CSE 373
Data Structures & Algorithms

Lecture 12

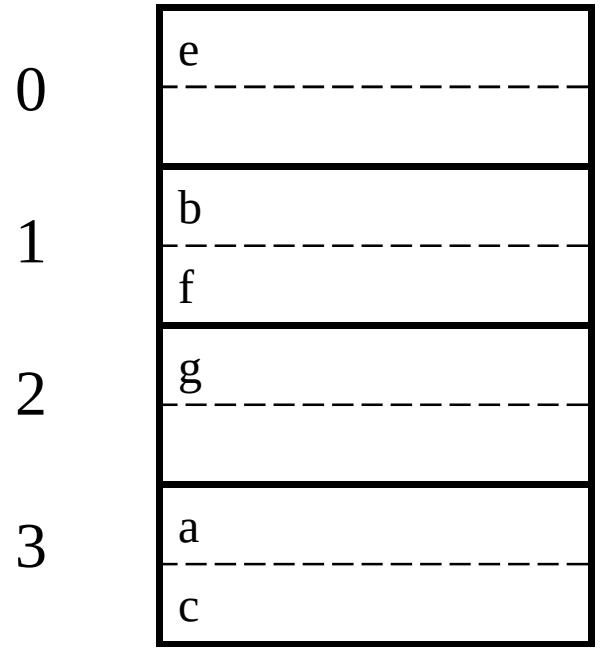
Hashing (III)

Summary

- Extensible Hash Tables
  - Weiss chapter 5.7
- Linear Hash Tables
  - Not covered in the textbook
  - Hence, not required for the midterm

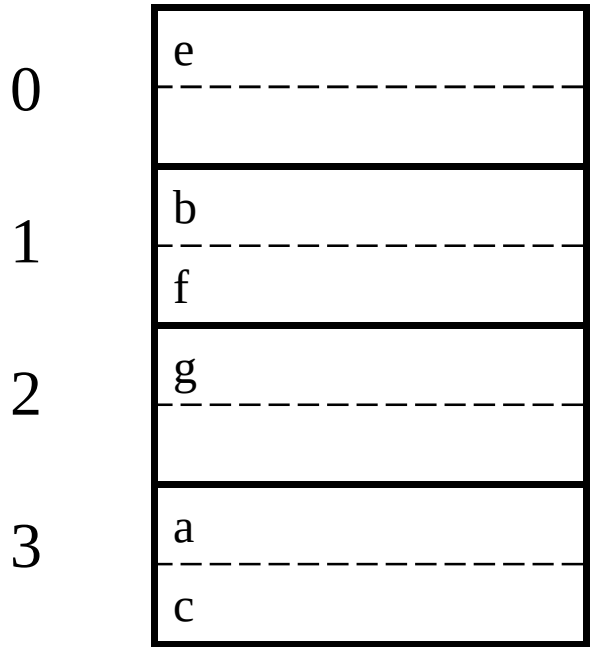
Hash Tables on Disk

- Idea: 1block = 1bucket
- M = # keys per block



Example

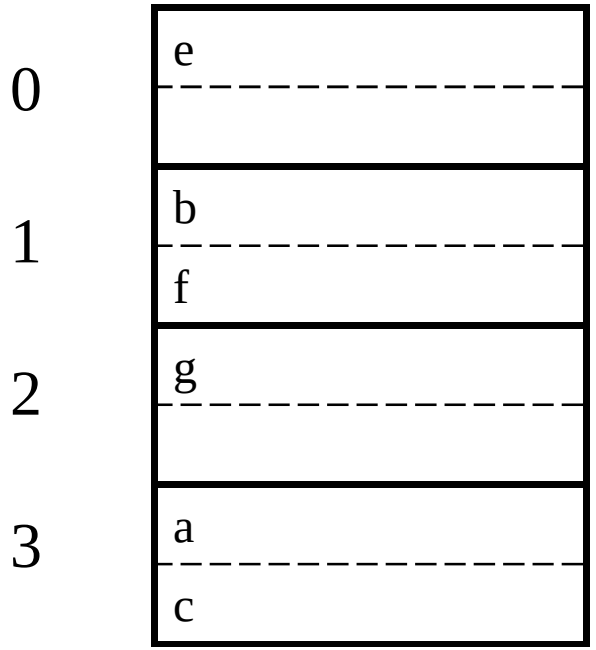
- Assume M = 2
- h(e)=0
- h(b)=h(f)=1
- h(g)=2
- h(a)=h(c)=3



Here: h(x) = x mod 4

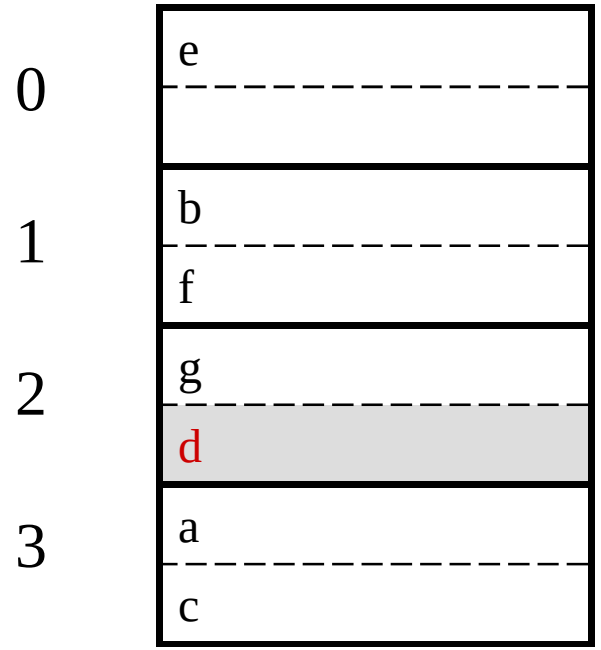
Searching in a Hash Table

- Search for a:
- Compute h(a)=3
- Read block 3
- 1 disk access



Insertion in Hash Table

- Place in right bucket, if space
- E.g. h(d)=2

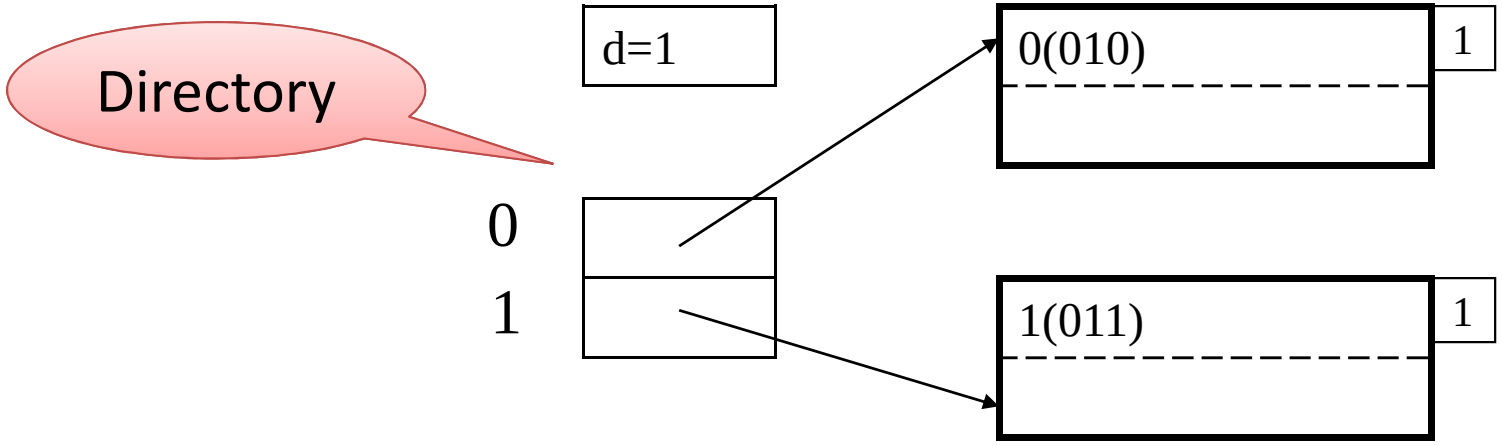


Extensible Hash Table

- Allows has table to grow, to avoid performance degradation
- Assume a hash function h that returns numbers in $\{0, \ldots, 2^D - 1\}$
- Start with $n = 2^d << 2^D$, only look at first d most significant bits

Extensible Hash Table

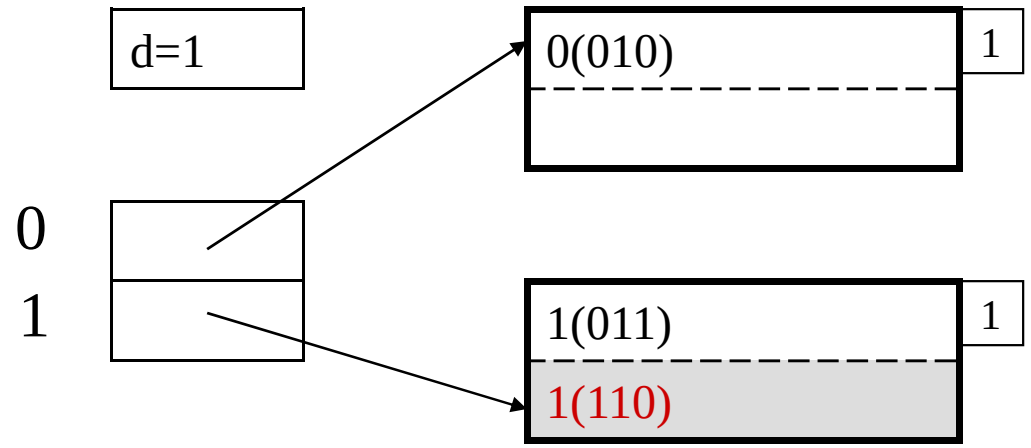
- D=4=number of bits computed by hash function
- d=1=number of bits currently used
- $n=2^d=2$=directory size



- Note: we only look at the first bit (0 or 1)

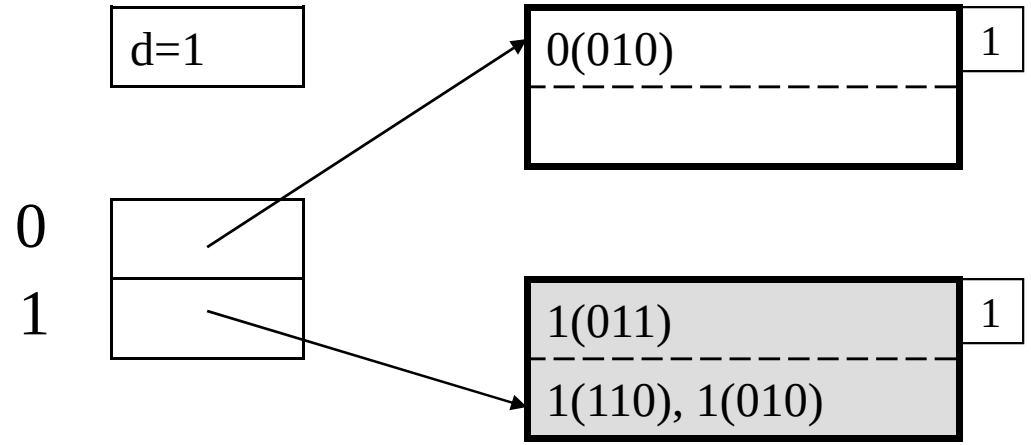
Insertion in Extensible Hash Table

- Insert 1110



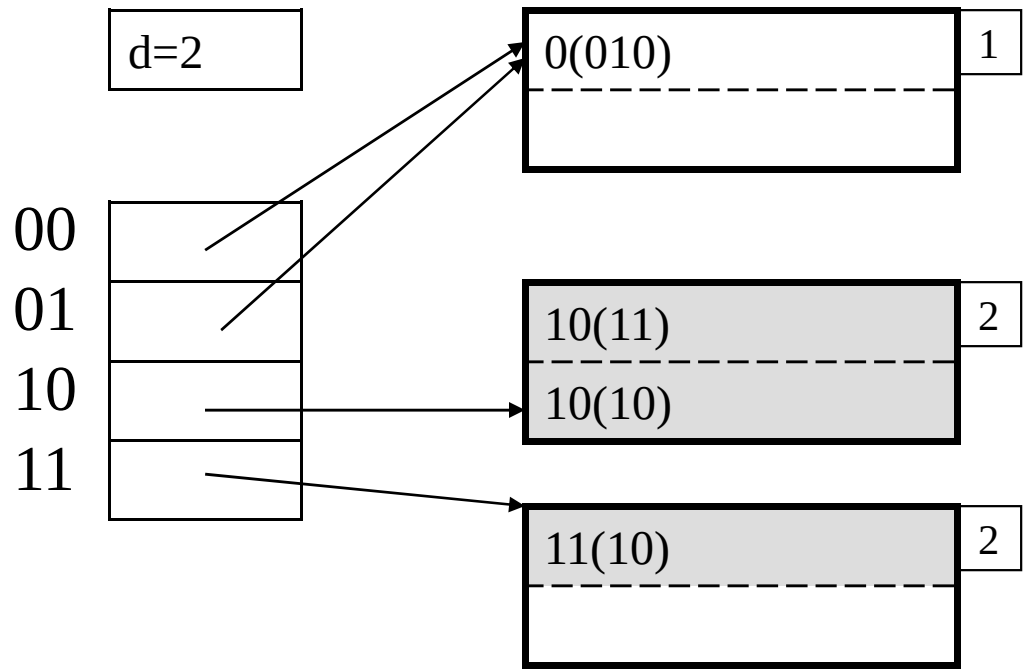
Insertion in Extensible Hash Table

- Now insert 1010



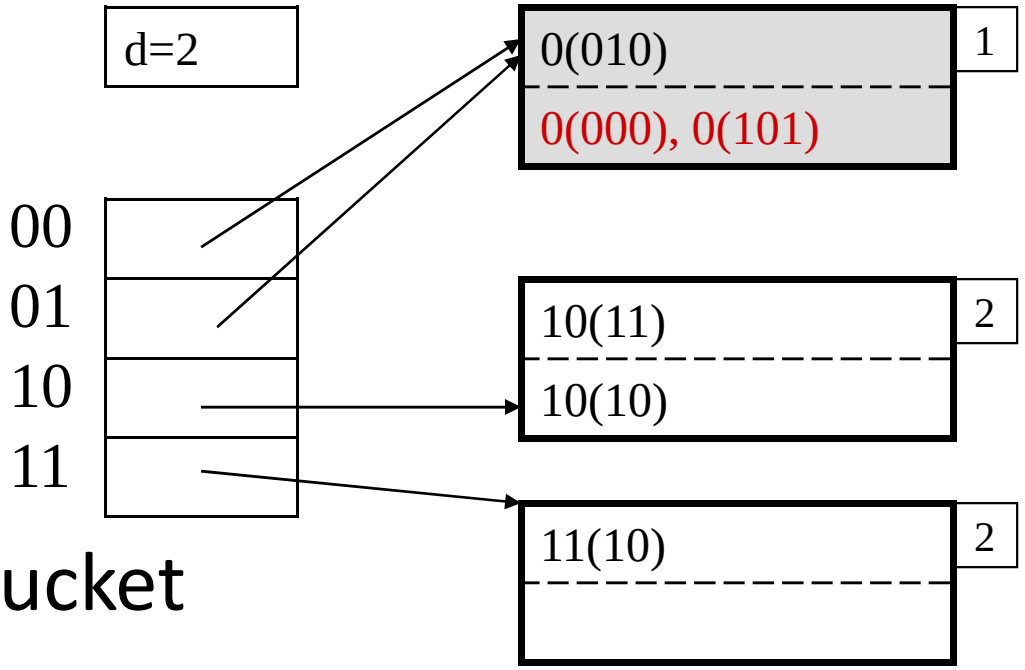
- Need to extend directory, split buckets
- d becomes 2

Insertion in Extensible Hash Table



Insertion in Extensible Hash Table

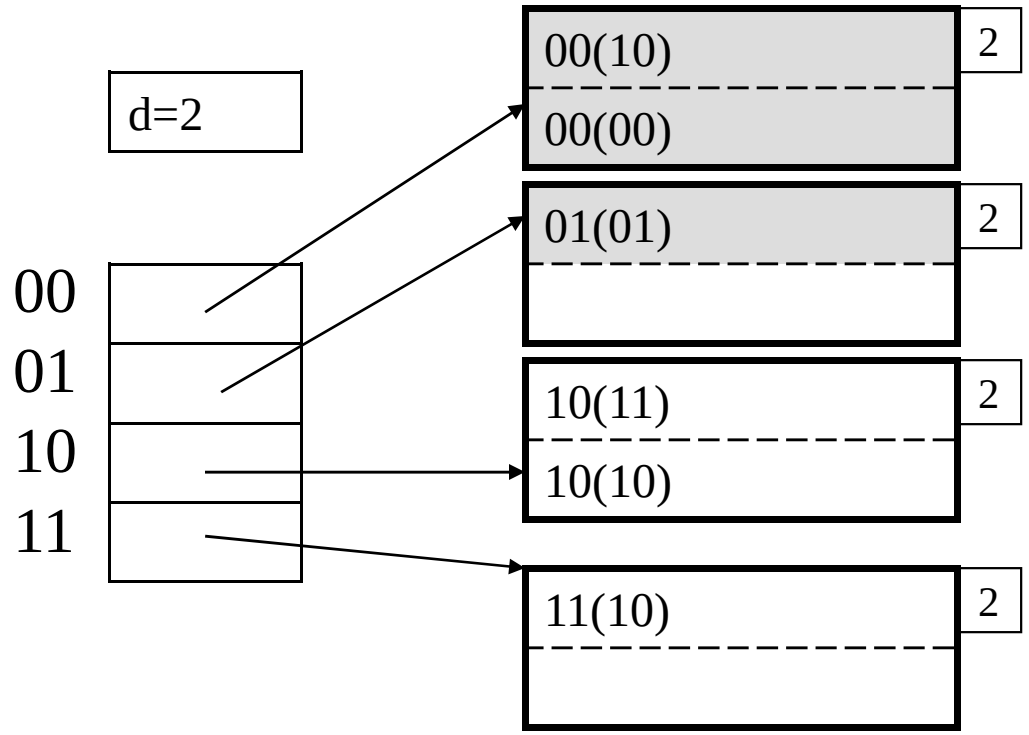
- Now insert 0000, then 0101



- Need to split bucket

Insertion in Extensible Hash Table

- After splitting the block



Extensible Hash Table

- How many buckets do we need to inspect during an insertion ?

- How many entries in the directory do we need to touch after an insertion ?

Performance Extensible Hash Table

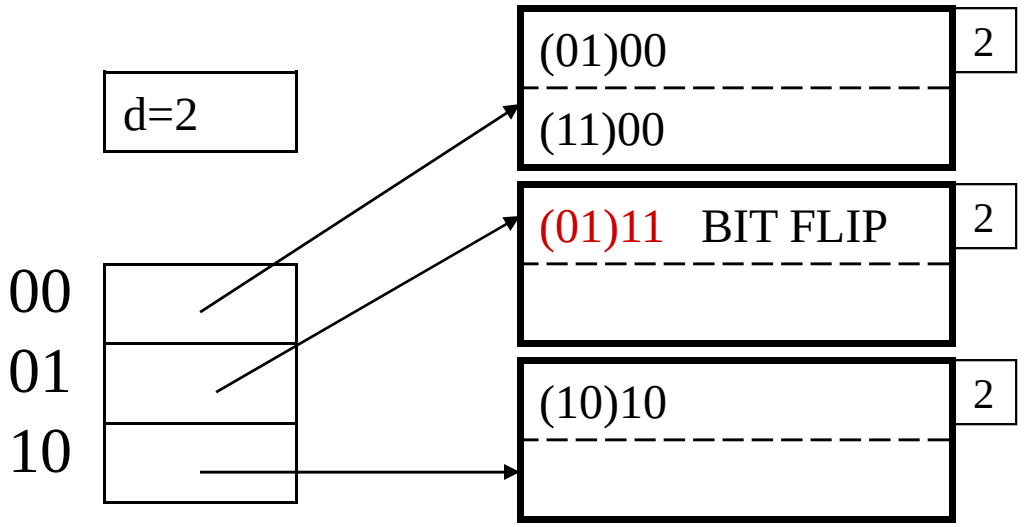
- No chaining needed: access always O(1)
- BUT:
  - Extensions can be costly and disruptive
  - After an extension directory may no longer fit in memory

Linear Hash Table

- Idea: extend directory size n only by one
- Problem: n = no longer a power of 2
- Let d be such that $2^d <= n < 2^{d+1}$
- After computing h(k), use last d bits:
  - If last d bits represent a number ≥ n, change Most Significant Bit (MSB) from 1 to 0
  - This way we are guaranteed to get a number < n
  - This is called BIT FLIP
- Note:
  - Extensible hash tables use the *first* d bits
  - Linear hash table use the *last* d bits
  - What are the tradeoffs ? Think about this during the next few slides…

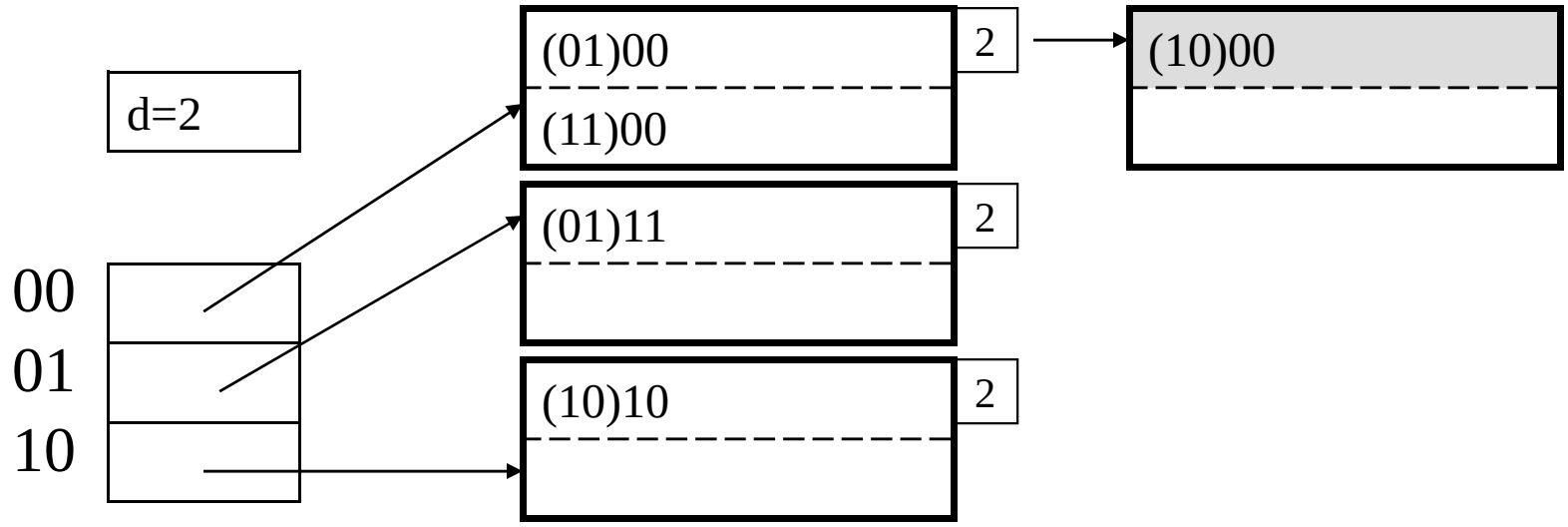
Linear Hash Table Example

- n=3



Linear Hash Table Example

- Insert 1000: overflow blocks…

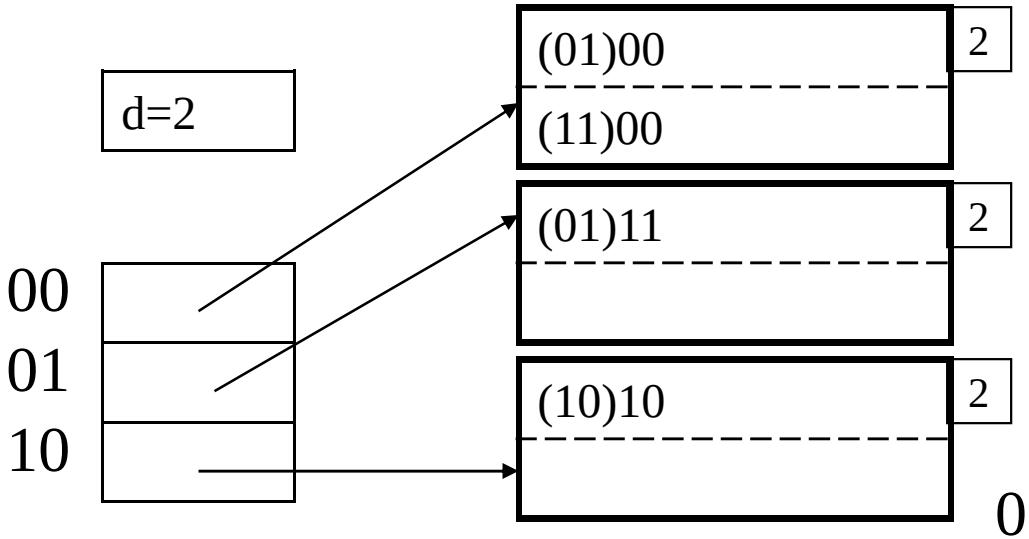


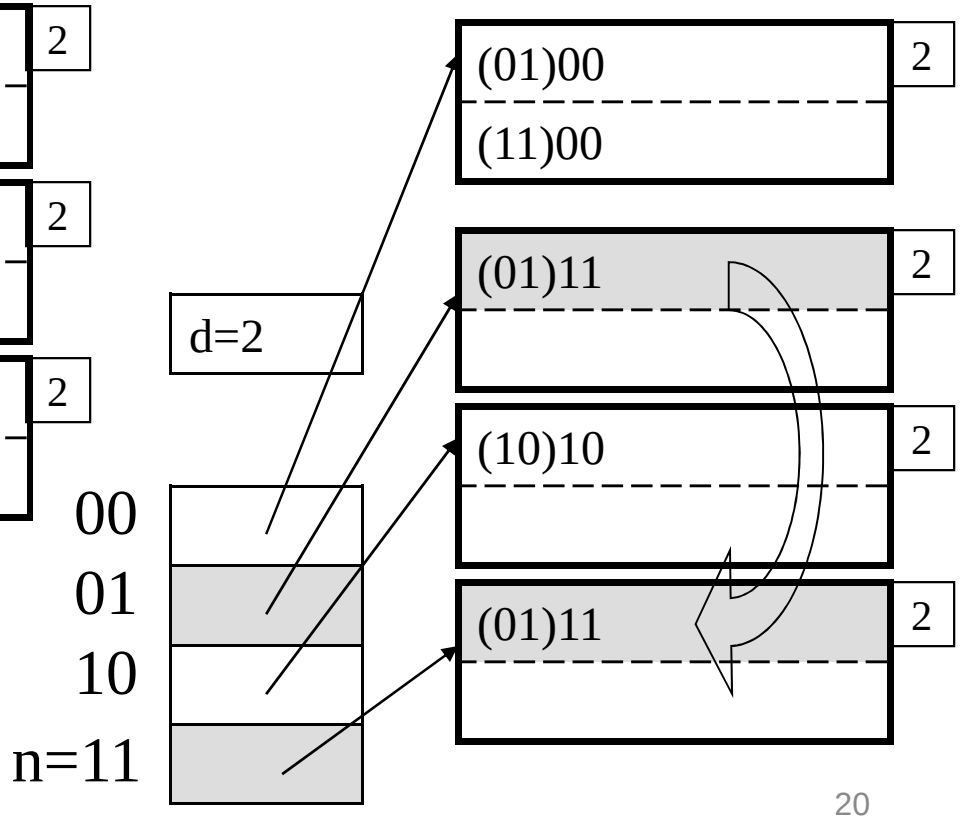
Linear Hash Tables

- Extension: independent on overflow blocks
- Extend n:=n+1 when average number of records per block exceeds (say) 80%

Linear Hash Table Extension

- From n=3 to n=4

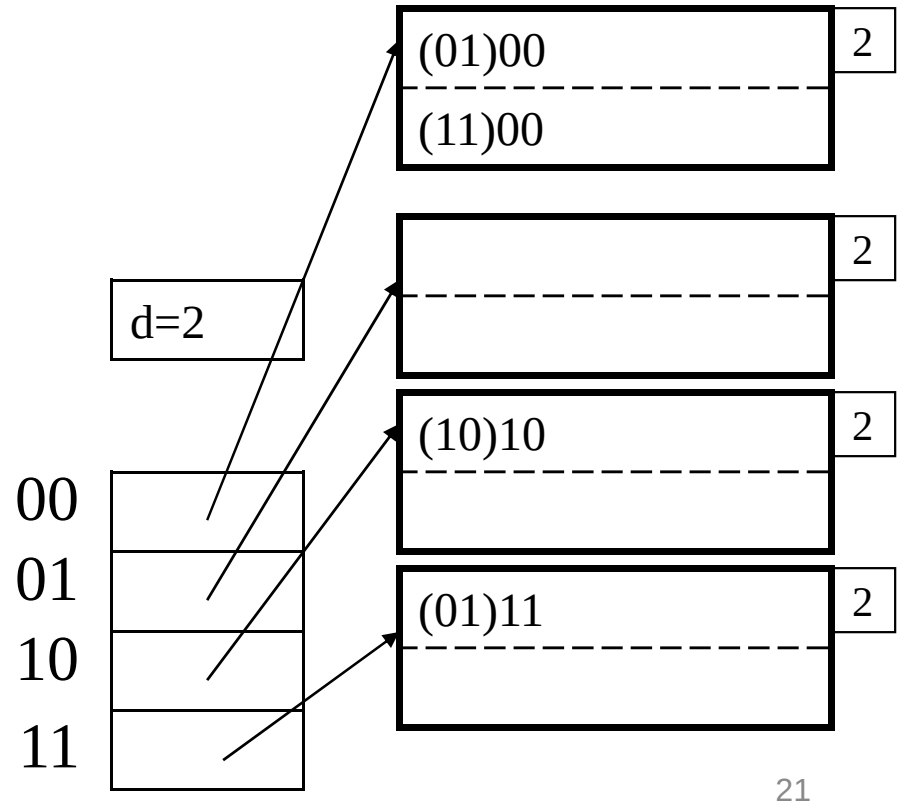




- Only need to split one bucket (which one ?)

Linear Hash Table Extension

- From n=3 to n=4 finished



Linear Hash Table Extension

From n=4 to n=5: need new bit

Example: Insert 1000