Functional Hash Maps in a Data Parallel Language

William Henrich Due [1] Martin Elsman [1] Troels Henriksen [1]

[1]Department of Computer Science, University of Copenhagen

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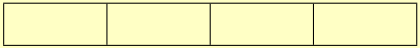
Contact: widu@di.ku.dk

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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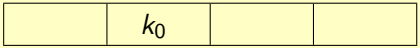

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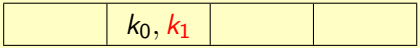

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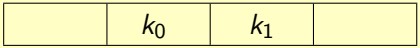
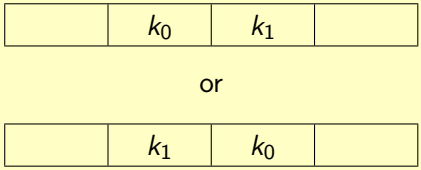


Core Ideas

- Concurrency.
- Collision resolution.



Hash Maps in Functional Array Language

- Avoid collisions.
- Bulk operations.

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

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- Fredman-Komlós-Szemerédi (FKS) construction.

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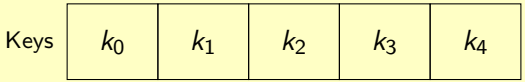
Perfect Hashing with FKS



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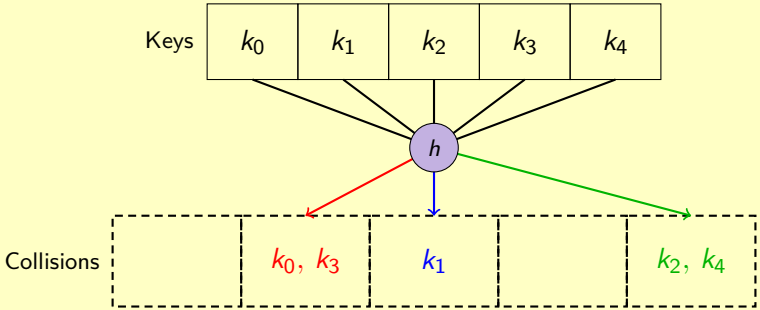

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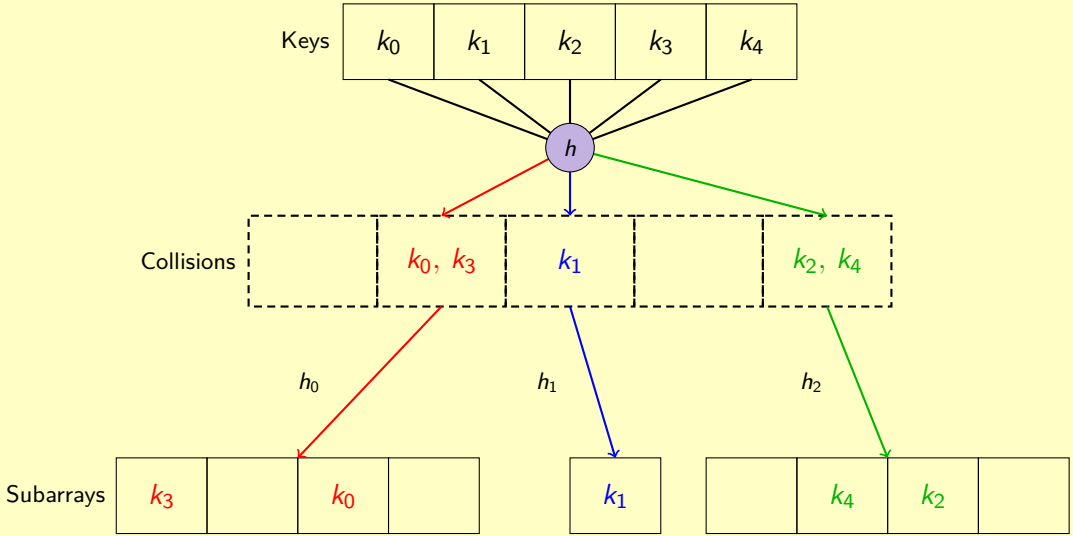

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$\mapsto$

$\texttt{while}$ any collisions in subarrays $\texttt{do}$

  $\texttt{map}\ \lambda keys \rightarrow$ pick new hash functions

Benchmarks

	64-bit integer keys ($n = 10^7$)		
	Construction	*Lookup*	*Membership*
Futhark (hash maps)	18.3	3.3	1.6
Futhark (binary search)	40.9	6.2	5.8
Futhark (Eytzinger)	42.3	4.3	2.4
cuCollections	2.7	1.1	0.9

All times in milliseconds.

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