细谈
Laziness & Persistence

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提纲

- Laziness
  - 按需求**值**、delay/force/realized?/lazy-seq
  - 无**穷**序列（infinite sequences）
  - Chunked Sequence
- Persistence
  - []: Persistent bit-partitioned vector trie
  - {}: Array-mapped hash trie

Laziness

Laziness—按需求值

- Call by name vs Call by value

```
(defn do-some-magic [cheap expensive]
  (if (some-condition)
    (force expensive)
    cheap))

(do-some-magic
  "tom"
  (delay (Thread/sleep 10) "jerry"))
```

Laziness—无穷序列

```
(take 5 (range))
;;-> (0 1 2 3 4)

(def powers-of-two (iterate (partial * 2) 1))

(take 10 powers-of-two)
;;-> (1 2 4 8 16 32 64 128 256 512)

(nth powers-of-two 11)
;;-> 1024
```

Laziness—Chunked Seq

```
(def gimme #(do (print \.) %))
(take 1 (map gimme (range 32)))

;;-> (0)..................................
```

只取第一个元素，为啥打印了32个.？

每次求32个元素的值

是 cache 与 laziness 折中的一种方法

Laziness—Chunked Seq

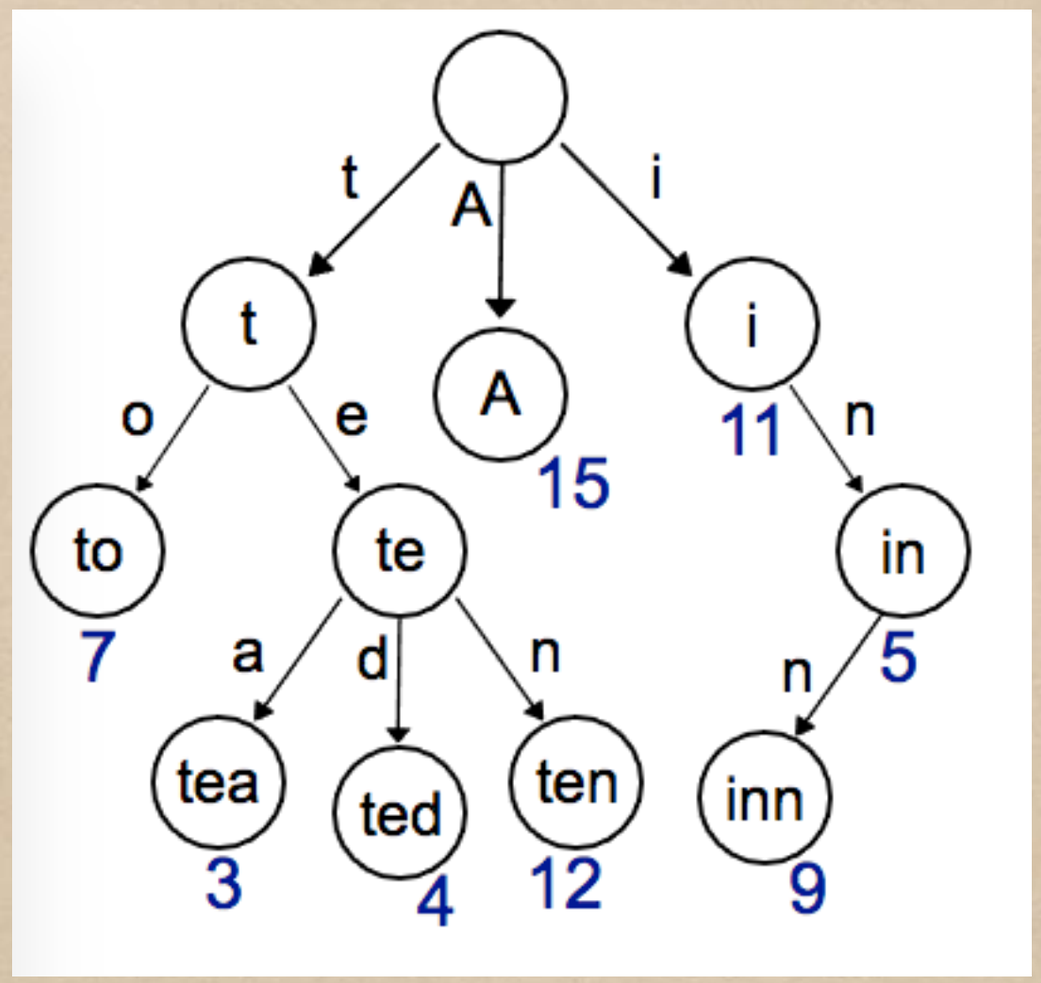
```
(def gimme #(do (print \.) %))
(def foo (map gimme (range 64)))

(take 4 foo)
;;-> (0 1 2 3)................................

(take 5 foo)
;;-> (0 1 2 3 5)

(nth foo 32) ;; 求第33个元素时才再次求值
;; -> ……————————————..32
```

Persistence

Persistent bit-partitioned vector trie

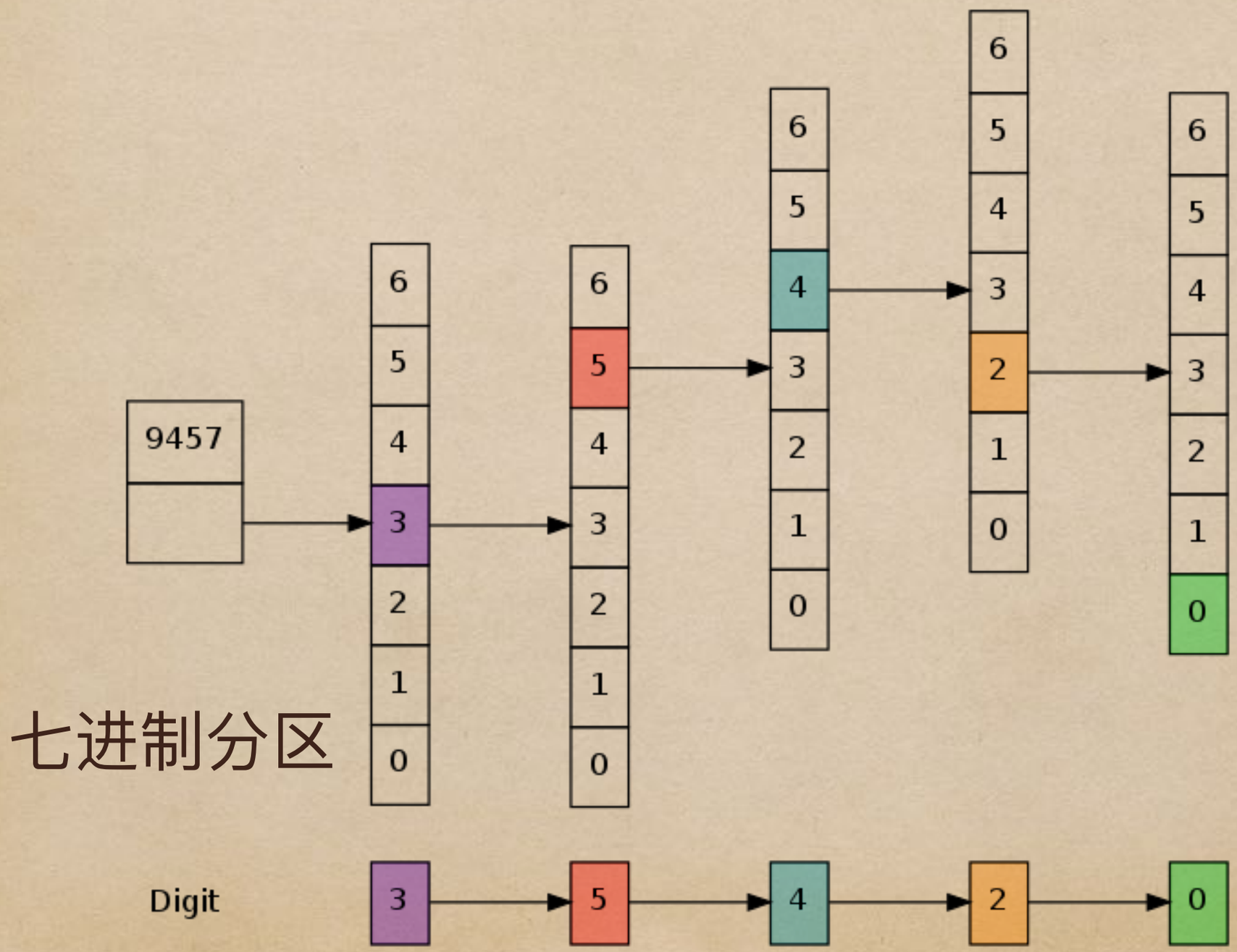
- Persistent: 所有版本的数据均可**见**
- vector 数**组**，一小段**连**在一起的内存
- trie 前**缀树**

Trie



前缀树：词频统计、前缀匹配

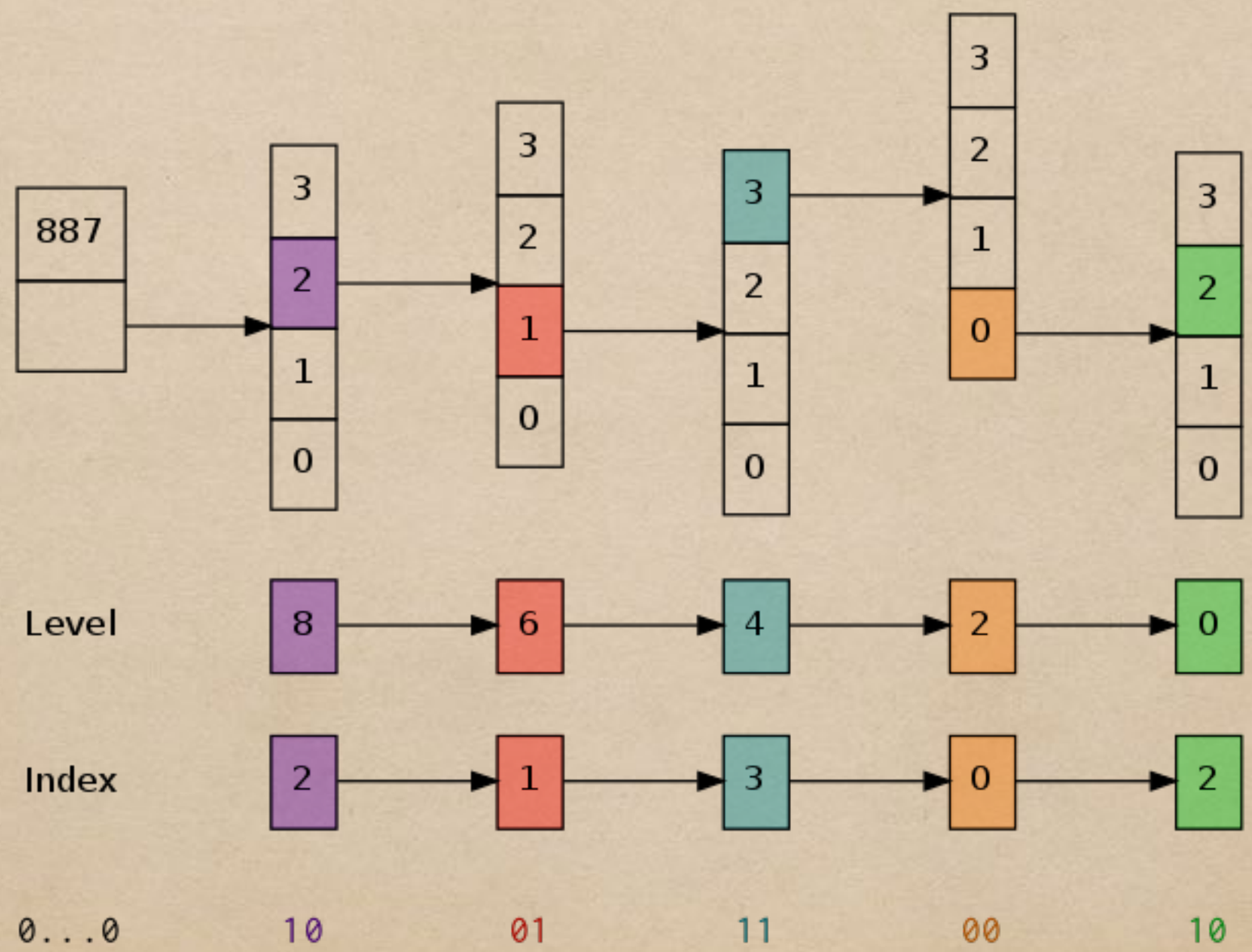
Digit Partitioning



七进制分区

```
public class DigitTrie {
  public static final int RADIX = 7;

  // Array of objects. Can itself contain an array of objects.
  Object[] root;
  // The maximal size/length of a child node (1 if leaf node)
  int rDepth; // equivalent to RADIX ** (depth - 1)

  public Object lookup(int key) {
    Object[] node = this.root;

    // perform branching on internal nodes here
    for (int size = this.rDepth; size > 1; size /= RADIX) {
      node = (Object[]) node[(key / size) % RADIX];
      // If node may not exist, check if it is null here
    }

    // Last element is the value we want to lookup, return it.
    return node[key % RADIX];
  }
}
```

Bit Partitioning

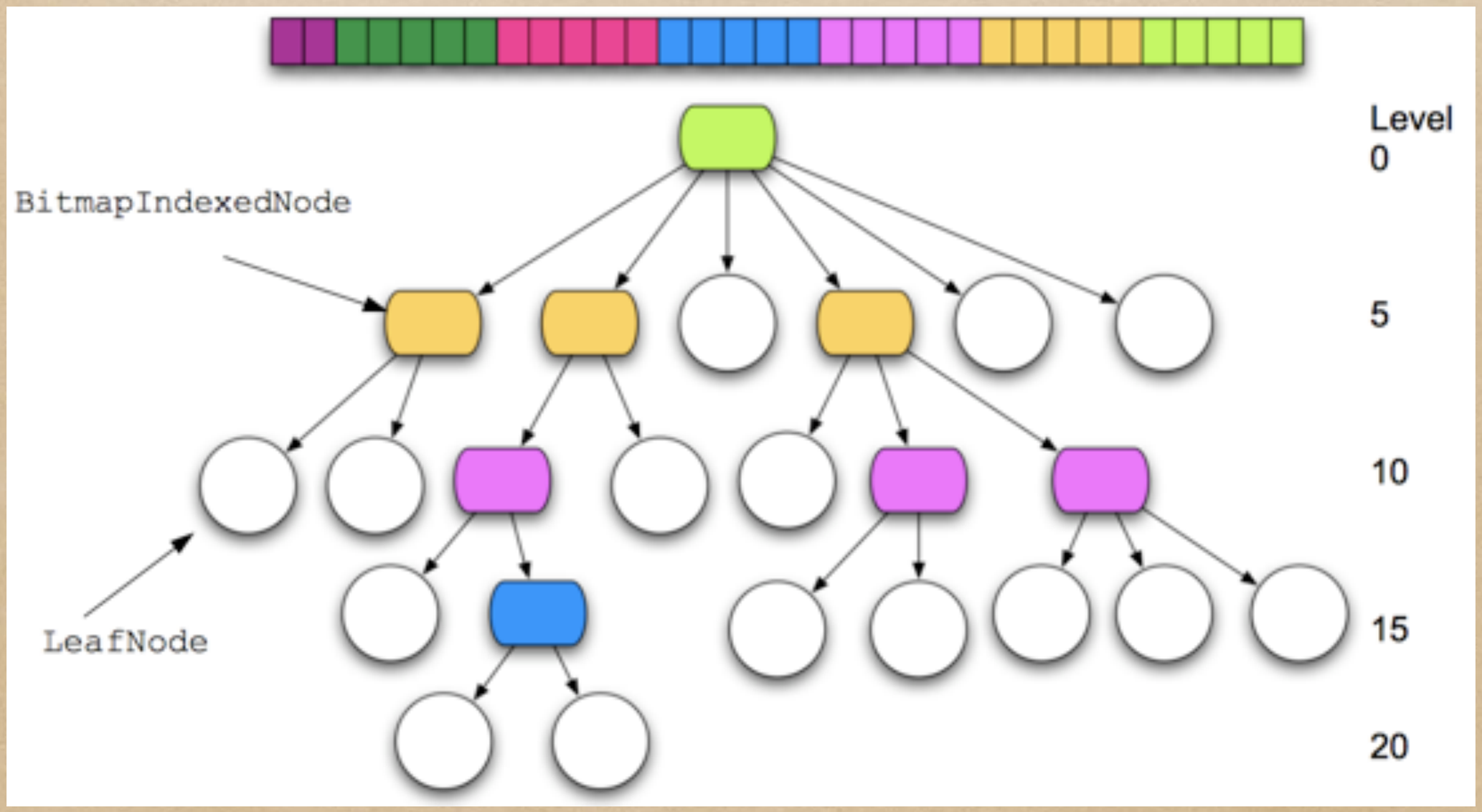


```
public class BitTrie {
  public static final int BITS = 5,
                          WIDTH = 1 << BITS, // 2^5 = 32
                          MASK = WIDTH - 1; // 31, or 0x1f

  // Array of objects. Can itself contain an array of objects.
  Object[] root;
  // BITS times (the depth of this trie minus one).
  int shift;

  public Object lookup(int key) {
    Object[] node = this.root;

    // perform branching on internal nodes here
    for (int level = this.shift; level > 0; level -= BITS) {
      node = (Object[]) node[(key >>> level) & MASK];
      // If node may not exist, check if it is null here
    }

    // Last element is the value we want to lookup, return it.
    return node[key & MASK];
  }
}
```

PersistentVector

```
public Object[] arrayFor(int i){
        if(i >= 0 && i < cnt)
                {
                if(i >= tailoff())
                        return tail;
                Node node = root;
                for(int level = shift; level > 0; level -= 5)
                        node = (Node) node.array[(i >>> level) & 0x01f];
                return node.array;
                }
        throw new IndexOutOfBoundsException();
}

public Object nth(int i){
        Object[] node = arrayFor(i);
        return node[i & 0x01f];
}
```

PersistentHashMap



Bit-partitioning 的问题

- map.put(key, val)
- key 的 hash 值不是连续的整数，如果每个节点存32个太浪费空间，如何解决?
- 如果只存N个，如何保证bit与index的对应关系

解决方法

- 解决方法增加一个函数： [0, 31] –> [0, n)
- 要求：查询快 O(1)
- bitpos & index 的组合

bitpos

- $\{10^n \mid n >= 0\}$.　1 后面 n 个 0
- mask 求出当前**节**点的 index

```
int mask(int hash, int shift){
  return (hash >>> shift) & 0x01f;
}

int bitpos(int hash, int shift){
    return 1 << mask(hash, shift);
}
```

index

- bitmap 一个32位的int，每位代表相**应**的子**节**点是否存在元素，1 存在，0 不存在。

```
final int index(int bit){
    return Integer.bitCount(bitmap & (bit - 1));
}
```

BitmapIndexedNode#find

```
public IMapEntry find(int shift, int hash, Object key){
   int bit = bitpos(hash, shift);
   if((bitmap & bit) == 0)
      return null;
   int idx = index(bit);
   Object keyOrNull = array[2*idx];
   Object valOrNode = array[2*idx+1];
   if(keyOrNull == null)
      return ((INode) valOrNode).find(shift + 5, hash, key);
   if(Util.equiv(key, keyOrNull))
      return (IMapEntry) MapEntry.create(keyOrNull, valOrNode);
   return null;
}
```

解决 Hash 冲突

- **链**表法 ✅
- **开**放地址法
- 再哈希法

扩展阅读

- http://hypirion.com/musings/understanding-persistent-vector-pt-1
- http://blog.higher-order.net/2009/09/08/understanding-clojures-persistenthashmap-deftwice

Thank You.

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