Congestion Control in IEEE 802.11p

Date: 2006-01-16

Authors:

Name	Company	Address	Phone	email
Lothar Stibor	Philips & ComNets, Chair of Communication Networks, RWTH Aachen University	Kopernikusstr. 16, 52074 Aachen, Federal Republic of Germany	+49-241-802-0547	lsr@comnets.rwth-aachen.de
Yunpeng Zang	Philips & ComNets, Chair of Communication Networks, RWTH Aachen University	Kopernikusstr. 16, 52074 Aachen, Federal Republic of Germany	+49-241-802-5829	zangyp@ieee.org
Hans-Jürgen Reumerman	Philips Research Laboratories	Weißhausstr. 2, 52066 Aachen, Federal Republic of Germany	+49-241-600-3629	hans-j.reumerman@philips.com

Abstract

- **Proposed solution for K.5**
- **Proposed wording of section K.6**

- **Revision history**
  - R2
    - Included comments from discussion on January 18th
  - R1
    - Added proposed wording for K.5
  - R0
    - Proposed wording for K.6

K.5

Private message restriction on CCH (K.5)

- K.5: „Private transmissions on the Control Channel shall be limited in duration and minimum interval of transmission. The limits of Control Channel usage for private applications using broadcast frame transmissions are defined in the following Table and note. These limits apply to fragmented messages as well as messages contained within one frame.“

Transmission Duration	**RSUs**	**OBUs**
Maximum Data Transmission Duration	**750 µsec**	**580 µsec**
Minimum Interval between Data Transmissions	**100 msec[a]**	**750 msec**

[a]10 msec Minimum Transmissions Intervals are allowed in low power (10 dBm EIRP) operations.

Intention of restriction

- **CCH must be protected from congestion in order to fulfill its purpose**
  - Network organization
  - Broadcast safety messages
  - Initiate service channel transmissions
  - Announce available services
- **Possible “private” messages on the CCH**
  - Announcement of services
  - Low priority broadcasts
- **Prevent STAs from blocking the wireless medium with low priority messages**

Problem description

- **What the 802.11p MAC can‘t do**
  - doesn‘t know categories like „private“
  - Has no facility to track transmission intervals
  - Distinguish between CCH & SSH
- **What the 802.11p MAC can do**
  - Knows about access categories (ACs)
  - Enforce transmission time restrictions via transmission opportunities (TXOPs) in units of 32 µs
  - Fragment frames that doesn’t fit in a single TXOP

Conclusion

- **Solution 1**
  - Set the TXOPlimit for the both low priority ACs AC_BK and AC_BE to
    - 23 for RSU -> 23 * 32 µs = 736 µs
    - 18 for OBU -> 18 * 32 µs = 576 µs
  - Fragmentation for frames from AC_BK and AC_BE that doesn't fit in a single TXOP
- **Solution 2**
  - Move this problem to 1609.4

Proposed wording for K.5

- K.5: „Low priority transmissions shall be limited in duration. The limitation shall be applied to transmissions of the access categories AC_BE and AC_BK by setting the TXOP limit to 23 for RSUs and 18 for OBUs.“

K.6

Necessity of Congestion Control

- **The WAVE communication protocol is build on control channel (CCH) communication**
  - Initiation of the WAVE BSS
  - Safety relevant messages
  - Initiation of Service Channel (SCH) communication
  - Announcement of services
- **Contention based CCH access schema (EDCA)**
  - Number of collisions grow with number of participating stations
    - Larger latencies due to large contention windows (CWs)
    - Many collisions with high priority transmissions due to small CWs
  - EDCA is known to work only with less than approx. 50% medium occupancy time

=> CCH congestion has to be avoided at all cost!

Measuring Congestion

- **Physical layer**
  - Medium occupancy time
- **MAC layer**
  - Medium occupancy time
  - Packet Error Rate (PER)
- **MAC Extension layer (MACX)**
  - Transmission queue length
  - Frame delay
  - Contention window size
  - Short / long retry counters

Benefits and drawbacks

- **PHY layer**
  - Has no knowledge of CCH interval and SSH intervals
  - Is not able to distinguish between SSH and CCH congestion
- **MAC layer**
  - Large PER may be caused by bad propagation conditions
  - Has no knowledge of CCH interval and SSH intervals
  - Medium occupancy time is a well fitting measure for channel congestion, each STA in communication range has the same measurement
- **MACX layer**
  - Transmission queue length needs time to build up
  - Unsuccessful transmissions add to existing CCH congestion
  - Frame delay can only be measured after successful transmission
  - MACX layer is out of scope of 802.11p

Reaction on upcoming CCH congestion

- **Binary approach**
  - Congestion can be avoided by not transmitting at all
- **Leveled**
  - Depending on the grade of congestion only high priority access categories (ACs) are allowed to transmit

CCH state	Measure of CCH congestion	Allowed ACs binary	Allowed ACs leveled
Everything is fine	tbd	0, 1, 2, 3	0, 1, 2, 3
Lots of traffic	tbd	0, 1, 2, 3	1, 2, 3
Upcoming congestion	tbd	none	2, 3
congestion	tbd	none	3

Responsibility of congestion control

- Somebody must be responsible for congestion control
- Not all varieties of upper layers will play fair
- We have no influence on all possible upper layer solutions for 802.11p
- The MAC layer may not have all information, needed for efficient congestion control

Conclusions

Two step approach:

- **Step 1**
  - An efficient congestion control algorithm shall be implemented in the MACX layer
    - Efficient congestion control can only be done in the MACX layer
    - The algorithm is out of scope of 802.11p
- **Step 2**
  - The MAC layer shall enforce the congestion control
    - The MAC layer shall monitor the medium occupancy time
    - The MAC shall report the measured medium occupancy time to the MACX layer
    - The MAC layer shall reject transmission attempts from the MACX layer for low priority ACs, when congestion is detected

Proposed wording for K.6

- **K.6 Control Channel Congestion**

- **Congestion on the current channel shall be monitored to ensure it does not fail under congested conditions. The STAs MLME shall monitor the medium occupancy time on the current channel by measuring the CCA busy indication. This measure shall be reported to the upper layers. If the medium occupancy time on the current channel is larger than 50%, the MAC layer shall reject the transmission attempt from upper layers for all but the highest priority access category with the transmission status "undeliverable" in the MA-UNITDATA-STATUS.indication.**