Siphon: Overload Traffic Management using Multi-Radio Virtual Sinks in Sensor Networks

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Outline

- Introduction
- Siphon design
- Simulation evaluation
- Conclusion and Discussion
Introduction

- The existing experimental mote networks of any size can only operate under fairly light workloads.
- These applications commonly experience periods of persistent congestion and high packet loss.
- The bottleneck is sink.
Introduction

- **Funneling effect:**
  - Since events generated under varying workloads move quickly toward sink points. This leads to increased transit traffic intensity, congestion, and packet loss so that reducing application fidelity measured at sink.
  - As a result, the sensors nearest the sink will use energy at the fastest rate.
Introduction

- Since most congestion control schemes [2][6][7] have been proposed typically assume that all nodes are equal, they don’t adequately address the funneling effect.
- The paper proposes a method that randomly or selectively distributes some multi-radio virtual sinks (VSs) to siphon off events.
Siphon

- Virtual Sinks are equipped with a secondary long-range radio interface (e.g., IEEE802.11, or WiMAX in the future) that can dynamically form a secondary ad hoc network rooted at physical sink.
- They take selected traffic off the original WSN before the onset of congestion and move it to the physical sink using the secondary radio network.
Siphon design

- The detailed design of Siphon algorithm
  - Virtual sink discovery and visibility scope control
  - Congestion detection
  - Traffic redirection
Siphon design-overview
Virtual sink discovery and visibility scope control

- Since there is no guarantee that a VS is adjacent to a congested region, a method for nodes to discovery a VS nearby is necessary.

- A signature byte is embedded in the periodic broadcasted control packets originated by physical sink. The byte contains a VS-TTL value.
Virtual sink discovery and visibility scope control

- **Detail steps:**
  - Physical sink broadcasts the signature byte with VS-TTL = $\ell$.
  - For VS nodes, if a signature byte is received, then identify the forwarder as next Siphon hop. And rebroadcast the byte after setting VS-TTL = $\ell$ by the two radio interfaces.
  - For common nodes, they record the VS ID and VS-TTL into a VS list and rebroadcast the packet after decrease VS-TTL.
Congestion detection

- It indicates the proper time a sensor should attempt to utilize any VSSs it has discovered.
- Two techniques:
  - **Node-initiated**: when local channel load approaches or exceeds a theoretical upper bound or the buffer grows beyond a high mark. The packets generated by the nodes will set the redirection bit.
  - **Post-facto**: When physical sink measured application fidelity degrades below a certain threshold, physical sink propagate the signal by its secondary radio interface.
Traffic redirection

- That is enabled by the use of one *redirection bit* in the network layer header.

- Two approaches:
  - On-demand: the bit is set only when congestion is detected
  - Always-on: the bit is always set

- When a redirected packet is received, the node checks the list and forward to nearest VS.
Simulation evaluation

Performance metrics:

- **Energy Tax** = \( \frac{\text{Tot. pkts dropped in the network1}}{\text{Tot. pkts rcvd at the physical sink}} \)

- **Energy Tax Savings** = \( \frac{\text{(Avg E.Tax w/o Siphon)} - \text{(Avg E.Tax w/ Siphon)}}{\text{(Avg E.Tax w/o Siphon)}} \)

- **Fidelity Ratio** = \( \frac{\text{(Pkts rcvd at the physical sink w/Siphon)}}{\text{(Pkts rcvd at the physical sink w/o Siphon)}} \)

- **Residual Energy** = \( \frac{\text{(Remaining energy)}}{\text{(Initial energy)}} \)
Simulation evaluation

- early congestion detection

![Simulation evaluation graph](image-url)
Simulation evaluation

virtual sink’s visibility scope impact

![Graph showing the impact of visibility scope on fidelity ratio and energy tax savings.](image)
Simulation evaluation

- scalability

![Graph showing simulation evaluation results.](image)
Conclusion and Discussion

• The paper proposes a solution of growing need for improved congestion control, load balancing and overload traffic management by using a secondary radio network to siphon off overload traffic.

• Since WSN has many physical constraints, combination with other tools to achieve application requirement seems an alternative trend.