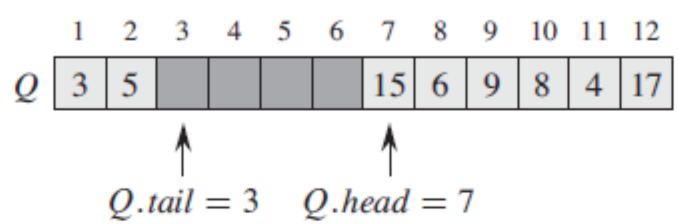
- 作业讲解
  - TC第10.1节练习4、5、6
  - TC第10.2节练习1、2、3、6
  - TC第10.3节练习4、5
  - TC第10.4节练习2、3、4
  - TC第10章问题3

TC第10.1节练习4

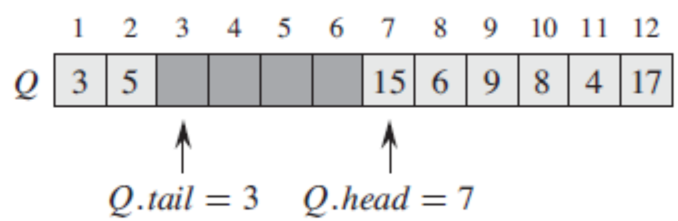
- Rewrite ENQUEUE to detect overflow.
  - if (Q[Q.tail] != null) ... 对不对？
    - 元素本身可能就是null
  - if (Q.tail == Q.head) ... 对不对？
    - 不能区分队列是满还是空

- 总是预留一个空位置
  - if (Q.tail%Q.length+1 == Q.head) overflow
    - if ((Q.tail+1)%Q.length == Q.head) overflow 对不对？
  - if (Q.head == Q.tail) underflow



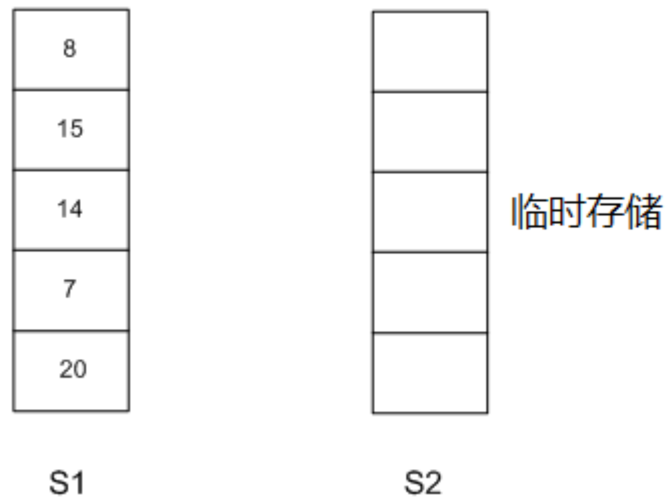
TC第10.1节练习5

- deque_from_tail
  - … x = Q[Q.tail]; Q.tail--; … 对不对？

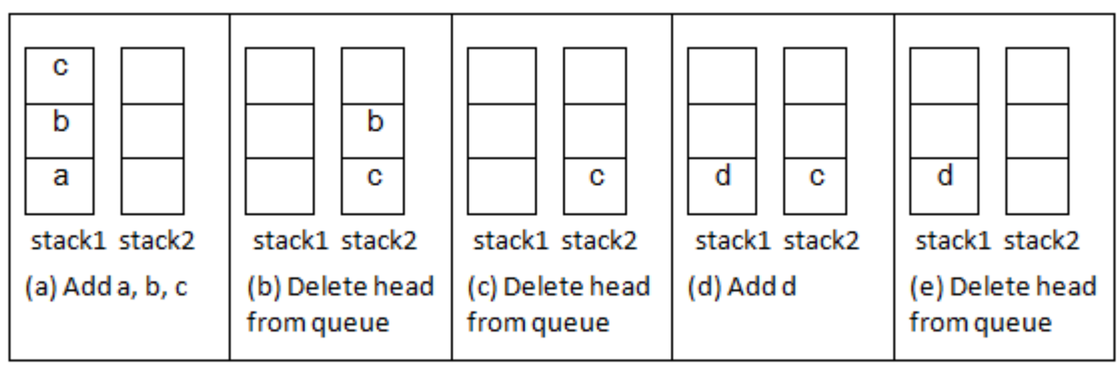


TC第10.1节练习6

- 方法1



- 方法2

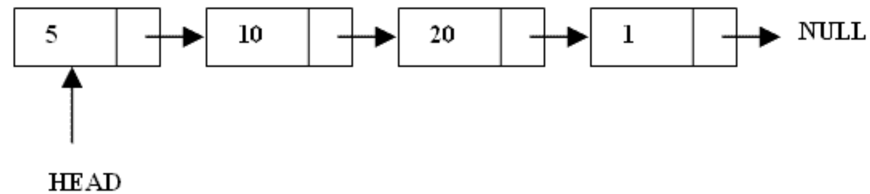


TC第10.2节练习1

- DELETE

```
p = L.head;
while (p.next != x) {
    p = p.next;
}
...
```

对不对？

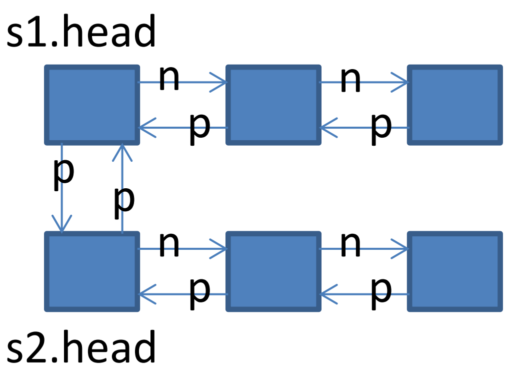



```
p = L.head;
while (p!=x && p!=null) {
    p = p.next;
}
...
```

TC第10.2节练习6

- Support UNION in O(1) time using a suitable list data structure.

s1.head.prev = s2.head;
s2.head.prev = s1.head;
s = s1.head;
return s;
对不对？

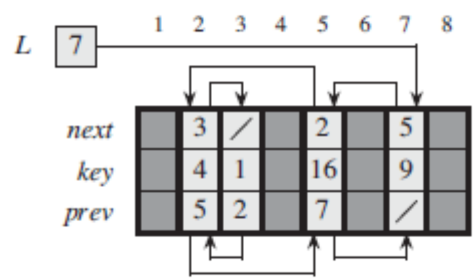


s.head = s1.head;
s1.tail.next = s2.head;
s.tail = s2.tail;

TC第10.3节练习4、5

- Using the first m index locations in the multiple-array representation
  Hint: Use the array implementation of a stack.
  - 插入：分配第m+1个位置
  - 删除：如果删除的不是第m个位置，与第m个位置交换

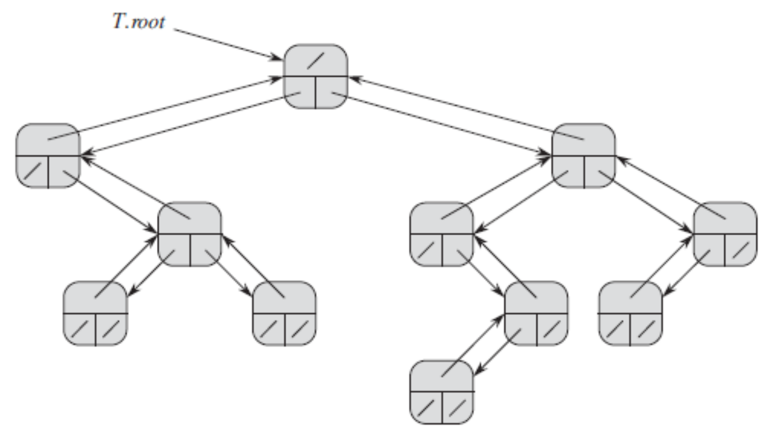
- COMPACTIFY-LIST：搜索和移位



TC第10.4节练习3、4

- Nonrecursive traversal, using a stack

```
push(root);
while(stack is not empty) {
   curr = pop();
   print(curr);
   if (curr.left != null) push(curr.left);
   if (curr.right != null) push(curr.right);
}
```



loop invariant是什么？

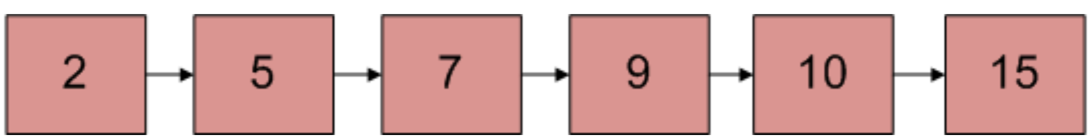
Arbitrary rooted tree, using the left-child, right-sibling representation：
与binary tree一样处理

TC第10章问题3

- CLS：(跳-)走-(跳-)走-……
- CLS'：(跳-)(跳-)……-走-走-……
- CLS的总里程 = 最后一次成功的跳 + 之后所有的走(≤while执行次数)

- (a) CLS执行t次while之后，有三种结果
  - CLS没找到 (Line 10)：CLS'执行t次for、≤t次while
  - CLS走到了 (Line 11)：CLS'执行t次for、≤t次while
  - CLS跳到了 (Line 7)：CLS'执行t次for
- (b) E=E(for+while)=E(for)+E(while)=O(t)+E(X_t)=O(t+E(X_t))
- (c) $E[X_t]=\sum_{r=0}^{d} rP(X_t=r)=\sum_{r=1}^{d} P(X_t\geq r)\leq\sum_{r=1}^{n} P(X_t\geq r)\leq\sum_{r=1}^{n}\left(1-\frac{r}{n}\right)^t$

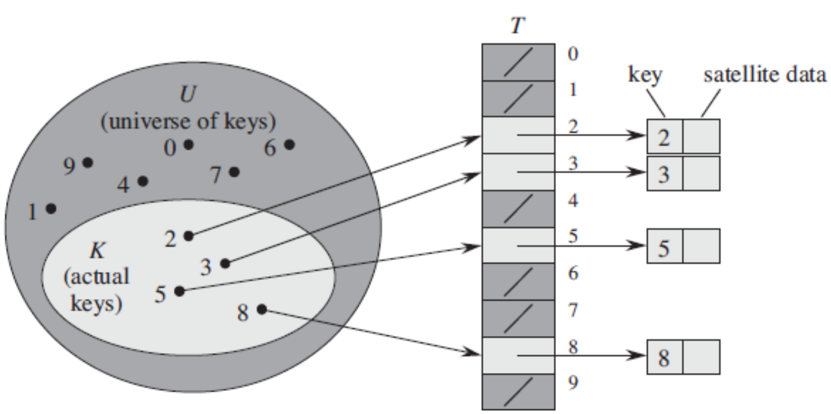
  d是k的实际位置　(C.25)

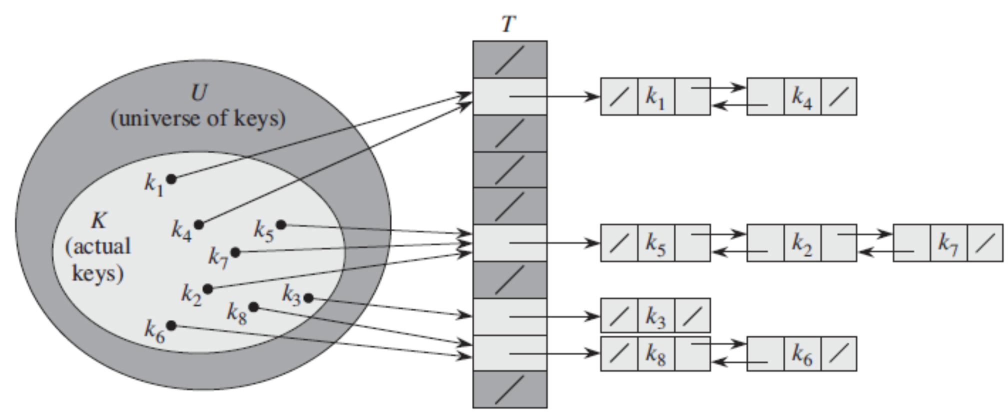


- 教材讨论
  - TC第11章
  - CS第5章第5节

问题1：dictionary

- 什么是dictionary？
- 你如何理解它的两种实现？
  - direct-address table
  - hash table
- 你能分析它们的存储空间和插入/删除/查找时间吗？
- 因此，你能对比它们的优缺点吗？





问题1：dictionary (续)

- 你理解这段话了吗？

In a hash table in which collisions are resolved by chaining, an unsuccessful search takes average-case time $\Theta(1+\alpha)$, under the assumption of simple uniform hashing.

In a hash table in which collisions are resolved by chaining, a successful search takes average-case time $\Theta(1+\alpha)$, under the assumption of simple uniform hashing.

What does this analysis mean? If the number of hash-table slots is at least proportional to the number of elements in the table, we have $n = O(m)$ and, consequently, $\alpha = n/m = O(m)/m = O(1)$. Thus, searching takes constant time on average. Since insertion takes $O(1)$ worst-case time and deletion takes $O(1)$ worst-case time when the lists are doubly linked, we can support all dictionary operations in $O(1)$ time on average.

- 对于dynamic set，如何做到那个“if”？

问题1：dictionary (续)

```
void addEntry(int hash, K key, V value, int bucketIndex) {
    if ((size >= threshold) && (null != table[bucketIndex])) {
        resize(2 * table.length);
        hash = (null != key) ? hash(key) : 0;
        bucketIndex = indexFor(hash, table.length);
    }

    createEntry(hash, key, value, bucketIndex);
}
```

问题2：hash function

- 你如何理解一个好的hash function应有的这些要素？
  - Satisfies (approximately) the assumption of simple uniform hashing.
  - Derives the hash value in a way that we expect to be independent of any patterns that might exist in the data.

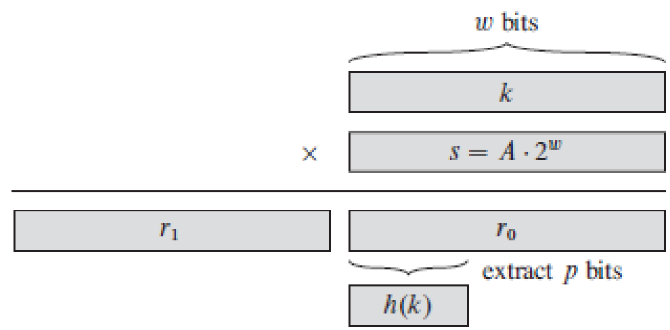
- 你如何理解simple uniform hashing？
  它对hash table为什么至关重要？

问题2： hash function (续)

- 你理解这两种hash function了吗？

$$h(k) = k \bmod m$$

$$h(k) = \lfloor m\,(kA \bmod 1) \rfloor$$



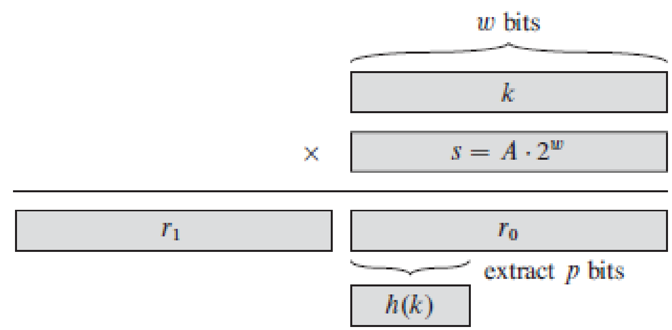
- 这些hash function在实际中能确保是simple uniform hashing吗？
  如果不能，可能的原因是什么？如何解决？

问题2：hash function (续)

- 你理解这两种hash function了吗？

$$h(k) = k \bmod m$$

$$h(k) = \lfloor m\,(k A \bmod 1) \rfloor$$



- 这些hash function在实际中能确保是simple uniform hashing吗？
  如果不能，可能的原因是什么？如何解决？
  - universal hashing: to choose the hash function randomly in a way that is independent of the keys that are actually going to be stored

问题3： probability calculations in hashing

- 你会计算这些期望值吗？
  - expected number of items per location n/k
  - expected number of empty locations $k(1-\frac{1}{k})^n$
  - expected number of collisions $n-k+k(1-\frac{1}{k})^n$
  - expected time until all locations have at least one item

$$\sum_{j=1}^{k} \frac{k}{k-j+1}$$

问题4： collision resolution

- 你理解open addressing了吗？
  它与chaining的本质区别是什么？
  因此，它有哪些相对的优缺点？

```
HASH-INSERT(T, k)
i = 0
repeat
    j = h(k, i)
    if T[j] == NIL
        T[j] = k
        return j
    else i = i + 1
until i == m
error "hash table overflow"
```

```
HASH-SEARCH(T, k)
i = 0
repeat
    j = h(k, i)
    if T[j] == k
        return j
    i = i + 1
until T[j] == NIL or i == m
return NIL
```

问题4：collision resolution (续)

- 一个好的h函数应该具有哪些特点？

- 你理解这些h函数了吗？它们为什么不是最好的h函数？
  - linear probing $h(k,i) = (h'(k) + i) \bmod m$
  - quadratic probing $h(k,i) = (h'(k) + c_1 i + c_2 i^2) \bmod m$
  - double hashing $h(k,i) = (h_1(k) + i h_2(k)) \bmod m$
- 你理解这些具体原因了吗？
  - linear probing: primary clustering
  - quadratic probing: secondary clustering

问题4：collision resolution (续)

- 一个好的h函数应该具有哪些特点？
  - The probe sequence is a permutation of <0, 1, …, m-1>.
  - uniform hashing: The probe sequence of each key is equally likely to be any of the m! permutations of <0, 1, …, m-1>.
- 你理解这些h函数了吗？它们为什么不是最好的h函数？
  - linear probing $h(k,i) = (h'(k) + i) \bmod m$
  - quadratic probing $h(k,i) = (h'(k) + c_1 i + c_2 i^2) \bmod m$
  - double hashing $h(k,i) = (h_1(k) + i h_2(k)) \bmod m$
- 你理解这些具体原因了吗？
  - linear probing: primary clustering
  - quadratic probing: secondary clustering

问题4： collision resolution (续)

- 你理解perfect hashing了吗？
  它与chaining的本质区别是什么？
  因此，它有哪些相对的优缺点？