RowClone: Fast and Energy-Efficient In-DRAM Bulk Data Copy and Initialization

Carnegie Mellon University   **Intel Pittsburgh**

RowClone: Fast and Energy-Efficient In-DRAM Bulk Data Copy and Initialization

Processor ⟷ **Channel** ⟷ **Memory**

Limited bandwidth ↗   ↖ High energy

Bulk Data Copy   Data Initialization

Forking   Zeroing   Checkpointing   VM Cloning

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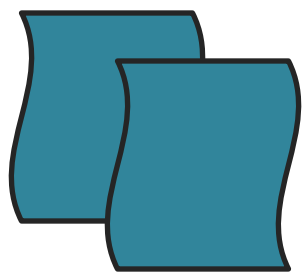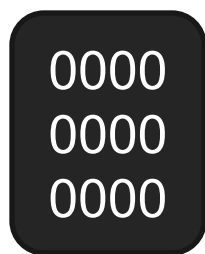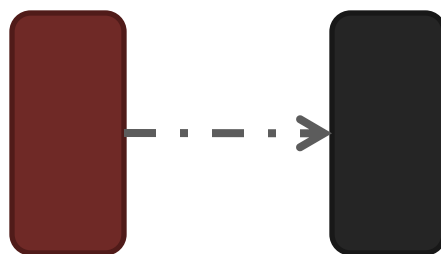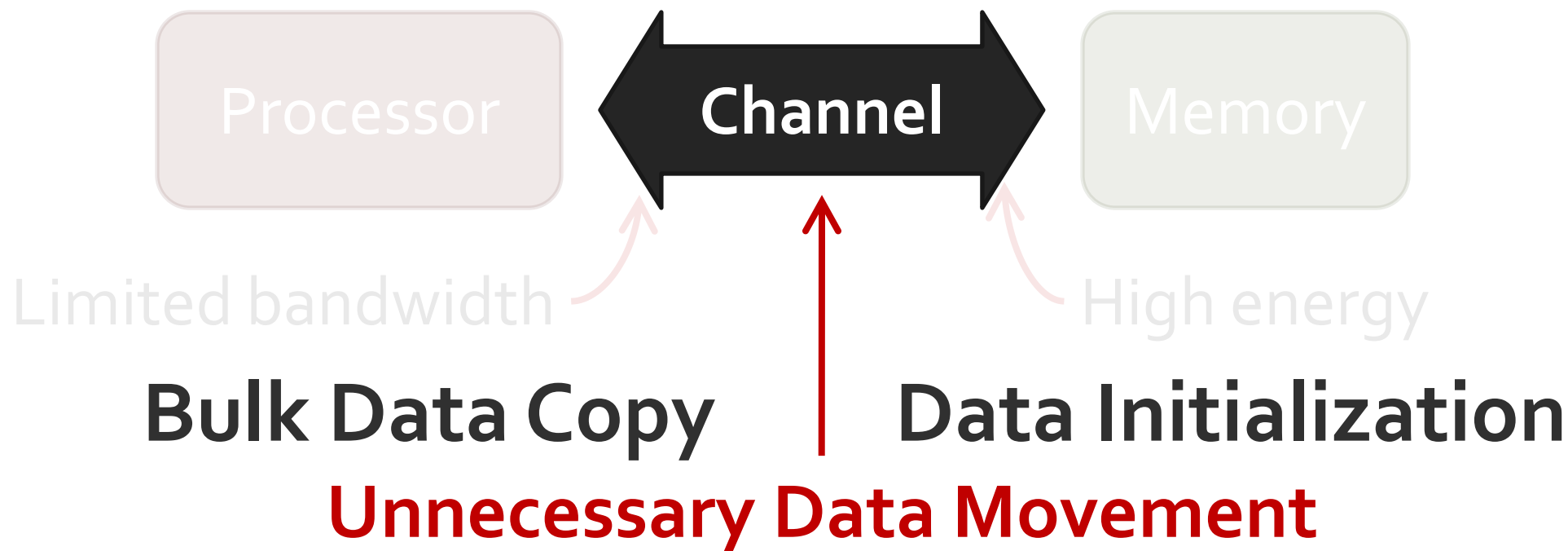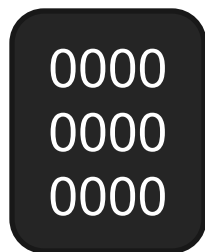

Processor ⟷ **Channel** ⟷ Memory

Limited bandwidth — High energy

Bulk Data Copy — **Data Initialization**

Unnecessary Data Movement

Forking — Zeroing — Checkpointing — VM Cloning

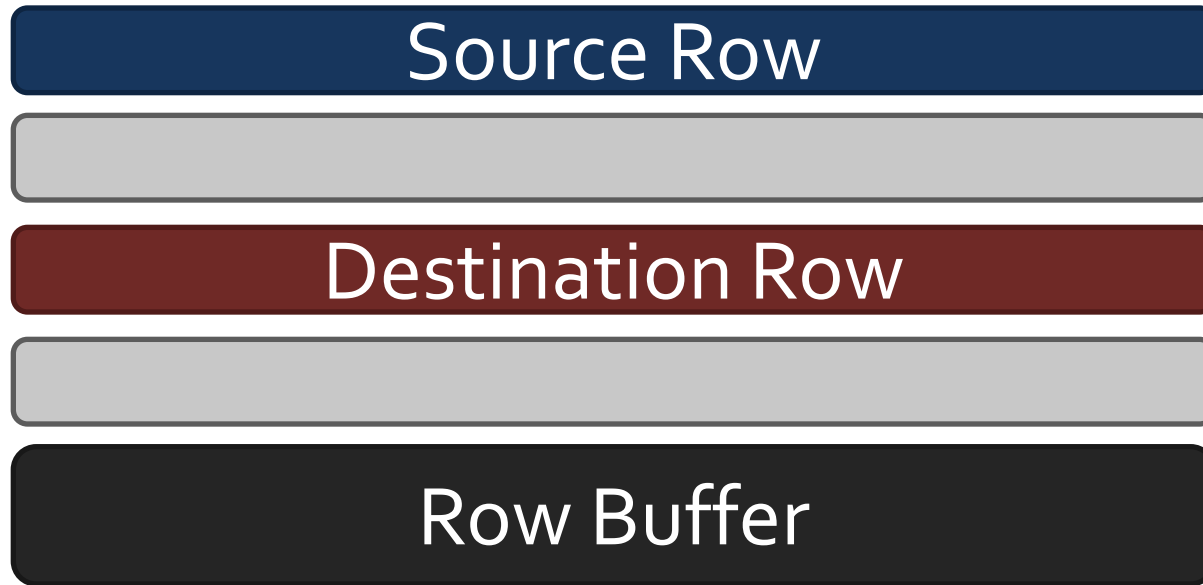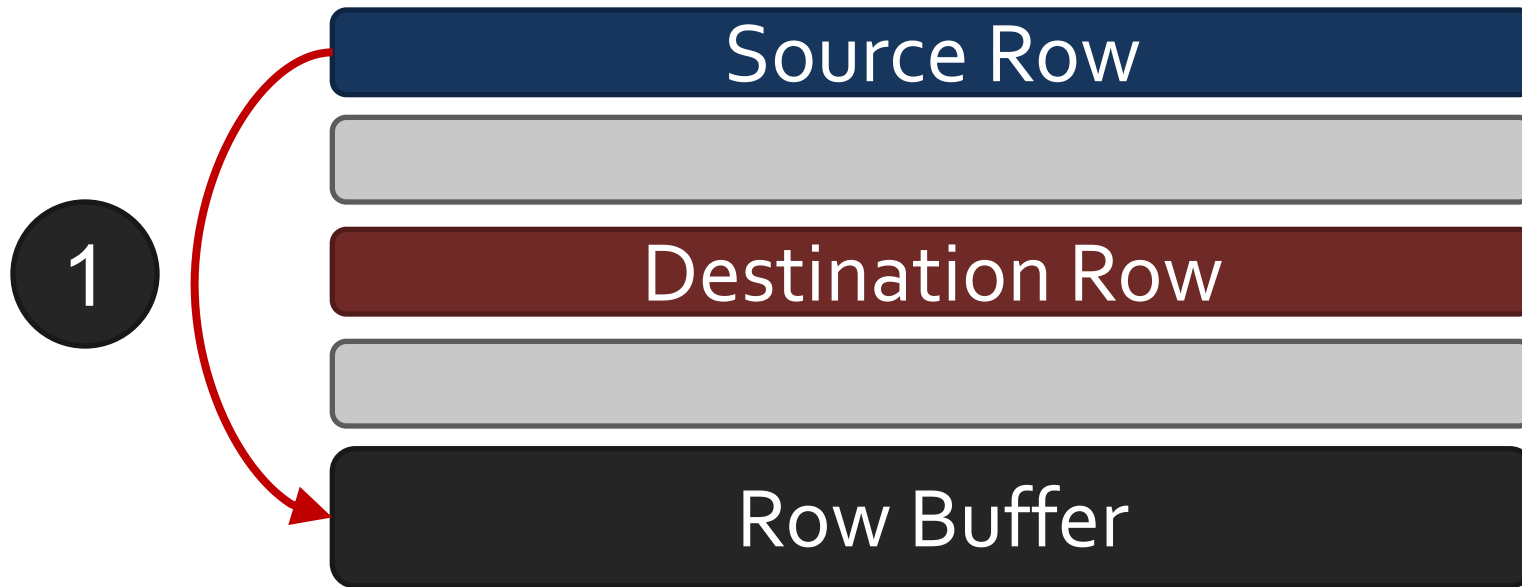**Carnegie Mellon University** — **Intel Pittsburgh**
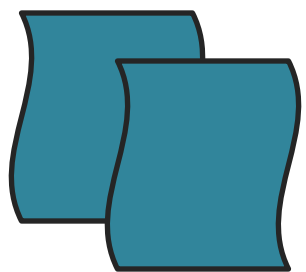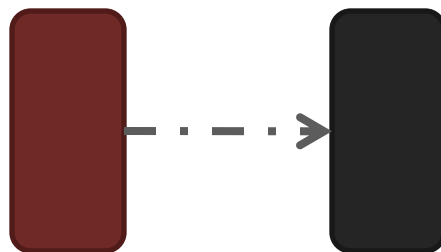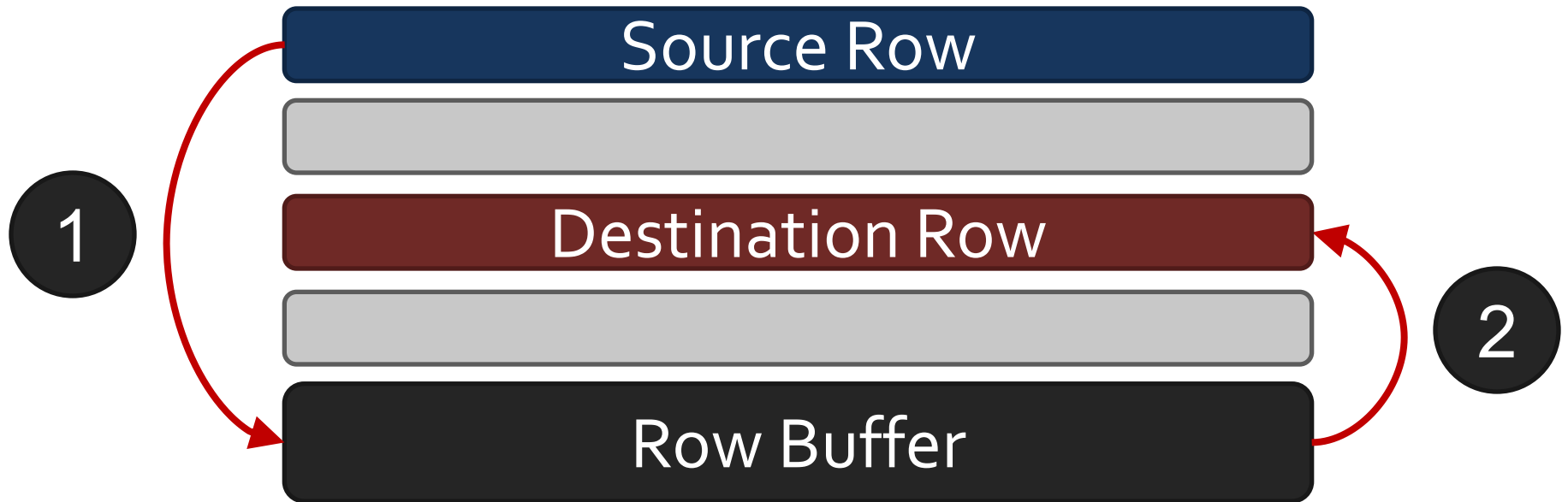
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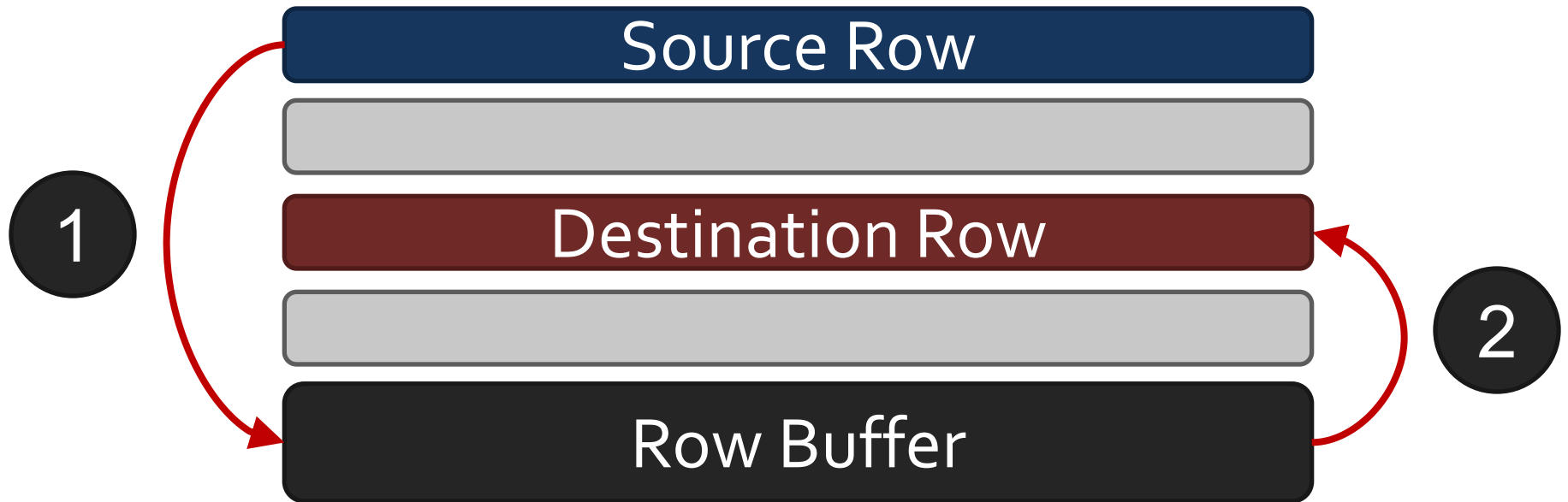

Copy from source row to row buffer

RowClone: In-DRAM Bulk Copy & Initialization

Source Row

Destination Row

Row Buffer

1

2

Copy from source
row to row buffer

Copy from row buffer
to destination row

RowClone: In-DRAM Bulk Copy & Initialization

Source Row	
	(1)
Destination Row	
	(2)
Row Buffer	

Copy from source row to row buffer

Latency **11x** ↓

Copy from row buffer to destination row

Energy **74x** ↓

Very few changes to DRAM
(0.01% increase in die area)

RowClone: In-DRAM Bulk Copy & Initialization

- End-to-end system design to exploit DRAM substrate

- Several applications that benefit from RowClone

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8-Core System

Performance
Current Systems — RowClone — 27%

DRAM Energy Efficiency
17%