An Optimized Degree Strategy for Persistent Sensor Network Data Distribution

Zhang Wei, Zhang Qinchoao and Xu Xianghua
Wireless sensor network

- self-organizing
- multi-hop
- dynamic topology
- energy-resources restriction
A typical sensor network
- Sensor nodes generate source data
- Sink nodes or mobile collector node collect these data

Special Scenarios (Disaster)
Problem description

Data persistence

Preserve data from failed sensor nodes

Deliver data to sink(s) as much as possible

Maximize Data Persistence

Sink

6 of 10 symbols reach sink. Persistence = 60%
Network coding

Fountain codes

- **Michael Luby**, “LT Codes” introduced the first rateless erasure codes—LT codes

- LT codes

```
Data

Encoding

Transmission

Received

Decoding

Data
```
LT Codes

- LT based storage system
  - Aly et al. "Fountain Codes Based Distributed Storage Algorithms for Large-scale Wireless Sensor Networks"
LT Codes based storage algorithm
- k sensor nodes and n storage nodes (k<n)
- WSN considered as a distributed data storage and collecting system
**LT codes**

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- **Encoding**
  - S1
  - S2 ⊕ S3
  - S4
  - d=2  d=1  d=2  d=3

- **Decoding**
  - If not collect data S2, the other encoded data can not be decoded
Decoding Performance of classic Distributed LT Codes

- cliff effect

The decoding rate is quite low
Our approach

- **Two main purpose:**
  - To achieve better source data gathering and decoding performance.
  - To insure that the data persistence is not remarkably affected.

- **Network model:**
  - $n$ sensor nodes, $k$ source nodes ($k < n$)
  - There is a mobile collector $S$ in the network
  - **Limited storage:** Each node can only possess one packet
Network model

- The distributed storage system

![Diagram of distributed storage system]

- Source Packets
  - $S_1$ → $e_1$
  - $S_2$ → $e_2$
  - $S_3$ → $e_3$
  - $S_k$ → $e_m$

- Stored Packets
  - Source Packets

Source Packets
△ Our algorithm: PLTD-Alpha

- Network construction
- Encoding source data
- Storage strategy
- Decoding

 Initialization phase
 Encoding phase
 Storage phase
 Decoding phase

Hangzhou Dianzi University  Grid and Service Computing Lab
Initialization phase

- Network constructing with degree level
- The collector broadcasts a beacon
Packet header fields design

| Sensor ID | Source data | Hop Count | flag |

Initialization phase

- WSN
  - Sensor nodes
  - Storage nodes
  - Collector
Initialization phase

Network constructing with degree level

the collector at the predefined position broadcasts a beacon

- WSN
  - Sensor nodes
  - Storage nodes
  - Collector

Prioritized nodes
Initialization phase

Coding degree of each prioritized node $d_c(u) = 1$. The other nodes make $d_c(u)$ according to the given by Ideal Soliton distribution $\Omega_{is}(d)$.

$g_c(u)$ according to $\Omega_{is}(d)$

**Prioritized nodes**

- **WSN**
  - Sensor nodes
  - Storage nodes
  - Collector

$d_c(u) = 1$
Encoding phase
- Example of a data packet forwarding in the network
Nodes randomly send source packets and encoding the data according to the encoding algorithm. The nodes finish its encoding phase. The data in prioritized area are stored with high persistence.

The mobile collector gets into the network from the entry and visits the nodes on a certain path.
Experiments and results

Data collecting in random networks
- Data recovery performance in network with $n=100$, $k=10$ and $n=100$, $k=20$
Experiments and results

Group A

Data collecting in random networks

- Data recovery performance in network with \( n=100 \), \( k=10 \) and \( n=100 \), \( k=20 \)
Experiments and results

Group B

- **Data collecting in random networks**
  - Data recovery performance in network with $n=900$, $k=90$ and $n=900$, $k=180$
Experiments and results

Data collecting in random networks

- Data recovery performance in network with $n=900$, $k=90$ and $n=900$, $k=180$
Data collecting in disaster networks

- A subset of the sensor nodes may be destroyed and stop working.

Experiments and results
Network connectivity

- Data recovered with different network density
- And with different communication radius

Experiments and results

Group D
Conclusions and future work

- Cliff effect is observed and PLTD-Alpha algorithm is proposed.
- With PLTD-Alpha, persistent data packets can be submitted to the sink node according to its degree in order.
- PLTD-Alpha can greatly improve the data collection and decoding efficiency of sensor network while data persistence is not notably affected.
- In our future work, we will focus on the self-adaptation feature of PLTD, in order to further improve the performance and reduce the dependency.
Thank You!

Zhang Wei - Email: magherozhw@gmail.com