Introduction to PHY and MAC contributions

“Case for DOQPSK High-rate Physical Medium”(077)

and

“Requirements and Recommended Functions in High-rate MAC” (079)

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What is addressed

- Obvious: size, cost, power drain, but also:
- “Decimegabit” transfer rates
- Easily modelable MAC with DETERMINISTIC capacity for connection-type and packet services.
- Provides for rate scalable and basic radio modulation
- Coordination of MAC and PHY
- Constructive use of overlapping coverage
- High utilization traffic assignment

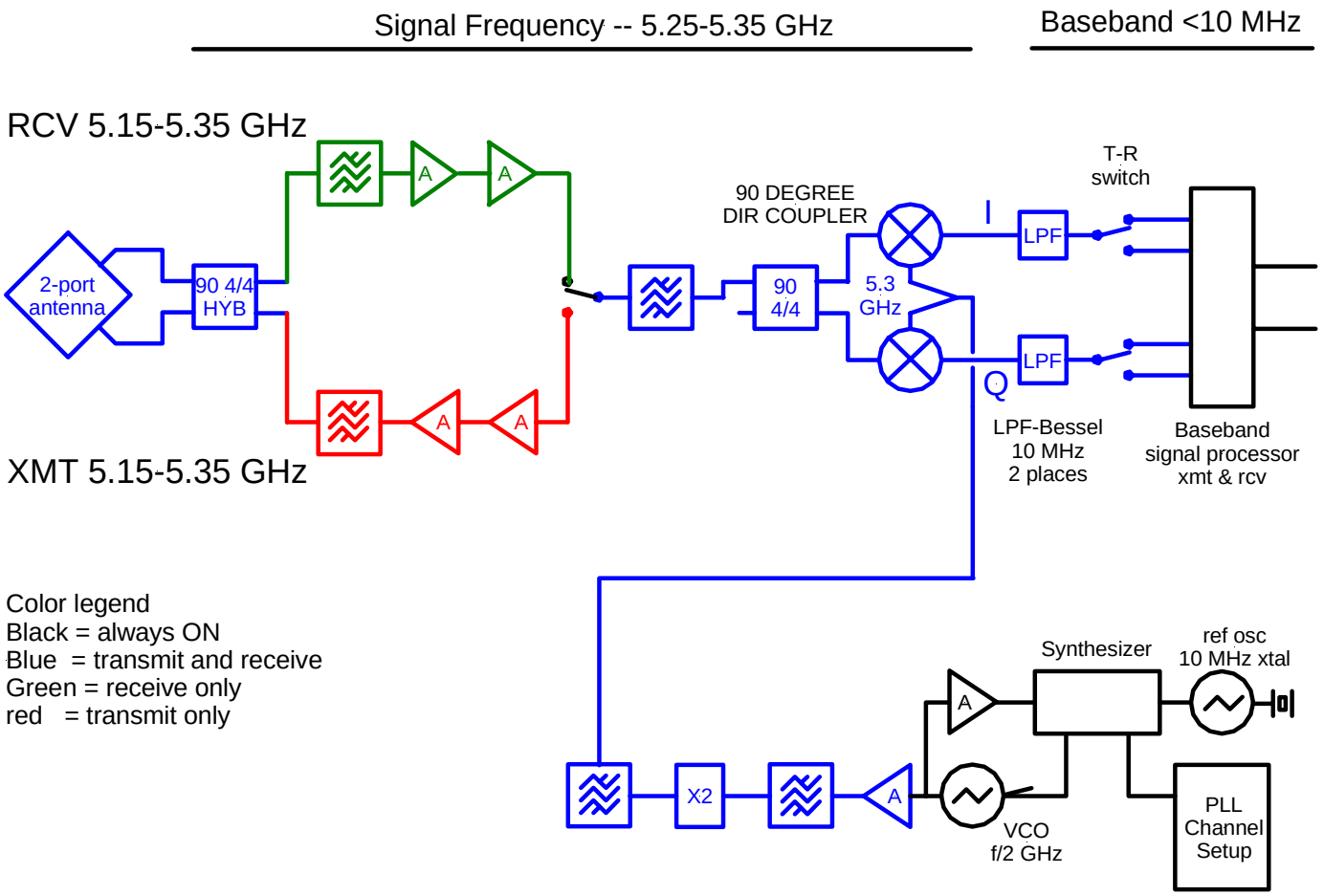
What the PHY paper is about

"Case for DOQPSK High-rate Physical Medium Modulation"

- Near constant envelope I and Q parallel data paths
- Shape pulse modulation with either Bessel or better FIR filter
- ***Demodulation using prior pulse as a phase reference for current pulse avoiding need for phase locked reference in demodulator***
- Preamble based acquisition of bit clock with coast through burst interval
- Shows the simplicity and flexibility of the implementation.

PHY paper purpose

- Most of it is obvious and is to show additional support
- It may not be obvious that the phase lock on the received carrier is not required for demodulation
- Models of the radio can be built now without custom parts and in moderate commercial quantities
- Integrated antennas for access point and station are essential to FCC type acceptance, and are normalizing influence on system design and simulation



5.15-5.35 GHz Half-Duplex Radio Modem
Figure 3

C. A. Rypinski
File: NIIRaMdm_a2q

Main topics in the MAC paper

"Requirements and Recommended Functions in High-Rate MAC"

- Paper is a reference on the factors that should be considered--particularly including traffic assumptions, integrated data and services and system plan for frequency reuse
- Shows interrelationship between modulation, channel coding and antenna directivity in optimizing frequency reuse
- Shows starting point **isochronous period frame structure** including broadcast header on downlink and provisions for propagation delay through the system
- Shows un-novel access methods and multiple uses of polling

MAC paper purpose--A

- Suggest a protocol that might take only ten pages of state diagram (not 80)
- Show a mostly **deterministic** access method
- To show simplicity of PERMISSION, REQUEST, GRANT, TRANSFER, ACK procedure for all traffic transfers
- Asymmetric, complementary protocol makes station simpler, and also the control terminal

MAC paper purpose--B

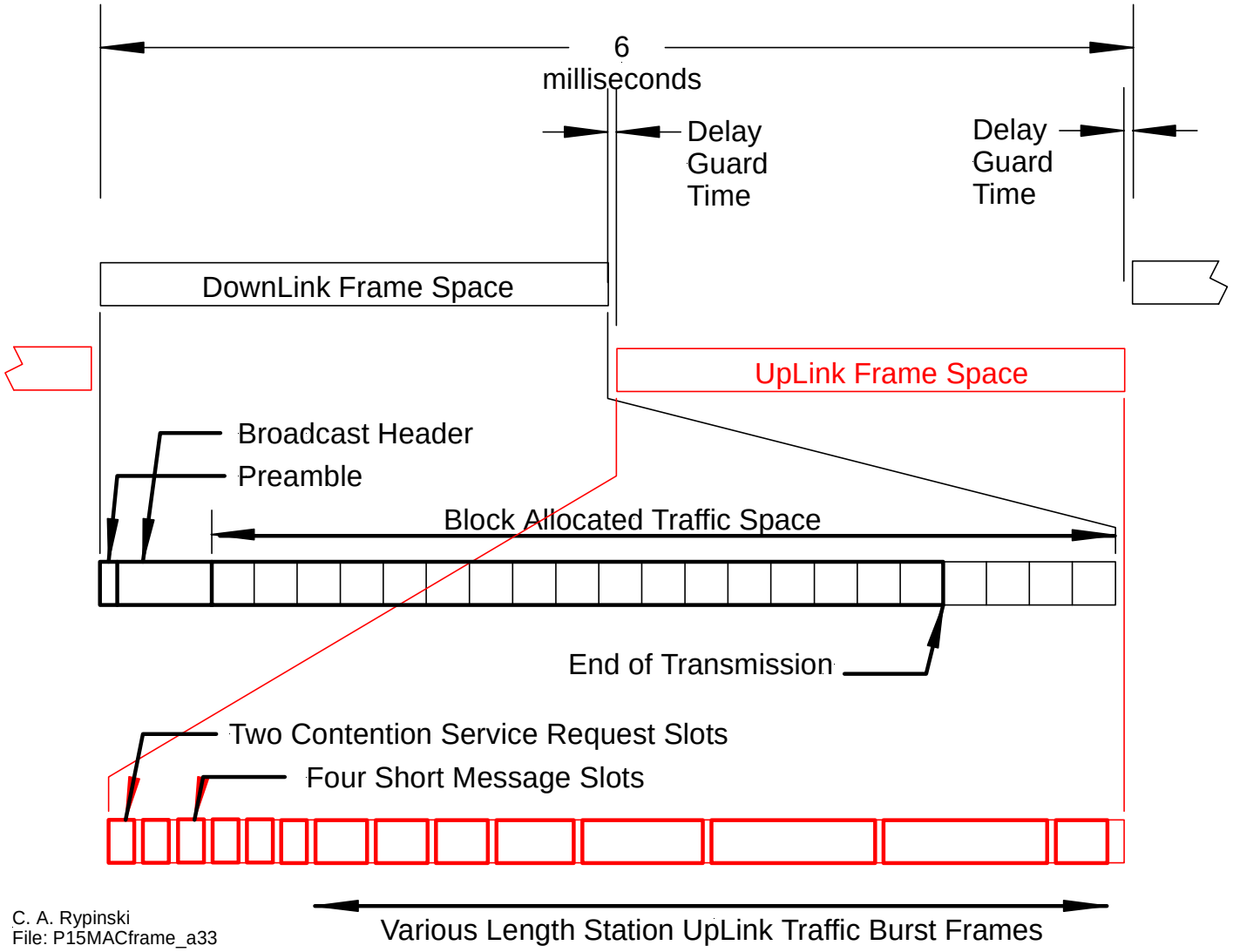
- The simpler PAN applications are served by subsetting, to functions necessary
- Station has constant small vocabulary for any size of infrastructure
- Use of polling is appropriate access method for short reach systems
- Uses isochronous frame rate with asynchronous transfer within the frame

MAC paper purpose--C

- The down-link frame consists of preamble, broadcast field and traffic field
- The first part of the broadcast field contains system identification, frame parameters and other information used by all stations
- The next part is ACK/NACK for previous traffic received
- The next part broadcasts identification of stations to which traffic will be sent and the index as to where it will appear
- The next part broadcasts identification of stations granted access for traffic to be sent up and the index as to where it will appear

MAC paper purpose--D

- Central control shared by many access points provides many important benefits
- Any amount of function may be provided to deal with and condition traffic for external networks
- Multiple access points may be coordinated to manage redundant coverage as path diversity; and very much faster because all control and status information is at one point
- A common data base maintained in real time enables retrieval of facts knowable before a communication is initiated


6
milliseconds
Delay
Guard
Time
Delay
Guard
Time
DownLink Frame Space
UpLink Frame Space
Broadcast Header
Preamble
Block Allocated Traffic Space
End of Transmission
Two Contention Service Request Slots
Four Short Message Slots
C. A. Rypinski
File: P15MACframe_a33
Various Length Station UpLink Traffic Burst Frames

MAC paper purpose--E

- By concentrating all broadcast and addressed control messages in the first part of the downlink frame, a station may determine whether there is any traffic for it, and then sleep for the remainder of the frame
- The shutdown of the LO multiplier and power amplifier chain within the radio is a substantial power saving when compared with radios that must be ready for broadcast messages at all times
- This refinement of battery drain reduction is a result of cooperation between MAC and PHY

MAC paper purpose--F

- The default frame period is 6 millisecond which with 48 octets transferred per frame corresponds to a 64 Kbps one-way B channel
- Other frame periods at 8 and 12 milliseconds are possible and useful
- The longer the frame period, the more fixed time losses are diluted down.
- For transmitting 54 octet ATM cells, there would be no change in the period--the burst would just last 6 bits longer

MAC paper purpose--G

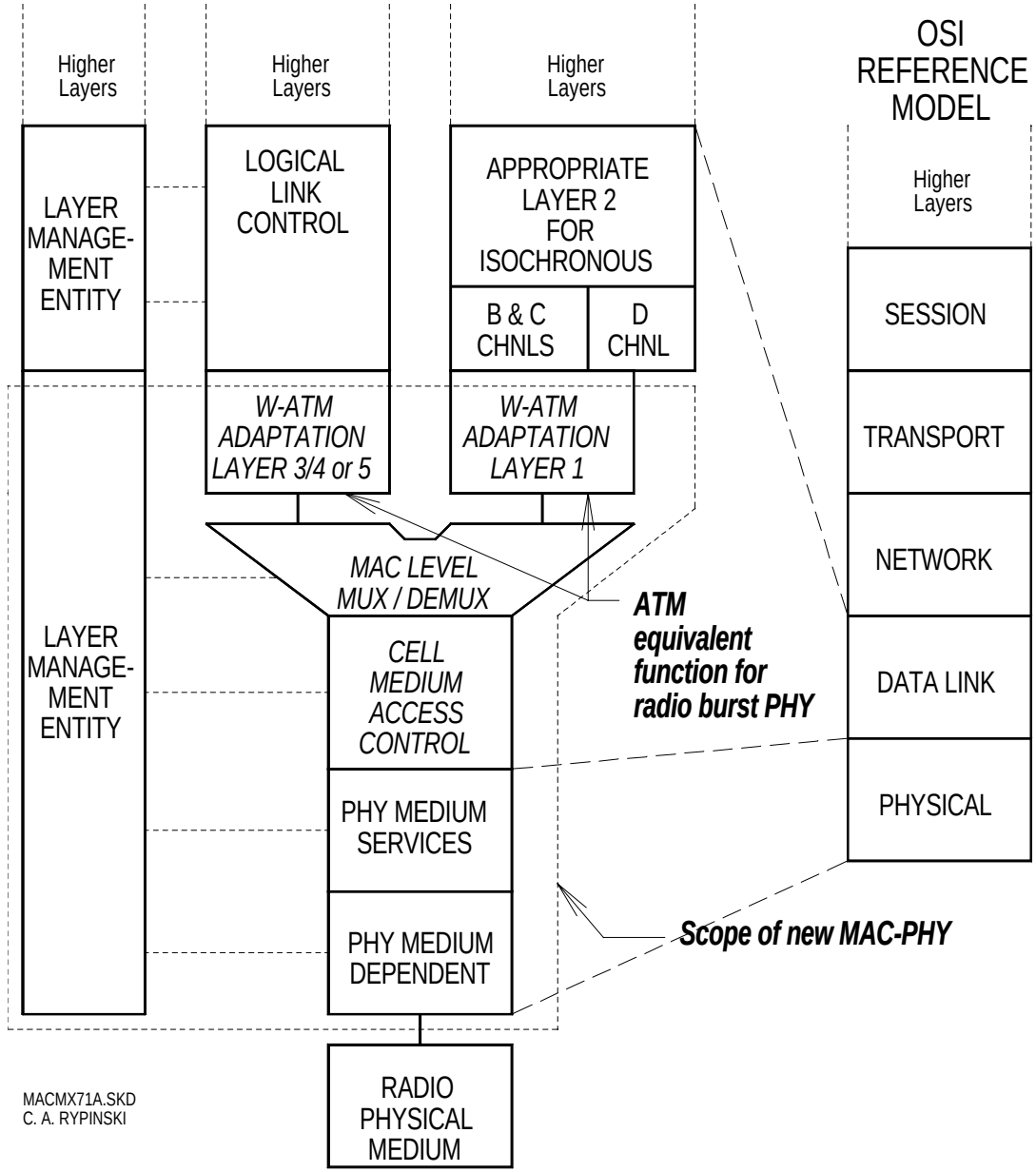
- The polling function serves multiple purposes: access point association check, detection of disappeared stations, change of station settings (channel, power), sleep mode control, and non-contending receipt of service requests
- The frequency of poll can be adaptive to reduce access delay for active stations
- Sleep mode can be software defined and managed to adapt activity level
- An open address poll also can solicit association requests

MAC paper purpose--H

- The station message vocabulary contains the following received message types:
  - Poll with sleep mode control, settings change
  - Poll with solicitation of service request
  - Allotment of time for sending and receiving of traffic
- and these transmitted message types:
  - Association
  - Service request
  - Ack response to received packet traffic
  - Up traffic transfer
- and must be able to process the general part of the broadcast header

MAC paper purpose--I

- Segmentation of large files and packets is commonplace for less reliable medium to avoid excessive investment of channel in flawed transfers
- Segment size is favorable in the range of 256-512 octets
- Using header preamble-based synchronization, segment size is influenced by the accuracy of the radio bit clock crystal-- error determines how long the bit clock can run without refreshing
- Use of crystals accurate to 10 ppm is recommended which could be satisfactory for a run of 1000 octets without margin


Higher Layers
Higher Layers
Higher Layers
OSI REFERENCE MODEL
Higher Layers
LAYER MANAGE-MENT ENTITY
LOGICAL LINK CONTROL
APPROPRIATE LAYER 2 FOR ISOCHRONOUS
B & C CHNLS
D CHNL
SESSION
W-ATM ADAPTATION LAYER 3/4 or 5
W-ATM ADAPTATION LAYER 1
TRANSPORT
MAC LEVEL MUX / DEMUX
NETWORK
ATM equivalent function for radio burst PHY
LAYER MANAGE-MENT ENTITY
CELL MEDIUM ACCESS CONTROL
DATA LINK
PHY MEDIUM SERVICES
PHYSICAL
PHY MEDIUM DEPENDENT
Scope of new MAC-PHY
MACMX71A.SKD
C. A. RYPINSKI
RADIO PHYSICAL MEDIUM

Traffic Blocking Characteristics

- System behavior must be defined for traffic offered that is in excess of capacity
- All possible states resulting from high traffic in combination with source disappearance at the worst possible time must be considered
- the service request facility must be out-of-band relative to the traffic carrying bandwidth so that requests can be analyzed and queued for order of arrival service
- traffic may be served immediately, delayed and served, or it may be refused and cleared--the queues created enable high utilization of traffic transfer capacity (Erlang C)

Avoiding Difficulty in MAC Design--1

- The entry to all states should be the result of a positive event following a defined state
- The delay or absence of an expected event is not a usable logic, but a processed abnormality--presence or absence of a radio signal is not a usable state
- Received signal quality must be measured as window shrinkage tolerance and not by rf level
- Minimizing the number of defined states is less important than minimizing the number of undefined states

Avoiding Difficulty in MAC Design--2

- Address space should be generous and far greater than expected traffic capacity in one coverage
- Fault detection should be ample and detailed
- Logs should be maintained for traffic, faults and temporary overloads to enable diagnosis of system abnormalities
- Security against unexpected power loss at the worst time must be provided

Options on Frequency Reuse

- The frequency reuse provision using 4-slot time division can be omitted with zero affect on the station--the provision is entirely an infrastructure function
- A frequency reuse provision based on channel coding could probably convert code space to data space to obtain 4-bits per 15/16 bit symbol--this would be a method of greatly increasing delay spread tolerance without frequency reuse
- Multi-level modulation will NOT normally provide a capacity advantage in an interference-limited system design

Options on increased data transfer rate

- The best method of doubling is to double the channel bandwidth with some penalty because the power spectral density is not easily (sometimes legally) doubled
- Higher order modulations may be used with the same radio circuits
- 9QPR would increase transfer rate by 1.4, and 16QAM by 2 and at the same time interference susceptibility would be proportionally increased.
- A data transfer rate of 20 Mbps in channel 20 MHz wide at 27 db down is a close call but 16 Mbps is conservative--FIR filtering will help

Differentiating against 802.11 MAC

- Deterministic capacity and delay analysis
- Provides true connection-type service with reserved future capacity and predictable through-system transit time
- Provides bandwidth-on-demand connections suitable for video streams
- The user station is identical for systems large and small
- The station is simpler (much smaller state diagram) because all the intelligence is in the shared infrastructure

Differentiating against 802.11a PHY (OFDM)

- 2.5 vs. 25 millisecond acquisition time
  ~50 vs. 250+ nanosecond delay spread tolerance
- Active time supply power many times greater for OFDM DSP processor for comparable data rate in signal processors--compare DOQPSK vs. QPSK at 18 Mbps
- 0 vs. 7 db backoff on PA 1 dB compression point