

How to Collaborate ?

*Pricing for Enabling Forwarding in Wireless
Ad Hoc Networks*

Narayan Mandayam

(joint work with O. Ileri & S. Mau)

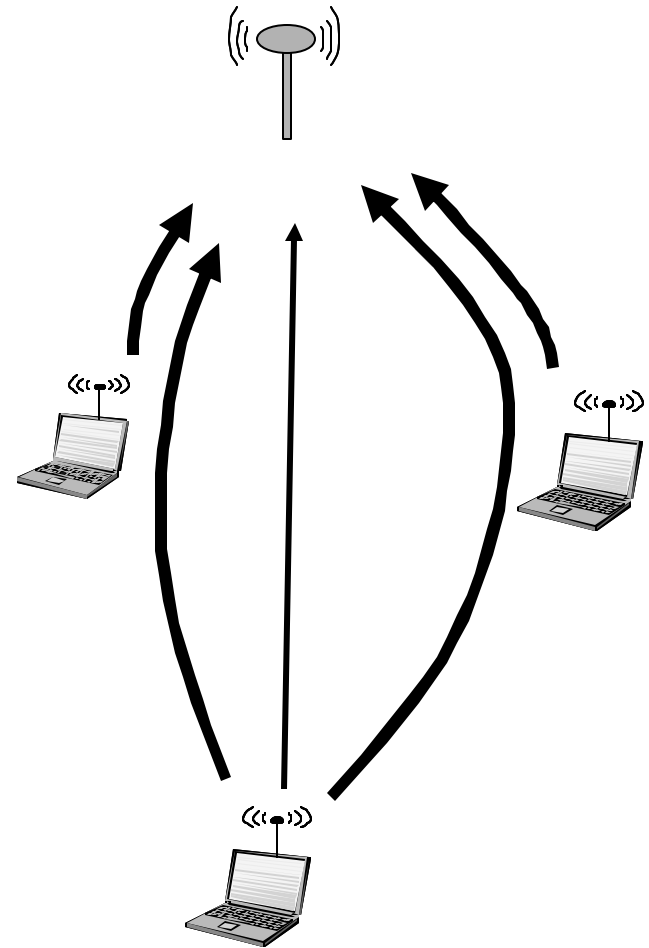
Fostering Cooperation Through “Bribery”

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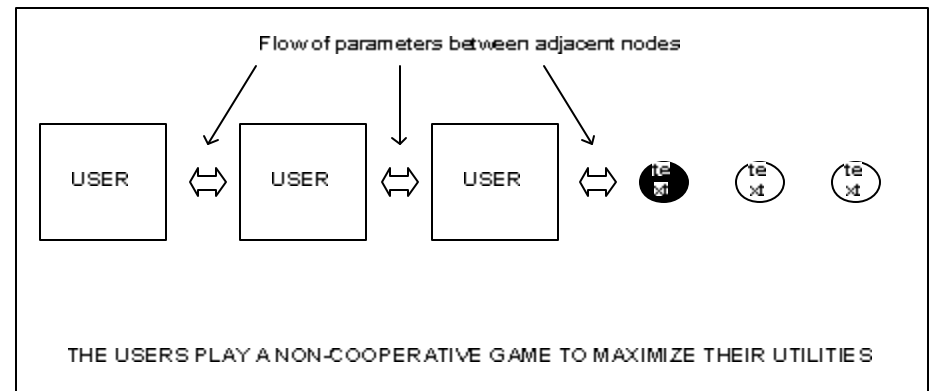
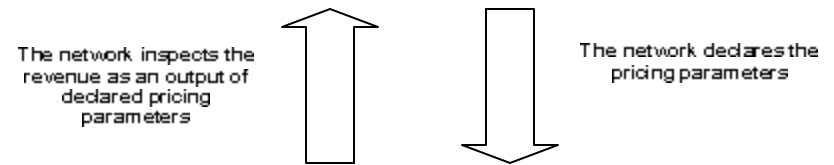
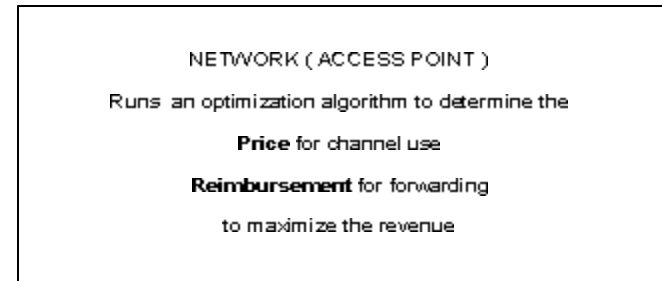
Forwarding in Ad Hoc Networks?

- 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 ?

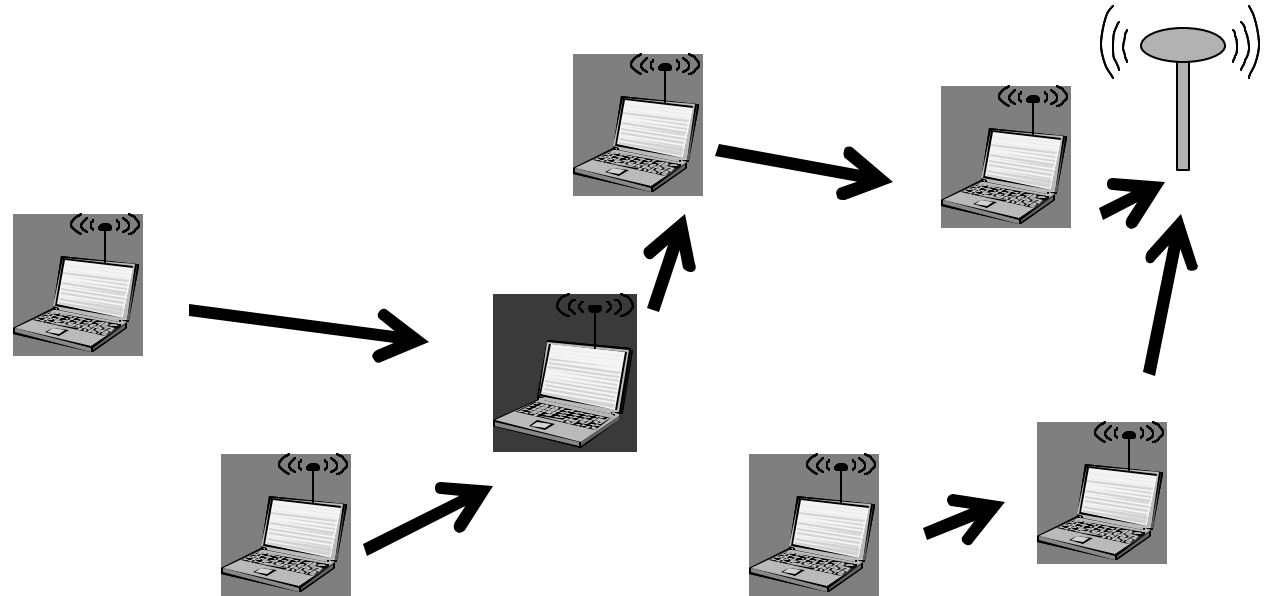


A Microeconomic Framework for Enabling Forwarding: Pricing & Reimbursement

- Nodes control their:
 - Transmit powers
 - Forwarding Preferences
 - Destination Preferences**to maximize bits/Joule**
- The network controls:
 - Pricing Coefficient λ
 - Reimbursement Coefficient: m**to maximize its revenue**



Example: A “Mesh” Network

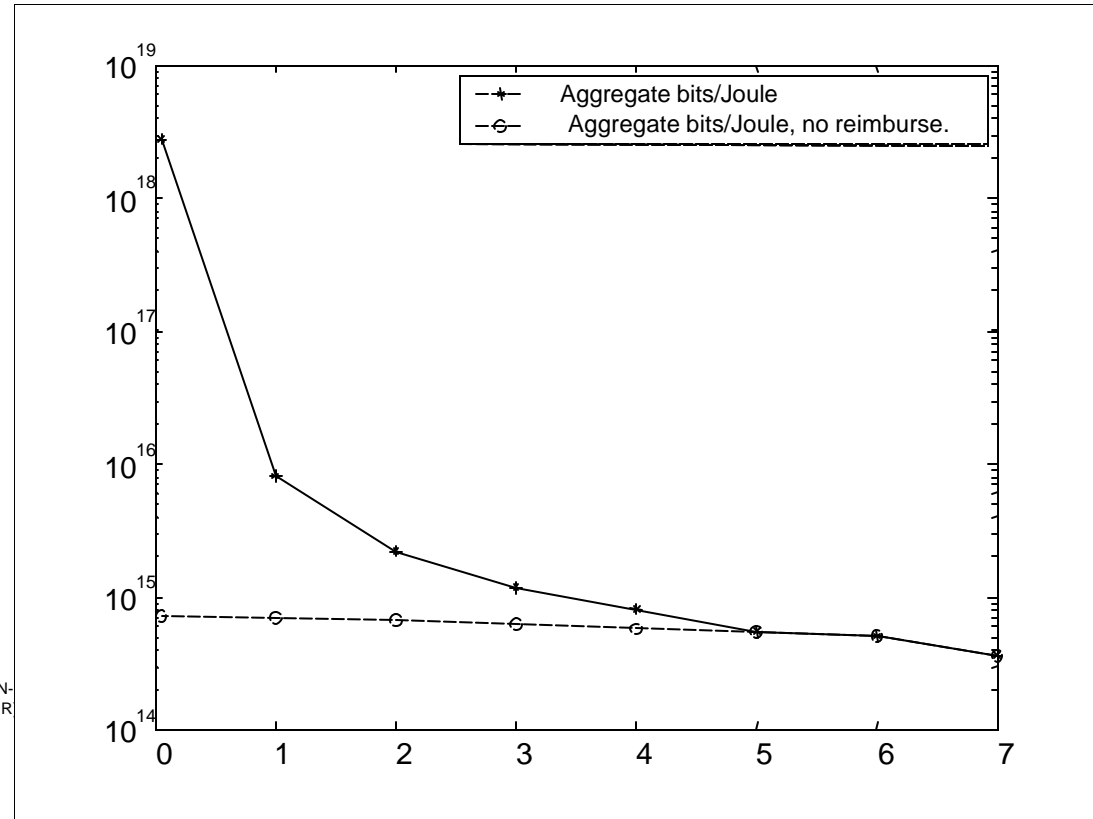
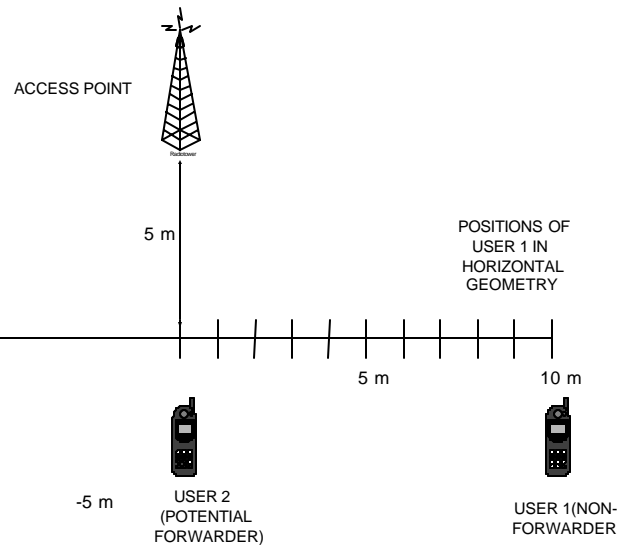


The blue laptop

- 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

Horizontal Trajectory



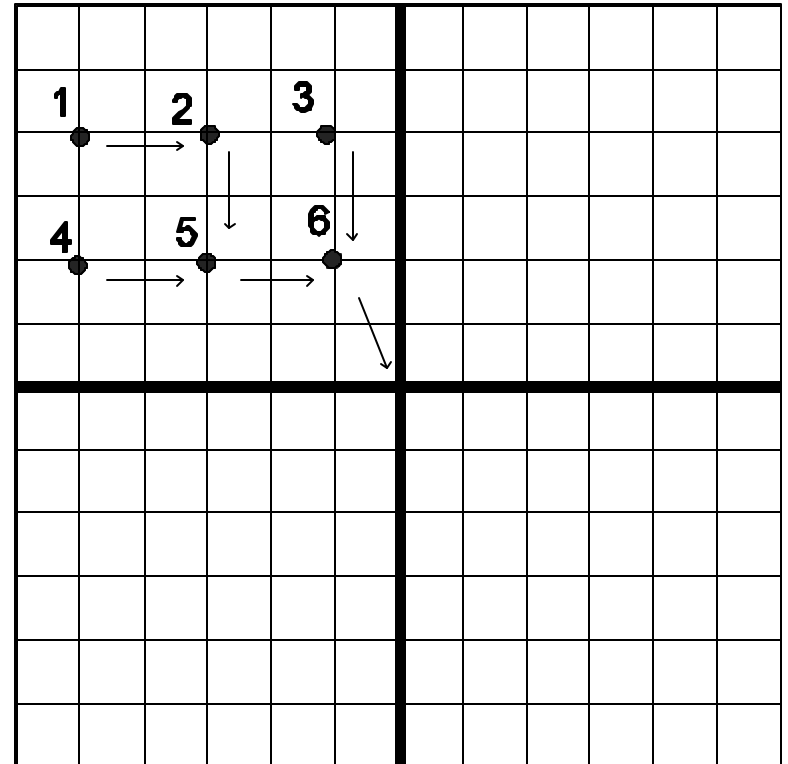
- Incentives for forwarding works when nodes tend to “cluster”
 - The aggregate bits/Joule in network is higher
 - Network revenue is also higher

A “Clustering Measure for Cooperation”

- “Clustering” Measure (Based on initial routes):

$$k \equiv \frac{\text{avg. internodal dist.}}{\text{avg. connection dist. to AP}}$$

$$k = \frac{\frac{1}{\binom{6}{2}} \sum_{i=1}^6 \sum_{\substack{j=1 \\ j \neq i}}^6 d_{ij}}{d_{6a}}$$



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