Transactions Letters

Burst-by-Burst Adaptive Joint-Detection CDMA/H.263 Based Video Telephony

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***Abstract*—Since wireless channels exhibit dramatic near-instantaneous channel-quality fluctuations, it is unrealistic to expect that a transceiver relying on time-invariant modulation and coding modes is capable of delivering as good a performance as a near-instantaneously adaptive arrangement. Hence, a near-instantaneously adaptive joint-detection code division multiple access (CDMA)-based video transceiver is proposed for wireless video telephony. Specifically, the transceiver is capable of reconfiguring itself in 1, 2, and 4 bits/symbol direct-sequence CDMA modes and delivers an unimpaired video quality associated with a peak signal-to-noise ratio (PSNR) of 34–41 dB for channel SNRs in excess of about 5 dB over the COST207 bad urban channel model at video rates between 5–26.9 kbits/s using 176 × 144 pixel quarter common intermediate format (QCIF) and 128 × 96 pixel sub-QCIF (SQCIF) video formats.**

***Index Terms*—CDMA, H.263, reconfigurable modulation, video telephony, wireless video.**

I. MOTIVATION AND BACKGROUND

WITH the advent of powerful signal processing, the performance of wireless communications systems has substantially improved over the years. Although it is not particularly desirable that the instantaneous time-variant wireless channel quality predetermines the achievable transmission integrity, in previous generations of mobile systems, this was typically the case, since the transceiver could only vary the transmitted power, and hence was incapable of reconfiguring itself in different communications modes. In order to mitigate these problems, the so-called intelligent multimode transceivers (IMTs) are capable of reconfiguring themselves in high-rate, but less error-resilient or lower-rate, but more error-resilient modes [1].

Similar principles were documented, for example, in [2]–[5] in the context of various fixed-rate proprietary video codecs, which were designed for constant-rate, rather than time-variant-rate, video telephony, e.g., over existing second-generation mobile radio systems, such as the Global System of Mobile communications (GSM). However, the various quadrature amplitude modulation (QAM) systems contrived in [3]–[5] were re-configurable on a static, rather than on a near-instantaneous or dynamic basis. This was also the case in [6], where instead of the fixed-rate proprietary video codecs of [2]–[5], the time-variant rate H.263 video codec was invoked, assisted by an adaptive rate-control and packetization scheme. This rate-control regime allowed us to render the bit rate generated constant for the sake of communications convenience over wireless links. In contrast to the above statically reconfigurable transceivers—which operated without channel equalizers in a narrow-band channel—in this contribution, a more advanced near-instantaneously reconfigurable wideband video transceiver is proposed and its video performance benefits are quantified. Furthermore, in harmony with the recent third-generation Pan-American, Pan-European, and Japanese mobile radio standards [7], code division multiple access (CDMA) is employed and its performance in enhanced by joint-detection (JD) and turbo-coding techniques.

Over narrow-band Rayleigh-fading wireless channels the signal-to-noise ratio (SNR) may fluctuate by about 40 dB. These propagation-induced channel quality variations can be counteracted with the aid of burst-by-burst (BbB) adaptive transceivers. Adaptive quadrature amplitude modulation [8] (AQAM) transceivers hence attempt to adjust their modem modes on a near-instantaneous basis, in order to match the modem mode of the forthcoming transmission burst to the predicted channel quality.

AQAM was studied, for example, in [1], [8], [9]. Variable coding rate concatenated coded AQAM schemes were studied by Matsuoka *et al.* in [10], whilst the effects of variable-rate, variable-power arrangements were investigated Goldsmith and Chua in [11] and [12] in information theoretic and channel-capacity terms. A range of *practical modem design aspects of AQAM, such as the effects of AQAM mode signalling errors and delay, channel quality prediction, etc.* were disseminated, for example, in [13], [14] and in particular in [1, Ch. 6 and 7]. The associated channel-quality-induced bit-rate fluctuation was mitigated using data buffering. However, this buffering-imposed delay, which may become excessive for interactive, real-time videotelephony. This delay was reduced in [13] by frequency hopping and statistical multiplexing. The effects of co-channel interference were quantified in [1], [14].

In the early unequalized narrow-band AQAM modems typically the estimated channel SNR was used as the channel quality metric, governing the modem mode selection. However, in dispersive environments, this channel quality metric becomes unreliable and hence in wideband modems the mean-squared error (MSE) at the decision feedback equalizer's (DFE) output was advocated in conjunction with powerful block turbo codecs [1], [15].

Manuscript received January 3, 2001. This work was supported by Mobile VCE (U.K.), by EPSRC (U.K.), and by the European Commission.

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Publisher Item Identifier S 1051-8215(02)05259-X.

In the rest of this contribution, a range of BbB AQAM JD-CDMA video transceivers are investigated. Specifically, Section II portrays the benchmark system's architecture and parameters. The proposed robust video-coding technique is highlighted in Section III. Section IV introduces the basic switched multimode JD-ACDMA system. The proposed near-instantaneously reconfigurable or BbB AQAM JD-CDMA transceiver is decribed in Section V and its performance is characterized, before concluding in Section VI. Let us now introduce the system's philosophy in the next section.

II. THE JD-ACDMA TRANSCEIVER

The duplex JD-CDMA scheme proposed operates on the basis of the following philosophy.

- The channel quality estimation is based on evaluating the MSE at the output of the JD-CDMA multi-user equalizer at receiver A and comparing it to the AQAM mode-switching thresholds, as suggested for wideband single-carrier Kalman-filtered DFE-based modems in [1, Ch. 6 and 7].
- The decision concerning the AQAM mode of the forthcoming CDMA transmission burst of transmitter B is based on the prediction of the channel quality experienced by receiver A, e.g., using the prediction techniques of [1], [16].
- Specifically, the channel-quality estimation is performed at receiver A but *receiver A has to instruct the remote transmitter B as to what modem mode has to be used in order to meet the target integrity requirements of receiver A.* Both explicit low-delay signalling as well as blind-detection-assisted implicit signalling can be used [1], [8].

Employing a low spreading factor (SF) of 16 allowed us to improve the system's multiuser performance with the aid of JD techniques [17], whilst imposing a realistic implementational complexity. This is because the JD operation is based on inverting the system matrix, which is constructed from the convolution of the channel's impulse response (CIR) and the spreading codes. Hence, maintaining a low SF is critical to the implementational complexity. We note, furthermore, that the implementation of the JD receivers is independent of the number of bits per symbol associated with the modulation mode used, since the receiver simply inverts the associated system matrix and invokes a decision concerning the received symbol, irrespective of how many bits per symbol were used. Therefore, JD receivers are amenable to amalgamation with the above 1, 2 and 4 bits/symbol CDMA modem, since they do not have to be reconfigured,when the modulation mode is switched.

In this performance study we used the Pan-European FRAMES proposal [18] as the basis for our CDMA system. The associated transmission frame structure is shown in Fig. 1, while a range of generic system parameters is summarized in Table I. In our performance studies, we used the COST207 [19] seven-path bad urban (BU) channel model, whose CIR is portrayed in Fig. 2.

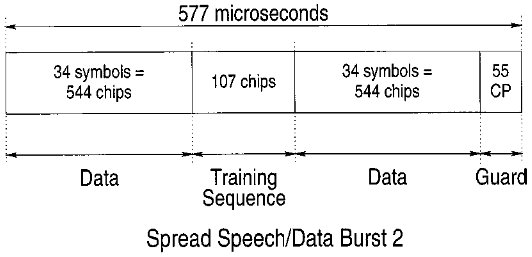

Fig. 1. Transmission burst structure of the FMA1 spread speech/data mode 2 of the FRAMES proposal [18].

TABLE I
GENERIC SYSTEM PARAMETERS USING THE FRAME'S SPREAD SPEECH/DATA MODE 2 PROPOSAL [18]

Parameter	
Multiple access	TDMA/CDMA
Channel type	C0ST 207 Bad Urban
Number of paths in channel	7
Normalised Doppler frequency	3.7×10^{-5}
CDMA spreading factor	16
Spreading sequence	Random
Frame duration	4.615 ms
Burst duration	577 μs
Joint detection CDMA receiver	Minimum mean square error block decision feedback equalizer (MMSE-BDFE)
No. of Slots/Frame	8
TDMA frame length	4.615ms
TDMA slot length	577μs
TDMA slots/Video packet	3
Chip Periods/TDMA slot	1250
Data Symbols/TDMA slot	68
User Data Symbol Rate (kBd)	14.7
System Data Symbol Rate (kBd)	117.9
Channel Coding	1/2-rate, K=9 convolutional

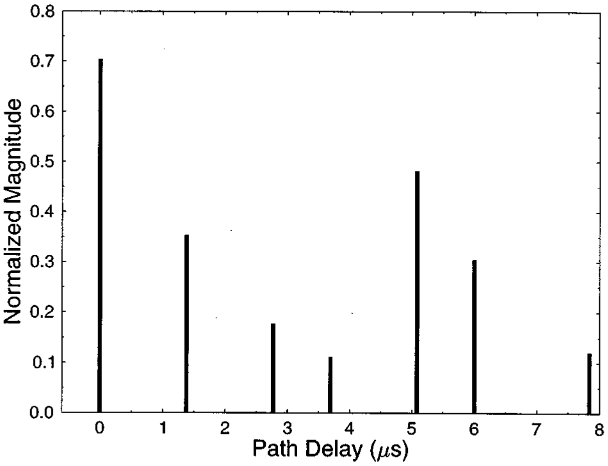

Fig. 2. Normalized channel impulse response for the COST 207 [19] seven-path BU channel.

III. ROBUST VIDEO CODING

In this contribution, we transmitted 176×144 pixel quarter common intermediate format (QCIF) and 128×96 pixel sub-QCIF (SQCIF) video sequences at 10 frames/s using a reconfigurable time division multiple access (TDMA)/CDMA transceiver, which can be configured as a 1, 2, or 4 bits/symbol BbB AQAM scheme, as shown in Fig. 3.

The H.263 video codec [2] extensively employs variable-length compression techniques and hence achieves a high compression ratio. However, as all entropy- and variable-length coded bit streams, its bits are extremely sensitive to transmission errors.

This error sensitivity was counteracted in our system by invoking an adaptive packetization and packet-dropping regime when the channel codec protecting the video stream became incapable of removing all channel errors. Specifically, we refrained from decoding the corrupted video packets in order to prevent error propagation through the reconstructed video frame buffer [6]. Hence, these corrupted video packets were dropped at both the transmitter and receiver, and the reconstructed frame buffer was not updated until the next video packet replenishing the specific video frame area was received. This required a low-delay, strongly protected, video-packet acknowledgment flag, which was superimposed on the transmitted payload packets [6]. The associated video performance degradation was found perceptually unobjectionable for packet dropping- or transmission frame error rates (FERs) below about 5%, although this issue will be detailed in more depth during our further discourse. Due to lack of space, some of the implementation details are omitted, but can be found in [6].

Our system operates using a programable-rate H.263 decoder, where the packet disassembly block in Fig. 3 discards all the corrupted video packets. A 16-bit cyclic redundancy checking (CRC) is added to every video packet for detecting corrupted packets. In addition to the CRC, each video packet has a header, containing information which allows the packet disassembly block of Fig. 3 to appropriately the combine macroblock information, which has been mapped to and transmitted in several consecutive packets. The video encoder receives feedback information from the decoder, informing it of the success or failure of the previous packet. In case of corruption, the packet disassembly block effectively conceals the packet loss by replacing the affected area of the picture with the corresponding area from the previous video frame.

In addition to rendering the video information more robust, the packet assembly and disassembly block is flexible enough to assemble larger video packets, when higher order modulation modes are used in case of a high instantaneous channel quality. The bit-rate control mechanism of the video encoder is closely linked to the packet assembly block in order to compensate for the rapid changes in the AQAM mode and packet size.

IV. SWITCHED MULTIMODE TRANSCEIVER

Initially, we investigated the performance of a statically switched multi-mode convolutionally coded JD CDMA video system supporting two users. Due to using orthogonal spreading codes and JD, the system only required about 1-dB higher SINR for attaining a given BER, in comparison to a two-user scenario when supporting, e.g., eight users, although these results are not included here due to lack of space. Hence, the system was capable of maintaining a near-single-user performance as long as the number of subscribers was less than that in the so-called fully loaded scenario, where the number of users serviced is identical to the number of chips in the spreading sequence. The associated convolutional codec parameters are summarized in Table II, along with the operational-mode specific transceiver parameters of the proposed statically switched multi-mode system. Explicitly, this initial system uses a switched multi-mode transceiver, which changes modes much less frequently, on a call-by-call basis rather than near-instantaneously, as does the BbB AQAM trasceiver described in Section V.

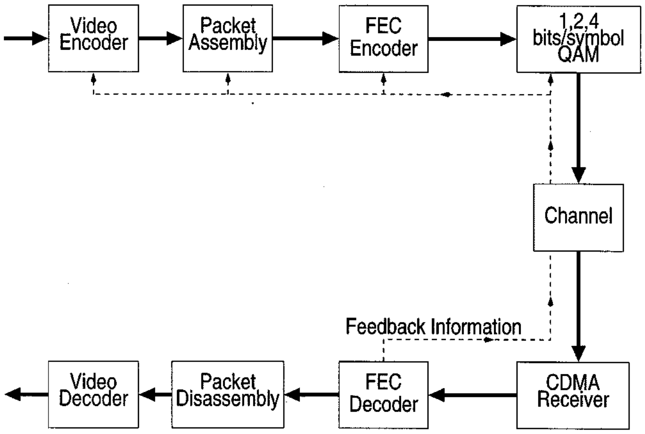

Fig. 3. Reconfigurable transceiver schematic.

Below, we now detail the video-packetization method employed. The reader is reminded that the number of QAM symbols per TDMA frame was 68 according to Table I. In the 4QAM/JD-CDMA mode, this would give 136 bits per TDMA frame. However, if we transmitted one video packet per TDMA frame, then the packetization overhead would absorb a large percentage of the available bitrate. Hence, we assembled larger video packets, thereby reducing the packetization overhead, and arranged for transmitting the contents of a video packet (including its header) over three consecutive TDMA frames, as indicated in Table I. Therefore, each protected video packet consists of $68 \times 3 = 204$ QAM symbols, yielding a transmission bit rate of between 14.7 and 58.9 kbits/s for BPSK/JD-CDMA and 16QAM/JD-CDMA, respectively. However, in order to protect the video data, we employed half-rate, constraint-length, nine convolutional coding, using octal generator polynomials of 561 and 753. The useful video bitrate was further reduced due to the 16-bit CRC used for error detection and due to the nine-bit repetition-coded video packet error flag transmitted over the reverse link. This results in video packet sizes of 77, 179, and 383 bits for each of the three AQAM modes. The useful video bit rate was finally further reduced by the $8 \ldots 10$-bit video packet header, resulting in useful or effective video bitrates ranging from 5 to 26.9 kbits/ in the BPSK/JD-CDMA and 16QAM/JD-CDMA modes, respectively.

The proposed multi-mode system can switch amongst the 1-, 2-, and 4-bit/symbol QAM schemes under network control,

TABLE II
OPERATIONAL-MODE SPECIFIC TRANSCEIVER PARAMETERS FOR THE PROPOSED MULTIMODE SYSTEM

Features	Multi-rate System		
Mode	BPSK	4QAM	16QAM
Bits/Symbol	1	2	4
FEC	Convolutional Coding		
Octal Gen. Pol.	561; 753		
Coding-rate	$R = 1/2$		
Constraint-length	$K = 9$		
Transmitted bits/packet	204	408	816
Total bitrate (kbit/s)	14.7	29.5	58.9
FEC-coded bits/packet	102	204	408
Assigned to FEC-coding (kbit/s)	7.4	14.7	29.5
Error detection per packet	16 bit CRC		
Feedback bits / packet	9		
Video packet size	77	179	383
Packet header bits	8	9	10
Video bits/packet	69	170	373
Unprotected video-rate (kbit/s)	5.0	12.3	26.9
Video framerate (Hz)	10		

based upon the prevailing channel conditions on a call-by-call basis. As seen in Table II, when the channel is benign, the effective video bit rate will be approximately 26.9 kbits/ps in the 16QAM/JD-CDMA mode. However, as the channel quality degrades, the modem will switch to the BPSK mode of operation, where the video bit rate drops to 5 kbits/ and for maintaining a reasonable video quality, the video resolution has to be reduced to SQCIF (128 × 96 pels).

Fig. 4 portrays the packet loss ratio (PLR) for the multi-mode system, in each of its QAM modes for a range of channel SNR's. It can be seen in the figure that above a channel SNR of 14 dB the 16QAM/JD-CDMA mode offers an acceptable packet loss ratio of less than 5%, while providing an effective video rate of about 26.9 kbits/. If the channel SNR drops below 14 dB, the multimode system is switched to 4QAM/JD-CDMA and eventually to BPSK/JD-CDMA, when the channel SNR is below 9 dB, in an effort to maintain the required quality of service, which is dictated by the packet loss ratio. The video packet acknowledgment flag is highly protected for ensuring the correct operation of our robust video transceiver. We have found that when repeating the feedback message nine times and using majority logic decisions (MLD), the flag does not become corrupted, unless the PLR increases to about 50%. It is, therefore, assumed that both the switched multimode system and the BbB AQAM system (to be described in Section V) would have switched to the most robust modulation mode before such a situation may occur.

The video quality is commonly measured in terms of the PSNR. Fig. 5 shows the video quality in terms of the PSNR versus the channel SNR for each of the modulation modes.

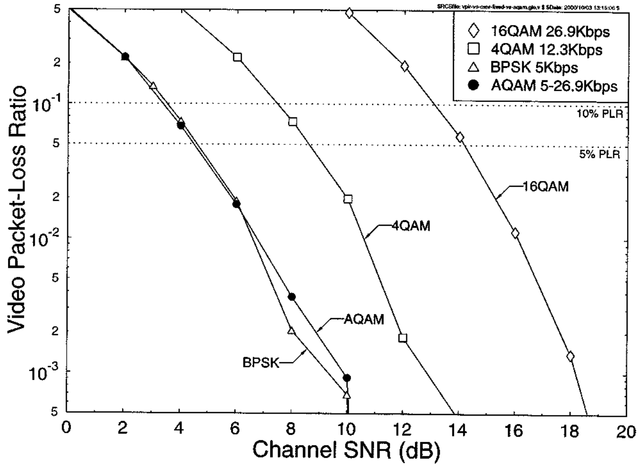

Fig. 4. Video PLR versus channel SNR for the three modulation schemes of the multi-mode system, compared to the BbB adaptive modem. Both systems substain 2-users using JD over the channel model of Fig. 2.

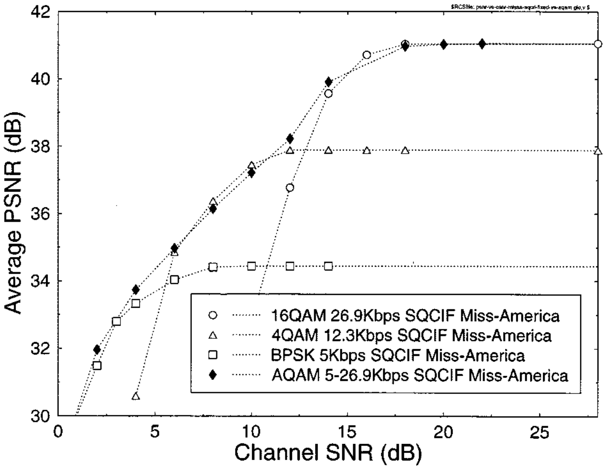

Fig. 5. Average decoded video quality (PSNR) versus channel SNR comparision of the fixed modulation modes of BPSK, 4QAM, and 16QAM, and the BbB adaptive modem. Both supporting 2-users with the aid of JD. These results were recorded for the Miss-America video sequence at SQCIF resolution (128 × 96 pels) over the channel model of Fig. 2.

The graph also shows the performance of our BbB AQAM JD CDMA modem, which will be discussed further in Section V. As expected, the higher effective throughput bit rate of the 16QAM/JD-CDMA mode provides a better video quality. However, as the channel quality degrades, the video quality of the 16QAM/JD-CDMA mode is reduced due to the channel impairments, and hence it becomes beneficial to switch from the 16QAM/JD-CDMA mode to 4QAM/JD-CDMA at an SNR of about 14 dB, as it was also suggested by the packet loss ratio performance of Fig. 4. Although the video quality expressed in terms of PSNR is superior for the 16QAM/JD-CDMA mode in comparison to the 4QAM/JD-CDMA mode at channel SNRs in excess of 12 dB, due to the excessive PLR, the perceived video quality appears inferior in comparison to that of the 4QAM/JD-CDMA mode, even though the 16QAM/JD-CDMA PSNR is higher for channel SNRs in the range of 12–14 dB. More specifically, we found that it was beneficial to switch to a more robust CDMA mode, when the PSNR was reduced by about 1 dB with respect to its unimpaired PSNR value. This ensured that the packet losses did not become subjectively obvious, resulting in a higher perceived video quality, as the channel quality deteriorated.

The effect of packet losses on the video quality quantified in terms of PSNR is portrayed in Fig. 6. The figure shows how the video quality degrades as the PLR increases. Again, for reasons of space economy, the figure also shows the performance of our BbB adaptive modem, which will be discussed later in Section V. It has been found that in order to ensure a graceful, unobjectionable degradation of video quality as the channel SNR reduced, the best policy was to switch to a more robust modulation mode when the PLR exceeded 5%. The figure clearly shows that there is a loss of PSNR when switching to a more robust modulation mode. However, if the system did not switch until the PSNR degraded to that of the more robust modulation mode, the perceived video quality associated with the original higher bit rate, higher PSNR—but channel-impaired stream—became inferior. Based on the above statically reconfigured multimode scheme, let us now focus our attention on near-instantaneous or BbB reconfiguration in the next section.

V. BbB Adaptive Videophone System

A BbB adaptive modem [1] maximizes the system's BPS throughput—and the achievable video quality—by using the most appropriate modulation mode for the current instantaneous channel conditions. This is in contrast to our previous switched multi-mode scheme, which switches modulation modes much less frequently, on a call-by-call time-scale, based on the packet loss statistics. Explicitly, BbB adaptation becomes significantly more flexible and powerful in terms of avoiding transmission errors by temporarily reconfiguring the modem in a robust transmission mode, when the channel quality is low. Fig. 7 exemplifies how a BbB AQAM JD CDMA modem changes its modulation modes based on the fluctuating channel conditions. The adaptive modem uses the SINR estimate at the output of the joint-detector for estimating the instantaneous channel quality, and hence to set the modulation mode.

The BbB-adaptive AQAM mode switching thresholds were optimized in 1996 by Torrance *et al.* [1], [20] for achieving the highest possible average BPS throughput while maintaining the target average BER. Powell's optimization was invoked for finding a set of switching thresholds, which were constant, regardless of the instantaneous channel SINR encountered. However, in 2001, Choi *et al.* [1], [21] recognized that a higher BPS throughput can be achieved, if under high channel SINR conditions the activation of high-throughput AQAM modes is further encouraged by lowering the switching thresholds. More explicitly, a set of SNR-dependent mode switching levels was derived with the aid of Lagrangian, rather than Powell optimization [1], [21], which keeps the average BER of AQAM constant, while maximizing the achievable throughput. Choi's set of thresholds is important for the sake of determining the best possible performance of the BbB-adaptive AQAM scheme. Our procedure of determining the thresholds was based on an off-line threshold adjustment technique designed for maintaining the target PLR of 5%, but Tang's recently proposed intelligent *on-line threshold learning* scheme may be readily adopted for this purpose [22].

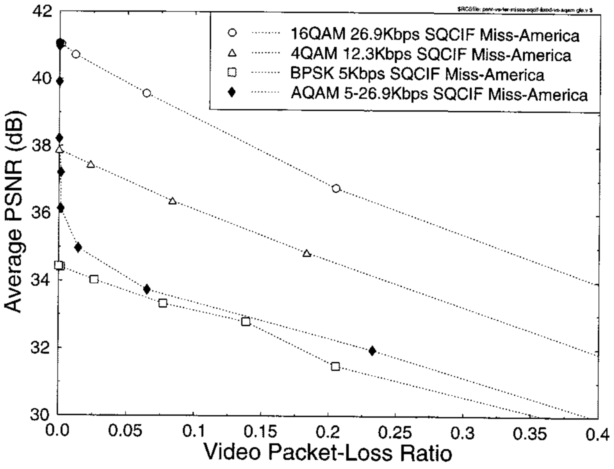

Fig. 6. Decoded video quality (PSNR) versus video packet loss ratio comparision of the fixed modulation modes of BPSK, 4QAM, and 16QAM, and the BbB adaptive modem. Both supporting 2-users with the aid of JD. These results were recorded for the Miss-America video sequence at SQCIF resolution (128 × 96 pels) over the channel model of Fig. 2.

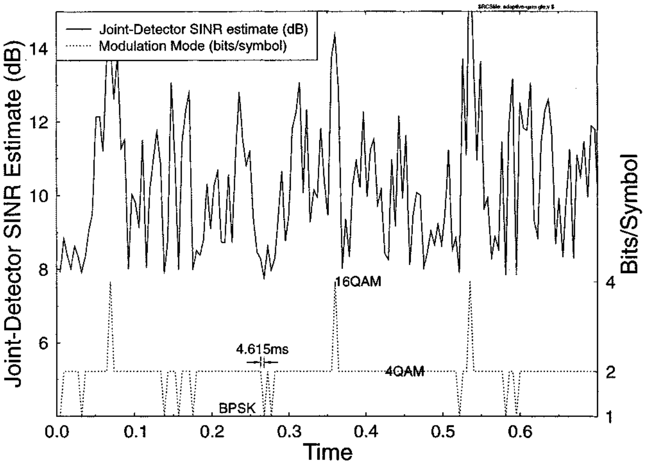

Fig. 7. Example of modem mode switching in a dynamically reconfigured BbB modem in operation, where the modulation mode switching is based upon the SINR estimate at the output of the joint-detector over the channel model of Fig. 2.

Apart from the choice of the thresholds, another important issue is the signalling of the BbB AQAM JD CDMA modes. In [23], the modulation mode to be used by the transmitter was determined on a symbol-by-symbol basis by the channel-state predictor. As a design alternative, Otsuki *et al.* [24] proposed using a four-chip Walsh code for signalling the modem modes, while Torrance and Hanzo [20] advocated the employment of a specific uneven error protection based PSK modulation constellation having five phasors for signalling a set of five AQAM modes, which were nonuniformly distributed on the 5-PSK constellation ring. The performance of various blind mode signalling schemes was documented in [1], [8]. The performance degradations imposed by outdated channel quality estimates arriving after a feedback delay of one transmission burst were documented for various normalized Doppler frequencies in [1], [8]. These were counteracted by increasing the AQAM mode switching thresholds for the sake of more cautiously activating the high-BPS AQAM modes, which slightly reduced the achievable BPS throughput. These effects can be further mitigated using powerful channel quality prediction techniques [1], [16].

The probability density function (PDF) of the adaptive modem using each modulation mode for a particular channel SNR is portrayed in Fig. 8. It can be seen that, at high-channel SNRs, the modem predominantly uses the 16QAM/JD-CDMA modulation mode, while at low-channel SNRs, the BPSK mode is most prevalent.

The advantage of the dynamically reconfigured BbB AQAM JD CDMA modem over the previously described statically switched multimode system is that the video quality is gracefully degraded, on a near-instantaneous basis, as the channel conditions deteriorate. The switched multimode system results in more visible reductions in video quality, when the modem switches to a more robust modulation mode on a call-by-call basis. Fig. 9 shows the effective throughput bitrate of the dynamically reconfigured BbB AQAM JD CDMA modem, compared to the three modes of the statically switched multimode system.

The effective throughput bit rate is the bit rate provided by the noncorrupted packets. Hence, the reduction of the fixed modem modes' effective throughput at low SNRs is due to the fact that, under such channel conditions, an increased fraction of the transmitted packets are corrupted and have to be dropped, hence reducing the effective throughtput. The figure shows the graceful reduction of the throughput bitrate, as the channel quality deteriorates. The BbB AQAM JD CDMA modem matches the BPSK mode's bit rate at low channel SNRs, and the 16QAM mode's bit rate at high SNRs. The dynamically reconfigured BbB AQAM JD CDMA modem characterized in the figure perfectly estimates the prevalent channel conditions, although in practice the estimate of channel quality is not perfect and is inherently delayed. Hence, our results constitute an upper-bound performance.

The smoothly varying effective throughput bit rate of the BbB AQAM JD CDMA modem translates into a smoothly varying video quality, as the channel conditions change. The video quality measured in terms of the average PSNR was shown versus the channel SNR in Fig. 5 in contrast to that of the individual fixed QAM modes. The figure demonstrates that the BbB AQAM JD CDMA modem provides similar or better video quality over a large proportion of the SNR range shown, than the individual QAM modes. However, even at channel SNRs where the BbB AQAM JD CDMA modem has a slightly reduced PSNR, the perceived video quality of the adaptive modem is better, since the video packet loss rate is far lower than that of the fixed QAM modes.

Returning to Fig. 4, the video PLR versus channel SNR is shown for the three fixed QAM modes and for the BbB AQAM JD CDMA modem with perfect channel estimation. Again, the figure demonstrates that the video PLR of the BbB AQAM JD CDMA modem is similar to that of the fixed BPSK modem mode. However, the adaptive modem exhibits a significantly higher throughput bit rate, as the channel SNR increases. If imperfect channel estimation is used, the throughput bit rate of the adaptive modem is reduced slightly. Furthermore, the video PLR seen in Fig. 4 is slightly higher for the AQAM/JD-CDMA scheme due to invoking higher order AQAM modes as the channel quality increases. However, it is realistic to maintain the video PLR within the targets for the range of channel SNR's considered.

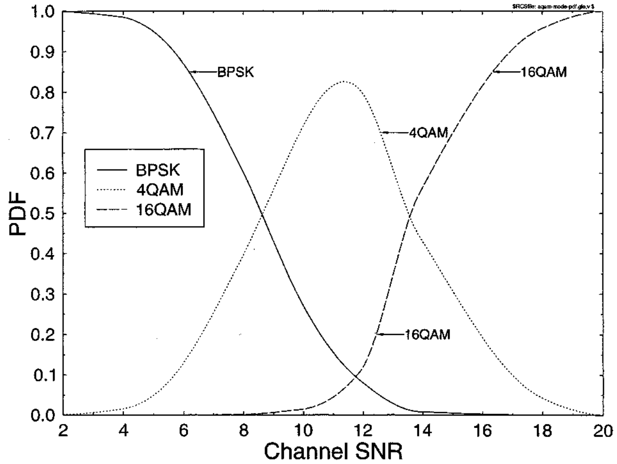

Fig. 8. PDF of the various adaptive modem modes versus channel SNR over the channel model of Fig. 2.

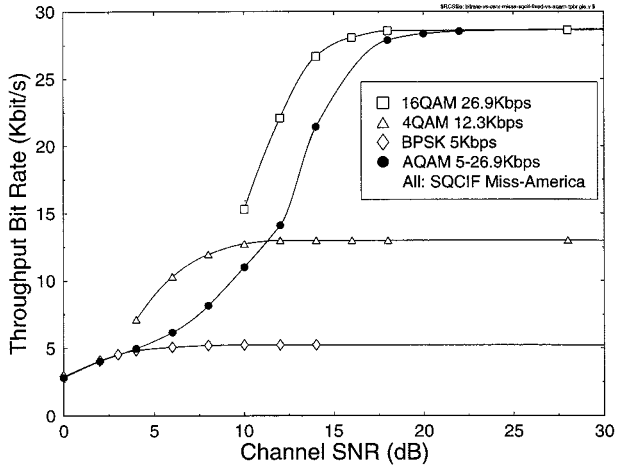

Fig. 9. Throughput bit rate versus channel SNR comparision of the three fixed modulation modes (BPSK, 4QAM, 16QAM) and the adaptive BbB modem (AQAM), both supporting two users with the aid of JD over the channel model of Fig. 2.

The interaction between the video quality measured in terms of PSNR and the video PLR can be more explicitly seen in Fig. 6. It can be seen that the adaptive modem slowly degrades the decoded video quality from that of the error free 16QAM fixed modulation mode as the channel conditions deteriorate. The video quality degrades from the error-free 41-dB PSNR, while maintaining a near-zero video PLR, until the PSNR drops below about 36 dB PSNR. At this point, the further-reduced channel quality inflicts an increased video PLR and the video quality degrades more slowly. The PSNR versus PLR performance then tends toward that achieved by the fixed BPSK modulation mode. However, the modem achieved better video quality than the fixed BPSK modem, even at high PLRs. Our *future research* concentrates on invoking joint equalization and channel coding in the proposed AQAM-based JD-CDMA scheme, which is referred to as turbo equalization. This will be combined with turbo trellis-coded modulation [1], [15], rather than separate coding and modulation.

VI. CONCLUSION

In conclusion, the proposed BbB AQAM JD CDMA video transceiver outperformed the statically switched multimode-based transceiver. The transceiver guaranteed a near-unimpaired video quality for channel SNRs in excess of about 5 dB over the COST207 dispersive Rayleigh-faded channel. The benefits of the BbB AQAM JD CDMA video transceiver clearly manifest themselves in terms of supporting a perceptionally un-impaired video quality under time-variant channel conditions, where a single-mode transceiver's quality would become severely degraded by channel effects. The dynamically reconfigured BbB AQAM JD CDMA modem gave better perceived video quality—due to its more graceful reduction in video quality—than a statically switched multimode system as the channel conditions degraded. The highly robust video-packetization regime allowed us to utilize the channel capacity more efficiently than error-sensitive video-compression techniques, which require a BER of 1×10^{-4} and lower.

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