4세대 이동통신을 위한 적응 부호화 하이브리드 ARQ 시스템에 관한 연구

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A Study on the Hybrid Automatic Repeat Request AdaptiveCode System for 4 Generation Mobile Communication

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ABSTRACT

본 논문에서는 4세대 이동통신을 위한 적응부호화 하이브리드 ARQ 시스템 모델을 제안하고, 제안 시스템의 성능을 분석 검토 하였다. 또한 적응 하이브리드 시스템의 프레임 효율도 분석하였다. 결과로부터 제안 시스템이 성능이나 효율에서 우수함을 확인 할 수 있었다.

키워드

4세대 이동통신, 적응부화, 하이브리드 ARQ, 프레임 효율

Ⅰ. Introduction

Aiming at communication to exchange any kind of information anytime, anywhere, and with anyone, the research development of multimedia mobile communication is being executed worldwide. Mobile communication systems wad first developed fir voice commu- nications, however the low and medium data transmission services by PDC and PHS systems are currently popularized to transmit e-mail messages among users. Wireless access systems which can carry more high speed data and broadband signals are strongly demanded for multimedia services due to the high performance of portable computers. Wireless LANs whose frequencies are 2.4GHz and 19GHz bands have been already comm- ercialized for indoor use, however those systems do not become widespread because of lower data transmission capability and their cost. In order to spread wireless LANs at business offices and etc, Multimedia Mobile Access Communication Systems Promotion Council(MMAC Council) was establishes and the demonstrative exper- iments and stand- ardization of the broad band high performance mobile communication systems are going to be proceeded, It is comparable to " Fiber to the Home" and is following the IMT-2000. These systems provide us with more than 20Mbps of data rate, using 5-GHz band. Furthermore, they are able to comm- unicate with identical terminals, to support mobility with walking speed in the service area both indoor and outdoor. Also, technical conditions of broad band mobile access system using 5-GHz band frequency have been inquired ay Telecomm- unications since last year, and prepa- rations for the report is being executed.

In general, 4G systems are expected to provide at least the following features:

High Usability and Global Coverage: 4G systems are expected to fulfill the anytime, anywhere, any technology requirement. In order to meet this challenge, 4G networks are expected to be heterogeneous and all-IP-based, while mobile terminals are foreseen as highly integrated multi-technology, multihomed syste- ms able to utilize a wide range of applications provided by multiple wireless network.

Broadband Connectivity and Quality of Service: 4G systems will provide not only telecommunications services, but also data and multimedia services; thus, peak speeds of more than 100 Mb/s in stationary mode with an average of 20 Mb/s when traveling are expected. To support multimedia services, end-to-end QoS and good system reliability are also required.

High Network Capacity: Network capacity should be at least 10 times that of 3G systems. This will quicken the download time of a 10Mbyte file from 200 s on 3G to 1 s on 4G, enabling high-definition video to stream to phones and create a virtual reality experience on high-resolution handset screens.

Service Personalization: In order to overcome the saturated mobile communications market, operators will seek new 4G users in widely different locations, occupations, and economic classes. In order to meet the demands of these diverse users, service providers should design personal and highly customized services for them.

User-Oriented Services: Users will ask to be able to form any service provider at the same time.

Low Cost: The underlying network for 4G must be able to support fast speed and large volume data transmission at a lower cost than today.

Wireless and/or mobile access networks which cam be connected to the fiber access networks as so-called "last 100-meter link"and transmit the high speeds data are demanded in the multimedia communication era. Thus, in the wireless/mobile communication field. enlargement of communication capacity per terminal (more 100Mbps of broad-band signal transmission) and expansion of mobility have been further required. And as the rapid incr- ease of cellular phone at the present, we also predict that a shortage of frequency will occur in the future.

Therefore, immediate research development of advanced mobile/wireless access communication systems which are able to accommodate more channels and to transmit broader band signals is intensely expected.

In satellite communication systems, Ka-band (30/20GHZ) began to be used for the purpose of increasing channel capacity. In Ka-band satellite communication systems, the deterioration of received power caused by rain is remarkable, i. e., the channel state temporarily changes. Therefore, it is a problem how to overcome the temporary degradation of communication quality. Then, it is prefe- rable to change error-correcting capability according to the channel state[1]-[3]. When a return channel is available, an adaptive forward error correction (AFEC) system which adaptively alters the error-correcting capability according to channel state can be combined with an automatic repeat request (ARQ) system and the channel state monitored by a receiver can be informed to a transmitter.

For practical use, we would like to have not switching between a set of encoders and decoders, but one encoder and one decoder which can be modified without changing their basic structure. This can be achieved by using a nonsystematic Reed-Solomon code (NRS code). This paper presents an ARQ/QFEC hybrid system using an NRS code. Using an NRS code, we only need to change the number of information symbols fed to the encoder and we need not change the hardware of the encoder when we want to change the error correcting capability. On decoding, only minor adjustments need which can be accommodated as some adjustments need which can be accommodated as some adjustable parameters by the decoder. Thus we can obtain AFEC with one encoder and one decoder. In an ARQ/AFEC system, code rate is traded with error-correcting capability and there exists the optimum error correcting capability that makes the frame efficiency maximum for certain bit error rate. The performance of this system, which gives the maximum frame efficiency, is shown.

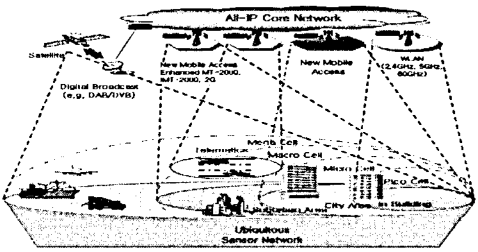

Fig.1. Concept of 4G mobile communication

II. Trend of Mobile Access Systems

Figure 2 shows the research and development trend of mobile and wireless access systems. There are two directions for the advance of multimedia mobile access. One the former high speed mobility, the system is equivalent to the extension of transmission speed of IMT-2000 of mobility of 5-GHz band mobile access systems. Due to the high speed mobility, the microwave frequencies as carrier frequencies as carrier frequencies must be used to perform macrocell zones. The final target of data rate in the microwave mobile access systems will be between 10Mbps and 20Mbps. On the other hand, a maximum of information rate of 156Mbps has been performed by an ultra high speed wireless LAN system developed [1], bey the realization of seamless system is also anticipated to be used in various enviro- nments, such as in door and outdoor. The advanced multimedia mobile transmission rate from rate from approximately 10Mbps to 1Gbps under low mobile environment will be demanded to meet the requirement of the broadband transmission capability of fiber access networks.

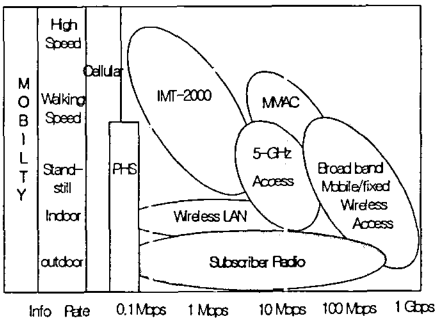

Fig.2. Trend of Mobile/Wireless Access Systems

Ⅲ. NRS Code

An NRS code[4], which is a special case of redundant residue polynomial code[5], is constructed as follows: We represent k information symbols $(u_0, u_1, \cdots, u_{k-1})$, $u_i \in GF(2^m)$, by a polynomial:

$$F(x) = u_0 + u_1 x + \cdots + u_{k-1} x^{k-1}. \quad (1)$$

Then the codeword v of an NRS code is

$$v = (F(0), F(1), F(\alpha), \cdots, F(\alpha^{n-2})) \quad (n = 2^m) \quad (2)$$

where α is a primitive element in $GF(2^m)$. $f(x)$ is recaptured from v by

$$F(x) = \sum_{\beta \in GF(2^m)} F(\beta) \frac{M(x)}{(x-\beta)} \quad (3)$$

where $M(x) = \Pi_{\beta \in GF(2^m)}(x-\beta) = x^n - x$ and $M(x)/(x-\beta)$ has value 1 in $x = \beta$ for every $\beta \in GF(2^m)$.

The NRS code can correct less than or equal to t symbol error if $n-k \geq 2t$ [4],[5]. We can generate the NRS codes with several error correcting capability by only varying the number of information symbols fed to the encoder and decode them using Euclid's algorithm by minor adjustment of some parameters[6].

Ⅳ. Performance

This section shows the frame efficiency of the ARQ/AFEC system. The frame efficiency of an ideal ARQ system, which is the upper bound on frame efficiency of any ARQ system, is equal to the probability that the frame is correctly received. So, the frame efficiency of the ARQ/AFEC system using ideal ARQ is equal to the product of the code rate and the probability that the frame is correctly decoded by AFEC system. Now, we assume that ideal ARQ is used and that independent bit errors occur.

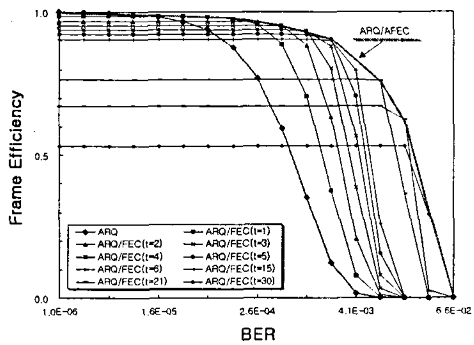

Fig. 3 Frame efficiency vs. bit error rate.

When a frame is encoded by an NRS code over GF(2m) which corrects less than or equal to t symbol errors, the probability Pc that the frame is correctly decoded is

$$P_c = \sum_{i=0}^{t} \binom{n}{i} P_b^i (1-P_b)^{n-i} \quad (4)$$

where $P_b = 1-(1-p)^m$ and p is bit error rate on a transmission channel. Then the frame efficiency η of the ARQ/AFEC system is

$$\eta = P_c(n-2t)/n \quad (5)$$

where n is the length of an NRS code. There exists the maximum frame efficiency for certain bit error rate since Pc is small when t is small and $(n-2t)$ is small when t is great. Figure 1 shows the maximum frame efficiency of the ARQ/AFEC system when $m=8$, $n=128$. For comparison, the frame efficiency of the ARQ/FEC system which has constant error correcting capability and that of ARQ without FEC are also shown in Fig.2. In an ideal ARQ system without AFEC, the frame efficiency is $(1-p)^N$ where N is the length of the frame and N=1024 in Fig. 3. As shown in Fig. 2, the frame efficiency of the ARQ/AFEC system is much higher than that of ARQ without AFEC for low bit error rate, and the ARQ/AFEC system has higher frame efficiency in wide rage of bit error rate though the ARQ/FEC system has high frame efficiency only for certain bit error rate.

V. Conclusion

An ARQ/AFEC hybrid system which adaptively alters the error correcting capability according to channel state using an NRS code was proposed and the performance was presented. The error correcting capability of the code is altered according to the channel state. The frame efficiency of the ARQ/AFEC system is much higher than that of ARQ without AFEC for low bit error rate. The system has the advantage that it can alter the error correction symbols fed to the encoder and it need not change the hardware of the encoder.

Acknowledgement

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