Mill: Scalable Area Management for P2P Network based on Geographical Location

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Background

- Development of Wireless Technology & Positioning Devices
  - cars, PDAs, mobile phones…
  - easily connect to the Internet
  - get the actual position
- Demand for location related service
  - weather information (mobile phone)
  - traffic information (car navigation)

Goal

- share sensing data on Ubiquitous Environment
- we can use sensing data of any place.
  - more detailed traffic and weather information
    - provide new geographical services
    - solve environmental problem

Requirements

- Scalability
  - manage a large number of devices
- Region search
  - weather and traffic information is deeply related with geographical position
- Fast Search
  - location-related information is easily affected by TIME (and location)

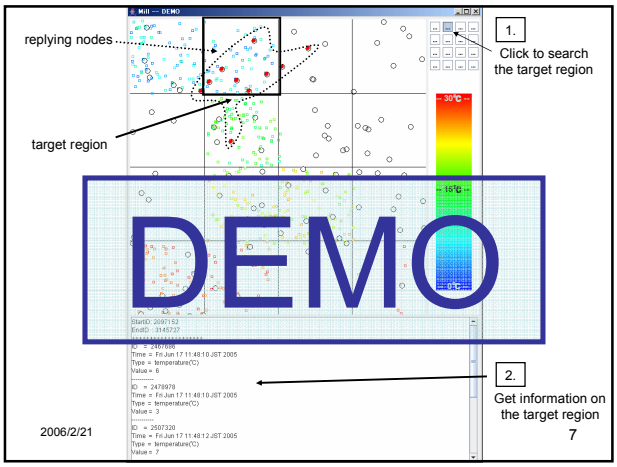
Related-work

- DHT-based P2P network
  - Chord, Tapestry, Pastory
  - routing cost: O(logN)
  - hashed ID is NOT match Geographical Info
    - so much queries are generated
- Geographical-based P2P network
  - CAN, LL-net
  - routing cost: O(sqrt(N))
  - complex area management
    - There are some kind of special nodes(Super nodes, etc)

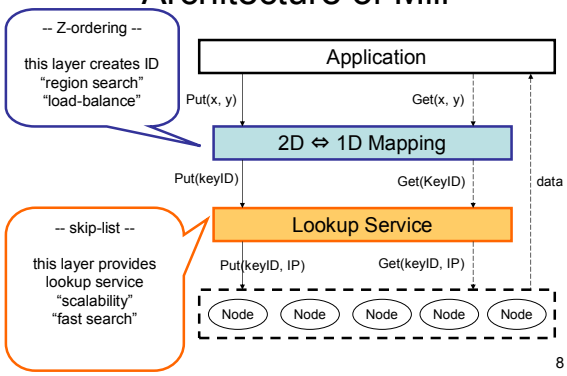
comparison of related work

	DHT	CAN, LL-net	Mill
Search cost	**O(logN)**	**O(sqrtN)**	**O(logN)**
Region search	**Huge queries**	**Few queries**	**Few queries**
Require "special node" or "lots of management cost"	**NO**	**YES**	**NO**

: Blue square means good feature



Architecture of Mill



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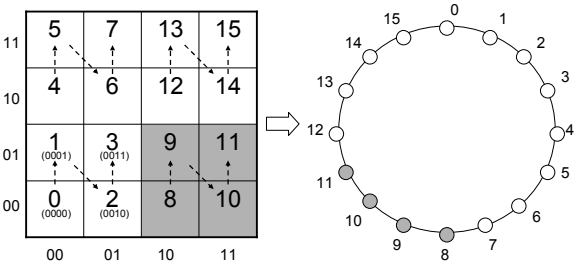
Z-ordering



- the number of IDs is created by alternating x-bit and y-bit
- a particular square region consist of consecutive IDs

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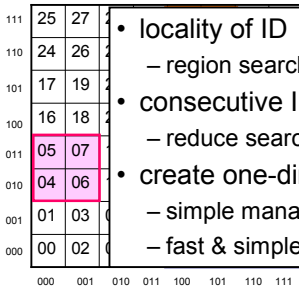
features of Z-ordering



- locality of ID
  - region search, load-balance
- consecutive ID
  - reduce search queries
- create one-dimension ID
  - simple management
  - fast & simple search

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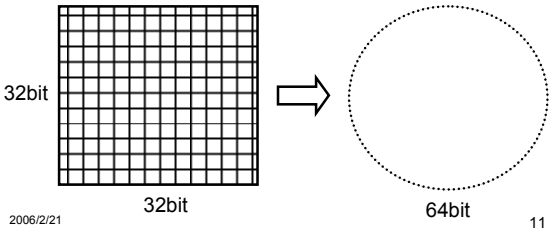
real use

- in real use Mill's ID space is large(64 bit)
  - The earth is divided 64bits -> 1 squire is mill-meter order
- searching cost DON'T rise on "64 bit ID space"
  - ONLY define "start-ID" and "end-ID"
- each node has 64bit ID -> effect on storage device (HDD, memory)
  - today's HDD, memory is GByte order (effect is small)



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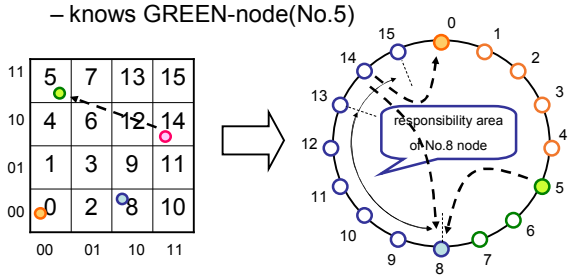
ex.) Join & Leave

- each node is responsible for part of IDs
- RED-node(No.14) is new node
  - knows GREEN-node(No.5)



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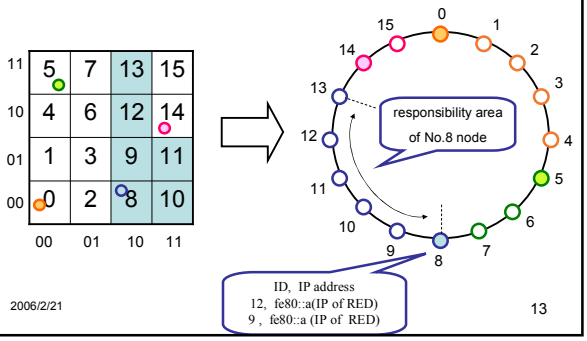
ex.) store & search information

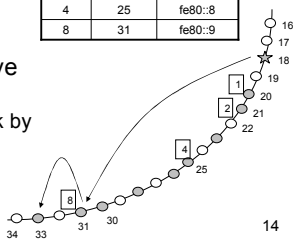


skip-list search

- skip-list algorithm
  - manage power of 2 hops away nodes as like 1,2,4,8
  - searching cost is O(logN)
  - routing table size is O(logN)
- when some nodes leave or disconnect
  - recover overlay network by using routing table

the routing table of the node (Node-ID: 18)

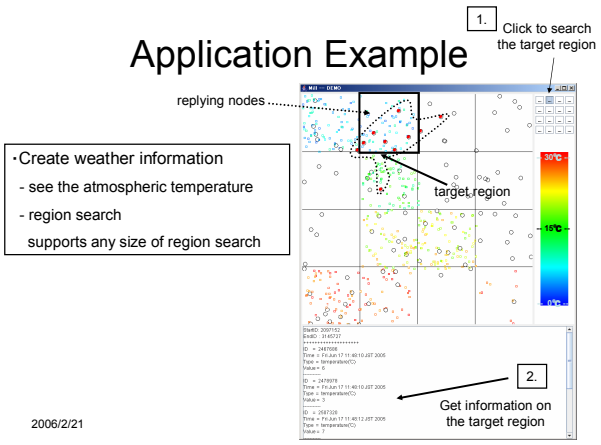
hops	Node-ID	IP-address
1	20	fe80::6
2	21	fe80::7
4	25	fe80::8
8	31	fe80::9



Simulation environment

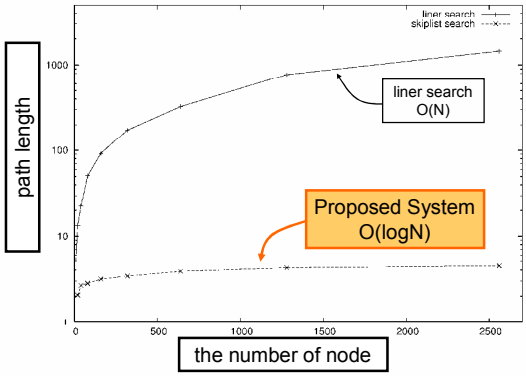
CPU	Pentium4 2.4GHz
Memory	1GB
Programming language	Java 2 SDK ver1.4.2-05
OS	WindowsXP-SP2
the number of nodes	10 → 2560
ID-space	2^{24} (4096 X 4096)
Transfer method	Random walk

Application Example



・Create weather information
- see the atmospheric temperature
- region search
supports any size of region search

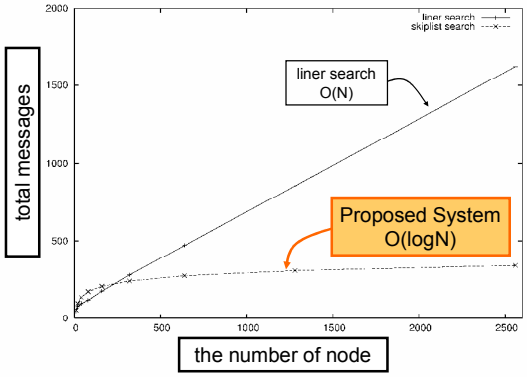
Routing Cost



Routing Cost (search 20bits area)

- Mill – O(logN)
  - path length: 10 hops (N=10,000)
- DHT – O(logN)
  - path length: 10 * 2^20 ≒ 10millon hops
  - hashed ID is NOT match Geographical Info
- CAN – O(sqrtN)
  - path length: 100 hops(N=10,000)
- LL-net – O(sqrtM) (M: number of areas)
  - path length: 10 hops(M=100)
  - can NOT search areas flexibly (limitation of area size)

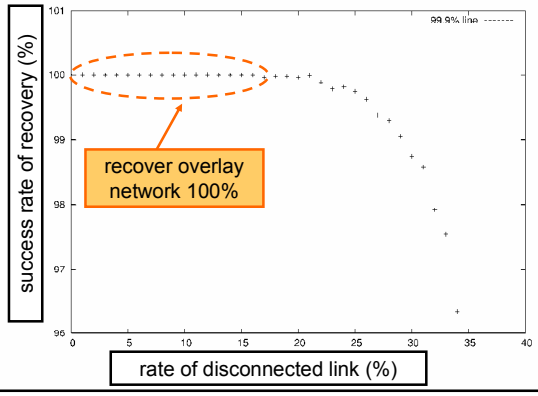
Messaging Cost (per 1 node)



management cost

- Mill & DHTs – O(logN)
  - just manage neighbor nodes(on routing table)
- CAN – O(sqrtN)
  - just manage neighbor nodes
  - how to divide area(responsibility) is complex
- LL-net – O(N)
  - super-node and rendezvous-node(RN) are needed
  - On each area, RN manages every normal node

Robustness



Summary

- Scalability
  - message cost: O(logN)
- Region search
  - can search any size of square(few queries)
- Fast search
  - routing cost: O(logN)
- Other features
  - robustness
- Future work
  - improve load-balance, support poor devices, etc…