Nature Inspired Techniques for solving networking problems

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Flock-based Congestion Control

- Problem: Congestion in Wireless Sensor Networks
- Our aim: Simple, scalable, robust, self-adaptable, energy-efficient Congestion Control Mechanism
- Successfully employed **bird flocking behavior** to prevent (or minimize) congestion → Flock-based Congestion Control (FCC) mechanism with all the aforementioned characteristics
- Concept: ‘guide’ packets to form flocks and flow towards a global attractor (sink), whilst trying to avoid obstacles (congestion regions)
Flock-based Congestion Control

• Each packet:
  – follows simple (attraction / repulsion / perturbation) rules to travel hop-by-hop to the sink
  – chooses its new hosting node (from $M$ neighbors within its field of perception)
  – Packet evaluates its new hosting node on the basis of the **desirability function** for each node $m \in M$:

  **CEC Approach:**
  
  $$D_{im}(t) = Rth_{im} \ast [\alpha \ast r_m(kT) + (1 - \alpha) \ast (1 - p_m(kT))]$$
  
  $$Rth_{im} = \frac{s_{im}^2}{s_{im}^2 + \theta_m^2}$$

  **JSAC Approach:**
  
  $$D_m(k) = \alpha \ast r_m(k) + (1 - \alpha) \ast (1 - p_m(k))$$
  
  $$D_{im}'(t) = g \cdot d_{im}(t) \cdot D_m(k)$$

  • Measures the tendency of each packet $i$ to move towards neighboring node $m$ taking into account node $m$’s loading ($p_m$) and the wireless channel conditions ($r_m$) in its vicinity
  • Node with the highest desirability function is chosen as the new hosting node
Flock-based Congestion Control

- Algorithm consists of a set of rules: Simple to implement at the individual node level
- Effective parameter tuning needed (see slides 4, 5, 6, and 7)
- FCC self-adapts to network changing conditions and proves to be robust against node failures

Fig. 12. Number of packets arrived at each node (a) before node failures, and (b) after node failures. Nodes fail at $t = 60$ seconds.

- FCC outperforms typical conventional WSN congestion control approaches (results [here](#))
CEC paper
35 pkts/sec

$\theta_0 = 0.1$

$\alpha = 0.4$
Packet delivery ratio

CEC paper
25 pkts/sec

\[ \alpha = 0.5 \]

\[ \theta_0 = 0.1 \]
JSAC paper
35 pkts/sec

Figure depicts best case ($\alpha$, $e$ and $c$) values.

Packet delivery ratio

alpha

e

$c$
End-to-end Delay

alpha
e
c

JSAC paper
35 pkts/sec
Comparative Evaluations

- FCC outperforms No Congestion Control and Queue-based Congestion Control Protocols
- FCC achieved:
  - 20% higher PDR than the No CC protocol
  - 7-20% (depending on transm. rate) higher PDR than the Queue-based CC protocol