Routing for Network Capacity Maximization in Energy-constrained Ad-hoc Networks

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Outline

- Introduction
- Related work
- The CMAX algorithm
- Implementation issues
- Simulation results

Introduction

- Objective
  - Maximize total number of messages successfully carried by the network (network capacity)
  - No assumptions on future message arrivals

Related work

- Motivated by max-min zP_{min}
  - Assumes messages generate at constant rate
  - Involves several shortest path computation

CMAX Algorithm

Step 1. Consider routing message k on the network G. Eliminate all links $(i, j) \in A$ for which $e_{ij} > \frac{E_i(k)}{l_k}$ to form a reduced network.

e_{ij} := energy consumed for transmitting a unit message along link *(i, j)*

$E_i(k)$:= the residual energy of node i when k generated

CMAX Algorithm (cont'd)

Step 2. Associate weights w_{ij} with each link (i, j) in the reduced graph, where $w_{ij} = e_{ij}(\lambda^{\alpha_i(k)} - 1)$.

λ := appropriate constant

CMAX Algorithm (cont'd)

Step 3. Find the shortest path from s_k to d_k in the reduced graph with link weights w_{ij}, as defined in Step 2.

s_k := source node of message *k*

d_k := destination node of message *k*

w_{ij} := weight of link *(i, j)*

CMAX Algorithm (cont'd)

Step 4. Let γ_k be the length of the shortest path found in Step 3 ($\gamma_k = \infty$ if no path was found). If $\gamma_k \leq \sigma$, route the message along the shortest path, otherwise reject it.

σ := appropriate constant

Competitive bound

Theorem 1: Let $\lambda = 2(n\rho + 1)$ and $\sigma = ne_{\max}$. For all messages k, let

$$l_k \leq \frac{\min_{i \in N} E_i}{e_{\max} \log \lambda} \qquad (1)$$

Then

$$\frac{L(k)}{L_{opt}(k)} \geq \frac{1}{1 + 2\log\lambda} \qquad \forall k.$$

→ Competitive ratio of CMAX : $O(\log n\rho)$

Implementation

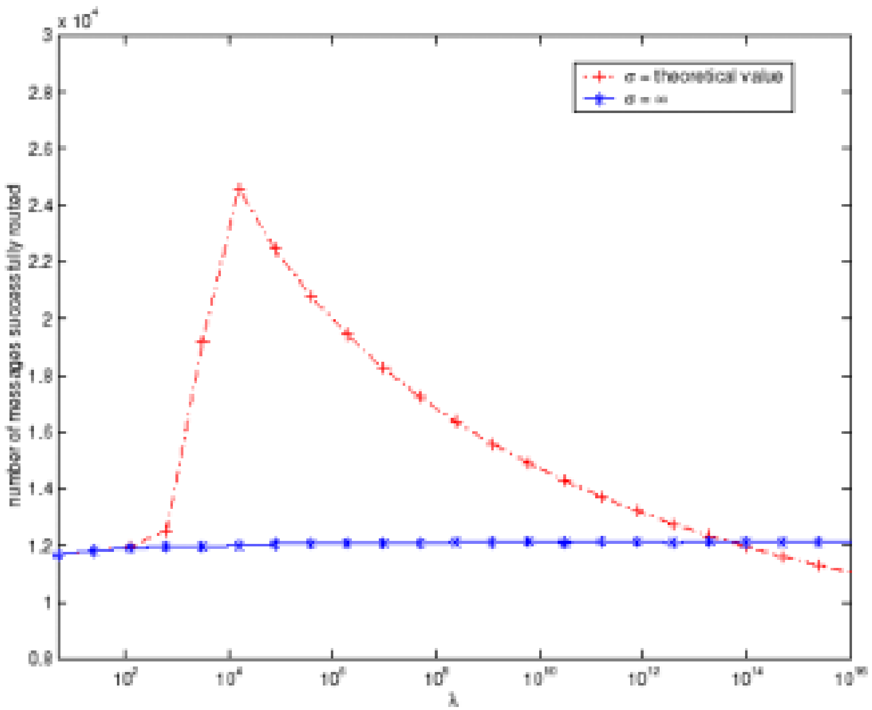
- Whole network topology
  - Relatively static → any changes disseminated throughout the network
- Current energy utilization at each node
  - Changes frequently
  - Dissemination of global energy information is not feasible in large networks
  - → use Limited Flooding Approach

Limited Flooding Approach

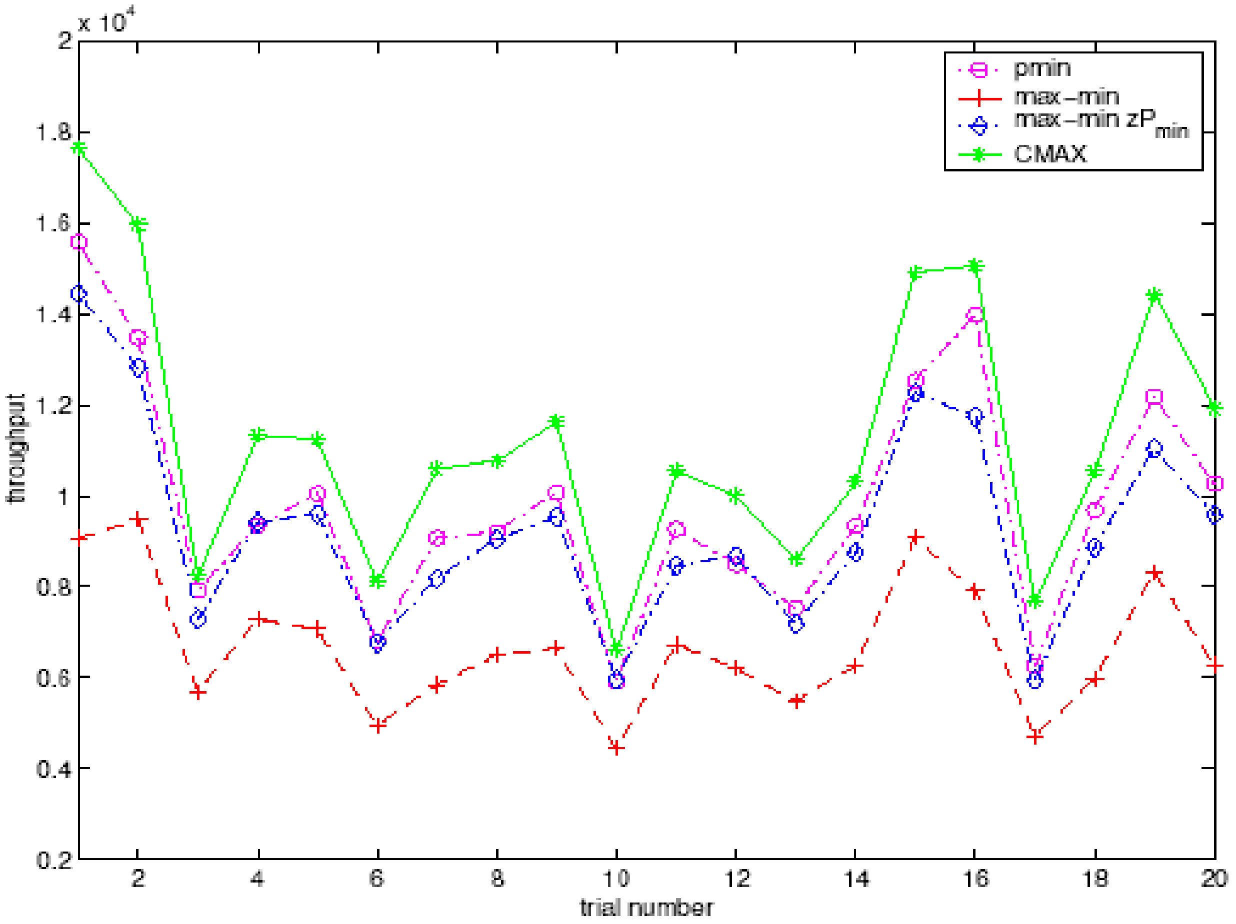
- In order to get neighborhood's energy information.
- Hop-by-hop routing like OSPF
  - Each node computes shortest path
  - Periodically broadcast its residual energy
  - Within limited distance
- We call it D-CMAX

Effect of λ and σ

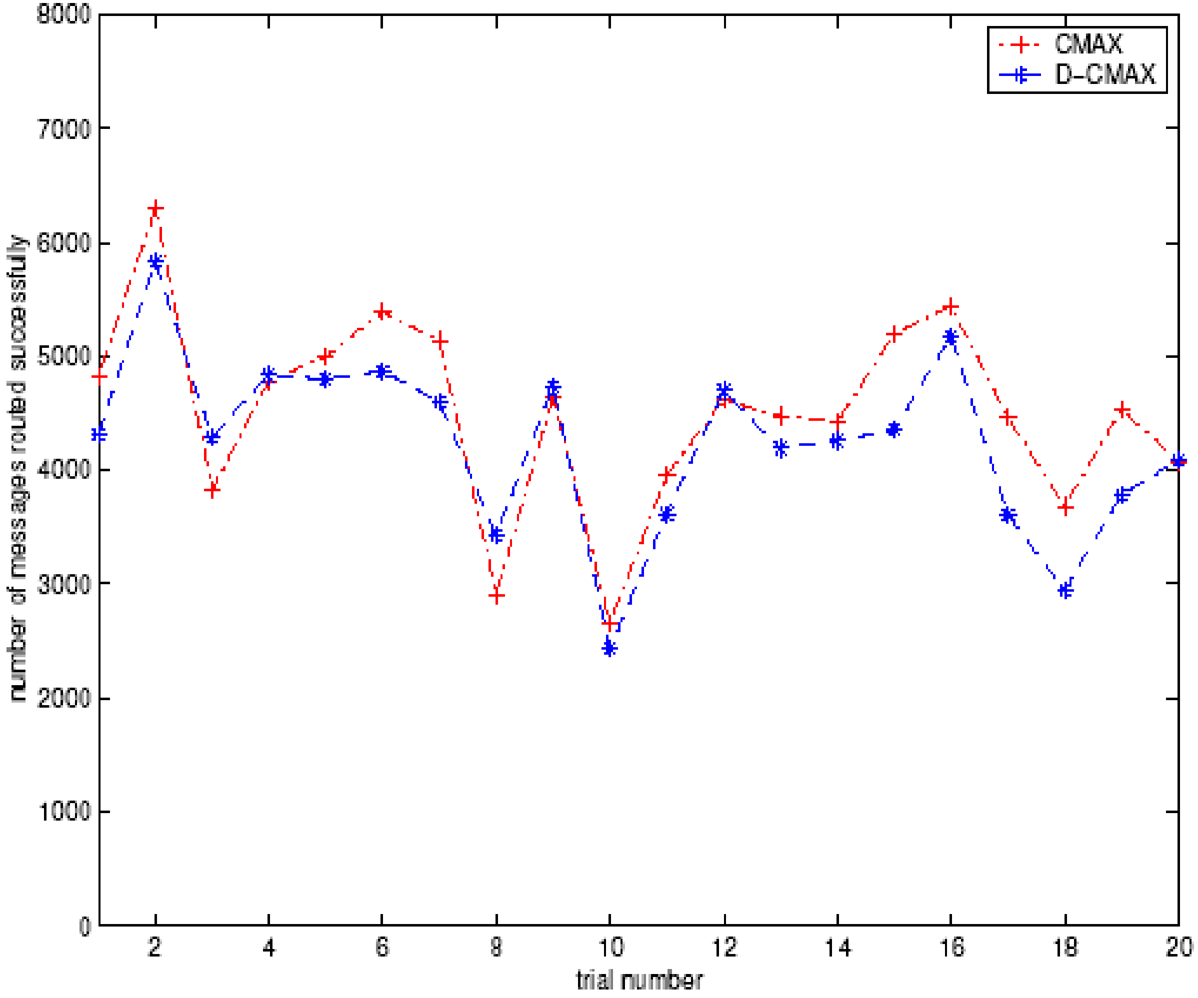
- σ <= 70, λ <= 140,000 from Theorem 1.
- σ < ∞ implies admission control



Simulation result



CMAX vs. D-CMAX



Discussions

- How much does the energy consumption decrease?