performance evaluation of the IEEE 802.16 ARQ mechanism

Alexander Sayenko

Nokia Research Center,
Finland

NOKIA

Vitaliy Tykhomyrov, Olli Alanen,
Henrik Martikainen, Timo Hämäläinen

Telecommunication laboratory,
MIT department,
University of Jyväskylä,
Finland

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

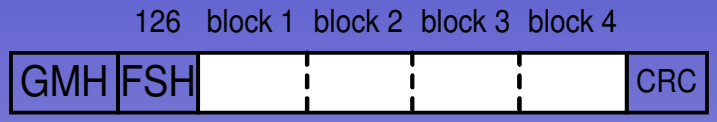
Outline

- key features and parameters of the ARQ mechanism
- choosing the ARQ feedback type
- simulation results

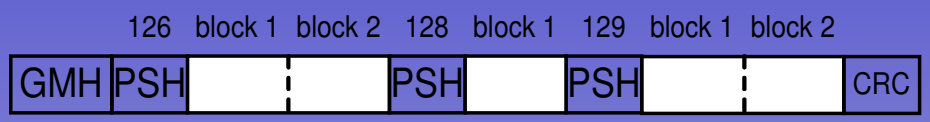
Importance of the Research

- the ARQ mechanism enables a connection to resend data at the MAC level if an error is detected
- the ARQ mechanism is controlled by a number of parameters
- the specification defines them but it does not provide concrete values and solutions
- the performance of the 802.16 ARQ mechanism has not been studied sufficiently, especially by means of extensive simulations

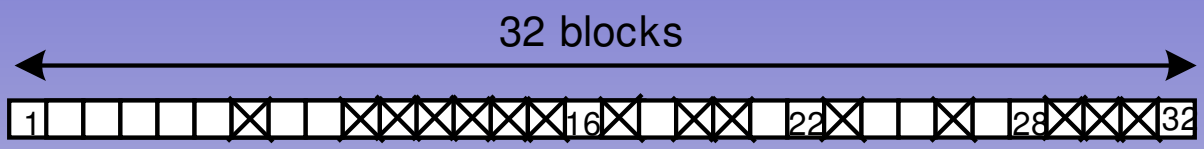
IEEE 802.16 ARQ Mechanism and the ARQ Feedback Types



fragmentation



packing



Selective ACK

BSN :1	MAP :1111110110000001	MAP :0100110110110001

Cumulative ACK

BSN :6

Cumulative with Selective ACK

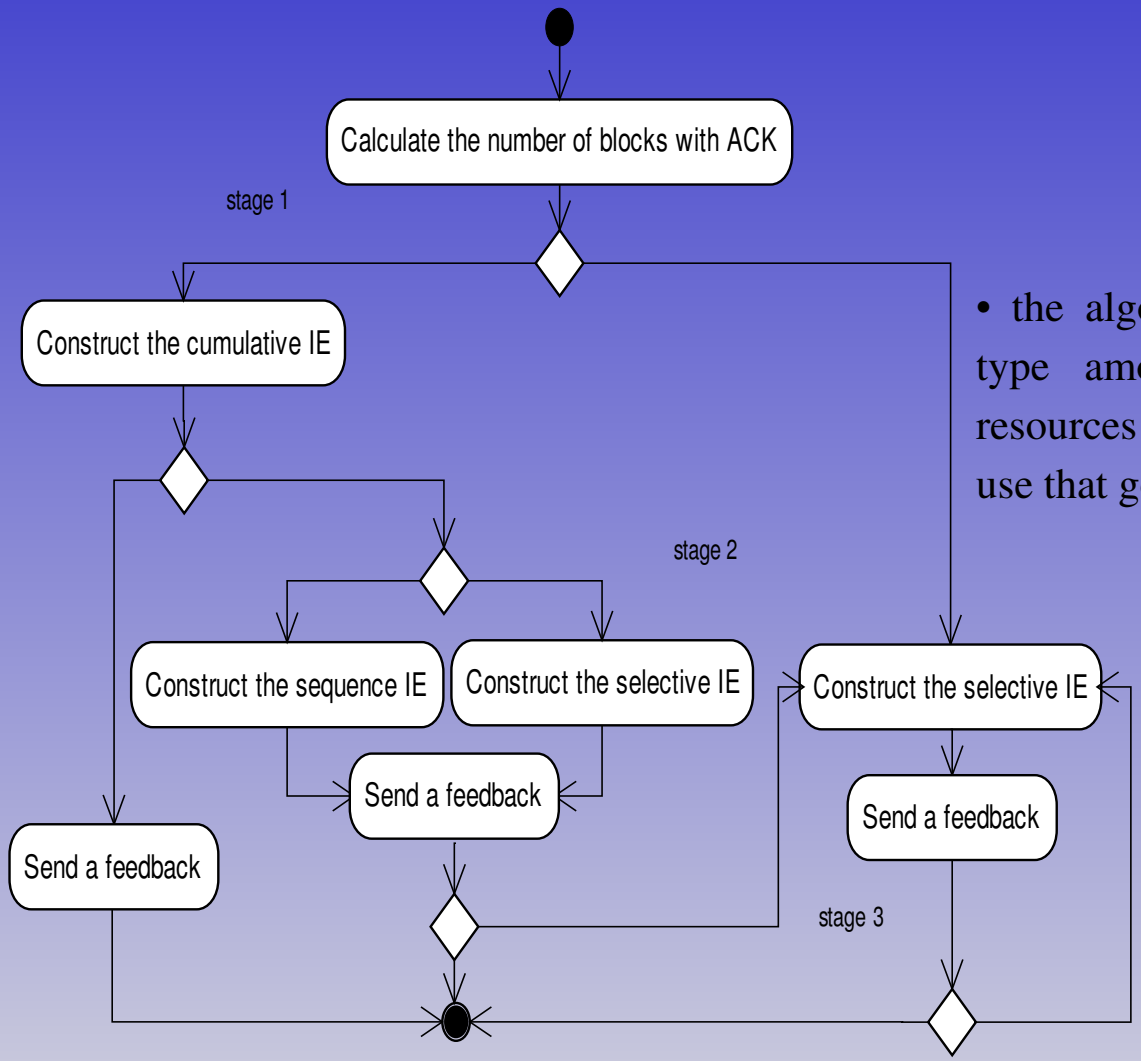
BSN:6	MAP :1011000000101001

Cumulative with Block Sequence ACK

BSN :6	Seq: 010	1	2	6	Seq: 101	1	1	1
	Seq: 010	2	2	1	Seq: 101	2	1	2

Example of ARQ feedback types

Choosing the Feedback Type



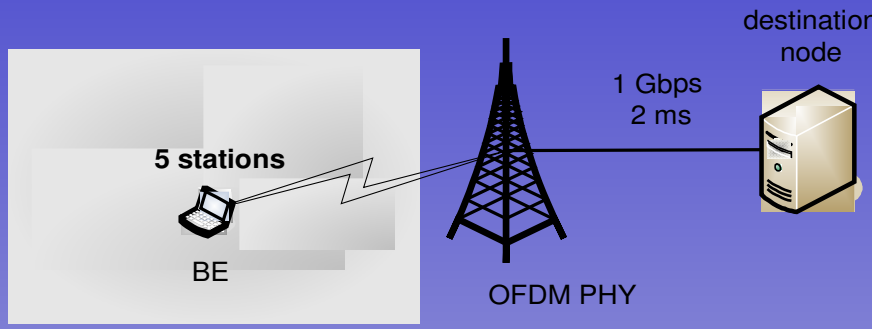
- the algorithm is needed to choose a feedback type among the available ones, while good resources utilization is a criterion we decided to use that governs our algorithm

Algorithm for choosing ARQ feedback types

Simulation Analysis of the 802.16 ARQ Mechanism. Network Structure

The network parameters

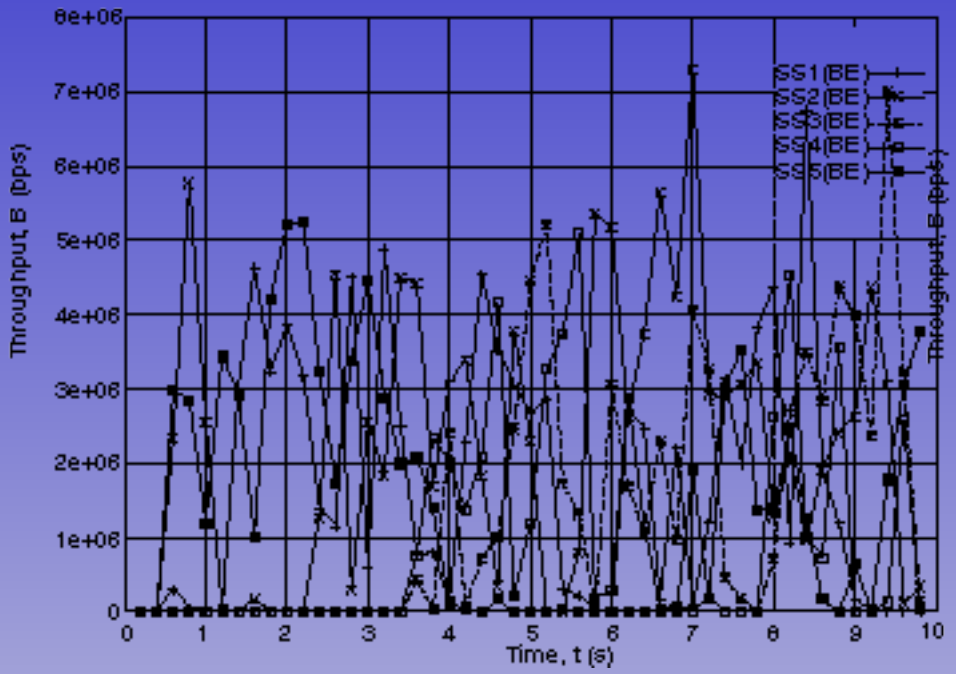
Parameter	Value
PHY / Bandwidth	OFDM / 7 MHz
Cyclic prefix length	1 / 32
Duplexing mode	TDD
Frames per second	400 (2.5 ms per frame)
Slots per frame	75
MCS	64-QAM3/4 (108 bytes/slot)
PER	10%
Ranging transm. opportunities	1
Ranging backoff start / end	0 / 15
Request transm. opportunities	4
Request backoff start / end	3 / 15
Fragmentation / packing	ON / ON
PDU size	As large as possible
CRC / ARQ	ON / ON
ARQ feedback / ARQ types	Standalone / all
ARQ block size / ARQ window	16 bytes / 1024
ARQ block rearrangement	ON
ARQ deliver in order	ON



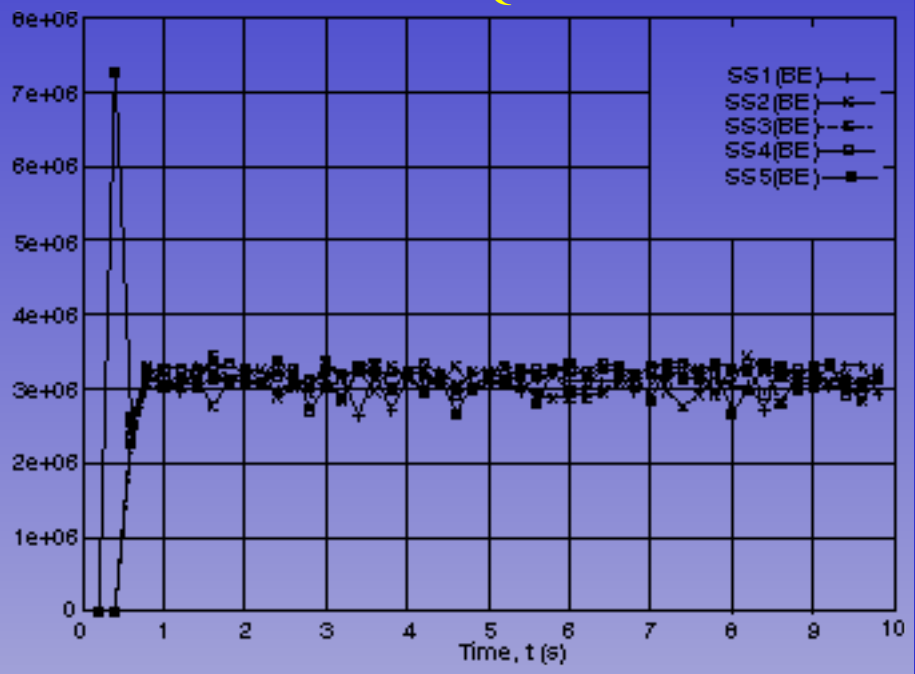
- **five SSs**
- **one wired node**
- **an SS hosts exactly one FTP-like application that sends data over the TCP protocol to a wired node**

General ARQ Results

no ARQ



ARQ



Uplink connections throughput (errors at PHY)

ARQ / errors	- / -	+ / -	- / +	+ / +
Uplink data (MB)	21.602	21.089	9.813	18.525

Amount of transferred data

ARQ Feedback Types

ARQ block size(B)	16	32	64	128	256	512	1024
Selective (%)	18.8	13.1	11.6	11	11.3	11.2	11.2
Cumulative (%)	64.6	69.3	70.2	70.8	70.9	71	71
Cumulative+selective (%)	0	0	0	0	0	0	0
Cumulative+sequence (%)	16.6	17.6	18.2	18.1	17.8	17.8	17.8
Total messages	23163	21734	21836	21552	21433	21219	21219

The ARQ feedback type statistics

Conclusions

- the ARQ mechanism can improve significantly the performance of the TCP based applications
- an SS can choose smaller PDU sizes to achieve a smooth data transmission when the ARQ block rearrangement is disabled
- small ARQ blocks, such as those of 16 and 32 bytes, require much larger ARQ window
- the selective type is the only type a connection can send if there are negative ACKs in the beginning of the ARQ transmission window

Future Research

- to study the optimal parameters of the ARQ mechanism
- to compare the results provided by the ARQ mechanism and the H-ARQ mechanism available in the OFDMa PHY

Thank You for Attention