한국항행학회 논문지 제 11 권 제 4 호 2007년 12월

빌딩 보안 어플리케이션의 적응 오류제어와 적응 변조의 에너지 효율에 관한 연구

Energy Efficiency for Building Security Application of Adaptive Error Control and Adaptive Modulation

롱보라*, 강희조*

Long Bora*, Heau-Jo Kang*

요 약

무선 스마트카드는 빌딩 보안 어플리케이션에 주된 역할을 하고 있다. 본 연구는 사용자에게 보다 편리함을 주고 스마트카드 시스템의 성능 개선을 제안한다. 스마트카드는 카드 리더기에 삽입을 하지 않고 장치에서 수 센티미터 떨어져도 접근이 허용된다. 적응형 변조와 오류 제어를 통해 전력소비를 제어하는 성능은 필요하다. 본 논문에서는 적응형 리드 솔로몬 코드 기반의 FEC와 링크에서 M계수를 변화시킨 M-FSK변조에 대하여 연구한다. 적응형 변조와 적응형 오류 정정은 다른 다양한 정적스키마와 에너지 효율을 비교한 결과 50% 이상 에너지를 저장한다.

Abstract

Since the wireless smart card has played a main role in the identification security application for the building access; this research has its purpose to improve the performance of the smart card system and aims to offer more convenient to user. The contactless cards do not require insertion into a card reader and can work up to centimeters away from the reading device. To be able to cope with this performance the controlling of power consumption through the adaptive modulation and error control is needed. This paper addresses a forward error control (FEC) scheme with the adaptive Reed-Solomon code rate and an M-ary frequency shift keying (M-FSK) modulation scheme with the varying symbol size M over the link. The result of comparing energy efficiencies of adaptive error correction and adaptive modulation to other various static schemes shows to save over 50% of the energy consumption.

Key words : Adaptive M-FSK, Adaptive FEC, Wireless device energy management, Energy Efficiency

I. 서 론

Let's have a glance on Smart cards. There are available in two basic types, the distinguishing feature being whether the card has a microprocessor (CPU) or not. Cards without CPU are called memory cards, the one with CPU are called smart cards, chip cards or microprocessor cards. The general usage of the term smart card is usually for cards with a CPU, shown in Fig. 1[1].

* 목원대학교 컴퓨터공학부(Division of Computer Engineering, Mokwon University)
· 제1저자 (First Author) : Long Bora
· 교신저자 (Corresponding Author) : Heau Jo Kang
· 접수일자 : 2007년 11월 19일

Energy is a key point to achieve such an advanced building access application. With the objective to greatly ease the card user, card has to be able to communicate with reader even it is kept inside the user wallet. In this concept the reader is not required to transmit the signal but to collect the secured identification information which is transmitted by smart card through the interfaced sensors network. The received ID signal from smart card is compared to the database record for making a decision which the system allows access to the guard only in the case that the comparing is matched.

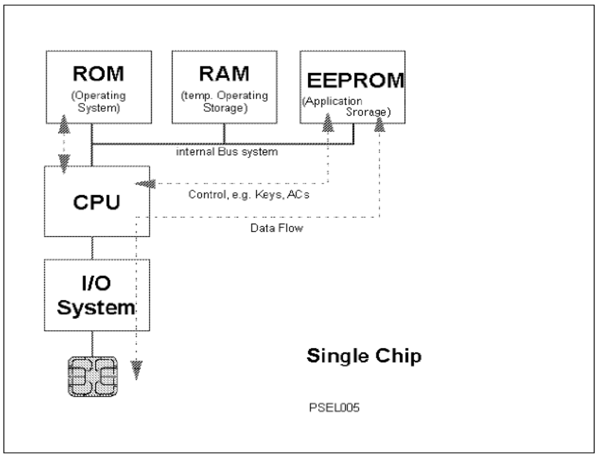

그림 1. 스마트카드의 내부구조
Fig. 1. Smart card internal architecture

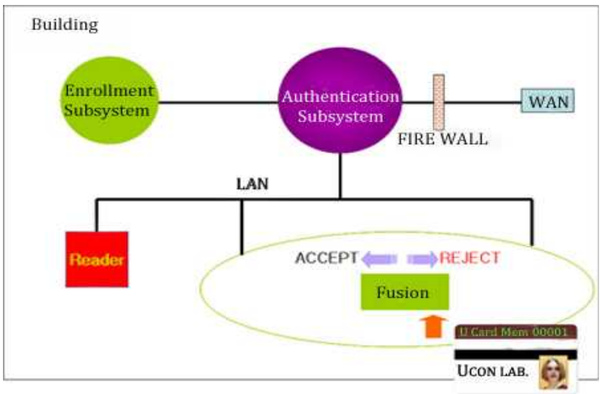

그림 2. 빌딩접속 시스템
Fig. 2. Building access system

Battery life is a major concern for the wireless communication devices, so energy managements are the key of success. The energy efficient modulation and error control schemes play a main role in saving energy for smart card as well as other similar wireless systems. This paper will analyze on the challenge of controlling power in the varying wireless environment while the bit error rate is maintained. With the mobility of smart card, interference from other signals, absorption from clothing and people as well as the reflections from building and other objects makes the smart card wireless link be the imperfect one. So the error control scheme that is going to be apply for this burst error channel must be capable to handle such an error to avoid the re-transmission that can be energy efficient for the high (Eb/No). The introduced schemes must not intolerable delay, jitter and bandwidth that prevents fulfilling the required QoS of the application. We don't study in detail on the comparison of the FEC and ARQ performance as we find more references which have been done by many researchers [2]. Although more complex adaptive error correction schemes consume more energy through increased computation and communication, they can provide the constant quality and stringent delay provisions required for the smart card system, this is the rationale behind investigating both adaptive modulation and energy schemes.

A comparison of the various modulation schemes are presented in Table I, Table II, and Table III[3]. Quadrature Amplitude Modulation is very bandwidth efficient and achieves a high bit rate using limited bandwidth but it requires a higher Eb/No to achieve the same quality as M-ary shift keying and M-ary frequency shift keying. Through what is shown in Table I, II, and III we can conclude that MFSK is the adaptive modulation approached for the smart card channel condition.

표 1. MPSK의 대역폭과 전력 효율
Table 1. Bandwidth and power efficiencies of MPSK signals[3]

M	2	4	8	16	32	64
B_η=RB/B	0.5	1	1.5	2	2.5	3
Eb/Nofor BER=10-6	10.5	10.5	14	18.5	23.5	28.5

(B: First null bandwidth of M-PSK signals)

표 2. MFSK의 대역폭과 전력 효율
Table 2. Bandwidth and power efficiencies of MFSK[3]

M	2	4	8	16	32	64
B_η	0.4	0.57	0.55	0.42	0.29	0.18
$E_b/N_o$for BER=10^{-6}	13.5	10.8	9.3	8.2	7.5	6.9

표 3. MQAM의 대역폭과 전력 효율
Table 3. Bandwidth and power efficiencies of MQAM signals [3]

M	2	4	8	16	32	64
B_η	1	2	3	4	5	6
$E_b/N_o$for BER=10^{-6}	10.5	15	18.5	24	28	33.5

Ⅱ. Channel Model

The performance of the system is hugely degraded by radio propagation channel at the layout environment inside and outside the building, the construction materials, and the building type. Due to the motion of people, equipment and objects most of statistics of the channel varies with time [4]. The indoor channel is defined by a high path losses and large variations in losses. In a factory environment, the overall path loss is found to be log-normal with 7.1dB standard deviation, whereas in an office environment we will study the signal envelope in Nakagami-m fading Channel, which the PDF is given by[5]

$$P_\alpha(R)=\frac{2m^m R^{2m-1}}{\Gamma(m)\Omega^m}EXP(-\frac{m}{\Omega}R^2), \quad R\geq 0 \quad (1)$$

where $\Gamma(.)$ is the gamma function, $\Omega=\overline{R}^2$ and

$$m=\frac{\Omega}{var(r^2)} \quad (2)$$

m is the scale and shape parameters of the distribution. For $m=1$ we have a Rayleigh fading channel and as $m\rightarrow\infty$ we have channel that becomes non fading. At $m=1/2$ we have one sided Gaussian fading distribution [5].

Ⅲ. Adaptive Error Control

The error correction methods are being used to optimal the performance of the telecommunication system, the main type of error corrections are ARQ (Automatic Repeat Request), FEC and the hybrid of the two. In case of ARQ schemes are good to be applied when the link quality is good and the re-transmission are rare, oppositely from FEC schemes that irrespective of the channel condition it is added the fix over head for every sent packet which required more energy consumption. So FEC shouldn't be used for the good quality link for the sake of energy consumption saving. Since ARQ requires the two ways communication as well as more buffering this is also unacceptable to apply in smart card system.

Forward error correction is used to assure optimal performance. The redundant code makes time delay be the less issue. It is based on RS (Reed-Solomon coding) which is particular useful for burst error correction.

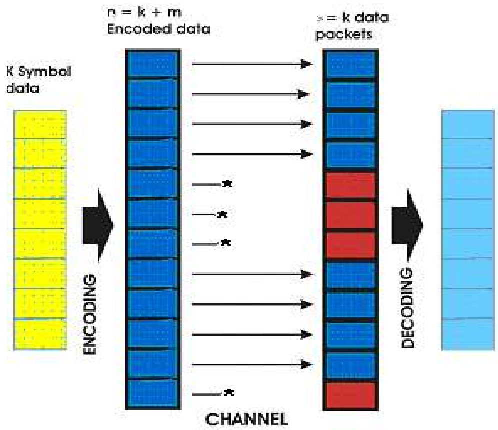

그림 3. 오류정정
Fig. 3. Error correction

The Reed-Solomon codewords are non-binary cyclic codes with symbols made up of bit sequences, where m is a positive integer having value greater than 2. $RS(n,K)$ codes with m bit symbols exist for all n and k for which[6]

$$0 < K < n < 2^m + 2 \qquad (3)$$

where K is number of data symbol bits being encoded and n is the total number of codes symbol in the encoded block. The ratio of redundant bit to data bits within a block is the redundancy code denoted by $(n-k)/k$; the ratio of data can be thought of as the ratio portion of a code constituting information to the entire packet length as illustrated in Fig 3.

The error correction of RS code is $(n-k)/2$ this code can handle a noise burst of $(n-k) \times m/2$.

Due to the dynamic environment of the Smart card system the ARQ and FEC schemes are not possible to provide the energy efficiency. An adaptive FEC error control scheme can tremendously improve the energy efficiency. Most of error controls are designed with fixed value for the link layer parameters which correspond to the worst channel condition.

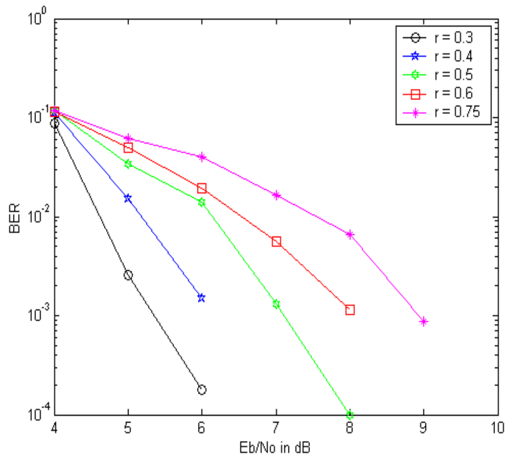

그림 4. SNR 대 BER의 코드율 비교
Fig. 4. SNR VS. BER for different code rate

By changing the static scheme to react dynamically in varying channel condition the energy efficiency can be accomplished while maintainable BER.

Figure 4 illustrates the BER vs. bit energy per noise ratio for 5 different code rates: 0.3, 0.4, 0.5, 0.6, and 0.75. This reduces the energy required to transmit a single information bit. If the BER is computed and the code rate adapted, energy efficiency can be greatly improved.

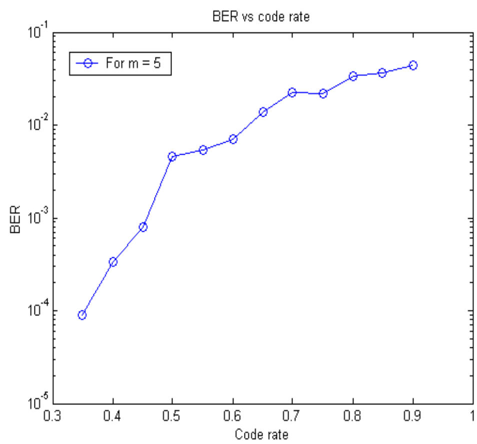

그림 5. BER 대 코드율 'r'
Fig. 5. BER vs. code rate 'r'

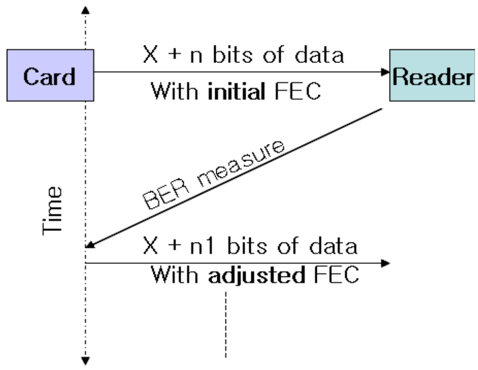

그림 6. 적응 오류정정 과정
Fig. 6. Adaptive error correction process

The adaptive FEC scheme is applied to the communication system between reader and smart card. Initially a test data packet is sent, and the receiver measures the transmission efficiency by comparing the BER with the current code rate. If the BER is lower than the requirement, an increasing of the code rate signal may be conveyed back to the transmitter. A comparison plot between BER and code rate is given in Fig.5[7].

The processing detail about reader and smart card is described in the next two sections.

1-1. Reader

The data received by reader contains with the number of error bits. But since the adaptive FEC is used this error data can be recovered after computing process. η_f indicates the quality link at reader. This error rate efficiency is defined at some where between 0 and 1.

1-2. Smart Card

$\eta = (10^{-3})$ is the efficiency value that the smart card system has to achieve. Either the smart card or receiver, η_f the measure efficiency is compared to η as in the tables bellow:

In case,

a. $\eta_f > \eta$ is the number of bit error, Ne, is more then expected the code rate 'r' need to reduce by 0.01 for the next packet to be transmitted.

b. $\eta_f < \eta$ is 'r' needs to be increased by 0.01.

c. $\eta_f = \eta$ is code rate r does not need to be adjusted.

The proposed scheme is evaluated against a fixed code rate for worst channel conditions. A Nakagami-m fading model is used to model the indoor office environment. In this model, noise power is assumed to change rapidly for fast fading and slowly for slow fading. In our simulation, for fast fading channels, the noise power varies 10 times over the packet length whereas for slow fading it varies 5 times. Table IV compares the consumed energy in the transmission of 100 data packets using the three error control strategies: ARQ, fixed code rate RS and adaptive RS. The adaptive error control strategy consumes 43-50% less energy. Table V shows the percentage of energy savings by using adaptive error correction for m=5 and BER of 10-3 [8].

표 4. 100패킷당 전체 에너지 소비
Table 4. Total energy consumed for 100 packets

STRATEGY	ENERGY (J)
No coding (ARQ)	5.2
r = 0.5, m = 5	0.96
variable	0.45

표 5. 고정 코드율과 적응 방법의 에너지 저장효율
Table 5. Energy savings of adaptive strategy over fixed code rate scheme

Fixed code rate	Energy saved using Adaptive error control(%)
r = 0.5, m=5	59
r = 0.75,m=5	46
No coding (ARQ)	91

IV. Adaptive Modulation

In Fig. 7. we can see the difference M-FSK performance depends on the level of M (where M=2b).

In the indoor environment of smart card which considered to be a Nakagami-n channel, to maintain the desired BER along with energy efficiency for MFSK we need to use adaptive modulation and in this model M level is not set to be a fixed one. Although the basic idea of changing the modulation in real time has been used to increase the throughput in the presence of fading channels[8] - [10], the concept has not been many exploited for lower power purpose.

First, smart card transmits the bit stream with a high level of modulation (i.e: b=8) and then it has to wait for the feedback acknowledge from the reader. After the received signal's BER is calculated at reader, it sends feedback message to the smart card so that smart card can adjust on bit number of modulation level. In case the BER is lower than the desired rate then b needs to be decreased by 1 and if BER is greater than 10-3 (the desired rate) b needs to be increased by 1 else b just stayed the same level.

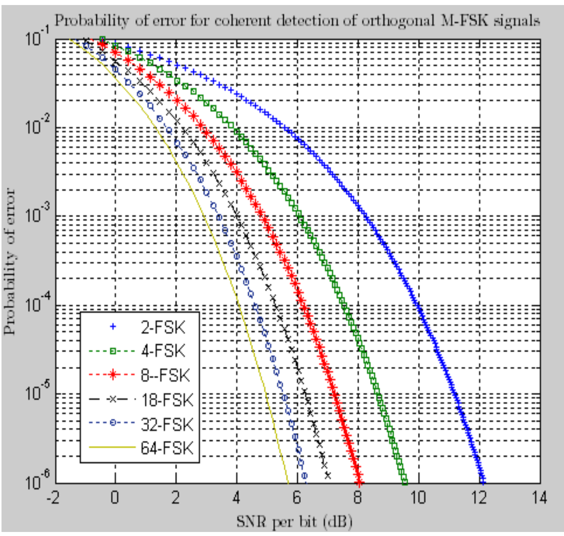

그림 7. 비트수에 따른 M-FSK의 성능변화
Fig. 7. M-FSK Performance with the different bit number of modulation

V. Conclusion

The Adaptive FEC scheme reduces power consumption over 50% of Non-Adaptive ARQ and FEC. This process helps smart-card to achieve the better performance by selecting the optimal code rate depends on the channel condition, also the adaptive M-FSK modulation scheme which is proposed to use, improves the performance of smart card in Nakagami-m fading channel where the wireless smart card link is considered to be. The further study on energy efficiency of both adaptive Error correction and adaptive modulation for other systems that the energy is primary concerned, will be the future work.

Reference

[1] Jorge Ferrari Robert Mackinnon, Susan Poh Lakshman Yatawara, "Smart Cards: A Case Study". *International Technical Support Organization IBM,*October 1998

[2] Zorzo.M.,"Performanfce of FEC and ARQ Error Control in bursty channels under delay constraints", *VTC'98, Ottawa,Canada,* May 1998

[3] Theodore S.Rappaport,"Wireless Communication : Principles and Practice", *Upper Saddle River, NJ:* Prentice Hall,1996.

[4] Seong-Cheol Kim, Henry L.Bertoni, Miklos Stern, "Pulse propagation characteristics at 2.4 GHz inside buildings", *IEEE Trans. On Vehicular Technology,* vol.45, no.3, August 1996.

[5] Paul J. Crepeau, senior member of IEEE "Uncoded and Coded Performance of MFSK and DPSK in Nakagami Fading Chanel", *IEEE.* 1992,

[6] Bernard Sklar, “Digital Communications: Fundamentals and Applications", Chapter 9. Modulation and Coding Trade-off, Englewood Cliffs, NJ: Prentice Hall, 1988.

[7] Mansi P. Narkhede, Rosano S.Sileira and Lisa Ann Osadciw Ph.D. "Adaptive Modulation and Error Control for Energy Effiency for Wireless Smart Card." *Syracuse University*, NY.

[8] Ziemer, R. E., and Peterson, R. L., Introduction to Digital Communications, Macmillan Publishing Com

pany, 1992.
[9] Ue, T., Sampei, S., Morinaga, N., Hamaguchi, K., "Symbol Rate and Modulation Level Controlled Adaptive Modulation/TDMA/TDD System for High-Bit Rate Wireless Data Transmission", *trans. on Vehicular technology,* vol. 47, no. 4, pp. 1134-1147, Nov. 1998.
[10] Curt Schurgers and Mani B. Srivastava, "Energy Efficient Wireless Scheduling: Adaptive Loading in Time", *Networked and Embedded Systems Lab, Electrical Engineering Dept.*, University of California, LA.
[11] Webb, W., Steele, R., "Variable rate QAM for Mobile Radio", *IEEE Trans. on Comm*., vol.43, no.7, pp.2223-223-, July 1995.
[12] Balachandran, K., Kadaba, S,Nanda "Channel quality estimation and rate adaptation for cellular mobile radio", *IEEE JSAC*, vol.17, pp. 1244-1256, July 1999.

Long Bora

1999년~2003년 : Royal University of Phnom Penh (Cambodia)
2005년~2007년 : Jeonju Technical College
2007년~현재 : Mokwon University, Division of Computer Science, Master program student.
관심분야 : Multimedia Telecom, Wireless Mobile Communication.

강 희 조 (姜熙照)

1994년 한국항공대학교 대학원 항공전자공학과 (공학박사)
1996년~1997년 일본 오사카대학교 공학부 통신공학과 객원교수
1990년~2003년 2월 동신대학교 전자정보통신공학부 교수
2003년~현 재 : 목원대학교 컴퓨터공학부 교수
관심분야 : 멀티미디어통신, 유비쿼터스, 무선이동통신, 가시광통신, 모바일 컴퓨터, 환경전자공학, RFID, 인지적무선통신, 기술정책