Functional Hash Maps in a Data Parallel Language

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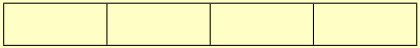
Open Adressing Example

- 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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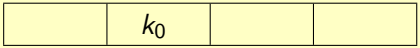

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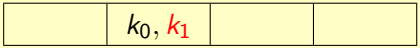

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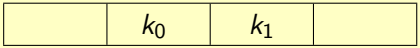
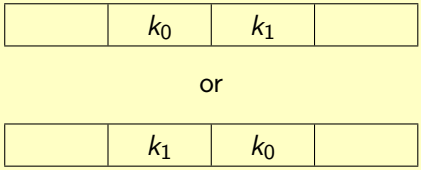


Core Ideas

- Concurrency.
- Collision resolution.



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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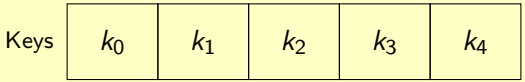
Perfect Hashing with FKS



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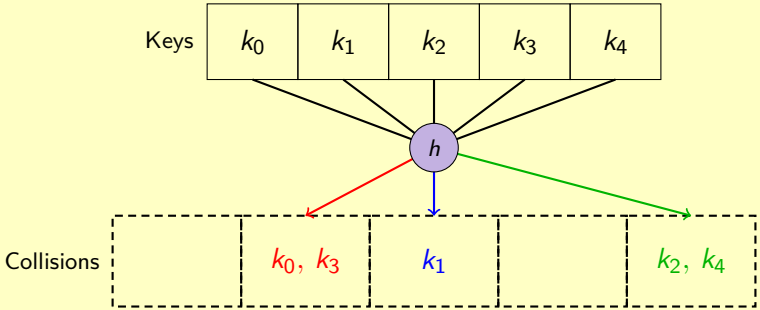

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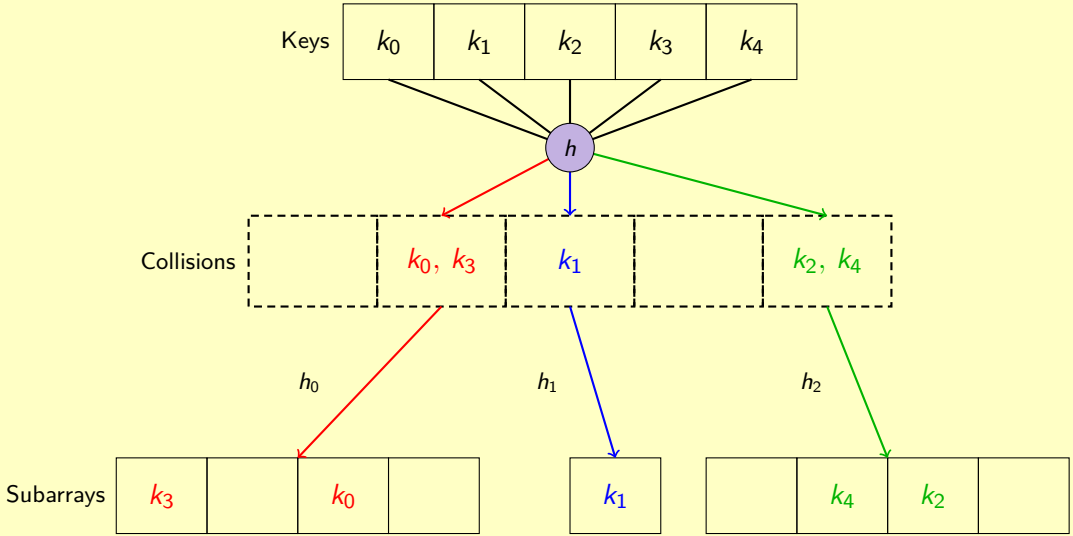
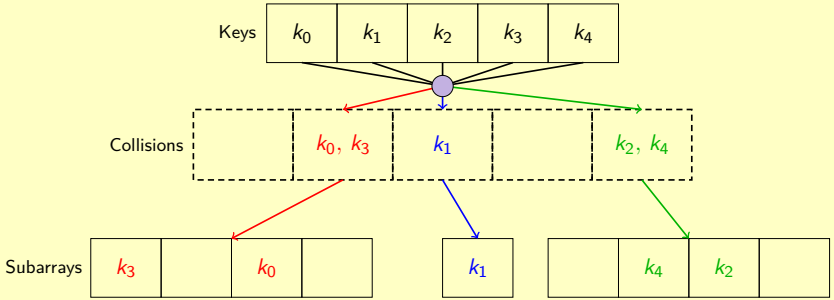


Flattening The Finding of Collision-free Hash Functions



`map` $\lambda subarrays \rightarrow$

`while` h_i leads to collisions `do`

Pick a random hash function h_i

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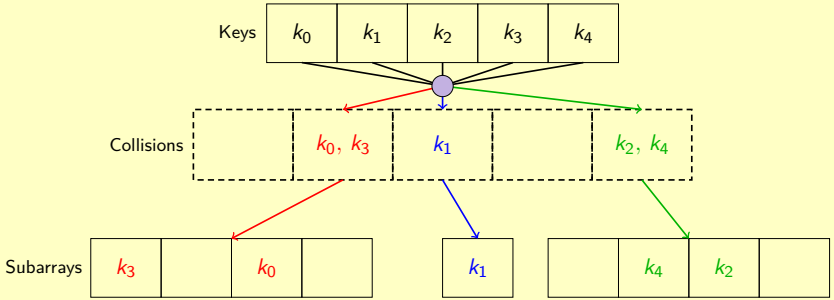

`map` $\lambda subarrays \rightarrow$

`while` h_i leads to collisions `do`

Pick a random hash function h_i

$\mapsto$

`while` any collisions in subarrays `do`

`map` $\lambda keys \rightarrow$ pick new hash functions

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