Simulation Results of Backoff Protocol with Poisson-based Counter Selection

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Introduction

- Opportunity of ubiquitious wireless access leads to development of wide range of applications with different requirements to QoS params:
  - throughput;
  - transmission delay;
  - transmission jitter.
- Medium Access Control (MAC) can be considered as QoS mechanism:
  - decentralized competition-based access control protocols can impair QoS parameters
- Hence widely used competition-based distributed coordination functions (DCF) don't provide appropriate QoS

Goal

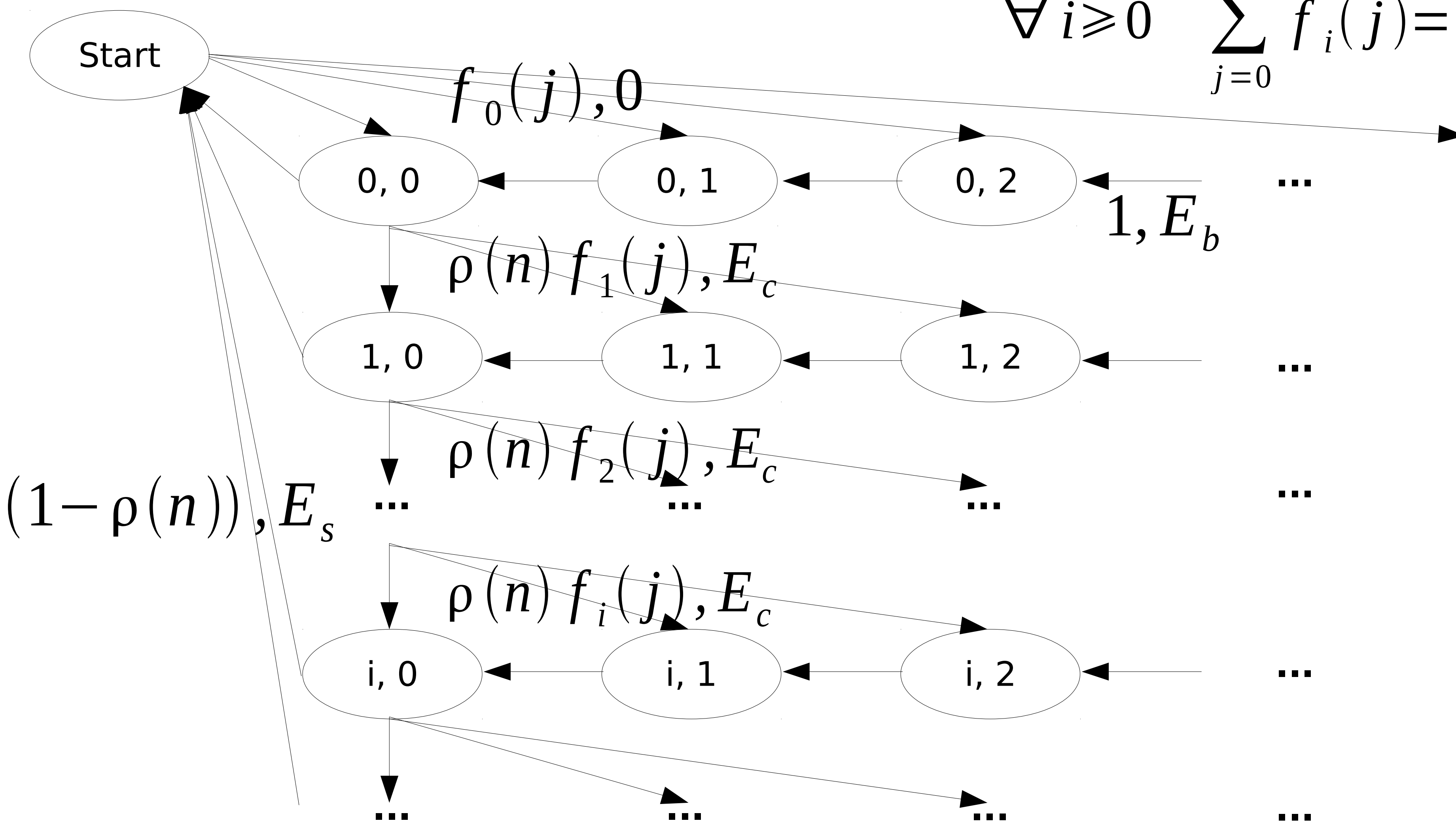
On the basis of the performance analysis model of self-organized network segment based on medium access control with backoff protocol as a collision avoidance mechanism, propose an algorithms with better QoS parameters than in wide spread Wi-Fi и HomeRF.

Problems

- To reveal a drawbacks of distributed coordination function with binary exponential backoff.
- To carry out the analysis of distributed coordination function with Poisson-distributed backoff counter selection.

General model

$$\forall i \geqslant 0 \quad \sum_{j=0}^{\infty} f_i(j) = 1$$



DCF operation as a semi-Markov process

A process { s(t), b(t) }, where

s(t) – number of consecutive collisions

b(t) – backoff counter

Transition probabilities of an embedded Markov chain

$P\{ \text{Start} \mid (i, 0) \} = 1 - \rho(n)$

$P\{ (0, j) \mid \text{Start} \} = f_0(j)$

$P\{ (i, j) \mid (i, j + 1) \} = 1$

$P\{ (i, j) \mid (i - 1, 0) \} = \rho(n) f_i(j)$

Initial distribution

$P\{ \{s_0, b_0\} = \text{Start} \} = 1$

Transitions of semi-Markov process

Let ς\{ (i, j) | (q, r) \} be the random variable determining duration of stay in (q, r) state before transition to (i, j) state.

Mean transition times

$$E\varsigma\{ \text{Start} \mid (i, 0) \} = Es$$

$$E\varsigma\{ (0, j) \mid \text{Start} \} = 0$$

$$E\varsigma\{ (i, j) \mid (i, j + 1) \} = Eb(n)$$

$$E\varsigma\{ (i, j) \mid (i - 1, j) \} = Ec$$

Mean durarion of transmission slot

$$Et(n) = \rho(n)Ec + (1 - \rho(n))Es$$

Denote as Ep a mean duration of data frame transmission

General model analysis

In this work ergodicity criteria of the process have been obtained:

These are the convergence of the series

$$\sum_{i=0}^{\infty}\sum_{k=0}^{i}(1+E\phi_i)\rho(n)^k(1-\rho(n))$$

and convergence to positive of

$$\sum_{i=0}^{\infty}\rho(n)^i\sum_{j=0}^{i}\left(1-\sum_{r=1}^{\infty}f_i(r)\right)$$

QoS-parameters

Normalized throughput

$$T(n)=\frac{n\tau(n)(1-\rho(n))E_p}{(1-\tau(n))E_b(n)+\tau(n)E_t(n)}$$

Average delay

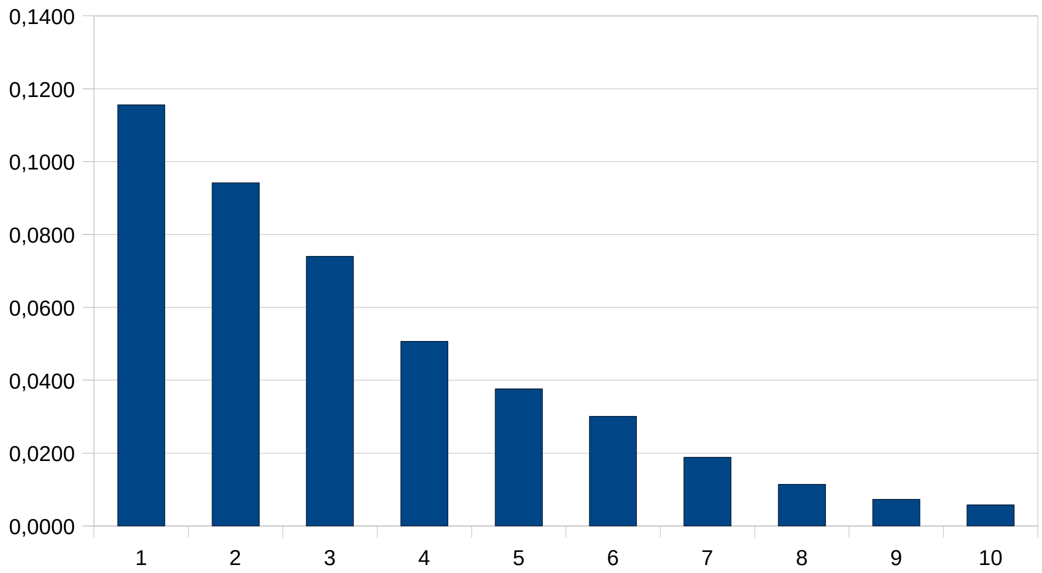
$$E_d(n)=\left((1-\rho(n)^m)+m\frac{\rho(n)^{2m-1}}{(1-\rho(n)^m)}\right)\times$$

$$\times((1-\rho(n)^{m-1})E_t(n)+\sum_{r=1}^{m}\left(\frac{1}{2^r W}E_c(n)+\frac{(2^r W-1)}{2}E_b(n)\right)\rho(n)^r(1-\rho(n))^{m-r})$$

DCF with BEB drawbacks

A node selects a backoff counter value according to uniform distribution from [0; 2^iW — 1], but due to negative drift the density of counter distribution is non-uniform!

Example. Simulation of Network segment with 16 nodes



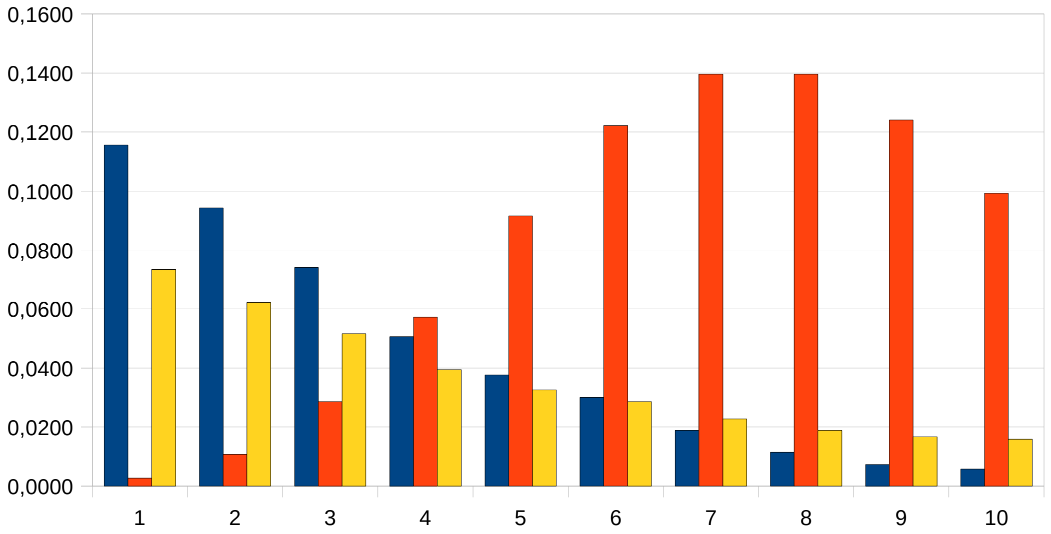
Counter selection distribution should equalize counter distribution

Poisson distribution:

- Distributes most of its density near its parameter value
- Fast decreasing tale

Example. Simulation of

Network segment with 16 nodes



DCF with Poisson-distributed counter selection

Distribution of counter selection after i consequtive collisions

$$f_i(j)=e^{-\lambda_i}\frac{\lambda_i^j}{j!}$$

Transition probabilities of an embedded Markov chain of semi-Markov process

$$P_{0,j:i,0}=(1-\rho(n))e^{-\lambda_0}\frac{\lambda_0^j}{j!}$$

$$P_{i,j:i,j+1}=1$$

$$P_{i,j:i-1,0}=\rho(n)e^{-\lambda_i}\frac{\lambda_i^j}{j!}$$

PEB Analysis Results

Chosen function of Poisson parameter change

$$\lambda_i = 2^i x \lambda$$

Initial parameter value

$$\lambda = \lambda_0 = \frac{1}{2}(W+1)$$

where W is the corresponding parameter of DCF with BEB

Then the probability of frame transmission can be expressed as

$$\tau(n) = \frac{2(1-\tau(n))^{(n-1)} - 1}{(2+\lambda)(1-\tau(n))^{(n-1)} - 1}$$

Simulation results comparison

The following positive sides of use of DCF with Poisson-based counter selection comparing to DCF with uniformly distributed counters:

- normalized network capacity decreases (delay increases) less sharply (these results are in agree with research of analytical model);
- maximum delay jitter on an simulation runs are less for about 5%.

Conclusion

In this work the following results have been achieved:

1. A DCF based on Poisson distributed backoff counter was constructed
2. Proposed DCF was analysed and a number of simulation experiments have been carried out