Relaying Incentivization for Multihop Wireless Networks

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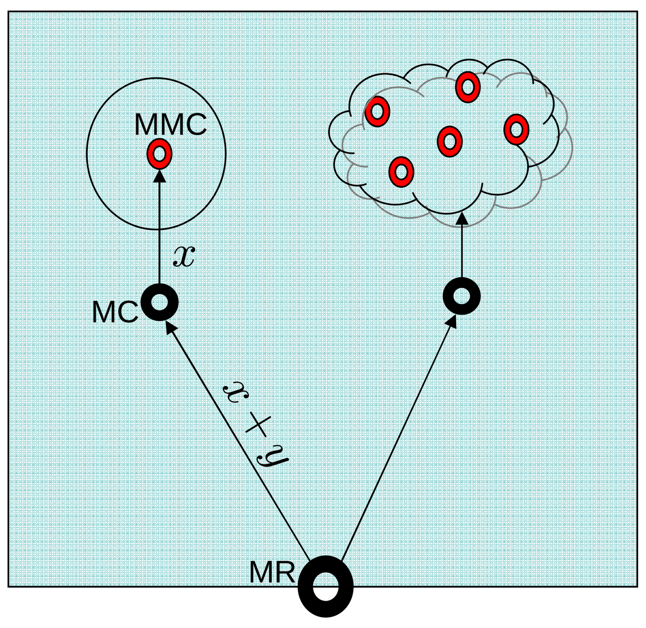
Nodes in multihop wireless networks are required to relay traffic from source to destination. This operation is not free: they need to share their bandwidth and power budget with other users. We discuss incentive mechanisms via pricing to motivate relaying and to avoid undesirable effects such as selfish use of network resources and/or random packet dropping.

Financial Model for Network Users

- Mesh Client's net utility: $U_n(y_n) - My_n + D(x_n)$
- Discount function:
- Linear: $D(x_n) = dx_n$
- Supper-additive: $D(x_n) = exp(dx_n) - 1$
- Sub-additive: $D(x_n) = d\log(1 + x_n)$
- User seeks to maximize its utility:

$$y_n = (U_n')^{-1}\left(M - D'(x_n)\frac{\partial x_n}{\partial y_n}\right)$$



- In the absence of any incentive, MC would like to consume all of the bandwidth.
- With incentive:
  - Portion y of the traffic is still requested for its own benefit
  - Portion x of the traffic is relayed for other nodes
  - How much x is the relaying node willing to carry for others?
  - How much y will it request such that its net utility is maximized?

Example Scenario: CDMA mesh networks

Example Scenario: ALOHA-based mesh networks

- Objective: coverage for MCs out-of-range (MMCs) with infrastructure (BS and MRs)
- Incentive method: give in-range MCs discount for their own traffic based on the amount of relaying they do for MMCs
- Method: set up an Iterative game between the MR (infrastructure) and the in-range MCs (network users)

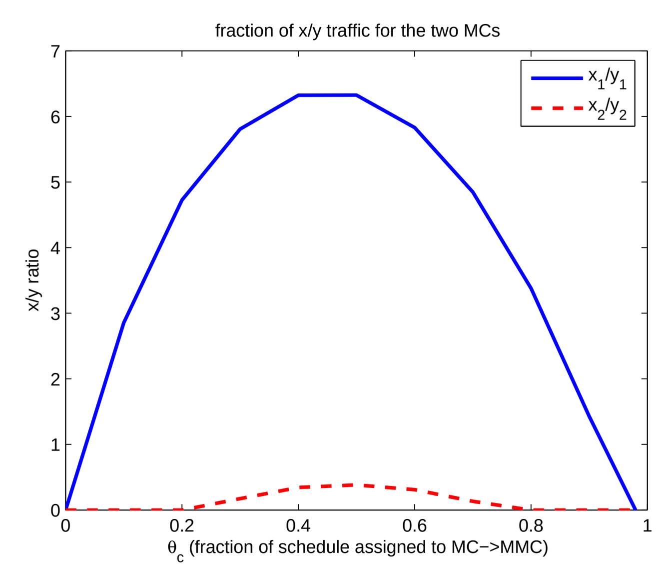
- Adjustable parameters: transmission powers
- Portion of schedule spent for others' traffic depends on the provided discount factor: $\theta_c = \mu \times d$

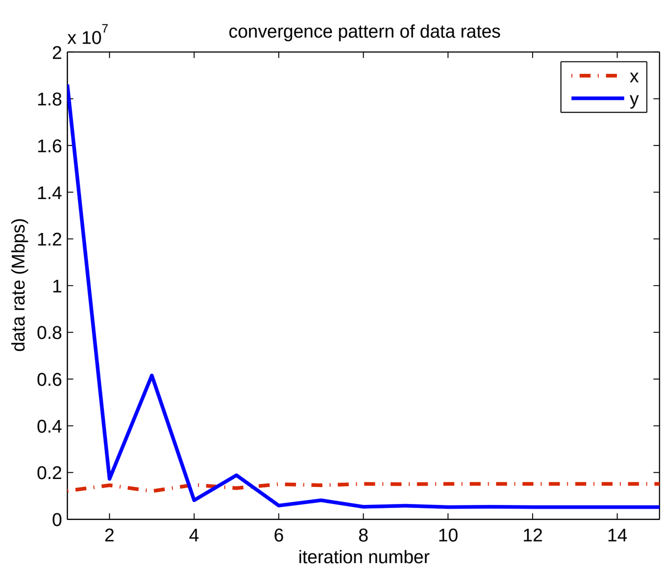
$$\pi_{(\mathrm{MR},\mathrm{MC}n)}(i+1) = \pi_{(\mathrm{MR},\mathrm{MC}n)}(i) \times \frac{(2^{(\frac{x_n(i)+y_n(i)}{\alpha(1-\theta_c)}-1)})}{\mathrm{SINR}_{\mathrm{MC}n}}$$

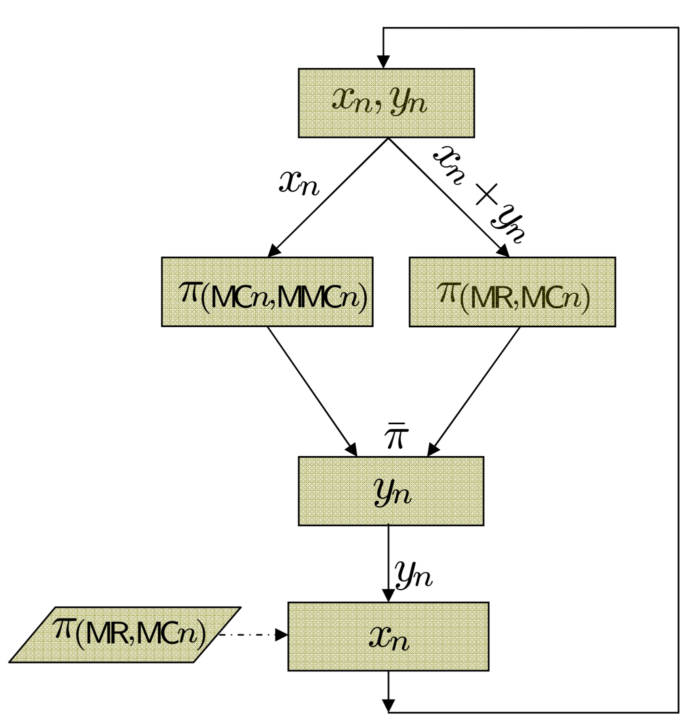
$$\pi_{(\mathrm{MC}n,\mathrm{MMC}n)}(i+1) = \min\left(\pi_{(\mathrm{MC}n,\mathrm{MMC}n)}(i) \times \frac{(2^{(\frac{x_n(i)}{\alpha\theta_c}-1)})}{\mathrm{SINR}_{\mathrm{MMC}n}}, \pi^{\max}_{\mathrm{MC}n}\right)$$

$$y_n(i+1) = \min\left\{(U_n')^{-1}\left(M - D'(x_n(i)) \cdot \frac{\partial x_n}{\partial y_n}(i)\right), (x_n(i) + y_n(i))\right\}$$

$$x_n(i+1) = \alpha(1-\theta_c)\log_2(1 + \mathrm{SINR}_{\mathrm{MC}n}) - y_n(i+1)$$







- Adjustable Parameters: access probabilities
- $x_n = p_n(1 - P_{MR})\prod_{i \neq n}(1 - P_i)$ and $X + Y = P_{MR}\prod_{n=1}^{N}(1 - p_n)$

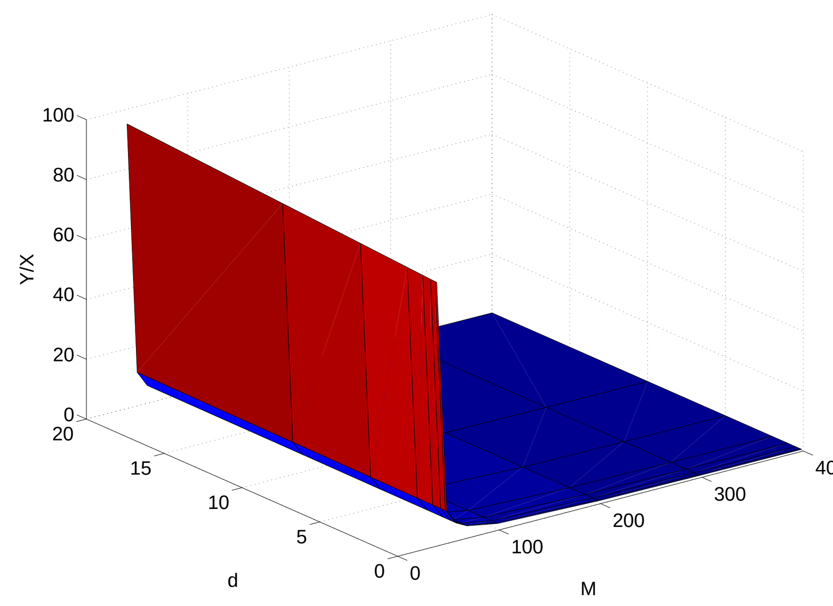
$$p_n^{(k+1)} = \min\left\{\frac{x_n^{(k)}}{(1-P_{MR}^{(k)})\prod_{i\neq n}(1-p_i^{(k)})},\ 1\right\}$$

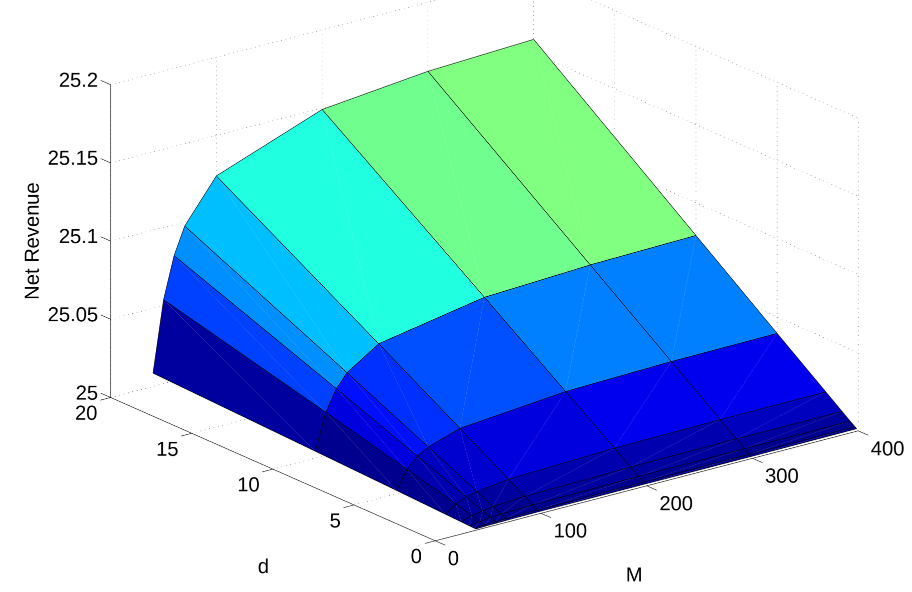
$$P_{MR}^{(k+1)} = \min\left\{\frac{Y^{(k)}+X^{(k)}}{\prod_n(1-p_n^{(k)})}, 1\right\}$$

$$x_n^{(k+1)} = p_n^{(k+1)}(1 - P_{MR}^{(k+1)})\prod_{i\neq n}(1 - p_i^{(k+1)})$$

$$y_n^{(k+1)} = (U_n')^{-1}\left(M - D'(x_n^{(k+1)})\frac{\partial x_n}{\partial y_n}(\underline{p}^{(k+1)})\right)$$

Demand Ratio vs. M and d





Net revenue vs. M and d

This Work is Sponsored by NSF Grant No 0219747.