Chapter 6, Hash tables:

- General introduction; separate chaining (Monday)
- Open addressing (**Today**)
- Hash functions (Friday)
- Perfect hashing (next week Monday)
- Hash table performance (next week Wednesday)

Today:

- Review/finish hash table concepts
- Basic idea and example of open addressing
- Terminology, code, and invariant
- Probing strategies
- Deletion

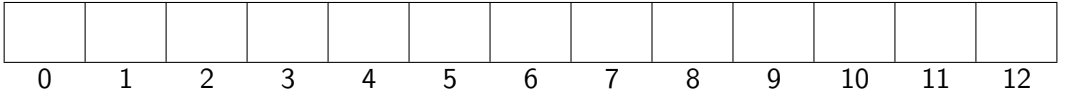
Hash functions should distribute the keys *uniformly* and *independently*.

Uniformity:

$$P(h(k) = i) = \frac{1}{m}$$

Independence:

$$P(h(k_1) = i) \quad = \quad P(h(k_1) = i \mid h(k_2) = j)$$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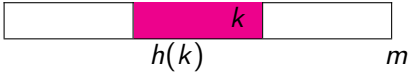
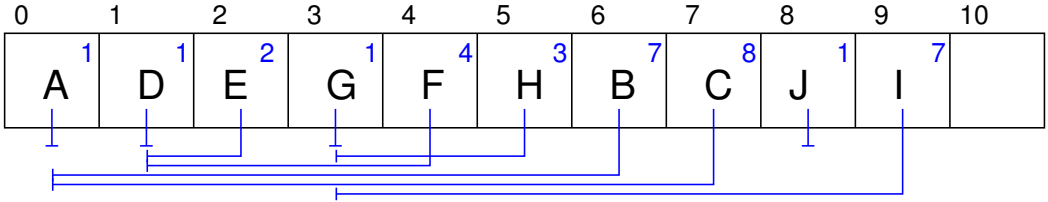
Invariant (Class `OpenAddressingHashMap`)

1. *The table it not full; there exists* $i \in [0, m)$ *such that* $\texttt{table}[i] = \texttt{null}$.
2. *There are no breaks in the chain for any key in the table; for all* $i \in [0, m)$ *such that* $\texttt{table}[i]$ *contains key* k,
   - *if* $h(k) \leq i$, *then for all* $j \in [h(k), i]$, $\texttt{table}[j] \neq \texttt{null}$;
   - *if* $i < h(k)$, *then for all* $j \in [0, i] \cup [h(k), m)$, $\texttt{table}[j] \neq \texttt{null}$.

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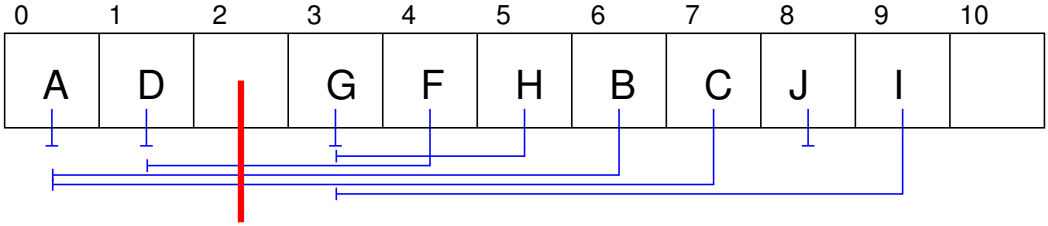
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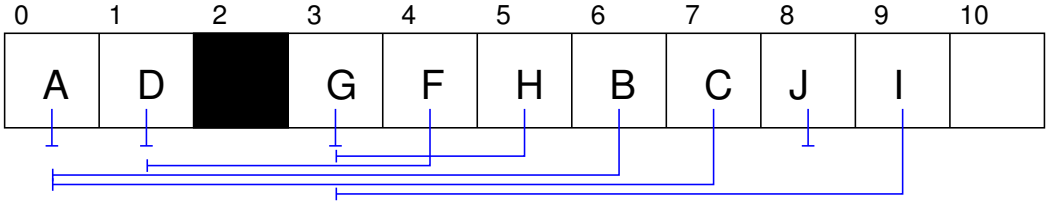
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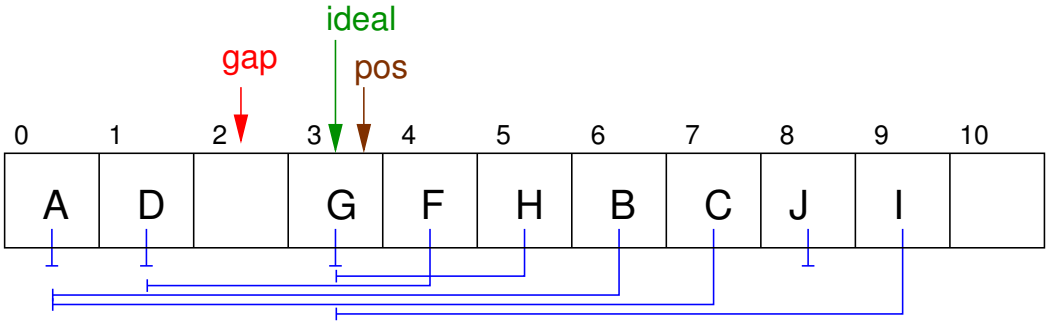
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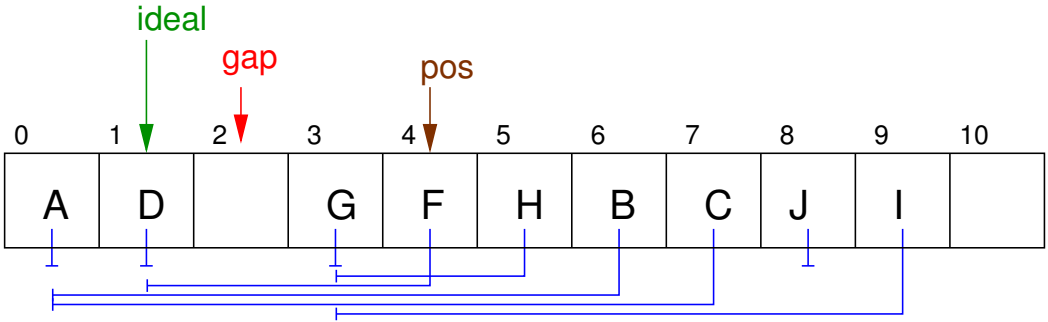
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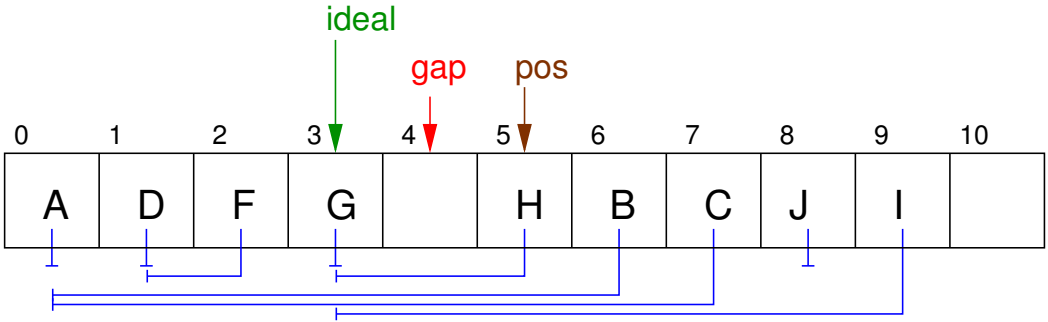
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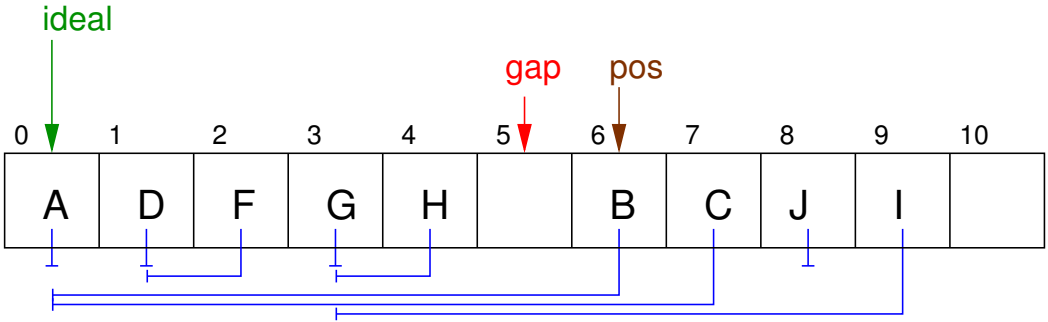
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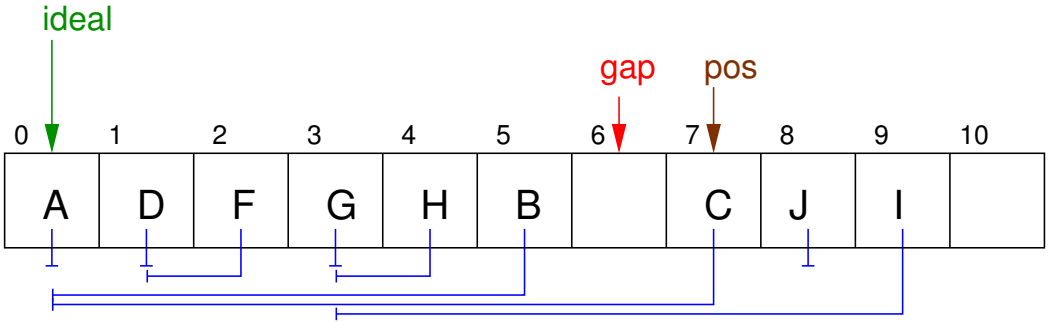
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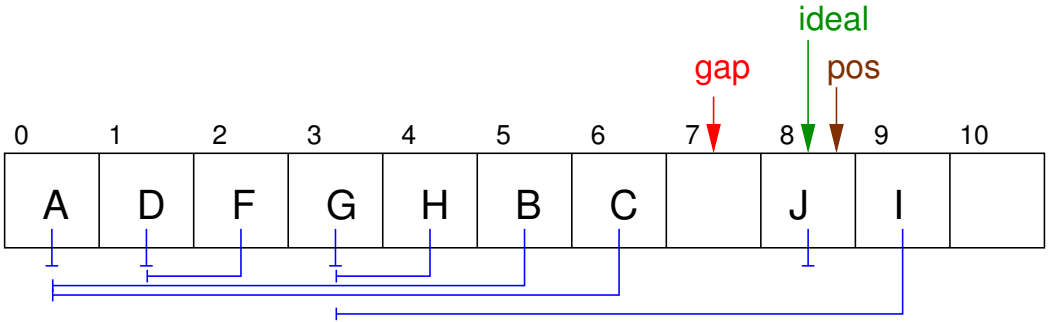
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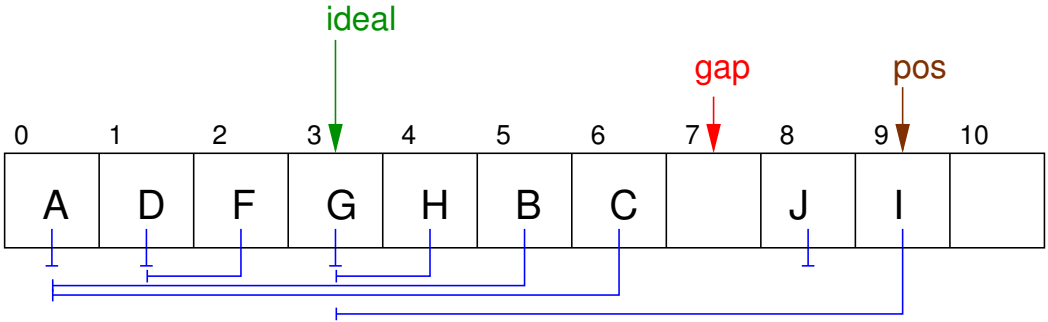
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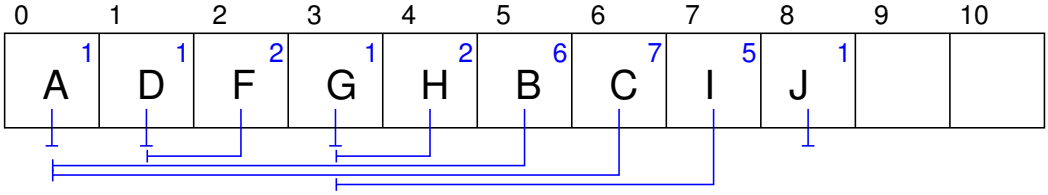
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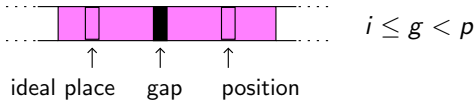
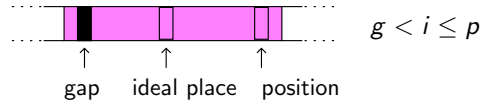
Cases to plug the gap



Cases to skip the gap



Invariant (Loop of optimized remove in linear probing.)

For all positions $k \in (i, j)$, gap is the only position, if any, between its ideal place ($h(\texttt{keys}[k])$) and its actual place (k).

Coming up: *(all end-of-day)*

Do **Optimal BST** *project (suggested by this past Monday, April 10)*
Do **Open addressing with linear probing** *project (suggested by Wednesday, Apr 19)*

Due **Thurs Apr 13**
Read Section 7.3
Do Exercises 7.(4,5,7,8)
Take quiz

Due **Mon, Apr 17**
Read Sections 7.(4 & 5)
(No practice problems or quiz)