SurF: Data Dissemination with Selective Negotiation in WSNs

Xiaolong Zheng[1], Jiliang Wang[2],
Wei Dong[3], Yuan He[2], Yunhao Liu[1,2]

[1] Hong Kong University of Science and Technology, Hong Kong
[2] Tsinghua University, China
[3] Zhejiang University, China

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

清華大學

浙江大學
Zhejiang University

IEEE MASS 2013

Roadmap

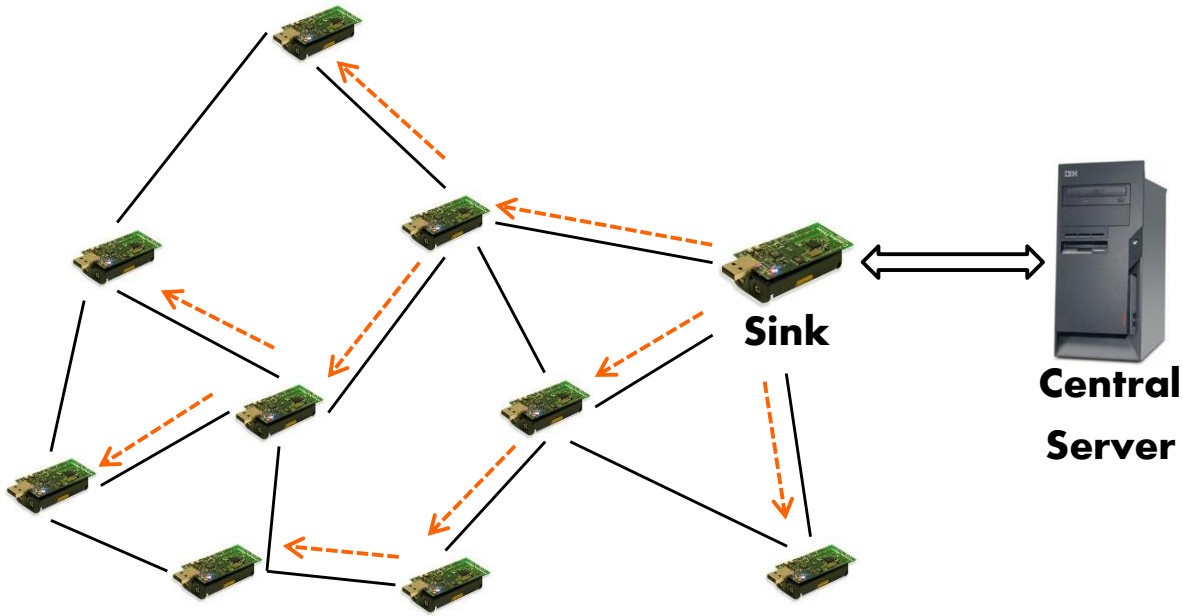
- **Background & Motivation**
  - -- *Flooding VS Negotiation*
  - -- *Motivation*
- **Protocol Design**
  - -- Overview of SurF
  - -- Best strategy estimation
  - -- State transition
- **Experimental Evaluation**
  - -- Experimental Settings
  - -- Experimental Results
- **Conclusion**

Background

Data dissemination

Data dissemination is a core building block in WSNs.

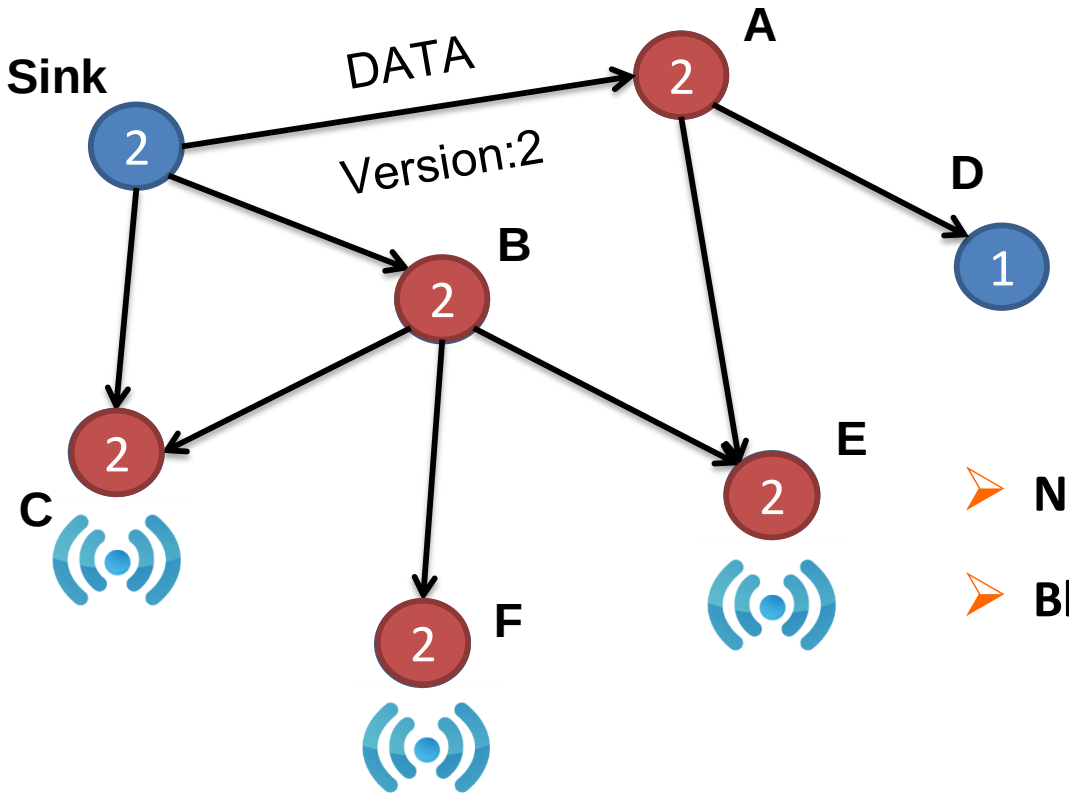
General scenario: Reliably disseminate data over a multi-hop sensor network from sink to all the other nodes.



Background

Flooding

Flooding is a way to do data dissemination.

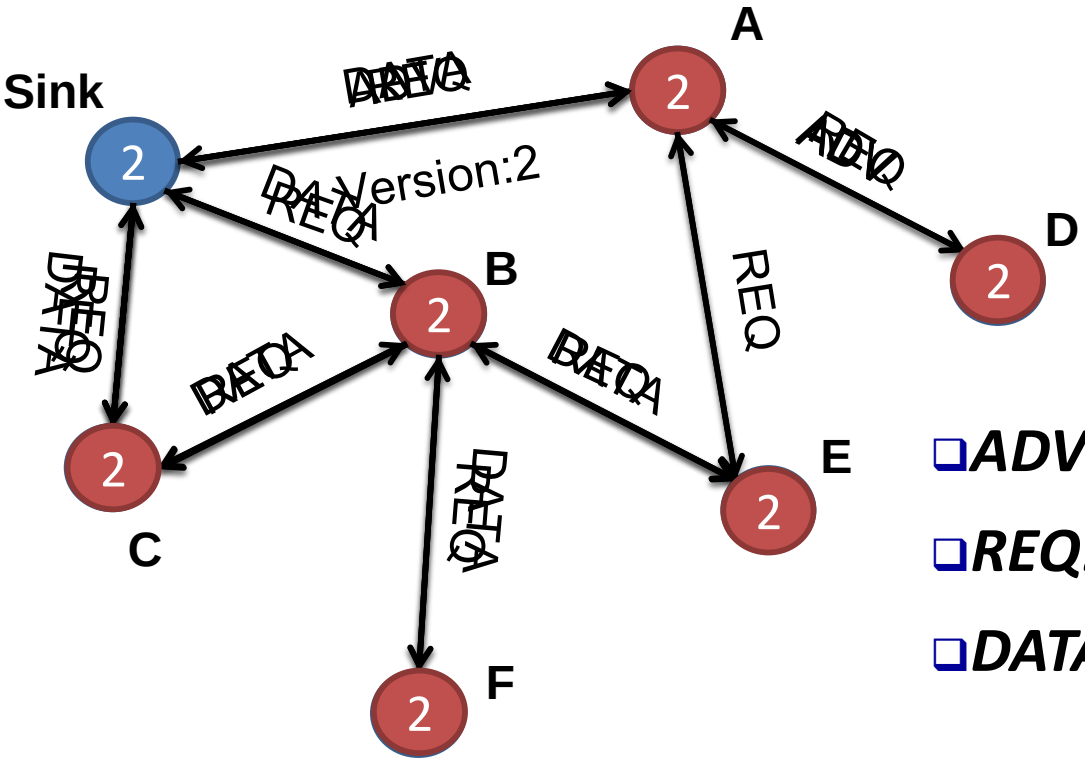


- **No guarantee for reliability**
- **Blind retransmissions**

Background

Negotiation-based methods

Negotiation is a mechanism for reliability and efficiency by a three-way handshake.



- ***ADV: advertisement***
- ***REQ: request***
- ***DATA: data messages***

Motivation

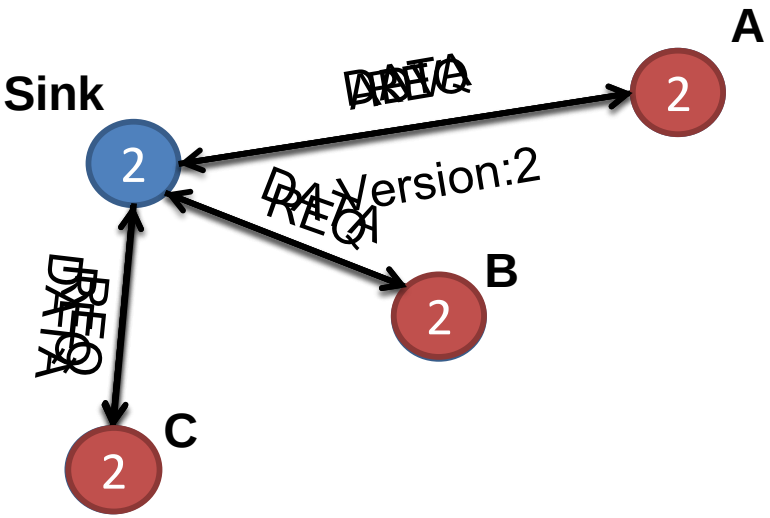
HKUST

Negotiation

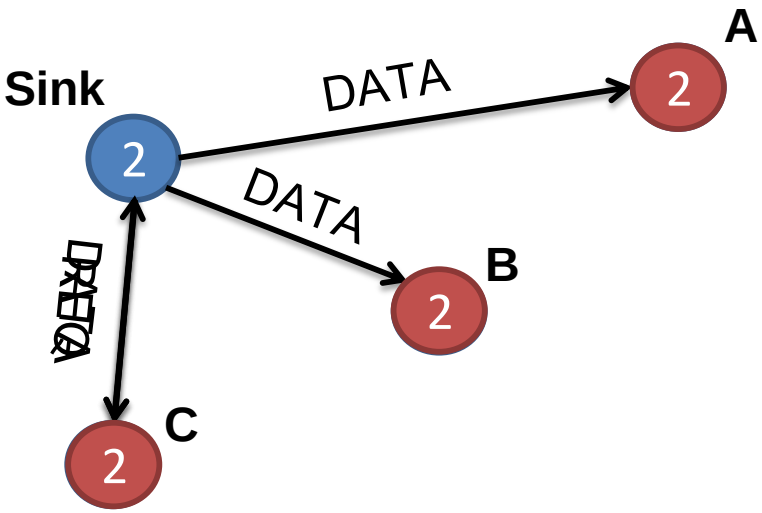
- **Advantages:**
  - ✓ **Guarantees the reliability by using REQ as NACK**
  - ✓ **Avoid blind retransmissions**
- **Disadvantages:**
  - ✓ **Incurs additional control messages**
  - ✓ **Prolongs the completion time**

Motivation

Key question: Is negotiation *always* necessary?



1 ADV + 1 REQ + 1 DATA



0 ADV + 0 REQ + 0 DATA

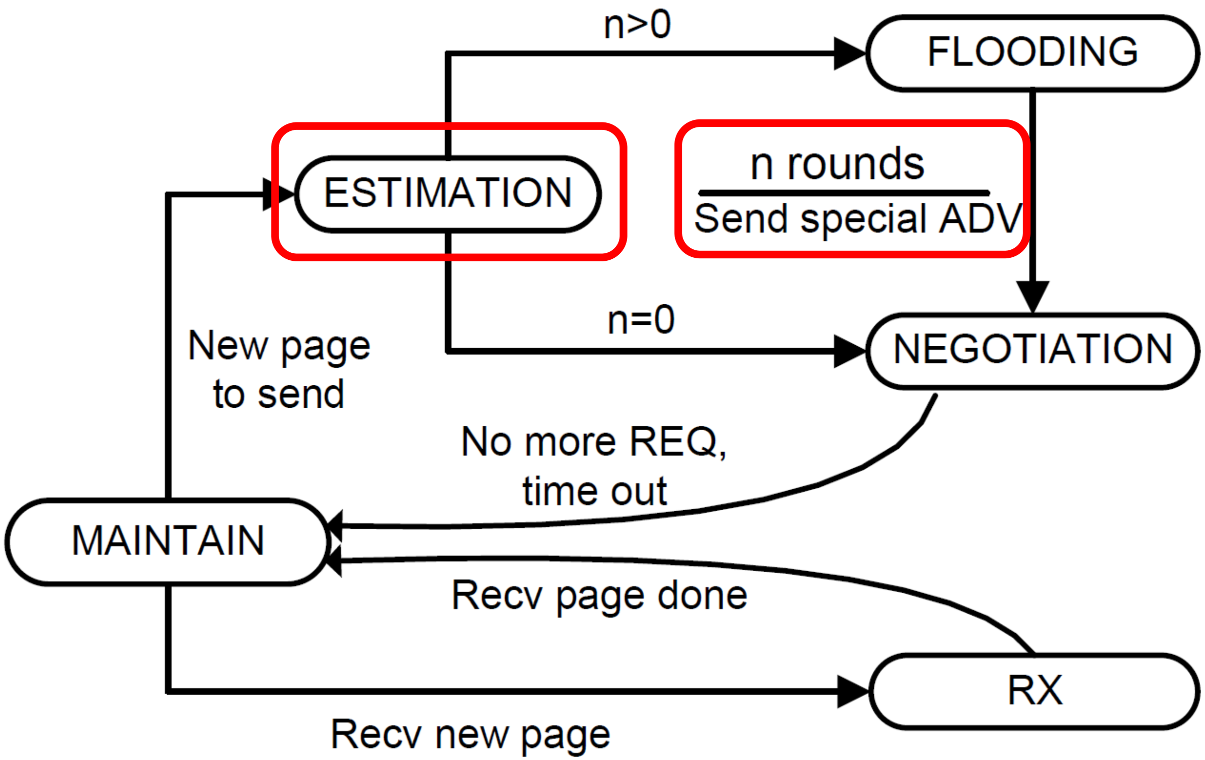
Key idea: *Selectively* use the negotiation only when necessary

Protocol Design

Overview of SurF (Survival of the Fittest)

Design Issue 1: Accurate estimation for minimizing the completion time

Design Issue 2: Efficient and reliable stage transition



Best Strategy Estimation

HKUST

Best strategy estimation problem:

Minimizing the completion time of data dissemination, given the information of neighboring nodes.

Strategy alternation: flooding <--> negotiation

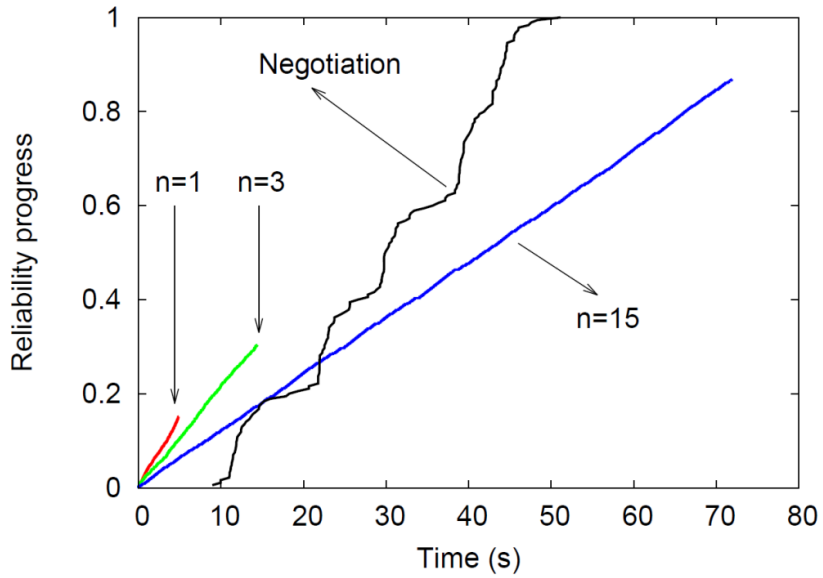
Best transition point deciding problem:

Deciding the optimal transition point from flooding to negotiation.

Best Strategy Estimation

Deciding the best transition point:

Deciding the times of flooding (n) for minimum completion time.



n: number of rebroadcasting

$$Realibility = \frac{\#\ of\ received\ packets}{\#\ of\ packets\ that\ are\ expected\ to\ receive}$$

Best Strategy Estimation

HKUST

Deciding the best transition point:

We model the completion time of dissemination in single hop.

Thus, each node can decide its times of flooding in distributed manner.

$$T(n) = \begin{cases} T_{negotiation}, & n = 0; \\ n \times T_{flooding} + T'_{negotiation}, & 0 < n < N_F; \\ N_F \times T_{flooding}, & n = N_F; \end{cases}$$

***n*: times of flooding**

***N_F*: times of flooding needs to achieve the required reliability**

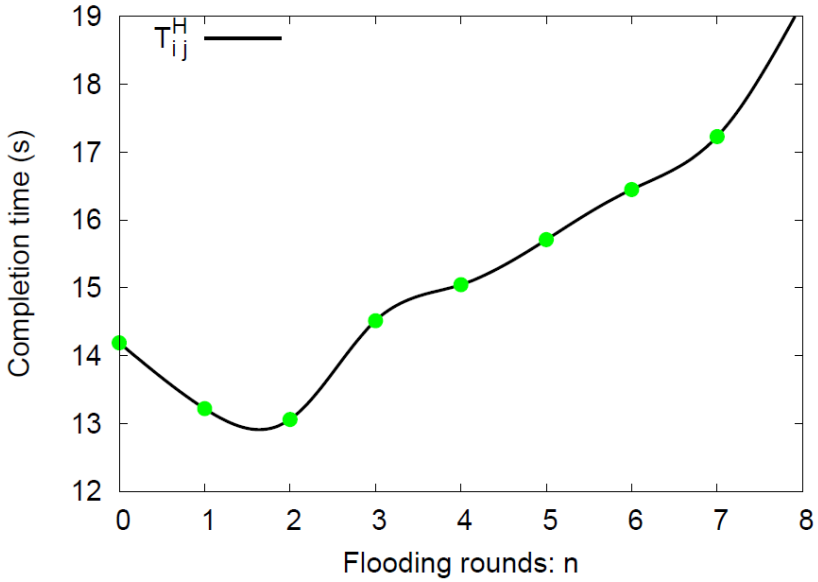
Best Strategy Estimation

HKUST

Deciding the best transition point:

We model the completion time of dissemination in single hop.

Thus, each node can decide its times of flooding in distributed manner.



State Transition

HKUST

Efficient and reliable state transition:

A receiver should be aware of the strategy that the sender adopts to cooperate with the sender.

- ***Efficient transition:***

  Active notification of sender's transition

- ***Reliable transition:***

  Periodical ADV messages to announce the transition

Protocol Design

HKUST

Method in flooding phase:

Probabilistic flooding

- ***mitigating collision by random back-off scheme***

  Random back-off time: 10-25ms

- ***Reducing the redundancy by probabilistic rebroadcasting***

  Rebroadcasting probability: 0.9 initially and adjusted during the process

Method in negotiation phase:

Deluge

Roadmap

- **Background & Motivation**
  - -- *Flooding VS Negotiation*
  - -- *Motivation*
- **Protocol Design**
  - -- Overview of SurF
  - -- Best strategy estimation
  - -- State transition
  - -- Strategies
- **Experimental Evaluation**
  - -- Experimental Settings
  - -- Experimental Results
- **Conclusion**

Experimental Evaluation

HKUST

Environmental settings:

Platform: TelosB / TinyOS 2.1.1

Network size: 5×8

Power: level 1

Data size: 1~10K Bytes

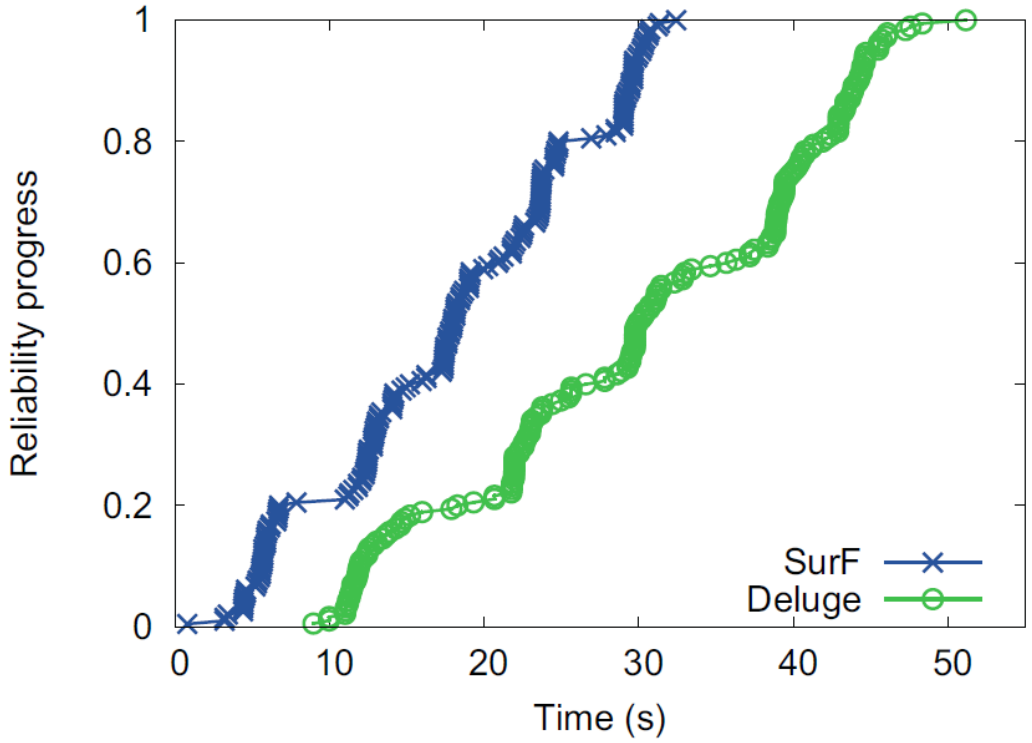
Metric: completion time & energy

Experimental Evaluation

HKUST

Evaluation Result:

Shorter completion time compared to Deluge

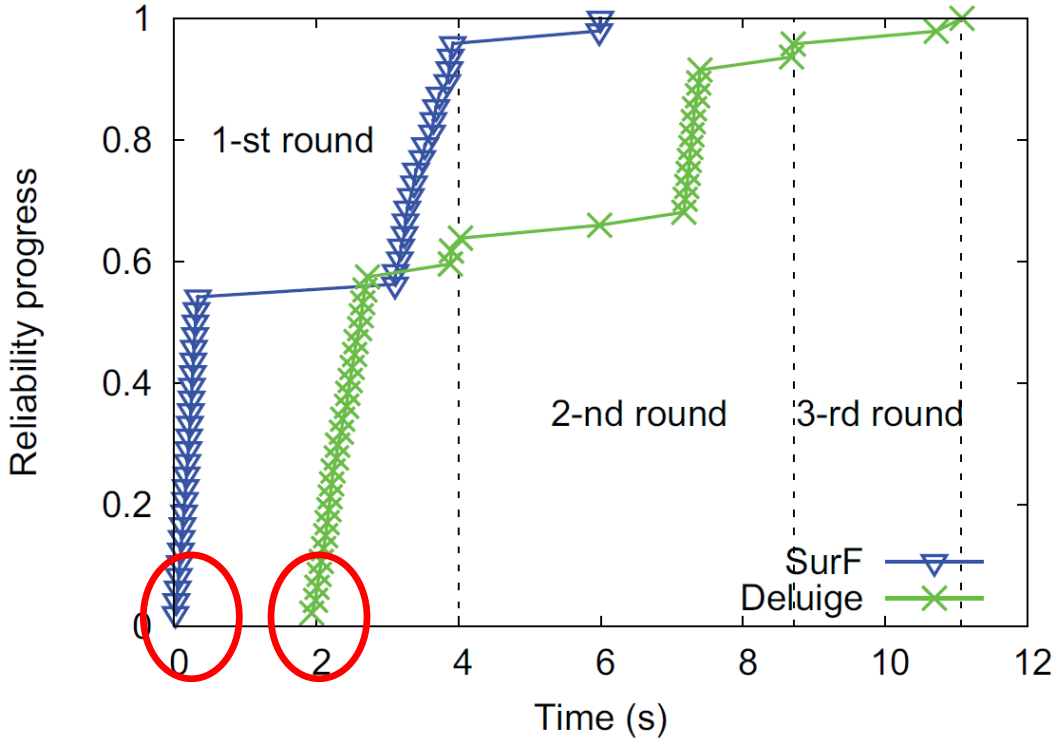


Experimental Evaluation

HKUST

Evaluation Result:

How does SurF reduce completion time?

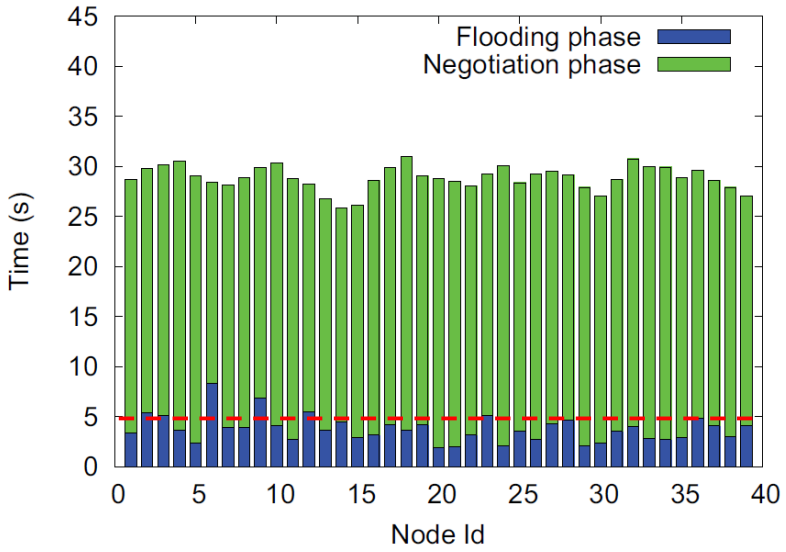


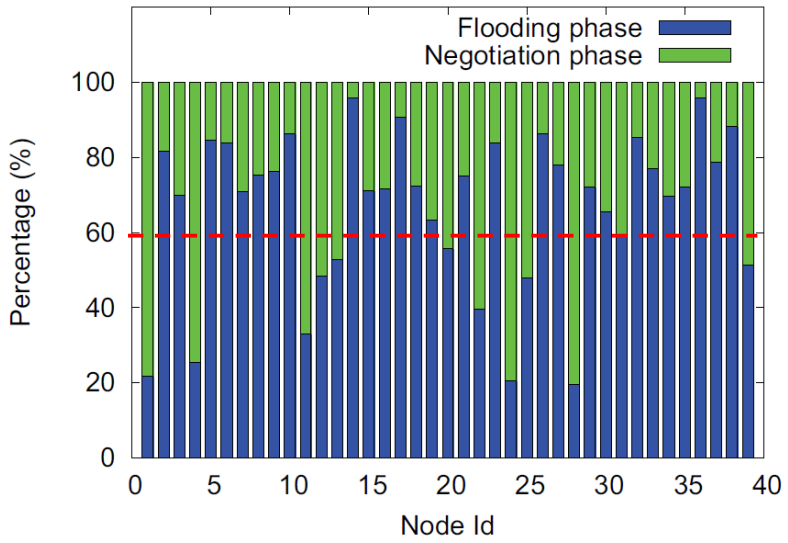
Experimental Evaluation

HKUST

Evaluation Result:

How well does flooding perform in SurF?





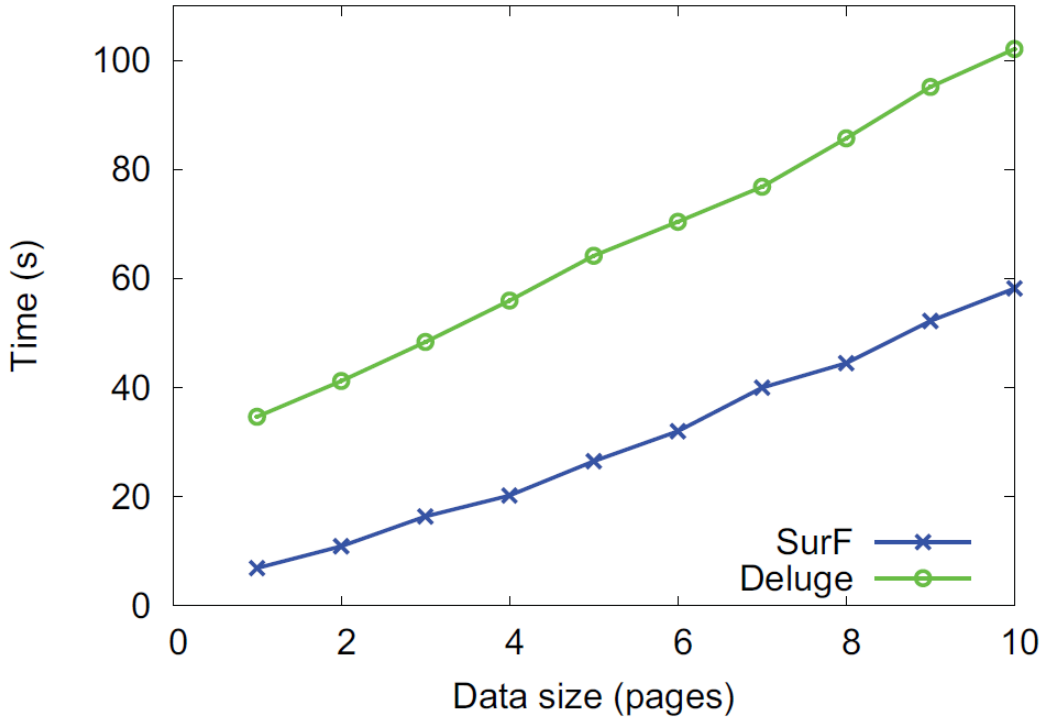
Complete 60% of data dissemination in only 15% of the total time!

Experimental Evaluation

HKUST

Evaluation Result:

Completion time VS data size



Conclusion

HKUST

Fast Data Dissemination:

- *Negotiation scheme is necessary for reliability*
- *Selectively adopts negotiation instead of during the whole process*
- *Reduces the unnecessary negotiation for shorter completion time*

Key Observation:

- *The negotiation is not always necessary during the whole process.*
- *Flooding is not totally destructive to data dissemination.*
- *The hybrid schemes can make use of the advantages while avoid their weaknesses.*

Q & A

HKUST

Thank You!