Greedy Hybrid Rate Adaptation in Dynamic Wireless Communication environment

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Outline

1. Introduction
2. System model
3. GHRA algorithm
4. Simulation Results
5. Conclusion

Outline

Motivation

- Time-varying channel in the wireless communication system
- Rate adaptation (RA): a strategy to update the transmission rate in dynamic wireless environment

RA algorithms

- Metrics
  - channel state information (CSI), SINR
  - MAC: ACK/NACK
  - PHY: SNR, RSSI
- Adapt rate
  - Sequential rate adjustment
  - Best rate adjustments

RA algorithms

- MAC: Auto rate fallback (ARF), etc.
- PHY: SNR-Guided Rate Adaptation (SGRA), Receiver-based auto rate (RBAR), etc.

Some notable question

- ACK/NACK
  - can not quickly response
- RSSI or SNR
  - did not accurately capture the changes
- Probe
  - send frames at other rates to track channel

Outline

System model

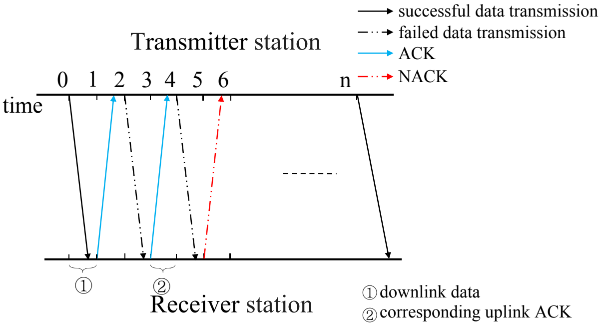


Figure 1: Packet transmission in TDD systems.

The ACK/NACK signals, in general, are the delayed response to the quality of the transmission.

Outline

GHRA

- Adopt both RSSI and ACK/NACK information
- Model the rate selection problem as a multi-armed bandit (MAB) problem, gives an estimation reward for each rate under each RSSI level S_l
  - environment: channel, RSSI
  - arm: the rate collection $\{\mathcal{R}_k\}_{k=1}^{K}$
  - reward: $r_k = ACK_i \cdot R_k$, ACK_i is a binary number, represents whether the packet is successfully transmitted based on ACK/NACK feedbacks
- Set the appropriate probe ratio to deviate from the temporary optimal rate in the time-varying channel.

GHRA

- Estimate the reward: $Q'_k = \alpha^{ln(\Delta_t+1)} Q_k + (1 - \alpha^{ln(\Delta_t+1)}) r_k$
- Selection:

$$k = \begin{cases} \arg\max_{k \in K} Q'_k, & p = 1 - \epsilon, \\ [\arg\max_{k \in K} Q'_k] + 1, & p = \epsilon. \end{cases} \quad (1)$$

- Adapt the probe ratio ϵ based on the extent of changes in estimated reward Q'_k as value-difference based exploration (VDBE)

VDBE

Select probe ratio ϵ based on the extent of changes in estimated reward Q'_k

$$f(\sigma) = \left| \frac{e^{Q'_k/\sigma} - e^{Q_k/\sigma}}{e^{Q'_k/\sigma} + e^{Q_k/\sigma}} \right|, \tag{2}$$

where σ is a positive constant called inverse sensitivity. The exploration ratio of the next moment in our rate adaptation scheme is updated as

$$\epsilon' = \delta \cdot f(\sigma) \cdot \mathbf{1}_{ACK_i} + (1 - \delta) \cdot \epsilon, \tag{3}$$

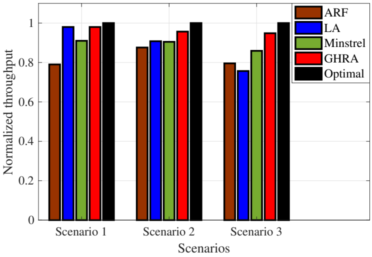
where $\delta \in [0, 1)$. GHRA only explores higher rates which probe ratio should be reduced when received NACK signals.

Outline

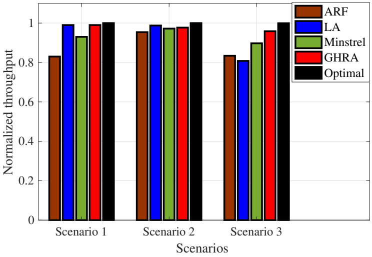
Simulation Results

- A SISO system with rates: $\{\mathcal{R}_k\}_{k=1}^{15}$, channel states: $\{\mathcal{C}_m\}_{m=1}^{100}$, RSSI: $\{\mathcal{S}_l\}_{l=1}^{35}$
- Examine the performance of GHRA compared with the other three RA algorithms: ARF, LA, and Minstrel
- Three scenarios: a static channel with constant RSSI, a static channel with varying RSSI, and a time-varying channel with varying RSSI

Simulation Results



(a) Normalized throughput in different scenarios with delayed ACK/NACK.



(b) Normalized throughput in different scenarios with timely ACK/NACK.

Figure 2: Normalized throughput obtained by different algorithms.

Simulation Results

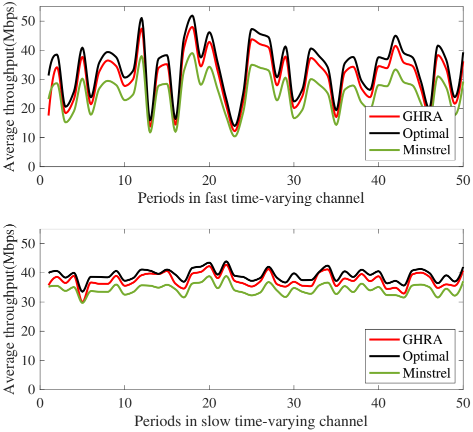


Figure 3: Performance in the channel with different varying degrees

Outline

- a greedy hybrid rate adaptation (GHRA) algorithm
- Model the rate selection problem as a MAB problem.
- Update the probe ratio based on VBDE.
- Achieve better performance compared to other classical algorithms in various channel conditions.

Thanks for listening!