Transport Problem in DSN with Delay Control

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We try to solve the ‘blind-point’ problems in DSN …

For example,

• People mostly focus on Energy-saving; how about in some real-time DSN applications?

• People already knew longer sleep duration is better than longer idle duration, but how do we control the ‘Sleep mode’?

• People proposed lots of routing algorithms; But sometimes we also need a good transport layer design…
This talk focuses on 2 problems in DSN

- Delay Control in DSN
- SN Transport Layer Design
A easily-ignored Problem...

• For Most Microsensor Networks, Energy-saving is the biggest problem.

• But for Some real-time DSN applications, delay is a crucial problem.

♦ In a building, there is a good power-supply.

♦ Lots of Wireless Camera Sensors.

♦ Real-time video data are needed.
Self-organized sensor network. The cluster heads are squares, the gateway nodes are diamonds, and the ordinary sensor nodes are circles. The transmission areas of the four cluster heads are indicated by the four large circles.
A hierarchical DSN

\[
C_1^{[1]} = \begin{bmatrix}
1 & 1 \\
0 & 1 \\
1 & 1
\end{bmatrix}
\]

\[
C_2^{[1]} = \begin{bmatrix}
1 & 1 \\
1 & 0
\end{bmatrix}
\]
Model’s Characteristics

1. Seamlessly implement the system resource allocation algorithm (Bandwidth Allocation)
2. Decoupling of the control loops
3. Easily model each flow T.V. delay
4. It can be extended to end-to-end congestion control in a straightforward manner
Some Concepts in the delay model

- Forward Delay (Data From Sub-node to Super-node)
- Backward Delay (Buffer Control Information from Super to Sub)
- Both delays are T.V.
- VQ: Virtual Queues (Buffers)

RC: Rate Controllers located at the Super-node
Delay Control Problem

1. To adapt to fast Video changes, the super-node dynamically allocate Wireless Bandwidth to its sub-nodes.

2. This allocation should be based on the weight of the coming data (i.e., how important it is).
Robust Delay Controller Design
Example
Controller
Transport Layer Design

Too Little Work in this Field!
How about these SN applications?

- Integration with Internet
- Re-tasking applications
Challenges

1. Unlike protocols such as TCP, the end-to-end communication schemes in sensor networks are not based on global addressing.

2. Addressing: Attribute-based naming is used to indicate the destinations of the data packets.

3. Thousands of sensors need to be reprogrammed in a controlled, reliable, robust and scalable manner.

4. Need to support cluster-based communications.

5. Isolating reliable applications from the unreliable nature of wireless sensor networks (Overcoming errors).
Transport Layer Solutions

1. No IP address
2. Reliable Communication

Application Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

OO Invocation Layer
Error-Overcoming Layer
OO Invocation Layer

Based on RIT, Computer Science --- M2M Protocol
Not need IP address...

M2MP Message

M2MP Packet

- **Message ID**: 4 bytes
- **Fragment number**: 4 bytes (L = Last fragment flag)
- **Fragment (payload)**: 0 .. 498 bytes
- **Checksum**: 2 bytes
Invocation Layer Architecture

- Distributed communication & collaboration
- Distributed services
  - Java environment
  - Native platform

Diagram:
- Distributed applications
  - Anhinga Spaces
  - Jini Mobile Edition (JiniME)
  - Anhinga Device Profile (ADP) Java API
  - Anhinga Java Virtual Machine (AVM)
  - Many-to-Many Protocol
    - M2MP on Ethernet
    - M2MP on Bluetooth
  - Platform OS
    - Ethernet Driver
    - Serial Driver
    - 802.11 interface
    - Bluetooth radio
Implement collaborative application
Below the OO Invocation Layer ...

- It’s not enough to implement M2M communications
- We need to overcome the wireless error
- Traditional TCP end-to-end retransmission is not strong in Ad hoc SN
Error-Overcoming Layer

Designing Goals:

- Minimum Requirements for the routing layer
- Minimum Signaling (Lightweight protocol)
- Responsive to high error rate of SN
Solutions

• Don’t use end-to-end error recovery
Solutions

- Don’t use too many retransmissions

Successful Delivery Rate

Packet Loss Rate (0.0 ~ 0.9)

No retransmission

3/5/7 retransmissions, respectively (From low to high curves)
Solutions

Making trade-off between “Packet forwarding” & “store-and-forward”
Other Research Tasks on DSN

Based on LEACH protocol from Dr. Heinzelman (MIT) --
- A Cluster-based Deployment, we combine Data Querying & Routing Algorithm
Main Steps

Step 1: Using LEACH Algorithm to find Cluster Heads
Step 2: Belief Quality Test
Step 3: Objective Sensor Selection
Step 4: Go back Step 2
Flow Chat of Data Query
Thank You

- Our Work is still going, hope to exchange ideas with you.