Physical Layer ARQ: New Proposed Feature for 802.16ab

Document Number: IEEE 802.16abc-01/27
Date Submitted: 2001-09-03

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Venue: 802.16 meeting, Sept 8-12, 2001, Denver, CO
Base Document: Working Group Comments on document 802.16ab-01/01r1

Purpose: This presentation presents the concept for the proposed new physical ARQ feature, the benefits of such a feature and the interaction of this feature with other PHY and MAC functions.

Physical Layer ARQ: New Proposed Feature for 802.16ab

8 September 2001

Joe Kwak

Interdigital Communications

Presentation Outline

- Purpose
- Definition of Physical Layer ARQ
- Benefits of Physical Layer ARQ
- Unique features of Physical Layer ARQ
- Implementation Challenges
- Draft Figures for Specification

Purpose

- ¥ **A Physical Layer ARQ (PARQ) approach exists which can significantly increase link performance.**
- ¥ **ETSI's 3GPP group is working on a modification to WCDMA which will use a fast feedback Hybrid ARQ scheme to improve performance for High Speed Downlink Packet Access (HSDPA) applications.**
- ¥ **This scheme may also be used as a physical layer feature in 802.16ab for BFWA applications.**
- ¥ **Interdigital Communications (IDC) solicits the support (and wrath) of the sub11 group to add an optional Physical Layer ARQ feature to the 802.16ab standard.**
- ¥ **IDC would be pleased to collaborate on this effort with other interested parties.**

Definition of Physical Layer ARQ (PARQ)

¥ ARQ function embedded in the downlink Physical Layer, between data scrambling and FEC on TX side and around the FEC decoder on the RX side.

¥ At RX side, uses Hybrid ARQ combining of retransmission with original errored transmission to improve performance

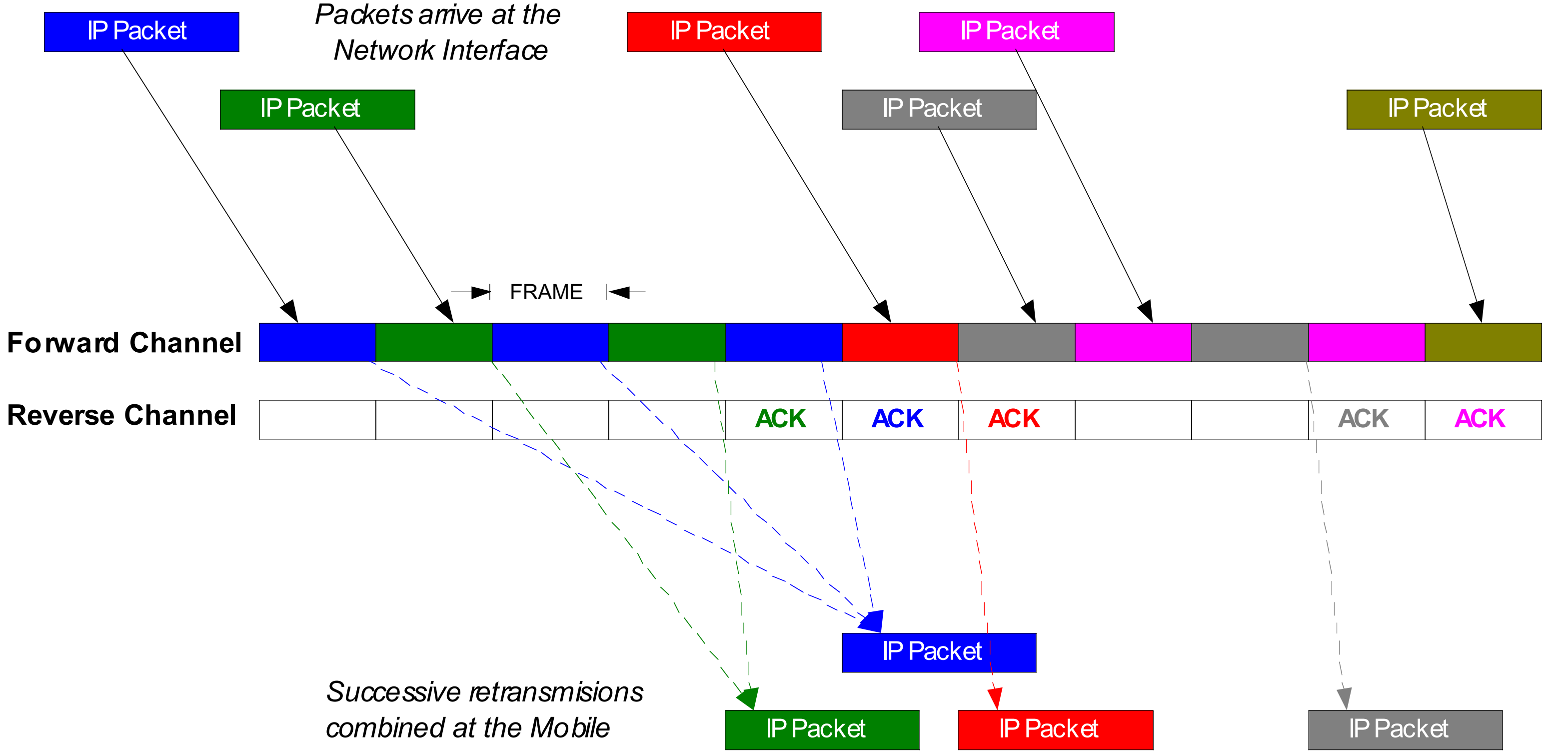
¥ Uses N-channel architecture with Stop-and-Wait protocol with a small TX and RX buffer for each channel

¥ N-channel implementation eliminates the idle transmit periods typical of Stop-and-Wait protocols.

¥ Requires low-latency uplink signaling channel for ARQ feedback

¥ Proposed for Downstream only

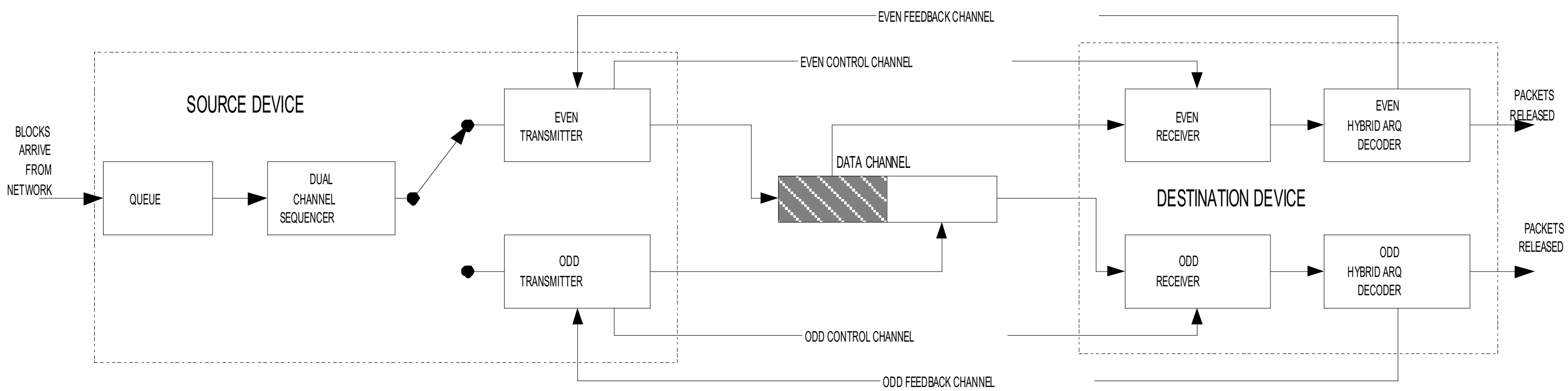
Dual Channel Adaptive Hybrid ARQ Example



¥ **Dual Channel Stop-and-Wait ARQ *enables* Adaptive Hybrid ARQ (HARQ)**

- **The dual channels avoid stalls normally associated with stop-and-wait by providing a one frame delay to communicate ACKs**
- **Memory and control overhead costs of HARQ significantly reduced**
- **Transmit PARQ blocks released within 5 Frames after two retransmissions**
- **Nmax parameter used to limit number of retransmissions and end-to-end transmission delay**

Dual Channel Stop-and-Wait architecture

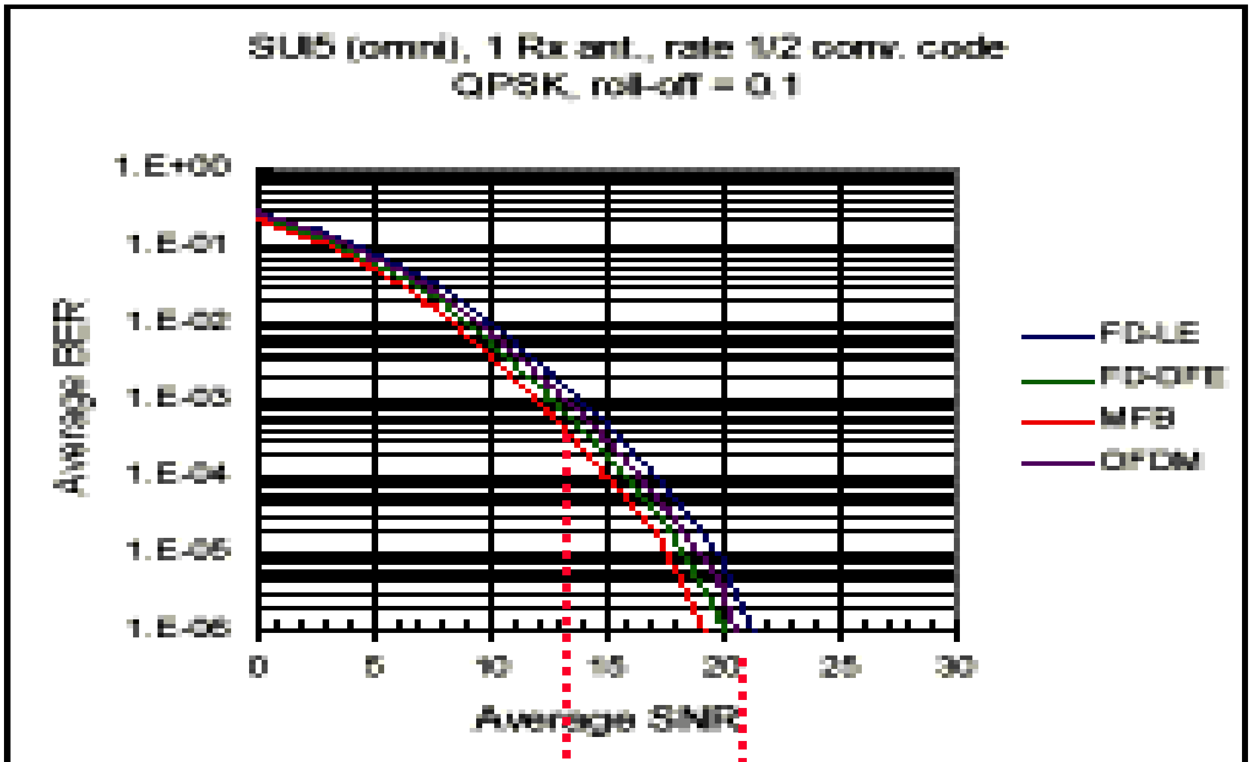


Key Benefits of PARQ feature

- Significant improvement (2-7 db lower SNR) in PHY layer by operating at much higher BLERs (5-20% BLER) with smaller blocks
- PARQ trades delay and some capacity for reduced Eb/No operating point without compromising end-to-end error rate.
- Improved performance using advanced Hybrid ARQ techniques: Chase combining, or Turbo coding with code combining
- Achieves ARQ benefits without MAC modifications: Layer 1 feature independent of Layer 2 ARQ.
- Proposed as a PHY optional feature for systems or links which require the additional gain

PARQ SNR Gain Example

Simulation Results from 802163p-01_31r2.pdf



Improvement using PHY ARQ = 7 dB

PHY ARQ operating point:
BER = 10-3 (10% BLER, 100 bit block)

MAC ARQ operating point:
BER = 10-6 (.1% BLER, 1000 bit block)

Possible uses for decreased SNR requirement

- Increased capacity by earlier switch to higher order modulation in AMC
- Lower CPE costs by using lower grade RF components with some performance degradation
- Increased downlink range, extending cell radius
- Reduced downlink power in BS to minimize cell-cell interference and increase PA backoff in multicarrier case

Impact on current 802.16ab Draft Standard

- PHY agnostic, may work with either SC-FDE or OFDM schemes
- Requires design of new upstream Fast Feedback Channel (FFC)
- May be used in both FDD and TDD modes, though FFC for TDD is more complex
- Proposed in downstream, but also possible for upstream
- Proposed as optional feature with configurable PHY parameters in MAC layer, NOT assumed to be required for all SS's or for all links for a given SS.

PARQ Unique Features

- **PARQ is Adaptive**
  - **Adapts to instantaneous link quality**
  - **Adds redundancy only when needed**
  - **Receiver saves failed transmission attempts to help future decoding**
  - **Every transmission helps, increasing the packet success probability**
- **PARQ uses Hybrid ARQ combining technique**
  - **Method 1 : Code Combining (Chase, 1985)**
    - Packet contains info and redundancy
    - Retries are identical to first packet attempt
    - Max-ratio combining of symbols
  - **Method 2 : Turbo coding + Code Combining**
    - Packet contains info and redundancy
    - Retries contain additional redundancy
    - More complex than Method 1, but offers potential throughput gain

Adaptive Modulation and Coding and Physical layer ARQ are Complementary

¥ **Adaptive Modulation and Coding**

—**Gives the flexibility to match Modulation Coding Scheme to the average channel conditions for each user**

¥ Coarse data rate selection, large SNR steps

—**Drawbacks**

¥ Sensitive to measurement error and delay

¥ Still needs an ARQ

¥ **Physical layer ARQ**

—**Independent of various thresholds, variable link adaptation within large AMC SNR step.**

—**Automatically adapts to instantaneous channel conditions**

¥ Insensitive to measurement error and delay

¥ Fine data rate adjustment

—**Requires Fast Feedback Channel (FFC) for ARQ signaling**

PARQ can improve AMC

¥ ARQ retransmission statistics can provide new input to AMC decision algorithm

¥ Use of fast feedback ACK/NACKs for AMC decision permits lower latency channel adaptation than is possible using only MAC or higher layer QOS feedback.

¥ Use of fast feedback ACK/NACKs for Channel estimates may permit more effective adaptive transmission techniques (subchannel probing/nulling for OFDM)

¥ In some applications, may eliminate need for MAC layer ARQ retransmissions

Challenges for PHY ARQ Implementation

¥ **Design of Fast Feedback Channel (FFC) for Uplink:**

— Compatible with all options: SC-FDE/OFDMA in either TDD/FDD mode

— For TDD, Downlink MAP may interleave idle periods to provide intervals for SS to transmit FFC in Upstream.

— Channel rate of FFC depends on choice of PARQ block sizes and Duplex mode.

— PARQ block sizes to be compatible with MAC, SC-FDE and OFDMA

¥ **Proposed approach is a low rate CDMA Uplink channel spread across the entire uplink band:**

— Will not interfere with (orthogonal to) normal SC or MC Upstream modulations; will add to Upstream interference power level, however.

— Family of CDMA codes can be allocated to SS's and provide source identification to BS.

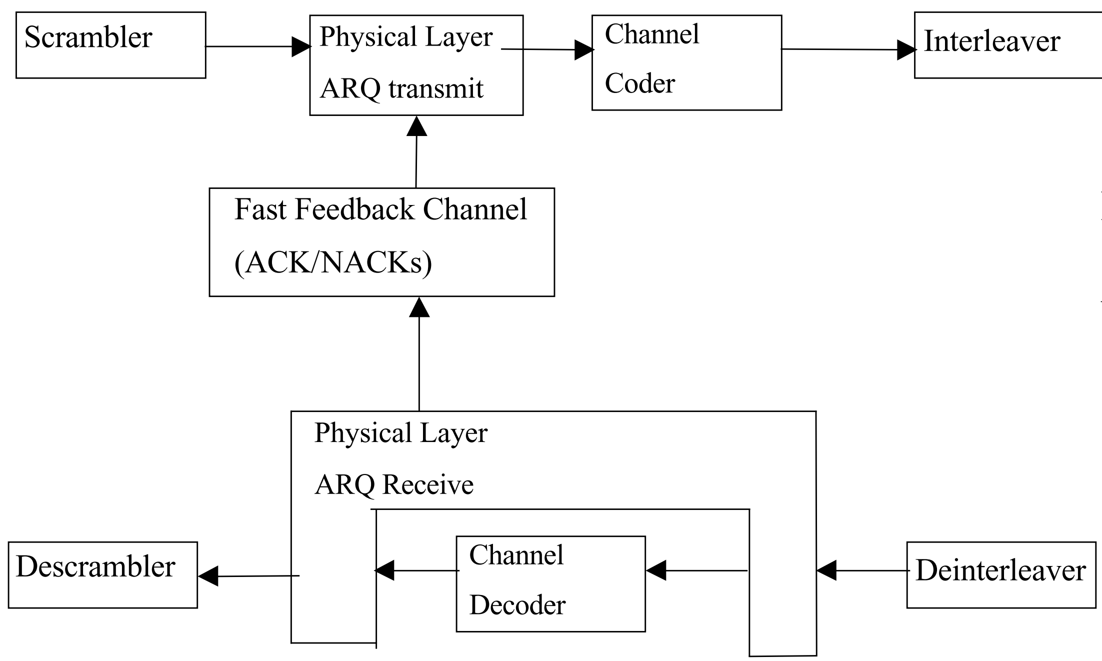
— FFC rate can be reduced by permitting simultaneous uplink transmissions from different SSs on different codes.

— May reuse CDMA transmitter used in SS for ranging.

Draft Figures for Specification

- **The following 2 charts are provided here to indicate suggested figure modifications and new figures referenced in my comments on 802.16ab-01/01r1**

Modifications for Figure 149, page 57



Note: All other aspects of the figure remain unchanged.

¥ **Figure 149a--Generic PHY block diagram**

Draft new Figure xx, page 74