Name-Based Replication Priorities in Disaster Cases

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Important in Case of Disaster

- Trapped people want to communicate with anyone – *not necessarily their friends and family only.*
- First responders want to distribute important information to the general public – *not to a specific person only.*

Multi-recipient transmission is essential.

- There are many rescue teams in several different areas, each of which needs to communicate with people *within this area – not necessarily elsewhere*.
- Messages to groups of people within some area are important for some amount of time – *not forever*.

Communication after disasters needs to be bounded in ***time and space***.

Important in Case of Disaster

- A *SOS* message calling for help, or a message from the fire brigade regarding first aid is more important that *"chit chatting"* or ads

  Prioritisation of what to transfer/disseminate becomes of vital importance.

- Vital parts and devices of the network fail, therefore, the traditional end-to-end, IP-based intrastructure cannot be depended upon.

  Communication needs to be based on ***ad hoc, delay- and disruption-tolerant*** *communications*.

Building *Name-Based Replication* on DTN Foundations

- We associate each message generated in an infrastructureless, disaster scenario with a *Name and some attributes*.
- We exploit the information that can be exposed in a content name and propose *Name-Based Replication*, where:
  - Nodes store-carry-and-forward messages:
    - with specific time and space limits, and
    - with priorities as to what to replicate
  - Time-space limits, as well as priorities are included within the message's name (or attributes field)

- Most DTN works focus on *point-to-point* communications – *not on multirecipient transmission.*
- In DTN nodes have to look into the message contents to make decisions on whether to replicate or not – *with NREP decisions are made based on the name.*
- The ultimate target is to deliver a message to some specific destination node, or Internet access point and want to optimise that delivery.
- IP-based DTN protocols are *destination-focused* and *content-agnostic*.

NREP Design Challenges

- Design Challenges
  - Which parameters differentiate between types of messages?
    - E.g., Time bounds? Space bounds? Message type (SOS vs chat)?
  - What's the structure of a *Name*?
    - Flat or hierarchical?
  - Which of them should be included in the name and which as attributes?
    - What is the most important and what is less important?
- Naming Design and Parameters that influence message differentiation
  - *Type* of message: SOS, First Responders (Disaster Management), chat
  - The *geographical reach* of the message: `radius/district/`
  - The *lifetime* of the content: `temporal-validity`

NREP Design Choices

- Design Choices
  1. *Hierarchical* is working better than flat in this case
     - `Emergency/SOS` or `Warning/Shelter`
  2. The *name* shows the priority
     - `Emergency, Warning, chat`
  3. Time and space limits are kept as *attributes*,
     - `boroughX/ttl=2h, radius=Xkm/ttl=Yhours`
  4. User-defined priorities kept as attributes too
     - user-perceived importance, e.g., from 1-5 how useful/important was the message
- Example Priorities and Namespaces
  - High Priority
    - From first responders: `Warning/DangerousArea` – spreads everywhere, does not expire
    - From civilians: `SOS` – spreads locally, expires quickly (to avoid spreading after help received)
  - Medium Priority
    - From civilians: `Info/Shelter, Info/Food` – spreads locally, expires if needed after a while (e.g., food will run out)
  - Low Priority
    - From civilians: `Chat` – spreads locally or everywhere, expires soon

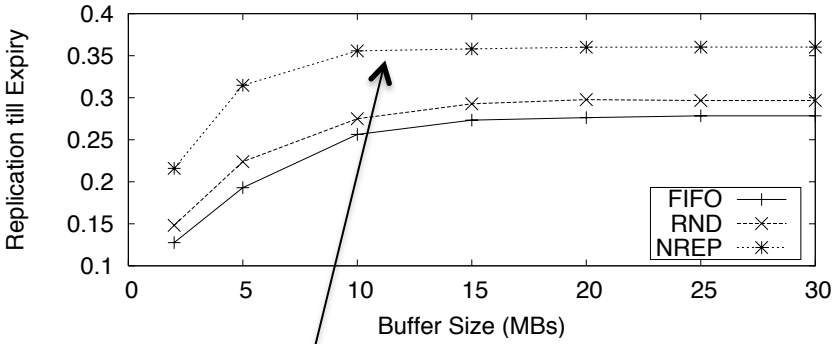
NREP Design Advantages

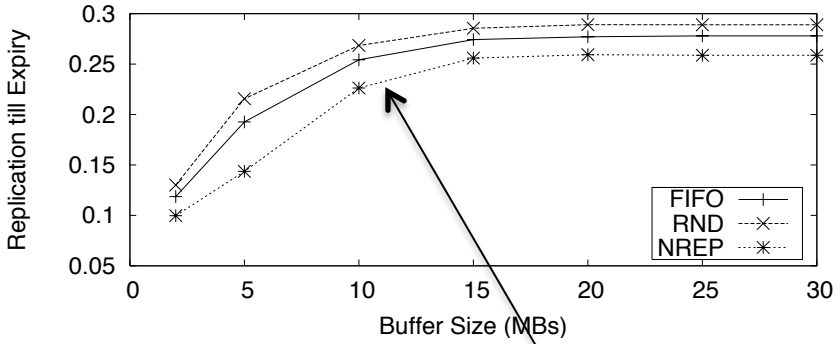
- Hierarchical design:
  - content can be filtered according to a longest prefix match
  - Namespace has a globally understood prioritisation value
- Namespace cannot be manipulated/hijacked by individual users
  - This depends on the application, so cannot be individually set
  - To avoid misuse, important messages are kept short, e.g., SOS is just a few characters so cannot be used for chat
- Attributes are set by sender, but can be modified by individual users/ encounters
- Low energy devices have the option to only look at the name and make decisions based only on that
- More powerful devices (e.g., base-stations) can look further at the attributes
- Users can exchange messages based on their energy levels
    - Receive only Priority: `High/Emergency`, Space: `LclBorough`, Temp-Val: `ExpSoon`

Performance Evaluation

- We use the ONE Simulator and simulate 12h of post-disaster case
- Two main scenarios:
  - First scenario shows importance of prioritisation (but is not very realistic)
    - 16 km^2 area, around 500 nodes
  - Second scenario shows what happens in reality
    - 1 km^2 area, around 300 nodes
- High Priority messages get generated *less frequently - expire later*
- Low Priority messages get generated *more frequently - expire soon*
- Metrics:
  - Replication till Expiry: the longer a message lives the higher the potential to inform more users
  - Replications per message (and per class): indirectly shows the number of nodes that received a message
- Replication Algorithms: NREP, FIFO, RND, SAF (Smaller Area First)

Scenario I
Focus: Prioritisation w/o time, space limits





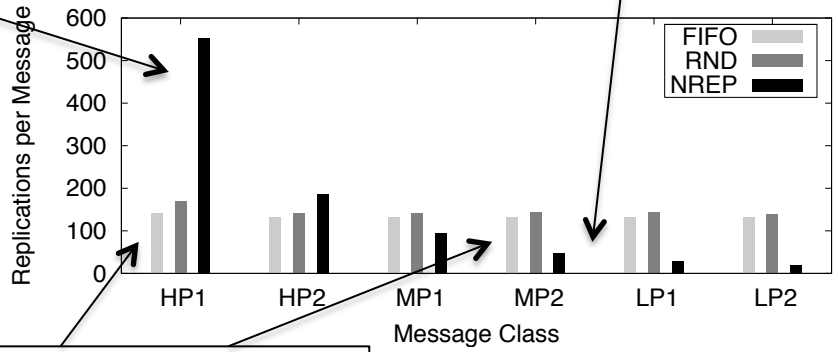
High Priority (HP) Class

Low Priority (LP) Class

NREP: More HP messages

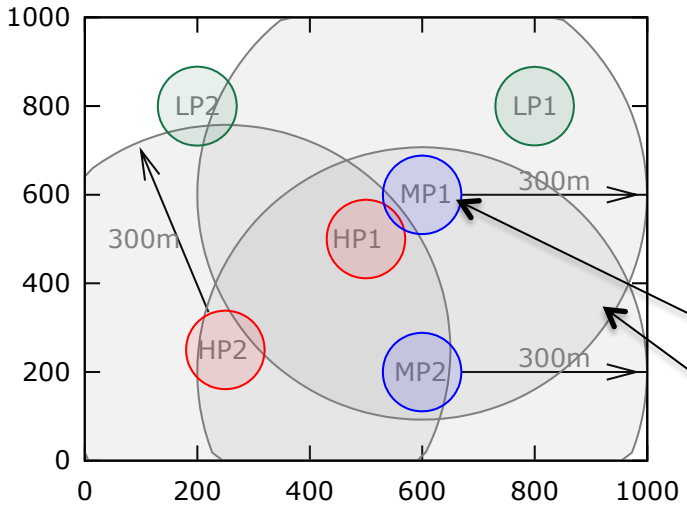
NREP: Less LP messages

You're equally likely to receive an important `warning` message or relay a random `chat` message between two users



FIFO, RND: No differentiation

Scenario II
Focus: Prioritisation w/ time, space



Disaster Area

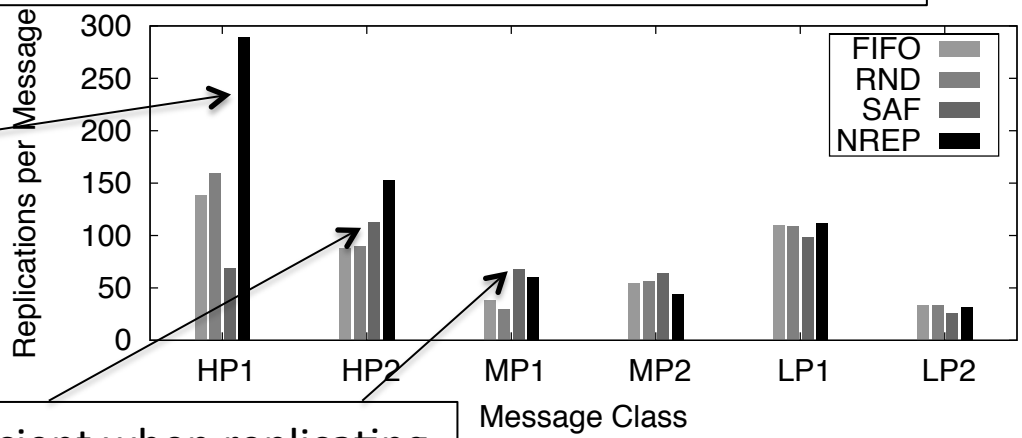
- Area: 1 km^2, 300 nodes
- 6 Message Classes: 2 HP, 2 MP, 2 LP
- The higher the priority the longer the TTL and the Generation Interval
- *Target: the higher the priority the more the nodes a message should reach*

Messages generated in small circles

Messages replicate in large circles
(where no circles, messages replicate everywhere)

NREP reaches ~95% of nodes for HP1

NREP keeps more HP msgs in the nodes' buffers and replicates more of these msgs upon encounters.



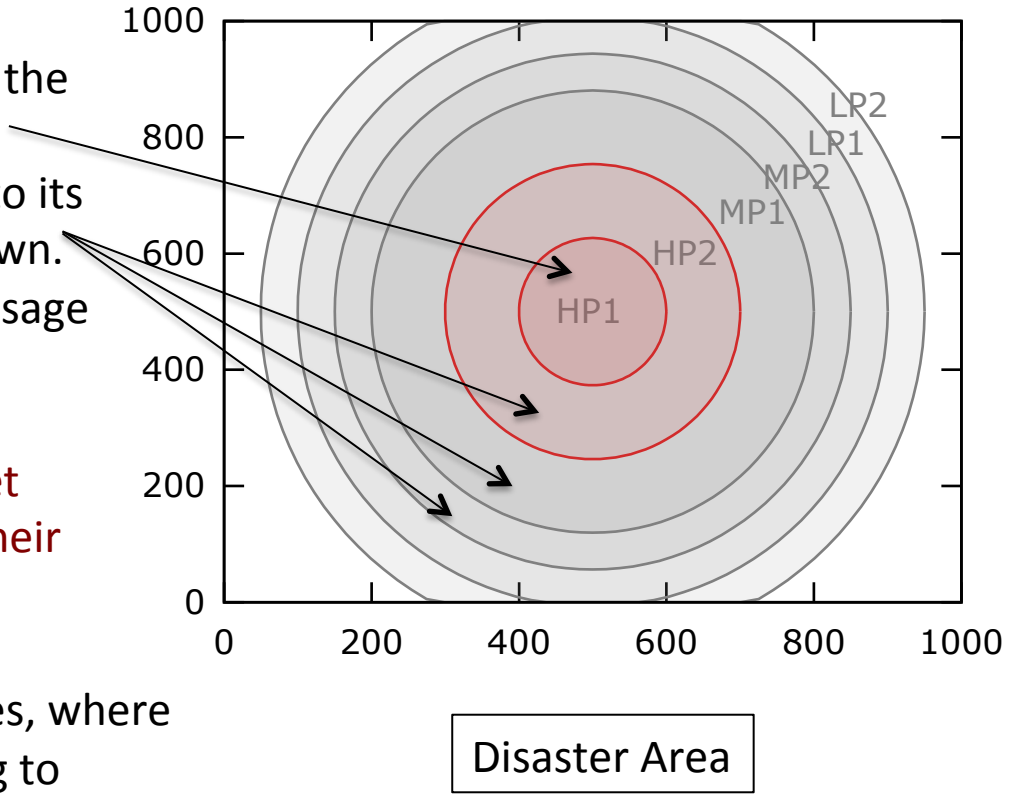
SAF is more efficient when replicating in small areas (MP1, MP2, HP2).

Scenario II
Focus: Prioritisation w/ overlapping space

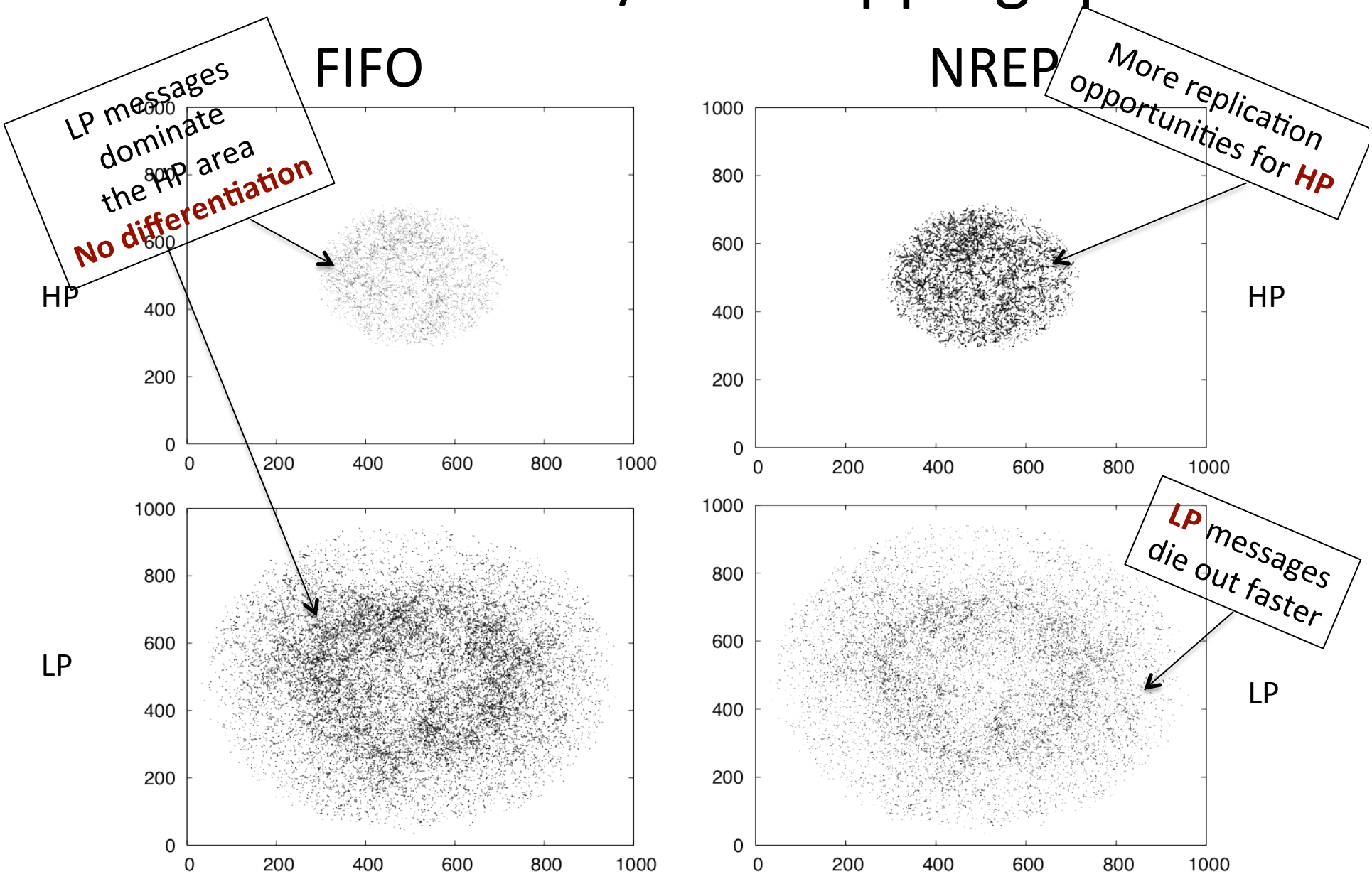
- All messages generated within the HP1 small circle.
- Each message class replicates to its corresponding larger circle as shown.
- The lower the priority of a message class the further it spreads.

Intention: show how messages get replicated in space according to their priority.

- We capture the *x,y* co-ordinates, where messages get replicated according to their priority class.



Prioritisation w/ overlapping space



Conclusions

- NREP looks promising for the management of emergency situations
- *Communication Resilience* is important in conjunction with (and not in contrast to) *Network Resilience*
- Ad hoc communication is essential to achieve Communication Resilience and realise NREP
- ICN should work together with DTN: these are two complementary areas – not conflicting ones
- Issues for future work:
  - **Time-Space Limits:** There is a tradeoff between resource consumption and time-space limits: what's the best deal
  - **Priorities:** smaller-area first or larger-area first?

Thanks!
Questions?

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