Advanced Computer Networks

Distributed Hash Table

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Search in P2P networks

- In client-server model, the server is well known
  - e.g., http://www.google.com:80/
- In P2P, everyone is a potential server
  - how to find “a” server for a request?
  - Napster
    - centralized directory server
  - Gnutella
    - scoped flooding search
  - scalability? reliability?

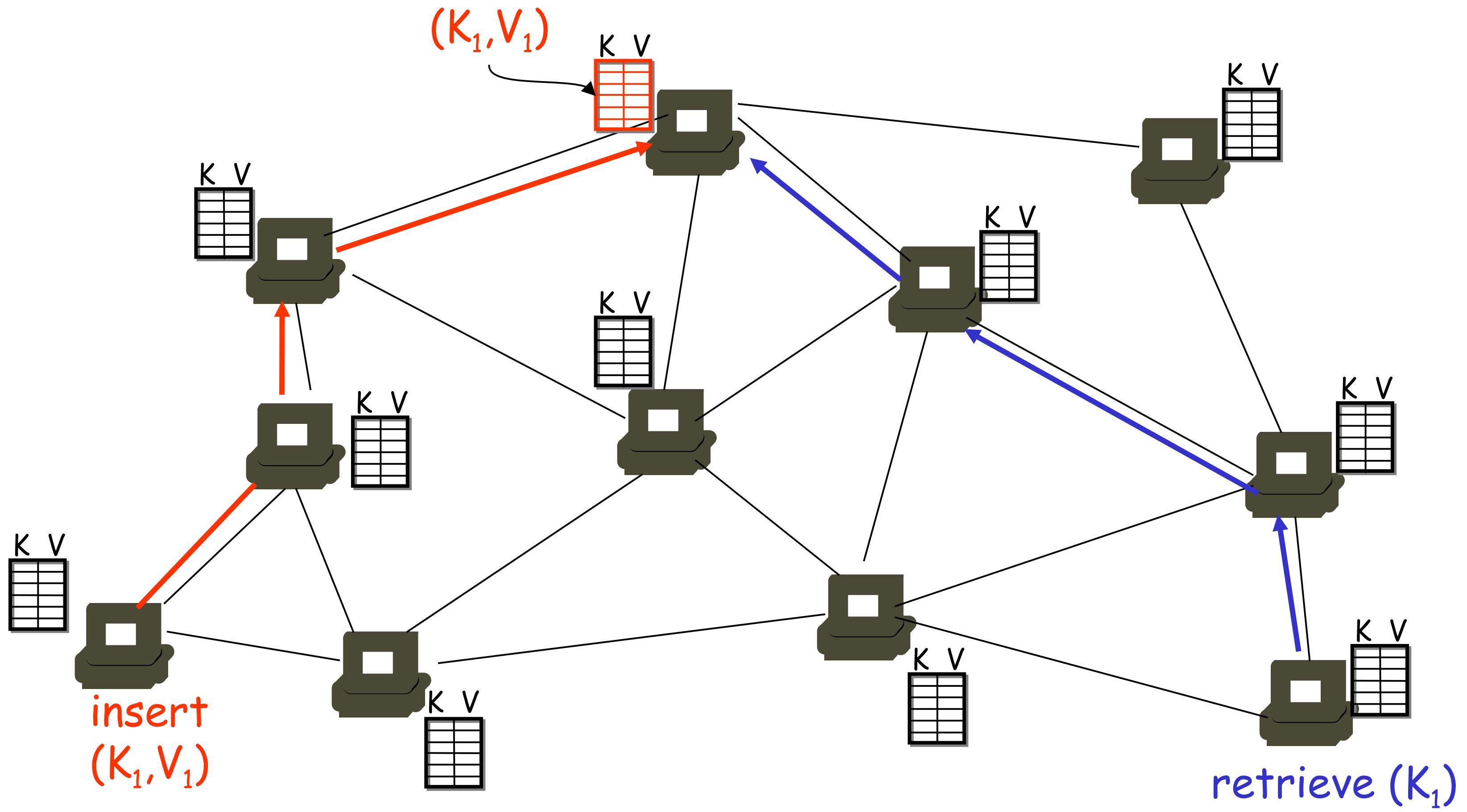
Abstract P2P networks

- Service primitives
  - put (key, data); // insert data identified by key
  - get (key); // retrieve data by key
    - data: files, services, or any objects
    - key: file name, service name, or any label
    - applications: file swap, storage, content delivery, etc
- Design goals
  - scalability
  - robustness
  - performance

Distributed Hash Table

- Hash table
  - map keys to values
  - by hash function
  - insert and lookup: usually O(1)
  - need to deal with hash collisions
- Distributed Hash table
  - no hash coordinator
    - consistent hashing
  - robustness: self-repair

Ideas



http://www.icir.org/sylvia/sigcmm01.ppt

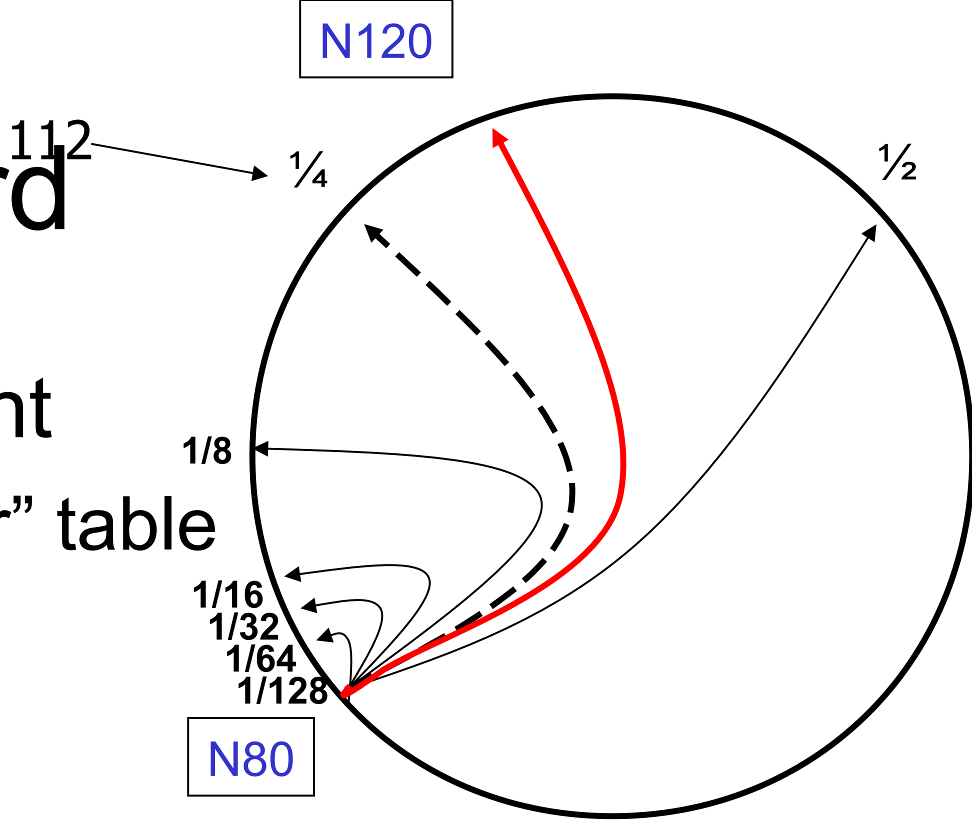
Schemes

- Chord
  - Ӈ circular key space
  - Ӈ lookup: O(N)
    - with O(1) successor list

```
Lookup(my-id, key-id)
    n = my successor
    if my-id < n < key-id
        call Lookup(id) on node n    // next hop
    else
        return my successor          // done
```

* what if bidirectional?

Chord



- Performance improvement
  - lookup: O(log N) w/ “finger” table
    - O(log N) finger entries

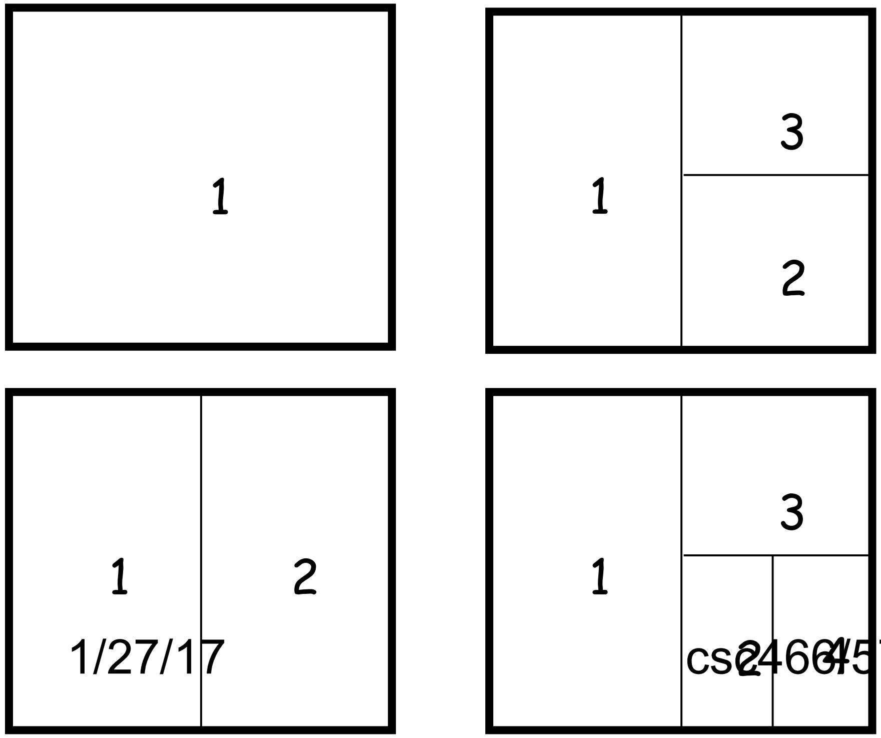
```
Lookup(my-id, key-id)
    look in local finger table for
        highest node n s.t. my-id < n < key-id
    if n exists
        call Lookup(id) on node n    // next hop
    else
        return my successor          // done
```

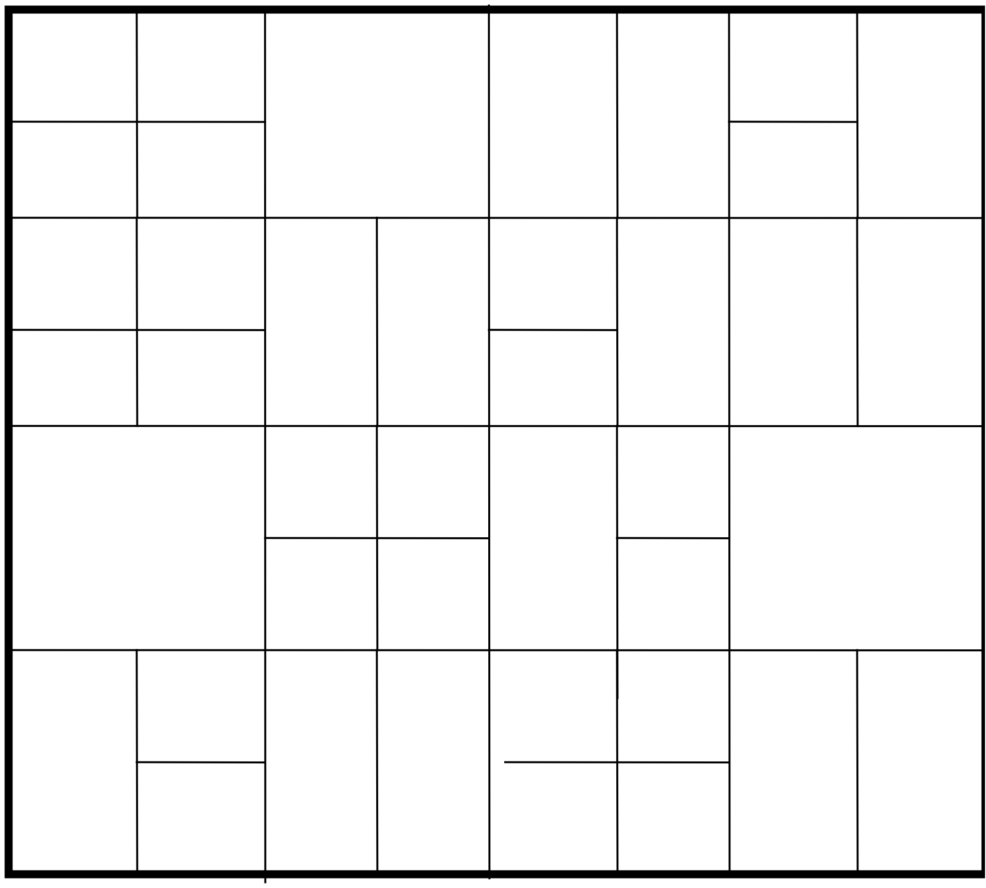
* how about node join and leave?

http://pdos.csail.mit.edu/~rtm/slides/sigcomm01.ppt

Content-addressable networks

- 2-d example
  - H́ a virtual space torus
    - h_x(key) and h_y(key)
  - H́ partitioned among nodes





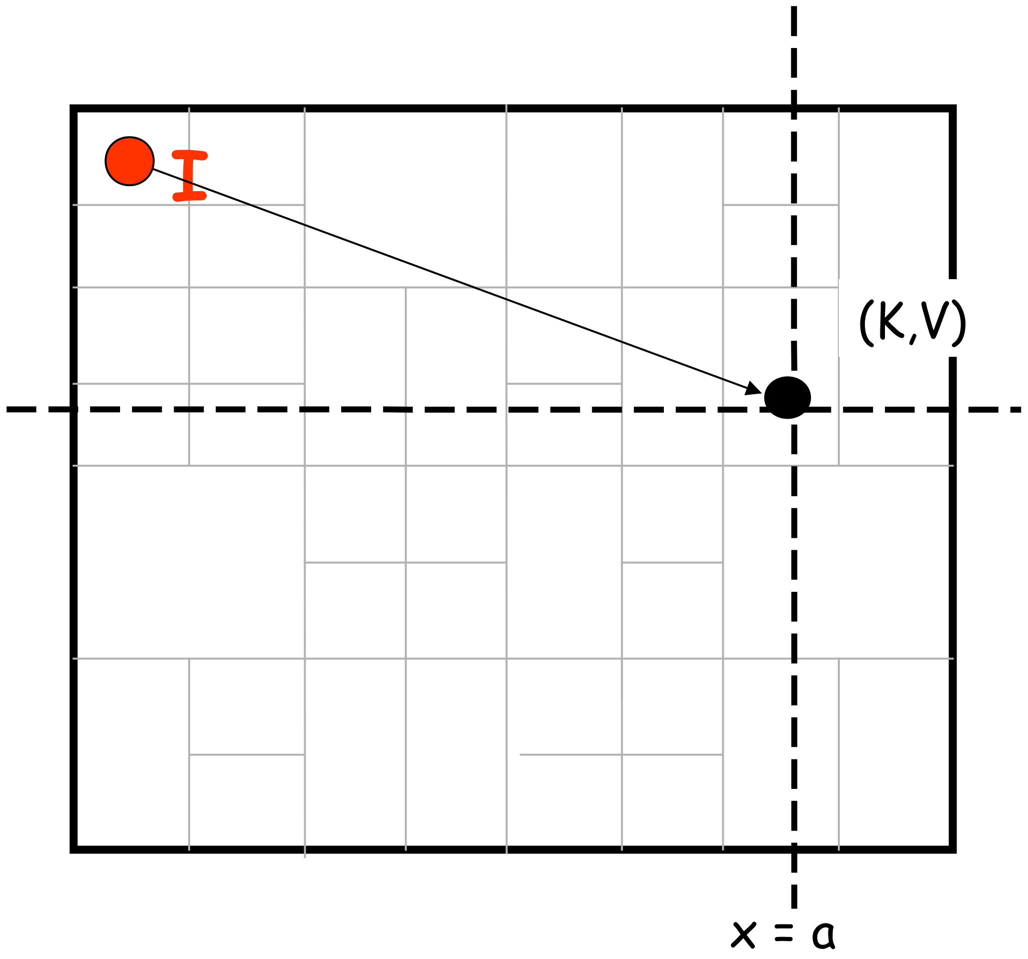
Put (key, data)

node I::insert(K,V)

(1) $a = h_x(K)$
$b = h_y(K)$

(2) route(K,V) -> (a,b)

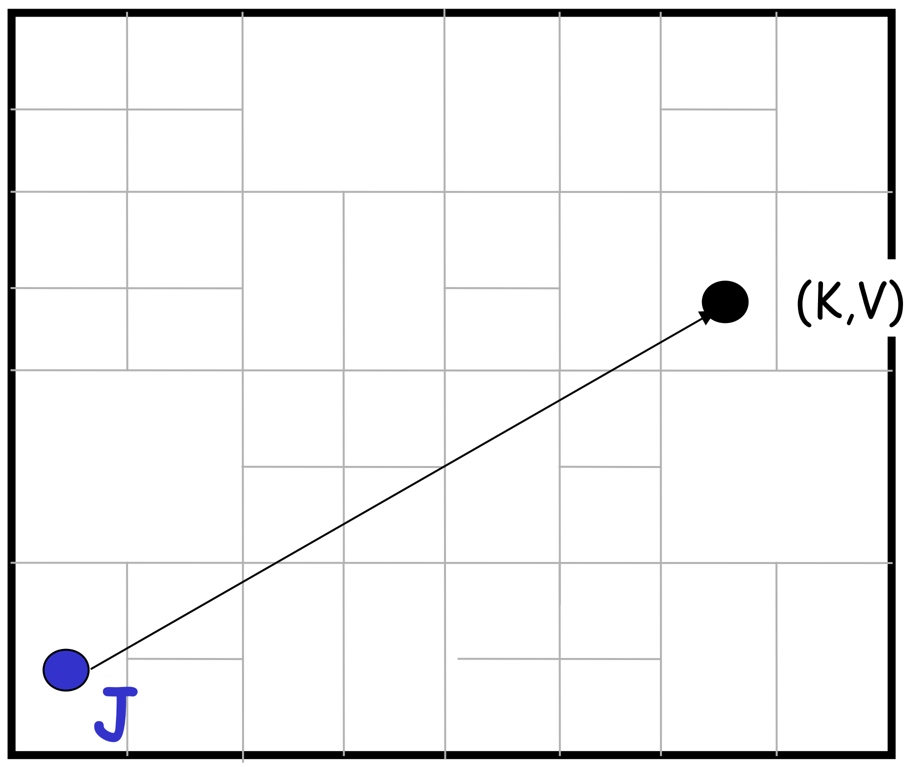
(3) (a,b) stores (K,V)



Get (key)

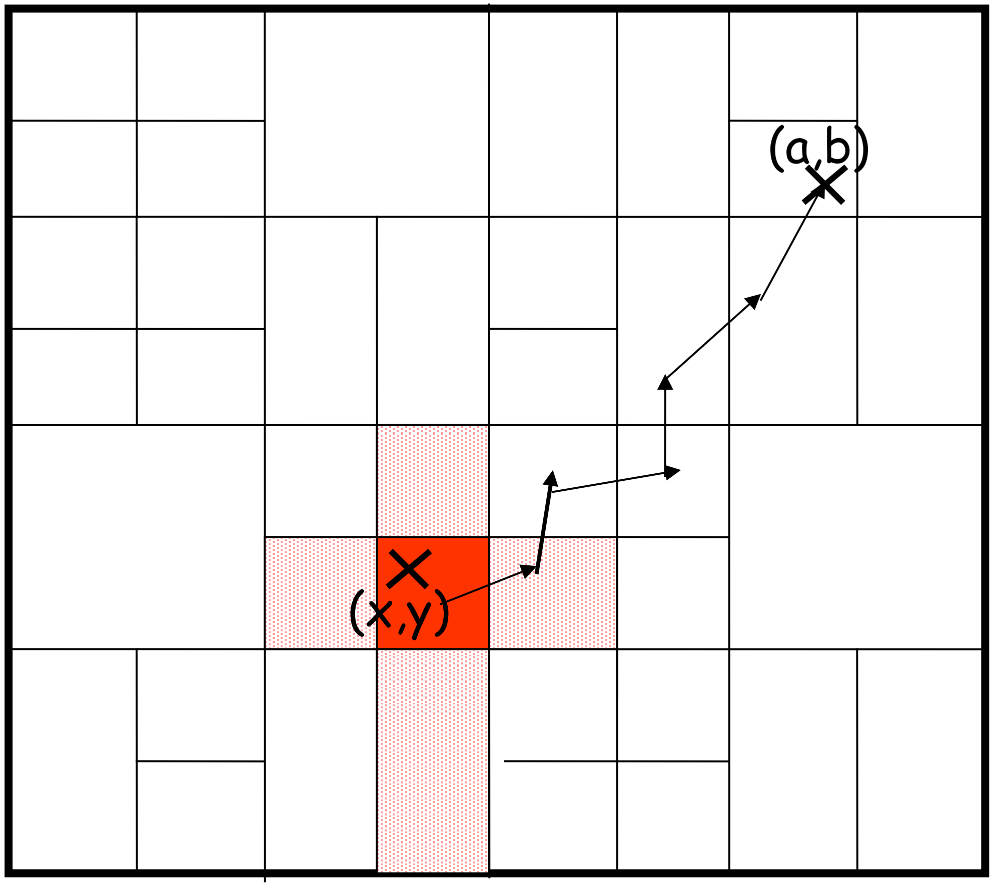
```
node J::retrieve(K)

(1)  $a = h_x(K)$
     $b = h_y(K)$
```



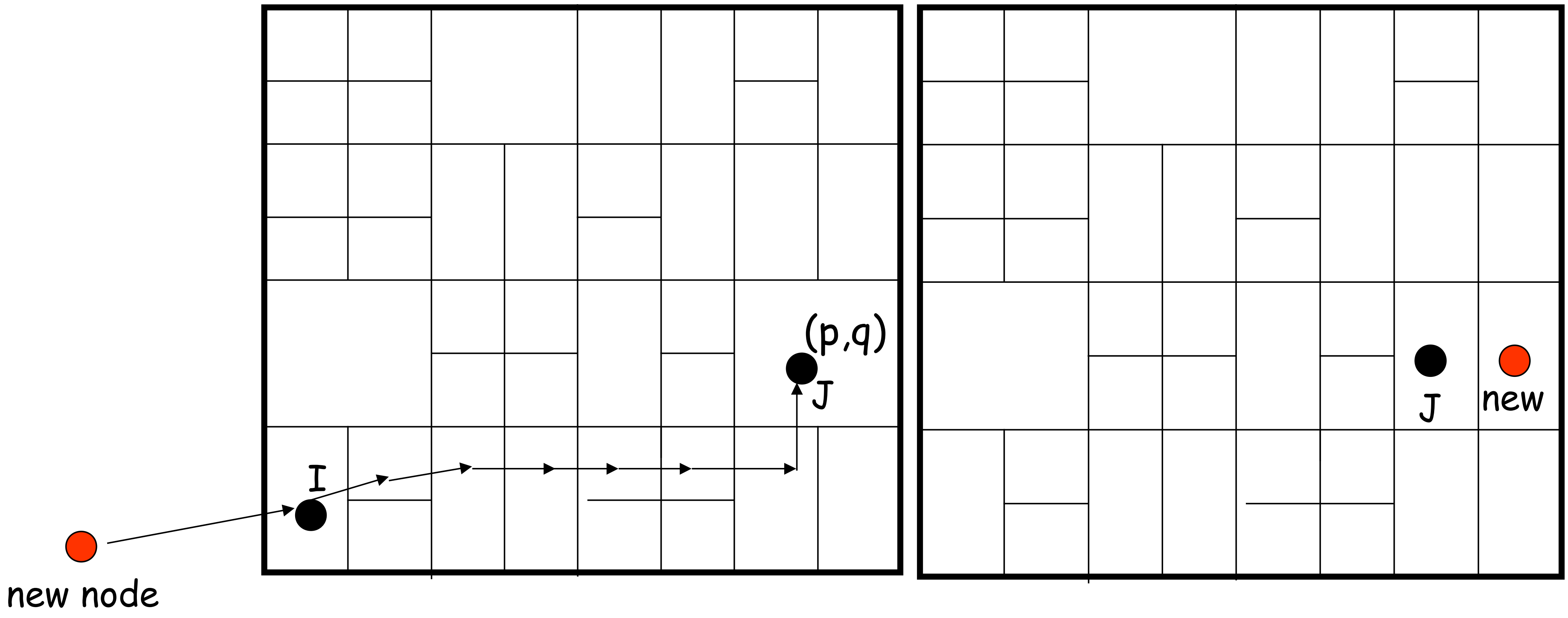
CAN routing

- Neighborhood routing
  - a node only knows how to reach its neighbors
- For 2-d space
  - 4 neighbors
  - or O(d) in general
- Path length
  - $O(d\ n^{1/d})$
- Resilience
  - multi-path



Node join and leave

- Bootstrap node



Comparison

- CAN
  - $O(d\ n^{1/d})$ hops
  - $O(d)$ neighbors
    - can be independent of n
- Chord
  - $O(\log N)$ hops
  - $O(\log N)$ neighbors

Next lecture

- Unstructured P2P
  - [CRBLS03] Yatin Chawathe, S. Ratnasamy, Lee Breslau, Nick Lanham, Scott Shenker, "Making Gnutella-like P2P Systems Scalable", Sigcomm 2003. Gnutella

- reading summary schedule
  - posted on crosscourse (xc)