Design and Evaluation of Scalable Ubiquitous Discovery System

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Outline

- Background, Goal, Scenario
  - Sensor data gathering from flood of sources in the Internet
- Approach
  - P2P network by handsets
- Problems caused by unstable wireless link
- Proposed method
  - An extension of multi-route function to an existing protocol
- Evaluation
- Conclusion

Background: Data gathering via sensor networks

- Various sensor data of objects are gathered in real time locally
  - Communication: Power saving wireless ad hoc networks
  - Types of sensors: Location, temperature, and accelerated velocity
- Mobile phones can be an entrance to sensor network
  - Handsets are connected to the Internet via gateways
  - Required information can be accessed anytime, anywhere

Good grounding of attractive sensor network applications is provided

Goal: Real time data gathering from flood of sources

- Applications
  - Object tracing: path or present location of objects are monitored
  - Status monitoring: temperature or impact shock are monitored
- Latest information should be instantly replied to user requests

Required information are searched over vast & distributed sources

My Cat

2004.5.

2004.7.

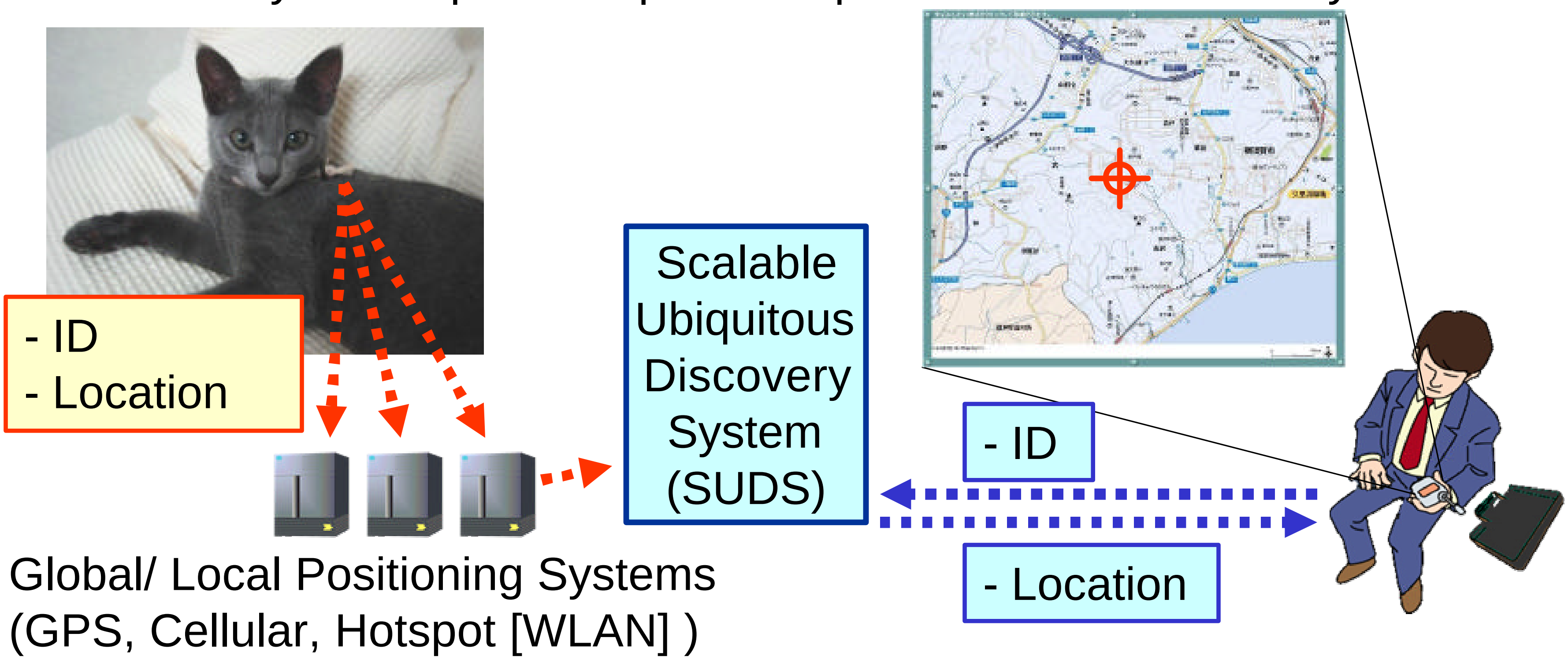
Momo ('Peach' in Japanese)

Toddling Kitty → Running from wall to wall

How can I find her if she get out of house ?

Scenario: Tracking of momo using SUDS

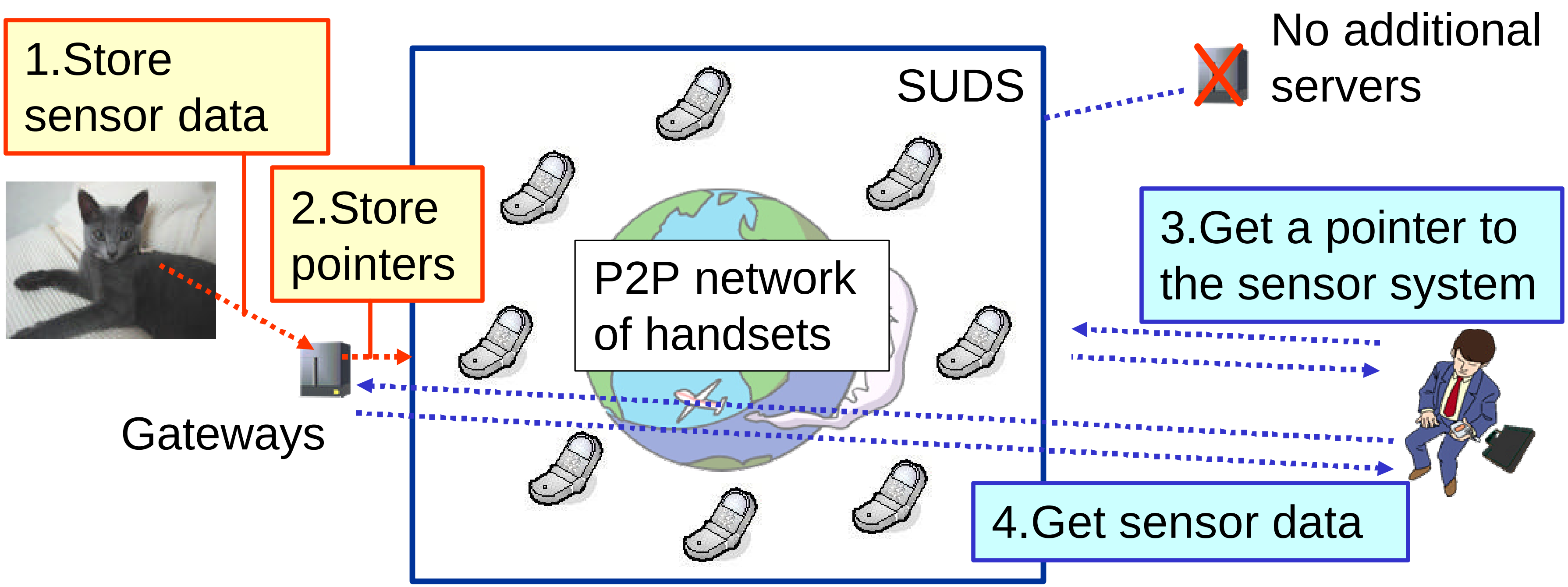
- A pet collar is tracked from mobile phone
  1. Various location sensor systems are monitoring location of the collar
  2. A user know the ID of the collar beforehand
  3. In case the pet is lost, the user sends a query of the ID
  4. The system replies the path and present location instantly



What architecture is appropriate to realize this scenario ?

Approach: Handsets become Distributed servers

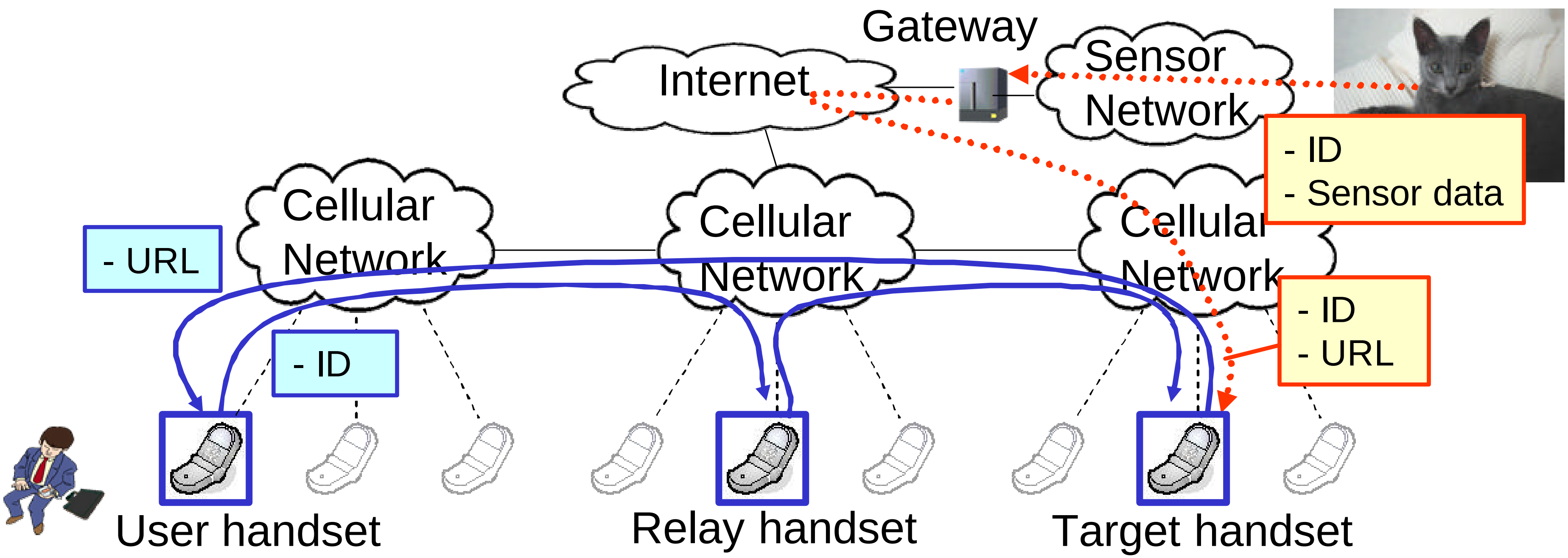
- How to gather sensor data ?
  - Sensor data is generally stored in gateway servers
  - Handsets in SUDS store pointers to gateway servers
- Features
  - No additional server is required other than gateways
  - Handsets works as alternatives of servers



SUDS is composed of handsets, which gather pointers to gateways

Communication Model

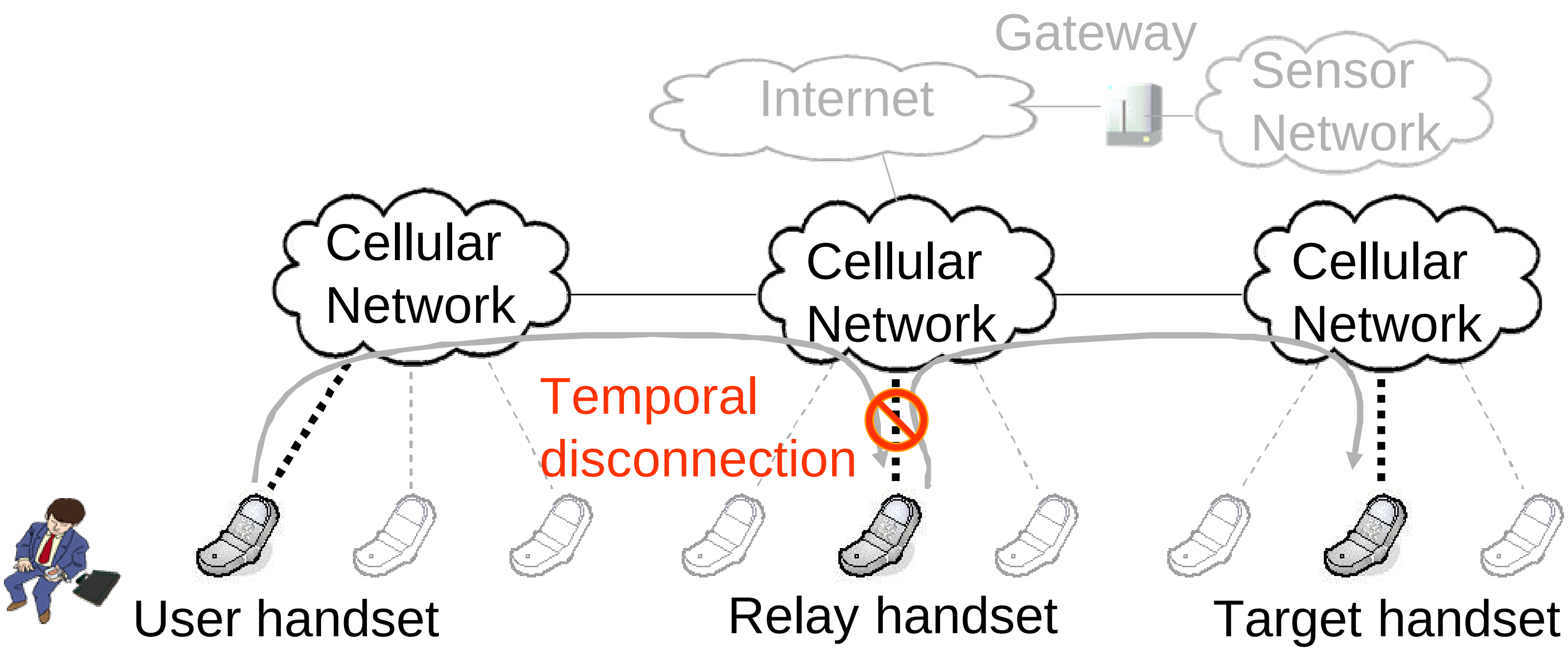
- Model
  - Information is searched via multiple handsets
- Assumption
  - Flat-rate system: No additional charge to relay handsets
  - Incentive are given for battery consumption of relay handsets



Queries are transferred via relay handsets in SUDS

Problem: Disconnection of wireless communication

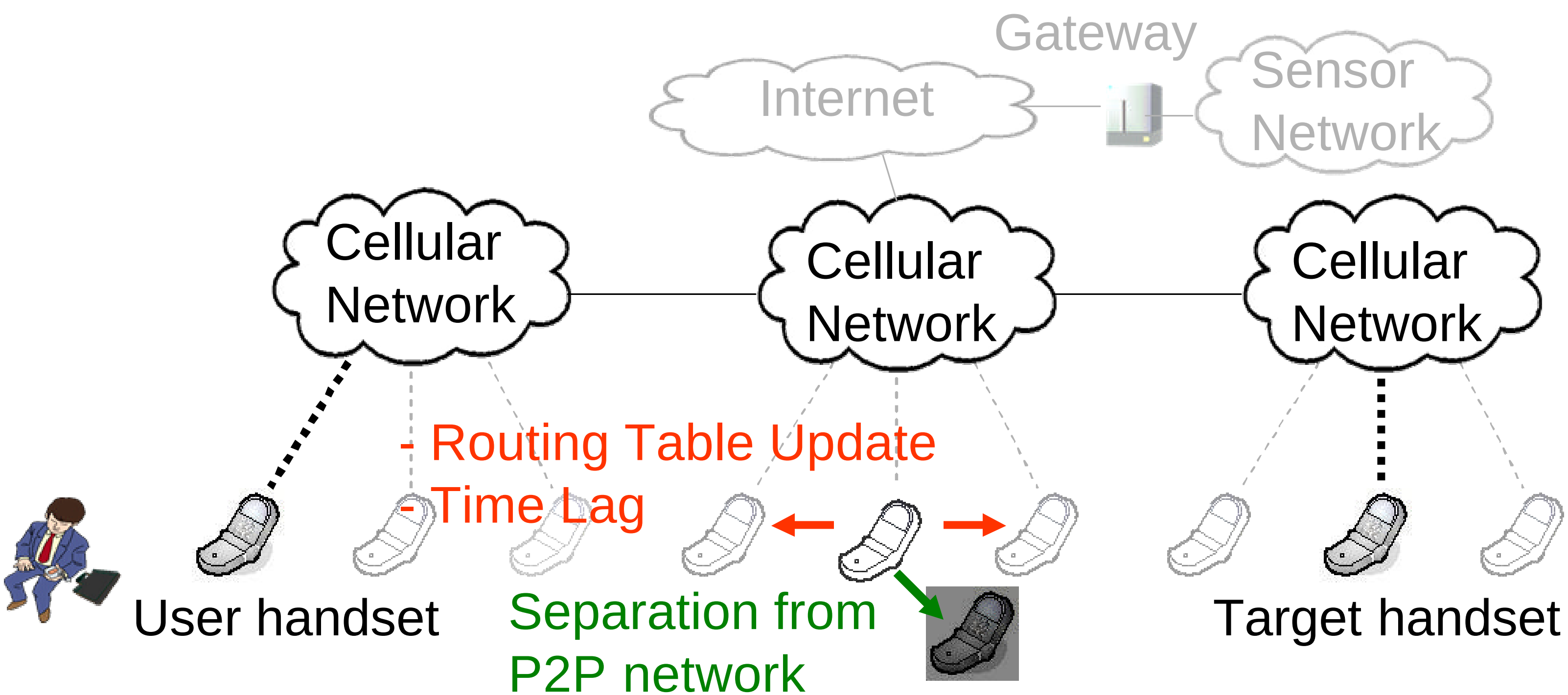
- Previous P2P protocols are designed for servers on wired networks
  - Temporal disconnection of wireless network cause interruption of query transmission
  - More relay handsets, worse responsiveness



Interruption of query transmission caused by wireless link must be avoided

Previous Work of P2P Protocols

- In case wireless link is temporally disconnected..
  - Responsiveness gets worse because relay is interrupted
  - It doesn't work to separate the disconnected peer
    - > Frequency of routing table update increases
    - > Time lag exists to notice the disconnection



Dilemma of responsiveness degradation or redundant routing table update

Requirements

- It is required to eliminate the tradeoff between the following 2 points
  - Provide high responsiveness in the face of temporal disconnectin
  - Decrease traffic of routing table update caused by peer separation

How can we achieve high responsiveness without peer

Proposal: Multi-route Transfer Method

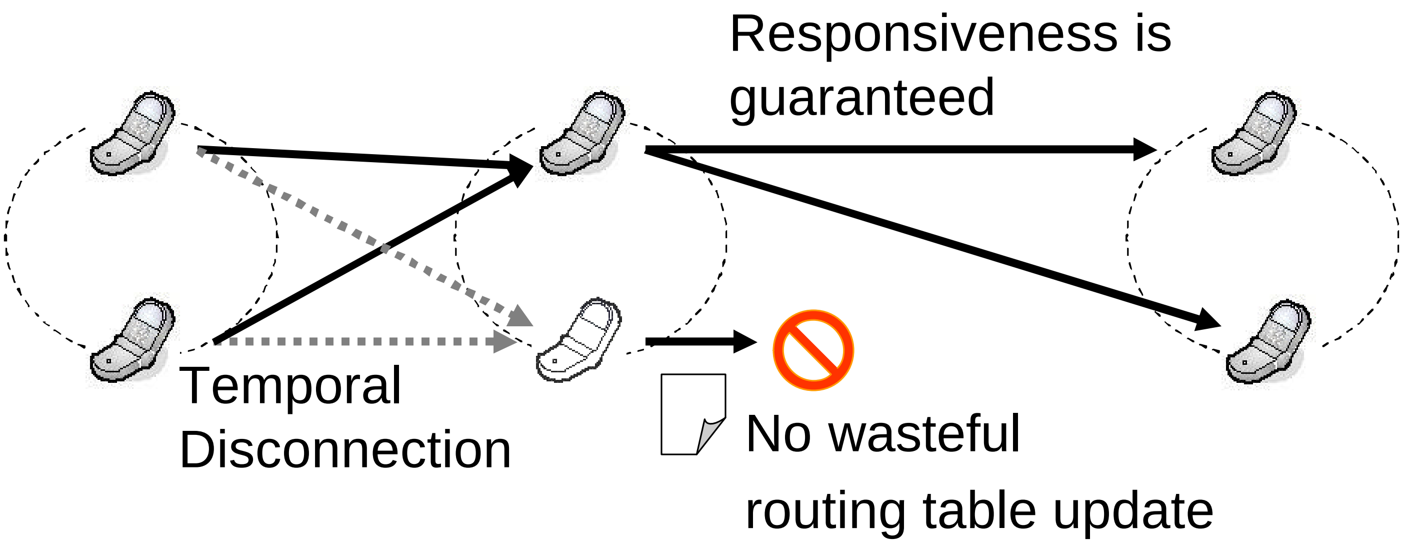
- Basic policy
  - An extension to Chord protocol which provides high scaliability
    - > Chord provides smaller value of path length than CAN
    - > Chord provides more flexible routing than Pastry & Tapestry
- Proposed function
  - Provide multiple routes from a user handset to a target handset

Protocol / Feature	CAN	Pastry, Tapestry	Chord	SUDS
Path length	$O(dN^{1/d})$	**O(log(N))**	**O(log(N))**	**Based on Chord**
Flexibility of routing		×	?	
Remarks			**Lacks responsiveness**	**Achieve high resposiveness by using multi-route**

Multi-route transfer method is added as an extension to Chord protocol

P2P protocol with multi-route function

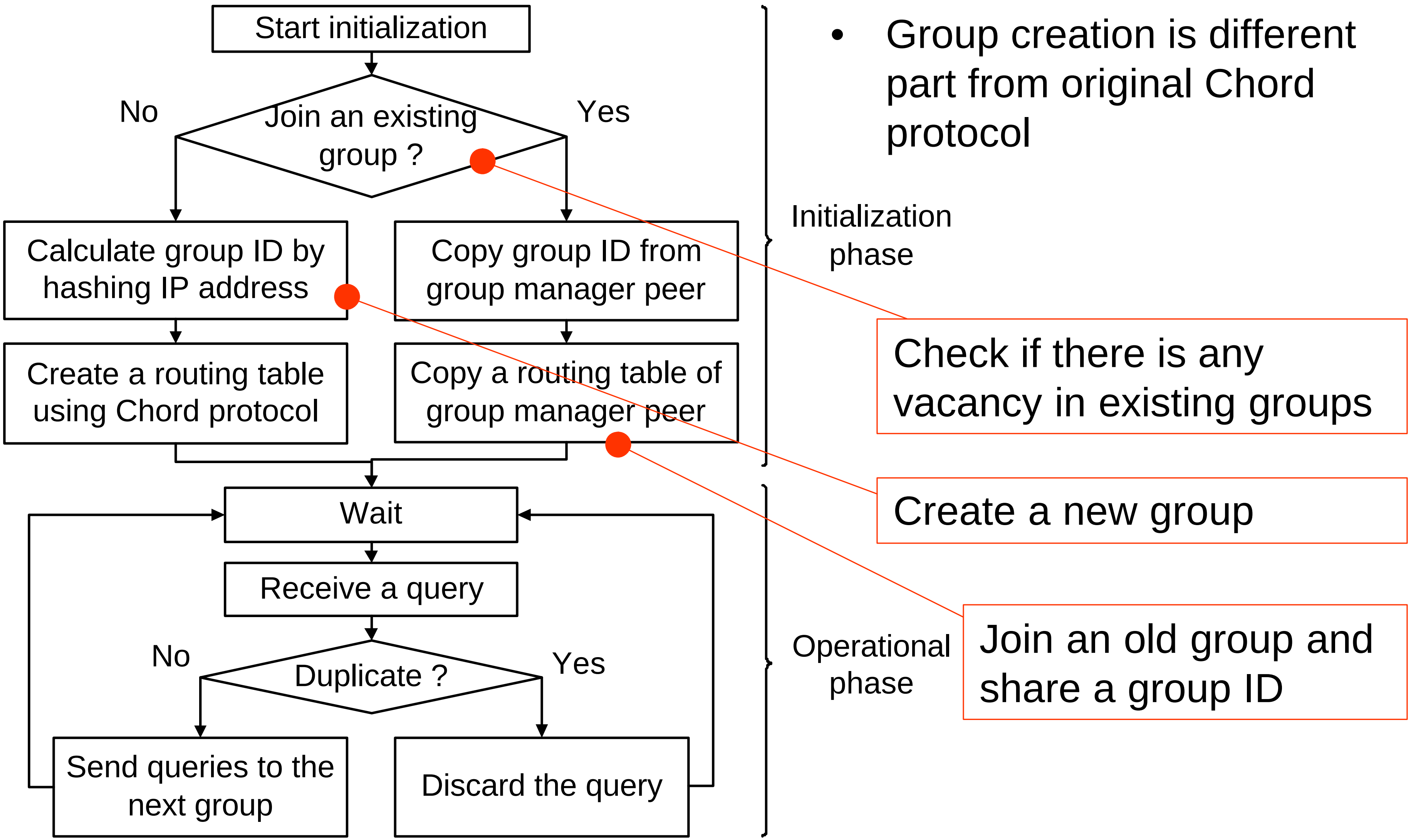
- Multiple peers create a group
  - Multiple routes are constructed between 2 groups
  - Even if part of peers are disconnected, responsiveness is guaranteed by alternative path
  - Disconnected peers are not separated from the P2P network and continues to hold a routing table



Responsiveness is provided without separation of disconnected peer

Behaviour of A Peer

- Group creation is different part from original Chord protocol



Group members share a group ID and the same routing table

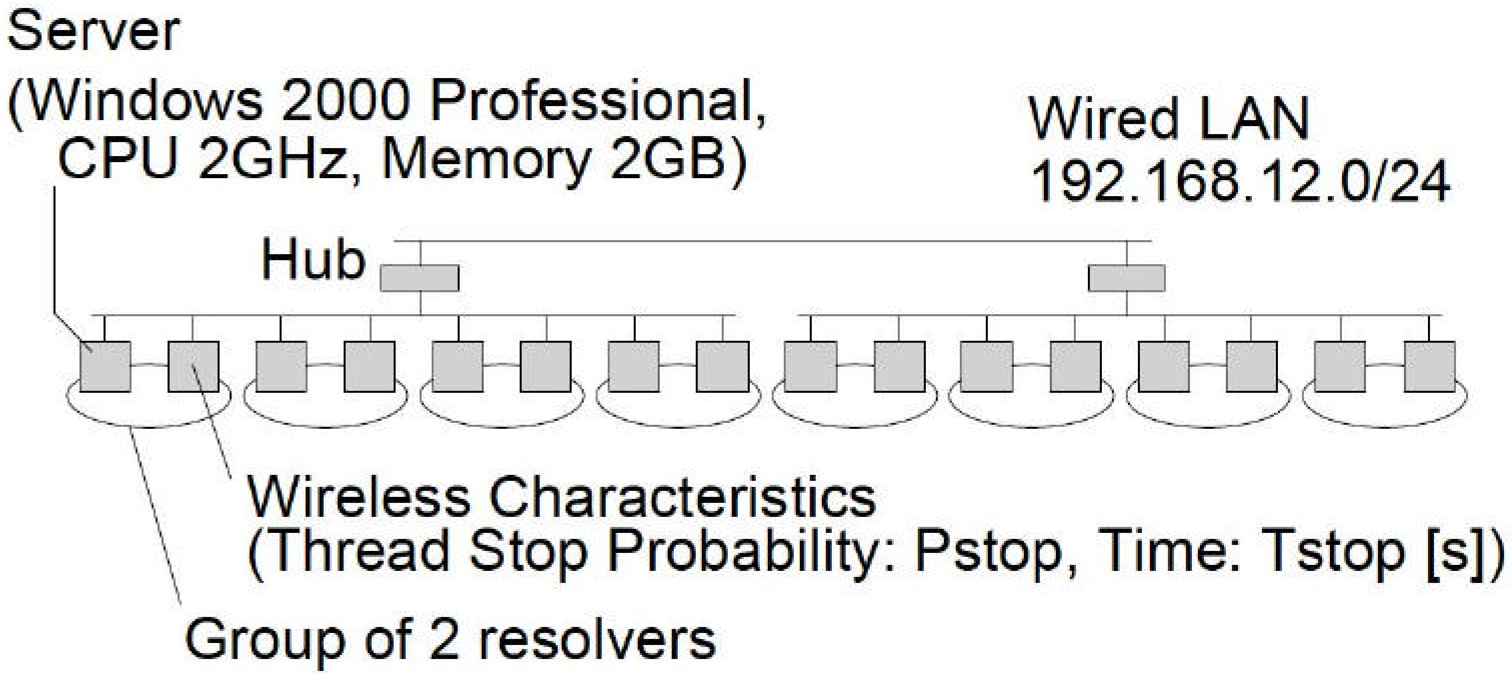
Evaluation

- Protocol Comparison
  - Chord
  - Proposed Multi-route P2P Routing
- Evaluation Item
  - Responsiveness
  - Communication traffic of routing queries

Can we get good responsiveness by using the proposed method ?
How much additional traffic is generated by redundant routes ?

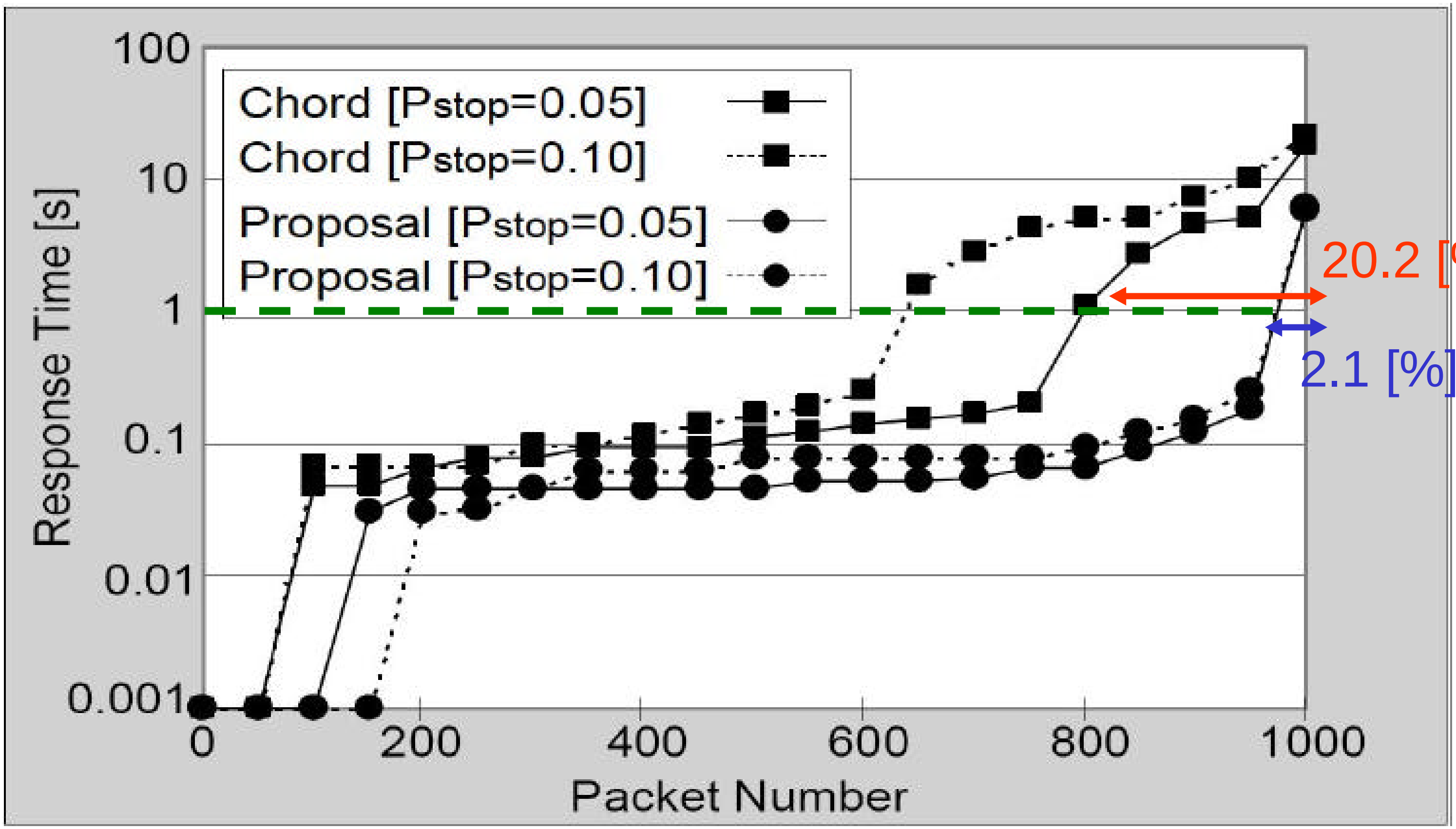
Evaluation System

- Chord and the proposed protocol are implemented to 16 servers
- Neighboring 2 servers create a single group
- Brief fluctuation of wireless network is emulated by stopping threads
  - Stop threads for Tstop = 5 [s]
  - The probability of thread stop is Pstop = 0.50 or 0.10



Improvement of Responsiveness

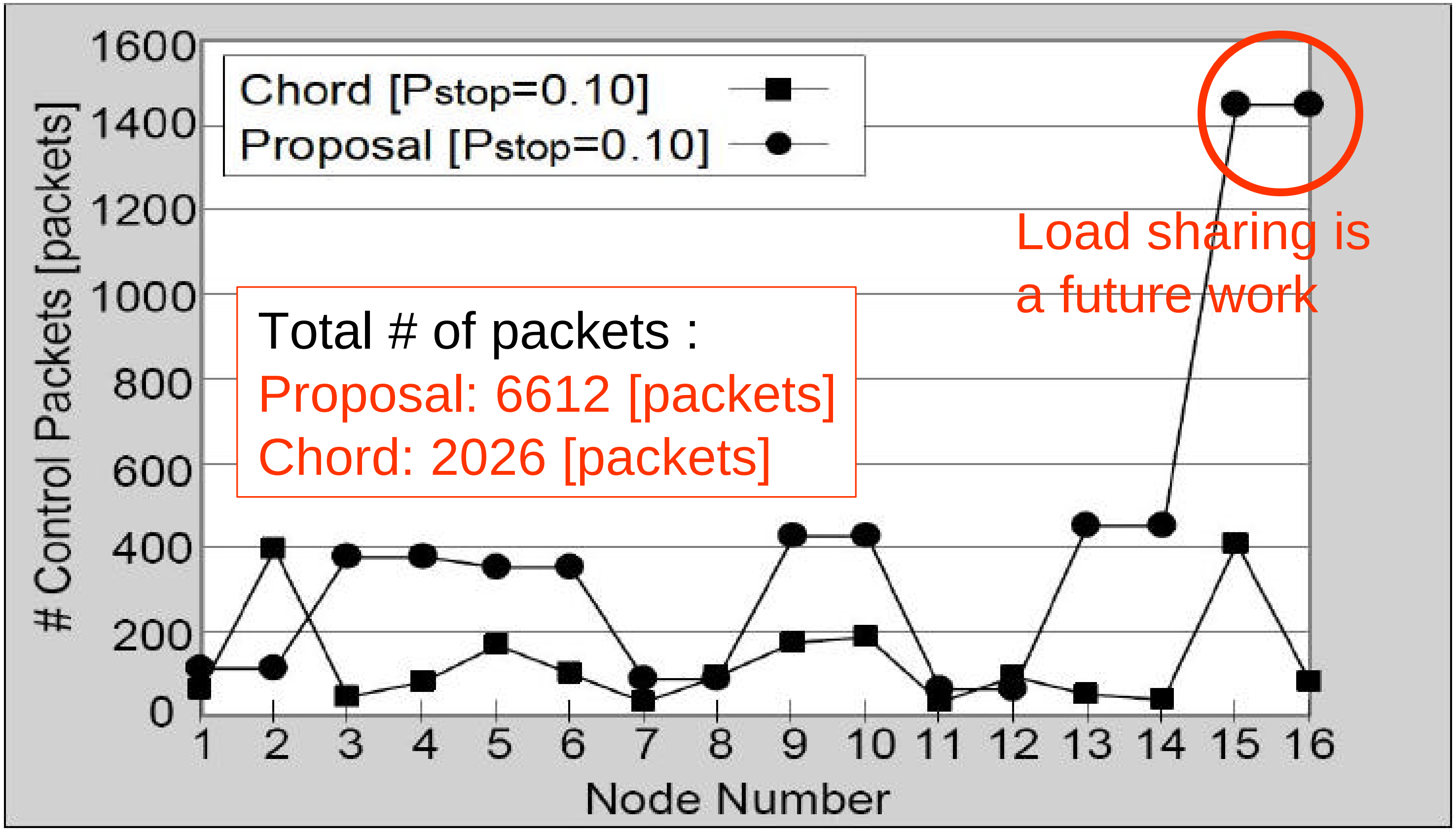
- Responsiveness is greatly improved by the proposed method
  - In Chord protocol, 20.2 [%] of the response were longer than 1 [s]
  - In the proposed protocol, the same value was only 2.1 [%]



Responsiveness is improved by multi-route function

Increase of Control Packets

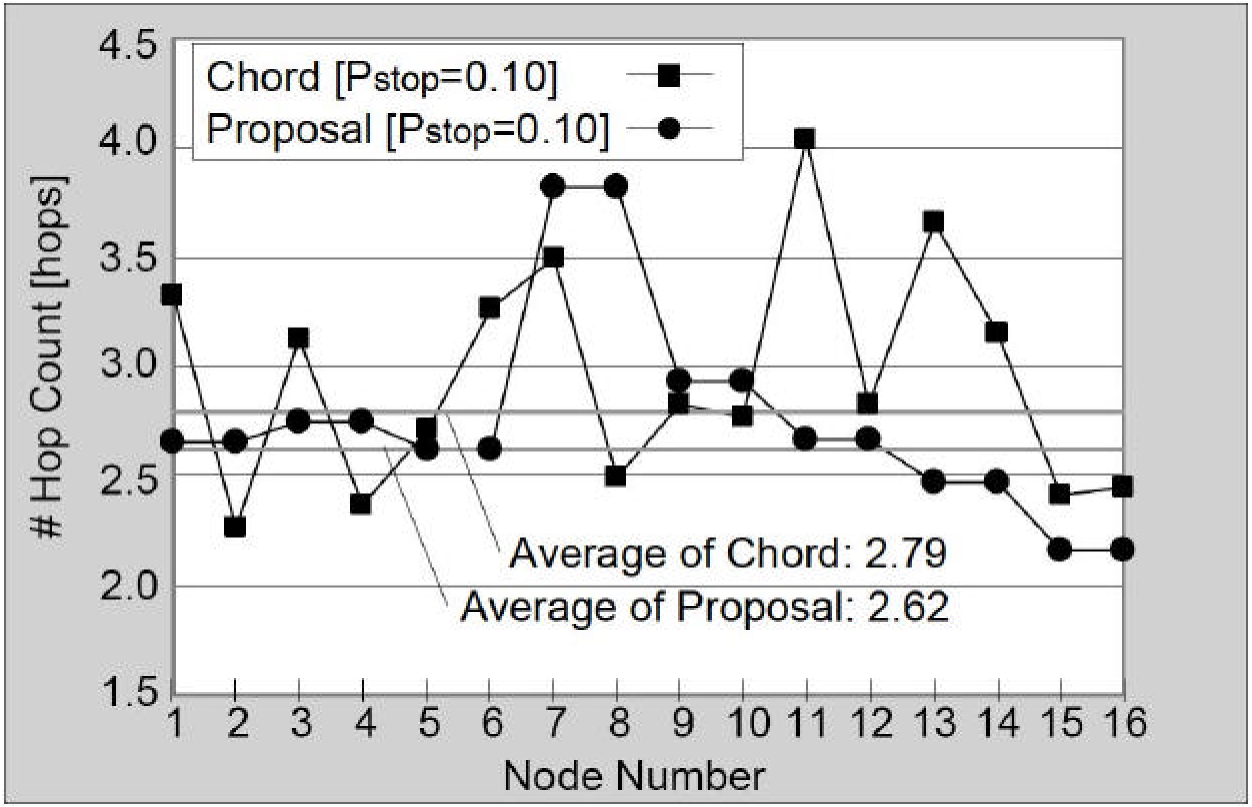
- Number of control packets increased threefold in the proposed method
  - It's acceptable because queries are not so large (several tens of bytes)
- Load sharing among groups is a future work



Increased communication traffic is acceptable

Reduction of hop count

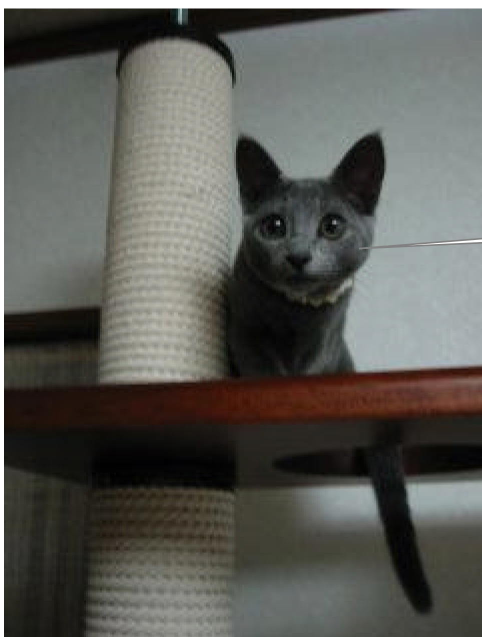
- Hop count is slightly improved
- Side benefit caused by the decrease of entities
  - The number of entities in P2P network is decreased from the number of independent peers to that of groups



Number of hops is decreased in the proposed method

Conclusion

- We proposed a multi-route P2P protocol for wireless network
  - High responsiveness under temporal network disconnection
  - Avoidance of inefficient traffic of routing table update
- Future Work
  - Load sharing among groups



Thank you for your attention !