ArDeZ: An Asymmetric Rendezvous Based MAC for Sensor Networks

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Outline

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  – Channel Setup
  – Generating Pseudo-random Rendezvous Periods
  – Transmissions: broadcast and unicast
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Background

• Sensor Networks
  – Low cost nodes equipped with a processor, a low data rate transceiver, modest memory, and one or more sensors
  – Precision agriculture, bush fire monitoring, etc.
  – Energy constrained
• Medium Access Control (MAC)
  – Coordinating channel access in an energy efficient manner.
  – Issues:
    • collisions, idle-listening, overhearing, synchronization, and control overheads.

ArDeZ - Overview

• Pair-Wise Time Hoping
  – Seed → pseudo random rendezvous periods
• Mean rendezvous period (MRP)

Communication period

Time

1
2-92
1-92
1-92
2-92
1-92
1-92
2-92
1-92

S1
S2
S3
ArDeZ – Channel Setup

- Invite message
  - Frequency dictated by Invite’s Mean Rendezvous Period (MRP)
- Scan for a maximum WaitNeighbor time
- Upon receiving an Invite message, a sensor selects an invite slot randomly.

- Invite Slot

ArDeZ – Generation Rendezvous Periods

\[
U_{seed}^{i+1} = S_u^i + U^{\text{seed}} \\
D_{seed}^{i+1} = S_d^i + D^{\text{seed}}
\]

Advertise in Invite Messages, and selected by an invitee

\[
S_u^i = (C_u U_{seed}^i + C_d) \% 255 \\
S_d^i = (C_u D_{seed}^i + C_d) \% 255
\]

C_u and C_d are constants

\[
U_{\text{seed}}^i = \frac{S_u^i}{255} \times \text{MRP} \\
D_{\text{seed}}^i = \frac{S_d^i}{255} \times \text{MRP}
\]

Jump offset
MRP controls how “far” we jump into the future

- First rendezvous period is relative to the reception time of the Invite Message. Subsequent periods are relative to the last rendezvous period’s end time.
**ArDeZ – Supporting Broadcast**

Node 2 transmits, all other neighbors listen.

**B2 – Broadcast seed.**

**ArDeZ – Transmitting and Receiving**

- MaxWait – minimize idle listening
- Send a packet every z rendezvous periods to avoid losing synchronization

**Analysis – Overlapping periods**

- 8-bit
- 16-bit

**Analysis – Channel Setup**
Simulation

- ns-2 (ns-allinone-2.1b9)
- CBR – 100 packets, 50 bytes
- Only establish channels to a neighbor that has a path to the sink
- Data rate – 20 Kb/s
- Rendezvous period length, 30ms
- Random number range, 0 … 255
- Energy
  - Tx (12 mAh), Rx (1.8 mAh), asleep (5 μAh)

Results – Channel Setup

Results – Network Setup Time (36 nodes)

Results – Node Density vs. Packet Delivery Ratio
Conclusion

- ArDeZ – An asymmetric MAC that uses pseudo-random sleep/wake periods.
  - Uplink and downlink channels with different duty cycles
- Simple setup procedure
  - Low signaling overheads
- No global synchronization or superframe
- Duty Cycle controlled by adjusting each link’s Mean Rendezvous Period (MRP)

Current Work

- Comparisons with other MACs
  - SMAC, TRAMA, WiseMAC, etc...
- Design and implementation of routing and transport protocols that make use of MRP
- Collision free extensions
  - Listening to neighbors’ seeds
Questions?

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