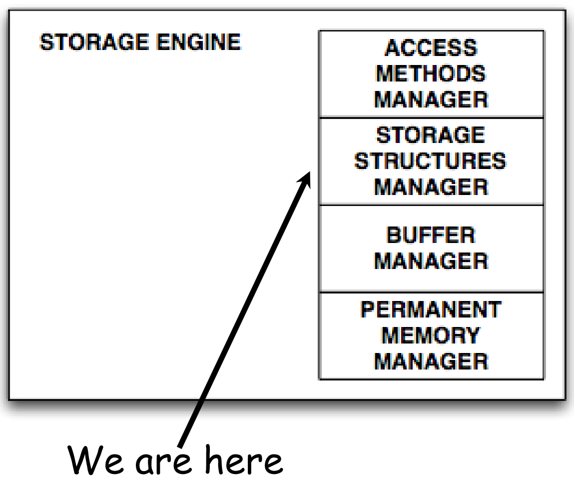
Organizations for key search

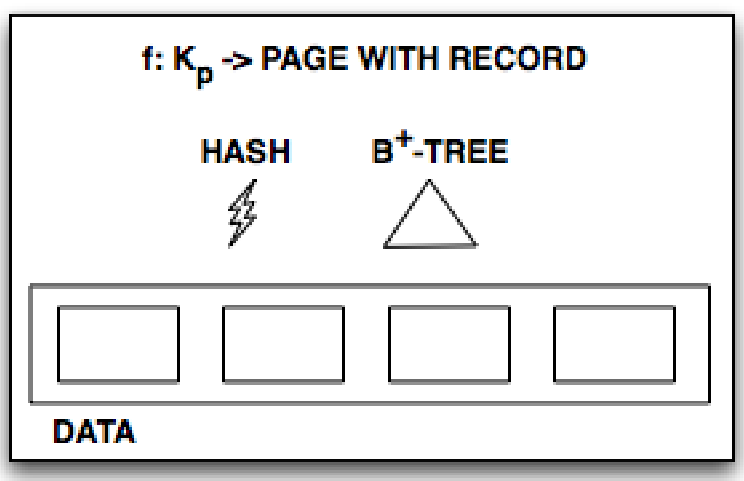
- Goal: Quick search for a record of a table with a given key value



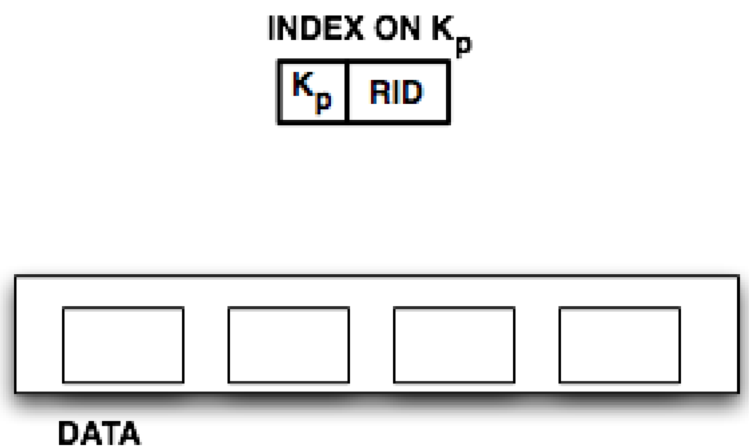
Organizations for key search

- Definition. An organization is called *primary* if it determines the way records are physically stored, otherwise it is called *secondary*.

PRIMARY



SECONDARY

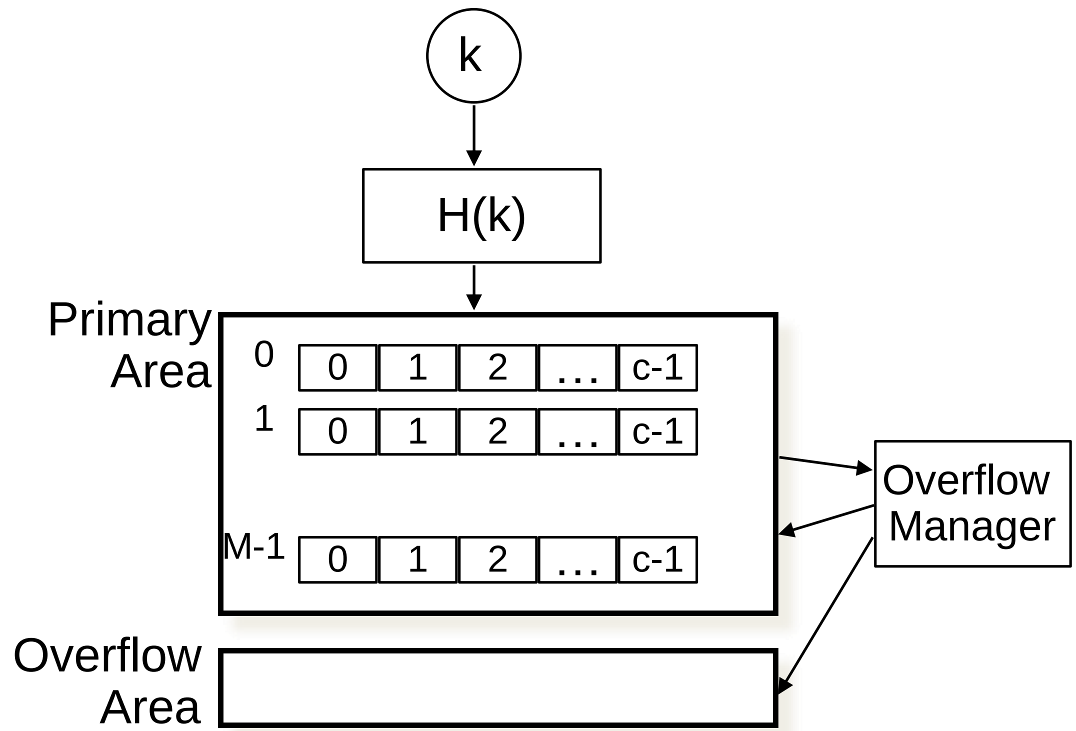


Static and dynamic organizations

- Static:
  - After insertions or deletions may need a reorganization
- Dynamic:
  - Gradually evolves with insertion and deletions

Static hashing organizations

- Assumption: N records, with same and fixed size, stored in M pages of capacity c.
- Design Parameters
  - Page capacity (c)
  - Loading factor
    $(d = N/(M \times c))$
  - Hash function H
  - Overflow management



Hash function

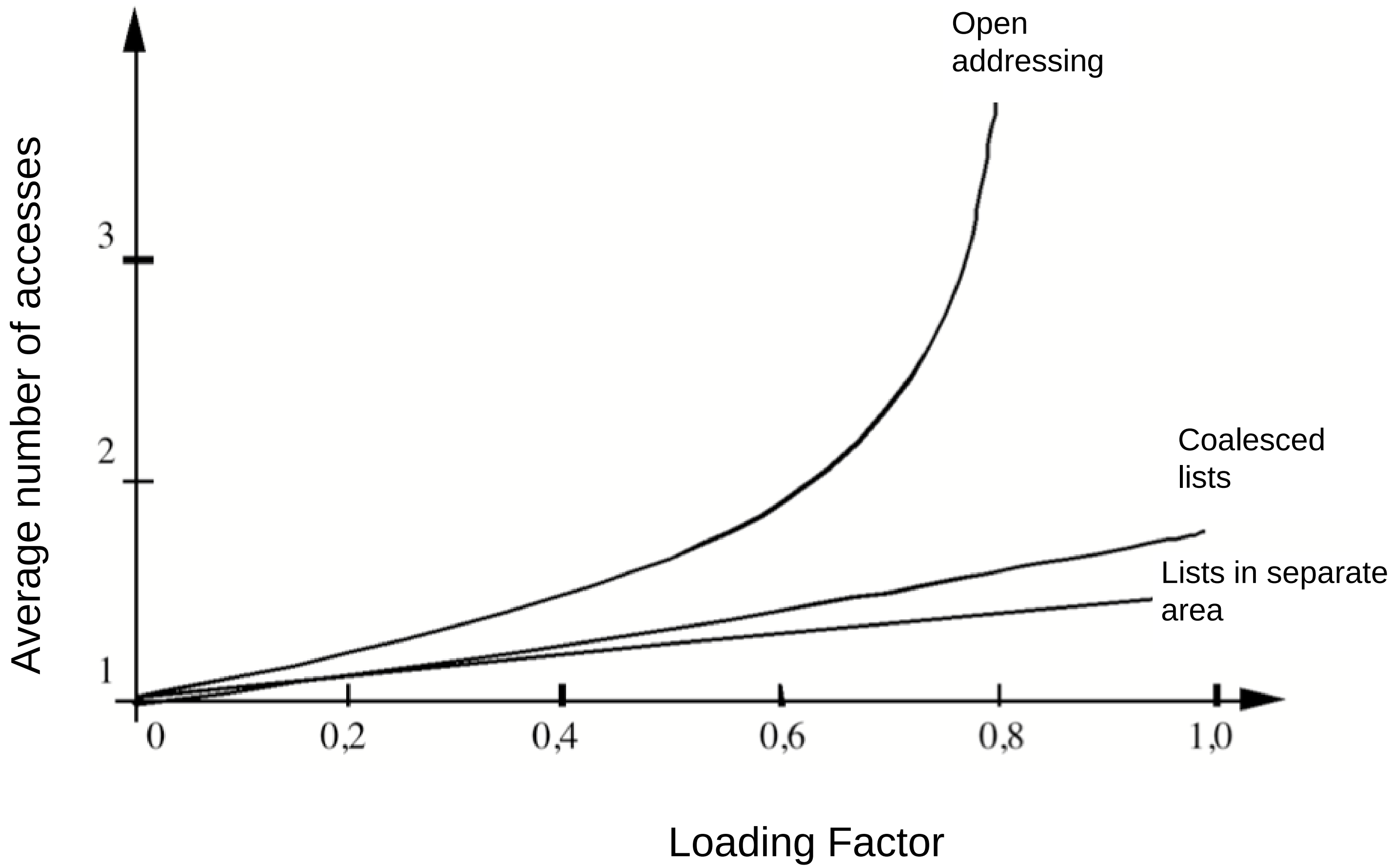
- Produces addresses uniformly distributed in the interval (0,M-1)
- The typical hash function, with M prime:
    - H(k) = f(k) mod M
- Two keys produce a *collision* if H(k1) = H(k2)
- If the number of collisions is greater than the page capacity, there is an *overflow*. Overflows increase the search cost.

Overflow management

- Open overflow:
  - Overflow records are put in the first available page
- Chained overflow:
  - Overflow records are put in a separate area, and chained together (by page or by record)

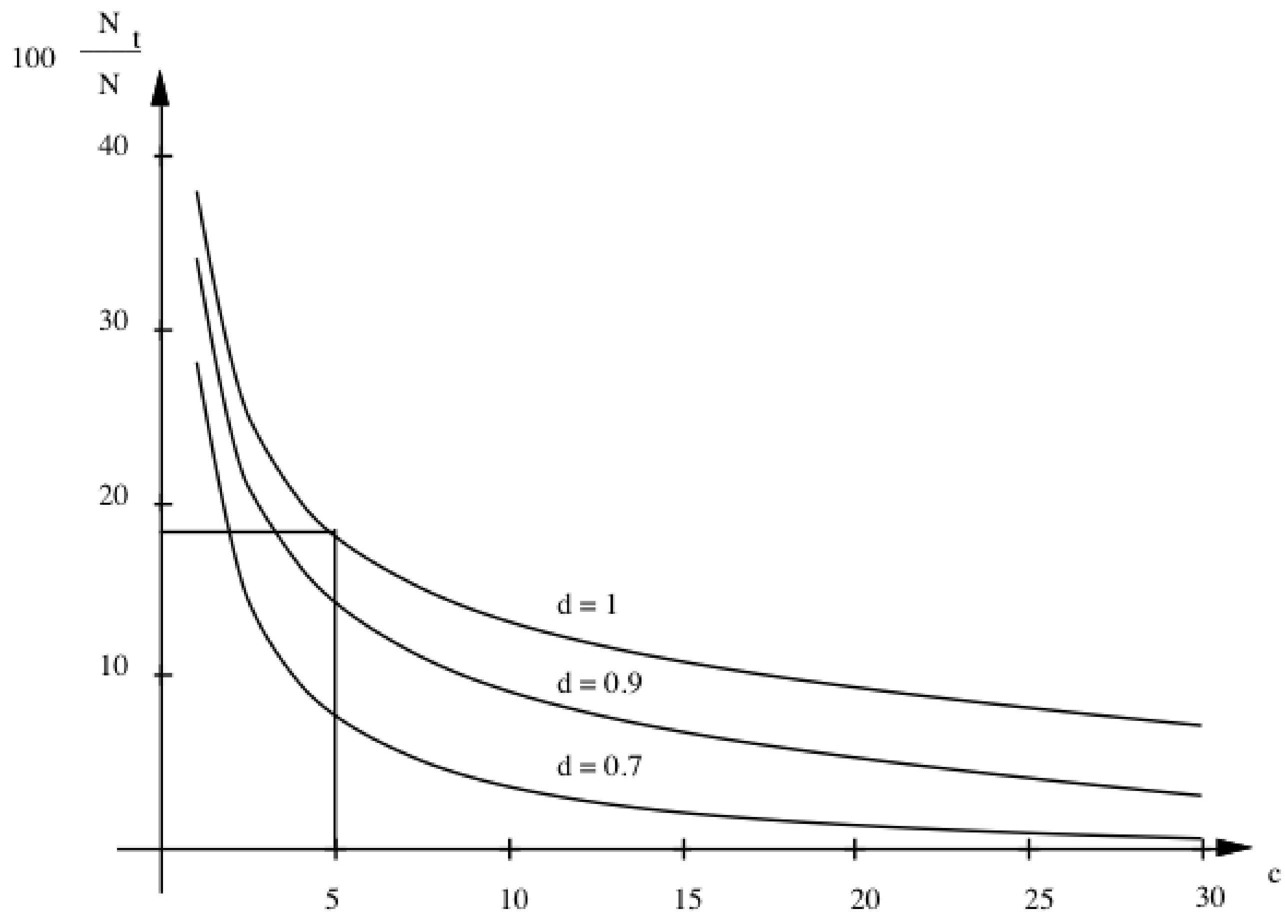
Loading factor

High loading factor reduces primary area size but increases the probability of overflow



Page capacity

- If page capacity increases, overflows decrease
- Hashing is convenient with a large page capacity (>=10)



Performance

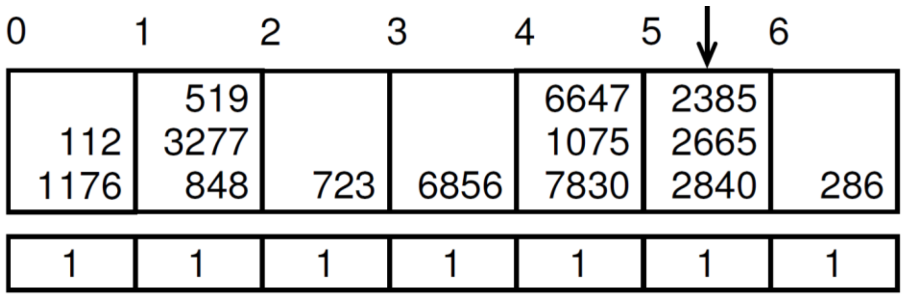
- With few overflows:
  - Excellent performance for equality search
  - Range search?
- With many overflows:
  - Reorganization is needeed

Dynamic hashing organizations

- With auxiliary data structures:
  - Virtual hash
  - Extendible hash
- Without auxiliary data structures:
  - Linear hash
  - Spiral hash

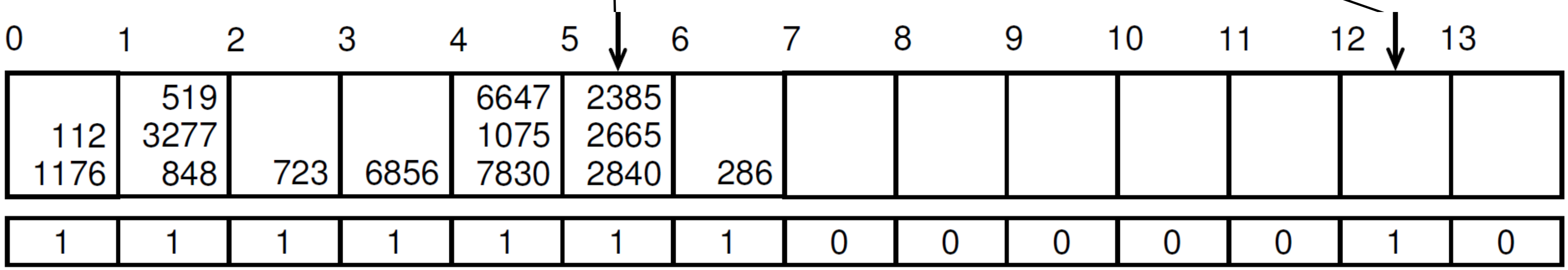
Virtual hash

Start with $H_j(k) = k \textbf{ mod } (2^j \times M)$, $j = 0$



$H_j(3820) = 5$

$H_{j+1}(k) = H_j(k)$ $H_{j+1}(k) = H_j(k) + 2^j M$



Virtual hash

PageSearch (r , k):

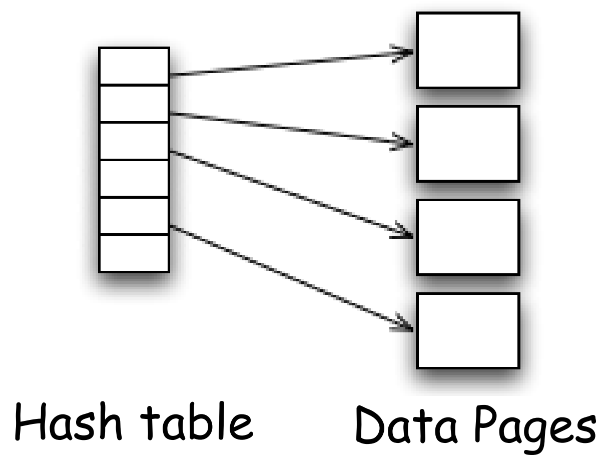
if B(H_r(k)) = 1 **then** H_r(k)

else PageSearch (r – 1, k)

0	1	2	3	4	5	6	7	8	9	10	11	12	13
112 1176	519 3277 846	723	6856	6647 1075 7830	2365 2665	286						3520 2940	
1	1	1	1	1	1	1	0	0	0	0	0	1	0

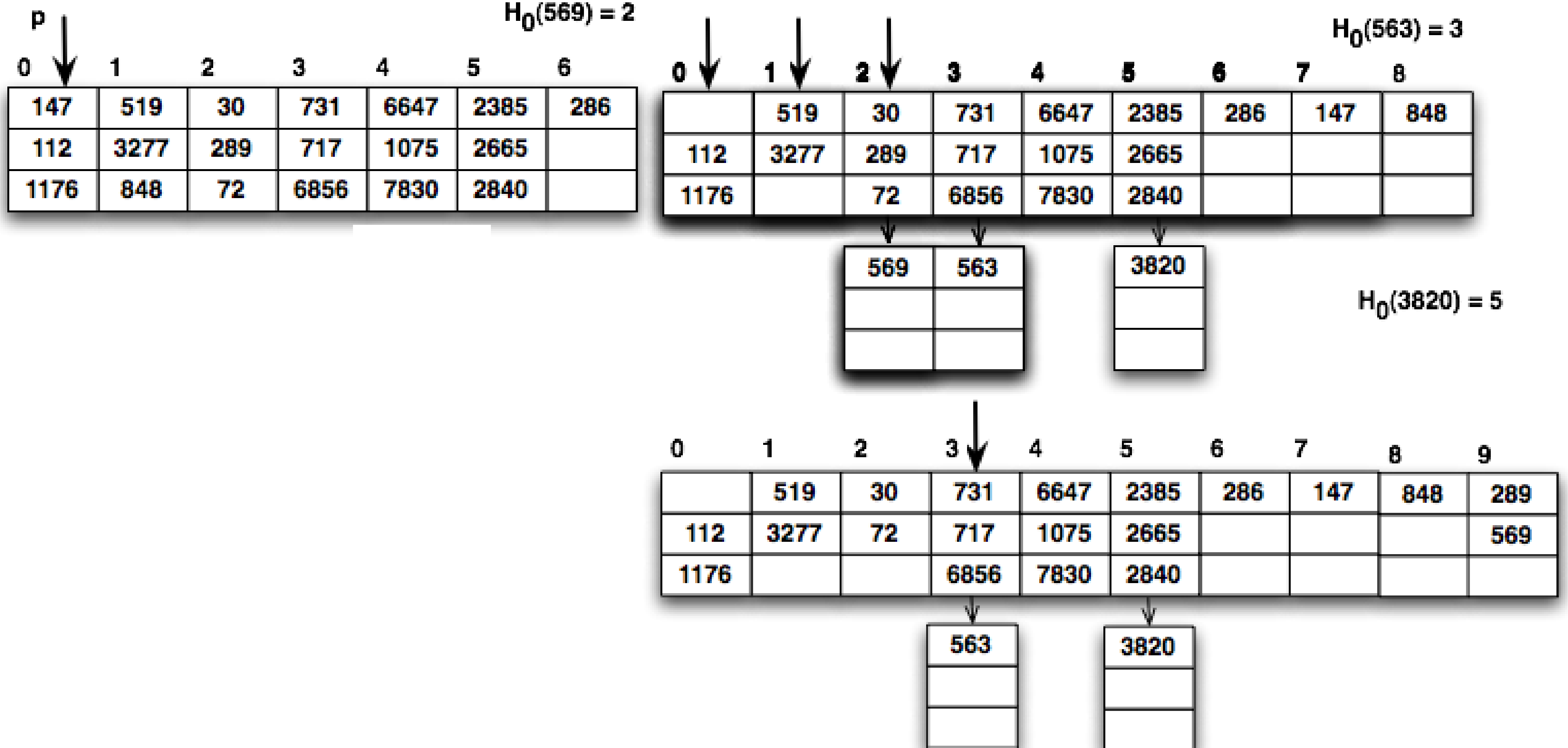
Extendible hash

- Idea: substitute B with an index with references to pages, and double the index
- The index is smaller than primary area, and can be compressed with several techniques



Linear hash

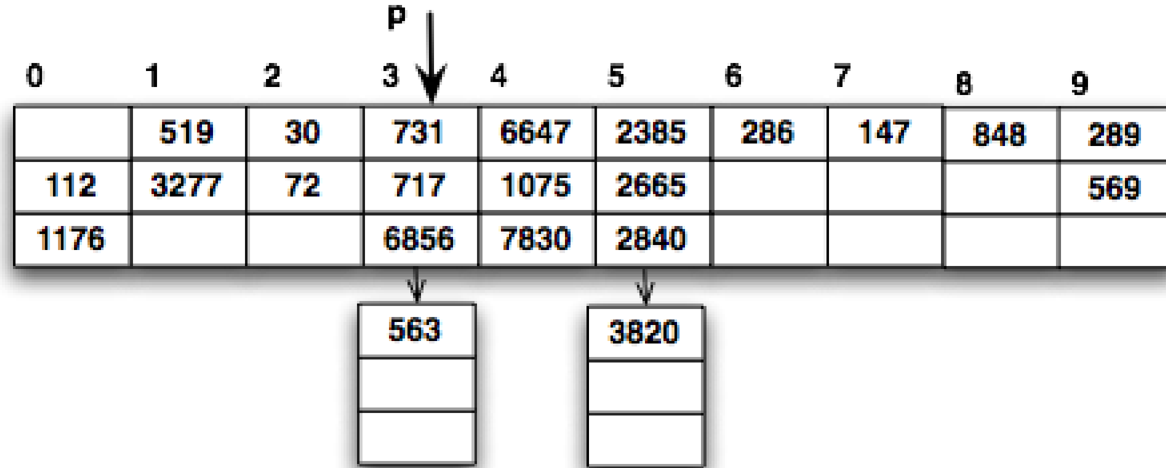
Start with M pages and $H_0(k) = k \textbf{ mod } M$ $\quad H_i(k) = k \textbf{ mod } (2^i \times M)$



Linear hash

$H_0(k) = k \textbf{ mod } M$

$H_i(k) = k \textbf{ mod } 2^i \times M$



function SearchPage(p, k: integer): integer;

begin

if $H_i(k) < p$

then SearchPage := $H_{i+1}(k)$

else SearchPage := $H_i(k)$

end

Spiral hash

- With Linear Hash, unsplitted pages are crammed
- Better a spiral data area
- The hashing function is uneven. The load is high at the beginning of the address space and tapers off towards the end.

Summary

- Hash organizations are simple to implement
- Static
  - When is well designed (80% page occupancy), a record is retrieved with ~1 page access
  - Hard to keep 80% when size changes
- Dynamic
  - Complex but well behaved (spiral hashing)
- Problem:
  - for range search they are useless !