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An energy-efficient cross-layer adaptive modulation and coding scheme for software defined radio

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Abstract

An energy-efficient cross-layer adaptive modulation and coding scheme for software defined radio

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In this paper, a simple and novel cross-layer adaptive modulation and coding (AMC) scheme, which increases the energy efficiency of the wireless communication system is proposed. Traditionally, AMC has been used to improve MAC-layer performance in terms of coded bit error rate, packet error rate, and throughput. The modulation and coding scheme is switched according to signal-to-noise ratio thresholds at the PHY layer. We extend the approach, proposing a framework for energy-efficient cross-layer AMC that captures the impact of both MAC layer and PHY layer parameters on the AMC switching criteria. Cross-layer designs are naturally suited to software defined radio applications. Not only are they readily implemented in software, but also they are integral to the radio components. They can optimize performance of the radio either for a given configuration or adaptively. Through an example of CSMA/CA MAC layer and WLAN physical layer, we demonstrate our AMC scheme and verify its effectiveness by simulation.

Biography

Linda Davis received the B.E.(Elec.) degree with first class honours from the University of Adelaide in 1994, and the Ph.D. degree from the University of Melbourne in 1999. Since August 2008, she has been with the Institute for Telecommunications Research (ITR) at the University of South Australia as an Associate Research Professor in wireless communications.

Linda has a mix of industrial and academic research and development experience, having held positions at Bell Laboratories Research, Agere Systems, Macquarie University, and the Defence Science and Technology Organisation (DSTO). Her research interests include communication theory, wireless physical layer design, and algorithms, architectures, and implementations for advanced communication receivers including software defined radio.

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cross-layer design for SDR

SDR configures radio for user utility

- interoperability
- spectrum efficiency, white-space
- quality of service, throughput, delay tolerance
- energy efficiency

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✓ flexibility in combination of MAC and PHY

✓✓ cross-layer design
- integral to radio components
- adapts to radio configuration
- optimized utility and performance within configuration

SDR for cross-layer design

SDR is capable of both run-time reconfiguration and cross-layer optimization

- software implementation of MAC
- software controlled reconfiguration of PHY
- MAC has access to PHY layer parameters

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component level and system level power management can be integrated into every layer of SDR

key idea

minimize energy consumption of link

- goal is to transmit information, N_s bits
- energy consumption through
    * RF transmission + re-transmission of info packets
    * RF transmission of ACK/NACK for each packet
    * receiver RF and processing power assumed negligible

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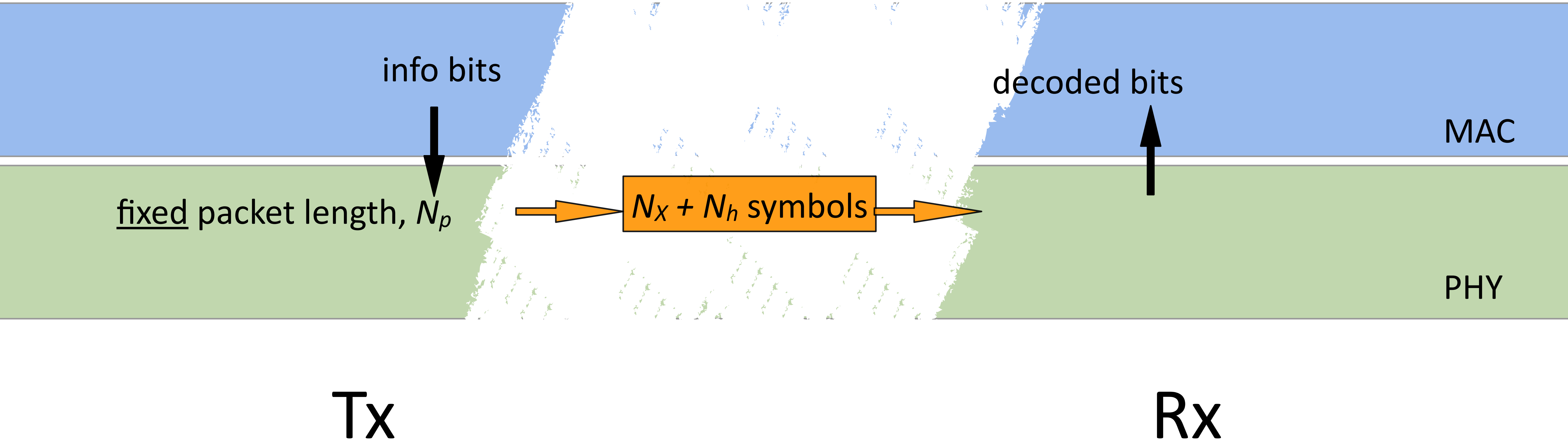
use adaptive modulation and coding

optimize both MAC and PHY parameters for N_s bits

adaptive modulation and coding

adaptive modulation and coding (AMC)

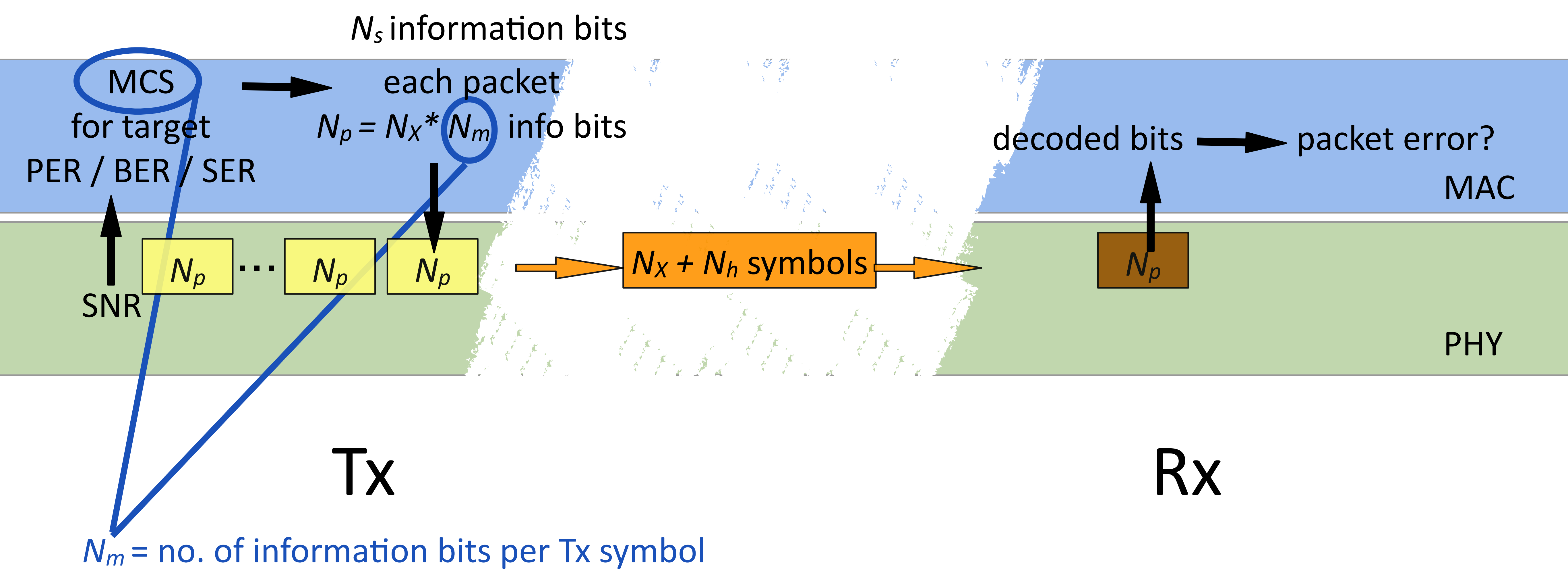
- traditionally used to increase throughput
- subject to peak / average power constraint



adaptive modulation and coding

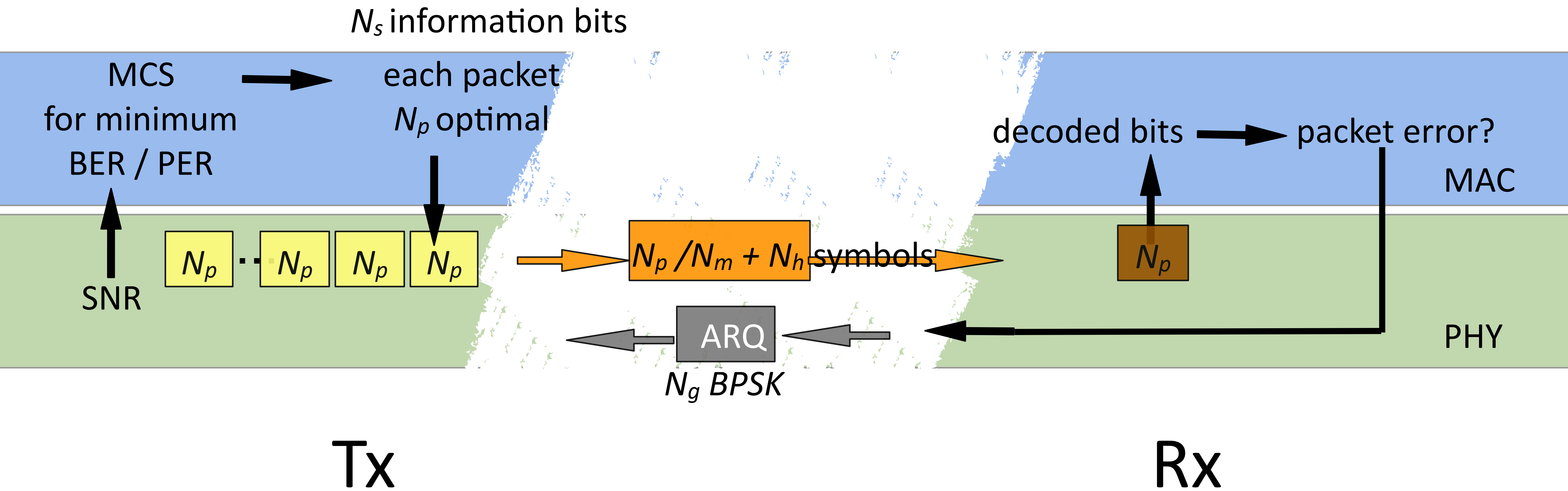
adaptive modulation and coding (AMC)

- traditionally used to increase throughput
- subject to peak / average power constraint
- send high-rate data in favourable channels N_m ↑
- send low-rate data in difficult channels N_m ↓



cross-layer scheme

- simple re-transmission scheme (MAC)
- adaptive modulation and coding (PHY/MAC)
- optimize info packet length, N_p (MAC)



energy

total energy consumption for N_s bits depends on

- transmission power (energy per symbol)
- MCS
- packet length, N_p
- number of re-transmissions

    i.e. packet length and bit error rate

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energy trade-off with MCS and N_p

our scheme

simplify by including MAC collisions in effective BER
- simulate, measure

choose MCS with lowest BER for each SNR

for equal transmission power in forward and reverse link,
optimal packet length is

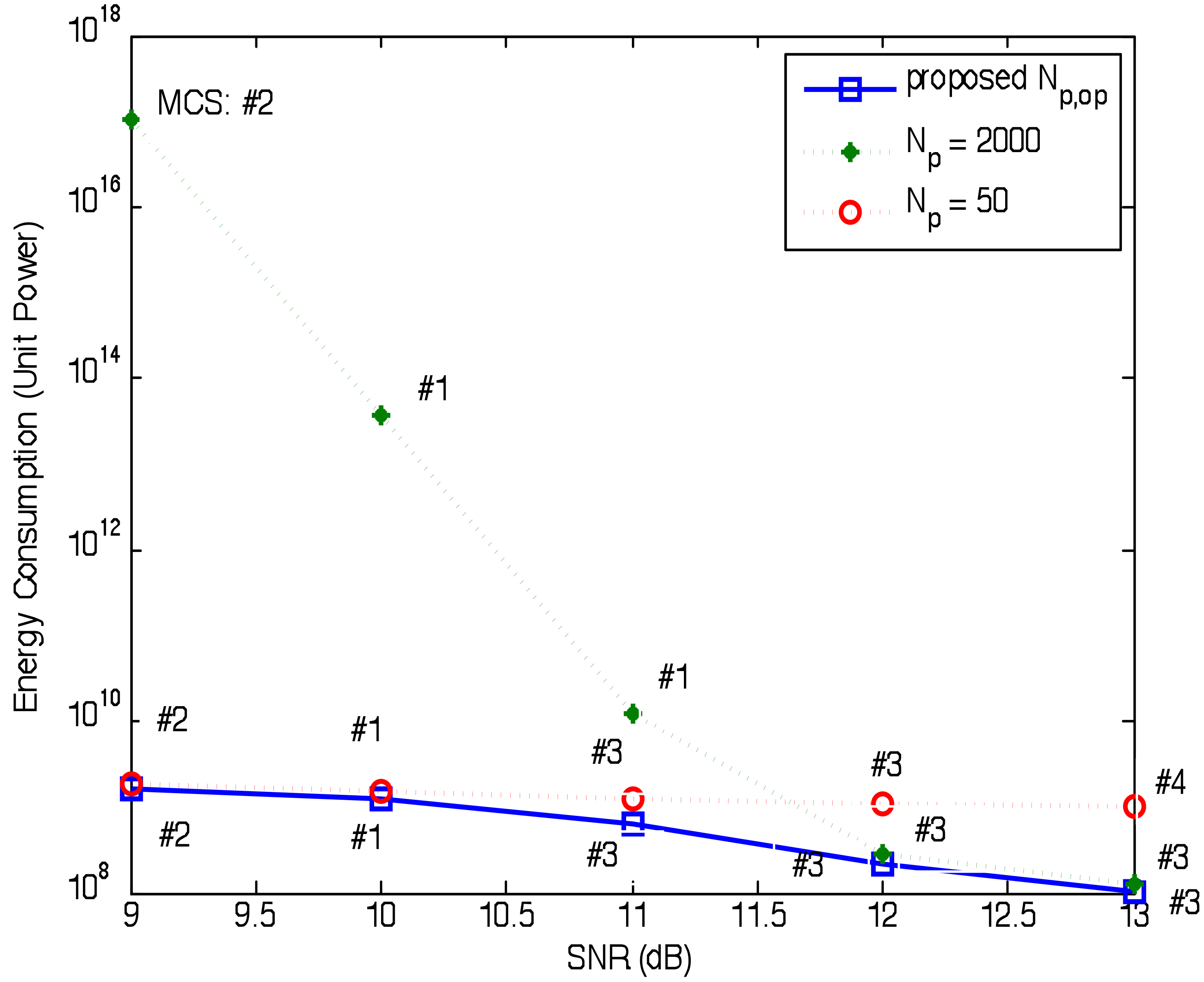
$$N_{p,op} = \frac{N_m}{2}\sqrt{\frac{\ln\alpha N_m N_g^2 - 4N_g}{N_m \ln\alpha}} - \frac{N_m N_g}{2}$$

case study WLAN OFDM

MCS, *m*	#1	#2	#3	#4
link Mbps	6	9	12	18
modln	BPSK	BPSK	QPSK	QPSK
code rate	½	¾	½	¾
N_m	0.5	0.75	1.0	1.5
SNR	**BER measured from WLAN simulation**			
9 dB	0.018	0.0101	0.0178	0.1082
10 dB	0.006	0.008	0.0109	0.0420
11 dB	0.002	0.003	0.0031	0.0122
12 dB	0.0005	0.001	0.002	0.0041
13 dB		4.38e-8	4.125e-7	2.18e-4

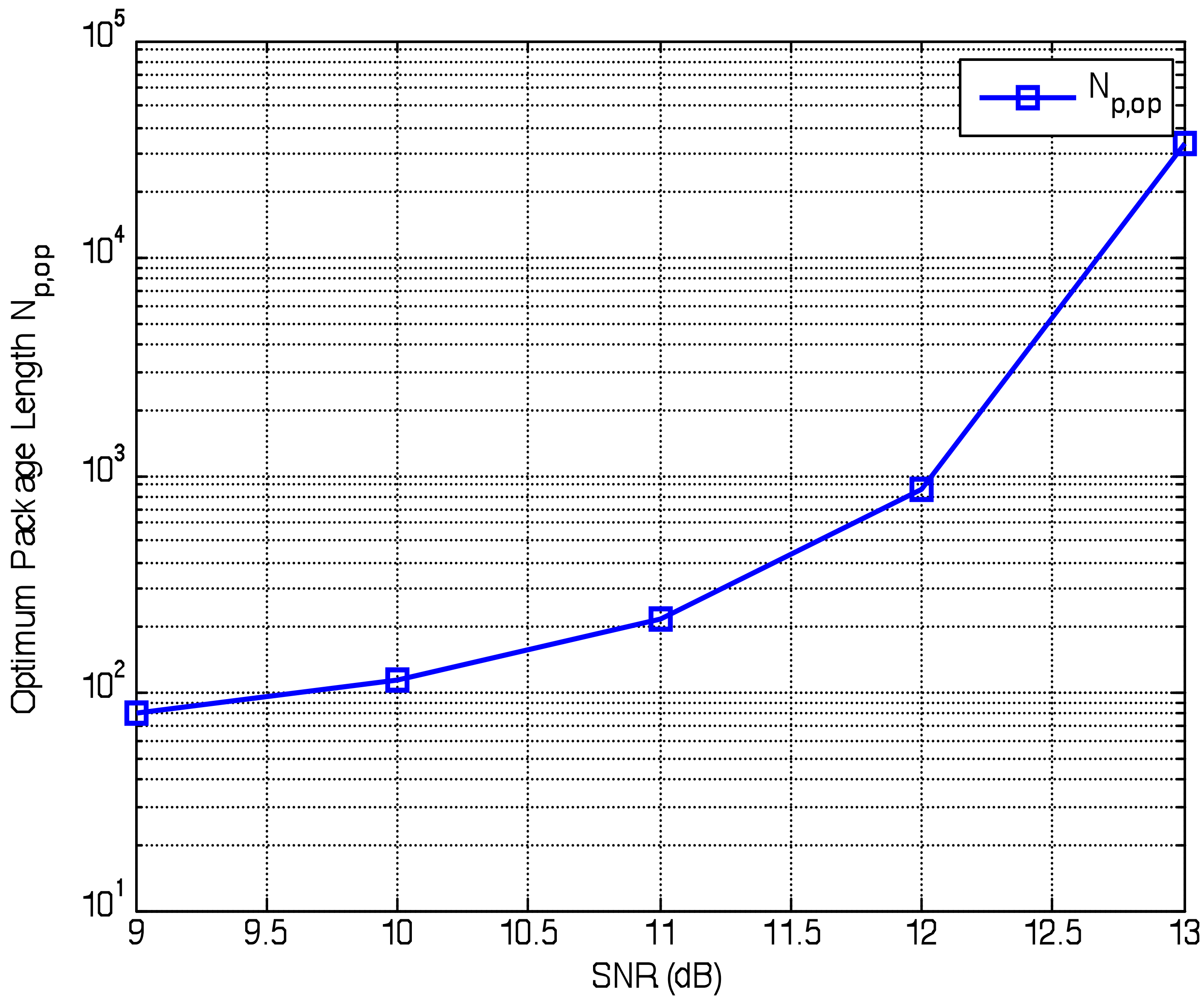
$N_g = 480$

energy trade-off with MCS and N_p



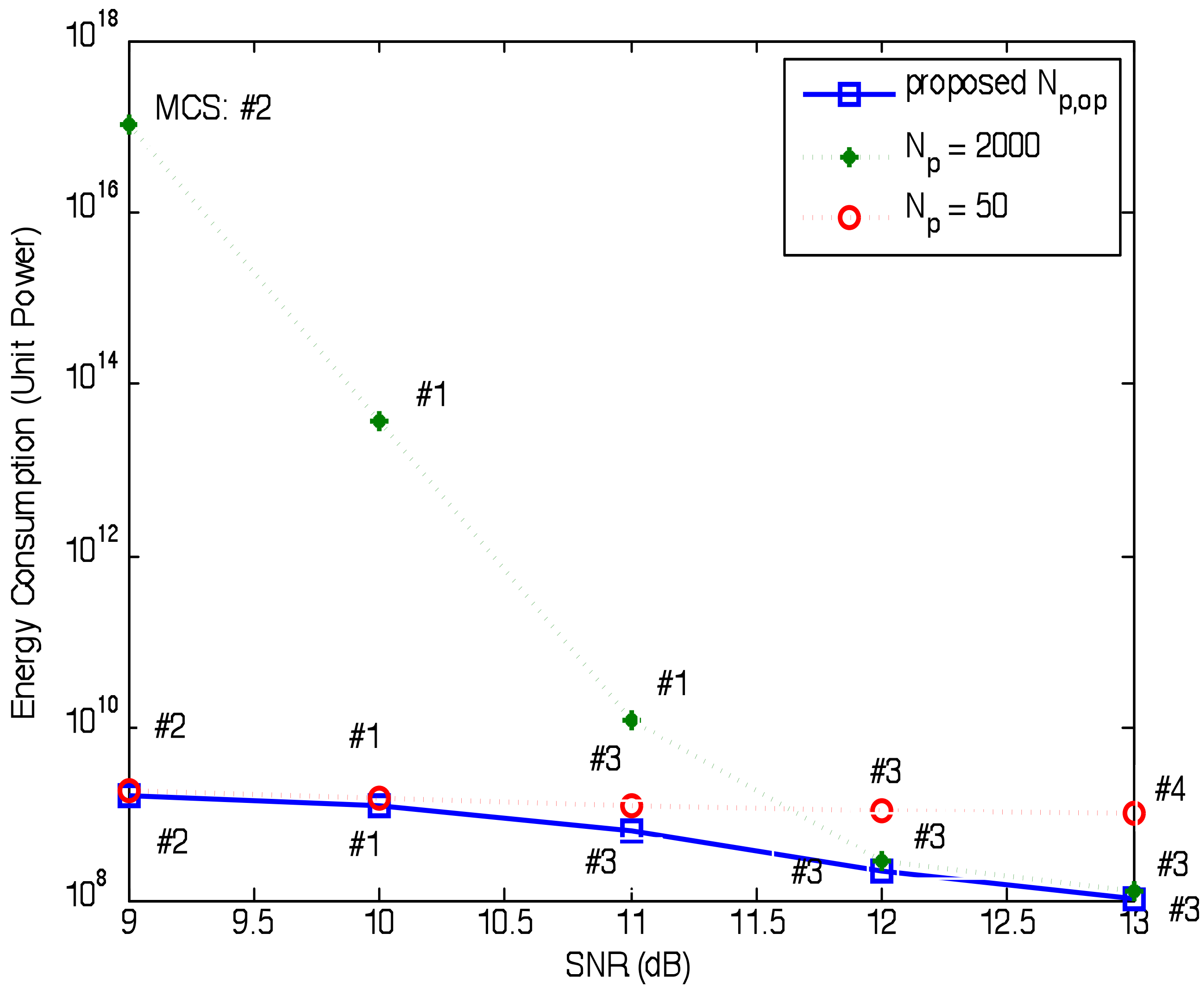
Energy consumption vs SNR for AMC using fixed packet length, N_p, and proposed optimized packet length for energy-efficiency.

optimal packet length, N_p



The Optimum Packet Length vs SNR

energy trade-off with MCS and N_p



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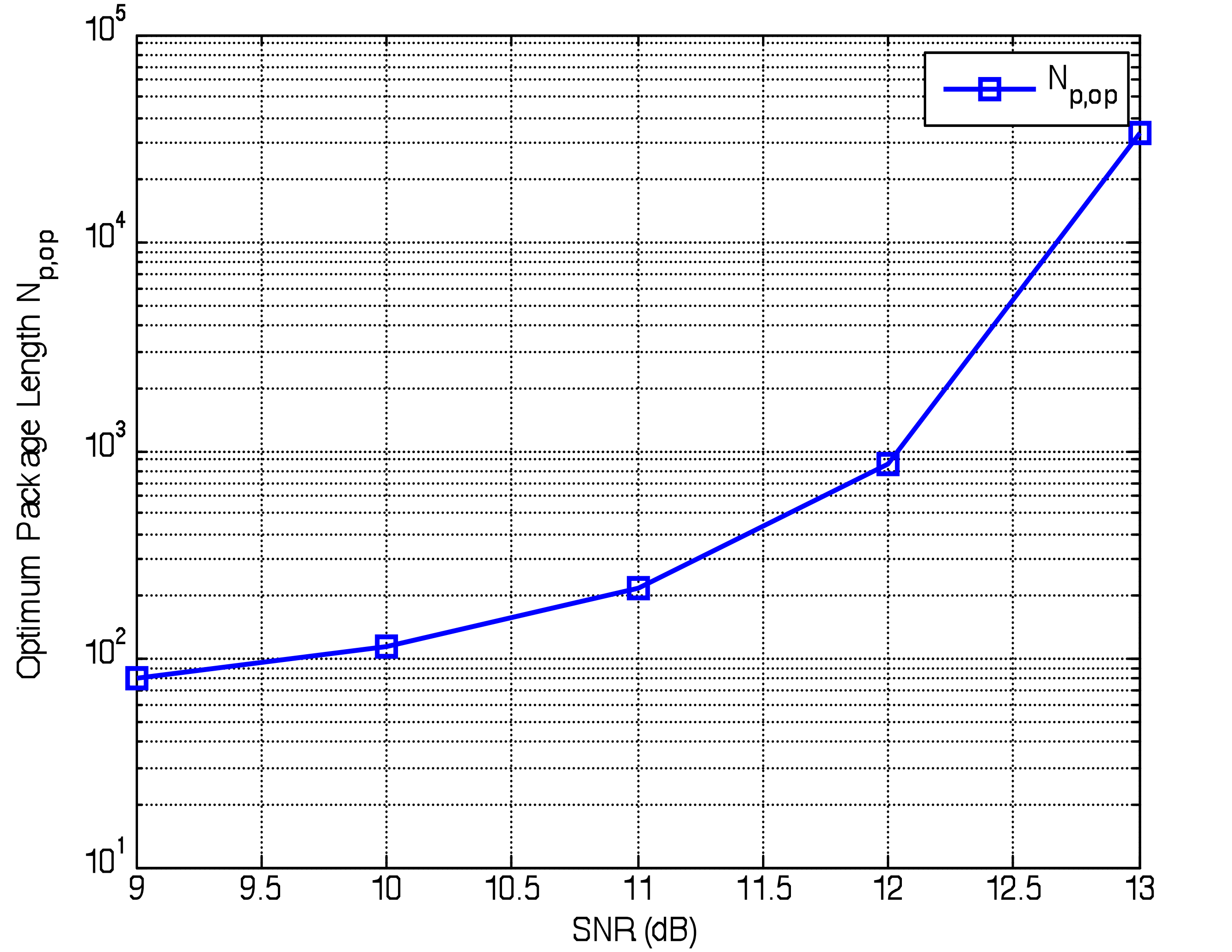

The Optimum Packet Length vs SNR

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