Functional Hash Maps in a Data Parallel Language

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August 22nd, 2025

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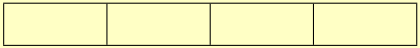
Open Adressing Example

- Keys $k_0, k_1 \in K$.
- Hash function $h : K \to \{0, 1, 2, 3\}$.
- $h(k_0) = h(k_1) = 1$.



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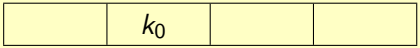

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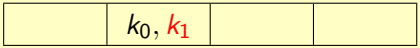

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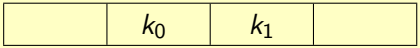
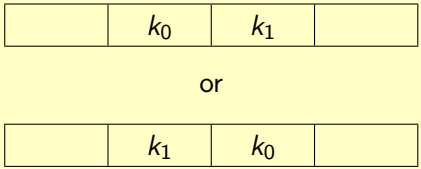


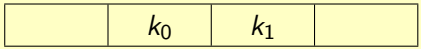
Core Ideas

- Concurrency.

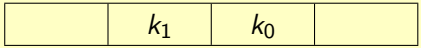


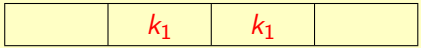
Core Ideas

- Concurrency.
- Difficult.



or





Hash Maps in Functional Data Parallel Languages

- Avoid collisions.
- Bulk operations.

$$\texttt{map} : (\alpha \to \beta) \to [n]\alpha \to [n]\beta$$
$$\texttt{from\_array} : [n](\alpha, \beta) \to \textbf{hashmap}\ \alpha\ \beta$$

Hash Maps in Functional Data Parallel Languages

- Avoid collisions.
- Bulk operations.
- Fredman-Komlós-Szemerédi (FKS) construction.

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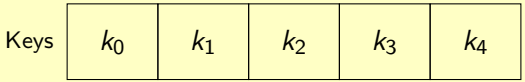
Perfect Hashing with FKS



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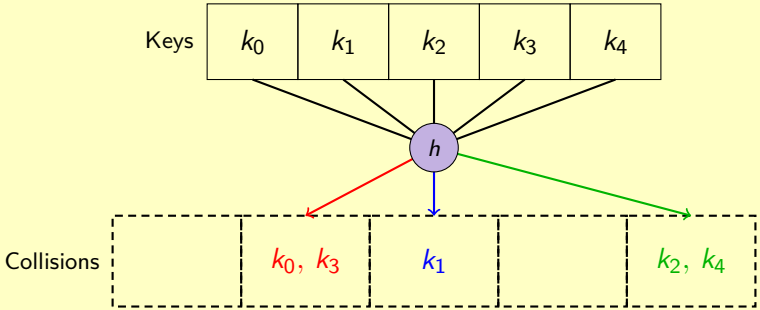

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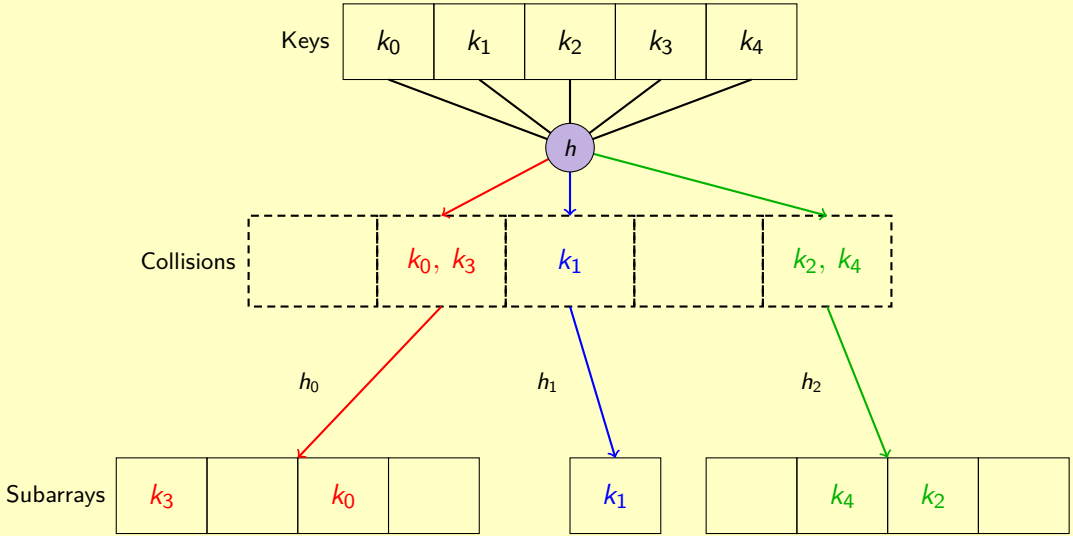
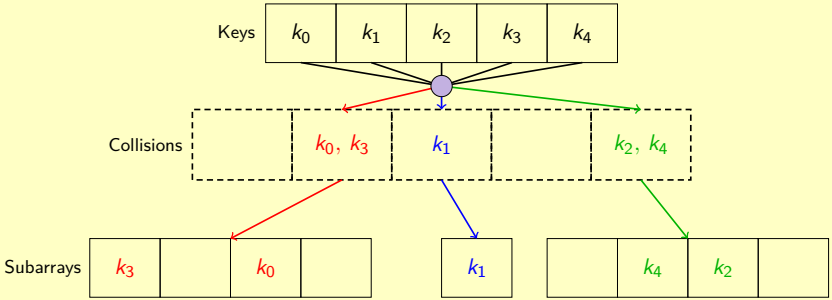


Flattening The Finding of Collision-free Hash Functions



map $\lambda subarray \rightarrow$

  while h_i leads to collisions do

    Pick a random hash function h_i

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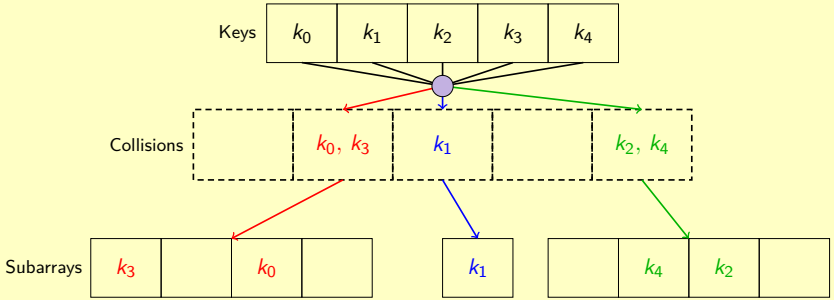

`map` $\lambda subarray \rightarrow$

`while` h_i leads to collisions `do`

Pick a random hash function h_i

$\mapsto$

`while` any collisions in subarrays `do`

`map` $\lambda key \rightarrow \ldots$

Benchmarks

	64-bit integer keys ($n = 10^7$)	
	Construction	*Lookup*
Futhark (hash maps)	18.3	3.3
Futhark (binary search)	40.9	6.2
Futhark (Eytzinger)	42.3	4.3
cuCollections	2.7	1.1

All times in milliseconds measured on an A100 GPU.

The End

Towards Efficient Hash Maps in Functional Array Languages

https://arxiv.org/abs/2508.11443

Code

https://github.com/diku-dk/containers

https://github.com/diku-dk/futhark-hashmap-experiments