Reversed Matrix Adaptive Backoff

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Binary Exponential Backoff

- ***Binary Exponential Backoff*** *(BEB)* deals with collisions, which occur when few stations send signals over the same shared medium simultaneously (damage on physical layer).

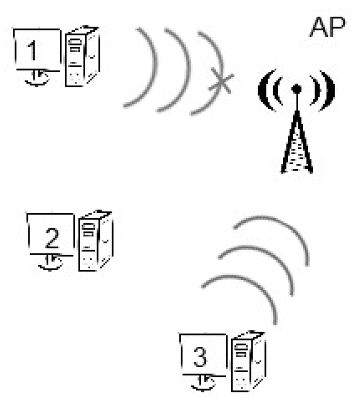
- For every station where a reply is missed (i.e., **a collision**)!
  - Resend a message deferred by a ***random interval of time*** defined by the BEB algorithm.
  - Random interval of time is size of contention window (CW), which depends on the number of attempts (i):

$$CW=\min(1024\,2^{i})$$

- ***Unfairness from the start*!** The signal of closest station in case of wireless communication is stronger, while remaining may be sensed by remote station only as some noise.

- Standard BEB is liable to ***capture effect***, capture of a shared medium for some period of time, i.e., one station sends messages while for the others the network are always busy.

Problems of BEB



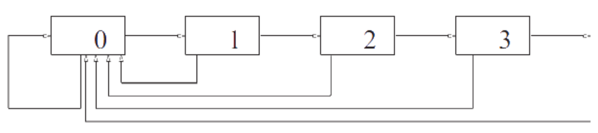
- **Example:**
  - 1 Access Point (AP)
  - 3 Wireless Stations (STAs)
  - STA 3 is closer to the AP than STA 1.
  - STAs 1 and 3 send signals simultaneously.

- If the signal of STA 3 is stronger than STA 1, then more probably signal of STA 3 will be accepted, while signal of STA 1 will be corrupted (sensed as a noise).

- Capture effect by the STA 3 over STAs 1 and 2.
Unfair setup from the start => problems with QoS for STAs 1 and 2.

Details

- **In BEB after each collision a station waits random amount of time.**
- **T**he waiting time is defined by a state machine, **contention window (CW)** for every state and the size of a timeslot.



- **S**tates are shown on the picture
  - whenever a collision occurs **current state increases by one (i+1),**
  - otherwise with success or discard of an unsent message **current state sets to the initial state (0)**.

- **If** *b* is *increase factor*, CWmax – *maximum size of contention window*, and *i* is the *state number*, then contention window CW for each state in **general backoff protocol** is calculated as following:

$$CW=\min(CW\max, b^{i})$$

- As we can see, BEB has simple returning mechanism to an initial state, it can be expressed as a matrix

$$\begin{pmatrix} 1 & 0 & 0 & \dots & 0 \\ 1 & 0 & 0 & \dots & 0 \\ 1 & 0 & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 1 & 0 & 0 & \dots & 0 \end{pmatrix}$$

Matrix Adaptive Backoff

We introduce a class of BEB protocols – *Matrix Adaptive Backoff* (*MAB*). It is defined the same way as BEB, but with different returning mechanism.

$$\begin{pmatrix} 1 & 0 & 0 & 0 & \dots & 0 \\ 1 & 0 & 0 & 0 & \dots & 0 \\ p_{2,0} & p_{2,1} & 0 & 0 & \dots & 0 \\ p_{3,0} & p_{3,1} & p_{3,2} & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \\ p_{M,0} & p_{M,1} & p_{M,2} & p_{M,3} & \dots & 0 \end{pmatrix}$$

Also, we introduce extension of MAB – **Reversed MAB** (**RMAB**). **T**he returning mechanism for that protocol has the following view

$$\begin{pmatrix} p_0 & p_1 & \dots & p_i & \dots & P_M \\ 1 & 0 & 0 & 0 & \dots & 0 \\ p_{2,0} & p_{2,1} & 0 & 0 & \dots & 0 \\ p_{3,0} & p_{3,1} & p_{3,2} & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \\ p_{M,0} & p_{M,1} & p_{M,2} & p_{M,3} & \dots & 0 \end{pmatrix}$$

Simulation of new backoff schemes was done on NS-3 simulator with WiFi devices. **RMAB is much more fair, than standard BEB with the same throughput!!!**

Simulation

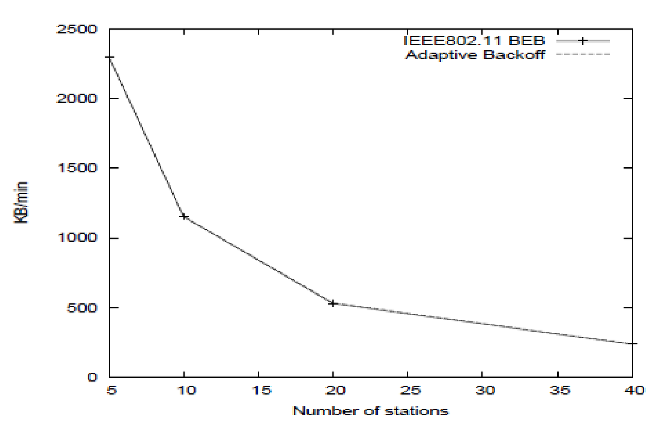


Figure 1: Average throughput for a saturation during 1 min

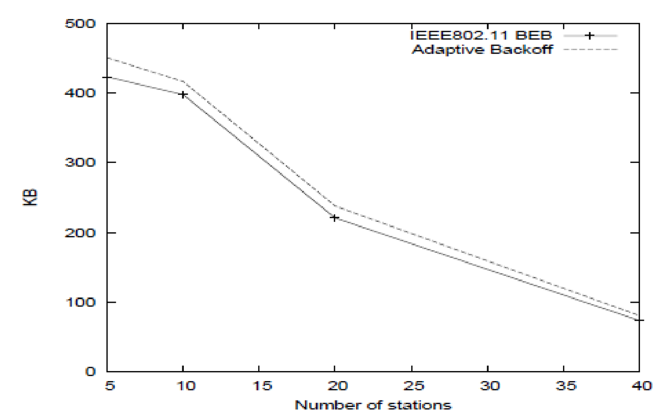


Figure 2: Standard deviation for stations during 1 min

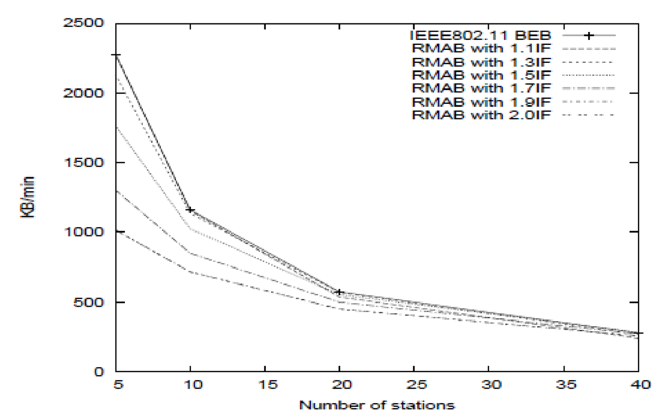


Figure 3: Average throughput for RMAB during 1 min

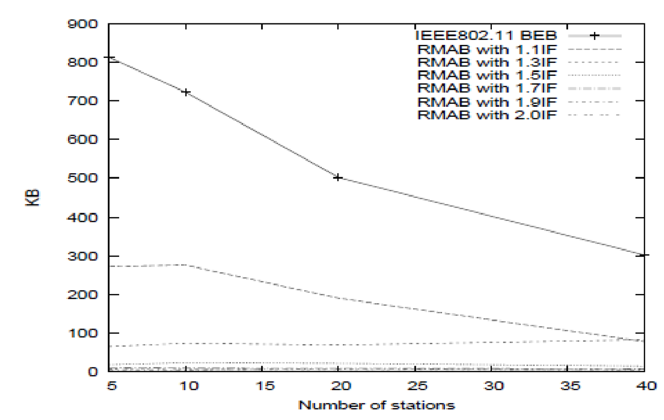


Figure 4: Standard deviation for RMAB during 1 min

Conclusion

Done:

- **W**e introduce new classes of BEB protocols – MAB and RMAB with mathematical analysis of state distribution.
- **T**hrough NS-3 simulation, we showed that RMAB can reduce capture effect of BEB.
- **T**horough analysis of these protocols was done from theoretical perspective and some basic simulations.
- **A** new DCF model for NS-3 simulator which simplifies study of new protocols without hard-coding and without a number of limitations.

Future work:

- **E**xtend simulation on more number of stations.
- **D**evelopment of intellectual RMAB which depends on network load.
- **I**mprove throughput of the protocol.