802.11 Wireless LAN Multiplayer Game Capacity and Optimization

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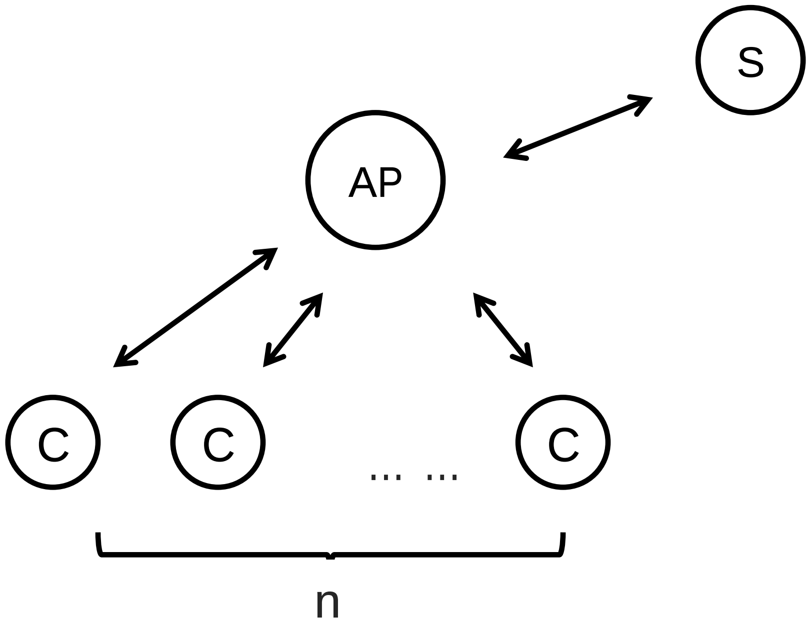
Problem definition and introduction

A bunch of people are playing network game together in an IEEE 802.11 wireless LAN



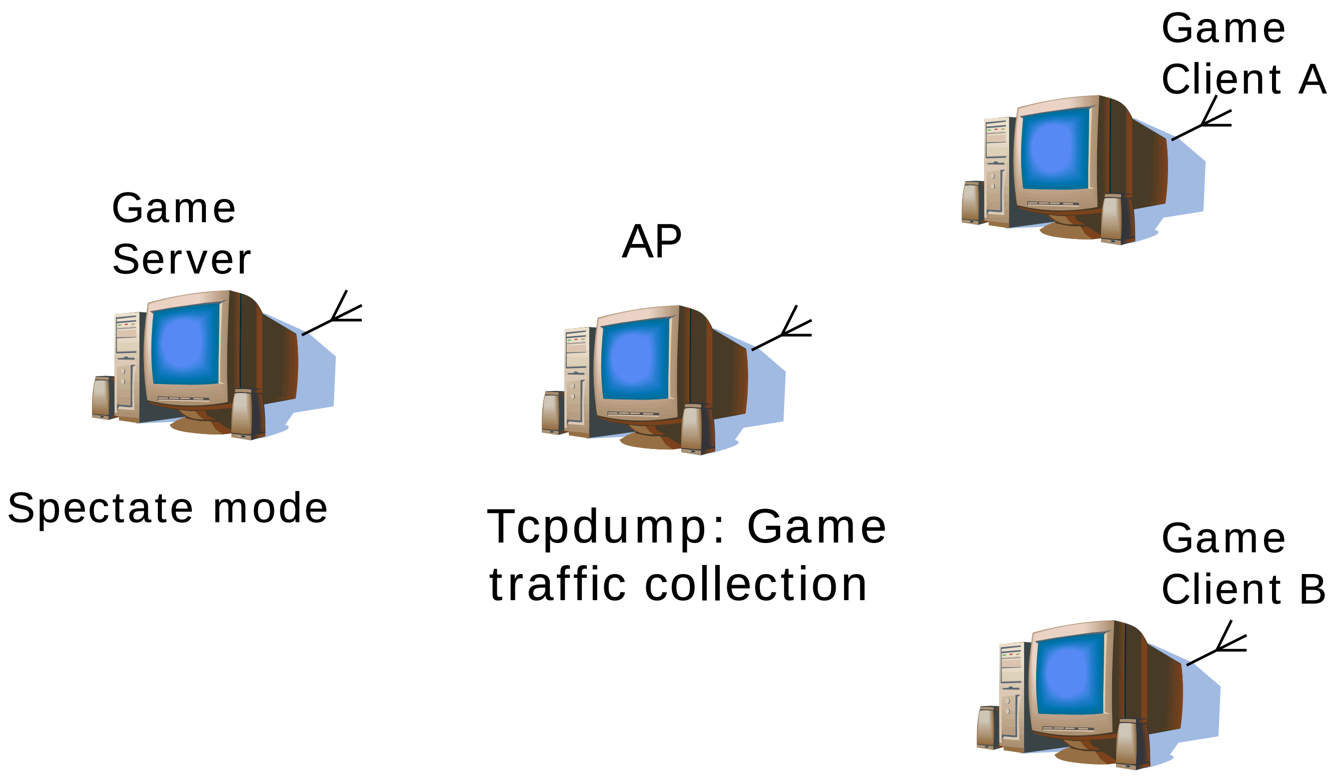
How many players can an 802.11 network support? If 802.11e (TXOP) is used, it can have more players?

Outline

1. Wireless network game traffic measurement
2. Model the network game performance over an 802.11 network
3. Network optimization with 802.11e and TXOP
4. Results and performance
5. Conclusions and future works

Wireless network game traffic measurement

A clean normal indoor 802.11b wireless network, 4 Linux PCs (6-8 meters away), Game: Quake 4

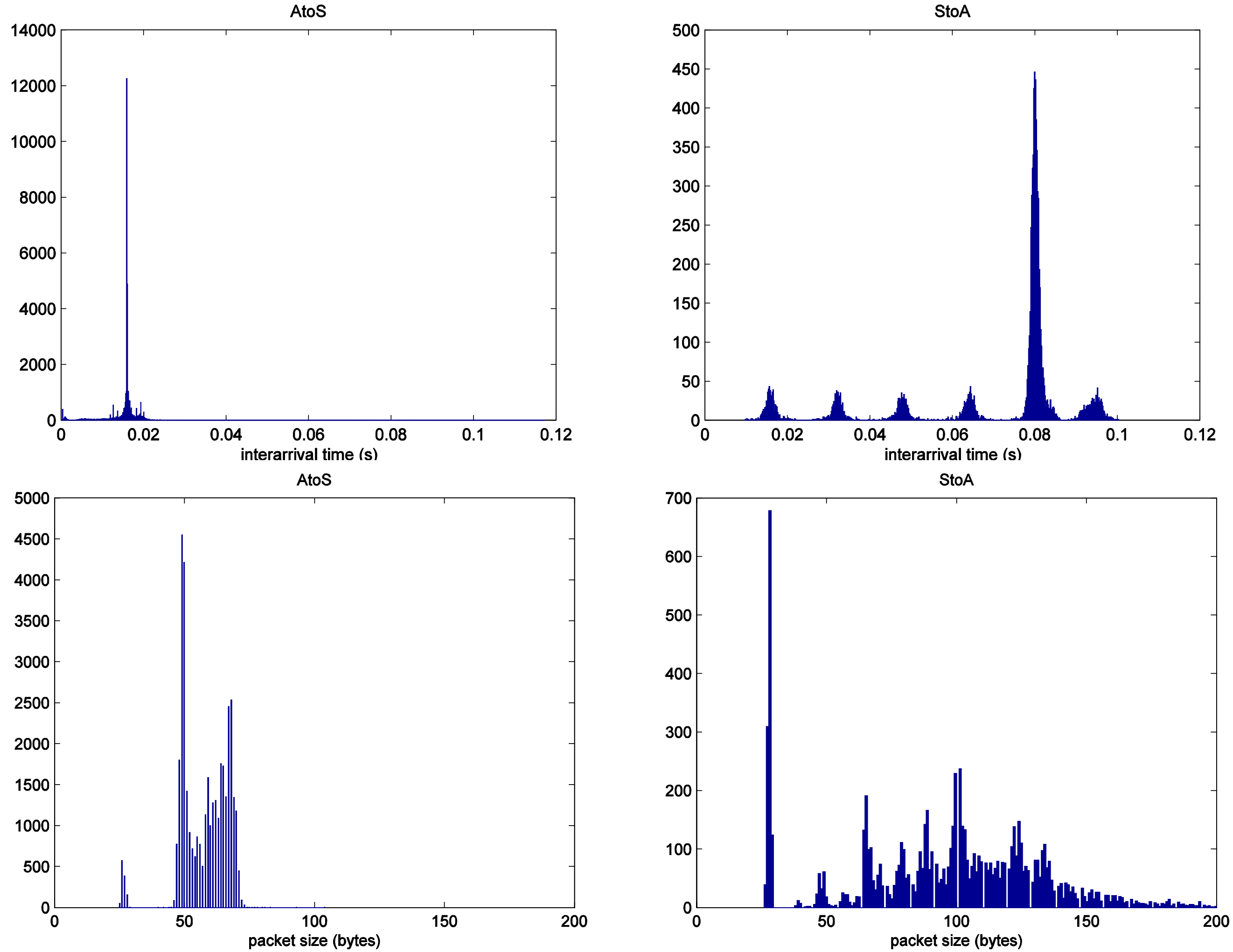


We care about packet arrival rate, size and bytes rate

Wireless network game traffic measurement

Inter-arrival time

Packet size distribution



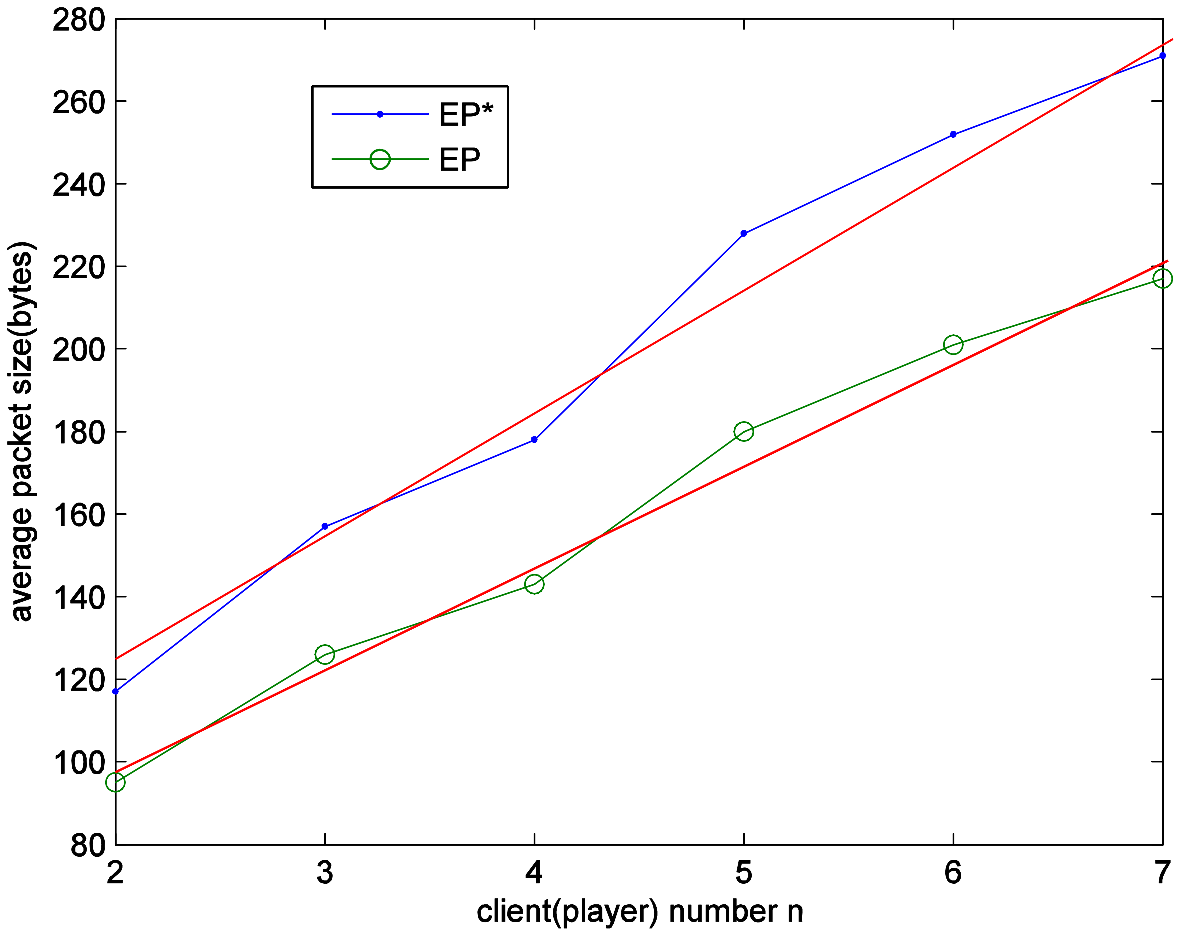
Client to Server

Server to Client

ARMA(1,1) process (Armitage et. al.)

Wireless network game traffic

Server to Client packet size increases with the number of players. (Armitage, Branch et. Al.)



802.11 MAC: Distributed Coordination Function (DCF): Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) with exponential backoff

- After transmission choose rand(0, *CW*-1).
- Wait until medium idle.
- Count down in slots
- Transmit when get to 0 (if you have a packet).
- If ACK then $CW \leftarrow CW_{min}$ else $CW \leftarrow 2CW$

Model: Nonsaturation two dimensional Markov chain model (Bianchi, Malone, Duffy, Leith)

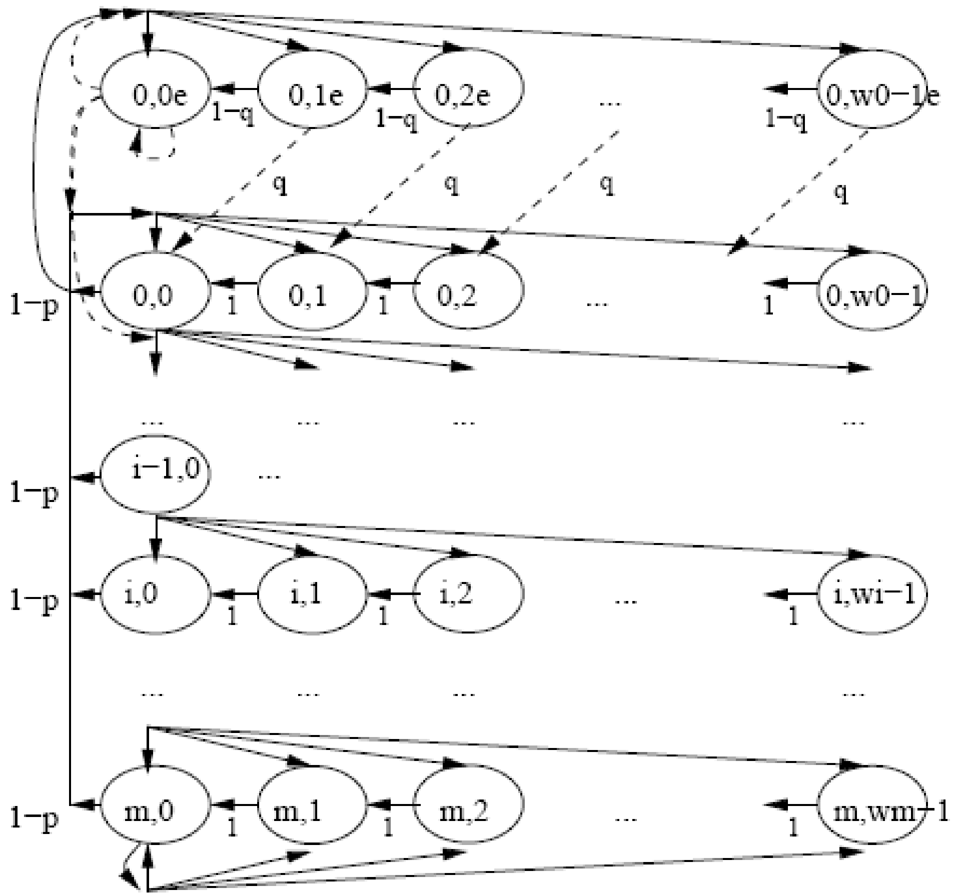


Fig. 10. Markov chain model of 802.11 MAC

Model: Nonsaturation two dimensional Markov chain model (Bianchi, Malone, Duffy, Leith)

Transmission probability τ, conditional collision probability *p*, packet arrival rate *q*, MAC parameters *w, m*

$$\begin{cases} \tau_1 = f(q_1, p_1, w, m) \\ p_1 = 1 - \prod_{i \neq 1} (1 - \tau_i) \\ \tau_2 = f(q_2, p_2, w, m) \\ p_2 = 1 - \prod_{i \neq 2} (1 - \tau_i) \\ \ldots \quad \ldots \end{cases}$$

Numerically solving these nonlinear equations

IEEE 802.11 MAC scheme and model

Objective performance indicators

Throughput

$$S = \frac{P_s P_{tr} E[P]}{(1 - P_{tr})\sigma + P_{tr} P_s T_s + P_{tr}(1 - P_s) T_c}$$

MAC (network) delay

$$D = E[\sum_{i=1}^{N} L_i] = E[N]E[L]$$

MAC (network) jitter (we draw the 802.11 MAC jitter formula which was not there)

$$J = \mathrm{var}[D] = E[(\sum_{i=1}^{N} L_i)^2] - E[D]^2$$

To get subjective performance indicators from objective indicators: MOS (mean opinion score) – delay and jitter

Network impairment

$$X = 0.104 \times ping\_average + jitter\_average$$

Mean opinion score

$$MOS = -0.00000587 X^3 + 0.00139 X^2 - 0.114 X + 4.37$$

(Wattimena et.al, NetGames 06)

By using the delay and jitter calculated with our model, the MOS indicator turns to be very reasonable (to show later in our results)

Network improvement with 802.11e parameter

Problem of basic 802.11 DCF network:

It could has bottleneck at AP when there are many stations for supporting data traffic such as VOIP (Cliford et. al. 2005) or Games

We will use 802.11e parameters such as TXOP to improve the network for Games traffic.

Avoiding the bottleneck at AP and Server by using 802.11e (TXOP)

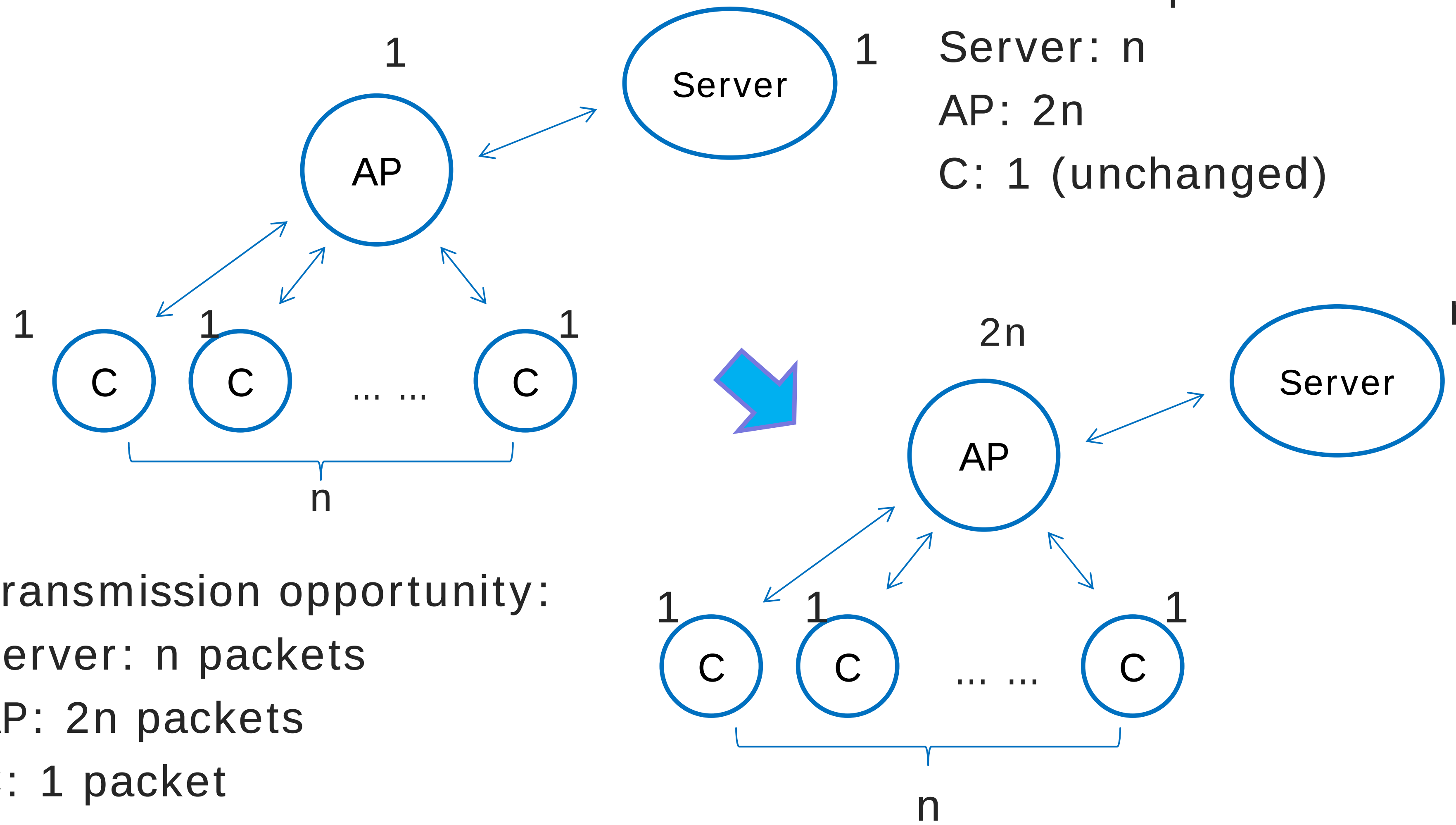
TXOP (transmission opportunity) to give priority and to support burst like traffic in AP and Server

TXOP setup in 802.11e:

Server: n

AP: 2n

C: 1 (unchanged)



Transmission opportunity:

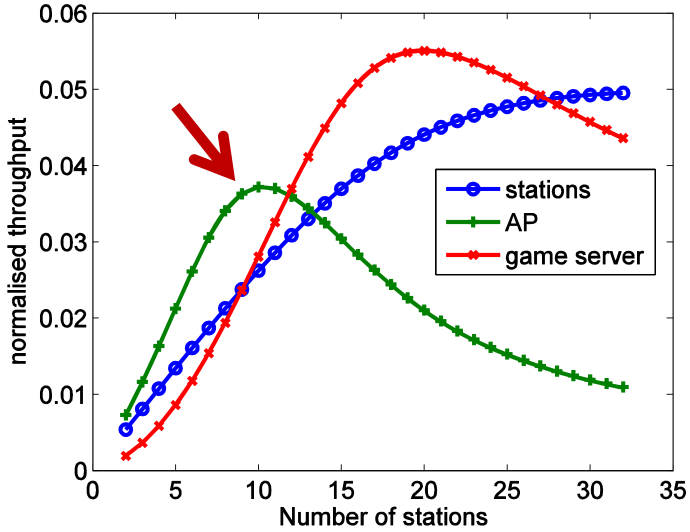
Server: n packets

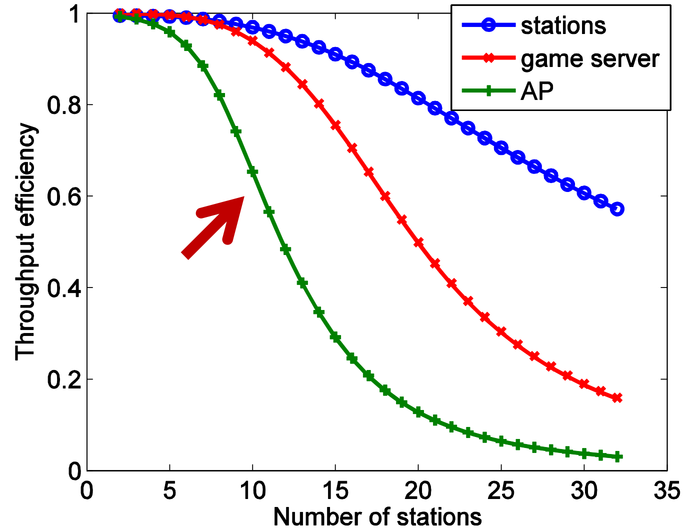
AP: 2n packets

C: 1 packet

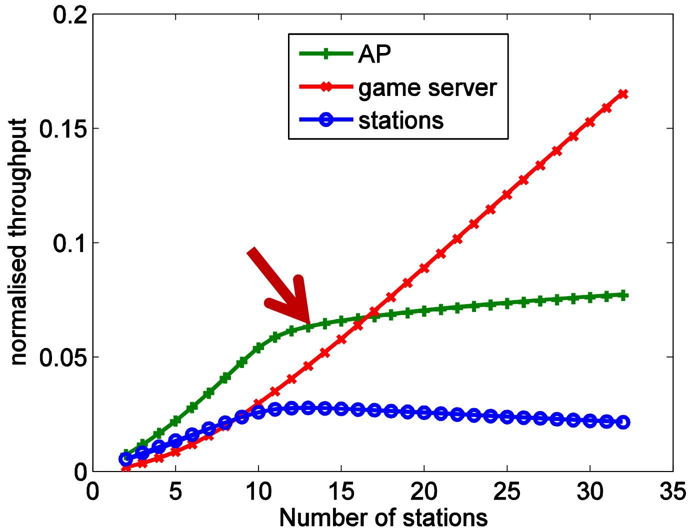
Results and Performance

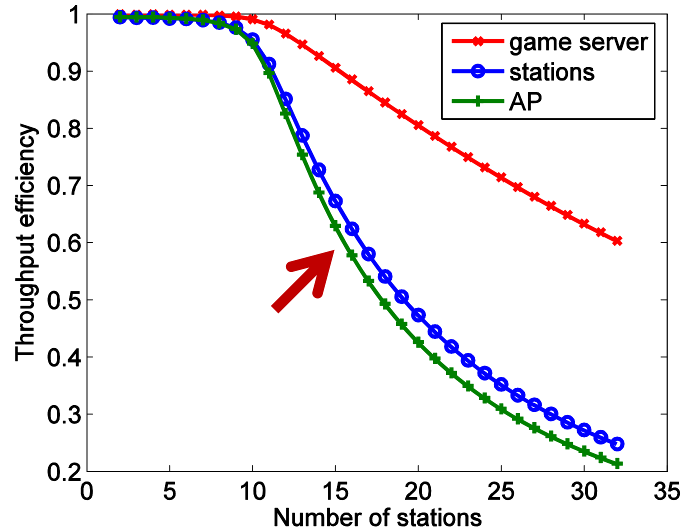
Basic DCF (11Mbps 802.11b)





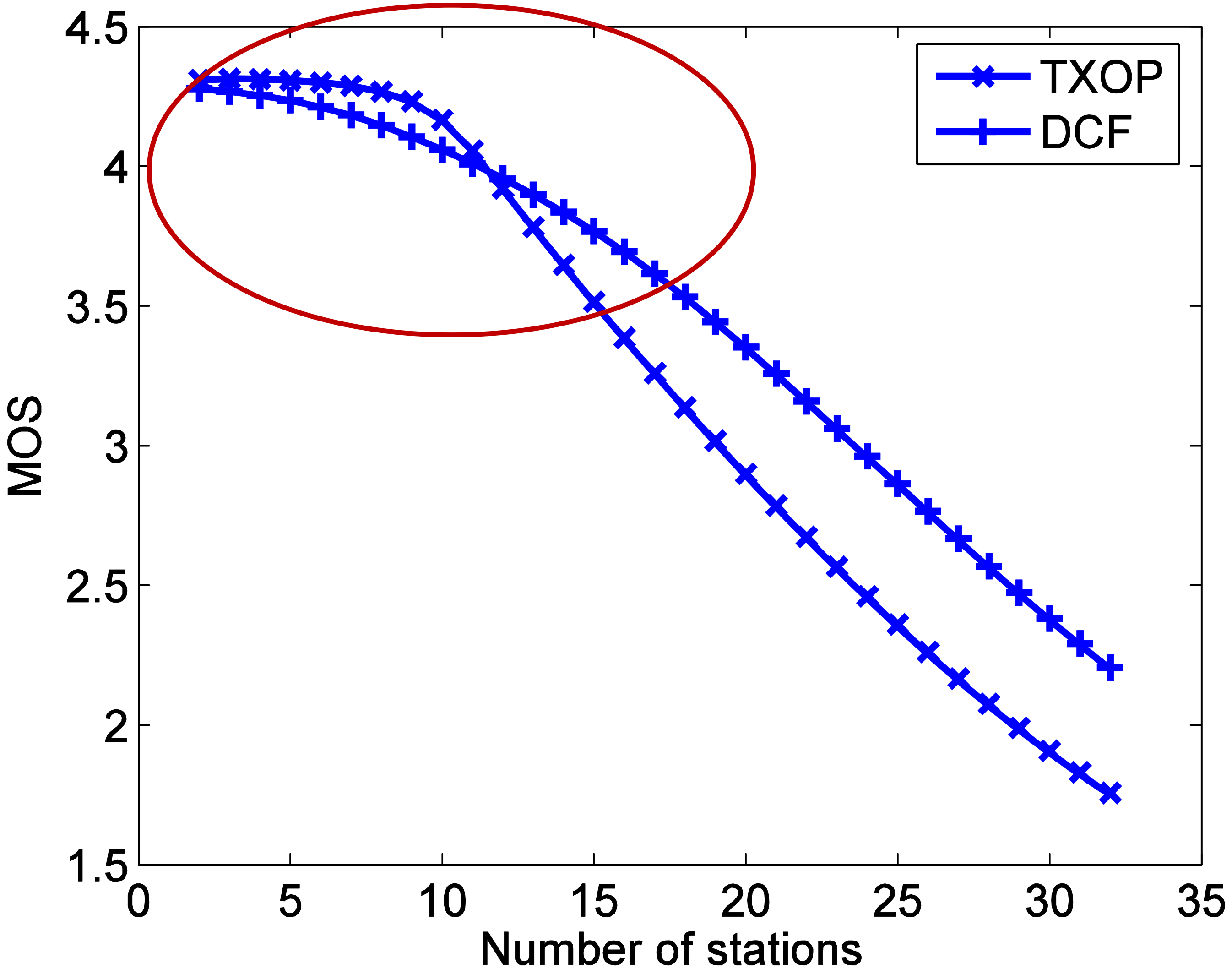
AP and Server priority with TXOP (11Mbps 802.11b)





Results and Performance

MOS in comparison



Future works and conclusions

Conclusions:

- We have a theoretical (analytical) model to describe the support and performance of 802.11 protocol for multiplayer games traffic which can extend many situation (11b, 11g, different games)

- 802.11e parameters to optimize the network to have a better support for games

- Capacity of normal DCF 11b network: 10 players
 Capacity of AP and Server with TXOP prioritised 11b network: 15 players

Future works and conclusions

Validate this theoretical model (results) in real network testbed

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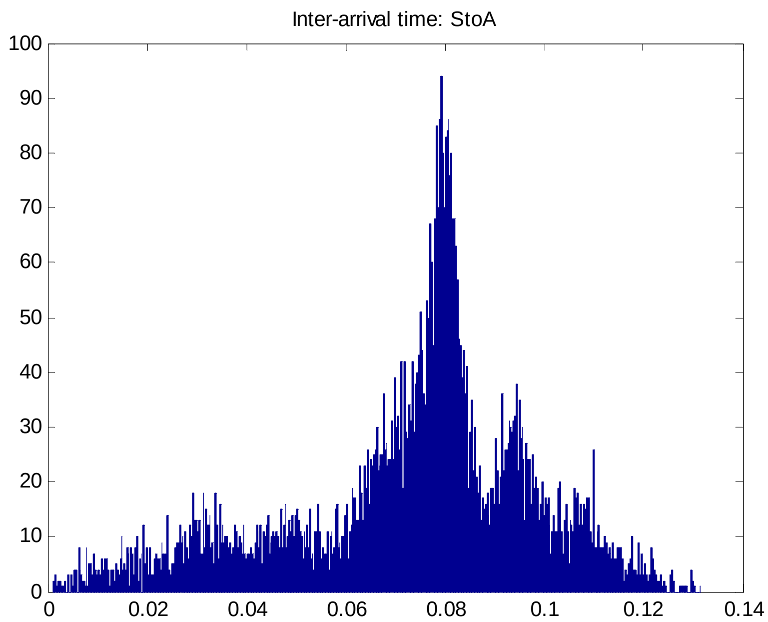
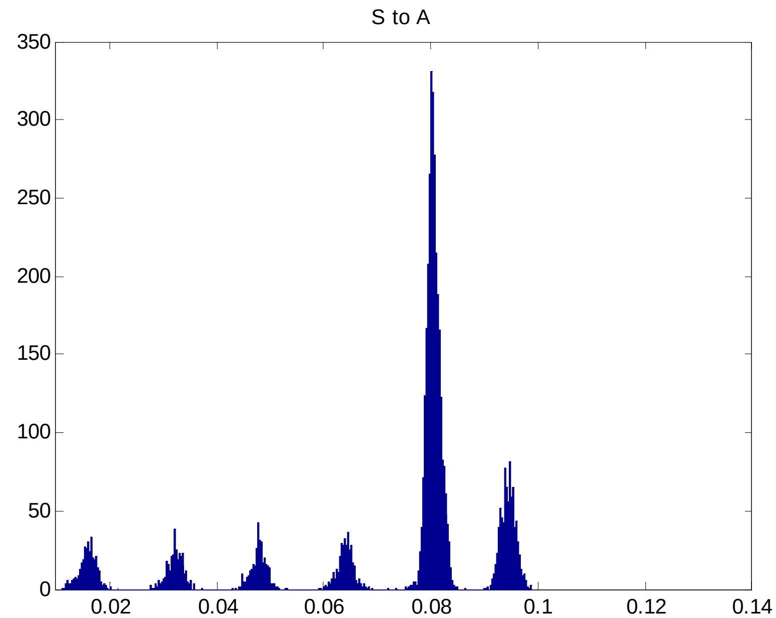
Lag sensed in 10 players, especially
when people meet and when shooting



10 players



2 players

Future works and conclusions

- Network with background traffic

- Other network topology such as server is in a wired network, not in the wireless network (we have got some results)

- Other 802.11e parameters

Thank you! ☺