

## Physical Layer ARQ: New Proposed Feature for 802.16ab

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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.

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# **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**

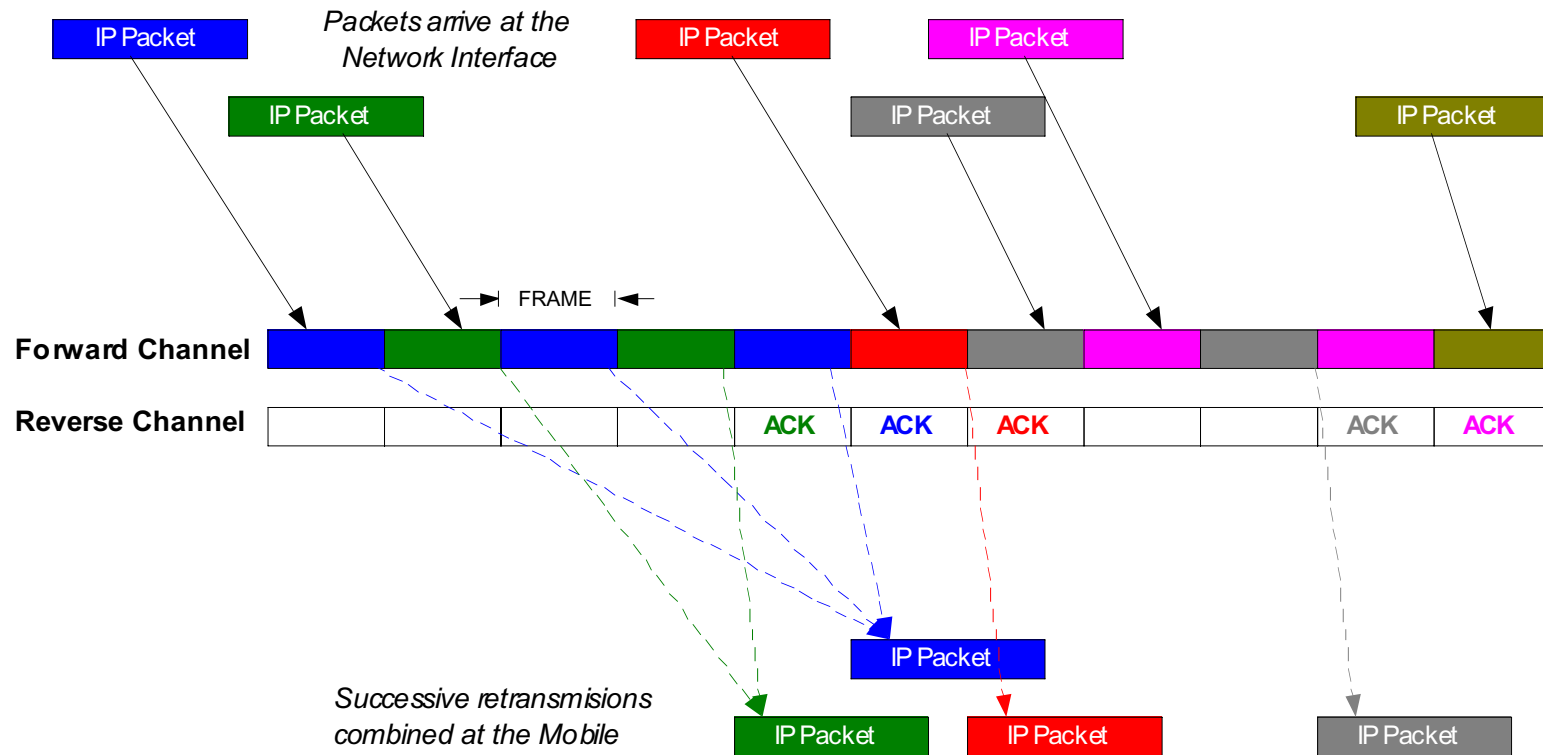
# Purpose

- ∕ 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**

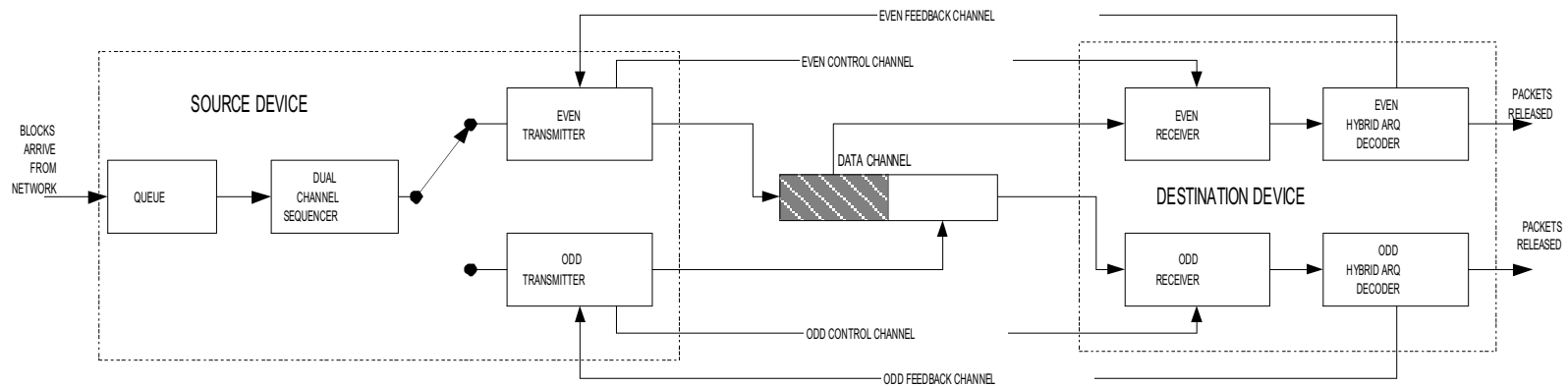
# Dual Channel Adaptive Hybrid ARQ Example



## ∞ 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



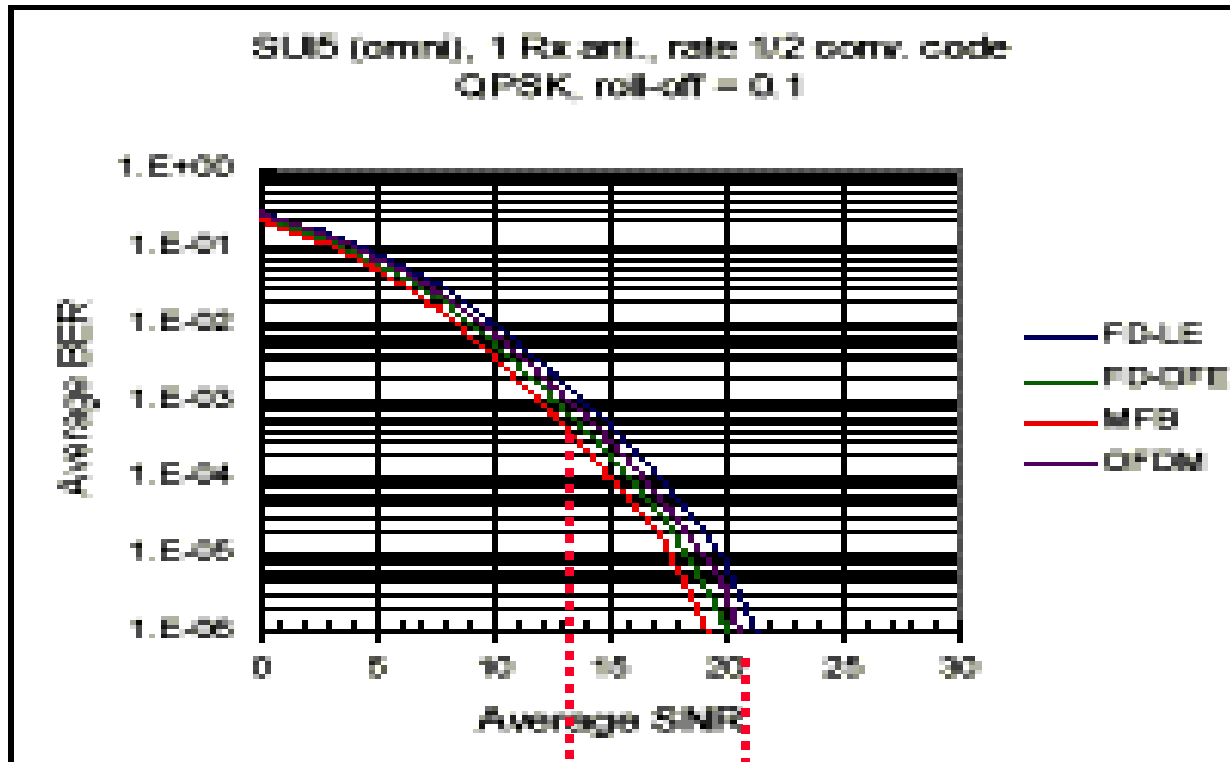
## Key Benefits of PARQ feature

- ∕ 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:

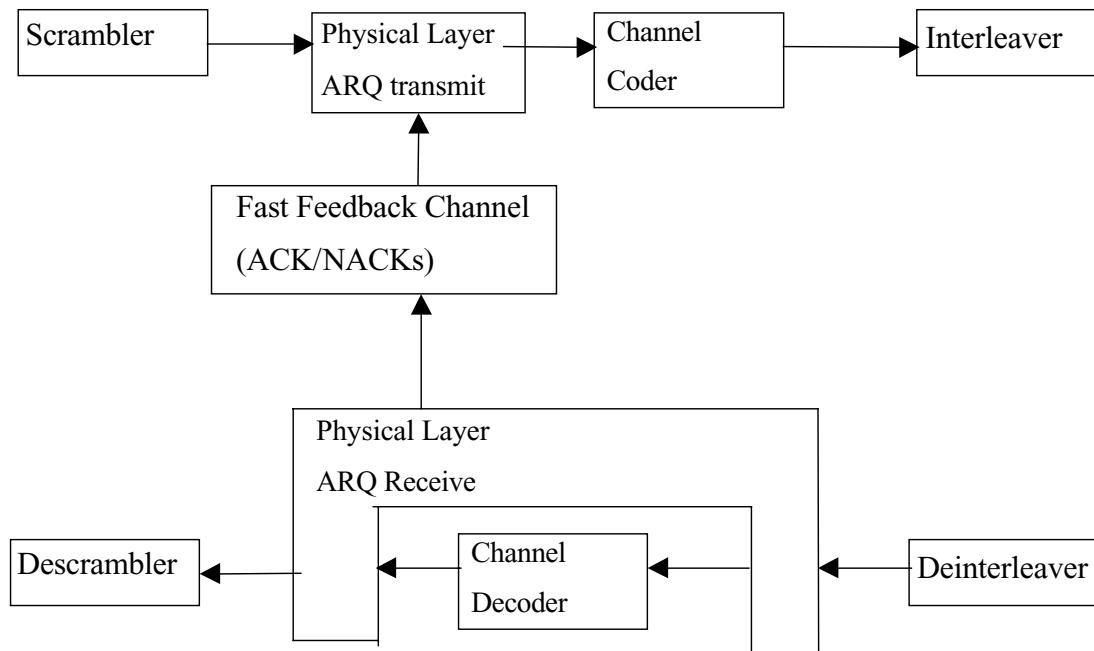
- Will not interfere with (orthogonal to) normal SC or MC Upstream modulations; will add to Upstream interference power level, however.
- Family of CDMA codes can be allocated to SS's and provide source identification to BS.
- FFC rate can be reduced by permitting simultaneous uplink transmissions from 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

