How to Collaborate?

Pricing for Enabling Forwarding in Wireless Ad Hoc Networks

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(joint work with O. Ileri & S. Mau)
Fostering Cooperation Through “Bribery”

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Forwarding in Ad Hoc Networks?

• Forwarding reduces interference, saves battery life, increases coverage area

• There are two kinds of costs associated with packet forwarding:
  – Power Consumption (REAL COST)
  – Delay in Own Data (OPPORTUNITY COST)

• Why (and how) will autonomous nodes forward?
A Microeconomic Framework for Enabling Forwarding: Pricing & Reimbursement

- Nodes control their:
  - Transmit powers
  - Forwarding Preferences
  - Destination Preferences
to maximize bits/Joule

- The network controls:
  - Pricing Coefficient $\lambda$
  - Reimbursement Coefficient: $\mu$
to maximize its revenue
Example: A “Mesh” Network

The blue laptop
• Enjoys its own data reaching the access point.
• Pays for its outgoing throughput to adjacent devices.
• Gets reimbursed for data it relays for others only if the data reaches the access point.
Two User – One Access Point Example

- Incentives for forwarding works when nodes tend to “cluster”
- The aggregate bits/Joule in network is higher
- Network revenue is also higher

Horizontal Trajectory

\[ \begin{align*}
\text{ACCESS POINT} & \quad \text{POSITIONS OF USER 1 IN HORIZONTAL GEOMETRY} \\
5 \text{ m} & \\
-5 \text{ m} & \quad \text{USER 2 (POTENTIAL FORWARDER)} \\
& \quad \text{USER 1 (NON-FORWARDER)} \\
\end{align*} \]
A “Clustering Measure for Cooperation”

- “Clustering” Measure (Based on initial routes):
  \[ \kappa \equiv \frac{\text{avg. internodal dist.}}{\text{avg. connection dist. to AP}} \]

\[ \kappa = \frac{1}{\binom{6}{2}} \sum_{i=1}^{6} \sum_{j=1}^{6} d_{ij} \]

\[ \kappa = \frac{1}{\binom{6}{2}} \sum_{j \neq i}^{6} d_{6a} \]
Results & Ongoing Work

• We have designed an algorithm to achieve Most Pareto Superior Nash equilibrium
  - Experiments suggest cooperation decreases as the ratio $K$ increases, i.e., less clustering

• Study of the relationship between the threshold ratio over which cooperation is reduced and the number of nodes in the network.

• Implement a 2-node-1-AP scenario on MOBNETS testbed using rudimentary protocols

• Extension of the framework to study a more fundamental information-cost metric

• Effect of interference