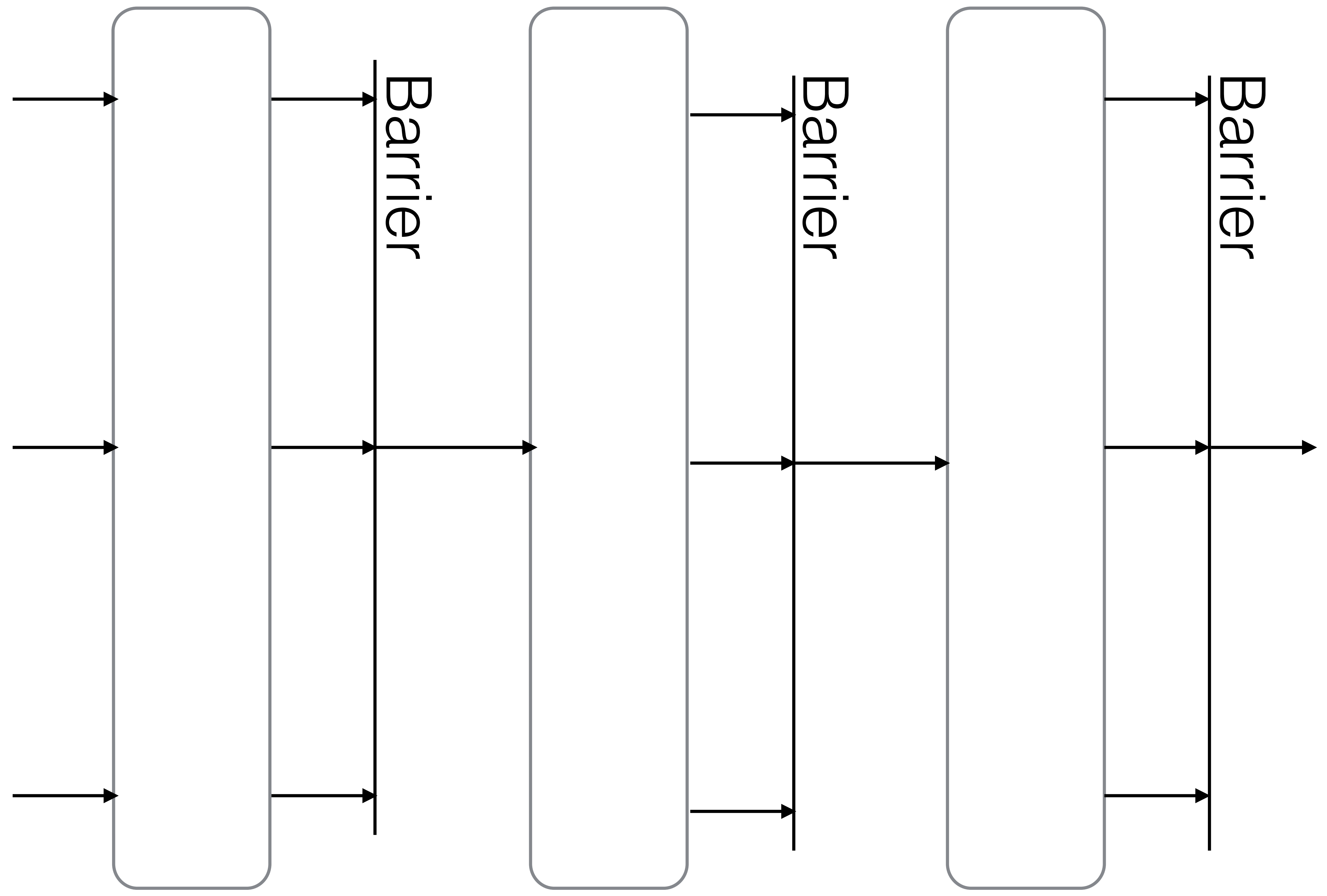

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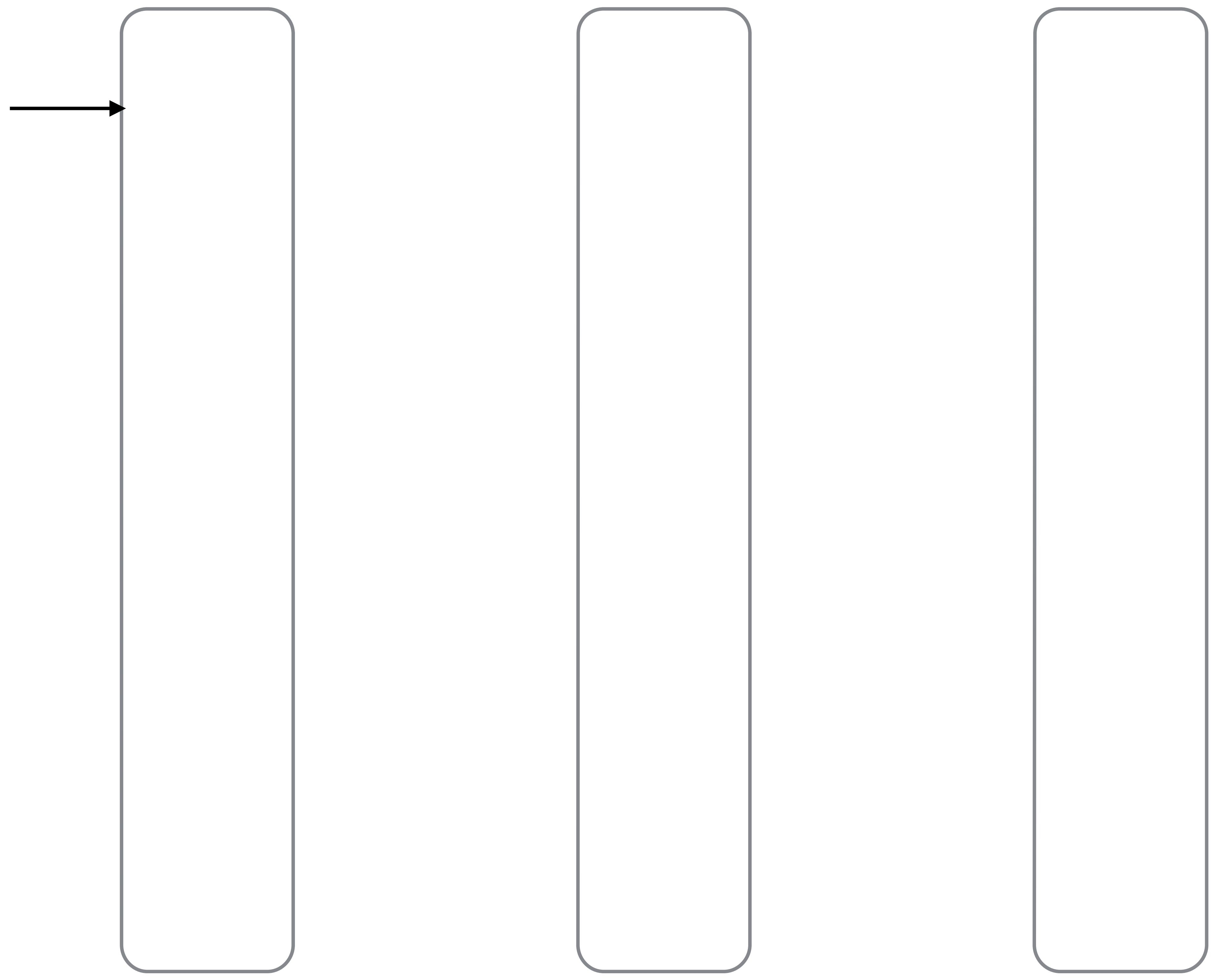

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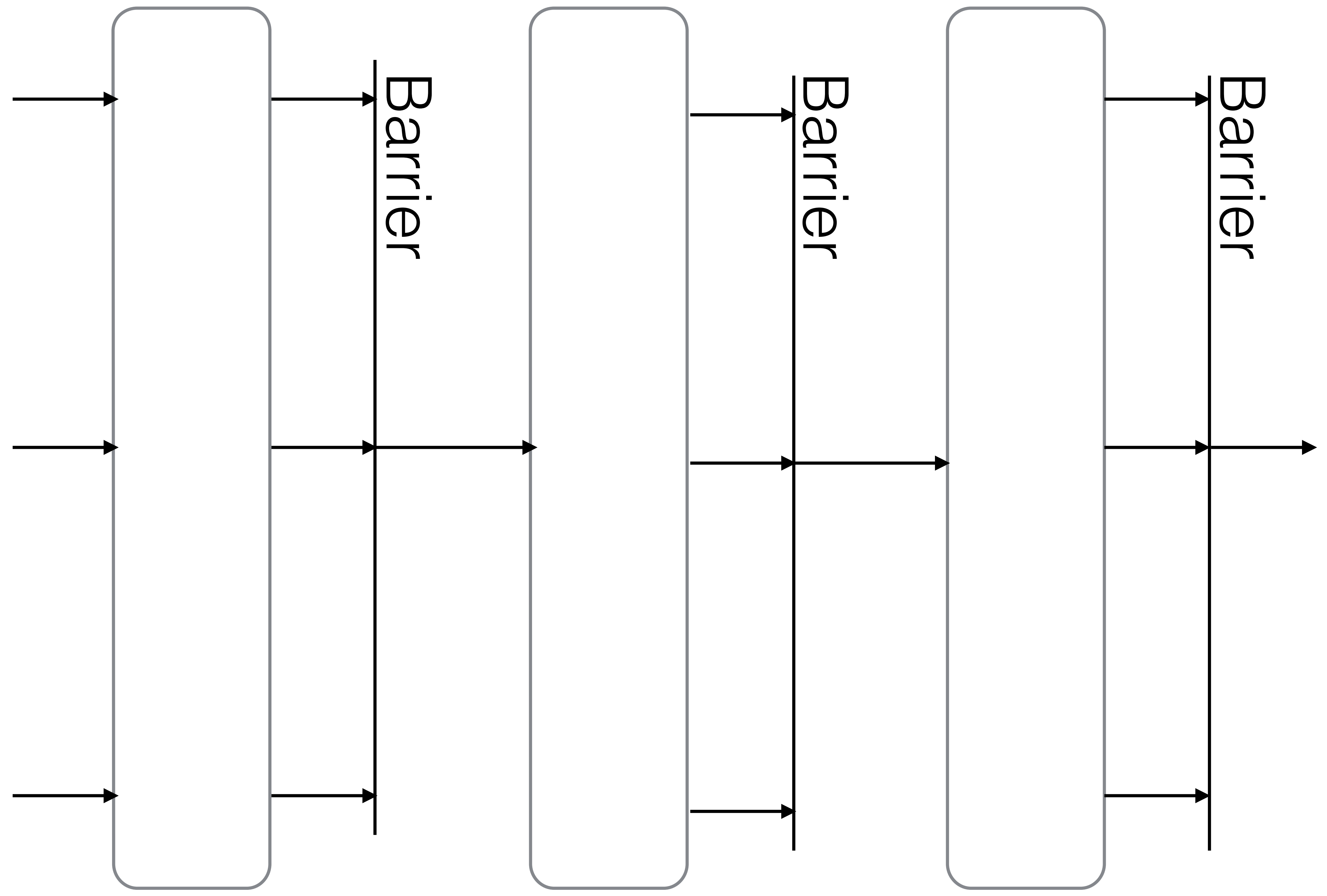

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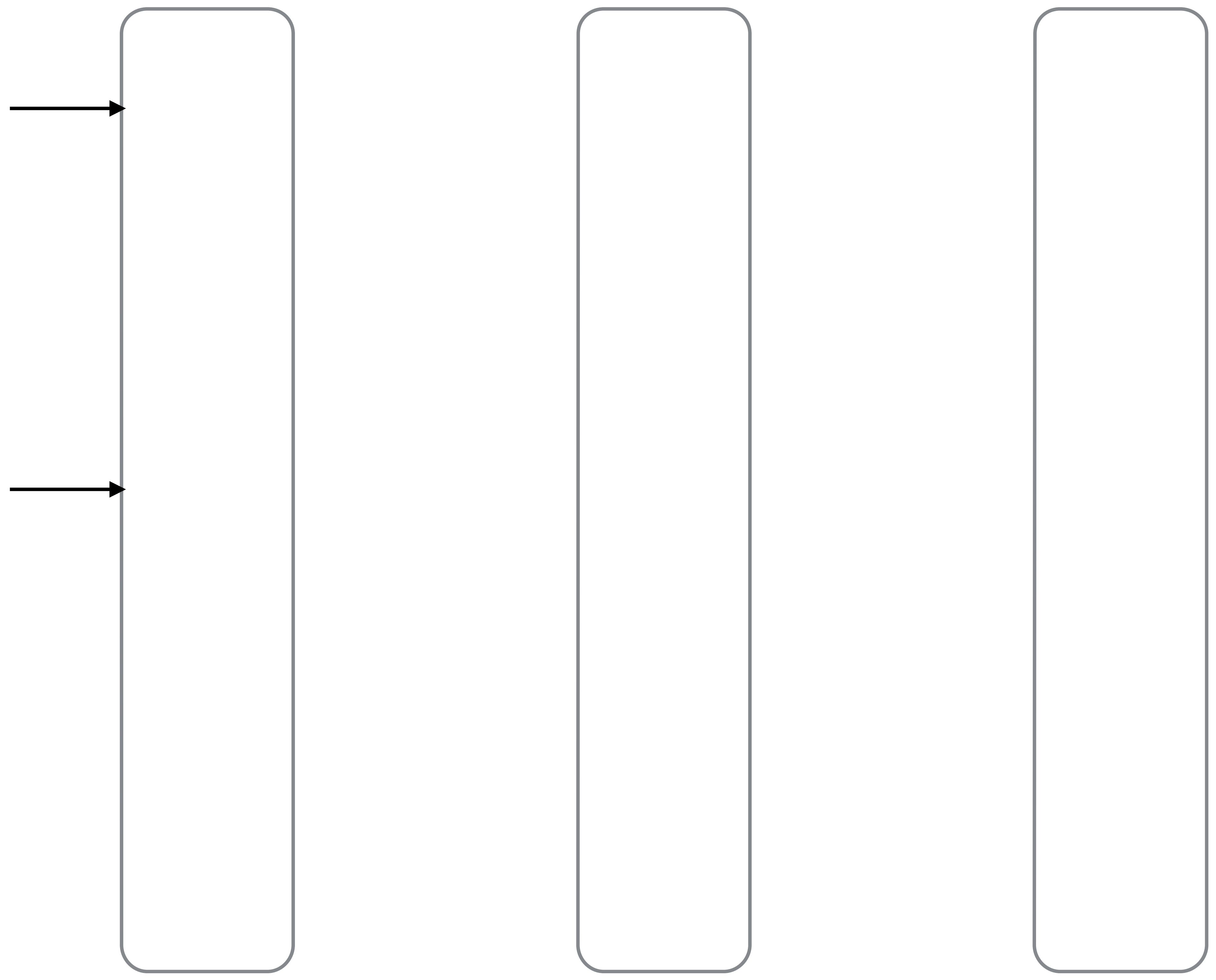

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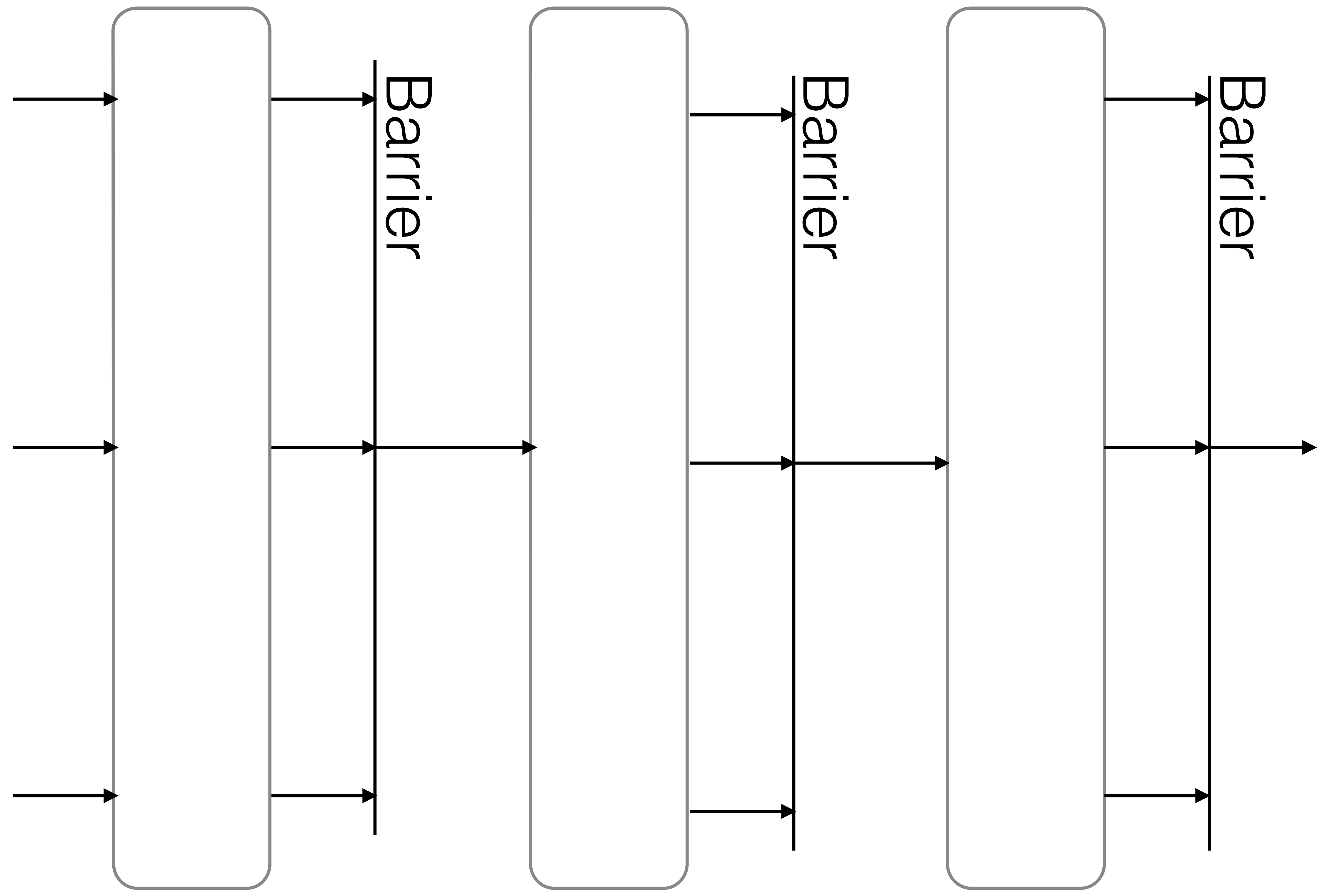

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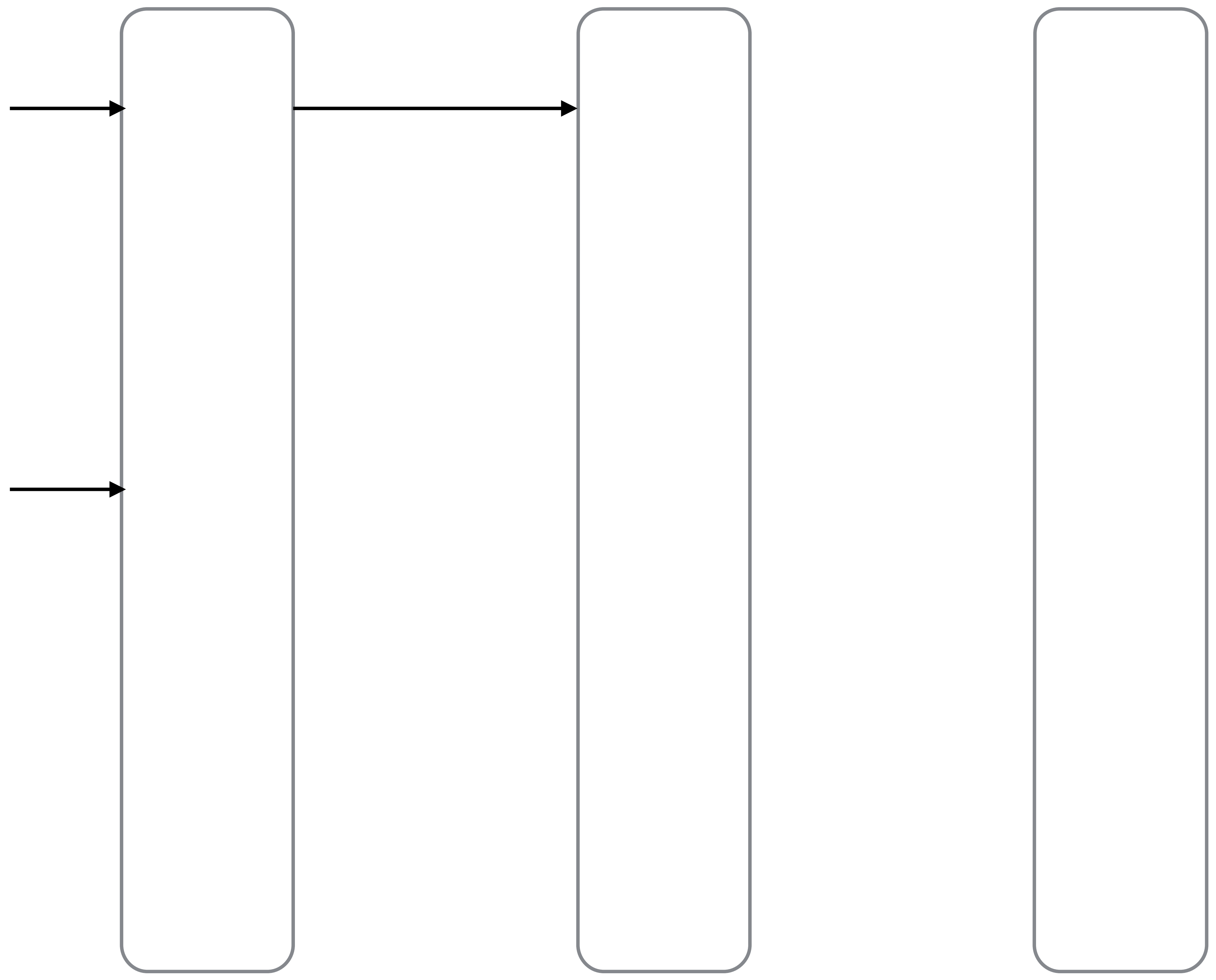

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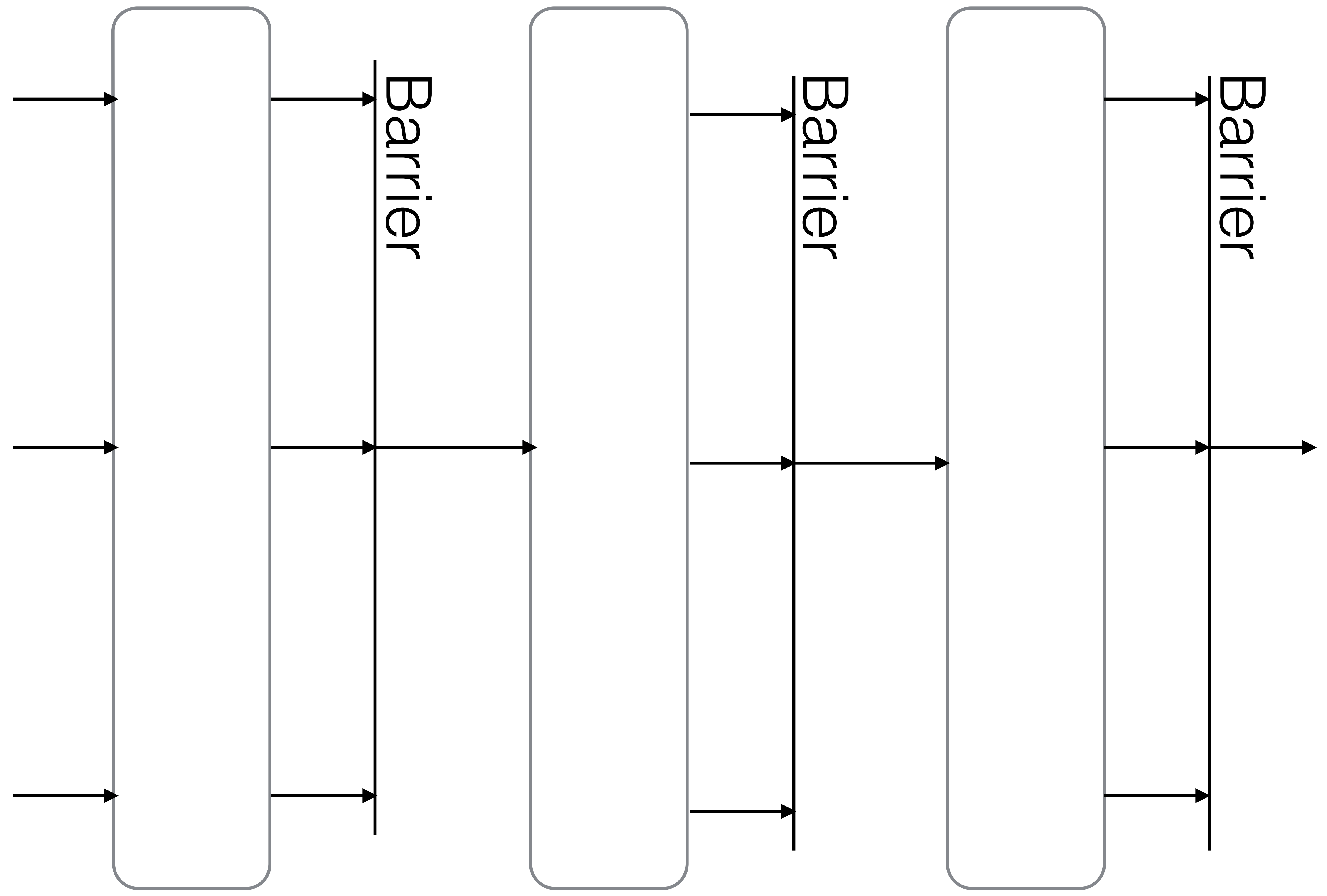

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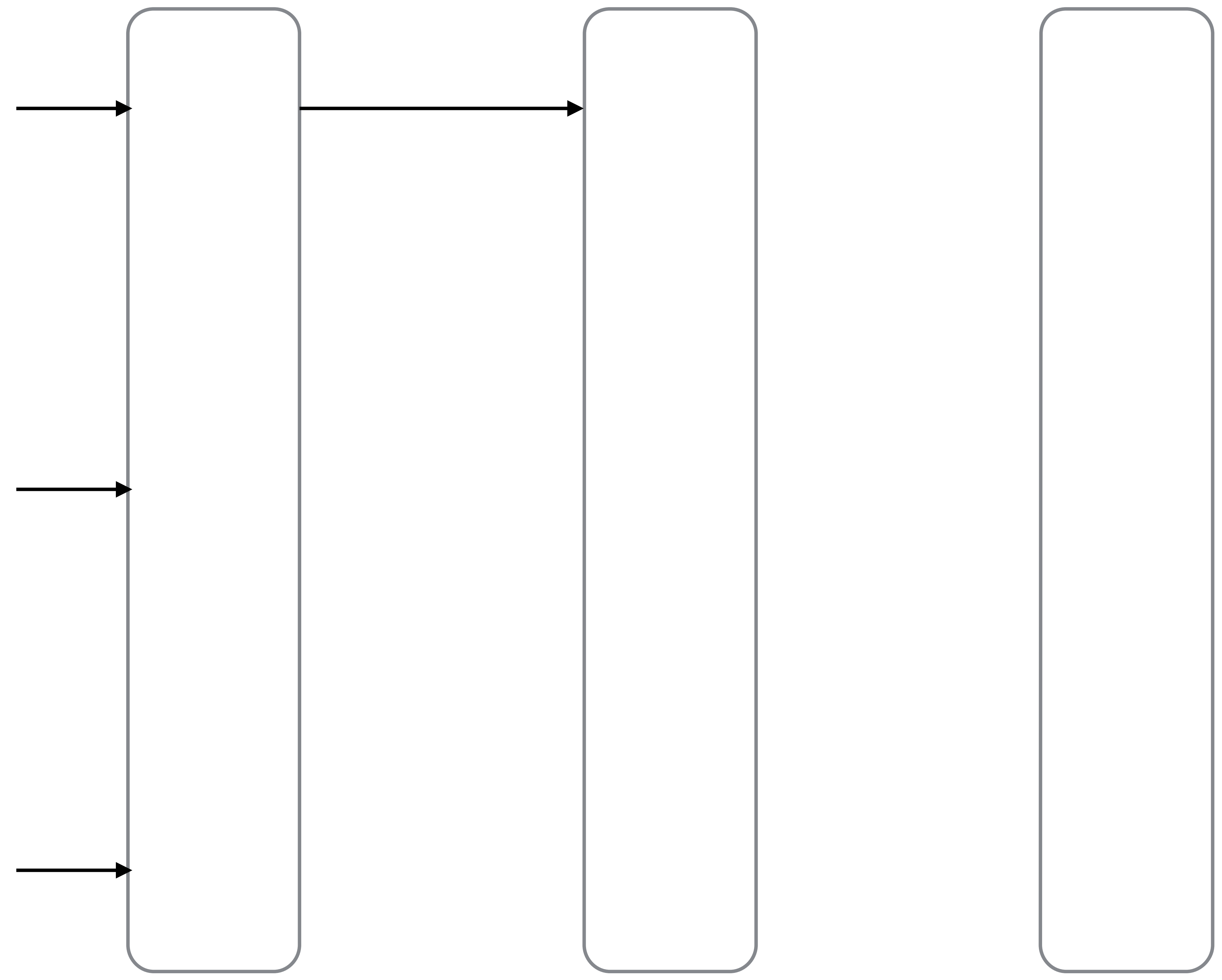

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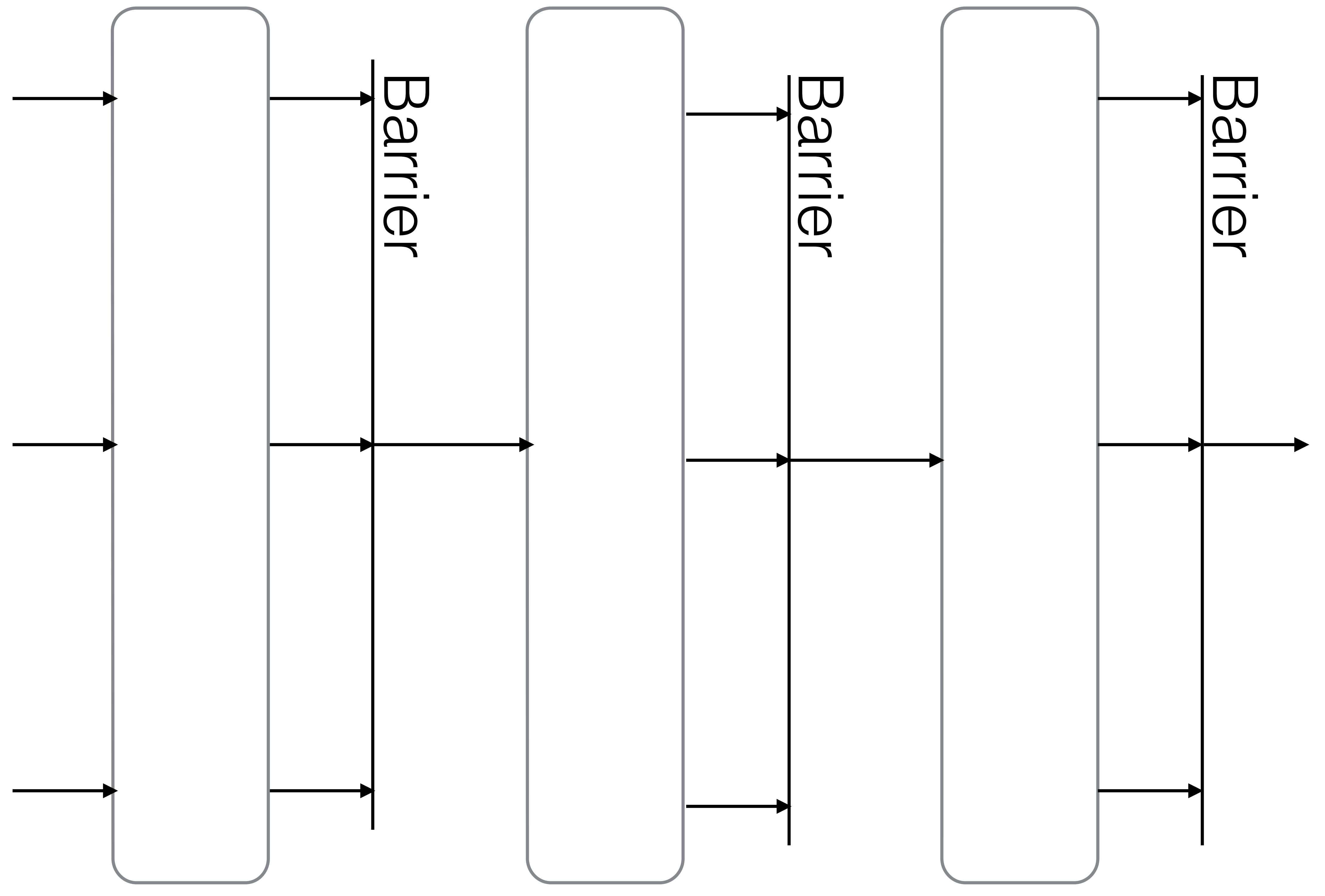

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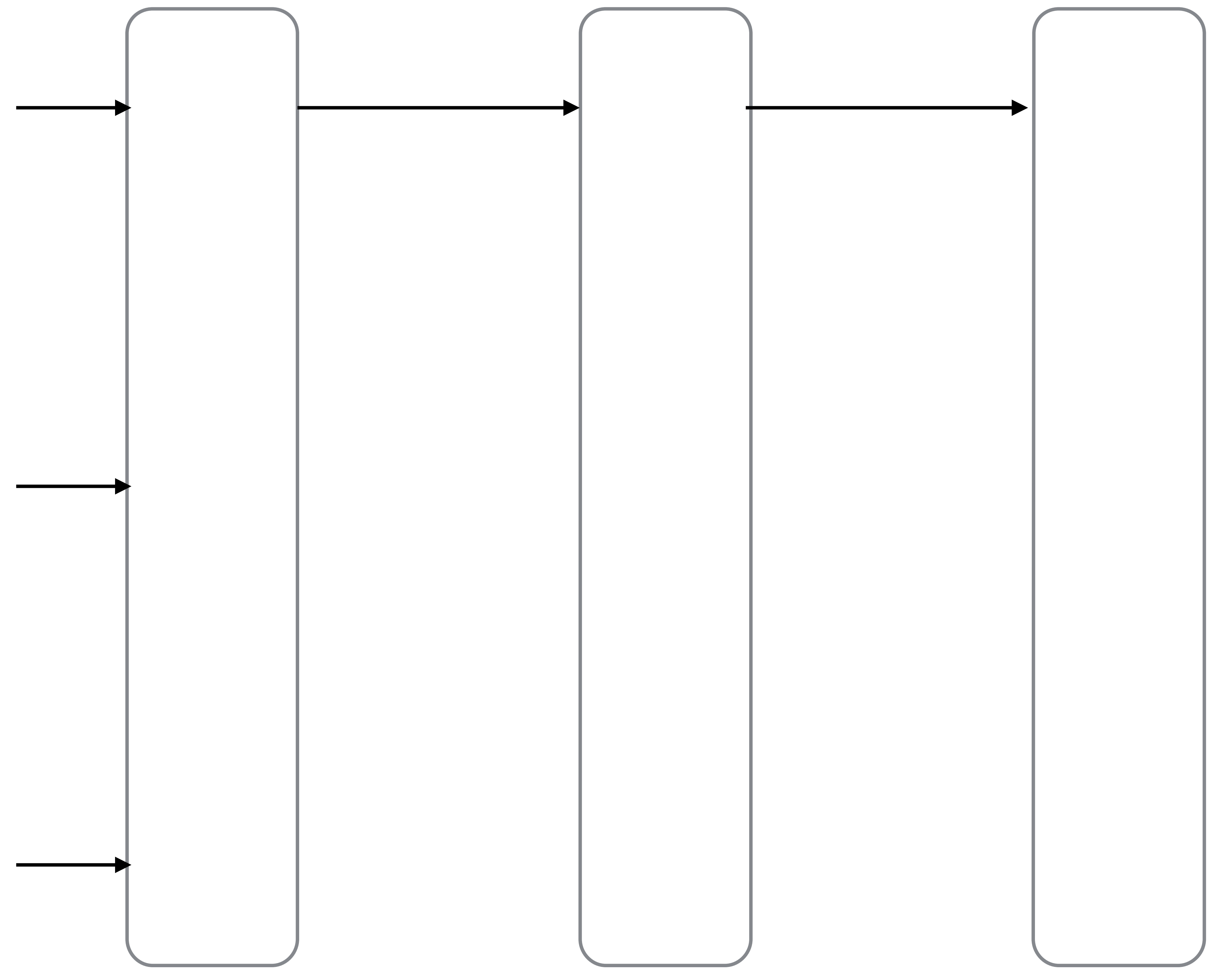

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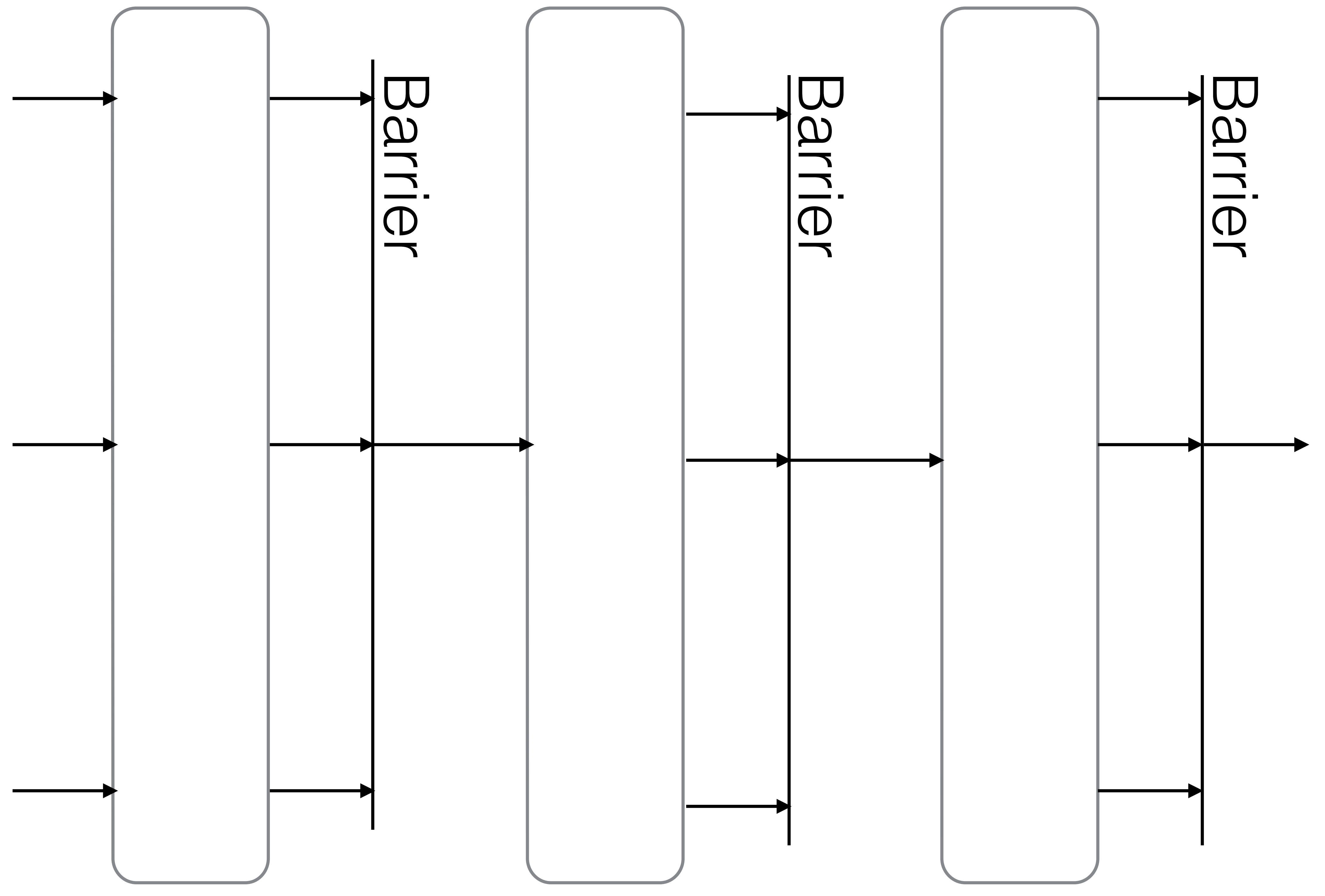

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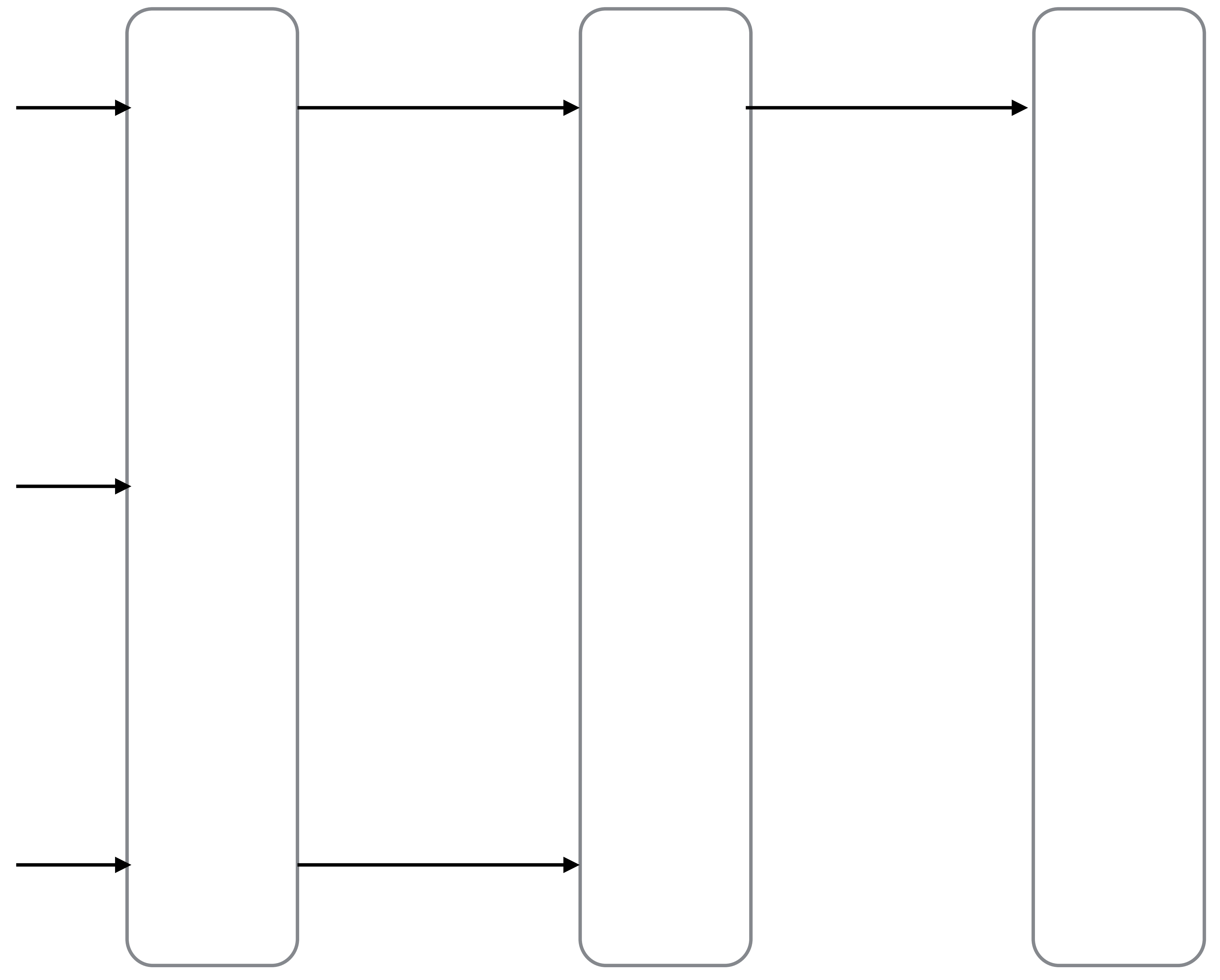

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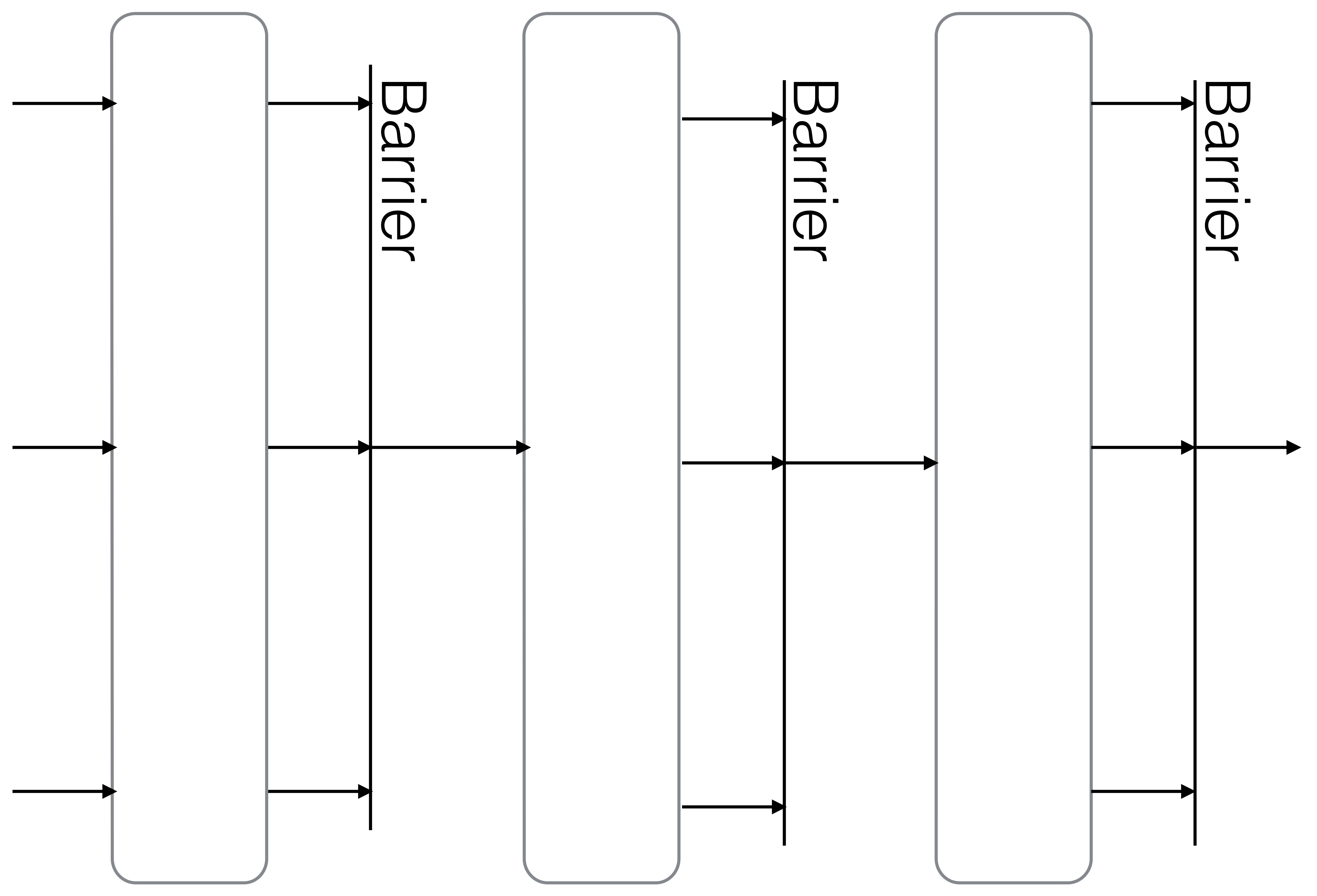

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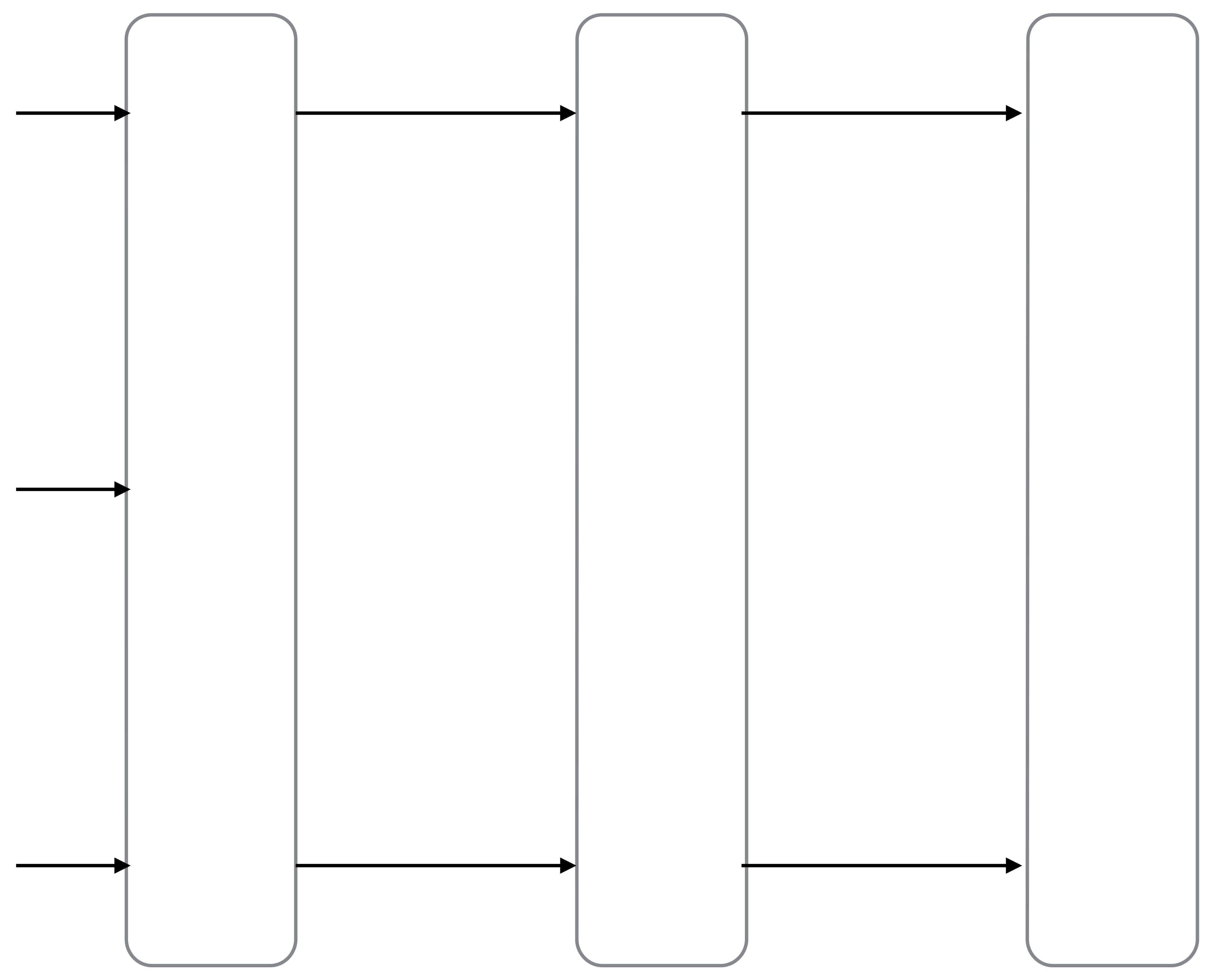

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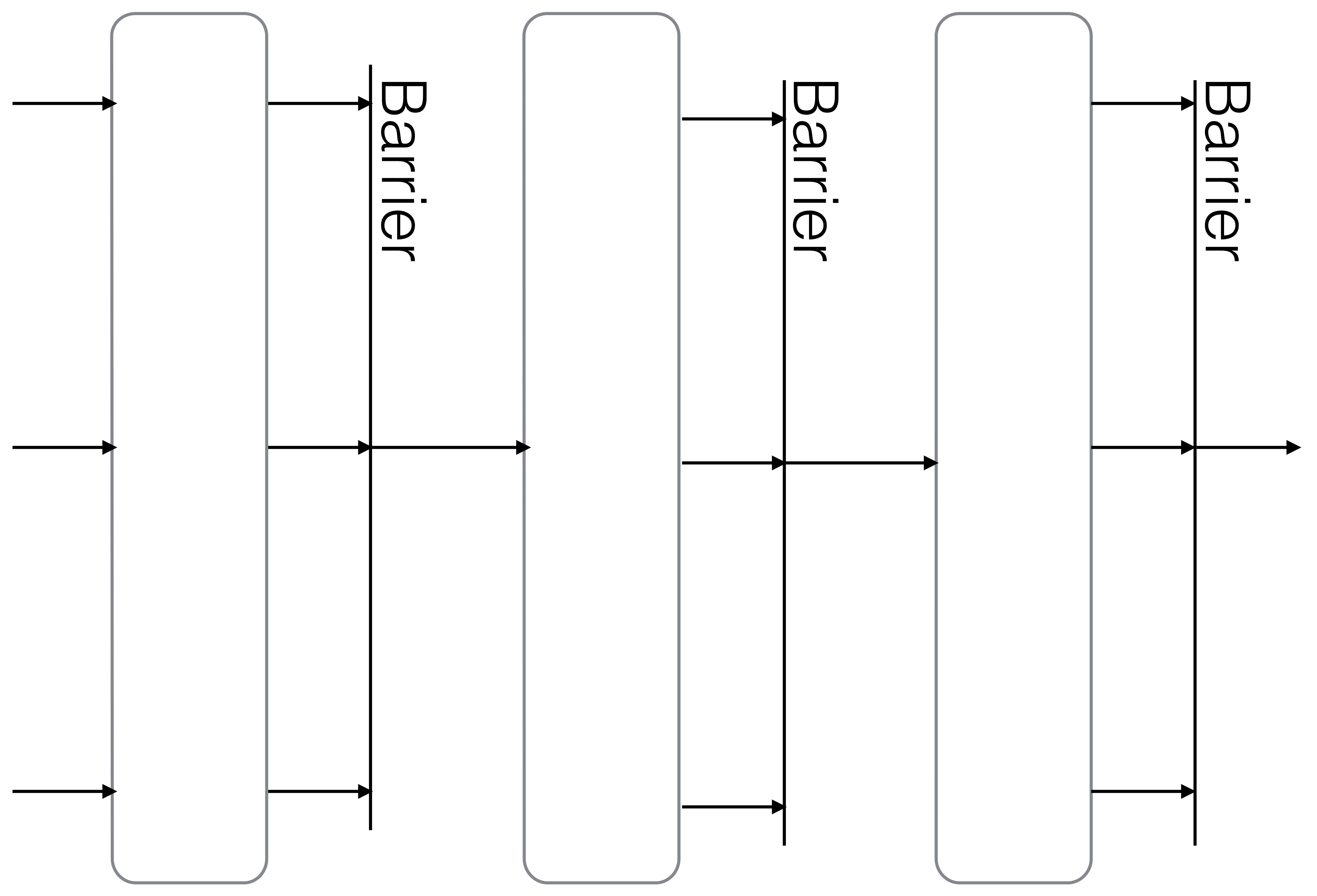

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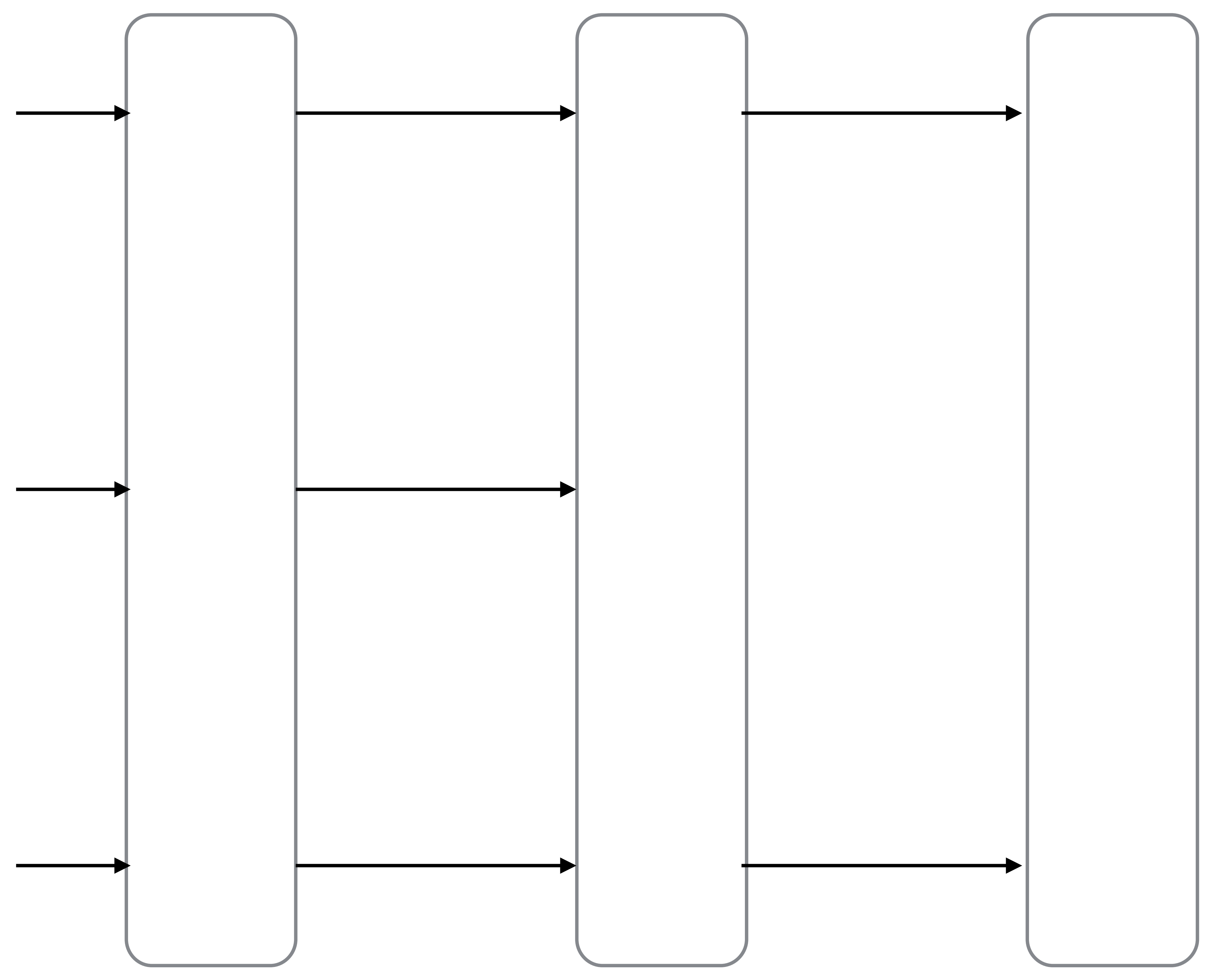

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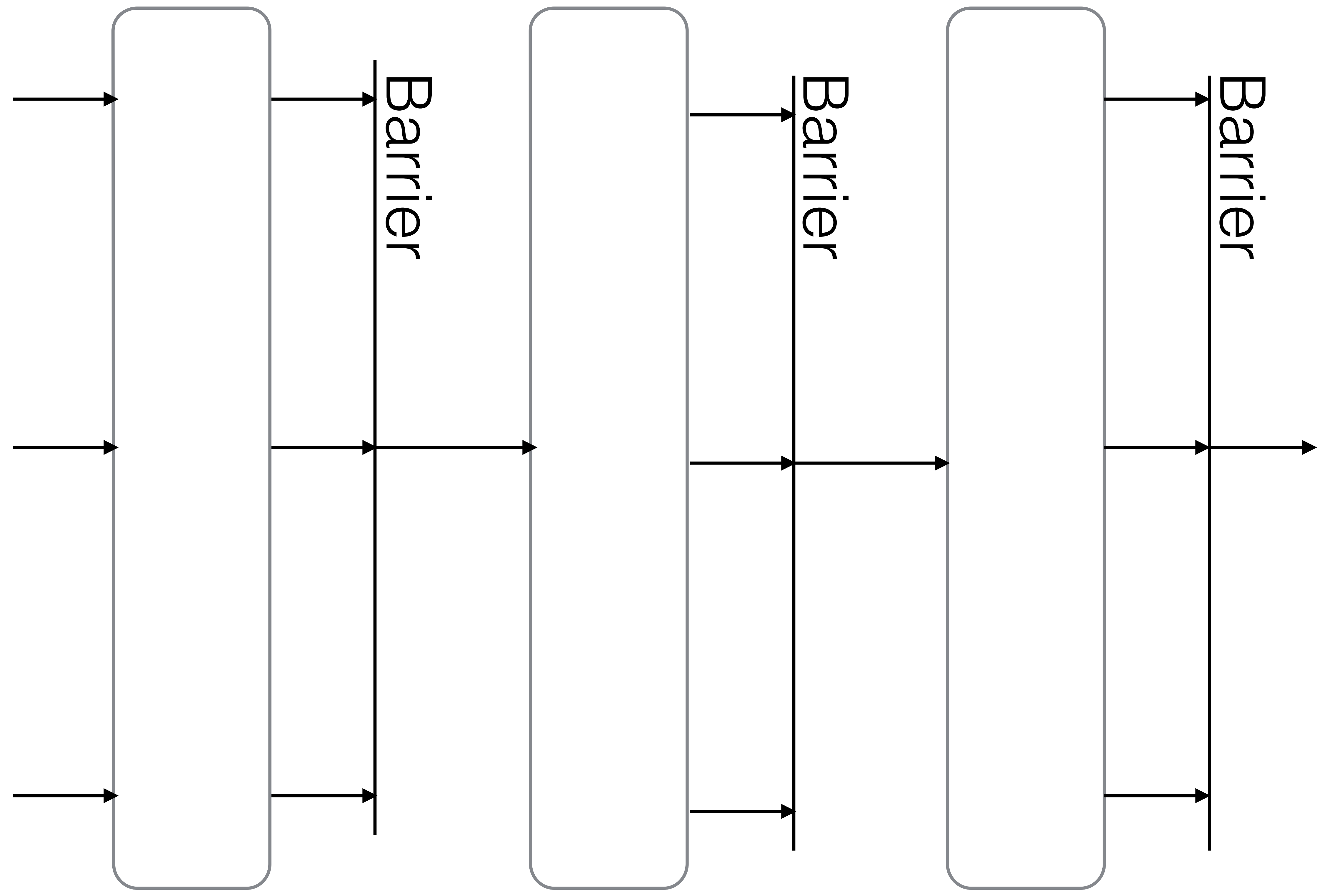

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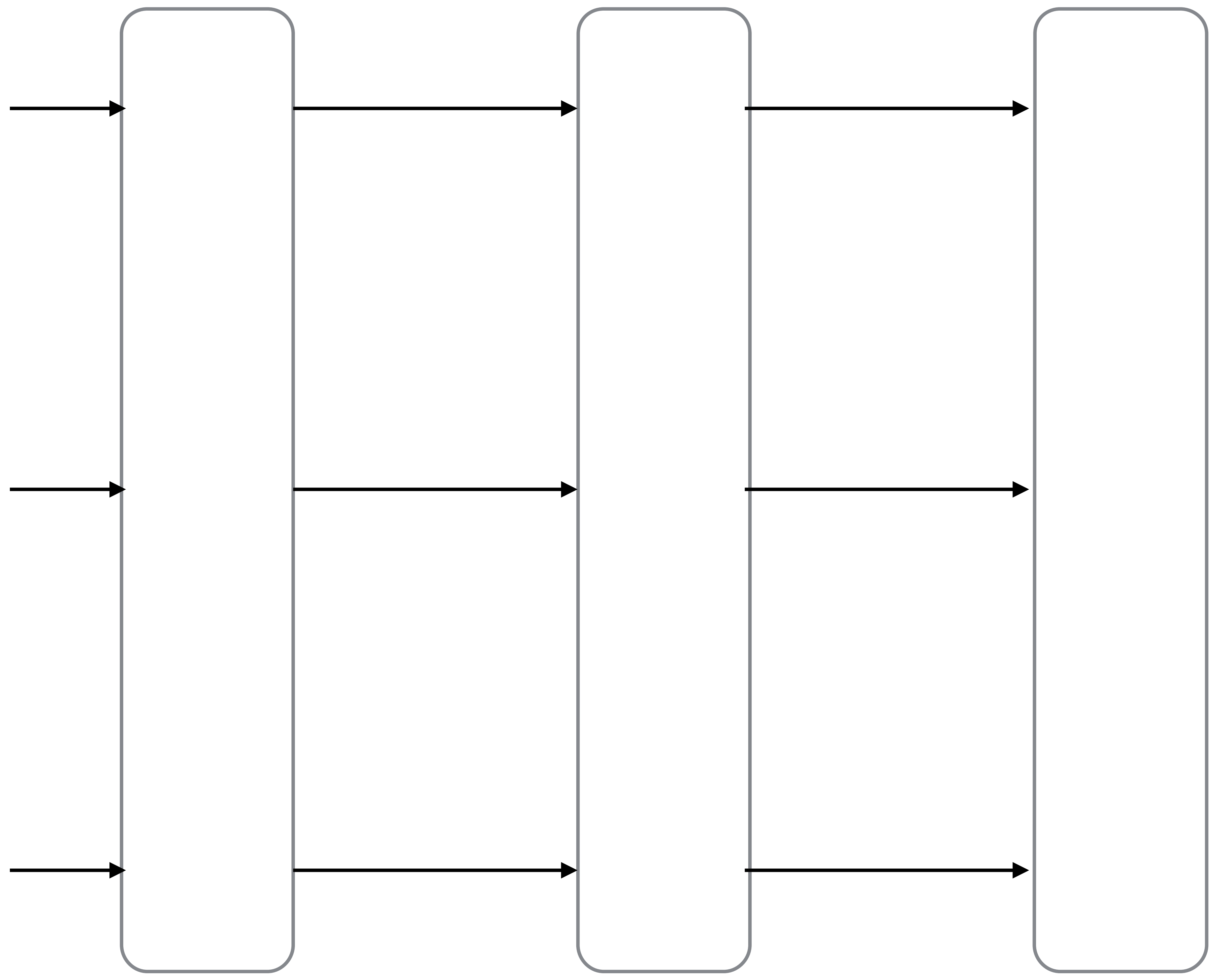

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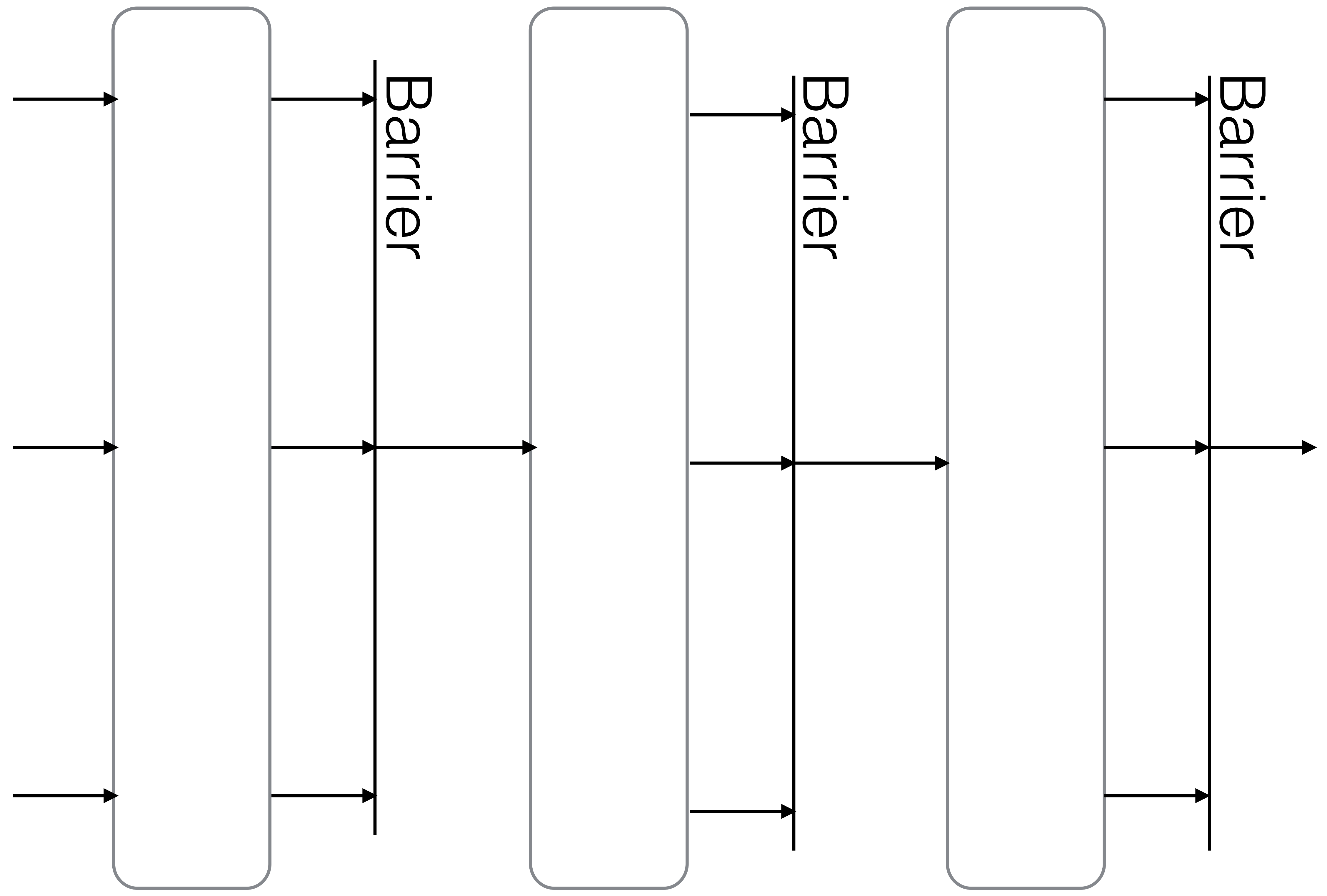

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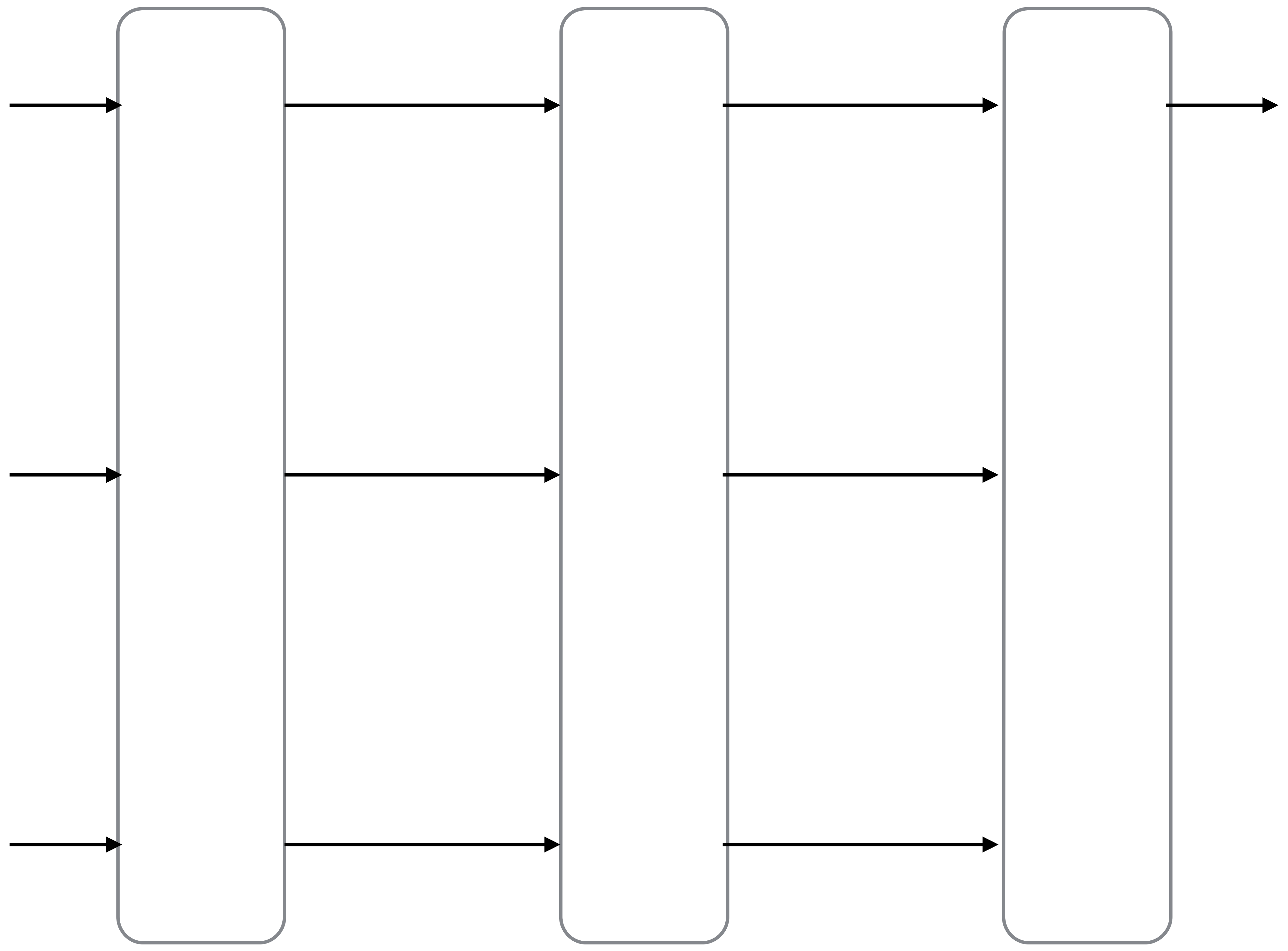

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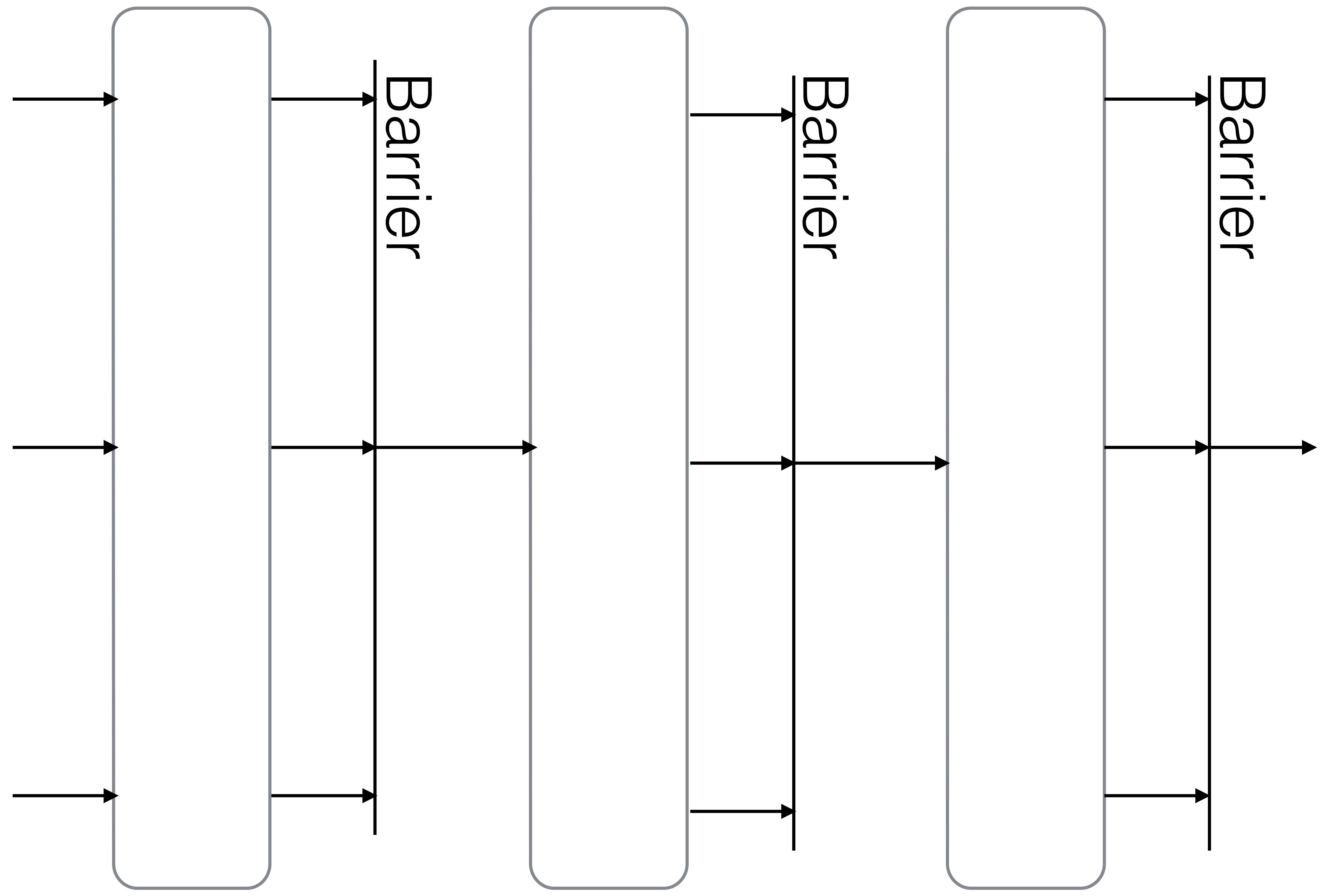

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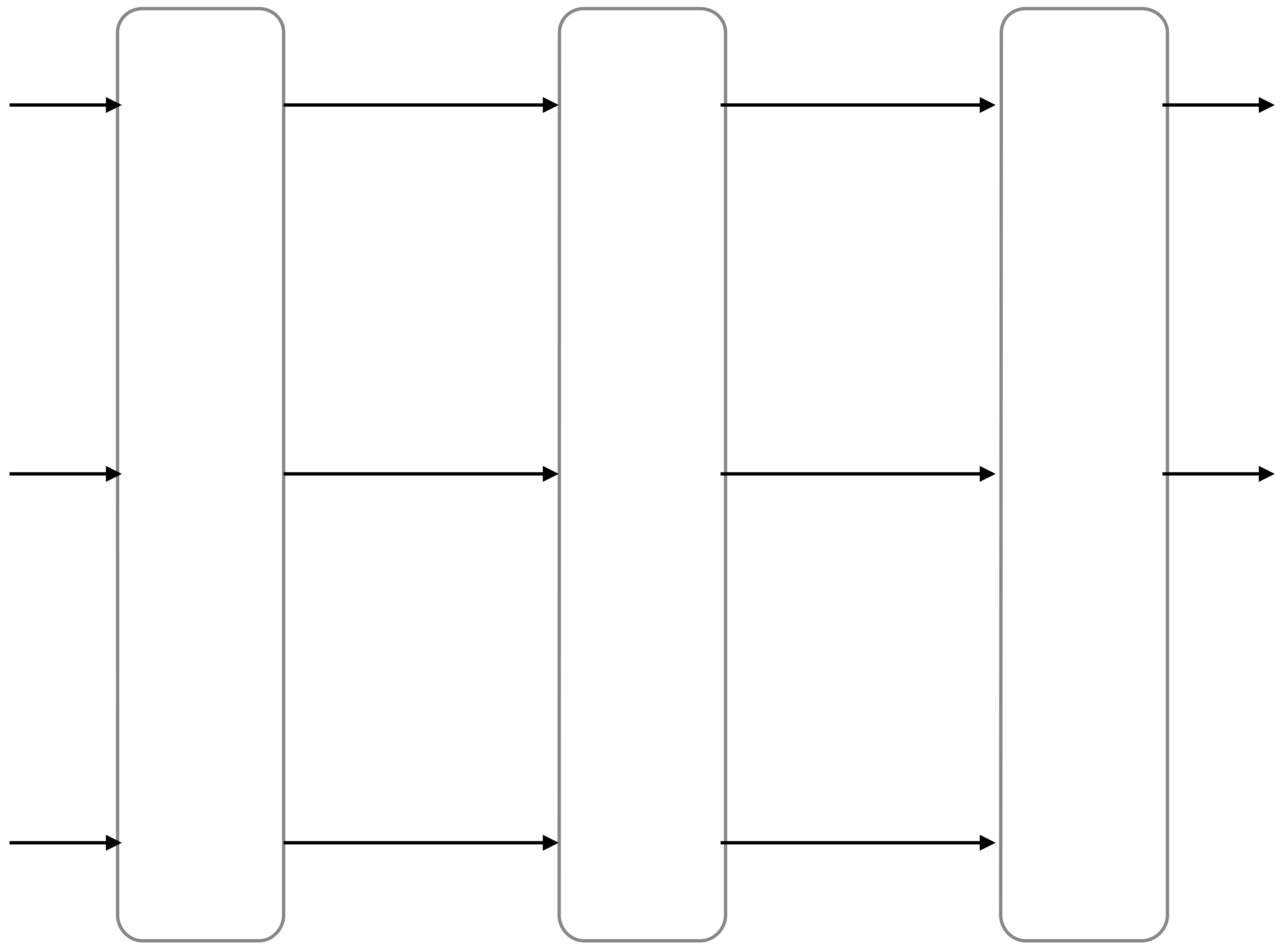

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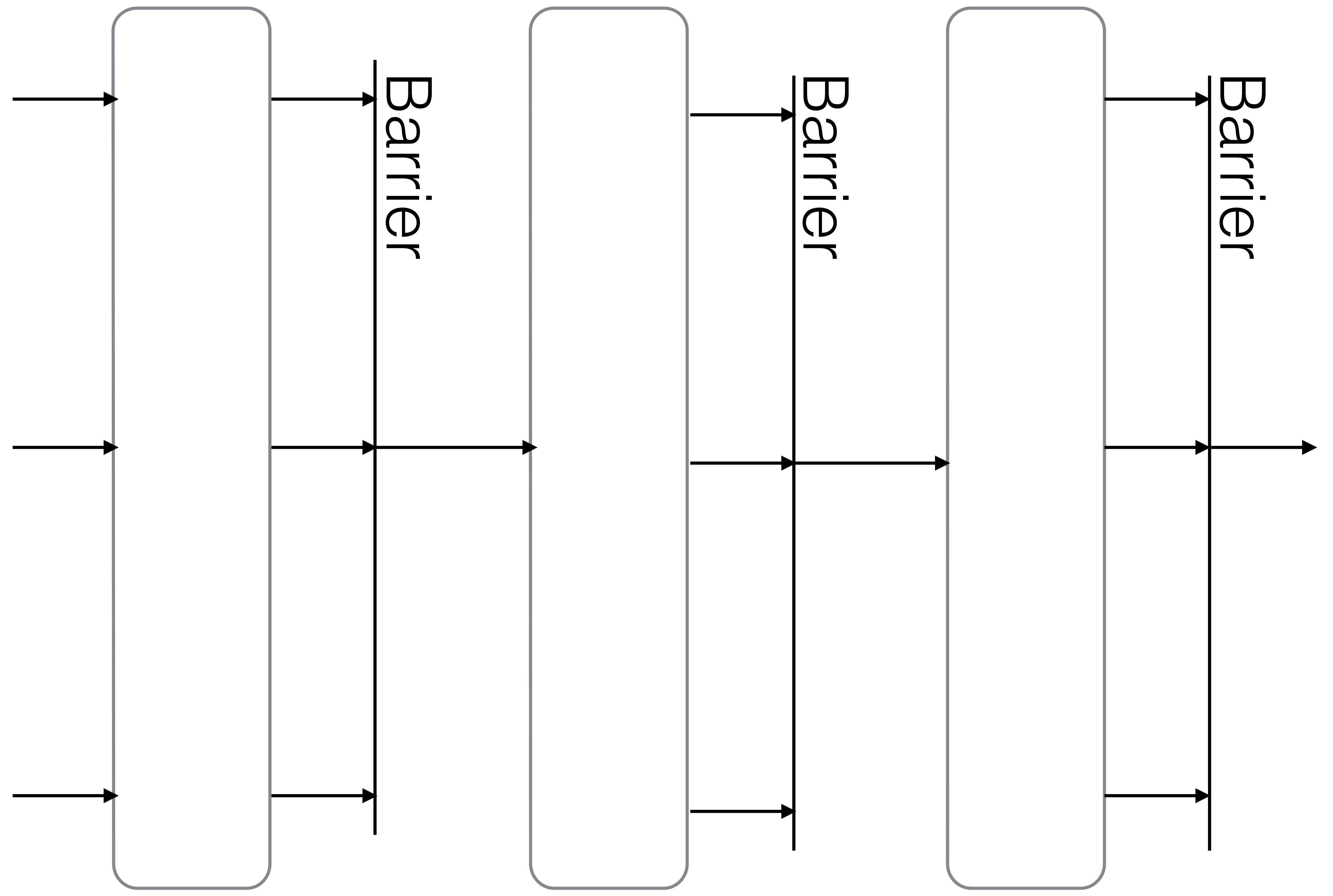

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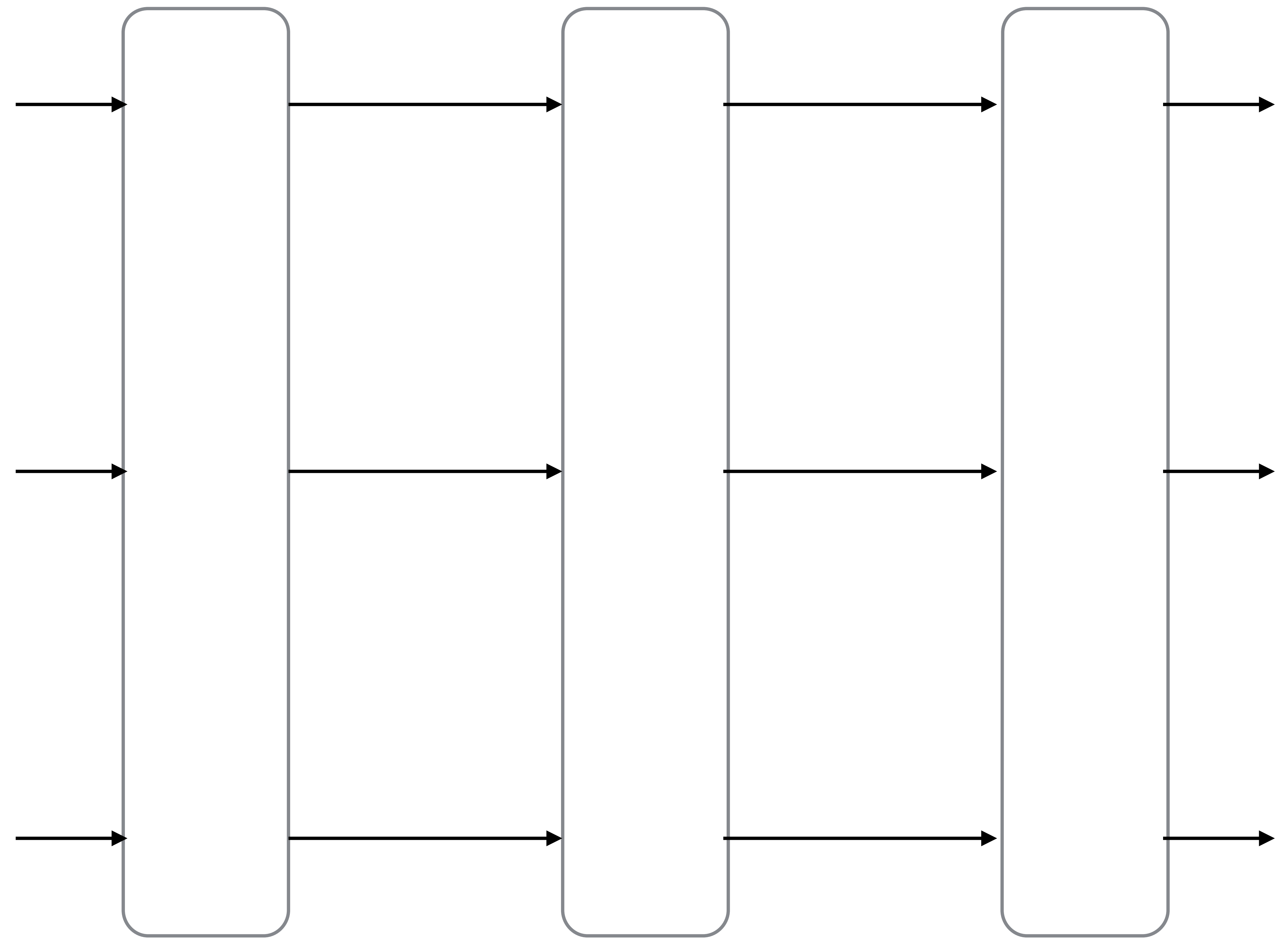

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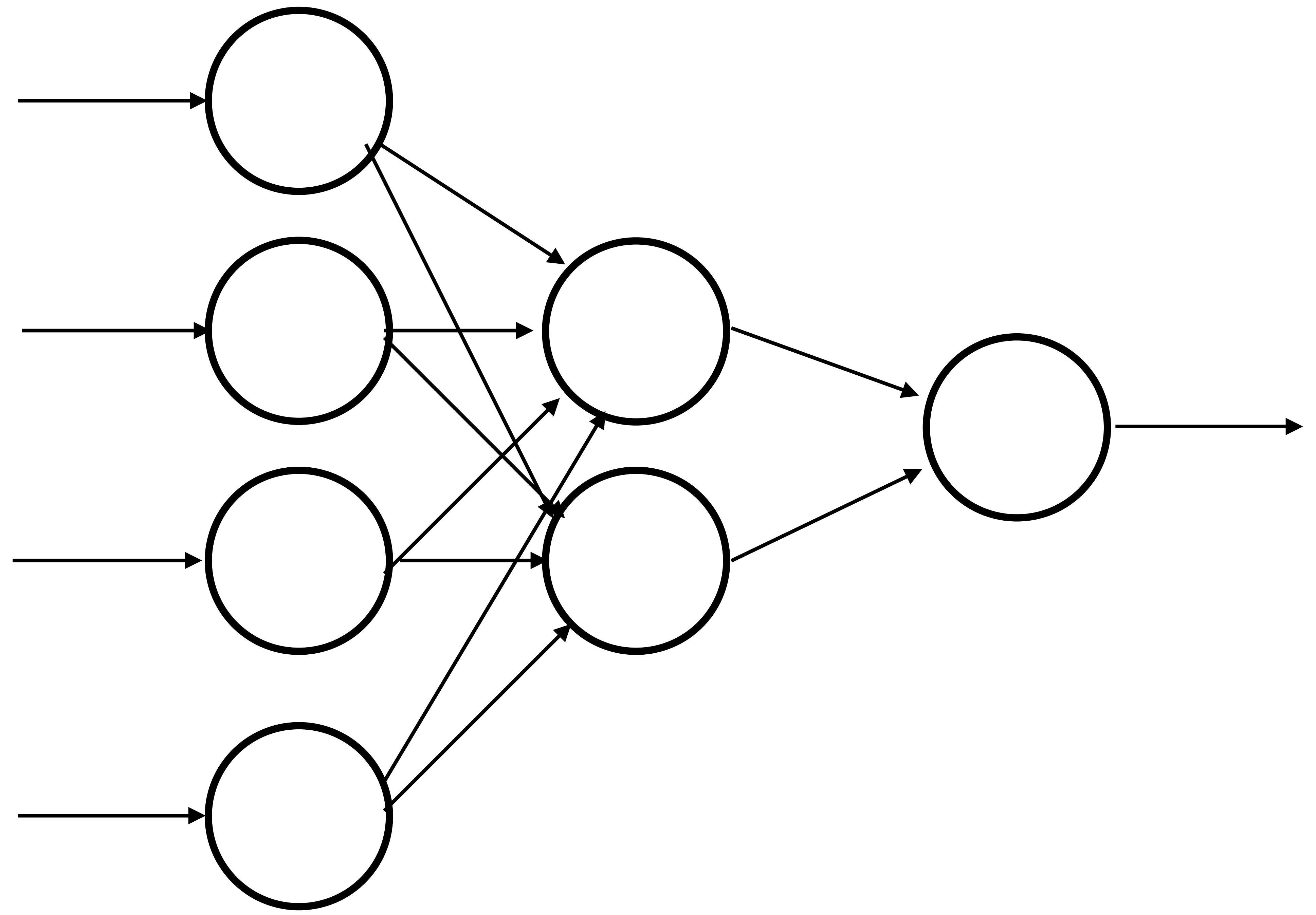
	BSP	Out-of-Order Processing
Batch	✔	✔
Iterative	✔	✔
Streaming	? (latency)	✔
Graph Processing	?	?

Question: What Execution Model to Use?

	BSP	**Out-of-Order Processing**
Fault Tolerance	Simple: lineage for stages, stateless nodes	Hard: Stateful nodes, need to checkpoint.
Programming Model	Simple?	Don't program directly, execution engine.
Performance	Potentially slow: wait at barriers.	Potentially faster: Avoid synchronization and ordering when possible.

A Closer Look at Performance



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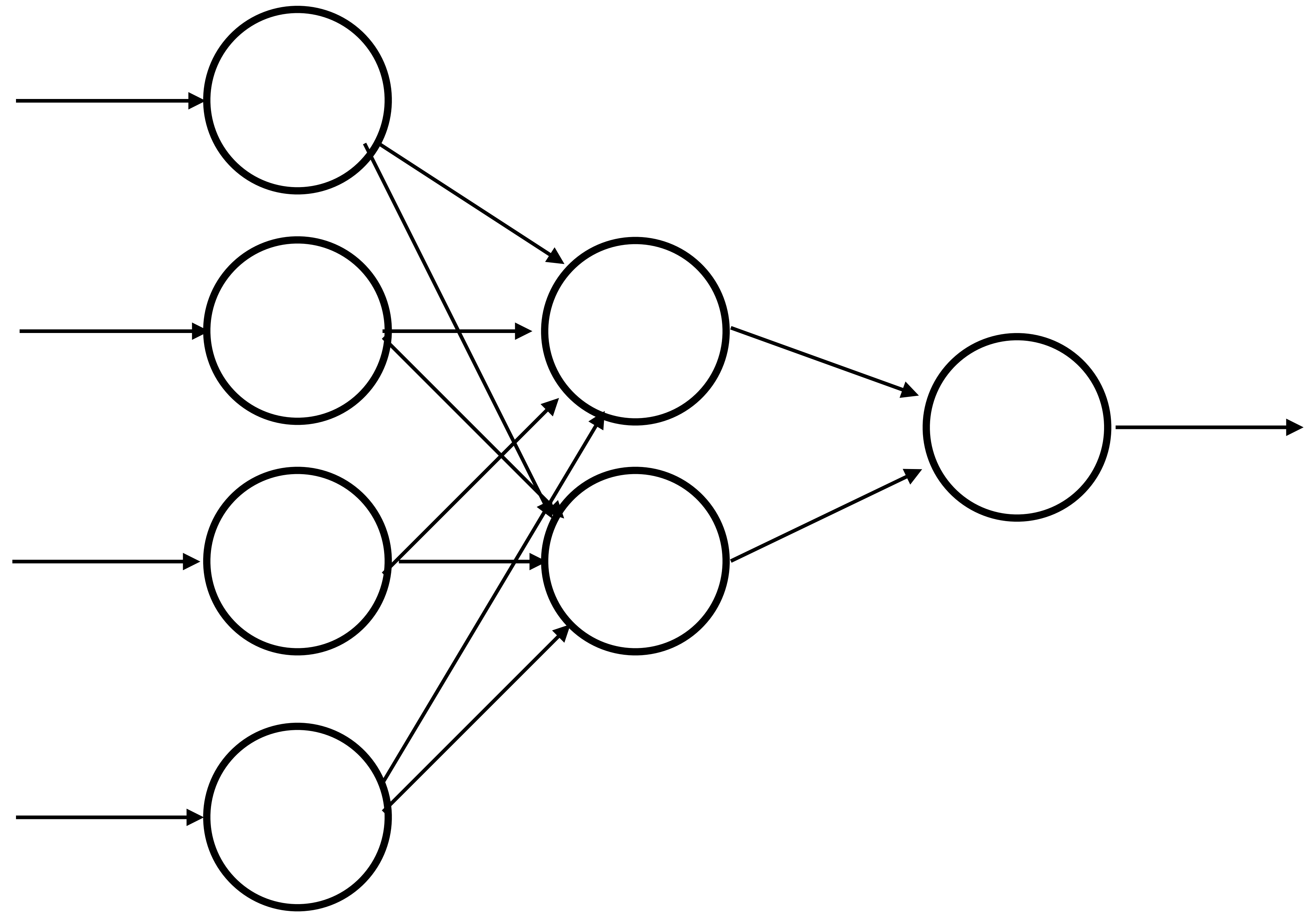

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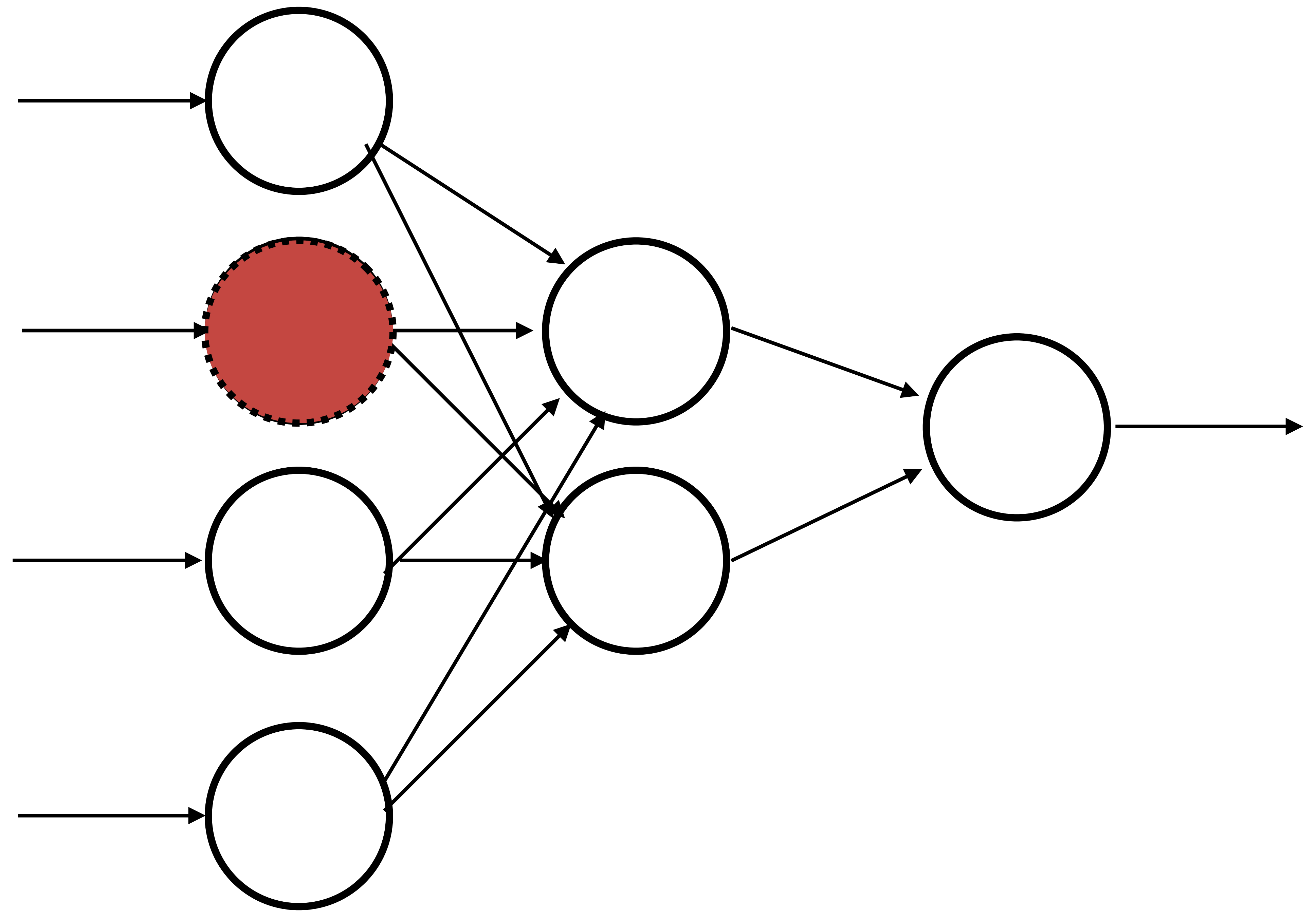

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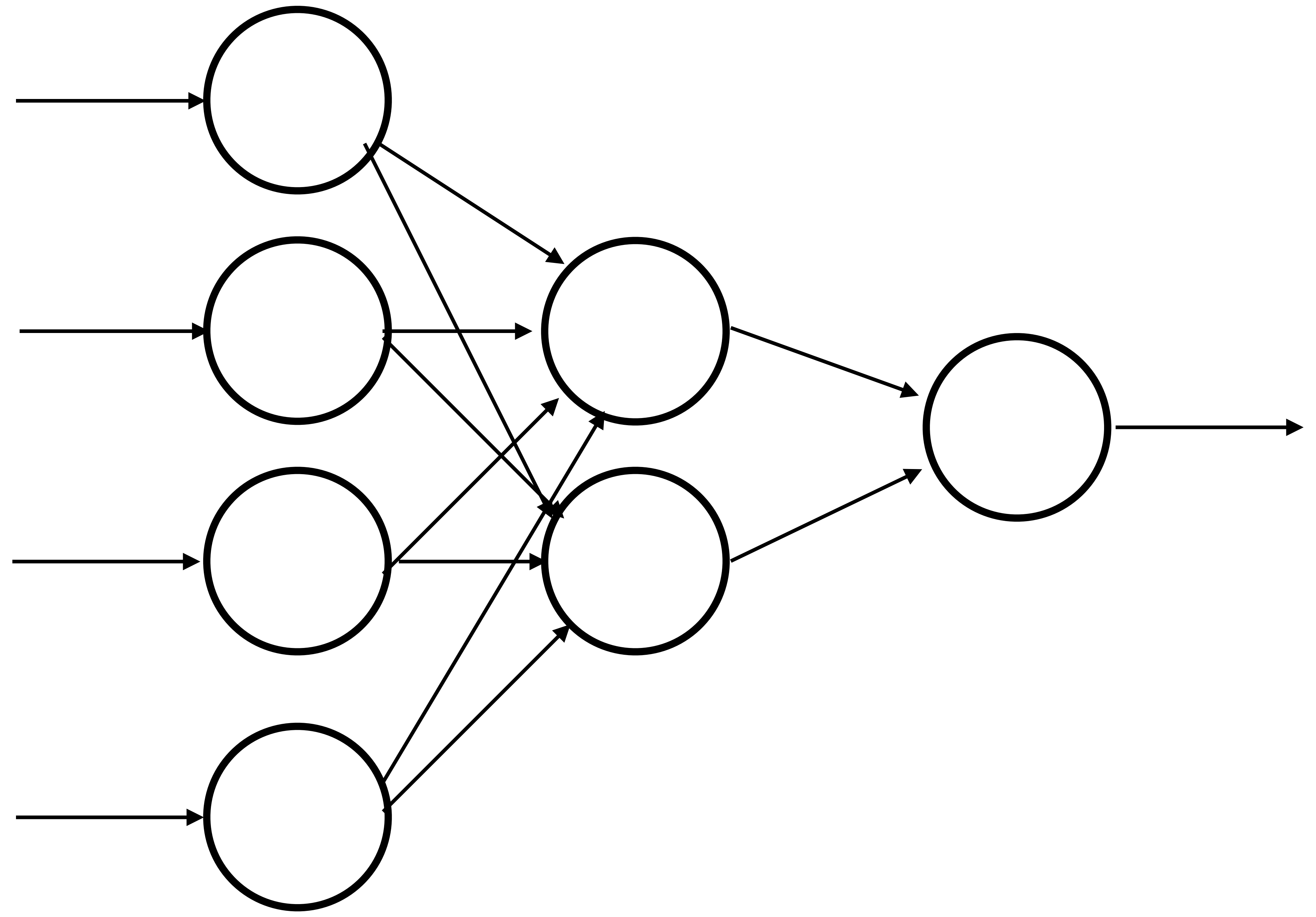

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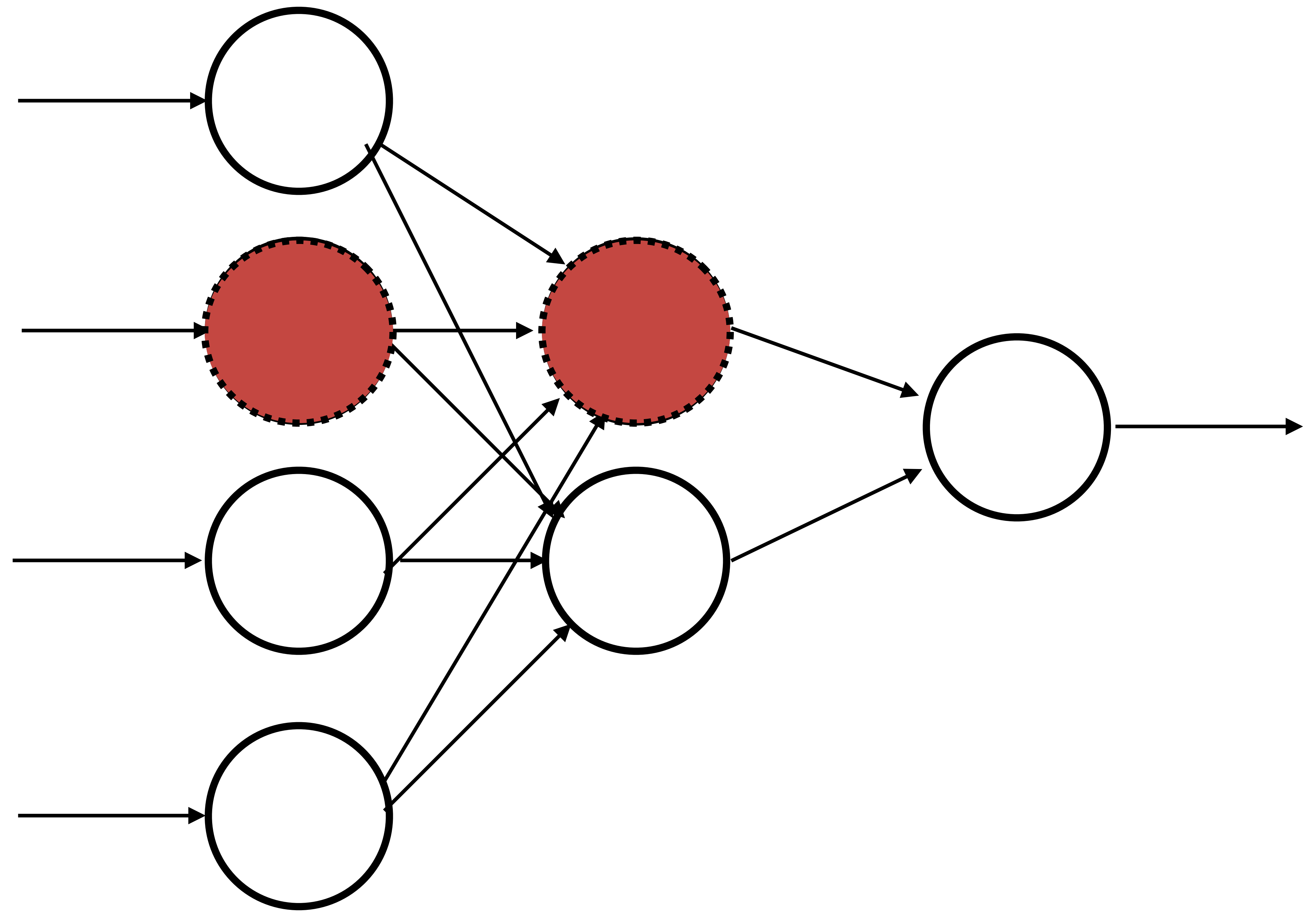

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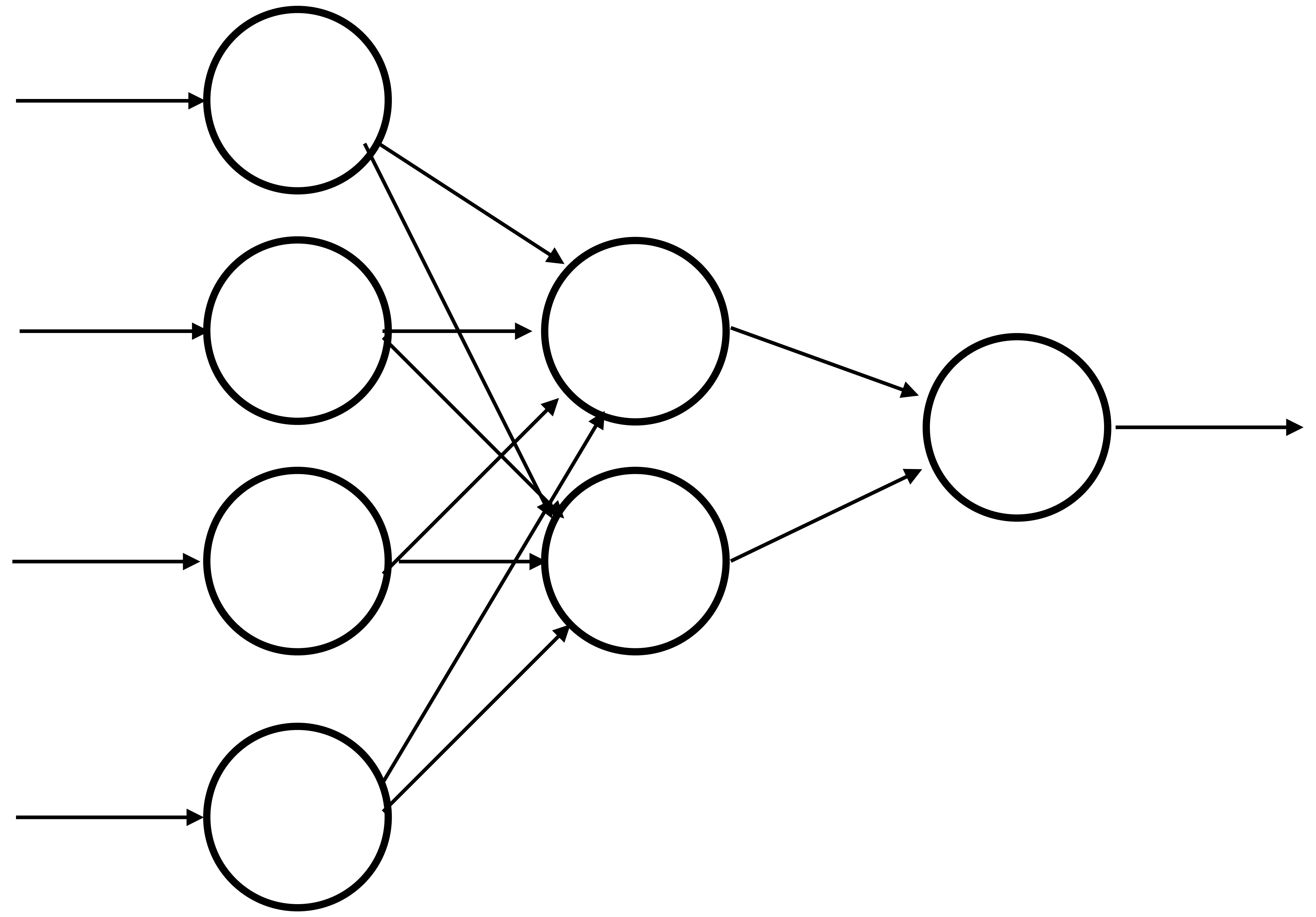

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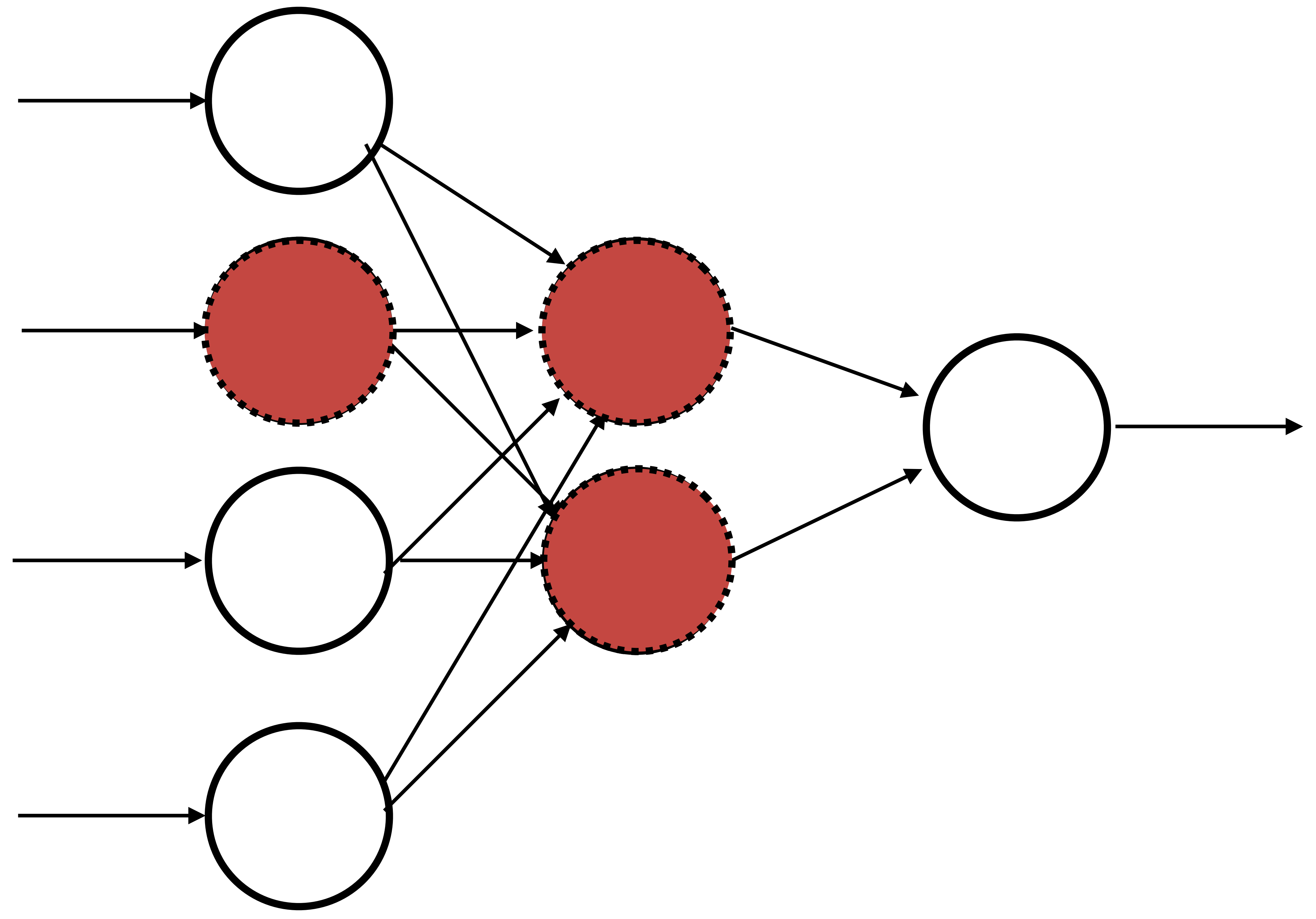

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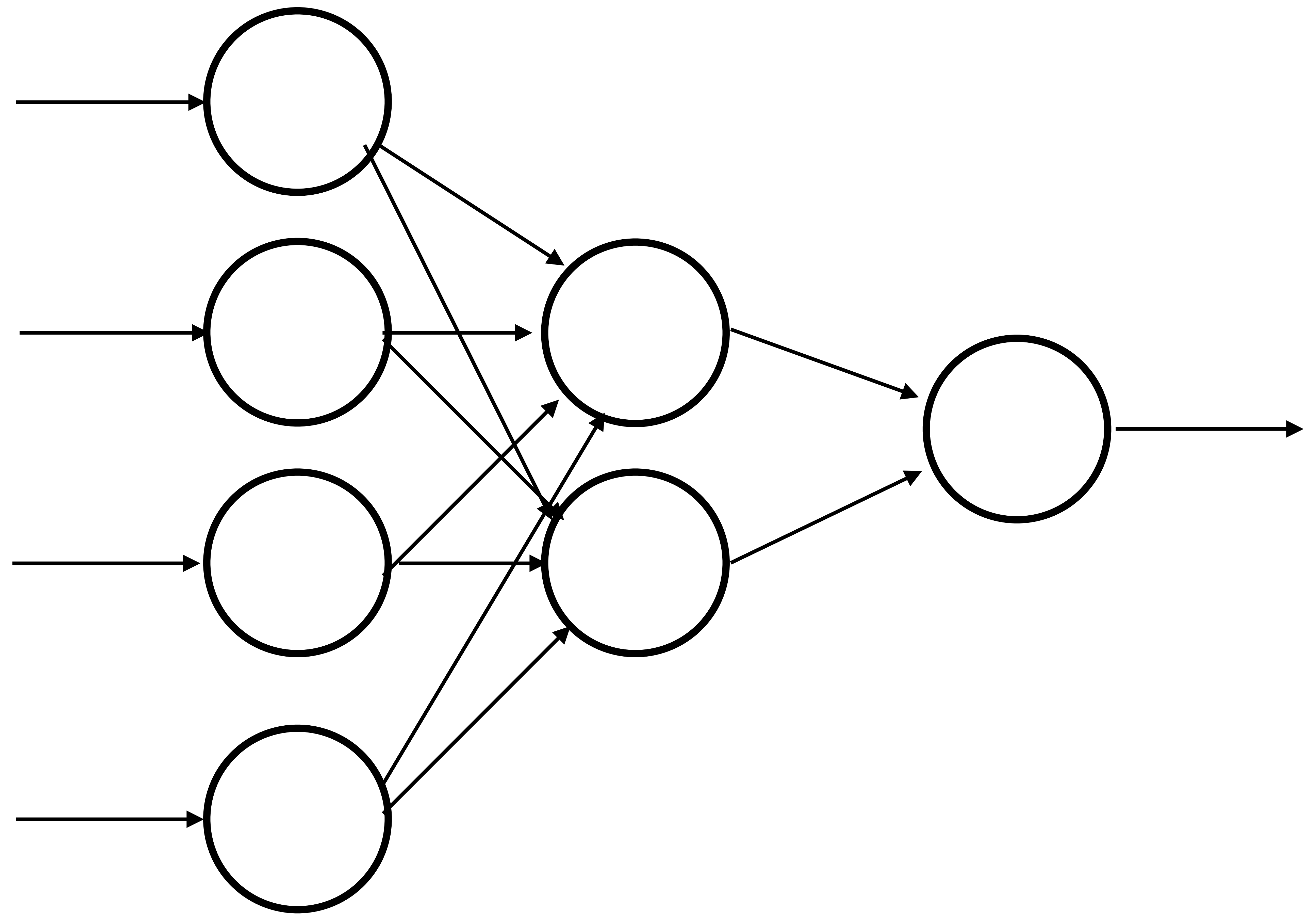

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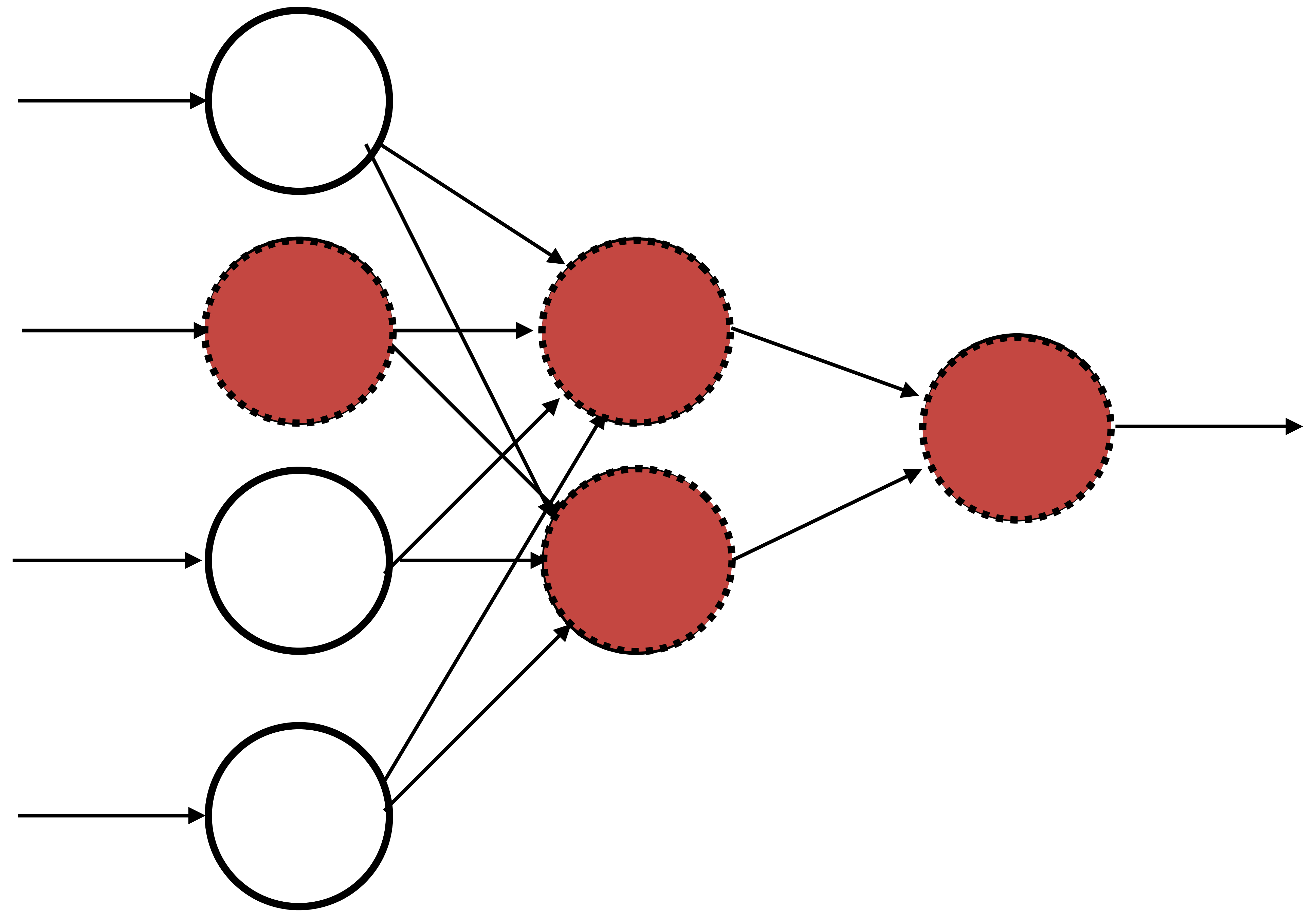

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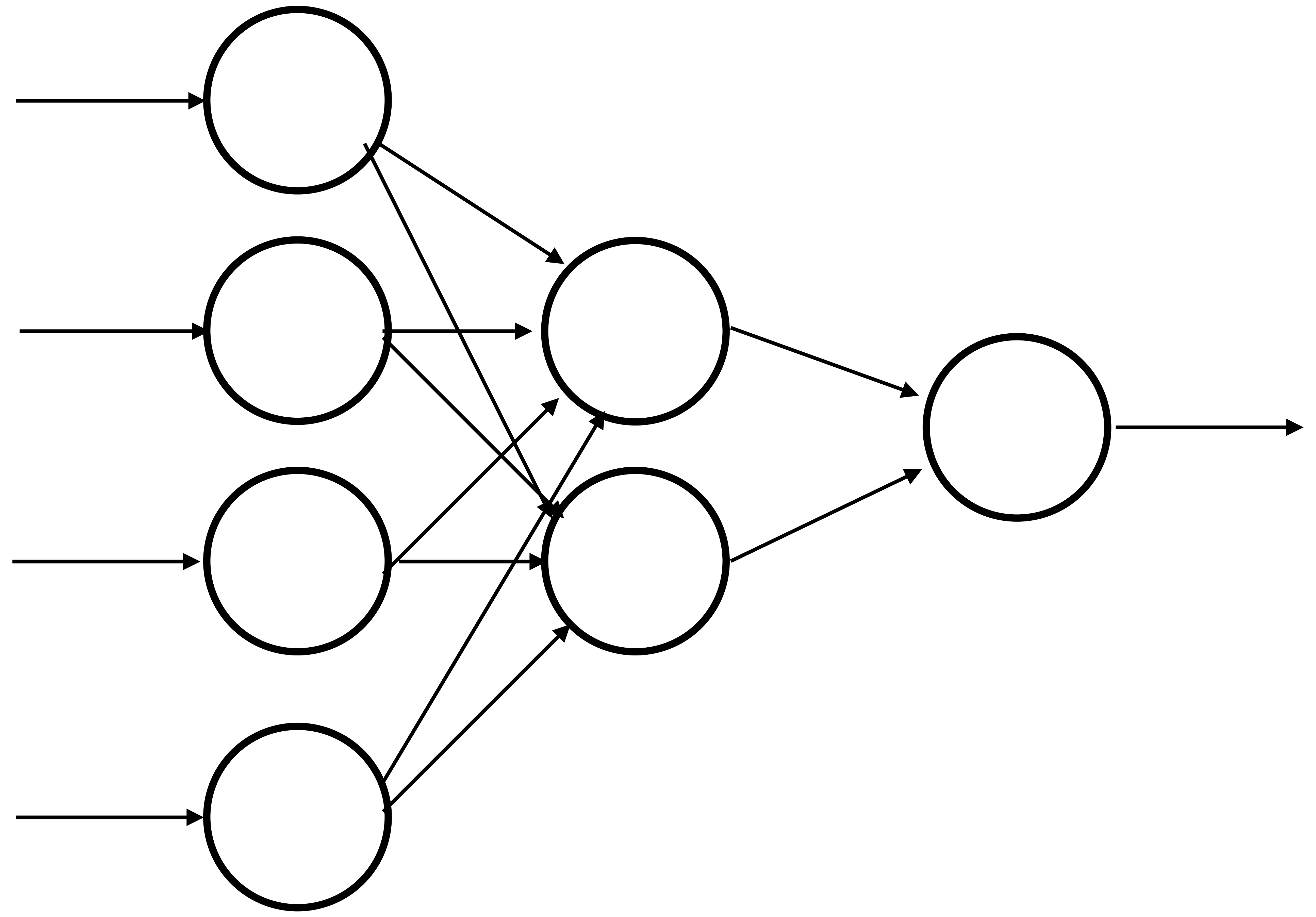

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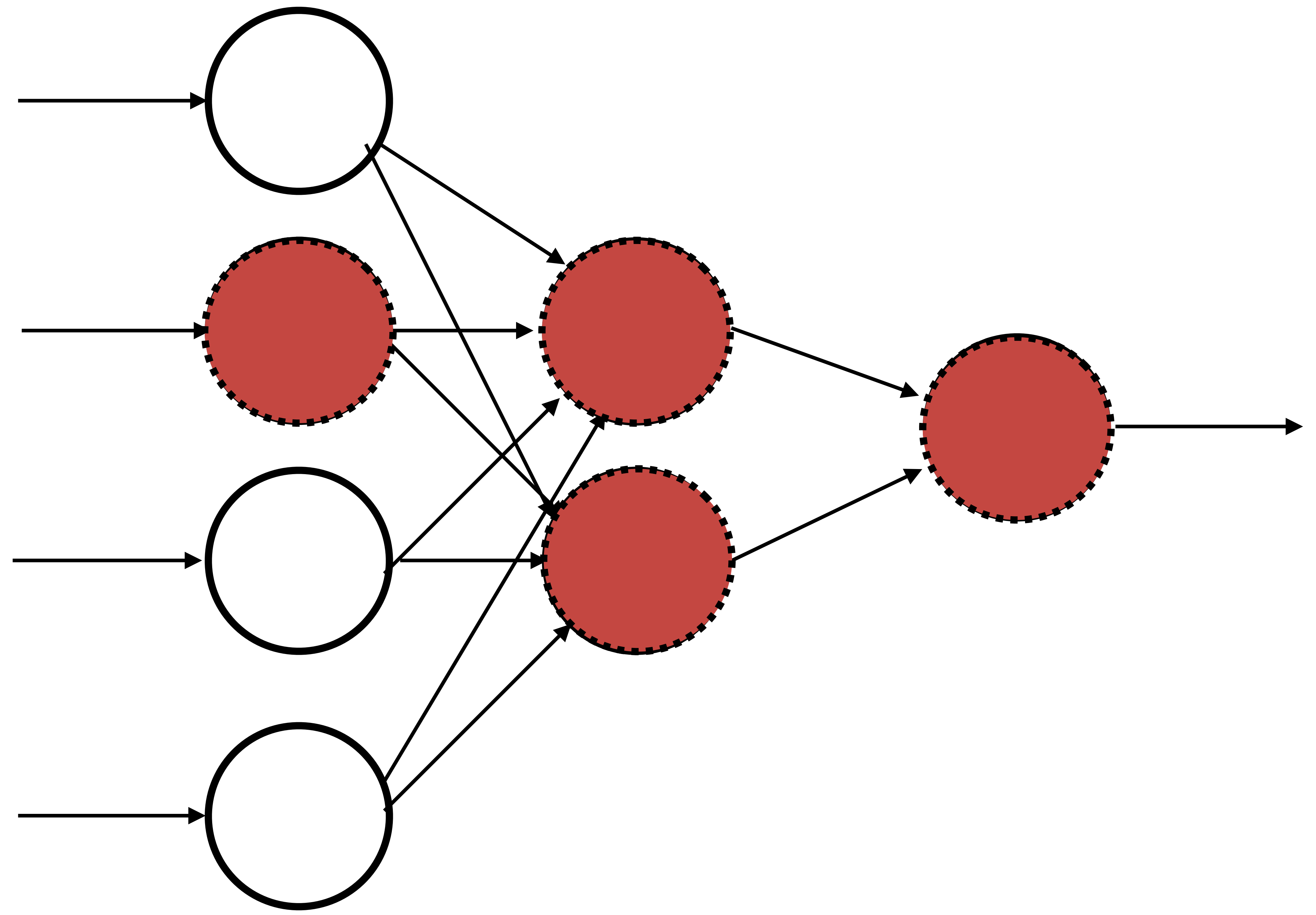

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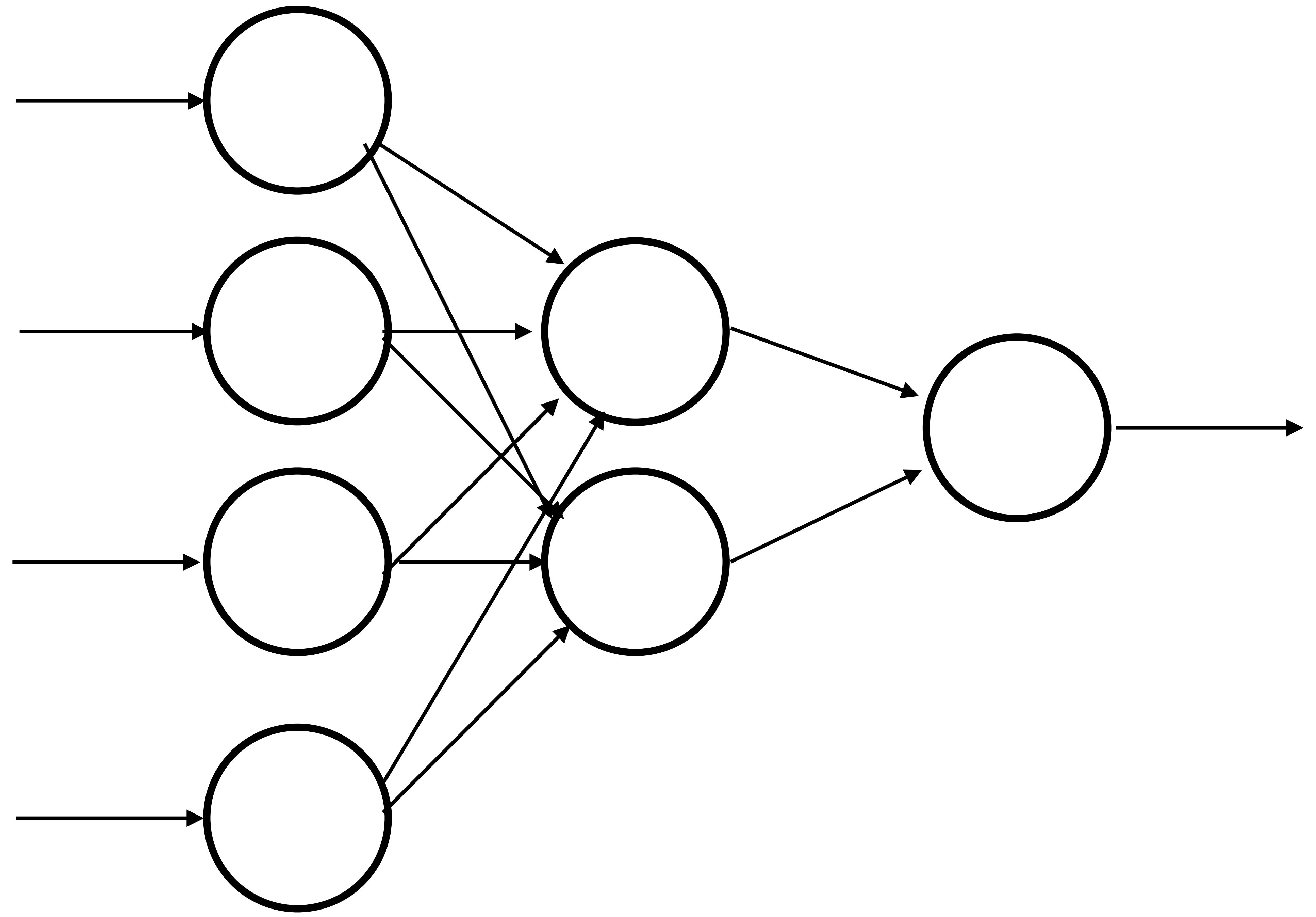

Out-of-Order Processing
(Assuming partial results are still useful)

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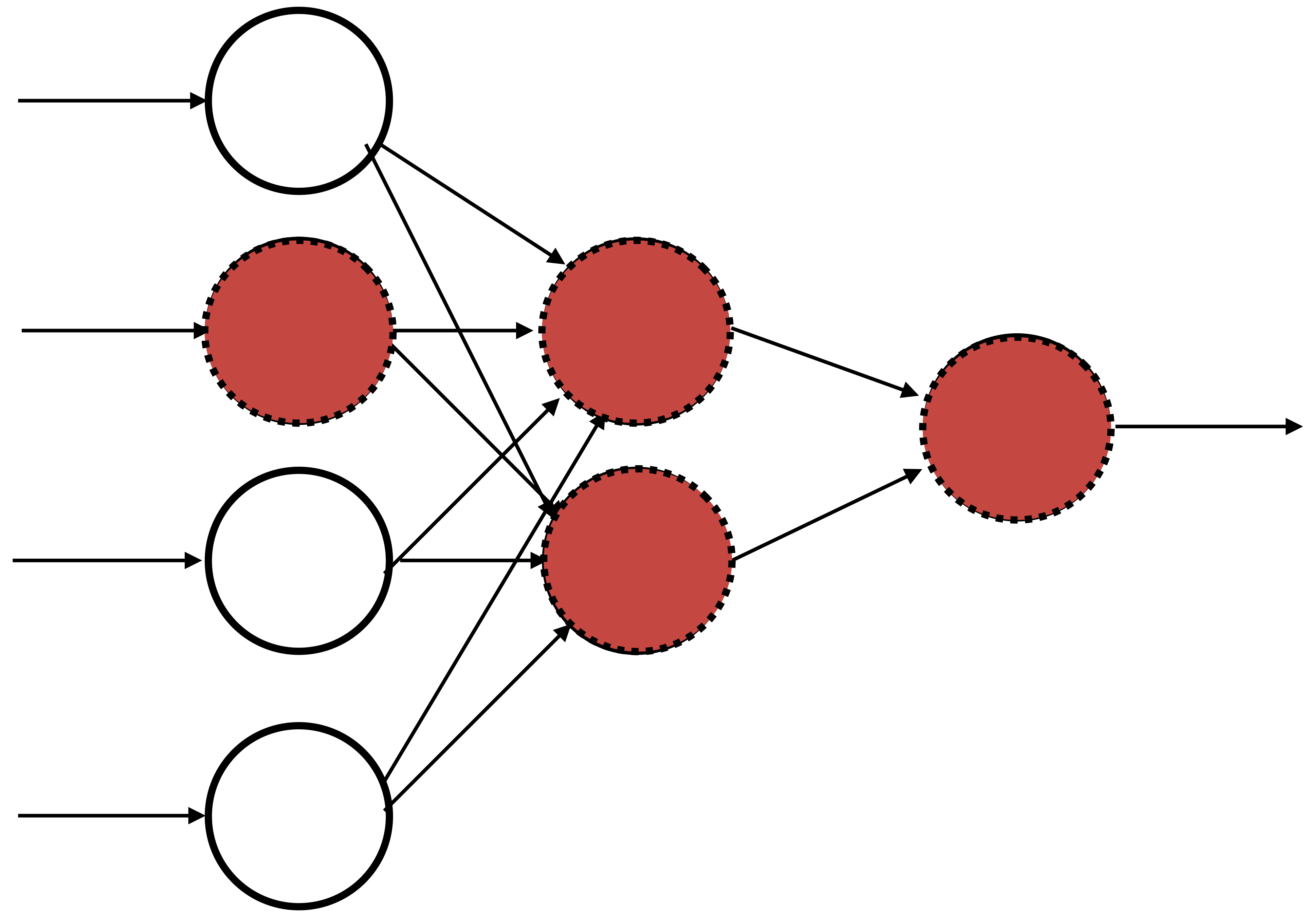

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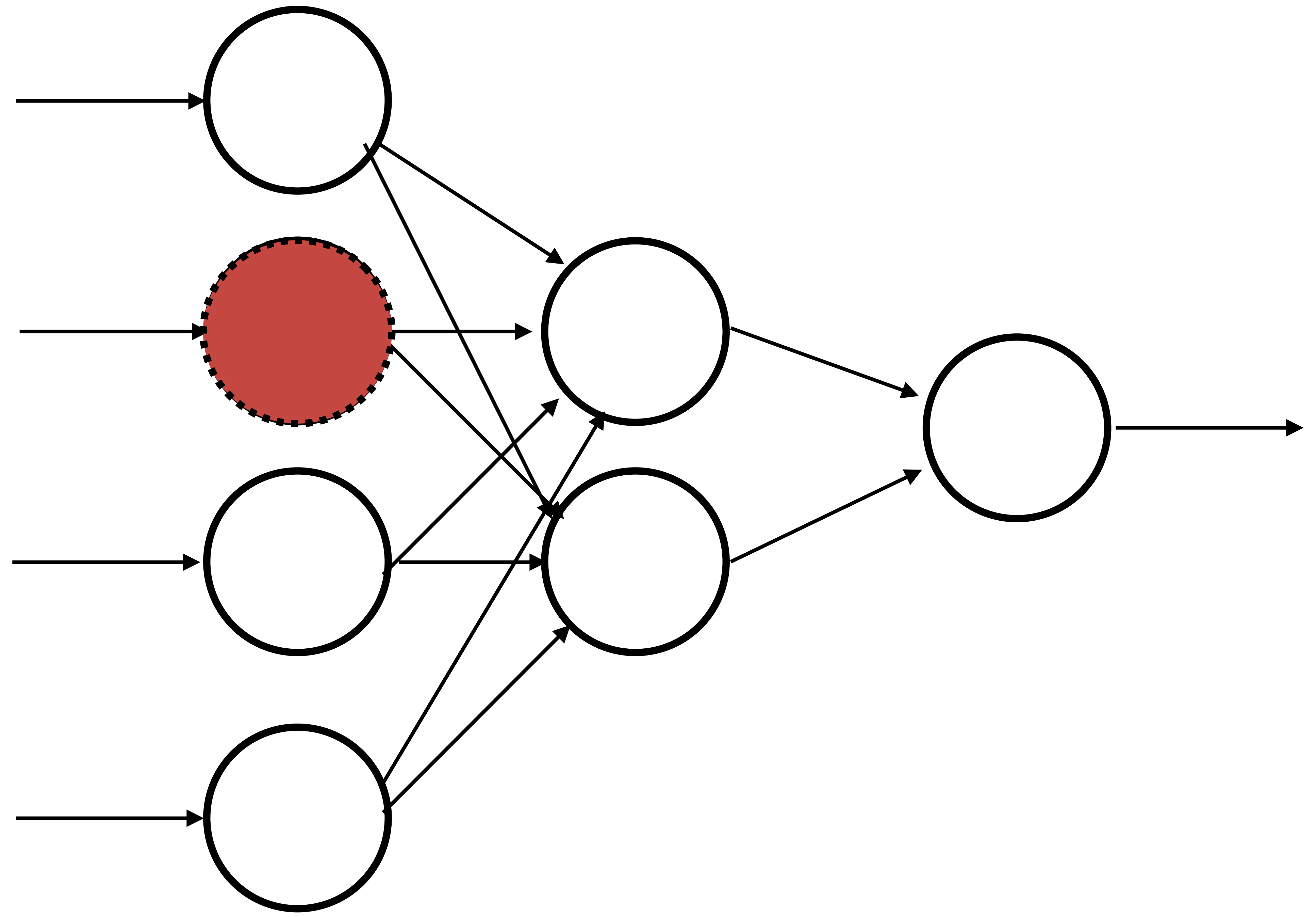

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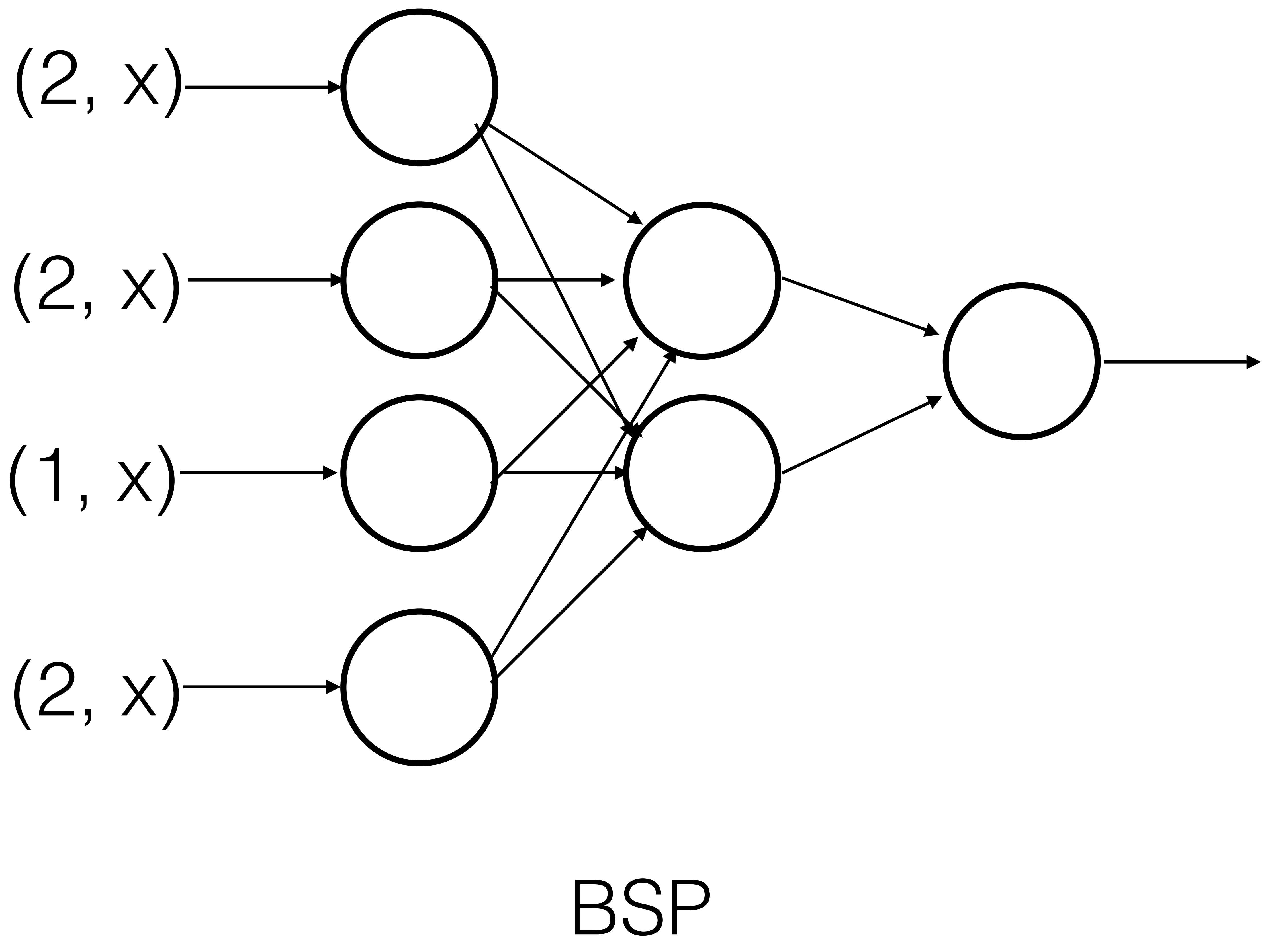

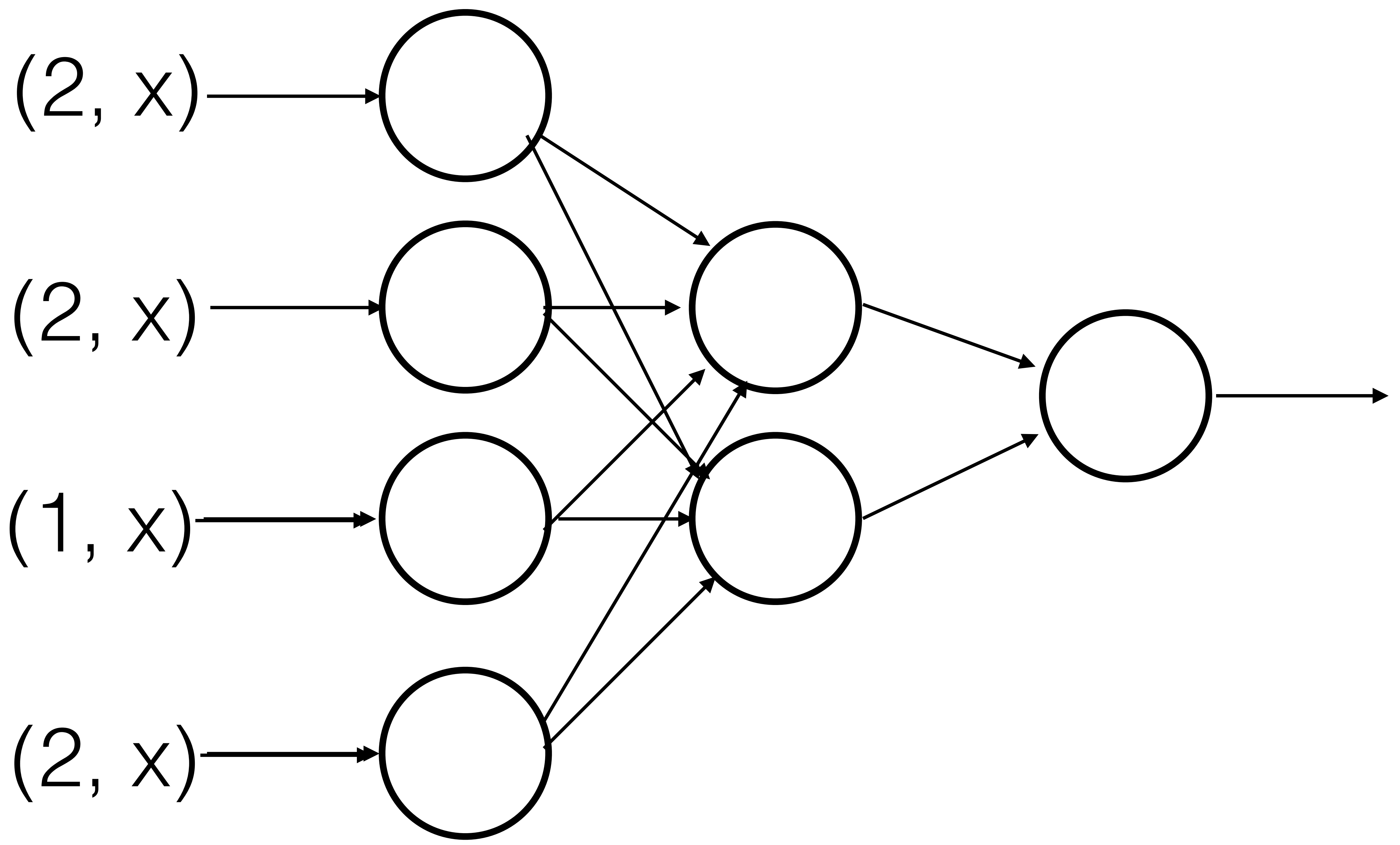

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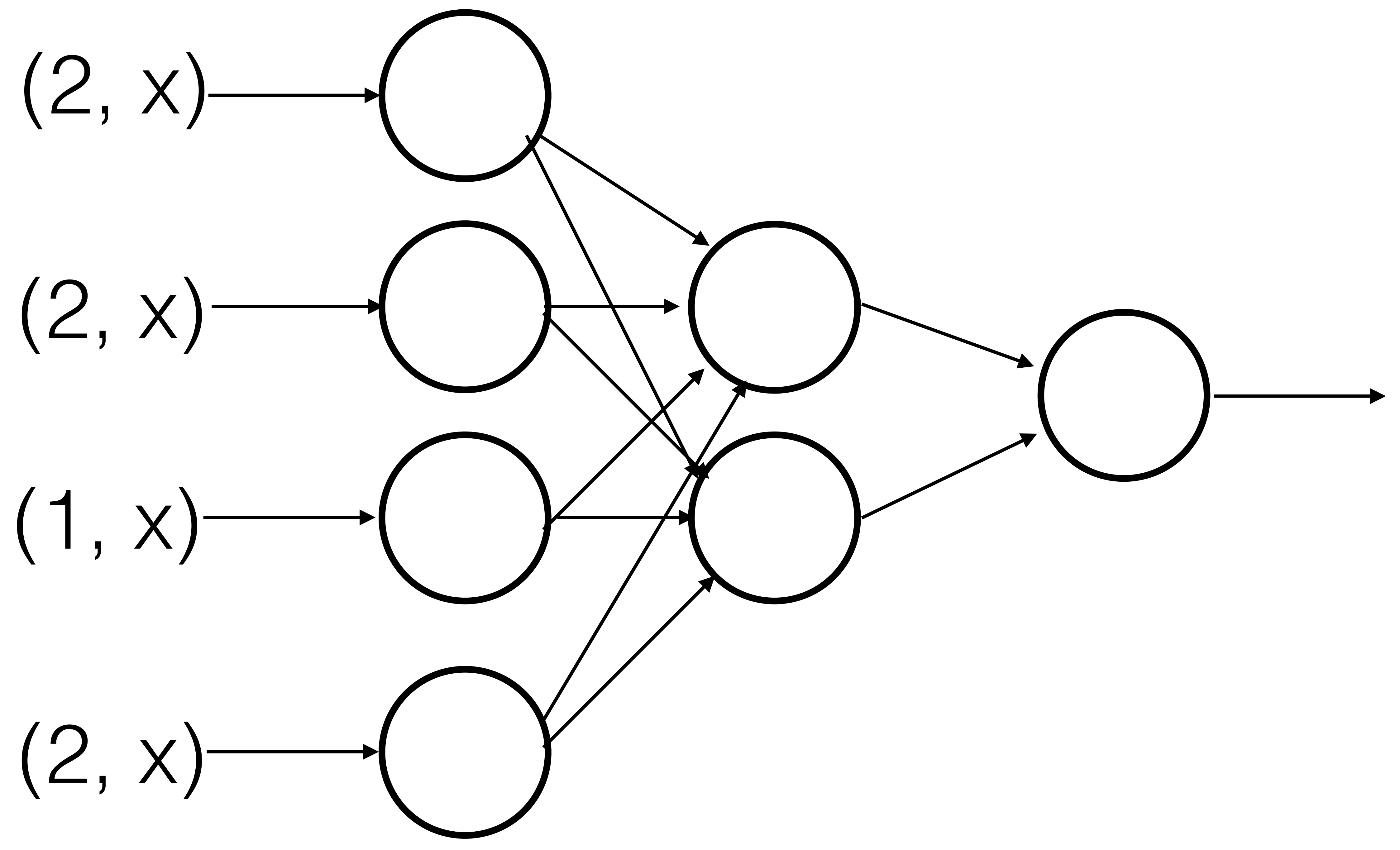

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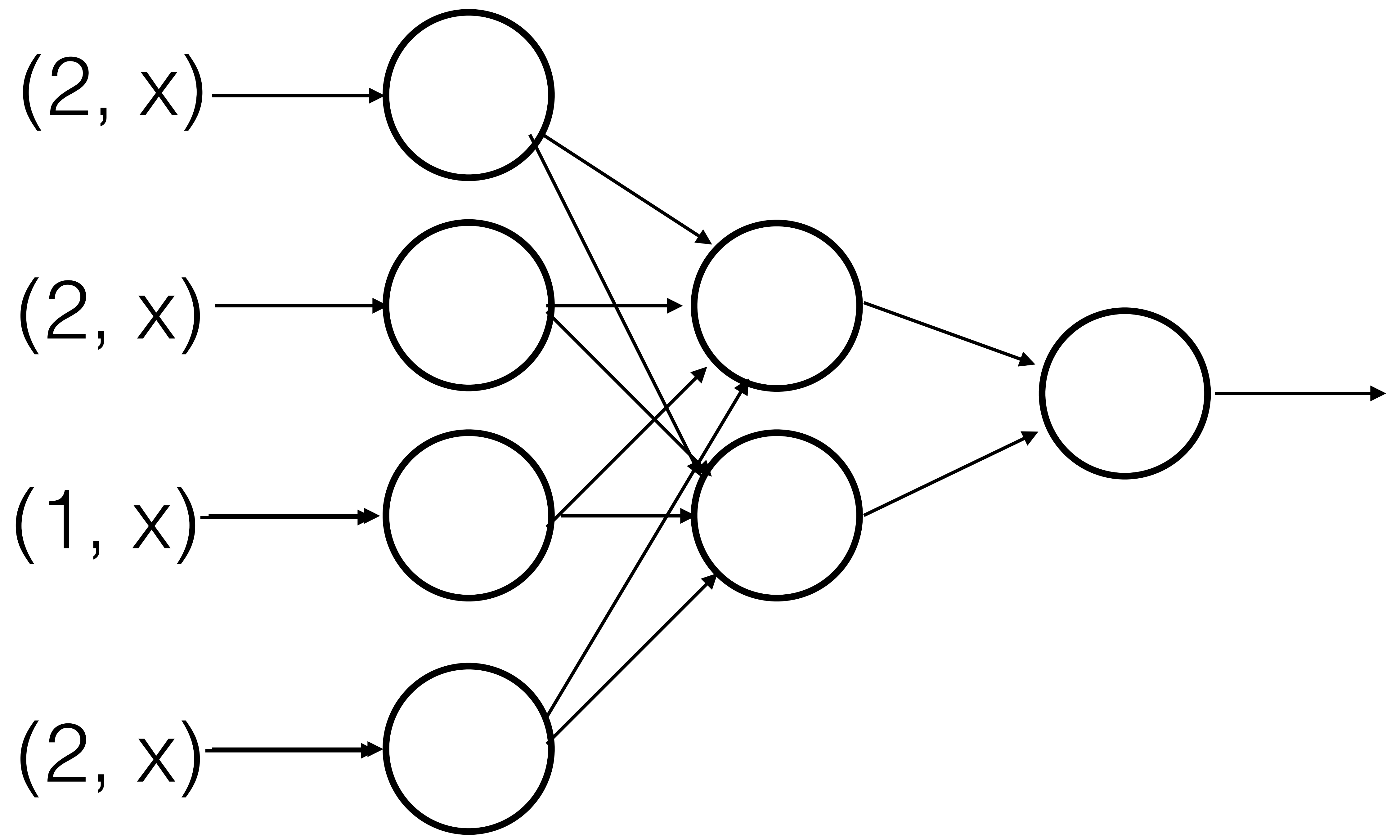

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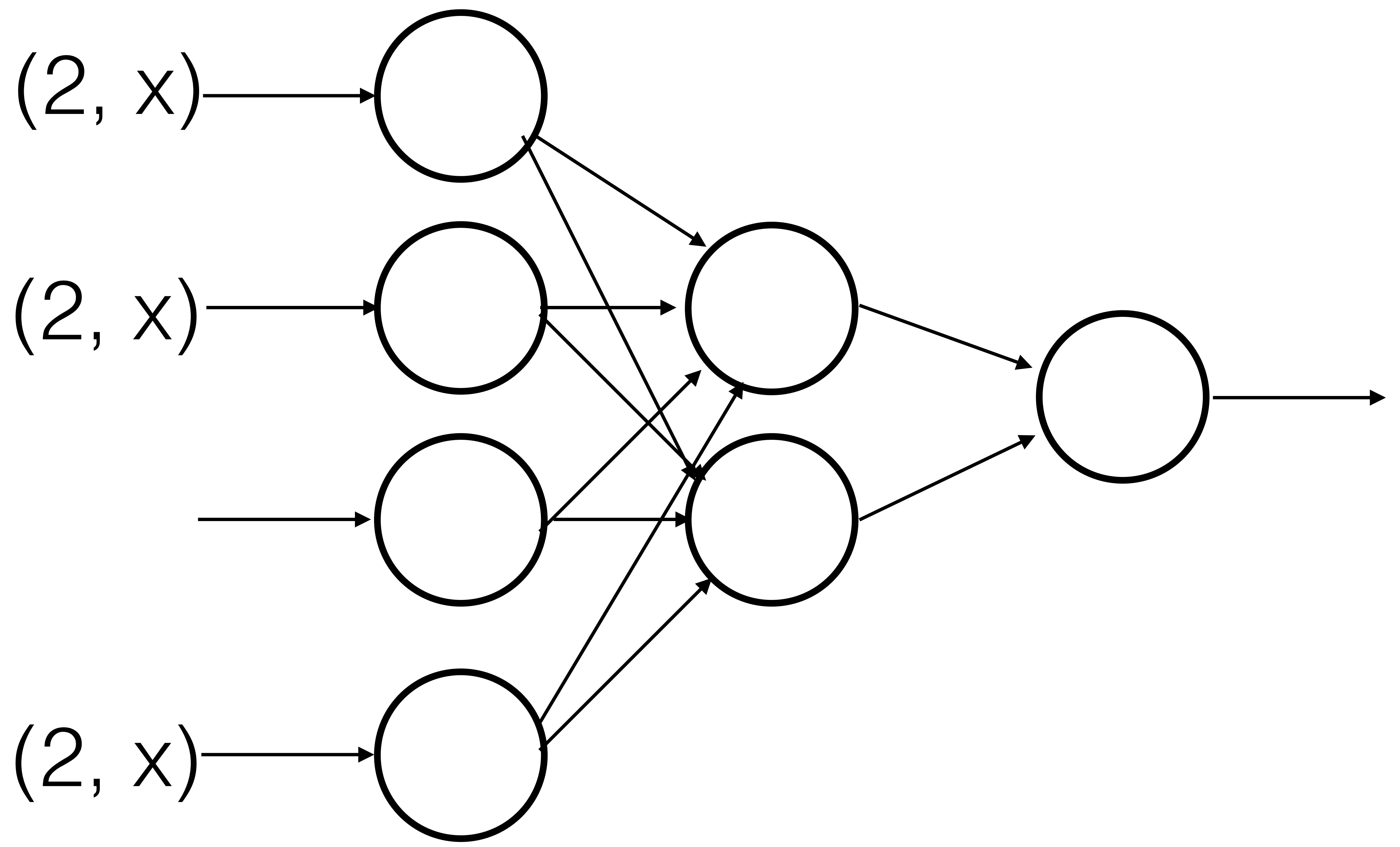

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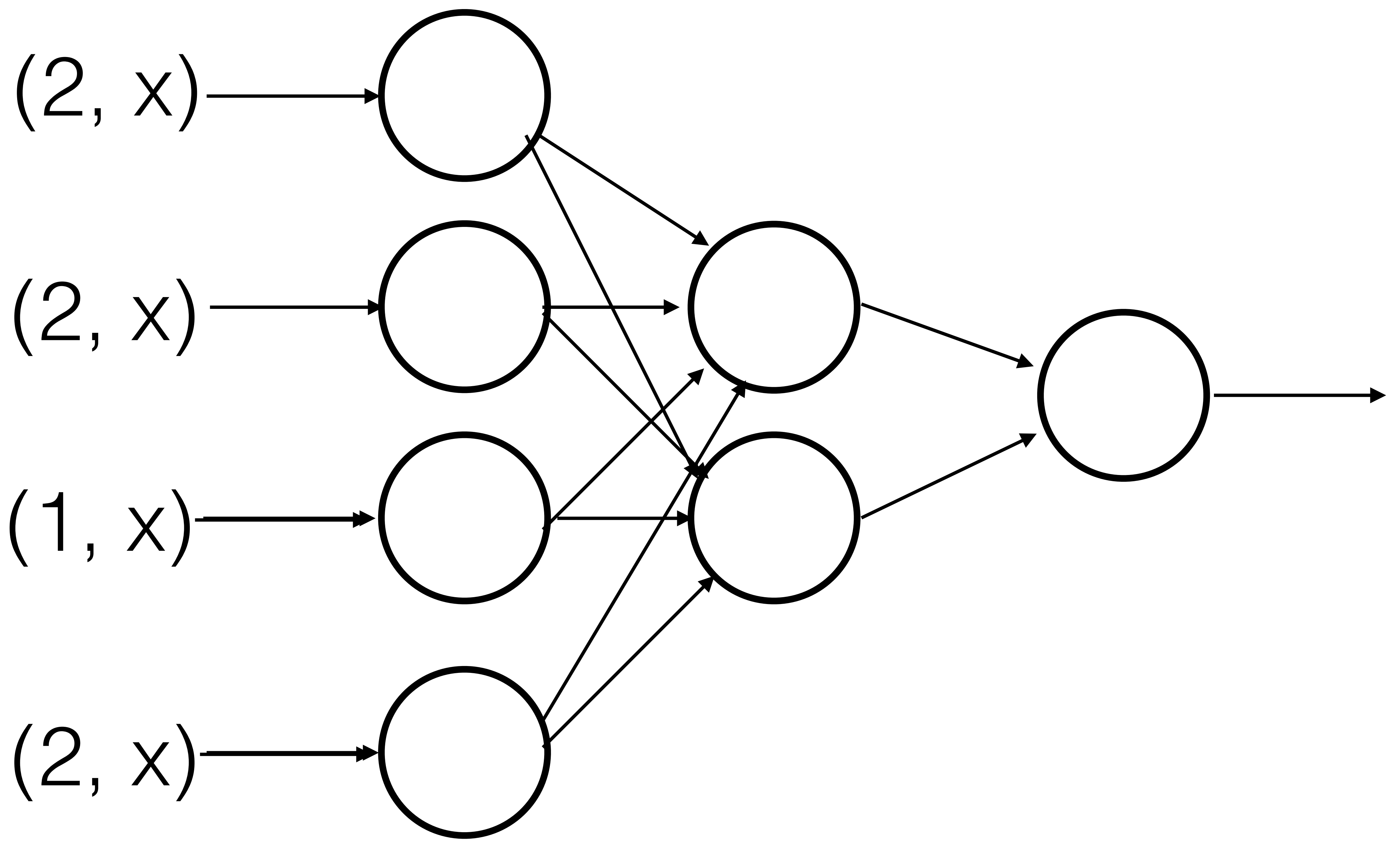

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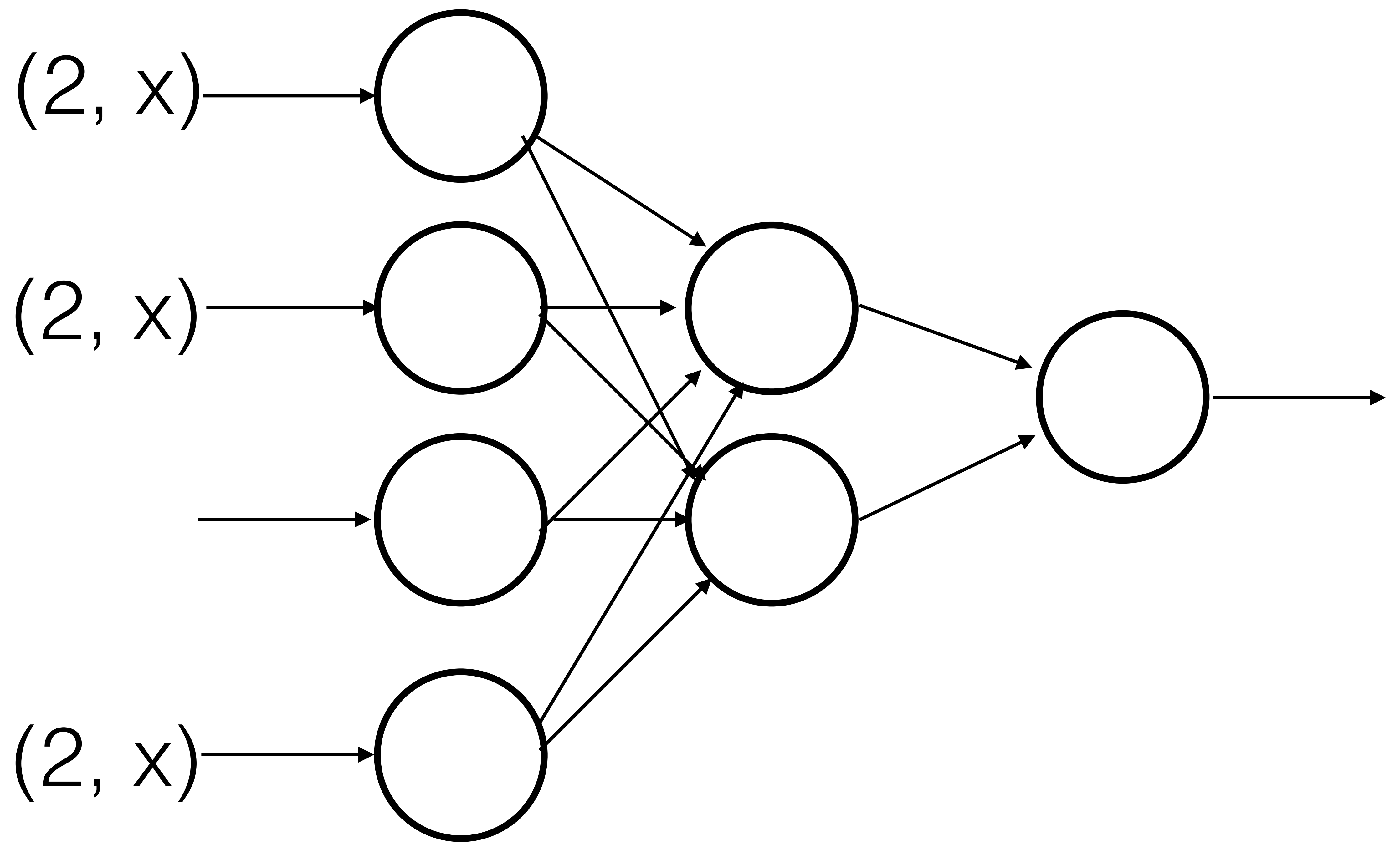

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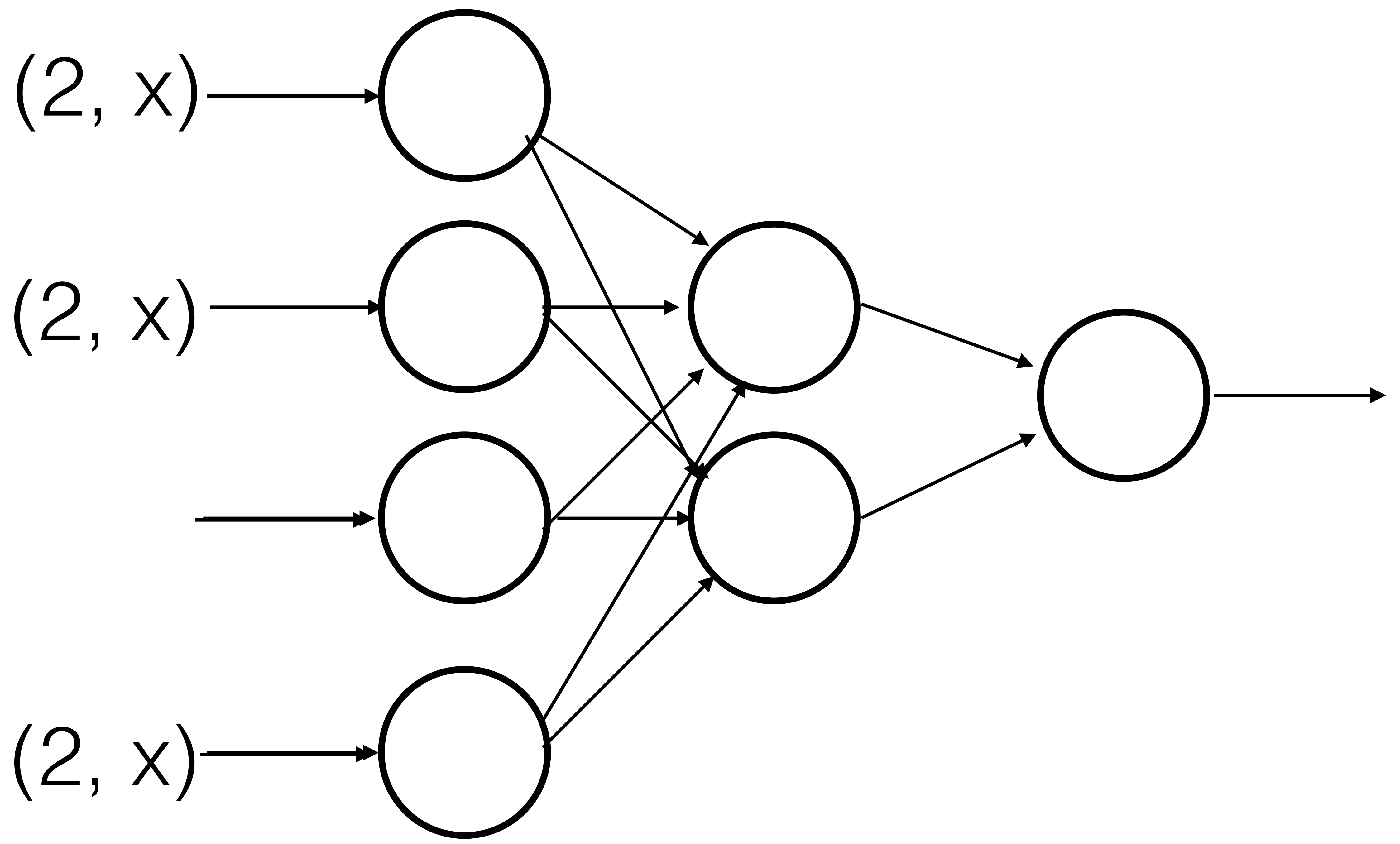

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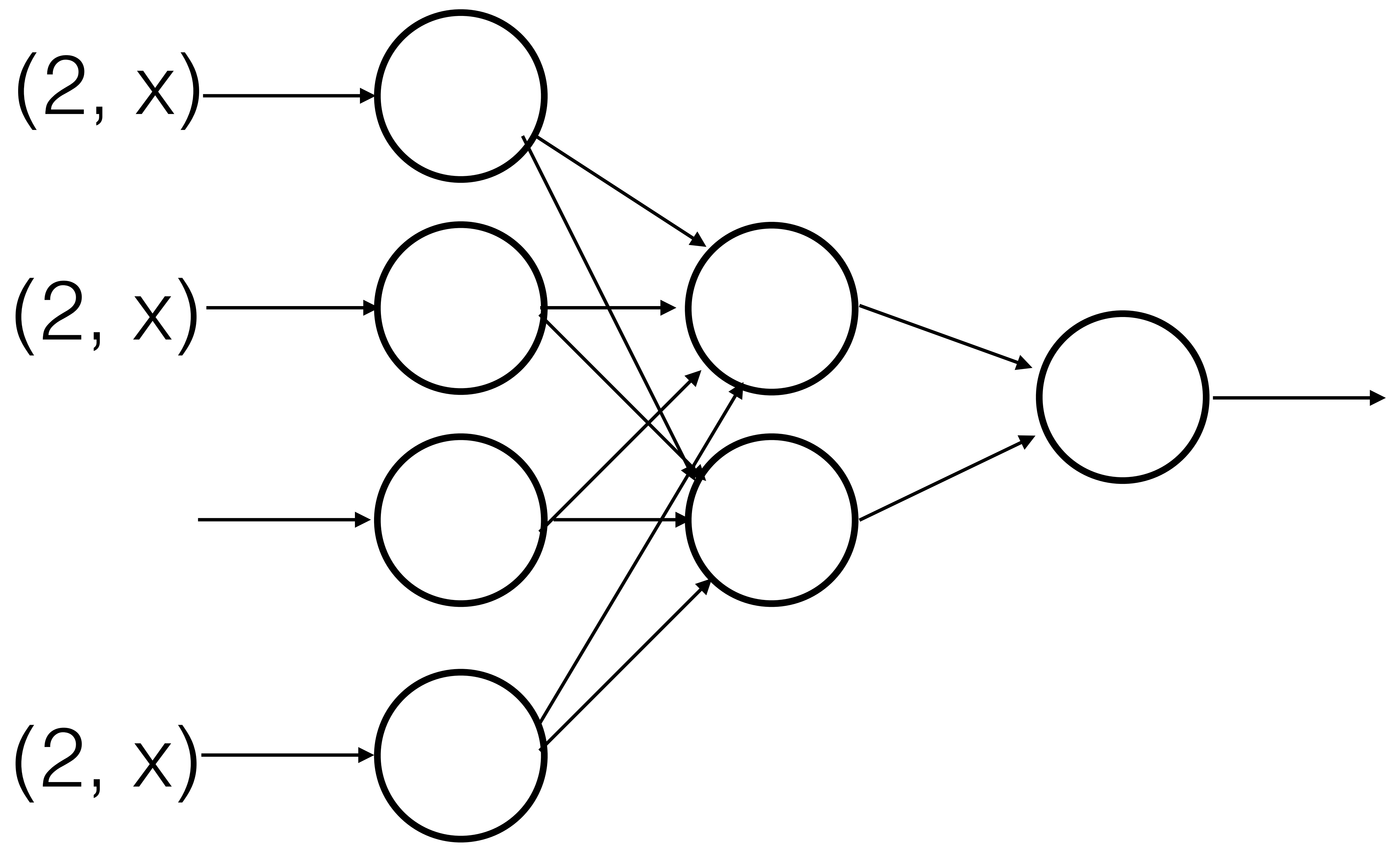

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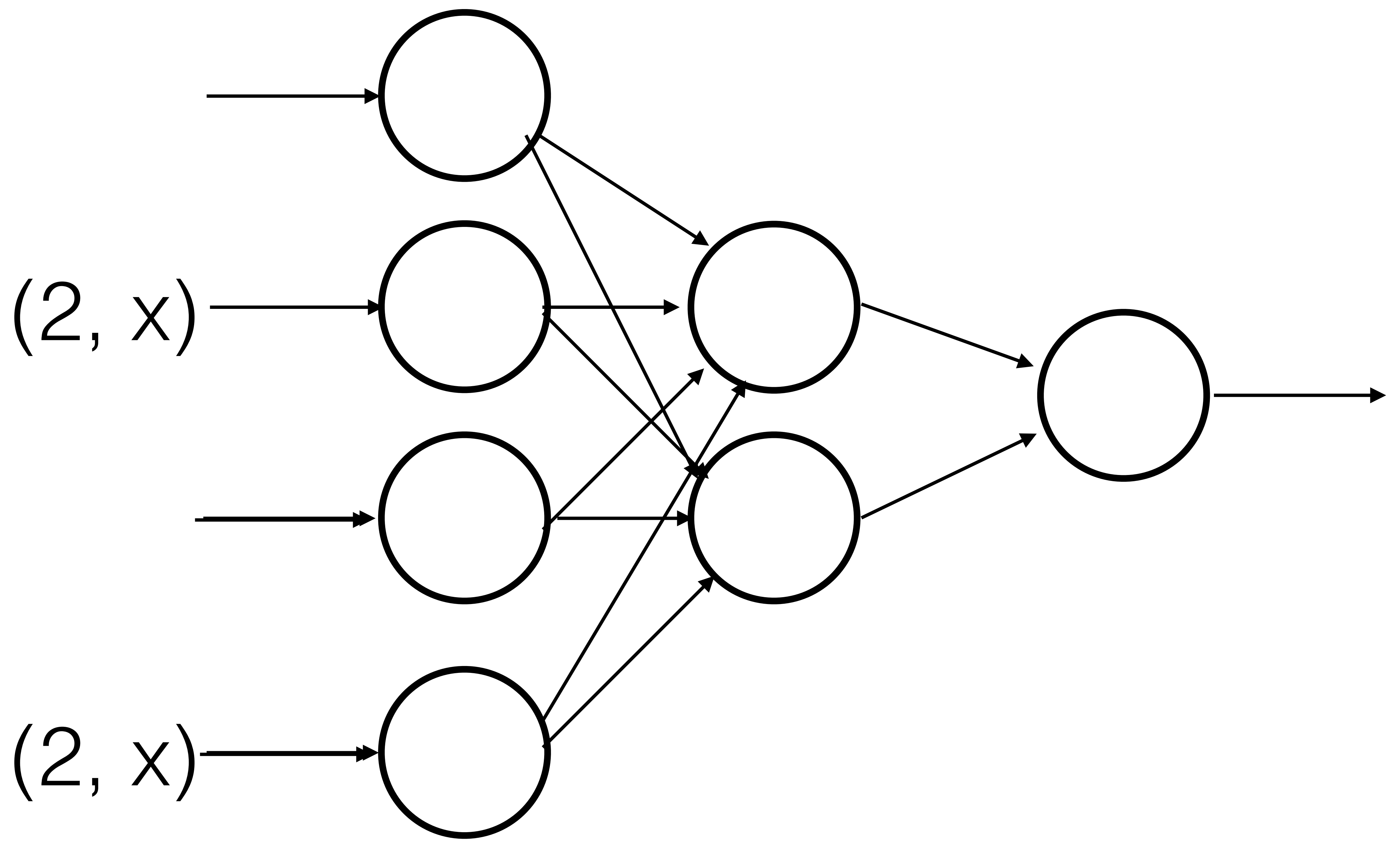

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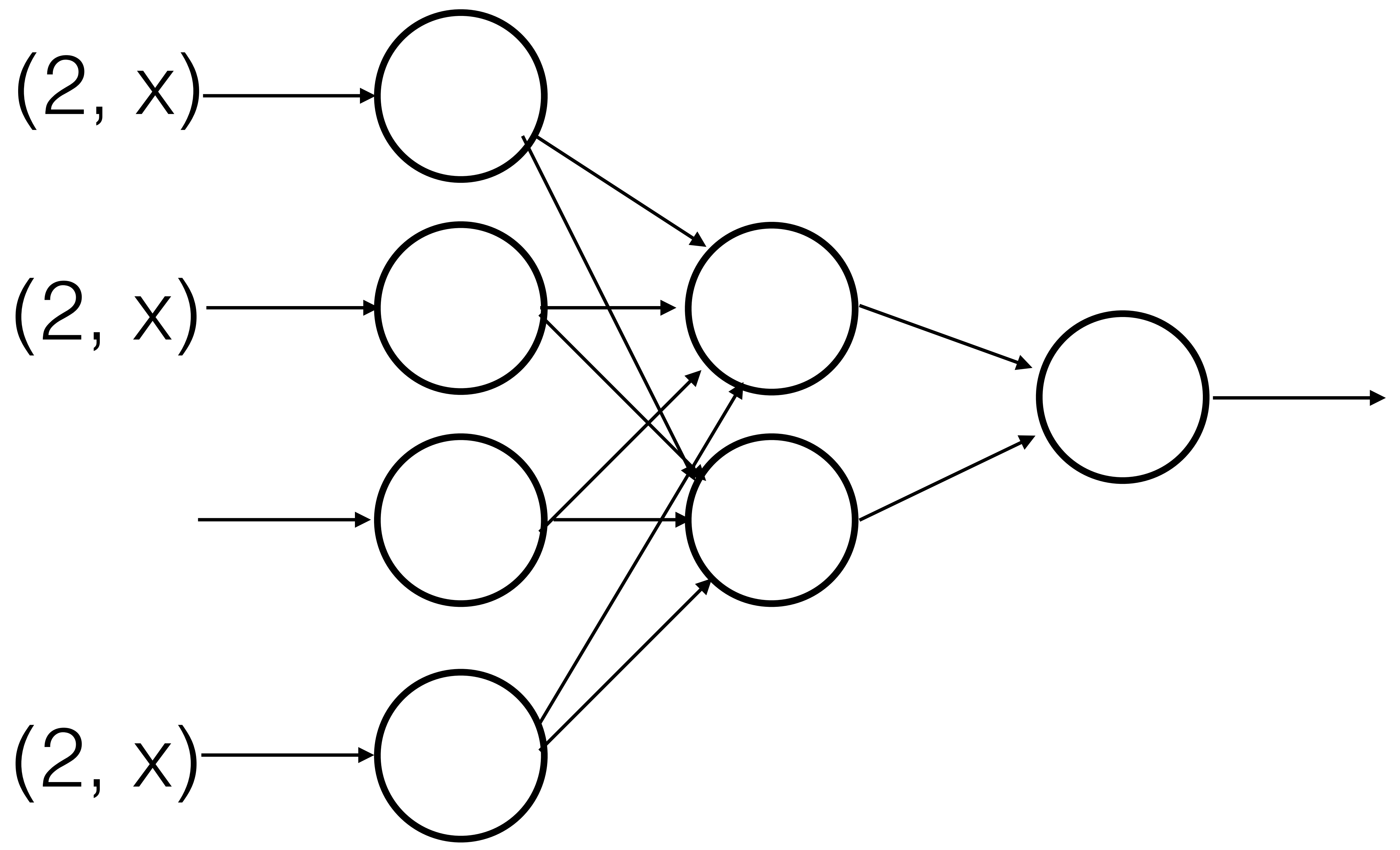
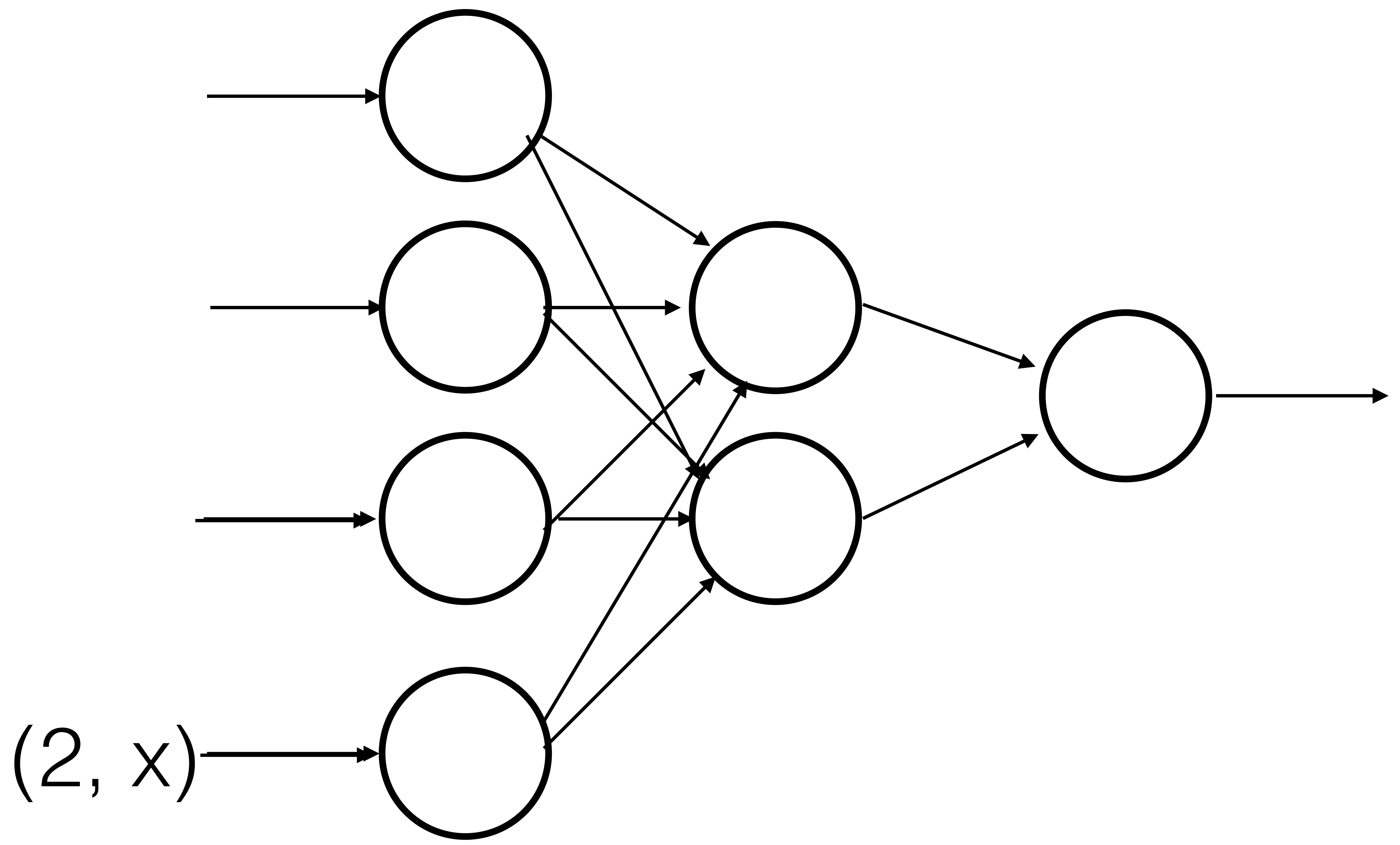


BSP



Out-of-Order Processing
(Assuming no interdependence between different epochs)

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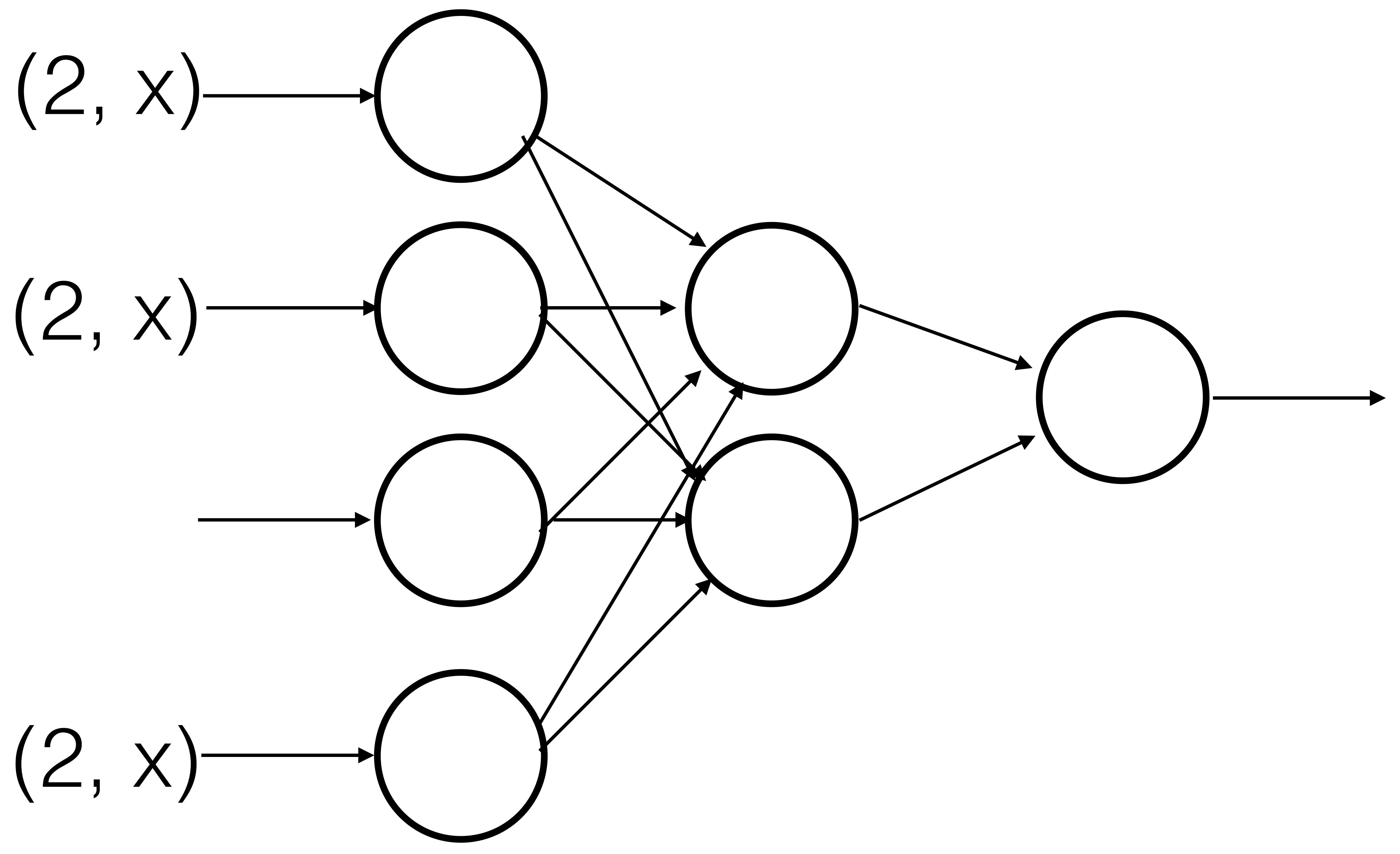
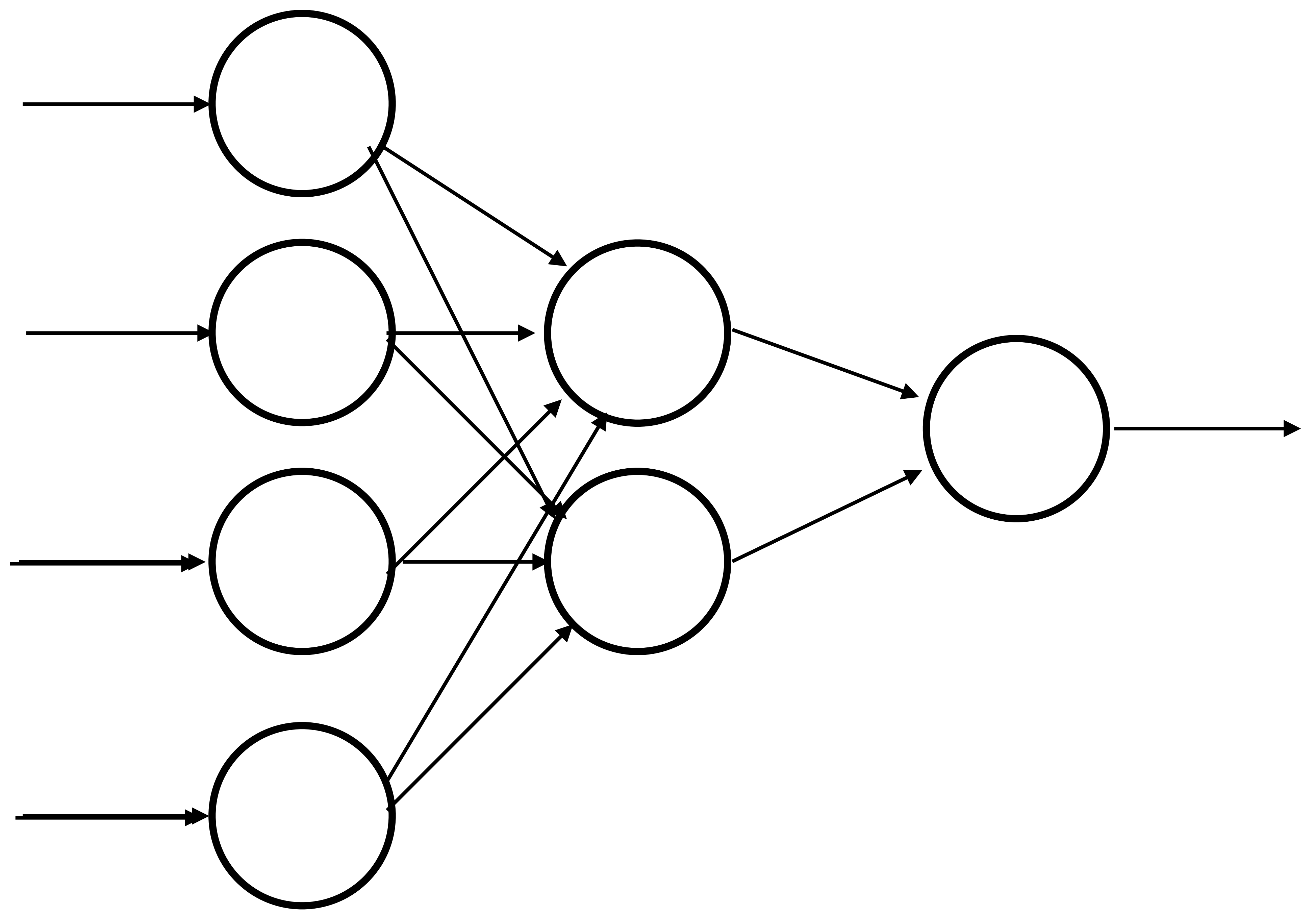


BSP



Out-of-Order Processing
(Assuming no interdependence between different epochs)

Problems to Solve

- Out-of-order is great, but also need to be able to implement BSP.
  - Implemented using progress tracking/notification mechanism.
  - Assume data has timestamps, timestamps have partial order.
  - Processing data with time t results in output with t’ => t’ ≥ t
  - Really time is a logical vector, components for loop counters
- Need loop counters for synchronization in iterative computation.

Problems to Solve

- Stateful Nodes: Revisit all the old problems
    - Fault tolerance: Use checkpointing, but a major weakness.
    - Straggler Mitigation: Use better systems, existing things don’t work

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- Recently: Frank McSherry implemented Naiad in Rust
- Lots of blog posts claiming faster performance than Spark, etc.
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- Performance improved because: Naiad, Rust, the really unsafe serialization?
- Can someone who is not Frank McSherry build using Naiad?
    - Will it be as efficient?

More Serious Questions

- Do we really need these multi-paradigm systems?
  - This is quiet complex.
  - Spark, since Spark Streaming and GraphX has gotten complex.
  - Worth it?
- What should BSP systems learn from Naiad?
- Should we reimplement Spark like systems on top of Naiad?
- Scheduling?