Proactive data replication using semantic information within mobility groups in MANETs

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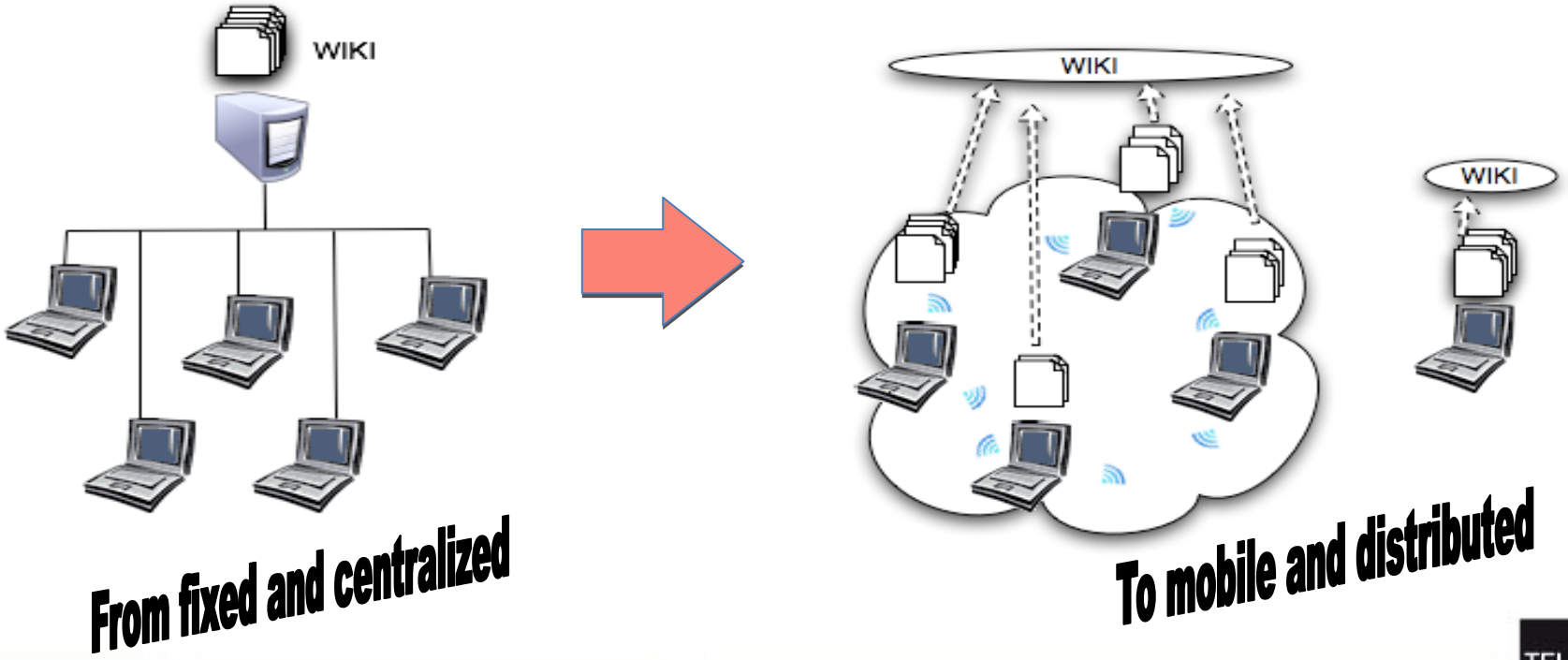
Motivation & context

- **MANET (Mobile Ad-hoc NETwork):**
  - Self configuring network of mobile terminals also acting as routers
- **Network infrastructure may not be present**
  - Too expensive to deploy / to use
  - Travel situation / Unpractical
- **Objective: support data sharing among MANET participants**

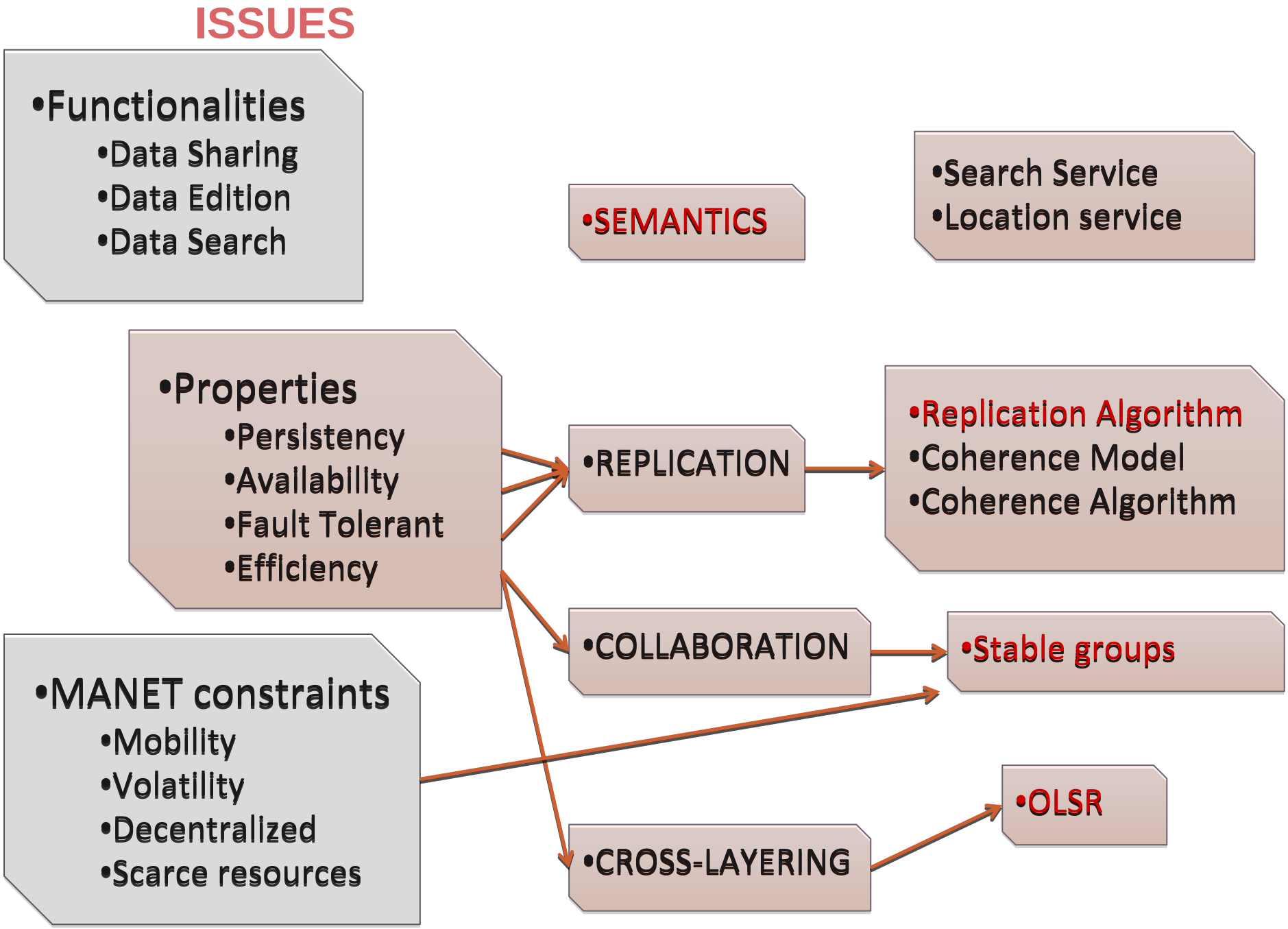
- **Illustrative scenario**
  - In a school,
    - Kids have mobile terminals
    - Collaborative edition of a Wiki
  - Kids leave on a field trip
  - On site
    - They edit the wiki
  - Upon return
    - Modifications are integrated

Context and challenges

- **Challenges:**
  - mobile and volatile terminals,
  - limited capacities (battery, bandwidth),
  - better adapted to P2P than to client/server



ISSUES


•Functionalities
•Data Sharing
•Data Edition
•Data Search
•SEMANTICS
•Search Service
•Location service
•Properties
•Persistency
•Availability
•Fault Tolerant
•Efficiency
•REPLICATION
•Replication Algorithm
•Coherence Model
•Coherence Algorithm
•COLLABORATION
•Stable groups
•MANET constraints
•Mobility
•Volatility
•Decentralized
•Scarce resources
•CROSS-LAYERING
•OLSR

Related work

- **P2P Wiki**
  - Distriwiki
    - 2007, Ball State University, USA
    - No coherence
  - Wooki
    - 2007, Loria, France
    - Large scale with nomadism
  - Swooki
    - 2008, Loria, France
    - Large scale with nomadism
  - Xwiki Concerto
    - 2007, ANR project, France
    - Large scale with nomadism
  - These systems do not address MANET specificities

- **Data sharing for MANET**
  - adHocFS
    - 2003, Inria Rocquencourt, France
    - Distributed unix like file system
    - Ocaml, non available
  - Xmiddle
    - 2002, University College London, UK
    - XML data shared
    - Java, not maintained

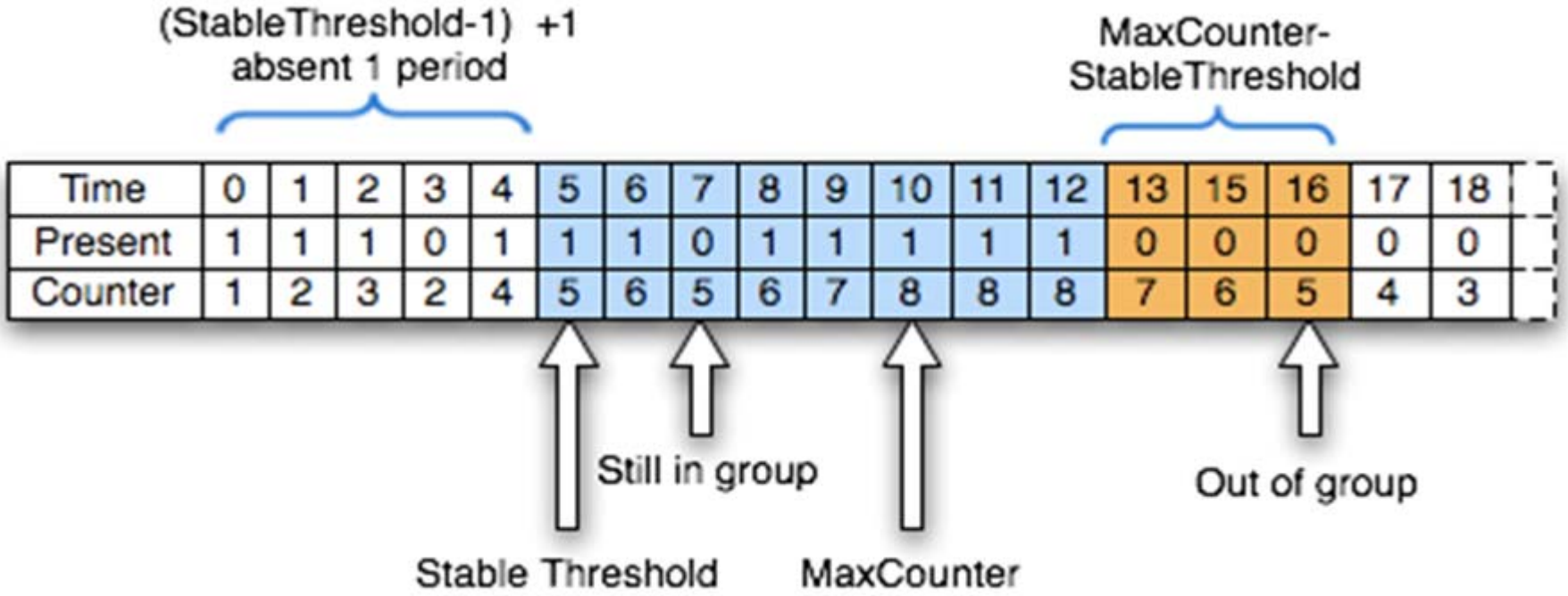
- **Data replication:**
  - work from Hara that is most similar to ours
  - but strong asumptions on data access frequency and patterns (suited to sensor networks with cyclic data exchanges)

- **While they suit their purposes these systems do not fulfil our requirements**

Proposal: Stable Group Creation

- **Cross-layering: routing table from OLSR**
- **Based on past presence**
  - Peer A looks at routing table
  - Associates counter to each other peer P
  - If P present : counter increases, else counter decreases
  - If counter>stableTreshold, P is in stable neighbour

    Here: StableThreshold=5. maxCounter = 8



Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	15	16	17	18
Present	1	1	1	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0
Counter	1	2	3	2	4	5	6	5	6	7	8	8	8	7	6	5	4	3

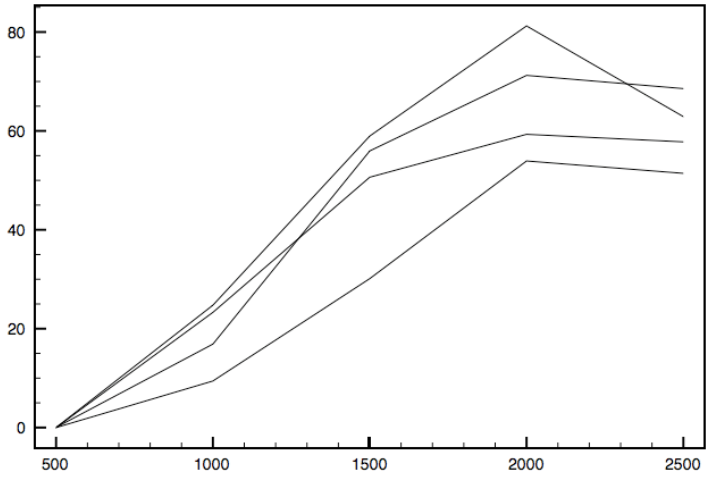
How does it compare to existing algorithms?

- **GPS based**
  - Predict accurate trajectory: computation heavy
  - Centralized: scales?
  - GPS dependent
- **Multiple route based**
  - N broadcast messages to advertise neighbours: scales?
  - Must maintain graph
- **Distance based**
  - Based on routing graph => 0 message if proactive routing
  - Does not deal with disconnections

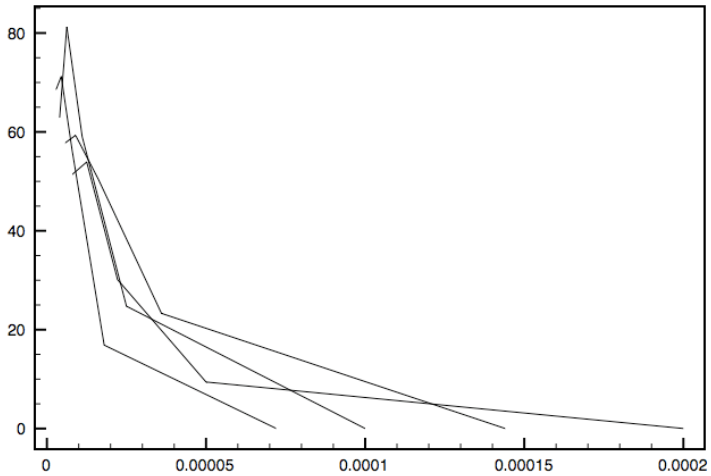
- **Our proposal**
  - 0 message exchanged
  - Scales
    - As much as OLSR
    - No extra messages
    - Simple computation
  - Thresholds depend on the network dynamicity
  - OLSR dependent
    - Would work with other proactive routing protocol

Evaluation

- **Nb message = 0**
- **We evaluate accuracy, in NS3**
  - Create simulated mobility group MBG: nodes sticking together
  - Execute algorithm to create group SNG
  - Accuracy: do the 2 groups match?
- **Observation:**
  - Accuracy = F(size of simulated area, node density)
  - Small area: sustained connectivity even if peers not walking together
  - We detect all the prearranged neighbours
  - If density high, we detect nodes that are not part of the MBG (because of high connectivity)



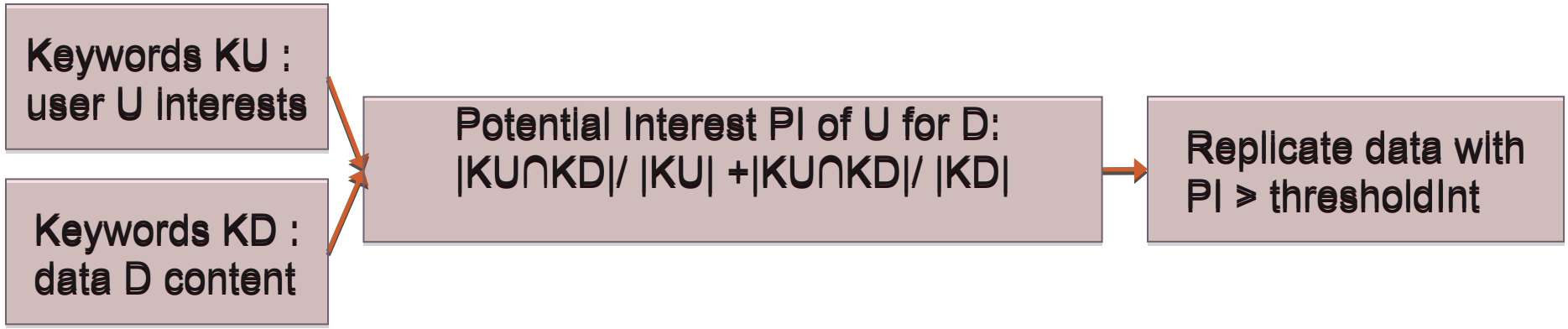
X= area length, Y=accuracy



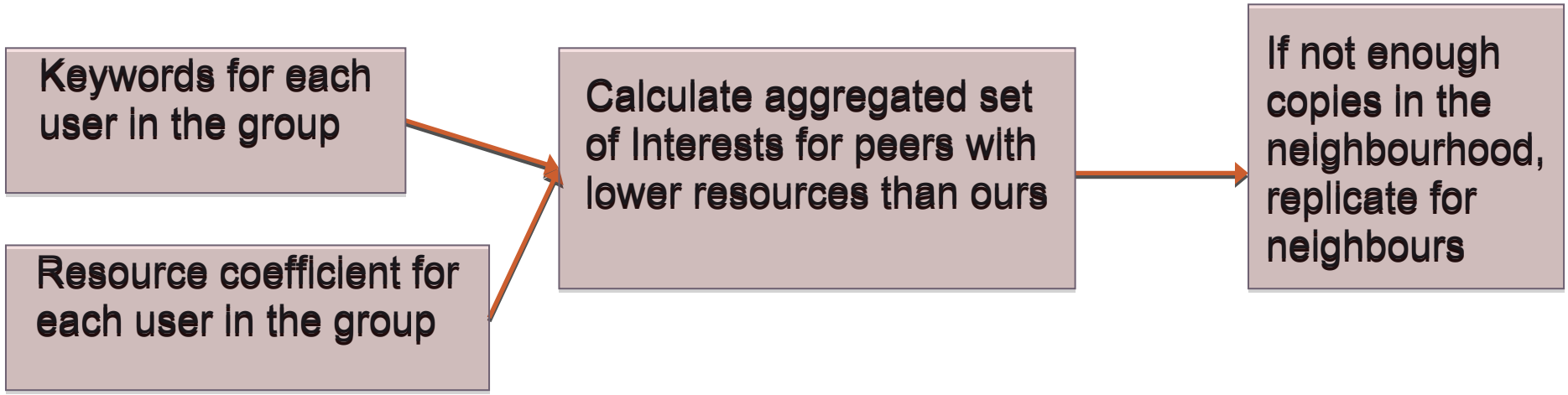
X=node density, Y=accuracy

Proposal: Collaborative Data Replication (1/2)

Match user to data, based on interests



In a stable group, replicate for neighbours



Proposal: Collaborative Data Replication (2/2)

- **Within a stable neighbourhood**
  - Interests and resource coefficient are exchanged
  - Aggregated interests are computed

- **When a new data is created**
  - It is advertised through the network with its keywords
  - 2 phases algorithm:
    - Peers compute their Potential Aggregated Interest PAI
      - If PAI > threshold, peers replicate the data
    - If not enough replicas
      - Other replicas are created in the neighbourhood

Evaluation

- **Reasonable messages cost: if size of network=M, size of stable group=N**
  - N(N-1): to exchange interest & resources info within stable group
  - M-1 msg: (or 1 broadcast) to advertize creation of data
  - N(K+1) msg: if K replicas created within a stable group

- **The algorithms were tested in the prototype of the IST-POPEYE project.**

- **Difficulties to proceed with simulations**
  - Replay traces?
    - Traces from distributed files system: do not log semantics
    - Traces of wiki (eg: wikipedia dump): do not log read accesses
  - Simulate random accesses?
    - Proposal based on predicting non random accesses
  - Simulate non random accesses?
    - Use interests & metadata to decide which data the simulated user accesses
    - Done by our system
    - Biaised results
  - Solution: collect our own traces ?

Proposal - other issues not adressed in this paper

- **Coherency**
  - Open/close within reach, eventual consistency overall
  - Coherency algorithm: commutative replicated data type Treedoc
    - Designing a commutative replicated data type for cooperative editing system, N. Preguiça and M. Shapiro, 2008
- **Interests learning**
  - Based on access patterns
  - Memorize each time a keyword is accessed
  - Keywords accessed often become new interests
- **Search service**
  - Keyword based: associates set of keyword to data ID
  - Fully replicated on OLSR MPR (cross-layering)
- **Location service**
  - Associated data ID to host ID
  - Fully replicated on OLSR MPR (cross-layering)

Conclusion

- **We have proposed:**
  - An algorithm to build stable neighbourhoods based on past stability, rather than on proximity.
  - The use of semantic information to manage data and calculate
    - interests and do proactive replication.
    - aggregated interests and do collaborative replication.
  - The use of accesses patterns to automatically gather semantic information:
    - Automatic learning is not newbut we have not found any use of it in data caching.
- **Ongoing work**
  - Algorithms validation
    - Test on prototype
    - Simulation with NS3
  - Implementation
    - A nomadic wiki taking into account the specificities of MANETs
    - On top of Transhumance
      - Middleware for MANet, available on sourceforge
      - Built on top of OLSR

Transhumance middleware for MANETs

- **Supported by the ANR (French national Research Agency)**
  - Partners: Orange Labs, Thales Communications, 3iE, CODETIC, Telecom ParisTech
- **Prototyped on Nokia 770 under Linux OS**
- **Source code**

  http://sourceforge.net/projects/transhumance/
- **More (including video clip of demo) at**

  http://www.infres.telecom-paristech.fr.fr/~demeure/TRANSHUMANCE

Thank you ! Questions ?

http://www.telecom-paristech.fr/~demeure/TRANSHUMANCE