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Glossary

E_b	Energy per information bit
E_s	Energy per decoded bit
N_o	Single sided noise density
P_b	Bit error probability without decoding being concerned
P_c	Bit error probability after using PCC
P_{tc}	Bit error probability after using PTC
P_d	Probability that the wrong path at distance d is selected
C/M	Ratio of the direct to diffusely related signal energy
bps	Bit per second
pdf	Probability density function
σ^2	Noise variance

List of Abbreviations

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ACK	positive ACKnowledgment
ACTS	Advanced Communications Technologies and Services
APP	A Posteriori Probability
ARIB	Association of Radio Industries and Businesses
ARQ	Automatic Repeat reQust
ATM	Asynchronous Transfer Mode
AWA	ATM Wireless Access
AWGN	Additive White Gaussian Noise
BC	Block Code
BER	Bit Error Ratio
B-ISDN	Broadband-ISDN
BPSK	Binary Phase Shift Keying
B-R	Base to Remote
BRAN	Broadband Radio Access Networks
BS	Base Station
BSD	Berkeley Software Distributions
CBR	Constant Bit Rate
CC	Convolutional Code
CDMA	Code Division Multiple Access
CI	Control Information
CLP	Cell Loss Priority
CLR	Cell Loss Rate
CRC	Cyclic Redundancy Code
CSI	Channel State Information
DLC	Data Link Control
DQRUMA	Distributed Queuing Request Update Multiple Access
D-TDMA	Dynamic TDMA
EEP	Equal Error Protection
ETSI	European Telecommunications Standards Institute

FEC	Forward Error Protection
FPLMTS	Future Public Land Mobile Telecommunication System
GBN	Go Back N
GFC	Generic Flow Control
HARQ	Hybrid ARQ
HDTV	High Definition TeleVision
HEC	Header Error Control
HI	Handoff Indicator
HIPERLAN	HIgh PEformance Radio LAN
IMT	International Mobile Telecommunications
ISDN	Integrated Service Digital Networks
ITU	International Telecommunication Union
ITU-T	ITU-Telecommunications standards sector
LAN	Local Area Network
LIB	Least Important Bit
LLC	Logical Link Control
LLR	Log Likelihood Ratio
LoS	Line of Sight
MAC	Media Access Control
MAP	Maximum A Posteriori
MIB	Most Important Bit
ML	Maximum Likelihood
MMAC	Multimedia Mobile Access Communications
MPT	Ministry of Post and Telecommunications
NAK	Negative AcKnowledgment
NII	National Information Infrastructure
NNI	Network Node Interface
OSI	Open Systems Interconnection
PCC	Punctured Convolutional Code
PCS	Personal Communication Service
PRIME	Partial selective Repeat superIMposEd
PTC	Punctured Turbo Code
PSK	Phase Shift Keying
PSN	Packet Sequence Number
PT	Payload Type
QoS	Quality of Service
QPSK	Quadrature PSK
RCPC	Rate Compatible Punctured Convolutional

RCPT	Rate Compatible Punctured Turbo
RM	Radio Module
RSC	Recursive Systematic Convolutional
R-B	Remote to Base
SHF	Super High Frequency
SNR	Signal to Noise Ratio
SOVA	Soft Output VA
SR	Stop and Repeat
SSI	Source Significance Information
ST	Service Type
SW	Stop and Wait
TC	Turbo Code
TE	Terminal Equipment
TDM	Time Division Multiple
TDMA	TDM Access
UBR	Unspecified Bit Rate
UEP	Unequal Error Protection
UNI	User Network Interface
VA	Viterbi Algorithm
VBR	Variable Bit Rate
VC	Virtual Channel
VCI	Virtual Channel Identifier
VPI	Virtual Path Identifier
WAN	Wide Area Network
WAND	Wireless ATM Network Demonstrator
WATM	Wireless ATM
WG	Working Group
1G	First generation mobile communication system
2G	Second generation mobile communication system
3G	Third generation mobile communication system
4G	Fourth generation mobile communication system

Abstract

One of the most challenging and important issues in wireless asynchronous transfer mode (ATM) is the data link control (DLC) protocol. For each different service type, the DLC protocol should provide an appropriate error control mechanism to protect against the relatively poor characteristics of the wireless medium.

In this thesis, the quality of services (QoS) is classified into two kinds, which have different formats of wireless ATM cells in DLC protocols. For the stream mode services, such as audio and video, forward error correction (FEC) schemes in DLC protocols should be applied to correct and filter out erroneously received ATM cells before they enter the low error rate fixed network. In general, header bits are considered to be more important than payload bits so as to require two-level unequal error protection (UEP). Then, the code (FEC-H) for the header is assigned with a low local coding rate R_H to ensure correct deliveries and a low cell loss rate. At the same time, the code (FEC-P) for the payload is designed to be with a higher rate R_P than the one of FEC-H for effective transmissions. For the packet mode services such as data transfer, some buffering delay can be tolerated, then hybrid automatic repeat request (HARQ) schemes are applied. Since the channel state temporarily varies, it is preferable to correct the frequent error-patterns and less-frequent error-patterns by FEC and ARQ technologies, respectively.

Most of schemes in the DLC protocols of wireless ATM only adopt block codes (BCs), however, the other important codes — convolutional codes (CCs) and Turbo codes (TCs) are not discussed. This thesis applies rate compatibility punctured convolutional (RCPC) codes and rate compatibility punctured Turbo (RCPT) codes to the DLC protocols of wireless ATM to realize four error control schemes:

1. FEC Scheme I in the DLC Protocol of wireless ATM

   Four UEP schemes (PC-UEP1, PC-UEP2, PC-UEP3 and PC-UEP4) are proposed, corresponding to the coding rate of RCPC codes for the header: $R_H = \frac{8}{12}, \frac{8}{16}(=\frac{1}{2}), \frac{8}{20}$ and $\frac{8}{24}(=\frac{1}{3})$, respectively. Their CLR performances over Gaussian, Rayleigh fading and Ricean fading channels are deeply analyzed, which shows PCC schemes make significant reductions in CLR. In addition, a detailed study of the effect of the code and channel parameters and the contrasting

performance of hard and soft decisions on the received symbols are included. Besides, analyses show that these schemes have good balances for CLR and the payload BER.

2. FEC Scheme II in the DLC Protocol of wireless ATM

   Like RCPC codes, RCPT codes need only one encoder circuit and one decoder circuit for the various FEC-H and FEC-P even if their code rates, and thus the levels of error protection are different. The FEC Schemes II (PT-UEP1 and PT-UEP2) are examined over the Rayleigh fading channel. With almost the same good balance, FEC scheme II can achieve much lower CLR than FEC scheme I and the previous block code schemes.

3. HARQ Scheme I in the DLC Protocol of wireless ATM

   HARQ schemes I (PC-HA1 and PC-HA2) are realized on the basis of the FEC schemes I (PC-UEP4 and PC-UEP2). The throughput over Gaussian and Rayleigh fading channel is calculated by the lower bound method. The results show that HARQ I schemes have a higher throughput than the FEC schemes.

4. HARQ Scheme II in the DLC Protocol of wireless ATM

   HARQ scheme II combines the performance of Turbo codes with the frugal use of incremental redundancy inherent in the RCPC codes so as to be able to apply all of the useful results on RCPT codes to HARQ schemes. The simulations are conducted to estimate their CLR and throughput. HARQ II schemes (PT-HA1 and PT-HA2) reach a higher throughput than the corresponding FEC schemes and HARQ I schemes.

As the fundamental of these schemes, the punctured CCs (PCCs) are studied deeply in this thesis. Two theorems about the generator polynomial matrix and the constraint length of PCCs are deduced. By virtue of them, the puncturing realizations of the known good nonsystematic high rate $R = \frac{l}{n}$ CCs from nonsystematic $R = \frac{1}{n}$ CCs and the known good systematic high rate CCs from $R = \frac{1}{2}$ systematic CCs are proposed.