Z25 Adaptive and Mobile Systems
Dr. Cecilia Mascolo

DFT-MSN: The Delay Fault Tolerant Mobile Sensor Network for Pervasive Information Gathering

Y. Wang and H. Wu
University of Louisiana at Lafayette

Motivation of the Paper

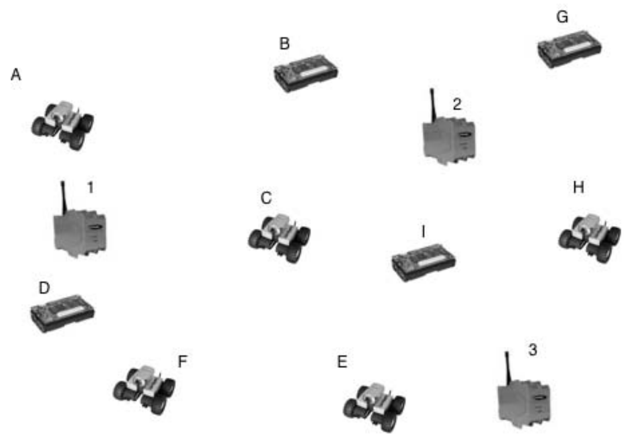
- Mobile sensors (humans carrying devices, body sensor networks)
  - Collect data on flu virus in areas with high human activities to prevent explosion of flu
  - Air quality monitoring for tracking average toxic gas taken by people every day
- Connectivity among mobile sensors is poor (no mesh): short connection range, battery issues, memory (storage) issues

Topic of this Paper

- Delay and fault tolerant mobile sensor network for pervasive information gathering

- Wearable sensor nodes forming loosely connected mobile sensor network
- High end sink nodes (HES). Possibly deployed at strategic locations
- Data cannot always be delivered directly to the sensor nodes

Scenario



The network

- Mobile ad hoc network (with sensor nodes)
  - Sparse
  - Data delivery delay (tolerable)
  - Faults -> redundancy (data will be copied)
  - Limited resources -> buffer size to store data limited
  - Short transmission range
  - Low computing capability
  - Low battery (potentially)

Related Work

- **ZebraNet**
- DTN research
- CAR
- Prophet
- **Message Ferrying**

Basic Approach 1

- Direct transmission to sink
  - When sensor gets in contact with sink it sends the data
  - No multihop routing
  - Data stored in the queue
  - Sensors active only at certain times
- Analytical and simulation results showing:
  - Increasing message length, traffic load and delivery delay increase and total n of messages in the queues or processed increases (case: infinite buffer)
  - When queues are full messages are dropped (case: finite buffer)
  - See pictures 2a and 2b

Basic Approach 2

- Flooding: broadcast data to nearby sensors which store data in their queues and rebroadcast
- Lower delivery delay
- More traffic and energy overhead

- Optimized flooding: estimate delivery probability and stop flooding when reached.
- Delivery probability is derived by estimating the average number of copies made in a period of time
  - Less duplicates! Less overhead-> less energy consumption

Comments

- 1st approach minimizes transmission and energy at the expense of long delays: with high buffer size or low delivery ratio (with limited buffers)
- 2nd approach minimizes delivery delays but it has higher overhead in terms of traffic and energy
- Optimized flooding is based on unlimited buffer size and globally synchronized activation periods
- …quite limiting assumptions in sensor DTN

DFT-MSN: the approach

- *When to transmit data (ie to whom)*
- *Which message to transmit*
- *Which message to drop*
- Nodal delivery probability: likelihood that a sensor I can deliver a message to a sink
- E(i)=(1-a)[E(i)]+aE(k) when transmitting to K
- E(i)=(1-a)[E(i)]
- a is used to keep the history
- [E(i)] del prob before the update
- If k is a sink E(k)=1
- 0<E(i)<1

Message fault tolerance

- Each message carries a field which stores its fault tolerance
- Fij denotes the fault tolerance of message j in the queue of sensor I
- How do we calculate fault tolerance of messages?
  - Delivery probability based
  - Message hop count based

Fault tolerance based on delivery probability

- Initial fault tolerance of message is 0
- Fault tolerance is associated to the number of times a message has been forwarded
- Each sensor i forwards at z1..zs sensor neighbours.
- New fault tolerance applied when message transmitted
- $Fz_kj=1-(1-[Fij])(1-E(i)) \prod_{(z \neq zk)}(1-E(z))$
- $Fij=1-(1-[Fij]) \prod_{z}(1-E(z))$

Data delivery

- Queue management:
  - Priority based on fault tolerance
  - Small F means the message should be transmitted with high priority (top of queue)
  - An arrived message is dropped when queue is full and its F is larger than the last msg or its F is larger than a threshold

Buffer space

- Estimation of buffer space
  - For sensor I, its buffer space B(x) with x a certain fault tolerance $B(x)=K\text{-sum}_{m=1..x}(k_m)$

  Where km is the num of msg with fault tolerance m

  K max size of buffer

  Note that even if buffer is full with K messages B(x), with x small may still be higher than 0

Data transmission

- Based on delivery probability
- When contacting neighbors nodes Z, i gets their delivery probability and available buffer space
- Multicasts message j (top of queue) to subset of Z
- This subset (phi) is identified by the algorithm:

Identification of receivers for a message

Node i

```
phi=0
for z:1..Z do
  if E(i) < E(z) and Bz(Fij)>0 then
  phi=phi U z
endif
if (1-(1-Fij) ∏(m ∈ phi) (1-E(m))> G) then
  break
endif
endfor
```

G threshold of delivery probability

Evaluation settings

- 3 sinks (varied for simulations)
- 100 sensors
- 200 sq m/ 25 40 sq m zones
- Speed 0 to 5 m/s
- Probability of moving out of a zone: 20%
- Transmission range 10m
- Buffer 200 msgs
- Sending 0.01msg per sensor per second
- 1000 seconds of simulation

Evaluation

- Figure 6a/b
- Figure 7a/b
- Figure 8b
- Fig 9

Comments

- Delivery probability a bit arbitrary
- Nice buffer space dependent on fault tolerance of message
- Activation and sleeping of sensors ignored
- Flooding evaluation flawed
- Mobility model simplistic