

Network Coding Aware Rate Selection in Multi-Rate IEEE 802.11 Networks

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Goal

- Set link rates to maximize goodput considering network coding
- Note: goal is *not* to maximize coding opportunities

Problem

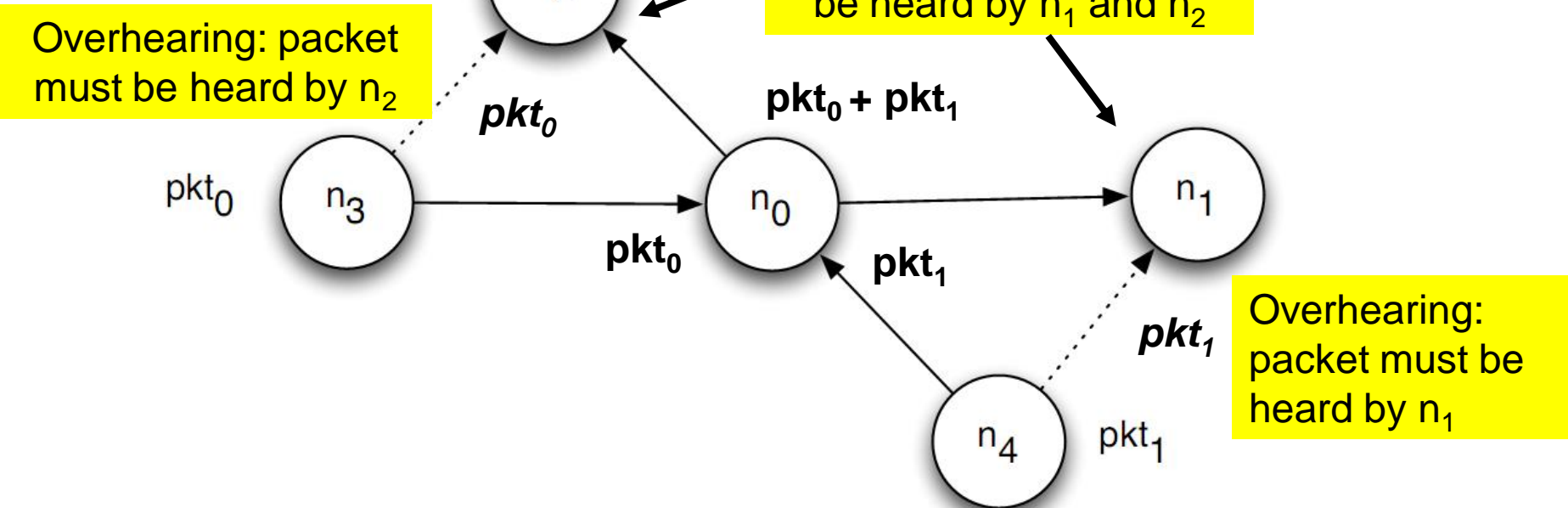
- Trade-off exists between rates and ability to perform network coding
- Currently rate adaptation does not consider requirements of network coding

Contributions

- Identification of traffic patterns that present coding opportunities in realistic networks
- Analysis of goodput in these scenarios with multiple rates and network coding
- Design of NCRS algorithm
- Thorough evaluation
- **NCRS provides 50% higher gain over routing than non-aware rate selection algorithms**
- **Builds upon work started as part of CBMANET (Infocom 2008)**

COPE-like NC

- Network coding performed opportunistically hop-by-hop
 - simple XOR of packets
- Two considerations
 - multicasting
 - overhearing



Approach

- **Determine number of transmissions required to deliver packets to destinations**
 - consider network coding
 - consider delivery probabilities given SNRs
 - consider link and network layer retransmissions
- **Estimate of expected goodput**
- **Goal: select rates to maximize goodput**

$$NCRS(\{(R_{i\{j\}}, SNR_{ij})\}) = \{(\gamma_i^l, R^l)\} \text{ where} \quad (30)$$

$$n_j \in J, \text{ and } \gamma_i^l \text{ is solution of} \quad (31)$$

$$\text{Maximize } \sum_l \gamma_i^l \delta_i^l \text{ where } \sum_l \gamma_i^l = 1, \quad (32)$$

$$\delta_i^l = R^l \left(1 + \sum_{k \neq m, n_k \in J} q''_{iJ}{}^k\right) / Z_{iJ}^m, \quad (33)$$

$$n_m \text{ is a direct target and is cts-node,} \quad (34)$$

$$\min_j (R_{i\{j\}}) \leq R^l \leq \max_s (R_{i\{s\}}), \quad (35)$$

$$n_s \in J \text{ and } n_s \text{ is a direct target} \quad (36)$$

$R_{i\{j\}}$: rate on link i,j

γ : fraction of air time

δ : expected goodput from analysis

q'' : probability packet received at non-CTS node including rx

Z : expected number of retransmissions

Maximum rate selected based on target nodes (not overhearing)

Topology

- 5 x 10 grid of 50 nodes
- Grid points separated by 100m, coordinates then randomized
- Resulting environment: SNR ranges between 6dB and 12dB

Traffic

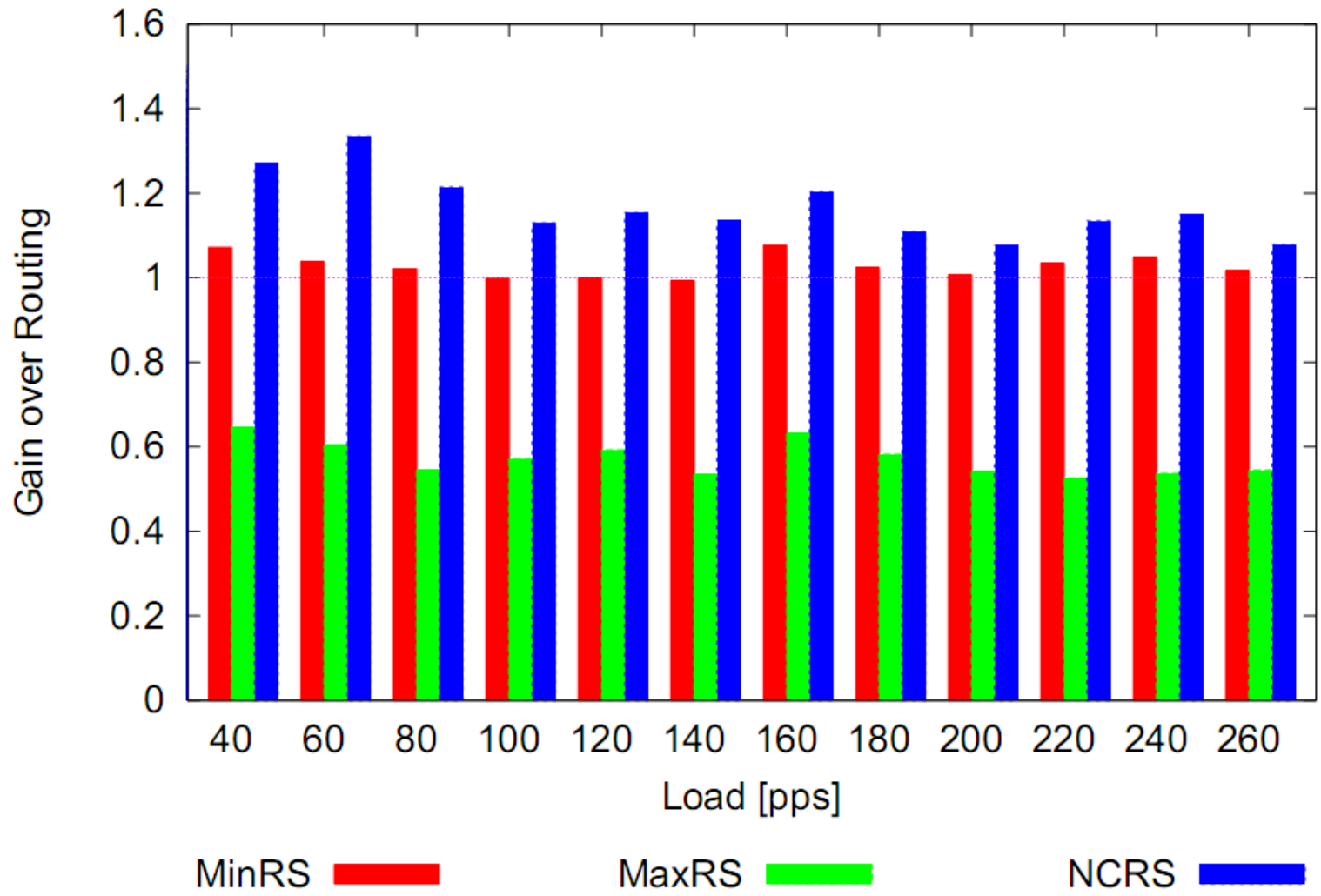
- 4, 8 or 12 flows
- 3-5 nodes/flow
- CBR traffic equal for all flows

Observations

- Scenario results in 3, 4 and 5 node scenarios

12 Flows

- NCRS outperforms MinRS by up to 30% and MaxRS by up to over 70%



Developed Network Coding-aware Rate Selection Algorithm

- Based on analysis of goodput with network coding in realistic scenarios
- Maximizes expected goodput
- Builds upon existing rate adaptation algorithms (we used AARF)

Results

- NCRS outperforms other simpler algorithms
- NCRS is robust against congestion