IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

FASTVDO LLC, **Plaintiff,** **v.** **TECHNICOLOR, INC., TECHNICOLOR USA, INC., and TECHNICOLOR CREATIVE SERVICES USA, INC.,** **Defendants.**	**Civil Action No. 12-cv-1429-RGA** **DEMAND FOR JURY TRIAL**

AMENDED COMPLAINT

Plaintiff FastVDO LLC ("FastVDO") alleges as follows:

PARTIES

1. FastVDO is a Florida limited liability corporation with a principal place of business at 750 N. Atlantic Ave., Cocoa Beach, FL 32931.

2. On information and belief, Technicolor, Inc. is a Delaware corporation with a principal place of business at 6040 Sunset Boulevard, 6th Floor, Hollywood, CA 90028.

3. On information and belief, Technicolor USA, Inc. is a Delaware corporation with a principal place of business at 101 West 103rd Street, Indianapolis, Indiana 46290.

4. On information and belief, Technicolor Creative Services USA, Inc. is a Delaware corporation with a principal place of business at 1631 Gardena Avenue, Glendale, CA 91204. Technicolor, Inc., Technicolor USA, Inc., and Technicolor Creative Services USA, Inc. are collectively referred to as "Technicolor."

JURISDICTION AND VENUE

5. This is an action for patent infringement arising under the patent laws of the United States of America, 35 U.S.C. § 1, *et seq.*, including § 271. This Court has subject matter jurisdiction under 28 U.S.C. §§ 1331 and 1338(a).

6. This Court has personal jurisdiction over Technicolor because, among other reasons, Technicolor is incorporated under the laws of the State of Delaware, and Technicolor has conducted and continues to conduct regular and ongoing business in Delaware. Additionally, on information and belief, Technicolor has committed direct and indirect acts of infringement in this District by making, using, importing, offering for sale, and/or selling infringing products, and inducing others to perform method steps claimed by FastVDO's patent in Delaware.

7. Venue is proper in this district under 28 U.S.C. §§ 1391(b)-(c) and 1400(b) because, among other reasons, Technicolor is incorporated under the laws of the State of Delaware, and Technicolor has conducted and continues to conduct regular and ongoing business in Delaware. Additionally, on information and belief, Technicolor has committed direct and indirect acts of infringement in this District by making, using, importing, offering for sale, and/or selling infringing products, and inducing others to perform method steps claimed by FastVDO's patent in Delaware.

COUNT I

(Infringement of U.S. Patent No. RE 40,081)

8. FastVDO is the owner by assignment and merger of United States Patent No. RE 40,081 ("the '081 patent"), entitled "Fast Signal Transforms With Lifting Steps." The '081 patent reissued on February 19, 2008, based on an initial application filed December 16, 1998. A true and correct copy of the '081 patent is attached hereto as Exhibit A. The '081 patent enables digital video compression through the coding and decoding of blocks of digital image intensities with a block coder and transform coder that utilizes an invertible linear transform having a +/-1 butterfly step, a lifting step, and a scaling factor. International Telecommunications Union – Telecommunication Standardization Sector (ITU-T) H.264 (also known as MPEG-4 Part 10, Audio Video Coding or AVC) (herein "H.264" or "MPEG-4 AVC") is a video compression standard that performs digital image compression by coding and decoding blocks of digital image intensities with a block coder and with a transform coder that includes an invertible linear

transform, which is representable as a cascade using at least one +/-1 butterfly step, at least one lifting step, and at least one scaling factor. The FastVDO patent is essential to the H.264 standard, and it was properly identified to the International Telecommunications Union on May 14, 2003, before the promulgation of the H.264 standard in March 2005.

9. On information and belief, in violation of one or more provisions of 35 U.S.C. § 271, Technicolor has infringed one or more claims of the '081 patent by making, using, importing, selling, or offering to sell digital media devices, software, equipment, videos and services that use H.264 to code and/or decode video, including, but not limited to, Home Network Media Tablet, Media Touch 2, DSI803 HD DVR Set-Top Box, the Tiger AVC encoding system, and its BD/DVD Compression & Authoring services. Additionally, Technicolor has had knowledge of the '081 patent since at least November 8, 2012,[1] or alternatively since being served with this complaint, and Technicolor has induced others, such as its customers and/or consumers of H.264 content produced by its customers, to code and/or decode video with H.264 and practice the method steps of the '081 patent with its marketing materials, advertising materials, manuals and customer support services since at least this time. For example, the marketing material for Technicolor's Home Network Media Tablet explains that this product "provides a new and exciting way for end-users to enjoy entertainment, information, communication services and much more anywhere in their home." *See* Home Network Media Tablet product brief at 2 (attached hereto as Exhibit C). The H.264 video encoding and decoding capabilities of the Home Media Network Media Tablet are featured in its technical specification. *Id.* at 7. Similarly, the marketing material for Technicolor's DSI803 Satellite Set-Top Box explains that an H.264 codec is used to provide highest quality video. *See* DSI803 HD DVR MPEG-4 Satellite Set-Top Box product brief at 1 ("Use of a wide range of video codecs, including MPEG-4 (H.264) in both standard and high-definition (SD and HD) for highest video quality.") (attached hereto as Exhibit D). Additionally, Technicolor encodes video using H.264 for its customers and causes consumers of digital content to decode these with

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[1] *See* Exhibit B.

H.264 for viewing. *See* Blu-Ray/DVD Compression and Authoring services product brief (attached hereto as Exhibit E) ("Technicolor continues to lead the way in pioneering Blu-Ray and DVD technology. … Technicolor serves its customers as a leading-edge provider of equipment, including the Tiger AVC encoder, the BD test center and JIVE author.").[2] These marketing and technical materials exemplify how Technicolor induces its customers to use its accused products to code and/or decode videos with H.264, and/or code digital images with H.264 and transmit these compressed videos to others for decoding and viewing to perform the method steps of the '081 patent (e.g., coding and decoding blocks of digital image intensities with a block coder and transform coder that utilizes an invertible linear transform having a +/-1 butterfly step, a lifting step, and a scaling factor). By continuing the representative aforementioned activities with knowledge of the '081 patent and its essentiality to the H.264 standard, Technicolor has known, or should have known, that it was inducing infringement by causing the method steps of the '081 patent to be performed.

PRAYER FOR RELIEF

FastVDO prays for the following relief:

1. A judgment that Technicolor has directly infringed (either literally or under the doctrine of equivalents) one or more claims of the '081 patent;

2. A judgment that Technicolor has induced the infringement of one or more claims of the '081 patent;

3. A permanent injunction enjoining Technicolor and its officers, directors, agents, servants, affiliates, employees, divisions, branches, subsidiaries, parents, and all others acting in active concert or participation with them, from infringing each of the '081 patent;

4. An award of damages resulting from Technicolor's acts of infringement in accordance with 35 U.S.C. § 284;

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[2] *See also* http://broadcastengineering.com/hdtv/tiger-grabs-hd-dvd-blu-ray-compression-tail (interview with general manager of the research labs were the Tiger encoder was developed) ("I think we've moved the bar up a little bit in terms of video quality for H.264 and consumers.") (attached hereto as Exhibit F).

5. A judgment and order finding that this is an exceptional case within the meaning of 35 U.S.C. § 285 and awarding to FastVDO its reasonable attorneys' fees;

6. A judgment and order requiring Technicolor to provide an accounting and to pay supplemental damages to FastVDO, including without limitation, pre-judgment and post-judgment interest; and

7. Any and all other relief to which FastVDO may show itself to be entitled.

DEMAND FOR JURY TRIAL

FastVDO demands a trial by jury on all issues so triable.

Dated: September __, 2013

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Exhibit A

US00RE40081E

(19) **United States**
(12) **Reissued Patent**
Tran et al.

(10) **Patent Number: US RE40,081 E**
(45) **Date of Reissued Patent: Feb. 19, 2008**

(54) **FAST SIGNAL TRANSFORMS WITH LIFTING STEPS**

(75) Inventors: **Trac D. Tran**, Columbia, MD (US); **Pankaj Topiwala**, Clarksville, MD (US)

(73) Assignee: **Fast VDO LLC**, Columbia, MD (US)

(21) Appl. No.: **10/629,303**

(22) Filed: **Jul. 29, 2003**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **6,421,464**
Issued: **Jul. 16, 2002**
Appl. No.: **09/212,210**
Filed: **Dec. 16, 1998**

(51) **Int. Cl.**
G06K 9/36 (2006.01)

(52) **U.S. Cl.** **382/232**

(58) **Field of Classification Search** 382/232, 382/233, 236, 238, 239, 240, 242, 248, 250; 358/426.13, 426.14; 348/384.1, 394.1, 395.1, 348/400.1–404.1, 407.1–416.1, 420.1–421.1, 348/425.1, 430.1, 431.1, 699; 341/51, 63, 341/65, 67, 107; 364/724.011, 724.04, 724.05, 364/724.13, 724.14, 725.01, 725.02; 708/400; 375/240.11, 240.16

See application file for complete search history.

(56) **References Cited**

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Sweldens, Wim, "The Lifting Scheme: A custom design construction of biorthogonal wavelets", pp. 1–29, Nov. 1994.*

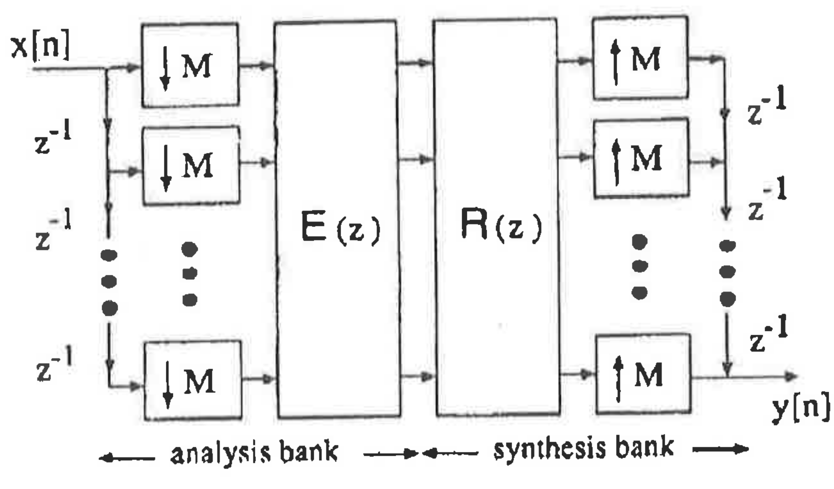
(Continued)

Primary Examiner—Jose L. Couso
(74) *Attorney, Agent, or Firm*—Burns & Levinson LLP; Kimberly B. Whitehead

(57) **ABSTRACT**

This invention introduces a class of multi-band linear phase lapped biorthogonal transforms with fast, VLSI-friendly implementations via lifting steps called the LiftLT. The transform is based on a lattice structure which robustly enforces both linear phase and perfect reconstruction properties. The lattice coefficients are parameterized as a series of lifting steps, providing fast, efficient in-place computation of the transform coefficients as well as the ability to map integers to integers. Our main motivation of the new transform is its application in image and video coding. Comparing to the popular 8×8 DCT, the 8×16 LiftLT only requires 1 more multiplication, 22 more additions, and 6 more shifting operations. However, image coding examples show that the LiftLT is far superior to the DCT in both objective and subjective coding performance. Thanks to properly designed overlapping basis functions, the LiftLT can completely eliminate annoying blocking artifacts. In fact, the novel LiftLT's coding performance consistently surpasses that of the much more complex 9/7-tap biorthogonal wavelet with floating-point coefficients. More importantly, our transform's block-based nature facilitates one-pass sequential block coding, region-of-interest coding/decoding as well as parallel processing.

39 Claims, 5 Drawing Sheets



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Liang, et al., "ITU–Telecommunications Standardization Sector", A 16–bit architecture for H.26L treating DCT Transforms anf quantization, pp. 1–2, May 29, 2001.*

* cited by examiner

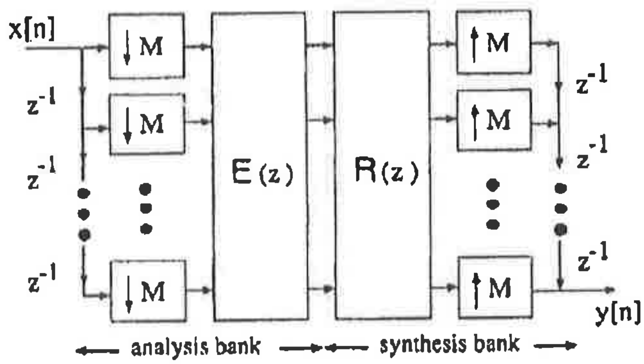

Figure 1

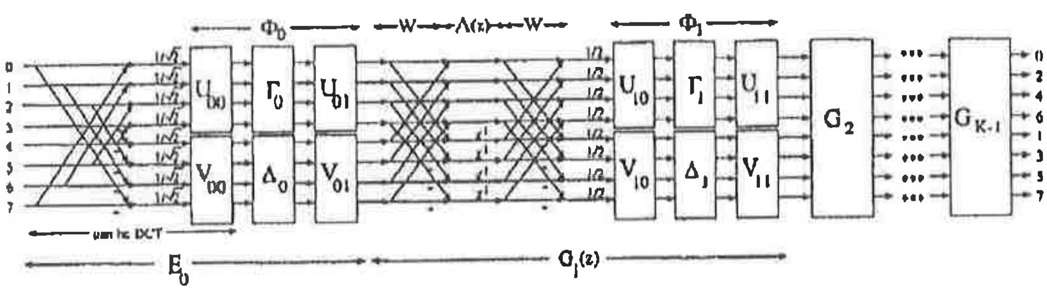

Figure 2

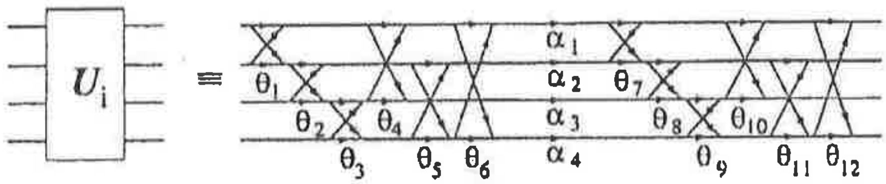

Figure 3

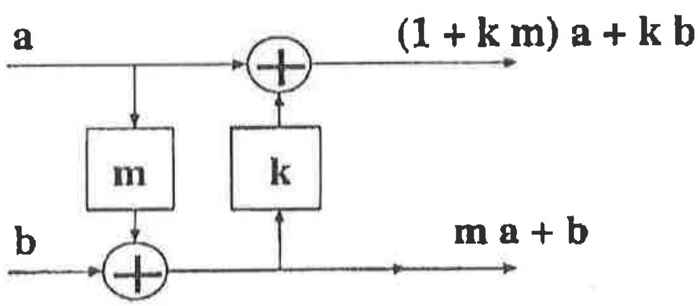

Figure 4

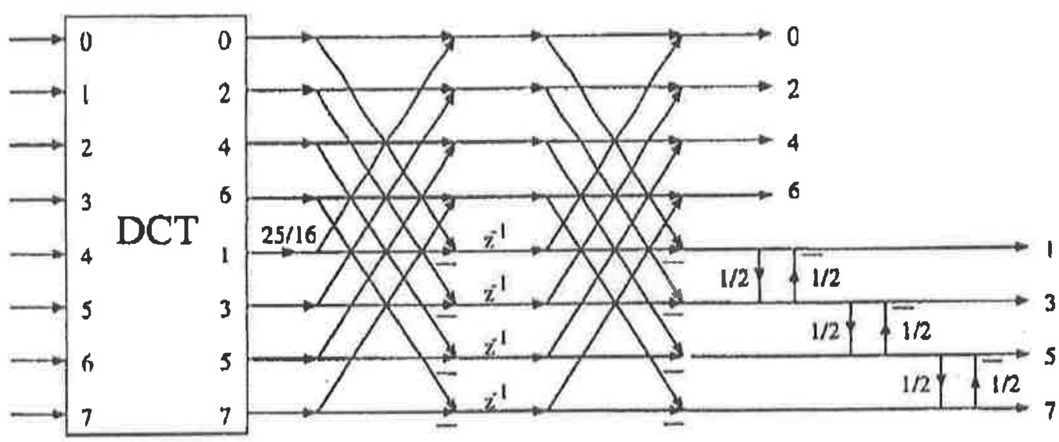

Figure 5

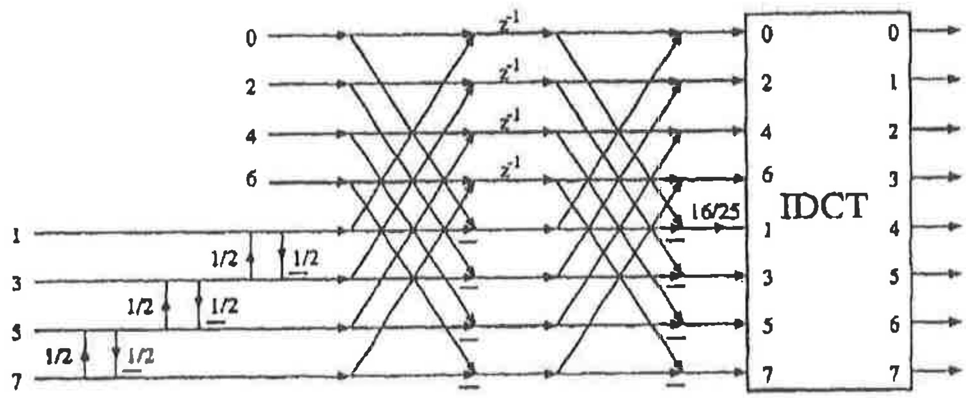

Figure 6

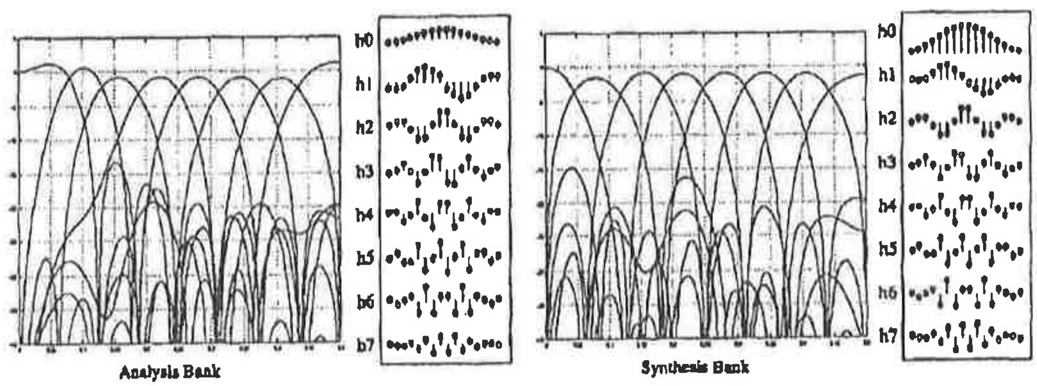

Figure 7

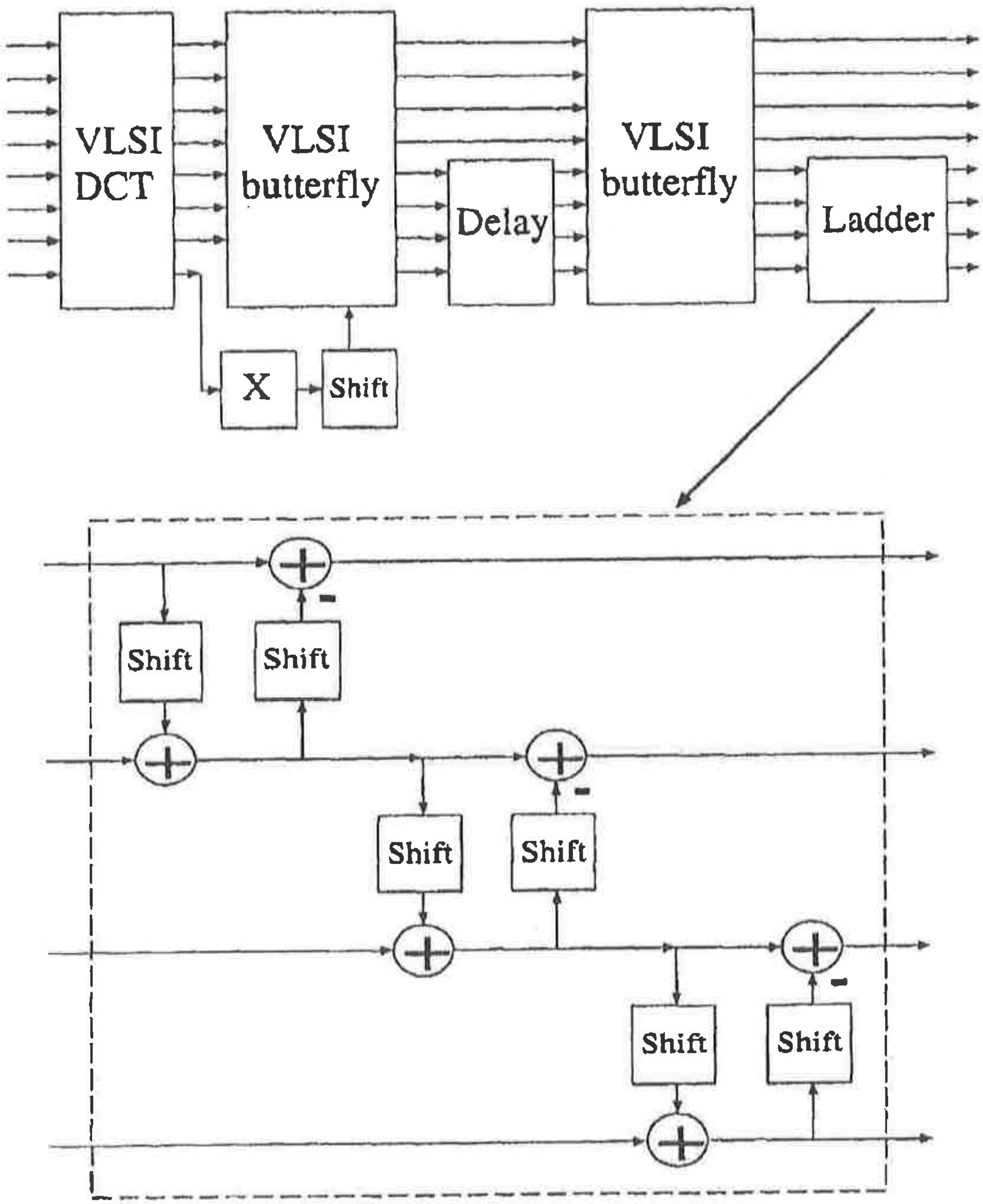
VLSI DCT
VLSI butterfly
Delay
VLSI butterfly
Ladder
X
Shift
Shift
Shift
Shift
Shift
Shift
Shift

Figure 8

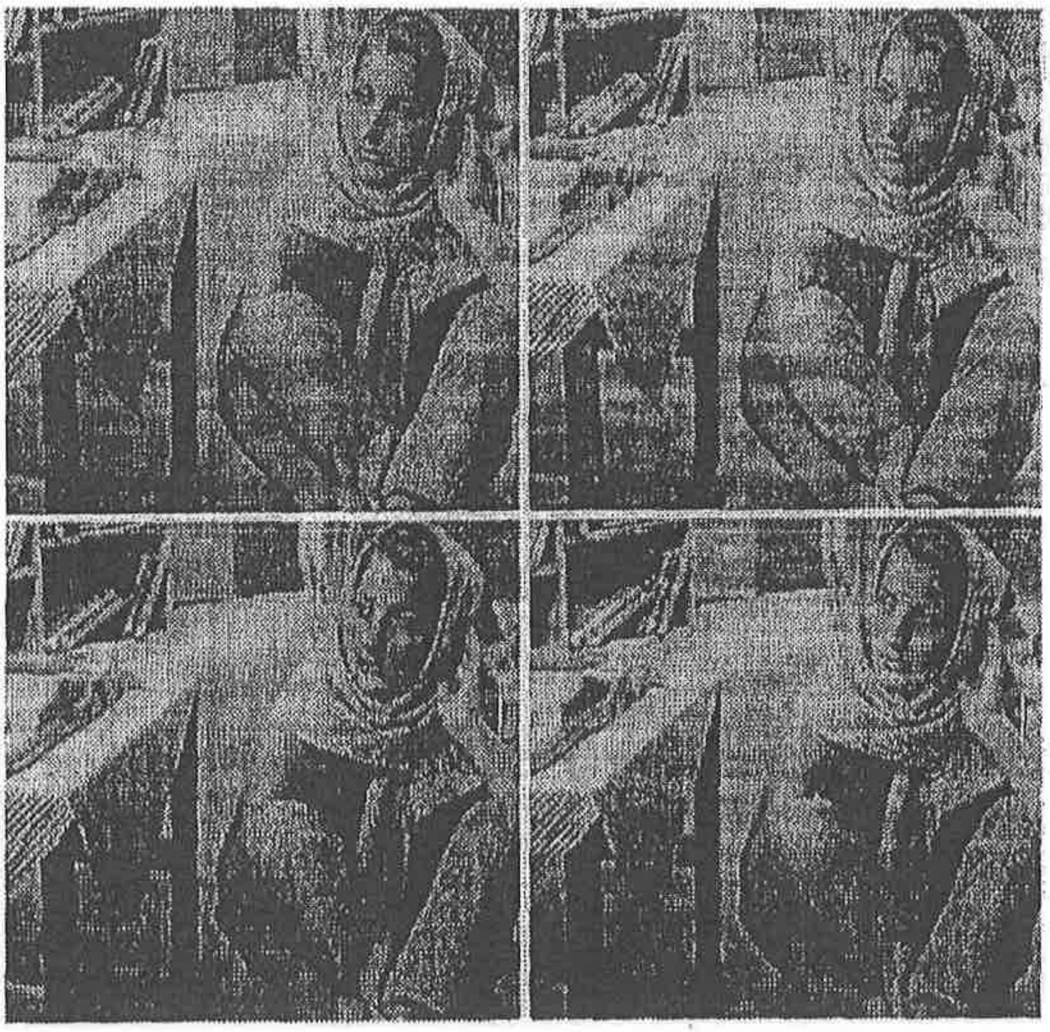

Figure 9

FAST SIGNAL TRANSFORMS WITH LIFTING STEPS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

FIELD OF THE INVENTION

More than one reissue application has been filed for the reissue of U.S. Pat. No. 6,421,464. The Instant Reissue application Ser. No. 10/629,303 filed Jul. 29, 2003 and U.S. application Ser. No. 11/896,522, filed Sep. 4, 2007 which is a Continuation of U.S. Reissue application Ser. No. 10/629, 303.

The current invention relates to the processing of images such as photographs, drawings, and other two dimensional displays. It further relates to the processing of such images which are captured in digital format or after they have been converted to or expressed in digital format. This invention further relates to use of novel coding methods to increase the speed and compression ratio for digital image storage and transmission while avoiding introduction of undesirable artifacts into the reconstructed images.

BACKGROUND OF THE INVENTION

In general, image processing is the analysis and manipulation of two-dimensional representations, which can comprise photographs, drawings, paintings, blueprints, x-rays of medical patients, or indeed abstract art or artistic patterns. These images are all two-dimensional arrays of information. Until fairly recently, images have comprised almost exclusively analog displays of analog information, for example, conventional photographs and motion pictures. Even the signals encoding television pictures, notwithstanding that the vertical scan comprises a finite number of lines, are fundamentally analog in nature.

Beginning in the early 1960's, images began to be captured or converted and stored as two-dimensional digital data, and digital image processing followed. At first, images were recorded or transmitted in analog form and then converted to digital representation for manipulation on a computer. Currently digital capture and transmission are on their way to dominance, in part because of the advent of charge coupled device (CCD) image recording arrays and in part because of the availability of inexpensive high speed computers to store and manipulate images.

An important task of image processing is the correction or enhancement of a particular image. For example, digital enhancement of images of celestial objects taken by space probes has provided substantial scientific information. However, the current invention relates primarily to compression for transmission or storage of digital images and not to enhancement.

One of the problems with digital images is that a complete single image frame can require up to several megabytes of storage space or transmission bandwidth. That is, one of today's 3½ inch floppy discs can hold at best a little more than one gray-scale frame and sometimes substantially less than one whole frame. A full-page color picture, for example, uncompressed, can occupy 30 megabytes of storage space. Storing or transmitting the vast amounts of data which would be required for real-time uncompressed high resolution digital video is technologically daunting and virtually impossible for many important communication channels, such as the telephone line. The transmission of

digital images from space probes can take many hours or even days if insufficiently compressed images are involved. Accordingly, there has been a decades long effort to develop methods of extracting from images the information essential to an aesthetically pleasing or scientifically useful picture without degrading the image quality too much and especially without introducing unsightly or confusing artifacts into the image.

The basic approach has usually involved some form of coding of picture intensities coupled with quantization. One approach is block coding; another approach, mathematically equivalent with proper phasing, is multiphase filter banks. Frequency based multi-band transforms have long found application in image coding. For instance, the JPEG image compression standard, W. B. Pennebaker and J. L. Mitchell, "JPEG: Still Image Compression Standard," Van Nostrand Reinhold, 1993, employs the 8x8 discrete cosine transform (DCT) at its transformation stage. At high bit rates, JPEG offers almost lossless reconstructed image quality. However, when more compression is needed, annoying blocking artifacts appear since the DCT bases are short and do not overlap, creating discontinuities at block boundaries.

The wavelet transform, on the other hand, with long, varying-length, and overlapping bases, has elegantly solved the blocking problem. However, the transform's computational complexity can be significantly higher than that of the DCT. This complexity gap is partly in terms of the number of arithmetical operations involved, but more importantly, in terms of the memory buffer space required. In particular, some implementations of the wavelet transform require many more operations per output coefficient as well as a large buffer.

An interesting alternative to wavelets is the lapped transform, e.g., H. S. Malvar, Signal Processing with Lapped Transforms, Artech House, 1992, where pixels from adjacent blocks are utilized in the calculation of transform coefficients for the working block. The lapped transforms outperform the DCT on two counts: (i) from the analysis viewpoint, they take into account inter-block correlation and hence provide better energy compaction; (ii) from the synthesis viewpoint, their overlapping basis functions decay asymptotically to zero at the ends, reducing blocking discontinuities dramatically.

Nevertheless, lapped transforms have not yet been able to supplant the unadorned DCT in international standard coding routines. The principal reason is that the modest improvement in coding performance available up to now has not been sufficient to justify the significant increase in computational complexity. In the prior art, therefore, lapped transforms remained too computationally complex for the benefits they provided. In particular, the previous lapped transformed somewhat reduced but did not eliminate the annoying blocking artifacts.

It is therefore an object of the current invention to provide a new transform which is simple and fast enough to replace the bare DCT in international standards, in particular in JPEG and MPEG-like coding standards. It is another object of this invention to provide an image transform which has overlapping basis functions so as to avoid blocking artifacts. It is a further object of this invention to provide a lapped transform which is approximately as fast as, but more efficient for compression than, the bare DCT. It is yet another object of this invention to provide dramatically improved speed and efficiency using a lapped transform with lifting steps in a butterfly structure with dyadic-rational coefficients. It is yet a further object of this invention to provide a transform structure such that for a negligible complexity surplus over the bare DCT a dramatic coding performance gain can be obtained both from a subjective and objective point of view while blocking artifacts are completely eliminated.

SUMMARY OF THE INVENTION

In the current invention, we use a family of lapped biorthogonal transforms implementing a small number of dyadic-rational lifting steps. The resulting transform, called the LiftLT, not only has high computation speed but is well-suited to implementation via VLSI.

Moreover, it also consistently outperforms state-of-the-art wavelet based coding systems in coding performance when the same quantizer and entropy coder are used. The LiftLT is a lapped biorthogonal transform using lifting steps in a modular lattice structure, the result of which is a fast, efficient, and robust encoding system. With only 1 more multiplication (which can also be implemented with shift-and-add operations), 22 more additions, and 4 more delay elements compared to the bare DCT, the LiftLT offers a fast, low-cost approach capable of straightforward VLSI implementation while providing reconstructed images which are high in quality, both objectively and subjectively. Despite its simplicity, the LiftLT provides a significant improvement in reconstructed image quality over the traditional DCT in that blocking is completely eliminated while at medium and high compression ratios ringing artifacts are reasonably contained. The performance of the LiftLT surpasses even that of the well-known 9/7-tap biorthogonal wavelet transform with irrational coefficients. The LiftLT's block-based structure also provides several other advantages: supporting parallel processing mode, facilitating region-of-interest coding and decoding, and processing large images under severe memory constraints.

Most generally, the current invention is an apparatus for block coding of windows of digitally represented images comprising a chain of lattices of lapped transforms with dyadic rational lifting steps. More particularly, this invention is a system of electronic devices which codes, stores or transmits, and decodes M×M sized blocks of digitally represented images, where M is an even number. The main block transform structure comprises a transform having M channels numbered 0 through M−1, half of said channel numbers being odd and half being even; a normalizer with a dyadic rational normalization factor in each of said M channels; two lifting steps with a first set of identical dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration, M/2 delay lines in the odd numbered channels; two inverse lifting steps with the first set of dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration; and two lifting steps with a second set of identical dyadic rational coefficients connecting each pair of adjacent odd numbered channels; means for transmission or storage of the transform output coefficients; and an inverse transform comprising M channels numbered 0 through M−1, half of said channel numbers being odd and half being even; two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent odd numbered channels; two lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration; M/2 delay lines in the even numbered channels; two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration; a denormalizer with a dyadic rational inverse normalization factor in each of said M channels; and a base inverse transform having M channels numbered 0 through M−1.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a polyphase representation of a linear phase perfect reconstruction filter bank.

FIG. **2** shows the most general lattice structure for linear phase lapped transforms with filter length L=KM.

FIG. **3** shows the parameterization of an invertible matrix via the singular value decomposition.

FIG. **4** portrays the basic butterfly lifting configuration.

FIG. **5** depicts the analysis LiftLT lattice drawn for M=8.

FIG. **6** depicts the synthesis LiftLT lattice drawn for M=8.

FIG. **7** depicts a VLSI implementation of the analysis filter bank operations.

FIG. **8** shows frequency and time responses of the 8×16 LiftLT: Left: analysis bank. Right: synthesis bank.

FIG. **9** portrays reconstructed "Barbara" images at 1:32 compression ratio.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Typically, a block transform for image processing is applied to a block (or window) of, for example, 8×8 group of pixels and the process is iterated over the entire image. A biorthogonal transform in a block coder uses as a decomposition basis a complete set of basis vectors, similar to an orthogonal basis. However, the basis vectors are more general in that they may not be orthogonal to all other basis vectors. The restriction is that there is a "dual" basis to the original biorthogonal basis such that every vector in the original basis has a "dual" vector in the dual basis to which it is orthogonal. The basic idea of combining the concepts of biorthogonality and lapped transforms has already appeared in the prior art. The most general lattice for M-channel linear phase lapped biorthogonal transforms is presented in T. D. Tran, R. de Queiroz, and T. Q. Nguyen, "The generalized lapped biorthogonal transform," ICASSP, pp. 1441–1444, Seattle, May 1998, and in T. D. Tran, R. L. de Queiroz, and T. Q. Nguyen, "Linear phase perfect reconstruction filter bank: lattice structure, design, and application in image coding" (submitted to EEE Trans. on Signal Processing, April 1998). A signal processing flow diagram of this well-known generalized filter bank is shown in FIG. **2**.

In the current invention, which we call the Fast LiftLT, we apply lapped transforms based on using fast lifting steps in an M-channel uniform linear-phase perfect reconstruction filter bank, according to the generic polyphase representation of FIG. **1**. In the lapped biorthogonal approach, the polyphase matrix E(z) can be factorized as

$$E(z) = G_{K-1}(z)G_{K-2}(z)\ \ldots\ G(z)E_0(z), \tag{1}$$

where

$$G_i(z) = \frac{1}{2}\begin{bmatrix} U_i & 0 \\ 0 & V_i \end{bmatrix}\begin{bmatrix} I & I \\ I & -I \end{bmatrix}\begin{bmatrix} I & 0 \\ 0 & z^{-1}I \end{bmatrix}\begin{bmatrix} I & I \\ I & -I \end{bmatrix} \tag{2}$$

$$= \frac{1}{2}\Phi_i \times W \times \Lambda \times W, \text{ and}$$

$$E_0(z) = \frac{1}{\sqrt{2}}\begin{bmatrix} U_0 & U_0J_{M/2} \\ V_0J_{M/2} & -V_0 \end{bmatrix}. \tag{3}$$

In these equations, I is the identity matrix, and J is the matrix with 1's on the anti-diagonal.

The transform decomposition expressed by equations (1) through (3) is readily represented, as shown in FIG. 2, as a complete lattice replacing the "analysis" filter bank E(z) of FIG. 1. This decomposition results in a lattice of filters having length L=KM. (K is often called the overlapping factor.) Each cascading structure $G_1(z)$ increases the filter length by M. All U_i and V_i, i=0,1, . . . , K−1, are arbitrary M/2×M/2 invertible matrices. According to a theorem well known in the art, invertible matrices can be completely represented by their singular value decomposition (SVD), given by

$$U_i=U_{i0}\Gamma_iU_{i1},\ V_i=V_{i0}\Delta_iV_{i1}$$

where U_{i0}, U_{i1}, V_{i0}, V_{i1} are diagonalizing orthogonal matrices and Γ_i, Δ_i are diagonal matrices with positive elements.

It is well known that any M/2×M/2 orthogonal matrix can be factorized into M(M−2)/8 plane rotations θ_i and that the diagonal matrices represent simply scaling factors α_i. Accordingly, the most general LT lattice consists of KM(M−2)/2 two dimensional rotations and 2M diagonal scaling factors α_i. Any invertible matrix can be expressed as a sequence of pairwise plane rotations θ and scaling factors α_i as shown in FIG. 3.

It is also well known that a plane rotation can be performed by 3 "shears":

$$\begin{bmatrix}\cos\theta_i & -\sin\theta_i\\ \sin\theta_i & \cos\theta_i\end{bmatrix}=\begin{bmatrix}1 & \frac{\cos\theta_i-1}{\sin\theta_i}\\ 0 & 1\end{bmatrix}\begin{bmatrix}1 & 0\\ \sin\theta_i & 1\end{bmatrix}\begin{bmatrix}1 & \frac{\cos\theta_i-1}{\sin\theta_i}\\ 0 & 1\end{bmatrix}.$$

This can be easily verified by computation

Each of the factors above is capable of a "lifting" step in signal processing terminology. The product of two which effects a linear transform of pairs of coefficients:

$$\begin{bmatrix}a\\ b\end{bmatrix}\rightarrow\begin{bmatrix}1+km & k\\ m & 1\end{bmatrix}\times\begin{bmatrix}a\\ b\end{bmatrix}.$$

The signal processing flow diagram of this operation is shown in FIG. 4. The crossing arrangement of these flow paths is also referred to as a butterfly configuration. Each of the above "shears" can be written as a lifting step.

Combining the foregoing, the shears referred to can be expressed as computationally equivalent "lifting steps" in signal processing. In other words, we can replace each "rotation" by 3 closely-related lifting steps with butterfly structure. It is possible therefore to implement the complete LT lattice shown in FIG. 2 by 3KM(−2)/2 lifting steps and 2M scaling multipliers.

In the simplest but currently preferred embodiment, to minimize the complexity of the transform we choose a small overlapping factor K=2 and set the initial stage E_0 to be the DCT itself Many other coding transforms can serve for the base stage instead of the DCT, and it should be recognized that many other embodiments are possible and can be implemented by one skilled in the art of signal processing.

Following the observation in H. S. Malvar, "Lapped biorthogonal transforms for transform coding with reduced blocking and ringing artifacts," ICASSP97, Munich, April 1997, we apply a scaling factor to the first DCT's antisymmetric basis to generate synthesis LT basis functions whose end values decay smoothly to exact zero—a crucial advantage in blocking artifacts elimination. However, instead of scaling the analysis by $\sqrt{2}$ and the synthesis by $1/\sqrt{2}$, we opt for 25/16 and its inverse 16/25 since they allow the implementation of both analysis and synthesis banks in integer arithmetic. Another value that works almost as well as 25/16 is 5/4. To summarize, the following choices are made in the first stage: the combination of U_{00} and V_{00} with the previous butterfly form the DCT;

$$\Delta_0=\operatorname{diag}\left[\frac{25}{16},1,\ \ldots\ ,1\right],$$

and $\Gamma_o=U_{00}=V_{00}=I_{M/2}$. See FIG. 2.

After 2 series of ±1 butterflies W and the delay chain Λ(z), the LT symmetric basis functions already have good attenuation, especially at DC (ω=0). Hence, we can comfortably set $U_1=I_{M/2}$.

As noted, V_1 is factorizable into a series of lifting steps and diagonal scalings. However, there are several problems: (i) the large number of lifting steps is costly in both speed and physical real-estate in VLSI implementation; (ii) the lifting steps are related; (iii) and it is not immediately obvious what choices of rotation angles will result in dyadic rational lifting multipliers. In the current invention, we approximate V_1 by (M/2)−1 combinations of block-diagonal predict-and-update lifting steps, i.e.,

$$\begin{bmatrix}1 & u_i\\ 0 & 1\end{bmatrix}\times\begin{bmatrix}1 & 0\\ -p_i & 1\end{bmatrix}.$$

Here, the free parameters u_i and p_i can be chosen arbitrarily and independently without affecting perfect reconstruction. The inverses are trivially obtained by switching the order and the sign of the lifting steps. Unlike popular lifting implementations of various wavelets, all of our lifting steps are of zero-order, namely operating in the same time epoch. In other words, we simply use a series of 2×2 upper or lower diagonal matrices to parameterize the invertible matrix V_1.

Most importantly, fast-computable VLSI-friendly transforms are readily available when u_i and p_i are restricted to dyadic rational values, that is, rational fractions having (preferably small) powers of 2 denominators. With such coefficients, transform operations can for the most part be reduced to a small number of shifts and adds. In particular, setting all of the approximating lifting step coefficients to −1/2 yields a very fast and elegant lapped transform. With this choice, each lifting step can be implemented using only one simple bit shift and one addition.

The resulting LiftLT lattice structures are presented in FIGS. 5 and 6. The analysis filter shown in FIG. 5 comprises a DCT block 1, 25/16 normalization 2, a delay line 3 on four of the eight channels, a butterfly structured set of lifting steps 5, and a set of four fast dyadic lifting steps 6. The frequency and impulse responses of the 8×16 LiftLT's basis functions are depicted in FIG. 8.

The inverse or synthesis lattice is shown in FIG. 6. This system comprises a set of four fast dyadic lifting steps 11, a butterfly-structured set of lifting steps 12, a delay line 13 on four of the eight channels, 16/25 inverse normalization 14, and an inverse DCT block 15. FIG. 7 also shows the frequency and impulse responses of the synthesis lattice.

The LiftLT is sufficiently fast for many applications, especially in hardware, since most of the incrementally added computation comes from the 2 butterflies and the 6 shift-and-add lifting steps. It is faster than the type-I fast LOT described in H. S. Malvar, Signal Processing with Lapped Transforms, Artech House, 1992. Besides its low complexity, the LiftLT possesses many characteristics of a high-performance transform in image compression: (i) it has high energy compaction due to a high coding gain and a low attenuation near DC where most of the image energy is concentrated; (ii) its synthesis basis functions also decay smoothly to zero, resulting in blocking-free reconstructed images.

Comparisons of complexity and performance between the LiftLT and other popular transforms are tabulated in Table 1 and Table 2. The LiftLT's performance is already very close to that of the optimal generalized lapped biorthogonal transform, while its complexity is the lowest amongst the transforms except for the DCT.

To assess the new method in image coding, we compared images coded and decoded with four different transforms:

DCT: 8-channel, 8-tap filters

Type-I Fast LOT: 8-channel, 16-tap filters

LiftLT: 8-channel, 16-tap filters

Wavelet: 9/7-tap biorthogonal.

In this comparison, we use the same SPIHT's quantizer and entropy coder, A. Said and W. A. Pearlman, "A new fast and efficient image coder based on set partitioning in hierarchical trees," IEEE Trans on Circuits Syst. Video Tech., vol. 6, pp. 243–250, June 1996, for every transform. In the block-transform cases, we use the modified zero-tree structure in T. D. Tran and T. Q. Nguyen, "A lapped transform embedded image coder," ISCAS, Monterey, May 1998, where each block of transform coefficients is treated analogously to a full wavelet tree and three more levels of decomposition are employed to decorrelate the DC subband further.

Table 1 contains a comparison of the complexity of these four coding systems, comparing numbers of operations needed per 8 transform coefficients:

Transform	No. Multiplications	No. Additions	No. Shifts
8 × 8 DCT	13	29	0
8 × 16 Type-I Fast LOT	22	54	0
917 Wavelet, 1-level	36	56	0
8 × 6 Fast LiftLT	14	51	6

In such a comparison, the number of multiplication operations dominates the "cost" of the transform in terms of computing resources and time, and number of additions and number of shifts have negligible effect. In this table, it is clear that the fast LiftLT is almost as low as the DCT in complexity and more than twice as efficient as the wavelet transform.

Table 2 sets forth a number of different performance measures for each of the four methods:

Transform	Coding Gain (dB)	DC Atten. (−dB)	Stopband Atten. (−dB)	Mir. Freq. Atten. (−dB)
8 × 8 DCT	8.83	310.62	9.96	322.1
8 × 16 Type-I Fast LOT	9.2	309.04	17.32	314.7
8 × 16 Optional LT	9.62	327.4	13.5	55.54
8 × 16 Fast LiftLT	9.54	312.56	13.21	304.85

The fast LiftLT is comparable to the optional 8×16 LT transform in coding gain and stopband attenuation an significantly better than the DCT.

Reconstructed images for a standard 512×512 "Barbara" test image at 1:32 compression ratio are shown in FIG. 9 for aesthetic and heuristic evaluation. Top left **21** is the reconstructed image for the 8×8 DCT (27.28 dB PSNR); top right shows the result for the 8×16 LOT(28.71 dB PSNR); bottom left is the 9/7 tap wavelet reconstruction (27.58 dB PSNR); and bottom right, 8×16 LiftLT (28.93 dB PSNR). The objective coding results for standard 512×512 "Lena," "Goldhill," and "Barbara" test image (PSNR in dB's) are tabulated in Table 3:

	Lena				Goldhill				Barbara			
Comp. Ratio	9/7 WL SPIHT	8 × 8 DCT	8 × 16 LOT	8 × 16 LiftLT	9/7 WL SPIHT	8 × 8 DCT	8 × 16 LOT	8 × 16 LiftLT	9/7 WL SPIHT	8 × 8 DCT	8 × 16 LOT	8 × 16 LiftLT
8	40.41	39.91	40.02	40.21	36.55	36.25	36.56	36.56	36.41	36.31	37.22	37.57
16	37.21	36.38	36.69	37.11	33.13	32.76	33.12	33.22	31.4	31.11	32.52	32.82
32	34.11	32.9	33.49	34	30.56	30.07	30.52	30.63	27.58	27.28	28.71	28.93
64	31.1	29.67	30.43	30.9	28.48	27.93	28.34	28.54	24.86	24.58	25.66	25.93
100	29.35	27.8	28.59	29.03	27.38	26.65	27.08	27.28	23.76	23.42	24.32	24.5
128	28.38	26.91	27.6	28.12	26.73	26.01	26.46	26.7	23.35	22.68	23.36	23.47

PSNR is an acronym for power signal to noise r-atio and represents the logarithm of the ratio of maximum amplitude squared to the mean square error of the reconstructed signal expressed in decibels (dB).

The LiftLT outperforms its block transform relatives for all test images at all bit rates. Comparing to the wavelet transform, the LiftLT is quite competitive on smooth images—about 0.2 dB below on Lena. However, for more complex images such as Goldhill or Barbara, the LiftLT consistently surpasses the 9/7-tap wavelet. The PSNR improvement can reach as high as 1.5 dB.

FIG. 9 also shows pictorially the reconstruction performance in Barbara images at 1:32 compression ratio for heuristic comparison. The visual quality of the LiftLT reconstructed image is noticeably superior. Blocking is completely avoided whereas ringing is reasonably contained. Top left: 8×8 DCT, 27.28 dB. Top right: 8×16 LOT, 28.71 dB. Bottom left: 9/7-tap wavelet, 27.58 dB. Bottom right: 8×16 LiftLT, 28.93 dB. Visual inspection indicates that the LiftLT coder gives at least as good performance as the wavelet coder. The appearance of blocking artifacts in the DCT reconstruction (upper left) is readily apparent. The LOT transform result (upper right) suffers visibly from the same artifacts even though it is lapped. In addition, it is substantially more complex and therefore slower than the DCT transform. The wavelet transform reconstruction (lower left) shows no blocking and is of generally high quality for this level of compression. It is faster than the LOT but significantly slower than the DCT. Finally, the results of the LiftLT transform are shown at lower right.

Again, it shows no blocking artifacts, and the picture quality is in general comparable to that of the wavelet transform reconstruction, while its speed is very close to that of the bare DCT.

We claim:

1. An apparatus for coding, storing or transmitting, and decoding M×M sized blocks of digitally represented images, where M is an even number, comprising

a. a forward transform comprising
  i. a base transform having M channels numbered 0 through M−1, half of said channel numbers being odd and half being even;
  ii. an equal normalization factor in each of the M channels selected to be dyadic-rational;
  iii. a full-scale butterfly implemented as a series of lifting steps with a first set of dyadic rational coefficients;
  iv. M/2 delay lines in the odd numbered channels;
  v. a full-scale butterfly implemented as a series of lifting steps with said first set of dyadic rational coefficients; and
  vi. a series of lifting steps in the odd numbered channels with a second specifically selected set of dyadic-rational coefficients;
b. means for transmission or storage of the transform output coefficients; and
c. an inverse transform comprising
  i. M channels numbered 0 through M−1, half of said channel numbers being odd and half being even;
  ii. a series of inverse lifting steps in the odd numbered channels with said second set of specifically selected dyadic-rational coefficients;
  iii. a full-scale butterfly implemented as a series of lifting steps with said first set of specifically selected dyadic-rational coefficients;
  iv. M/2 delay lines in the even numbered channels;
  v. a full-scale butterfly implemented as a series of lifting steps with said first set of specifically selected dyadic-rational coefficients;
  vi. an equal denormalization factor in each of the M channels specifically selected to be dyadic-rational; and
  vii. a base inverse transform having M channels numbered 0 through M−1.

2. The apparatus of claim 1 in which the normalizing factor takes the value 25/16 and simultaneously the denormalizing factor takes the value 16/25.

3. The apparatus of claim 1 in which the normalizing factor takes the value 5/4 and simultaneously the denormalizing factor takes the value 4/5.

4. The apparatus of claim 1 in which the first set of dyadic rational coefficients are all equal to 1.

5. The apparatus of claim 1 in which the second set of dyadic rational coefficients are all equal to ½.

6. The apparatus of claim 1 in which the base transform is any M×M invertible matrix of the form of a linear phase filter and the inverse base transform is the inverse of said M×M invertible matrix.

7. The apparatus of claim 1 in which the base transform is the forward M×M discrete cosine transform and the inverse base transform is the inverse M×M discrete cosine transform.

8. An apparatus for coding, compressing, storing or transmitting, and decoding a block of M×M intensities from a digital image selected by an M×M window moving recursively over the image, comprising:

a. an M×M block transform comprising:
  i. an initial stage
  ii. a normalizing factor in each channel
b. a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising
  i. a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;
  ii. a bank of delay lines in a first group of M/2 alternating lines;
  iii. a second bank of butterfly lifting steps with unitary coefficients, and
  iv. a bank of pairs of butterfly lifting steps with coefficients of 1/2 between M/2−1 pairs of said M/2 alternating lines;
c. means for transmission or storage of the output coefficients of said M×M block transform; and
d. an inverse transform comprising
  i. a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising
    a) a bank of pairs of butterfly lifting steps with coefficients of 1/2 between said M/2−1 pairs of said M/2 alternating lines;
    b) a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;
    c) a bank of delay lines in a second group of M/2 alternating lines[,]; and
    d) a second bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;
  ii. a de-scaling bank[,]; and
  iii. an inverse initial stage.

9. A method of coding, storing or transmitting, and decoding M×M sized blocks of digitally represented images, where M is [an even number] *a power of 2*, comprising

a. transmitting the original picture signals to a coder, which effects the steps of
  i. converting the signals with a base transform having M channels numbered 0 through M−1, half of said channel numbers being odd and half being even[,];
  ii. normalizing the output of the preceding step with a dyadic rational normalization factor in each of said M channels;
  iii. processing the output of the preceding step through two lifting steps with a first set of identical dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;
  iv. transmitting the resulting coefficients through M/2 delay lines in the odd numbered channels;
  v. processing the output of the preceding step through two inverse lifting steps with the first set of dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration; and
  vi. applying two lifting steps with a second set of identical dyadic rational coefficients connecting each pair of adjacent odd numbered channels to the output of the preceding step;
b. transmitting or storing the transform output coefficients;
c. receiving the transform output coefficients in a decoder; and
d. processing the output coefficients in a decoder, comprising the steps of
  i. receiving the coefficients in M channels numbered 0 through M−1, half of said channel numbers being odd and half being even;
  ii. applying two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent odd numbered channels;

iii. applying two lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;

iv. transmitting the result of the preceding step through M/2 delay lines in the even numbered channels;

v. applying two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;

vi. denormalizing the result of the preceding step with a dyadic rational inverse normalization factor in each of said M channels; and

vii. processing the result of the preceding step through a base inverse transform having M channels numbered 0 through M−1.

10. A method of coding, compressing, storing or transmitting, and decoding a block of M×M intensities from a digital image selected by an M×M window moving recursively over the image, comprising the steps of:

a. Processing the intensities in an M×M block coder comprising the steps of:
   i. processing the intensities through an initial stage;
   ii. scaling the result of the preceding step in each channel;

b. processing the result of the preceding step through a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising
   i. a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;
   ii. a bank of delay lines in a first group of M/2 alternating lines;
   iii. a second bank of butterfly lifting steps with unitary coefficients, and
   iv. a bank of pairs of butterfly lifting steps with coefficients of 1/2 between M/2−1 pairs of said M/2 alternating lines;

c. transmitting or storing the output coefficients of said M×M block coder;

d. receiving the output coefficients in a decoder; and

e. processing the output coefficients in the decoder, comprising the steps of
   i. processing the output coefficients through a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising
      a) a bank of pairs of butterfly lifting steps with coefficients of 1/2 between said M/2−1 pairs of said M/2 alternating lines;
      b) a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;
      c) a bank of delay lines in a second group of M/2 alternating lines;
      d) a second bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;
      e) a de-scaling bank; and

f. processing the results of the preceding step in an inverse initial stage.

11. The apparatus of claim 1 in which the [constants] *coefficients* are approximations chosen for rapid computing rather than exact [constants] *coefficients*.

12. A method of coding, storing or transmitting, and decoding a block of M×M intensities from a digital image selected by an M×M window moving recursively over the image, comprising:

a. processing the intensities in an M×M block coder comprising the steps of:
   i. processing the intensities through an initial stage;
   ii. scaling the result of the preceding step in each channel;

b. processing the result of the preceding step through a transform coder using a method of processing blocks of samples of digital signals of integer length M comprising processing the digital samples of length M with an invertible linear transform of dimension M, said transform being representable as a cascade, using the steps, in arbitrary order, of:
   i) at least one +/−1 butterfly step,
   ii) at least one lifting step with rational complex coefficients, and
   iii) at least one scaling factor;

c. transmitting or storing the output coefficients of said M×M block coder;

d. receiving the output coefficients in a decoder; and

e. processing the output coefficients in the decoder into a reconstructed image using the inverse of the coder of steps a. and b.

13. The method of claim 12 wherein the method of processing blocks of samples of digital signals of integer length M additionally comprises the step of at least one time delay.

14. The method of claim 12, wherein the rational complex coefficients in the at least one lifting step are dyadic.

15. The method of claim 12, wherein

a) said invertible transform is an approximation of a biorthogonal transform;

b) said biorthogonal transformation comprises a representation as a cascade of at least one butterfly step, at least one orthogonal transform, and at least one scaling factor;

c) said at least one orthogonal transform comprises a cascade of
   i) at least one ±1 butterfly step,
   ii) at least one planar rotation, and
   iii) at least one scaling factor;

b) said at least one planar rotation being represented by equivalent lifting steps and scale factors; and,

c) said approximation is obtained by replacing floating point coefficients in the lifting steps with rational coefficients.

16. The method of claim 15, wherein the coefficients of the lifting steps are chosen to be dyadic rational.

17. The method of claim 12, wherein the invertible transform is a unitary transform.

18. The method of claim 12, wherein

a) said invertible transform is an approximation of a unitary transform;

b) said approximation of the unitary transform comprises a representation of the unitary transform as a cascade of at least one butterfly step, at least one orthogonal transform, and at least one scale factor;

c) said at least one orthogonal transform being represented as a cascade of
   (1) at least one ±1 butterfly steps,
   (2) at least one planar rotation, and
   (3) at least one scaling factor;

d) said at least one planar rotation being represented by equivalent lifting steps and scale factors; and,

e) said approximation being derived by using approximate rational values for the coefficients in the lifting steps.

19. The method of claim 18, wherein the invertible transform is an approximation of a transform selected from the group of special unitary transforms: discrete cosine transform (DCT); discrete Fourier transform (DFT); discrete sine transform (DST).

20. The method of claim 18, wherein the coefficients of the lifting steps are dyadic rational.

21. The method of claim 18, wherein at least one of the following lifting steps is used, whose matrix representations take on the form:

$$\begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ b & 1 \end{bmatrix},$$

where a, b are selected from the group:

±{8, 5, 4, 2, 1, ½, ¼, ¾, 5/4, 1/8, 3/8, 2/5, 5/8, 7/8, 1/16, 3/16, 5/16, 7/16, 9/16, 11/16, 13/16, 15/16, 25/16}.

22. The method of claim 21, wherein the invertible transform is an approximation of a transform selected from the group: discrete cosine transform (DCT); discrete Fourier transform (DFT); discrete sine transform (DST).

23. The method of claim 22, wherein the approximation of the 4 point DCT is selected from the group of matrices:

$$\left\{\begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}, \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -2 & 2 & -1 \end{bmatrix}, \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 5 & -2 & 2 & -5 \end{bmatrix}\right\}.$$

24. The method of claim 19 in which the invertible transform is an approximation of a transform selected from the group three point DCT, 4 point DCT, 8 point DCT, and 16 point DCT.

25. The method of claim 19 in which the invertible transform is an approximation of a transform selected from the group 512 point FFT, 1024 point FFT, 2048 point FFT, and 4096 point FFT.

26. A method of coding, storing or transmitting, and decoding sequences of intensities of integer length M recursively selected from a time ordered string of intensities arising from electrical signals, the method comprising the steps of

a) recursively processing the sequences of intensities of integer length M with an invertible forward linear transform of dimension M, said transform being representable as a cascade using the steps, in a preselected arbitrary order, of:
   ii) at least one ±1 butterfly step,
   iii) at least one lifting step with rational complex coefficients, and
   iv) applying at least one scaling factor;

b) compressing the resulting transform coefficients;

c) storing or transmitting the compressed transform coefficients;

d) receiving or recovering from storage the transmitted or stored compressed transform coefficients;

e) decompressing the received or recovered compressed transform coefficients; and

f) recursively processing the decompressed transform coefficients with the inverse of the forward linear transform of dimension M, said inverse transform being representable as a cascade using the steps, in the exact reverse order of the preselected arbitrary order, of:
   ii) at least one inverse butterfly corresponding to each of the at least one ±1 butterfly step;
   iii) at least one inverse lifting step corresponding to each of the at least one lifting step with rational complex coefficients; and,
   iv) applying at least on inverse scaling factor corresponding to the at least one scaling factor.

27. The method of claim 26 wherein the method of processing blocks of samples of digital signals of integer length M additionally comprises the step of at least one time delay.

28. The method of claim 26, wherein the rational complex coefficients in the at least one lifting step are dyadic.

29. The method of claim 26, wherein

a) said invertible transform is an approximation of a biorthogonal transform;

b) said biorthogonal transformation comprises a representation as a cascade of at least one butterfly step, at least one orthogonal transform, and at least one scaling factor;

c) said at least one orthogonal transform comprising a cascade of
   i) at least one ±1 butterfly step,
   ii) at least one planar rotation, and
   iii) at least one scaling factor;

b) said at least one planar rotation being represented by equivalent lifting steps and scale factors; and,

c) said approximation being obtained by replacing floating point coefficients in the lifting steps with rational coefficients.

30. The method of claim 29, wherein the coefficients of the lifting steps are chosen to be dyadic rational.

31. The method of claim 26, wherein the invertible transform is a unitary transform.

32. The method of claim 26, wherein

a) said invertible transform is an approximation of a unitary transform;

b) said approximation of the unitary transform comprises a representation of the unitary transform as a cascade of at least one butterfly step, at least one orthogonal transform, and at least one scale factor;

c) said at least one orthogonal transform being represented as a cascade of
   (1) at least one ±1 butterfly steps,
   (2) at least one planar rotation, and
   (3) at last one scaling factor;

d) said at least one planar rotation being represented by equivalent lifting steps and scale factors; and,

e) said approximation being derived by using approximate rational values for the coefficients in the lifting steps.

33. The method of claim 32, wherein the invertible transform is an approximation of a transform selected from the group of special unitary transforms: discrete cosine transform (DCT); discrete Fourier transform (DFT); discrete sine transform (DST).

34. The method of claim 32, wherein the coefficients of the lifting steps are dyadic rational.

35. The method of claim 32, wherein at least one of the following lifting steps is used, whose matrix representations take on the form:

$$\begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ b & 1 \end{bmatrix},$$

where a, b are selected from the group:

$$\pm\{8, 5, 4, 2, 1, 1/2, 1/4, 3/4, 5/4, 1/8, 3/8, 2/5, 5/8, 7/8, 1/16, 3/16, 5/16, 7/16, 9/16, 11/16, 13/16, 15/16, 25/16\}.$$

36. The method of claim 35, wherein the invertible transform is an approximation of a transform selected from the group: discrete cosine transform (DCT); discrete Fourier transform (DFT); discrete sine transform (DST).

37. The method of claim 36, wherein the approximation of the 4 point DCT is selected from the group of matrices:

$$\left\{\begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}, \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -2 & 2 & -1 \end{bmatrix}, \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 5 & -2 & 2 & -5 \end{bmatrix}\right\}.$$

38. The method of claim 33 in which the invertible transform is an approximation of a transform selected from the group three point DCT, 4 point DCT, 8 point DCT, and 16 point DCT.

39. The method of claim 33 in which the invertible transform is an approximation of a transform selected from the group 512 point FFT, 1024 point FFT, 2048 point FFT, and 4096 point FFT.

* * * * *

Exhibit B

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November 7, 2012

VIA FEDEX

Lanny Raimondo, CEO
Technicolor, Inc.
6040 Sunset Boulevard, 6th Floor
Hollywood, CA 90028

Re: FastVDO LLC and United States Patent No. RE 40,081

Dear Mr. Raimondo:

Russ, August & Kabat has been engaged by FastVDO LLC, which owns valuable intellectual property in the field of video coding and in particular U.S. Reissue Patent No. 40,081 to Dr. Pankaj Topiwala et al ("the FastVDO patent"), entitled "Fast Signal Transforms with Lifting Steps." The FastVDO patent claims a novel video coder that includes a block coder and a transform coder using an invertible linear transform representable as a cascade of at least one butterfly step, at least one lifting step and at least one scaling step. Dr. Topiwala disclosed this special video coder to the ITU ("International Telecommunications Union") standards committee, and it was adopted as an essential part of the H.264 video coding standard. We have completed an analysis of your products and services and believe that your company, including its subsidiaries and/or affiliates, such as Technicolor USA, Inc., makes, uses, or sells products or services that would benefit from a license to this patent. For your convenience, I have enclosed a copy of the FastVDO patent.

More specifically, your digital media devices, software, equipment, and services, such as Home Network Media Tablet, Media Touch 2, DSI803 HD DVR Set-Top Box, the Tiger AVC encoding system, and its BD/DVD Compression & Authoring services, are advertised as meeting the H.264 standard. By making, using, or selling these products or methods for coding that include a video coder using, among other things, an invertible linear transform representable with at least one of each of a butterfly step, a lifting step, and a scaling step – the same coding process specified by the H.264 standard you are infringing the FastVDO patent. Additionally, you are causing one or more claims of the FastVDO patent to be performed with your marketing materials, advertising materials, manuals and customer support services, which promote the ability of your products to code and/or decode with H.264 and assist your customers' use of these features.

FastVDO prefers to avoid the need for protracted litigation and is open to discussing a license to the FastVDO patent. I look forward to hearing from you to discuss these matters.

Very truly yours,

Russ, August & Kabat

/s/ Alexander C.D. Giza

Alexander C.D. Giza

Enclosures

Exhibit C

CREATE | MANAGE | DELIVER | DISCOVER

technicolor

HOME NETWORK MEDIA TABLET

AN INNOVATIVE SERVICE PLATFORM

OUR VALUE PROPOSITION

- The Home Network Media Tablet has been defined to:
  - Consume online and home audio and video
  - Access the web and its unlimited set of applications
  - Interact with other equipments thanks to its set of open interfaces
- The Home Network Media Tablet is a platform that helps generate new revenue streams from more value added services through tailored content and applications
- The Home Network Media Tablet provides a new and exciting way for end-users to enjoy entertainment, information, communication services and much more anywhere in their home
- Androïd Operating System provides a fast-growing community of applications developers

The Home Network Media Tablet:

- Connected device for DSL, Cable & Satellite operators
- Portable at home / WiFi 802.11n
- Multitouch capacitive touch-screen
- Excellent user experience
- Deployed with leading service providers

OUTSTANDING USER EXPERIENCE

KEY FEATURES FOR THE END USER

Our second generation Home Network Media Tablet offers multi-screen interactivity, high quality communications and home control, in addition to great ease of use and a customizable interface.

Connect Communities thanks to a full package of communication features:

- Its microphone and camera offer native online chat possibilities,
- Voice over IP telephony and high-end video communications,
- All integrated with users' favourite social networks.

Entertain Consumers thanks to its strong media assets:

- The end-users can easily consume online and personal audio/video content.
- Its high quality sound and video capability positions it to ideally enjoy multi-screen synchronized media.

Control the Home and Interact with other equipments:

- Through its set of open interfaces, this new generation of Media Tablet is a truly advanced remote control for digital home services and devices, such as set-top boxes.
- Its hardware platform offers the flexibility to bring additional connectivity onboard like Home Automation on wireless mode such as Zigbee or Z-Wave.

Many more specific applications are available upon request

Technicolor's strengths and insights are based on its extensive experience of working with service providers over many years. Technicolor is able to provide an almost infinite range of applications customized specifically for its customers' requirements.

By actively partnering with service providers to explore the market's many possibilities, Technicolor can help its customers identify the most successful and sustainable business models that can be developed through our Home Network Media Tablet platform.

ABOUT PCCW

PCCW is Hong Kong's premier telecommunications provider and a world-class player in Information & Communications Technologies, with a presence in the Americas, Europe, Africa, the Middle East, mainland China and other Asian locations. As the provider of Hong Kong's first quad-play experience, PCCW/HKT offers a range of innovative services and media content across four platforms - fixed-line, broadband internet access, TV and mobile.

PCCW CASE STUDY

Technicolor is a true pioneer in the tablet sector with many successful commercial launches around the world. PCCW is just one example of these customers. They selected Technicolor as their supplier and smoothly launched high quality IPTV, video voice calling, kids' learning and many other multimedia services over our tablet in June 2009.

Challenges

Due to the limitations of their first generation home multimedia device eye1 (a phone-like device, small sized LCD, low performance CPU, not portable, etc), PCCW wanted to develop a new generation portable terminal for home use. PCCW wanted it to be with a large screen, best-in-class WiFi connectivity, light weight but with low power demands to deliver PCCW's converged services, such as IPTV, video calls and multimedia content, to its local subscribers. They are the very first one among operators to launch such services in a WiFi environment.

Solution

Technicolor provided the best end-to-end solution for PCCW. Not only did we develop the new generation portable multimedia device for PCCW, but we also provided a variety of software applications to help PCCW customize the service package.

Benefits

- With this so called "eye2" WiFi device, PCCW is able to provide excellent user experience and more multimedia services.
- PCCW is also able to find creative ways to building new business models and stay ahead of competitors.

> Our subscribers have rapidly accepted the huge advantages of a seamless multimedia service over IP. We are so glad to launch the first and foremost 'eye 2' in Hong Kong. It embodies telephone, TV, multimedia player, infotainment and interactive functionalities. Supported by PCCW's quadruple-play platform, we put every part of the service and unique user experience into the hands of our subscribers.
>
> Tom Chan, managing director of PCCW's Consumer Group

In recognition of their achievement, PCCW was honored with other 10 winners by IPTV World Series Awards in the Most Innovative New Service category on March 2010.

WHY TECHNICOLOR?

Our Home Network Media Tablet Provides a Wide Range of Key Benefits.

For Service Providers

- Provide an exciting new user experience
- Offer more value-added services through tailored content
- Generate new revenue streams
- Retain existing broadband customers/acquire new customers
- Improve ARPU through cost-effective investment
- Lead to next generation of Digital Home

For End-Users

- 5 products in 1!
  - Phone,
  - TV,
  - Radio,
  - Digital photo frame,
  - MP4, replaced by the Wireless Multimedia v2.0
- Ease of use: just one touch to initialize the tablet
- Rich applications, content, service accessible
- Premium entertainment platform
- Advanced communication tool
- Rich information center

Complete digital home ecosystem

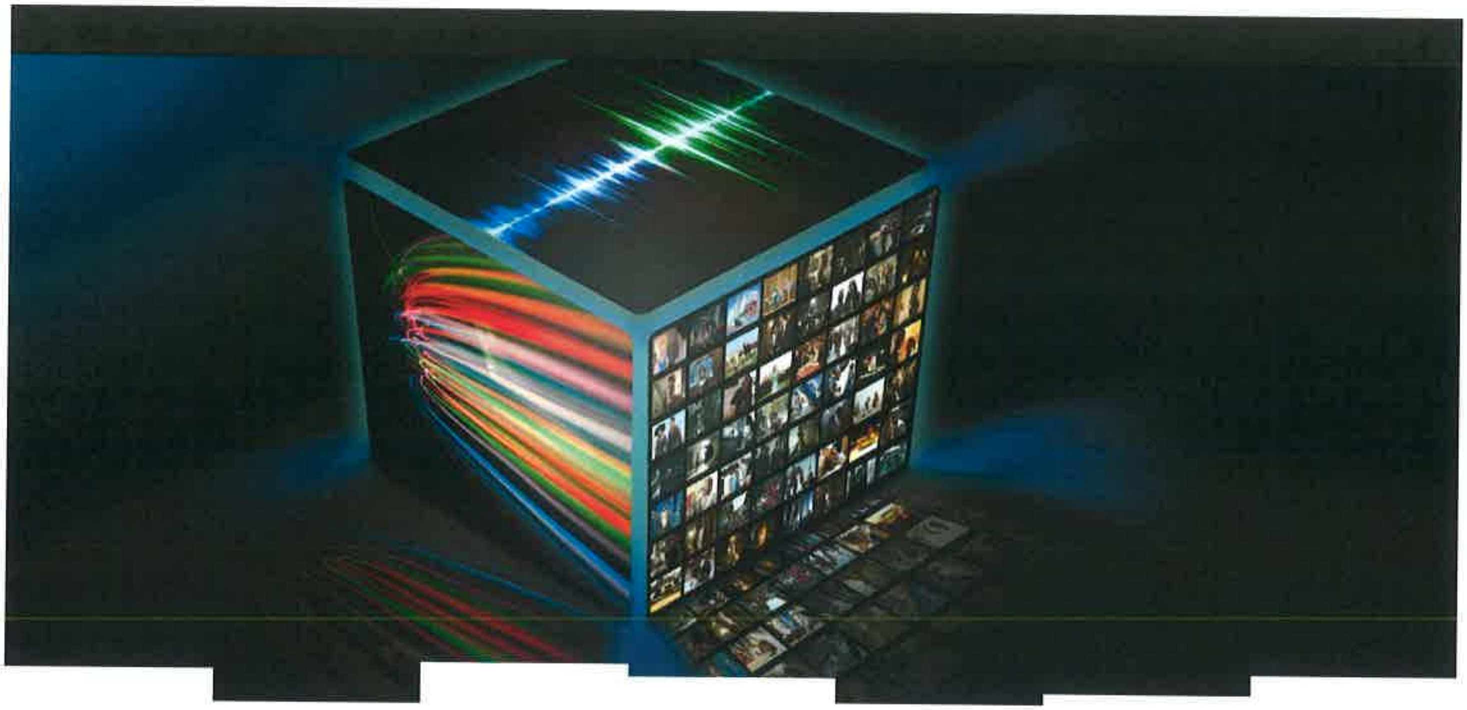
By leveraging Technicolor's know-how in connected home applications, we are able to provide a broader road map leading to end-to-end digital home networking that exploits the power and flexibility of other Technicolor products beyond just the Home Network Media Tablet. Technicolor is now developing domestic applications still further, adding richness and depth, and creating new ways for operators to monetize their offerings through innovative products and services.

Technicolor's applications currently available on the tablet cover three main domains:

My Communications

My Home Management

My Digital Content



PRODUCT OFFERING

The Home Network Media Tablet is an enhanced version of our already successful 1.0 device with substantial new improvements.

- Android OS (SDK available soon)
- Capacitive touch-screen, 7" 800x480 WVGA
- Freescale IMX51 chipset
- Up to H264 MP HD 720p decoding for high screen resolution and quality compression capability
- Supports multiple formats in processing videos, music and photos
- Intuitive and user friendly interface with ergonomic menu
- Open GL (UI animations and transitions)
- Integrated microphone and camera for video calls
- WiFi 802.11n
- 3G (optional)
- DECT (optional)

Product Packages

We fully understand the market dynamics. As a result, we offer a variety of flexible options around a state-of-art product at a highly competitive price.

- **Option A.**
  Standalone Home Network Media Tablet box
- **Option B.**
  Home Network Media Tablet box + specific applications
- **Option C.**
  Home Network Media Tablet box + specific applications + Technicolor applications server services

TECHNICAL SPECIFICATIONS

Operating System
- Android OS

Application Development
- Support for Android applications. An SDK solution for customized environment is available
- Support of HTML and Javascript based remote sites
- Support Flash plug in

Screen
- Touch-screen display 16/9: control by fingers
- High screen resolution = VGA 800 X 480 Pixels
- Screen size = 7"

Sound Quality
- 2 high quality stereo speakers (2 Watts RMS)
- Ability to plug in an external stereo headphone
- Advanced 3D sound effects

Device Control
- 4 buttons below the screen for easy navigation
- Physical buttons to instantly control volume

Content Sharing Techno
- UPnP AV profile

Power Supply
- Rechargeable batteries through its docking station,
- Battery type: L i-Ion
- Autonomy: 3 hours of video streaming in WiFi

Formats
- Music: MP3, WMA, AAC
- Video decoding: H264 (Up to H264 MP HD 720p decoding), DivX, Xvid, VC1 (wmv), H263
- Video encoding: H264, H263
- Photo: JPEG, PNG, BMP

Connectivity
- USB 2.0 host
- Jack audio/video out 3,5 mm
- SD card reader

Wireless Standard
- WiFi: 802.11 n
- 3G module available as option
- DECT available as option

Miscellaneous
- ARM cortex A8 CPU, 800MHz
- Microphone and camera integrated for video calls
- Flexible foot to optimize the angle of view when using away from its docking station
- Upgradable by air

Size
- Height: 134mm
- Length: 198mm
- Thickness: 25mm
- Weight: 600g, including battery

Accessories
- Docking station as battery charger

EXTENSIVE WORLDWIDE PRESENCE

Vancouver	Princeton	Mexico	Rennes	Piaseczno	Beijing
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telcosales@technicolor.com

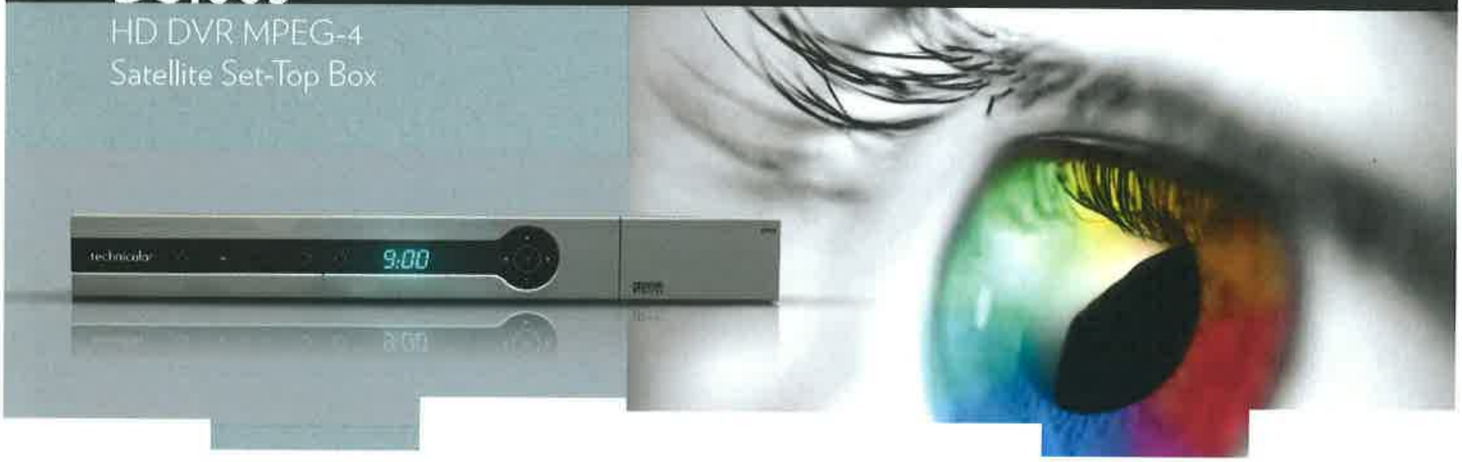
technicolor

Exhibit D

technicolor

DSI803

HD DVR MPEG-4 Satellite Set-Top Box



SATELLITE
VIDEO

Technicolor, world leader in video technologies, offers its 3rd generation HD DVR in the DSI803 series. The DSI803 represents an advancement over previous models through the integration of front end and back end silicon into a single SoC.
The high performance and customizable series will provide flexibility in design in order to support multiple customers.

Customizable Features

- RF front-end
- Industrial design (ID)
- Flexible Back panel layout and outputs: RF Mod, S-Video, 2 RCA Stereo/Video Out, V.90 Modem, Ethernet, USB 2.0, serial port, S-Video, SPIDF, Component Video, eSata, SCART
- Middleware
- c.Link ® Coaxial Home Networking

Features at a Glance

- Use of a wide range of video codecs, including MPEG-2 and MPEG-4 (H.264) in both standard and high definition (SD and HD) for highest video quality
- Advanced System on Chip (SOC) hardware architecture for video decoding and display
- Multiple DVB-S / DVB-S2 Tuners and Demods
- Single Decode HD DVR up to 500 GB hard drive
- High Definition Multi-media Interface (HDMI 1.3) with HDCP copyright protection
- Support of digital sound
- Simultaneous HD/SD video outputs
- Wide range power supply 90VAC - 265VAC

DSI803

HD DVR MPEG-4
Satellite Set-Top Box

Technical Specifications

Dual DVB-S/DVB-S2 Channel Interface

Modulation	QPSK & 8PSK
LNB power capability	2 x 350mA
LNB Control Capability	2x 22KHz DiSEqC2.0
Symbol Rates	10-30 Mbauds (DVB-S2) 5-45 Mbauds (DVB-S)
Digital Input frequency range	950 - 2150 MHz

MPEG Video Decoder

Standard	MPEG2 - MP@ML; AVC/H.264 (aka MPEG4 part 10) - HP@L4; VC1 AP@L4.
Aspect ratio	4:3, 16:9, Pan & Scan, letterbox
Video Scaling	Variable

OSD

Colors	16 / 16 million Colors
Resolution	2 to 16 bits per pixel
Overlay	MPEG stills/live image insertion Partial / full over analog video

MPEG Audio Decoder

Standard	MPEG1 layers 1-3; MPEG4 AAC – LC / HE; Dolby Digital (AC3).
Decompression	MPEG Layers 1, 2 (Mono, Dual Channel, Joint Stereo, Stereo), Dolby Digital down-mix to stereo
SPDIF audio output format	PCM (decompressed stereo), Compressed Dolby digital (5.1)

System Resources

Processor	BCM7335
System/Video RAM	From 128 to 512 Mbytes with additional video RAM if needed
FLASH	Up to 128 Mbytes

Software

Middleware Solutions	OpenTV™ Core 2.0, NDS MediaHighway™ (Fusion CDI)
Access Control	VIDEOGUARD™*, NAGRAVISION™

Common Interfaces

Main input connector	Detachable lead
Satellite Input	2 x F type
RF input	IEC-type, female or F type
RF output	IEC-type, male or F type (loopthrough)
SCART sockets	TV and VCR (with RGB loopthrough)
Analog Audio	Twin RCA Stereo audio outputs (left and right)
Analog Video	CVBS, S-Video*, Y,Pr,Pb*
Digital Audio	SPDIF audio output (electrical or optical)
Digital Video	HDMI 1.3
Ethernet Port	2x 10/100 baseT on host CPU *
PSTN Modem Port	RJ-11
USB	One or two * USB 2.0 host
Smart Card Reader	1 or 2 * slots, ISO 7816 1, 2 & 3

General Data

Safety and EMC regulations compliant	(CE marking)
Operating Temperature Range	+5°C to +45°C
Mains Voltage	90-265VAC, 47-63Hz
Power Consumption	27 watts
Lower Power Mode	15 watts
Standby Power Mode	< 1 watts
Passive Standby	EuP low power standby regulations *
Dimensions	55h x 340w x 240d mm

* can be supported as option

DSI803

HD DVR MPEG-4
Satellite Set-Top Box

Technical Specifications

Front Panel

- 4 digits – 7 segments display or light ring *
- 7 LEDs
- 13 keys max
- Smart-card slot(s) without door/flap
- Optional Bank Card

Options

- c.LINK® Coaxial Home Networking
- V22/22bis to V92 PSTN modem *
- RF modulator (UHF range) (standards : PAL B/G, I, K, D) *
- Channel 3-4 RF remodulator (NTSC) *
- RCA video output *
- Additional pair of L&R RCA audio outputs with second RCA video output (exclusive with SCARTs) *
- S-video output *
- Second smart card reader : ISO 7816 1, 2 & 3 *
- Second USB on the front panel *

RCU Protocols

- R2000 (Technicolor)
- RC-5/6 – RCMM 1.5 (Philips)
- r-STEP (Ruwido)
- NEC

Loader

- Full code software download mechanism
- Authentication of downloaded material
- CA vendor security

Other

- 250-320-500 Gbytes hard-disk drive
- Hardware support for set-top box pairing/mating

* can be supported as option

Technicolor Professional Services are available to address your demands for qualified technical support & warranty, product maintenance, access to training courses and tailor-made solutions to specific product evolution. For more information, please ask your usual contact person.

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satellitesales@technicolor.com

technicolor

Exhibit E

technicolor

Blu-ray/DVD

Compression & Authoring

Ensure the success of your Blu-ray/DVD project without compromise.

Technicolor brings a full array of services to your Blu-ray and DVD businesses to make it your single source supply chain. The level of experience and technological innovation are second to none. An efficient and streamlined Compression & Authoring process makes more efficient the delivery of feature film, video, television episodic series, trailers and added value content.

Experience

Technicolor continues to lead the way in pioneering Blu-ray and DVD technology. Proven expertise in mastering, proprietary state of the art encoding process, replication and security are the hallmarks of a trusted partner.

Innovation

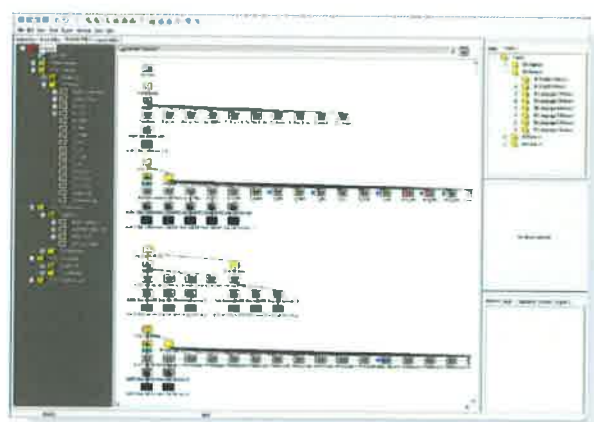
Technicolor serves its customer as a leading-edge provider of equipment, including the Tiger AVC encoder, the BD test center and JIVE author.

Flexibility

Whether it's a bundled custom solution or selections from our value chain of services, Technicolor has the services to meet your needs – from authoring to subtitling to replication. Technicolor can manage content types from high profile theatrical releases to quality for value in B and C titles.

Quality

Process and quality verification steps, vigilant oversight by trained technicians and dedicated management means Technicolor delivers consistent quality services to meet client needs and expectations.



Blu-ray/DVD Compression & Authoring

Features and Benefits

Authoring Made Easy

Technicolor leads the way with an advanced BD JIVE GUI-based Java programming framework that enables interactive content and BD Live functions. From downloading trailers, to social networking on Facebook and Twitter, and more bonus features, BD-JIVE powers the next generation of interactive media.

Security through Experience

Technicolor has led the way in securing content via its pioneering anti-piracy technology including video and audio watermarking.

State of the Art Blu-ray infrastructure

The next generation Tiger AVC encoding system and workflow manager make ingestion easy and efficient. A purpose-built optical disk compression tool, Tiger's one of the fastest most highly optimized encoders on the market. Its scene-by-scene multi-pass encoding makes for efficient workflow management.

More services that are available individually or as part of bundled packages:

- Replication
- Audio encoding
- International Versioning
- Subtitling
- Localization
- Packaging
- Menu Design
- Dubbing
- Distribution

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Exhibit F

Tiger grabs HD-DVD, Blu-ray compression by the tail

Broadcast Engineering

Nov. 21, 2006

Thomson has developed a new MPEG-4 AVC compression engine aimed at the production of HD-DVD and Blu-ray for the home movie market.

Working with the Thomson-owned Technicolor Labs, the Thomson corporate research labs in Princeton, NJ, created Tiger to be an exceptionally high quality video encoder for the HD optical disc formats that streamlines the process and delivers workflow efficiency.

HD Technology Update spoke with the general manager of the research labs, Jeffrey Cooper, to find out more about Tiger.

HD Technology Update: What are the primary strengths of the Thomson Tiger compression engine for MPEG-4 AVC?

Jeffrey Cooper: We focused on two main aspects for this tool. One was very high video quality to support HD-DVD and Blu-ray applications, and second was optimized workflow for the compression authoring service business.For optimization, we reached out to Technicolor for input, relying on their customer-side insights.

We created a special user interface that streamlined how Technicolor does their compression authoring work to make it more efficient.

HDTU: What aspects of the user interface make the process more streamlined than other encoding tools?

JC: Tiger has quite a few features that streamline and improve the encoding process. For example, it provides full thumbnails so you can navigate through the content. It allows scene-by-scene or even frame-by-frame re-encoding, with many parameters exposed to the compressionist. With these tools, compressionists can control a number of components of the frame coding process.

So, the customary workflow is, compressionists do an automatic encode, which for Tiger is a multipass process, and then they do a quality analysis viewing. Typically, they note an item here or there. What we've done enables compressionists to go back in and very quickly identify those frames that need to be modified. The advanced user interface, including the video player, is used interactively with the content to modify parameters and then perform the re-encode. In fact, compressionists can even start re-encoding some scenes before the whole quality analysis is done.

There are a lot of other features like that, which enable encoding to be more efficient and provide the compressionist with more control. There is the ability to categorize scenes depending on the content type and to notate where the scene changes are.

The encoder has a lot of smarts on its own,such as detecting scene changes and fades, but the compressionist also has those tools and they enable him to further perfect the encoding process.

HDTU: How efficient is Tiger in terms of compression?

JC: It's very efficient, we believe. Again, it's aimed at the very high quality — what we call transparent video quality — for HD-DVD and Blu-ray. The bit rates there tend to be in the teens. We've run Tiger down to 10Mb/s for these applications and achieved very good quality, transparent quality. So, we think it's definitely met its requirements.

HDTU: What strategies have been employed to assure maximum efficiency and accuracy in encoding?

JC: Any encoder of this nature has to be compliant and testing it for compliancy has been a major part of our work. There are two aspects of compliancy: H.264 compliancy and compliancy with HD-DVD and Blu-ray.

We've used several approaches and testing methods. On H.264, we've been verifying our bit streams against what I describe as golden decoders — actually several. For both H.264 and next-generation DVD formats, there are verification tools available in the industry from several different parties, and our streams go through those. Then finally, they get burned to some test discs, which are played on all the devices in the industry that are available.
So, it's been quite a big effort to make sure Tiger is compliant, and I really believe we have perhaps one of the most compliant encoders in the industry right now. High definition is still a pretty young DVD format. It's just emerging, so there's been a lot of effort to make sure the Tiger bit streams are compliant to the new standards.

HDTU: Can you discuss what strategies or technologies are being used to address anomalies that arise during difficult scene changes like those with lots of motion answer?

JC: Tiger includes what we call a preprocessor before the encoder. What that preprocessor does is examine video content and characterize the types of video frames to be encoded. I have already mentioned things like citing where scene changes or fades are very important for the encoder to know.

There are a lot of things we look for. We look for motion as you mentioned. We make sure we are aware of, if you will, the true motion that is in the picture. We look for dissolves, which is a type of fade that mixes two different scenes and can cause the encoder a lot of problems. We make sure we are notifying the encoder of where those things are.

There's typically noise and film grain in the image, and the film grain needs to be identified and preserved. We look for the film grain, and we apply the correct encoding strategy to preserve it. There are a lot of varieties in the grain types.

Banding is another thing we look for, especially in animated content or content that has some CG in it. At one point or another through the compression process, banding can occur. So, we have some debanding strategies within the encoder itself. There has been a pretty major effort to make sure we address banding issues.

Those are some examples, but there are some other things we look for that provide inputs to the encoder for rate control and things like that. So, overall a pretty big piece of Tiger's encoding process is the work done in preprocessing.

The actual AVC encoder is a multipass encoder. In addition to preprocessing, it goes through multiple passes. During those passes, there is some evaluation of the quality within the encoder and it works to improve the video quality in difficult areas. The encoder has quite a bit of intelligence already, and once it goes through all of that, the compressionist can still go back and tweak things further.

HDTU: When the preprocessor identifies, for instance a dissolve, what does it do?

JC: There are tools within AVC that can be specifically leveraged for things like dissolves or fades. There is a tool called weighted prediction, which is one of several technology contributions to AVC by Thomson.

Basically, what we do is try to use weighted prediction and other tools of AVC to encode fades, dissolves and other scene transitions as efficiently as possible. The way weighted prediction works is essentially it allows you to add a kind of an alpha blend to the reference frames, and as you can imagine for a dissolve, it can then get very good performance from a compression perspective.

HDTU: Will MPEG-4 AVC remain primarily targeted at distribution and transmission, or do you believe it will have a role in the production chain from acquisition, perhaps ENG, to post production?

JC: I think we're seeing some interest in the industry for acquisition and post within with the MPEG standards body right now. There are some profiles still being finalized for intra-only support and 4:2:2 and 4:4:4.

Of course, MPEG 4-AVC already supports very high bit depths, so the standard is certainly capable. I see some movement in the industry. There are some prosumer cameras coming to market. There's certainly potential for this format to be used for acquisition and post, but those applications are still not firmly entrenched.

HDTU: How will Tiger begin showing up in the marketplace?

JC: Today, it's been deployed within Thompson's Technicolor division. It's being used there for productions that are moving into the manufacturing stage. I can't give you any title names at this point, but they will be coming to market within the next few months.

Right now, Thomson is exploring some exciting opportunities for Tiger outside of Thomson, but at this point I have no announcements I can make.

HDTU: Is there anything you'd like to add?

JC: We're very proud of the tool. I think one of the nice things about developing this tool was leveraging the two synergies within Thomson, that is Technicolor system knowledge, if you will, in this area and Thomson's compression expertise. They really came together to make quite a powerful tool.

We're just excited to see it being used to create titles for consumers to enjoy. I think we've moved the bar up a little bit in terms of video quality for H.264 and for consumers.

Tell us what you think!
HDTU invites response from our readers. Please submit your comments to editor@broadcastengineering.com. We'll follow up with your comments in an upcoming issue.

Discuss this Article 0

NAME:

EMAIL: Anonymous (optional) Sign in or register to use your Broadcast Engineering ID

YOUR COMMENT: *

SUBMIT COMMENT

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