

"A Message Ferrying Approach for Data Delivery in Sparse Mobile Ad Hoc Networks"

Wenrui Zhao, Mostofa Ammar, Ellen Zegura

Seminar Number One:

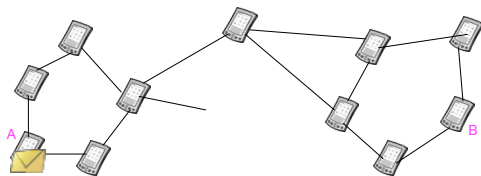
Neal Lathia
LJ Mendoza
Roberto Rosetti
John Tang



Contents

- DTN overview
- Message Ferrying
- Evaluation
- Critique
- Related Work

DTN



DTN Previous Work

- Mobility Assisted
 - "Store-carry-forward" paradigm
 - Reactive schemes
 - Mobility inherent in devices (i.e. animals)
 - Wait for mobility!
 - Example: Epidemic routing
 - Proactive schemes
 - Nodes move themselves

Message Ferrying

Main Concepts

- Proactive Scheme
- Provides a high level view of connecting self contained clusters
- Two main Components
 - 1. Regular mobile nodes
 - Mobile
 - Have "assigned tasks" that require mobility
 - Limited resources
 - 2. Message Ferry
 - Responsible for carrying data between regular nodes
 - Paper assumes: no constraints on resources

Main Concepts



- Messages
 - Nodes have a message buffer
 - Drop message when full
 - Timeout value
 - Drop message when expired
- Introduce *non-randomness*
 - Node initiated Message Ferrying (NIMF)
 - Ferry initiated Message Ferrying (FIMF)

Assumptions



- Sparse Networks
- Only single ferry
- Location Awareness
- Ferries have unlimited resources
- Mobility
 - Task-oriented
 - Messaging-oriented



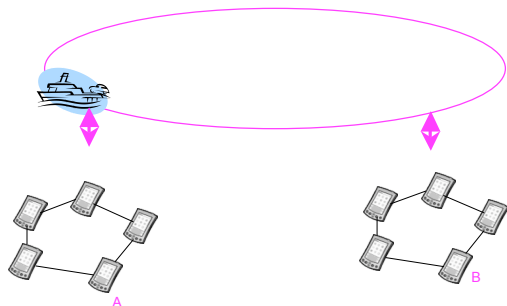
NIMF Node Initiated Message Ferrying

NIMF



- Assume:
 - Ferry on pre determined route
 - Nodes know this route
- Messaging:
 - Nodes moves to known ferry route
 - Hierarchy

NIMF



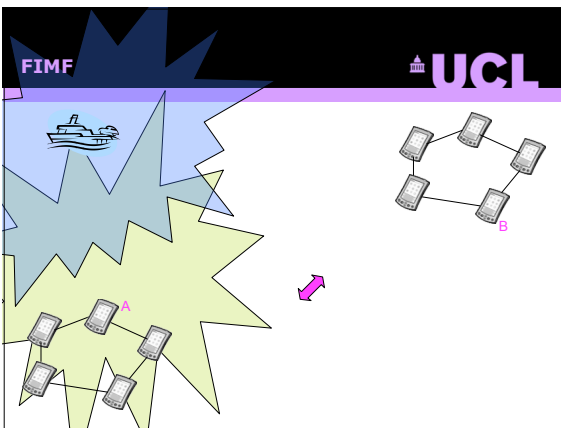
NODE Trajectory Control: Goals



- Determines when a node should proactively move to meet a ferry.
 - a.) Reduce negative impact on assigned tasks
 - Work Time Percentage (WTP) above threshold
 - b.) Minimise message drops (Buffer/Delay)
 - Drop rate above some threshold

FIMF Ferry Initiated Message Ferrying


- Assume
 - Ferry runs around like a "messenger boy"
- Messaging:
 - Ferry moves to node
 - Long Range radio to setup meet
 - Short Range radio for message transfers




- Request service from Ferry
- Two messages
 - SERVICE_REQUEST
 - LOCATION_UPDATE
- Use Long Range Radio
- Goals:
 - Consider energy constraints
 - Minimise message drops

- Goal: minimise message drops
- Ferry Route problem
 - Find the route that minimises the message drop rate
 - NP-hard
- Evaluate 2 Heuristics:
 - Nearest Neighbour (NN)
 - Greedy decision
 - Traffic Aware (TA)
 - Considers location & message drop information


Evaluation Metrics & Methodology

Metrics 

- **Communication**
 - Short range:
 - 802.11 DCF as MAC layer
 - 250m transmission range
 - 0.282W transmit power
 - Long range:
 - Data transmission no loss or delay
 - Transmit power d^k where d =distance & $k=4$


Metrics 

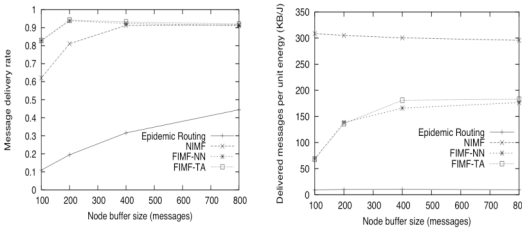
- **Nodes**
 - 40 nodes in 5000m²
 - 25 sources → send msg every 20s.
 - Message size = 500 bytes
 - Timeout = 8000s.
 - Movement: random-waypoint model, 5m/s, 50s. pause time
 - Node buffer size = 400 msg
- **Ferry**
 - Single ferry, 15m/s speed

Metrics 

Scheme	Parameter	Value
NIMF	WTP threshold (ω)	0.9
FIMF	Transmission range of nodes' long range radio (R_l)	2000
	Distance threshold for request transmission (γ)	1800
	NMR threshold (λ)	0.001
Both	Avg time between a node's visits with the ferry (α)	1000
	Message drop threshold (β)	0.3


Table 1: Default parameter settings

Node buffer size 




(a) Message delivery rate

(c) Delivered messages per unit energy

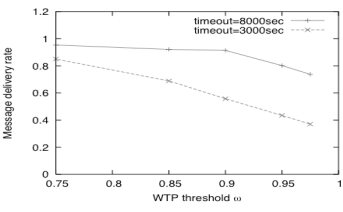
Node mobility 

- Random-waypoint model (RW)
- Limited random-waypoint model (LRW)
- Area-based model (AB)

Mobility Model (speed)	Scheme	Delivery Rate	Delay (sec)	Energy efficiency (KB/J)
Random Waypoint (0 - 10m/s)	NIMF	0.953	3490	306
	FIMF	0.938	3530	172
Limited Random Waypoint (0 - 10m/s)	ER	0.437	1039	10
	NIMF	0.893	3918	289
Area Based (0 - 10m/s)	FIMF	0.842	4145	129
	ER	0.127	2076	9
Random Waypoint (0 - 5m/s)	NIMF	0.842	3739	288
	FIMF	0.883	3838	144
Limited Random Waypoint (0 - 5m/s)	ER	0.155	1476	9
	NIMF	0.912	3569	300
Area Based (0 - 5m/s)	FIMF	0.931	3691	181
	ER	0.316	1546	10
Random Waypoint (0 - 5m/s)	NIMF	0.699	3896	267
	FIMF	0.850	4091	137
Area Based (0 - 5m/s)	ER	0.061	2221	6
	NIMF	0.731	3862	271
Area Based (0 - 5m/s)	FIMF	0.841	4036	137
	ER	0.112	2239	8

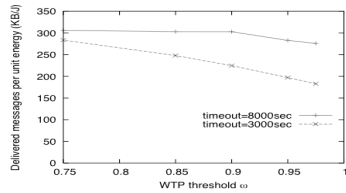
NIMF Performance 

- **Impact of WTP threshold**



(a) Message delivery rate

• Impact of WTP threshold



(c) Delivered messages per unit energy

NMR average notification message in a second

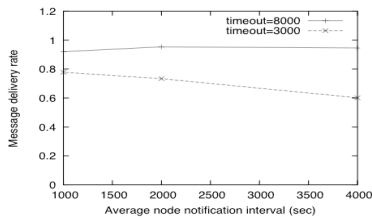
$$NMR = \frac{\#msg}{1sec} \quad 1/NMR = \frac{1sec}{\#msg}$$

Example:

$$NMR = 0,001 \frac{1}{sec} = 10^{-3} \frac{1}{sec}$$

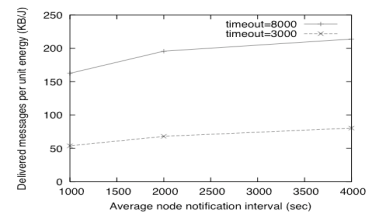
$$1/NMR = \frac{1}{10^{-3}} sec = 10^3 sec = 1000sec$$

• Impact of NMR threshold



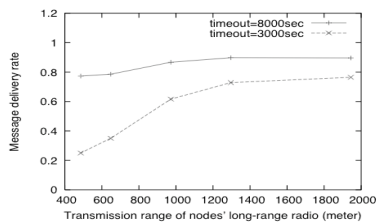
(a) Message delivery rate

• Impact of NMR threshold



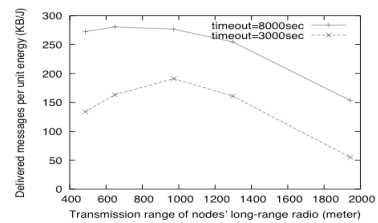
(c) Delivered messages per unit energy

• Impact of transmission range

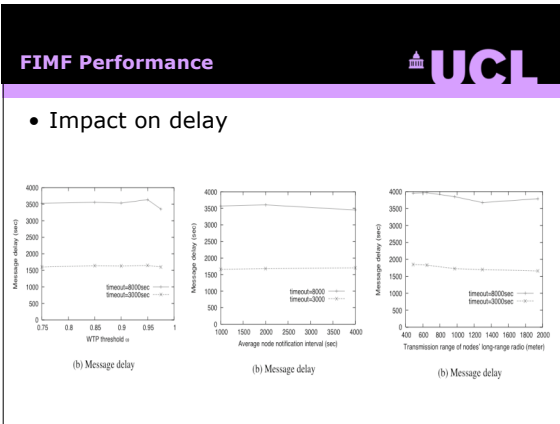


(a) Message delivery rate

• Impact of transmission range



(c) Delivered messages per unit energy




- ### MF Advantages
- Deterministic routing improves:
 - Data delivery
 - Energy Efficiency
 - Compared to flooding techniques

Message Ferrying in Delay-Tolerant Networks

- Is it an optimal way to perform asynchronous communication in a mobile network?

Previous Work

- Message ferrying to connect disconnected stationary nodes



The diagram shows two stationary nodes, represented as orange tents with green awnings, connected by a yellow bus with a driver. This illustrates message ferrying between disconnected nodes.

- This paper: mobile nodes

- ### Assumptions
- No existing infrastructure or centralized administration
 - Rapidly deployable and self-configuring sparse MANETs where network partitions can last for a significant period

- ### Assumptions
- Regular nodes are assumed to have assigned tasks that involve movement in the deployment area and limited resources such as battery, memory, and computation power
 - Long distance communication can rapidly decrease node's battery power

Message Ferrying



- Current ad hoc routing protocols focus on connected networks where end-to-end paths exist between any two nodes in the network
- In sparse networks partitions are not exceptional events
- Using a message ferry as a relay reduces the burden on the whole network
 - Better solution than flooding

Applications



- Crisis Driven
 - Disaster relief, battlefields
- Geography Driven
 - Wide area sensing, surveillance
- Cost Driven
 - Using a message ferry as a cost-effective alternative
- Service Driven
 - Using a message ferry to provide services not available in current infrastructure

Message Ferrying



- Mobility assisted approach
 - “[...] to introduce non-randomness to help deliver data”
- Are mobility patterns random?
 - Can (unpredictable) node movement be realistically simulated by random waypoint?
 - Does random waypoint apply to the described application domains:
 - Military
 - Disaster Relief

The Ferry



- The ferry moves around the deployed area according to known routes
 - The route must be related to the network partition to enable communication
 - Known? Predictable? Dynamic?
- Design based on location-awareness and mobility
 - Each node is aware of its own location
 - for example, receiving GPS signals

Location Sensing



- Is it (currently) reasonable to assume existence of GPS/location sensing abilities in all possible application domains?
- Is asynchronous communication possible without location information?
 - Logical connectivity of network, predictability of node movement

The Ferry



- The ferry:
 - Moves faster than the nodes
 - Moves to intercept regular nodes
 - How to deal with multiple requests
 - “it is difficult, if not impossible, to design an optimal ferry route”
 - Is a single carrier of messages the best way to perform asynchronous communication in a mobile network?
 - Single point of failure

- NIMF/FIMF: determines who moves to initiate communication
- FIMF: Both the ferry and the regular nodes are equipped with long range transmitters
 - Evaluation does not compare Message Ferrying with simply equipping nodes with long range transmitters

- NIMF: Considerations of energy usage to move compared to energy usage for long range transmission
 - Node must interrupt work to intercept the ferry
 - Balance between performance gain in data delivery and performance degradation in assigned tasks from proactive movement

- Nodes require
 - Short range transmitters
 - Long range transmitters
 - Location sensing devices (GPS)
- Work is affected by trajectory changes for communication
- The ferry is a single point of failure
- Is it an optimal way to perform asynchronous communication in a mobile network?

- Ad-hoc Routing (connected networks)
 - DSR, DSDV, GPSR
- InfoStation Architecture
- DTN: Delay Tolerant Network Architecture
 - Interplanetary Research Group
- Probabilistic Routing
 - PROPHET: Probabilistic Routing Protocol using History of Encounters and Transitivity
 - CAR: Context-Aware Routing (UCL)
- Data MULE (Monday afternoon)
- Zebra NET (Wednesday) /DakNet
- DFT-MSN (Last Friday)
- Mobile Relay Protocol

- Any questions?

