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Simple, Time Aware, Distributed Community Detection System for Pocket Switched Networks with Data Forwarding Capabilities

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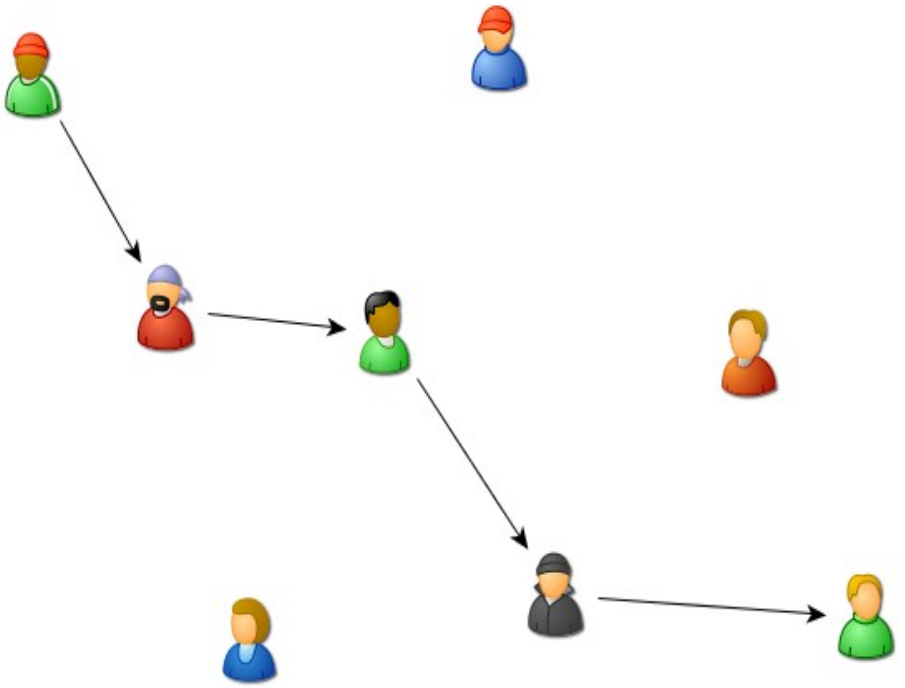
Overview

- A Pocket Switched Network (PSN) is a type of Mobile ad-hoc network (MANET) formed by devices which humans carry.
- Investigation:
  - What are the issues?
  - What can be done to improve:
    - Data Latency and delivery rates?
    - Routing overheads?
- Present:
  - Simple Time Aware Routing (STAR) for PSNs.

Pocket Switched Networks

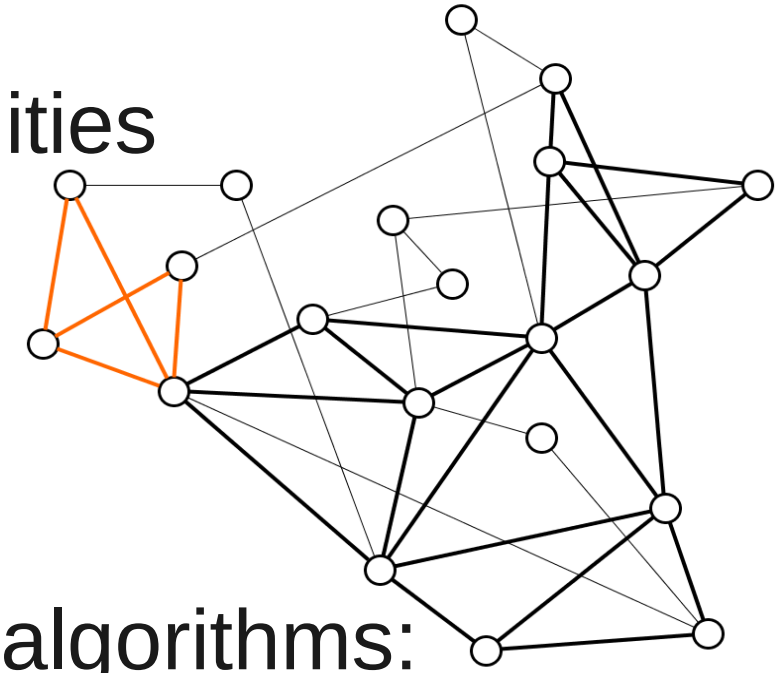
- Wireless network hardware carried by people.
- Complete Uniformity:
  - No special consideration given to static devices. Mobile nodes, static routers and cell towers treated the same.
- Technology Assumptions:
  - Bluetooth – Approx 10m range. Slow due to the security implementation and scanning phases of current of devices.
  - WiFi – Longer range, greater power usage, 802.11s ad-hoc standard in draft (preview in Linux 2.6.26).

What are the issues with PSNs?



- People are mobile.
- Time to data delivery.
- Are PSNs suitable for:
  - Text?
  - Voice?
  - Video?
- Can existing technology be adapted?
- There are other fundamental issues not discussed here such as security and power.

Communities: Improving Data Delivery



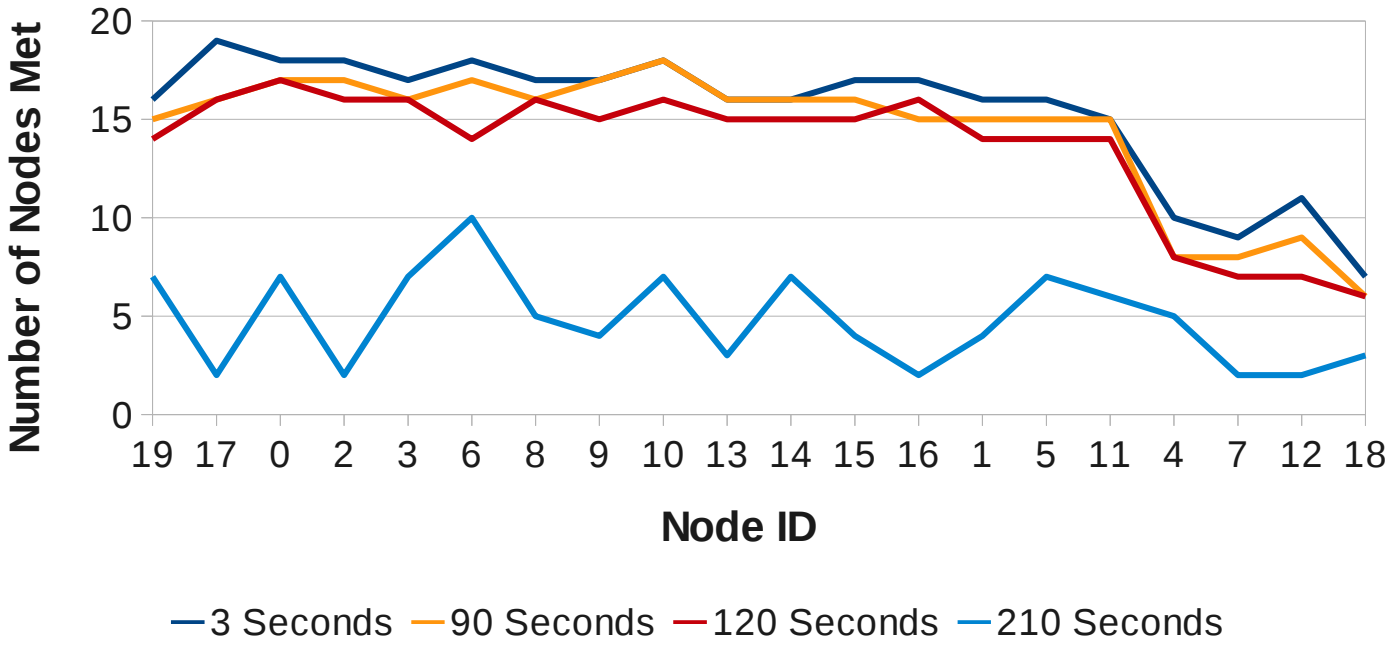
- The identification of communities in a MANET can reduce the amount of traffic created when forwarding messages [Hui 2007].
- Many distributed community algorithms:
  - SIMPLE
  - K-Clique
- Partition nodes into subsets based on some measure of **encounters**.

How Do We Measure Encounters?

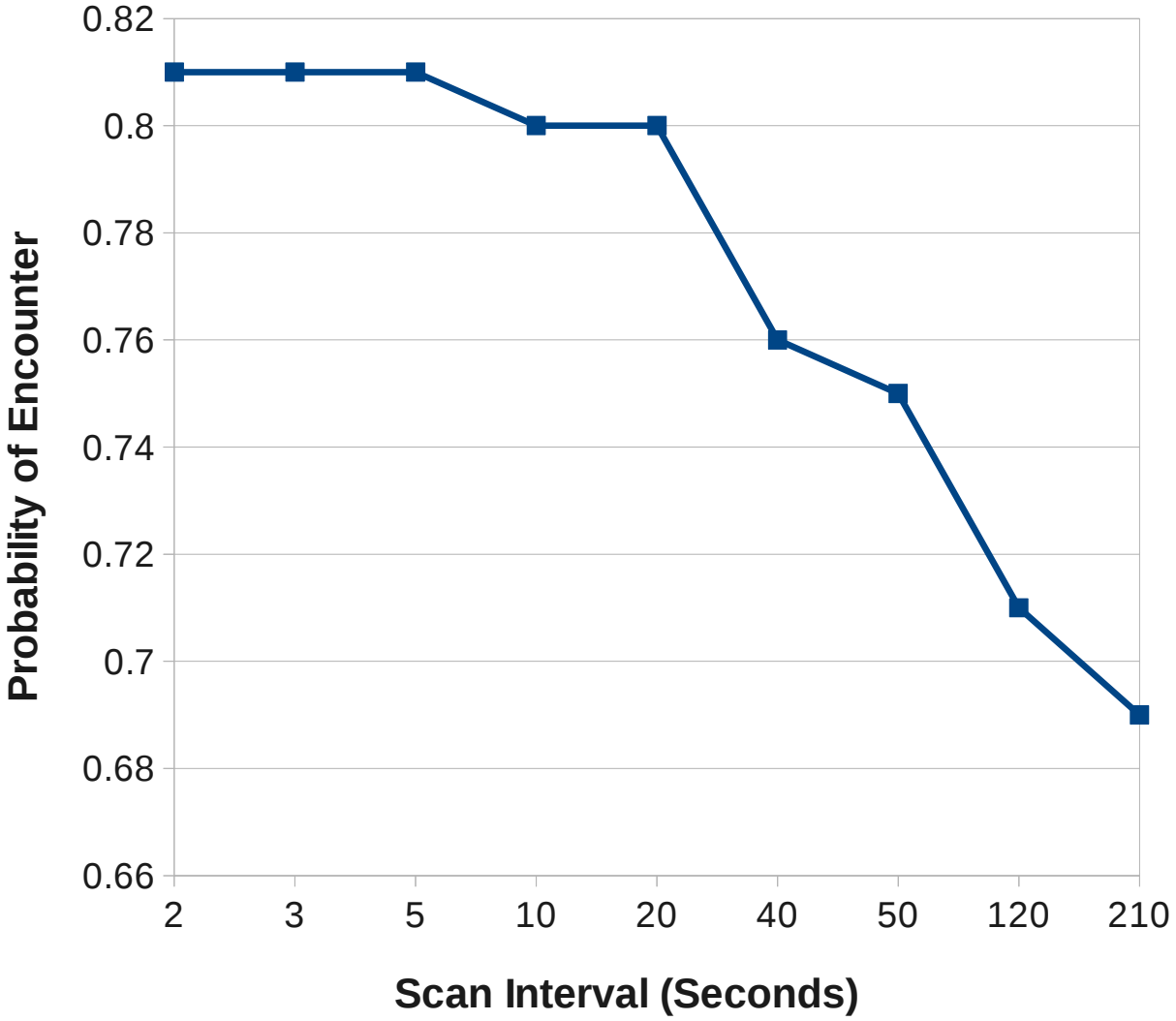
1)Total connection time.

2)Counting the times devices come into contact.

- Frequency of scans for neighbours affect the number of encountered nodes whilst mobile.



Frequency of neighbour scans affect the probability of a specific encounter whilst mobile



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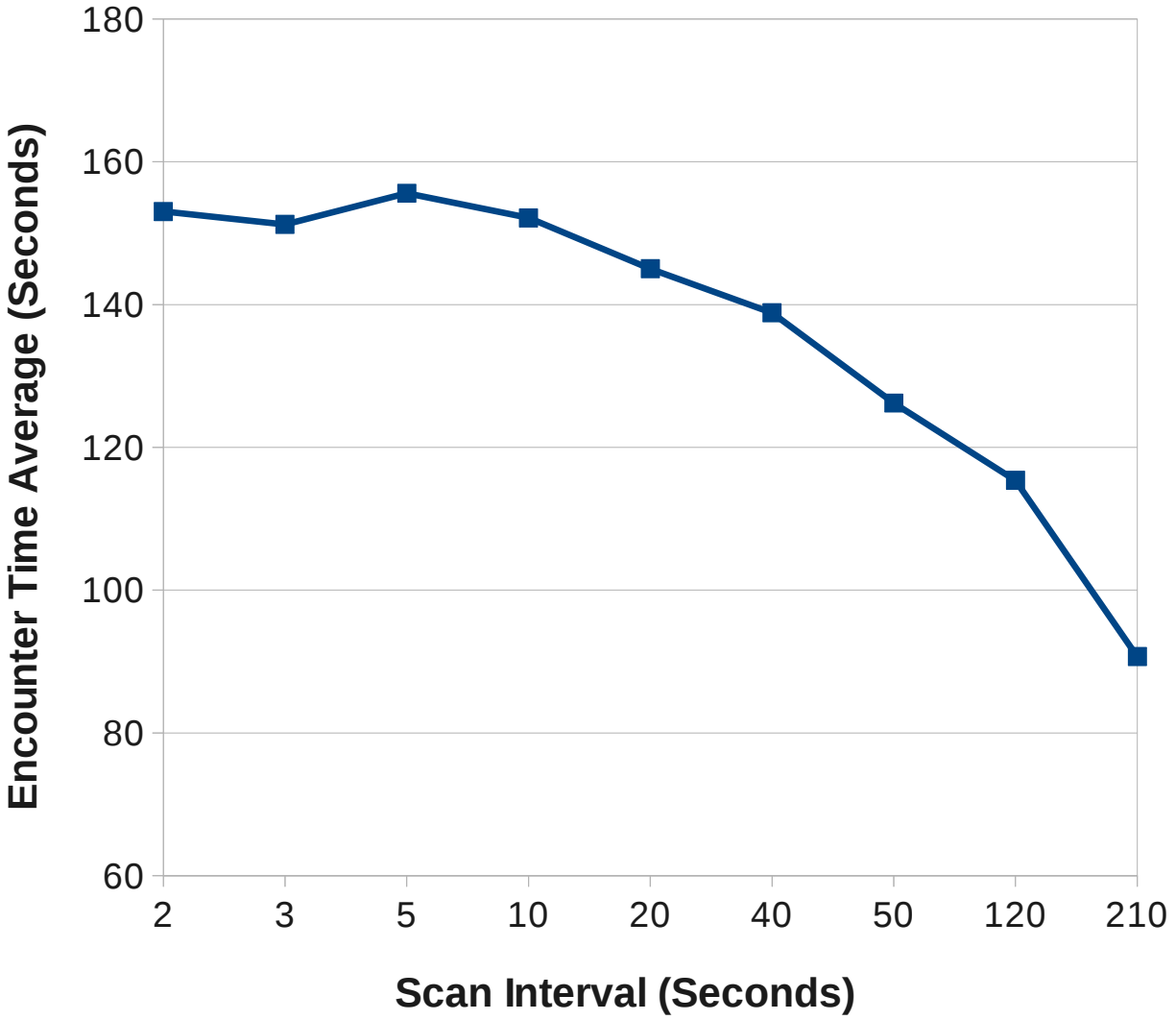
Frequency of neighbour scans also affects the total time devices are in contact whilst mobile.



How We Measure Encounters is Important

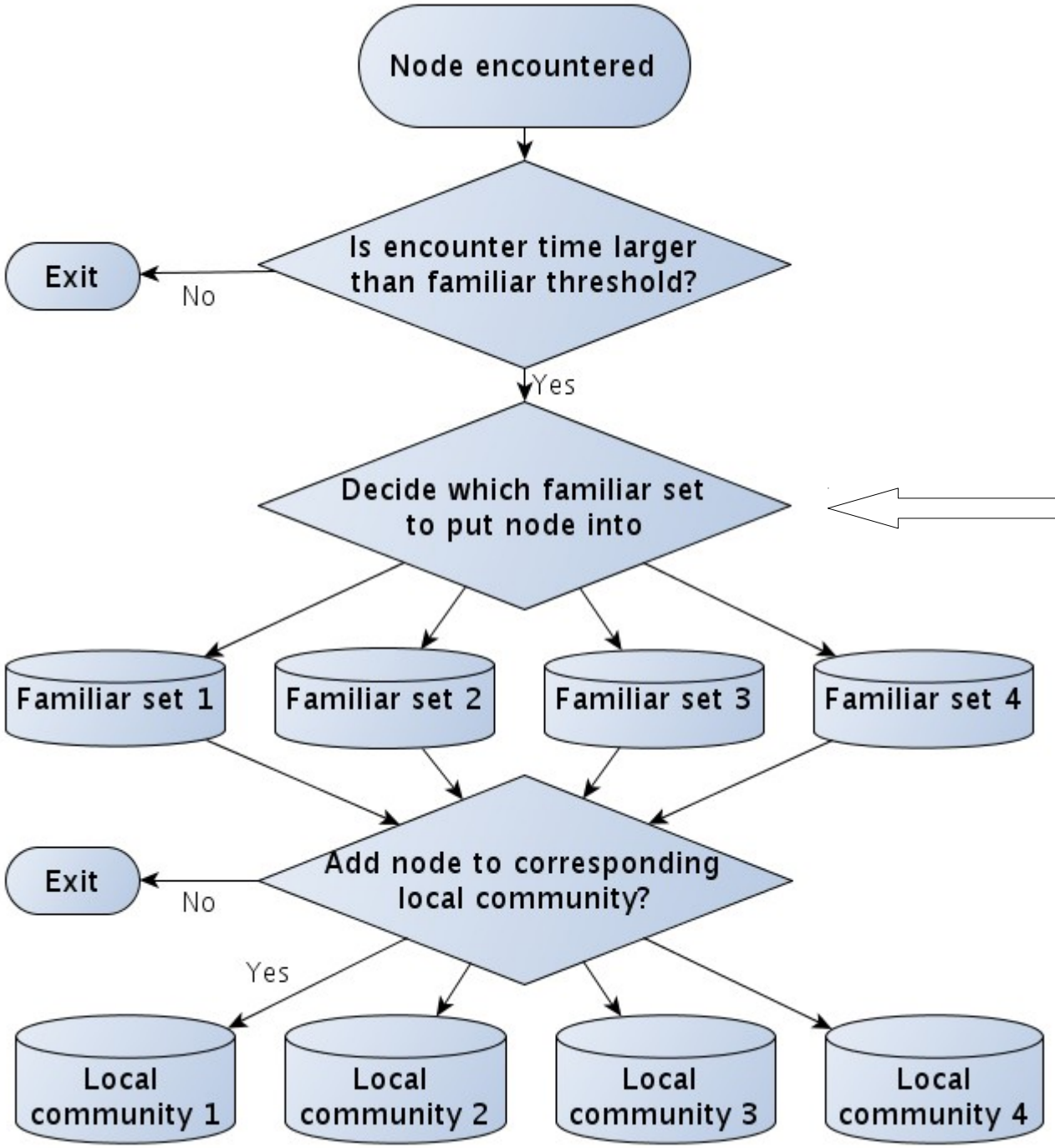
- Not enough to just say “mobile”.
  - Encounter statistics are also affected by movement patterns.
  - The Working Day Movement model (WDM) [Ekman 2008] has been shown to be less susceptible to scanning intervals as nodes exhibit more continuous co-location [Keraenen 2009].
- People have a home location where they may spend a lot of time.
- Patterns are repeated on a day to day or week to week basis [Henderson 2008].

Simple Time Aware Routing (STAR)

- Proactive routing protocol for data transfer between communities.
- Distributed community detection, based on encounters between devices at different times.
- Certain times of the day have their own discrete communities.
  - Does calculating communities for different time periods improve message delivery?
- Based on work by the Haggle project in Cambridge and the SIMPLE Community Detection Algorithm [Hui 2007].

STAR - Algorithm Introduction

- Each node maintains 4 copies of the following:
  - **Familiar Set**: Set of nodes which are connected for a continuous amount of time which exceeds a certain threshold.
  - **Local Community**: Nodes from the familiar set selected by the SIMPLE Community Detection Algorithm [Hui 2007].
- Each combination of Familiar Set and Local Community represents the same 6 hour period for all days.



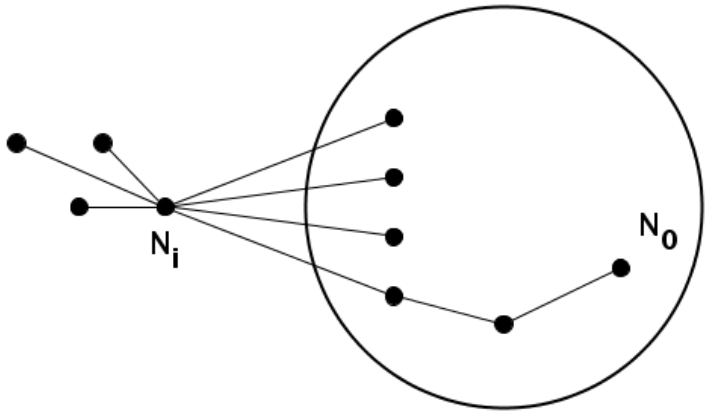
Which Bin?

Very simple, encounter Before:

- 6am?
  - Familiar Set 1
- 12pm?
  - Familiar Set 2
- 6pm?
  - Familiar Set 3
- 12am?
  - Familiar Set 4

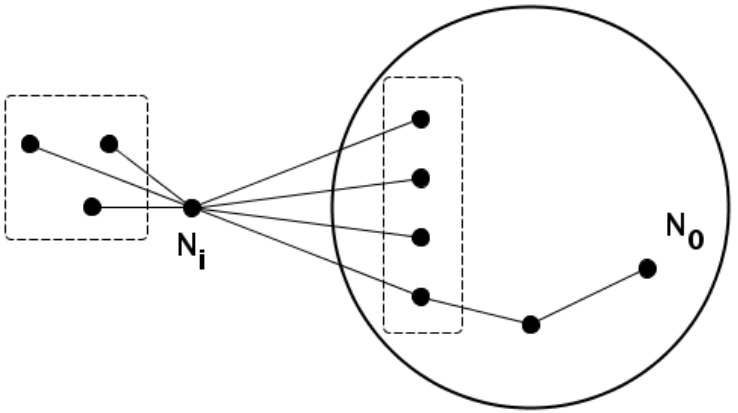
Local Community Joining

a)



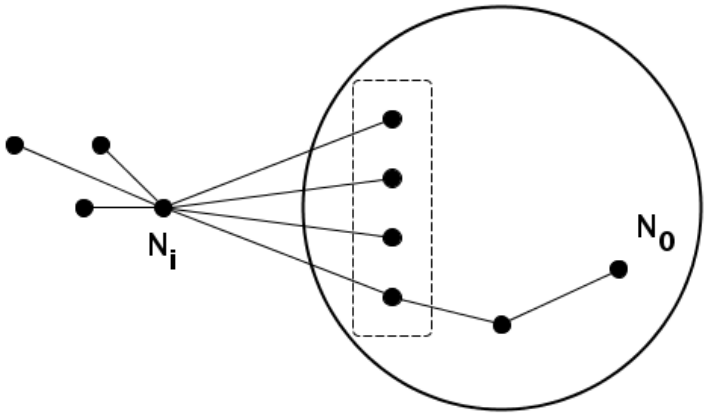
We want to see whether N_i should be added to C_0

b)



So we first count to the number of vertices in N_i's familiar set = $\left(\square + \square\right)$

c)



Then we count the number of vertices in both N_i's familiar set and also in the local community of N_0 = $\square$

d)

And we admit N_i to C_0 if

$\square > \left(\square + \square\right) \times \lambda$

SIMPLE as described in [Hui 2007]

SIMPLE Includes Merging of Communities

- Merge If:

  The number of nodes overlapping in both Local Communities, is higher than the union of both Local Communities multiplied by the Merging Threshold (γ).

- Merging mechanism:

  Taking a set union of both peers Local Communities.

Data Forwarding

- Very simple, single hop routing.
- No message duplication.
- Single message “delegate” within community.

```
for each EncounteredNode test
    if EncounteredNode is destination
        DeliverMessage(EncounteredNode)
    else if LocalCommunityOf(EncounteredNode) contains
      destination and LocalCommunityOf(CurrentNode)
       does not contain destination then
        SetAsDelegate(EncounteredNode);
    end
end
```

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Do Discrete Local Community Sets Improve Data Delivery?

	STAR	SIMPLE
Simulation Time (Seconds)	604800	604800
Messages Created	50587	50587
Messages Started	5532.4	6521
Messages Relayed	5475.8	6449.4
Messages Aborted	56.6	71.6
Messages Removed	5397.2	6314.6
Messages Delivered	3184.6	2175.8
Delivery Probability	0.063	0.043
Overhead Ratio	0.71852	1.9635
Latency Avg	170909	154706
Hopcount Avg	1.0176	1.0357
Buffertime Avg	180421	173824

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How Different Time Thresholds can Affect Data Routing in STAR

- Time threshold with which to promote peers to the Familiar Set changes data delivery statistics

	3 Seconds	10 Seconds	20 Seconds
Messages Started	6927.8	5532.4	4747.2
Messages Relayed	6849.8	5475.8	4704.6
Messages Aborted	78	56.6	42.6
Messages Removed	6618.4	5397.2	4688.6
Messages Delivered	1826	3184.6	3945.6
Delivery Probability	0.0361	0.06294	0.07798
Overhead Ratio	2.75096	0.71852	0.19234
Latency Avg	152442	170910	178328
Hopcount Avg	1.0593	1.0176	1.00444
Buffertime Avg	165860	180421	182206

Future Work on STAR

- **Adaptive Scanning:** Change familiar threshold and scanning intervals depending on time, location, speed.
- **Adaptive sets:** Ageing and removal of contacts from a single set of familiar and local communities.
- **Multi-Role nodes:** The boundary set of local communities could be used for data forwarding.
- **Probabilistic data forwarding:** Forward data between clusters.
- Implementation and packet size optimisation.

Conclusions

- Defining discrete communities can improve data delivery in Pocket Switched Networks.
- Much more work to do, for example:
  - Make the algorithm adaptable by ageing encounters.
  - Use different scanning intervals at different times.
- Can Pocket Switched Network algorithms be implemented into Bluetooth?

Questions?