15-122: Principles of Imperative Computation

Recitation 14 Solutions

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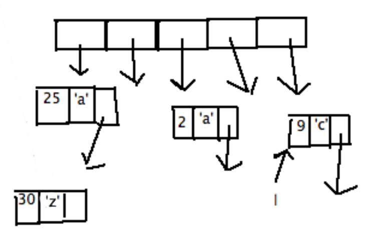
ht_insert

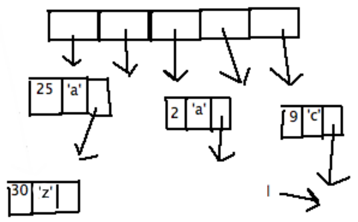
```
1  void ht_insert(ht H, elem e)
2  //@requires is_ht(H);
3  //@requires e != NULL; // We require that elem is a pointer type
4  //@ensures is_ht(H);
5  //@ensures ht_lookup(H, elem_key(e)) != NULL;
6  {
7     key k = elem_key(e);
8     int i = hash(k, H->capacity);
9
10    chain* p = H->table[i];
11    while (p != NULL)
12    //@loop_invariant is_chain(p, i, H->capacity);
13    {
14       //@assert p->data != NULL;
15       if (key_equal(elem_key(p->data), k)) {
16          /* overwrite existing element */
17          p->data = e;
18          return;
19       } else {
20          p = p->next;
21       }
22    }
23    //@assert p == NULL;
24    /* prepend new element */
25    chain* q = alloc(struct chain_node);
26    q->data = e;
27    q->next = H->table[i];
28    H->table[i] = q;
29    (H->size)++;
30    return;
31 }
```

Insert the key 14 with the value 'j' into the hash table pictured earlier in the handout, after updating the key '30' to 'z'. Start your diagrams after line 8 of the insert code.

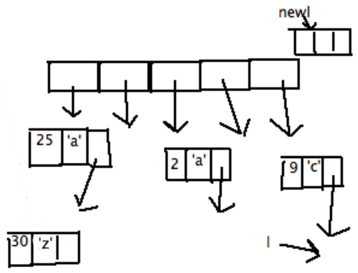
Solution: First we set l to point to the same thing that H[4] points to.



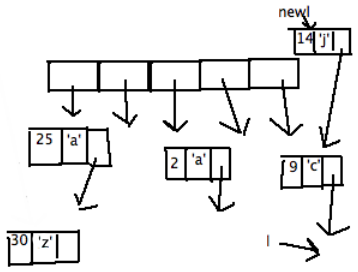
Next, we start to iterate, since 9 isn't the key we're looking for:



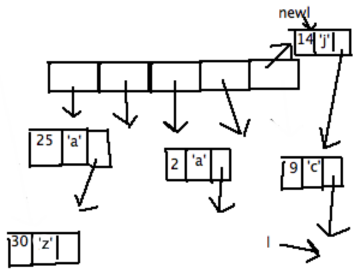
But now `l == NULL`, so we break out of the while loop. Next, we allocate space for a new `struct list_node`:



To save space, I'll do the next two steps in one diagram:



Next, we repoint `H->table[h]` and increment `H->n`, which I don't show here.



Hashtable lookup

Next, work together to write hashtable lookup code, using the following interface and struct definition of hashtables:

```
struct chain_node {
  elem data;        /* data != NULL */
  struct chain_node* next;
};
typedef struct chain_node chain;

```

```
struct ht_header {
 int size;     /* size >= 0 */
 int capacity;   /* capacity > 0 */
 chain*[] table;  /* \length(table) == capacity */
};
typedef struct ht_header* ht;

/* ht_lookup(H, k) returns NULL if key k not present in H */
elem ht_lookup(ht H, key k)
//@requires is_ht(H);
;
```

Solution:

```
elem ht_lookup(ht H, key k)
//@requires is_ht(H);
{
   int i = hash(k, H->capacity);
   chain* p = H->table[i];
   while (p != NULL)
   //@loop_invariant is_chain(p, i, H->capacity);
   {
      //@assert p->data != NULL;
      if (key_equal(elem_key(p->data), k)) {
         return p->data;
      } else {
         p = p->next;
      }
   }
   /* not in chain */
   return NULL;
}
```