Optimizing aggregate throughput of upstream TCP flows over IEEE 802.11 wireless LANs

International symposium on Personal, Indoor and Mobile Radio Communications 2007
PIMRC 2007

Nakjung Choi, **Jiho Ryu**, Yongho Seok, Taekyoung Kwon and Yanghee Choi
Seoul National University

Outline

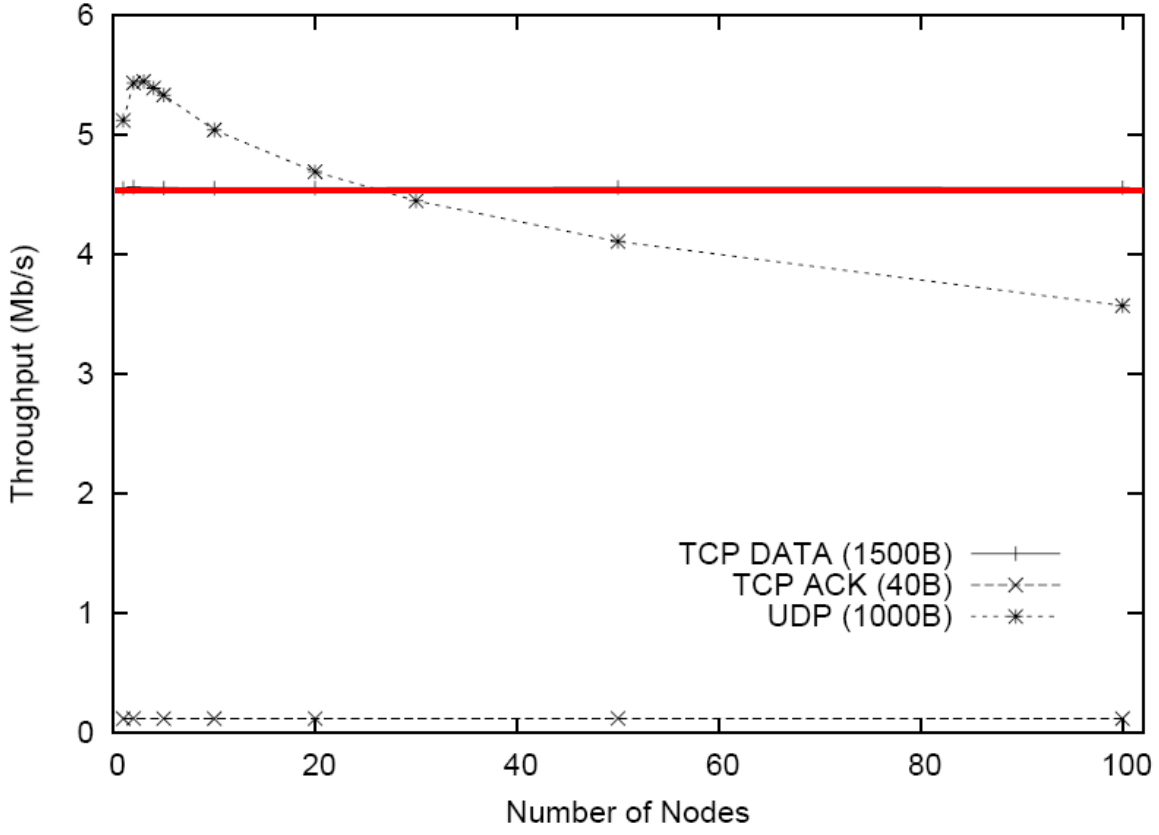
- Introduction
- TAP (TCP ACK Priority)
- Performance Evaluation
- Conclusion

Introduction

- TCP's congestion control mechanism
  - Slow start
    - Congestion window (cwnd) is set to 1
    - cwnd is increased exponentially until it reaches slow start threshold
  - Congestion avoidance
    - After cwnd reaches the ssthresh
    - cwnd is increased by 1/segment after each RTT
    - Linearly increasing.
  - When a station has sent cwnd of TCP data, it cannot send more data until it receives a TCP ACK from the recipient.

Introduction

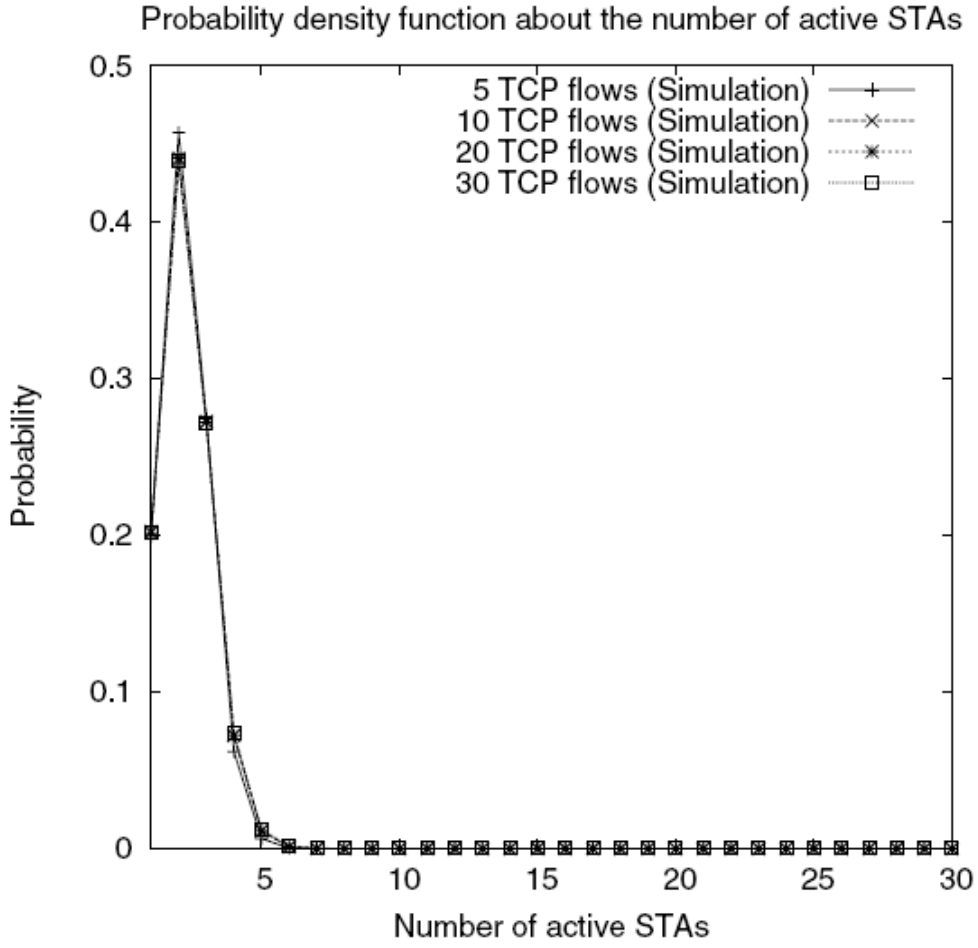
- Aggregated goodput of TCP flows
  - S. Choi, K. Park, and C. Kim, “On the performance characteristics of WLANs: revisited,” ACM Sigmetrics.



jhryu@mmlab.snu.ac.kr

Introduction

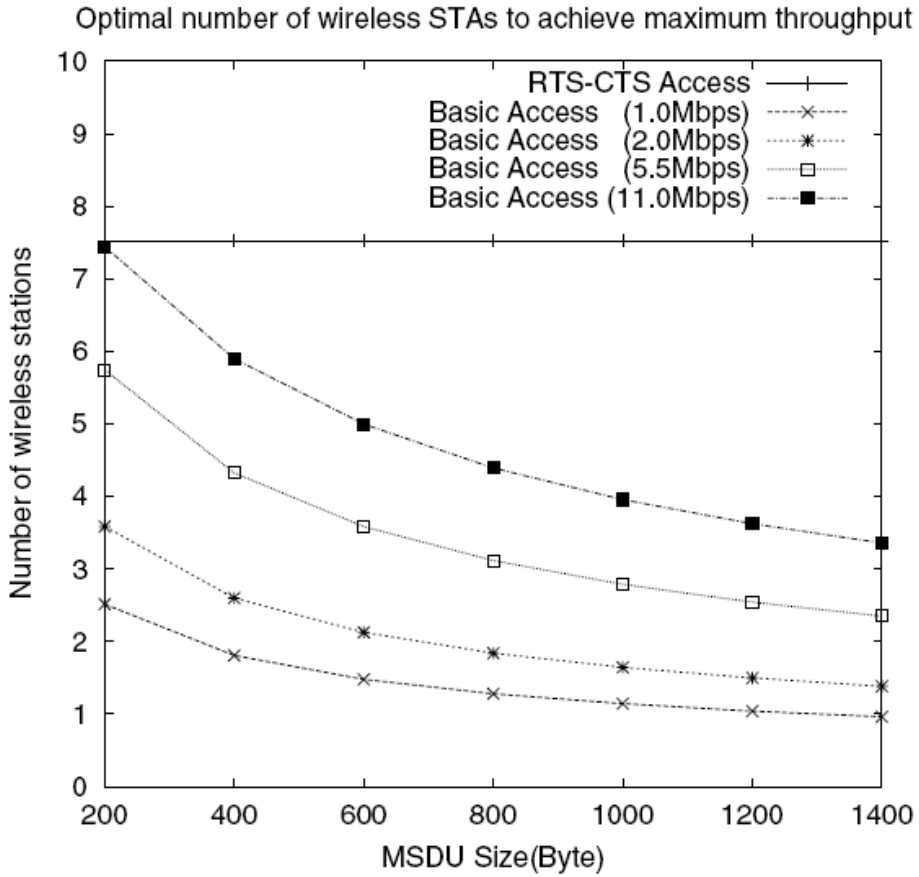
- PDF of the # of active stations for uploading TCP



jhryu@mmlab.snu.ac.kr

Introduction

- Optimal number of wireless STAs to achieve maximum throughput



jhryu@mmlab.snu.ac.kr

Outline

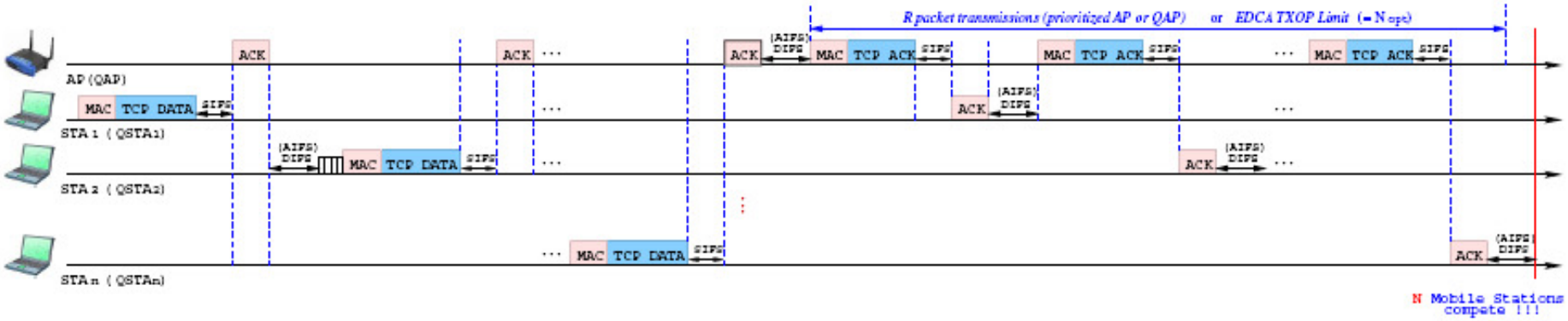
- Introduction
- TAP (TCP ACK Priority)
- Performance Evaluation
- Conclusion

TCP ACK Priority

- How can we increase the number of active stations?
  - TCP ACK Priority
    - If the maximum aggregate throughput of a WLAN can be achieved when n STAs (including an AP) contend to access the wireless channel → can be obtained from previous analysis
    - The AP transmits TCP ACKs to n -1 STAs in a way that preempts all other transmissions.
    - AP intentionally transmits the TCP ACK packet at the 0^{th} slot after a DIFS, with no backoff time.

TCP ACK Priority

- Incorporation



(a) IEEE 802.11 DCF 0^{th}-slot or IEEE 802.11e EDCA TXOP

  - 802.11e
    - Transmission Opportunity (TXOP) feature
  - 802.11n
    - Packet aggregation

jhryu@mmlab.snu.ac.kr

Outline

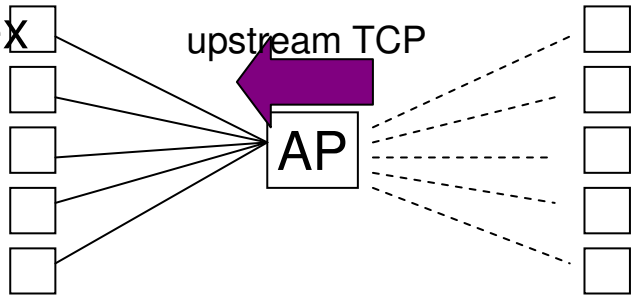
- Introduction
- TAP (TCP ACK Priority)
- Performance Evaluation
- Conclusion

Performance Evaluation

- NS2 simulator
  - Wireless part: n STAs and one AP
  - n hosts in the wired part

  - Traffic: FTP model, 1024-bytes TCP DATA
  - DATA tx rate: 11 Mbps
  - RTS/CTS tx rate: 1 Mbps
  - Simulation time: 200 seconds

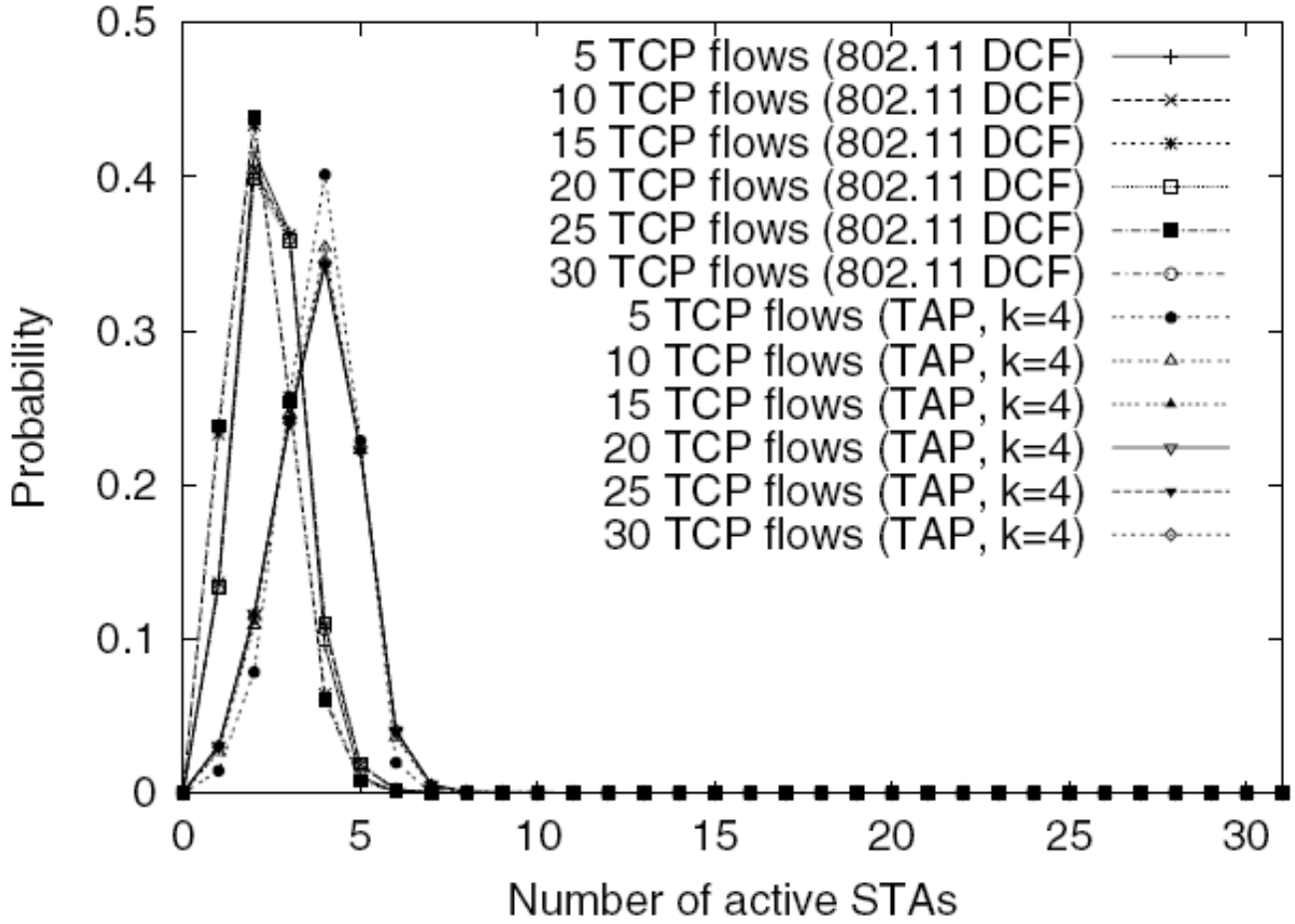
  - PDF of the number of active STAs, aggregate throughput , and fairness index



jhryu@mmlab.snu.ac.kr

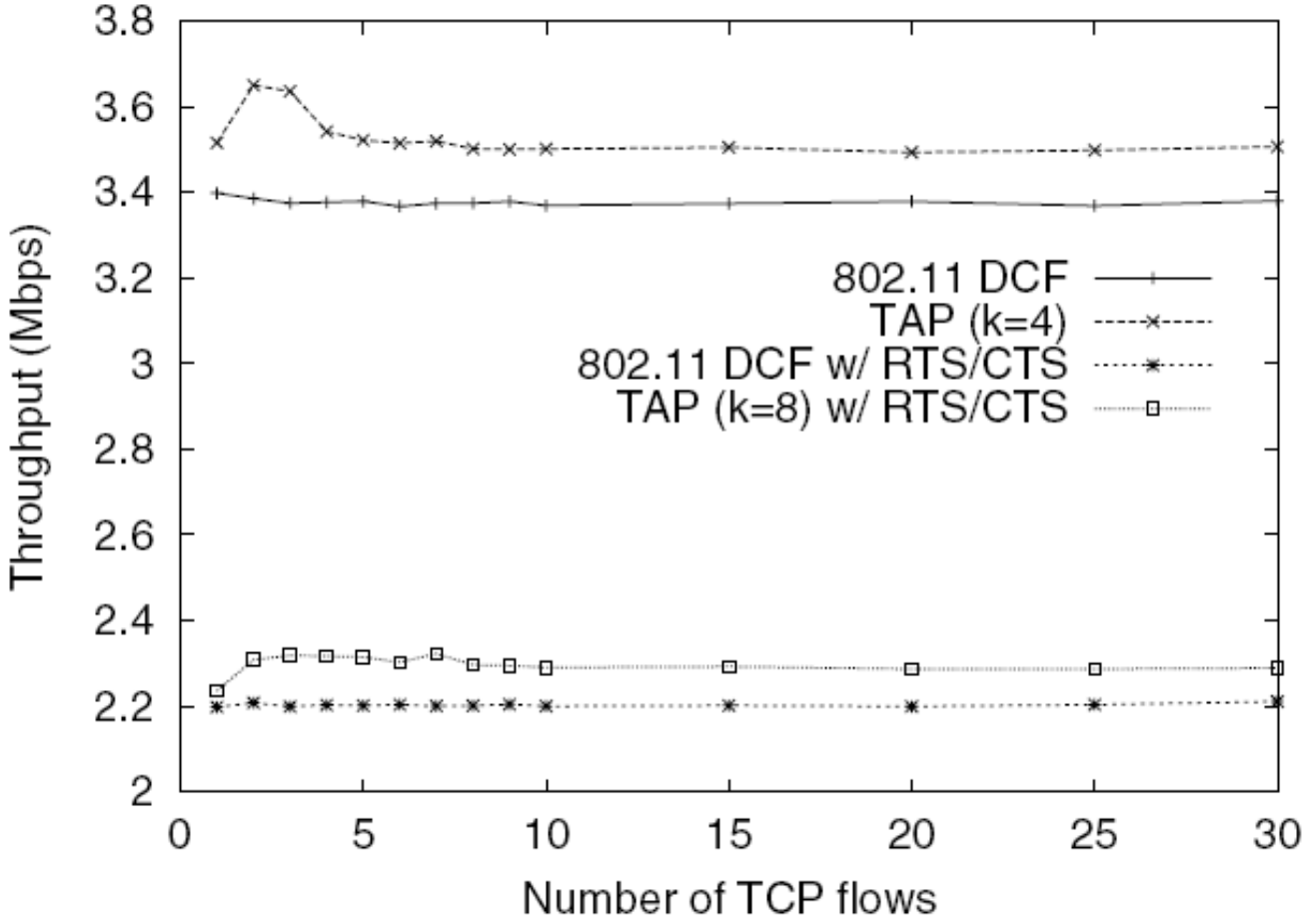
Performance Evaluation

- PDF of the number of active STAs
  - without RTS/CTS → optimal n is 4



Performance Evaluation

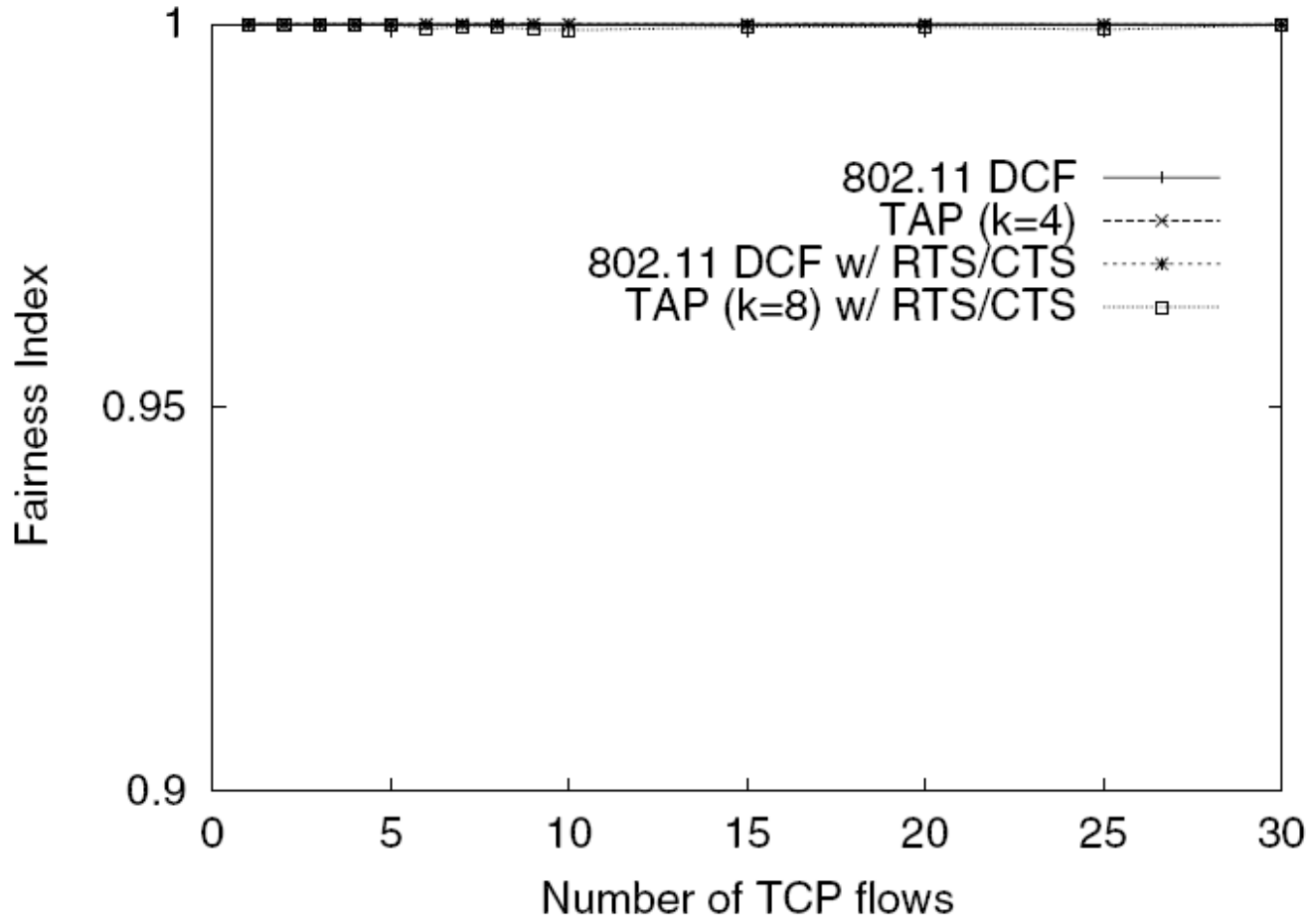
- Aggregated TCP goodput



jhryu@mmlab.snu.ac.kr

Performance Evaluation

- Fairness Index – long-term, Jain Fairness Index



jhryu@mmlab.snu.ac.kr

Conclusion

- TCP ACK Priority
  - 0^{th} time slot is used to transmit the TCP ACK packet
  - 802.11e's TXOP can be used too.
  - Make the optimal number of competing stations contend for media access.
  - Higher aggregate TCP goodput is achieved.

Thank you!!
Q&A

jhryu@mmlab.snu.ac.kr