

Channel-Aware Transmission of Feedback Messages for WiMAX ARQ

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Outline

- Introduction
- Performance Metric of Feedback Messages
- Channel-Aware Transmission of Feedback Messages
 - Channel estimation
 - Interval selection of feedback messages
 - Formation of feedback messages
- Results
- Conclusions

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Introduction

- Automatic Repeat reQuest (**ARQ**) in the WiMAX is used to coop with error-prone transmission environments.
- Types of the feedback information elements (IE) defined in the WiMAX standard: **selective**, **cumulative**, **cumulative and selective**, **cumulative and block sequence**.
- **Timing** to send the feedback and the **types** of feedback IEs are up to the implementation.

Contributions

- A novel **performance metric** is also proposed to measure the performance in a more comprehensive way.
- A **channel-aware feedback transmission scheme** is proposed by first predicting the channel condition and then deciding the feedback intervals and message types.

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The Proposed Performance Index

- The performance evaluation metric P_{eff} is defined to consider the influence of both **transmission latency** and the required **bandwidth** to transmit feedback messages.

$$P_{eff} = P_{eff-acked} \cdot r_{acked}$$

$P_{eff-acked}$: the performance factor for the received ARQ blocks

r_{acked} : the ratio of the received ARQ blocks to the number of total ARQ blocks

$$P_{eff-acked} = \frac{n_{acked}}{BW_{overhead} \cdot f_{delay}}, \quad f_{delay} = (1 + \sum_{\text{ARQ block } j \in L} d_j)^i$$

$BW_{overhead}$: bandwidth to transmit the corresponding feedback messages

d_j : the retransmission delay of ARQ blocks

n_{acked} : the number of ack-ed ARQ blocks

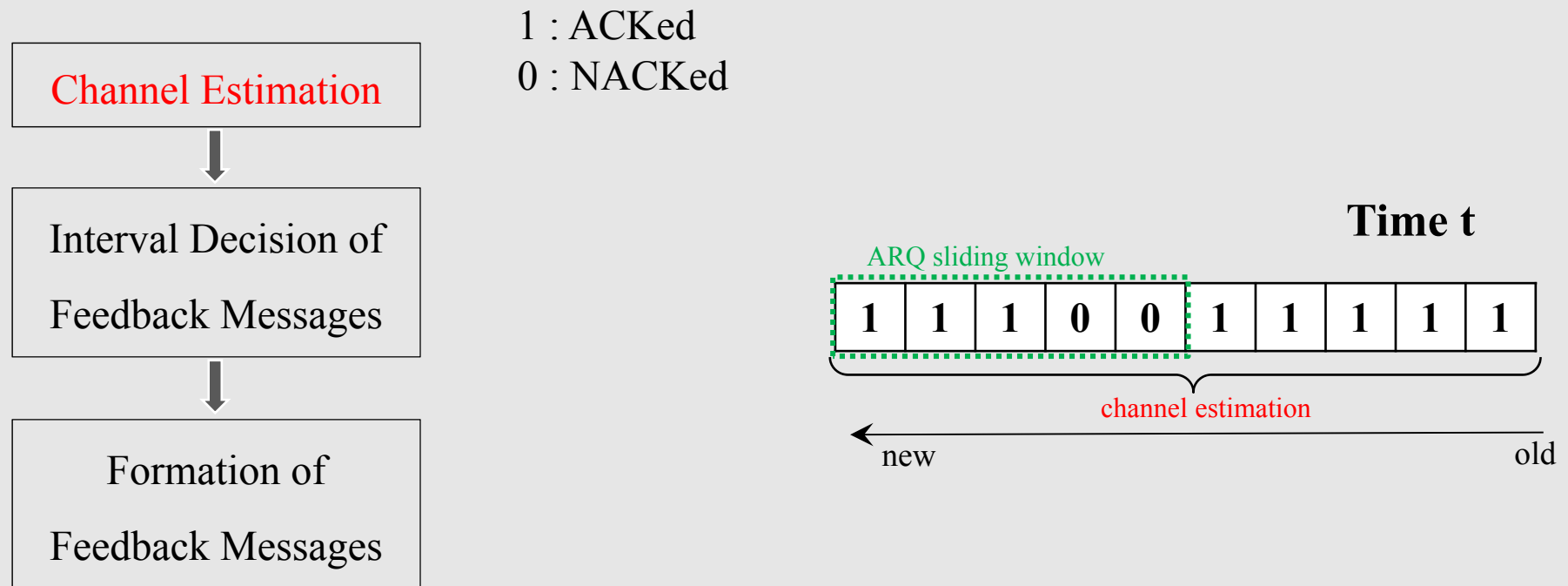
set L: contains all the ARQ blocks that are retransmitted

i : indication of the importance of the retransmission delay

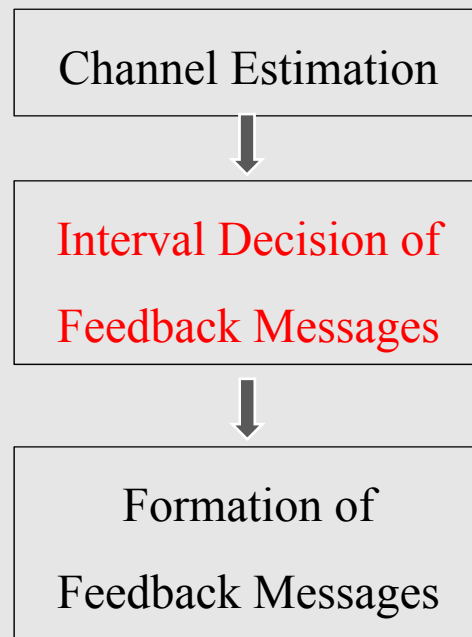
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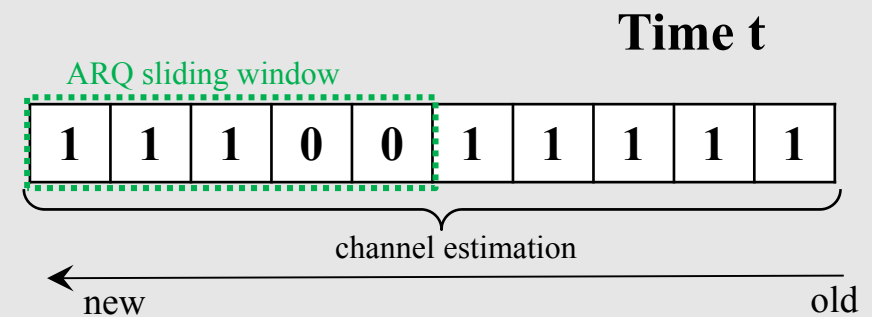
The Proposed Channel-Aware Transmission of Feedback Messages



The Proposed Channel-Aware Transmission of Feedback Messages

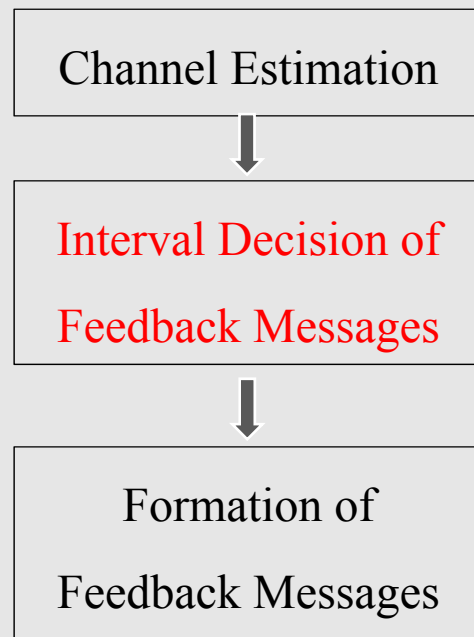


1 : ACKed
0 : NACKed

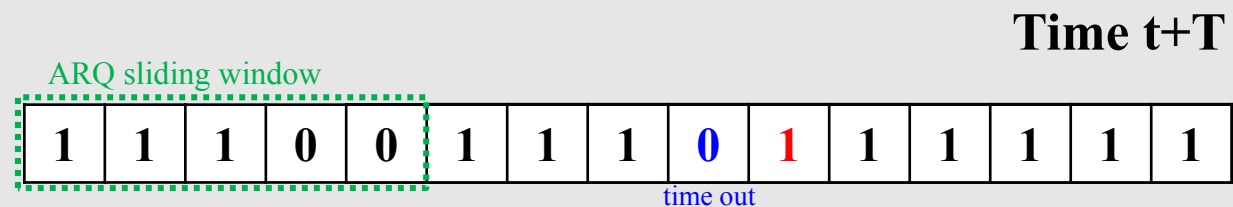


- After interval T , send feedback messages. ARQ sliding window might move to a new position already.

The Proposed Channel-Aware Transmission of Feedback Messages

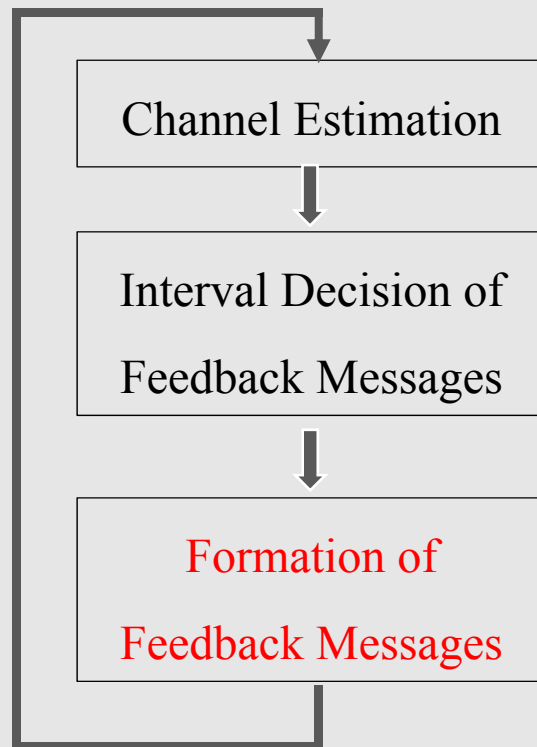


1 : ACKed
0 : NACKed

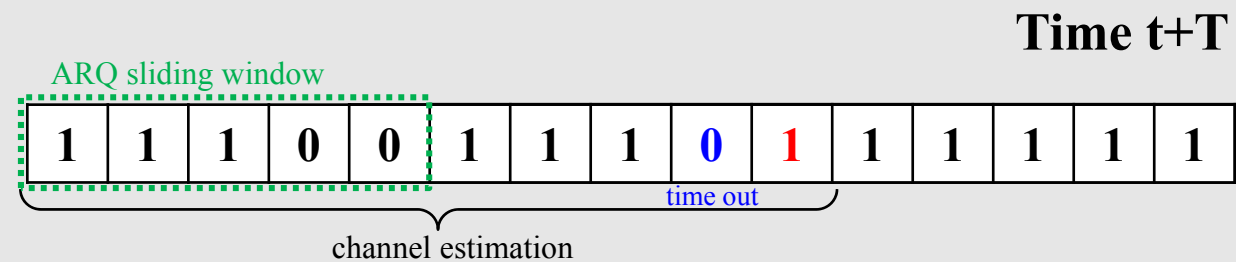


- After interval T , send feedback messages. ARQ sliding window might move to a new position already.

The Proposed Channel-Aware Transmission of Feedback Messages



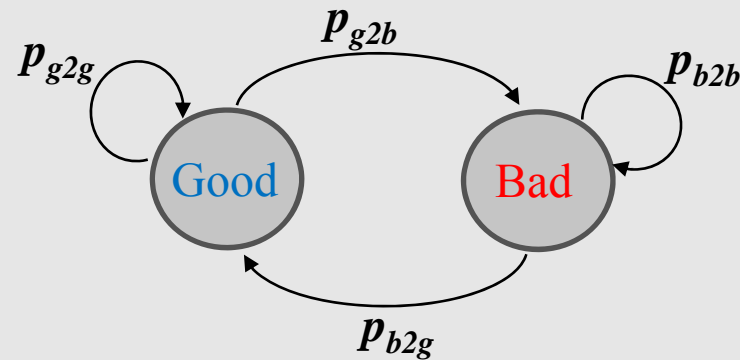
1 : ACKed
0 : NACKed



- Feedback messages are formed and sent. Move to next cycle.

Channel Estimation

- The model is based on **the two-state Markov chain**.
- The two states (good and bad) represent whether an ARQ block is received or not.



P_{g2g} : transition probability from state *good* to state *good*

P_{b2b} : transition probability from state *bad* to state *bad*

P_{g2b} : transition probability from state *good* to state *bad*

P_{b2g} : transition probability from state *bad* to state *good*

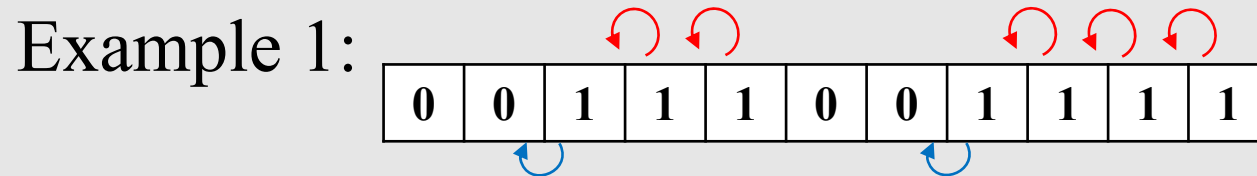
Channel Estimation

Interval Decision of
Feedback Messages

Formation of
Feedback Messages

Channel Estimation - Example

- The estimation of those transition probabilities is based on **counting of the events** of state transitions in the past.



Among 7 good states:

1 : ACKed
0 : NACKed

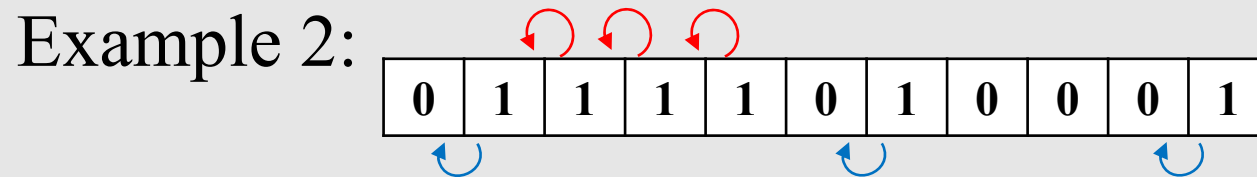
⇒ From good to good : **5**

From good to bad : **2**

$$\therefore P_{g2b} = \frac{2}{5 + 2} = \frac{2}{7}$$

Channel Estimation - Example

- The estimation of those transition probabilities is based on **counting of the events** of state transitions in the past.



Among 6 good states:

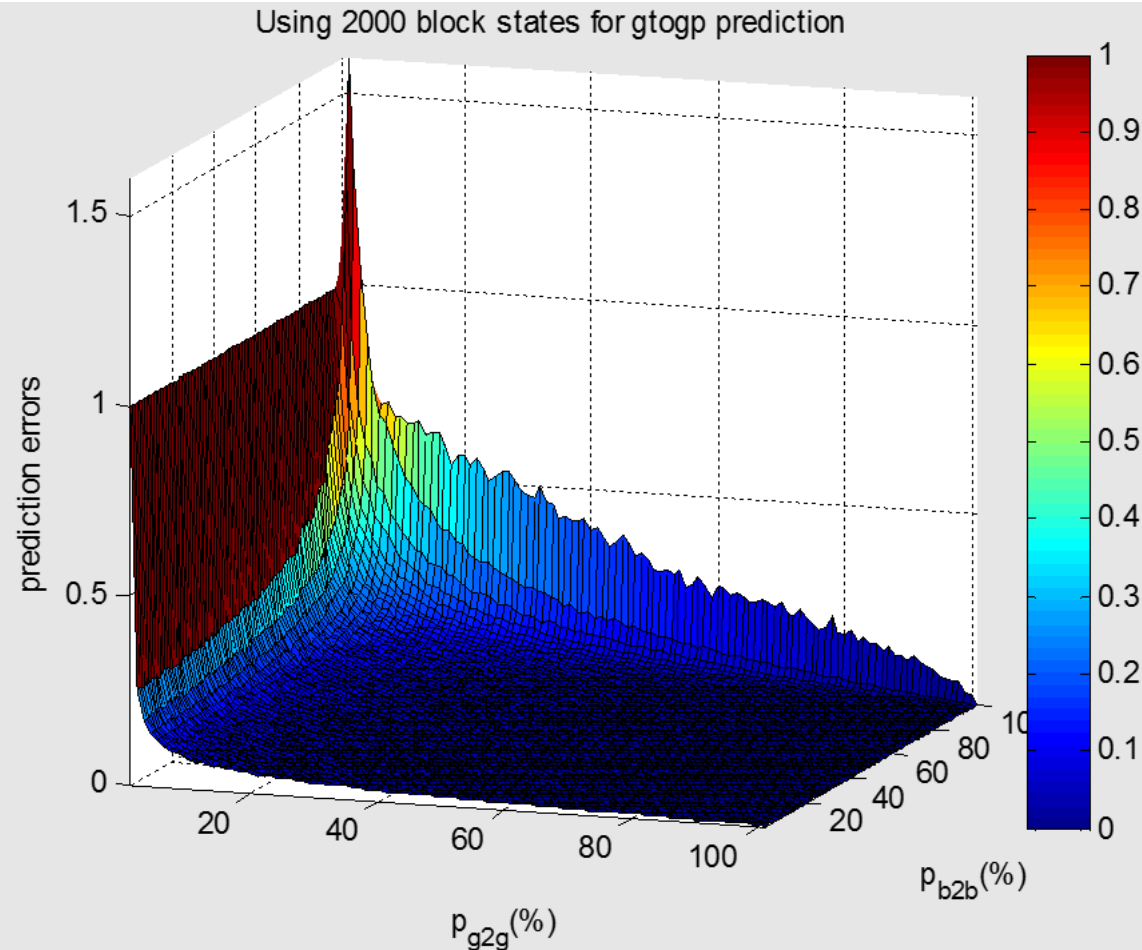
1 : ACKed
0 : NACKed

⇒ From good to good : 3

From good to bad : 3

$$\therefore P_{g2b} = \frac{3}{3+3} = \frac{3}{6}$$

Channel Estimation - Performance



Results of using the reception status of the previous 2000 blocks for the prediction of p_{g2b} .

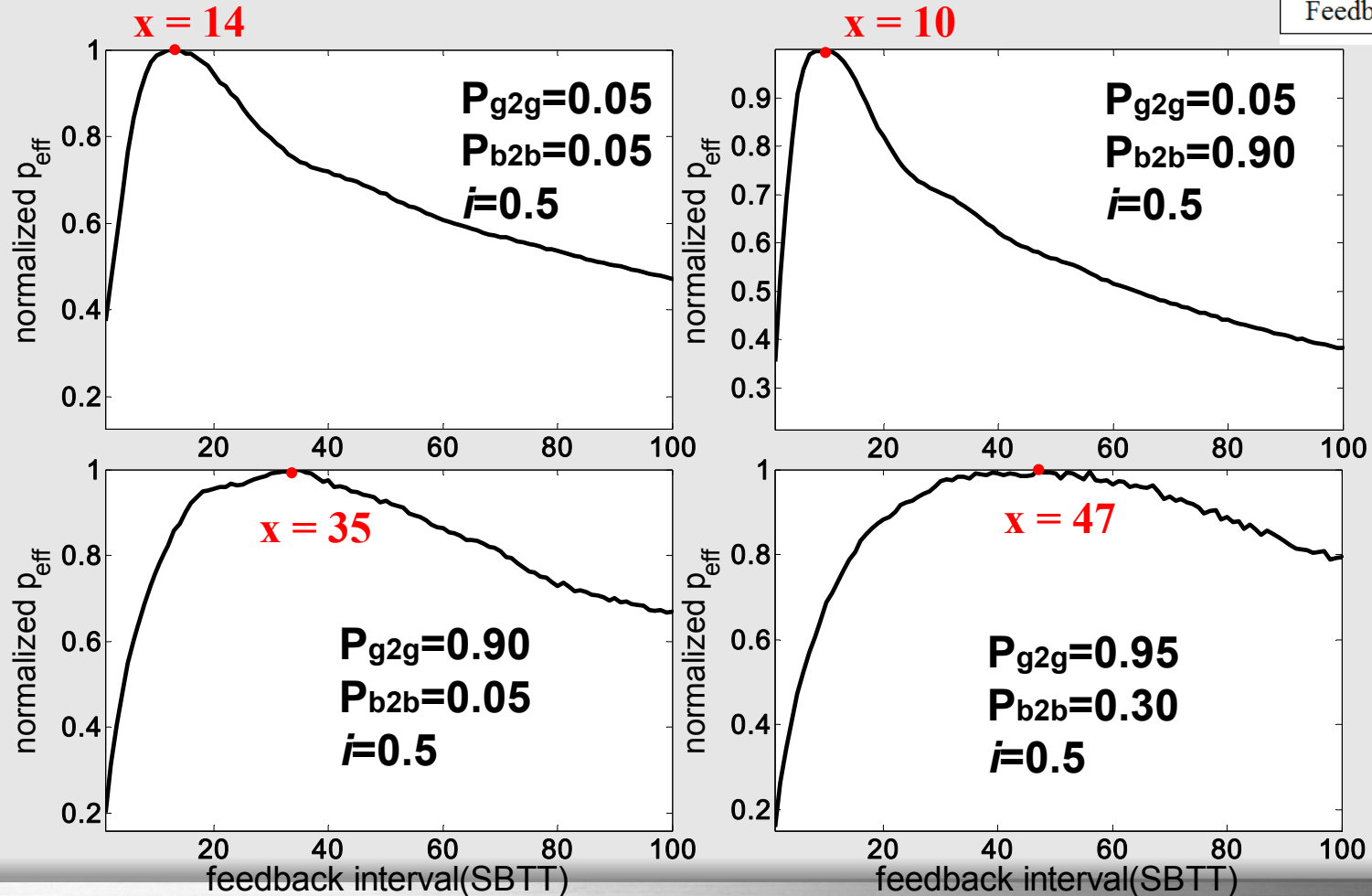
Feedback Interval and Channel Condition

Channel Estimation

Interval Decision of
Feedback Messages

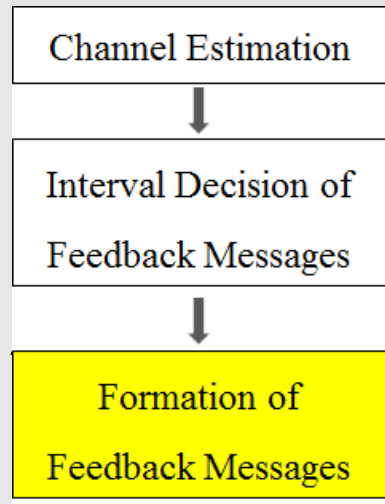
Formation of
Feedback Messages

- Significant peak indicates **strong correlation** between the **channel condition** and **feedback interval**.

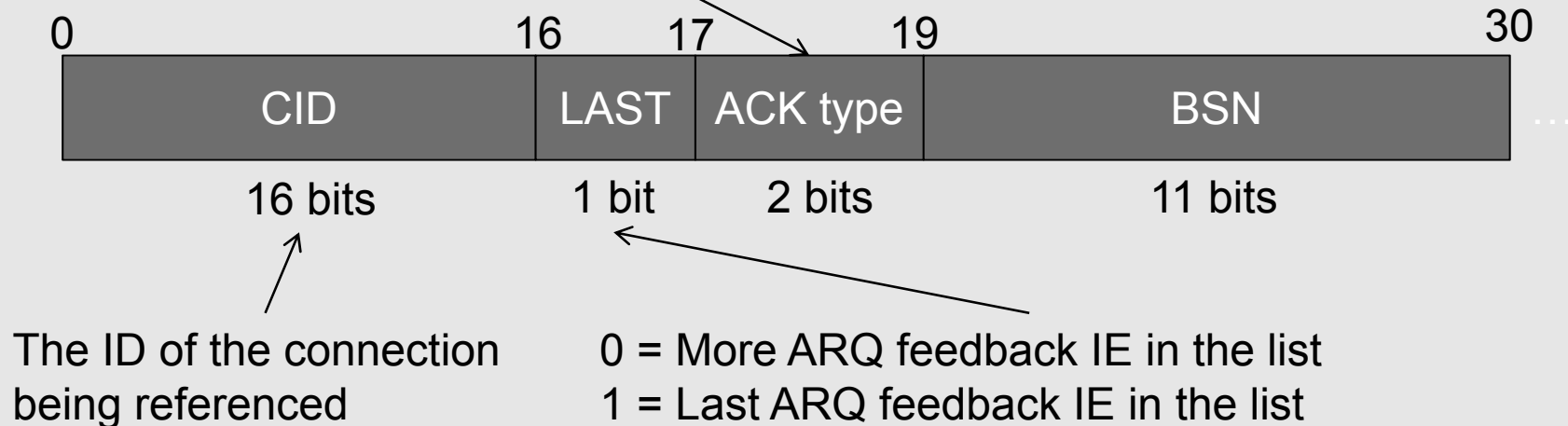


802.16e: ARQ Feedback Message Types (1/3)

- Type 0 (0x0) – Selective ACK
- Type 1 (0x1) – Cumulative ACK
- Type 2 (0x2) – Cumulative with Selective ACK
- Type 3 (0x3) – Cumulative with Block Sequence



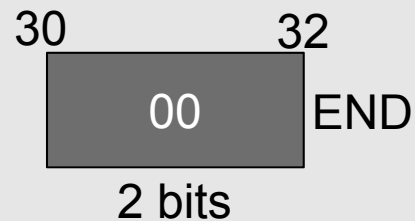
Common part:



802.16e: ARQ Feedback Message Types (2/3)

■ Type 1:

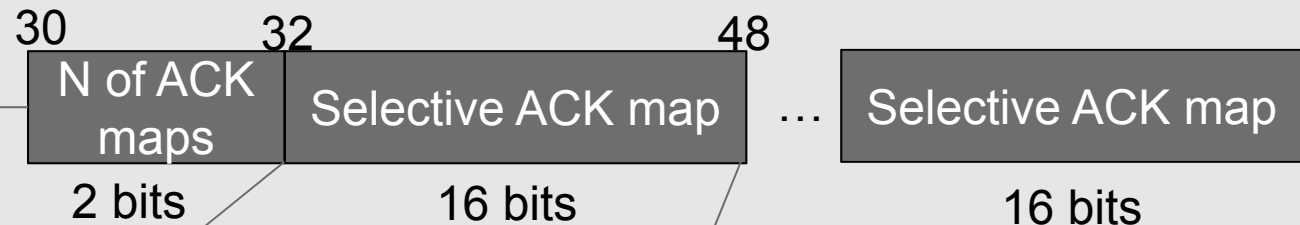
Cumulative



■ Type 0:

Selective

0x0 = 1 map
0x1 = 2 maps
0x2 = 3 maps
0x3 = 4 maps



1 1 1 1 0 1 1 ... 0 1 1 0 0 1

BSN BSN+1 BSN+2 ...

1 – received w/o errors

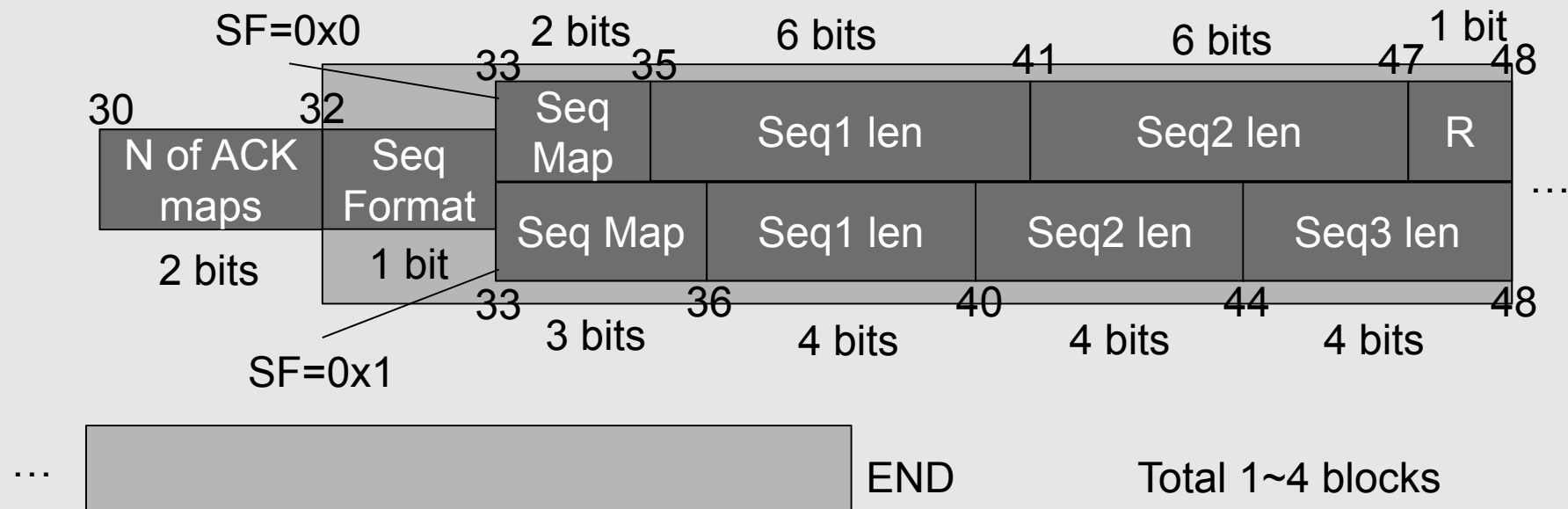
0 – corrupted or not received

■ Type 2: first bit of first map must be set to 1

Cumulative with Selective

802.16e: ARQ Feedback Message Types (3/3)

■ Type 3: Cumulative with Block Sequence



1 010 0011 1010 1000 → 0001111111111000000000..
 3 10 8

0 01 000010 010010 0 → 0011111111111111111111...
 2 18

Examples of Different Types of Feedback IE

ARQ sliding window : Example 1

BSN:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	1	1	1	0	0	1	1	1	0	1	1	0	1	1	1

Selective ACK

BSN:1	1	1	1	1	0	0	1	1	1	0	1	1	0	1	1	1
-------	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Cumulative ACK + Selective ACK

BSN:4	BSN:5	0	0	1	1	1	0	1	1	0	1	1	1
-------	-------	---	---	---	---	---	---	---	---	---	---	---	---

Cumulative and Selective ACK

BSN:4	0	0	1	1	1	0	1	1	0	1	1	1
-------	---	---	---	---	---	---	---	---	---	---	---	---

Cumulative and Block Sequence ACK

BSN:4	Seq:010	2	3	1	Seq:101	2	1	3
-------	---------	---	---	---	---------	---	---	---

Examples of Different Types of Feedback IE

ARQ sliding window : Example 2

BSN:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1

Selective ACK

BSN:1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1
-------	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Cumulative ACK + Selective ACK

BSN:3	BSN:4	0	0	0	0	1	1	1	1	1	1	1	1	1
-------	-------	---	---	---	---	---	---	---	---	---	---	---	---	---

Cumulative and Selective ACK

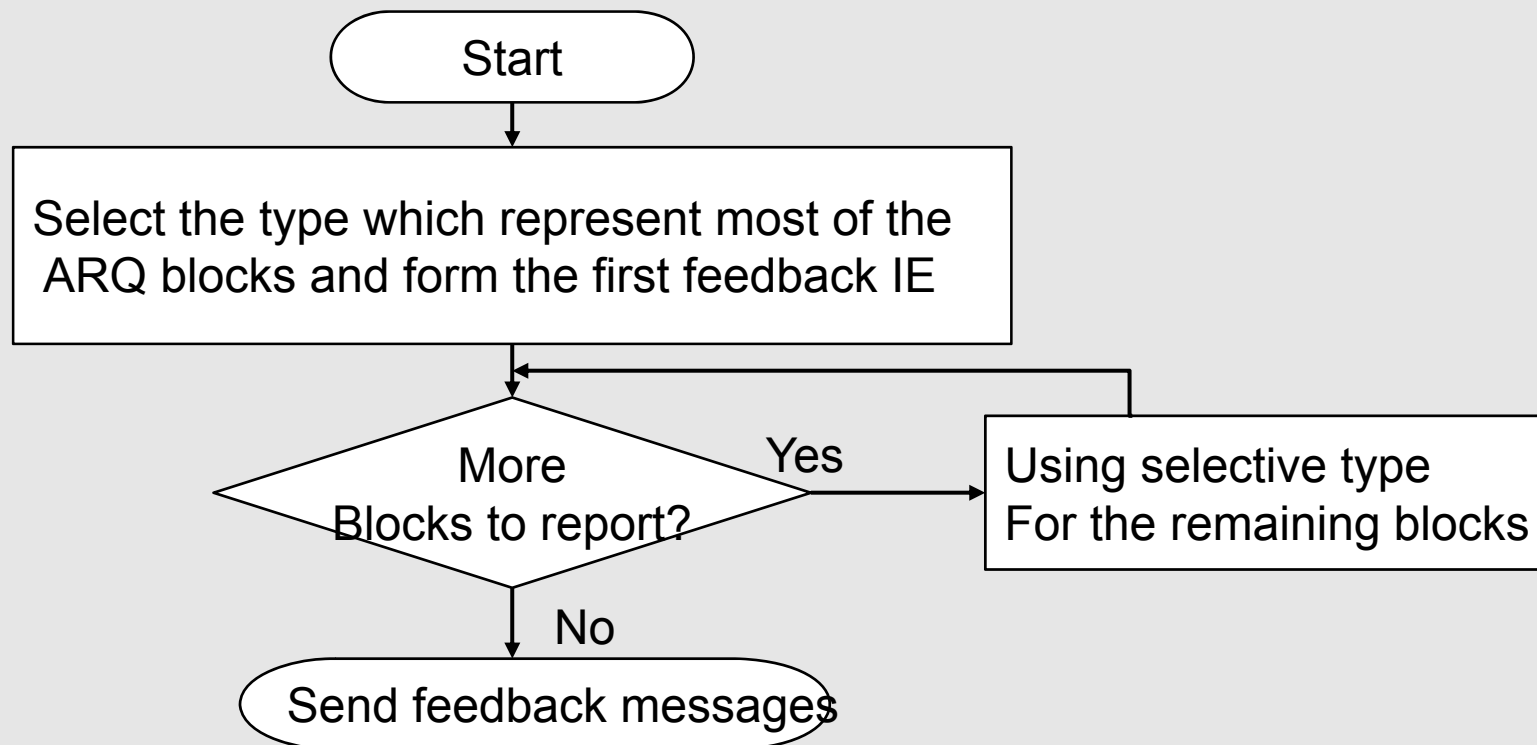
BSN:3	0	0	0	0	1	1	1	1	1	1	1	1	1
-------	---	---	---	---	---	---	---	---	---	---	---	---	---

Cumulative and Block Sequence ACK

BSN:3	Seq:010	4	9	0
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Formation of Feedback Messages

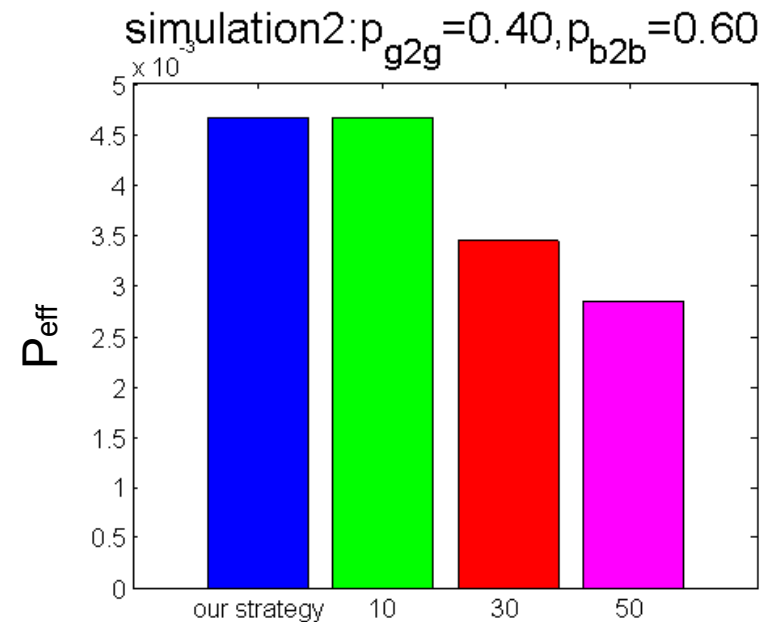
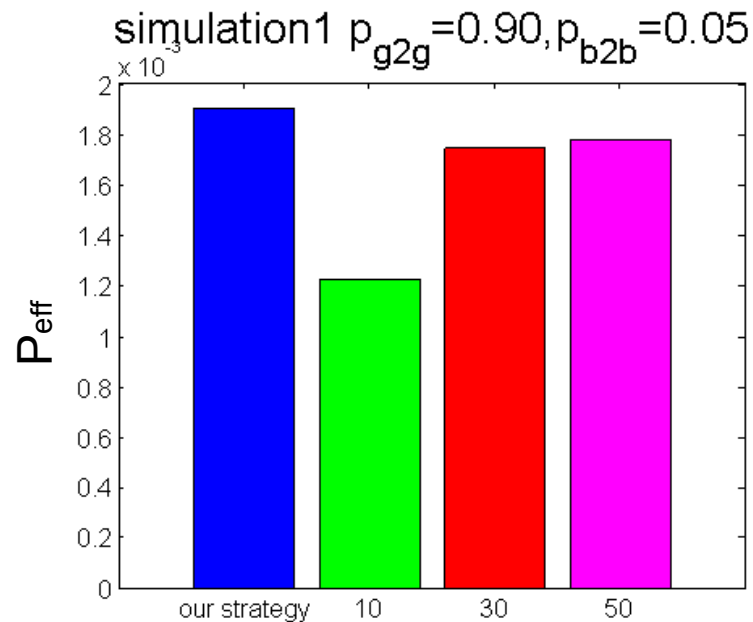
- Based on the content of the sliding window, feedback messages are formed for transmission.



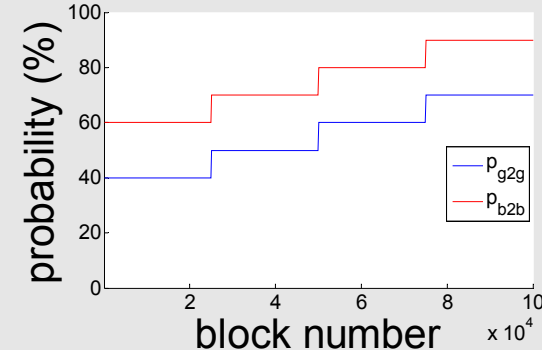
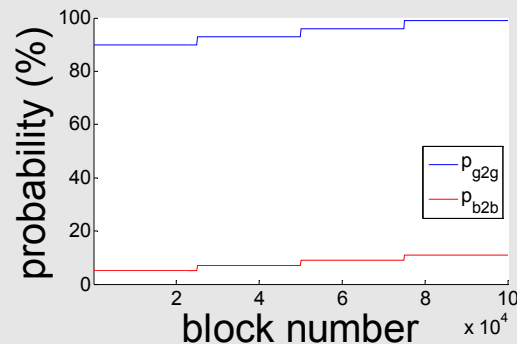
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Performance Comparison



10/30/50: Sheu et al, "Smart ARQ Report Strategy (SARS) for the IEEE 802.16e Wireless Metropolitan Network," VTC 09.



- For both simulation, the performance of the proposed method is better for both slower and faster channel variation.

Conclusion

- A channel-aware transmission of feedback messages is proposed with good performance, when the **delivery delay** of retransmission and the **bandwidth efficiency** of feedback messages are considered.

- Questions?

- Thank you !