SINA

A networking framework for spontaneous interactions in MANETs

August, 2009

Agenda

- Background and Problem definition
- Design considerations and Proposed architecture
- Evaluations
- Future research items

BACKGROUND AND MOTIVATIONS

When spontaneous interactions meet ubiquitous computing

Promoting interactions

Socializing

Group wise

Transforming places

Ephemeral

Ad hoc

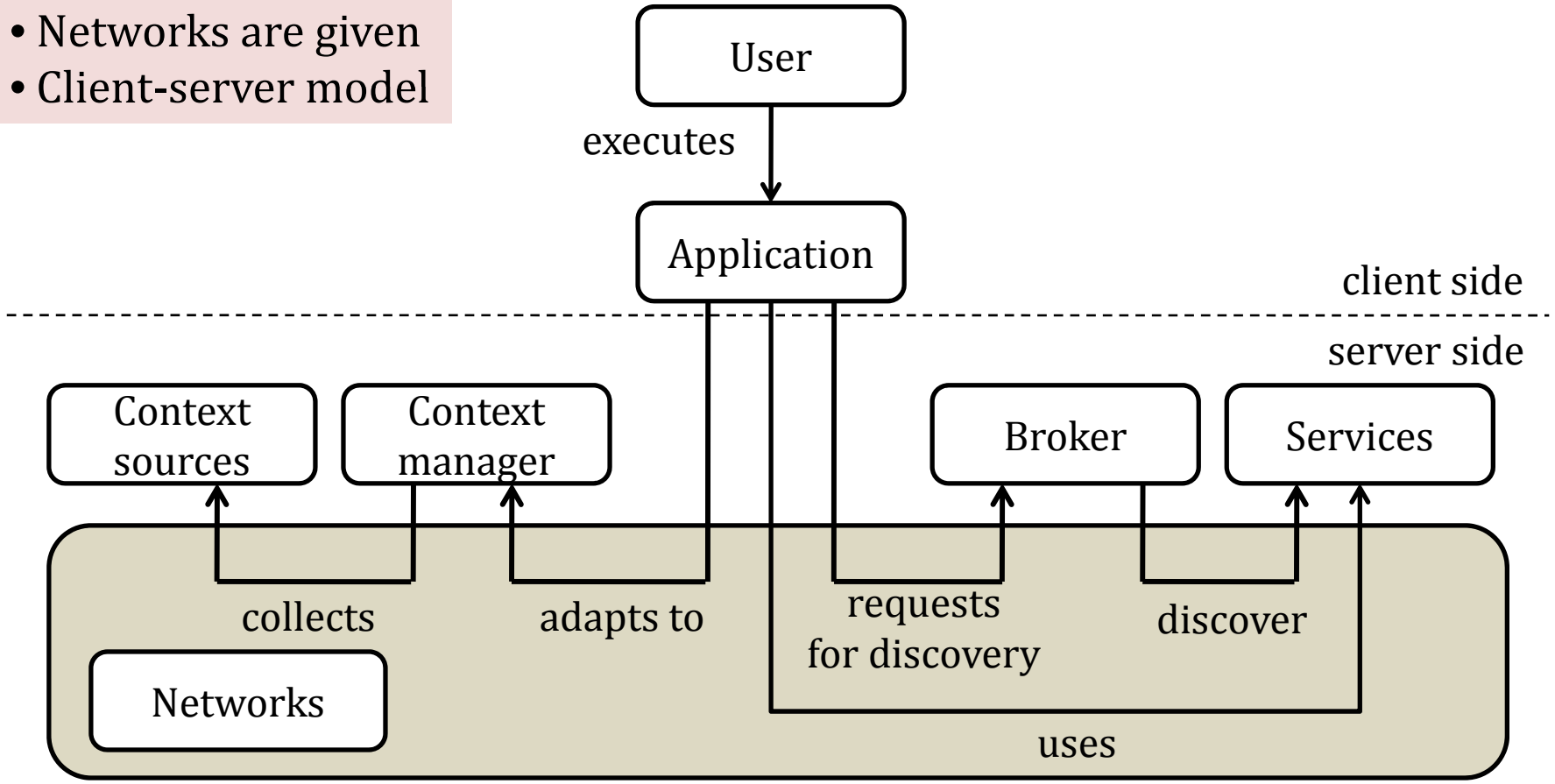
Minimal

Application driven

Networking in spontaneous interactions

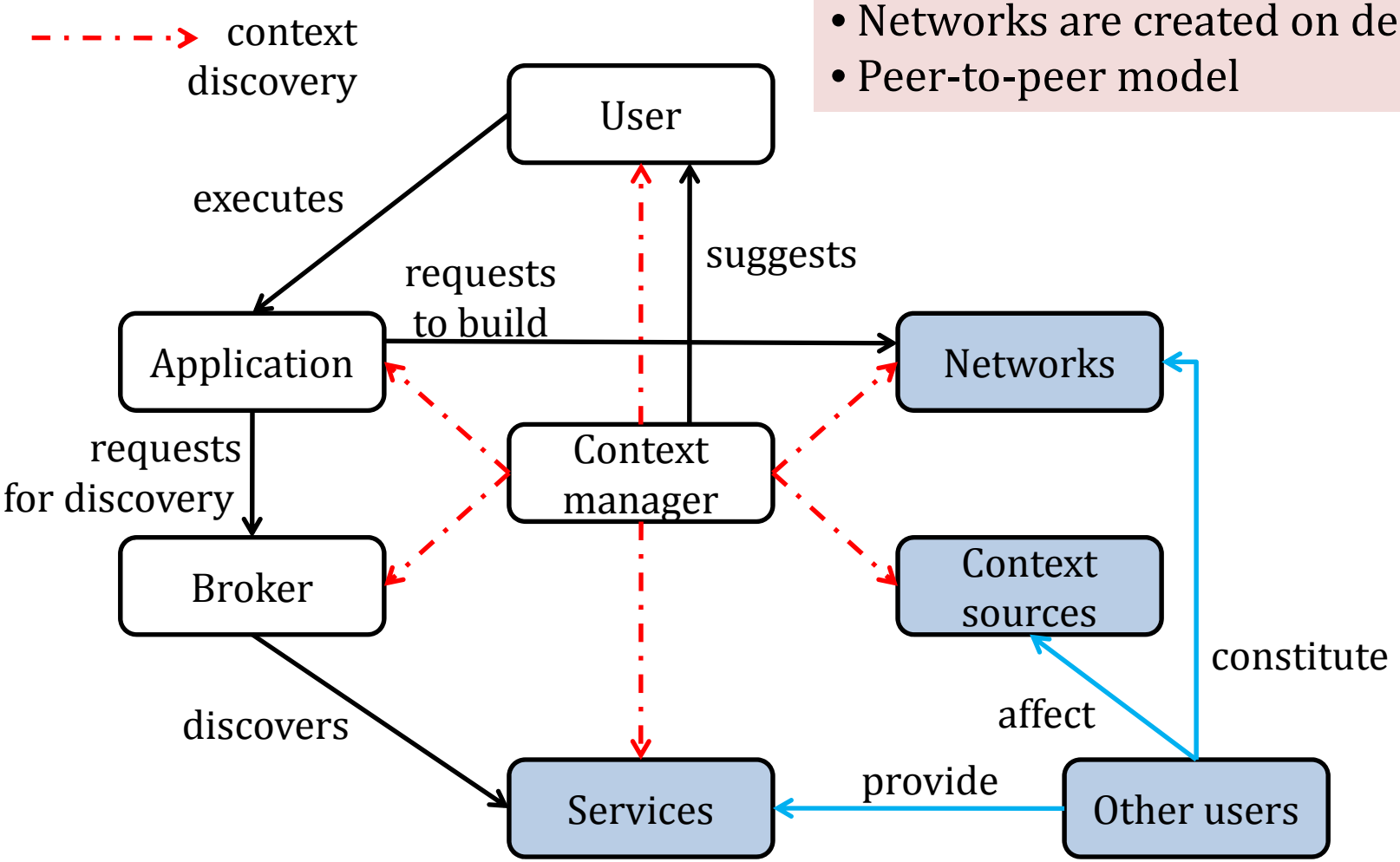
Traditional ubiquitous computing applications

- User initiated
- Networks are given
- Client-server model



Spontaneous interactions

- Context triggered
- Networks are created on demand
- Peer-to-peer model

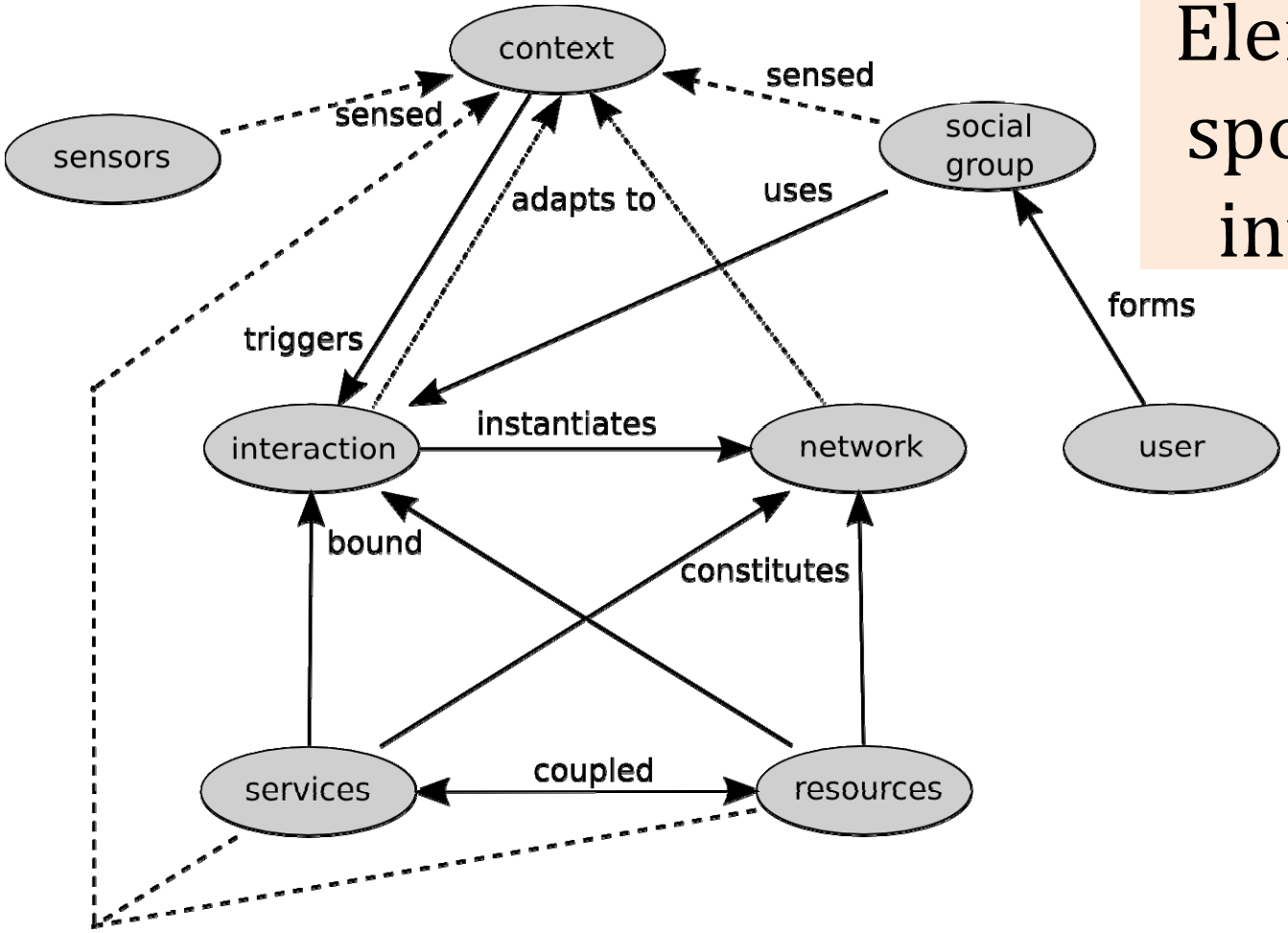


Problem definition

- IP networking
  - Built in advance and sustained forever
    - Networks are ephemeral: Necessary as long as the corresponding application runs.
  - Application neutral
    - Wide variety of applications require networks with various forms and functions.
  - Peers are represented as numbers having no application level semantics.
    - Dynamic: An error is the norm, while stability is the exception.
    - Dense: Very probable to discover alternatives
- Ad hoc networking
  - (+) It supports ephemeral networks of dynamic nodes.
  - (+) It does not assume an infrastructure.
  - (-) It is either application neutral (e.g. most of MANET routing) or for single application (e.g. sensor networks)
- Network virtualization
  - (+) Networks are "customizable" in "an application driven" manner.
  - (-) It assumes "infrastructure provider".
  - (-) Time span of "ephemera" is far longer than spontaneous interactions.
  - (-) It does not deal with dynamism of routing nodes.

DESIGN CONSIDERATIONS AND PROPOSED ARCHITECTURE

Elements of a spontaneous interaction



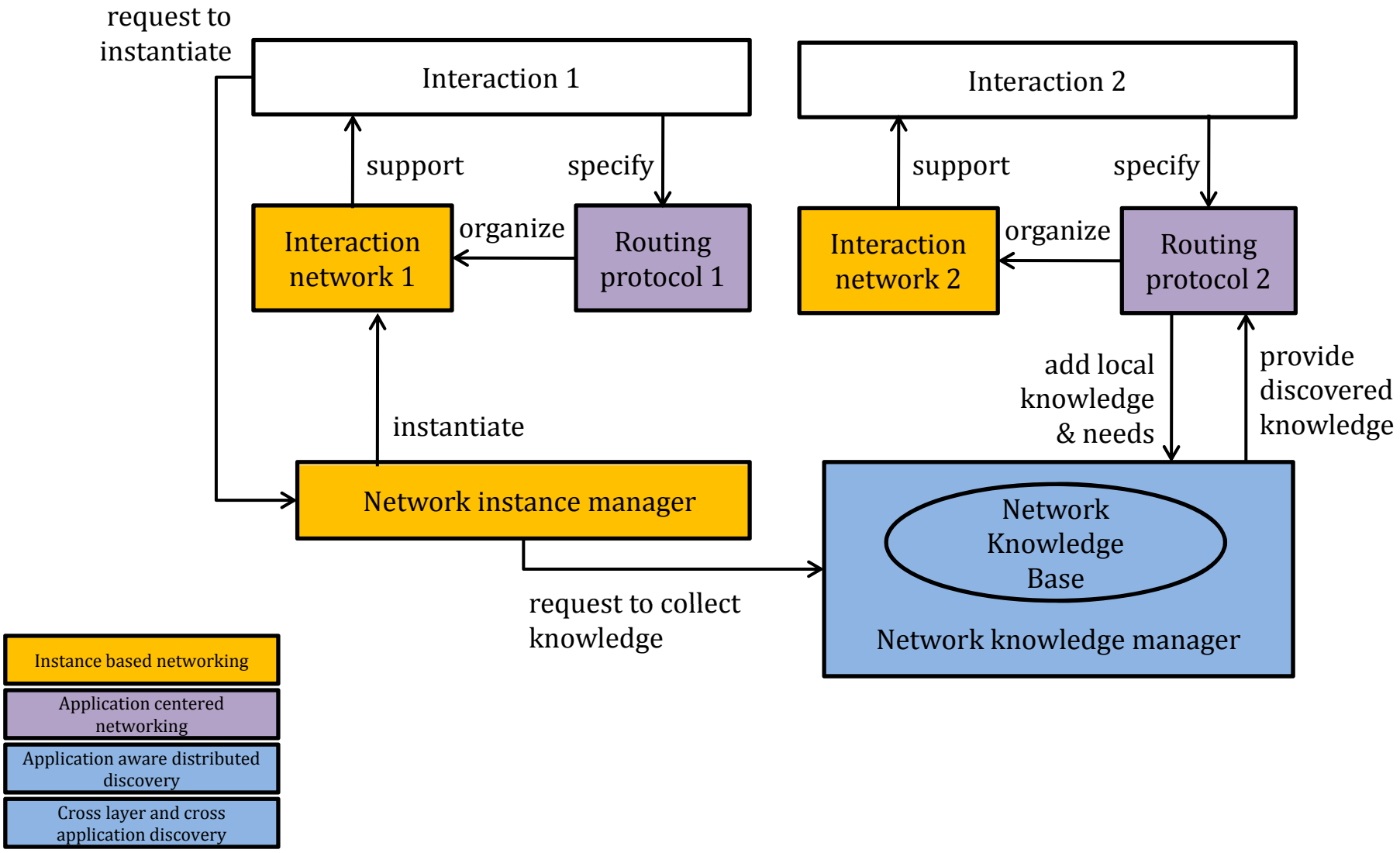
Key design considerations

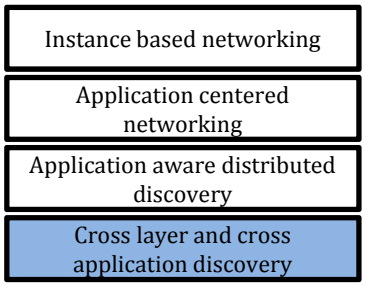
1. Application awareness in networking
2. Support of awareness with efficient discovery of everything needed

Spontaneous interaction networking principles

Instance based networking	❖ Instance based ❖ Networks are (virtually) built on demand of an application ❖ Resolves: Unnecessary maintenance of networks ❖ Spans over only relevant nodes. ❖ Resolves: Flooding based discovery overhead
Application centered networking	❖ Application centered: A network is configured and maintained by its corresponding application. ❖ Resolves : Either insensitive or oversensitive application neutral networking
Application aware distributed discovery	❖ Application aware: Discovery rules are from applications. ❖ Resolves : Application agnostic (path) recovery ❖ Distributed: Discovery is done at every node without collecting all information at a server node. ❖ Resolves: Delay and overhead of centralized discovery approaches
Cross layer and cross application discovery	❖ Cross layer: Discoveries across layers are aggregated in a point. ❖ Resolves: Duplicated discovery across layers ❖ Cross application: Aggregates discovery requests from different applications ❖ Resolves: Duplicated discovery across applications

Proposed architecture



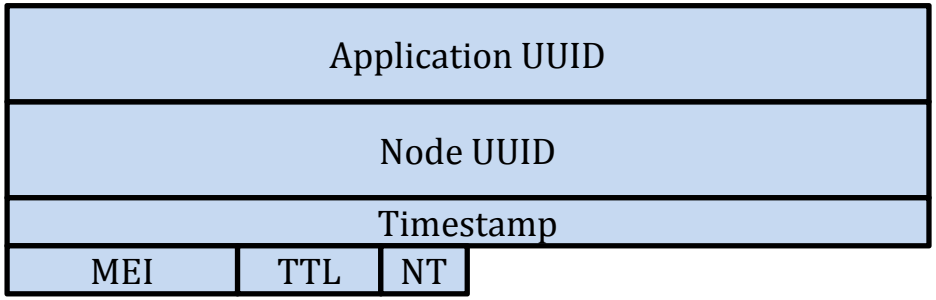


Design

Cross layer and cross application discovery

- Network Knowledge Record (or NKR)
  - A common format to disseminate network knowledge including topology, user characteristics as well as application specific information
- Network Knowledge Base (or NKB)
  - A set of NKRs generated locally or obtained from networks.
- Types of NKR
  - Topology
    - System defined
    - Mandatory information based on which application specific network instances are created.
  - User-application-profile (or UAP)
    - Application defined but handled by Network Knowledge Manager (or NKM)
    - Describes a user's preference on an application
    - Used to match users who may share an application
  - Application defined NKR (or ADN)
    - Any information for an application to disseminate
    - Understood by the application only

Packetization of header of NKR



Instance based networking

Application centered networking

Application aware distributed discovery

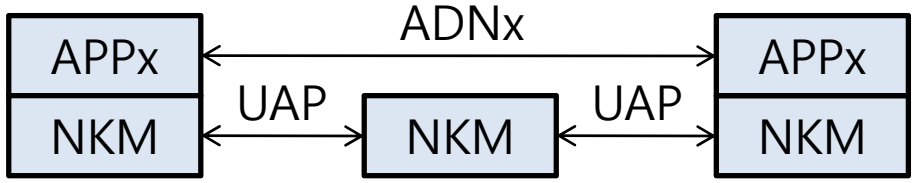
Cross layer and cross application discovery

Design

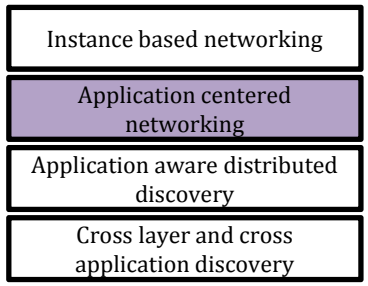
Application aware distributed discovery

- Application Defined NKRs (or ADNs) are exchanged between nodes having the same application.

Two ways of application awareness



- Every node in the network executes discovery according to applications' needs as described in UAP.
  - UAP := Threshold (Condition Tuple)+
  - Condition Tuple := (... type, my value, target value, match weight, ...)
    - Type: Only mandatory types are allowed (integer, string, Boolean)
    - Other person's "my value" is compared with my "target value" to see whether I want to invite the person.



Design

Application centered networking

- Allow applications to control networking as needed
- Using application specific routing
  - An application can implement its own routing, which may use topology information provided by NKB as well as application specific information obtained from ADN.
- Using an interface to shared topology information
  - Change topology information exchange interval as needed
    - NKM provides a coordination logic to handle requests from several applications.
  - Suppression of less likely deliverable messages
    - E.g. a code snippet from a chat application

```
NKRecord *r;
r = GetAnNKRecord(node, chat->nimHandle, UUID_NKB_TOPOLOGY, dest);
if(r == NULL) return; // no route
if(r->timeStamp < getTime()-20*SECOND) return; // too old path
SendChatMessage();
```

Instance based networking

Application centered networking

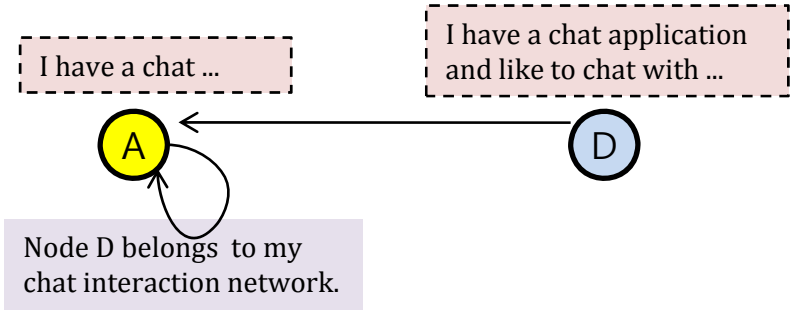
Application aware distributed discovery

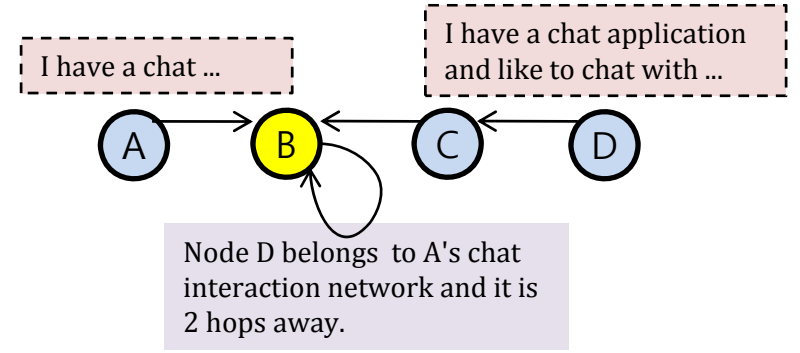
Cross layer and cross application discovery

Design

Instance based networking

- Formation of an interaction network
  - Exchange of UAP lets NKM to know which nodes belong to the interaction network of the corresponding application.
  - Intermediate nodes also come to know which nodes belong to the interaction network.
- Interaction between an application and a interaction network
  - Callback
    - An application registers a callback function that is called when (1) NKM receives an NKR whose application UUID is same with the application or (2) a match in UAP is found locally or remotely.
  - Flooding
    - A primitive function provided by NKM.
    - Sent to members of an interaction network using the combination of broadcast and unicast
    - Broadcast and unicast are probabilistically suppressed to avoid excessive message exchanges.



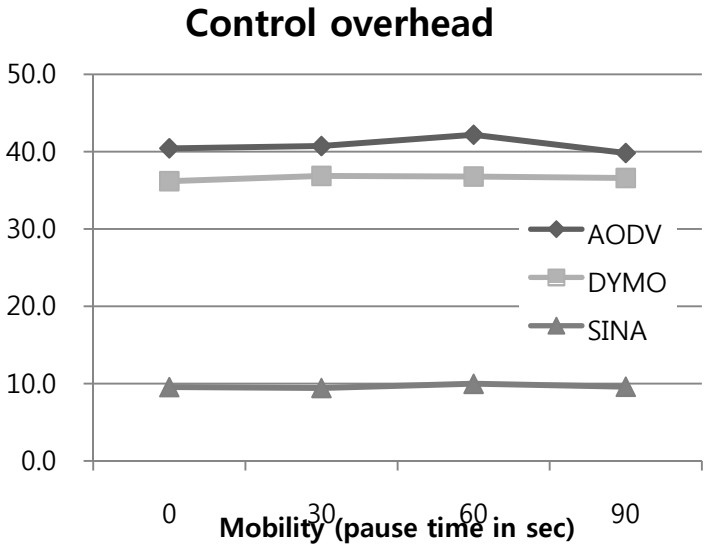


EVALUATIONS

Simulation settings

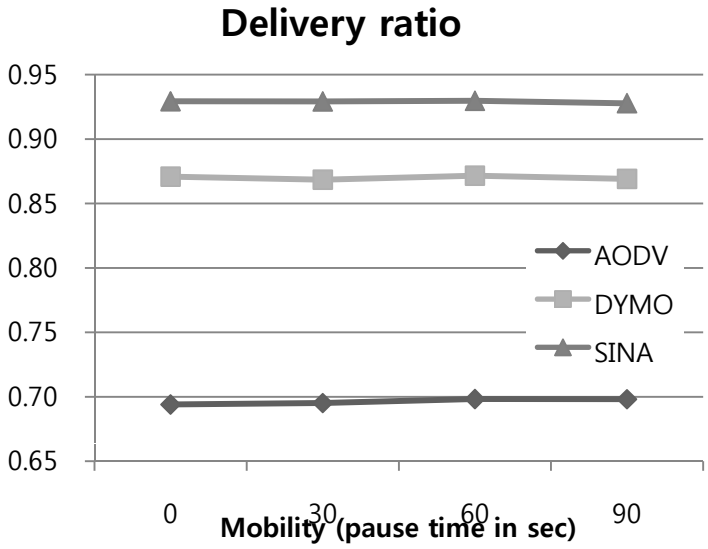
- Use Qualnet 4.5
- Two scenarios
  - "CHAT Scenario"
    - Represents a peer-to-peer & one-to-one (or one-to-few) communication induced from a discovery of a chance
    - Triggers a chat application based on UAP match
    - Shows how well the proposed architecture discover spontaneous interaction chances
  - "PUB/SUB Scenario"
    - Represents a producer-consumer & one-to-many communication
    - Publishes events as soon as subscribers are found
    - Shows how effectively an interaction network reduces the communication overhead by including only relevant members nodes in the network

Evaluations: CHAT Scenario



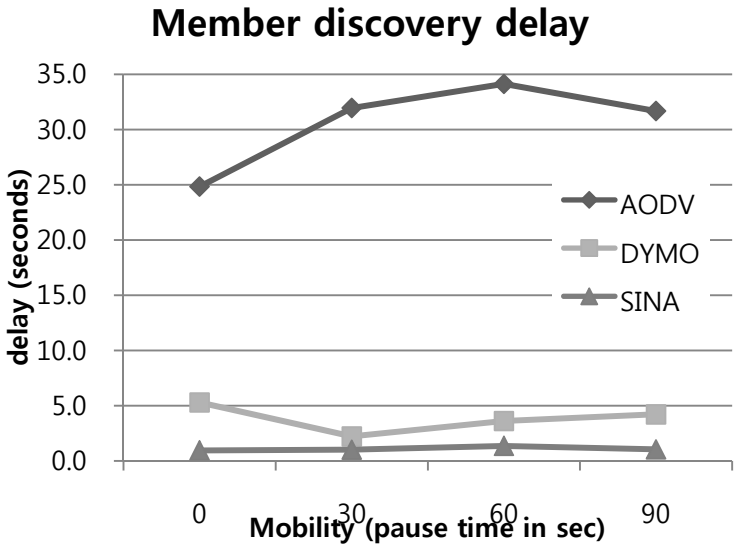
Cross layer discovery effective reduces overall overhead.

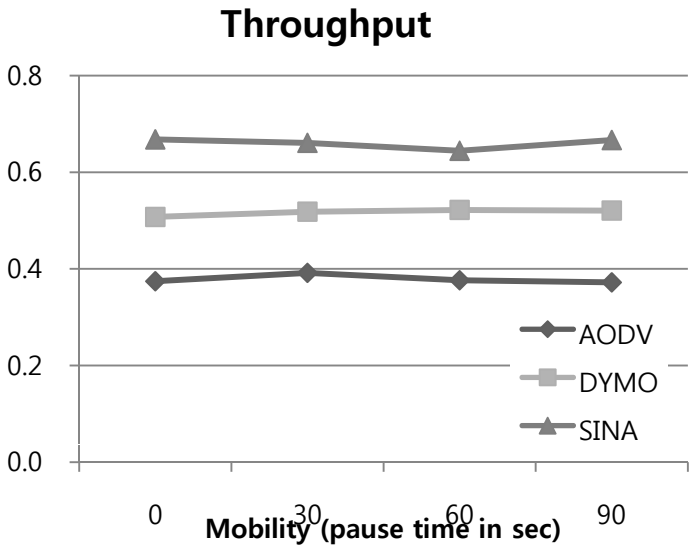
Application centered networking controls a network more effectively.



Evaluations: CHAT Scenario

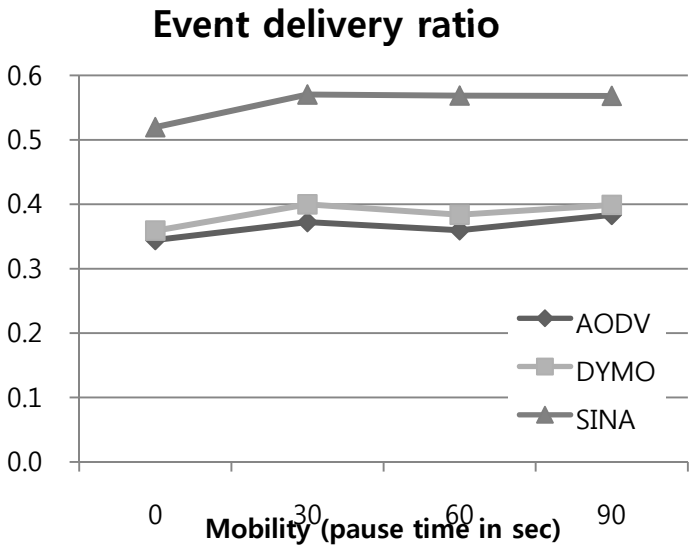
Distributed & application aware discovery finds out interaction chances quickly.





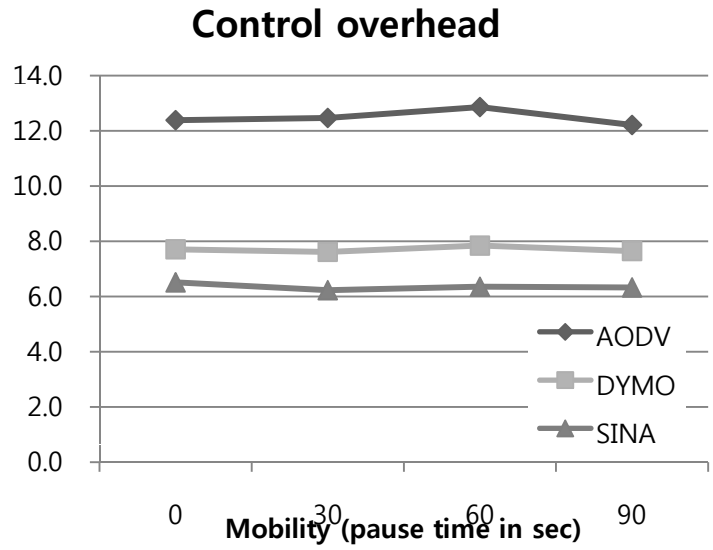
Quick discovery of an interaction chance combined with a network of high delivery ratio result in increased throughput.

Evaluations: PUB/SUB Scenario

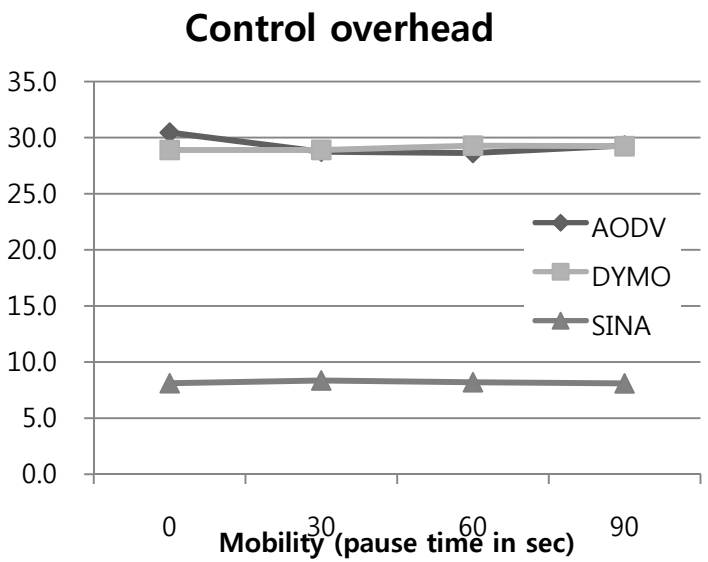


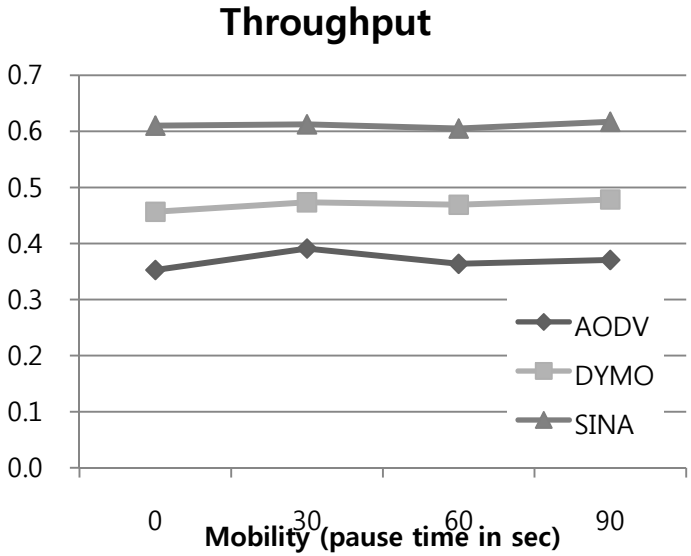
Use of flooding enables the delivery of more events.

An interaction network is effectively reduces the overhead of flooding.



Evaluations: Both scenarios





The proposed architecture works better with more application running in parallel due to cross application aggregation of discovery overhead.

FUTURE RESEARCH ITEMS

Future research items

- Exploitation of advances in radio technologies in interaction network generation and management
  - Radio hierarchy or multi radio
    - E.g. Wi-Fi for interaction network and Bluetooth for control plane to built interaction networks
  - Cognitive radio or software defined radio
- Inter-interaction collaboration
  - Harmonization of demands of (possibly competing) interaction networks
  - Export of information of an interaction network to other interaction networks to reduce overhead